Chapter 2 Table of Contents

CHAPTER 2. PROBLEM STATEMENT

2.1 Introduction

This chapter summarizes sediment conditions in the Elk River and its tributaries, and evaluates these conditions with respect to water quality standards, including those designed to protect domestic and agricultural water supplies and cold-water salmonid fisheries. Increased sediment delivery is accelerated by land management activities including construction and road-related activities, silvicultural operations and agricultural practices, including ranching and grazing, and hydromodification resulting from urban development. Increased instream sediment loads resulted in destabilizing changes to channel geometry, including aggradation of the stream bed, pool infilling, stream bank aggradation and erosion and alteration of flood plains and other flood prone areas. Significant alteration of stream channels, floodplains and other flood prone areas has resulted in increases in frequency and magnitude of localized flood events resulting in impacts to public health and safety and the creation of nuisance conditions in the watershed. Increased sediment loads also effect the near stream environment altering riparian vegetation diversity and density and potentially altering temperature and other aquatic habitat-based standards.

This chapter includes a description of the water quality standards applicable to the Elk River watershed. It describes impacts of sediment on domestic and agricultural water supplies and salmonid habitat. A qualitative and, where data are available to support it, a quantitative assessment of existing instream and watershed conditions in the Elk River watershed are included.

One of the primary impacts produced by excessive sediment supply in the Elk River watershed is the adverse effect on domestic and agricultural water supplies. Both suspended sediment loads and the progressive deposition of fine-grained sediment within the channel adversely affect existing and probable future water supplies in the watershed. Elevated sediment and instream organic material can produce offensive tastes and odors in drinking water supplies. It can also damage surface water supply intake equipment and treatment systems, as well as domestic plumbing and household appliances. Elevated turbidity promotes bacteriological growth by providing increased growth-sustaining surface area. It also reduces the effectiveness of water disinfection systems/processes that are used to provide potable water from the instream domestic water supplies. Turbidity levels in Elk River rise quickly at the onset of a runoff producing storm and remain elevated for prolonged periods following the storm event, thus limiting the time period available for residents to withdrawal relatively clear water to re-fill their collection/retention systems. Further, the continued presence of fine-grained sediment has filled pools which historically supported domestic and agricultural water supply systems. Watershed-wide decreases in pool depths have limited the locations that are currently available to support water supply intake systems. Insufficient pool depth and associated decrease in volume of water stored per pool location, has resulted in an increases risk of water withdrawal activities causing an adverse impact to fish by significantly decreasing the area available for cold water habitat. Shallow pools also result in increased water temperatures and provide increased rooting medium for instream vegetation such as floating duck weed and reed species.

Another adverse impact caused by excessive sediment supply in the Elk River watershed is to the threatened cold-water salmonid fishery. Excessive sediment fills pools, reducing available habitat. Fine sediment, which constitutes most of the excessive sediment load, fills and buries gravels that salmonids require to successfully spawn and incubate fry. In addition, the influx of fine sediments reduces the number of macroinvertebrates available to provide a plentiful food supply during salmonid rearing. Elevated suspended sediment and turbidity levels adversely impact the ability of cold-water fishes to find food due to poor visibility, limiting their feeding opportunities. This results in reduced growth rates of juveniles. Scientific literature has documented the linkage between ocean success and the size of out-migrant smolts (Miller and Sadro 2003). Excess sediment produces wider, shallower channels decreasing the area and volume of suitable habitat, resulting in decreased salmonid survival during gestation, rearing, and migration. The degradation of sediment conditions below water quality objectives adversely affects beneficial uses related to coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), and steelhead trout (*O. mykiss*).

Adverse impacts have also affected recreational uses, including contact (e.g. swimming and wading) and non-contact (e.g. boating and fishing) recreation. Elk River was historically used for swimming, boating and fishing, as well as for general aesthetic enjoyment. Current channel conditions in Elk River make it unsuitable for swimming and boating due in part to pools being inundated with sediment, and the presence of streamside (e.g. Himalayan blackberry) and instream (e.g. sedges, reeds, etc) vegetation and wood. The establishment of non-native streamside vegetation such as Himalayan blackberry, at the expense of native vegetation, has resulted in the loss of the natural community of herbs, forbs and shrubs that historically provided streamside vegetation while allowing unfettered access to the riparian zone and stream by residents and wildlife.

Impacts to recreational and subsistence fishing are the same as those habitat impairments affecting the cold-water fishery (see description above). The aesthetic enjoyment historically enjoyed in Elk River has been impaired by a number of factors, including but not limited, the excessive deposition of fine sediment resulting in the significant alteration of historic pool and riffle areas, elevated suspended sediment loads causing unpleasant, often offensive appearing and smelling surface water, and the acceleration of actively eroding stream banks.

The analysis presented in this report is based on data gathered by Regional Water Board staff and data contributed by landowners and organizations working in the Elk River watershed. As additional data become available from sources such as local groups and government agencies, the Regional Water Board can modify the TMDL and implementation plan, if necessary.

2.2 Water Quality Standards

Water quality standards are adopted by the Regional Water Board to protect public health and welfare, enhance the quality of water, and serve the purposes of the federal Clean Water Act (as defined in Sections 101(a)(2), and 303(c) of the Clean Water Act). State water quality standards, as contained in the applicable Basin Plan and State Plans and Policies, consist of 1) designated beneficial uses; 2) the water quality objectives to protect those designated uses; 3) implementation of the Federal and State policies for antidegradation; and 4) general policies for application and implementation. In accordance with the federal Clean Water Act, TMDLs are set at a level necessary to achieve applicable water quality standards. This section describes the state water quality standards applicable to the Elk River watershed.

2.2.1 Beneficial Uses

Beneficial uses of water are those uses of water that may be protected against quality degradation such as, but not limited to, domestic, municipal, agricultural supply, industrial supply, power generation, recreation, aesthetic enjoyment, navigation, preservation and enhancement of fish, wildlife and other aquatic resources or preserves (CWC § 13050 (f)).

Existing and potential beneficial uses for the Elk River (Hydrologic Unit 110.00) are designated, in large part, in Table 2-1 of the North Coast Basin Plan (page 2-8.00) and are identified below.

- Municipal Water Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Industrial Process Supply (PRO)
- Groundwater Recharge (GWR)
- Freshwater Replenishment (FRSH)
- Navigation (NAV)
- Hydropower Generation (POW)
- Water Contact Recreation (REC-1)
- Non-Contact Water Recreation (REC-2)
- Commercial or Sport Fishing (COMM)
- Cold Freshwater Habitat (COLD)
- Wildlife Habitat (WILD)
- Rare Threatened or Endangered Species (RARE)
- Migration of Aquatic Organisms (MIGR)
- Spawning, Reproduction, and/or Early Development (SPWN)
- Aquaculture (AQUA)

Additional beneficial uses of water in the Elk River watershed include flood peak attenuation/flood water storage (FLD), wetland habitat (WET) and water quality enhancement (WQE). These beneficial uses of water were adopted by the Regional Water Board in 2003 as part of the Region's ongoing planning process. At that time, no staff resources were available to update corresponding sections of the Basin Plan to reflect the addition of these beneficial uses of water. As such Table 2-1 of the 2007 Basin Plan (pages 2-5.00 to 2-12.00) does not provide a complete reflection of the existing beneficial uses of water in the Elk River watershed. Although these designations are not yet indicated in Table 2-1 of the Basin Plan, there is ample evidence supporting the existence of these beneficial uses in Elk River. State and federal antidegradation laws requires that all beneficial uses of water be protected regardless of whether or not the use is formally designated in the Basin Plan. As such the Elk River TMDL and associated implementation plan will be developed to ensure protection and restoration of these beneficial uses of water along with those uses indicated in Table 2-1 of the Basin Plan.

2.2.2 Water Quality Objectives Related to Sediment

Basin Plans contain both numeric and narrative water quality objectives which specify limitations on certain water quality parameters that are not to be exceeded as a result of waste discharge. Those objectives pertinent to the Elk River Sediment TMDL are listed below in Table 2.1 of this Staff Report.

Table 2.1 Sediment-related Water Quality Objectives Applicable to Elk River

Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.
Suspended Sediment Load	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

In addition to narrative and numeric water quality objectives, the North Coast Basin Plan contains a provision for "controllable water quality factors". The controllable factors provision is presented below:

> Controllable water quality factors shall conform to the water quality objectives contained herein. When other factors result in the degradation

> of water quality beyond the levels or limits established herein as water quality objectives, then controllable factors shall not cause further degradation of water quality. Controllable water quality factors are those actions, conditions, or circumstances resulting from man's activities that may influence the quality of the waters of the State and that may be reasonably controlled (NCRWQCB, 2007 3-1.00).

If controllable water quality factors (adverse effects associated with human activities) are currently out of conformance with Basin Plan water quality objectives then actions must be taken to bring those factors into conformance with Basin Plan objectives such that beneficial uses of water are maintained and restored.

2.2.3 Waste Discharge Prohibitions

The Regional Water Board is authorized, by Section 13243 of the Porter-Cologne Water Quality Control Act, to create Waste Discharge Prohibitions and specify conditions or locations where the discharge of all or some waste will not be permitted.

The Basin Plan (NCRWQCB 2007, 4-1.00) states that point source waste discharges (pollutants discharged through a discrete conveyance such as a pipe, ditch or channel), except as stipulated by the Thermal Plan, Ocean Plan, and the action plans and policies contained in the Point Source Measures section of the Basin Plan, are prohibited in Humboldt Bay.

The North Coast Basin Plan contains an *Action Plan for Logging, Construction, and Associated Activities* (NCRWQCB 2007, 4-26.00). This Action Plan contains waste discharge prohibitions for those two specific land use activities (logging and construction) in the North Coast Region. The *Action Plan for Logging, Construction, and Associated Activities* prohibition language is as follows:

> 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.

2.2.4 Nuisance Conditions

California Water Code section 13050 defines nuisance to mean anything which meets all of the following requirements:

(1) Is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property.

(2) Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal.

(3) Occurs during, or as a result of, the treatment or disposal of waste.

2.2.5 Agricultural Wastewater Management Policy

The Basin Plan also includes a *Policy for Agricultural Wastewater Management*, which is applicable to the entire North Coast Region, including the Elk River watershed. In 1972 the USEPA was directed, by amendments to Public Law 92-500, to set up a permit system for dischargers that would be administered by the State of California for waters within the State. At the present time, federal regulations require permits for various types of discharges from agricultural operations including feed lots with 1,000 or more slaughter steers and heifers or dairies with 700 head or more, including milkers, pregnant heifers, and dry mature cows. However, the policy also states “the state may prescribe waste discharge requirements for any point source discharger regardless of size (NCRWQCB 2007, p.4-23.00 to 4-24.00).”

At this time there are no facilities in the Elk River watershed that meet the minimum federal permitting criteria described above. If however such an activity were to occur in the watershed or if the Regional Water Board deemed it necessary, coverage would need to be sought under the appropriate permit for the activity.

2.2.6 Antidegradation Policies

There are two antidegradation policies that are applicable to all waters in the North Coast Region – a State policy and a federal policy. The State antidegradation policy is titled the *Statement of Policy with Respect to Maintaining High Quality Waters in California* (Resolution 68-16). The federal antidegradation policy is found at title 40, Code of Federal Regulations, section 131.12. Both policies are incorporated in the Basin Plan for the North Coast Region. Although there are some differences in the State and federal policies, both require that whenever surface waters are of higher quality than necessary to protect the designated beneficial uses, such existing quality shall be maintained unless otherwise provided by the policies.

The state antidegradation policy applies more comprehensively to water quality changes than the federal policy. In particular the state policy applies to both groundwater and surface water whose quality meets or exceeds water quality objectives. The state policy establishes two conditions that must be met before the quality of high quality waters may be lowered by waste discharges.

First, the state must determine that lowering the quality of high quality waters:
1) Will be consistent with the maximum benefit to the people of the state,
2) Will not unreasonably affect present and anticipated beneficial uses of such water, and
3) Will not result in water quality less than that prescribed in state policies (e.g., water quality objectives in Water Quality Control Plans).

Second, any activities that result in discharges to high quality waters are required to a) meet waste discharge requirements that will result in the best practicable treatment or control of the discharge necessary to avoid pollution or nuisance and b) maintain the highest water quality consistent with the maximum benefit to the people of the state. If such treatment or control results in a discharge that maintains the existing high water quality, then a less stringent level of treatment or control would not be in compliance with 68-16. Likewise, the discharge could not be allowed under Resolution 68-16 if a) the discharge, even after treatment, would unreasonably affect beneficial uses or b) would not comply with applicable provisions of water quality control plans.

The federal Antidegradation Policy applies to surface waters, regardless of the water quality. Where water quality is better than the minimum necessary to support instream uses, the federal policy requires that quality to be maintained and protected, unless the state finds, after ensuring public participation, that:

1) Such activity is necessary to accommodate important economic or social development in the area in which the waters are located,
2) Water quality is adequate to protect existing beneficial uses fully, and
3) The highest statutory and regulatory requirements for all new and existing point source discharges and all cost-effective and reasonable best management practices for non point source control are achieved.

Under this policy, an activity that results in discharge would be prohibited if the discharge will lower the quality of surface waters that do not currently attain water quality standards.

Both the state and federal antidegradation policies acknowledge that an activity that results in a minor water quality lowering, even if incrementally small, can result in a violation of antidegradation policies through cumulative effects, especially, for example, when the waste is a cumulative, persistent, or bioaccumulative pollutant.

2.2.7 State Policy for Control of Non-Point Sources of Pollution

The 2004 State Water Resources Control Board (SWRCB) *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (NPS Policy) establishes requirements for both nonpoint source dischargers and Regional Water Board regulation of those dischargers. The NPS Policy “explains how the Porter-

Cologne Act mandates and authorities, delegated to the SWRCB and Regional Water Boards by the California Legislature, will be used to implement and enforce the NPS Program Plan" (SWRCB, 2004). The NPS Program Plan is the *Plan for California's Nonpoint Source Pollution Control Program* adopted by the SWRCB in 1999 to provide a compilation of management measures that control nonpoint source pollution. To ensure implementation of these management measures, the NPS Policy requires that "all current and proposed nonpoint source discharges must be regulated under waste discharge requirements (WDRs), waivers of WDRs, a basin plan prohibition, or some combination of these tools" (SWRCB, 2004). The NPS Policy enables the Regional Water Board to use its enforcement tools in regulating nonpoint source dischargers that do not comply with their permit, conditional waiver, or the Basin Plan prohibitions. The State NPS Policy "provides a bridge between the NPS Program Plan and the SWRCB Water Quality Enforcement Policy" (SWRCB, 2004).

The following is a summary of the three administrative tools available to the Regional Water Board to control non point sources of pollution as reaffirmed in the 2004 State NPS Policy. .

1. Waste Discharge Requirements (WDRs): WDRs are the Regional Water Board's water quality control permits that may include effluent limitations or other requirements that are designed to implement applicable water quality control plans (which will include the Elk River Action Plan if adopted), including designated beneficial uses and the water quality objectives established to protect those uses and prevent the creation of nuisance conditions. Dischargers operating under a WDR must submit an annual fee to the Regional Water Board to cover administrative costs.

2. Waivers of WDRs: The requirements for a discharger to apply for WDRs may be waived by the Regional Water Board for a specific discharge or a specific category of discharge if the Regional Water Board determines that the waiver is consistent with all applicable State and the Basin Plan and is in the public interest. All waivers are conditional and may include specific management practices that must be implemented to be eligible for the waiver. Waivers may be terminated at any time and may not exceed five years in duration without being renewed through a public Regional Water Board adoption hearing.

3. Prohibitions:
The Regional Water Board may prohibit discharges of waste or types of waste either through WDRs or through waste discharge prohibitions amended into the Basin Plan. The prohibition may be made conditional by including specific conditions under which application or enforcement of the prohibition may be waived. Regional Water Boards may also use conditional Basin Plan prohibitions as the primary administrative tool for implementation programs – for example, in cases where a Regional Water Board desires to prohibit discharges unless certain procedural or substantive conditions are met.

2.3 Summary of Sediment Conditions and Associated Impacts in the Elk River Watershed

A combination of natural and management-related (controllable) factors have joined in Elk River to affect the condition of beneficial uses of water and the water quality necessary to support them. Natural conditions that are relevant to the sediment loads in the Elk River watershed are as follows:

- *Geologic Formations*: Elk River is comprised primarily of “young” and erodible geologic formations. The dominant Wildcat Group is characterized by steep and dissected topography sculpted by debris sliding with shallow landslides commonly associated with headwall swales, inner gorges, and hollows. The rock units of the Yager Formation are typically deeply weathered and sheared and subject to deep-seated flow failures on moderate slopes. Shallow landsliding and deep-seated bedding plane failures are common in terrain formed from the Hookton Formation. Common in the Central Belt Franciscan complex are large, deep-seated landslides and earthflows enclosing blocks of competent sandstone which create steep slopes and weather to soils that have little strength and are susceptible to debris slides and debris flows.

- *Elk River Valley Geomorphology:* The Elk River drainage network originates from the northwestern California Coast Range and flows across the low gradient coastal plain to Humboldt Bay. The long-term erosional processes in Elk River are heavily influenced by sea level and its changes due to climate, base level changes and uplift caused by tectonic movement, localized uplift due to folds and faults, and resulting channel incision in response to uplift. Uplift is balanced by erosion via channel incision and steep slopes. Elk River is unique among Humboldt Bay tributaries in that the majority of the watershed is underlain by weak Hookton and Wildcat rocks and sheared Yager rocks, allowing for rapid denudation as the drainage network incises through the formations. Additionally, high uplift rates result in steep slopes and shallow soil.

- *Coastal Redwood Forest Ecosystem*: The hillslopes of the Elk River watershed are dominated by redwood forests. The redwood forest ecosystem is complex and site conditions evolved over thousands of years, with each component contributing to the stability, fertility, and purifying effects to water quality. Nutrient rich soils were developed through long processes of chemical and physical weathering. The unmanaged forest ecosystem delivered extensive organic material which further built the soil, protected it from erosion, and created complexity which helped to sort and meter sediment in the watercourse network. The unmanaged forest ecosystem supported extensive networks of fungus and the forest floor acted as a high capacity sponge. The extensive canopy and duff intercepted and minimized the rainfall reaching the forest floor. Trees uptook groundwater via evapotranspiration and contributed instream wood to provide aquatic habitat elements.

Management influences have interacted with the natural conditions to result in excessive sediment loads.

- *Timber Harvest Activities:* Timber harvest activities result in canopy removal reducing interception and evapotranspiration rates. This leads to increased effective rainfall reaching the ground with resultant increases in peak runoff and altered hydrographs. Canopy removal results in a decrease in the duff layer and a loss of recruitment trees, critical components in the development of the vegetative layer or "sponge" that used to absorb and buffer raindrop impact. The mycroryzal network is also altered, reducing nutrient cycling. Large wood recruitment to streams is reduced. Compaction from heavy equipment and falling operations leads to collapse of existing soil pipes which transported water through a subsurface flow network. The collapse of these pipes leads directly to an increase in drainage (stream) network capable of transporting sediment and more rapid delivery of water downslope. Historic logging left a footprint of unstable fill, inadequate stream crossings, and poorly located roads which continue to contribute sediment to the stream system. In Elk River, these landuse activities resulted in violation of the sediment prohibitions: The recent extensive logging on the geologically weak and tectonically active unstable slopes in the Elk River led to massive and unprecedented landslide sediment discharges.

- *Grazing*: Grazing activities in the Elk River Valley have affected the riparian vegetation community and bank stability. In some locations, the riparian area is merely a few tree widths wide, dominated by willow, alder, and invasive non-native Himalaya blackberry. In areas where livestock have access to the river, there is evidence of bank erosion. Further, manure contributes nutrients, which in combination with sediment impairments and degraded riparian conditions, lead to reduced dissolved oxygen and poor water quality conditions.

- *Urban Development*: Urban development has occurred primarily in the Humboldt Hill and Cutten areas of lower Elk River and Martin Slough. Urbanization involves clearing and alteration of vegetation causing reduction of rainfall interception, compaction of permeable soils, and covering of land with impermeable surfaces. These effects, referred to as hydromodification, cause channel scour and destabilization of bed material, altered flow regimes, and habitat function.

- *Modifications to Humboldt Bay*: Potentially relevant management modifications of Humboldt Bay include jetty construction at the inlet, channel deepening at various locations in the bay, and construction of the railroad and Highway 101 grades across lower Elk River and other portions of the bay shoreline. The effect of these modifications is likely a more simplified channel as Elk River enters the bay. At certain flows, the tides likely act as a hydraulic control for waters flowing downstream in Elk River. There is uncertainty regarding the affects Humboldt Bay exerts on Elk River and visa-versa.

The effects of the management-related excessive sediment, in combination with unique natural conditions have resulted in water quality standards not being met:

- *Altered Channel and Floodplain Morphology*: The sediment supply in Elk River has overwhelmed the transport capacity of the river resulting in rapid channel and floodplain aggradation. Deep pools and gravel bars have been filled in and silted over, respectively. The naturally steep stream banks and low terraces floodplains that defined the former bankfull channel have been inundated with repeated deposition of excessive amounts of silt-sized sediment. The broader floodplain was also covered in silt. Comparison of historic data collected by the U.S. Geological Survey (USGS) to those collected more recently by Palco on the Mainstem Elk River indicates the 2003 channel capacity is approximately 35 percent less than the 1965 historic channel capacity.

- *Cumulative Effects*: Persisting sediment loads, in combination with sluggish hydraulics, and sediment properties have combined to leave fine grained settable sediment in place, resulting in an elevated channel base level. Channel armoring is ongoing with both sediment particles and vegetation, further locking in an elevated base level. Channel cross-sections continue to be reduced due to sediment deposits. Existing regulatory process that cover individual timber harvest plans and other projects were ineffective at preventing cumulative effects, hence the need to develop a program to restore the beneficial uses of water in the Elk River watershed. This TMDL and implementation program is that restoration program

- *Nuisance Flooding*: Overbank flooding occurs at an elevated frequency and magnitude. Fields, roadways, driveways, homes and septic systems are frequently inundated. Measurements made by Palco indicate that 1998 bankfull discharge decreased by 60 percent compared to that 1965, as measured by the USGS. The community of Elk River experiences nuisance conditions as defined by Porter-Cologne.

- *Beneficial uses are not supported*.
    - Domestic and Agricultural Water Supplies: Portions of Mainstem, North Fork, and South Fork Elk River have historically relied on surface water intakes in the river for domestic and agricultural water supplies. High suspended sediment concentrations cause the water to be unusable much of the winter period. Lack of pool depth limits water locations available for water intakes. No alternative water supply currently exists.
    - Salmonids: Elk River is an important stream to salmonid species. Habitat conditions are degraded by fine sediment, including smothering of gravels, lack of suitable spawning gravels, lack of pool depth , and high suspended sediment concentrations and durations.

- Recreation: Swimming, wading, fishing, and aesthetic enjoyment are impaired due to degraded stream conditions.

- *Water Quality Objectives are not achieved*: High suspended sediment concentrations result in adverse impacts to beneficial uses. Fine sediment deposition has occurred rapidly and continues to occur, filling pools, smothering spawning gravels, resulting in adverse impacts to beneficial uses. Further, deposition of settleable material reduces cross-sectional areas, contributing to nuisance flooding conditions. Turbidities are elevated in the watershed, greatly exceeding the numeric objective. Suspended sediment loads are elevated and have resulted in adverse impacts to beneficial uses and crat a nuisance condition.

These problems, when taken together, demonstrate water quality impairments caused by excessive sediment loads in Elk River; beneficial uses of water are not supported and water quality objectives are not being achieved. Each of these is described in greater detail below.

2.3.1 Natural Factors Relevant to Sediment Conditions

2.3.1.1 **Geologic Formations in the Elk River Watershed**

As described in Section 1.4.4 of this Staff Report, Elk River is underlain by weak and erodible geologic formations. The natural sediment conditions and dominant erosional processes are influenced by the presence of these formations. Additionally, these formations produce silt and sand, influencing the suspended sediment loads.

The area underlain by the Wildcat Group is characterized by steep and dissected topography sculpted by debris sliding, and is known for high historical erosion rates from such slope failures. Shallow landslides in the Wildcat Group are commonly associated with headwall swales, inner gorges, and hollows. This bedrock has low permeability, which allows it to easily become saturated with water, and this combined with bedding planes subparallel to the hillslope make it prone to landsliding.

The Yager Formation found predominantly in the southeastern portion of the watershed is a sandstone-dominated rock unit. This rock type commonly forms relatively steep cliffs. This can result in the creation of local base level control points where streams have eroded through the younger, less resistant Wildcat deposits. The argillite-dominated rock units of these formations are typically deeply weathered and sheared and subject to deep-seated flow failures on moderate slopes (Marshall and Mendes 2005).

The Hookton deposits and similar Quaternary marine terrace and Quaternary river terrace deposits of poorly consolidated sand and gravel are prone to shallow landsliding on steep slopes and terrace risers. Combined, these deposits underlie 17.4 percent of the Elk River watershed. Shallow landsliding and deep-seated bedding plane failures are common in Hookton terrain.

Franciscan Melange is relatively less important by area than the aforementioned formations. In many places, the more competent blocks stand in relief, without apparent arrangement or system, where they have been left as weaker surrounding rocks were eroded away. Large, deep-seated landslides and earthflows enclosing competent blocks are common in the Central Belt Franciscan complex (Marshall and Mendes 2005). Blocks of competent sandstone commonly create steep slopes and weather to soils that have little strength and are susceptible to debris slides and debris flows.

2.3.1.2 **Elk River Valley Geomorphology**

The Elk River drainage network originates from the northwestern California Coast Range and flows across the low gradient coastal plain to Humboldt Bay. The long-term erosional processes in Elk River are heavily influenced by sea level and its changes due to climate, base level changes and uplift caused by tectonic movement, localized uplift due to folds and faults, and resulting channel incision in response to uplift.

The Mendocino Triple Junction, located just offshore of Cape Mendocino in northern California, is a geologic triple junction where the San Andreas Fault meets the Mendocino Fault and the Cascadia Subduction Zone. This is an area where three separate tectonic plates cojoin: the Pacific Plate, the North American Plate and the Gorda Plate. The Gorda Plate is the southern-most fragment of the Juan de Fuca plate subducting beneath North America within the Cascadia Subduction Zone. This zone rises and falls during earthquakes. In between earthquakes, uplift results as pressure is exerted at the subduction zone. The uplift occurs both at the ridgeline in Elk River and perhaps at the mouth. Additionally, there is localized uplift related to folding and faulting. The Little Salmon Fault, located near in the headwaters of Elk River, contributes. There are likely smaller, unmapped faults that also influence localized uplift.

Uplift is balanced by erosion via channel incision and steep slopes. Elk River is unique among Humboldt Bay tributaries in that the majority of the watershed is underlain by weak Hookton and Wildcat rocks and sheared Yager rocks, allowing for rapid denudation as the drainage network incises through the formations. Additionally, high uplift rates results in steep slopes and shallow soil. These areas are prone to shallow slope failures.

Sea level rises and falls with changes in climate. During the interglacial periods of the late Pleistocene, sea level rose and flooded the Coastal Plane numerous times, including Elk River valley, filling it with sediment. It likely flooded it to the confluence of North Fork and South Fork Elk River, but not likely much farther upstream.

Historical observations indicate the Elk River was a gravel bedded stream in both the North Fork and South Fork, with cobble present in lower South Fork Elk River (RCAA, 2003). Small gravel and sand were observed in the 1960's by USGS in the mainstem Elk River (Patenaude, 2004). Additionally, gravel was apparently mined from the mouth of Elk River to build streets in what is now Eureka (Winzler, 2002). Sediment entering a channel is either transported downstream, or alters the channel morphology by being deposited. Sediment transport rates depend on channel characteristics and sediment composition. Larger particles move along the bed and are referred to as bed load. Finer particles are moved as suspended sediment. Intermediate-sized particles may be suspended and then settle out as flows recede (Reid and Dunne, 2003). The historic observations indicate that Elk River's bedload was comprised of at least small gravel, including in the lower Elk River, where channel gradients are less than 1 percent.

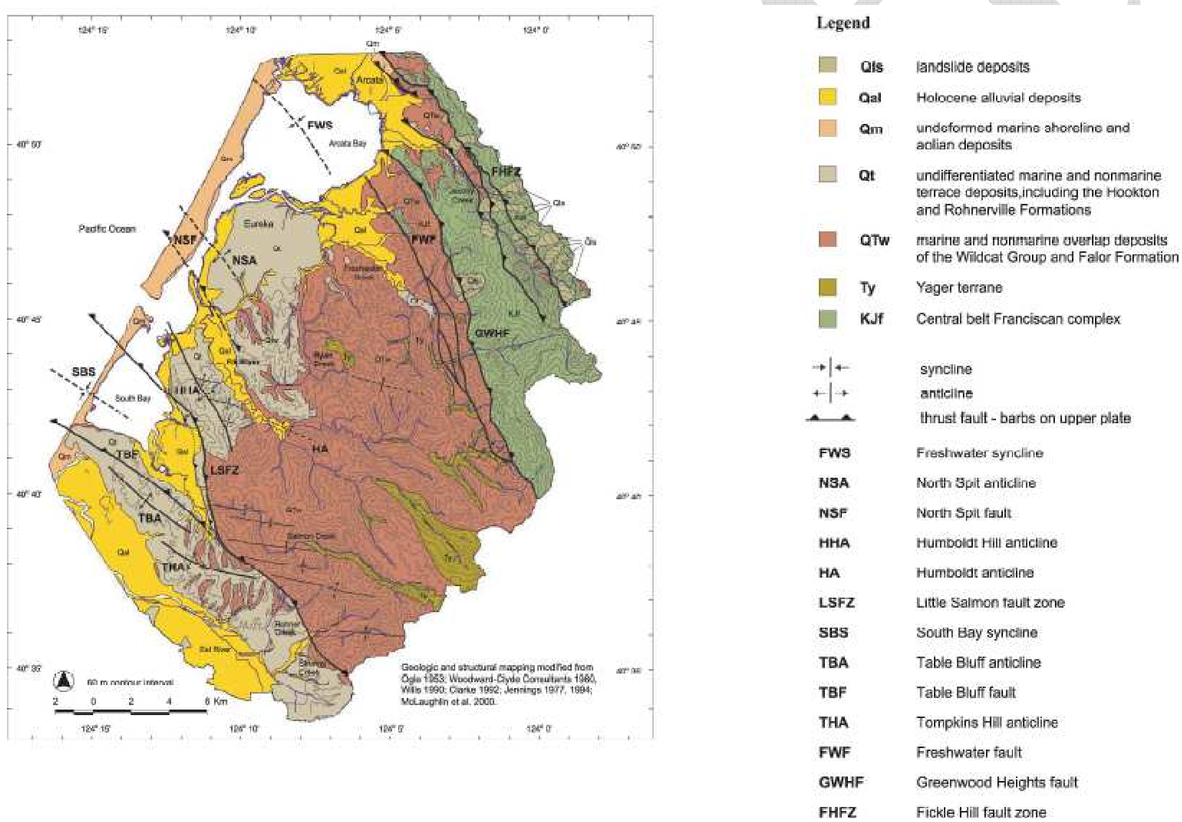

Figure 2.1 Geologic and structural map of Humboldt Bay and its tributaries (as reproduced by Stallman (2003)).

Elk River is unique in that is among the largest freshwater tributaries of Humboldt Bay and enters the bay across from and just north of the inlet to Humboldt Bay from the Pacific Ocean. It is logical to assume that due to the proximity of Elk River to the bay inlet significant tidal action influences the water and sediment routing from the lower end of Elk River.

2.3.1.3 **Coastal Redwood Forest Ecosystem**

The hillslopes of Elk River are dominated by coastal redwood forest. In favorable parts of their range, including Elk River, redwoods can live up to 2,000 years and stand more that 300 feet tall. Redwood is among the world's fastest growing conifers, up to one-foot per year. They sprout from either seed or their parent's roots, taking advantage of an established root system and the energy and nutrient reserves contained within them (SRL, 2009). Both the wood and bark is high in tannins, resulting in resistance to fungal disease and insect infestation and making these trees slow to rot once they fall to the forest floor. The thick bark protects and insulates the trees from periodic fires.

The redwood forest is source of much organic material, in the form of needle and leaf drop, limbs, and tree fall. All of these levels of organic material contribute to soil formation, protect the soil from erosion and ultimately support networks of microorganisms (fungi, bacteria, microscopic invertebrates, and single celled protozoa). These microorganisms play crucial roles in nutrient cycling, including fixing atmospheric nitrogen into the soil, enhancing the fertility of the forest and contributing to forest health.

The soil supports understory vegetation. In combination with duff, the understory vegetation covers surfaces and practically no bare soil is observable (Figure 2.2).

The redwood forest soils of Elk River evolved over thousands of years. Soil formation is a result of a complex interplay between parent material, time, climate, plants, animals, and slope (Tarbuck and Lutgens, 1985). The nature of parent material determines the rate of weathering and in turn, the rate of soil formation. The longer soil development occurs, the thicker the soil mantel becomes. The longer the soil has time to develop, the greater the changes in the physical and chemical properties of the soil in comparison to the parent material.

Figure 2.2 Understory vegetation associated with old-growth forest located in Little South Fork Elk River in the Headwaters Forest Reserve. (Photo by Adona White, Regional Water Board staff, January 2006.)

Plants and animals supply organic material to the soil and affect soil fertility and influence the rate of weathering. Organic matter increases the soils water storage capacity. Burrows and holes aid the passage of water and air through the soil. Steeper slopes generally have thinner soil layers with the soil mantle more prone to failure. Soil is accumulated in hollows and other hillslope depressions. Thus soil horizons on the hillslopes and in hollows or depressions tend to be differentiated.

Lateral roots of redwood trees extend well into the shallow soil horizons surrounding them. The roots extract nutrients and water from the soil profile. The mycology network can extend the roots ability to uptake nutrients far beyond the extent of the roots themselves (Stamets, 2005). Coast redwoods rely on summer fog for moisture during long, dry Mediterranean summers; their tall branches actually capture fog and contribute water to the forest floor, helping to sustain soil moisture during the driest portion of the year.

The extensive canopy of the redwood forest offers interception storage and cycling of water through evapotranspiration. Canopy intercepts rainfall, reducing the intensity of rainfall as it reaches the forest floor, decreasing the potential for accelerated soil erosion. Further the interception storage allows rainfall to be delivered in a metered fashion over time, tempering the peak flows associated with storms. Reid and Lewis (2007) found that in second growth redwood forests, interception and evapotranspiration accounted for 20 percent of the overall rainfall, even in the largest of the measured storms. It seems logical to assume that the canopy of unmanaged forests, like those naturally occurring in Elk River, would reduce the effective rainfall by more than that documented for second-growth forests.

When large scale mass wasting events, such as landslides and debris flows, reach a watercourse they can deliver large volumes of both coarse and fine grained sediment. In unmanaged forests large diameter trees can also be transported to the watercourse during or subsequent to these events providing an important source of large wood to streams. The woody debris provides complex habitat structure crucial for cold water fish habitat as well providing an effective mechanism in metering and sorting instream sediment.

2.3.2 Management Factors Relevant to Sediment Conditions

2.3.2.1 **Timber Harvest Activities**

Elk River has been managed since the late 1800’s for timber products. While methods of harvesting, yarding, and transporting logs have changed with new technologies, significant alterations to the forest processes occur with harvesting.

Timber harvest operations include development of a transportation (road) system to provide access to forested basins, cutting and falling of trees, yarding logs to the transportation system, and movement of logs to a mill. Once the logs are removed, the site may be prepared for replanting by broadcast burning or other site preparation activities. If required the site is then replanted. Each of these activities has potential impacts to water quality, as described in Table 2.2 below.

Collectively these impacts affect forest hydrology, alter topography, and can lead to sediment delivery to the aquatic system.

Table 2.2 Potential sediment-related impacts associated with timber harvest activities

Tree harvest/removal	• Removes canopy cover • Increases the effective rainfall reaching the ground • Reduces evapotranspiration • Increased water can surcharge hillslopes resulting in landslides, etc • Increased water in watercourses can result in accelerated bank erosion and extension of the channel network • Increases surface erosion, loss of top soil, and disturbance of mycology network • Removes duff producers • Results in root die off, decreasing slope stability • Removes large wood from the terrestrial and aquatic systems thus reducing the size and quantity of wood delivered via bank erosion and landslides
Tree falling	• Causes compaction of soil, resulting in altered subsurface hydrology • Damages remaining vegetation
Tree yarding	• Causes compaction of soil, resulting in altered hydrology • Construction or reopening of skid trails • Formation of cable corridors • Involves transport of large equipment, requiring wider roads and fuel transportation over stream
Earthworks (includes landings, skid trails, and roads)	• Causes compaction of soil, resulting in altered hydrology • Intercepts subsurface soil pipes and exposes shallow groundwater to sediment delivery, causes diversions from one watercourse to another, and alters the forest hydrology • Results in piles of fill increasing weight, altering hydrology, and can result in discharges and threatened discharges of sediment • Can cut through areas of low slope stability and result in landslides • Loss of top soil via use of blades • Construction and reopening of stream crossings, both permanent and temporary crossings • Disturbs understory vegetation • Remain on the landscape between harvesting
Roads	• Construction of roads disturbed forested areas • Construction and maintenance of stream crossings can change natural channel form and can result in destabilization of bed and banks; require substantial earth disturbance to install, upgrade, and remove • Diversions of water from one drainage to another, potentially dewatering or overwhelming channels and causing erosion • Creation of fill slopes that can result in failures due to lack of compaction, oversteepened slopes, or drainage issues • Creation of cut banks (steep areas above the road) that remain unvegetated • Surface erosion from roads produce fine sediment • Winter road use can compromises drainage structures requiring constant maintenance and disturbance, pumps fine sediment through rock surfacing and contributes to surface erosion. • Water withdrawals from the river for road watering during periods of lowest flow can affect aquatic resources • Road removal and upgrading, especially at stream crossings, can result in post treatment sediment flushes that can be individually and cumulatively significant.
Site preparation	• Mechanical site prep scrapes and piles branches, duff, and soil • Burning reduces cation exchange capacity and long-term productivity of soil and exposes soil to erosion, • Herbicides bind with soil particles increasing erosion and can be detrimental to amphibians, fish, and humans

2.3.2.1.1 Landuse Activities Resulting in Violation of Sediment Prohibitions

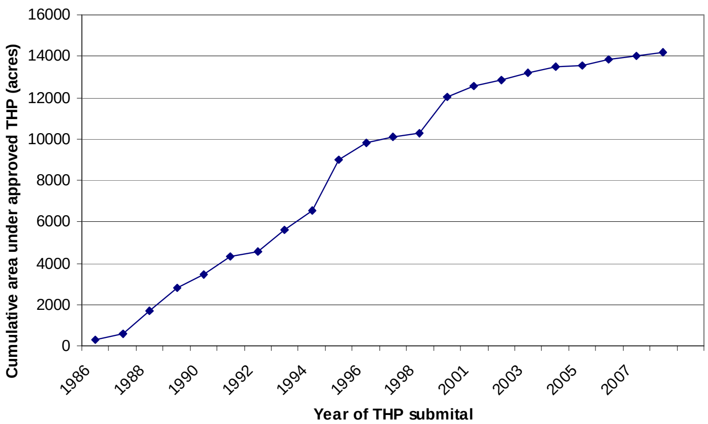

Figure 2.3 Cumulative annual acreage in approved timber harvest plans in the 14,382 acre North Fork Elk River watershed, 1986-2008.

Beginning in 1986, the rate of timber harvest operations in the North Fork Elk River were substantial accelerated as compared to previous harvest rates in the sub-basin. Due in part to the accelerated rate of acres harvested each year and the increase in the amount of timber removed from each harvest area (use of even age silviculture instead of uneven age silviculture), accelerated impacts to water quality were also observed. Between 1986 and 2008, 14,169 acres of the 14,386 acre North Fork Elk River drainage was approved for harvest under a number of THPs (Figure 2.3). While some of the THPs harvest areas overlapped one another, nearly the entire drainage has been subject to intensive timber harvest activities.

Over the long history of timber harvesting in Elk River, logging practices have changed extensively. The footprint of pre-forest Practice Act logging remain on the landscape in the form of failing Humboldt crossings, eroding instream landings and poorly constructed and maintained road systems built with the sensitive riparian areas of perennial watercourses, to name a few. Active and threaten discharge from these types of sites constitute violations of the sediment prohibitions contained within the *Action Plan for Logging, Construction, and Associated Activities* (see Section 2.2.3 of this Staff Report). These active and threatened sediment delivery sites should have been treated or stabilized as mitigation measures for each of the approved THPs. These mitigation or corrective measures were necessary to ensure that THPs were in conformance with the Basin Plan (a requirement of the Forest Practice Rules) as well as to avoid significant watershed impacts from the extensive harvest activity in the watershed. During the mid- to late 1990's numerous mitigation measures required under the approved THPs, including those required for water quality protection, were not implement as required. These existing sediment delivery sites remained on the landscape, continuing to contribute some amount of "controllable" sediment to the Elk River watershed in violation of the sediment prohibition. In addition, the active timber harvest operations resulted in extensive soil disturbance from felling and yarding (particularly from ground based equipment), new road construction and road reconstruction across unstable areas, perched, uncompacted fill on steep slopes, undersized and poorly constructed stream crossings, etc. See Table 2.2 for a more complete list of potential sediment generating activities associated timber operations.

The logging practices being exercised in the North Fork Elk River resulted in the CDF inspectors citing fifty-one (51) violations of the California Forest Practice Rules (FPR) on fourteen (14) separate THP projects from 1995 to 1998 (Johnson, 1998). These violations were primarily based on the lack of installation of the minimum protections required under the FPR to prevent the discharge or threatened discharge of sediment to the North Fork Elk River. The extensive disturbance of the drainage combined with the number of activities resulting in violations of both the FPR and the Basin Plan resulted in the drainage being subjected to significant adverse cumulative impacts to the beneficial uses of water (NCRWQCB, 2000).

Over this same time period (1995 to 1998), several years experienced higher than average rainfall (Figure 2.4). The highly disturbed landscape, when exposed to significant rainfall events, eroded at an unprecedented level.

At the same time, residents of Elk River and Regional Water Board staff began noticing adverse impacts to surface waters and their beneficial uses within these watersheds, resulting from increased inputs of sediment. For example, the residents who were using surface water for their domestic and agricultural water supplies began noticing increased silt in their drinking water and deposited around their water intakes. Residents reported that water became very turbid even during minor storms, and the intensity and duration of flooding increased. During the winters of 1995/1996 and 1996/1997, in particular during the latter winter, numerous large landslides occurred within the Elk River watershed, delivering significant quantities of sediment to watercourses within these stream system (NCRWQCB, 2000) (Figure 2.5).

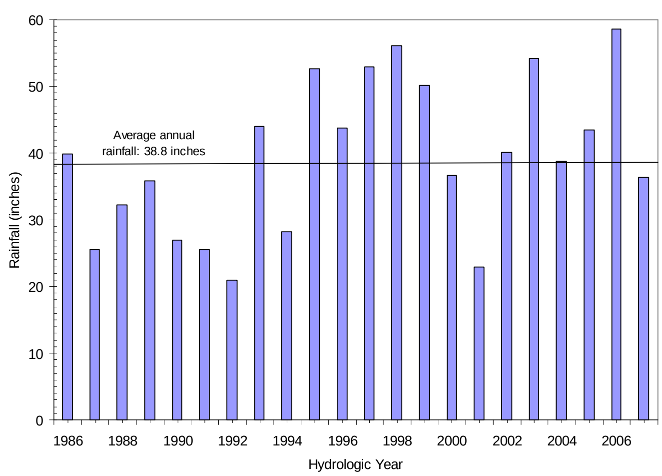

Figure 2.4 Annual rainfall for the period 1986-2007, as measured by NOAA in Eureka. The long term annual average rainfall is 38.8 inches.

A CDF report[1] documents the field conditions of November 13 & 14, 1997, and concluded that "the large storms between 1993 and 1997 have:

1. routed stored sediment from lower order tributary watersheds down to the low gradient storage reaches of Elk River, and
2. caused significant amounts of landsliding associated with old roads and landings to occur (some of these roads and landings were part of recent Timber Harvesting Plans), generating considerable volumes of new sediment to route downstream."

[1] California Department of Forestry and Fire Protection. November 20, 1997. Memorandum to Mr. Tom Osopowich, Resource Manager. Subject: 5400 Forest Practice Regulation, 5410 Forest Practice Act, Hydrologic Review of the Elk River Watershed.

The CDF Report further goes on to describe cumulative watershed effects based upon widespread channel aggradation in the lower part of the watershed, "as a result of:

1. a watershed with moderately unstable geologic composition,
2. past poor road, landing, and crossing location and construction (from 1930's to the early 1970's),
3. very large recent stressing storms, and
4. a high level of recent logging operations in the basin (e.g. about 50 percent of the North Fork drainage has been harvested with accompanying impacts over the past 10 years)."

In an attempt to rectify the violations of the Discharge Prohibitions 1 and 2 of the *Action Plan for Logging, Construction, and Associated Activities*, the Regional Water Board issued a series of clean-up and abatement orders, beginning with CAO 97-115, to Palco. It stated, in part:

> "The dischargers have caused or permitted earthen material and organic debris to be discharged or deposited where it is, or probably will be, discharged into unnamed tributaries to the North Fork Elk River and into the North Fork Elk River, and have threatened to cause or permit earthen material to be discharged into unnamed tributaries to the North Fork Elk River and into North Fork Elk River. Such waste has been and will probably continue to be discharged into waters of the State, where it has or threatens to create a condition of pollution or nuisance. Winter rainfall/runoff threatens to continue the discharge unless and until the waste is cleanup and abated."

Figure 2.5 Landslide into West Fork Bridge Creek, originating from THP 1-95-097, addressed in CAO 1-97-115. Photo taken by Elmer Dudik, September 9, 1997)

It was the collective assessment of the staffs of the Regional Water Board, CDF, and CDFG that the North Fork Elk River had suffered cumulative significant adverse effects from past and present timber harvest activities, as evidenced by accumulations of fine and coarse sediment in watercourses. These accumulations resulted in significant filling of stream channel pools and the deterioration of water supplies over the winters of 1995/1996 and 1996/1997. Palco submitted a required workplan pursuant to CAO 97-115 (PWA, 1997), which identified seven sediment deliver sites. The workplan estimated that there were 7,160 cubic yards of sediment and organic debris discharged into the North Fork Elk River and its tributaries from these sites where cleanup was deemed infeasible or for which mitigation measures were not recommended in the workplan. The workplan also noted that these sites would continue discharge excess sediment over the next several years.

Further, in compliance with CAO 97-115, Palco submitted a sediment source inventory for North Fork Elk River watershed (PWA, 1998). The 1998 source inventory identified that timber harvesting, including road construction activities had resulted in increased sediment production and yield to the North Fork Elk River. Analyses conducted by Regional Water Board staff (NCRWCQB, 2000), based on this source inventory, determined that of the 84,250 cubic yards delivered to the stream system between 1994 and 1997, 95 percent was delivered due to anthropogenic sources. Additionally, during the same time period (and storm event history), the rates of landsliding and associated sediment delivery from recently harvested areas were significantly higher than the rates of landsliding and sediment yield due to landslides from non-harvested areas. During the period from 1994 to 1997, landslide sediment yield from recently harvested areas (areas harvested less than 15 years ago) was approximately 1300% (13 times) greater than background landslide sediment yield rates (sediment inputs from areas harvested more than 15 years ago) in the North Fork Elk River watershed (Reid,1998).

The Regional Water Board issued Cleanup and Abatement Order No.98-100 requiring, in part, that the Palco restore the historic and potential domestic and agricultural supply beneficial uses of the North Fork Elk River and that the Palco continue these abatement activities until the effects of sediment discharges decline to historic (prior to 1993) levels. Order 98-100 also required that the Palco provide alternative water supplies for downstream water users. Order 98-100 superseded the portions of Cleanup and Abatement Order No. 97-115 that addressed water supplies.

Figure 2.6 Landslide delivering into South Fork Elk River, originating from THP 96-059 (Photo be Elmer Dudik February 23, 1997).

The remaining sediment discharge sites identified by the 1998 source analysis (PWA, 1998) were to be treated as specified in workplans pursuant to CAO 97-115. However, due to the slow rate of treatment of the identified sites, a subsequent CAOs was issued to the Palco requiring identification, prioritization, and cleanup of controllable sediment source sites (R1-2002-0114, modified by CAO R1-2006-0055) which was transferred to HRC when they acquired ownership in 2008.

Meanwhile, on South Fork Elk River, the rate and scale of timber harvest operations were not as extensive as on North Fork Elk River. As such, the same level of investigation and enforcement did not occur in South Fork Elk River. However, there were also large, harvest-related landslides that discharged significant amounts of material into South Fork Elk River in 1997 (Figure 2.6). Subsequent investigations identified numerous sediment sources that constitute violations of the Discharge Prohibitions 1 and 2 of the *Action Plan for Logging, Construction, and Associated Activities*. Identification, prioritization, and cleanup of these controllable sediment source sites are required by CAO R1-2004-0028 which was also transferred to HRC in 2008.

2.3.2.2 **Grazing**

Uncontrolled grazing activities can affect the function of riparian areas resulting in adverse impacts to beneficial uses of water. If given unrestricted access, livestock tend to prefer riparian areas to drier upland areas due to higher forage volume, proximity to water, and microclimate (UC Cooperative Extension, 1993). The potential effects of livestock grazing on aquatic habitat are summarized below (UC Cooperative Extension, 1993).

- Elevated stream temperatures due to lack of streamside cover
- Bank and upland erosion contributing to sediment delivery to channels
- High coliform bacteria counts
- Channel widening due to bank erosion
- Altered channel form
- Alteration, reduction, or elimination of native vegetation
- Replacement of riparian species with non-native vegetation


Figure 2.7 Cattle with free access to Martin Slough (Photo by Adona White, 2008).

Many of these effects may be minimized by implementation of appropriate grazing practices. Until recently, small grazing operations have not been subject to specific water quality regulatory requirements. In the past development of grazing management plans were voluntary. However, the adoption of the 2004 State NPS Policy (SWRCB, 2004) reaffirmed the Regional Water Board’s responsibility to regulate all sources of non point source pollution, including from grazing and other agricultural activities. These activities are subject to regulation by the Regional Water Board via adoption of applicable prohibitions, WDRs, and waivers (see Section 2.2.7 above for more information).

Numerous sections of Elk River are unprotected from cattle access and has degraded riparian conditions and bank erosion associated with the grazing activities (Figure 2.7).

2.3.2.3 **Urban Development**

Urban land uses that alter vegetation and land cover result in 1) reduction of rainfall interception, 2) compaction of permeable soils, and/or 3) covering of permeable soil on vegetated land with impervious surfaces such as structures, streets, sidewalks, and parking lots. These conditions concentrate surface flows, increase the time fit takes for rainfall to reach a watercourse (time of concentration), and increase the magnitude and intensity of runoff. This typically results in increased peak flows and higher runoff volumes and velocities. The altered flow regime results in increased bank instability, erosion, channel incision, intensified flooding, and the discharge of fine sediment to watercourses. Further, due to increased peak runoff (rainfall moving off the landscape without having a chance to permeate into the soil horizon), groundwater recharge is reduced. Low flow conditions are likely to occur earlier in the year with greater impacts to beneficial uses from these altered hydrologic regimes. These impacts can significantly impair aquatic function through alteration of instream habitat features such as filling of pools and loss of undercut bank habitat, decrease in the spatial and temporal extent of the stream's wetted channel, and loss of large diameter woody tree species, an important component in the formation of complex habitat structures.

2.3.2.4 **Modifications to Humboldt Bay**

Humboldt Bay is the largest shipping port in California north of the San Francisco Bay. The harbor is used for recreation and industry. The Humboldt Bay Harbor, Recreation and Conservation District manages bay uses and is responsible for dredging activities needed to allow large ships access to Humboldt Bay. The most recent channel deepening projects were completed in April 2000 to improve navigation safety and commerce. The need for maintenance dredging is dependent on dredge channel locations and configuration, dredge material, redistribution of bay sediments and new sediment inputs to the bay from tributaries and via the bay inlet.

Similarly as management modifications to the bay inlet and shoreline have proceeded, there is a likelihood that those modifications have also influenced the lower Elk River.

Among the modifications to the bay are structural changes to the inlet in the construction of jetties intended to break waves and allow boats safe passage through the inlet, dredging of channels for navigation within the bay, the construction of bridges, dikes and levees around the bay edge to support and protect railroads and roadways, and the construction of docks and marinas for commercial and recreational boats.

The Humboldt County Department of Public Works maintains records of historical conditions in Humboldt County. Regional Water Board staff reviewed historic maps of Humboldt Bay dating back to 1851. These maps generally provide bathymetry information from soundings conducted by the US Coastal Survey and the US Army Corps of Engineers. While the surveys were primarily conducted at low tide, it is likely that varying surface were exposed and thus the data is not completely comparable.

However when viewed as a set, the maps provide indications of changes in features over time.

The earliest available survey including the Elk River area is from 1851; the jetties were not yet constructed. Elk River is shown with an island approximately one-half mile upstream of its confluence with Humboldt Bay. Additionally, the area just south of Elk River is indicated as having some sort of armoring present. An 1854 map shows an Indian village on a land spit located just upstream of the mouth of the river and a trail across the river; the river entered the bay parallel to the bay inlet. An 1858 map also depicts the land spit and a road where the trail was; a map note states that the bar in the bay is constantly changing, perhaps indicating that it is comprised of mobile material (e.g. sand, gravel). Indian villages were located on either side of the inlet. An 1886 map makes this same statement and shows breakers on either side of the inlet, a lighthouse is mapped at one of the Indian villages, a road was built over Elk River, as well as a road over Martin/Swains's Slough (approximately where Elk River Road now exists). Also it appears that some control structures were placed at the mouth of Elk River separating it from the land spit; mud is shown just beyond the mouth. An 1897 map depicts a slight tilt to the south of the mouth of Elk River. A 1901 map depicts construction of jetties and does not include a spit at the mouth of Elk River. A 1903 map shows little change compared to the 1901 map.

The 1911 map shows a railroad line running from Fields Landing to the north with a crossing over the mouth of Elk River. Just to the south of the mouth of Elk River the bay was diked for the railroad line. Another 1911 map includes bathymetry of lower Elk River and includes the railroad crossing at the mouth, a bridge over Elk River, and across Martin Slough the additional of another railroad and two additional bridges. A similar map was published in 1931, also showing bathymetry of lower Elk River, the previous crossing and the newly constructed State Highway to San Francisco. Important notes on this map include the appearance of a sand spit approximately 2500' in length at the mouth of Elk River and a note that Elk River downstream of the Highway crossing is dry at low water. The 1940 map depicts the spit as 5500' in length, parallel to the bay's shore causing the Elk River to deliver into the bay in a more northerly direction toward Eureka. The 1940 map shows the spit as approximately 6300' in length.

As documented in the historical maps, channels within the bay were modified to allow the passage of ships. It is logical to assume that alteration of the bay hydraulics would lead to alteration in water and sediment routing of Elk River. The Humboldt Bay Harbor, Recreation and Conservation District compiled "*Historic Atlas of Humboldt Bay and the Eel River Delta"* which is a GIS comparison of the aforementioned Humboldt Bay maps. These maps indicate the most significant differences to the Elk River spit are observable when comparing the 1855, 1944, 1958, and 2005 shorelines (Figure 2.8)

The extent to which the bay affects the hydraulics of Elk River is not well understood. Future analyses are necessary to understand how and when the tides of Humboldt Bay cause a tidal back-water effect on Elk River flows.

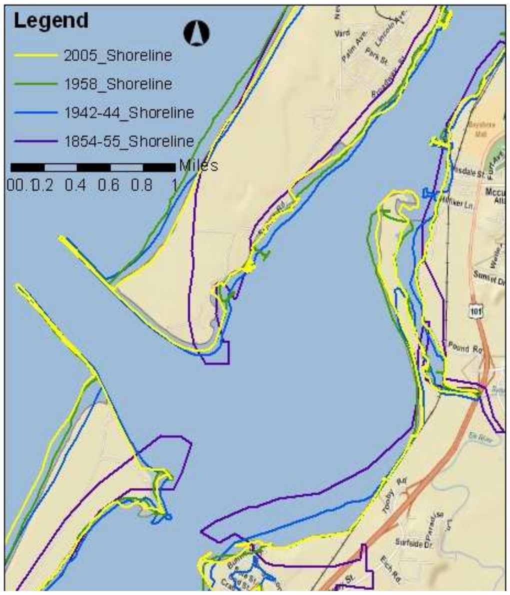

Figure 2.8 Humboldt Bay inlet and Elk River spit, compared over historic time periods (data from HBHRCD, 2007)

Prior to the railroad construction up South Fork Elk River, Elk River was used to transport logs to Humboldt Bay for processing and shipping. Historically there was a log pond located on South Fork Elk River where logs were stored until the rains contributed enough streamflow to float the logs downstream. The effects of this practice in unknown, however it likely caused artificial floods and may have contributed both to channel incision and deposition.

2.3.3 Effects of Excess Sediment

2.3.3.1 **Altered Channel and Floodplain Morphology**

In a stream that is in equilibrium, sediment inputs are balanced with a stream's ability to transport sediment. If sediment inputs overwhelm a stream's capacity to transport, then sediment deposition occurs and stream morphology changes. Deposition is a natural process, especially in low gradient reaches of river. However if supply overwhelms transport, the rate of deposition and the reaches where deposition occurs can be significantly altered. Further, as the system's sediment supply increases, the particle sizes the stream can transport decrease, resulting in a fining (covering of sands, gravels and cobbles, etc) of the channel.

The sediment supply in Elk River has overwhelmed the transport capacity of the river resulting in rapid channel and floodplain aggradation. Available lines of evidence include historic observations by long-time residents, comparisons of historic data and more recent topographic and flow measurements, and field investigations by Regional Water Board staff.

According to historic observations by long-time residents, significant topographic alterations occurred in Elk River, especially in the area around the confluence of the North Fork and South Fork Elk River. Beginning in 1997 residents of Elk River began to address the Regional Water Board regarding reduced water quality, channel filling, degraded beneficial uses, and increased frequency and magnitude of flooding. Staff of the Regional Water Board, CDFG, CDF, and California Department of Mines and Geology[2] investigated these complaints and corroborated the resident observations. A series of significant rain-storms occurred in the late 1990's following the initiation of the accelerated logging rates. These storms triggered unprecedented hillslope landsliding, as well as road-related mass wasting events. Much of the sediment released from these events was delivered to the river system.

Figure 2.9 Resident Kristi Wrigley at her family's 100-yr old North Fork Elk River apple orchard indicating the height above the ground surface that the apple tree branches spread from the trunk. The 2.5 foot trunk is now buried in sediment. (Photo by RCAA NRS staff, December 16, 2003)

In North Fork Elk River, the effects of the excess sediment discharges resulted in very pronounced altered instream conditions. The majority of the discharged sediment was comprised of fine-grained particles originating from the Wildcat Formation. One hypothesis is that since many of the sediment sources appear to have originated from large scale mass wasting events like landslides and debris flows, the poorly sorted sediment had cohesive properties due to the relatively high percentage of clay sized particles. When this material was delivered to the fluvial system, it was deposited in low gradient reaches and "stuck". The deep pools and mobile gravel bars that were once present were filled in and covered with silt. Large instream wood was buried (Figure 29). The silt sized sediment covered the steep channel banks and completely covered the low terraces that formerly defined the bankfull channel. The floodplain has also been covered in a substantial layer of fine grained sediment.

The trunk of a 50-year old apple tree was buried up to its branches (approximately 2.5 feet) at an apple orchard located on North Fork Elk (Figure 2.9). Evidence of excessive sediment deposition on the floodplain includes burial of fence posts in up to four feet of sediment (Figure 2.10).

These changes likely occurred prior to 1997 but were not as noticeable until the major landslide sediment slugs were deposited. Interviews with residents and land managers

[2] The California Department of Mines and Geology is now called the California Geologic Survey.

in the Elk River indicate that channel structural changes began around 1987 (RCAA NRS, 2003) and by 1993 significant changes in water quality were noticeable (Dudik, 1998).

Figure 2.10 Fence post in lower Elk River buried approximately 4 foot in sediment (Photo by Adona White,

The Regional Water Board issued Cleanup and Abatement Order R1-1997-115 to Palco requiring the identification of sediment sources on their ownership in the North Fork Elk River, development of a remediation plan to correct those identified sediment sources. It also required that Palco undertake the restoration of impaired domestic and agricultural water supplies in North Fork Elk River. The resulting investigations found that significant amounts of sediment had been discharged to the river system but that removal of that sediment would be too environmentally damaging and rather work should focus on treatment of threatened sediment discharge sources (PWA, 1998). At the time, no investigation of possible in channel restoration activities was pursued.

From 1958 to 1967, the USGS operated a stream gage downstream of the confluence of North Fork and South Fork on Mainstem Elk River (Figure 1.3). This gage data provides the best record of baseline channel conditions prior to the period of accelerated channel deposition. Regional Water Board staff compiled and analyzed the gage records to illustrate hydrologic and hydraulic conditions in Elk River during the 10-year period of historic record (Patenaude, 2004). Monthly discharge, stage, and channel conditions were among several parameters monitored at the USGS gage station.

Beginning in 1997, a Humboldt State University graduate student and Palco employee reestablished the streamflow gage. A comparison of the historic baseline data with more recent conditions in Lower Elk River demonstrate changes in bed elevation, channel capacity, and bankfull discharge. It is important to note that the gage station is situated adjacent to a permanent bridge. Bridge structures routinely affect scour and deposition patterns, likely underestimating the overall changes due to increased velocities at the constriction caused by the bridge abutments. However, the magnitude of change in the channel over time is still significant.

The extent of changes in channel bed elevation was explored by Regional Water Board staff (Patenaude, 2004) via a comparison of stream gage records from USGS and Palco. Specifically, the channel capacity as a function of cross-sectional area was estimated from the USGS data. The changes in cross-sectional area are summarized in Table 2.3 for hydrologic year (HY) 1958, 1959, and 1965. These data indicate that there was not a significant change in cross-sectional area as a result of the 1964 event; an important finding considering that 1964 was one of the most well-known channel-altering events on modern record and should reflect the watershed's response to significant rainfall on a post-1940's (advent of large scale ground based yarding equipment) landscape. Comparison of the Palco collected data to the USGS data indicates the 2003 channel capacity is 400 square feet less than the 1965 historic channel capacity (decreased by at least 35 percent) (Table 2.3).

Table 2.3 Estimated Channel Capacity of Elk River at Gage Station (based on USGS records (Patenaude, 2004)

Water Year	Cross Sectional Area (ft^2)
1958	1180
1959	1163
1965	1158
2003	758

Further, large scale changes in channel dimensions result in significant reduction in the volume of water that the channel can contain during a storm event before spilling over onto the floodplain. This results is more frequent and extensive flooding. Patenaude (2004) compared stream discharge from Water Year (WY) 1965 to WY 1998. The reported 1998 bankfull discharge is 1370 cubic feet per second (cfs) less than the 1965 historic bankfull discharge of 2250 cfs (Conroy 1998) (Figure 2.11). Another perspective is that bankfull discharge has decreased by 60 percent or that the channel can currently only contain 40 percent of the instream flow that it was capable of conveying historically.

As demonstrated by Figure 2.11, the change in channel cross-sectional area is not solely a result of deposition on the channel bed but also as a result of channel constriction or narrowing. The material been deposited near the confluence of North Fork and South Fork is comprised of silt and sand sized sediment. The silt has a cohesive property which results in sediment “draping” on the banks covering riparian vegetation and overloading the steep stream banks with unstable or “perched” sediment.

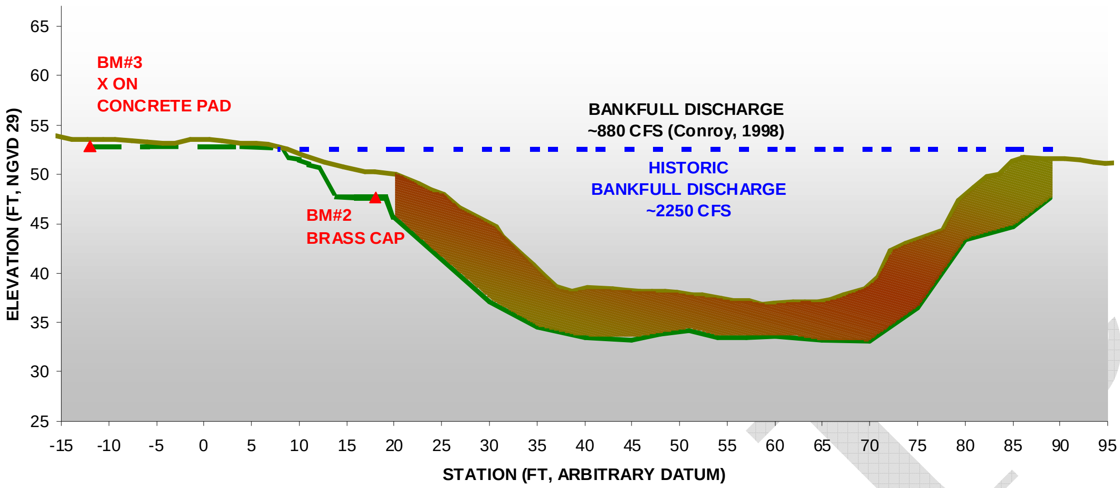

Figure 2.11. Illustration of Diminished Channel Capacity, Compared between WY 1965 and 2003 (Cross-sections based on USGS and .Palco surveys)

Sediment impacts in the South Fork Elk River are similar to those observed in North Fork and Mainstem Elk River. However the activities which initiated these impacts occurred approximately ten (10) years after the commencement of these activities in the other two sub-basins. Similarly, the response was delayed.

There have been various studies evaluating the hydraulics of the area around the confluence of North and South Fork Elk River. While the studies have been focused and contain some questionable analyses and conclusions, they indicate, along with recent stream gage date that:

- Stream velocities are low, especially during floods, allowing suspended sediment to drop out, especially on recessional limbs.
- The channel is choked with riparian vegetation that has fallen in and contributes to the channel roughness elements.
- Bridges and associated approaches likely act as constrictions.
- There has not been much recent residential development in the flood plain.
- The water surface slope indicates a backwater effect at high flows.
- The channel now cannot contain flows associated with relatively frequent streamflow events.

However, there remain significant questions regarding the Elk River fluvial system that need to be better understood prior to undertaking significant in-channel restoration activities. Such questions include, in part:

- Are there critical hydraulic controls that limit flow and sediment routing in the lower Elk River?
- What are the existing patterns of sediment storage in the channel?
- What is the spatial and temporal influence of Humboldt Bay on sediment routing and hydrodynamics in the Elk River?
- What are the potential trajectories of sediment supply, transport and storage within the channel network?
- How may changes in stream morphology alter flow distributions, depths and velocities in channels and across floodplains?
- What are the expected ecological responses to potential trajectories in physical processes?
- Are the existing flow strengths in the main channel sufficient to initiate a trajectory of recovery by eroding in-channel sediment deposits? (This question would assume a zero sediment supply)

These questions form the basis of the future studies that are needed to guide development and implementation of appropriate restoration activities.

2.3.3.2 Cumulative Effects

Recent and ongoing high sediment loads, in combination with the Elk River's instream hydraulics and the chemical and physical properties of the sediment load resulted in the excessive deposition of fine grained cohesive material elevating the channel base and constricted channel width. Armoring of the channel is ongoing by both sediment particles and vegetation, further locking in an elevated base elevation. Channel cross-sectional areas continue to be reduced due to sediment deposits.

Figure 2.12 Fresh sediment deposits on floodplain following overbank flood. (Photo taken on South Fork Elk River at BLM parking lot by Adona White, January 4, 2003).

Significant discharges of sediment and organic debris to watercourses have aggraded the stream channels in the low gradient reaches of Elk River, significantly reducing channel capacity and, along with increased peak flows, have contributed to increased flood frequencies and severity. The following section describes the data and analyses available describing how sediment loads have resulted in deposition of material and has resulted in nuisance conditions and adverse affects to beneficial uses.

Due to the changes in flood frequency and interest in sediment patterns, an increased monitoring effort commenced the late 1990s by both Palco and resident and citizen monitoring groups. Efforts are ongoing to link the different surveys to common points, actual elevations, and identify the historic versus current topography and flood footprints. Preliminary analyses provided herein demonstrate that in lower Elk River, deposition is continuing under current sediment loads.

As stated earlier, the sediment deposits are comprised of silt and sand sized particles. Bank slumps have occurred extensively in the confluence area. They were first observed as relatively small and discrete features. However since 2002, there are numerous bank slumps. Some have been observed to extend into native materials, not limited to flood deposits. Bank slumps are commonly observed within the current flood-prone reach.

The streamflow records indicate that velocities in the depositional reaches are fairly low, considering the flow rates. The cohesive sediment coating the stream bed and banks, along with low velocities, and lack of habitat complexity, and high suspended sediment loads combine in a manner that perpetuates the degraded conditions. The consequence is a sluggish system which readily deposits sediment, cannot scour the stored sediment, and does not readily drain during high flow events, causing numerous overbank events. The overbank flows spread over large areas in the broad valley and deposit sediment. As a result the floodplain is also building at a high rate.

A further confounding factor is the bank slumps occurring. Sediment deposits on the banks are not stable. Slumps of the fresh deposits and native material reenter the channel (further described in Chapter 3: Source Analysis). However, slumps are also observed to extend into native material (Figure 2.13). The riparian vegetation, comprised primarily of willow and red alder, enter the channel along with the bank slump material.

Further, the freshly deposited sediment on the banks is readily colonized by the invasive non-native Himalaya blackberry. Recently, observations indicate that channel deposits are also being colonized by a grass, armoring the elevated channel bed (Figure 2.14). The consequence is vegetative roughness elements further influence the low velocities in the system limiting scour capability and reducing the systems ability to efficiently drain water, thus further causing floods locking in the higher channel elevation.

Figure 2.13 Bank slump on Mainstem Elk River (Photo by Nancy Sievert).

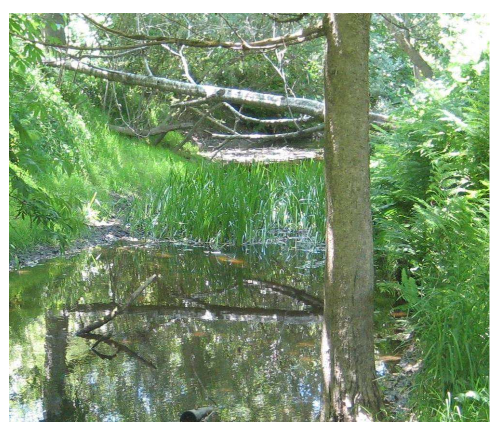

Figure 2.14 Grass colonizing channel on lower North Fork Elk River near the confluence with South Fork (Photo by Adona White, 2008)

Stream cross-sections have been measured in lower Elk River by Salmon Forever since 2001. HRC also collects stream cross-section information as part of their monitoring programs. However, due to their evaluations being submitted to Regional Water Board staff only in hard copy, annual comparisons could not be verified. Only the cross-sections that could be verified are presented herein to demonstrate the relative scour and deposition occurring since 2001 at locations as surveyed by Salmon Forever. Figure 2.15-2.18 demonstrate the cross-section data plots as well as the common survey area, within which the cross-sectional areas are compared year to year. Generally it appears that HY 2003 resulted in channel scour and deposition occurred in the subsequent years. These cross-sections are consistent with other observations about ongoing deposition.

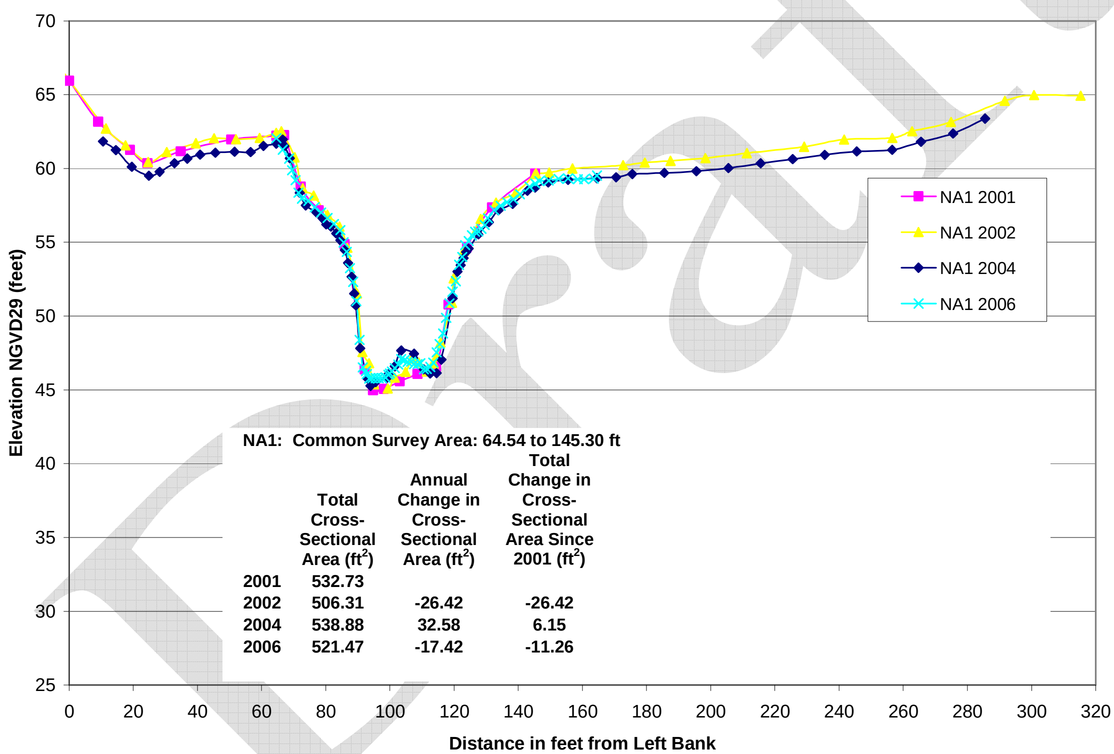

Figure 2.15 Surveys of Cross-Section NA-1 located on lower North Fork Elk River.

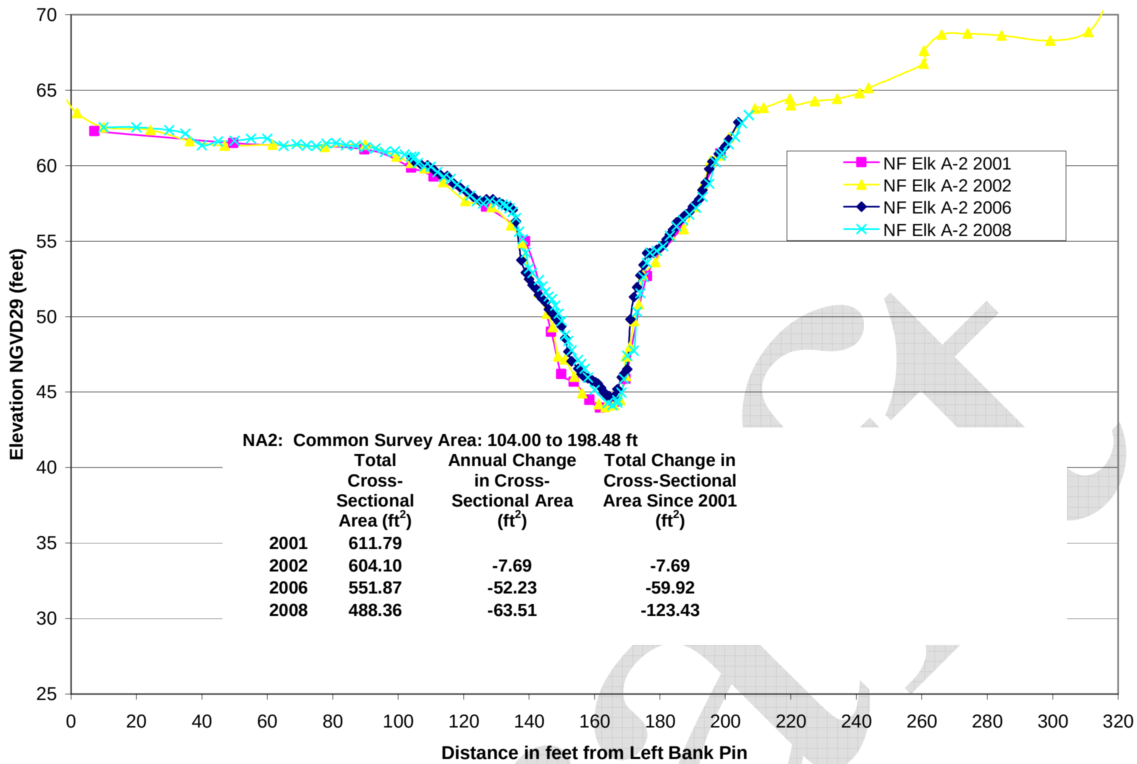

Figure 2.16 Surveys of Cross-Section NA-2 located on lower North Fork Elk River.

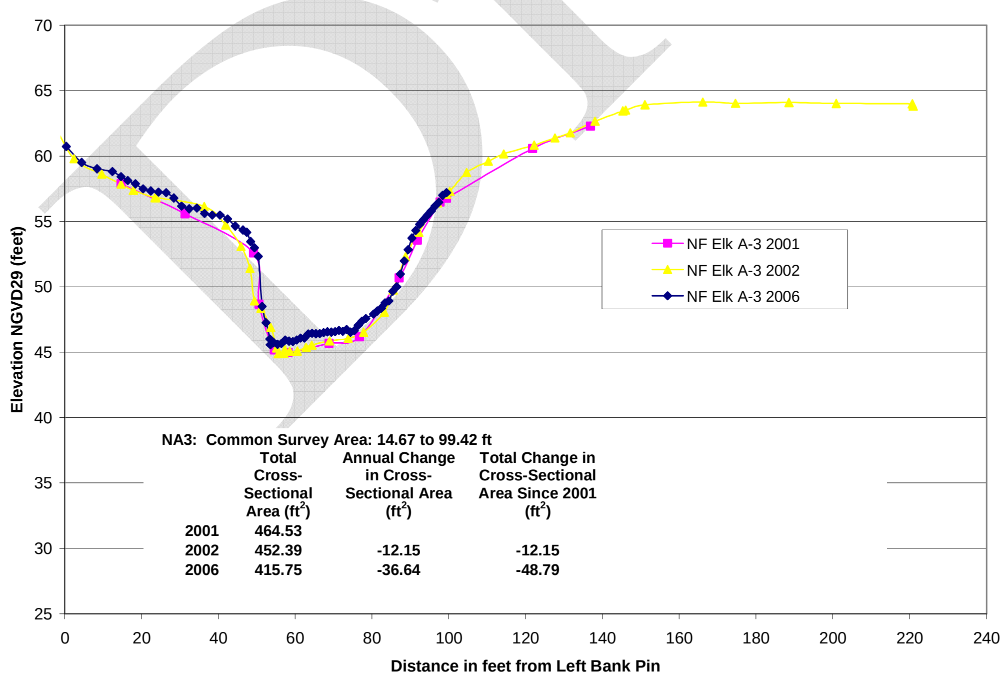

Figure 2.17 Surveys of Cross-Section NA-3 located on lower North Fork Elk River.

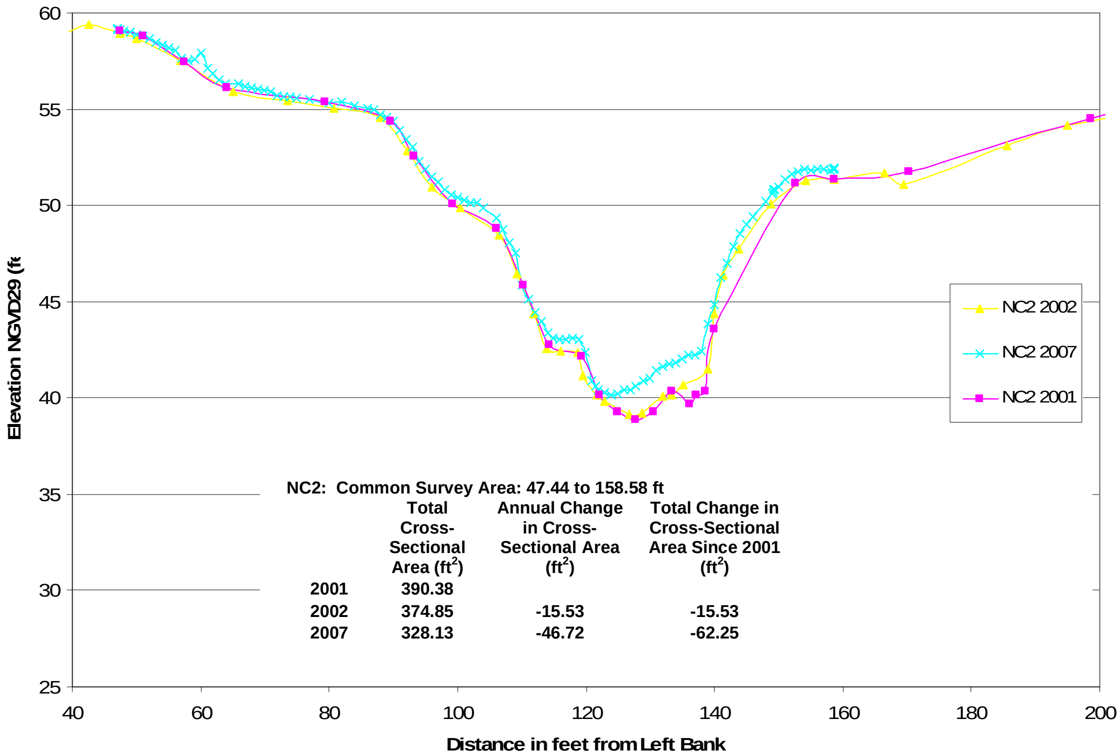

Figure 2.18 Surveys of Cross-Section NC-2 located on lower North Fork Elk River near the confluence with South Fork Elk Rver.

2.3.3.3 **Nuisance Flooding**

The incidence of flooding in the Elk River watershed has increased at an elevated frequency and magnitude due to land use activities and “controllable water quality factors”. Fields, roadways, driveways, homes and septic systems are frequently inundated. Potentially serious impacts to health and safety are associated with these flood events, as residents attempt to cross flood waters, as emergency vehicles are limited from accessing homes, and as power can be lost to people dependent on health-support machinery. Additionally health impacts from contaminated flood water entering a home include damage to walls, flooring, furniture, etc. and the potential for growth of harmful molds in homes. The frequency of flooding events in the Elk River watershed has led to increased costs to landowners and a general lack of wellbeing to residents of the Elk River community.

Overbank floods now occur at a frequency of four times per year on North Fork Elk River (Regional Water Board staff, 2006). As a consequence there is flooding of roads, fields, fences, and homes at intervals that are much frequent than occurred historically. This affects the livelihoods of those who live in the community of Elk River. South Fork and Mainstem also flood, though their frequency of occurrence is not as readily quantifiable as on North Fork (Regional Water Board, 2006).

The Regional Water Board received a petition on October 2, 2003 (the Petition), signed by 64 Elk River residents, requesting, in part that the Regional Water Board issue a Cleanup and Abatement Order (CAO) to Palco, requiring dredging of sediment deposits in North Fork, South Fork and Mainstem Elk River. To date, the Regional Water Board has not issued a CAO on this matter. Nor has a feasibility study been conducted on potential solutions to the flooding situation in Elk River. The Petition contends, in part, that the channel deposits is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property and that the entire community or neighborhood, or any considerable number of persons, at the same to is affected.

Figure 2.19 Lower North Fork Elk River during a flood (photo part of Regional Water Board public files.

Figure 2.21 Flooded field and roadway on mainstem Elk River (Photo by Adona White).

Figure 2.20 Upper Mainstem Elk River at Elk River Courts. (Photo courtesy of Humboldt County Public Works Dept, taken February 18, 2004).

Figure 2.22 Flooding in the driveway of a residence on upper Mainstem Elk River at Elk River Courts (Photo by Nancy Seivert).

2.3.3.4 **Beneficial Uses are not supported**

The beneficial uses of water in Elk River that are most impaired by and sensitive to excessive sediment loads are related to domestic and agricultural water supplies, cold water habitat and salmonid fishery, and contact and non-contact recreation.

2.3.3.4.1 Domestic and Agricultural Water Supplies

The TMDL analysis supports the finding that domestic and agricultural water supplies are impaired. There are currently no alternative water supplies available to the effected residents. Residents in the North Fork, South Fork, and Mainstem Elk River have historically relied upon surface water for domestic and agricultural water supplies.

Currently, in the Martin Slough sub-basin domestic water supply hookups are provided by the City of Eureka and the Humboldt Community Services District (for areas outside of the Eureka City limits). In 1981-82, the Humboldt Community Services District installed a water main to Mainstem Elk River (approximately to one-quarter (1/4) mile downstream of Berta Road). At that time one property owner put up the majority of the capital cost to install the main (Pers Comm. Micky Holstrom, 2008). Upstream of the service area provided by the water main, residents rely on individual water systems.

Some of the individual water system intakes draw from springs, however the majority rely on a pump intake system in the river, usually in a pool. Water supplies are impaired by fine sediment in both the winter and summer periods. In the summertime, the availability of suitable pools from which to draw water is limited due to pools being filled with fine sediment; the river's summer storage is limited due to filling of pools. In the winter time, turbidity levels rise quickly at the onset of a storm, remain elevated following storms, thus limiting the time period available to withdraw water. Additionally, increased sediment and organic material can produce tastes and odors offensive to the senses, can damage surface water supply intakes, treatment systems and domestic plumbing and appliances. Increased turbidity due to excessive fine sediments also provides a medium to promote bacteriological growths and reduces the effectiveness of water disinfection for domestic water supplies.

To ensure water is safe to drink and will not harm agricultural equipment, a determination is made by the user as to whether the turbidities are low enough to pump. According to long-time resident Kristi Wrigley, turbidities are appropriate for agricultural use below 40 nephelometric turbidity units (NTUs) and appropriate for domestic use below 20 NTUs. Historically, after a storm, the river would clear enough for use in 3-5 days (Pers Comm Kristi Wrigley, 2008).

In 1997, following a series of storms which initiated logging-related sediment inputs (see Chapter 3: Source Analysis) Regional Water Board staff conducted investigations that resulted in the issuance of Cleanup and Abatement Order (CAO) No. 97-115 for discharges of sediment from timber harvest operations in North Fork Elk River. As a result of the logging related effects on the drinking water beneficial use, the Regional Water Board ordered Palco (CAO No. 98-100) to provide alternative water systems to residences whose water supplies had been adversely affected by the increased sediment discharges along North Fork Elk River. Order No. 98-100 contained findings that verified resident's observations regarding the significant adverse impacts in water quality since 1993. The CAO confirmed that land use activities had resulted in creation of conditions that produced tastes and odors in their water supplies that were offensive to the senses, increased the frequencies of maintenance and replacement of hot water heaters and water treatment facilities, as well as damage to agricultural spray equipment and surface water supply intakes. Residents also reported significant changes in stream morphology including the filling of pools in the stream channel.

Implementation of Order 98-100 is ongoing; twelve residences received "replacement" water supplies as a result of the Order 98-100. The replacement water supplies range from wells to pump systems with filtration and disinfection systems. The systems are substantially more complicated that the resident's historic supplies and require annual operations and maintenance. For example, since residents did not historically pump during turbid conditions and the new systems are designed to handle the more turbid conditions, the contact tanks and filters require more frequent cleaning.

The Regional Water Board has received complaints from South Fork and Mainstem Elk River residents of degradation of water supplies from both surface and groundwater systems (wells). Residents report to the Regional Water Board that these effects continue in nature and extent. Regional Water Board staff observations have verified these reports. In response, at a March 16, 2005 Regional Water Board hearing, based on written suggestions from Palco representatives, the Regional Water Board adopted a motion which resulted in Palco delivering drinking water supplies to six (6) South Fork and eight (8) Mainstem Elk River residents for the period of one year. No long-term resolution on this issue has been reached to date.

2.3.3.4.2 Cold Freshwater Fisheries

Humboldt Bay is California's second largest estuary and provides vital fish and wildlife habitat. The Bay provides refuge and nursery habitat for more than 120 fish species, many with important commercial and recreational fisheries value. Humboldt Bay is also a biodiversity hotspot in that its wetlands and dunes are habitat for at least 20 State-and federally-listed or otherwise sensitive species (CDFG 2008). Humboldt Bay is California's largest producer of oysters and a vital nursery for juvenile Dungeness crab. Due in part to significant declines in the salmon fisheries, Dungeness crab is now a mainstay of the local fishing industry accounting for more than 50 percent of the economic value of Humboldt County's fishing industry (Prosperity 2007).

Numerous sensitive species, including State and federally listed species occur in the Elk River. Anadromous salmonids utilizing the watershed include:

- Coho salmon (*Oncorhynchus kisutch*), state and federally listed as threatened;
- Chinook salmon (*Oncorhynchus tshawytscha*), federally listed as threatened;
- Coastal cutthroat trout (*Oncorhynchus clarki clarki*), listed as a state species of special concern; and
- Steelhead (*Oncorhynchus mykiss*), federally listed as threatened.

Coho salmon populations in Elk River and its tributaries have been designated by DFG as key populations to maintain or improve as part of the *Recovery Strategy of California Coho Salmon* (CDFG 2004). Coho salmon have undergone at least a 70 percent decline in abundance since the 1960s statewide, and is currently at 6 to 15 percent of its abundance during the 1940s (CDFG 2004). Humboldt Bay tributaries support some of the last significant populations of wild coho salmon remaining in California (Brown et al. 1994).

The following sections provide some background information on the summaries of observations of salmonids and the location and condition of salmonid habitat within the Elk River watershed.

2.3.3.4.2.1 Salmonid Observations

While there has been no comprehensive salmonid population monitoring program in Elk River (as is occurring in the adjacent Freshwater Creek), numerous fisheries surveys have been conducted in the Elk River. Electroshocking, carcass, and redd surveys have been conducted by Palco, the Institute for River Ecosystems, Natural Resources Management, and CDFG (HBWAC, 2005). Trend analysis is difficult because the surveys have varied in timing and effort, along with relatively short (temporal) monitoring duration. However, the survey results do provide usable absence/presence data. Fish spawner surveys have been conducted in North and South Fork Elk River by CDFG as early as the 1950s. Compiled below are the total numbers of coho, Chinook, and steelhead carcasses and redds as observed during spawner surveys from 1986 to 2003. It must be noted that surveys conducted in the same year may double count fish because the same sites may have been surveyed within short periods of time. There is no appropriate level of interpretation included with this information due to the incongruent nature of its collection. Fish trend monitoring is complicated by the cyclic flux of salmonid populations.

The CDFG North Coast Watershed Improvement Center has conducted fisheries inventory stream surveys in numerous tributaries to Elk River. These surveys document the recent extent of these beneficial uses (spawning, rearing, migration, etc). Appendix C contains summaries of the fish and habitat surveys conducted in these Elk River tributaries. Regional Water Board staff summarized these data by hydrologic year (HY) and species for North Fork and South Fork Elk River. These data are presented in the eight charts of Figure 2.23.

While stream surveys were only conducted in recent years, limited anecdotal and written accounts exist describing Elk River fisheries over a greater time period. These accounts indicate that the Elk River fisheries were abundant.

The importance of estuaries to salmonids is described by Miller and Sado (2003):

> "For salmonids other than coho salmon, faster growth in the estuary and larger size at ocean entrance has been shown to account for higher marine survival (Reimers 1973; Macdonald et al. 1988; Levings et al. 1989; Solazzi et al. 1991; Northcote 1997; Pearcy 1997; Trotter 1997). These survival benefits to coho salmon have largely been inferred from these studies, but coho salmon have substantially different life histories and estuary use patterns."

In the adjacent Freshwater Creek, studies by CDFG suggest that coho rearing in the stream-estuary ecotone (and therefore larger in size than stream reared coho) have higher marine survival than stream reared coho.

A recent effort by CDFG to sample the utilization of different portions of the Humboldt Bay estuary has offered insight into overwinter utilization of smaller streams by coho. In a Martin Slough field note dated April 7, 2009, Mike Wallace, Fisheries Biologist for CDFG states:

> "It appears a large number of juvenile coho reared throughout the winter in Martin Slough. This project has observed the arrival of smaller "stream-rearing" coho to the freshwater-estuary ecotone in Martin Slough and other Humboldt Bay tributaries in past years. The recapture of another juvenile coho originally tagged in Elk River Slough (now a total of five this year) is further evidence that juvenile coho throughout the Humboldt Bay watershed redistribute themselves, primarily downstream, to over-winter in low gradient habitat in the freshwater-estuary ecotone ringing Humboldt Bay. This "fall redistribution" of coho salmon searching for winter habitat has been observed by other researchers throughout the Pacific Northwest including the Klamath River basin. Continued studies of life history strategies of juvenile salmonids in Humboldt Bay tributaries appear to have relevance throughout a large portion of their range and may be representative of other watersheds in California and beyond.
>
> We continued to capture juvenile coho in the east tributary again this month after they were absent throughout the summer and fall. This strongly suggests that they probably use this small stream only for over-winter habitat and as a refuge from high flows. We will continue to sample the east tributary throughout the rest of the year to determine their rearing patterns in this tributary. This small tributary is an example of seasonally important habitat for coho that might be overlooked during summer surveys. Seasonally flowing streams, ponds, and wetlands appear to provide temporary but important rearing opportunities for juvenile salmonids in the Humboldt Bay watershed."

Results from the recent sampling efforts are shown in Figures 2.24- 2.26.

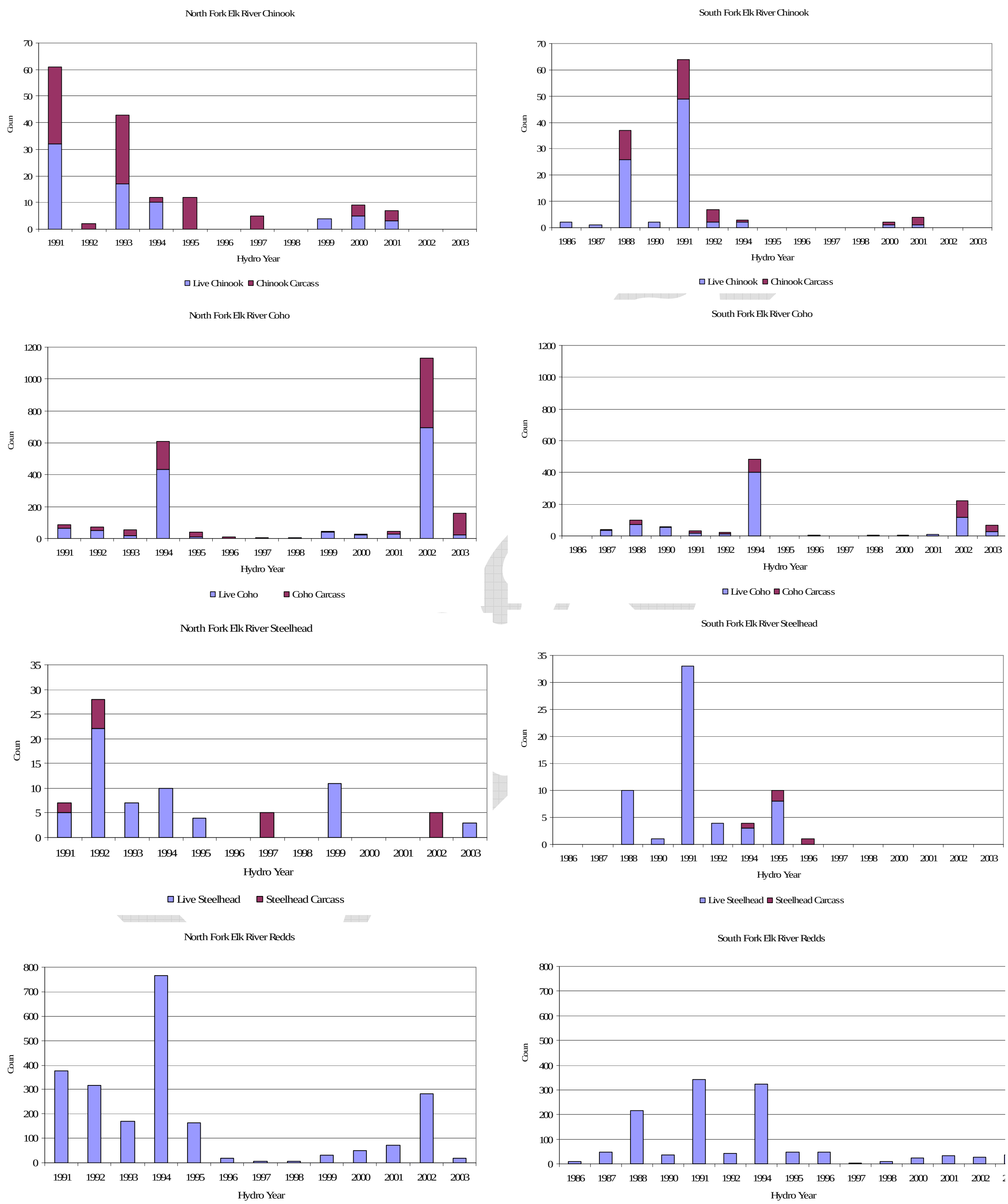

Figure 2.23 North Fork and South Fork carcass and redd survey results, 1986-2003.

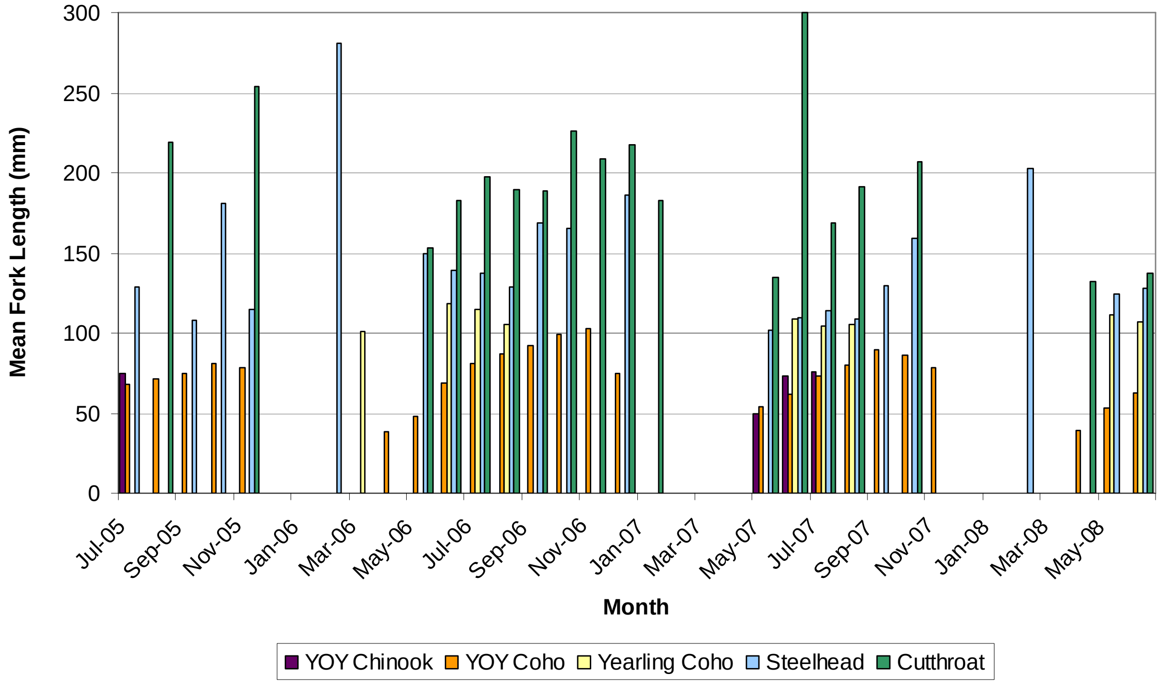

Figure 2.24 Monthly mean fork length (in millimeters) of young of the year (yoy) Chinook salmon, yoy coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout in the Upper Elk River Slough. (Data collected and provided by Mike Wallace of CDFG).

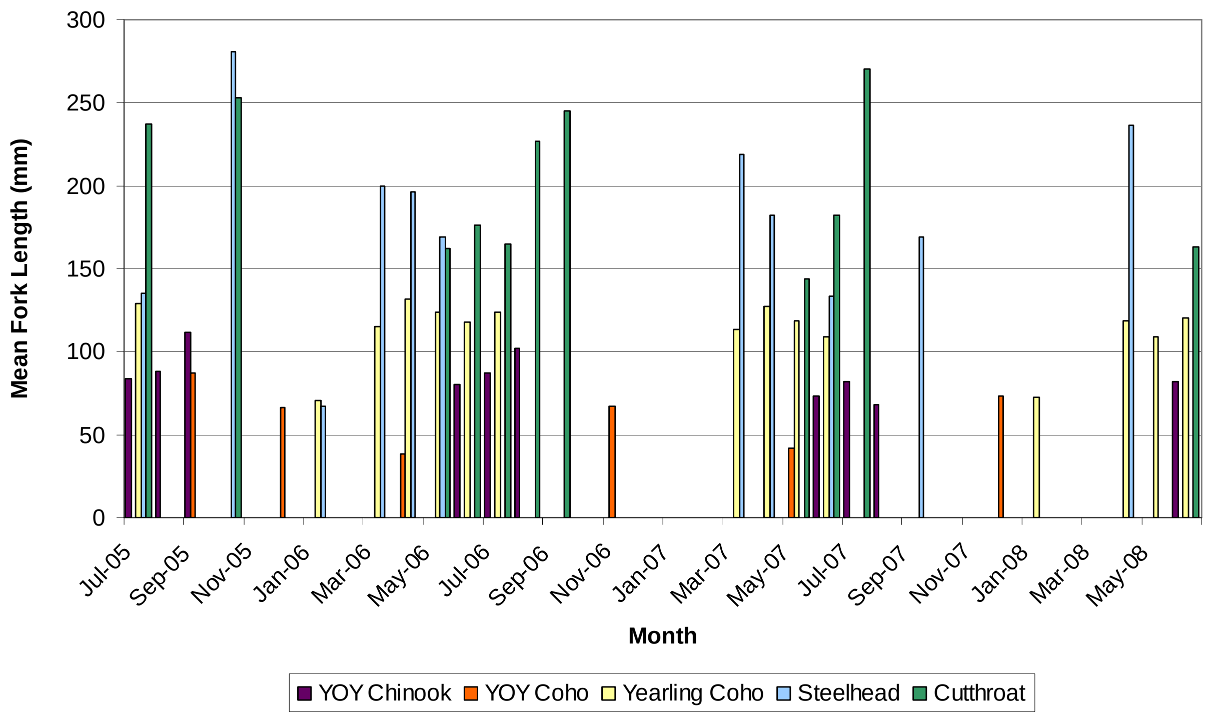

Figure 2.25 Monthly mean fork length (in millimeters) of young of the year (yoy) Chinook salmon, yoy coho salmon, yearling and older coho salmon, juvenile steelhead trout, and cutthroat trout in the Lower Elk River Slough. (Data collected and provided by Mike Wallace of CDFG).

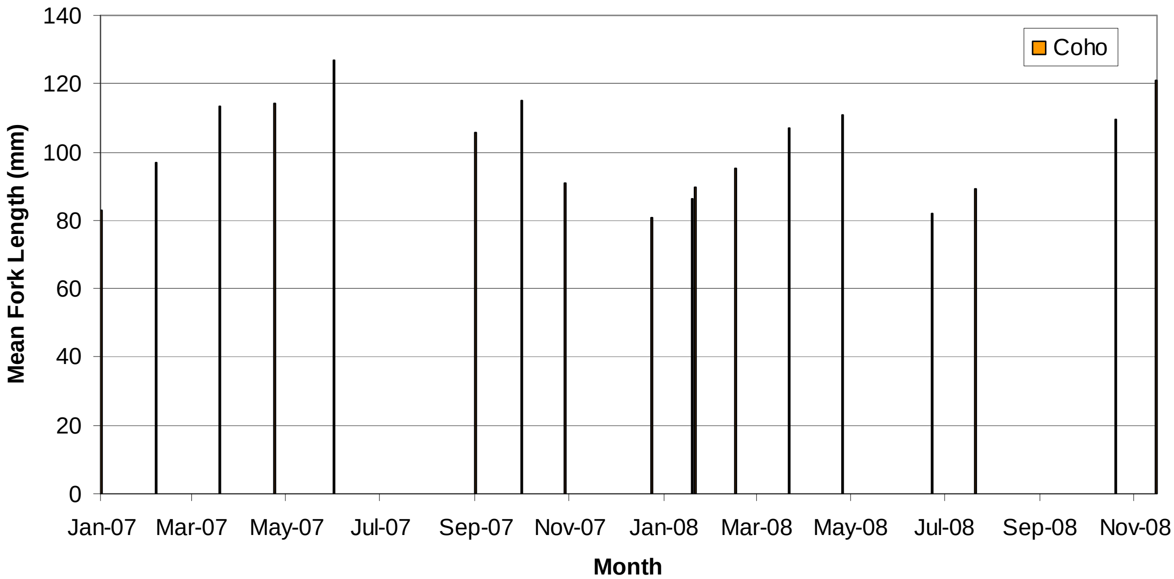

Figure 2.26 Monthly mean fork length (in millimeters) of all captured coho salmon in the Martin Slough. (Data are preliminary and were collected and provided by Mike Wallace of CDFG).

The coho captured in Martin Slough are among the largest from estuaries and sloughs around the bay. This sampling effort highlights the importance of enhancing these tyes of habitat fisheries.

2.3.3.4.2.2 Salmonid Habitat Location and Habitat Conditions

Elk River is included in the Eureka Plain Hydrologic Unit according to both the Basin Plan and CDFG's *Coho Recovery Plan* (2004). Figure 2.27 shows the coho salmon distribution in the Eureka Plain. When population, risk, and watershed conditions are considered, CDFG identifies the Eureka Plan as having a "high" restoration and management potential (5 on a scale of 1-5). CDFG (2004) identified impairments in the Humboldt Bay watershed including high instream sediment levels, stream channel aggradation and widening, lack of stream habitat structure (i.e., deep pools), high water temperatures, and loss of functioning estuary habitat. Observers have seen changes in the occurrence and magnitude of flooding and in the fish-community structure, such as avoidance of degraded tributaries by spawning adults. Simplification of the stream channels has decreased the quantity and quality of aquatic habitat. Human-made obstructions to upstream and downstream migration frequently restrict access of adult and juvenile salmonids to spawning and rearing habitat. Culverts and tide gates have been identified as fish passage barriers.

Significant recent effort has gone into identifying and designing tide gates that have a muted tidal signal and allow for fish passage. A tide Gate on Martin Slough is slated for replacement in an effort lead by Redwood Community Action Agency.

Culverts that act as fish passage barriers are to be identified by timber companies as part of timber harvest plan preparation. However, there is not a comprehensive program by which barriers are identified on other private lands.

Associated with the Elk River and Salmon Creek Watershed Analysis (Palco, 2004) Palco and Hart Crowser mapped current fish distribution in the Elk River watershed, including identification of potential barriers to migration (Figure 2.28).

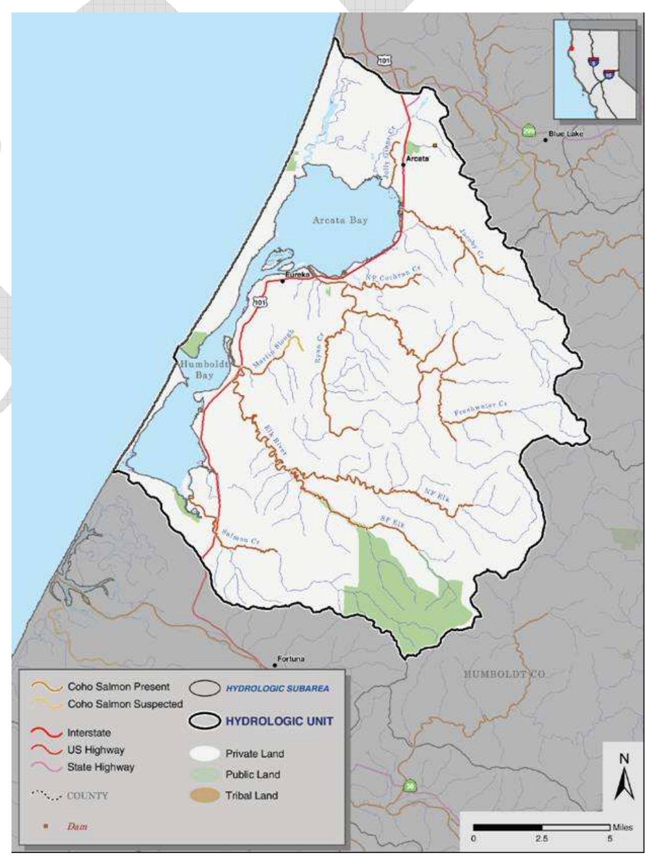

Figure 2.27 Eureka Plain Hydrologic Unit (Source: CDFG Coho Recovery Plan Figure 6-11).

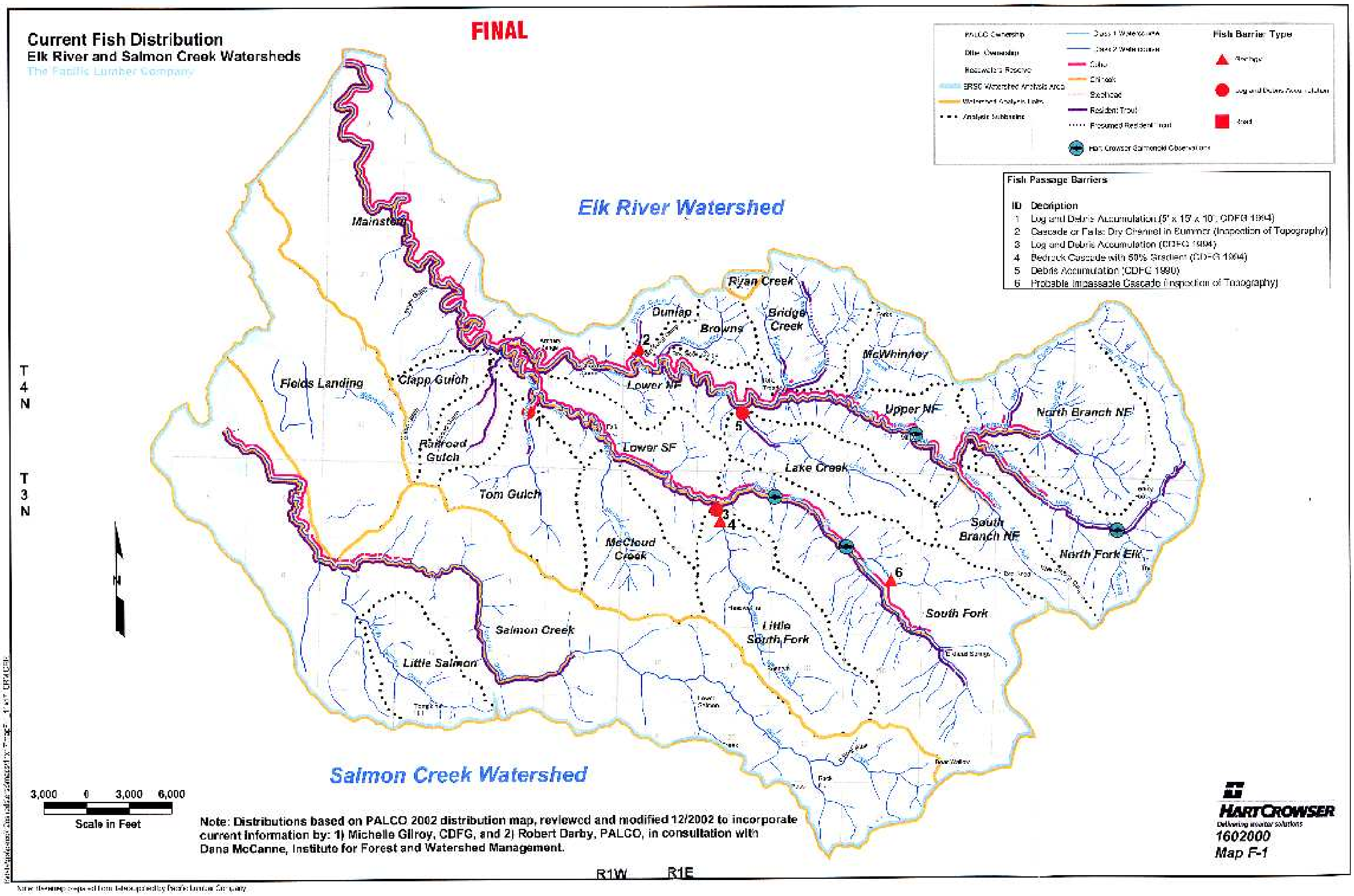

Figure 28 Distribution of fish habitat it Elk River as identified by Palco and Hart Crowser in Figure F-1 of the Elk River and Salmon Creek Watershed Analysis (2004).

Excessive fine sediment has been shown to detrimentally affect spawning gravel and to reduce survival from egg to emergence stages by reducing intragravel oxygen and gravel permeability and by entombing fish larvae within gravel interstices. Excess fine sediment can also reduce the production of food organisms for juvenile fish. Furthermore, increased excessive bedload results in deposition of sediment that reduces stream pool size and habitat availability for aquatic species, and reduces channel capacity, which leads to increased flooding of adjacent lands. It also results in reduced summer storage due to filled pools, and may reduce surface flow since much of the flow is subsurface during the summer.

Available data on instream sediment conditions for Elk River are derived from the Palco's Habitat Conservation Plan Trend Monitoring Program. Trend monitoring data provided herein are from Palco's 2000, 2004 and 2006 Trend Monitoring Annual Reports. Channel trend monitoring has occurred at nine stations, including one on Mainstem Elk River, four on North Fork Elk River, and four on tributaries to Elk River (North Branch Elk River, South Branch North Fork Elk River, Bridge Creek and South Fork Elk River)[3]. Station locations are provided in Figure 2.29 and the associated station codes are provided in Table 2.4. The sediment-related parameters are discussed in relation to the desired conditions as described in *Desired Salmonid Freshwater Habitat Conditions for Sediment-Related Indices* (North Coast Regional Water Board, 2006)[4]

Table 2.4. HRC (formerly Palco) trend monitoring station number and location.

Station Number	Location
90	North Fork Elk River
91	North Branch Elk River
104	South Branch North Fork Elk River
167	North Fork Elk River
162	North Fork Elk River
168	Bridge Creek
14	North Fork Elk River
175	South Fork Elk River
166	Mainstem Elk River
214	North Fork Elk River
217	South Fork Elk River

[3] Two stations (station 214 on North Fork Elk River and station 217 on South Fork Elk River) were added in 2005 and only have two years of data. Data collection was discontinued after 2004 at stations 90 (North Fork Elk River), 91 (North Branch Elk River), 104 (South Branch North Fork Elk River) and 168 (Bridge Creek).

[4] North Coast Regional Water Quality Control Board. July 28, 2006. Desired Salmonid Freshwater Habitat Conditions for Sediment-Related Indices.

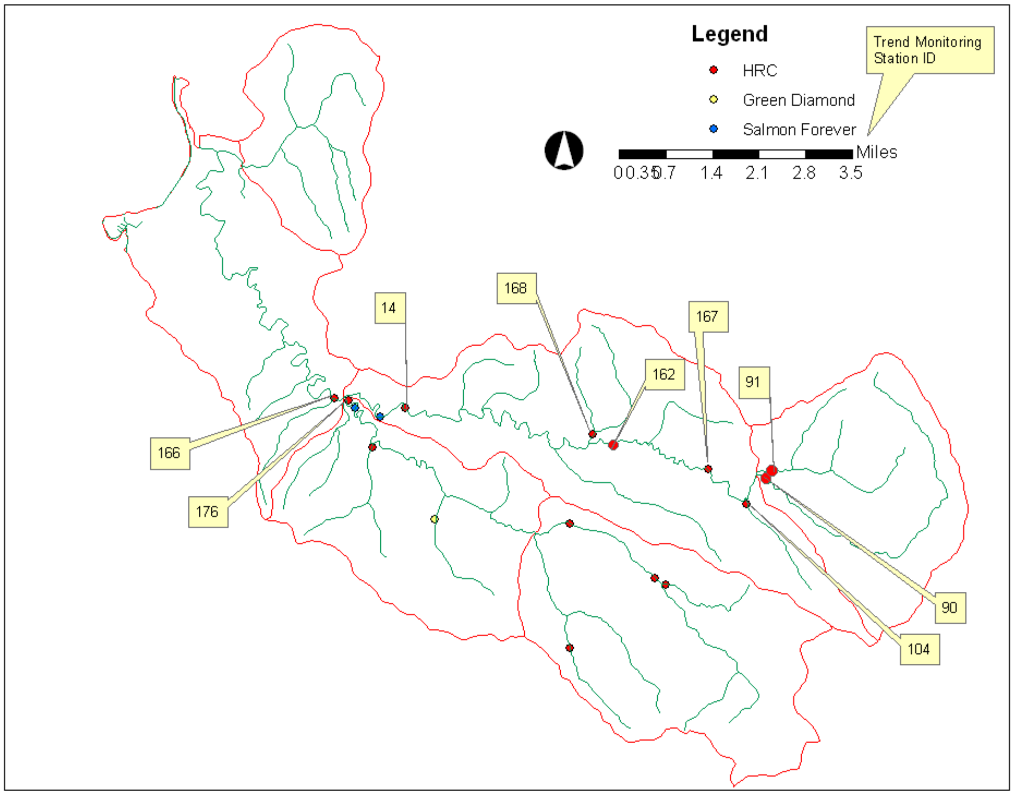

Figure 2.29. HRC (formerly Palco) Trends Monitoring Stations in Elk River

Pebble Count (D_{50}) Conditions

D_{50} is a measure of the particle size distribution of the surface of a streambed, specifically the particle size for which 50 percent of the sample has a diameter smaller than the D_{50} value. The channel bed surface layer is typically coarser than the underlying layers as the surface is often deficient of finer fractions present in the subsurface distributions, as fines are winnowed away by streamflow. It is helpful to understand channel material for interpreting biological function and channel stability. In some cases surface layers act as armor layers as they persist through transport events. As of the 2006 Annual Report, 100 percent of the measured stations did not meet the desired condition of 65-95 millimeters. In 2000-2001, one station (11 percent of the total stations) met the target, and in 2002, three stations (33 percent) met the target. Otherwise, for all other years reported none of the stations met the target (Figure 2.230).

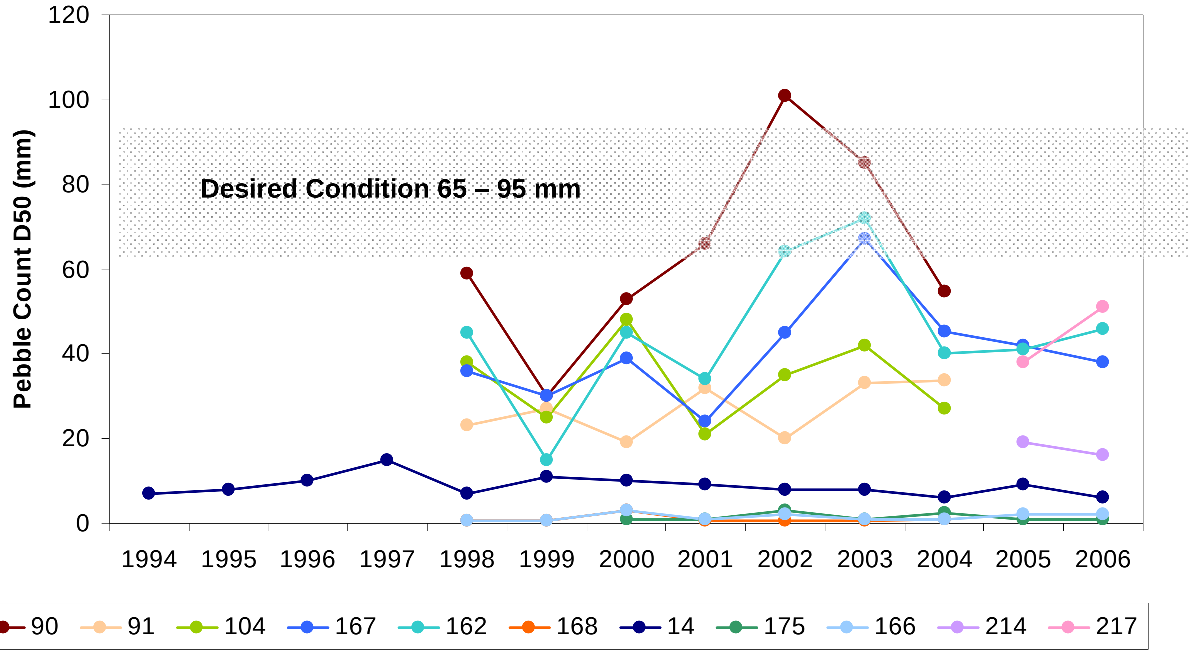

Figure 2.30. Pebble Count D_{50} Conditions in Elk River.

Percent Fines

Channel bed material is sampled for various purposes, including as a measure of gravel suitability for spawning salmonids and other aquatic organisms. In addition, these data can be used for inputs into sediment transport models, as they are indicative of a river's overall stability, including its ability to transport its sediment supply. Channel substrate is collected in bulk using shovel samples and sieved to determine the percent of the bed comprised of diameters less than a particular sieve size.

Percent Fines <0.85 mm

A grain size of 0.85 mm is indicative of coarse sand; particles finer than 0.85 mm can smother gravels, thus entombing fish eggs and aquatic insects. Figure 2.31 shows percent fines measured at Elk River stations. In 2006, 43 percent of the stations met the target of greater than 14 percent for particles less than 0.85 mm. Fifty-seven (57) percent of the stations demonstrated improvement (tending towards coarser particle sizes) as compared to the previous year with 43 percent became finer grained. None of the stations demonstrate steady trends of improvement over the period of record.

Percent Fines <6.35 mm

A grain size of 6.35 mm is indicative of fine gravel, less than which may be too small for successful spawning because the particles can become mobilized in stream flows. Figure 2.32 shows percent fines less than 6.35 mm for Elk River stations. 29 percent of the stations measured in 2006 met the target condition of greater than 30 percent for this parameter, while 57 percent of the stations showed improvement. Only station 90 showed a steady trend, becoming finer each year until the station was dropped in 2004.

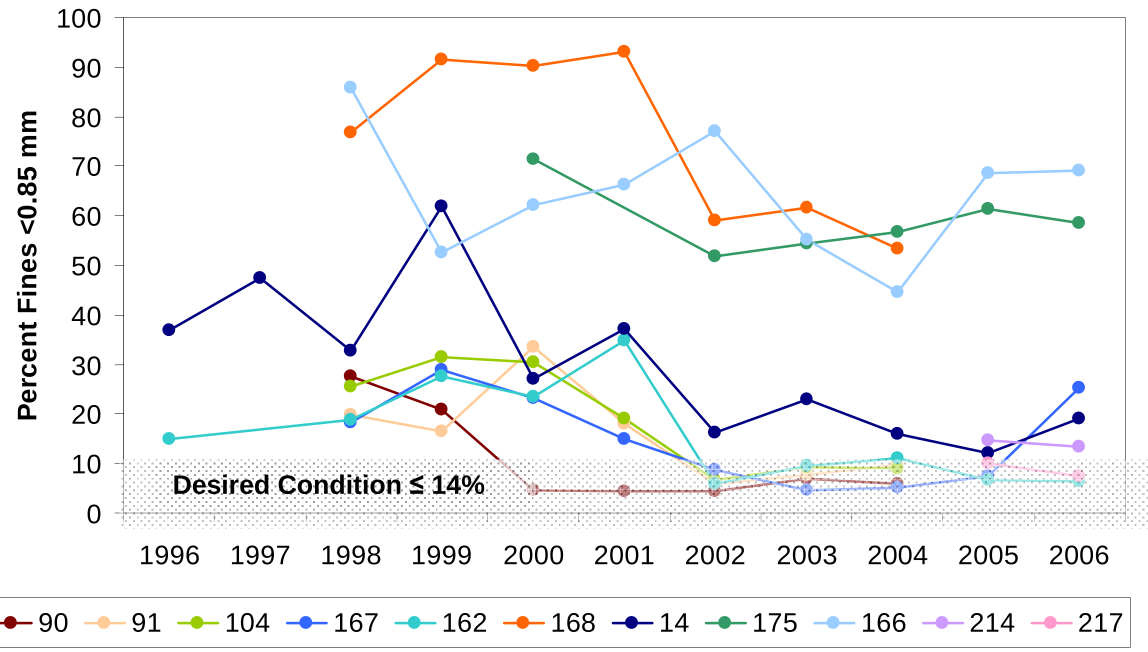

Figure 2.31. Percent Fines <0.85 mm Conditions in Elk River.

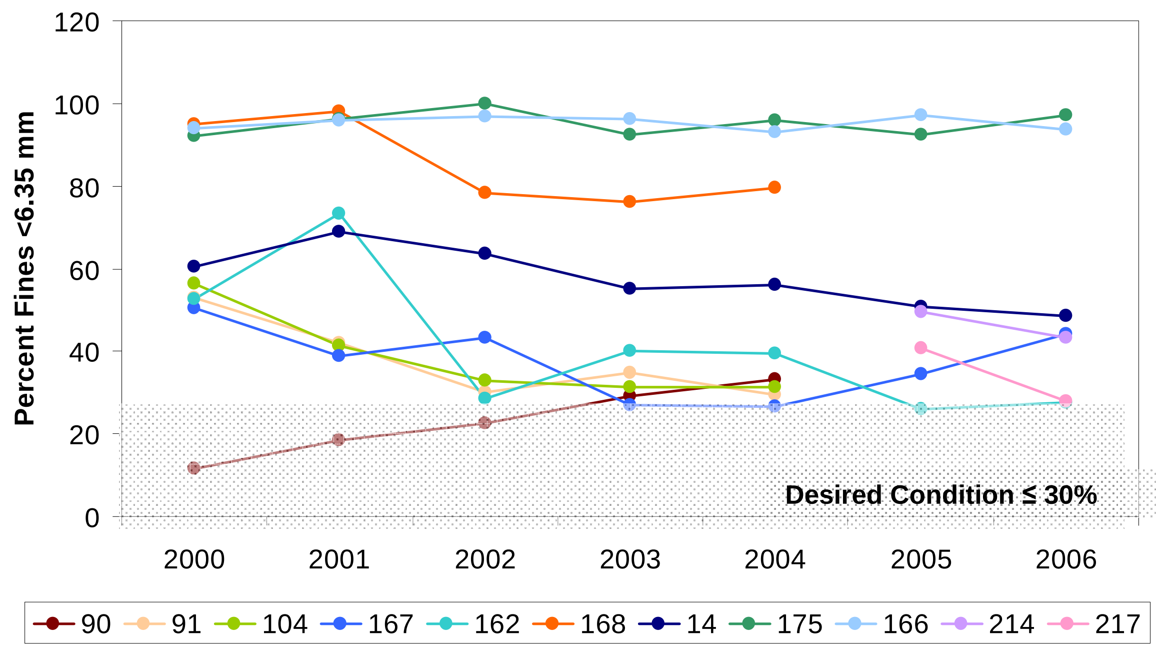

Figure 2.32. Percent fines <6.35 mm Conditions in Elk River.

Pool Conditions: Average Residual Pool Depth
Pools of 3-feet and greater have been identified for as critical for salmonid fisheries, especially for coho salmon habitiat. Deep pools are necessary to meet temperature needs of salmonids as well as provide cover from predation. Generally, pool depths in the trend monitoring reaches are not supportive of

fisheries habitat needs. In Elk River, many residents have historically relied on surface water intakes for domestic and agricultural supply; thus pools are necessary to support these historic beneficial uses. Low pool depths are indicative of aggraded channel conditions. Over the period of record, pool depths improved slightly in 2002 and 2003, with 67 percent and 44 percent showing improvement, respectively. In 2004, conditions worsened with 56 percent of the stations decreasing in pool depths. Slight improvement was detected from 2005 to 2006 at 71 percent of the stations, though no stations met the target of 3 feet or greater (Figure 2.33).

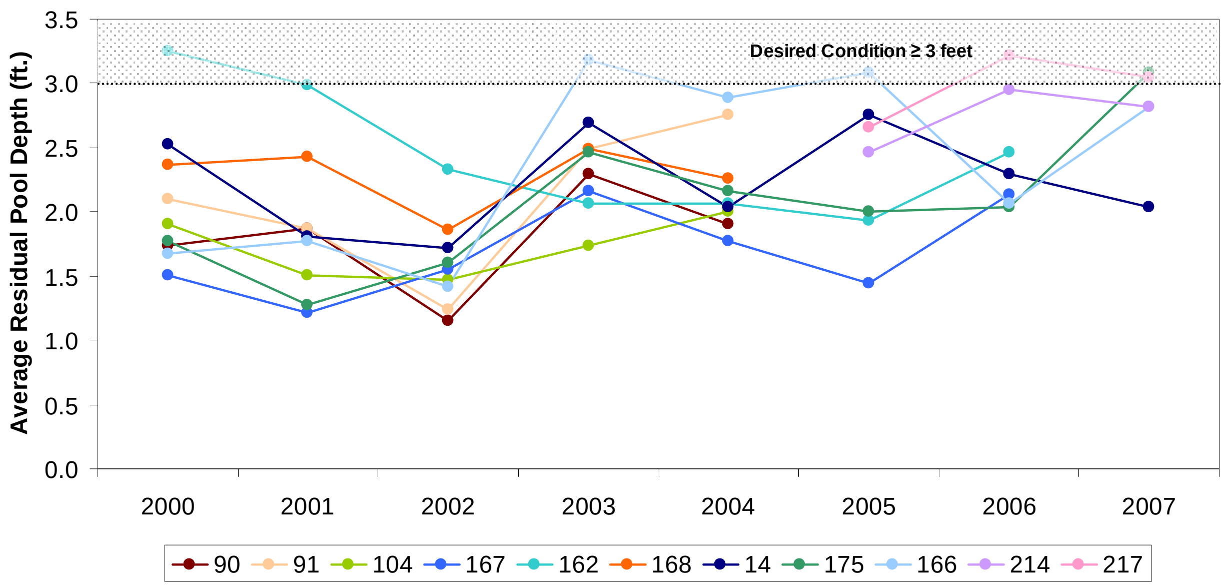

Figure 2.33. Average residual pool depth conditions in Elk River

2.3.3.4.2.3 Suspended Sediment Impacts to Fish

Suspended sediment is the amount of particles suspended in the water column. It is measured in milligrams of suspended sediment per liter of water (mg/L) or in parts per million (ppm). High suspended sediment concentrations can negatively impact the cold water fishery by causing reduced feeding and growth rates, avoidance behavior, physiological stress, and death in salmonid species.

Over the past several years, methods and equipment for monitoring instream turbidity and suspended sediment concentrations and sediment load conditions have been refined to allow monitoring of remote locations, such as forested watersheds like Elk River. These methods involve the use of automated in-situ equipment for measuring stage and turbidity. A pump sampler is triggered to collect a water sample which is then analyzed in a laboratory for turbidity verification and suspended sediment concentration. Field staff make observations and measurements of stage, streamflow, and collect depth integrated samples over the streams depth and width for verification with the in-situ measurements. Through a series of data relationships the raw data is corrected and finalized to yield turbidity, stage, discharge, and suspended sediment concentration at time steps of ten (10) to fifteen (15) minutes.

Beginning in 2003, Palco, GDRCo, and Salmon Forever began monitoring for instream turbidity, suspended sediment concentration, and streamflow conditions. Figure 2.25 demonstrates the locations of the monitoring stations in Elk River.
Data from these stations provide a measure of whether suspended sediment and turbidity levels in the Elk River watershed are supportive of salmonids, as discussed in the following sections. Specifically, staff evaluated the monitoring data collected in Elk River to evaluate the relative magnitude of ill effects on salmonids resulting from the measured suspended sediment and turbidity concentrations using a model developed by Newcomb and Jensen (1996). Note that data are not available for every station in every year of the analyses.

The Elk River monitoring station locations represent a variety of drainage areas (Figure 2.34).

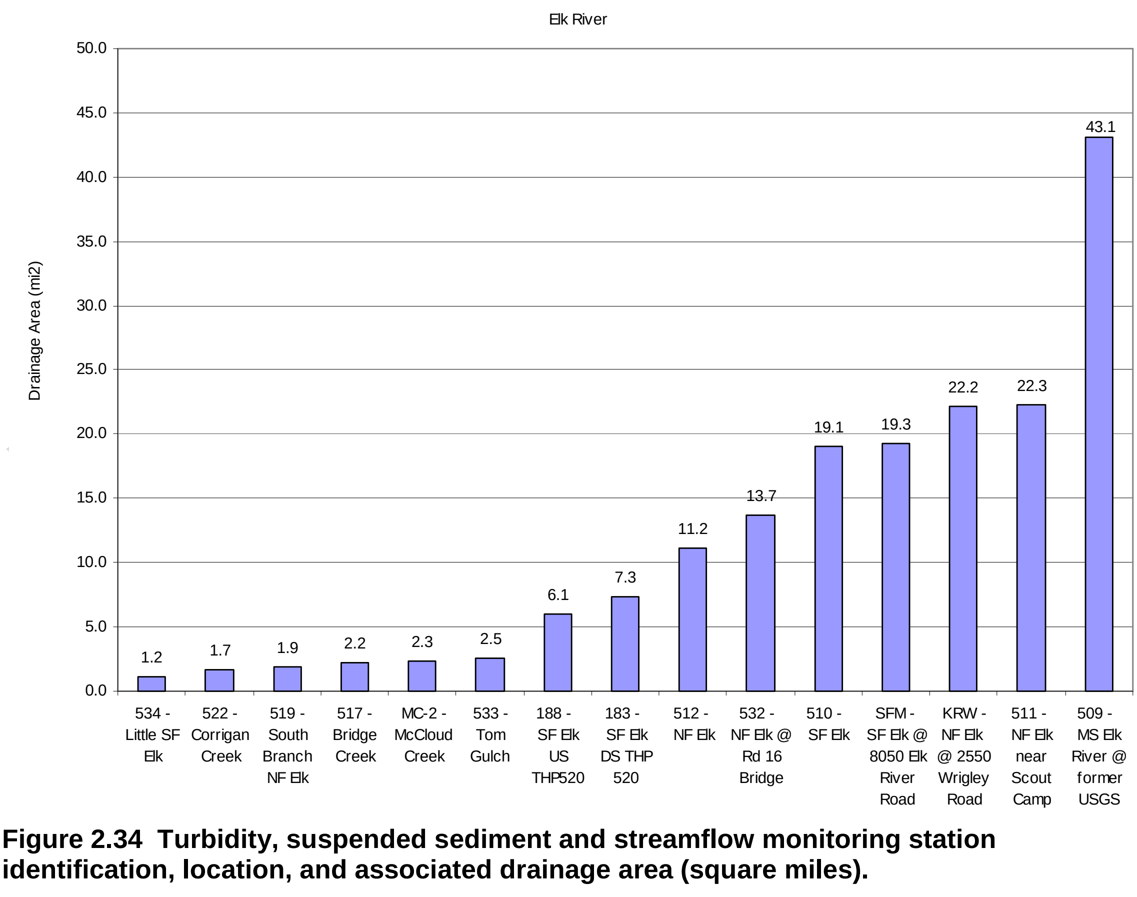

Figure 2.34 Turbidity, suspended sediment and streamflow monitoring station identification, location, and associated drainage area (square miles).

2.3.3.4.2.3.1 Severity of Ill Effects to Juvenile Salmonids

Newcombe and Jensen (1996) developed an empirical model which estimates the Severity of Ill Effects (SEV) Index, which represents the biological impacts to salmonids and other fish species, resulting from exposure to various suspended sediment concentrations and durations. This empirical model utilizes fisheries and suspended sediment research which correlate concentrations to an observed effect on the sampled population, such as salmonid avoidance of turbid waters, reduced feeding rates, reduced growth rates, or death. Newcombe and Jensen provide a provides a very useful means of evaluating if exposure to the measured suspended sediment concentrations and durations have an adverse affect on salmonid beneficial uses in the Elk River watershed. It should be noted that the data sets used by the authors included a combination of turbidity and suspended sediment concentration all of which were all converted to suspended sediment concentration. Similarly, staff used the Elk River suspended sediment concentration data, also correlated to turbidity.

Table 2.5 presents the range of severity of ill-effects that fish experience upon exposure to excess suspended sediment, as indexed by Newcombe and Jensen
.

Table 2.5. Severity Index describing severity of ill effects associated with excess suspended sediment, as presented in Table 1 of Newcombe and Jensen, 1996.

SEV	Description of Effect
	Nill Effect
0	No behavioral effects
	Behavioral Effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
	Sublethal Effects
4	Short-term reduction in feeding rates; Short-term reduction in feeding success
5	Minor physiological stress; Increase in rate of coughing; Increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation
8	Indications of major physiological stress; Long-term reduction in feeding rate; Long-term reduction in feeding success; Poor condition
	Lethal and Paralethal Effects
9	Reduced growth rate; Delayed hatching; Reduced fish density
10	0-20% mortality; Increased predation; Moderate to severe habitat degradation
11	>20-40% mortality
12	>40-60% mortality
13	>60-80% mortality
14	>80-100% mortality

Newcomb and Jensen’s meta-analysis used eighty (80) studies documenting the effects of suspended sediment on fish; the data associated with these studies were pooled to allow for an expanded database which the authors provide as Appendix Table A-1 in their report. The data were then grouped into six groups based upon four criteria: 1) taxonomy (salmonids and non-salmonids), 2) life stage (eggs, larvae, juveniles, and adults), 3) life history (estuarine versus freshwater and anadromous species), and 3) particle size of sediment (fine (<75 micrometers (µm)) and course (75-250 µm). Each of the six groups of data were then evaluated by regressing the severity of ill-effects on suspended sediment dose (concentration and duration). The resulting predictive models take the form:

$$SEV = a + b \cdot \ln(Duration(hr)) + c \cdot \ln(Concentration(mg / L))$$, where:

SEV = severity of ill effect
a = Intercept
b,c = slope coefficients

The coefficients *a, b,* and *c* vary depending on the data group. Most applicable in Elk River is the Group 3 model, "juvenile salmonids," as this model is predictive of the severity of ill effects on one of the most sensitive life stages of species of concern in Elk River. However, the Group 3 model included data for Arctic Graylings, a fish that does not occur in Elk River and evolved under more turbid conditions. In order to more closely model the conditions in Elk River, the data utilized in Group 3 by the authors were reevaluated by Regional Water Board staff to determine the appropriate coefficients corresponding to salmon and trout species (without inclusion of the Arctic Grayling). Using the "solver" feature of Excel staff solved the non-linear system for the values of the intercept and the two coefficients of the equation which minimized the sum of squared residuals of the observed versus predicted value for SEV. Because the data presented in Newcombe and Jensen demonstrate that Arctic Graylings are generally less sensitive than trout and salmonids, the effect of removing them from the equations is a small increase in severity of ill-effect experienced by the fish for a given concentration and duration.

The modified Model 3 thus takes the form:

$$SEV = 1.1184 + 0.8074 \cdot \ln(Duration(hr)) + 0.6814 \cdot \ln(Concentration(mg/L))$$

For the purpose of illustration of the difference the modification makes, Figure 2.9 compares the original Model 3 with the Modified Model 3. The result is that the same SEV value (SEV 6 in the example depicted) is achieved with a slightly shorter duration of a particular suspended sediment concentration. The effect is minimized with increasing suspended sediment concentrations.

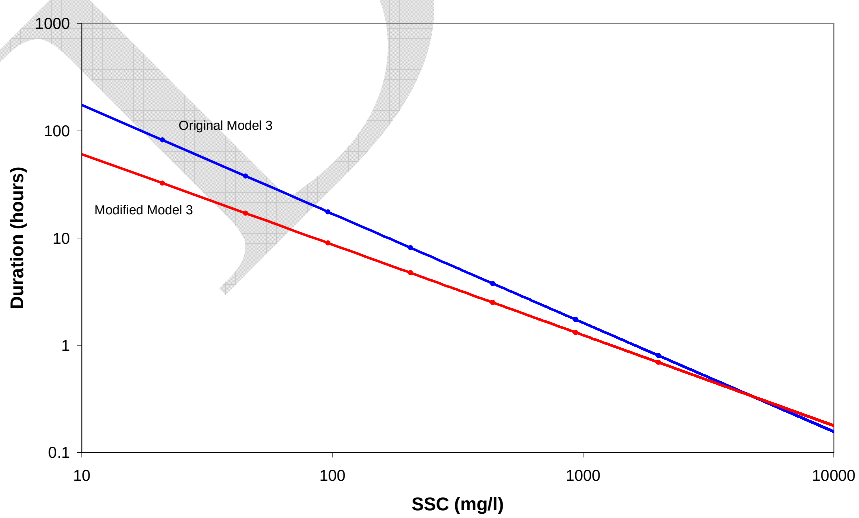

Figure 2.35 Comparison of original and modified Model 3 for the purposes of illustration.

The Elk River monitoring data were then evaluated with this predictive model to determine how juvenile salmonids are affected by current suspended sediment conditions in Elk River. The results of the model are presented in Figures 2.36 – 2.39 for hydrologic years (HY) 2003-2007, respectively.

A SEV value of 4, corresponding to short term-reduction in feeding rates and success could be considered as an important threshold over which conditions are not fully supportive of beneficial uses. While the SEV values are expected to vary throughout the year, the greater the amount of time that SEV values of 4 or greater are experienced, the greater the estimated impact on the conditions of juvenile salmonids and their subsequent ability to survive ocean conditions.

Since sediment transport responds to runoff, the suspended sediment and turbidity water quality monitoring data should be viewed in the context of rainfall. Table 2.6 provides the annual rainfall volumes, as measured by NOAA in Eureka, as well as the relative percentage of average rainfall, for the hydrologic years analyzed in this section.

Table 2.6 Annual rainfall volume and relative percentage of average annual rainfall volume (38.83 inches) as measured by NOAA at National Weather Service at Woodley Island in Eureka.

Hydrologic Year	Rainfall Volume (inches)	Percentage of Average Annual Rainfall
2003	54.18	140%
2004	38.75	100%
2005	43.46	112%
2006	58.68	151%
2007	35.35	91%

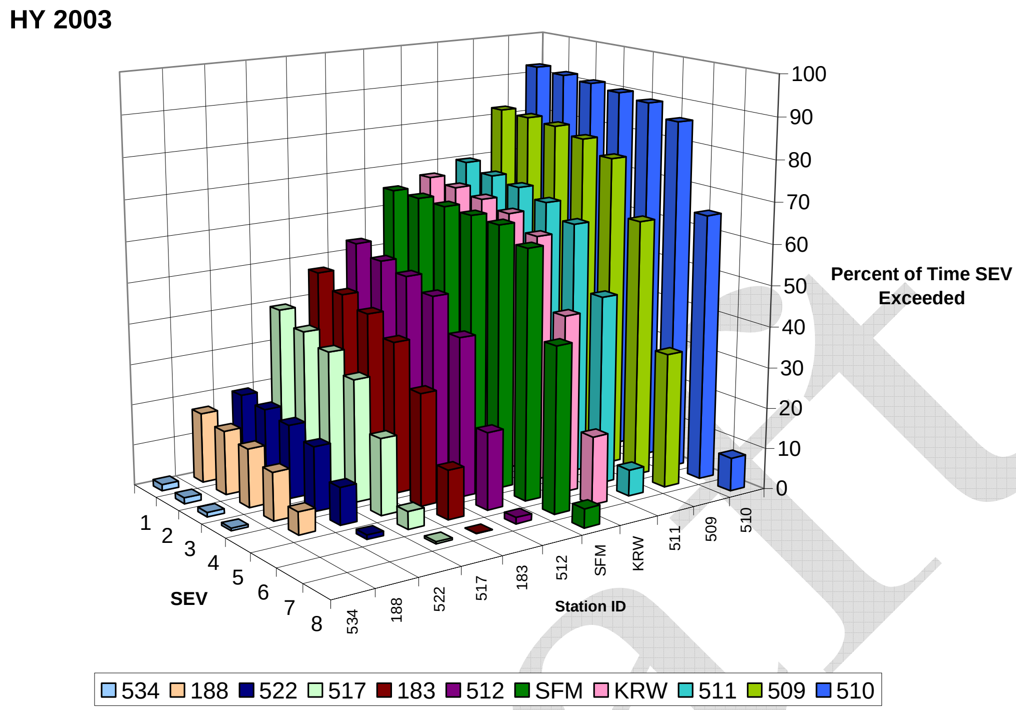

Figure 2.36 Percent of time SEV values exceed at Elk River stations for HY2003

Precipitation was 140% of normal in HY 2003. The 2003 data are spread largely based on drainage area (i.e., the larger drainage areas have greatest percentage of time at higher SEV levels). Station 510 on lower South Fork Elk River demonstrates the greatest impacts to juvenile salmonids, with less than 10% of the time experiencing indications of major physiological stress, long-term reduction in feeding rate and success, and poor condition (SEV 8). With the exception of stations 534 on Little South Fork Elk River, 188 on upper South Fork Elk River, and 522 on Corrigan Creek, all stations demonstrate that short term impacts to feeding rates and success (SEV 4) occurs at least 20% of the time.

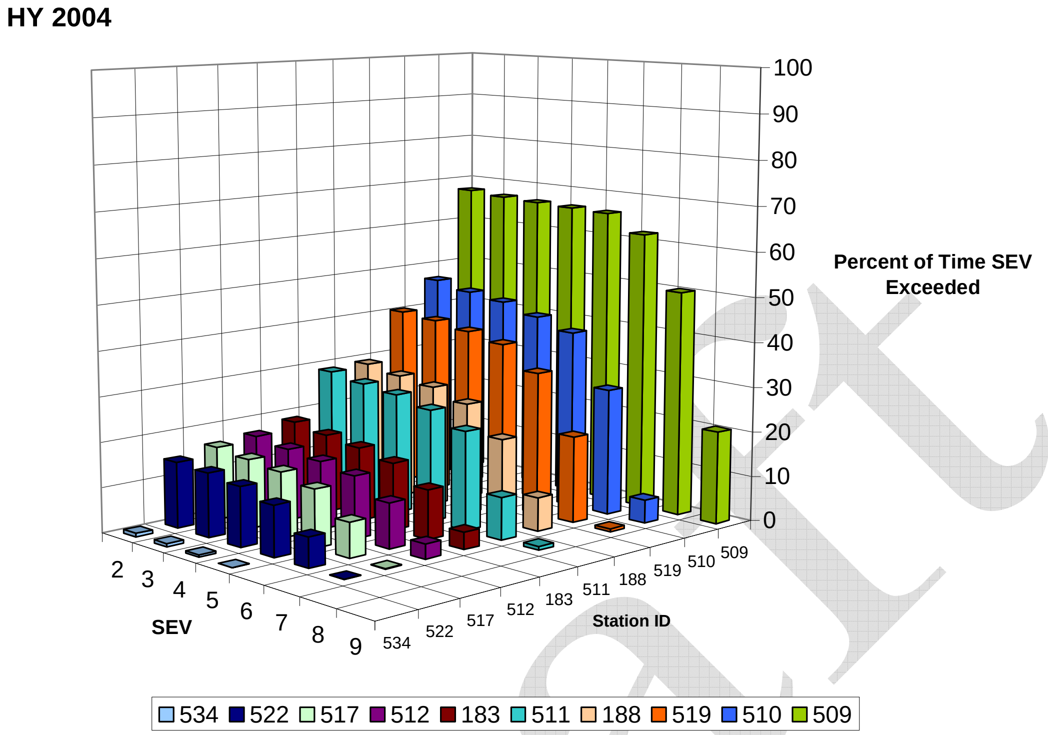

Figure 2.37 Percent of time SEV values exceed at Elk River stations for HY2004.

HY 2004 was an average rain year. The data demonstrate more apparent groupings in HY 2004. This year, station 509 on upper Mainstem Elk River demonstrates the greatest impact to juvenile salmonids. Reduced growth rate, delayed hatching, and reduced fish density (SEV 9) was estimated to occur nearly 20% of the time, indications of major physiological stress, long-term reduction in feeding rate and success, and poor condition (SEV 8) were estimated nearly 50% of the time. Station 510, on lower South Fork, and station 519, on South Branch North Fork Elk, demonstrate that moderate habitat degradation (SEV 7) occurred around 20% of the time, and moderate physiologic stress (SEV 6) occurred around 30% of the time. It is worth note that station 519 has high suspended sediment doses considering it only has a 2.1 mi^2 drainage area. Stations 188, on upper South Fork Elk River, and 511, on lower North Fork Elk River, demonstrate that minor physiologic stress, increased rates of coughing and respiration (SEV 5) occurred approximately 20% of the time. It is interesting to note that in HY 2004, Station 509, 510, and 511 are in different groupings.

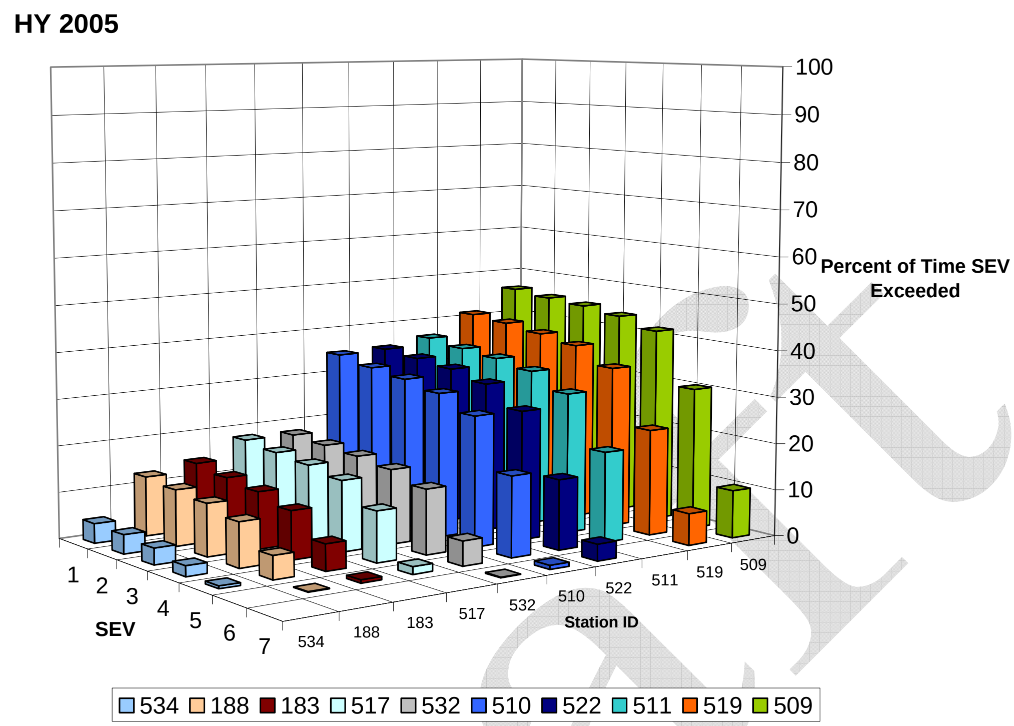

Figure 2.38 Percent of time SEV values exceed at Elk River stations for HY 2005.

The rainfall in HY 2005 was 112 percent of average. Station 509 demonstrates the greatest impacts to salmonids, however, less than in HY 2004. Short-term reduction in feeding rates and success were estimated to occur 20-30 percent of the time at stations 532, 510, 522, 511, 519, and 509. It appears that station 522, located on Corrigan Creek (drainage area of 1.3 mi^2) shifted into high suspended sediment doses, compared to earlier years, especially when considering the small drainage area.

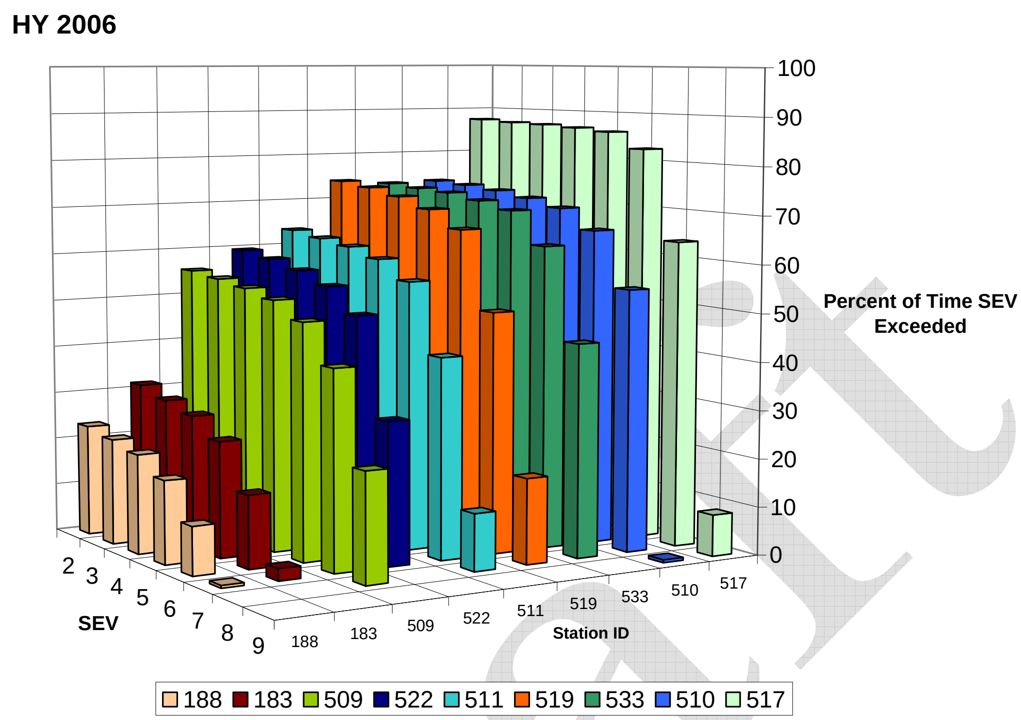

Figure 2.34 Percent of time SEV values exceed at Elk River stations for HY2006.

The HY 2006 precipitation volume was 151 percent of average. In HY 2006, station 517, located in Bridge Creek, demonstrated the greatest impacts to salmonids due to suspended sediment dose. This was an unexpected finding given the relatively small drainage area (2.2 mi^2) of the sub-basin. In Bridge Creek, the lethal and paralethal effect for reduced growth rate, delayed hatching, and reduced fish density (SEV 9) were estimated just less than 10% of the time, and sublethal effects including moderate habitat degradation (SEV 7) were experienced 80% of the time. Station 509, 522, 511, 519, 533, and 510 all demonstrate chronically high suspended sediment doses much of the time, with short term reduction in feed and feeding success rates (SEV 4) approximately 50-60 percent of the time, while stations 183 and 188, experienced SEV 4 approximately 20% of the time.

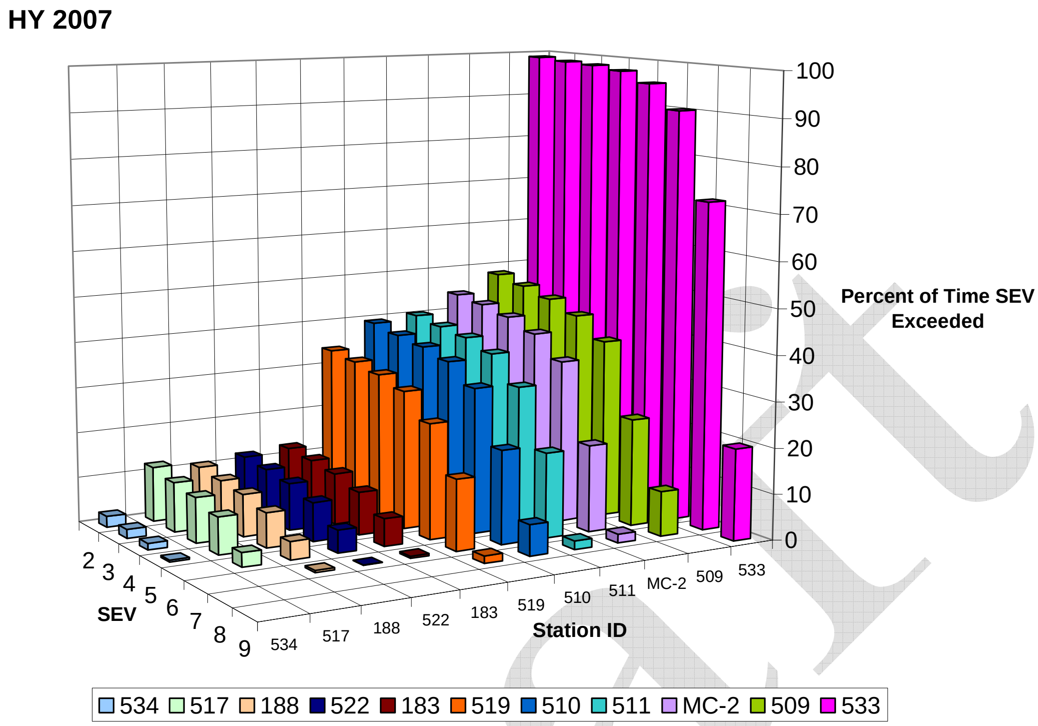

Figure 2.39 Percent of time SEV values exceed at Elk River stations for HY2007.

HY 2007 had 91 percent of average annual rainfall. Station 533, on Tom's Gulch (with a drainage area of 2.5 mi^2), demonstrates the most extreme conditions for salmonids of the HY year. Lethal and paralethal effects of reduced growth rate, delayed hatching and reduced fish mortality (SEV 9) nearly 20 percent of the time and indications of major physiological stress, long term reduction in feeding rate and success, and poor condition (SEV 8) 70 percent of the time. Stations 519, 510, 511, MC-2, and 509 are somewhat grouped with moderate physiological stress (SEV 6) occurring approximately 20 percent of the time and short term reduction in feeding rates and success (SEV 4) estimated to occur between 30-45 percent of the time. Station MC-2, on McCloud Creek (drainage area of 2.3 mi^2) was added in HY2007 and is among the middle grouping. It should be noted that HY 2007, Stations 510 and 511, on lower South Fork and lower North Fork, respectively are more similar than in the other years analyzed. Stations 517, 188, 522, and 183 experienced short term reduction in feeding rates and success (SEV 4) less than 10 percent of the time.

While the Severity Index analyses are but one measure of potential impacts to the cold water fisheries of Elk River, they indicate that through-out the basin salmonids are experiencing sublethal effects much of the time, and in some locations, lethal and paralethal effects for a shorter cumulative period of the time.

2.3.3.4.3 Recreation

Both contact (REC-1) and non-contact (REC-2) recreational uses are affected by sediment in Elk River. Contact recreation includes swimming, wading, and fishing. Non-contact recreation includes picnicking, hiking, camping, boating, or aesthetic enjoyment in conjunction with aforementioned activities.
Due to the degraded stream conditions, contact recreation is not supported in Elk River. Swimming is limited by the lack of pool depth and both swimming and wading are limited by the accumulation of small wood debris and branches due to vegetation fallen into the channel, and especially by the overall displeasing conditions. The displeasing conditions include, the channel bottom being comprised of silt, which squishes underfoot, the smell resulting from anaerobic conditions, and the presence of duckweed. Fishing is limited by degraded habitat.

Non-contact recreation is somewhat limited due to the sediment impairment, namely boating and aesthetic enjoyment. Boating is difficult due to lack of stream depth and the accumulation of small vegetative debris. Aesthetic enjoyment is limited due to the degraded stream conditions.

2.3.3.5 Water Quality Objectives Are Not Achieved

Ongoing monitoring provides data by which staff evaluated if water quality objectives, as provided in Table 2.1 of this Staff Report, are achieved in Elk River. Monitoring of turbidity, suspended sediment, and streamflow allows for evaluations of compliance with the objectives for suspended material, turbidity, and suspended sediment. The water quality objective for settleable material is determined via cross-sectional measurements. This section puts staff evaluations in the context of water quality objectives.

Suspended Material
The water quality objective for suspended material states that “Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.” Available information indicates that in Elk River the suspended sediment concentrations aversely affect domestic and agricultural water supplies and cold freshwater fisheries habitat. As describe din Section 2.3.3.4.1, the suspended sediment concentrations in Elk River limit the ability of residents to collect water for long periods following storms over which the river remains unsuitable for use due elevated concentrations. Similarly, the suspended sediment concentrations cause more frequent maintenance of filters and cleaning of storage tanks due to suspended sediment concentrations.

The cold freshwater fisheries are adversely affected by elevated suspended sediment concentrations. As described in Section 2.3.3.4.2, the combination of the concentration and durations of elevated suspended sediment concentrations at numerous locations in Elk River adversely affect salmonids by limiting their ability to feed, by causing physiological stress, and by causing habitat degradation.

Settleable Material
The water quality objective for settleable material states that, "Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses." Deposition of fine sediment continues to deposit on the bed, reduce channel cross-sectional area, adversely affecting beneficial uses and contributing to nuisance flooding. Sediment loads have and continue to result in deposition of material which fills in pools smother spawning gravels, adversely affecting salmonid habitat and water supplies. The deposition of settleable material narrows and reduces cross-sectional area and channel conveyance capacity, contributing to nuisance flooding. Following floods, the deposition of settleable material on the floodplain on roadways and fields, on equipment, and in homes results in a nuisance condition for residents of the Elk River watershed.

Turbidity
The water quality objective for turbidity states, "Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof." Turbidity is significantly elevated above naturally occurring background conditions through-out the basin.

The Little South Fork Elk River (LSFER) offers a watershed representative of naturally occurring conditions for Elk River TMDL project, as it nearly undisturbed by management activities. Along with Little South Fork Elk River (Station 534), two adjacent subbasins, Corrigan Creek (Station 522) and South Branch North Fork Elk River (Station 519) serve as comparison basins in the Source Analysis (Chapter 3 of this Staff Report) as they have similar drainage area, geologic formations, hillslope gradients, and differ in their management history, as the latter two subbasin have undergone timber harvesting and roading activities (Manka, 2005). Comparison of turbidity-discharge rating curves from these three comparison subbasins offers an indication of how, for the same discharge per unit area, turbidity levels vary as compared to naturally occurring conditions.

Data for HY 2004, an average rainfall year, from the three comparison subbasins were evaluated. The discharges were normalized to account for the drainage area differences, though relatively minor (ranging from 1.2-1.7 mi^2). Rating curves were constructed for turbidity (NTU) versus discharge per unit area (cfs/mi^2) and linear trend lines were fit to the data for each station. The resulting trend lines are plotted in Figure 2.40. This analysis indicates that, for the same discharges per unit area at Corrigan Creek, turbidity levels range from 281 percent to 930 percent greater than those at Little South Fork Elk River, for low to high discharges, respectively. For the same discharges per unit area at South Branch North Fork Elk River, turbidity levels range from 178 percent to 1642 percent greater than those at Little South Fork Elk River, for relatively low to high discharges, respectively. Although there's uncertainty associated with regression analysis and comparing across subbasins, and variability in natural conditions, this analysis demonstrates that there is significant discrepancy between natural and managed basins in Elk River with respect to turbidity. These turbidity differences (far greater than 20 percent) provide persuasive evidence that the water quality objective for turbidity is exceeded.

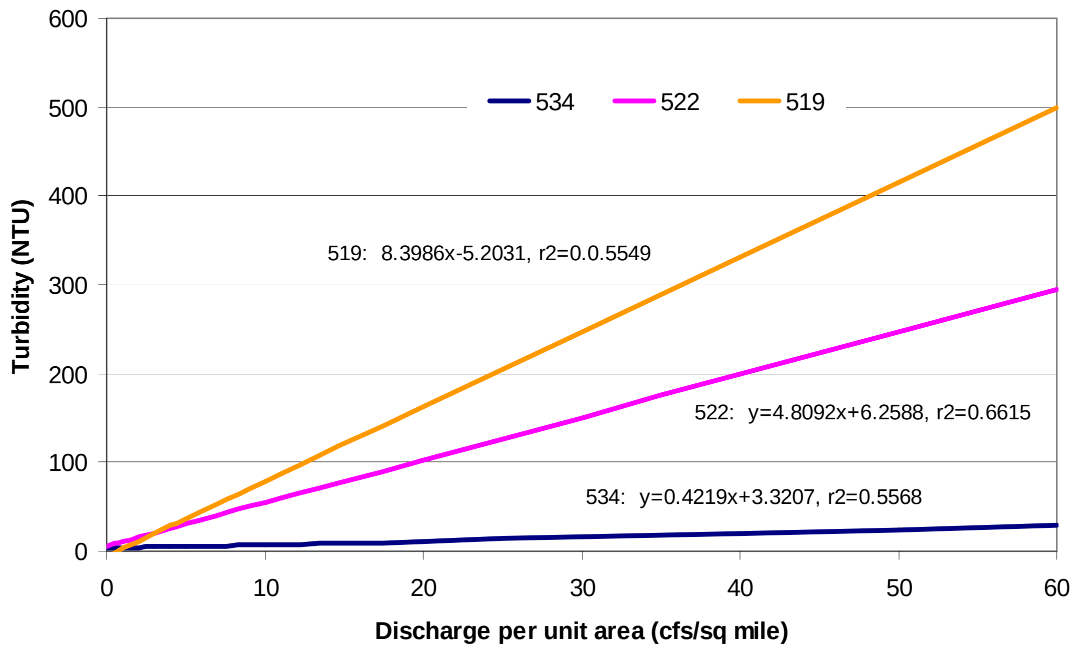

Figure 2.40 Comparison of ratings curves for three comparison subbasins in Elk River, indicating the extent to which turbidity levels vary for the same discharge per unit area.

Suspended Sediment Load

The water quality object for suspended sediment loads states, "The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause a nuisance or adversely affect beneficial uses." The suspended sediment loads in Elk River currently constitute the majority of the sediment load (this is explored further in Chapter 3 of this Staff Report). The current suspended sediment loads have been elevated by controllable factors and do adversely affect beneficial uses and cause nuisance, as discussed throughout this Chapter.

2.4 Chapter 2 References

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