

**REVISED PROPOSAL TO DESIGN AN AERATION-MIXING  
SYSTEM TO REDUCE BLUE-GREEN ALGAL  
(CYANOBACTERIAL) BLOOMS IN DEVILS LAKE, OREGON**

**Proposal for the Devils Lake Water Improvement District**

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**Total Amount: \$99,500**

Date: Revised: 2 February 2016

# **REDUCTION OF BLUE-GREEN ALGAL (CYANOBACTERIAL) BLOOMS IN DEVILS LAKE, OREGON**

## **Background: eutrophication**

Devils Lake, Oregon is a shallow, eutrophic lake covering about 685 acres. It is managed by the Devils Lake Water Improvement District (DLWID). Although close to the Pacific Ocean a small hill shelters it from ocean breezes so it is somewhat warmer and more suitable for water-based recreation than its location predicts. The area has been occupied for over 100 years, first in farming and logging and then recreational use of the area. The resultant land disturbance and wastewater inflows have caused cultural eutrophication defined by an increased the nutrient supply to the lake. Eutrophic waters are characterized by low dissolved oxygen in deeper waters, low water clarity and extensive nuisance algae blooms, particularly blue-green algae (Cyanobacteria). Devils Lake is not used for drinking water but blue-green blooms can form concentrated harmful aquatic blooms (CHABs) which can kill domestic animals if they drink the water and may indirectly cause problems for water contact use. Excess algae blooms die and sink where they decompose and use up oxygen in the bottom waters, causing problems for fish such as salmon which migrate through the lake from the nearby ocean. In addition, anoxic bottom water can produce foul odors in late summer and the fall.

Given the lake's history and bathymetry there are likely two main nutrient sources for algal growth; legacy nutrients in the sediments and nutrients flowing into the lake between spring and fall.

*Internal loading* occurs in the lake's deeper areas (15-22 feet). When these become anoxic in summer they release phosphate, iron and ammonia that reach the surface waters and stimulate algal blooms. There are also extensive shallow area, especially at the southern outlet end that were formerly covered with submerged aquatic vegetation (SAV) which are now mostly absent due to grazing by grass carp. These fish contribute to internal loading by rapidly recycling nutrients that would otherwise be retained in the SAV. Some increase in SAV would be useful but too much can interfere with boating and swimming so full restoration of the original SAV coverage is neither planned nor desirable.

*External loading* in the immediate lake drainage comes from the septic tanks feeding the shallow groundwater and inflowing streams. Much of the domestic wastewater is diverted, treated and discharged to the ocean but there are still active septic tanks close to the shore and some streams bring nutrients into the lake during the algal growth season. More wastewater treatment is planned but effects on the lake will take at least a decade due to buildup of septic tank leach field nutrients in the soils.

## **Possible solutions for CHABs**

There are 5 watershed and 17 in-lake methods for lake restoration. There are sufficient water quality data in the DLWID files to determine which of the available methods for lake restoration are possible. The Devils Lake Water Improvement District (DLWID) has informally reviewed most of these methods and concluded that some form of oxygenation, aeration or a blend of these

methods is the most likely method for Devils Lake. Preliminary discussion between Alex Horne and Paul Robertson in April supported a blend of a conventional aeration-oxygenation system in the deeper water along with Vigorous Epilimnetic Mixing (VEM) in the shallower areas. The Achilles Heel of blue-green algae is their intolerance to lake mixing. This is why they are common in warm, thermally-stratified waters and rare in cool well-mixed ones. This proposal will review the 17+5 available methods to check that aeration-VEM is the appropriate choice. The proposal will then prepare a bid document to install an aeration-oxygenation system. It will include much of the initial design of an aeration-VEM system, the location and size of the compressors and piping. It will also cover the permitting of the project including project management, permitting and land use services, civil and electrical-mechanical design, project specification and bidding documents. This proposal does not include assistance with selection of the bidder.

### **Administration**

Alex Horne will work with all interested parties to specify the conceptual design and rationale for the project. HBH Consulting Engineers will be a subcontractor providing the bulk of the the required Oregon Certified Engineering work as well as the other civil services needed. Ken O'Hara working with Richard Steele at billing via Atmos will work directly with AHA to produce required design specs and drawings to submit to HBH for approval or any further modification needed based on their local experience. Costs for projects with several groups can be increased if each is processed through a central prime contractor. To reduce such costs, it is proposed that AHA and HBH submit invoices directly to DLWID. AHA will check and attach the Atmos invoices as part of AHA invoices with no added fee. The project is quite small and Paul Robertson is experienced in most aspects of the project and will work with HBH and AHA to smooth meetings with the regulators and local planning agencies that can eat up consulting time. Other contracting arrangements are possible if desired by DLWID.

#### **BUDGET** (more details of the HBH items see separate attachment)

<b>Task description</b>	<b>Consultant</b>	<b>Cost \$</b>
<b>AHA</b>		
Review data, determine methods to be used	AHA	3,000
Conceptual design of system, initial layout	AHA	9,000
Preparation of drawings to CAD scale, specification of pipes, compressors, regulators, diffusers size & shape	AHA-Atmos	10,000
<i>Sub-total AHA</i>	AHA-Atmos	<i>22,000</i>
<b>HBH</b>		
Project management	HBH	1,600
Permitting services	HBH	10,800
Survey services	HBH	7,500
Civil Design Services	HBH	27,500
Electrical-mechanical design services	HBH	7,800
Project Specs & bidding docs	HBH	14,900
Bid assistance services	HBH	5,400
Reimbursables	HBH	2,000
<i>Sub-total HBH</i>	<i>HBH</i>	<i>77,500</i>
<b>Overall TOTAL</b>	<b>All</b>	<b>99,500</b>

## Other information

**Expected method of operation.** Professor Horne will examine the data, continue cooperation with Paul Robertson and Dr. Ken O'Hara, make recommendations and provide the initial conceptual design. Dr. Ken O'Hara who has extensive experience of aeration installation in lakes and VEM in Europe and the USA will take that design and specify the kinds of hose, diffusers, regulators, pumps and other connections needed. Atmos will turn those into the kind of CAD designs needed for a bid document. HBH will then take that information, check it and modify as needed in consultation with the other contractors and incorporate it into a final bid document.

**Alex Horne Associates** (AHA) is a small consulting company founded in 1971 and based in the San Francisco Bay Area. AHA has carried out almost 400 projects ranging from lake and reservoir restoration, treatment wetlands design and heavy metal and organic pollution. Though generally working as a sub-contractor to larger consulting firms AHA often works as a prime contractor with local, federal and international government agencies and private individuals. AHA has a Federal Tax ID # 68-0077282. AHA carries errors & omissions insurance (Hartford). Billing will be monthly following work done. [anywaters@comcast.net](mailto:anywaters@comcast.net); 510-525-4433.

**Atmos** is a small consulting company registered in the UK and works closely with and provides CAD design and other services for Dr. Ken O'Hara, the co-inventor (with Dr. Horne) of the VEM technology expected to be recommended for Devils Lake. Richard Steele is the Technical Director ([www.atmosconsulting.com](http://www.atmosconsulting.com), [E\\_richard.steele@atmosconsulting.com](mailto:E_richard.steele@atmosconsulting.com); 01144-1352748256). Mr. Steele has worked with Dr. Horne and Dr. O'Hara on reservoir aeration and wetlands projects. Atmos costs will be billed via AHA with no added admin costs.

**HBH** is a mid-sized multi-disciplinary firm based in Newberg, Oregon that works on a variety of public and private projects. HBH provides quality, economical engineering services to clients throughout the Pacific Northwest. Billing policy is shown in the attached HBH documents.

**Field Work.** Dr. Horne has already spent a full day with Paul Robertson on the lake and its surroundings and has examined much of the available water quality data so only one further trip to the lake is envisaged in this budget. HBH is close to the lake and will make numerous trips for meetings with wildlife agencies, surveying and planning and is budgeted above.

**Disclosures.** *Dr. Ken O'Hara* is the patent holder of the regulators that will probably be needed to make the VEM-aeration system work in a large water body like Devils Lake. He will thus receive financial compensation if the diffusers are used in the final installation. The situation is similar to the Speece Cone oxygenation method where Prof. Dick Speece holds a patent. *Alex Horne* has no financial or other interests in any of the consultants or likely suppliers of equipment for Devils Lake. As an independent consultant he has, when appropriate, recommended most of the consultants and suppliers in the field of lake, reservoir, river, estuary and ocean mixing and oxidation.

**Memo to:** Paul Robertson, MSc, Lake Manager, Devils Lake Water Improvement District  
Lincoln City, Oregon

**From:** Alex Horne, Alex Horne Associates (AHA) Consultant, El Cerrito CA

**Re:** Revised project for water quality improvement in the lake: 2 stages and a stop work clause

**Date:** 19 January 2016

**SUMMARY.** The proposed work will be in two phases; an initial survey of possible management methods and a second preliminary design phase. In the second phase the DLWID will have the ability to stop the project at any time.

**Phase One: 17 + 5 methods review and recommendations.** This will be the analysis of the 17 in-lake methods and 5 watershed methods for lake management. Since, the exact purpose of the other consultant HBH will depend on the outcome of this stage, it must come first for AHA and before work starts with HBH. I propose to use no more than \$3,000 from my budget for this first stage (as listed in the July 2015 revised proposal). As you know it is likely that some form of aeration-oxygenation-mixing is a strong candidate for final selection for Devils Lake but some other option or mix of options are still possible. The work required of HBH would not change too much for most likely options since their work is on-shore as well as underwater construction design and the HBH scope could be modified if needed.

**Work Product from phase one.** A short report on the lake's algae problems based on the available literature will lead to the following **for the lake:**

1. A short table stating the problem(s) with primary and secondary causes in the lake
2. A long table of the 17 in-lake methods of management, the applicability of each one for Devils Lake, and a recommendation for use as a yes, no, maybe or limited classification
3. A bullet list of the yes, maybe or limited classes with further discussion and a final recommendation to proceed or not for each method.
4. A second shorter bullet list of in-lake method(s) based on # 3 and recommended for consideration by the Devils Lake BOD and the lake manager.

**For the watershed:**

5. A short table stating the problem(s) with primary and secondary causes in the watershed
6. A short table of the 5 watershed methods of management, the applicability of each one for Devils Lake, and a recommendation for use as a yes, no, maybe or limited classification
7. A bullet list of the yes, maybe or limited classes with further discussion and a final recommendation to proceed or not for each option.
8. A second shorter bullet list of watershed method(s) based on # 7 and recommended for consideration by the Devils Lake BOD and the lake manager.

After the consideration by the BOD and Lake Manager, a final choice(s) can be made and the rest of the Alex Horne (AHA) and HBH contracts can be started.

**Phase two: preliminary system design.** Once the method (e.g. VEM, aeration, alum, dredging, HOS etc) or method combination (e.g. VEM + conventional aeration), is selected in phase 1, then the initial design of the system can begin in phase 2. The work product will be a series of drawings of locations of the system with details of the pipe size, length, type of diffusers and regulators

(where needed), and compressor requirements as discussed in the full contract. This work will be carried out by a combination of AHA and Atmos (Dr. O’Hara). Once the preliminary design is complete it will be passed on to HBH who will review the preliminary design, use their experience with aeration and local codes and supplies to suggest any changes. HBH will also add the on-shore section (permits, pump housing, electricity etc. – see their contract) so that the final document will can be put out to bid by a contractor. During all stages AHA, Atmos and HBH will be in contact with documents passed back and forth as needed to make the process most efficient.

Stop work clause. During phase 2 the project can be stopped at any time by the DLWID with an obligation only to pay for work that had been completed by AHA & Atmos up to that date (HBH are not included in this agreement but will make a separate agreement). Termination or delay of the project at any time will be made by the DLWID in writing or by email.

*Alex J. Horne*

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