Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Outsloping is used within areas of high- and moderate-burn severity where loss of control of water is a risk.

Description
Outsloped road templates disperse water and reduce erosion. Outsloping is useful in most locations, particularly for dispersing surface drainage on flat road grades. Outsloping is often combined with other road treatments, including rolling dips and armored crossings to control water.

Purpose of Treatment
Outsloping is a tool to drain water effectively from the road surface while preventing its concentration.

Emergency Stabilization Objective
Outsloping reduces adverse effects to water quality by dispersing runoff on roads and fillslopes.

Suitable Sites
This treatment is intended for use in one or more of the following locations.

- Outslope areas that concentrate flows
- Areas of high- and moderate-burn severity
- Road grades under 10 percent
- Areas susceptible to run-on from adjacent burned areas

Cost
Outsloping is performed along road segments where concentrated flow can cause adverse effects. Recent watershed contracts cited a cost of $2 per linear foot.

Outsloping can be contracted or accomplished by available forest road crews.
Cost factors include the following variables:

- Road prism shape (inslope or outslope)
- Size and extent of existing berm
- Presence and extent of vegetation

Treatment Effectiveness
No formal effectiveness monitoring data is available on road outsloping. Informal observations show both immediate and long-term facility and resource benefits, including less sediment delivered to stream channels and reduced road maintenance.

Ensure proper compaction and clearly identify road access needs. Rilling and sheet erosion can occur without proper roadbed compaction. Traffic use during wet road conditions reduces the effectiveness of the treatment.

In areas with highly erodible soils, outsloping roads with unvegetated soils may increase erosion. Other road treatments including rolling dips, armoring, and slope protection may be necessary in these areas.

Project Design and Implementation Team Information

Equipment
Outsloping is accomplished with an excavator, dozer, grader, and watertruck. The excavator pulls back the fill and places the material in the ditch. The dozer assists in moving and reshaping the road profile and the grader completes the final profile. Use water to moisten the soil for final shaping and compacting. Production rates vary depending on the degree of outsloping and the amount of material to be moved. Contact the forest engineer for updated cost and production rates for work performed on the forest.

Design
After the BAER assessment team has designated the potential treatment area, review these field sites with the engineer and soil scientist. Key design considerations include the length of road to outslope, erodibility of the fillslope, and treatment locations. Combinations of land, channel, and road treatments reduce or mitigate adverse effects downstream.

Construction Specifications

1. Perform any necessary clearing and grubbing, excavation and embankment, and erosion control to reshape the roadbed.
2. Construct the roadway to conform to the typical sections shown on the drawings.
3. Shape the roadway to provide drainage of surface water as shown on the drawings. (Often, a crawler-tractor dozer blade is used.)
4. Use an excavator to prevent sidecasting of material outside the traveled way.
5. Protect the cutslopes from undercutting by locating suitable borrow material from the berm or fillslope and place as shown on the drawings.
6. Remove all berms for maximum dispersal of water.
7. Accentuate the existing slope to 4 percent outslope.

8. Finish roadbed to a smooth riding surface with a motorgrader.
9. Ensure sufficient moisture exists to obtain compaction across the full roadway.
10. Remove berms on insloped roads and shape the roadway to outslope short segments.

Equipment

Heavy equipment (and operators) used to shape the road prism include:

- Dozer – D6
- Grader –12G
- Watertruck
- Service truck
- Equipment operator
- Truck driver (watertruck)
- Laborer (swamper)

Safety

Outsloping can be implemented safely if all hazards are mitigated. Review, update, and include the following items in the JHA:

- Equipment rollover from working near the road edge
- Accidents from nonoperational backing devices
- Lack of appropriate warning signs to road users
- Damage to vehicles from the windrow created between passes

Treatment Monitoring Recommendations

Implementation

- Was the work performed as designed?
- Were contract requirements met?
  - o Compaction to standard?
  - o Outslope grade at 4 percent?
  - o Was the berm removed?
- Was additional hillslope treatment performed such as mulching to protect the fillslope?

Effectiveness

- Are there signs of road-surface rilling?
- Are there signs of sediment delivery to the nearest channel?
- Are there indications of concentrated flow?
- Are there signs of slope failures?
- What storm events occurred prior to monitoring?

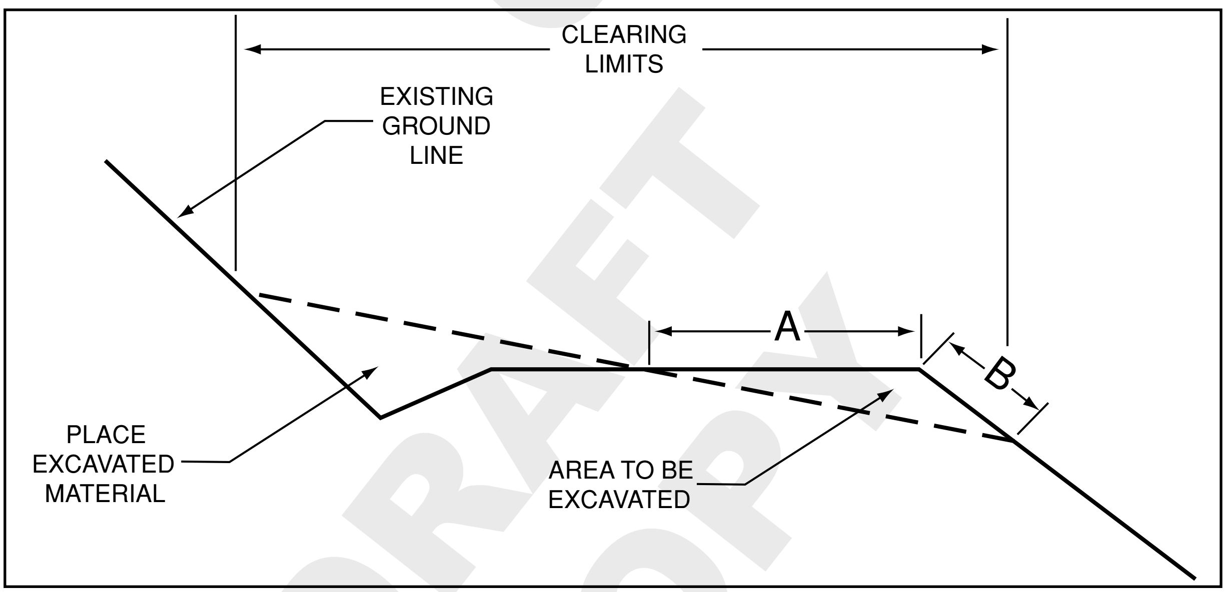

Figure 63. Outsloped road cross-section.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Rolling dips are implemented in high- and moderate-burn severity watersheds where loss of control of water and subsequent impact to infrastructure has been identified by the BAER assessment team. Rolling dips or armored crossings are used where existing road drainage is inadequate to handle increased runoff, sediment, and debris associated with the effects of the fire. This treatment may be implemented in connection with other road drainage improvement measures.

Description

Roadway dips modify the road drainage by altering the template and allowing surface flows to frequently disperse across the road. Dips are used in two ways: First, on an insloped road the dips take water from the inside of the road and transport it across the road to a designated and armored location that provides a relief. Second, on an outsloped road, frequent rolling dips provide a change in grade to disperse flows (Napper, unpublished paper).

Purpose of Treatment

Rolling dips are used to drain water effectively from the road surface and prevent concentration of water. Rolling dips also provide a relief for surface waterflow on the road and serve as a relief valve in the event of culvert plugging.

Emergency Stabilization Objectives

Rolling dips are used to reduce the risk to the road infrastructure from loss of water control. Rolling dips also reduce adverse effects to soil, water, and aquatic habitat from increased erosion.

Suitable Sites

Rolling dips are used in one or more of the following locations:

- Roads with a continuous grade and infrequent drainage structures.
- Culverts (below) that have diversion potential.
- Roads where frequencies between inspection and maintenance may be limited after the fire.
- Roads with grades less than 12 percent.
- Roads where outsloping is not feasible.

Cost

In recent Pacific Southwest Region (R5) watershed restoration contracts, rolling dips were implemented to improve road drainage and reduce risk of culvert plugging. Costs for rolling dips ranged from $390 to $1,200 per dip.

Cost factors include the following variables:

- Material consistency.
- Production rates (estimate 2 to 4 dips per day depending grade and excavation).
- Amount of excavation and material movement.
- Equipment necessary (water may be necessary to ensure appropriate compaction if the road is very dry).
- Armoring requirements.

Treatment Effectiveness

No formal effectiveness monitoring data exists on rolling dips. Rolling dips and outsloping are common BAER treatments used to disperse flows and prevent stream diversion. Rolling dips are constructed easily with a dozer but often are too short in length, or too shallow to contain the expected flows. In addition, rolling dips can be compromised by driving through them in wet soils, creating rutting. Treated roads with traffic should be armored to maintain the rolling dips' effectiveness. In addition, BAER implementation teams should pay special attention to locating rolling dips and staking each site.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review these field sites with the engineer to ensure site suitability. Key design considerations include access needs during the emergency period, diversion potential at culverts, road gradient, and slope length.

Clearly identify the locations of the dips using stakes, GPS coordinates, and maps. Consider equipment travel distance between sites and whether the equipment would be transported or walked from each location. Identify logical treatment units that reduce travel time.

Construction Specifications

- Identify the road segment to be treated and determine spacing guidelines.
- Consider intervals suggested in guides based on erosion hazard rating, road grade, and road design speed.
- Ensure that the existing design (spacing) of dips on the road may be sufficient especially when combined with an outslope or inslope to standard specifications.
- Add dips to create a drivable overflow structure. Dip placement in this application is immediately below or downgrade of the culvert.
- Perform any necessary clearing or grubbing to construct the dips as shown on the drawings.
- Excavate and use borrow material during embankment; excavate drainage; shape the roadway (to 4-percent outslope unless otherwise designated in writing) in the drainage dips. The dip invert shall slope 4-percent greater than the road grade.
- Construct dips with a skew angle to the line perpendicular to the centerline of the roadway, as designated in writing. The typical angle is 30 degrees.
- Recommend armoring the surface and lead out.

Equipment Material

Dips are constructed with a dozer, typically a D6 or larger, and may be finished to a smooth driving surface with a motorgrader. A watertruck may be required to provide adequate moisture for compaction. Dips in BAER applications may be armored with rock to reduce rutting.

Safety

Rolling dips can be safely implemented if all hazards are mitigated. Review and update the JHA and include the following items:

- Heavy equipment use.
- Equipment rollover risk on unstable ground.
- Accidents from backing.
- Rough road surface during construction.

Treatment Monitoring Recommendations: Implementation

- Was the dip built as designed using the appropriate length, depth, skew, and armoring?

Effectiveness

- Did the dip carry runoff?
- Are the dips correctly spaced?
- Is the length between dips correct?
- Are the dips correctly located (addressing both road and hillslope runoff)?
- Did the dip prevent diversion potential?
- Did a nearby culvert plug or exceed its capacity?
- Was the armoring outflanked?
- Did sediment deposit in the dip?

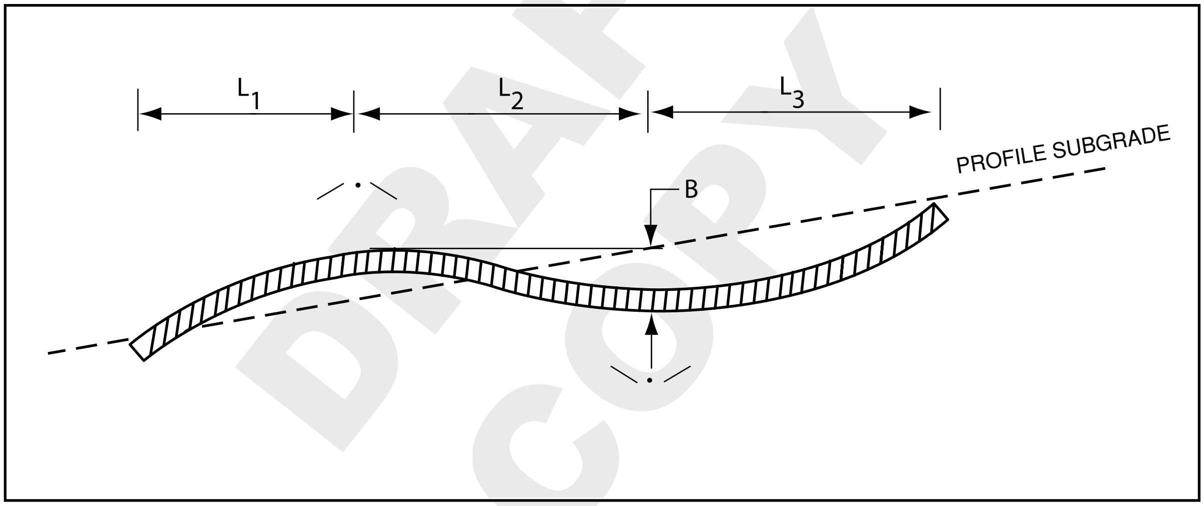

Figure 64—Rolling dip profile. Note: Dip dimensions, L1, L2, L3, and B will be designated in writing and staked on the ground by the engineer.

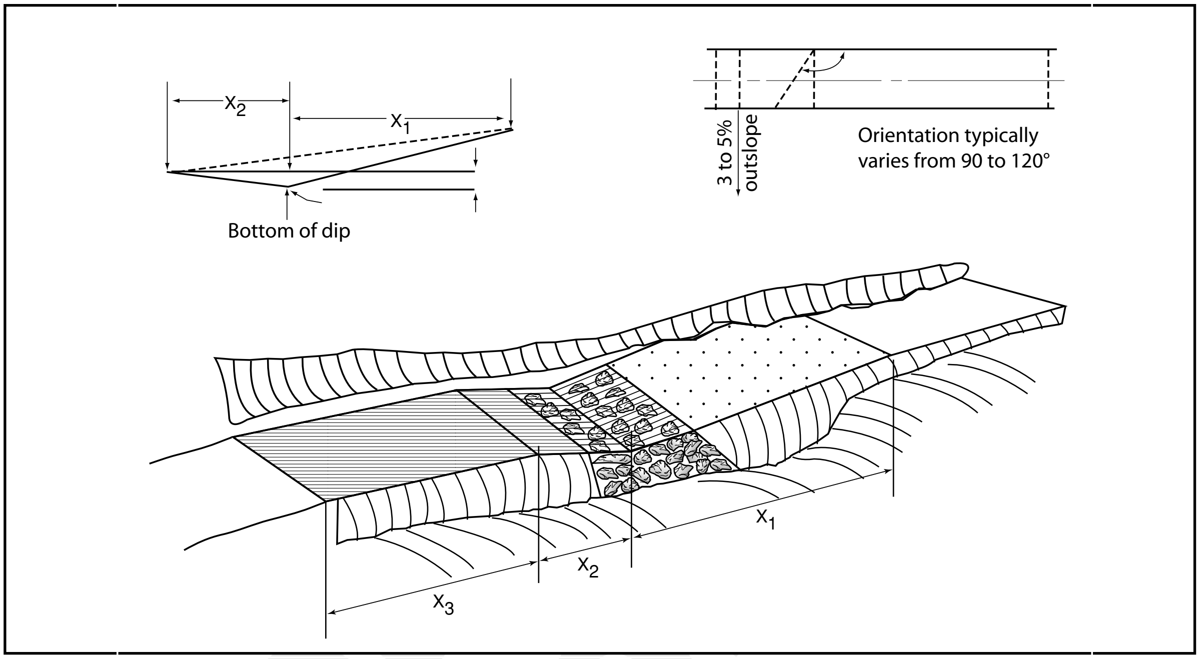

Figure 65—Armored rolling dip.

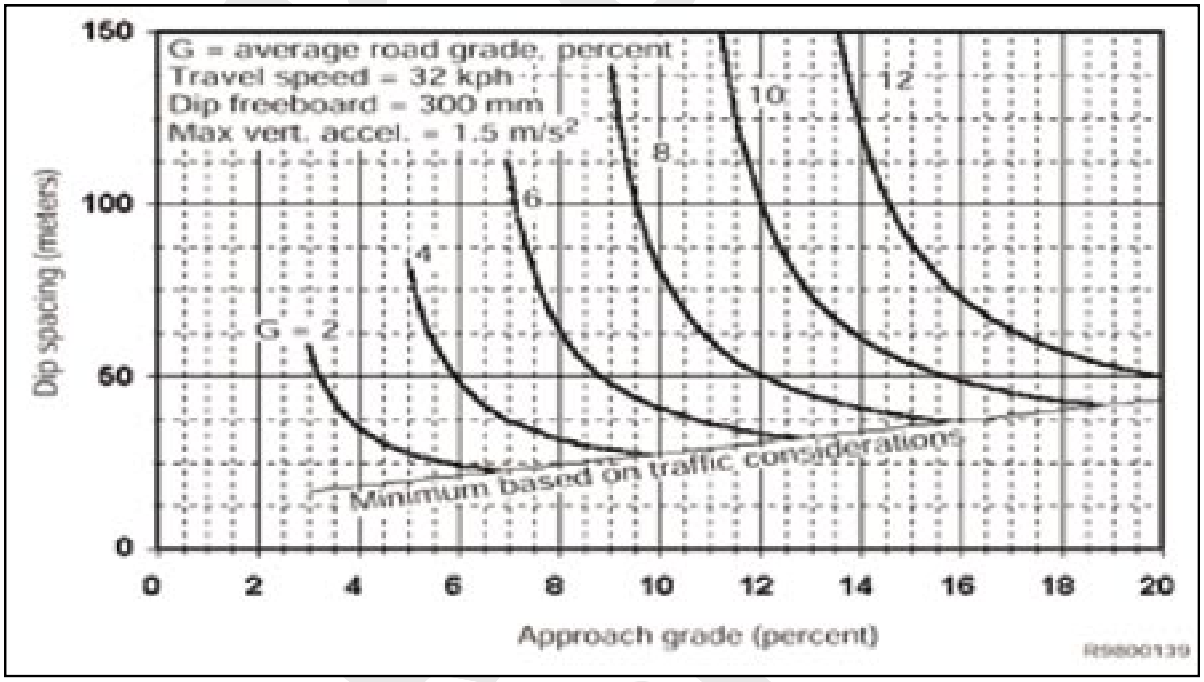

Figure 66—Rolling dip spacing guidelines.

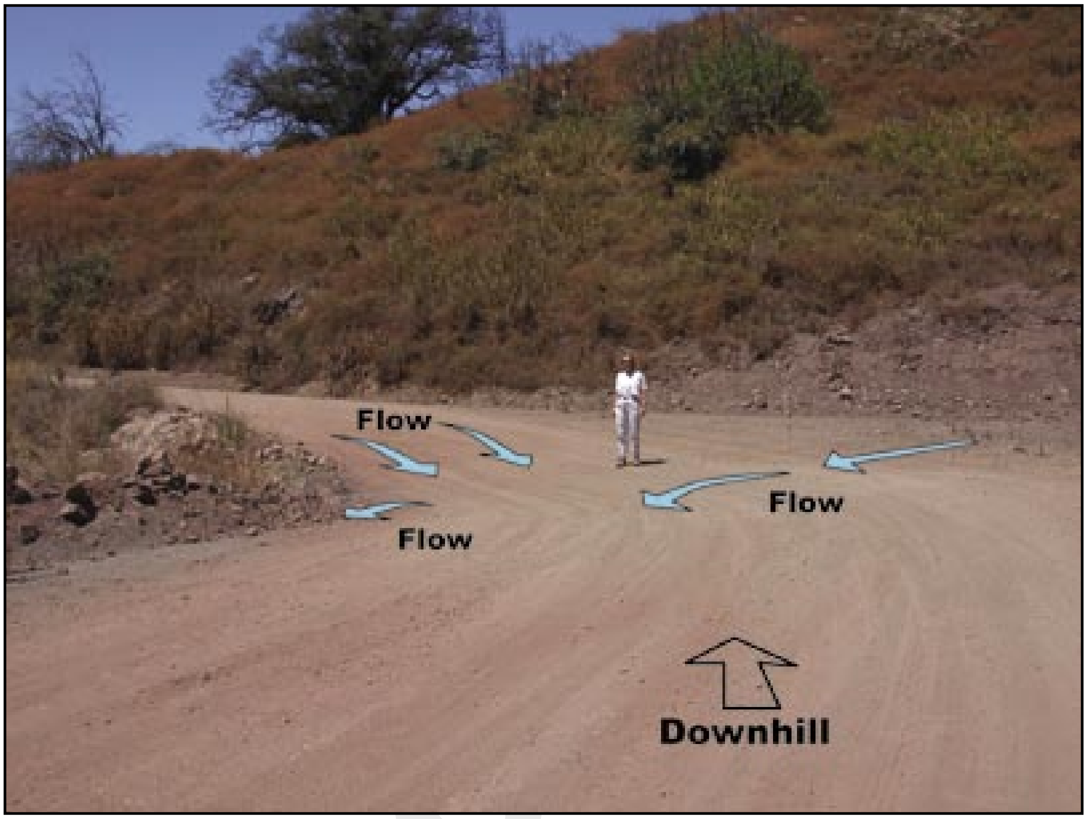

Figure 67—Rolling dip.

Figure 68—Rolling dips must be long enough to accommodate vehicle traffic.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Overflow structures are used on roads to control runoff across the road prism and to protect the road fill. Structures are placed in defined channels, or more commonly, in areas between defined channels where increased storm runoff is predicted due to reduced infiltration (Napper, unpublished paper).

Description

Post-fire storm runoff comes from various sources including streams, hillslopes, and defined road drainage structures. Controlling the runoff to avoid culvert failure, maintain access, and prevent road and fillslope erosion is important.

The structure used depends on the road design, maintenance, and service level. Typical methods include armored rolling dip, overside drain, or imbricated (overlapped) rock-level spreader.

Purpose of Treatments

Overflow treatments are used to protect the fillslope and reduce erosion from increased storm runoff.

Emergency Stabilization Objectives

Overflow structures reduce risk from fillslope erosion and downcutting to the road infrastructure. The structures also reduce adverse effects to soil, water, and aquatic habitat from fillslope erosion.

Suitable Sites

This treatment is intended for use in one or more of the following locations:

- Roads located below high-and moderate-burn severity areas.
- Road segments that have a long continuous grade and infrequent drainage.
- Roads that are insloped.

Overflow Structures

Armored rolling dips provide increased capacity when hydrologic analysis indicates the current pipe size is too small for the short-term increased storm runoff created by the fire. The dips prevent stream diversion by safely channeling increased flows back into the channel. Armored rolling dips are used instead of culvert upgrading when there are constraints on timing, access, or with the road fill (insufficient roadway cross section to bed a larger pipe).

Overside drains (berm drains and down drains) are placed in stream crossings where no culvert or armoring exists and in locations where the embankment (fillslope) needs protection. Berm drains protect embankments in the following situations:

- Burn below the road was moderate or high severity and lacks vegetative cover.
- Berm is a part of the original road design and removing it is impractical.
- Overside drains help maintain control of water in a concave topography with berm drains by directing runoff into natural channels.

Imbricated rock-level spreaders have been used on high standard roads including State highways and county roads. The imbricated rock-level spreader is a permanent structure that is built with large rock placed in a stairstep (shingled) design on excavated benches with either little or no grade along the revetment's length (longitudinal axis). The spreader protects the road fill from overland flows (Brown, personal communication).

Cost

The three types of treatment vary in cost. Cost estimates can be developed based on material and installation requirements.

Armored rolling dips are constructed with a minimum of 10 cubic yards of riprap through the road prism and additional riprap, or in some cases larger material, may be required on the fillslope. Equipment used to place material includes a dozer and backhoe. Prices range from $500 to $2,000 per structure depending on the amount of riprap required (Napper, unpublished paper).

Overside drains (berm drains with down drains) are assembled onsite by a crew. To improve effectiveness the berm drains work better when they transition with an asphalt curb.

Imbricated rock-level spreader is built with Class 5 rock at a minimum. Geotextile may also be used to prevent loss of fines. An excavator is used to build the benches and to place the rock.
Cost factors include the following variables:

- Distance from rock source
- Traffic access needs during construction
- Size and length of fillslope

Treatment Effectiveness

Armored rolling dips are effective low-cost treatments when properly designed and implemented. Consider the anticipated increase in flow and vehicle access needs on the road prior to building the dip. Qualitative monitoring of armored rolling dips found erosion problems when the dip was too short and when insufficient riprap was used on the fillslope.

Overside drains fail if not properly designed, installed, and maintained. The drains fail for several reasons. First, the corrugated metal is more resistant to erosive forces than the surrounding soil, so the overside drain will remain when the surrounding soil erodes. Use an overside drain on paved roads with an asphalt curb in areas of high- and moderate-burn severity where little vegetation remains and root strength will not stabilize a berm. Secondly, maintenance of the drainage structure is required to clear deposited soil, ash, and debris. Finally, install the overside drain with adequate length to protect the fillslope, so discharge does not cause erosion at the slope's toe.

Imbricated rock-level spreaders (rock armored overflow) have been used by the U.S. Department of Transportation Federal Highways Administration (FHWA) to protect fillslopes in areas that burn frequently. Initial qualitative monitoring indicates these structures are effective when they discharge directly onto a highly vegetated/wooded zone. In burn areas, where this is not possible, the bottom tier should be buried to be flush with the existing ground. Armoring or paving the shoulder or berm that discharges into the spreader provides a smooth transition for surface flow and prevents erosion around the structure (Brown, personal communication).

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review these field sites with the engineer and hydrologist to ensure the site suitability. Different sites may require different overflow structures. Key design considerations include:

- Vehicle use and access needs
- Maintenance requirements of the structure
- Land treatments implemented on the hillslope
- Size of contributing area
- Fillslope erodibility

Analyzing these design considerations allows the designers to mix and match appropriate overflow treatments for the area. If the structure may affect a water feature, obtain needed stream/wetland alteration permits. Use permit exemptions as appropriate for Federal requirements.

Construction Specifications

Armored rolling dip

1. Visit each site to determine exact needs. The site geometry determines the amount of material required.
2. Determine the volume of material to be removed to make the crossing and the volume of rock needed for the armoring.
3. Stake the portion of the road prism that will be lowered to provide the flood flow path. Ensure that this staking will place the flow where it will be controlled with the armoring.
4. Determine the rock source. Make arrangements for procuring the rock and ensure that it is sized appropriately.
5. Contact your call-when-needed contractor and arrange for a site visit for the treatment sites. Show the contractor the diagrams and drawings. Ensure that the contractor understands what a successful treatment should look like.
6. Coordinate with other road users to inform them that work is scheduled on these crossings.
7. Stockpile sufficient rock nearby, but out of the way, at each treatment site.
8. Construct the rolling dip ensuring it is deep enough with the rock placement to accommodate increased stormflows (Napper, unpublished paper).

Overside Drains

1. Identify the location for the overside drain.
2. Consider the existing road design and length of contributed area.
3. Match the size of the overside drain to the contributing area.
4. Reinforce the existing berm with an asphalt berm on paved roads and when placing a drain in a dip or low spot.
5. Assemble the overside drain.
6. Anchor the drain at all locations and provide energy dissipation at the outlet to prevent erosion.

Imbricated Rock-Level Spreader (Rock armored overflow)

1. Dig benches in the fillslope to a predetermined depth or until a structurally sound foundation is reached.
2. Line the benches with geotextile to prevent loss of fines during runoff events if rock is not encountered.
3. Design benches with a flat or very mild grade along the longitudinal axis.
4. Slope benches slightly into the face of the excavation for added stability.
5. Place rocks such that joints are staggered and consecutive rows are overlapping.
6. Place the bottom tier of the structure flush to the ground to prevent erosion.
7. Construct a paved shoulder that directs surface flow into the spreader to ensure a smooth transition from paved road to the rock-level spreader (Brown, personal communication).

Equipment/Materials

The following equipment/material is required:

Equipment

- Excavator with bucket and thumb.
- Dozer – equivalent to a D6.

Material

- Riprap and/or boulders appropriately sized for the specific site.
- Overside drain.

Safety

Overflow structures can be implemented safely if all hazards are mitigated. Review, update, and include the following items in the JHA.

- Working with heavy equipment
- Cuts and abrasions from assembling overside drain
- Walking and working on unstable ground

Treatment Monitoring Recommendations

Implementation

- Was the structure installed as designed?
- Was grade lowered through the rolling dip to provide stormflow passage?
- Were permit final reports submitted or exemption's documented?

Effectiveness

- Was the structure tested by the design stormflows at the time of monitoring?
- Did the structure pass the stormflows?
- Are there an adequate number of structures for the increased runoff?
- Are there signs of erosion or rilling on the road or toe of slope?
- Are there signs that the riprap material may have moved?
- Is the riprap size sufficient?
- Did the structure receive maintenance?
- Does the structure require maintenance to properly function?

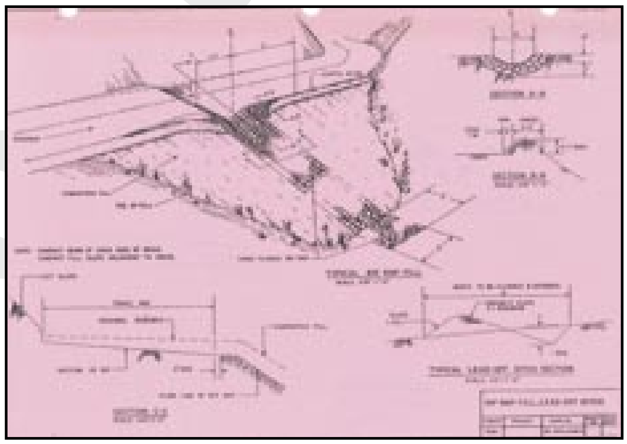

Figure 69—Armored rolling dip (profile view).

Figure 69a—Completed armored rolling dip.

Figure 70—Metal overside drain.

Figure 71—Failed metal overside drain.

Figure 72—Rock armor used to replace failed overside drain.

Figure 73—Imbricated rock level spreader is used on paved roads to protect the road fill.

Figure 74—Imbricated rock level spreader used by FHWA in areas that burn often and control of water on the fillslope is critical.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
A low-water stream crossing (LWSC) protects transportation infrastructure, reduces or eliminates the loss of control of water, and reduces the threat to water quality. LWSCs can be designed to accommodate aquatic passage.

Description
LWSCs temporarily replace culverts during the period of extreme watershed response and eliminate the potential for plugging and stream diversion of a natural channel. There are three common types of LWSCs:

Natural fords. For most BAER treatments the natural ford crossing is a quick, efficient treatment that responds to the emergency created by the fire. Natural ford crossings eliminate culvert failure from plugging and are easily implemented on roads that meet the site-selection criteria. The natural ford conforms to the streambed or the desired crossing elevation above the streambed. The grades of the roadway approaches are shaped to provide a smooth transition with slopes less than 10 percent. The crossing is constructed of crushed stone, riprap, boulders, pre-cast concrete slabs, or other suitable material.

Vented ford with pipes. This is a structure with pipes under the crossing that accommodate low flows without overtopping the road. High water will periodically flow over the crossing. Approaches are designed to provide acceptable grades of less than 10 percent by shaping the roadway or adjusting the crossing elevation. The pipes or culverts may be embedded in earth fill, aggregate, riprap, or portland cement concrete. The vented ford works well when fisheries and water quality requirements prohibit vehicles from entering the stream and where bedload is unlikely to plug the culverts.

Low-water bridge. A flat-slab bridge deck is constructed at about the elevation of the adjacent stream banks, with a smooth cross section designed to allow high water to flow over the bridge surface without damaging the structure. Use the low-water bridge when normal daily flow cannot pass economically or effectively through a vented ford, especially when fish passage is required.

Purpose of Treatment
LWSCs prevent stream diversion and keep water in its natural channel. A LWSC prevents erosion of the road fill and reduces adverse effects to water quality. LWSCs maintain access to areas once storm runoff rates diminish.

Emergency Stabilization Objective
LWSCs or fords reduce the risk to the road infrastructure and adverse effects to water quality and aquatic habitat.

Suitable Sites
The natural ford is appropriate in the following locations (FSH 7709):

- Use LWSC structures on traffic-service level "C" and "D" roads where water overtops the road continuously or intermittently during and following mild floods.
- Roads crossing ephemeral or seasonally flowing channels.
- Roads where traffic can be interrupted during periods of mild to severe flooding.
- Fisheries and water quality requirements allow vehicles to enter the stream.
- The normal daily flow is less than 6 inches deep.
- Hydrologic analysis requires expensive pipe sizes or pipes that do not fit the roadway cross section.
- Culverts are at risk of plugging and diverting from increased runoff and bedload.
- Road crossings where high sediment delivery is expected.

Cost
Costs for LWSCs range from $500 to $2,500 for an unvented ford. Costs increase for a vented ford or low water bridge. Consult the forest engineer for updated costs.
Cost factors include the following variables:

- Amount of material to be moved from stream channel.
- Amount of riprap required to armor exposed and erodible slopes.
- Distance from material source (rock plant).
- Depth of fill or embankment.
- Distance to disposal site.
- Use of force account crews or indefinite delivery/indefinite quantity contracts.

Treatment Effectiveness
Ford crossings effectively eliminate loss of water control at road/stream crossing. Poor design or implementation results in greater damage to the infrastructure and water quality. Common problems include the overall stability of the endwall (also known as fordwall) design. Design the endwall to accommodate increased stormflows and associated bedload and debris. Bury the endwalls deep enough, or provide them with an erosion-resistant splash pad to prevent undermining. When the top of the endwall is placed at stream grade or below, problems with downcutting or aggradation of material above the structure are avoided. If the gradient is too flat through the structure, aggradation may occur requiring maintenance to remove the material deposited. The typical failure is undercutting of the endwall due to insufficient armoring (Napper, unpublished paper).

Informal monitoring indicates that flexible structures (those created with boulders versus grouted) adjust to changes and do not undercut or scour-out from underneath. The boulder or riprap structure has a size gradation of material so voids are not created. The structure is long enough to avoid outflanking with high flows.

Jersey barriers (also known as K-rails) are less effective as an endwall material since they are not flexible. Placing a jersey barrier at grade is more difficult than boulders. Where a culvert is being replaced by a LWCS, establishing the stream grade can be difficult. Look carefully to find clues of the original streambed level masked by years of deposition.

Project Design and Implementation Team Information

Design
Many design possibilities exist for natural fords. If the stream has a flat slope and a rock or gravel bottom, construct a natural ford by lowering the road grade to the stream bottom.

USDA Forest Service Handbook direction notes the following design considerations: On streams with steep slopes, or with rough, rocky, or soft sandy bottoms, level the bottom with a coarse gravel, or riprap. Install an endwall on the downstream edge of the road to hold the leveling layer in place. The endwall is both long enough and buried below the natural stream grade to ensure the walls will not be undermined. Allow sufficient length to prevent outflanking when the channel is moving both bedload and debris.

Successful endwalls can be built with:
- Loose boulders.
- Rock-filled gabions.
- Planks
- Jersey barriers.

Method of Implementation/Installation

1. Excavate the existing fill material at the stream crossing.
2. Remove the culvert and any unsuitable material associated with the culvert, including all soft or spongy material.
3. Incorporate suitable excavated material into the roadway on either side of the crossing.
4. Dispose of unsuitable material at designated disposal sites.
5. Reshape the drainage to establish the natural stream channel grade.
6. Look for indications of stream gradient associated with stream cobbles, boulders, and vegetation.
7. Dig a trench for placement of the endwall once the channel is reshaped and stream gradient through the crossing is set.
8. Place the boulders, Jersey barrier, or rock-filled gabions in the trench.
9. Backfill along the trench.
10. Place a graded mix of riprap and boulders below any structure if there is more than an 8-inch drop of water from the structure to prevent scouring. With larger drops, a revetment blanket may be required for spillway armor (Napper, unpublished paper).

Equipment
Various equipment is required depending on the design of the ford crossing. However, basic equipment to remove the culvert and shape the road grade includes the following:
- Dump trucks (belly dump, semidump).
- Excavator with bucket and thumb attachment.
- Dozer with adjusting blade (D-6 or larger) depending on the amount of material to be moved.

Safety
A LWSC is implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Working around moving equipment.
- Lifting heavy rocks or materials may cause muscle and back strain.
- Shifting equipment loads may have potential for rollover.
- Working near hazard trees.
- Working in and near a stream zone with unstable footing.

Treatment Monitoring Recommendation Implementation

- Was the project implemented as designed?
- What was the size and depth of material placed?
- Is the structure long enough and the ends high enough to avoid potential outflanking?
- If the road is above the stream grade, were materials placed downstream to protect the fillslope and road embankment?

Effectiveness
Ask the following questions to determine treatment effectiveness:

- Was any riprap material moved from the site?
- Was the structure tested at the time of review by the design storm?
- Was the structure outflanked by any flows?
- Was the slope of the road adequate to allow material to move across the structure?
- Are there indications of rilling or headcutting?

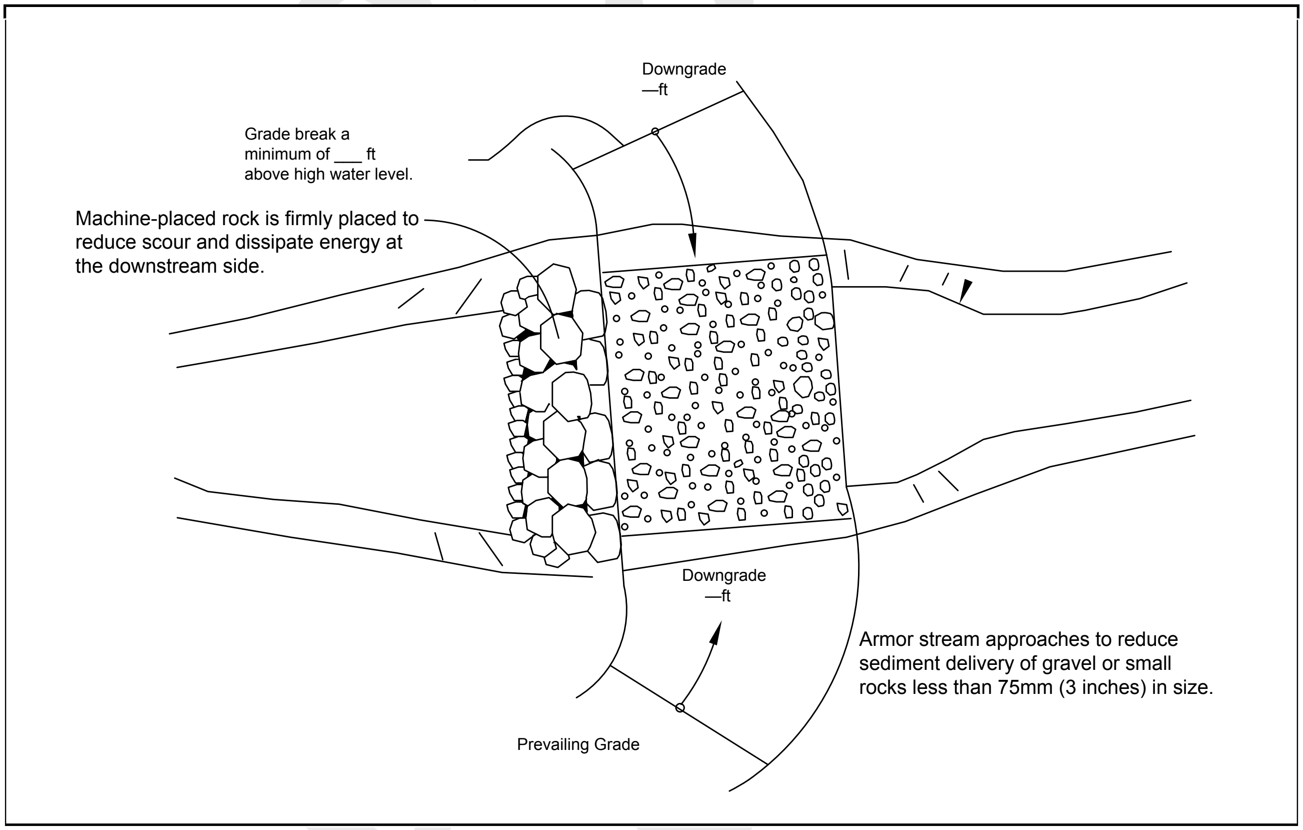

Figure 75—Low water stream crossing diagram.

Figure 76—Low water stream crossing replaces a 24-inch culvert.

Figure 77—Ensure adequate length of the endwall and armor the outlet to prevent scouring.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Culvert modification addresses the flooding and debris concerns identified by the team as a result of the fire. Culvert modification usually involves upgrading the culvert size for increased runoff and associated bedload and debris. Upgrades occur on perennial channels where road access is required and the existing culvert does not meet USDA Forest Service direction for aquatic species passage.

Description

Culvert modification replaces fire-damaged culverts or upgrades culverts for increased flow or debris expected as a result of the fire. Upgrades must be compatible with road and trail management plans as well as forest plans and interim direction such as Pacfish/Infish guidelines for culvert sizing. When upgrading is undertaken solely to protect the road or trail investment, the cost for upgrading should be less than the cost to repair damages after they occur (BAER Guidance Paper-Roads and Trails Treatments).

Culvert upgrading design and treatment implementation incorporates each forest's direction for both hydraulic capacity of the culvert and any requirements for aquatic species passage. Given the values at risk, the treatment must be quickly designed and implemented to maintain access and protect aquatic resources. If vehicle access is not needed, temporary culvert removal is an option until the area stabilizes.

Purpose of Treatments

The purpose of culvert modification is to increase the flow and debris passage capacity to prevent road damage.

Emergency Stabilization Objectives

The objectives are to prevent the loss of the road infrastructure and reduce risks to critical natural resources and downstream values.

Suitable Sites

This treatment is intended for use in one or more of the following locations:

- High-burn severity watersheds.
- Drainages with undersized culverts.
- Road access is required.

Cost

Culvert upgrades are costly and vary from $20,000 to $150,000 per structure. Cost factors include the following variables:

- Culvert size (diameter and length)
- Culvert type
- Site access
- Site hazards
- Fill (remove and replace)
- Headwall and endwall
- Inlet reconfigurations

Treatment Effectiveness

Effectiveness monitoring of this treatment is only qualitative. The treatment rates 'well' when the new culvert is installed prior to the first rains and withstands the flows and debris associated with the post-firestorm runoff. 'Poor' ratings reflect the inability to perform the upgrade in a timely manner or culverts still not large enough and failing.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review these field sites to ensure suitability and determine the best culvert modification for each site. Because the design and construction of each culvert upgrade will vary by location, design teams should include engineers, hydrologists, and fishery biologists. The design team should identify resource objectives to select the best treatment for each site. Consult the contracting officer early and frequently for timely implementation of the treatment.

The design team may select installation of metal end sections on culverts to help channel debris flow to reduce plugging. Metal end sections add approximately 15 percent to the hydraulic efficiency of inlet-controlled culverts.

Safety

Culvert modifications are implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Working with heavy equipment.
- Working in and near a stream zone with unstable footing.
- Working near hazard trees.

Treatment Monitoring Recommendations

Implementation

- Was the project implemented as designed?

Effectiveness

- Did the structure (including overflow devices) function as designed?
- Does the structure allow aquatic organism passage for all life stages?
- What size storm events had the structure received at the time of monitoring?

Figure 78—Metal end sections are attached to culvert inlets to improve the hydraulic efficiency and reduce the potential for plugging.

Figure 79—This larger pipe was installed to replace an undersized culvert that had failed in the past.

Figure 80—This culvert was modified with two culverts and risers to handle increased flows and potential woody debris.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Debris racks (trash racks) and debris deflectors are structural measures that protect culverts from plugging with debris and causing potential stream diversion. Debris varies in size and includes sediment, rock, small and large limbs, and logs. Debris countermeasures depend on the size and type of debris anticipated from the fire.

A debris deflector is a structure placed at the culvert inlet to route the major portion of the debris away from the culvert entrance. (USDOT FHWA, 2004) Debris deflectors are used for medium (tree limbs or large sticks) to large (logs or trees) floating debris.

A debris rack is a structure placed across the stream channel to collect the debris before it reaches the culvert entrance. Debris racks are usually vertical and at right angles to the streamflow, but they may be skewed with the flow or inclined with the vertical. (USDOT FHWA, 2004) Debris racks are used for small (small limbs or sticks) and medium floating debris.

Description

A debris rack is a barrier across the stream channel which stops debris too large to pass through a culvert. Debris racks are designed for small and medium floating debris. The storage area must be large enough to retain the anticipated type and quantity of debris expected in one storm or between cleanouts. Debris racks are constructed in sections using heavy rail, steel, wood, or chainlink fence material. Rail and steel construction are stronger and more resilient to stormflows than either wood or chainlink racks.

Debris deflectors are generally V-shaped structures with the apex pointed upstream. Common designs have the apex as the lowest point of the structure. Deflectors function by diverting medium and large floating debris and large rocks from the culvert inlet to accumulate in a storage area where debris is removed after the flood subsides. The deflector's structural stability and orientation with the flow make it suitable for large culverts, high-velocity flows, and debris consisting of heavy logs, stumps, or large boulders.

Purpose of Treatments

Debris structures (racks and deflectors) are designed to protect culverts from catastrophic road failure by catching floatable debris in streams that would plug culverts. Accumulated debris is removed periodically or cut into smaller pieces to pass through the culvert. Debris structures protect downstream habitat by trapping fine and coarse detritus from sheet, rill, gully, channel, and bank erosion behind the structure. All the material behind the debris structure can be removed and placed at a designated location out of the channel.

Emergency Stabilization Objectives

Debris structures protect the transportation infrastructure, public safety, and downstream resource values.

Suitable Sites

The treatment is intended for use in one or more of the following locations:

- Drainages at risk of plugging with debris.
- Culverts that can accommodate the storm runoff design capacity but may have increased bedload and debris.
- Movement of both bedload and debris.
- Identification of crossings where stream diversion is possible.
- Downstream infrastructure, public safety, or other resources are at risk.

Cost

Debris structures vary in price depending on materials. Costs for log debris racks used in the southwest ranged from $100 to $4,000 each. The lower cost log debris racks often are constructed with onsite material and built in series up the channel to store more material.

Debris structures constructed with heavy rail or steel range from $3,000 to $30,000 or more depending on the size and materials required. A heavy rail or steel structure may be worth the investment, depending on the type of material that is mobilized and the values at risk below.
Cost factors include the following variables:

- Structural measure required to withstand the anticipated debris and storm runoff (debris deflector or debris rack).
- Site location and access.
- Materials required for implementation.
- Number of structures and locations.
- Availability of knowledgeable crew or contractor.
- Maintenance frequency.

Treatment Effectiveness

No quantitative data exists on the effectiveness of debris structures. However, anecdotal information indicates they can be effective with proper implementation and maintenance. Problems can occur if the design structure is too small for the stormflows and associated debris. Effectiveness monitoring of debris structures is needed.

Debris-structure effectiveness depends on identifying anticipated debris type, amount, and maintenance. For BAER teams new to an area, obtaining historical information without someone familiar with the areas is difficult. Discussions with the forest engineer, road crew, and hydrologist may identify areas prone to debris jams. Timely inspection and removal of debris from the debris structures is critical to their success. BAER teams must consider storage capacity above the debris rack or the size of the accumulation area for a debris deflector prior to recommending this treatment.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review each field site to ensure suitability and determine which debris structure is appropriate.

Field survey data should include the following (USDOT FHWA, 2004):

- Classification of the expected debris size.
- Quantity of expected debris.
- Future changes in debris type or quantity due to the fire.
- Stream and watershed characteristics upstream of the site.
- Streamflow velocities in the vicinity of the culvert.
- Direct and indirect evidence related to the delivery potential of floating debris.
- Cross sections of the area available for debris storage at the site.
- Data on the maximum allowable headwater and embankment height for a culvert structure.

Once this information is gathered, the implementation team can identify the type of structure required at each site and materials can be ordered.

Implementation Specifications

Debris Rack

Do not place the debris rack in the plane of the culvert entrance because it will plug easily. “Where a well-defined channel exists upstream of the culvert, the debris rack should be placed upstream from the culvert entrance a minimum distance of two times the culvert diameter. However, they should not be placed so far upstream that debris enters the channel between the rack and the culvert inlet.” (USDOT FHWA, 2004) Other guidelines for locating the debris rack include adding the size of the culvert diameter to the fill height and then multiplying that number by 1.5. The final number is the distance from the culvert entrance where the structure should be placed (Kuyumjian, personal communication). In other scenarios the channel type and access to the area may dictate the debris rack’s location. Consult with the forest engineer, hydrologist, and geologist when locating the debris rack. If a large debris storage area exists at the rack location, maintenance frequency is reduced and added safety is provided against overtopping the installation during a single storm.

The general dimensions of a trash rack vary from site to site. The straining area of a rack should be at least 10 times the cross-sectional area of the culvert being protected. Vertical bars are spaced from one-half to two-thirds the minimum culvert dimension to allow lighter debris to pass through the rack and the culvert. The overall rack dimensions should be a function of the amount of debris expected per storm, the frequency of storms, and the schedule of expected cleanouts. When a rack is installed at the upstream end of the wingwall, it should be at least as high as the culvert (USDOT FHWA, 2004).

Rack height should allow some freeboard above the expected depth of flow in the upstream channel for the design flood. Racks 10- to 20-feet high have been constructed.

Vertical racks that receive the full impact of floating debris and boulders should have their brace members set in concrete.

Debris Deflectors

Debris deflectors usually are built of heavy rail or steel sections. However, timber and steel pipe can be used if the debris is light floating or fine detritus. Salvaged railroad rails may be used.

The deflector is built at the culvert entrance and aligned with the stream rather than the culvert so that the accumulated debris does not block the channel. For multiple pipes install a single deflector or individual deflectors can be built over each pipe.

General dimensions for deflectors provided by the FHWA recommends that the angle at the apex of the deflector should be between 15 and 25 degrees, and the total area of the two sides of the deflector should be 10 times the cross-sectional area of the culvert. The deflector's base width and height should be at least 1.1 times the respective dimension of the culvert. The upstream member is vertical on most installations. However, a sloping member at the apex (sloping downstream from bottom of member) reduces the impact of large floating debris and boulders and probably prevents debris from gathering at that point.

"Spacing between vertical members should not be greater than the minimum culvert dimension nor less than one-half the minimum dimension. A spacing of two-thirds the minimum dimension is commonly used. Where headwater from the design flood is expected to be above the top elevation of the deflector and floating debris is anticipated, horizontal members should be placed across the top. The spacing of horizontal members on the top should be no greater than one-half the smallest dimension of the culvert opening." (USDOT FHWA, 2004)

Equipment

Heavy equipment generally is required for installing a heavy rail or steel structure debris rack or debris deflector. The equipment may include a backhoe or excavator, depending on the size of the debris rack and whether it is prefabricated or welded onsite. A hand crew can build a log debris structure. If the logs are large a backhoe can help expedite the process.

Safety

Debris structures are implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Working around moving equipment.
- Working near hazard trees.
- Lifting heavy rocks or materials can cause muscle and back strain.
- Working in and near a stream zone with unstable footing.
- Welding onsite requires eye protection.

Treatment Monitoring Recommendations
Implementation

- Was the project implemented as designed?
- Is the structure placed in the channel away from the culvert opening to prevent plugging?

Effectiveness

- Did debris move down the channel?
- Did the debris rack prevent the culvert from plugging?
- Did the area receive the design storm event at the time of monitoring?
- Is the culvert functioning as designed?
- Did the treatment protect the road?

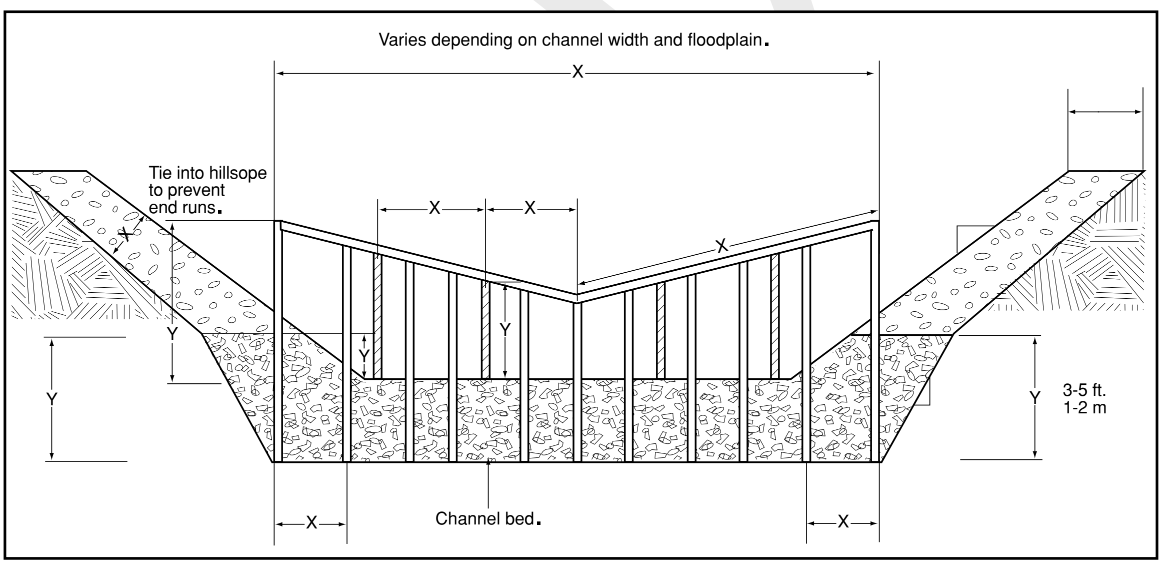

Figure 81—Typical debris rack structure.

Figure 82—Debris rack effectively trapping material from plugging the culvert.

Figure 83—Debris racks must be long enough to avoid material from outflanking the structure.

Figure 84—Debris deflector is located at inlet of culvert..

Figure 85—Large debris deflector on crossing below a major interstate.

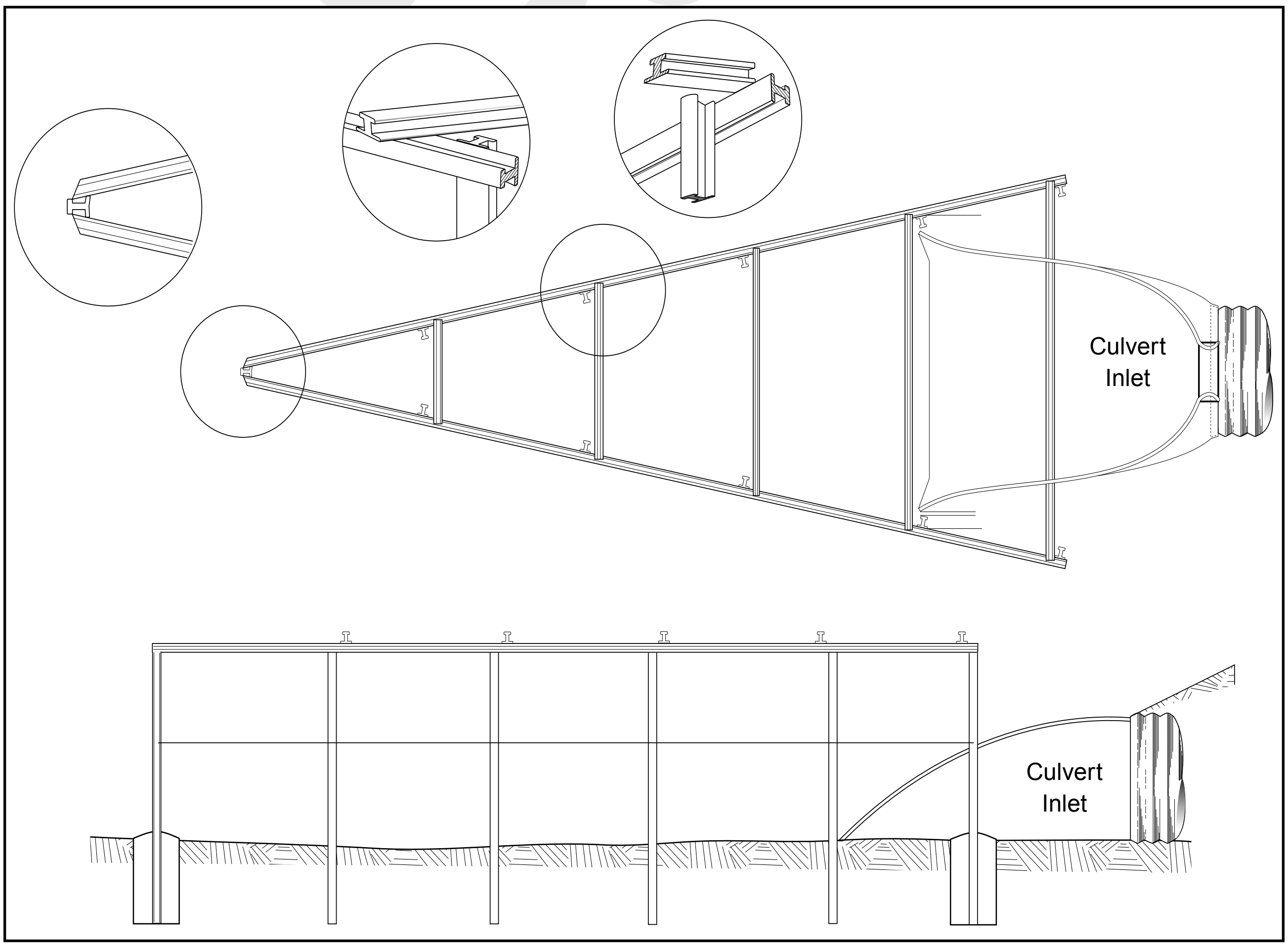

Figure 86—Typical debris deflector structure.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Risers are used to protect transportation infrastructure on roads with large fills where access must be maintained (paved roads, county roads). Risers cannot be used in areas where aquatic passage is required.

Description
Riser pipes are a low-cost, quickly implemented treatment that provides sediment storage upstream of a crossing that would otherwise plug. Each riser is designed individually to meet the needs and mitigate the risks at a particular crossing. Riser pipes function to sieve debris and allow passage of water. The riser pipe allows accumulation of bedload sediments released from the drainage due to the loss of soil cover and reduced infiltration from water repellant soils. The sediment and ash captured in the basin can be removed with a backhoe or extend-a-hoe and properly disposed (Napper, unpublished paper).

Purpose of Treatments
Riser pipes help prevent culverts from plugging with sediment and floating debris. The pipes capture sediment and reduce downstream impacts to water quality. Riser pipes also reduce peak flows by storing water and sediment.

Emergency Stabilization Objective
Risers are used to protect the road infrastructure from failure.

Suitable Sites
Riser installation is intended for application at one or more of the following locations:

- Access at road crossings with a culvert inlet is limited by conventional equipment (backhoe).
- Access (storm inspection) during the winter and spring is precluded by snow or soft roadbed.
- Drainages with high-burn severity and erosion predictions indicate a high risk of sediment delivery.
- Channels (confined) that have high bedload transport.
- Culverts that range from 18 to 48 inches.
- Roads that are paved (county roads) and provide access to residences.*
- Channels (stream) that have high bedload transport capabilities.*
- Channels that are seasonal.

*Riser pipes are often used by county and State road departments on higher volume roads where they can frequently check and maintain the structures.

Cost
Risers are inexpensive temporary treatments that can be implemented with a force account road crew or through a construction contract. Contract prices in 2003 for a 36-inch diameter corrugated metal pipe welded to an elbow were $750 to $1,400 for labor and material. The riser and elbow were then collared onto the existing culvert.
Cost factors include the following variables:

- Job done by force account or contract
- Culvert size and inlet condition
- Location and access of site(s).

Treatment Effectiveness
No effectiveness monitoring data exists for risers aside from anecdotal information. Risers are used by both the USDA Forest Service and county road departments and have performed well when maintained. Problems occur if the structures are not routinely checked and debris removed from the basins. Risers are temporary treatments that are easily disassembled and returned to the forest equipment yard when no longer needed. Risers are installed quickly and at a low cost. They also trap sediment and maintain culvert function effectively.

Project Design and Implementation Team Information

Design
After the BAER assessment team has designated potential treatment areas, review these sites in the field with the engineer and hydrologist to ensure site suitability. Key design considerations include the following:

- Culvert size.
- Inlet condition.
- Riser height.
- Sediment storage capacity.
- Maintenance frequency.
- Sediment disposal areas.
- Culvert diversion potential (may require placing an armored or rolling dip on the road too).

Once the design is complete, stake each site, obtain GPS coordinates for the location, and contact the local force account crew or the call-when-needed contractor to arrange a site visit.

Construction Specifications

There are several riser-pipe designs and installation methods. Two common methods are discussed below:

Drop-Inlet Design

The drop-inlet design is the most adaptable and common because there is no direct connection to the existing pipe. The vertical riser is a corrugated metal pipe with a notch cut into the bottom (to the diameter of the pipe being enclosed) and fits over the culvert, effectively sealing off the opening from the surrounding soil. The drop-inlet riser should be no less than 36 inches in diameter. Vertical notches or slits are cut into the riser with the lowest notch opening placed above the area backfilled. As much as one-third of the riser height may be backfilled to stabilize the structure.

Risers over 8 feet in height may require backfilling or anchoring to keep them from moving with the expected flow velocities. Anchors help until the accumulation of a soil surrounding the pipe secures it in place.

Armor the bottom of the riser with large rocks (8 to 12 inches) to protect from scouring. The erosive force of the water pouring in from the sides and top can be powerful. The rock armor must not be higher than the invert of the culvert and should be at least 1-foot thick.

Place a steel grate at the top of the riser to keep floatable debris out. An antivortex collar is used to prevent a vortex from damaging the road fill.

Include a dewatering feature for large risers behind high embankments to relieve the possible buildup of hydrostatic pressures. This feature can be as simple as a few small holes near the bottom of the pipe covered with filter cloth to allow drainage into the riser and through the culvert.

T-Design

The T-design or elbow attachment requires that a collar be attached to the existing culvert that runs beneath the embankment. The collar connects the existing pipe to the elbow riser. The height of the elbow riser is based on the fill height or the expected accumulation of sediment and debris between maintenance. Because pipe inlets are often damaged, collar installation may require excavation to expose the pipe sufficiently to cut off the damaged section. This riser type has slits and a grate over the top, too.

The angle between the existing pipe and the riser should be less than 90 degrees for efficient flows and maintenance. This riser design in a large fill has the potential to back up water behind the embankment and create a hydrostatic condition. The hydrostatic pressure can be alleviated by installing a section of perforated pipe near the bottom or by perforating the pipe used and wrapping it with filter cloth.

Equipment/Materials

Riser pipes are relatively easy to install, depending on size. Equipment includes the selected riser attachment, backhoe, chain, labor, riprap (for inside the drop-inlet design), grate, and any additional tiedowns to stabilize the riser.

Safety

Risers are implemented safely if all hazards are mitigated. Review, update, and include the following items in the JHA.

- Working with heavy equipment.
- Lifting heavy objects.
- Walking and working on unstable ground.

Treatment Monitoring Recommendations

Implementation

- Was the structure installed as designed?
- Were all the design components implemented (anchors, rock armor, relief for hydrostatic pressure, slits, perforations, stability of riser, height of collared T relative to fill)?

Effectiveness

- Was the structure tested according to the design storm identified in the 2500-8 at the time of monitoring?
- Was the storage area adequate for the frequency of maintenance and the size of the contributing area?
- Was sediment trapped and did water continue to pass through the structure?
- Was the road infrastructure maintained without loss to the road or access?

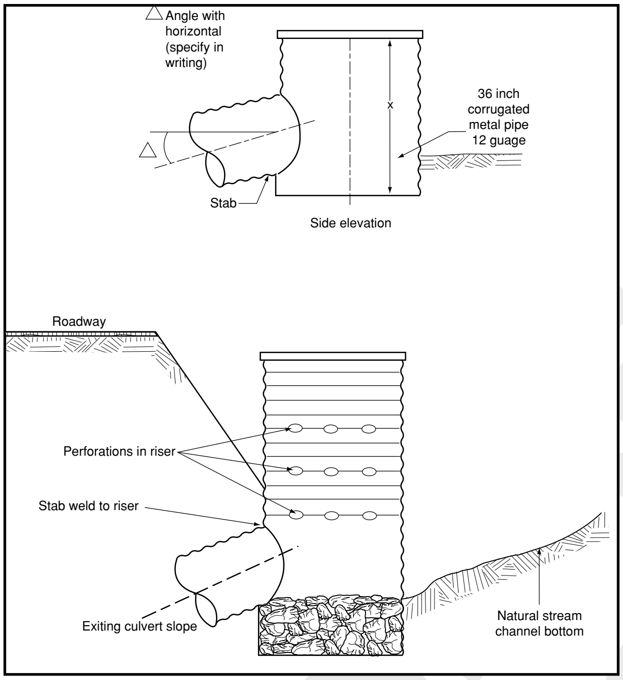

Figure 87—Perforated drop-inlet riser.

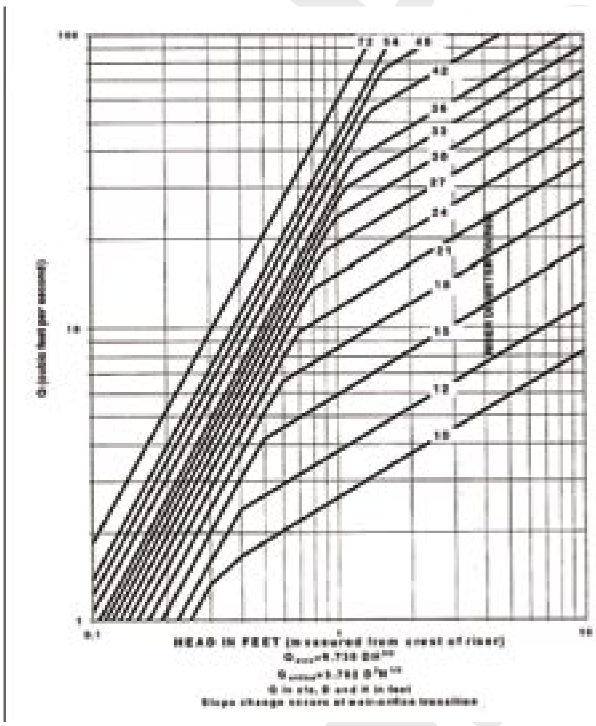

Figure 88—Riser sizing chart.

Figure 89—Riser located next to county road and receives frequent maintenance to remove material.

Figure 90—Small riser used to prevent plugging of culvert.

Figure 91—Riser is attached to the culvert headwall to reduce culvert plugging.

Figure 92—Ensure the openings on the riser are sized to allow water to flow freely into the structure. Small openings can plug with fine detritus.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Catchment-basin cleanout is used in stream channels, above culverts, and in catchment basins where the threat of sediment reducing the culvert capacity and creating a flash flood is identified as an emergency.

Description
Catchment-basin cleanout increases the channel capacity for predicted sediment. The size of the catchment basin and the contributing sediment source dictate treatment frequency.

Purpose of Treatments
Catchment-basin cleanout is the removal of organic debris and sediment deposits to prevent them from becoming mobilized in debris flows or flood events.

Emergency Stabilization Objectives
Catchment-basin cleanout protects the transportation and facility infrastructure.

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Road crossings where existing sediment reduces the culvert capacity
- Streams where fish requirements are not a concern
- Areas with high values-at-risk have been identified
- Locations where clearing can be done prior to the first damaging rain

Cost
Catchment-basin cleanout varies from $200 to $2,000 for each basin
Cost factors include the following variables:

- Amount of material removed.
- Location of disposal site.
- Cost for move-in and move-out.
- Frequency of catchment-basin cleanout.

Treatment Effectiveness Information
No quantitative effectiveness monitoring data is available on catchment-basin cleanout but anecdotal information suggests the treatment is effective.

In many areas the culvert capacity is limited by lack of maintenance. Removing and disposing of material prior to storm events is effective. This treatment does require inspection of the catchment basins between storm events to determine whether additional cleanout is necessary.

Project Design and Implementation Team Information

Design
After the BAER assessment team has designated potential treatment areas, review these field sites with the forest engineer and hydrologist. Key design considerations include channel gradient, design storm, catchment basin capacity, and material to be removed at each site. Review the burn severity above the catchment basin and determine whether upslope treatments adequately mitigate the sediment delivered to the basin.

Construction Specifications
For sediment removal projects identify:

- Sediment disposal areas with stakes and flags.
- Limits of excavation required.
- Vegetation to be left undamaged.

If you are removing a lot of material with numerous trucks, develop a traffic safety plan. Appropriate temporary road closures while equipment is working also may be necessary.

Equipment
Heavy equipment is used to remove sediment and may include excavators, backhoes, front end loaders, and dumptrucks.

Safety
Catchment-basin cleanout can be implemented safely if all hazards are mitigated. Review and update the JHA as needed and include the following items in the JHA.

- Traffic safety plan.
- Snag hazards are identified and removed.
- Work involving heavy equipment.

Treatment Monitoring Recommendations
Implementation

- Was the work performed as designed?
- Was the work completed prior to the first storm?
- Were designated disposal areas stabilized?

Effectiveness

- Did the culvert plug with sediment?
- Was the structure damaged?
- What storm events had occurred prior to monitoring?

Figure 93—Removing accumulated sediment to ensure culvert capacity prior to seasonal storms can reduce the risk to the transportation infrastructure.

Figure 94—Typical equipment used to cleanout basins include excavators, backhoes, and dumptrucks.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Use storm inspection/response (previously called storm patrol) in high- and moderate-burn severity watersheds where access is required (road cannot be stormproofed and closed) and there is a high risk of loss of water control from inadequate drainage structures. Storm inspection/response must be more cost effective than upsizing or modifying existing drainage structures (BAER Guidance Paper-Roads and Trail Treatments).

Description
Storm inspection/response keeps culvert and drainage structures functional by cleaning sediment and debris from the inlet between or during storm events on roads where access is required. Storm inspection/response performed during the storm should meet safety considerations in the JHA (Napper, unpublished paper).

Purpose of Treatment
Storm inspection/response provides needed road access throughout the designated storm season by ensuring road drainage function.

Emergency Stabilization Objective
Storm inspection/response is an efficient measure to protect the transportation infrastructure after a wildfire. The treatment is used in lieu of more costly upgrades that are not feasible due to expense or design timeframe (Napper, unpublished paper).

Suitable Sites
Storm inspection/response is intended for use in one or more of the following locations:
- Road crossings where loss of control of water or exceedance is identified.
- Road access is necessary throughout the storm season.
- Road crossings where high sediment and debris is anticipated.
- Roads susceptible to landslides.
- Roads with all-season surfacing (aggregate or asphalt).

Cost
Cost estimates can be obtained from estimating force-account salary or from existing construction contracts. Storm inspection is performed with forest road crews, IDIQ contracts, or construction contracts.

Equipment	Rate (per day)	Basis
Backhoe	$390.00	2005 RSMeans
Front-end loader	$465.00	2005 RSMeans
Pick-up truck (4 by 4)	$63.50	2005 RSMeans
Tandem dumptruck (11 mt)	$272.00	2005 RSMeans
4-person crew	$970.00	2005 RSMeans

Cost factors include the following variables:
- Distance from site to staging area.
- Difficulty with access (downed logs and rocks blocking road).
- Inclement weather slowing productivity.
- Location of disposal site.
- Number of anticipated storm responses.

Treatment Effectiveness
No formal effectiveness monitoring data exists on storm inspection/response. Informal observations indicate cost effectiveness because many road problems are avoided with timely clearing and cleaning of road crossings.

Problems occur when a dedicated team is not made available to conduct the storm inspection and response. In some cases the patrol area is too large for a forest to do and contracting may be a solution. In accessible areas some forests have used storm patrols instead of installing trash racks or larger culverts.

Project Design and Implementation Team Information

Design
After the BAER assessment team has designated potential treatment areas, review these field sites. Key considerations include access requirements for private inholdings, structures, or facilities. Review the area with the engineer and identify critical areas or structures needing inspection.

Identify any hazards that require mitigation prior to implementation. Determine who will conduct the inspections. Inspection and response is done with force account or contract.

Implementation Specifications
- Determine the road inspection response areas.
- Divide the burn into areas or zones to help determine the number of people needed to effectively cover the area.
- Identify the higher elevations versus the lower elevations and plan your strategy for access.

- Identify high-priority areas that may require daily or frequent access.
- Identify surfaced roads and nonsurfaced roads to further decide on where the access will be.
- Identify high-risk structures or high-value areas that are prone to storm damage (Napper, unpublished paper).

Equipment/Tools
The following equipment and tools are used for the clearing of structures and restoring drainage function.

Equipment
- Backhoe w/extendahoe
- Dump truck (5- or 10-yard)
- Service truck (4 by 4) with winch

Tools
- Axe or pulaski
- Barricades
- Chain saw
- Come-along
- Digging bar (large)
- Pitch fork
- Rake
- Shovel
- Signs (hazardous condition)
- Signs (storm warning)
- Tow chain with hooks

Safety
Storm inspection/response is implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Make safety first and include the following in the JHA.
- Identify a communications plan (radios and spare batteries).
- Establish safety officer position and authority.
- Know the weather forecast and scout for hazards (trees, high-water, debris flows).
- Drive according to the road conditions, not on the perceived urgency of the task.
- Prepare for bad weather by taking additional food and blankets.

Ensure that work leaders and supervisors know the types and locations of the stabilization treatments. Have the communications and safety plans reviewed by the work leaders on a daily basis. Weather reports are a key element of the safety plan.

Driving on wet roads where rutting will occur defeats the purpose of a road patrol. Walking short distances to specific sites is more prudent. Road patrols should never be performed by only one person.

Road hazards discovered during road inspections should be barricaded immediately and reported.

Treatment Monitoring Recommendations
Implementation
- Were contract requirements met?
- What was the storm-patrol response time?
- Was material removed from areas identified by the BAER assessment team?

Effectiveness:
- Were there drainage structure failures?
- Was identified access maintained? If not, for what duration was access restricted?
- What type of storm event mobilized material? (Duration and intensity)
- Size and extent of material mobilized?

Figure 95—Rubber tire backhoes are an integral component of storm inspection/response.

Figure 96—Tracklaying excavators are very effective when moving large amounts of material quickly.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Use trail stabilization on trails lacking adequate drainage features for anticipated increased runoff.

Description
Trail stabilization methods include rolling dips, rubber belt waterbars, rock waterbars, and rock spillways. The stabilization methods selected may vary but are designed to reduce trail erosion or damage.

Purpose of Treatments
Trail stabilization provides drainage and stability to reduce trail damage or downstream values at risk.

Emergency Stabilization Objectives
Stabilization objectives are to reduce loss of property and unacceptable degradation to downstream values.

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Trails within or below high-burn severity areas
- Trails with sustained grade through burned areas that lack adequate drainage
- Trail segments that have the potential to deliver sediment to streams
- Trails where previous drainage structures were damaged by the fire
- Stream crossings with diversion potential

Cost
Trail stabilization costs in the Southwest Region (R3) from FY 2000 to 2003 ranged from $1,000 to $3,000 per mile.
Cost factors include the following variables:

- Number of structures required within the treatment area.
- Availability of material onsite.
- Crew skill level.
- Hazards adjacent to the trail requiring mitigation.

Treatment Effectiveness
No quantitative data exists on the effectiveness of this treatment. Clearly identify treatment areas so work can be done prior to the first damaging storm event. These treatments require a well qualified crew that can install the structures correctly for adequate drainage.

Project Design and Implementation Team Information

Design
Review the BAER assessment team findings on the ground to validate treatment areas. Place flags, stakes, and/or GPS coordinates at the treatment locations. Determine the materials available and select the appropriate stabilization method for the trail use.

Tools/Equipment
Tools and equipment required depend on the stabilization method used. Basic trail construction equipment is required for most methods. Rubber belt waterbars require purchasing treated timbers, galvanized nails, and a rubber conveyor belt.

Safety
Trail stabilization is implemented more safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Work in remote locations.
- Hazard trees along the trail.
- Trail crossings with unstable footing.
- Objects that require heavy lifting.

Treatment Monitoring Recommendations
Implementation

- Was the treatment implemented as designed?
- Were an adequate number of drainage structures placed to accommodate the increased runoff.
- Were energy dissipaters used to disperse flows at drainage crossings?
- Was trail outsloping within specification?

Effectiveness

- Are there signs of erosion and sediment delivery on the trail?
- How far did the runoff extend down the trail?
- Did the existing drainage structures perform as designed?
- Are more frequent drainage structures necessary?
- At the time of review were the structures tested according to the design storm identified in the FS 2500-8?

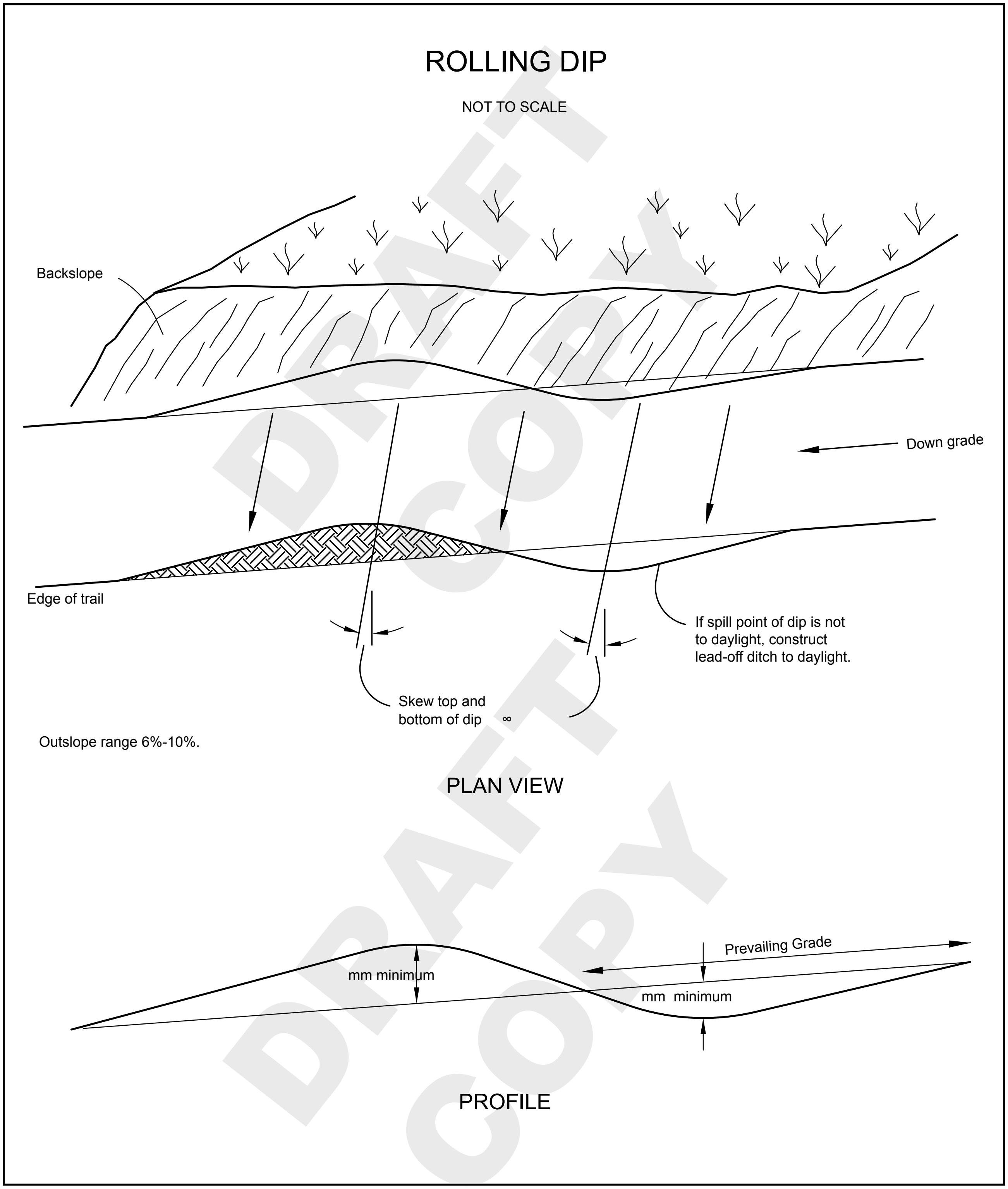

Figure 97—Trail rolling dip.

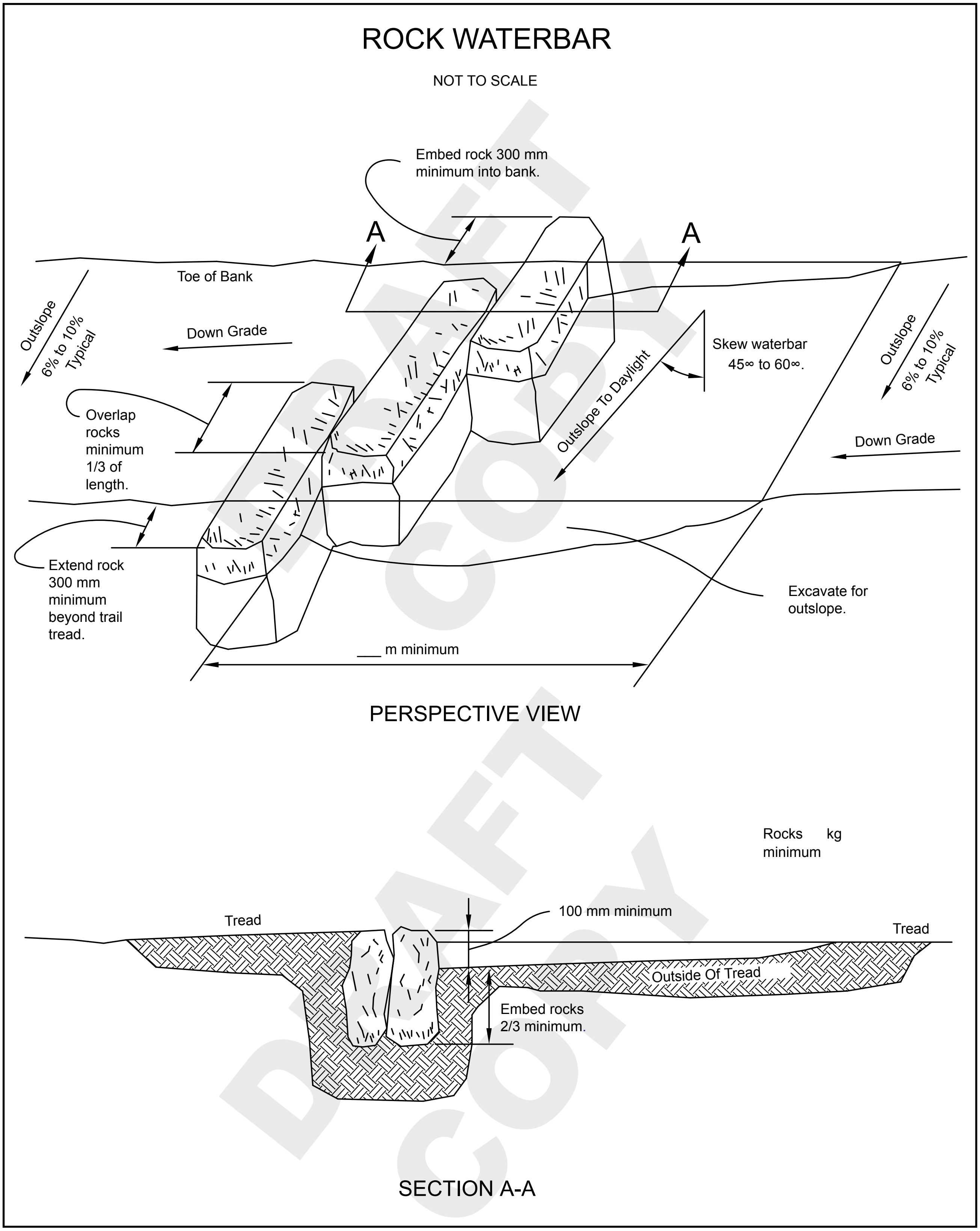

Figure 98—Trail rock waterbar.

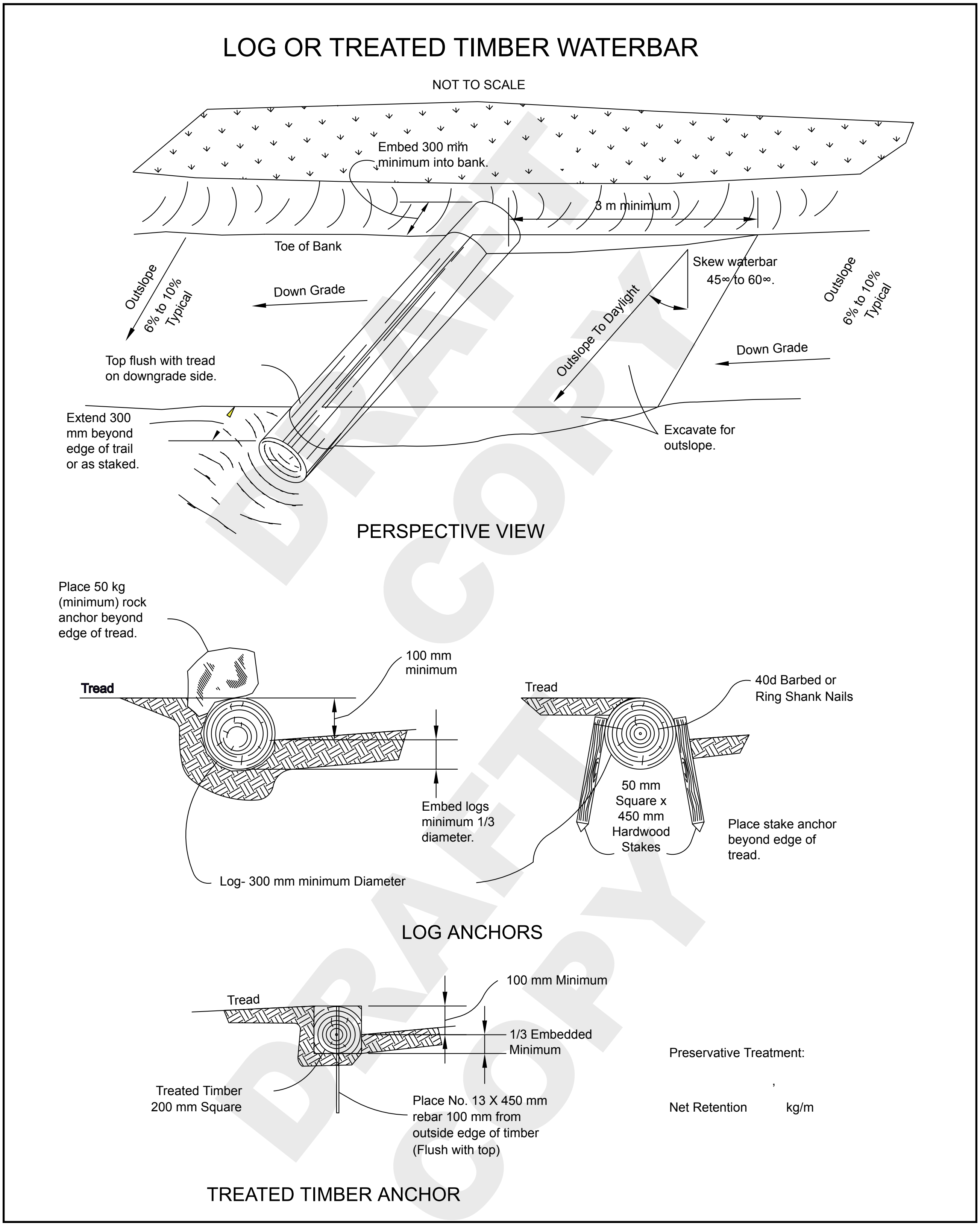

Figure 99—Log or treated timber waterbar for trails.

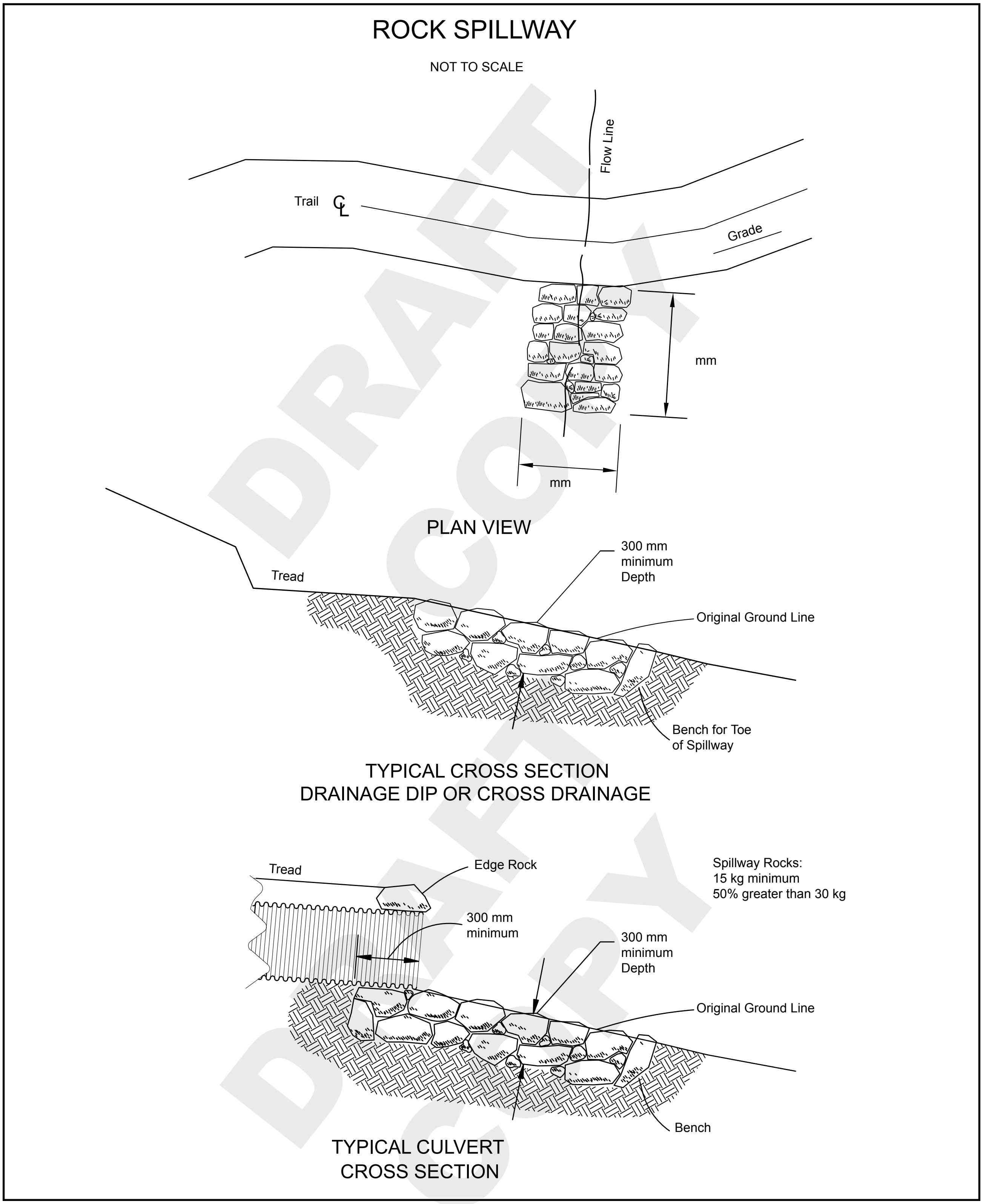

Figure 100—Trail rock spillway.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Road decommissioning (as a BAER treatment) is for unclassified roads (nonsystem, jammer roads) that are destabilized though loss of vegetation and high-burn severity surrounding the unclassified road. This treatment is not used on classified (system) roads.

Description

Road-decommissioning treatment includes subsoiling (tilling), restoring original hillslope conditions with recontouring of the road fill, restoring drainage through the road prism, and reducing further hillslope erosion. Road decommissioning uses an excavator and or dozer with rippers to pull material into the road and break through compacted soil layers improving infiltration.

Purpose of Treatments

Road decommissioning of unclassified roads improves infiltration, restores hillslope hydrology, and reduces erosion of sidecast material.

Emergency Stabilization Objectives

Road decommissioning stabilizes soil, thereby reducing degradation of natural resources and downstream values.

Suitable Sites

This treatment is intended for use in one or more of the following locations:

- Areas with high-burn severity and high-soil erosion potential.
- Roads (unclassified) destabilized by the fire through vegetation loss.
- Loss of stabilizing vegetation to hold soil and prevent erosion
- Areas where vegetative treatments are unlikely to be effective
- Hillslope with multiple unclassified roads (jammer roads)

Cost

Road decommissioning costs vary depending on the extent of the treatment. Cost estimates for recontouring the road prism in the Northern Region (R1) ranged from $7,000 to $8,000 per mile.

Costs generally are lower for this treatment because unclassified road prisms tend to be narrow, free of vegetation, and lack large cuts and fills. Equipment can treat these areas faster than in other more traditional road decommissioning restoration treatments.
Cost factors include the following variables:

- Hazard trees (or other hazardous conditions) requiring mitigation prior to implementation.
- Costs to move-in and move-out of proposed treatment locations.
- Equipment type and size necessary to implement the treatment.

Treatment Effectiveness

Road decommissioning of unclassified roads and old jammer logging roads was implemented successfully in Region 1. No quantitative data is available on soil-erosion rates but visual inspection reveals that the decommissioned unclassified roads became vegetated within the first year after treatment. Emergency treatment objectives to improve infiltration and reduce erosion by restoring the slope were achieved in the treated areas.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites. Key design considerations include site suitability for the treatment and method of road decommissioning. Heritage resources clearance is required. Identify potential hazards to mitigate before treatment implementation. Starting at the top of the watershed lay out the site with flags, stakes, or GPS coordinates. Determine road length to be decommissioned for each treatment area.

Tools/Equipment

Road decommissioning typically is implemented with a D-6 dozer (or similar equipment) with winged rippers mounted on the toolbar or an excavator. Equipment size depends on the road width, level and depth of compaction, and equipment availability. The excavator pulls sidecast material and fills to restore the original hillslope. Afterwards, the excavator places debris onto the treated area. Often a dozer and excavator will work together in tandem to implement the treatment. Ensure that the road prism is fractured adequately before pulling the fill material.

Safety

Road decommissioning is implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Working in and around heavy equipment.
- Operating on steep slopes.
- Working near hazard trees along the treatment area.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were guidelines for tilling depth followed?
- Were any seasonal channels encountered and opened to restore natural drainage patterns?
- Was available woody debris placed on the treated area?

Effectiveness

- Did the treatment reduce erosion and allow for vegetative recovery?
- Is the slope stabilized through use of the treatment?
- What storm events had occurred prior to monitoring?