

## Section H

# Causal Mechanisms and Prescriptions

### Introduction

The following Causal Mechanism Reports and Prescriptions were specifically prepared for use in the Willow/Freezeout Creeks Interim Watershed Mitigation Addendum (IWMA). The prescriptions are designed to provide protection of the aquatic resources that are the primary factors to salmonid production as identified in this watershed analysis. The prescriptions are meant to be used in addition or in-lieu, where possible, to the current California Forest Practice Rules and Company Policies as outlined in the Mendocino Redwood Company Management Plan, Policies and Targets (MRC, 2000) and Mendocino Redwood Company Option A (MRC, 2000). A prescription is only presented if it deviates from these regulations or policies. These prescriptions are meant to help address issues for the entire watershed to aid in the stewardship of aquatic resources of the Mendocino Redwood Company ownership in the Willow/Freezeout Creeks WAU.

The land management prescriptions presented here are the protections that Mendocino Redwood Company will pursue to provide protection of aquatic resources. In addition to these prescriptions Mendocino Redwood Company will build and maintain all of its roads at the standards presented in the Handbook for Forest and Ranch Roads (Weaver and Hagans, 1994).

The causal mechanism reports present the situations where watershed conditions are a likely source of a primary limiting factor. By addressing each of these situations with an appropriate prescription the situations that could impact sensitive resources will either be removed or their impact significantly lessened. This is to attempt to provide protection to watershed values from receiving significant or cumulative impacts from future management actions.

Monitoring will be conducted in the Willow/Freezeout Creeks WAU to ensure that these prescriptions are providing necessary protection to aquatic resources (see Section H, Willow/Freezeout Creeks WAU Monitoring Plan). This monitoring is part of an adaptive management approach that tests the hypothesized protections the prescriptions are developed to meet. If it is found that the prescriptions are not providing the appropriate protections, then they will be updated and improved.

### Factors Limiting Salmonid Production in the Willow/Freezeout Creeks WAU

The watershed analysis performed in the Willow/Freezeout Creeks WAU identified several factors that likely limit the production of anadromous salmonids in those watersheds. This section summarizes these factors and potential linkages to sources of the limiting factors in the watersheds. The limiting factors considered are

migration barriers, water quality, water quantity, sedimentation, temperature, large woody debris, and nutrients.

**Table 1.** Primary factors limiting salmonid production in the Willow/Freezeout Creeks WAU.

Anadromous Salmonid Life Stage	Factor	Reason	Current and Future Source(s)
Spawning	Fish migration barrier, Willow Creek.	High sediment inputs from past forest management activities and straightening of lower reaches of Willow Creek have created coarse sediment aggradation and resulted in adult fish migration barrier.	<ul style="list-style-type: none"> <li>• Stored sediments in upper channel reaches.</li> <li>• Mass wasting from shallow and deep seated landslides.</li> <li>• Sediment delivery from fluvial erosion created from roads and skid trails.</li> <li>• Degradation and bank erosion in headwater streams.</li> </ul>
Spawning	Fish migration barrier, Freezeout Creek.	Just within the MRC property the Freezeout Creek channel does not facilitate anadromous fish migration.	<ul style="list-style-type: none"> <li>• Naturally occurring high gradient channel with cascades and waterfalls limits anadromous fish migration.</li> </ul>
Rearing	Sedimentation	High sediment inputs from past forest management activities has filled pools and lowered the diversity of rearing habitat	<ul style="list-style-type: none"> <li>• Stored sediments in upper channel reaches.</li> <li>• Mass wasting from shallow and deep seated landslides.</li> <li>• Sediment delivery from fluvial erosion created from roads.</li> <li>• Sediment delivery from skid trail erosion.</li> <li>• Degradation and bank erosion in headwater streams.</li> </ul>
Rearing, Over-wintering	Large woody debris (LWD)	LWD need is high in the majority of the watercourses in the WAU. This limits pool formation, high flow refuge, habitat cover and sediment routing.	<ul style="list-style-type: none"> <li>• Conifer trees adjacent to watercourses.</li> </ul>
Rearing, Spawning	Water Quality	High erosion rates suggest a possibility of high fine sediment in transport in the watersheds increasing storm water turbidity.	<ul style="list-style-type: none"> <li>• Surface erosion from roads and skid trails.</li> <li>• Fluvial erosion from roads and skid trails.</li> <li>• Bank erosion and stored sediments in stream channels.</li> </ul>

The consideration of primary limited factors (Table 1) is based on conclusions drawn from the various modules of the watershed analysis performed in the Willow/Freezeout Creeks WAU. The land management prescriptions developed in this watershed analysis attempt to address the source(s) of the primary factors limiting salmonid production.

**Causal Mechanism and Prescription Reports**

Each Causal Mechanism Report and Prescription has specific headings to provide background on the watershed situation and prescription. The following is the description of these headings.

*Resource Sensitive Area:* the area encompassed by the prescription, the module describing the input process is referenced here.

*Source Variable and Process:* this briefly states what is the source variable of a primary limiting factor. These inputs can be both detrimental and beneficial to the aquatic resource.

*Limiting Factor Vulnerability:* this is the vulnerability of the limiting factor. See the appropriate modules (stream channel condition, riparian function or fish habitat) for justification of this vulnerability.

*Delivered Hazard Rating:* this is the relative hazard of inputs (sediment, wood, or heat) delivering or affecting the limiting factor being discussed. See the mass wasting, surface erosion, or riparian module for justification of these hazards.

*Rule Call:* the rule call is the guidance for the prescription. Rule calls of prevent mean that the prescription must prevent the action described in the situation sentence. A minimize rule call means that the prescription must minimize the action described in the situation sentence. A standard rule call means no prescription needs to be developed that Company Policy or standard California Forest Practice Rules will be utilized. The rule call is determined by using the limiting factor vulnerability and the input process in the rules matrix (Table H-1).

Table H-1. Rule Call Matrix for Prescription Development

		Likelihood of Adverse Change and Deliverability		
		Low	Moderate	High
Limiting Factor	Low	Standard	Standard	Standard
	Moderate	Standard	Minimize	Prevent
Mendocino Redwood Co., LLC		H-3		September, 2001

Vulnerability

**High**

Standard

Prevent

Prevent

*Situation Sentence:* presents the situation that will be addressed by the prescription.

*Triggering Mechanisms or Issues:* presents the list of management actions that could impact the identified input process or sensitive resource. These actions should be addressed by the prescription.

*Prescriptions:* specific land management actions for the proposed causal mechanism.

**Causal Mechanism Report and Prescription #1**

**Resource Sensitive Area:** Mass Wasting Map Unit (MWMU) 1  
Stream Channel Geomorphic Units II, III and IV  
See Mass Wasting and Stream Channel Condition modules

**Source Variable(s) and Limiting Factor(s):** Sedimentation from mass wasting and bank erosion.  
Fish migration barrier from sediment aggradation in Willow Creek.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** High to Moderate

**Rule Call:** Prevent

**Situation Sentence:**

Small shallow seated landslides and bank erosion are common within the over-steepened slopes of the MWMU 1 topography. The immediate proximity of watercourses to these landslides provides direct delivery of fine and coarse sediment. Poor rearing habitat due to high coarse sediment levels is common in Willow Creek. Downstream aggradation and channel widening from coarse sediment in the downstream reaches of Willow Creek has created fish migration problems to the upstream habitat of Willow Creek. Fine sediment inputs are likely creating higher than natural turbidity during storm flows potentially affecting fish physiology, reduce feeding or in the worst cases increase mortality.

**Triggering Mechanisms or Issues:**

Road Construction  
Road Placement  
Timber removal  
Ground yarding equipment and skid trails

**Prescriptions:****MWMU 1 road placement, construction and management:**

Road placement, construction and management:

- New road construction in MWMU 1 on slopes greater than 50 percent will not occur unless it is the only access available. If new road construction must occur on slopes of 50 percent slope or greater in MWMU 1 it will only be to gain entry in and out of MWMU 1 and construction developed with the approval of a Certified Engineering Geologist.
- Seasonal roads (gets used annually) in MWMU 1 will have the surface of new road construction or re-opened existing roads armored with rock.

- Temporary roads (roads only used periodically, every few years or decades) in MWMU 1 will be storm-proofed (as per Weaver and Hagans, 1994) prior to the winter period and the surface stabilized with grass seed, mulch or other cover product.
- Any road that is within MWMU 1 will not have winter period heavy truck or log hauling traffic unless armored with a rock surface.

*Adjacent to Class I Watercourses:*

- MWMU 1 will receive no harvest on inner gorge slopes unless approved by a California Licensed Geologist. On other areas (non-inner gorge slopes) within MWMU 1 in addition to the riparian protections timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 75 feet slope distance after the break in slope of the inner gorge or a maximum of 190 feet.
- For those areas that do not have a well defined inner gorge topography in MWMU 1 protections will be 190 feet slope distance in width from the watercourse transition line. Timber harvest must retain 50% overstory canopy.
- The area of protection in MWMU 1 will be an equipment limitation zone (ELZ) except when slopes are less than 40%, or at designated crossings, or on established stable roads or tractor trails.
- The slopes of the inner gorge or the first 65 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.
- The area directly adjacent to the break in slope of the inner gorge will retain those trees with a root mass that maintains the stability of that slope break.

*Adjacent to Class II watercourses:*

- On slopes adjacent to Class II watercourses in MWMU 1, in addition to the riparian protections, timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The MWMU 1 protections will extend from the edge of the watercourse transition line up to the break in slope of the inner gorge and 50 feet slope distance after the break in slope of the inner gorge to a maximum distance of 150 feet. For those areas that do not have a well defined inner gorge topography in MWMU 1 protections will be 150 feet slope distance in width from the watercourse transition line.
- MWMU 1 will be an equipment limitation zone (ELZ) except when slopes are less than 40%, at designated crossings, and on established stable roads or tractor trails.

- The slopes of the inner gorge or the first 65 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.
- The area directly adjacent to the break in slope of the inner gorge will retain those trees with a root mass that maintains the stability of that slope break.

**Causal Mechanism Report and Prescription #2**

**Resource Sensitive Area:** Mass Wasting Map Unit (MWMU) 2  
Stream Channel Geomorphic Unit IV and some III  
See Mass Wasting and Stream Channel Condition modules

**Limiting Factor(s) and Source Variable(s):** Sedimentation from mass wasting and bank erosion.  
Fish migration barrier from sediment aggradation in Willow Creek.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** High to Moderate

**Rule Call:** Prevent

**Situation Sentence:**

The incised topography adjacent to watercourses of MWMU 2 has high risk for shallow seated landslide sediment delivery. The landslides in MWMU 2 are typically associated with destabilization of the toe of a watercourse's steep side slopes. Landslides or soil failures could be aggravated by soil disturbance by heavy equipment, road building or removal of ground stabilizing vegetation. The immediate proximity of watercourses to these soil failures provides direct delivery of fine and coarse sediment. Poor rearing habitat due to high coarse sediment levels is common in Willow Creek. Downstream aggradation and channel widening from coarse sediment in the downstream reaches of Willow Creek has created fish migration problems to the upstream habitat of Willow Creek. Fine sediment inputs are likely creating higher than natural turbidity during storm flows potentially affecting fish physiology, reduce feeding or in the worst cases increase mortality.

**Triggering Mechanisms or Issues:**

Road construction  
Road placement  
Loss of soil cover or stability from timber removal  
Ground yarding equipment and skid trails

**Prescriptions:**

Road construction, placement or management:

- Alternatives to road construction or road use, such as cable yarding, helicopter yarding or alternative road placement, will be pursued in MWMU 2.
- New road construction will be avoided in MWMU 2 except when no other feasible route is available. In situations where a new road must go through MWMU 2 new road construction is required to have full bench construction with all construction

materials end hauled or a similar treatment and the road operation that meets the lowest risk for erosion will be utilized. If the new road construction occurs in MWMU 2 it must avoid areas where there is a significant likelihood of sediment delivery. The exception is when a qualified certified engineering geologist approves the operations.

Adjacent to Class II watercourses:

- On slopes adjacent to Class II watercourses in MWMU 2, in addition to the riparian protections, timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The MWMU 2 protections will be 100 feet slope distance in width extending from the edge of the watercourse transition line.
- MWMU 2 will be an equipment limitation zone (ELZ) except when slopes are less than 50%, or designated crossings, or on established stable roads.
- The slopes of the inner gorge or the first 65 feet, whichever is longer, will be an equipment exclusion zone (EEZ) except for designated crossings and existing truck roads.

Adjacent to Class III watercourses:

- The MWMU 2 protections adjacent to Class III watercourses will extend from the edge of the watercourse transition line on both sides of the watercourse up to a break in slope <70% gradient or 100 feet slope distance, whichever is shortest.
- On slopes adjacent to Class III watercourses in MWMU 2 timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- MWMU 2 protection area is an equipment limitation zone except when slopes are less than 50%, at designated crossings, and on established stable roads.
- Trees with their root mass adjacent to or in the channel that promotes channel stability will be retained, if a redwood clump, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

**Causal Mechanism Report and Prescription #3**

**Resource Sensitive Area:** Mass Wasting Map Unit (MWMU) 3  
Stream Channel Geomorphic Units II - IV  
See Mass Wasting and Stream Channel Condition Modules

**Limiting Factor(s) and Source Variable(s):** Sedimentation from mass wasting.  
Fish migration barrier from sediment aggradation in Willow Creek.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

Steep and/or convergent slopes of MWMU 3 can have shallow seated landslides associated with them. These landslides can travel moderate distances across hillslopes to reach streams or draws where sediment delivery and sometimes debris flows occur. When sediment delivery occurs with these landslides, sediments will travel down the watercourses and are delivered to river and stream channels. If the frequency and amount of shallow seated landslides are increased from management actions in MWMU 3 this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Road Construction  
Road Placement  
Vegetation removal  
Ground yarding equipment and skid trails

**Prescriptions:**

Forester will utilize available resources for identification of unstable areas or areas with predicted slope instability. These include Map A-1 of Mass Wasting Assessment for the Willow/Freezeout Creeks WAU, Division of Mines and Geology landslide maps (if available), past Timber Harvest Plans and SHALSTAB.

Forester will walk the ground of this unit prior to prescribing operations. If upon field review the unit is confirmed to meet the definition of MWMU 3 the following guidelines apply:

- No harvest, road, or landing construction activity will occur in areas identified in the field as having a significant likelihood of sediment delivery to a watercourse from mass wasting unless a site-specific assessment is conducted and operations approved by a California Licensed Geologist, with

the exception of helicopter or cable yarding that retains over 50% of the overstory canopy.

For Class III watercourses in MWMU 3 the following standards apply:

- A protection zone will extend 25 feet slope distance in width extending from the edge of the watercourse transition line. Timber harvest must retain a minimum of 50% overstory canopy dispersed evenly across the slopes.
- The watercourse will have a 50 foot equipment limitation zone extending from the edge of the watercourse transition line for both sides of the watercourse.
- Trees with their root mass adjacent to or in the channel that promotes channel stability will be retained, if a redwood clump, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.

**Causal Mechanism Report and Prescription #4**

**Resource Sensitive Area:** Mass Wasting Map Unit (MWMU) 6  
Stream Channel Geomorphic Units II - IV  
See Mass Wasting and Stream Channel Condition Modules

**Limiting Factor(s) and Source Variable(s):** Sedimentation from mass wasting.  
Fish migration barrier from sediment aggradation in Willow Creek.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** Moderate

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Minimize

**Situation Sentence:**

MWMU 6 are identified earthflows or earthflow complexes. These features can be active, dormant or have sections of the landslide active with sections of the landslide dormant. Increases in sub-surface water from loss of evapo-transpiration or concentrated water from road drainage can activate or accelerate movement and sediment delivery from these features. The increased sediment delivery could contribute to adverse fish habitat by pool filling, increased channel scour, fine sediments smothering spawning gravel and loss of stream channel complexity.

**Triggering Mechanisms or Issues:**

- Road Construction
- Road Placement
- Vegetation removal
- Ground yarding equipment and skid trails

**Prescriptions:**

No regeneration harvest treatments will be allowed in MWMU 6 unless 50% overstory canopy is retained (averaged across the stand). In those areas of MWMU 6 where an earthflow is active no harvest will occur unless approved by a registered geologist.

Road or tractor trail drainage must be dispersed off of roads/trails in this unit. Concentrated road/trail drainage must be corrected. If new roads/trails are developed in this terrain then concentrated drainage must be avoided.

**Causal Mechanism Report and Prescription #5**

**Resource Sensitive Area:** Mass Wasting Map Unit (MWMU) 7  
Stream Channel Geomorphic Units II - IV  
See Mass Wasting and Stream Channel Condition Modules

**Limiting Factor(s) and Source Variable(s):** Sedimentation from mass wasting or fluvial erosion.  
Fish migration barrier from sediment aggradation in Willow Creek.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** Moderate to Low

**Resource Vulnerability:** Moderate

**Rule Call:** Minimize

**Situation Sentence:**

MWMU 7 is typically divergent or mildly convergent slopes with moderately steep topography. The hazard for shallow seated landslides is relatively low, but MWMU 8 can have shallow seated landslides associated it. Shallow seated landslides in MWMU 8 will occur in isolated areas of steep convergent topography. These areas are infrequent in MWMU 7 (typically associated with MWMU 4) but do occur and must be considered. MWMU 7 has a risk for earthflows, however, none were mapped in this unit. The high clay content of the accelerated creep terrain makes it particularly vulnerable for gully development if water is concentrated from road drainage.

**Triggering Mechanisms or Issues:**

Road Construction  
Road Placement  
Vegetation removal  
Ground yarding equipment and skid trails

**Prescriptions:**

Forester will utilize available resources for identification of the infrequent unstable areas or areas with predicted slope instability in MWMU 7. These include Map A-1 of Mass Wasting Assessment for the Willow/Freezeout Creeks WAU, Division of Mines and Geology landslide maps (if available), past Timber Harvest Plans and SHALSTAB. In those isolated areas in MWMU 7 that may have potential risk for sediment delivery for mass wasting the following guidelines apply:

- No harvest, road, or landing construction activity will occur in areas identified in the field as having a significant likelihood of sediment delivery to a watercourse from mass wasting unless a site-specific assessment is conducted and operations approved by a registered geologist, with the exception of helicopter or cable yarding that retains at least 50% overstory canopy.

Road drainage must be dispersed off of roads in this unit. Concentrated road drainage must be corrected. If new roads are developed in this terrain then concentrated drainage must be avoided.

**Causal Mechanism Report and Prescription #6**

**Resource Sensitive Area:** High Erosion Hazard Roads  
Roads or sections of: BS, FO, HC, RT-024, HC-023  
Stream Channel Geomorphic Units I to IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

These roads have areas of long watercourse contributing road lengths that increase the amount of fine sediment delivery. The roads are typically without a rock surface (native surface) that makes the road surface a higher fine sediment source. Sections of these roads are directly adjacent to watercourses. Water drainage off these roads can increase or cause fluvial erosion contributing both fine and coarse sediment deliveries to watercourses. If the frequency and amount of erosion is increased from management actions this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Long undrained tread approaches to watercourse crossings.  
Sections of road within the AMZ.  
Wet weather use

**Prescriptions:**

The long undrained road approaches to watercourse crossings on these roads will be treated with one or a combination of several of these options:

- 1) Ditch relief culverts can be installed to drain water and sediments concentrated in inside ditches. The ditch relief culverts would be placed such that the majority of long undrained approaches to watercourse crossings of the road would be relieved prior to the watercourse crossing. The discharges of water and sediment from the ditch relief culverts would drain on to the adjacent hillslope where no additional erosion is predicted.
- 2) Rocked rolling dips or rolling dips can be installed in the road prism. The rolling dips would be placed such that the majority of long undrained approaches to watercourse crossings of the road would be relieved prior to the watercourse crossing. The discharges of water and sediment from the ditch relief culverts would drain on to the adjacent hillslope where no additional erosion is predicted.

- 3) Long road approaches to watercourse crossings can have the road prism re-shaped such that the road is outsloped toward its outside edge. This out-sloped road would be done so that it allows continuous drainage of the road surface away from the watercourse crossings.

Section of these roads with high controllable erosion areas will be upgraded. The road prism will be out-sloped, perched fill material will be removed and the road prism narrowed where feasible. Unnecessary culverts will be removed and replaced with rocked fords, additional rocked rolling dips will be installed as needed.

**Causal Mechanism Report and Prescription #7**

**Resource Sensitive Area:** Moderate Road Erosion Hazard Rating Roads  
Geomorphic Units I - IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** Moderate

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Minimize

**Situation Sentence:**

The majority of roads in the Willow/Freezeout Creeks WAU have a moderate road surface erosion hazard. These roads have current and potential erosion associated with them and the likelihood of delivery of that erosion to watercourses. In some cases a few large, discrete erosion problems occur on these roads. There are also some potential erosion problems associated with these roads and that need to be repaired or corrected. However, the overall condition of these roads does not require a high priority for repairs.

**Triggering Mechanisms or Issues:**

Road maintenance  
Controllable sediment repairs

**Prescriptions:**

Maintenance and observation of road conditions on these roads will be conducted by the high standards set in the Handbook for Forest and Ranch Roads (Weaver and Hagans, 1994).

Roads that have not been abandoned in the Willow/Freezeout Creeks WAU will be monitored at least once annually during the winter period to look for potential culvert problems, road fill failures, trespassing damages, road drainage problems, or excessive sediment delivery.

**Causal Mechanism Report and Prescription #8**

**Resource Sensitive Area:** High treatment immediacy with high or moderate sediment delivery potential sites on roads in the Willow/Freezeout Creeks WAU.  
Geomorphic Units I - IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

Individual culverts, bridges, landings and road erosion sites were inventoried and ranked based on their priority for treatment and relative degree of likelihood of sediment delivery. In the Willow/Freezeout Creeks WAU 9 sites were identified as having a high treatment immediacy along with at least a moderate potential of future sediment delivery. These 9 sites are those sites with potential controllable erosion that are in need of immediate action or maintenance. All have a significant concern for a large discrete input of coarse and fine sediment to watercourses. If the frequency and amount of erosion is increased from management actions this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Road infrastructure upgrades

**Prescriptions:**

The high treatment immediacy controllable erosion sites will be the highest priority for erosion control, upgrade or modifications to existing design. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site.

**Causal Mechanism Report and Prescription #9**

**Resource Sensitive Area:** Moderate treatment immediacy with high or moderate sediment delivery potential sites on roads in the Willow/Freezeout Creeks WAU.  
Geomorphic Units I - IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** Moderate

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Minimize

**Situation Sentence:**

Individual culverts, bridges, landings and road erosion sites were inventoried and ranked based on their priority for treatment and relative degree of likelihood of sediment delivery. In the Willow/Freezeout Creeks WAU 14 sites were identified as having a moderate treatment immediacy along with at least a moderate potential of future sediment delivery. These 14 sites are those sites with potential controllable erosion that are in need of action or maintenance in the near future. All have a concern for a large discrete input of coarse and fine sediment to watercourses. If the frequency and amount of erosion is increased from management actions this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Road infrastructure upgrades

**Prescriptions:**

The moderate treatment immediacy controllable erosion sites will be the next highest priority (relative to the high treatment immediacy sites) for erosion control, upgrade or modifications to existing design. The moderate treatment immediacy sites will be addressed when in close proximity to high treatment immediacy sites.

**Causal Mechanism Report and Prescription #10**

**Resource Sensitive Area:** Diversion potential sites along roads in the Willow/Freezeout Creeks WAU.  
Geomorphic Units I - IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

When roads cross watercourses the resulting crossing structure (culvert or bridge) has a potential to fail. When the crossing fails the watercourse has potential to either stay within the “natural” channel or be diverted away from the channel. Typically a diversion away from a “natural” channel in a failed crossing is due to low areas adjacent to the crossing that allows water to be routed either down the road surface or through fill material. This potential for diversion of water if a crossing failed can be a secondary erosion process that can create significant sediment inputs, sometimes greater than the actual crossing failure itself. This water diversion potential is an important concern to correct on roads. Within the Willow/Freezeout Creeks WAU 53 sites have been identified as having a water diversion potential. If the frequency and amount of erosion is increased from management actions this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Improved road drainage and infrastructure upgrades

**Prescriptions:**

These diversion potential sites will be a high priority for correction. These sites will be scheduled for repair based on operational considerations of harvest scheduling, proximity and availability of equipment, magnitude of the problem, and accessibility to the site. It is very likely that these sites will be addressed when in close proximity to high treatment immediacy sites.

**Causal Mechanism Report and Prescription #11**

**Resource Sensitive Area:** Undersized culverts in the Willow/Freezeout Creeks WAU.  
Geomorphic Units I - IV  
Surface and Fluvial Erosion Module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

Culverts must pass not only water beneath roads but the sediment and debris that is transported down the watercourses. If a culvert is not properly sized for the water, sediment and debris that must be conveyed through it can plug or be over topped. This can cause water to flow over road fill material creating surface or fluvial erosion of the road or potentially having the fill material at the crossing completely fail. In the Willow/Freezeout Creeks WAU 23 culverts were determined (remotely) to not be able to pass the 50-year flood. Additional 3 culverts were determined not to be able to pass the 100-year flood.

**Triggering Mechanisms or Issues:**

Road crossing failure from plugged culverts or culverts that lack the capacity to pass the necessary water and debris.

**Prescriptions:**

The 23 culverts that will not pass the 50 year flood will be visited in the field and a determination will be made if the culverts are indeed under-sized (identification of under-sized culverts was done by an office-based evaluation that could be inaccurate). If after field review the culverts are found to be under-sized it will be a high priority for replacement to a watercourse crossing structure that will pass the 100-year flood.

The 3 culverts that will not pass the 100 year flood will be visited in the field and a determination will be made if the culverts are indeed under-sized for this sized flood event (identification of under-sized culverts was done by an office-based evaluation that could be inaccurate). If after field review the culverts are found to be under-sized for the 100 year flood it will be a moderate priority for replacement to a watercourse crossing structure that will pass the 100-year flood. Typically the upgrade will occur once the culvert has reached the end of its operational life.

The field review will consist of determining the cross section area of the bankfull channel and comparing it the cross sectional area of the culvert in question. A rule of thumb is that to pass the 100 year flood the culvert opening area needs to be 3 times as large as the bankfull channel cross section area (Cafferata, Spittler, and Wopat, 2000).

**Causal Mechanism Report and Prescription #12**

**Resource Sensitive Area:** WLPZ (aka AMZ roads) sections of road HC in the Willow/Freezeout Creeks WAU.  
Stream Channel Geomorphic Unit I  
Road Erosion Modul

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** Moderate

**Rule Call:** Prevent

**Situation Sentence:**

HC road has sections of road in the watercourse and lake protection zone (WLPZ) of a Class I watercourse. Section of this road is directly adjacent to or in close proximity to the watercourse. Because the road sections are in such close proximity to a class I watercourse surface erosion and cut and fill slope failures from this road often deliver sediment directly to the watercourse. If the frequency and amount of erosion is increased from management actions this can contribute to poor rearing habitat, downstream aggradation or high turbidity.

**Triggering Mechanisms or Issues:**

Road surface treatment  
Road prism upgrade  
Road drainage improvement  
Wet weather use

**Prescriptions:**

Road surface and prism treatment and road management:

- Roads used annually in the AMZ will have the surface of new road construction or re-opened existing roads armored with a rock surface.
- Roads used periodically, every few years or decades in AMZ will be storm-proofed (as per Weaver and Hagans, 1994) prior to the winter period and the surface stabilized with grass seed, mulch or other cover product.
- Any road that is within a Class I or II watercourse AMZ will not have winter period heavy truck or log hauling traffic, except emergency situations, unless the road tread is armored with a rock surface.

The road prism and drainage design for AMZ roads will be based on the high road design standards prescribed in the Handbook for Forest and Ranch Roads (Weaver and Hagans, 1994). If the AMZ road does not currently meet those standards then these roads will be a high priority for upgrades.

Winter period hauling conditions will be monitored carefully. In order to avoid sediment movements and damage to road surface, there will be no log or heavy equipment hauling during periods of rainfall or when roadside ditches are flowing surface runoff, or when road is saturated and cannot support heavy loads, except in emergency situations. At the first sign of measurable rain, trucks will make their final trip out on the road, and trucks not yet on the road will be asked to return home. The road will not be used until rainfall has stopped and the road surface has dried sufficiently so that the surface will not be damaged by use. Only a Mendocino Redwood Company employee will make or grant the authority to a contractor for this determination.

**Causal Mechanism Report and Prescription #13**

**Resource Sensitive Area:** Winter Operating Plan  
Willow/Freezeout Creek WAU

**Limiting Factor(s) and Source Variable(s):** Sedimentation from surface and fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** High

**Rule Call:** Prevent

**Situation Sentence:**

Pursuant to the California Forest Practice Rules – Protection for Threatened and Impaired Watersheds, 2000, sections 916.9, 936.9 and 956.9:

Excerpts from (K): From October 15 to May 1 no timber operations shall take place unless the approved plan incorporates a complete winter period operating plan pursuant to 14 CCR 914.7(a) [934.7(a), 954.7(a)].

This watershed analysis proposes a general winter operating plan for the entire Willow/Freezeout Creeks WAU covering operations from April 1 to May 1 and October 15 to November 15.

**Triggering Mechanisms or Issues:**

Erosion Hazard Rating  
Site Preparation  
Yarding System  
Operating period  
Erosion control facilities timing  
Precipitation form  
Ground conditions  
Silvicultural condition  
Operation within WLPZ  
Equipment use limitations  
New road construction  
Known unstable areas

**Winter Operating Plan**

*(MRC proposes the following winter operating plan for the Willow/Freezeout WAU)*

<p>Hand falling is proposed all year round, with access designated by Mendocino Redwood Company. Road construction, tractor and cable logging operations are not proposed for the time period November 15 to April 1. Road construction, tractor and cable logging operations and site preparation are proposed for the period of 4/1 through 11/15.</p>
<p>EHR: EHR for all areas within the Willow/Freezeout Creeks WAU are not anticipated to be affected or change due to operations between 4/1-5/1 and 10/15-11/15. Erosion Control methods will be installed concurrent with roadwork activities during the period of 4/1 through 5/1 or 10/15 through 11/15. EHR ratings will not change from operations between the periods of 4/1 and 11/15.</p>
<p>SITE PREPARATION: No site preparation is proposed for the period 4/1 to 5/1. Site preparation can occur from 10/15 to 11/15 but will be restricted to dry conditions where soils are not saturated.</p>
<p>YARDING SYSTEM: Both cable and tractor systems could be used during the period of 4/1 through 5/1, and 10/15 through 11/15. In general, cable yarding is proposed for the steep ground, tractor on the gentler terrain. For tractor operations between the periods of 4/1 through 5/1, and 10/15 through 11/15, tractor roads may be constructed, reconstructed, or used on slopes over 40% and within 200 feet of a Class I, II or III watercourse, as measured from the watercourse or lake transition line, as long as evaluated by the RPF. Tractor roads that present a low risk of sediment delivery will be used. Operations of trucks and heavy equipment on roads and landings shall be limited to those with a stable operating surface or where soils are dry and not saturated.</p>
<p>OPERATING PERIOD: Tractor and cable yarding are limited to the period of 4/1 through 11/15. Tree felling may occur all year round.</p>
<p>EROSION CONTROL FACILITIES TIMING: For all year - Tractor yarding or the use of tractors for constructing other tractor roads shall be done only during dry, rainless periods where soils are not saturated. <u>All tractor roads shall have drainage and/or drainage collection facilities installed as soon as practical following yarding and prior to the start of any rain that causes overland flow across or along the disturbed surface.</u> (1) Erosion control structures shall be installed on all constructed skid trails and tractor roads prior to sunset if the U.S. Weather Service forecast is a “chance” (30% or more, or a flash flood warning or watch) of rain within the next 24 hours, and prior to weekend or other shutdown periods. A forecast can be obtained from U.S. Weather Service.</p>

<p><b>CONSIDERATION OF FORM OF PRECIPITATION:</b> The most common form of precipitation in this area is rain - snow would be rare.</p>
<p><b>GROUND CONDITIONS:</b> To avoid soil compaction and erosion, tractor logging shall be done only during dry, rainless period where soils are not saturated and the amount of soil compaction minimized. The landings and truck roads, when necessary, and in site specific occurrences, will be surfaced with rock in depth and quantity sufficient to maintain a stable surface. Any soft areas, or areas where water ponding occurs, will be built up with rock to allow for better drainage.</p>
<p><b>SILVICULTURAL SYSTEM - GROUND COVER:</b> Ground disturbance/vegetation removal will not be affected by operating within the period of 4/1-5/1 or 10/15-11/15.</p>
<p><b>OPERATION WITHIN THE WLPZ:</b> Hand falling may occur year-round. All other harvest operating are confined to the period 4/1 to 11/15 and must follow the prescriptions set forth in this watershed analysis.</p>
<p><b>EQUIPMENT USE LIMITATIONS:</b> See <b>YARDING SYSTEM</b> above. Tractors and cable yarding shall only operate between the period of 4/1 through 11/15.</p>
<p><b>NEW ROAD CONSTRUCTION:</b> No road construction will occur for the period 4/1 to 5/1. Road construction can occur from 10/15 to 11/15 but will be restricted to dry conditions where soils are not saturated.</p>
<p><b>KNOWN UNSTABLE AREAS:</b> No harvest will occur on known, active, unstable areas. Operations in these areas would be limited to use of existing truck roads.</p>

**Causal Mechanism Report and Prescription #14**

**Resource Sensitive Area:** Aquatic Management Zone

**Limiting Factor(s) and Source Variable(s):** Large woody debris, high or moderate in-stream demand (see Riparian section, Map D-1)

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** High

**Rule Call:** Prevent

**Situation Sentence:**

Large woody debris (LWD) is an important component of stream habitat. Large woody debris provides sediment storage in channels, creates areas of scour for pool creation, provides cover for fish habitat and adds channel roughness for habitat complexity. Historic forest management practices did not require watercourse protection measures like current California Forest Practice Rules mandate. Historic removal of LWD from the Willow/Freezeout Creeks River WAU has created a deficient of LWD available for fish habitat and stream channel diversity. Historic harvesting practices has removed many of the large conifer trees which provide the current and future large woody debris recruitment needed in these areas. Therefore, the stream channels in the above listed areas have a high in-stream LWD demand and need increased LWD recruitment.

**Triggering Mechanisms or Issues:**

Recruitment of large woody debris  
Big tree retention in riparian zone

**Prescriptions:**

These high and moderate in-stream LWD need areas (see Map D-1, Riparian Condition Module) will receive an AMZ with the following specifications to encourage LWD recruitment to stream channels:

Adjacent to Class I watercourses:

- The AMZ will be 190 feet<sup>1</sup> slope distance in width extending from the edge of the bankfull channel for both sides of the watercourse. An aquatic protection zone (APZ) will be 65 feet slope distance in width extending from the edge of the bankfull channel for both sides of the watercourse. The exception to this is MWMU 5, it will have a 75 foot slope distance AMZ.
- The AMZ will maintain a 75% absolute canopy and only high retention selection selection (see Mendocino Redwood Company Option A for definitions), except for conifer restoration treatments in hardwood dominated riparian areas, are allowed for 150 feet slope distance extending from the edge

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<sup>1</sup> : Lindquist, J.L. and M.N. Palley. 1963. Empirical yield tables for young-growth redwood, Ca. Ag. Exp. Sta. Bull. 796 shows the maximum 100-year site III redwood potential tree height as 154 feet. The 154 feet is corrected for slope distance assuming a 80% slope, yielding 190 feet.

of the bankfull channel for both sides of the watercourse. The exception to this is MWMU 5. MWMU 5 will have a 75 foot slope distance high retention selection, with an additional 75 feet of restrictions of regeneration harvest.

- The additional length of the AMZ can receive silvicultural treatments but must follow guidelines for mass wasting protection as presented in prescriptions 1-7. The APZ will allow only high retention selection silviculture specifications but will also receive higher tree retention standards. For High LWD demand sections of watercourse 12-15 trees per side per 100 meters of watercourse length must be permanently retained, permanent marking of these trees will occur at such time that adjacent areas in the AMZ are being marked for harvest. For Moderate LWD demand sections of watercourse 8-12 trees per side per 100 meters of watercourse length must be permanently retained. For Low LWD demand sections of watercourse 5-8 trees per side per 100 meters of watercourse length must be permanently retained. Priority will be given to the largest 20% diameter trees.
- The AMZ will be an equipment limitation zone (ELZ) except when slopes are less than 40%, at designated crossings, and on established stable roads.
- The APZ will be an equipment exclusion zone (EEZ) except for designated crossings.

Adjacent to Class II watercourses:

- The AMZ will be 100 feet slope distance in width extending from the edge of the bankfull channel for both sides of the watercourse. An aquatic protection zone (APZ) will be 65 feet slope distance in width extending from the edge of the bankfull channel for both sides of the watercourse. The exception to this in MWMU 1 (see prescription #1 for variation of widths for Class II AMZ in these units).
- The AMZ will maintain a 75% absolute canopy and only high retention selection silviculture specifications (see Mendocino Redwood Company Option A for definitions), except for conifer restoration treatments in hardwood dominated riparian areas.
- The APZ will allow only high retention selection silviculture specifications but will also receive higher tree retention standards. For High LWD demand sections of watercourse 12-15 trees per side per 100 meters of watercourse length must be permanently retained, permanent marking of these trees will occur at such time that adjacent areas in the AMZ are being marked for harvest. For Moderate LWD demand sections of watercourse 8-12 trees per side per 100 meters of watercourse length must be permanently retained. For Low LWD demand sections of watercourse 5-8 trees per side per 100 meters of watercourse length must be permanently retained. Priority will be given to the largest 20% diameter trees.
- The APZ will retain trees with their root mass adjacent to or in the channel that promotes channel stability, if a redwood clump, at least 50% of the clump must be retained with emphasis on leaving the largest trees on the clump.
- Considerations for effective shade over the watercourse will be included in this APZ as stated in Prescription #25.

- The AMZ will be an equipment limitation zone (ELZ) except when slopes are less than 40%, at designated crossings, and on established stable roads.
- The APZ will be an equipment exclusion zone (EEZ) except for designated crossings.

Downed LWD within the AMZ will be maintained unless removed for stream enhancement or restoration purposes.

Sanitation salvage logging will not be conducted in those areas of high retention selection silviculture in the AMZ.

Within the AMZ, areas of 100 square feet or greater of exposed mineral soil following harvest operations must be mulched, grass seeded, covered with slash or have some appropriate cover material provided.

These high in-stream LWD need areas will be considered a high priority for restoration of in-stream LWD structure. Mendocino Redwood Company will actively pursue and promote restoration efforts in these watercourses, including conversion of hardwood dominated riparian stands to conifer.

**Causal Mechanism Report and Prescription #15**

**Resource Sensitive Area:** Canopy closure over Class I and II watercourses  
Riparian Function module

**Limiting Factor(s) and Source Variable(s):** Canopy closure and stream temperature

**Delivered Hazard Rating:** Low

**Limiting Factor Vulnerability:** Low

**Rule Call:** Standard

**Situation Sentence:**

Stream temperatures in the Willow/Freezeout Creeks River WAU are in good range of maximum weekly average temperature (MWAT) suggested for salmonids. High water temperature from lack of shade can be deleterious and even fatal to many fish and aquatic species and warrant concern. Therefore, maintaining these good water temperature values is important.

**Triggering Mechanisms or Issues:**

Recruitment of shade  
Tree retention in riparian zone

**Prescriptions:**

If harvest activity is proposed in the APZ along Class I and perennial Class II watercourses then effective shade of the watercourse must be managed for. A perennial Class II watercourse is defined as having flow after June 1 in an average water year. Effective shade is a function of vegetation height, stream width and/or topographic barriers. Effective shade over perennial watercourses will not be reduced below 70 percent canopy, unless as part of an approved riparian restoration project (hardwood conversion to conifer). Cumulatively across the entire the WEMA area the shade canopy must average above 85 percent stream shading for perennial watercourses. Those areas with natural grassland openings in the Willow/Freezeout Creek WEMA are excluded from the shade averaging.

**Causal Mechanism Report and Prescription #16**

**Resource Sensitive Area:** Gully erosion (Grassland areas and forested areas)  
Surface and Fluvial Erosion module

**Limiting Factor(s) and Source Variable(s):** Sedimentation from fluvial erosion.  
Water quality; turbidity from fine sediment.

**Delivered Hazard Rating:** High

**Limiting Factor Vulnerability:** High

**Rule Call:** Prevent

**Situation Sentence:**

The grassland gullies in Willow Creek are a significant source of sediment delivery. The Franciscan Melange terrain found in Willow Creek is prone to gully development and has been shown to have a large sediment delivery load associated with it. This sediment delivery is often in the headwater areas of tributary streams to Willow Creek. However, when transported downstream can affect fish bearing reaches of Willow Creek.

**Triggering Mechanisms or Issues:**

- Loss of vegetation in gully prone areas
- Increased water delivery from poor road or skid trail drainage
- Lack of large woody debris in forested watercourses

**Prescriptions:**

Where road drainage is concentrating water on grassland slopes or in depressions or watercourses in forested areas, the road will be re-shaped to provide for more dispersed water drainage. Where road drainage has previously created gully erosion, the drainage point will be armored to prevent further erosion.

Tractor roads (skid trails) will have erosion control structures placed on them prior to rainy season to disperse water off surfaces and away from potential gully erosion areas. Skid trails, where feasible, will have slash, debris or mulch placed on them to lower surface and gully erosion hazard.

The aquatic management zone prescriptions #14 and #15 are hypothesized to promote LWD recruitment to class I and II watercourses. In class III watercourses, trees that are adjacent to the bank, in the channel or are promoting channel stability will be retained to help promote LWD recruitment and channel stability.

MRC will pursue restoration opportunities to slow or stop gully erosion in Willow Creek.

MRC will develop a grazing plan for the grassland areas of Willow Creek to attempt to regulate the amount of vegetation removal and timing of grazing.

**Literature Cited**

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