Humboldt Redwood™

Elk River/Salmon Creek

Watershed Analysis Revisited

June 13, 2014

Cover photo: Upper North Fork Elk River

Project Description

Title: Elk River Watershed Analysis Revisit

Purpose: Aquatic Habitat Conservation Plan Monitoring Report

Date Initiated: 2000

Projected End Date: 2014

Manager: Mike Miles/Gretchen Woessner

Executive Summary: Watershed Analysis (WA) is a ‘cornerstone’ of the HRC Aquatic Habitat Conservation Plan (AHCP). HRC’s approximate 209,000 acre ownership is divided into eight watershed analysis units (WAU). A focused baseline analysis has been conducted for all eight WAUs. The basic premise of the analysis is to document changes in erosion or riparian function resulting from forest management which have, or could cause an adverse change in aquatic habitat conditions. Establishing and maintaining an inventory of hillslope, riparian, and in-stream conditions, related to sediment, wood, and temperature, is necessary to facilitate scientific understanding, and is tracked over time through various trends and effectiveness monitoring protocol. Based on findings, forest managers are informed and management prescriptions, and policies, monitoring efforts, and restoration priorities can be tailored to the unique setting of each watershed in order to accomplish the AHCP’s goal “to maintain or achieve, over time, a properly functioning aquatic habitat condition… essential for the long term survival of anadromous salmonids…” and other covered aquatic habitat dependent species.

The AHCP requires periodic review of trends and effectiveness monitoring studies, along with any relevant new science, for each of the eight WAUs to determine if WA based prescriptions are successful in maintaining, or trending habitat conditions towards the AHCP’s goal of properly functioning. Conditions and processes related to mass wasting, surface erosion, riparian function, and stream channel are examined independently, and collectively, from both management and biological perspective. The findings of this periodic, focused re-visitation may result in the change of forestry prescriptions through an adaptive management process subject to review, and establishment, by the signatory HCP wildlife agencies.

See Section 9.0

Reviewed:

Director, Forest Science

Mike Miles

Project Manager

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendices are provided on CD.

LIST OF MAPS

LIST OF ACRONYMS

ACP	Aquatic Conservation Plan
ATM	Aquatic Trends Monitoring
CDEC	California Data Exchange Center
CAL FIRE	California Department of Forestry and Fire Protection
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CFPR	California Forest Practice Rules
cfs	Cubic Feet per Second
CMZ	Channel Migration Zone
CSZ	Cascadia Subduction Zone
CWE	Cumulative Watershed Effects
yd^3	Cubic yards
DBH	Diameter at Breast Height
HCP	Habitat Conservation Plan
HMD	Hardwood stand, small trees, moderate/dense canopy (RCU type)
HRC	Humboldt Redwood Company, LLC
HY	Hydrologic Year
LSF	Little Salmon Fault
LWD	Large Woody Debris
MMD	Mixed conifer–hardwood stand, small trees, moderate/dense canopy (RCU type)
MTJ	Mendocino Triple Junction
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	National Marine Fisheries Service
NRCS	Natural Resource Conservation Service
PALCO	the Pacific Lumber Company
PFC	Properly Functioning Condition
RCU	Riparian Condition Unit
RM	River Mile
TMDL	Total Maximum Daily Load
$tons/mi^2/year$	Tons per square mile per year
WAU	Watershed Analysis Unit
WLPZ	Watercourse and Lake Protection Zones
WQ	Water quality
WWII	World War II

1 INTRODUCTION

1.1 PURPOSE

The goal of Humboldt Redwood Company's Aquatic Conservation Plan (ACP, HCP §6.3), developed in agreement with federal and state resource agencies, is to maintain or achieve, over time, a properly functioning aquatic habitat condition in streams and rivers affected by the landowner's forest management activities. The purpose of the HCP watershed analysis process is to promote local understanding of linkage between aquatic habitat conditions and processes and forest management activities in order to establish best management practices for protecting, restoring, and enhancing the aquatic habitat of specified salmonids, amphibians, and reptiles. These species include Northern California steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*Oncorhynchus kisutch*), northern red-legged frog (*Rana aurora aurora*), foothill yellow-legged frog (*Rana boylii*), tailed frog (*Ascaphus truei*), southern torrent salamander (*Rhyacotriton variegatus*), and the northwestern pond turtle (*Emys marmorata marmorata*).

Watershed Analysis was initially completed for the Elk River, Salmon Creek, and Fields Landing Watershed Analysis Units (WAUs), collectively referred to as ERSC, in 2005. Following synthesis of baseline information gathered during this initial assessment and critical review by all parties (CDFW, NMFS, USFWS, CGS, CAL FIRE, NCRWQCB and the public), watershed-specific HCP prescription modifications were developed and established. The HCP requires Watershed Analysis "re-visitation" at regular intervals for the purpose of evaluating watershed response to the prescriptions (i.e. monitoring results), consideration of any further development of science that may influence prescriptions, and to document trends within each WAU relative to the ACP goal.

2 WATERSHED CHARACTERISTICS

2.1 LOCATION

The Elk River flows westward along the west side of the northern California Coast Range into Humboldt Bay south of Eureka in Humboldt County, CA (Maps 1 and 2). The Elk River Watershed encompasses approximately 33,700 acres (52.7 mi^2). The watershed contains two major forks, the North and South forks. The watershed area for North Fork (NF) and South Fork (SF) are about 14,336 acres (22.4 mi^2) and 13,120 acres (20.5 mi^2), respectively. Approximately 22,200 acres of the watershed is owned and managed by HRC (Table 2-1). HRC lands account for approximately 66% of the watershed; 98% of the NF Elk basin, 50% of the SF basin, and a small section of the mainstem region near the confluence. For the purpose of Watershed Analysis the mainstem section and tributaries to the mainstem section covered by the HCP are included as part of the SF Elk River. This is done to facilitate comparison with the Elk River TMDL. Other ownerships within the watershed include the Headwaters Forest Reserve managed by Bureau of Land Management, Green Diamond Resource Company, City of Eureka, and mixed private residential and industrial ownership.

The Salmon Creek drainage is adjacent to the southern ridge of the Elk River drainage and is bordered on the south by the Eel Delta WAU (PALCO 2002a). The Salmon Creek WAU has a basin area of approximately 13,000 acres, of which HRC owns 620 acres; most of which is located in the headwaters of Little Salmon Creek. Two small parcels (approximately 63 acres) are contiguous with the Elk River ownership along the north ridge of the Salmon Creek Watershed, and 25 acres are contiguous with the Eel Delta ownership along the south ridge.

The Fields Landing WAU is a small 3,765-acre area draining directly into Humboldt Bay between the Elk River and Salmon Creek (ERSC) WAUs. HRC owns 71 acres of land in the Fields Landing WAU, which lie along the eastern edge, contiguous with the Elk River ownership block. Because of the extremely small ownership area, its location in a narrow strip along the ridge top, and the general lack of stream channels on it, analyses in this report will usually incorporate the HRC-owned land in the Fields Landing WAU with the Elk River analyses.

For the purposes of analysis the WAU has been divided into 21 nested sub-basins, and in some instances the two major forks (North and South) are compared and contrasted. Map 3 presents the distinctions of sub-basins throughout the ERSC WAU.

Table 2-1. ERSC WAU area by ownership.

Sub-basin Name	Sub-basin Area (acres)	Area of HRC HCP Ownership (acres)	Non-HRC Ownership (Acres)	Percent of HRC HCP Ownership
North Fork Elk	2795.1	2795.1	0.0	100.0%
North Branch NF Elk	2560.6	2560.6	0.0	100.0%
South Branch NF Elk	1224.9	1224.9	0.0	100.0%
Upper North Fork Elk	1644.2	1644.2	0.0	100.0%
McWhinney Creek	810.1	810.1	0.0	100.0%
Bridge Creek	1420.9	1419.8	1.2	100.0%
Lake Creek	1362.4	1362.4	0.0	100.0%
Lower NF Elk	1578.8	1309.6	269.1	83.0%
Browns Gulch	574.0	573.8	0.2	100.0%
Dunlap Gulch	423.8	411.4	12.4	97.4%
NF Elk Sub-watershed Total	***14394.8***	***14111.9***	***282.9***	***98.0%***
South Fork Elk	5140.2	3626.8	1513.4	70.6%
Little South Fork Elk	2327.0	18.0	2308.9	0.6%
Lower South Fork Elk	1840.3	1138.0	702.3	61.8%
McCloud Creek	1521.0	209.6	1311.4	13.7%
Tom Gulch	1605.9	1188.6	417.4	74.1%
Railroad Gulch	762.0	714.0	48.0	94.0%
Clapp Gulch	654.1	581.3	72.9	89.0%
Mainstem Elk	5564.0	319.9	5244.1	5.7%
SF Elk Sub-watershed Total	***19414.5***	***7796.2***	***11618.4***	***40.2%***
Elk River Watershed Total	***33809.3***	***21908.1***	***11901.3***	***64.8%***
Fields Landing Watershed	***3814.4***	***75.9***	***3738.5***	***2.0%***
Salmon Creek	11838.4	61.4	11777.0	0.5%
Little Salmon Creek	1207.3	530.0	677.4	43.9%
Salmon Creek Watershed	***13045.7***	***592.4***	***12453.4***	***4.5%***

*For the purpose of the watershed analysis, HRC mainstem Elk River ownership is included in the South Fork Elk River Sub-watershed

2.2 TOPOGRAPHY

The Elk River and Salmon Creek Basins drain to the northwest and have well developed alluvial floodplain valleys that extend from Humboldt Bay several miles upstream. These streams drain low hills in the upper parts of the basins and lower ridges on their northern and southern margins. The elevation within the watershed ranges from sea level at Humboldt Bay to approximately 2,400 feet with about 85% of the basin lying below 1,640 feet.

The Elk River meanders across a well defined floodplain in the lower half of the basin. Tributaries to the Elk River are deeply incised into the landscape with low gradient mainstem channels that typically transition sharply to moderately steep headwater tributaries. The HRC ownership is limited to upland areas of this WAU. Table 2-2 presents a summary of major slope gradient classes by acres for the HRC

HCP ownership by sub-watershed, and Figure 2-1 presents major slope gradient classes as a percent of HCP lands.

Table 2-2. Major slope class area by sub-watershed of the HRC HCP area within the ERSC WAU.

	Acres within Slope Class				
Sub-basin Name	**0-35%**	**35-50%**	**50-65%**	**>65%**	**Total**
North Fork Elk	1094.1	705.1	528.6	467.4	2795.2
North Branch NF Elk	871.8	783.7	588.5	316.7	2560.7
South Branch NF Elk	576.2	347.1	190.7	111.0	1224.9
Upper North Fork Elk	799.5	467.7	262.8	114.2	1644.2
McWhinney Creek	261.7	249.6	217.6	81.3	810.2
Bridge Creek	315.0	422.7	479.2	202.7	1419.7
Lake Creek	509.6	426.9	287.6	138.4	1362.4
Lower NF Elk	628.4	353.3	221.4	106.4	1309.6
Browns Gulch	237.0	196.5	109.8	30.6	573.8
Dunlap Gulch	166.4	138.2	83.2	23.6	411.4
NF Elk Sub-watershed Total	***5459.8***	***4090.7***	***2969.3***	***1592.3***	***14112.1***
South Fork Elk	1729.2	1065.0	573.7	258.9	3626.8
Little South Fork Elk	15.8	1.8	0.3	0.0	18.0
Lower South Fork Elk	587.7	341.6	157.7	51.0	1137.9
McCloud Creek	110.2	62.5	28.7	8.4	209.7
Tom Gulch	705.1	293.8	132.8	56.9	1188.6
Railroad Gulch	342.7	181.3	119.1	70.9	713.9
Clapp Gulch	207.5	161.0	126.8	86.0	581.3
Mainstem Elk	155.0	83.1	52.0	29.9	319.9
SF Elk Sub-watershed Total	***3853.2***	***2190.1***	***1191.1***	***561.9***	***7796.3***
Elk River Watershed Total	***9313.0***	***6280.7***	***4160.4***	***2154.2***	***21908.4***
Fields Landing Watershed	***42.8***	***20.3***	***9.7***	***3.1***	***75.9***
Salmon Creek	36.8	16.9	6.4	1.4	61.5
Little Salmon Creek	290.0	150.5	65.2	24.1	529.8
Salmon Creek Watershed Total	**326.8**	**167.4**	**71.6**	**25.5**	**591.2**

Streams in the Fields Landing WAU drain directly to Humboldt Bay, including several small streams, such as Willow Brook, that drain the southwest side of Humboldt Hill, and some wetland regime channels that drain the Salmon Creek delta. The land area is approximately evenly divided between the steep area draining the Humboldt Hill terrace and the flat delta lands between Humboldt Hill, Salmon Creek, and the bay.

Little Salmon Creek flows through a low-gradient, moderately broad valley for the first 3 miles above its confluence with the mainstem Salmon Creek, which flows into the southern end of Humboldt Bay. Upstream, hills pinch the channel and form a narrow valley with moderately steep slopes on either side.

The HRC ownership is located in the middle to upper portion of Little Salmon Creek and spans the transition from low-gradient Class I channel to the moderately steep Class II channel reach.

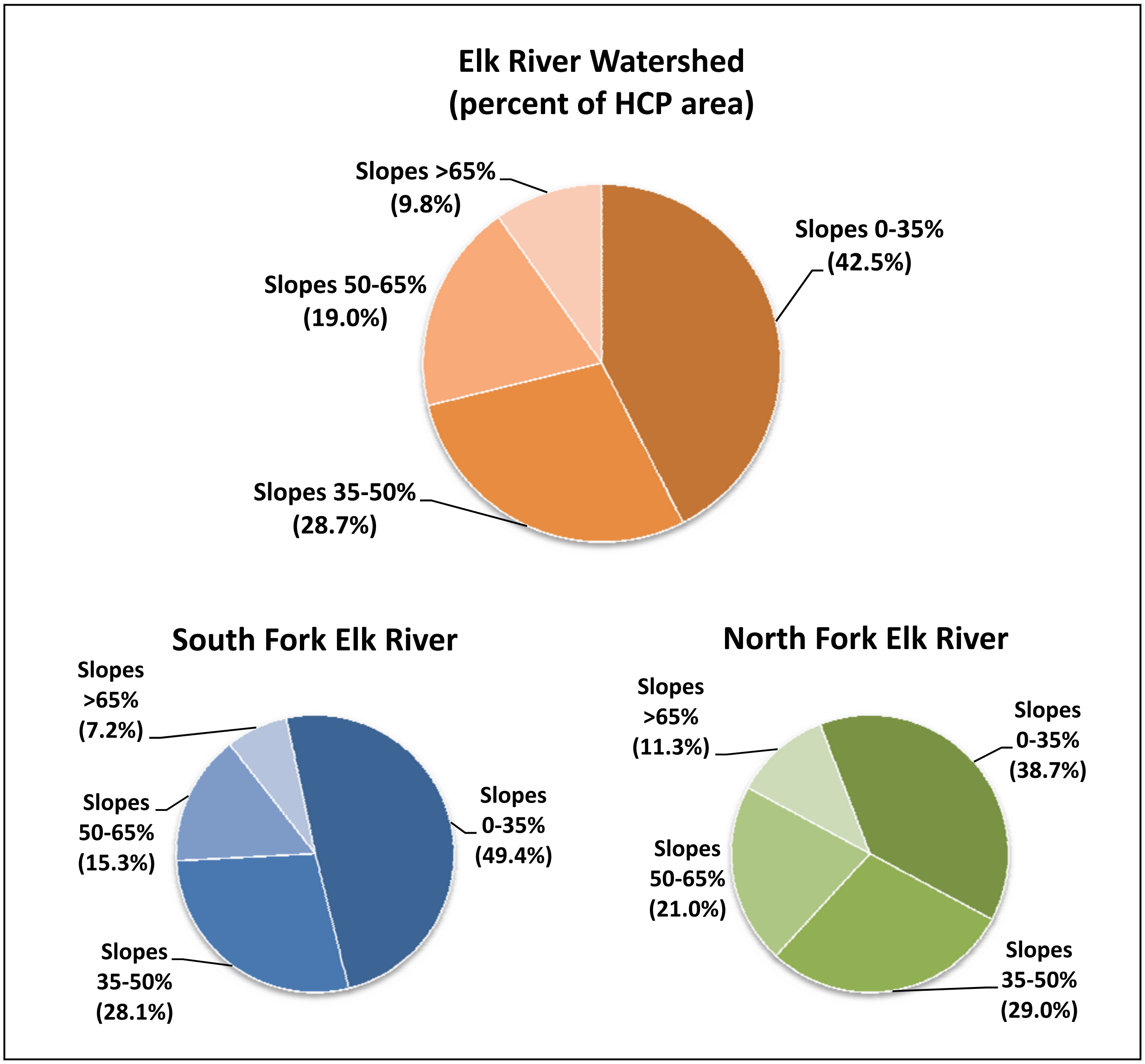

Figure 2-1. Distribution of topography within the HRC Elk River HCP area.

2.3 STREAM CLASS

Stream classes are described in the California Forest Practice Rules (CFPR) by watercourse characteristics or key-indicator beneficial uses, and are identified as Class I, II, III, or IV streams on Map 4 for the ERSC WAU. CFPR Class I streams include stream reaches that supply domestic water (within 1,000 feet) and/or have fish that are always or seasonally present and contain habitat to sustain fish migration and spawning. CFPR Class II streams are streams that have fish always or seasonally present offsite within 1,000 feet downstream, and/or streams that support aquatic habitat for non-fish aquatic species. These streams typically flow year-round, or at minimum beyond the winter season. CFPR Class III streams are generally smaller watercourses that have no aquatic life present but show evidence of being capable of sediment transport to Class I or Class II streams. They are typically ephemeral in nature with flows limited to the winter period in response to extended rainfall. Table 2-3 presents a summary of the Class I, II, and III channel lengths by sub-basin in the HCP area of the Elk River, Salmon Creek, and Fields Landing WAUs.

2.4 GEOLOGY AND SEISMIC REGIME

The Elk River watershed is tectonically active with frequent earthquakes of magnitude <4 and occasional magnitude of > 6.5 occurring within the past 2 decades.. The basement lithologies of the watersheds are comprised of massive, poorly indurated marine mudstones and siltstones with some sandstones. The following description of the geology underlying Elk River and its northern neighbor, the Freshwater Creek watershed, is taken from Stillwater Sciences (2007, pg 4):

> *The two basins are located along the southeastern margin of the actively uplifting and deforming southern Cascadia forearc basin at the leading edge of the northward migrating Mendocino triple junction. Northwest-trending faults and folds bound the dominant mountain ranges. The two basement units in the area include the Franciscan Complex Central Belt-a Mesozoic to early Cenozoic age accretionary mélange enclosing blocks of more coherent sandstone, greenstone, and chert; and the Yager terrane – a Paleogene trend-shope deposit of thin-bedded argillite and sandstone turbidites with minor pebbly conclomerate (Ogle, 1953: McLauglin et al., 2000, Marshall and Mendes 2005). The Wildcat Group, a thick transgressive-regressive sequence of marine siltstone and fine-grained sandstone of late Miocene to Pliocene age, rests unconformably on these basement units. Undifferentiated shallow water marine and fluvial deposits of middle to late Pleistocene age (Hookton Formation and related deposits) cap broad, accordant ridges across the western portions of the Elk River basin.*

Sediments within the Elk River basin derive primarily from undifferentiated late Miocene through Pleistocene marine sediments of the Wildcat Group, which underlies approximately 75% of the Elk River lands covered under the HCP. This group of sediment is a fine sandy siltstone and claystone that breaks apart easily. Watershed areas proportioned by lithologic units are provided in Table 2-4 and Figure 2-2.

Table 2-3. Stream class lengths on HRC HCP covered lands within the ERSC WAU.

Sub-basin Name	Class I (miles)	Class II (miles)	Class III (miles)	Total (miles)
North Fork Elk	5.14	12.40	21.95	39.49
North Branch NF Elk	3.13	13.73	26.32	43.19
South Branch NF Elk	1.42	3.73	11.06	16.21
Upper North Fork Elk	5.31	7.11	18.81	31.23
McWhinney Creek	2.05	3.62	9.97	15.64
Bridge Creek	3.35	7.89	19.45	30.68
Lake Creek	2.51	6.01	16.37	24.89
Lower NF Elk	4.94	6.07	10.57	21.59
Browns Gulch	0.39	3.99	3.51	7.88
Dunlap Gulch	0.58	1.39	3.52	5.48
NF Elk Sub-watershed Total	***28.83***	***65.94***	***141.52***	***236.29***
South Fork Elk	1.07	17.56	26.57	45.19
Little South Fork Elk	0.00	0.00	0.00	0.00
Lower South Fork Elk	0.00	4.61	13.09	17.70
McCloud Creek	0.32	0.00	1.42	1.74
Tom Gulch	2.33	6.63	10.14	19.10
Railroad Gulch	0.54	3.62	5.21	9.38
Clapp Gulch	0.51	3.10	3.96	7.57
Mainstem Elk	0.00	2.06	1.95	4.01
SF Elk Sub-watershed Total	***4.77***	***37.59***	***62.34***	***104.70***
Elk River Watershed Total	***33.60***	***103.52***	***203.86***	***340.99***
Fields Landing Watershed Total	***0.00***	***0.00***	***0.07***	***0.07***
Salmon Creek	0.00	0.00	0.33	0.33
Little Salmon Creek	0.61	3.26	4.42	8.29
Salmon Creek Watershed Total	**0.61**	**3.26**	**4.75**	**8.62**

Table 2-4. Distribution of lithologic units on HRC HCP covered lands within the ERSC WAU.

Lithologic Unit	North Fork Elk		South Fork Elk		*Elk River Total*		*Fields Landing*		*Salmon Creek*	
	Area (acres)	% of Area	Area (acres)	% of Area	*Area (acres)*	*% of Area*	Area (Acres)	% of Area	Area (Acres)	% of Area
Wildcat Group undifferentiated (QTw)	10750.9	76.2%	5777.6	74.1%	***16528.5***	***75.4%***	*50.2*	*66.2%*	*488*	*82.8%*
Yager Formation (y1)	1061.6	7.5%	1567.8	20.1%	***2629.4***	***12.0%***	*0.0*	*0.0%*	*0*	*0.0%*
Franciscan mélange (cm2)	2233.9	15.8%	0.0	0.0%	***2233.9***	***10.2%***	*0.0*	*0.0%*	*0*	*0.0%*
Alluvium/terrace (Qal/Qt)	65.5	0.5%	450.8	5.8%	***516.3***	***2.4%***	*25.7*	*33.8%*	*101*	*17.2%*
Total for HCP Area	***14,111.9***	***100%***	***7,795.0***	***100%***	***21,908.2***	***100%***	***75.0***	***100%***	***589***	***100%***

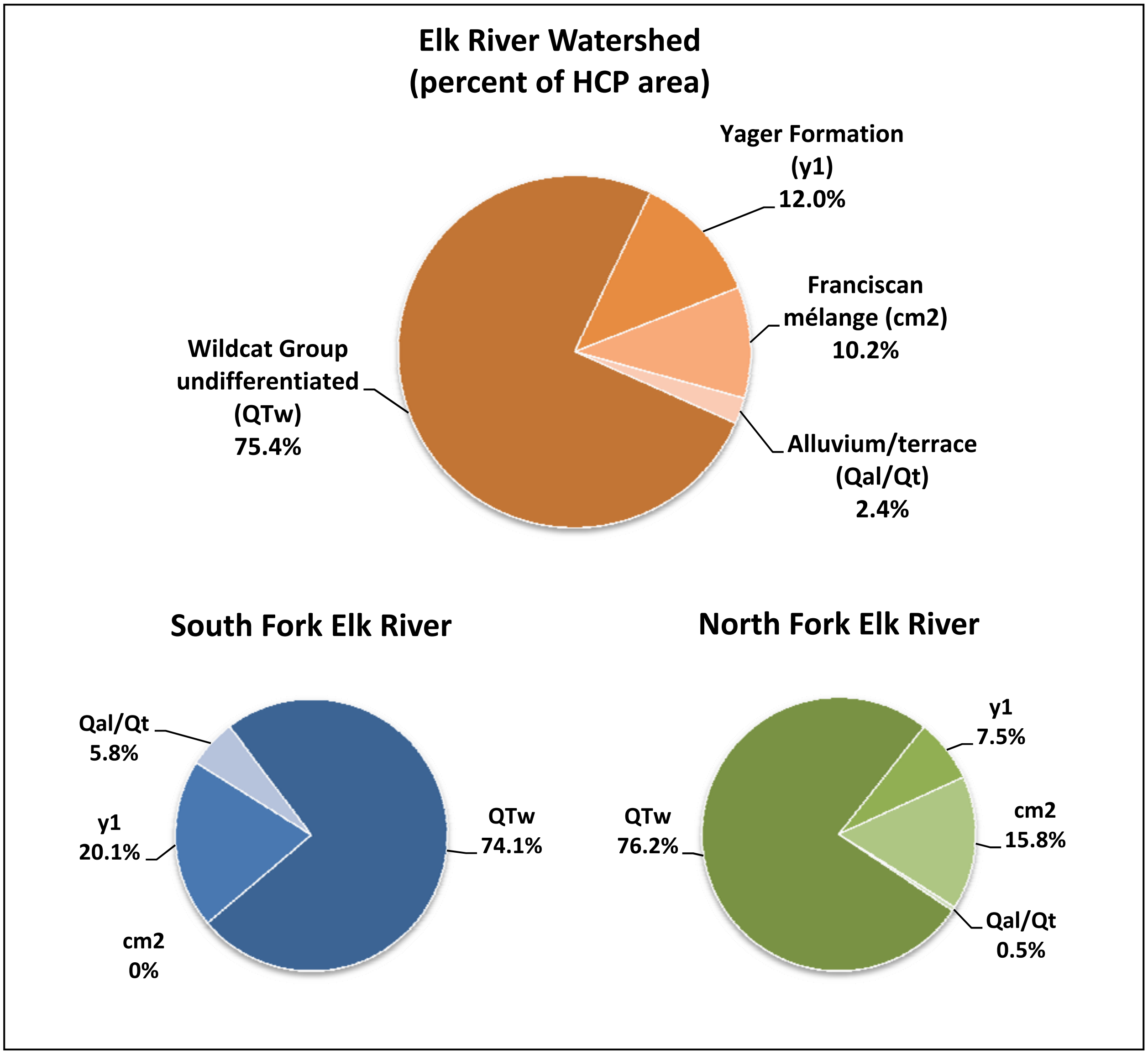

Figure 2-2. Distribution of lithologic units within the HRC ERSC HCP area.

Further detailed characterizations of the Elk River geologic setting can be found in the following documents:

- Landslide Inventories for the 2003, and 2006, 2010 Storm Seasons, Elk River, Humboldt Co., CA and Construction of a sediment budget for the decade 2001-2010 (Oswald 2012; Appendix 1)
- Elk River/Salmon Creek Watershed Analysis (PALCO 2005)
- Landslide Hazard in the Elk River Basin, Humboldt County, California (Stillwater Sciences 2007)

Detailed characterizations of the Elk River Earthquake history can be found at the following locations:

- USGS Earthquake Hazards Program: http://earthquake.usgs.gov/earthquakes/shakemap/list.php?y=2012&n=nc

2.5 VEGETATION

The maritime coastal climate supports a coniferous lowland forest community comprised of redwood (*Sequoia sempervirens*), western hemlock (*Tsuga herophylla*), Sitka spruce (*Picea sitchensis*), grand fir (*Abies grandis*) and Douglas-fir (*Pseudotsuga menziensii*). While conifers are the prevalent tree type, hardwoods including primarily red alder (*Alnus rubra*), tanoak (*Notholithocarpus densiflorus* var. *densiflorus*) (in drier sites), willow (*Salix spp.*), big-leaf maple (*Acer macrophyllum*), California bay laurel (*Umbellularia californica*) and wax myrtle (*Morella californica*) can be found in the watershed. Current vegetation composition is presented in Table 2-5 as acres of HCP land per sub-watershed. Figure 2-3 presents the current vegetation composition for the Elk River Watershed by percent of HRC HCP area.

Table 2-5. Vegetation type by sub-basin and sub-watershed in the HRC HCP area of the ERSC WAU.

	Vegetation Type (HCP Only) – Total Acres								
Sub-basin Name	**Redwood**	**Redwood/ Douglas-fir**	**Redwood/ Hardwood**	**Douglas-fir**	**Douglas-fir/ Redwood**	**Douglas-fir/ Hardwood**	**Conifer/ Hardwood**	**Hardwood**	**Non-timber**
North Fork Elk	393.1	727.7	42.0	36.0	794.4	0.0	276.5	473.5	51.9
North Branch NF Elk	469.6	1040.6	44.0	0.0	861.1	12.8	72.0	17.5	43.0
South Branch NF Elk	49.1	243.0	0.0	0.0	583.0	0.0	57.6	262.1	30.1
Upper North Fork Elk	638.7	647.1	0.0	3.9	245.9	0.0	12.5	88.6	7.5
McWhinney	213.0	581.9	0.0	0.3	1.6	0.0	0.0	0.0	13.4
Bridge Creek	444.9	944.8	0.0	0.0	7.1	0.0	0.0	4.7	18.3
Lake Creek	508.4	374.2	0.0	3.2	158.9	0.0	277.5	37.0	3.1
Lower NF Elk	1056.7	24.7	56.8	0.0	0.0	0.0	0.0	163.8	7.7
Browns Gulch	291.2	251.4	22.0	0.0	0.0	0.0	0.0	9.2	0.0
Dunlap Gulch	225.9	180.5	0.0	0.0	0.0	0.0	0.0	5.0	0.0
NF Elk Sub-watershed Total	***4290.4***	***5015.9***	***164.8***	***43.4***	***2652.1***	***12.8***	***696.1***	***1061.4***	***174.9***
South Fork Elk	891.0	1133.5	0.0	0.0	1364.3	3.3	10.6	173.0	51.1
Little South Fork Elk	10.3	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0
Lower South Fork Elk	1049.1	5.9	0.4	0.0	0.0	0.0	47.6	30.8	4.1
McCloud Creek	197.6	0.0	0.0	0.0	0.0	0.0	11.5	0.4	0.0
Tom Gulch	1016.8	0.3	0.2	0.0	0.0	0.0	105.8	52.6	12.9
Railroad Gulch	443.7	59.8	13.2	0.0	0.0	0.0	139.0	58.4	0.0
Clapp Gulch	297.5	90.0	8.7	0.0	0.0	0.0	115.5	69.5	0.0
Mainstem Elk	265.0	17.5	0.0	0.0	0.0	0.0	9.1	28.3	0.0
SF Elk Sub-watershed Total	***4171.1***	***1307.0***	***22.4***	***0.0***	***1372.0***	***3.3***	***439.2***	***413.1***	***68.1***
Elk River Watershed Total	***8461.5***	***6323.0***	***187.2***	***43.4***	***4024.0***	***16.1***	***1135.3***	***1474.6***	***243.1***
Fields Landing Watershed Total	***14.1***	***7.1***	***0.0***	***0.0***	***0.0***	***0.0***	***27.9***	***26.8***	***0.0***
Salmon Creek	41.2	4.9	0.0	0.0	0.0	0.0	0.0	15.2	0.0
Little Salmon Creek	141.1	254.1	0.0	0.0	0.0	0.0	93.2	39.1	2.4
Salmon Creek Watershed Total	***182.3***	***259.0***	***0.0***	***0.0***	***0.0***	***0.0***	***93.2***	***54.4***	***2.4***

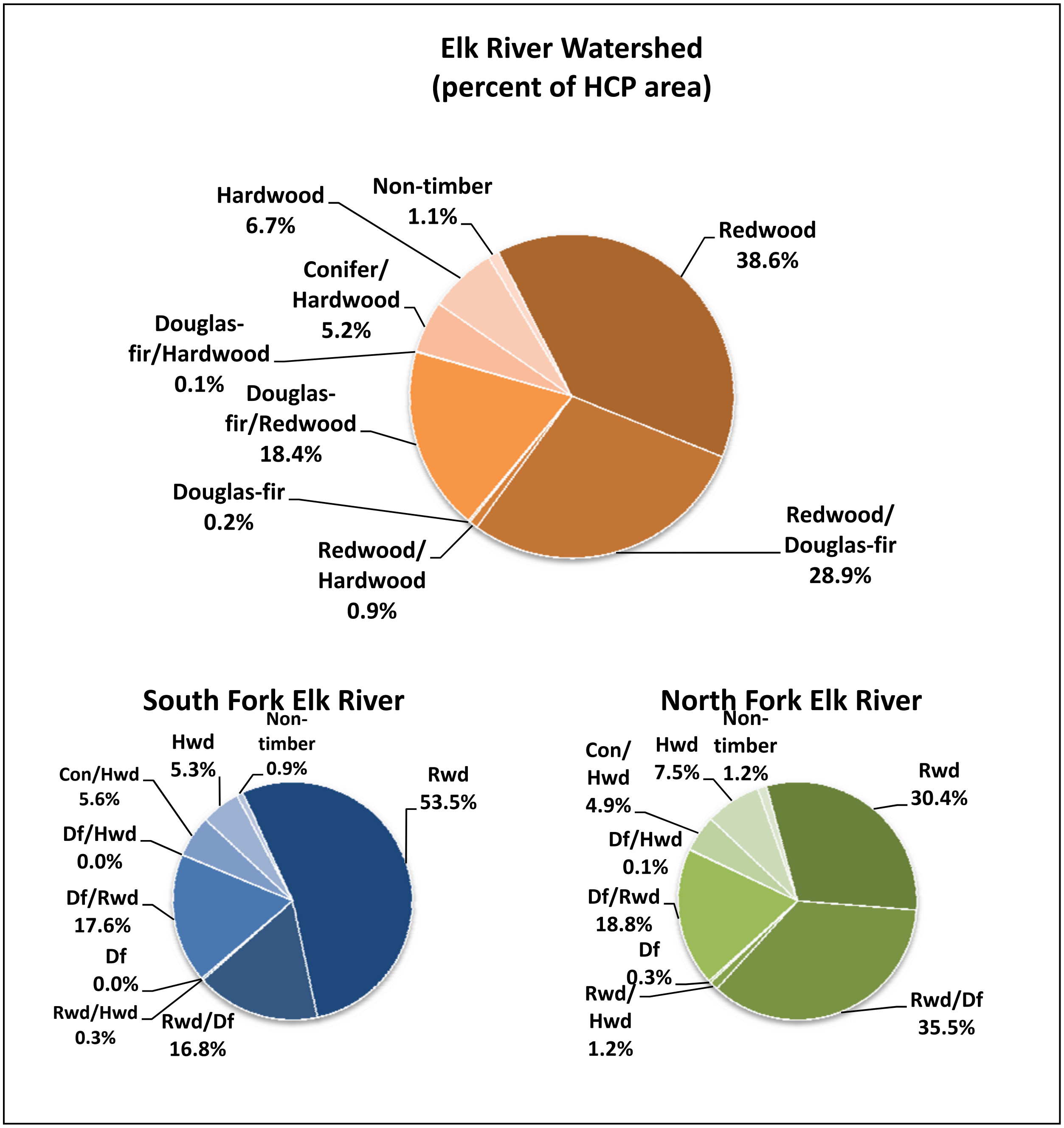

Figure 2-3. Composition of vegetation within the HRC Elk River HCP area.

2.6 CLIMATE AND STORM HISTORY

The Mediterranean climate of the Elk River and Salmon Creek basins is evident in mild, wet winters with varying rainfall and storm intensities. Rainfall data collected at the Woodley Island National Weather Station (NWS) in Eureka, CA, indicates an average annual rainfall of 39.20 inches[1] with roughly 90% of the annual precipitation falling as rain during the months of October through May. Precipitation is calculated by the "hydrologic year" that runs from October 1 through September 30th and is numbered for the year in which it ends. In general, both temperature and precipitation increase considerably with elevation and distance from Woodley Island. Rain gauge data collected in 2011 by HRC at locations throughout the Elk River watershed shows average annual rainfall ranging from 15 to 38 percent above that recorded at the Woodley Island station in Eureka, which supports a general belief that storms generate about 25% more rainfall within the Elk River drainage than that recorded at the Eureka NWS Station.

HRC continues to utilize the Woodley Island National Weather Station in Eureka, CA for precipitation information. Rainfall is monitored daily and serves as a potential trigger for monitoring efforts. Total annual precipitation measured at the Eureka Station is presented in Figure 2-4 for the years 1888-2011, plotted with the corresponding cumulative average rainfall.

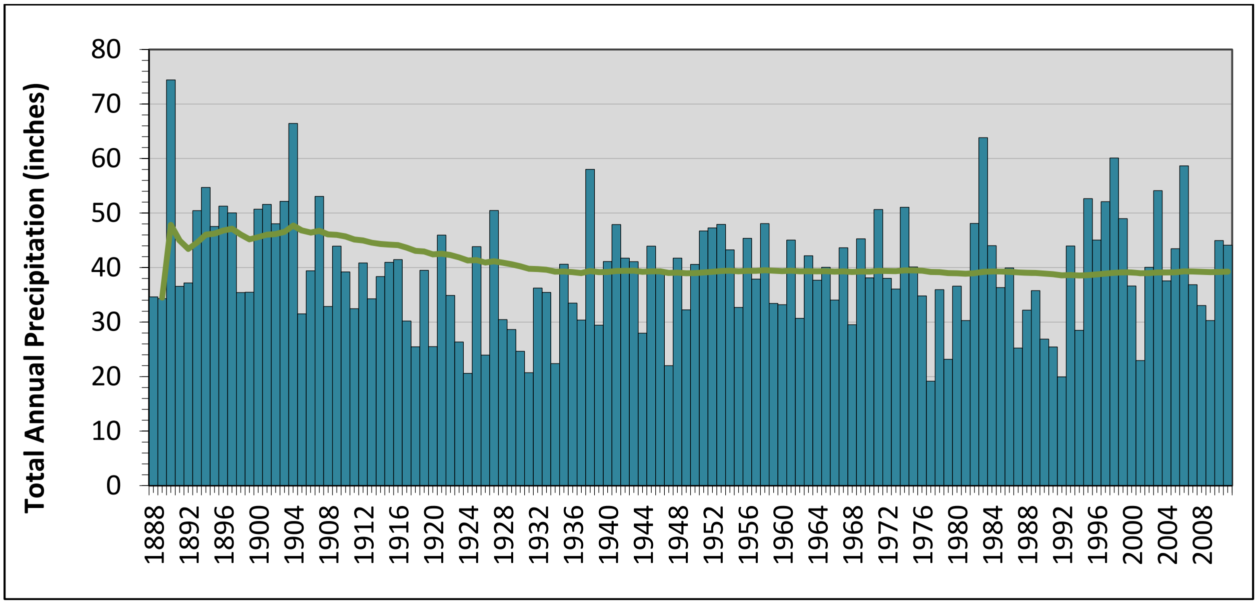

Figure 2-4. Total annual precipitation at NWS Eureka, CA by hydrologic year, 1888-2011.

Annual rainfall was near average (± 10%) for hydrologic years (HY) 2000, 2002, 2004, and 2007. Storm events in HY 2003 and 2006 were the first significant precipitation events since the implementation of the

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[1] California Date Exchange Center (http://cdec.water.ca.gov/cgi-progs/profile?s=SCA&type=precip)

HCP in 1999 and were within the top 10 wettest seasons *on record* at the NWS Eureka gauge. HY 2003 was 38% above average, with annual rainfall of 54.1 inches and HY 2006 was 50% above average with 58.67 inches. Both seasons ended with a prolonged and sometimes intense series of storms that occurred late in the season when ground water levels were high and hill slopes were saturated.

These conditions are considered the set-up to the precipitation-triggered landslides associated with these seasons. HRC's HCP considers a rainfall event that exceeds 3 inches per day as a potentially "geomorphically effective event;" that is, this daily rainfall is indicative of a storm large enough to have significant erosion initiating capability. Importantly, this threshold assumes that landslides, as well as other erosion processes that occur only during larger storm events, may be triggered at this intensity of rainfall. Rainfall of 4 inches per day exceeds most landslide thresholds available from the scientific literature (e.g., Caine 1980, Innes 1983). Table 2-6 provides a summary of precipitation data for the years 1988 to 2011.

Table 2-6. Precipitation Parameters at the NWS Eureka, CA station 1988-2011.

Hydrologic Year	Annual rainfall (inches)	Max daily rainfall (inches)	Max 48 hour rainfall (inches)	# Days rainfall >1"	# Days rainfall >2"	# Days rainfall >3" (and >4")
1988	32.20	1.96	2.78	8	0	0
1989	35.77	1.97	2.74	5	0	0
1990	26.89	1.41	2.31	2	0	0
1991	25.45	1.34	1.55	4	0	0
1992	19.95	1.74	1.78	4	0	0
1993	43.97	1.78	2.45	4	0	0
1994	28.50	2.74	3.36	7	2	0
1995	**52.66**	1.97	3.4	**13**	0	0
1996	45.04	**2.81**	**3.53**	**13**	**3**	0
1997	**52.09**	**4.86**	**6.99**	**13**	**4**	**1**
1998	**60.10**	**4.12**	**4.14**	**16**	**4**	**1**
1999	48.97	**4.37**	**6.59**	10	**3**	**1**
2000	36.64	1.89	3.07	8	0	0
2001	22.95	1.20	1.71	1	0	0
2002	40.07	2.26	3.1	10	2	0
2003	**54.11**	**6.79**	**8.82**	12	**3**	**1**
2004	37.57	1.89	2.69	9	0	0
2005	43.45	1.77	3.05	**13**	0	0
2006	**58.67**	2.04	2.67	**16**	1	0
2007	36.86	2.32	3.29	4	1	0
2008	33.06	1.99	2.5	9	0	0
2009	30.30	1.74	2.02	5	0	0
2010	44.96	1.76	2.55	12	0	0
2011	44.11	2.05	2.75	10	0	0

Bold numbers denote uppermost five within each category

In the 117 years of rainfall record at Eureka, daily rainfall between 3-4 inches occurred on 19 occasions, between 4 and 5 inches on 10 occasions, and over 6" per day just once. The 4 inch daily rainfall event that occurred in HY1997 was the first such event to occur following a span of 36 years. Larger events were more common in the first half of the century.

In the years between 2001 and 2011, one daily rainfall event equal to or greater than 4 inches occurred. On December 27-28, 2002 (HY 2003), 6.79 inches of rain fell in Eureka within a 24-hour period. This set many duration/volume records at the NWS station (PALCO 2004), and was by far the largest single-day rainfall event and highest total rainfall month in the 123 years of record. This storm event caused well-documented widespread flooding and landsliding throughout Humboldt County and the North Coast.

During the 2006 storm season, two-day moving average of precipitation exceeding one inch in 24 hours was surpassed 13 times. Prior to the storm of December 30-31, 2005, about 20 inches of rain had fallen since October 1 (HY 2006) with almost 9 of those inches in the 12 preceding days (NWS Eureka data). This set the stage for the 6th highest flood on record. The Eel River at Scotia was reported to crest at 53.13 feet on December 31, 2005, 2.13 feet above flood stage, two days following the storm. On that same day, the Mad River, flood stage 22 feet, crested at 23.33 feet. Major highways and county roads were impassable as a result of landsliding and power was lost to large portions of the community for several days.

The 2010 and 2011 storm season annual precipitation totals were above average but less than the 2003 and 2006 totals.

Additional characterization of weather events and climate can be found in the following documents:

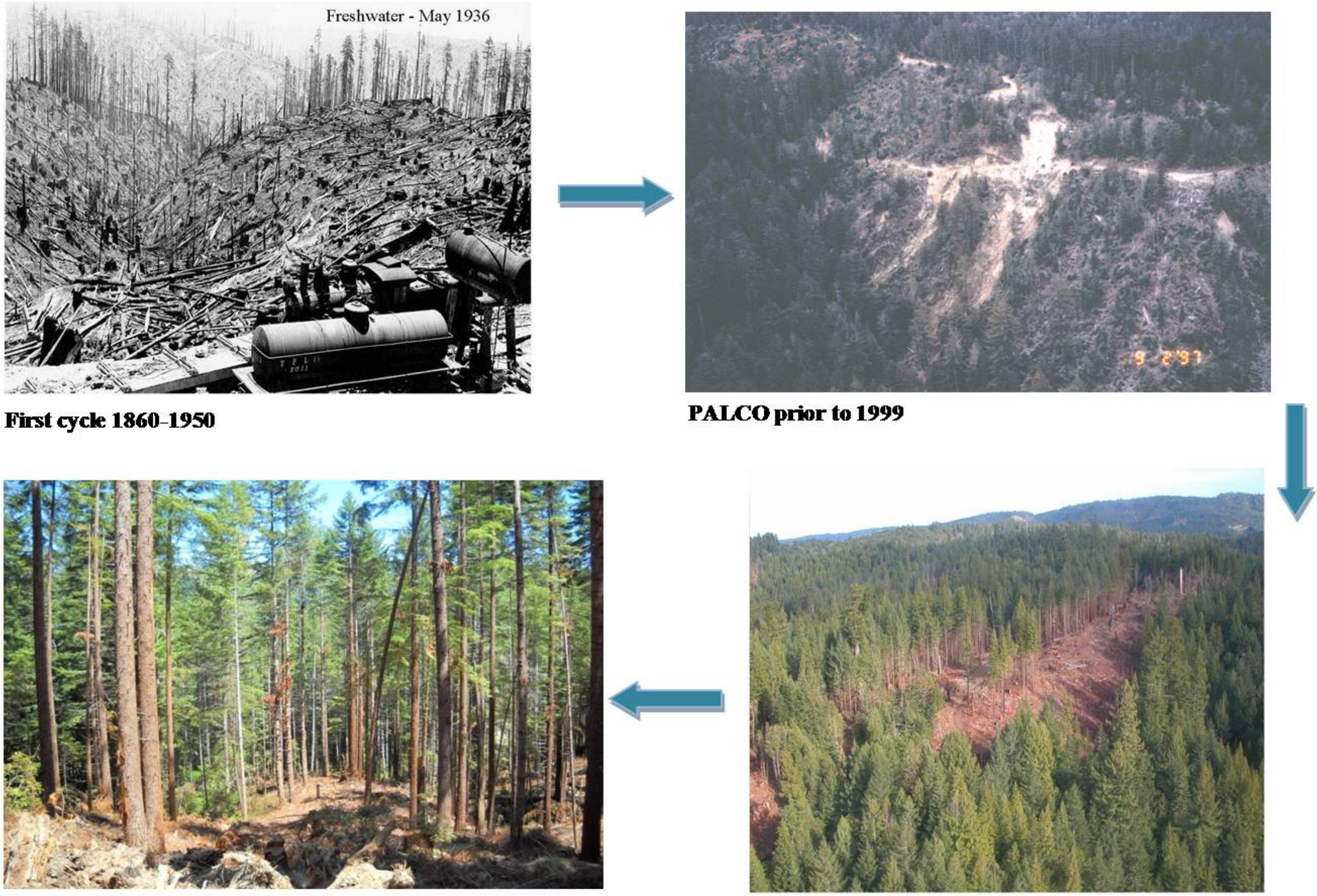
- Elk River/Salmon Creek Watershed Analysis (PALCO 2005)
- Landslide Inventories for the 2003, and 2006, 2010 Storm Season, Elk River, Humboldt Co., CA and Construction of a sediment budget for the decade 2001-2010 (Oswald 2012, Appendix 1)
- Analysis of Rainfall Characteristics of the December 2002 Storm at Eureka, CA (Dhakal 2005, Appendix 2)

3 LAND USE AND FOREST MANAGEMENT

Major land uses in the watershed are forestry, agricultural/residential, and power line right-of-way. Rural land use primarily includes pasturing and there are residential homes along the lower reaches of the mainstem Elk River and the North Fork and South Fork branches. Forest management is the dominant land use on HCP covered lands.

The majorities of timberlands in Elk River were formerly owned by the Pacific Lumber Company (PALCO) and are now owned by the Humboldt Redwood Company (HRC) following financial reorganization of PALCO in 2008 through bankruptcy proceedings. The watershed has been actively logged since the 1860's and forests are now in their second or third generation. Earlier harvest history is provided in PWA (1998) and PALCO (2005). An extensive road system has been developed over the last century (~ 7 mi/mi^2). Constructed to varying standards over this time period, much of the system has been upgraded or decommissioned to HCP storm-proofed standards over the past thirteen years.

During much of the historical period, high impact activities were conducted without regard to landscape sensitivity to erosion processes or riparian forest integrity. Since 1974, California Forest Practice Rules have guided forest management practices to minimize impacts of activities on water quality and sedimentation. Updates to these rules during the past 40 years have continually improved protections related to road construction and maintenance practices and riparian management as scientific understanding of linkage to aquatic habitat conditions and processes has increased. The HRC (formerly PALCO) HCP has further strengthened conservation measures, guided specifically by studies of environmental conditions found on HCP covered lands. Figure 3-1 provides photographs illustrating typical logging practices during various eras.



First cycle 1860-1950

PALCO prior to 1999

HRC uneven-age management 2008-current

PALCO 1999-2008

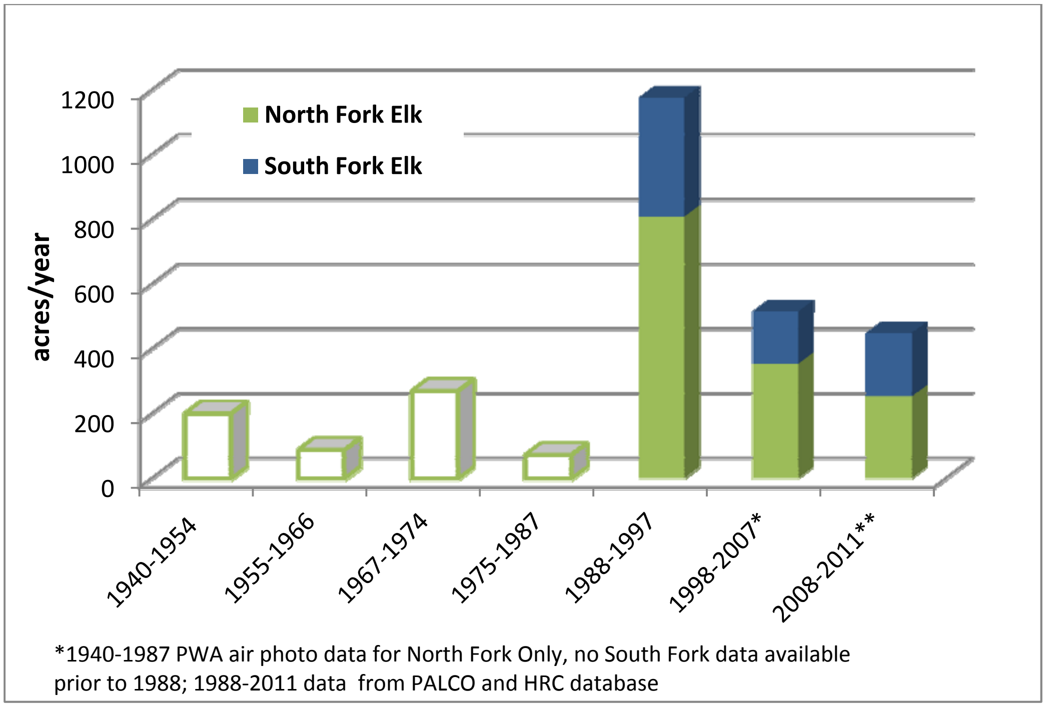
Figure 3-1. Photographs illustrating forest silvicultural practices history in Elk River and Freshwater Creek.

3.1 HISTORIC LAND USE AND HARVEST HISTORY

The majority of lands within the ERSC WAU have been privately managed for industrial timber operations for many years. Timber harvest within the watershed began near the bottom of the watershed in the 1860's with oxen yarding, progressing upstream using "steam donkeys" and railroad logging into the 1920's. The first railroad tracks for timber access were laid in the 1880s and expanded over time into the 1930's. In the 1870s, prior to railroad access, tens of millions of board feet of old-growth logs were delivered from the forest to mills on the bay by "manufactured" flash flooding. This was done through the construction of seasonal dams which captured the first flows of the rainy season in the fall and early winter in order to float millions of board feet of logs placed in the stream channel down to the bay upon sudden dam removal. These sudden high flows which the carried the logs down the stream were referred to as "booms" or "freshettes". The first mill in the upper watershed was established along the South Fork Elk River in 1884. Early tractor and diesel powered high lead cable logging was introduced to the watershed in the 1940's. Much of the timbered watershed was logged a second time beginning in the 1980s utilizing modernized high-lead and skyline cable yarding methods to selectively harvest residual old-growth and larger second growth, primarily with partial cutting and thinning harvests. Clearcut logging was also used to a lesser extent during this time period, primarily in the North Fork.

Harvest rates in terms of acres per year logged is known to varying degrees of certainty over the last seven decades. PWA estimated acres logged for the period of 1940 – 1987 for the North Fork Elk River using historical aerial photographs (PWA 1998). No data was collected for the South Fork Elk River during this exercise. PALCO and subsequently HRC have recorded acres harvested on an annual basis since 1988. These records indicate an average of 1,176 acres harvested annually from 1988 through 1997. Little to no harvesting occurred in the watershed from 1999 through 2001 immediately following the implementation of the HCP and amidst heightened concerns over adverse cumulative effects. Estimated harvest rate in average acres per year by decade is illustrated in Figure 3-2.

The initial ERSC Watershed Analysis Report (PALCO 2005) provides a detailed account of the WAU's logging history (1880 – 2002) (pages 12-17).



*1940-1987 PWA air photo data for North Fork Only, no South Fork data available prior to 1988; 1988-2011 data from PALCO and HRC database

Figure 3-2. Elk River estimated harvest rate history.

3.2 CONTEMPORARY LAND USE AND HARVEST HISTORY (2001-2011)

Timber harvest operations in Elk River changed significantly following implementation of the PALCO HCP, and again with the change of ownership from PALCO to HRC in August of 2008. From 2001 through July of 2008, PALCO used primarily even-age silviculture in harvesting mainly second growth redwood and Douglas fir. Clearcut unit size and environmental impacts were reduced by HCP conservation measures restricting harvest adjacent to watercourses and on unstable areas. HCP wet weather road use limitations, new road construction standards, and requirements for "storm-proofing" and road system monitoring were implemented. After July 2008, with the transition in ownership from PALCO to HRC, timber harvesting was converted to mainly uneven-aged selection silvicultural practices. HRC immediately ended traditional clearcutting, minimized the use of herbicides, and implemented an old growth tree retention policy. HRC continues to support, develop, and implement the HCP. Details regarding erosion control, riparian function conservation and restoration, and watershed monitoring strategies and practices are provided throughout this report within the section(s) pertaining to each topic.

A total of 5,627.7 acres were harvested within the Elk River watershed from 2001 through 2011 (3,475.7 acres in NF Elk River and 2,152.0 in SF Elk River) (Figure 3-3 and Map 5). Consequently, average annual acres logged during this 11 year time period was 511.5 acres. No harvest occurred within the Fields Landing watershed and 170 acres were harvested within HRC ownership of the Salmon Creek watershed. Harvested acres account for each entry so that if the same acre is harvested twice during this time period it is represented as two acres in this harvest summary. The annual harvest rates by sub-basin provided in Table 3-1 were calculated using total acres harvested as a percentage of the entire watershed or sub-watershed area (including non-HRC ownership) and subsequently divided by 11 years. These rates ranged from 0 to 3.36% of total sub-basin acres per year. The highest rates of harvest within this time period occurred in Lake Creek (3.36% acres/year), and Browns Gulch (3.33% acres/year). All other rates were less than three percent of the total sub-basin acres per year. Overall, the approximate rate of HRC harvest within the entire watershed was 1.51% acres/year (2.20% in NF Elk and 1.01% in SF and mainstem Elk River). Cable and helicopter yarding were the primary logging methods, with tractor logging limited to lesser inclined slopes (i.e. <40%). Even-age and uneven-age cut proportions range widely from sub-basin to sub-basin but were 0.44 even-age and 0.56 uneven-age cut overall for the entire watershed (Table 3-1). Annual harvest acres by sub-watershed show 11 years of harvest levels less than 1,000 acres per year (Figure 3-4) since 2000. This compares to the previous analysis period (1988-2000) in which 1,000 acres of harvest were exceeded annually six times.

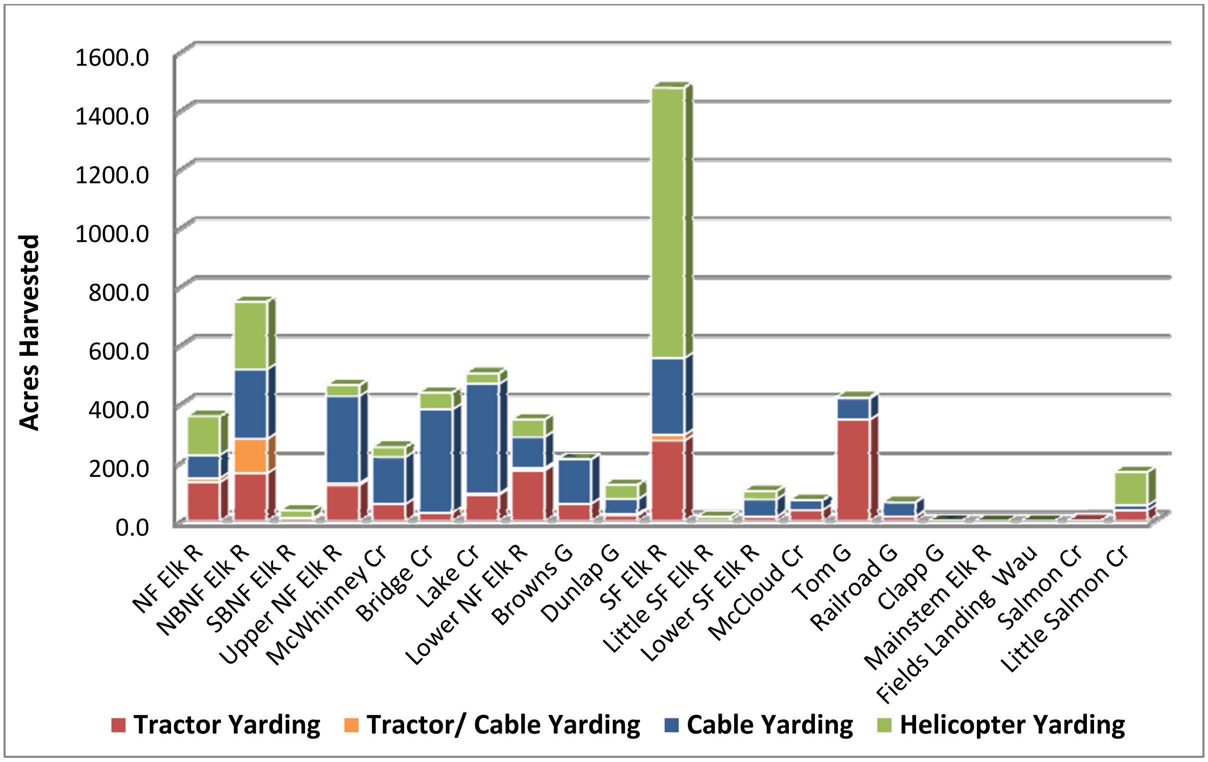


Figure 3-3. ERSC HCP area harvested by harvest methods and sub-basin 2001-2011.

Table 3-1. HRC ERSC Annual harvest acres by mechanism and sub-watershed 2001-2011.

	Harvest Mechanism (acres)								
Sub-basin Name	**Tractor Yarding**	**Tractor/ Cable Yarding**	**Cable Yarding**	**Helicopter Yarding**	***Total***	***% of Total Sub-basin Area[1]***	***Annual Rate of Harvest** (% sub-basin acres/years)[1]*	***Even-age Harvest proportion***	***Uneven-age Harvest proportion***
North Fork Elk	132.3	13.9	78.8	132.2	357.2	12.8%	1.16%	0.24	0.76
North Branch NF Elk	163.2	116.8	237.9	229.7	747.6	29.2%	2.65%	0.47	0.53
South Branch NF Elk	9.9	0.0	0.0	25.4	35.3	2.9%	0.26%	0.29	0.71
Upper North Fork Elk	121.7	8.1	296.8	36.6	463.1	28.2%	2.56%	0.52	0.48
McWhinney Creek	57.8	0.0	160.2	34.3	252.3	31.1%	2.83%	0.81	0.19
Bridge Creek	28.4	0.0	352.7	56.2	437.2	30.8%	2.80%	0.77	0.23
Lake Creek	89.6	4.4	373.7	36.5	504.2	37.0%	3.36%	0.17	0.83
Lower NF Elk	172.7	8.3	106.0	58.5	345.5	21.9%	1.99%	0.59	0.41
Browns Gulch	59.2	0.0	151.3	0.0	210.5	36.7%	3.33%	0.59	0.41
Dunlap Gulch	20.3	3.4	50.9	48.1	122.8	29.0%	2.63%	0.76	0.24
NF Elk Sub-watershed Total	***855.2***	***154.8***	***1,808.3***	***657.4***	***3,475.7***	***24.1%***	***2.20%***	***0.50***	***0.50***
South Fork Elk	274.3	20.0	261.4	922.2	1,477.9	28.8%	2.61%	0.27	0.73
Little South Fork Elk	0.6	0.0	0.0	13.2	13.8	0.6%	0.05%	0.51	0.49
Lower South Fork Elk	14.1	0.0	59.8	28.2	102.1	5.5%	0.50%	0.32	0.68
McCloud Creek	37.6	0.0	34.1	0.0	71.8	4.7%	0.43%	0.81	0.19
Tom Gulch	345.6	0.0	72.8	3.3	421.7	26.3%	2.39%	0.39	0.61
Railroad Gulch	16.0	0.0	48.3	0.0	64.2	8.4%	0.77%	0.94	0.06
Clapp Gulch	0.0	0.0	0.5	0.0	0.5	0.1%	0.01%	1.00	0.00
Mainstem Elk	0.0	0.0	0.0	0.0	0.0	0.0%	0.00%	0.00	0.00
SF Elk Sub-watershed Total	***688.2***	***20.0***	***476.8***	***966.9***	***2,152.0***	***11.1%***	***1.01%***	***0.34***	***0.66***
Elk River Watershed Total	***1,543.4***	***174.8***	***2,285.1***	***1,624.4***	***5,627.7***	***16.6%***	***1.51%***	***0.44***	***0.56***
Fields Landing Watershed Total	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	***0.0%***	***0.00%***	***0.00***	***0.00***
Salmon Creek	2.6	0.0	0.0	0.0	2.6	0.0%	0.00%	1.00	0.00
Little Salmon Creek	36.1	0.0	17.5	113.8	167.4	13.9%	1.26%	0.74	0.26
Salmon Creek Watershed Total	***38.7***	***0.0***	***17.5***	***113.8***	***170.0***	***1.3%***	***0.00%***	***0.74***	***0.26***

[1] Percent of total area includes both HRC and non-HRC ownerships

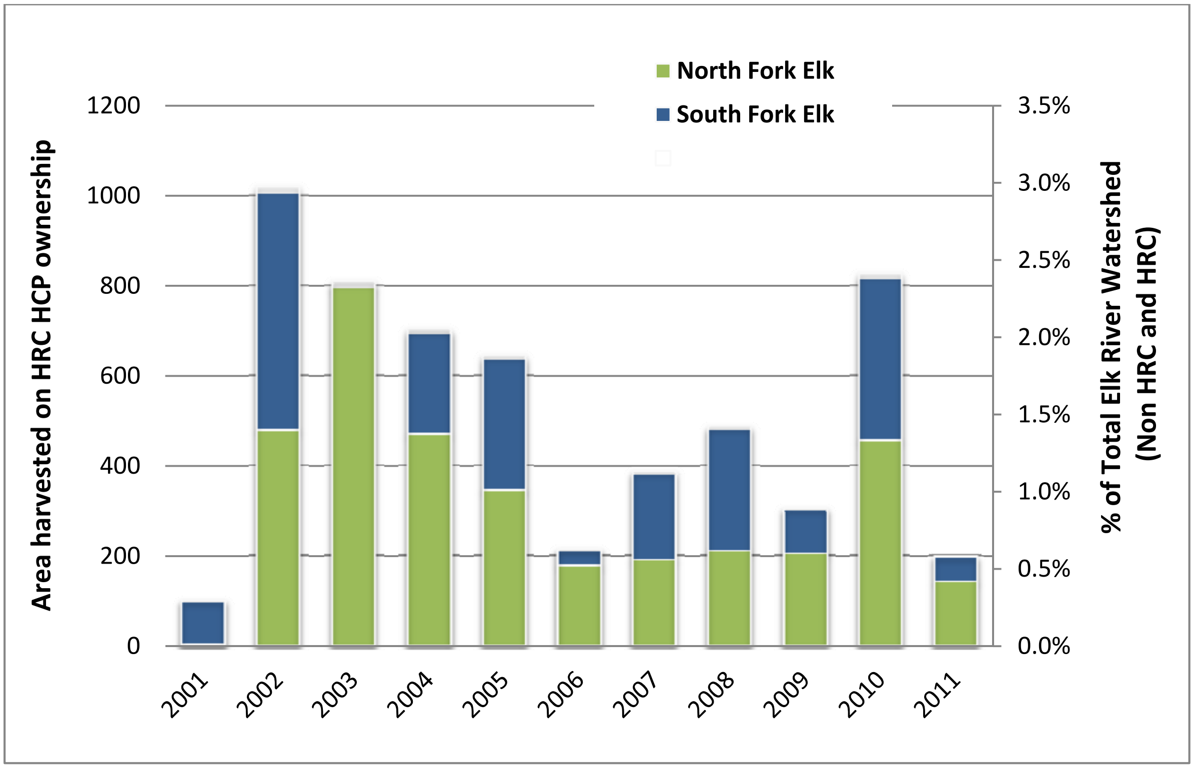


Figure 3-4. Elk River watershed acres harvested by PALCO/HRC and percent of the total Elk River watershed (2001-2011).

4 SEDIMENT BUDGET

HRC maintains a sediment source budget for each Watershed Analysis Unit (WAU) on its ownership. This budget allows for comparison and analysis of sediment sources over time and at a spatially distributed scale (by sub-basin) across the watershed. Recognition of the relative importance of each sediment source allows for management to address identified areas of concern. Comparison of forest management-related sediment delivery to background delivery (i.e. on-going natural processes apart from land use activities) provides for an understanding of significance. Tracking delivery spatially, over a designated time period, is somewhat complicated and relies upon a suite of quantification measures from full inventories, to sample surveys, to modeled estimates. Methods used for estimating annualized rates of delivery (tons/mi^2/year) for the current Elk River sediment budget period (2001-2011) are presented with the full sediment budget in Appendix 3.

	BACKGROUND	**PRE-HCP MANAGEMENT**	**HCP MANAGEMENT**
MASS WASTING	**Landslides :** • Deep-seated • Shallow-seated • Streamside and bank erosion	**Landslides from:** • Non-stormproofed roads • Non-HCP harvest • Streamside and bank erosion	**Landslides from:** •HCP roads •HCP harvest •Streamside and bank erosion
SURFACE EROSION	• Soil Creep	• Skid Trails • Road gullies/washouts	• HCP harvest • HCP road surface • Road gullies/washouts

For the purpose of analysis, sediment sources are divided into three general categories as presented in the above diagram. **Background** sediment sources are those that are part of natural processes with little to no apparent linkage in causal mechanism to land use activities. These include open slope landslides and earthflows on hillslopes occupied by advanced forest regeneration (>15-30 years) and older forests, natural soil creep, and stream bank erosion. Management-related sediment sources are separated into two categories in order to assess contemporary HCP performance versus continuing sediment delivery from older sources caused by pre-HCP logging including historic un-regulated (pre 1974) practices. **Pre-HCP** sources include landslides, smaller streamside landslides and bank erosion, gullies, and washouts from pre-HCP harvest settings, legacy abandoned roads, and portions of the maintained contemporary road system not yet upgraded to HCP stormproofed standards. Pre-HCP sediment sources also include an estimate of continued sediment delivery from older skid trails, particularly where such features intersect with watercourses (e.g. stream crossings and in-channel skidding corridors). Contemporary **HCP**

Management sources include landslides, smaller streamside landslides/bank erosion, gullies and washouts, and surface erosion (sheet and rilling) associated with HCP harvesting, and delivery from roads following storm-proofing treatments.

In the timeframe of 2001-2011 the overall calculated unit rate for sediment yield to streams from all sources within the Elk River HRC ownership was 535 tons/mi^2/year (529 tons/mi^2/year for the HRC ERSC Watersheds combined). Natural processes and lingering (Pre-HCP) legacy sediment sources are primary drivers of contemporary yield, with road-related surface erosion as the most significant contemporary (HCP) management influence. Figure 4-1 and Figure 4-2 illustrate the relative contribution of specific sources and processes. Figure 4-3 compares the sediment budget period (2001-2011) with the previous period (1988-2000).

NOTE: Analyses and comparisons made throughout this document may or may not include the Salmon Creek and Fields Landing Watersheds depending upon availability of data. In most instances, figures and tables will indicate whether or not data is applicable to the entire Elk River Salmon Creek Watershed Analysis Unit or only Elk River.

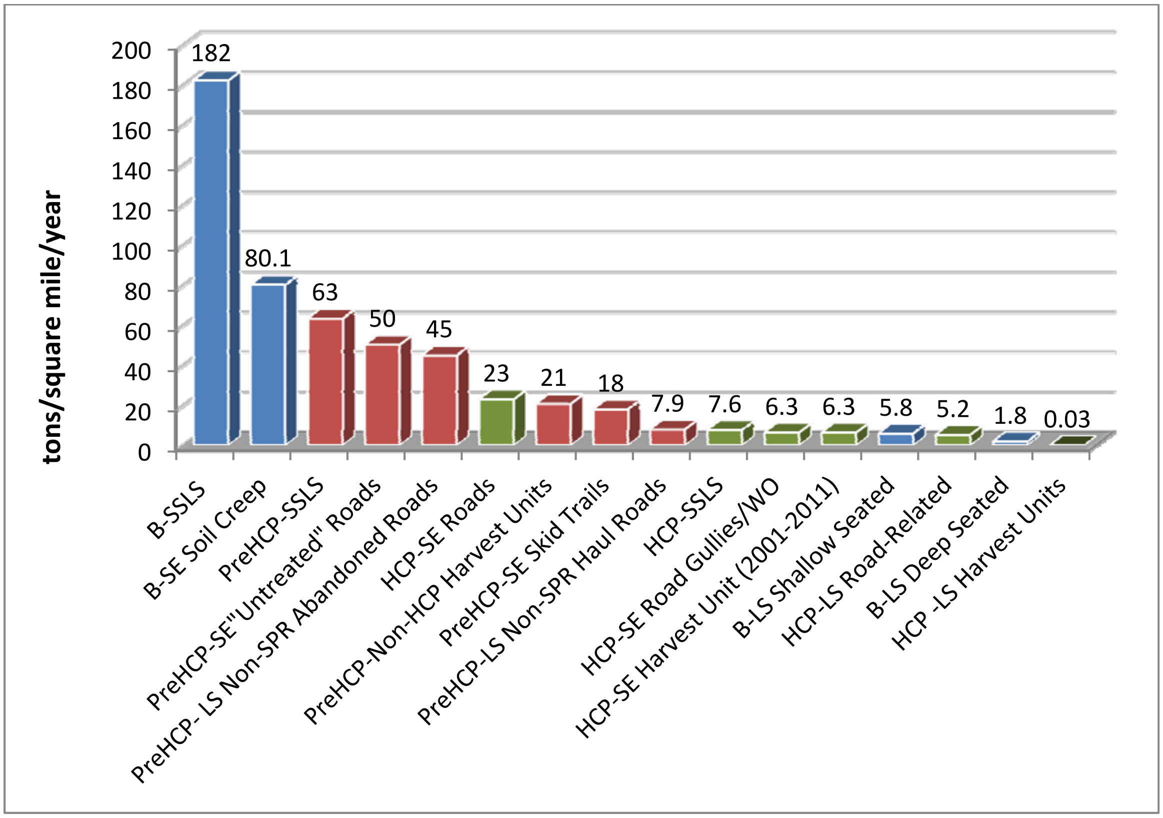


Figure 4-1. ERSC estimated sediment delivery from HRC HCP ownership, 2001-2011.

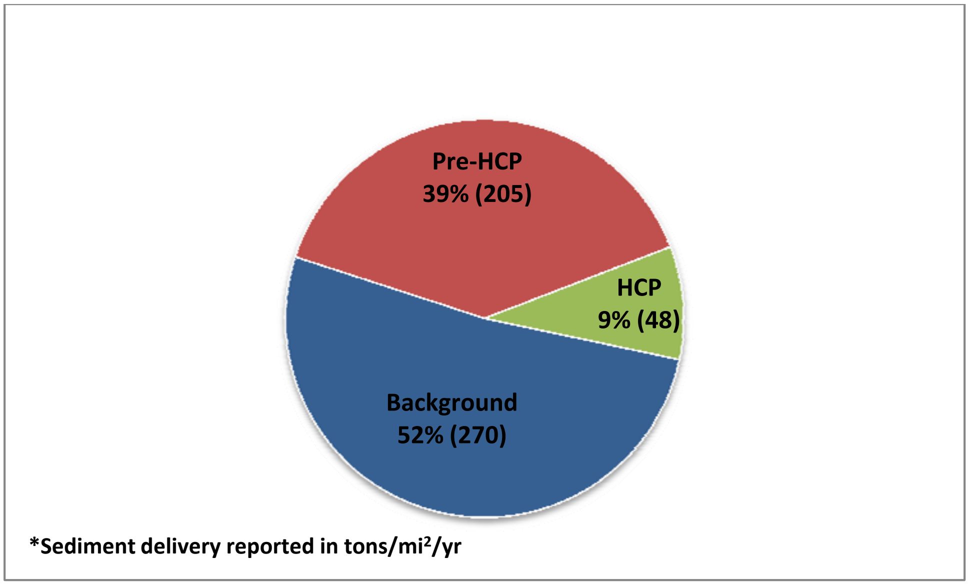


Figure 4-2. ERSC estimated sediment delivery for HRC HCP land by source category, 2001-2011.

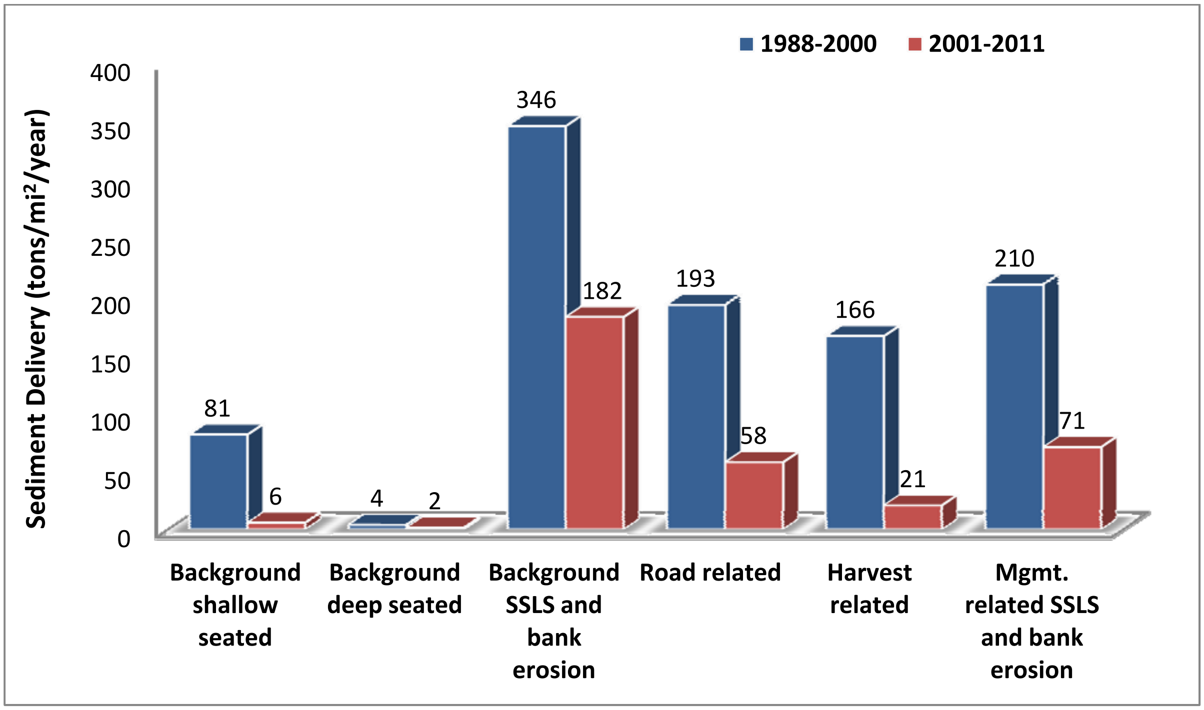


Figure 4-3. Elk River Watershed HRC HCP land estimated landslide sediment delivery rate by source 1988-2000 vs. 2001-2011.

4.1 MASS WASTING

4.1.1 Mass Wasting Avoidance Strategy

The overall strategy and enforceable prescriptions for controlling management-related mass wasting is outlined in the HCP (§6.3.3) and more specifically in the current Elk River HCP Prescriptions (Appendix 4 – HCP §6.3.3.7).

In summary, specific hillslope and road related prescriptions within the ERSC WAU exist for identified potential mass wasting geomorphic conditions, such as inner gorge and headwall swales as well as for historic earthworks associated with high hazard mass wasting areas. Registered Professional Foresters (RPFs) are trained to identify active or potential unstable areas on the ground, and consult with Licensed Geologists in the management or avoidance of these areas. The use of existing slope stability hazard maps and models, along with review of recent and historic aerial photographs are used in scoping for active or potential unstable slopes during timber harvest planning consistent with modern and state-of-the-art standards of geologic practice. Hillslope monitoring for the purpose of understanding the relationship between land management and landslide occurrence includes aerial photo review, field investigations, helicopter fly-overs, focused effectiveness monitoring projects, and post-event forensic analyses.

Road-related mass wasting sources are further addressed and minimized across the property by employing specific standards for constructing, stormproofing and upgrading roads. Monitoring of road-related sources is completed through the Annual Road Inspection Program (ARIP) to proactively identify potential road-related mass wasting sources, and through the Roads BMPEP program to review the quality and effectiveness of completed work. The most recent report for the Road BMPEP program is included in Appendix 5.

4.1.2 Hillslope Landslide-related Sediment Source Inventory (2000-2010)

Results from the most recent watershed-wide landslide inventory of HRC's Elk River ownership can be found in a 2012 report prepared by Oswald Geologic (Appendix 1). Additionally, all landslides are presented with lithologic units on Map 6 by storm year and delivery volume. Landslide activity was investigated, mapped, and described throughout the Elk River drainage, including specifically for 2003, 2006 and 2010 storm seasons. Landslides were not inventoried for the Salmon Creek or Fields Landing watersheds and therefore comparisons to the previous sediment budget for these watersheds are not made. Aerial photographs were utilized to make estimates of sediment production and delivery to watercourses for each storm season, and landslide attributes were analyzed to quantify associations with geomorphic and management criteria. The 2003 and 2006 storm seasons were significant when compared with historical precipitation data, set several records for seasonal and monthly totals, and are considered landslide-triggering events because of the widespread landsliding experienced across Humboldt County and the north coast region during these winters. The 2010 storm season was the third most significant water year recorded in the decade of study, with an annual precipitation total above the ten year average. Data from these three storm seasons was used to construct the hillslope landslide delivery component of the sediment budget. Note that rate data values may be slightly different within the ERSC Watershed Analysis Revisit than in Oswald's Landside report due to differences in volume mass conversions (1.53 tons/yd in Oswald vs. 1.4 tons/yd in the sediment budget).

Oswald mapped 126 landslides that occurred within the years of 2001 to 2010. Landslide frequency and volumes by year and sub-basin are presented in Table 4-1 and Table 4-2. Approximately 60% (N=75) of these 126 landslides delivered to a watercourse, with a calculated average of 12.5% of the total measured displaced volume actually delivering to a watercourse. Fifty-three percent (N=67) were determined to be reactivations of previous failures.

Table 4-1. Elk River hillslope landslides 2001-2011.

	Total number of slides	Displaced volume (yd^3)	Number of slides delivered	Delivered volume (yd^3)
2003	68	78064	46	12411
2006	54	106491	27	10621
2010	4	497	2	99
Total observed	***126***	***185052***	***75***	***23121***
Decade Total	***--***	***188527***	***--***	***23824***
Annual Rate (yd^3/year)		***18853***		***2383***

Table 4-2. Landslide delivery for 2003, 2006, 2010 and estimated delivery 2001-2011 by sub-basin.

Sub-basin	Area (acres)	Area (mi^2)	Number of slides delivered	Volume delivered (yd^3)	Estimated Delivery rate (tons/mi^2/year)
Mainstem	319.9	0.50	0	0	0.0
Bridge Creek	1419.8	2.22	5	462.7	26.5
Dunlap Gulch	511.4	0.80	0	0	0.0
Browns Gulch	573.8	0.90	2	154.6	21.9
NF Elk River	2795.1	4.37	14	1700.7	49.6
McWhinney Creek	810.1	1.27	1	1043.0	104.9
North Branch NF Elk	2560.6	4.00	6	660.8	21.0
Lower NF Elk	1309.6	2.05	8	747.7	46.5
Lower SF Elk	1138.0	1.78	3	8087.6	578.9
Railroad Gulch	714.0	1.12	0	0	0.0
Clapp Gulch	518.3	0.81	2	43.9	6.9
Upper NF Elk	1644.2	2.57	7	1400.5	69.4
Tom Gulch	1188.6	1.86	0	0	0.0
Lake Creek	1362.4	2.13	14	3408.0	203.8
McCloud Creek	209.6	0.33	0	0	0.0
SF Elk River	3626.8	5.67	8	5247.7	117.9
South Branch NF Elk	1224.9	1.91	5	173.8	11.6
Little SF Elk	18.0	0.03	0	0	0.0
Total		***34.29***	***75***	***23131.1***	***85.9***

Figure 4-4 presents the measured volume of sediment displaced, and subsequently delivered, as well as the stream class to which delivery occurred. Slides most frequently delivered to Class III watercourses, however the cumulative volume of sediment delivery was highest for Class I watercourses.

Over half of the delivery to Class I watercourses during this ten year time period came from one “very large” landslide (LS 716). This landslide delivered an estimated 7,911 yd^3 of sediment to a Class I stream in the lower SF Elk River sub-basin, which accounts for about 95% of the total delivered sediment to Class I watercourses across HCP covered lands in the entire Elk River watershed for the 2006 storm season. LS 716 along with several other large slides are discussed later in this section.

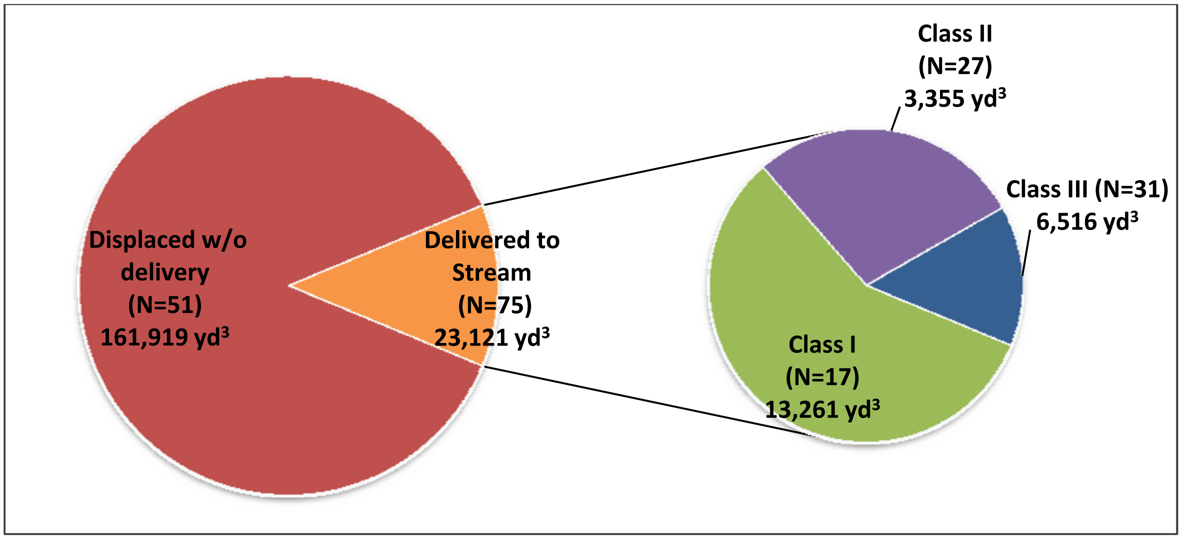


Figure 4-4. Elk River HRC HCP landslide volume displaced and delivered by stream class.

The majority of landslide delivery originated from non-stormproofed roads (Figure 4-5). These road failures (N=30) most commonly originated from or immediately adjacent steep stream side slopes. Pre-HCP harvest units logged prior to 1999 were the second greatest source of landslide origin.

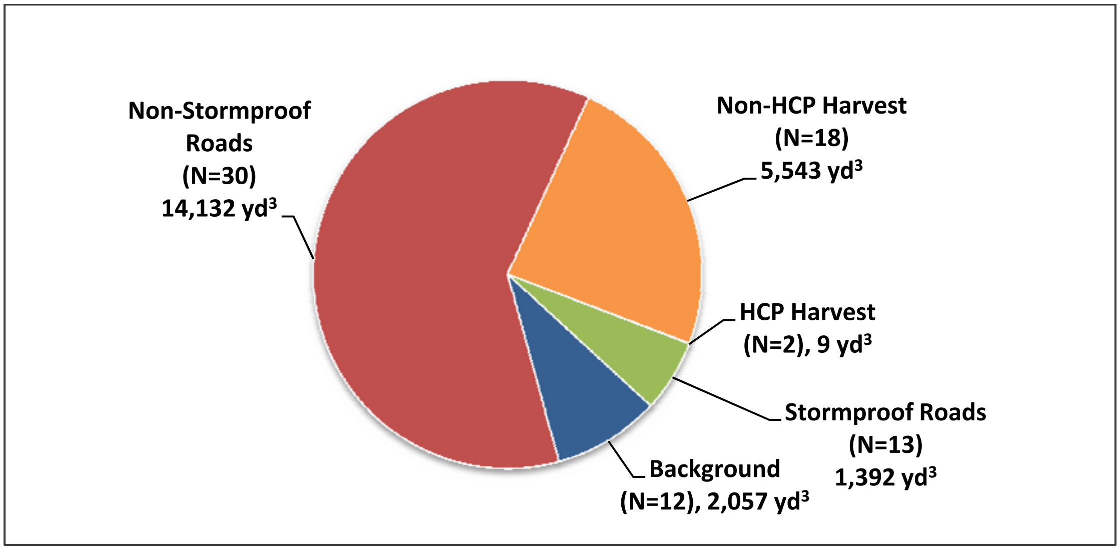


Figure 4-5. Elk River HRC HCP area watershed landslide inventory sediment source volume delivered.

Oswald identified two hillslope landslides originating from HCP harvest units. Both units were harvested in 2003 utilizing clearcut silviculture, and the landslides were identified on the 2003 aerial photo series. One unit was logged via helicopter and the other by cable. LS263, which delivered an air photo estimated two (2) yd^3 of sediment, was located within an area of the THP excluded from harvest operations (i.e. no harvest) as a result of pre-harvest THP geologic review. The second HCP harvest-associated landslide

(LS167) is estimated to have delivered seven (7) yd^3 and originated from a harvested area. Combined these two landslides delivered an estimated nine (9) yd^3 (0.004 % of total volume from hillslope landslides).

Thirteen (13) landslides were identified in association with HCP stormproofed roads based on GIS storm-proofing history, accounting for 6% of the total landslide volume. However, as the storm-proofing occurred during the same year as the landslide, HRC suspects that four of these slides (delivering a total of 115 yd^3) occurred during the winter prior to summertime storm-proofing activities, and that part of the subsequent storm-proofing was to address these failures. No system was in place at the time of Oswald's analysis to account for instances where landslides were recorded for the same year as storm-proofing, and thus these volumes remain in the HCP road category as part of Oswald's report and for the purpose of sediment budget accounting.

"Background" mass wasting was found to be uncommon, although this data point is confounded by the fact that much of the watershed has experienced harvesting over the last 30 years, so forest stands with no harvest activities over the last 15-30 years are also uncommon.

The dominant geomorphic association for recent mass wasting was found to be streamside slopes and large (1,000 – 2,000 yd^3) to very large (delivering more than 2,000 yd^3) deep-seated landslides. These two geomorphic associations make up about 87% of the total landslide delivery to watercourses in the Elk River watershed (Figure 4-6). Streamside slopes inclined greater than 65% were a greater source of sediment than slopes less than 65%.

Five landslides categorized as 'large' and 'very large' accounted for 55% of all delivered sediment for the three storm seasons combined (Figure 4-7). The four 'large' landslides delivered a total of 4,831 yd^3 in 2003 within the South Fork Elk, Lake Creek, and McWhinney sub-basins; while the one 'very large' landslide delivered 7,911 yd^3 in 2006 in the Lower South Fork Elk sub-basin (LS 716). Two of the four large mass wasting events were debris slides associated with old clearcuts while the other two were associated with non Storm-proofed pre-HCP road fills. Three of the four occurred at existing landslide locations and therefore constitute the reactivation of existing landslides; whereas one was a new failure. The 'very large' 2006 landslide originated from a much larger ancient landslide complex that extends up towards the ridge (personal communication Sam Flannigan BLM). It was a reactivation, with a complex failure mode associated with an abandoned haul road. These five slides are well reflected in the high sediment production rates for these sub-basins. Landslide delivery volume and rates are presented by sub-basin in Table 4-2 above.

Deep-seated translational rockslides and earthflows are differentiated from shallow seated landslides in the "background" category of the sediment budget, but not in the pre-HCP and HCP management categories. The effect of forest management on deep-seated features is often a point of discussion but was not a considered criterion in the development of the current sediment budget, and deep-seated failures are categorized as management-related when other criteria for such classification are met.

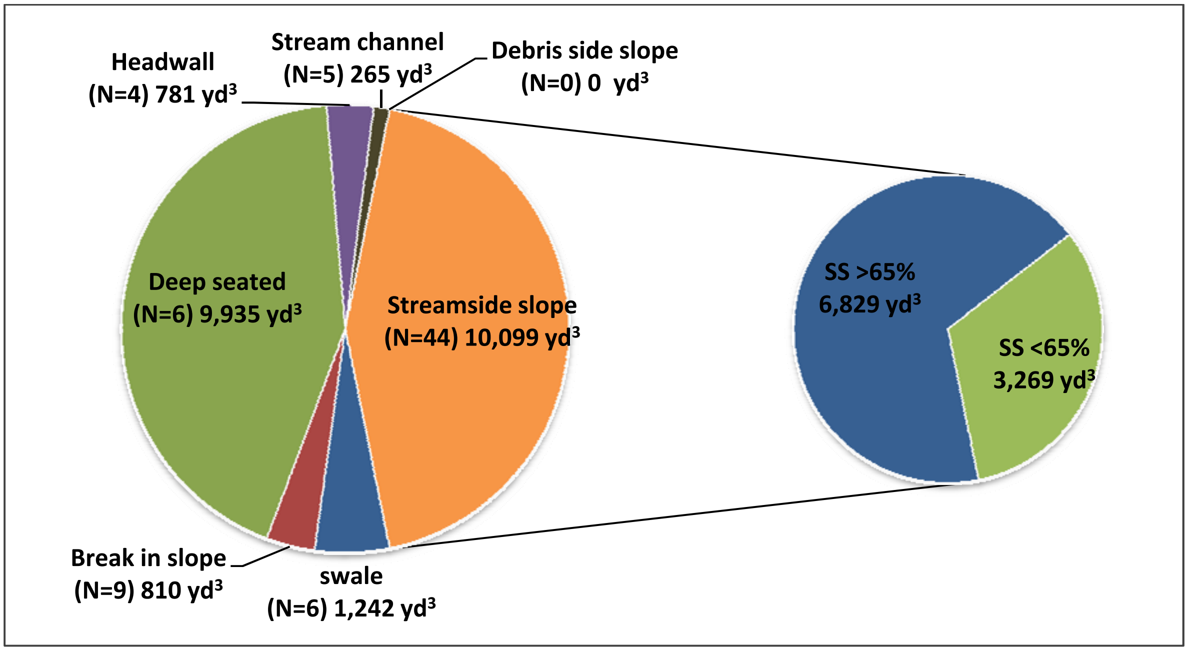


Figure 4-6. Elk River HRC HCP landslide inventory sediment delivery volume by geomorphic association.

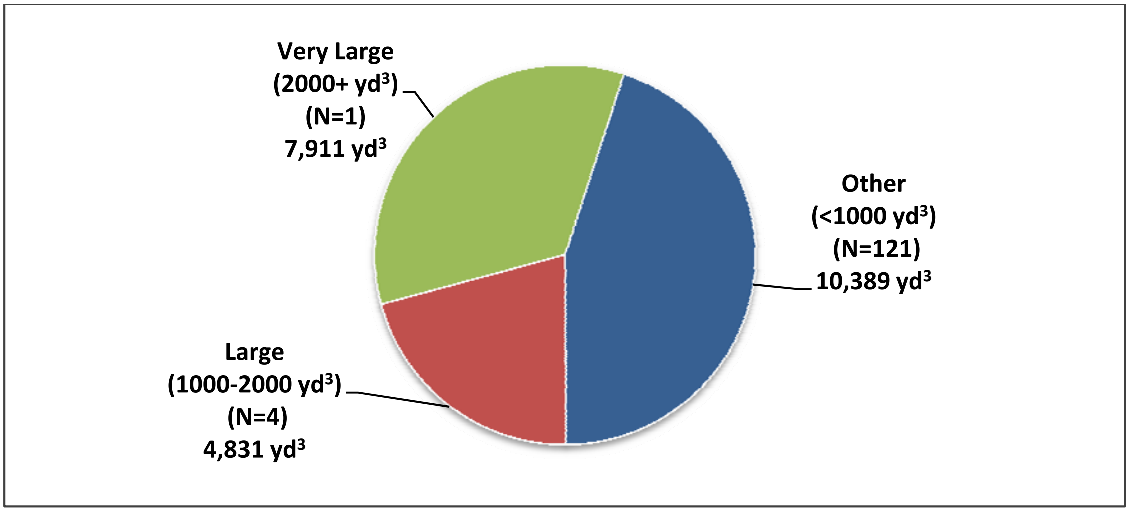


Figure 4-7. Elk River HRC HCP area hillslope landslide delivery by slide volume, 2003, 2006, 2010.

Approximately 82% of the total number of landslides mapped by Oswald, and 81% of volume delivered from these landslides (990 tons/mi^2) originated from areas mapped as underlain by the Wildcat Group. Approximately 76% of HCP covered lands in the Elk River watershed are underlain by the Wildcat Group.

Combined, the 2003 and 2006 storm seasons made up about 97% of the estimated decade hillslope landslide delivery total. Further explanation regarding the significance of the 2003, 2006, and 2010 storm seasons relative to historical record; landslide inventory methodology; and other key findings can be found in Oswald's full report (Appendix 1).

4.1.2.1 Hillslope landslide comparison by decade (1988-2000 vs. 2001-2011)

Contemporary landslide delivery volumes were compared to those of the previous decade for the purposes of evaluating trends in landslide delivery over time, and to gain insight into the effectiveness of the current Mass Wasting Avoidance Strategy being employed in Elk River.

The significance of the 2003, 2006, and 2010 storm seasons have been discussed. The prior landslide analysis period (1988-2000) also had its significant events including the nearby 7.1 magnitude Cape Mendocino earthquake in 1992, and four significant storm seasons beginning in HY 1996 recorded as four of the wettest years in the previous 50 year Eureka record. Total rainfall for the month of December 1996 was 21.3 inches and is the second highest amount on record, the highest being the later HY 2002 event of 23.3 inches. The December 1996 event caused extensive flooding and landsliding throughout Humboldt County. In addition to HY 1997, significant storm events with daily rainfall exceeding 4 inches occurred in hydrologic years 1998 and 1999; a daily rainfall amount not observed previously in Eureka since 1960. This four-year stretch of very wet weather was preceded by 10 very dry years (HY 1985-1995).

The most significant difference in methods between landslide inventory relied upon for the initial WA conducted by Hart-Crowser (2005) compared to this WA re-visit were the subsequent different approaches used to classify landslides as background (non-management related) versus management related. The initial WA defined landslides that were on management units logged more than 15 years prior as background; whereas the current "revisitation" uses a more complicated formula developed in collaboration with the HCP agencies in 2005, classifying landslides as "non-management" only if they originate from any of the following locations:

- Un-managed slopes
- Managed slopes where >30 years have passed since the last harvest and that harvest involved ground-based yarding operations
- Managed slopes where >20 years have passed since last harvest and that harvest removed >50% canopy
- Managed slopes where >15 years have passed since last harvest and that harvest removed <50% canopy

This current approach generally requires a longer time period elapse following harvest for a landslide to be classified as non-management than required for the previous 1988-2000 analysis. This is worthy of noting when viewing Figure 4-10 below. However this difference in categorization has no effect on overall landslide inventory results, as the actual air photo inventory methods used for the original WA are very similar to those used in the current analysis; thus comparison of landslide activity between these two decades can be made with reasonable confidence.

An annual landslide delivery estimate of 86 tons/mi^2/year is reported for the current sediment budget period (2001-2011) compared to 444 tons/mi^2/year for the previous period (1988-2000) (Elk River HRC HCP covered lands; Figure 4-8). Figure 4-9 presents individual sub-basin performance. Figure 4-10 presents management-associated landslide delivery. All three figures represent data collected through air photo interpretation methods and do not include results or data from streamside landslide and bank erosion field surveys which are presented separately in section 4.1.3.

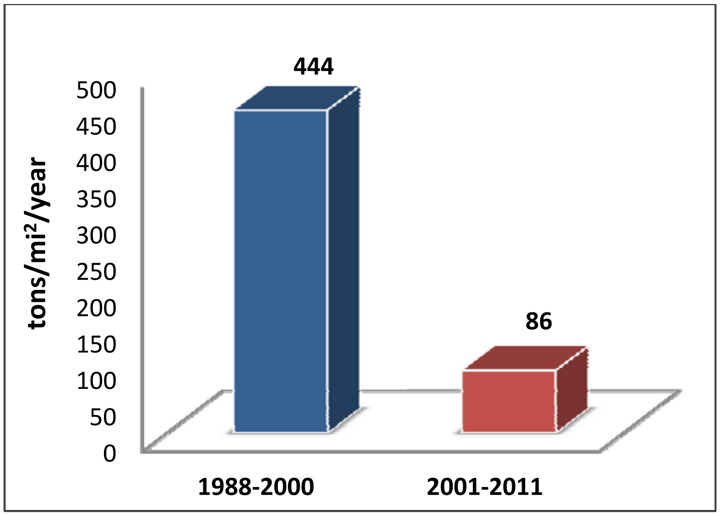


Figure 4-8. Elk River HRC HCP area hillslope landslide delivery rates 1988-2000 vs. 2001-2011.

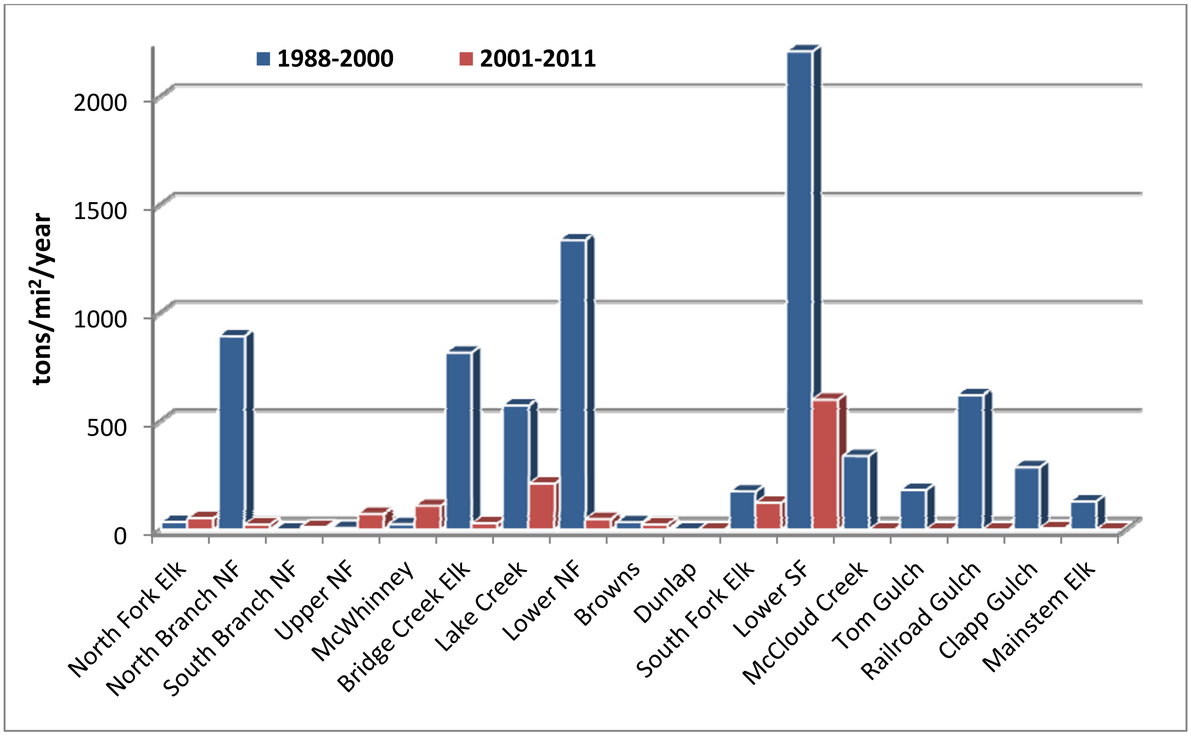


Figure 4-9. Elk River HRC HCP area sub-basin landslide volume estimated delivery rates 1988-2000 vs. 2001-2011.

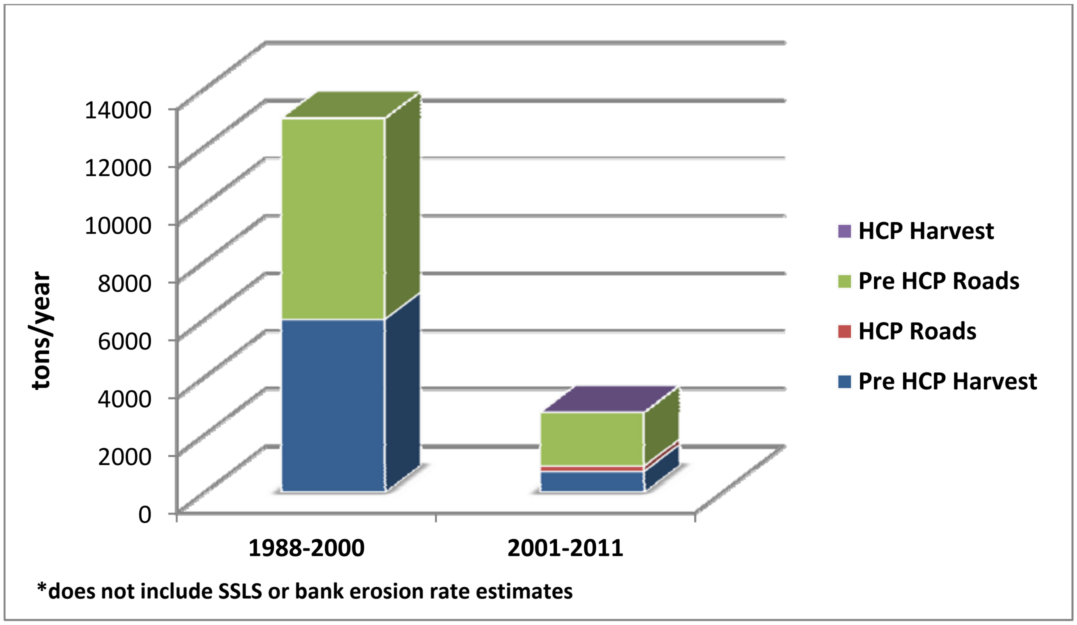


Figure 4-10. Elk River HRC HCP area estimated hillslope landslide sediment delivery from management-associated sources 1988-2000 vs. 2001-2011.

4.1.3 Streamside Landslide-Related Sediment Sources

Twenty-six (26) miles of combined Class I, II, and III watercourses were field surveyed for evidence of streamside landslides and significant bank erosion. These sources are important elements in the development of refined sediment budgets, as these smaller features are typically not apparent on aerial photography because of the generally dense riparian canopy cover. A description, along with results, of this investigative study can be found in a 2012 report prepared by SHN Consulting Engineers and Geologists (Appendix 6).

In summary, recent (2000-2012) sediment contributions from these two source types (streamside landslides and bank erosion) were estimated by conducting representative field surveys using standardized methods (HRC's "WOP-51: Reconnaissance Level Streamside Landslide Inventory"). Transects were completed in a variety of mainstem and tributary reaches selected to provide a cross-section of lithologies, stream classes, and land-use histories. The results of individual transects were then extrapolated to non-surveyed watercourses including those found in neighboring sub-basins with similar geologies and land use histories.

Survey results indicate low rates of streamside mass wasting relative to other studied watersheds within the HRC ownership (Upper Eel 2007, Bear River 2008, Mattole 2012). Field surveys identified just over 6,500 cubic yards of sediment delivery from nearly 26 miles of stream length. Because Elk River is a coastal watershed with moderate topographic relief, stream valleys tend to have broad cross-sections with wide valley bottoms. As such, stream impingement on valley sidewalls is infrequent and undercutting is rare. This condition is in contrast to steeper, more deeply incised stream valleys found elsewhere on the property (e.g. Bear River, Mattole, Eel River tributaries).

Consistent with the qualitative assessment by the field surveyors, streamside landsliding and bank erosion is more frequent along the sidewalls of mainstem stream reaches (Class I and Class II) than in headwater areas (Figure 4-11). Nonetheless, the cumulative total length of Class III watercourses throughout the watershed makes them a noteworthy contributor of volume (Figure 4-12). In the field, it was further noted that flow in Class 3 headwater areas was either occurring underground ("subterranean flow" in networks of soil pipes) or in broad channels with gently sloping sidewalls that were not susceptible to erosion and undercutting. One exception, the (Little) North Branch North Fork Elk stream segment, includes a high rate of Class 3 sediment delivery as a result of one 20-cubic-yard slide that occurred in a short (81 foot) survey reach, artificially elevating the sediment delivery rate.

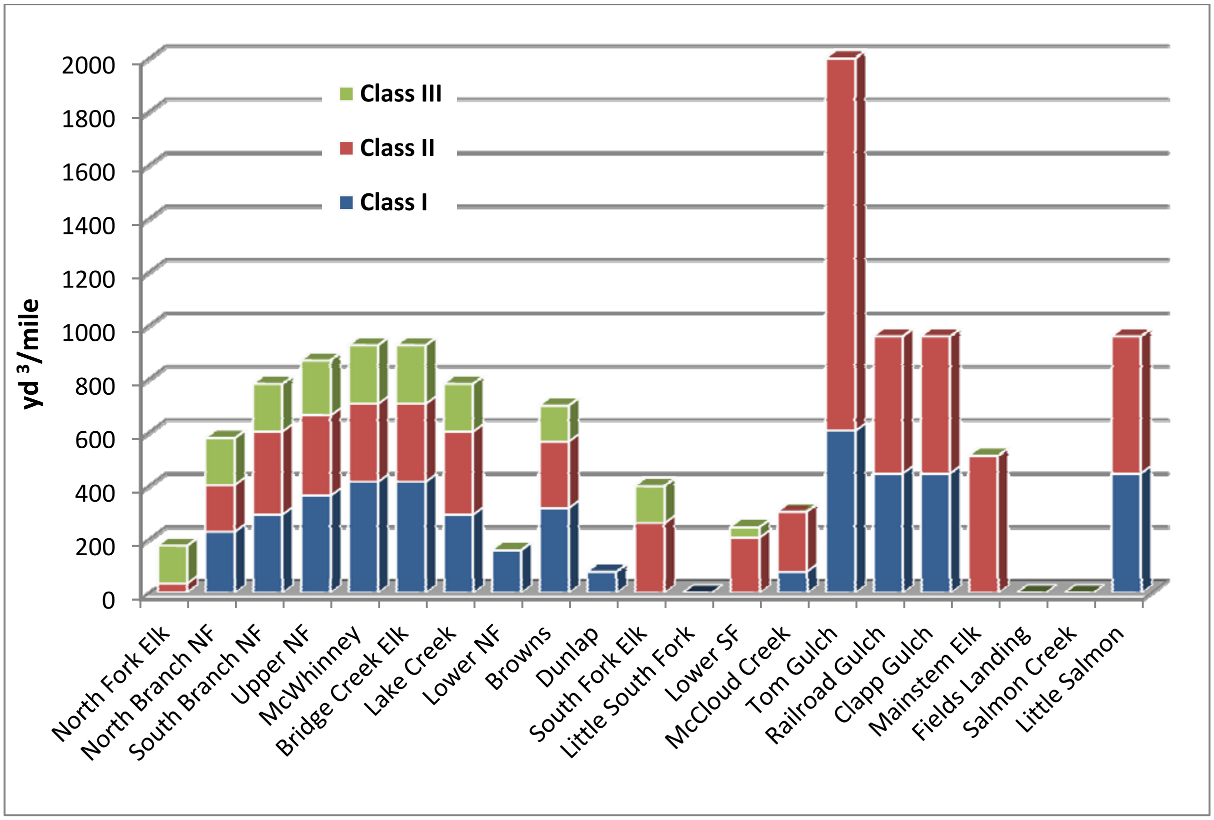


Figure 4-11. ERSC HRC HCP area streamside landslide and bank erosion sediment delivery rate by stream class and sub-basin, 2001-2011.

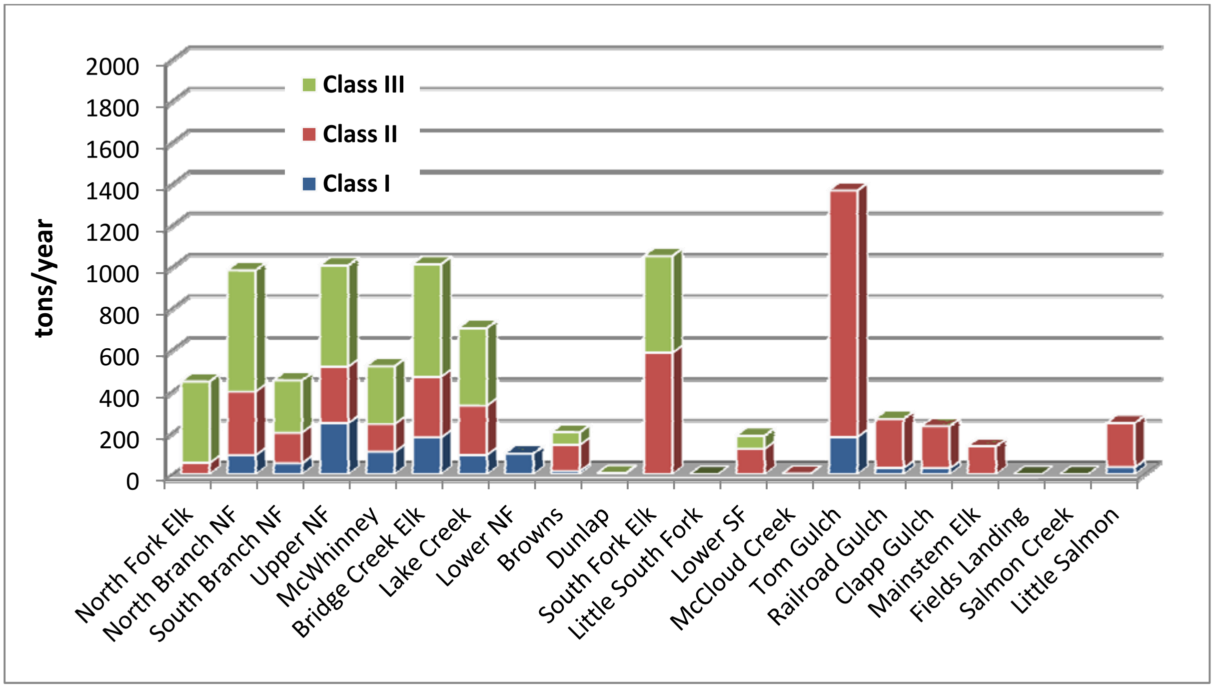


Figure 4-12. ERSC HRC HCP area streamside landslide and bank erosion sediment delivery by stream class and sub-basin based on unit rate and cumulative length of each stream class, 2001-2011.

The highest rate of streamside landsliding for surveyed areas was found in the Tom Gulch sub-basin, a "soft" rock sub-basin that is entirely underlain by Wildcat Group sediments. Tom Gulch is a north-flowing tributary in the lower watershed that is more deeply incised than adjacent sub-basins. Geologically, this incision exposes a deeper section of the Wildcat sequence, which is finer-grained and appears susceptible to streamside landsliding. Nineteen mass wasting features in Tom Gulch were observed, which accounted for more than 1,400 cubic yards of estimated sediment delivery. Nine slides along just under 0.5 mile of Class II stream surveyed in Tom Gulch delivered an estimated 600 cubic yards of sediment, which is a rate of more than 1,400 cubic yards per stream mile. No surveys were completed within Class III stream segments in Tom Gulch, so a rate for this watercourse class was extrapolated from surveys conducted in nearby drainages with Wildcat geology.

Bridge Creek is also associated with higher streamside landsliding rates relative to other surveyed areas. Eight measured slides along a 1.29-mile stretch of Class II waters along the "east" fork of Bridge Creek delivered more than 700 cubic yards of sediment. Eight slides encountered along a 0.94-mile-long segment of Class I stream ("west" fork) delivered nearly 600 cubic yards of sediment. These relatively high rates are associated with small numbers of relatively large landslides. (These were not noted to be related to erosion at the toes of larger landslides that may have been accounted for in the hillslope landslide survey.) Other surveyed segments within the Bridge Creek sub-basin were not associated with elevated sediment delivery rates.

Causal mechanisms related to recent management were virtually non-existent as no apparent interaction between streamside slopes and upslope management was observed during any survey. In every stream segment surveyed, a broad, intact riparian zone was present to buffer the stream from adjacent management areas. The report authors found streamside landsliding and bank erosion to be occurring independently of recent management with primary causal mechanisms most frequently related to unstable geology and natural flow deflection. Remnants from historic operations including in-channel cut old growth logs, root wads attached to stumps, and instabilities associated with historic skid trails were observed and reported as additional causal mechanisms responsible for approximately 25% of the observed streamside delivery (Figure 4-13).

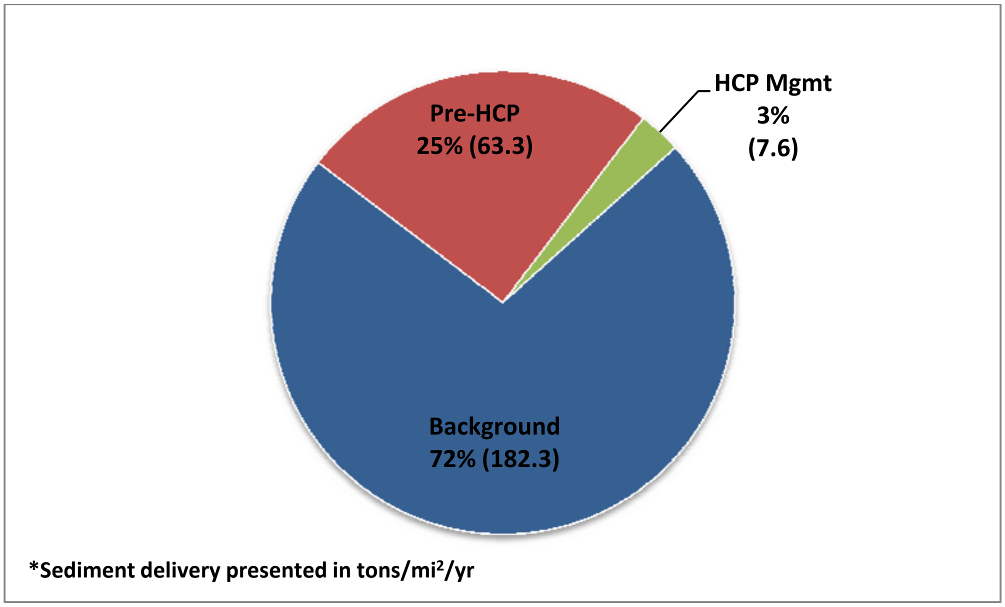


Figure 4-13. ERSC HRC HCP area calculated origin of streamside landslide sediment delivery, 2001-2011.

Increases in storm-related peak flows due to timber harvest (i.e. reduction in canopy interception and forest transpiration) may increase streamside erosion rates compared to sub-basins with no recent harvest activity. HRC hypothesizes that current watershed-wide harvest constraints combined with selection silvicultural methods and limited operations adjacent stream channels reduce the significance of harvest influence on peak flows in headwater streams to the extent that effects on channel erosion rates are minimal. To represent potential for some minimal effect from increased peak flow in years immediately following harvest, Formation Environmental assumed three percent of the background delivery (i.e. delivery with no observed management association) might actually occur as a result of contemporary harvest. The general belief is that effect on peak flow from management diminishes as storm size increases. Storms of significant enough size to cause stream bank erosion would likely do so with or without influence of increased runoff resulting from recent harvest, given HRC landscape planning and silvicultural policies, NCRWQCB harvest limitation constraints, and HCP and FPR watershed protection measures relative to riparian ground disturbance and soil compaction. Concern and uncertainty regarding this potential source of sediment input has resulted in this relationship being the focus of current ongoing THP-scale effectiveness monitoring studies.

Overall, streamside landslide and bank erosion processes currently account for approximately 75 percent of the delivered sediment from landslides in the ERSC WAU (Figure 4-14). We interpret this condition as indicative of a recovering watershed where reduction in upslope management-related sources result in natural streamside processes resuming a greater role in the sediment budget, relative to all sources.

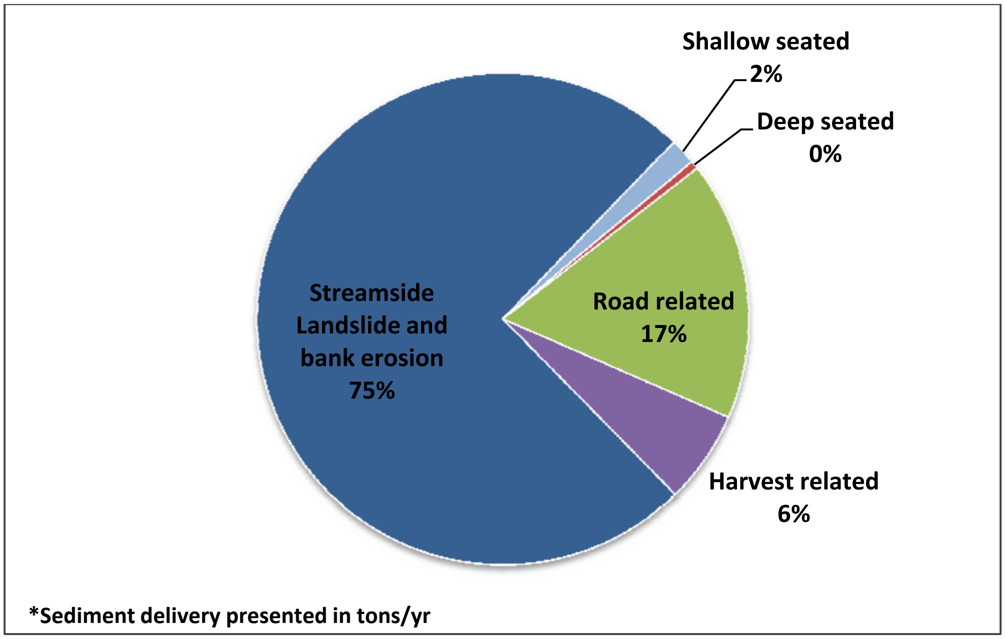


Figure 4-14. Sediment delivery by landslide type, 2001-2011.

4.1.3.1 Streamside landslide and bank erosion comparison by decade (1988-2000 vs. 2001-2011)

The initial ERSC Watershed Analysis (1988-2000) also calculated streamside landslide and bank erosion process rates from extrapolated field survey data. For the 1988-2000 sediment budget, three sections of mainstem NF Elk River (three miles total) were surveyed, and stream miles and area of the entire watershed (HCP and non-HCP) were used to calculate rates. Values were split (50:50) to be assigned background and management related. In order to better compare these two decades, only HCP-covered lands from this earlier survey were used to calculate rates.

Streamside landslide and bank erosion processes accounted for the majority of landslide sediment delivery for both decades (Figure 4-15) with a total estimated rate of 556 tons/mi^2/year from 1988 to 2000 compared to a much reduced rate of 253 tons/mi^2/year during the decade 2001 to 2011.

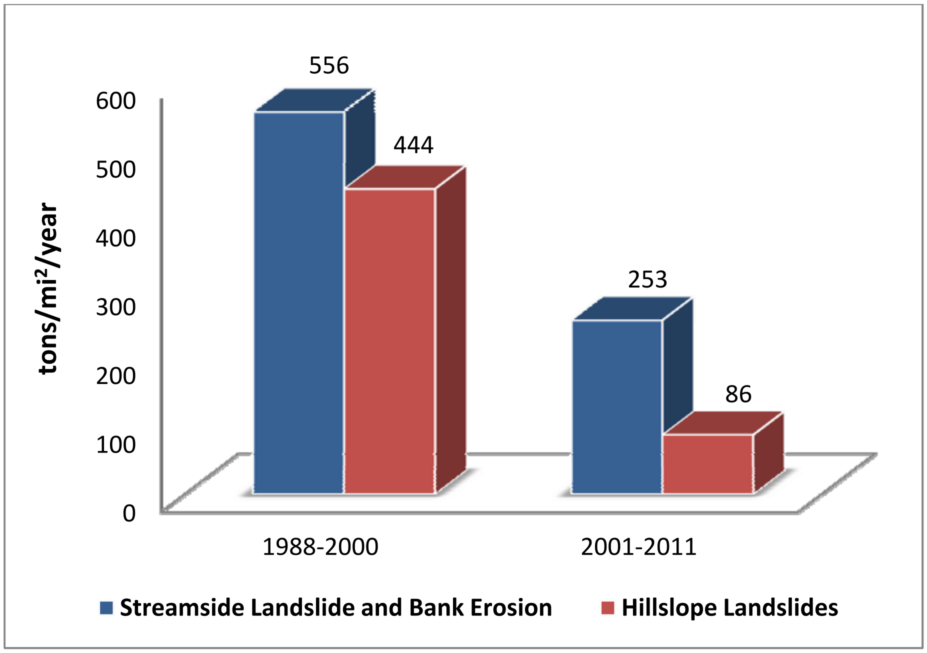


Figure 4-15. ERSC HRC HCP streamside landslide and bank erosion estimated delivery rates compared to hillslope landslides, 1988-2000 vs. 2001-2011.

4.1.3.2 Subterranean Flow

Very early in the process of conducting the 2012 streamside landslide/bank erosion surveys, it became apparent to the surveyors that stream flow in many headwater areas underlain by Wildcat sediments was occurring underground in a complex network of pipes and chambers. This subterranean plumbing system was only visible where roof collapse has occurred and sinkholes formed (refer to SHN report for photographs). In the zero and first order headwaters in Wildcat terrain, relatively narrow pipes a few feet wide and deep were observed. Farther downstream, the dimensions and complexity of the plumbing system increased. Chambers were encountered with dimensions in excess of 10 feet, typically involving flow over and around large old growth stumps and root wads.

In general, the subterranean plumbing system develops within the immense accumulation of old growth logging debris (e.g., slash, logs, stumps, and root wads) left over from the early harvest entries. Concentration of the debris, and subsequent traverse during early tractor logging, results in a new "valley bottom" surface, above the stump/debris complex. This new "surface" has sufficient soil cover to have revegetated with ground cover and young conifer. The streams, however, remain at their natural grades, beneath the debris layer.

Discussions with BLM staff (particularly Sam Flanagan, BLM geologist) familiar with the nearby old-growth headwaters forest indicate that similar subsurface piping is observed in unmanaged forests in Wildcat terrain, although it does not appear as prevalent or as complex as that observed in managed forests in the study area described herein. In unmanaged forests, the subterranean flow appears to occur as woody debris accumulates in stream channels through tree fall and streamside landslides.

Erosion and sediment delivery from roof collapse, unstable sidewalls, and subterranean bank erosion is occurring within the underground plumbing network as evident by accumulations of recent sediment deposition in fans and small terraces where the underground flow daylights.

This type of sedimentation is not accounted for in the Elk River streamside landslide or bank erosion estimates as these are pre-existing in-channel sources (i.e. stored sediment metering through the stream system). However, it is important to acknowledge contributions from this in-channel source relative to observed downstream sediment yield and water quality. It would be exceedingly difficult to obtain accurate estimates of the amount of erosion and sedimentation in the pipe network, as the erosion is occurring in inaccessible locations.

4.2 SURFACE EROSION

Surface erosion is considered to be the wearing away of soils from the land surface by wind or water. For the purposes of the ERSC Watershed Analysis, surface erosion sources are categorized by process/source of origin including: soil creep, harvested areas, legacy skid trails, road surface, road gullies, road crossings, and road fill failures (both pre- and post- treatment).

Table 4-3 and Figure 4-16 through Figure 4-18 present sediment delivery rate by general and specific surface erosion source categories. Overall, surface erosion processes accounted for approximately 35% of the total 2001-2011 sediment source budget.

Each source category, measures used to control sediment delivery from roads, and the results of effectiveness studies for the purpose of assessing these measures, are presented in this section.

Table 4-3. Surface erosion sediment delivery by source (2001-2011) HRC HCP area within the ERSC WAU.

Surface Sediment Source	Sediment Delivered		
	Tons per Year	Tons per Square Mile per Year	Percent of Total
Soil Creep	2,827	80.1	44%
Timber Harvest Surface Erosion (average for 2001-2011)	222	6.3	3%
Road Surface Erosion (average for 2001-2011)	807	22.9	12%
Post HCP-Treated Stream Crossing Washouts and Road Gullies	223	6.3	3%
Pre-HCP Skid Trails	628	17.8	10%
Pre-HCP “Untreated” Roads	1,769	50.0	27%
Total HCP Lands (35.27 square miles)	***6,475***	***183.5***	***100%***

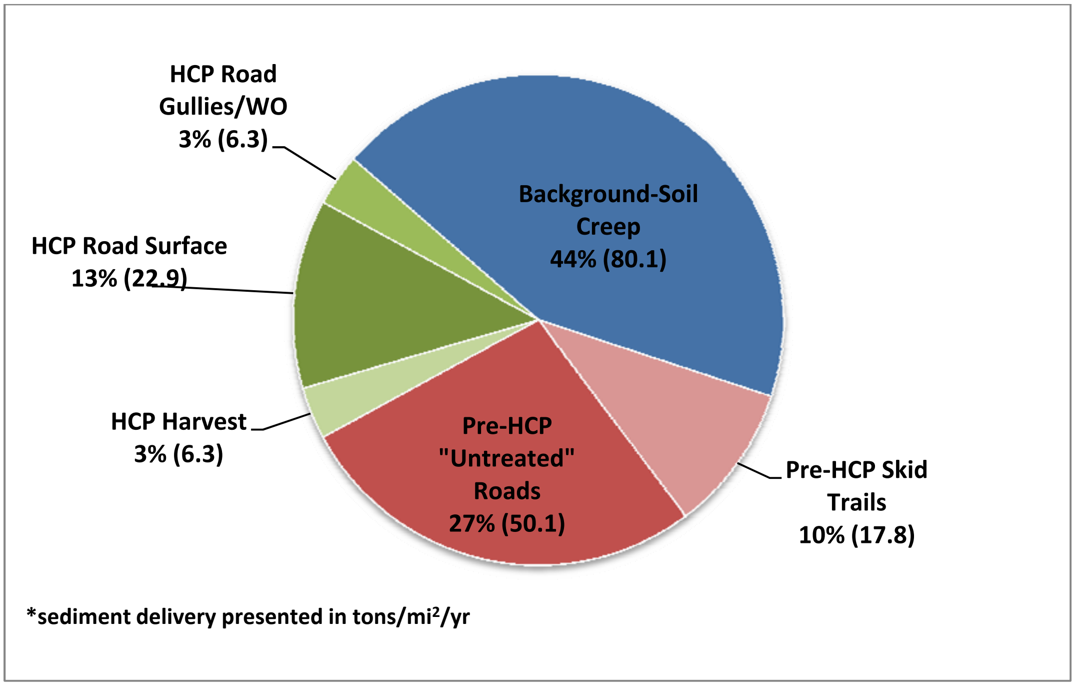


Figure 4-16. ERSC HRC HCP area sources of sediment delivery from surface erosion, 2001-2011.

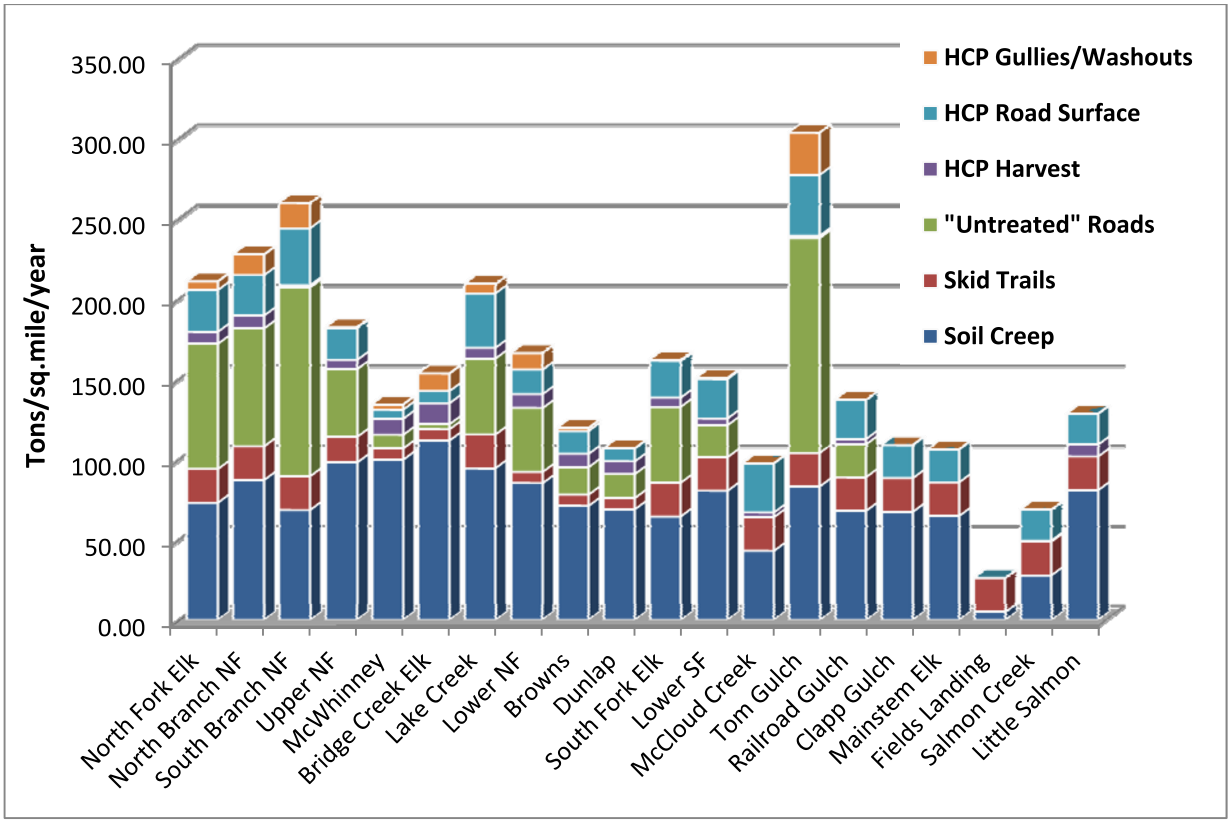


Figure 4-17. ERSC HRC HCP covered lands surface erosion delivery rate sources by sub-basin 2001-2011.

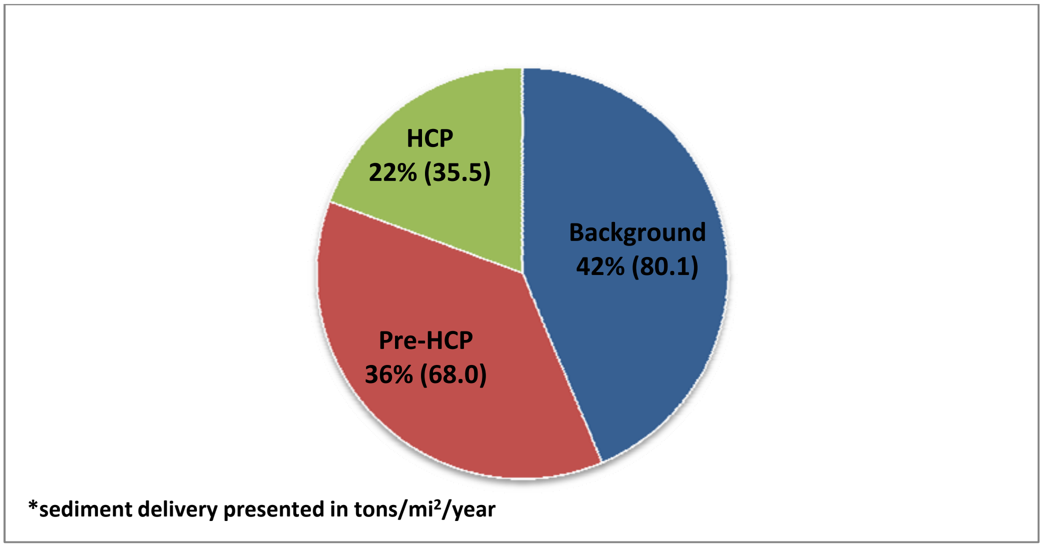


Figure 4-18. Source of sediment delivery from surface erosion ERSC HRC HCP area, 2001-2011.

4.2.1 Soil Creep

Soil creep is defined as the slow, down slope movement of the soil mantle due to gravity. Soil creep rates were calculated with the following formula (WDNR 1997):

ANNUAL SEDIMENT YIELD FROM SOIL CREEP =
LENGTH OF STREAM CHANNEL X 2 BANKS X SOIL DEPTH X SOIL CREEP RATE X SOIL BULK DENSITY

A unit rate for soil creep of 1.5mm/year was used for calculations with a set three (3) foot soil depth and 1.4 tons/yd^3 soil density. The unit rate was determined from an average of soil creep rates used in the initial ERSC Watershed Analysis following a regional scientific review. Soil creep accounted for an estimated 42% of the sediment delivery from surface erosion with a rate of 80.1 tons/mi^2/year. Because of the calculation method, differences between sub-basins throughout the watershed are a result of differences in stream lengths (Figure 4-17 above). Calculations within the initial ERSC Watershed Analysis used varying rates and soil thicknesses based on geology and slope and was estimated to be 129 tons/mi^2/year. The initial WA calculated values for all streams lengths within the watershed (HCP and non-HCP lands) and only calculated soil creep for stream banks not included in the streamside landslide and bank erosion estimates.

4.2.2 Hillslope (Harvest Units)

All timber harvest operations in the ERSC watershed under HRC ownership are subject to the ERSC (ERSC 2005) Watershed Analysis Prescriptions (Appendix 4). These enforceable forestry prescriptions were established as part of the HCP Watershed Analysis process (HCP §6.3.2) in collaboration with state and federal HCP signatory wildlife agencies including CDFW, NMFS, and USFWS. The prescriptions are designed to prevent or minimize sediment delivery to streams through a combination of equipment exclusion zones, harvest restrictions, and other disturbance minimization measures applied adjacent to watercourses.

Some key erosion control elements of the prescriptions include:

- 50- and 30-foot no-harvest zones adjacent Class I and Class II watercourses respectively, substantially minimizing or eliminating ground disturbance within the highest hazard area relative to sediment delivery.
- 150-foot wide riparian management zones (RMZ) adjacent Class I (fish-bearing) watercourses, and a slope-dependent 75- or 100-foot RMZ width adjacent Class II watercourses, within which heavy ground-based skidding equipment use (e.g. tractors, skidders, forwarders, etc.) is excluded with minimal exception, and within which all pre-existing down wood (e.g. trees, logs, limbs) is retained, substantially minimizing ground disturbance within the highest hazard area relative to sediment delivery.

- A slope-dependent 50- or 100-foot RMZ for slopes adjacent and leading to Class III watercourses, within which heavy ground-based skidding equipment use (e.g. tractors, skidders, forwarders, etc.) is excluded with minimal exception, and within which all pre-existing down wood (e.g. trees, logs, limbs) is retained, substantially minimizing ground disturbance within the highest hazard area relative to sediment delivery.
- A multivariate hillslope management plan using a combination of models, landslide hazard maps, field investigation, licensed geologic input, and enforceable WA-based prescriptions for identified high hazard areas including inner gorges and steep streamside slopes, headwall swales, and areas of significant past ground disturbance resulting in local instability.

In addition to these prescriptions, HRC practices uneven-age selection silviculture forestry which maintains and grows mature forest cover. Logging methods include cable and helicopter yarding on moderate to steep slopes, and a mixture of ground-based and cable yarding of down timber on slopes inclined less than 40 percent.

Estimates of sediment delivery rates from surface erosion as a result of ground disturbance during timber harvest activities are categorized as hillslope surface erosion and presented in Table 4-4. These values were calculated by sub-basin using the HRC WEPP model which is explained in the Freshwater Creek Watershed Analysis (PALCO 2003). All management-slope-stream buffer combinations for areas harvested by HRC in the HCP area from 2001 through 2011 were analyzed. All units included in the calculations were harvested under HCP restrictions and therefore all sediment delivery is considered to be HCP harvest related. A delivery rate of 6.3 tons/mi^2/year was estimated to be associated with HCP harvest for 2001-2011. For comparison, the initial ERSC Watershed Analysis used the same methodology and estimated 7.2 tons/mi^2/year of surface erosion from harvest units for the years 1988-2000.

Table 4-4. ERSC HRC HCP area sediment delivery from hillslope surface erosion by sub-basin, 2001-2011.

Sub-basin	HCP Area (mi^2)	Total Sediment Delivery 2001-2011 (Tons)	Annual Avg Sediment Source Delivery (tons/yr)	Annual Avg Sediment Source Delivery ($tons/mi^2/yr$)
North Fork Elk	4.37	359.6	32.7	7.5
North Branch NF	4.00	354.1	32.2	8.0
South Branch NF	1.91	27.5	2.5	1.3
Upper NF	2.57	165.2	15.0	5.8
McWhinney	1.27	139.5	12.7	10.0
Bridge Creek Elk	2.22	319.5	29.0	13.1
Lake Creek	2.13	156.3	14.2	6.7
Lower NF	2.05	195.7	17.8	8.7
Browns	0.90	81.9	7.4	8.3
Dunlap	0.64	56.1	5.1	7.9
NF Elk Sub-watershed Total	***22.0***	***1855.3***	***168.7***	***7.6***
South Fork Elk	5.67	357.7	32.5	5.7
Little South Fork	0.03	0.0	0.0	0.0
Lower SF	1.78	82.7	7.5	4.2
McCloud Creek	0.33	10.5	1.0	2.9
Tom Gulch	1.86	30.3	2.8	1.5
Railroad Gulch	1.12	40.7	3.7	3.3
Clapp Gulch	0.91	0.0	0.0	0.0
Mainstem Elk	0.50	0.0	0.0	0.0
SF Elk Sub-watershed Total	***12.2***	***521.9***	***47.4***	***3.9***
Elk River Watershed Total	***34.2***	***2377.1***	***216.1***	***6.3***
Fields Landing Watershed Total	***0.12***	***0.0***	***0.0***	***0.0***
Salmon Creek	0.10	0.7	0.1	0.7
Little Salmon	0.83	67.5	6.1	7.4
Salmon Creek Watershed	**0.9**	**68.2**	**6.2**	**6.9**
ERSC Total	***35.3***	***2445.3***	***222.3***	***6.3***

4.2.3 Hillslope (Legacy Skid Trails)

Estimates for sediment delivery from legacy skid trails originate from the NCRWQCB draft TMDL. The NCRWQCB used studies conducted primarily or entirely on HRC ownership to arrive at an overall estimate of 21 $tons/mi^2/year$ (15 $yd^3/mi^2/year$) for sub-basins where tractor logging was a prevalent harvesting method (1950s through the 1980s). HRC used this estimate in all sub-basins except for those where tractor logging was not a prevalent yarding method based on historic aerial photo review and field-based forester knowledge of historic land use. In these latter sub-basins, the TMDL rate was adjusted downward by 33%, and in one instance 75% to account for known skid trail frequency. As a result, overall sediment delivery from legacy skid trails is estimated at a rate of 17.8 $tons/mi^2/year$, accounting for approximately 10% of the total surface erosion delivery. This source of sediment is typically associated with historic tractor stream crossings that were not removed, or only partially removed, upon completion of use. Remaining crossing fill in the channel is subject to erosion during high flow events. Eroding remnants of historic skid trails up and down stream channels also fall under this category.

4.2.4 Hillslope (Roads)

HRC maintains an approximate 210 mile road network throughout the ERSC Watershed Assessment area; approximately six (6) miles per square mile (Map 7 and Table 4-5). In addition to this maintained road system, approximately 42 miles of legacy abandoned road in the watershed has been treated for erosion control and decommissioned since 1999.

Surface Erosion is categorized into three sources for sediment delivery from roads:

- Road surface
- Gullies and washouts from untreated roads (non HCP upgraded/stormproofed)
- Gullies and washouts from HCP treated roads

The following sub-sections explain how annual delivery estimates for the sediment budget were calculated by Formation Environmental for each of these sources. Section 4.2.5 then discusses control of these sediment sources including current inventory, best management practices, and effectiveness study results regarding these practices.

Table 4-5. HRC HCP Road conditions within the ERSC WAU 2011.

Sub-basin Name	**HCP Area Road Miles**		**Road Density- Treated Miles/sq. mile**				**Road Density-Untreated Miles/sq. mile**				**Road Density[1] Miles/sq. mile**
	Treated	***Untreated***	***Paved***	***Gravel***	***Native "Dirt"***	***Decom***	***Paved***	***Gravel***	***Native "Dirt"***	***Legacy/ aband***	***Total***
North Fork Elk	26.55	4.54	0.00	4.50	0.60	0.98	0.00	0.24	0.80	0.00	6.14
North Branch NF Elk	21.57	4.11	0.00	2.51	1.71	1.17	0.00	0.15	0.88	0.00	5.25
South Branch NF Elk	11.60	2.47	0.00	3.05	0.08	2.93	0.00	0.14	1.14	0.00	4.42
Upper North Fork Elk	11.47	3.92	0.00	2.47	1.03	0.97	0.00	0.41	1.11	0.00	5.03
McWhinney Creek	6.79	1.17	0.00	3.97	1.01	0.39	0.00	0.71	0.22	0.00	5.90
Bridge Creek	11.93	1.79	0.00	4.20	1.18	0.00	0.00	0.48	0.33	0.00	6.18
Lake Creek	10.45	7.83	0.00	2.04	2.07	0.80	0.00	0.01	3.30	0.38	7.79
Lower NF Elk	11.44	4.03	0.98	2.05	2.36	0.20	0.01	0.26	1.40	0.29	7.36
Browns Gulch	6.24	2.15	0.06	4.43	0.71	1.76	0.00	0.15	2.11	0.14	7.61
Dunlap Gulch	3.66	1.79	0.05	3.20	1.51	0.92	0.00	1.33	1.46	0.00	7.55
NF Elk Sub-watershed Total	***121.69***	***33.80***	***0.09***	***3.21***	***1.22***	***0.99***	***0.00***	***0.29***	***1.17***	***0.07***	***6.06***
South Fork Elk	32.50	9.65	0.00	1.79	2.77	1.18	0.00	0.75	0.96	0.00	6.26
Little South Fork Elk	0.26	0.03	0.00	0.00	7.61	1.79	0.00	0.00	1.07	0.00	8.67
Lower South Fork Elk	3.65	7.94	0.00	0.63	1.42	0.01	0.00	0.25	4.21	0.00	6.52
McCloud Creek	0.59	1.62	0.00	0.00	0.00	1.79	0.00	0.00	4.94	0.00	4.94
Tom Gulch	12.99	3.21	0.00	0.49	2.87	3.63	0.00	0.00	1.73	0.00	5.09
Railroad Gulch	7.68	2.56	0.00	1.01	2.66	3.22	0.00	0.00	2.30	0.00	5.96
Clapp Gulch	3.93	4.83	0.00	0.17	1.67	2.49	0.00	0.00	5.32	0.00	7.15
Mainstem Elk	2.22	2.47	0.00	0.00	4.43	0.00	0.00	0.00	4.94	0.00	9.37
SF Elk Sub-watershed Total	***63.82***	***32.31***	***0.00***	***1.11***	***2.50***	***1.64***	***0.00***	***0.38***	***2.27***	***0.00***	***6.26***
Elk River Watershed Total	***185.51***	***66.12***	***0.06***	***2.46***	***1.68***	***1.22***	***0.00***	***0.33***	***1.56***	***0.04***	***6.13***
Fields Landing Watershed Total	***0.11***	***0.72***	***0.00***	***0.00***	***0.93***	***0.00***	***0.00***	***0.00***	***6.03***	***0.00***	***6.97***
Salmon Creek	0.12	0.64	0.00	0.00	0.00	1.20	0.00	0.00	6.70	0.00	7.90
Little Salmon Creek	0.04	7.07	0.00	0.00	0.00	0.05	0.00	3.64	4.90	0.00	8.59
Salmon Creek Watershed Total	***0.16***	***7.71***	***0.00***	***0.00***	***0.00***	***0.17***	***0.00***	***3.26***	***5.09***	***0.00***	***8.51***

[1] Total road density does not include roads decommissioned to stormproofed standards

4.2.4.1 Road Surface

Sediment delivery as a result of road surface erosion was estimated using analysis from SEDMODL2 with inputs from HRC road inventory data adjusted for updated traffic factors developed by Dr. Kate Sullivan reflecting HCP wet weather road use restrictions applied to all roads (Sullivan 2011: *Sediment Production from Stormproofed Roads on Humboldt Redwood Company Lands*). SEDMODL2 is a GIS application based on an empirical model developed by the Washington Department of Natural Resources used throughout the Pacific Northwest. It uses the following equation:

TOTAL SEDIMENT DELIVERED = TREAD + CUTSLOPE, WHERE:

> ***TREAD = GEOLOGIC EROSION RATE × TREAD SURFACING FACTOR × <u>TRAFFIC FACTOR</u> × SEGMENT LENGTH × ROAD WIDTH × ROAD SLOPE FACTOR × PRECIPITATION FACTOR × DELIVERY FACTOR***
>
> ***CUTSLOPE = GEOLOGIC EROSION RATE × CUTSLOPE COVER FACTOR × SEGMENT LENGTH × CUTSLOPE HEIGHT × DELIVERY FACTOR***

The following revised traffic factors developed by Sullivan et al (2011) were used:

- Heavy traffic/active mainline (main haul): 0.04
- Moderate traffic/active secondary (primary): 0.05
- Light traffic/not active (secondary, spur): 0.01
- No traffic/abandoned (abandoned): 0.1

A full explanation of SEDMODL2 and post model data adjustments is included in the methods for Watershed Analysis (PALCO 2000).

Sediment delivery rates from road surfaces (2001 through 2011) were estimated to be approximately 22.9 tons/mi^2/year (12.7% of all surface erosion) for HCP managed roads. The initial ERSC Watershed Analysis estimated a rate of 38 tons/mi^2/year based on similar SEDMODL calculations but without the benefit of HCP traffic factor adjustments.

Three sub-basins stand out as having higher road surface erosion relative to other sub-basins. Tom Gulch had the highest road surface erosion delivery rate (37.9 tons/mi^2/year) due to geology, overall road density, length and density of untreated abandoned dirt roads, delivery from abandoned dirt roads, delivery factors (more road lengths closer to or with stream crossings), and higher number of cutslopes. South Branch North Fork Elk River and Lake Creek also had relatively high rates for some of the same reasons. Cutslope sediment delivery estimates were generally larger than tread erosion for all sub-basins, and these three sub-basins typically had the highest cutslope erosion delivery rates (per unit area).

4.2.4.2 Untreated Roads

An annual sediment delivery estimate from untreated roads (i.e. roads not yet upgraded to HCP stormproofed standards), resulting from gullies and washouts of fill and/or cutbanks, including watercourse crossing failures, was calculated using the 1998-2003 ***management discharge site*** rate provided in the NCRWQCB's Draft TMDL for Upper Elk River (Peer Review Draft – Table 4.32). This rate (55 tons/ mi^2/year) was used by the NCRWQCB to adjust estimates of future yield from inventoried road-related sediment sources to correspond with actual past yield rates. The TMDL rate was applied without adjustment for the period of 2001-2005, and then reduced for the subsequent period of 2006-2011 to account for the treatment (erosion control) of sites implemented during the first period. The reduction in rate corresponded directly with the amount/percentage of future delivery controlled by treatment during the first period analyzed (2001-2005). An annual sediment delivery rate of 50 tons/mi^2/year for the entire sediment budget period was calculated as the weighted average of the tons/year for each period (2001-2005, 2006-2011), and assumes both periods had failure-triggering events (i.e. 2003 and 2006).

This method for estimating annual delivery rate is somewhat crude as it relies on estimates of future sediment delivery (which are inherently uncertain) made during the initial road inventories, most of which were conducted over a decade ago. Thus, confidence is low in the precision of annual delivery rate estimates. However being based upon actual field inventories, the approach does provide for a generally accurate representation of relative sub-basin delivery.

Individual sub-basin estimates were calculated as follows: For each period, the percentage of future yield for each sub-basin (based on spatially explicit field inventories) relative to the watershed total was calculated. The tons/year for each sub-basin was then calculated, for each period, based on the tons/year previously calculated for the entire watershed multiplied by the individual percentage (yield) for each sub-basin.

Based on the field inventories of future delivery, approximately 60 percent (30 tons/mi^2/year) of the estimated annual delivery originated directly from failing watercourse crossings including legacy culverts, log-fill, and fords. ***Tom Gulch and South Branch North Fork Elk River had the highest rates of sediment delivery from pre-HCP untreated roads with 134 tons/mi^2/year and 118 tons/mi^2/year respectively.*** Both sub-basins had older, extensive, poorly constructed road systems including mainline haul roads located parallel to Class I streams and a relatively high number of mid-slope stream crossings. Both sub-basins have also experienced significant HCP stormproofing and road decommissioning in recent years to address this situation. The effectiveness of these treatments in the Tom Gulch sub-basin is discussed in detail further on in this section.

Comparing pre-HCP untreated road sediment delivery from the current sediment budget (2001-2011) to the previous budget (1988-2001) is infeasible due to a significant difference in methods. The initial ERSC Watershed Analysis “road gullies/washouts” volumes were estimated from road inventories on North and South Fork Elk River referred to as “light” inventories which accounted only for estimated past volume delivery, not potential future yield, as provided for in the subsequent more thorough road inventories referenced for the current sediment budget. It is also difficult to discern if the same breadth of road-related sources were accounted for in the initial analysis as in the current analysis.

4.2.4.3 Post-HCP Treated Road Gullies and Washouts

HRC monitors road construction and reconstruction practices closely. This is accomplished through a formal annual road auditing and inspection program which tracks performance and evaluates effectiveness. The program is patterned after the U.S. Forest Service Best Management Practice Evaluation Program (BMPEP) as required by the HCP and is similar to the approach used by CAL-FIRE for assessing the effectiveness of forest practice rules in Cafferata and Munn (2002).

For the purpose of sediment budget estimates, post-treatment delivery has been quantified from discharge notifications submitted by HRC to the NCRWQCB discovered during these road inspections and other general field visits. Estimated delivery from these sources occurred at a rate of 6.3 tons/mi^2/year and accounted for about 3% of all surface erosion from 2001-2011. Tom Gulch and South Branch North Fork Elk River stood out as having relatively higher rates than other watersheds. This is likely due to the abundance of sites worked on within these sub-basins as well as significant post-treatment adjustment at several very large work sites as described in detail in section 0.

Confidence in delivery estimates for this source is moderate to high as the inventories from which rates originate are current and based on actual observed delivery.

4.2.5 Control of Sediment from Roads

4.2.5.1 HCP Stormproofing, upgrading, and road use restrictions

Upgrading and stormproofing are HCP terms for proactively reducing road-related sediment delivery by disconnecting roads from the stream system through the installation of additional cross drains, removing or stabilizing unstable fills, replacing failing or undersized culverts with culverts and bridges sized to accommodate 100-year flood events, rocking or otherwise treating hydrologically-connected native road surfaces, and in some instances decommissioning roads altogether. *As of 2011, HRC has storm-proofed and upgraded 185.5 miles (75%) of the 251.6 mile Elk River road system.* Approximately 42 miles of this treated road amount has involved the decommissioning (i.e. removal from the contemporary road system) of legacy logging roads. Results from effectiveness studies, discussed further on in this report, have found storm-proofing and decommissioning moderately to highly successful in the control of once chronic sediment sources; however there have been notable exceptions, and consequently lessons learned (see section 4.2.5.4).

In addition to storm-proofing, road use restrictions are implemented across HRC property. HCP §6.3.3.6 describes conditions under which various types of road use – from log hauling to light vehicle use – is permitted during the wet weather period (October 15 – May 1). Roads are required to meet and be maintained to a specific "permanent" standard designed to minimize sediment delivery if log hauling is to occur during dry periods of the wet weather period. Log hauling is typically prohibited during and immediately following periods of measureable precipitation until a HRC forester inspects the condition of the road surface, and gives the "green light" to resume.

HCP §6.3.3.5 outlines road inspection requirements to be conducted to ensure road maintenance needs are identified on an annual basis and in response to large storm events. These include an annual (April – October) road system inspection conducted for the purpose of identifying maintenance needs, as well as preventative winter season storm-triggered inspections following 3 inches or more of precipitation within a 24-hour period.

4.2.5.2 Road Related Sediment Source Inventory

As mentioned previously, HRC maintains an inventory of road-related sediment sources across its ownership including the Elk River/Salmon Creek WAU. Two watershed-wide road system inventories (PWA 1998, North Fork Elk; PWA 2006, South Fork Elk and mainstem) conducted in conformance with HCP §6.3.3.1 are at the cornerstone of this inventory for Elk River, with newly developed sediment sites added to the database as they are found via routine road inspections, monitoring activities, and during THP development. This inventory serves as the basis for prioritizing and scheduling road upgrading and storm-proofing activities and tracking progress towards watershed restoration goals as roadwork system improvements are completed.

One hundred eighty six miles of the 260 mile combined Elk River/Salmon Creek (ERSC) road system have been upgraded and/or stormproofed since 1997 resulting in the prevention or removal of an estimated 326,900 cubic yards of sediment from entering the ERSC stream system.

According to HCP requirements (§6.3.3.2), and formal order from the NCRWQCB (Cleanup and Abatement Orders R1- 20040028 and R1-2006-0055), HRC (as had its predecessor, PALCO) has prioritized remediation of the worst sites first, i.e., those most likely to fail or deliver the greatest volume of sediment to waters and specifically to fish-bearing streams. A five year goal to complete 80 of the top 100 environmentally highest ranked sites (in terms of active or potential sediment delivery combined with biological impact considerations) was established in 2007 as a requirement of the NF and SF Elk River CAOs. HRC achieved this requirement, and continues to remediate treatable sediment sources according to HCP requirements and company restoration forestry policy as stated in the HRC Management Plan (http://www.mrc.com/plans-reports/management-plan/). Figure 4-19 and Figure 4-20 present the progress of sediment source remediation in the NF Elk and SF Elk watersheds from 1997 through 2012. The volumes presented in these figures are for completed road sites and do not include off-road sources or road sites designated for "no treatment." "No treatment" designation is provided for sites where environmental disturbance related to accessing and treating the site is likely to have a greater adverse impact on watershed values (e.g. sediment, temperature, habitat) than the potential benefits gained by treatment.

As of 2012, the current inventory of road-related sediment sources identified for future treatment is estimated at 31,397 cubic yards. Figure 4-21 shows the spatial distribution of these 151 sediment sources by sub-basin.

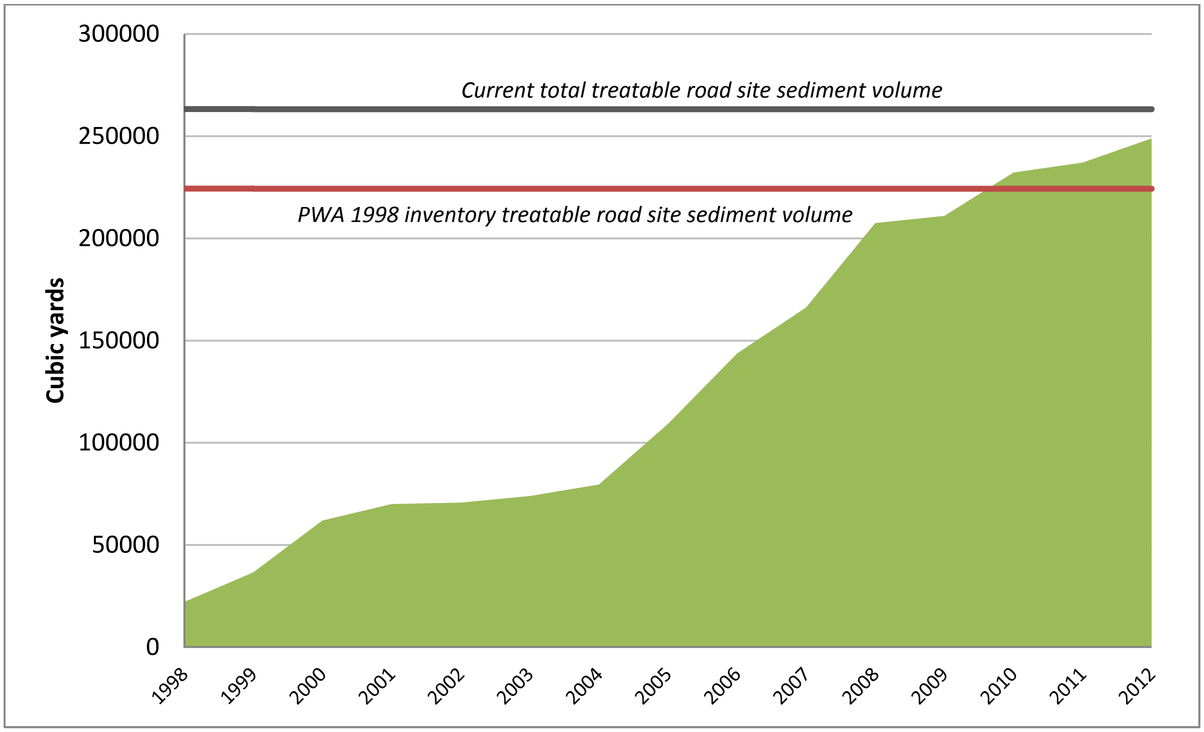


Figure 4-19. North Fork Elk River HRC HCP area road-related sediment delivery volume controlled 1998-2012.

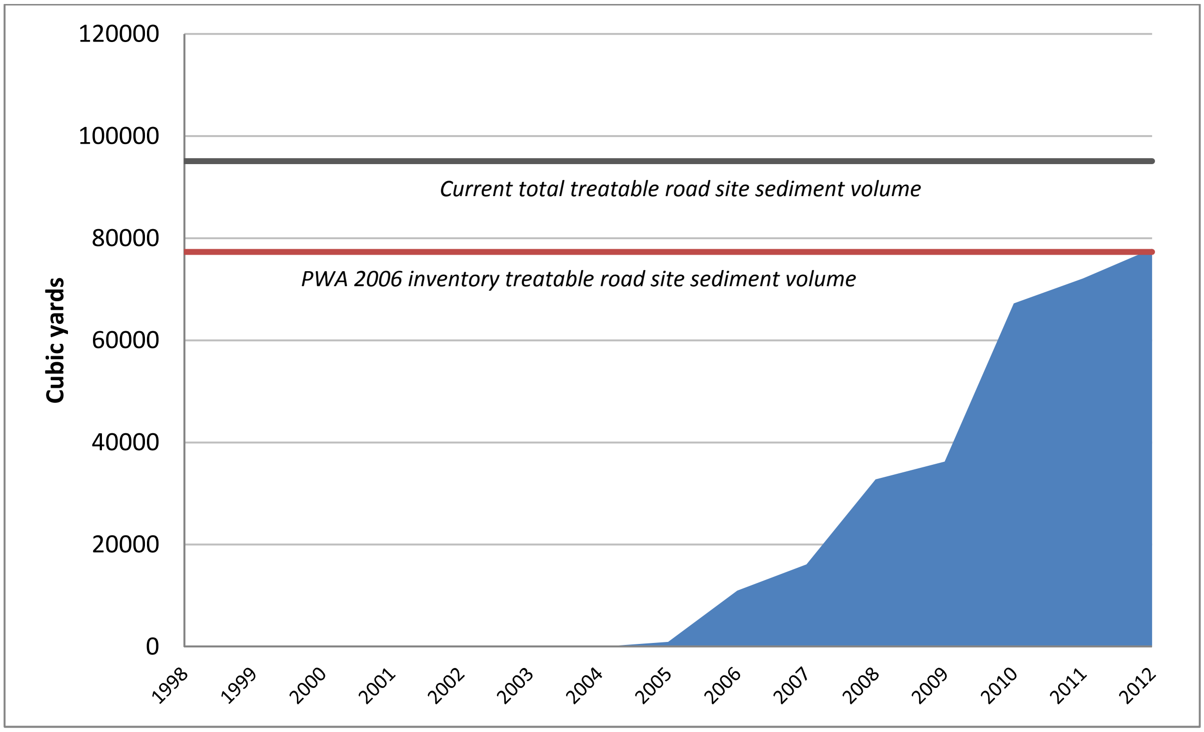


Figure 4-20. South Fork Elk River HRC HCP area road-related sediment delivery volume controlled 1998-2012.

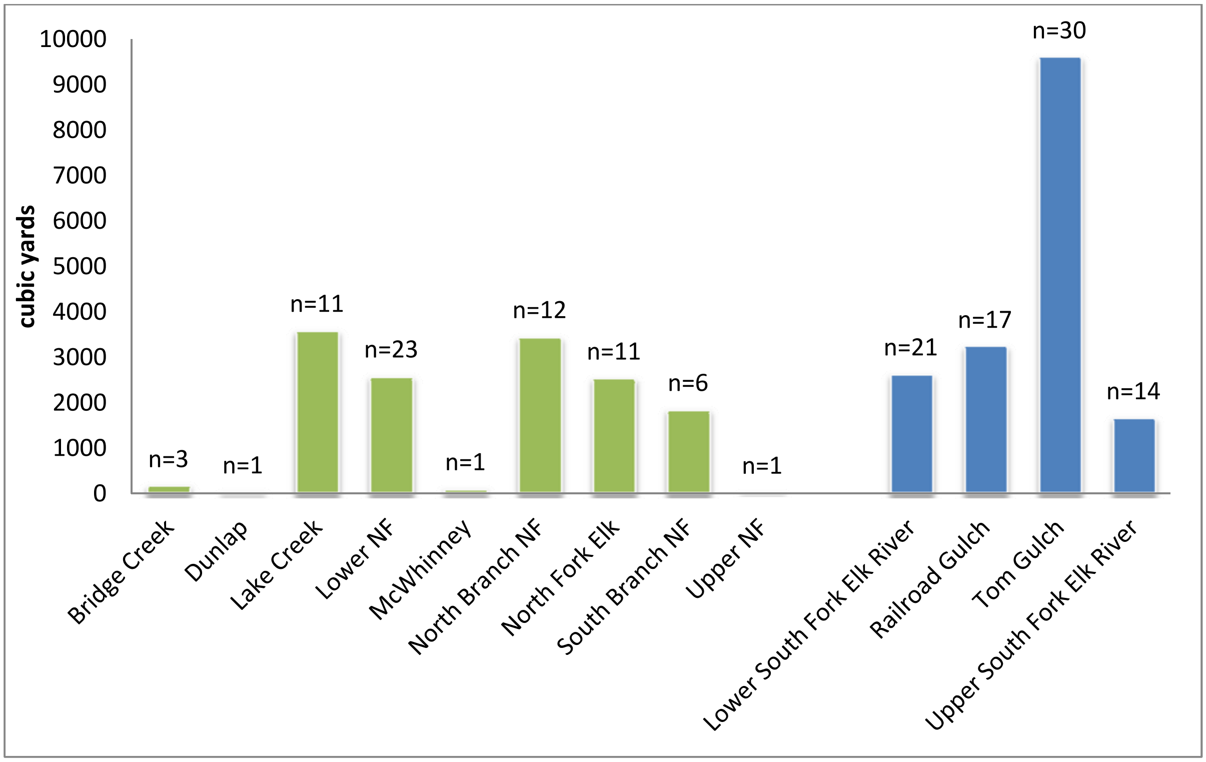


Figure 4-21. Estimated future Elk River HRC HCP road-related sediment yield to stream pending treatment (volume and number of sites by sub-basin).

4.2.5.3 Effectiveness Studies - Control of Sediment from Roads

HRC, and its predecessor, have undertaken several scientific studies over the last decade in order to better understand the effectiveness of HCP storm-proofing and wet weather restriction practices in preventing storm-triggered sediment delivery from roads. Two of these studies, designed and implemented under the supervision of Dr. Kate Sullivan, are summarized below and presented fully in appendices.

Sediment Production from Stormproofed Roads on HRC Lands (HRC 2011), (Appendix 7)

Objectives of this study were to quantify the amount of sediment generated from HRC storm-proofed roads, determine the effect of vehicle use on sediment generation from different road surfaces, quantify the erosion rates from road surfaces managed according to HCP guidelines, and determine road locations and lengths that deliver sediment to streams. Combined, data from this study was used to validate sediment models and assumptions, mainly SEMODL and SEDMODL2.

All road segments measured during this study represented common road conditions found on the property. Sites were primarily in the wildcat geology located in the Freshwater and Elk River watersheds. The study methods produced highly repeatable results among sites and years. Study results have implications for a number of the HCP strategies including the effectiveness of wet weather hauling restrictions, road surfacing and construction, hydrologic disconnection at stream crossings, road sediment modeling, and sediment budgets.

Key findings from this report included:

- Sediment load produced during events was primarily related to total rainfall amount and runoff volume.
- Sediment concentration during storms followed a “supply-limited” pattern as observed in previous studies such as Bilby et al. (1989) and Reid and Dunne (1984). Sediment concentration was highest at the initiation of runoff and declined sharply in the first hours of a rainfall event as sediment washed from the road surface. There was no relationship between discharge rate (Q, mL/s) and suspended sediment concentration (mg/L) at any site.
- The effects of traffic before and/or during events were low but detectable at a few of the road segments. At others traffic effects could not be detected despite very heavy traffic.
- The annual total sediment yield from rocked road segments was very low compared to previous studies and compared to SEDMODL estimates. Situations that appeared to lead to higher sediment yields included not fully stabilized cutslopes, very steep gradients, pit-run rocked surfaces with log truck traffic, and new construction.
- The relevance and importance of parameters used in the WDNR model and SEDMODL, including total precipitation, erosion, traffic levels, vegetative cover density, surfacing material, and time since construction were validated in this study. The baseline erosion rate based on geology provided in the WDNR manual was consistent with observed within the context of model application, based on sediment measured from native surface roads.

- Both the WDNR (SEDMODL) and WEPP models significantly over-predict sediment relative to observed on HRC roads managed with HCP road management strategies.
- The traffic factor applied to heavily used mainline roads (log truck traffic) based on regional studies was originally 20 times greater than a base condition of light pickup use only. Changing the factor to just 0.04 times the base rate correctly models sediment for all mainline road segments. This essentially eliminates the traffic effect as a factor influencing sediment yield on roads managed with HCP construction and use standards.

This study was primarily designed to determine erosion rates for use in sediment budgeting. However, the study also directly assessed the effectiveness of some of the road management practices implemented under the HCP to minimize sediment generation, and results had implications for others. These further findings include:

- The very low sediment yields observed from heavily used roads confirmed the effectiveness of the wet weather hauling restrictions. Erosion rates were at least 10 times lower than observed in other similar studies in the coastal regions of the Pacific Northwest dominated by rainfall precipitation (e.g. Bilby et al. 1989).
- The lowest sediment yields were observed on road surfaces rocked with the most durable material. Strategic use of the best rock on the locations with the greatest potential for delivery of road surface runoff to streams, such as within the hydrologically connected segments, would further minimize sediment delivery.
- As expected, erosion rates were significantly higher on dirt roads. HCP requirements to hydrologically disconnect and effectively manage surface runoff, and rigid adherence to seasonal restrictions prevent/minimize discharge for native surfaced roads.
- Sediment yields were higher on newly constructed roads for the first year after construction. Yield declined to low levels the year following. Scheduling construction a year prior to use for log hauling would enable the road to harden and help minimize sediment input.
- Several study segments had cutslope issues that affected sediment yield. Incomplete vegetative cover resulted in visibly active erosion on one secondary road, illustrating the importance of achieving proper cutslope stability and vegetative cover.
- Allowing ditches to vegetate appears to have also helped minimize the sediment generated with road and ditch runoff on heavily used road segments.
- The low road erosion rates observed in this study have significant implications for sediment budgeting in HRC watersheds. Road surface sediment models were adjusted for the ERSC Watershed Analysis Revisit based on some of the results of this study.

Effectiveness of Road Construction Practices in Preventing Sediment Delivery: Monitoring Report for 2006 to 2010 (HRC 2012) (Appendix 5)

In 2005, HRC implemented a road auditing and inspection program to track performance and evaluate effectiveness of road projects at minimizing road-related sediment delivery to streams. This program is patterned after the U.S. Forest Service Best Management Practice Evaluation Program (BMPEP) as required by the HCP (§6.3.5.1.3).

The objective of the road construction/deconstruction specifications is to produce a road that is "storm-proofed," meaning it is capable of weathering all storms including large magnitude, infrequent events (defined as the 100-year storm) with little to no damage to water crossings and minimum sediment delivery. The HRC road monitoring program evaluates the effectiveness of stormproofing specifications in minimizing sediment delivery to streams. Field inspections center on stream crossings and their contributing road segments during and subsequent to occasions when roads are vulnerable to erosion. Data collection is done in the form of an implementation audit immediately following construction, wet weather and post wet weather inspections, and erosion void monitoring.

Key findings from this report include:

- Post-construction sediment delivery volumes were found to have declined greatly from previous findings and substantially lower than reported from elsewhere in the region. Zero or small volumes (< 1yd^3) of sediment were delivered following construction at 71% of crossings. Delivery was less than 10 yd3 at 90% of sites.
- Each year, a few sites had large volumes of erosion. A number of these have been investigated to determine how to prevent such erosion in the future. Taking the population as a whole, generally about 0.6% of the sediment "saved" (i.e. removed or stabilized) each year by stormproofing projects delivers to the stream.
- HRC project design implementation rates are high. Despite the conservative decision rule used during the audit process in determining non-conformance, most aspects of road design are in conformance 90 to 100% of the time at the component level with even higher rates, when possible, at the subcomponent level.
- Less than half of audit non-conformances resulted in "problems" observed on the roads in the following winter. Further, not all problems led to erosion and not all erosion sites delivered sediment to streams. Out of the small number of sites failing one or more specifications, only about 15% eventually delivered sediment to streams. These results were taken under consideration and improvements were made to the audit process; specifically, to enable distinction between minor and major deviations to specifications in the future, such that a minor specification non-conformance does not necessarily mean the entire site fails to meet conformance to specifications.

Overall, the HRC road auditing and inspection plan has shown that road work is being done effectively to minimize sediment delivery to watercourses. When activities do result in sediment discharge, HRC can identify why it occurred and adaptively manage future potentially similar situations. Examples of this are presented in special cases to follow.

4.2.5.4 Control of Sediment from Roads - Special Cases

The road monitoring program (Roads BMPEP) has so far identified two situations where standard road construction/deconstruction practices have been less reliable in preventing erosion. These are fully discussed in the Appendix 5 BMPEP Report and summarized below. Differences in post-activity erosion in these locations were apparent almost the moment projects began. These cases have unique problems that appear to be confined to mapped geologic locations. HRC continues to adapt practices in these situations following exploration of the nature of the observed problems and trial and error experiments to reduce erosion impacts.

Tom Gulch

Tom Gulch is a sub-basin of the South Fork Elk River located on the western side of the watershed and is mapped wholly within the Wildcat geologic formation. This sub-basin is also near the mapped transition to the highly erodible Hookton formation that dominates the hilly topography of the lower and western portion of Elk River from about Railroad Gulch to Humboldt Bay.

Streamflow and subsurface water behaves differently in Tom Gulch than other sub-basins in Elk River and Freshwater Creek. Based on analysis of stream hydrographs from all 22 HRC sites in the area, Sayama et al. (2011) attribute this hydrologic uniqueness to the permeability of the bedrock and larger ex-filtration zones related to the relatively low relief of the sub-basin. These authors concluded that groundwater readily seeps between soils and an active bedrock zone within lower topography areas such as Tom Gulch, creating greater saturation near the stream zone. Storm rainfall creates quick lateral saturated subsurface flow through connection between the soil water and streamflow. HRC geologists investigating the erosion problems at the road construction sites independently zeroed in on unusual subsurface hydrologic behavior as a causative factor. This hydrologic condition is inherent in the watershed topography/geology but may have been exacerbated by the extensive skid trail network that has altered the natural hydrology of the area with channel filling as practiced 40 years ago when existing roads and skid trails were built.

Road upgrading and decommissioning has been active in Tom Gulch since 2006. Forty (40) sites have been upgraded and 33 sites have been decommissioned since 2006 within this sub-basin. These were chosen as priority sites based on an environmental ranking. Inspections and studies showed that sites with larger erosion volumes occurred more frequently in Tom Gulch and were larger than more typical sites elsewhere. The proportion of delivery volumes in the 1 – 5 and 6 – 50 cubic yard volume categories in Tom Gulch were twice those of standard closed and upgraded crossings. Sediment delivery increased through the monitoring period and also increased with storm size and size of project. Decommissioned sites in Tom Gulch were significantly responsive to storm size.

Discussions regarding construction/deconstruction techniques and scheduling of Tom Gulch projects has been ongoing since 2006. Given the lessons learned and the sensitivity of the watershed, HRC has developed the following strategies:

- Avoid standard decommissioning of pulling back to 2:1 from top to bottom.
- Preference is given to upgrading roads rather than decommissioning, and minimizing excavations.
- Recognize current site-specific conditions and propose construction techniques to mimic those conditions. For example sink holes may be evidence of subsurface channels. Backfilling the sink hole with rock and mimicking the current condition is preferred.
- Consider rate of treatment. More adjustment is expected in this sub-basin which already has the highest rates of suspended sediment concentration among in-channel monitored streams in the Elk River watershed. Road restoration work should be spread out over time, allowing recent work to stabilize before attempting additional work.
- Consider “no treatment” as an option for well-vegetated sites on roads no longer needed for management activities.
- Slash pack skid trails and crossings. Slash not only slows surface water and reduces impact, but also retains water, releasing back into the soil over time, rather than just during the rain event.

Lake Creek Road Closure - the “Big Dig”

In 2010, HRC removed eight (8) stream crossings as part of a mid-slope road decommissioning project in Lake Creek, a tributary to the NF Elk River. These crossings involved substantial amounts of fill and large wood (massive Humboldt crossings) placed in stream channels underlain by the Wildcat geologic formation. To give a sense of size – one site had as much as 40 feet of overburden associated with historic landing and road construction, and ultimately 80,000 cubic yards of fill material was removed from this site alone.

HRC followed the standard operating paradigm of 2010 as required in the HCP, removing all man-made fills at these large Humboldt crossings. Challenges posed by these projects were significant. It was necessary to excavate and remove large volumes of soil and mature vegetation and re-contour the slopes to a natural topography at the landscape scale. The soils were so deep and the bedrock geology so incompetent (unconsolidated) that a natural hard bedrock surface could not be found anywhere within the excavation; whereas "soil pipes" on the other hand were encountered throughout. Class II channels were created through hundreds of feet of relatively steep topography, and tributaries joined in the middle of the excavation area. Although these channels were trained with large logs and debris, excavating crossings of this size and complexity created long, steep-gradient channels flanked by steeply inclined banks prone to erosion and downcutting.

These sites were originally inventoried as several thousand cubic yard excavations and looked like the upper photographs in Figure 4-22. The chronology of excavation at one of the eight (8) sites is shown in this figure and Figure 4-23. Significant bank exposure lent itself to slope stability problems due to lack of reinforcing roots and locally over steepened slopes.

Overall there was a net loss after the winter rains of about 2% of the volume of sediment saved based on HRC's tracking of excavation volumes. The eight sites varied in erosion volumes but all were relatively large compared to typical sites. All of the Big Dig sites delivered more than 20 cubic yards individually, with a measured average of 269.33 cubic yards combined (median = 32.25). Erosion came in many forms, but channel-adjacent slope failure/sloughing and channel incision/downcutting were the dominant processes/sources.

These were projects with little precedent on timberlands due to their size and underlying geology. The principles that are the basis for specifications for closing roads and decommissioning crossings were applied (i.e. excavate to natural channel gradient and topographic slopes). In this case, the scope and scale of these excavations required a great deal of onsite supervision and experimentation, and a geologist was onsite to supervise the excavation through its entirety. Future planning for erosion control of larger sites such as these should consider the following:

- Placing less emphasis on removal of fill and recovery of natural channel bottom and focusing on how best to control erosion and sediment delivery through establishment of an engineered channel with appropriate grade control and adjacent bank height and inclination. This will likely yield less potential for post-treatment adjustment (sediment delivery). This reduction in excavation volume and overall footprint reduces the area where erosive soil pipes can develop or be exposed, and limits the aerial extent of disturbance outside of the channel available for bank erosion and sloughing from further up slope prior to vegetation re-establishment.

- Analysis should be made regarding stream power and its potential to move uncontrolled sediment (e.g. grade control).

- Limiting excavation of top fill to a point where stable large logs are encountered and then back fill with rock.

- Rate of restoration and its impact on downstream resources. In this case, Lake Creek and the North Fork Elk River are sensitive to sediment inputs due to downstream concerns over aggradation and flooding, and even though there was a small rate of adjustment relative to the volume of sediment removed, the amount of sediment delivered was significant. Projects of this scope may need to be reassessed to determine whether long-term decrease in potential delivery outweighs potential for near-term post-treatment adjustment when concerns over receiving water sediment loading are immediate in nature.

Figure 4-22. Time sequenced photographs of the excavation of the "Big Dig" site.

Figure 4-23. Photograph of Big Dig site in North Fork Elk the summer following site deconstruction.

5 RIPARIAN FUNCTION

Riparian function can be defined as the interaction of various hydrologic, geomorphic, and biotic processes within the riparian environment (WDNR 1997). Riparian areas are transition zones between terrestrial and aquatic ecosystems and provide important functions for stream ecology, including temperature regulation and input of large woody debris, organic matter and nutrients (Gregory, Lamberti et al. 1987; Figure 5-1). Riparian forests both affect and can be affected by the active stream channel as well as by geologic and topographic features. Riparian forests influence stream channel complexity, bank cohesion, fish and wildlife habitat, thermal regulation of stream temperature and riparian microclimate, and support the aquatic and terrestrial food web in the form of insect and organic matter.

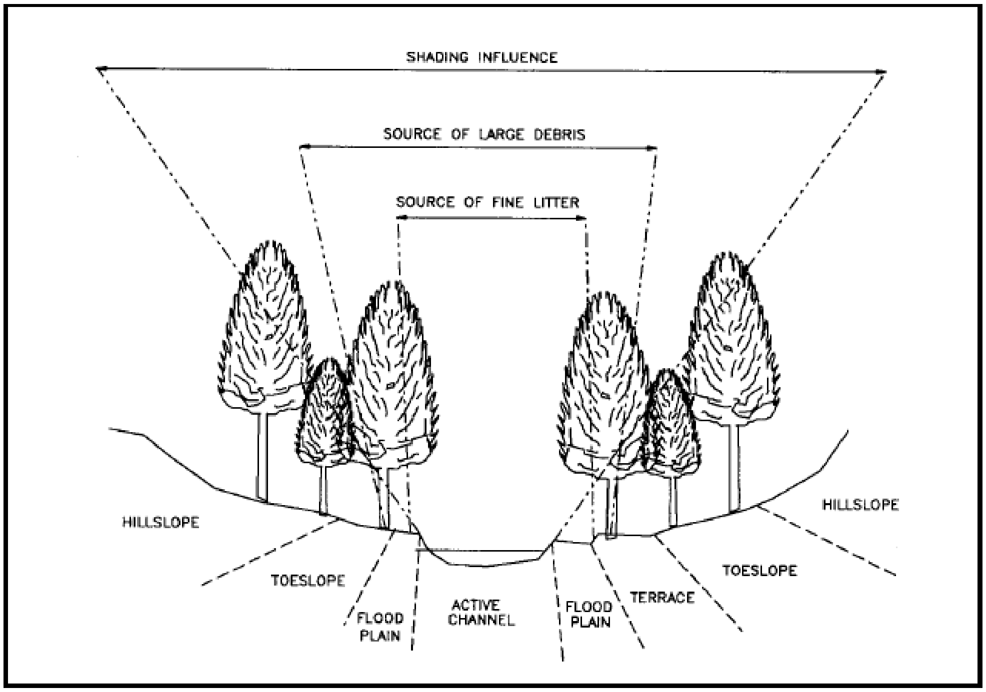


Figure 5-1. Diagrammatic representation of functional roles of riparian zones (Lanberti and Gregory 1989).

These processes may be lost or degraded as riparian vegetation is altered in size, density, or species composition (USDA 1995). Loss of riparian vegetation can also have detrimental effects on bank stability as root strength is lost or diminished.

5.1 CURRENT CONDITIONS

Coast redwood trees are the dominant conifer species within the riparian zones of the ERSC watersheds. Other conifer species including Douglas-fir, Sitka spruce, western hemlock, and red cedar are also present. Hardwood species including red alder, over six sub-species of willow, and big leaf maple occur immediately adjacent and on flood plains of larger streams. The initial ERSC Watershed Analysis found that riparian stands in the Upper Elk River watershed region were comprised of mainly large and medium sized conifer and mixed stands whereas the lower watershed region was dominated by young hardwood and mixed riparian stands. Many of these lower stands also included scattered large conifers in the overstory. Throughout the rest of the watershed, dense stands dominated by medium sized conifers made up the highest percentage of any stand type in the riparian areas (46 percent of the total stream length). Stands of small conifers or mixed regeneration were present in approximately 25 percent of the riparian areas. No information has been collected to update the known stand conditions, however given the harvest restrictions and time passed it is reasonable to assume that trees within the riparian zone are now larger and stands are denser than found to be in initial surveys.

5.2 CURRENT PRESCRIPTIONS

5.2.1 Harvest Prescriptions

All Class I watercourses on the HRC HCP covered lands within the ERSC WAU have a Riparian Management Zone (RMZ) divided into an inner and outer band. Because the initial Watershed Analysis found the Lower North Fork Elk River riparian area to be less stocked with large conifers, a more restrictive single-band 150-foot no-harvest RMZ prescription combined with a Riparian Forest Enhancement Plan was implemented along a specified 8-mile reach extending from the lower property boundary upstream to the confluence with Bridge Creek. All other Class I RMZs on HCP covered lands have a 150-foot RMZ width divided into a no-harvest inner band of 0 to 50 feet and a “selective-entry” outer band from 50 to 150 feet. Prescriptions for the outer band require a minimum retention of 50% overstory and 50% understory conifer canopy post harvest. In addition the 18 largest trees per acre within 100 feet of the watercourse are retained. The entire 150 foot wide RMZ is an equipment exclusion zone (EEZ) and no harvesting of pre-existing down wood (i.e. large woody debris [LWD]) is permitted within the zone.

All Class II waters within the ERSC WAU have a RMZ width based on streamside slope; if less than 50%, the total RMZ width is 75 feet. If greater than 50% the total RMZ width is 100 feet. The theory behind this variability is that steeper slopes are prone to greater surface erosion run-out distances as well as increased mass wasting potential. The inner band consists of a 30 foot no harvest zone with additional stream buffering provided by variable, slope dependent 30 to 75 or 30 to 100 foot “selective entry” outer band, as discussed above. Prescriptions for the outer band require a minimum retention of 60% well-distributed, multi-storied conifer canopy post harvest. The entire RMZ is an equipment exclusion zone (EEZ) and no harvesting of pre-existing down wood is permitted within the zone.

The initial ERSC Watershed Analysis identified a relatively large Class II reach of Corrigan Creek as being capable of transporting LWD directly to Class I waters. It is referred to as the "Corrigan Creek Class II LWD Transport Zone." The outer band of the RMZ for this specific Class II stream reach was extended to a fixed 150 foot distance for the purpose of increasing opportunity for LWD recruitment.

All Class III RMZs are 0 to 50 feet (slope distance) for slopes less than 50 percent and 0 to 100 feet for slopes 50 percent and greater, measured from the watercourse transition line. Class III watercourses with mass-wasting associated LWD transport potential have no harvest within ten feet of the edge of the bank-full channel on each side of the watercourse.

Refer to Appendix 4 for further detail regarding RMZ prescription requirements and protection measures.

5.2.2 Riparian Harvest

A cumulative total of approximately 33 acres of Class I RMZ Outer Band, and 68 acres of Class II RMZ Outer Band were harvested using single-tree selection from 2001 to 2011 in the North Fork Elk River sub-watershed. Significantly less riparian harvest has occurred in the South Fork Elk River sub-watershed, with a cumulative total of approximately 3 acres and 2 acres in the Outer Band of Class I and II RMZs respectively (Table 5-1). This lesser harvest in the South Fork is representative of less HRC ownership in the sub-watershed, as well as the presence of a 200 foot riparian zone located on both sides of the South Fork Elk River mainstem. This corridor along the South Fork Elk River is controlled by BLM as a result of the 1999 Headwaters Agreement and is not managed for timber harvest.

Table 5-1. Riparian harvest on HRC HCP land 2001-2011.

	North Fork Elk River Acres harvested	**South Fork Elk River Acres harvested**	***Total***
Class I Outer Band	33	3	***36***
Class II Outer Band	68	2	***70***
Total	**101**	***5***	***106***
Estimated Total RMZ[1]	2245.5	858.1	3101.6
Estimated RMZ Harvest	***4.5%***	***0.6%***	***3.4%***

[1] Estimate based on stream class miles and averaged RMZ widths

No harvest has occurred within the "Corrigan Creek Class II LWD Transport Zone" (RMZ) since its establishment in 2005.

5.3 PRESCRIPTION EFFECTIVENESS

5.3.1 Stream Temperature and Canopy Cover

Canopy cover is considered to be the percent of stream channel shaded by the natural spread of overstory canopy. While there are many other influences that affect stream temperature, canopy cover shields the watercourse from solar heating. Summer water temperatures can be limiting to the success of juvenile salmonid growth and feeding. The APFC target value for a stream's maximum weekly average temperatures (MWAT) is less than 16.8°C. Water temperature below this level is considered to provide an optimum condition for Coho salmon.

The initial Elk River Watershed Analysis found that, with one exception, stream temperatures throughout the watershed were meeting this target. The exception was the station in the region referred to as Bible Camp on the lower NF Elk River where stream temperatures exceeding 16.8°C were recorded during 3 of the 4 years monitored. It was also reported that stream canopy conditions throughout the watershed were adequate except for in the region upstream and adjacent to the Bible Camp monitoring reach.

As part of the HCP Aquatic Trends Monitoring (ATM) program, stream temperature values have been collected at up to 10 monitoring stations annually throughout the watershed (Map 8). Riparian and over-stream mid-channel canopy cover is also measured at these locations. For the purpose of this analysis, data has been grouped into areas similar in temperature regime and/or region of the watershed. Figure 5-2 and Figure 5-3 present average MWAT by year for the regions of NF and SF Elk River. Data was not available at every station every year so available values were averaged together by year. All data can be reviewed by station and year in PALCO and HRC Annual Trend Monitoring Reports for years 2001-2011.

The Upper North Fork tributary region includes the North Branch (ATM 91) and South Branch (ATM 104) tributaries as well as the mainstem of the NF Elk River (ATM 90) above the confluence with these two tributaries. The MWAT values in this heavily shaded region have remained consistently cool with an average ranging from 13.3 to 15.0 °C.

The Upper North Fork region (upstream of the Conifer Depleted Zone) including ATM stations 167 and 162 has also remained cool with annual average MWAT temperatures ranging from 14.7 to 16.2°C.

Downstream along the lower NF Elk River region (ATM 14 and 214), in the vicinity of the Church Camp and the Boy Scout Camp, average annual MWAT values ranged from 17.2 – 19.0° C prior to 2008, but have shown a decreasing trend since 2008 (< 16.8° C), as mid channel canopy has continued to close in above the stream.

Measured MWAT in the SF Elk River at ATM 175 located near the South Fork – North Fork confluence, and upstream near the mouth of Corrigan Creek at ATM 217, has also shown a cooling of stream temperature in recent years. The average annual MWAT has ranged from 13.8 to 17.1°C over the data period. As noted in Figure 5-3, site 217 was established in 2005 and on average has an MWAT that runs 1.5°C less than that recorded at site 175. Over-stream canopy cover along the South Fork has remained constant at greater than 90 percent.

One station (ATM 166) is monitored on the mainstem of Elk River, a short distance downstream of the North Fork – South Fork confluence. Stream temperature there has achieved the standard PFC matrix target (≤ 16.8°C), and been trending cooler since 2008.

MWAT values have been below 16.8°C, and therefore meeting the target, at all stations since 2008. While a fairly consistent trend towards cooler temperatures has been observed, there is also some variation throughout the watershed (Figure 5-2 and Figure 5-3). These cool temperatures appear to correlate with an over-stream mid-channel canopy cover that has either remained fairly constant or has been trending toward an increased canopy cover. This can be seen in the SF Elk River (>90% canopy) and in the Upper North Fork where canopy cover most recently ranged from 80 – 90 percent (Figure 5-4). Both Upper and Lower North Fork regions exhibited a temporary reduction in canopy closure possibly due to peak flow-associated scouring events from the winter of 2006 (HY 2007). Water temperatures in North Fork and mainstem Elk River also were elevated in 2007 likely from a combination of temporarily reduced upstream canopy and high air temperature. Timber harvest has little to no effect on mid-channel canopy closure as no harvest occurs within 50 feet of the stream bank, or along the lower North Fork Elk within 150 feet.

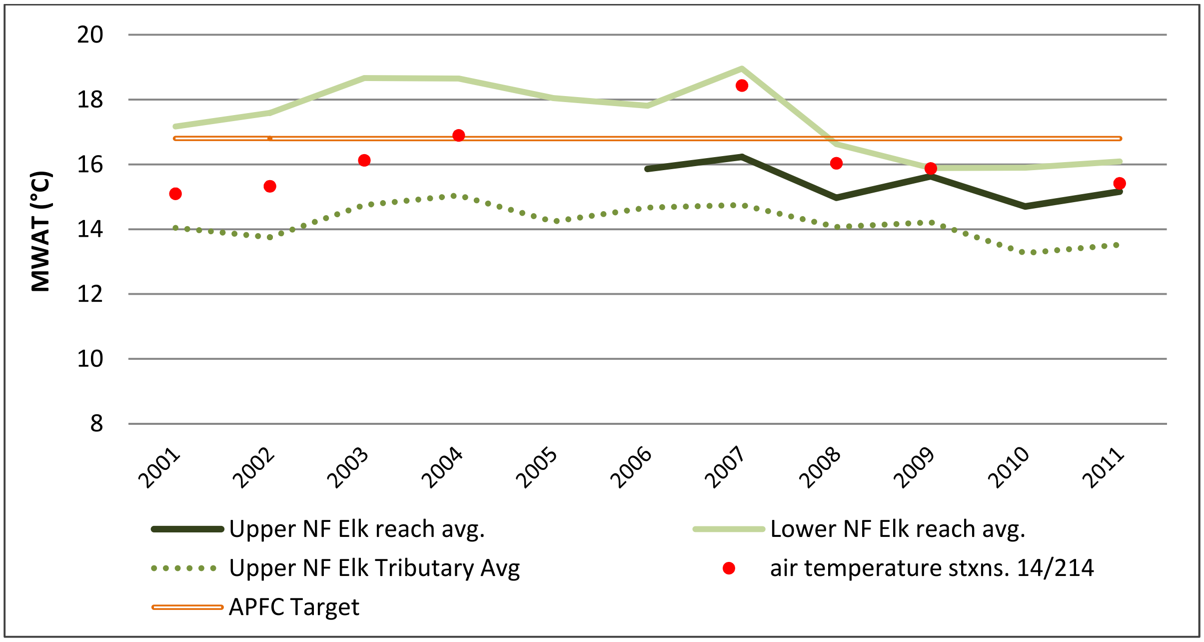


Figure 5-2. North Fork Elk River HRC ATM water temperature records 2001-2011.

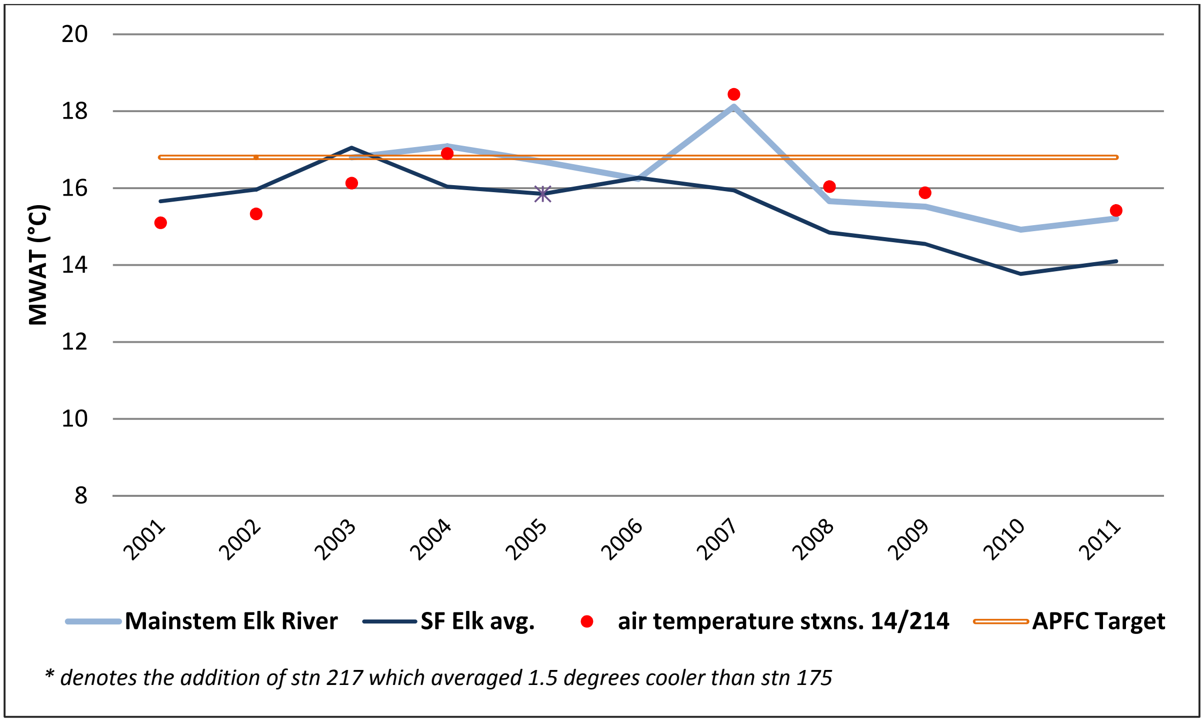


Figure 5-3. South Fork and mainstem Elk River HRC ATM water temperature records 2001-2011.

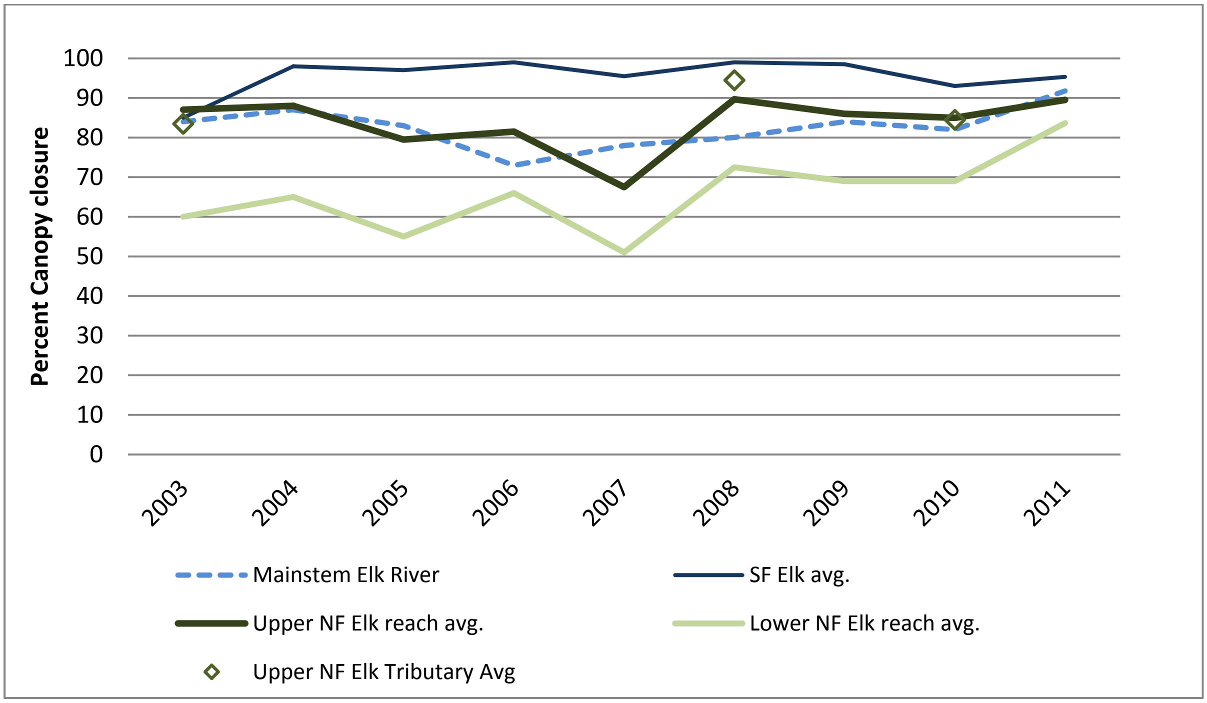


Figure 5-4. Elk River HRC ATM mid-channel canopy closure measurements 2003-2011.

5.3.2 LWD Recruitment

The initial ERSC Watershed analysis found that approximately half of the riparian stands along Class I and Class II watercourses were capable of supplying LWD of functional size and amount to the stream channel to meet PFC objectives. Riparian Management Zone (RMZ) prescriptions were subsequently formulated with the objective of conserving this condition where present and trending the majority of the remaining area towards this "properly functioning" condition over time.

LWD recruitment surveys conducted in the adjacent Freshwater Creek watershed in 2004 found that a significantly larger percentage of trees (LWD) were recruited from nearer the channel than that reported in studies conducted elsewhere in the region (Benda 2002; Reid and Hilton 1999). These 2004 surveys were conducted along Class I stream reaches measuring diameter, height, and volume of the standing forest on both sides of the stream. Downed trees in the riparian zone were inventoried for number, size, direction of fall, cause of mortality, and whether they reached the stream channel. The survey area for down wood extended perpendicular to the channel approximately 200 feet into the riparian forest. An instream wood survey measured all pieces of LWD within the channel reach. Preliminary analysis of data from Freshwater Creek confirms that LWD pieces that are recruited to Class I streams originate from within 100 feet of the channel (Sullivan, in draft). Most is entering from trees standing less than 30 feet from the channel. These results appear to confirm the assumptions used to develop prescriptions for LWD recruitment including establishment of 50 foot no harvest zones immediately adjacent to Class I streams based on then available literature (Murphy and Kioski 1989, McDade et al. 1990, Reid and Hilton 1998, McKinley 1997).

5.3.3 North Fork Elk River Riparian Enhancement Plan

The Lower North Fork Elk River Riparian Enhancement Plan was developed as a Watershed Analysis recommendation in response to an initial finding of the Elk River WA (2005) that the lower reach of the North Fork Elk River from the property boundary upstream past the Boy Scout Camp was deficient in long-term large wood recruitment potential.

The objective of the plan is to increase conifer stocking in areas previously dominated by hardwoods and brush. Increasing streamside conifer densities is intended to eventually promote cooler microclimate riparian conditions and increase future LWD delivery potential providing long-term ecologic benefits for aquatic resources. Secondary long-term benefits include increased riparian stand complexity (e.g. multi-layered canopies) considered beneficial for terrestrial species.

Several suitable sites (i.e. immediately inside the property-line, Bible Camp, and Boy Scout Camp) were located within the target area and prepared for planting by masticating or lopping and scattering small hardwood trees and brush. Conifer seedlings including redwood and Sitka spruce were subsequently planted throughout the sites. All in all, several acres were planted (circa 2007-2010) and survival of planted trees to date HRC estimates at greater than 70 percent. Figure 5-5, Figure 5-6, and Figure 5-7 illustrate typical sites before treatement, immediately after treatment, and in 2014, respectively.

Figure 5-5. Example of Lower North Fork Elk River Riparian Enhancement Area, pre-treatment, 2007.

Figure 5-6. Lower North Fork Elk River Riparian Enhancement Area, post-treatment, 2007.

Figure 5-7. Example of Lower North Fork Elk River Riparian Enhancement Area, seven year old planted redwood and Sitka spruce, 2014.

6 STREAM CHANNEL

6.1 HISTORICAL PERSPECTIVE

Since the beginning of European settlement of the Humboldt Bay region in the 1850s, the condition and function of Elk River and its flood plain (including coastal marsh habitat) have been influenced by land use (farming, ranching, and timber), and urbanization and infrastructure encroachment (roads, bridges, and houses). Levees and dikes were constructed to create and maintain valley bottomlands suitable for farming and ranching, and roads and railroads built to access these enterprises, regions further to the south, and early timber operations. As a result, much of the pre-existing wetlands and coastal marsh habitat converted to drier farmlands. This hardening of the landscape over time has reduced the bay coastline's ability to attenuate high tides, instead forcing these tides further upriver. Stabilization of the bay mouth by constructing jetties off of the north and south spits hardened the entrance of the bay and resulted in the eroding away of much of what is referred to as Buhne Point (now the community of King Salmon). Sediments eroded from Buhne Point subsequently deposited at the mouth of Elk River causing the channel to turn north and lengthen prior to entering the bay. Interestingly, a recently completed thalweg survey of Elk River found the river currently reaches sea level nearly four miles upstream of its actual entrance into Humboldt Bay and thus has zero gradient along this final reach. One hypothesis is that this might demark the approximate edge of the pre-European settlement coastal marsh habitat.

Historic timber operations directly affected channel conditions in several ways including use of smaller channels as skid roads for log transport and the larger mainstem channels as the original means by which to transport logs to Humboldt Bay for milling (Figure 6-1). The Humboldt Times newspaper reported routine use of man-made dams throughout the 1870s to create early winter season floods ("booms") by which loggers drove millions of board feet of old growth logs down the river to the bay. *Falk's Claim*, authored by John Humboldt Gates (1983), describes the process:

> *At that time the only way to move logs was by oxen and mule teams, so the loggers felled only trees which were nearest the river, then cut them into shorter sections with hand saws which measured from 6 to 24 feet in length. The woodsmen usually left behind the lower 20 feet of the tree because these logs were too big to handle. All the work was done in the summer months, so that by fall the river bed was loaded with the sectioned trees. A dam was then constructed downriver of the waiting logs, and as the autumn rains descended, the water level rose until these logs floated freely. The next phase of the operation (and the one that made living downstream somewhat troublesome) was to blow the dam up with high explosives. This sent a flash flood of water and huge timbers cascading down the river. Many of the logs made it all the way down the valley and into the bay, where they were lashed together and towed to the D.R. Jones mill. Quite a few logs, however, ran aground or became tangled in snarls of debris. Jones then sent crews back up river to free the ones that were easily accessible. Those that were too deeply imbedded were not salvaged. As the rains*

> *continued to pour throughout the winter, more debris floated downstream and formed log jams around these embedded snags, which eventually blocked the river and sent it over the banks into the farmlands of the lower valley. This went on for several years before complaints from the farmers forced an end to the flash –flood method of log delivery. (P.14-15)*

Figure 6-1. Logs stacked in Elk River in 1892, waiting for a winter freshet to carry them downstream. Seth Buck Collection.

Periodic clearing of logs and other debris was not an uncommon practice throughout much of the County's history and there are many anecdotal accounts by residents, ranchers, and County managers of the necessity for stream clearing for flood management purposes (PALCO 2005). In the 1970s and 1980s, reaches of the river were cleared of large wood/log jams believed to be a limiting factor to fisheries by the (then) California Department of Fish and Game. These log jams also contributed to channel roughness and reduced channel carrying capacity, consequently contributing to flooding.

More recently, recognition that fish habitat benefits from fairly high loading of large wood resulted in an end to the practice of state sponsored stream cleaning. These benefits include sorting gravels, trapping sediment, creating pools, and providing for insect fall and cover. The subsequent listing of the Coho salmon (1997), Chinook salmon (1999), and steelhead (2000) as threatened further affected the extent to which, and how, stream channel conditions and riparian vegetation is managed. The current mostly "hands-off" approach to in-channel management has led to an increasing trend in woody debris loading, riparian vegetative growth, and consequently, increased channel roughness, downstream of HRC's ownership as well as within the bottom of the ownership on the NF Elk River where stream gradient is typically <0.2%. While there may be ecological benefits to this development including a high level of shade canopy contributing to cold water temperatures (see section 5. 3.1), insect food source, shelter from predators, and hydraulic complexity of particular biological importance during peak flow events, these conditions also promote sediment deposition and storage, as scour and transport is impeded.

6.2 CURRENT CONDITIONS

ATM monitoring in Elk River includes repeated surveys of the streambed at 10 monitoring sites. Streambed surveys are conducted to determine elevation and cross-sectional area changes over time. Cross-sections are measured perpendicular to flow to characterize and quantify streambed scour or fill. Longitudinal profiles are measured at the thalweg along a length of channel and provide information pertaining to variations in complexity and sinuosity of the reach over time. Changes in channel dimensions are sensitive to sediment and LWD loading and are correlated to instream habitat characteristics. To increase accuracy and repeatability, a Topcon Total Survey Station has been used at these permanent benchmarked sites since 2003, replacing the survey auto-level used during the previous 5 years.

Each monitored stream reach has a minimum of 5 permanent cross-sections where measurements are taken at each grade break across the channel. Relative change in cross-sectional area is determined from measurement to measurement below a reference elevation. This elevation is typically set at a channel feature associated with bankfull depth or top of bank. Cross-sections are measured in years when habitat is surveyed. In 2011, cross sections were measured at ten ATM stations in the Elk River Watershed. Seven mid to lower reach stations, relative to HRC's ownership, are measured annually at the request of the NCRWQCB, while three upstream headwater stations are monitored every three years as part of the HCP-specific ATM program (Map 8 and Table 5-1 in section 5.2.2 above). Thalweg measurements have been taken less frequently, occurring every 1-6 years beginning as early as 1999. More specifics regarding methodology and data analysis can be found in the 2011 ATM Annual Report (Appendix 8).

Observations and habitat data in Elk River indicate a region of sediment deposition lower in the watershed where stream gradient is less than 0.2 percent and the channel has a meandering pattern. Stream gradients are presented for the HCP ERSC WAU in Map 9. The upstream boundary of this region in the NF Elk River begins near ATM 214 and in the SF Elk River begins near ATM 175 (Table 6-1 and Map 8). In this region, the channel bed is composed of a much higher percent of fine sediment than found upstream. A clear change in substrate condition can be observed in the SF Elk River near the mouth of Tom's Gulch, where substrate transitions from a coarser, gravelly composition found upstream of this confluence, to a sands- and fines-dominated condition downstream. The mainstem Elk River channel downstream of the North Fork – South Fork confluence has experienced a slow but steady reduction in bankfull area, with most of the deposition occurring along the banks of the channel. Figure 6-2 presents a single cross section plot from this mainstem station (ATM 166) with all years of available data plotted. This serves as an example of the data collected and utilized to determine overall trends throughout the decade. Rates of scour and fill, cross-section plots, and thalweg profile plots taken at stations throughout the watershed can be found in the HRC 2011 ATM Annual Report.

Table 6-1. Summary of HRC ATM sites with trends determined from analysis of cross section and thalweg surveys.

ATM Site #	Watershed Location	Upstream Watershed Area (acres)	Reach Gradient	Overall Trend
166	Main Stem	26393	0.1%	Steady Aggradation
175	South Fork Elk River - Lower	12418	0.1%	Slight Aggradation
14	North Fork Elk River - Lower	12521	0.1%	Steady Aggradation
214	North Fork Elk River - Lower	12302	0.2%	Limits of Aggradation, mixed scour and fill
162	North Fork Elk River - Mid	8738	0.6%	Mix of scour and fill - no pattern
167	North Fork Elk River - Mid	7230	2.1%	Mix of scour and fill - no pattern
217	South Fork Elk River -Mid/Upper	4030	1.6%	Mix of scour and fill - no pattern, noisy
90	North Fork Elk River - Upper	2766	2.1%	Mix of scour and fill - no pattern, noisy
91	NB North Fork Elk River	2581	1.5%	Mix of scour and fill - no pattern, noisy
104	SB North Fork Elk River	1207	2.8%	Mix of scour and fill - no pattern, noisy

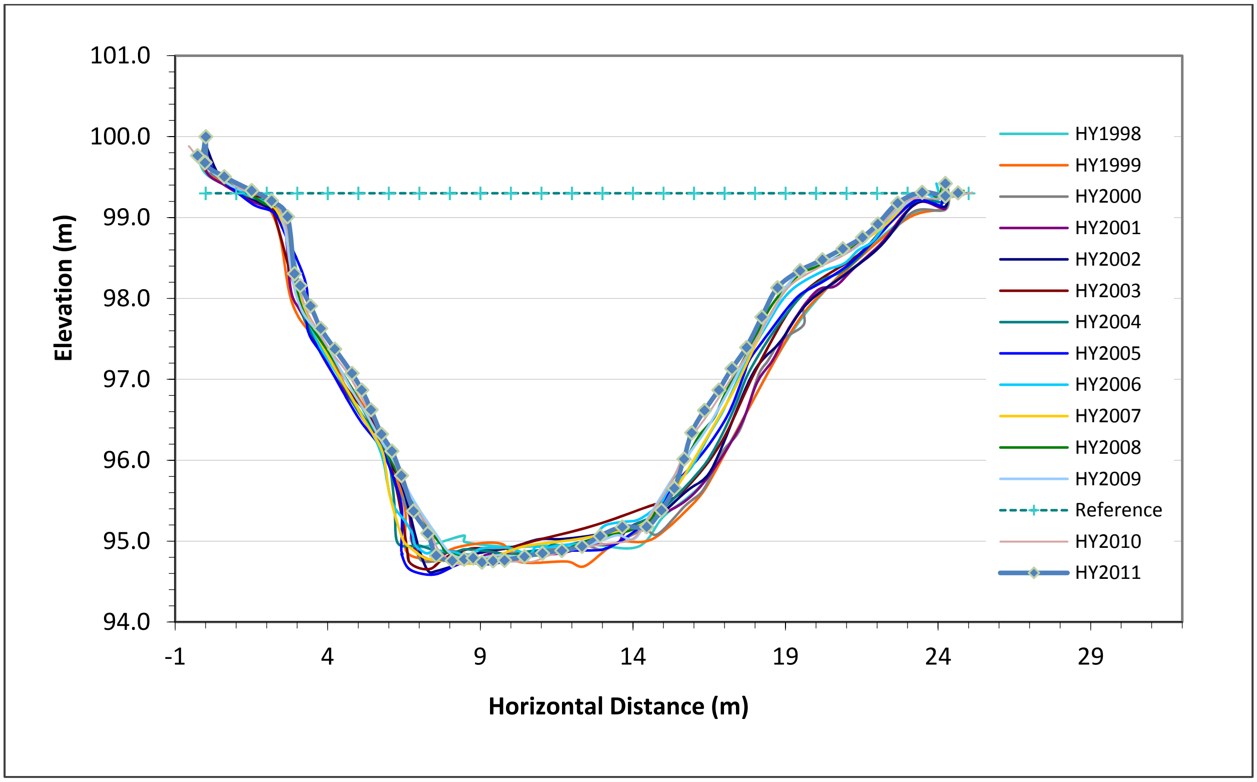


Figure 6-2. Cross-section at HRC ATM 166 exhibiting aggradation along mainstem Elk River.

HRC is participating in data collection efforts to support the Elk River Recovery and Assessment Project. One of the key elements of this data collection effort is a thalweg survey, measured from the mouth of Elk River upstream onto HRC's property on the NF Elk River. The general premise of this study is to quantify current stream conveyance capacity for the purpose of modeling future restoration scenarios that could address NCRWQCB concerns over flooding frequency and sediment-related salmonid habitat impairment.

6.3 STORED SEDIMENT

6.3.1 Headwater Streams

Class III channel headward migration (channel enlargement) has been identified as a potential source of sediment to streams (Buffleben, 2010; Reid et. al, 2009, PWA, 1999). It has been demonstrated at Caspar Creek (Reid et al. 2010), Freshwater Creek (PWA 1999), and Elk River (Buffleben 2009) that unmitigated logging can cause the headward migration of channel heads. This process inputs sediment to streams and leaves raw banks prone to further erosion. If mechanisms have been properly interpreted, the majority of effect may have already occurred as a result of first cycle logging activity. Dewey (2007) and PWA (1999) confirmed that upward channel migration was rapid following initial logging entry. This observation was also confirmed by Buffleben (2009), who found a large reduction in channel initiation watershed size compared to an old growth basin. Buffleben surmised this was due to the high density of skid trails and the accompanying removal of vegetation in these channel head locations.

An effectiveness project was implemented in 2011 within the Beck's THP (10-012) in Freshwater Creek to measure the effect of current management practices on Class III channel heads. A total of 60 channel heads were monumented across Class III headwater channels within the Beck's watershed. Of the 60 sites, 20 sites were within the THP, 31 sites were outside the THP but were below roads, and nine (9) sites were on open slopes with no THP or roads influence within the upstream watershed boundary. The plots, flagged and marked with two (2) rebar pins on either side of the headwater channel, were established at the furthest upstream extent of observable overland flow/active channel. Preliminary results indicate there was no active channel migration at any of the 60 test plots after two winter seasons (HY2012 and HY2013).

Streamside landslides and bank erosion have also been identified as a source of sediment to streams (PWA 1999, Sullivan 2012). The effectiveness of HRC's various management practices to protect streamside areas is currently being measured within the Beck's THP effectiveness project. In October 2011, a 4,000-foot reach was surveyed to measure all streamside landslides and bank erosion. Resurvey of this reach occurred in October 2013. Preliminary results indicate no measureable increase in streamside landslide or bank erosion activity after two winter seasons.

A similar effectiveness project is planned to be implemented beginning in HY2014 within Railroad Gulch, a tributary to South Fork Elk River. Class III channel headward migration and streamside landslides/bank erosion will be evaluated similar to the Beck's THP project.

6.3.2 Flooding

The lower mainstem Elk River, which extends from the confluence of the North and South Forks of Elk River to the eastern banks of Humboldt Bay, is bordered by a broad alluvial flat. This flat ranges from two-tenths of mile in width near the North Fork/South Fork confluence to just over ¾ of a mile wide downstream of Martin Slough. A majority of this low relief area is identified on the Flood Insurance Rate Maps (FIRM) produced by the Federal Emergency Management Agency (FEMA) as being part of the 100-year flood zone.

The alluvial flat along this reach of Elk River has developed over time by means of recurring flooding and related processes of erosion and deposition. Frequency of floodplain inundation depends on several factors including climatic conditions, stream bank composition, and the channel configuration.

Floodplains similar to those present along the lower reaches of Elk River are known to provide a wide range of benefits to natural systems including but not limited to:

- Provide flood storage and conveyance.
- Reduce flood velocities.
- Reduce flood elevations.
- Support high rates of plant growth.
- Provide breeding and feeding grounds.
- Maintain biodiversity.

While historical accounts identify flooding as a natural and long standing occurrence in the Elk River valley, flood frequency has reportedly increased in recent years as channel conveyance has been reduced due to ongoing sedimentation. Flooding typically occurs first, and most often, at the location known locally as Dead Women's Curve (DWC). This approximate 200-foot section of road parallels the North Fork Elk River within a few feet of the main channel, and dips toward the river as it flows through a sharp meander bend (Figure 6-3). DWC has flooded approximately 50 times in the last ten years with the number of measured events per year ranging from 0 to 8 (Table 6-2). Flooding events are defined as an event where measurable water is present at the lowest part of the road (Figure 6-3). The duration of events with water on the road surface ranges from less than an hour to as long as three days. *Road flooding in excess of 0.75 meters on the road surface is estimated to make the road impassable to passenger car traffic (personnel observation, D. Manthorne). It is important to note that the frequency and duration of events causing the road to be impassable is substantially less than the frequency and duration of all recorded "flooding" events.* For example, in HY2012 four events created impassable road conditions while the road remained passable during the other four events, based on the 0.75 meter threshold. Although not all flooding events make this section of the Elk River Road impassable, this episodic flooding is a nuisance to residents and a safety concern.

Figure 6-3. Mainstem Elk River at Dead Woman's Curve during a flood event, 2012.

Table 6-2. Summary of flooding events defined by water on the road surface since 2003.

Hydrologic Year	Number of Flooding Events	Number of Rainfall Days			Annual Rainfall (inches)	Maximum Daily Rainfall (inches)
		>3 inches	>2 inches	>1 inch		
2003	8	1	3	12	54.11	6.79
2004	7	0	0	9	37.57	1.89
2005	2	0	0	13	43.45	1.77
2006	9*	0	1	16	58.67	2.04
2007	5	0	1	4	36.86	2.32
2008	4	0	0	9	33.06	1.99
2009	0	0	0	5	30.30	1.74
2010	3	0	0	12	44.96	1.76
2011	4	0	1	10	44.11	2.05
2012	8	0	2	11	39.72	2.26

* HY2006 was not measured, flooding estimated from exceedence of minimum flow (695 cfs)

The channel capacity at DWC was estimated in 2005 to be at ~60% of the expected bankfull capacity for a stream of this size, causing flooding events at stream flows in excess of 695cfs (Sullivan and Dhakal, 2005).

Several factors contribute to localized increased flood frequency in the lower Elk River valley. Increased channel roughness in the form of abundant bank vegetation and woody debris accumulations reduce stream flow velocity and entrap sediments (Figure 6-4). As a result of increasing roughness combined with a general lack of stream channel gradient (<0.2%), velocities, even at peak flows, are generally insufficient to generate any significant channel scour. Reduced velocities limit sediment transport capacity and consequently result in deposition in the reaches of greatest channel roughness. This deposition further impinges on the channel over time and provides a fertile environment for additional vegetative growth, consequently further increasing roughness. Changes on the extended flood plain, further back from the channel itself, have occurred over the last 100 years as areas that were once open and grass-dominated are now covered by shrubs, willows, and conifers. This increasing out-of-channel vegetative roughness affects stream flow velocities and flood plain carrying capacity, resulting in flows being pushed further out from the channel than would otherwise occur if the flood plains were less vegetated.

Figure 6-4. Mainstem Elk River vegetation at HTM 509.

The situation is further compounded by sea level and tidal influences. Elk River arrives at sea level (0% gradient) several miles upstream of its confluence with Humboldt Bay, and as previously discussed, a hardened bay front resulting from levees and other infrastructure forces extreme tides up river, temporarily halting down river flow altogether.

Sea level measured at the North Spit of Humboldt Bay since 1977 has the highest rate of rise along the California coastline at 18.6 inches per century (4.73mm/yr) (Russell 2012). This is largely because the land surrounding Humboldt Bay is subsiding. Sea level is estimated to continue to rise 6 inches by 2030, 12 inches by 2050 and 36 inches by 2100 (Laird 2013). Sea level rise at the mouth of Elk River is further complicated by local and regional tectonics. A significant seismic event in the Humboldt Bay region could cause some areas to immediately subside and sea level to suddenly rise perhaps by more than 1 m. This earthquake-induced rise in sea level would be in addition to the relative sea-level rise projected above.

As previously noted, there are numerous accounts of historic channel clearing and vegetation management by locals for flood control purposes; however such efforts have been significantly reduced in response to increased regulation aimed at protecting listed fish species. Channel roughness is likely to continue to increase without proactive channel and stream bank vegetation maintenance (Sullivan and Dhakal, 2005).

Storm-triggered increases in sediment loading associated with past logging operations upstream, primarily landsliding and road failure, are often cited as a significant source of channel filling. Several studies including those cited in the original PALCO 2005 Elk River WA report indicate a significant land use induced increase in sediment delivery to the stream system in the late 1990s (refer to Section 4.0 for further discussion). Nearly a century of unregulated logging practices prior to the 1974 establishment of the California Forest Practice Rules also contributed substantial amounts of sediment into lower order stream channels. This in-channel stored sediment supply is presumed to be an important factor in downstream sediment loading concerns.

Sediment delivery has been significantly reduced since the implementation of proactive HCP measures in 1999, and other subsequent regulatory measures. Sediment delivery from *current* forest management practices is estimated to contribute less than 10 percent of all hillslope sediment delivery within the ERSC WAU. However as much as 40 percent of all sediment delivery over the last decade is estimated to originate from legacy land use associated sources. Therefore HRC’s watershed restoration program addressing erosion control of these legacy sources (e.g. old skid trails, abandoned haul roads, stored in-channel sediment), where feasible, is an important element of ongoing sediment control (discussed in detail throughout section 4.2).

Near-term mitigation of flooding events affecting the county road at the locations identified above can likely best be achieved through increasing overall channel conveyance capacity in the immediate vicinity combined with the re-engineering of road infrastructure. A summary of flooding history, channel morphology, causes, and potential solutions was prepared by Sullivan and Dhakal and presented by PALCO in 2005 (Appendix 9). Preliminary models of conveyance capacity are being completed for Elk River in a collaborative effort to address flooding concerns. Although HRC does not own the stream reaches subject to nuisance flooding, the company is assisting in this collaborative effort.

6.4 SEDIMENT-RELATED WATER QUALITY MONITORING

Suspended sediment, turbidity, and streamflow have been monitored at 14 sites within the Elk River watershed over the past 10 years. Each monitoring site is equipped with continuous measuring turbidimeters and depth recorders that collect measurements every 15 minutes from October to May. Physical water samples are collected during storms and streamflow is measured over a range of flows for development of a stage discharge curve. This combination of measures allows the continuously-recorded turbidity and depth to be translated to streamflow (m^3s^{-1}) and sediment load. Sites are dispersed throughout the watershed and capture major sub-basins and sections of both forks of Elk River (Map 8). Duration of monitoring record for each site varies, with 12 sites having a minimum record of 6 or more years.

A recently completed report titled "Trends in Sediment-Related Water Quality after a Decade of Forest Management Implementing and Aquatic Habitat Conservation Plan" (2013), prepared by Kate Sullivan, PhD (Appendix 10), presents the findings to date of this monitoring effort in combination with additional measurements taken in the neighboring Freshwater Creek watershed. The report focuses on the annual sediment yield transported past each station each year and turbidity characteristics compared to regionally significant thresholds.

The primary management-related questions addressed in Sullivan's report are:

- Do current management practices prevent sediment delivery to streams?
- Does the application of practices and strategies for the watershed as a whole result in declining sediment loads and improving water quality over time?

This study introduces a rainfall erosivity index as a parameter to account for weather-related effects on sediment transport. This weather-related parameter or its highly correlated counterpart – annual unit peak discharge – accounted for about 80% to 90% of the annual variation observed in sediment-related water quality characteristics at each site and served to normalize for weather effects in the statistical analyses.

Sullivan's analysis found a decreasing trend in suspended sediment concentrations during the measurement period from 2003 to 2011 at nearly all of the hydrology monitoring stations. The downward-trending sediment yield largely reflects the weather history during the period, and the erosivity index explained 80% to 99% of the variation from year to year. Although the weather pattern was the major factor in declining sediment yields during the study period, statistical analysis found a small, but significant decline related to time. This relationship suggests some cumulative benefits from the sediment prevention and restoration activities in the watersheds. However it should be noted that in review of Sullivan's analysis, Mr. Jack Lewis, USFS PSW (retired), found that a statistically significant decline in sediment yield was limited to trend measurements taken in Freshwater Creek and that Elk River data, when viewed alone, did not show a decreasing trend, but rather more of a steady-state (BOF Monitoring Study Group Presentation, April 2014).

Hydrologic monitoring confirmed that there are large differences among the sub-basins in sediment yield. Geology plays some role in that very high loads were observed only within the Wildcat lithology. Basin area appears influential on sediment yield with higher loads associated with larger watershed area, but results were not statistically significant. Much variability is attributed to unique local situations including underlying geologic conditions, stored in-channel sediment loads, and effectiveness of road decommissioning activities. The South Branch North Fork Elk River and Toms Gulch are identified as particularly high sediment load producers in the Elk River watershed, and this may in part be due to the high density of both decommissioned and untreated roads found within both. Underlying geology also plays a significant role in Tom Gulch where soft sedimentary rock and a large earthflow complex combine to produce relatively fine-grained channel substrate, lending to the increased rates of streamside landslides and bank erosion.

Section 4.1.3 discusses details of analyses leading to HRC's estimate of streamside landslides. In her report, Dr. Sullivan estimates channel headward migration and bank erosion associated with first cycle logging may contribute as much as one-third of the current observed (in-stream) sediment export during average years. The HRC sediment budget for 2001-2011 estimates pre-HCP (legacy) loading rates from streamside landslides and bank erosion to be 63 tons/mi^2/year, approximately 24% of management related sediment loading and 12% of all sediment loading from HRC HCP covered lands.

Sullivan's report also addresses the findings of a recently published paper by Klein et al. titled "Logging and turbidity in the coastal watersheds of northern California" (2012). Klein et al. presented a regional analysis of turbidity response to forest management in north coastal California, finding that the 10-15 year prior harvest rate had a positive and statistically significant effect on the 10% turbidity exceedence in

2005. Sullivan replicated the multivariate analysis from this paper using the full HRC data set. Her analysis confirms these findings for 2005; however, the same analysis conducted for each year of the HRC monitoring record from 2003 to 2011 did not find a statistically significant relationship among these parameters for years other than 2004 and 2005. Furthermore, applying the Klein *et al.* analysis on the combined nine years of data (controlling for weather effects), Sullivan found a decreasing relationship between the previous 10-15 year harvest rate and the 10% turbidity exceedence. Thus, the conclusions reached by Klein *et al*. (2012) regarding relationship between rate of harvest and turbidity were not generally applicable to Elk River or Freshwater Creek.

7 FISHERIES ASSESSMENT

This fisheries assessment is focused on in-stream habitat and water quality conditions that influence the growth and survival of fish species covered by the HCP. These include Northern California steelhead (*Oncorhynchus mykiss)*, Chinook salmon (*O. tshawytscha)*, Coho salmon (*O. kisutch*), and coastal cutthroat trout (*O. clarki clarki*). Historic observations have confirmed the presence of 15 fish species within the Elk River and Salmon Creek Watersheds. The majority of these species reside within the estuarine regions downstream of HRC's ownership.

Extensive research and field verification was completed for the initial ERSC Watershed Analysis to describe the distribution and habitat utilization of each covered species throughout the ERSC Watershed. Changes and additional information gathered during the decade have been incorporated into HRC GIS coverage subsequent to field confirmation (Map 10). As described in section 2.3, Class I streams are fish bearing or having the potential to be fish bearing watercourses. This does not indicate current fish distribution, but rather identifies the extent of streams with existing and/or potential fish habitat. Likewise, Map 10 presents known fish distribution whish may not be currently utilized due to migrational barriers. Barriers are commonly found during other investigations and the coverage is not comprehensive at this time. Within the ERSC WAU there are 34.2 miles of Class I streams; 28.8 miles in NF Elk River, 4.8 miles in SF Elk River, and 0.61 miles in Salmon Creek (Table 2-3 in section 2.3 above). Stream classification determines land management activity restrictions adjacent to the watercourse under the HCP (see section 5.2 above).

7.1 AQUATIC TRENDS MONITORING

For the purposes of this analysis, similar to section 5.3.1, ATM sites have been placed into regions based on location within the watershed, drainage area and similarities in sediment transport processes. The uppermost North Fork Elk group includes the North Branch (ATM 91) and South Branch (ATM 104) as well as Upper North Fork Elk (ATM 90) located upstream of both the North and South Branch confluences. The mid-North Fork Elk grouping includes ATM stations 167, 162, and 214. Station 217 represents the mid-South Fork Elk region. The last grouping is in what is referred to as the deposition zone, and includes the lowest ATM stations on both North Fork (ATM 14) and South Fork (ATM 175) of Elk River as well as station 166 on mainstem Elk River. Table 7-1 provides some basic information regarding these stations including information collected at each. Representative photos are included as Figure 7-1. The sensitivity of parameters to localized stream activities make it difficult to assess overall habitat conditions without grouping stations together or increasing the length of sampling reaches significantly. Multiple samples and stations have been averaged and any questionable data was removed and replaced with the most current reliable data as judged by the reviewer. Data was not available at every station every year so available values were averaged together for the entire period. All data can be reviewed in PALCO and HRC Annual Trend Monitoring Reports for years 2001-2011.

Table 7-1. Current Elk River HRC ATM Monitoring Stations and Analysis Regions.

ATM Site #	Stream name	Avg. Bankfull Width (m)	Upstream Acreage	Reach Gradient (%)	Elevation (ft)	Water Temp. (annual)	Streambed, Habitat, Canopy, Sediment and LWD
	Upper North Fork Region						
91	North Branch NF Elk	7.6	2,581	1.5	410	X	X
104	South Branch NF Elk	6.3	1,207	2.8	360	X	X
90	Upper North Fork	12.8	2,766	2.1	419	X	X
	Mid North Fork Region						
167	North Fork Elk	14.6	7,230	2.1	262		X
162	North Fork Elk	14.0	8,738	0.6	134		X
214	North Fork Elk	15.0	12,302	0.2	80	X	X
	Mid South Fork Region						
217	South Fork Elk	8.9	4,030	1.6	510	X	X
	Deposition Zone						
14	North Fork Elk	10.0	12,521	0.1	62	X	X
175	South Fork Elk	9.9	12,200	0.0	39	X	X
166	Mainstem Elk	15.0	26,393	0.1	39	X	X

Upper North Fork Reach (Site 90)

Mid South Fork Reach (Site 217)

Mid North Fork Reach (Site 214)

Deposition Zone (Site 175-SF Elk)

Deposition Zone (Site 14-NF Elk)

Deposition Zone (Site 166-Mainstem Elk)

Figure 7-1. Photographs of HRC ATM monitoring sites representative of regions.

A review of composite graphs indicates high variability in measures associated with sediment and large woody debris (LWD). This is more likely indicative of the sampling variability and less likely an indication of watershed wide changes in these parameters based on QAQC evaluation presented in the

2011 ATM Trends Annual report. A review of current methods and recommendations for future monitoring is presented in Appendix 12.

7.1.1 Large Woody Debris

Large woody debris plays an essential role in providing quality salmonid habitat. LWD is a valuable biological and structural element within the stream. The APFC targets for instream wood focus on size, volume, and frequency as a function of channel width (Bilby and Ward 1989; Fox 1994); essentially, quantifying if there is enough wood throughout the watercourse functioning to provide pools and cover. Field surveys at the ATM reach include the measurement of all pieces at least partially within bankfull throughout the reach as well as identifying key pieces and association with pools.

Figure 7-2 presents the multiple LWD target parameters for 2003-2011 by region in the watershed. LWD diameter appears to be fairly consistent throughout the watershed with a slight decrease moving downstream. Similarly, LWD length remains consistent. Diameter targets are well exceeded in the upper and mid watersheds but APFC length targets are rarely met. Volume frequency and density are highest in the upper reaches and decrease progressing down the watershed. Station 214 is the location where frequency and volume of wood begins to dramatically decrease moving downstream. Regions upstream consistently exceed volume and frequency targets. Key piece frequency in the upper watershed group meet APFC targets whereas values are below target for all other sampling reaches. Identification of LWD key pieces has been problematic throughout the sampling effort and HRC needs to further develop sampling accuracy for this parameter. Overall, wood presence and functionality appears to be similar between South Fork and North Fork Elk River and no increasing or decreasing trends over time stand out in the dataset. When compared, LWD presence and functionality is lowest for the grouped stations furthest downstream, presumably due to greater volume of flow during peak flow events, softer bed material vulnerable to scour and mobilization, and need for increasing piece size as channel width increases in order to stabilize in one location for an extended period of time.

LWD is a major factor in physically creating in-stream habitat through substrate capture and scouring processes. The APFC target suggests that at least 50% of pools should have LWD present within their boundaries, referred to as “associated with LWD.” Pools present throughout all reaches of Elk River far exceed this target; the mid reach grouping of ATM stations has the lowest average, but is still at nearly 70% association (Figure 7-3). There are no specific targets for pool formation by LWD or frequency of pools associated or formed by wood. It is not clear from the data if pieces of wood are large enough to remain stable in the channel and perform as key pieces, making a larger impact on pool formation.

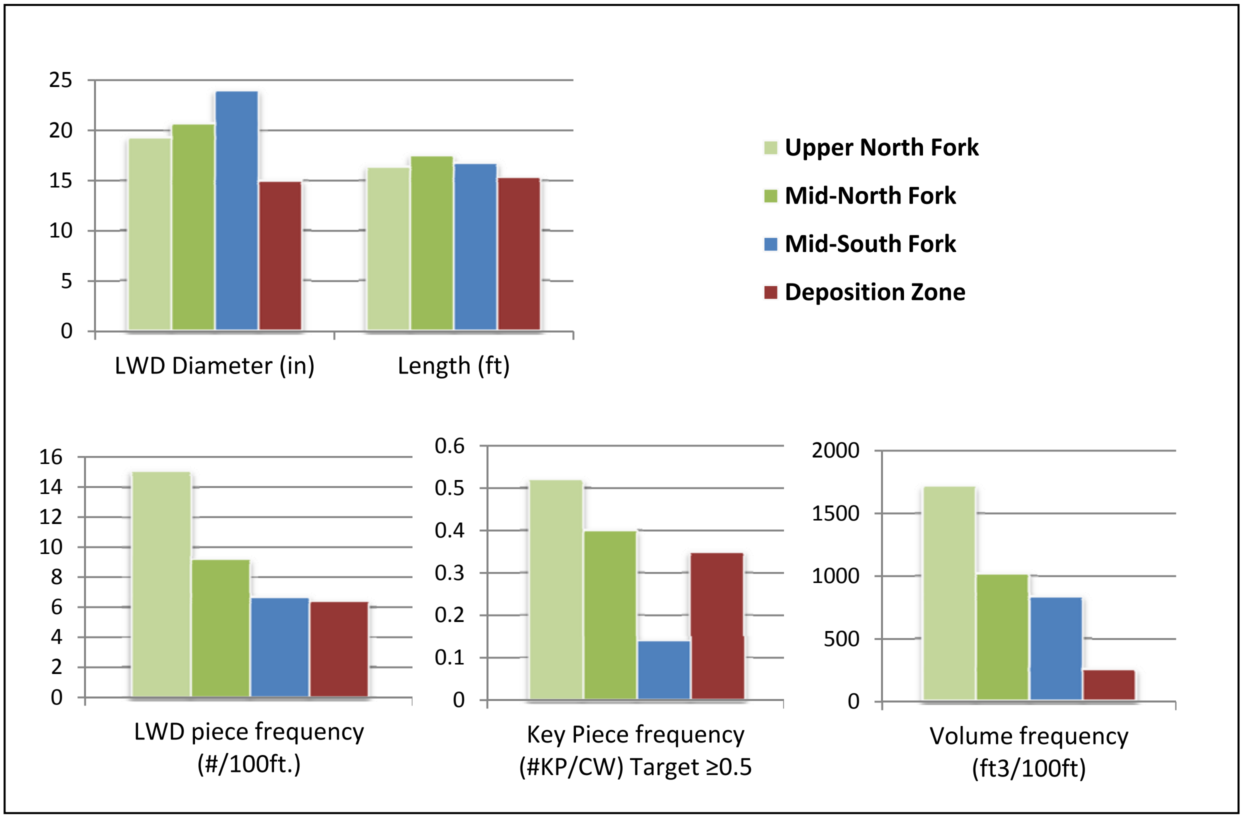


Figure 7-2. Elk River ATM large woody debris parameter data, 2003-2011.

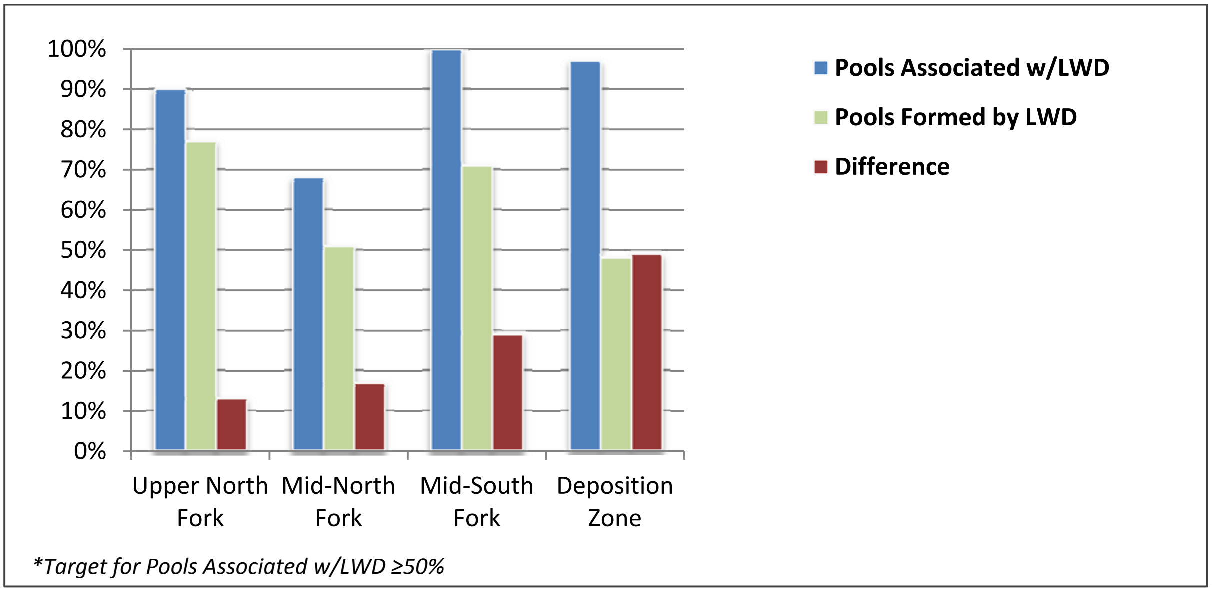


Figure 7-3. Elk River ATM pools associated/formed by LWD parameter data, 2003-2011.

In 2005, a survey was completed on North Fork Elk River to quantify the number and volume of LWD for the entire reach of watercourse with a stream gradient of less than 4%. This was done in a manner that

LWD metrics (including those specific to LWD jams) could be assessed spatially within this region. The survey started along the property line and ended approximately 43,000 feet upstream on the North Fork Elk River. This length of survey encompassed ATM stations 14, 214, 162 and 167. Preliminary data is presented in Figure 7-4 as actual volume and number of pieces per 100 feet along with the APFC target values for these metrics calculated at the ATM stations. ATM station locations are designated with a darkened bar.

The target for number of LWD pieces per 100 feet is met consistently throughout the upper survey region and less consistently in the lower. LWD volume targets are met less often in the mid and lower regions of the survey reach. When compared to the jam volume distribution (Figure 7-5), it appears that the upper region meets volume and piece targets with little dependence on LWD jams. In the mid and lower survey region LWD volume targets that are met appear more dependent on jams. Currently there are no APFC targets for jam volume or distribution. The number of LWD pieces is naturally variable but appears to be lower and less variable in the middle region. HRC intends to further analyze this data and repeat the survey regularly in the future. Future surveys will also include information on the origin of pieces.

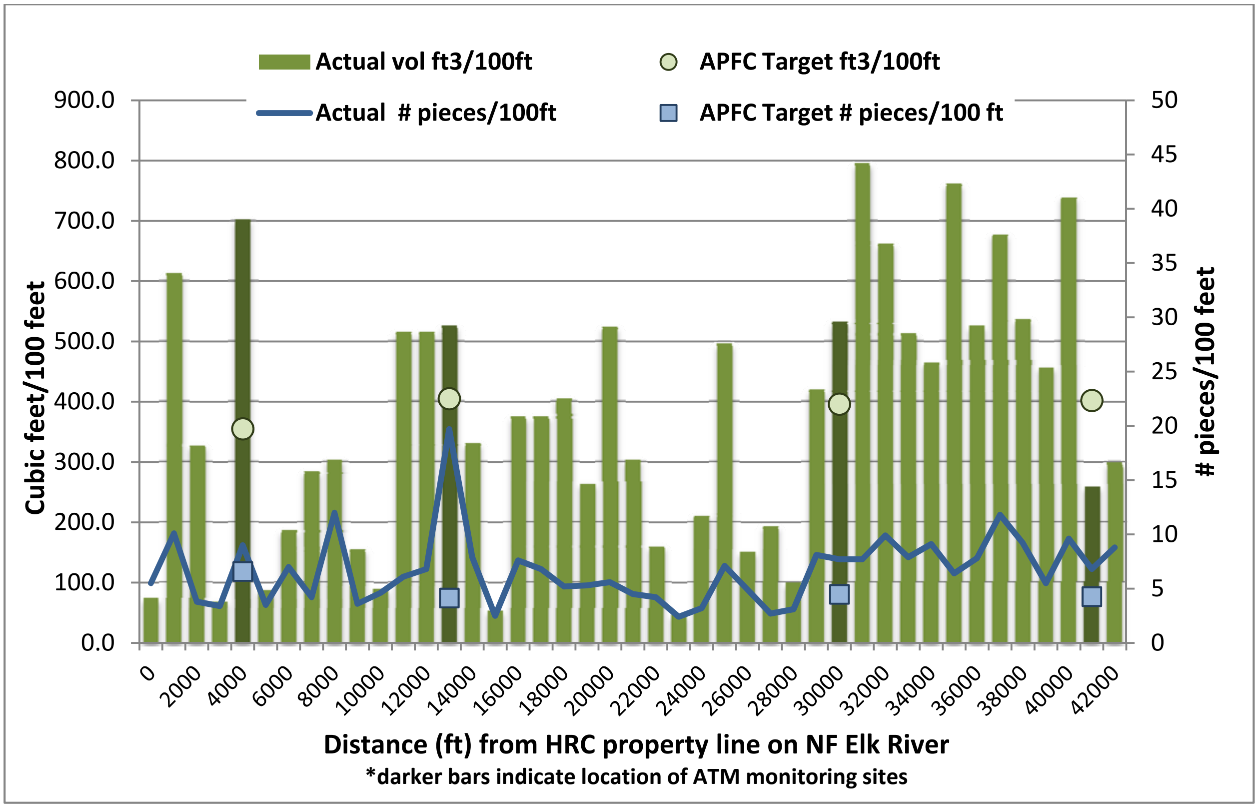


Figure 7-4. 2005 LWD actual vs. APFC target values, preliminary data, NF Elk River.

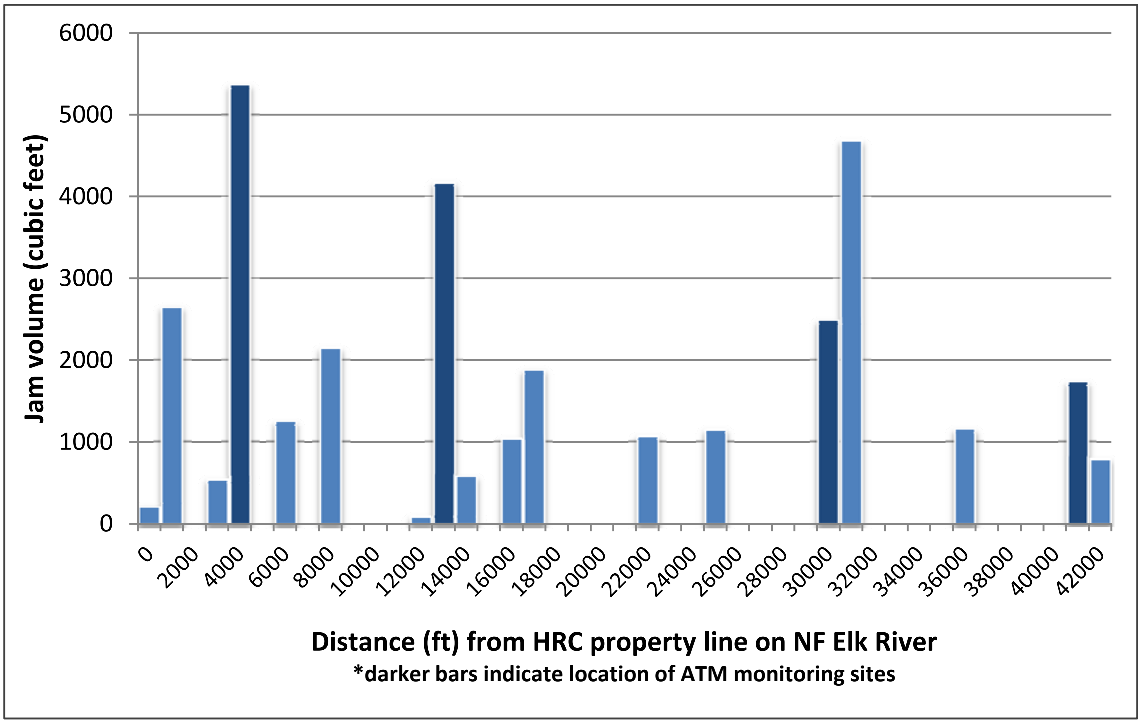


Figure 7-5. 2005 LWD jam volume and sequence, HRC preliminary data, NF Elk River.

A point of interest in Figure 7-5 is the location of the ATM monitoring sites in respect to large LWD jams. All ATM sites within the LWD Light monitoring reach contain large LWD jams, most being near the beginning of the reach and in one case, both at the beginning and end of the reach. The ATM data reflects the presence of these jams in the same year which provides information highly influenced by the local jam rather than representative of an entire channel segment. This supports the need to lengthen survey reaches to increase sampling size and minimize localized influences, as presented in the Aquatic Trend Monitoring Proposal (Appendix 12).

7.1.2 Pool Habitat

During ATM habitat surveys, habitat units are categorized and measured throughout the reach. This data is used to assess stream conditions relative to fixed APFC targets for pool depth, area, and spacing. These targets include that pool surface area comprise at least 25% of the watercourse, pools have at least a 3 foot residual depth, and be spaced such that there is one pool at least every 6 channel widths of length.

As expected, pools lower in the watershed are larger and deeper than those in the higher gradient smaller stream regions of the upper watershed (Figure 7-6). Pool characteristics in the North Fork and South Fork are similar, although South Fork pools have tended to be slightly deeper, perhaps as a result in part of the hydraulic effect of greater wood loading in the monitored South Fork ATM reach. Pool area throughout the watershed far exceeds the targets; however pool frequency decreases in the deposition zone. There are no consistent trends in pool habitat over the sampling period and sampling results have been variable. Overall pool habitat in the Elk River watershed is largely influenced by the localized geology and LWD characteristics. Upper and mid regions of the watershed have a favorable combination of larger substrate, higher gradient, and LWD that provide frequent, diverse pools. The lower region has much smaller substrate, and less significant LWD structure which results generally in large, less frequent, less complex pools.

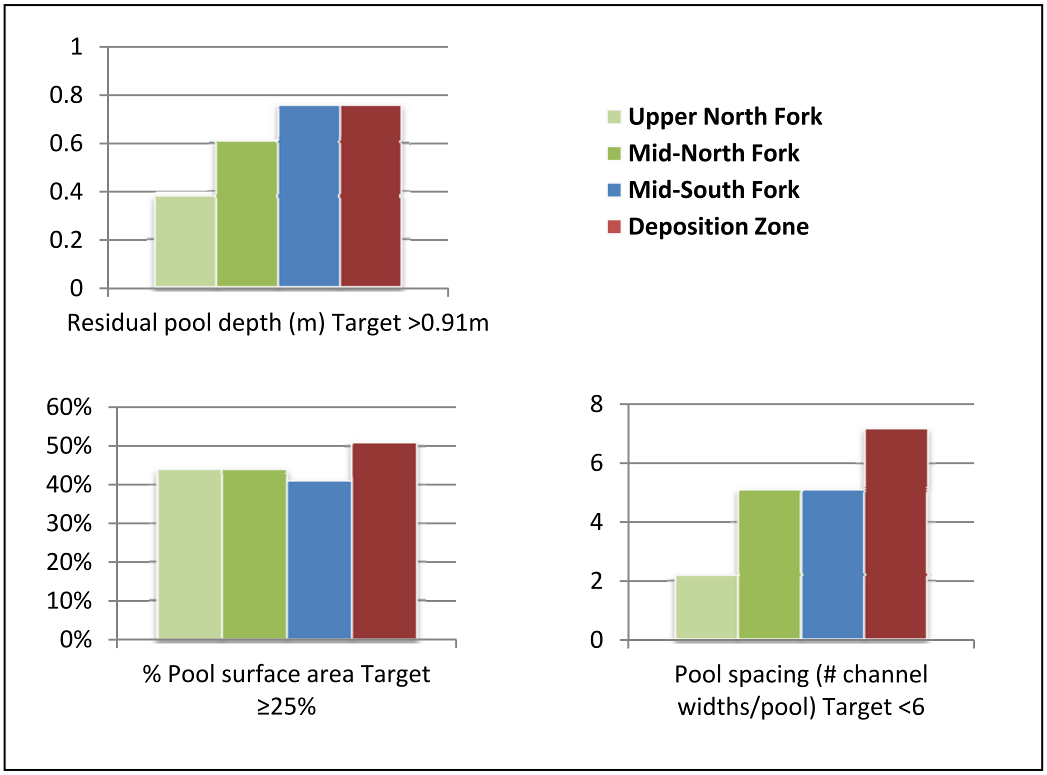


Figure 7-6. Elk River ATM pool habitat parameter data, 2003-2011.

7.1.3 Surface and Sub-surface Streambed Sediment

Sediment that composes the streambed can be separated into two categories: surface sediment is the top layer of material and sub-surface sediment lies beneath the top layer. Both measures characterize the sediment composition, which is a vital factor in the availability of salmonid spawning gravels as well as the success of egg incubation and emergence. Surface sediment is measured using a standardized pebble count method of 300 pieces per sampling site at three different riffles within the reach. Findings are reported as a D50 value that is the intermediate measurement of the median (50th) particle in millimeters. Sub-surface sediment is measured using a shovel sampling method at three pool tailouts within the sampling reach. Sediment volume must be a minimum of 2,000 grams of particles under 125 cm in size.

Samples are dry sieved in HRC's State licensed sediment processing laboratory. Methods for surface and sub-surface sediment sampling have been consistent and comparable for the years of 2003 through 2011.

Data collected does not present any strong trends over the nine years as sites display variability from year to year and site to site independent of trends. Data can be used to characterize regions of the watershed and identify areas of concern that need more consideration for future monitoring. Sediment parameters tend to be the least likely to achieve APFC targets in the lower reaches of Elk River on HRC ownership underlain by Wildcat lithology. The majority of sites meet criteria for fine sediment less than 0.85 mm but no sites meet targets for percent particles less than 6.35 mm (Figure 7-7). Geomean, bed surface D50, and Fredle Index are mostly below target due to the large fraction of substrate less than 6.35 mm. Sediment in the lower deposition zone, completely underlain by Wildcat geology, is largely small sediment with very high percentages of fine sediment (Figure 7-7). This region has shown little change over the sampling period and any changes that may have occurred cannot be separated from sampling variability values. The combination of lower gradients, reduced stream velocity, and increased channel roughness acts to reduce channel conveyance and cause deposition at some locations.

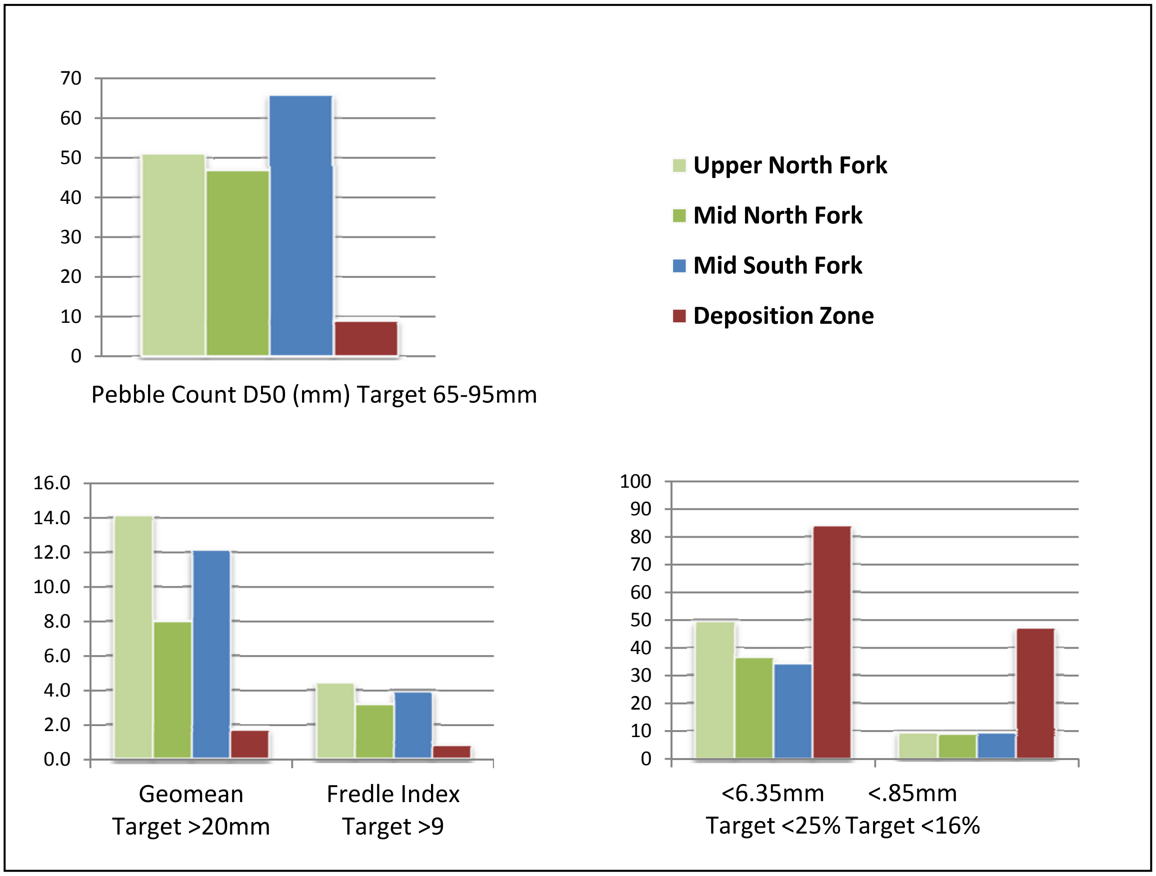


Figure 7-7. Elk River ATM surface and sub-surface sediment parameter data; 2003-2011.

7.1.4 Canopy and Temperature

Canopy measurements are taken within the riparian zone and over the mid channel throughout the sampling reach. Water temperature is also measured using a data recorder from June through September annually and used to calculate the maximum weekly average temperature (MWAT). Although there are many different factors influencing water temperature, shade over the channel as well as air temperatures are dominant factors in reducing direct thermal heating. Measurements for riparian canopy are taken every 200 feet on both sides of the stream within the riparian zone (30 feet from bankfull) with an APFC target of 85% closure and 90% where stream temperatures do not meet the APFC target value.

Water temperature records confirm that all Elk River ATM reaches have suitable temperatures for salmonid rearing during the summer months. Stream temperature at all sites have either stabilized or decreased over the decade. In the absence of a major drought event or severe canopy removal, it is unlikely that temperature will be a limiting factor in this watershed. Water temperature and canopy are further discussed in section 5.3.1 above.

7.1.5 Confidence and Applicability of Data

HRC (and previously PALCO) has collected instream data at the ATM stations for over 15 years. Over this time the methods and intensity of effort has been adjusted several times in attempts to increase the value of data collected. Reviewing the last 10 years of data collected under consistent methods and effort give us a greater understanding of the significance to which this data can be used to draw conclusions on character and trends within the watershed. There are specific parameters such as LWD key piece that have very large variability due to surveyor interpretation and there are other parameters such as water temperature that are highly controlled and more reliable. HRC believes that the location and length of monitoring reaches are not adequate for meeting the purpose of detecting trends due to the limited sample size. HRC would like to focus more on core parameters with higher confidence and those more relative to the watershed-specific concerns.

7.2 FISHERIES

Information on fish populations and distribution has been collected throughout the Elk River WAU by different state, federal and private parties over the last decade, and various life stages have been investigated in attempt to assess salmonid status within the area. Fish surveys conducted in Elk River include estuary/ecotone juvenile seining, summer juvenile density and presence/absence surveys, as well as winter adult spawner surveys. Findings can be useful to update fish distribution maps, evaluate assumptions and applicability of APFC targets, and importantly assist HRC and others in making future management decisions, including those surrounding restoration and enhancement.

7.2.1 Fish Populations

Juvenile sampling data (Table 7-2) indicate Coho and steelhead have been utilizing all major reaches between 2001 and 2012. In 2013, HRC began employing methods developed by Garwood and Ricker (2013) to achieve a relative measure of Coho density and occupancy in various reaches of the Elk River. A multiple pass, snorkel survey approach was used to survey 3 to 5 pools per aquatic habitat trend monitoring (ATM) reach. Locations and findings from these surveys are presented in Figure 7-8 and Table 7-2. Results indicate the highest Coho densities (76 to 110 per pool) occur within the middle North Fork Elk reach. Habitat surveys in 2013 indicate this reach contained the greatest amount of off channel habitat, which could be related to the high Coho density relative to other reaches in the watershed. The downstream depositional reaches were found to have the second greatest densities of Coho, ranging from 26 to 75 fish per pool. Coho were also observed in the Upper North Fork Elk Reaches but to a lesser extent (0.2 to 23 per pool).

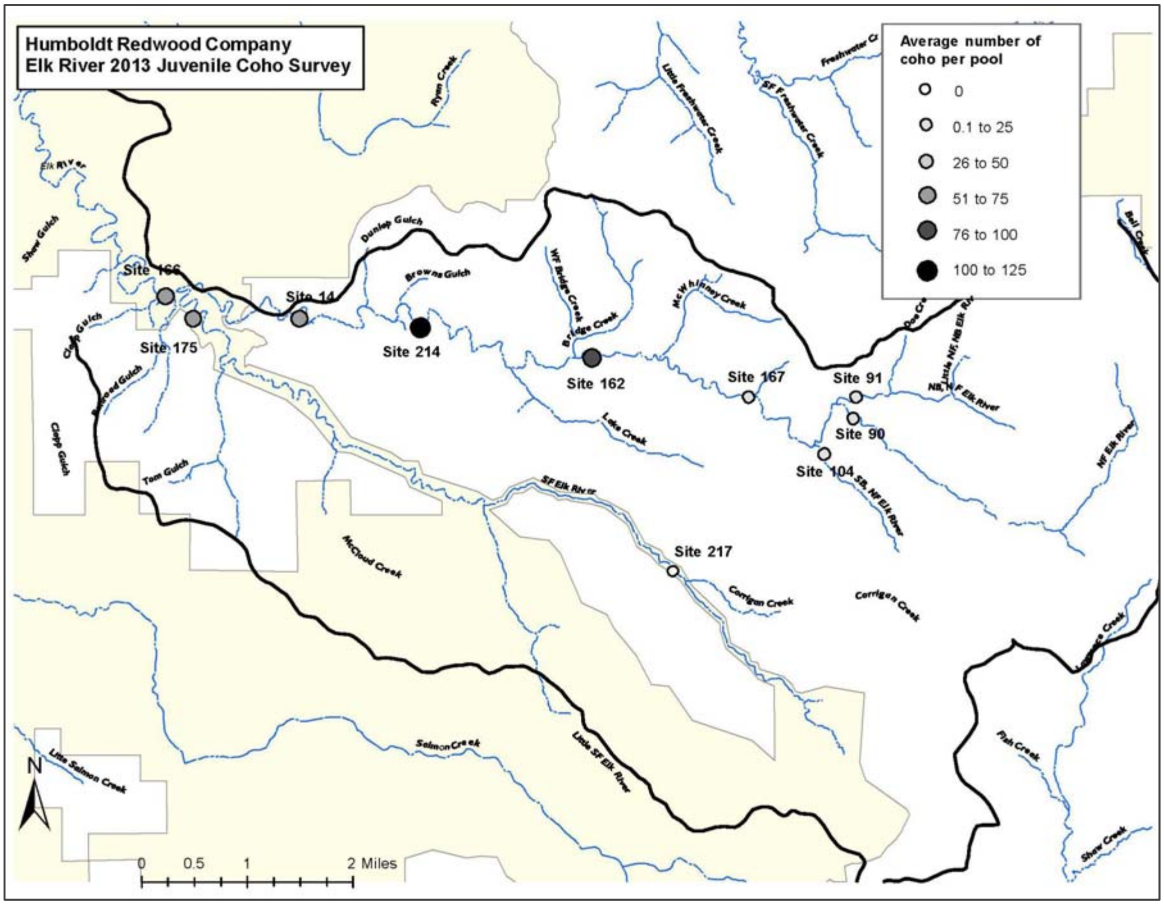


Figure 7-8. HRC Elk River 2013 juvenile Coho dive survey findings.

Table 7-2. 2013 HRC Elk River juvenile Coho dive survey results.

Site Name	ATM Site #	Average Density (#fish/pool)	Average Pool Volume (m^3)	Sample Size (# of pools)	95% Confidence Interval
NB NF Elk River	91	22.6	18.5	5	13.2
SB NF Elk River	104	0.2	5.2	5	0.4
Upper NF Elk River	90	19.5	17.4	3	15.7
Upper Middle NF Elk River	167	20.0	12.7	5	11.9
Middle NF Elk River	162	76.9	62.9	4	20.9
Lower Middle NF Elk River	214	109.8	116.1	5	44.8
Upper SF Elk River[1]	217	0.0	31.0	5	0.0
Lower NF Elk River	14	74.0	46.3	5	25.5
Lower SF Elk River	175	36.5	30.8	4	17.6
Mainstem Elk River	166	26.3	39.4	3	17.4

[1] *Station 217 is upstream of a known salmonid migration barrier*

CDFW conducts spawner surveys on 1.9 to 6.8 miles of stream at established reaches of the North and South Forks of Elk River annually (Table 7-3). Redds are identified, counted and categorized by salmonid species. The majority of redds are unable to be identified by species and are categorized as unknown. A review of data on observed live and dead fish present during the redd survey indicates that very few Chinook are utilizing either North or South Fork Elk River. For this reason, it is assumed that the majority of redds are that of Coho Salmon. The reaches surveyed and number of visits varies by year based on stream conditions and available staffing. In winters with more storm activity, fewer surveys were conducted due to unsafe flows and decreased visibility. Surveys were generally completed for the season by mid-February but did range from January 22nd to March 19th. Ideally, data would have been collected until no new redds were found but this was not the case in most years. Regardless of sampling effort, the number of redds are totaled and divided by the sampling distance completed during each sampling period. Results from this data indicate a significant increase of Salmonid redd densities in 2011 and 2012 (Figure 7-9).

Table 7-3. Elk River spawner survey reach location and effort; CDFW 2003.

North Fork Elk River

2003-2008	2009	2010-2011	2012	reach #	*miles from mouth*		Reach Distance (miles)
					start	*finish*	
x			x	1039	3.4	5.5	2.2
x	x	x		1040	5.5	7.4	1.9
x			x	1041	7.4	8.8	1.4
x				1042	8.8	10.2	1.4
South Fork Elk River							
x	x			1099	1.6	3.5	1.9
	x	x	x	1100	3.5	5.2	1.7
			x	1101	5.2	7.3	2.1

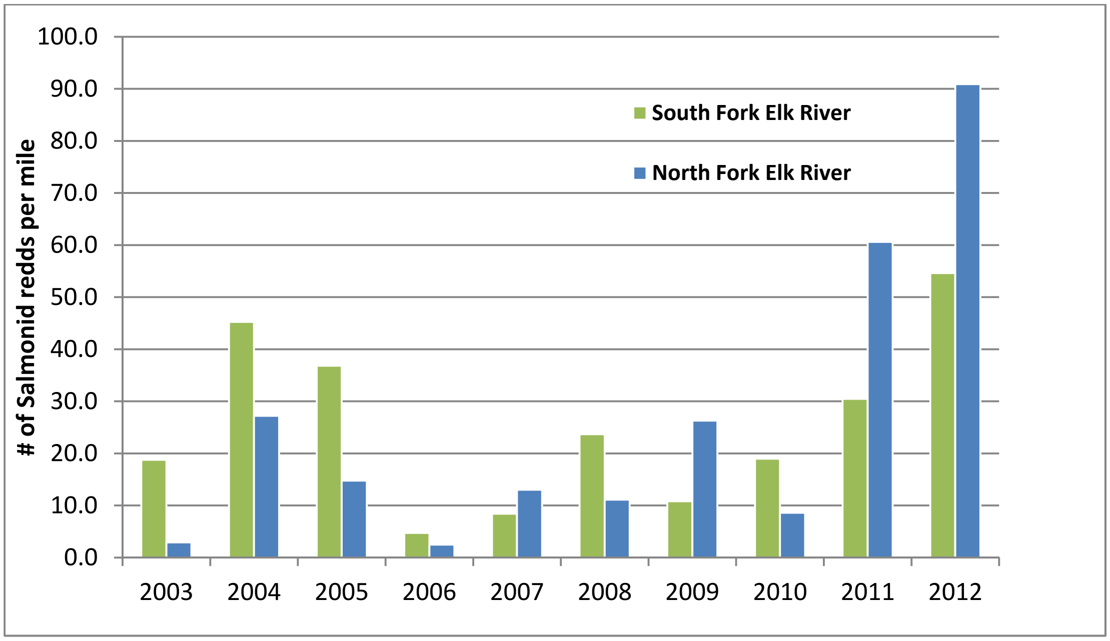


Figure 7-9. North and South Fork Elk River Salmonid redd density, CDFW winter spawner surveys, 2003-2012.

To put the local trends of Elk River into context with regional salmonid runs, redd densities in Elk River can be compared with Coho adult escapement estimates of other Southern Oregon Northern California populations. Escapement numbers from Prairie Creek and Freshwater Creek were generated from weir counts and spawner surveys conducted by CDFW (Figure 7-10).

Fish escapement is defined as the estimate number of adult fish returning to the particular stream or watershed in a particular year. Index reach redd density metrics estimate the number of redds created in a particular reach of stream. In Elk River, trend estimates can only be made for the particular index reach, not for the entire watershed. Redd densities have been shown to be highly correlated to basin-wide escapement estimates when reaches were chosen at random in nearby Freshwater Creek (Ricker and Anderson, 2012).

With the exception of the 2011 and 2012 spawning year classes, redd density trends in this index reach are generally consistent with adult Coho escapement estimates of other Southern Oregon Northern California populations from 2003 to 2011 (Moore et al 2012; Duffy 2012; Williams 2011). Favorable ocean conditions (Peterson 2012) and mild winter weather since 2006, may explain the significant increase in spawning adult Coho in 2011 and 2012 within Elk River. Years with winters producing intensive rainfall and associated flow events can scour newly created salmonid redds and displace overwintering juvenile Coho in reaches lacking suitable overwintering habitat. You would expect to see the implications of this throughout the lifecycle of that year class. Fishing regulations and reduced ocean harvest have been in place during the entire reporting period (2003-2012) and may or may not be a contributing factor in the recently improved Coho runs.

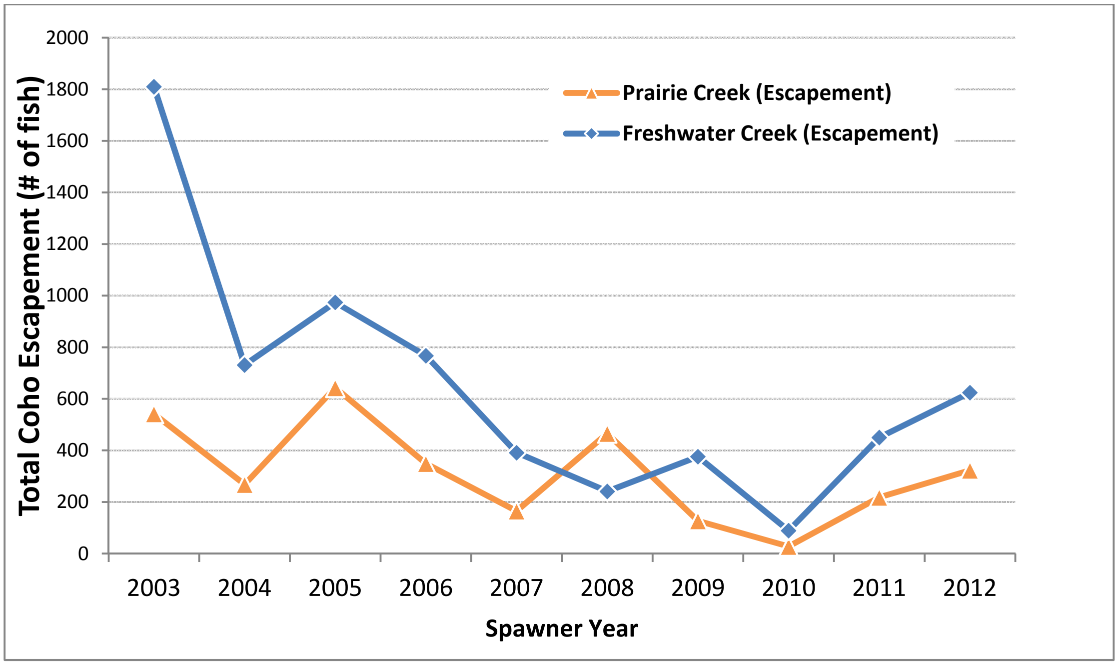


Figure 7-10. FreshwaterCreek and Prairie Creek adult Coho escapement estimates; CDFW 2003-2012.

Further discussion on regional fish populations can be found in:

- Escapement, spawning distribution and migration patterns of adult salmonids in Freshwater Creek (Moore 2012)
- Redwood Creek life cycle monitoring. Final Project Report, (Duffy 2011)

7.2.2 Salmonid Habitat Value

Physical in-stream habitat conditions were addressed in section 7.1 above and provide the basis for further analysis of habitat value for the HCP covered salmonid species. ATM data from 2011 was used to assign species-specific habitat value for the major Elk River reaches based on APFC targets, scientific literature, regional value comparison, and professional judgment. HRC considers this approach preliminary and plans to build on this with regional data and further investigation. Metrics use pool, LWD, and temperature parameters to assign habitat value as “poor”, “fair”, or “good” (Table 7-4, Table 7-5, and Table 7-6).

Table 7-4. Salmonid spawning habitat value assessment criteria.

Spawning (Fredle Index)[1]

Fish	Poor	Fair	Good
Chinook	<3	3 to 9	>9
Coho	<3	3 to 9	>9
Steelhead	<2	2 to 6	>6
Cutthroat	<2	2 to 6	>6

[1] *Lotspeich and Everest (1991)*

Table 7-5. Salmonid summer rearing habitat value assessment criteria.

Summer Rearing (Pool Depth /Complexity/Temperature)[1]

Fish Species	Residual Pool Depth (meters)	Pool Spacing /Channel Width	Total LWD piece / 100’ (% of PFC target)	Temperature (MWAT °C)
	Poor			
Coho	<0.3	>10	<60%	>16.8
Steelhead	<0.1	NA	<60%	>16.8
Cutthroat	<0.1	NA	<60%	>16.8
	Fair			
Coho	0.3 to 0.9	6 to 10	61 to 100%	14.1 to 16.7
Steelhead	0.1 to 0.3	NA	61 to 100%	14.1 to 16.7
Cutthroat	0.1 to 0.3	NA	61 to 100%	14.1 to 16.7
	Good			
Coho	>0.9	<6	>100%	<14
Steelhead	>0.3	NA	>100%	<14
Cutthroat	>0.3	NA	>100%	<14

[1] *PFC Matrix Criteria, Cannata et al. (2006), Platts (1983), and Ricker and Anderson (2011)*

Table 7-6. Salmonid winter rearing habitat value assessment criteria.

Winter Rearing (pool depth and complexity)[1]

Fish Species	Residual Pool Depth (meters)	Pool Spacing /Channel Width	Total LWD piece / 100’ (% of PFC target)	Average Stream Gradient	Off Channel Rearing Habitat Present
	Poor				
Coho	<0.3	>10	<60%	>4%	None
Steelhead	<0.1	NA	<60%	>4%	None
Cutthroat	<0.1	NA	<60%	>4%	None
	Fair				
Coho	0.3 to 0.9	6 to 10	61 to 100%	3%	Moderate
Steelhead	0.1 to 0.3	NA	61 to 100%	3%	Moderate
Cutthroat	0.1 to 0.3	NA	61 to 100%	3%	Moderate
	Good				
Coho	>0.9	<6	>100%	<2%	High
Steelhead	>0.3	NA	>100%	<2%	High
Cutthroat	>0.3	NA	>100%	<2%	High

[1] *PFC Matrix Criteria, Bilby and Ward (1994), Platts (1983), and Cannata et al.(2006)*

Table 7-7, Table 7-8, and Table 7-9 characterize Chinook salmon, Coho salmon, and steelhead/cutthroat habitat value at each Elk River reach.

Table 7-7. Chinook salmon habitat rating and trends in Elk River.

Reach	ATM Sites	Spawning Habitat Condition
Upper North Fork	90, 91, 104	Fair
Mid North Fork Elk	214, 162, 167	Fair
Mid South Fork Elk	217	Fair
Deposition Zone	14, 175, 166	Poor

Table 7-8. Coho salmon habitat rating and trends in Elk River.

Reach	ATM Sites	Spawning habitat Condition	Summer Rearing Condition	Winter Rearing Condition
Upper North Fork	90, 91, 104	Fair	Good	Fair
Mid North Fork Elk	214, 162, 167	Fair	Good	Good
Mid South Fork Elk	217	Fair	Fair	Fair
Deposition Zone	14, 175, 166	Poor	Fair	Fair

Table 7-9. Steelhead/cutthroat trout habitat rating and trends in Elk River.

Reach	ATM Sites	Spawning habitat Condition	Summer Rearing Condition	Winter Rearing Condition
Upper North Fork	90, 91, 104	Fair	Good	Fair
Mid North Fork Elk	214, 162, 167	Fair	Good	Good
Mid South Fork Elk	217	Fair	Fair	Fair
Deposition Zone	14, 175, 166	Poor	Fair	Fair

Based on index reach trends data, salmonid habitat conditions for all key life history stages are in fair to good condition. The exception is within the lower reaches of NF Elk River where underlying geology and deposition combine to limit suitable spawning substrate. ATM index reach data show all major reaches upstream of the deposition zone have spawning habitat that is fair to good. Summer and winter rearing conditions are considered fair to good within all of the major reaches.

As the qualitative metrics for the habitat value assessments are based on a variety of sources, HRC requested further review from Stillwater Sciences in order to determine their validity. In their analysis, Stillwater suggested that "…the habitat parameter data and assignments of qualitative (poor, fair and good) values needs to be better supported…" and went on to state that a confidence rating cannot be applied until further supporting documentation is provided. They also stated that assigning these values in order to understand the varying levels of habitat quality in the watershed is a good idea, and tentatively agreed with the assigned values. In light of Stillwater's opinion regarding this information, HRC has included references, also footnoted at the bottom of Tables 7-4, 7-5, and 7-6 which serve to inform the development of the habitat value system.

During storm events, juvenile salmonids typically seek shelter in the lower flows of side- and off-channel habitat to feed and meet energy budgets. Ricker and Anderson (2011) observed high densities of overwintering Coho in nearby Freshwater Creek floodplain off-channel habitats when juvenile density levels were high. This type of habitat is limited in the lower regions of Elk River, downstream of HRC property, due to historical manipulation of the channel, urbanization and agricultural uses. Reconnecting access to historic floodplains has been shown to increase Coho production at a greater rate when compared to any other habitat enhancement modification project (Roni et al 2010). Restoration projects such as enhancement or creation of off-channel habitat and reconnection of flood plains in the channelized lower Elk River should be considered.

7.2.3 Salmonid Feeding Patterns

Continuous turbidity data from Elk River water quality monitoring sites was used to explore turbidity regimes as they pertain to salmonid feeding. In this analysis, we explored turbidity limitations on fish feeding because of the strong correlation to growth and ultimately survival. The energy gained through winter feeding is an important part of the year-round energy budget and significantly influences overwintering growth and survival (Harvey and Wilzbach 2009).

Salmonids employ two main types of feeding strategies throughout the winter. Drift feeding occurs in the main channel flow and benthic feeding occurs in areas of reduced velocity found often in backwater, side channel, and off-channel flows. As turbidity rises above 25 NTU during high flows, the ability of fish to efficiently drift feed decreases as reactive distance is minimized (Sweka and Hartman 2001). Between 25 and 100 NTU, Coho feed successfully by utilizing a benthic feeding strategy in low velocity habitats. Harvey and White (2007) found Coho were significantly feeding on entrained oligochaetes during higher stream flows and elevated turbidity conditions (weighted average greater than 100 NTU). In a laboratory study, Bisson and Bilby (1982) noted Coho avoided conditions greater than 70 NTU when give a choice between clean and turbid water. The Bisson and Bilby (1982) results suggest, when given a choice, Coho seek turbidity levels (< 70 NTU) which enable both drift and benthic feeding strategies to be employed, thus optimizing food intake. However, Harvey and White (2007) results indicate Coho continue to feed between 70 to 100 NTU, if low velocity habitats are present, by employing a benthic feeding strategy.

Continuous turbidity values collected every 15 minutes from the lower NF Elk River (station 511) from the 2011 hydrologic year were used to calculate total hours of turbidity values greater and less than 25 and 100 NTU per month (Figure 7-11). These turbidity value thresholds were based on the premise that drift feeding is reduced significantly at turbidity levels greater than 25 NTU (Sweka and Hartman 2001), while benthic feeding becomes limited at levels greater than 100 NTU (Harvey and White 2008; White and Harvey 2007). Between October 15 2009 and May 23, 2010, suitable benthic feeding conditions existed 95% of the time, while suitable drift feeding conditions occurred 77% of the time. April 2010 was a period with the greatest storm frequency. During this time, suitable benthic feeding conditions occurred 88% of the time, while suitable drift feeding conditions occurred 44% of the time.

Duration of avoidance and focused feeding behavior was calculated as hours of turbidity greater than 70 NTU (Figure 7-12). Turbidity measurement locations were intended to provide a baseline of turbidity in the North Fork deposition zone.

Low gradient channel morphology, such as the channel types of the lower North Fork deposition reach, is conducive to establishing low velocity pools and off-channel habitats during higher flows (Bell 2001, Ricker and Anderson 2011). Although further research is warranted to better characterize food availability during receding turbidity limbs, it appears that during a normal water year, the lower North Fork Elk River winter turbidity regime and physical habitat condition enables juvenile overwintering salmonids to consistently feed during the winter months.

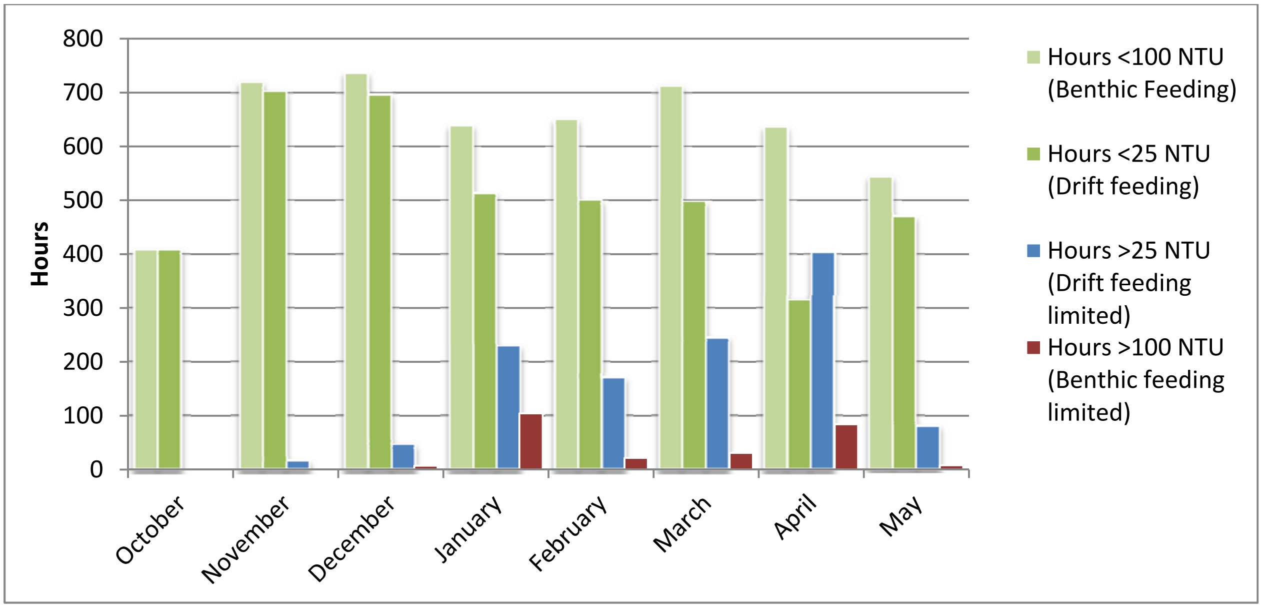


Figure 7-11. Turbidity and predicted Coho feeding mechanism durations at Lower NF Elk River (station 511); October 2009 through May 2010.

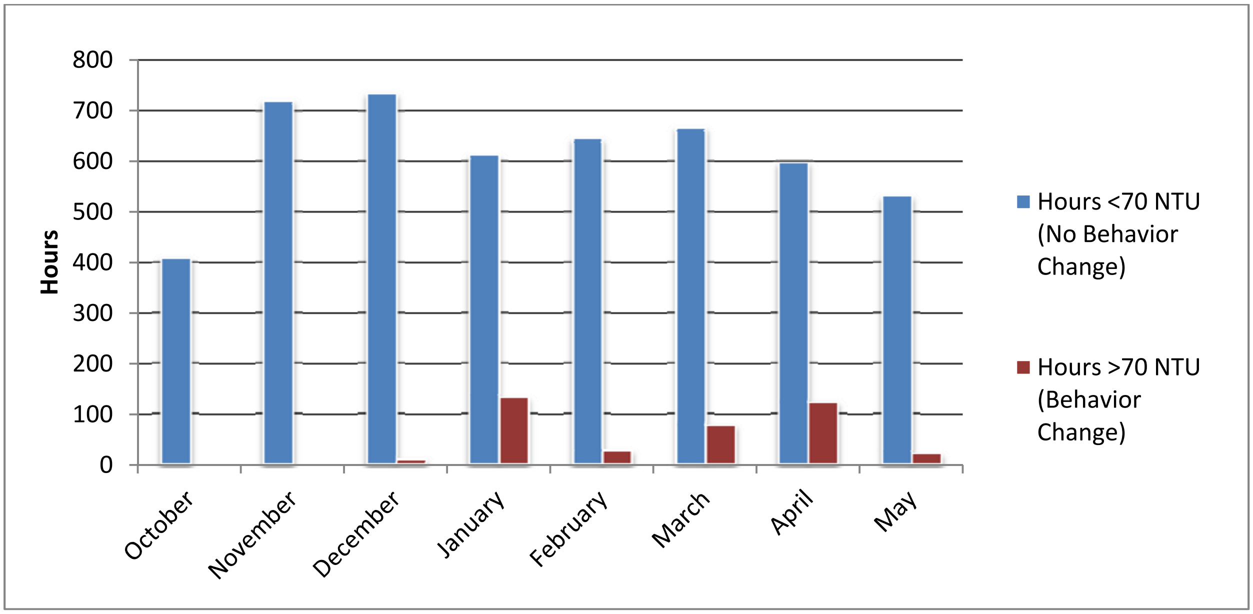


Figure 7-12. Turbidity and predicted Coho feeding behavior durations at Lower NF Elk River (station 511); October 2009 through May 2010.

HRC recognizes there are other specific effects of suspended sediment on salmonid behavior, physiology, and habitat (Berg and Northcote 1985; Newcombe and Jensen 1996). The most commonly used method of assessing effects of suspended sediment on salmonids is the use of a severity of ill effects index developed by Newcombe and Jensen (1996). References used in Newcombe and Jensen (1996) are primarily lab based studies which focus on drift feeding in a static environment. These studies do not take into account the various Coho feeding behaviors or available food items found in natural streams. Therefore, we chose not to use this index because references used to generate sub-lethal effect scores are inaccurate. Further, there has been no evidence linking survival and growth of Coho to behaviors such as abandonment/avoidance or minor/moderate physiological stress. Lethal concentration studies (Servizi and Martens 1991; Stober et al 1981) have found acute lethal effects of high suspended sediment concentrations on Coho juveniles where mortality (LD_{50}) was observed at sediment concentrations of 509 mg/L for 96 hours. Elk River mainstem has not exceeded this sediment concentration duration threshold between 2003 and 2012.

7.2.4 Migration Barriers

No off-road surveys have been completed recently to specifically identify <u>all</u> fish passage barriers within the Elk River watershed; however, barriers are identified during stream visits for other sampling efforts as well as during individual timber harvest plan preparation. All newly discovered barriers are added to HRC's GIS database and used to update distribution and potential restoration maps. A temporary adult salmonid migration woody debris barrier was identified in Upper North Fork Elk River by CDFW in

Figure 7-13. Migrational fish barrier on SF Elk River approximately 1/2 mile downstream of confluence with Corrigan Creek.

2009 and confirmed by HRC in 2012. There are approximately 4 miles of suitable spawning and rearing habitat for Coho, steelhead, cutthroat, and to a lesser extent Chinook, upstream of this barrier. Another temporary woody debris barrier on the SF Elk River approximately ½ mile below Corrigan Creek (Figure 7-13) is precluding fish migration based on the 2012 presence/absence data. Further investigation of habitat and fish distribution upstream of these barriers, along with other considerations such as stored sediment, is warranted before implementing restoration activities.

One known anthropogenic infrastructural fish barrier (e.g. culvert or log-fill stream crossings) is located on HRC's ownership in Clapp Gulch. The culvert causing this partial barrier will be replaced with a bridge in 2014 as part of the McCloud-Shaw THP (1-12-110HUM), improving juvenile salmonid access to seasonally available off-channel wetland habitat adjacent to the primary channel.

7.2.4.1 Goals for Future Restoration

- Assess tributaries and upper major reaches to determine current fish extent, barriers, and restorable habitat in conjunction with new Timber Harvest Plan layout. This will enable restoration actions to be permitted and implemented through the THP process.
- Assess the Upper North Fork and South Fork Elk River barriers to determine the benefit and feasibility of removal in conjunction with state and federal agencies.
- Work with downstream landowners to restore overwintering floodplain and off-channel habitat.
- Focus enhancement projects on overwintering habitat on HRC property.

8 AMPHIBIANS AND REPTILES

HRC completes annual monitoring of covered species habitat and presence as described under the Aquatic Conservation Plan (ACP) in the HCP. These covered species include southern torrent salamander (*Rhyacotriton variegatus*), tailed frog (*Ascaphus truei*), northern red-legged frog (*Rana aurora aurora*), foothill yellow-legged frog (*Rana boylii*), and northwestern pond turtle (*Emys marmorata*). Distribution of covered species continues to be fairly widespread in suitable habitat. The ERSC WAU continues to host quality habitat for southern torrent salamanders, northern red-legged frogs, and tailed frog. Monitoring efforts have not focused on habitats preferred by yellow legged frogs or western pond turtles, which are more limited in the ERSC WAU.

All information gathered since the initial Watershed Analysis supports those earlier findings. HRC surveys have indicated that red-legged frogs within the property-wide study area deposit their eggs from October through February which is considerably earlier that suggested in literature for other regions of the West Coast (Storm 1960, Brown 1975, Licht 1969). Property-wide monitoring has also found that ponded waters were often heavily utilized for egg deposition (one site with over 320 egg masses), while pools observed within watercourses were not utilized.

At this time, all monitoring suggests that prescriptions intended to protect watercourses by minimizing water temperature increases, minimize sediment input and encourage LWD recruitment continue to provide good habitat for amphibians and reptiles within the ERSC WAU.

Further detail regarding Amphibian and Reptiles can be found in the following documents:

- Elk River/Salmon Creek Watershed Analysis (PALCO, 2005)
- 2011 Amphibian Reptile Report (HRC 2012)

9 RECOMMENDATIONS

Watershed analysis re-visitation provides information to HRC Resource Managers and the Wildlife Agencies as to near and long term effectiveness of forest management prescriptions in maintaining or achieving properly functioning aquatic habitat conditions over time. Review of trends and effectiveness monitoring studies may result in the revision of the prescriptions as part of adaptive management, or lead to the conducting of additional analysis which may subsequently trigger prescription modification (HCP §6.3.2.3). Any proposed prescription modification(s) are subject to the same processes as the initial Watershed Analysis including review and establishment by the wildlife agency or agencies. Individual Aquatic Monitoring plans for each WAU may also be updated in response to findings and/or new questions raised regarding watershed trends and HCP effectiveness (HCP §6.3.5). Identification and/or prioritization of watershed management activities including potential restoration or enhancement projects may also result from watershed analysis re-visitation.

9.1 FOREST MANAGEMENT

9.1.1 Hillslope Management (§6.3.3.7)

No recommendations for changes to the current Hillslope Management Prescriptions are proposed, as to date the current strategy appears highly effective in preventing and minimizing management related input.

The dominant geomorphic association for 2001 - 2011 mass wasting was found to be streamside slopes and large (1,000 – 2,000 yd^3) to very large (delivering more than 2,000 yd^3) deeper-seated landslides. These two geomorphic associations make up about 87% of the total landslide delivery to watercourses in the Elk River watershed (see Figure 4-6 in section 4.1.2). Streamside slopes inclined greater than 65% were a greater source of sediment than slopes less than 65% by more than two to one in terms of volume delivered. Landslide volume delivery originating from headwall locations was approximately 3% of total LS delivery for the sediment budget period.

The greatest amount of *management associated* landslide delivery originated from non-stormproofed roads (n=30; 14,130 yds^3 total) and older pre-HCP harvest settings (n = 18; 5,545 yds^3), followed by landsliding associated with stormproofed roads (n=13; 1,400 yds^3). Landslide delivery associated with non-road related HCP timber harvest activities was very limited (n=2; 9 yds^3).

The air photo analysis-based annual landslide delivery estimate of 86 tons/mi^2/year reported for the current sediment budget period (2001-2011) was substantially less than the 444 tons/mi^2/year reported for the previous period (1988-2000) (Elk River HRC HCP covered lands; see Figure 4-8 in section 4.1.2.1).

Small streamside landslide and bank erosion processes account for the majority of mass wasting sediment delivery with a total estimated rate of 556 tons/mi^2/year from 1988 to 2000 compared to a much reduced rate of 253 tons/mi^2/year during the decade 2001 to 2011. Small streamside landslide and bank erosion causal mechanisms related to HCP management were virtually non-existent due to "broad, intact HCP riparian zones" buffering streams from adjacent management areas (SHN 2012).

The findings support continued focus on stormproofing roads to reduce road-related landslide occurrence. Findings also indicate current hillslope management practices implemented in the watershed have to date, been highly effective at avoiding HCP timber harvest-associated landsliding.

9.1.2 Channel Migration Zone and Riparian Management (§6.3.4.1)

Recommendation for potential revision to two unique riparian management zone (RMZ) prescriptions is proposed as follows.

We recommend additional review of the Lower North Fork Elk River Conifer Depletion Zone prescription (§6.3.4.1.2 bullet #5) which currently establishes a 150-foot No Harvest RMZ for approximately 8 miles along the main channel of the North Fork Elk River. As discussed in section 5.3.3 of this WA Revisited Report, the Riparian Enhancement Plan conifer plantings appear to be on a good, long term (50 year plus) trajectory of providing future LWD recruitment to the stream channel. Additionally, regional studies as well as Sullivan's findings presented in section 5.3.2 suggest that recruitment of LWD pieces come primarily from within 50 feet adjacent the stream channel, consistent with the Inner Band No Harvest Zone provided by the standard HCP Class I RMZ. With no reported trend towards increasing LWD loading in the lower reach following a decade of this special prescription implementation, and available science suggesting 50 feet as a reasonable distance for capturing the vast majority of wind throw and bank erosion recruitment, there appears little justification for continuing with a 150-foot No Harvest Zone.

We recommend implementing a LWD recruitment survey of this approximately 8 mile reach. The purpose of this survey is to document and evaluate the distance from the edge of the channel migration zone (CMZ) or active channel that large wood recruitment, in the form of tree fall, is originating. Adjustment to the No Harvest Zone of the RMZ can then be made to ensure at least 80 percent of recruited large wood from riparian tree fall is included within the Inner Band No Harvest Zone, recognizing a minimum 50 foot no harvest zone is a requirement of any future prescription adjustment.

We note that this strategy combined with the established prescription to retain all down wood located within the RMZ plus the 18 largest trees per acre located within 100 feet of the watercourse lake and transition line, and the requirement to retain trees with the highest potential for recruitment in the outer band when meeting outer band post-harvest canopy requirements, represents a comprehensive and likely highly effective strategy for large wood recruitment. Active restoration (i.e. LWD placement projects) is recommended as perhaps the most effective short term method for increasing wood loading.

Our second recommendation pertains to the Corrigan Creek LWD Transport Zone prescription (§6.3.4.1.3 bullet #4). As stated previously in section 5.2.3, no harvest has occurred within the Corrigan Creek Class II LWD Transport Zone (RMZ) since its establishment in 2005. Recent field review of this stretch of Corrigan Creek has confirmed the location of the Class I – II break as mapped but also found channel geomorphology above this break in classification *not to be conducive* to large wood transport due to insufficient channel width (≈ five feet), and the presence of a boulder substrate further limiting transport capacity. There is no physical evidence to suggest that this Class II watercourse performs similar to a Class I watercourse in terms of downstream large wood transport and thus the purpose of the special prescription is moot. In addition we note the logic behind the current special prescription appears flawed, as the previously noted current scientific finding indicates recruitment seldom occurs from beyond 50 feet of the watercourse transition line, let alone 100 feet. The concept of increasing the Outer Band to 150 feet for the purpose of increasing recruitment is not supported by current science. For these reasons, HRC recommends discontinuing the prescription specific to this zone and instead applying the standard ERSC Class II protection measures. These proposed prescription changes based on watershed analysis are provided in Appendix 11.

No other recommendations are made as current prescriptions appear beneficial for stream temperatures and erosion control, and available science, including local studies, suggests zone widths are adequate for optimizing streamside LWD recruitment.

Figure 9-1. Corrigan Creek, immediately upstream of Class I/II transition.

9.1.2.1 Temperature

The Upper North Fork tributary region includes the North Branch (ATM 91) and South Branch (ATM 104) tributaries as well as the mainstem of the NF Elk River (ATM 90) above the confluence with these two tributaries. The MWAT values in this heavily shaded region have remained consistently cool with an average ranging from 13.3° to 15.0° C.

The Upper North Fork region (upstream of the Conifer Depleted Zone) including ATM stations 167 and 162 has also remained cool with annual average MWAT temperatures ranging from 14.7° to 16.2° C.

Downstream along the lower NF Elk River region (ATM 14 and 214), in the vicinity of the Church Camp and the Boy Scout Camp, average annual MWAT values ranged from 17.2° to 19.0° C prior to 2008, but have shown a decreasing trend since 2008 (< 16.8° C) as mid channel canopy has continued to close in above the stream.

Measured MWAT in the SF Elk River at ATM 175 located near the South Fork – North Fork confluence, and upstream near the mouth of Corrigan Creek at ATM 217, has also shown a cooling of stream temperature in recent years. The average annual MWAT has ranged from 13.8° to 17.1° C over the monitored period. As noted in Figure 5-3 (section 5.3.1), site 217 was established in 2005 and on average has an MWAT that runs 1.5°C less than that recorded at site 175. Over-stream canopy cover along the South Fork has remained constant at greater than 90 percent.

One station (ATM 166) is monitored on the mainstem of Elk River, a short distance downstream of the North Fork – South Fork confluence. Stream temperature there has achieved the standard PFC matrix target (≤ 16.8°C), and been trending cooler since 2008.

In summary, MWAT values have been below 16.8° C, and therefore meeting the target, at all stations since 2008. While a fairly consistent trend towards cooler temperatures has been observed, there is also some variation throughout the watershed (Figure 5-2 and Figure 5-3, section 5.3.1). These cool temperatures appear to correlate with an over-stream mid-channel canopy cover that has either remained fairly constant or has been trending toward greater canopy cover. This can be seen in the SF Elk River (>90% canopy) and in the Upper North Fork where canopy cover most recently ranged from 80 – 90 percent (Figure 5-4, section 5.3.1). Both Upper and Lower North Fork regions exhibited a temporary reduction in canopy closure possibly due to peak flow-associated scouring events from the winter of 2006 (HY 2007). Water temperatures in North Fork and mainstem Elk River also were elevated in 2007 likely from a combination of temporarily reduced upstream canopy and high air temperature. Timber harvest has little to no effect on mid-channel canopy closure as no harvest occurs within 50 feet of the stream bank, or along the lower North Fork Elk within 150 feet.

9.1.2.2 Large Wood

In-stream LWD volume frequency and density are highest in the upper reaches and decrease progressing down the watershed. ATM Station 214 near Brown's Gulch is the location where frequency and volume of wood begins to dramatically decrease moving downstream. Regions upstream consistently exceed volume and frequency targets. Key piece frequency in the upper watershed group meet APFC targets whereas values are below target for all other sampling reaches. Identification of LWD key pieces has been problematic throughout the sampling effort and HRC needs to further refine sampling accuracy for this parameter.

Overall, wood presence and functionality appears to be similar between South Fork and North Fork Elk River with no increasing or decreasing trends standing out in the dataset. LWD presence and functionality is lowest for the grouped ATM stations furthest downstream, presumably due to greater transport capacity associated with higher stage discharge and increasing channel width.

LWD recruitment surveys conducted in the adjacent Freshwater Creek watershed in 2004 found that a significantly larger percentage of trees (LWD) were recruited from nearer the channel than that reported in studies conducted elsewhere in the region (Benda 2002; Reid and Hilton 1999). These 2004 surveys were conducted along Class I stream reaches measuring diameter, height, and volume of the standing forest on both sides of the stream. Downed trees in the riparian zone were inventoried for number, size, direction of fall, cause of mortality, and whether they reached the stream channel. The survey area for down wood extended perpendicular to the channel approximately 200 feet into the riparian forest. An instream wood survey measured all pieces of LWD within the channel reach. Preliminary analysis of data from Freshwater Creek confirms that LWD pieces that are recruited to Class I streams originate from within 100 feet of the channel (Sullivan, in draft). Most is entering from tree fall originating less than 30 feet from the channel. These results appear to confirm the assumptions used to develop prescriptions for LWD recruitment including establishment of 50-foot No Harvest Zones immediately adjacent Class I streams based on then available literature (Murphy and Kioski 1989, McDade et al. 1990, Reid and Hilton 1998, McKinley 1997).

9.1.2.3 Bank Stability

Approximately twenty-six miles of combined Class I, II, and III watercourse surveys conducted throughout the watershed indicates no visible relationship between HCP (post 1999) timber harvest and bank erosion. RMZ Inner Band No Harvest Zones in combination with Equipment Exclusion Zones and required licensed geologic investigations effectively limit management activities on sensitive banks immediately adjacent streams.

9.2 MONITORING

9.2.1 Aquatic Trend Monitoring Program

The Class I Aquatic Trend Monitoring (ATM) program tracks riparian and aquatic habitat conditions over time. Specifically, the program is designed to assess spawning and rearing habitat conditions for HCP covered salmonids including Northern California steelhead (*Oncorhynchus mykiss)*, Chinook salmon (*O. tshawytscha)*, Coho salmon (*O. kisutch*), and coastal cutthroat trout (*O. clarki clarki*). All of these species are found in the Elk River watershed, and while their habitat requirements are somewhat similar, the HCP emphasizes properly functioning habitat conditions for Coho salmon as the limiting factor around which management is designed.

There are currently 10 Class I ATM reaches monitored on HCR's ownership in the ERSC watershed (Table 7-1). Individual ATM monitoring reaches range from 189 to 450 meters (30x bankfull width).

For several years, HRC has been concerned with certain sampling protocols, insufficient sample size for certain parameters, lack of a biological monitoring element, influences from non-HCP covered lands, and emphasis on time spent collecting an over-abundance of data resulting in less time for meaningful analyses.

The following actions have been made or are proposed to address these concerns:

- Revise Watershed Operating Protocols. WOP 12, Stream and Riparian Canopy Cover Measurement. Proposed changes to WOP 12 relates to the frequency of canopy cover measurements within a reach. The current WOP states that canopy measures will be taken every 61m beginning at 15.2m upstream of the 0+00 start point. The proposed changes will increase the number of canopy measurements taken in each reach with measurements being taken every 25m beginning at 25m upstream of the 0+00 start point. Clarify WOP 14, Habitat Typing and Measurement, or develop new WOP addressing large woody debris measurement and key piece identification.
- Establish and implement biological monitoring protocols for annual collection of fisheries and macro-invertebrate data collection. Currently, HRC is using the California Department of Fish and Wildlife 2013 Juvenile Coho Salmon Spatial Structure Protocol for defining pools to be snorkeled. HRC is considering using the Marine Pollution Studies Laboratory's Surface Water

Ambient Monitoring Program (SWAMP) protocol, or similar, for collecting benthic macro-invertebrate samples.

- Reduce the overall number of ATM stations based on the results of a comparative analysis of all stations for the purpose of identifying reaches in reasonable close proximity that have reflected similar conditions and trends over time Figure 9-2).

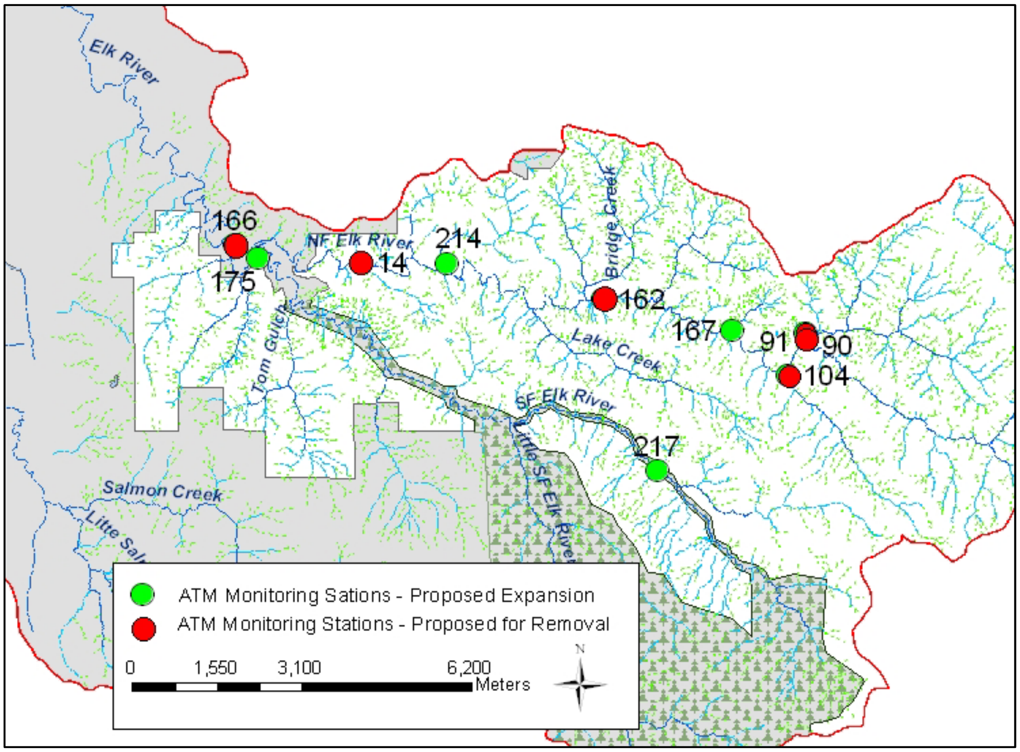


Figure 9-2. HRC Elk River ATM Stations – proposed expansion and removal of stations.

- Each ATM station will consist of the following:
    - A minimum of six (6) established cross-sections, utilizing *existing* cross sections to the maximum extent feasible, and selecting any necessary new locations based on criteria found in HRC's WOP 25 (*Stream Surveying for Cross-Sectional and Longitudinal Profiles*).
    - Riparian forest (RMZ) and overstream canopy, Maximum Weekly Average Temperature (MWAT), pool frequency, depth, and percent habitat type, stream channel surface sediment (D_{50} pebble counts), and instream large wood data including frequency, volume, and key piece information will be collected throughout the *entire* ATM reach.
- Discontinue Longitudinal Profiling at ATM reaches, instead relying upon established cross-sections, and periodic longer thalweg surveys as needed.

- Limit to specific lower ATM stations or discontinue altogether bulk sediment samples, instead relying upon D_{50} counts to characterize channel substrate.
- Complete an in-stream LWD inventory and recruitment origin analysis for North Fork Elk River for comparison with previous 2005 and future surveys, for the purpose of ongoing trends and effectiveness analysis, and for reference in consideration of adjusting the Lower North Fork Elk River Conifer Depletion Zone prescription (§6.3.4.1.2 bullet #5) as discussed above in section 9.1.

9.2.2 Hydrology Trends Monitoring

Turbidity and suspended sediment data has been collected at a total of 16 different locations in Elk River since 2003 with 12 of these stations having a monitoring record of six years or more (section 6.4). This has provided a robust dataset for analysis of turbidity and suspended sediment throughout the watershed. There are currently 10 stations being monitored annually in Elk River throughout the wet weather season including eight trend monitoring stations and two additional stations involved with an HCP effectiveness study, and 20 stations (including these 10) on HRC property-wide.

Physically managing this number of stations property-wide during peak flow storm events to ensure proper functioning, along with the sheer volume of data collection and processing is a difficult task for the four person crew assigned to the program. A typical storm year may see as many as 9,000 sediment samples analyzed at HRC's state certified sediment lab in Scotia; these samples come from the 20 hydrology stations located across the property in three different watershed analysis units. With much learned to date from this past effort regarding local sub-basin yields, and in light of reduced monitoring staff consistent with reduction in timber harvest levels, the HRC science department is recommending a reduction in the overall number of hydrology stations property-wide, primarily in the Freshwater Creek WAU, to allow for greater emphasis on quality control and analysis of watershed characteristics, trends, processes, and land use effects linked to recorded measurements.

HRC recognizes concerns over turbidity and sediment loading in the Elk River watershed in particular and proposes to continue annual monitoring of eight long term hydrology stations along with the two additional stations being monitored for the Railroad Gulch HCP Effectiveness Study described below. The restart of monitoring at station 522 (Corrigan Creek) in exchange for an end to monitoring station station 509 (Elk River mainstem) is proposed pending NCRWQCB approval. The Corrigan station represents water quality from 100% HCP covered lands with active operations and is one of three sub-basins extensively studied by the NCRWQCB over the last decade, whereas the station 509 located on the mainstem is situated on an increasingly unsafe bridge, has HRC monitored stations located in reasonably close proximity above it on both the North and South Fork Elk, has been repeatedly vandalized, and has water quality reflective of land uses other than HCP-covered lands.

We also recommend the relocation of Hydrology Station 534 currently on BLM land in the Headwaters Forest. This station is very difficult to access and therefore manage, and the small contributing drainage area to the station significantly limits the natural variation of inherent watershed conditions and processes reflected in the recorded water quality data. Moving station 534 downstream closer to the confluence with the South Fork Elk River will roughly triple the contributing drainage area, increase natural variability in contributing landscape terrain, and importantly provide greater ease of access, while continuing to monitor non-industrial timberlands in the Elk River watershed as a point of reference. Table 9-1 presents HRC's proposed Hydrology monitoring stations for hydrologic years 2015 through 2024.

Table 9-1. HRC Recommended Hydrology Monitoring Stations for HY 2015-2024.

Location	Station ID	Basin Area (km^2)	Basin Area (mi^2)	Monitoring Record	Proposed Status (next 10-year period)
Mainstem Elk River (metal Bridge)	509	111.53	43.06	2003-2014	Inactive
S. Fork Elk River	510	50.25	19.40	2003-2014	Active
N. Fork Elk River	511	56.82	21.94	2003-2014	Active
N. Fork Elk River	532	35.03	13.53	2005-2014	Active
Clapp Gulch	543	2.28	0.88	2013	Inactive
Railroad Gulch	514	3.01	1.16	2013.00	Inactive
Bridge Creek	517	5.71	2.20	2003-2014	Active
S. Branch N. Fork Elk River	519	4.90	1.89	2004-2012	Inactive
Corrigan Creek	522	4.33	1.67	2003-2012	Active
S. Fork Elk Mainstem (below 520)	183	19.49	7.53	2003-2011	Inactive
S. Fork Elk Mainstem (above 520)	188	16.12	6.23	2003-2014	Active
Tom's Gulch	533	6.45	2.49	2006-2014	Active
Little S. Fork Elk (headwaters)	534	3.03	1.17	2004-2014	Active[1]
Doe Creek tributary	550	0.14	0.05	2006-2012	Inactive
Railroad Gulch - East Branch	683	1.46	0.56	2014	Active
Railroad Gulch - West Branch	684	1.28	0.49	2014	Active

[1] Propose moving station 534 downstream and establishing new station number

No changes to Hydrology Monitoring Station data collection protocols are proposed.

9.3 EFFECTIVENESS MONITORING

9.3.1 Railroad Gulch Effectiveness Study

HRC, with third-party assistance, has designed a Best Management Practices Evaluation Program (BMPEP) to be implemented in the Railroad Gulch sub-basin to test the effectiveness of HCP prescriptions in minimizing sediment-related impacts from harvest and harvest-related activities including road management. This project consists of studies that will test prescriptions designed to prevent and minimize sediment production and delivery from potential sources including roads, landslides, bank erosion, upslope head-cutting and harvest unit surface erosion. Eight (8) hypotheses have been formulated addressing overall THP sediment minimization and prevention effectiveness, including streambank and hillslope mass wasting avoidance, stream channel erosion, and road-related sediment delivery.

Studies will take place solely within the Railroad Gulch sub-basin, focusing on the approved McCloud-Shaw THP (1-12-110HUM) along the East Branch, while the West branch of Railroad Gulch will serve as the control. This project was implemented in HY2014 prior to THP implementation to obtain baseline data and is planned for substantial completion by 2019, the third year following the completion of all timber harvest plan activities. At this time, harvest is scheduled to be completed by end of year 2016. Results of these studies will add to the growing body of work either validating current sediment prevention and minimization practices or providing for informed adaptive management. The project location is of particular geologic interest because it is conducive to the study of the poorly-indurated and fine grained nature of the Hookton Formation and underlying undifferentiated Wildcat Group sediments found in the lower to middle reach of the Elk River watershed. The Railroad Gulch Best Management Practices Evaluation Project Plan is included as Appendix 13.

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