

**Klamath River Hydroelectric Project**  
**Interim Measures Implementation Committee:**  
**Interim Measure 11**

**Link River Algae Removal Demonstration**

**Project:**

**Phase 1 Final Report**

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**Attachment A:** Link River Algae Removal Demonstration Project: Conceptual Project Description



# 1 Introduction

The Klamath Hydroelectric Settlement Agreement (KHSA; as amended on April 6, 2016) includes Interim Measure 11 (Interim Water Quality Improvements), which is intended to address water quality improvement in the Klamath River during the interim period leading up to potential dam removal by a designated Dam Removal Entity (DRE). Regarding Interim Measure 11, the KHSA states “The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir.” Interim Measure 11 calls for PacifiCorp to fund such projects in consultation with the Interim Measures Implementation Committee<sup>1</sup> (IMIC).

Interim Measure 11 activities during the 2016-2017 period include the *Link River Algae Removal Demonstration Project*. This project is follow-up to an initial assessment of potential algae harvesting and removal at Link River dam that was completed in early 2016.<sup>2</sup> The initial assessment indicated that it would likely be feasible to build an algae removal system, but that the system could face some hurdles with regard to regulatory approvals (e.g., Endangered Species Act, water rights, and other permits) and proper disposal of resulting harvested algae material. To further assess feasibility of an algae removal system, including design and permitting needs, a demonstration (i.e., pilot) project that could be located near Link River dam was proposed by IMIC members.

The overall Demonstration Project is to be conducted in four phases:

- Phase 1: Conceptual project description; regulatory permitting and approvals assessment; disposal needs assessment
- Phase 2: Pilot design and cost estimate; operational plan and cost estimate; permit and regulatory approvals applications; algae composting and disposal study plan; monitoring plan
- Phase 3: Final regulatory approvals; contractor selection; pilot facility fabrication and installation
- Phase 4: Operations of pilot facility; algae disposal study; monitoring, analysis, and reporting

As this four-phase process unfolds, it is possible that a fatal flaw might emerge that precludes implementation of the Demonstration Project. The risk associated with any such flaws are reduced by breaking the Demonstration Project down into the phases outlined above. At the conclusion of the Demonstration Project, analysis of monitoring data along with review of actual operational costs should allow a decision regarding the feasibility of a full-scale facility and development of design for that facility, if appropriate.

This report describes the results of Phase 1 tasks, including: (1) development of descriptions of the proposed demonstration project concept, technology, and system location; (2) results of discussions with key regulatory agencies to determine permitting requirements and likely timelines for approvals; and (3) determination of potential options for use and disposal of harvested algae material.

## 2 Conceptual Description of the Demonstration Project

As the first task of Phase 1, a conceptual description of the proposed demonstration project was prepared. The conceptual description summarizes what is currently known or proposed regarding: (1) the algae harvest,

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<sup>1</sup> The IMIC is comprised of representatives from PacifiCorp and other parties to the KHSA (as amended on April 6, 2016). The purpose of the IMIC is to collaborate with PacifiCorp on ecological and other issues related to the implementation of the Non-Interim Conservation Plan Interim Measures set forth in Appendix D of the amended KHSA.

<sup>2</sup> For details see: CH2M. 2016. Interim Measure 11, Activity 7 – Assessment of Potential Algae Harvesting and Removal Techniques at Link River Dam. Technical Memorandum prepared for PacifiCorp. 66 pp. Available online at: <http://www.pacificorp.com/es/hydro/hl/kr.html#>.

collection, and transport techniques; (2) anticipated Demonstration Project facilities locations; (3) proposed construction and operations and maintenance activities; (4) screen sizes and approach water velocities; and (5) water pumping (screening) and water loss (that amount remaining in the wet algae that is not returned to the river) rates. The conceptual description served as the basic introductory material to inform discussions with IMIC members, regulatory agency representatives, and other stakeholders. These discussions formed the information gathering effort necessary to complete the Phase 1 assessment of the Demonstration Project as outlined above. The conceptual description was distributed to the IMIC by PacifiCorp via email on March 14, 2017 and is provided in Attachment A. Key highlights of the conceptual description are described below.

## 2.1 Location

The Demonstration Project facilities are proposed to be located between the A Canal intake and Link River dam, downstream of the log boom at Link River dam (Figure 1). This general location provides some advantages, including: (1) ease of access; (2) close proximity to power sources and post-processing facilities; (3) being at the terminal end of Upper Klamath Lake where algae removal can have greatest effects on downriver water quality; and (4) being in a more riverine-like channel environment where water velocities are higher (than upstream in the lake proper), allowing more effective operation of the proposed screening system (as described further below).



Figure 1. Proposed Link River Algae Removal Demonstration Project facilities location and layout.

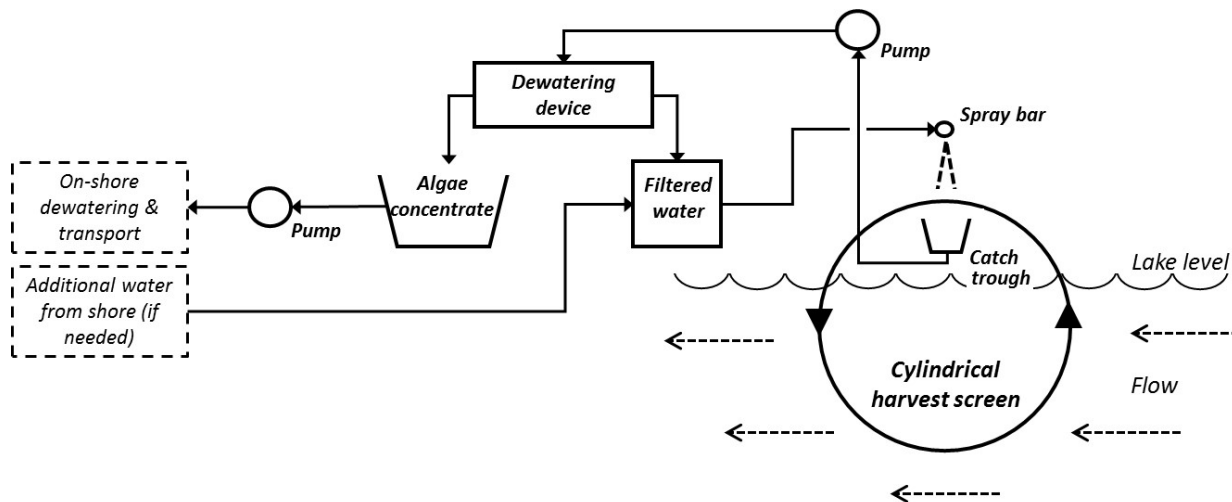
## 2.2 Proposed Demonstration Project Facilities and Operations

The Demonstration Project facilities will be designed, constructed, and operated by the New Algae Company (NAC) of Klamath Falls, Oregon. Additional information on NAC is provided in Attachment A. Demonstration project facilities will include an algae harvesting system that consists of up to three rotating cylindrical harvest screens arranged in a linear formation perpendicular to the water current (Figure 1). Each cylindrical harvest screen will be 5 to 6 feet (ft) in diameter and 16 ft long, resulting in a total horizontal length of 48 ft (i.e., up to 3 screens of 16 ft long each). The rotating cylindrical harvest screens will be held in place via cables anchored on the adjacent shorelines or the lake bottom.

Each cylindrical harvest screen will be wrapped in stainless steel screen with a screen opening of 0.14 inch. The submerged screened area in the flow of water will be about 4 ft deep. The cylinders will rotate at about 2-4 revolutions per minute (RPM) powered by a submersible variable-speed electric motor. As water from upstream encounters the screens, algae material will collect on the rotating screen surfaces. As this accumulation occurs, the screen mesh openings will progressively narrow (i.e., become narrowed to less than the effective 0.14-inch opening size), which will further reduce or retard the amount of flow that penetrates through the screens even as algae material continues to accumulate on the rotating screen surfaces. The narrow mesh and flow retardation should prevent or minimize impingement or entrainment of fish and larger debris on the screens, and instead allow fish and larger debris to go under or around the harvest screen.

Over the top of the cylindrical harvest screens, a set of nozzles mounted on a spray bar will spray water directly down at the harvest screen perpendicular to the mesh (Figure 2). This spray will cause the accumulated algae material to be washed through the screen and into a catch trough for collection on the inside of the cylinder (Figure 2). Material larger than the screen mesh opening will be returned back to the river on the downstream side of the cylindrical harvest screens.

The algae material that is collected into the catch trough will be an algae/water mixture that will be pumped into a mechanical dewatering device located in the channel adjacent to the screens (Figure 2). This dewatering device will remove excess water from the algae/water mixture and concentrate the algae material into a thicker slurry (consisting of 1 percent solids and 99 percent water). The excess water removed by the dewatering device will be collected and filtered in a separate box (i.e., filtered water box shown in Figure 2) for use in supplying water for the spray bar (as described above). Operation of the spray bar will require water supplied at a rate of about 5 to 15 gallons per minute (gpm). The excess water removed from the dewatering unit (and supplied from the filtered water box) might not be sufficient to provide the full rate amount needed for the spray bar. If so, additional water from another source, such as a shore-side well or municipal water supply, may be needed to augment the rate needed for the spray bar.



**Figure 2. Conceptual schematic of Proposed Link River Algae Removal Demonstration Project facilities set-up.**

From the dewatering device, the concentrated algae slurry will be collected in a trough and then pumped to shore via a 2-inch hose (i.e., algae concentrate box and pump shown in Figure 2). The algae concentrate that is pumped to shore will undergo additional dewatering using mechanical dewatering equipment installed in semi-truck trailers placed in the gravel parking area on the east shore (Figure 1). This dewatering equipment will further remove lake water from the algae concentrate to produce a thicker paste consisting of 5 to 8

percent solids and 92 to 95 percent water. The water removed in this dewatering step would be returned (via a 1½-inch hose) to the river directly, or used to augment the spray bar (as described above), if needed. The more-concentrated algae paste would then be pumped into a tanker truck and hauled off-site for use or disposal (as described further below). If the algae paste is determined by NAC to be of acceptable quality for food and supplement use (e.g., the desired *Aphanizomenon flos-aquae* [*Aphanizomenon*] content is present, and potential algal toxins are absent or otherwise within safe levels), a cooling/refrigeration step may be added before loading the material into the tanker truck.

The cylindrical harvest screens and associated harvesting process features (Figure 2) will be constructed off-site in component parts with final assembly on-site or at NAC's nearby shore-side facility. During deployment, the system will be floated into location and then fixed at the location with cables that will be attached to a dead-man/anchor on shore, or an anchor placed on the bottom/under water that can be retrieved when done. During operation, aside from the partially-submerged cylindrical harvest screens, the other associated system features (i.e., dewatering device, collection trough, filtered water box, and pumps) will be floating atop or extend above the water surface. There will be no piers or pilings.

The required electrical power will be obtained from an electrical service or by diesel or gas generators that are brought on site. By having an electrical service provided, the sound and fuel use (along with the risk of a fuel spill) could be eliminated and have less impact on the surrounding area. The power requirement would be 3-phase 480 volt (V) service and would be used to operate equipment (e.g., dewatering equipment, air compressors, pumps, drive motors).

As indicated above, an additional shore-side water supply may be needed to augment the 5 to 15-gpm rate needed for the spray bar atop the harvest screens. This additional water supply would preferably be from a well or other available clean water source that would be compatible for discharge into Link River. If additional shore-side water supply is available, connections from the supply source to the spray bar over the harvest screens would be made after backflow devices are properly installed. If additional shore-side water supply is not available, the design can be modified to incorporate the use of river water with appropriate intake and screening features.

## 3 Assessment of Needed Permits and Regulatory Approvals

Several permits or regulatory approvals were identified as potentially applicable to the Demonstration Project (Table 1). Associated contacts were made with regulatory representation (Table 1) to further discuss the requirements and potential timelines for those permits or regulatory approvals. The findings from these contacts were presented to the IMIC by PacifiCorp and CH2M at the IMIC Meeting of April 20, 2017, and are summarized in the following sections below.

### 3.1 Removal-Fill Permit

Oregon's Removal-Fill Law (ORS 196.795-990) and the Federal Clean Water Act § 404 requires a Removal-Fill Permit from the U.S. Army Corps of Engineers (COE) and the Oregon Department of State Lands (DSL) for activities that would remove or fill material in wetlands or waterways. In Oregon, the DSL and COE jointly issue the Removal-Fill Permit. This joint Removal-Fill Permit has the key advantage of being a "one-stop shop" for obtaining the approvals of many other key federal, state, and local regulatory agencies (including most of those listed in Table 1).

The DSL and COE jointly welcome prospective Removal-Fill Permit applicants to meet with the agencies as part of regularly scheduled interagency pre-application meetings. The meetings supplement existing pre-application coordination led by the COE and DSL. The intent of the meetings is to provide meaningful comment



and feedback to prospective applicants early in the process to help them effectively prepare permit applications and address agency concerns.

PacifiCorp and CH2M initiated discussions with the DSL and COE to determine whether the project would be an appropriate topic for an interagency pre-application meeting at which we could present and obtain preliminary feedback on the Project. Based on review of the conceptual description of the project (Attachment A) and answers to other questions via email, DSL and COE concluded the demonstration project will not require a Removal-Fill Permit and therefore a pre-application meeting was not necessary. The DSL and COE based this conclusion on an estimate that the demonstration project system features would consist of potential removal and fill of material below the water surface (i.e., Ordinary High Water) of less than 50 cubic yards (CY). The DSL and COE clarified that the various floating system features (e.g., access dock, pumps, dewatering device, and collection troughs) do not count toward the 50 CY threshold. However, DSL and COE also clarified that the need for a Removal-Fill Permit (involving potential removal and fill of material greater than 50 CY) should be revisited if a full-build Link River algae removal project is pursued in the future.

**Table 1. List of Regulatory Agencies and Permit or Approval Types Potentially Needed for the Link River Algae Removal Demonstration Project.**

Agency	Permit/Approval Type	Need? <sup>A</sup>	Contact (*=IMIC Participant)
Oregon Department of State Lands (DSL)/U.S. Army Corps of Engineers (COE)	Removal-Fill Permit	No (see rationale in text)	Russ Klassen (DSL) Jaime Davis (COE)
Oregon Department of Environmental Quality (DEQ)	Water Quality Certification	No (see rationale in text)	Sara Christensen (DEQ)
Oregon Department of Fish & Wildlife (ODFW)/U.S. Fish & Wildlife Service (USFWS)	Fish passage requirements	Possible	Ted Wise (ODFW)* Josh Rasmussen (USFWS)
	In-water timing guidelines	Likely	Ted Wise (ODFW)* Josh Rasmussen (USFWS)
	Habitat mitigation recommendations	Possible	Ted Wise (ODFW)* Josh Rasmussen (USFWS)
	Incidental Take Authorization	Yes (see rationale in text)	Ted Wise (ODFW)* Josh Rasmussen (USFWS)
	Fish screening requirements	Yes (see rationale in text)	Ted Wise (ODFW)* Josh Rasmussen (USFWS)
Oregon Parks & Recreation Department: State Historic Preservation Office (SHPO)	Archeological review	Possible	Dennis Griffin (SHPO)
Oregon Water Resources Department (OWRD)	Water Use Permit	Possible	Kyle Gorman (OWRD)* Mary Grainey (OWRD)*
Local (e.g., City of Klamath Falls, Klamath County)	Land use and construction approvals	Likely	Stephanie Brown (Klamath County) Klamath Falls City Planning Dept.

A: "No" indicates that the permit or regulatory approval is not needed, "Yes" indicates that the permit or regulatory approval is needed, "Likely" indicates that the permit or regulatory approval is probably needed, and "Possible" indicates that the permit or regulatory approval is questionable or perhaps unlikely to be needed, but should be verified.

## 3.2 Fish-Related Regulatory Requirements

Two resident fish species listed as endangered under the federal Endangered Species Act (ESA) occur in the Project area – the Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*). Other fish species of concern in the Project area include redband trout (*Oncorhynchus mykiss*) and lamprey (*Entosphenus* spp.). The U.S. Fish and Wildlife Service (USFWS) and Oregon Department of Fish and Wildlife (ODFW) provided information on likely fish-related regulatory requirements and preliminary feedback on the Project.

### 3.2.1 Endangered Species Act Requirements

The ESA prohibits the take of fish and wildlife species listed as endangered or threatened. As defined in the ESA, “take” includes harm or harassment as well as more directed activities such as hunting, capturing, collecting, or killing [16 USC 1532(19)]. By regulation, USFWS has defined “harm” as an act that kills or injures listed species, and may include habitat alteration that significantly impairs essential behavioral patterns, such as feeding, breeding, and sheltering (50 CFR 17.3). The ESA is administered by the Secretary of the Interior through the USFWS for resident freshwater species or the National Marine Fisheries Service (NMFS) for marine and anadromous species. Because there are no listed anadromous species in the waters near Link dam, the following discussion focuses on the USFWS.

Section 7 of the ESA requires all federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any species listed under the ESA, or to result in the destruction or adverse modification of its designated critical habitat. Where a project must obtain federal approval or funding, Section 7 of the ESA applies. Under the Section 7 process, consultation with the USFWS usually begins with preparation of a Biological Assessment (BA) by the “action agency” (or the actual permit applicant). Based on review of the BA, consultation may conclude in a timely, straightforward manner if the BA finds, and USFWS concurs that the action has “no effect” or is “not likely to adversely affect” the listed species.

Alternatively, if the BA determines that action “may affect” and is “likely to adversely affect” a listed species, USFWS will issue a Biological Opinion (BO) that discusses whether the action will jeopardize the species existence or adversely modify critical habitat, and identify needed conservation measures, or reasonable and prudent alternatives. If a project is allowed to proceed, the process concludes with issuance of an incidental take statement that allows for incidental take of the listed species by the approved actions (and implemented measures) that is not a violation of the ESA.

The Section 7 process is mandatory where federal approval or funding is involved. Its primary advantage is that is by far the most often-applied and routine ESA compliance mechanism. It is typically the most predictable and least time-consuming approach to obtaining ESA incidental take authorization. Because the proposed demonstration project does not require federal approval or involve federal funding, the Section 7 process is not an available pathway by which the proposed demonstration project could obtain incidental take coverage under the ESA.

It is possible that a federal connection or “nexus” could be obtained if a federal agency were to sponsor or fund the proposed demonstration project. However, at this time no such sponsorship or funding is apparent. It is also possible that a federal nexus could be obtained if a future full-build version of the project were to require federal approvals or involve federal funding. However, even to determine such a possible federal nexus would require commitment to substantial design and planning of the full-build version of the project even though most aspects of the full-build version of the project have not been tested and are not yet known to be feasible. To follow this route would involve substantial financial risk should designs or operations and maintenance needs change during the pilot phase leading to re-design of the full-build version.

Section 10 of the ESA is the other available approach to obtaining incidental take authorization. Section 10(a)(1)(A) of the ESA allows USFWS to issue permits for scientific research purposes or to enhance the

propagation or survival of endangered or threatened species. Permitted research activities must not operate to the disadvantage of the listed species and must provide bona fide and necessary or desirable scientific information. Research permits include conditions necessary to minimize and monitor the impacts of the proposed activities. Possession of a section 10(a)(1)(A) permit is regarded as a privilege in that USFWS must balance permit issuance with duties to protect and recover listed species.

Preliminary feedback on the Project from USFWS indicated that a Section 10 scientific permit (via ESA Section 10(a)(1)(A)) would likely not be an available compliance option because take would be incidental to the proposed action. Instead, USFWS indicated that Section 10(a)(1)(B) of the ESA would be the more appropriate available compliance path for the proposed demonstration project.

Section 10(a)(1)(B) of the ESA allows USFWS to authorize taking of endangered and threatened species by non-federal entities that is incidental to, but not the purpose of, otherwise lawful activities. Under Section 10(a)(1)(B), such authorizations are granted through the issuance of incidental take permits. The Section 10 process for obtaining an incidental take permit has three primary phases: (1) development of a Habitat Conservation Plan (HCP); (2) the formal permit processing phase; and (3) the post issuance phase.

During the HCP development phase, the project applicant prepares a plan that integrates the proposed activity with the protection of listed species. In addition to a detailed discussion of the proposed action, an HCP submitted in support of an incidental take permit application must include the following information:

- Impacts likely to result from the proposed taking of the species for which coverage is requested
- Measures that will be implemented to monitor, minimize, and mitigate impacts
- Funding that will be made available to undertake such measures
- Procedures to deal with unforeseen circumstances
- Alternative actions considered that would not result in take
- Additional measures that USFWS may require as necessary or appropriate for purposes of the HCP

To issue the permit, the USFWS must find that: (1) the taking will be incidental; (2) the applicant will, to the maximum extent practicable, minimize, and mitigate the impacts of such taking; (3) the applicant ensures adequate funding is available for the HCP and procedures to deal with unforeseen circumstances; (4) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; (5) the applicant has amended the HCP to include any measures (not originally proposed by the applicant) that the USFWS determines are necessary or appropriate; and (6) there are adequate assurances that the HCP will be implemented.

While Section 10 of the ESA is an available approach to obtaining incidental take authorization, development and approval of HCPs have a history of being time-consuming and expensive. Also, the outcome and ultimate conservation requirements from the Section 10/HCP process lacks predictability. Working through the Section 10/HCP process may be practical for a full build project that would be in place for years, but because of the uncertainty associated with the process it is considered impractical for the proposed demonstration project.

In summary, because there are two ESA-listed sucker species present in the area, incidental take authorization would need to be obtained from USFWS for the proposed Demonstration Project. The most predictable and straightforward approach to obtaining incidental take authorization is through the ESA Section 7 process, but the Section 7 process is not available for the proposed Demonstration Project because the project lacks the requisite nexus to federal approval or funding. Instead, USFWS indicated that the more appropriate approach to obtaining incidental take authorization would be through Section 10(a)(1)(B) of the ESA. However, the Section 10(a)(1)(B) process is considered impractical because it would entail development and approval of an HCP (among other requirements) that would be time-consuming and expensive with an outcome that lacks

predictability. Therefore, obtaining ESA authorization remains a major hurdle and creates substantial uncertainty facing the proposed Demonstration Project.

### 3.2.2 Fish Screen Requirements

Preliminary feedback on the Project from ODFW indicated that fish screening criteria are in effect for the upper Klamath Basin that would be applicable to the proposed cylindrical algae harvest screens. In 2005, ODFW and USFWS (along with the California Department of Fish and Wildlife) recommended fish screen criteria for use in the upper Klamath Basin that are based on the NMFS fish screen criteria for juvenile salmonids in Pacific Northwest; the current version of these criteria were updated by NMFS in 2011.

The screen requirements (NMFS 2011) recommended for the proposed cylindrical algae harvest screens would include:

- Screen mesh maximum openings of 3/32 inch (0.094 inch).
- Approach velocity (velocity of the flow perpendicular to the face of the screens) of no more than 0.2 feet per second (fps). This is the criteria for screens that are not self-cleaning screens. Approach velocity can be up to 0.4 fps for screens being actively cleaned.
- Sweeping velocity (velocity of the flow parallel along the face of the screens) must be greater than the approach velocity (for screens larger than 6 feet long).

Specific water velocities in the area where the proposed Project would be located have not been measured. However, the hydraulics in this area appear more river-like with water velocities possibly approaching 1 fps. Placing the harvest units perpendicular to the flow maximizes their efficiency, but also maximizes the velocity at which water encounters the screen while minimizing the sweeping velocity. The primary concern expressed by ODFW and USFWS is the impingement of larval suckers on the harvest screens. Because the larval suckers occupy the surface waters and are poor swimmers, they are particularly susceptible to impingement on screens.

Preliminary feedback on the Project from ODFW suggested that design adjustments be considered to meet the screening criteria. One suggestion would be to angle the proposed cylindrical algae harvest screens so that they are not perpendicular to flow thereby reducing approach velocities and increasing sweeping velocities. Another suggestion would be to design wing walls or similar devices at the upstream end of the proposed cylindrical algae harvest screens that could help induce sweeping flow across the face of the screens.

In considering this feedback, the NAC indicated that the screen mesh size of 3/32 inch can likely be accommodated (the current proposal is for 0.14 inch, which is a little larger than 1/8 inch). However, this smaller mesh size likely would make the cylindrical algae harvest screens less efficient in capturing algae material (but to an unknown degree until further testing was done).

The NAC indicated that angling of the screens so that they are not perpendicular to flow can also be accommodated. However, this would likely make the cylindrical algae harvest screens less efficient in capturing algae material (but to an unknown degree until further testing was done). In any case, the NAC indicated that an approach velocity of no more than 0.4 fps would be difficult to achieve because of the riverine flow conditions at the proposed Demonstration Project location. Such riverine flow conditions are desirable to enhance the ability of the system to harvest a substantial amount of algae material.

At the suggestion of ODFW, NAC was asked about the possible functionality of installing the proposed Demonstration Project in the A Canal downstream of the existing screens installed by the U.S. Bureau of Reclamation (Reclamation). By locating the proposed Demonstration Project in the A Canal downstream of the existing screens, the need for the proposed Demonstration Project to obtain an incidental take permit and meet fish screening criteria would be eliminated. In response, the NAC was concerned that Reclamation's screen acts to break blue-green algae colonies (especially of *Aphanizomenon*) up to the point that algae

harvest efficiency and quantity from the A Canal would not be representative of what could be found upstream of Link dam. In other words, harvesting from the A Canal for a pilot project might not provide the desired efficiency and quantity of algae biomass removal from the Klamath River system that is sought from this technological approach.

### 3.2.3 In-Water Timing of Potential Algae Collection Relative to Fish Presence

The specific timing of proposed Demonstration Project operations has not yet been determined. However, operations ideally would encompass the period of peak seasonal blue-green algae production (especially of *Aphanizomenon*) in Upper Klamath Lake and Link River, which extends from about June through October (ODEQ 2002, 2010).

Regarding the possible timing of proposed Demonstration Project operations, USFWS suggested that operations of the proposed Demonstration Project not be started until at least the end of June (and preferably mid-July) to avoid the period of presence of larval suckers (Table 2). USFWS suggested that larval suckers, which are small and passively drift, would be vulnerable to potential harm by the cylindrical harvest screens from possible impingement and entrainment.

**Table 2. Estimated Periodicity of Key Fish Species in the Vicinity of Link River Dam<sup>A</sup>. (Source: FERC 2007)**

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
<b>Shortnose and Lost River Suckers</b>												
Adult Migration			2	4	4	2						
Adult Spawning				4	4	4						
Incubation				4	4	4	2					
Larval Emergence					4	4	4					
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
<b>Redband Trout</b>												
Adult Migration			2	4	4	2					4	4
Adult Spawning			2	4	4	2						
Incubation				4	4	4	4					
Fry Emergence					4	4	4	2				
Rearing	4	4	4	4	4	4	4	4	4	4	4	4
<b>Lamprey</b>												
Adult Migration	4	4	4	4	4	4	4	2	2	2		
Adult Spawning				2	4	4	4	2				
Incubation				2	4	4	4	4				
Rearing	4	4	4	4	4	4	4	4	4	4	4	4

A: Numbers in table represent duration in weeks. Shaded cells indicate peaks in use or occurrence.

ODFW suggested that operations of the proposed Demonstration Project also are of concern during the months of July through September because of the likely presence of juvenile rearing redband trout, suckers, and lamprey (Table 2). ODFW suggested that the cylindrical harvest screens, unless designed to conform to

screening criteria, could result in impingement and entrainment, and therefore harm these juveniles. ODFW also indicated that the proposed Demonstration Project location is within a fairly popular recreational fishing area and expressed concern that the presence of proposed Demonstration Project facilities could interfere with recreational fishing access and use in the area.

### 3.3 Other Regulatory Permits or Approvals

Several other regulatory permits or approvals have been identified as likely or possibly needed for the proposed Demonstration Project (Table 1). These other regulatory permits or approvals are considered non-controversial and obtainable for the proposed Demonstration Project, but could require some adjustments to Project design and implementation depending on specific requirements.

## 4 Assessment of Use and Disposal of Harvested Algae Material

The specific uses and disposal of algae material collected by the Demonstration Project are yet to be determined. There are a few possible use and disposal options that would be investigated during Phase 2 of the Demonstration Project. These include:

1. Use as a food supplement via NAC's established process
2. Land-applied fertilizer
3. Compost component
4. Commercial landfill

Under the first option, NAC has indicated that they would determine whether the material is of acceptable quality for food and supplement use (e.g., the desired *Aphanizomenon* content is present, and potential algal toxins are absent or otherwise within safe levels). If so, the collected material would be transported by tanker truck to the NAC processing plant in Klamath Falls to be added to material to be processed according to NAC's standard procedures for food and supplement manufacturing.

In addition, the Klamath Soil and Water Conservation District (KSWCD) has contacted the IMIC (via Eli Asarian) and CH2M (Ken Carlson) about the possibility of using harvested algae material from Upper Klamath Lake as a land-applied soil fertilization amendment. Further discussions with KSWCD should be conducted during Phase 2 to assess and identify potential testing of harvested algae material from the Demonstration Project as a soil amendment.

There has also been discussion in the IMIC about using the material as a component in commercial compost or landfill. Potential use of the material as a component in commercial compost or landfill could be further assessed during Phase 2.

A key question for the various disposal options relates to the fate of microcystin toxins that may be present in harvested material. The toxin breakdown process would need specific focused investigation during Phase 2 of the Demonstration Project.

## 5 Additional Considerations

As an action item from the IMIC Meeting of April 20, 2017, PacifiCorp and CH2M (Demian Ebert and Ken Carlson) followed-up with NAC regarding the feasibility of scaling down the Demonstration Project. The IMIC assumed that scaling down the demonstration project might reduce or eliminate fish screening and related ESA-take concerns that had been expressed by ODFW and the USFWS. The NAC indicated the following:

- The pilot system could be reduced in size to a minimum of one cylindrical harvest screen (5 to 6 feet in diameter and 16 feet long), rather than the three now proposed. Thus, the proposed system would be about one-third the size of the current proposed system. A demonstration system any smaller than this would not be reasonably scalable to a full-build system. Costs for the in-water portion would scale down by about two-thirds, but the shore-side facilities and labor requirements would be very similar to those currently proposed.
- The harvest screens could be made compliant with the NMFS criteria for screen mesh size. However, compliance with the approach and sweeping velocities would depend on the specific location for the facility and screen orientation.
- For the pilot study, the cylindrical harvest screen operation could be adjusted, if desired, by: (1) changing orientation to the flow (e.g., angled to the flow rather than perpendicular); or (2) rotating the upstream face of the screen downward (rather than upward). However, for any of these adjustments, algae collection efficiency is reduced and the quantity of algae collected would diminish.

## 6 Conclusions and Recommendations

Regardless of whether the Demonstration Project is scaled down, if it has to be placed in the lake, then the ESA-compliance issue remains a major challenge. At this point, committing the time and funding to prepare an ESA Section 10 HCP for the Demonstration Project does not appear to be a reasonable use of IM11 funds. Additionally, available IM11 funds are likely not sufficient for implementation of the Demonstration Project. Even at reduced size, the pilot could easily cost substantially more than is available in the IM11 budget over the years that it would take to complete the design work, prepare an HCP, and complete a Section 10 consultation process.

Because of the uncertainty surrounding the ESA issues and the overall expense of the Demonstration Project, it does not appear worth proceeding with the Demonstration Project at this time. However, if one of the federal agencies in the upper basin was willing to step forward and take the lead, the more straightforward ESA Section 7 consultation process could be used. Additional funding support would also have to be obtained, but should both of these events occur, perhaps the Demonstration Project is worth pursuing further.

## 7 References

- Federal Energy Regulatory Commission (FERC). 2007. Final Environmental Impact Statement for Hydropower License. Klamath Hydroelectric Project. FERC Project No. 2082-027. Oregon and California. Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing, Washington, DC. November 16, 2007.
- National Marine Fisheries Service (NMFS). 2011. Anadromous Salmonid passage facility design. July 2011. Available online at: [www.habitat.noaa.gov/pdf/salmon\\_passage\\_facility\\_design.pdf](http://www.habitat.noaa.gov/pdf/salmon_passage_facility_design.pdf)
- Oregon Department of Environmental Quality (ODEQ). 2002. Upper Klamath Lake Drainage Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP). May 2002.
- Oregon Department of Environmental Quality (ODEQ). 2010. Upper Klamath and Lost River Subbasins Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WPMP). Prepared by the Oregon Department of Environmental Quality. December 2010.





**Attachment A:  
Link River Algae Removal Demonstration Project:  
Conceptual Project Description**



# Link River Algae Removal Demonstration Project: Conceptual Project Description

*Version: June 2, 2017*

## Introduction

The Klamath Hydroelectric Settlement Agreement (KHSA; as amended on April 6, 2016) includes Interim Measure 11 (Interim Water Quality Improvements), which is intended to address water quality improvement in the Klamath River during the interim period leading up to potential dam removal by a designated Dam Removal Entity (DRE). Regarding Interim Measure 11, the KHSA states “The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir.” Interim Measure 11 calls for PacifiCorp to fund such projects in consultation with the Interim Measures Implementation Committee<sup>1</sup> (IMIC).

Interim Measure 11 activities during the 2016-2017 period include the *Link River Algae Removal Demonstration Project*. This project is follow-up to an initial assessment of potential algae harvesting and removal at Link River dam that was completed in early 2016.<sup>2</sup> The initial assessment indicated that it likely would be feasible to build an algae removal system, but that the system could face some hurdles with regard to regulatory approvals (e.g., Endangered Species Act, water rights, and other permits) and proper disposal of resulting harvested algae material. To further assess feasibility of an algae removal system, including design and permitting needs, a demonstration (i.e., pilot) project that could be located near Link River dam has been proposed by IMIC members.

It is proposed that the overall pilot project be conducted in four phases:

- Phase 1: Conceptual project description; permitting and disposal needs assessment.
- Phase 2: Pilot design and cost estimate; operational plan and cost estimate; permit and regulatory approvals applications; algae composting and disposal study plan; monitoring plan.
- Phase 3: Final regulatory approvals; contractor selection; pilot facility fabrication and installation.
- Phase 4: Operations of pilot facility; algae disposal study; monitoring, analysis, and reporting.

As this four-phase process unfolds, it is possible that a fatal flaw might emerge that precludes implementation of the pilot project. The risk associated with any such flaws are reduced by breaking the pilot project down into the phases (as outlined above). At the conclusion of the pilot project, analysis of monitoring data along with review of actual operational costs should allow a decision regarding the feasibility of a full-scale facility and development of design for that facility, if appropriate.

In support of Phase 1 of this process, this document contains a summary description of the proposed technology and the conceptual pilot project. This summary describes what is currently known or proposed

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<sup>1</sup> The IMIC is comprised of representatives from PacifiCorp and other parties to the KHSA (as amended on April 6, 2016). The purpose of the IMIC is to collaborate with PacifiCorp on ecological and other issues related to the implementation of the Non-Interim Conservation Plan Interim Measures set forth in Appendix D of the amended KHSA.

<sup>2</sup> For details see: CH2M. 2016. Interim Measure 11, Activity 7 – Assessment of Potential Algae Harvesting and Removal Techniques at Link River Dam. Technical Memorandum prepared for PacifiCorp. 66 pp. Available online at: <http://www.pacificorp.com/es/hydro/hl/kr.html#>.

regarding: (1) the algae harvest, collection, and transport techniques to be used; (2) anticipated pilot project facilities locations; (3) proposed construction and operations and maintenance activities; (4) screen sizes and approach water velocities; and (5) water pumping (screening) and water loss (that amount remaining in the wet algae that is not returned to the river) rates. This summary will be used as the basic introductory material to inform discussions with IMIC members, regulatory agency representatives, and other stakeholders (e.g., during conference calls and meetings) for completing the Phase 1 assessment of the pilot project as outlined above.

The Link River Algae Removal Demonstration Project facilities will be designed, constructed, and operated by the New Algae Company (NAC) of Klamath Falls, Oregon. Additional information on NAC is provided in Appendix A.

## Summary Description of the Proposed Pilot Project

### Location

The Link River Algae Removal Demonstration Project facilities are proposed to be located between the A Canal and Link River dam, upstream of the log boom at Link River dam (Figure 1). This general location provides some advantages, including: (1) ease of access; (2) close proximity to power sources and post-processing facilities; (3) being at the terminal end of Upper Klamath Lake where algae removal can have greatest effects on downriver water quality; and (4) being in a more riverine-like channel environment where water velocities are higher (than upstream in the lake proper), allowing more effective operation of the proposed screening system (as described further below).

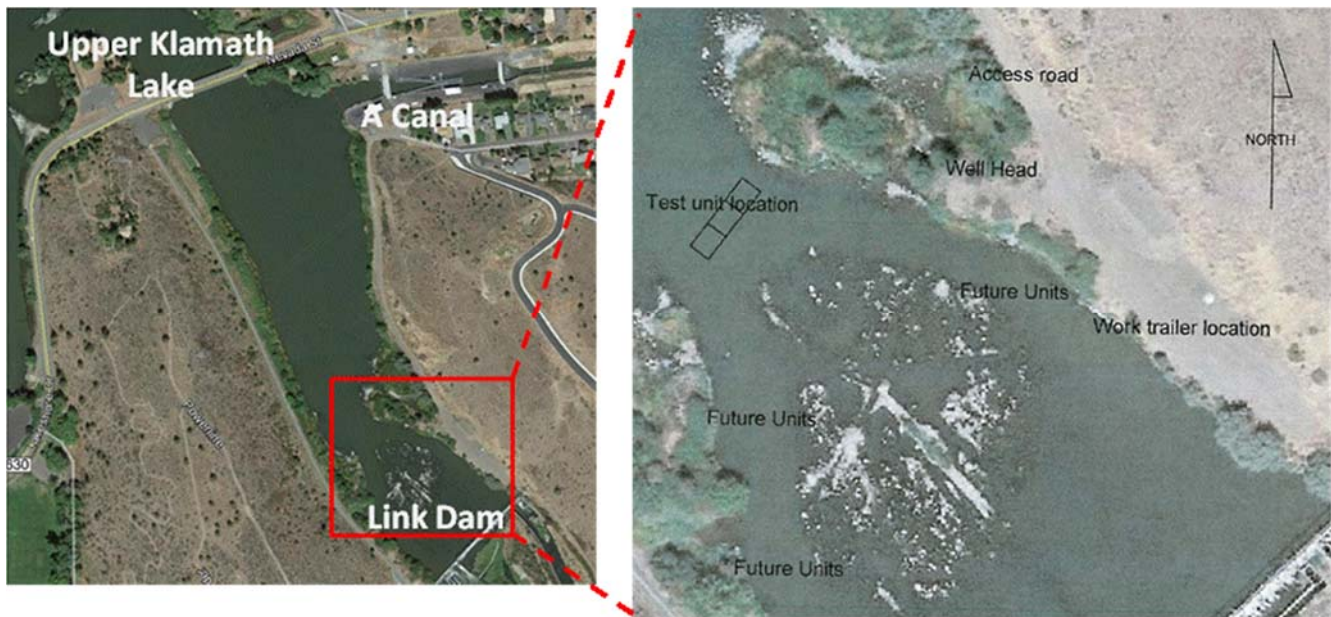


Figure 1. Proposed Link River Algae Removal Demonstration Project facilities location and layout.

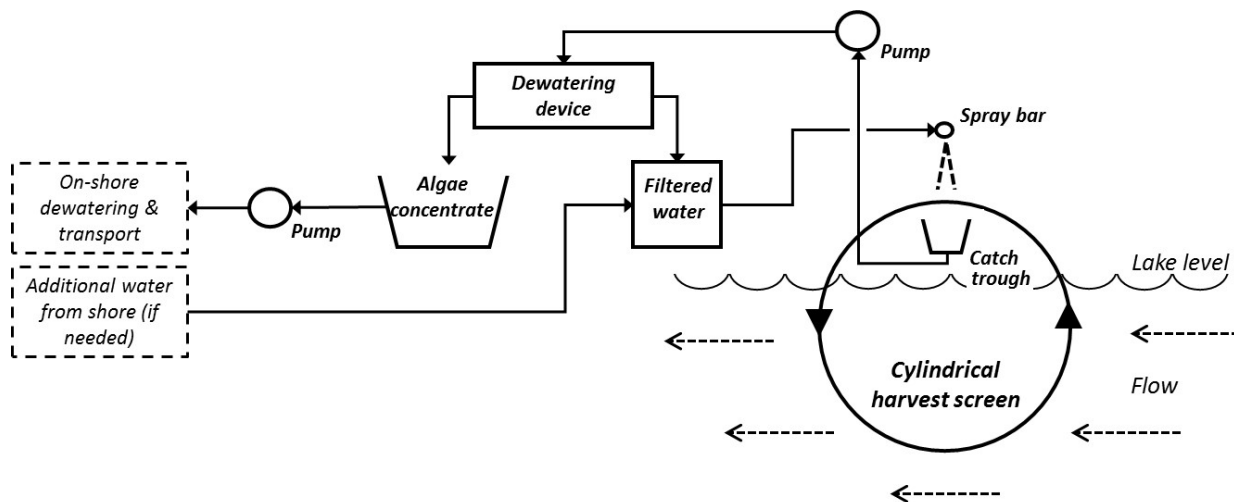
### Proposed Pilot Project Facilities and Set-up

The Link River Algae Removal Demonstration Project facilities will include an algae harvesting system that consists of up to three rotating cylindrical harvest screens arranged in a linear formation perpendicular to the water current (Figure 1). Each cylindrical harvest screen will be 5 to 6 feet (ft) in diameter and 16 ft long, resulting in a total horizontal length of 48 ft (i.e., up to 3 screens of 16 ft long each). The rotating cylindrical harvest screens will be held in place via cables anchored on the adjacent shorelines.

Each cylindrical harvest screen will be wrapped in stainless steel screen with a screen opening of 0.14 inch. The submerged screened area in the flow of water will be about 4 ft deep. The cylinders will rotate at about 2-4 revolutions per minute (RPM) powered by a submersible variable-speed electric motor. As water from upstream encounters the screens, algae material will collect on the rotating screen surfaces. As this accumulation occurs, the screen mesh openings will progressively narrow (i.e., become narrowed to less than the effective 0.14-inch opening size), which will further reduce or retard the amount of flow that penetrates through the screens even as algae material continues to accumulate on the rotating screen surfaces. The narrow mesh and flow retardation will prevent or minimize impingement or entrainment of fish and larger debris on the screens, and instead allow fish and larger debris to go under or around the harvest screen.

Over the top of the cylindrical harvest screens, a set of spray nozzles mounted on a spray bar will spray water directly down at the harvest screen perpendicular to the mesh (Figure 2). This spray will cause the accumulated algae material to be washed through the screen and into a catch trough for collection on the inside of the cylinder (Figure 2). Material larger than the screen mesh opening will be returned back to the river on the downstream side of the cylindrical harvest screens.

The algae material that is collected into the catch trough will be an algae/water mixture that will be subsequently pumped into a mechanical dewatering device located in the channel adjacent to the screens (Figure 2). This dewatering device will remove excess water from the algae/water mixture and concentrate the algae material into a thicker slurry (consisting of 1 percent solids and 99 percent water). The excess water removed by the dewatering device will be collected and filtered in a separate box (i.e., filtered water box shown in Figure 2) for use in supplying water for the spray bar (as described above). Operation of the spray bar will require water supplied at a rate of about 5 to 15 gallons per minute (gpm). The excess water removed from the dewatering unit (and supplied from the filtered water box) might not be sufficient to provide the full rate amount needed for the spray bar. If so, additional water from another source, such as a shore-side well or municipal water supply, may be needed to augment the rate needed for the spray bar.



**Figure 2. Conceptual schematic of Proposed Link River Algae Removal Demonstration Project facilities set-up.**

From the dewatering device, the concentrated algae slurry will be collected in a trough and then pumped to shore via a 2-inch hose (i.e., algae concentrate box and pump shown in Figure 2). The algae concentrate that is pumped to shore will undergo additional dewatering using mechanical dewatering equipment installed in semi-truck trailers placed in the gravel parking area on the east shore (Figure 1). This dewatering equipment will further remove lake water from the algae concentrate to produce a thicker paste consisting of 5 to 8

percent solids and 92 to 95 percent water. The water removed in this dewatering step would be returned (via a 1½-inch hose) to the river directly, or used to augment the spray bar (as described above), if needed. The more-concentrated algae paste would then be pumped into a tanker truck and hauled off-site for use or disposal (as described further below). If the algae paste is determined by NAC to be of acceptable quality for food and supplement use (e.g., the desired *Aphanizomenon flos-aquae* [*Aphanizomenon*] content is present, and potential algal toxins are absent or otherwise within safe levels), a cooling/refrigeration step may be added before loading the material into the tanker truck.

## Access, Safety, and Utility Support

The cylindrical harvest screens and associated harvesting process features (Figure 2) will be constructed off-site in component parts with final assembly on-site or at NAC's nearby shore-side facility. During deployment, the system will be floated into location and then fixed at the location with cables that will be attached to a dead-man/anchor on shore, or an anchor placed on the bottom/under water that can be retrieved when done. During operation, aside from the partially-submerged cylindrical harvest screens, the other associated system features (i.e., dewatering device, collection trough, filtered water box, and pumps) will be floating atop or extend above the water surface. There will be no piers or pilings.

The existing gravel parking area on the east shore provides excellent access for the proposed demonstration project. During the test period, the land-based equipment would be installed on two semi-truck trailers that can be easily moved off site when not in use. The work site can be designed and used with safety and security in mind. If desired or required, safety and security can be enhanced by limiting the public access (e.g., using security fencing) and installing locked gates. On-site workers will be trained on safe operations.

Once the cylindrical harvest screens are anchored in position with cables (and safety systems in place), access from the east bank to the east end of the harvest screens would be accomplished by a new floating dock (that will be about 7 to 9 ft wide and 30 to 50 ft long). A dock gate would be required to restrict access. This dock would also provide the support structure to carry power, water, and compressed air (for the pumps) to the harvesting equipment and algae concentrate lines back to shore.

The required electrical power will be obtained from an electrical service or by diesel or gas generators that are brought on site. By having an electrical service provided, the sound and fuel use (along with the risk of a fuel spill) could be eliminated and have less impact on the surrounding area. The power requirement would be 3-phase 480 volt (V) service and would be used to operate equipment (e.g., dewatering equipment, air compressors, pumps, drive motors).

As indicated above, an additional shore-side water supply may be needed to augment the 5 to 15-gpm rate needed for the spray bar atop the harvest screens. This additional water supply would preferably be from a well or other available clean water source that would be compatible for discharge into Link River. If additional shore-side water supply is available, connections from the supply source to the spray bar over the harvest screens would be made after backflow devices are properly installed. If additional shore-side water supply is not available, the design can be modified to incorporate the use of river water with appropriate intake and screening features.

## Use and Disposal of Collected Algae Material

The specific uses and disposal of algae material collected by the Link River Algae Removal Demonstration Project are yet to be determined. There are a few possible use and disposal options that will be investigated during implementation of the pilot project. These include:

1. Use as a food supplement via NAC's established process
2. Land-applied fertilizer
3. Compost component
4. Commercial landfill

Under the first option, NAC will determine whether the material is of acceptable quality for food and supplement use (e.g., the desired *Aphanizomenon* content is present, and potential algal toxins are absent or otherwise within safe levels). If so, the collected material will be transported by tanker truck to the NAC processing plant in Klamath Falls to be added to material to be processed according to NAC's standard procedures for food and supplement manufacturing.

Other potential uses and disposal of algae material collected by the Link River Algae Removal Demonstration Project will be identified during upcoming planned discussions with IMIC members, regulatory agency representatives, and other stakeholders (e.g., during conference calls and meetings) for completing the Phase 1 assessment of the pilot project as outlined in the *Introduction* above. For example, the Klamath Soil and Water Conservation District (KSWCD) has contacted the IMIC about the possibility of using harvested algae material from Upper Klamath Lake as a land-applied soil fertilization amendment. Further discussions with KSWCD will be conducted during Phase 1 to assess and identify potential testing of harvested algae material from the pilot project as a soil amendment during subsequent phases of the pilot project. There has also been discussion about using the material as a component in commercial compost. A key question for both the fertilizer and compost disposal options relates to the fate of microcystin toxins that may be present in harvested material. The toxin breakdown process will need specific focused investigation during a pilot project.

### **Additional Collection of Needed Information**

While some information has been obtained from IMIC members, regulatory agency representatives, and other stakeholders during Phase 1 discussions, there remains a substantial amount of information that still needs to be obtained. This additional information is necessary to inform Phase 2 actions and activities. Phase 2 actions supported by this information include specifics of the pilot project design and cost estimate; the pilot project operational plan and cost estimate; permits and regulatory approvals; and an associated algae composting and disposal study plan.

A complete list of the necessary information has not been completely compiled. The information below is what is known to be necessary at this point and this list will continue to grow as Phase 1 unfolds. At this time, necessary information includes:

- Estimated required harvested biomass amount (in tons or gallons) to achieve described water quality improvement downstream;
- Sampling to characterize algae biomass composition and concentrations at the pilot project location;
- Bathymetry in the channel area surrounding the pilot project location;
- Water velocity and depth measurements in the channel area surrounding the pilot project location under differing flow conditions during the May-October period;
- Tests of potential fish entrainment and impingement on screens;
- Identification of specific optional uses and disposal of algae material collected; and
- Identification and approvals from applicable property owners whose property may be used for the pilot project or associated project activities.

To support pilot project design and operation planning, additional information will need to be obtained or questions answered during Phase 1 with regard to the access and utilities at the pilot project site (as shown in Figure 1). Examples of needed site-specific information include:

- Verification that the road along the east shoreline near the proposed site (Figure 1) is in adequate condition to support use associated with the pilot project. Initial reconnaissance indicates that the road is mostly graveled and has adequate width, but may need additional rock/gravel close to the

existing road gate. The existing road gate is in poor condition and may need to be upgraded to support continuous use.

- Verification that electrical power is available. It is assumed that power may be available at nearby Link River dam, but the availability and adequacy of this power must be assessed.
- Verification that possible auxiliary water is available, if needed. There appears to be an 8-10 inch water well on site that is capped and locked. Could this water be used for the pilot project, if needed?
- Verification that access to the east side shore is adequate. If necessary, will it be possible to remove the large pile of gravel and rock in the middle of east side parking area? Is restricting public access to the east side shore during the project an issue?



## Appendix A: New Algae Company – the Conceptual Pilot Project Technology Supplier

The Link River Algae Removal Demonstration Project facilities will be designed, constructed, and operated by the New Algae Company (NAC) of Klamath Falls, Oregon. NAC provides outstanding local expertise and capabilities in the harvesting of algae. NAC began harvesting algae (specifically focused on *Aphanizomenon flos-aquae* [*Aphanizomenon*]) in the Klamath Falls area in 1982. NAC manufactures and distributes food supplements derived from *Aphanizomenon* powder. NAC started algae harvesting from the C Canal flume south of Klamath Falls. In 1990, the operation was moved to the upstream entrance of the C Canal (which adjoins the downstream end of the A Canal). NAC's algae harvesting operation stayed at that location until the operation was moved to Upper Klamath Lake in 2001 where they currently conduct algae harvesting operations during the summer months.

Over their 35 years of algae harvest experience, NAC has successfully used 11 different designs of harvest equipment and methods, with each successive method aimed at perfecting the care and efficiency of the algae gathering and separation from ambient waters. NAC harvest equipment designs started with the capability to process of water flow rates of about 20 cubic feet per second (cfs) and worked up to processing rates around 1,000 cfs.

NAC's algae harvest activities and product development adhere to the company's strong environmental stewardship ethic. NAC responsibly consults and collaborates with organizations having local regulatory or resource management authority, including the Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Klamath Irrigation District, Oregon Department of Agriculture, and others.

The products from NAC's algae harvest activities are backed by several important certifications that attest to the company's drive for product quality and safety. NAC adheres to the U.S. Food and Drug Administration's (FDA) Good Manufacturing Practices as certified by NSF International.<sup>3</sup> NSF International annually audits NAC processes, facilities, training, and documentation to insure NAC is compliant with all applicable FDA regulations.

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<sup>3</sup> NSF International was founded in 1944 from the University of Michigan's School of Public Health as the National Sanitation Foundation (NSF) to standardize sanitation and food safety requirements. To date, NSF International has developed more than 80 public health and safety American National Standards. NSF International is an accredited, independent third-party certification body that tests and certifies products to verify they meet these public health and safety standards. NSF International also has been collaborating with the World Health Organization since 1997 in water quality and safety, food safety and indoor environments.