## APPENDIX D

**Draft inventory results, erosion control and erosion prevention plan for roads managed by the Nash-Mill road association**

The Nash-Mill road association manages approximately 14 miles of road within the Mill Creek watershed. The Nash-Mill roads are mostly located either along east and north portions of the lower mainstem of Mill Creek and adjacent to the Little Mill Creek and Stump Hollow tributaries. PWA personnel inventoried all of these roads for potential sediment delivery to the main stem and its tributaries, and to determine maintenance reaches of road and sites that would adversely affect the condition of the road, but not deliver sediment to streams.

Sites with either future sediment delivery or which are maintenance sites were inventoried using a PWA data form (Figure 2 and Map 1). Table 29 displays the distribution of site types mapped during the sediment source investigation. Six potential landslides which pose a risk of delivering sediment to streams were identified along all the Nash-Mill roads. Every stream crossing was inventoried and described in detail for all Class I, II or III watercourses. Stream crossings are sensitive areas since they represent the greatest opportunity for sediment to be introduced into stream channels. Regardless of the size of the stream, once sediment is introduced to a stream it will eventually be transported downstream to a fish bearing stream and ultimately impact fish habitat.

Road surface drainage problems were also identified where long stretches of road or ditch deliver fine sediment to stream channels. The "other" category of sites includes miscellaneous erosional features such as gullies, ditch relief culverts, swales or springs that have the potential to deliver sediment to a stream channel. Finally, maintenance sites were inventoried where there is no sediment delivery but where chronic road surface drainage problems could affect the long term condition of the road. These sites include long stretches of road surface or ditch that do not deliver sediment to streams or ditch relief culverts that drain long segments of road onto gently sloping to flat hillslopes. All sites were mapped on 1 : 12,000 aerial photo mylar overlays.

A total of 58 sites were identified with a risk of future sediment delivery along roads within the Nash-Mill road association (Table 29). Sites include 34 stream crossings, 6 potential landslides, 3 specific road surface sites and 15 miscellaneous "other" sites. Of the 58 inventoried sites, 56 have been recommended for erosion prevention treatment. In addition, 9.4 miles (67%) of the 14 miles of road managed by the Nash-Mill road association currently deliver sediment and runoff to streams. Finally, 20 sites were identified as maintenance reaches of road (non-sediment delivery sites).

***Landslides*** - Potential road-related landslides identified during the road inventory were divided into cutbank failures, landing fill failures, road fill failures, deep seated failures and others. Of the 6 identified sites of future road-related mass wasting, 4 are road fills, 1 is a cutbank failure and 1 is a potential deep seated failure. Left untreated, road-related landslides are expected to deliver over 3,800 $yds^3$ to the stream system.

***Stream crossings*** - Thirty-four stream crossings were identified in the field with 26 being culverted fill crossings and 8 being unculverted fill crossings. Total future erosion and sediment yield from stream crossing sites is approximately 19,650 $yds^3$ if erosion prevention measures are not undertaken.

The most significant problem from stream crossings inventoried on roads in the Nash-Mill road association arise from stream crossings with a diversion potential. Of the 34 crossings inventoried, 24 have a diversion potential and 11 are currently diverted. Treatment for stream diversions is easy and requires installation of a "critical" dip placed at the down-road hinge line of the stream crossing to direct flow back into its natural drainage.

Significant erosion can also occur from undersized culverts and poor culvert installation. Undersized culverts can plug causing flow to overtop the road and cause erosion of the stream crossing fill, or flow can be diverted down the road to create hillslope gullies. Of the 26 culverted stream crossings, 11 have a moderate to high plug potential. Erosion can also occur as a result of poorly installed culverts causing major gully erosion below the outlet. Approximately 59% of the total future sediment yield would result from erosion associated with stream crossing failures.

**Table 29. Site classification and sediment yield from inventoried sites in the Nash-Mill road association, Mill Creek watershed, Mendocino County, California .**

| Site Type | Number of sites or road miles | Number of sites or road miles to treat | Future yield ($yds^3$) | Stream crossings w/ a diversion potential (#) | Streams currently diverted (#) | Stream culverts likely to plug (plug potential rating = high or moderate) |
|---|---|---|---|---|---|---|
| Landslides | 6 | 5 | 3,823 | NA | NA | NA |
| Stream crossings | 34 | 34 | 19,650 | 24 | 11 | 11 |
| Road surface | 3 | 3 | 126 | NA | NA | NA |
| Other | 15 | 14 | 424 | NA | NA | NA |
| Total (all sites) | 58 | 56 | 24,023 | 24 | 11 | 11 |
| Persistent surface erosion | 9.40 | 9.40 | 9,191 | NA | NA | NA |
| **Totals** | **58** | **56** | **33,214** | **24** | **11** | **11** |

[1]Assumes 25' wide road prism and cutbank contributing area, and 0.2' road/cutbank surface lowering over the next decade.

*"Other" and Road Surface sites* - Fifteen "other" sites were identified for future sediment yield to stream channels. "Other" sites are mainly ditch relief culverts with gullies below their outlets. Approximately 420 $yds^3$ of future sediment yield is expected to occur associated with these miscellaneous sites. The "other" sites represent approximately 1% of the total predicted sediment yield from road-related erosion.

Concentrated road surface runoff can generate fine sediment which can negatively impact general stream health and fish habitat. A total of 9.4 miles of the roadbed, ditch and cutbank currently persistently deliver fine sediment and runoff to stream channels. Cutbank, road bed and ditch erosional processes are predicted to yield nearly 9,200 $yds^3$ (28%) of sediment to nearby streams over the next decade, if road drainage practices remain the same. Relatively easy treatments can be applied to upgrade road systems to prevent material from entering stream channels. These include installing a series or combination of road surface treatments such as rolling dips, outsloping, and/or additional ditch relief culverts to disperse runoff.

**Treatment Priority**

Table 30 and Map 2 outline the treatment immediacy for all 56 inventoried sites with future sediment delivery as well as the 20 maintenance sites along roads in the Nash-Mill road association. Altogether, 24 sites were identified as having a high or high-moderate treatment immediacy with a potential sediment delivery of approximately 17,100 $yds^3$. Twenty-eight sites were listed with a moderate or moderate-low treatment immediacy and account for nearly 6,000 $yds^3$. Finally, 3 sites were listed as having a low treatment immediacy which could yield approximately 120 $yds^3$ of future sediment delivery. Twenty maintenance sites with no future sediment delivery were identified and recommended for erosion control treatment to improve road surface drainage.

**Treatments**

Table 31 lists the site specific treatments for all inventoried sites recommended for erosion prevention work in the Nash-Mill road association. Recommended erosion prevention work includes upgrading existing roads located in stable locations and maintaining sections of roads that do not have future sediment delivery but need road surface drainage improvements. Upgrading typically consists of properly installing new culverts designed to accommodate the 50 - year return interval peak storm flow and debris which will be in transport. Upgrading also includes improving the road drainage by utilizing different road surface treatments such as installing frequent rolling dips or additional ditch relief culverts and/or outsloping the road bed. When rolling dips are constructed, itemized costs include 10 $yd^3$ of road rock per rolling dip.

It is estimated that erosion prevention work will require the excavation of just over 8,900$yds^3$ at 27 stream crossing sites. Approximately 66% of the volume excavated is associated with upgrading stream crossings and nearly 32% of the volume is a result of excavating potentially unstable road fills (landslides).

Other miscellaneous treatments for inventoried sites on roads in the Nash-Mill road association will include culvert replacements and installations, installation of downspouts to prevent culvert outlet erosion, a variety of road surface treatments (such as rolling dips, berm removal and

**Table 30. Treatment priorities for all inventoried sediment sources in the Nash-Mill road association, Mendocino County,California**

| Treatment Immediacy or Priority | Upgrade sites (#) | Decommission sites (#) | Upgrade/ Decom. Problem | Future sediment delivery ($yds^3$) | Maintenance sites (#) | Maintenance Problem |
|---|---|---|---|---|---|---|
| High | **9** (site #: 2, 4, 28, 33, 37, 46, 49, 62, 65) | **0** | 1 ditch relief culvert, 2 landslides, 6 stream crossings | 14, 166 | **0** | |
| Moderate/ High | **15** (site #: 10, 16, 17, 25, 26, 35, 39, 47, 48, 58, 59, 60, 99, 102, 142) | **1** (site #: 100) | 1 road surface, 1 gully, 2 landslides, 2 ditch relief culverts, 10 stream crossings | 2, 923 | **0** | |
| Moderate | **19** (site #: 1, 3, 6, 9, 11, 15, 27, 36, 38, 45, 53, 54, 56, 61, 64, 67, 68, 101, 149) | **0** | 3 ditch relief culverts, 5 gullies, 11 stream crossings | 5,140 | **3** (site #: 8, 18, 20) | 1 ditch relief culverts, 1 gully, 1 road surface |
| Moderate/ Low | **9** (site #: 29, 30, 34, 38.1, 50, 51, 57, 97, 148) | **0** | 2 road surface, 2 ditch relief culverts, 5 stream crossings | 883 | **4** (site #: 23, 32, 66, 141) | 2 ditch relief culverts, 2 road surface |
| Low | **3** (site #: 29.1, 96, 143) | **0** | 1 landslide, 2 stream crossings | 116 | **13** (site #: 7, 12, 13, 14, 19, 21, 22, 24, 31, 52, 55, 95, 98) | 6 ditch relief culverts, 7 road surface |
| **Total** | **55** | **1** | | **23,228** | **20** | |

outsloping) and additional ditch relief culverts to lessen erosion and fine sediment delivery from the road surface during wet winter months. Re-rocking the road prism for approximately 100 feet has been prescribed at every rolling dip location. Each site has an individual data form which outlines the problem and describes in detail the recommended treatment and the estimated heavy equipment and labor requirements necessary at each site.

**Table 31. Recommended treatments along inventoried roads in the Nash-Mill road association, Mill Creek watershed, Navarro River, Mendocino County, California.**

| Treatment | No. | Comment | Treatment | No. | Comment |
|---|---|---|---|---|---|
| Critical dip | 17 | To prevent stream diversions | Outslope road & retain ditch | 6 | Outslope 4,190 feet of road & retain ditch to improve road surface drainage (3 maintenance sites for 1,330') |
| Install cmp | 8 | Install a cmp at an unculverted fill | Inslope road | 5 | Inslope 1,605 feet of road to improve road surface drainage (1 maintenance site for 100') |
| Replace cmp | 18 | Upgrade an undersized cmp | Install rolling dips [1] | 215 [1] | Install rolling dips to improve road drainage (75 maintenance related rolling dips) |
| Excavate soil | 27 | Typically fillslope & crossing excavations; excavate a total of 8,901 $yds^3$ | Remove ditch | 2 | Remove 550 feet of inboard ditch |
| Down spouts | 8 | Installed to protect the outlet fillslope from erosion (1 maintenance site) | Clean ditch | 3 | Clean 330 feet of ditch |
| Wet crossing | 6 | Install 1 rocked ford and 5 armored fill crossings | Remove berm | 13 | Remove 10,345 feet of berm to improve road surface drainage (5 maintenance sites for 4,520') |
| Rock road surface | 263 | Rock road surface using 361,205 $ft^2$ (2675 $yd^3$) of rock | Install ditch relief cmp | 41 | Install ditch relief culverts to improve road surface drainage (1 maintenance site) |
| Armor fill face | 1 | Rock armor to protect outboard fillslope from erosion using 180 $ft^2$ of rock | Install bridge | 1 | Install bridge where stream is large and culvert or wet crossing is not feasible |
| Install flared inlet | 4 | Installed to increase Cmp capacity | No treatment recommended | 3 | |
| Outslope road & fill ditch | 47 | Outslope 38,734 feet of road to improve road surface drainage (10 maintenance sites for 9, 540') | | | |

[1] Additional ditch relief culverts (DRC) can be substituted for rolling dips. Each additional DRC will increase costs by 125% (i.e. more than double the costs).

## Equipment needs

Tables 32 and 33 list the expected heavy equipment and labor requirements by treatment immediacy to treat inventoried sites with future sediment delivery and maintenance sites (i.e., sites

with no future sediment delivery to a stream). Costs and heavy equipment requirements for sites with sediment delivery and maintenance sites have been separated since it is assumed that 1) maintenance sites on inventoried roads do not have impacts on water quality and/or fish bearing streams, 2) the work is the responsibility of the individual landowner to fund and 3) the work is not fundable through California Department of Fish and Game S. B. 271 grants.

**Table 32. Estimated heavy equipment and labor requirements for treatment of inventoried sites with sediment delivery in the Nash-Mill road association, Mill Creek watershed, Mendocino County, California.**

| Treatment Immediacy | Site (#) | Excavated Volume ($yds^3$) | Excavator (hrs) | Tractor (hrs) | Dump Truck (hrs) | Grader (hrs) | Labor (hrs) |
|---|---|---|---|---|---|---|---|
| High, High/Moderate | 25 | 7,803 | 222 | 288 | 35 | 32.75 | 73 |
| Moderate, Low/Moderate | 28 | 934 | 137 | 270 | 36 | 42.75 | 67 |
| Low | 3 | 164 | 5 | 8 | 9 | 0 | 3 |
| **Total** | **56** | **8,901** | **364** | **566** | **80** | **75.5** | **143** |

Treatments for the 56 sites with potential sediment delivery along 14 miles of the roads in the Nash-Mill road association will require approximately 364 hours of excavator and 566 hours of tractor time to complete all prescribed upgrading, erosion control and erosion prevention work (Table 32) . Approximately 80 dump truck hours are needed for endhauling excess spoil and importing rock for rocking wet crossings and the road surface in selected locations. Dump truck times for road rocking following construction of rolling dips are included with rock costs. One hundred and forty-three hours of labor is necessary for installing new culverts and other miscellaneous tasks, and 181 hours are for seeding, mulching and planting activities. The remaining equipment hours apply to prescribed road surfacing treatments.

Table 33 lists the expected heavy equipment required to treat maintenance sites with no sediment delivery. Prescribed treatments emphasize various road surface drainage mostly utilizing a tractor and a grader.

**Labor intensive needs**

Many potential work sites will need mulching, seeding and/or tree planting following re-construction activities. These include fillslopes at stream crossings where new culverts are to be installed, at fillslope excavations to prevent future landsliding, as well as at all areas where excess spoil material derived from excavations is disposed of. Where roads are proposed for outsloping or where rolling dips will be constructed, all disturbed areas outside the road prism/bed will also be seeded and mulched. Costs have been included for laborers to seed and mulch approximately

12.5 acres of ground following heavy equipment work along the Nash-Mill road system. Weed free straw mulch will be applied at 4000 pounds/acre. Native seeds should be applied at 20 pounds/acre and follow the guidelines in the Navarro Watershed Restoration Plan (Entrix, 1998).

**Cost estimate for inventoried sites along 14 miles of road in the Nash-Mill road association**
Tables 34 and 35 summarize the necessary costs by equipment types for the 56 sites with future sediment delivery and 20 maintenance sites with no future delivery, respectively. The estimate includes costs for seed and mulch, new culverts, downspouts, flaired inlets, as well as rock necessary for rip rap and road surfacing at rolling dip and other specific locations. Proposed costs include heavy equipment and labor times to remove the existing crossing at site 58 and refit the site with a flatcar bridge (Note: the costs to purchase the bridge are not included). Hours represent direct equipment times and do not include travel time between work sites, additional costs for unseen complications or the time needed for conferences with equipment operators. These additional times are accounted for as "logistics" and are added to the total equipment hours to determine the total project cost (Tables 34 and 35).

**Table 33. Estimated heavy equipment and labor requirements for treatment of inventoried maintenance sites in the Nash-Mill road association, Mill Creek watershed, Mendocino County, California.**

| Treatment Immediacy | Number (#) | Excavated Volume ($yds^3$) | Excavator (hrs) | Tractor (hrs) | Grader (hrs) | Laborers (hrs) |
|---|---|---|---|---|---|---|
| High, High/Moderate | 0 | 0 | 0 | 0 | 0 | 0 |
| Moderate, Low/Moderate | 7 | 0 | 3 | 18 | 9 | 5 |
| Low | 13 | 0 | 0 | 57 | 23 | 0 |
| **Total** | **20** | **0** | **3** | **75** | **32** | **5** |

Total costs for the project are estimated at approximately $ 287,677. to treat the 56 sites inventoried with future sediment delivery and to significantly reduce sediment yield from the 9.4 miles of road feeding sediment annual to streams. Total costs to improve road drainage at maintenance sites with no future sediment delivery is $15,099. The average cost effectiveness value of the project is $ 8.87 per cubic yard of sediment prevented from entering Mill Creek and its tributaries. Costs in Tables 34 and 35 assume that the work in the watershed will be accomplished during a single summer work period using two equipment teams. **(Note: Costs to re-rock the whole road system following implementing the proposed storm-proofing activities are not included in this table.)**

The cost estimate includes a minimal amount of layout, coordination, monitoring and reporting hours for a PWA professional to work with equipment operators to insure the plan is cost effectively implemented, as proposed, and treatments are installed or constructed properly and according to specifications.

Finally, the costs in Tables 34 and 35 are based on a number of assumptions and estimates. The costs provided are reasonable if work is performed by outside contractors, with no added overhead for contract administration, and pre- and post-project surveying. Movement of equipment to and from the site will require the use of low-boy trucks. The majority of treatments listed in this plan are not complex or difficult for equipment operators experienced in road maintenance and road building operations on forest lands.

**Table 34. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on inventoried sites with future sediment delivery in the Nash-Mill road association, Mill Creek watershed, Mendocino County,California**

| Cost Category[1] | | Cost Rate[2] ($/hr) | Estimated Project Times | | | Total Estim. Costs[5] ($) |
|---|---|---|---|---|---|---|
| | | | Treatment[3] (hours) | Logistics[4] (hours) | Total (hours) | |
| Move-in; move-out[6] (Low Boy expenses) | | 70 | 20 | -- | 20 | 1,400 |
| Heavy Equipment | D-5 size tractor | 85 | 566 | 170 | 736 | 62,560 |
| | Excavator | 115 | 364 | 110 | 474 | 54,510 |
| | Dump Truck | 60 | 80 | 24 | 104 | 6,240 |
| | Grader | 85 | 75.5 | 23 | 99 | 8,415 |
| Laborers | | 20 | 322 | 96 | 418 | 8,360 |
| Rock Costs: (includes trucking for 2,675 yd$^3$) | | | | | | 49,928 |
| Culvert materials costs: (1700'=18", 955'=24", 190'=30", 110'=36", 90'=48", 150'=60", and 160'=72") | | | | | | 51,264 |
| Mulch, seed and plant materials for 12.5 acres of disturbed ground | | | | | | 20,000 |
| Layout, Coordination, Supervision, and Reporting[7] | | 50 | -- | -- | 500 | 25,000 |
| **Total Estimated Costs** | | | | | | **$ 287,677** |
| **Cost-effectiveness: $8.87 spent per cubic yard saved** | | | | | | |

[1]Costs for miscellaneous tools and materials have not been included in this table. Costs for administration and contracting are variable and have not been included. Costs and dump truck time (if needed) for re-rocking the whole road surface have not been estimated.

[2] Costs listed for heavy equipment include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.

[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.

[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.

[6] Lowboy hauling for tractor and excavator, five hours round trip. Costs assume 2 hauls for two pieces of equipment to the Mill Creek watershed (one to move in and one to move out).

[7] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, establishing permanent photo point and other effectiveness monitoring, training of equipment operators, supervision during equipment operations, supervision of labor work and post-project documentation and reporting).

**Table 35. Estimated logistic requirements and costs for road-related erosion control and erosion prevention work on inventoried maintenance sites in the Nash-Mill road association, Mill Creek watershed, Mendocino County,California**

| Cost Category[1] | | Cost Rate[2] ($/hr) | Estimated Project Times | | | Total Estim. Costs[5] ($) |
|---|---|---|---|---|---|---|
| | | | Treatment[3] (hours) | Logistics[4] (hours) | Total (hours) | |
| Move-in; move-out[6] (Low Boy expenses) | | 70 | -- | -- | -- | — |
| Heavy Equipment | D-5 size tractor | 85 | 75 | 23 | 98 | 8,330 |
| | Excavator | 115 | 3 | 1 | 4 | 460 |
| | Grader | 85 | 31.5 | 10 | 41.5 | 3,528 |
| Laborers | | 20 | 5 | 1.5 | 6.5 | 130 |
| Culvert materials costs | | | | | | 651 |
| Layout, Coordination, Supervision, and Reporting[7] | | 50 | -- | -- | 40 | 2,000 |
| **Total Estimated Costs** | | | | | | **$ 15,099** |

[1]Costs for tools, for mulching and related materials (grass seed, fertilizer and straw), and for plant materials have not been included in this table. Costs for administration and contracting are variable and have not been included. Costs and dump truck time (if needed) for re-rocking the road surface have not been estimated.

[2] Costs listed for heavy equipment include operator and fuel. Costs listed are estimates for favorable local private sector equipment rental and labor rates.

[3] Treatment times include all equipment hours expended on excavations and work directly associated with erosion prevention and erosion control at all the sites.

[4] Logistic times for heavy equipment (30%) include all equipment hours expended for opening access to sites on maintained and abandoned roads, travel time for equipment to move from site-to-site, and conference times with equipment operators at each site to convey treatment prescriptions and strategies. Logistic times for laborers (30%) includes estimated daily travel time to project area.

[5] Total estimated project costs listed are averages based on private sector equipment rental and labor rates.

[6] Lowboy hauling for tractor is accounted for in cost estimate table for upgrade sites with future sediment delivery.

[7] Supervision time includes detailed layout (flagging, etc) prior to equipment arrival, training of equipment operators, supervision during equipment operations, supervision of labor work and post-project documentation and reporting).