EXECUTIVE SUMMARY

The Klamath River Water Quality Workshop was held on September 10-13, 2012 in Sacramento, California, to evaluate large-scale techniques for improving water quality in the Upper Klamath Basin and to inform decision-making on nutrient reduction approaches. The workshop focused on upper basin projects to foster a new, healthier equilibrium condition for basin headwaters, to treat both the symptoms and the causes of elevated phosphorus and nitrogen levels, and, ultimately, to support water quality improvements in downstream reaches of the Klamath River. Workshop participants included over 100 attendees representing roughly 13 federal and state (California, Oregon) agencies, multiple tribes, and several consulting firms, academic institutions, and utilities. Six large-scale pollutant reduction techniques were evaluated at the workshop, including the following:

- Wetland restoration (habitat focus)
- Treatment wetlands (water quality focus)
- Diffuse source (decentralized) treatment wetlands
- Algal filtration
- Sediment dredging
- Sediment sequestration of phosphorus and aeration/oxygenation

This report summarizes information presented at the workshop and, based on feedback from workshop participants and the project Steering Committee, presents conceptual designs for pilot projects to improve water quality in the Upper Klamath Basin. The report is organized into four sections, as follows.

SECTION 1 provides a summary of water quality challenges in Upper Klamath Basin; this information was also presented in a technical document given to workshop participants (Stillwater Sciences et al. 2013) and reviewed as background information at the workshop. Section 1 addresses the following topical questions:

- What are the water quality problems in Upper Klamath Lake and the Klamath River?
- What are the reasons for poor water quality?
- Where do the excessive amounts of phosphorus in Upper Klamath Lake come from?
- Can the phosphorus and algae problem be fixed?
- How do social and cultural factors influence the planning for Upper Klamath River Basin water quality improvement projects?

SECTION 2 presents an overview of the large-scale water quality improvement techniques evaluated by participants at the workshop, including goals and capabilities, basic design elements, and examples of similar applications. The results of workshop small-group evaluation sessions for each of the techniques are presented along with the generalized cost estimates considered by participants during their evaluations. Pros and cons of the different techniques are summarized at the end of Section 2, developed using feedback from workshop participants and the project Steering Committee. Detailed documentation of the workshop itself, including the agenda, participant list, and individual comments and observations of workshop participants during the small-group evaluation sessions and a design charrette, is presented as Appendix A to this report.

SECTION 3 moves beyond the workshop, presenting pilot project conceptual designs developed by the project technical team for three overarching techniques: wetland rehabilitation, sediment removal (dredging), and sediment sequestration of phosphorus with oxygenation/aeration. Briefly, the pilot project conceptual designs include the following:

Diffuse Source Treatment Wetlands (DSTWs)

Small (1 to 10s of acres), flow-through and terminal wetlands located along creeks and canals or in low-lying areas in fields within the Wood River and Sprague River valleys. These systems would require minimal earthwork, pumping, and infrastructure. A network of DSTWs would decrease external loading of phosphorus and nitrogen to Upper Klamath and Agency lakes and decrease resulting nuisance algal blooms in these waterbodies.

Large Wetlands

Large (10s to 1,000s of acres) wetlands on the margins of Upper Klamath and Agency lakes, along the Keno Impoundment, and along the Klamath Straits Drain. These systems would be designed to decrease external loading of phosphorus and nitrogen to Upper Klamath and Agency lakes and the Keno Impoundment and to provide habitat for the endangered shortnose and Lost River suckers.

Northwestern view of wetlands and fields adjacent to Upper Klamath Lake. Photo: David Garden.

Sediment Removal (Dredging)

Targeted dredging of a portion of Upper Klamath Lake just south of Goose Bay containing relatively high concentrations of phosphorus, thereby decreasing the potential for internal loading of phosphorus to the lake and subsequent nuisance algal blooms. Based on the results of pilot testing, dredged sediments would be re-deposited in adjacent areas targeted for wetland rehabilitation, as well as local agricultural areas that would benefit from subsidence reversal and soil amendment.

Sediment Sequestration of Phosphorus and Aeration/ Oxygenation

Buffered alum dosing and oxygenation in Lake Ewauna and the Keno Impoundment, predicated on the successful outcome of bench-scale water quality and toxicity tests. Alum micro-floc and oxygen would be injected into a pilot site in Lake Ewauna to reduce oxygen demand and sequester or inactivate phosphorus in the sediments and water column.

The pilot project conceptual designs described in Section 3 are "place based" to the degree possible, given available information. They are also intended to help fill information gaps related to the application of each project type in the basin. Several other creative ideas were discussed by workshop participants as possible contributors to improved water quality in the Upper Klamath Basin and, where relevant, these ideas have been incorporated into the conceptual designs. The

primary design elements presented herein represent a starting point, since full implementation would, in most cases, require additional knowledge gained from the pilot projects. If one or more of the conceptual designs were to be considered for implementation funding, further development of the design elements presented in Section 3 would be necessary.

SECTION 4 presents a discussion of anticipated benefits from linking short-term projects that treat the symptoms of poor water quality in the Upper Klamath Basin, to longer-term projects that treat the causes. Additional ideas generated at the workshop that require further development are also listed in Section 4, along with a set of ongoing research needs identified by workshop participants.

IN SUMMARY, no one project or technique can solve the basin-scale water quality problems affecting Upper Klamath Lake, its tributaries, and its primary downstream waterbody, the Klamath River. This report progresses from a summary of our current understanding of upper basin water quality problems to a set of linked projects to address those problems, acknowledging along the way that a fully feasible long-term solution requires a mosaic of techniques to provide conditions that support multiple beneficial uses. The conceptual nature of the pilot project designs also acknowledges gaps in our current understanding of how each of the project types would function in the unique setting of the Upper Klamath Basin.

Ultimately, linking multiple projects in space and time represents an exciting opportunity to improve water quality in the basin. By design, the workshop was focused on evaluating six specific techniques pre-selected by the project Steering Committee. However, there was widespread agreement among workshop participants that while these six techniques could be used to accelerate water quality improvements, they should be a complement, not a substitute, for a comprehensive watershed-based approach to address the root causes of excess phosphorus. Sustainable long-term improvements to water quality will require reductions in the amount of phosphorus that runs off land and is delivered to Upper Klamath Lake through its tributaries. With continuing education, outreach, and appropriate incentives for land owners and managers, the successful implementation of water quality improvement projects, such as the ones included in this report, can be accomplished in a way that supports local social norms and cultural traditions, and builds on the existing science, to substantially improve water quality in the Upper Klamath Basin.