UPPER ELK RIVER SEDIMENT TMDL:

ASSESSMENT OF THE FIRST FIVE YEARS

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Final Staff Report
Upper Elk River Sediment TMDL
Assessment of the First Five Years

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North Coast Regional Water Quality Control Board

August 2022

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Acronyms

AHCP	Aquatic Habitat Conservation Plan
ATM	Aquatic Trends Monitoring
BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife
CGS	California Geologic Survey
CWC	California Water Code
CSDS	Controllable Sediment Discharge Sources
DDW	Division of Drinking Water
DFA	Division of Financial Assistance
ECP	Erosion Control Plan
ERRA	Elk River Recovery Assessment
ERRP	Elk River Recovery Plan
FPR	Forest Practice Rules
GDRC	Green Diamond Resources Company
HRC	Humboldt Redwood Company
MATO	Master Agreement for Timber Operations
MRP	Monitoring and Reporting Requirements
NHE	Northern Hydrology and Engineering
NMFS	National Marine Fisheries Service
NTMP	Nonindustrial Timber Management Plans
NRCS	Natural Resource Conservation Service
NTO	Notice of Timber Operation

NWS	National Weather Service
OLS	Ordinary Least Squares
OPP	Office of Public Participation
PG	Professional Geologist
ROWD	Report of Waste Discharge
SAFER	Safe and Affordable Funding for Equity and Resilience (SAFER)
SEV	Severity of Ill Effects
SSC	Suspended Sediment Concentrations
THP	Timber Harvest Plan
TMDL	Total Maximum Daily Load
UER	Upper Elk River
USFWS	U.S. Fish and Wildlife Service
WAU	Watershed Analysis Unit
WDR	Waste Discharge Requirement
WY	Water Year

Section 1: Introduction

Located in Humboldt County, the Elk River Watershed is 58.3 square miles and drains directly into the Humboldt Bay, south of Eureka, CA. Due to excessive sedimentation the entire watershed was placed on the Section 303(d)-Impaired Waters List of the Clean Water Act in 1998. Designed to address and reduce the excessive sediment sources in the upper 44.2 square miles of the watershed, the North Coast Regional Water Quality Control Board (https://www.waterboards.ca.gov/northcoast/) adopted a sediment total maximum daily load (TMDL) and an implementing TMDL Action Plan in 2016. The Upper Elk River Sediment TMDL Action Plan (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/180319/ACTION_PLAN_FOR_THE_UPPER_ELK_RIVER_SEDIMENT_TMDL.pdf) establishes the sediment loading consistent with current conditions in the impacted reaches[1], identifies a process for assessing and implementing necessary and feasible remediation and restoration actions, and describes a program of implementation."

To achieve its goals, the TMDL Action plan identifies three main elements: the Watershed Stewardship Program, the Elk River Recovery Assessment (ERRA), and Waste Discharge Requirements (WDRs) and/or Waivers of WDRs. In combination, these components are designed to reduce sedimentation, reduce nuisance flooding, expand sediment assimilative capacity, and establish an overall pathway to beneficial use recovery and water quality attainment.

The Watershed Stewardship Program is a community-based program under which implementation of health and safety projects, remediation and restoration activities, and science and coordinated monitoring serves to support beneficial use enhancement and a trajectory of watershed recovery including abatement of nuisance flooding and an expansion of sediment loading capacity. The Watershed Stewardship Program is discussed in greater detail in Section 3 of this report.

The Elk River Recovery Assessment (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/190516/ERRA Framework Final compiled_031419.pdf), completed by CalTrout in 2019, is a comprehensive sediment and hydrodynamic modeling tool with which to evaluate different restoration and recovery strategies. This modeling tool predicts the routing of water and sediment through the watershed from above the confluence of the north and South Forks to Humboldt Bay under varying precipitation events when 1) sediment

[1] The impacted reach extends from the confluence of Brown's Gulch on the North Fork Elk and Tom Gulch on the South Fork Elk to the mainstream Elk River at Berta Road and is contained within the delineated boundaries of the Upper Elk Watershed

loading is reduced (boundary condition) and 2) a variety of restoration actions are implemented in appropriate reaches as recommended by a Technical Advisory Committee. The ERRA provides the basis for development of the Elk River Watershed Stewardship Program: Sediment Remediation and Habitat Rehabilitation Recovery Plan (https://caltrout.org/wp-content/uploads/2019/05/Elk-River-Stewardship-Recovery-Plan-Public-Draft-July_2022.pdf), which translates restoration concepts into landowner-vetted reach-scale projects. The Recovery Plan is a separate document, produced as a public draft in July 2022, which is a companion to this TMDL Assessment Report.

The TMDL Action Plan identifies WDRs as "the primary regulatory mechanism utilized by the Regional Water Board to control nonpoint source pollution from past and ongoing timber harvest activities." WDRs were adopted by the Regional Water Board for the two commercial timber harvest operations in the watershed, Humboldt Redwood Company, LLC (HRC) and Green Diamond Resource Company (GDRC). WDRs and their implementation are discussed in greater detail in Section 4 of this report.

Table 4 of the TMDL Action Plan requires:

"By 2021, the Regional Water Board shall evaluate the available information to assess the degree to which 1) adopted WDRs and waivers have successfully controlled sediment delivery from the upper watershed to the impacted reaches and 2) the efforts of the Watershed Stewardship Program are making sufficient progress towards achievement of health and safety, coordinated monitoring, and sediment remediation improvements."

Section VII (Monitoring and Adaptive Management) of the TMDL Action Plan also provides:

"Approximately five years after adoption, Regional Water Board staff will conduct a formal assessment of the effectiveness of the implementation plan, including an evaluation of the effectiveness of WDRs and waivers, and make any necessary revisions to this TMDL Action Plan. This includes a review of the sediment source analysis and water quality data for the Upper Elk River, sediment deposition in the impacted reach and Lower Elk River, and the need for a Lower Elk River sediment TMDL, using Recovery Assessment tools and other available data, as appropriate. During reassessment, the Regional Water Board will consider how effective the requirements of the TMDL program of implementation are at meeting the TMDL, achieving water quality objectives, restoring the beneficial uses of water, and abating nuisance flooding conditions in the Upper Elk River Watershed. The success of the TMDL will be assessed based on water quality trends in the Upper Elk River Watershed, particularly the attainment of water quality standards in the impacted reach. Ultimately success is achieved when nuisance conditions are abated, and beneficial uses are supported."

This report presents the results of staff's assessment of TMDL implementation in the Elk River watershed to date, with associated findings and recommendations. It begins with general background information (Section 2). The report then includes assessment of activities within the Watershed Stewardship Program and progress towards recovery planning (Section 3), activities under the Waste Discharge Requirements and Waivers (Section 4), and assessment of changes in water quality conditions. It does not include a reassessment of the TMDL source analysis or recommendations for changes to the TMDL Action Plan at this time since the available data provide no evidence of appreciable improvements in water quality conditions or expansion of assimilative capacity for sediment. Section 5 presents analyses of available data and the results. Section 6 includes a summary of the findings and staff' recommendations. A key recommendation is to standup a Science and Coordinated Monitoring Workgroup under the Watershed Stewardship Program, so as to establish a coordinated monitoring program that ensures data are collected in a manner capable of addressing key watershed health questions. This coordination is particularly important with respect to adaptive management, including consideration of future revisions to either the WDRs or TMDL.

It is important to note that the Elk River Watershed is a working landscape supporting residential, ranching, farming, and timber activities, as well as public access to conservation lands. The purpose of the TMDL Action Plan is to correct nuisance flooding conditions, restore beneficial uses and attain water quality standards. It is not to return the watershed to a pre-disturbance condition. Rather the goal is to regain a level of hydrological and ecosystem function, which supports beneficial uses, controls nuisance flooding and thus allows for the free use and enjoyment of public and private property across all sectors.

Section 2: Background

Periods of intensive logging over geologically unstable terrain in a watershed already subject to natural landslides and tectonic events has had detrimental impacts to water quality. Excessive sedimentation has caused widespread and ongoing exceedance of water quality objectives and impairment of beneficial uses, as well as nuisance conditions[2]. The term "nuisance is defined in Water Code section13050(m) as:

"*…anything which meets all of the following requirements: (1) Is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property. (2) Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal. (3) Occurs during, or as a result of, the treatment or disposal of wastes*."

Of particular concern to the TMDL Action Plan is the period during the late 1980-1990s when the timber operations of Pacific Lumber Company/Maxam (Palco) radically altered the sediment transport and hydrologic conditions of the watershed with intensive logging that destabilized slopes, increased peak flows, and accelerated sediment delivery to watercourses. Sediment from that era initiated a nuisance flooding condition just above the confluence of the North and South Forks of the Elk River and continuing to Berta Road, which continues today with ongoing aggradation in that reach, loss of channel cross-sectional area, and multiple overbank flooding events per year. It simultaneously resulted in impacts to water supplies, recreational opportunities, and salmonid habitat.

It is in this context that a sediment Total Maximum Daily Load was adopted for the Upper Elk River Watershed. Please see the Upper Elk River Technical Analysis for Sediment (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/151222/03_20151021_Upper_Elk_River_Tech_Analysis_for_Sediment.pdf) for further background.

[2] Listed under Section 303(d) of the Clean Water Act as impaired in 1998

Section 3: Watershed Stewardship and Recovery Planning

Under Water Code section 13000 as enacted in 1969, “the Legislature finds and declares that the people of the state have a primary interest in the conservation, control, and utilization of the water resources of the state, and that the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state. The Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality, which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.”

Further, Water Code section 13243 authorizes the Regional Water Board to prohibit the discharge of waste in Waste Discharge Requirements (WDRs) or the Basin Plan under certain conditions or in certain areas. In addition, Water Code section 13304 authorizes the Regional Water Board to order a person who discharges waste or threatens to discharge waste into waters of the state that causes or threatens to cause a condition of pollution or nuisance to clean up the waste or abate the effects of the waste, or in the case of threatened pollution or nuisance take other necessary remedial action.

In conformance with the Water Code, the Regional Water Board adopted: 1) the TMDL Action Plan defining the current assimilative capacity of the Elk River watershed for sediment and sedimentation, and the actions necessary to expand the current assimilative capacity and reduce sediment sources in conformance with water quality standards and protection against nuisance conditions, 2) WDRs for two industrial timberland owners, Humboldt Redwood Company (HRC) and Green Diamond Resources Company (GDRC), providing the restrictions necessary to control all controllable sources of waste sediment associated with timber operations in the Upper Elk River Watershed. The Regional Water Board did not require cleanup of past waste sediment discharges under a Cleanup and Abatement Order, largely because the past owner (Palco) responsible for those discharges declared bankruptcy and no longer owns the property where HRC and GDRC conduct operations. Instead, the Regional Water Board approved a Watershed Stewardship Program as a key element of the TMDL Action Plan, combining regulatory and non-regulatory resources of the Regional Water Board as the appropriate approach for endeavoring watershed recovery.

The issues confronting the Elk River Watershed are not wholly unique. The Regional Water Board’s Watershed Stewardship Program is a participatory program designed to coordinate activities, build watershed-based partnerships, and improve and enhance watershed conditions across the North Coast Region. The program seeks to foster collaboration between component programs, stakeholders and agency staff by establishing effective collaborative partnerships to improve water quality and ecological

resiliency throughout the region and uses both regulatory and non-regulatory tools and resources.

Impacts to water bodies in the North Coast Region such as the Elk River are often the result of large-scale landscape disturbances, which have physically altered watershed processes that directly contribute to ongoing pollutant loading and reduce the affected water body's assimilative capacity (i.e., resilience). The stewardship approach to these legacy impacts applies a coordinated program of regulation, grant support, and watershed partnerships to address both the historic and contemporary water quality issues in a comprehensive and cohesive manner, which marshals the resources of multiple agencies and responsible parties.

3.1 Elk River Watershed Stewardship Program

The Elk River is a watershed where the water quality conditions are no longer supportive of beneficial uses nor adequate to prevent nuisance conditions. This is largely due to the altered state of the watershed, wherein sediment and water are no longer transported normally in the stream channel during smaller storms. Instead, the channel capacity for water and sediment has been decreased by excessive sedimentation that results in multiple out-of-bank flows on an annual basis. The Watershed Stewardship Approach (Stewardship Approach) with its adaptive management component provides a framework for coordinating sediment source control and remediation/restoration actions, while also partnering with other essential organizations well-suited to provide health and safety protections. The Regional Water Board has a dedicated Humboldt Bay Steward, whose job includes coordinating the Elk River Watershed Stewardship Program.

The Stewardship Approach is being utilized in the Elk River watershed because:

- The Regional Water Board did not choose to issue a Cleanup and Abatement Order to require cleanup of past waste sediment discharges;
- The nuisance flooding conditions affecting properties associated with the impacted reach of the Elk River (Figure1) and other downstream public and private properties will not be corrected by sediment source control measures alone;
- There are several active Regional Water Board programs and contracted projects contributing to recovery requiring coordination and integration of activities across all participants;
- The magnitude and diversity of recovery actions will require the combined mandate and resources of multiple agencies to undertake stream restoration, improvements in public infrastructure, and to restore a reliable source of drinking water to watershed residents;
- The recovery program requires close coordination with landowners to implement voluntary restoration activities on their property.

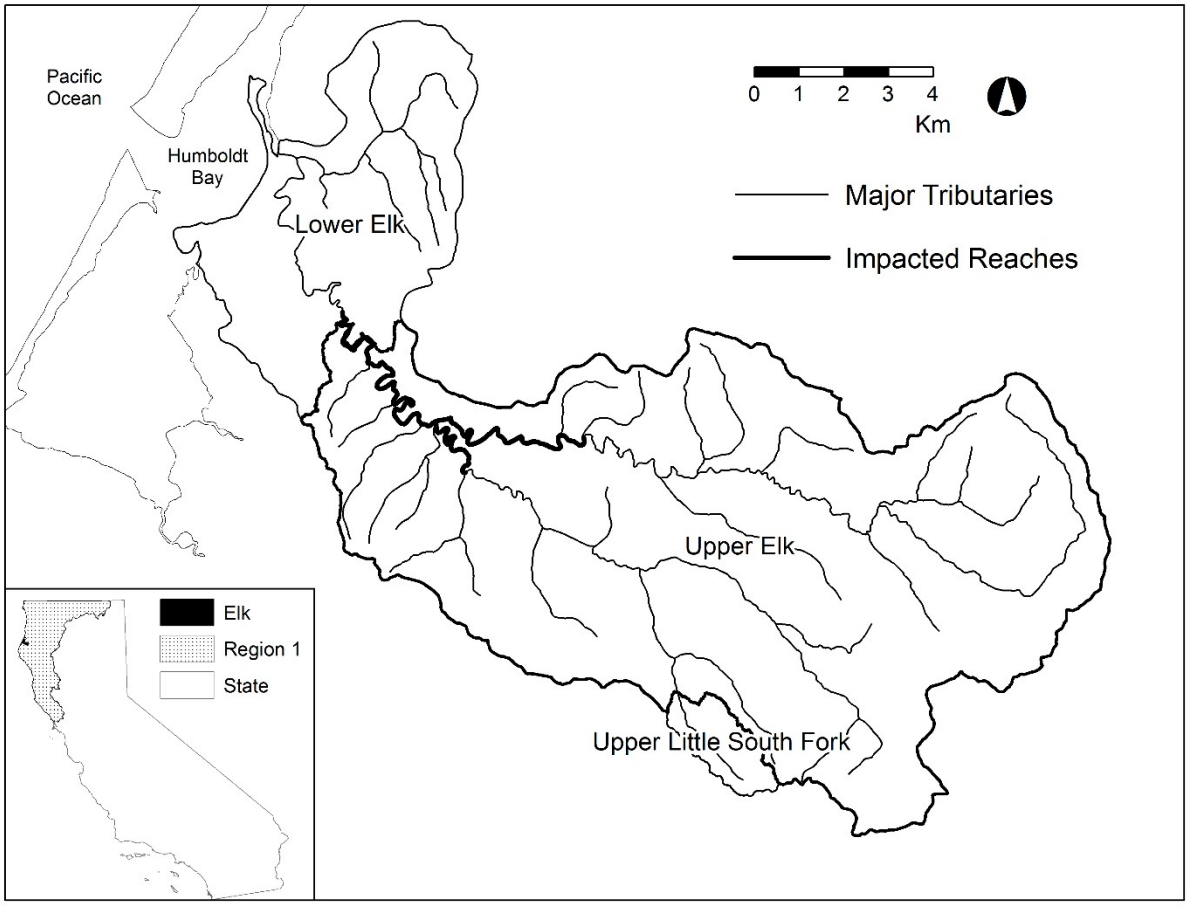

Figure 1. Elk River Watershed

The Elk River Stewardship Program is a community-based effort to restore the beneficial uses of water in Elk River and reduce nuisance flooding conditions. Following its initiation under the leadership of Humboldt County, the Elk River Stewardship Program has been implemented since 2019 by CalTrout and its subcontractors, Northern Hydrology Engineering and Stillwater Sciences under the guidance and support of the Regional Water Board, including grant and contract support. The purpose of the Stewardship Program is to couple its approach to reducing waste sediment discharge from the upper watershed (see Section 4) with its effort to engage Elk River stakeholders in a collaborative planning, design, and implementation process that seeks to:

Identify Strategies to:

- Improve the hydrologic and sediment processes, water quality conditions, and aquatic and riparian habitat functions in Elk River

- Reduce nuisance flooding and the consequent risks to residents and properties, and improve transportation routes during high water conditions
- Improve drinking water and agricultural water supplies for residents in Elk River

Ensure actions are prioritized and integrated to:

- Collectively yield the greatest benefit to residents and natural resources in the Elk River watershed
- Ensure actions are implemented in a cost-effective manner

Conduct a monitoring and adaptive management program to:

- Track responses and outcomes of implemented actions
- Quantify project benefits and temporary and permanent impacts

3.2 Elk River Recovery Assessment and Recovery Plan

Table 4 of the TMDL Action Plan requires that

"By 2017, CalTrout will produce a final report detailing the results of full-scale sediment and hydrodynamic modeling, including feasible remediation and restoration activities sufficient to achieve water quality standards and return the watershed to a trajectory of recovery."

The State Water Resources Control Board (State Water Board) funded through the Cleanup and Abatement Account the development of a sediment transport and hydrodynamic model called the Elk River Recovery Assessment: Recovery Framework (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/190516/ERRA Framework Final compiled_031419.pdf). The ERRA was built as a predictive tool to assess watershed response to 1) reduction in sediment loading from the upper watershed and 2) implementation of various appropriate restoration approaches in reaches across the watershed from just above the confluence of the north and South Forks of the Elk River all the way to Humboldt Bay. The development of the ERRA and the modeling scenarios were guided by a Technical Advisory Committee comprised of technical experts, representatives from the timber companies, and residents. The final ERRA report was submitted by CalTrout in March 2019.

The ERRA established a restoration framework, which formed the basis for development of the Elk River Watershed Stewardship Program: Sediment Remediation and Habitat Rehabilitation Recovery Plan (https://caltrout.org/wp-content/uploads/2019/05/Elk-River-Stewardship-Recovery-Plan-Public-Draft-July_2022.pdf) also developed by CalTrout and its subcontractors under contract to the Regional Water Board. Completion of the Recovery Plan is contemporaneous with this staff assessment, so is not summarized here. It presents a landowner-vetted strategy for sediment remediation and habitat rehabilitation approaches across four planning areas from just above the confluence of the north and South Fork all the way to

Humboldt Bay. This planning document provides the basis for funding, design, permitting, and implementation of on-the-ground restoration activities beginning immediately.

3.3 Evolution of Elk River Watershed Stewardship

Table 4 of the TMDL Action Plan describes the expected actions of the Watershed Stewardship Program as follows:

"By 2016, in coordination with a steering committee, Humboldt County will initiate a watershed stewardship program for the Elk River Watershed in conformance with the 319(h) grant contract, including establishment of: a Health and Safety workgroup responsible for developing recommendations appropriate for resolving water supply, flooding, and road access issues; a Science and Coordinated Monitoring workgroup responsible for developing recommendations appropriate for improving the effectiveness of water quality, sediment and flow monitoring efforts throughout the watershed; a Sediment Remediation workgroup responsible for developing recommendations appropriate for remediating instream stored sediment and improving floodwater conveyance, sediment transport, and ecosystem function. Final reports documenting the workgroup's recommendations, including plans and schedules are due in 2018."

In 2014, the Regional Water Board saw the need for a comprehensive coordination framework for the Elk River watershed and initiated a series of meetings to discuss the development of a watershed stewardship charter (later defined as an operating agreement) with local organizations. The operating agreement was intended to guide voluntary partnerships for a watershed stewardship approach for Elk River recovery. Several organizations were engaged in the process, with the following serving on the steering committee: USDA Natural Resource Conservation Service (NRCS), Regional Water Board, CalTrout, Humboldt County, and Humboldt County University of California Cooperative Extension Service. The first Stewardship Operating Agreement meetings were convened in the fall of 2014. Steady progress was made in crafting a charter and the group submitted a proposal to fund its work. The 319(h) grant was awarded to Humboldt County in March 2015.

The initial focus of the Steering Committee was to organize a series of public meetings to 1) communicate the findings of the ERRA, 2) gauge the public's interest in a large-scale watershed restoration effort and 3) solicit public input on restoration priorities. The public meetings were well attended and successful in communicating technical findings and soliciting input on stewardship priorities. In addition, two newsletters were developed, and an initial Elk River Watershed Stewardship Program website created.

It was a challenge to align and coordinate the ERRA contract activities of CalTrout and the 319(h) grant activities of the County, which together constituted the foundation for

the Watershed Stewardship Program. Not only were they funded under separate agreements that started at different times, but they also had different lead contractors, deadlines, and areas of focus. CalTrout was the prime contractor for the technical based ERRA, and the Humboldt County was the lead contractor for the community-based Watershed Stewardship Program. Due in large part to these difficulties the Watershed Stewardship Program underwent a major transition in January 2017 when Humboldt County terminated its involvement in the Watershed Stewardship Program.

Regional Water Board staff worked with State Board staff to transfer the remaining funds to CalTrout who was selected because of their existing role on the Elk River Watershed Stewardship Steering Committee and their work on the ERRA. During this transition period the ERRA model scenarios developed in collaboration with the ERRA Technical Advisory Committee, were run, and provided a technical basis to begin designing a recovery program. Because the recovery program would require the voluntary participation of individual landowners, the project team shifted their stakeholder involvement from public meetings to individual meetings with potentially affected landowners. The program progressed from a general conceptual recovery strategy, the ERRA, to a more detailed Recovery Plan (https://caltrout.org/wp-content/uploads/2019/05/Elk-River-Stewardship-Recovery-Plan-Public-Draft-July_2022.pdf), released for public review in July 2022.

- Stewardship program pivoted from large-scale community meetings to meetings with individual landowners, especially those whose property would be involved in recovery activities
- With landowner approvals an Elk River Watershed Stewardship Program: Sediment Remediation and Habitat Rehabilitation Recovery Plan (https://caltrout.org/wp-content/uploads/2019/05/Elk-River-Stewardship-Recovery-Plan-Public-Draft-July_2022.pdf) has been completed
- Presentation to the community and Regional Water Board will be conducted at the special Regional Water Board meeting in Eureka scheduled for August 30, 2022

Table 1 includes a summary of the timeline and milestones for Watershed Stewardship Program. The table does not include many of the essential milestones completed by the ERRA and others (e.g., Salmon Forever, City of Eureka, California Department of Fish and Wildlife) also working in the watershed on shared recovery and restoration objectives but includes broad strokes.

Table 1. Elk River Watershed Stewardship Program Timeline and Milestones 2013-2022

Date(s)	Program Phase	Milestone Description
2013 – 2018	ERRA (preceded the establishment of the Stewardship Program)	• Elk River Summit public workshop • Elk River Hydrodynamic and Sediment Transport Modeling Pilot Project • Advisory team meetings to review and inform model development • Completion of Steel Bridge removal pilot project.
2014 - 2017	Operational Charter Development, Establishment of Stewardship Program Steering Committee, Initial Public Engagement	• Facilitated meetings among organizations committed to supporting long-term voluntary coordination framework for watershed restoration. Steering Committee consisted of Humboldt County, UC Berkeley Humboldt Extension Service, USDA Natural Resource Conservation Service, CalTrout, and the Regional Water Board. • Individual meetings with residents and local organizations (e.g., Humboldt County Farm Bureau) to inform charter development. • Elk River Watershed Stewardship Charter signed in June 2016. • Series of Steering Committee meetings to define objectives of the program and to coordinate with the ERRA • Public workshops to receive community input on scope and objectives • Outreach facilitated through newsletter distribution and the creation of a project website • Transition from Humboldt County to CalTrout as lead contractor
2016 – 2017	Initial Implementation of the Stewardship Program	• Initiate design plans for two pilot projects (Wrigley Orchard and Elk River Flood Curve). • Development of recovery strategy modeling scenarios to evaluate three implementation program approaches • Initiated pilot project permitting process and CEQA analysis.

Date(s)	Program Phase	Milestone Description
		• South Fork conceptual planning process begun including baseline condition surveys and vegetation mapping. • Integration of the ERRA and Stewardship Program to ensure full consideration of the scientific conclusions drawn from the sediment and hydrodynamic modeling of the ERRA into the planning and implementation efforts
2017 - 2020	Integration of ERRA with Stewardship Program and Development of Recovery Plan	• Meeting with individual landowners to share ERRA modeling scenario results and proposed restoration actions • Compiled landowner-supported actions into a Preferred Recovery Strategy • Information compiled into a single report: Elk River Assessment Recovery Framework providing reach by reach restoration prescriptions for several categories of restoration activities (i.e., vegetation management, sediment remediation, riparian restoration, channel realignment) • Conduct several resource management agency meetings to begin permitting discussions for the Recovery Plan
2019 - 2022	Translating HST Model Scenarios into Design Documents, Pilot Project Development, Environmental Reporting (CEQA), Permitting, Program Design Reports Elk River Recovery Plan	• Run additional HST modeling scenarios with additionally collected data, which supported development of an updated sediment remediation and habitat restoration action plan • Continue CEQA and permitting activities for Wrigley Orchard and Elk River Flood Curve Projects. • Design plans completed to 65% for Elk River Flood Curve and 100% for Wrigley Orchard. • Newsletter distributed • Produce a monitoring framework to guide watershed stewardship and adaptive management activities. • Conducted a pilot modeling exercise to investigate climate change impacts on rainfall – runoff impacts. Technical

Date(s)	Program Phase	Milestone Description
		memorandum reporting on results indicating impacts for 100-year floodplain boundary • Initiate Health and Infrastructure Community Surveys to better understand impacts and solutions for drinking water, flooding, and impacts on septic systems • Project Design reports completed in this period include: • ERRA: Recovery Framework • Elk River Sediment Remediation Pilot Implementation Projects: Basis of Revised 65% Draft Engineering Designs • South Fork Elk River 10% Design Report • Elk River Mainstem Reaches (MSR) 1-2 10% Design Report • Elk River Stewardship Program, Final Project Report: Landowner Outreach, Technical Advisory Committee Outreach, Stewardship Meetings, Newsletters • Elk River Sediment Remediation and Habitat Rehabilitation: Draft Project Description

3.4 Health and Safety

Staff have identified five topics critical to understanding health and safety issues in the Elk River watershed: 100-year flood levels, road flooding, impacts to structures, onsite waste treatment systems, and drinking water supply. It was initially identified that these topics would be addressed by the Stewardship Program with Humboldt County as the lead. With the loss of Humboldt County as lead of the Stewardship Program who was well suited to direct progress on the health and safety issues, the progress on those issues has been sparse in this first 5-year period of TMDL implementation; it clearly deserves more immediate attention. To that end, the Regional Water Board has hired a new Humboldt Bay Watershed Steward whose duties include leadership on the topics of health and safety, particularly identifying appropriate agencies and resources with the authority to address these infrastructure needs.

On the other hand, under the leadership to CalTrout, there has been tremendous progress in the realm of recovery planning, including the completion of the Recovery Plan from which to initiate funding, design, permitting, and implementation of sediment remediation and habitat rehabilitation projects. Completing the Recovery Plan is crucial to making progress correcting the fundamental causes of health and safety issues, but the timeline for completion of these projects is long.

While leading the Watershed Stewardship Program, Humboldt County established a Road Flooding Workgroup and committed to hold four public meetings. The meetings were designed to identify potential road improvement projects that would alleviate nuisance flooding on Elk River Road, Wrigley Road, Zanes Road, Berta Road, and Elk River Court. However, only one meeting was held prior to Humboldt County ending their leadership role in the Stewardship Program. Attendees of that 2016 meeting were asked to complete surveys to address their flooding experiences including magnitude, frequency, direct impacts from flooding, relative interest in roads projects designed to alleviate flooding, and perceived causes for severe road flooding in the Elk River watershed. Eight participants submitted hard copy responses and two completed the survey online. A majority of respondents identified the need to alleviate road flooding as either “very important” or “extremely important.” Road Flooding Workgroup survey results are included as Appendix A.

As part of the previously discussed ERRA, Northern Hydrology and Engineering (NHE) subcontracted by CalTrout later expanded the model to also include extreme flood events up to the 1% annual chance flood. The results are presented in the September 2020 technical memorandum 1% Annual Chance Flood Elevation Estimates for the Lower Elk River, Humboldt County (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/211025/NHE_ElkRiver_100yrWSE_Memo_200929_DS.pdf), posted to the Regional Water Board’s Elk River TMDL web page. This analysis may be useful to FEMA,

Humboldt County, and other entities with authorities associated with flood protection and mitigation.

The 100-year Flood Memo has been distributed to stakeholders, including Humboldt County. Re-engagement with county staff suggests that road flooding around Humboldt Bay is an issue not unique to the Elk River watershed. Further, the County may be under-resourced to address this issue itself. Staff have determined that further engagement with the County, the Office of Emergency Response, and the FEMA could be fruitful. This is an area of growth for the Watershed Stewardship Program.

3.5 Community Drinking Water Programs

Regional Water Board staff have begun discussions with the Division of Drinking Water, (https://www.waterboards.ca.gov/drinking_water/programs/), Division of Financial Assistance (https://www.waterboards.ca.gov/water_issues/programs/grants_loans/), and Office of Public Participation (https://www.waterboards.ca.gov/about_us/public_participation/).

The Safe and Affordable Funding for Equity and Resilience (SAFER) (https://www.waterboards.ca.gov/safer/) program is run jointly by Division of Drinking Water, Division of Financial Assistance, and Office of Public Participation to address the continuing disproportionate environmental burdens in the state by creating a fund that will assist in providing safe drinking water in every California community. Through conversations with these State Water Board divisions, Regional Water Board staff have identified the need to engage Humboldt County, the Humboldt Bay Community Services District, and the Humboldt Bay Municipal Water District in discussions of potential SAFER program fund applications, as well as other water infrastructure and drought relief program funding options. This is an area of further growth for the Watershed Stewardship Program.

3.6 Health and Safety Interviews

Regional Water Board staff prepared a set of interview questions (Appendix B) designed to address each of the five critical health and safety topics identified above (i.e., 100-year flood levels, road flooding, impacts to structures, onsite waste treatment systems, and drinking water supply). Staff identified initial interview participants as those residents of properties at increased risk of flooding hazards based on the 100-Year Flood Memo. In March 2022, initial outreach and interview scheduling efforts began. In an effort to increase engagement, Regional Water Board staff offered in person, phone, or virtual interviews with the participant selecting the interview method. Thirteen property owners expressed interest in participating in the first phase of the health and safety interviews. Later phases of this effort will include a broader group of residents and additional stakeholders. Interviews began in May 2022 and are expected

to continue through summer 2022. To date, nine interviews have been conducted, eight in-person and one via conference call.

Health and safety interviews are designed to serve two primary purposes: 1) record residents' recent experience of flooding and related hazards and 2) prepare a comprehensive list of the solutions participants favor for reducing the impact of those hazards. Participants are provided NHE's 100-year flood memo and given the opportunity to ask questions about its findings. They are also asked to describe the frequency, duration, and extent of flooding on their property and to identify any critical infrastructure that has been inundated including onsite wastewater treatment and drinking water system, access to roads, and impacts to agricultural function.

As of May 2022, nine groups of Elk River property owners have been interviewed. (Interviews with remaining impacted property owners still to be scheduled). Road flooding was the most frequently identified challenge, noted by five of the nine groups. Loss of drinking water supply was identified as a major challenge by four groups, while decreased property value was noted by three groups. Other challenges discussed by property owners include a loss of agricultural function of the property, risk to property and personal safety, loss of recreational and fishing beneficial uses, flooded structures, silt accumulation, loss of wash water supply, and impacts to septic systems.

Health and safety interviews are not designed to gauge property owners' positions on any specific land use activity and the topic of support for solutions to flooding challenges was presented as an open-ended, unprompted set of questions. When asked what solutions they support to address the challenges discussed, timber harvest restrictions and related source control were proposed by 1/3 of the property owners interviewed. Two groups noted that they support connection to a community water system and two groups identified raising structures on their property as a valuable solution. Other proposed solutions include, among others, constructing or replacing bridges, geomorphic projects to promote channel incision and sediment delivery to Humboldt Bay, sediment removal from the channel, construction of flood control channels and/or culverts, removing log jams, and riparian restoration projects.

Upon completion of the first phase of health and safety interviews, Regional Water Board staff will determine how best to expand the group of participants. Once all interested parties have had the opportunity to complete the interview process, Regional Water Board staff will review the responses and identify priority projects supported by the community. Many of the suggested solutions are outside of the authority and expertise of the Regional Water Board and will require engagement with other organizations and agencies (e.g., Humboldt County, Department of Water Resources, Office of Emergency Response).

Section 4: Waste Discharge Requirements

Timber harvesting is one of the primary land uses in the Elk River Watershed. Current data from Humboldt County indicates that approximately 84% of the watershed is zoned as Timber Production[3] Zone. The two largest owners are Humboldt Redwood Company, LLC (HRC) and Green Diamond Resource Company (GDRC). HRC owns and actively manages approximately 209,000 acres in the Upper Elk Watershed while GDRC owns and operates 22,000 acres. The Bureau of Land Management (BLM) is also a major landowner along the South Fork, but only minimal forest management activities occur on BLM land. In addition to the HRC and GDRC various smaller landowners throughout the watershed continue to conduct timber operations.

All timber operations, regardless of owner, must adhere to specific Forest Practice Rules (FPRs) and must be conducted under valid Timber Harvest Plans (THPs), Nonindustrial Timber Management Plans (NTMPs), or Notices of Emergency, or Exemptions and must also be permitted under Waste Discharge Requirements (WDRs) or Waivers of WDRs from the Regional Water Board.

THPs for HRC and GDRC are covered under WDRs that are specific to their Elk River timberlands (Orders No. R1-2019-0021 and R1-2020-0001, respectively). THPs on other ownerships may be covered under either General WDRs (Order No. R1-2004-0030) or the Categorical Waiver (Order No. R1-2014-0011). NTMPs must seek coverage under the NTMP General WDR, Order No. R1-2013-0005. Exemption and Emergency Notices are ministerial projects under the FPRs and are automatically covered under the Categorical Waiver.

Table 4 of the TMDL Action Plan requires for sediment source control:

"Humboldt Redwood Company shall implement its revised WDRs adopted by the Regional Water Board to implement phase 1 of the Upper Elk River Sediment TMDL and a zero load allocation"

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[3] (g) "Timberland production zone" or "TPZ" means an area which has been zoned pursuant to Section 51112 or 51113 and is devoted to and used for growing and harvesting timber, or for growing and harvesting timber and compatible uses, as defined in subdivision (h).

With respect to the general plans of cities and counties, "timberland preserve zone" means "timberland production zone."

"Green Diamond Resource Company shall implement its revised South Fork Elk River management plan approved by the Regional Water Board to implement phase 1 of the Upper Elk River Sediment TMDL and a zero sediment load allocation."

"Prior to any timberland management activities, non-industrial timberland owners shall enroll under the General NTMP WDR in Tier B (Order No. R1-2013-0005 General Waste Discharge Requirements for Dischargers for Timber Operations on NTMPs) or a future Order that replaces Order No. R1-2013-0005."

"For other timber harvest plans, landowners shall enroll individual THPs under the General Timber WDRs (Order No. 2004-0030) or a future Order that replaces Order No. R1-2004-0030 and incorporate any additional conditions identified during the timber review process as necessary to be consistent with the TMDL Action Plan"

"The Bureau of Land Management shall request enrollment of any projects with potential sediment discharges under the U.S. Forest Service Waiver (Order No. R1-2015-0021) or a future Order that replaces Order No. R1-2015-0021."

4.1 Regulatory Requirements

All timber operations conducted under the plans described above must comply with additional requirements including all applicable FPRs, Habitat Conservation Plans, California Department of Fish and Wildlife (CDFW) Master Agreement for Timber Operations, and Regional Water Board WDRs or Waiver of WDRs. While Regional Water Board permits rely in large part on the FPRs, Habitat Conservation Plans and the CDFW Master Agreement for Timber Operations, the Regional Water Board may also establish additional requirements as deemed necessary for water quality protection. Therefore, in addition to establishing specific requirements, Regional Water Board permits establish a direct regulatory relationship with project proponents and explicitly make enforceable water quality protection requirements. Water quality protection requirements are designed to meet the following goals:

- **Control sediment-** Identify and treat existing controllable sediment discharge sources. Implement management practices to prevent or minimize the potential for creating new sediment discharge sources. (e.g., special limitations in winter conditions).
- **Protect riparian zones-** Establish minimum tree retention and limit ground disturbance. This serves to control and filter sediment discharge, protect vulnerable streambanks and hillsides, protect stream temperature, and promote large wood recruitment potential into streams.
- **Protect stream temperature-** Adequate riparian zone protection ensures that trees that provide shade to watercourses with summertime flow are retained thereby keeping stream temperatures naturally cooler.

- **Prevent exacerbating cumulative impacts-** Minimize project specific impacts, which exponentially increase when distributed throughout the watershed (e.g., established harvest rate thresholds for HRC and GDRC).
- **Establish monitoring requirements-** Complete regular site inspections to ensure best management practices implementation and function. Monitoring requirements for HRC and GDRC include monitoring of water quality, aquatic habitat/stream conditions, and landslides.

Regional Water Board requirements may vary dependent upon the type of permit or plan and can either apply to the lifetime of the specific plan area, or to a larger area where the plan exceeds the life of an individual THP. For example, WDRs for HRC and GDRC include specific THP requirements as well as additional requirements independent of THP, which are primarily related to monitoring and sediment control from roads.

NTMPs are long term management plans that provide landowners with an approved plan to conduct timber operations by submitting a Notice of Timber Operations (NTO) to CAL FIRE. An NTO is effective for one year and requires landowners (or their consulting foresters) to conduct an evaluation of the NTMP to ensure conditions have not changed, and/or address any changed conditions as needed. The NTMP General WDR provides two options for compliance, Tier A and Tier B. Tier A permits landowners to enroll individual NTOs and requires the identification and implementation of corrective action of sites within the NTO that could adversely impact beneficial uses of water. Tier B requires landowners submit and maintain an Erosion Control Plan (ECP) consisting of an inventory and schedule for implementation of corrective action for controllable sediment discharge sources. Except under Exemptions and Emergencies, Regional Water Board permits establish requirements that landowners develop ECPs and conduct annual inspections of the project area.

4.2 Timber Harvesting and Associated Activities 2016-2021

Regional Water Board staff conduct rigorous oversight of all forest management projects in the Elk River Watershed, including office review of all proposed projects, field review of most projects during the approval process and subsequently during active operations and following completion of operations. The purpose of the field oversight is to ensure compliance with water quality requirements, evaluate implementation and effectiveness of management practices designed to protect water quality, and provide feedback and guidance to landowners on water quality protection. Since the TMDL Action Plan was adopted by the Regional Water Board in May 2016, staff from the Forest Activities Program have conducted 39 field inspections, including pre-consultations, preharvest, active and completion inspections. All inspections are documented by an inspection memo and/or database record.

Staff conducted 27 inspections of HRC operations, 4 inspections of GDRC operations, and 6 inspections of the operations of other timberland owners. In general, Regional Water Board staff find high levels of compliance with applicable water quality requirements associated with timber operations.

4.2.1 Humboldt Redwood Company

On November 30, 2016, the Regional Water Board adopted Order No. R1-2016-0004, which superseded the 2006 WDR for HRC management activities in the Elk River Watershed. The Order established general and specific requirements for their timber harvesting and associated management activities to control sediment and temperature impacts. It also included best management practices intended to implement applicable water quality standards from the Water Quality Control Plan for the North Coast Region Basin Plan (https://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/basin_plan_documents/), which includes the TMDL Action Plan. Below is a summary of the requirements contained in Order No. R1-2016-0004, which is not intended to replace or revise the actual conditions contained within the order.

Order No. R1-2016-0004 is based largely on the Report of Waste Discharge (ROWD) submitted to the Regional Water Board by HRC in 2015, with additional measures as warranted to meet applicable water quality protection requirements.

The ROWD includes HRC's proposed long term strategy, including measures designed to prevent or minimize water quality impacts from activities associated with its forest management, including:

- Timber harvesting
- Road use, construction, reconstruction, decommissioning, repair, and maintenance
- Measures to prevent or minimize controllable sediment discharge from roads, skid trails, landslides, and other sources related to timberland management
- Retention of riparian vegetation to preserve and/or restore shade, supply large wood, filter sediment from upslope sources, help maintain and restore channel form and in-stream habitat, and moderate peak flows
- Treatment of controllable sediment discharge sources
- In-stream and riparian zone habitat restoration by enhancement of in-stream large wood for habitat restoration
- Implementation and Effectiveness Monitoring
- Watershed trend monitoring

On June 6, 2019, in response to a directive from the State Water Board, the Regional Water Board adopted Order No. R1-2019-0021, which revised certain requirements of the 2016 Order. The primary revisions were increased Riparian Management Zones

and additional limitations on wet weather log hauling. The existing requirements, discussed below, include.

- Riparian zone protection, which requires minimum 50% post-harvest overstory canopy cover within 300 feet of Class I and II watercourses and 150 of Class III watercourses
- Identification and treatment of controllable sediment discharge sources
- Review by Professional Geologist (PG) of all proposed activities, including harvesting and construction or reconstruction of roads and watercourse crossings
- Wet weather requirements that winter period hauling shall cease for a period of 48 hours following a precipitation event that results in 0.25 inches or more of rainfall within any 24-hour period
- Implementation of HRC's Elk River/Salmon Creek Watershed Analysis hillslope management prescriptions
- A requirement that HRC conduct a study to evaluate the feasibility of methods to control, trap, or meter out sediment from in-channel sources; and
- A robust hillslope and in-stream monitoring requirement

4.2.1.1 Habitat Conservation Plan

All of HRC ownership in the Elk River watershed is covered by a multi-species state and federal Habitat Conservation Plan (HCP) approved in 1999. A critical element of the HCP is Watershed Analysis, in which HRC's approximate 209,000-acre ownership is divided into eight primary watersheds for focused inventory and investigation of conditions and processes related to mass wasting, surface erosion, riparian function, stream channel, and aquatic habitat. The first Watershed Analysis conducted for the Elk River/Salmon Creek Watershed Analysis Unit (WAU) involved several years of study culminating in a final report released in 2005. Forest management prescriptions pertaining to slope stability and riparian forest protection were developed and formally established in consultation with multiple state and federal agencies including National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), and California Geological Survey (CGS), as a result of this process. Regional Water Board staff participated intermittently in the initial watershed analysis as well.

The 2014 *Elk River/Salmon Creek Watershed Analysis Report* analyzed the effectiveness of HRC's forestry prescriptions in Elk River, along with watershed trends affecting aquatic habitat conditions. A primary purpose of the report was to assess the effectiveness of the current Elk River/Salmon Creek forestry prescriptions in meeting the HCP Aquatic Conservation Plan goal 'to maintain or achieve, over time, a properly functioning aquatic habitat condition'. As such, the report was an important supporting document to the ROWD relevant to understanding the effects of contemporary forestry practices on beneficial uses of waters of the state. Many of the HCP prescriptions

related to water quality protection, such as road management, geologic prescriptions, riparian protection, and in-stream monitoring have been incorporated into the WDR.

Another important element of the HCP is its Road Auditing and Inspection Program patterned after the U.S. Forest Service Best Management Practice Evaluation Program. This program evaluates the effectiveness of road treatment in minimizing sediment delivery to streams. The program has been in effect since 2006 and has been established as an element of monitoring and reporting requirements of the WDR.

4.2.1.2 Timber Harvesting

HRC utilizes uneven-aged single-tree and small group selection silviculture within its timberlands in the Upper Elk River watershed. Variable retention may be used in some instances to address certain stand conditions, such as high levels of whitewood or hardwood species, animal damage, or general poor form and vigor due to past logging history. Other silvicultural methods that may be applied infrequently include Rehabilitation of Understocked Areas, Seed Tree Removal, and Sanitation Salvage. Consistent with the ROWD, HRC does not utilize the clearcut harvest method.

4.2.1.3 Harvest Rate Limitations

Harvest rate limitations were first established in the Elk River Watershed by the Regional Water Board with adoption of WDRs in 2006. Those WDRs established harvest limits that applied separately to HRC's (originally PALCO) timberlands in the North and South Fork Elk River. HRC owns approximately 14,049 acres in the 14,336 acres North Fork and 6,560 acres of the 13,120 acres in the South Fork Elk River. Harvest rate limitations from the 2006 WDR were based on two empirical models, the Landslide Reduction Model in the North and South Forks, and the Peak Flow Reduction Model (Peak Flow Model) in the North Fork only. The Peak Flow Model, which was designed to limit harvest related increases in peak flow, established a limit of 264 Equivalent Clearcut Acres[4] per year in the North Fork. The Landslide Reduction Model was designed to limit harvest related landslides and applied to both the North and South Fork watersheds. Annual harvest limits from the Landslide Reduction Model for the North Fork Elk watershed was 266 acres in low hazard zones, 21 acres in high hazard

[4] Equivalent clearcut area (ECA) is a widely used methodology developed by the USFS to account for the relative impacts of different types of silvicultural treatment. It assigns a weighting factor of one to clearcutting and a value less than one for partial harvesting silvicultural treatments. The weighting factor for a silvicultural treatment is multiplied by total area treated under each silviculture to arrive at a normalized disturbance calculation. Therefore, 100 acres of selection harvest, which is typically assigned a ECA factor of 0.5, would be counted as 50 equivalent clearcut acres.

zones, or any combination of acres between the high and low hazard zones that satisfies the following relationship:

Low Hazard Harvest Acres=-12.807(High Hazard Harvest Acreage)+266.01*

Annual harvest limits for the South Fork Elk River from the Landslide Reduction Model was 114 acres on the Discharger's lands in the South Fork Elk River watershed for all hazard zones combined.

The Elk River WDR included a "zero landslide-related discharge" requirement for harvest acreage in excess of the landslide reduction model limits. Regional Water Board staff developed a methodology for evaluating enrollment of harvest acreage in excess of the limits based on the landslide reduction model but not to exceed those established under the Peak Flow Model.

With adoption of the revised WDRs in 2016, harvest limits based on the two empirical models were replaced by a threshold of concern of 2% equivalent clearcut acres in any sub watershed over any 10-year period. With each enrollment application, HRC provides a table showing harvest acreage for the previous 10-year period and calculations demonstrating the average annual equivalent clearcut area for that period for each sub watershed in which the plan is located.

Regional Water Board and HRC staff evaluated the relative risk of sediment production and discharge in each sub watershed in the Upper Elk River. Based on suspended sediment data, landslide hazard, and observations by field staff of areas dominated by the Hookton Formation[5], areas within portions of six sub watersheds were identified as high risk to water quality for the purposes of the WDR. Those six subwatersheds are: Clapp Gulch, Railroad Gulch, Tom Gulch and Lower South Fork in the South Fork Elk River and Lower North Fork and South Branch North Fork in the North Fork Elk River. For the five-year period following adoption of the WDR, timber harvesting in the high risk areas is limited to units of THP 1-12-110 HUM, which was approved by CAL FIRE prior to the completion of the Upper Elk River TMDL. THP 1-12-110 HUM includes harvest in the high risk subwatersheds of Clapp Gulch, Railroad Gulch, Tom Gulch and Lower South Fork. No later than five years from the date of adoption of the WDR in

[5] From Tetra Tech (2015) "Geology: The argillite-dominated rock units of the Yager terrain are typically deeply weathered and sheared and subject to deep-seated flow failures on moderate slopes (Marshall and Mendes 2005). Deep-seated landslides and earthflows enclosing blocks of component sandstone are common in the Franciscan Complex Central Belt. These blocks commonly create steep slopes and weather to soils that have little strength and are susceptible to debris slides and debris flows (Marshall and Mendes 2005). Shallow landsliding and deep-seated bedding plane failures are common in Hookton terrain (Marshall and Mendes 2005)."

June 2019, the Regional Water Board will consider the conditions limiting harvest activities in high-risk areas, and after public notice and comment will provide staff direction on potential changes to the harvest limitations. In the absence of changes to the WDR, harvesting in high-risk areas for the period beginning five years after the adoption of the WDR will be limited to the acreage identified in the ROWD.

On November 15, 2021, as required by the monitoring and reporting requirements established by Order No. R1-2019-0021, HRC submitted a 5-year synthesis report, which is discussed in more detail below. Since 2016, HRC has harvested approximately 3775 acres under 15 separate THPs. Harvesting was primarily under single tree or group selection with 38 acres harvested under the variable retention silviculture method. The Table below provides a breakdown of harvest acreage by sub watershed 2016-2021 and the percent of the subwatershed harvested, calculated as clearcut equivalent acres over the previous 10-years, as provided by the WDR.

Table 2. Humboldt Redwood Company Harvest Acreage by Sub Watershed

Subwatershed	Acreage	% Harvest (10 year rolling average)
Bridge Creek	200	1.15
Browns Gulch	3	1.78
Clapp Gulch	17	0.13
Dunlop Gulch	34	2.63*
Lake Creek	2	1.38
Lower NF	211	0.77
Lower SF	361	1.27
Mainstem Elk	193	0.17
McCloud Creek	39	0.13
McWhinney Creek	121	1.51
North Branch NF	773	1.87
North Fork Elk	623	1.24
Railroad Gulch	103	0.73
South Branch NF	133	1.04
Tom Gulch	9	0.03
Upper NF	44	1.11
Total	3,775	0.97

*Exceedances of the 2% timber harvest rate limitation are only seen in Dunlop Gulch.

4.2.1.4 Sediment Control-Roads

As required by the WDRs, as of October 15, 2021, HRC's entire road system has been storm proofed or decommissioned. Road inventories were conducted prior to decommissioning and any necessary sediment control work was implemented. Table 3 summarizes the current status/classifications of the road network.

Table 3. Humboldt Redwood Company Total Roads by Classification

Road Classification	Total Miles
Permanent (Rocked/paved)	97
Seasonal (Native Surface)	124
Decommissioned	36

According to the HRC 5-year synthesis report (Miles, 2021), HRC has treated 104 road-related sediment discharge sites since 2016 for an estimated control of approximately 15,600 cubic yards of sediment delivery. An additional 12 historic off-road skid trail sites, primarily old watercourse crossings, were treated for the removal and control of an estimated 220 cubic yards of sediment discharge. The report further states that over 350,000 cubic yards of sediment have been removed or prevented from entering the Elk River stream system as a result of storm proofing road activities conducted on its ownership over the last 20 years.

4.2.1.5 Feasibility Study

The WDR requires HRC to conduct a feasibility study for control of in-channel sediment sources on its timberlands. In response, HRC implemented a sediment trapping pilot project in the lower reach of Bridge Creek, a tributary to the North Fork Elk River, pursuant WDRs. The project involved the 2019 removal of approximately 100 cubic yards of stored sediment, trapped in-channel behind a log jam. The log jam was retained intact during and following sediment removal, for the purpose of both aquatic habitat value and future sediment trapping. Several years of cross-sectional channel measurements were taken prior to removal of the stored in-channel sediment to evaluate pre-excavation aggradation and sediment accumulation. Cross-sectional measurements continue to be taken annually, post sediment removal, to evaluate subsequent channel change including any measurable sediment entrapment. Results to date indicate two percent or less of the Bridge Creek's sub-basin measured sediment load are being captured at this location annually. While the study demonstrated that in-stream structures can be utilized to trap and remove sediment, the difficulty in finding

suitable locations that can be accessed by equipment and the relatively insignificant total volume of sediment removed, staff conclude that sediment trapping may not have a significant role in watershed restoration efforts.

4.2.1.6 Restoration

Recently HRC and its non-profit partner Trout Unlimited were notified in November of 2020 that HRC's North Fork Elk River Salmonid Habitat Enhancement Project Designs proposal was selected for funding by CDFW through the agency's Fisheries Habitat Restoration program. The project is the engineering design step for restoration actions that reduce road related sediment delivery and restore and enhance 1.5 miles of instream, floodplain, and off-channel habitats along the North Fork Elk River. Input of large wood into the stream channel for the benefit of rearing and spawning habitat as well as sediment storage and sorting, is a significant component of the project. The project is intended to improve water quality and increase habitat complexity for all life stages of salmon and steelhead; and is consistent with and implements recommendations found in the ERRA.

4.2.1.7 HRC Compliance Summary

Regional Water Board staff closely track HRC's compliance with applicable water quality requirements, including permit provisions, through frequent field inspections and monitoring and reporting requirements. In general, staff find HRC's compliance with permit provisions to be very high.

Since adoption of the revised WDR in November 2016, the Regional Water Board has issued one Notice of Violation for sediment discharge resulting from two poorly constructed watercourse crossings on a new ridgetop road. HRC reconstructed the two crossings properly to control the discharge and the violations were considered adequately resolved.

During a November 9, 2017, preharvest inspection, staff encountered two reconstructed culverted watercourse crossings on a road within the logging area of the proposed THP 1-16-112 HUM. At both locations, fill slopes were failing and discharging earthen material to watercourses. On November 22, 2017, the Regional Water Board received discharge notifications from HRC for each site, as required under section II.M of the Order, describing site conditions and documenting corrective action taken on November 20, 2017, to control sediment discharge to receiving waters, including photographs showing work that has been implemented. Subsequent site visits confirm that corrective action remains effective, and no further discharge has occurred.

4.2.2 Green Diamond Resource Company

Green Diamond owns 1,905 acres in the South Fork of Elk River, mostly in the McCloud Creek sub watershed. In June 2010, the Regional Water Board adopted an ownership-wide Road Management WDR (Order No. R1-2010-0044). In October 2012 the

Regional Water Board also adopted the ownership-wide Forest Management WDRs (Order R1-2012-0087) for associated activities on GDRC property within the North Coast Region. The Road Management WDR covers systematic road upgrading and decommissioning, as well as maintenance and monitoring of the road system associated with the Road Management Plan from GDRC Aquatic Habitat Conservation Plan (AHCP). Conditions specific to the Elk River in the GDRC Roads Management and Forest Management WDRs largely rely upon the GDRC Operating Conservation Program, with specific prescriptions described in the South Fork Elk River Management Plan.

GDRC conducted a full road assessment within GDRC Elk River ownership in 2006, with additional sites identified during THP development since 2006. To date, 96.6% of the sites have been treated, representing an estimated total of over 38,000 cubic yards, or 98.7% of the road related sediment volume that could have potentially delivered to a watercourse.

GDRC maintains a master inventory of all sediment discharge sites deemed feasible to treat, including road-related sites both associated and not associated with THPs, non-road related sites associated with THPs (e.g., skid trail crossings), and non-road related sites not associated with THPs. All controllable sediment discharge sites at which corrective action was deemed feasible have been treated. Ongoing regular inspections to identify and treat new discharge sites are undertaken by GDRC.

The South Fork Elk River Management Plan addresses watershed specific operating procedures in the following five key categories:

- Riparian Prescriptions
- Geological Prescriptions
- Harvesting, Yarding and Hauling Prescriptions
- Road Management
- Seasonal Restrictions

On February 6, 2020, the Regional Water Board adopted Order No. R1-2020-0001, which was developed to be consistent with the hillslope indicators and numeric targets contained in the 2016 Total Maximum Daily Load Action Plan. This Order superseded portions of the GDRC Forest Management WDR that apply to certain activities conducted by GDRC on its timberlands in the Upper Elk River Watershed. The 2020 Order retains much of the provisions of the South Fork Elk River Management Plan. A summary of these requirements is for discussion purposes only; they are not intended to replace or revise the requirements as they are described in the adopted orders. The primary revision resulting from the new order are RMZ requirements that GDRC must retain a minimum of 50% post-harvest forest overstory canopy cover well distributed throughout the area and not utilize group openings larger than 0.25 acres within 300 feet from Class I and II watercourses and 150 feet from Class III watercourses.

The 2012 Order limited harvest rate in their South Fork Elk River timberlands to no more than 75 acres per year, calculated on a 3-year rolling average. The 2020 requirements established a reduced rate of harvest, limiting GDRC to 55 acres per year of net clearcut, calculated on a 3-year rolling average.

Since 2016, GDRC has had three active THPs. Table 4 shows the THPs and annual harvest acreage 2016-2021.

Table 4. Green Diamond Resource Company Harvest Acreage 2016-2021

Year	1-12-113 HUM (Acres)	1-14-119 HUM (Acres)	1-17-116 HUM (Acres)	Total Acres	Rolling 3 Year Average (Acres)
2016	0	28	0	28	34
2017	0	0	0	0	34
2018	0	0	73	73	34
2019	0	0	0	0	24
2020	0	33	63	96	56
2021	0	0	0	0	32

It should be noted that acreage reported above is total harvest acres, not net clearcut

4.2.3 Other Timber Harvest Plans

In addition to the two large industrial timberland owners, other landowners continue to conduct timber operations in the lower portions of the Elk River watershed under THPs, NTMPs, Exemptions and Emergencies, as summarized below:

4.2.3.1 Timber Harvest Plans:

Since 2016, there have been five new Timber Harvest Plans submitted in the Elk River watershed on properties other than HRC and GDRC, totaling 92.7 acres.

Table 5. Timber Harvest Plans in Elk Watershed Since 2016

THP Number	Acreage	Subwatershed	Enrollment Status	Silviculture
1-20-00029-HUM	40	Lower Elk	GWDR 6/2/20	Group Selection

THP Number	Acreage	Subwatershed	Enrollment Status	Silviculture
1-21-00082-HUM	19	Lower N/S Elk	GWDR 6/2/22	Seed Tree Seed Step
1-20-00070 HUM	8	Lower Elk	GWDR 6/30/20	Group Selection
1-21-00038-HUM	7	Lower Elk	GWDR 6/29/21	Group Selection
1-21-00051-HUM	19	Lower Elk	Not Enrolled	Selection

In staff's judgment, these THPs are either outside the Upper Elk River Watershed boundary affected by the load allocation of the TMDL or presented prescriptions consistent with the Action Plan.

4.2.3.2 Non-Industrial Timber Management Plans:

Non-industrial Timber Management Plan (NTMPs) are long term management plans, which provide landowners with an approved plan to conduct timber operations by submitting a Notice of Timber Operations (NTO) to CAL FIRE. NTMPs must utilize uneven age management (no clearcutting). NTOs are valid for one year and require landowners (or their consulting foresters) to conduct an evaluation of the NTMP to ensure conditions have not changed and/or address any changed conditions. The NTMP General WDR, Order No. R1-2013-0005, provides two options for compliance, Tier A and Tier B. In Tier A, landowners can enroll individual NTOs and requires identification and implementation of corrective action of sites within the NTO that could adversely impact beneficial uses of water. Tier B requires landowners submit and maintain an Erosion Control Plan (ECP) consisting of an inventory and schedule for implementation of corrective action for controllable sediment discharge sources.

There are three NTMPs in the Elk River watershed, two of which submitted one Notice of Timber Operations since 2016 and one which has submitted four NTOs since 2016.

Table 6. Non-industrial Timber Management Plans in the Elk Watershed Since 2016

NTMP Number	NTO Year	Acres*	Subwatershed	Enrollment Status
1-01NTMP-004 HUM	2017	Less than 10**	Clapp Gulch	Tier B
1-02NTMP-034 HUM	2021	35	Lower Elk	Tier A
1-03NTMP-013 HUM	2016	204	Lower Elk	Tier A
1-03NTMP-013 HUM	2019	138	Lower Elk	Tier A
1-03NTMP-013 HUM	2021	35	Lower Elk	Tier A
1-03NTMP-013 HUM	2022	35	Lower Elk	Tier A

*NTOs do not always complete harvesting on the entire acreage listed, and therefore, subsequent NTOs may cover either identical or overlapping area covered by previous NTOs. As such, the acres listed in multiple NTOs may not necessarily be cumulative.

**A small portion of the northeastern corner of 1-01NTMP-004 HUM is located in the headwaters of Clapp Gulch.

4.2.3.3 Notices of Exemption

The Forest Practice Rules (FPR) includes three types of timber harvesting projects that are exempt from the requirement that a landowner prepare and submit a THP; Exemptions, Emergencies and Conversion Exemptions.

FPR section 1038 exempts the timber operations listed below from THP preparation and submission requirements. Such exemptions include restrictions on use of heavy equipment on steep slopes, construction of roads and skid trails, timber operations on unstable areas and riparian areas, and winter period operations.

Since 2016, 31 Notices of Exemption have been filed on timberlands other than HRC and GDRC within the Elk River watershed on a total of 639 acres. In addition, both HRC and GDRC have submitted Exemptions, HRC for forest fire prevention on 69.9 acres and GDRC for removal of dead and dying trees on the bulk of its Elk River timberlands.

4.2.3.4 Bureau of Land Management – Headwaters Reserve

The Bureau of Land Management (BLM) manages the 7,472-acre Headwaters Forest Reserve, of which 4,424 acres are located in the South Fork Elk River (comprising 30 percent of the South Fork), in partnership with the California Department of Fish and Wildlife. The Headwaters Reserve was purchased from Pacific Lumber in 1999 by the Federal and State governments and is managed as an ecological refuge and for environmental education.

BLM conducted two forest thinning/fuels management projects, consisting of masticating and chipping small trees and understory vegetation on 81 acres in 2017 and 103 acres in 2018. It also conducted two fish habitat improvement projects on the South Fork Elk River, including modification of a debris jam to improve fish passage in 2019 and an accelerated wood recruitment project on 1.75 miles of stream in 2021.

4.3 Monitoring and Reporting Requirements

Monitoring and reporting requirements are an essential mechanism for Regional Water Board to review and comment on ongoing activities and track compliance with requirements and progress in sediment control and restoration and efficiently focus staff resources and prioritize inspection efforts.

As a condition of their continued operations both HRC and GDRC are required to monitor water quality and potential sediment sources (e.g., roads, landslides, logging activities), and report any changed conditions. Further, HRC is required to provide a five-year synthesis report (2016-2021).

4.3.1 Humboldt Redwood Company Monitoring Requirements

Section IV of Order No. R1-2019-0021, Waste Discharge Requirements, describes HRC's Monitoring and Reporting Requirements for their holdings in the Upper Elk River watershed. Monitoring requirements are divided as follows:

1. Inspections of roads and timber harvest areas
2. Landslide monitoring to identify new or reactivated mass wasting activity
3. Water quality monitoring, including aquatic trends monitoring (ATM) every 3 years and hydrology trends monitoring annually

HRC is required to submit an annual report by January 31 of each year, which summarizes the previous year's activities, including the results of monitoring. The annual report also includes a workplan of all planned management activities in the reporting year. Further, HRC is required to submit a Five-Year Synthesis Report (Synthesis Report) to evaluate the effectiveness of its management activity in preventing and minimizing discharge of sediment and protection of water temperature increases that may impact beneficial uses of water in the Upper Elk River.

The first Synthesis Report was submitted on November 15, 2021. It contains:

- Timber harvest summary
- HRC Road Status Summary
- Landslide summary
- Water quality and stream channel condition trends
- Restoration summary
- Effectiveness Monitoring Summary

In a letter dated March 18, 2022, the Executive Officer approved the Synthesis Report as complete, though noting disagreement with some conclusions and the lack of scientific support for other conclusions in the report. Section 4.2.1 includes a review of timber harvest, road status, and restoration. Section 5 includes staff's analysis of the suspended sediment data that were available at the time of the assessment (water quality assessment), the aquatic trend monitoring analyses presented by HRC (stream channel condition trends), and a paired watershed study conducted in Railroad Gulch and presented by HRC (effectiveness monitoring). The Landslide Summary was unverifiable and is not included here. A general summary of Regional Water Board comments on the approved Synthesis Report are included in Appendix D.

4.3.2 Green Diamond Resource Company (GRDC) Monitoring Requirements

Attachment C of Order R1-2020-0001, Waste Discharge Requirements, describes GDRC's monitoring and reporting requirements for their holdings in the Upper Elk River watershed. GDRC's holdings are limited to lands in the McCloud sub watershed, a tributary to the South Fork Elk River. Monitoring requirements are divided as follows:

1. Inspections of roads and non-road sediment sources
2. Inventory and treatment of road and non-road sediment sources
3. Landslide monitoring to identify new or reactivated mass wasting activity

Water quality monitoring, including stage, velocity, streamflow, turbidity, and suspended sediment. These data are to be collected for 30-consecutive days with no rain between October 1 and May 15. GDRC submitted annual reports on timber harvest, watershed stewardship, the Master Inventory, and water quality trend monitoring. GDRC must provide reports of landslide inventories by December 31 of the most recent photo flight year.

Section 5: Data Assessment and Trend Analysis

Table 4 of the TMDL Action Plan requires that:

"By 2021, the Regional Water Board shall evaluate the available information to assess the degree to which 1) adopted WDRs and waivers have successfully controlled sediment delivery from the upper watershed to the impacted reaches and 2) the efforts of the Watershed Stewardship Program are making sufficient progress towards achievement of health and safety, coordinated monitoring, and sediment remediation improvements."

Section VII. Monitoring and Adaptive Management of the TMDL Action Plan specifies that:

"*Approximately five years after adoption, Regional Water Board staff will conduct a formal assessment of the effectiveness of the implementation plan, including an evaluation of the effectiveness of WDRs and waivers, and make any necessary revisions to this TMDL Action Plan. This includes a review of the sediment source analysis and water quality data for the Upper Elk River, sediment deposition in the impacted reach and Lower Elk River, and the need for a Lower Elk River sediment TMDL, using Recovery Assessment tools and other available data, as appropriate. During reassessment, the Regional Water Board will consider how effective the requirements of the TMDL program of implementation are at meeting the TMDL, achieving water quality objectives, restoring the beneficial uses of water, and abating nuisance flooding conditions in the Upper Elk River Watershed. The success of the TMDL will be assessed based on water quality trends in the Upper Elk River Watershed, particularly the attainment of water quality standards in the impacted reach. Ultimately success is achieved when nuisance conditions are abated, and beneficial uses are supported."*

The data analyzed in this section come primarily from Humboldt Redwood Company (HRC) via the monitoring and reporting requirements (MRP) of the WDR and Aquatic Habitat Conservation Plan (AHCP) (USFWS, 2019). Other data sources include the Elk River Recovery Assessment (ERRA) the Watershed Stewardship Program; Green Diamond Resource Company (GDRC); and various collaborators from academic institutions such as Humboldt State University.

The initial and primary focus of the data assessment and trend analysis was to assess available data for evidence that sediment sources in the upper watershed are controlled and impairments to beneficial uses are alleviating, water quality conditions are improving, and nuisance flooding conditions are improving. The analyses contained in this section are largely focused on the period of 2016 to 2021, the first five years of implementation under the TMDL Action Plan. Where appropriate, however, longer trends are considered. Not all data useful for this phase of TMDL assessment were

available to us in the timeframe necessary for the review. But sufficient data for a subset of monitoring locations in the upper watershed were available and are fundamental to the analyses described below.

During the course of staff's analysis for this report we determined that the data collected under existing monitoring programs in the Elk River watershed do not constitute all that is necessary to assess all of the questions highlighted above. As such, staff have concluded that the development of a Science and Coordinated Monitoring Workgroup as contemplated in the TMDL Action Plan would be useful and is overdue. Such a workgroup could identify key monitoring questions, design a coordinated monitoring program, inform revision to the existing monitoring and reporting requirements of permittees, establish hypotheses appropriate for special study, and design a framework for adaptive management over the long term.

5.1 Overview and Summary

Consistent with requirements of the TMDL Action Plan, the purpose of this data assessment is to determine the degree to which sediment sources from the upper watershed are controlled and whether impairments to beneficial uses are alleviating, water quality conditions are improving, and nuisance flooding conditions are improving. To evaluate these questions, staff presents analyses from three sources. First, staff conducted an independent analysis of water quality trends in suspended sediment concentration and aquatic habitat parameters, which informs progress towards controlling sediment discharges and restoring the salmonid-related Beneficial Uses. Second, staff summarizes the work and findings of HRC's Synthesis Report relative to its paired watershed study in Railroad Gulch and its Aquatic Trend Monitoring (ATM) Program. Third, staff summarizes the work and findings of CalTrout, Northern Hydrology Engineering, and Stillwater Sciences in its 2019 Elk River Recovery Assessment: Recovery Framework document as it relates to trends in channel cross sections in the impacted reach. The following are the main findings from these analyses:

- After controlling for the influence from precipitation, streamflow, and calendar day, suspended sediment concentrations ("residual" SSC) have not changed from beginning of the record in Water Year[6] (WY) 2003 to WY2020. The same result of no trend also occurs between WY2008 and WY2020, with the former being the year that HRC assumed ownership of Elk River timberlands. The monitoring locations for SSC analysis comprise the mainstem, the North Fork, and the South Fork, all geographically close to one another (≤ 2 miles).
- Limiting the trend analysis to the last five years (WY2016-WY2020), staff found statistically significant increasing trends in SSC at the lower North and South

[6] The Water Year or Hydrologic Year is defined as October 1st through September 30th

Fork Elk River above their confluence. Due to fewer number of years (smaller dataset) and other analysis methods reporting no statistically significant results, the increasing trend at these locations is weakly supported.

- The severity of ill effects (SEV) scores quantify behavioral and physiological response of salmonids to suspended sediment concentrations. Staff analyzed ten HRC water quality monitoring stations for SEV scores. Only three stations show statistically significant time trends: the mainstem directly below the North and South Fork confluence (increasing SEV); the lower South Fork (decreasing); and Bridge Creek in the North Fork subbasin (decreasing). Greater SEV scores mean more severe effects and decreasing SEV scores indicate improved conditions. This result is consistent with the TMDL's findings for the impacted reaches where large in-channel sediment deposition are resistant to scour.
- Aquatic Habitat Trends data provide useful information for tracking watershed conditions related to sediment distribution and movement. HRC collected ATM data from seven locations throughout the watershed and data was compared to Aquatic Properly Functioning Conditions. Sites in the upper watershed are either at, or nearing, desired conditions for sediment related Aquatic Properly Functioning Condition parameters. However, sites downstream, specifically in the impacted reach, are far from desired conditions for sediment related parameters. Over the past five years, sediment related parameters in the impacted reach have shown a slight trend toward desired conditions, however, continued monitoring over the coming years will provide useful information as to whether conditions are improving due to management related activities or if modifications to management practices are necessary.
- In-channel cross-section data up through 2016 as reported in the ERRA Framework indicates continued channel aggradation, ranging from minimal to severe.
- The results of the Railroad Gulch study are confounded by landslide activities in the reference watershed, which prevent clear conclusions relative to the effects of management activities on water quality conditions.

5.2 Staff Analysis of Water Quality Trends

Parameters or variables for water quality trend analysis are residual suspended sediment concentrations (SSC) and the severity of ill effects (SEV) scores. Residual SSC is the difference between the observed and model predicted SSC. Conceptually, this residual value is the SSC after accounting for covariates included in a regression model. SEV is a rating scale that quantifies the effects on aquatic life due to continuous exposure time duration at fixed SSC values. The scale was initially developed by Newcombe & Macdonald (1991). Models for SEV can vary for different salmonid life stages (Newcombe & Jensen, 1996).

5.2.1 Data

Data used for this assessment are turbidity, SSC, stage or water depth, stream discharge or flow, and precipitation. The first four datasets are generally paired such that one predicts the other using a rating curve. Specifically, turbidity and stage (water depth) are measured on a continuous basis with observations collected every fifteen (15) or thirty (30) minutes. Simultaneous SSC and discharge measurements are more difficult and costly to acquire, and so they are collected over the range of the monitoring location's turbidity and stage. The paired datasets have a statistical relationship such that continuous turbidity or stage measurements can estimate continuous SSC or discharge, respectively. For stage-discharge rating curves, discharge is manually measured (i.e., cross-sectional area times velocity) at stages that correspond to different wetted perimeters as well as at different points in time during one or more rainstorm event(s). These rating curves generally follow power law relationships and may be modeled piecewise, corrected for hysteresis, and other post-processing procedures.

Turbidity threshold sampling (TTS) is the method for collecting SSC samples. TTS utilizes a field-deployed and an automated turbidimeter, stage measurement device, data logger, and a pumping sampler. When turbidity and stage measurements reach certain thresholds, the pump sampler begins collecting water grab samples at the same temporary frequency as the turbidimeter until the other measurement readings fall below the thresholds. The pumped samples are then analyzed in a laboratory to manually measure SSC. While similar in concept to stage-discharge, the turbidity-SSC rating curves may follow different statistical models, which are often fitted per storm event and the inter-storm periods. SSC samples are also considerably more frequent than discharge measurements (Lewis & Eads, 2001).

HRC maintains a rainfall gauge network within the Elk River watershed, but those gauges only have daily totals and the earliest year in HRC's record is 2010. For hourly precipitation measurements, HRC, stakeholders, and other interested parties rely on the National Weather Service (NWS) station on Woodley Island located in Eureka, CA. However, the Woodley Island (aka EKA) weather station is more representative of the coastal plain than the upper watershed and relying entirely on EKA introduces bias and inaccuracy (NCRWQCB, 2016). Instead, this assessment uses radar-based precipitation estimates, collected hourly and in a spatial grid with cell edge length at approximately four (4) kilometers. These estimates are bias corrected using rain gauge measurements where available. The data source for this gridded precipitation dataset is the National Center for Atmospheric Research (NCAR et al., 2000). Table 2 shows the total precipitation by water year (WY) in the Upper Elk River watershed for the period of record.

The continuous data aggregate to the annual WY scale to produce various metrics such as annual water yield, suspended sediment load (SSL), and tenth percentile turbidity (NTU15). Please see Table 7 and Figure 3 for more details of the annual metrics and a map of the monitoring locations, respectively. Annual datasets are relatively coarse, and not all monitoring location or stations will share the same number of years as stations are decommissioned due to funding and/or different catchments are prioritized for monitoring. Nevertheless, the annual datasets altogether can cover a large spatial range within the watershed. Additionally, annual data are more likely to (a) follow a normal probability distribution and (b) be independent and identically distributed (i.i.d.). Production and trend analysis of various annual scale metrics are found in HRC Five-Year Synthesis Report and will not be repeated here (Miles, 2021).

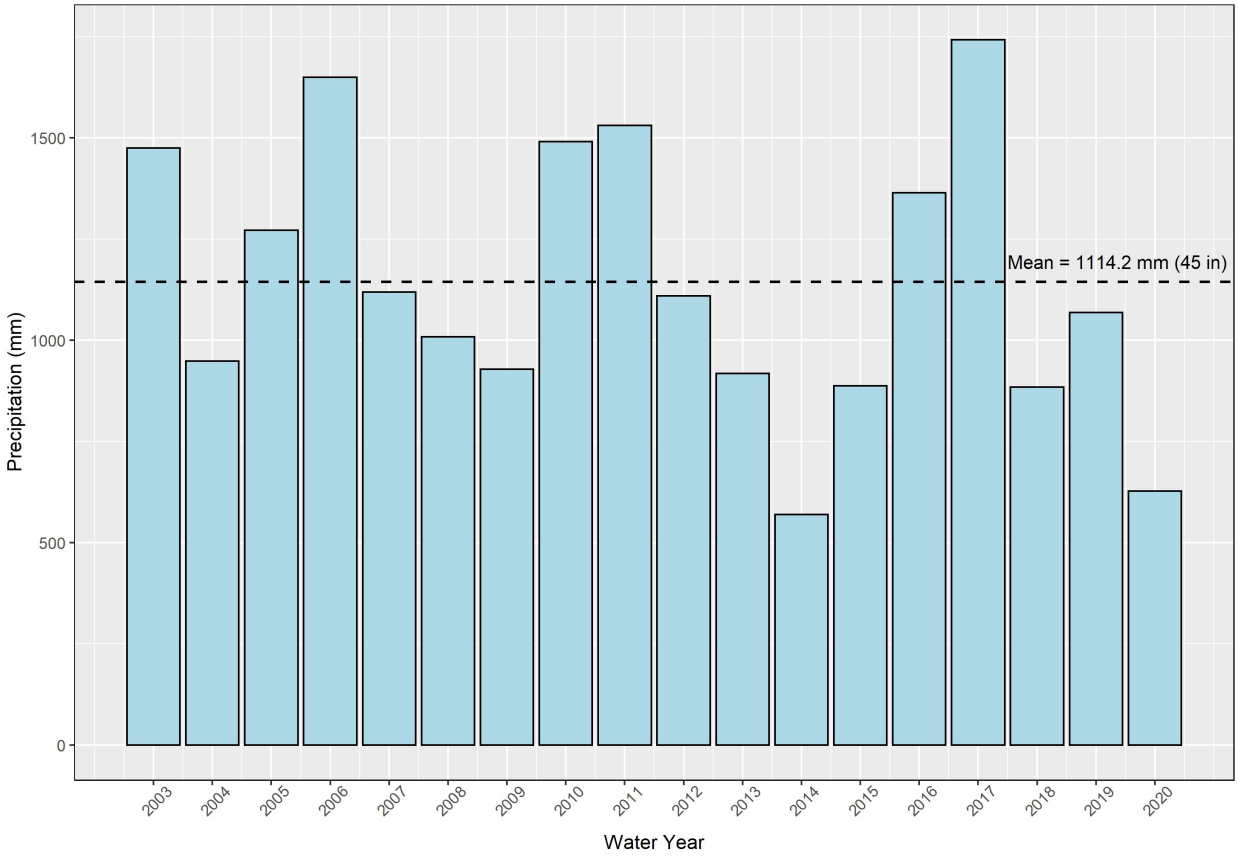

Figure 2. Annual precipitation for station HRC509 catchment

Table 7: Metrics and other quantities analyzed by Humboldt Redwood Company and Regional Water Board

Metric	Definition	Units	Analyzed By
10NTU	10% Exceedance Turbidity	NTU	HRC
RUN	Total Runoff (mm)	mm	HRC
PPT	Annual Precipitation at EKA	mm	HRC
NDG1	Days above (1) inch rainfall	days	HRC
PQ	Peak flow	$m^3 \cdot s^{-1}$	HRC
MDP	Maximum daily precipitation	mm	HRC
SY	Sediment yield	$Mg \cdot km^{-2}$	HRC
FWMC	Flow-weighted mean concentration	$mg \cdot L^{-1}$	HRC
Residual SSC	Observed – model predicted SSC	$\log(mg \cdot L^{-1})$	NCRWQCB
Mean SEV	Arithmetic mean SEV score for one WY	unitless	NCRWQCB
Median SEV	Median or 50^{th} percentile SEV score for one	unitless	NCRWQCB
Max SEV	Maximum SEV score for one WY	unitless	NCRWQCB
90^{th} SEV	90^{th} percentile SEV score for one WY	unitless	NCRWQCB

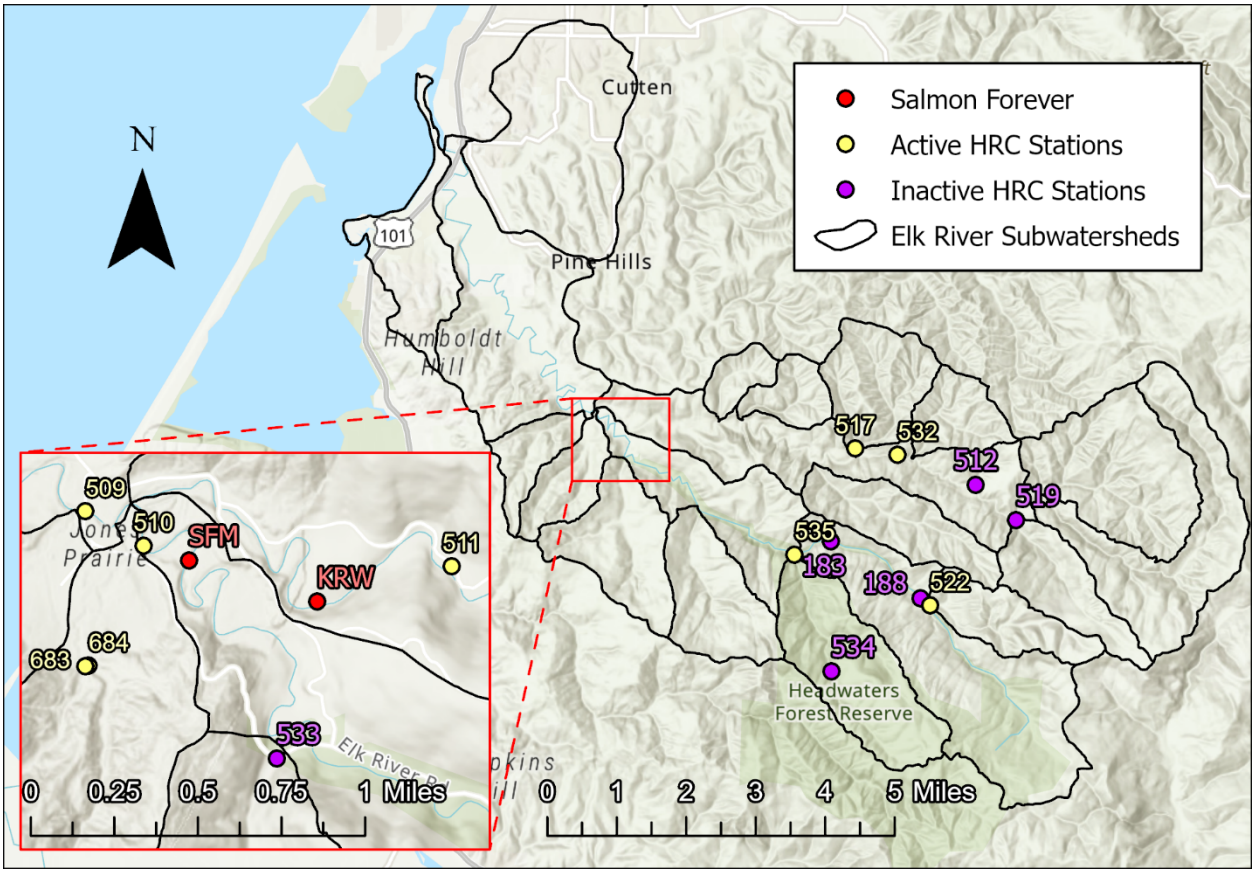

Figure 3. Map of Elk River hydrologic and water quality monitoring stations

5.2.2 Suspended Sediment Concentrations

5.2.2.1 Methods

The general methods for assessing time trends in residual SSC include: 1) graphical interpretation of data visualization such as time-series plot, correlograms, and model fits; 2) formal hypothesis testing using parametric and non-parametric methods; and 3) regression analysis. These methods are not mutually exclusive and complement each other where applicable (e.g., regression diagnostic plots). Exact statistical methods employed for hypothesis testing and regression modeling are largely determined by whether the estimate or metric are at the annual scale (see Table 7). Staff's analysis of suspended sediment concentrations uses each of these three approaches.

Annual metrics that are independent and normally distributed can be used with common statistical methods such as the *t*-tests, analysis of variance (ANOVA), Pearson's r correlation, and ordinary least squares (OLS) regression. However, normality is not assumed for any metric, and this assessment uses primarily non-parametric methods

for detecting trends. The non-parametric are the Mann-Kendall (MK) test and the Theil-Sen estimator.

The MK test is based on the rank correlation statistic or Kendall's τ. The variable of interest is sorted by time and then their ranks are tested for monotonic trends, which are trends that strictly rise or fall. If τ is statistically significant, then the variable has an increasing (positive τ) or decreasing (negative τ) time trend. The Theil-Sen estimator takes the form of a simple, univariate linear equation—i.e., y = mx + b. The coefficients *m* and *b* are based on the data's medians with *m* being the Sen slope, which is the median slope of all slopes calculated from all possible pairs of data points. Similarly, *b* is the median intercept of all intercepts after solving for all slopes. The Sen slope provides an estimate of a trend's magnitude. Both methods are non-parametric and do not require knowing the data's probability distribution. As such, the Sen slope and the MK test are common methods for trend detection in environmental data (Mustapha, 2013).

The regression analysis uses a multiple log-linear model of SSC against the independent variables or covariates: discharge, antecedent precipitation, calendar day of year, and linear time. The full specifics of the regression model development can be found in Appendix B. The general form of the regression model[7] is:

$$\log(SSC) \sim \beta_0 + \beta_1 log(Q) + \beta_2 \sqrt{API} + \beta_3 \sin(2\pi \cdot f_{doy}) + \beta_4 t$$

Where *Q* is stream discharge ($m^3 \cdot s^{-1}$); *API* is antecedent precipitation index (unitless); f_{doy} is calendar day of year fraction (unitless, e.g., January 1st would be 1/365 ≈ 0.003 during a non-leap year); and *t* is linear time (years). The various *β* terms are the model *coefficients*. In this model formulation, the coefficients can be exponentiated and then interpreted as a percent change in SSC per unit covariate. The most relevant covariate for this assessment is linear time. If the linear time coefficient is statistically significant, then a time trend exists[8]. The sign of the coefficient indicates the direction of the trend: positive indicates that SSC is increasing and negative means decreasing. The magnitude of the coefficient indicates the percent change rate of the trend. The probability of a trend not being different from zero is the coefficient's *p-value*, a number

[7] Unless otherwise specified, log refers to the natural logarithm with the base of e, the natural number.

[8] No statistical analysis can produce completely certain results. So "exist" really means that the trend has at least a 95 percent chance of existing—more precisely, the probability of the coefficient's true value being equal to zero is less than 0.05 or 5 percent.

bounded by 0 to 1. Statistical significance is defined as a p-value less than 0.05 or α (alpha), the so-called "critical" threshold value.

As mentioned previously, SSC samples are more frequent and fully continuous during periods where turbidity thresholds are exceeded (i.e., during storm events). With a long record dating back to WY2003, the SSC datasets are large and statistically robust—that is, the presence of anomalous values are unlikely to change the overall result. That said, because the SSC samples are frequent in time, serial autocorrelation is likely present. Serial autocorrelation arises when the present value depends on or correlates with its previous values; how many values back is called the *lag* (i.e., lag 1 is previous value, lag 2 is the previous two, etc.).

Fitting an OLS regression model to a response variable with autocorrelation usually results in autocorrelated residuals, which violates one of the fundamental assumptions of OLS that the residuals are independent and identically distributed. The consequences of autocorrelated residuals results in an "inefficient" estimate of the model's coefficients. Statistical inefficient in means that the variance or "error" for coefficient estimates and fitted values are inaccurate and often biased downward (Granger & Newbold, 1974). To solve the autocorrelation issue, regression modeling uses the generalized least squares (GLS) method, which is a flexible model that can accommodate different error correlation structures. The importance of discussing OLS, GLS, and autocorrelation is that statistically inefficient estimates may *incorrectly* lead to a low p-value and, consequently, a finding of statistically significant results when in fact, they are not significant.

5.2.2.2 Results

For graphical interpretation, the regression model is fitted without a linear time term and then the model residuals or residual SSC are plotted with linear time on the horizontal axis and residual on the vertical. The MK test is conducted on the mean annual residual SSC for whole period of record (WY2003-WY2020). For the regression analysis, these regression models include linear time and then its coefficient's p-value is assessed for significance. The p-value is assessed three times for three model fits, each corresponding with a timespan: a) the entire period; b) when HRC assumed timberland ownership (WY2008-WY2020); and c) the last five years (WY2016-WY2020). Outliers are also removed from the model fits. For complete details on results from this data assessment, please see Appendix C.

Due to lack of readily usable[9] data at the time that this assessment began, Regional Water Board staff only use SSC sample data for three monitoring stations: HRC509 on mainstem Elk River immediately downstream of the South and North fork confluence; HRC510 on lower South Fork; and HRC511 on the lower North Fork. As shown on, HRC510 and HRC511 locations are immediately above the South and North Fork confluence, respectively. These stations and their locations are very close to each other with all three being approximately one mile or less from each other. As such, comparisons between these three may not yield much information about upslope and other land disturbance processes' impact on SSC. That is, their lower watershed locations and cumulative effects may "drown" out any signal produced in the upper watershed.

Where data are available, staff strongly recommend performing the residual SSC analysis to all upstream monitoring stations. By including the upper watershed, the overall results of this analysis may substantially change once staff are able to disentangle the SSC trends and signals between different catchments and their respective management history.

[9] Readily usable in this case is defined as tabular and machine-readable file data formats. Example of readily usable data formats: comma separated value text files (CSV) and Microsoft Excel spreadsheets. SSC sample data for all other stations are either in non-usable formats or not in Regional Water Board possession.

5.2.2.3 Visual Inspection

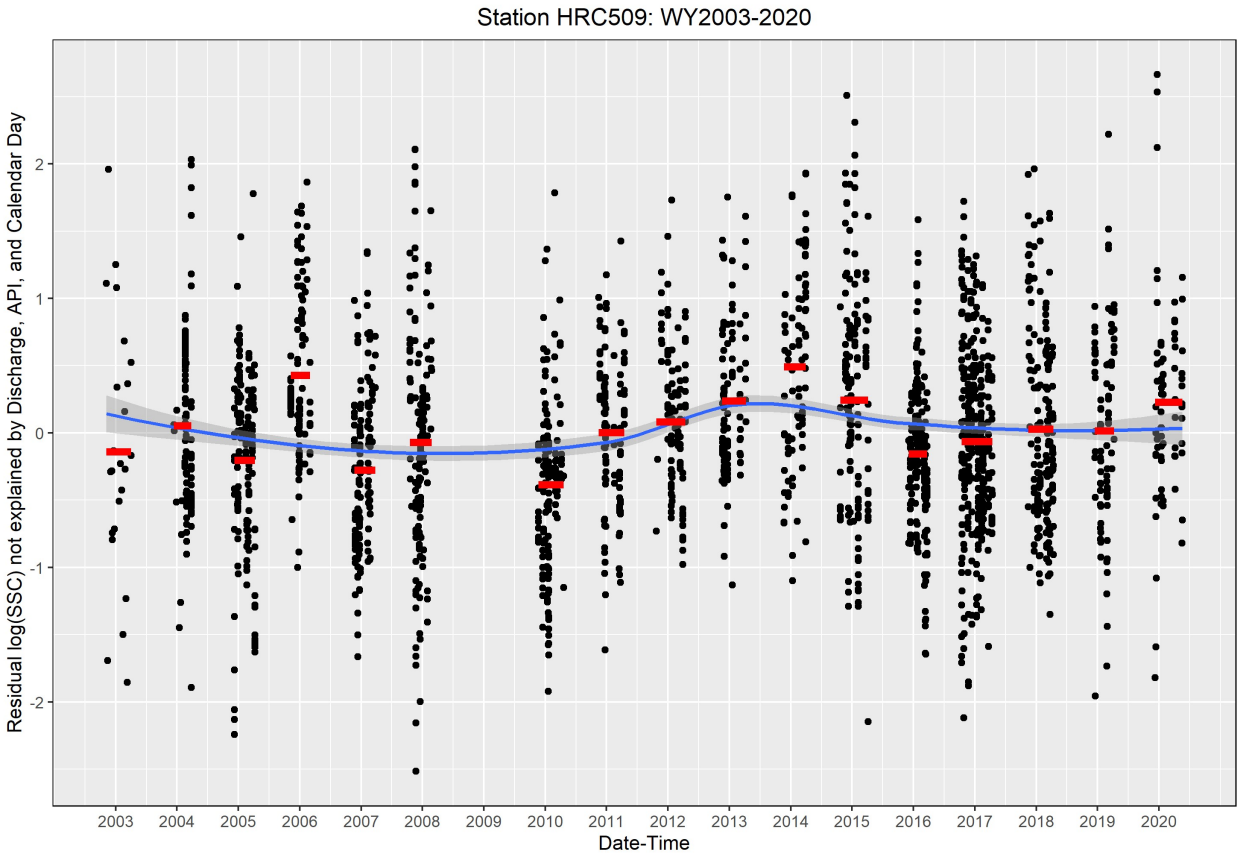

Figure 4. Mainstem station HRC509 residuals with outliers removed

Figure 4 shows station HRC509's residual SSC over the full period of record. Black dots are the individual residuals; the red bars are the annual mean residual; and the blue line is the locally estimated scatterplot smoothing (LOESS[10]) curve with the curve's confidence interval in gray. From WY2003 to WY2020, the linear trend appears relatively flat—that is, residual SSC at the beginning shows little difference with the end. That said, the curve has a noticeable dip or convex shape between WY2003 and WY2012 with observed SSC being lower than predicted after controlling for discharge, antecedent precipitation, and calendar day. The exception to this dip is WY2006 whose mean annual residual SSC is the second highest of all years, but WY2006 also has the second highest annual precipitation total. Immediately after the dip, a bump appears

[10] LOESS stands for locally estimated scatterplot smoothing. LOESS us an algorithm that produces "smooth" curves from a scatterplot, capturing general patterns in the data.

between WY2012 and WY2016, right in the middle of the historic 2011-2017 California drought (Luo et al., 2017).

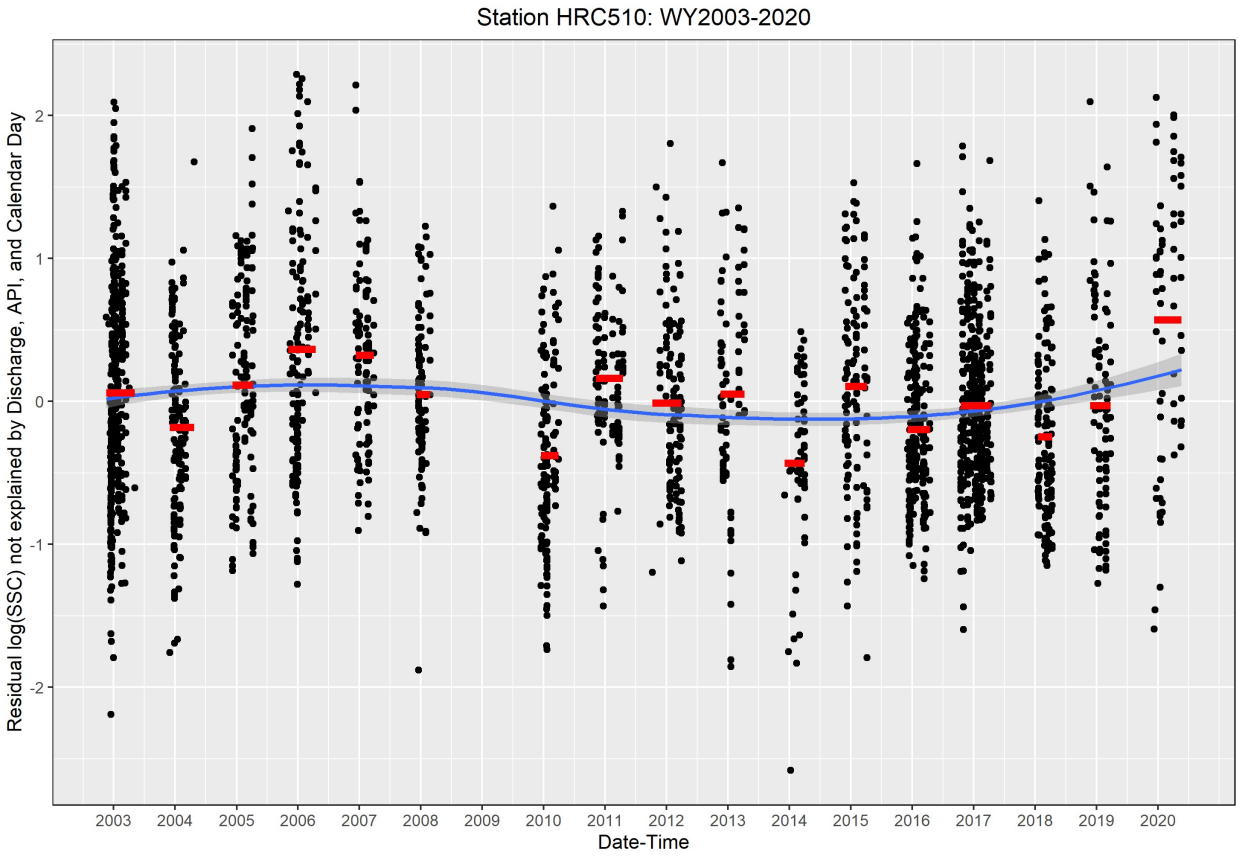

Figure 5. South Fork station HRC510 SSC residuals with outliers removed

Figure 5 shows SSC residuals over time at station HRC510 on the lower South Fork Elk River. In contrast with HRC509, the LOESS curve is somewhat inverted compared to HRC510 with an initial rise and then subsequent fall; however, the confidence bands for the curves are much closer to zero, indicating that the deviations from zero may not be statistically significant. Residual SSC spikes at the end in WY2020. One possible explanation for the spike is the presence of a sediment discharge source that is not affected by precipitation, streamflow, or calendar day. This source would continue discharging and with low flows and low water volume, any sediment input would result in higher SSC.

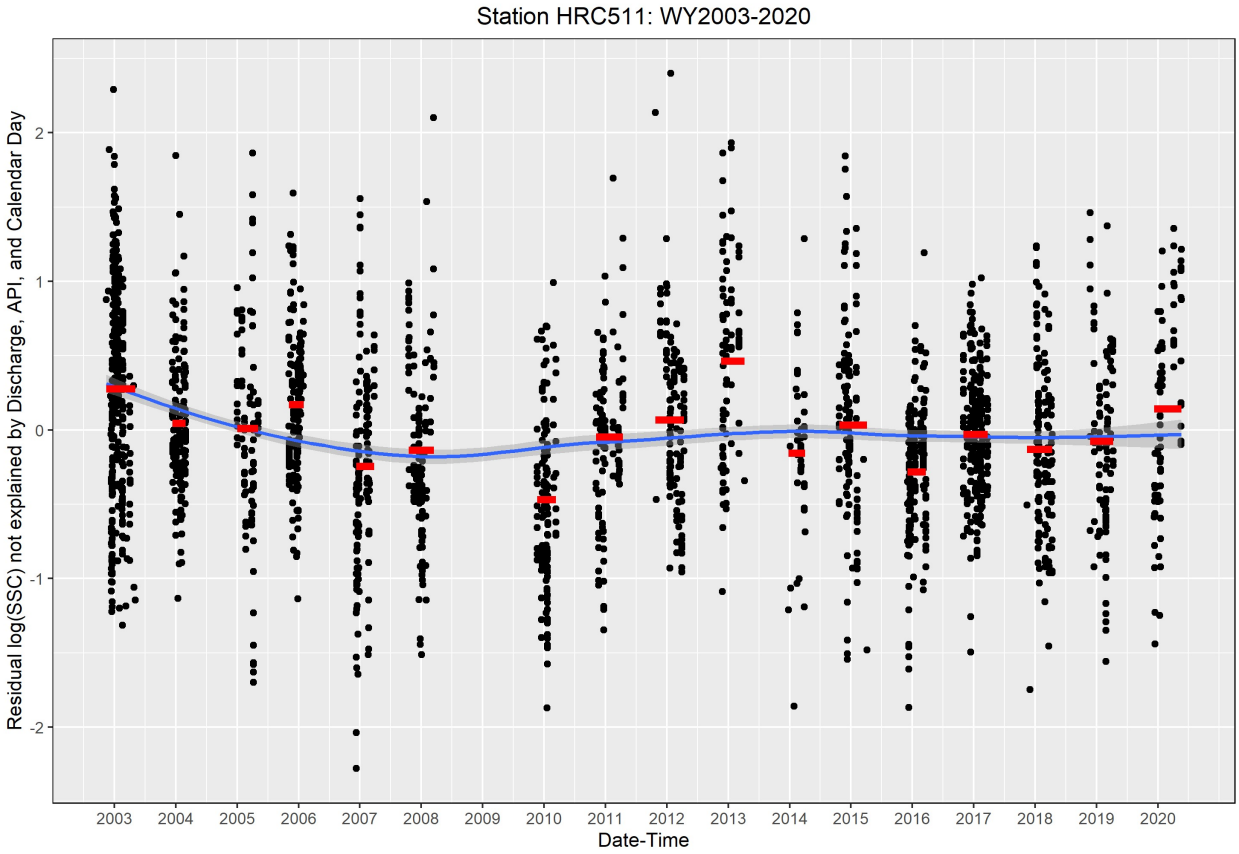

Figure 6. North Fork station HRC511 SSC residuals with outliers removed

Figure 6 shows the residual SSC for station HRC511 on lower North Fork Elk River with the outliers removed. The initial values from WY2003 to WY2010 indicate a steeper downtrend than the dip seen at HRC509. The annual mean SSC residuals then climb, peaking at WY2013, a year with below average precipitation and near the beginning of the 2011-2017 drought. After the climb, residual SSC falls and stays near zero through WY2020.

In general, the plots indicate stations HRC509 (mainstem) and HRC511 (North Fork) are more similar to each other than with HRC510 (South Fork). The mainstem and North Fork stations exhibit a dip during the earlier years, then subsequently rise in the middle before flattening out. While the LOESS curve shows a more pronounced rise in HRC509, the rise at HRC511 seems to be due to WY2013 being an anomalous year. HRC510 is the odd one out with a rise at the beginning, dip in the middle, and then a large uptick in WY2020.

Overall, these visual interpretations of these plots by themselves do not provide conclusive information about SSC trends since WY2003. The year-to-year individual differences may be random noise or the result of some unknown and unquantified

variable. Without further testing of variables, visual conclusions are weak. Specifically, visual interpretation of plots is qualitative at best, but at worst can be misleading.

5.2.2.4 Non-Parametric Trend Testing

The mean annual residual SSC values are tested against time or water year for the entire period of record. Annual values are used because the TTS method collects pump samples in an episodic (i.e., storm-based) manner, complicating season definition needed for seasonal MK tests. Table 8 shows the results of the MK test and Sen slopes for the three stations. None of the annual mean residuals have statistically significant results, indicating no monotonic trends and static conditions since WY2003.

Table 8: Trends in mean annual log SSC residuals

Station	Location	Trend	MK p-val	Significant
509	Mainstem	Increasing	0.232	No
510	South Fork	Decreasing	0.343	No
511	North Fork	Decreasing	0.537	No

5.2.2.5 Regression Analysis and Findings

Table 9 shows the results of the regression analysis when including linear time (t) in the GLS model. The model is then refitted with the trimmed time periods corresponding to HRC's present ownership and the last five years.

Table 9: Statistically significant regression results for linear time

Station	Start WY	p-value	% per year	Low CL %	Up CL %
510	2016	0.001	+15.57	+6.053	+25.948
511	2016	0.041	+8.657	+0.336	+17.667

Only two station-time period model fits produce statistically significant coefficients: HRC510 on South Fork and HRC511 on the North Fork, both based on using the last five years. From WY2016 through WY2020, residual SSC at HRC510 on South Fork is increasing at approximately 15.6 percent per year with a confidence interval of 6.1 percent and 25.9 percent. Residual SSC at HRC511 on North Fork is increasing at 8.7 percent per year with a confidence interval of 0.34 percent and 17.7 percent. This means that after correcting for effects of discharge, antecedent precipitation, and calendar day, suspended sediment concentrations have increased at these two sites during the last five years.

The p-value for HRC510's time coefficient is highly significant as it is far below the 0.05 significance threshold. The same cannot be said for HRC511 as the p-value is very close to the threshold. Considering the potential implications for the TMDL program of implementation (e.g., role of timber harvest operations on increased suspended sediment discharges), these results warrant greater scrutiny.

To better assess these data, the other trend detection methods are re-applied to the constrained time period, followed by visual inspection of SSC residuals. Table 10 shows the MK tests and Sen slopes for HRC510 and HRC511 in the last five years. Note: both datasets have equal size (n = 5), and with a rank-based correlation, the calculated Kendall's τ being the same for both stations are not an unexpected result. While both Sen slopes are positive, the p-values for τ are not statistically significant. With such a small sample size, the MK test is unlikely to give significant results unless the change in log residual SSC over time is very large in absolute terms; that is, the estimated *t* coefficients are small relative to the other covariates.

Table 10: MK tests and Sen slopes for mean annual log SSC residual for WY2016-WY2020

Station	Location	Trend	MK p-value	Significant
510	South Fork	Increasing	0.221	No
511	North Fork	Increasing	0.221	No

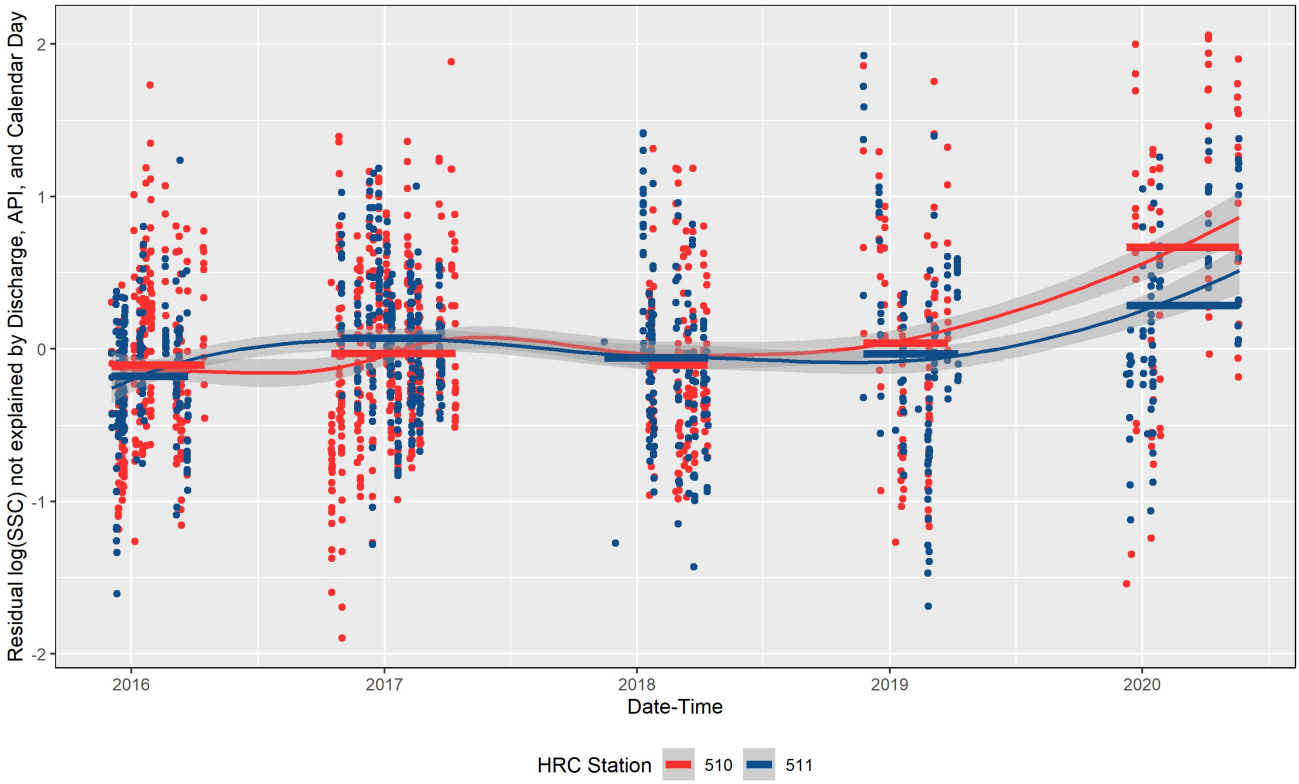

Figure 7. SSC residuals for stations HRC510 and 511 while using only the last five years for statistical modeling

Figure 7 shows the model residuals of the shortened time period when excluding linear time. WY2020 seems to be driving the uptrend as all the other years have their means hovering around zero. So, while the regression analysis results have statistically significant increasing trends in residual SSC since WY2016, the other methods either have disagreement (MK test) or indicate high leverage from WY2020 (visual inspection). Data points with high leverage tend to skew the results, similar to how extreme values affect the mean of a sample population. Over time as more data becomes available, redoing this regression analysis would likely provide more insight on whether the statistically significant trend in the North and South Forks is genuine or is a result of outliers.

5.2.3 Severity of Ill Effects

5.2.3.1 Methods

Based on a meta-review of studies investigating suspended sediment impact, the Severity of Ill Effects (SEV) model is a regression equation taking the form:

$$SEV = a + \mathrm{b} \cdot \log(SSC) + c \cdot \log(ED)$$

Where *ED* is the time continuous exposure duration in hours at a fixed SSC value specified in the formula with *a*, *b*, *c* as regression coefficients. Regression coefficient values vary with life stage, taxon, and publication. Consistent with the ERRA analyses, staff use the salmonid eggs/larvae and juvenile life stages from Newcome and Jensen (1996). Additionally, staff also use Coho salmon under yearling and juvenile life stages from Bray (2000), which were not used in the ERRA. While Newcombe and Jensen included observation data of Coho salmon, their model pooled many other non-salmonid species. Bray (2000) calibrated the SEV model to just Coho salmon; moreover, the Bray model parameters are more recent and may provide more accurate results. The SEV scale ranges from 0 to 14 with 0 being no effect and 14 being greater than 80 percent fish mortality. The scale has four general groups: no effect (SEV = 0); behavioral effects (1-3); sublethal effects (4-8); and lethal effects (9-14).

Table 11 contains descriptions of select SEV scores and the effects they describe, modified from Newcombe & Jensen (1996). For the ERRA, SEV scores' purpose is to contrast different sediment transport and hydraulic model scenarios. Using observed SSC data from WY2003 through WY2015 at monitoring locations HRC509 (mainstem downstream of South and North Forks' confluence), 510 (lower South Fork), and 511 (lower North Fork), the ERRA's SEV analysis yielded scores between 5.0 and 13.4 for the eggs/larvae life stage and between 5.7 and 8.6 for the juvenile life stages. Table 11 provides qualitative descriptions of aquatic life effects associated with SEV scores.

Given SSC and corresponding exposure durations, SEV can be visualized as a grid. Newcombe and Jensen (1996) constructed the grid by discretizing a range of SSC, as shown in Figure 8. The right vertical axis has increments of one natural log unit, and on the left is the corresponding SSC in mg/L after exponentiation (e.g., e0 = 1). ERRA used an SSC range of three (3) through eight (8) log units or 55 to 2981 mg/L. For this assessment, staff discretized the entire range in 0.1 log units, resulting in exactly 121 corresponding exposure durations and calculated SEV scores. Each monitoring station and each WY have 121 SEV scores. From the raw SEV scores, the following summary or descriptive statistics are calculated: mean, median, 90th percentile, and maximum SEV scores. These annual descriptive statistics are the basis of the SEV trend analysis, which differs from the approach in the ERRA.

Table 11: Select SEV scores and their associated effects on aquatic life

SEV Score	Effects Description
5	Minor physiological stress; increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation
8	Indications of major physiological stress; long-term reduction in feeding

SEV Score	Effects Description
9	Reduced growth rate; delayed hatching
10	0-20% mortality; moderate to severe habitat degradation
13	>60-80% mortality

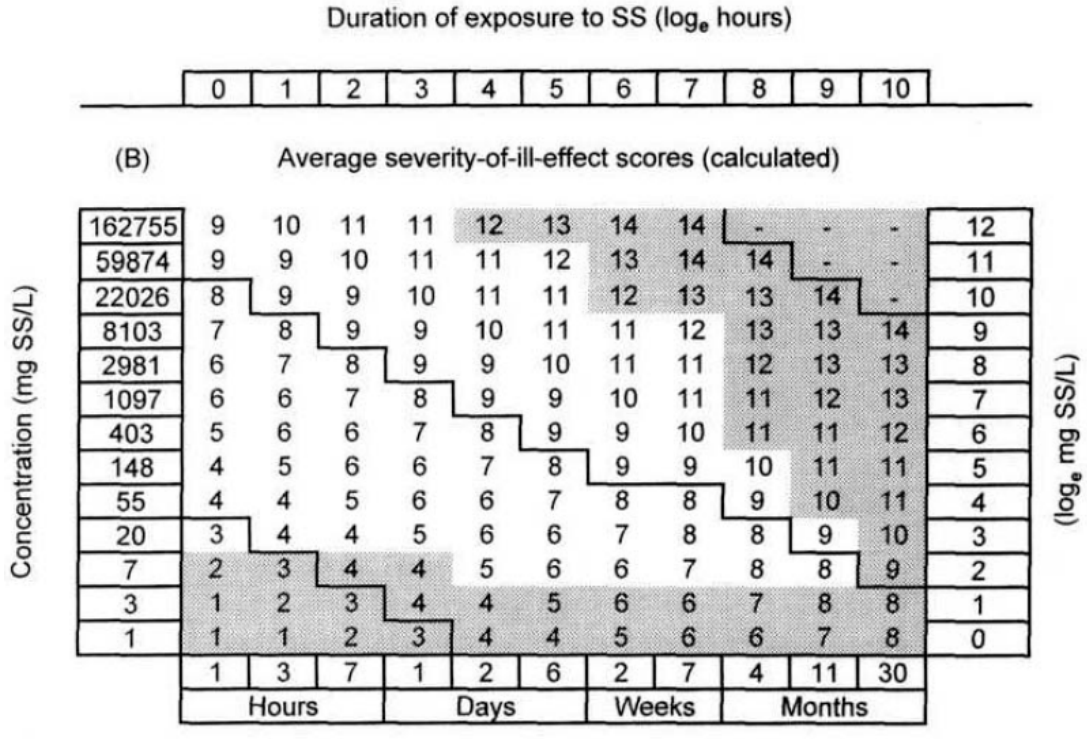

Figure 8. Newcombe and Jenson (1996) figure showing SEV as a function of SSC and SSC time duration

The same non-parametric methods for residual SSC (MK test and Sen slope) are used again for assessing trends in descriptive SEV score statistics. The MK test requires a minimum of four (4) samples (i.e., four years). Trend tests are performed for every unique combination of life stage, SEV statistic, and monitoring station (e.g., maximum SEV for juveniles at station HRC509 on the mainstem). For trend testing, selected stations must meet two criteria: a) contains at least four years and b) either currently operating or ceased operation after WY2016. While somewhat arbitrary, the latter requirement reflects the five-year review time span (WY2016 – WY2020).

The MK test can also be applied to a geographic area, a variation also known as the regional MK test (Helsel & Frans, 2006). The regional MK test is based on the seasonal MK test, that latter of which is usually used for sub-annual data exhibiting cyclical patterns. Each season is a “block” or group, and the regional test replaces the season block with location. The regional MK test and its associated Sen slope can indicate

whether the area of interest has an overall trend direction and magnitude. Because the Elk River watershed is relatively small at 58.3 mi^2, monitoring data may have inter-station correlation due to spatial autocorrelation of underlying processes. Particularly, if the catchment draining to the monitoring station's location is a subset of another (e.g., nearly all monitoring stations' catchments are contained within HRC509 or the mainstem's catchment). The software package for conducting MK tests can modify results to account for inter-station correlation (Marchetto, 2021). Conceptually, correcting for inter-station correlation is similar to correcting the effects of serial autocorrelation on the SSC regression coefficients for the purpose of obtaining accurate p-values.

5.2.3.2 Results

Figure 9 contains violin plots showing the distributions of SEV scores across WYs, descriptive statistic, and salmonid life stages, aggregating scores across all monitoring stations. SEV scores below 4 describe behavioral effects and no physiological symptoms. Sublethal effects (SEV scores 4 – 8) include minor to major physiological stress. Lethal and paralethal effects (SEV 8 – 14) start at reduced growth rate and progressively increases mortality rate until the maximum score. The eggs/larvae life stage faces the most risk, because their SEV scores are higher than the other life stages. The annual median eggs/larvae SEV statistic has higher variability and the largest range, but most scores hover between 7 and 10 (sublethal to lethal effects). The maximum SEV statistic may be the most concerning with its mean being above 13 and going off the scale; the maximum is 14 and its associated effects include greater than 80 percent mortality.

With four (4) life stages or model parameters; four (4) descriptive statistics; and ten (10) stations, a total of 160 trend tests were conducted. Of those 160, only four are statistically significant. That is, at the majority of stations, statistical analysis is not able to determine if conditions are worsening or improving over time. Table 12 shows the results of trend tests on the descriptive SEV statistics where the trends' p-value are less than 0.05; highlighted rows are statistically significant. Between WY2003 and WY2020, station HRC509 (mainstem) has seen an increase in the median SEV score for eggs/larvae and juvenile (Bray) life stages.

For eggs/larvae, the average median SEV statistic across all years at HRC509 is approximately 9.75, a score that describes effects of reduced growth rate, delayed hatching, and reduced fish density. Scores 10 and above describe increasing mortality rate, which is 0–20 percent of the population at SEV 10; 20–40 percent at 11; etc. until 14, the maximum score, the effects of which is 80–100 percent mortality. Using the average score as a starting point and assuming a constant trend, a median SEV score of 10 would be present in less than two years and an 11 score would be present in less than ten years. For juveniles and with Bray's model, the rate of increase is half of the

eggs/larvae. The average median is 7.33, which describes moderate habitat degradation. If constant, the score would move to 8 within ten years; 8 describes major physiological stress and long-term reduction in feeding rate.

The other two trends are more optimistic—the maximum SEV statistic for station HRC510 (lower South Fork) and 90th percentile statistic for HRC517 (Bridge Creek, tributary to North Fork) are both decreasing, but at relatively lower rates. Assuming a constant trend, these SEV scores would decrease by one in ten to twenty years. Although their scores are high—SEV 12 describes 40 – 60 percent mortality—the SEV statistics (90th percentile and maximum) for HRC510 and HRC517 are less useful as they do not describe a central tendency and instead are extreme values. High SEV scores are to be expected at the extremes, and their slow rate of decrease is less informative of future conditions. Nevertheless, any decrease at all should be noted in this heavily impaired watershed.

Table 12: Statistically significant trends in descriptive SEV statistic. Mean SEV statistic is the arithmetic average across all years of data. Increasing SEV indicates worsening conditions.

Station	Life Stage	SEV Statistic	Trend	ΔSEV/year	Mean
509	Eggs/Larvae	Median	Increasing	+0.137	9.75
517	Eggs/Larvae	90th Percentile	Decreasing	-0.071	12.3
509	Juvenile (Bray)	Median	Increasing	+0.072	7.33
510	Juvenile (N&J)	Maximum	Decreasing	-0.044	11.1

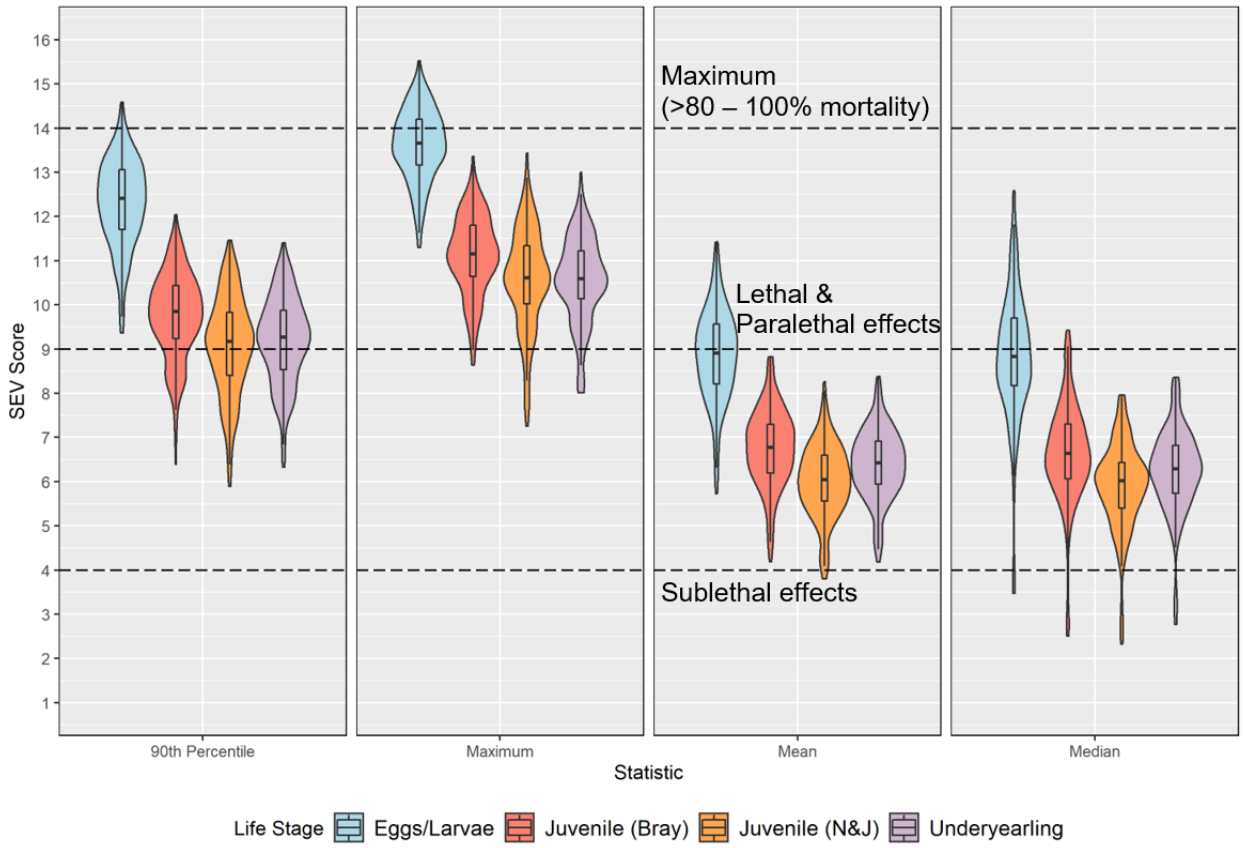

Figure 9. Distribution of descriptive SEV statistics by life stages across all stations and all years

5.2.4 Discussion

Overall, water quality trends for the Upper Elk River have mostly remained in stasis over the period of record. Weak evidence exists for worsening SSC conditions in the period of 2016-2021 at the lower South Fork (HRC510) and lower North Fork (HRC511) monitoring stations (see Table 9 and Figure 7. SSC residuals for stations HRC510 and 511 while using only the last five years for statistical modeling).

Evidence also exists for worsening ill effects for salmonid eggs, larvae, and juveniles at the mainstem station (HRC509) just below the confluence (Table 12). However, there are two bright spots. The SEV analysis shows a decrease in the maximum ill effects for juveniles in the lower South Fork station and a decrease in the 90th percentile ill effects on eggs/larvae at the Bridge Creek station, a tributary to the North Fork Elk.

The Elk River's current state is heavily impaired, and the evidence referenced above suggests that conditions may be improving in the upper watershed and worsening in the confluence area. Specifically, ill effects for salmonids are decreasing in Bridge Creek and the lower South Fork. Ill effects for salmonids at station HRC509 are increasing;

and sediment concentrations have increased since 2016 at stations HRC510 and HRC511. Assessment results for the confluence area are consistent with the TMDL's original findings, which brought focus to the immobile in-channel sediment deposition within the impacted reaches and sediment loading from the North and South Forks to the impacted reach. Yet, the analyses performed require some discussion before coming to firm conclusions about the TMDL's program of implementation, trends in water quality conditions, and conclusions about the efficacy of upper watershed controls on sediment discharge.

First, covariates in the SSC regression models are not directly related to causal mechanisms for sediment discharge. Streamflow could arguably be the hydrologic response to both rainfall and/or upslope management operations, but this analysis cannot disentangle natural and anthropogenic hydrologic responses. Therefore, further assessment is warranted to avoid fallacious inferences by omission. Examples of such inferences or conclusions can include: (a) no trend means current management practices have no effect on sediment concentrations or (b) legacy sources are so great or too entrenched to detect their depletion in the current data. These conclusions cannot be directly supported, and both are speculative at best.

The TMDL Action Plan requires the Regional Water Board to conduct an assessment over the last five years. This requirement was met by restricting the data record to WY2016-WY2020. The restriction produced statistically significant results for increasing sediment concentrations at the North and South Fork monitoring stations, but the results were not corroborated by the other trend analysis methods, which produce no statistically significant results. Thus, doubts remain as to whether the last five years' SSC increases are real or due to random chance or other factors not included in this assessment.

With respect to the whole data record (WY2003-WY2020), the most likely conclusion for water quality is fairly mundane: SSC has not substantively changed at the three monitoring stations after accounting for variability attributed to the covariates. Any non-zero residual SSC may be random errors/noise or attributed to an unknown variable or process, thus deserving further evaluation. Until a similar regression analysis incorporates covariates related to management practices and/or legacy sediment discharge sources, interpreting their effect on SSC warrants skepticism. Examples of such analyses include Klein et al. (2012) or Lewis (1998). Klein (2012) included variables related to roads (e.g., density and use type) and timber harvest in clearcut

equivalent area[11] since 1990. Lewis (1998) took a paired watershed approach with the treatment watershed undergoing various disturbance actions such as road cuts, skid trails, and yarding. While neither study utilized the same regression model—particularly, the temporal resolution—both papers nevertheless provide example variables. Staff recommends that the next steps for the residual SSC trend analysis be to develop the same regression models for the monitoring locations in upstream catchments. The main downstream stations and trend signals are likely complicated by or entangled with cumulative effects of activities on the landscape and/or by the heavy sediment deposition in the impacted reaches.

SEV scores describe the state of salmonid health and habitat. SEV is function of SSC as well as SSC's time duration. While SSC by itself may not be any different from WY2003, changes in sediment fate and transport could explain the trends in SEV scores. That is, suspended sediment lingers at HRC509 (mainstem) longer than at HRC517 (Bridge Creek). SEV scores in general depend on the validity of the empirical models developed by Newcombe and Jensen (1996) and Bray (2000), especially the latter's models being directly related to Coho salmon, a species for which the Elk River watershed historically supported in large populations (NCRWQCB, 2014). While the SEV scale itself has seen scrutiny due to scoring subjectivity, the scale is still used widely as a semi-quantitative method for assessing SSC impacts on fisheries (Smedley et al., 2011). The Newcombe & Jensen (1996) model fits are not stellar with r^2 values for eggs/larvae and juvenile being approximately 0.60 and 0.55, respectively [12]. As a point of reference, the ordinary least squares (OLS) analysis performed for this assessment had r^2 greater than 0.70.

However, the bar for acceptable model goodness-of-fit in ecological studies is different due to inherent uncertainties in environmental data. Møller & Jennions (2002) reviewed forty-three (43) published papers and from those papers' results, the maximum r^2 found is 0.487 with more than 80 percent of values having r^2 lower than 0.10. Thus, in comparison, the Newcombe and Jensen (1996) models have excellent r^2 values and

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[11] Clearcut equivalent area (CCE) transforms different silvicultural practices into a standardized unit based on the impacts of clearcutting. The transformation is typically done as a fraction weighting factor, e.g., commercial thinning has a weighting factor of 0.50

[12] In simple linear regression, r2 is also known as the coefficient of determination, which indicates the amount of variance that a model predicts compared to the response variable's variance. For more complex models, the coefficient of determination's mathematical definition may not be applicable, and r2 takes on different forms and names. The one used here and in papers referenced is the squared Pearson correlation between the observed and model predictions.

model fits. Still, alternatives or modifications to the original SEV model likely exist. Because the data assessment is a continuation of prior work—particularly, the ERRA—the investigation of alternative methods is outside the scope of this analysis but should nevertheless be considered in future assessment iterations as well as proposed activities for the coordinated science and monitoring components of the Watershed Stewardship Program.

Given everything presented in the water quality trends analysis, current data and methods employed all indicate persistent sediment impairments in Elk River. Without additional data related to anthropogenic activity, the question of whether this persistence is due to contemporary upper watershed timberland management, legacy sources, or a new equilibrium favoring greater "natural" sediment discharge cannot be answered. Nevertheless, hydrology and water quality data are valuable assets, and continued data collection efforts are critical in monitoring the effects of future recovery actions implemented through the Watershed Stewardship Program.

5.3 Summary and Review of HRC Studies

In compliance with its MRP, HRC submitted a report in November 2021, which synthesized the data it collected and analyzed in the previous five years. The report included assessment of landslide activity, water quality trends, aquatic habitat trends, and the results of a paired watershed study (as well as summaries directly associated with timber operations and summarized in Section 4.2.1). In staff's review of the Landslide Monitoring, we found that there were insufficient data (including photographs) for us to independently corroborate the presented findings. This section remains silent on that topic, reserving discussion for a time when the Science and Coordinated Monitoring workgroup can address the topic collaboratively. As above, staff were able to independently analyze water quality data (e.g., suspended sediment data) to present findings, which are described in Section 5.2. In this section, staff summarizes HRC's findings relative to its Aquatic Trend Monitoring, which we were able to verify. Similarly, staff summarize the approach and findings of the Railroad Gulch Paired Watershed Study, with uncertainties identified.

5.3.1 Aquatic Trend Monitoring

Collecting data on in-stream physical habitat characteristics is essential for tracking watershed conditions and trends related to the distribution and movement of sediment throughout the watershed. The Class I Stream Aquatic Habitat Trends Monitoring Summary for the Elk River Watershed (Lackey, 2021) or Appendix C in HRC 5-year Synthesis Report highlights trends over the complete record of available monitoring data (2002 – 2020). Therefore, this section of this report provides an overview of those findings and the relevance of those findings in light of key beneficial uses SPAWN, COLD, and MIGR. HRC staff conducted aquatic trends monitoring (ATM) of Class I

stream habitat at seven locations for channel substrate (pebble counts), pools, large wood, riparian canopy, water temperature, fish surveys, and channel cross sections. Water quality trend monitoring by HRC is a requirement of the Monitoring and Reporting Program (MRP) which is a primary component of Order No. R1-2019-0021. As described in Section 4.3, Section IV of R1-2019-0021 requires ATM every three years. Within the period of 2016 to 2021, ATM parameters were measured once in 2017 and a second time in 2020.

ATM data is compared to desired condition thresholds defined by the Aquatic Properly Functioning Conditions matrix. ATM parameters vary spatially throughout the watershed as well as temporally. Some ATM parameters are doing well compared to Aquatic Properly Functioning Conditions benchmarks and are either above or trending towards desired conditions. For example, canopy cover and stream temperature are within the Aquatic Properly Functioning Conditions desired conditions for all ATM sites and are not of concern at this time. However, temperature data was only collected once each year, so a greater resolution of data would provide useful information as to the effectiveness of canopy cover improving stream temperature conditions. The Regional Water Board's Temperature Policy highlights the importance of shade to stream temperature, but multiple additional influences on stream temperature can also be important. Other ATM parameters that are doing well compared to Aquatic Properly Functioning Conditions benchmarks include upstream substrate parameters, which are either achieving or close to achieving desired conditions.

However, downstream sites, specifically those within the impacted reaches (ATM175 and ATM166), are much further from desired conditions for these same parameters. ATM 175 is located along the South Fork Elk River above the confluence of the North Fork Elk River, and ATM 166 is located along the main stem below the confluence (Figure 10). For both stations, ATM parameters that are either achieving, or close to achieving desired conditions include all pool characteristics, stream temperature, and canopy cover, based on the two monitoring events reported in the 2016-2021 period. Median particle diameter (D_{50}) of the stream bed surface shows a slight coarsening trend, however, the 2020 D_{50}'s (ATM 175 = 6mm; ATM 166 = 7mm) are still far from the Aquatic Properly Functioning Condition target (65-95mm) (Figure 11). A positive trend suggests a slight coarsening of substrate particle size. A greater number of temporally spaced samples above and within the impacted reach would allow testing of statistical significance of trends for these parameters and whether data will reach desired conditions within the lifespan of the Habitat Conservation Plan (HCP).

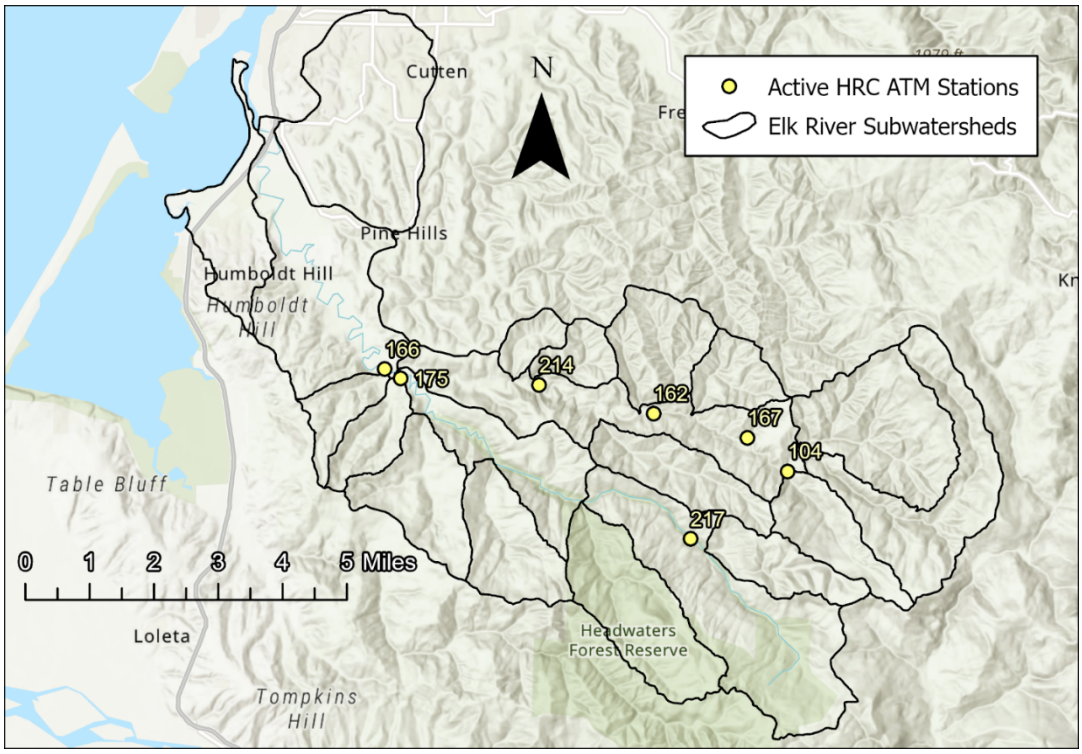

Figure 10. Map of ATM stations in Elk River

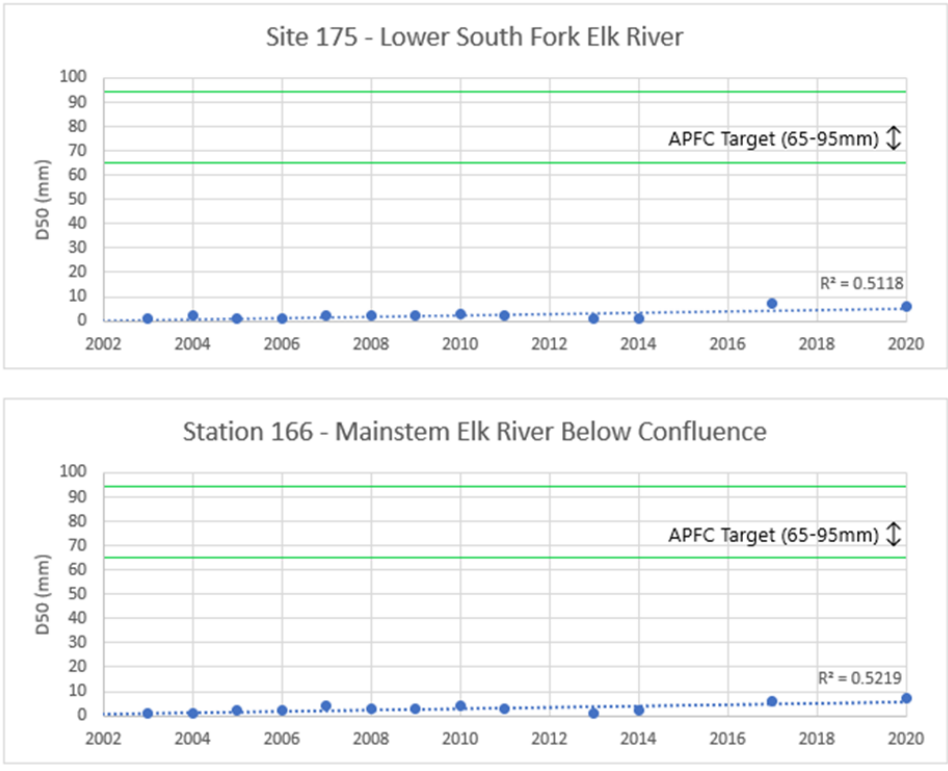

Figure 11. Temporal trends in median particle diameter (D50) from two ATM stations within the impacted reaches

HRC also presented cumulative frequency plots for mean surface particle sizes of three riffles measured within ATM 175 and ATM 166. Although raw data were not provided, these plots were visually analyzed and compared to desired conditions[13] of sediment-related indices for salmonid freshwater habitat (NCRWQCB, 2006). These parameters are directly tied to salmonid spawning habitat, and when streambeds are composed of too much fine sediment, redds can be covered, preventing the emergence of fry. Desired condition for percentage of particles less than 0.85mm (% Fines < 0.85) is less than or equal to 14%. Desired condition for percentage of particles less than 6.4mm (% Fines < 6.4) is less than or equal to 30%. Between 2005 and 2014, both conditions were not met at these sites. In 2017 and 2020, desired conditions for % Fines < 0.85 were met at both ATM 175 and ATM 166, however, desired conditions for % Fines < 6.4 have not been met to date for either site. Establishing appropriate thresholds of significance for substrate at these sites should be a high priority for a Science and Coordinated Monitoring Workgroup.

Summaries of change in cross sectional area were also provided in Appendix C of HRC's 5-year Synthesis Report. Both sites in the impacted reaches experienced an overall net sum of aggradation (ATM 175 = -0.15 square meters and ATM 166 = -12.98 square meters). When analyzing recent changes in cross sectional area (2017 and 2020), ATM 175 (lower South Fork) continued to experience aggradation with a net sum of -5.28 m² and ATM 166 (mainstem below the confluence) experienced scour with a net sum of 6.26 m². Raw data for further analysis was not provided and discussion of the relationship between watershed activity and change in cross sectional area was not included in Appendix C. Future reporting of data in a useable format will allow for comprehensive analysis of scour and aggradation trends in the watershed amongst all parties.

Based on the available data, it is difficult to determine the cause of recent coarsening of streambed substrate in the impacted reaches. Consistent with previous recommendations, development of specific monitoring questions (such as: what are the appropriate desired conditions for aquatic habitat in the impacted reach?) through a Science and Coordinated Monitoring Workgroup should inform monitoring strategies.

[13] Desired conditions for % Fines are not included in Aquatic Properly Functioning Conditions, therefore desired conditions from an internal Regional Water Board Staff report, " Desired Salmonid Freshwater Habitat Conditions for Sediment-Related Indices," (NCRWQCB, 2006) are used for these parameters.

5.3.2 Railroad Gulch Paired Watershed Study

As part of the monitoring and reporting requirements outlined in Order R1-2019-0021, HRC submitted to the Regional Water Board *Evaluation of Best Management Practices in Railroad Gulch, Elk River Watershed: Final Report*, a summary report describing the results of their effectiveness monitoring programs for roads and timber harvest management practices in Railroad Gulch. The paired-watershed study was conducted by researchers from Humboldt State University, HRC, Colorado State University, Battelle Ecology, US Forest Service, and LRE Water Co. The objective of the study was to collect and evaluate specific sediment production, storage and delivery data to test the effectiveness of Habitat Conservation Plan (HCP) prescriptions in limiting sediment production and delivery from potential sources related to management practices. Railroad Gulch is a sub-basin of the Lower South Fork Elk River that consists of an East Branch and West Branch, each covering comparable areas. Nearly half of the East Branch is covered by the McCloud-Shaw Timber Harvest Plan (THP), while no timber activities have been conducted in the West Branch since 2003, allowing it to serve as the control watershed. The similar geology and terrain and isolation of timber harvesting to just one branch make Railroad Gulch a good location for a paired-watershed study.

A wide range of data were collected and analyzed for the Railroad Gulch study, including stage, continuous and storm turbidity measurements, road erosion, landslide characteristics, channel cross-sections, bed material size, and isotopic analysis of millennial scale erosion rates. The study finds elevated sediment loads in the East Branch (treatment) relative to the West Branch (control). Regional Water Board staff support both the study's paired watershed design and the study's objective of evaluating HCP prescriptions in limiting sediment production and delivery. The study addresses the effects of road construction and use on sediment production in particular detail and with an appropriate level of statistical rigor.

In spite of the good study design however, the Railroad Gulch study contained a number of confounding factors. Examples of these factors include the 2017 landslide in the control watershed; inherent differences in channel density and streambed grain size between East and West Branches; and large uncertainty in Be^{10} estimates between the control and treatment as well as compared to the rest of Elk River. The authors note that while it is likely that elevated sediment loads result in part from roads and harvest activities, they also suggest that non-harvest related differences between the two watersheds such as channel density and streambed grain size play a role as well. The authors ultimately conclude that road construction, road use, and timber harvesting have limited impacts on sediment loads in Railroad Gulch. Staff did not find these conclusions well-supported. In addition to the 2017 landslide and other confounding factors discussed above, the requirement in Order R1-2019-0021 to address the effects of management practices on sediment production in sensitive riparian zones is absent.

Though a paired watershed study offers the potential to shed light on the relationship between management activities and water quality conditions, in the absence of raw data underlying the study, more detailed descriptions of how authors arrived at specific conclusions and because of the presence of several confounding factors, staff is unable to fully support the conclusions presented in the report.

5.4 Summary and Review of Elk River Recovery Assessment Cross-Section Analysis

The Elk River mainstem, North Fork and South Fork have shown a loss of channel cross-sectional area over time due to sedimentation. Cross-sectional area has been used to assess trends in sedimentation and loss of flow capacity, which results in an increase in overbank flooding. Both the listing of the Elk River watershed on the 303(d) list in 1998 and the adoption of the TMDL Action Plan in 2016 are actions reflective of this ongoing sedimentation.

CalTrout, Stillwater Sciences, and Northern Hydrology and Engineering prepared a technical memorandum dated March 2019 titled Elk River Recovery Assessment: Recovery Framework (https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/elk_river/pdf/190516/ERRA Framework Final compiled_031419.pdf) following adoption of the TMDL Action Plan. Among other things, this memorandum assessed the record of cross-section data up through 2016, the last year of record. As reported in the Recovery Framework document:

"Transect surveys conducted at 23 sites in the North Fork Elk River, South Fork Elk River, and Mainstem Elk River by HRC over a period from 1997 to 2016 indicate consistent trends in reduced cross-sectional area since 1997. There were also typically net decreases in channel cross-sectional area observed at 27 sites surveyed in the North Fork Elk River, South Fork Elk River and Mainstem Elk River by the ERRA team and partners from 2002 to 2014."

Table 13: From CalTrout et al (2019), Changes in bed elevations and cross-sectional areas at bridge sites

Bridge site	Average bed elevation change	Average bed elevation change	Percent reduction in cross-section area	Percent reduction in cross-section area
	Period	Change, ft	Period	% change
North Fork Bridge	1947-2002	4.2	1971-2016	44
Steel Bridge	1958-2015	6.2	1958-2016	24
Zanes Road	1969-2014	6.3	2006-2016	5
Berta Road	1969-2016	6.5	1969-2016	50

As described in the ERRA, these data indicate a continued loss of channel cross-sectional area, which is relevant to conditions of nuisance flooding. The Science and Coordinated Monitoring workgroup should consider continuing collection of these data and discuss appropriate adaptive management thresholds.

5.5 Evaluation of TMDL Effectiveness

Section VII (Monitoring and Adaptive Management) of the TMDL Action Plan says:

"Approximately five years after adoption, Regional Water Board staff will conduct a formal assessment of the effectiveness of the implementation plan, including an evaluation of the effectiveness of WDRs and waivers, and make any necessary revisions to this TMDL Action Plan. This includes a review of the sediment source analysis and water quality data for the Upper Elk River, sediment deposition in the impacted reach and Lower Elk River, and the need for a Lower Elk River sediment TMDL, using Recovery Assessment tools and other available data, as appropriate. During reassessment, the Regional Water Board will consider how effective the requirements of the TMDL program of implementation are at meeting the TMDL, achieving water quality objectives, restoring the beneficial uses of water, and abating nuisance flooding conditions in the Upper Elk River Watershed. The success of the TMDL will be assessed based on water quality trends in the Upper Elk River Watershed, particularly the attainment of water quality standards in the impacted reach. Ultimately success is achieved when nuisance conditions are abated, and beneficial uses are supported."

The main goals of this assessment and data analyses were to evaluate the overall effectiveness of the TMDL Implementation Plan and to report the current conditions in the Upper Elk River watershed with respect to water quality and aquatic habitat

parameters. Ideally, the quantitative element of this evaluation would allow staff to definitively tease apart sediment contribution and effects from land management versus the natural background, for example. However, significant data gaps were present when staff began its assessment. Beyond the gaps in SSC sample data in the upper watershed, and raw aquatic habitat monitoring data, staff were also originally hampered by a dearth of management-related data, such as annual harvest activity data. As such, staff were unable to develop an analytical approach to testing land management activities as covariates associated with SSCs. Instead, staff's analyses focused on the trends and effects of suspended sediment at a subset of monitoring stations for the period of 2016-2021 where data were more readily available.

Notably, the results of even this relatively focused work indicates that conditions are in stasis; with evidence of potential worsening at stations near the confluence and impacted reach during the period of 2016-2021 and cross-section data indicating continued aggradation in the impacted reach. As such, consideration of revisions to the TMDL source analysis, loading calculations, or assimilative capacity calculations are premature. Similarly premature are revisions of WDR requirements to either decrease or increase sediment control and discharge protections, including the protections afforded by timber harvest limitations.

With respect to the Lower Elk River, the Recovery Plan identifies recovery actions throughout the Elk River watershed from just above the confluence of the North and South Forks, all the way to the estuary. These recovery actions are derived from modeling results and vetted with individual affected landowners. Proposed recovery actions in the lower watershed include significant sediment remediation and habitat rehabilitation efforts, specifically endeavoring to improve flood pathways and direct sediment deposition. Further, the stormwater management requirements of the City of Eureka and permitted dairies in the lower watershed periodically will be updated to reflect ongoing sediment control needs in the lower watershed. Finally, the Regional Water Board has committed to developing a Grazing Management Program, which will among other things address sediment discharge. These actions are an alternative to an established TMDL to direct sediment source control from landowners downstream of Berta Road (i.e., the boundary between the lower and upper watersheds). A TMDL alternative is allowed by U.S. EPA. Based on these factors, staff have determined that it is not necessary to develop a TMDL specific to the Lower Elk River, at this time.

Consistent with the TMDL Action Plan's monitoring and adaptive management approach, on-going assessment of watershed conditions and determination of potential revisions to the TMDL and program of implementation will be an adaptive process. This report serves as one milestone in that assessment process. Coordinated monitoring and assessment will inform future reviews. To support this on-going process, Regional Water Board staff have several findings and recommendations, outlined below.

At the time of this document's preparation and after several communications, staff did receive substantial water quality data from HRC for upper watershed monitoring stations, including harvest-related data. These data will be valuable to further explore questions of water quality trends; beneficial use improvement; changes to the rate of overbank flooding; sediment loading; assimilative capacity; and the relationship of roads, harvest, riparian protection, and other management factors to these issues. Coordination amongst parties and renewed watershed collaboration (e.g., development of a Science and Coordinated Monitoring Workgroup) will vastly improve the potential to design and implement an effective analytical framework. In any event, staff propose that the same trend analysis methods applied to the three monitoring stations near the confluence be extended to other monitoring stations in the upper watershed for which there is SSC sample data.

While staff greatly appreciate the final delivery of these datasets from HRC, limitations in the Monitoring and Reporting Program (MRP) language led to delays such that this review could not include these data in the overall assessment within the timeframe prescribed by the TMDL Action Plan. Additionally, the details for aquatic trends monitoring originating in the HCP remain largely unchanged as written in the WDR's MRP. Thus, another issue that needs addressing is updating the requirements of the MRP and improving clarity on expected deliverables, including delivery of data in useable format.

Language regarding submission of monitoring data in usable formats[14] is found only in a subsection of the MRP detailing annual summary report for water quality monitoring. Since the WDR's adoption, only water quality has been submitted in usable format. Only after formal letters citing Water Code section 13267 did staff receive the data requested. Data submitted in non-usable formats present a significant barrier to analysis. For example, for raw data in the form of tables embedded in PDF (portable document format) files to be used, it must be converted to tabular form, introducing transcription errors in the process, which must be quality controlled/quality assured before use in data analysis. This data format issue is particularly notable in data related to timberland management, e.g., the lack of geospatial data for harvested areas and road updates.

With respect to the aquatic habitat indicators, monitoring requirements and collection frequency are not linked to the relevant data analyses. The MRP states in general terms that monitoring data can "improve understanding of the spatial and temporal association between sediment loads and management activities." However true this statement, the

[14] Staff define usable data as electronic tabular or otherwise machine readable using non-proprietary computer software. Data of a spatial nature (e.g., landslide locations or aerial imagery) must also be georeferenced and readable in non-proprietary GIS (geographic information systems) computer software.

parameters listed plus their collection frequencies (once every three years) are likely insufficient. For example, common trend detection methods (i.e., the Mann-Kendall) require a minimum number of four observations as well as minimal gaps to provide useful inferences.

Data collection and information generation should flow in a loop from permittee, to core regulatory staff, to planning/adaptive management staff, and back to permittee, along with dissemination to other stakeholders where relevant or requested. This process need not occur once every five years and can be done annually. Maintaining such a routine will ensure that data are consistently submitted in usable formats and that time-based regulatory requirements such as the Five-Year Review (plus others expected in 2026 and 2031) are completed in a timely manner.

The WDR highlighted the Watershed Stewardship Program as the main or proper forum for discussing methods and manner of assessing monitoring data, including examining potential research questions and their data requirements. Up until the Five-Year Synthesis Report's release and staff's active work on this data assessment, neither the Regional Water Board nor timberland owners have coordinated on the science and monitoring front. This lack of coordination is partially due to issues beyond either party's control (i.e., the Watershed Stewardship Program's initial stall, staffing changes, the Covid pandemic, etc.), but going forward, the parties should agree to a style and frequency of data sharing, and develop joint goals and protocols for communication and coordination, including, where appropriate, other stakeholders in the watershed. Watershed Stewardships' publication of the Elk River Recovery Plan includes coordinated monitoring and science recommendations. These recommendations should form the starting point for discussion between Regional Water Board and HRC/GDRC staff, as well as the broader engagement of a Science and Coordinated Monitoring Workgroup.

Finally, the ERRA is now a completed modeling tool that may continue to prove useful in assessment, adaptive management, and future revision of the TMDL. It offers the ability to predict water quality outcomes of multiple sediment loading and remediation/rehabilitation scenarios, even beyond those that were funded as part of the ERRA and Elk River Recovery Plan projects. It may be particularly useful in reassessing assimilative capacity in the impacted reach, once recovery actions have been designed.

Section 6: Summary of Findings and Recommendations

This section summarizes staff's findings and recommendations relative to the requirements described in Table 4 and Section VII of the TMDL Action Plan at this five year milestone.

Table 4 of the TMDL Action Plan requires:

Timberland owners will implement WDRs and waivers of WDRs *"to implement phase 1 of the Upper Elk Sediment TMDL and a zero load allocation."*

"By 2016, in coordination with a steering committee, Humboldt County will initiate a watershed stewardship program for the Elk River Watershed in conformance with the 319(h) grant contract, including establishment of: a Health and Safety workgroup responsible for developing recommendations appropriate for resolving water supply, flooding, and road access issues; a Science and Coordinated Monitoring workgroup responsible for developing recommendations appropriate for improving the effectiveness of water quality, sediment and flow monitoring efforts throughout the watershed; a Sediment Remediation workgroup responsible for developing recommendations appropriate for remediating instream stored sediment and improving floodwater conveyance, sediment transport, and ecosystem function. Final reports documenting the workgroup's recommendations, including plans and schedules are due in 2018."

"By 2017, CalTrout will produce a final report detailing the results of full-scale sediment and hydrodynamic modeling, including feasible remediation and restoration activities sufficient to achieve water quality standards and return the watershed to a trajectory of recovery."

"By 2021, the Regional Water Board shall evaluate the available information to assess the degree to which 1) adopted WDRs and waivers have successfully controlled sediment delivery from the upper watershed to the impacted reaches and 2) the efforts of the Watershed Stewardship Program are making sufficient progress towards achievement of health and safety, coordinated monitoring, and sediment remediation improvements."

Section VII (Monitoring and Adaptive Management) of the TMDL Action Plan also provides:

"Approximately five years after adoption, Regional Water Board staff will conduct a formal assessment of the effectiveness of the implementation plan, including an evaluation of the effectiveness of WDRs and waivers, and make any necessary revisions to this TMDL Action Plan. This includes a review of the sediment source analysis and water quality data for the Upper Elk River, sediment deposition in the impacted reach and Lower Elk River, and the need for a Lower Elk River sediment TMDL, using Recovery Assessment tools and other available data, as appropriate.

During reassessment, the Regional Water Board will consider how effective the requirements of the TMDL program of implementation are at meeting the TMDL, achieving water quality objectives, restoring the beneficial uses of water, and abating nuisance flooding conditions in the Upper Elk River Watershed. The success of the TMDL will be assessed based on water quality trends in the Upper Elk River Watershed, particularly the attainment of water quality standards in the impacted reach. Ultimately success is achieved when nuisance conditions are abated, and beneficial uses are supported."

6.1 Summary of Findings

The Regional Water Board adopted the TMDL Action Plan for the Upper Elk River Watershed in 2016, which was subsequently approved by the State Water Resources Control Board, Office of Administrative Law, and U.S. Environmental Protection Agency. The whole of this report presents staff's assessment of TMDL implementation at this five-year milestone as required in Table 4 and Section VII of the TMDL Action Plan. This section summarizes staff's findings relative to these requirements, while Section 6.2 of this report presents staff's recommendations.

6.1.1 Watershed Stewardship

Table 4 of the TMDL Action Plan requires that a Watershed Stewardship Program be developed, including a Science and Coordinated Monitoring Workgroup, a Health and Safety Workgroup, and a Sediment Remediation Workgroup. Staff's findings are that the Watershed Stewardship Program has been robustly stood-up, with dramatic accomplishments specifically related to development of an actionable Recovery Plan ready for grant funding, design, permitting and implementation (See 6.1.2). However, early growing pains, including loss of Humboldt County as the grant funded lead entity, resulted in significant delays relative to development of workgroups as noted below.

1. The Science and Coordinated Monitoring Workgroup has not yet been established and has emerged as a high priority, with a first meeting soon to be scheduled.
2. The Health and Safety Workgroup has not yet been established. But recent efforts show promise, including a) efforts to coordinate directly with affected residents and b) identify agencies and programs with funding and authority to address flooding of public and private infrastructure and assess and supply public drinking water. It is a high priority of the Humboldt Bay Steward to continue and complete one-on-one interviews with residents; identify the proper agencies, programs and funding resources to address noted health and safety issues; and develop a strategic plan for implementing noted actions. Establishing a Health and Safety Workgroup may continue to be an important element of the strategic plan, depending on community support.

3. The Sediment Remediation Workgroup was not established. But, the concept of Sediment Remediation Workgroup was altered when CalTrout became the new Watershed Stewardship Program lead. Rather than route sediment remediation and habitat restoration concepts through a workgroup, CalTrout worked directly with landowners on whose property remediation/restoration projects were considered. Through this one-on-one engagement, CalTrout has been able to complete a well vetted, thorough and thoughtful Recovery Plan, which provides the immediate basis for design, permitting, funding and implementation of restoration and rehabilitations projects, as prioritized across four Planning Areas.

6.1.2 Elk River Recovery Assessment

Table 4 of the TMDL Action Plan requires the completion of the Elk River Recovery Assessment: Recovery Framework (ERRA) to report the findings derived from a sediment transport and hydrodynamic model developed to test the predicted effect of sediment loading reduction and multiple restoration scenarios. The CalTrout team composed and engaged a Technical Advisory Committee made up of local experts, agency representatives, timber company representatives, and residents. The Recovery Framework was completed as required.

Further, the Recovery Framework formed the basis for development of the Elk River Watershed Stewardship Program: Sediment Remediation and Habitat Rehabilitation Recovery Plan (https://caltrout.org/wp-content/uploads/2019/05/Elk-River-Stewardship-Recovery-Plan-Public-Draft-July_2022.pdf), which was not required by the TMDL Action Plan, but the necessary next step towards grant funding, design, permitting, and implementation of reach-specific sediment remediation and habitat rehabilitation projects. The Recovery Plan was completed in July 2022 and is a companion to this staff report. It represents an enormous advancement in our ability to begin implementation of recovery actions.

1. Development of the Recovery Plan was not specified in the TMDL Action Plan but is the natural outgrowth of the Recovery Framework. The loss of Humboldt County as the lead entity for Watershed Stewardship has meant a delay in establishing workgroups, especially to address health and safety and science and coordinated monitoring (See 6.1.1). On the other hand, the significant benefit of CalTrout as the new lead for Watershed Stewardship, is the dramatic advances in sediment remediation and habitat rehabilitation planning. As a result of CalTrout's leadership, the Recovery Plan is now available as the critical starting point from which to generate project designs, receive permits, acquire funding, and ultimately implement the restoration and rehabilitation projects that will reduce overbank flooding and otherwise improve the ability of the Elk River to transport sediment and water in a manner consistent with beneficial use protection.

2. The Recovery Plan includes a monitoring framework, which will advance the work of the Science and Coordinated Monitoring Workgroup when it is formed.

6.1.3 Waste Discharge Requirements

Table 4 of the TMDL Action Plan requires that waste discharge requirements (WDRs) and waivers of WDRs be implemented to implement phase 1[15] of the Upper Elk River Sediment TMDL and a zero load allocation. Key milestones and findings include:

1. HRC WDR was revised in 2016 and again in 2019.
2. GDRC WDR was revised in 2020.
3. Available data are insufficient to comprehensively assess the degree to which WDRs and Waivers have successfully controlled sediment delivery to the impacted reach.
4. Focused data assessment indicates conditions are generally in stasis, with evidence of worsening in and around the confluence of the north and South Forks and continued aggradation in the impacted reach.

6.1.4 Effectiveness of the Implementation Plan

Table 4 of the TMDL Action Plan requires assessment of the degree to which the revised WDRs have controlled sediment discharges and the Watershed Stewardship Program has made sufficient progress. Similarly, Section VII of the TMDL Action Plan requires that at about the five-year milestone staff assess the effectiveness of the implementation plan, with considerations for revisions to the TMDL Action Plan, particularly the sediment source analysis. It further requires consideration of changes in sedimentation trends in the impacted reach and the degree to which a Lower Elk River Sediment TMDL is necessary. The subsections above summarize staff's findings relative to implementation of the WDRs and progress in implementation of the Watershed Stewardship Program. This subsection focuses on staff's findings relative to a) revision to the TMDL Action Plan and sediment source analysis, b) sedimentation in the impacted reach, and c) the need for a Lower Elk River Sediment TMDL.

1. Staff found no evidence that suspended sediment concentrations at stations in the upper watershed are decreasing, though aquatic trend monitoring data indicates some locations where statistically significant trends show improvement. There is not, however, definitive evidence that implementation of the WDRs is

[15] Phase 1 of the Upper Elk River Sediment TMDL refers to the phase in which the assimilative capacity for additional sediment to the top of the impacted reach is calculated as zero. Future phases of the TMDL will be established following completion of recovery actions and expansion of the impacted reach and lower river for additional sediment. At that time, a new sediment load allocation will be calculated, which is consistent with the expanded assimilated capacity.

successfully controlling all controllable sources of sediment. Nor is there clear evidence that changes to the WDRs is necessary at this time in order to increase sediment controls. On the other hand, some revisions to HRC's MRP is necessary and appropriate.

2. Staff find that implementation of the HRC WDR since 2019 and the GDRC WDR since 2020 is too short a time to expect detectable signals of improved sediment source control and water quality conditions. Further, the currently available data is inadequate to detect such a signal, even with sufficient time.
3. In channel cross-sections show continued aggradation in the impacted reach, though the existing dataset available to staff only includes data up through 2016.
4. Implementation of the Recovery Plan is intended to begin with proposed recovery actions in the lower river and estuary where there is substantial opportunity to improve stream channel-floodplain interaction and beneficial sediment deposition.
5. Staff plan to begin development of a Grazing Program in the near future, which will help address any sediment discharge issues associated with lower river grazing activities.
6. The Regional Water Board already implements a Dairy Program and a Stormwater Program, which address sediment discharge issues. As needed, the requirements of these programs can be updated to improve sediment discharge control from dairies in the lower watershed and from the City of Eureka.
7. Staff finds that it is premature to consider any revisions to the TMDL, including the sediment source analysis, calculation of assimilative capacity, or implementation plan.
8. Staff conclude that a sediment TMDL to address sources of sediment in the lower watershed are not necessary at this time, as existing regulatory programs can directly address individual sources, as necessary. Further, staff find that the Recovery Plan adequately addresses the sediment remediation and habitat rehabilitation needs from the top of the impacted reach down through the estuary, thereby identifying recovery actions necessary in the lower watershed.

6.2 Recommendations

This section enumerates a series of recommendations, divided by category, that result from staff's assessment as described in the sections above. Recommendations are related to implementation of the Watershed Stewardship Program, the Recovery Plan, and WDRs, with a special attention to the issue of science and coordinated monitoring. Science and coordinated monitoring is an area of special focus because of the limitations to this five year assessment, which are the result of significant data gaps. Further, staff's ability to assess TMDL effectiveness in the future, will be improved by better collaboration and coordination around science and monitoring, as will adaptive management of WDRs and implementation of recovery actions.

6.2.1 Watershed Stewardship

1. Staff recommend the formation of the Science and Coordinated Monitoring Workgroup. A Science and Coordinated Monitoring Workgroup can develop a coordinated monitoring plan, beginning with the monitoring framework included in the Recovery Plan. A coordinated monitoring plan will help to ensure that data are collected in a manner capable of addressing key questions of watershed health and recovery, inform revision to the existing monitoring and reporting requirements of permittees, establish hypotheses appropriate for special study, and design a framework for adaptive management over the long term.
2. Staff recommend completion of the Health and Safety Interviews and completion of a final summary report.
3. To address issues related to drinking water, staff recommend the engagement of Humboldt County, the Humboldt Bay Community Services District, and the Humboldt Bay Municipal Water District in discussions of potential Safe and Affordable Funding for Equity and Resilience (SAFER) program fund applications, as well as other water infrastructure and drought relief program funding options.
4. To address issues related to flooding generally, staff recommends engagement with the Federal Emergency Management Agency (FEMA) through the California Office of Emergency Services and its contractor The Nature Conservancy. In coordination with the Coastal Conservancy, the Regional Water Board could be a State government applicant for FEMA funding designed to support installation of green infrastructure to abate flooding. Such funding would support recovery actions described in the Recovery Plan.
5. To address issues related to flooding on public roads, staff recommends continued engagement with Humboldt County to encourage the County to assess and prioritize county roads within Elk River watershed in need of flood retrofit.
6. To address issues related to flooding of private infrastructure, staff recommends engagement with a Health and Safety Workgroup to identify and engage with agencies with authority and resources to address these issues (e.g., including private roads, private structures, onsite wastewater treatment systems, and others).

6.2.2 Recovery Plan

1. Staff recommend implementation of the Recovery Plan, with CalTrout as the lead. This will require Regional Water Board support on grant applications, as a grant applicant itself (e.g., see discussion of FEMA grant above), in 401 permitting, with monitoring and assessment resources, and with Stewardship resources.

2. Staff recommend the engagement of upper and lower watershed landowners in support of grant applications; other funding (as applicable); and recovery action design, implementation, and assessment.

6.2.3 WDRs

1. Staff recommend that the water quality protections of the current WDRs not be reduced until there is evidence that impairment conditions are improving.
2. Staff recommend that data collection required by the MRPs be expanded beyond once every three years to a more statistically significant number (i.e., the Mann-Kendall). Further, staff recommend MRPs require a minimum number of four observations as well as minimal gaps to provide useful inferences. Finally, the MRPs should be revised to provide greater clarity on issues such as data format, useability, and sharing.
3. Staff recommend the engagement of HRC and GDRC in the Science and Coordinated Monitoring Workgroup when it is formed. Their engagement will be critical to establish meaningful monitoring questions, identify additional data and analyses that may help inform adaptive management, and establish appropriate thresholds to support modification of MRPs, WDRs, and the TMDL, as warranted.
4. Regional Water Board staff and HRC and GDRC staff should be more active in coordinating science and monitoring. While the MRP is correct in saying that the Watershed Stewardship Program is the appropriate forum for such coordination and dialogue, the process need not wait for a more formal workgroup to emerge. That is, staff should build the foundation in anticipation of an active group existing. The Elk River Recovery Plan provides detailed guidance on recommended direction (i.e., monitoring framework); the MRP should incorporate these recommendations to the extent feasible.
5. Staff recommend that Suspended Sediment Concentration analyses, as described in Section 5, be applied to the whole upper watershed dataset, where there are sufficient data to do so. Staff further recommend that an approach to assessing management-related covariates be considered. Staff should collaborate with HRC and GDRC on this work, at least until a Science and Coordinated Monitoring workgroup is established under the Watershed Stewardship Program.

6.2.4 Future Assessment

The TMDL Action Plan's reassessment milestones are summarized here:

- 2026: Evaluate the available information to assess the degree to which recommended health and safety, coordinated monitoring, and sediment remediation improvements have been achieved.

- 2031: Re-evaluate the sediment loading capacity and load allocation for the Upper Elk River Watershed and revise accordingly.

Staff intend that a Science and Coordinated Monitoring workgroup, once active, become the venue for discussing and addressing science and monitoring needs relative to implementation of the TMDL and the assessment of trends towards recovery. Implementation of new monitoring and assessment efforts should be distributed among: the timberland owners through their associated MRPs; the implementers of the Recovery Plan; the Regional Water Board including its Surface Water Ambient Monitoring Program (SWAMP); other agency partners (e.g., California Department of Fish and Wildlife bioassessment team); and other watershed stakeholders. Associated with this workgroup will be the need for agreement around data sharing and collaboration on assessment. With a long vacant Steward position now filled as a Humboldt Bay Steward, staff are eager to enter into this next phase of TMDL implementation with greater coordination, collaboration, and observable action on the ground.

Attachments

Attachments are made available via the North Coast Regional Water Board website, FTP, cloud service, or other electronic means. If the request is delivery by physical media, the requestor must provide flash memory storage device ("USB drives"). Requestors will pay any and all postage or other transport fees if request is by mail. Regional Water Board staff will not transmit data for any other physical media (e.g., optical discs, hard disk drives) unless requestor physically presents the device at the Regional Water Board office.

Due to file and data storage limits, all attachments after A-1 are available only by request. Similarly, raw, unprocessed data are also only available by request, with the exception of NCAR precipitation datasets, which are available at from NCAR/UCAR[16] for Stage IV and EOL[17] for Stage II. The free, open source *7z*[18] software or other compatible archival file manager are needed to open these archival files. Please contact Lance.Le@waterboards.ca.gov or NorthCoast@waterboards.ca.gov for these requests. If using the latter email address, please add *Attn: Basin Planning Unit* in the body or title of email.

A-1 Data_Reassessment.7z
Electronic archival file containing the RStudio project for the water quality trends analysis. Archive contains code (*.R); pre-processed data (*.csv); raw markdown (*.rmd); draft documentation (*.docx); figures (*.png); select binary data (*.Rdata or *.rds); and other files needed to replicate this analysis.

A-2 full_dataset.zip
Archive file for binary data (*.RData) related to generalized least squares model fitting outputs using full dataset.

A-3 without_outliers.zip
Archive file for binary data (*.RData) related to generalized least squares model fitting outputs using dataset with outliers removed.

[16] https://rda.ucar.edu/datasets/ds507.5/ (https://rda.ucar.edu/datasets/ds507.5/)

[17] https://data.eol.ucar.edu/dataset/21.089 (https://data.eol.ucar.edu/dataset/21.089)

[18] https://www.7-zip.org (https://www.7-zip.org/)

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