Assessment of Long Term Water Quality Changes for the Klamath River Basin Resulting from KHSA, KBRA, and TMDL and NPS Reduction Programs

FINAL
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Prepared by the Water Quality Sub Team for the Secretarial Determination Regarding Potential Removal of the Lower Four Dams on the Klamath River

Klamath Settlement

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EXECUTIVE SUMMARY

This assessment, prepared by the Water Quality Sub Team (WQST) in support of the Secretarial Determination for the Klamath Hydroelectric Settlement Agreement (KSHA) process, qualitatively considers anticipated water quality effects in the Klamath Basin under the No Action and the Proposed Action alternatives. Under the Proposed Action Alternative (positive determination for dam removal), anticipated restoration measures related to KSHA and the Klamath Basin Restoration Agreement (KBRA) are considered, with regard to pace and potential for achieving water quality improvements. The primary purpose of this assessment is to discern the relative impacts of the Proposed Action as compared with the No Action alternative, including how these actions may interact with existing and proposed Total Maximum Daily Load (TMDL) implementation efforts and other ongoing water quality related programs in the Klamath Basin. The assessment represents the most comprehensive consideration to date of potential water quality related actions under KHSA and KBRA that would either directly or indirectly affect water quality in the Klamath Basin.

Water quality in the Klamath Basin has been significantly degraded by anthropogenic sources, and improvements are needed in both the upper and lower basins to meet water quality standards and support restoration of fisheries, including endangered Coho salmon (*Oncorhynchus kisutch*) and Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). The Klamath River, in both Oregon and California, has regularly exceeded (i.e. not met) water quality standards for temperature, nutrients, dissolved oxygen (DO) and related parameters (pH, chlorophyll-*a*, microcystin, ammonia, and organic enrichment) for a number of years. The peak timing of these exceedances, and thus stress to fish, generally occurs from June–October (the "critical period"). Water quality improvement plans, known as TMDLs, are in effect for Upper Klamath Lake, the Lost River and Klamath River, and tributaries to these waters (including the Salmon, Scott and Shasta Rivers in California). To improve water quality and achieve water quality standards and TMDL goals, including reducing stress on fish populations, various restoration projects are underway or in development. Some proposed projects are similar to those envisioned under KHSA and KBRA. Regardless of the mechanism to achieving them, water quality improvements in the Klamath River, from Upper Klamath Lake to the estuary, are essential to support the fisheries in the Klamath Basin as a whole.

This qualitative analysis of potential water quality improvements, under the Proposed Action and the No Action alternative, focuses on nutrients (nitrogen and phosphorus) and organic matter (OM) reductions as water quality targets to reduce water quality-related stressors to fish populations. Increases in DO levels and reductions in pH are affected by and thus are expected to follow improvement trends for nutrients and OM; therefore, DO and pH are not directly evaluated in this assessment. Likewise, changes in algal biomass including toxigenic cyanobacterial blooms also are indirectly assessed by this evaluation. Although they represent significant impairments, they are also dependent on nutrient and temperature changes as well as habitat

modifications such as the removal of lacustrine environments in reservoirs. Assessments of water temperature patterns under the Proposed Action and the No Action alternative, including climate change scenarios, are presented separately (Perry et al., 2011).

Under the No Action alternative, efforts to address water quality impairments and meet water quality standards and targets would rely on ongoing and proposed restoration projects under the TMDLs and other efforts. The Clean Water Act (CWA) regulatory agencies plan to periodically review the suite of efforts to achieve water quality standards and TMDL targets, under an adaptive management approach. These reviews will use information from effectiveness monitoring and related research efforts to refine management actions and targets, as needed. It is uncertain if water quality standards could be achieved by the end of the analysis period (i.e., 2062) using only these projects. In contrast, consideration of the Proposed Action Alternative includes removal of four dams as well as potential restoration projects associated with KHSA and KBRA; these collectively provide greater opportunities for water quality improvements that, together with TMDL implementation projects, would represent the most effective means to bring about significant and expeditious improvements toward meeting water quality standards and supporting fisheries by the end of the analysis period (i.e., 2062).

Under the Action Alternative, KHSA and KBRA actions could result in notable water quality improvements. The smallest relative improvements in nutrient concentrations are projected for the tributaries feeding into Upper Klamath Lake; while small, the potential reductions there would help improve water quality conditions in downstream reaches. In contrast, the potential is high for water quality improvements in Upper Klamath Lake, Link River, and Keno Reservoir, where water quality impairments present significant stress to fish populations. However, until KBRA projects (including size, location, etc.) are selected, implemented, and evaluated, the uncertainty around the magnitude and pace of water quality improvements are largely unknown. In the Klamath Hydroelectric Project (KHP) reach, dam removal would produce significant and rapid improvements – particularly during the "critical period" - for temperature, algal biomass, microcystin, and DO. In the KHP reach, as well as in the Klamath River below Iron Gate Dam, nutrient concentrations are expected to improve over time; however the magnitude and pace of these improvements are uncertain. Improvement to water quality is also anticipated below the Scott River to the estuary, though to a lesser degree.

Uncertainties related to implementation of KBRA and KHSA affect this assessment of projects identified under the Action Alternative. Projects in this assessment are necessarily addressed in a qualitative manner because KBRA legislation and funding are not yet finalized. For KHSA, planning and evaluation efforts are underway to identify water quality improvement projects under Interim Measure 10 (Water Quality Conference) and Interim Measure 11 (Water Quality Pilot Projects); however, with further planning, the projects may be modified. Additionally, advances in scientific and analytical tools may result in a better understanding of the potential for different approaches to improve water quality in the Klamath Basin, thereby enhancing the selection, design, and pace of restoration projects. To the extent possible, new information

gained between now and March 2012 will be made available to further inform the Secretarial Determination. Importantly, the information provided herein does not constitute recommendations on specific KBRA or KHSA proposed actions or establish water quality or restoration policy for the Klamath Basin.

1 INTRODUCTION

In the upper reaches of the Klamath Basin, the Wood, Sprague and Williamson River sub-basins flow into Upper Klamath Lake, a large shallow lake (approximately 80,000 acres with an average depth of 8 feet). Waters leaving Upper Klamath Lake via the Link River Dam form the Klamath River, which continues through the Keno Reservoir impoundment to Keno Dam, through the Klamath Hydroelectric Project (KHP) reach with its four dams and associated impoundments (JC Boyle in Oregon, Copco I and II and Iron Gate reservoirs in California), before flowing an additional 190 miles to the Klamath River Estuary and Pacific Ocean.

Klamath Basin water quality, particularly in Upper Klamath Lake, has degraded over time. While natural phosphorus from the upper basin geology has historically supported a productive ecosystem, paleolimnological research shows evidence of change in Upper Klamath Lake to an increasingly shallow, hypereutrophic lake (Eilers et al., 2004; and Colman et al., 2004). Based on more than 40,000 years of continuous paleoclimatic record for Upper Klamath Lake, Colman et al. (2004) concluded that both diatoms and remains of blue–green algae demonstrate progressive eutrophication of the lake in the 20th century, especially after about 1920. Colman et al. (2004) found "[T]he conclusions are compatible with a parallel study of recent limnological changes by Eilers et al.", and concluded: "The results also provide a comparison between natural conditions in Upper Klamath Lake and current, anthropogenically disturbed conditions, and show that the lake has been significantly impacted by human activities."

Conditions in the Upper Klamath Basin are a significant factor contributing to the downstream deterioration of water quality in the Klamath River and the decline of fisheries in the basin. In the Upper Klamath Basin, Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) were listed as endangered under the federal Endangered Species Act (ESA) in 1988.[1] In the Lower Klamath Basin, Coho salmon (*Oncorhynchus kisutch*) was listed as threatened under ESA in 1995.[2] Anthropogenic activities have resulted in physical and biological degradation. Impairments that threaten both species include loss of wetland habitat and impeded fish passage. Additional water quality impairments that threaten Coho include: increased water temperature, altered seasonal temperature patterns, reduced dissolved oxygen, elevated nutrient loading, exposure to algal toxins, pH levels outside of optimal ranges, and increased turbidity. To support

[1] U.S. Fish and Wildlife Service Species Reports - http://ecos.fws.gov/tess_public/SpeciesReport.do?lead=8&listingType=L

[2] NOAA's NMFS Southern Oregon/Northern California Coast Coho ESU - http://swr.nmfs.noaa.gov/recovery/Coho_SONCCC.htm#_Toc103497318

these species, recovery actions are needed to reduce the magnitude and duration of water quality impairments and improve habitat.

Water quality in the Klamath River is not protective of beneficial uses, as it does not meet standards for temperature, nutrients, dissolved oxygen (DO) and related parameters - pH, chlorophyll-a, ammonia, microcystin (toxin produced by cyanobacteria *Microcystis aeruginosa*), and organic matter. As a result of these impairments, both Oregon and California included Klamath Basin waters on their respective Clean Water Act (CWA) Section 303(d) lists of impaired water bodies. Once listed on a state's 303(d) list, Total Maximum Daily Loads (TMDLs), or water quality improvement plans, must be developed to address those impairments.

TMDLs have been developed and are in effect in Oregon, for Upper Klamath Lake and its tributaries and the Oregon reaches of the Lost River and the Klamath River, and in California, for both the Lost and Klamath Rivers and tributaries to the Klamath River. These TMDLs comprise a critical component of the current and future regulatory environment in the Klamath River Basin. Impairments addressed by the TMDLs include temperature, nutrients, DO and other related parameters (pH, chlorophyll-a, ammonia, microcystin and organic enrichment). The relationships between upstream and downstream waters, such as between Upper Klamath Lake and the Klamath River, and the effects of anthropogenic activities over time are addressed in the TMDLs. The water quality impairments, and stressors to fish, are most severe from June through October, which we herein label as the "critical" period (Dunsmoor and Huntington, 2006). The TMDLs establish pollutant reductions to ensure that water quality standards are achieved, including during the "critical" period, and beneficial uses supported (e.g., Coho and sucker fisheries).

TMDL implementation efforts in the Klamath Basin, some ongoing and others in development, are expected to produce improvements in water quality. Under an adaptive management process, water quality agencies plan to evaluate implementation effectiveness by assessing the status of beneficial uses and the cumulative effects of actions relative to identified environmental indicators and improvement goals. Using feedback from monitoring efforts and related research, state water quality agencies have identified plans to evaluate and review restoration actions and system management, and optimize programs and/or TMDL targets and allocations, as appropriate, to meet water quality goals. However, the effectiveness of these programs and the pace of such improvements are not specified, and hence their ability to be met during the time frame for the analysis period (2012–2062) remains unknown.

2 PURPOSE

Under the Klamath Hydroelectric Settlement Agreement (KHSA), the Secretary of Interior will make a determination on removal of four Klamath Hydroelectric Project (KHP) dams - J.C. Boyle, Copco I and II, and Iron Gate - in the year 2020. Further, the KHSA provides path forward towards their removal in the event of a positive determination (Klamath Hydroelectric Settlement Agreement, 2010). An important consideration in the Secretarial Determination process is if

water quality in both the upper and lower basin could support fisheries and other beneficial uses – including Coho salmon throughout the Basin, and suckers in the upper basin. The purpose of this evaluation is to provide an assessment of proposed activities under KBRA and KHSA that would directly or indirectly affect water quality in the Klamath Basin over the fifty-year period considered for the Secretarial Determination (2012 – 2062). The EIS/EIR analysis of water quality effects considers KBRA at a broader, programmatic level and therefore does not evaluate anticipated water quality impacts from specific KBRA projects or example projects.

This assessment of future water quality changes discerns the relative impacts of the Proposed Action as compared with the No Action alternative, including how these actions may interact with existing TMDL implementation plans and other existing water quality related programs in the Klamath Basin. The set of example projects and associated potential water quality improvements provided within this document do not constitute recommendations on specific KBRA or KHSA proposed actions or establish water quality or restoration policy for the Klamath Basin. To the extent that restoration projects can be adapted in response to future scientific information, restoration policies in the Basin could change accordingly.

3 ASSESSMENT

3.1 Approach

To support the analysis of long-term anticipated effects on water quality under the Proposed Action and the No Action alternative for the Secretarial Determination process, the Water Quality Sub-Team (WQST) compiled expected and potential actions and/or measures from established management plans that could have direct or indirect water-quality related effects. Some of the KHSA and KBRA planned projects are targeted specifically for water quality improvements, whereas others are oriented towards habitat improvement and would provide indirect benefits to water quality; additionally, some of these projects are also part of TMDL implementation plans (ODEQ, 2010, and NCRWQCB 2010). For the Proposed Action alternative, KBRA and KHSA projects were evaluated qualitatively for potential water quality effects. While quantitative analyses of water quality changes with various implementation efforts are available in separate studies and modeling efforts - including FERC relicensing efforts (FERC 2007), Oregon and California Klamath River TMDL development (ODEQ 2010, and NCRWQB 2010a), and tribal water quality studies (Asarian and Walker, 2009) - a dynamic quantitative modeling tool is not currently available to address the specific effects on water quality (specifically dissolved oxygen and nutrients, in Upper Klamath Lake and the Klamath River) under the full Proposed Action Alternative (KHSA and KBRA) with TMDL related restoration efforts and climate change. Further, quantitative modeling of dynamic processes - with inherent uncertainty in representation of physical and biological processes affecting water quality - was not deemed appropriate for this analysis.

This assessment addresses nutrients and organic matter (and indirectly addresses dissolved oxygen and other related parameters including pH, chlorophyll-a, ammonia, microcystin and organic enrichment), which currently do not meet the States water quality standards and thus contribute to degradation of beneficial uses in the basin. Water temperature, which also fails to meet the States water quality standards, is only briefly addressed here; separate modeling exercises undertaken as part of the Secretarial Determination studies provide more quantitative predictions for the effects of the Proposed Action and No-Action alternatives on water temperature (Perry et al., 2011). However, the likely temperature changes under the two alternatives are considered for their influence to nutrient processing, primary production, and dissolved oxygen solubility. Additionally, contaminants in and potential oxygen demand exerted by resuspended reservoir sediments - considered to be short-term issues (up to 2 years, during and immediately following dam removal) - are being addressed separately (CDM and Stillwater Sciences 2011).

Differences in the magnitude and pace of water quality improvements under the Proposed Action and the No Action alternative are qualitatively addressed. Under the Proposed Action, KHSA and KBRA water quality improvement projects would occur in addition to TMDL water quality improvement projects; the combined effects of these programs are expected to be complimentary, enhancing the magnitude and pace of water quality improvements, and resulting in greater benefits than would be otherwise achievable by the TMDL program alone (i.e., the No Action alternative).

This assessment: (1) compiles ongoing projects and prospective projects being evaluated and planned under other parallel processes, (2) provides an assessment of the direction and general magnitude of resulting long-term water quality changes anticipated from those projects, and (3) briefly describes the inherent assumptions and uncertainties of the assessment. Example projects represent reasonably foreseeable actions based on currently documented plans, and are used to project water quality trends. Additionally, advances in scientific and analytical tools may result in better ability to predict water quality improvements in the Klamath Basin. To the extent possible, new information gained between now and March 2012, potentially modifying the understanding of the water quality effects of potential projects, will be made available to further inform the Secretarial Determination.

Uncertainties exist related to KHSA and KBRA projects identified under the Proposed Action Alternative and affect the assessments presented here. There is inherent uncertainty related to future funding, choice of projects implemented, and the future scientific understanding and management of water quality in the Klamath Basin. Uncertainty is particularly applicable regarding KBRA projects, as KBRA legislation and funding are not yet finalized. Thus, many KBRA restoration projects will remain largely conceptual in nature until decisions are made following the Secretarial Determination. Planning and evaluation efforts for KHSA such as water quality improvement projects under Interim Measure 10 (Water Quality Conference) and Interim Measure 11 (Water Quality Pilot Projects) are underway. This assessment uses the most current

information available, evaluating those options to be developed at the IM-10 conference as pollutant reduction options and pilot projects for the Klamath Basin. Implementation of KHSA and KBRA projects is not guaranteed, and the extent of water quality improvements yielded by these projects depends on factors yet to be specified in final project selection and design (e.g., scaling depending on available resources). Therefore, projects in this assessment are necessarily addressed in a qualitative manner.

3.2 Klamath Hydropower Settlement Agreement

The KHSA lays out the process for additional studies, environmental review, and a decision by the Secretary of the Interior regarding whether removal of the four dams: 1) will advance restoration of the salmonid fisheries of the Klamath Basin, and 2) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and tribes. Under the Proposed Action, the removal of the four PacifiCorp dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) in a 12-month period, as described in the KHSA, would result in short-term (<2 years following dam removal) and long-term (2 - 50 years following dam removal) changes to water quality in the Klamath River. Short-term effects for reservoir-derived sediments on dissolved oxygen (Stillwater Sciences 2011), chemical compounds of interest in sediments (CDM 2011), and water temperature (Perry et al., 2010), including climate change, are addressed separately.

In addition to dam removal, multiple interim measures (IMs) stipulated in the KHSA are anticipated to potentially affect water quality, either directly or indirectly (Appendix Table 1). Briefly, these interim measures include the following (Klamath Hydroelectric Settlement Agreement, 2010):

- IM 3: Iron Gate Turbine Venting – study, implementation and monitoring, of turbine venting to improve dissolved oxygen in waters immediately downstream of Iron Gate Dam (e.g., to the Iron Gate Hatchery Bridge);
- IM 5: Iron Gate Flow Variability - annual evaluations of the feasibility of enhancing fall and early winter flow variability to benefit salmonids downstream of Iron Gate Dam. Implementation would depend on the findings of the feasibility analysis;
- IM 6: Fish Disease Relationship and Control Studies – provides funding for research on fish disease interactions, including water quality factors;
- IM 10: Water Quality Conference – provides $100,000 in funding to host a conference to inform implementation of IM 11. The focus of this measure is to solicit expert input regarding preliminary feasibility for application of several potential nutrient reduction technologies in the Klamath Basin primarily above Iron Gate dam, as described below;
- IM 11: Interim Water Quality Improvements – provides $500,000 for studies or pilot projects focused on nutrient reductions, including, at a minimum: 1) Development of a Water Quality Accounting Framework; 2) Constructed Treatment Wetlands Pilot Evaluation; 3) Assessment of In-Reservoir Water Quality Control Techniques (e.g., Solar Bees); and 4) Improvement of J.C. Boyle Reservoir Dissolved Oxygen. Post Secretarial Determination provides up to $5.4 million for project implementation, and up to

$560,000/year in Operation and Maintenance costs. Other pilot projects will also be considered by the Interim Measures Implementation Committee;

- IM 13: Flow Releases and Ramp Rates – provision to maintain current operations from J.C. Boyle Dam to the J.C. Boyle Bypass Reach. If the Secretarial Determination is affirmative, this measure indicates that J.C. Boyle Dam should be removed last and that, if anadromous fish have volitional passage to the J.C. Boyle bypass reach after removal or partial removal of the lower dams and before J.C. Boyle is transferred, PacifiCorp will operate J.C. Boyle as a run of river facility; and,
- IM 15: Water Quality Monitoring – provides funding of $500,000/year for long-term baseline water quality monitoring and blue-green algae and algal toxin monitoring to protect public health during the Interim period (WY2012–WY2020).

These interim measures apply during 2010–2020. For some measures, water quality improvements may be achieved within the interim period 2010–2020; others are not explicitly included in the analysis of the Proposed Project or No Action alternative (Appendix Table 1). Interim measures No. 10 and 11 create a framework for planning and implementation of projects to affect long-term, sustained improvements in water quality in the Klamath Basin. Under Interim Measures 10 and 11, nine consensus-based project options have been identified and retained for further evaluation (engineering studies) using criteria developed by experts and participants at the IM-10 workshop. These projects included:

1. Wetland treatment systems
2. Wastewater treatment systems
3. Algae / biomass removal
4. Ambient water treatment systems
5. Sediment nutrient sequestration
6. Sediment removal
7. Wetland restoration
8. Oxidation Technologies
9. Diffuse Source Treatment Systems

The final list of projects to be implemented depends on the final engineering feasibility analyses, therefore the projects (Table 1).used for this qualitative evaluation are subject to change pending the outcome of these analyses.

3.3 Klamath Basin Restoration Agreement

The Klamath Basin Restoration Agreement (KBRA) is intended to:

1. Restore and sustain natural fish production and provide for full participation in river harvest opportunities of fish species throughout the Klamath Basin;
2. Establish reliable water and power supplies for agricultural uses, communities, and National Wildlife Refuges, and
3. Contribute to public welfare and sustainability of all Klamath Basin communities.

Within the KBRA, the Fisheries and the Water Resources Programs encompass the majority of the actions envisioned under the agreement (Appendix Table 2). The vast majority of the KBRA implementation actions are for fisheries restoration, reintroduction, and actions that enhance the amount of water available for fish (Klamath Basin Restoration Agreement, 2010). Restoration actions include, but are not limited to, prevention of fish entrainment, provision of fish passage, and re-introduction of fish to the Upper Klamath Basin.

KBRA Goals and Action Elements under both the Fisheries Program and Water Resources Program that are likely to affect water quality in the basin are summarized in Appendix Table 2, where elements likely to improve water quality are shown in bold. Some actions, including the *restoration and permanent protection of riparian vegetation* and the *implementation of KHSA and dam removal* under the Fisheries Program, as well as *support for state TMDLs* under the Water Resources Program, are anticipated to have non-flow-related water quality effects. In Appendix Table 3, specific water quality projects addressed in the KBRA's Appendix C, Table C-2 are summarized along with associated ecosystem functions and water quality parameters likely to be affected.

3.4 Klamath Basin TMDLs and Non-Point Source Reduction Programs

Multiple efforts are being undertaken by agency, county, and state entities to affect water quality improvements in the Klamath River Basin. Some are ongoing while others are anticipated through the TMDL and Non-Point Source (NPS) reduction programs. The programs anticipated to have the most significant benefits to water quality - involve the following:

In Oregon,

- Water quality management plans (e.g., for City of Klamath Falls, USBR, USFWS, as well as agricultural management plans)
- Water quality restoration plans (e.g., for Upper Klamath Lake tributaries), and
- Land use and management plans (LRMPs) (e.g., for USFS and BLM).

In California,

- Irrigated lands discharge program (e.g., tailwater discharges, degradation of riparian areas, and destabilized stream banks)
- Timber harvest plans (for non-federal lands), and
- Forest management plans (for federal lands), including implementation of BMPs.

Known examples of such ongoing or planned TMDL and NPS programs in the basin are summarized in Appendix Table 4.

4 Synthesis of Water Quality effects under KBRA, KHSA, and TMDL Actions

A large set of candidate water-quality related measures have been identified as potentially occurring under KBRA, KHSA, and/or TMDL and NPS reduction programs (Appendix Tables 1, 3, and 4). To provide an assessment of the direction and general magnitude of resulting long-term water quality changes, example ongoing and prospective projects that are anticipated to result in water quality changes in the Klamath River are identified in Table 1. Implementation of projects such as those listed in Table 1 would be expected to improve water quality over the period of analysis; however, the magnitude and timing of such improvements can only be estimated. Under the Proposed Action Alternative, the KHSA and KBRA projects, taken together with the Klamath Basin TMDL and NPS programs, provide a broad outline for a water quality recovery strategy for the Klamath River. With regard to long-term water quality improvements, the complementary goals of the KBRA, KHSA, together with TMDL and NPS programs, would support the most efficient level of water-quality improvement measures. Under the No Action alternative, the existing water quality recovery strategy is limited to the ongoing Klamath Basin TMDL and NPS programs. Water quality improvement projects (Appendix Table 3) would be implemented under the No Action alternative. However, it is assumed that implementation would occur at a slower pace and lesser scale as compared with implementation possible under the Proposed Action, and thus water quality improvements for nutrients and organic matter (and related parameters) under the No Action alternative have a lesser likelihood of, and much longer timeframe for: (1) achieving water quality conditions that support beneficial uses, and meet standards and TMDL targets, and/or (2) advancing the restoration of salmon fisheries.

4.1 Assumptions for the Assessment of Water Quality Changes

The direction and relative magnitude of change for nutrient concentrations is assessed for the period beginning in 2010 and ending 50 years following the start (2012) of the Secretarial Determination period of analysis, or 2062. Current conditions are defined as typical concentrations measured between 2007 and 2010 as part of various monitoring programs conducted in the basin, including monitoring conducted by USBR, USFWS, PacifiCorp, Klamath Tribes, Karuk Tribe, and Yurok Tribe. Time frames for the anticipated nutrient and organic matter changes depend on the types and extent of projects implemented. Qualitative assessments of example projects, by specific location or project type, are presented in Table 1 for the Proposed Action and No Action alternatives.

Future changes in dissolved oxygen are not explicitly addressed in this assessment or Table 1. Achievement of dissolved oxygen water quality standards is presumed to be dependent on significant progress towards reducing Total Nitrogen (TN), Total Phosphorus (TP) and organic

matter loads. Oregon and California Klamath River TMDL allocations for nutrients and organic matter were established to ensure that the site-specific dissolved oxygen objectives could be met (ODEQ, 2010; and NCRWQB, 2010a). Under the Proposed Action alternative other factors are expected to contribute to improved dissolved oxygen conditions, including, but not limited to: (1) physical habitat improvements (e.g. removal of impoundments that stratify), (2) improved temperature conditions (e.g., reduced temperature inputs through improved management of agricultural return flows, and reduced heat load / solar gain associated with removal of impoundments and shorter residence time); and (3) improved seasonal flow variation leading to more frequent periphyton scour flows. However, improvements in dissolved oxygen from the aforementioned factors could be negated to some degree by global warming; therefore, dissolved oxygen recovery is not necessarily linear through time or affected only by nutrient reductions.

Similarly, future changes related to cyanobacteria blooms (and thus cyanotoxins) are not explicitly addressed in the Table 1 assessment. Implementation of the Proposed Action would be expected to reduce these cyanobacterial blooms in the Klamath Hydroelectric Reach and below due to a variety of factors. Of the many factors that may influence these blooms, the removal of the lacustrine (reservoir) environments behind the dams is likely to have the most pronounced influence. Removal of the reservoirs would eliminate optimal habitats for the growth and proliferation of toxigenic nuisance algal species such as *Microcystis aeruginosa*. While algal (and toxins) produced in Upper Klamath Lake could still be transported into the Klamath Hydroelectric Reach and downstream at levels exceeding water quality objectives for Oregon and California, additional in situ production of the toxins would be significantly less likely to occur in the free-flowing river following dam removal. Furthermore, future restoration actions associated with KBRA that would accelerate nutrient reductions may lessen the geographic extent of blooms in the remaining habitats (e.g. Upper Klamath Lake and Keno Reservoir). As with DO, improvements in bloom conditions (i.e., reduced magnitude and frequency of blooms) that may be associated with restoration actions could be offset by climate change; however, predictions of such interactions are too complex and uncertain to be reliable at this time.

4.2 Anticipated Pace of Water Quality Changes

Under the No Action alternative, the state water quality agencies would continue working with entities responsible for TMDL allocations, as well as other stakeholders, developing and implementing projects to progress towards meeting water quality objectives and TMDL targets; these target may or may not be achieved by 2062. Additionally, TMDL implementation is an adaptive management process. Advances in scientific and analytical tools may result in a better understanding of the potential for different approaches to improve water quality in the Klamath Basin, thereby enhancing the selection, design, and pace of restoration projects. Mechanisms exist for the state water quality agencies to revisit TMDL implementation projects, as well as allocations and targets, if warranted by new information.

Under the Proposed Action, dam removal is expected to result in significant temperature, dissolved oxygen and cyanobacteria improvements; and nutrients and organic matter reductions

are expected to be accelerated, relative to those achieved under a no action (dams in) scenario. As such, improvements to water quality have greater likelihood of approaching the TMDL targets by the end of the analysis period (i.e., 2062). Further, KBRA projects (see Appendix Table 2) would provide additional resources and opportunities for water quality projects to be initiated and improvements to nutrients to be realized before 2062. This demonstrates that the most significant difference between the Proposed Action and the No Action alternative relative to water quality is the accelerated pace of achieving water quality improvements.

General conclusions drawn from the water quality analysis include the following:

- Water quality in the Klamath Basin is impaired due to anthropogenic activities.
- Implementation of water quality improvement projects under the KBRA and KHSA, and collaboration with TMDL implementation efforts, have the potential to synergistically and significantly restore ecosystem functionality (e.g., wetland nutrient removal), but are not intended to restore to pre-disturbance conditions.
- Dam removal will have an immediate effect on water quality (e.g., temperature, DO and cyanobacteria) both within and downstream of the Klamath Hydroelectric Project reach.
- Water quality improvements (e.g., nutrient and organic matter reductions) in Upper Klamath Lake and in the Klamath River upstream of Keno Dam are critical to the success of water quality and fisheries restoration in the Klamath River as a whole.
- Further scientific investigations are needed to identify control strategies for the legacy nutrient load (i.e., nitrogen, phosphorus) present in Upper Klamath Lake sediments. Actual selected strategies for controlling nutrient loads (e.g., capping, dredging, water column biomass removal, or other methods to sequester sediment nutrient sources) may be less effective than the presumed scenarios and the removal assumptions used for this qualitative assessment of water quality trends.
- Further scientific investigations will continue to inform the restoration policies in the Basin. For instance, TMDLs could be periodically revisited and allocations or targets adapted if new scientific information suggests changes that are both appropriate (i.e., provide supporting conditions) and protect beneficial uses.

Further development of these concepts is ongoing as part of planning, feasibility, and design efforts for water quality improvements in the Klamath Basin, and may result in additional information that can be used to refine this assessment of future changes in water quality.

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Table 1. Summary of Example Water Quality Projects to Decrease Nutrient Loads in the Klamath Basin

[Based on currently available information, the example projects represent potential water quality (nutrient) improvements under the Proposed Action and/or the No Action alternative, including implementation of Klamath Basin TMDLs, as cited below or shown in Appendix Table 3. KHSA Interim Measures (IMs) are described in Appendix Table 1. "Improvements" are defined as decreasing June-October nutrient concentrations or loads. Time periods indicated are for the projects' resulting effects on water quality rather than for implementation or construction. Descriptive terms for estimated change follow the hierarchy of Slight < Moderate < Significant]

Location	Example Projects[1]	Example Project Reference to Appendix Tables 1, 3, and 4	Estimated Direction and Time Period of Change for Combined Water Quality (Nutrient) Restoration Projects	
			Proposed Action[4]	No Action
Tributaries to Upper Klamath Lake (Williamson, Sprague, Wood rivers)	TNC Williamson River Delta Restoration	• Table 3 – KBRA Reference No. 18.2.1, Settlement Measures and Commitments Item No. 3 • Table 4 – TMDL/NPS example project listed under Tributaries to Upper Klamath Lake	Slight but steady improvements for TP and TN. 2010-2062, continuing into the future	Slight but steady improvements of TP and TN. 2010-2062, continuing into the future
	Treatment wetlands/engineered ambient treatment system[2]	• Table 1 – KHSA IM 10 & 11 (Constructed Wetlands) • Table 3 – KBRA Settlement Measures and Commitments Item No. 4 - Sprague River • Table 4 – TMDL/NPS Klamath WQ Tracking and Accounting Program[3] listed under General		
	Aquatic habitat restoration • Riparian shading, upland erosion control • Sediment source immobilization (fence construction, grazing management)	• Table 3 – KBRA Settlement Measures and Commitments Item Nos. 3, 5, 7 • Table 4 – TMDL/NPS example projects include USFS and BLM Land Use and Management Plans (LRMPs)		
	Non-Point Source BMP Implementation Programs	• Table 4 – TMDL/NPS example projects include ODA Agriculture Water Quality Management (AWQM) plans		

Table 1. Summary of Example Water Quality Projects to Decrease Nutrient Loads in the Klamath Basin

[Based on currently available information, the example projects represent potential water quality (nutrient) improvements under the Proposed Action and/or the No Action alternative, including implementation of Klamath Basin TMDLs, as cited below or shown in Appendix Table 3. KHSA Interim Measures (IMs) are described in Appendix Table 1. "Improvements" are defined as decreasing June-October nutrient concentrations or loads. Time periods indicated are for the projects' resulting effects on water quality rather than for implementation or construction. Descriptive terms for estimated change follow the hierarchy of Slight < Moderate < Significant]

Location	Example Projects[1]	Example Project Reference to Appendix Tables 1, 3, and 4	Estimated Direction and Time Period of Change for Combined Water Quality (Nutrient) Restoration Projects	
			Proposed Action[4]	No Action
Upper Klamath Lake	Wetland Restoration • Agency Lake/Barnes Ranch Wetland Restoration • Wood River wetland restoration	• Table 3 – KBRA Reference No. 18.2.2 and 18.2.3, Settlement Measures and Commitments Item Nos. 76, 77 • Table 4 – TMDL/NPS Klamath WQ Tracking and Accounting Program[3] (listed under General), and USFWS/USBR Agency Lake/Barnes Ranch Wetland Restoration	Moderate and steady improvements for TP and TN 2010-2026 , continuing into the future	Slight but steady improvements in TP and TN 2025–2030, continuing into the future
	Engineered ambient treatment system[2]	• Table 1 – KHSA IM 10 & 11 (Constructed Wetlands) • Table 4 – TMDL/NPS Klamath WQ Tracking and Accounting Program[3] listed under General	Moderate-to - Significant improvements in TP and TN 2018–2026, continuing into the future	Slight- to - Moderate improvement in TP and TN 2018–2022 and continuing into the future
	Sediment nutrient source immobilization/sequestration or biomass removal	• Table 1 – KHSA IM 10 & 11 - IMIC Pilot Project Identification for future consideration under KBRA (location TBD)	Significant improvements in TP and TN 2018–2026, continuing into the future	Moderate improvements in both TP and TN 2022–2062, continuing into the future

Table 1. Summary of Example Water Quality Projects to Decrease Nutrient Loads in the Klamath Basin

[Based on currently available information, the example projects represent potential water quality (nutrient) improvements under the Proposed Action and/or the No Action alternative, including implementation of Klamath Basin TMDLs, as cited below or shown in Appendix Table 3. KHSA Interim Measures (IMs) are described in Appendix Table 1. "Improvements" are defined as decreasing June-October nutrient concentrations or loads. Time periods indicated are for the projects' resulting effects on water quality rather than for implementation or construction. Descriptive terms for estimated change follow the hierarchy of Slight < Moderate < Significant]

Location	Example Projects[1]	Example Project Reference to Appendix Tables 1, 3, and 4	Estimated Direction and Time Period of Change for Combined Water Quality (Nutrient) Restoration Projects	
			Proposed Action[4]	No Action
Link River to Keno Dam (includes Lower Lost River)	Treatment wetlands/engineered ambient treatment system[2] • engineered ambient treatment system (e.g., at the Klamath Straits Drain) • Organic and Nutrient load reduction and Wetland Restoration at Keno Reservoir • upland treatment wetlands (location TBD)	• Table 1 – KHSA IM 10 & 11 (Constructed Wetlands) - IMIC Pilot Project Identification for future consideration under KBRA • Table 3 – KBRA Reference 10.1, Settlement Measures and Commitments Item Nos. 2, 11, 12 • Table 4 – TMDL/NPS Klamath WQ Tracking and Accounting Program[3] listed under General	Moderate –to- significant in TP and TN 2018–2026, tapering to Slight improvements into the future	Slight improvements in both TP and TN 2018–2022, continuing into the future
Klamath River - Keno Dam to Iron Gate	Aquatic habitat restoration • Riparian shading, upland nutrient interception	• Table 3 – KBRA Settlement Measures and Commitments Item Nos. 11, 12, 13, 14, and 16	Moderate improvement in TP and TN 2018–2026	Slight annual nutrient retention in reservoirs for TP and TN Ongoing, as existing
	Treatment wetlands/engineered ambient treatment system[2] (e.g., associated with footprints of J.C. Boyle and Copco I reservoirs)	• Table 4 – TMDL/NPS Klamath WQ Tracking and Accounting Program[3] listed under General		

Table 1. Summary of Example Water Quality Projects to Decrease Nutrient Loads in the Klamath Basin

[Based on currently available information, the example projects represent potential water quality (nutrient) improvements under the Proposed Action and/or the No Action alternative, including implementation of Klamath Basin TMDLs, as cited below or shown in Appendix Table 3. KHSA Interim Measures (IMs) are described in Appendix Table 1. "Improvements" are defined as decreasing June-October nutrient concentrations or loads. Time periods indicated are for the projects' resulting effects on water quality rather than for implementation or construction. Descriptive terms for estimated change follow the hierarchy of Slight < Moderate < Significant]

Location	Example Projects[1]	Example Project Reference to Appendix Tables 1, 3, and 4	Estimated Direction and Time Period of Change for Combined Water Quality (Nutrient) Restoration Projects	
			Proposed Action[4]	No Action
Klamath River - Iron Gate to Turwar	Aquatic habitat restoration • Riparian shading, upland nutrient interception, floodplain rehabilitation, livestock exclusion ,prescribed burning of upland forest areas, and road decommissioning	• Table 3 – KBRA Reference 10.1.2, and Commitments Item Nos. 22 and 25; and for tributaries - Settlement Measures and Commitments Item Nos. 17, 19, 22, 25, 27	Slight improvements based on upstream nutrient reductions. Projects should maintain river TP and TN. Reductions in upstream river retention are assumed as nutrient concentrations decrease over time.	Slight improvements based on upstream nutrient reductions. Projects should maintain river TP and TN. Reductions in upstream river retention are assumed as nutrient concentrations decrease over time.
	Non-point Source BMP Implementation Programs/Projects	• Table 4 – TMDL/NPS example projects include Targeted Watershed Initiative Grants, Estuary Initiative Grant, 319 Grants, Road Sediment Source Reduction Programs		
	CA Non-Point Source Waiver Program	• Table 3 – KBRA Settlement Measures and Commitments Item Nos. 18, 19, 20, 21, 23, 24, 25 • Table 4 – TMDL/NPS example projects include Agricultural Waiver Program (NCRWQB, in process), Timber Harvest Plans, USFS Waiver Program (NCRWQB, 2010c) listed under CA General		

[1] The planning, feasibility analyses, and, in some cases pilot studies, currently underway as part of KHSA Interim Measures 10 and 11 may in result in an updated list of example projects for improving water quality in the Klamath Basin.

[2] Ambient treatment systems include treatment wetlands, algae harvesting, and package wastewater treatment systems (NCRWQB 2010).

[3] Per the Water Quality Control Plan (Basin Plan) for the North Coast Region (NCRWQB 2010b), Table 4-18 (Implementation Actions) for Klamath River and Lost River TMDL, and identified in KHSA Interim Measure 11 (development of a water quality accounting framework). A Memorandum of Agreement (MOA) was signed by the NCRWQB, ODEQ, and US EPA Regions 9 and 10 (2009); it proposes the development of a basin-wide accountability program to track water quality improvements, facilitate planning and coordinate TMDL implementation among stakeholders.

[4] Evaluation assumption as noted by projected dates refers to an earlier initiation and completion of example projects under Proposed Action vs. No Action scenarios.

APPENDIX

Appendix Table 1. KHSA Interim Measures Related to Water Quality in the Klamath River Basin

[[KHSA Interim Measures (IMs) are from the Klamath Hydroelectric Settlement Agreement (2010)]

Interim Measures No. & Name	Interim Measure Summary Description	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	WQ Improvements Achieved During Interim Period (2010-2020)?
Upper Klamath Lake and Klamath River: Link River Dam to Keno Reservoir AND Keno Reservoir to Iron Gate Dam			
Interim Measure 10: Water Quality Conference	Provide $100K funding for conference to inform implementation of Interim Measure 11 with a focus on nutrient reductions in the Klamath Basin primarily upstream of Iron Gate Dam	Nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus), organic matter	Possibly
Interim Measure 11: Interim Water Quality Improvements	Studies or pilot projects for 1) Development of a Water Quality Accounting Framework; 2) Constructed Treatment Wetlands Pilot Evaluation; 3) Assessment of In-Reservoir Water Quality Control Techniques (i.e., Solar Bees); 4) Improvement of J.C. Boyle Reservoir Dissolved Oxygen.	Water temperature, dissolved oxygen, nutrients (nitrate, ammonium, organic nitrogen, ortho-phosphorus, total phosphorus), *Microcystis aeruginosa* concentrations, chlorophyll-a	1) No 2) No 3) Possibly 4) Possibly
Interim Measure 15: Water Quality Monitoring	Funding for WQ monitoring until the dams are removed.	Water temperature, dissolved oxygen, pH, total suspended solids, nutrients (nitrate, ammonium, organic nitrogen, ortho-phosphorus, total phosphorus), *Microcystis aeruginosa* concentrations, chlorophyll-a	No - measure is for monitoring only
Keno Reservoir to Iron Gate Dam			
Interim Measure 13: Flow Releases and Ramp Rates	Maintain current operations from J.C. Boyle Dam to J.C. Boyle Bypass Reach. If determination is affirmative, remove J.C. Boyle last and operate J.C. Boyle as run of river facility following the removal or partial removal of lower dams and until J.C. Boyle is transferred.	Flow	No
Iron Gate Dam to Trinity River			
Interim Measure 3: Iron Gate Turbine Venting	Turbine venting to improve dissolved oxygen downstream of Iron Gate Dam to fish hatchery bridge (limited to approx ¼ mile of river)	Dissolved oxygen	Possibly
Interim Measure 5: Iron Gate Flow Variability	Annually evaluate feasibility of enhancing fall and early winter flow variability to benefit salmonids downstream of Iron Gate Dam. If feasible, implement.	Flow	Possibly
Interim Measure 6: Fish Disease Relationship and Control Studies	Funding for research on fish disease interactions	*Ceratomyxa shasta*	No

Appendix Table 2. KBRA Goals and Action Elements under the Fisheries and Water Resources Programs.

[Action Elements shown in bold are likely to improve water quality. Source for KBRA Goals and Action Elements: Klamath Basin Restoration Agreement, 2010]

Fisheries Program	Water Resources Program
Goals	
• **Restore and maintain ecological functionality and connectivity to historic habitat** • Re-establish and maintain naturally sustainable and viable populations of fish to the full capacity of the restored habitats • Provide for full participation in harvest opportunities	• Address water supply reliability • Ensure affordable power for On- and Off-Project agricultural users, and for moving water through the Reclamation Project
Action Elements	
Restore and permanently protect riparian vegetation Restore stream channel functions Prevent entrainment of fish into diversions (screen irrigation channel intakes – specifically intakes into the Reclamation Project system) **Provide for fish passage to historic habitat – the Agreement specifically identifies implementation of KHSA and dam removal as the method for achieving this element** [a] Re-introduce salmonid fisheries into the Upper Klamath Basin – re-introduction is to be a passive process and specifically excludes the Trinity River watershed above the confluence with the Klamath River; Lost River and its tributaries; and Tule Lake basin Re-introduction of fish above the Iron Gate Dam is to be accomplished through dam removal and the restoration of a free flowing stream condition Provide additional water for fish – provisions protect instream flows and maintain the elevation of Upper Klamath Lake and include a number of programs and actions including: • **An interim program of water lease and purchase to reduce diversions above Upper Klamath Lake** • **Establishes limits on diversions for the Reclamation Project (reduces the availability of irrigation water to 100,000 acre feet less than the demand in the driest years to protect mainstem flows)**	An On-Project Water Users Program that: • Sets diversion limits • Provides additional water in some years up to 10,000 acre feet (dependent on either dam removal or the provision of additional storage) • **Addresses water and agricultural management on LKNWR and TLNWR** • Provides water rights assurances between Federal agencies and Tribes • **Addresses operation of the Reclamation Project** An Off-Project Water Program which includes: • An Off-Project Water Settlement • **Voluntary water use retirement program** Development of a Power for Water Management Program Measures to provide additional water storage and conservation (see also item vii(d) under the Fisheries Program above)

Appendix Table 2. KBRA Goals and Action Elements under the Fisheries and Water Resources Programs.

[Action Elements shown in bold are likely to improve water quality. Source for KBRA Goals and Action Elements: Klamath Basin Restoration Agreement, 2010]

Fisheries Program	Water Resources Program
• **Voluntary program of water right retirement in upper basin expected to add up to 30,000 acre feet per year to Upper Klamath River (includes Wood River, Sprague River, Sycan River (except Sycan Marsh), and Williamson River)** • Increase water storage and conservation Breach levees on Williamson River Delta (Completed) – adds 28,000 acre feet of storage Reconnect Barnes and Agency Lake Ranches to Agency Lake (project underway) – adds 63,700 acre feet of storage Reconnect Wood River wetlands to Agency Lake (under study) – adds 16,000 acre feet of storage • **Monitoring of groundwater use to ensure river flows are not affected** • **Specifies allocations to Reclamation Project and to Lower Klamath NWR (LKNWR) and Tule Lake NWR (TLNWR)** • Assess effects of climate change on basin water budget Monitor and apply adaptive management to habitat restoration, fish reintroduction efforts, and fisheries harvest practices	**Development of a Drought Plan** **Assessment of the impact of climate change** Development of an Emergency Plan Measures to produce Environmental Water which include: • **Measures described above including support for KHSA, limitations on diversions, retirement of water use rights, creation of additional storage, and implementation of the Fisheries Program** • **An interim water lease and purchase program** • Conversion of existing PacifiCorp water rights to in-stream water rights • **Support for state TMDLs**

[a] Actions related to dam removal are expected to affect water quality.

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

[KBRA Funding Allocations reflect the Revised Appendix C2 of KBRA dated June 20, 2011. In most cases, affected water quality parameters are not specified in the KBRA. For the purposes of this compilation, water quality parameters are assumed based on readily available information by project and/or location in the Klamath River. Source for KBRA Measures: Klamath Basin Restoration Agreement, 2010]. **Note: formatted to print on 11"x17" sheet.**

KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
General										
Fisheries: Restoration	10.1.2 Klamath River Fisheries Restoration Plan	2	Phase I establishes restoration priorities and criteria for restoration project selection for the 15 years following the Effective Date. Specific elements will include, but may not be limited to, restoration and permanent protection of riparian vegetation, water quality improvements, restoration of stream channel functions, measures to prevent and control excessive sediment inputs, remediation of fish passage problems, and prevention of entrainment into diversions. Phase I includes management and reduction of organic and nutrient loads in and above Keno Reservoir and in the Klamath River downstream.	2,500		Flows, riparian shading and nutrient interception, nutrient and sediment inputs, organic inputs	Water temperature, dissolved oxygen (DO), nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus), total suspended sediments (TSS)		X	
Water Resources	20.5.4.A Additional Measures to Protect Environmental Benefits of Flows	--	No waiver of federal Clean Water Act requirements or of comparable state water quality standards or implementation mechanisms is intended by any provision of KBRA. KBRA proactively addresses a significant number of water quality issues in the Klamath Basin.	--		Nutrient inputs, reservoir seasonal dynamics, algal bloom dynamics, fish disease	Water temperature, sediment, dissolved oxygen, pH, ammonia toxicity, nutrients, organic enrichment, chlorophyll-a, microcystin, and water quality impairment.			
Water Resources	20.5.4.B Additional Measures to Protect Environmental Benefits of Flows	--	Support the development and implementation of appropriate TMDLs and other water quality improvement programs adopted by the states within the Klamath Basin.	--		Nutrient inputs, reservoir seasonal dynamics, algal bloom dynamics, fish disease	Water temperature, sediment, dissolved oxygen, pH, ammonia toxicity, nutrients, organic enrichment, chlorophyll-a, microcystin, and water quality impairment.			
Tributaries to Upper Klamath Lake										
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	53	Tributaries water quality/nutrients/sediment	4,340		Multiple	Water temperature, dissolved oxygen (DO), total suspended sediments (TSS), nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus)		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	3	Williamson River aquatic habitat restoration	4,272	KBRA Restoration Needs (Barry et al., 2010): Mainstem Williamson River and Tributaries Riparian Corridor Management (e.g., fence construction, offstream livestock watering)	Riparian shading, erosion, nutrient interception(Barry et al., 2010)	Water temperature, sediment, nutrients (Barry et al., 2010)		X	

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

[KBRA Funding Allocations reflect the Revised Appendix C2 of KBRA dated June 20, 2011. In most cases, affected water quality parameters are not specified in the KBRA. For the purposes of this compilation, water quality parameters are assumed based on readily available information by project and/or location in the Klamath River. Source for KBRA Measures: Klamath Basin Restoration Agreement, 2010]. **Note: formatted to print on 11"x17" sheet.**

KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	4	Sprague River aquatic habitat restoration	49,099-	KBRA Restoration Needs (Barry et al., 2010): Mainstem Sprague River and Tributaries Riparian Corridor Management (e.g., fence construction, offstream livestock watering, grazing management, improving dryland range to reduce need for riparian pastures), Stream Channel Restoration (e.g., spring improvement, enhancement, and reconnection), and Water Quality Improvement (e.g., treatment wetlands for irrigation drainwater).	Riparian shading, erosion, nutrient interception[2]	Water temperature, sediment, nutrients**Error! Bookmark not defined.**		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	5	Wood River Valley aquatic habitat restoration	12,684	KBRA Restoration Needs (Barry et al., 2010): Mainstem Wood River and Tributaries Riparian Corridor Management (e.g., fence construction, offstream livestock watering, grazing management)	Riparian shading, erosion, nutrient interception[2]	Water temperature, sediment, nutrients**Error! Bookmark not defined.**		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	7	Williamson & Sprague Rivers USFS uplands	11,000		Riparian shading, erosion, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	10	Upper Klamath Lake watershed USFS uplands	3,220		Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Upper Klamath Lake										
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	47	Upper Klamath Lake bloom dynamics	1,400		Seasonal algal bloom dynamics	Seasonal algal concentration, chlorophyll-a		X	
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	48	Upper Klamath Lake water quality/phytoplankton/zooplankton	5,670		Seasonal phytoplankton & zooplankton dynamics	Seasonal algal concentration, chlorophyll-a, zooplankton		X	
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	49	Upper Klamath Lake internal load/bloom dynamics	2,800		Seasonal algal bloom dynamics, internal phosphorus loading	Organic phosphorus, total phosphorus, algal concentration, algal speciation		X	

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

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KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	50	Upper Klamath Lake external nutrient loading	3,626		Nutrient inputs	Nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus)		X	
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	51	Upper Klamath Lake analysis of long-term data sets	600		Not specified	Not specified		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	8	Upper Klamath Lake aquatic habitat restoration	12,692		Instream flow, stream channel function	Water temperature		X	
Fisheries: Restoration	18.2.1 Williamson River Delta Restoration	--	TNC breached levees (Nov 2008) to restore Upper Klamath Lake storage capacity and reconnect historic lake bed. KBRA Parties agree to support fish and water quality monitoring following the restoration.	--	KBRA Restoration Needs (Barry et al. [2010]): Levee Removal Setback or Breaching	Assume - water storage, nutrient cycling[2]	Assume - water storage, nutrient cycling[2]		X	
Water Resources	18.2.2 Agency Lake/Barnes Lake Reconnection via Wetlands Restoration	76	Diked and drained areas of Agency Lake and Barnes Ranches that once were part of Agency Lake will be operated as pumped storage within existing dikes, with the goal of reconnecting to Agency Lake by breaching existing dikes.	2,777	KBRA Restoration Needs (Barry et al., 2010): Upper Klamath/Agency Lake Lake-fringe Wetlands Restoration (e.g., floodplain wetland restoration and storage)	Assume - water storage, nutrient cycling[2]	Assume - water storage, nutrient cycling[2]		X	
Water Resources	18.2.3 Wood River Wetland Restoration	77	Reconnect Wood River Wetland to Agency Lake when physical and biotic conditions are sufficient to provide the wetland restoration benefits for which the property was acquired.	2,777	KBRA Restoration Needs (Barry et al., 2010): Upper Klamath/Agency Lake Lake-fringe Wetlands Restoration (e.g., floodplain wetland restoration and storage)	Assume - water storage, nutrient cycling (Barry et al., 2010)	Assume - water storage, nutrient cycling(Barry et al., 2010)		X	
Upper Klamath River: Link River Dam to Keno Reservoir. [Note that some of these programs may also apply to Upper Klamath Lake]										

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

[KBRA Funding Allocations reflect the Revised Appendix C2 of KBRA dated June 20, 2011. In most cases, affected water quality parameters are not specified in the KBRA. For the purposes of this compilation, water quality parameters are assumed based on readily available information by project and/or location in the Klamath River. Source for KBRA Measures: Klamath Basin Restoration Agreement, 2010]. **Note: formatted to print on 11"x17" sheet.**

KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Water Resources	On-Project Water Users Program /14.3.1 On-Project Plan and Power for Water Management Fund/15.2 On-Project Plan	66	Limitations on specific diversions for the Klamath Reclamation Project intended, particularly in drier years, to increase water availability for Fisheries purposes and for the allocation and delivery of water to National Wildlife Refuges. The DIVERSION quantity as specified in Appendix E-1 for the irrigation season will increase by 10,000 acre-feet in some years effective March 1 after the earlier of: (i) the physical removal of all or part of each of the Hydroelectric Facilities has occurred and achieved a free-flowing condition and volitional fish passage; (ii) 10,000 acre-feet of new storage has been developed under Section 18.3; or (iii) the KBCC, on or after February 1, 2020 and after receipt of recommendations from the TAT, determines the increase is appropriate.	92,500		Flows	Water temperature			X
Water Resources	19.2.3 Preparation, Adoption, and Approval of the Drought Plan	78	Drought Plan Development	--		Flow	Flow, water temperature			
Water Resources	19.5 Off-Project Reliance Program	83	Off-Project Reliance Program	12,000[7]		Flow	Flow, water temperature			X
Water Resources	20.3 Managed Environmental Water	84	Real Time Water Management	--		Flow	Flow, water temperature			
Water Resources	Appendix E-1 Klamath Reclamation Project Diversion Limitations pg E.14	--	3. For purposes of this Stipulation and any Order thereon, the diversion at each of the following facilities shall be presumed to equal the following amounts during the period March – October unless it is demonstrated to the OWRD that a lesser amount is diverted during such period: Facility Presumed diversion Mar – Oct (AF) KID Pumping Plants #1-10 Combined = 2,600 Ady #1-7 Combined = 2,031 Johnston Pumping Plant = 678 Pioneer Pumping Facility = 1,495 Modoc Culvert = 217 Reames Pumping Plant = 417	--		Flows	Water temperature		??	??
Water Resources	20.2.1-20.2.5	--	Support the KHSA Limits on diversions from the Klamath River and Upper Klamath Lake associated with the Klamath Reclamation Project. Retire water uses above Upper Klamath Lake. Seek to secure additional water storage in the Upper Klamath Basin. Implement the Fisheries Restoration and Reintroduction Plans.	--		Flows	Water temperature		??	??

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

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KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Water Resources	20.5.4.C Additional Measures to Protect Environmental Benefits of Flows	--	Undertake reasonable efforts to oppose any additional out-of-basin water transfers from the Klamath River Basin.	--		Flows	Water temperature		??	??
Water Resources	15.1.2 Water Diversions for Tule Lake and Lower Klamath National Wildlife Refuges	63	Klamath Basin Wildlife Refuges: O&M North and P Canals	--		Flow	Flow, water temperature		X	X
Water Resources	15.1.2 Water Diversions for Tule Lake and Lower Klamath National Wildlife Refuges	64	Klamath Basin Wildlife Refuges: Walking Wetland Construction	2,300		To be determined	To be determined		X	X
Klamath River: Keno Reservoir to Iron Gate Dam (Project Reach)										
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	57	Keno Reservoir water quality/algae/nutrient	5,628		Seasonal reservoir dynamics	Water temperature, dissolved oxygen (DO), total suspended sediments (TSS), nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus), algal speciation and concentration		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	11	Keno Reservoir water quality studies and remediation actions	49,589	KBRA Restoration Needs (Barry et al., 2010): In or Above Keno Reservoir Organic and Nutrient Load Reduction and Management (e.g., study of management and reduction of organic and nutrient loads, implement recommended organic and nutrient reduction loads)	Reservoir seasonal dynamics	Water temperature, dissolved oxygen (DO), total suspended sediments (TSS), nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus)		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	12	Keno Reservoir wetlands restoration	4,995	KBRA Restoration Needs (Barry et al., 2010): In or Above Keno Wetlands (e.g., restore wetlands on Keno Reservoir)	Nutrient cycling	Water temperature, nitrogen (nitrate, ammonium, organic nitrogen), phosphorus (ortho-phosphorus, total phosphorus)		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	13	Keno to Iron Gate upland private and BLM	--		Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen			
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	14	Keno to Iron Gate upland USFS (Goosenest)	1,400		Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	

Appendix Table 3. KBRA Measures Related to Water Quality in the Klamath Basin

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KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	16	Keno to Iron Gate tributaries - diversions and riparian	1,500		Flows, riparian shading, and nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Mid-Klamath River: Iron Gate Dam to Trinity River										
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	22	Mid Klamath River & Tributaries (Iron Gate to Weitchpec) aquatic habitat restoration	4,950	Proposed Restoration Actions (Stillwater Sciences, 2010): #1 Floodplain Rehabilitation; #8 Purchase Water Rights; #9 Use Prescribed Fire and Thinning; #10 Decommission and Upgrade Roads; #11 Livestock Exclosures	Instream flow, riparian shading, erosion, nutrient interception, stream channel function[2]	Water temperature, sediment, nutrients[2]		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	23	Mid Klamath Tributaries USFS upland	9,400	Relevant TMDL: NCRWQB (2006) Relevant TMDL Process: "USFS Waiver" Process (NCRWQB, 2010c)(Appendix Table 4)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	24	Mid Klamath Tributaries private upland	5,600	Relevant TMDL: NCRWQB (2010a) Relevant TMDL Process: "Non-Federal Lands Timber Waiver" and "Non-Federal Lands AG Waiver" Processes in Appendix Table 4, also listed in NCRWQB (2010b)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Shasta River										
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	17	Shasta River aquatic habitat restoration	12,400	Proposed Restoration Actions (Stillwater Sciences, 2010): #30 Floodplain Rehabilitation; #31-33 Instream Flow Studies; #35-36 Exclude Livestock from Channels	Instream flow, riparian shading, erosion, nutrient interception, stream channel function	Water temperature, sediment, nutrients[2]		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	18	Shasta River USFS uplands	--	Relevant TMDL: NCRWQB (2006) Relevant TMDL Process: "USFS Waiver" Process (NCRWQB, 2010c) (Appendix Table 4)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Scott River										
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	19	Scott River aquatic habitat restoration	4,950	Proposed Restoration Actions (Stillwater Sciences, 2010): #23 Floodplain Rehabilitation; #24 Focus Restoration Activities on Coldwater Accretion Reaches; #25 Strategically Purchase Conservation Easements and Water Rights; #26 Exclude Livestock from Channels; #27 Treat Road-Caused Sediment Discharges; #28 Use Prescribed Fire and Thinning	Instream flow, riparian shading, erosion, nutrient interception, stream channel function[2]	Water temperature, sediment, nutrients[2]		X	

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KBRA Program	KBRA Reference No.	Appendix C-2 Settlement Measures and Commitments Item No.	KBRA Project (wording taken directly from KBRA Appendix C-2)	KBRA Funding Allocation ($2007 Thousands)	Additional Project Description (where information is available)	*Which ecosystem attribute or function, as related to WQ, is likely to be affected or addressed by the Project?*	*Which WQ parameter(s) is likely to be affected or is addressed by the Project?*	Program or Element is…		
								Ongoing/ Occurring Now	Increased in magnitude or accelerated schedule with KBRA	New Program initiated by KBRA
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	20	Scott River USFS uplands	1,630	Relevant TMDL: NCRWQB (2007) Relevant TMDL Process: "USFS Waiver" Process (NCRWQB, 2010c) (Appendix Table 4)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	21	Scott River private uplands	575	Relevant TMDL: NCRWQB (2007) Relevant TMDL Process: "Non-Federal Lands Timber Waiver" and "Non-Federal Lands AG Waiver" Processes in Appendix Table 4, also listed in NCRWQB (2010b)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Salmon River										
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	27	Salmon River aquatic habitat restoration	3,320	Proposed Restoration Actions (Stillwater Sciences, 2010): #38 Floodplain Rehabilitation; #39 Improve Riparian Zones; #40 Restore Natural Fire Regime; #41 Decommission and Upgrade Roads	Instream flow, riparian shading, erosion, nutrient interception, stream channel function[2]	Water temperature, sediment, nutrients[2]		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	28	Salmon River USFS uplands	5,500	Relevant TMDL: NCRWQB (2005) Relevant TMDL Process: "USFS Waiver" Process (Appendix Table 4)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Lower Klamath River: Trinity River to Estuary										
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	25	Lower Klamath River & Tributaries (Weitchpec to mouth) aquatic habitat restoration	15,000	Proposed Restoration Actions (Stillwater Sciences, 2010): #12-13 Floodplain Rehabilitation; #16 Decommission and Upgrade Roads; #17-18 Exclude Livestock and Remove Feral Cattle from Riparian Areas; #19-20 Riparian Enhancement; #21 Use Prescribed Fire and Thinning	Instream flow, riparian shading, erosion, nutrient interception, stream channel function[2]	Water temperature, sediment, nutrients[2]		X	
Fisheries: Restoration	10.1 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	26	Lower Klamath private uplands	32,500	Relevant TMDL Process: "Non-Federal Lands Timber Waiver" and "Non-Federal Lands AG Waiver" Processes in Appendix Table 4, also listed in NCRWQB (2010b)	Riparian shading, nutrient interception	Water temperature, nutrients, dissolved oxygen		X	
Not specified										
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	41	(Fish) Disease	7,268		Conditions supportive of fish parasites	*Ceratomyxa shasta* spore counts, infection rates		X	
Fisheries: Monitoring	12.2 Non-Federal Parties Funding Appropriation for Fisheries Restoration Program	46	Water Quality	1,500		To be determined	To be determined		X	

Appendix Table 4. TMDL Processes and NPS Restoration Efforts in the Klamath River Basin

[Abbreviations: WWTP, Waste Water Treatment Plant; NCRWQB, North Coast Regional Water Quality Board; ODEQ, Oregon Department of Environmental Quality; CDFG California Department of Fish and Game; TNC, The Nature Conservancy; USFWS, U. S. Fish and Wildlife Service; USFS, U.S. Forest Service; BLM, Bureau of Land Management; USBR, U.S. Bureau of Reclamation; RCD, Resources Conservation District; MOU, Memorandum of Understanding; MOA, Memorandum of Agreement; NPDES, National Point Discharge Elimination System; BMP, Best Management Practice; DMA, Designated Management Agency]. **Note: formatted to print on 11"x17" sheet.**

Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
General				
Klamath Tracking and Accounting Program – Water Quality improvements throughout basin Anticipated projects (actual projects are yet to be determined) may include centralized treatment options (treatment wetlands. Algae harvesting, WWTP, etc) (Klamath Watershed Partnership, 2010)	Nutrients, dissolved oxygen, chlorophyll-a, water temperature, microcystin		X	X
General - Oregon				
OR Dept Agriculture Water Quality Management (AWQM) plans - work with local farmers and ranchers to develop agriculture water quality management area plans to address pollution contributions on Non-Federal agricultural lands (SB1010 Plan (Oregon Department of Agriculture, 2007)	Ammonia toxicity, dissolved oxygen, pH, chlorophyll-a, water temperature	X		
General - California				
CA Agricultural Waiver - NCRWQCB Waiver for discharges associated with agriculture including irrigated agriculture and grazing on Non-Federal lands (NCRWQB 201b; NCRWQB, *in process*). Website providing most recent draft documents and updates on permit development process: http://www.waterboards.ca.gov/northcoast/water_issues/programs/irrigated_lands/	Nutrients, dissolved oxygen, water temperature, sediment		X	X
CA Statewide NPDES Stormwater Permits for Caltrans Activities. General Permit (NPDES Permit No. CAS000003) (CSWCRB 2010), the California Construction General Stormwater Permit (NPDES Permit No. CAS000002) (CSWCRB 2009), and the California Non-Construction General Stormwater Permit (NPDES Permit No. CAS000001) CSWCRB 2007).	Sediment	X		
Five Counties Salmonid Conservation Program and Waiver certifying 5 County Program for County Roads (applies to Del Norte, Humboldt, Siskiyou, and Trinity counties) – impact mitigation and implementation of BMPs. (Five Counties Salmonid Conservation Program, 2002) http://www.5counties.org/Projects/FinalGeneralProjectPages/RoadsManual800.htm	Sediment	X		

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Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
Timber Harvest Plans, WDRs, and waivers – timber harvest activities on non-federal lands (NCRWQB 2009, 2010b). (http://www.waterboards.ca.gov/northcoast/board_decisions/adopted_orders/pdf/2009/090610_0038_Waiver_NonFedTimber.pdf)	Nutrients, water temperature, sediment	X	X	
NCRWQCB Thermal Refugia Basin Plan Restriction (NCRWQB, 2010b)	Water temperature		X	X
CDFG Policy on Suction Dredge Mining Permitting (expected in 2012) http://www.nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=27429	Water temperature, dissolved oxygen	X	X	
USFS Waiver – for non-point source discharges associated with certain activities on lands managed by the USFS (NCRWQB, 2010d) http://www.waterboards.ca.gov/northcoast/water_issues/programs/timber_operations/timber_waiver/100616/100617_10_0029_Waiver_USFS.pdf	Nutrients, water temperature, sediment	X	X	
CDFG Instream Flow Assessments – pilot http://www.dfg.ca.gov/water/instream_flow_docs.html http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=14106	Water temperature	X		
Upper Klamath Lake and Tributaries to Upper Klamath Lake				
TNC's Williamson River Delta Restoration, http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/oregon/placesweprotect/	Phosphorus	X	X	
USFWS/USBR Agency Lake/Barnes Ranch Wetland Restoration (includes Wood River wetland restoration). Future disposition of these properties are subject to conditions of the KBRA (Klamath Basin Restoration Plan, 2010)	Phosphorus		X	X
Sprague Watershed Riparian Restoration and Habitat Enhancement - USFWS and Klamath Tribe. (USFWS, 2011; Barry et al., 2010)	Sediment	X	X	X

Appendix Table 4. TMDL Processes and NPS Restoration Efforts in the Klamath River Basin

[Abbreviations: WWTP, Waste Water Treatment Plant; NCRWQB, North Coast Regional Water Quality Board; ODEQ, Oregon Department of Environmental Quality; CDFG California Department of Fish and Game; TNC, The Nature Conservancy; USFWS, U. S. Fish and Wildlife Service; USFS, U.S. Forest Service; BLM, Bureau of Land Management; USBR, U.S. Bureau of Reclamation; RCD, Resources Conservation District; MOU, Memorandum of Understanding; MOA, Memorandum of Agreement; NPDES, National Point Discharge Elimination System; BMP, Best Management Practice; DMA, Designated Management Agency]. **Note: formatted to print on 11"x17" sheet.**

Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
City of Klamath Falls Water Quality Management Plan – storm water runoff from roads to tributaries. TMDL allocations for this DMA for Upper Klamath and Lost River Subbasins are addressed through compliance with Oregon Administrative Rules, OAR-340-042-0080(3)., (Oregon Department of Environmental Quality 2007, http://www.deq.state.or.us/wq/tmdls/docs/impl/07wq004tmdlimplplan.pdf; http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_042.html)	Sediment			X
Oregon Department of Transportation (ODOT) NPDES and MOU for water quality protection plans as a DMA - including project development, construction, and O&M using Routine Road Maintenance, Water Quality and Habitat Guide Best Management Practices and Pollution Control Plan and Erosion Control Plans. (Oregon Department of Transportation and Oregon Department of Environmental Quality, 2011)	Sediment, water temperature	X		
USFS and BLM Water Quality Restoration Plans (WQRPs) - including BMPs to achieve water quality standards and address the nonpoint Load Allocations as a DMA. Complies with MOA between US Bureau of Land Management and Oregon Department of Environmental Quality (2003; (http://www.deq.state.or.us/wq/nonpoint/docs/BLMDEQMOA.pdf) and MOU between USDA Forest Service and Oregon Department of Environmental Quality (2002; http://www.deq.state.or.us/wq/nonpoint/docs/USFSDEQMOU.pdf)	Sediment, total phosphorus (TP), total nitrogen (TN),	X		
Klamath County Lands) - TMDL allocations for Upper Klamath Lake Drainage are addressed by Klamath County (2003) as a DMA. TMDL allocations for Upper Klamath and Lost River Subbasins are addressed through compliance with Oregon Administrative Rules, OAR-340-042-0080(3), http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_042.html	Sediment, total phosphorus (TP), total nitrogen (TN),	X		
US Bureau of Reclamation Water Quality Management Plan. Under Oregon State Law for TMDLs and compliance with Oregon Administrative Rules, OAR-340-042-0080(3). Reclamation is obligated as a DMA to submit a WQMP for USBR Klamath Project. This plan is currently in development.	Phosphorus, Nitrogen, Biochemical Oxygen Demand (BOD)	X		

Appendix Table 4. TMDL Processes and NPS Restoration Efforts in the Klamath River Basin

[Abbreviations: WWTP, Waste Water Treatment Plant; NCRWQB, North Coast Regional Water Quality Board; ODEQ, Oregon Department of Environmental Quality; CDFG California Department of Fish and Game; TNC, The Nature Conservancy; USFWS, U. S. Fish and Wildlife Service; USFS, U.S. Forest Service; BLM, Bureau of Land Management; USBR, U.S. Bureau of Reclamation; RCD, Resources Conservation District; MOU, Memorandum of Understanding; MOA, Memorandum of Agreement; NPDES, National Point Discharge Elimination System; BMP, Best Management Practice; DMA, Designated Management Agency]. **Note: formatted to print on 11"x17" sheet.**

Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
US Fish and Wildlife Service Water Quality Management Plan and Cooperative Conservation Plan: Water Quality Management Plan: As a DMA, TMDL allocations addressed through compliance with OAR-340-042-0080(3). http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_042.html and Cooperative Conservation Plan (CCP) -- In progress–updates on draft documents available at: http://www.fws.gov/klamathbasinrefuges/KBNWR%20CCP%20DOCS.html	Sediment, total phosphorus (TP), total nitrogen (TN),	X		
Oregon Department of Forestry (ODF) Forest Practices Act - Northwest Forest Plan Agency's Implementation of BMPs on non-federal forest lands - BMPs exist for Forest Roads and Culverts management; Forest Riparian Area Management; Increased shade. TMDL allocations addressed by state rules OAR 629-635-000 through OAR 635-660. http://arcweb.sos.state.or.us/pages/rules/oars_600/oar_629/629_635.html	Sediment, total phosphorus (TP), total nitrogen (TN), water temperature	X		
City of Chiloquin NPDES Permit - wastewater treatment plant and sanitary sewer system; separate municipal storm sewer system management. TMDL allocation for this DMA met through compliance with ORS-468B.050	Total phosphorus (TP) and total nitrogen (TN)	X		
City of Klamath Falls – Non-point sources including municipal storm sewer system; Maintenance, construction and operation of parks and other city owned facilities and infrastructure. TMDL allocations for this DMA addressed through compliance with OAR-340-042-0080(3), (ODEQ 2007) http://www.deq.state.or.us/wq/tmdls/implementation.htm, http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_042.html	Total phosphorus (TP) and total nitrogen (TN)	X		
Targeted Watershed Initiative Grant, Upper Klamath, Oregon – Restoration of wetlands, streambanks, and habitat; construction of treatment wetlands; and education/outreach/ http://water.epa.gov/grants_funding/twg/upload/2009_01_20_watershed_initiative_2006_upper_klamath.pdf.	Nutrients, organic matter, water temperature, chlorophyll-a, pH	X		
Lost River				
California's Klamath Project Management Agency Agreement (MAA) - cooperative agreement for implementing TMDL for Klamath Project area. With USBR, USFWS, Tule Lake Irr. Dist, RWQCB	Nutrients, organic matter, dissolved oxygen, water temperature		X	X

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Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
OR Water Management Districts Water Quality Management Plan - for non-federal water delivery and drainage systems. TMDL allocations for these DMAs addressed through compliance with OAR-340-042-0080(3).	Nutrients (NH3 and pH), dissolved oxygen, water temperature			X
OR Dept Agriculture Water Quality Management (AWQM) plans – As a DMA, work with local farmers and ranchers to develop agriculture water quality management area plans to address pollution contributions on private agricultural lands (SB1010 Plan) (Oregon Department of Agriculture, 2007)	Ammonia toxicity, dissolved oxygen, pH, chlorophyll-a, water temperature	X	X	
US Bureau of Reclamation Water Quality Management Plan. Under Oregon State Law for TMDLs and compliance with Oregon Administrative Rules, OAR-340-042-0080(3), Reclamation is obligated as a DMA to submit a WQMP for Reclamation's Klamath Irrigation Project. This plan is currently in development.	Ammonia, chlorophyll-a, dissolved, oxygen, pH, water temperature		X	X
Upper Klamath River: Link River Dam to Keno Reservoir[3]				
Oregon Department of Forestry (ODF) - Forest Practices Act Implementation of BMPs on non-federal forest lands. TMDL allocations as a DMA addressed by state rules OAR 629-635-000 through OAR 635-660.	Sediment, water temperature	X		
USFS and BLM Water Quality Restoration Plans (WQRPs)- including BMPs to achieve water quality standards and address the nonpoint Load Allocations as a DMA. Includes Forest Ecosystem Management Assessment Team (FEMAT) timber harvest management that protects aquatic and associated riparian habitats adequate to provide for threatened species and at risk species. TMDL allocations addressed by compliance with MOA between ODEQ and BLM (http://www.deq.state.or.us/wq/nonpoint/docs/BLMDEQMOA.pdf) and MOU between ODEQ and USFS (http://www.deq.state.or.us/wq/nonpoint/docs/USFSDEQMOU.pdf)	Sediment, water temperature	X		
NPDES Permits Klamath Fall WWTP, South Suburban WWTP, Columbia Plywood, Collins Forest Products. TMDL allocation met through compliance with ORS-468B.050	Nutrients, dissolved oxygen, water temperature			X

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Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
PacifiCorp Water Quality Management Plan - for Oregon reaches of Klamath river and Keno and JC Boyle reservoirs - to address load allocations. Will includes KHSA Interim Measures (yet to be determined) and KBRA Efforts (Positive Secretarial Determination would transfer Keno Dam to USBR authority, requiring USBR Water Quality Management Plan for Keno) (PacifiCorp, 2009)	Dissolved oxygen, water temperature			X
Mid-Klamath River: Keno Dam to Iron Gate Dam				
PacifiCorp Implemetation Plan for CA reaches of Klamath river – addressing load allocations in project area from Stateline to below Iron Gate. Will includes KHSA Interim Measures (yet to be determined) and KBRA Efforts (PacifiCorp, 2011)	Nutrients and dissolved oxygen, water temperature, chlorophyll-a, *Microcystis aeruginosa*, periphyton		X	X
PacifiCorp (2011) Implementation Plan for CA, Copco and Iron Gate reservoirs – addressing load allocations – will indude KHSA Interim Measures (yet to be determined) and KBRA Efforts	Water temperature, dissolved oxygen			X
Mid-Klamath River: Iron Gate Dam to Trinity River				
PacifiCorp/CDFG NPDES permit for Iron Gate Hatchery (NPDES Permit No. CA0006688 and Monitoring and Reporting Program WDR No. R1-2000-17, NCRWQB, 2000)	Nutrients, dissolved oxygen, water temperature		X	X
Shasta River				
Shasta Valley Resources Control Board + Shasta Water Association Dam Demobilization and Water Quality Project - identify and prioritize tail waters for reuse and WQ benefit; via replacement of a diversion structure that will impound much less water and allow for fish passage, and install various on-farm improvements that will help maximize water use efficiency. http://www.fws.gov/yreka/partners.html	Sediment, dissolved oxygen, water temperature, fish passage, nutrients	X		
CDFG Instream Flow Assessments – pilot http://www.dfg.ca.gov/water/instream_flow_docs.html http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=14106	Water temperature	X		
Scott River				
CDFG Instream Flow Assessments – pilot http://www.dfg.ca.gov/water/instream_flow_docs.html http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=14106	Water temperature	X		

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Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
Road Sediment Source Reduction: Lower Scott - USDA Forest Service- reconstruction/repair of 7.7 miles of roads in the Canyon, Tompkins, and Kelsey Creek Watersheds. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/319h/docs/2010/2010fundinglist.pdf	Sediment	X		
Riparian Restoration Project - maintenance and riparian planting and streambed restoration, including restoring 800 feet of actively eroding streambank, and re-vegetating 15-20 acres of riparian corridor and restore shade potential on 7 acres. (Siskiyou RCD, 2010)	Sediment, water temperature	X		
Salmon River				
USFS Sediment Control Work (319 Grant) (NCRWQB, 2005), http://www.waterboards.ca.gov/water_issues/programs/grants_loans/319h/docs/2008/2009rcmmnd_fndng.pdf	Sediment	X		
South Fork Trinity River				
Trinity County RCD Watershed Restoration - watershed restoration activities (decommissioning and road upgrade) on USFS road networks to reduce sediment loads. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/319h/docs/exhibit_1_recommendfundlist.pdf	Sediment	X		
Trinity Record Of Decision (Department Of Interior, 2000; http://www.trrp.net/?page_id=72)	Water temperature	X		
Lower Klamath River: Below Trinity through Estuary				
West Coast Estuary Initiative Grant/Yurok Waukell Creek - Restoration of Off-Estuary Wetland and Stream Habitats of Waukell Creek, Klamath River (Yurok Tribal Fisheries Program). Issues - Salmon, off-estuary habitat loss; habitat restoration, channel and floodplain restoration, road stream crossing improvements, cottonwood shade tree planting. http://www.epa.gov/region9/water/watershed/grants.html	Fisheries, nutrients, sediment, water temperature			X

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Plan/Program/Process/Restoration Effort	Which WQ parameter(s) is likely to be affected or is addressed by the Project?	Program or Element is…		
		Ongoing/ Occurring Now[1]	Increased in magnitude or accelerated schedule with KBRA	Future Program[2]
Targeted Watershed Initiative Grant - restoration project between the Yurok, Trinity County and the RCD, decommissioning road segments and stream crossings in upper Terwer Creek, stream bank stabilization and riparian restoration in lower Terwer Creek. http://water.epa.gov/grants_funding/twg/upload/2007_04_04_watershed_initiative_2005_trinity_lower_klamath.pdf	Sediment	X		

[1] Regulatory or on-the-ground starting time for the project or restoration effort is in 2010 or before.

[2] Regulatory or on-the-ground starting time for the project or restoration effort is in 2011 or after.

[3] Some of these programs may also apply to Upper Klamath Lake.