

Chelan County Natural Resources Department  
Vulnerability and Habitat Suitability Analysis  
for Aquatic Invasive Species in Lake Chelan



**Work That Matters**

8.31.18 | Request for Qualifications





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August 31, 2018

Hillary Heard  
Natural Resource Specialist  
Chelan County Natural Resources Department  
411 Washington Street, Suite 201  
Wenatchee, WA 98801

**Subject:** SOQ for Vulnerability and Habitat Suitability Analysis for Aquatic Invasive Species (AIS) in Lake Chelan

Dear Ms. Heard:

Environmental Science Associates (ESA) is excited to submit our Statement of Qualifications (SOQ) for this project. In addition to ESA, the proposed project team brings AIS and water quality researchers from Tetra Tech, Inc. (Tetra Tech) and Portland State University (PSU). The core team members are recognized leaders in the development of scientifically sound survey methods for a number of AIS, the development of AIS management plans, and the implementation and oversight of control projects. We have worked collaboratively with diverse groups of stakeholders, including federal, state, local, and non-profit partners, to develop consensus-based management strategies for a number of western waterbodies.

ESA's proposed project manager and lead biologist is Dr. Toni Pennington, supported by Shannon Brattebo, PE (Tetra Tech) as the field lead, and Rich Miller (PSU) as the lead for education/outreach planning and the development of AIS surveying protocols. Relying on our experience working with AIS issues in a variety of aquatic ecosystems across the West, including lakes, reservoirs, and rivers, we strongly believe that emphasis on a high-level pathways analysis that would support a robust prevention program is the most prudent use of limited funds. Our project approach and suggested tasks are intended to demonstrate this emphasis on prevention and monitoring activities.

We appreciate your review of our SOQ and look forward to discussing this project with you. Please feel free to contact me at 971.295.5016 or [tpennington@esassoc.com](mailto:tpennington@esassoc.com) if you have any questions or need further clarification on anything we've proposed.

Thank you,

A handwritten signature in black ink, appearing to read 'Toni Pennington', with a stylized flourish at the end.

Toni Pennington, PhD  
Project Manager/Senior Aquatic Biologist



# Introduction



## Project Understanding

The impact of aquatic invasive species (AIS) on the ecology, economics, and aesthetics of water bodies across the U.S. has been well documented. In fact, costs of nearly \$0.5 billion annually to the greater Pacific Northwest region and Canada are estimated as a result of a dreissenid mussel invasion.<sup>1</sup>

Lake Chelan is popular for boating and fishing, and contributes to the aesthetic and tourism appeal of the communities of Chelan and Manson, Washington. The introduction of new AIS or substantial expansion of existing nuisance species could result in significant impacts to the region's economy and the ecological health of Lake Chelan. Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) are non-native aquatic plant species known to occur in Lake Chelan and are generally isolated to the Wapato Basin in the southern end of the Lake. Protecting and restoring this valuable resource from the impacts of AIS is a key mission of the Vulnerability and Habitat Suitability Analysis for AIS in Lake Chelan.

## Introduction to the Team

The team proposed for the Vulnerability Assessment and Habitat Suitability Analysis for AIS in Lake Chelan brings together scientists and researchers from Environmental Science Associates (ESA), Tetra Tech, Inc. (Tetra Tech) and Portland State University (PSU). Team members have a long history of working in a variety of aquatic ecosystems across the West including lakes, reservoirs, and rivers. The team has worked collaboratively with diverse groups of stakeholders, including federal, state, local, and non-profit partners, to develop consensus-based management strategies for these waterbodies.

The core team members are recognized leaders in the development of scientifically sound survey methods for a number of AIS, the development of AIS management plans, and the implementation and oversight of control projects. The project manager, Dr. Toni Pennington, has direct experience in the development of AIS management plans, conducting surveys and research, and providing education and outreach on both invasive plants and invertebrates. She has worked on previous, similar projects with both Shannon Brattebo, PE and Rich Miller, ensuring a cohesive and collaborative approach.

Resumes of key personnel and relevant project descriptions are provided in the following pages. ESA also has a full staff of biologists, permitting specialists, water resources engineers, and GIS experts for any additional tasks that may be needed.

<sup>1</sup>PSMFC (Pacific States Marine Fisheries Commission). 2015. Advancing a Regional Defense Against Dreissenid in the Pacific Northwest. A report prepared by the Pacific Northwest Economic Region and Pacific States Marine Fisheries Commission. Available: [http://www.pnwecr.org/uploads/2/3/2/9/23295822/advancing\\_a\\_regional\\_defense\\_against\\_dreissenids\\_in\\_the\\_pacific\\_northwestfinal.pdf](http://www.pnwecr.org/uploads/2/3/2/9/23295822/advancing_a_regional_defense_against_dreissenids_in_the_pacific_northwestfinal.pdf)

# Firm and Team Qualifications

## Environmental Science Associates

ESA is a professional services consulting firm specializing in environmental studies and engineering; planning and permitting; and landscape architecture. Founded in 1969, ESA is a 100% employee-owned corporation with 510 employees nationwide. We have been serving state, regional, and local agencies throughout Washington and Oregon for over 25 years from offices in Seattle, Portland, and Bend. ESA is pleased to have recently added Dr. Toni Pennington to our Northwest Region team to expand our aquatic biological services. Toni brings over 20 years of experience in aquatic biology, with extensive experience in the development of AIS management plans across multiple local, state, and federal agencies.

- Most notably, Toni was the lead author for the Lake Tahoe Region AIS Management Plan and its subsequent 5-year update.
- Toni is currently leading a project for Willamette Riverkeeper to develop an AIS Action Plan that will provide members of the Willamette Aquatic Invasives Network with guidance on sites and species to prioritize for AIS management to secure funding.
- In partnership with Tetra Tech and PSU, Toni is also the lead aquatic plant biologist for a survey of flowering rush in the Upper Columbia River.
- Toni is also the lead aquatic plant biologist for implementing the Seattle City Light Boundary Hydroelectric Project (FERC No. 2144) AIS Control and Prevention Plan and, in partnership with PSU, providing field support in surveying for other AIS species at the Boundary Project, including dreissenid mussels, New Zealand mudsnails, and Asian clams.

## Tetra Tech, Inc.

Tetra Tech is a multidisciplinary civil engineering, planning, applied sciences, and environmental services firm committed to providing growing communities with facilities and systems to improve the quality of life, protect public health and safety, and restore environmental quality. Tetra Tech was founded in 1966 and has over 17,000 employees and 330 offices worldwide.

Shannon Brattebo, PE, proposed field lead, brings 19 years of experience in a variety of water resources areas, including lake management, water quality monitoring and modeling, and integrated aquatic plant management.

- Shannon has been the project manager and principal field investigator for the Lake Spokane Nutrient Monitoring Program for Avista Utilities for the past nine years. Shannon also advises Avista staff on aquatic invasive plant species, including flowering rush, Eurasian watermilfoil, and curly-leaf pondweed, within Lake Spokane and the Spokane River.
- In partnership with ESA and PSU, Shannon is the current project manager and lead field staff for a survey of flowering rush in the Columbia River for Chelan County Noxious Weed Board.

## Center for Lakes and Reservoirs at Portland State University

The Center for Lakes and Reservoirs (CLR) was established by the Oregon State legislature to address lake management and invasive aquatic species issues in Oregon. The CLR is in the Environmental Science and Management Department at PSU, which has a major focus on watershed and aquatic ecosystem management. The proposed lead for Education/Outreach efforts, Rich Miller, brings 21 years of experience in aquatic resources including aquatic plant and animal surveys and identification, water quality study design, quality assurance and quality control implementation, data analysis, and public outreach and education.

- Rich has been conducting early detection monitoring for aquatic invasive plants and animals in waterbodies across the Pacific Northwest over the past four years.
- He has managed the U.S. Army Corps of Engineers (USACE) mussel veliger collection efforts in the Columbia River Basin over the past two years.
- Rich has led early detection surveys for AIS molluscs for the Boundary Hydroelectric Project (FERC No. 2144) AIS Control and Prevention Plan.
- Rich is managing and helped develop the Oregon Lake Watch Program; he has trained over 80 volunteers to survey, identify, and report high-priority invasive plants and animals.

## Toni Pennington, PhD | Project Manager, Senior Aquatic Biologist

Toni is a senior aquatic biologist with extensive experience in the management and research of aquatic plants; sampling and analysis plans for freshwater systems; AIS prevention and management programs; water quality data planning, collection, analysis; data QA/QC; identification of aquatic, wetland, and terrestrial plants; wetland delineations according to USACE guidance; and environmental documentation for large- and small-scale projects in aquatic and upland environments. Toni has worked closely with a variety of shareholders in multidisciplinary teams to implement science-driven solutions for a range of local to federal clients.

### Relevant Experience

**Lake Tahoe Region AIS Management Plan, NV and CA. Project Manager/ Technical Lead/Primary Author.** Toni led the development of a bi-state plan for preventing and managing AIS in the Tahoe Basin, including dreissenid mussels, aquatic plants, and warm water fishes. The plan was developed according to guidance provided by the Aquatic Nuisance Species Task Force and required considerable interaction with the Tahoe Regional Planning Agency, the states of California and Nevada, and numerous federal stakeholders and researchers in the Tahoe Region to identify plan goals, prioritize management actions, and synthesize AIS laws and regulations relevant to the Lake Tahoe Region. Toni was recognized by the client (USACE) for her role as project manager in keeping this complex project on schedule and delivering a product that met multi-stakeholder consensus.

**Lake Tapps Integrated Aquatic Vegetation Management Plan (IAVMP) and Implementation, Pierce County, WA. Lead Aquatic Plant Biologist.** Toni led the development of the Lake Tapps IAVMP based on Washington Department of Ecology's outline in "A Citizens' Manual for Developing Integrated Aquatic Vegetation Management Plans," (Gibbons et al. 1994). Since 2010, Toni has led lake surveys to estimate plant density, summarizing the pros and cons of various aquatic plant control methods and the applicability of each; participated in public meetings, identifying beneficial and recreational use; and made final recommendations for management of Eurasian watermilfoil.

**Eurasian Watermilfoil Control Strategies, Pend Oreille River, ID. Project Manager/Technical Lead.** In partnership with the US Army Engineer Research and Development Center, Toni was the technical lead for a demonstration project of how a granular formulation of the aquatic herbicide triclopyr moves through dense milfoil beds in flowing waters of the Pend Oreille River. Herbicide residual and an inert Rhodamine WT dye samples were collected while acoustic Doppler current profiler technology was simultaneously used to measure continuous, 3D velocity throughout the water column.

**Upper Columbia River Flowering Rush Surveys, Chelan County, WA. Lead Aquatic Plant Botanist.** Toni is surveying for flowering rush in the upper Columbia River. Given the geographic scope of the survey area, the approach is to first use an in-house GIS exercise to prioritize survey locations (e.g., shorelines with gradual slopes, backwater areas). Surveys were conducted in Lake Pateros in 2017 and work will continue in the Rock Island Pool in 2018. To date, flowering rush has not been identified in the target survey areas.



#### EDUCATION:

Ph.D., Environmental Sciences and Resources, Portland State University

M.S., Aquatic Biology, Texas State University at San Marcos

B.S., Environmental Biology, Fort Lewis College

#### CERTIFICATIONS:

PADI Open Water SCUBA Diver

Swiftwater Rescue

First Aid/CPR

#### AREAS OF EXPERTISE:

- Aquatic invasive species
- Aquatic plant management
- Water quality data monitoring, analysis, and QA/QC
- Leading field evaluation teams
- Limnological investigations
- Vegetation surveys

## Shannon Brattebo, PE | Field Lead

Shannon is an environmental engineer/limnologist with a broad range of interests and expertise. Shannon has 19 years of consulting experience during which she has participated in multiple water quality, limnological, water resources, environmental restoration, and watershed planning studies for local, state, and federal agencies. Her areas of expertise include lake and watershed management, lake restoration, nutrient modeling, water quality monitoring, stormwater water quality management, integrated aquatic plant management, river restoration, stormwater Best Management Practices (BMP) design, and flood damage assessments. Shannon has been the technical lead for Tetra Tech on several nutrient and lake management projects.

### Relevant Experience

**Upper Columbia River Flowering Rush Survey, Chelan County, WA.** *Lead Field Technician.* Tetra Tech was hired by the Chelan County Noxious Weed Control Board (CCNWCB) to conduct flowering rush (*Butomus umbellatus*) surveys in select areas of the Columbia River, including the Rock Island Pool (between Rock Island Dam and Rocky Reach Dam) and Lake Pateros (between Wells Dam and Chief Joseph Dam). Flowering rush is a Class A noxious weed in the State of Washington, meaning eradicating existing infestations and preventing new infestations are the higher priority. Surveys were conducted in roughly 56 miles of shoreline in August 2017. Shannon is the lead field technician for this project, directing field logistics and coordinating the survey plan with the team. Shannon is also responsible for identifying and recording all aquatic plant species observed during the survey and summarizing those observations in summary report. A survey of the Rock Island Pool is anticipated the summer of 2018.

**Lake Spokane Nutrient Monitoring, WA.** *Project Manager/Principal Field Investigator.* Tetra Tech is assisting Avista Utilities with their annual reporting requirements to Ecology and FERC and providing an assessment of water quality conditions within Lake Spokane and nutrient dynamics through 2017. Shannon is responsible for project coordination with Avista, coordinating field sampling events, collecting water quality samples and hydrolab profiles, collecting phytoplankton and zooplankton samples, and performing QA/QC on the resulting data. Shannon is also responsible for submitting deliverables such as field notes, hydrolab data, and a final report to Avista.

**Lake Ballinger Integrated Aquatic Vegetation Management Plan, Mountlake Terrace, WA.** *Project Manager/Technical Lead.* Tetra Tech is assisting the City of Mountlake Terrace and the Lake Ballinger Forum in developing an IAVMP for Lake Ballinger. The plan focuses on addressing the aquatic invasive plant species Eurasian watermilfoil (*Myriophyllum spicatum*), fragrant water lily (*Nymphaea*), and curly-leaf pondweed (*Potamogeton crispus*) which dominate the littoral plant community. Shannon is the project manager and technical lead for this project and is responsible for coordinating field logistics and overall project coordination. She is also responsible for leading community outreach and involvement efforts and producing fact sheets, presentations, and management option tables for distribution to the project steering committee, lake residents, forum members, and multiple city stakeholders.



#### EDUCATION:

M.S., Civil/Environmental Engineering,  
University of Washington

B.S., Civil/Environmental Engineering,  
Seattle University

#### CERTIFICATIONS:

Professional Engineer, Civil: ID #14135

Professional Engineer, Civil: SD #8740

#### AREAS OF EXPERTISE:

- Lake management
- Water quality monitoring
- Lake restoration
- Nutrient dynamics and assessment
- Aquatic invasive plants
- Watershed management
- Stream restoration
- Stormwater management



## Rich Miller | Education/Outreach Planning Lead

Rich is the lead research assistant for the CLR at PSU with 21 years of experience conducting aquatic monitoring, surveys, and research. His responsibilities at PSU include developing proposals and budgets, drafting quality assurance project plans for water quality data collection, limnological data collection, surveys for invasive aquatic plant and animals and species identification, laboratory sample analyses, database management, data analysis, drafting of technical reports, presentation of results and general information to scientific and general audiences. His duties also include participating in working groups, management of a water quality laboratory, scheduling and management of field work, crews and equipment usage, maintenance of field and laboratory equipment, tracking usage of vehicles and boats, management of the Atlas or Oregon Lakes, CLR, and Oregon Lake Watch websites. He also trains and manages citizen science volunteers.

### Relevant Experience

**Upper Columbia River Flowering Rush Survey, Chelan County, WA. *Technical Lead.*** Rich is leading a team providing flowering rush surveys in the Columbia River downstream from the Oregon/Washington border and upstream of McNary Dam. He has designed and conducted field surveys, managed field crews, identified aquatic plants, managed GIS data collection and databases, and drafted technical reports. His team was the first field crew to find flowering rush in Oregon. Rich is a member of the Flowering Rush Working Group which coordinates efforts to survey and treat flowering rush in the Columbia River.

**Aquatic Invasive Plant and Animal Surveys, Various locations in OR. *Technical Lead.*** Rich was the technical lead for aquatic invasive plant and animal species surveys in lakes, reservoirs and streams throughout Oregon for the Oregon Department of Agriculture, Bureau of Land Management, U.S. Forest Service (USFS), Portland General Electric, and PacifiCorp. He designed and conducted field surveys, identified aquatic plants, managed GIS data collection, managed databases, and drafted technical reports.

**Aquatic Plant Community Assessments, North Douglas Betterment, OR. *Technical Lead.*** For this project for the Department of Environmental Quality and the USFS, Rich was the technical lead for aquatic plant biomass assessments using grab sampling and hydroacoustic methods. He designed and implemented sampling schemes, generated bathymetric and plant coverage maps, and drafted summary reports.

**Oregon Lake Watch Program, Various Locations in OR. *Project Manager.*** Rich developed, implemented, and is managing a citizen-science program for the early detection of aquatic invasive plants and animals, and tracking of water quality conditions in Oregon's lakes and reservoirs. He is responsible for recruiting volunteers, training, managing data, and drafting reports.

***Dreissena spp.* Subcomponent for a CE-QUAL-W2 Water Quality Model. *Technical Lead.*** Rich developed a subcomponent of the CE-QUAL-W2 water quality model. Zebra mussel survivorship and growth were monitored in relation to water quality parameters with the intent of developing a model to simulate reservoir operations that would limit suitable habitat for zebra mussels due to anoxic water and desiccation at key points in mussel lifecycles.



**Portland  
State  
UNIVERSITY**

#### EDUCATION:

M.S., Environmental Science and Management, Portland State University (in progress)

B.S., Interdisciplinary Studies, Aquatic Systems Analysis, Humboldt State University

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#### AREAS OF EXPERTISE:

- Aquatic plant survey techniques and species identification
- Aquatic invasive species outreach and education

# Relevant Project Experience

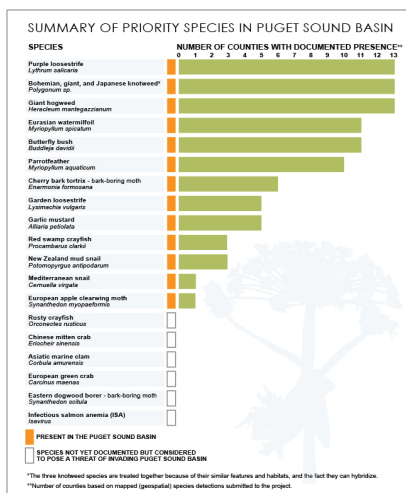


**CLIENT:** Chelan County Noxious Weed Board  
**LOCATION:** Upper Columbia River, WA  
**PERSONNEL INVOLVED:**  
 Toni Pennington  
 Shannon Brattebo  
 Rich Miller

## Upper Columbia River Flowering Rush Survey

Flowering rush (*Butomus umbellatus*) is known to occur in numerous northern states and most Canadian provinces. It is known to occur in Washington in the Columbia, Pend Oreille, Spokane, and Yakima rivers as well as isolated populations in Pierce and Whatcom counties. It is capable of growing in a wide variety of freshwater habitats including rivers, streams, backwater areas and lakes where it can grow to depths in excess of 20 feet and establish a monoculture that outcompetes other species. Flowering rush is a Class A noxious weed in the State of Washington, meaning eradicating existing infestations and preventing new infestations are the highest priority. It is also considered a priority species by the Washington Invasive Species Council and Prohibited by the Washington State Department of Agriculture. The purpose of this work is to survey for flowering rush in the Wells Pool portion of the upper Columbia River between Chief Joseph and Wells Dams and the Rock Island Pool, between Rock Island and Rocky Reach Dams.

Surveys were conducted summers of 2017 and 2018 by scanning the shoreline and nearshore areas of the reservoir pool from a boat piloted as close to the shoreline as possible. The boat operator visually surveyed the shoreline and also monitored the output of a BioBase sonar system. BioBase uses a Lowrance HDS depth finder with an additional StructureScan HD sonar to scan images of structures beneath the vessel. The survey crew stopped approximately every half river mile to collect submerged plants with a double-sided thatch rake. The location of each half river mile rake toss was recorded in a Trimble GPS unit as well as water depth, plant species present, plant density, and relative percent cover. Samples were also collected from pre-identified transect lines perpendicular to the shoreline or zig zag through the area. To date, no flowering rush has been found within the study area.



**CLIENT:** WISC  
**LOCATION:** Seattle, WA  
**FIRM INVOLVED:** ESA

## Puget Sound Invasive Species Baseline Assessment Phase II

ESA worked with the Washington Invasive Species Council, administered by Washington State Recreation and Conservation Office (RCO), to inventory and assess the presence, distribution and management actions for 15 priority invasive species and species groups in the Puget Sound basin. ESA and partners collected information from disparate sources for a more regional look at successes, gaps in efforts, gaps in information, and gaps in authorities. A database of information, species maps, and an online mapping tool was created and is provided as a resource through the Council's website. This phase of the project also involved the creation of mobile web applications for iPhone and Android devices to provide a mechanism for continual updated information. This Baseline Assessment will serve as an initial step towards a statewide, strategic response to the threat of invasive species.

## Water Quality QAPPs and Aquatic Invasive Species Control and Prevention Plan

Seattle City Light (SCL) was required to implement a water quality monitoring program in the 17.5-mile reservoir of its Boundary Hydroelectric Project (FERC Project No. 2144) on the Pend Oreille River in northeastern, Washington as part of their settlement agreement in the FERC relicensing process. Quality Assurance Project Plans (QAPPs) for SCL's four proposed water quality plans: 1) Aquatic Invasive Species Control & Prevention, 2) Dissolved Oxygen Attainment, 3) Fish Tissue Sampling, and 4) Temperature Attainment Plans were developed by Tetra Tech per the requirements described by the Washington Department of Ecology (Ecology).

Since approval of the Aquatic Invasive Species Control Prevention Plan, elements of the plan have been implemented by all members of the proposed project team. Specifically, for macrophytes: implementing suppression activities, mapping and verification, and effectiveness monitoring of control efforts; and for invertebrates: conducting surveys for other AIS including dreissenid mussels and New Zealand mudsnails across the entire Boundary Project from Box Canyon Dam to the Forebay Dam. Plankton tows collected from across the project area are analyzed for dreissenid veligers, substrate samplers are deployed across the Project to inspect for mussel colonization, and various substrates such as boat docks, booms, and bridge pilings are inspected for colonization.

## Lake Tahoe Aquatic Invasive Species Management Plan

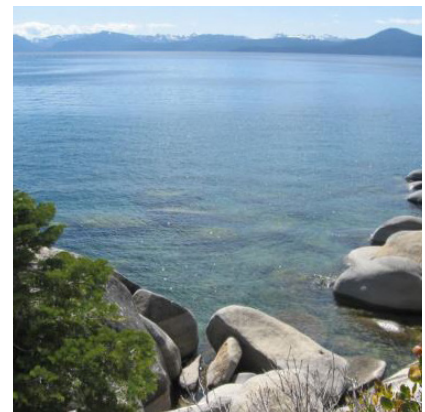
The AIS Management Plan is part of a multi-stakeholder collaborative effort supported by an interagency agreement between the USACE, Sacramento District and the California Tahoe Conservancy. Examples of AIS include aquatic plants (e.g. Eurasian watermilfoil), invertebrates (e.g. quagga mussels), and warm water fish (e.g. largemouth bass).

The purpose of the Plan is to minimize the deleterious effects of AIS in the Lake Tahoe Basin by: 1) preventing new introductions of AIS to the Tahoe Basin; 2) limiting the spread of existing AIS populations in the Tahoe Basin; and 3) abating harmful ecological, economic, social and public health impacts resulting from AIS. The team was responsible for coordinating with numerous regional, state, and federal stakeholder groups to achieve these goals.

Plan elements included: 1) summaries of existing and potential AIS, current and potential management strategies, introduction pathways, and existing programs and regulations; 2) an analysis of economic impacts; 3) facilitation of stakeholder discussions to identify lead entities for implementing management actions; and 4) coordinating with the Aquatic Nuisance Species Task Force (ANSTF) to facilitate Plan approval. The ANSTF is an intergovernmental organization responsible for implementing mandates under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990.



**CLIENT:** Seattle City Light  
**LOCATION:** Pend Oreille County, WA  
**PERSONNEL INVOLVED:**  
 Toni Pennington  
 Shannon Brattebo  
 Rich Miller



**CLIENT:** USACE, Sacramento District  
**LOCATION:** Stateline, NV  
**PERSONNEL INVOLVED:**  
 Toni Pennington

## Lake Spokane Nutrient Monitoring

Long Lake Dam, which is owned and operated by Avista Utilities, creates a reservoir, Lake Spokane, in a 23-mile stretch of the Spokane River. Portions of the river, including Lake Spokane, have seasonal levels of dissolved oxygen that do not meet Washington State’s water quality standards. Ecology has been working to address these impairments through the development of a water quality improvement plan or Total Maximum Daily Load (TMDL).

Ecology conducted a two-year baseline sample collection effort in Lake Spokane in order to gather more up-to-date data to verify the baseline condition recorded and modeled in 2001 and/or to account for any changes that may have taken place in Lake Spokane within the last 10 years. Avista assisted Ecology in their data collection efforts by performing one sampling event each month, from June - September, in 2010 and 2011. Tetra Tech was hired by Avista to perform this monthly monitoring on Lake Spokane.

Under a 50-year FERC license for the Long Lake Dam, Avista (with field support from Tetra Tech) implemented a Dissolved Oxygen Water Quality Attainment Plan (DO WQAP) to monitor the lake. As part of this effort, monthly water samples and field measurement profiles were collected once per month during June through September in both 2010 and 2011 at six locations on Lake Spokane. From 2012 - 2017, team members collected water samples, field measurements, phytoplankton, and zooplankton samples twice per month during June - September, and once per month May - October at the same six monitoring locations. All samples were collected according to Ecology’s Quality Assurance Project Plan with approved revisions made by Avista and Tetra Tech in 2012, followed by annual monitoring summaries and a detailed assessment of water quality conditions in Lake Spokane. These include long-term climatic and water quality trends, as well as lake response to further reduced inflowing nutrient concentrations. Water quality monitoring continues through 2018.



**CLIENT:** Avista Utilities  
**LOCATION:** Lake Spokane, WA  
**PERSONNEL INVOLVED:**  
Shannon Brattebo

## Oregon Lake Watch Program

PSU developed volunteer protocols for monitoring water quality and surveying for aquatic invasive plants and animals in freshwater lakes in Oregon. This program is organized by the CLR at PSU with funding from the Oregon State Marine Board’s sale of Aquatic Invasive Species Permits and the Oregon State Weed Board grant program. The goals of the program are early detection of AIS, collection of long-term water quality data, and encouraging appreciation of Oregon’s many natural lakes and multi-use reservoirs. Since 2014, Rich has trained over 80 volunteers to identify and survey for high-impact aquatic invasive plants and animals across Oregon.

## Aquatic Invasion Plant Early Detection Monitoring

In partnership with the Oregon Department of Agriculture, PSU has developed survey methods and conducted surveys targeted at species such as flowering rush in the Columbia River, variable leaf watermilfoil in Oregon coastal lakes, and water primrose in Willamette River side channels. PSU has also provided species identification for project partners and the public.



**LOCATION:** Various Locations in OR  
**PERSONNEL INVOLVED:** Rich Miller

# Project Understanding & Approach



ESA team member surveying aquatic plants during a habitat assessment in the Upper Tualatin River basin for Clean Water Services (left). To the right: New Zealand mudsnails (*Potamopyrgus antipodarum*) at Devils Lake, Oregon.

## Prevention is the Key

The concentration of water column calcium has routinely been used as a benchmark for assessing the potential of a waterbody to support all life stages of zebra/quagga mussels<sup>2</sup>. Oligotrophic Lake Tahoe was once considered “low risk” for establishment based on low calcium levels (site dependent, but generally <10 ppm)<sup>2</sup>; however, more recent research on the survival of mussels in water collected from Lake Tahoe suggests otherwise<sup>3</sup>. Additionally, “hotspots” such as concrete boat ramps, tributaries, and groundwater inputs, have been anecdotally attributed to mussel survivorship in otherwise low-calcium waters<sup>4</sup>.

Given the proximity of other invasive species near Lake Chelan, the known presence of two invasive plants and Asian clams in the lake, and the extensive recreational use of Lake Chelan, our proposed approach is to focus efforts to prevent new AIS introductions to Lake Chelan; making the assumption that habitat conditions are conducive to additional AIS. Based on our experience working in numerous waterbodies threatened by AIS, focusing on the suitability of habitat may not be the best use of limited funds.

→ For example, though it is assumed that calcium levels in Lake Chelan are insufficient to support all life stages of zebra/quagga mussels, there is a high degree of uncertainty of how other factors such as food availability, temperature, dissolved oxygen, and pH, often associated with microhabitats (e.g.,

tributary inputs) factor into supporting populations. Additionally, if prevention efforts are presented in a broad clear message, implemented, and enforced, then prevention is presumably effective against multiple species; “clean, drain, dry” if applied correctly, limits the spread of numerous AIS.

Prevention is widely recognized as the first line of defense and most cost-effective measure to protect aquatic ecosystems from the impacts of AIS; however, responding to new and expanding populations is more common. The use of available information on habitat conditions, water quality, recreational use, and bathymetry would be used to develop pathway analyses to target prevention and monitoring efforts for Lake Chelan; reducing within lake spread as well as new AIS introductions.

→ For example, developing routine sampling protocols for eDNA, identifying the most effective locations for boat inspection stations, and developing approaches to work with local marinas to monitor/inspect boats.



<sup>2</sup>Whittier, T.R., P.L. Ringold, A.T. Herlihy, and S.M. Pierson. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena* spp.). *Frontiers in Ecology* 6: 180-184.

<sup>3</sup>Davis, C.J., E.K. Ruhmann, K. Acharya, S. Chandra, and C.L. Jerde. 2015. Successful survival, growth, and reproductive potential of quagga mussels in low calcium water: is there uncertainty of establishment risk? *PeerJ*, Inc., doi: 10.7717/peerj.1276. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4636400/#ref-3>

<sup>4</sup>Wimbush et al. (2009) Wimbush J, Frischer ME, Zarzynski JW, Nierzwicki-Bauer SA. Eradication of colonizing populations of zebra mussels (*Dreissena polymorpha*) by early detection and SCUBA removal. Vol. 19. *Lake George: Aquatic Conservation: Marine and Freshwater Ecosystems*; 2009. pp. 703–713.

# Tasks, Assumptions, and Budget

Given the uncertainty of available data, developing a comprehensive list of tasks and associated budgets is challenging. Based on the general project approach outlined above, the following tasks, assumptions, and estimated budgets are presented, followed by recommendations for additional work when additional data and funding are available. *Note: The budget for each task is not intended to be a final estimate and would be further refined once a work plan is developed.*

PRIMARY TASKS			
Task	Description/Assumption	Deliverable(s)	Est. Budget
1. Identify available data and gaps	Identify available information on: <ul style="list-style-type: none"> <li>• Recreational use (types of watercraft, point of origin, numbers)</li> <li>• Boat inspection data from Lake Chelan and other lakes in the region</li> <li>• Known established AIS in Lake Chelan</li> <li>• AIS in nearby waterbodies</li> <li>• Substrate types</li> <li>• Water quality data</li> </ul>	<ul style="list-style-type: none"> <li>• Results summarized in narrative and in tables with recommendations for data needs</li> </ul>	\$6,500
2. Develop pathway analysis	<ul style="list-style-type: none"> <li>• Based on available data, identify vulnerable points of entry for AIS (e.g., location and usage of boat launches, popular shoreline fishing points, etc.) and species of greatest concern for introduction</li> </ul>	<ul style="list-style-type: none"> <li>• Results summarized in narrative and in tables with recommendations for increased prevention measures (e.g., boat cleaning stations, mandatory boat inspections, messaging, etc.)</li> </ul>	\$6,500
3. Conduct boater survey	<ul style="list-style-type: none"> <li>• If boat usage information is insufficient for the pathways analysis, an onsite survey that includes point of origin, type of vessel, time between waterbodies, etc. is recommended</li> <li>• Assumes this effort will not be conducted by the proposed project team, but by Chelan County staff to reduce expenses</li> </ul>	<ul style="list-style-type: none"> <li>• Develop questionnaire, compile results in graphical and tabular formats</li> <li>• Integrate results into the pathways analysis</li> </ul>	\$8,000
4. Messaging	<ul style="list-style-type: none"> <li>• Assist the County in developing and conveying appropriate messaging to lake users; for example, signage in marinas, inspection trainings, and citizen scientist training to monitor for AIS</li> <li>• Assumes one site visit/tour with staff knowledgeable about recreational use at Lake Chelan</li> </ul>	<ul style="list-style-type: none"> <li>• Recommendations for the most appropriate education and outreach materials for Lake Chelan</li> </ul>	\$5,000
5. Develop plans for AIS and water quality/habitat monitoring	<ul style="list-style-type: none"> <li>• Develop AIS monitoring protocols that are reproducible and defensible; adapting and incorporating rapid response protocols from accepted sources (e.g., <i>Washington Dreissenid Mussel Rapid Response Plan</i>)</li> <li>• Additional water quality data may be needed if sufficient information is not available to support the pathways analysis</li> <li>• Important water quality parameters and habitat features would be collected from key locations around the lake (e.g., tributaries, boat launches, known septic inputs, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>• Develop a sampling plan and quality assurance project plan</li> </ul>	\$10,000

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## Tasks, Assumptions, and Budget, Continued

FOLLOW-ON TASKS			
Task	Description/Assumption	Deliverable(s)	Est. Budget
6. Identify specific locations for boat inspections and/or washing	<ul style="list-style-type: none"> <li>Depending on the outcome of the Pathways Analysis, provide recommendations for additional boat washing and/or inspection stations</li> <li>If unknown, information on access, power, water, and disposal would be needed</li> <li>Assumes in-person site visit</li> </ul>	<ul style="list-style-type: none"> <li>Results summarized in narrative and in tables with recommendations for boat inspections and/or washing stations</li> </ul>	<ul style="list-style-type: none"> <li>TBD</li> </ul>
7. AIS monitoring	<ul style="list-style-type: none"> <li>Implement AIS and water quality/habitat monitoring</li> <li>Assumes three sample events per year conducted by the consultant</li> <li>Costs could be significantly reduced if consultant trained County staff</li> </ul>	<ul style="list-style-type: none"> <li>Implement AIS monitoring plan</li> <li>Frequent meetings with County staff</li> <li>Annual report</li> <li>Update monitoring</li> </ul>	<ul style="list-style-type: none"> <li>TBD</li> </ul>

## References

Contact Name	Contact Information	Project
<b>Mike Mackey</b> <i>Chelan County Noxious Weed Manager</i>	Chelan County Noxious Weed Board  412 Washington Street Wenatchee, WA 98801 509.667.6550 mike.mackey@co.chehalan.wa.us	Upper Columbia River Flowering Rush Survey
<b>Dennis Zabaglo</b> <i>Aquatic Resources Program Manager/Principal Environmental Specialist</i>	Tahoe Regional Planning Agency  PO Box 5310 Stateline, NV 89449 775.589.5255 dzabaglo@trpa.org	Lake Tahoe Aquatic Invasive Species Management Plan
<b>Henry Chen</b> <i>Capital Projects Director</i>	Cascade Water Alliance  520 112th Avenue NE, Suite 400 Bellevue, WA 98004 425.283.0367 hchen@cascadewater.org	Lake Tapps Integrated Aquatic Vegetation Management Plan and Implementation
<b>Christine Pratt</b> <i>Senior Environmental Analyst</i>	Seattle City Light  700 5th Avenue, Suite 300 Seattle, WA 98124-4023 206.386.4571 Christine.pratt@seattle.gov	Water Quality QAPPs and Aquatic Invasive Species Control and Prevention Plan