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November 5, 2012

Transmitted via electronic mail, return receipt requested

State Water Resources Control Board
Office of Chief Counsel
Jeannette L. Bashaw, Legal Analyst
1001 "I" Street, 22nd Floor
Sacramento, CA 95814
Tel: (916) 341-5155
Email: jbashaw@waterboards.ca.gov

RE: Petition for Review of North Coast Regional Water Board Order R1-2012-0087; Waste Discharge Requirements for Discharges Related to Green Diamond Resource Company's Forest Management Activities Conducted Within the Area Covered by its Aquatic Habitat Conservation Plan in the North Coast Region; Humboldt and Del Norte Counties

Dear Responsible Officials,

The Environmental Protection Information Center, Mad River Alliance and Sierra Club, Redwood Chapter (hereinafter "Petitioners") respectfully submit this petition for review to the California State Water Resources Control Board (hereinafter "State Water Board") to review and set aside as unlawful the above captioned order by the North Coast Regional Water Quality Control Board (hereinafter "Regional Water Board"). Below we set forth the necessary information to comply with applicable state law concerning the submission of petitions for review to the State Water Board.

Identification of Petitioners:

Lead Petitioner:
Environmental Protection Information Center
Attn: Andrew J. Orahoske, Conservation Director
145 G Street, Suite A
Arcata, California 95521
Office: (707) 822-7711
Email: andrew@wildcalifornia.org

Mad River Alliance
Attn: David Feral
Tel: (707) 382-6162
Email: theferals@suddenlink.net

Sierra Club, Redwood Chapter
Attn: Diane Beck
P.O. Box 238
Arcata, CA 95518
Tel: (707) 445-2690
Email: dfbeck@northcoast.com

Action of the Regional Water Board Subject to this Petition for Review

North Coast Regional Water Board Order R1-2012-0087; Waste Discharge Requirements for Discharges Related to Green Diamond Resource Company's Forest Management Activities Conducted Within the Area Covered by its Aquatic Habitat Conservation Plan in the North Coast Region; Humboldt and Del Norte Counties. The Regional Water Board adopted Order R1-2012-0087 on October 4, 2012. See Exhibit A.

Copies of the petition for review have been sent to the Regional Water Board and to the discharger, Green Diamond Resources Company.

Statement of How the Petitioners are Aggrieved

Petitioners are aggrieved by the action because the order will result in continued pollution from logging operations in the affected watersheds. This continued pollution fails substantive requirements of the law and also fails the public trust. Petitioners are nonprofit advocacy organizations with members that enjoy the watersheds at issue and their beneficial uses. By failing to adopt stricter regulation of logging in the challenged order, the Regional Water Board has harmed Petitioners.

The Environmental Protection Information Center ("EPIC") works to protect and restore ancient forests, watersheds, coastal estuaries, and native species in Northern California. EPIC uses an integrated, science-based approach, combining public education, citizen advocacy, and strategic litigation. The Regional Water Board's action challenged in this petition will harm EPIC and its members by harming water quality and biological diversity that EPIC and its members work to protect.

The Mad River Alliance works to protect clean water and the biological integrity of the Mad River watershed for the benefit of its human and natural communities. The Regional Water Board's order challenged in this petition will harm MRA and its members due to continued logging and water quality degradation in the Mad River watershed.

The Sierra Club and its members are harmed by the Regional Water Board's order challenged in this petition for review. The Sierra Club has decades of experience addressing water pollution

issues, including logging pollution. Sierra Club members use and enjoy watersheds and beneficial uses threatened by the challenged order.

Statement of the Reasons, Points and Authorities

The Regional Water Board's action was inappropriate and improper because it does not improve water quality in the affected watersheds and violates state and federal laws. All issues raised in this petition for review were presented to the regional board before the regional board acted. See Exhibit B.

Violations of the California Environmental Quality Act

The Regional Water Board violated the California Environmental Quality Act ("CEQA") by failing to prepare an Environmental Impact Report ("EIR") and for filing deficient environmental documentation. The Regional Water Board prejudicially abused its discretion in violation of CEQA by relying on inadequate as an informational documentation, not supporting its actions with substantial evidence in the record.

Furthermore, the Regional Water board failed to sufficiently account for cumulative impacts to water quality and other resources from logging within impaired watersheds. "Cumulative impacts" are defined as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." (Cal. Code Regs., tit. 14, §15355). "The cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time." (*Id*., subd. (b).)

Petitioners raised the issue of cumulative impacts from clearcut logging as discussed in recent peer review scientific literature, including Klein et al. (2012). The comments submitted by Petitioners, including specific comments from Klein and other researchers were rejected by the Regional Water Board without reliance on substantial evidence in the record. See Exhibit C.

An additional CEQA violation occurred due to the complete failure of the Regional Water Board to disclose or analyze the impacts to state and federally listed species. This CEQA violation is also a violation of other state and federal law as described below.

Violations of the California and federal Endangered Species Acts

The Regional Water Board completely failed to account for impacts to two imperiled species, Eulachon or Candle Fish (*Thaleichthys pacificus*) and Longfin Smelt (*Spirinchus thaleichthys*). This is true even though both species are negatively impacted by poor water quality and sediment that results from logging operations. The Regional Water Board relies on the Final Environmental Impact Statement for Green Diamond's Aquatic Habitat Conservation Plan ("HCP"), issued pursuant to the federal Endangered Species Act ("ESA"). Neither Eulachon nor Longfin Smelt is analyzed in this document. Nor were these species evaluated in the Initial Study / Mitigated Negative Declaration that the Regional Water Board relied upon for the challenged order.

Under the California Endangered Species Act ("CESA"), the Regional Water Board is required to consult with the California Department of Fish and Game over impacts to species listed under CESA or the ESA and acquire the a "take" permit. See. CA Fish and Game Code 2080.1 & CA Fish and Game Code 2081. The Regional Water Board failed to even consider Eulachon or Longfin Smelt, let alone consult over the impacts of their actions.

Under the federal Endangered Species Act, again, consultation is required to take place and take permits issued. See 16 U.S.C. §§ 1531 *et seq*. Green Diamond's Aquatic HCP and incidental take permit does not allow for "take" of Eulachon, and therefore the company is in ongoing violation of the terms for reinitiation under the ESA. This liability is imputed to the Regional Water Board's action.

Requested Relief

Petitioners request that the State Water Board hold unlawful and set aside the Regional Water Board's action and order R1-2012-0087. In addition, we request that the State Water Board direct the Regional Water Board to do the following:

- Re-evaluate compliance with CEQA, the Porter-Cologne Act, federal Clean Water Act, and the federal and California Endangered Species Acts.
- Limit timber harvest rate and ground disturbance to less than 1.5% annually within all watersheds where Green Diamond has ownership.
- Require the use of only selection logging techniques and ban clear cut logging.
- Work with Community and Stakeholder Groups living within the Mad River watershed and other watersheds affected by Green Diamond logging to develop a sediment, turbidity, flow, nutrient and temperature monitoring program that is peer reviewed, transparent and managed by a third party or the Regional Board (not Green Diamond).
- Utilize the Monitoring Program for Adaptive Management

On behalf of all Petitioners,

Andrew J. Orahoske, Conservation Director
Environmental Protection Information Center
145 G Street, Suite A
Arcata, California 95521
Office: (707) 822-7711
Email: andrew@wildcalifornia.org

ORDER R1-2012-0087

WASTE DISCHARGE REQUIREMENTS

FOR

DISCHARGES RELATED TO GREEN DIAMOND RESOURCE COMPANY'S FOREST MANAGEMENT ACTIVITIES CONDUCTED WITHIN THE AREA COVERED BY ITS AQUATIC HABITAT CONSERVATION PLAN

IN THE

NORTH COAST REGION

HUMBOLDT AND DEL NORTE COUNTIES

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I. FINDINGS

The California Regional Water Quality Control Board, North Coast Region (hereinafter Regional Water Board), *finds*:

1. On February 16, 2012, pursuant to Water Code section 13260(a), Green Diamond Resource Company (Green Diamond) submitted a draft report of waste discharge (ROWD) to the North Coast Regional Water Quality Control Board (Regional Water Board) for discharges related to its forest management activities that occur within the area covered by its Aquatic Habitat Conservation Plan (AHCP) and Master Agreement for Timber Operations (MATO). The AHCP and MATO contain management measures that minimize impacts and protect and improve water quality that the Regional Water Board intends to rely on, in part, and in conjunction with existing regulations in order

to implement Basin Plan water quality standards and restore the beneficial uses of water across Green Diamond's ownership. This approach will result in greater consistency across multiple state and federal agencies, streamline paperwork submittals, and promote landscape-based stewardship of water quality.

2. The project area covered by this Order includes all commercial timberland acreage on the west slopes of the Klamath Mountains and the Coast Range of California in Del Norte and Humboldt counties where Green Diamond owns land or harvesting rights that are covered by the AHCP. This area is currently 384,400 acres, and is subject to adjustment as Green Diamond buys and sells property. This area is located in portions of the following watersheds: Smith River, Lower Klamath River, Redwood Creek, Maple Creek, Little River, Mad River, Jacoby Creek, Freshwater Creek, Elk River, Salmon Creek, Van Duzen River and the Eel River.

3. The ROWD was deemed complete on July 26, 2012. The ROWD includes a description of the forest management activities currently conducted pursuant to the AHCP, which are subject to various state and federal regulations.

4. This Order is intended to complement Order R1-2010-0044 *Waste Discharge Requirements for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR), which together provide complete, programmatic, ownership-wide waste discharge coverage to Green Diamond for the project area.

5. Management activities to be covered by this Order are as follows:
   - **Timber Product Harvest**
     Felling and bucking timber
     Yarding timber (ground-based, cable, aerial)
     Loading and other landing operations
     Landing construction and maintenance
     Salvaging timber products
     Transporting timber and rock products
     Road construction and reconstruction[1]
     General road use[1]
     Rock pit construction and use
     Water drafting
     Equipment maintenance
   - **Silvicultural Regimes and Methods**
     Regeneration harvest (clearcut)
     Commercial thinning
     Other silvicultural methods include single tree selection, group selection, seed tree, and shelterwood

[1] This management activity may be migrated into Order R1-2010-0044, the Roads WDR, at a later date.

- **Timber Stand Regeneration and Improvement**
  Site preparation, prescribed burning, and slash treatment
  Planting
  Vegetation management (mechanical cutting and chipping, (herbicides not covered))
  Pre-commercial thinning (cutting trees, sawing or chipping rows or groups, pruning – material left on site)
- **Minor Forest Product Harvest**
  Burls, stumps, boughs, and greenery
- **In-stream and Riparian Restoration**
  Improving in-channel habitat (altering the local channel morphology by placing objects such as logs, root wads, and boulders in or adjacent to the stream channel that provide or create additional habitat complexity, structure, or cover)
  Improving riparian habitat (providing bank stability and future recruitment of wood and shade canopy to the stream)
- **Mitigation Measures**
  Management measures designed to control potential discharges and minimize impacts associated with the activities listed above

Waste Discharge Requirements

6. Water Code section 13260(a) requires that any person discharging waste or proposing to discharge waste within any region that could affect the quality of the waters of the state, other than into a community sewer system, must file with the appropriate Regional Water Board a ROWD containing such information and data as may be required.

7. Under Water Code section 13263, the Regional Water Board shall prescribe requirements as to the nature of any proposed or existing discharge with relation to the receiving water conditions. Requirements shall implement any relevant Water Quality Control Plan requirements and take into consideration beneficial uses and objectives reasonably required to protect such uses, and other relevant factors.

8. This Order sets out waste discharge requirements (WDRs) for non-point source management activities described in finding 5, that have the potential to discharge wastes that affect waters of the state from only those portions of Green Diamond's ownership covered by its Aquatic Habitat Conservation Plan (AHCP). The potential water quality impacts are primarily associated with erosion, sediment delivery, and/or changes to riparian systems that may reduce shade and affect water temperatures. The Order includes conditions that prevent or minimize sediment discharges and that limit harvesting adjacent to streams.

Basin Plan

9. The beneficial uses and water quality objectives for the watersheds in the coverage area are contained in the Water Quality Control Plan for the North Coast Region (Basin Plan).

The primary beneficial uses of concern for this Order are the cold freshwater habitat (COLD), spawning, reproduction, and/or early development (SPWN), migration of aquatic organisms (MIGR), and rare, threatened, or endangered species (RARE). Green Diamond's AHCP was designed to conserve habitat for and mitigate impacts to the aquatic species that are most sensitive to elevated sediment and temperature conditions. Evidence of salmon population declines is contained in the listing of all the major species under the Endangered Species Act by the National Marine Fisheries Service and the California Endangered Species Act by the Department of Fish and Game. Salmon populations are listed by distinct population segments, or evolutionarily significant units. The listings that apply to the watersheds in the project area are as follows:

Species Common Name, *Scientific Name*	Federal Listing Status	State Listing Status
Chinook salmon, *Oncorhynchus tshawytscha*		
California Coastal evolutionarily significant unit (ESU)	Threatened	None
Southern Oregon and Northern California Coastal ESU	None	None
Upper Klamath/Trinity Rivers ESU	None	None
Coho salmon, *Oncorhynchus kisutch*		
Southern Oregon/Northern California Coast ESU	Threatened	Threatened
Steelhead, *Oncorhynchus mykiss*		
Northern California distinct population segment	Threatened	None
Klamath Mountains Province ESU	None	None
Resident rainbow trout, *Oncorhynchus mykiss*	None	None
Coastal cutthroat trout, *Oncorhynchus clarki clarki*	None	Concern
Tailed frog, *Ascaphus truei*	None	Concern
Southern torrent salamander, *Rhyacotriton variegatus*	None	Concern

10. Pursuant to the Basin Plan, the existing and potential beneficial uses of waters that could be affected by the proposed activities include:

a. Municipal and Domestic Supply (MUN)
b. Agricultural Supply (AGR)
c. Industrial Service Supply (IND)
d. Industrial Process Supply (PROC)
e. Groundwater Recharge (GWR)
f. Freshwater Replenishment (FRSH)
g. Navigation (NAV)
h. Hydropower Generation (POW)
i. Water Contact Recreation (REC-1)
j. Non-contact Water Recreation (REC-2)
k. Commercial and Sport Fishing (COMM)
l. Aquaculture (AQUA)
m. Warm Freshwater Habitat (WARM)
n. Cold Freshwater Habitat (COLD)
o. Estuarine Habitat (EST)
p. Marine Habitat (MAR)
q. Wildlife habitat (WILD)
r. Preservation of Areas of Special Biological Significance (BIOL)
s. Rare, Threatened, or Endangered Species (RARE)
t. Migration of Aquatic Organisms (MIGR)
u. Spawning, Reproduction, and/or Early Development (SPWN)
v. Shellfish Harvesting (SHELL)
w. Native American Culture (CUL)

x. Flood Peak Attenuation/Flood Water Storage (FLD)
y. Wetland Habitat (WET)
z. Water Quality Enhancement (WQE)
aa. Subsistence Fishing (FISH

The Basin Plan contains water quality objectives developed to protect the above-listed beneficial uses of water. Economic considerations were evaluated as required by law during the development of these objectives. Conditions, prohibitions, and provisions contained in this Order implement these previously developed water quality objectives. Compliance with water quality standards will protect these beneficial uses.

Total Maximum Daily Loads

11. A number of the watersheds in Green Diamond's AHCP ownership are listed as impaired on the Clean Water Act section 303(d) list:
Lower Klamath River—sediment/siltation, temperature, nutrients, dissolved oxygen
Redwood Creek—sediment/siltation, temperature
Mad River—sediment/siltation, turbidity, temperature
Jacoby Creek—sediment
Freshwater Creek—sediment/siltation
Elk River—sediment/siltation
Lower Eel River—sediment/siltation
Van Duzen River—sediment/siltation

12. Placement on the 303(d) list generally triggers development of a pollution control plan called a Total Maximum Daily Load (TMDL) for each waterbody and associated pollutant/stressor on the list. TMDLs have been established for the following hydrographic areas and pollutants on Green Diamond's ownership:
Lower Klamath River—sediment/siltation, temperature, nutrients, dissolved oxygen
Redwood Creek—sediment/siltation, temperature
Mad River—sediment/siltation, turbidity
Van Duzen River—sediment/siltation
Lower Eel River—sediment/siltation, temperature

13. The 2004 Sediment TMDL Implementation Policy (Resolution R1-2004-0087) and Temperature Policy (Resolution R1-2012-0013) provide for the control of sediment and temperature pollution by using existing permitting and enforcement tools where possible and support the combination of TMDL requirements with region-wide nonpoint source programs for efficiency and to avoid duplicative regulation. The Regional Water Board Staff Work Plan to Control Excess Sediment in Sediment-Impaired Watersheds directs staff to develop ownership-wide WDRs regionally, and specifically to develop ownership-wide WDRs for Green Diamond in those watersheds in which Green Diamond operates, as a key task to comprehensively control excess sediment. The Staff Report for the Klamath River TMDLs recognizes the Green Diamond AHCP as establishing a solid framework for Klamath River TMDL compliance because of its stringent water quality protections (Chapter 6-Implementation, 6.5.5.4).

14. Implementation measures for achieving recovery of watersheds impaired for sediment and temperature are similar for watersheds throughout the North Coast Region and include management practices, riparian buffers and inventory and cleanup of legacy sediment sites. As described in more detail below under Applicable Regulatory Programs, the AHCP, MATO and Roads WDR include these elements, as well as monitoring provisions necessary for TMDL compliance.

15. The conditions of this Order, CEQA mitigations, and the required management measures are expected to achieve TMDL load allocations and recover impaired watersheds. The Regional Water Board considers this Order to constitute TMDL implementation for the 303(d) listed and TMDL watersheds in which Green Diamond conducts covered management activities.

Elk River

16. Green Diamond owns and/or conducts timber harvesting activities on approximately 1,900 acres (15%) of the 12,442-acre South Fork Elk River watershed. Green Diamond's ownership in the South Fork Elk River watershed is located in the tributaries McCloud Creek, Tom Gulch, and Railroad Gulch. The South Fork is one of the two major tributaries of Elk River, the other being the North Fork Elk River. The Elk River is located southeast of Eureka and flows into Humboldt Bay.

17. The Elk River watershed is listed as an impaired water body under section 303(d) of the Clean Water Act due to sedimentation/siltation. Increased rate and depth of flooding due to sediment has caused impacts to spawning habitat, water supplies and other property damage in this unique and sensitive watershed.

18. Since 2006, Green Diamond has operated in the South Fork Elk River Watershed under Waste Discharge Requirements through Resolution R1-2006-0042, Order R1-2006-0043, and Monitoring and Reporting Program R1-2008-0092 (collectively, "Watershed-Wide Waste Discharge Requirements for Timber Harvesting Plan Activities Conducted by, or on Land Owned by, the Green Diamond Resource Company in the South Fork Elk River Watershed, or "*SF Elk WWDR*").

19. Conditions specific to the Elk River in this Order rely, in large part, upon the South Fork Elk River Management Plan. Green Diamond submitted the original version of the South Fork Elk River Management Plan in May 2006. On July 26, 2012, Green Diamond submitted an updated version of its South Fork Elk River Management Plan. The South Fork Elk River Management Plan contains watershed-specific elements tailored to the uniquely sensitive geology in the South Fork Elk River.

20. Since 2006, Green Diamond has harvested a total of 340 acres in the South Fork Elk River Watershed. 152 road-related sediment discharge sites have been treated and an additional 29 road sites will be treated by 2015, completing all of the sites identified in a watershed-wide road assessment inventory. Approximately 26,602 cubic yards of sediment have been prevented from discharging due to treatment of these road sites.

21. This Order supersedes the SF Elk WWDR and incorporates its substantive conditions.

22. A TMDL for the Elk River, pursuant to Section 303(d) of the Clean Water Act, is currently under development by the Regional Water Board. The TMDL may contain timeframes or tasks that differ from those contained in the Elk River component of this Order. At such time as the TMDL is adopted, the provisions of the Elk River component of this Order and/or the South Fork Elk River Management Plan will be reviewed and adjusted, as appropriate, to ensure compliance with the TMDL.

23. The sections of this Order and the attached Monitoring and Reporting Program specific to activities in the Elk River were designed to anticipate requirements of the TMDL currently in development, provide site specific requirements for this uniquely sensitive watershed, and establish a feedback loop to ensure adequate implementation of and maximize effectiveness of management measures.

24. The South Fork Elk River Management Plan may be updated, with approval by the Regional Water Board, due to necessary changes from TMDL adoption, changes to the Basin Plan, or adaptive management.

Applicable State and Federal Regulatory Programs

25. On June 10, 2010, the Regional Water Board adopted Order R1-2010-0044, *Waste Discharge Requirements for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR). The Roads WDR provides waste discharge coverage for activities performed under Green Diamond's Road Management Plan from the AHCP. The Road Management Plan is a comprehensive program to systematically prioritize, upgrade and decommission portions of the road system, maintain a prioritized road-related sediment source inventory, implement routine maintenance and monitoring of the mainline and secondary road system, accelerate treatment of high and moderate priority sediment sources, design detailed annual work plans, and perform post-treatment compliance and effectiveness monitoring.

26. Concurrently with development of the Roads WDR, the California Department of Fish and Game (DFG) developed a Master Agreement for Timber Operations (MATO, 1600-2010-0114-R1). DFG has jurisdiction over the conservation, protection, restoration, enhancement, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species under state law including Fish and Game Code section 1600 et seq.

27. The MATO section 11.0 A contains conditions (starting on page 21) for authorized activities including watercourse crossing installation, repair, replacement, maintenance, and upgrading and activities associated with in-stream and riparian restoration projects. Conditions necessary for protection of water quality and biological resources in streams include:

    - General—conditions for construction activities at stream sites
    - New road construction—conditions for design and construction of roads
    - Upgrading—conditions for process and materials used in upgrading existing roads
    - Decommissioning—conditions for treatments of sites that will be removed
    - Erosion control—conditions to minimize erosion and prevent sediment delivery from road work activities
    - Water drafting—conditions for water extraction
    - In-stream restoration projects—procedures, oversight, and restrictions

28. The California Department of Forestry and Fire Protection (CAL FIRE) is the state agency responsible for overseeing timber harvesting activities through implementation of the Forest Practice Rules (Cal. Code Regs., tit. 14, §§895-1115.3). Non-federal landowners proposing to harvest timber are required to have an approved timber harvest plan (THP), prepared by a registered professional forester (RPF), prior to starting timber harvesting activities. Pursuant to the Forest Practice Rules (FPRs), the Regional Water Board, DFG, California Geological Survey, and other agencies are also responsible agencies that review THPs and provide recommendations to CAL FIRE as part of a "Review Team". The Regional Water Board will continue to participate as a Review Team member for individual THPs proposed by Green Diamond to ensure compliance with this Order.

29. In July 2007, Green Diamond began implementing the Aquatic Habitat Conservation Plan (AHCP) and Candidate Conservation Agreement with Assurances approved in June 2007 by the National Marine Fisheries Service and the U.S. Fish & Wildlife Service for the conservation of the following aquatic species: Chinook salmon, coho salmon, steelhead, cutthroat trout, rainbow trout, southern torrent salamander, and tailed frog. The biological goals of the AHCP are to maintain cool water temperature, minimize and mitigate human-caused sediment inputs, provide for the recruitment of large wood into all stream classifications, and allow for the maintenance or increase of populations of the covered species through minimization of timber harvest-related impacts.

30. The Operating Conservation Program is contained in section 6.2 of the AHCP and details all of the enforceable measures to be implemented as part of timber harvest operations. The elements listed below are tailored to the needs of specific hydrographic planning areas as defined and described in AHCP section 4.2.1.5. The Operating Conservation Program includes:

    - Riparian Management Measures (AHCP section 6.2.1)— buffer zone widths, canopy retention requirements, tree selection guidelines

- Slope Stability Measures (AHCP section 6.2.2)— identification of geologic features, buffer zone widths, harvest limitations, site-specific evaluations by a professional geologist
- Road Management Measures (AHCP section 6.2.3)— decommissioning and upgrading standards, landing and road construction requirements, accelerated treatment of legacy sediment sources, hydrologic disconnection standards, inspection protocol, timing protocols
- Harvest-Related Ground Disturbance Measures (AHCP section 6.2.4)— yarding restrictions, site preparation restrictions, seasonally appropriate access restrictions

31. Watercourse buffer zones under Green Diamond's Operating Conservation Program require significantly higher canopy retention than buffer zones required by the current FPRs (AHCP section 6.2.1). Additionally, where there are defined steep slopes, additional harvesting restrictions are implemented to provide another level of protection to sensitive areas (AHCP section 6.2.2).

32. The majority of legacy sources of anthropogenic sediment are associated with roads. Discharge sources located on Green Diamond's mainline and secondary road system will be covered under Order R1-2010-0044 *Waste Discharge* Requirements *for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR). The Roads WDR requires systematic treatment of road-related sediment sources across Green Diamond's ownership independent of timber harvest plans. Other legacy sediment sources, such as those located up-slope on skid trails, are less conducive to a property wide inventory due to the challenges of evaluating them across a vast acreage.

33. Non-road legacy sediment sources will be evaluated, inventoried, and addressed concurrently with timber harvest plans, under coverage of this Order. The inventories will be included in each pertinent THP and sites will be treated prior to completion of the THP.

34. The Regional Water Board relies, in part, on the MATO, applicable provisions of the FPRs, and Green Diamond's AHCP requirements that are related to protection of water quality, which are included specifically or by reference, as enforceable provisions of this Order. Collectively, these regulatory mechanisms require implementation of specific prescriptions or management practices that provide a significant level of water quality protection. This Order is intended to work in conjunction with, and to supplement, the existing regulations in order to implement Basin Plan water quality standards and restore the beneficial uses of water across Green Diamond's ownership. As such, those applicable MATO conditions, FPRs, and AHCP prescriptions that provide water quality protection are included as enforceable conditions of this Order.

35. A monitoring and reporting program (Attachment B, MRP R1-2012-0088) is necessary to assess the implementation and effectiveness of mitigation measures required under this Order and provide feedback for adaptive management. The Effectiveness

Monitoring Program (AHCP section 6.2.5) and Implementation Monitoring Measures (AHCP section 6.2.7)will give the Regional Water Board relevant feedback regarding the effectiveness of the Order in protecting and enhancing water quality across the project area. Effectiveness of the management measures contained in the Operating Conservation Plan will be evaluated in relation to the AHCP biological goals and objectives (AHCP section 6.1),which include benchmarks that correlate to the primary beneficial uses of concern and comprise water temperature, sediment, and habitat concerns. The biennial report that Green Diamond is required to submit to the Regional Water Board, National Marine Fisheries Service, and United States Fish and Wildlife Service includes information summarizing the application of and compliance with management measures and monitoring programs.

Water Quality Certification

36. In-stream restoration projects that involve construction and other work in waters of the United States may require a federal permit pursuant to section 404 of the Clean Water Act. Section 401 of the Clean Water Act (33 U.S.C. §1341) requires every applicant for a federal license or permit to provide water quality certification from the state. The Regional Water Board Executive Officer may issue a decision on a water quality certification application. (CCR, tit. 23, § 3838, subd. (b).) State water quality certification conditions shall become conditions of any federal license or permit for the project. This Order includes a general water quality certification for activities and associated discharges for in-stream restoration projects that require federal permits.

37. The Regional Water Board may issue a general water quality certification for a class or classes of activities that are the same or similar, or involve the same or similar types of discharges and possible adverse impacts to water quality if it determines that these activities are more appropriately regulated under a general certification rather than individual certifications (Cal. Code Regs., tit. 23, §3861). General certifications apply for a fixed term not to exceed five years, must be conditioned to require subsequent notice to the Regional Water Board at least 30 days prior to commencement of the activity, and include appropriate monitoring and reporting requirements. A fee is also required pursuant to California Code of Regulations, title 23, section 3833, sub.(b)(3).

38. In-stream restoration projects will be submitted with the Annual Work Plan associated with Order R1-2010-0044 and will include all of the information required for, and be in compliance with, all of the conditions referenced in the MATO, Section 11.0 A.8 (DFG Notification 1600-2010-0114-R1). Unless the Regional Water Board determines that the project or activity does not meet the specified criteria for coverage under the general water quality certification, this Order will provide Clean Water Act section 401 certification for the federal permit required for that project.

Fees and Administration

39. Pursuant to Water Code section 13260 (d)(1), Green Diamond shall submit an annual fee for this Order according to a fee schedule established by the State Water Resources Control Board (State Board).

40. For in-stream restoration projects that require water quality certification, Green Diamond shall submit the appropriate fee at least 30 days prior to commencement of the activity. Annual fee schedules are detailed in the California Code of Regulation, title 23, section 2200(a)(3).

41. Green Diamond THPs in the AHCP area submitted to the Review Team after adoption of this Order will not require enrollment under Order R1-2004-0030, General Waste Discharge Requirements for Discharges Related to Timber Harvest Activities on Non-federal Lands in the North Coast Region (GWDR) or Order R1-2009-0038, Categorical Waiver of Waste Discharge Requirements for Discharges Related to Timber Harvest Activities on Non-federal Lands in the North Coast Region (Waiver). Green Diamond THPs will be reviewed by Regional Water Board staff during CAL FIRE's Review Team process for compliance with this Order. In this regard, any Green Diamond THP in the project area where water quality issues identified by Regional Water Board staff have not been resolved to the satisfaction of the Regional Water Board Executive Officer will be considered for denial of coverage under Section V of this Order.

42. Designated Regional Water Board staff will be notified of the commencement of THP activities each calendar year within a 15 day period prior to the start of timber operations.

43. Upon completion of a THP, the RPF will submit the AHCP post-harvest forms for the THP, the CAL FIRE final completion report, and a final certification notice to certify completion and compliance of the THP with this Order. The Regional Water Board will review the certification and may schedule a field inspection to verify conformance of the THP with this Order. The RPF will be notified in writing regarding approval or disapproval of the certification.

44. In considering this Order under the California Environmental Quality Act (CEQA), the Regional Water Board used the Environmental Impact Statement (EIS) issued by the U.S. Fish & Wildlife Service and National Marine Fisheries Service for the AHCP. When a project requires compliance with both CEQA and the National Environmental Policy Act (NEPA), and the federal EIS is prepared first and meets the requirements of CEQA, CEQA provides that the state agency should use the EIS rather than preparing a separate EIR or negative declaration, pursuant to California Code of Regulations, title 14, section 15221. On August 1, 2012, the Regional Water Board circulated a Notice of Intent and letter that added any points of analysis not covered in the EIS but required under CEQA. In that Notice and letter, the Regional Water Board provided public notice of the availability of the EIS and its intent to rely on the federal document. The EIS and supplemental letter were completed in compliance with CEQA, and reflect the Regional

Water Board's independent judgment and analysis. The Regional Water Board has reviewed this information and has considered this along with all the other information in the record prior to making its decision to issue this Order. In addition, potential environmental effects associated with the project were also analyzed under CEQA in the Initial Study/Mitigated Negative Declaration (IS/MND) prepared by the California Department of Fish and Game for the MATO and Roads WDR. The Regional Water Board has reviewed and considered the IS/MND as responsible agency prior to taking action on the Order. (Cal. Code Regs., tit. 14, § 15162.) The Regional Water Board adopts the CEQA findings required under Public Resources Code section 21081 as detailed in Appendix E. Mitigation measures necessary to reduce or eliminate significant water quality impacts are included as conditions of approval in the Order section below.

THEREFORE, pursuant to Water Code section 13263, the Regional Water Board approves and adopts Order R1-2012-0087, and directs the Executive Officer to file all appropriate notices. Green Diamond shall comply with the following:

II. SPECIFIC CONDITIONS

A. Timber Harvesting Plan Review
Individual timber harvesting plans will be reviewed as part of CAL FIRE's Review Team (FPR 1037.5) to confirm compliance with this Order. Participation, as deemed necessary, in First Review, pre-harvest inspections, and Second Review will provide the opportunity for representatives of the Regional Water Board to make any necessary site-specific water quality recommendations to ensure compliance with this Order, and for any subsequent changes to the THP to be made prior to CAL FIRE approval. If the THP is approved by CAL FIRE with no non-concurrences and all water quality issues identified by Regional Water Board staff have been resolved to the satisfaction of the Regional Water Board Executive Officer, then the THP shall be considered in conformance with the conditions of this WDR.

B. Notification of Commencement of Timber Harvesting Plan Activities
Each calendar year, within a 15 day period before beginning timber operations, and not later than the day of the start of timber operations, the Regional Water Board shall be notified of the actual commencement date for the start of operations for each THP. The notification shall be directed to the designated personnel at the Regional Water Board by telephone or by electronic mail.

C. Timber Harvest Plan Completion and Certification of Compliance
Upon completion of a THP, the RPF shall submit the AHCP post-harvest forms for the THP, the CAL FIRE final completion report, and a final certification notice to certify completion and compliance of the THP with this WDR. The Regional Water Board shall review the certification and may schedule a field inspection to verify conformance of the THP with this WDR. The RPF shall be notified in writing (including email) regarding approval or disapproval of the certification.

D. Green Diamond Aquatic Habitat Conservation Plan
Except for discharges described in Condition E below, this WDR provides waste discharge coverage for discharges from Green Diamond's forest management activities described in finding 5 carried out under the AHCP. All applicable mitigation measures identified in the Operating Conservation Program (AHCP Section 6.2) are requirements under this Order, including those identified in finding 30.

E. Treatment of Road Related Sediment Sources
Discharge sources located on Green Diamond's mainline and secondary road system are covered under Order R1-2010-0044 *Waste Discharge* Requirements *for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR).

F. Treatment of Other (Non-road Related) Sediment Sources
Other controllable sediment discharge sources, e.g. failing skid trail crossings and watercourse diversions within timber harvest units, will be evaluated, inventoried, and addressed concurrently with THPs. The inventory shall be included in the THP and shall include the following information:

1. A description of the proposed activity, including the type and scope of work.
2. Whether the proposed activity will occur on a Class I, II, III, or IV watercourse or restorable fish-bearing stream.
3. An estimate of the potential sediment volume that could discharge if left untreated.
4. An estimate of the relative potential for sediment delivery.
5. A description of the current site condition.
6. Where warranted, construction drawings, diagrams or sketches, cross sections with dimensions, or other information.

G. In-stream and Riparian Restoration
All applicable mitigation measures identified in the MATO are requirements under this Order, including those identified in finding 27. In-stream restoration projects shall be identified and reviewed via the Annual Work Plan associated with the Roads WDR (Order R1-2010-0044) and shall comply with all of the conditions referenced in the MATO, Section 11.0 A.8 (DFG Notification 1600-2010-0114-R1).

H. Discharge Notifications
Should it be determined by Green Diamond or the Regional Water Board that a discharge is causing or contributing to an exceedence of a water quality standard or violation of an applicable water quality requirement, Green Diamond shall:

Implement corrective measures immediately following discovery and notify the Regional Water Board by telephone or email as soon as possible, but no later

than 48 hours after the discharge was discovered. This notification shall be followed by a report within 14 days that includes:

- The date the exceedence or violation was discovered
- The name and title of the person discovering the exceedence or violation
- A map showing the location of the exceedence or violation site
- A description of recent weather conditions prior to discovering the exceedence or violation
- The nature and cause of the exceedence or violation
- Photos of the site characterizing the exceedence or violation
- The management measures currently being implemented
- Any maintenance or repair of management measures
- Any additional management measures that will be implemented to prevent or minimize discharges that are causing the exceedence or violation
- An implementation schedule for corrective actions
- The signature of the person preparing the report

Compliance with the required technical reports and the implementation of required corrective measures shall not prevent the Regional Water Board from taking enforcement action under any other requirements of this Order.

I. Green Diamond shall comply with the Monitoring and Reporting Program R1-2012-0088 attached to this Order.

III. SPECIFIC CONDITIONS FOR THE SOUTH FORK ELK RIVER WATERSHED

The following conditions apply to lands where Green Diamond owns and/or conducts timber harvesting activities in the South Fork Elk River watershed.

A. South Fork Elk River Management Plan
All THPs in the South Fork Elk River must adhere to Green Diamond's South Fork Elk River Management Plan, included as Attachment C to this Order.

B. South Fork Elk River Sediment Reduction Plan

1. Green Diamond shall maintain a master inventory of all sediment discharge sites deemed feasible to treat, including road-related sites both associated with THPs and not associated with THPs, non-road related sites associated with THPs (i.e. skid trail crossings), and non-road related sites not associated with THPs. The inventory shall include a site identification number, the location shown on a scaled map, the volume of sediment to be treated, treatment priority, and the proposed treatment. Upon completion of all the sites from the master inventory, maintenance of the master inventory will not be required.

2. All road related sites from the master inventory and all non-road related sites associated with THPs shall be treated by 2015.

3. All controllable non-road related sites not associated with THPs shall be inventoried by 2015 and treated by 2018.

4. Annual proposed treatments of sites from the master inventory shall be submitted via the Annual Work Plan for the Roads WDR (Order R1-2010-0044).

5. Upon completion of all sites from the master inventory, inventory and treatment of any new road related sediment sources in the South Fork Elk River Watershed shall be conducted pursuant to Green Diamond's Routine Road Maintenance Program and the Roads WDR (Order R1-2010-0044).

IV. GENERAL CONDITIONS

A. Discharge Prohibitions

1. The discharge of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited.

2. The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited.

3. Discharges of waste, which are not otherwise authorized by waste discharge requirements, or other orders issued by the Regional Water Board or the State Water Resources Control Board, to waters of the state in violation of Basin Plan standards, are prohibited.

4. Discharges must not cause or threaten to cause pollution, contamination, or nuisance.

5. Discharges must not adversely impact human health or the environment or the beneficial uses of water set out by the Basin Plan.

6. Discharges of waste in the Klamath River Basin that violate any narrative or numeric water quality objective, that are not authorized by waste discharge requirements or other order or action by the Regional Water Board or State Water Resources Control Board, are prohibited.

B. If any dispute arises regarding implementation of this Order, Green Diamond and Regional Water Board staff will attempt to resolve it through field examination and discussion.

C. Green Diamond must comply with all applicable mitigation measures identified in Attachment E of this Order (CEQA findings). Notwithstanding general condition B above, above, compliance with these mitigation measures and all other conditions are requirements under this Order, and violation of any such requirements subjects Green Diamond to enforcement action, including civil liability, under the Water Code.

D. Green Diamond shall comply with any additional mitigation measures identified and required pursuant to the CAL FIRE CEQA-equivalent process.

E. Green Diamond must allow Regional Water Board staff entry onto the affected property, with reasonable notice, for the purpose of observing, inspecting, photographing, videotaping, measuring, and/or collecting samples or other monitoring information to document compliance or non-compliance with this Order.

F. Green Diamond must allow Regional Water Board staff access to copy, at reasonable times, any records that must be kept under the conditions of this Order.

G. All activities covered by this Order must comply with local, state, and federal law.

H. No discharge of waste into the waters of the state, whether or not the discharge is made pursuant to waste discharge requirements, shall create a vested right to continue to discharge. All discharges of waste into waters of the state are privileges, not rights (Water Code, section 13262, subd. (g)).

I. Prior to implementing any change to the project or activity that may have a significant or material effect on the findings, conclusions, or conditions of this Order, Green Diamond must obtain the written approval of the Regional Water Board Executive Officer.

J. In the event of unforeseen circumstances such as fire, wind, earthquake, flood, pest or pathogen infestation, or landslides of a scale not reasonably foreseeable, Green Diamond shall initiate a meeting with the Executive Officer to discuss potential changes to the conditions of this WDR.

K. The Regional Water Board may add to or modify the conditions of this Order, with notice and as appropriate, to implement any new or revised water quality standards and implementation plans adopted and approved pursuant to the Porter-Cologne Water Quality Control Act or section 303 of the Clean Water Act.

L. This Order may be modified, revoked and reissued, or terminated for cause. Significant changes to the AHCP or MATO which influence this Order, affect compliance with the conditions of this Order, or contribute to a violation or exceedence of applicable water quality requirements should receive written approval from the Regional Water Board Executive Officer to avoid the possible need to reopen this Order.

V. RESCISSION AND DENIAL OF COVERAGE

The Executive Officer shall rescind or deny the applicability of this Order to any individual project or activity if the Executive Officer makes any of the following determinations:

1. The project or activity does not comply with any condition or provision of this Order.
2. The project or activity is reasonably likely to result or has resulted in a violation or exceedence of any applicable water quality requirement.
3. The project or activity has varied in whole or in any part from the approved project in any way that could adversely affect water quality.
4. When requested by Green Diamond, another state agency (upon a demonstration that the project or activity would cause an exceedence of water quality standards or otherwise violate this Order), a subdivision of the state (county), or a federal agency, and with concurrence by the Executive Officer.
5. The project or activity is the subject of an unresolved non-concurrence filed by Regional Board staff with CAL FIRE.
6. The project or activity meets the WDR terms, but may still result in discharge that could affect the quality of waters of the state.

Upon receipt of a written notice of rescission or denial of coverage for a project or activity under this Order, the applicability of this Order to the covered project or activity is immediately terminated. Upon termination, Green Diamond must immediately cease all activities that may result in un-permitted discharges of waste to waters of the state, other than activities necessary to control further discharges.

VI. 401 CERTIFICATION FOR IN-STREAM RESTORATION PROJECTS

IT IS HEREBY ORDERED, THE REGIONAL WATER BOARD CERTIFIES THAT in-stream restoration projects in compliance with the conditions of this order will comply with sections 301, 302, 303, 306, and 307 of the Clean Water Act, and with applicable provisions of state law, subject to the following additional terms and conditions:

1. This certification action is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to Water Code section 13330 and title 23, California Code of Regulations, section 3867.

2. This certification action is not intended and shall not be construed to apply to any discharge from any activity involving a hydroelectric facility requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license unless the pertinent certification application was filed pursuant to title 23, California Code of Regulations, section 3855, subdivision (b) and the application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.

3. Certification is conditioned upon total payment of any fee required under California Code of Regulations, title 23, section 3833, subdivision (b)(3). Annual Fee Schedules are detailed in the California Code of Regulation, title 23, section 2200.

4. This general certification applies only to in-stream restoration projects subject to this Order.

5. Green Diamond shall notify the Regional Water Board, at least 30 days prior to commencement of the activity, and submit information regarding the construction schedule, other relevant information, and the appropriate fee. The Regional Water Board will notify Green Diamond within 30 days if the project or activity does not meet the specified criteria for coverage.

6. The authorization of this certification for any dredge and fill activities expires five (5) years from the date the activity commences.

7. Any relevant conditions of this Order are enforceable conditions of this general water quality certification.

8. In the event of any violation or threatened violation of the conditions of this certification, the violation or threatened violation shall be subject to any remedies, penalties, process, or sanctions as provided for under state law. For purposes of section 401(d) of the Clean Water Act, the applicability of any state law authorizing remedies, penalties, process, or sanctions for the violation or threatened violation constitutes a limitation necessary to assure compliance with the water quality standards and other pertinent requirements incorporated into this certification.

9. The general water quality certification portion of this Order may be modified as needed by the Executive Officer of the Regional Water Board.

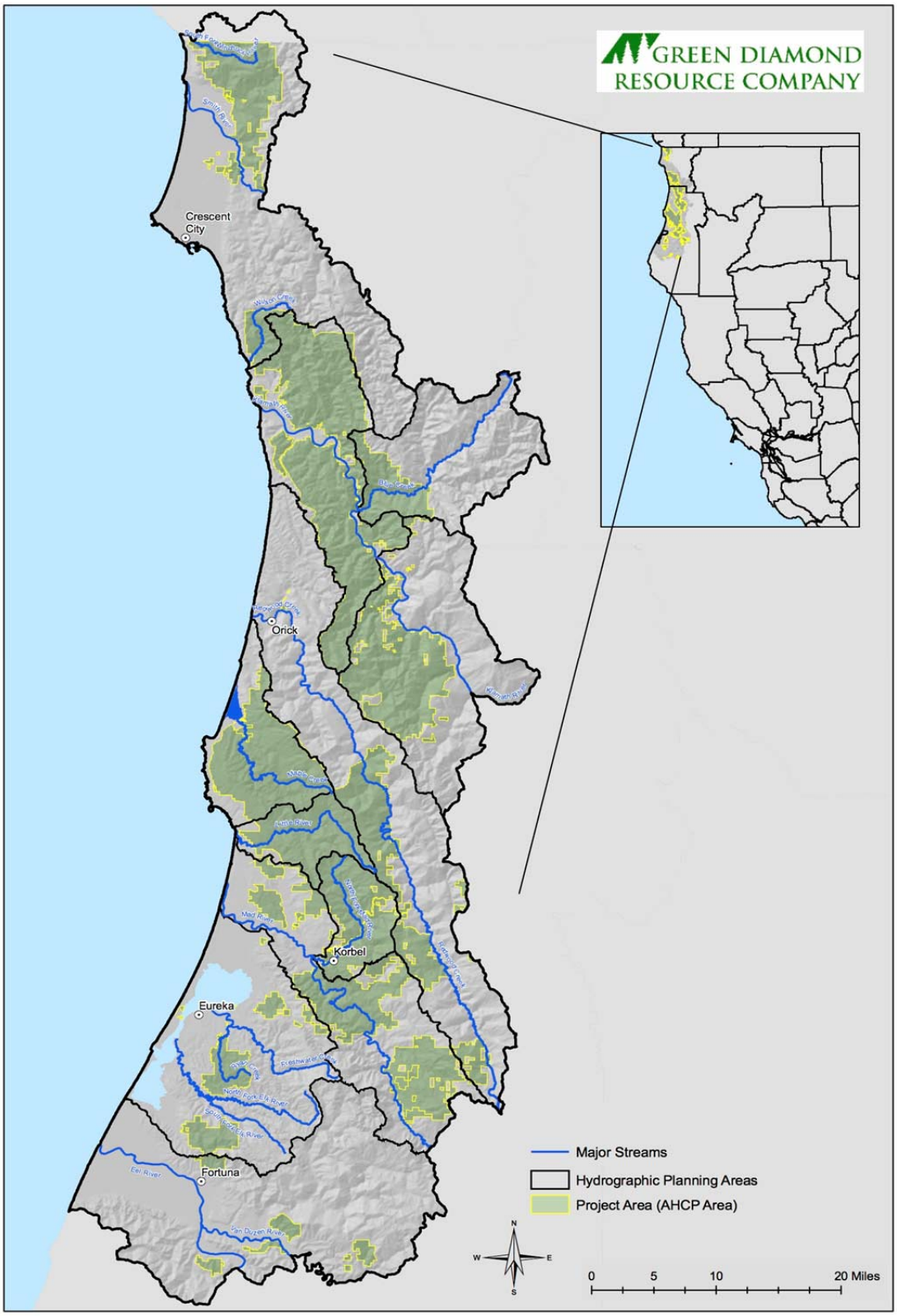
Certification:

I, Matthias St. John, Executive Officer do hereby certify that the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, North Coast Region, on October 4, 2012.

_____

Matthias St. John
Executive Officer

ATTACHMENT A



Attachment B

MONITORING AND REPORTING PROGRAM R1-2012-0088

FOR

WASTE DISCHARGE REQUIREMENTS
FOR
DISCHARGES RELATED TO GREEN DIAMOND RESOURCE COMPANY'S FOREST MANAGEMENT ACTIVITIES CONDUCTED WITHIN THE AREA COVERED BY ITS AQUATIC HABITAT CONSERVATION PLAN IN THE NORTH COAST REGION

HUMBOLDT AND DEL NORTE COUNTIES

This Monitoring and Reporting Program (MRP) is issued pursuant to Water Code section 13267(b) and requires Green Diamond Resource Company (Green Diamond) to implement the MRP described below. The purpose of the MRP is to ensure that Green Diamond complies with waste discharge requirements established by Order R1-2012-0087 (the Order), to track activities covered under the Order, and to evaluate the effectiveness of the Order in protecting and restoring the beneficial uses of water.

The Regional Water Board has delegated its authority to the Executive Officer to revise, modify, and reissue the MRP. Green Diamond must develop and implement additional monitoring and reporting requirements when the necessity of such measures is supported by evidence and the measures are described in writing by the Executive Officer.

I. MONITORING

A. Roads
Monitoring of Green Diamond's road system will occur pursuant to Order R1-2010-0044, *Waste Discharge Requirements for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR)

B. Non-road Sediment Sources
Non-road controllable sediment discharge sources, e.g. failing skid trail crossings and watercourse diversions within timber harvest units, shall be inspected twice after treatment to evaluate the implementation and effectiveness of the completed treatment. One inspection shall occur prior to the winter period, and once following a full winter. If the site has stabilized and there is no reasonable potential for waste discharge in violation of the Basin Plan, no further monitoring of the site will be required.

If any minor maintenance issue, such as debris plugging or damage to waterbreaks, is identified following treatment, maintenance shall be conducted as soon as feasible prior to the next winter period.

If a major maintenance issue, such as fill failure resulting in significant sediment delivery or watercourse diversion, major maintenance shall be conducted as soon as feasible prior to the next winter period and the site shall be monitored for an additional year, once prior to the winter period, and once following a full winter.

C. Effectiveness Monitoring

The Effectiveness Monitoring component of Green Diamond's Aquatic Habitat Conservation Plan (AHCP) evaluates the success of the conservation program in achieving the biological goals and objectives of the AHCP. Over time, better ways to manage watersheds that may further benefit aquatic species and their habitats may emerge. The Effectiveness Monitoring and Adaptive Management programs were developed to incorporate new information into practice as it becomes available. The Effectiveness Monitoring measures are also expected to give the Regional Water Board relevant feedback regarding the effectiveness of the Order in protecting water quality. Current Effectiveness Monitoring measures include:

1. Rapid Response Monitoring

   Provides early warning signals to ensure that the biological goals and objectives of the AHCP will be met.
   - Annual property-wide water temperature monitoring in Class I and Class II watercourses
   - Paired water temperature monitoring on Class II watercourses
   - Tailed frog monitoring
   - Southern torrent salamander monitoring
   - Implementation and effectiveness monitoring of road management measures
   - Road maintenance assessments

2. Response Monitoring

   Monitors the effectiveness of the conservation measures in achieving the biological goals and objectives of the AHCP.
   - Class I channel monitoring
   - Class III sediment monitoring

3. Long-term Trend Monitoring/Research

   Have the potential to provide feedback for adaptive management, but in some circumstances, decades may be required before that can occur.
   - Steep streamside slope delineation study
   - Steep streamside slope assessment
   - Mass wasting assessment
   - Long-term habitat assessments
   - Large woody debris monitoring
   - Summer juvenile population estimates

- Out-migrant trapping
- Turbidity threshold sampling

4. Experimental Watersheds Program
   Four watersheds, judged to be representative of the different geologic and physiographic provinces across the AHCP area were designated for additional monitoring and research on the interactions between forestry management and riparian and aquatic ecosystems.
   - Little River (Little River Hydrographic Planning Area (HPA))
   - South Fork Winchuck River (Smith River HPA)
   - Ryan Creek (Humboldt Bay HPA)
   - Ah Pah Creek (Coastal Klamath HPA)

D. Monitoring Specific to the Elk River
   Monitoring efforts specific to the Elk River watershed are intended to evaluate the effectiveness of the Order in protecting water quality and in moving the watershed toward recovery from cumulative impacts.

1. Master Inventory
   All sediment sources under the master inventory shall be inspected after treatment, once prior to the winter period (October 16) and once following the winter period (after May 14) to ensure that all prescribed management measures have been implemented, are functioning as designed, and that no new sediment sources have developed.

2. Road Related Sites after Completion of Master Inventory Treatments
   Upon completion of all sites from the master inventory, inventory and treatment of any new road related sediment sources in the South Fork Elk River watershed shall be conducted pursuant to Green Diamond's Routine Road Maintenance Program (AHCP 6.2.3.9) and the Roads WDR (Order R1-2010-0044).

3. South Fork Elk River Sediment Reduction Effectiveness Monitoring
   The purpose of the South Fork Elk River Sediment Reduction Effectiveness Monitoring plan is to quantify sediment delivery and effectiveness at treated sites and provide feedback to refine sediment control measures in the Elk River.

   a. Parameters to be measured, before and after the first winter period after treatment
      - Visual Observations
      - Photographic control points
      - Void volumes
      - Longitudinal profiles

   b. Locations
      Monitoring shall be conducted at a representative sample of treated sites, from both simple and complicated categories of treatment. Once treatment of

sites from the master inventory has been completed, this monitoring effort shall continue for a subset of sites treated in the Elk River through the Routine Road Maintenance program.

4. Landslide Monitoring
   The purpose of landslide monitoring is to determine if there are changes to the landslide pattern and delivery rate in the Elk River in response to land management activities and to identify new landslides that occur in the years between analyses.

   a. The landslide inventory shall include the following:
      - Unique identifier code
      - Primary watershed name
      - Sub-basin name
      - Aerial photo year number and scale
      - Feature type
      - Reactivation status
      - Landslide dimensions and volume
      - Delivery percentage, volume, and certainty
      - Watercourse class affected
      - Aspect of hillslope
      - Geomorphic association (i.e. inner gorge, headwall swale, planar slope, break in slope, vertical and horizontal/convex and concave slope, other unstable areas, etc.)
      - Hillslope angle
      - Proximity to watercourse
      - Land use history at point of initiation, upslope, and downslope (including harvesting and roading)
      - Field visit status
      - Stand age class at time of failure (under or over 15 years)
      - Geologic unit
      - Field observation notes

   b. Location
      All Green Diamond lands in the South Fork Elk River watershed shall be inventoried.

   c. Method
      Aerial photo review shall be coupled with a subsample of field inventories to locate and map landslide features. At a minimum, the landslide inventory shall occur every 3-5 years, subject to the availability of aerial photos.

5. Water Quality Trend Monitoring

   a. Parameters to be measured
      - Stage (m or feet)

- Velocity (m/sec or ft/sec)
- Streamflow (m^3/sec or ft^3/sec)
- Turbidity (NTU)
- Suspended sediment concentration (mg/L)

b. Location
The water quality monitoring station is located in McCloud Creek, tributary to South Fork Elk River. The station is situated on Humboldt Redwood Company property approximately 400 feet upstream of the confluence with South Fork Elk River and 2,200 feet downstream of Green Diamond's property.

c. Frequency
Turbidity and stage will be measured simultaneously at 10-minute increments. Streamflow shall be measured at an interval to ensure that a wide range of all flows is measured and incorporated into the stage-streamflow relationships at the monitoring locations.

Sampling shall begin no later than October 1 annually. The monitoring shall continue each year until there has been a period of 30 continuous days of no rain, at least until May 15. If these conditions are not met, then turbidity monitoring may cease on June 30 for the remainder of the dry season.

d. Analysis
Informational items related to streamflow, turbidity, and suspended sediment concentration shall be developed by Green Diamond according to hydrologic year, including rating curves for stage-streamflow, field turbidity-lab turbidity, streamflow-turbidity, and turbidity-suspended sediment relationships. These relationships shall be used to develop "finalized data" which represent stage, lab turbidity, and streamflow.

II. REPORTING

A. Annual THP Summary
By June 30 of every year, an annual summary for each THP currently being covered by this Order shall be submitted by the RPF. The annual summary shall, at a minimum, contain the following information:
- THP number
- Current status of harvesting, including which units were harvested
- Current status of any sediment source treatments, including THP-related road sites and non-road sites such as skid trail crossings.
- Current status of site preparation activities
- Whether any new sediment sources have been discovered

B. AHCP Post-harvest Report Forms
By January 31 of every year, for each THP where all the felling, logging, loading, hauling, and hazard abatement operations have been completed, the RPF shall submit the AHCP Post-harvest Report Form. An example of the form is included at the end of this MRP.

C. AHCP Biennial Report
Per the Implementation Agreement between the National Marine Fisheries Service, United States Fish and Wildlife Service, and Green Diamond, Green Diamond creates a biennial report describing its activities pursuant to the Operating Conservation Plan (Section 6.2 of the AHCP). The biennial report provides information relevant to the AHCP regarding implementation, minor modifications, compliance of individual THPs, land transactions, road management measures, training programs, monitoring efforts, and more.

Green Diamond shall submit to the Regional Water Board a copy of the Biennial Report on March 15 every two years, concurrently with submission to the National Marine Fisheries Service and United States Fish and Wildlife Service.

D. Data Submission
Upon request, Green Diamond must provide any records that must be kept under the conditions of the Order or this MRP.

E. Reporting Specific to the Elk River

1. Master Inventory
An updated copy of the master inventory maintained per the Order shall be submitted annually, by March 31, to the Regional Water Board and shall include the status of the treatment for each site (i.e. completed, to be scheduled, year scheduled for treatment). Upon completion of all the sites from the master inventory, maintenance and submission of the master inventory will not be required, and inventory and treatment of any new road related sediment sources in the South Fork Elk River Watershed shall be conducted pursuant to Green Diamond's Routine Road Maintenance Program and the Roads WDR (Order R1-2010-0044).

2. South Fork Elk Sediment Reduction Effectiveness Monitoring
Green Diamond must submit, by December 1 each year, a report describing the sites currently being monitored, with the following information:
- The monitoring location selection criteria
- The unique site identification
- Site attributes
- A description of the pre-winter monitoring activities
- Comparative pre- and post-winter photos
- Comparative pre- and post-winter longitudinal profiles
- Comparative pre- and post-winter void monitoring

3. Annual Harvest Reports
   By January 31 of each year, Green Diamond shall submit an Annual Harvest Report with a scaled map containing the following information for completed and planned timber harvesting:

   a. Acres felled/to be felled, by silvicultural prescription

   b. Acres yarded/to be yarded, by yarding technique

   c. Acres subject to/to be subject to mechanical site preparation

   d. Acres reported to the nearest acre, with the THP number, harvest unit number, and hazard class.

   e. A brief description of the methods and/or data sources used to calculate the number of acres.

4. Landslide Monitoring
   Green Diamond shall provide reports of landslide inventories by December 31 of the most recent photo flight year. If there is some technical reason limiting the ability to conduct the inventory and report by the due date, Green Diamond shall request an extension, in writing within 10 days prior to the due date, with the specific reasons described for the delay.

5. Water Quality Trend Monitoring
   Green Diamond shall submit a report by November 1 each year containing all of the raw and processed data from the previous hydrologic year (October 1-September 30). The report shall include:
   - A description of each monitoring site
   - A list of equipment used in the collection of data
   - All raw and processed data in tabular form
   - Graphics and supporting data representing the relationships used in any data transformation
   - Complete disclosure of all possible sources of error
   - An activity log of monitoring activities at each sites and observations made by field staff.
   - Optionally, the report may also include an analysis of the data and discussion of findings with recommendations for improvements or changes to this requirement

GREEN DIAMOND RESOURCE COMPANY

AHCP Post Harvest Report

THP Name: GDRCO No:

RPF: CDF No:

Units

Unit	TTRRSSLL	Gross Acres	Clear Cut Acres	Selection Acres	No Harvest Acres	In Unit ROW Acres	Out Unit ROW Acres	Other Acres

Hazard Abatement

Unit	Treatment Type	Treatment Date	Treatment Acres	AHCP Criteria Met

Reason if AHCP Criteria Are Not Met:

Unit	Issue	Acres Affected	Percent Non Compliance	Reason Not Met

Riparian

Feature	Requirements Met?
I	
II-1	
II-2	
Modified Tier A III	

Reason Requirements Not Met:

Geology

Unit	Feature	Watercourse	Basal Area Retent.(ft²)	Slide ID	Length (ft)	Acres of Retent.	Clear Cut Acres	Alt RX?	Alt RX Silviculture	Alt RX Met?	Retent. Req. Met?

Reason Retention or Alternate Prescription Not Met:

South Fork Elk River Management Plan

Green Diamond Resource Company

5/11/2006
Revised 7/26/2012

Green Diamond Resource Company (Green Diamond) has developed the South Fork Elk River Management Plan (SFERMP) as a sediment reduction strategy for its timberland ownership within the South Fork of Elk River Watershed. The key goal of this strategy is to implement operational procedures and measures specifically aimed at reducing sediment production, transport, and deposition into watercourses. This plan specifically describes the measures the company will apply to ensure that its operations will achieve this goal, protect water quality and beneficial uses and mitigate or avoid significant impacts to aquatic habitat. These measures were conceived, developed and revised in the context of watershed-specific physical characteristics, past management activities, and future Green Diamond management objectives of South Fork Elk River, as well as to meet the pending Elk River TMDL requirements.

The South Fork Elk River Watershed is significantly influenced by a geologic formation known as the Wildcat Group. This formation incorporates undifferentiated rocks composed of soft yellowish brown to bluish gray siltstones, clay stones and fine sandstones, which, because of their lack of strength and durability, are prone to erosion. This fine grained material becomes easily mobilized and has a high potential to reach fish bearing stream habitat.

Recognizing the underlying geology and the erodible nature of the soils within significant areas of the South Fork Elk River Watershed and acknowledging that Green Diamond planned to re-enter the South Fork Elk River watershed (within its ownership) to harvest timber and maintain road systems; it was deemed necessary and appropriate that watershed specific measures be instituted to ensure the continued protection and enhancement of water quality and aquatic habitat. The SFERMP addresses watershed specific operating procedures in the following five key categories: A) Riparian Prescriptions, B) Geological Prescriptions, C) Harvesting, Yarding and Hauling Prescriptions, D) Road Management and E) Seasonal Restrictions.

These categories include practices directed toward managing riparian zones to protect aquatic habitat, minimizing soil disturbance, minimizing movement of sediment into watercourses, and identifying potential off-site measures which could aid in reducing overall sediment contribution to the system. Green Diamond will follow these measures during administrative activities and incorporate these measures into THPs, within Green Diamond's South Fork Elk River property.

A. Riparian Prescriptions

1) Class I Riparian Management Zone (RMZ):
   a) 150 feet on each side of the watercourse.
   b) At least 85% overstory will be retained, where it currently exists, within the first 75 feet of the watercourse and at least 70% within the remainder of the Class I RMZ. 70% of the overstory canopy and understory vegetation within all Class I RMZ's will be retained.
   c) Class I watercourses will be provided with an additional 25 foot SOZ on slopes between 0-30% or 50 foot SOZ on slopes >30%, where understory vegetation, hardwoods and mid-canopy conifers will be retained on site.
   d) No trees will be harvested that contribute to maintaining bank stability. Redwoods will be preferentially harvested over other conifers
   e) The following criteria will be used to identify trees within the RMZ as potential candidates for marking to harvest due to their low likelihood of recruitment to the watercourse. (The determination of trees to be marked within the RMZ will be predicated on ensuring that overstory canopy retention standards and slope stability measures are met (See Aquatic Habitat Conservation Plan (AHCP) Sections 6.2.1 and 6.2.2), as well as ensuring that trees that are likely to recruit to the watercourse are not marked for harvest.)
      Criteria for trees that have a low likelihood of recruiting are:
      - Tree has an impeded "fall-path" to the stream (e.g., upslope family members of a clonal group blocked by downslope stems); or
      - Tree or the majority of the crown weight of the tree is leaning away from stream and the tree is not on the stream bank or does not have roots in the stream bank or stream; or
      - The distance of the tree to the stream is greater than the height of the tree; or
      - Tree is on a low gradient slope such that gravity would not carry the fallen tree into the stream or objects such as trees and large rocks impede its recruitment path; or
      - Tree is not on an unstable area or immediately downslope of an unstable area; or
      - Harvesting of the tree will not compromise the stream bank or slope stability of the site or directly downslope of the site.
   f) Trees may be felled within Class I RMZs to create cable yarding corridors as needed to ensure worker safety, subject to the canopy closure requirements set forth above. Such trees will be part of the harvest unit.
   g) There will be only one harvest entry into Class I RMZs during the life of the AHCP, which will coincide with the even-aged harvest of the adjacent stand.
   h) The Class I RMZ is an equipment exclusion zone (EEZ), except for a) existing roads and landings; b) construction of new spur roads to extend operations outside the RMZ; c) road watercourse crossings; d) skid trail watercourse crossings; and e) designated skid trail intrusions.

The exception for skid trail watercourse crossings is only applicable when the following conditions are met:

- Construction and use of skid trail watercourse crossings within the RMZ may occur only when construction and use of alternative routes to otherwise inaccessible areas outside of the RMZ would result in substantially greater impacts to aquatic resources. Preference shall be given to utilizing existing skid trail watercourse crossing sites in the RMZ over establishing new skid trail watercourse crossing sites in the RMZ.
- Skid trail watercourse crossings shall not be constructed or used in the RMZ to provide access to RMZs for the purpose of their harvest.
- Within the Class I RMZ, trees may be felled to facilitate skid trail watercourse crossing construction and use. All such felled trees will be retained as downed wood in the RMZ.
- Green Diamond will submit to the Services an explanation, justification, and map of any proposed skid trail watercourse crossings as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

The exception for skid trail intrusions is only applicable when the following conditions are met:

- RMZ hillslopes are less than 25%.
- Construction and use of skid trails within the RMZ may occur only when construction and use of alternative routes to otherwise inaccessible areas outside of the RMZ would result in substantially greater impacts to aquatic resources. Preference shall be given to utilizing existing skid trails in the RMZ over construction of new skid trails in the RMZ.
- Skid trails will not be constructed or used in the RMZ to provide access to RMZs for the purpose of their harvest.
- Within the RMZ, only trees less than 10 inches in dbh may be felled to facilitate skid trail use. All such felled trees will be retained as downed wood in the RMZ.
- Green Diamond has submitted to the Services an explanation, justification, and map of the proposed skid trail and use in the RMZ as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

i) Any ground disturbance caused by management activities that is larger than 100 square feet within an RMZ will be mulched and seeded or otherwise treated to reduce the potential for sediment delivery from sheet and gully erosion. Minimum standards for seeding and mulching operations are 30 pounds per acre of seed and a minimum mulching depth of two inches, covering at least 90% of the surface area.

j) No salvaging within the inner zone of the Class I RMZ. If any part of the salvageable piece is in the inner zone, the entire piece will be left.
k) Salvaging of downed trees within the outer zone of the Class I RMZ is permitted if the following criteria are met:
   - The wood is not currently, and is unlikely in the future to be, incorporated into the bankfull channel (including wood located below unstable areas);
   - The wood is not contributing to bank or slope stability; or
   - The wood is not positioned on a slope such that it can act to intercept sediment moving toward the stream.

2) <u>Class II RMZ:</u>
   a) 75 feet or 100 feet on each bank of all Class II watercourse.
   b) A 75-foot minimum buffer will be used on the first 1,000 feet of 1st order Class II watercourses (Class II-1 watercourses). Downstream of this first 1000-foot section, the RMZ will be expanded to at least 100 feet.
   c) A 100-foot minimum buffer will be used on all 2nd order or larger Class II watercourses (Class II-2 watercourses).
   d) Where a 1st order Class II watercourse flows directly into a Class I watercourse, the Class II RMZ will be at least 100 feet on each bank for the first 200 feet of Class II channel upstream of the Class I RMZ boundary.
   e) First order Class II watercourses with sideslopes >50% with ground based operations, will have an RMZ of 100 feet.
   f) A 30 foot inner zone within the RMZ will be established, measured from the watercourse transition line.
   g) An outer zone of the RMZ will be established and extend the remaining 45 feet or 70 feet (depending on whether it is a Class II-1 watercourse or a Class II-2 watercourse, respectively).

      At least 85% overstory canopy will be retained in the inner zone. The RMZ inner zone is not flagged. Canopy closure retention standards in the inner and outer RMZs will be determined by varying the mark of harvest trees.
   h) At least 70% overstory canopy will be retained in the outer zone.
   i) No trees will be harvested that contribute to maintaining bank stability. Redwoods will be preferentially harvested over other conifers.
   j) Trees may be felled within RMZs to create cable yarding corridors as needed to ensure worker safety, subject to the canopy closure requirements set forth above. Such trees will be part of the harvest unit.
   k) There will be only one harvest entry into Class II RMZs during the life of the AHCP, which will coincide with the even-aged harvest of the adjacent stand.
   l) The Class II RMZ is an EEZ, except for a) existing roads and landings; b) construction of new spur roads to extend operations outside the (RMZ); c) road watercourse crossings; d) skid trail watercourse crossings; and e) designated skid trail intrusions.

The exception for skid trail watercourse crossings is only applicable when the following conditions are met:

- Construction and use of skid trail watercourse crossings within the RMZ may occur only when construction and use of alternative routes to otherwise inaccessible areas outside of the RMZ would result in substantially greater impacts to aquatic resources. Preference shall be given to utilizing existing skid trail watercourse crossing sites in the RMZ over establishing new skid trail watercourse crossing sites in the RMZ.
- Skid trail watercourse crossings shall not be constructed or used in the RMZ to provide access to RMZs for the purpose of their harvest.
- Within Class II-1 RMZs, trees may be felled and harvested to facilitate skid trail watercourse construction and use. All harvested trees will be counted towards estimated reductions in "full tree equivalents" (FTE) values and reductions in potential recruitment of LWD (See AHCP Section 6.2.7.3).
- Within Class II-2 RMZs, trees may be felled to facilitate skid trail watercourse crossing construction and use. All such felled trees shall be retained as downed wood in the RMZ and shall be counted towards estimated reductions in FTE values and reductions in potential recruitment of LWD.
- Green Diamond will submit to the Services an explanation, justification, and map of any proposed skid trail watercourse crossings as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

The exception for skid trail intrusions is only applicable when the following conditions are met:

- RMZ hillslopes are less than 25%.
- Construction and use of skid trails within the RMZ may occur only when construction and use of alternative routes to otherwise inaccessible areas outside of the RMZ would result in substantially greater impacts to aquatic resources. Preference shall be given to utilizing existing skid trails in the RMZ over construction of new skid trails in the RMZ.
- Skid trails will not be constructed or used in the RMZ to provide access to RMZs for the purpose of their harvest.
- Within the RMZ, only trees less than 10 inches in dbh may be felled to facilitate skid trail use. All such felled trees shall be retained as downed wood in the RMZ and shall be counted towards estimated reductions in FTE values and reductions in potential recruitment of LWD.
- Green Diamond has submitted to the Services an explanation, justification, and map of the proposed skid trail and use in the

RMZ as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

m) Any ground disturbance caused by management activities that is larger than 100 square feet within an RMZ will be mulched and seeded or otherwise treated to reduce the potential for sediment delivery from sheet and gully erosion. Minimum standards for seeding and mulching operations are 30 pounds per acre of seed and a minimum mulching depth of two inches, covering at least 90% of the surface area.

n) No salvaging within the inner zone of the Class I RMZ. If any part of the salvageable piece is in the inner zone, the entire piece will be left.

o) Salvaging of downed trees within the outer zone of the Class I RMZ is permitted if the following criteria are met:
   - The wood is not currently, and is unlikely in the future to be, incorporated into the bankfull channel (including wood located below unstable areas);
   - The wood is not contributing to bank or slope stability; or
   - The wood is not positioned on a slope such that it can act to intercept sediment moving toward the stream.

3) <u>Class III protection measures:</u>
Green Diamond will apply one of two levels of protection measures within Class III watercourses on their ownership within South Fork Elk River. Class III watercourses having average side slopes under 60% will be provided Modified Tier A protection measures and Class III watercourses having average side slopes over 60% will be provided Tier B protection measures.

a) Modified Tier A Class III Protection Measures:
   - 30 foot EEZ except for a) existing roads, b) road watercourse crossings, c) skid trails*, and d) skid trail watercourse crossings**.
   - Where side slopes average between 30% and 60%, the EEZ shall be expanded to 50 feet.
   - Retain all Channel Zone Trees*** – all species.
   - Retain all LWD on the ground (not including felled trees) within the EEZ.
   - Retain all sub-merchantable conifers and safe snags.
   - Retain a minimum of 15 square feet of basal area of hardwoods per acre where it exists before harvest, including the largest hardwoods available for this purpose. Retain all hardwoods when less than 15 square feet basal area is present before harvest.
   - Retain at least 50% of the understory vegetation following completion of yarding operations.
   - Broadcast burning will not occur within Green Diamond's properties in South Fork Elk River.

b) Tier B Class III Protection Measures:

- 50 foot EEZ except for a) existing roads, b) road watercourse crossings, c) skid trails*, and d) skid trail watercourse crossings**.
- Retain all Channel Zone Trees*** – all species.
- Retain a minimum average of one conifer 15 inches dbh or greater per 50 feet of stream length within the EEZ.
- Retain all hardwoods and non-merchantable conifers located within the EEZ except where necessary to create cable corridors or for the safe falling of merchantable trees.
- Retain all LWD on the ground (not including felled trees) within the EEZ.
- Broadcast burning will not occur within Green Diamond's properties in the South Fork of Elk River.

* The exception for skid trail intrusions is only applicable when the following conditions are met:

1. EEZ hillslopes are less than 25%.
2. The location and use of skid trails within the EEZ may occur only when the use of alternative routes to otherwise inaccessible areas outside of the EEZ would result in substantially greater impacts to aquatic resources. Intrusion into the EEZ is preferred if the alternative routes would result in greater road length and additional watercourse crossings. Preference will be given to utilizing shovel logging equipment and using existing skid trails in the EEZ over locating new skid trails in the EEZ.
3. Skid trails will not be used in the EEZ to provide access to EEZs for the purpose of their harvest.
4. All bare mineral soil greater than 100 square feet created by management activities within the EEZ, will be mulched or treated with slash to adequately cover the exposed soil area prior to any onset of rain or upon completion of operations, whichever occurs first.
5. Green Diamond has submitted to the Services an explanation, justification, and map of the proposed entry into the EEZ as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

** The exception for skid trail watercourse crossings is only applicable when the following conditions are met:

1. Construction and use of skid trail watercourse crossings within the Class III EEZ may occur only when construction and use of alternative routes to otherwise inaccessible areas outside of the RMZ would result in substantially greater impacts to aquatic resources. Preference shall be given to utilizing existing skid trail watercourse crossing sites in the Class III over establishing new skid trail watercourse crossing sites in the Class III.
2. Within Class III EEZs, trees may be felled and harvested to facilitate skid trail watercourse crossing construction and use.

3. Green Diamond will submit to the Services an explanation, justification, and map of any proposed skid trail watercourse crossings as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

*** A "Channel Zone Tree" is defined as follows: A tree with its trunk or surface roots located within the channel or extending into the channel. Typically these trees serve the function as "control points" (retaining sediment and/or preventing channel head cutting) within the channel. When growing on the bank with surface roots extending into the channel, trees can also contribute to overall bank stability.

B. Geologic Prescriptions

A California licensed Registered Professional Forester (RPF) is responsible for conducting field reconnaissance of all proposed timber harvest units specifically for the purpose of identifying unstable areas, as described by the California Forest Practice Rules and using California
Licensed Forestry Association 1999 Check List. The RPF is also responsible for determining the need for additional site assessment by a California licensed Professional Geologist (PG) based on the presence or absence of indicators of unstable areas.

During THP development, an RPF will 1) impose the default prescriptions applicable below if it is determined that any portion of the THP meets the definitions for a steep streamside slope (SSS), headwall swale, deep-seated landslide or shallow rapid landslide; 2) exercise professional discretion to avoid operations in unstable areas; or 3) retain a California PG to develop site-specific alternative prescriptions to the default prescriptions. The default prescriptions below as well as complete avoidance of operations in unstable areas are considered conservative prescriptions. For that reason, where unstable areas are avoided or default prescriptions applied, RPFs will not necessarily retain the services of a PG for further site evaluation and prescription development and a geological report will not typically be included with a proposed THP as a matter of necessity.

Where RPFs determine that unstable areas or indicators of unstable areas exist within a harvest unit and they require a professional geological assessment, RPFs will consult with Green Diamond's staff geologist to develop appropriate site-specific forestry-related prescriptions. Professional geological assessments also may be performed by qualified licensed professional geological consultants, depending on workload or scheduling constraints of Green Diamond's staff geologist. Professional Geologists who conduct geological assessments for RPFs must comply with the California Department of Consumer Affairs Geological Licensing Act and will be expected to utilize professional discretion to follow the guidelines of the California Department of Conservation Division of Mines and Geology Note 45 (Guidelines for Engineering Geological Reports for Timber Harvesting Plans) to whatever extent may be necessary depending on site-specific conditions and the scope of a given project.

1) <u>Steep Streamside Slopes:</u>

a) Identify all steep streamside slopes (SSS) greater than or equal to 60% leading to Class I or II watercourses.
b) The initial default maximum width of the SSS zone, measured from the watercourse transition line, is 200 feet for Class I and Class II-2 watercourses and 75 feet for Class II-1 watercourses.
c) The SSS zone will be comprised of an inner zone (Riparian Slope Stability Management Zone [RSMZ]) and an outer zone (Slope Stability Management Zone [SMZ]).
d) The width of the RSMZ will be the same as the applicable watercourse RMZ, except where a qualifying slope break exists within that distance the RSMZ may only extend to the slope break. A "qualifying slope break" is an interruption of slope gradient of sufficient degree and scale to reasonably impede sediment delivery to watercourses from shallow landslides originating above the slope break.
e) The width of the SMZ will be either the remainder of the distance to the default maximum SSS distance for that Hydrographic Planning Area (HPA) or to a qualifying slope break, whichever is shorter.
f) The RSMZs will be comprised of an inner zone and an outer zone.
g) The inner zone of RSMZs on all Class I watercourses will be 70 feet, except where a qualifying slope break exists within that distance the RSMZ inner zone may only extend to the slope break, and the outer zone, if any, will be the remainder of the applicable RMZ distance except where a qualifying slope break exists within that distance.
h) The inner zone of RSMZs on all Class II watercourses will be 30 feet, except where a qualifying slope break exists within that distance then the RSMZ inner zone may only extend to the slope break, and the outer zone, if any, will be the remainder of the applicable RMZ distance except where a qualifying slope break exists within that distance.
i) On Class I and Class II-2 watercourses, Green Diamond will not conduct harvesting on the inner zone of the RSMZ and there will be 85% overstory canopy retention in the outer zone of the RSMZ.
j) On Class II-1 watercourses, Green Diamond will retain 85% overstory canopy in the inner zone of the RSMZ and 75% overstory canopy in the outer zone of the RSMZ.
k) The silviculture prescription employed within SMZs will be single tree selection.
l) Even spacing of unharvested trees will be provided where the trees are available to allow it, and all hardwoods will be retained. All species and size classes represented in pretreatment stands will be represented post-harvest where feasible.
m) If cable corridors through SMZs are necessary to conduct intermediate treatments (e.g., commercial thinning) in adjacent stands prior to even-aged harvest, Green Diamond will apply the restrictions in this section except harvesting of trees in the SMZs will be limited to cable corridors only. Any cable roads established in the SMZ as part of the intermediate treatment will,

to the extent feasible, be reused during the even-aged entry in the adjacent stands.

n) Where no SMZ is identified, the standard default prescriptions for RMZs will apply.
o) Green Diamond may fall trees within RSMZs and SMZs for worker safety and to create cable yarding corridors of up to 25 feet in width.
p) Green Diamond's road construction will avoid RSMZs and SMZs where feasible. Where such zones cannot be avoided or where major road reconstruction is required, the road alignment within a RSMZ or SMZ will be evaluated by a PG and a RPF with experience in road construction in steep forested terrain. In addition, Green Diamond will submit to the Services an explanation, justification, and a map of the proposed exception as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

2) Headwall Swales:
   a) The silviculture prescription employed on a field verified headwall swale will be single tree selection.
   b) Even spacing of unharvested trees will be provided where the trees are available to allow it, and all hardwoods will be retained.
   c) All species and size classes represented in pretreatment stands will be represented post-harvest where feasible
   d) There will be only one harvesting entry in headwall swales during the term of the AHCP.
   e) Green Diamond may fall trees on a field verified headwall swale for worker safety and to create cable yarding corridors of up to 25 feet in width
   f) Green Diamond's new road construction will avoid field-verified headwall swales where feasible. Where such areas cannot be avoided or where road reconstruction is required, the terrain will be evaluated by a PG and RPF with experience in road construction in steep forested terrain. In addition, Green Diamond will submit to the Services an explanation, justification, and a map of the proposed exception as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2)

3) Deep-Seated Landslides:
   a) No cut within the boundaries of the deep-seated landslide and 25-foot no cut buffer upslope of the main scarp of the slide.
   b) Green Diamond will not construct new roads across active deep-seated landslide toes or scarps, or on steep (greater than 50% gradient) areas of dormant slides, without approval by a PG and a RPF with experience in road construction in steep forested terrain.

4) Shallow Rapid Landslides:
   a) The following measures will apply to field-verified shallow rapid landslides that are at least 200 square feet in plan-view and that observably deliver

sediment to a watercourse or exhibit indicators of instability with the potential to deliver sediment directly to a watercourse:

- No cut within the boundaries of the landslide.
- 50-foot buffer above the slide with at least 70% overstory retention.
- 25-foot buffer along the sides of the slide with at least 70% overstory retention.
- Avoid new road construction on shallow rapid landslide where feasible. Where such areas cannot be avoided or where major road reconstruction is required, the terrain will be evaluated by a PG and RPF with experience in road construction in steep forested terrain. In addition, Green Diamond will submit to the Services an explanation, justification, and a map of the proposed exception as part of the informational copy of the THP notice of filing (see AHCP Section 6.2.7.2).

C. Harvesting, Yarding and Hauling Prescriptions

The following prescriptions have been developed to ensure that Green Diamond's logging operations are designed and implemented to minimize overall ground disturbance that could generate and cause sediment delivery into watercourses.

1) Green Diamond will adhere to a 4-year harvest adjacency versus the 3- year adjacency requirement in the California FPRs. This extension of the harvest adjacency in this watershed will serve to further reduce potential impacts from harvest activities and will distribute them over greater time and space. This will avoid concentrating harvest units over a short period into individual sub-basins within Green Diamond's South Fork Elk River ownership.

2) Green Diamond will limit the rate of harvest in South Fork Elk River to approximately 75 acres per year, calculated on a 3-year rolling average. The 3-year rolling average provides operational flexibility while maintaining a low annual harvest rate.

3) Skyline cable yarding systems will be the preferred harvest method on slopes averaging greater than 35%.

4) In areas where road construction would require building across steep slopes with large amounts of endhaul construction, long cable skyline yarding (average yarding distance >1000 feet) will be prescribed in areas with long continuous steeper slopes, therefore eliminating the need for additional roads. Emphasizing both short and long skyline cable yarding systems will reduce the overall road mileage and site impacts that are associated with road building as well as reduce impacts associated with ground based yarding systems.

5) Green Diamond intends to use shovel logging in ground based harvest areas. Ground based yarding will be limited to slopes less than 35%. Shovel logging has been shown to minimize ground disturbance due to low ground pressure, no need to construct skid trails, operating on top of slash rather than bare soil, and the opportunity to utilize residual vegetation to slash pack temporary constructed haul roads to minimize raindrop impact and surface erosion. Exceptions to shovel logging will be confined to isolated areas where topographic conditions or other circumstances would require excessive road construction to utilize cable yarding. In these circumstances other ground based equipment may be required and its use will be explained and justified during the THP approval process.

6) Newly constructed temporary roads located in shovel logging areas will be decommissioned by removing temporary crossings, draining the road (waterbars and rolling dips) and slash packing the road surface prior to closure.

7) Helicopter yarding will be considered and prescribed in areas that would require the construction of roads across steep slopes with high hazard topography (i.e. unstable slopes). Although this harvesting method is expected to have limited use within the watershed, its application if required, will be explained and justified in the THP.

8) See seasonal restrictions below for harvesting, yarding and hauling activities.

9) No broadcast burning will be conducted in South Fork Elk River. Burning of piles accumulated during harvesting operations, may occur.

D. Road Management Prescriptions

A full road assessment within Green Diamond's South Fork Elk River ownership was completed in 2006. Green Diamond developed and has been following a South Fork Elk River Road Management Plan that prioritized all assessment sites located within the drainage and proposed recommendations for treatment by the end of 2015. As of the end of 2011, Green Diamond has completed 84% of the sites representing approximately 77% of the sediment volume that could potentially deliver to a watercourse. Green Diamond will treat the remaining 16% of the controllable sediment discharge sites by the end of 2015.

Taking into consideration the location of these roads and associated sites, relative condition, potential future risk of failure (due to location), and the location for long term future use, specific roads and road segments have been identified to be either upgraded or decommissioned. Some roads will be decommissioned permanently, and others will be temporarily decommissioned (ear marked for eventual reconstruction and upgrading in the future (20-30 years) when the surrounding young plantations are ready for harvest and road access is again needed. In either case, the goal of the decommissioning process is to

remove the need for continued maintenance as well as removing the risk of road related sediment input from crossing failures, diversions, and side cast failures. Roads chosen for decommissioning will be essentially hydrologically disconnected from the stream network so that the potential for future road related sediment delivery into watercourses would be minimal. Roads not designated for decommissioning will be upgraded to the "Road Upgrading" procedures outlined in Green Diamond's Road Management Waste Discharge Requirements (WDR) and Master Agreement for Timber Operations (MATO). These roads as well as newly constructed roads in the future will be part of our permanent transportation system and consist of roads that are properly located, hydrologically disconnected and well maintained. Operational procedures have been developed for all road types so that, after treatment, sediment delivery into watercourses will be mitigated.

I. ROAD DECOMMISSIONING

Over the past 10 years of decommissioning experience, Green Diamond has learned that there is value in insuring that the project is implemented correctly and efficiently the first time. By insuring that all reasonable and feasible operational procedures are site specifically identified and carried out during the decommission process, efficiency is maximized and the risk of unacceptable future failures or significant streambed adjustments is minimized. Green Diamond will adhere to the following site-specific Operational Procedures for road decommissioning in addition to those outlined in the Road Management WDRs, MATO and AHCP:

a) To further guard against road surface rilling and sheet erosion associated with erodible Wildcat soil types, Green Diamond will treat all decommissioned road surfaces with grass seed and straw mulch at 2" depth and 90% coverage.

b) All designated waste disposal sites will be compacted with a tractor or excavator packed in lifts and treated with straw mulch and grass seeded.

c) An emphasis and priority will be made to initiate and finish all pull back sites and stream crossing removals on a specific road during the same summer season if feasible. If the road to be decommissioned can not be completed in one season due to weather or operational constraints, the following procedure will be initiated to minimize any additional sediment contribution from erosion control points (ECPs) until final site completion occurs:

    Sites not treated by the pull back, disconnect, and mulch/seed protocol, will be left in a "no further disturbance" condition. This means partially failing stream crossings will have the holes and depressions of the fills temporarily filled and packed with hay bails and/or clean wood chunks and covered with a layer of soil for short term minimal equipment access to lower sites. These temporary sites will be constructed to be easily pulled back out without the need for refilling a fill with soil. The intent of this practice is to ensure that operations do not introduce any additional sediment into watercourses and

that these sites that can not feasibly be treated via permanent pull back of all soil and organics in one season will be prepared for "over wintering" with clean materials that can be retrieved the next operating season. At that time, the temporary fill structure can be utilized to access equipment to achieve necessary decommissioning past the site and/or pulled out correctly that final season

d) Some roads have been abandoned and are in a condition where no treatment would be required because they are completely revegetated, no longer pose a threat to aquatic systems, and are in a condition that would render the disturbance inherent in decommissioning counter-productive. The road assessment process will determine whether treating certain roads or road segments would be counter-productive.

e) Green Diamond field personnel will work cooperatively with water quality staff to ensure that the final decommissioning product meets the expectations and mutual goals.

II. ROAD UPGRADING

It is Green Diamond's goal to ensure that all roads designated for upgrading will be improved in such a way as to minimize future risk for failure and resulting sediment delivery to watercourses. Green Diamond will adhere to the following site-specific Operational Procedures for road upgrading in addition to those outlined in the Road Management WDRs, MATO and the AHCP:

a) Ditch relief culverts will be installed to meet the following specifications**:

Road Grade	**Maximum Spacing (Feet) for Ditch Relief Culverts**
2%	600
4%	530
6%	355
8%	265
10%	210
12%	180
14%	155
16%	135
18%	115

** Additional ditch relief culverts will be installed if site specific erosion indicators continue to exist.

b) Procedures designed to ensure sediment is not mobilized during winter quad use and delivered to watercourses is provided in the Road Sediment Reduction Plan (See Section D. IV.).

III. NEW ROAD AND LANDING CONSTRUCTION

As part of THP preparation, RPFs perform a detailed field reconnaissance to identify and locate the best access between topographic control points that are critical to a harvesting operation. When designing, locating, and constructing roads and landings, Green Diamond will adhere to the following site-specific Operational Procedures in addition to those outlined in the MATO and AHCP:

a) In areas located on steep slopes or adjacent to watercourses where management of sidecast is not feasible, the practice of endhauling will be employed. A dump truck will transport the excavated material to a stable disposal area where sediment cannot deliver to any watercourses. Waste material will be seeded and mulched prior to October 15th of the same year.
b) Where feasible, and within the limits of safety considerations, all new seasonal secondary and spur roads will be constructed with an outsloped surface rather than a crowned road with an inside ditch. Outsloped roads can reduce potential maintenance problems caused by bank sloughing, ditch plugging, and drainage diversion.
Ditch relief culverts will be installed according to the specifications outlined in the Road Upgrading section (See Section D. II. a). Additional ditch relief culverts and rolling dips will be installed where appropriate to adequately disconnect the roads from the watercourses and to minimize ditch water accumulation on slide prone landforms such as inner gorges.

i. Erosion Control for New Roads

a) Procedures designed to ensure sediment is not mobilized and delivered to watercourses during winter quad use is provided in the Road Sediment Reduction Plan (See Section D. IV.)
b) All watercourse crossings and cross drains will be installed and functional prior to the winter period as defined below. In addition, by the beginning of the winter period, all waterbars, rolling dips, and road and landing construction associated with straw mulching and grass seeding will be completed in order to minimize suspended or mobilized sediment delivery to a watercourse.
c) All running surfaces of seasonal unsurfaced roads will be straw mulched and seeded prior to the first winter season following initial construction. This practice will protect against significant rain drop, sheet, and rill erosion on newly constructed, non-compacted, and unseasoned road surfaces.

IV. Road Sediment Reduction Plan

In recognition of the sensitive geology and the erodible nature of the soils within large areas of the South Fork Elk River Watershed, Green Diamond has developed a watershed plan incorporating measures designed to reduce sediment production from existing roads. This plan addresses the erodible nature of the soils within existing roadbeds and provides a mechanism to ensure that reasonable and feasible measures are undertaken to disconnect roadways from watercourses so that significant sediment delivery to aquatic habitat does not occur. The majority of operational activities occur during the summer season because of the lack of suitable rock nearby for road surfacing. Winter access on these erodible native surface roads with heavy equipment and pickups is not feasible. "Quad only" limited winter operations will be allowed for in THPs in this watershed. Winter quad use will ensure that Green Diamond continues to have the needed access to property within the watershed so that THP layout, tree planting, and cutting activities, as well as other administrative functions can occur year round. The persistent use of quads on unsurfaced dirt roads during the winter months (in areas with erodible Wildcat soils) can mobilize sediments from the exposed road surface unless specific measures and procedures are undertaken to minimize these potential sediment sources, and they are disconnected from watercourses.

The following measures will be implemented to ensure sediment is not mobilized from existing roadways and deposited into aquatic habitat resources. Priority will be placed upon higher use roads and more vulnerable stream crossings. Practices proposed in this plan will also be utilized on new roads as they are developed in the future.

a) Ensure that all existing watercourse crossings have a properly designed "critical dip" installed at or immediately adjacent to the crossing to reduce diversion potential.

b) A disconnect rolling dip or water bar will be installed up grade from the crossing and designed to deposit on the forest floor. RPF's or their designees will be responsible for identifying in the field the location for permanent rolling dips used to disconnect the road from the watercourse crossings.

c) Identify the main-line administrative roads that will be utilized via quads on a more consistent basis during the winter months (e.g. S-1000, S-2000, S-2500 up to road point MC21road). All watercourse crossings will have a permanent rolling dip disconnect installed up grade from the crossing and designed to deposit on the forest floor. The disconnect rolling dip as well as a minimum of 75' of road way leading into and including the crossing will be rocked. Filter fabric in conjunction with an average depth of 6" of clean rock will be used. If the roadway parallels a RMZ, the distance to be rocked will be the length of the RMZ road or 75 feet whichever is longer.

d) Main-line administrative roads will also be assessed to identify chronic erosion problems associated with isolated steeper road gradients. These sections of road will also be treated with an average depth of 6" of clean rock with filter fabric.

e) Where secondary roads are identified that are occasionally used during winter months for quad access, all watercourse crossings will be straw mulched and grass seeded for a minimum of 75 feet including the disconnect rolling dip. If the roadway parallels a RMZ, the distance to be mulched will be the length of the RMZ road or 75 feet whichever is longer. This measure has proven to be an effective erosion prevention method utilized extensively in the past on new roads within drainages with similar soil types. This option will allow Green Diamond to effectively treat roads and crossings commensurate with their anticipated use (and risk of sediment mobilization).

f) Where extended segments of roadway are located in a through-cut or outside bermed condition, a permanent tractor or excavator constructed ditch-out will be built to further minimize the distance between rolling dips and water bars.

g) The interval of strategically placed rolling dips and waterbars will be installed according to the standards provided below to ensure that ditch line and surface road water from storm events is efficiently dispersed onto the forest floor. Additional rolling dips and waterbars will be installed if site specific erosion indicators continue to exist.

Road Grade	**Maximum Spacing (feet) for Rolling Dips and Waterbars**
2%	500
4%	400
6%	300
8%	250
10%	200
12%	175
14%	150
16%	125
18%	100

h) Other erosion prevention methods such as silt fences or sediment settling basins will be utilized in site specific places where measures described above may not be adequate to prevent sediment input into watercourses.

i) All roads maintained for consistent or occasional winter quad use (See Road Sediment Reduction Plan) will be signed "Consistent Winter ATV Use OK" or "Occasional Winter ATV Use OK", respectively. All other roads within the watershed will have no quad use during the winter period.

The measures provided above will not only aid in significantly reducing sediments mobilized from winter quad use, but also dramatically reduce the potential for sediment introduction into streams from normal sheet erosion and rilling that can occur on unsurfaced roads located in the Wildcat geology type that experience no winter ATV traffic.

V. ROAD MAINTENANCE

As previously described, Green Diamond will treat the remaining road sites identified in the 2006 road inventory by the end of 2015. Roads upgraded prior to 2011 will be maintained as described below. The remaining road sites to be treated in South Fork Elk River, will also be maintained as described below following their treatment.

a) Green Diamond will inspect all mainline roads annually for needed maintenance.

b) Roads appurtenant to THPs will be inspected annually through the maintenance period of the THP. This inspection will assess the effectiveness and condition of all erosion control and drainage structures.

c) Secondary roads will be inspected and treated according to Green Diamond's Routine Road Maintenance Program and Road Management WDRs.

d) After the maintenance period of the THP expires, secondary roads will inspected and treated according to Green Diamond's Routine Road Maintenance Program and Road Management WDRs.

e) Road maintenance activities include brushing, waterbarring, constructing rolling dips, culvert replacement, grading (including berm removal or maintenance where appropriate), installation of critical dips at watercourse crossings to reduce diversion potential, outsloping roads, patch rocking, dust abatement, resurface rocking, cleaning ditches, and cleaning inlets and outlets of culverts.

f) Road maintenance activities, other than by hand labor, will only be conducted during the non-winter period due to equipment access limitations.

g) Grading will not be used to blade off wet soil to provide conditions for extended periods of operation on a deteriorated road surface.

h) Road maintenance inspections will assess the following:
   - Adequate waterbar and/or rolling dip spacing, depth, interception of the ditch line, and complete diversion of water flow onto undisturbed soil.
   - Adequate road surface drainage and all outside berms are breached.
   - Ditches are open and properly functioning, free of debris that could plug the ditch or a culvert and cause a diversion of water onto the road surface.
   - Culverts are functioning properly (e.g., the culvert is not rusted out or separated at a joint; water is flowing through the pipe and not underneath; sediment and debris is not reducing the pipe capacity).

i) The road maintenance assessment will be completed with enough time to initiate and complete all necessary repairs prior to winter period.

j) Landing debris associated with harvesting operations will be evaluated to determine the need for either burning or pull-back to reduce any potential for landing failure and debris avalanches associated with overloading the landing with slash.

k) Upon completion of timber operations, landings will be drained to prevent water accumulation. Concentrated flows will not be channeled over fills and will only be discharged onto stable areas. Discharge points will be located on stable landforms and where stable discharge points are absent, adequate erosion protection and energy dissipation will be employed.

E. Seasonal Restrictions

As previously described in this Management Plan, the South Fork Elk River has a uniquely erodible soil type that is not only easily mobilized with vehicular traffic but tire traction is completely lost with the slightest amount of road surface moisture. This situation coupled with lack of rock for road surfacing and the remoteness of the watershed results in a shorted operating window. The following measures reflect these conditions and the need to appropriately address them to minimize impacts to aquatic resources.

1. The winter period for this management plan is from Oct.15th, to May 15th. An exception to this will be limited to the brief time frame from Oct. 15th to Nov.1st, and from May 1st to May 15th when the potential for extended seasonal dry periods exist. This exception will be implemented only when the "Early Spring Drying" or "Dry Fall" conditions exist, as described in the AHCP. This stipulation acknowledges the sensitivity of the watershed and associated soils, while providing flexibility to achieve harvest and road repairs/upgrading goals in a "short season, limited access" area when conditions warrant.

2. Yarding (except helicopter yarding with no heavy equipment), hauling, or road construction activities will not occur during the winter period (as defined above). Timber falling, site preparation (pile burning), and administrative access (THP preparation, planting, monitoring) can be conducted year round.

3. Log hauling will be suspended, regardless of the time of year, if a storm event causes saturated soil conditions on haul roads. Hauling will not be resumed until the RPF or his designee determines that the road can withstand truck traffic without causing deterioration of the road surface and subsequent loss of surface material. Operation of trucks and heavy equipment on roads and landings will be limited to those with a stable operating surface.

4. Access during the winter period for activities such as timber falling, site preparation burning, maintenance inspections, reforestation, or timber harvesting plan layout will be restricted to the use of low ground pressure ATVs operating on designated signed roads only (See Road Sediment Reduction Plan, Section D. IV.).

Attachment D

Final Certification Notice

to Certify Completion and Compliance with
Waste Discharge Requirements
For
Discharges Related to Green Diamond Resource Company's Forest
Management Activities Conducted within
the Area Covered by its Aquatic Habitat Conservation Plan
In the
North Coast Region
Order No. R1-2012-0087

Project Information

_____	_____
CAL FIRE THP Number	Project Size (acres)
_____	_____
Watershed Name	
_____	
Section, Township, Range Number(s)	

Contact Information

_____	_____
Timberland Owner/Representative	Registered Professional Forester
_____	
_____	
_____	_____
Address	Telephone number

Certification

I understand and certify that the above listed project was in conformance with the approved project and all applicable provisions of the Waste Discharge Requirements, and that discharges from the project were in compliance or are expected to comply with all applicable water quality requirements.

_____	_____
Signature Discharger/Duly Authorized Representative	Date

Attachment E

CEQA Findings

ATTACHMENT E

CALIFORNIA ENVIRONMENTAL QUALITY ACT
FINDINGS OF FACT FOR ORDER R1-2012-0087
WASTE DISCHARGE REQUIREMENTS
FOR
DISCHARGES RELATED TO GREEN DIAMOND RESOURCE COMPANY'S FOREST MANAGEMENT ACTIVITIES CONDUCTED WITHIN
THE AREA COVERED BY ITS AQUATIC HABITAT CONSERVATION PLAN
IN THE
NORTH COAST REGION

I. PROJECT OVERVIEW

Discharges from forest management activities covered by proposed Order R1-2012-0087 (Project), including timber product harvest, silvicultural regimes and methods, timberstand regeneration and improvement, minor forest product harvest, instream and riparian restoration, and mitigation measures, have the potential to affect water quality. Under the California Porter-Cologne Water Quality Act, discharges of waste to waters of the state require the issuance of waste discharge requirements (WDR) unless otherwise waived. WDRs prescribe requirements, such as limitations on temperature, toxicity, or pollutant levels, as to the nature of any discharge. (Water Code, § 13260, subd. (a).) The Project also includes activities that may require a Clean Water Act section 404 permit from the Army Corps of Engineers (Corps). Under section 401 of the federal Clean Water Act (33 U.S.C. §§ 1251-1387), every applicant for a federal license or permit which may result in a discharge into navigable waters to provide the licensing or permitting federal agency with certification that the project will be in compliance with specified provisions of the Clean Water Act, including water quality standards and implementation plans promulgated pursuant to section 303 of the Clean Water Act (33 U.S.C. § 1313). Clean Water Act section 401 directs the agency responsible for certification to prescribe effluent limitations and other limitations necessary to ensure compliance with the Clean Water Act and with any other appropriate requirement of state law. Section 401 further provides that state certification conditions shall become conditions of any federal license or permit for the project.

In July 2007, Green Diamond began implementing the Aquatic Habitat Conservation Plan (AHCP) approved in June 2007 by the National Marine Fisheries Service and the U.S. Fish & Wildlife Service. On June 10, 2010, the Regional Water Board adopted Order R1-2010-

0044, *Waste Discharge Requirements for Discharges Related to Road Management and Maintenance Activities Conducted Pursuant to the Green Diamond Resource Company Aquatic Habitat Conservation Plan in the North Coast Region* (Roads WDR). The Roads WDR provides waste discharge coverage for activities performed under Green Diamond's Road Management Plan from the AHCP. Concurrently with development of the Roads WDR, the California Department of Fish and Game (DFG) developed a Master Agreement for Timber Operations (MATO, 1600-2010-0114-R1). The California Department of Forestry and Fire Protection (CAL FIRE) is the state agency responsible for overseeing timber harvesting activities through implementation of the Forest Practice Rules (Cal. Code Regs., tit. 14, §§895-1115.3). The Regional Water Board is not a party to or otherwise bound by any agreements and assurances Green Diamond may have with other state and federal agencies; however, the AHCP and MATO contain management measures that minimize impacts and protect and improve water quality that the Regional Water Board intends to rely on, in part, and in conjunction with existing regulations in order to implement Basin Plan water quality standards and restore the beneficial uses of water across Green Diamond's ownership. This approach will result in greater consistency across multiple state and federal agencies, streamline paperwork submittals, and promote landscape-based stewardship of water quality. The Regional Water Board will continue to participate as a Review Team member for individual THPs proposed by Green Diamond to ensure compliance with this Order.

The project area includes all commercial timberland acreage on the west slopes of the Klamath Mountains and the Coast Range of California in Del Norte and Humboldt counties where Green Diamond owns land or harvesting rights that are covered by the AHCP. This area is currently 384,400 acres, and is subject to adjustment as Green Diamond buys and sells property. This area is located in portions of the following watersheds: Smith River, Lower Klamath River, Redwood Creek, Maple Creek, Little River, Mad River, Jacoby Creek, Freshwater Creek, Elk River, Salmon Creek, Van Duzen River and the Eel River.

II. CEQA FINDINGS OF FACT

As indicated in the Regional Board's August 1, 2012 Notice of Intent, in October 2006, the U.S. Fish & Wildlife Service and National Marine Fisheries Service issued an Environmental Impact Statement (EIS) covering the AHCP. Where, as here, a project requires compliance with both CEQA and the National Environmental Policy Act (NEPA), and the federal EIS is prepared first and meets the requirements of CEQA, CEQA provides that the state agency should use the EIS rather than preparing a separate EIR or negative declaration, pursuant to California Code of Regulations, title 14, section 15221. The NOI added any points of analysis not covered in the EIS but required under CEQA. For those aspects of the project for which the Regional Board is relying on the EIS, the Regional Board is the lead agency under CEQA , in connection with the proceeding to consider issuing WDRs and water quality certification for the Project. (Pub. Resources Code, §§ 21000-21177.) The Regional Water Board is a responsible agency under the California Environmental Quality Act (CEQA) with regard to its consideration of the IS/MND issued by the Department of Fish and Game

in support of its issuance of a MATO. The IS/MND analyzed activities carried out in riparian areas, stream crossings and roadways, including obstruction and sediment removal, vegetation removal, bank stabilization, maintenance of watercourse crossings, water drafting and diversion, deposition and disposal of material, decommissioning and instream restoration. While there is considerable overlap in the EIS and IS/MND, the Regional Water Board relies on both for the most complete and comprehensive impacts analyses.

CEQA requires that the lead agency make one or more of a set of three findings whenever an EIR identifies a significant effect on the environment. These findings are set forth in section 21081, subdivision (a) of the Public Resources Code:

(1) Changes or alterations have been required in, or incorporated into, the project which mitigate or avoid the significant effects on the environment.

(2) Those changes or alterations are within the responsibility and jurisdiction of another public agency and have been, or can and should be, adopted by that other agency.

(3) Specific economic, legal, social, technological, or other considerations, including considerations for the provision of employment opportunities for highly trained workers, make infeasible the mitigation measures or alternatives identified in the environmental impact report. (See also Cal. Code Regs., tit. 14, §15091.)

When significant effects are subject to a finding under paragraph (3) of subdivision (a), the public agency finds that specific overriding economic, legal, social, technological, or other benefits of the project outweigh the significant effects on the environment (Pub. Resources Code, § 21081, subd.(b)).

A public agency shall provide that measures to mitigate or avoid significant effects on the environment are fully enforceable through permit conditions, agreements, or other measures. Conditions of project approval may be set forth in referenced documents which address required mitigation measures or, in the case of the adoption of a plan, policy, regulation, or other public project, by incorporating the mitigation measures into the plan, policy, regulation, or project design. (Pub. Resources Code, § 21081.6, subd.(b).)

All of the potentially significant impacts identified in the EIS and IS/MND will be fully avoided or rendered less than significant by implementation of the AHCP measures, including identified mitigation measures, referenced in the EIS and IS/MND. These findings are made under Public Resources Code, section 21081, subdivision (a)(1). All measures are incorporated as conditions of Order R1-2012-0087 issued by the Regional Water Board to Green Diamond and, as applicable in the previous approved Road Management WDRs and the MATO. Further, as proposed by Green Diamond, all these measures are incorporated into the Project to avoid the significant environmental effects identified in the EIS and IS/MND. Green Diamond is responsible for carrying out these mitigation measures as well as monitoring and reporting under the WDRs.

Public Resources Code section 21081.6, subdivision (a) requires that if a public agency makes changes or alterations in a project to mitigate or avoid the significant adverse environmental effects of the project, it must adopt a monitoring or reporting program to ensure compliance with the changes or alterations. The Regional Board has imposed a number of conditions in the Order to protect and improve water quality, including incorporation of all the impact mitigation and avoidance measures included in the EIS and IS/MND. The Regional Water Board has adopted a monitoring and reporting program (MRPR1-2012-0088) for the Project pursuant to Water Code section 13267(b) and approval of the WDRs. This MRP will assess the implementation and effectiveness of the measures required under the Order and provide feedback for adaptive management. The MRP also implements the monitoring and reporting requirements under Public Resources Code section 21081.6, subdivision (a).

Geology, Geomorphology, and Mineral Resources

Impact 1: Implementation of the project could adversely impact surface erosion, hillslope mass wasting, bank stability, and road-related sediment production.

Potential adverse impacts to geology and geomorphology include acute or chronic changes in geomorphic and hydrologic processes that affect soil productivity and delivery of surface materials to streams and rivers. Potential impacts could be localized or dispersed over a wide area. The primary processes with the potential to result in impacts to geology and geomorphology and deliver sediment to watercourses are:

- Surface erosion
- Hillslope mass wasting
- Reduced bank stability
- Road related sediment production

Geomorphology and geologic impacts include movement of surface materials, including soils, weathered rock, and sediment (i.e., hillslope mass wasting). When delivered to streams, these materials can affect water quality (see Section 4.3, Hydrology and Water Quality) and fish habitat (see Section 4.4, Aquatic Resources). In the past, sediment inputs to stream networks resulted from existing roads, implementation of THPs, natural conditions, and legacy conditions. Excessive sediment, both coarse and fine has resulted in significant adverse effects to watercourses. Future management-related sediment delivery to impaired streams above existing levels could prolong the time required for recovery of habitat. Mineral-resource depletion, fire-prevention and fire-suppression activities, and earthquakes or volcanic eruptions would have no or negligible direct or indirect impacts.

A number of ownership-specific AHCP measures (described in Mitigation Measures 1-4 below) are required to minimize and mitigate the individual and cumulative impacts of forest management activities on geology and geomorphology and to reduce sediment inputs.

Implementation of Mitigation Measures 1-4 will reduce geologic and geomorphologic impacts to a less-than-significant level.

Mitigation Measure 1: Implement the AHCP Measures Directed at Surface Erosion

To address potential impacts on surface erosion, Green Diamond must implement riparian conservation measures, harvest-related ground disturbance measures, and the Road Management Plan.

Riparian Management Zone (RMZ) management prescriptions in the AHCP are designed to impede sediment delivery in areas where sediment has relatively short transport distances to watercourses. These measures include minimum overstory canopy-retention standards within the inner and outer zones of the RMZ, limitations on equipment use, and retention of trees judged to be critical to maintaining bank stability. Vegetation is well documented as an effective means of erosion prevention and control because it absorbs the impact of rain drops, reduces runoff velocity, increases water percolating into the soils, and binds soils with roots (Goldman et al., 1986; Gray and Sotir, 1996). Vegetative buffers are also effective in preventing or impeding eroded sediment from reaching watercourses. Vegetative buffers on toe slopes have also been observed to intercept sediment from upslope landslides. Modified Tier A Class Ill protection measures will reduce ground disturbance, retain bank stabilizing vegetation, and retain vegetative over-story and ground cover. These measures are similar in type and scope to the RMZ and surface erosion measures in the AHCP (i.e., the measures consist of varying RMZ widths, restrictions on ground disturbance, and vegetation retention requirements). Application of these measures further reduce the level of surface erosion, bank destabilization, and, ultimately, delivery of fine sediment to stream channels and aquatic habitat, in areas with highly erodible soil types.

Harvest-related ground disturbance conservation measures are designed to minimize management-related surface erosion. In particular, there are operational restrictions on silvicultural and logging activities during those time periods when timber operations have a greater potential for sediment delivery to watercourses. The time period restrictions allow only those harvest activities with relatively low ground disturbance (and associated low potential for surface erosion), such as shovel logging and skyline and helicopter yarding, to be conducted during the winter period. Those harvest activities that have the potential to create more ground disturbance (e.g., skid trail construction and mechanized site preparation) are limited to the summer period, with some activities (e.g., ground-based yarding with tractors, skidders, or forwarders) extending into the early spring or late fall if certain favorable climatic conditions occur. More closely spaced waterbreaks are required on highly erodible soil types upslope of RMZs or Equipment Exclusion Zones (EEZs) where skyline yarding roads require treatment. In addition, some harvest-related ground disturbance measures focus on minimizing ground disturbance and the associated exposure of bare mineral soil within harvest units.

Road-related conservation measures are designed to reduce road-related sediment production and delivery to streams. In particular, the road measures increase the estimated proportion of hydrologically disconnected roads to 93 percent. The measures also place strict wet weather restrictions on road use, construction, upgrading and decommissioning. The MATO and Roads WDR also contain specific erosion control measures designed to minimize and prevent sediment from entering watercourses during and following road treatment activities.

These measures are specified in AHCP Sections 6.2.1, 6.2.3, 6.2.4, MATO Section 11.A.6 and incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 2: Implement the AHCP Measures Directed at Hillslope Mass Wasting

To address potential impacts on hillslope mass wasting, Green Diamond must implement riparian conservation measures and slope stability measures. The slope stability measures are intended to reduce landslide occurrences and sediment production from landslides associated with steep streamside slopes, headwall swales, and active deep-seated landslides.

The riparian conservation measures and the steep stream slope prescriptions address stream-side landslides. Timber harvesting is prohibited within the inner zone of all Class I RMZs and 2nd order or larger Class II RMZs that are located below designated steep streamside slope management zones (SMZs), except for purposes of creating cable-yarding corridors when other options are impractical. RMZ areas located below an SMZ are referred to as Riparian Slope Stability Management Zones (RSMZs) in the AHCP. Retention of a minimum 85 percent overstory canopy closure is required in Class I and 2nd order or larger Class II outer zones where RSMZs have been established. Limited timber harvesting is permitted within the first 1,000 feet of a 1st order Class II RSMZ inner zone subject to 85 percent overstory canopy closure retention post-harvest. A minimum 75 percent canopy retention within the first 1,000 feet of a 1st order Class II RSMZ outer zone is also required. Single-tree selection is the initial default silvicultural prescription within designated SMZs. One commercial harvesting entry is permitted within SMZs for the term of the AHCP, except where cable corridors are necessary to conduct intermediate treatments. If cable corridors through SMZs are necessary to conduct intermediate treatments (e.g. commercial thinning) in adjacent stands prior to even-aged harvest, the restrictions in AHCP/CCAA Section 6.2.2.1.7 apply except harvesting of trees in the SMZs are limited to cable corridors only. Any cable roads established in the SMZ as part of the intermediate treatment are, to the extent feasible, reused during the even-aged entry in the adjacent stand. All hardwoods within SMZs are retained with unharvested conifers evenly distributed, wherever possible, such that all species and size classes represented in pretreatment stands are generally represented post-harvest. Applied in areas with highly erodible soil types, the modified Tier A Class Ill protection measures require an EEZ width of 30 feet with 15 square feet of basal area of hardwoods and all channel zone trees retained. Tier B Class III watercourse

have an EEZ with of 50 feet with 100% hardwood retention and one conifer retained every 50 feet of stream length.

In high-risk headwall swales, single-tree selection is the initial default silvicultural prescription. All hardwoods within headwall swales are retained with unharvested conifers evenly distributed, wherever possible, such that all species and size classes represented in pretreatment stands are generally represented post-harvest. Only one commercial harvesting entry is permitted within headwall swales for the term of the AHCP.

Active deep-seated landslides are provided with not-cut zones on the toe and 25 feet upslope from the top of the toe, except for purposes of creating cable-yarding corridors when other options are impractical. No-cut zones are also established upslope of the scarp of deep-seated landslides. The body of active deep-seated landslides are evaluated by a California Professional Geologist.

Harvesting is prohibited within the boundaries of shallow rapid landslides and a minimum 70 percent overstory canopy buffer is retained within 50 feet above and 25 feet on the sides of the slide.

During THP development RPFs survey the THP area to determine whether portions of plan meet the CFPR definition of unstable areas. Additionally RPFs determine if portions of the THP area contain headwall swales, steep streamside slopes, deep-seated landslides or shallow rapid landslides.

RPFs do one of the following when he or she determined that any portion of the THP met the definition of a steep streamside slope; headwall swale; deep-seated landslide or shallow rapid landslide:

- Impose the default prescription applicable to that feature as set forth above, or
- Retain a California Professional Geologist to:
  - Evaluate the likelihood that timber harvesting operations will cause, or significantly elevate the risk of causing or reactivating, landslides within these areas that will likely result in sediment delivery to watercourses; and
  - Work with the RPF to prepare a more cost-effective, site-specific alternative to the default prescription designed to minimize that likelihood and minimize and mitigate potentially significant impacts on aquatic species from sediment delivery resulting from landslides caused or exacerbated by timber harvest operations. Alternative prescriptions can be applied to any of these areas except RSMZs. A qualified biologist is involved in evaluating the potential biological consequences whenever a more cost effective alternative to the default prescription is proposed.

The alternate approach could be applied to portions of any SMZ outside of RMZs, field verified headwall scarps, deep-seated landslides or shallow rapid landslides. THPs for which a geologic report has been prepared (and whose conclusions allow for measures other than those specified in the AHCP) are identified as such when submitted for review by CDF and other agencies, including the Regional Water Board. A THP map and letter of

notice that describes the alternative prescriptions are sent to the Services when a THP with alternative prescriptions is proposed.

The goal of the slope stability conservation measures in the AHCP is to reduce management-related landslide occurrences and associated sediment loads, which will minimize the possible effects of management-related sediment input on aquatic species from mass-soil movement. Tree retention in SMZs and associated RSMZs, headwall swales, deep-seated landslides, and shallow rapid landslides is expected to maintain a network of live roots that will preserve soil cohesion and contribute to slope stability in these areas. Tree retention also is expected to help maintain forest canopy, which will preserve some measure of rainfall interception and evapotranspiration. Maintenance of rainfall interception and evapotranspiration is expected to contribute to slope stability conditions in some locations by minimizing the likelihood of management-induced high ground water ratios. Limited road construction and road reconstruction on unstable slopes and in RMZs will likely result in avoiding or reducing the undercutting and overburdening of sensitive hill slopes and help avoid unnatural concentration of storm runoff on these slopes. The application of more conservative SMZ prescriptions in HPAs more susceptible to hillslope mass wasting, plus the avoidance or limitation of timber harvesting in certain landslide-prone areas, will result in a reduced potential for sediment delivery to streams in the area covered by the AHCP. On this basis, the measures in the AHCP are anticipated to result in improvements in water quality.

These measures are specified in AHCP Sections 6.2.1 and 6.2.2 and incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 3: Implement the AHCP Measures Directed at Bank Stability

To address potential impacts on bank stability, Green Diamond must implement the riparian conservation measures.

The riparian conservation measures for Class I and II watercourses require retention of 85 percent overstory canopy closure in the RMZ inner zone and prohibit harvesting of trees that are likely to recruit to stream channels. Tier B Class-III measures require retention 100% hardwood retention and trees that are judged to be critical to maintaining bank stability and Modified Tier A Class Ill protection measures require the retention of 15 square feet of basal area of hardwoods and all channel zone trees. Collectively these riparian conservation measures will likely lead to increased bank stability. In addition, implementation of the general riparian conservation measures in the AHCP is expected to contribute to streambank stabilization.

These measures are specified in AHCP Sections 6.2.1 and incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 4: Implement the AHCP Measures Directed at Road-related sediment production

To address potential impacts on road-related sediment production, Green Diamond must implement the measures described in the AHCP Road Management Plan and Roads WDR.

Road-related surface erosion and road-related mass wasting are recognized as major contributors to the sediment budget in most managed watersheds. The AHCP includes road management conservation measures for both new and existing roads to address potential road-related sediment production. The AHCP provides a methodology to classify roads on the basis of use and to prioritize road work and site-specific repairs. The road conservation measures improve the standards for general road repairs and upgrades and improve the design standards for stream crossings. The standards for temporary and permanent road decommissioning are also improved under the AHCP. A training program is required for equipment operators and supervisors on the Road Management Plan and other AHCP/CCAA standards and practices to ensure familiarity with the measures. Green Diamond is required to provide $2.5 million (inflation adjusted) per year for 15 years to accelerate the repair of high-and moderate-risk sediment delivery sites across the area covered by the AHCP. All high and moderate-risk sediment delivery sites must be treated by the end of AHCP term. The road-related conservation measures also increased restrictions on wet weather road use, construction, upgrading, and decommissioning.

These road-related measures are specified in AHCP Sections 6.2.3 and MATO Section 11 and incorporated in the Roads WDR, Order R1-2012-0087 Condition II.D.

Cumulative effects. The cumulative impact of implementing all these measures on erosion and sediment control under the AHCP would be an improvement of aquatic resources and riparian habitat conditions in each of the 11 Hydrographic Planning Areas over time. The Road Management Plan and the accelerated road sediment site repair provide the greatest sediment control benefits among the AHCP sediment conservation measures. Implementing the AHCP (as well as the requirements of the MATO, Roads WDR and IS/MND) will incrementally reduce adverse conditions associated with on-going and past land management activities.

Hydrology and Water Quality

Impact 2: Implementation of the project could adversely impact hydrology, water temperature and sediment control.

The EIS evaluated the potential impacts of expected changes in watershed characteristics on hydrology and water quality as a result of implementing forest management activities under the AHCP. The primary water quality parameters of concern for the evaluation were suspended sediment, turbidity, and water temperature. The EIS identified the following potentially significant impacts:

Increases in summertime stream temperatures can adversely affect the salmonid and aquatic species by reducing growth efficiency, increasing disease susceptibility, changing the age of smoltification, causing loss of rearing habitat, and shifting the competitive advantage of salmonids over non-salmonid species. Decreases in water temperatures are beneficial to aquatic resources. Stream temperatures can be affected by direct shading, reduced surface and groundwater flows and sediment disposition and can affect the survival and/or reproduction of both salmonids and amphibians.

Hydrology in forested areas can be affected by peak flows during storm events that can cause scour, alter channel morphology, and cause flooding. Alteration of snow pack, enhancement of runoff throughout timber harvest units or along roads, interception of groundwater flows by roads, and alteration of evapotranspiration through changes in forest structure all have the potential to affect hydrology. In particular, snow buildup in logged areas above 2,000 feet elevation and subsequent melting during rainstorms (known as rain-on-snow events) results in enhanced flows and increased potential for erosion. Summer base flows could increase in logged versus unlogged areas in the short term and return to pre-harvest conditions within a few years. Excessive sediment input can fill pools, eliminate spawning gravels, decrease channel stability, increase nutrient and contaminant loads, and modify overall channel morphology. Sediment input is important in directly affecting fish and fish spawning success but is also useful as a surrogate for changes in concentrations of sediment-associated contaminants (primarily metals and many pesticides) and nutrient input.

The AHCP includes a number of ownership-specific measures (described in Mitigation Measures 5-7 below) to minimize and mitigate the individual and cumulative impacts of forest management activities on hydrology and water quality. Implementation of Mitigation Measures 5-7 will reduce hydrologic and water quality impacts to a less-than-significant level.

Mitigation Measure 5: Implement the AHCP Measures Directed at Hydrology

To address potential impacts on hydrology, Green Diamond must implement riparian conservation measures, slope stability conservation measures, road management measures and harvest-related ground disturbance measures.

Through the road upgrading and decommissioning program, it is anticipated that 93 percent of the road network will be hydrologically disconnected from area watercourses. Mitigation measures such as hydrologic disconnects, cross-drains, rolling dips, and outsloping, reduce the amount of concentrated surface runoff at any point along the road surface. As these measures are implemented, water from inboard ditches is dispersed onto the forest floor where it infiltrates and reduces the potential effects on peak flows and sediment delivery associated with road network runoff.

In general, harvest-related ground disturbance can cause soil compaction and result in reduced infiltration capacity of soils and altered subsurface water movement, leading to increased surface runoff. The riparian conservation measures require Equipment Exclusion Zones (EEZs) that result in a reduction of locations potentially exposed to soil compaction from use of heavy equipment. In addition, for those areas in which heavy equipment is used, site preparation measures (including seasonal operating limitations for tractors, skidders, and forwarders, and minimized use of tractor and-brushrake piling) will reduce potential for ground compaction related to covered activities compared to pre-AHCP conditions. These harvest-related ground disturbance prevention/conservation measures are expected to reduce: (1) adverse impacts of operations-related alterations in hydrology (by minimizing soil compaction that can increase the magnitude of peak flows) and (2) the volume of sediment available for runoff during peak flow events.

The slope stability conservation measures will result in a greater reduction in sediment delivery from steep streamside slopes and unstable areas than forest operations without these measures by avoiding new road construction on these features or by substantial upgrades of existing roads already located on these features. In addition, tree retention in these and other potentially unstable areas will preserve rainfall interception and evapotranspiration.

The riparian conservation measures maintain in-channel large woody debris (LWD) and provide increased potential for LWD recruitment. The presence of LWD in stream channels aids in pool formation, and sediment storage and sorting. Increased LWD recruitment and the volume of LWD are expected to improve aquatic habitat and stream substrate conditions.

Conservation measures under the AHCP are anticipated to minimize the potential impacts that could otherwise result from altered hydrology. They will reduce the impacts of forest management on surface runoff and peak flows, reduce soil compaction and disturbance, and maintain or enhance in-channel LWD. Adverse impacts to hydrology and water quality that would occur will be minimized by the improved riparian conditions resulting from riparian management and decreased sediment production and delivery.

These measures are specified AHCP Sections 6.2.1, 6.2.2, 6.2.3 and 6.2.4 and MATO Section 11. All these measures are incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 6: Implement the AHCP Measures Directed at Water Temperature

To address potential impacts on water temperature, Green Diamond must implement riparian conservation measures, road management measures and the slope stability measures.

The riparian conservation measures have overstory canopy closure requirements and tree retention standards that are more protective overall than those implemented prior the AHCP approval. The minimum width of RMZs on Class I (fish bearing) watercourses is 150 feet with 85% overstory canopy retention in the inner zone (50-70 feet depending on slope class) and 70% overstory retention in the remaining outer zone. Class II watercourses have a minimum buffer width of 75-100 feet with 85% overstory canopy retention in the inner zone (30 feet) and 70% on the remaining outer zone.

Implementation of riparian measures will help to maintain stream shading in the critical "inner zone" where microclimate effects are anticipated to have the greatest potential to affect water temperatures. Overall, overstory canopy closure, while expected to slightly decrease in the short term following harvesting is likely to increase in all stands as they regenerate following timber harvesting. The overall increase in overstory canopy closure is anticipated to result in slight decreases in water temperatures in streams. Any increase in water temperature that might occur in any individual location is expected to be slight and less than significant.

Reduced sediment delivery as a result of implementing the road management measures, the slope stability measures and the MATO, also could indirectly contribute to minor decreases in water temperature. Sediment input, particularly increases in fine sediment, can affect stream temperatures through changes in channel morphology such as reduced pool volume and increased channel width. With the slope stability and road management measures designed to minimize management-related sediment inputs, sediment production and delivery will be reduced. relative to existing conditions and conditions prior to AHCP implementation.

These measures are specified in AHCP Sections 6.2.1, 6.2.2 and 6.2.3 and MATO Section 11 and are incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 7: Implement the AHCP Measures Directed at Sediment Control

To address potential impacts on sediment control, Green Diamond must implement riparian conservation measures, slope stability measures, road management measures, and harvest-related ground disturbance measures.

The riparian conservation measures are designed to impede sediment delivery in areas where sediment has relatively short transport distances to watercourses. These measures include increased overstory canopy retention standards within RMZs, limitations on equipment use, retention of trees likely to recruit as LWD, and retention of trees that contribute to maintaining bank stability. Implementing the retention standards is expected to result in almost no loss in total forest canopy in the inner zone of RMZs along Class I and Class II watercourses, and is anticipated to increase overstory canopy along Class II watercourses. This overstory canopy impedes sediment mobilization in these critical areas, where sediment has relatively short transport distances to watercourses. On this basis, the

measures associated with the AHCP are anticipated to result in reductions in sediment delivery.

Harvest-related ground disturbance conservation measures focus on minimizing ground disturbance and exposure of bare mineral soil within harvest units. These measures include: (1) site-specific site preparation methods, (2) limited operating periods for the construction of skid trails and use of ground-based yarding equipment, (3) limiting use of ground-based yarding equipment that requires constructed skid roads to slopes less than or equal to 45 percent (with some exceptions), (4) preferential use of cable yarding systems, and (5) water-barring of cable corridors, where necessary. All of these ground disturbance conservation measures will minimize the potential for soil compaction and management related surface erosion within harvest units.

Sediment production from hillslope mass wasting is greatest in steep streamside slopes, headwall swales, and deep-seated landslides. These areas are subject to default slope stability conservation measures intended to reduce landslide occurrences and associated sediment production. The implementation of the AHCP results in these sensitive areas receiving additional protection by establishing slope management zones (SMZs) upslope of the RMZ along Class I and Class II watercourses. The width of the SMZ vary among the 11 HPAs, with wider more conservative SMZs identified for those HPAs with the potential deliver sediment from the longer locations from watercourses. Single tree selection harvest is the most intensive silvicultural prescription allowed within the SMZ and no harvesting is allowed in the inner portion of the RMZ downslope of the SMZ (i.e., the RSMZ) along Class I and larger Class II watercourses. In addition, no harvest is allowed within the toe and 25 feet upslope from the top of the toe or scarp of historically active deep-seated landslides. Alternative prescriptions to the default slope stability measures may be developed through site-specific review by a California registered geologist.

Tree retention in the SMZs and associated RSMZs is expected to maintain a network of live roots that will provide soil cohesion and contribute to slope stability in these areas. Tree retention also is expected to help maintain forest canopy, which preserves some measure of rainfall interception and evapotranspiration. Maintenance of rainfall interception and evapotranspiration is expected to contribute to slope stability conditions in some locations by minimizing the likelihood of high ground water ratios that are management related. Limited road construction and road reconstruction on unstable slopes and in RMZs will result in avoiding or reducing the undercutting and overburdening of sensitive hill slopes, helping to avoid unnatural concentration of storm runoff on these slopes. The implementation of SMZs (and the application of more conservative SMZ prescriptions in HPAs more susceptible to hillslope mass wasting) will reduce impacts because of reduced potential for sediment delivery to streams.

Road-related erosion and hillslope mass wasting are known to be substantial contributors to the sediment budget in most managed watersheds. The Road Management Plan and associated conservation measures in the MATO will reduce road-related sediment production and delivery to watercourses relative to pre-AHCP measures and existing

conditions. The Road Management Plan provides for accelerated repair of high- and moderate-risk sediment delivery sites on roads. The road-related conservation measures will reduce road-related sediment production and, therefore, result in benefits to the aquatic resources because of reduced potential for sediment delivery. AHCP measures emphasize strategic identification and classification of roads targeted for improvement. High- and moderate-risk sediment delivery sites will be addressed using an accelerated program.

Green Diamond has performed a general assessment of its ownership that identifies road-related sediment sources requiring treatment (e.g., stabilization of dirt or other remediation to prevent road-related, sediment-producing failures or hillslope mass wasting events). The Road Management Plan is designed to provide treatment of all high- and moderate-risk sediment delivery sites, and to minimize potential delivery of sediment to riparian and aquatic areas. In addition, the AHCP requires that Green Diamond provide an average of $2.5 million per year for the first 15 years of the AHCP (for a total of $37.5 million) to accelerate implementation of the treatments for the high- and moderate-risk sites. (The acceleration period is to be adjusted following revision of the estimate of sediment yield from high- and moderate-risk sediment delivery sites at the end of the first five years following issuance of the Permits. The acceleration period and monetary commitment could be adjusted (upward or downward) by up to 1.5 years and $3.75 million depending on the revised estimate of sediment yield.)

These measures are specified in AHCP Sections 6.2.1, 6.2.2, 6.2.3 and 6.2.4 and MATO Section 11 and incorporated in Order R1-2012-0087 Condition II.D.

Cumulative effects. Past timber management within the 11 HPAs had affected peak flows, water temperatures and sedimentation of streams. Changes in peak flows (timing and intensities) has resulted in additional water runoff throughout timber harvest units or along roads, the interception of groundwater flows by roads, and alteration of evapotranspiration through changes in forest structure. The normal hydrologic cycles for some of the HPAs have also been modified by dams, water diversions, development, and agriculture. These activities have resulted in adverse environmental conditions in some locations including insufficient stream flows, and have resulted in instances of increases in stream temperatures, stranded juvenile entrainment, and alterations to aquatic habitat.

Existing adverse conditions related to the hydrologic cycle are expected to improve. Implementation of the measures in the AHCP will result in an incrementally greater improvement in conditions. The most important measures will address road upgrading and decommissioning programs that would hydrologically disconnect the road network from area watercourses on a THP-by-THP basis (see AHCP Section 6.2.3), although incremental short-term and localized increases in the peak flows will likely occur in association with timber harvesting. AHCP measures will reduce the incremental impacts of forest management activities and result in improvements over what would occur under the No Action alternative.

Aquatic Resources

Impact 3: Forest management activities could adversely impact hydrology, riparian conditions, sediment production and delivery and aquatic habitat.

The EIS evaluated potential impacts of forest management activities on habitat and biota, including:

- Changes in peak flows that have the potential to affect channel morphology through bed scour and bank erosion
- Reduction (over time) in the amount of Large Woody Debris (LWD) that could be recruited into the watercourses, contributing to reduced sediment storage sites, and reduced pool numbers and volumes
- Removal of riparian vegetation, resulting in altered thermal regimes, changes in nutrient cycling, and destabilization of streambanks
- Increases in sediment supplies from surface erosion, hillslope mass wasting, and bank erosion, leading to channel aggradation, loss of pool volume, and degradation of spawning gravels

Such changes to the stream channel and associated riparian areas could adversely or beneficially affect the quantity and quality of aquatic habitat for aquatic species through changes in temperature, sedimentation, habitat complexity, and connectivity. These impacts are potentially significant.

The AHCP requires a number of ownership-specific measures (described in Mitigation Measures 8-12 below) to minimize and mitigate the individual and cumulative impacts of forest management activities on aquatic resources. **Implementation of Mitigation Measures 8-12 will reduce potential impacts on aquatic resources to a less-than-significant level.**

Mitigation Measure 8: Implement the AHCP Measures Directed at Hydrologic Effects

To address potential impacts on aquatic resources, Green Diamond must implement riparian conservation measures, road management measures and harvest-related ground disturbance measures.

Under the harvest-related ground disturbance measures, there are greater seasonal operating limitations that minimize soil compaction. This could decrease the magnitude of peak flows and the volume of sediment available for runoff during such events. The road treatment accelerated period associated with the road management plan will increase the rate at which roads will be hydrologically disconnected from the watercourses. The riparian management measures will also increase LWD recruitment. Over time these measures will increase the amount of LWD in streams, ultimately increasing the

overwintering habitat for juvenile salmonids. This could avoid species displacement that can be caused by altered hydrology by providing increased habitat options for salmonids.

Harvest-related ground disturbance can reduce the infiltration capacity of soils and alter the process of subsurface water movement through soil compaction, leading to increased surface runoff. Site preparation measures include seasonal operating limitations for tractors, skidders, and forwarders, and minimized use of tractor-and-brushrake piling. These harvest-related ground disturbance conservation measures substantially reduce the impacts of any operations-related alterations in hydrology by minimizing soil compaction, which can increase the magnitude of peak flows and reduce the volume of sediment available for runoff during peak flow events.

Riparian conservation measures reduce potential impacts of altered hydrology on aquatic habitat. Specifically, the riparian conservation measures maintain in-channel LWD and provide increased LWD recruitment potential through enhanced riparian conservation measures. The presence of LWD in stream channels aids in pool formation, sediment storage and sorting, provides refugia from peak flows, and maintains overwintering habitat for anadromous and resident salmonids and other fishes.

Conservation measures reduce the impacts of forest management on surface runoff and peak flows, reduce soil compaction and disturbance, and maintain or enhance in-channel LWD. Any impacts to aquatic habitat that could occur are mitigated by improved riparian conditions resulting from riparian management and decreased sediment production and delivery.

These measures are specified in AHCP Sections 6.2.1, 6.2.3, and 6.2.4 and are incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 9: Implement the AHCP Measures Directed at Improving Riparian Conditions

To mitigate or avoid potential impacts on riparian conditions, Green Diamond must implement the AHCP's riparian conservation measures and slope stability measures.

The AHCP limits commercial entry into the RMZs to one harvest entry during the term of the AHCP, except where cable corridors are necessary to conduct intermediate treatments. The RMZs are at least 150 feet wide along Class I watercourses, with a variable-width inner zone ranging from 50 to 70 feet. The AHCP limits harvesting to only those trees that have a low likelihood of recruitment within Class I RMZs. The AHCP also establishes SMZs upslope of Class I watercourses in areas identified as steep streamside slopes.

Minimum 100-foot-wide RMZs are established along 2nd order or larger Class II watercourses; minimum RMZ width along 1st order Class II watercourses are 75 feet. The RMZ contains a 30-foot wide inner zone for Class II watercourses within which 85 percent

of the overstory canopy is retained post-harvest; at least 70 percent overstory canopy is retained within the outer zone of Class II RMZs. The AHCP limits harvesting to only those trees that have a low likelihood of recruitment within the first 200 feet of Class II RMZs adjacent to a Class I RMZ. The AHCP also establishes SMZs upslope of Class II watercourses in areas identified as steep streamside slopes.

Overall, the AHCP provides riparian protection along Class III watercourses by establishing minimum 30- to 50-foot-wide EEZs. Within the EEZ of Tier A (less than 60 percent to 70 percent slopes) Class III watercourses, all existing LWD on the ground is retained and there is no fire ignition during site preparation. Within the EEZ of Tier B (greater than 60 percent to 70 percent slopes) Class III watercourses, all hardwoods and nonmerchantable trees are retained, as are all conifers that contribute to bank stability or act as a control point (retaining sediment or preventing headcutting) in the channel; at least one conifer per 50 feet of stream length is retained. Within the EEZ of modified Tier A (applied in areas with highly erodible soil types) Class III watercourses, 15 square feet of basal area of hardwoods and all channel zone trees are retained.

Overall, the riparian conservation measures under the AHCP provide greater protection of riparian functions such as LWD recruitment, stream shading, sediment filtration, bank stability, and nutrient input. These measures contribute to maintenance and development of a more suitable microclimate for amphibians and other species that use habitats along streams, and benefit habitat used by the various life stages of fish species present in streams. The protection measures and the effects of these additional protections provided under the AHCP on individual riparian functions and related aquatic functions are described below.

<u>LWD Recruitment</u>:
The overstory canopy closure requirements and tree retention standards will help to increase the potential for LWD recruitment so that in-channel LWD loading and size is likely to increase in the future. Whether such an increase will occur within a given stream reach depends on the current condition and trend of existing LWD levels, and the length of time necessary to recruit additional wood to streams from adjacent riparian areas. For example, if little or no recruitment of wood has occurred recently, and existing pieces of wood are decaying or being washed out of a stream reach, in-stream levels of wood could continue to decline for some time, despite the fact that riparian management provides an increase in sources of future LWD and thereby increased potential for wood recruitment in the future.

The AHCP is expected to provide additional LWD recruitment by retaining at least 15 conifer stems greater than 16 inches dbh per acre. All trees within the inner zone of RMZs along Class I streams and portions of Class II streams that are determined to be likely to recruit LWD to the stream channel are retained. Numerous criteria are used to identify trees with a low likelihood of recruitment to the watercourse as potential candidates for harvesting within the RMZ. These criteria include, but are not restricted to, distance from the stream, direction of the tree lean, intercepting trees, side slope gradient, slope stability,

and streambank stability. The riparian conservation measures ensure that all trees with the greatest potential for LWD function (e.g., that can influence fluvial processes or provide cover for fish) are retained. The limitation to a single commercial harvest entry into the RMZ (except where cable corridors are necessary for intermediate treatments) ensure that this additional LWD recruitment potential will be maintained.

Riparian conservation measures will minimize and mitigate impacts of past practices and improve LWD recruitment in streams. These measures will help to maintain and improve channel complexity and provide habitat necessary for all life stages of salmonids and amphibians. Implementation of these riparian conservation measures will result in increased tree retention and LWD recruitment that will help mitigate effects of altered hydrology that could occur as a result of upslope management.

Stream Shading:
Overstory canopy closure requirements and tree retention standards help to maintain stream shading in the critical "inner zone" where microclimate effects have the greatest potential to impact amphibians directly or impact anadromous and resident salmonids indirectly through changes in water temperatures. Although the inner zone width along Class I watercourses is slightly less under the AHCP than pre-AHCP measures, the effects on microclimate and stream temperatures are not expected to be substantially different. Overstory canopy closure will likely increase over current conditions in all stands as they regenerate after timber removal and could temporarily decline slightly following harvesting in the future. In some stands there could be an immediate net reduction of overstory canopy closure of up to approximately 15 percent to 20 percent following timber harvest in the outer zone that will be replaced within 5 to 10 years by recovery of the remaining tree crowns. On average, the average-sized harvest unit (currently about 25 acres) can influence approximately 1,000 feet of watercourse if the unit surrounds or is adjacent to a watercourse.

On the basis of the minimal changes in temperature under the most extreme annual conditions, and the anticipated substantial increase in riparian protection under the AHCP, a measurable increase in water temperature in Class I or larger Class II streams caused by minor reductions in canopy closure following timber harvesting is not anticipated. Limiting entry (i.e., a single commercial entry during the term of the Permits except where cable corridors are necessary for intermediate treatments) into the RMZ will further reduce any potential minor impact from any slight temperature increases. Any increase in water temperature will be slight and less than significant. Stream temperatures will be maintained or improved.

Sediment Filtration:
Although sediment can be delivered to streams from outside of the riparian zone, maintenance of riparian buffers aids in filtering overland sediment flow and helps to minimize direct sediment inputs from or through the riparian zone. Exclusion of heavy equipment and mechanical site preparation within Class I and Class II RMZs, plus exclusion of heavy equipment in Class III EEZs, minimize the level of ground disturbance that occurs

adjacent to watercourses. Maintaining at least 50 percent surface cover and treating bare soil in excess of 100 square feet minimizes the potential for management-related sediment delivery from within the RMZs along Class I and Class II watercourses. The RMZs are at least 150 feet wide along Class I watercourses, with a variable-width inner zone ranging from 50 to 70 feet within which 85 percent of the overstory canopy is retained post-harvest; at least 70 percent overstory canopy is retained within the outer zone of Class I RMZs. Minimum 100-foot-wide RMZs are established along 2nd order or larger Class II watercourses; minimum RMZ width along 1st order Class II watercourses are 75 feet. The RMZ has a 30-foot wide inner zone for Class II watercourses within which 85 percent of the overstory canopy is retained post-harvest; at least 70 percent overstory canopy is retained within the outer zone of Class II RMZs. LWD recruitment helps minimize the effects of sediment production and delivery by providing in-channel LWD, which functions to sort and increase the storage of sediment within stream channels. All of these improved functions will benefit aquatic and riparian habitat used by aquatic species.

Streambank Stability:
Management-induced erosion and hillslope mass wasting from watercourse banks can be amplified by increased peak flow intensity and duration, as well as by reductions in root reinforcement of soil cohesion when vegetation is removed. Riparian conservation measures for Class I and II watercourses require 85 percent overstory canopy retention in the RMZ inner zone and prohibit harvesting of trees that are likely to recruit to stream channels. In addition, Tier B Class-III measures require retention of trees that are judged to be critical to maintaining bank stability. The current FPRs also require that removal of trees may not result in any measurable decrease in the stability of a watercourse bank.

Nutrient Input:
Riparian conservation measures favor conifer retention over hardwoods in the RMZs. The level of harvest in both the inner and outer zones of all RMZs will maintain the overstory canopy, so that the longer-lived conifers will eventually replace the short-lived hardwoods. In the long term, this is anticipated to reduce the level of nutrient inputs, although such a process will be slow and gradual, and will not result in complete elimination of hardwoods or complete elimination of insufficient levels of nutrient input from riparian areas where it already exists.

Aggradation of channels and scour from debris flows favor recolonization by the more rapidly growing hardwoods such as red alder. Therefore, both the slope stability and road management measures will tend to cause a decline in riparian hardwoods over time and a corresponding decrease in nutrient inputs. However, as noted above, this will be a long and gradual process that will not result in the total elimination of hardwoods.

It is anticipated that any effects on aquatic species and their habitats will be minimal (i.e., less than significant) and mitigated by the benefits of increased LWD recruitment through the retention of conifers. This is particularly relevant where structural elements of aquatic habitat are more limiting than nutrient availability.

These measures are specified in AHCP Sections 6.2.1 and 6.2.2 and incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 10: Implement the AHCP Measures Directed at Sediment Production and Delivery.

To address potential impacts on sediment production and delivery, Green Diamond must implement riparian conservation measures, slope stability measures, road management measures, and harvest-related ground disturbance measures.

Sediment production and delivery to streams will be reduced. Potential benefits associated with reduced sediment loading, include, among others, increased quantity and quality of suitable salmonid spawning gravels, greater survival of salmonid eggs and alevins in the gravels, and increased production of aquatic invertebrates that serve as foods for fish and other species.

Reduced sediment delivery to streams also could contribute to small decreases in water temperature. Sediment input, particularly increases in fine sediment, can affect stream temperatures through changes in channel morphology such as reduced pool volume and increased channel width. With the slope stability and road management measures designed to minimize management-related sediment inputs, sediment production and delivery will be reduced.

Sediment production from surface erosion is of most concern on slopes that are adjacent to watercourses, although erosion does occur higher on the hillslopes and within harvest units. The RMZ management prescriptions include conservation measures designed to impede sediment delivery in areas where sediment has relatively short transport distances to watercourses. These measures include minimum overstory canopy retention standards within RMZ inner and outer zones, limitations on equipment use, and retention of trees judged to be critical to maintaining bank stability. The retention standards ensure that there will be almost no net loss in total forest canopy in the inner zone of RMZs along Class I and Class II watercourses, and will greatly increase overstory canopy along Class II watercourses relative to existing conditions. This overstory canopy will impede sediment detachment in these critical areas, where detached sediment will have relatively short transport distances to watercourses.

Also, harvest-related ground disturbance measures focus on minimizing ground disturbance and the exposure of bare mineral soil within harvest units. The AHCP contains conservation measures, including site preparation methods, limited operating periods for the construction of skid trails and use of ground-based yarding equipment, limiting use of ground-based yarding equipment that requires constructed skid roads to slopes less than or equal to 45 percent (with some exceptions), preferential use of cable yarding systems, and water-barring of cable corridors where necessary. The AHCP also includes conservation measures for treatment of bare mineral soil within RMZs and on stream

crossings. All of these ground disturbance conservation measures are expected to contribute directly to minimizing management related surface erosion within harvest units.

Sediment production from hillslope mass wasting is greatest in RMZs, steep streamside slopes, headwall swales, and deep-seated landslides. These areas are subject to specific slope stability conservation measures intended to achieve a reduction in management-related sediment delivery from landslides. Steep streamside slopes receive additional protection through establishment of SMZs upslope of the RSMZ along Class I and Class II watercourses. The width of the SMZ varies among the 11 HPAs, with wider SMZs identified for those HPAs with potential to deliver sediment to watercourses from the longest distances. Selection harvest is the most intensive silvicultural prescription allowed within the SMZ without geologic review, and no harvest is allowed in the inner portion of the RMZ downslope of the SMZ along Class I and larger Class II watercourses. In addition, no harvest is allowed within the toe and 25 feet upslope from the top of the toe or scarp of active deep-seated landslides without geologic review.

Tree retention in the SMZs and associated RSMZs is expected to maintain a network of live roots that will preserve soil cohesion and contribute to slope stability in these areas. Tree retention also helps maintain forest canopy, which preserves some measure of rainfall interception and evapotranspiration. Maintenance of rainfall interception and evapotranspiration is expected to contribute to slope stability conditions in some locations by partially mitigating high ground water ratios that may be management related. Limited road construction and road reconstruction in SMZs and RSMZs are expected to reduce the undercutting and overburdening of sensitive hillslopes and help avoid unnatural concentration of storm runoff on these slopes.

The riparian conservation measures for Class I and II watercourses that require 85 percent overstory canopy retention in the RMZ inner zone, and that prohibit harvesting of trees that are likely to recruit to stream channels, will likely lead to increased bank stability. The Tier B Class-III measures that require retention of trees determined to be critical to maintaining bank stability will also contribute to increased bank stability.

Road-related erosion and hillslope mass wasting are known to be important contributors to the sediment budget in most managed watersheds. Eroded sediment can be delivered to watercourses through gullies or rills or through sheet transport processes from roads or through hillslope mass wasting. The Road Management Plan and associated conservation measures in the MATO will reduce road related sediment production and delivery to watercourses relative to pre-AHCP measures.

The Road Management Plan includes:

- A methodology to classify roads on the basis of use and prioritize road work and site-specific repairs
- Standards for road repairs and upgrades
- Standards for stream crossing, culvert repairs and upgrades

- Standards for temporary and permanent decommissioning of roads
- A training program for equipment operators and supervisors on the Road Management Plan and other AHCP standards and practices
- An accelerated repair of high-and moderate- risk sediment delivery sites
- A commitment to address all of the high- and moderate-risk sites by the end of the term of the AHCP
- Increased restrictions on wet weather road use, construction, upgrading, and decommissioning

Green Diamond has performed a general assessment of its ownership within the AHCP covered area that identifies road-related sediment sources requiring treatment (e.g., stabilization of dirt or other remediation to prevent road-related, sediment-producing failures or hillslope mass wasting events). The Road Management Plan is designed to provide treatment of all high- and moderate-risk sediment delivery sites over the term of the Permits, to minimize potential delivery of sediment to riparian and aquatic areas. In addition, the AHCP requires that Green Diamond provide an average of $2.5 million per year for the first 15 years of the AHCP (for a total of $37.5 million) to accelerate implementation of the treatments for the high- and moderate-risk sites. Implementation of the Road Management Plan will result in improved sediment control by accelerating the reduction of sediment loading. This will result in direct beneficial effects to aquatic and riparian species.

These measures are specified in AHCP Sections 6.2.1, 6.2.2, 6.2.3 and 6.2.4 and MATO Section 11 and incorporated in Roads WDR Order R1-2012-0087 Condition II.D.

Mitigation Measure 11: Implement the AHCP Measures Directed at Protecting and Improving Aquatic Habitat.

To address potential impacts on aquatic habitat, Green Diamond must implement riparian conservation measures, slope stability measures, road management measures, harvest-related ground disturbance measures and a special project.

Water quality and substrate in streams are expected to improve because of reduced sediment delivery. There will be little or no change in other clean water parameters such as nutrient loading, contaminant loading (e.g., herbicides), and dissolved oxygen levels. Because improvements in overstory canopy closure, shading, sedimentation, and turbidity are expected, future thermal conditions for aquatic species will be similar to or better than existing conditions. Habitat complexity will likely increase through increased LWD loading, similar or increased bank stability, and reduced sediment delivery.

Potential fish passage problems at existing road crossings are documented during the road inventory process, and culverts that are impeding fish passage are prioritized for replacement with a bridge or other “fish friendly” structure. As culvert replacement is

implemented over time, fish passage problems at road crossings will be eliminated. These actions will result in improved stream connectivity and have the potential for providing access to potentially suitable, but presently unavailable, habitat in some stream reaches.

There are stream reaches that occur above natural barriers to anadromy that appear to have habitat for anadromous salmonids, particularly coho salmon. Green Diamond will undertake a special project that is expected to expedite the conservation of this species by increasing the available habitat for spawning and rearing. Green Diamond will undertake a project involving trapping and transporting coho that are native to the stream system around a barrier during the spawning season for a ten-year period and allow them to spawn. Prior to undertaking the project, Green Diamond will evaluate the selected stream to assess whether salmonids residing in the basin above the barrier will be adversely affected by the translocation. The project will include monitoring of subsequent spawning, utilization of summer rearing habitat by the juvenile fish, and outmigrant trapping to document the number of smolts leaving the system. The upper North Fork of the Mad River has been identified as being one of the top candidate sites for the initial project. Impacts associated with relocating anadromous salmonids upstream of natural barriers will be thoroughly evaluated prior to implementation.

These measures are specified in AHCP Sections 6.2.1, 6.2.2, 6.2.3, 6.2.4, and 6.2.8 and MATO Section 11 and incorporated in Order R1-2012-0087 Condition II.D.

Mitigation Measure 12: Implement the AHCP Measures Directed at Research, Monitoring and Adaptive Management Program

To further address potential impacts on aquatic resources, Green Diamond must implement research and monitoring measures, including effectiveness monitoring, wildlife surveys, environmental assessments and watershed studies.

In addition to the required and voluntary research and monitoring activities presently being conducted by Green Diamond, additional monitoring is being conducted under the AHCP to document the level of effectiveness of the AHCP measures.

Effectiveness monitoring is designed to evaluate the implementation and overall effectiveness of the Operating Conservation Program in achieving the AHCP's biological goals and objectives. This monitoring tracks trends in the quality and quantity of habitat for the covered species (as well as the distribution and relative abundance of the covered species) and provides information to better understand the relationships among specific aquatic habitat elements and the long-term persistence of the covered species. The effectiveness monitoring projects include temperature monitoring, channel and erosion monitoring, salmonid and amphibian population monitoring, and LWD assessments. These and other monitoring efforts are described in detail in Appendix D of the AHCP and incorporated into the Regional Water Board's MRP.

Monitoring data are collected year-round, as with some in-stream temperature recorders, or seasonally, as with the Class I channel dimensions monitoring. The data collected through some monitoring projects are analyzed on an annual basis and other monitoring projects on a longer time interval. The intent is to provide a timely review of monitoring data that have monitoring thresholds associated with them to allow for corrective actions, if necessary, to occur. Based on the results of the effectiveness monitoring, changes to management and conservation measures could be implemented through adaptive management.

Adaptive management is an important tool for natural resource management when there is substantial scientific uncertainty regarding appropriate management and conservation strategies. Adaptive management has two key features: (1) a direct feedback loop between science and management, and (2) the use of management strategies as a scientific experiment. Green Diamond's monitoring and adaptive management program incorporates both these features with the goals of: (1) increasing the understanding of watershed processes and the effects of management activities on the habitats and populations of the covered species over the term of the Permits; and (2) modifying some of the AHCP's conservation measures as necessary in response to this new information. Order Conditions I and L provide for Regional Water Board Executive Officer approval of any significant changes to the Order, including any alterations of AHCP water quality prescriptions, and only if modified prescriptions are found to be equally or more protective of water quality.

The overall benefit of the monitoring and adaptive management program is to: (1) monitor through time the habitat and populations of the covered species where they currently exist; (2) document the expected trend in recovery in areas that have been affected by past management activities or natural disturbances; (3) modify or augment existing conservation measures where necessary; and (4) re-allocate resources to make the AHCP more efficient, where warranted. In addition, the monitoring and experimental studies that are conducted as part of the AHCP will further the knowledge on conservation of aquatic species on managed landscapes, potentially benefiting these species throughout their range.

These measures are specified in AHCP Section 6.2.5 and incorporated in Order R1-2012-0087 Condition II.D.

<u>Cumulative effects</u>. The anticipated improvement in riparian conditions and the reduction in sediment production and delivery to streams would speed the improvements expected over time under existing conditions, and would likely result in improved physical habitat for the covered species. Improvements in aquatic and riparian habitat benefiting the covered species would, in general, benefit other species associated with these habitats.

Vegetation/Plant Species of Concern

Impact 4: Forest management activities could adversely impact vegetation resources, riparian areas, listed plant species and other plant species of concern.

Forest management activities in the Project Area could adversely affect [ ] These impacts are potentially significant.

The AHCP requires a number of ownership-specific measures (described in Mitigation Measure 13 below) to minimize and mitigate the individual and cumulative impacts of forest management activities on vegetation and plant species of concern**. Implementation of Mitigation Measure 13 will reduce these impacts to a less-than-significant level.**

Mitigation Measure 13: Implement the AHCP Measures Directed at riparian area management, Research, Monitoring and Adaptive Management Program

To address potential impacts on vegetation and species of concern, Green Diamond must implement the AHCP's research and monitoring measures, including effectiveness monitoring, wildlife surveys, environmental assessments and watershed studies.

The AHCP requirements include:

- Class II RMZ widths of 75 to 100 feet
- EEZs of 30 to 50 feet for Class III watercourses
- Inner- and outer-zone tree and overstory canopy retention standards for RMZs
- No mechanical site preparation by wheeled or tracked equipment in Class I or Class II RMZs

In addition, the AHCP:

- Prohibits timber harvesting within the "inner zone" of all Class I RSMZs and 2nd order or larger Class II RSMZs that are located below designated "steep streamside slope management zones" (SMZs), except for purposes of creating cable-yarding corridors when other options are impractical. Retention of a minimum 85 percent overstory canopy closure is be required in Class I and 2nd order or larger Class II RSMZ "outer zones."
- Limits timber harvesting within the first 1,000 feet of a 1st order Class II RSMZ inner zone subject to 85 percent overstory canopy closure retention post-harvest. A minimum 75 percent overstory canopy retention within the first 1,000 feet of a 1st order Class II RSMZ outer zone is also required.
- Prohibits timber harvesting within the entire RSMZ for the Coastal Klamath and Blue Creek Hydrographic Areas.
- Uses single-tree selection as the initial silvicultural prescription within SMZs headwall swales. In addition, only one commercial entry is allowed within SMZs and headwall swales for the term of the Permit (except for cable corridors necessary to conduct intermediate treatments). All hardwoods within SMZs and headwall swales are retained

and, wherever possible, Green Diamond provides for even spacing of unharvested conifers such that all species and size classes represented in pretreatment stands are generally represented post-harvest. The AHCP provides flexibility for this default prescription to be modified pursuant to site-specific geologic review.

- Establishes no-cut zones within the toe, and 25 feet upslope from the top of the toe of active deep-seated landslides, except for purposes of creating cable-yarding corridors when other options are impractical. Similarly the AHCP establishes no-cut zones upslope of the deep-seated landslide scarp so as to taper to the lateral margins of the scarp. The AHCP provides flexibility for this default prescription to be modified pursuant to site-specific geologic review.
- Prohibits timber harvesting within the boundaries of shallow rapid landslides, and retains a minimum 70 percent overstory canopy within 50 feet above and 25 feet on the sides of shallow rapid landslides. The AHCP provides flexibility for this default prescription to be modified pursuant to site-specific geologic review.

Activities conducted under the MATO and Roads WDR are subject to conditions detailed in a property-wide survey and consultation process for sensitive plants developed by Green Diamond and DFG, which is described in the *Green Diamond Resource Company Sensitive Plant Conservation Plan* (see MATO Attachment 2). Implementation of these measures will avoid or minimize potential adverse impacts to sensitive plant species. Green Diamond will continue to minimize adverse effects to listed plants and plant species of concern, including continuing to adhere to measures contained in the FPRs (special protections afforded to meadows and wetlands), Green Diamond's own Plant Protection Program, and other measures identified during the THP preparation and review process.

Survey and monitoring results from 2001-2008 suggest the most efficient and effective approach to the long-term conservation of sensitive plants on Green Diamond lands is through adaptive management that is informed by appropriate inventory, monitoring and research. A combination of compatible land management practices, plant protection measures (PPMs), property-wide consultations, and area-specific botanical management plans (BMPs) provide the foundation of the SPCP. Various conservation strategies will continue to be developed, implemented, reviewed and revised over time with the ultimate goal of dividing the ownership into botanical management areas (BMAs). The BMAs are managed under BMPs that rely on known existing conditions within the BMA rather than project-by-project surveys.

These measures are specified AHCP Sections 6.2.1 and 6.2.2 and MATO Attachment 2 and incorporated in Order R1-2012-0087 and MRP E1-2012-0088.

Terrestrial Habitat/Wildlife Species of Concern

Potential benefits to listed species under the Proposed Action would generally be greater than under the No Action Alternative, primarily because of increased overstory-canopy requirements within Class II RMZs, retention of all LWD within Class III Tier A EEZs, and retention of evenly distributed conifer trees within SMZs. Also, slightly more land would

likely be left undisturbed in riparian areas relative to the No Action Alternative. These differences would amplify benefits described under the No Action Alternative for listed species and other wildlife species of concern that breed or forage in older trees and late-seral-forest stands. The EIS found that individual and cumulative impacts upon terrestrial habitat/wildlife species of concern would be less than significant.

Air Quality

Under existing conditions, PM10 would be generated by slash-burning activities associated with site preparation under even-aged management. Although various alternative management practices would result in some change in PM10 generation, these changes are not expected to be significant.

Visual Resources

Implementation of the AHCP may reduce, to some degree, the visual effects of commercial forest management relative to the historical level. Individual and cumulative impacts upon visual resources would be less than significant.

Recreational Resources

Recreational opportunities would continue to occur, subject to written entry permits. The potential for harvest-related impacts would likely be similar to current conditions. Some potential for additional benefits to recreational experiences provided by improved riparian and fishery conditions. Individual and cumulative impacts upon recreation would be less than significant.

Cultural Resources

Current FPRs contain measures for protection of cultural resources that would minimize the effects of timber harvesting on cultural resources. No significant individual or cumulative effects would result from implementation of the Project.

Land Use

Current land use would continue in a manner consistent with local land use plans and compatible with surrounding land uses. Individual and cumulative impacts on land use resources from implementation of the project would be less than significant.

Comments on "Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects, June 2012"

By: Randy D. Klein, Hydrologist, Redwood National and State Parks
1655 Heindon Road, Arcata CA 95521/707-825-5111/ Randy_Klein@nps.gov
(Sept. 10, 2012)

The comments that follow respond to a document written, I believe, by Kaete King, staff engineer with the North Coast regional Water Quality Control Board (NCRWQCB), though the document (herein called the 'Review') neglects to list the authorship. The 'Review' argues that forest practices in current use by Green Diamond Resource Company (GDRC) keep cumulative effects to a minimum, or at least to a level that meets the limits set forth in the North Coast Basin Plan (NCRWQCB, 2011). It advocates for granting of a 'Waiver of Waste Discharge Requirements' (WWDR) for GDRC while ignoring recent research demonstrating the importance of considering and regulating harvest rate in protecting water quality. Ironically, the 'Review' attempts to refute findings in Klein and others (2012) which was based upon a report provided to and funded by the NCRWQCB (Klein and others, 2008), and one whose co-author was, until being promoted to a position with the State Board, a staff member of the NCRWQCB, Dr. Matt Buffleben. Quotes from the 'Review' are shown in *italics*, below.

From page 33 of the 'Review', it states: "*It has been well documented that forest roads can cause significant increases in erosion rates within a watershed (Haupt 1959, Gibbons and Salo 1973, Beschta 1978, Rice et al. 1979, Cederholm et al. 1980, Reid and Dunne 1984, Furniss et al. 1991, Sidle et al. 1985; Montgomery 1994; Veldhuisen and Russell 1999; Sidle and Wu 2001; Brardinoni et al. 2002)*." I have no argument with this. Roads are being appropriately re-engineered by GDRC to reduce sediment threats. However, that cannot be used to justify ignoring the well-documented sediment threats triggered by removing trees from steep hillslopes (Reid and others, 2010; Reid and Keppeler, 2012; Klein and others, 2012; Klein and others, 2008; Klein, 2003).

Also from page 33 of the 'Review', "*Gibbons and Salo (1973) concluded that the sediment contribution per unit area from forest roads is usually greater than that contributed from all other timber harvesting activities combined.*" This is a very old study that is irrelevant to cotemporary timber harvesting and road maintenance and construction.

Again from page 33: *"Although roads have been shown to play a significant role in affecting water quality, Klein et al. (2012) found that roads did not significantly influence observed turbidity levels in managed watersheds."* This is a mischaracterization of our study results. We said that although harvest rate trumped road variables among our study sites, one or more road variables we considered was still significant. To quote from our journal article (Klein and others, 2012, p. 142):

> "Contrary to our expectations, some research results (Reid and Dunne, 1984; Anderson, 1970; Anderson, 1975; Anderson, 1979), and conventional wisdom, road variables added little statistical value beyond harvest rate and drainage area in explaining turbidity variations, possibly resulting from incomplete and/or inaccurate road data. For example, road lengths are probably underrepresented in 'off-the-shelf' data sets used here. Perhaps more accurate road data would have elevated the importance of road variables in explaining turbidity. But roads were indirectly accounted for in that they are closely linked to harvest rate: the density of the road network and the intensity of road use typically rise with increasing harvest rate. The correlations in the full data set were $r = 0.80$ ($n = 28$, $p < 0.001$) between 15-year mean annual harvest rate and basin-wide road

density and were $r = 0.70$ ($n = 28$, $p < 0.001$) between mean annual harvest rate and nonpaved road construction in the 15 years prior to the turbidity data period (WY2005)."

Also from pages 33-34 of the 'Review': "*Their results indicated that harvest rate and drainage area explained much of the observed variation. However their analysis and conclusions were potentially flawed in a variety of critical ways".*

"1. Their analysis included only a single year of turbidity data (WY 2005) so they were not able to evaluate the inherent annual variability of turbidity within and between watersheds." This is simply not true; we included WY2004 and WY2005 turbidity data in Table 5 and in Figs. 2 and 3. The results were very similar for the two water years, showing greatly elevated turbidities associated with high rates of timber harvest. Also, in an earlier study (Klein, 2003), turbidity data from WY2000-2002 showed the same relationship to harvest rate as Klein and others (2012).

"*2. They used an equivalent clearcut area disturbance index based on "high' and "low" harvest using three, 5-year increments and found that the years 1990-1994 preceding the turbidity data record explained most of the turbidity differences between sites. They assert that this result substantiates a rate of harvest impact; however, Green Diamond believes the authors are associating impacts of historical practices to the impacts of contemporary practices."* This depends on one' definition of 'historical'; we contend that the 15-year period includes contemporary practices. Clearcutting remains the dominant silviculture used on GDRC lands. (see Figs. 1-3, below).

"*3. They also speculate that the link to the period 10-15 years preceding the WY2005 turbidity record was due to a lag effect for root decay and subsequent harvest-related landslide occurrences; however, there was no landslide inventory information presented for their study watersheds to substantiate this claim. They only reference a study (e.g. Reid, 2012) that evaluated harvest-related landslide rates from harvest practices that occurred in the late 1980s and early 1990s (which included clearcutting, broadcast burning and later treatment with herbicides) to support this assumption.*" True, we cited the Caspar Creek landslide data to support the lag between harvesting and landslide initiation. We note that the Mad River TMDL landslide inventory acknowledged serious inadequacies in the landslide dataset due to limited field verification of aerial photo inventory data and the inability to inventory smaller landslides. Thus, this criticism applies to conclusions in the 'Review' and other documents that rely on the Mad River TMDL.

Also from p. 34 of the 'Review': "*Klein et al. (2012) also assert that there are no regulations in place to control rates of harvest. This statement is simply not true in California. As described above there are several provisions in the CFPRs that control the timing, location and intensity of timber harvest (See 14 CCR 913.1(a)(1), (a)(3), and (4)(a)).*" The CFPR codes cited above do not explicitly provide for harvest rate limits at a watershed scale. If harvest rates are indeed limited, how could the clearly excessive harvest rates have been applied in Elk River and Freshwater Creek under Palco ownership in the 1990s-2000s? Back then, the Regional Board actually <u>imposed</u> harvest rate limitations through the WWDR process, in direct contradiction to the proposed WWDRs for GRDC lands without such limitations.

Figures 1-3 show recent harvesting in Maple Creek, north of Trinidad. These are current images available through GoogleEarth showing basing-wide and closer views of GRDC's harvesting.

Figure 1. Overview of timber harvest plan areas in Maple Creek, tributary to Big Lagoon, as of 2011. Recent clearcuts are obvious, as are slightly older clearcuts.

Figure 2. View of multiple recent harvest areas in a portion of Maple Creek, 2011. Recent clearcuts compose well over half the area shown.

Figure 3. Closer view of GRDC clearcuts in Maple Creek. Some of these cuts appear to use skid trails for tractor yarding, while others use high lead cable yarding. Both of these yarding techniques result in immediate sediment delivery to streams. Clearcutting itself causes gully and landslide erosion years after the harvest is implemented.

Continuing with the 'Review', it is stated on p. 34 that: "*In addition the combined application of Green Diamond's management measures will result in approximately 25% of a watershed in RMZs and other partial harvest retention areas that will consist of older forests with high basal area and dense canopy cover.*" RMZs allow harvest; they are not exclusion zones. The clearcut equivalent area approach used in Klein (2003), Klein and others (2008) and Klein and others (2012) accounts for the lower impacts associated with lighter harvests, unlike the Maple Creek analysis in the 'Review' (discussed later).

Also from p. 34 of the 'Review': "*While harvesting practices that are used today still can cause significant adverse impacts to aquatic resources if poorly implemented, there are rules and regulations in place to avoid, minimize and mitigate the impacts and to ensure the measures are implemented. The California FPRs are among the most restrictive in the United States. Beyond that, Green Diamond has been operating under HCPs that have consistently provided more protections that the standard CFPRs. The most recent being the Aquatic HCP, beginning in 2007, that requires additional mitigation measures and provides further aquatic resource protections. The*

measures in the Plan were developed for Green Diamond's ownership taking into account existing habitat and watershed conditions and were designed to address the specific activities that Green Diamond employs to conduct its management while minimizing and mitigate the impacts of those activities on aquatic species and their habitats and to protect water quality." This sounds good, but BMPs alone cannot protect water quality if harvest rates are too high. While it would be nice to believe that GRDCs practices are indeed protecting water quality, this has not been demonstrated by the 'Review' or any other data-based analysis. This despite the fact the GDRC has been collecting continuous turbidity and stream discharge data in the Mad River, Little River and Maple Creek for years. If indeed the AHCP is improving conditions for fish despite high harvest rates on their lands, then it would seem beneficial to release those data to verify this. Instead, they chose to keep their data unavailable to the public and scientific community.

There are analyses of Maple Creek turbidity data In the 'Review', pages 16-19. To quote from p. 16: "*Turbidity threshold sampling (TTS) data collected from 2005-2012 at two sites in Maple Creek watershed (Figure 2) indicate that stream turbidity has generally decreased over time. This change is evident from assessment of the annual relationship between stage and turbidity (Figure 3). Assuming a constant slope, an increase in the y-intercept would suggest an increase in the overall turbidity levels in the watershed across all ranges of water depths (or stream flows), whereas, a decrease in the y-intercept would suggest a decrease in the overall turbidity levels in the watershed across all ranges of water depths (or stream flows). Assuming a constant y-intercept, an increase in the slope over time would suggest that turbidity levels are higher for a certain water depth (or stream flow), whereas, a decrease in slope would suggest that turbidity levels are lower for a certain water depth (or stream flow). Over the past seven years of monitoring, the slopes of these relationships have remained constant at mainstem Maple Creek (MSM linear regression: t-value = 0.9935, p = 0.3588, R2 = 0.1423) and North Fork Maple Creek (NFM linear regression: t-value = 1.5226 , p = 0.1787, R2 = 0.2787) but the y-intercepts of these relationships have decreased significantly at both sites (MSM linear regression: t-value = -2.7786, p = 0.0321, R2 = 0.5627 and NFM linear regression: t-value = -2.6362 , p = 0.0387, R2 = 0.5367). The constant slope suggests that road management has not negatively impacted turbidity. In fact, the change in the regression intercept translates into a decrease in turbidity across the range of stages (discharges) at each site. We evaluated the current rate of harvest above each turbidity station to assess the observed changes in turbidity (Figure 4). The rate of harvest was lagged by one year in an attempt to align the potential impact of harvesting with the expected response from the turbidity monitoring. The decrease in turbidity appears to be independent from the rate of harvest in each sub-basin. This decrease is likely attributable to the collective suite of sediment minimization measures described above and implemented by Green Diamond in conjunction with the AHCP*."

This analysis, in particular, warrants scrutiny because it is one of only a few that actually uses data to support approval of the WWDR. Several issues are addressed point-by-point: 1) the use of stream stage rather than stream discharge is inappropriate because distorts the results compared to the traditional, more valid comparisons with discharge, and the assertion in the 'Review' that stage and discharge are equal is not true. The two variables are not even linearly related, rather discharge is typically an exponential function of stage. 2) the use of slopes and intercepts are similarly inappropriate, being based upon stream stage. 3) the regressions used to support the argument that recent management has not degraded water quality are very weak, with R^2 values of 0.14, 0.28, 0.56 and 0.54. R^2 values below 0.50 do not support the argument, and those above 0.50 are fairly weak. 4) the number of data points (eight in Figs. 4 of the 'Review') are too few on which to base an analysis in support of approval of a regulatory document covering so vast a land base and so long a time period. 5) R^2 values are not the only, nor the best way to evaluate regression results; an analysis of residuals must also be done to

evaluate whether or not linear regression is an appropriate analysis method. 6) if we ignore the weak regression lines in Fig. 4 of the 'Review' and simply look at the data points, the trend is increasing turbidity with increasing harvest rate for the three most recent years shown (2010-2012), in direct contradiction to the main argument in this section of the 'Review'.

On p. 27 of the 'Review', statistics of channel profile trends are graphed against harvest rate. This is inappropriate because there is a much longer lag time than just one year: the coarse sediment that causes channel profile adjustments comes from landslides and channel terrace erosion, sources that affect downstream channels long after a watershed disturbance has occurred. Also, the long profile statistics plotted do not give any indication of habitat quality. For that, pool numbers and depths would provide at least some rudimentary information on aquatic habitat trends.

In summary, the 'review' relies almost entirely on verbage to advocate for approval of the WWDR on GDRC lands, despite the fact that data exist to make a quantitative evaluation. With all the TTS monitoring Green Diamond Resource Company has done, they are in a great position to demonstrate whether or not their watersheds are recovering, or if there is degradation of water quality in areas with high rates of recent harvest.

The 'Review' attempts to discredit the peer-reviewed journal article I recently co-authored (Klein, 2012), despite the fact that the initial study was funded by the Regional Board itself, and does so with misstatements and inappropriate analyses. Through years of turbidity and timber harvest data analyses, the inescapable conclusions are: 1) high rates of timber harvest seriously degrade water quality; 2) watersheds with high harvest are far out of compliance with the North Coast Basin Plan; 3) BMPs alone are not effective enough to prevent cumulative watershed effects; 4) high turbidities in managed basins cannot be explained away as 'legacy effects'; and 5) the single focus on roads in recent years, although greatly reducing water quality effects from logging operations, fails to address the well-documented role of tree removal on sediment delivery to streams. I urge you to defer approval of the WWDR for GRDC lands until reasonable limits on the rate of timber harvest are incorporated.

Literature Cited

Klein, R.D. 2003 "Duration of turbidity and suspended sediment transport in salmonid-bearing streams, North Coastal California. Report to US Environmental Protection Agency, Region IX, San Francisco, CA. 29 p.

Klein, R.D., Trush, W.J., Buffleben, M.S., 2008. Watershed Condition, Turbidity, and Implications for Anadromous Salmonids in North Coastal California Streams. Report to North Coast Regional Water Quality Control Board, Santa Rosa, CA, 105 pp. Downloadable from:
http://www.waterboards.ca.gov/northcoast/publications_and_forms/available_documents/

Klein, R.D., Lewis, J., Buffleben, M.S. 2012. Logging and turbidity in the coastal watersheds of northern California. Geomorphology, v. 139–140, pp. 136-144. Downloadable from:
http://www.sciencedirect.com/science/article/pii/S0169555X11005277

Reid, L.M., and Keppeler, E. T. 2012. Landslides after clearcut logging in a coast redwood forest. U.S. Forest Service Gen. Tech. Rep. PSW-GTR-238. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. P. 163-172. Downloadable from:
http://www.fs.fed.us/psw/publications/documents/psw_gtr238/

Reid, L.M., Dewey, N.J., Lisle, T.E., Hilton, S. 2010. The incidence and role of gullies after logging in a coastal redwood forest. Geomorphology, v. 117, pp. 155–169.

Comments on "Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects, June 2012"

By: Randy D. Klein, Hydrologist, Redwood National and State Parks
1655 Heindon Road, Arcata CA 95521/707-825-5111/ Randy_Klein@nps.gov
(Sept. 10, 2012)

The comments that follow respond to a document titled **"Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects"** dated June 12, 2012**,** and written by Green Diamond Resource Company (GDRC) to support their 'Report of Waste Discharge' (ROWD) submitted to the North Coast Regional Water Quality Control Board (NCRWQCB). The document (herein called the 'Review') argues that forest practices in current use by Green Diamond Resource Company (GDRC) keep cumulative effects to a minimum, or at least to a level that meets the limits set forth in the North Coast Basin Plan (NCRWQCB, 2011). It advocates for granting of a 'Waiver of Waste Discharge Requirements' (WWDR) for GDRC while ignoring recent research demonstrating the importance of considering and regulating harvest rate in protecting water quality. In part, the 'Review' attempts to refute findings in Klein and others (2012) which was based upon a report provided to and funded by the NCRWQCB (Klein and others, 2008), and one whose co-author was, until being promoted to a position with the State Board, a staff member of the NCRWQCB, Dr. Matt Buffleben. Quotes from the 'Review' are shown in *italics*, below.

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Again from page 33: *"Although roads have been shown to play a significant role in affecting water quality, Klein et al. (2012) found that roads did not significantly influence observed turbidity levels in managed watersheds."* This is a mischaracterization of our study results. We said that although harvest rate trumped road variables among our study sites, one or more road variables we considered was still significant. To quote from our journal article (Klein and others, 2012, p. 142):

> "Contrary to our expectations, some research results (Reid and Dunne, 1984; Anderson, 1970; Anderson, 1975; Anderson, 1979), and conventional wisdom, road variables added little statistical value beyond harvest rate and drainage area in explaining turbidity variations, possibly resulting from incomplete and/or inaccurate road data. For example, road lengths are probably underrepresented in 'off-the-shelf' data sets used here. Perhaps more accurate road data would have elevated the importance of road variables in explaining turbidity. But roads were indirectly accounted for in that they are closely linked to harvest rate: the density of the road network and the

intensity of road use typically rise with increasing harvest rate. The correlations in the full data set were $r = 0.80$ ($n = 28$, $p < 0.001$) between 15-year mean annual harvest rate and basin-wide road density and were $r = 0.70$ ($n = 28$, $p < 0.001$) between mean annual harvest rate and nonpaved road construction in the 15 years prior to the turbidity data period (WY2005)."

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"1. Their analysis included only a single year of turbidity data (WY 2005) so they were not able to evaluate the inherent annual variability of turbidity within and between watersheds." This is simply not true; we included WY2004 and WY2005 turbidity data in Table 5 and in Figs. 2 and 3. The results were very similar for the two water years, showing greatly elevated turbidities associated with high rates of timber harvest. Also, in an earlier study (Klein, 2003), turbidity data from WY2000-2002 showed the same relationship to harvest rate as Klein and others (2012).

"*2. They used an equivalent clearcut area disturbance index based on "high' and "low" harvest using three, 5-year increments and found that the years 1990-1994 preceding the turbidity data record explained most of the turbidity differences between sites. They assert that this result substantiates a rate of harvest impact; however, Green Diamond believes the authors are associating impacts of historical practices to the impacts of contemporary practices."* Again, this mischaracterizes our study. The regression analyses we performed used clearcut equivalent area as a continuous variable. The harvest rate categories of 'high', 'low', 'legacy' and 'pristine' were not used in the regressions, but were used in permutation tests. Both analyses indicate a strong dependency of turbidity on rate of harvest. One's definition of 'historical', however, is subjective. We contend that the 15-year period of harvesting we considered includes contemporary practices because clearcutting remains the dominant silviculture used on GDRC lands (see Figs. 1-3, below).

"*3. They also speculate that the link to the period 10-15 years preceding the WY2005 turbidity record was due to a lag effect for root decay and subsequent harvest-related landslide occurrences; however, there was no landslide inventory information presented for their study watersheds to substantiate this claim. They only reference a study (e.g. Reid, 2012) that evaluated harvest-related landslide rates from harvest practices that occurred in the late 1980s and early 1990s (which included clearcutting, broadcast burning and later treatment with herbicides) to support this assumption.*" True, we cited the Caspar Creek landslide data to support the lag between harvesting and landslide initiation. We note that the Mad River TMDL landslide inventory acknowledged serious inadequacies in the landslide dataset due to limited field verification of aerial photo inventory data and the inability to inventory smaller landslides. Thus, this criticism applies to conclusions in the 'Review' and other documents that rely on the Mad River TMDL.

Also from p. 34 of the 'Review': "*Klein et al. (2012) also assert that there are no regulations in place to control rates of harvest. This statement is simply not true in California. As described above there are several provisions in the CFPRs that control the timing, location and intensity of timber harvest (See 14 CCR 913.1(a)(1), (a)(3), and (4)(a)).*" The CFPR codes cited above do not explicitly provide for harvest rate limits at a watershed scale. If harvest rates are indeed limited, how could the clearly excessive harvest rates that were applied in Elk River and Freshwater Creek under Palco ownership in the 1990s-2000s? Back then, the Regional Board actually <u>imposed</u> harvest rate limitations through the WWDR process, in direct contradiction to the proposed WWDRs for GRDC lands without such limitations.

Figures 1-3 show recent harvesting in Maple Creek, north of Trinidad. These are current images available through GoogleEarth showing basing-wide and closer views of GRDC's harvesting.

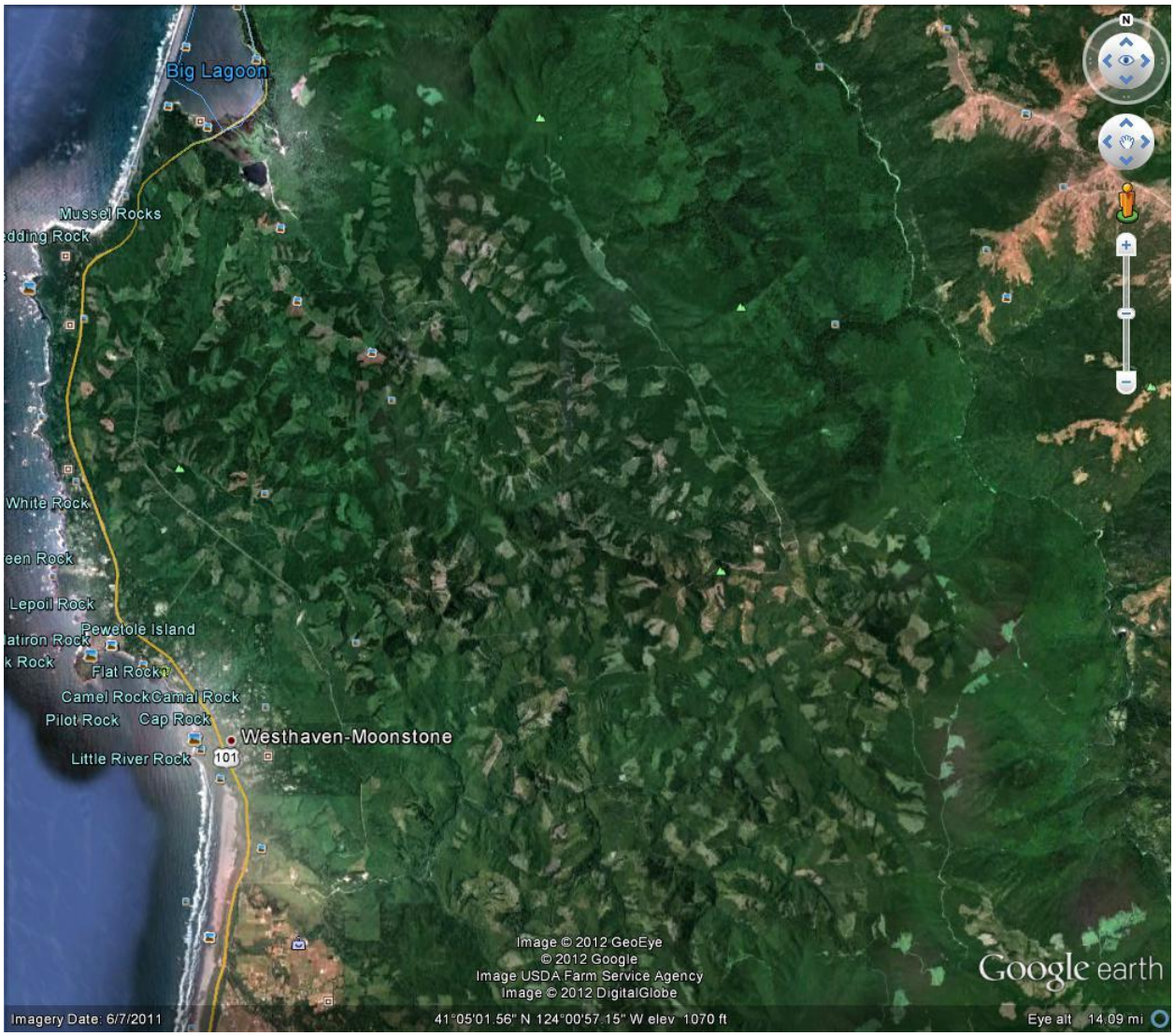

Figure 1. Overview of timber harvest plan areas in Maple Creek, tributary to Big Lagoon, as of 2011. Recent clearcuts are obvious, as are slightly older clearcuts.

Figure 2. View of multiple recent harvest areas in a portion of Maple Creek, 2011. Recent clearcuts compose well over half the area shown.

Figure 3. Closer view of GRDC clearcuts in Maple Creek. Some of these cuts appear to use skid trails for tractor yarding, while others use high lead cable yarding. Both of these yarding techniques result in immediate sediment delivery to streams. Clearcutting itself causes gully and landslide erosion years after the harvest is implemented.

Continuing with the 'Review', it is stated on p. 34 that: "*In addition the combined application of Green Diamond's management measures will result in approximately 25% of a watershed in RMZs and other partial harvest retention areas that will consist of older forests with high basal area and dense canopy cover.*" RMZs allow harvest; they are not exclusion zones. The clearcut equivalent area approach used in Klein (2003), Klein and others (2008) and Klein and others (2012) accounts for the lower impacts associated with lighter harvests, unlike the Maple Creek analysis in the 'Review' (discussed later).

Also from p. 34 of the 'Review': "*While harvesting practices that are used today still can cause significant adverse impacts to aquatic resources if poorly implemented, there are rules and regulations in place to avoid, minimize and mitigate the impacts and to ensure the measures are implemented. The California FPRs are among the most restrictive in the United States. Beyond that, Green Diamond has been operating under HCPs that have consistently provided more protections that the standard CFPRs. The most recent being the Aquatic HCP, beginning in 2007, that requires additional mitigation measures and provides further aquatic resource protections. The*

measures in the Plan were developed for Green Diamond's ownership taking into account existing habitat and watershed conditions and were designed to address the specific activities that Green Diamond employs to conduct its management while minimizing and mitigate the impacts of those activities on aquatic species and their habitats and to protect water quality." This sounds good, but BMPs alone cannot protect water quality if harvest rates are too high. While it would be nice to believe that GRDCs practices are indeed protecting water quality, this has not been demonstrated by the 'Review' or any other data-based analysis. This despite the fact the GDRC has been collecting continuous turbidity and stream discharge data in the Mad River, Little River and Maple Creek for years. If indeed the AHCP is improving conditions for fish despite high harvest rates on their lands, then it would seem beneficial to release those data to verify this. Instead, they chose to keep their data unavailable to the public and scientific community.

There are analyses of Maple Creek turbidity data In the 'Review', pages 16-19. To quote from p. 16: "*Turbidity threshold sampling (TTS) data collected from 2005-2012 at two sites in Maple Creek watershed (Figure 2) indicate that stream turbidity has generally decreased over time. This change is evident from assessment of the annual relationship between stage and turbidity (Figure 3). Assuming a constant slope, an increase in the y-intercept would suggest an increase in the overall turbidity levels in the watershed across all ranges of water depths (or stream flows), whereas, a decrease in the y-intercept would suggest a decrease in the overall turbidity levels in the watershed across all ranges of water depths (or stream flows). Assuming a constant y-intercept, an increase in the slope over time would suggest that turbidity levels are higher for a certain water depth (or stream flow), whereas, a decrease in slope would suggest that turbidity levels are lower for a certain water depth (or stream flow). Over the past seven years of monitoring, the slopes of these relationships have remained constant at mainstem Maple Creek (MSM linear regression: t-value = 0.9935, p = 0.3588, R2 = 0.1423) and North Fork Maple Creek (NFM linear regression: t-value = 1.5226 , p = 0.1787, R2 = 0.2787) but the y-intercepts of these relationships have decreased significantly at both sites (MSM linear regression: t-value = -2.7786, p = 0.0321, R2 = 0.5627 and NFM linear regression: t-value = -2.6362 , p = 0.0387, R2 = 0.5367). The constant slope suggests that road management has not negatively impacted turbidity. In fact, the change in the regression intercept translates into a decrease in turbidity across the range of stages (discharges) at each site. We evaluated the current rate of harvest above each turbidity station to assess the observed changes in turbidity (Figure 4). The rate of harvest was lagged by one year in an attempt to align the potential impact of harvesting with the expected response from the turbidity monitoring. The decrease in turbidity appears to be independent from the rate of harvest in each sub-basin. This decrease is likely attributable to the collective suite of sediment minimization measures described above and implemented by Green Diamond in conjunction with the AHCP*."

This analysis, in particular, warrants scrutiny because it is one of only a few that actually uses data to support approval of the WWDR. Several issues are addressed point-by-point: 1) the use of stream stage rather than stream discharge is inappropriate because it distorts the results compared to the traditional, more valid comparisons with discharge, and the assertion in the 'Review' that stage and discharge are equal is not true. The two variables are not even linearly related, rather discharge is typically an exponential or power function of stage. 2) the use of slopes and intercepts are similarly inappropriate, being based upon stream stage. 3) the regressions used to support the argument that recent management has not degraded water quality are very weak, with R^2 values of 0.14, 0.28, 0.56 and 0.54. R^2 values below 0.50 do not support the argument, and those above 0.50 are fairly weak. 4) the number of data points (eight in Figs. 4 of the 'Review') are too few on which to base an analysis in support of approval of a regulatory document covering so vast a land base and so long a time period. 5) R^2 values are not the only, nor the best way to evaluate regression results; an analysis of residuals must also be done

to evaluate whether or not linear regression is an appropriate analysis method. 6) if we ignore the weak regression lines in Fig. 4 of the 'Review' and simply look at the data points, the trend is increasing turbidity with increasing harvest rate for the three most recent years shown (2010-2012), in direct contradiction to the main argument in this section of the 'Review'.

On p. 27 of the 'Review', statistics of channel profile trends are graphed against harvest rate lagged by one year. This is inappropriate because there is a much longer lag time than just one year: the coarse sediment that causes channel profile adjustments comes from landslides and channel terrace erosion, sources that affect downstream channels long after a watershed disturbance has occurred. Also, the long profile statistics plotted do not give any indication of habitat quality. For that, pool numbers and depths would provide at least some rudimentary information on aquatic habitat trends.

In summary, the 'review' relies almost entirely on verbage to advocate for approval of the WWDR on GDRC lands, despite the fact that data exist to make a quantitative evaluation. With all the TTS monitoring Green Diamond Resource Company has done, they are in a great position to demonstrate whether or not their watersheds are recovering, or if there is degradation of water quality in areas with high rates of recent harvest.

The 'Review' attempts to discredit the journal article I recently co-authored (Klein, 2012), despite the rigorous peer review process that preceded publication, and does so with misstatements and inappropriate analyses. Through years of turbidity and timber harvest data analyses, the inescapable conclusions are: 1) high rates of timber harvest seriously degrade water quality; 2) watersheds with high harvest are far out of compliance with the North Coast Basin Plan; 3) BMPs alone are not effective enough to prevent cumulative watershed effects; 4) high turbidities in managed basins cannot be explained away as 'legacy effects'; and 5) the single focus on roads in recent years, although greatly reducing water quality effects from logging operations, fails to address the well-documented role of tree removal on sediment delivery to streams. I urge you to defer approval of the WWDR for GRDC lands until reasonable limits on the rate of timber harvest are incorporated.

Literature Cited

Klein, R.D. 2003 "Duration of turbidity and suspended sediment transport in salmonid-bearing streams, North Coastal California. Report to US Environmental Protection Agency, Region IX, San Francisco, CA. 29 p.

Klein, R.D., Trush, W.J., Buffleben, M.S., 2008. Watershed Condition, Turbidity, and Implications for Anadromous Salmonids in North Coastal California Streams. Report to North Coast Regional Water Quality Control Board, Santa Rosa, CA, 105 pp. Downloadable from:
http://www.waterboards.ca.gov/northcoast/publications_and_forms/available_documents/

Klein, R.D., Lewis, J., Buffleben, M.S. 2012. Logging and turbidity in the coastal watersheds of northern California. Geomorphology, v. 139–140, pp. 136-144. Downloadable from:
http://www.sciencedirect.com/science/article/pii/S0169555X11005277

Reid, L.M., and Keppeler, E. T. 2012. Landslides after clearcut logging in a coast redwood forest. U.S. Forest Service Gen. Tech. Rep. PSW-GTR-238. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. P. 163-172. Downloadable from:
http://www.fs.fed.us/psw/publications/documents/psw_gtr238/

Reid, L.M., Dewey, N.J., Lisle, T.E., Hilton, S. 2010. The incidence and role of gullies after logging in a coastal redwood forest. Geomorphology, v. 117, pp. 155–169.

From: Andrew Orahoske <andrew@wildcalifornia.org>
Sent: Wednesday, September 12, 2012 4:30 PM
To: King, Kaete@Waterboards; St.John, Matt@Waterboards
Subject: Comments on R1-2012-0087 - ROWD
Attachments: Stubblefield et al 2011.pdf; GDRC_WWDR_R Klein comments.pdf

North Coast Regional Water Quality Control Board
c/o Kaete King & Matt St. John
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

RE: R1-2012-0087 – Waste Discharge Requirements for Timber Harvest on Green Diamond Resource Company lands

Dear Responsible Officials,

The Environmental Protection Information Center (EPIC) submits the following comments and attached supporting documentation regarding the document entitled: "Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities as they Relate to Rate of Harvest and Cumulative Watershed Effects, June 2012" (hereinafter "Green Diamond Review" or "Review") that was provided for the proposed order for Green Diamond Resource Company (GDRC) waste discharge requirements (WDRs).

We would like to thank the water board for additional time to review these materials. EPIC disagrees with the water board staff's assertion in the Green Diamond Review that existing regulatory restrictions on timber harvest are sufficient to meet water quality objectives. See Green Diamond Review at 1-2.

The case study provided in the Review focuses on the Maple Creek watershed. EPIC contends that this watershed is not a good representation of the sediment & temperature impaired watersheds on Green Diamond's property. This is because the geology in Maple Creek is not as erodible and prone to increased turbidity as other watersheds, such as the entire Mad River. By choosing to focus on Maple Creek and giving a summary of turbidity data from that watershed, the Review cannot credibly support a conclusion that other watersheds have seen similar results.

We incorporate by reference all comments provided to the water board on the Green Diamond Review by Randy Klein and attached to these comments. We would also like to bring to the water board's attention that turbidity and sediment are not the only concerns with clearcutting and short rotation forestry as practiced by Green Diamond. Also attached, we argue that Stubblefield et al (2012) clearly shows that Green Diamond's forestry practices reduce the overall summer flow in watersheds because the regenerating stands of densely stocked trees simple use more water than forests that are more complex in structure. This reduction in summer flow is not addresses in the Green Diamond Review. A reduction in summer flow directly impacts water quality, especially temperature at critical times of the year when aquatic species may be at risk due to a combination of high temperatures and low flow.

In conclusion, we urge the water board to reopen the public process and start over on developing the Green Diamond WDR for timber harvest operations. We cannot support the proposed permit because it does not ensure compliance with the Clean Water Act or the Porter-Cologne Act. In the interests of

efficiency, we respectfully request that the water board staff engage with EPIC and other local stakeholders to develop a proposed order that more appropriately addresses the best available science.

Andrew J. Orahoske
Conservation Director

Environmental Protection Information Center
145 G Street, Suite A
Arcata, CA 95521
Office: (707) 822-7711
Mobile: (707) 407-9020
www.wildcalifornia.org

From: Blatt, Fred@Waterboards
Sent: Thursday, September 13, 2012 12:20 PM
To: bill.trush@gmail.com; Randy_Klein@nps.gov; rdklein@sbcglobal.net; Fowler, David@Waterboards; JHENDRIX@dfg.ca.gov; Buffleben, Matthew@Waterboards; lreid@fs.fed.us; lreid@fs.fed.us; BVALENTINE@dfg.ca.gov; CBabcock@dfg.ca.gov; JCroteau@dfg.ca.gov; SSniado@dfg.ca.gov; SSTANISH@dfg.ca.gov; jacklewis@suddenlink.net; Joe_Seney@nps.gov; mary_ann_madej@usgs.gov; White, Adona@Waterboards; theferals@suddenlink.net; andrew@wildcalifornia.org
Cc: King, Kaete@Waterboards; St.John, Matt@Waterboards
Subject: Clarification - GDRC Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects

Hello All:

I need to provide a point of clarification for some misinformation that has unfortunately circulated regarding the "GDRC Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects" document.

It has been erroneously reported to many of you that Kaete King, Environmental Scientist with the North Coast Regional Water Quality Control Board, was the author the Green Diamond document referenced above. This is completely untrue.

The referenced document was prepared solely by staff of the Green Diamond Resource Company and submitted as part of a packet of information for their Report of Waste Discharge (ROWD) as required for preparation of Waste Discharge Requirements (WDRs). This document was not written by the Regional Board or our staff and does not represent the position of the Regional Board or its staff.

If you have any questions regarding this clarification, please feel free to contact me.

Thank you,

Fred Blatt
Division Chief
Nonpoint Source and Timber Harvest Division

North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

From: Andrew Orahoske <andrew@wildcalifornia.org>
Sent: Thursday, September 13, 2012 1:35 PM
To: Blatt, Fred@Waterboards; bill.trush@gmail.com; Randy_Klein@nps.gov; rdklein@sbcglobal.net; Fowler, David@Waterboards; JHENDRIX@dfg.ca.gov; Buffleben, Matthew@Waterboards; lreid@fs.fed.us; lreid@fs.fed.us; BVALENTINE@dfg.ca.gov; CBabcock@dfg.ca.gov; JCroteau@dfg.ca.gov; SSniado@dfg.ca.gov; SSTANISH@dfg.ca.gov; jacklewis@suddenlink.net; Joe_Seney@nps.gov; mary_ann_madej@usgs.gov; White, Adona@Waterboards; theferals@suddenlink.net
Cc: King, Kaete@Waterboards; St.John, Matt@Waterboards
Subject: RE: Clarification - GDRC Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects

Fred,

The document fails to identify the authors, and the water board failed in identifying the document from the outset, so I am even more confused about this process now than before.

If, as you say, Green Diamond provided this disputed document to the water board as part of "package" of materials, then why haven't you provided that full package of materials to the public for consideration? Even more baffling is the partial release late in the process, and then more confusion about its origin, only to attempt clarification after the public comment period has closed again. This is absolutely astonishing considering numerous well paid staff are supposedly responsible.

Again, we reiterate our request that this process start over and that the proposed order be pulled from the October meeting agenda. There has been a distinct lack of communication with the public and important stakeholders concerning a permit that will rubber stamp damaging logging practices on roughly 400,000 acres within numerous watersheds impaired by the effects of logging and road-building.

I see only one way forward for water board staff to proceed at this juncture. Start over in the light of day.

Andrew

Andrew J. Orahoske
Conservation Director

Environmental Protection Information Center
145 G Street, Suite A
Arcata, CA 95521
Office: (707) 822-7711
Mobile: (707) 407-9020
www.wildcalifornia.org

From: Blatt, Fred@Waterboards [mailto:Fred.Blatt@waterboards.ca.gov]
Sent: Thursday, September 13, 2012 12:20 PM

To: bill.trush@gmail.com; Randy_Klein@nps.gov; rdklein@sbcglobal.net; Fowler, David@Waterboards; JHENDRIX@dfg.ca.gov; Buffleben, Matthew@Waterboards; lreid@fs.fed.us; lreid@fs.fed.us; BVALENTINE@dfg.ca.gov; CBabcock@dfg.ca.gov; JCroteau@dfg.ca.gov; SSniado@dfg.ca.gov; SSTANISH@dfg.ca.gov; jacklewis@suddenlink.net; Joe_Seney@nps.gov; mary_ann_madej@usgs.gov; White, Adona@Waterboards; theferals@suddenlink.net; andrew@wildcalifornia.org
Cc: King, Kaete@Waterboards; St.John, Matt@Waterboards
Subject: Clarification - GDRC Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects

Hello All:

I need to provide a point of clarification for some misinformation that has unfortunately circulated regarding the "GDRC Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects" document.

It has been erroneously reported to many of you that Kaete King, Environmental Scientist with the North Coast Regional Water Quality Control Board, was the author the Green Diamond document referenced above. This is completely untrue.

The referenced document was prepared solely by staff of the Green Diamond Resource Company and submitted as part of a packet of information for their Report of Waste Discharge (ROWD) as required for preparation of Waste Discharge Requirements (WDRs). This document was not written by the Regional Board or our staff and does not represent the position of the Regional Board or its staff.

If you have any questions regarding this clarification, please feel free to contact me.

Thank you,

Fred Blatt
Division Chief
Nonpoint Source and Timber Harvest Division

North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

12September2012

Brief Comments by Dr. William J. Trush:

The recent North Coast RWQCB study, *Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities as They Relate to Rate of Harvest and Cumulative Watershed Effects* does not warrant concluding that implementation of Green Diamond's management practices, and the current regulatory provisions in place, "avoid, minimize and mitigate potential negative impacts of Green Diamond's operations on the aquatic system and protect, and in some cases improve, water quality." I am not saying that Green Diamond engages in poor forest management practices (given my first-hand experience living in Fieldbrook Valley the last 20 years), but that potential cumulative watershed effects have not been assessed adequately. This remains the greatest threat to salmon/steelhead population recovery and general stream/river ecosystem health in coastal Northern California watersheds.

I agree with Randy Klein's submitted comments regarding the NCRWQCB's June 2012 review. Turbidity has the analytical advantage of being a quick-response, dependent variable for recent, cumulative watershed disturbance. An analysis based on individual annual turbidigraphs with quantitative thresholds could have been a major step taken toward transparency and objectivity. What I found most disappointing, however, was the absence (and it is so glaring that 'avoidance' rather than 'absence' is more appropriate) of any quantitative threshold upon which the turbidity analysis was performed and evaluated. Maintenance of the status quo for listed watersheds is the measure of performance offered/assumed. How can that be an acceptable standard by which a state agency stewards our natural resources? And if turbidity has decreased, as the NCRWQCB review contends, has it decreased enough? Is 'better than it was' (e.g., measured as change in a regression's annual intercept between 2005 and 2012) good enough? Quantitative thresholds as part of a defensible and objective answer, rather than the too-familiar blur of deflecting questions and citing of other public agency agreements/policies, is the agency's responsibility to the public. Could the NCRWQCB authors of this review give us an example of what a hypothetically unacceptable Figure 4 might look like, and outline what actions would have been recommended if that was the actual outcome? I might then be able to decipher what the NCRWQCB considers a significant negative effect and translate that back to individual annual turbidigraphs for an objective cumulative effects analysis. Unfortunately this NCRWQCB review kept the burden-of-proof for cumulative watershed effects squarely on the shoulders of threatened fish and impaired stream ecosystems.

Bill Trush
4598 13th Street
Fieldbrook, CA 95519
Bill.Trush@gmail.com

Dave Feral
Mad River Alliance
134 Esther Lane
Arcata, CA 95521

September 12, 2012

North Coast Regional Water Quality Control Board
David C. Joseph Room
5550 Skylane Blvd., Ste. A
Santa Rosa, CA 95403

RE: August 23, 2012 Meeting, Item # 9:
Waste Discharge Requirements (WDR) for Discharges Related to Green Diamond Resource

Dear Regional Board Members:

I want to thank you and your staff for extending the public comment period from September 3, 2012 to September 12, 2012, allowing more time for the public to review the document *"Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects" (June 2012)* (hereafter "Green Diamond Review of Operations Paper").

This seven business day extension notwithstanding, I would like to respectfully point out the timeline of events as they unfolded in my perspective in regard to the aforementioned document ("I"). Second, I will make comments regarding the Green Diamond Review of Operations Paper ("II").

I.

On Monday, April 23rd, 2012, I sent to NCRWQCB Staffer Ms. Kaete King an e-mail regarding Green Diamond's Forest Waste Discharge Requirements (FWDR), reprinted below:

Dear Ms. King,

I am a landowner on the Mad River near Blue Lake Ca. I'm very interested in learning more regarding the Waste Discharge Permit process. I have a lot to learn. I understand that there is a meeting on June 7th in Willow Creek to examine Green Diamonds WDR for their entire ownership. Unfortunately I will not be able to make it to the June meeting in Willow Creek due to prior engagement, however I may have a friend that can attend. *In any case I would like to be informed about the state and timeline for the GD ownership wide WDR. Can you please keep me in the loop?*

Cheers!,
Dave Feral
Blue Lake, CA
707.822.2514

On Tuesday April 24 I held a phone conversation with Ms. King regarding the process of Green Diamond filing a FWDR within the Mad River Watershed and the potential relationship harvest may have upon sediment delivery to the tributaries and mainstem of the Mad River. During the course of our conversation it became apparent to me that Ms. King was unaware of a recent peer review publication that had recently been published in the publication *Geomorphology* by Klein, et al., entitled: *Logging and turbidity in the coastal watersheds of northern California. (2012)*

Below is a copy of the e-mail I sent Ms. King on 24th 2012 indicating my interest and exactly where to read to get the information I was trying to convey to her in our phone conversation regarding timber harvest and potential landslides related to harvest. Klein, et al. (2012) was attached to that e-mail, reprinted below:

Original Message --------
Subject: Mad River
Date: Tue, 24 Apr 2012 10:53:04 -0700
From:theferals <theferals@suddenlink.net>
To:kking@waterboards.ca.gov

Hi Kaete,

Thank you for getting back to me regarding my questions, sorry to rush off the phone like that, and I hope we can continue our discussion regarding sediment in the Mad River. I have attached the paper I was referring to during our conversation, if you take a look at the discussion section 5 page 143 the left hand column explains more clearly what I was trying to explain. I look forward to learning more about this as the process unfolds, please send me any articles you think will help me understand the processes involved in sediment delivery to the system., and any updates on this as you can

Thanks again for your help on this

Dave Feral
Mad River
707.834.3623

Please note from my conversation with Kaete on April 24th is seemed apparent that she had yet not read the paper by Klein, et al. (2012).

In my e-mail (dated April 24) please note, I ask: "*please send me any articles you think will help me understand the processes involved in sediment delivery to the system, and any updates on this as you can"* (this is in reference to the phone conversation and my e-mail on April 23).

It is now my understanding that the Green Diamond Review of Operations Paper was worked on and substantially completed between April 24th and June 2012 by Ms. King and possibly others.

In the letter most recently sent to me (dated: September 5, 2012) by board staff Executive Officer Matthias St. John, it was explained:

> *In your letter, you requested an additional 30 days of public comment in order to review a document that was posted on the Regional Water Board website after the public workshop on August 23, 2012. This document is part of the Report of Waste Discharge provided by Green Diamond in its application for Waste Discharge Requirements.* ***Documents supporting the development of the Green Diamond Forest Management WDR have always been available upon request.*** *There is no legal requirement to publish all materials on the Regional Water Board website, and this particular document was provided and posted in response to a member of the public who spoke at the August 23 workshop. As a courtesy and upon your request and the request of another member of the public, the Regional Water Board will allow an additional seven (7) days for limited review of the documents associated only with the Report of Waste Discharge, with a new close of public comment date of 5:00 p.m. on September 12, 2012. Again, additional comments are limited only to the Report of Waste Discharge. The documents associated with the Report of Waste Discharge are*:
>
> - Project Description
> - Covered Activities Matrix
> - Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects

I want to point out in the letter it states: "[d]ocuments supporting the development of the Green Diamond Forest Management WDR have always been available upon request."

And, in my e-mail (dated April 24) I state this: : "*please send me any articles you think will help me understand the processes involved in sediment delivery to the system, and any updates on this as you can."*

Given that my e-mail on April 23rd and my phone conversation with Ms. King on **April 24, 2012,** was in regards to the Green Diamond FWDR, then you may understand my

dismay when a document prepared and substantially completed by her by June, 2012 was not made available to me until after I had made a presentation to the North Coast Regional Water Quality Control Board roughly three months later on August 23, 2012. The clear intention of my e-mail on April 24th was that Ms. King should please send me any relevant papers or updates regarding **"the processes involved in sediment delivery to the [Mad River] system."** The implication of that clear request was **to receive *all and any* information relating to findings or research having the potential to impact policymaking regulating sediment delivery to the Mad River Watershed**. It is clear that the Green Diamond Review of Operations Paper relates directly to that topic, or to borrow a legal term, was "on point." Accordingly, this Paper was unknown to me until a very short number of days before the scheduled close of the Public Comment Period. While the extension of Public Comment Period by seven business days helps to mitigate this fact I would like to avoid problems like this in the future. Please let me know what the procedures are and how to best communicate with staff in order to work together more effectively.

II.

In the Second half of this letter I will address the document entitled: "Review of Green Diamond Resource Company's Timber Harvest Operations and Forest Management Activities As They Relate to Rate of Harvest and Cumulative Watershed Effects" (June 2012). My comments are in **blue, the review paper is in green:**

Section *I. Forest Management Effects on the Aquatic System and Green Diamond's Conservation Strategies to Minimize, Mitigate or Avoid Impacts on Water Quality and Aquatic Species* **through** *Section (1) Road Management Measures*

This describes in theory how management practices Green Diamond Resource Company employs are supposed to offset negative anthropogenic effects in the Watershed. There does seem to be excessive conjecture here with many claims that have yet to be substantiated. These conjectural claims include:

"The AHCP's harvest-related ground disturbance measures reduce the impacts of any operations related to altered hydrology by minimizing soil compaction which can increase the magnitude of peak flows and the volume of sediment available for runoff during such events." (Pg. 9) **and** "Collectively these riparian and slope stability measures provide root strength to mitigate management related sediment inputs associated with stream bank instabilities." (Pg. 13).

Though these claims are persuasive, there is no evidence in this paper that supports these claims.

First, the study of Maple Creek does not use *clearcut equivalent* area, so the harvest rates compared with turbidity are artificially high, making it appear that higher harvest rates don't result in much of a turbidity increase. Second, the 1-year lag of harvesting versus turbidity data doesn't even come close to capturing the 'effects' period (minimum of 15

years after harvest). Finally, the data points plotted in Fig 4 are poorly represented by the regression lines - there is actually an uptick in 2011-2012 in the y-intercept for the relationship between stream stage (their surrogate for discharge) and turbidity.

On page 21 in the **Riparian Management Measures** it is stated:

"There is an immediate net reduction of canopy cover of approximately 15-20% following timber harvest in the outer zone, which will be replaced within 5-10 years by recovery of the remaining tree crowns. ***As a result, there should be little or no measurable change in water temperature as a result of canopy reduction following timber harvest."***

Shouldn't it be management's goal to improve the situation, not simply keep temperatures the same? Aren't these waters *already* temperature-impaired?

On page 31 it states: "the establishment of equipment exclusion zones on watercourses that do not support aquatic life (Class III)."

This is just not the case. I suggest a study of the Hyporheic Zone:

***Dicamptodon tenebrosus* Larvae Within Hyporheic Zones of Intermittent Streams (Class III stream) in California** Feral et. al. *Herpetological Review*, 2005, 36(1), 26–27.

> "We found individual larval *D. tenebrosus* in 22 samples. Fifteen larvae were captured in the 0 to -30 cm traps and seven in the -30 to -60 cm traps. Larvae ranged from 39–83 mm total length (mean ± SE = 55.2 ± 2.6 mm). Similar numbers of salamanders were captured in each tributary, and captures occurred throughout the year and did not appear to vary with season. *D. tenebrosus* were captured in all three stream locations, although more were captured at the lower sites (9) than in the middle (7) or upper (6) sites. All *D. tenebrosus* captures occurred when surface flow was < 4 cm deep, and the majority of captures (18 of 22) occurred when there was no surface flow. "

MacDonald, et al. (2004) found that erosion rates from roads can be one or more orders of magnitude higher than erosion rates from skid trials and non-compacted areas in harvest units.

This study is done in the Sierra Mountain Range, not a good comparison to the geology of the Mad River Watershed.

Although roads have been shown to play a significant role in affecting water quality, Klein, et al. (2012) found that roads did not significantly influence observed turbidity levels in managed watersheds.

This is a mischaracterization of Klein, et al. (2012) study results. A clear way to explain this is to actually quote the author:

> "Regression analyses of turbidity on watershed natural physiographic characteristics and land use histories (logging and roads) showed the rate of recent logging (mean annual percent of watershed area) explained the greatest amount of variability in turbidity at the 10% exceedence level. Drainage area was also significant but was secondary to harvest rate. None of the other watershed variables was found to improve the regression models. Despite much improved best management practices, contemporary timber harvest can trigger serious cumulative watershed effects when too much of a watershed is harvested over too short a time period."

The above quote is taken from the abstract. If one reads beyond this, one finds that Klein, et al. (2012) acknowledges the role roads play in sediment delivery:

> "Because they intersect frequently on the landscape, logging road stream crossings are *perhaps the most prominent sources of delivery of sediment to streams*. Erosion from within cut units is less likely to reach a stream, depending on site topographic and hydrologic attributes and the effectiveness of streamside buffers. Although buffers are a commonly applied BMP that limit the occurrences or volumes of sediment from reaching a channel, instances of 'break-through' (hillslope-eroded sediment passing through a buffer) can occur nonetheless, as we have observed in the field. Rivenbark and Jackson (2004) documented one breakthrough occurrence for about every 8 ha of clearcut forestlands in the southeastern U.S., with 14% of the 187 breakthroughs inventoried traveling>30 m before reaching a stream channel." (emphasis added)

Klein et. al. also explain:

> "Contrary to our expectations, some research results (Anderson,1970, 1975, 1979; Reid and Dunne, 1984), and conventional wisdom, road variables added little statistical value beyond harvest rate and drainage area in explaining turbidity variations, possibly resulting from incomplete and/or inaccurate road data. For example, road lengths are probably underrepresented in 'off-the-shelf' data sets used here. Perhaps more accurate road data would have elevated the importance of road variables in explaining turbidity. But roads were indirectly accounted for in that they are closely linked to harvest rate: the density of the road network and the intensity of road use typically rise with increasing harvest rate. The correlations in the full data set were r=0.80 (n=28, pb0.001) between 15-year mean annual harvest rate and basin-wide road density and were r=0.70 (n=28, pb0.001) between mean annual harvest rate and non-paved road construction in the 15 years prior to the turbidity data period (WY2005)."

It is agreed that roads are a contributing factor, however Klein, et al. (2012) found harvest rate and type to have much higher correlation to sediment being delivered to streams in this study.

1. Their Klein, et al. (2012) analysis included only a single year of turbidity data (WY 2005) so they were not able to evaluate the inherent annual variability of turbidity within and between watersheds.

Table 5 and figure 2 in Klein et. al. both clearly shows the use of water years 2004 and 2005.

Also Klein et. al.: "Data for the 2003, 2004, and 2005 winter runoff seasons (WY2003, 2004, and 2005) were assembled and prepared for analysis."(page137)

And, Klein et. al. state:

> "The permutation test was selected because it is an exact, easily interpretable, nonparametric test suitable for small sample sizes, and it can be used with unbalanced repeated measures designs. The data are unbalanced because three more sites were available in 2005 (n=27) than in 2004 (n=24). And the 2004 and 2005 measurements of 10%TU for a given station are highly correlated (r=0.96), so they must be treated as repeated measures. For this permutation test, the group labels for any two groups being compared are reassigned to the paired (2004, 2005) turbidity values, in every possible permutation, and the 2004 and 2005 differences in mean 10%TU between the two groups are computed for each permutation. The proportion of permutations for which both the 2004 and 2005 differences equal or exceed the differences observed in the actual sample is interpreted as the probability of the observed result having occurred if group identity were unrelated to 10%TU. A small probability indicates that there is a significant relation between harvest rate and turbidity."

Klein et al. (2012) also assert that there are no regulations in place to control rates of harvest. This statement is simply not true in California. As described above there are several provisions in the CFPRs that control the timing, location and intensity of timber harvest (See 14 CCR 913.1(a)(1), (a)(3), and (4)(a)).

It is significant to note that the riparian protections that Green Diamond suggests being restrictive are not as strict as the 2010 ASP rules passed by CalFire which apply to everyone who doesn't have an AHCP. Green Diamond also claim that the forest practice rules have provisions which control the rate of harvest, but this is only true indirectly. There is nothing in the current CFP rules which directly addresses rate of harvest. There are adjacency requirements and practical limitations which may prevent a Timber Harvest Plan from cutting even faster than Green Diamond already does, but nothing that says X% of the watershed must be in stands > 50 yrs old, for example.

Given the disparity of opinion on this I suggest we work toward a reasonable solution to this matter. **As is I suggested in my last letter and presentation on August 23rd, an annual rate of harvest of < 1.5 % selective cut is recommended to reduce the cumulative ill effects for salmonids living in the Mad River Watershed.** In addition to this, **the Mad River Alliance also formally requests that all sediment monitoring data be available for public comment on an ongoing basis and all analysis be completed by a reputable third party.**

Please also consider this letter a formal request to receive all future data, reports and documentation prepared for, which relate to, or which could impact policymaking in regard to sediment delivery rates and waste discharge rates of timber harvesting operations taking place in the Mad River Watershed.

Sincerely,

Dave Feral
Mad River Alliance
134 Esther Lane
Arcata, CA 95521

Mission
The Mad River Alliance works to protect clean water and the biological integrity of the Mad River watershed for the benefit of its human and natural communities.

From: St.John, Matt@Waterboards
Sent: Wednesday, September 12, 2012 10:46 AM
To: King, Kaete@Waterboards; Blatt, Fred@Waterboards; Olson, Samantha@Waterboards
Subject: Fwd: GDRC Timber Harvest Operations and Forest Management Activities As TheyRelate to Rate of Harvest and Cumulative Watershed Effects

Sent from my iPhone

Begin forwarded message:

> **From:** <Randy_Klein@nps.gov>
> **Date:** September 12, 2012 6:39:04 AM PDT
> **To:** "Reid, Leslie -FS" <lreid@fs.fed.us>
> **Cc:** Jon Hendrix <JHENDRIX@dfg.ca.gov>, "Randy_Klein@nps.gov" <Randy_Klein@nps.gov>, Brad Valentine <BVALENTINE@dfg.ca.gov>, Curt Babcock <CBabcock@dfg.ca.gov>, "JCroteau@dfg.ca.gov" <JCroteau@dfg.ca.gov>, "Susan Sniado" <SSniado@dfg.ca.gov>, Stacy Stanish <SSTANISH@dfg.ca.gov>, <mbuffleben@waterboards.ca.gov>, <mary_ann_madej@usgs.gov>, <Matt.St.John@waterboards.ca.gov>, <bill.trush@gmail.com>, <awhite@waterboards.ca.gov>, <Joe_Seney@nps.gov>
> **Subject: RE: GDRC Timber Harvest Operations and Forest Management Activities As TheyRelate to Rate of Harvest and Cumulative Watershed Effects**
>
> Leslie, thanks for clarifying that issue. There was much more in Ms. King's 66-page report than I could hope to address in the extremely short time between when the report became available to the public (several days ago) and the deadline for comments (today at 5 pm).
>
> Randy D. Klein, Hydrologist
> Redwood National and State Parks
> 1655 Heindon Road
> Arcata, CA 95521
> (707) 825-5111
> "Randy_Klein@nps.gov"
>
> -----"Reid, Leslie -FS" <lreid@fs.fed.us> wrote: -----
>
> To: Jon Hendrix <JHENDRIX@dfg.ca.gov>, "Randy_Klein@nps.gov"

<Randy_Klein@nps.gov>
From: "Reid, Leslie -FS" <lreid@fs.fed.us>
Date: 09/11/2012 02:48PM
cc: Brad Valentine <BVALENTINE@dfg.ca.gov>, Curt Babcock <CBabcock@dfg.ca.gov>, "JCroteau@dfg.ca.gov" <JCroteau@dfg.ca.gov>, Susan
Sniado <SSniado@dfg.ca.gov>, Stacy Stanish <SSTANISH@dfg.ca.gov>
Subject: RE: GDRC Timber Harvest Operations and Forest Management Activities As TheyRelate to Rate of Harvest and Cumulative Watershed Effects

Hi, Jon -- Wow. Those statements regarding paired watershed studies are the equivalent of an assertion that "you no longer need to believe in gravity because Newton used an old-fashioned apple." Paired watershed studies are powerful in part because they allow certain variables to be controlled for, and this facilitates better understanding of the underlying causes of observable treatment effects. That understanding can then be applied to help understand the effects of other types of treatments. To the extent that other treatments influence the variables controlling responses in similar ways, those responses will be similar.

In the case of Caspar Creek, for example, the paired-basin studies documented the magnitude of the influences of particular timber operations on hydrologic and sediment response, and the studies also provided the information needed to understand why those effects came about. The hydrological changes were due largely to the reduction in canopy after logging (i.e., not to roads or compaction), and comparison of results for 1970s tractor-yarded selection cuts vs. 1990s cable-yarded clearcuts show similar patterns for peakflow change, with moderate differences in magnitudes.

In particular, the observed peakflow changes for the clearcutting are predictable on the basis of measurements of changes in rainfall interception and estimates of transpiration changes after logging. In other words, it doesn't matter what practices were used to clearcut and yard the trees, since it's the absence of the trees that generated the effect. Helicopter logging would generate about the same kind of peakflow response as ox-team-logging would if the same area was clearcut.
--Leslie

-----Original Message-----
From: Jon Hendrix [mailto:JHENDRIX@dfg.ca.gov]
Sent: Tuesday, September 11, 2012 1:57 PM
To: Reid, Leslie -FS; Randy_Klein@nps.gov
Cc: Brad Valentine; Curt Babcock; JCroteau@dfg.ca.gov; Susan Sniado; Stacy Stanish

Subject: Re: GDRC Timber Harvest Operations and Forest Management Activities As TheyRelate to Rate of Harvest and Cumulative Watershed Effects

Randy,

Thank you for your comments. You answered most of my questions pertaining to your paper(s) and statistical analyses.

I'm wondering if you and/or Leslie would address the report's assertions (copied below) about paired watershed studies.

In referencing these studies in our comments, DFG provides the usual caveats of older practices vs. newer ones. But to say their use is inappropriate is like saying paleontologists should ignore the fossil record. As you state, we don't get data from the project proponent, which leaves us with utilizing research from our research forests. I find these comments dismissive at best and ignore paired watershed study findings that investigated a wide array of operations (i.e., in Caspar) that included old methods and experimented with improved methods such as not burring and buffering headwater streams in clearcuts.

"Given the substantial changes in every aspect of contemporary forest management, attempting to draw inferences from paired watershed studies that included substantial areas of historical logging is clearly inappropriate." (page 30)

and

"Historical paired watershed studies were extremely valuable in understanding the fundamental effects of timber harvest on water quality, water quantity and watershed processes and were instrumental in guiding the development of current forest practices and protections to avoid, minimize and mitigate forest management impacts. However the use of these studies to evaluate the effects of present day forest practices on aquatic resources is inappropriate." (page 32)

Again, Thanks,

Jon Hendrix
Environmental Scientist
California Department of Fish and Game
Coastal Timberland Planning
Northern Region
32330 North Harbor Drive,

Fort Bragg, CA 95437
Ph. 707.964.1691
Fx. 707.964.1487
jhendrix@dfg.ca.gov

<Randy_Klein@nps.gov> 9/11/2012 11:05 AM
>>>

All, here are my comments on the referenced document by Ms. King.

Randy D. Klein, Hydrologist
Redwood National and State Parks
1655 Heindon Road
Arcata, CA 95521
(707) 825-5111
"Randy_Klein@nps.gov"

-----"Fowler, David@Waterboards" <David.Fowler@waterboards.ca.gov>
wrote:

To: "Randy_Klein@nps.gov" <Randy_Klein@nps.gov>, Jon Hendrix
<JHENDRIX@dfg.ca.gov>, "Buffleben, Matthew@Waterboards"
<Matthew.Buffleben@waterboards.ca.gov>
From: "Fowler, David@Waterboards" <David.Fowler@waterboards.ca.gov>
Date: 09/10/2012 07:46AM
cc: "lreid@fs.fed.us" <lreid@fs.fed.us>, Brad Valentine
<BVALENTINE@dfg.ca.gov>, Curt Babcock <CBabcock@dfg.ca.gov>, Joe
Croteau
<JCroteau@dfg.ca.gov>, Susan Sniado <SSniado@dfg.ca.gov>, Stacy Stanish
<SSTANISH@dfg.ca.gov>, "jacklewis@suddenlink.net"
<jacklewis@suddenlink.net>
Subject: Re: GDRC Timber Harvest Operations and Forest Management
Activities As They Relate to Rate of Harvest and Cumulative Watershed
Effects

I believe the primary author is Kaete King.

David Fowler
North Coast Regional Water Quality Control Board

5550 Skylane Blvd., Ste. A
Santa Rosa, CA 95403
David.fowler@waterboards.ca.gov
707-576-2756

On 9/5/12 4:28 PM, "Randy_Klein@nps.gov" <Randy_Klein@nps.gov> wrote:

Hi Jon,

I have taken a brief look at this document and have some initial thoughts

I

will forward to you soon. For now, there are some statements that are

quite

simply wrong in there regarding what was in the paper I co-authored

with

Jack Lewis and Matt Buffleben (cc'd on this) this past January.

I was surprised to see no author atttibuted to the document; any idea

who

wrote it?

Randy D. Klein, Hydrologist

Redwood National and State Parks

1655 Heindon Road

Arcata, CA 95521

(707) 825-5111

"Randy_Klein@nps.gov"

-----Jon Hendrix <JHENDRIX@dfg.ca.gov> wrote: -----

To: <lreid@fs.fed.us>, <Randy_Klein@nps.gov>

From: Jon Hendrix <JHENDRIX@dfg.ca.gov>

Date: 09/05/2012 04:03PM

cc: Brad Valentine <BVALENTINE@dfg.ca.gov>, Curt Babcock

<CBabcock@dfg.ca.gov>, Joe Croteau <JCroteau@dfg.ca.gov>, Susan

Sniado

<SSniado@dfg.ca.gov>, Stacy Stanish <SSTANISH@dfg.ca.gov>, David Fowler

<DFowler@waterboards.ca.gov>

Subject: GDRC Timber Harvest Operations and Forest Management

Activities

As

They Relate to Rate of Harvest and Cumulative Watershed Effects

Randy and/or Leslie,

I'm curious if you've reviewed and/or have comments on the, "Review

of

Green Diamond Resource Company's Timber Harvest Operations and Forest

Management Activities As They Relate to Rate of Harvest and

Cumulative

Watershed Effects June 2012".

Found at:

http://www.waterboards.ca.gov/northcoast/board_decisions/tentative_orders/

It's on the NCRWQCB's list of items for their October 4, 2012 board
meeting.

I can't tell who authored it, but, it makes several curious assumptions

- including some about comparing current management to 'historical' paired watershed studies, rate of harvest and turbidity, current management effects on legacy (sediment) impacts, Klein et al. 2012, etc.

DFG timber review staff have waded into the ROH/BMP/turbidity and sediment 'waters' recently. We've relied upon the work of Randy and others and the Caspar Creek Study watershed findings. So we're interested in learning what others knowledgeable in forest hydrology might have to share regarding this report, its assumptions, findings, etc.

Jon Hendrix
Environmental Scientist
California Department of Fish and Game
Coastal Timberland Planning

Northern Region
32330 North Harbor Drive,
Fort Bragg, CA 95437
Ph. 707.964.1691
Fx. 707.964.1487
jhendrix@dfg.ca.gov

(See attached file: GDRC_WWDR_R Klein comments.pdf)

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September 28, 2012

North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Ste. A
Santa Rosa, CA 95403

RE: R1-2012-0087 – Waste Discharge Requirements for Timber Harvest on Green Diamond Resource Company lands

Dear Responsible Officials,

We are writing on behalf of the Mad River Alliance and the Environmental Protection Information Center (EPIC). The Mad River Alliance works to protect clean water and the biological integrity of the Mad River watershed for the benefit of its human and natural communities. EPIC works to protect and restore ancient forests, watersheds, coastal estuaries, and native species in Northern California. EPIC uses an integrated, science-based approach, combining public education, citizen advocacy, and strategic litigation.

In this letter we addresses three important facets related to the Waste Discharge Requirements (WDR) for Timber Harvest on Green Diamond Resource Company lands that is to be voted on by the North Coast Regional Water Quality Control Board (NCRWQCB) on October 4, 2012.

- Logging methods and sediment sources

- Failure to Analyze Impacts of the proposed WDR on Eulachon or Candle Fish (*Thaleichthys pacificus*) and Longfin Smelt (*Spirinchus thaleichthys*)

- Request that the Board send the proposed permit back to the staff and applicant to encourage cooperation between all parties and to find a solution that is in compliance with the law and involves stakeholders.

Logging Methods and Sediment Sources

The NCRWQCB's response to Mad River Alliance's request to limit timber harvest rate in the Mad River Watershed has been dismissed, with this response:

> The Mad River Alliance asks that the Regional Water Board (RWB) limit harvest rates in the Mad River to less than 1.5% for all THPs. The quoted rate is derived from one scientific paper, Klein et al., 2012. We are aware of the Klein et al. paper, and while it has interesting conclusions regarding the cumulative effects of logging, it lacks specific information regarding the mechanisms and sources of these impacts. We do not believe, at the current time, that the results of one scientific paper are sufficient to modify the way timber harvest activities are regulated in the north coast region.
>
> See Response to Comments.

Today we submit four peer reviewed scientific papers for the board and staff to examine the building evidence that clear-cut and harvest rate do have a significant effect on sediment inputs to a river system. If the board and staff would like I can provide more peer reviewed papers that link clear-cut harvest method and harvest rate to increased surface erosion and landslide activity. We are happy to research this topic for the NCRWQCB. The below is just a small sample.

Imaizumi et al. (2008), explain: "Total landslide volume in forest stands clearcut [showed] a fourfold increase compared with control sites during the period when harvesting affected slope stability. Because landslide scars continue to produce sediment after initial failure, sediment supply from landslides continues for 45 yr in the Sanko catchment."

Montgomery et al. (2000) explain "Our monitoring shows that storms with 24 hr rainfall recurrence intervals of less than 4 yr triggered landslides in the decade after forest clearing and that conventional monitoring programs can substantially underestimate the effects of forest clearing. Our regional analysis further substantiates that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest."

Klein et al. (2012) explains: "Despite much improved best management practices, contemporary timber harvest can trigger serious cumulative watershed effects when too much of a watershed is harvested over too short a time period."

In Trush et al. (2008) explain: "[A]verage annual harvest rates greater than about 1.5% (representing a 67-year rotation cycle) should be avoided in North Coast watersheds, with the caveat that watershed-specific adjustments are possible based on more detailed analyses."

Eulachon and Failure to Analyze the Impacts

While reviewing all aspects of the proposed WDR for Green Diamond we noticed a clear oversight resulting in the exclusion of a fish species that is listed as threatened under the Federal Endangered Species Act. The fish known as the Eulachon or Candle Fish (*Thaleichthys pacificus*) has been excluded from the listing of fish species that are sensitive to the impacts of elevated sediment and temperature in the Mad River Watershed.

On March 18, 2010, the National Marine Fisheries Service (NMFS) listed the southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*) as threatened under the Endangered Species Act (ESA). See 75 Fed. Reg. 13012. NMFS identified the geographical area occupied by the species and included the Mad River. Eulachon consistently spawned in large numbers in the Mad River as recently as the 1960s and 1970s (Moyle et al. 1995, Moyle 2002, Gustafson et al. 2010). However, in recent years eulachon numbers have declined, and they are now considered rare (Sweetnam et al. 2001). Based on observations by the California Department of Fish and Game (CDFG) spawning occurs as far upstream as the confluence with the North Fork of the Mad River.

The river below this point contains overlapping spawning and incubation sites and migration corridor features. Several special management concerns exist for the Mad River. The river has one dam, Matthews Dam, about one third of the way down the river from its source (NMFS

2008). The operation of dams (and water diversions) may affect water flow, water quality parameters, substrate quality, and depth within eulachon habitat. Pollution and runoff are potential management concerns in the Mad River.

Spawning substrates typically consist of silt, sand, gravel, cobble, or detritus (Gustafson et al. 2010). However, pea sized gravel (Smith and Saalfeld 1955) and coarse sand (Langer et al. 1977) are the most commonly used. Road building, gravel mining and timber harvest occur within the Mad River watershed and erosion from these activities has the potential to increase sediment deposition in aquatic environments (Gomi et al. 2005, Rashin et al. 2006).
In addition, the removal of riparian vegetation (which also increases erosion), and urbanization may cause decreased water quality. Pollution and runoff from these activities can adversely affect the water quality, sediment quality, and substrate composition of eulachon critical habitat. Excessive runoff may increase turbidity and alter the quality of spawning substrates.

Water Temperature: Suitable water temperatures, within natural ranges, in eulachon spawning reaches. Water temperature between 4°C and 10°C (39º F and 50ºF) in the Columbia River is preferred for spawning (WDFW and ODFW 2001) although temperatures during spawning can be much colder in northern rivers (e.g., 0ºC - 2ºC [32ºF - 36ºF] in the Nass River; Willson et al. 2006). High water temperatures can lead to adult mortality and spawning failure (Blahm and McConnell 1971).

The Eulachon has been excluded from this process in violation of CEQA, the Porter-Cologne Act and the federal Clean Water Act. Indeed, CEQA clearly requires that the NCRWQCB disclose and analyze all potential environmental impacts of the permitted actions, and the documentation for this proposed WDR completely fails to address Eulachon and the impacts of the permitted activities on this species.

Longfin Smelt and Failure to Analyze Impacts

The Mad River Estuary contains Longfin smelt (*Spirinchus thaleichthys*), a species that the California Fish and Game Commission determined should be listed under the California Endangered Species Act (CESA) as threatened throughout their range in California which includes the Mad River (CFGC 2009).

The NCRWQCB failed to analyze the impacts of the proposed WDR on Longfin smelt in violation of CEQA, the Porter-Cologne Act, Clean Water Act and CESA.

Conclusion

The Mad River Alliance and EPIC request that NCRWQCB send the proposed WDR and supporting documentation back to staff and the applicant to correct these and other deficiencies. We request that the Board:

1) Re-evaluate compliance with CEQA, the Porter-Cologne Act, federal Clean Water Act, and the federal and California Endangered Species Acts.
2) Limit harvest rate to < 1.5% per year within all watersheds

3) Require Green Diamond to use only selection logging techniques and ban clear cut logging.
4) Work with Community and Stakeholder Groups living within the Mad River Watershed and other watersheds affected by Green Diamond logging to develop a sediment and temperature monitoring program that is peer reviewed, transparent and managed by a third party.
5) Utilize the Monitoring Program for Adaptive Management

Dave Feral
Mad River Alliance
134 Esther Lane
Arcata, CA 95521

Andrew J. Orahoske
Conservation Director
Environmental Protection Information Center
145 G Street. Suite A
Arcata, CA 95521
andrew@wildcalifornia.org

Literature Cited

Imaizumi,F. R.C. Sidle and R. Kamei. 2008. Effects of forest harvesting on the occurrence of landslides and debris flows in steep terrain of central Japan. Earth Surface Processes and Landforms Earth Surf. Process. Landforms 33, 827–840.

Klein, R.D., J. Lewis , M. S. Buffleben. 2012. Logging and turbidity in the coastal watersheds of northern California. Geomorphology 139-140: 136–144

Montgomery, D.R. , K.M. Schmidt, H. M. Greenberg and W. E. Dietrich. 2000. Forest clearing and regional landsliding. Geological Society of America http://geology.gsapubs.org/content/28/4/311.abstract.

Trush W., M. S. Buffleben, and R. Klein. 2008. Watershed Condition, Turbidity and Implications for Anadromous Salmonids in North Coastal California Streams. A Report to the California North Coast Regional Water Quality Control Board.

National Marine Fisheries Service (NMFS). 2011. Critical Habitat for the Southern Distinct Population Segment of Eulachon, Final Biological Report.

California Department of Fish and Game. 2009. Report to the Fish and Game Commission: A status review of the longfin smelt (*Spirinchus thaleichthys*) in California.46 pages. http://www.dfg.ca.gov/delta/data/longfinsmelt/documents/LongfinsmeltFactSheet_July09.pdf

Geomorphology xxx (2011) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Logging and turbidity in the coastal watersheds of northern California

Randy D. Klein [a,*], Jack Lewis [b], Matthew S. Buffleben [c]

[a] Redwood National and State Parks, 1655 Heindon Road, Arcata, CA 95521, USA
[b] 647 Elizabeth Dr., Arcata, CA 95521, USA
[c] North Coast Regional Water Quality Control Board, 5550 Skylane Blvd., Santa Rosa, CA 95403, USA

ARTICLE INFO

Article history:
Received 21 April 2011
Received in revised form 7 October 2011
Accepted 8 October 2011
Available online xxxx

Keywords:
Turbidity
Timber harvest
Cumulative watershed effects
Best management practices

ABSTRACT

Continuous turbidity data for the 2004–2005 winter runoff seasons were used to assess water quality characteristics in 28 coastal watersheds in northern California. Turbidity probes collected data during the winter period, typically spanning the months of October–May. Stream biota, such as salmonids, suffer not only from turbidity extremes but also from chronic turbidity. We used turbidity at the 10% exceedence level to index chronic turbidity in the 28 streams. Watersheds draining to the streams spanned disturbance categories from pristine redwood forest to intensive commercial timber harvest. Grouping the sites by timber harvest history showed that the pristine (unharvested, or 'background') group mean was 8 FNU (formazin nephelometric units) at the 10% exceedence level in water year 2005 (WY2005), while the legacy (older) harvest, low, and high harvest rate group means were 16, 32, and 61 FNU, respectively. Regression analyses of turbidity on watershed natural physiographic characteristics and land use histories (logging and roads) showed the rate of recent logging (mean annual percent of watershed area) explained the greatest amount of variability in turbidity at the 10% exceedence level. Drainage area was also significant but was secondary to harvest rate. None of the other watershed variables was found to improve the regression models. Despite much improved best management practices, contemporary timber harvest can trigger serious cumulative watershed effects when too much of a watershed is harvested over too short a time period.

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1. Introduction

Degradation of water quality – especially turbidity and suspended sediment – has long been recognized as one of the most important risks from timber harvest and road building. Lieberman and Hoover (1948) measured a 22-fold increase in mean turbidity and a 42-fold increase in the maximum turbidity because of the style of logging employed in the mid-20th century. Nolan and Janda (1995) computed suspended sediment discharges at stream gaging stations in Redwood Creek, finding that recently logged watersheds yielded 10 times more suspended sediment than unharvested terrain. Gomi et al. (2005) compiled data from numerous studies of logging effects in the western US, with post-logging suspended sediment yield increases ranging from 0 to 1000% and post-logging recovery times ranging from zero to over four years. Keppeler et al. (2003, p. 5) reported that "sediment yields do not appear to recover as quickly [as streamflows] and persist at double the pretreatment levels 12 years after harvest" for tributaries in North Fork Caspar Creek, California.

Elevated turbidity and suspended sediment concentrations and durations can have negative short- and long-term effects on aquatic biota. Salmonids in particular may be adversely affected at several life stages in freshwater (Newcombe and MacDonald, 1991; Newcombe and Jensen, 1996; Henley et al., 2000; Newcombe, 2003), although White and Harvey (2007) found that in some cases, adaptive feeding strategies used by trout may overcome difficulties in finding food in turbid conditions. Klein et al. (2008, Part B) detailed the linkages between harvest rates, elevated chronic turbidity, reduced growth of juvenile salmonids, and impaired spawning escapement. Furthermore, Reeves et al. (1993) found that harvest rate was inversely associated with juvenile salmonid diversity.

Most research has implicated logging roads as the foremost harvest-related feature in elevated erosion and sedimentation. Roads, landings, and skid trails can be a source of landslides (Keppeler et al., 2003) and surface erosion (e.g., Reid and Dunne, 1984; Johnson, 1988). Within-unit erosion and sediment delivery from mass movement and gullying also contribute to elevated post-logging sediment discharge (e.g., Brardinoni et al., 2003; Reid et al., 2010).

Timber harvesting and road building standards have certainly evolved since Lieberman and Hoover (1948) conducted their study. Forest practice rules in California (following passage of the Z'berg-Nejedly Forest Practice Act of 1973) devote much language to restricting practices that were most damaging to streams and hillslopes. Numerous rule changes and additions have been incorporated since the 1970s. The rules are, in effect, best management practices (or BMPs), and are generally considered to perform reasonably

* Corresponding author. Tel.: +1 707 825 5111; fax: +1 707 822 8411.
E-mail addresses: Randy_Klein@nps.gov, rdklein@sbcglobal.net (R.D. Klein), jacklewis@suddenlink.net (J. Lewis), mbuffleben@waterboards.ca.gov (M.S. Buffleben).

0169-555X/$ – see front matter Published by Elsevier B.V.
doi:10.1016/j.geomorph.2011.10.011

well if implemented properly and in a timely manner. However, BMPs, even when aggressively applied, cannot prevent all erosion from harvested slopes and forest roads (Keppeler et al., 2003; Reid et al., 2010), and the cumulative effects from multiple harvest areas may be additive (Lewis et al., 2001) or synergistic where one erosion feature triggers another (e.g., a debris flow plugs a culvert, which then diverts stormflow down a logging road, triggering gully formation and landsliding) or a biological threshold is crossed. Consequently, although BMPs may reduce erosion and sediment delivery for a given harvest area relative to unregulated harvesting, if too large a proportion of a watershed is subject to harvest-related disturbances in a compressed time frame, water quality can be seriously degraded and stream biota harmed (Henley et al., 2000; Klein et al., 2008).

The use of turbidity to assess the water quality impacts of forestry operations has increased in California and is used at various scales (Harris et al., 2007). Long-term turbidity monitoring programs, some limited to grab sampling, have been used to detect recovery trends in Washington (Reiter et al., 2009). Since Lewis (1996) demonstrated the effectiveness of using turbidity as a surrogate for suspended sediment concentration in load estimation, many northern California stream gaging stations have been equipped with automated turbidity sensors coupled with pumping samplers. This technological shift has improved suspended load estimation over competing methods that rely on sediment rating curves and stream discharge. This paper utilizes the data being collected by automated turbidity sensors in forested watersheds along the northern California coast to identify watershed characteristics and land use histories that are the principal causes of elevated turbidity regimes.

2. Study area

Our study area spans three coastal counties in northern California (Del Norte, Humboldt, and Mendocino counties, Fig. 1). All are located in the Coast Range Mountains from about 240 to 500 km north of San Francisco. The region is subject to high rates of tectonic uplift and strong earthquakes. Slopes typically are steep and soils highly erodible. Rainfall occurs almost exclusively in the winter months, often as multiday intense rainfall events that produce large floods. The combination of these factors results in some of the highest sediment loads in the U.S. (Paulson et al., 1993), although within-region variability is considerable. While much can be attributed to natural processes, human disturbance can greatly accelerate erosion and sediment delivery to streams.

The 28 watersheds for which turbidity data were assembled range in drainage area from 2.9 to 72.8 km^2 (Table 1), with several smaller watersheds nested within larger ones. Because these are small coastal watersheds, snow accumulation and melt are seldom hydrologically significant. Turbidity levels in the region are largely a function of suspended sediment concentrations, and the two are typically well-correlated (Lewis, 2002). The largest portion of stream-suspended loads consists of inorganic particles generated from erosion of mineral soils and rock via surface erosion from bared areas, gully, and mass erosion processes. Adequate continuous turbidity data were available for up to 28 sites, as listed in Table 1.

The study watersheds included several that are virtually pristine redwood forests and several harvested 40+ years ago residing in Redwood National and State Parks. Others are located on private or state-owned timberlands and subject to varying levels of past and ongoing timber harvest along with minor influences from ranching and residential development. Two of the streams (North and South Fork Caspar Creek) are located within an experimental forest that is the site of long-term watershed research (Henry, 1998).

3. Methods

To prepare for the analysis, continuous (10- or 15-minute sampling interval) turbidity data sets were assembled from various sources, including Federal agencies, a nonprofit group, a private timber company, and individuals (see Klein et al., 2008, for a detailed listing of data contributors). In addition to turbidity, data sets also included continuous stream stage and often discharge data. Our data analysis period spanned three water years (WY2003-2005), but not all of the 28 sites had adequate data for each year, as indicated in Table 1. Because WY2005 had the greatest number of sites with complete data, that year was chosen for more detailed analyses.

Automated turbidity data were collected by deploying sensors in the water column using an articulating boom secured above the stream (see Eads and Lewis, 2002, for a description). An onshore data logger controls sensor operation and records stage and turbidity data. Only rarely are automated turbidity data sets free from spurious observations upon retrieval from the field. Raw data must be reviewed and corrected as needed prior to being considered representative of field conditions and thus ready for analysis. Most data contributors provided corrected turbidity data, but some data were provided in raw form and needed corrections.

To make corrections, data were imported to a common spreadsheet and plotted along with stage and/or discharge data. Such plots are essential for revealing suspect data, which usually consist of short duration spikes reflecting a leaf or some other object obscuring sensor optics or gradually ascending values that reflect algal growth on sensor optics. Corrections consisted of reducing suspect values to match valid observations bounding the suspect data. Corrected observations typically composed very small percentages (mean = 7%) of the full data sets used.

Another important issue in comparative turbidity studies is compatibility (or lack thereof) of data collected using different sensor types or makes (Davies-Colley and Smith, 2001). In laboratory testing, Lewis et al. (2007) found that different sensors returned sometimes very different turbidity values when immersed in the same sediment type and concentration. The greatest differences occurred at high turbidities. The present study included data from two sensor types commonly used for stream studies in the region: the OBS-3 sensor (formerly made by D&A Instruments Company, presently made by Campbell Scientific, Inc.) and the DTS-12 sensor (made by Forest Technology Systems, Inc.). Equations were developed for application to specific watersheds using the results of Lewis et al. (2007), and OBS-3 data were converted to equivalent values for the DTS-12 before conducting turbidity exceedence analyses, as detailed in Klein et al. (2008). Data for the 2003, 2004, and 2005 winter runoff seasons (WY2003, 2004, and 2005) were assembled and prepared for analysis.

Before performing exceedence analyses, data sets were truncated to include data from only December–May, the rainy season that typically encompasses almost all turbidity events. Although this period excluded several small, early season storms, several of the assembled data sets had irreparable or no data prior to December. As with flow duration analyses, we sorted the turbidity data from largest to smallest and computed the percent of time each value was equaled or exceeded (i.e., exceedence probability). The 10% exceedence probability (that turbidity level exceeded 10% of the time being considered, or 10%TU) was derived from the continuous data to represent chronic turbidity. Turbidity at the 10% exceedence level captures stormflow turbidities that occur between storm peaks and winter baseflows, providing a single value to index chronic exposure for salmonids.

Geographical information system (GIS) and other data were obtained for the study watersheds to characterize both the natural and human-affected propensity for watershed erosion and stream turbidity. The variables considered for analysis are listed in Table 2. Data categories included natural watershed physiographical characteristics (hypsometry, slope steepness, stream density, slope stability modeling results, and rainfall intensities), historical timber harvest and associated activities (yarding, road building) from California timber harvest plan ('THP') records, and attributes of the road network. U.S. Geological Survey 10 m DEM data were used to compute

Please cite this article as: Klein, R.D., et al., Logging and turbidity in the coastal watersheds of northern California, Geomorphology (2011), doi:10.1016/j.geomorph.2011.10.011

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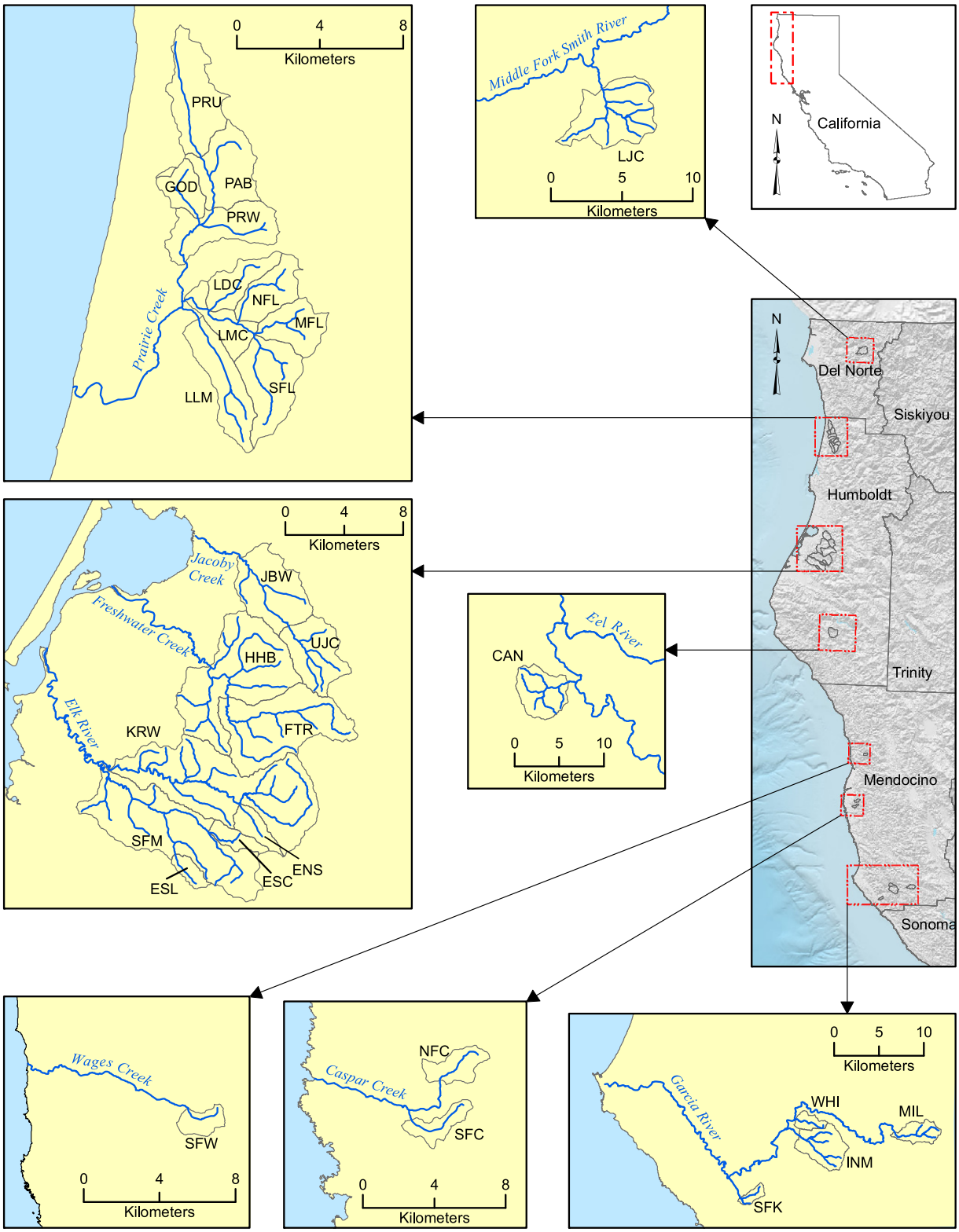

Fig. 1. Watersheds and counties in study area, north coastal California.

watershed slope and hypsometric integral (Dowling, et al., 1998) and for input to SINMAP (Pack et al., 1998), a slope stability modeling program that outputs 'stability index,' or factor of safety (FS), map data indicating areas of relatively high likelihood of shallow debris slides. Road and stream data were also obtained from the U.S. Geological Survey. THP data files were obtained from the California Department of Forestry and Fire Protection and included harvest acreages and road data from within harvest areas. These data were used in regression analyses with WY2005 10%TU as the dependent variable to determine which were the best predictors of chronic turbidity.

Different types of timber harvest impose different disturbance levels per unit area of harvest, with clearcut harvest and tractor yarding (still widely used) creating most disturbance. Consequently, harvest areas were weighted by the silvicultural method according to

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Table 1
Attributes of streams and watersheds used in this study.

Stream [a]	Site Code	Harvest Catergory	Drainage area (km^2)	Mean basin slope (%)	Basin relief (m)	Mean annual precip.[b] (mm)	Data period WY
Whitlow Creek	WHI	High	4.9	41	427	1400	2004–05
S Branch NF Elk River	*ENS*	High	4.9	31	518	1400	2004–05
North Fork Elk River	*KRW*	High	57.4	35	701	1400	2003–05
Inman Creek	INM	High	19.5	43	579	1400	2005
Corrigan Creek	*ESC*	High	4.1	33	396	1400	2004–05
South Fork Elk	*SFM*	High	50.0	30	610	1400	2004–05
North Fork Caspar Creek	NFC	High	4.8	36	244	1400	2003-05
Freshwater Cr at HH Bridge	*HHB*	High	72.8	32	671	1400	2005
Lower Jacoby Creek	*JBW*	Low	35.1	32	640	1400	2003–05
Upper Jacoby Creek	*UJC*	Low	15.1	38	488	1400	2003–05
Freshwater Creek at Roelofs	*FTR*	Low	33.1	38	853	1400	2004–05
Mill Creek	MIL	Low	9.4	39	305	1400	2004–05
SF Wages ab Center Gulch	SFW	Low	2.9	58	488	1400	2004–05
South Fork Caspar Creek	SFC	Low	4.1	33	305	1400	2003–05
South Fork Garcia R	SFK	Low	3.5	45	579	1400	2005
Prairie Cr above May Cr	*PRW*	Legacy	33.4	29	549	1650	2004–05
South Fork Lost Man Creek	*SFL*	Legacy	10.2	39	610	1650	2003–05
Lost Man Creek at Hatchery	*LMC*	legacy	31.3	30	427	1650	2003–05
Middle Fork Lost Man Creek	*MFL*	Legacy	5.8	36	518	1650	2004–05
North Fork Lost Man Creek	*NFL*	Legacy	5.8	34	488	1650	2004–05
Larry Damm Creek	*LDC*	legacy	4.8	26	488	1650	2004–05
Little Jones Creek	LJC	Legacy	22.3	51	945	2670	2003–05
Canoe Creek	*CAN*	Legacy	26.2	43	975	2670	2004–05
Little South Fork Elk River	*ESL*	pristine	3.1	23	244	1400	2004–05
Godwood Creek	*GOD*	Pristine	3.8	29	213	1650	2003–05
Little Lost Man Creek	*LLM*	Pristine	9.1	29	640	1650	2003–05
Prairie Cr above Boyes Cr	*PAB*	Pristine	19.9	31	427	1650	2004–05
Upper Prairie Creek	*PRU*	Pristine	10.8	29	396	1650	2003–05

[a] Humboldt County subset streams appear in *italics*.
[b] From isohyetal maps at: http://frap.cdf.ca.gov/webdata/maps/statewide/rainmap.pdf.

state guidelines (NCRWQCB, 2006) to account for varying levels of ground disturbance and potential water quality impacts. Weighting of the silvicultural prescription ground surface areas by the values listed in Table 3 reduced the effective areas of lower disturbance types, and resultant harvest rate variables were expressed as 'clearcut equivalent area.' Harvest, yarding, and road building data up to 15 years (1990–2004) prior to the turbidity measurements (WY2005) were assembled from timber harvest plan records kept by the California Department of Forestry and Fire Protection. This period was broken into three 5-year subperiods (see Table 2) to explore the relative importance of harvest age. Clearcut equivalent harvest rate was expressed as the annual mean percent of watershed area for individual time periods used.

Multiple regression analyses were performed to determine which watershed variables best explained differences in chronic turbidity for WY2005 among the watersheds since this water year had most stations. Regressions were performed on two groups: (i) all streams and (ii) a subset of streams loosely clustered in Humboldt County, CA. Regressions initially used only the highest correlate with the *Y*-variable (10%TU) from each watershed variable category, and additional variables were subsequently added if they significantly improved the model. When no further improvement was possible by adding variables, improvement was sought by substituting highly correlated predictors for one another. The primary diagnostic for evaluating model improvement was the corrected Akaike's Information Criterion (AIC_c) (Burnham and Anderson, 2002). The best model was considered to be the one that minimized the AIC_c. Because a wildfire severely burned nearly 75% of Canoe Creek (CAN) in 2003 (Scanlon, 2007) just prior to the turbidity records used here, this watershed was omitted from the regression analyses.

We considered it important to investigate whether we might be overfitting our data in the regression analysis by having the luxury of selecting among 30 predictors: if one has enough random variables, a 'good' relationship can always be found between the predictors and the response variable. So, a permutation test (Good, 2005) was performed by randomly reassigning the 10%TU (response variable) to our vector of 30 explanatory variables 1000 times and fitting a stepwise regression with two predictors to each resulting data set. The proportion of regression r^2 values at least as great as that obtained for the actual sample is indicative of whether or not our response is truly related to the predictors or whether the relationship appears significant as a result of fitting the model to noise.

As an additional test of overfitting and to determine how well the model could be expected to perform with independent data, prediction error was calculated (Efron and Tibshirani, 1993) leaving one observation out at a time. In this procedure, each observation is predicted from the regression coefficients calculated without that observation. The cross-validation prediction error is computed as the root mean square difference (RMSE) between each prediction and its observed response.

As noted earlier, some of our sites were nested within each other, raising the concern that the regression assumption of independence may have been violated. If there is such a dependency then reported *p*-values may be too low. To investigate this possibility, absolute differences between regression residuals for each watershed pair were evaluated in relation to watershed nesting factor, defined as the proportion of the larger watershed occupied by the smaller. The absolute differences were transformed as needed to normalize them for t-tests and regression. We then looked for significant differences between their means for nested and nonnested watershed pairs in the full data set and the Humboldt County subset, and examined linear regressions of the transformed differences on nesting factor. Similar residuals (i.e., smaller transformed differences) for nested or more highly nested watersheds would indicate lack of independence.

The watersheds (except Canoe Creek) were also placed into harvest rate categories, including pristine (never harvested), legacy (no harvest since 1990), low harvest (<1.4% CCE 10–15), and high harvest (≥1.5% CCE 10–15). To evaluate where legacy-harvested watersheds fall in the spectrum from pristine watersheds to those that have been intensively harvested in recent years, we performed another type of

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Table 2
Predictor variables considered in regression analyses.

Watershed variables	Units	Code
Drainage area	km^2	DRA
Mean watershed slope	Percent	AWS
Perrenial stream density	km/km^2	PSD
Intermittent stream density	km/km^2	ISD
Total stream density	km/km^2	TSD
SINMAP area with FS < 1	Percent of area	SIN < 1
SINMAP area with FS 1.0-1.1	Percent of area	SIN 1.0
SINMAP area with FS 1.1-1.2	Percent of area	SIN 1.1
SINMAP area with FS > 1.2	Percent of area	SIN > 1.2
Hypsometric integral	n/a	HYP
Basin relief	Meters	RLF
WY2005 annual precipitation recurrence interval	Years	ANP
WY2005 max. 1-day precipitation recurrence interval	Years	1DP
WY2005 max. 2-day precipitation recurrence interval	Years	2DP
WY2005 max. 3-day precipitation recurrence interval	Years	3DP
Basin-wide road characteristics		
Basin-wide road density: all roads	km/km^2	GRD
Basin-wide road density: lower slope roads	km/km^2	LSRD
Basin-wide road density: mid-slope roads	km/km^2	MSRD
Basin-wide road density: upper slope roads	km/km^2	USRD
Data from approved THPs [a]		
Clearcut equivalent area, 1990–2004	Weighted % of area	CCE 0–15
Clearcut equivalent area, 1995–2004	Weighted % of area	CCE 0–10
Clearcut equivalent area, 2000–2004	Weighted % of area	CCE 0–5
Clearcut equivalent area, 1995–1999	Weighted % of area	CCE 5–10
Clearcut equivalent area, 1990–1994	Weighted % of area	CCE 10–15
Tractor yarded area, 1990–2004 (15-yr)	Percent of area	TYA-15
Permanent roads constructed 1990–2004	km/km^2	PRC-15
Seasonal roads constructed 1990–2004	km/km^2	SRC-15
Temporary roads constructed 1990–2004	km/km^2	TRC-15
Temporary and seasonal roads constructed 1990–2004	km/km^2	TSR-15
All nonpaved roads constructed, 1990–2004	km/km^2	ARC-15

[a] THP data (road lengths, harvest, and yarding areas) are expressed on a per-unit area basis for the entire gaged watershed; clearcut equivalent area (CCE) variables are expressed on a mean annual basis.

permutation test (Good, 2005) to compare means between the legacy group and each of the other groups. For this test we utilized 2004 and 2005 data. The permutation test was selected because it is an exact, easily interpretable, nonparametric test suitable for small sample sizes, and it can be used with unbalanced repeated measures designs. The data are unbalanced because three more sites were available in 2005 ($n=27$) than in 2004 ($n=24$). And the 2004 and 2005 measurements of 10%TU for a given station are highly correlated ($r=0.96$), so they must be treated as repeated measures. For this permutation test, the group labels for any two groups being compared are reassigned to the paired (2004, 2005) turbidity values, in every possible permutation, and the 2004 and 2005 differences in mean 10%TU between the two groups are computed for each permutation. The proportion of permutations for which both the 2004 and 2005 differences equal or exceed the differences observed in the actual sample is interpreted as the probability of the observed result having occurred if group identity were unrelated to 10%TU. A small probability indicates that there is a significant relation between harvest rate and turbidity. For the comparison between legacy and pristine groups, a one-sided test was used, as the only reasonable alternative to the null hypothesis of no difference is that legacy watersheds have higher turbidity. For the comparisons between legacy and the contemporary harvest groups, two-sided tests were employed, because the relative impacts of legacy and contemporary harvesting are controversial. In the two-sided tests, the absolute values of the differences are compared rather than the raw differences.

The 10%TU represents just one point along a turbidity duration curve that we used to characterize relatively low, chronic turbidity for this analysis. As is intuitively obvious and evident from the biological literature cited above, higher turbidities can also have biological impacts. To provide a more comprehensive portrayal of the range of turbidities among the four harvest categories, we took the means of WY2005 turbidity values for the sites within each category at each probability and plotted the group mean turbidity duration curves.

4. Results

Rainfall for WY2005 was near normal at about 90% of the mean in the northern portion of the study area and slightly above normal in the southern portion. Turbidities at the 10% exceedence probability ranged from 3 to 116 FNU (formazin nephelometric units; Anderson, 2004), as shown in Table 4 along with turbidities at several other exceedence levels. The cumulative time > 25 FNU spanned a factor of 100, ranging from 15 to 1566 h, as shown in Table 4 along with cumulative hours above several other turbidity levels. Water in the most turbid streams rarely (and only briefly) fell to < 25 FNU (approximate threshold for biological effects) the entire wet season. In contrast, some streams were exceptionally clear, with five located in Federally-protected areas only exceeding 100 FNU for just 0–2 hours total in WY2005.

Table 5 summarizes turbidity results for the study streams (CAN omitted) for WY2004 and WY2005 grouped as harvest rate categories. Means of harvest rate, drainage area, and 10%TU are shown for each water year. The permutation tests indicated that the legacy group was significantly more turbid than the pristine group ($p=0.0088$), and less turbid than the high harvest group ($p=0.0009$), but not significantly different from the low harvest rate group ($p=0.0542$). In WY2005, mean 10%TU nearly doubled with each step upward in harvest category from pristine to high harvest; results for WY2004 showed slightly smaller increases. The 10%TU for individual sites within each category are plotted in Fig. 2 to illustrate the range of turbidities within each category, which also increases with each step upward in harvest intensity. While some legacy and low harvest sites had low turbidities (nearly as low as some pristine sites), none among the high harvest category were < 24 FNU.

Turbidity duration curves for the harvest categories are plotted in Fig. 3. As illustrated, the differences in turbidity among harvest categories extended throughout the range of recorded turbidities. Differences were large at the 10% exceedence probability and increased at lower exceedence probabilities (less frequently occurring, higher turbidities). For example, the mean for pristine streams was 36 FNU at the 1% and 113 FNU at the 0.1% exceedence levels, while the means for high harvest were 290 and 734 FNU, respectively.

The best fit from multiple regression analyses using both the full set of streams ($n=27$ with CAN omitted) and the Humboldt County

Table 3
Weighting factors for areas of silvicultural prescriptions.

Silvicultural prescription	Weighting factor
Clearcut	1.00
Commercial thin	0.50
Group selection	0.50
Rehabilitation of understocked areas	1.00
Road right of way	1.00
Sanitation salvage	0.75
Shelterwood preparation cut	0.75
Shelterwood removal cut	0.75
Shelterwood seed cut	0.75
Selection	0.50
Seed tree removal cut	0.75
Seed tree seed cut	0.75
Alternative prescription	0.75
Variable retention	0.50

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Table 4
Harvest rates, turbidities at specified exceedence probabilities, and cumulative hours above specified turbidities for WY2005.

Site	Harvest rate	Turbidity (FNU) at specified exceedence					Cumulative hours above specified turbidity					
Code [a]	CCE10-15	0.1%	1%	2%	5%	10%	1000	500	200	100	50	25
SFM	2.43%	1245	551	370	185	116	11	54	195	513	936	1566
KRW	3.87%	766	376	271	161	93	1	25	157	399	810	1538
ENS	3.98%	1416	483	303	144	76	13	41	150	320	678	1290
HHB	2.20%	620	281	197	107	67	1	8	85	238	670	1413
FTR	1.10%	675	254	167	87	57	0	8	67	184	550	1363
CAN	0.00%	509	225	152	92	56	0	6	56	186	485	936
JBW	1.32%	794	307	205	96	53	1	14	90	211	470	1016
ESC	2.64%	785	249	148	78	50	1	14	56	140	440	1058
UJC	1.15%	1662	293	167	75	42	8	23	71	150	349	860
SFC	0.03%	258	110	77	48	37	0	0	10	52	197	909
NFC	2.21%	359	107	65	43	33	0	0	17	46	174	829
WHI	4.66%	416	149	92	48	29	0	2	26	78	209	552
INM	2.93%	327	127	64	40	26	0	0	24	53	138	504
SFL	0.00%	548	197	107	42	22	0	7	43	94	187	387
MFL	0.00%	590	157	87	40	21	0	8	32	76	172	379
LMC	0.00%	494	131	72	33	18	0	4	27	62	136	317
MIL	0.18%	235	99	73	34	18	0	0	6	43	140	308
NFL	0.00%	343	145	79	36	18	0	0	29	67	150	322
LDC	0.00%	213	106	66	31	16	0	0	7	48	120	278
LLM	0.00%	256	77	47	26	16	0	0	11	32	78	227
PRW	0.00%	290	94	55	26	14	0	0	11	38	98	229
ESL	0.00%	79	31	22	16	12	0	0	0	2	15	71
SFK	0.01%	259	71	45	20	11	0	0	10	24	76	180
PRU	0.00%	81	26	17	10	6	0	0	0	1	16	45
GOD	0.00%	66	23	16	9	6	0	0	0	0	12	34
LJC	0.00%	41	25	14	8	5	0	0	0	0	0	46
SFW	0.07%	60	15	10	6	4	0	0	0	0	7	16
PAB	0.00%	82	24	14	6	3	0	0	0	1	14	41

[a] See Table 1 for corresponding stream names; *italics* indicates Humboldt County streams; data in bold are pristine sites.

subset ($n=19$ with CAN omitted) included just two explanatory variables: clearcut equivalent area for the period 10–15 years before the WY2005 turbidity record (1990–1994) and drainage area. Clearcut equivalent area was highly significant ($p<0.0002$) in both models. Drainage area was highly significant ($p=0.0013$) in the full set model, but less so ($p=0.018$) in the Humboldt County set. The full set model resulted in an RSE (residual standard error) of 17.5 and adjusted multiple r^2 of 0.63. Other models using just harvest rate (including annual mean harvest rate 0–15 years prior to the turbidity record) also performed well. Regressions using the Humboldt County stream subset ($n=19$) had a superior fit over that for the full set with an RSE of 13.7 and adjusted multiple r^2 of 0.82. A comparison of observed and predicted 10%TU from these regressions (Figs. 4 and 5) illustrates the lower variance for the Humboldt County set and shows that nearly all streams conform fairly well to the models. The most significant outlier in both models is South Fork Elk River (SFM), which lies mainly in the Wildcat Formation, a highly erodible geologic unit formed largely from poorly consolidated Tertiary alluvial sediments.

In the permutation tests for regression overfitting, out of 1000 stepwise regressions on data sets with randomly shuffled responses, only one had an r^2 (0.672) exceeding that of the observed full data

Table 5
Turbidities of harvest rate category group means for WY2004–2005 and permutation test p-values.

Harvest category	Harvest rate	Drainage area (km^2)	WY2005 10%TU (FNU)	WY2004 10%TU (FNU)	Permutation Test p-value
High	3.1%	27.3	61	52	0.001
Low	0.6%	14.7	32	26	0.054
Legacy	0.0%	16.2	16	16	N/A
Pristine	0.0%	9.3	8	6	0.009

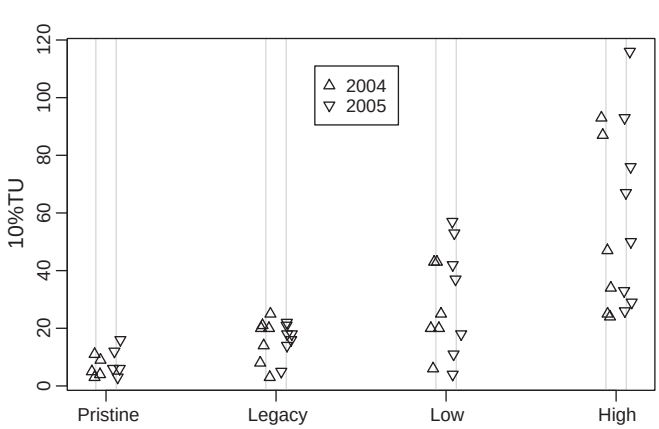

Fig. 2. 10%TU for study sites grouped by harvest rate category.

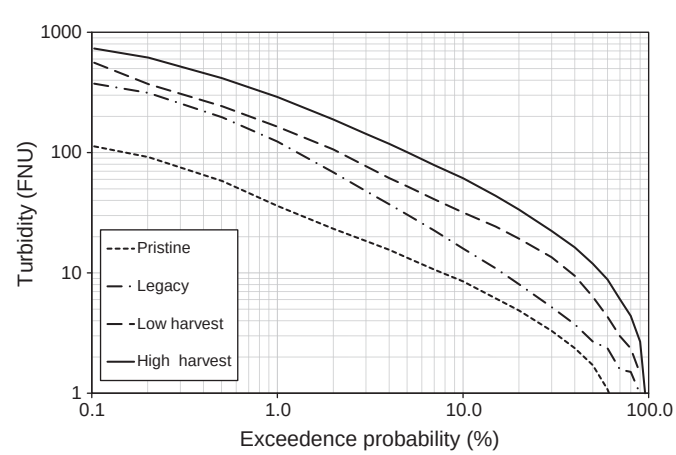

Fig. 3. Turbidity duration curves for WY2005 for four harvest rate categories.

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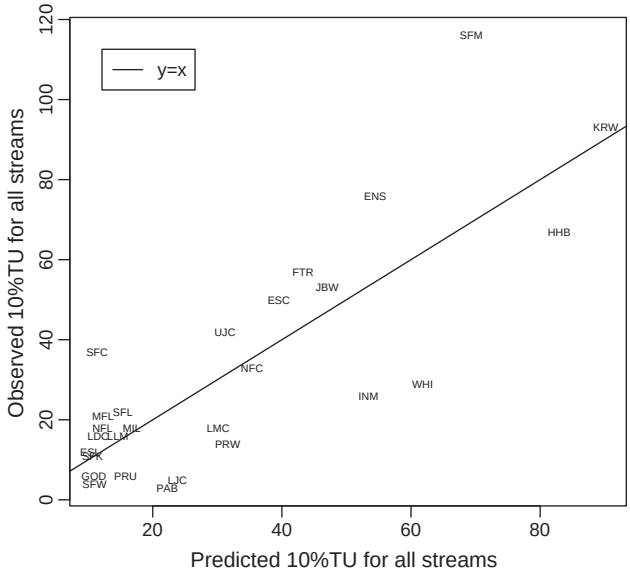

Fig. 4. Observed 10%TU values for 27 streams (excludes Canoe Creek) compared to those predicted by regression on drainage area and clearcut equivalent area for the period 10–15 years before the WY2005 turbidity record.

set (0.660). For the Humboldt County subset, none of the 1000 regressions produced an r^2 exceeding that of the observed data (0.842). The highest r^2 for the permuted Humboldt data sets was 0.784. These tests indicate an underlying relationship between our predictors and 10%TU (and drainage area) that is not a fortuitous result of the number of explanatory variables considered.

Cross-validation prediction error, leaving out one observation at a time from the full data set ($n=27$), was 23.6 FNU for the regression model without drainage area, compared with 20.3 when drainage area was included and 16.5 for the regression on the full data set. These results support the inclusion of drainage area in the model but indicate a bias of 3.8 FNU in the RMSE of the unvalidated two-variable model. For the Humboldt County data set, the corresponding prediction errors were 17.6, 15.7, and 12.6, again supporting the inclusion of drainage area and indicating a bias of 3.1 FNU in the RMSE of the unvalidated two-variable model. Such bias in estimated prediction error is to be expected with small data sets such as these.

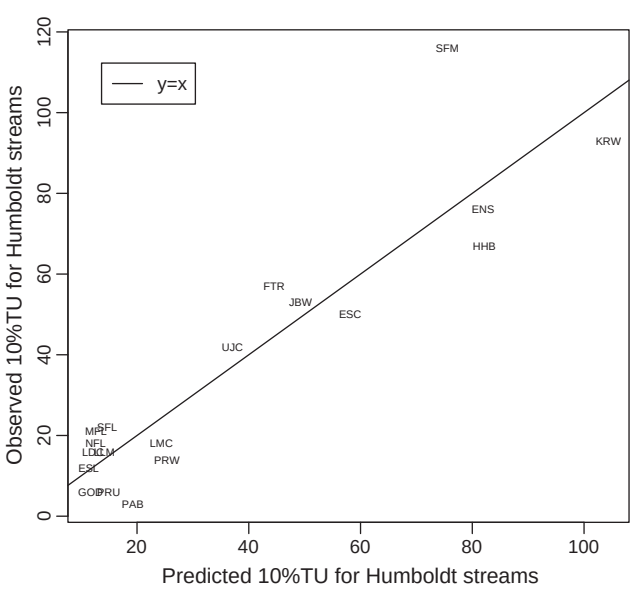

Fig. 5. Observed 10%TU values for 19 Humboldt county streams (excludes Canoe Creek) compared to those predicted by regression on drainage area and clearcut equivalent area for the period 10–15 years before the WY2005 turbidity record.

The tests for independence of nested watersheds revealed no significant difference between the means of the transformed differences for nested and non-nested watershed pairs for the full data set ($p=0.97$) or the Humboldt County subset ($p=0.80$). A cube root transformation was found to best normalize the absolute differences between residual pairs. Linear regressions of the transformed differences on nesting factor were also not significant ($p=0.33$ full data set, $p=0.69$ Humboldt County subset). Lack of independence would have to be very marked to invalidate the highly significant regression results for harvest rate, and there is scant evidence in our data that nested watersheds were correlated.

5. Discussion

The rate of timber harvest, expressed as mean annual clearcut equivalent area for the period 10–15 years preceding the turbidity data record, explained much of the large differences in chronic turbidity among the study watersheds, with drainage area playing a subordinate, but still significant, role. These findings suggest the importance of rate of timber harvest and were consistent with the earlier results of Klein (2003) in a similar study, for which fewer sites were available.

Basin geomorphic characteristics reflect basin-shaping processes and susceptibility to erosion-accelerating disturbances. To account for this, several variables (e.g., watershed slope and relief, stream density, SINMAP shallow landsliding potential) were derived for the study watersheds to serve as surrogates for natural erosion susceptibility. However, their contribution in explaining turbidity variations was insufficient to be included in the best fit regression models. Certainly, natural factors that determine the inherent erosional susceptibility of hillslopes exert strong control on stream water quality, but with the exception of drainage area, they were overshadowed by human disturbance in this study. By narrowing the geographical range of streams to just the Humboldt County subset, geography was used to reduce natural variability and regression results were improved.

Contrary to our expectations, some research results (Anderson, 1970, 1975, 1979; Reid and Dunne, 1984), and conventional wisdom, road variables added little statistical value beyond harvest rate and drainage area in explaining turbidity variations, possibly resulting from incomplete and/or inaccurate road data. For example, road lengths are probably underrepresented in 'off-the-shelf' data sets used here. Perhaps more accurate road data would have elevated the importance of road variables in explaining turbidity. But roads were indirectly accounted for in that they are closely linked to harvest rate: the density of the road network and the intensity of road use typically rise with increasing harvest rate. The correlations in the full data set were $r=0.80$ ($n=28$, $p<0.001$) between 15-year mean annual harvest rate and basin-wide road density and were $r=0.70$ ($n=28$, $p<0.001$) between mean annual harvest rate and nonpaved road construction in the 15 years prior to the turbidity data period (WY2005).

Large differences were observed in WY2004-2005 turbidities at the 10% exceedence level between managed watersheds and background levels exhibited by pristine streams. Even streams with no harvest in the prior 15 years, legacy sites, as a group, would have been far out of compliance with the regulatory limit for northern California streams: "Turbidity shall not be increased more than 20% above naturally occurring background levels" (NCRWQCB, 2011, p. 3–3.00). Individually, all but two actively harvested watersheds would have been out of compliance with this standard in WY2005, a relatively normal hydrologic year. We note that extremely destructive harvesting prior to implementation of California's forest practice rules in about 1980 (legacy effects) is a likely contributor to 10%TU in

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all but the pristine category of our watersheds. Legacy harvest erosional features are often cited as primarily responsible for persistent turbidity impairment in actively harvested watersheds, but our data suggest this is only partly true. As shown in Table 5, the mean 10%TU for the low harvest group was twice that of the legacy group (though the difference was not statistically significant), and the mean for the high harvest group was nearly four times that of the legacy group. Thus, the extent of water quality degradation in actively harvested watersheds, wherein modern BMPs are used, cannot be solely attributed to residual effects of more destructive harvesting practices of the past. In fact, modern logging practices appear to be the dominant factor, with turbidity impairment rising with increasing rate of harvest.

The fact that clearcut equivalent area for the period 10–15 years preceding the turbidity dataset was the best predictor of chronic turbidity suggests that harvesting could have much larger impacts and last for much longer time periods than in the paired watershed studies cited by Gomi et al. (2005). One reason for this lag time in harvest effects may be the role of root biomass and decay following harvest (Burroughs and Thomas, 1977; Ziemer, 1981). With respect to the redwood-dominated forests of our analysis, previous work (Ziemer and Lewis, 2006, unpublished) indicated that live redwood root mass declined rapidly for the first few years before starting to increase again, while dead root mass increased for 5–10 years before declining. Total root biomass reached a minimum at 10–15 years after harvest in redwood forests, declining slower and to a lesser degree than in the mixed conifer forests studied earlier by Ziemer (1981). The 15-year harvest period we considered likely encompassed root-strength minimums for harvest that took place in the beginning of the period. Although storm sequence is important too, landslides have the highest risk of occurring when the soil shear strength from roots reaches a minimum. Thus, a decade or more after harvest may be required before harvest-related landslides occur and elevate sediment production and turbidity. Logging appears to have increased the incidence of large landslides in the North Fork Caspar watershed. In 35 years of monitoring the North Fork Caspar Creek, the three largest landslides (1700–2600 m^3) all occurred on clearcut hillslopes 15, 12, and 10 years after harvesting (Reid, in press).

Compounding the loss of root strength following harvesting are the increased pore water pressures that must result from reductions in interception and transpiration. Reid and Lewis (2009) measured mean interception loss rates of 21% during large winter storms in the second-growth redwood and Douglas-fir stands of North Fork Caspar Creek. The corresponding increase in effective rainfall reaching the forest floor was 27%. Elevated soil moisture levels might last only a decade or so without further silvicultural treatments, but subsequent burning, herbiciding, and thinning is typical in many areas and can prolong or renew hydrologic changes (e.g. Keppeler et al., 2003). In addition to increasing the potential for landsliding, as Reid et al. (2010) showed, gullies may form or enlarge a decade or more following harvest within clearcut units because of elevated soil water. Thus, even in the absence of logging roads, sediment delivery through landsliding and gully erosion can impair downstream water quality long after an area is logged.

The crude weighting factors in Table 3 may not properly reflect relative changes in hillslope hydrology and root strength. For example, in second-growth redwood forests which have regenerated largely by root sprouting, groups of trees often share a common root system. When the forest is reharvested selectively, residual trees may be able to access harvested trees' root systems for water uptake, growing rapidly when the canopy is opened up, and resulting in less root dieback and more efficient water utilization than an 'equivalent' clearcut (Reid and Lewis, 2011). Further, since a given silvicultural method can be applied at varying intensities, a system that takes into account the proportion of basal area or wood volume removed from harvested areas would likely perform better than the blanket weightings used in this analysis.

Because they intersect frequently on the landscape, logging road stream crossings are perhaps the most prominent sources of delivery of sediment to streams. Erosion from within cut units is less likely to reach a stream, depending on site topographic and hydrologic attributes and the effectiveness of streamside buffers. Although buffers are a commonly applied BMP that limit the occurrences or volumes of sediment from reaching a channel, instances of 'break-through' (hillslope-eroded sediment passing through a buffer) can occur nonetheless, as we have observed in the field. Rivenbark and Jackson (2004) documented one breakthrough occurrence for about every 8 ha of clearcut forestlands in the southeastern U.S., with 14% of the 187 breakthroughs inventoried traveling > 30 m before reaching a stream channel.

We observed differences among geographically separated clusters of our data set. One noticeable trend was that watersheds in Mendocino County had lower turbidities, despite having relatively high harvest rates in some cases (particularly Inman and Whitlow Creeks; Table 4). One reason for this trend may be that winter operations are less prevalent in Mendocino County than in Humboldt County. Conducting timber operations during winter greatly increases the potential for sediment delivery because of the erosional effects of rainfall and runoff energy on freshly disturbed ground and log hauling on unsurfaced and poorly engineered roads. Furthermore, highly erodible soils, such as those formed on the Wildcat Formation in Humboldt County, have naturally greater turbidity levels and are particularly susceptible to land use disturbances.

6. Conclusions

Although the rate of timber harvest has been acknowledged among scientists, regulatory agencies, and legislators as a factor contributing to declining water quality and aquatic habitat for some time, regulatory controls on harvest rate do not presently exist. Instead, the regulatory community has largely relied on site-specific best management practices (BMPs) to attempt to maintain water quality. In a compilation of information on BMP programs for states in the Western U.S., the Council of Western State Foresters (2007) reported that compliance with BMPs, where quantified, was mixed. And although BMP effectiveness monitoring projects exist in several western states, little in the way of published results was found. Certainly BMPs have helped reduce site-specific erosion and resultant turbidity and suspended sediment impacts from timber harvest, but they are neither perfectly conceived nor perfectly implemented. Consequently, severe degradation of water quality can occur despite use of BMPs in watersheds where too much of the land base is harvested over too short a time period.

Contemporary erosion prevention treatments for logging roads (e.g., decommissioning of abandoned roads, 'storm-proofing' actively used roads) have greatly reduced threats to downstream water quality, but other factors contributing to cumulative watershed effects remain unaddressed. Current BMPs do not address the effects of tree removal on hillslope hydrologic changes and loss of root strength from decay. However, limiting the rate of harvest in erosion-prone terrain, perhaps in the form of new BMPs, could do much to close the gap between what regulatory programs desire to achieve and actual water quality conditions in streams.

Managing cumulative watershed effects requires a working, continually updated knowledge of the complexities of natural and anthropogenic factors and their interactions operating on a watershed scale, but such a process continues to elude regulatory institutions. Thirty years ago, Coats and Miller (1981) outlined the primary obstacles to that end and proposed several solutions, including a 'watershed information systems' approach to provide the knowledge base for cumulative effects management. Since then, technological

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advances in geographic information systems (GIS) make this approach more feasible. Whatever the tool applied, unless and until a watershed approach is taken that addresses the full spectrum of potential effects of timber harvesting, high levels of chronic turbidity will continue to impair salmonid populations and other aquatic biological resources in working forestlands.

Acknowledgments

The authors appreciate turbidity data contributions from the U.S. Forest Service Redwood Sciences Laboratory in Arcata, CA, the nonprofit group Salmon Forever, hydrologists Peter Manka and Terry Jo Barber (and her client, Mendocino County Resource Conservation District), Campbell Timber Company, and support from Redwood National and State Parks in operating turbidity stations in the Prairie Creek watershed. Adona White of the California North Coast Regional Water Quality Control Board secured and provided funding and logistical support for the project on which this paper is based.

References

Anderson, C.W., 2004. Turbidity (version 2.0). National Field Manual for the Collection of Water-quality Data. Techniques of Water-Resources Investigations. Book 9, Chap. A6, Section 6.7, U.S. Geological Survey. last accessed Sept. 7, 2011 at: http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html.

Anderson, H.W., 1970. Principal components analysis of watershed variables affecting suspended sediment discharge after a major flood. International Association of Scientific Hydrology. Publication 96, 404–416.

Anderson, H.W., 1975. Sedimentation and turbidity hazards in wildlands. Watershed Management. Proc. Watershed Management Symposium, Div. Irrigation and Drainage: Am. Soc. Civil Eng. Logan, Utah Aug 1–13, pp. 347–376.

Anderson, H.W., 1979. Sources of sediment-induced reductions in water quality appraised from catchment attributes and land use. Proc. Third World Congress on Water Resources. Mexico City, April 23–28, vol. 8, pp. 3603–3613.

Brardinoni, F., Slaymaker, O., Hassan, M.A., 2003. Landslide inventory in a rugged forested watershed: a comparison between air-photo and field survey data. Geomorphology 54, 179–196.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference: a Practical Information-theoretic Approach, 2nd Edition. Springer-Verlag, New York, USA.

Burroughs Jr., E.R., Thomas, B.R., 1977. Declining root strength in Douglas-fir after felling as a factor in slope stability. U.S.D.A. For. Serv. Intermountain For. & Range Exp. Sta. Res. Paper INT-190. 27 pp.

Coats, R.N., Miller, T.O., 1981. Cumulative silvicultural impacts on watersheds: a hydrologic and regulatory dilemma. Environmental Management 5 (2), 147–160.

Council of Western State Foresters, 2007. Forestry Best Management Practices for Western States: a Summary of Approaches to Water Quality Implementation and Effectiveness Monitoring, Lakewood, CO. 20 pp.

Davies-Colley, R.J., Smith, D.G., 2001. Turbidity, suspended sediment, and water clarity: a review. Journal of the American Water Resources Association 37 (5), 1085–1101.

Dowling, T.I., Richardson, D.P., O'Sullivan, A., Summerell, G.K., Walker, J., 1998. Application of the hypsometric integral and other terrain based metrics as indicators of catchment health: a preliminary analysis. Technical Report No. 20/98, CSIRO Land and Water, Canberra, Australia. 49 pp.

Eads, R., Lewis, J., 2002. Continuous turbidity monitoring in streams of northwestern California. In: Gray, J. (Ed.), Turbidity and Other Sediment Surrogates Workshop Proceedings. U.S. Geological Survey, Reno, NV. 3 pp.

Efron, B., Tibshirani, R.J., 1993. An introduction to the bootstrap. Monographs on Statistics and Applied Probability, 57. Chapman and Hall, New York.

Gomi, T., Moore, R.D., Hassan, M.A., 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. Journal of the American Water Resources Association 41 (4), 877–898.

Good, P., 2005. Permutation Tests: a Practical Guide to Resampling Methods for Testing Hypotheses, 3rd Ed. Springer Series in Statistics, New York.

Harris, R.R., Sullivan, K., Cafferata, P.H., Munn, J.R., Faucher, K.M., 2007. Applications of turbidity monitoring to forest management in California. Environmental Management 40, 531–543.

Henley, W.F., Patterson, M.A., Neves, R.J., Lemly, A.D., 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. Reviews in Fisheries Science 8 (2), 125–139.

Henry, N., 1998. Overview of the Caspar Creek watershed study. Conference on Coastal Watersheds: The Caspar Creek Story, May 1998, Ukiah, CA. : Gen. Tech. Rep. PSW-GTR-168. U.S.D.A. Forest Service, Albany, CA, pp. 1–9.

Johnson, R.C., 1988. Changes in the sediment output of two upland drainage basins during forestry land use changes. In: Bordas, M.P., Walling, D.E. (Eds.), Sediment Budgets: Proceedings of the Porto Alegre Symposium, Porto Alegre, Brazil. Intl. Asso. Hydol. Sci., Wallingford, U.K. , pp. 463–471.

Keppeler, E., Lewis, J., Lisle, T.E., 2003. Effects of forest management on streamflow, sediment yield, and erosion, Caspar Creek experimental watersheds. The First Interagency Conference on Research in the Watersheds, Benson, AZ. U.S. Dept. of Agriculture, Agricultural Research Service, Beltsville, MD. 6 pp.

Klein, R.D., 2003. Duration of turbidity and suspended sediment transport in Salmonid-bearing streams, North Coastal California. Report to U.S. Environmental Protection Agency, San Francisco, CA. 26 pp.

Klein, R.D., Trush, W.J., Buffleben, M.S., 2008. Watershed condition, turbidity, and implications for anadromous salmonids in North Coastal California Streams. Report to North Coast Regional Water Quality Control Board, Santa Rosa, CA. 105 pp.

Lewis, J., 1996. Turbidity-controlled suspended sediment sampling for runoff-event load estimation. Water Resources Research 32 (7), 2299–2310.

Lewis, J., Keppeler, E., Ziemer, R.R., Mori, S.R., 2001. Impacts of logging on storm peak flows, flow volumes and suspended sediment loads in Caspar Creek, California. In: Wigmosta, M.S., Burges, S.J. (Eds.), Land Use and Watersheds: Human Influence on Hydrology and Geomorphology in Urban and Forest Areas. : Water Science and Application, Volume 2. American Geophysical Union, Washington, DC, pp. 85–125.

Lewis, J., 2002. Estimation of suspended sediment flux in streams using continuous turbidity and flow data coupled with laboratory concentrations. In: Gray, J. (Ed.), Turbidity and Other Sediment Surrogates Workshop Proceedings. U.S. Geological Survey, Reno, NV. 3 pp.

Lewis, J., Eads, R., Klein, R.D., 2007. Comparisons of turbidity data collected with different instruments. Report to California Dept. of Forestry and Fire Protection and the North Coast Regional Water Quality Control Board, Santa Rosa. 19 pp.

Lieberman, J.A., Hoover, M.D., 1948. The effect of uncontrolled logging on stream turbidity. Water and Sewage Works, July 1948. 4 pp.

NCRWQCB (North Coast Regional Water Quality Control Board), 2006. Order No. R1-2006-0039: Watershed-wide Waste Discharge Requirements for Timber Harvesting Plan Activities. Salmon Creek Corporation and the Pacific Lumber Corporation in the Elk River Watershed, Santa Rosa, CA. 24 pp.

NCRWQCB (North Coast Regional Water Quality Control Board), 2011. Water Quality Control Plan for the North Coast Region, Santa Rosa, CA. 271 pp.

Newcombe, C.P., MacDonald, D.D., 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11, 72–82.

Newcombe, C.P., Jensen, J.O.T., 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16, 693–727.

Newcombe, C.P., 2003. Impact assessment model for clear water fishes exposed to excessively cloudy water. Journal of the American Water Resources Association 39 (3), 529–544.

Nolan, K.M., Janda, R.J., 1995. Impacts of logging on stream-sediment discharge in the Redwood Creek basin, northwestern California. In: Nolan, K.M., Kelsey, H.M., Marron, D.C. (Eds.), Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California. Professional Paper, 1454. U.S. Geological Survey, U.S. Government Printing Office, Washington, DC, pp. L1–L8.

Pack, R.T., Tarbaton, D.G., Goodwin, C.N., 1998. The SINMAP approach to terrain stability mapping. Paper submitted to the 8th Congress of the International Association of Engineering Geology, Vancouver, BC, Canada, 21–25 September. 8 pp.

Paulson, R.W., Chase, E.B., Williams, J.S., Moody, D.W., 1993. National water summary 1990–1991; hydrologic events and stream water quality. U.S.G.S. Water Supply Paper 2400. U.S. Geological Survey, Washington, DC, p. 132.

Reeves, G.H., Everest, F., Sedell, J., 1993. Diversity of juvenile anadromous salmonid assemblages in coastal Oregon basins with different levels of timber harvest. Transactions of the American Fisheries Society 122 (3), 309–317.

Reid, L.M., in press. Landslides after clearcut logging in a coast redwood forest. In: Coast Redwood Forests in a Changing California. Proceedings of a Conference held June 21-23, Santa Cruz, CA.

Reid, L.M., Dunne, T., 1984. Sediment production from forest road surfaces. Water Resources Research 20 (11), 1753–1761.

Reid, L.M., Lewis, J., 2009. Rates, timing, and mechanisms of rainfall interception loss in a coastal redwood forest. Journal of Hydrology 375 (3–4), 459–470.

Reid, L.M., Lewis, J., 2011. Evaluating cumulative effects of logging and potential climate change on dry-season flow in a coastal redwood forest. Proc. Fourth Interagency Conference on Research in the Watersheds. : Scientific Investigations Report 2011–5169. U.S. Geological Survey, Reston, VA, pp. 186–191.

Reid, L.M., Dewey, N.J., Lisle, T.E., Hilton, S., 2010. The incidence and role of gullies after logging in a coastal redwood forest. Geomorphology 117, 155–169.

Reiter, M., Heffner, J.T., Beech, S., Turner, T., Bilby, R.E., 2009. Temporal and spatial turbidity patterns over 30 years in a managed forest of western Washington. Journal of the American Water Research Association 45 (3), 793–808.

Rivenbark, B.L., Jackson, C.R., 2004. Concentrated flow moving through silvicultural streamside management zones, southeastern Piedmont, USA. Journal of the American Water Research Association 40 (4), 1043–1052.

Scanlon, H., 2007. Progression and behavior of the Canoe Fire in coast redwood. In: Standiford, R.B., Giusti, G.A., Valachovic, Y., Zielinski, W.J., Furniss, M.J. (Eds.), Proceedings of the Redwood Region Forest Science Symposium: What Does the Future Hold? Gen. Tech. Rep. PSW-GTR-194 U.S. For. Ser. Pac. SW Res. Sta., Albany, CA, pp. 223–231.

White, J.L., Harvey, B.C., 2007. Winter feeding success of stream trout under different streamflow and turbidity conditions. Transactions of the American Fisheries Society 136, 1187–1192.

Ziemer, R.R., 1981. Roots and the stability of forested slopes. Erosion and Sediment Transport in Pacific Rim Steeplands: Int. Assoc. Sci. Hydrol. Publ. No. 132, pp. 343–361.

Ziemer, R.R., Lewis, J., 2006. Root biomass in redwood and mixed conifer forests. Unpublished report. U.S.D.A. For. Serv. Pacific Southwest Res. Sta., Arcata, CA.

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