# BOX CANYON HYDROELECTRIC PROJECT (NO. 2042)
# AQUATIC PLANT MANAGEMENT PLAN
# 2021 UPDATE

**Prepared by:**

**Pend Oreille Public Utility District**
**No. 1 of Pend Oreille County**
**130 N. Washington**
**Newport, WA 99156**

**2021**

# TABLE OF CONTENTS

## 1.0 EXECUTIVE SUMMARY

The APMP submitted by the District and approved by the FERC Order on September 2, 2007, was a compilation of three independently prepared planning documents. The core plan titled INTERIM AQUATIC PLANT MANAGEMENT PLAN FOR THE PEND OREILLE RIVER BETWEEN RIVER MILE (RM) 34.4 AND RM 90.1 (2004) (IAPMP ), was developed through a collaborative process with Pend Oreille County (County) and the District to meet the aquatic plant management needs of both County goals and District mandates.

Included in this core document was an in-depth description of the physical and biological characteristics of the management reach, an evaluation of beneficial and recreational uses and how plant management would augment those uses, and a discussion of containment alternatives. None of this information has changed to the point of affecting the implementation of this plan and was left for reference, in Appendix A.

The first addition to this core document was titled AQUATIC PLANT MANAGEMENT PLAN (2005), which provided an additional introduction to describe why the District submitted the County's IAPMP to comply with section II.D of the Washington Department of Ecology (WDOE) water quality certification. It also listed the 10 specific tasks within the IAPMP that the District was responsible for implementing.

The second addition to the IAPMP, written to meet the requirements of the USFS Condition 17, was an addendum titled ADDENDUM DECEMBER 2006 AQUATIC PLANT MANAGEMENT NEAR PUBLIC BOAT LAUNCHES IN BOX CANYON RESERVOIR. This addendum focused on clarifying actions to be taken by the District at all public boat launches. These public launches pose the greatest risk as a point source for the transfer of non-native aquatic plants to nearby Forest Service lakes. The addendum describes the planned boat launch treatment, effectiveness monitoring, an adaptive management process to modify annual treatment in response to annual monitoring results, and public education and outreach required at each public launch.

The intent of this Aquatic Plant Management Plan revision is to summarize the objectives set by each document, identify goals established in the plans to meet those objectives, and update the approved amended plan with recent changes in equipment, schedule of operation, permit requirements, and plan implementation. Each of the original APMP components, as approved by FERC order, are included in appendix A for reference, in order to preserve the original intent of each document, its process of development, and its public and agency comments.

## 2.0 INTRODUCTION

The Box Canyon Hydroelectric Project (Project), FERC No. 2042, is operated by the Public Utility District No. 1 of Pend Oreille County (District). The Box Canyon Hydroelectric Project is located on the Pend Oreille River in northeast Washington State, approximately 100 miles north of the city of Spokane. On July 11, 2005, the Federal Energy Regulatory Commission (Commission or FERC) issued an order for a new license (Order) for the Project.

In Article 401 of the Order, FERC required the District to prepare an Aquatic Plant Management Plan (APMP) to meet U.S. FS Section 4(e) 17, and Washington Department of Ecology Water Quality Certification II D Conditions. A summary of those condition requirements are as follows:

Section II D of Washington Department of Ecology's (WDOE) Water Quality Certification (WQC) Conditions require the APMP to include containment methods for Eurasian watermilfoil *Myriophyllum spicatum* (EWM) and any other non-native nuisance aquatic plants in the reservoir, plus an implementation schedule and provision for periodic monitoring to track progress toward meeting the goals of the plan. Section II D also requires the licensee to prepare and submit annual reports to the WDOE detailing progress toward meeting the goals of the plan, including recommendations for modifying the plan as needed.

U.S. Forest Service (FS) Condition 17 requires the licensee to prepare an Aquatic Plant Management Plan in consultation with and approved by the FS prior to filing the plan with the Commission within 1 year of the license issuance. The plan must address the control of EWM, within Box Canyon Reservoir (BCR) and the prevention of the spread of this plant to other water bodies within the Colville National Forest. The plan must also include control actions, an implementation schedule, and a monitoring plan for evaluating the effectiveness of the proposed actions.

As the original APMP was developed in cooperation with, and implemented by, Pend Oreille County as the primary entity responsible for aquatic plant management in the BCR, the FERC orders approving and amending the plan identified specific tasks within the APMP that the District was responsible for regardless of the County's continued participation. These tasks are listed by Condition below.

To avoid confusion during annual planning and implementation, tasks referring to coordination with or implementation by Pend Oreille County were identified and reworded to compensate for the County's withdrawal from aquatic plan management. Any task documented as complete during an annual report prior to December 2012 will be noted as such but not discussed further in this plan update.

Tasks specific to the DOE Water Quality Certification Conditions are:

a. Provide funding for implementation of the APMP at the level of $80,000 annually, for the duration of the license, or until the plan's success allows for reduced effort. (Modified to remove county involvement)

b. Sponsor an annual public meeting to discuss aquatic plant management in Pend

Oreille River and publicize the schedule for the rotovator for the upcoming year. (Modified to remove county involvement)

c. Establish a web-based posting site that identifies where rotovation will be occurring on a two-week to one-month interval. (Completed)

d. Convene an annual meeting with participation by interested natural resource agencies and citizen representatives to review revision to the APMP. This meeting would be held in the early spring so that any new action can be implemented within the upcoming growing season. (Modified to remove county involvement)

e. Post and maintain signs at all public boat launches that educate river users about proper cleaning of watercraft to remove aquatic plan debris and minimize spread to other water bodies.

f. Work with the County to review and incorporate new aquatic plant control methods into the plan as they become available.

g. Work with the County to secure grants to support the plan.

h. Provide $50,000 in 2007 for the purchase of a second mechanical removal machine, (in addition to the annual contribution of 80,000). (Completed)

i. Annually monitor index sites as specified in the plan. The frequency of monitoring may be adjusted as the APMP is implemented.

j. Investigate the feasibility and opportunities of a cost sharing program that supports property owners along the shores of BCR interested in implementing alternative treatments to aquatic plant beds as prescribed in the County's APMP. This was a topic at the 2006 annual review meeting. (Completed)

Tasks specific to FS Condition 17 are:

1. Develop, fully fund, and implement a schedule for rotovation to control EWM along the edge of BCR, at a minimum, and at all public boat ramps and access points;

2. Fully fund and implement as necessary, other actions to supplement rotovation;

3. Develop, fully fund, and implement a monitoring plan to determine the effectiveness of any implemented treatment as a means to reduce the density of EWM plants within treatment areas;

4. Develop and implement an ongoing public education and signage plan for the Project area to educate the public about the dangers of spreading EWM to other waters; and

5. Update the plan at least every 5 years incorporating improved technology for the control or eradication of EWM.

## 3.0 GOAL AND OBJECTIVES

The goal of this Aquatic Plant Management Plan is to guide the use of environmentally compatible cost-effective methods to manage the distribution of aquatic plants, and through education and site specific treatment, minimize risk for expansion of invasive aquatic plant species to waters surrounding the Pend Oreille River. This management approach reflects multiple resource management objectives and includes public involvement and education activities.

Objectives:

1. Define aquatic plant management actions for specific areas within the Pend Oreille River Management Reach, specifically all public access areas, public and high-use private boat launches, select aquatic habitat refugia.

2. Provide guidance and evaluation of the rotovation/harvesting program in order to minimize the spread of non-native aquatic plant species to other water bodies and maximize a safe environment for recreational users.

3. Identify and provide access to information on additional aquatic plant control alternatives that can be initiated at the homeowner and institutional level.

## 4.0 HISTORY OF AQUATIC PLANT MANAGEMENT IN THE REACH

In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2, 4-dichlorophenoxyacetic acid (2,4-D DMA) was tested for use in the control of EWM (WATER

1988). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide. In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The Pend Oreille River program was the first large-scale operation of its kind in the United States.

Historically Pend Oreille County and the National Aquatic Weeds Program of the U.S. Army Corps of Engineers each provided 50% of the funding for the rotovation program. By 2007, when FERC approved the amended IAPMP, the District, through a MOU with the County, funded between 50% and 90% of the rotovation program to a maximum of $80,000 annually.

One major goal of the IAPMP was to acquire a second mechanical removal machine to replace or augment the current aging rotovator. This goal was met in 2008 due to a mandated $50,000 contribution by the District, $40,000 from Pend Oreille County, and a $200,000 by Tech Cominco America, under the stipulation that the new machine be a harvester not a rotovator to reduce water quality issues during summer low flow. The new harvester was tested and permitted in the summer of 2009. Due to a lack of funding in 2010, Pend Oreille County terminated its aquatic plant management activities and transferred ownership and operation of the rotovator, harvester, and all associated equipment to the District.

In subsequent years, the District has managed the APMP program first to meet mandatory conditions of the license order, then address any remaining goals of the IAPMP with District or grant funds when available.

Treatment in the Management Reach has changed several times since it first began. Increased operator skill and knowledge of treatment areas, removal of underwater obstacles (see permit conditions in appendix E), and the choice between two different types of machines has increased speed of treatment in recent years. Historically all treatment areas, regardless of priority, were rotovated, on average, once every 18 to 24 months, and approximately 200 acres of shoreline weed bed adjacent to private docks was rotovated per year, moving from one end of the reservoir to the other.

### 4.1 Recent Changes to Treatment Methods and Schedule

The reason a plan update was necessary is that three significant changes have occurred to aquatic plant treatment in the last 5 years of APMP implementation. The first was a result of effectiveness monitoring at boat launches in 2007 and 2008 that indicated EWM regrowth was occurring at many launches before the 18 to 24 month rotovation schedule provided sufficient removal. In 2009, the District requested a change in treatment schedule requiring rotovation of each public and high use private launch at least once each year at a time of low water, during spring and/or fall to address EWM regrowth. This new treatment schedule was implemented to ensure the highest level of protection at these potential points of transmission. Effectiveness surveys completed in 2010 through 2013 indicate this new boat launch treatment schedule remains highly effective.

The second change came as a result of extensive environmental impact testing for both the harvester and rotovator to secure new Hydraulic Project Approval (HPA) permits for each machine. The studies were performed in 2008 and 2009 (Appendix B). These studies provided guidance for a low impact implementation schedule and developed suggested BMPs for each machine to assist in the permit application process.

The newly developed BMPs required an alternating implementation schedule for the two machines. The rotovator was restricted to treating priority areas at times of the year when water temperatures are below 65 ºF(18.3 ºC), while the harvester could only start working after spring high-waters recede and water temperatures are 65 ºF(18.3 ºC) and higher. This 65 ºF(18.3 ºC) compliance point for both machines was selected by WDFW and included in the current permits based results of the impact studies in Appendix B. The goal of this management schedule is to reduce use of the rotovator during times of lower efficiency and focus harvester activity when warmer temperatures reduce the likely hood that the harvester will encounter and potentially impact a sensitive species of fish.

The third change to standard treatment was developed in response to the colonization of several treatment areas by *Butomus umbellatus* Flowering rush (FLR) a Class A noxious weed. Due to the presence of FLR at or near several sites in the treatment area, standard treatment including rotovation and harvesting will be limited to sites known to be free of FLR.

Launches or treatment areas with untreated or partly treated FLR present below the water line will only be harvested, with no rotovation until 4 consecutive annual surveys have shown the treatment area to be clear of FLR, or it is determined by the Sub-committee that rotovation is unlikely to further exasperate the spread of FLR in system. Diver assisted removal, ground barrier treatments or alternative treatments will be performed on FLR at the treatment sites annually to address any new occurrences and allow harvesting of the other vegetation to complete site treatment.

## 5.0 AQUATIC PLANT COMMUNITY

The majority of the aquatic plant communities within the Pend Oreille River, inclusive of sloughs, consist of mixed beds of native and non-native plants. At least nineteen aquatic plant species are known from the Management Reach (Table 1). Of these, the non-native EWM and *Potamogeton crispus* or Curly leaf pondweed (POCR) have been known to dominant the system as a whole. Past surveys have shown as much as eighteen percent of the vegetated acres were comprised of near monoculture beds of EWM. EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep.

Annual index site surveys show overall, EWM occurrence varies dramatically from one year to the next. Years of low EWM dominance tend to follow unusually high or relatively long snowpack run-off out of the mountains of Idaho and Montana which restricts early season growth. Consecutive annual surveys suggest effects of high water years on EWM population carry over to one or more following years (see APMP annual reports 2007 through 2013).

Aquatic plant vegetation tends to be greatest in the reach from Riverbend to Furport (RM 60.0¬80.0). This reach of river is wide, shallow and tends to have the greatest littoral habitat and substrate suitable for aquatic plant growth. Thirty-five percent of the wetted area within this reach is vegetated, with the majority of the vegetated area classified as having dense/moderate growth.

The abundance of POCR was notably less in 2007 through 2010 surveys relative to 1997, or 2011 through 2013. This non-native species was one of the most abundant plant species observed in 1997, but was only seen in a few of the index sites until the last few years. *Potamogeton natans* or Floating-leaved pondweed (PONA), a native species, was less common in 1997; however, it was dominant at many of the index sites in recent years. Information on the presence of the FLR, from District surveys and from independent surveys by the County and Washington Department of Ecology, show individual plants in up to 4 index sites and near several more.

**Table 1. Common Aquatic Plants within the Management Reach**

| **Common Name** | **Scientific Name (Acronym)** | **Native to Pend Oreille County** |
|---|---|---|
| Eurasian Watermilfoil | *Myriophyllum spicatum (EWM)* | No |
| Siberian Watermilfoil | *Myriophyllum sibiricum (EWM)* | Yes |
| Curly leaf pondweed | *Potamogeton crispus (POCR)* | No |
| Coontail | *Ceratophyllum demersum (CEDE)* | Yes |
| Waterweed | *Elodea Canadensis (ELCA)* | Yes |
| Water star-grass | *Heteranthera dubia (HEDU)* | Yes |
| Close-leaved pondweed | *Potamogeton foliosus (POFO)* | Yes |
| Long-leaved pondweed | *Potamogeton nodusus (PONO)* | Yes |
| Fennel-leaved pondweed | *Potamogeton pectinatus (POPE))* | Yes |
| Eel-grass pondweed | *Potamogeton zosteriformis (POZO)* | Yes |
| Robbins' pondweed | *Potamogeton robbinsii (PORO)* | Yes |
| Richardson's pondweed | *Potamogeton richardsonii (PORI)* | Yes |
| Yellow flag iris | *Iris pseudacorus (YFI)* | No |
| Flowering rush | *Butomus umbellatus (FLR)* | No |
| Floating-leaved pondweed | *Potamogeton natans (PONA)* | Yes |
| **Incidental species** | | |
| Nuttall's waterweed | *Elodea nutallii (PONU)* | Yes |
| (No Common Name) | *Zannichellia palustris (ZAPA)* | Yes |
| Diverse-leaved pondweed | *Potamogeton diversifolius (PODI)* | Yes |
| Large-leaved pondweed | *Potamogeton amplifolius (POAM)* | Yes |
| Grass-leaved pondweed | *Potamogeton gramineus (POGR)* | Yes |
| Whitewater crowfoot | *Ranunculus aquatilis (RAAQ)* | Yes |
| Mixed Native Pondweed | *Potomogeton spp. (PON)* | Yes |

No aquatic plants known from the Pend Oreille River Management Reach are federally listed as endangered, threatened, or species of concern. Although several are currently maintained on the Washington Natural Heritage Program's list of Known Occurrences of Rare Plants in Washington for Pend Oreille County.

# 6.0 METHODS

## 6.1 Treatment

### 6.1.1 Rotovation and Harvesting

The District began operating the annual aquatic plant management program with the primary effort focused on all high use public and private boat launches and special use areas in 2011. The District will no longer be treating private docks or shorelines unless they are specified as a high use area in the APMP or indicated as a priority by a resource agency during the annual review process. The District will continue to haul plant material away from public boat launches immediately after treatment where off-site removal has been specified.

Annual Rotovation will begin as soon as weather and river conditions allow, and will continue until high flows prevent useful operation, or at a time when all the high use areas have received treatment. Rotovation is most effective at root removal and has the least impact on fish when operated at times of the year when leaf/stem biomass is low (Apendix B). This preferred period of operation occurs after dieback in the fall through spring before runoff. In early spring of each year, (February through April) and / or in the fall after river flows recede (November through December), rotovation will focus on all public recreation and access areas.

After spring high-water subsides, work will shift primarily to the harvester. To maximize the cutting effectiveness of the harvester, treatment begins mid-June to mid-July, at a point when flows drop to under 40,000 kcfs and lowering water elevations in the river start exposing new summer growth. As suggested by the recommended BMP's listed in appendix B the harvester will only operate during the warmer summer months to reduce potential interactions and impacts with native salmonids which require cold water. To provide a clear management point a minimum water temperature of 65 $^{o}$F(18.3 $^{o}$C) was provided as a condition of the HPA for harvester operation. This warm water season typically extends through October, with the continued focus on maintaining weed free boat launches and public recreation areas as waters recede.

The default treatment area surrounding a public boat launch, regardless of machine used, will include 50 feet along the shoreline on either side of the launch. This default treatment will also include any associated beach, boat landing area, or swim area, and will extend outward at a 45 degree angle to a water depth of 18 feet, or the edge of the aquatic plant bed, whichever is less deep (figure 1 and appendix D). Treatment depth will depend on the machine. The effective maximum depth of the Rotovator is 18 feet and the harvester is 6 feet.

At present, standard site specific plans call for rotovation and/or harvesting of all aquatic vegetation within the default treatment area and off-site disposal of all collected plant material. The two common exceptions to this treatment plan include:

- Sites identified during surveys as "No Action Required" (e.g., no noxious or hazardous weeds present). If a priority launch/swim area receives a "No Action Required" designation, summer low-flow checks during harvesting will still be required to monitor and manage for potential regrowth.

- Sites identified with current or historic presence of FLR. Due to the unknown effectiveness of individual treatments and regrowth potential, these sites will be treated on a site by site basis according to the FLR treatment area protocol below.

6.1.2 Flowering Rush Treatment Areas

Due to the relatively new presence of FLR at several treatment areas, alternate treatment methods will be employed to remove this and other vegetation if necessary at sites colonized by FLR. Based on site conditions, location, severity of the infestation, and depth of the clone(s) present the most cost effective option or combination of treatments will be selected and applied.

Limited information is known regarding the effectiveness or limitations of each alternate method. Potential FLR treatment alternatives include, but are not limited to:

- Hand pulling
- Diver assisted pulling
- Diver assisted suction removal
- Framed barrier installation
- Bio control agents
- Herbicide

All treatment activities involving FLR will be done with a fragment collection net deployed. Nether herbicide nor bio control agents are currently proposed for use in treating FLR under this plan but will be considered as a treatment option, per approval of the Subcommittee.

6.1.3 Yellow Flag Iris Treatment

The District acquired a Forest Service Title II grant to aid the management of EWM and *Iris pseudacorus* or Yellow flag iris (YFI). Using part of these funds in 2012 District staff mapped the both shorelines of the Box Canyon reservoir noting location and approximate cluster size of YFI. Its presence was documented at or near 6 boat launch treatment sites including, Alaska Lane, Panhandle, Pondoray Shores, Lazy River Farmettes, Cusick, and Edgewater.

Initial treatment followed, starting in the fall of 2013, 14 individual stands of iris were treated with herbicide at these boat launch sites in the fall while low water allowed for spraying in the dry. This effort was done under contract with the County Weed Board under existing permits. Additional treatments followed as needed targeting early fall when water levels are at their lowest and YFI plants are actively moving carbohydrates to roots. No herbicide treatments will be done on plants below the waterline.

## 6.2 Monitoring

6.2.1 Aquatic Plant Monitoring at Boat Launches

The FERC issued a license order on September 7, 2007, approving the District's final amendment to the APMP. This amendment focused on additional treatment and prioritization of treatment of EWM around the public boat launches in the BCR to address Forest Service (FS) concerns about the spread of non-native invasive aquatic plants from the BCR to other waters on nearby FS lands. The amendment to the APMP notes that the intensity of the treatment at each boat launch is to be commensurate with the level of boat activity at each launch and the composition of the nearby aquatic plant beds.

A first survey of the boat launches was completed in 2006 to gather information for developing site-specific plans. Information gathered included:

1) Beneficial use considerations at the boat launch;
2) Character of the plant bed, such as density, length, and width of the plant bed, and percent of EWM and curly leaf pondweed;
3) List of treatments;
4) List of options for disposal of plants; and,
5) List of alternative treatment options, if available.

Annual monitoring will occur at each public boat launch. Monitoring will cover the entire potential treatment area for each launch and associated swim area as shown in Appendix D. Monitoring will occur from August to early October when plant biomass is at its peak and the water elevation is low. Surveyors will visually estimate the outer boundary of aquatic plant beds using a classification system similar to that used in the 1997 survey (Appendix A). The density of infestation will be noted for each plant bed within the treatment area (dense or sparse). The date and type of treatment will be noted in the survey report. The three most dominant species within each plant community will be recorded as well as the location and concentration of any noxious weed. Field notes will be prepared on the standardized form shown in Figure 1 and hand sketched maps indicating each zone of growth will be drawn on the aerial photos of each treatment area Appendix D. The updated (hand sketched) maps will be archived along with field data forms. Results from the each year’s annual surveys will be incorporated into the site specific treatment program starting the following spring.

The effectiveness of site specific treatment strategies will be reviewed annually; however, it is recognized that three to five years of treatment may be necessary to fully evaluate the effectiveness of some strategies.

**Site Specific Strategy for Aquatic Plant Management Near boat Launches in Box Canyon Reservoir**

Survey Date ________________ Person(s) preparing plan: ______________________

Site Name ___________________ TWP/SEC/R _________ River Mile/Bank_______

**Aquatic Plants** *Characterize aquatic plants and draw on sketch map (Note: aquatic plant beds at site may be divided into sub-areas if distinct differences are observed. Note dimensions of treatment area and estimated length (ft) and width (ft) of each sub-area plant bed within treatment area. List 3 most dominant species; note overall density for all plants; estimate % invasive species (nearest 10% increment) based on % of total area of plant bed*

<u>Sub-Area 1</u> (use this if only one type of plant bed) Length (ft)________ Width (ft)_____
Dominant species (1) ______________ (2)______________ (3)________________
Circle One: Dense Sparse %FLR ____________% EWM_________ %POCR_______

<u>Sub-Area 2</u> (use this if only one type of plant bed) Length (ft)________ Width (ft)_____
Dominant species (1) _______________ (2)_________________ (3)________________
Circle One: Dense Sparse %FLR ____________% EWM_________ %POCR___________

<u>Sub-Area 3</u> (use this if only one type of plant bed) Length (ft)________ Width (ft)_____
Dominant species (1) _______________ (2)_________________ (3)________________
Circle One: Dense Sparse %FLR_____________% EWM_________ %POCR___________

Yellow Flag Iris Present Yes / No
Flowering Rush Present Yes / No

**Check which beneficial use considerations apply and add comment**

| | **Beneficial Uses** | **Comment** |
|---|---|---|
| | Safety for boaters | |
| | Safety for swimmers | |
| | Level of boater use of ramp | |
| | Approach pattern for boats to and from ramp | |
| | Do boats beach or spend time in immediate area | |
| | Other beneficial uses at site | |
| | Cultural resources | |

Comments_____________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

Figure 1. Standardized boat launch monitoring form.

Survey Date _________ Person(s) preparing plan: ___________________________
Site Name ____ TWP/SEC/R _________ River Mile/Bank_______

**Preferred Option(s) for treatment M**ore than 1 strategy may be elected; sub-areas may be treated differently. Note both short term (2-5 years) and long term strategy

| **No.** | **Treatment** | **Acres** | **Cost/Acre** | Total Cost |
|---|---|---|---|---|
| 1 | **Rotovation with Removal** | | | |
| 2 | **Rotovation without Removal** | | | |
| 2a | Plants placed on bank | | | |
| 2b | Removal by public | | | |
| 2c | Removal by heavy equipment | | | |
| 2d | Leave on bank above seasonal high water | | | |
| 2e | Plants placed on barge | | | |
| 3 | **Harvester with removal** | | | |
| 4 | **Diver hand pull and remove** | | | |
| 5 | **Bottom barriers** | | | |
| 6 | **Substrate armoring** | | | |
| 7 | **Chemical treatment** | | | |
| 8 | **Biological treatment** | | | |
| 9 | **Other** | | | |
| 10 | **No Action** | | | |

*Summarize Treatment strategy*

*Preferred Option for disposal of plant material*

| | | **Comment** |
|---|---|---|
| 1 | Access for alternate treatments | |
| 2 | Constraints for placing plant material onshore for disposal | |
| 3 | Access for equipment to retrieve and transport plant material offsite | |
| 4 | Likelihood of public use of rotovated plant material | |
| 5 | Hazard and/or aesthetic concerns for plant material place on shoreline | |

*Summarize disposal strategy*

Figure 1. Standardized boat launch monitoring form (Continued).

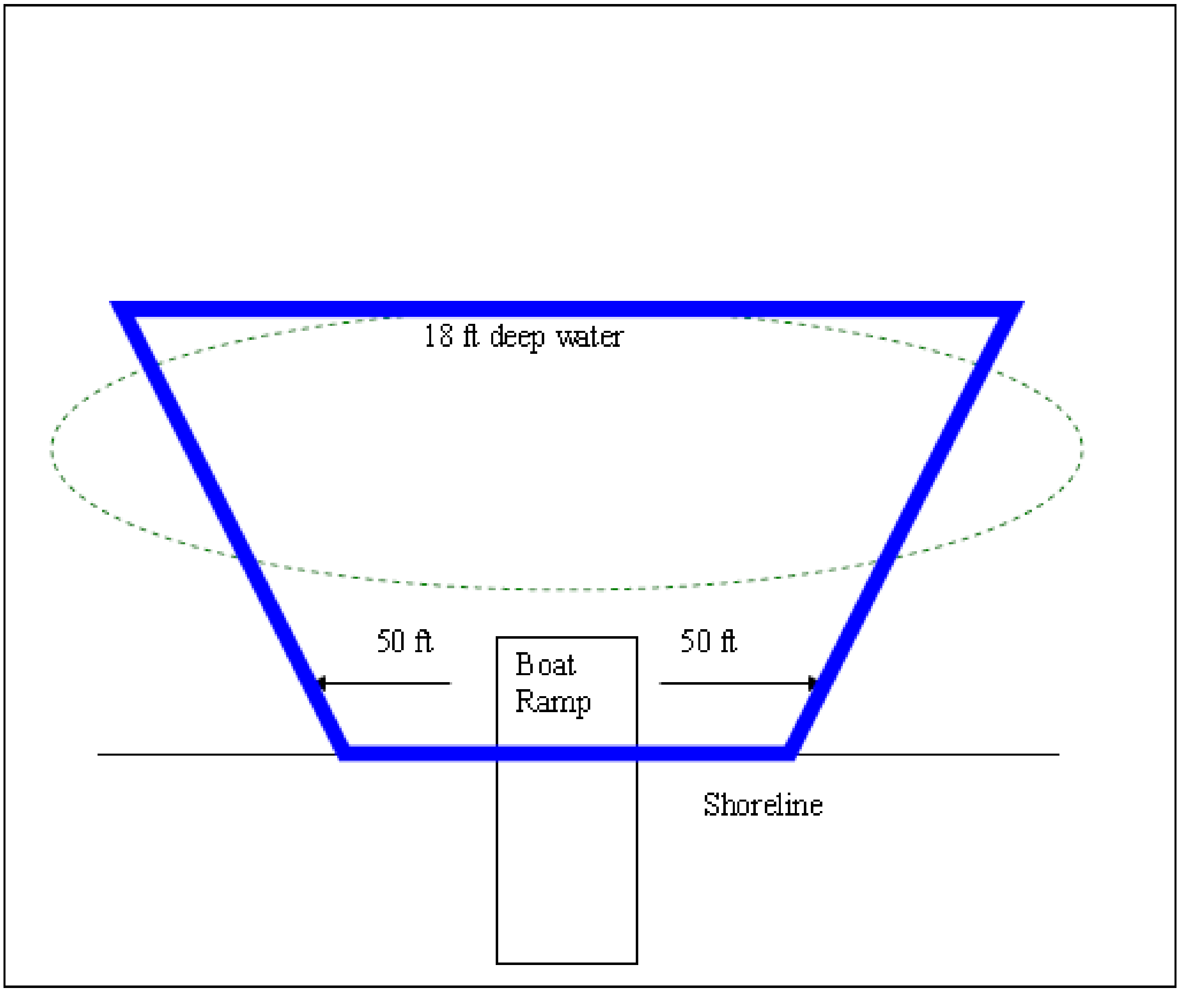



**Figure 2 Typical treatment area near public boat launch** The treatment area is shown in heavy blue line. The portion of the aquatic plant bed (dashed green line) that is within the treatment area will be treated according to site specific plan

Figure 1. Standardized boat launch monitoring form (Continued).

## 6.2.2 Aquatic Plant Index Site Monitoring

The APMP specifies techniques for annual monitoring to track trends in the distribution, composition, and abundance of aquatic plants within BCR. Twenty index sites were established for annual monitoring of aquatic plant communities. The majority of the index sites encompassed an area approximately 300 yards (275 m) in length parallel to the shoreline and extending from the shoreline outward to a depth of 18 feet (approximately 5.5 m), which is the limit for most aquatic plant growth in the Pend Oreille River. At some of the index sites, the survey area was modified to adapt to localized channel topography. The index sites were distributed throughout the length of the Pend Oreille River between Albeni Falls Dam and the Box Canyon Dam safety net. The selected index sites represent a range of aquatic plant community types. Maps showing the location of each index site and an inset of each transect location are shown in Appendix C.

Three transects were established at each index site. Each transect extends perpendicular from the shoreline out to the edge of the aquatic plant bed or to a water depth of 18 feet, whichever comes first. The first transect was located at the upstream end of the index sites. Subsequent transects were established at approximately 100 yard (92 m) increments downstream. Each transect width is approximately 40 feet (12 m).

Surveys are conducted along each transect beginning from the shore end. Visual assessments are made from a boat platform to characterize the relative density and composition of plants along each transect. Stations are recorded at each point where the density and/or composition of the plant bed changes. Station 1 is always at the closest boat access point to the shore. Data on plants between the shoreline and station 1 are recorded. Each station description is representative of the portion of the transect extending from that station outwards to the next station. A global positioning system (GPS) is used to record the geographic coordinates of each station along each transect. Depth readings are recorded at each station from the boat depth finder or weighted drop line.

Information recorded at each station includes:

- Geographic *x,y* coordinates
- Bottom depth
- Plant density (sparse or dense)
- Plant composition
  - Native – less than 10% non-native plants
  - Mixed – 10% - 49% non-native
  - Non-native - greater than 49% non-native
- Species observed

The plant community types used for the index monitoring are consolidated relative to those applied in the 1997 mapping effort (Appendix C). The previously mapped categories of “dense” and “moderately dense” were found to be not statistically different based on plant biomass. The 1997 mapping distinguished mixed beds with 10%-49% EWM from mixed beds with 50% – 89% EWM. Currently, general site categorization is assigned as **dense** or **sparse** for total vegetative cover, and **native**, **non-native,** or **mixed** rating for vegetation composition using the following category descriptions:

- Sites with 50% or more densely vegetated stations are designated Dense. Remaining sites are designated Sparse. (A densely vegetated station is an area with more that 50% ground cover.)

- Index sites with 50% or greater dominance by EWM and POCR at more than half of their stations are categorized as **Non-native**.

- Index sites with 90% or greater dominance by native vegetation at more than half of their stations are categorized as **Native**.
- All other index sites are categorized as **Mixed**.
- Stations with no vegetation are removed from analysis.

An example of how this rating system is applied is as follows:
Index Site #1 had three transects with a total of 12 vegetated stations. Nine of those stations were identified as dense; 9 of the 12 were 90% or more native vegetation, 1 was dominated by POCR and two were comprised of mixed vegetation; giving this site an overall rating of **Dense - Native**.

## 7.0 PUBLIC OUTREACH

There are four components to the APMP public outreach program.

- The first is a public meeting held annually in the summer to educate private landowners on plant identification, the benefits of native aquatic vegetation, tools and techniques for private nuisance vegetation management, and the resources available through the County.
- The second tool to assist in public outreach is a web site designed to inform users on District aquatic plant management goals and on-going treatment in the project area. The web page also provides information on nuisance species like EWM and curly leaf pondweed, FLR and YFI with links to other resources and agencies to help with private weed control programs. A key resource for private landowners to develop and permit individual aquatic weed control is a guidance document produced by WDFW called *Aquatic Plants and Fish publication #APF-1-98*. A link to this document and other information is provided on the District APMP web page which is hosted, maintained, and updated by the District, and can be viewed at: [http://www.popud.org/programs/milfoil-control](http://www.popud.org/programs/milfoil-control). https://www.popud.org/projects/box-canyon-dam/aquatic-weed-control/
- The District creates one or more Customer Connect digital newsletters per year with articles written to provide private landowners and customer's updated information similar to what is covered in the annual public meeting and website. These newsletters are emailed out to all our PUD customers on our mailing list (approximately 1,400) and is posted to all electronic billing notifications.
- The final tool used for public education is signage discussing the hazards of transporting aquatic plants from one system to another. The District installs and/or maintains these signs annually at all public and major private boat launches.

## 8.0 ANNUAL AGENCY MEETINGS AND APMP MODIFICATIONS

The APMP is a living document. Interested resource agencies and citizen representatives meet annually to review the Aquatic Plant Management Plan. The annual monitoring data will be reviewed at these District sponsored meetings. A schedule for rotovation / harvesting and other management activities planned within the coming year will be reviewed. The group will also consider information from other aquatic plant research and new aquatic plant control techniques to improve control efforts. The management plan will be updated annually as needed based upon input during public meetings and the annual resource agency meeting. The district will continue to participate in cooperative aquatic plant management efforts by the County and/or Tribe to the greatest extent possible within the scope of the FERC order.

## 9.0 PERMITTING

Rotovation, harvesting, and other invasive weed control activities require local and state permits, whether the activities are carried out by the county or by individual landowners. The District has completed intensive impact studies of the rotovator and harvester to assist in the permitting process the reports from those studies and subsequent permits are included in Appendix E. The District will maintain all permits required to meet the goals of this APMP. Any new management techniques will be reviewed prior to implementation to determine the extent of permits required. The District will work with all Tribal Federal, State and County entities to acquire all permits required to implement the measures in this plan. If the district cannot attain the permits required to perform an action within this plan it will continue with all remaining permitted actions and work with members of the APMP subcommittee to development alternative treatments.

# Appendix A

# Original APMP Documents

**Pend Oreille County Public Utility District**

Administrative Offices - P.O. Box 190 • Newport, WA 99156 • (509) 447-3137 • FAX (509) 447-5824
Box Canyon Hydro Project - P.O. Box 547 • Ione, WA 99139 • (509) 446-3137 • FAX (509) 447-6790

January 22, 2006 7

Ms. Magalie Roman Salas, Secretary
Federal Energy Regulatory Commission
Office of the Secretary
888 First St. NE, Room 1-A
Washington, D.C. 20426

SUBJECT: Box Canyon Hydroelectric Project FERC No. 2042
Forest Service Addendum to Aquatic Weed Management Plan

Dear Ms. Salas:

Public Utility District No.1 of Pend Oreille County (District), licensee of the Box Canyon Hydroelectric Project (Project) files the attached revised ADDENDUM to the AQUATIC PLANT MANAGEMENT PLAN FOR USDA FOREST SERVICE RESERVATION LANDS WITHIN BOX CANYON RESERVOIR to fulfill the requirements of The U.S. Forest Service 4(e) Condition No.17 in Appendix B to the District's License Order for the Project (112 FERC 61,055).

The U.S. Forest Service 4(e) Condition No. 17 states that:

"Within one year of license issuance, the Licensee shall prepare an Aquatic Plant Management plan in consultation with the USDA Forest Service and approved by the USDA Forest Service and file the plan with the Commission. The plan shall address the control of Eurasian water milfoil (EWM), within BCR and the prevention of the spread of this vegetation to other water bodies on National Forest System Lands.

The District filed the original plan on August 29th, 2006, as required, and the Forest Service while supportive of the approach, indicated they believed it did not fulfill the requirements of their condition. We have since been in consultation with the Forest Service to and modified the measures so that they now satisfy the Service's concerns for the boat launches and the National Forest lands within the Project boundary. According to our communications with the Forest Service and the attached letter, we understand we have now fully addressed the Forest Service concerns regarding aquatic weeds with the enclosed plan, which is being incorporated as an addendum to the Pend Oreille County plan.

Copies of consultation records regarding this plan are attached including a letter from the Forest Service approving the plan.

If you have questions or concerns regarding this filing, please feel free to contact me at (509) 447-9331.

Sincerely,

Mark Cauchy

Mark Cauchy
Director of Environmental and Regulatory Affairs

cc: Service list

Attachments

**SERVICE LIST**

Ms. Magalie Salas, Secretary
Federal Energy Regulatory Commission
888 First St. NE, Room 1-A
Washington, D.C. 20426

Mr. Erich Gaedeke
Federal Energy Regulatory Commission
Portland Regional Office
101 SW Main St., Suite 905
Portland, OR 97204

Mr. Christopher Watson, Attorney of Record
Department of the Interior
Office of the Solicitor
Division of Indian Affairs
1849 C Street NW, MS 6456
Washington, DC 20240

Regional Director Bureau of Indian Affairs
NW Regional Office
Attn: Mr. Robert Dach
911 NE 11th Ave.
Portland, OR 97232-4169

Ms. Susan B. Martin, Field Supervisor
Upper Columbia River Basin Field Office
U.S. Fish & Wildlife Service
11103 E. Montgomery, Suite 2
Spokane, WA 99206

Mr. Rick Brazell, Supervisor
U.S. Forest Service
Colville National Forest
765 S. Main
Colville, WA 99114

Mr. Glenn Koehn
U.S. Forest Service
Colville National Forest
765 S. Main St.
Colville, WA 99114-2507

Mr. Steve Zender
Washington State Department of
Fish and Wildlife
2525 Eagle-Lambert Road
Chewelah, WA 99109

Mr. Doug Robison
Washington State Department of
Fish and Wildlife
2315 N. Discovery Place
Spokane, WA 99216

Mr. Ron Kreizenbeck, Acting Administrator
U.S. Environmental Protection Agency
Region 10
1200 – 6th Avenue
Seattle, WA 98101

Ms. Jean Parodi
Washington State Department of Ecology
4601 N. Monroe, Suite 202
Spokane, WA 99205-1295

Cindy Robertson
Program Coordinator
Idaho Department of Fish and Game
P.O. Box 25
Boise, ID 83707

Charles Corsi
Regional Supervisor
Idaho Department of Fish and Game
2750 Kathleen Avenue
Coeur d'Alene, ID 83815

Mr. Glen Nenema, Chairman
Kalispel Tribe
P.O. Box 39
Usk, WA 99180-0039

Mr. Deane Osterman
Kalispel Indian Tribe
Box 39
Usk, WA 99180

Mr. Phillip Katzen
Kanji & Katzen
100 S. King St, Suite 560
Seattle, WA 98101

200701235016 Received FERC OSEC 01/23/2007 11:46:00 AM Docket# P-2042-000

**Addendum December 2006**
**Aquatic Plant Management near Public Boat Launches in Box Canyon Reservoir**

The spread of Eurasian watermilfoil (EWM) from Box Canyon Reservoir to other waterbodies in Pend Oreille County and waters within nearby US Forest Service lands is a key concern. Plant material inadvertently transported on watercraft is a common mode of spread for invasive aquatic plants. The County's Interim Aquatic Plant Management Plan (IAPMP) lists a management goal for public boat launches as "maximizing the reduction and containment of identified problematic macrophytes [around public boat launches] through rotovation and education." There are 22 public boat launches within Box Canyon Reservoir (District 2000). Their locations are shown in Figure 1. Currently, the rotovator treats aquatic plant beds at these boat launches similar to other target areas within Box Canyon Reservoir (BCR). Treatment now occurs approximately once every 18 months at any given site. The standard treatment is rotovation of plant beds and, where feasible, the plant material is stacked on the bank. Further reduction in the density and duration of the presence of EWM and curly pondweed (both non-native invasive species) in the near vicinity of public boat launches within BCR is desired.

The County's IAMP will be updated to note the following objectives and actions directed at the containment of non-native aquatic plant species around public boat launches in BCR.

The objective for aquatic plant management in the vicinity of public boat launches is to minimize the spread non-native aquatic plants to other water bodies and maximize a safe environment for recreational users.

A prescription will be developed specific to each public boat launches within BCR. This strategy will be based on a site inspection of the site and will guide treatment of aquatic plants. Table 1 lists factors to consider when developing a site specific strategy. Table 2 is a list of possible treatments. Actions other than those listed in Table 2 may be elected if new technologies or existing alternatives better ensure meeting management objectives. Attachment A is a form to be used when preparing a site specific strategy.

The default treatment area surrounding public boat launches includes 50 ft along shoreline to either side of launch and extending outwards at a 45 degree angle to a water depth of 18 ft or edge of aquatic plant bed, whichever is lesser. A typical treatment area is shown in Figure 2.

Annual monitoring will occur at each public boat launch. Monitoring will include the entire treatment area. These monitoring sites are in addition to the index sites identified in the IAMP. Monitoring procedures will be similar to those listed in the IAMP for the index sites. Monitoring will occur in August through early September when plant biomass is at its peak. Surveyors will visually estimate the outer boundary of aquatic plant beds using a classification system similar to that used in the 1997 survey. The 1997 aquatic plant maps will serve as a base map for initiating surveys. The treated area will be assumed to match that described on the site specific strategy for a given boat launch.

The density of infestation will be noted for each plant bed within the treatment area (dense or sparse). The date and type of treatment will be noted in the survey report. The three most dominant species within each plant community will be noted. Field notes will be prepared on a standardized form. The updated (hand sketched) maps will be archived along with field data forms. The effectiveness of site specific strategies will be reviewed annually; however, it is recognized that three to five years may be necessary to fully evaluate the effectiveness of some strategies.

The schedule for developing and implementing site specific plans for boat launches will be initiated in summer 2006. The District and the County will inspect each site and cooperatively develop site strategies using the form in Attachment A. These strategies will become part of the IAMP. Implementation of the strategies will begin implementation in 2007. Initially, in 2007, implementation will be constrained to being within the current budget level for the aquatic plant management in BCR. If alternate strategies are identified that require funding in excess of that currently available, the District will work with the County to seek additional funding sources.

If for some unforeseen reason the County suspends participation in the aquatic weed program, the District will fully fund implementation of the site specific aquatic plant management prescriptions developed for all public boat launches. In addition, the District will monitor and treat any new future public boat ramps. The primary treatment at public boat launches is rotovation and removal of aquatic vegetation. Removal is defined as transporting the rotovated vegetation for disposal at a location where it can not be re-introduced into the reservoir within the range of seasonal water levels. The site specific plans will include designation of onshore temporary storage locations as well as details on how the plant material will then be moved for off-site disposal. In addition to or in lieu of rotovation with removal, other actions, that best address the site specific plan objectives for each boat launch will be fully funded by the District. The District's commitment to fund the rotovation program does not preclude the District or other parties from seeking support funding for this program from other third parties.

In consultation with the Forest Service, the District will also evaluate and implement new measures at all public boat launches based on site specific plan objectives for each boat launch as new methods become available and are accepted as scientifically sound and effective practices by state and local agencies.

**Table 1 Factors to consider when developing site specific strategies for boat launches**

| | Beneficial Uses | | Treatment |
|---|---|---|---|
| 1 | Safety for boaters | 11 | Rotovator access |
| 2 | Safety for swimmers | 12 | Underwater obstructions |
| 3 | Level of boater use of ramp | 13 | Bed slope and range of water depths |
| 4 | Approach pattern for boats to and from ramp | 14 | Substrate size |
| 5 | Do boats beach or spend time in immediate area | 15 | High water velocities |
| 6 | Other beneficial uses at site | 16 | Low water velocities |
| 7 | Cultural resources | 17 | Frequency of treatment needed |
| | **Character of Plant Bed** | 18 | Cost of alternate treatments |
| 8 | Size of area supporting plant growth | | **Removal & Disposal of plants** |
| 9 | Density of plants | 19 | Access for alternate treatments |
| 10 | % invasive plants (EWM & curly pondweed) | 20 | Constraints for placing plant material onshore for disposal |
| | | 21 | Access for equipment to retrieve and transport plant material offsite |
| | | 22 | Likelihood of public use of rotovated plant material |
| | | 23 | Hazard and/or aesthetic concerns for plant material placed on shoreline |

**Table 2 Treatment Alternatives for Boat Launches**

| No. | Treatment |
|---|---|
| 1 | **Rotovation with Removal** |
| 1a | Plants placed on bank |
| 1b | Removal by public |
| 1c | Removal by heavy equipment |
| 1d | Leave on bank above seasonal high water |
| 1e | Plants placed on barge |
| 2 | **Rotovation without Removal** |
| 3 | **Harvester with removal** |
| 4 | **Diver hand pull and remove by suction pump** |
| 5 | **Bottom barriers** |
| 6 | **Substrate armoring** |
| 7 | **Chemical treatment** |
| 8 | **Biological treatment** |
| 9 | **Other** |
| 10 | **No Action** |

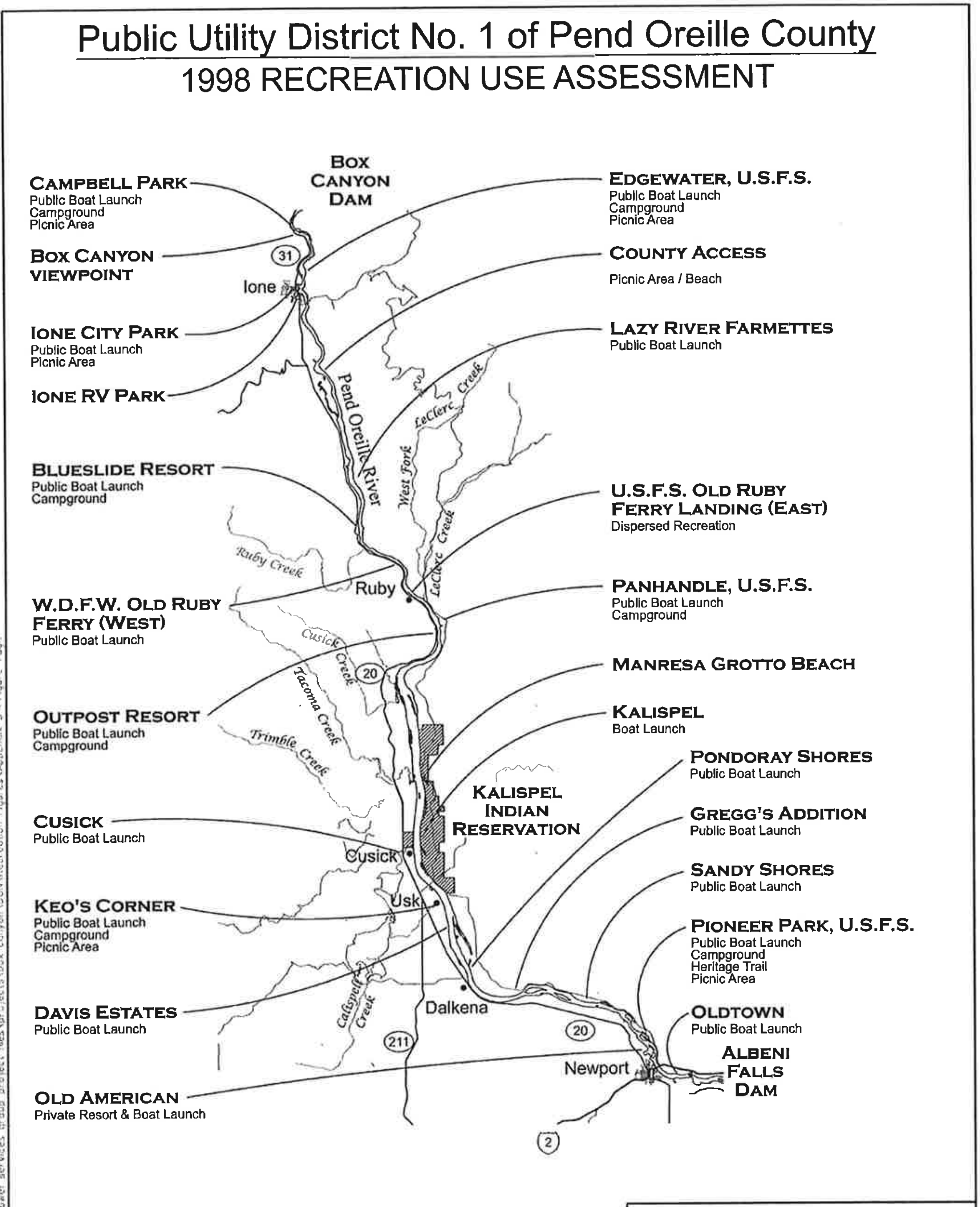



FIGURE 1
RECREATION STUDY
AREA MAP

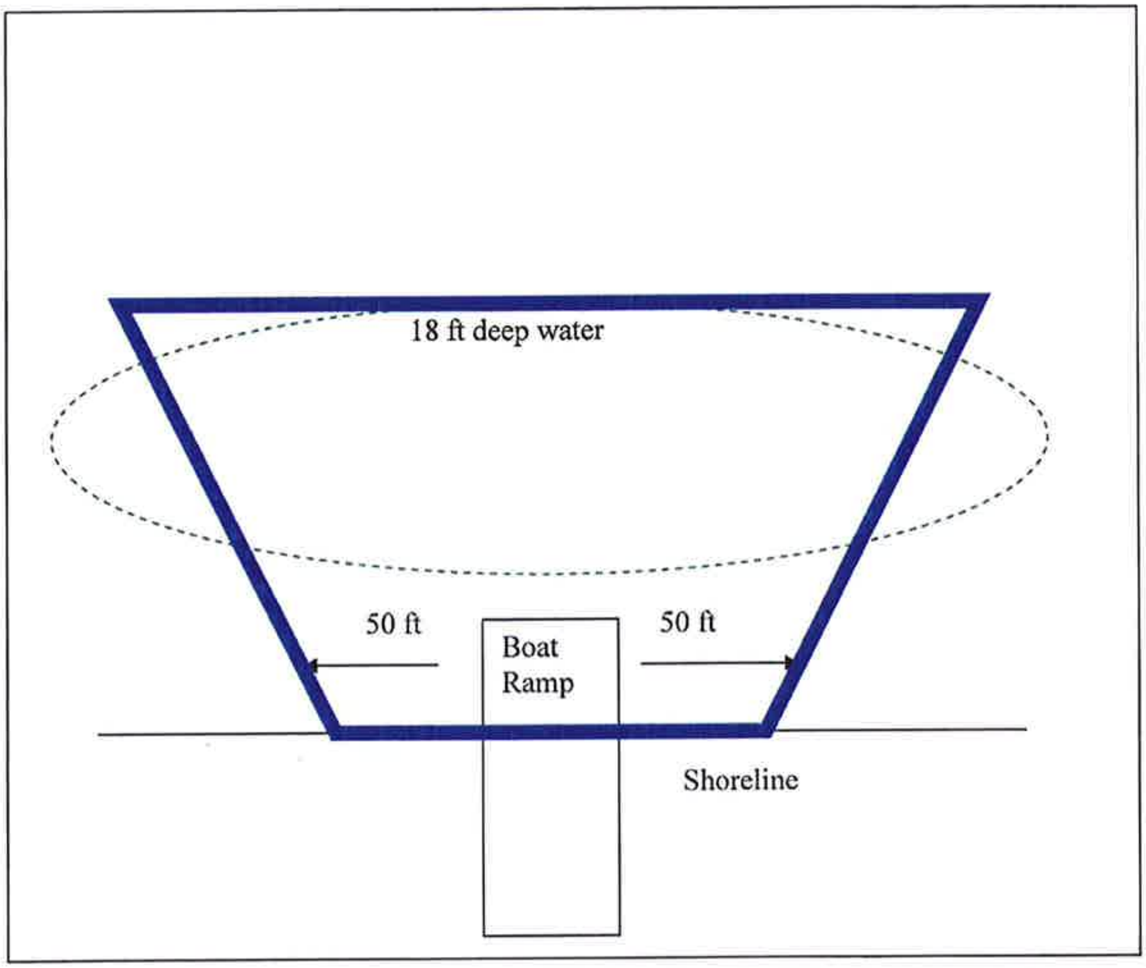



**Figure 2 Typical treatment area near public boat launch**. The treatment area is shown in heavy blue line. The portion of the aquatic plant bed (dashed green line) that is within the treatment area will be treated according to site specific plan

**Site Specific Strategy for Aquatic Plant Management Near boat Launches in Box Canyon Reservoir**

Survey Date ________ Person(s) preparing plan ________________________

Site Name __________________ TWP/SEC/R ________ River Mile/Bank_______

**Aquatic Plants** *Characterize aquatic plants and draw on sketch map (Note: aquatic plant beds at site may be divided into sub-areas if distinct differences are observed. Note dimensions of treatment area and estimated length (ft) and width (ft) of each sub-area plant bed within treatment area. List 3 most dominant species; note overall density for all plants; estimate % invasive species (nearest 10% increment) based on % of total area of plant bed*

Sub-Area 1 (use this if only one type of plant bed) Length (ft)_______ Width (ft)_____
Dominant species (1) ______________ (2)_______________ (3)_____________
Circle One: Dense Sparse % EWM________ %POCR__________

Sub-Area 2 (use this if only one type of plant bed) Length (ft)_______ Width (ft)_____
Dominant species (1) ______________ (2)_______________ (3)_____________
Circle One: Dense Sparse % EWM________ %POCR__________

Sub-Area 3 (use this if only one type of plant bed) Length (ft)_______ Width (ft)_____
Dominant species (1) ______________ (2)_______________ (3)_____________

Circle One: Dense Sparse % EWM________ %POCR__________

**Check which beneficial use considerations apply and add comment**

| | **Beneficial Uses** | **Comment** |
|---|---|---|
| | Safety for boaters | |
| | Safety for swimmers | |
| | Level of boater use of ramp | |
| | Approach pattern for boats to and from ramp | |
| | Do boats beach or spend time in immediate area | |
| | Other beneficial uses at site | |
| | Cultural resources | |

Comments____________________________________________________________

200701235016 Received FERC OSEC 01/23/2007 11:46:00 AM Docket# P-2042-000

Survey Date __________

Site Name ______________________ TWP/SEC/R __________ River Mile/Bank ________

**Preferred Option(s) for treatment** More than 1 strategy may be elected; sub-areas may be treated differently. Note both short term (2-5 years) and long term strategy

| No. | Treatment | Acres | Cost/Acre | Total Cost |
|---|---|---|---|---|
| 1 | **Rotovation with Removal** | | | |
| 1a | Plants placed on bank | | | |
| 1b | Removal by public | | | |
| 1c | Removal by heavy equipment | | | |
| 1d | Leave on bank above seasonal high water | | | |
| e | Plants placed on barge | | | |
| 2 | **Rotovation without Removal** | | | |
| 3 | **Harvester with removal** | | | |
| 4 | **Diver hand pull and remove** | | | |
| 5 | **Bottom barriers** | | | |
| 6 | **Substrate armoring** | | | |
| 7 | **Chemical treatment** | | | |
| 8 | **Biological treatment** | | | |
| 9 | **Other** | | | |
| 10 | **No Action** | | | |

*Summarize Treatment strategy*

**Preferred Option for disposal of plant material**

| | | Comment |
|---|---|---|
| 1 | Access for alternate treatments | |
| 2 | Constraints for placing plant material onshore for disposal | |
| 3 | Access for equipment to retrieve and transport plant material offsite | |
| 4 | Likelihood of public use of rotovated plant material | |
| 5 | Hazard and/or aesthetic concerns for plant material place on shoreline | |

*Summarize disposal strategy*

USDA United States Department of Agriculture | Forest Service | Colville National Forest | Headquarters Office
765 South Main
Colville, WA 99114
509-684-7000
Fax: 509-684-7280

**File Code:** 2770
**Date:** January 10, 2007

Mark Cauchy
Director Environmental and Regulatory Affairs
Pend Oreille County Public Utility District
PO Box 190
Newport , WA 99156



Dear Mr. Cauchy:

The Forest Service is in receipt of the *Addendum December 2006 Aquatic Plant Management Near Public Boat Launches in Box Canyon Reservoir* forwarded to this office by Pat Buckley, Natural Resource Manager, on December 27, 2006.

With the inclusion of this Addendum into the Aquatic Plant Management Plan approved by the Federal Energy Regulatory Commission (March 29, 2006) and its adoption by Pend Oreille County, the managing partner of the program, the USDA Forest Service approves the Aquatic Plant Management Plan required under Forest Service License Condition No. 17 (112 FERC 61,055 and 117 FERC 61,205).

The Forest Service appreciates the cooperative approach taken in developing this Addendum. We look forward to other cooperative efforts working with you and your staff in the implementation of the license for the Box Canyon project.

Sincerely,

for RICK BRAZELL
Forest Supervisor

cc: Betty M Higgins, Walt Dortch

**Pend Oreille County Public Utility District**

Administrative Offices - P.O. Box 190 • Newport, WA 99156 • (509) 447-3137 • FAX (509) 447-5824
Box Canyon Hydro Project - P.O. Box 547 • Ione, WA 99139 • (509) 446-3137 • FAX (509) 447-6790

December 27, 2006

Mr. Rick Brazell
US Forest Service
Colville National Forest
765 S. Main St.
Colville, WA 99114-2507

Re: Box Canyon Hydroelectric Project, FERC No. 2042
Aquatic Plant Management Plan per USFS 4(e) License Condition No. 17

Dear Mr. Brazell:

I am pleased to present to you the enclosed document entitled *Addendum December 2006, Aquatic Plant Management Near Public Boat Launches in Box Canyon Reservoir.* As you know, USFS 4(e) License Condition No. 17 in the new license (112 FERC 61,055) issued on July 11, 2005 for the Box Canyon Project (Project) requires the Public Utility District No.1 of Pend Oreille County, as licensee of the Project, to file an Aquatic Plant Management Plan (APMP) for approval of the USDA Forest Service.

The District believes that through the work of the Box Canyon Technical Committee Water Quality Subcommittee, agreement has been reached on the wording of the Forest Service's APMP, which will be incorporated as an Addendum into the Pend Oreille County's Aquatic Plant Management Plan (December 2005). The District is therefore requesting the Forest Service to respond with its agreement that the plan fulfills the requirements of the Forest Service's 4(e) Condition No. 17. The District would like to file the addendum, the MOU between the District and the County, this letter and the Forest Service response with the Federal Energy Regulatory Commission as soon as possible. Please contact me at 509-447-9334, or Mark Cauchy at 509-447-9331, if you would like to discuss this matter or need additional information.

Sincerely

Patrick V. Buckley
Natural Resource Manager

Enclosure
cc: Service List

## SERVICE LIST

Mr. Rick Brazell, Supervisor
U.S. Forest Service
Colville National Forest
765 S. Main
Colville, WA 99114

Mr. Glenn Koehn
U.S. Forest Service
Colville National Forest
765 S. Main St.
Colville, WA 99114-2507

Mr. Tom Shuhda
U.S. Forest Service
765 S. Main
Colville, WA 99114

Ms. Jean Parodi
Washington State Department of Ecology
4601 N. Monroe, Suite 202
Spokane, WA 99205-1295

Mr. Ron Curren
Director of Public Works
Pend Oreille County Planning Dept.
P.O. Box 5066
Newport, WA 99156

Pat Buckley
Natural Resources Manager
Pend Oreille PUD
P.O. Box 190
Newport, WA 99156

Mark Cauchy
Director, Regulatory & Environmental Affairs
Pend Oreille PUD
P.O. Box 190
Newport, WA 99156

Janet White
EES Consulting
570 Kirkland Way, Suite 200
Kirkland, WA 98033

Kent Doughty
EES Consulting
1155 N. State St., Suite 700
Bellingham, WA 98225

# BOX CANYON LICENSE TECHNICAL COMMITTEE
## HABITAT SUBCOMMITTEE MEETING
## AQUATIC WEED ADDENDUM

November 29, 2006
Pend Oreille PUD, Newport
10:00 a.m.

Present: Tom Shuhda and Glenn Koehn, U.S. Forest Service; Ron Curren, Pend Oreille County; Pat Buckley and Mark Cauchy, Pend Oreille PUD

Via conference call: Jean Parody, WA State Department of Ecology; Janet White and Kent Doughty, EES Consulting, consultant to Pend Oreille PUD

The meeting was called to order at 10:07 a.m. by Mark Cauchy, Pend Oreille PUD.

<u>This meeting was recorded.</u>

The agenda for this meeting was reviewed.

Glenn Koehn explained the concerns of by the Forest Service regarding the Non- native Aquatic Weed Management Plan Addendum:

1. Fully funding of the rotovation and removal of the non-native aquatic weeds at the 22 public boat launches is not clearly stated within the addendum. Mark agreed that the language to address this concern will be supplied and added. Removal of the cut weeds at these boat launches was discussed. Ron Curren noted that the County may have sites available for storage and decomposition of hauled aquatic weeds. Mark noted that the District is willing to transport if access can be accomplished.
2. Fully funding of other measures to remove non-native aquatic weeds is not addressed as well. Other actions may be deemed necessary due to lack of success with rotovation. The addendum should note that additional work is going to be funded and carried out if necessary. Mark agreed that the District will supply and add the requested language. Any implementation of new measures is site specific and based on the site specific plans.

Kent Doughty noted that the Addendum does provide for other measures if rotovation is not a viable option.
Mark noted that "fully funded" may include available funds from entities other than the PUD.
Pat Buckley has surveyed the 22 public boat launches. Approximately 2/3 of boat ramps had high density aquatic weeds. Pat was also noting obstructions for the rotovator or sections that will not be easily accessible to the machine. Kent and Pat will use the maps and the survey data available to come up with some prescriptions.

200701235016 Received FERC OSEC 01/23/2007 11:46:00 AM Docket# P-2042-000



Ron expressed concern about obstructions that have not been identified or are very poorly located. These obstructions can cost the program days.

Other options of treatment were discussed including weevils, chemicals, etc.
Glenn indicated that the Forest Service is not interested in requiring specific treatment, but would like to keep open minds to new and innovative options.

If language within the addendum is corrected on the two issues addressed here today, that will be acceptable to the Forest Service. Mark will attempt to compile these changes within the next few days and send to Glenn for approval.

Future meetings:
The scheduling of future meetings was discussed. Mark will notify by email all members in order to set future meetings.

There being no further business the meeting was adjourned at 10:34 a.m.

MEMORANDUM OF UNDERSTANDING A-2006-47

This Memorandum of Understanding is made and entered into this 14th day of Aug, 2006, by and between Public Utility District No. 1 of Pend Oreille County (the PUD) and Pend Oreille County, Washington (POC).

This Memorandum of Understanding is for the administration of the Pend Oreille County Aquatic Weed Management Plan.

It is understood that under the requirements of the recently issued 50-year license for the Box Canyon Hydroelectric Project, the PUD is required to provide an annual update and review of the Pend Oreille County Milfoil Program for Aquatic Weed Management.

It is understood that the PUD and POC has had a long-standing relationship on the issue of milfoil. For water quality and safety issues, we need to continue with this management.

The parties agree as follows:

1. Revisions to the text of the Aquatic Management Plan will be made by Addendums on an annual basis, during the month of August each year.

2. Any Addendums considered shall be prepared following public meetings advertised and open to the public for its review and comments.

3. Staffs of both the PUD and POC may prepare revisions to the document, after review and approval by their respective Commissioners, that could be incorporated as living documents.

4. After approval, the Addendums shall be signed by the Board of Commissioners from both the PUD and POC.

BOARD OF COMMISSIONERS
PEND OREILLE COUNTY, WASHINGTON

Ken Oliver, Chairman

Dean Cummings, Vice-chairman

Mitch Brown, Member

ATTEST:

Clerk of the Board

**BOARD OF COMMISSIONERS**
**PUBLIC UTILITY DISTRICT NO. 1**
**OF PEND OREILLE COUNTY**

ATTEST:

Rachel Heckler
Clerk of the Board

Daniel L. Peterson, President

Curtis J. Knapp, Vice-president

Kenneth R. Hirsch
Kenneth R. Hirsch, Secretary

Submission Contents

**BOX CANYON HYDROELECTRIC PROJECT**
**FERC No. 2042**

# AQUATIC PLANT MANAGEMENT PLAN

**Prepared for**

**Public Utility District No. 1 of Pend Oreille County**
**Newport Washington**

**Prepared by**
**EES Consulting, Inc.**
**Bellingham, Washington**

EES Consulting

**December 2005**

**TABLE OF CONTENTS**

# 1.0 INTRODUCTION

The Washington Department of Ecology (WDOE) issued a water quality certification under section 401 of the Clean Water Act, for the relicensing of the Box Canyon Hydroelectric Project (FERC No. 2042), as an amended order dated February 21, 2003. The conditions of the certification were incorporated into the license for the Project, which was issued by the Federal Energy Regulatory Commission (FERC) on July 11, 2005 (112 FERC 61,055, ordering paragraph G). To comply with section II.D of the certification, the Public Utility District No. 1 of Pend Oreille County (District) submitted an Aquatic Plant Management Plan (APMP) to WDOE for review and approval within thirty days of license issuance.

## 1.1 Background

Pend Oreille County adopted and submitted the Interim Aquatic Plant Management Plan for the Pend Oreille River (RM 34.4-90.1) to WDOE in January 2004. The County is the primary entity for implementing the AQMP for Box Canyon Reservoir. This plan was adopted by the County Commissioners on January 12, 2004.

## 1.2 Discussion

The District supports the County's AQMP. The District has historically and continues to provide the majority of the funding for the County's rotovation program, which is a central component of the AQMP. The District also conducted many of the studies that form a basis for the AQMP. The cooperative approach of the District providing funding and technical support, and the County managing aquatic plant management programs for Box Canyon Reservoir has proven to be an effective arrangement that has been in place for more than a decade. The AQMP also has public support within Pend Oreille County and specifically within the community of residents with properties adjoining the reservoir. The AQMP has also been subject to a public review process.

Submitting a separate aquatic plant management plan to WDOE to satisfy the 401 requirement would be disruptive to the cooperative arrangements that are already in place and confuse established responsibilities. Therefore, the District is adopting AQMP, which the District developed together with the County, as the guide for aquatic plant management in Box Canyon Reservoir. This plan is a living document that can be adapted to management needs as the plan progresses. The plan includes a public process for reviewing and updating the plan periodically. It would be counter to the spirit of this plan for the District to modify it without public participation or submit an alternate plan to WDOE. The AQMP includes a statement of goals, characterization of the existing conditions, methods for containment of Eurasian watermilfoil and other non-native aquatic plants, monitoring methods, a schedule for plan implementation, and protocols for plan review and reporting. The District believes that this plan satisfies all of the requirements for an Aquatic Plant Management Plan under the WDOE 401 certification.

The County's AQMP is attached as an Appendix to this plan. The District is submitting this plan with its full support and in satisfaction of the requirement of the 401 certification for the submittal of an aquatic plant management plan. Although the 401 certificate states that implementation of the plan shall begin as soon as WDOE approves the plan, the County with the District's support will continue with its ongoing implementation of the plan.

Specific tasks that the District is responsible for in the implementation of the AQMP are:

a. Provide the County with funding for implementation of the APMP at the level of $80,000 annually, for the duration of the FERC license, or until the County is able to secure sufficient funding from other sources, or until the plan's success allows for reduced effort.

b. Work with WSU Extension Service and County Public Works to sponsor an annual public meeting to discuss aquatic plant management in Pend Oreille River and publicize the schedule for the rotovator for the upcoming year.

c. Establish a web-based posting site that identifies where rotovation will be occurring on a two-week to one-month interval.

d. Convene an annual meeting in cooperation with the County with participation by interested natural resource agencies and citizen representatives to review revisions to the aquatic plant management plan. This meeting will be held in the early spring so that any new actions can be implemented within the upcoming growing season.

e. Post and maintain signs at all public boat launches that educate river users about proper cleaning of watercraft to remove aquatic plant debris and minimize spread to other water bodies.

f. Work with the County to review and incorporate new aquatic plant control methods into the plan as they become available.

g. Work with the County to secure grants to support the plan.

h. Provide $50,000 in 2007 for the purchase of a second rotovator.

i. Annually monitor index sites as specified in the plan. The frequency of monitoring may be adjusted as the living document AQMP is implemented.

j. Investigate the feasibility and opportunities of a cost sharing program that supports property owners along the shores of Box Canyon Reservoir interested in implementing alternative treatments to aquatic plant beds as prescribed in the County's APMP. This will be a topic at the 2006 annual review meeting.

# APPENDIX A

# INTERIM AQUATIC PLANT MANAGEMENT PLAN FOR THE PEND OREILLE RIVER (RM 34.4-90.1)

# INTERIM AQUATIC PLANT MANAGEMENT PLAN FOR THE PEND OREILLE RIVER (RM 34.4-90.1)

**Prepared by:**
**Pend Oreille County**
**Newport, Washington**

**January 2004**

Pend Oreille County

# Board of Commissioners

*Mike Hanson*
District #1

*Mitch Brown*
District #2

*Sam Nicholas*
District #3

*Chris Mylar*
Clerk of the Board

(509) 447-4119
FAX: (509) 447-0595

Post Office Box 5025
Newport, WA 99156-5025

January 12, 2004

To whom it may concern:

We the Board of County Commissioners have reviewed and accept the Interim Aquatic Plant Management Plan for the Pend Oreille River "RM34.4-90.1".

Please contact our office if you have any questions.

Thank you.

Sincerely,

Sam Nicholas

Sam Nicholas, Chairman

Mitchell D Brown

Mitch Brown, Vice-Chairman

Mike Hanson

Mike Hanson, Member

BOCC/cm

# EXECUTIVE SUMMARY

Upon adoption by the Pend Oreille County Commissioners, this document stands as the Interim Aquatic Plant Management Plan for the Pend Oreille River between River Mile (RM) 34.4 and RM 90.1. Dense and nuisance growth of aquatic plants in this portion of the river, in particular the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) and to some extent, curlyleaf pondweed (*Potomogeton crispus*), creates a negative impact on beneficial uses such as swimming, boating, fish management, wildlife, and aesthetics.

This Plan describes the aquatic plant communities in the river, identifies management goals and objectives, describes beneficial uses in the river and explains the management strategies considered effective in minimizing negative impacts to beneficial uses by reducing aquatic plant density.

The primary management strategy is the continued use of rotovation and root-ripping. At least 200 acres will be rotovated during the dormant and early growing season and 100 acres root-ripped during the growing season, annually. Both shorelines will be followed and treated in an orderly fashion, currently moving downriver, turning around when the northernmost point of treatment is reached to move back up river again. Areas targeted for treatment -- rotovation or root-ripping -- include public boat launches, public swim areas, areas around private docks, and developed shorelines.

Several years ago at a milfoil workshop held cooperatively between the Pend Oreille Cooperative Extension Service, Pend Oreille County Noxious Weed Control Board (Weed Board) and Public Utility District No. 1 of Pend Oreille County (the District), discussion ensued between interested landowners and the office of the 5th Congressional District U.S. Representative regarding the benefit of operating a second machine. The discussion resulted in Congressional funding earmarked for half the purchase price of another Aquamog. In the meantime, the Aquamog the County currently operates to fulfill the management mission, nears the end of its useful life. As a county with a small tax base and limited industry, Pend Oreille County cannot afford even half the purchase price of a new Aquamog. Therefore, we seek grant funds to assist us by covering one quarter the cost of a new Aquamog to replace the aging equipment rather than operating it as a second vessel. Our plans for the remaining 25% (local match) includes drawing from the County and the District.

In addition to rotovation, private landowner control using hand cutting, weed pulling, weed rolling devices and bottom barrier mats to reduce aquatic macrophyte densities in localized areas will be encouraged. The Weed Board will also facilitate landowner groups who want to employ herbicide treatment to suitable localized areas by obtaining the required permit and coordinating contractor services.

This Interim Plan was prepared by Pend Oreille County, in consultation with the District, which has provided financial support to the O&M portion of the County's rotovation program for the past 10 years.

# TABLE OF CONTENTS

APPENDICES

Appendix A – Pend Oreille PUD Customer Survey, Aquatic Plant Management
Appendix B – Review of Rotovation Effectiveness Studies for the Pend Oreille River
Appendix C – A Literature Review of Control Methods for Management of Eurasian Watermilfoil
Appendix D – Aquatic Plant Maps
Appendix E – Consultation Record – Public Meetings/Involvement
Appendix F – HPA Permit
Appendix G – Rotovation History Maps
Appendix H – Biological Assessment for Box Canyon License Amendment
Appendix I – WDOE Water Quality Monitoring Data

# INTRODUCTION

The growth of aquatic plants in the Pend Oreille River between Albeni Falls Dam and the Box Canyon Dam has resulted in impacts to beneficial uses in the Reservoir. Large, dense beds of aquatic plants can impair recreational activities such as boating, fishing, and swimming. In addition, the proliferation on non-native species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potomogeton crispus*) may negatively impact resident warm-water and cold-water fish populations. In populated and popular recreational areas, dense aquatic plant growth also poses an aesthetic concern. Pend Oreille County (County), the Pend Oreille Public Utility District No. 1 (District), and members of the public formed the Box Canyon Water Quality Working Group to address these concerns.

Also of concern to the County is the condition of the existing Aquamog, which is used to rotovate the weed beds in the Pend Oreille River. The Aquamog is 15 years old and has been rebuilt a number of times. With a new machine, far less time will be required for maintenance and machine down time; therefore, it will be on the river a greater amount of time doing the job intended. The Aquamog that the County is seeking to secure grant funds for has more horsepower and can move faster and more efficiently because of design modifications.

# GOAL

The goal of this Interim Aquatic Plant Management Plan is to guide the use of cost-effective methods to manage the composition, structure, and distribution of aquatic plant beds and to minimize the expansion of invasive aquatic plant species within portions of the Pend Oreille River and surrounding waters. This management approach reflects multiple resource management objectives and includes public involvement and education activities.

# OBJECTIVES

- Define aquatic plant management actions for specific areas within the Pend Oreille River Management Reach that best address the target beneficial uses for that particular site.

- Provide guidance and evaluation of the rotovation program in order to maximize beneficial uses within the Management Reach.

- Identify additional aquatic plant control alternatives that can be initiated at the homeowner and institutional level.

- Acquire a new Aquamog for the County to use in continuing its mechanical treatment program.

# HISTORY OF AQUATIC PLANT MANAGEMENT IN THE MANAGEMENT REACH

In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2, 4-dichlorophenoxyacetic acid (2,4-D DMA) was tested for use in the control of EWM (WATER 1988). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide (WATER 1985). In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The Pend Oreille River program was the first large-scale operation of its kind in the United States.

Historically the National Aquatic Weeds Program of the U.S. Army Corps of Engineers provided 50% of the funding for the rotovation program. Currently, the District funds 90% of the rotovation program, with the County contributing the remaining 10% (pers. comm., P. Buckley, District, August 26, 2003).

Rotovating in the Management Reach has expanded since it first began, while overall treatment costs per area have declined during recent years. The decreased cost reflects increased operator skill and knowledge of treatment areas, removal of underwater obstacles, and increased speed of treatment. Treatment has been completed faster in many areas because of less aquatic plant biomass regrowth. Treatment areas are rotovated, on average, every 18 to 24 months. The County tracks these rotovated areas. Approximately 200 acres per year are being treated, with treatments focusing on high use areas of the river mainstem. The sloughs usually are not rotovated with the exception of Tiger Inlet and other populated areas providing there is adequate water depth to provide access. Rotovating is done year-round, weather and river conditions permitting, as high flows and ice restrict operations. Certain areas, such as Tiger Inlet, have seasonal restrictions for rotovating due to bass spawning.

# DESCRIPTION OF MANAGEMENT REACH

The Pend Oreille River flows from Lake Pend Oreille in Idaho into Canada through northeastern Washington. Box Canyon Dam and powerhouse are located near Ione, in Pend Oreille County 17.4 river miles (RM) upstream of Seattle City Light's Boundary Dam. The Box Canyon Reservoir extends 55.7 miles along the Pend Oreille River, from Box Canyon Dam at RM 34.4 to Albeni Falls Dam at RM 90.1, in Bonner County, Idaho. Albeni Falls Dam, which is managed by the U.S. Army Corps of Engineers, regulates the outflow of Lake Pend Oreille. Operating as a run-of-the-river facility, inflows to the Box Canyon Dam equal outflow, and the BCR does not store water. River flows in excess of the dam's turbine capacity are spilled. Water flushing time (the average time required for complete flushing of the reservoir) is short. Reservoir flushing time average 2.5 days during spring runoff (1.8 days in June 1989, 3.1 days in June 1990, and 4.2 days during summer low flows (Falter et al. 1991). The estimated water travel time from Albeni Falls Dam to Box Canyon Dam is on the order of 12 to 36 hours depending on the flow rate of the river (District, 2000).

This Interim Plan is primarily directed towards the Pend Oreille River in the reach between Albeni Falls Dam and Box Canyon Dam. This includes the area between River Mile (RM) 34.4 – RM 90.1. In this Plan, all references to this portion of the Pend Oreille River will be referred to as the Management Reach. Future actions may include areas north of the Box Canyon Dam.

**Land and Shoreline Use**

Land use within or adjacent to the Management Reach includes the following categories: Agriculture, Open Forested, Open Grassland/Shrubs, Open Riparian Trees and Shrubs, Commercial Developed/Dense Housing/Powerlines/Railroad/Paved Areas, Residential/Scattered Houses, and Recreation and Public Access Sites. The towns and communities of Ione, Cusick, Usk, Dalkena, Furport, Newport, Oldtown and the Kalispel Indian Reservation are located along the Pend Oreille River adjacent to the Management Reach. Numerous residential developments, and public recreation and public access sites are also located along the Pend Oreille River along the Management Reach. Residential, recreation and retirement-home development along the river has increased in recent years; numerous subdivisions exist or are under development. Forest, agriculture, and open lands along the river are being replaced by the growth of residential subdivisions (District, 2000).

Approximately 75% of the land adjacent to the Management Reach is privately owned. Privately held lands are generally towns, farmland, ranches, homes and cabins. There are approximately 1,700 parcel owners within this reach of the river and approximately 1,200 houses (pers. Comm.. T. Orth, Pend Oreille County Assessor's Office, December 19, 2003). The landowners for the other 25% consist of the Kalispel Indian Tribe, U.S. Forest Service, U.S. Bonneville Power Administration, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Bureau of Land Management, Pend Oreille County, and Washington State (District, 2000).

**Nonpoint Nutrient Source Locations**

Nonpoint water quality sources are pollutant factors that are not associated with a specific identifiable single geographic location. These nonpoint water quality sources are typically attributable to land use within a watershed and, because of their diffused nature, it is often difficult to quantify cause and effect relationships. EPA (1993) suggested possible nonpoint sources potentially affecting water quality of the Management Reach to include animal keeping practices, agriculture, on-site sewage disposal, stormwater and highway runoff, forest practices, land development, landfills, and gravel extraction. No quantifiable effects or source examples were cited in this report for the somewhat generic list of land use practices (District, 2000).

**Water Quantity & Quality**

The Pend Oreille River flows northwest between Albeni Falls Dam and Box Canyon Dam. The annual peak flow on the Pend Oreille River generally occurs during April, May and June, fed by snowmelt and precipitation in the headwaters of the Pend Oreille River and Clark Fork River, which originates on the western slopes of the Rocky Mountains in Montana. The highest average weekly flows occur during June, and the average annual flood is 79,445 cfs (based on period of record 1/1/56 - 12/31/95).

The upstream drainage area for the Management Reach is 24,930 square miles. Of this total drainage, about 24,230 square miles are upstream of Albeni Falls Dam (RM 90.1), and the remaining 700 square miles of the drainage area lies between Albeni Falls Dam and Box Canyon Dam (RM 34.4). There are 22 streams that flow into the Management Reach. Three major tributaries are Calispell Creek and the Trimble/Tacoma drainage, located near Cusick, and LeClerc Creek. Many tributaries flow into the river via shallow sloughs.

The Pend Oreille River in the Management Reach is a cool-water mesotrophic system. Maximum August temperature based on a two-year average from 1989-1990 was 71.2 °F (21.75°C) (Falter et al. 1991). The reservoir is characteristic of a riverine environment with good water quality (Pelletier and Coots 1990; Bennett et al. 1990; Falter et al. 1991; EPA 1993).

Numerous water quality studies for the Pend Oreille River have been undertaken in recent years. The water quality information presented in the Initial Consultation Document (ICD) summarizes the findings of these studies. Three existing reports were particularly useful in summarizing existing water quality information. Skillingstad and Scholz (1993) examine trends in water quality of the Pend Oreille River based on previously published data. Falter et al. (1991) presents a comprehensive inventory of water quality conditions throughout the reservoir.

Dissolved oxygen (D.O.) is an important determinant of aquatic biota. D.O. levels for the Pend Oreille River within the management reach for the Aquatic plant management plan are at or above 100% saturation for most of the year. Falter et al. (1991) reported a D.O. range of 5.20 mg/L to 13.22 mg/L. District monitoring in 1997 and 1998 reported a range of 7.2 mg/L to 12 mg/L based on modified Winkler tests and up to 14 mg/L based on direct measurements of the partial pressure for D.O. D.O. is typically highest in January through March and reaches a low in August, with no stratification in the river. Skillingstad et al. (1993) reported similar findings (D.O. range of 7.6 mg/L to 12.2 mg/L). Generally, D.O. levels are above 10 mg/L during fall, winter, and spring (October - May) and below 9 mg/L during summer months. The Washington Department of Ecology (WDOE) 303(d) list decision matrix (May 28, 1996) lists a single excursion of D.O. below the water quality standard of 8.0 mg/L. Falter et al. (1991) recorded D.O. levels below the water quality standard on three dates in 1989/1990. (Warmer water can hold less D.O.; therefore, D.O. levels (mg/L) decrease while waters remain fully saturated.)

Conductivity in the main river increases from a low in the spring to a summer peak of 160 umhos and then decreases in the fall. Conductivity is inverse to flow during spring and summer because higher flows tend to dilute or flush out the major ions.

Carbon dioxide ($CO_2$) does not remain as a dissolved gas in hard water systems where a pH greater than 8.3 exists. Aquatic plants rely on $CO_2$ as a source of carbon uptake during photosynthesis. The Pend Oreille River is a hard water system for which heavy aquatic plant growth further depletes $CO_2$ to near zero levels in mid-summer. $CO_2$ levels are highest in the spring high flow period (28.89 mg/L in April 1988 as reported by Skillingstad and Scholz 1993).

Total alkalinity is a measure of a river's buffering capacity to resist changes in pH. Both annual and seasonal variation in alkalinity are well documented; variation is attributable to discharge, aquatic plant growth, and may be related to dissolved gas levels. Falter and Olson (1991) reported a range of 73 - 80 mg/L in mid-August 1990.

The Pend Oreille River is slightly alkaline with pH measurements ranging from 7.17 to 8.78 (Falter et al. 1991). The WDOE placed the Pend Oreille River on the 303(d) list based on three excursions of pH outside of the water quality standards. These excursions were reported by Pelletier and Coots (1990). High pH in the summer is typical of rivers with heavy aquatic macrophyte growth (Wetzel 1983).

A special condition has been established by Washington State for maximum water temperature criteria for the Pend Oreille River. The maximum allowable temperature is 20°C. Human activities shall not result in more than a 0.3°C increase when water temperatures naturally exceed this maximum criteria. River temperatures exceed this maximum during July and August, and the river is on the State's 303(d) list for temperature. Surface water releases from Albeni Falls Dam exceed 20°C for the period beginning in early July and lasting through late September.

Transparency is a good indicator of trophic status when evaluated in combination with nutrient loading and temperature. Secchi disk readings are used to describe transparency and these readings also provide a direct relationship to the depth of light penetration. The range of Secchi disk readings for the Pend Oreille River is within the range typical for mesotrophic rivers. Transparency increases during low flow periods when there are less suspended particulates and macrophytes are directly competing with phytoplankton for nutrients (range 11 - 22 ft). Transparency is affected by phytoplankton growth and suspended solids; in turn transparency affects macrophyte growth. Macroscopic plants do not generally grow below a point where available light is at 1% of the surface value (Wetzel 1983). Light penetrating a dense aquatic plant bed in the river near Calispell Slough showed 2% light available at 8.2 ft (Falter et al. 1991). Secchi depths of 13-14 ft in August were consistent with aquatic macrophyte distribution becoming sparse at water depths greater than 13 ft and nearly absent at depths greater than 18 ft (relative to Cusick water elevation 2,032 ft MSL).

The range of total nitrogen levels measured in the Pend Oreille River between Albeni Falls Dam and the forebay of Box Canyon Dam since construction of the Box Canyon Project are 0.0 to 1.2 mg/L (Skillingstad and Scholz 1993). The Pend Oreille River can be classified as bordering between oligo-mesotrophic and mesotrophic (low-moderate to moderately fertile) based on total nitrogen (FLA 2000).

**Aquatic Plant Community**

The majority of the aquatic plant communities within the Pend Oreille River, inclusive of sloughs, consist of mixed beds of native and non-native plants. Nineteen aquatic plant species are known from the Management Reach (Table 1). Of these, the non-native Eurasian watermilfoil (EWM) and curlyleaf pondweed are the most dominant. Eighteen percent of the vegetated acres are comprised of near monoculture beds of EWM. EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep.

Aquatic plant vegetation tends to be greatest in the reach from Riverbend to Furport (RM 60.0-80.0). This reach of river is wide, shallow and tends to have the greatest littoral habitat and substrate suitable for aquatic plant growth. Thirty-five percent of the wetted area within this reach is vegetated, with the majority of the vegetated area classified as having dense/moderate growth.

**Table 1. Common Aquatic Plants within the Management Reach**

| Common Name | Scientific Name | Native to WA? |
|---|---|---|
| Eurasian Watermilfoil | *Myriophyllum spicatum* | No |
| Siberian Watermilfoil | *Myriophyllum sibiricum* | Yes |
| Curlyleaf Pondweed | *Potamogeton crispus* | No |
| Coontail | *Ceratophyllum demersum* | Yes |
| Waterweed | *Elodea canadensis* | Yes |
| Water star-grass | *Heteranthera dubia* | Yes |
| Close-leaved pondweed | *Potamogeton foliosus* | Yes |
| Long-leaved pondweed | *Potamogeton nodusus* | Yes |
| Fennel-leaved pondweed | *Potamogeton pectinatus* | Yes |
| Eel-grass pondweed | *Potamogeton zosteriformis* | Yes |
| Robbins' pondweed | *Potamogeton robbinsii* | Yes |
| Richardson's pondweed | *Potamogeton richardsonii* | Yes |
| **Incidental species** | | |
| (No Common Name) | *Potamogeton natans* | Yes |
| Nuttall's waterweed | *Elodea nutallii* | Yes |
| (No Common Name) | *Zannichellia palustris* | Yes |
| Diverse-leaved pondweed | *Potamogeton diversifolius* | Yes |
| Large-leaved pondweed | *Potamogeton amplifolius* | Yes |
| Grass-leaved pondweed | *Potamogeton gramineus* | Yes |
| Whitewater crowfoot | *Ranunculus aquatilis* | Yes |

Aquatic plants tend to be sparse in deeper waters or in areas with coarse gravel or cobble substrate. (See Appendix C). Plant growth is limited at depths of greater than 13 ft and non-existent at depths greater than 18 ft. Three species dominate the aquatic plant flora found in the BCR. EWM and curlyleaf pondweed are capable of dense growth within 0-13 ft, but growth is particularly limited for EWM at depths greater than 11 ft. The native waterweed (*Elodea canadensis*) is most prevalent within the surf zone at the water's edge where it can form very dense beds. It can also be dominant within shallow sloughs. Additional information on plant species found in the BCR can be found in the FLA (District 2000).

No aquatic plants known from the Pend Oreille River Management Reach are state or federally listed as endangered, threatened, sensitive, or species of concern. Although *Heteranthera dubia* (water star-grass) was formerly maintained on the Washington Natural Heritage Program Review list, it was recently downlisted to Watch list status, reserved for those taxa that are more common than previously thought (http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html). *Heteranthera dubia* is common throughout the Management Reach, though rarely dominant.

**Fisheries of the Pend Oreille River**

The information presented below is taken directly from the Box Canyon Final License Application (District 2000) and the Initial Consultation Document (CES 1997). Previous investigations by the University of Idaho (Bennett and Liter 1991; Bennett and Garrett 1994) and Eastern Washington University (Ashe and Scholz 1992) described the fisheries resources in management reach and its major tributaries. Fish populations are comprised of both indigenous and introduced species. Table 2 summarizes species known to inhabit the management reach of the Pend Oreille River or are suspected of residing there.

| **TABLE 2<br>SUMMARY OF FISH SAMPLED OR EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER MANAGEMENT REACH** |
| --- |
| Family *Acipenseridae* |
| White sturgeon (*Acipenser transmontanus*) |
| Family *Catostomidae* |
| Largescale sucker (*Catostomus macrocheilus*) |
| Longnose sucker (*Catostomus catostomus*) |
| Family *Centrarchidae* |
| Black crappie (*Pomoxis nigromaculatus*) |
| Largemouth bass (*Micropterus salmoides*) |
| Pumpkinseed (*Lepomis gibbosus*) |
| Family *Cottidae* |
| Sculpin (*Cottus spp.*) |
| Family *Cyprinidae* |
| Goldfish (*Carassius auratus*) |
| Northern pikeminnow (*Ptychocheilus oregonensis*) |
| Peamouth (*Mylocheilus caurinus*) |
| Redside shiner (*Richardsonius balteatus*) |
| Tench (*Tinca tinca*) |
| Family *Esocidae* |
| Northern pike (*Esox lucius*) |
| Family *Ictaluridae* |
| Black bullhead (*Ictalurus melas*) |
| Brown bullhead (*Ictalurus nebulosus*) |
| Family *Percidae* |
| Walleye (*Stizostedion vitreum vitreum*) |
| Yellow perch (*Perca flavescens*) |
| Family *Salmonidae* |
| Brook trout (*Salvelinus fontinalis*) |
| Brown trout (*Salmo trutta*) |
| Bull trout (*Salvelinus confluentus*) |
| Cutthroat trout (*Oncorhynchus clarki*) |
| Kokanee (*O. nerka*) |
| Lake trout (*Salvelinus namaycush*) |
| Mountain whitefish (*Prosopium williamsoni*) |
| Rainbow trout (*O. mykiss*) |

Data collected during studies from 1988 – 1990 indicate that the most abundant game species in the reservoir are yellow perch (37% of the total, ranging from 26% - 43%), pumpkinseed (21.1%), largemouth bass (7.7%), and black crappie (*Pomoxis nigromaculatus*) (2.2%). The most abundant non-game species are tench (*Tinca tinca*) (7.6%), ranging from 5% - 10%), northern pikeminnow (*Ptychocheilus oregonensis*) (6.9%), largescale sucker (*Catostomus macrocheilus*) (5.4%), and largemouth sucker (*Catostomus macrocheilus*) (2.3%) (Bennett and Liter 1991; Ashe and Scholz 1992).

Salmonid species known to occur in the reservoir include brown trout, cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*O. mykiss*), bull trout (*Salvelinus confluentus*), brook trout (*Salvelinus fontinalis*) and mountain whitefish (*Prosopium williamsoni*). Both cutthroat trout and bull trout are native to the Pend Oreille River and its tributaries. Trout, although present, comprised less than 1% of the total fish captured using electroshocking, gillnetting and seining methods, giving further substantiation that the reservoir does not provide habitat preferred by trout. Brown trout were the most abundant of the trout, with 492 captured from 1988 - 1990 in these studies. It is doubtful that these trout spawned in Box Canyon Reservoir; and the origin of the fish is not known for certain (Bennett and Liter 1991). Further investigations by Bennett and Garrett (1994) indicate that large brown trout spent about 3 years in the tributaries before migrating to the reservoir to rear. Bennett and Liter (1991) also state brown and rainbow trout are both found upstream in the Pend Oreille and that it is possible that these fish may migrate downstream in the spring when water temperatures rise and/or high discharges may stimulate the fish to migrate downstream.

Bull trout, westslope cutthroat trout, brown trout and rainbow trout use the Pend Oreille River primarily as a migratory corridor and for limited rearing. Water temperatures in the late summer – early fall preclude use of the reservoir. With the exception of the upper few miles of the reservoir downstream of Albeni Falls Dam, there is no suitable spawning substrate.

It appears that water temperature, lack of habitat diversity, and possibly food availability are the major factors that limit trout production in the management reach of the Pend Oreille River. Maximum temperatures recorded in 1988 were several degrees higher than temperatures optimal for bull, rainbow, and cutthroat trout (Ashe and Scholz 1992). Generally, there is low habitat diversity within the reservoir. Only about 8 miles of the management reach contains habitat components preferred by trout; the balance of the reach consists mainly of shallow, slow-moving water, numerous sloughs and backwater areas, and has an abundance of macrophytes. There are very few deep pools within the reservoir and the substrate is mostly composed of mud (Ashe and Scholz 192). Riffles, which are food-producing areas for trout, were mostly eliminated when the reservoir was created. Preferred prey items of trout are absent, and trout and whitefish compete with other fish species for these prey items present in the reservoir (Ashe and Scholz 1992).

Even though trout were few in numbers in the reservoir, some were large and of trophy size. Bennett and Liter (1991) reports a 24-inch (600 mm) brown trout and a 30 + inch (762 mm) rainbow trout, suggesting that some of these trophy-sized trout offer some potential for management within the reservoir.

Non-native species of fish have been introduced into the management reach and tributaries. Northern pike (*Esox lucius*) have migrated downstream from the Clark Fork River, Montana. Walleye (*Stizostedion vitreum*) were planted by Washington Department of Fish and Wildlife (formerly Washington Department of Game and Washington Department of Wildlife) in 1983 and 1984 (500,000 and 253,000, respectively) (Bennett and Liter 1991). WDFW also planted 148 tagged adult walleye in 1987 (WDFW, Spokane, as cited in Ashe and Scholz 1992). During the course of the studies, several anglers reported catching walleye, but there were no confirmed sitings of walleye made, or were there any walleye caught during the fisheries studies conducted (Ashe and Scholz 1992; Bennett and Liter 1991). Recently, a 29-inch walleye was caught downstream of Box Canyon Dam near Metaline Falls (Newport Miner 1996).

Bull trout and cutthroat trout are native to the Pend Oreille and its tributaries. Brown trout were introduced to the Pend Oreille via plantings in the 1890's from an original Scottish strain (Hisata, as cited in Ashe and Scholz 1992). Rainbow trout found in Box Canyon Reservoir and its tributaries are likely descendants from early hatchery plantings (5,125 - 151,700) from 1945 - 1951. An additional 48,445 cutthroat trout were also planted during this period (Bennett and Liter 1991). Hatchery plantings were discontinued in the late 1950s due to poor angler harvest, except for intermittent tributary stocking of hatchery brook trout that has continued into the 1990s (Bennett and Garrett 1994).

Sturgeon have also been reported in the management reach; however efforts reported in Ashe and Scholz (1992) indicate no success, in spite of setting 19, 18 ganglion sturgeon set lines for 243 hours from May - July, 1988. Kokanee (*Oncorhynchus nerka*), land-locked sockeye salmon, have also been observed in the management reach, but these are presumed to have originated upstream in Lake Pend Oreille, Idaho, and flushed over Albeni Falls Dam (Ashe and Scholz 1992; Bennett and Liter 1991).

Results of studies of game species found in the Pend Oreille River by target species are given below.

***Largemouth Bass***

Largemouth bass are currently the largest sized game fish in the reservoir with a sufficiently large population to provide a recreational fishery. Largemouth bass are not native to Washington and spread into the Columbia River system after being introduced into Idaho in 1916 (Scott and Crossman 1973 as cited in Bennett and Liter 1992). Prior to the creation of Box Canyon Reservoir, largemouth bass habitat was limited in area. Even though largemouth bass are less than 10% of the fish assemblage present in the reservoir, they are now the primary sport fish in the reservoir (Bennett and Liter 1991).

Ashe and Scholz (1992) determined that bass tended to have slow growth rates compared to other locations in the northern and northwestern United States (as cited in Pend Oreille PUD 1992). Bennett and Liter (1991) found that the largest body growth increment occurred at age 1. At age 4, growth increments of bass in the reservoir decline and after age 7, little growth occurs. Ashe and Scholz (1992) found that largemouth bass seemed to display a marked weight gain after reaching six years of age, and postulated that this was due to changes in bass diet preferences. Bass preferred to eat sizeable perch and pumpkinseed, which would account for the marked increase in weight.

Estimated survival of 0 age bass in Box Canyon Reservoirs is low, and is generally attributed to the short growing season and their relatively small size (Bennett and Bowles 1985 as cited in Bennett and Liter 1991). The 1989 and 1990 year classes were weak in the fall and were then followed by low over-winter survival rates of 0.4 - 3.9%. It is suspected that poor over-winter survival of young bass in the Pend Oreille River may be partially due to the lack of cover during the winter months. Aquatic macrophytes provide the majority of the cover in the rivers and sloughs. In the winter, when aquatic macrophytes die back, little physical cover remains for fish species. Ashe and Scholz (1992) postulate that larger bass may then cannibalize smaller bass.

According to Stuber et al. (1982 as cited in Ashe and Scholz 1992), optimal riverine habitat for largemouth bass is characterized by large, slow-moving rivers with soft bottoms, aquatic vegetation and relatively clear water. Based on this assessment, the Pend Oreille River appears to have optimal micro habitat for largemouth bass production. Several factors, however, appear to limit production and different life stages.

The major factors limiting largemouth bass during the rearing stage in the Pend Oreille River were identified as cold water temperatures, competition for food between juvenile bass and yellow perch, and lack of cover during the winter months (Ashe and Scholz 1992).

The major limiting factor affecting the adult bass in the reservoir is the density of the macrophyte beds in the Pend Oreille River. Most of the fish captured during electrofishing surveys (Ashe and Scholz 1992) were associated with weed beds in littoral areas. Prince and Maughan (1979 as cited in Ashe and Scholz 1992) state that prey that are attracted to structure become concentrated in vegetation, thereby increasing encounter rates with, and vulnerability to, foragers that also reside there. Although pumpkinseed and yellow perch are abundant in the macrophyte beds, predation rates are reduced as structural complexity increases (Svino and Stein 1982 as cited in Ashe and Scholz 1992). These beds pose serious obstacles to adult largemouth bass; this decreased predation results in an abundance of yellow perch, increasing the number of fish that compete with younger age classes of largemouth bass for food (Ashe and Scholz 1992).

***Yellow Perch***

Bennett and Liter (1991) sampled yellow perch and found them to generally range from 2 - 9 inches (51 229 mm) in length with a mean of 6.5 inches (165 mm). They postulate that the lack of quality-sized yellow perch (8 inches/150 mm; Nielsen and Johnson 1983 as cited in Bennett and Liter 1991) may be the result of dense aquatic vegetation. In water bodies where aquatic plants occupy large areas (estimated at covering 56% of the reservoir) a reduction in the condition and growth of fishes results in a stunted fish population (Cole and Shireman 1980 as cited in Bennett and Liter 1991). They further state that higher mortality will be required before any quality sized perch are rearing in Box Canyon Reservoir, and that presently there is limited predation on yellow perch, even though they are the preferred prey of largemouth bass in the reservoir.

### *Black Crappie*

Bennett and Liter (1991) sampled black crappie and found them to range in size from 2.6 - 8.3 inches (66 - 210.1 mm). Based on scale analysis, Ashe et al. (1991 as cited in Ashe and Scholz 1992) determined that each year-class tended to be smaller than in other locations in the northern and northwestern United States. Black crappie also have declining growth rates at around age 4, as well as high mortality rates. Bennett and Liter (1991) estimated instantaneous total mortality of 70% for black crappie during the study period, the highest mortality rate of all gamefish sampled. Black crappie exhibited relatively slow growth. The combination of high mortality and slow growth results in few fish getting to a sufficiently large size to be acceptable size to the anglers (Bennett and Liter 1991). Harvest on this stock is nearly zero, with <0.01% of the population being taken by anglers (Ashe and Scholz 1992).

## Wildlife

Table 3 summarizes species known or suspected to inhabit the area around the Pend Oreille River.

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
|---|
| Large Mammals |
| White-tailed deer (*Odocoileus virginianus*) |
| Mule deer (*Odocoileus hemionus*) |
| Elk (*Cervus elaphus)* |
| Black bears (*Ursus americanus*) |
| Moose (*Alces alces*) |
| Woodland caribou (*Rangifer tarandus caribou*) |
| Mountain lion (*Felis concolor*) |
| Other Mammals |
| Coyote (*Canis latrans*) |
| Common raccoon (*Procyon lotor*) |
| Mink (*Mustela vison*) |
| Striped skunk (*Mephitis mephitis*) |
| Shrew (*Sorex* sp.) |
| Yellow-bellied marmot (*Marmota flaviventris*) |
| Red squirrel (*Tamiasciurus hudsonicus*) |
| Chipmunk (*Tamias* sp.) |
| American beaver (*Castor canadensis*) |
| Muskrat (*Ondantra zibethica*) |
| Common porcupine (*Erethizon dorsatum*) |
| Gray wolf (*Canis lupus*) |
| Grizzly bear (*Ursus arctos horribilis*) |
| Yuma myotis (*Myotis yumanensis*) |
| Big brown bat (*Eptesicus fuscus*) |
| Townsend's big-eared bat (*Corynorhinus townsendii* ) |
| Western pipistrel (*Pipistrellus hesperus*) |
| Long-legged myotis (*Myotis volans*) |

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
|---|
| Bobcat (*Felis rufus*) |
| Northern river otter (*Lutra canadensis*) |
| Short-tailed weasel (*Mustela erminea*) |
| Long-tailed weasel (*M. frenata*) |
| Northern flying squirrel (*Glaucomys sabrinus*) |
| Northern pocket gopher (*Thomomys talpoides*) |
| Ground squirrels (*Spermophilus* spp.) |
| Western jumping mouse (*Zapus princeps*) |
| Deer mouse (*Peromysus maniculatus*) |
| Bushy-tailed woodrat (*Neotoma cinerea*) |
| Snowshoe hare (*Lepus americanus*) |
| Voles (*Microtus pennsylvanicus*, *M. longicaudus*, and *Clethrionomys gapperi*) |
| Pine marten (*Martes americana*) |
| Badger (*Taxidea taxus*) |
| Wolverine (Gulo gulo) |
| Lynx (*Lynx canadensis*) |
| Fisher (*Martes pennanti*) |
| <u>Waterfowl</u> |
| Canada goose (*Branta canadensis*) |
| Mallard (*Anas platyrhynchos*) |
| American widgeon (*Anas americana*) |
| Common merganser (*Mergus merganser*) |
| Lesser scaup (*Aythya affinis*) |
| Tundra swan (*Cygnus columbianus*) |
| American coot (*Fulica americana*) |
| Gadwall (*Anas strepera*) |
| Blue-winged teal (*A. discors*) |
| Green-winged teal (*A. crecca*) |
| Cinnamon teal (*A. cyanoptera*) |
| Northern shoveler (*A. clypeata*) |
| Wood duck (*Aix sponsa*) |
| Ruddy duck (*Oxyura jamaicensis*) |
| Common goldeneye (*Bucephala clangula*) |
| Hooded merganser (*Lophodytes cucullatus*) |
| Northern Pintail (*Anas acuta*) |
| Canvasback (*Aythya valisineria*) |
| Redhead (*Aythya americana*) |
| Ring-necked Duck (*Aythya collaris*) |
| Barrow's Goldeneye (*Bucephala islandica*) |
| Bufflehead (*Bucephala albeola*) |
| <u>Loons and Grebes</u> |
| Common Loon (*Gavia immer*) |
| Red-necked Grebe (*Podiceps grisegena*) |
| Horned Grebe (*Podiceps auritus*) |
| Eared Grebe (*Podiceps nigricollis*) |

**TABLE 3**
**SUMMARY OF ANIMALS SURVEYED OR EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER AND SURROUNDING AREA**

Pied-billed Grebe (*Podlymbus podiceps*)
Western Grebe (*Aechmophorus occidentalis*)
Clark's Grebe (*Aechmorphorus clarkii*)

Pelicans
American White Pelican (*Pelecanus erythrorhynchos*)
Cormorants
Double-crested Cormorant (*Phalacrocorax auritus*)
Cranes, Rails and Coots
American Coot (*Fulica americana*)
Virginia Rail (*Rallus limnicola*)
Sora ( *Porzana carolina*)
Sandhill Crane (*Grus canadensis*)
Shorebirds
Spotted sandpiper (*Actitis macularia*)
Killdeer (*Charadrius vociferous*)
Common snipe (*Gallinago gallinago*)
Greater yellowlegs (*Tringa melanoleuca*)
American Avocet (*Recurvirostra americana*)
Black-necked Stilt (*Himantopus mexicanus*)
Lesser Yellowlegs (*Tringa flavipes*)
Solitary Sandpiper (*Tringa solitaria*)
Willet (*Catoptrophorus semipalmatus*)
Whimbrel (*Numenius phaeopus*)
Marbled Godwit (*Limosa fedoa*)
Pectoral Sandpiper (*Calidris melanotos*)
Baird's Sandpiper (*Calidris bairdii*)
Western Sandpiper (*Calidris mauri*)
Least Sandpiper (*Calidris minutilla*)
Long-billed Dowitcher (*Limnodromus scolopaceus*)
Short-billed Dowitcher (*Limnodromus griseus*)
Wilson's Phalarope (*Phalaropus tricolor*)
Red-necked Phalarope (*Phalaropus lobatus*)
Wading Birds
American Bittern (*Botaurus lentiginosus*)
Great Blue Heron (*Ardea herodias*)
Cattle egret (*Bubulcus ibis*)
Raptors
Bald eagle (*Haliaeetus leucocephalus*)
Northern saw-whet owl (*Aegolius acadicus*)
Red-tailed hawk (*Buteo jamaicensis*)
American kestrel (*Falco sparverius*)
Turkey Vulture (*Cathartes aura*)
Northern Harrier (*Circus cyaneus*)
Sharp-shinned Hawk (*Accipiter striatus*)
Cooper's Hawk (*Accipiter cooperii*)

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
|---|
| Northern Goshawk (*Accipiter gentilis*) |
| Rough-legged Hawk (*Buteo lagopus*) |
| Golden Eagle (*Aquila chrysaetos*) |
| Osprey (*Pandion haliaetus*) |
| Merlin (*Falco columbarius*) |
| Peregrine Falcon (*Falco peregrinus*) |
| Long-eared Owl (*Asio otus*) |
| Short-eared Owl (*Asio flammeus*) |
| Great-horned Owl (*Bubo virginianus*) |
| Snowy Owl (*Nyctea scandiaca*) |
| Barred Owl (*Strix varia*) |
| Northern Pygmy-Owl (*Glaucicium gnoma*) |
| |
| Gulls and Terns |
| Bonaparte's Gull (*Larus philadelphia*) |
| Ring-billed Gull (*Larus delawarensis*) |
| Forster's Tern (*Sterna forsteri*) |
| Caspian Tern (*Sterna caspia*) |
| Black Tern (*Chlidonias niger*) |
| |
| Passerines |
| Violet-green swallow (*Tachycineta thalassina*) |
| Black-capped chickadee (*Parus atricapillus*) |
| Red-breasted nuthatch (*Sitta canadensis*) |
| American robin (*Turdus migratorius*) |
| European starling (*Sturnus vulgaris*) |
| Song sparrow (*Melospiza melodia*) |
| Red-winged blackbird (*Agelaius phoeniceus*) |
| Red-naped sapsucker (*Sphyrapicus nuchalis*) |
| Northern flicker (*Colaptes auratus*) |
| Downy woodpecker (*Picoides pubescens*) |
| Hairy woodpecker (*P. Villosus*) |
| Lewis' woodpecker (*Melanerpes lewis*) |
| Pileated woodpecker (*Drycopus pileatus*) |
| Black-backed Woodpecker (*Picoides arcticus*) |
| Common Nighthawk (*Chordeiles minor*) |
| Vaux's Swift (*Chaetura vauxi*) |
| Black Swift (*Cypseloides niger*) |
| Black-chinned Hummingbird (*Archilocus alexandri*) |
| Calliope Hummingbird ( *Stellula calliope*) |
| Rufous Hummingbird (*Selasphorus rufus*) |
| Belted Kingfisher (*Ceryle alcyon*) |
| Western Wood-Pewee (*Contopus sordidulus*) |
| Willow Flycatcher (*Empidonax trailii*) |
| Alder Flycatcher (*Empidonax alnorum*) |
| Least Flycatcher (*Empidonax minimus*) |

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
| --- |
| Hammond's Flycatcher (*Empidonax hammondii*)<br>Dusky Flycatcher (*Empidonax oberholseri*)<br>Say's Phoebe (*Sayornis saya*)<br>Eastern Kingbird (*Tyrannus tyrannus*)<br>Western Kingbird (*Tyrannus verticalis*)<br>Northern Shrike (*Lanius excubitor*)<br>Loggerhead Shrike (*Lanius ludovicianus*)<br>Red-eyed Vireo (*Vireo olivaceus*)<br>Warbling Vireo (*Vireo gilvus*)<br>Cassin's Vireo (*Vireo cassinii*)<br>Steller's Jay (*Cyanocitta stelleri*)<br>Gray Jay (*Perisoreus canadensis*)<br>American Magpie (*Pica hudsonia*)<br>Common Raven (*Corvus corax*)<br>American Crow (*Corvus brachyrhynchos*)<br>Horned Lark (*Eremophila alpestris*)<br>Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)<br>Bank Swallow (*Riparia riparia*)<br>Tree Swallow (*Tachycineta bicolor*)<br>Cliff Swallow (*Petrochelidon pyrrhonota*)<br>Barn Swallow (*Hirundo rustica*)<br>Mountain Chickadee (*Poecile gambeli*)<br>Chestnut-backed Chickadee (*Poecile rufescens*)<br>White-breasted Nuthatch (*Sitta carolinensis*)<br>Pygmy Nuthatch (*Sitta pygmaea*)<br>Brown Creeper (*Certhia americana*)<br>Bewick's Wren (*Thryomanes bewickii*)<br>House Wren (*Troglodytes aedon*)<br>Winter Wren (*Troglodytes troglodytes*)<br>Marsh Wren (*Cistothorus palustris*)<br>American Dipper (*Cinclus mexicanus*)<br>Golden-crowned Kinglet (*Regulus satrapa*)<br>Ruby-crowned Kinglet (*Regulus calendula*)<br>Mountain Bluebird (*Sialia currucoides*)<br>Western Bluebird (*Sialia mexicana*)<br>Varied Thrush (*Ixoreus naevius*)<br>Veery (*Catharus fuscescens*)<br>Swainson's Thrush (*Catharus ustulatus*)<br>Hermit Thrush (*Catharus guttatus*)<br>Gray Catbird (*Dumetella carolinensis*)<br>American Pipit (*Anthus rubescens*)<br>Bohemian Waxwing (*Bombycilla garrulus*)<br>Cedar Waxwing (*Bombycilla cedrorum*)<br>Orange-crowned Warbler (*Vermivora celata*)<br>Nashville Warbler (*Vermivora ruficapilla*)<br>Yellow Warbler (*Dendroica petechia*) |

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
|---|
| Yellow-rumped Warbler (*Dendroica coronata*)<br>Townsend's Warbler (*Dendroica townsendii*)<br>American Redstart (*Setophaga ruticilla*)<br>Northern Waterthrush (*Seiurus noveboracensis*)<br>Mourning Warbler (*Oporornis philadelphia* )<br>MacGillivray's Warbler (*Oporornis tolmiei*)<br>Common Yellow Warbler (*Dendroica petechia*)<br>Yellow-rumped Warbler (*Dendroica coronata*)<br>Townsend's Warbler (*Dendroica townsendii*)<br>American Redstart (*Setophaga ruticilla*)<br>Northern Waterthrush (*Seiurus noveboracensis*)<br>Mourning Warbler (*Oporornis philadelphia* )<br>MacGillivray's Warbler (*Oporornis tolmiei*)<br>Common Yellowthroat (*Geothlypis trichas*)<br>Wilson's Warbler ( *Wilsonia pusilla*)<br>Yellow-breasted Chat (*Icteria virens*)<br>Western Tanager (*Piranga ludoviciana*)<br>Black-headed Grosbeak (*Pheuticus melanocephalus*)<br>Lazuli Bunting (*Passerina amoena*)<br>Spotted Towhee (*Pipilo maculatus*)<br>American Tree Sparrow (*Spizella arborea*)<br>Clay-colored Sparrow (*Spizella pallida*)<br>Chipping Sparrow (*Spizella passerina*)<br>Savannah Sparrow (*Passerculus sandwichensis*)<br>White-crowned Sparrow (*Zonotrichia leucophrys*)<br>Fox Sparrow (*Passerella iliaca*)<br>Lincoln's Sparrow (*Melospiza lincolnii*)<br>Dark-eyed Junco (*Junco hyemalis*)<br>Snow Bunting (*Plectrophenax nivalis*)<br>Western Meadowlark (*Sturnella neglecta*)<br>Bobolink (*Dolichonyx oryzivorus*)<br>Brown-headed Cowbird (*Molothrus ater*)<br>Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)<br>Red-winged Blackbird ( *Agelaius phoeniceus*)<br>Brewer's Blackbird (*Euphagus cyanocephalus*)<br>Bullock's Oriole (*Icterus bullockii*)<br>Evening Grosbeak (*Coccothraustes verpertinus*)<br>Pine Grosbeak (*Pinicola enucleator*)<br>House Finch (*Carpodacus mexicanus*)<br>Red Crossbill (*Loxia curvirostra*)<br>Common Redpoll (*Carduelis flammea*)<br>Pine Siskin (*Carduelis pinus*)<br>American Goldfinch (*Carduelis tristis*)<br>House Sparrow (*Passer domesticus*) |

| TABLE 3<br>SUMMARY OF ANIMALS SURVEYED OR<br>EXPECTED TO INHABIT BOX CANYON RESERVOIR PEND OREILLE RIVER<br>AND SURROUNDING AREA |
| --- |
| Upland Game Birds |
| Ruffed grouse (*Bonasa umbellus*) |
| Mourning dove (*Zenaida macroura*) |
| California Quail (*Callipepla californica*) |
| Ring-necked Pheasant (*Phasianus colchicus*) |
| Wild Turkey (*Meleagris gallopavo*) |
| Rock Dove (Columbia livia) |
| Band-tailed Pigeon (Columbia fasciata) |
| Reptiles and Amphibians |
| Western painted turtle (*Chrysemys picta belli*) |
| Common garter snake (*Thamnophis sirtalis*) |
| Wandering garter snake (*Thamnophis elegans vagrans*) |
| Western toad (*Bufo boreas*) |
| Pacific chorus frog (*Pseudacris regilla*) |
| Columbia spotted frog (*Rana luteiventris*) |
| Northern leopard frog (*R. Pipiens*) |
| Bullfrog (*R. Catesbeiana*) |
| Long-toed salamander (*Ambystoma macrodactylum*) |
| Rubber boa (*Charina bottae*) |
| Northern alligator lizard (*Elgaria coerulea*) |
| Western skink (Eumeces skiltonianus) |

White-tailed deer (*Odocoileus virginianus*) is the most abundant big-game species in the study area. This species favors areas where forage, thermal cover, and hiding cover are in proximity (Witmer et al. 1985). These include forest edges, young forests with abundant browse, and fields near forest or shrub habitats. Mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and black bears (*Ursus americanus*) are believed to be present at low density in the river corridor.

An expanding population of moose (*Alces alces*) is centered in the Selkirk Mountains and individual moose are occasionally sighted in the vicinity of the Pend Oreille River (Rodrick and Milner 1991, WDFW 1996b). Woodland caribou (*Rangifer tarandus caribou*) do not typically occur in the study area, but a small population of this Endangered species persists in the Selkirk Mountains, mostly in mature or old-growth forests; caribou could occasionally cross the Pend Oreille River. A study of mountain lion (*Felis concolor*) interactions with caribou and other ungulates is currently being conducted, northeast of the management reach of the Pend Oreille River, by Washington State University personnel under the guidance of Dr. R. Wielgus (pers. comm. November 12, 1999).

Other mammals documented by Reese and Hall (1991) and Reese et al. (1993) were coyote (*Canis latrans*), common raccoon (*Procyon lotor*), mink (*Mustela vison*), striped skunk (*Mephitis mephitis*), shrew (*Sorex* sp.), yellow-bellied marmot (*Marmota flaviventris*), red squirrel (*Tamiasciurus hudsonicus*), chipmunk (*Tamias* sp.), American beaver (*Castor canadensis*), muskrat (*Ondantra zibethica*), and common porcupine (*Erethizon dorsatum*). Also documented in or near the study area are gray wolf (*Canis lupus*), grizzly bear (*Ursus arctos horribilis*), Yuma myotis (*Myotis yumanensis*), big brown bat (*Eptesicus fuscus*), Townsend's big-eared bat (*Corynorhinus townsendii* ), western pipistrel (*Pipistrellus hesperus*), and long-legged myotis (*Myotis volans*) (WDFW 1996b, USFS 1996, pers. comm. H. Fergusen, USFWS, November 1, 1999).

Species not documented in these reports but likely or known to occur based on other information include bobcat (*Felis rufus*), northern river otter (*Lutra canadensis*), short-tailed weasel (*Mustela erminea*), long-tailed weasel (*M. frenata*), northern flying squirrel (*Glaucomys sabrinus*), northern pocket gopher (*Thomomys talpoides*), ground squirrels (*Spermophilus* spp.), western jumping mouse (*Zapus princeps*), deer mouse (*Peromysus maniculatus*), bushy-tailed woodrat (*Neotoma cinerea*), snowshoe hare (*Lepus americanus*), and voles (*Microtus pennsylvanicus*, *M. longicaudus*, and *Clethrionomys gapperi*) (Burke 1976, Larrison 1976, Whitaker 1996). At least nine species of bats are possible.

Trap records for Pend Oreille County suggest that muskrat and American beaver are the major furbearer species (Jordan and Starkey 1984). Other species included in historic harvest records are pine marten (*Martes americana*), mink, short-tailed weasel, common raccoon, bobcat, coyote, American badger (*Taxidea taxus*), and lynx (*Lynx canadensis*); however, some of these species may have been trapped at higher elevations outside of the Pend Oreille River corridor.

Beaver lodges are found throughout the Pend Oreille River drainage at the water's edge, but there are few between RM 76 to RM 60, a reach in which the shoreline is mostly open fields and sparse shrub stands. This reflects the close association of American beaver to forest and shrub habitats capable of supporting their nutritional needs. Forty-five lodges were active in 1989, and 54 were active in 1990 (Reese and Hall 1991). The lodges did not appear, in that study, to be adversely affected by seasonal fluctuations in river level. Assuming four animals per lodge, the population was estimated to be about 200.

According to Reese and Hall (1991) the most abundant species of waterfowl (i.e., the group comprised of ducks, geese, and swans) in the study area are Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), American widgeon (*Anas americana*), and common merganser (*Mergus merganser*) based on frequent sightings in several habitats in different seasons. Several other species of waterfowl, including lesser scaup (*Aythya affinis*) and tundra swan (*Cygnus columbianus*) almost certainly qualify as abundant at least seasonally. Other water-related birds rated as abundant were American coot (*Fulica americana*) and great blue heron (*Ardea herodias*).

Species of waterfowl that nest in the river corridor include Canada goose, mallard, gadwall (*Anas strepera*), blue-winged teal (*A. discors*), green-winged teal (*A. crecca*), cinnamon teal (*A. cyanoptera*), northern shoveler (*A. clypeata*), American widgeon, wood duck (*Aix sponsa*), ruddy duck (*Oxyura jamaicensis*), common goldeneye (*Bucephala clangula*), common merganser, and American coot. Important nesting areas identified by Reese and Hall (1991) and Reese et al. (1993) include Everett Island, Indian Island, Cusick Slough, Tacoma-Trimble Slough, and Usk Slough. Other areas with relatively high numbers of waterfowl broods were Davis Creek, Calispell Creek, and a pond near Furport.

Thousands of ducks, geese, and tundra swans also rest and feed in the area during spring and fall migrations, with large numbers at Calispell Lake and seasonally flooded wetlands in the Cusick area (Calispell Flats). Smaller numbers of waterfowl, including geese, mallard, lesser scaup (*Aythya affinis*), common goldeneye, common merganser, and hooded merganser (*Lophodytes cucullatus*), have been observed over-wintering in ice-free areas along the river.

Four species of shorebirds (spotted sandpiper [*Actitis macularia*], killdeer [*Charadrius vociferus*], common snipe [*Gallinago gallinago*], and greater yellowlegs [*Tringa melanoleuca*]) were documented in the 1989 and 1990 surveys. No large concentrations of migrating shorebirds were detected. According to US Forest Service comments on the Draft Application sandhill cranes have been noted in the vicinity of the Management Reach during spring and fall migration.

A great blue heron rookery was detected in 1990 in a stand of cottonwoods opposite the mouth of Cusick Creek. There were at least 22 active nests in 1990 (Reese and Hall 1991). A second larger rookery (75 active nests) was found in 1994 (WDFW 1996b).

Thirteen species of raptors were recorded by Reese and Hall (1991), the most common of which were bald eagle (*Haliaeetus leucocephalus*), osprey, northern saw-whet owl (*Aegolius acadicus*), red-tailed hawk (*Buteo jamaicensis*), and American kestrel (*Falco sparverius*). Osprey nest in relatively large numbers in the river corridor, particularly between Newport and Cusick. In 1989 there were 50 active nests, 74 percent of which were on pilings. Other nest sites in descending order of use were snags, power poles, live trees, and goose nest platforms. Nests occur near roads, railroads, near the Albeni Falls Dam, and in other areas where noise and human activities are commonplace. Ninety percent of the 29 nests examined by Reese and Hall (1991) were successful in fledging at least one young.

Reese and Hall (1991) recorded 62 bird species in this group, of which 55 were passerines (perching birds); 41 of the 62 species were rated as likely breeders in the area. These species were recorded in the Pend Oreille River corridor during surveys conducted in 1989 and 1990. The high number of species is indicative of varied habitats, the large area encompassed by the study area, and its situation along a migrational flyway.

Species in this group rated by Reese and Hall (1991) as abundant, based on frequent sightings in several habitats, are violet-green swallow (*Tachycineta thalassina*), black-capped chickadee (*Parus atricapillus*), red-breasted nuthatch (*Sitta canadensis*), American robin (*Turdus migratorius*), European starling (*Sturnus vulgaris*), song sparrow (*Melospiza melodia*), and red-winged blackbird (*Agelaius phoeniceus*). Species of woodpeckers documented were red-naped sapsucker (*Sphyrapicus nuchalis*), northern flicker (*Colaptes auratus*), downy woodpecker (*Picoides pubescens*), hairy woodpecker (*P. villosus*), Lewis' woodpecker (*Melanerpes lewis*), and pileated woodpecker (*Drycopus pileatus*). A total of nineteen species of cavity-nesting birds were recorded during these surveys. The only upland game birds verified were ruffed grouse (*Bonasa umbellus*) and mourning dove (*Zenaida macroura*), both uncommon. Although no threatened or endangered avian species occurred during the surveys, the pileated woodpecker is often looked at to indicate mature or old-growth forests (Schroeder 1983). Pileated woodpeckers were observed only in mixed deciduous-coniferous forests and in cedar forests.

Reptiles and amphibians (collectively, herptiles) are not diverse in northeastern Washington, but documented species in the study area include western painted turtle (*Chrysemys picta belli*), common garter snake (*Thamnophis sirtalis*), wandering garter snake (*Thamnophis elegans vagrans*), western toad (*Bufo boreas*), Pacific chorus frog (*Pseudacris regilla*), Columbia spotted frog (*Rana luteiventris*), northern leopard frog (*R. pipiens*), bullfrog (*R. catesbeiana*), and long-toed salamander (*Ambystoma macrodactylum*) (McAllister 1995). Amphibian searches conducted by WDFW personnel in April and June 1995 failed to locate northern leopard frogs at sites where they had previously been recorded (Leonard et al. 1999). Species of herptiles that are possible in the study area but not yet documented by published records or museum collections are rubber boa (*Charina bottae*), northern alligator lizard (*Elgaria coerulea*), and western skink (*Eumeces skiltonianus*) (Nussbaum et al. 1983, Stebbins 1985). Two of the species (northern alligator lizard and western skink) have reportedly been observed by USFS personnel.

**Threatened and Endangered Species**

***Federal Threatened and Endangered Species***

Table 4 lists those threatened and endangered species evaluated for the Box Canyon Hydroelectric Project license amendment. Complete details are found in the Biological Assessment, attached as Appendix H. Bull trout is the only aquatic animal species and Ute Ladies' tresses is the only semi-aquatic plant listed.

**TABLE 4**
**THREATENED AND ENDANGERED SPECIES EVALUATED FOR THE BOX CANYON HYDROELECTRIC PROJECT LICENSE AMENDMENT**

| Common Name | Scientific Name | USFWS Status |
|---|---|---|
| **FISH** | | |
| Bull trout | *Salvelinus confluentus* | Threatened |
| **MAMMALS** | | |
| Gray wolf | *Canis lupus* | Endangered |
| Grizzly bear | *Ursus arctos* | Threatened |
| Canada lynx | *Lynx canadensis* | Proposed |
| **BIRDS** | | |
| Peregrine Falcon | *Falco peregrinus* | Endangered |

| TABLE 4<br>THREATENED AND ENDANGERED SPECIES EVALUATED FOR THE BOX CANYON HYDROELECTRIC PROJECT LICENSE AMENDMENT | | |
|---|---|---|
| Bald eagle | *Haliaeetus leucocephalus* | Threatened |
| **PLANTS** | | |
| Ute ladies'-tresses | *Spiranthes diluvialis* | Threatened |

Bull Trout *(Salvelinus confluentus)*

Bull trout do not actively spawn in the Box Canyon Reach of the Pend Oreille River. Bull trout use the river primarily as a migration corridor to spawn in tributaries to the river. Some limited rearing may occur in the river, but warm water temperatures in the summer make the Pend Oreille River unsuitable for year-round rearing. Known areas of bull trout utilization will be avoided during management activities.

Ute Ladies'-Tresses *(Spiranthes diluvialis)*

Rare plant surveys have been conducted for the relicensing of Box Canyon Dam for the District, beginning in 1996. Surveys for the entire reservoir and associated habitats were completed in 1998. The reservoir and adjacent habitats were surveyed at the appropriate time of year of this three-year period, including all potential habitat for *Spiranthes diluvialis*. *Spiranthes diluvialis* were specifically targeted during 1997 and 1998 field surveys. No *Spiranthes diluvialis* were identified during any surveys. It has been concluded that *Spiranthes diluvialis* is not present in the Box Canyon Amendment area.

### *NATURAL HERITAGE PROGRAM*

The District consulted the Washington Department of Natural Resources Natural Heritage Program's database to verify threatened and endangered species that were present in the Box Canyon Reservoir area. Only one species, Adder's tongue (*Ophioglossum pusillum*), was discovered during rare plant surveys of the Box Canyon Reservoir (District 2002).

*Ophioglossum pusillum* is an unusual fern species with an upright fertile spike and a single, undivided basal frond. Its typical habitat is moist meadows and woods and boggy areas. It is identifiable May through September. It is a circumboreal species known from Alaska to the east coast, with many states and Canadian provinces in between. In Washington, *Ophioglossum pusillum* is included on the Threatened list (WNHP 1997). It is also included on the USFS Region 6 Sensitive Plant List. *O. pusillum* is known from nine sites in scattered counties in Washington (WNHP 1998).

In the Project area, a *Ophioglossum pusillum* population with several hundred plants was located on county-owned land in a fen (a non-sphagnum peaty bog) near Cusick. Plants were in scattered clumps on the edges of the fen where water from the fen seeps into the adjacent creek. As long as the habitat is not disturbed and the upslope hydrology is not altered, there are no apparent threats to the population and its habitat. Aquatic plant management would not be taking place in this area, so there should be no effect to this population.

## BENEFICIAL AND RECREATIONAL USES

This Interim Aquatic Plant Management Plan was developed in consideration of identified beneficial use resources, ESA regulatory constraints, and cultural resource protection. Other regulations and policy guidelines taken into consideration included county land use planning, FERC operating rules for water level elevations at Cusick, and tribal management plans. Additional tasks included identifying overlaps in multiple resource areas, and balancing needs with program costs and user group interests. Overall, eleven beneficial uses and resource goals in aquatic plant management were identified and are summarized in Table 5 below.

**Table 5. Beneficial Uses and Resource Goals for the Management Reach.**

| Beneficial Use | Goal |
|---|---|
| ***Boat Launches*** | Maximize the reduction and containment of identified problematic macrophytes through rotovation and education. |
| ***Swimming*** | Maximum containment of aquatic plants in public swim areas. For public beaches where swimming is not a primary use, the management goal is guided by other resource concerns. Contain aquatic plant growth near private docks and swim beaches, but priority is on public areas. |
| ***Fish Habitat-Salmonids*** | Provide that the aquatic plant management plan is consistent with fisheries management. Ensure that aquatic plants are not a barrier to tributary spawning. |
| ***Fish Habitat-Warm Water Fisheries*** | Manipulation of identified aquatic beds, mainly in sloughs to favor warm water fisheries as identified by fisheries management. |
| ***Shoreline Wetlands*** | Protect and maintain shoreline wetlands and their functionality with no rotovation within the wetlands. If possible, control the spread of non-native invasive aquatic plants from the reservoir to the adjacent wetlands. |
| ***Waterfowl Habitat*** | Aquatic plant management plan should be consistent with the wildlife management goal of maintaining a healthy great blue heron population, and avoid improving habitat for cormorants. |
| ***Shoreline Erosion and Hazard Occurrence*** | Emphasize emergent native plants in areas of moderate to high hazard bank erosion during the aquatic plant-growing season to reduce erosion caused by wave action. |
| ***Bald Eagle/ Osprey Habitat*** | Aquatic plant management plan should be consistent with the wildlife goal to maintain an abundant and easily acquired food supply. |
| ***Cultural*** | Treatment options will be specified on a confidential site-by-site basis to preserve the cultural integrity of the area. Rotovation will not be conducted at known cultural sites. |

| Table 5. Beneficial Uses and Resource Goals for the Management Reach. | |
|---|---|
| **Beneficial Use** | **Goal** |
| ***Amphibians*** | Rotovation is considered unlikely to impact amphibian populations. |

**Beneficial Use and Aquatic Plant Maps**

Beneficial use maps were developed in order to understand resource interactions and to assist in the development and implementation of management plans for the Management Reach. These maps are included in the Box Canyon Project Final License Application (FLA), (District, 2000). *The complete map sets are available for viewing at the Pend Oreille PUD office in Newport. Other locations where these maps are available for viewing include the public library in Newport, Pend Oreille County Planning Department, and Washington Department of Ecology (Jean Parodi-Spokane).*

In 1997, the aquatic plant communities within the Management Reach were mapped using a community classification scheme based on biomass, density, and percent species composition. Five plant community categories were used in these efforts; pure Eurasian watermilfoil, mixed beds dominated by milfoil (50-90% milfoil), mixed beds with milfoil (10-49% milfoil), mixed beds with no to minimal milfoil (<10% milfoil) and unvegetated. These categories were further classified to a subjective assessment of plant density. Aerial near-infrared imagery and field mapping data were combined to create a GIS map layer of aquatic plant community distribution. A complete description of the methods and the aquatic plant maps are located in Exhibit E, Water Quantity and Quality, of the Box Canyon Dam FLA. They are also provided in this document as Appendix D.

Aquatic plant maps can be used as a GIS layer in conjunction with beneficial use maps. These can serve as an important management tool to determine the appropriate control methods for particular resource areas, and to highlight those areas that require intensive aquatic plant control. Using a balanced approach to accommodate multiple beneficial use areas, priority areas for immediate aquatic plant control were determined based on the beneficial use maps. These priority areas included public and private boat launches and swimming areas. Containment intensity and control methods were also based on fisheries data which included key salmonid and bass habitat and spawning areas as well as aquatic-dependent wildlife habitat, such as waterfowl feeding areas. In areas of known fish spawning, restrictions were placed on the timing of the aquatic plant control efforts. Cultural areas were also identified and included. The locations of the cultural areas were excluded from the public maps, as the site locations are classified information. Additional factors included shoreline erosion and flooding effects.

Aquatic plant species and bed distributions are known to change annually, e.g., 1997 mapping showed few areas of *R. aquatilius*. This can be attributed to effects from flooding that occurred in 1996. As a result, site-specific assessments may be warranted prior to implementation of significant management actions.

**Beneficial Use Resource Goals**

Beneficial use resources, and the goals related to aquatic plant management are detailed in Tables 6 through 15 below.

| **Table 6. Boat Launches** | |
|---|---|
| ***Location*** | Locations shown on Aquatic Plant Maps |
| ***Period*** | May–September, with some activity year round. |
| ***Management Goal*** | Maximize the reduction and containment of identified problematic macrophytes through rotovation and education. |
| ***Management Effects*** | Current rotovation program concentrates on minimizing aquatic plant beds around public boat launches. Shoreline development for public access is often associated with boat launches. |
| ***EWM Impacts*** | Improper cleaning of boats can spread invasive plants to other waterbodies. |
| ***Action*** | Emphasize education at public boat launches. Public educational signs at boat launches regarding cleaning of aquatic vegetation from watercraft are posted. Focus on areas with dense beds of non-native plants. |
| ***Comments*** | When cleared of plants, swimmers use boat approach areas. Redirect swimming to nearby areas cleared of plants at a safe distance from high-use boat launches. |

| **Table 7. Public Beaches / Swim Areas / Private Swim Areas** | |
|---|---|
| ***Location*** | Locations shown on Aquatic Plant Maps |
| ***Period*** | May-September, with some activities year round |
| ***Management Goal*** | Maximum containment of all aquatic plants in public swim areas. For public beaches where swimming is not a primary use, the management goal is guided by other resource concerns. Rotovation of aquatic plant growth near private docks and swim with priority on public areas. |
| ***Management Effects*** | Swimmers prefer aesthetics of areas without dense aquatic plant beds. Swimmer safety is enhanced by rotovation. |
| ***How is Area Affected*** | Dense plant beds create a safety hazard and detract from enjoyment for the public and shoreline property owners. |
| ***Comments*** | Safety of swimmers is a concern. Safety at boat launches a concern. Provide shoreline property owners with information on the ecological value of native aquatic plants and alternative treatment methods geared to individuals. |

| **Table 8. Warm Water Fisheries** | |
|---|---|
| ***Location*** | Primarily sloughs (see FLA, District 2000). Bass-spawning habitat was mapped as part of relicensing studies for the Box Canyon Dam. |
| ***Period*** | April 1-July 1. |
| ***Management Goal*** | Manipulation of identified aquatic plant beds to favor warm water fisheries as identified by fisheries management. |
| ***Management Effects*** | Plant beds should be maintained at modest densities to maximize foraging for fish growth and predation success of largemouth bass. Plants support |

| Table 8. Warm Water Fisheries | |
|---|---|
| | zooplankton population and are cover for small fish. Rotovating is not done in sloughs during spawning periods. Increase structural habitat diversity. |
| ***How is Area Affected*** | Varies by life stage/summer seasonal cover for largemouth bass predation focus. |
| ***Comments*** | Literature review suggests the highest densities of all life stages of bass are achieved by rotovating a cruising lane up the middle of the sloughs parallel with the long axis of the slough.<br><br>Rotovate beds or provide shading to facilitate forage lanes for predatory fish like bass. Need baseline information on size structure of predator (bass) and prey (panfish, yellow perch) species and follow-up monitoring to determine if efforts are successful. |

| Table 9. Native Salmonids | |
|---|---|
| ***Location*** | Cold water tributaries and sloughs |
| ***Period*** | Times to avoid include migration period for bull trout, whitefish, and cutthroat trout, in addition to spawning period for largemouth bass. |
| ***Management Goal*** | Aquatic Management Plan consistent with fisheries management. |
| ***Management Effects*** | Rotovation cleans substrate used by salmonids. Rotovation is not effective in cobble habitats; however, aquatic plants are sparse to non-existent in cobble areas of river. |
| ***How is Area Affected*** | Change in plant density from sparse or absent to dense in areas with gravel or cobble substrate could lead to degradation of spawning/rearing habitat. Flow velocity obstructions would likely be a necessary catalyst to allow plants to become established at dense levels where bed is now coarse gravel/cobble. |
| ***Comments*** | Aquatic plants should not be allowed to be a passage barrier to tributaries. Native salmonids are the priority species and management of macrophytes should avoid negative impacts.<br><br>Issues: Effective management may require zoning of the reservoir and sloughs as identified for targeted species. Some sloughs may be managed as a migration corridor while others as largemouth bass forage. |

| Table 10. Cultural Resources | |
|---|---|
| ***Location*** | 121 Site locations (locations are confidential) |
| ***Period*** | Year round avoid disturbance at cultural sites as they are identified. |
| ***Management Goal*** | Site-specific treatment options will have to be designed on a site-by-site basis, if necessary. Site confidentiality should be preserved to protect cultural sites. |
| ***Management Effects*** | Many inundated sites are not known especially on or adjacent to private lands or areas. Where rotovation is already ongoing, there is reduced potential to cause further damage should unidentified sites exist. |
| ***Action*** | Rotovation not conducted at known sites to avoid bed disturbance. |
| ***Comments*** | Not all archeological sites are known. Develop mechanism or model that identifies areas likely/unlikely to have sites. Shading may be the best option |

| Table 10. Cultural Resources | |
|---|---|
| | in areas of low velocity, if active management is necessary. Kalispel Tribe is to compare rotovation sites with known submerged archeological sites and notify County if necessary. Protection is through avoidance of rotovation. |

| Table 11. Shoreline Wetlands | |
|---|---|
| ***Location*** | Locations shown on beneficial use maps as semi-permanent to permanently flooded wetlands. |
| ***Period*** | Year round |
| ***Management Goal*** | Protect and maintain shoreline wetlands and their functionality. Control spread of non-native invasive aquatic plants from reservoir to adjacent wetlands. |
| ***Management Effects*** | Spread of non-native invasive plans to surrounding wetlands. |
| ***How is Area Affected*** | Non-issue for seasonal open water wetlands. Flooding and wildlife can transport non-native invasive aquatic plants from the river and sloughs into surrounding open water wetlands, where these invasive plants can out-compete native emergent vegetation. Habitat diversity is degraded and open water within surrounding wetlands is reduced. |
| ***Action*** | Wetlands are not rotovated. Other methods may be employed if necessary. |
| ***Comments*** | Wetland areas may also have important cultural significance as a traditional harvest of native roots (e.g., camas). |

| Table 12. Colonial Nesting Water Birds (Great Blue Heron and Double Crested Cormorant) | |
|---|---|
| ***Location*** | Nest areas are shown on beneficial use maps. |
| ***Period*** | Breeding season: April/May – August |
| ***Management Goal*** | Aquatic Management Plan should be consistent with wildlife goal: Maintain healthy great blue heron population (not at risk by rotovation). Avoid improving habitat for cormorants (perceived as undesirable species). |
| ***Management Effects*** | Unlikely to have any effect on great blue heron, which feed in shallow water. It is unknown what effects plant beds have on cormorants. Presumably they do not feed in dense beds. There are many areas where these birds can feed both in the river and at Calispell Lake. |
| ***How is Area Affected*** | Unclear- probably little effect, however, there is at least some potential to affect food availability. |
| ***Comments*** | Operators have viewed cormorants feeding downriver of rotovated areas. |

| Table 13. Osprey and Bald Eagle Nest Sites and Feeding Areas | |
|---|---|
| ***Location*** | Nest sites shown on beneficial uses maps, feeding areas are not shown. |
| ***Period*** | Osprey (April) May – September |
| ***Management*** | Aquatic plant management should be consistent with wildlife goal to maintain |

| | |
|---|---|
| ***Goal*** | an abundant and easily acquired food supply. |
| ***Management Effects*** | Uncertain: There is no evidence that either species is currently limited by food supply. It is possible that these species benefit from dense weed beds that force small to medium size fish to swim above the beds where they are more easily caught. The provision of passageways through dense weed beds might allow fish to swim deeper. |
| ***How is Area Affected*** | Little is known of when Osprey or Bald Eagle feed most heavily – both can travel long distances to feed. There is little likelihood that nesting bald eagles would be disturbed by rotovation. Osprey (more numerous and with many nests on pilings) are presumably unaffected by disturbance from boats, or presumably by rotovation. |
| ***Comments*** | Bottom feeding fish are often stirred up by rotovation and come to the surface. Rotovator operators have observed osprey feeding behind the rotovator. |

| **Table 14. Amphibian** | |
|---|---|
| ***Location*** | Locations shown on beneficial uses map |
| ***Period*** | May to October |
| ***Management Goal*** | Where bullfrog abundance is documented as a problem, contain surface level aquatic plants to aid in the control of bullfrog populations especially in sloughs. This management goal is secondary to other aquatic plant management goals since the effects are minimal. |
| ***Management Effects*** | The only species of amphibian likely to be affected by aquatic plant control in the river is bullfrog. Bullfrogs are considered an undesirable species so an adverse effect would be anything that could *improve* conditions for this species. |
| ***How is Area Affected*** | Bullfrogs have been observed floating/sitting on aquatic plants, which are at the surface. Clearing plants may reduce this habitat feature. Net effects of rotovation is beneficial (reduction in bullfrog habitat); however activities in the river are not likely to have a major effect (positive or negative) on this species because other habitats (ponds and borrow pits) are abundant in the region. |
| ***Comments*** | |

| **Table 15. Shoreline erosion and hazard occurrence** | |
|---|---|
| ***Location*** | Moderate to high hazard erosion areas shown on beneficial uses map |
| ***Period*** | From after spring high water in June through October. |
| ***Management Goal*** | Emphasize emergent native plants in areas where moderate to high hazard bank erosion occurs during growing season (June – October). |
| ***Management Effects*** | Areas devoid of shoreline vegetation are most vulnerable to initiation of accelerated erosion processes. |
| ***How is Area Affected*** | Dense aquatic plant beds at the surface can reduce bank undercutting caused by wind and boat generated waves. Spring high flow bank undercutting is not affected since plant beds are not at the surface this early in the growing season. |

| Table 15. Shoreline erosion and hazard occurrence | |
|---|---|
| ***Comments*** | As erosion problems occur mostly where banks are steep and currents are swift, areas where aquatic plant beds are minimal. |

# CONTAINMENT ALTERNATIVES

The Pend Oreille Public Utility District No.1 completed a literature review of control methods for the management of EWM. (District 2000). This is included as Appendix C. A review of the effectiveness of rotovation within the Pend Oreille River between Albeni Falls and Box Canyon dams is provided in Appendix B. Control methods reviewed included mechanical methods such as harvest, and rotovation, drawdown, sediment covers and shading methods, manual removal methods (handpulling); dredging; weed rolling; and use of ultrasound. Biological methods reviewed included introduction of herbivorous fish, insect control (including milfoil weevils). Competitive plantings, and plant pathogens were also reviewed for use as EWM control methods. Preventative controls of spread of EWM to other water bodies include boater education with signage at public boat ramps.

**No-Action Alternative**

Currently, large, dense beds of aquatic plants have proliferated throughout the Management reach. If these plants are not controlled through mechanical, biological, or chemical means, this proliferation of plants will continue, and will potentially spread to other areas where the plants are currently absent or contained. Without control, the following effects are likely to be observed:

- Increased impairment of recreational activities such as boating, fishing, and swimming
- Decreased aesthetics in populated areas
- Increased risks to human health and safety (i.e., decreased swimmer safety; boating safety)
- Continuing and increased negative impacts to both cool and warm-water fish populations (i.e., beds too thick for effective feeding areas for largemouth bass; decreased velocity in gravel/cobble spawning areas for salmonids)
- Decreased protection for shoreline wetlands from the spread of non-native invasive plants.

**Environmental Manipulation** (reduce nutrient sources, handpulling, drawdown, bottom barriers)

***Drawdown***

When used as a method of aquatic plant control, drawdowns are designed to expose the target plants to drying or freezing conditions (or both) in hopes of killing the plants. Drawdown is widely used elsewhere, in part because it is included in many water management regimes for reasons other than EWM control. This Management Reach-wide control method has been explored as a potential option for aquatic plant control within the shallows of the Pend Oreille River upstream of Box Canyon Dam.

At this time, the use of drawdown is not recommended in the Management Reach. A two-year study to determine the efficacy of drawdown as a management strategy was conducted in Campbell Pond, a 2.32-acre test site near Box Canyon Dam. The drawdown did not affect Eurasian watermilfoil frequency or biomass in Campbell Pond. Although significant increases in the cover of bare ground were observed, it was indicative of a loss of native species and not Eurasian watermilfoil. This represented a loss of native plant cover in the two years following drawdown (Framatome 2003).

***Bottom Barriers***

Although bottom barriers can be effective tools in reducing the aquatic macrophytes, their use in the Management Reach is not recommended on a large-scale. Although homeowners can install bottom barriers with the appropriate permits, the use of bottom barriers throughout the reservoir is not cost-effective and would interfere with rotovation efforts.

**Mechanical Control**

***Rotovation and Root Ripping***

Rotovation involves the tilling of bottom sediments to dislodge plant roots and control aquatic macrophyte growth. Root ripping involves hooking the aquatic plant biomass and pulling the plants out by the roots. The primary goal of rotovation and root ripping in the Management Reach is the physical removal of EWM. Rotovation is done using a boat-mounted Aquamog™ with an 8-foot long tiller attachment. Root ripping is done using the same Aquamog with a 14-foot rake attachment. The effective operational depth is 16-18 ft, which is capable of reaching virtually all suitable EWM habitat. A two-pass rotovating treatment is typically employed; the first pass is parallel to the shore and the second pass is perpendicular to shore. Additional rotovating may be necessary if post-treatment inspection detects that areas were missed. Root ripping is only appropriate once plant bed growth reaches a high density. It requires multiple passes through the plant beds. It is not as clean as rotovation and cannot clear as close to docks; but, it can make an area usable to watercraft users and swimmers at a more rapid rate during the height of the growing season.

Pend Oreille County maintains a chronological record of areas rotovated. Location, month and year of rotovation were plotted on maps for all sites rotovated within a three-year period prior to the August 1997 mapping effort. GIS was used to generate acreage within each plant community class sorted by season and year since last rotovated. Rotovation in summer months (July and August) was distinguished from winter-month rotovation. High water and bass spawning timing typically preclude rotovation in late May and June. No rotovation occurred in 1997 between June and the time of survey due to high water conditions. Areas where only spot rotovation occurred were analyzed separately. Maps (Appendix G) show the history of rotovation within the management reach.

**Biological Control**

***Milfoil Weevil***

The milfoil weevil (*Euhrychiopsis lecontei*) has exhibited considerable promise as a biological control agent for EWM. The milfoil weevil is milfoil-specific, native to North America, and associated with declines of EWM both in the lab and the field. Unfortunately, the success of weevils in the Management Reach is most likely limited.

Milfoil-weevil experiments within the Management Reach were conducted in 2001 and 2002 to explore the feasibility and success of using milfoil weevils as a milfoil containment option. Milfoil weevil collection, rearing, and introduction efforts were successful, resulting in the estimated production of nearly 16,000 weevil eggs and larvae over two years. However, these efforts failed to establish substantial weevil populations in a partially enclosed bay in the Pend Oreille River, and Eurasian watermilfoil in the test area appeared unaffected. The recommendation of this study was to terminate milfoil-weevils as a management strategy (Framatome 2003). However, as more information is developed in other areas, revisiting this strategy may be warranted.

***Grass Carp***

The use of herbivorous fish, such as grass carp (*Ctenopharyngodon idella*) has been limited for EWM control and their introduction and use within the Pend Oreille River is neither recommended nor permitted by the State. The grass carp is an herbivorous fish native to China that has been used in aquatic plant control efforts in the United States since 1963. Control is initiated by stocking pre-determined levels of fish into an area of concern. Due to the expense of trucking, stocking, and monitoring large numbers of imported grass carp, this is a large-scale method not appropriate for homeowner implementation within the river. In addition, fish are mobile and unlikely to remain at their stocking site, diluting any potential benefits for a particular site. Homeowner use in ponds that do not connect to the river would be an individual choice.

**Chemical Control**

Currently, the use of herbicides control is limited by the nature of the river's flowing water and the Washington State Department of Ecology for use within the Management Reach. A goal of this plan is to identify areas appropriate for herbicide control, contact the affected landowners and water rights holders and solicit their cooperation in organizing an herbicide application. The

County would obtain the required permit, collect the fees associated with the work and contract out the application.

### *Herbicide Options*

1. Dow DMA 4, 24D. Use of this product has been extensive with excellent results. Cost approximates $225-250 per acre depending on water depth. This product targets Eurasian watermilfoil while having no impact on the other plants.

2. Aquathol Super K. This granular herbicide is very effective with respect to rapid control of both Eurasian Milfoil and Potomogetons such as curly leaf pondweed. It is not very effective on Elodea. It is also a contact herbicide so it is more of a maintenance treatment. This product goes out for about $500.00 per acre.

3. Reward. This broad spectrum liquid herbicide is very effective when targeting most submerged aquatic plants. It also is a contact herbicide, so it would be a maintenance treatment. The cost is $265.00 per acre.

4. Renovate. This product is not yet registered for use in Washington State waters. It is effective at controlling Eurasian watermilfoil while having a lesser effect on native plants. Cost may be prohibitive at up to $1,000 per acre.

5. Sonar 4AS or Sonar 5P or SRP. As a liquid or pellet, it is a broad spectrum and systemic herbicide. It is effective at controlling Eurasian watermilfoil, although not selectively so. Lower rates can achieve good milfoil control while creating less damage to native plants. Long exposure times are needed. Cost may be prohibitive from $700 up to $1,000 per acre.

Along with greater product availability, application techniques, such as the use of curtain barriers, have been developed to target applications that maximize targeted affect while minimizing non-target damage.

## Other Technologies

### *Commercial Control Options*

Both harvesting and hand removal by SCUBA divers have been commercial options available to the waterfront property owner at various times throughout the past 10 years. It is anticipated these options will remain available through the life of this plan. Coordinating with landowner choices and the publicly operated Aquamog will remain a function of the Weed Board.

### *Harvesting*

Harvesting of EWM is a viable method for creating briefly weed-free areas in infested waters; however, EWM regrowth begins immediately and can be complete within weeks. Studies conducted in Lake Washington (WA) and Lake Minnetonka (MN) indicated that harvested areas grew faster than the control areas (Aquatic Research, Incorporated 1986; Crowell et al. 1994). In

Lake Washington, total EWM regrowth was documented in 30 days. After 60 days, biomass was substantially the same in control and harvest sites. Harvested sites had a 71 percent increase in plant density as compared to pre-harvest levels, while control sites had increased only 41 percent. Harvest has also been shown to change species distributions, favoring fast-recovering species (Engel 1990). Others concur, suggesting that repeated harvests will select for harvest tolerant species (like EWM) over time. Please see Appendix C for further details.

# PUBLIC INVOLVEMENT

During the relicensing process for the Box Canyon Dam, the Pend Oreille Public Utility District coordinated a series of meetings of the Box Canyon Water Quality Work Group. The public was invited to attend and contribute to the meetings. Copies of minutes from these meetings and associated correspondence are included in Appendix E. In 2000, this group developed and distributed a survey to ratepayers in the District to document public concern on aquatic plant management in the Box Canyon Reservoir. Results of this survey are included in Appendix A.

A public workshop was held November 13, 2003 (Appendix E). Public comments from that meeting included interest in having a second rotovator crew working the Pend Oreille River. Pend Oreille County cannot afford to do this proposal. The prospect of forming a LUID to help generate revenue to pay for a second crew was discussed. The Board of County Commissioners have been apprised of the situation and are aware of this request. Series of public meetings have been held with both the County and the District commissioners regarding the rotovation program and the need for a new rotovator and grant funds.

# INTEGRATED MANAGEMENT STRATEGY

### Budget (O & M, Planning, and Capital Costs)

In 2003, the Pend Oreille Board of County Commissioners charged the Pend Oreille County Noxious Weed Control Board (Weed Board) with the fiscal and operational management of the Pend Oreille River milfoil control program. The 2003 budget was set at $99,266. During this year, the District has supported the program at 90% of the funding level with a cap of $75,000. The County has made up the remainder from the general fund.

The proposed budget for 2004 is $373,900. Of that amount, $125,900 covers expenses for two vessel operators, a portion of supervisory, support and substitute staff, employee benefits, fuel and supplies to operate and maintain the vessel and vehicle rental fees for crew travel. Planning costs are included in the basic funding. The remaining $248,000 covers Aquamog replacement costs.

In 2003, the County was granted Congressional funding at 50% to purchase a new Aquamog (estimated cost $250,000). Currently, the County and the District are working to secure funds from the State for another 25% of the purchase price. The remaining 25% must be matched at the local level. Plans for attaining this local match include surplussing the current vessel, accessing funding from Title II of the Secure Rural Counties and Schools Act of 2000, and the capital fund set up by the District from excess O&M funds unspent in previous years.

## Funding Strategy

The Pend Oreille County Weed Board anticipates the District's continued commitment to financial support for the river milfoil control program.

The Weed Board sent a proposal to the Board of County Commissioners to provide basic funding for its programs through a fee assessed to the lands of the county benefiting from the county weed control programs. Due to river conditions, such as ice, extremely low temperatures and high water, the vessel cannot operate every day throughout the year. This amounts to 20-25% of the crew time that cannot be charged to the milfoil program. Funding from the other Weed Board programs will support the crew as full-time employees.

In 2003, the County was granted Congressional funding at 50% to purchase a new Aquamog (estimated cost $250,000). Currently, the District and the County are working to secure funds from the State for another 25% of the purchase price. The remaining 25% must be matched at the local level (local costs will be primarily shared by the County and the District).

## Rotovation

It is important to note that although EWM and other aquatic macrophytes are effectively reduced by rotovation, recolonization rates can vary widely. In some cases, re-established macrophytes have exceeded pre-treatment densities, although the recolonization may not be dominated by EWM. Therefore, when evaluating rotovation effectiveness, it is important to evaluate both the total aquatic macrophyte density and EWM density. While rotovation is effective, it is best viewed as a maintenance program for controlling, not eradicating EWM and other invasive aquatic plants.

For the Management Reach, rotovation is the preferred method for controlling EWM densities. Aquatic plant beds that have been rotovated generally can go 2 to 3 seasons between treatments versus 2 to 3 months when harvested. It is also less expensive to rotovate the plant beds rather than handpulling or employing SCUBA divers. Herbicides hold limited applicability for use in flowing water. A 1997 study which examined pre- and post rotovation aquatic plant densities indicated that the rotovation program is effective at reducing plants in the Management Reach and suggested that the rotovation may contribute to a shift in species composition (Appendix B). Generally, areas that had been rotovated were revegetated within one year. Beds were composed of mixed species beds dominated by curly leaf pondweed or waterweed. EWM generally was not dominant until the third summer after rotovation and even then most beds were dominated by other species.

This year was the first season of extensively employing root ripping with the rake attachment. Monitoring in successive years will yield information on the effective results.

## Need for New Rotovator

The existing Aquamog is 15 years old and has been rebuilt a number of times. With a new machine, far less time will be required for maintenance and machine down time; therefore, it will be on the river a greater amount of time doing the job intended.

**Promote Homeowner Control**

In addition to rotovation, landowners and individuals are encouraged to participate in the process of aquatic plant management. Methods such as hand pulling, hand cutting, weed rakes, or weed rolling are encouraged. These methods can have a localized effect on the density of aquatic weeds in defined swimming or boating beneficial use areas. (also possible formation of LID to help generate revenue to pay costs)

**Preventative Control and Education**

Preventative control measures include improving education of users within the watershed to the effects of introduced, non-native plants to the water body. Although preventative control does not improve the aquatic plant conditions within the Management Reach, it is a key part of this Interim Aquatic Plant Management Plan to promote awareness of reducing EWM and possibly, new exotic plant infestations within the Management Reach and surrounding watersheds. EWM has yet to be eradicated from any large water body to which it has been introduced. Therefore, preventing the spread of EWM into uninfested areas is of great importance.

Current preventative measures include signs at all boat launches that warn against the spread of milfoil. The County has also held two milfoil workshops over the last two years covering identification, aquatic plant ecology, survey techniques, herbicide control and techniques the homeowner can employ, including the WDFW permit requirement. For the future, other preventative measures include continuing with regularly scheduled yearly or biennial educational programs and developing and distributing pamphlets at educational programs, with boat licenses or at recreational and commercial facilities. The County will also be sending notification to landowners when the Aquamog will be working in their area and will include a pamphlet with that mailing. Landowners will be encouraged to organize and patrol their community boat launches to ensure owners with boats and trailers pull out and clean off their equipment.

**Research**

Research will include follow-up studies to determine the rotovation and root-ripping success in reducing EWM in the Management Reach.

**Action Plan**

***Short-Term Actions***

Short term actions will be implemented within one to five years. Those actions that identify an annual activity will begin in 2004.

- The Weed Board staff will rotovate a minimum of 200 acres/year and will focus on public swim and boat launch areas and secondary focus on private developed shoreline. Eighty percent of the staff time is available for rotovator field work. Weather conditions such as ice, high river flows, and extremely low temperatures create safety issues that preclude vessel operation the other 20% of the time. The same areas as have been historically rotovated will continue to be rotovated with all the areas shown on the maps in Appendix G treated at least once every three years. The areas intended for rotovation in 2004 – 2006 are the same as those indicated on the maps in Appendix G. The sequence of rotovation within this time period is dependent upon scheduling, maintenance, reported problem areas and weather. Generally, the rotovator progresses continuously in one direction along the river and then begins treatment in the return direction.

- In a cooperative effort, the Extension Service, Weed Board, and District will promote public outreach for individual and private aquatic plant control management by holding a public meeting in 2004 to describe this plan and to solicit/encourage public involvement.
- Sponsor one public meeting each year to discuss aquatic plant management within the Pend Oreille River. The schedule for rotovation during the following season will be publicized at this meeting and public comments on the plan's implementation will be gathered for subsequent evaluation.
- The District shall establish a web-based posting that identifies where rotovation will be occurring on a two-week to one-month interval.
- Convene an annual meeting with interested natural resource agencies and citizen representation to review revisions to the Aquatic Plant Management Plan. This meeting will be held in the early spring so that any new actions can be considered for implementation within the upcoming growing season.
- Pend Oreille County will continue to post and maintain signs at all public boat launches that educate river users about proper cleaning of watercraft to remove aquatic plant debris and minimize spread to other waterbodies.
- The Weed Board shall request the Kalispel Tribe to annually update the County file, which identifies areas with known submerged cultural artifacts that might be damaged by rotovation. The County does not rotovate these areas.
- The Weed Board shall work with the Kalispel Tribe to identify two locations to rotovate fish "cruising" lanes within aquatic weed beds that promote warm water fisheries. Each cruising lane will be no shorter than 100 m, and the lanes will be rotovated annually.
- The Weed Board, the Cooperative Extension Service, and the District shall jointly apply for grants to purchase a new rotovator.
- The Weed Board and the District will conduct annual monitoring of aquatic plant index areas to assess plant diversity and the level of infestation by invasive species using appropriate field protocols and aquatic plant maps (Appendix D) to record annual changes.
- The Weed Board will maintain records of dates and areas where rotovation occurs.

### *Long-Term Actions*

Long-term actions require long-range planning and will be implemented within a ten-year time frame.

- A cooperative effort between the Weed Board and Cooperative Extension Service will promote citizen involvement in aquatic plant management for Pend Oreille County by establishing a master weed manager's program that focuses on aquatic plant management. This program will be patterned after Master Gardener's programs, which trains volunteers to act as information contact points to the public.

- The Weed Board and the District will request incorporation of the Aquatic Plant Management Plan into fish management plans for the Pend Oreille River that are developed by the resource management agencies and Kalispel Tribe.
  Incorporate aquatic plant management into the Bull Trout recovery plan for Pend Oreille River in Washington.
- The Weed Board and landowners, working in cooperation with the WDOE, will implement and investigate herbicide containment alternatives, as appropriate in the Pend Oreille River Management Reach.
- The Weed Board and the District shall review and incorporate new aquatic plant control methods as they become available within the permitting process.
  - All parties will encourage additional research for EWM control by promoting/seeking additional funding and working with the U.S. Army Corps of Engineers, WDOE, and universities.
  - The Weed Board will coordinate landowners' permit to cover individual landowners' EWM control projects..
  - Communicate with Seattle City Light and cities of Metaline and Metaline Falls about aquatic plant concerns downstream of the Management Reach.
  - The Weed Board and landowners will review the feasibility of establishing a lake district to supply additional funds, in order to support the rotovation program.
  - Investigate other alternative funding sources for implementation of the Aquatic Plant Management Plan.

**Adaptive Management for Evaluation and Monitoring of Aquatic Plant Management**

Twenty index sites will be established for annual monitoring of aquatic plant communities. Each index site will be 300 m in length parallel to the shoreline and extend from the shoreline outward to a depth of 5.5 m (approximately 18 ft, which is the limit for most aquatic plant growth in Pend Oreille River). The sites will be selected by the Pend Oreille County Noxious Weed Control Board through a review of the most current aquatic plant maps for Pend Oreille River. The initial selection of sites will be based on the 1997 aquatic plant maps for the Box Canyon Reservoir (Appendix D) and will include areas representative of each of the following plant community types:

- Moderate to dense beds with >90% non-native
- Moderate to dense mixed species beds with 10%-89% non-native
- Moderate to dense beds with <10% non-native
- Sparse mostly non-native plant beds

The index sites will be distributed throughout the length of the Pend Oreille River between Albeni Falls Dam and the Box Canyon Dam safety net. Sites will be located both within the main channel and within sloughs. At least half of the main channel index sites selected will be within areas rotovated within the last three years. Once established, the index sites will remain the same for subsequent annual surveys. The survey will occur in August through early September when plant biomass is at its peak. Surveyors will visually estimate the outer boundary of aquatic plant beds using a classification system similar to that used in the 1997 survey (it is recommended that the categories be revised to consider all non-native invasive aquatic plant species rather than just Eurasian watermilfoil. The 1997 aquatic plant maps will serve as a base map for initiating surveys. Surveyors will note the approximate areal percentage of the index area populated by aquatic plants. The density of infestation will be noted for each plant bed within the index area (dense or sparse). Rotovation or other plant containment activities within an index area within the last three years will be noted in the survey report. The three most dominant species within each plant community will be noted. Field notes will be prepared on a standardized form. The updated (hand sketched) maps will be archived along with field data forms. This information will be made available at the annual agency resource meetings, which convene to review the Aquatic Plant Management Plan implementation. Revisions to the Aquatic Plant Management Plan may then consider the results of this survey.

The County will maintain records of the rotovated sections within the Management Reach. The activity log should include the time, intensity, and location of rotovation and root ripping activities. The total area rotovated will be tabulated annually to determine if the target of a minimum of 200 acres rotovated and 100 acres root-ripped is met each year. The area rotovated or root-ripped can be estimated from the 1997 aquatic plant community base maps. Although plant species composition can be variable over time, the suitable habitat to sustain plant communities is generally consistent over time. The acreage of aquatic plant beds occurring along each shoreline development area can be calculated by GIS from the 1997 base map. The County can then use this information as a quick reference as to the acreage of plant beds associated with each reach that is treated.

A monitoring and evaluation strategy will be incorporated into any test pilot programs implemented as part of this management plan that evaluate the effectiveness of alternative containment strategies.

A record of the annual public meeting to be held to incorporate public concerns on the implementation of the Aquatic Plant Management Plan will be prepared and filed with the County.

Interested resource agencies and citizen representatives will meet annually to review the Aquatic Plant Management Plan. The monitoring data will be reviewed at these meetings. A schedule for rotovation and other management activities planned within the coming year will be reviewed. The beneficial uses maps will also be reviewed to determine if there is a need to update these maps. The groups will also consider information from other aquatic plant research and new aquatic plant control techniques to improve control efforts. The management plan will then be updated based upon input during public meetings and the annual resource agency meeting.

**Permitting**

Rotovation and EWM control activities require local and state permits, whether the activities are carried out by the County or by individual landowners. The County is currently examining the feasibility of obtaining a Management Reach-wide Hydraulic Project Approval (HPA) permit for EWM management that would also apply to individual homeowner actions. A copy of the permit is located in Appendix F.

# REFERENCES


Bennett, D.H, C.M. Falter, K. Reese, W. McLaughlin, W.D. Sawle. M. Liter, J.W. Carlson, J. Hall, and N. Sanval. 1990. Fish, Wildlife, and Recreational Characterisitics of Box Canyon Reservoir, 1989 Annual Report. College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID.

Coots, R. and B. Carey. 1991. Pend Oreille River Fishery/Rotovation Study. Washington Dept. of Ecology, Environmental Investigations and Laboratory Services Program, Surface Water Investigations Section. Olympia, WA.

Coots, R. and R. Willms. 1991. Pend Oreille River Primary Productivity and Water Quality of Selected Tributaries. Washington Dept. of Ecology. Olympia, WA.

Falter, C.M., C. Baines, J.W. Carlson. 1991. Water Quality, Fish and Wildlife Characteristics of Box Canyon Reservoir, WA Section 2 Water Quality. College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID.

Falter, C.M. and O. Olson. 1991. Periphyton as Indicators of Enrichment in Lake Pend Oreille, Idaho. Final Report Submitted to the Idaho Division of Environmental Quality. Boise, ID.

Falter, C.M. and B.W. Riggers. 1993. Aquatic Community Responses to Aquatic Macrophyte Habitat Alterations in Box Canyon Reservoir, Washington. Final Report Submitted to Pend Oreille County PUD No. 1. Newport, WA.

Framatome ANP, 2003. Box Canyon Project Aquatic Plant Containment Pilot Studies, 2000-2002. Prepared for Public Utility District No. 1 of Pend Oreille County.

Pelletier, G. and R. Coots. 1990. Progress Report No. 1 Pend Oreille River Water Quality Study. Washington Department of Ecology. Olympia, WA.

Public Utility District No. 1 of Pend Oreille County, Washington. January 2000. Box Canyon Hydroelectric Project, FERC No. 2042, Application for New License. Newport, WA.

Skillingstad, T.H. and A.T. Scholz. 1993. Trends in Water Quality in the Box Canyon Reservoir of the Pend Oreille River Adjacent to the Kalispel Indian Reservation. Fisheries Tech. Rep. No. 44. Upper Columbia United Tribes Fisheries Center. Eastern Washington Univ. Cheney, WA.

Skillingstad, T.H., B.L. Ashe, and A.T. Scholz. 1993. An Assessment of Water Quality and Biota in the Pend Oreille River Before and After the Introduction of Effluent from a Thermonuclear Newsprint Mill. Fisheries Tech. Rep. No. 47. Upper Columbia United Tribes Fisheries Center. Eastern Washington Univ. Cheney, WA.

U.S. EPA (United States Environmental Agency). 1993. Clark Fork-Pend Oreille Basin Water Quality Study: a Summary of Findings and a Management Plan. EPA 910/R-93-006. Region 10. Seattle, WA.

Water, 1988. Pend Oreille River Eurasian Watermilfoil Control Program 1988. Pend Oreille County. Newport, WA.

Wetzel, R.G. 1983. Limnology, 2nd edition. Saunders College Publishing. New York, NY.

Williams, C.H. 1981. Studies on the Ability of a *Potamogeton pectinatus* Community to Remove Dissolved Nitrogen and Phosphorus Compounds from Lake Water. J. Of Applied Ecology 18:619-637.

# APPENDIX A

# PEND OREILLE COUNTY PUD CUSTOMER SURVEY
# AQUATIC PLANT MANAGEMENT

total surveys 1320 | included in data 942 | blank or unreadable 378

**1. Where is your primary residence? (Check one)**

| | Freq. |
|---|---|
| On the PO between OT and Dam | 150 |
| 1/2 mile of PO river | 120 |
| Somewhere else in PO county | 227 |
| In another county or state | 210 |
| no response | 235 |
| | 942 |

Note: Results tallied by residence category are only inclusive of those surveys reporting primary residence

**2. Are you satisfied with the current rotovation program?**

| | Freq. |
|---|---|
| Yes | 236 |
| No | 344 |
| No response/Does not know | 362 |
| | 942 |

| Question 2 | | | |
|---|---|---|---|
| Yes | No | None | |
| 26 | 115 | 9 | On the PO between OT and Dam |
| 62 | 32 | 26 | 1/2 mile of PO river |
| 126 | 70 | 31 | Somewhere else in PO county |
| 43 | 121 | 46 | In another county or state |
| | | | |

**3. Rank boat launches in order of importance**
Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

| # | Question 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | | NI | SMI | SI | SMI | EI | NO | No Res |
| # | On the PO between OT and Dam | 74 | 11 | 19 | 7 | 18 | 3 | 18 |
| # | 1/2 mile of PO river | 36 | 16 | 7 | 14 | 16 | 17 | 14 |
| # | Somewhere else in PO county | 96 | 24 | 22 | 18 | 28 | 31 | 8 |
| # | In another county or state | 62 | 12 | 21 | 0 | 1 | 29 | 85 |

**4 Rank swimming and public areas**
Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

| # | Question 4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | | NI | SMI | SI | SMI | EI | NO | No Res |
| # | On the PO between OT and Dam | 74 | 45 | 15 | 4 | 8 | 1 | 3 |
| # | 1/2 mile of PO river | 75 | 16 | 7 | 4 | 6 | 5 | 7 |
| # | Somewhere else in PO county | 85 | 24 | 22 | 32 | 26 | 13 | 25 |
| # | In another county or state | 153 | 17 | 12 | 10 | 8 | 2 | 8 |

**5 Rank wildlife habitat**
Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

| # | Question 5 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | | NI | SMI | SI | SMI | EI | NO | No Res |
| # | On the PO between OT and Dam | 56 | 32 | 25 | 19 | 6 | 3 | 9 |
| # | 1/2 mile of PO river | 68 | 11 | 16 | 18 | 3 | 4 | 9 |
| # | Somewhere else in PO county | 98 | 28 | 37 | 16 | 12 | 9 | 27 |
| # | In another county or state | 103 | 16 | 20 | 53 | 3 | 6 | 9 |

**6 Rank fish spawning in order of importance**
Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

| # | Question 6 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | | NI | SMI | SI | SMI | EI | NO | No Res |
| # | On the PO between OT and Dam | 42 | 32 | 31 | 7 | 9 | 3 | 26 |
| # | 1/2 mile of PO river | 34 | 25 | 18 | 8 | 3 | 24 | 8 |
| # | Somewhere else in PO county | 108 | 31 | 33 | 6 | 9 | 13 | 27 |
| # | In another county or state | 107 | 21 | 13 | 5 | 26 | 18 | 20 |

**7 Rank fishing areas in order of importance**
Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

| # | Question 7 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| # | | NI | SMI | SI | SMI | EI | NO | No Res |
| # | On the PO between OT and Dam | 48 | 31 | 32 | 11 | 18 | 4 | 6 |
| # | 1/2 mile of PO river | 39 | 42 | 15 | 10 | 3 | 4 | 7 |
| # | Somewhere else in PO county | 107 | 25 | 36 | 8 | 15 | 13 | 23 |
| # | In another county or state | 134 | 25 | 17 | 32 | 7 | 9 | 11 |

**8. Fish and wildlife habitat can benefit from selective rotovation. If necessary, would you be willing to redirect some of the current rotovation to benefit these resources, even if it meant docks and**

| | Resp. |
|---|---|
| Yes | 268 |
| No | 201 |
| No opinion | 289 |
| No response/Does not know | 184 |

| | Question 8 | | | |
|---|---|---|---|---|
| | Yes | No | No Op. | none |
| On the PO between OT and Dam | 40 | 68 | 18 | 24 |
| 1/2 mile of PO river | 37 | 66 | 11 | 6 |
| Somewhere else in PO county | 72 | 72 | 54 | 29 |
| In another county or state | 78 | 93 | 29 | 10 |

**9.supplemental and alternative methods**

| Response | Count |
|---|---|
| continue with rotovation | 165 |
| increase rotovation area | 129 |
| winter reservoir drawdown | 151 |
| homeowner and rotovation | 160 |
| biological treatment | 270 |
| no opinion | 67 |

| Question 09 | CR | IR | WRD | H&R | BT | NO |
|---|---|---|---|---|---|---|
| On the PO between OT and Dam | 38 | 51 | 52 | 47 | 69 | 9 |
| 1/2 mile of PO river | 26 | 20 | 18 | 12 | 44 | 9 |
| Somewhere else in PO county | 78 | 27 | 23 | 34 | 46 | 46 |
| In another county or state | 23 | 31 | 31 | 37 | 60 | 13 |

**10. At what level would you be willing to participate in the Aquatic Plant Management Plan**

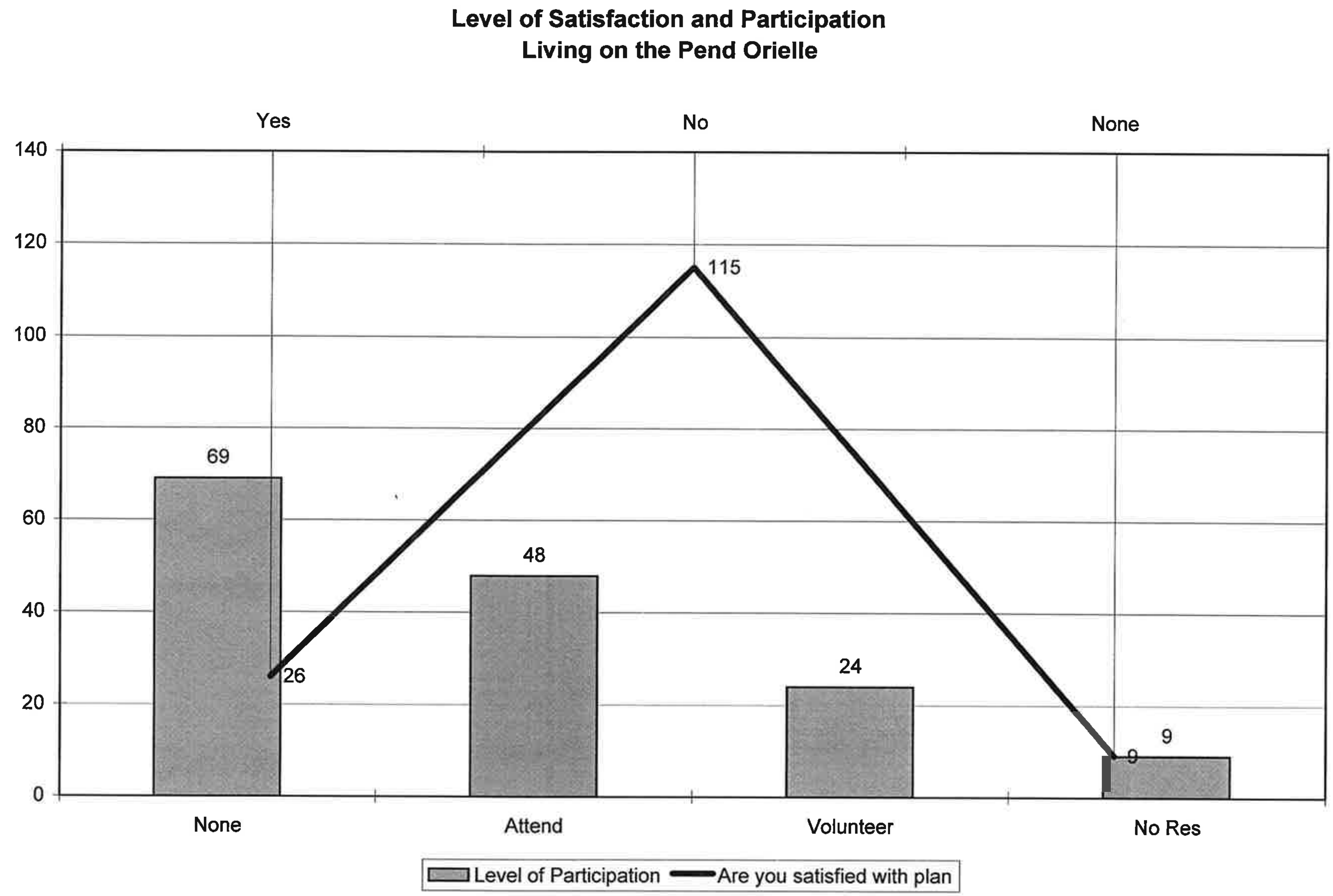
| Response Label | |
|---|---|
| Sorry, not able to participate | 395 |
| Attend public meetings | 173 |
| Volunteer and participation | 145 |
| No response/Does not know | 229 |

| Question 10 | None | Attend | Volunteer | No Res |
|---|---|---|---|---|
| On the PO between OT and Dam | 69 | 48 | 24 | 9 |
| 1/2 mile of PO river | 41 | 25 | 6 | 48 |
| Somewhere else in PO county | 187 | 18 | 6 | 16 |
| In another county or state | 167 | 21 | 12 | 10 |

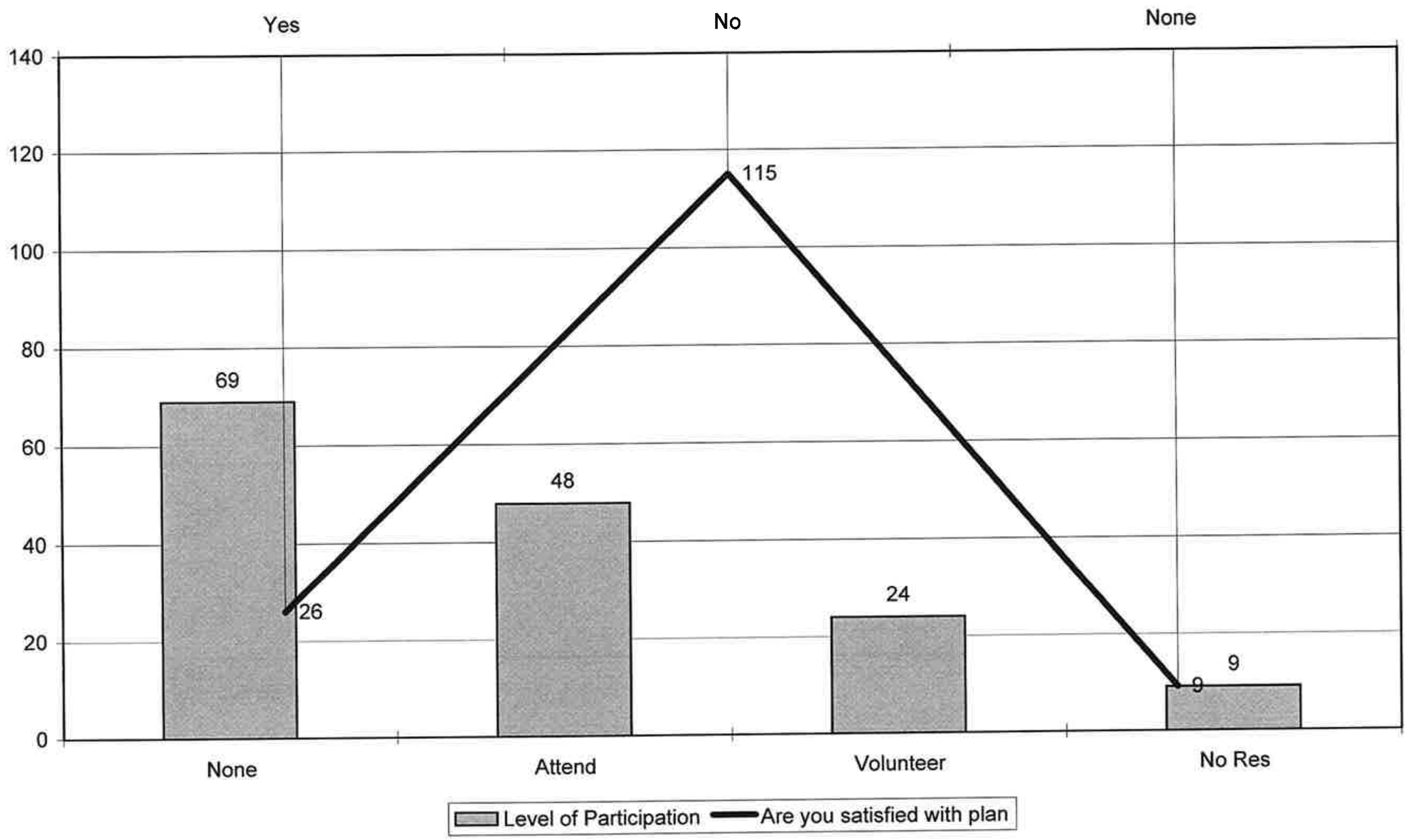
**11. As a rate payer how much would you be willing to pay on your monthly utility bill for continued and\or additional aquatic plant management with the Box Canyon Reservoir?**

| Response Label | |
|---|---|
| 0 | 203 |
| 0.5 | 106 |
| 1 | 122 |
| 2 | 126 |
| 5 | 175 |
| 5.00+ | 96 |
| No response/Does not know | 114 |

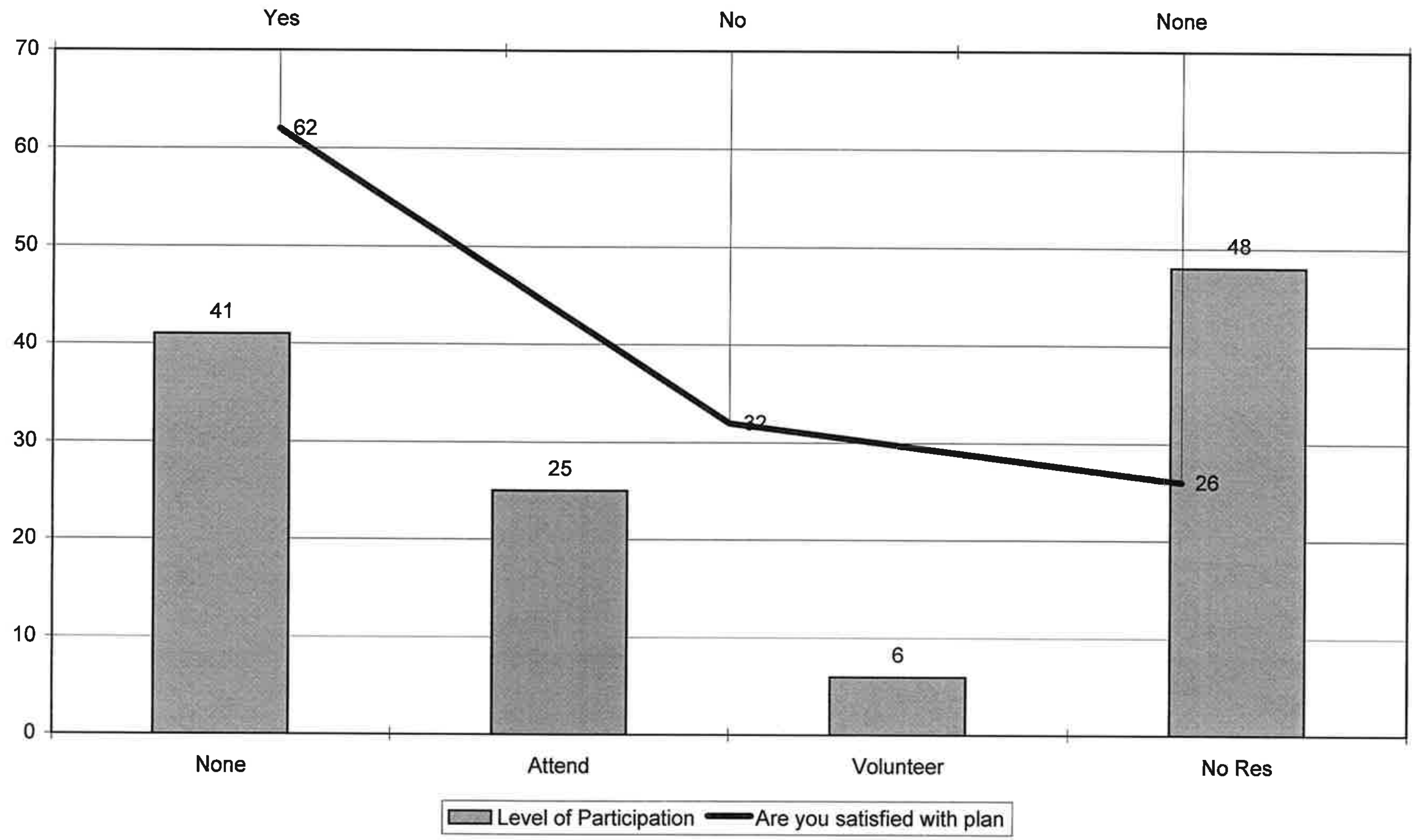
| Question 11 | $0.00 | $0.50 | $1.00 | $2.00 | $5.00 | >$5.0 | No res. |
|---|---|---|---|---|---|---|---|
| On the PO between OT and Dam | 44 | 1 | 20 | 23 | 27 | 16 | 19 |
| 1/2 mile of PO river | 57 | 6 | 18 | 18 | 15 | 2 | 4 |
| Somewhere else in PO county | 95 | 20 | 35 | 34 | 11 | 2 | 30 |
| In another county or state | 64 | 18 | 23 | 23 | 16 | 18 | 48 |


Level of Satisfaction and Participation
Living on the Pend Orielle
Yes
No
None
140
120
100
80
60
40
20
0
69
26
115
48
24
9
9
None
Attend
Volunteer
No Res
Level of Participation
Are you satisfied with plan

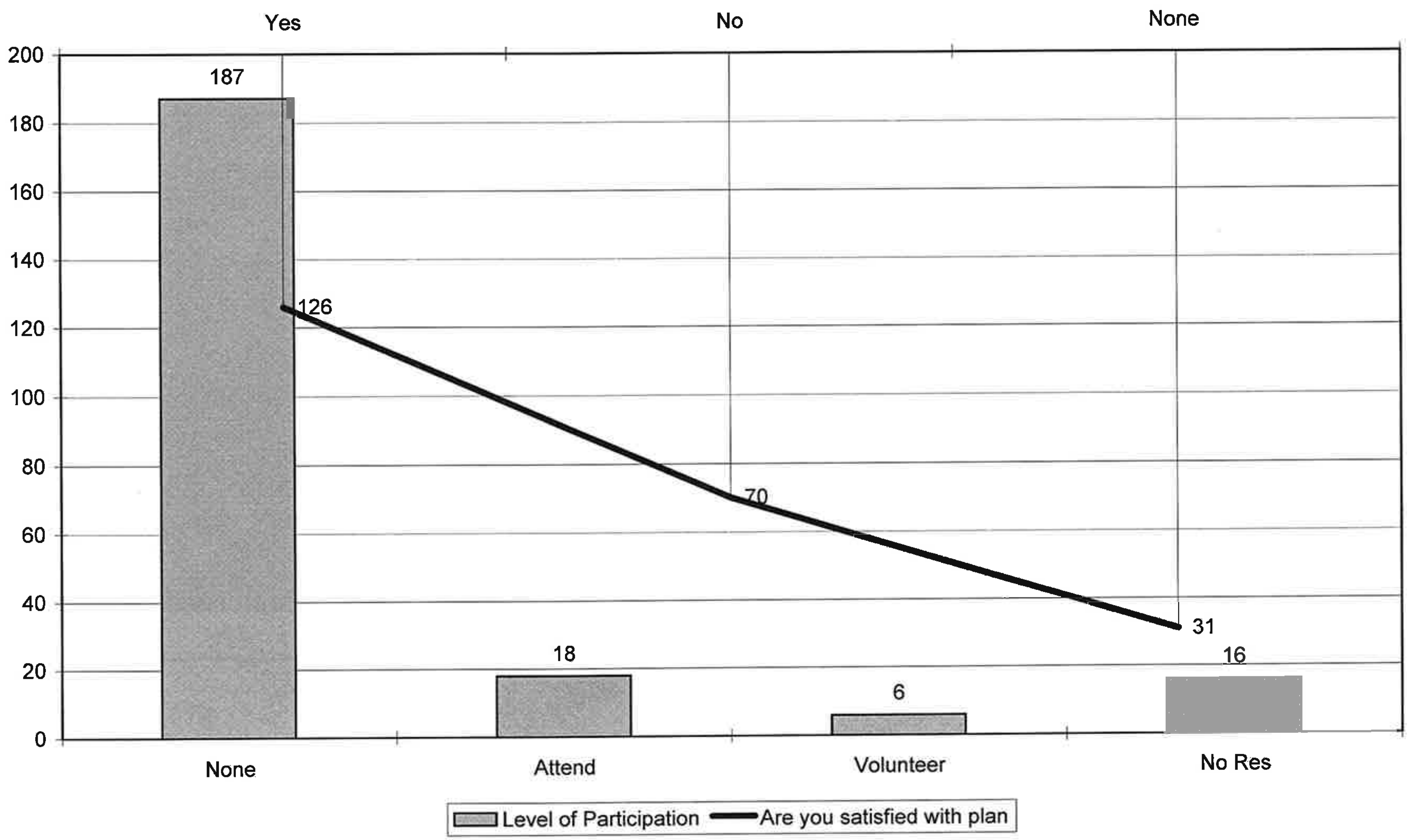
## Level of Satisfaction and Participation Living on the Pend Orielle



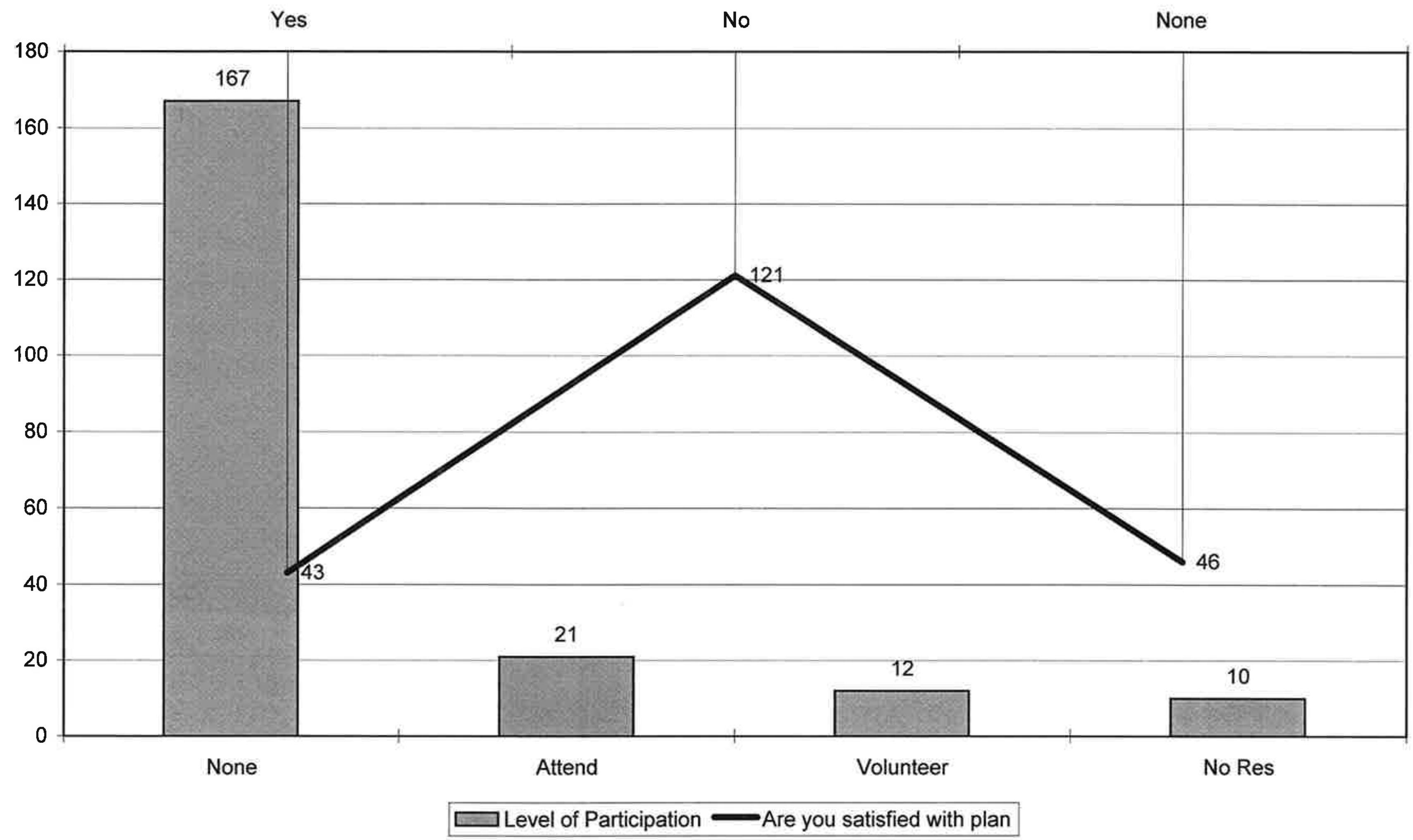
**Level of Satisfaction and Participation**
**Living 1/2 mile of PO**



## Level of Satisfaction and Participation
## Living somewhere else in PO County

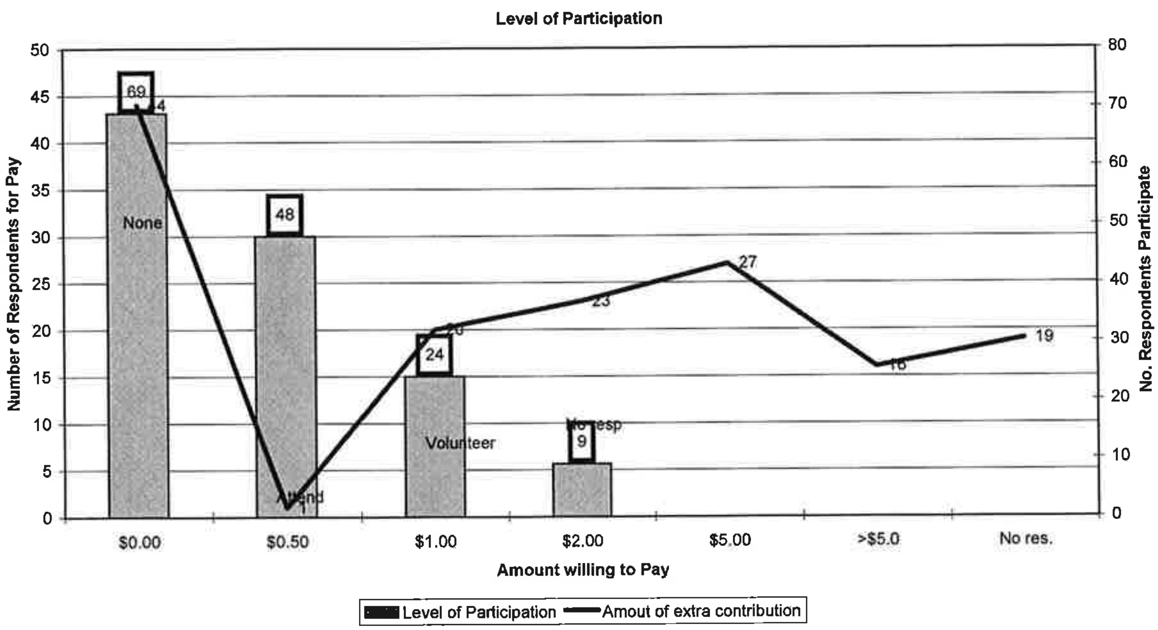


**Level of Satisfaction and Participation**
**Living in another County or State**



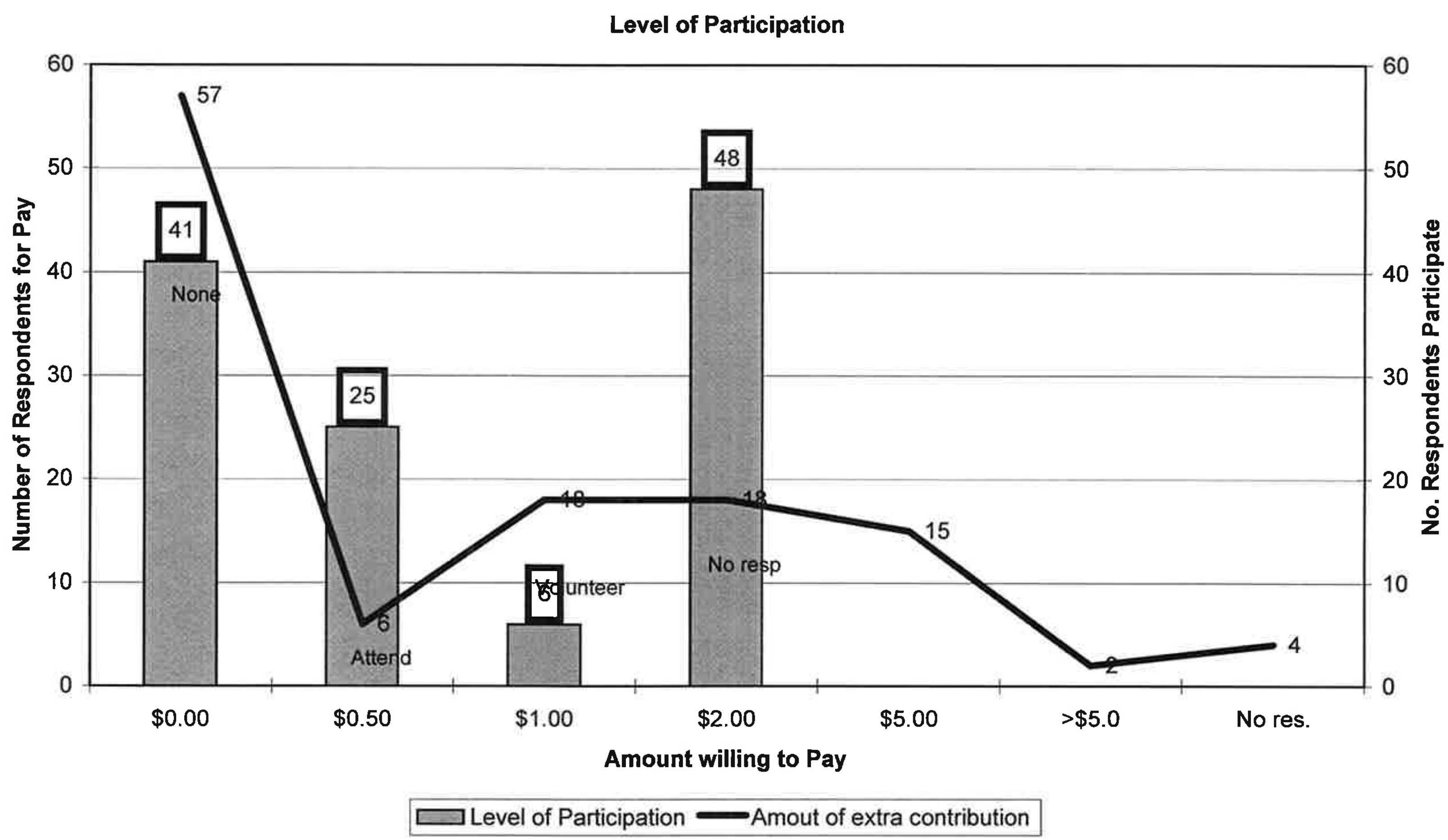
**Level of Satisfaction and Amt of Contribution**

**Living on BCR**



## Level of Satisfaction and Amt of Contribution

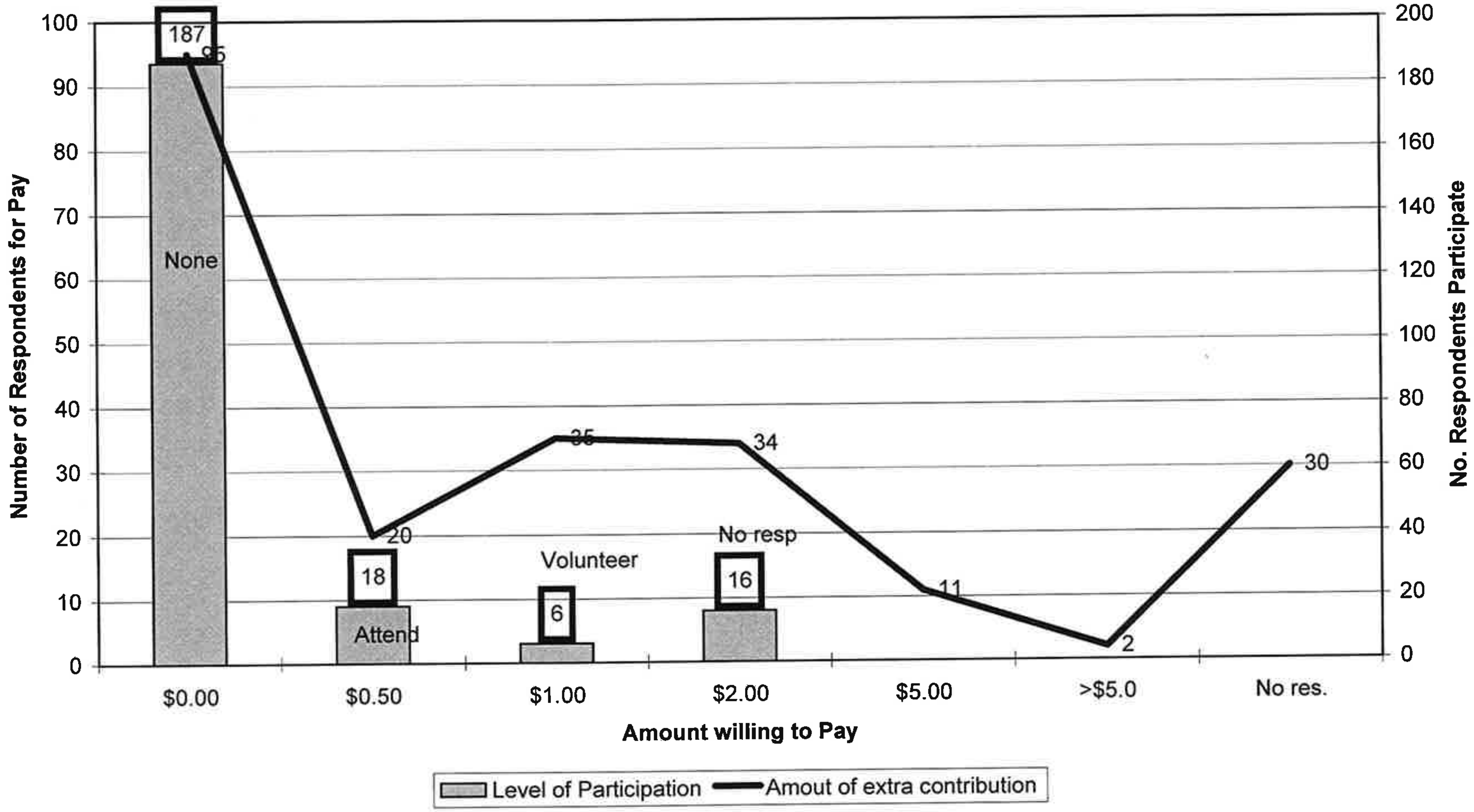
## Living within 1/2 Mile of BCR



**Level of Satisfaction and Amt of Contribution**

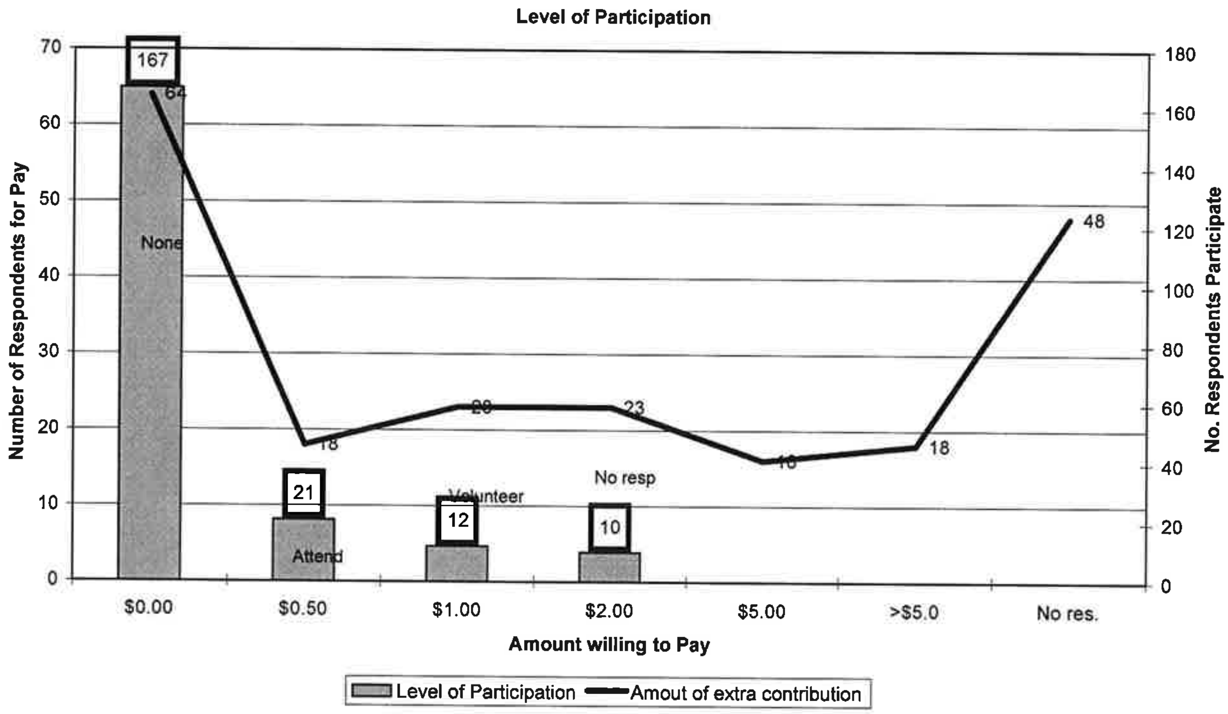
**Living somewhere else in PO County**

**Level of Participation**

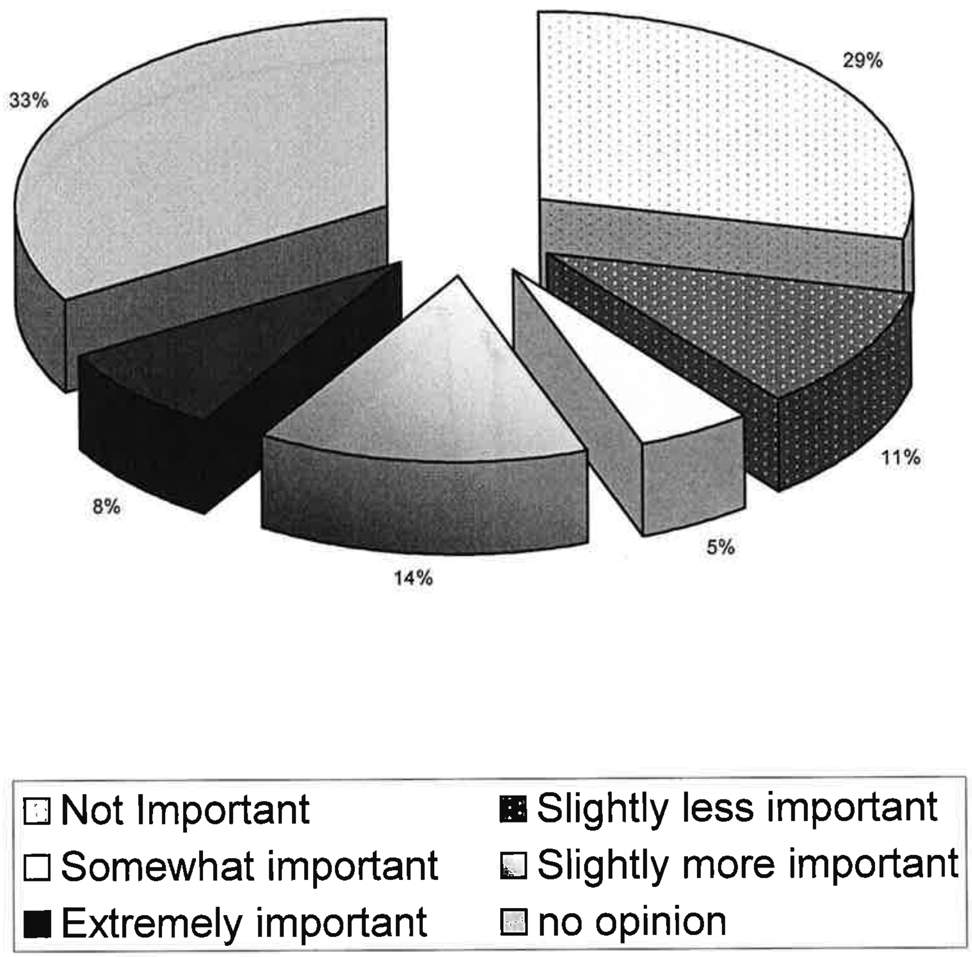


## Level of Satisfaction and Amt of Contribution

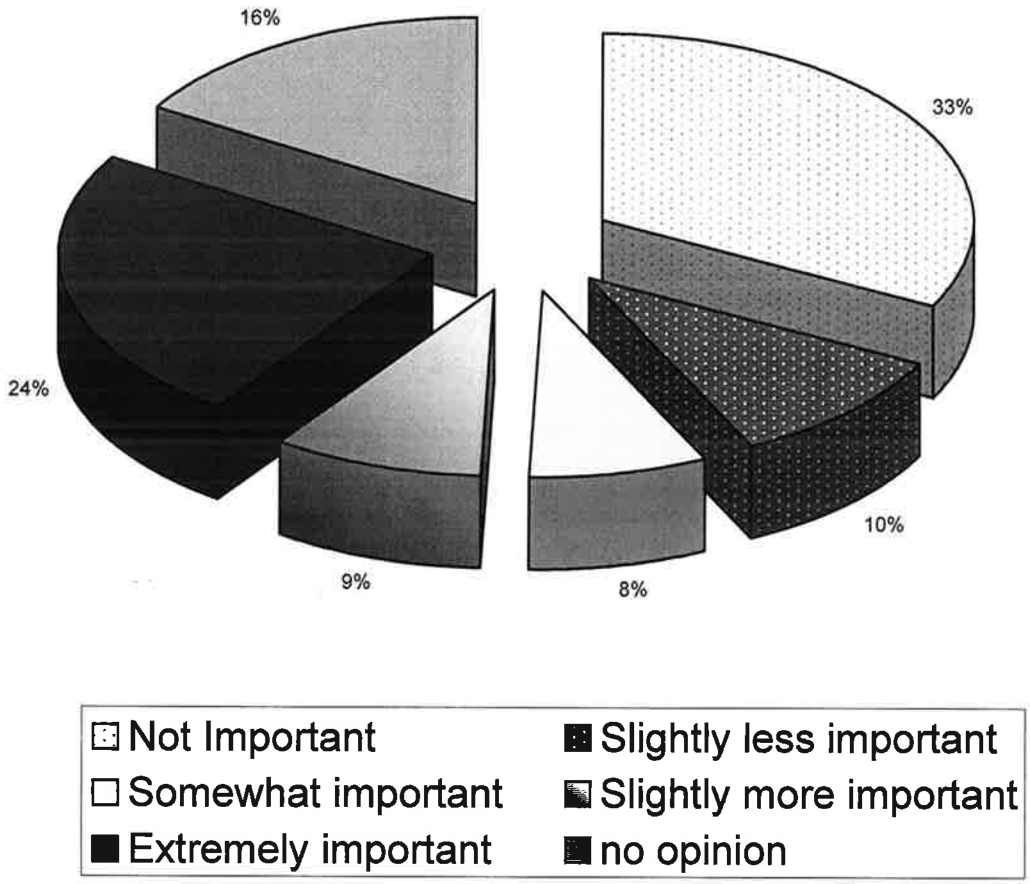
## Living in Another County or State



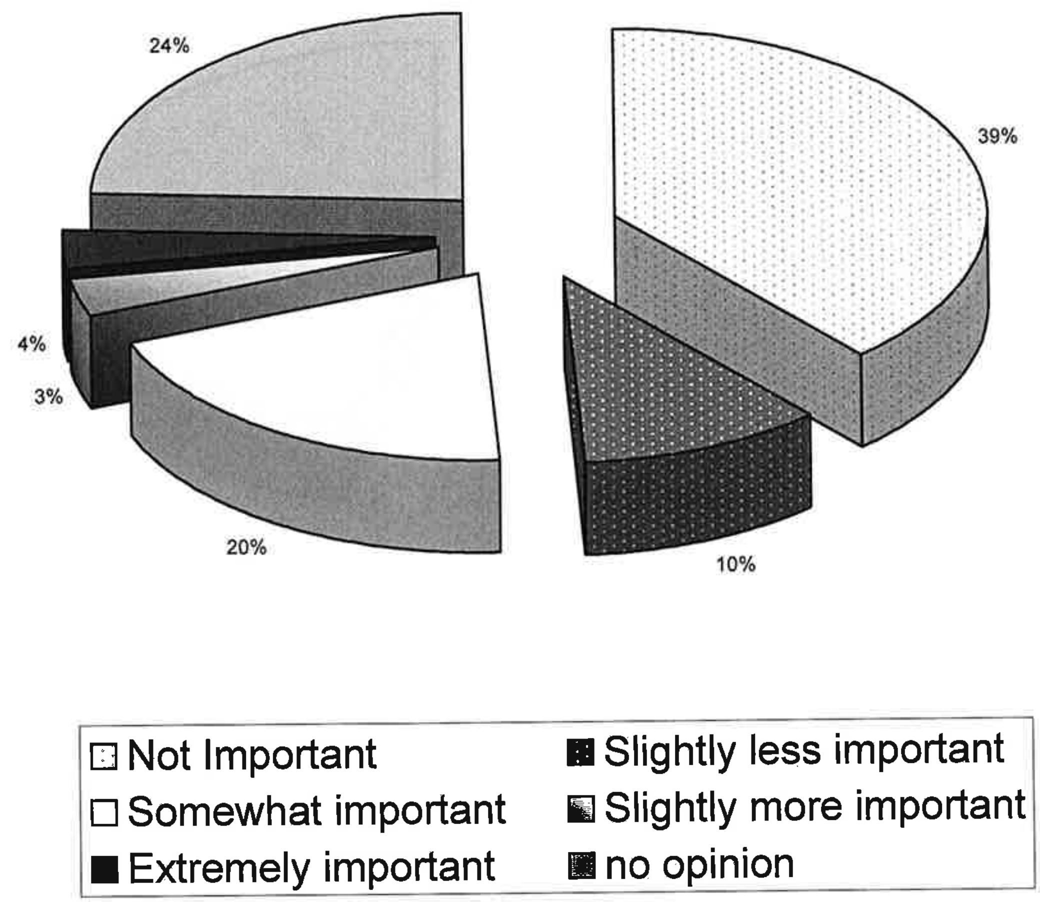
**Overall Rank Boat Launches**



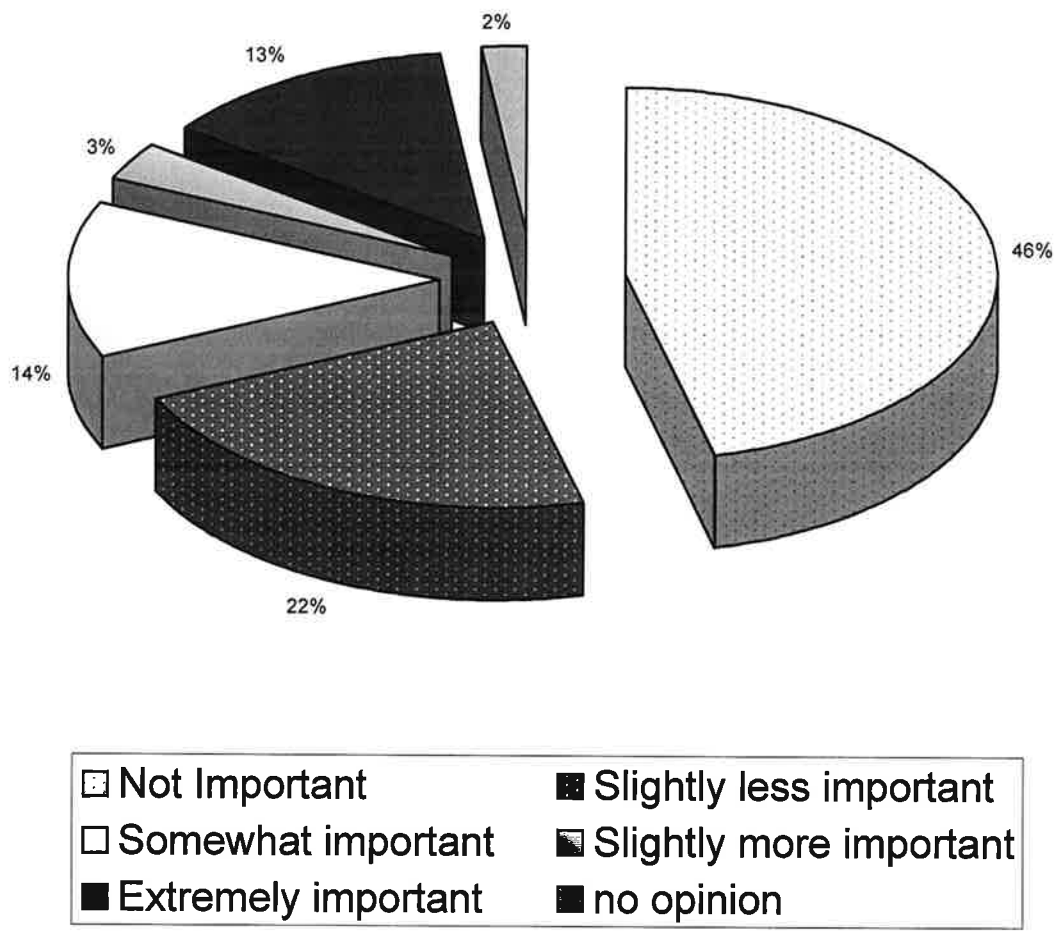
**Overall rank swimming and public areas**



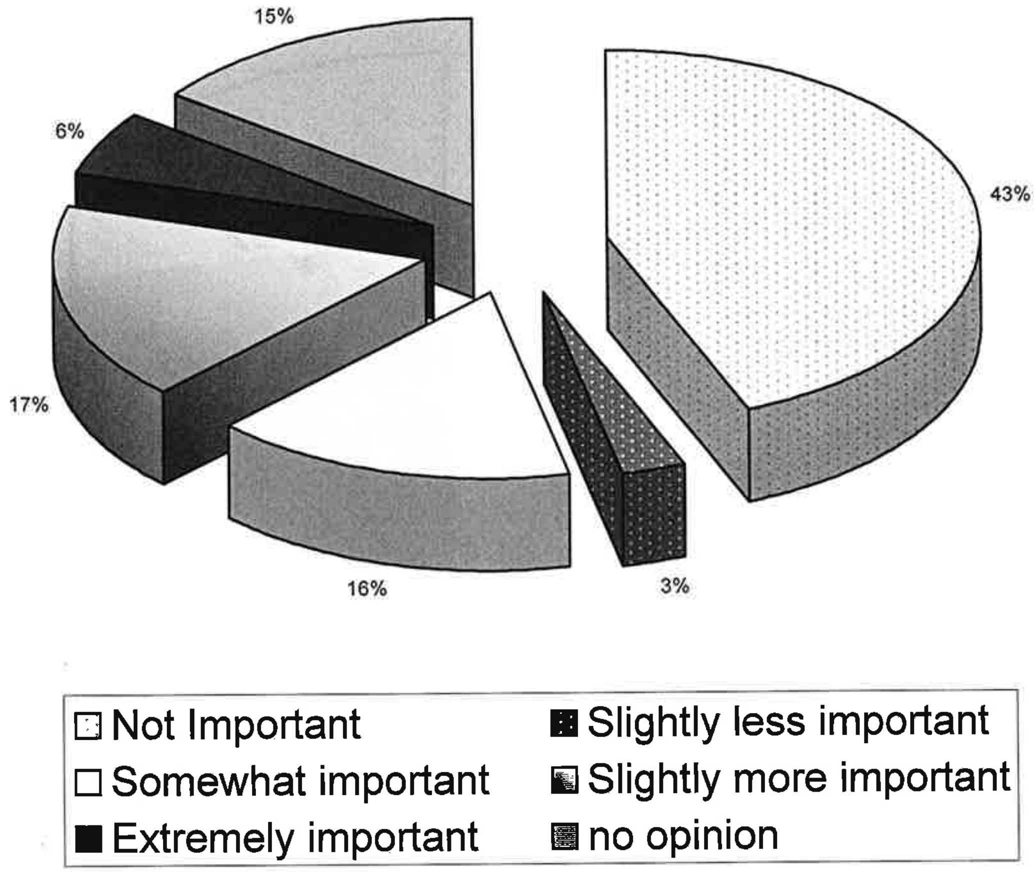
**Overall rank wildlife**



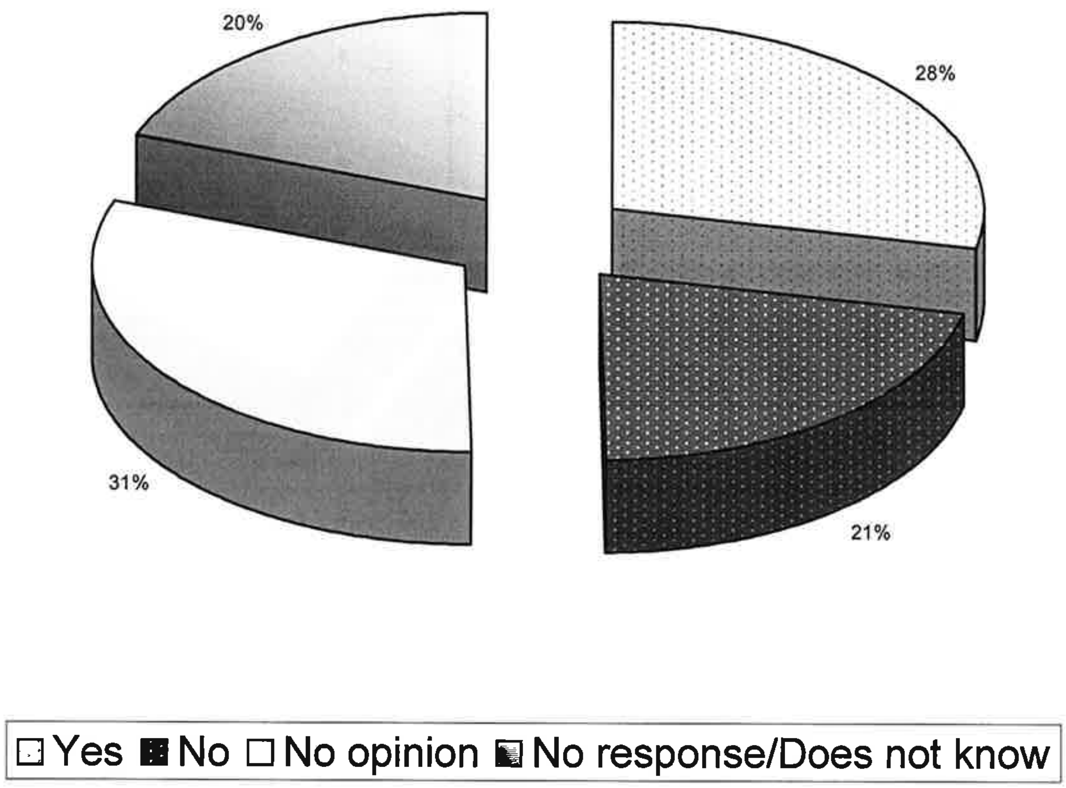
## Overall rank fish spawning



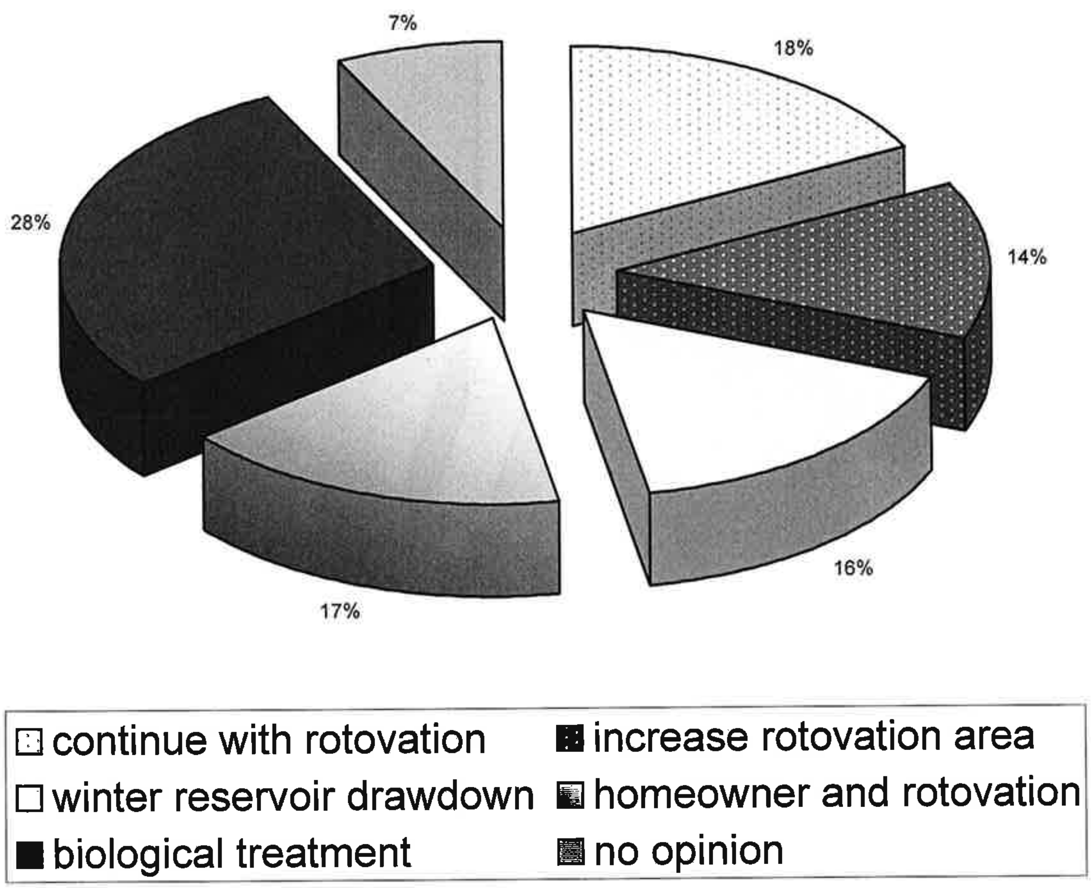
**Overall rank fishing areas**



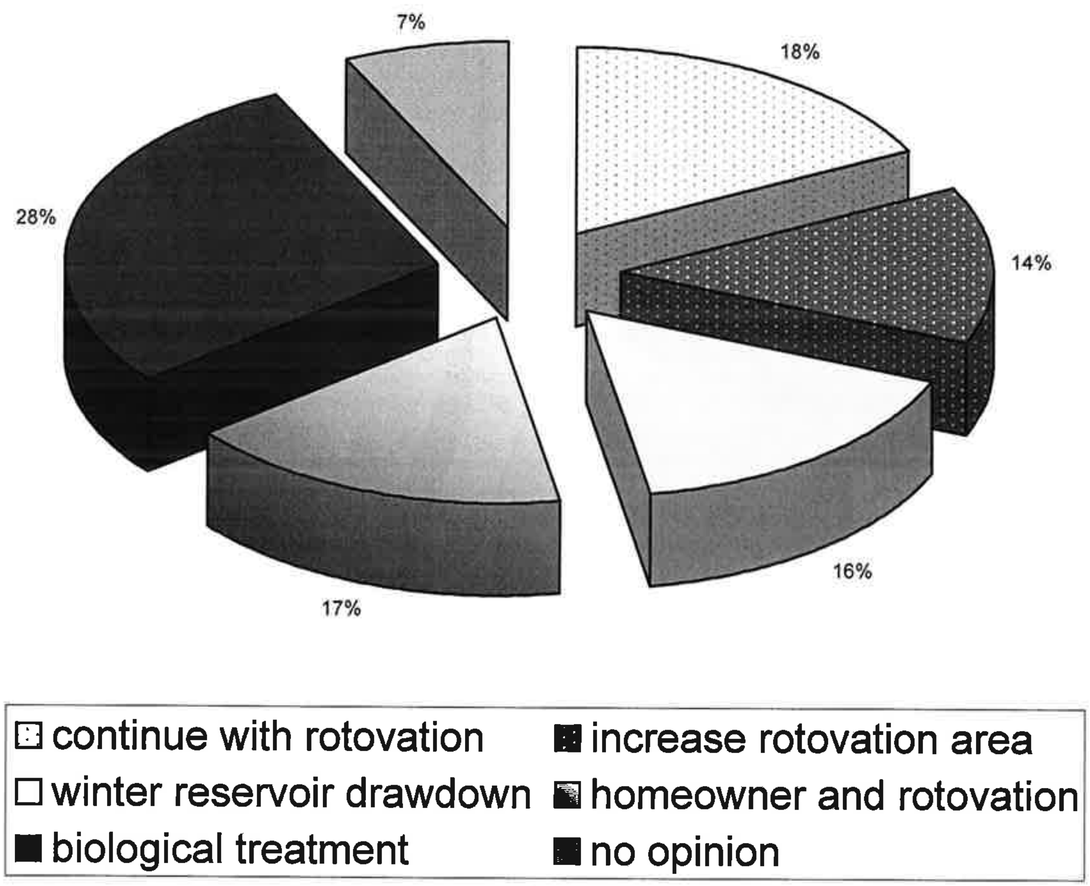
## Redirect Rotovation



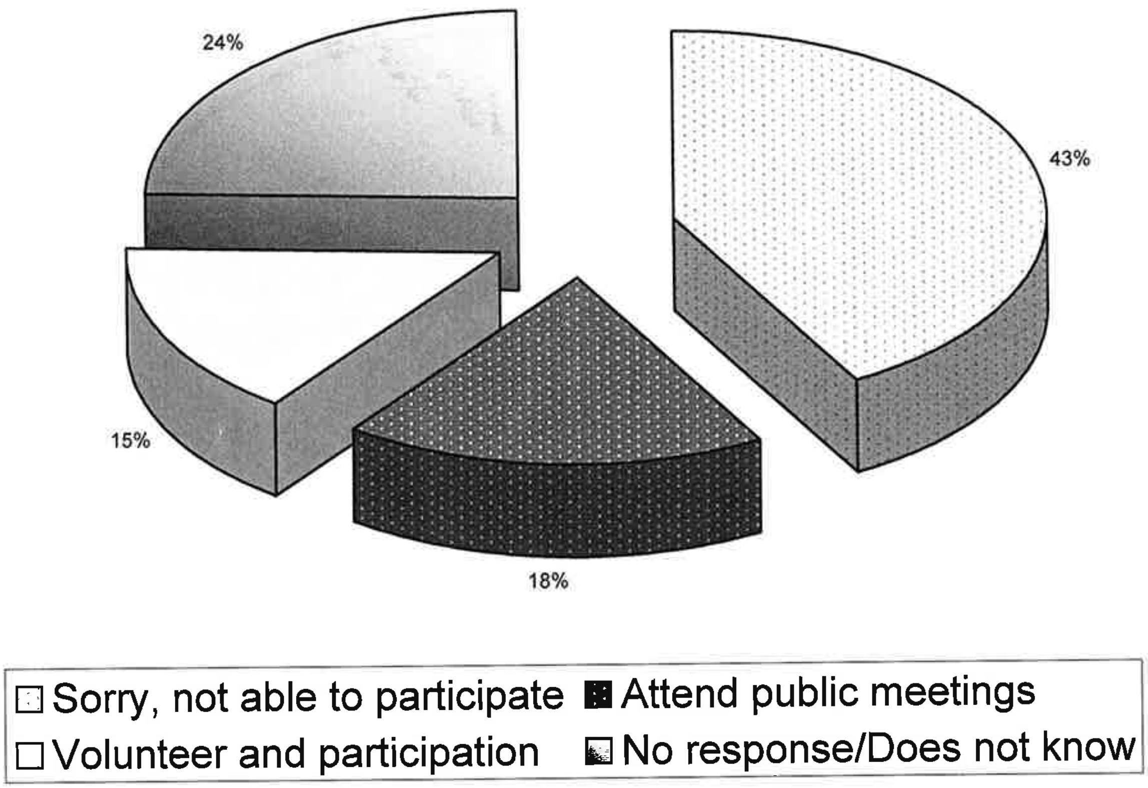
## Overall alternative methods



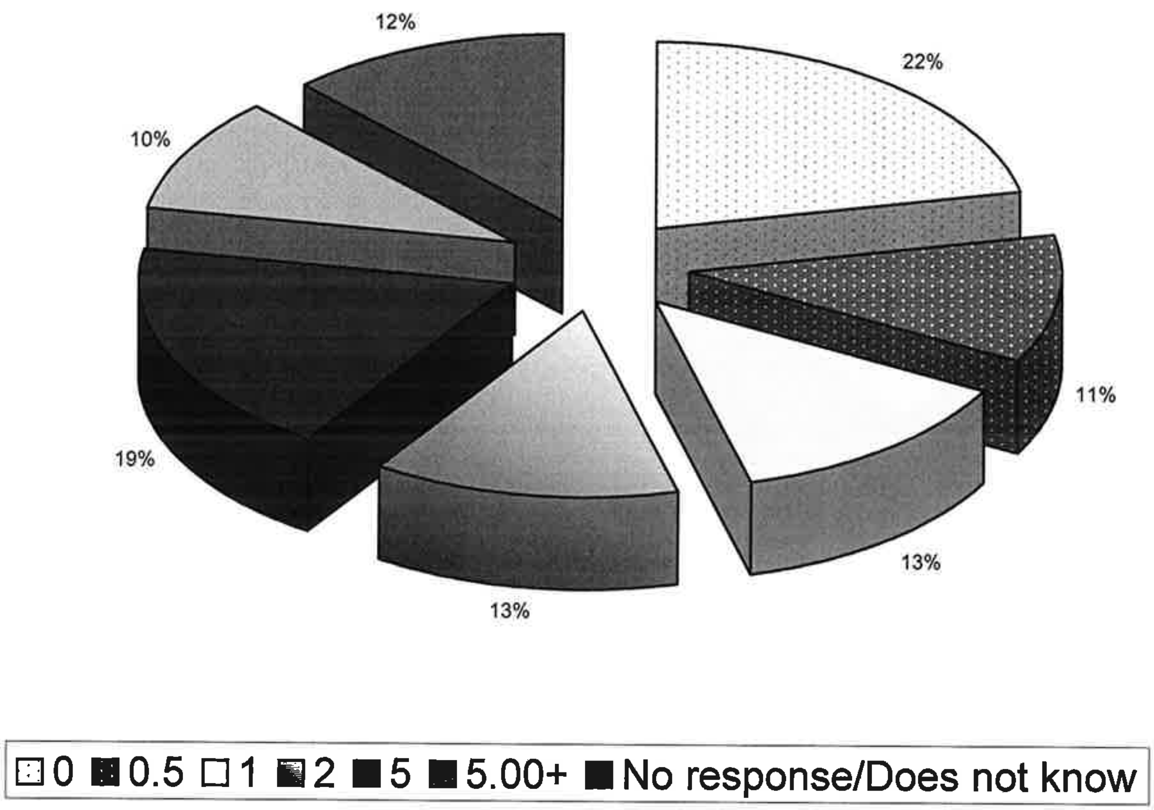
**Overall alternative methods**



## Overall Participation



**Overall additional expense**



# APPENDIX B

# REVIEW OF ROTOVATION EFFECTIVENESS STUDIES FOR THE PEND OREILLE RIVER

# REVIEW OF ROTOVATION EFFECTIVENESS STUDIES FOR THE PEND OREILLE RIVER

## INTRODUCTION

Rotovation, the tilling of bottom sediments to dislodge plant roots, has been used to control aquatic macrophyte growth in the Box Canyon Reservoir since 1986. The primary goal of rotovation in the Box Canyon Hydroelectric Project area is the physical removal of Eurasian watermilfoil (*Myriophyllum spicatum spicatum*) (EWM), an invasive, non-native aquatic macrophyte. Rotovation also removes other plant species, including the non-native curled pondweed (*Potamogeton crispus*), which is probably the most abundant and widely distributed aquatic plant in the project area (CES/DES Relicensing Study Update, February 1998).

EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep. There is limited plant growth on substrates between 10 and 18 feet in depth; no plants root in substrates greater than 18 feet deep. The majority of aquatic plant communities within the reservoir are mixed beds of native and non-native plants. In general, the densest beds have a high percentage of EWM.

From 1987 to1988 the aerial distribution of total aquatic plants did not change significantly between Box Canyon Dam and Usk. However, EWM increasingly dominated the plant community. During this period, EWM occupied nearly all available littoral habitat between Box Canyon Dam and River Bend, and continued to invade upstream areas. Between 1986 and 1988, the distribution of EWM expanded 11 miles upstream, from the Calispell River tributary (RM 69.5) to Indian Island (RM 80.5). In 1989, EWM was found upstream to RM 85.7. Apparently, the upstream dispersal of EWM occurs primarily through boating activity. Today, EWM distribution extends upstream to Albeni Falls although plant communities are limited upstream of the Newport bridge due to riverine, high velocity conditions.

EWM is a nuisance to recreational activities such as boating, fishing and swimming. In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D DMA) was used to slow the rate of advance of EWM (WATER 1985). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide. In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The British Columbia Ministry of Environment, Lands, and Parks pioneered this control technology and have successfully employed rotovation in the Okanagan Lakes Chain (Cooke et al. 1986). The Pend Oreille River program in 1986 was the first large-scale operation of its kind in the United States. The following discussion describes the effectiveness of rotovation efforts in selected areas of the Pend Oreille River.

## ROTOVATION PROGRAM

Most studies report rotovation effectiveness as a percent reduction in stem density of EWM per unit area of substrate. Post-rotovation stem densities are compared to pre-rotovation densities. Some studies have reported *carryover effectiveness* in the season or year following rotovation by comparing stem density in rotovated plots after a prescribed period of time (usually one year) to stem density in control plots that did not receive rotovation treatment.

1986 rotovation. In 1986, 38 acres of monotypic EWM and multi-species beds of aquatic plants were rotovated in the Pend Oreille River. Concurrent testing of the herbicide Sonar and planting of dwarf spike-rush were evaluated. Stem density of EWM decreased from 63-90 percent immediately following rotovation. Other aquatic species were removed at similar rates, with the exception of *Elodea canadensis,* which dominated shallow areas that were tilled less completely by the rotovator. One year later, carryover effectiveness ranged from 10-25 percent reduction in EWM stem density. The stem densities of all aquatic macrophytes were reduced from 7-25 percent after one year. Notably, the stem density of Elodea *canadensi*s increased 500 percent after one year in one rotovation plot. These results indicate that carryover control was attained for EWM but not necessarily for aquatic plants in general. Immediately after rotovation, EWM stem densities were effectively reduced, but by the second year the results were variable and total stem densities of all aquatic plants were similar to pre-rotovation levels (WATER 1988).

1987 rotovation. In 1987, 80 acres of EWM beds were rotovated, including dense EWM beds located in embayments near Ione and pioneer colonies near Usk. One year after rotovation, the EWM stem density was reduced by 90 percent in the Ione Park Swim bay. However, stem density of *Potamogeton* spp. increased by 20-fold in the Ione swim bay and *Elodea canadensis* also demonstrated increased stem densities. Apparently, tillage may enhance the growth of certain non-target plant species. In two adjacent rotovation plots in the main river channel, one plot had a 44 percent increase in EWM stem density, while another plot had a 25 percent decrease after one year (WATER Environmental Services 1988, 1990).

1988 rotovation. In 1988, approximately 55 acres were rotovated. Rotovation efforts were concentrated in the Dalkena-Furport area (RM 77-80) where new colonies of EWM were identified in 1987. Due to excessive plant biomass in EWM beds, the control program utilized a three-step system in 1988. First, plant stems were cut close to the substrate using a T-bar cutter. Then the plant fragments were gathered using a clam rake tool. After initial removal of this material, the substrate was tilled using the rototiller head to dislodge plant roots (WATER Environmental Services 1988: Pend Oreille River Eurasian watermilfoil Control Program 1988).

Immediately after rotovation, stem density was reduced from 85-94 percent. After one year, stem density in one rotovation plot increased by 44 percent over pretreatment density. This increase was mainly due to small root systems resulting from reinfestation by fragments from outside the plot. Another plot had 25 percent lower stem density than pre-treatment levels after one year (WATER 1990).

1992 rotovation. In 1992, rotovation treatment significantly reduced macrophyte biomass in four months following rotovation (Falter et al. 1991)

Current program. Approximately 200 acres per year were being rotovated in the Pend Oreille River as of 1995. The rotovator is a boat-mounted Aquamog 8-foot long tiller with an effective operational depth of 16-18 feet. In each site two passes are made with the rotovator; the first pass is parallel to the shore and the second pass is perpendicular to the shore. Fragments are not typically collected except in areas of heavy infestation where plant material can be rolled onto the tiller blade and deposited on shore. Most of the plant material washes up on the shore downstream of the treatment site. Rotovation treatments focus on high use areas in the main river channel. The only slough rotovated is Tiger Inlet.

## RE-ESTABLISHMENT OF MACROPHYTES FOLLOWING ROTOVATION

Studies show that EWM will re-establish in rotovated sites, either from EWM fragments or remaining root crowns (WDOE 1998, Cooke et al. 1993). After rotovation, dislodged EWM root crowns and stems float to the surface and are either collected or left to wash to shore (Cooke et al. 1993). Since EWM reproduces mainly by fragmentation and dispersal, rotovation may intensify EWM infestations by creation of fragments. While it is generally believed that the fragments released by harvest are fewer than those that would have been released by the intact bed, no research has addressed this question specifically in Box Canyon Reservoir or similar systems (Cooke et al. 1993). Certainly, collection of plant biomass after rotovation would decrease the likelihood of re-establishment of EWM fragments. However, this control method would be extremely labor and time-intensive, and appropriate disposal options would have to be found for the harvested plant biomass.

In addition to fragment dispersal, EWM will readily recolonize rotovated sites if the substrate is incompletely tilled. In the Pend Oreille River, more substrate area was missed by the rotovator with parallel tilling sweeps than with two perpendicular sweeps (WATER 1988). Areas of the substrate tend to be missed more often when the operator guides the rotovator using visual tracking. Aquatic resource managers in British Columbia have used a portable surface buoy system to improve machine tracking and reduce the occurrence of missed areas. In dense macrophyte beds, successive annual treatments are recommended to attain a reduction in root masses, especially during the initial treatment years (WATER 1988).

In addition to EWM, other species of aquatic plants will invade sites after rotovation (Maxnuk 1979, Bryan and Armour 1982, Gibbons and Gibbons 1988, Cooke et al. 1993). In particular, the non-native *Potamogeton crispus* invades readily (Maxnuk 1979).

The eventual re-establishment of macrophytes in rotovated sites is inevitable without continued preventatives such as herbicides or repeat rotovation. Thus, the objective of rotovation programs should be to maximize the benefits of each rotovation treatment.

Newroth (1986) suggests conducting rotovation treatments in the winter or spring, when EWM biomass is reduced and fragments are less viable. To minimize reinvasion by EWM and other species, WATER (1988) recommends rotovation in the fall, followed by a subsequent rotovation treatment in the spring.

## ECOLOGICAL EFFECTS OF ROTOVATION

Most rotovation studies concentrate on rates of plant removal and recolonization. Very few studies have addressed the ecological effects of rotovation. In Box Canyon Reservoir, aquatic macrophytes provide aquatic habitat complexity. The distribution of macrophytes likely influences the density, diversity and distribution of aquatic animals.

Removal of macrophyte biomass by rotovation has dramatic effects on fish and invertebrate habitat. Rotovation can affect fish cover, water temperature, light penetration, sedimentation patterns, and DO levels, which in turn may affect primary and secondary productivity (Falter et al. 1991). Macrophytes act as □nutrient pumps□ via growth and senescence, translocating nutrients from the sediments into the water column. Removal of macrophytes eliminates this important function. Falter et al. (1991) investigated the effects of rotovation on phytoplankton and zooplankton communities. Phytoplankton density and biomass and zooplankton density, biomass and diversity decreased in rotovated areas. They concluded that extensive rotovation may be detrimental to the zooplankton food base of juvenile sport fishes. Their recommendation, from a fisheries management perspective, was that □clear cut□ and widespread rotovation treatments be cautiously evaluated.

## ROTOVATION EFFECTIVENESS

Cooke et al. (1993) provide a recent review of rotovation effectiveness, particularly for the removal of EWM. In British Columbia, rotovation reduced EWM by 80-97 percent and carryover benefits were documented to persist for a year or more. They found that two tillage passes were required to provide acceptable standards of control, particularly in silt and clay substrates. They recommend significant overlap in rototilled strips to avoid missing areas of substrate. According to Cooke et al. (1993) regrowth of EWM in rotovated areas is dependent on the following factors:

- The time and care taken by the equipment operator, and operator experience
- The condition of the rotovation equipment
- The physical conditions of the treatment site (including presence of obstacles and rocks, slope, substrate type)
- The proximity and density of untreated sources of viable EWM fragments to aid reinfestation
- The frequency of previous derooting treatments of the area and the pretreatment density of the target plants

Rotovation effectiveness in the Pend Oreille River has been variable. While stem density of EWM and other aquatic macrophytes are effectively reduced by rotovation, recolonization rates vary widely. Carryover effectiveness has been observed, however in some cases density of re-established macrophytes exceeds pre-treatment densities. This highlights the fact that in evaluating the effects of rotovation, it is important to note the total aquatic macrophyte stem density in studies, not simply EWM stem density, as other species may invade at increased rates rotovation treatment.

# APPENDIX C

# A LITERATURE REVIEW OF CONTROL METHODS FOR MANAGEMENT OF EURASIAN WATERMILFOIL

# A Literature Review of Control Methods for Management of Eurasian Watermilfoil

November 1999

# A LITERATURE REVIEW OF CONTROL METHODS FOR MANAGEMENT OF EURASIAN WATERMILFOIL

## 1.0 INTRODUCTION

The purpose of this Literature Review, completed as part of the Box Canyon Hydroelectric Project Relicensing effort, is to review alternative Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM) control methods to support efforts at implementing cost-effective control programs within the Box Canyon Reservoir. This review addresses the effectiveness of alternative EWM control methods applied both regionally and within the Box Canyon Reservoir. Interviews with resource managers involved with EWM control elsewhere were sought as well as reviewing both published and unpublished literature. Only those treatment methods which are applicable to the Box Canyon Project area were reviewed (i.e., currently available chemical treatments are not considered a feasible alternative treatment method for the Box Canyon Reservoir due to river velocities and the possible contamination of numerous water supply systems. Various control strategies and their effectiveness are discussed. Ecological effects on other resources potentially resulting from EWM control are also noted. The effectiveness of boat wash stations, education programs and other means for controlling the spread of EWM to other water bodies is an important component of many aquatic weed management programs and merits discussion in this review. A companion literature review of the ecological significance of aquatic plant management to fisheries resources has been distributed to the agencies, Tribe and interested parties participating in the Box Canyon Relicensing process (District February 15, 1998).

## 2.0 DESCRIPTION OF THE BOX CANYON RESERVOIR

Box Canyon Hydroelectric Project is located on the Pend Oreille River in northeastern Washington. Box Canyon Dam and powerhouse are located near Ione, in Pend Oreille County, Washington and are 17.4 river miles (RM) upstream of Seattle City Light's Boundary Dam. The Box Canyon Reservoir (BCR) extends 55.7 miles along the Pend Oreille River, from Box Canyon Dam at RM 34.4 to Albeni Falls Dam at RM 90.1, in Bonner County, Idaho. Box Canyon Hydroelectric Project is a run-of-river facility which means inflow to the Project equals outflow from the Project, and the Project uses water in the river as it flows past the dam to generate power. The Project does not store water. River flows in excess of the Project's turbine capacity are spilled.

Hydrology at the Box Canyon Project is characterized by large spring and early summer flows fed by snowmelt and precipitation in the headwaters of the Pend Oreille River and Clark Fork River, which originates on the western slopes of the Rocky Mountains in Montana. The Pend Oreille River flows northwesterly between Albeni Falls Dam and Box Canyon Dam. The annual flood on the Pend Oreille River generally occurs during the spring because of melting snow pack. The highest average weekly flows occur during June. Almost all of the floods occur during the spring months of April, May and June. The average annual flood is 79,445 cfs (based on period of record 1/1/56 - 12/31/95).

The upstream drainage area for the Box Canyon Reservoir is 24,930 square miles. Of this total drainage, about 24,230 square miles are upstream of Albeni Falls Dam (RM 90.1), and the remaining 700 square miles of the drainage area is between Albeni Falls Dam and Box Canyon Dam (RM 34.4). There are 22 streams which flow into Box Canyon Reservoir; the major tributaries are Calispell Creek and Trimble/Tacoma drainage. Many of the tributaries flow into the river via sloughs which are typically shallow. The average annual flow at Box Canyon Dam is about 26,000 cfs.

The Box Canyon Reservoir is a cool-water mesotrophic system based on nutrients (maximum August temperature based on a two year average from 1989-1990 of 71.2EF [21.75EC]) (Falter et al. 1991). Water quality is good (Pelletier and Coots 1990; Bennet et al. 1990; Falter et al. 1991; EPA 1993). The reservoir is characteristic of a riverine environment. Nutrients appear to be a limiting factor for productivity.

The aquatic plant community within BCR is diverse with many native plants. Eurasian watermilfoil (*Myriophyllum spicatum)* and curled pondweed (*Potamogeton crispus*) are the only non-native aquatic plant species observed in the Project area. Of these two species, considerably greater regional and national focus has been on the invasive problems of water milfoil. Preliminary assessments of field observations suggest curled pondweed is the most widely distributed aquatic plant. The majority of aquatic plant communities within the reservoir, inclusive of sloughs, are mixed beds of native plants or native plants growing in combination with EWM. The densest beds had a high percentage of EWM.

## 3.0 HISTORY OF AQUATIC PLANT CONTROL IN BCR

Use of the herbicide 2,4-D had been tested since 1982, but was subsequently banned nationally for EWM management in late 1985. Rotovation on the Pend Oreille River began in 1986 with concurrent test trials of the herbicide Sonar and plantings of dwarf spikerush (Gibbons et al. 1987).

Rotovating in the BCR has expanded from its first initiation and overall treatment costs (based on area covered) have declined during recent years. The decreased cost reflects increased operator skill and knowledge of treatment areas, removal of underwater obstacles, and increased speed of treatment. Treatment is faster because of considerably less biomass upon return treatment. Rotovating is done year round, weather and river conditions permitting; high flows and ice restrict operations. There are seasonal restrictions for rotovating in potential spawning areas such as Tiger Inlet during bass spawning periods. Approximately 200 acres per year are being treated (as of 1995) with treatments focusing on the main river. The sloughs are not rotovated with the exception of Tiger Inlet. The primary focus is on high use areas.

The County systematically tracks areas rotovated. Treatment areas are rotovated, on average, every 18 to 24 months. Rotovation is done using a boat-mounted Aquamog™ 8-foot long tiller. The effective operational depth is 16 - 18 ft, which is capable of reaching virtually all suitable EWM habitat. A two-pass rotovating treatment is typically employed; the first pass is parallel to the shore and the second pass is perpendicular to shore. Additional rotovating may be done if the post treatment inspection detects areas missed. Macrophyte biomass is not collected, and most of the material washes up on the shore a short distance downstream.

## 4.0 CURRENT STATUS OF CONTROL PROGRAMS

Pend Oreille County operates a rotovating program with 50% of the funding historically provided by the national Aquatic Weeds Program of the US Army Corps of Engineers. Federal funding of this program is not presently available. The Pend Oreille Public Utility District (District) is funding 80% of the rotovation program in 1998 with the County providing the remaining 20% of the 1998 budget. (pers. comm., P. Wilson, Pend Oreille County Public Works Dept., March 18, 1998).

## 5.0 MECHANICAL METHODS OF EURASIAN WATERMILFOIL CONTROL

Mechanical control methods employ the physical extraction of plants or plant parts to effect a temporary reduction in aquatic plant biomass or cover. Methods range from intensive, manual operations that are able to target one species, to large-scale efforts involving specialized equipment that impacts all aquatic plants in an area. Large scale efforts such as rotovating or harvesting are only recommended for use in systems with existing infestations. Small scale, intensive efforts are characteristic of programs to prevent infestation; these efforts are often used in conjunction with education and other preventative methods (see section 7.0) No mechanical method has yet achieved permanent control of a target species, although most do result in temporary changes in species distributions or densities. Mechanical control methods are reviewed below for their efficacy and for ecological considerations; case studies are provided for the most widely used methods.

### 5.1 HARVESTING

Harvest involves the physical separation of plant biomass from roots through the use of large floating harvester units. Harvest is the most common management tactic for EWM infestations, and generally used for short-term aesthetic control around docks, swimming areas, or other high-use zones. Harvester designs are varied, but usually include an underwater cutting bar, plant collection device, and storage area for collected plants. Plants in a target area are cut, the cut stems collected immediately or after treatment, and transported to shore for disposal or subsequent use (see section 9.0, Uses of Aquatic Plant Biomass). Plant roots remain in place. Because harvest can be expensive, often requires multiple treatments each season, and results in commercial quantities of biomass that must be disposed of, its use is typically at a governmental or organizational level.

#### 5.1.1 Effectiveness of Harvesting

Harvest results in an immediate but short-term removal of EWM and other aquatic plant biomass from the target area. The literature reports various metrics for the results of harvest: volume or as weight of plants removed per unit area, the average depth of weed-free water, and reduction in stem density. Due to the variability in terminology, the immediate reduction in aquatic plants to be expected from harvest operations is difficult to specify but can be dramatic;

immediate EWM biomass reductions of over 85 percent have been reported (Gibbons 1986). Other studies have found less impressive results: Sytsma (1984) documented harvests in Lake Union, Washington that reduced EWM biomass by less than 50 percent. Harvest in Lake Washington during the same year brought immediate biomass reductions of only 36 percent, due to the limited reach of the harvester (Aquatic Research Incorporated 1986). Local conditions and harvester type are likely to play a strong role in determining the immediate effectiveness of any harvest treatment.

To better assess short-term efficacy, most studies focus on the time lag until EWM regrowth, which begins immediately and can be complete within weeks. The 1986 harvest in Lake Washington, Washington realized an increase in EWM-free water depths for a maximum of one month in all areas (Aquatic Research Incorporated 1986). EWM beds harvested in Lake Minnetonka, Minnesota were comparable to control beds within 42 days; harvested areas grew faster than controls (Crowell et al. 1994). Harvesting in British Columbia in the early 1970s was followed by post-harvest EWM regrowth that was usually complete within 60 days (Newroth and Soar 1986). A literature review by Gibbons (1986) reported EWM regrowth rates ranging from 100 percent regrowth within 30 days to 51 percent regrowth within 47 days. This sort of regrowth by EWM prompted Newroth (1974) to note that "the main drawback to the harvester control (of EWM) is its apparently endless nature." Reflecting this sentiment, most literature acknowledges that more than one harvest is required per season to maintain any semblance of EWM control (e.g. Sytsma 1984, Aquatic Research Incorporated 1986, Gibbons 1986 Newroth and Soar 1986, Cooke et al. 1993). Single treatments have been found at times to actually increase EWM growth and density relative to control sites (Aquatic Research Incorporated 1986). When single treatments are used, timing appears to have an effect, with late-season harvests deemed more effective if single harvests must be considered (Kimbel and Carpenter 1981, Sytsma 1984, Gibbons 1986, Cooke et al. 1993).

During early studies of harvesting, it was hoped that consecutive harvests within or in successive years would result in long-term control of EWM by stressing the plants or reducing total nonstructural carbohydrate (TNC) allocations to roots. Reduced TNC allocations, it was theorized, could result in increased overwintering mortality or reduced biomass the season following harvest (Kimbel and Carpenter 1981, Sytsma 1984). This hypothesis is not supported by the literature. Sytsma (1984) found that although multiple EWM harvests in Lake Union, Washington, reduced TNC levels, winter accumulations of TNC rendered the change negligible. Kimbel and Carpenter (1981) reported lower TNC concentrations and reduced EWM biomass in harvested areas the year following harvest in Lake Wingra, Wisconsin, suggesting a slight "carry-over" effect. However, overwintering TNC levels were similar in harvest and control plots; this indicates the carry-over reduction in biomass was not a result of harvest-caused changes in TNC allocation patterns. Biomass differences may instead be related to the natural variation in aquatic plant populations. Long-term observations by Painter (1988) found that in Buckhorn Lake, Ontario, "the effect of (summer) harvesting on (EWM) biomass did not appear to be related to shoot or root carbohydrate concentration trends." Sytsma (1984) suggested that late-season harvests followed by midwinter harvests might reduce winter and early spring TNC accumulation, providing more long-term effects. This possibility does not appear to have been empirically tested, and harvesting remains a solely short-term management option that requires multiple within-season treatments for the control of EWM in areas of interest.

### 5.1.2 Ecological Considerations for Harvesting

*Fragmentation*

EWM reproduces largely by means of fragmentation and dispersal (Smith and Barko 1990). Concerns exist that mechanical harvest may exacerbate EWM infestations by encouraging fragmentation. The creation of EWM fragments by harvest has been well documented (Zisette, 1983, Newroth and Soar 1986). A study of the effects of mechanical harvesting of EWM in Lake Washington, Washington, evaluated the resulting offshore plant fragments and found that harvest elevated offshore fragment levels when accompanied by strong winds. One day after treatment, fragment levels in some areas remained partially elevated, but had decreased at one study site (Aquatic Research Incorporated 1986).

It is generally believed that the fragments released by harvest are fewer than those that would have been released had the bed been left intact or those created by adjacent, untreated EWM beds autofragmenting over time (Zisette 1983, Cooke et al. 1993). This hypothesis has not been tested in the field, but appears reasonable, given the high background levels of fragments in EWM-infested systems (Aquatic Research Incorporated 1986). Nevertheless, mechanical harvest is not recommended for use in systems without severe EWM infestations that are already generating a large fragment load (Newroth 1980, Cooke et al. 1993, WDOE 1998). Harvest and other management activities used early during the EWM invasion of Okanagan Lake "coincided with a rapid expansion" of EWM (Newroth 1980). Small or localized infestations are better managed with hand derooting by divers or other intensive methods that are less likely to induce fragmentation (see Section 5.5, Manual Control) (pers. comm., Mark Swarthout, Thurston County Lake Management, March 4 1998).

*Native Plants*

EWM quickly regrows at harvest sites, but the long-term effect on native and other aquatic plant species in EWM beds is not well documented in the literature. Some speculation exists that harvesting may select against some native macrophytes, maintaining EWM infestations even as they are managed (Nichols and Lathrop 1994). Although the multiple confounding factors involved with changing aquatic plant populations have made this assertion difficult to assess in the field, some evidence has been presented. Harvest has been shown to change species distributions, favoring fast-recovering species (Engel 1990). Nicholson (1981) presented perhaps the best evidence, documenting the suppression of native *Potamogeton, Ranunculus, and Vallisneria* species by EWM harvest in Chatauqua Lake, New York. Carpenter and Adams (1977) concur, suggesting that repeated harvests will select for harvest tolerant species (like EWM) over time.

*Weevils*

Management activities that include harvesting can detrimentally affect beneficial herbivores such as the milfoil weevil. Mechanical harvesters have been shown to negatively impact milfoil weevil populations (Chambers et al. 1994). Since weevil populations are typically distributed in clumps, the potential exists to impact a large proportion of a local weevil population while addressing only a small proportion of the EWM in a heavily infested system (pers. comm., Mariana Tamayo, University of Washington, February 26 1998). This possibility has not been tested and remains speculative.

*Water Quality*

The effects of EWM harvesting on water quality appear to be limited, in part because harvest areas tend to be small in relation to the larger infested waterbody. Harvesting can cause a short-term increase in turbidity, including resuspension of sediment and epiphytes that were on harvested plants (Nichols and Shaw 1983, Cooke et al. 1993). Some harvest activities have been associated with algal blooms, but the link is not well-established (Cooke et al. 1993). The most studied effect of harvesting on water quality involves the potential for the removal of nitrogen and phosphorus through the removal of biomass, which could provide a benefit to eutrophic systems. A full assessment of the effects of aquatic plants on nutrient dynamics is beyond the scope of this review. However, Nichols (1974) reviewed early studies on this topic, and found reported conclusions to be mixed. Cooke et al. (1993) suggest that research since then has discounted the technique for use in most systems.

### 5.1.3 Case Study of Harvesting

A field test of mechanical harvesting as part of the 1986 EWM control program in Lake Washington, Washington is documented by Aquatic Research, Incorporated (1986). Three sites dominated by EWM were harvested in July of 1986; one of the three was harvested a second time in August of 1986. Harvest areas were measured for biomass, plant height, and depth of weed-free water, and compared to control sites before and after treatment. Additional measurements were taken to estimate the effect of harvest on EWM fragment production and spread. Results were not collected following the second harvest at one site.

Harvest resulted in the clearance of an average of one meter of weed-free water and an immediate reduction in biomass of 36 percent. Total EWM regrowth was documented within 30 days, although reduced lake levels during this time accelerated the process. EWM in harvest areas grew faster than control sites. After 60 days, biomass was substantially the same in control and harvest sites; biomass at all sites had increased by an average of 14 percent. Harvested sites had a 71 percent increase in plant density as compared to pre-harvest levels; control sites had only increased 45 percent. (One control site was dropped from analysis due to an unexplained EWM decline.) EWM fragments were produced during harvest, but the only offshore increase deemed substantial was found during high wind conditions. Fragment collection on shore, an aesthetic concern of lakeshore residents, was not found to be affected by harvest activities.

This work is emblematic of many harvesting studies, in that its primary focus was on the short-term efficacy and impacts of a management technique. It documented that harvesting is a viable method of creating briefly weed-free areas in infested waters, and that fragmentation may not be of concern in infested waters where background levels of EWM fragments are high. No attempt was made to assess the long-term effects of this management practice, possibly because the use of harvest methods implies a goal of the limited reduction of EWM infestation rather than long-term management.

## 5.2 ROTOVATION AND OTHER DEROOTING METHODS

The limited effectiveness of harvest methods prompted the development in the late 1970s of rotovation, the boat-based rototilling of bottom sediments and rooted plant material. This method is geared toward removing the entire EWM plant, including root crown, with the goal of effecting more long-term control. Originally developed in British Columbia, the method is now common for the large scale control of severe EWM infestations, and is the method currently used in BCR. After rotovation, dislodged EWM root crowns and stems float to the surface and are either collected or left to wash to shore (Cooke et al. 1993). Because the method is expensive, potentially injurious to salmon, and requires completion of an extensive permitting process (Cooke et al. 1993, pers. comm., Kathy Hamel, WDOE, February 20 1998), it is most likely not an appropriate choice for small-scale homeowner-initiated control. Rotovation is best suited for large scale applications. The high capital investment typically requires government or agency funding for rotovation programs.

The typical rotovator is a barge-mounted design with a rotating tillage head. Other in-sediment designs include amphibious or boat-based cultivators, differentiated from the rotovator primarily by the lack of the rotating head. At least one of these cultivators is in use in British Columbia; results are comparable to those obtained by rotovation (Cooke et al. 1993). Because the two methods are largely alike, and as cultivation is not commonly used, only rotovation is addressed below.

### 5.2.1 Effectiveness of Rotovation

Rotovators have been evaluated in multiple waterbodies in British Columbia and Washington, including the Pend Oreille River. Results from most studies show immediate reductions in plant densities in the 90 to 98 percent range as compared to pre-treatment densities (Maxnuk 1979, Bryan and Armour 1982, Gibbons et al. 1987, WATER Environmental Services 1988, Cooke et al. 1993). Gibbons and Gibbons (1988) cited work suggesting one rotovation treatment is as effective as three or more mechanical harvests (Newroth 1985). At least two perpendicular passes are recommended for acceptable control because some plants are usually missed with only one pass (Maxnuk 1979). Missed plants can result in the failure of the treatment and extensive same-year regrowth of EWM (Gibbons et al. 1987). Maxnuk (1979) found "rapid reinfestation" five months after rotovation, an effect he attributed to missed plants. Rotovation effectiveness can also be affected by bottom substrate characteristics and underwater obstacles. Maxnuk (1979) found consistently higher EWM removal rates in sandy substrates as compared to clay or muck. Underwater obstacles must be removed before rotovation of an area if the treatment is to be successful (Gibbons and Gibbons 1988). Rotovation in thick beds of EWM can clog the rotating head. To avoid this, rotovation treatments should be planned in the winter or spring, during or after plant dieback (WDOE 1998a). Seasonal timing of rotovation is also thought to reduce the EWM fragmentation resulting from rotovation (see Section 5.2.2, Ecological Considerations).

A successful rotovation treatment will result in "carryover" EWM control into the season following treatment (Maxnuk 1979, Cooke et al. 1993, WDOE 1998). In the Pend Oreille river near Ione, EWM stem density one year following rotovation was 90 percent reduced from pre-rotovation levels in 1987 (WATER Environmental Services 1988). Possibly as a result of the variability of initial treatments, carryover effectiveness is not generally consistent between sites. Adjacent rotovation plots in the Pend Oreille River in 1988 showed opposite results a year after rotovation: one plot had a 44 percent increase in EWM stem density compared to pre-treatment levels, while the other showed a 25 percent decrease. A nearby control site showed virtually no change (WATER Environmental Services 1990). All studies have found that EWM will re-invade rotovated sites over time, either from EWM fragments or remaining root crowns (WDOE 1998, Cooke et al. 1993).

### 5.2.2 Ecological Considerations for Rotovation

*Fragmentation*

The retention of EWM plant fragments resulting from rotovation (e.g., by the use of floating booms) is currently not an aspect of most rotovation efforts. Because EWM reproduces largely by means of fragmentation and dispersal (Smith and Barko 1990), concerns exist that rotovation may exacerbate EWM infestations by encouraging fragmentation. The creation of fragments by rotovation has been documented (Maxnuk 1979, Newroth 1986) but not quantified. (Some efforts have been made to quantify fragmentation resulting from harvest.) It is generally believed that the fragments released by rotovation are fewer than those that would have been released had the bed been left intact or those created by adjacent, untreated EWM beds autofragmenting over time (Cooke et al. 1993). This hypothesis has not been tested in the field, but appears reasonable, given the high background levels of fragments in EWM-infested systems (Aquatic Research Incorporated 1986).

To minimize the possible effects of rotovation-created EWM fragmentation, Newroth (1986) suggests restricting rotovation treatments to winter or spring, when EWM biomass is reduced and fragments are less viable. Most importantly, rotovation is not recommended for use in systems without severe EWM infestations that are already generating a large fragment load (Newroth 1980, Cooke et al. 1993, WDOE 1998). Rotovation and other management activities used early during the EWM invasion of Okanagan Lake "coincided with a rapid expansion" of EWM (Newroth 1980). Small or localized infestations are better managed with hand derooting by divers or other intensive methods that are less likely to induce fragmentation (see Section 5.5, Manual Control) (pers. comm., Mark Swarthout, Thurston County Lake Management, March 4 1998).

*Native Plants*

The effects of EWM rotovation on other aquatic plants, both native and non-native, are generally considered to be positive. Other aquatic plants, native and non-native, quickly invade treatment sites following the removal of EWM, sometimes within weeks (Maxnuk 1979, Bryan and Armour 1982, Cooke et al. 1993, pers. comm., Kathy Hamel, WDOE, February 20 1998). Maxnuk (1979) documented the rapid colonization of rotovated sites by the non-native invasive plant *Potamogeton crispus* (curled pondweed) (cf. Boulduan et al. 1994). Bryan and Armour (1982) found same-year infestations of *P. crispus* and EWM following rotovation. Other species of *Potamogeton* also appear to be encouraged by the removal of EWM (Gibbons et al. 1987, Cooke et. al 1993). Gibbons and Gibbons (1988) documented the explosive growth of *Elodea canadensis* (Canadian elodea) following rotovation of a mixed bed of aquatic plants, including EWM. The effects of rotovation on the growth of other aquatic plant species is apparently short-lived: all reviewed literature suggests that EWM will re-invade rotovated sites in the absence of additional treatments.

Sexual reproduction has long been considered an insignificant aspect of the EWM life cycle and survival strategy (e.g. Aiken 1979, Smith and Barko 1990), even though the seeds have been found to germinate well under a wide range of conditions (Coble and Vance 1987, Hartleb et al. 1993). More recent work suggests that the EWM seed bank may play an important role in the success of EWM, and that sediment disturbance can initiate germination (Hartleb et al. 1993). One implication of this work may be that in areas cleared of EWM (through herbicides or drawdown), sediment disturbances such as rotovation could rapidly re-infest an area or waterbody by encouraging seed germination. This implication has not been tested in the field and remains speculative.

*Trophic Structure*

The effects of rotovation on benthic invertebrates have not been studied widely. Studies in Lake Osoyoos, Washington, found no significant effects of rotovation on the diversity or species structure of benthic invertebrates. Initial densities and species diversity of invertebrates were low, possibly as a result of the EWM infestation (Gibbons et al 1987).
The effect of rotovation on other invertebrates does not appear to have been studied at all. However, it has been hypothesized that management activities such as rotovation can detrimentally affect beneficial herbivores such as the milfoil weevil. Mechanical harvesters have been shown to negatively impact milfoil weevil populations (Chambers et al. 1994). Since weevil populations are typically distributed in clumps, the potential exists to impact a large proportion of a local weevil population while addressing only a small proportion of the EWM in a heavily infested system (pers. comm., Mariana Tamayo, University of Washington, February 26 1998). This possibility has not been tested in the field, and remains speculative.

Falter and Riggers (1993) studied the effects of different rotovation cutting patterns within EWM beds of the Pend Oreille River. They found phytoplankton density and biomass were reduced in rotovated plots but phytoplankton diversity remained unchanged. Zooplankton density, biomass, and diversity were reduced as a result of rotovation. They hypothesized that aquatic macrophytes control the phytoplankton levels in Box Canyon Reservoir by providing nutrients to the water column via "sediment pumping." Zooplankton communities respond to changes in habitat complexity and reduced phytoplankton. Changes in these food base trophic levels have important fisheries management implications.

*Water Quality*

The most extensive documentation of the effects of EWM rotovation on water quality is provided by Bryan and Armour (1982). They measured turbidity, oxygen, and nitrogen levels, along with 24 other parameters, previous to and at intervals following rotovation. Predictably, large increases in turbidity were found post-treatment, but no long-lived changes were found in any parameter. Caution is generally advised before rotovating in small waterbodies or areas with potentially toxic sediments (Gibbons and Gibbons 1988, Cooke et al. 1993, WDOE 1998).

### 5.2.3 Case Study of Rotovation

The 1986 EWM control program in the Pend Oreille river, Washington, is well documented by Gibbons and Gibbons (1988). The program consisted of the rotovation of 36 acres of monotypic EWM and multi-species beds of aquatic plants. Part of the rotovated area had been previously treated with chemical herbicides (2, 4-D). Three beds were rotovated in overlapping, parallel transects using a barge-mounted system with an prototype high-speed rotating head. Two treatment beds were mostly composed of EWM, with minor components of *Potamogeton* spp. (pondweeds), *Ranunculus* sp. (buttercup), and *Elodea canadensis* (Canadian elodea). A third bed was dominated by *Ranunculus* near shore, but EWM in deeper waters. The reduction in EWM densities in the three beds following rotovation ranged from 63 percent to 90 percent. Other aquatic plant species were removed at similar rates, with the exception of *E. canadensis*, which dominated shallow areas in one transect that were tilled less intensively by the rotovator.

Two of the three transects were evaluated one year after the treatment. One transect was re-infested with EWM, although at a 25 percent lower stem density than pretreatment levels. This first transect had shown an EWM reduction of 86 percent from pretreatment levels when it was first rotovated. The second transect, which had shown a 90 percent reduction in EWM stem density after rotovation, remained largely free of EWM one year post-treatment. However, this second transect was the site of an explosive growth of *Elodea canadensis*, which increased in stem density by 500 percent in the year following rotovation. Second-year stem densities of all aquatic plants were within 25 percent of original pretreatment densities on the first transect, and 7 percent of original densities on the second, indicating carryover control of EWM but not aquatic plants in general.

This case study illustrates many of the benefits and limitations of rotovation for the control of EWM. Results were varied, but effectively reduced EWM stem densities in the first year of treatment. Existing site conditions, substrates, and species compositions probably played a large role in the results of rotovation. Carryover effects into the second year were mixed. The only site that showed effective second-year control of EWM also had strong growth of a native aquatic plant, *Elodea canadensis*. Total stem densities of all aquatic plants for this transect approached that found before rotovation. Persons who prefer the removal of all aquatic plants, or who cannot differentiate between EWM and other aquatic plants, would likely find the second-year carryover results of this treatment less than satisfactory. Nevertheless, even these mixed results were more effective than those reported by harvesting treatments in other systems.

### 5.2.4 Other Derooting Methods

Early investigations by the British Columbia Ministry of the Environment included the use of high-pressure underwater jets to dislodge EWM root crowns and the use of rototillers mounted on land-based tractors or amphibious vehicles (Bryan and Armour 1982, Gibbons 1986). Both of these methods were found ineffective. The hydraulic jets proved unable to dislodge large EWM clumps, even after repeated passes. Increased power to the jets was thought to cause the unit to lift off the bottom. Trials of the hydraulic jets were not continued past 1976. Land based tractors were only able to operate in water depths below 0.6 meters. Although amphibious shallow-water rototilling from tracked vehicles resulted in short term stem density reductions of 49-98 percent, the maximum operating depth of the vehicles was only 1.25 meters (Gibbons 1986). This is only a fraction of the depth infested by EWM in many areas. Neither of these shallow-water rototilling units is discussed in recent literature on effective derooting techniques.

## 5.3 WATER LEVEL DRAWDOWN

Drawdown is defined here as the intentional lowering of water levels in a lake or reservoir. When used as a method of aquatic plant control, drawdowns are designed to expose the target plants to drying or freezing conditions (or both) in hopes of killing them off. This method was pioneered by the Tennessee Valley Authority (TVA), and is still used there as part of a larger program to manage a variety of aquatic plants, including EWM (Smith 1967, TVA 1990, 1993). Drawdown is widely used, in part because it is included in many water management regimes for reasons other than EWM control. Most drawdowns are wintertime efforts; summer drawdowns are poorly represented in the literature and are not reviewed here. Drawdown can be used on any size waterbody, although its use on BCR is clearly a large scale effort not within the realm of homeowner-initiated efforts.

### 5.3.1 Effectiveness of Drawdown

Drawdown is widely considered to be one of the most effective tools in the land manager's arsenal for the control of EWM infestations. The TVA considers drawdown "the most effective and most economical single method of management available" for the control of aquatic plants, including EWM (TVA 1990). The Mississippi State Extension Service (1997) refers to drawdown as "one of the most useful. . .pond management practices." Published results of drawdowns suggest that a more tempered evaluation may be warranted when the target species is EWM. Cooke (1980a) grouped EWM with species "strongly resistant to exposure," requiring at least three weeks of desiccation if any control is to be achieved. His review of all published studies found the genus *Myriophyllum* showed either no change or no clear response to winter drawdowns. Repeated drawdowns in the Tennessee Valley have required supplementation with large herbicide applications, and EWM still remains a dominant plant in many reservoirs (TVA 1972, 1990, 1993, Goldsby et al. 1978, Bates et al. 1985). A winter drawdown in Blue Lake, Oregon, was not effective, prompting the use of herbicides. Above-freezing temperatures were cited as the cause of the failure (Gieger 1983). Nichols and Shaw (1983) cite four studies in asserting that drawdown can control EWM, but the studies either used herbicides in conjunction with drawdowns or EWM was very limited in the study area.

Other studies and anecdotal evidence suggest that at least some successes exist for the control of EWM with drawdowns. Bates et al. (1985) cite TVA drawdowns that did not include herbicide applications, including a one-week drawdown that left a weed free band for two growing seasons. They speculate that the drawdown increased silt deposition on plants, or disrupted a "physiological adaptation to a certain depth" in the EWM. Siver et al. (1986) found that two successive years of deep drawdowns (2-2.7 meters) provided effective short-term control of EWM in a Connecticut Lake. The U.S. Bureau of Reclamation may have had at least partial success using drawdown to control EWM in Banks Lake, Washington (Gieger 1983, WDOE 1998c). Cooke et al. (1993) state that EWM is "highly susceptible to dry, freezing conditions." Similarly, the WDOE believes that while drawdown is not well suited for western Washington, "drawdowns can work in eastern Washington" due to the subfreezing winter temperatures (pers comm., Kathy Hamel, WDOE, February 20 1998).

The conflicting views of drawdown presented in the literature may hinge on weather patterns. Many studies that describe a failure to control EWM with drawdown did not subject exposed EWM root crowns to prolonged freezing weather. The best documented successes all involve extended periods of freezing temperatures (e.g., Siver et al. 1986). Cooke et al. (1993) reviewed work by Culver et al. (1980) suggesting that drawdown success in the eastern U.S. is high, possibly due to the severe winters. Stanley (1976) found that EWM was killed after 96 continuous hours of freezing temperatures in the lab. Thus it is reasonable to assert that winter drawdowns are not without potential for EWM control in waterbodies such as BCR where extended subfreezing temperatures are common. However, a review of the literature suggests that even the short-term efficacy of drawdowns as a EWM control method is subject to a number of unknowns that could induce failure. In addition, the long-term effectiveness of drawdown for EWM control is entirely undocumented in the literature. No study describing the successful use of drawdown to control EWM (without additional treatments, such as herbicides) documents long-term results or the rate of reinfestation of EWM. It has been suggested, though, that yearly drawdowns in some smaller TVA reservoirs have kept them free of EWM over time by killing any new infestation in the first year (Bates et al. 1985).

The seed ecology of EWM may be a factor in the inconsistent results of drawdowns reported in the literature. Sexual reproduction (and thus seed production) has long been considered an insignificant aspect of the EWM life cycle and survival strategy (e.g. Aiken 1979, Smith and Barko 1990), even though the seeds have been found to germinate well under a wide range of conditions (Coble and Vance 1987, Hartleb et al. 1993). Authors recommending the use of drawdowns for aquatic plant control generally acknowledge that the method encourages aquatic plants that survive drawdowns as seed (e.g., Webb 1990). Recent work suggests that this group of survivors includes EWM, and that the role of sexual reproduction in EWM has been underestimated. Standifer and Madsen (1997) report that EWM seeds are highly resistant to desiccation, and remain viable even after a drying period of 36 weeks. They argue that "management by drawdown will not cause significant seed mortality." Since the seed production of EWM is quite high, and the seeds are not killed by freezing (Hartleb et al. 1993), their logic appears strong. Although this new work has yet to be confirmed by field studies, it is supported by anecdotal evidence from Washington. Following EWM eradication by herbicides, Lois Lake, Washington underwent a natural drought-induced drawdown. When water levels returned, a spontaneous flush of EWM re-infested the lake. It is suspected that surviving EWM seeds were stimulated to germinate by the drawdown (pers comm., Kathy Hamel, WDOE, February 20 1998).

### 5.3.2 Ecological Considerations for Drawdown

Like reports of effectiveness, reports of the ecological effects of winter drawdown are variable in the literature. It is generally accepted that repeated drawdowns can substantially change plant species distributions, but no patterns were found that could be used to suggest possible trends. Beard (1973) found a total change of dominance patterns following one year of drawdown in Wisconsin; EWM was only a minor component of the system. Siver et al. (1986) found strong establishment of wavy water-nymph (*Najas flexilis*) following the successful use of drawdown to control EWM. Cooke (1980a) noted that drawdown can increase levels of emergent plants that are attractive to waterfowl. Cooke et al. (1993) review work suggesting that winter drawdowns can have severe impacts to associated wetlands. They describe a winter drawdown in Lake Bomoseen, Vermont that affected a wide range of species, including invertebrates and threatened plants. Finally, drawdowns have been associated with algal blooms following reflooding. The mechanism behind this association has not been fully explained (Nichols and Shaw 1983). The impact of drawdowns on invertebrates in exposed sediments is not well known (Nichols and Shaw 1983). Drawdowns can have other important ecological, geomorphic, and socioeconomic effects.

### 5.3.3 Case Study of Drawdown

Candlewood Lake, Connecticut, is a strong example of the use of drawdown for partially successful control of a serious EWM infestation. A successive series of deep drawdowns (2-2.7 meters) were initiated during the winters of 1983 and 1984 in response to an invasion of EWM that had come to dominate the entire lake. Siver et al. (1986) established transects at three sites in the lake, and compared macrophyte densities and species diversity before and after each drawdown treatment.

In a shallow cove, aquatic plant biomass (90 percent EWM) was reduced by 97 percent after the first drawdown. Considerable regrowth of two formerly sparse water-nymph (*Najas)* species occurred; these became dominant at depths below 3 meters. Even with this regrowth, total aquatic plant densities following the second drawdown were reduced by 48 percent from the original, pre-drawdown level in 1983. In deeper areas of the lake, results were more mixed. One of the three transect sites showed little effect from the drawdowns; this was attributed to the steep banks at this site that kept the lowered lake surface in proximity to exposed EWM beds. A third site, which originally had the densest EWM infestation of the three, showed a 84 percent reduction in aquatic plant biomass after the second drawdown. Water-nymph (*Najas* spp.) became codominant with the remaining EWM at this third site. EWM below the 2.7 meter mark remained unaffected by the drawdowns, so EWM infestation remains a problem in Candlewood Lake. Nevertheless, consecutive drawdowns appeared to positively impact a problem infestation of EWM and allow the reestablishment of native macrophytes in this case.

## 5.4 SEDIMENT COVERS AND SHADING METHODS

Sediment covers and shading rely on habitat modification - the reduction or elimination of available light - to reduce or eliminate aquatic plant establishment and growth in specific areas of interest. Sediment covers are generally plastic or fiberglass sheets that are placed directly over bottom sediments and secured. Covers can be placed by divers or during deep drawdowns (e.g. Cooke and Gorman 1980). Sediment covers are not species-specific, and will control all aquatic plants in an area. Although at least one extreme (and failed) effort has been made to cover an entire pond (Cooke 1980b), the use of sediment covers is considered a small scale control method best suited for control of aquatic macrophytes in particular areas of interest, such as around docks or boat launches (Gibbons 1986). Sediment covers are easiest to apply and most effective when installed over a flat sediment surface. Sediment covers are expensive to purchase and require regular maintenance, but are effective and well-suited to homeowner-initiated control efforts. Shading methods are not widely used and appear inappropriate for use in BCR; they are reviewed only briefly.

### 5.4.1 Effectiveness of Sediment Covers

A wide variety of materials have been evaluated as sediment covers. Early efforts included simply spreading sand or gravel over an area, but plant regrowth was rapid as resedimentation occurred and plant roots or shoots penetrated the material (Cooke 1980b, Cooke et al. 1993). Other early and less than successful methods included the use of standard black polyethylene plastic and large burlap sheets. Burlap decayed rapidly in field trials, but had the benefit of being gas-permeable, so the gaseous products of benthic metabolism less often gathered and lifted the sheeting. Polyethylene was also short lived in field trials, and required perforation to allow gases to escape. Plants typically grew through the perforations. In addition, polyethylene floats and was therefore difficult to apply and secure, especially on uneven underwater surfaces. Sand or other ballast placed over the plastic often shifted with wave action. Entire sheets were found to wash away during storms. Despite these obvious drawbacks, the use of sediment covers showed strong potential: most sheeting materials were found to effectively control aquatic plants for when kept in place and before sediment accumulation occurred (Armour et al. 1979).

These early experiences suggest that an ideal sediment cover is long-lived, gas permeable, negatively buoyant, and removable so that accumulated sediment can be cleaned off. Two such materials appear offer at least most of these characteristics: the fiberglass screening sold under the trade name Aquascreen, and woven polypropylene erosion control sheeting. Polypropylene is gas-permeable, but floats. Cooke and Gorman (1980) applied Typar polypropylene sheets to an Ohio lake after a winter drawdown, anchored it with cement blocks, and found almost complete short-term effectiveness in controlling water-nymph (*Najas*) and various pondweed (*Potamogeton*) species. Lewis et al. (1983) found polypropylene sheeting controlled EWM for three seasons, although accumulated sediments supported some plants. Perkins (1980) found Aquascreen to be extremely effective for EWM control in Union Bay, Washington. The fiberglass panels are gas permeable, do not float, and are easily removed for cleaning, moving, or overwinter storage. Aquascreens provided up to 78 percent declines in plant biomass after two months in place; same-season regrowth of EWM was considered minimal. Screen removal prevented sediment accumulation. Close contact with bottom sediments was found to be essential for effective control. Aquascreen sheeting also proved effective for EWM control in Lake Washington, although EWM did take root in one area with high sediment accumulations (see Section 5.4.3, Case Study) (Zisette 1983).

Although a considerable literature exists documenting the various sediment cover materials and methods, no assessments appear to have been made in riverine systems such as BCR. Therefore an unstudied element for most reviewed work on sediment covers is the ability of the material to stay in place in the face of a constant current. In addition, placement of sediment cover materials may be more difficult in moving water (Cooke et al. 1993). Zisette (1983) partially alleviates these concerns with evidence that wave action and currents actually assist Aquascreen control efforts by discouraging sediment accumulation on the screens.

Sediment accumulation or material decay is expected to render any treatment ineffective absent the removal, maintenance, and re-application of sediment covers (Cooke et al. 1993) As a result, no studies of long-term effectiveness are found in the literature. The removal, cleaning, and subsequent re-application of sediment covers allows this method to essentially be a series of effective, short-term control efforts. Alternately, multiple applications of burlap have been suggested; its rapid decay would likely alleviate any need to remove and maintain large screens (Gibbons 1986). The regrowth of EWM following sediment cover removal (without re-application) does not appear to be at issue: after the removal of sediment covers in Lake George, New York, EWM re-infested 44 percent of a study site within 30 days (Boylen et al. 1996).

### 5.4.2 Ecological Considerations for Sediment Covers

The effective use of sediment covers involves the control of all aquatic macrophytes, including nontarget species. Because it is a method of habitat modification, sediment covers have the potential to impact any resident species in proximity to the treatment area. Sediments under covers may become anoxic (Armour et al. 1979). Cooke et al. (1993) cite work showing the local elimination of aquatic macroinvertebrates after sediment covering. Anoxic conditions were suspected. However, since sediment covers are exclusively used as a small scale method of aquatic plant control, their potential for wide ecological impact appears limited.

### 5.4.3 Case Study of Sediment Covers

Zisette (1993) documents the use of Aquascreens as an aquatic plant control method in Lake Washington, Washington during the summer of 1983. Although EWM was the primary target species, the screens were installed in swimming and other high-use areas where aquatic macrophytes in general are considered a nuisance. Aquascreens were installed at three locations, and evaluated in comparison to control sites. Aquatic plants, including EWM, were effectively controlled at two of the three sites. EWM density following Aquascreen installation was below one plant per square meter, and no plants surfaced, thus indicating a high effectiveness for this method. Control sites developed dense stands of EWM, and plants grew above one meter below the surface. Macrophytes were not effectively controlled by Aquascreens at a third site, which supported dense EWM growth in sediment accumulations of up to 4 centimeters. This third site was sheltered, and not subject to wave action or currents that would discourage sediment accumulations. This work suggests that the removal and cleaning of sediment covers is an essential part of the method. In the absence of such maintenance, sediment covers are not likely to provide macrophyte control over time.

### 5.4.4 Shading

Shading involves either covering the water surface or dyeing the water itself in order to limit light to aquatic plants and thereby effect control. Cooke et al. (1993) review these largely unused and uninvestigated methods. As they are "fringe" methods unlikely to be suited for use in BCR, they are not covered here in detail. Covering the water surface is unlikely to be an aesthetically or recreationally acceptable option in any system. In addition, the effective control established for on-sediment covers makes the use of floating shading appear unwarranted. The only commercially available water dye does not appear suited for use in flowing water, and is not approved for use in proximity to potable water intakes, making its use appear unwarranted as well.

## 5.5 MANUAL METHODS

Manual methods involve the hand removal of EWM plants and roots, sometimes with the assistance of a boat-based suction dredging device. Manual control methods, including diver-based methods, are often used in situations where the limited accuracy and risk of fragmentation from mechanical methods such as harvesting and rotovation are undesirable. Manual methods can be effective but are expensive and slow (Maxnuk 1979). As a result, manual efforts are best used as an aspect of preventive control, eliminating infestations before they have a chance to spread (Newroth 1981, Cooke et al. 1993). Alternately, manual control can be an effective method of clearing an area of high use, such as a dock or boat ramp. Although divers are not always needed for manual control methods, any deep-water work will clearly require them. The efficacy of manual control efforts, especially when diver-based, is strongly influenced by individual expertise and interest (pers. comm., Mark Swarthout, Thurston County Lake Management, March 4, 1998).

### 5.5.1 Effectiveness of Manual Methods

Manual methods are widely used for localized aquatic plant control, with generally positive results. The main drawback to their use, besides the expense, is their inability to control large or extremely dense infestations, which are better addressed through the use of larger-scale methods such as sediment covers or rotovation (Bryan 1975, Maxnuk 1979, Cooke et al. 1993, Boylen 1996). Hand harvest of EWM roots and plants in Lake George, New York was over 80 percent effective in the first year of application. Hand harvesting reduced the number of EWM plants found in subsequent years (Boylen et al. 1996). Suction-assisted manual harvest ("diver dredging") in British Columbia lakes achieved 85 to 97 percent removal of EWM roots (Maxnuk 1979). Divers were assisted by a boat-mounted small-scale pumping unit. Careful uprooting of EWM by divers is an essential, although largely undocumented, part of the preventive approach to EWM control employed on Long Lake, Washington. Rapid EWM reinfestation is predicted in the absence of such efforts (pers. comm., Mark Swarthout, Thurston County Lake Management, March 4, 1998).

### 5.5.2 Ecological Considerations for Manual Methods

Manual methods appear to have limited potential for environmental impacts. They are considered to have the lowest risk of EWM fragmentation of all mechanical control methods, and as a result are appropriate for use in systems with limited EWM infestations where fragmentation is an issue (Newroth 1981). The effects on non-target macrophytes are minimal, as impacts are easily limited to the target plant species (Boylen et al. 1996). The assistance of suction devices brings the potential for short-term turbidity increases, but few other water quality concerns (Cooke et al. 1993). As manual methods are generally small-scale efforts not involving serious habitat alteration, the potential for widespread ecological impacts as a result of manual EWM control is most likely small.

### 5.5.3 Case Study of Manual Methods

Maxnuk (1979) described suction assisted manual EWM control by divers in British Columbia lakes in 1977. Mean EWM shoot density before and after treatment was measured to determine the effectiveness of the operations. Over three study sites, measured reductions in EWM shoots ranged from 80 to 97 percent. Local conditions were cited as the main reason for lowered effectiveness in some areas. In addition, suspended sediments resulting from the treatment eliminated visibility at times, further hampering operations. Post-treatment evaluations found that many shoots were newly rooted fragments, either from non-treated EWM beds or from the treatment itself. As a result, Maxnuk noted that " a return to the *M. spicatum* dominant condition can be expected if follow-up treatments are not applied." Later evaluations by Newroth, though, suggest that this suction-assisted diver control limited the spread of EWM in areas where the infestation was small (Maxnuk 1979, Newroth 1981). This program has been discontinued in British Columbia, partly due to the high costs associated with intensive diver-based control efforts (Cooke et al. 1993.)

## 5.6 DREDGING

The large scale dredging and onshore disposal of sediments, an occasional lake restoration technique, has been suggested as a method for aquatic plant control, and investigated at least once. Available evidence suggests that large-scale dredging is expensive, strongly disruptive to the benthic community, associated with long-term declines of native species, and possibly associated with algal blooms. In addition, it appears ineffective for the control of EWM: dredging in a British Columbia lake was followed by EWM regrowth within six months, and the dredging of a Wisconsin lake may have even encouraged EWM domination of the post-dredging plant community (Bryan 1975, Nichols and Shaw 1983, Wade 1990).

## 5.7 WEED ROLLING

Weed rolling is a new method of mechanical control that does not appear to have been reviewed in the literature. This method maneuvers a rolling underwater cylinder in an arc of up to 270 degrees to compress and agitate sediments. When used on a regular basis (once a weed after initial clearance of aquatic plants), weed rolling apparently "creates and maintains areas of open water adjacent to docks" (WDOE 1998b). Because costs are low and permitting requirements limited, weed rolling would appear to be an attractive alternative for small-scale, homeowner-initiated control. As it impacts only a small area, ecological considerations are likely to be limited to short-term turbidity. Further review of the efficacy of weed rolling may be warranted.

## 5.8 ULTRASOUND

The experimental use of high-intensity ultrasonic frequency sound waves to control EWM was the subject of research in British Columbia in the 1980s (Newroth and Soar 1985). Damage to EWM apical fragments was induced at simulated water depths of up to 4.5 meters, suggesting the potential to impact EWM growth. The researchers hoped to develop a model with sound frequencies specific to EWM, but had not done so as of the last citation of the technique (Gibbons 1986). No current research on this method is available in the literature.

## 6.0 BIOLOGICAL METHODS OF EURASIAN WATERMILFOIL CONTROL

Biological control is defined as a control effort based on the use of a living organism or virus (Pieterse and Murphy 1990). The limitations of mechanical and chemical control methods have prompted extensive research into biological methods of aquatic plant and EWM control. Cooke et al. (1993) point out that the use of biological control technologies implies an intent to reduce rather than eliminate the target species, because of the dependence of the control agent on the target. The ideal control agent, they suggest, would establish a "dynamic equilibrium" between itself and the target, reducing the target to a more acceptable level. Other characteristics of ideal biological control agents include strong host specificity, ease of rearing and use, and an inability of the control agent to itself become a nuisance.

Classical biological control methods involve the intentional introduction of an organism from the target species' native range to induce control. Some recent attempts at biological control (e.g. the milfoil weevil (*Euhrychiopsis lecontei*) and the fungus *Mycoleptodiscus terrestris*) have focused instead on the augmentation of native species that show potential to control the target. Both classical and other biological control methods involving fish, invertebrates, pathogens, and competitive plantings are reviewed and assessed for potential effectiveness and ecological considerations; case studies are provided for the most widely used methods.

## 6.1 HERBIVOROUS FISH

Two types of fish are currently in use for aquatic plant control, those in the genus *Tiliapa*, and the grass carp (*Ctenopharyngodon idella*). Although *Tiliapa* are used in California for aquatic plant control (Sheldon 1997a), their use elsewhere is poorly documented in the literature, and is not reviewed here in detail. *Tiliapa* are generally not used for EWM control, most likely because they share with the grass carp a dislike for EWM and will only eat it after the removal of more preferred species (Sheldon 1997a). In addition, *Tiliapa* show poor winter survival in waters below 50° F (Nichols and Shaw 1983), making them an inappropriate choice for BCR.

The grass carp is an herbivorous fish native to China that has been used in aquatic plant control efforts in the United States since 1963. Control is initiated by stocking pre-assessed levels of fish into an area of concern. Fish/area ratios have been developed for closed water systems and software exists to predict required stocking densities (Bain 1996). Due to the expense of trucking, stocking, and monitoring large numbers of imported grass carp, this is a large-scale method not appropriate for homeowner implementation. In addition, fish are mobile and unlikely to remain at their stocking site, diluting any potential benefit to any particular set of homeowners.

### 6.1.1 Effectiveness of Herbivorous Fish Introduction

Grass carp have been introduced into at least 33 states in the US and over 50 nations worldwide (Washington Department of Wildlife 1990). Although the definition of effective biological control differs among managers according to their goals, the introduction of grass carp is generally considered to have been effective in a number of systems that are not dominated by EWM. Control of hydrilla in Florida lakes using grass carp has been partially successful (Clapp et al. 1994). Grass carp are widely used in the Netherlands for aquatic plant control in drainage canals, and have been found to be effective and cheaper than other control methods (Van der Zweerde 1990).

Because grass carp will eat a variety of aquatic plants, including desirable native plants, many workers have attempted to describe feeding preferences for the fish (e.g., Fowler 1978; Catarino et al. 1997). Preferences have been found to be influenced by a number of factors, including water temperature, fish size, and water system type (i.e., riverine versus littoral systems) (Pine and Anderson 1991). The exact feeding preference hierarchy of grass carp varies among studies, but EWM ranks consistently low in the preference hierarchy in all reviewed research. Pine and Anderson (1991) report that EWM rated 11 out of 13 plants tested in carp feeding preference trials, preferred only to waterhyacinth and coontail. Experimenting in artificial ponds, Catarino et al. (1997) found that grass carp had an intermediate preference for milfoil, eating it before parrotfeather and waterhyacinth. Leslie et al. (1987) classified Florida aquatic plant species into preference categories and rated EWM at the lowest level, "unpalatable."

The consensus in the literature is that grass carp will preferentially target species other than EWM for feeding efforts. The removal of all preferred aquatic macrophytes, including beneficial native species, is expected before feeding on EWM will occur (Sheldon 1997). As a result, the effectiveness and utility of grass carp as a biocontrol agent for EWM is strongly limited, and does not appear to be an appropriate choice for BCR. Reflecting this, the Washington State Noxious Weed Control Board recommends against the use of grass carp for the control of EWM (WDOE 1998c).

### 6.1.2 Ecological Considerations for Herbivorous Fish Introduction

The development of reliably sterile triploid (three sets of chromosomes) grass carp in the early 1980's has largely alleviated concerns about the possibility of establishment of wild populations of grass carp. Self-sustaining wild populations of introduced diploid grass carp have been documented in a number of areas outside the United States, and reproduction of introduced diploids has occurred within the United States (Van der Zweerde 1990). Introductions of diploid grass carp in Arkansas in 1963 resulted in their spread to parts of the Southeast (Cooke et al. 1993) Since sterile triploid grass carp cannot establish self-sustaining populations and have limited life spans, triploid grass carp introductions are not now considered a risk for reproduction and possible invasion into other systems (TVA 1990).

Grass carp introductions have rarely achieved an intermediate level of aquatic plant control. As a result, concerns exist regarding the near-elimination of preferred or more palatable aquatic plants in a system or area. Such an elimination would likely have severe detrimental impacts to organisms that use these species for food or habitat. In BCR, most plants preferred by grass carp are native species. Thus the introduction of grass carp into BCR could result in the suppression of native species, possibly resulting in an increased presence or dominance of EWM, and associated impacts to plant-dependent fauna. McKnight (1995) found the introduction of grass carp into Guntersville Reservoir (see below) "reduced native aquatic vegetation in some areas while milfoil remained unaffected." He recommends against the use of grass carp in areas dominated by unpalatable species such as milfoil, due to the potential impact to native plant species and associated waterfowl.

### 6.1.3 Case Study of Herbivorous Fish Introduction

One of the largest scale introductions of grass carp is that initiated by the Tennessee Valley Authority (TVA) in response to a continuing infestation of exotic aquatic weeds that began with EWM in the 1950's and continued with hydrilla in the early 1980's. In 1990, the TVA released 100,000 sterile triploid grass carp into Guntersville reservoir, a 67,900 acre impoundment (TVA 1990). Simultaneous aquatic plant control activities included extensive herbicide use (primarily 2,4-D, specific to EWM) and intermittent water level drawdowns. Despite these control efforts, submersed aquatic plant coverage increased by 827 acres from 1991 to 1992. Hydrilla, a preferred food of grass carp, was effectively controlled, declining to 1 acre of coverage in 1992 from 2900 acres in 1988 (TVA 1993). EWM remained the dominant aquatic plant species in the reservoir. A smaller study in the Guntersville reservoir conducted by the TVA in 1987 found that grass carp sequentially impacted pondweeds, then EWM, over a period of three years EWM showed extensive regrowth in the fourth year.

It should be noted much of the TVA's work took place within the context of large and unexplained variation in aquatic plant populations in the Tennessee Valley and across parts of the United States. Declines in EWM coverage were noted nationwide in the late 1980's; in the Tennessee Valley this continued into 1991 (Smith 1994) The multiple confounding factors impacting aquatic plant populations in the Guntersville reservoir make inference a difficult task, but it is reasonable to assert that EWM was not effectively controlled by the introduction of grass carp into Guntersville reservoir. Control of hydrilla, the primary target of the grass carp introduction, appears to have been successful.

## 6.2 INSECT-BASED BIOLOGICAL CONTROL

The intentional introduction of insects for the control of aquatic plants was first attempted in 1964 (Pieterse 1990). Since that time, insects have been found to provide effective aquatic plant control for alligatorweed and water hyacinth in the southern United States (Sheldon 1997a, Olem and Flock 1990). The insects used for biological control of aquatic plants tend to be specialists, impacting only the target species. This does not imply general aquatic plant control or a reduction in total aquatic plant biomass. As a result, the potential exists for a successful biological control program to be perceived as inadequate if no differentiation is made between the target species and aquatic plants as a whole. A number of insects have been evaluated for the control of EWM; the most promising are reviewed in detail.

### 6.2.1 Milfoil Weevils

Research efforts were initiated in 1989 in an attempt to determine the agents causing the sudden decline of EWM in Brownington Pond, Vermont. Available evidence pointed to a native North American aquatic weevil, *Euhrychiopais lecontei* (Sheldon 1990). Extensive research has since occurred, generally suggesting that the milfoil weevil shows considerable promise as a biological control agent for EWM because it is milfoil-specific, native to North America, and associated with declines of EWM both in the lab and the field (Creed et al. 1992, Creed and Sheldon 1994, Sheldon and Creed 1995, Sheldon 1997a, Sheldon 1997b, Newman et al. 1996). Creed (in press) notes that the pattern of unexplained declines of EWM in lakes closely tracks the known national distribution of milfoil weevil populations. High weevil density in at least 9 known lakes has coincided with declines of EWM and its replacement with native plants (Sheldon 1997a). Research on the milfoil weevil has focused on lakes, with only limited survey work being directed toward riverine systems. Milfoil weevils have been found in low densities in Washington, including in the Pend Oreille River (pers. comm., Mariana Tamayo, University of Washington, February 26 1998).

The current body of knowledge on the milfoil weevil is limited, and additional research and weevil augmentation trials will be required to fully assess its potential as a biocontrol agent. Because this is an emerging field of research, it is unlikely that the milfoil weevil is appropriate for homeowner-initiated, small scale biocontrol efforts. Nevertheless, at least one company is preparing to sell milfoil weevils on the open market (pers. comm., Kathy Hamel, WDOE, February 20 1998).

### 6.2.1 Effectiveness of Milfoil Weevils

Adult milfoil weevils have been shown to significantly reduce EWM biomass and growth in outdoor laboratory studies (Creed and Sheldon 1993), and EWM biomass in enclosures in the field (Sheldon and Creed 1995). Loss of biomass resulted from feeding on both EWM leaves and stems. Other research by these authors documented what may be the most important impact of the milfoil weevil: feeding on EWM stems, especially tunneling into stems by larvae, results in a loss of EWM buoyancy (Creed et al. 1992). Since EWM growth is often limited by light availability (Olem and Flock 1990), EWM at lake bottoms may die. Mats of previously surfaced weevil-impacted EWM have been observed on lake bottoms (pers. comm., Mariana Tamayo, University of Washington, February 26 1998); damaged plants can drag down undamaged ones to intensify the effect of weevil feeding (Creed et al. 1992). Newman et al. (1996), working with EWM in experimental tanks, confirmed that milfoil impacts to EWM "are caused by plant damage rather than direct consumption." They found that weevil densities of ~300/m2 can quickly result in reduced biomass and growth of EWM.

Milfoil weevils have been associated with EWM declines in at least nine lakes (Sheldon 1997a, EPA 1997). The national distribution of milfoil weevils is similar to that of unexplained declines in North America (Creed, in press). Weevil-associated declines were manifested in extremely decreased abundance and biomass of EWM both rapidly and over time (EPA 1997). Some weevil-associated declines have resulted in the almost complete disappearance of EWM from a lake (EPA 1997). This not typical of most models of biological invasions and biological control, which are typically characterized by rapid expansion, quick decline, and subsequent oscillating equilibrium (Smith 1994). Monitoring data is generally not extensive enough to assess whether, in systems exhibiting EWM decline, the weevils and EWM are increasing and decreasing in such an opposing cycle of oscillating equilibrium. Some of the best monitoring data that exists for a single system - Brownington Pond, Vermont - does show cyclic densities of EWM and milfoil weevils (Sheldon 1997b). Therefore it is possible that EWM populations in decline due to milfoil weevil activity may expand in the future. Any control provided by milfoil weevils is specific to EWM, and may not reduce the total density of aquatic plants in a system. Sheldon (1997b) notes that many former EWM beds in Brownington Pond now support native aquatic plant populations.

Weevil augmentation studies have been initiated in number of states. This research is ongoing and results from most trials are not available (e.g. Jester 1997). No river or reservoir has been used as the site of augmentation research. Sheldon (1997b) reported preliminary results from weevil augmentation work in one large and two small lakes in Vermont and Massachusetts. By 1995, weevil populations in two sites in Lake Bomoseen, Vermont (surface area: 1100 ha) increased for two years after the last augmentation, and EWM biomass declined for two years running, as compared to control sites. EWM biomass was still considerable in 1995, the last year for which results are reported (~125-200 dry g/m$^2$). The decline in biomass, while significant, has not yet impacted EWM to the point where it is noticeable to homeowners (EPA 1997). Some researchers suspect that a substantial time lag (10 or more years) is required between weevil establishment and observed declines of EWM (pers. comm., Mariana Tamayo, University of Washington, February 26 1998, Sheldon 1997b). Augmentations in Massachusetts resulted in EWM damage, reduced or eliminated flowering, and some loss of buoyancy (as has been noted during various EWM "crashes" or steep declines) (Sheldon 1997b, EPA 1997). The reduction in flowering was discounted as an impact to EWM, because sexual reproduction is considered to be a minor component of the EWM lifecycle. However, recent work suggests that seed production (via sexual reproduction) may be an important part of the survival strategy of EWM (Standifer and Madsen 1997) (see section 5.3, Water Level Drawdown). Existing-conditions data are not available for either of the Massachusetts lakes, and researchers declined to perform biomass sampling because it impacts weevil populations (Sheldon 1997b). Therefore, the promising results from these lakes must be viewed with caution.

Use of the milfoil weevil as a biological control agent may preclude other management techniques. Sheldon and O'Bryan (1996) found that aquatic plant harvest in Lake Bomoseen significantly reduced milfoil weevil densities in harvested areas as compared to controls. Managers on Lake Bomoseen have since established "no harvest" areas in an attempt to maintain weevil populations. It is reasonable to suggest that rotovation, the predominant aquatic plant management tool in BCR, would also depress weevil densities (pers. comm., Mariana Tamayo, University of Washington, February 26 1998). Adult milfoil weevils overwinter in mud onshore

(Sheldon and O'Bryan 1996), and shoreline disturbance may be a factor impacting weevil populations as well (Tamayo and Grue 1996).

### 6.2.2 Ecological Considerations for Milfoil Weevils

Concerns regarding the establishment of a non-native species, often an aspect of biological control decisions, are not relevant to the milfoil weevil. It is a native herbivore, originally specific to northern water milfoil (*Myriophyllum sibiricum*) (Sloarz 1996). It appears to have expanded its host range to include EWM, and may be undergoing a complete host shift: milfoil weevils raised on EWM prefer EWM over northern water milfoil (Creed and Sheldon 1992, Solarz 1996). Newman et al. (1997) presented data that suggest weevils raised on EWM exhibit higher fitness than those raised on northern water milfoil, possibly accounting for the host expansion or shift.

Existing research indicates that milfoil weevils are milfoil specialists, and do not feed on or impact other aquatic plants at any point in their life cycle. Sheldon and Creed (1995) conducted weevil feeding trials on EWM and nine other aquatic macrophytes native to Vermont (including species from genera native to Washington as well). They found no evidence of feeding or damage to any native plant besides northern milfoil. Sheldon (1997b) found that native plants expanded into weevil-impacted milfoil beds, and have become dominant in many areas. Relatively little is known about the population dynamics of weevil populations.

### 6.2.3 Case Study of Milfoil Weevils

Most case studies on the milfoil weevil document milfoil declines and their association with weevil populations, rather than biological control efforts per se. The use of the milfoil weevil as a biological control agent through the use of augmentation trials is best documented for Lake Bomoseen, Vermont (see section 6.2.1). Researchers conducting augmentation work in Wisconsin do not expect results until 1999 (Jester et al. 1997).

### 6.2.4 Other Insects

Although most research has focused on the milfoil weevil (*Euhrychiopsis lecontei*), other native weevils are associated with EWM. Of these, *Phytobius leucogaster* (no common name) was found to adversely affect EWM. *Phytobius* adults and larvae feed on EWM, but most impact is concentrated on the inflorescences (Sheldon 1997a). Since sexual reproduction is often considered a minor component of EWM reproductive activity, *Phytobius* is not thought to be a candidate for biological control (Buckingham et al. 1981). However, recent work suggests that seed production (via sexual reproduction) may be an important part of the survival strategy of EWM (Standifer and Madsen 1997) (see section 5.3, Water Level Drawdown). As a result, the potential of *Phytobius* as a biological control agent may be re-evaluated in the future.

Creed and Sheldon (1994b) evaluated larvae of the moth *Acentria ephemerella* (no common name) alongside the milfoil weevil in efforts to establish the cause of EWM decline in Brownington Pond, Vermont. *A. ephemerella* consistently impacted the growth of EWM in laboratory studies, but was not associated with large-scale impacts in the field. *A. ephemerella* larvae did not affect EWM stem buoyancy, but did feed on stems in such a way as to suggest an increased risk of stem fragmentation (and thus EWM dispersal). Herbivory by *A. ephemerella* is believed to have caused rapid EWM declines in the Kawartha Lakes, Ontario (Painter and McCabe 1988). However, Buckingham and Ross (1981) found poor host specificity in *A. ephemerella*, diminishing its potential as a biological control agent for EWM. In addition, developing *A. ephemerella* larvae require water temperatures below 71.6° F, temperatures not always available in BCR (Buckingham and Ross 1981).

Surveys in British Columbia in the 1970s and 1980s suggested significant EWM Herbivory by a previously undescribed midge, *Cricotopus myriophylli*. Kangasniemi et al. (1992) found the midge caused "considerable grazing pressure" on EWM in a series of Okanagan Valley lakes. High densities of the milfoil midge prevented EWM from surfacing and flowing by damaging the EWM meristem and reducing total plant height. They estimated that midge densities of 500 larvae per square meter would prevent surfacing. *Cricotopus myriophylli* may also impact EWM vegetative reproduction: MacRae et al. (1990) found that EWM fragments with midge damage were for the most part not viable. Damage-inducing herbivory by the milfoil midge was only found on EWM and northern milfoil. Midge larvae preferentially fed on EWM over northern milfoil (MacRae et al. 1990). Although the milfoil midge is a promising candidate for biological control, all efforts to raise it in the lab have been unsuccessful (Kangasniemi et al. 1992, pers. comm., Mariana Tamayo, University of Washington, February 26 1998). As a result, its ultimate potential as a biological control agent is in question.

Two moth species in the genus *Parapoynx, P. stratiotata* and *P. badiusalis* (no common names), have been suggested as potential biological control agents for EWM, although research on both is limited. Habeck (1983) evaluated *P. stratiotata* both in the lab and the field, and found it to be a generalist feeder. Hosts in its native European range included coontail, pondweeds, and Canadian elodea (all genera native to Washington), in addition to EWM and other milfoils. *Parapoynx badiusalis* appears to be a generalist feeder as well (Sheldon 1997a), rendering both less than desirable as biological control agents.

## 6.3 COMPETITIVE PLANTINGS

The use of competitive species plantings for biological control of aquatic plants involves the introduction of a more desirable plant species to compete with the target species for one or more growth factors. The same technique has been investigated with plants that biochemically inhibit some aspect of the life cycle of another plant, a process known as allelopathy. Because the mechanisms of competition sometimes include allelopathy (Frank and Dechoretz 1980), and because the two methods strive for the same effects, they are reviewed together under the same label - competitive plantings.

Competitive plantings are extremely labor-intensive, and can require detailed maintenance during plant establishment (pers comm., Maribeth Gibbons, WATER Environmental Services, March 2, 1998). In addition, they are only suited to areas that will support the control agent. For instance, various species of spikerush have been investigated for the potential to control aquatic weeds. Spikerush is a genus of emergent plants not well suited for deep-water plantings (pers comm., Maribeth Gibbons, WATER Environmental Services, March 2, 1998). Because of these limitations, any effective competitive planting technique would be best used for small scale control efforts in specific areas of interest. Therefore any effective method of competitive plantings would likely be well suited for homeowner-initiated efforts.

### 6.3.1 Effectiveness of Competitive Plantings

The most investigated plant for competitive control of aquatic plants is dwarf spikerush (*Eleocharis coloradoensis*) (Charudattan 1990). Yeo and Thurston (1984) documented a hierarchy of competitive interactions with dwarf spikerush. They found EWM to be only mildly susceptible, behind such species as Canadian waterweed (*Elodea canadensis*) and fennel-leaved pondweed (*Potamageton pectinatus*). Frank and Dechoretz (1980) suggest that part of these interactions involve allelopathic activity by the dwarf spikerush. Although it may be useful for the control of other aquatic species (Yeo 1980), effective control of EWM by competitive plantings of dwarf spikerush has not been clearly demonstrated.

Jones (1994) investigated the ability of eight aquatic plant extracts to inhibit the growth of Hydrilla and EWM. He found that the extracts of both coontail (*Ceratophyllum demersum*) and tapegrass (*Vallisneria americana*) showed allelopathic attributes toward EWM in test tube assays. Results from tank studies were mixed, with some treatments of these species actually increasing EWM biomass relative to controls. EWM itself has been investigated for the presence of allelopathic agents: El-Ghazal and Riemer (1986) found that EWM and other aquatics suppressed germination of wheat and other terrestrial plants.

Two species not currently present in BCR, tapegrass (*Vallisneria americana*) and American lotus (*Nelumbo lutea*) were investigated as possible EWM control agents in field studies in the Tennessee Valley (Smart 1992, Doyle and Smart 1995). Small plots were cleared of EWM with an herbicide, planted with natives, and observed for three years. Although the original experiments were partially disrupted by herbivores, results were encouraging: established populations of both plants resisted invasion by EWM. American lotus apparently establishes a canopy that shades out EWM. Allelopathy may be the mechanism behind the competitive abilities of tapegrass (Jones 1994). However, many invasions of EWM have successfully displaced tapegrass in natural settings (Siver et al. 1986). Although possibly effective, the use of either of these plants for even small scale control of EWM would be inappropriate in BCR because they are non-native and possibly invasive (see below).

### 6.3.2 Ecological Considerations for Competitive Plantings

Competitive planting trials with dwarf spikerush are unlikely to have profound ecological impacts unless attempted on an inappropriately large scale. Dwarf spikerush is a native species that is widely distributed and not known to be a noxious weed. Coontail, which showed some allelopathic characteristics in laboratory studies, is already widespread in BCR. Any introduction to BCR of tapegrass (*Vallisneria americana*) or American lotus (*Nelumbo lutea*) has the strong potential for considerable ecological impacts, as neither are part of the native flora. American lotus, in particular, may be an invasive species: Doyle and Smart (1995) characterize it as “an aggressive growing plant. . .not desirable in high-use areas.”

### 6.3.3 Case Study of Competitive Plantings

In 1986, a field trial testing the use of competitive planting of spikerush (*Eleocharis*)to control EWM was initiated in the Pend Oreille river, Washington. Two beach sites near the town of Ione were cleared of EWM and hand-planted with plugs or strips of dwarf spikerush sod. The sites were monitored for one year. The study must be considered incomplete, as EWM removal was inadequate, one study area was largely washed away by a storm event, and no control site was established. However, the remaining control site showed some regrowth of spikerush the following year (pers. comm., Maribeth Gibbons, WATER Environmental Services, March 2, 1998). It is unclear if EWM control resulted from the spikerush or the previous year's rototilling treatment. Funding for this project was cut, and monitoring did not continue past 1987. The site has since been invaded by EWM (pers. comm., Maribeth Gibbons, WATER Environmental Services, March 2, 1998). This field trial did not convincingly demonstrate EWM control through the use of competitive plantings of dwarf spikerush.

## 6.4 PLANT PATHOGENS

The hypothesis that fungal, viral, or bacterial pathogens resulted in major EWM declines in Chesapeake Bay in the late 1960s resulted in considerable interest in the development of any such pathogens for use as biological control agents (Sheldon 1997a). Although the agents (biological or otherwise) responsible for the decline have never been identified, researchers continue to search for and evaluate potential candidates, both native and exotic (Sheldon 1997a, Bennett 1994). Over 15 plant pathogens have been evaluated for the control of EWM (Charudattan 1990, Sheldon 1997a). Of these, a native fungus, *Mycoleptodiscus terrestris* (no common name), has shown the most potential. *M. terrestris* was associated with rapid declines of EWM in Kentucky, and Michigan, and suggested as a cause of otherwise unexplained declines in Wisconsin (Shearer 1994b). *M. terrestris* significantly reduced EWM biomass in experimental pools; field tests in a small pond resulted in significant declines in EWM root, stem, and leaf biomass (Shearer 1994a). However, later field trials by other researchers produced no effects, possibly due to unfavorable temperatures or pathogen formulation (Shearer 1994a). No plant pathogens are currently in use or available for the control of EWM (or other aquatic weeds) (Sheldon 1997a).

## 7.0 PREVENTIVE CONTROL

EWM has yet to be eradicated from any large waterbody to which it has been introduced As a result, preventing the spread of EWM into uninfested waterbodies or areas is of obvious importance. Although by definition, prevention applies to waters not currently infested, thus limiting its applicability to BCR, effective prevention would limit impacts from BCR to other waters. Known vectors of new infestation include recreational boaters, migrating waterfowl, and the downstream or within-lake movement of EWM fragments (Cooke et al. 1993). Of these, boaters visiting multiple waterbodies in a single day are believed to be the primary source of new infestations in EWM-free waters. Most new infestations are found at boat ramps, and infestations tracked on a regional scale tend to follow major road corridors (pers. comm., Kathy Hamel, WDOE, March 3 1998). Only limited efforts have been made to slow or control the movement of EWM fragments within a water body (i.e. downstream) once a large infestation has become established. Quantitative studies on the distribution and efficacy of preventive programs of any sort are extremely limited in the literature, but suggest a benefit from education programs. The experience of some land managers suggests that these benefits are most effective in conjunction with an intensive survey and control effort in areas with small infestations of EWM.

## 7.1 CONTROL OF FRAGMENT SPREAD WITH WATER BARRIERS

In the late 1970's, agencies in British Columbia documented a substantial effort to prevent or minimize the downstream spread of EWM in the Okanagan River, still the only well-documented program of its kind. They placed and maintained wire mesh screen barriers throughout the Okanagan system and Osoyoos Lake from 1976 to 1979. Approximately 40 tons of fragments were retained in a single year (1978); four tons were estimated to have been missed (British Columbia Ministry of the Environment, 1981). New downstream infestations of EWM were documented during this time (Cooke et al. 1993), although the method may have slowed the process. Because of the high cost and limited demonstrable efficacy, large scale EWM fragment control as a preventative measure is now recommended only in particular circumstances, for instance in low flow situations or where upstream infestations are not extreme (Cooke et al. 1993). As a result, it is unlikely to be an appropriate or effective choice for BCR on either the small or large scale.

## 7.2 CONTROL OF FRAGMENT SPREAD WITH BOATER EDUCATION

Because recreational boaters are known to be an important vector of EWM transport to previously uninfested waters, many jurisdictions in the United States and Canada have implemented boater education efforts of varying degrees of intensity. Common education programs include signage at boat launches and the distribution of pamphlets at recreational or commercial facilities, or with boat licenses. More intensive programs have included voluntary boater "quarantine", road checkpoints, and civil penalties for the transport of exotic species (Gunderson 1995, Newroth 1994, pers. comm., Kathy Hamel, WDOE, February 20, 1998, pers. comm., Rob Salter, Chelan County Public Utility District, March 3, 1998). The effectiveness of boater education programs is reviewed below; it is assumed that they have no adverse environmental impacts that need be considered.

### 7.2.1 Effectiveness of Boater Education

Very little documentation of the methods used for boater education programs or their degrees of efficacy exists in the literature, but the studies that do exist show some benefit to boater education programs in the form of risk reduction. Gunderson (1995) surveyed boater opinions and practices in Minnesota, Wisconsin, and Ohio, and found that intensive efforts in Minnesota had effectively changed boater behavior, limiting the risk of spread of a number of exotic species including EWM. 70% of Minnesota boaters surveyed "took precautions" to avoid spreading exotic species, including EWM, while under 40% of Wisconsin and Ohio boaters did so. Minnesota's program included roadside checks and civil penalties along with more traditional means of education: signage, pamphlets, and various conferences and media outlets. Efforts in Wisconsin and Ohio were more limited, suggesting that increasing education efforts can result in increased benefit in the form of reduced risk. Even Minnesota's education program did not receive full compliance. It is reasonable to suggest that exotic species were transported, and that this program would be ineffective over time if not used in conjunction with other control efforts.

Although some education programs have raised awareness (see below) or changed boater behavior, none have been able to entirely stop the transport of EWM fragments. At least some programs have been successful in combining education with intensive surveying and aggressive control when small infestations are found. Few plant fragments are required to infest an area and EWM spreads quickly. The literature supports a conclusion that the effectiveness of boater education at milfoil containment is dependent upon complimentary direct control efforts. In addition, education appears best suited to prevent the infestation or reinfestation or relatively small waterbodies (i.e., lakes) rather than large systems with multiple access points (Cooke et al. 1993). As a result, boater education is unlikely to provide effective control of EWM in BCR, although it could be appropriate to reduce the risk of spread of EWM from BCR into other waters if combined with intensive survey and control efforts.

### 7.2.2 Case Studies of Boater Education

In 1977, agencies in British Columbia established an intensive boater education campaign in an attempt to prevent the spread of EWM to uninfested lakes. The program included signage, pamphlets, media outlets, and a multi-year voluntary "quarantine" where boaters stopped and their trailers were checked for EWM fragments. Compliance and boater awareness were found to be high (Dove and Taylor 1982). This education effort was used in conjunction with intensive diver-based surveys and control in specific lakes. The program failed to halt the spread of EWM, which infested Shuswap lake, a focal point of the quarantine. EWM has since spread in the Shuswap system to the point where large-scale mechanical control options have been initiated (Newroth 1994). Many other lakes remained free of EWM, which may be attributable to the intensive education and quarantine effort. Nevertheless, the program was shut down due to its cost (over $400,000 over three years) and failure to protect the Shuswap system (Cooke et al. 1993).

The WDOE began boater education efforts in the early 1970's that continue to the present day, consisting primarily of signage, pamphlets (distributed with boat licenses), and coordination with local groups. Although the spread of EWM has not been prevented, anecdotal evidence suggests that boater awareness is high. The WDOE is concerned that even aware boaters may transport fragments by means of personal watercraft (jet-skis), which may be impossible to clean effectively for single-day use (pers. comm., Kathy Hamel, WDOE, February 20, 1998).

An intensive prevention effort with an education component is in place for Long Lake in Thurston County, Washington. This program is funded by landowner taxes from a Lake Management District, and appears successful. EWM in the lake was originally controlled with a whole-lake herbicide application. The lake remains largely free of EWM. Boater education at boat ramps is used in conjunction with extensive surveys and hand-picking by divers to eradicate infestations before they spread (see section 5.5, Manual Control). Boaters are approached by volunteers (local homeowners) during high use weekends and their trailers examined for plant fragments; signs and pamphlets also warn boaters not to spread EWM. Long Lake is also the only waterbody in Washington to have installed a boat wash, consisting of a hose from a domestic water supply. No attempt was made to quantify its effects, and the wash station was discontinued a number of years ago. Despite this boater education component, intensive surveys and diver control appear to be the most essential part of the prevention program at Long Lake (pers. comm., Mark Swarthout, Thurston County Lake Management, March 4, 1998).

## 8.0 INTEGRATION OF MULTIPLE CONTROL TECHNIQUES

The integration of multiple control techniques is not well documented in the literature. Most control programs exist as a collection of various treatments rather than an integrated whole. As a result, many efforts involving multiple control methods are characterized by confounded effects, making inference about the results difficult. In addition, many involve the use of chemical control methods, which are beyond the scope of this review. Nevertheless, evidence suggests that the integration of multiple control methods can result in more effective and lasting control of EWM. Certain applications are aided when done in conjunction; drawdowns can be an opportunity to install or maintain sediment covers (Cooke and Gorman 1980, Cooke et al. 1993).

The scheduling of integrated control methods is important for maximizing synergistic effects. Biological control techniques which reduce EWM flowering and seed production in the growing season prior to a winter drawdown may result in the latter being more effective (see section 5.3, Water Level Drawdown). Shearer (1993) suggested integrating mechanical and biological control by mechanically stressing EWM to increase the effectiveness of pathogenic control. Integrated biological controls have been shown to be effective in other aquatic plants: the combination of waterhyacinth weevils and plant pathogens shows promise for the control of waterhyacinth (Charudattan 1990). Creed and Sheldon (1992) suggest that the milfoil weevil may stress EWM, rendering it more susceptible to pathogens, other herbivory, or overwinter mortality. None of these integrated treatments have been tested through an experimental design which allows evaluation of the effectiveness of their integration.

## 9.0 USES OF AQUATIC PLANT BIOMASS

Both harvesting and rotovating result in the manipulation and collection of large quantities of aquatic plant biomass. Because the collected plants are unsightly, can smell bad, and may consist of still-viable plant fragments, their disposal is often an issue. Aquatic plant biomass has been evaluated as poultry feed (Joyce 1990), pulp for paper production (Widyanto et al. 1983, Joedodibroto et al. 1983), and has been composted for reuse in gardens and parks, saving disposal costs (Wile et al. 1978, Joyce 1990). The composting of EWM biomass collected during mechanical harvest is the best-documented and most successful of these options (Joyce 1990, Cooke et al. 1993). The City of Seattle, for instance, harvested and composted 254.4 cubic yards of aquatic plant biomass in 1990 (an unusually low volume). An estimate of the saved transportation and disposal costs during 1990 is not available.

## 10.0 BIBLIOGRAPHY

Aiken, S.G., P.R. Newroth, and I. Wile. 1979. The Biology of Canadian Weeds. 34. *Myriophyllum spicatum* L. Canadian Journal of Plant Science. 59: 201-215.

Aisette, R.R. 1983. Milfoil Control Method Evaluation. Municipality of Metropolitan Seattle Water Quality Planning Division, Seattle, Washington.

Armour, G.D., D.W. Brown, and K.T. Marsden. 1979. An Evaluation of Bottom Barriers for Control of Eurasian watermilfoil in British Columbia. Studies on Aquatic Macrophytes, Part XV. British Columbia Ministry of the Environment, Victoria, British Columbia.

Aquatic Research Incorporated. 1986. Field Test of Mechanical Harvesting of Aquatic Macrophytes. Final Report prepared for the Municipality of Metropolitan Seattle, Water Quality Planning Division, Seattle, Washington.

Bain, M.B. 1996. Rivers and Impounded Waterways. *In*: J.R. Cassani (ed.), pp.61-77. Managing Aquatic Vegetation With Grass Carp: A Guide for Water Resource Managers. American Fisheries Society Introduced Fish Section, Bethesda, Maryland.

Barko, J.W., M.S. Adams, and N.L. Clesceri. 1986. Environmental Factors and Their Consideration in Management of Submersed Aquatic Vegetation: a Review. Journal of Aquatic Plant Management. 24: 1-10.

Barko, J.W. Ecology of Submersed Aquatic Macrophytes (Overview 1992): Advances, Management Implications, and Related Needs, pp. 197-200. *In*: Proceedings of the 27th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Barrett, S.C.H., C.G. Eckert, and B.C. Husband. 1993. Evolutionary Processes in Aquatic Plant Populations. Aquatic Botany. 44: 105-145.

Bates, A.L., E.R. Burns, and D.H. Webb. 1985. Eurasian watermilfoil (*Myriophyllum spicatum* L.) in the Tennessee Valley: an Update on Biology and Control. Tennessee Valley Authority, Muscle Shoals, Alabama.

Beard, T.D. 1973. Overwinter Drawdown: Impact on the Aquatic Vegetation in Murphy Flowage, Wisconsin. Technical Bulletin 61. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Bennett, C.A. 1994. Overseas and Quarantine Research on Biological Control of Aquatic Plants. Lake and Reservoir Management. 9: 56.

Bennet, D.H., M.C. Falter, K. Reese, W. McLaughlin, W.D. Sawle, M. Liter, J.W. Carlson, J. Hall, and N. Sanyal. 1990. Fish, Wildlife, and Recreational Characteristics of Box Canyon Reservoir. 1989 Annual Report. College of Forestry, wildlife, and Range Sciences. Univ. Of Idaho. Moscow, ID.

Bevington, J. 1986. Evaluation of an Alternative Type Aquatic Plant Harvester: One Year Later. Municipality of Metropolitan Seattle Water Quality Division, Seattle, Washington.

Bolduan, B.R., G.C. VanEckhout, H.W. Quade, and J.E. Gannon. 1994. *Potamogeton crispus* - The Other Invader. Lake and Reservoir Management. 10: 113-125.

Boylen, C.W., L.E. Eichler, and J.W. Sutherland. 1996. Physical Control of Eurasian watermilfoil in an Oligotrophic Lake. Hydrobiologia. 340: 213-218.

British Columbia Ministry of the Environment. 1981. A Summary of Biological Research on Eurasian watermilfoil in British Columbia. Aquatic Plant Management Program Information Bulletin Volume XI.

British Columbia Ministry of the Environment Water Management Branch, Victoria, British Columbia.

British Columbia Ministry of the Environment. 1986. Review of Aquatic Plant Management Methods and Programs in British Columbia. Aquatic Plant Management Program Information

Bulletin Volume XII. British Columbia Ministry of the Environment Water Management Branch, Victoria, British Columbia.

Bryan, A.D. (ed.). 1975. Experimental Hydraulic Dredging for Aquatic Weed Control in Vernon Arm, Okanagan Lake. Studies on Aquatic Macrophytes Part VIII. British Columbia Ministry of the Environment, Victoria, British Columbia.

Bryan, A.D., and G.D. Armour. 1982. Rotovating and Jetting for Aquatic Weed Control in Okanagan and Kalamalka Lakes. Studies on Aquatic Macrophytes Part XI. British Columbia Ministry of the Environment, Victoria, British Columbia.

Buckingham, G.R., and B.M. Ross. 1981. Notes on the Biology and Host Specificity of *Acentria nivea* (*=Acentropus nivens*). Journal of Aquatic Plant Management. 19: 32-36.

Buckingham, G.R., C.A. Bennet, and B.M. Ross. 1981. Investigation of Two Insect Species for Control of Eurasian watermilfoil. Technical Report A-81-4. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Carpenter, S.R., and M.S. Adams. 1977. Environmental Impacts of Mechanical harvesting on Submersed Vascular Plants. Report 77. Institute of Environmental Studies, University of Wisconsin, Madison, Wisconsin. Cited in Cooke et al. (1993).

Carpenter, S.R., and M.S. Adams. 1978. Macrophyte Control by Harvesting and Herbicides: Implications or Phosphorus Cycling in Lake Wingra, Wisconsin. Journal of Aquatic Plant Management. 16: 20-23.

Catarino, L.F., M.T. Ferreira, and I.S. Moreira. 1997. Preferences of Grass Carp for Macrophytes in Iberian Drainage Channels. Journal of Aquatic Plant Management. 36: 79-83.

Chambers, P.A., J.W. Barko, and C.S. Smith. 1994. Workshop Synthesis. Lake and Reservoir Management. 10: 57-59.

Charudattan, R. 1990. Biological Control of Aquatic Weeds by Means of Fungi. *In*: A.H. Pieterse and K.J. Murphy (eds), pp. 186-201. Aquatic Weeds: the Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, Oxford, England.

Clapp, D.F., R.S. Hestand, III, and B.Z. Thompson. 1994. Hauling and Post-stocking Mortality of Triploid Grass Carp. Journal of Aquatic Plant Management. 32: 41-43.

Coble, T.A. and B.D. Vance. 1987. Seed Germination in Myriophyllum spicatum L. Journal of Aquatic Plant Management. 25: 8-10.

Cooke, G.D. 1980a. Lake Level Drawdown as a Macrophyte Control Technique. Water Resources Bulletin. 16: 317-322.

Cooke, G.D. 1980b. Covering Bottom Sediments as a Lake Restoration Technique. Water Resources Bulletin. 16: 921-926.

Cooke, G.D., and M.E. Gorman. 1980. Effectiveness of Dupont Typar Sheeting in Controlling Macrophyte Regrowth After Overwinter Drawdown. Water Resources Bulletin. 16: 353-355.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers, Boca Raton, Florida.

Creed, R.P. and S.P. Sheldon. 1992. The Effect of the Weevil *Euhrychiopsis lecontei* on Eurasian watermilfoil: Results from Brownington Pond and Norton Brook Pond, pp 99-117. *In* Proceedings of the 27th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Creed, R.P. and S.P. Sheldon. 1994a. Potential for a Native Weevil to Serve as a Biological Control Agent for Eurasian watermilfoil. APCRP Technical Report A-94-7. Prepared for US Army Corps of Engineers, Washington D.C.

Creed, R.P. and S.P. Sheldon. 1994b. The Effect of Two Herbivorous Insect Larvae on Eurasian watermilfoil. Journal of Aquatic Plant Management. 32:21-26.

Creed, R.P. 1998 . A Biogeographic Perspective on Eurasian watermilfoil Declines: Additional Evidence for the Role of Herbivorous Weevils in Promoting Declines? Journal of Aquatic Plant Management (in press).

Crowell, W., N. Troelstrup, Jr., L. Queen, and J. Perry. 1994. Effects of harvesting on Plant Communities Dominated by Eurasian watermilfoil in Lake Minnetonka, Minnesota. Journal of Aquatic Plant Management. 32: 56-60.

Dove, R., and B. Taylor. 1982. The 1981 Aquatic Plant Quarantine Project. Studies on Aquatic Macrophytes, Part XXXVI. British Columbia Ministry of the Environment, Victoria, British Columbia.

Dove, R., and M. Wallis. 1981. The 1980 Aquatic Plant Quarantine Project. Studies on Aquatic Macrophytes, Part XXXIV. British Columbia Ministry of the Environment, Victoria, British Columbia.

Doyle, R.D. and R.M. Smart. 1994. Competitive Interactions of Native Plants with Nuisance Species in Guntersville Reservoir, Alabama, pp. 237-242. *In:* Proceedings of the 29th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

El-Ghazal, R.A.K., and D.N. Riemer. 1986. Germination Suppression by Extracts of Aquatic Plants. Journal of Aquatic Plant Management. 24: 76-79.

Engel, S. 1984. Evaluating stationary Blankets and Removable Screens for Macrophyte Control in Lakes. Journal of Aquatic Plant Management. 22: 43-48.

Engel, S. and S.A. Nichols. 1984. Lake Sediment Alteration for Macrophyte Control. Journal of Aquatic Plant Management. 22: 38-41.

Engel, S. 1990. Ecological Impacts of Harvesting Macrophytes in Halverson Lake, Wisconsin. Journal of Aquatic Plant Management. 28: 41-45.

Environmental Protection Agency (EPA). 1993. Clark Fork - Pend Oreille basin water quality study: a summary of findings and a management plan. EPA 910/R-93-006. Region 10. Seattle, Washington.

EPA (US Environmental Protection Agency). 1997. Use of Aquatic Weevils to Control a Nuisance Weed in Lake Bomoseen, Vermont. Clean Lakes Case Study EPA 81-F-97-002. US Environmental Protection Agency Office of Water, Washington, D.C.

Falter, C.M., C. Baines, J.W. Carison. 1991. Water Quality, Fish and Wildlife Characteristics of Box Canyon Reservoir, WA: Section 2 Water Quality. University of Idaho. Moscow, Idaho.

Falter, C.M. and B.W. Riggers. 1993. Aquatic Community Responses to Aquatic Macrophyte Habitat Alterations in Box Canyon Reservoir, Washington. Final Report submitted to Pend Oreille County PUD No. 1. Newport, Washington.

Frank, P.A., and N. Dechoretz. 1980. Allelopathy in Dwarf Spikerush (*Elocharis coloradoensis*). Weed Science. 28: 499-505.

Fowler, M.C. and T.O. Robeson. 1978. The Effects of Food Preferences and Stocking Rates of Grass Carp (*Ctenopharyngodon idella* Val.) on Mixed Plant Communities. Aquatic Botany. 5: 261-276.

Gangstad, E.O. 1982. Weed Control Methods for Recreation Facilities Management. CRC Press, Boca Raton, Florida.

Geiger, N.S. 1983. Winter Drawdown for the Control of Eurasian watermilfoil in an Oregon Oxbow Lake (Blue Lake, Multnomah County), pp. 193-197. *In*: Lake Restoration, Protection, and Management. Proceedings of the Second Annual Conference of the North American Lake Management Society. US Environmental Protection Agency Office of Water Regulation and Standards, Washington, D.C.

Gibbons, H.L., Jr., W.H. Funk, M. Durango-Boehme, and J.E. Eisenbeis. 1983. Investigation and Control of *Myriophyllum spicatum* in the Pend Oreille River, Washington. Report 47, State of Washington Water Research Center. Washington State University. Pullman, Washington.

Gibbons, H.L., Jr., M. Durango-Boehme, F.A. Verhalen, T.C. McKarns, J.P. Nyznyk, T.J. Belnick, W.H. Funk, E.E. Syms, A. Frankenfield, B.C. Moore, and M.V. Gibbons. 1983. Refinement of Control and Management Methodology for Eurasian watermilfoil in the Pend

Oreille River, Washington. Report 56, State of Washington Water Research Center. Washington State University. Pullman, Washington.

Gibbons, H.L., Jr., W.H. Funk, S.K. Julin, F.A. Verhalen, T.C. McKarns, J.P. Nyznyk, S.E. Ratcliffe, E.E. Syms, and S.T.J. Juul. 1984. Control of Eurasian watermilfoil. Project Completion Report for Grant GS4-023. State of Washington Water Research Center, Washington State University. Pullman, Washington.

Gibbons, M.V. 1986. A Literature Review on the Effectiveness of Mechanical Harvesting and Three Herbicides, and Status of Other Control Methods. Prepared by WATER Environmental Services for the Municipality of Metropolitan Seattle, Seattle, Washington.

Gibbons, M.V. and H.L. Gibbons, Jr. 1987. Pend Oreille River Eurasian watermilfoil Control Program, 1986. Prepared for Pend Oreille County by WATER Environmental Services, Inc., Bainbridge Island, Washington.

Gibbons, M.V., H.L. Gibbons, Jr., and R.E. Pine. 1987. An Evaluation of a Floating Mechanical Rototiller for Eurasian watermilfoil Control. Technical Report Prepared for the Washington Department of Ecology Water Quality Program, Olympia, Washington.

Gibbons, M.V., and H.L. Gibbons, Jr. 1988. Efficacy of Rotovation in Controlling Eurasian watermilfoil in the Pend Oreille River, Washington. Lake and Reservoir Management. 4: 153-160.

Glodsby, T.L., A.L. Bates, and R.A. Stanley. 1978. Effect of Water Level Fluctuation and Herbicide on Eurasian watermilfoil in Melton Hill Reservoir. Journal of Aquatic Plant Management. 16: 34-38.

Grace, J.B., and R.G. Wetzel. 1978. The Production Biology of Eurasian watermilfoil (*Myriophyllum spicatum* L.): a Review. Journal of Aquatic Plant Management. 16: 1-11.

Gunderson, J. 1995. Three-State Exotic Species Boater Survey: What Do Boaters Know and Do They Care? Aquatic Nuisance Species Digest 1: 8-10.

Habeck, D.H. 1983. The Potential of *Parapoynx stratiotata* L. as a Biological Control Agent for Eurasian watermilfoil. Journal of Aquatic Plant Management. 21: 26-29.

Hartleb, C.F., J.D. Madsen, and C.W. Boylen. 1993. Environmental Factors Affecting Seed Germination in *Myriophyllum spicatum* L. Aquatic Botany. 45: 15-25.

Hesser, E., and E.O. Gangstad. 1978. Nuisance Aquatic Plant Growth. Journal of Aquatic Plant Management. 16: 11-13.

Hill, B.H. 1979. Uptake and Release of Nutrients by Aquatic Macrophytes. Aquatic Botany. 7: 87-93.

Joedodibroto, R., L.S. Widyanto, and M. Soerjani. 1983. Potential Uses of Some Aquatic Weeds as Paper Pulp. Journal of Aquatic Plant Management. 21: 29-32.

Jones, H.L. 1993. The Allelopathic Ability of Three Species of Aquatic Plants to Inhibit the Growth of *Myriophyllum spicatum,* pp. 124--127. *In:* Proceedings of the 27th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Jones, H.L. 1994. Allelopathic Ability of Various Aquatic Plants to Inhibit the Growth of *Hydrilla verticaillata* L.f. Royle and *Myriophyllum spicatum* L., pp. 214--221. *In:* Proceedings of the 28th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Joyce, J.C. 1990. Practical Uses of Aquatic Weeds, pp. 274-291. *In*: Pieterse, A.H., and K.J. Murphy (eds.) Aquatic Weeds: The Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, Oxford, England.

Kangasniemi, B. 1983. Observations on Herbivorous Insects That Feed on *Myriophyllum spicatum* in British Columbia, pp. 214-218. *In*: Lake Restoration, Protection, and Management. Proceedings of the Second Annual Conference of the North American Lake Management Society. US Environmental Protection Agency Office of Water Regulation and Standards, Washington, D.C.

Kahl, R. 1993. Aquatic Macrophyte Ecology in the Upper Winnebago Pool Lakes, Wisconsin. Technical Bulletin 182. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Kangasniemi, B., H. Speer, and P. Newroth. 1993. Review of Eurasian watermilfoil Biocontrol by the Milfoil Midge, pp 17-22. *In*: Proceedings of the 27th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Kimbel, J.C., and S.R. Carpenter. 1981. Effects of Mechanical Harvesting on Myriophyllum spicatum L. Regrowth and Carbohydrate Allocation to Roots and Shoots. Aquatic Botany. 11: 121-127.

Lewis, D.H., I. Wile, and D.S. Painter. 1983. Evaluation of Terra track and Aquascreen for Control of Macrophytes. Journal of Aquatic Plant Management. 21: 103-104.

McKnight, S.K. 1995. Potential Effect of Grass Carp Herbivory on Waterfowl Foods. Journal of Wildlife Management. 59: 720-727.

MacRae, I.V., N.N. Winchester, and R.A. Ring. 1990. Feeding Activity and Host Preference of the Milfoil Midge, *Cricotopus myriophylli* Oliver (Diptera: Chironomidae). Journal of Aquatic Plant Management. 28: 89-92.

Madsen, J.D., L.W. Eichler, and C.W. Boylen. 1988. Vegetative Spread of Eurasian watermilfoil in Lake George, New York. Journal of Aquatic Plant Management. 26: 47-50.

Madsen, J.D., and C.W. Boylen. 1989. Eurasian watermilfoil Seed Ecology From and Oligotrophic and Eutrophic Lake. Journal of Aquatic Plant Management. 27: 119-121.

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, L.W. Eichler, and C.W. Boylen. 1991. The Decline of Native Vegetation Under Dense Eurasian watermilfoil Canopies. Journal of Aquatic Plant Management 29: 94-99.

Madsen, J.D., and D.H. Smith. 1997. Vegetative Spread of Eurasian watermilfoil Colonies. Journal of Aquatic Plant Management 35: 63-68.

Maxnuk, M.D. 1979. Evaluation of Rotovating and Diver Dredging for Aquatic Weed Control in the Okanagan Valley. Studies on Aquatic Macrophytes, Part XXII. British Columbia Ministry of the Environment Water Investigations Branch, Victoria, British Columbia.

Mesner, N., T. Sample, and J. Davis. 1985. Evaluation of an Alternative Type Plant Harvester. Municipality of Metropolitan Seattle Water Quality Division, Seattle, Washington.

Milkol, G.F. 1985. Effects of Harvesting on Aquatic Vegetation and Juvenile Fish Populations at Saratoga Lake, New York. Journal of Aquatic Plant Management. 23: 59-63.

Mississippi State Extension Service. 1997. Winter Drawdown: A Useful management Tool for Mississippi Farm Ponds. World Wide Web URL: http://www.ces.msstate.edu/pubs/is1501.htm. Version of July 7, 1997.

Municipality of Metropolitan Seattle. 1987. Union Bay Milfoil Fragment Cleanup. Municipality of Metropolitan Seattle Water Quality Division, Seattle, Washington.

Municipality of Metropolitan Seattle. 1990. Annual Milfoil Harvesting Report. Municipality of Metropolitan Seattle Water Pollution Control Department, Seattle, Washington.

Newman, R.M., K.L. Holmberg, D.D. Biesboer. 1996a. Can Eurasian watermilfoil Be Managed in Minnesota by Biological Control With Native or Naturalized Insects? Second Progress Report prepared for the Minnesota Department of Natural Resources, St. Paul, Minnesota. Cited in Tamayo and Grue (1996).

Newman, R.M., K.L. Holmberg, D.D. Biesboer, and B.G. Penner. 1996b. Effects of a Potential Biocontrol Agent, Euhrychiopsis lecontei, on Eurasian watermilfoil in Experimental Tanks. Aquatic Botany. 53: 131-
150.

Newroth, P.R. 1974. Aspects of Aquatic Weed Control by Mechanical Harvester. Studies on Aquatic Macrophytes Part V. British Columbia Ministry of the Environment Water Investigations Branch, Victoria, British Columbia.

Newroth, P.R. 1981. Case Studies of Aquatic Plant Management for Lake Preservation and Restoration in British Columbia, Canada, pp. 146-152. *In*: Restoration of Lakes and Inland Waters: International Symposium on Inland Waters and Lake Restoration. EPA 440/5-81-010. US Environmental Protection Agency, Washington, D.C.

Newroth, P.R. 1985. A Review of Eurasian watermilfoil Impacts and Management in British Columbia, pp. 139-153. *In*: Proceedings of the 1st International Symposium on Water milfoil (*Myriophyllum spicatum*) and Related Haloragaceae Species. Vancouver, British Columbia. Cited in Gibbons and Gibbons (1988).

Newroth, P.R, and R.J. Soar. 1986. Eurasian watermilfoil Management Using Newly Developed Technologies, pp. 252-257. *In*: Lake and Reservoir Management, Volume II. Proceedings of the Fifth Annual Conference and International Symposium on Applied Lake and Watershed Management. Lake Geneva, Wisconsin.

Newroth, P.R. 1994. Managing Eurasian watermilfoil in British Columbia. Lake and Reservoir Management. 9: 136-140.

Nichols, S.A., and B.H. Shaw. 1983. Physical, Chemical, and Biological Control of Aquatic Macrophytes, pp. 181-192. *In*: Lake Restoration, Protection, and Management. Proceedings of the Second Annual Conference of the North American Lake Management Society. US Environmental Protection Agency Office of Water Regulation and Standards, Washington, D.C.

Nichols, S.A., and R.C. Lathrop. 1994. Impact of Harvesting on Aquatic Plant Communities in Lake Wingra, Wisconsin. Journal of Aquatic Plant Management. 32: 33-36.

Nicholson, S.A. 1981. Effects of Uprooting in Eurasian watermilfoil. Journal of Aquatic Plant Management. 19: 57-59.

North American Lake Management Society. 1990. Lake and Reservoir Guidance Manual. EPA 440/4-90-006. Prepared for the US Environmental Protection Agency Office of Water Assessment and Watershed Protection Division, Washington, D.C.

Olem, H., and G. Flock (eds.). 1990. Lake and Reservoir Restoration Guidance Manual. 2nd Edition. EPA 440/4-90-006. Prepared by the North American Lake Management Society for the US Environmental Protection Agency, Washington, D.C.

Osborne, J.A. 1981. The Size of Grass Carp as a Factor in the Control of Hydrilla. Aquatic Botany. 11: 129-136.

Painter, D.S. 1988. Long-Term Effects of Mechanical Harvesting on Eurasian watermilfoil. Journal of Aquatic Plant Management. 26: 25-29.

Painter, D.S. and K.J. McCabe. 1988. Investigation Into the Disappearance of Eurasian watermilfoil From the Kawartha Lakes. Journal of Aquatic Plant Management. 26: 3-12.

Pelletier, G. And R. Coots. 1990. Progress Report No. 1 Pend Oreille River water quality study. Washington Dept. of Ecology. Olympia, Washington.

Perkins, M.A. 1980. Evaluations of Selected Non-Chemical Alternatives for Aquatic Plant Management. Prepared for the Municipality of Metropolitan Seattle by the University of Washington College of Engineering. University of Washington, Seattle, Washington.

Pieterse, A.H., and K.J. Murphy (eds). 1990. Aquatic Weeds: the Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, Oxford, England.

Pine, R.T., L.W.J. Anderson, and S.S.O. Hung. 1989. Effects of Static Versus Flowing Water on Aquatic Plant Preferences of Triploid Grass Carp. Transactions of the American Fisheries Society 118: 336-344.

Pine, R.T., L.W.J. Anderson, and S.S.O. Hung. 1990. Control of Aquatic Plants in Static and Flowing Water by Yearling Triploid Grass Carp. Journal of Aquatic Plant Management. 28: 36-40.

Pine, R.T. and L.W.J. Anderson. 1991. Plant Preferences of Triploid Grass Carp. Journal of Aquatic Plant Management. 29: 80-82.

Prodan, W.T. 1982. Milfoil Control in Seattle and the King County Region: Metro's Harvesting Program, pp. 198-199. *In*: Lake Restoration, Protection, and Management. Proceedings of the Second Annual Conference of the North American Lake Management Society. US Environmental Protection Agency Office of Water Regulation and Standards, Washington, D.C.

Scales, P., and A. Bryan. 1979. Transport of *Myriophyllum spicatum* Fragments by Boaters and Assessment of the 1978 Boat Quarantine Program. Studies on Aquatic Macrophytes, Part XXVII. British Columbia Ministry of the Environment, Victoria, British Columbia.

Shearer, J.F. 1993. Biocontrol of Hydrilla and Milfoil Using Plant Pathogens, pp. 79-84. *In*: Proceedings of the 27th Annual Meting, Aquatic Plant Control Research Program. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Shearer, J.F. 1993a. A Historical Perspective of Biocontrol of the Submersed Macrophytes *Myriophyllum spicatum* and *Hydrilla vertillata* Using Plant Pathogens, pp. 211-213. *In*: Proceedings of the 28th Annual Meting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Shearer, J.F. 1994b. Potential Role of Plant Pathogens in Declines of Submersed Macrophytes. Lake and Reservoir Management. 10: 9-12.

Sheldon, S.P. 1990. A Sudden Decline of a Eurasian watermilfoil Population in Brownington Pond, Vermont, pp. 302-303. *In:* Proceedings, 24th Annual Meeting, Aquatic Plant Control Research Program. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Sheldon, S.P., and R.P. Creed, Jr. 1993. The Effect of Feeding by a North American Weevil, *Euhrychiopsis lecontei*, on Eurasian watermilfoil (*Myriophyllum spicatum*). Aquatic Botany. 45: 245-256.

Sheldon, S.P., and R.P. Creed, Jr. 1995. Use of a Native Insect as a Biological Control for an Introduced Weed. Ecological Applications. 5: 1122-1132.

Sheldon, S.P. 1997a. Ecological Approaches for Biological Control of the Aquatic Weed Eurasian watermilfoil: Resource and Interference Competition, Exotic and Endemic Herbivores and Pathogens. *In*: D.A. Andow, D.W. Ragsdale, and R.F. Nyvall (eds.), pp. 53-71. Ecological Interactions and Biological Control. Westview Press, Boulder, Colorado.

Sheldon, S.P. 1997b. Investigations on the Potential Use of an Aquatic Weevil to Control Eurasian watermilfoil. Journal of Lake and Reservoir Management. 13: 79-88.

Siver, P.A., A.M. Coleman, G.A. Benson, and J.T. Simpson. 1986. The Effects of Winter Drawdown on Macrophytes in Candlewood Lake, Connecticut, pp. 69-73. *In* : Lake and Reservoir Management, Volume II. Proceedings of the Fifth Annual Conference and International Symposium and Applied Lake and Watershed Management. North American Lake Management Society, Lake Geneva, Wisconsin.

Smart, R.M. 1992. Aquatic Plant Competition Studies in Guntersville Reservoir, pp. 148-153. *In*: Proceedings, 26th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Smith, C.S., and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management. 28: 55-64.

Smith, C.S. 1993. Submersed Macrophyte Invasions and Declines, pp. 249-251. *In*: Proceedings of the 27th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Smith, C.S. 1994. Factors Contributing to the Decline of Eurasian watermilfoil in TVA Reservoirs, pp. 187-193. *In* Proceedings, 29th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Smith, G.E., T.F. Hall, Jr., and R.A. Stanley. 1967. Eurasian watermilfoil in the Tennessee Valley. Weeds. 15: 95-98.

Sorsa, K.K., E.V. Nordheim, and J.H. Andrews. 1988. Integrated Control of Eurasian watermilfoil, *Myriophyllum spicatum*, by a Fungal Pathogen and a Herbicide. Journal of Aquatic Plant Management. 26: 12-17.

Standifer, N.E., and J.D. Madsen. 1997. The Effect of Drying Period on the Germination of Eurasian watermilfoil Seeds. Journal of Aquatic Plant Management. 35: 35-36.

Stanley, R.A. 1976. Response of Eurasian watermilfoil to Subfreezing Temperatures. Journal of Aquatic Plant Management. 14: 36-39.

Sytsma, M.D. 1984. The Efficacy of Mechanical Harvesting in Controlling Nuisance Growth of *Myriophyllum spicatum* L. and Its Effect Upon Nonstructural Carbohydrate Allocation to Roots and Shoots. M.S. Thesis. University of Washington, Seattle, Washington.

Tamayo, M. and C.E. Grue. 1996. A Review of the Weevil *Euhrychiopsis lecontei* and other Insects as Potential Biological Control Agents for Eurasian watermilfoil (*Myriophyllum spicatum*). Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, Washington.

Tazik, P.P., W.R. Kodrich, and J.R. Moore. 1982. Effects of Overwinter Drawdown on Bushy Pondweed. Journal of Aquatic Plant Management 20: 19-21.

TVA (Tennessee Valley Authority). 1972. Control of Eurasian watermilfoil (*Myriophyllum spicatum* L.) in TVA Reservoirs. Environmental Statement TVA-OHES-EIS-72-8. Tennessee Valley Authority Office of Health and Environmental Science, Chattanooga, Tennessee.

TVA (Tennessee Valley Authority). 1990. Final Environmental Assessment: Demonstration of Use of Grass Carp in Management of Aquatic Plants in Guntersville Reservoir. TVA/RDG/EQS-90/3. Aquatic Biology Department, Muscle Shoals, Alabama.

TVA (Tennessee Valley Authority). 1993. Aquatic Plant Management Program: Current Status and Seasonal Workplan. Aquatic Biology Department, Muscle Shoals, Alabama.

Van der Zweerde, W. 1990. Biological Control of Aquatic Weeds by Means of Phytophagous Fish. *In*: A.H. Pieterse and K.J. Murphy (eds), pp. 201-221. Aquatic Weeds: the Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, Oxford, England.

Wade, P.M. 1990. Physical Control of Aquatic Weeds. *In*: Pieterse, A.H., and K.J. Murphy (eds.), pp. 93-136. Aquatic Weeds: the Ecology and Management of Nuisance Aquatic Vegetation. Oxford University Press, Oxford, England.

Wade, P.M. 1993. The Influence of Vegetation Pre-Dredging on the Post-Dredging Community. Journal of Aquatic Plant Management. 31: 141-144.

WATER Environmental Services. 1988. Pend Oreille River Eurasian watermilfoil Control Program 1988. Report Completion Report submitted to Pend Oreille County. WATER Environmental Services, Bainbridge Island, Washington.

WATER Environmental Services. 1990. Pend Oreille River Eurasian watermilfoil Control Program 1990. Report Submitted to Pend Oreille County. WATER Environmental Services, Bainbridge Island, Washington.

WDOE (Washington Department of Ecology). 1998a. Rotovation. World Wide Web URL: http://www.wa.gov/ecology/wq/plants/aqua027.html. Version of 21 January 1998.

WDOE (Washington Department of Ecology). 1998b. Weed Rolling. World Wide Web URL: http://www.wa.gov/ecology/wq/plants/aqua029.html. Version of 21 January 1998.

WDOE (Washington Department of Ecology). 1998c. Written Findings of the Washington State Noxious Weed Control Board. World Wide Web URL: http://www.wa.gov/ecology/wq/plants/aqua004.html. Version of 21 January 1998.

Webb, D.H. 1990. Drawdowns and Grass Carp for Aquatic Weed Control, Guntersville Reservoir, pp. 147-149. *In*: Proceedings of the 24th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Webb, D.H. 1993. Aquatic Macrophyte Assessment - Joint Agency Guntersville Project, pp 33-38. *In*: Proceedings of the 27th Annual Meeting, Aquatic Plant Control Research Program. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Widyanto, L.S., A. Sopannata, and U.S. Friend. 1983. Waterhyacinth as a Potential Plant in a Paper Factory. Journal of Aquatic Plant Management. 21: 32-35.

Wile, I. 1978. Environmental Effects of Mechanical Harvesting. Journal of Aquatic Plant Management. 16: 14-20.

Wile, I., J. Neil, G. Lumis, and J. Pos. 1978. Production and Utilization of Aquatic Plant Compost. Journal of Aquatic Plant Management. 16: 24-27.

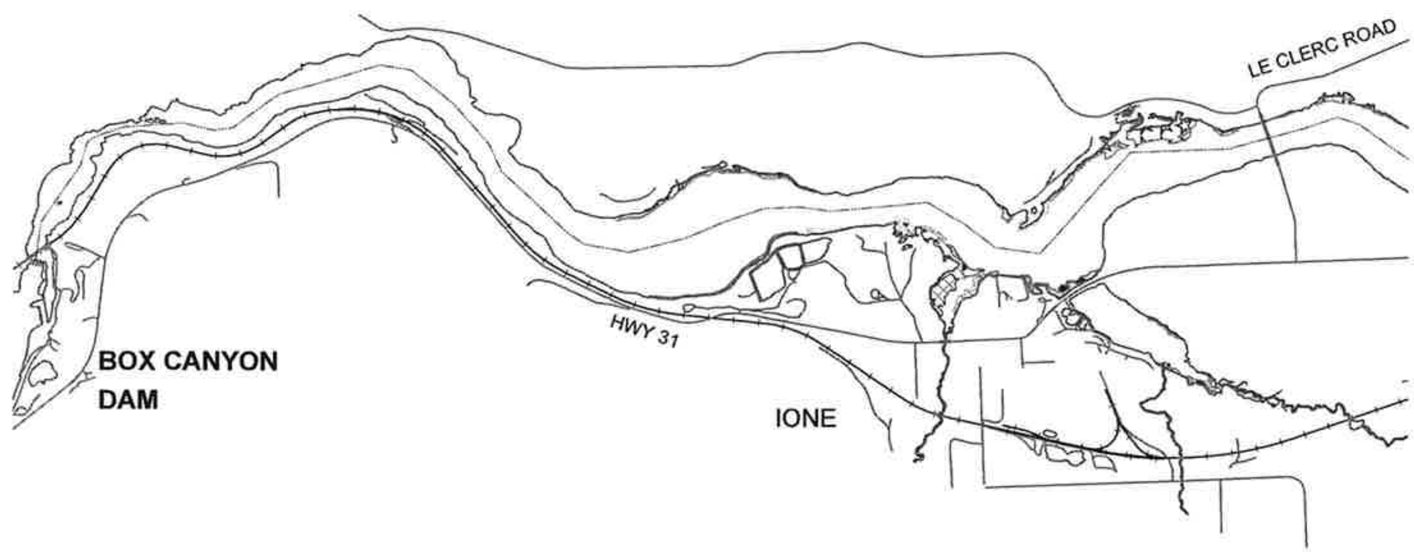
Yeo, R.R. 1980. Spikerush May Help Control Waterweeds. California Agriculture. 34: 12-13.

Yeo, R.R., and J.R. Thurston. 1984. The effect of Dwarf Spikerush (*Elocharis coloradoensis*) on Several Submersed Aquatic Weeds. Journal of Aquatic Plant Management 22: 52-56.

Zisette, R.R. 1983. Milfoil Control Method Evaluation. Prepared by Aquatic Control, Ltd. for the Municipality of Metropolitan Seattle Water Quality Planning Division, Seattle, Washington.

# APPENDIX D

# AQUATIC PLANT MAPS



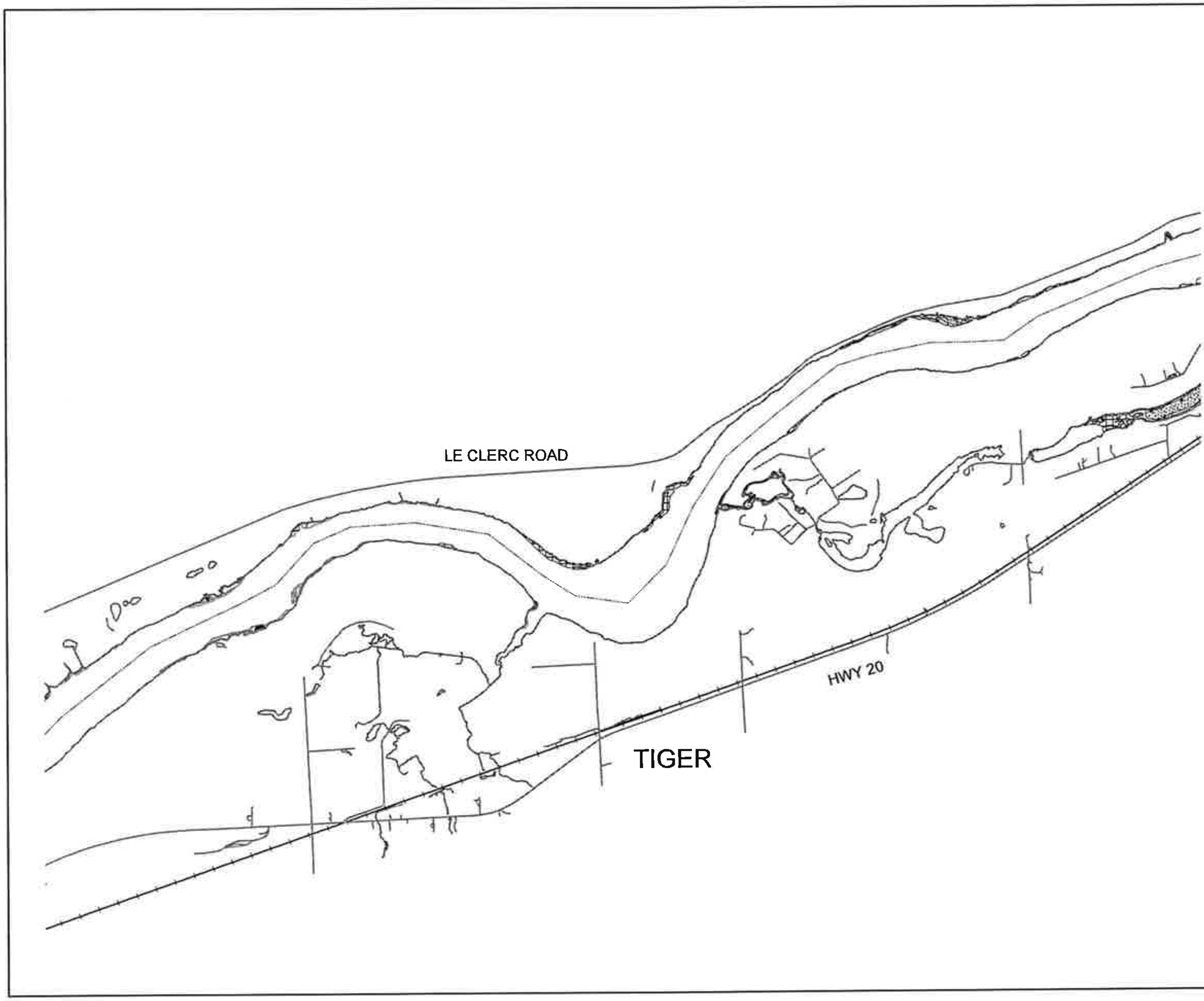

N

**Legend**

- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 1 of 11

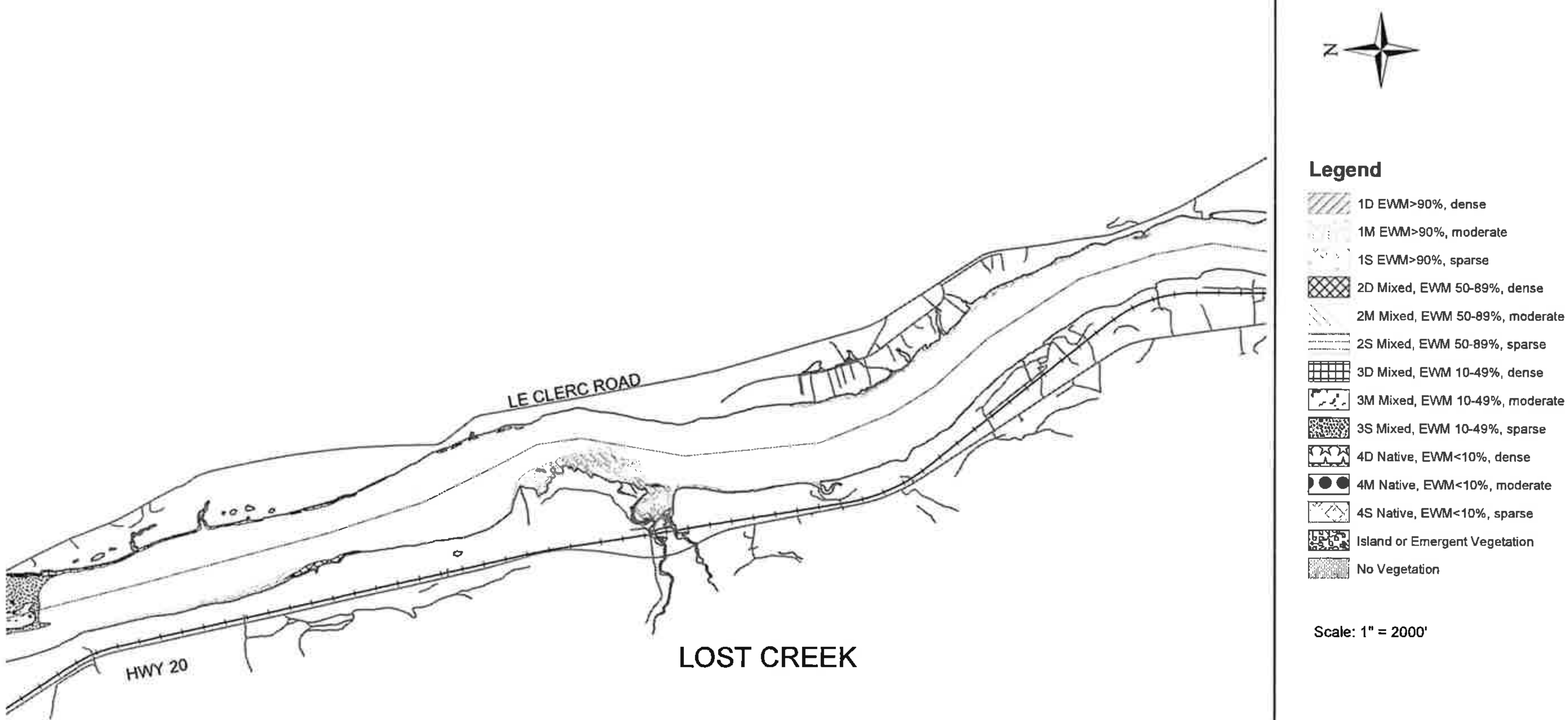



## Legend

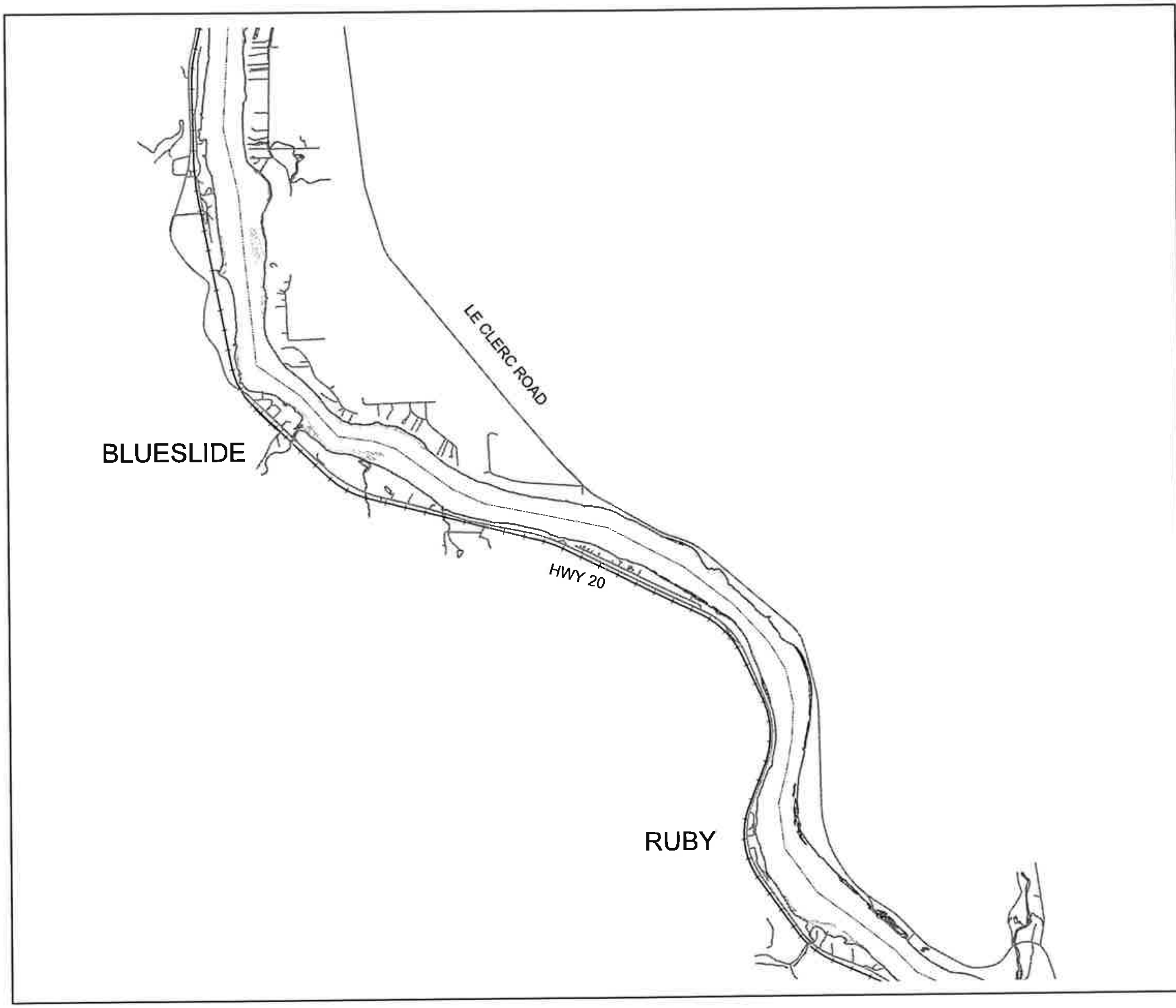
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emegent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 2 of 11




Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 3 of 11



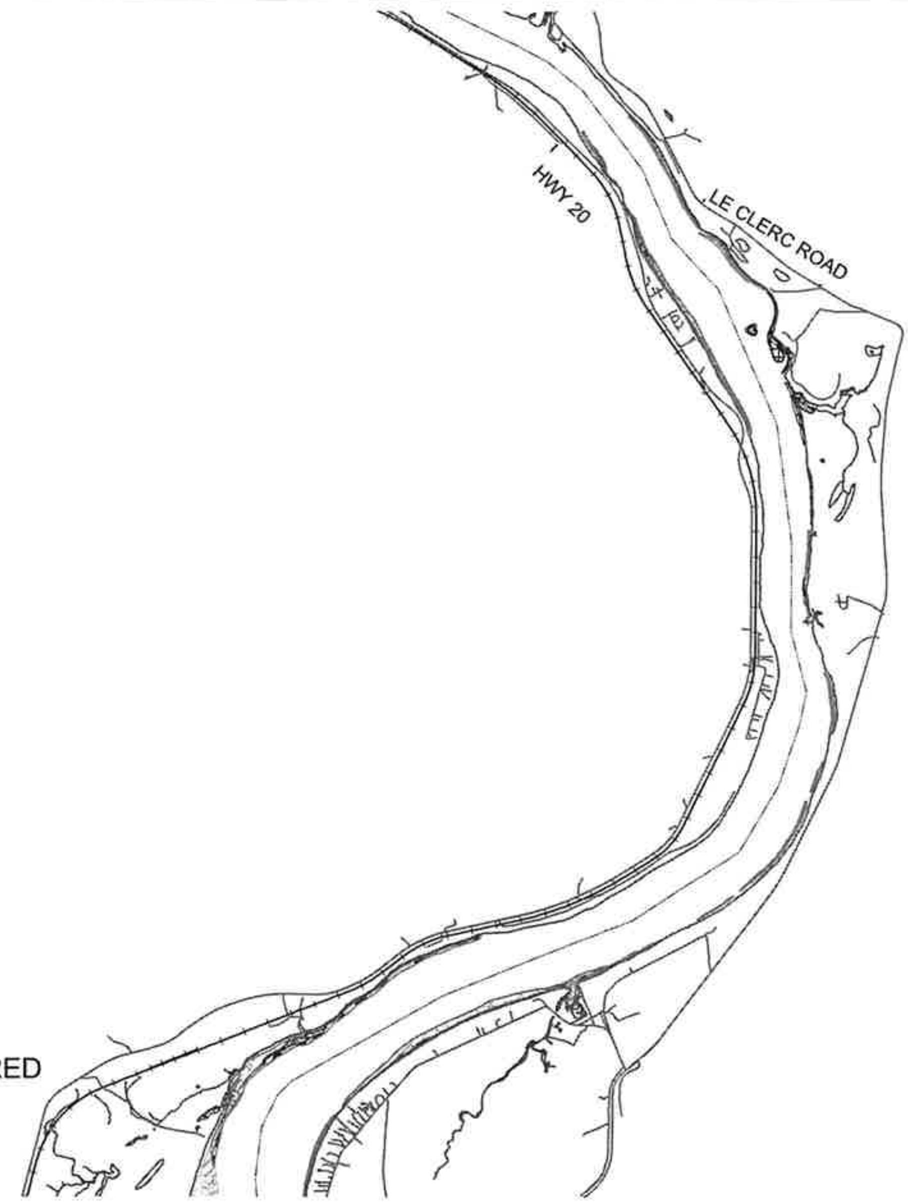

N

**Legend**

- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 4 of 11



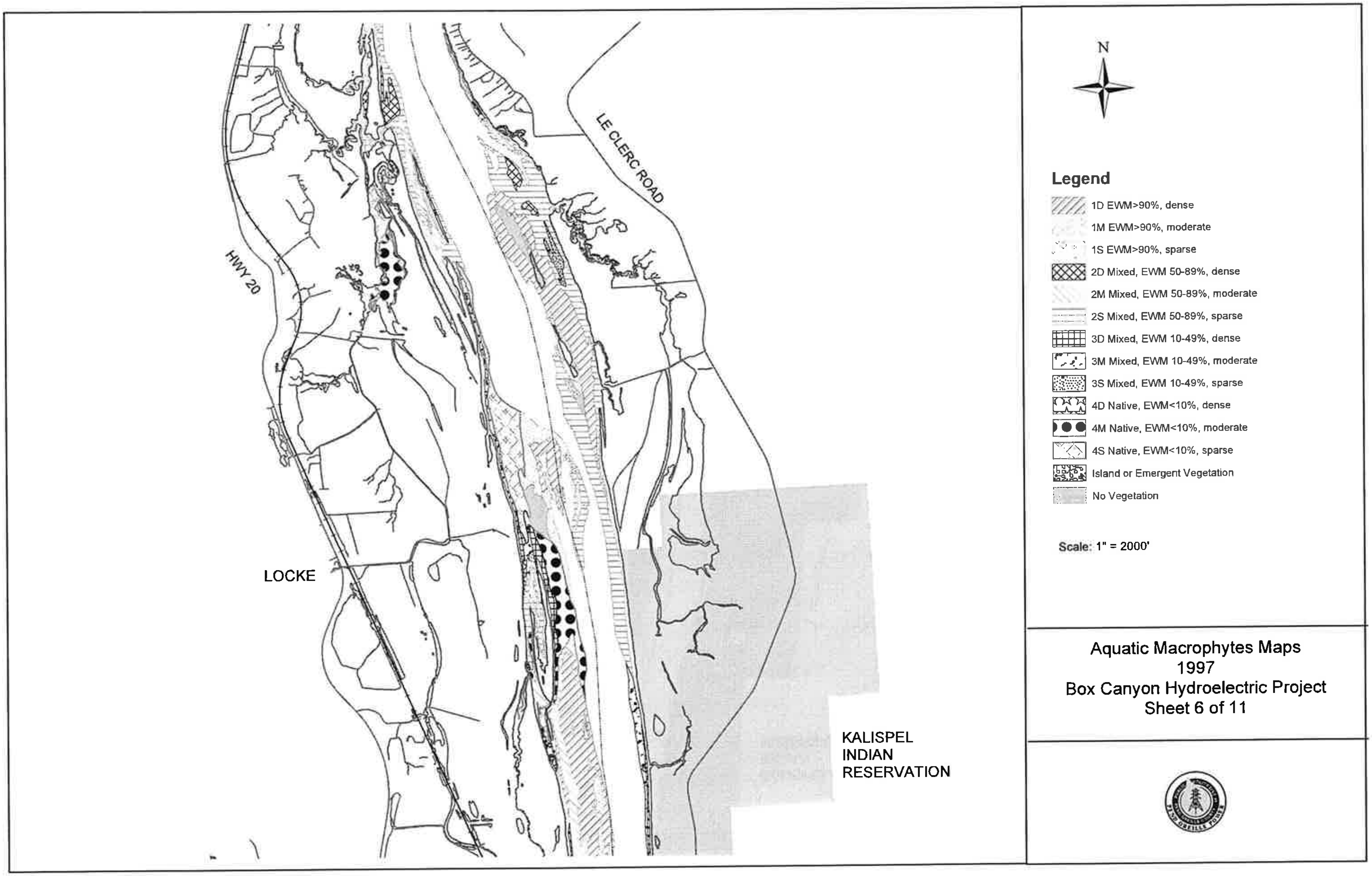

N

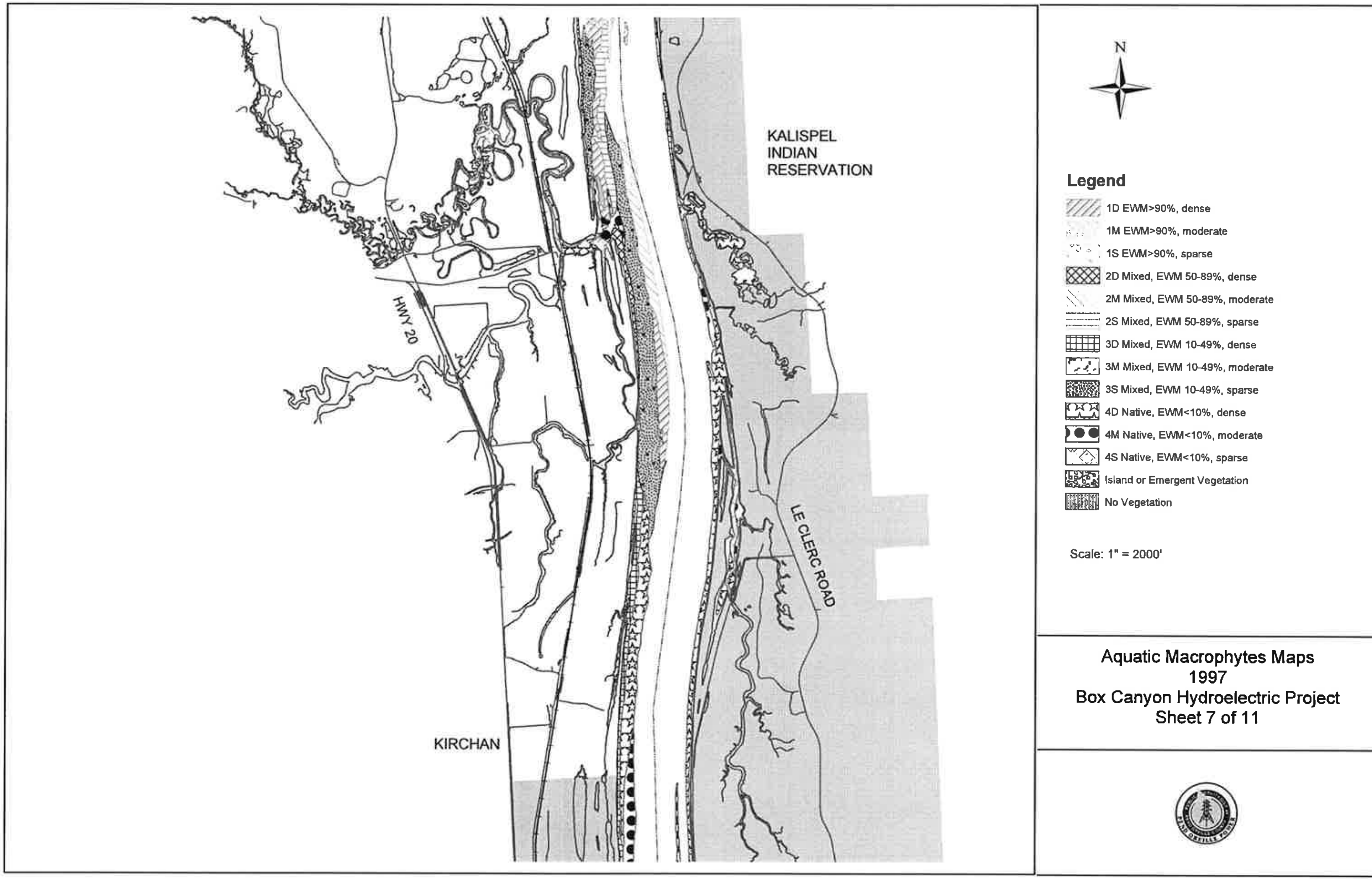
**Legend**

- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

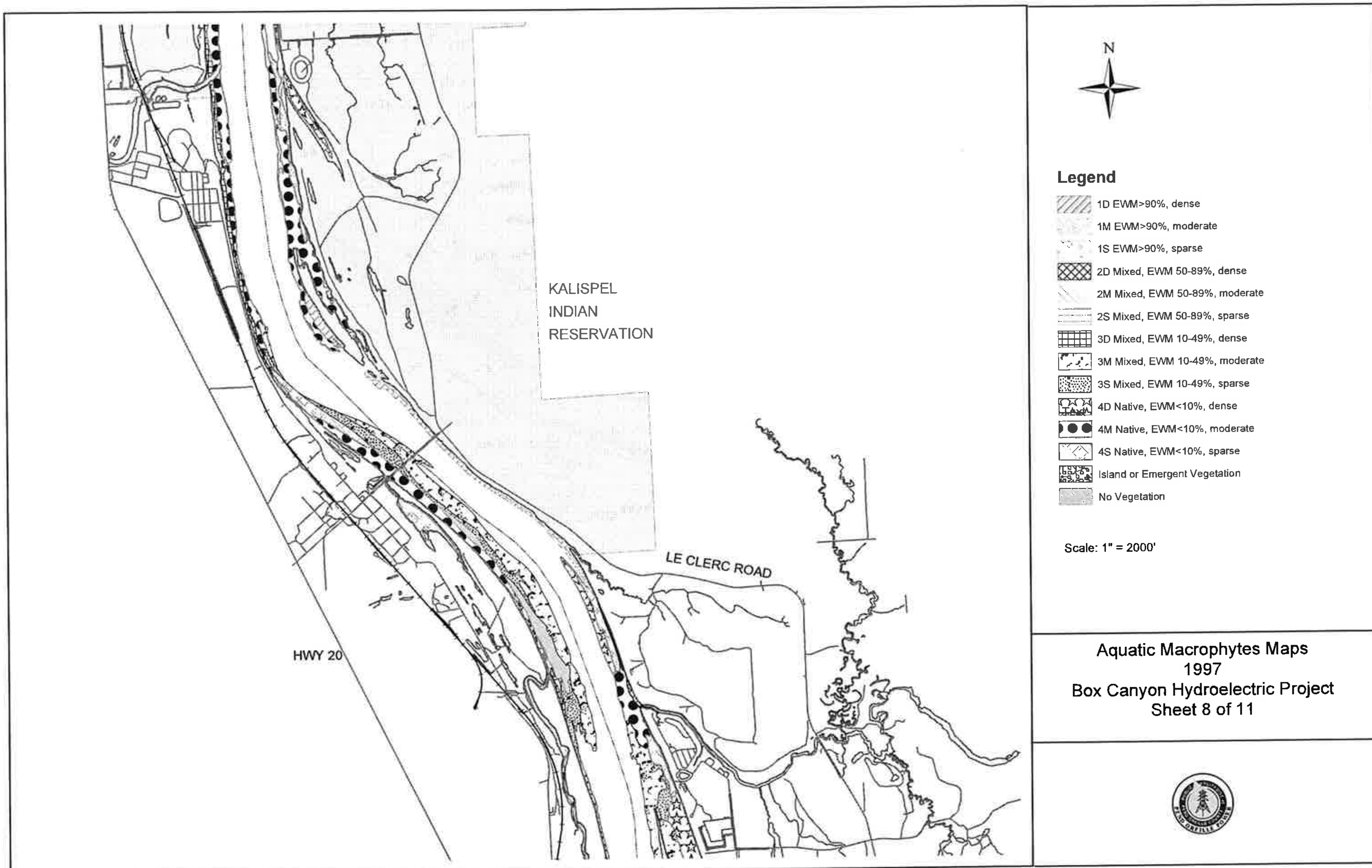
Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 5 of 11

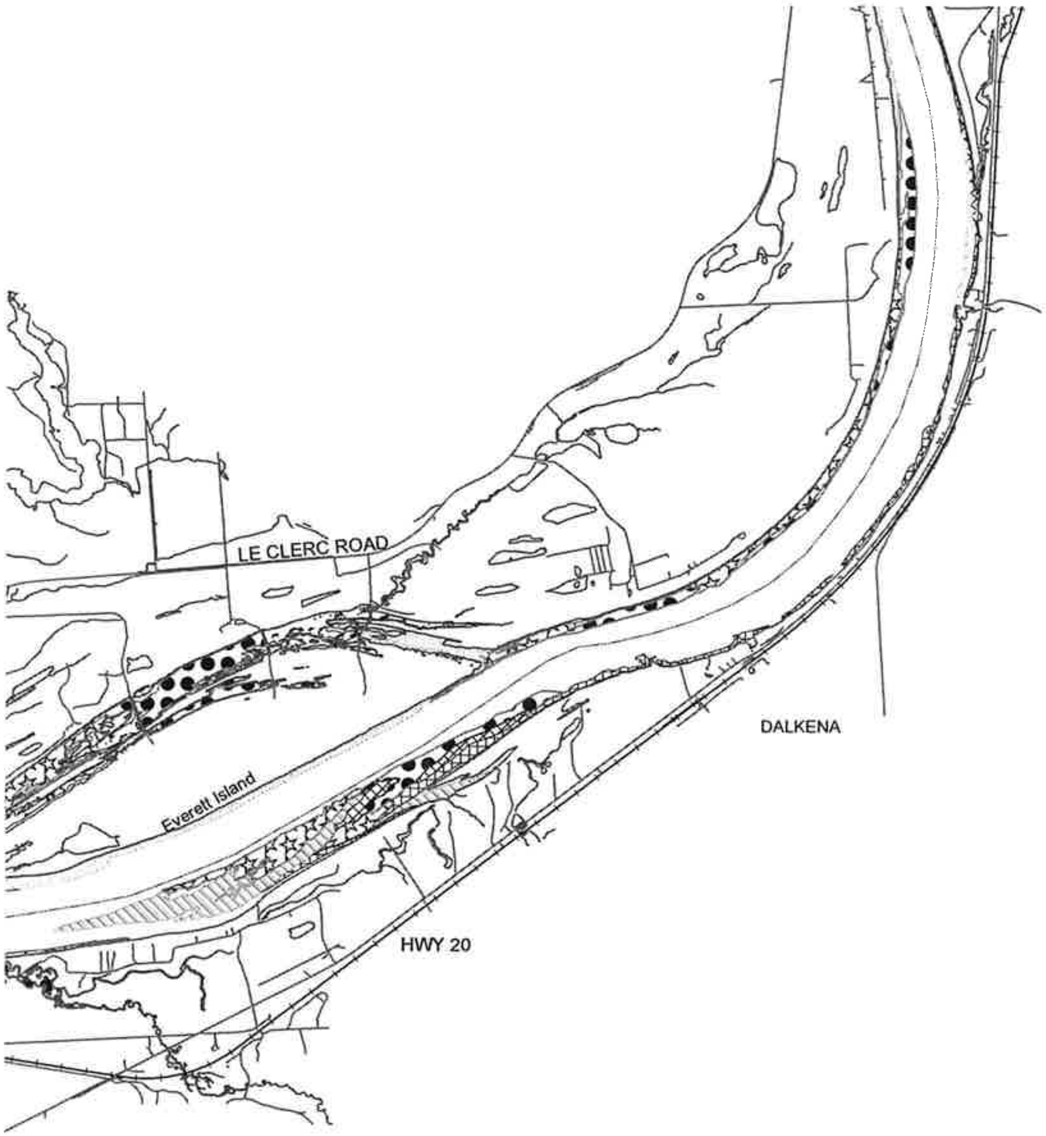

HWY 20
LE CLERC ROAD
LOCKE
KALISPEL
INDIAN
RESERVATION
N
Legend
1D EWM>90%, dense
1M EWM>90%, moderate
1S EWM>90%, sparse
2D Mixed, EWM 50-89%, dense
2M Mixed, EWM 50-89%, moderate
2S Mixed, EWM 50-89%, sparse
3D Mixed, EWM 10-49%, dense
3M Mixed, EWM 10-49%, moderate
3S Mixed, EWM 10-49%, sparse
4D Native, EWM<10%, dense
4M Native, EWM<10%, moderate
4S Native, EWM<10%, sparse
Island or Emergent Vegetation
No Vegetation
Scale: 1" = 2000'
Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 6 of 11




Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 7 of 11




Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 8 of 11

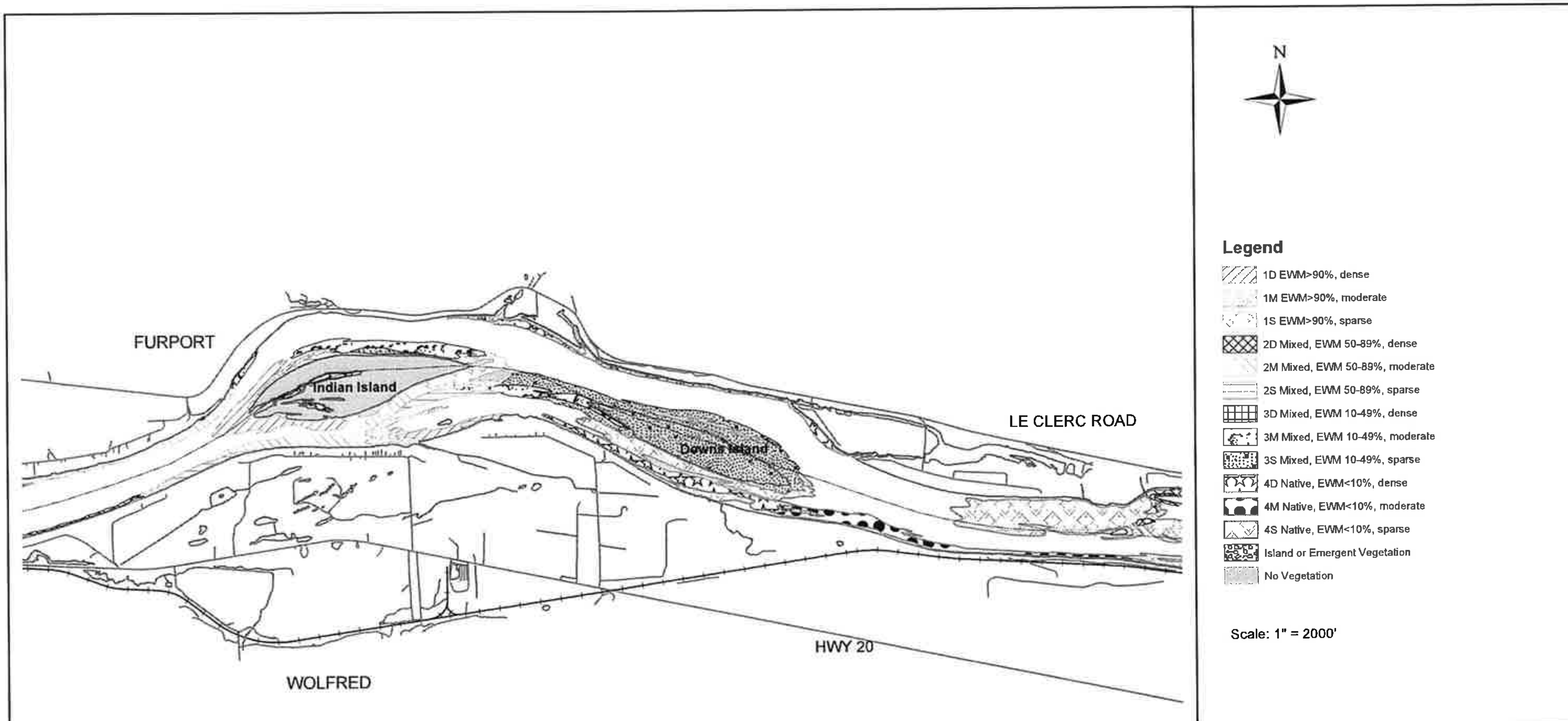



Legend

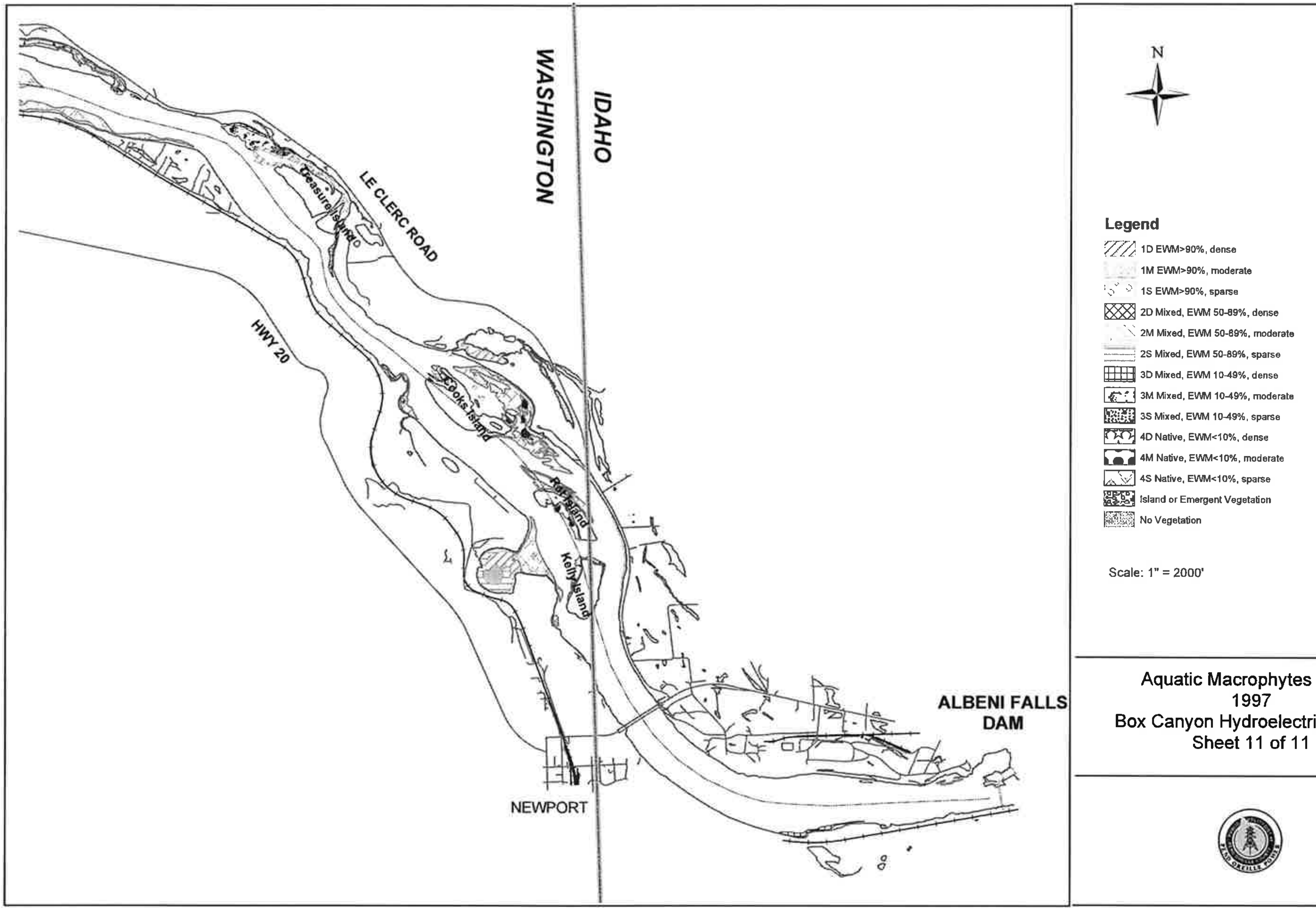
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 9 of 11




Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 10 of 11




Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 11 of 11

# APPENDIX E

# CONSULTATION RECORD

| CHRONOLOGICAL LIST OF AQUATIC PLANT MANAGEMENT MEETINGS HELD REGARDING BOX CANYON PROJECT AND/OR PEND OREILLE RIVER | | |
|---|---|---|
| **Meeting Date** | **Work Group** | **Meeting Attendees** |
| 4/17/97 | Aquatic Plant Study Group | USFS/WDOE/TSC/POCNWCB/POC/District/CES |
| 3/19/98 | Fisheries & Water Quality Work Groups | District/WDFW/WDOE/USFWS/USFS/KT/CAC/POC/CES |
| 4/23/98 | Aquatic Plant Management Group | CAC/POC/WDOE/TSC/USFWS/District/POCNWCB/POCD/USFS/RMI/CES |
| 8/3/98 | Water Quality Work Group | USFS/WDOE/TSC/WDFW/CAC/POCNWCB/POC/District/CES/GANDA |
| 11/6/98 | Water Quality Work Group | USFS/WDOE/TSC/WDFW/CAC/KT/POCNWCB/POCD/District/CES/GANDA |
| 5/25/99 | Fisheries & Water Quality Work Groups | CES/WDOE/District/POCNWCB/POCD/TSC/USFS/WDFW/CAC |
| 1/12/00 | Tri-State Council | EPA/IDEQ/MDEQ/WDOE/KT/DE&S/District/L&WC |
| 1/19/01 | Procrastinators Workshop | WSU Cooperative Extension Class |
| 1/25/01 | Weeds as Change Agents | WSU Cooperative Extension Class |
| 4/21/01 | Homeowners' Milfoil Workshop and Trade Fair | WSU Cooperative Extension Class |
| 5/10/01 | Water Quality Work Group | District/DE&S/GANDA/EPA/POCNWCB/WDOE/TSC/POC/Harza/WDOE/Homeowners |
| 12/19/01 | Pend Oreille Procrastinators Pesticide Recertification Class | WSU Cooperative Extension Class |
| 1/17/02 | Noxious Weed ID Session | WSU Cooperative Extension Class |
| 4/24/02 | Weeds and Wildlife Habitat | WSU Cooperative Extension Class |
| 11/13/03 | Eurasian Watermilfoil Workshop | WSU Cooperative Extension Class POCNWCB/District/WDOE |

CAC – Box Canyon Project Citizens' Advisory Committee
CES – Cascades Environmental Services
DE&S – Duke Engineering & Services
District-PUD No. 1 of Pend Oreille County
EPA – U.S. Environmental Protection Agency
GANDA – Garcia & Associates
IDEQ – Idaho Department of Environmental Quality
KT – Kalispel Tribe
L&WC – Land & Water Consulting
MDEQ – Montana Department of Environmental Quality
POC – Pend Oreille County Public Works
POCD – Pend Oreille Conservation District
POCNWCB – Pend Oreille County Noxious Weed Control Board
RMI – RMI/Aquatechnex
TSIC – Tri-State Interagency Council
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
WDFW – Washington Department of Fish & Wildlife
WDOE – Washington Department of Ecology

# Summary of Consultation
# Box Canyon Dam Relicense
# Aquatic Plants Study Scoping Meeting
# April 17, 1997

A meeting was held Wednesday April 17, 1997 at the District's office in Newport, WA to discuss ongoing and planned studies/management related to aquatic plants in the Box Canyon Reservoir (BCR). The meeting was initiated by the District as part of its efforts to consult with agencies on the Initial Consultation Document (ICD) and Draft Study Plan. The following people were in attendance.

| | | |
|---|---|---|
| Pat Buckley | District | (509) 447-3137 |
| Glenn Koehn | USFS | (509) 684-7189 or 7000 |
| Jean Parodi | WDOE | (509) 456-6160 |
| Ruth Watkins | TSIC | (208) 265-9092 |
| Sharon Sorby | POC Weed Board | (509) 447-2401 |
| John Blum | CES | (360) 671-1150 |
| Paul Wilson | POC Public Works | (509) 447-4821 |
| Kent Doughty | CES | (360) 671-1150 |
| Bob Geddes | District | (509) |

Following introductions, Kent Doughty stated that the purpose of the meeting was to assist in the coordination of efforts regarding milfoil management and to ensure studies done as part of the District's relicensing effort are both relevant and complimentary to ongoing and planned activities of other parties. Paul Wilson reviewed the County's current milfoil control program. Approximately 200 acres per year are rotovated (2.25% of reservoir total area). High use areas are targeted including public and privately managed boat launches and sub-divided areas. The County control program employs two people with an annual operating budget of approximately $85,000. Federal funding will be exhausted in April or May; cost for milfoil control programs will be equally shared by the District and the County for the remainder of this year. The Weed Board's emphasis is on information dissemination to the public. They are also pursuing funding opportunities through the State's boat trailer fee to do County mapping of milfoil in publicly accessible waters. While the Tri-State Implementation Council's (TSIC) primary focus is river nutrients, Ruth Watkins said that milfoil management is an objective. Ruth distributed a study description for TSIC's one time macrophyte and periphyton study. TSIC has asked the WDOE to add milfoil as a water quality concern on the 303d listing for the Pend Oreille River in Washington. The Forest Service has informal milfoil monitoring programs focussed on waters within its lands. Jean Parodi informed the group that the WDOE annually inventories milfoil conditions in the County (Contact Jennifer Parsons at WDOE Spokane office).

The need for good communication among represented groups at this meeting was stressed. Glenn Koehn encouraged the District to act as a clearing house during studies and/or development of a management plan since relicensing encompasses many of the related resource issues. He distinguished planning as a separate coordinating role from implementation of aquatic weed control. Pat Buckley noted that the District does not have regulatory jurisdiction nor does it want to infringe on management jurisdiction of other agencies. No lead entity(s) were identified but it was agreed that coordinators are needed for education, planning, and implementation; not necessarily the same party for each. The County Commissioners have expressed that they are encouraging other entities to assume responsibility for implementing the aquatic weed control program.

Funding opportunities for aquatic plant studies aimed at improving water quality through management include the Centennial clean water fund (Federal) and the boat trailer fee (State).

Study tasks aimed at developing an aquatic plant management plan were identified and preliminarily prioritized. These activities are in addition to existing programs. The attached table list priority tasks and shows coordination of effort.

| TASK | DESCRIPTION | PRIORITY | CONSTRAINTS | PLANNED ACTION |
|---|---|---|---|---|
| Map aquatic plants | Box Canyon Reservoir (BCR)<br>Forest Service lands<br>Other public waters in County<br>Distinguish treated areas | High | Resolve timing issues on getting credit for in kind cost sharing towards Weed Boards grant application in Oct 97 | 1. District to do mapping in BCR<br>2. Weed Board to pursue grant to map in other public waters<br>3. CES will distribute draft study plan in one month |
| Evaluate Rotovation Effectiveness | following treatment what is:<br>plant diversity<br>short term effects on intakes<br>EWM spreading hazard | Moderate | Complete literature review | Partially addressed by mapping |
| Research Alternative Control Methods | literature review both<br>large scale and homeowner options | High | None | District to initiate<br>WDOE can assist after April |
| Beneficial Use Map | Map uses in BCR<br>subsequently a definition of "control" and objectives can be defined | High | None | District to have prototype map and narrative to approach in time for Weed Boards Grant application 10/97 |
| Biological Control Pilot Project | Small scale test of weevil or other bio controls. Contained area best such as small slough<br>-effectiveness in flowing water<br>-ecological concerns<br>-limiting factors for weevil pop. | ? | Funding dependent | Weed Board may initiate limited pilot study |
| Sensitive, threatened, and endangered plants | survey BCR<br>WNHP concluded *Ranunculus aquatilis var. Longirostris* is not taxonomic entity. | Ongoing | None | District to complete summer 1997 |
| Public Education | | High | need to delay expansion | Conservation District and Weed Board currently informing public |
| Spreading Control/ Wash Stations | implementation/construction | Low to Moderate | Cost<br>Complete mapping and literature review | None |
| Landowner Initiated Projects | Cost sharing program | | Delay<br>funding not available yet | None |
| Fish enhancement | Experimental rotovation and ecological monitoring | Moderate to High | Fits with County program | Kalispel Tribe has identified sites to study in conjunction with District |

Pend Oreille County
Sharon L. Sorby, Coordinator
Phone: (509) 447-2401
FAX: (509) 447-5890
NOXIOUS WEED CONTROL BOARD
Courthouse / Post Office Box 5085 / Newport, Washington 99156-5085

# 1997 PEND OREILLE COUNTY NOXIOUS WEED LIST

I. Noxious weeds currently found growing in Pend Oreille County:

| Common Name | Scientife Name | Class | Toxicity |
|---|---|---|---|
| BIGHEAD KNAPWEED | *Centaurea macrocephala* | A | N |
| KNAPWEED, VOCHIN | *Centaurea nigrescens* | A | N |
| BUFFALOBUR | *Solanum rostratum* | A | N |
| STARTHISTLE, YELLOW | *Centaurea solstitialis* | B-designate | Y - to horses |
| TANSY RAGWORT | *Senecio jacobaea* | B-designate | Y - destroys liver |
| SCOTCH BROOM | *Cytisus scoparius* | B-designate | N |
| BUGLOSS, ANNUAL | *Anchusa arvensis* | B-designate | N |
| BUGLOSS, VIPER'S | *Echium vulgare* | B-designate | N |
| PURPLE LOOSESTRIFE | *Lythrum salicaria* | B-designate | N |
| WAND LOOSESTRIFE | *Lythrum virgatum* | B-designate | N |
| LEAFY SPURGE | *Euphorbia esula* | B-designate | Y - dermal |
| MUSK THISTLE | *Carduus nutans* | B-designate | N |
| PLUMELESS THISTLE | *Carduus acanthoides* | B-designate | N |
| MEADOW KNAPWEED | *Centaurea jacea x nigra* | B-designate | N |
| COMMON BUGLOSS | *Anchusa officianalis* | B-designate | N |
| KOCHIA | *Kochia scoparia* | B-designate | N |
| COMMON CATSEAR | *Hypochaeris radicata* | B-designate | N |
| RUSH SKELETONWEED | *Chondrilla juncea* | B-designate | N |
| EURASIAN WATERMILFOIL | *Myriophyllum spicatum* | B/B-designate | N |
| YELLOW HAWKWEED | *Hieracium caespitosum* | B/B-designate | N |
| ORANGE HAWKWEED | *Hieracium aurantiacum* | B | N |
| DIFFUSE KNAPWEED | *Centaurea diffusa* | B | N |
| SPOTTED KNAPWEED | *Centaurea biebersteinii* | B | N |
| DALMATIAN TOADFLAX | *Linaria dalmatica ssp. dalmatica* | B | N |
| OXEYE DAISY | *Leucanthemum vulgare* | B | N |
| SULFUR CINQUEFOIL | *Potentilla recta* | B | N |
| BABYSBREATH | *Gypsophila paniculata* | C | N |
| CANADA THISTLE | *Cirsium arvense* | C | N |
| BULL THISTLE | *Cirsium vulgare* | C | N |
| HOUNDSTONGUE | *Cynoglossum officianale* | C | Y |
| POISON HEMLOCK | *Conium maculatum* | C | Y - no known antidote |
| COMMON TANSY | *Tanacetum vulgare* | C | Y - dermal allergen |
| JAPANESE KNOTWEED | *Polygonum cuspidatum* | C | N |
| COMMON MULLEIN | *Verbascum thapsus* | C | N |
| BITTER NIGHTSHADE | *Solanum dulcamara* | C | Y |
| ST. JOHNSWORT | *Hypericum perforatum* | C | Y - causes photosensitivity |
| REED CANARYGRASS | *Phalaris arundinacea* | C | N |

**CLASS A AND B-DESIGNATE:** Weeds in these classes occur at a few sites within the county, are considered an economic threat, and will be controlled annually to prevent seed production until eradication is secured.

**CLASS B AND C:** These classes are mostly common in the county and will be controlled on right-of-ways and other areas where requested with the overall goal of containment and reducing the negative impact to below an acceptable level.

II. Noxious weeds NOT currently found growing in Pend Oreille County, but will be monitored and controlled if discovered:

| lass | Common Name | Scientific Name |
|---|---|---|
| A: | bean caper, Syrian | *Zygophyllum fabago* |
| | blueweed, Texas | *Helianthus ciliaris* |
| | clary, meadow | *Salvia pratensis* |
| | cordgrass, salt meadow | *Spartina patens* |
| | crupina, common | *Crupina vulgare* |
| | four o'clock, wild | *Mirabilis nyctaginea* |
| | hawkweed, mouseear | *Hieracium pilosella* |
| | hogweed, giant | *Heracleum mantegazzianum* |
| | hydrilla | *Hydrilla verticillata* |
| | Johnson grass | *Sorghum halepense* |
| | mallow, Venice | *Hibiscus trionum* |
| | nightshade, silverleaf | *Solanum elaeagnifolium* |
| | pegarum | *Peganum harmala* |
| | sage, Mediterranean | *Salvia aethiopis* |
| | starthistle, purple | *Centaurea calcitrapa* |
| | thistle, Italian | *Carduus pycnocephalus* |
| | thistle, milk | *Silybum marianum* |
| | thistle, slenderflower | *Carduus tenuiflorus* |
| | unicorn-plant | *Proboscidea louisianica* |
| | velvetleaf | *Abutilon theophrasti* |
| | woad, dyer's | *Isatis tinctoria* |
| I-DESIGNATE: | blackgrass | *Alopecurus myosuroides* |
| | bryony, white | *Bryonia alba* |
| | camelthorn | *Alhagi maurorum* |
| | cordgrass, common | *Spartina anglica* |
| | cordgrass, smooth | *Spartina alterniflora* |
| | deadnettle, hybrid | *Lamium hybridum* |
| | elodea, Brazilian | *Egeria densa* |
| | fanwort | *Cabomba caroliniana* |
| | fieldcress, Austrian | *Rorippa austriaca* |
| | gorse | *Ulex europaeus* |
| | hedgeparsley | *Torilis arvensis* |
| | indigobush | *Amorpha fruticosa* |
| | knapweed, black | *Centaurea nigra* |
| | knapweed, brown | *Centaurea jacea* |
| | knapweed, Russian | *Acroptilon repens* |
| | lepyrodiclis | *Lepyrodiclis holosteoides* |
| | loosestrife, garden | *Lysimachia vulgaris* |
| | nutsedge, yellow | *Cyperus esculentus* |
| | oxtongue, hawkweed | *Picris hieracioides* |
| | parrotfeather | *Myriophyllum aquaticum* |
| | pepperweed, perennial | *Lepidium latifolium* |
| | puncturevine | *Tribulus terrestris* |
| | sandbur, longspine | *Cenchrus longispinus* |
| | sowthistle, perennial | *Sonchus arvensis ssp. arvensis* |
| | Swainsonpea | *Sphaerophysa salsula* |
| | thistle, Scotch | *Onopordum acanthium* |

Cascades Environmental Services, Inc.

Fisheries and Natural Resource Consultants

cc file Box 2.3.1

To: Box Canyon Hydroelectric Project Relicensing
Fish Work Group & Water Quality Work Group

Feb 20, 1998

From: Kent Doughty, John Blum

Re: Box Canyon Hydroelectric Project Relicense studies
Technical meeting date for fisheries and water quality

*file code 3.7.3*
*key words: fish, water quality*
*file: let022098*.wpd*

Dear Participant,

A meeting is scheduled for Thursday March 19, 1998 at the Pend Oreille County Public Utility District office in Newport (130 N Washington St) to discuss fisheries and water quality studies for the Box Canyon Hydroelectric Project Relicensing. The meeting will start at 9am and will run all day. A preliminary meeting agenda is attached.

You have recently received a report entitled "Relicensing Study Update" February 15, 1998. This report includes summary results from 1997 field studies and describes any proposed modifications to study plans for 1998. It would be very helpful for you to review this document prior to the meeting on the 19th and bring it with you for reference to data tables. If you did not receive this document, please notify me.

If you have comments to be addressed by the Fish Work Group or the Water Quality work Group but will be unable to attend the upcoming meeting, I would be happy to relay those comments on to the Work Group(s) for you. Also please let me know if there are other items you wish to add to the agenda for this meeting.

Please note other meeting dates for Box Canyon which may be of interest to you. (Separate announcements are being sent out for those meetings.

- Mar 19 Fisheries Work Group (this announcement)
- Mar 25 Recreation
- Mar 20 Wildlife (date is tentative)

Sincerely,

Kent Doughty

cc: Fisheries Distribution List
Water Quality Distribution List
Box Canyon Citizens Advisory Committee

# TENTATIVE AGENDA
## BOX CANYON RELICENSE - FISHERIES & WATER QUALITY MEETING
## MARCH 19, 1998
## PEND OREILLE PUD OFFICE, NEWPORT

I Meeting convenes 9am

II Review 1997 field study results
- Adfluvial fish trapping
- Fish habitat mapping

III Study plans for 1998
- Adfluvial fish trapping
- Fish tagging protocol
- Completion of habitat mapping (substrate)
- Key trout habitat mapping

IV Salmonid habitat suitability indices

V Temperature studies
- 1997 study results
- 1998 field study plans

VI Aquatic plant literature review
- Discussion of reviews included in Feb 15, 1998 status report
- Aquatic plant management literature review
- Next steps

Adjourn by 3 PM

**Cascades Environmental Services, Inc.**

*Fisheries and Natural Resource Consultants*

cc file Box 2.3

To: Box Canyon Hydroelectric Relicense Process Water Quality Work Group
Citizens Advisory Committee

From: Kent Doughty
Date: March 31, 1998
re: Box Canyon Hydroelectric Project Relicense (FERC No. 2042)
Aquatic plant management meeting

The Pend Oreille Public Utility District No. 1 (PUD) is scheduling a meeting for Thursday April 23, 1998 at their Newport, WA office (130 N. Washington St) to discuss aquatic plant studies being conducted as part of the relicensing effort. The meeting will start at 9 a.m. and will end at approximately 1 p.m. A preliminary agenda is attached.

You should have received a copy of the "Relicensing Study Update including 1997 Study Results" (February 15, 1998). Review of this document prior to the meeting will help orient participants to the aquatic plant work completed to date. A working draft of the literature review of control methods for management of Eurasian water-milfoil was distributed at the recent fish/Water Quality meeting (March 19, 1998). A copy is enclosed for those that did not attend that meeting. Please contact me if you did not receive either of these documents or have other comments regarding this upcoming meeting.

Sincerely,

Kent Doughty

Distribution:
Water Quality Work Group
Fisheries Work Group
Citizen Advisory Committee
Bob Geddes
Jack Snyder
John Blum

# Box Canyon Hydroelectric Project: Water Quality Work Group
## Meeting Agenda
## April 23, 1998

9:00 am Start

I Introductions and review meeting objectives

II Aquatic Plant Mapping Results
- Species composition
- Distribution
- Ecological implications
- Management considerations
- Comparison with previous mapping efforts

III Discuss Draft Literature Review of Control Methods
- Overview
- Comments on comprehensiveness
- Relevance to Box Canyon

IV Rotovation Program
- Overview
- Integrating Program with aquatic plant map results
- Discuss needs for effectiveness review

V Beneficial Use Map
- Definition and objectives (see final study plan)
- Discuss integration with information on other resources

VI Next Steps

VII Roundtable comments

IX Adjourn (app. 1 p.m.)

cc file Box 6.5.1

# Cascades Environmental Services, Inc.

Fisheries and Natural Resource Consultants

To: Box Canyon Hydroelectric Project Relicense: Water Quality Work Group, Citizens' Advisory Committee, Interested Parties

From: Kent Doughty *Kent*

*File: BCDR 2.7.3*
*key words: water quality, macrophytes*

Date: July 15, 1998

RE: Meeting Announcement

A meeting to discuss progress on water quality studies for the Box Canyon Hydroelectric Project is scheduled for **Monday August 3, 10 a.m.** at the office of Washington Department of Ecology, 4601 N. Monroe St., Spokane, WA. The meeting will primarily focus on aquatic plant management. Since there is much to discuss, it is anticipated that the meeting might last until 3:30 p.m. A tentative agenda is attached. Please call me if you have suggested agenda modifications or need further information.

Tentative Agenda

I Introductions and review meeting objectives

II Status report for ongoing water quality studies

III Presentation of aquatic mapping results (Summer 1997 field mapping)

IV Need and approach for long term aquatic plant monitoring index sites

Lunch ???

V Rotovation Program: Review studies on effectiveness

VI Community education on aquatic plant control
- pamphlets
- workshop?

VII Experimental control methods
- milfoil weevil
- other

**Cascades Environmental Services, Inc.**

*Fisheries and Natural Resource Consultants*

July 22, 1998

Tom Shuhda
U.S. Forest Service
Colville National Forest
765 S. Main
Colville, WA 99114

6186

re: Rotovation effectiveness

*file: d/kd/box/sumcom/agency/ts072298let*
*file code: 4.2.3*
*key words: milfoil*

Dear Tom,

Enclosed are copies of publications describing rotovation effectiveness studies conducted by Pend Oreille County and the PUD. The County also took aerial slide normal color and infrared photography oblique view of the reservoir which I have copies. I will be comparing the earlier mapping of aquatic plants to our 1997 study to the extent feasible.and will present that comparison at the August 3 water quality meeting. I hope the enclosed studies will help familiarize you with previous investigations of rotovation effectiveness in preparation for discussions on this topic at the August 3rd meeting. The literature review on aquatic plant control previously prepared and distributed by the District also contains discussion on rotovation effectiveness both within the Pend Oreille and elsewhere. Please call me if you have any related questions to either the upcoming meeting or the enclosed articles.

Sincerely,

Kent Doughty

cc: Ruth Watkins TSIC

Cascades Environmental Services, Inc.

Fisheries and Natural Resource Consultants

Ms. Ruth Watkins
Tri-State Council
206 N. 4th Ave., Suite 157
Sandpoint, ID 83864

July 23, 1998

re: Box Canyon Hydroelectric Project: aquatic plant management

*file code: 4.6*
*d:\kd\box\sumcom\agency\rs0798let.wpd*

Dear Ruth,

The enclosed report from Resources Management Inc (RMI) will let you see the level of detail in mapping of aquatic plants we have available for the Box Canyon Reservoir. The mapping data files from RMI are being incorporated into the GIS for the Project. This will allow us to calculate summary statistics of acreage for various plant communities, compare rotovated and non-rotovated sites, and use this mapping as a tool for developing a beneficial use map which integrates other aquatic resource information. We are preparing color maps of the entire project area which will be at a scale 1:2000 (11 sheets) for use at our upcoming meeting and limited distribution.

Please note that the legends for the maps included with this report require one change. The plant community group "Native: EWM < 10%" needs to be changed to "EWM < 10%" since many of the areas in this group include curled pondweed which is non-native.

The report notes that ground truthing included quantitative scuba survey data for 39 transects. Ground truth data contributing to the enclosed maps also included extensive field mapping of plant community boundaries by surface visual assessment and raking.

At our upcoming meeting, I will be providing the Work Group with summary statistics of areal coverage by plant community within each of four river reaches described in the study plan. I will try and get that summary data to you ahead of the meeting but it may not be available in advance. I wanted to send you this working draft report since you will not be able to attend the August 3rd meeting.

A key task for the Work Group will be defining how we use this mapping data to work towards a beneficial use map which will guide future aquatic plant management in the Box Canyon reach.

Another item I will be thinking about in advance of our upcoming meeting is to propose a monitoring program at index sites. It is prohibitively expensive to do the level of mapping done in 1997 at less than a 10+ year frequency. However, it would be desirable to keep our

1111 North Forest Street • Bellingham, Washington 98225-5119 • (360) 671-1150 • FAX (360) 671-1152

knowledge of plant distribution current. A few preliminary thoughts on a monitoring program would be to use index sites to track potential expansion of heavily infested milfoil sites and track the relative proportion of milfoil within index sites located closer to Newport where milfoil is currently less dominant. I'd welcome your ideas on monitoring objectives prior to the meeting.

Please feel free to call me with any questions or comments on the enclosed material.

Sincerely,

Kent Doughty

cc w/o enc: John Blum
Jack Snyder
Bob Geddess

**Summary of Consultation**
**Water Quality Work Group Meeting**
**August 3, 1998**

A meeting of the Box Canyon Water Quality Work Group was held at the WDOE office in Spokane on August 3, 1998.

Agencies in attendance included:

| | |
|---|---|
| USFS | Pend Oreille Noxious Weed Control Board |
| WDOE | Pend Oreille County Planning Dept. |
| Tri-State Council | Pend Oreille PUD |
| WDFW | Cascades Environmental Services |
| Citizens's Advisory Committee | GANDA |

Kent Doughty (CES) reported on status of ongoing studies. Thermograph locations and instrument deployment techniques were discussed. He also reviewed the sampling locations, methods and parameters measured for monthly water quality monitoring. The group concurred that the monitoring objective is long term trend monitoring.

The group discussed water quality effects of aquatic plants. Glenn Koehn (USFS) asked if the work group has defined study objectives. If the focus is on milfoil then sampling might want to focus on the River Bend area. Kent noted that he was not able to find a control site where water quality was not affected by plants. The group considered Lake Pend Oreille but concluded the environment is so different that comparisons are not appropriate. The group identified sampling for dissolved oxygen, pH and nutrients are of primary interest in comparing water quality in plant beds to open water. It was decided that although it may be difficult to account for other factors (differences in channel shape/depth), water quality grab sampling should be conducted in an open water site and within a plant bed. Sampling will target August when plant biomass production in maximum and late fall when plants begin to die back.

John Blum next reviewed methods for macroinvertebrate sampling. Sampling will target key trout habitats. He noted that good substrates and large woody debris occur between Albeni Falls and Indian Creek , substrates downstream of LeClerc Creek are suitable for salmonids but exhibit mobility. Other key habitats occur upstream of Ione. Macroinvertebrate sampling methods and locations were reviewed. Kent asked the group to provide any feedback on the distributed methods paper by August 14$^{th}$.

Kent next presented the results of the 1997 aquatic plant mapping. The presentation included a comparison to 1988 mapping efforts. He noted that scaling, resolution and sample area differed.

The earlier studies also distinguished between Eurasian watermilfoil and M. exalbescens; the latter was considered native at the time of the earlier surveys but Kent noted that taxonomists now have re-assigned exalbescens to siberian milfoil which is also an exotic species. The effectiveness of the County rotovation program was also reviewed. CES analyzed the distribution of aquatic plants relative to rotovation history. Paul Wilson said the County focuses on high use areas. Paul Wilson also noted that before rotovation could focus on other areas with different management objectives, i.e., fish habitat management north of Cusick, the public would need to be informed to gain community support for any changes to the program. The group discussed options to use rotovation as a fish habitat enhancement tool by cutting cruising lanes within plant beds. Sharon Sorby noted that the recreation survey will help further define where aquatic plant control needs to focus. The group discussed plant fragmentation during rotovation as a cause of spreading milfoil. Sharon noted that plant fragmentation in July and August is a time when root establishment by fragments is most likely.

The group next discussed a pilot study of milfoil weevil control of milfoil. Sharon relayed that the Tribe had an interest in this study as well as concern for the effects on fish of the collapse of plant beds. Permits would be necessary if out of state weevils were introduced but not if local weevil populations were used. Kent distributed a letter from a local citizen interested and knowledgeable in raising milfoil weevils. He said this creates an opportunity for a source of local weevils that is necessary to initiate a study. The group set a short term goal of identifying pilot sites (require confined sites of less than 4 acres with predominantly milfoil growth). A handout on steps to initiate and evaluate a pilot project was distributed. Sharon Sorby noted that Gary Piper (WSU) pest control specialist may be able to provide some assistance on evaluating costs of using milfoil weevils as a control agent. Sharon Sorby and Jean Parodi expressed interested in helping to scope a pilot study. Ashenfelter Bay was suggested as a possible study site. Kent said he would review the aquatic plant maps for other potential study sites.

The development of beneficial uses maps was briefly discussed (see handout). The need for community workshops was also identified as a priority task. Ideas included education on the benefits of aquatic plants and setting realistic expectations on control success. DOE has a number of flyers available for public education on homeowner aquatic plant control options. It was suggested to coordinate with the Conservation District. It was also suggested that the WDOE flyers on aquatic plant control methods could be made available at the Districts booth at the fair.

It was decided that the next meeting should be combined with both the water quality work group and the fisheries work group

**BOX CANYON HYDROELECTRIC PROJECT**
**WATER QUALITY WORK GROUP**
**MEETING AGENDA**
**August 3, 1998 at WDOE Office; Spokane, WA**

10:00 a.m. Meeting start time

I Introductions and review meeting objectives

II Status report for ongoing water quality studies
- water physical/chemistry monitoring
- temperature monitoring
- effect of aquatic plants on water quality

III Macroinvertebrate Study

IV Presentation of aquatic mapping results (Summer 1997 field mapping)

V Comparison 1997 and 1988 aquatic plant mapping

Lunch ???

VI Rotovation Effectiveness: Review prior studies

VII Need and approach for long term aquatic plant monitoring index sites

VIII Alternate Control Pilot Study: Milfoil Weevil

IX Beneficial Uses Map

X Community education on aquatic plant control
  pamphlets
  workshop?

XI Next Steps and future meetings

**II Status report for ongoing water quality studies**

- **water physical/chemistry monitoring**
- **temperature monitoring**
- **effect of aquatic plants on water quality**

**III Macroinvertebrate Study**

## MACROINVERTEBRATES

Aquatic macroinveretebrate assemblages can provide and indirect assessment of the water quality and habitat condition in freshwater systems (Plafkin et al., 1989). In addition, information regarding the macroinvertebrate community may assist fishery biologists in determining the availability of food resources.

### Study Objective

The objectives of the benthic macroinvertebrate sampling are to characterize functional feeding groups in the reservoir and to develop appropriate numeric indices of biological integrity. The benthic community will be studied at sites identified as key trout habitats. Data shall primarily function as baseline information in the event of continued monitoring efforts. If a regional reference site has been identified, data may also be compared to these control sites.

### Methods

If key salmonid habitats are detected during the fisheries habitat mapping efforts, studies to characterize existing macroinvertebrate assemblages within these habitats will be conducted. The results of the fish habitat mapping (see Fisheries Section 4.4) will be reviewed in consultation with the Kalispel Tribe and other appropriate resource agencies to determine where key trout habitats are located. The methods described below are subject to modification upon consultation with appropriate resource agencies and the Kalispel Tribe regarding the results of the fish habitat survey. The final method selected will furnish biological index values similar to those defined by Plafkin et al. (1989). Macroinvertebrate sampling will take place in the first weeks of September, 1998 in order to be comparable with a previous study in the reservoir (Falter et al., 1991)

Approximately 3 benthic samples will be collected from at least 3 sites typical of each key trout habitat type identified in the fish surveys. If there is low invertebrate density, the 3 samples will be composited to represent the site. The means of collection and sampling area will be dependent upon the substrate occurring at these sites. Two suggested options include: 1) a diver operated substrate brush with attached 500 micron net for sampling a 1.0 $m^2$ area of boulder-cobble substrates; and 2) a Peterson Grab (0.30 $m^2$) for sampling sand-small cobble substrates. Where appropriate, (e.g., key trout habitat with accumulations of organic detritus) a separate qualitative coarse particulate organic matter (CPOM) sample will be collected for analysis of benthic shredders. If key trout habitat is identified near the mouths of tributaries, then a drift study will also be conducted. A 500 micron drift net will be deployed for twelve hours beginning at dusk (~ 8 p.m.). A velocity measurement will be taken at the 0.45 $m^2$ opening of the drift net when it is initially deployed (T=0 hrs) and just before it is removed from the channel (T=12 hrs). The velocity data allow drift density to be quantified as #/100 $m^3$.

Samples will be separated from ancillatory debris and sieved through a 500 micron mesh screen. The remaining organisms and material will be spread out on a gridded sorting tray. Macroinvertebrates will then be selected by taking all the organisms within a randomly selected grid. Grid selection will be repeated until a minimum of 100 organisms have been gathered for identification. If 100 organisms is achieved mid-square, the grid shall be sorted to completion. Organisms will be identified to the family level and assigned an appropriate functional feeding group category.

Data analysis will report percent dominant taxon, functional feeding group composition, and invertebrate density (#/$m^2$ for grab samples or #/100$m^3$ drift samples) for each sampling site. In addition, the data will be compared to the Box Canyon Reservoir Study by Falter et al., (1991).

## IV Presentation of aquatic mapping results (Summer 1997 field mapping)

# Aquatic Plant GIS Mapping
# Box Canyon Relicensing Project

## Summary of Project Methods and Results

Prepared for Duke Engineering & Services
July 1998

Stephen M. Farone
Resource Management, Inc.
2900-B 29th Avenue SW
Tumwater, WA 98512
(360) 754-4872

4

## Introduction

This report is submitted by Resource Management, Inc. (RMI) to Duke Engineering & Services (DE&S) in satisfaction of the requirements of "Box Canyon Relicensing Project, Aquatic Plant GIS Mapping Subcontract". This effort was undertaken in Coordination with Cascades Environmental Services (CES) to provide current and accurate maps showing the distribution of aquatic vegetation within the Box Canyon Hydroelectric Project. The digital GIS coverage produced illustrates twelve classes of submerged aquatic plant communities identified by CES in August 1997.

Submerged aquatic plant communities were mapped using a combination of techniques including interpretation of field data provided by boat survey, underwater SCUBA survey, and depth profile data, as well as manual interpretation and computer image processing of digital aerial imagery.

<u>Products Delivered</u>

- GIS vector polygon file and attribute table compatible with MicroStation platform.
  File name: BC97AQTC.e00
- GIS Metadata file
- Brief report summarizing methods with printed examples of map coverage.

Resulting GIS coverage of Box Canyon Relicensing Project area



5

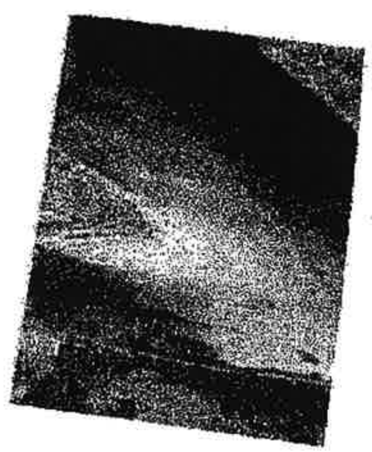
## Methods

### Materials

The methodology for this project was designed to maximize useful map and data for DE&S by using all available data. Multispectral digital aerial imagery, SCUBA field data, and bathymetric data were used together in this effort.

For reference, base coverages including shorelines, surface topography, roads and buildings adjacent to the project area were provided by DE&S in ArcINFO format. These coverages were used as the base map layer; all created data was projected to match this shoreline coverage.

The digital aerial imagery was collected for DE&S by Utah State University with their proprietary system which featured 0.5-meter pixel resolution over approximately 90% of the project, and 1.0-meter resolution over the remaining areas. The imagery was similar in appearance and utility to low resolution false color infrared (CIR) aerial photography. The three spectral bands sensed by the three camera system were centered in the green (0.55 um), red (0.65 um), and near-infrared (0.85 um) portions of the electromagnetic spectrum. Camera exposures were calibrated during collection using a four-band radiometer aligned to the cameras. All digital imagery was georeferenced and rectified to the match the existing ArcINFO GIS vector coverage of Box Canyon Reservoir. Further details of the image acquisition and processing can be found in the Draft Scope of Work: Delineation of Aquatic Plant Communities, Appendix A.



Digital Aerial Image

SCUBA (self-contained underwater breathing apparatus) dive survey conducted by CES in August 1997 yielded descriptive data and sketch-mapped locations on 1:4800 scale maps which were provided to RMI. These data consisted of diver's descriptions of aquatic plants at points along transects extending from shore to depth at 39 locations. General observations on aquatic plants were also noted on the maps at many more locations over the project.

Each sample in the dive transect data was classified by CES as one of 13 aquatic plant community categories, as follows:

1d = polygons including EWM estimated >90% of community, high density
1m = polygons including EWM estimated >90% of community, medium density
1s = polygons including EWM estimated >90% of community, low density
2d = polygons including EWM estimated 50-90% of community, high density
2m = polygons including EWM estimated 50-90% of community, medium density
2s = polygons including EWM estimated 50-90% of community, low density
3d = polygons including EWM estimated 10-49% of community, high density
3m = polygons including EWM estimated 10-49% of community, medium density
3s = polygons including EWM estimated 10-49% of community, low density
4d = polygons including EWM estimated <10% of community, high density
4m = polygons including EWM estimated <10% of community, medium density
4s = polygons including EWM estimated <10% of community, low density
Absent = polygons including no known submerged aquatic vegetation
In addition, one additional category "island_emergent" was created to classify areas in the resulting map coverage, which were above water line and included islands or emergent wetland vegetation.

Bathymetric data used by RMI included depth soundings of the river bottom collected by CES using an Acoustic Doppler Current Profiler. These data were georeferenced to the existing ArcINFO GIS vector base map of the project by DE&S and delivered to RMI in vector GIS format.

Data and Methodology Review

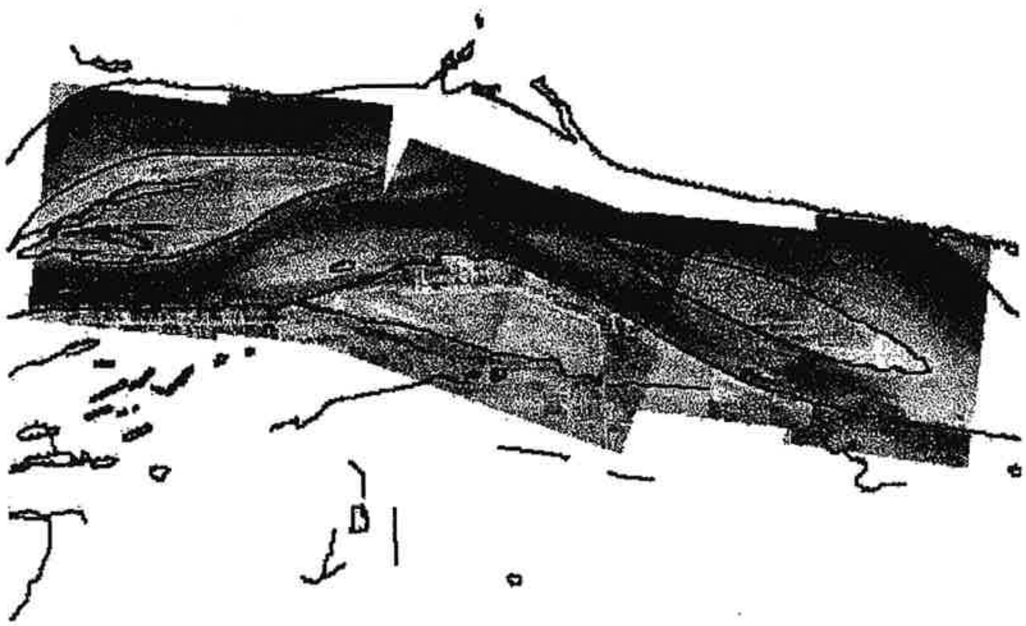
RMI reviewed all materials and data with Kent Doughty of CES. Results of RMI's initial viewing and tests of the image data were discussed, and adjustments in the mapping methodology were approved. Expectations for accuracy and detail of the final product were agreed upon. Requirements for final digital file output of the project results were discussed with Paul Just of DE&S.

SCUBA dive transect data in which locations had been classified to 13 plant community classes by CES was further generalized by RMI to a level of detail which could be consistently mapped using the provided aerial and field data. In general, submerged plant communities cannot be differentiated as clearly from aerial imagery as they can during underwater SCUBA survey, yet dive survey transects were not available in all areas. Generalizing the SCUBA transect data allowed the resulting map coverage to present a level of detail consistent between areas in which dive transect data was available and areas mapped only from aerial image interpretation.

Image Processing and Interpretation

Aerial imagery formatted for DE&S by the Remote Sensing Services Laboratory at Utah State University was formatted for use in MicroImages TNTmips image processing and geographic information system. All data was projected to State Plane projection, Washington North Zone, 1983 North American Datum, in feet. The imagery was overlaid with existing ArcINFO GIS vector coverage of the project area and checked for spatial accuracy.

Interpretation of the aerial imagery was performed using a combination of manual interpretation of digital images and digital image processing. Manual interpretation of images was performed while the images were viewed on a high-resolution computer monitor. This included delineating approximate boundaries between differing submerged plant communities by visible RGB color and texture, and classifying each delineated community as one of 13 types. CES's dive transect data and anecdotal field data was used extensively throughout this interpretation work, particularly since the appearance of plant communities on aerial imagery varies with the depth and movement of water and other parameters.

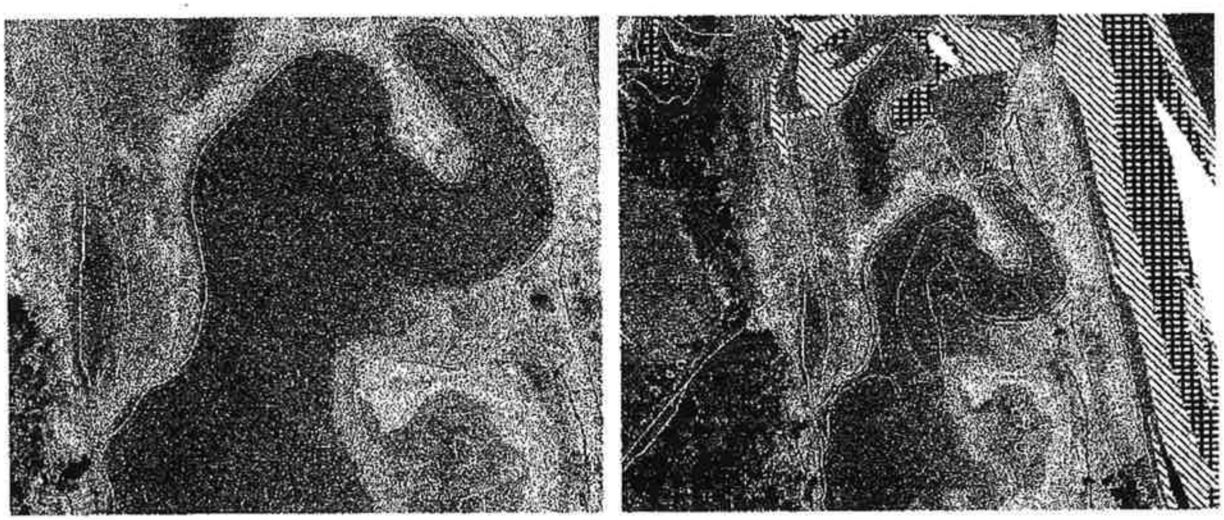


Shorelines from vector GIS data projected together with digital aerial images

Digital image enhancements were performed on some of the imagery where appropriate to assist in identifying similar plant communities. Due to artifacts present on the imagery such as contrast vignetting and internal lens reflections recorded on the images, consistent classification of many portions of the images through image processing was not feasible. Where possible, image processing was used to compare known sites described by dive transect data to adjacent unsurveyed areas. In these cases, image data was classified by a supervised image training and classification scheme in which approximate spectral signatures were sampled at image training sites (selected locations where dive transect data were coextant with high quality portions of images) and other features visible on the image that were spectrally similar to these training sites were then identified.

<u>GIS vector data production:</u>

Delineations of plant communities were performed with heads-up digitizing techniques in a vector GIS software environment. This allowed all images and reference map layers to be viewed together during the mapping process. All plant communities were delineated as vector polygons directly over the raw or processed images while working at a view scale of 1: 3600 (1 inch = 300 feet).

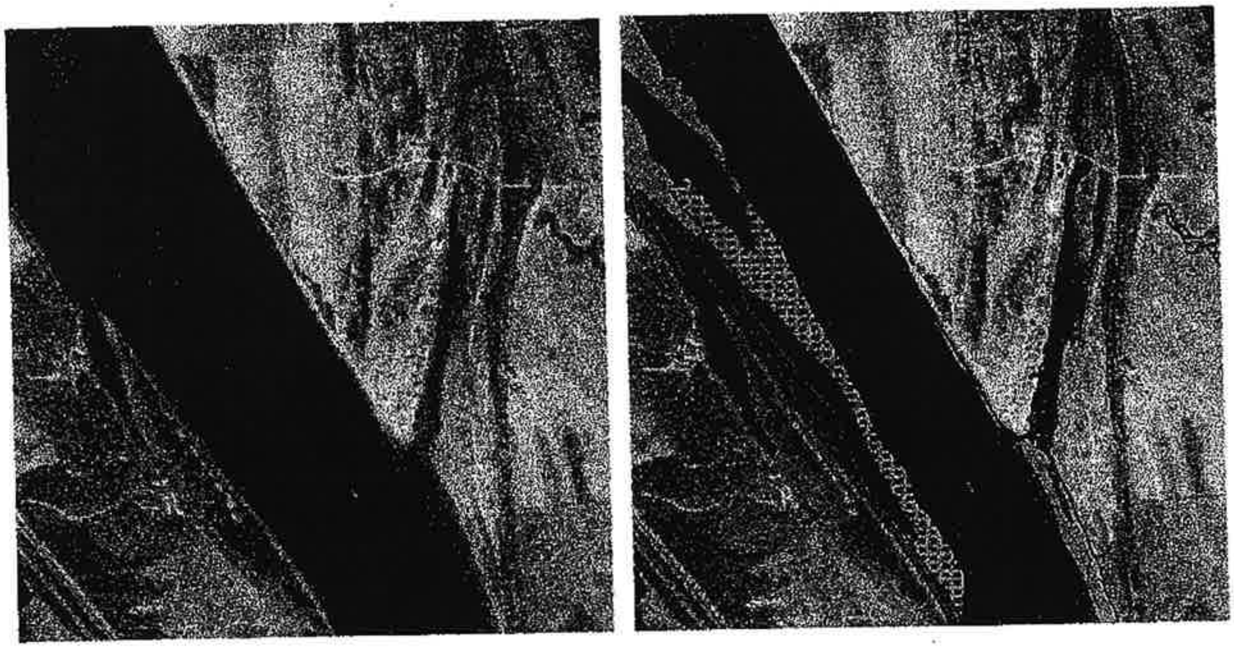


Heads-up digitizing process over aerial imagery and attribute attachment to polygons.

After completion of the vector coverage, additional vector data was received from DE&S representing bathymetric transects showing depths to substrate as recorded by CES with the Acoustic Doppler Current Profiler. This data was used to edit the deepwater boundaries of those plant communities not clearly visible on the aerial images. SCUBA dive transect data was used in conjunction with these bathymetric transect data to estimate unknown deepwater boundaries as closely as possible.

Once digitized, all polygon line segments were splined to smooth digitizing errors and thinned to reduce the density of line vertices. The resulting GIS vector layer was filtered and cleaned of topological errors and checked for valid vector topology.

Each polygon was attached to its appropriate class in the attribute database of 13 plant community classes. The cleaned GIS coverage and attribute table was then converted to ArcINFO GIS Export file format for transfer to DE&S.



Raw digital aerial image and resulting image overlaid with portion of GIS vector coverage

# PEND OREILLE RIVER
# EURASIAN WATERMILFOIL
# CONTROL PROGRAM 1988

## PENDD OREILLE COUNTY

Funding Assistance Provided by

U.S. Army Corps of Engineers

Washington State Department of Ecology

Pend Oreille County

WATER
*environmental services, inc.*

In association with

Kramer, Chin & Mayo, Inc.

December 1988

23

Summary of Areal Coverage of Aquatic Plants, by Group in the Reach of the Pend Oreille River Between Box Canyon Dam (rm 34.5) and Usk, Washington (rm 71.7), in acres (1988).

| Map # | Reach, in rivermiles | Group 1 | Group 2 | Group 3 | Group 4* |
|---|---|---|---|---|---|
| 1 | 71.7-69 | 55 | 222 | 30 | 100 |
| 2 | 69-66 | 110 | 328 | 20 | - |
| 3 | 66-63 | 268 | 410 | 52 | 10 |
| 4 | 63-59 | 190 | 310 | - | 61 |
| 5 | 55-59 | 53 | 29 | - | - |
| 6 | 55-51 | 40 | 22 | - | - |
| 7 | 51-47.5 | 56 | 15 | - | - |
| 8 | 47.5-44.5 | 69 | - | - | - |
| 9 | 44.5-41 | 57 | - | - | - |
| 10 | 41-37 | 47 | - | - | - |
| 11 | 37-34.5 | 11 | - | - | - |
| | | 956 | 1336 | 102 | 171 |

Group 1 =Dominated by Myriophyllum spicatum

Group 2 =Mixed plant community with M. spicatum, sparse and patchy

Group 3 =No M. spicatum, plant community dominated by M. exalbescens

Group 4*=Dominated by Elodea canadensis, Ranunculus sp., and Potamogeton spp., milfoil beginning to invade.



24

LEGEND FOR FIGURES 5 THROUGH 15

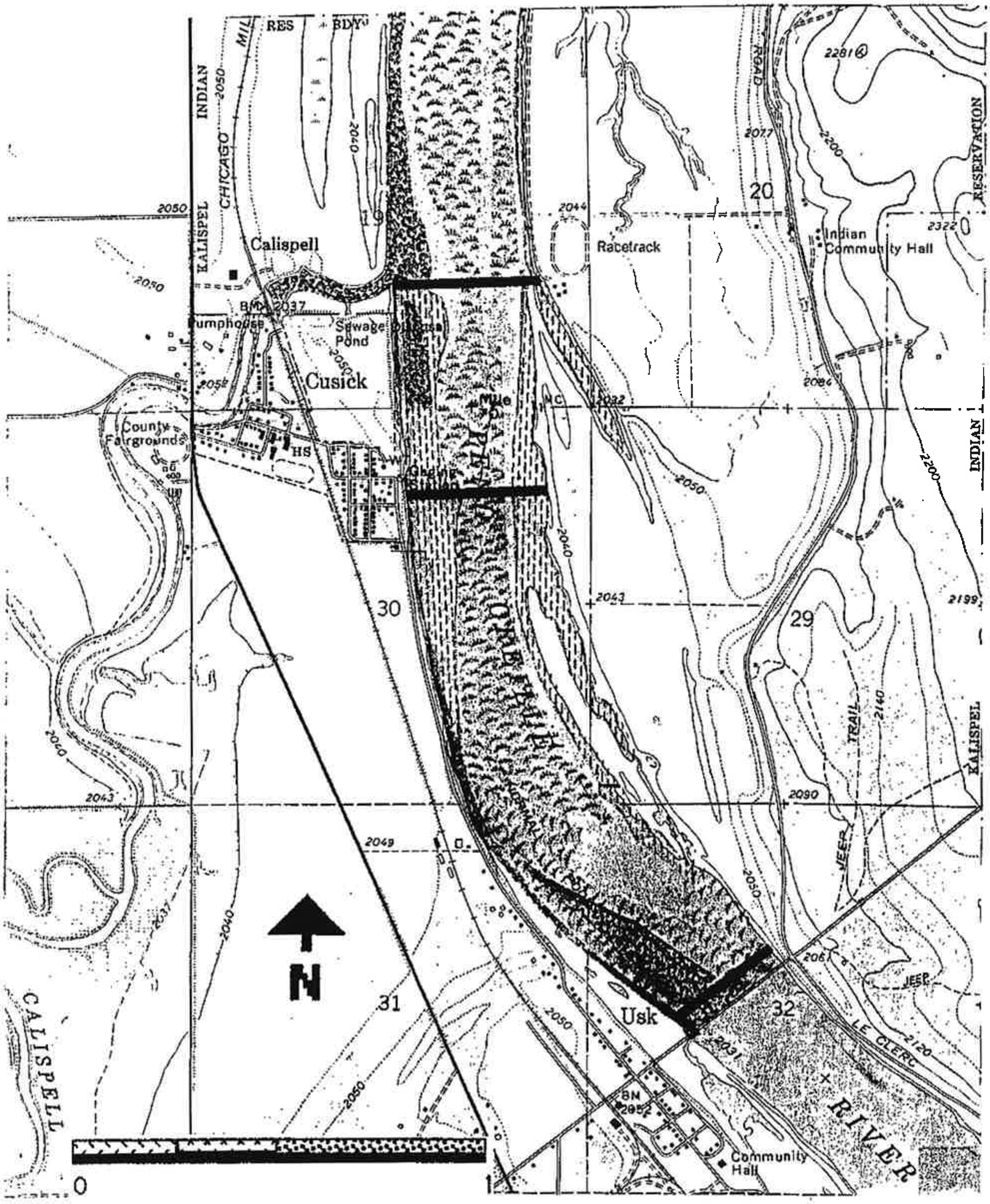
Aquatic macrophyte beds

**Group 1**. Dominated by Myriophyllum spicatum

**Group 2**. Mixed plant community with M. spicatum, sparse and patchy

**Group 3**. No M. spicatum, plant community dominated by M. exalbescens

**Group 4**. Dominated by Elodea canadensis, Ranunculus sp. and Potamogeton spp.




Mile

Figure 5. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 72-69).

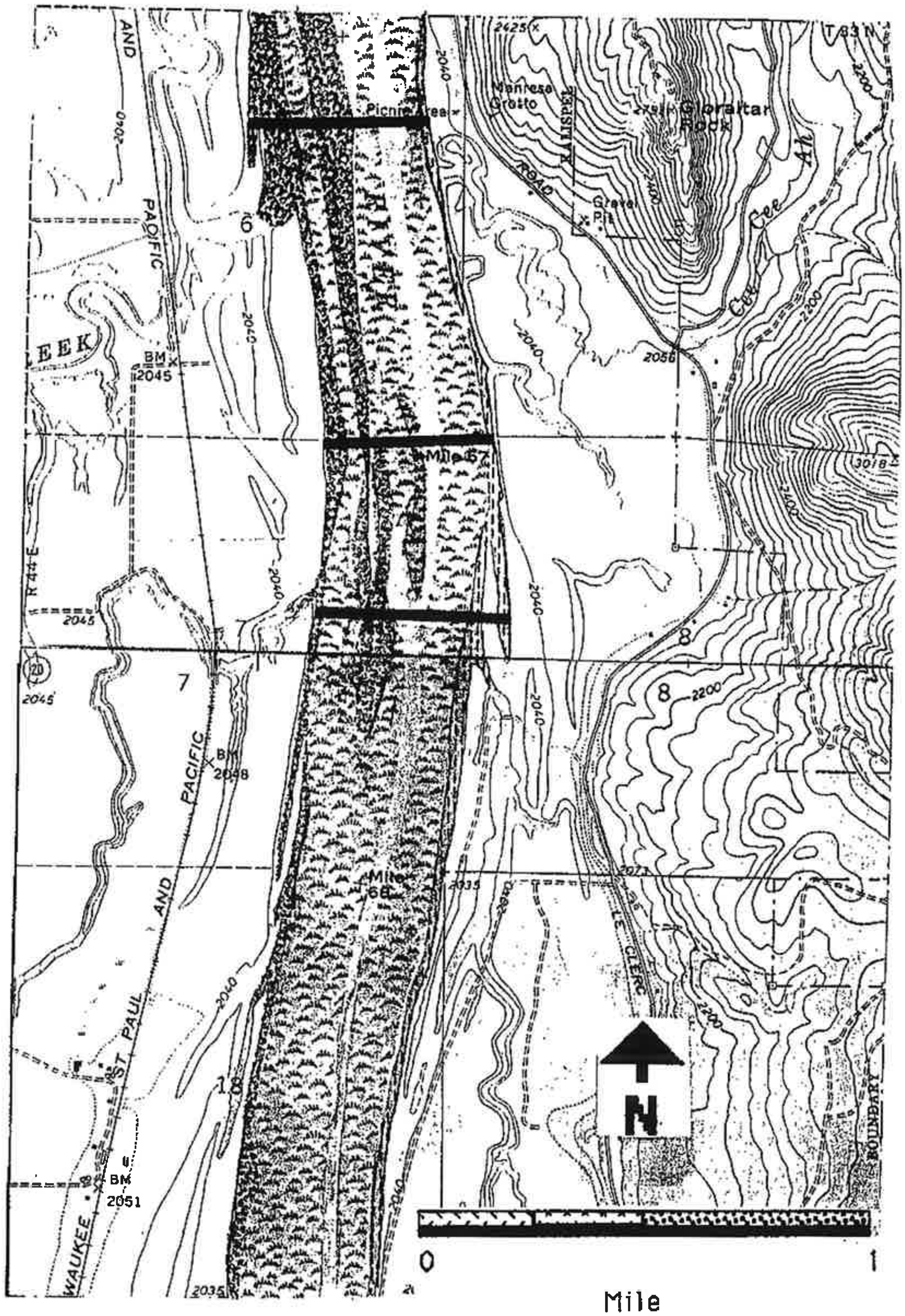



Figure 6. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 69-66).

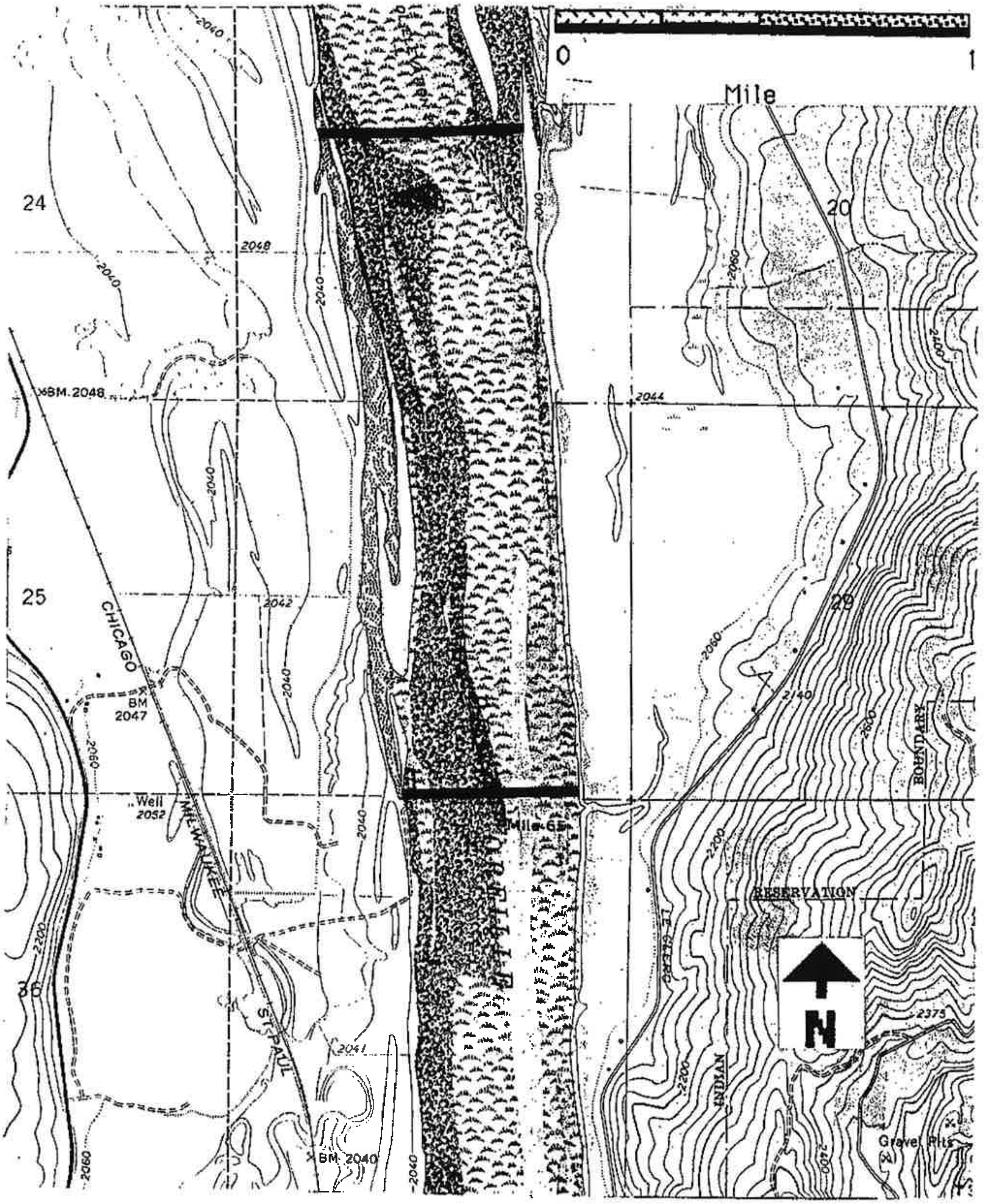



Figure 7. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 66-63).

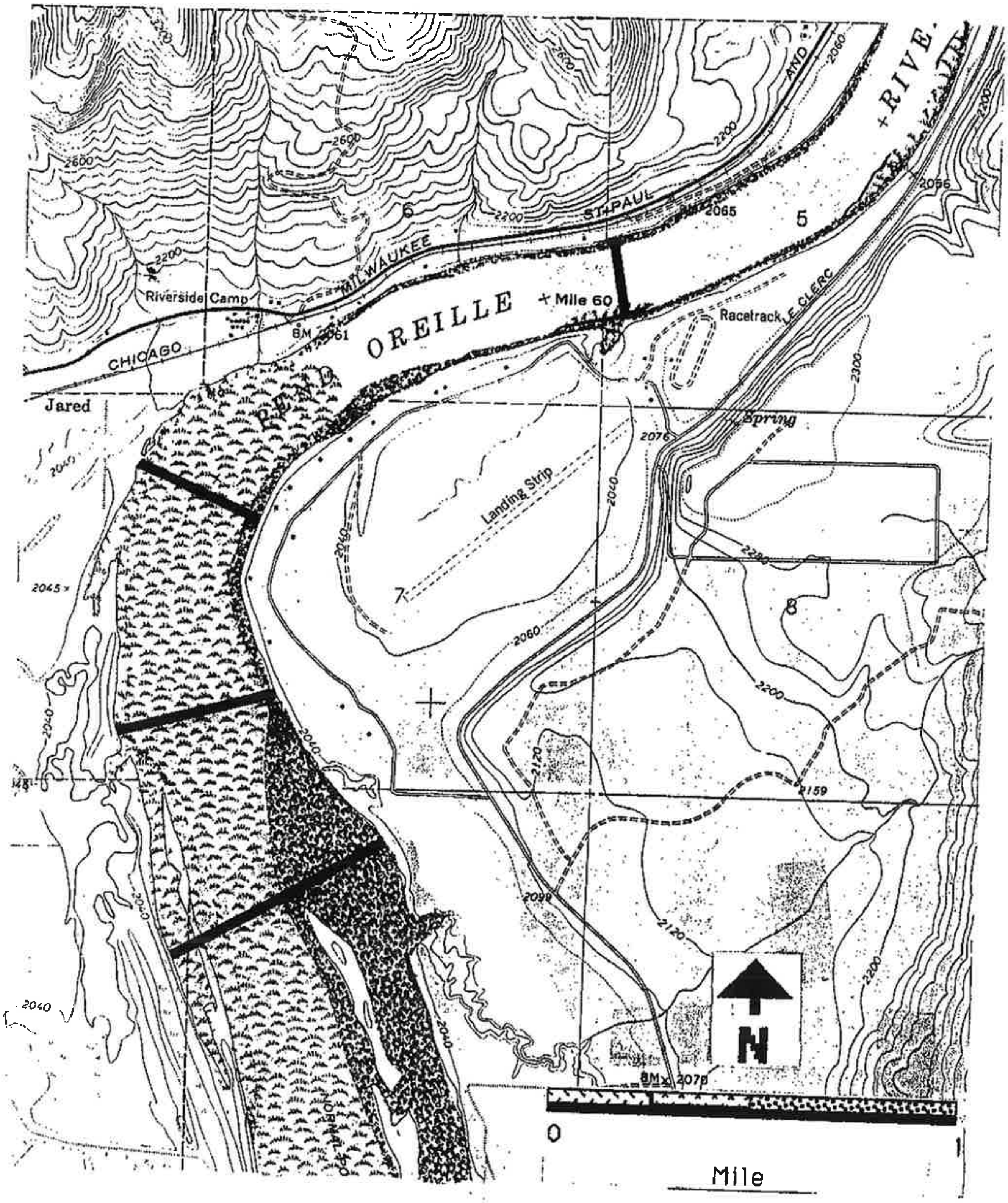



Figure 8. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 63-59).

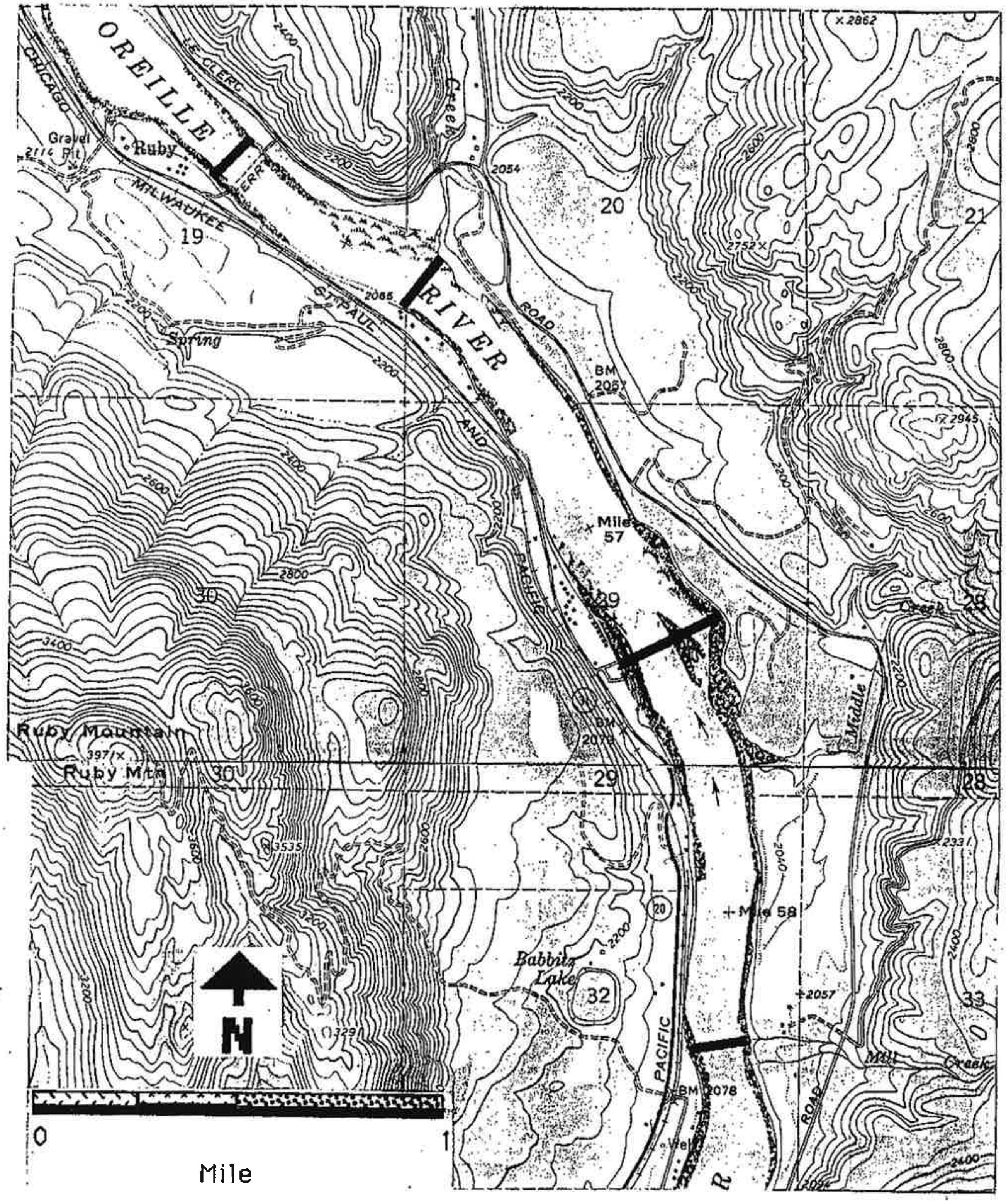



Figure 9. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 59-55).

30

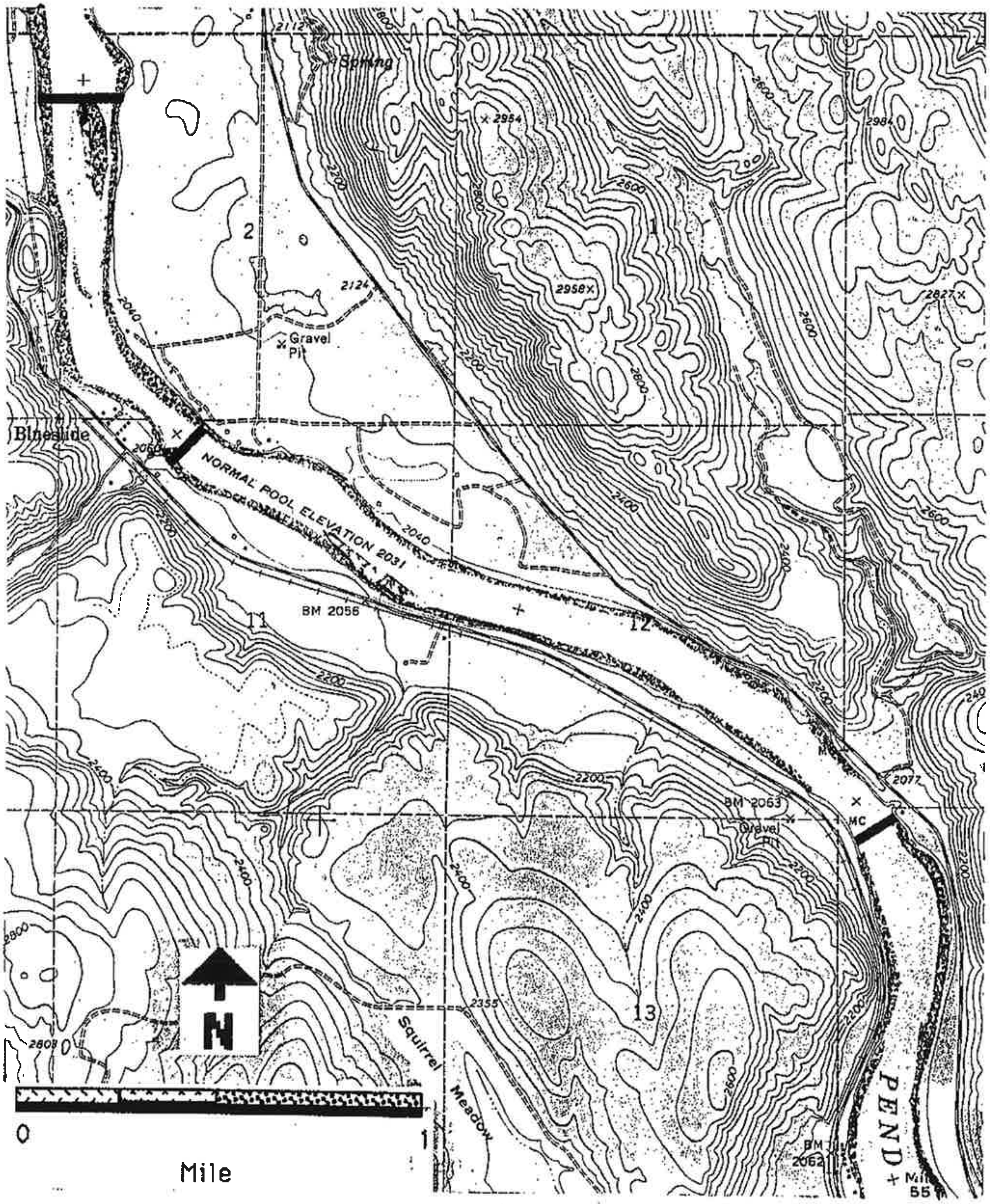



Figure 10. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 55-51).

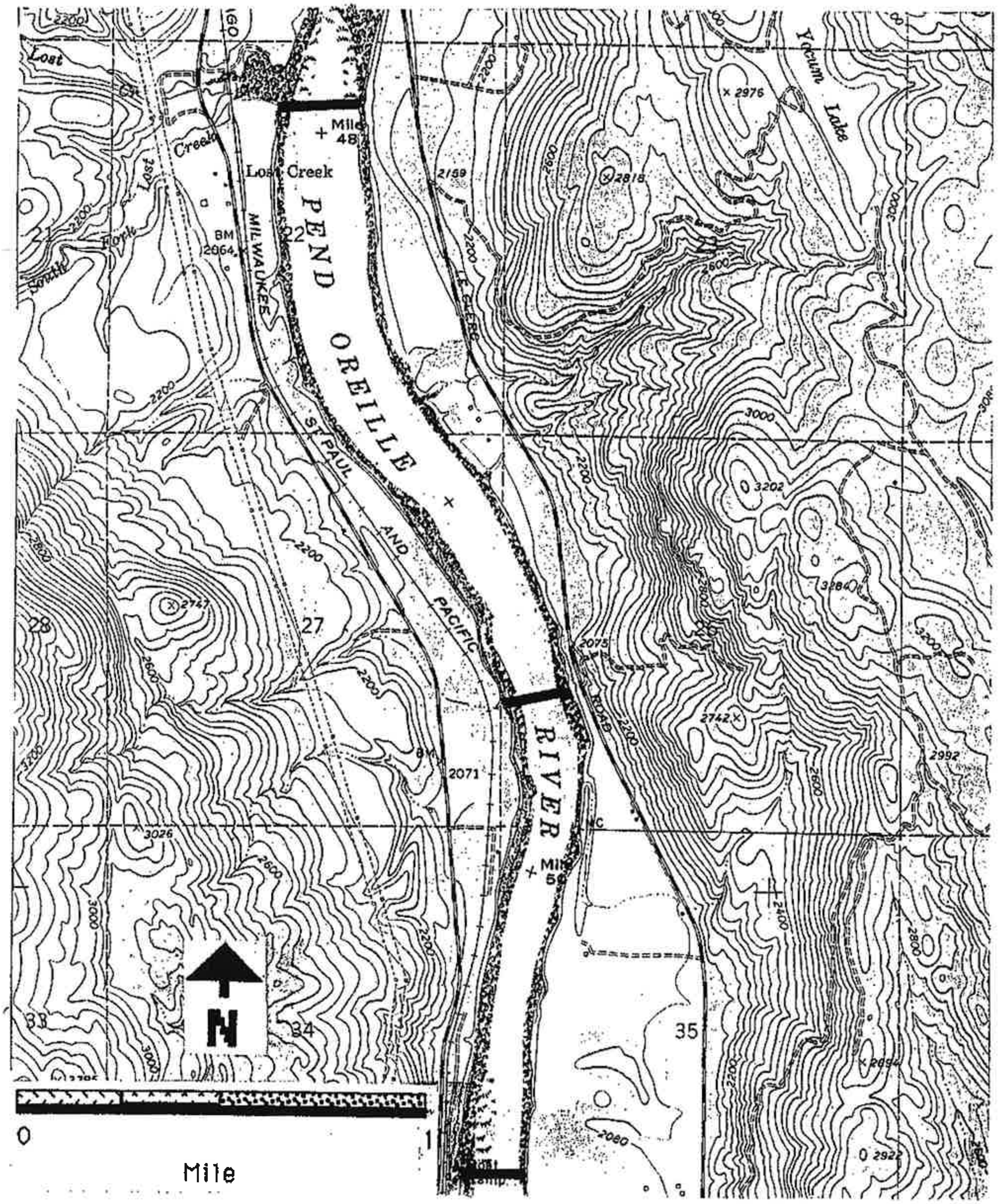



Figure 11. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 51-47.5).



32

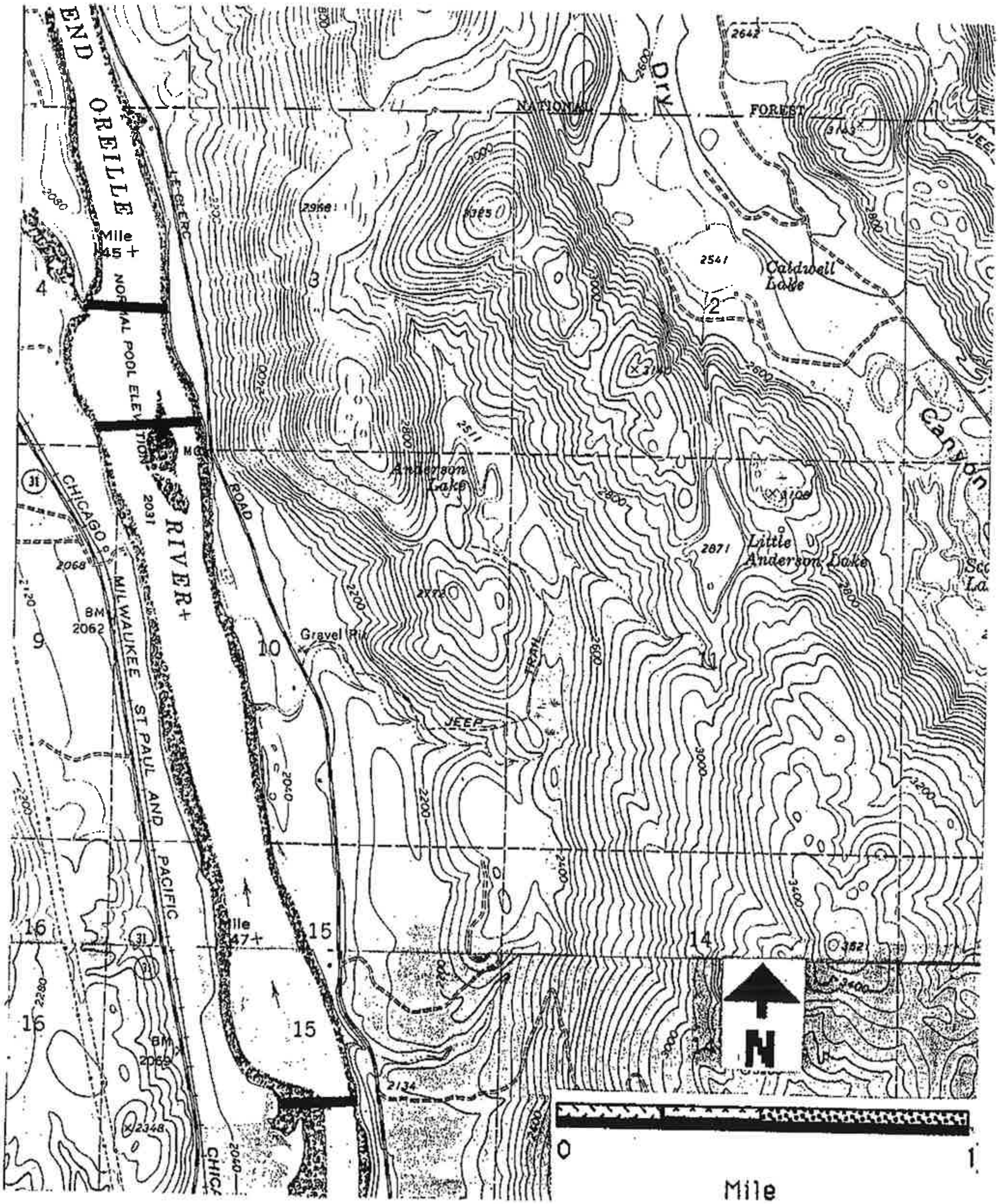



Figure 12. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 47.5-44.5).

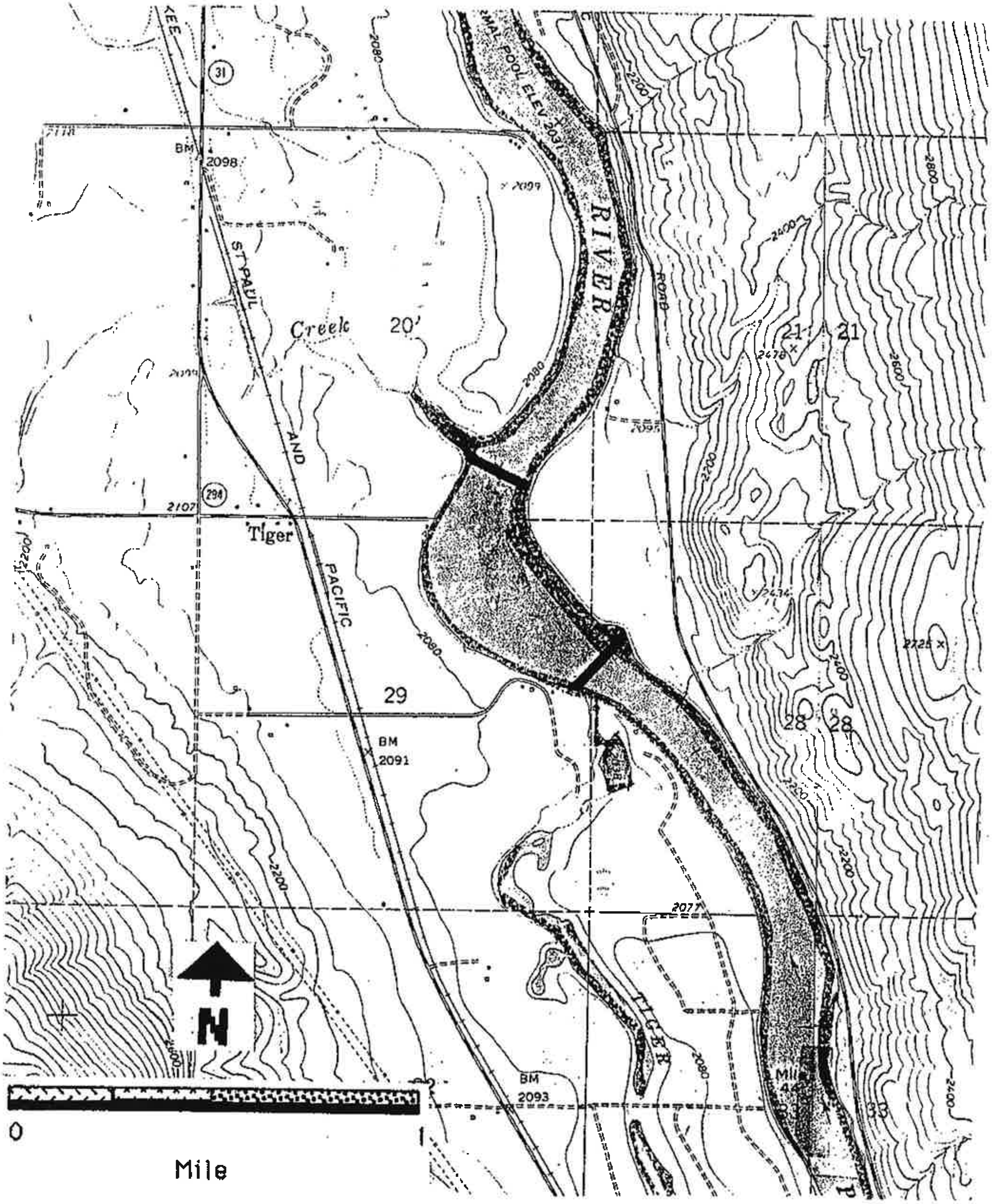



Figure 13. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 44.5-41).



34

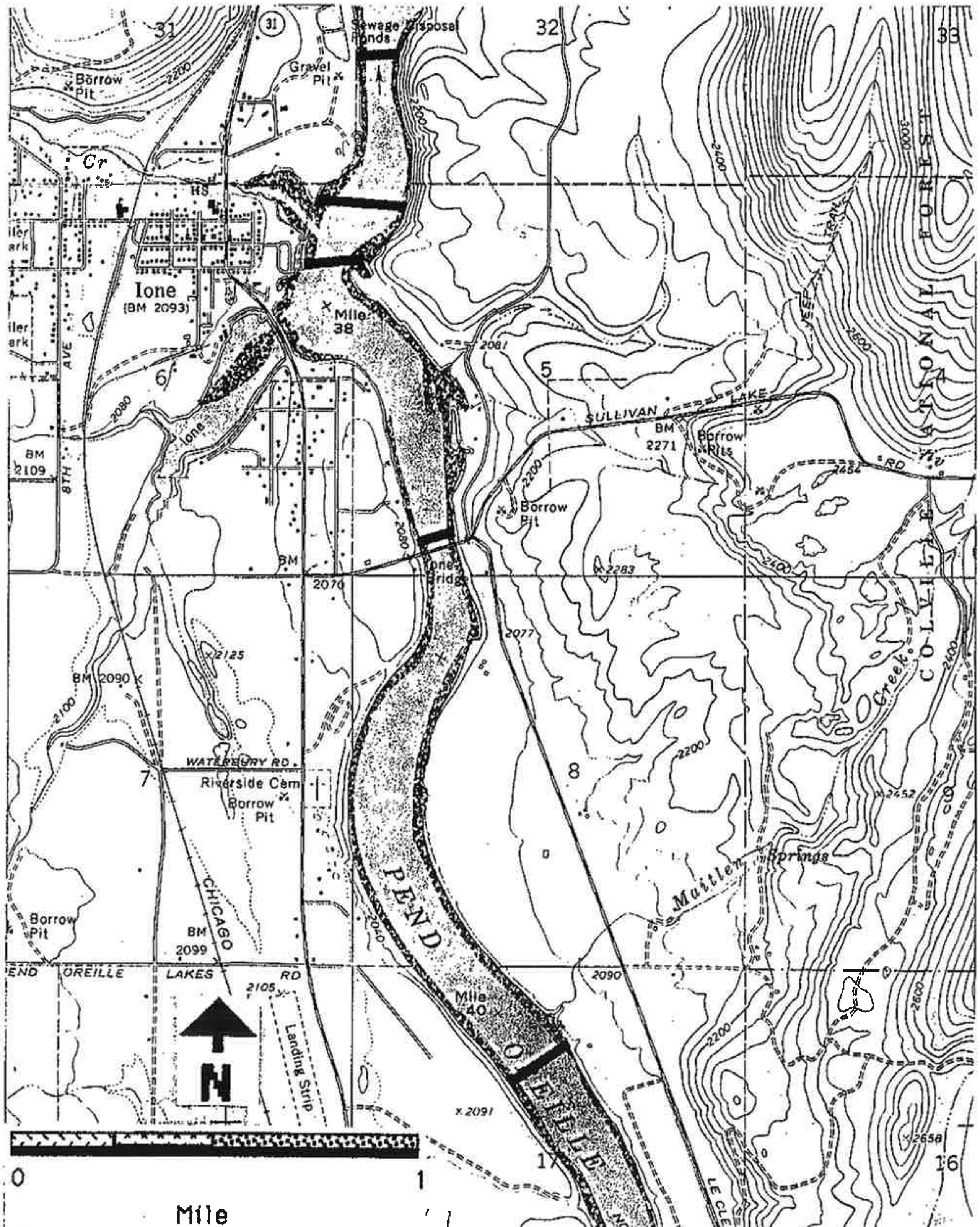



Figure 14. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 41-37).

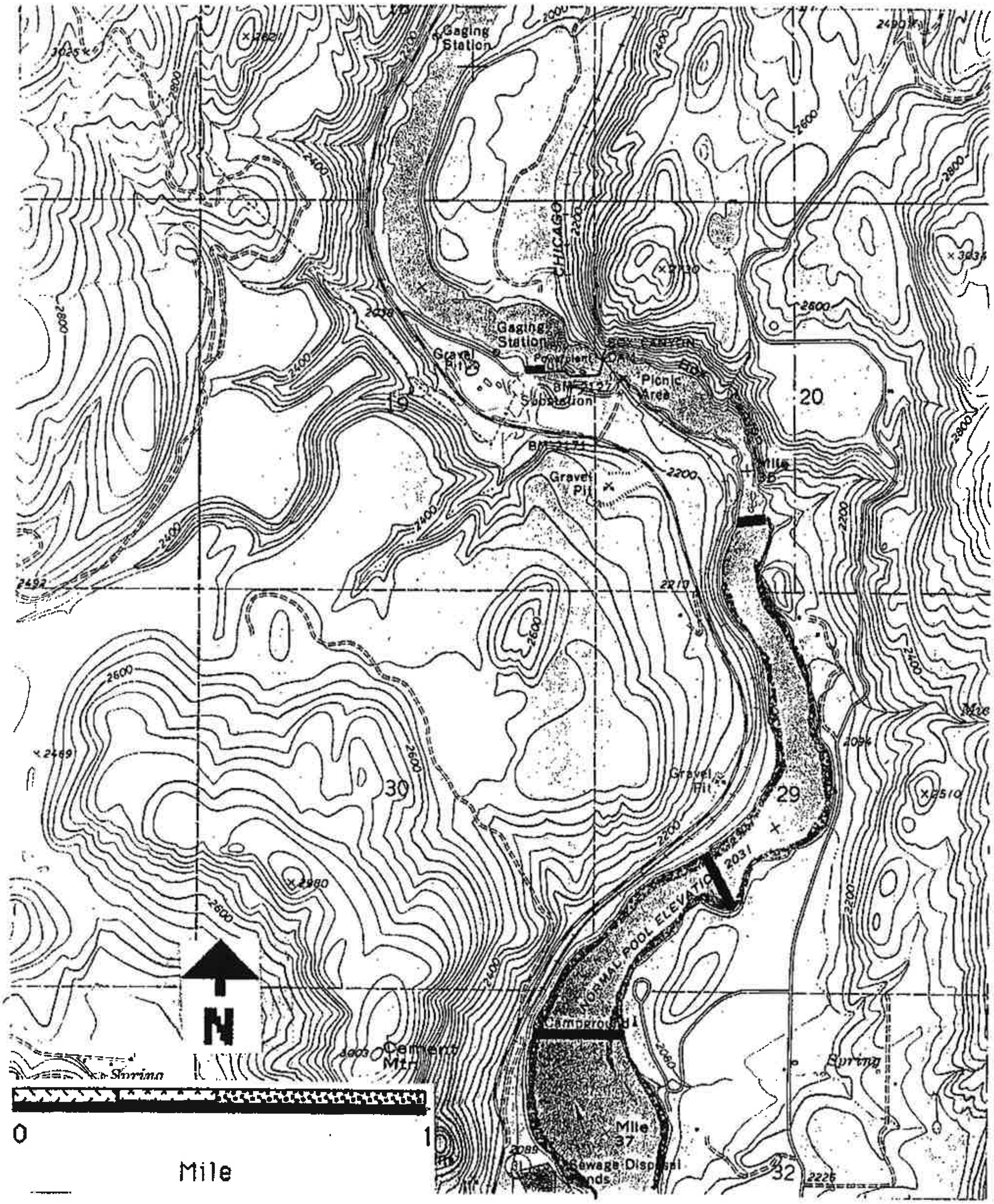



Figure 15. Areal distribution of major submerged aquatic plant species in the Pend Oreille River (RM 37–34.5).



36

# VI Rotovation Effectiveness: Review prior studies

## REVIEW OF ROTOVATION EFFECTIVENESS STUDIES FOR THE PEND OREILLE RIVER

### INTRODUCTION

Rotovation, the tilling of bottom sediments to dislodge plant roots, has been used to control aquatic macrophyte growth in the Box Canyon Reservoir since 1986. The primary goal of rotovation in the Box Canyon Hydroelectric Project area is the physical removal of Eurasian watermilfoil (*Miriophyllum spicatum spicatum*) (EWM), an invasive, non-native aquatic macrophyte. Rotovation also removes other plant species, including the non-native curled pondweed (*Potamogeton crispus*), which is probably the most abundant and widely distributed aquatic plant in the project area (CES/DES Relicensing Study Update, February 1998).

EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep. There is limited plant growth on substrates between 10 and 18 feet in depth; no plants root in substrates greater than 18 feet deep. The majority of aquatic plant communities within the reservoir are mixed beds of native and non-native plants. In general, the most dense beds have a high percentage of EWM.

From 1987 to1988 the aerial distribution of total aquatic plants did not change significantly between Box Canyon Dam and Usk. However, EWM increasingly dominated the plant community. During this period, EWM occupied nearly all available littoral habitat between Box Canyon Dam and River Bend, and continued to invade upstream areas. Between 1986 and 1988, the distribution of EWM expanded 11 miles upstream, from the Calispell River tributary (RM 69.5) to Indian Island (RM 80.5). In 1989, EWM was found upstream to RM 85.7. Apparently, the upstream dispersal of EWM occurs primarily through boating activity. Today, EWM distribution extends upstream to Albeni Falls although plant communities are limited upstream of the Newport bridge due to riverine, high velocity conditions.

EWM is a nuisance to recreational activities such as boating, fishing and swimming. In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D DMA) was used to slow the rate of advance of EWM (WATER 1985). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide. In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The British Columbia Ministry of Environment, Lands, and Parks pioneered this control technology and has successfully employed rotovation in the Okanagan Lakes Chain (Cooke et al. 1986). The Pend Oreille River program in 1986 was the first large-scale operation of its kind in the United States. The following discussion describes the effectiveness of rotovation efforts in selected areas of the Pend Oreille River.

## ROTOVATION PROGRAM

Most studies report rotovation effectiveness as a percent reduction in stem density of EWM per unit area of substrate. Post-rotovation stem densities are compared to pre-rotovation densities. Some studies have reported *carryover effectiveness* in the season or year following rotovation by comparing stem density in rotovated plots after a prescribed period of time (usually one year) to stem density in control plots that did not receive rotovation treatment.

**1986 rotovation.** In 1986, 38 acres of monotypic EWM and multi-species beds of aquatic plants were rotovated in the Pend Oreille River. Concurrent testing of the herbicide Sonar and planting of dwarf spikerush were evaluated. Stem density of EWM decreased from 63-90 percent immediately following rotovation. Other aquatic species were removed at similar rates, with the exception of *Elodea canadensis,* which dominated shallow areas that were tilled less completely by the rotovator. One year later, carryover effectiveness ranged from 10-25 percent reduction in EWM stem density. The stem densities of all aquatic macrophytes were reduced from 7-25 percent after one year. Notably, the stem density of *Elodea canadensis* increased 500 percent after one year in one rotovation plot. These results indicate that carryover control was attained for EWM but not necessarily for aquatic plants in general. Immediately after rotovation, EWM stem densities were effectively reduced, but by the second year the results were variable and total stem densities of all aquatic plants were similar to pre-rotovation levels (WATER 1988).

**1987 rotovation.** In 1987, 80 acres of EWM beds were rotovated, including dense EWM beds located in embayments near Ione and pioneer colonies near Usk. One year after rotovation, the EWM stem density was reduced by 90 percent in the Ione Park Swim bay. However, stem density of *Potamogeton* spp. increased by 20-fold in the Ione swim bay and *Elodea canadensis* also demonstrated increased stem densities. Apparently, tillage may enhance the growth of certain non-target plant species. In two adjacent rotovation plots in the main river channel, one plot had a 44 percent increase in EWM stem density, while another plot had a 25 percent decrease after one year (WATER Environmental Services 1988, 1990).

**1988 rotovation.** In 1988, approximately 55 acres were rotovated. Rotovation efforts were concentrated in the Dalkena-Furport area (RM 77-80) where new colonies of EWM were identified in 1987. Due to excessive plant biomass in EWM beds, the control program utilized a three step system in 1988. First, plant stems were cut close to the substrate using a T-bar cutter. Then the plant fragments were gathered using a clam rake tool. After initial removal of this material, the substrate was tilled using the rototiller head to dislodge plant roots(WATER Environmental Services 1988: Pend Oreille River Eurasian watermilfoil Control Program 1988).

Immediately after rotovation, stem density was reduced from 85-94 percent. After one year, stem density in one rotovation plot increased by 44 percent over pretreatment density. This increase was mainly due to small root systems resulting from reinfestation by fragments from outside the plot. Another plot had 25 percent lower stem density than pre-treatment levels after one year (WATER 1990).

**1992 rotovation.** In 1992, rotovation treatment significantly reduced macrophyte biomass in four months following rotovation (Falter et al. 1991)

**Current program.** Approximately 200 acres per year were being rotovated in the Pend Oreille River as of 1995. The rotovator is a boat-mounted Aquamog™ 8-foot long tiller with an effective operational depth of 16-18 feet. In each site two passes are made with the rotovator; the first pass is parallel to the shore and the second pass is perpendicular to the shore. Fragments are not typically collected except in areas of heavy infestation where plant material can be rolled onto the tiller blade and deposited on shore. Most of the plant material washes up on the shore downstream of the treatment site. Rotovation treatments focus on high use areas in the main river channel. The only slough rotovated is Tiger Inlet.

## RE-ESTABLISHMENT OF MACROPHYTES FOLLOWING ROTOVATION

Studies show that EWM will re-establish in rotovated sites, either from EWM fragments or remaining rootcrowns (WDOE 1998, Cooke et al. 1993). After rotovation, dislodged EWM root crowns and stems float to the surface and are either collected or left to wash to shore (Cooke et al. 1993). Since EWM reproduces mainly by fragmentation and dispersal, rotovation may intensify EWM infestations by creation of fragments. While it is generally believed that the fragments released by harvest are fewer than those that would have been released by the intact bed, no research has addressed this question specifically in Box Canyon Reservoir or similar systems (Cooke et al. 1993). Certainly, collection of plant biomass after rotovation would decrease the likelihood of re-establishment of EWM fragments. However, this control method would be extremely labor- and time-intesive, and appropriate disposal options would have to be found for the harvested plant biomass.

In addition to fragment dispersal, EWM will readily recolonize rotovated sites if the substrate is incompletely tilled. In the Pend Oreille River, more substrate area was missed by the rotovator with parallel tilling sweeps than with two perpendicular sweeps (WATER 1988). Areas of the substrate tend to be missed more often when the operator guides the rotovator using visual tracking. Aquatic resource managers in British

Columbia have used a portable surface buoy system to improve machine tracking and reduce the occurrence of missed areas. In dense macrophyte beds, successive annual treatments are recommended to attain a reduction in root masses, especially during the initial treatment years (WATER 1988).

In addition to EWM, other species of aquatic plants will invade sites after rotovation (Maxnuk 1979, Bryan and Armour 1982, Gibbons and Gibbons 1988, Cooke et al. 1993). In particular, the non-native *Potamogeton crispus* invades readily (Maxnuk 1979). The eventual re-establishment of macrophytes in rotovated sites is inevitable without continued preventatives such as herbicides or repeat rotovation. Thus, the objective of rotovation programs should be to maximize the benefits of each rotovation treatment.

Newroth (1986) suggests conducting rotovation treatments in the winter or spring, when EWM biomass is reduced and fragments are less viable. To minimize reinvasion by EWM and other species, WATER (1988) recommends rotovation in the fall, followed by a subsequent rotovation treatment in the spring.

## ECOLOGICAL EFFECTS OF ROTOVATION

Most rotovation studies concentrate on rates of plant removal and recolonization. Very few studies have addressed the ecological effects of rotovation. In Box Canyon Reservoir, aquatic macrophytes provide aquatic habitat complexity. The distribution of macrophytes likely influences the density, diversity and distribution of aquatic animals.

Removal of macrophyte biomass by rotovation has dramatic effects on fish and invertebrate habitat. Rotovation can affect fish cover, water temperature, light penetration, sedimentation patterns, and DO levels, which in turn may affect primary and secondary productivity (Falter et al. 1991). Macrophytes act as "nutrient pumps" via growth and senescence, translocating nutrients from the sediments into the water column. Removal of macrophytes eliminates this important function. Falter et al. (1991) investigated the effects of rotovation on phytoplankton and zooplankton communities. Phytoplankton density and biomass and zooplankton density, biomass and diversity decreased in rotovated areas. They concluded that extensive rotovation may be detrimental to the zooplankton food base of juvenile sport fishes. Their recommendation, from a fisheries management perspective, was that "clear cut" and wide spread rotovation treatments be cautiously evaluated.

## ROTOVATION EFFECTIVENESS

Cooke et al. (1993) provide a recent review of rotovation effectiveness, particularly for the removal of EWM. In British Columbia, rotovation reduced EWM by 80-97 percent and carryover benefits were documented to persist for a year or more. They found that two tillage passes were required to provide acceptable standards of control, particularly in silt and clay substrates. They recommend significant overlap in rototilled strips to avoid missing areas of substrate. According to Cooke et al. (1993) regrowth of EWM in rotovated areas is dependent on the following factors:

- The time and care taken by the equipment operator, and operator experience
- The condition of the rotovation equipment
- The physical conditions of the treatment site (including presence of obstacles and rocks, slope, substrate type)
- The proximity and density of untreated sources of viable EWM fragments to aid reinfestation
- The frequency of previous derooting treatments of the area and the pretreatement density of the target plants

Rotovation effectiveness in the Pend Oreille River has been variable. While stem density of EWM and other aquatic macrophytes are effectively reduced by rotovation, recolonization rates vary widely. Carryover effectiveness has been observed, however in some cases density of re-established macrophytes exceeds pre-treatment densities. This highlights the fact that in evaluating the effects of rotovation, it is important to note the total aquatic macrophyte stem density in studies, not simply EWM stem density, as other species may invade at increased rates rotovation treatment.

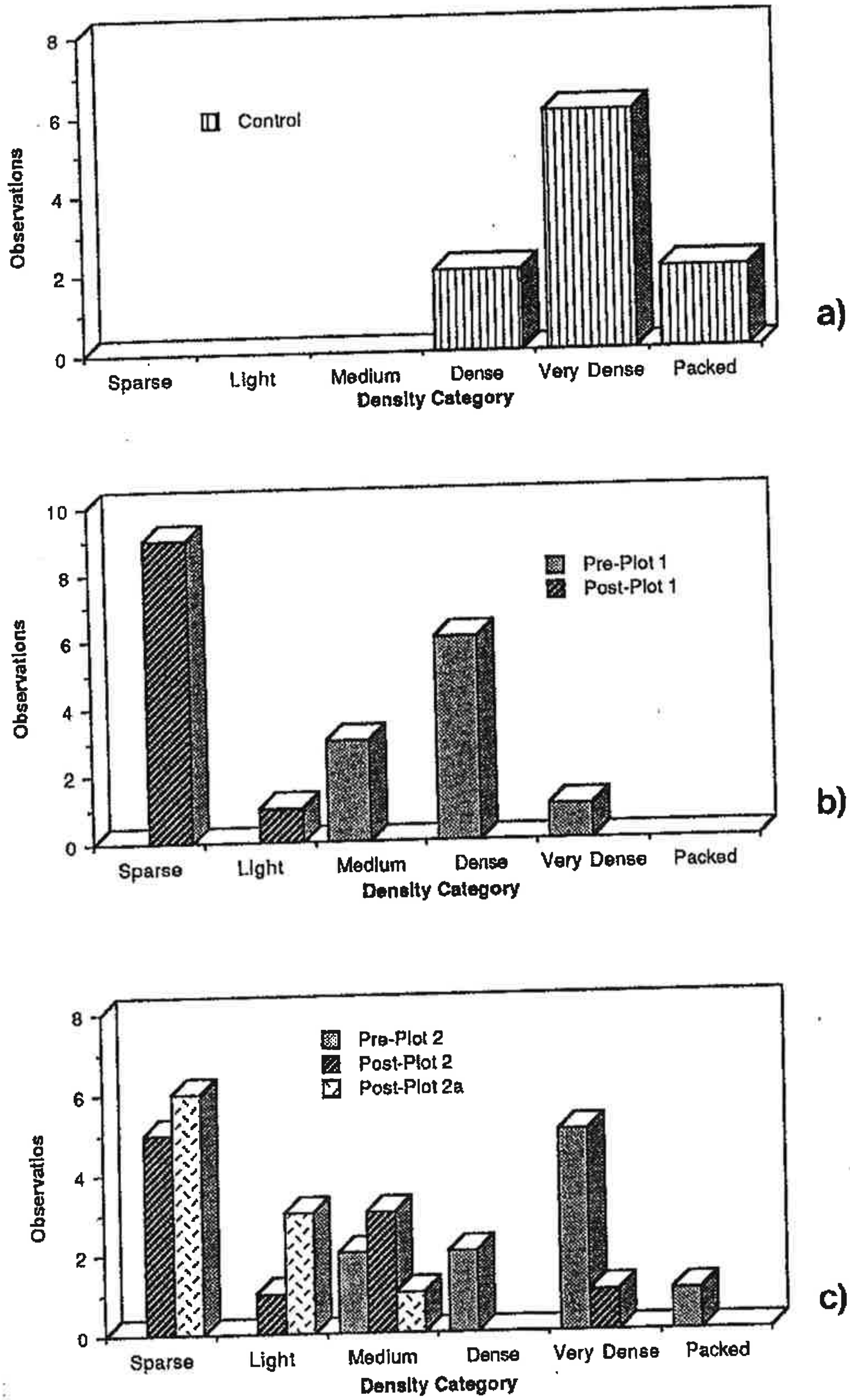



Figure 19. Histograms displaying milfoil stem count frequency distribution of a) Control Plot samples, and of pre- and post-treatment samples from b) Plot 1 and c) Plot 2.

Eurasian Watermilfoil density observations in rotovation performance trials Control Plot, test Plot 1, and test Plot 2 in the Pend Oreille River. Counts are in stems per square meter before and after rotovation.

| Plot Treatment | Plot 1 pre-tilling | Plot 1 post-tilling | Plot 2 pre-tilling | Plot 2 post-1st till | Plot 2 post-2nd till | Control Plot No-tilling |
|---|---|---|---|---|---|---|
| count/sq m | 270 | 0 | 520 | 0 | 0 | 560 |
| | 200 | 80 | 350 | 30 | 20 | 380 |
| | 360 | 0 | 320 | 0 | 0 | 370 |
| | 320 | 0 | 390 | 0 | 220 | 430 |
| | 300 | 10 | 390 | 0 | 0 | 400 |
| | 340 | 0 | 370 | 430 | 70 | 570 |
| | 220 | 0 | 400 | 130 | 0 | 310 |
| | 300 | 10 | 370 | 80 | 40 | 420 |
| | 140 | 50 | 200 | 190 | 90 | 270 |
| | 260 | 20 | 230 | 160 | 80 | 360 |
| Mean | 271 | 17 | 354 | 102 | 52 | 407 |
| Median | 285 | 5 | 370 | 55 | 30 | 390 |
| Standard Deviation | 68 | 27 | 90 | 136 | 69 | 96 |
| % Reduction | | -93.7 | | -71.2 | -85.3 | |



43

Ione Swim Bay: Plant stem density, before and one year after rotovation, in stems per square meter.

| Plant Species | Myriophyllum spicatum | | Ceratophyllum demersum | | Elodea canadensis | | Potamogeton spp. | | Chara sp. | | Ranunculus sp. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| count/sq m | 650 | 40 | 20 | 0 | 20 | 0 | 0 | 100 | 0 | 0 | 0 | 0 |
| | 900 | 90 | 20 | 0 | 0 | 20 | 20 | 590 | 0 | 0 | 0 | 0 |
| | 770 | 0 | 10 | 0 | 10 | 210 | 20 | 660 | 0 | 0 | 0 | 0 |
| | 750 | 110 | 0 | 0 | 0 | 220 | 20 | 430 | 0 | 0 | 0 | 0 |
| | | 80 | | 0 | | 300 | | 400 | 0 | 70 | 0 | 0 |
| | | 0 | | 0 | | 50 | | 170 | 0 | 390 | 0 | 0 |
| | | 170 | | 0 | | 660 | | 420 | 0 | 50 | 0 | 10 |
| | | 100 | | 10 | | 10 | | 90 | 0 | 70 | 0 | 0 |
| | | 50 | | 0 | | 170 | | 80 | 0 | 40 | 0 | 0 |
| | | 150 | | 0 | | 100 | | 30 | 0 | 0 | 0 | 0 |
| Mean | 768 | 79 | 13 | 1 | 8 | 174 | 15 | 297 | 0 | 62 | 0 | 1 |
| Median | 760 | 85 | | | | | | | | | | |
| Standard Deviation | 103 | 57 | | | | | | | | | | |



44

## VIII Alternate Control Pilot Study: Milfoil Weevil

## IX Beneficial Uses Map

**MILFOIL WEEVIL PILOT STUDY**
**STEPS TO DETERMINE FEASIBILITY**

I Understand and agree on limitations and opportunities of this control approach
- Only targets milfoil
- Other non-native plants contribute to problem and may replace milfoil
- Open water, flowing areas; may not be effective treatment
- Rotovation of weevil sites is counter productive
- Can't fully define effects geographically at micro-scale
- Results not apparent for 2-5 years
- Can reduce but not eliminate EWM

II Evaluate Cost feasibility relative to other control methods

III Determine necessary permits
- WA Dept. Agriculture
- WDFW stocking permit?
- DOE/EPA discharge permits?
- Bull trout concerns, consultation if federal action required

IV Select study sites
- allow controlled paired sites for evaluation
- need confined areas (small sloughs)
- initial tests likely limited to 1-4 acres per site
- must be in sites not subject to rotovation
- currently moderately to densely population with EWM
- Other?

V Establish pre and post treatment monitoring protocol
- plant biomass
- species composition
- weevil population
- Ecological effects?
- Physical and chemical site characteristics?
- Loon Lake Project may provide partial model for monitoring

VI Develop detailed study plan

VII Raise weevils in laboratory

VIII Release strategy

IX Coordinate with State and National efforts

X Monitor

XI Evaluate cost effectiveness as ongoing control tool

NOTED

JUL 28 1998

B. GEDDES

P.U.D. NO. 1
of Pend Oreille Co

JUL 14 1998

Received By ________
OK To File ________

Tom Peterson
P.O. Box 1947
Newport, WA 99156
(509)447-3433

7-12-98

Re: Milfoil Control

Bob Geddes, Director of Regulatory and Environmental Affairs
Public Utility District
P.O. Box 190
Newport, WA 99156

Dear Bob:

As we discussed in our previous telephone conversation, I hope to gain the support of the PUD in the use of a native aquatic weevil, Euhrychiopsis lecontei (Dietz), as the primary control method for reducing the Eurasian watermilfoil, Myriophyllum spicatum, population which currently infests the Box Canyon Reservoir. This can be accomplished by augmenting the existing weevil population using any of the following methods: 1) introduction of laboratory reared weevils, 2) relocation of adult weevils or 3) a combination of 1 and 2. All weevils are then placed in predetermined sites and monitored for density and milfoil reduction.

It is widely belived that Northern watermilfoil, Myriophyllum sibiricum, is the host to E. lecontei. Fecundity on Eurasian is approximately 5 times greater than on Northern milfoil and is non existent on the other aquatic plants in the reservoir. Weevil survival rates on Northern and Eurasian milfoil is 100% and ranges from 33% to 0% on the remaining plants in the reservoir. Since this native weevil only reproduces on these 2 plant species in our system, it is very unlikely that they would become a nuisance as is the case with other biological controls.

Unfortunately, weevil augmentation is not a quick fix solution to the milfoil problem. In order to drop a bed of milfoil you need to achieve a density of about 200 to 300 weevils per square meter. This will include weevils of all the different life stages such as egg, larvae, pupae and adult. Now if I were to rear adult weevils in my tanks, then put 1,000 weevils of various life stages into the Box Canyon system, after 90 days, there would be about 1.1 million in the system. It takes a little over 800,000 weevils to decimate an acre of milfoil. I could also introduce 1,000 adults into the system and after 90 days, there should be about 4.24 million weevils in the system which would equate to a reduction of 5.24 acres of milfoil. The time frame for weevil introductions would be from late June or early July to the middle of September. This time could be extended depending on water levels and weather conditions. You could also retain a number of weevils in the lab over the winter months and then begin the lab rearing process as soon as feasible in the spring.

Here's a brief explanation of how the lab rearing process works. I use a variety of different size tanks which are heated and aerated. Cleaned milfoil bundles are placed in the tanks and after the water temperature stabilizes, predetermined number of adult weevils are introduced into the tank. After 14 days, the milfoil bundles are removed and the weevils inumerated as to their life stage and placed in plastic bags along with the weevil laden milfoil. The adult weevils are retained in the lab and placed in prepared tanks and a new culture is started. The weevil laden milfoil is then introduced into predetermined sites in the reservoir.

If weevil augmentation was to go forward, I would recommend that multible test sites be selected in semi protected cove areas of approximately 1 acre or less. Use 1 or 2 of the sites as control plots where no augmentation is to occur. In the remaining sites, augment with any of the methods mentioned above. Given the date of augmentation and the number of weevils introduced, I can make an educated guess as to the extent of damage that will occur within a specified time frame.

With regards to costs, it is very difficult to determine without an idea of the numbers to be reared and in what time frame. However, I believe that the first year costs for lab reared weevils would between $1.25 and $1.50 per weevil and would go down to between $1.25 and $1.00 in subsequent years. This cost reduction is a reflection of reduced labor costs due to the increased availability of adult weevils in the reservoir as well as improved lab techniques. These costs include the necessary part time personnel but exclude any costs for permit fees and plant or density studies since their requirements are unknown at this time.

Well Bob, I really didn't intend that this letter be as long as it is but once I get started on weevils and milfoil I tend to get a little long winded. Here's the whole thing in a nutshell. A fairly aggressive augmentation program, with the introduction of between 12,000 and 18,000 weevils, could be done for less than $20,000. A very aggressive program with the introduction of between 30,000 and 40,000 wevils couuld be done for under $45,000.

If you have any questions or comments, please free to call me.

Sincerely,

Tom Peterson

Tom Peterson

## BENEFICIAL USES MAP

I Base Map is Project Area

II Aquatic plant distribution map

III Beneficial Uses to be Addressed
Identified in WACS
- fish rearing
- fish spawning
- fishing areas
- swimming
- boating and navigation
- irrigation and agricultural water supply
- wildlife habitat
- domestic water supply systems
- industrial water supply systems

Other Uses and Concerns
- cultural sites within project boundary at risk from rotovation
- Shoreline owners
- Focused aquatic recreation facilities (boat launches, etc)

III Review and Define Aquatic Plant Management Objectives

IV Develop management interaction causal mechanism statements
- situation
- triggering mechanisms for relation to aquatic plants
- type of affects
- sensitivity of affected resource

V Develop criteria for mapping each beneficial use

VI Data entry into GIS

VII Stakeholders review draft maps of beneficial uses overlaps

VIII Revise maps

IX Define aquatic plant management strategy
- control methods and target areas
- monitoring
- public education

**Summary of Consultation**
**Water Quality Work Group Meeting**
**November 16, 1998**

A meeting of the Box Canyon Water Quality Work Group was held at the WDOE office in Spokane on November 16, 1998.

Agencies in attendance included:

| | | | |
|---|---|---|---|
| Glenn Koehn | USFS | Sharon Sorby | Pend Oreille Noxious Weed Control Board |
| Jean Parodi | WDOE | Carol Mack | Pend Oreille County Conservation District |
| Ruth Watkins | Tri-State Council | Bob Geddes | Pend Oreille PUD |
| Tony Eldred | WDFW | Kent Doughty | Cascades Environmental Services |
| Kim Cress | Citizens's Advisory Committee | Dave Potter | GANDA |
| Scott Hall | KNRD | | |

The meeting began with a summary of the physical water quality monitoring program. Kent noted that although the study called for measuring pH and conductivity as part of the 24 hour sampling program, these parameters are not stable so data would be invalid since samples sit for up to 12 hours before analysis. Kent distributed and reviewed a summary of the monthly water quality data which reported the ranges in values for various parameters. A summary of sties where temperature was monitored in 1998 was also reviewed. Kent said he would be making analyses similar to how the 1997 data were treated by multiple correlation analysis among sites.

The group next discussed preliminary results comparing water quality within and outside of aquatic plant beds. It was suggested that water quality affected by plants could be compared to water quality in Lake Pend Oreille or the Clark Fork. Kent noted and the group concurred that there would be many confounding variables which would severely limit comparisons. Tony Eldred commented on a possible dissolved oxygen sag affecting adfluvial fish movement; a D.O. say may result in a signature within macroinvertebrate populations. The group agreed that repeating the sampling once during plant scensescence is desirable.

Sharon Sorby commented that the PONWCB's primary limitation to conduct a pilot study of alternate milfoil control methods is monetary. The group still shared interest in conducting a

**BOX CANYON HYDROELECTRIC PROJECT**
**WATER QUALITY WORK GROUP MEETING**
May 25, 1999
Ramada Inn at Spokane Airport

Water Quality Work Group 9:30 am - noon

I Status update on Relicensing process and schedule

II Turbine upgrade

III Dissolved Gas study

IV 1998 Temperature monitoring results

V Beneficial Uses Map

VI Preliminary discussion of Protection, Mitigation, and Enhancement Measures (PMEs)

VII Schedule for summer field season and upcoming Work Group meetings

Lunch

Fisheries Work Group 1 - 4:30 PM

I Habitat Mapping Study

II Adfluvial Trapping Study

III Radio telemetry Study

IV Preliminary discussion of Protection, Mitigation, and Enhancement Measures (PMEs)

V Ongoing studies, schedule for summer field season and upcoming Work Group meetings

VI Status update on Relicensing process and schedule

VII Turbine upgrade

pilot milfoil weevil study. Although the weevils only target milfoil, other species may be affected by their being pulled down with the collapse of milfoil stems. Sharon described how the weevils affect plant health of milfoil. The Conservation District could possibly provide some assistance in raising weevils for release; it might be a good volunteer task for the public if the work is not too technical. A sub-committee was formed to further refine objectives and plans for a weevil pilot study (Kent Doughty, Ruth Watkins, Jean Parodi, and Carol Mack). The group would also seek input from Cathy Hammil of the WDOE. Sharon noted that no permit is needed from the USDA for biocontrol if it is not interstate transfer.

Methods used to sample macroinvertebrates were next reviewed. Tony noted that it would be interesting to go back and visit some areas with marginal substrate suitability where fines show embeddedness on underwater video. The question is do these areas scour out of fines with spring high flow, i.e., seasonally suitable.

Kent and Jean next updated the work group on the objectives and activities of the transboundary gas group. The group concurred that regional coordination was important and made sense as an efficient approach to addressing local issues within a larger context. Several work group members noted that dissolved gas data above and below Albeni Falls dam would be of interest. Someone commented that Avista is sampling total dissolved gasses (TDG) in Lake Pend Oreille. Kent will try to locate that data. A study plan for monitoring TDG at box Canyon Dam was distributed. Glenn asked about the schedule for TDG monitoring work products. Kent noted that he would be working on securing permits for a fixed station monitor to be installed downstream of Box Canyon Dam.

Kent presented the group with options and considerations for a long term aquatic plant index site. The index site would serve to indicate changes from the 1997 baseline. Tony suggested keeping a sampling strategy as simple as possible. Ecological inferences are supplemental; not part of the design but addressed in discussion of results. It was suggested that index sites reflect beneficial uses. The group thought a frequency of a minimum of every other year was appropriate. The monitoring should provide feedback to rotovation effectiveness. No definite decisions were made regarding establishing an index monitoring program for aquatic plants.

The group briefly discussed the beneficial uses maps. It was suggested that a future meeting should focus on this topic as we always run out of time to give it adequate discussion time. Getting the public involved early in the process for identifying and applying beneficial uses maps was stressed by the group. Carol Mack noted that there is more public involvement in the summer. Bob Geddes replied that the 1998 summer public meeting was very poorly attended but got good attendance at a winter meeting. Carol said the Conservation District is planning a spring fair with information booths. This might be a forum to solicit public input on beneficial uses. Kim Cress said she could help contacting local clubs if a survey questionnaire were used with regard to defining beneficial uses. Kim, Carol and Sharon offered to assist DE&S in developing a survey form to learn public interests and concerns on aquatic plant control. A comment was made that enforcement of milfoil containment laws may be on the books but not often implemented due to priorities and public understanding of the issues.

The discussion next turned to a review of the focused area assessment conducted by Forest Service. Glenn said the schedule for a draft document is mid December for a rough draft. A draft would likely be distributed to the participants sometime in February of the coming year. It was noted that the FS might want to re-visit some elements of this document to incorporate new information from ongoing studies.

Box Canyon Water Quality Summary

Monthly and 24-hour data from February-May 1998 has been entered and summarized in Table 1 and Table 2. All sampling for the 24-hour data occurs in the forebay at Box Canyon Dam. Parameters for the 24 hour sampling effort include: turbidity, pH, and conductivity. Monthly water quality data is collected at 7 sites between the town of Newport, WA and the USGS gaging station downstream of the Box Canyon Dam. Parameters measured include: temperature, pH, free acidity, total acidity, phenolpthalein alkalinity, total alkalinity, carbon dioxide, total hardness.

Table 1. Range of 24-hour Data in the Forebay of Box Canyon Dam.

| Date | Turbididty (NTU's) | pH* | Conductivity (uS/cm) |
|---|---|---|---|
| 27 February 1998 | 1.11-4.79 | 7.81-8.00 | no data |
| 4 April 1998 | 2.26-8.35 | 7.90-8.13 | 12-20 |
| 1 May 1998 | 1.60-17.60 | 7.90-8.00 | 120-140 |

*pH data may be inaccurate due to a 24 hour holding period before analysis.

Table 2. Range of Monthly Water Quality Data Composited from 7 Sites Along the Pend Oreille River.

| Water Temp (C) | pH | Free Acidity (gpg) | Total Acidity (gpg) | Phenopthalein Alkalinity (gpg) | Total Alkalinity (gpg) | Total Hardness (gpg) | Carbon Dioxide (gpg) | DO (mg/L) | DO (% saturation) |
|---|---|---|---|---|---|---|---|---|---|
| 2.6-15.0 | 8.5-9.0 | 0.0 | 1.0 | 0.0 | 5.0-6.0 | 5.0-6.0 | 5.0 | 10.05-15.11 | 80.0-123.2 |

Interpretation of results are limited at this time due to an incomplete dataset. However, some general trends can be noted from the available water quality data. Dissolved Oxygen is consistently near or exceeds full saturation and pH tends to be alkaline. Relative differences in the alkalinity and acidity data suggests that the waters of the Pend Oreille River have little free acidity and some degree of buffering capacity. The inability to detect phenopthalein alkalinity indicates that hydroxide and carbonate ions are not contributing to the overall alkalinity found in the Pend Oreille River. The consistent Carbon Dioxide values can be explained by the tendancy for surface waters to remain in equilibrium with atmospheric Carbon Dioxide. However, photosynthesis and respiration from aquatic organisms can substantially influence this equilibrium.

## AQUATIC PLANT INFLUENCE ON WATER QUALITY
## PAIRED SAMPLING

Sample Date: 9/22/98 15:00 hrs
Sample Location: Upstream of River Bend RM 62.6

| Parameter | Milfoil bed | Open Water | Ambient |
|---|---|---|---|
| Barometric Pressure | | | 709 mg Hg |
| Weather | | | Light clouds |
| Air Temperature (C) | | | 28.4 |
| Water Depth (ft) | 4.2 | 20.1 | |
| Sample Depth (ft) | 2.5 | 3.0 | |
| Water Temperature (C) | 20.2 | 19.7 | |
| Ph | 9.09 | 8.71 | |
| Conductivity ($\mu$mhos) | 150 | 160 | |
| Alkalinity (mg/l) | 4 | 4 | |
| Sechi Depth (ft) | +4.2 | 17.0 | |
| $\%O_{2\ saturation}$ | 171.3 | 114.6 | |
| %TDG | 108.2 | 104.3 | |
| Total Nitrate (mg/l) | <0.05 | <0.05 | |
| TKN (mg/l) | <0.5 | <0.5 | |
| Total Phosphorous (mg/l) | <0.5 | <0.5 | |

## Milfoil Weevil Pilot Study Approach Outline

Study Objective:

Evaluate cost effectiveness and ecological implications for use of northern milfoil weevil as a component to long term aquatic plant management in the Box Canyon Reservoir.

**Study Components**

- Literature Review (completed)
- Pilot study plots
- Monitoring
- Review Cost and feasibility of program expansion

**Pilot Study Plot Criteria**

- Confined area of 3 - 10 acres
- Range of water depths within each site 1 - 18 ft at water elev 2030.6 ft MSL
- Currently dominated by milfoil
- Not subject to rotovation

**Study Duration**

Five years with annual monitoring; Review feasibility at three years

**Study Design Considerations**

- Results will not be apparent until 3 - 5 years
- Provide for control sites
- Statistical validation of plant density by species assemblage (EWM, curly pond weed, natives)
- Seasonally track weevil density
- Stratify plot samples within a site by water depth
- Study feasibility dependent upon suitable source of weevils
- Where practicable, locate sites for multi-purpose monitoring

**Schedule**

| | 1999 | | | | 2000 | | | | 2001 | | | | 2002 | | | | 2003 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Statistical Sample Design | ■ | | | | | | | | | | | | | | | | | | | |
| Study permitting | | ■ | | | | | | | | | | | | | | | | | | |
| Propagate weevils | | ■ | | | | | | | | | | | | | | | | | | |
| Baseline sampling | | | Jly | | | | | | | | | | | | | | | | | |
| Seed areas with weevils | | | ■ | | | | | | | | | | | | | | | | | |
| Monitor plant density | | | Aug | | | | Aug | | | | Aug | | | | Aug | | | | Aug | |
| Monitor weevil density | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | ■ | ■ | |
| Feasibility Review | | | | | | | | | | | ■ | | | | | | | | | ■ |

7

## Macroinvertebrate Sampling Summary

Macroinvertebrates were sampled in the Pend Oreille River and three of its tributaries from September 8-10, 1998. Outside of the macrophyte beds, the fish habitat mapping team identified 3 key salmonid habitat types and 3 unique habitat areas to be targeted for macroinvertebrate sampling. Three sites typical of each habitat type were sampled in addition to the unique habitat areas (see Table 1). A diver operated substrate brush sampled approximately 1 $m^2$ of lage woody debris (LWD), gravel/cobble, or cobble/boulder substrates in the Pend Oreille River. The same sampling technique was utilized in the unique habitat areas at the mouth of LeClerc Creek and in the unnamed slough (rivermile 42.2). At the mouth of Cedar Creek, however, a Peterson Grab (0.30 $m^2$) was used to sample invertebrates due to the silty substrate composition.

Table 1. Pend Oreille River Macroinvertebrate Sampling Sites with Corresponding Rivermile and Transect Number from the Habitat Mapping Studies.

| Habitat Type | Transect | Depth | Rivermile (location) | Notes |
|---|---|---|---|---|
| Gravel/Cobble | T-4 | 5.0' | 88.7 (LB) | silt layer covering substrate. |
| Gravel/Cobble | T-47.1 | 21.0' | 52.1 (RB) | |
| Gravel/Cobble | T-61 | 14.0' | 38.0 (RB) | silt layer covering substrate;two brown trout fry detected while sampling. |
| Cobble/Boulder | T-1 | 6.0' | 90.1 (LB) | low water velocity. |
| Cobble/Boulder | T-44.1 | 12.0' | 55.3 (LB) | sand and silt covering substrate. |
| Cobble/Boulder | T-54 | 22.0' | 45.2 (LB) | silt layer covering substrate. |
| Large Woody Debris (LWD) | T-2 | 8.0' | 89.9 (RB) | LWD derived from sawmill activities. |
| Large Woody Debris (LWD) | T-44.1 | 16.0' | 55.3 (RB) | |
| Large Woody Debris (LWD) | T-47.1 | 20.0' | 52.1 (RB) | |
| Mouth of Cedar Creek* | n/a | 4.0' | 37.4 (LB) | silt substrate, used Peterson Grab. |
| Mouth of LeClerc Creek* | n/a | 8.0' | 56.2 (RB) | gravel/cobble substrate overlaid with silt; patchy distribution of plants. |
| Unnamed Slough* | n/a | 13' | 42.2 (LB) | cool water in thalweg; clay substrate overlaid with organics. |

*Unique habitat area designated for sampling by fish habitat mapping team.

The loading of macroinvertebrates into the Pend Oreille River was also assessed by conducting drift studies at the mouth of Cedar, LeClerc, and Indian Creeks. Three 500 micron drift nets were deployed across the width of the channel for approximately twelve hours beginning at dusk (~ 8 p.m.). A velocity and depth measurement was taken at the 0.45 $m^2$ opening of each drift net when they were initially deployed (T=0 hrs) and just before they were removed from the channel (T=12 hrs). The velocity and depth data will allow drift density to be quantified as #/100 $m^3$.

**Generally, species richness and diversity are highest in late summer/early fall when its possible to capture the instar stages of various species before they enter their terrestrial form and leave the aquatic environment (Wisseman 1994, Plafkin et al 1989, Mangum 1986).**

Maxiaml reproduction occurs in the spring and fall, L09

**Summary of consultation for Box Canyon Hydroelectric Project**
**Tri-State Water Quality Council**
**January 12, 2000**

*File: kd/box/sumcom/agency/mtg/scom011200.doc*
*File code: 4.7.5*
*Key words: PM&E, water quality, monitoring*

The purpose for the meeting was to discuss the possible involvement of the Tri-State Water Quality Council (TSWQC) in a technical review role for the Box Canyon Hydroelectric Project during the new license period. The following people attended the meeting in Couer D'alene, Idaho, either in person or by telephone conference.

Chuck Rice, EPA Region 10
Julie DalSoglio, EPA Region 8
June Bergquist, Idaho DEQ
Gary Ingman, Montana DEQ
Bruce Anderson, Land & Water Consulting
Jean Parodi, Washington DOE
John Gross, Kalispel Tribe
Kent Doughty Duke Engineering & Services
Pat Buckley, Pend Oreille PUD

Others members of the TSWQC monitoring sub-committee who were not at this meeting (by phone or in person) include: Mike Beckwith, USGS; Will Kendra and Randy Coots, Washington DOE; Vicki Watson, University of Montana.

Kent Doughty provided a very brief overview of how the Box Canyon Project operates and the FERC licensing process. He noted that the District has to file its license application in January 2000. The text in the license application for describing technical review for water quality PM&E's/study reports was worded to create an opportunity for the involvement of the TSWQC without committing them to an obligation. Pat stressed that the District's intent is to provide an opportunity but not a burden.

Kent next reviewed the PM&Es for water quality as they are stated in the final license application. He advised that the final PM&Es for the license are subject to the FERC's review and NEPA. General water quality will be ongoing with monthly sampling; the objective is to understand long term trends in water quality through a monitoring program compatible with WDOE's for this reach of the Pend Oreille River. Total gas abatement studies include physical monitoring, biological monitoring, and abatement feasibility analysis. Aquatic plant management includes the development of an integrated management plan, ongoing rotovation, alternate control pilot studies, and a pilot winter drawdown study. The pilot drawdown will be in Campbell Pond where the potential adverse impacts are limited by the size of this water body. Education will also be a component of the aquatic plant PM&Es but would likely not require any technical review.

A handout was distributed which described the TSWQC responsibilities and the District's responsibilities (attachment 1).

Chuck Rice (EPA) commented that a funding level of $12,000 seemed up to an order of magnitude too small to accomplish all of the technical review, particularly if it required coordination with all of those involved in the systemwide approach to dissolved gas abatement and an in-depth review of TDG studies. He asked if a detailed estimate of the hours and tasks involved was used to develop the proposed budget estimate to which Kent replied no, it was based on a rough estimate of ¼ time and was meant to initiate discussion.

Chuck asked for an explanation of how the tri-State's potential role as technical review fit in with the regulatory responsibilities of agencies and tribes providing review and comment on FERC ordered license articles and the 401 certification. Kent noted that a technical reviewer would not usurp or negate any responsibility of the agencies to review license ordered reports/studies. The District is not asking nor is in a position to authorize regulatory authority on technical review. Chuck cautioned that there was the potential for the TSWQC to have conflicting opinions with another reviewing agency on technical review which could compromise the TSWQC working relationships and mission.

June Bergquist said the technical review role as described in the Project license application goes beyond the objectives of the TSWQC.

Kent asked the group what their perspective on the role of the TSWQC should be on the Box canyon Project. Gary Ingman noted that the aquatic plant management had a direct tie to the TSWQC objectives and potentially other water quality issues but not all of the PM&E's are directly related to the TSWQC's current mandate. Ruth noted that the TSWQC does provide a role as an information conduit to stakeholders interested in water quality issues along the Clark Fork/Pend Oreille drainage.

It was the group's opinion that technical review of gas abatement and gas monitoring is best suited to the Transboundary Group or other parties with appropriate expertise and focus. Technical review of other PM&Es raises both concerns and opportunities; the current proposal is likely too expansive.

While the proposal needs modification, it was agreed that a presentation to the full Council at its next meeting in April is still warranted. Kent and Ruth will work together to develop at least three options for a role by the TSWQC for presentation to the Council. The options might include the TSWQC to: simply provide review as one among many other stakeholders; act as an information conduit to others; limited focus of technical review; or have primary responsibility (but not regulatory authority) for technical review. An options paper will be circulated among this subcommittee prior to being presented to the Council. Material should be prepared in advance of the Council meeting so Council members will be familiarized with the proposal ahead of time.

Kent closed by saying the District's intent is to create an opportunity to better integrate the District's programs on Box Canyon Reservoir with the activities of the TSWQC within the larger Clark Fork/Pend Oreille system. If the TSWQC concludes that the technical review role is not a good fit with the Council's purpose, there are other mechanisms readily available for technical review. The Box Canyon Project currently has a technical committee, which will likely be expanded and continued under the new license.

**Tri State Water Quality Council**
**Monitoring Subcommittee**

Project: Box Canyon Hydroelectric Project (FERC No. 2042
River: Pend Oreille River Albeni Falls (RM 90.1) to just below Box Canyon Dam (RM 34.4)

Monitoring Objective: (*Preliminary and subject to discussion by aquatic work group and FERC license*) Monitor water quality conditions within Box Canyon Reservoir in a manner that compliments other ongoing water quality monitoring programs and contributes to an assessment of long term water quality trends. Monitoring is responsive to evaluating the effectiveness of FERC ordered water quality management plans and the goals and objectives of the Tri-State Water Quality Council.

Parameters for Monitoring: total dissolved gases, Dissolved oxygen, temperature, pH, conductivity, alkalinity, Carbon dioxide
possibly add nutrients: Nitrite-Nitrate Nitrogen, Total Persulfate Nitrogen, Total Phosphorus, Dissolved soluble Phosphorus

Monitoring Locations: Box forebay and tailrace - continuous recording
Usk bridge, Newport (possibly delete since WDOE samples at Newport) - Monthly

TSWQC Responsibilities:

- coordinating stakeholder review of activities described in the PM&E's related to water quality
- technical review of study plans for implementation of the water quality PM&Es
- technical review of the existing water quality baseline data for BCR to determine the need and purpose for a continuous monitoring station, which would be operated by the District in addition to the monthly sampling
- facilitate biennial review meetings of progress on PM&E's
- technical review of annual water quality report inclusive of water quality monitoring, dissolved gas studies, and aquatic plant management

District Responsibilities:

- Prepare study plans and management plans for implementing PM&Es
- Fund and conduct studies (design, field implementation, analysis, report)
- Prepare quarterly and annual reports and distribute to TSWQC
- Provide data and analytical results to TSWQC
- Participate in biennial review meetings
- Report to FERC on progress of water quality PM&E implementation and related license conditions
- Fund TSWQC for coordination and technical review

TSWQC Funding: Annual funding by the District for this position will not exceed $12,000.

cc file Box 6.5.1
L. Fortney



**Summary of Consultation**
**Box Canyon Hydroelectric Project**
**Water Quality Work Group Meeting**
**January 19, 2001**

*File: kd/box/sumcom/agency/mtg/2001/scom011901.doc*
*File code: 4.7.5*
*Key words: water quality, macrophytes, PM&E, management plan*

A meeting of the Box Canyon Water Quality Work Group meeting was held in Spokane on January 19, 2000. An attendance list is attached. Meeting handouts are also attached.

The meeting began with a report on the overall relicensing status by Mark Kilgore (third party FERC consultant on the EIS). Kilgore said FERC would be issuing an Additional Information Request (AIR) soon. The AIR will indicate the time period for consultation, completion of any additional studies and filing a response. Mark also noted the importance of documenting decisions on PME measures and actions reached within the Work Groups regarding Project PME measures so that these can be incorporated into the NEPA review.

A proposed schedule for the development of the Aquatic Plant Management Plan (APMP) was reviewed. The tentative target date for finalization of this plan is January 2002. The plan will not necessary go into effect until the time of license issuance although some components of the plan such as the County rotovation program and several pilot studies are ongoing now. Nancy Wellen (DOE) will check on SEPA review for the APMP; it was unsure if the SEPA review for the APMP can be rolled into the NEPA review process for the license.

Public involvement in the plan development is viewed as essential for its success. The District is distributing a public survey on aquatic plant concerns with its January billing. An article was also included in the newsletter. The County Extension is putting together a workshop on aquatic plant control aimed at landowners. The workshop will be April 21, 2001 and will include the participation of vendors. Presentations at the workshop will include:

- Industry talks/demonstrations on what homeowners can do
- Aquatic plant ecology (District presentation by Devin Malkin – DE&S botanist)
- Concerns with herbicide use (DOE)
- Rotovation program (County)
- HPA permitting needs for homeowners to treat plant beds (WDFW)
- Forming Lake Management Districts (DOE)
- Development of an Aquatic Plant Management Plan and public input (District presentation by Kent Doughty – DE&S)

The workshop will be advertised at the marinas and newspaper articles. Sharon said word of mouth is one of the most effective communication links within Pend Oreille County. It was suggested that aquatic plant management planning and the workshop to rely upon adds in the paper, direct communication with key people, and contact groups like the Kiwanas. Adding a link for aquatic plant management to the District's web page was also suggested. The District will also include notice of the upcoming workshop in its next newsletter and/or as a billing insert flyer. It was noted that this upcoming workshop is distinct from the workshop proposed in the FLA PME's for water quality; the latter will occur after completion of the APMP and project license issuance. Questions and ideas about the upcoming aquatic plant workshop should be addressed to Sharon Sorby.

Tina Bodkins (DE&S) led the group in a review of the overall goal and individual resource goals for the APMP. Additional comments on the draft goals should be forwarded to her by January 26th. She will then send out an edited version for a two-week review before finalizing goal statements.

The aquatic plant management plan will need to address both institutional and landowner actions. The plan will hopefully streamline the permitting process for landowners interested in treating aquatic plants by methods consistent with the plan. The plan should mention problems with use of herbicides; do's and don'ts. The Work Group advocated that the plan should include a section on how monitoring the plan's success will be accomplished. Sharon noted that a key component of evaluating the plan's success would be the evaluation of the spread of invasive non-native aquatic plants, particularly milfoil, to other water bodies. The State currently monitors the spread of milfoil. Sharon Sorby identified some water bodies in the area that currently have milfoil and when it was first documented in these waters. Milfoil infestation in the river was identified as a major problem in the 1970's and action plans were initiated. Lake Sasheen became infested in the 1980's. Milfoil infestation was documented in Little Pend Oreille Lake some time later. Most recently, milfoil has been found in Diamond Lake and Bead Lake was noted as becoming infested in 1998.

The afternoon began with a review of progress on the milfoil weevil study. Devin Malkin noted that the original study design called for eight to ten Eurasian watermilfoil-dominated sloughs to be examined, with half serving as control sites. He said that few areas were found that met these criteria, and as a result, the study design was changed to incorporate just three sites, chosen to represent a range of river conditions. He said that while the revised design would allow statistically rigorous analysis within each site, extrapolation of the results to the reservoir as a whole would be difficult. Devin then described the results of the first year's efforts. Baseline data were collected in summer 2000 at three sites, which will be treated in summer 2001 and subsequent years. The three sites are a riverine site near Everett Island, a semi-enclosed site near Ashenfelter Bay, an enclosed slough area on the back side of Everett Island. A handout on the weevil study is attached. Highlights of the weevil study are:

- 3 test sites selected: shoreline, in-river, and partially enclosed
- 50 random presence/absence observation points per site
- 50 random milfoil weevil samples per site (analysis not complete)
- Eurasian watermilfoil present in 100% of observations
- Weevil rearing beginning in mid-June of 2001; augmentation beginning in early July
- Expected production: 131 weevils per 20 gal. tank every two weeks
- Target: 5000 weevils per site

- Sampling to occur in August 2001: frequency, biomass, weevil abundance

Devin noted that plant species distribution shows high elasticity as noted by changes in species dominance within plant beds compared to the survey in 1997. Milfoil appeared less dominant in many areas in summer 2000. It was decided that it is important to have some untreated sites to be able to detect changes in milfoil biomass or frequency trends not related to weevil infestation during the pilot study. Devin noted that the natural spatial and temporal variability of the plant beds is great and an unworkably large sample size would be necessary to rigorously compare treated and untreated plant beds. The problem of unequal sample size and small number of treated sites would limit the power of statistical analyses. The group's discussion concluded that a statistical analysis between treated and untreated sites was not necessarily an objective; however, observational trends in biomass and stem frequency data within the untreated sites would be helpful in deciding if the milfoil weevil treatment has sufficient success to merit expansion as a milfoil management tool in the BCR.

This summer, we anticipate the need to raise and release about 15,000 milfoil weevils (from broodstock collected in the BCR). Collection and release will all be within Washington waters. The District is discussing the possibility of the Kiwanas Club or other local groups participate in raising the weevils. Releases will be in early July.

The winter draw down study at Campbell Pond was next reviewed. The pond was drained on December 15, 2000. Icing conditions have made it impossible to refill the pond, which has now been exposed for more than 21 days of sub-freezing weather. The grouped noted that snow pack and ice pack should be characterized in addition to the air and water temperature data being collected during the drawdown period. Highlights of the drawdown baseline data collection include:

- Drawdown for >21 days of subfreezing temperatures
- 201 random presence/absence observation points
- 40 random biomass samples
- Eurasian watermilfoil present in 41.3% of observations; composes 78.3% of biomass
- Additional factor: bottom barrier placement in 1988
- Sampling to occur in August 2001: frequency, biomass

Kent reviewed total dissolved gas (TDG) study results from 2,000. Numerous instrumentation problems with the tailrace instruments resulted in a lack of tailrace TDG data despite intensive efforts to correct problems. The instrument problems included mechanical breakdowns of several TDG probes. The instruments were serviced on a two-week basis or more frequent. Monitoring at the Box Canyon forebay is scheduled for spring, early summer 2001. A unit will also be installed at Kelly Island downstream of Albeni Falls. The servicing schedule will increase to every week. The group agreed that the priority would be to keep an operable unit in the tailrace; in the event of instrument breakdown, the unit at Kelly Island would be temporarily relocated to the box tailrace until repairs can be accomplished. The Corps of Engineers plans on at 2-3 weeks of monitoring in the Albeni Falls tailrace. The District will coordinate with the COE on monitoring activities downstream of Albeni. The district is continuing to participate in the Transboundary Gas Group meetings. Kent will forward work group members the biological research and monitoring issues paper prepared by Larry Fiddler and others for submittal to the TBGG. There was a brief discussion of biological monitoring for TDGP response downstream of Box Canyon dam. Kent noted some of the difficulties that occurred for Avista's study in Lake Pend Oreille, general challenges for biological monitoring and the District's concern that requests for biological monitoring should recognize how results would be applied to a compliance standard that is based on a physical criteria of 110% saturation. Tom Shuhda commented that if biological monitoring documented fish problems at levels below the water quality standard, then there might be management implications especially for listed species.

Next Meeting

The next meeting will be held **March 30**. Topics include:

- Diurnal dissolved oxygen study results (postponed from the 1/19/01 meeting discussion due to time constraints
- Review historical temperature data for BCR
- TDG monitoring plans for 2001
- Planning for the Extension Service's aquatic plant workshop on April 21
- Update on survey results for aquatic plant public views

There is also a Water Quality Work Group meeting scheduled for May 10. DE&S will attempt to coordinate the fish and water quality work group meeting dates to facilitate travel by participants.

**Action Item List:**

1. **Kent Doughty** to check with Ruth Watkins regarding TSWQC review of proposal to provide technical review for water quality monitoring and related studies after license issuance. Total dissolved gas study review would not be a component of the TSWQC review.
2. **Sharon Sorby** to provide a notice to Pat Buckley about the workshop for inclusion in the newsletter and/or utilities billing.
3. **Pat Buckley** will let Sharon know the schedule for getting notices in the newsletter and/or billings.
4. **Nancy Wellen (DOE)** will communicate to Kent Doughty about the schedule for SEPA review of the aquatic plant management plan (APMP). Need to determine if it is likely that SEPA for the APMP would adopt the NEPA for the license given that the latter would address aquatic plant management as one element of the license. Note that there will likely be elements of the aquatic plant management plan that are not integral to the project license, i.e., actions to be taken by County, homeowners and other parties.
5. **All** – Review and comment on distributed draft goal statements and respond to Tina Bodkins by Jan 26.
6. **Tina Bodkins** will edit and distribute final draft of goals that incorporate meeting discussion and other comments submitted by the 26th. **All** will then have two more weeks to comment on goals.

7. **Tina Bodkins** will talk to Mark Cauchy about adding a section to the District's web page for discussing aquatic plant management, providing general info on aquatic plants and advertising the Extension Service aquatic plant workshop.
8. **DOE** submit a request to Jennifer Parsons (DOE) to schedule a review of milfoil infestation in waters in Pend Oreille County, other than the Pend Oreille River.
9. **Devin** will evaluate the appropriate sample size for control plots for the weevil study in order to draw inferences about background trends in milfoil density. He will update the weevil study plan and distribute. **DOE** will request the Corps to review the study plan as well as internal review within DOE
10. **Devin and Kent** will submit plans on the weevil study to Steve Dama (WDFW) species collection and planting section.
11. **Kent** will distribute the biological research and monitoring issues paper drafted by the Transboundary Gas Group. He will also check if there is a report available yet on the laboratory experimental study on fish response to TDGP being conduct by Bonnie Antcliffe of B.C. Dept of Fisheries and Oceans.
12. **Kent** will add spill data at Albeni Falls to TDG graphs handed out at meeting.

# WQ Work Group 1/19/01

| Name | affiliation | email address | FAX |
|---|---|---|---|
| Kent Doughty | DE&S | kedoughty@dukeengineering.com | 360 671-1152 |
| Kevin Malkin | DE&S | dmalkin@dukeengineering.com | |
| Tonie Eldred | WDFW | eldretle@dfw.wa.gov | [illegible] |
| Mark Killgore | Louis Berger Group | mkillgore@LouisBerger.com | 425 883 [illegible] |
| Nancy Weller | Ecology | nwel461@ecy.wa.gov | |
| Jean Parodi | Wash. Ecology | jpar461@ecy.wa.gov | 509-456-6175 |
| Tom Shuhda | USFS | tshuhda@fs.fed.us | 509 684-7280 |
| JOHN GROSS | KNRD | jgross@knrd.org | 509 445 5302 |
| Pat Buckley | PO PUD | pbuckley@popud.com | (509) 447-9334 |
| Sharon Sorby | PO Weed Board | ssorby@coopext.cahe.wsu.edu | 509 447 2402 |
| Derick Potter | Garcia and Associates | dpotter@garciaandassociates.com | 406 582-[illegible] |
| Chuck Rice | US EPA | cricepa@ecy.wa.gov | 509 456 6175 |
| Tina Bodkins | DE&S | tbodkins@dukeengineering.com | ~~[illegible]~~ (cell) |
| | | [illegible] | 360-393-0122 |
| Rick Donaldson | USFWS (afternoon only) | | |

**Box Canyon Water Quality Work Group Meeting**
**Friday, January 19, 2001**
**Spokane Ramada Inn at the airport**
**9am – 3:30 pm**

9:00am Introductions

9:15 Status report on relicensing application

9:30 Aquatic Plant Management public survey update

9:45 Aquatic Plant Management plan

11:30 County's Aquatic Plant Workshop for Homeowners: how do we best tie in getting feedback on the development of an aquatic plant management plan

noon lunch

12:45 pm Milfoil weevil pilot study update

1:30 pm Winter drawdown pilot study update

2:00 pm Dissolved gas and dissolved oxygen study updates

3:15 pm Set future meeting dates and review action items

3:30 adjourn

# Pend Oreille County PUD Customer Survey

...e District is developing an aquatic plant management plan for the Box Canyon Reservoir. Your input on defining the management goal and selection of management strategies is vital for a successful plan. This plan will guide futur management of aquatic plants. Decisions on how to balance emphasis on containment of milfoil and other aquatic plan around docks and swim areas as well as enhancing fish and wildlife habitat will be vital elements of the plan.

There are at least 19 species of native and non-native aquatic plants occurring in the reservoir. The current means of treatment is rotovation, which is done year round. About 200 acres are rotovated each year; 74 of the acres are publicly owned. Areas are re-treated about every third year. Rotovators use underwater rototiller-like blades to uproot aquatic plants. Harvesting is another means of aquatic plant control that involves the physical separation of plant biomass from roots through the use of large harvester units. Harvesting requires multiple treatments and is quite expensive to employ. Winter water level drawdown is another means by which aquatic plants may be controlled; there is a current pilot study in Campbell Pond to determine the effectiveness of drawdowns. The PUD is also looking at biological control using a native weevil that feeds on milfoil.

Homeowners can assist in the containment of aquatic vegetation by using sediment covers and manual methods around private docks and swim areas. Community education, boater education and organized public involvement during high use times are vital to any aquatic vegetation plan.

---

**Because you are a ratepayer, your answers are important. All answers are confidential. Please complete this survey and return it with your payment.**

1) Where is your primary residence (Check one)?
   - ☐ On the Pend Oreille River from Oldtown to Box Canyon Dam at Ione
   - ☐ Within one-half mile of the Pend Oreille River from Oldtown to Box Canyon Dam at Ione.
   - ☐ Somewhere else in Pend Oreille County
   - ☐ In another county or state

2) Are you satisfied with the current methods used for aquatic plant management?

   ☐ Yes ☐ No

If no, why ______________________________

3) Aquatic Plants can adversely effect our enjoyment of the reservoir. Rank the following use areas in order of importance to you. (1 being the most important and 5 being the least important)

| RESOURCE TYPE | Very Important | | Somewhat Important | | Least Important | No Opinion |
|---|---|---|---|---|---|---|
| Boat launches | 1 | 2 | 3 | 4 | 5 | 6 |
| Swimming and Public Areas | 1 | 2 | 3 | 4 | 5 | 6 |
| Wildlife Habitat | 1 | 2 | 3 | 4 | 5 | 6 |
| Fish Spawning Areas | 1 | 2 | 3 | 4 | 5 | 6 |
| Fishing Areas | 1 | 2 | 3 | 4 | 5 | 6 |

4) Fish and wildlife habitat can benefit from selective rotovation. If necessary, would you be willing to redirect some of the current rotovation to benefit these resources even if it meant docks and swim areas were not rotovated as often?

☐ Yes ☐ No ☐ No opinion

5) There are several supplemental and/or alternative control methods for aquatic vegetation. Which methods would you like seeing used at Box Canyon Reservoir?

☐ Continue with the current rotovation plan

☐ Increase the area that is rotovated

☐ Winter reservoir drawdowns

☐ Homeowner employed methods in conjunction with rotovation

☐ Biological treatment

6) What level would you be willing to participate in the Aquatic Plant Management Plan Process?

☐ Sorry, Not able to Participate

☐ Attend public meeting and provide input towards plan

☐ Volunteer to participate in public awareness and boater education activities? (Handing out informational flyers on weekends etc)

7) As a ratepayer, how much would you be willing to pay on your monthly electric utility bill for continued and/or additional aquatic management within the Box Canyon Reservoir? **(Check one)**

☐ I would not be willing to pay anything ☐ 50 cents per month ☐ $1 per month
☐ $2 per month ☐ $5 per month ☐ I would be willing to pay more than $5 per month

Please write any additional comments or concerns regarding aquatic plant management below:

Because you are a PUD ratepayer, <u>**your**</u> **answers are very important to us**! Please complete this survey and return it to us with your payment. Your answers will be combined with all the other surveys we receive, so that your answers remain confidential. THANK YOU.

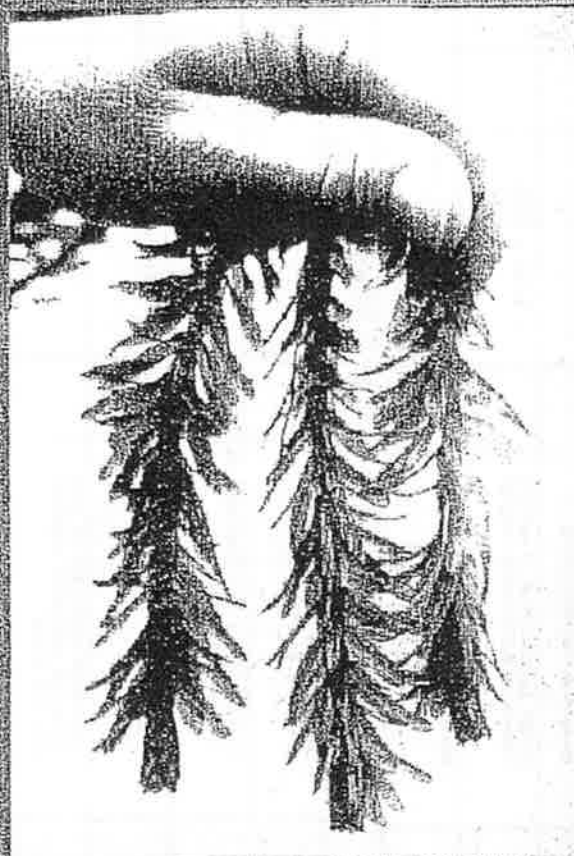
Please watch for future announcements on public meetings on the Aquatic Plant Management Plan.

Pend Oreille PUD 130 N Washington St. Newport WA 99156

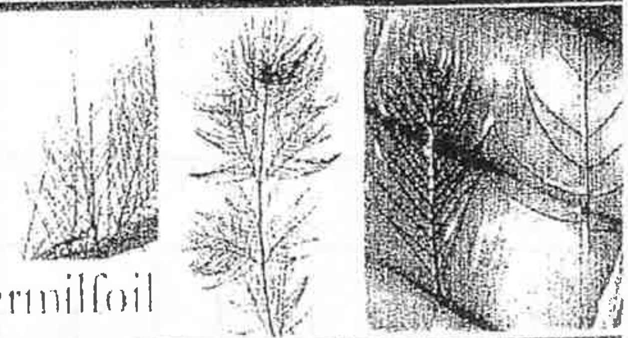
# Management Goal

Cost effectively manage the composition, structure and distribution of aquatic plant beds to minimize the expansion of invasive aquatic plant species both within Box Canyon Reservoir and surrounding waters. The level and approach to management will reflect multiple resource management objectives. Treatment, public involvement and education are important elements of a cost effective management plan.

# Schedule for completion of Aquatic Management Plan



Non-Native
Freshwater
Plants
Eurasian Watermilfoil



January 2001 | May | September | January 2002

11/26 | 1/14 | 3/4 | 4/22 | 6/10 | 7/29 | 9/16 | 11/4 | 12/23 | 2/10

| ID | Task Name | | |
|---|---|---|---|
| 0 | Plan Schedule | 11/2 | 1/17 |
| 1 | *Completed Steps prior to License application submittal* | | 1/19 |
| 2 | Identify Waterbody Features | | 1/19 |
| 3 | Identify Beneficial Use Areas | | 1/19 |
| 4 | *Pending WQ Work Group Steps* | 1/17 | 12/28 |
| 5 | Determing public involvement alternatives | | 1/17 |
| 6 | Finalization of Problem Statement | | 1/17 |
| 7 | Finalization of Resource Goals | | 1/17 |
| 8 | Review of Draft action plan | | 8/3 |
| 9 | Presentation of action plan to public | 1/17 | 1/17 |
| 10 | Review of public comments of action plan | 9/3 | 11/23 |
| 11 | Implementation | 11/19 | 12/28 |
| 12 | *WQ Work Group Meetings* | 1/19 | 10/12 |
| 13 | January-Focus on Public Involvement and Completion of management/resource goals | | 1/19 |
| 14 | March- Focus on public meeting number 1\Review survey results | 3/30 | 3/30 |
| 15 | May-Checkup on the plan | | 5/17 |
| 16 | August-Review draft management plan, and provide comments | 8/3 | 8/3 |
| 17 | October-Review and finalize plan for implementation | 10/5 | 10/12 |
| 18 | *Public Meetings* | 4/2 | 1/2 |
| 19 | April-Give highlights of plan, Determine individual resource interest groups | 4/2 | 4/2 |
| 20 | June-Discuss survey results, resource group recommendations | | 6/1 |
| 21 | September-Present Draft Action Plan, request comments | 9/3 | 9/3 |
| 22 | December- Present final plan | | 1/2 |

# Updates to Individual Resources

**Boat launches**

| | |
|---|---|
| Location: | Discreet locations shown on base map |
| Affected time: | May – September |
| Management effects: | Current rotovation program concentrates on public boat launches. Shoreline development for public access is often associated with boat launches |
| How affected: | Spreads to other sites |
| Management Goal: | Containment of identified problematic macrophytes. |
| *Comments:* | *Public educational signs at boat launches regarding cleaning of aquatic vegetation from watercraft. Focus on areas with non-natives. Education focus – public access. Minnesota DNR state they are not encouraging the use of boat wash stations, cost and misuse being the primary reasons. Should concentrate on public boat launches over private boat launches.* |

## Public beaches/swim areas/private swim sites

| | |
|---|---|
| Location: | Locations shown on base map |
| Affected time: | Peak season: May – September (Some activities year round) |
| Management Effects: | Swimmers do not like *aesthetics* |
| How affected: | Detracts from enjoyment for public and shoreline property owners. |
| Management Goal: | Maximum containment of all aquatic plants in public swim areas. For public beaches where swimming is not a primary use, the management goal is guided by other resource concerns. Contain aquatic plant growth near private docks and swim beaches to the extent management program funds allow but priority is on public areas. |
| *Issue:* | *Safety of swimmers is also a concern.* |

## Warm Water Fisheries

| | |
|---|---|
| Location: | To be identified; primarily sloughs |
| Affected time: | As identified by fisheries management plan. |
| Management Effects: | Plant beds should be maintained at modest densities to maximize foraging fish growth and largemouth bass predation. Plants support zooplankton population and are cover for small fish, rotovating not done in sloughs during spawning. |
| How affected: | Varies by life stage/ summer seasonal cover for large mouth bass predation focus |
| Management Goal: | Manipulation of identified macrophytes to favor warm water fisheries as identified by fisheries management. |
| *Comments:* | *Bass-spawning habitat is currently in the process of being mapped. Literature review suggests the highest densities of all life stages of bass are achieved by rotovating a cruising lane up the middle of the sloughs parallel with the long axis of the slough.*<br><br>*Native salmonids are the priority species and management of macrophytes should avoid their detriment. Rotovate beds or provide shading to facilitate forage lanes for predatory fish lake bass. Need baseline information on size structure of predator (bass) and prey (panfish, yellow perch) species and follow up monitoring to determine if efforts are successful.* |

## Native Salmonids

---

| | |
|---|---|
| Location: | Cold water tributaries and sloughs |
| Affected time: | Times to avoid include migration period for bull trout, whitefish, and cutthroat trout and the spawning period for large mouth bass. |
| Management effects: | |
| How affected: | Aquatic plants should not be allowed to be a passage barrier to tributaries.<br><br>Change in plant density from sparse or absent to dense in areas with gravel or cobble substrate could lead to degradation of spawning/rearing habitat. Flow velocity obstructions would likely be a necessary catalyst to allow plants to become established at dense levels where bed is now coarse. |
| Management Goal: | Aquatic Management Plan consistent with Fisheries Management Plan. |
| *Issues:* | *Effective management may require zoning of the reservoir and sloughs as identified for targeted species. Some sloughs may be managed as a migration corridor while others as largemouth bass forage.* |

## Cultural

| | |
|---|---|
| Location: | 121 Sites locations (locations are confidential) |
| Affected time: | We should be prepared to avoid further cultural sites as they become known |
| Management effects: | Many sites not known especially on private. |
| How affected: | Rotovation not conducted at known sites to avoid bed disturbance. |
| Management Goal: | Site-specific treatment options will have to be designed on a site-by-site basis. |
| *Comment:* | *Not all archeological sites are known. May have to develop a mechanism or model that identifies areas likely/unlikely to have sites. Shading may be the best option in areas of low velocity.* |
| *Note:* | *Kalispel Tribe to compare rotovation sites with known submerged archeological sites and notify County if necessary.* |

## Shorelin Vetlands

| | |
|---|---|
| Location: | Locations shown on habitat cover maps |
| Affected time: | Locations are semi-permanent to permanently flooded |
| Management effects: | |
| How affected: | Non-issue for seasonal open water wetlands |
| Management Goal: | Maintain wetlands for appropriate wetland species through management of emergent herbaceous vegetation canopy closure, height of nesting vegetation minimizing disturbance by people and domestic animals, and maintaining an optimum ratio of open water to emergent cover |
| *Issues:* | *Wetland areas may also have important cultural significance as a traditional harvest of native roots (e.g., camas)* |

## Rare plants

| | |
|---|---|
| Location: | Depicted on beneficial uses map |
| Affected time: | Growing season is dependent on variety of plant |
| Management effects: | *Heteranthia-dubia* is only true aquatic STE plant. It will re-vegetate in rotovated areas. |
| How affected: | Deposition of rotovated plant mass on shoreline in areas mapped as rare plant habitat could impact emergent and nearshore rare plant populations.<br><br>Spread of invasive, non-native aquatic plants to other wate bodies could be detrimental to rare populations elsewhere. |
| Management Goal: | Manage for the proliferation of identified rare and cultural plants and avoid further demise. |
| *Comment:* | *A number of federal, state, and local agencies, and the Kalispel Tribe have management responsibilities for managing the botanical resources in the Project vicinity.* |
| *Issues:* | *Cultural plants with significance to the Kalispel Tribe may also need to be considered. May need to consult with the Tribe on this.* |

## Colonial nesting water birds

*(great blue heron and double crested cormorant)*

---

| | |
|---|---|
| Location: | Nest areas shown beneficial use maps |
| Affected time: | April or May to August encompasses the breeding season |
| Management effect: | Unlikely to have any effect on great blue heron, which feed in shallow water. It is unknown what effects weed beds have on cormorants. Presumably they do not feed in dense beds. There are many areas where these birds can feed both in the river and at Calispell Lake. |
| How affected: | Unclear- probably little effect |
| Management Goal: | Aquatic Management Plan should be consistent with wildlife goal: Maintain healthy great blue heron population (not at risk by rotovation). Avoid improving habitat for cormorants (perceived as not a desirable species). |

## Amphibians

| | |
|---|---|
| Location: | Locations shown on beneficial uses map |
| Affected time: | May to October |
| Management effects: | The only species of amphibian likely to be affected by aquatic weed control in the river is bullfrog. (Bullfrogs are not considered a desirable species so an adverse affect would be anything that could *improve* conditions for this species.) |
| How affected: | Bullfrogs have been observed floating/sitting on aquatic weeds, which are at the surface. Clearing weeds may reduce this habitat feature. Net effects of rotovation beneficial (reduction in bullfrog habitat); however activities in the river are not likely to have a major effect (positive or negative) on this species because other habitats (ponds and borrow pits) are abundant in the region. |
| Management Goal: | Contain surface level aquatic plants to aid in the control of bullfrog populations especially in sloughs. |

**Osprey and Bald Eagle nest sites and feeding areas.**

---

Location: Nest sites shown on beneficial uses maps, feeding areas are not shown.

Affected time: Osprey (April) May - September

Management effects: Uncertain: There is no evidence that either species is currently limited by food supply. It is possible that these species benefit from dense weed beds that force large fish to swim above the beds where they are more easily caught. The provision of passageways through dense weed beds might allow fish to swim deeper.

How affected: Little is known concerning when Osprey or Bald Eagle feed most heavily – both can travel long distances to feed. There is little likelihood that bald eagles would be disturbed from nests by rotovation. Osprey (more numerous and with many nests on pilings) are presumably unaffected by disturbance from boats, or presumably by rotovation.

Management Goal: Aquatic plant management should be consistent with wildlife goal to maintain an abundant and easily acquired food supply.

## Shoreline erosion and hazard occurrence

| | |
|---|---|
| Location: | Moderate to high hazard erosion areas shown on beneficial uses map |
| Affected time: | Locations shown on elevation map |
| Management effects: | Successful shoreline erosion control would require control of the undercutting process at all bank elevations where high to moderate erosion occurs, including low pool. Areas devoid of shoreline vegetation are most vulnerable to initiation of accelerated erosion processes. |
| How affected: | |
| Management Goal: | Emphasize emergent native plants in areas where moderate to high hazard bank erosion occurs during growing season (June – October) due to wave action. |
| *Issues:* | *Erosion in areas where there is little vegetation may be caused by waves from wind fetch and boating* |

# BOX CANYON EURASIAN WATERMILFOIL MANAGEMENT STUDIES: SUMMARY, JANUARY 2001

**Milfoil weevil augmentation:**

- 3 sites: shoreline, in-river, and partially enclosed
- 50 random presence/absence observation points per site (Table 2)
- 50 random milfoil weevil samples per site (analysis not complete)
- Eurasian watermilfoil present in 100% of observations
- Weevil rearing beginning in mid-June of 2001; augmentation beginning in early July
- Expected production: 131 weevils per 20 gal. tank every two weeks (Table 3)
- Target: 5000 weevils per site
- Sampling to occur in August 2001: frequency, biomass, weevil abundance

**Winter drawdown for Eurasian watermilfoil control in Campbell Lake:**

- Drawdown for >21 days of subfreezing temperatures
- 201 random presence/absence observation points (Table 5)
- 40 random biomass samples (Table 6)
- Eurasian watermilfoil present in 41.3% of observations; composes 78.3% of biomass
- Additional factor: bottom barrier placement in 1988
- Sampling to occur in August 2001: frequency, biomass

# BOX CANYON EURASIAN WATERMILFOIL MANAGEMENT STUDIES: PROJECT UPDATE, JANUARY 2001

## 1.0 INTRODUCTION

This document presents partial first-year results from two aquatic plant management investigations performed by Duke Engineering & Services for the Pend Oreille Public Utility District No. 1 of Pend Oreille County, Washington. These efforts were designed to examine the local efficacy of reservoir drawdown and milfoil weevil augmentation as techniques for the management of Eurasian watermilfoil (*Myriophyllum spicatum*) in the Box Canyon Project area. Goals and methods for each of these studies were originally presented to the Water Quality Working Group at its May, 2000 meeting.

## 2.0 MILFOIL WEEVIL AUGMENTATION

### 2.1 Methods

Study site selection and data collection occurred during August of 2000. The original study design called for eight to ten Eurasian watermilfoil-dominated sloughs to be examined, with half serving as control sites. However, few areas were found that met these criteria; not surprisingly, the species composition of some aquatic macrophyte beds differs from that mapped in 1997. As a result, the study design was changed to incorporate just three sites, chosen to represent a range of river conditions: a mid-channel site off Everett Island, a partially protected site at the mouth of Ashenfelter Bay, and a partially enclosed site on the southeast side of Everett Island. At each site, 50 randomly placed species presence/absence points were observed, and 50 1-meter long Eurasian watermilfoil stems were collected and preserved in ethyl alcohol. Milfoil weevils and weevil damage were observed at each of these sites.

### 2.2 Results

Nine aquatic plant species were located at the three study sites (Table 1). Of these, Eurasian watermilfoil was by far the most frequent, occurring in 100% of randomly selected species frequency observation points (Table 2). Canadian elodea (*Elodea canadensis*) was the next most frequent, occurring in 30% of observations.

**Table 1. Aquatic macrophytes at milfoil weevil study sites, 2000.**

| Name | Common Name | Origin | Family |
|---|---|---|---|
| *Ceratophyllum demersum* | coontail | Native | Ceratophyllaceae |
| *Elodea canadensis* | Canadian waterweed | Native | Hydrocharitaceae |
| *Heteranthera dubia* | water star-grass | Native | Pontederiaceae |
| *Myriophyllum spicatum* | Eurasian watermilfoil | Exotic | Haloragaceae |

| | | | |
|---|---|---|---|
| *Potamogeton crispus* | curled pondweed | Exotic | Potamogetonaceae |
| *Potamogeton foliosis* | close-leafed pondweed | Native | Potamogetonaceae |
| *Potamogeton zosteriformis* | grass-leafed pondweed | Native | Potamógetonaceae |
| *Ranunculus aquatilis* | water buttercup | Native | Ranunculaceae |
| *Potamogeton richardsonii* | Richardson's pondweed | Native | Potamogetonaceae |

**Table 2. Aquatic macrophyte frequency at milfoil weevil study sites.**

| | MYSP | POFO | POCR | POZO | ELCA | RAAQ | PORI | HEDU | CEDE |
|---|---|---|---|---|---|---|---|---|---|
| Ashenfelter Bay raw frequency (n=50) | 50 | 12 | 6 | 1 | 14 | 2 | 0 | 0 | 5 |
| Ashenfelter Bay % | 100.0 | 24.0 | 12.0 | 2.0 | 28.0 | 4.0 | 0.0 | 0.0 | 10.0 |
| Mid-channel raw frequency (n=50) | 50 | 11 | 1 | 0 | 9 | 0 | 1 | 1 | 9 |
| Mid-channel % | 100.0 | 22.0 | 2.0 | 0.0 | 18.0 | 0.0 | 2.0 | 2.0 | 18.0 |
| Everett Island raw frequency (n=50) | 50 | 5 | 11 | 19 | 22 | 6 | 0 | [illegible] | [illegible] |
| Everett Island % | 100.0 | 10.0 | 22.0 | 38.0 | 44.0 | 12.0 | 0.0 | 8.0 | 6.0 |
| All sites raw frequency (n=150) | 150 | 28 | 18 | 20 | [illegible] | 8 | 1 | [illegible] | [illegible] |
| All sites % | 100.0 | 18.7 | 12.0 | 13.3 | 30.0 | 5.3 | 0.7 | 3.3 | 11.3 |

Milfoil samples collected during 2000 and preserved in alcohol remain to be processed. As a result, definitive background weevil abundance data for the three study sites are not available. Adult weevils and weevil eggs have been documented at each site, but preliminary estimates suggest that weevil abundances are low (<0.1 weevil per stem).

## 2.3 2001 Efforts

Dissections of Eurasian watermilfoil stems collected during 2000 will continue during the early months of 2001. The resulting estimate of milfoil weevil abundance will be used as a baseline with which to compare future data.

A target level of 15,000 milfoil weevils will be reared during the summer of 2001, following procedures established by Cofrancesco and Crosson (1999). Weevils will be collected from Box Canyon Reservoir beginning in mid-June and their progeny released beginning in July, when flow levels have tempered and temperatures are favorable. Approximately 5,000 weevils will be released at each site, in stages at two-week intervals as they are reared. Initial rearing efforts will assume a moderate level of survival and production. After the first two-week rearing period, weevil production will be quantified and the production rate adjusted accordingly.

**Table 3. Per-tank weevil production estimates under different survival scenarios.**

| | Survival Rate | | | | Production Rate | | | |
|---|---|---|---|---|---|---|---|---|
| | Egg | Larvae | Pupae | Total | # Females | Eggs/female/day | 14 day total | Tanks needed |
| Minimum | 0.65 | 0.78 | 0.69 | 0.35 | 10.00 | 1.00 | 48.98 | 77 |
| Midrange | 0.83 | 0.84 | 0.75 | 0.52 | 12.50 | 1.45 | 131.01 | 29 |
| Maximum | 1.00 | 0.90 | 0.80 | 0.72 | 15.00 | 1.90 | 287.28 | 13 |

Source: Cofrancesco and Crosson (1999).

Biomass sampling will be conducted at each site prior to weevil augmentation. These data will be used as a baseline with which to compare future biomass estimates. Aquatic plant frequency and weevil abundance at each site will be resampled after weevil augmentations are complete, and the results compared to 2000 baseline data under the null hypothesis of no effect of augmentation on Eurasian watermilfoil frequency and weevil abundance. Frequencies will be tested using contingency tables and chi-square tests, and weevil abundance will be tested using a nonparametric Mann-Whitney U test. Hypothesis tests will be conducted at the $\alpha = 0.1$ level.

## 3.0 DRAWDOWN

### 3.1 Methods

Aquatic macrophyte biomass and frequency data were collected during August of 2000 in Campbell Pond, a 2.32 acre impoundment near Box Canyon Dam. The pond was drawn down in December of 2000 and has not yet been refilled, as the water supply pipes are frozen. Exposed plants have now been subjected to more than 21 days of freezing temperatures and fewer than 24 total hours of above-freezing temperatures, and the pond will be refilled at the first opportunity.

### 3.2 Results

Two hundred and one presence/absence frequency observations were made in 0.1 square meter quadrats placed at randomly selected points in Campbell Pond. Seven species of aquatic plants were found during frequency observations (Table 4), plus small amounts of muskgrass (*Chara* sp.), a macroscopic algae. In addition, forty aboveground biomass samples were collected, separated by species, dried in a plant oven, and weighed to the nearest 0.1 gram.

**Table 4. Aquatic macrophytes in Campbell Pond, 2000.**

| Name | Common Name | Origin | Family |
|---|---|---|---|
| *Ceratophyllum demersum* | coontail | Native | Ceratophyllaceae |
| *Elodea canadensis* | Canadian waterweed | Native | Hydrocharitaceae |
| *Myriophyllum spicatum* | Eurasian watermilfoil | Exotic | Haloragaceae |
| *Potamogeton crispus* | curled pondweed | Exotic | Potamogetonaceae |
| *Potamogeton foliosis* | close-leafed pondweed | Native | Potamogetonaceae |
| *Potamogeton gramineus* | grass-leafed pondweed | Native | Potamogetonaceae |
| *Potamogeton richardsonii* | Richardson's pondweed | Native | Potamogetonaceae |

Eurasian watermilfoil was observed most frequently (Table 5), followed by close-leafed pondweed (*Potamogeton foliosis*) and bare substrate, which composed almost one quarter of all observations. Of the 201 frequency observations made, 82 (40.6%) had a single species, while 60 (29.7%) had two species. Eight observations (4%) included 3 species, and one (0.5%) had four.

**Table 5. Aquatic macrophyte frequency in Campbell Pond, 2000.**

| | CEDE | ELCA | MYSP | POCR | POFO | POGR | PORI | Bare |
|---|---|---|---|---|---|---|---|---|
| **Raw frequency (n =201)** | 13 | 9 | 117 | 6 | 81 | 3 | 1 | 50 |
| **Percentage of total** | 6.5 | 4.5 | 58.2 | 3.0 | 40.3 | 1.5 | 0.5 | 24.9 |

The results of biomass sampling are presented in Table 6. Eurasian watermilfoil was a component of 27 of the 40 samples (ranging from 0.1g to 15.5g), representing over 78% of the total biomass collected. Reflecting the results of frequency sampling, close-leafed pondweed was the next most abundant plant, and the only species besides Eurasian watermilfoil that composed more than 10% of the total biomass collected.

**Table 6. Biomass statistics for Campbell Pond, 2000.**

| | CEDE | ELCA | MYSP | POCR | POFO | POGR | PORI | Total |
|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| **Number of samples** | 1 | 8 | 27 | 2 | 19 | 1 | 1 | 40 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| **Mean per sample (g)** | 0.00 | 0.12 | 2.39 | 0.10 | 0.42 | 0.00 | 0.02 | 3.06 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| **Standard Error** | N/A | 0.05 | 0.60 | N/A | 0.12 | N/A | N/A | 0.59 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| **90% CI high** | N/A | 0.21 | 3.40 | N/A | 0.62 | N/A | N/A | 4.05 |

## 3.3 2001 Efforts

Aquatic plant frequency and biomass will be resampled during 2001 and the results compared to 2000 baseline data under the null hypothesis of no effect of drawdown on Eurasian watermilfoil biomass or frequency. Frequencies will be tested using contingency tables and chi-square tests; biomass means will be compared using t-tests. Hypothesis tests will be conducted at the $\alpha = 0.1$ level. A decision regarding a second year of drawdown in Campbell pond during the winter of 2001 will be made in the fall, when second year results are presented to the Water Quality Working Group.

## 4.0 REFERENCES

Cofrancesco, A.F., and H. Crosson. 1999. *Euhrychiopsis lecontei* (Dietz) as a potential biocontrol agent of Eurasian watermilfoil (*Myriophyllum spicatum* L.) U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. 6 pp.

# BOX CANYON DISSOLVED OXYGEN AND AQUATIC PLANTS STUDY

## Introduction

The primary intent of this study was to document diurnal dissolved oxygen patterns within aquatic plant beds and open water to determine if aquatic plant growth could account for atypical diurnal dissolved oxygen patterns reported in previous studies within the Box Canyon Reservoir. Coots and Willms (1991) observed that dissolved oxygen peaked at night in the Pend Oreille River near Riverbend, Washington. They attributed this peak to large photosynthetic activity upstream creating a lag time in normal diurnal dissolved oxygen trends at the sampling site; i.e., water travel time between plant beds and the water quality sampling sites caused the lag.

## Methods

Water quality parameters consisting of dissolved oxygen, pH, conductivity, and temperature were measured at several points on the Pend Oreille River near Riverbend, Washington. Data were collected during August 21-23 and November 1-3, 2000.

Two Datasonde 4a hydrolab units were placed in the Pend Oreille River on August 21-23, 2000. The hydrolabs were calibrated for dissolved oxygen (D.O.), temperature, pH, and specific conductance prior to use. The hydrolabs were placed at a depth of 1.0 -1.25 m at two locations and were set to record continuously at 15 minute intervals. The first location, RM 62.3, was a large macrophyte bed with a water column depth of 1.5-2.0 m. The second hydrolab was placed 0.5 miles downstream of the macrophyte bed in the main channel with a water column depth of 6.0 m. The August data collection was timed to monitor water quality during peak plant biomass production.

On November 1-3, a sampling was repeated during macrophyte senescence. Due to equipment limitations, only one hydrolab was deployed. The hydrolab was deployed for an approximte 24 hour period (Nov 1-2) at RM 62.3 in the middle of the remaining macrophyte bed. The instrument was subsequently moved on the evening of November 2 to an open channel location at RM 61.9 where it was operated for a 24 hour period.

During the study, water quality at the sites was verified with a YSI multiparameter probe twice daily for dissolved oxygen, conductivity, specific conductance, temperature, and pH. Measurements were then compared to the concurrent hydrolab data. Surface water temperatures were also checked with a NIST equivalent mercury thermometer. For further calibration, dissolved oxygen was also measured using Winkler titrations. All instruments were calibrated before and after deployment. Using the YSI meter, vertical profiles of the macrophyte bed (RM 62.3) and the open water channel (RM 61.9) were taken. Water quality at two additional open water channel sites (RM 59.8 and RM 60.9) and one additional macrophyte bed (RM 64.0) were monitored 1-2 times daily, over the two study periods.

## Results

<u>Pend Oreille Macrophyte Bed at RM 62.3</u>

More than 90% of the aquatic plant biomass within this plant bed is Eurasian watermilfoil (*Myriophyllum spicatum spicatum*), with some *Elodea canadensis* and *Potomogeton* species.

On August 21, 2000, dissolved oxygen peaked between 9:00 pm- 12:00 am; peak values ranged from from 10.9-11.5 mg/L. A D.O. low of 8.5 mg/L occurred at 4:00 am on the morning of August 22. Dissolved oxygen tended to increase over the afternoon on August 22 and peaked at midnight at 12.0 mg/L (Figure 1-2 ). Daily high temperatures lagged behind dissolved oxygen. Peak temperatures were 22.3°C at 0100 on 8/22 and 22.8°C at 0200 on 8/23. Over the course of the three-day period, the water column within the macrophyte bed exhibited dissolved oxygen supersaturation. Dissolved oxygen percent saturation ranged from 103-145%, with a mean saturation of 127% (Table 1).

Spikes in pH, temperature, and dissolved oxygen occurred on August 21 at 1445 and on August 22 at 0945 and 1510. These three spikes coincide with the time of our sampling at the site (Figure1-2 ). During this time period, the water around the hydrolab was disturbed due to the mixing action created by the prop boat arriving at the site.

Despite minimal depth within the macrophyte bed (1.5-2.0 m maximum depth), there were vertical differences in temperature, dissolved oxygen and pH during the August study period (Figure 9). On August 22, 2000, vertical profile measurements taken at 3:00 pm revealed a 3.0° C temperature difference from top to bottom. Temperature at 0.25 m was 23.01 °C dropping to 22.04 °C at 1.0 m and 20.01 °C at 1.7 m. During the same time period, dissolved oxygen increased from 11.1 mg/L at 0.25 m to 13.03 at 1.5m.

Supersaturated dissolved oxygen conditions within the bed were persistent throughout the August study with a mean dissolved oxygen saturation of 126.8%. Anoxic conditions within the macrophyte bed were not evident during the study except when the probe was allowed to rest just off bottom (1-2 cm) at the water-sediment interface. At this time, dissolved oxygen dropped to 0.9 mg/L and pH dropped to 8.17.

During the November 1-3 study, the biomass density within macrophyte bed was diminished compared to August. Typical diurnal dissolved oxygen and temperature trends were observed with temperature and dissolved oxygen peaking during the afternoon and decreasing at night (Figure 3). Mean temperature over the 3-day period was 9.19 °C. Percent dissolved oxygen saturation was lower in November than in August. Mean dissolved oxygen levels were 93.8%, ranging from 103.2% during the day to a low of 88.2% saturation at night.

Dissolved oxygen and pH had similar trends in both August and November (Figure 4). Using linear correlation, dissolved oxygen and pH were correlated in both August ($R^2$ = 0.63) and November ($R^2$ = 0.97 ). Although the linear relationship between dissolved oxygen and pH should not necessarily indicate cause and effect, they are indicative of the changes in the macrophyte bed due to the role of photosynthesis.

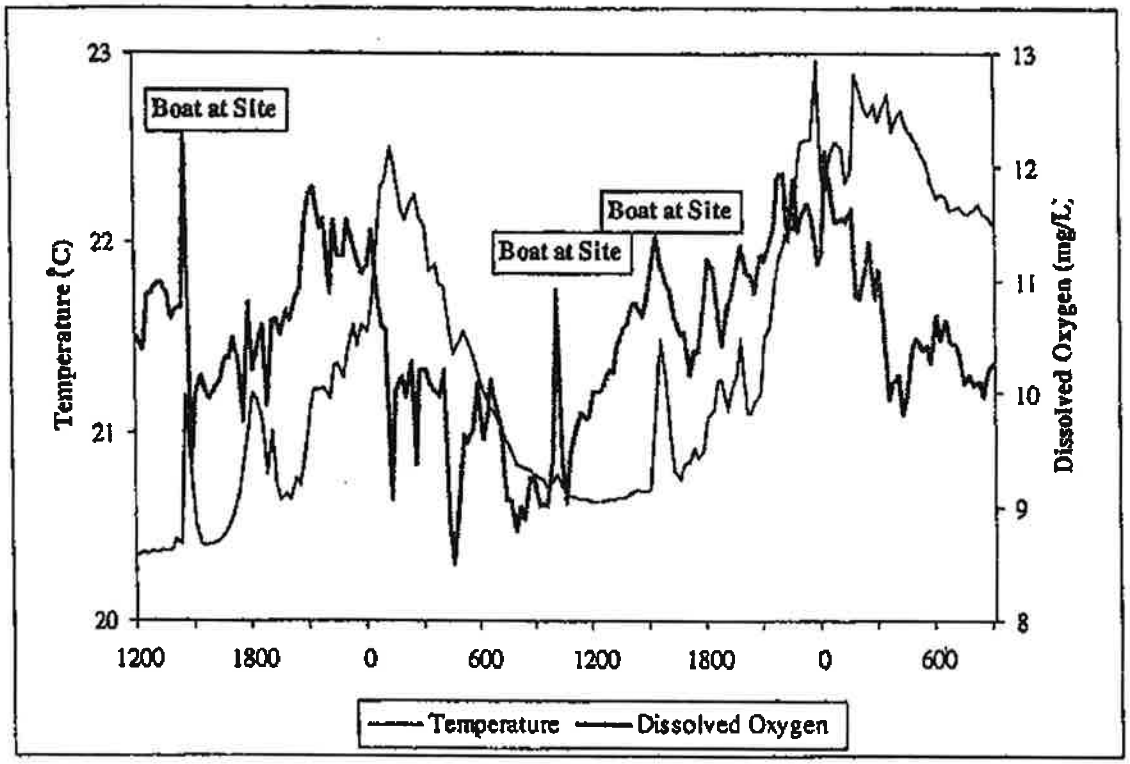



Figure 1 Dissolved oxygen and temperature within aquatic plant bed RM 62.3, August 21-23, 2000

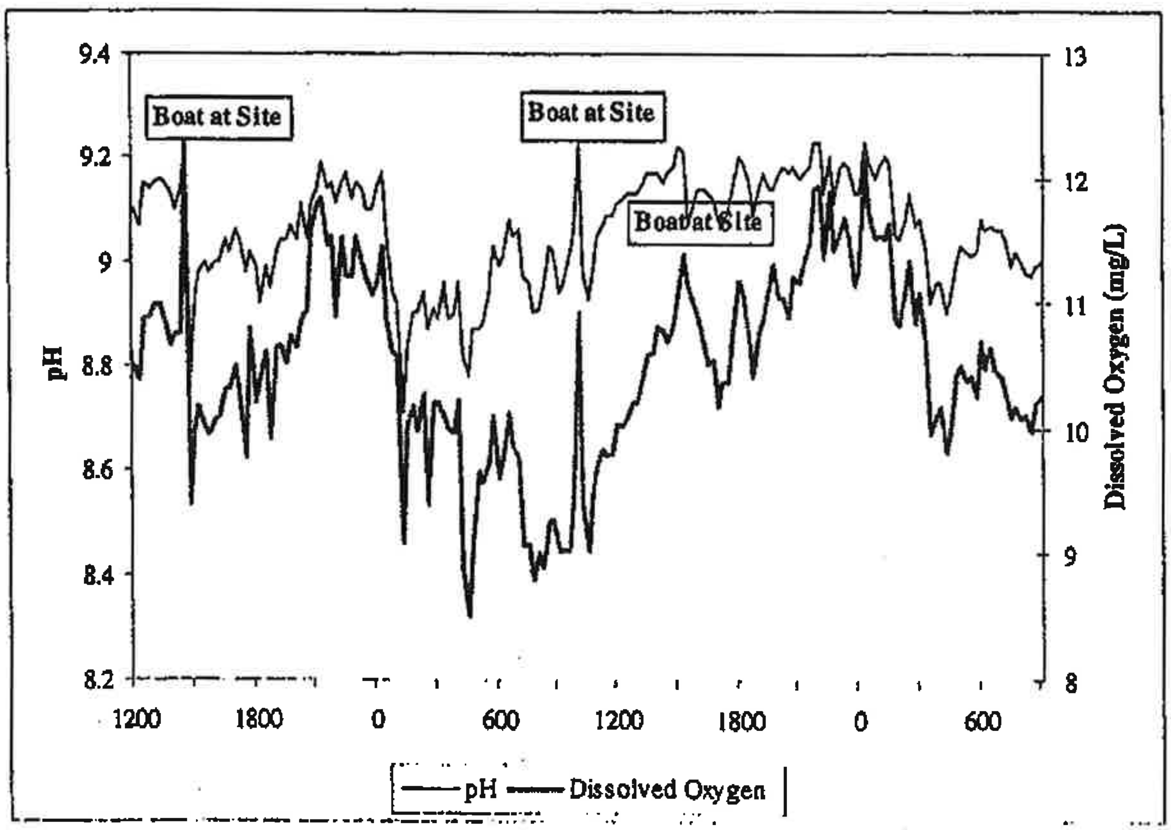



Figure 2 Dissolved oxygen and pH within aquatic plant bed RM 62.3, August 21-23, 2000

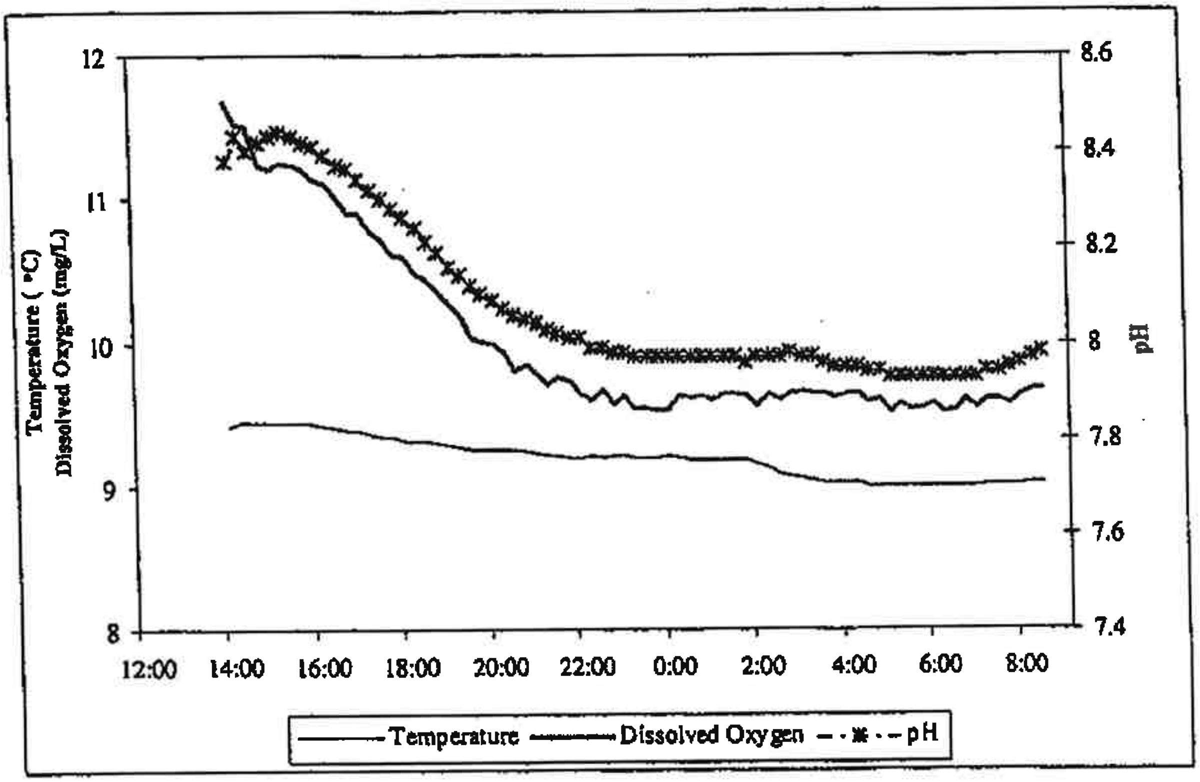



Figure 3 Temperature, dissolved oxygen and pH within aquatic plant bed RM 62.3 November 1-2, 2000

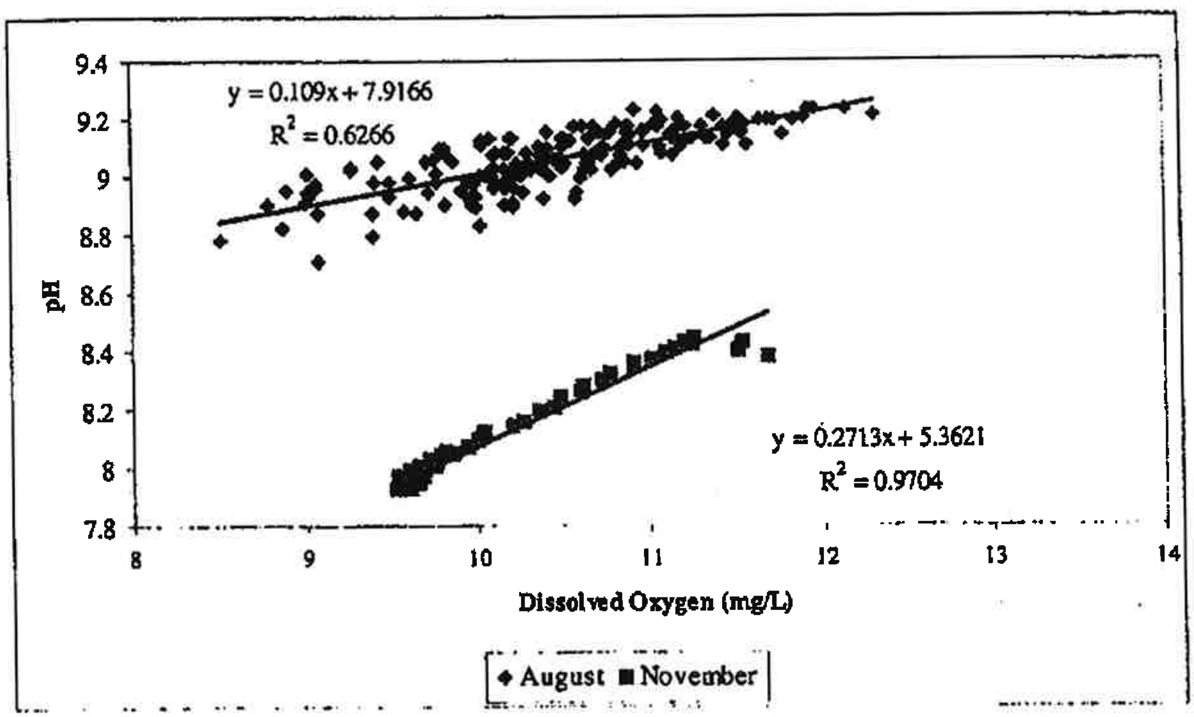



Figure 4 Correlation of Ph and dissolved oxygen within aquatic plant bed RM 62.3

Pend Oreille River Open Channel

The open channel site at RM 61.9 exhibited typical diurnal trends in August. Dissolved oxygen and temperature increased during the day and decreased at night (Figures 5-6). Temperature, percent dissolved oxygen saturation, and pH ranged from 20.9°C - 21.9 °C, 96.4% - 103.5%, and 8.57-8.71, respectively, during the August 3-day study period (Table 1). In November, diurnal changes were minimal with temperature, dissolved oxygen saturation and pH ranging from 9.18 °C - 9.47 °C, 95.7% - 99.4%, and 8.11-8.18, respectively (Figure 7).

Unlike within the macrophyte bed, vertical differences in temperature, pH, and dissolved oxygen were minimal. In addition, no correlations were found between dissolved oxygen and pH. Comparing August temperatures between RM 62.3 (macrophyte bed) and RM 61.9 (open channel) both sites have diurnal fluctuations. Fluctuations at RM 62.3 were more dramatic, ranging from 20.35 – 22.9, and lagged behind the open channel with peak temperatures occurring in the late evening, early morning hours (Figure 1-2). In comparison, temperatures at RM 61.9 ranged from 20.9 °C - 21.9 °C and peaked in the late afternoon (Figures 5-6). Despite differences in trends, overall mean temperature between the open channel and macrophyte site were minimal varying by 0.08 °C over the course of the 3-day study period.

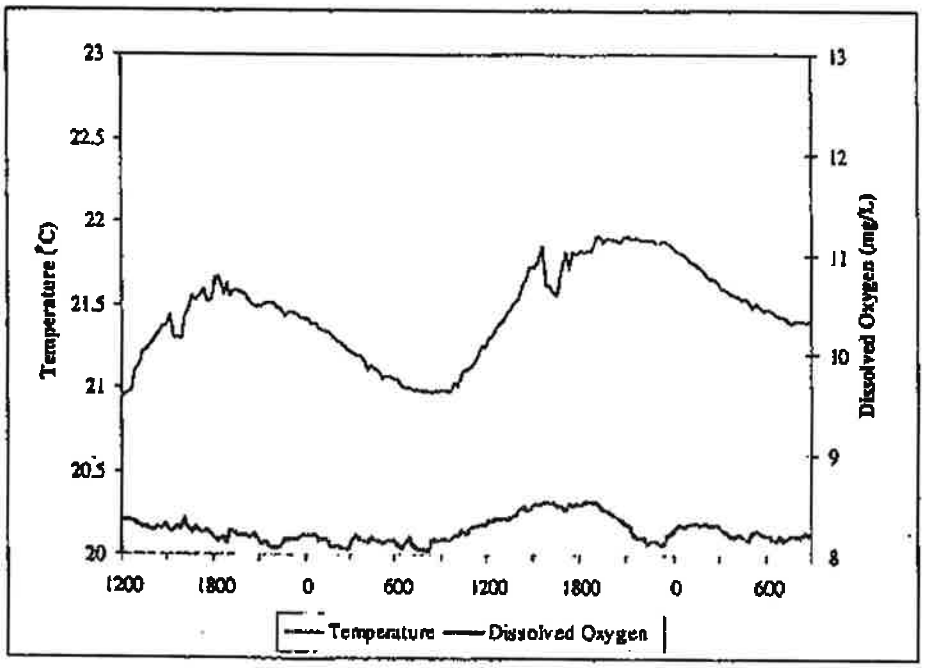



Figure 5 Dissolved oxygen and temperature open water RM 61.9 August 21-23, 2000

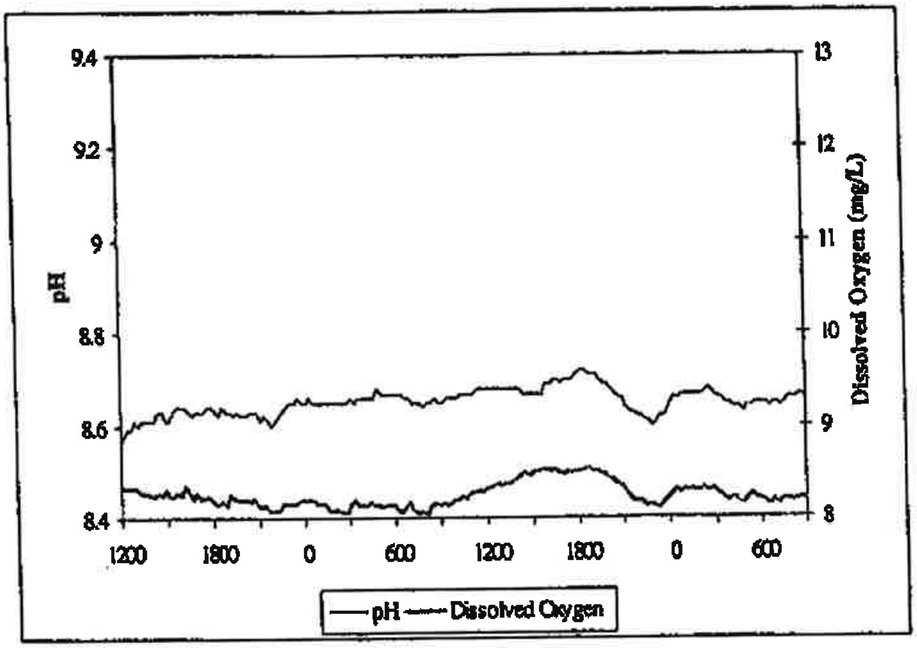



Figure 6 Dissolved oxygen and pH open water RM 61.9 August 21-23, 2000

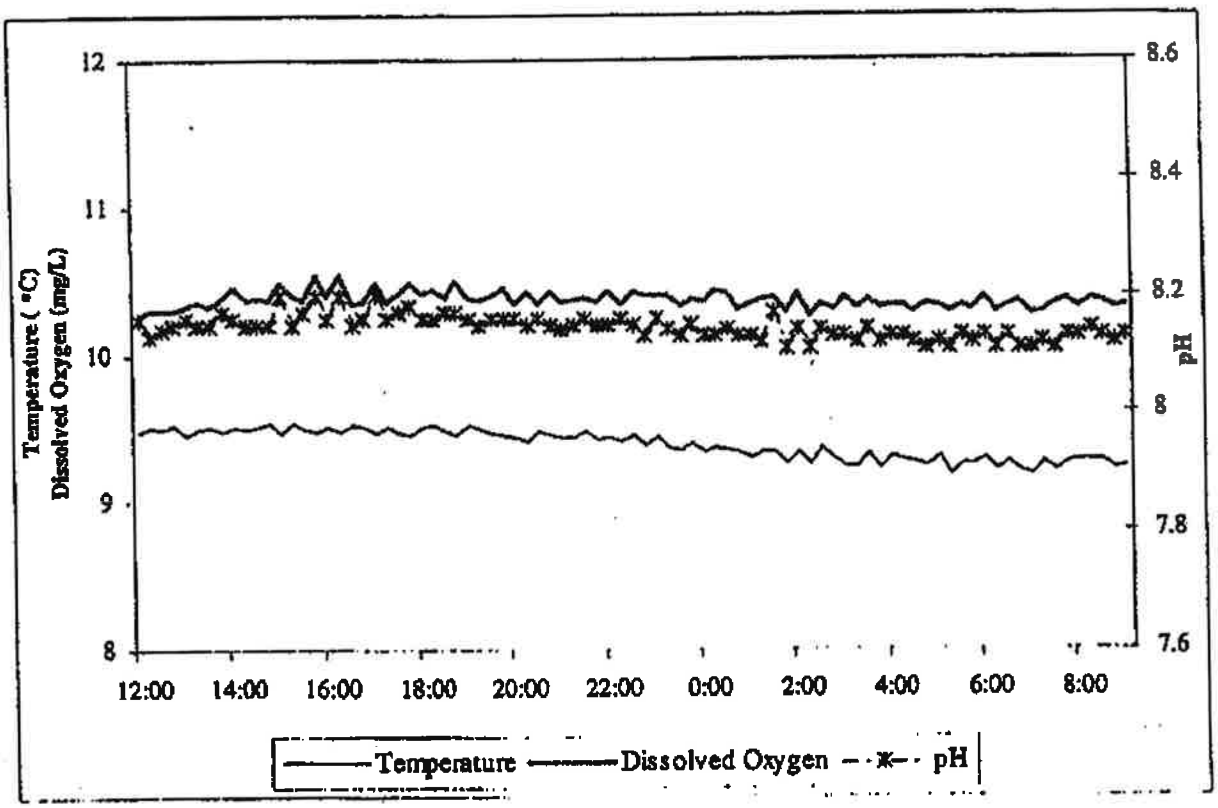



Figure 7 Temperature, dissolved oxygen and pH at open water site RM 61.9 November 1-2, 2000

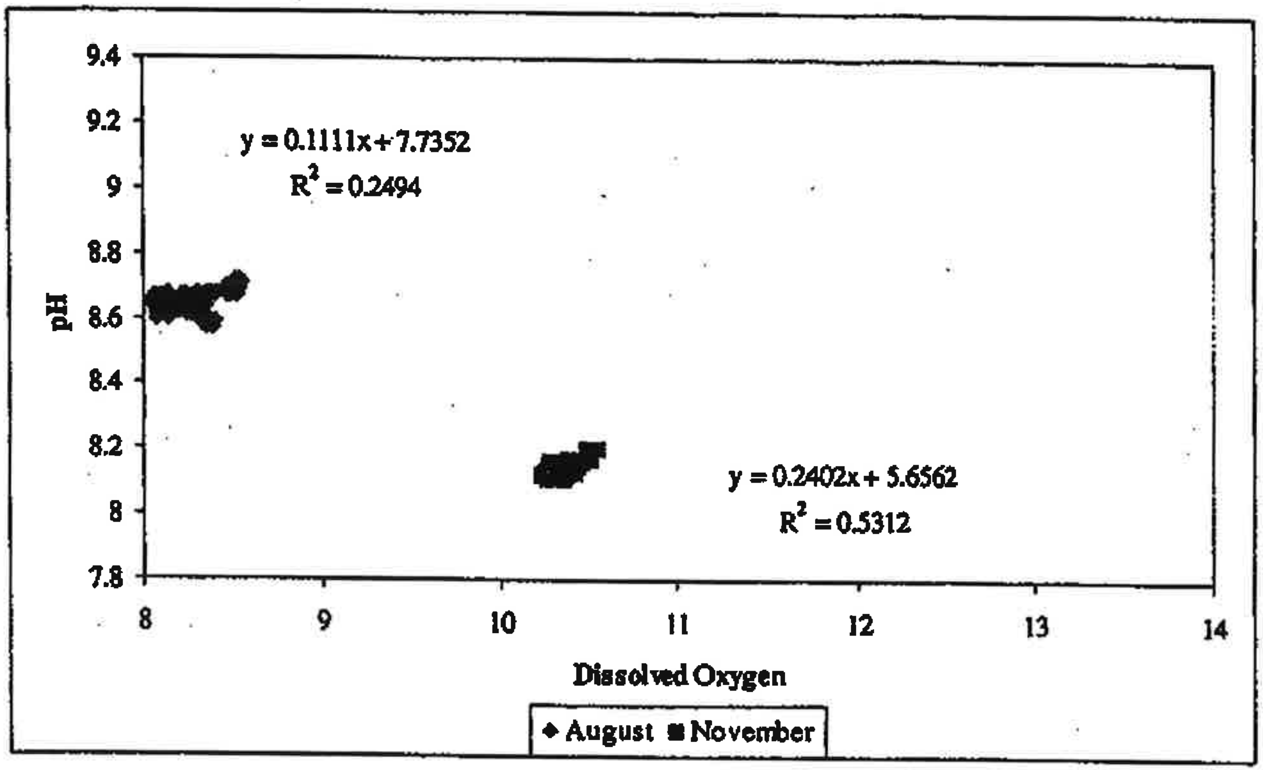



Figure 8 Correlation between ph and dissolved oxygen open water site RM 61.9

## Discussion

The ability of macrophyte beds to alter their environment is well documented. (Frodge et al. 1995, Frodge et al. 1990, Carter et al. 1991). Dense stands of weeds act as sediment traps, reduce flow, and can alter the nutrient regimes in the water column (Carpenter and Lodge, 1991). Frodge et al. (1990) found that macrophyte beds partitioned the littoral zone of two shallow Northwest lakes both vertically and horizontally. In the Box Canyon Reservoir, dense macrophyte beds within shallows develop a separate microhabitat from the main river channel. The macrophyte beds exhibited a vertical temperature gradient, elevated dissolved oxygen saturations, peaking as high as 151 %, and pH values that were 0.4-0.5 units higher in the macrophyte bed than in the main channel.

The lack of vertical mixing within the macrophyte bed is the most probable explanation for the unusual diel patterns in temperature, pH, and dissolved oxygen in the macrophyte bed as compared to the main channel. Water column mixing does not occur as easily in the macrophyte bed as in the open channel. *Myriophyllum spicatum* (Eurasian watermilfoil) outcompetes other submerged macrophytes by rapid growth to the surface and forming a dense canopy that shades out competition (Smith and Barko, 1990). The closed canopy reduces wind mixing and water velocity in the bed and can result in large changes in water quality (Frodge et al. 1990, Carter and Rybicki 1991). With reduced lateral river velocity within the bed and reduced vertical mixing due to wind, vertical temperature and dissolved oxygen gradients developed in the bed during the day, that did not develop in the open channel. When physical mixing of the bed did occur, due to the arrival of the boat, spikes in dissolved oxygen, pH, and temperature were documented. Frodge et al. (1990) found similar results that "physical manipulations of the surface canopy tended to increase local DO concentrations above ambient concentrations in adjacent undisturbed patches of *B. schreberi*".

Photosynthetic activity in the bed is immense. High rates of photosynthesis will elevate both pH (due to reduction of $CO_2$ in the water column thereby shifting the bicarbonate-carbonate balance toward a more basic environment ) and elevate dissolved oxygen (Horne and Goldman, 1992). Correlations between dissolved oxygen and pH were higher in the macrophyte bed (Figure 7) than in the open channel (Figure 8) indicating the effect of increased photosynthesis in the macrophyte bed. These correlations give further evidence of the macrophyte bed's ability to alter the water column environment in the Box Canyon Reservoir. Overall, dissolved oxygen saturation levels in the bed were 1.3 % higher than the open channel.

Coots and Willms (1991) reported similar nocturnal peaks in dissolved oxygen for Box Canyon Reservoir. They attributed the unusual peaks to upstream photosynthetic activity causing supersaturation of dissolved oxygen. They hypothesized the saturated dissolved oxygen remained elevated over time, during which the water had moved downstream to the sampling site. However, during the August 2000 study, no dissolved oxygen or temperature "time lagged" peaks occurred in the open water channel indicating the changes in dissolved oxygen, temperature, and pH were localized to within the macrophyte bed.

Usually, temperature and dissolved oxygen are lowest in the evening due to reduced solar input, and respiration by biota being greater than plant photosynthesis. However, temperature and dissolved oxygen peaked nocturnally in the macrophyte bed. Our hypothesis is that a breakdown of the temporary temperature vertical gradient occurs in the bed. In addition to a night time peak the shape of curve for diurnal temperature within the plant bed is protracted (Fig.1) relative to a more typical sinoid temperature curve as observed for the open water site (Fig. 3). Wind driven currents or cooling of the uppermost surface layer causing a vertical density current are two possible means to transfer warmer, highly oxygenated surface water to a deeper position at 1m where the hydrolab was located. The breakdown of the vertical gradient allows for top to bottom mixing of the water column in the macrophyte bed. The temperature peaks later in the evening are potentially due to the mixing of upper waters (0-0.5 m) of the bed with the lower cooler waters (1.0 –1.5 m). (Note: the hydrolab was placed at 1.0-1.25 m of water, and therefore remained in the cooler waters of the macrophyte bed). During the day, surface waters are warmer than the bottom waters of the bed. Lack of mixing and shading by the plant canopy causes the bottom waters of the bed to be cool relative to the surface. In the evening, the warmer surface waters begin to sink. On the surface, the temperature of the water is cooling - mixing downward into the macrophyte bed. Within the bed, the gradual movement of the surface waters into the bed warms the interior of the bed. The macrophyte bed acts as an insulation against heat loss as the water is contained in one area. As evening progresses, the water in the bed cools and the bed reaches an overall homeothermic temperature profile.

Dissolved oxygen profiles exhibit an opposite trend to that of the temperature profiles. Dissolved oxygen was highest at the lower depths in the afternoon. Overall the entire water column in the macrophyte bed is supersaturated with respects to the atmosphere. Dissolved oxygen in the upper water column was able to equlibrate with the atmosphere, thereby remaining lower in the afternoon. Dissolved oxygen saturation dropped, as the dissolved oxygen was given off at the water-air interface. Usually, mixing of the bottom waters is associated with oxygen debt in the upper water column, as in the case of large lakes with anoxic hypolimnions. However, in the Pend Orielle the bottom waters are supersaturated with dissolved oxygen as dissolved oxygen was highest 0-0.25 m off bottom. As this water was mixed with the upper water column it increased the dissolved oxygen concentrations at the level of the hydrolab.

## Conclusions

- Dense aquatic macrophytes in the Pend Oreille River are able to develop a microhabitat that has different temperature, dissolved oxygen, and temperature regimes than the open channel.

- Changes in dissolved oxygen, temperature, and pH are localized within dense macrophyte beds.
- Vertical gradients in temperature, pH, and dissolved oxygen developed in dense macrophyte beds and were not evident in the open channel sites.
- Dissolved oxygen levels were elevated in August. A dondition of anoxia was not evident, except at the sediment-water interface, in both August and November.

**Recommendations**

The interpretation for the atypical diurnal patterns for dissolved oxygen and temperature within the dense aquatic plant bed provide a plausible hypothesis for a mechanism. The data are not conclusive as to the mechanism; however, the data consistency with that reported previously by Coots and Willms (1991) confirm that atypical diel patterns occur within dense plant beds. Water quality within plant beds could be affected by aquatic plant management actions. Rotovation of fish lanes within aquatic plant beds is under consideration as an aquatic plant management strategy. Water quality can affect biotic health and productivity. A better understanding the mechanism for the atypical diurnal dissolved oxygen and temperature patterns within aquatic plant beds is therefore warranted.

Additional monitoring should be designed to discern if the atypical diurnal pattern within dense plant beds is attributable to within bed vertical mixing or movement of water through the bed from upstream points. A temporary flow barrier could be constructed around a portion of the plant bed. This would require plant and substrate disturbance so time should be allowed for suspended sediment to settle before sampling. Water quality could then be monitored within the enclosed portion of the plant bed as well as a second location in the bed where lateral flow is not restricted. A control sampling site where the same level of disturbance occurs but the barrier is not placed would allow the effects of disturbance to be discerned from the flow blocking. A second control site where plants have been rotovated or otherwise cleared from a location with similar water depths and river position is also suggested. This control site could aid in a comparison of vertical gradients occuring in shallows with and without plants. The monitoring could occur over a 48 hour period during August peak plant biomass production. Consecutive 48 hour periods may be necessary to effectively utilize instrumentation for each of the paired sites. Replicating the experiment in November does not seem necessary since the unusual D.O. pattern only occurred within the plant bed during August.

**References**

Carpenter, S.R. and Lodge, D.M. 1986. Effects of submersed macrophytes on ecosystem processes. Aquat. Bot. 26: 341-370.

Carter, V., N.B. Rybicki, and R. Hammerschlag. 1991. Effects of submersed macrophytes on dissolved oxygen, pH, and Temperature under different conditions of wind, tide, and bed structure. J. Freshwate. Ecol. (6)2: 121-133.

Frodge, J.D., D.A. Marino, G.B. Pauley, and G.L. Thomas. 1995. Mortality of largemouth bass (*Micropterus salmoides*) and steelhead trout (*Oncorhynchus mykiss*) in densely vegetated littoral areas tested using *in situ* bioassay. Lake and Reserv. Manage. 11(2) 343-358.

Frodge, J.D., G.L. Thomas, and G.B. Pauley. 1990. Effects of floating and submergent growth forms of aquatic macrophytes on littoral water quality. Aquat. Bot. 38:213-248.

Smith, C.S. and J.W. Barko. 1990. Ecology of eurasian watermilfoil. J. Aquat. Plant. Manage. 28: 55-64.

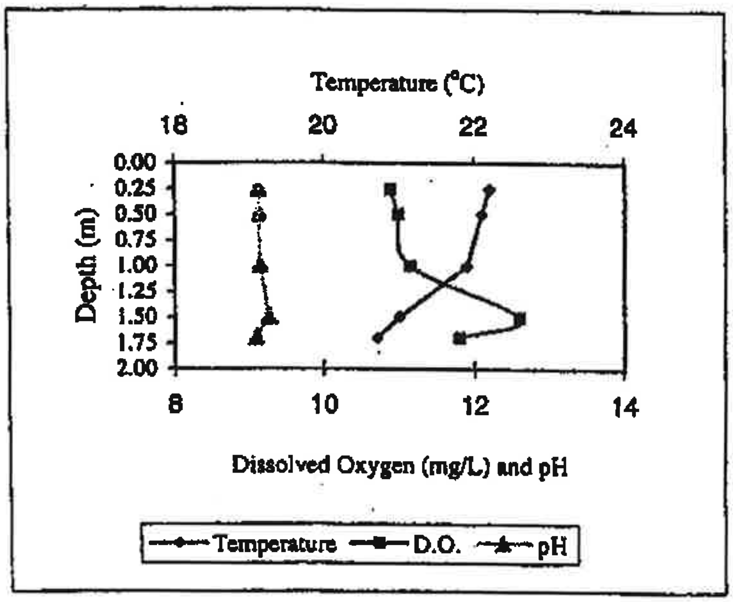
Coots and Willms 1991.

**Table 1.** Temperature, dissolved oxygen saturation, and pH mean and ranges for two sites in BCR RM 62.3 (Aquatic Plant Bed) and RM 61.9 (Open Water) August and November, 2000

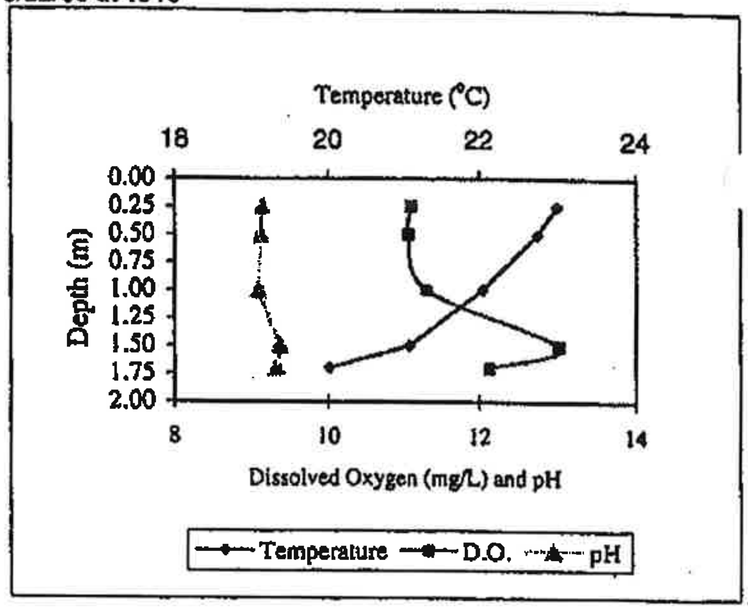
| Site | Mean Temperature | Temperature Range | Mean Dissolved Oxygen % Saturation | Dissolved Oxygen % Saturation Range | Mean pH | pH Range |
|---|---|---|---|---|---|---|
| **August 21-23, 2000** | | | | | | |
| Macrophyte Bed RM 62.3 | 21.37 | 20.35-22.9 | 126.8 | 103.2-151 | 9.05 | 8.78-9.23 |
| Open Channel RM 61.9 | 21.45 | 20.9-21.9 | 99.6 | 96.4-103.5 | 8.65 | 8.57-8.71 |
| **November 1-3, 2000*** | | | | | | |
| Macrophyte Bed RM 62.3 | 9.19 | 8.99-9.45 | 93.8 | 88.2-110.2 | 8.08 | 7.93-8.44 |
| Open Channel RM 61.9 | 9.39 | 9.18-9.47 | 97.4 | 95.7-99.4 | 8.14 | 8.11-8.18 |

*Hydrolab data from 11/1-11/2 for RM 62.3, and from 11/2-11/3 for RM 61.9.

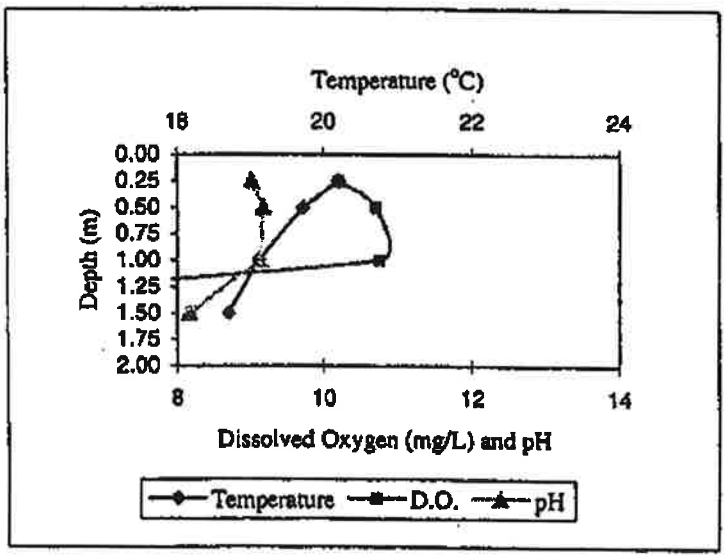
8/21/00 at 1445



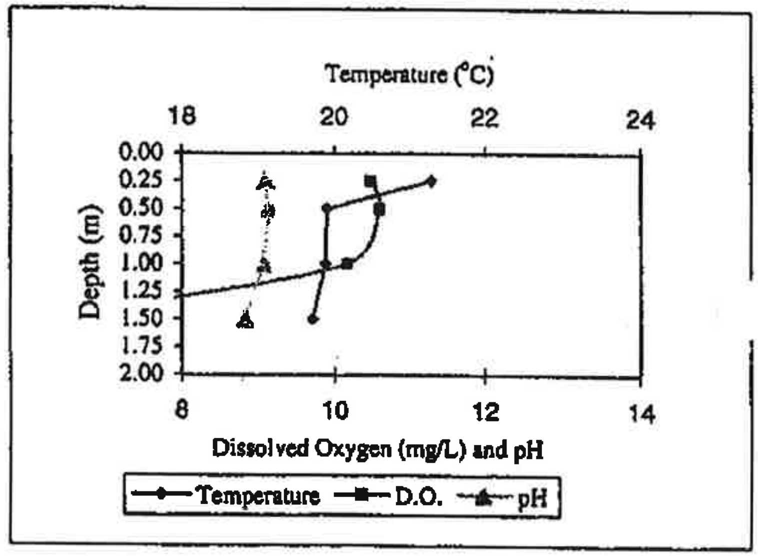

8/22/00 at 1510




8/22/00 at 0950




8/23/00 at 0905




8/23/00 at 0905

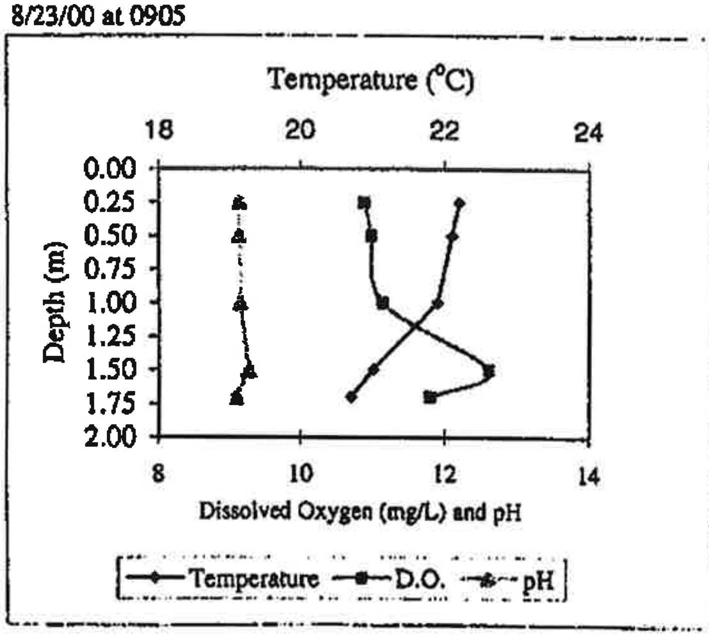
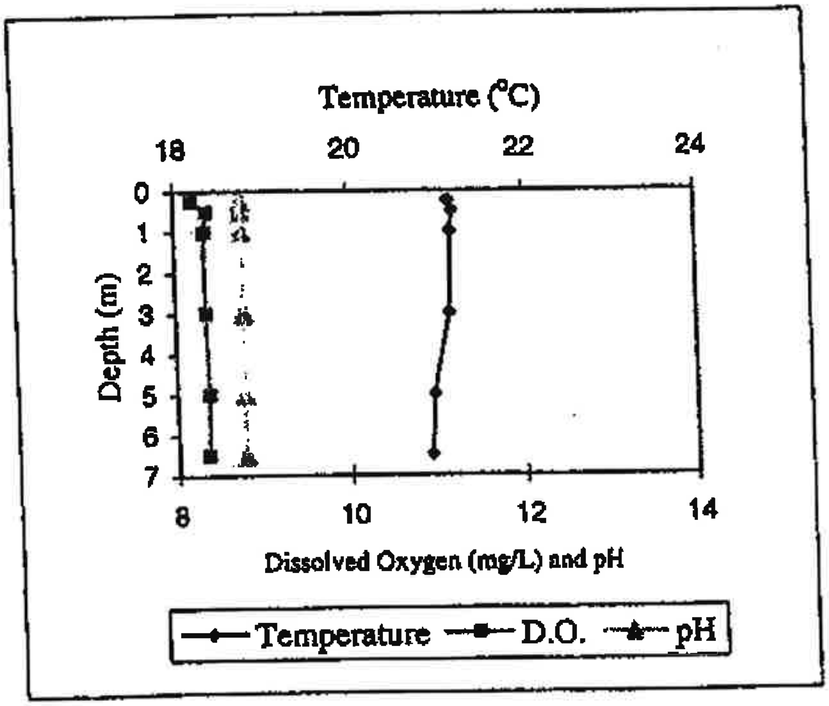
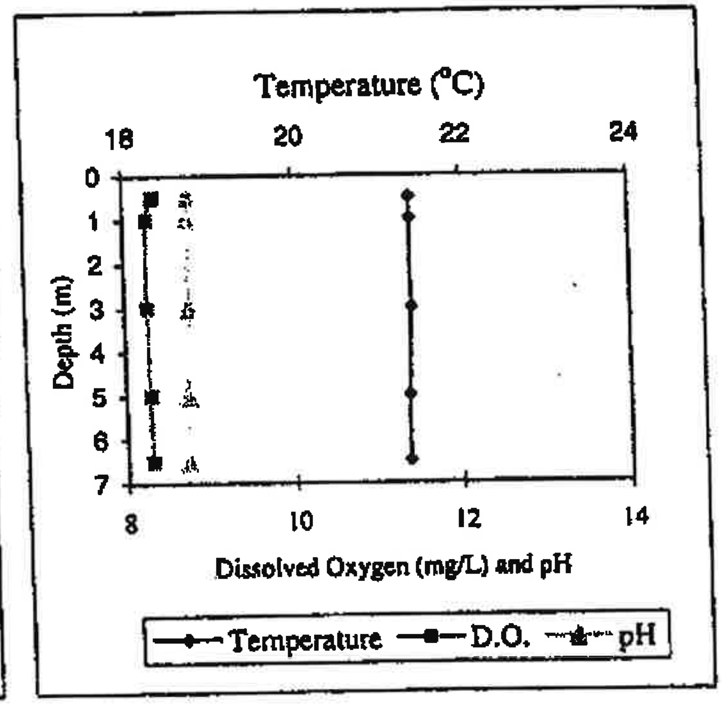



Figure 9. Temperature, dissolved oxygen, and pH depth profiles at RM 62.3 within plant bed, August 21-23, 2000.

:2/00 at 1005




8/23/00 at 0900




8/22/00 at 1540

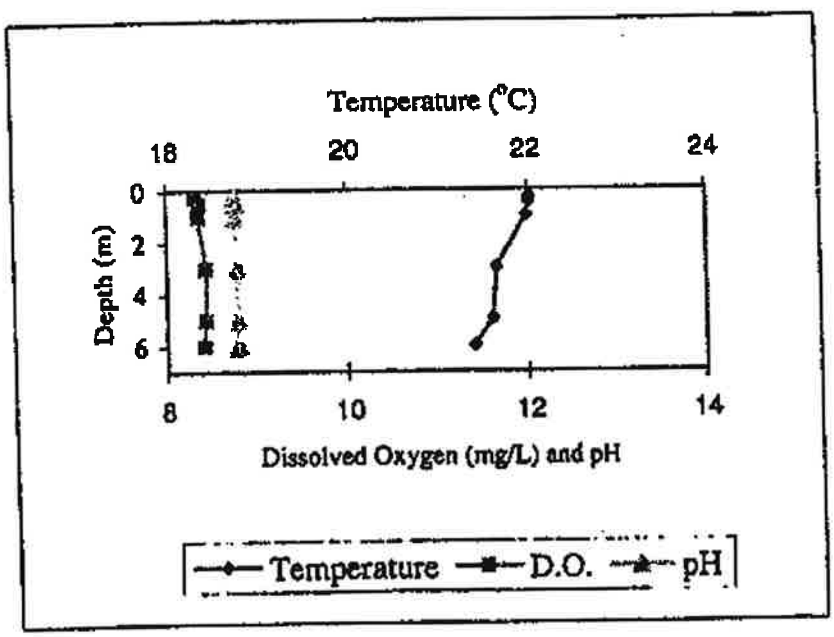



Figure 10. Temperature, dissolved oxygen and pH vertical profiles for RM 61.9 open water site, August 21-23, :

cc file Box 6.5.1
L. Fortway

# Box Canyon Hydroelectric Project
## Water Quality Work Group Meeting Agenda
## May 10, 2001
## Pend Oreille Public Utility District Office, 130 N Washington St. Newport, WA



10:00 am Introductions

10:15 am Aquatic Plant Management Plan

- Ideas and perspectives from the April 21 workshop:
- Review Plan Goals statement
- Develop list of action items that can be done now
- Schedule for completing plan
- Landowner/public involvement: how do we make a plan meaningful and useful
- List aquatic plant containment methods to consider in plan
  - Landowner options
  - Institutional options
  - Pros and cons
  - Identify methods appropriate for each resource goal statement

Lunch noon – 1pm on your own

1 pm Continue mornings discussion on aquatic plants

2:45 pm Next actions

3 pm Adjourn

***Distribution:***

Mr Art Acuff
Mr Joe Akai
Mr John Blum
Mr Mitch Brown
Mr Pat Buckley
Mr Sean Carney
Mr Mark Cauchy
Mr Chip Corsi
Mr Bill Dean
Mr Tony Eldred
Mr Eugene Fitzpatrick
Mr Russell Fletcher
Mr John Gross
Mr. Scott Hall
Mr Curt Holmes
Mr Donald Johnson
Mr. Mark Killgore
Mr John Kinney
Mr Glenn Koehn
Ms Kim Kress
Mr Sam Nicholas
Ms Jean Parodi
Mr David Potter
Mr. Tom Schuda
Mr. Chuck Rice
Mr. Doug Robison
Mr Jack Snyder
Ms Sharon Sorby
Mr. Dan Trochta
Ms Ruth Watkins
Mr Paul Wilson
Mr Ken Withers
Ms. Charlotte Yergens

L09

**Summary of consultation for Box Canyon Hydroelectric Project**
**Tri-State Water Quality Council**
**January 12, 2000**

*File: kd/box/sumcom/agency/mtg/scom011200.doc*
*File code: 4.7.5*
*Key words: PM&E, water quality, monitoring*

The purpose for the meeting was to discuss the possible involvement of the Tri-State Water Quality Council (TSWQC) in a technical review role for the Box Canyon Hydroelectric Project during the new license period. The following people attended the meeting in Couer D'alene, Idaho, either in person or by telephone conference.

Chuck Rice, EPA Region 10
Julie DalSoglio, EPA Region 8
June Bergquist, Idaho DEQ
Gary Ingman, Montana DEQ
Bruce Anderson, Land & Water Consulting
Jean Parodi, Washington DOE
John Gross, Kalispel Tribe
Kent Doughty Duke Engineering & Services
Pat Buckley, Pend Oreille PUD

Others members of the TSWQC monitoring sub-committee who were not at this meeting (by phone or in person) include: Mike Beckwith, USGS; Will Kendra and Randy Coots, Washington DOE; Vicki Watson, University of Montana.

Kent Doughty provided a very brief overview of how the Box Canyon Project operates and the FERC licensing process. He noted that the District has to file its license application in January 2000. The text in the license application for describing technical review for water quality PM&E's/study reports was worded to create an opportunity for the involvement of the TSWQC without committing them to an obligation. Pat stressed that the District's intent is to provide an opportunity but not a burden.

Kent next reviewed the PM&Es for water quality as they are stated in the final license application. He advised that the final PM&Es for the license are subject to the FERC's review and NEPA. General water quality will be ongoing with monthly sampling; the objective is to understand long term trends in water quality through a monitoring program compatible with WDOE's for this reach of the Pend Oreille River. Total gas abatement studies include physical monitoring, biological monitoring, and abatement feasibility analysis. Aquatic plant management includes the development of an integrated management plan, ongoing rotovation, alternate control pilot studies, and a pilot winter drawdown study. The pilot drawdown will be in Campbell Pond where the potential adverse impacts are limited by the size of this water body. Education will also be a component of the aquatic plant PM&Es but would likely not require any technical review.

A handout was distributed which described the TSWQC responsibilities and the District's responsibilities (attachment 1).

Chuck Rice (EPA) commented that a funding level of $12,000 seemed up to an order of magnitude too small to accomplish all of the technical review, particularly if it required coordination with all of those involved in the systemwide approach to dissolved gas abatement and an in-depth review of TDG studies. He asked if a detailed estimate of the hours and tasks involved was used to develop the proposed budget estimate to which Kent replied no, it was based on a rough estimate of ¼ time and was meant to initiate discussion.

Chuck asked for an explanation of how the tri-State's potential role as technical review fit in with the regulatory responsibilities of agencies and tribes providing review and comment on FERC ordered license articles and the 401 certification. Kent noted that a technical reviewer would not usurp or negate any responsibility of the agencies to review license ordered reports/studies. The District is not asking nor is in a position to authorize regulatory authority on technical review. Chuck cautioned that there was the potential for the TSWQC to have conflicting opinions with another reviewing agency on technical review which could compromise the TSWQC working relationships and mission.

June Bergquist said the technical review role as described in the Project license application goes beyond the objectives of the TSWQC.

Kent asked the group what their perspective on the role of the TSWQC should be on the Box canyon Project. Gary Ingman noted that the aquatic plant management had a direct tie to the TSWQC objectives and potentially other water quality issues but not all of the PM&E's are directly related to the TSWQC's current mandate. Ruth noted that the TSWQC does provide a role as an information conduit to stakeholders interested in water quality issues along the Clark Fork/Pend Oreille drainage.

It was the group's opinion that technical review of gas abatement and gas monitoring is best suited to the Transboundary Group or other parties with appropriate expertise and focus. Technical review of other PM&Es raises both concerns and opportunities; the current proposal is likely too expansive.

While the proposal needs modification, it was agreed that a presentation to the full Council at its next meeting in April is still warranted. Kent and Ruth will work together to develop at least three options for a role by the TSWQC for presentation to the Council. The options might include the TSWQC to: simply provide review as one among many other stakeholders; act as an information conduit to others; limited focus of technical review; or have primary responsibility (but not regulatory authority) for technical review. An options paper will be circulated among this subcommittee prior to being presented to the Council. Material should be prepared in advance of the Council meeting so Council members will be familiarized with the proposal ahead of time.

Kent closed by saying the District's intent is to create an opportunity to better integrate the District's programs on Box Canyon Reservoir with the activities of the TSWQC within the larger Clark Fork/Pend Oreille system. If the TSWQC concludes that the technical review role is not a good fit with the Council's purpose, there are other mechanisms readily available for technical review. The Box Canyon Project currently has a technical committee, which will likely be expanded and continued under the new license.

**Tri State Water Quality Council**
**Monitoring Subcommittee**

Project: Box Canyon Hydroelectric Project (FERC No. 2042
River: Pend Oreille River Albeni Falls (RM 90.1) to just below Box Canyon Dam (RM 34.4)

Monitoring Objective: (*Preliminary and subject to discussion by aquatic work group and FERC license*) Monitor water quality conditions within Box Canyon Reservoir in a manner that compliments other ongoing water quality monitoring programs and contributes to an assessment of long term water quality trends. Monitoring is responsive to evaluating the effectiveness of FERC ordered water quality management plans and the goals and objectives of the Tri-State Water Quality Council.

Parameters for Monitoring: total dissolved gases, Dissolved oxygen, temperature, pH, conductivity, alkalinity, Carbon dioxide
possibly add nutrients: Nitrite-Nitrate Nitrogen, Total Persulfate Nitrogen, Total Phosphorus, Dissolved soluble Phosphorus

Monitoring Locations: Box forebay and tailrace - continuous recording
Usk bridge, Newport (possibly delete since WDOE samples at Newport) - Monthly

TSWQC Responsibilities:

- coordinating stakeholder review of activities described in the PM&E's related to water quality
- technical review of study plans for implementation of the water quality PM&Es
- technical review of the existing water quality baseline data for BCR to determine the need and purpose for a continuous monitoring station, which would be operated by the District in addition to the monthly sampling
- facilitate biennial review meetings of progress on PM&E's
- technical review of annual water quality report inclusive of water quality monitoring, dissolved gas studies, and aquatic plant management

District Responsibilities:

- Prepare study plans and management plans for implementing PM&Es
- Fund and conduct studies (design, field implementation, analysis, report)
- Prepare quarterly and annual reports and distribute to TSWQC
- Provide data and analytical results to TSWQC
- Participate in biennial review meetings
- Report to FERC on progress of water quality PM&E implementation and related license conditions
- Fund TSWQC for coordination and technical review

TSWQC Funding: Annual funding by the District for this position will not exceed $12,000.

**Summary of Consultation**
**Box Canyon Hydroelectric Project**
**Water Quality work Group Meeting**
**May 10, 2001**

*File: kd/box/sumcom/agency/mtg/2001/scom051001.doc*
*File code: 4.7.5*
*Key words: water quality, macrophytes, PM&E, management plan*

The following people participated in a Meeting held on May 10, 2001 at the Pend Oreille PUD (District) office in Newport. The purpose of the meeting was to discuss the Aquatic Plant Management Plan (AQMP) for the Box Canyon Reservoir.

| | | | |
|---|---|---|---|
| Pat Buckley | District | Ruth Watkins | TSWQC |
| Mark Cauchy | District | Paul Wilson | PO County |
| Kent Doughty | DE&S | Eileen McLanahan | Harza |
| Dave Potter | GANDA | Walt Krahn | Homeowner |
| Chuck Rice | EPA | Archie Oestreicher | Homeowner |
| Sharon Sorby | POCWB | Jean Parodi | DOE |
| Nancy Weller | DOE | | |

Following introductions, the group reviewed the management goal statement. Kent Doughty stressed that agency and public participation in the plan development is essential for its success. Walt Krahn noted that cooperation is necessary and there is confusion as to the ownership of lands within the river channel; who is responsible for maintaining.

It was noted that public information on methods to contain plants and the ecological values of aquatic plants has to be easily accessible. The recent workshop was noted as an excellent public education experience.

Sharon Sorby led a brief discussion on Lake Associations. An association can encompass all or part of a water body but everybody within a geographic boundary needs to participate. Associations are a legal entity organized and with authority to tax themselves for lake [river] improvement over a specified period of time. Associations have opportunities to tap into grant monies. Ruth Watkins offered to look into some funding opportunities available to lake associations. Jean Parodi and Nancy will get a list of lake associations and contacts. It was suggested that when we hold a public meeting to discuss the plan that we invite a member from an active lake association to talk about what is involved in setting up an association.

Jean Parodi noted that some resources are widely dispersed in the reservoir and not necessarily attached to a single shoreline use. Water quality is affected by aquatic plants. The 401 water quality certification will need to demonstrate that the Project has a plan

Other Extension classes - (other than SOP program)

1/19/01 Procrastinators workshop - 12 attended

1/25/01 Weeds as Change Agents - 25 attended
- Sharon Sorby

1/17/02 Noxious Weed ID session - Master Gardener update
Sharon + Carol
28 attended

4/24/02 Weeds and Wildlife Habitat - 22 attended

4/ Panel of presenters

WSU Cooperative Extension
S. 418 Scott/PO Box 5045
Newport WA 99156
Cooperating agencies: Washington State University, U.S. Department of Agriculture and Pend Oreille County. Cooperative Extension programs are available to all without discrimination. Persons with a disability requiring special accommodations while participating in this program may call (509) 447-2401 at least five days before the program.

# Homeowners' Milfoil Workshop and Trade Fair

## April 21, 2001

## Cusick High School, Cusick, Washington

| | |
|---|---|
| 8:30 | **Sign-in,** Donuts & Coffee; view trade fair displays |
| 9:00 | **Building the Pend Oreille River Aquatic Vegetation Management Plan** |
| | **Why Plan?** *Kent Doughty, Duke Engineering* |
| | **The Role of Aquatic Vegetation in the Ecosystem** *Devin Malkin, Duke Engineering* |
| | **Our Rotovation Milfoil Control Program** - Past, Present & Future *Paul Wilson, POC Public Works* |
| | **Weevils for Biocontrol** *Devin Malkin, Duke Engineering* |
| 10:15 | Break |
| 10:30 | **A Few Landowner Options - Products & Methods for Landowner Aquatic Weed Control** *Terry McNabb, RMI/Aquatechnex* |
| | **Diver Dredging** *Doug Freeland, Kootenai County milfoil specialist* |
| | **Hydraulic Permits-The Mighty Booklet** *Doug Robison, Washington Department of Fish & Wildlife* |
| 12:00 | Lunch Break, Trade Show |
| 1:15 | **Herbicides & Water - Do They Mix? Renovate™-Can You?** *Shaun Hyde, SePRO* |
| | **Managing Reed Canary Grass** *Ron Crockett, Monsanto* |
| | **What Can You Do? - Regulations and Consequences for Illegal Herbicide Use** *Nancy Weller, Department of Ecology* |
| 2:30 | Break |
| 2:45 | **Show Me the Money-Finding the Funding** *Nancy Weller, Department of Ecology* |
| | **Refocus on Planning: Forming Sounding Board Committees** *Kent Doughty, Duke Engineering* |
| 3:30 | Adjourn |

**Call (509) 447-2401 to pre-register. Pre-registration needed for lunch count. Cost: $5 individual; $7.50 family, includes lunch.**

75 attended

Coop Ex

# Pend Oreille Procrastinators Pesticide Recertification Class
# Dec 19, 2001

**Sadie Halstead Middle School Room 116, 331 S. Calispel, Newport**

*Afternoon Session* *2 credits (applied for)*

**3:30-5:30 p.m.** **Practical Points for Pesticide Use**
Instructor: Sharon Sorby, Pend Oreille County Weed Board
(and WSU Cooperative Extension videos!)

Rinse and Recycle Plastic Pesticide Containers video (12 min)
Sprayer Prep with John and Daryl video (27 min)
Calibration video (32 min)
The Homeowners's Guide to Integrated pest Management and Pesticide Safety video (42 min)

**5:30- 6:00 p.m.** **Brown Bag Supper**
(beverages and cookies provided!)

*Evening Session* *3 credits (applied for)*

**6:00 - 7:00** **Pesticides, Labels, and Record Keeping**
Instructor: Scott Nielsen Washington State Department of Agriculture
Recordkeeping basics, reminders and updates
Labels--when violations occur

**7:00-8:00 p.m.** **Current Issues in Pesticide Use**
Instructor: Scott Nielsen Washington State Department of Agriculture
Pesticides and Weeds
Clopyralid in compost
Aquatic herbicide application and NPDES requirements

**8:00-9:00 p.m.** **Which Weeds to Watch**
Instructor: Sharon Sorby, Pend Oreille County Weed Board
Aquatic Weed ID
Kudzu--New Invader in the Pacific Northwest

---

Registration Fee--$7.50 (one or both sessions) --please call 447-2401 to pre-register
Or return to WSU/Pend Oreille Cooperative Extension, PO Box 5045, Newport WA 99156

_______ Afternoon session only Name_______________________

_______ Evening session only Phone_______________________

_______ Both sessions email_______________________

12 attended

```
* * *   PEND OREILLE COUNTY PUD #1   * * *          GYEAW_A
          Utility Billing Statement Control File

Billing Date              10/20/2003    Monday, October 20, 2003
Payment Due Date          __________
Budget Due Date           __________
Default Revenue Mo/Yr        10/2003    October, 2003

                 --------------+---------------*--------------+---------------
Billing Messages: ATTEND THE EURASIAN MILFOIL WORKSHOP AT THE USK COMMUNITY
                 CENTER, IN USK, NOVEMBER 13, 6-9:30 P.M. FOR AN UPDATE ABOUT
                 MILFOIL CONTROL STRATEGIES. CALL PEND OREILLE COUNTY EXTEN-
                 SION, 447-2401 TO REGISTER, AND FOR MORE INFORMATION.


F1=E.F.T. Message   F3=End Job        F8=Change Control file with dates
F9=Continue         F10=Enter/Update Messages by Area   F19=Calandar    Help
```

# Eurasian Watermilfoil Workshop
## ~ Identification and Management Update ~
November 13, 2003, 6:00 PM - 9:30 PM
Usk Community Center
2442 Black Road; Usk, WA

6:00-6:05 – Welcome and Introductions

6:05-7:20 – Jenifer Parsons – Aquatic Plant Specialist, DOE
"Aquatic Weeds: an overview of their identification, control, and role in the environment" and "The Potential of Milfoil Weevils as a Management Option"

7:20-8:40 – David VanderMeulen – Water Resources Scientist, Envirovision Corporation "Aquatic Plant Surveys and Homeowner Physical Control Methods"

8:40-8:55 – Break

8:55-9:30 – Sharon Sorby – County Weed Board Coordinator and
Pat Buckley – Natural Resource Manager, PUD
"Integrated Aquatic Vegetation Management Plan Introduction" - A discussion on the current Eurasian watermilfoil control program and future options on the Pend Oreille River.

18 attended

11/13/03

**Eurasian Milfoil Workshop** **PRE-REGISTERED & Sign In Sheet**

**6:00 p.m. – 9:30 p.m. Usk Community Center, 2442 Black Rd, Usk WA $5/person**

| NAME & ADDRESS Telephone/email address | PAID | Number of attendees In group | ADD TO MAILING LIST Y/N |
|---|---|---|---|
| Steve & Vicky Nolting<br>447-4567 | 5.00 | 2 | |
| Ray Williams | | 2 | |
| Ted Davis<br>14032 LeClerc Rd S.<br>Usk, WA. 99180 | 5 | 1 | Y |
| Scott Emch<br>PO Box 1338<br>Newport, WASH 99154 | 5.00 | 1 | Y |
| Mike Johnson | | 1 | |
| Tom Wimpy wimpyth@hotmail.com<br>3822 E 2nd 509-535-3035<br>Spokane, WA 99202 | $5 | 1 | Y |
| WALT KRAHN WALDOD@AOL.COM<br>BOX 31 509/238-6577<br>CHATTAROY, WA 99003 | $5 | | |
| David VanderMeulen<br>1220 4th AVE E<br>Oly[redacted], WA 98506 | – | | Y |
| MICHAEL D JOHNSON<br>711 RIVERBEND LOOP RD<br>CUSICK WA 99119 | | | Y |
| RAY & GLORIA WILLIAMS<br>551 GREGGS RD NEWPORT WA | $10 | 2 | |
| Darlene Donegan<br>122 - Sunny Side Dr.<br>Newport | 5.00 | 1 | Y |

$70.00

| | | | |
|---|---|---|---|
| Chester B. Elmer<br>2022 Elmers Loop Rd.<br>Newport, Wa. 99156-9653 | $5 | | |
| Harold A. Bond<br>PO Box 2200 Newport, WA 99156 | $5 | | |
| Jerry Rocheller 2 | $10 | | |
| Lucy Baue | $5 | | |

| CONTINUATION SHEET | PAID | CHECK IN ✓ | MAILING LIST Y/N |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

how to move the reservoir pH towards meeting the water quality standard. The AQMP should note how water quality is affected by plants and how the AQMP will help to meet the water quality standards. Jean noted that the District may need to model the effect of plant containment on pH; how much of a reduction in plant biomass is necessary to achieve a pH reduction to the 8.5 standard, if feasible.

An element of the AQMP needs to address homeowner use of chemicals for treatment of aquatic plants. What works, what's legal, where to go for help, etc. There is undoubtedly going to be some use of chemicals so it is important to help guide that use. Simply stating that there are no chemical treatments available for flowing river waters doesn't really help. Effort is needed to work with homeowners to bring chemical use into permitted applications.

The group discussed short term (1 – 6 months) strategies. Ideas included:

- Post the rotovation schedule on the PUD web site
- Notices in the Newport paper on the rotovator schedule
- Schedule rotovator maintenance for the high water period and winter ice months
- Compare the Pend Oreille rotovator program to other programs elsewhere
- Complete an efficiency analysis of the rotovator program
- Lost Creek is a possible site for cutting fish cruising lanes

The group worked on the forms for identifying the level of containment intensity. The attached worksheets summarize the comments on containment strategies by resource. It was decided that some of the categories could be consolidated. For instance, it doesn't matter who owns the boat launch; the level of treatment is the same dependent upon use level of the boat ramp. Another comment on the containment intensity addressed treatment within aquatic plant beds dominated by native plants. The treatment can be conditional to balance other resource needs with maintaining instream habitat.

Future meetings to continue development of the AQMP were scheduled for June 13 and July 18.

# Box Canyon Hydroelectric Project

**Water Quality Work Group Meeting Agenda**
**May 10, 2001**
**Pend Oreille Public Utility District Office, 130 N Washington St. Newport, WA**

10:00 am Introductions

10:15 am Aquatic Plant Management Plan

- Ideas and perspectives from the April 21 workshop:
- Review Plan Goals statement
- Develop list of action items that can be done now
- Schedule for completing plan
- Landowner/public involvement: how do we make a plan meaningful and useful
- List aquatic plant containment methods to consider in plan
  - Landowner options
  - Institutional options
  - Pros and cons
  - Identify methods appropriate for each resource goal statement

Lunch noon – 1pm on your own

1 pm Continue mornings discussion on aquatic plants

2:45 pm Next actions

3 pm Adjourn

# APPENDIX F

# HPA PERMIT

# HYDRAULIC PROJECT APPROVAL

RCW 77.55.100 - appeal pursuant to Chapter 34.05 RCW

Washington Department of FISH and WILDLIFE

State of Washington
Department of Fish and Wildlife
Habitat Program
600 Capitol Way N - MS 3155
Olympia, Washington 98501-1091

COPY

**DATE OF ISSUE:** November 20, 2002 RECEIVED **LOG NUMBER:** ST-F3987-01

NOV 22 2002

PEND OREILLE CO
PUBLIC WORKS

| PERMITTEE | AUTHORIZED AGENT OR CONTRACTOR |
|---|---|
| Pend Oreille County Public Works Department<br>ATTENTION: Paul Wilson<br>P.O. Box 5067<br>Newport, WA 99156<br>509-447-4821<br>Fax: 509-447-5890 | Not Applicable |

**PROJECT DESCRIPTION:** Rotovation as a means of controlling non-native aquatic plants ( eurasian millfoil).

**PROJECT LOCATION:** Box Canyon Reservoir. Pend Oreille River above Box Canyon Dam to Idaho State Line.

| # | WRIA | WATER BODY | TRIBUTARY TO | 1/4 SEC. | SEC. | TOWNSHIP | RANGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 1 | 62.0002 | Pend Oreille River | Columbia River | | | | | Pend Oreille |

NOTE: This Hydraulic Project Approval pertains only to the provisions of the Washington State Fisheries and Wildlife Codes. It is the permittee's responsibility to apply for and obtain any additional authorization from other public agencies (local, state and/or federal) that may be necessary for this project.

This Hydraulic Project Approval (HPA) does not authorize trespass onto property not owned by the permittee. It is the permittee's responsibility to obtain permission to enter property owned by others.

## PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin immediately and shall be completed by November 1, 2007.

2. Work shall be accomplished per plans and specifications entitled, JARPA, dated September 18, 2002, and submitted to the Washington Department of Fish and Wildlife, except as modified by this Hydraulic Project Approval. These plans reflect design criteria per Chapter 220-110 WAC. These plans reflect mitigation procedures to significantly reduce or eliminate impacts to fish resources. A copy of these plans shall be available on site during construction.

3. Removal of detached plants and plant fragments from the watercourse shall be as complete as possible. This is especially important when removing aquatic noxious weeds. Detached plants and plant fragments shall be disposed of at an upland site so as not to reenter state waters.

4. Extreme care shall be taken to ensure that no petroleum products, hydraulic fluid or other deleterious material from equipment used are allowed to enter or leach into the watercourse. Rotovators shall be well-maintained and where practicable, food-grade oil in the hydraulic systems should be used. Spill control equipment shall be maintained on the rotovator in sufficient number and quantity to control any spills emitting from the vessel.

5. If at any time, as a result of project activities or water quality problems, fish life are observed in distress or a fish kill occurs, operations shall cease and both the Washington Department of Fish and Wildlife and the Department of

State of Washington
Department of Fish and Wildlife
Habitat Program
600 Capitol Way North, MS 3155
Olympia, Washington 98501-1091



Ecology shall be notified of the problem immediately. The project shall not resume until further approval is given by the Washington Department of Fish and Wildlife. Additional measures to mitigate impacts may be required.

6. Existing fish habitat components such as logs, stumps, and large boulders may be relocated within the watercourse if necessary to operate the equipment. These habitat components shall not be removed from the watercourse.

7. Rotovators shall be operated at all times to cause the least adverse impact to fish life.

8. Every effort shall be made to avoid the spread of plant fragments through equipment contamination. The Public Works Department shall thoroughly remove and properly dispose of aquatic plant materials from all equipment used for aquatic weed control prior to the equipment's use in a body of water.

9. Alteration or disturbance of the bank and bank vegetation shall be limited to that necessary to conduct the project. All disturbed areas shall be protected from erosion, within seven calendar days of completion of the project, using vegetation or other means.

10. Rotovation shall not occur in the shallow flooded areas of the sloughs and the adjacent low lying areas during fish spawning periods. The spawning periods are triggered by higher spring flows and an increase in water temperature in the shallow areas compared to the main river channel. Temperature difference may range from 1 to 5 degrees celsius higher in the shallow water areas during spawning periods. May 15 - July 1

SEPA: FSEIS by WDOE final on January 1992.

APPLICATION ACCEPTED: November 20, 2002 ENFORCEMENT OFFICER: Charron W-43 [P1]

| | |
|---|---|
| Jeff Lawlor (509) 467-4085<br>Area Habitat Biologist | for Director<br>WDFW |

cc: Kevin Robinette, WDFW
Officer Holden, WDFW
HPA input, WDFW
Mike Hepp, WDOE NE Region
Tim Erkel, US Army Corps Engineers
Kalispel Tribe, P.O. Box 39 Usk, WA 99180
Pat Buckley, Pend Oreille PUD, P.O. Box 190, Newport WA 99156

## GENERAL PROVISIONS

This Hydraulic Project Approval (HPA) pertains only to the provisions of the Fisheries Code (RCW 77.55 - formerly RCW 75.20). Additional authorization from other public agencies may be necessary for this project.

This HPA shall be available on the job site at all times and all its provisions followed by the permittee and operator(s) performing the work.

This HPA does not authorize trespass.

The person(s) to whom this HPA is issued may be held liable for any loss or damage to fish life or fish habitat which results from failure to comply with the provisions of this HPA.

Failure to comply with the provisions of this Hydraulic Project Approval could result in a civil penalty of up to one hundred dollars per day or a gross misdemeanor charge, possibly punishable by fine and/or imprisonment.

All HPAs issued pursuant to RCW 77.55.100 or 77.55.200 are subject to additional restrictions, conditions or revocation if the Department of Fish and Wildlife determines that new biological or physical information indicates the need for such action. The permittee has the right pursuant to Chapter 34.04 RCW to appeal such decisions. All HPAs issued pursuant to RCW 77.55.110 may be modified by the Department of Fish and Wildlife due to changed conditions after consultation with the permittee: PROVIDED HOWEVER, that such modifications shall be subject to appeal to the Hydraulic Appeals Board established in RCW 77.55.170.

## APPEALS - GENERAL INFORMATION

IF YOU WISH TO APPEAL A DENIAL OF OR CONDITIONS PROVIDED IN A HYDRAULIC PROJECT APPROVAL, THERE ARE INFORMAL AND FORMAL APPEAL PROCESSES AVAILABLE.

A. INFORMAL APPEALS (WAC 220-110-340) OF DEPARTMENT ACTIONS TAKEN PURSUANT TO RCW 77.55.100, 77.55.110, 77.55.140, 77.55.190, 77.55.200, and 77.55.290:
A person who is aggrieved or adversely affected by the following Department actions may request an informal review of:
(A) The denial or issuance of a HPA, or the conditions or provisions made part of a HPA; or
(B) An order imposing civil penalties.
It is recommended that an aggrieved party contact the Area Habitat Biologist and discuss the concerns. Most problems are resolved at this level, but if not, you may elevate your concerns to his/her supervisor. A request for an INFORMAL REVIEW shall be in WRITING to the Department of Fish and Wildlife, 600 Capitol Way North, Olympia, Washington 98501-1091 and shall be RECEIVED by the Department within 30-days of the denial or issuance of a HPA or receipt of an order imposing civil penalties. The 30-day time requirement may be stayed by the Department if negotiations are occurring between the aggrieved party and the Area Habitat Biologist and/or his/her supervisor. The Habitat Protection Services Division Manager or his/her designee shall conduct a review and recommend a decision to the Director or its designee. If you are not satisfied with the results of this informal appeal, a formal appeal may be filed.

B. FORMAL APPEALS (WAC 220-110-350) OF DEPARTMENT ACTIONS TAKEN PURSUANT TO RCW 77.55.100 OR 77.55.140:
A person who is aggrieved or adversely affected by the following Department actions may request an formal review of:
(A) The denial or issuance of a HPA, or the conditions or provisions made part of a HPA;

(B) An order imposing civil penalties; or
(C) Any other "agency action" for which an adjudicative proceeding is required under the Administrative Procedure Act, Chapter 34.05 RCW.

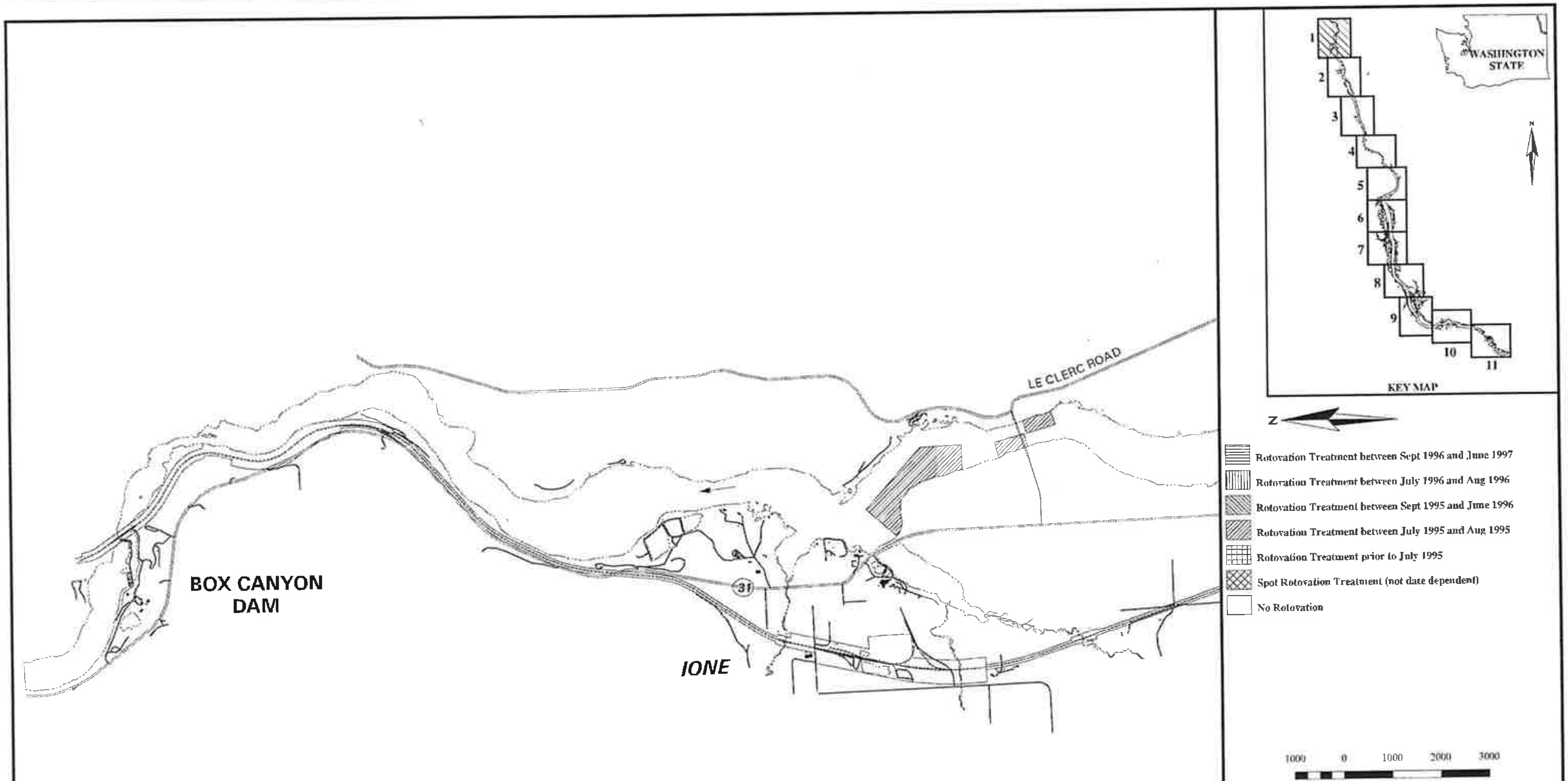
A request for a FORMAL APPEAL shall be in WRITING to the Department of Fish and Wildlife, 600 Capitol Way North, Olympia, Washington 98501-1091, shall be plainly labeled as "REQUEST FOR FORMAL APPEAL" and shall be RECEIVED DURING OFFICE HOURS by the Department within 30-days of the Department action that is being challenged. The time period for requesting a formal appeal is suspended during consideration of a timely informal appeal. If there has been an informal appeal, the deadline for requesting a formal appeal shall be within 30-days of the date of the Department's written decision in response to the informal appeal.

C. FORMAL APPEALS OF DEPARTMENT ACTIONS TAKEN PURSUANT TO RCW 77.55.110, 77.55.200, 77.55.230, or 77.55.290:
A person who is aggrieved or adversely affected by the denial or issuance of a HPA, or the conditions or provisions made part of a HPA may request a formal appeal. The request for FORMAL APPEAL shall be in WRITING to the Hydraulic Appeals Board per WAC 259-04 at Environmental Hearings Office, 4224 Sixth Avenue SE, Building Two - Rowe Six, Lacey, Washington 98504; telephone 360/459-6327.

D. FAILURE TO APPEAL WITHIN THE REQUIRED TIME PERIODS RESULTS IN FORFEITURE OF ALL APPEAL RIGHTS. IF THERE IS NO TIMELY REQUEST FOR AN APPEAL, THE DEPARTMENT ACTION SHALL BE FINAL AND UNAPPEALABLE.

# APPENDIX G

# ROTOVATION HISTORY MAPS



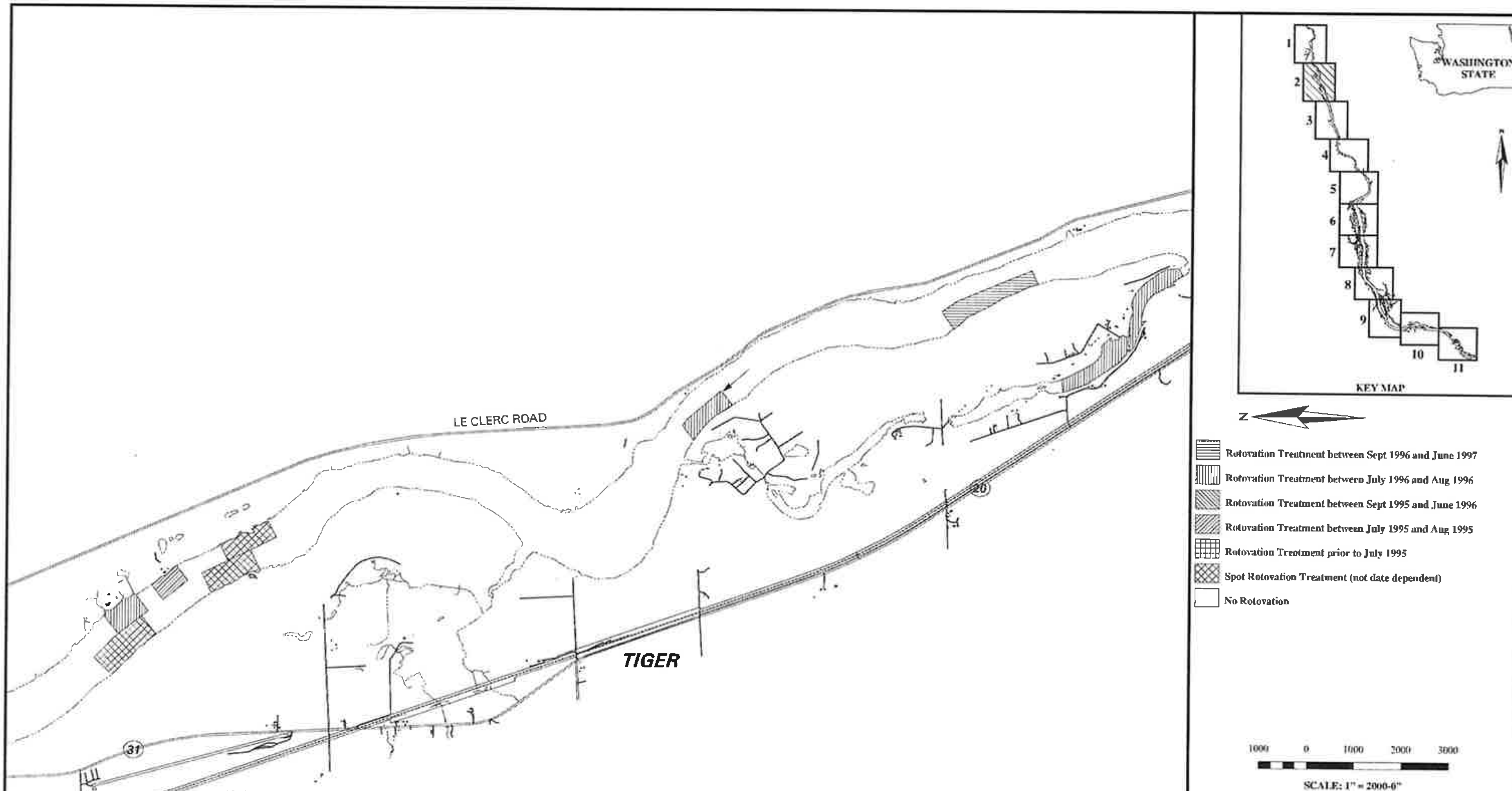

**ROTOVATION HISTORY MAPS**

BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 — May 1999

FIGURE E2-8 — SHEET 1 OF 11

DE&S Duke Engineering & Services



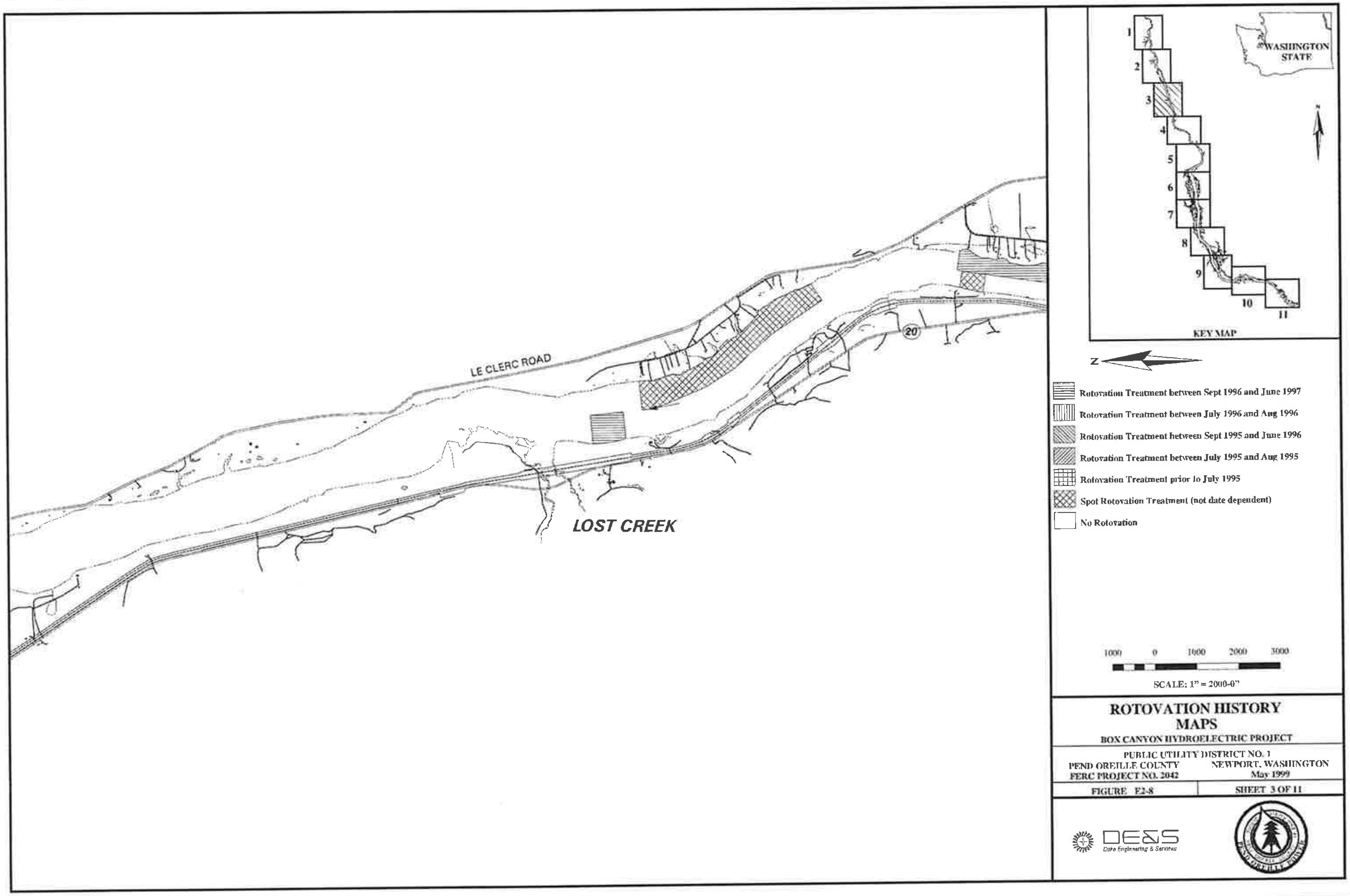

# ROTOVATION HISTORY MAPS

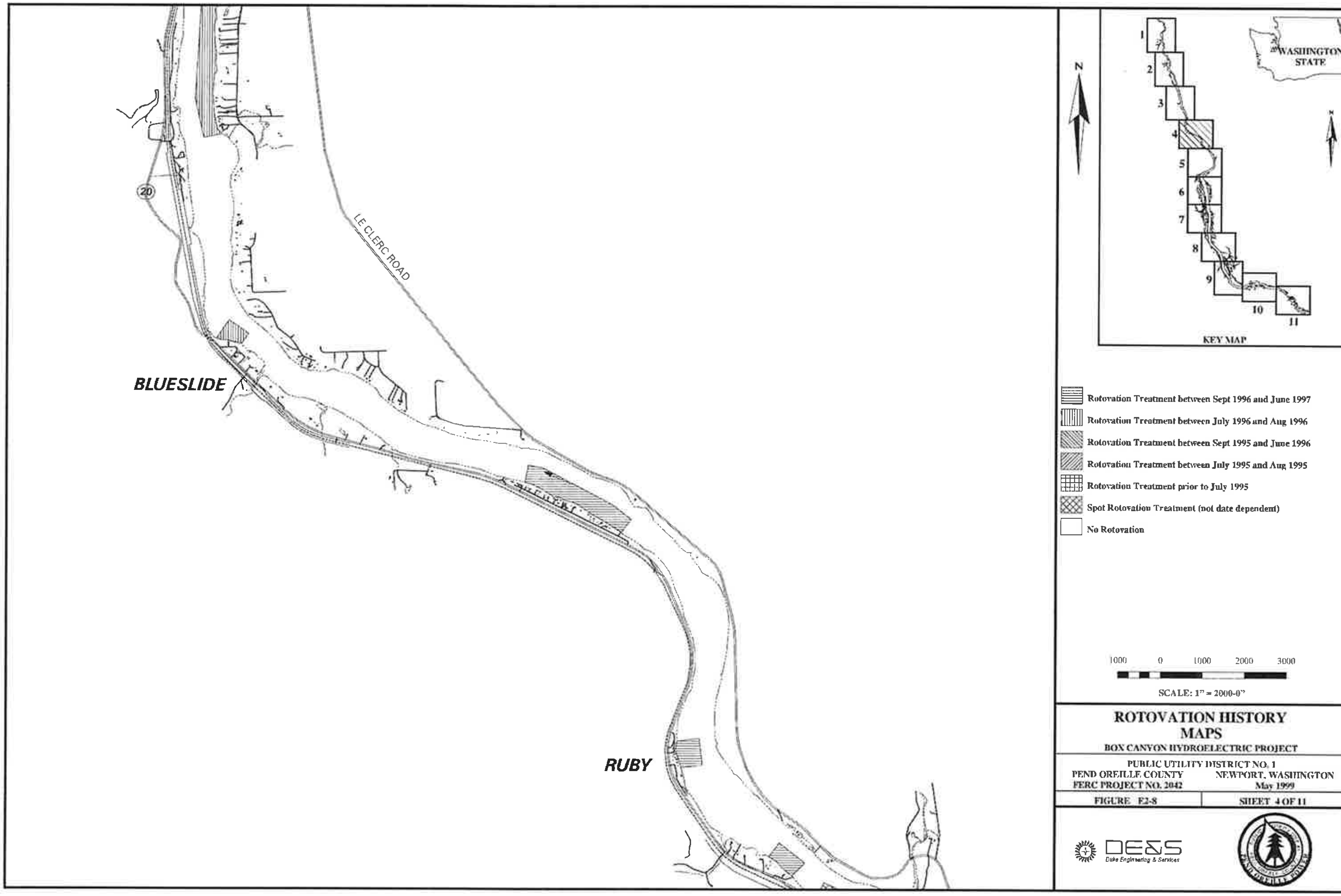
BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY
NEWPORT, WASHINGTON
FERC PROJECT NO. 2042
May 1999

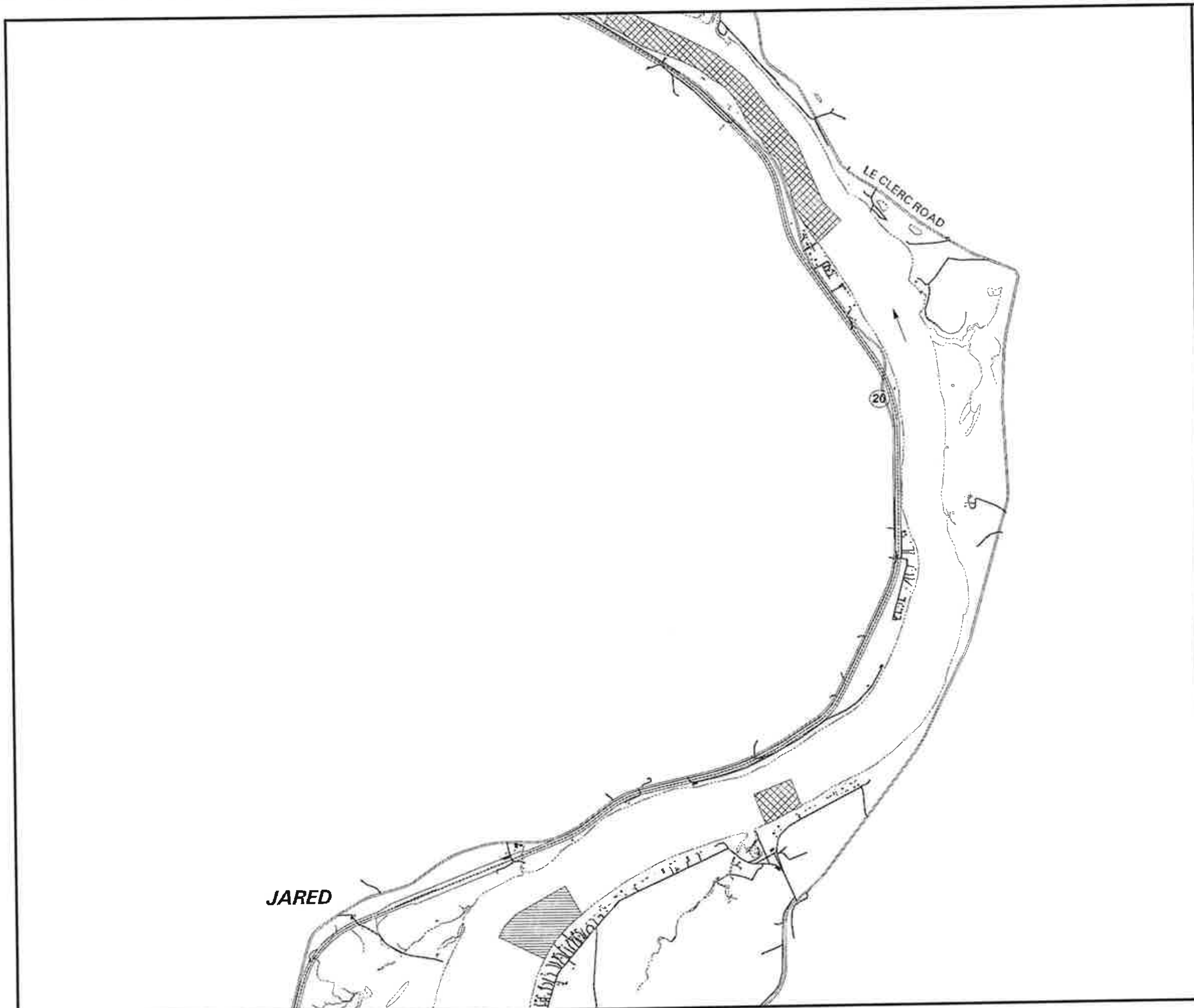
FIGURE E2-8
SHEET 2 OF 11

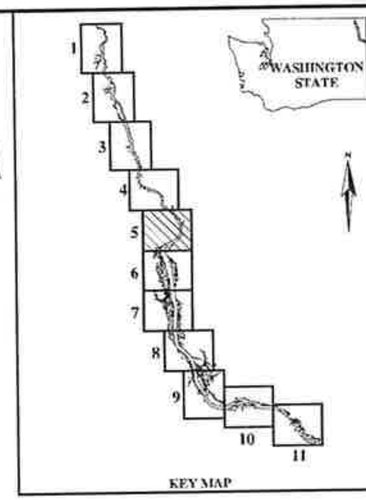
DE&S Duke Engineering & Services


WASHINGTON STATE
1
2
3
4
5
6
7
8
9
10
11
KEY MAP
N
Rotovation Treatment between Sept 1996 and June 1997
Rotovation Treatment between July 1996 and Aug 1996
Rotovation Treatment between Sept 1995 and June 1996
Rotovation Treatment between July 1995 and Aug 1995
Rotovation Treatment prior to July 1995
Spot Rotovation Treatment (not date dependent)
No Rotovation
LE CLERC ROAD
20
LOST CREEK
1000 0 1000 2000 3000
SCALE: 1" = 2000-0"
ROTOVATION HISTORY MAPS
BOX CANYON HYDROELECTRIC PROJECT
PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY
FERC PROJECT NO. 2042
NEWPORT, WASHINGTON
May 1999
FIGURE E2-8
SHEET 3 OF 11
DE&S
Duke Engineering & Services



LE CLERC ROAD
20
BLUESLIDE
RUBY
N
WASHINGTON STATE
1
2
3
4
5
6
7
8
9
10
11
KEY MAP
Rotovation Treatment between Sept 1996 and June 1997
Rotovation Treatment between July 1996 and Aug 1996
Rotovation Treatment between Sept 1995 and June 1996
Rotovation Treatment between July 1995 and Aug 1995
Rotovation Treatment prior to July 1995
Spot Rotovation Treatment (not date dependent)
No Rotovation
1000 0 1000 2000 3000
SCALE: 1" = 2000-0"
ROTOVATION HISTORY MAPS
BOX CANYON HYDROELECTRIC PROJECT
PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY
NEWPORT, WASHINGTON
FERC PROJECT NO. 2042
May 1999
FIGURE E2-8
SHEET 4 OF 11
DE&S
Duke Engineering & Services




Rotovation Treatment between Sept 1996 and June 1997

Rotovation Treatment between July 1996 and Aug 1996

Rotovation Treatment between Sept 1995 and June 1996

Rotovation Treatment between July 1995 and Aug 1995

Rotovation Treatment prior to July 1995

Spot Rotovation Treatment (not date dependent)

No Rotovation

1000 0 1000 2000 3000

SCALE: 1" = 2000-0"

# ROTOVATION HISTORY MAPS

BOX CANYON HYDROELECTRIC PROJECT

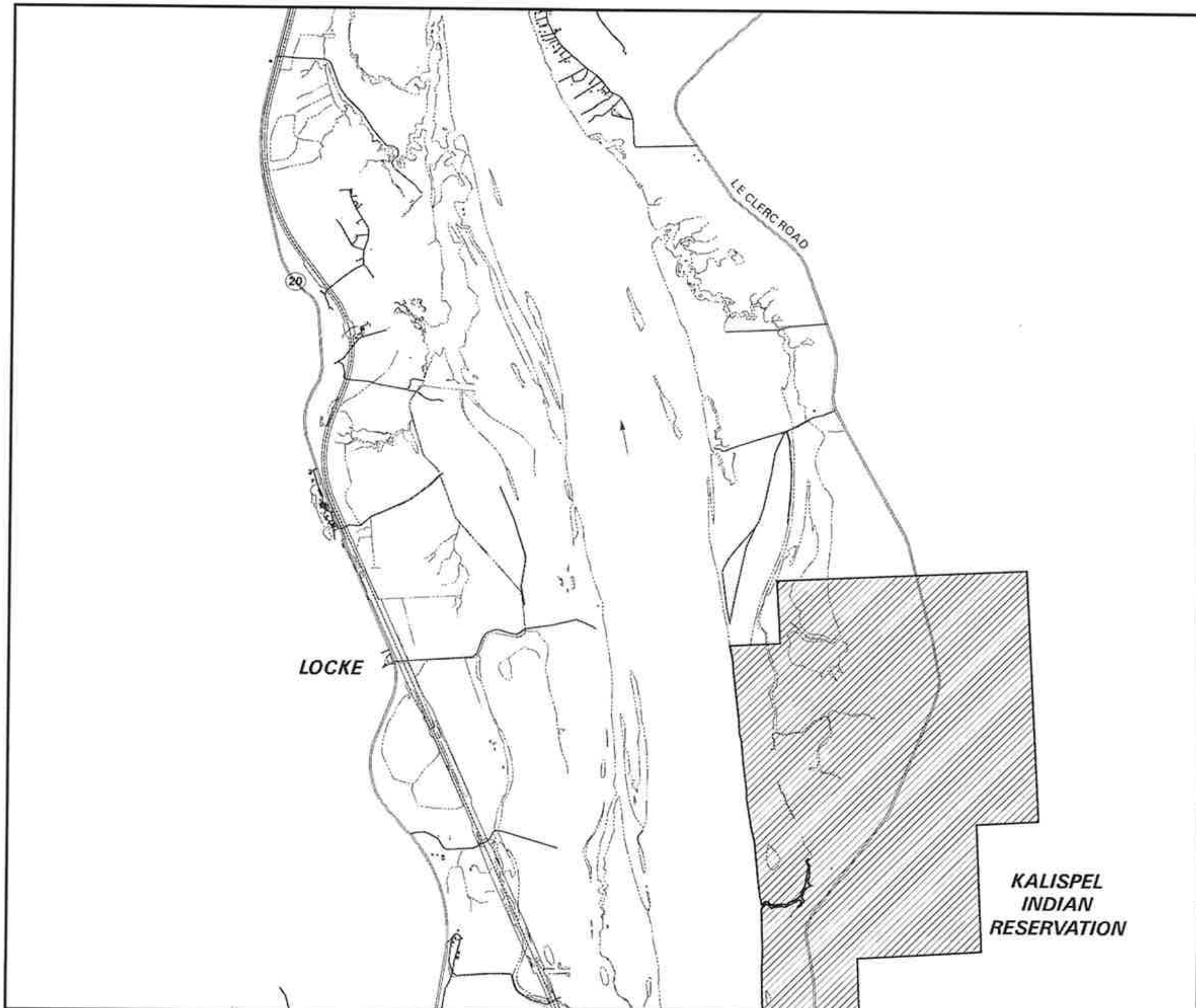
PUBLIC UTILITY DISTRICT NO. 1

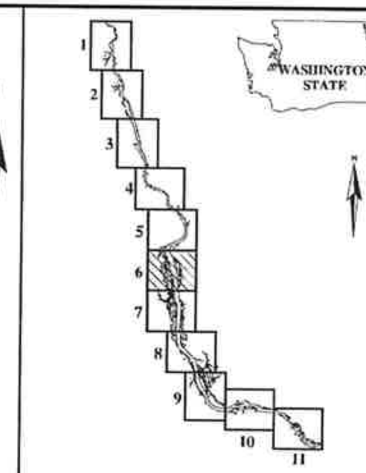
PEND OREILLE COUNTY NEWPORT, WASHINGTON

FERC PROJECT NO. 2042 May 1999

FIGURE E2-8 SHEET 5 OF 11

DE&S Duke Engineering & Services




KEY MAP

- Rotovation Treatment between Sept 1996 and June 1997
- Rotovation Treatment between July 1996 and Aug 1996
- Rotovation Treatment between Sept 1995 and June 1996
- Rotovation Treatment between July 1995 and Aug 1995
- Rotovation Treatment prior to July 1995
- Spot Rotovation Treatment (not date dependent)
- No Rotovation

1000 0 1000 2000 3000

SCALE: 1" = 2000-0"

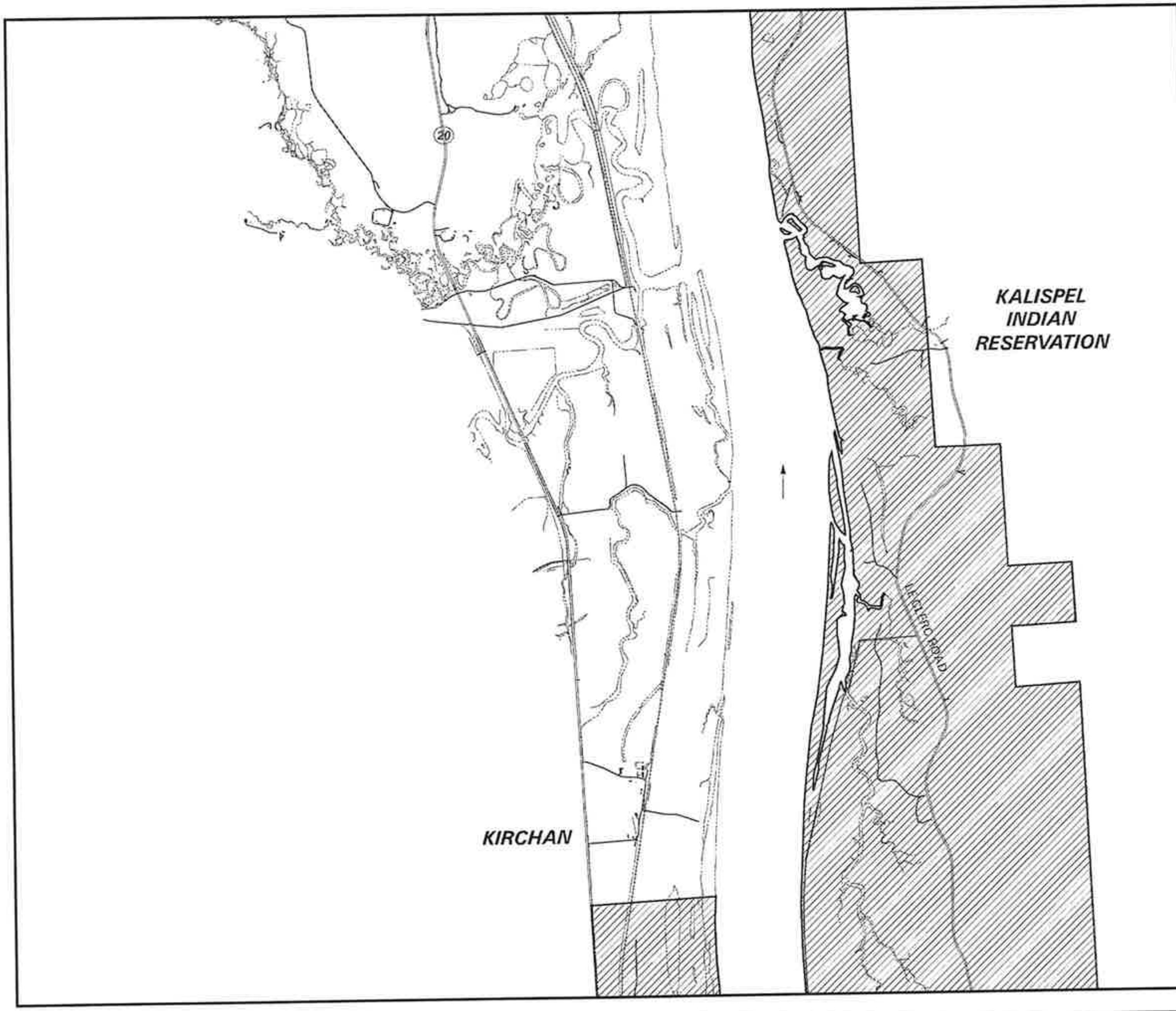
# ROTOVATION HISTORY MAPS

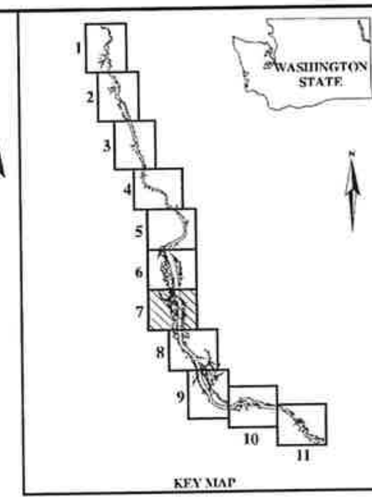
BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 May 1999

FIGURE E2-8 SHEET 6 OF 11

DE&S Duke Engineering & Services




- Rotovation Treatment between Sept 1996 and June 1997
- Rotovation Treatment between July 1996 and Aug 1996
- Rotovation Treatment between Sept 1995 and June 1996
- Rotovation Treatment between July 1995 and Aug 1995
- Rotovation Treatment prior to July 1995
- Spot Rotovation Treatment (not date dependent)
- No Rotovation

1000 0 1000 2000 3000

SCALE: 1" = 2000-0"

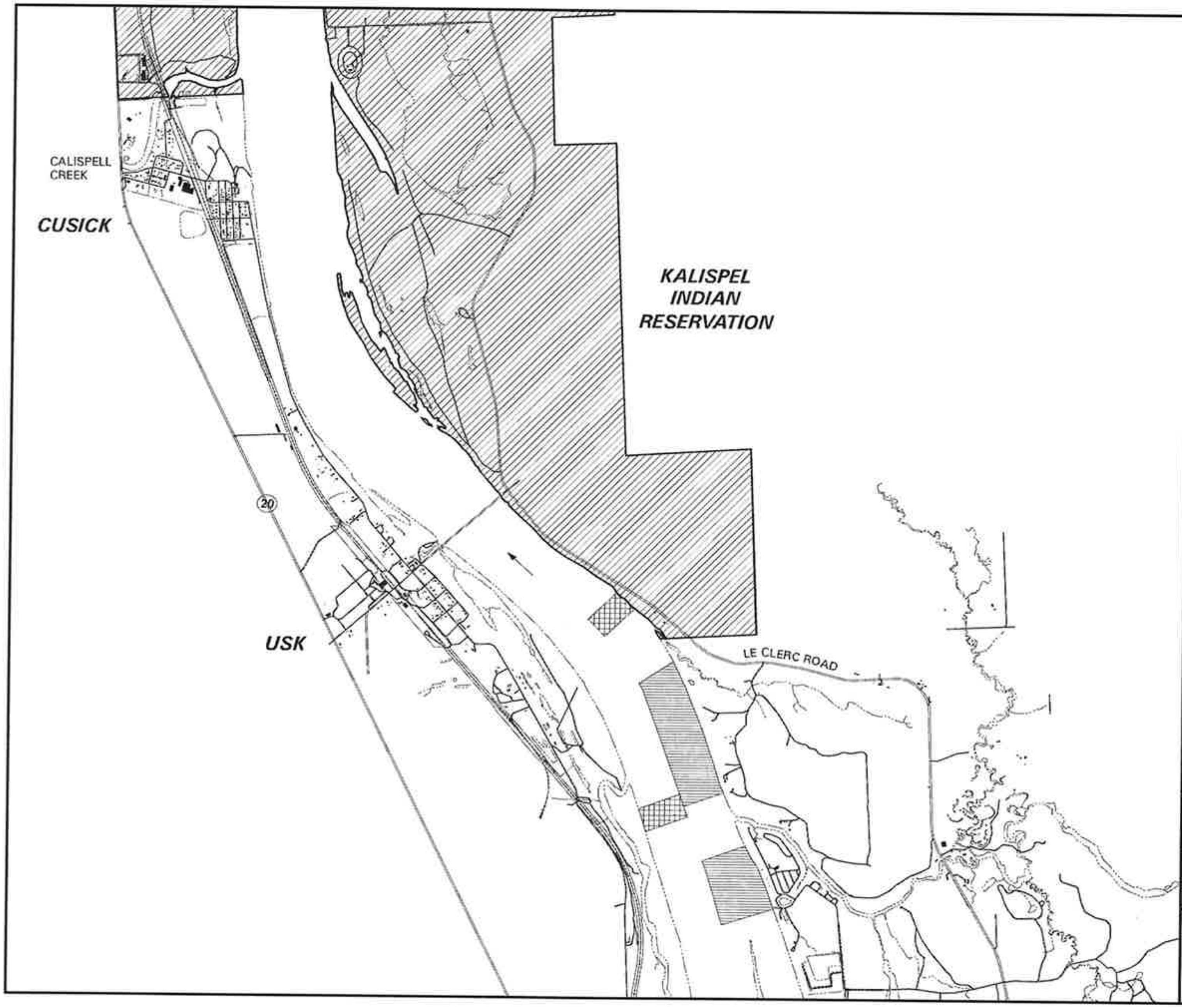
**ROTOVATION HISTORY MAPS**

BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 May 1999

FIGURE E2-8 SHEET 7 OF 11

DE&S
Duke Engineering & Services




**ROTOVATION HISTORY MAPS**

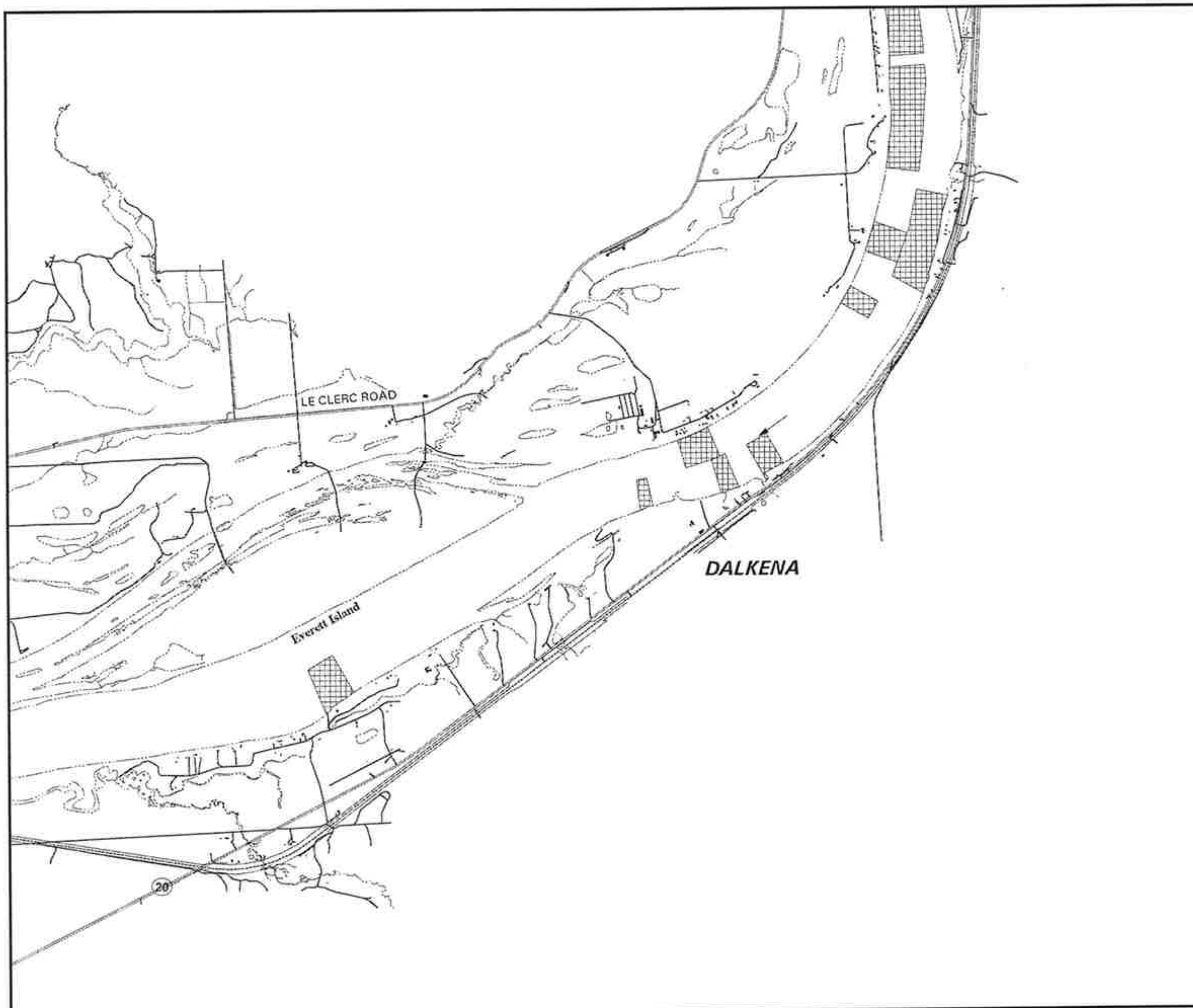
BOX CANYON HYDROELECTRIC PROJECT

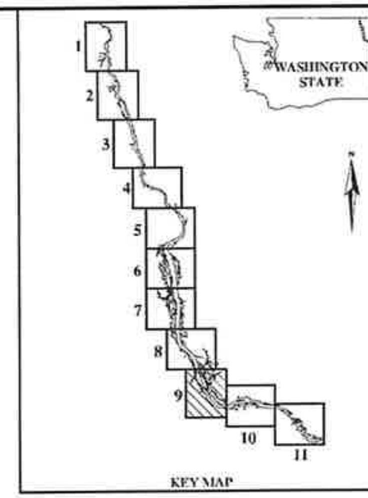
PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 — May 1999

FIGURE E2-8 — SHEET 8 OF 11

DE&S
Duke Engineering & Services

PEND OREILLE POWER




- Rotovation Treatment between Sept 1996 and June 1997
- Rotovation Treatment between July 1996 and Aug 1996
- Rotovation Treatment between Sept 1995 and June 1996
- Rotovation Treatment between July 1995 and Aug 1995
- Rotovation Treatment prior to July 1995
- Spot Rotovation Treatment (not date dependent)
- No Rotovation

1000 0 1000 2000 3000

SCALE: 1" = 2000-0"

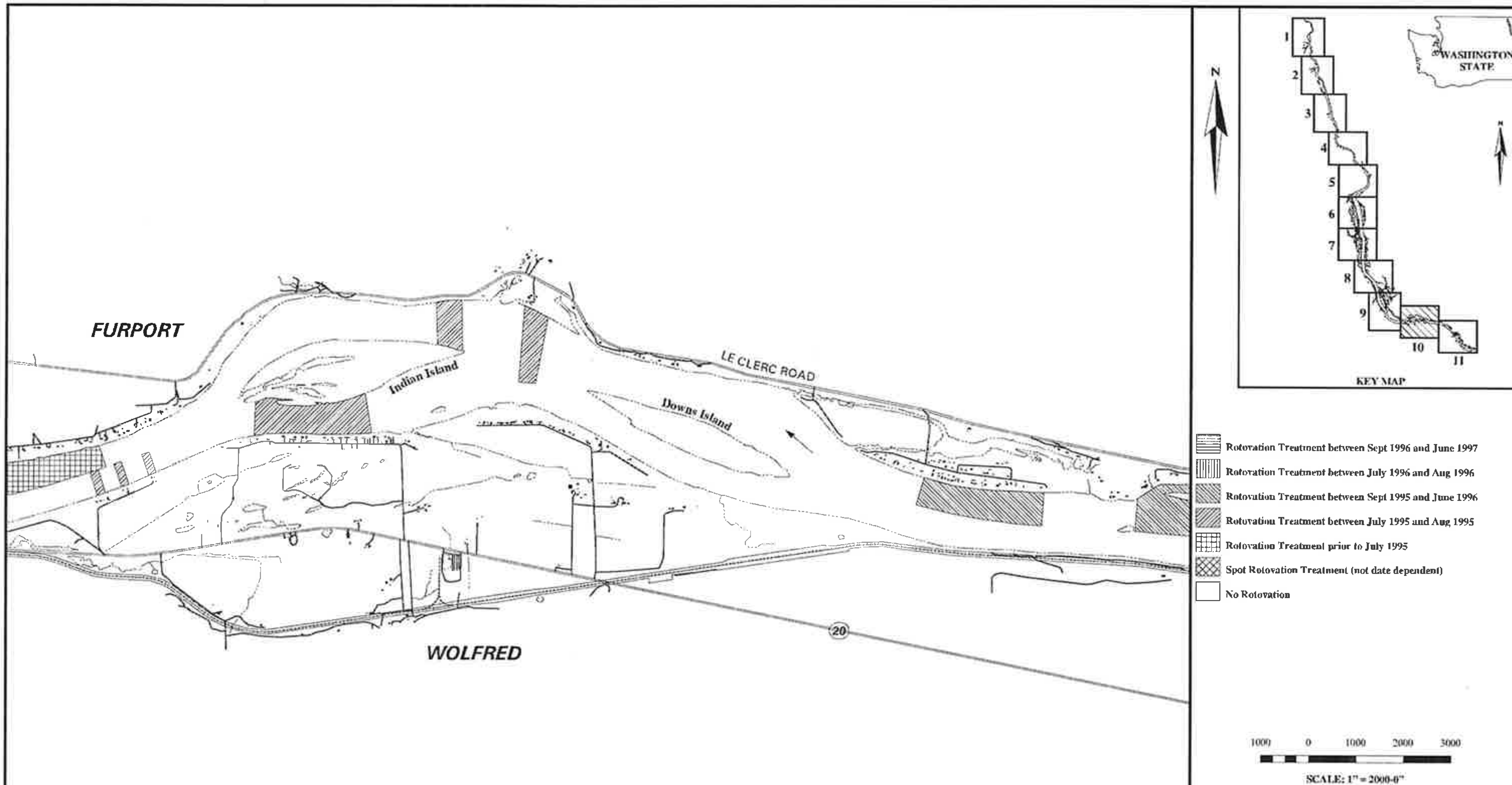
# ROTOVATION HISTORY MAPS

BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 May 1999

FIGURE E2-8 SHEET 9 OF 11

DE&S Duke Engineering & Services



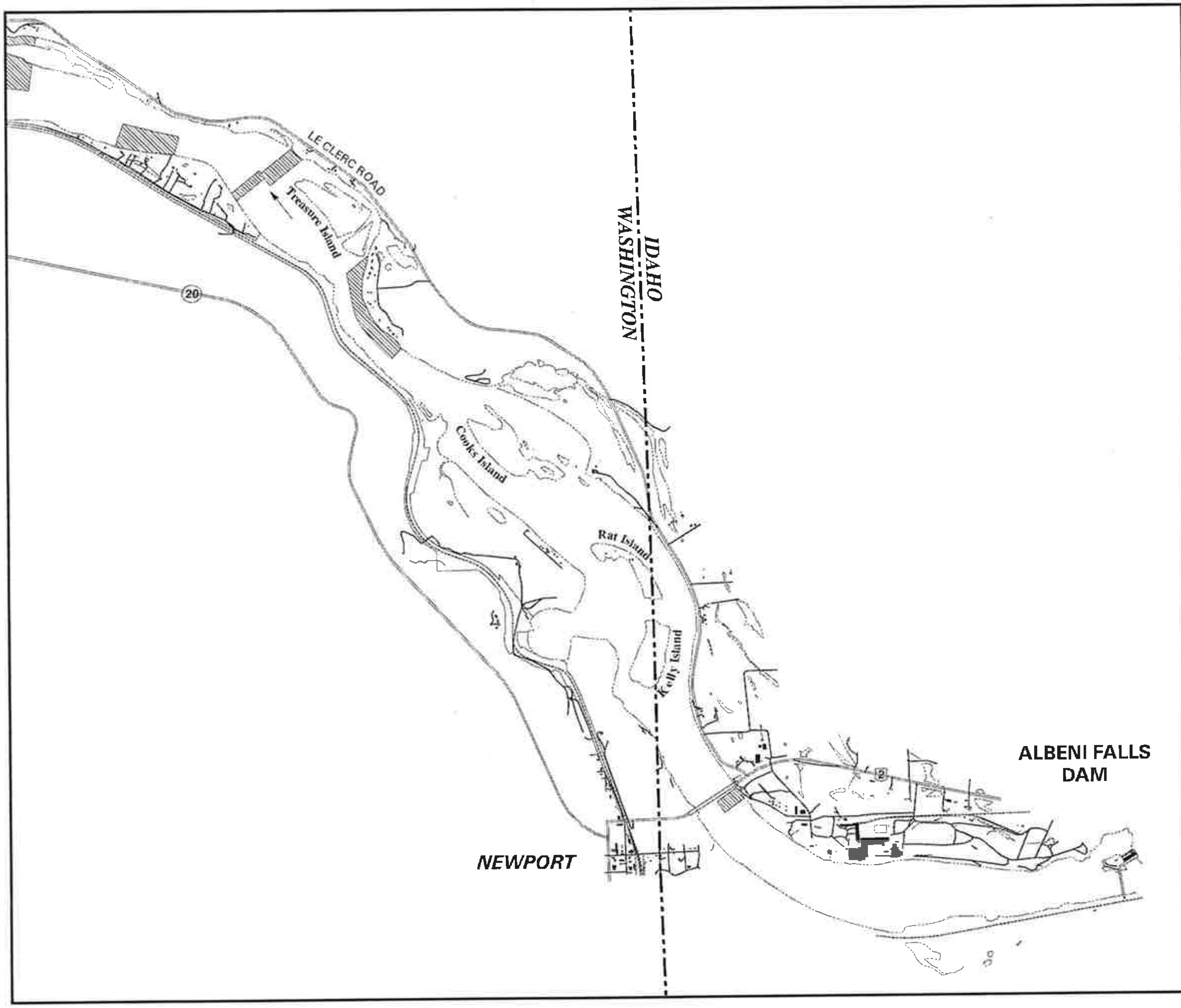

**ROTOVATION HISTORY MAPS**

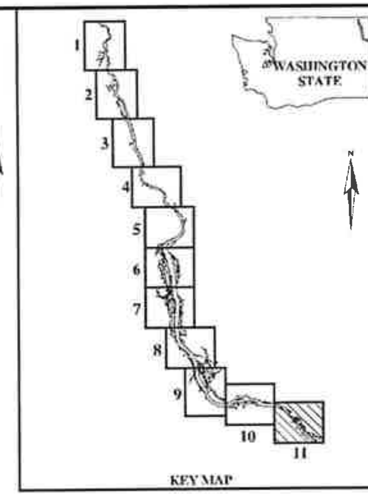
BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 — May 1999

FIGURE E2-8 — SHEET 10 OF 11

DE&S Duke Engineering & Services




- Rotovation Treatment between Sept 1996 and June 1997
- Rotovation Treatment between July 1996 and Aug 1996
- Rotovation Treatment between Sept 1995 and June 1996
- Rotovation Treatment between July 1995 and Aug 1995
- Rotovation Treatment prior to July 1995
- Spot Rotovation Treatment (not date dependent)
- No Rotovation

1000 0 1000 2000 3000

SCALE: 1" = 2000-0"

# ROTOVATION HISTORY MAPS

BOX CANYON HYDROELECTRIC PROJECT

PUBLIC UTILITY DISTRICT NO. 1
PEND OREILLE COUNTY — NEWPORT, WASHINGTON
FERC PROJECT NO. 2042 — May 1999

FIGURE E2-8 — SHEET 11 OF 11

DE&S
Duke Engineering & Services

# APPENDIX H

# BIOLOGICAL ASSESSMENT FOR BOX CANYON LICENSE AMENDMENT

# BIOLOGICAL ASSESSMENT

**for the**

# BOX CANYON HYDROELECTRIC PROJECT
# LICENSE AMENDMENT
# FERC NO. 2042

*Presented to:*

U.S. Fish and Wildlife Service
Upper Columbia River Basin Field Office

*Prepared for:*

Public Utility District No. 1 of Pend Oreille County
Newport, WA

*Prepared by:*

Duke Engineering & Services, Inc.
Bellingham, WA

November 25, 1998

**BIOLOGICAL ASSESSMENT for the BOX CANYON HYDROELECTRIC PROJECT LICENSE AMENDMENT FERC No. 2042**

## TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

**BIOLOGICAL ASSESSMENT**
**for the**
**BOX CANYON HYDROELECTRIC PROJECT LICENSE AMENDMENT**

## 1.0 INTRODUCTION

This Biological Assessment (BA) is prepared for the amendment application to the Box Canyon Hydroelectric Project (FERC No. 2042)(Amendment Application). The Amendment Application was submitted to FERC on February 14, 1997 and requested authorization to set the project boundaries as shown in Exhibit G drawings of the License Amendment Application. The purpose of the Amendment was to add project lands in the upstream portion of the project reservoir that were not included within the original project boundary. The proposed Amendment would incorporate lands along the Pend Oreille River that are at or below elevation (El.) 2041.0 feet, as measured at the Cusick gage and are above El. 2028.0, into the project boundary. In addition, parties to this proceeding, including the Public Utility District No. 1 of Pend Oreille County (District), or Licensee, propose that an Offer of Settlement (Settlement) filed on May 14, 1998, be made part of the license Amendment for the Box Canyon Project.

Effective July 10, 1998, the Columbia River population segment of bull trout (*Salvelinus confluentus*) was listed as a threatened species under the Endangered Species Act. The Endangered Species Act of 1973 (Act) requires Federal agencies to "ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat of such species." The purpose of the Act is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" and "to provide a program for the conservation of such endangered species and threatened species..."

On July 10, 1998, FERC informed the U.S. Fish and Wildlife Service (USFWS) that they had designated the District as the non-federal representative for conducting informal consultation with the USFWS on the proposed Amendment application and Offer of Settlement for the Box Canyon Project. FERC instructed the District to prepare and file a draft BA that evaluates the potential effects of the proposed Amendment and Settlement on threatened bull trout, as well as other listed threatened and endangered species.

Under Section 4 of the Act (Determination of Endangered Species or Threatened Species) the Secretary of the Interior is granted the power to determine whether any species is considered threatened or endangered, based on the present status of the species. Section 7 of the Act (Interagency Cooperation) specifies that, to more effectively carry out the purpose of the Act, all other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary of Interior, utilize their authorities by "taking such action necessary to insure that actions authorized, funded, or carried out by" the Federal departments and agencies "do not jeopardize the continued existence of any listed species (pursuant to Section 4) or result in the destruction or modification of critical habitat of such species."

The consultation process is designed to assist the Federal agencies when complying with the Act, and authority of consultation has been delegated by the Secretary of the Interior to the Director of the USFWS. The consultation process involves several phases:

1. A general description of the proposed action and a formal request for a listing of proposed and listed endangered and threatened species potentially affected by the proposed action is submitted to the USFWS by the affected agency.

2. USFWS responds with a list of proposed, candidate, and listed species within the proposed project area.

3. The Federal agency (or designee) prepares a BA which identifies the project, details the biology of the species on the list submitted by the USFWS, analyzes the cumulative effects of the project, and determines if there is likely to be an effect (either beneficial or adverse) on any listed or proposed species. When the BA is complete, the agency requests consultation with USFWS.

3a. If the BA concludes the project is "not likely to adversely affect" listed species or critical habitat, the agency may choose either informal or formal consultation.

- If informal consultation is chosen, the agency (or designee) asks for written concurrence by the USFWS for the conclusion of the BA of "not likely to adversely affect;" if USFWS agrees and a concurrence letter is obtained from the Service, consultation is complete.

- If formal consultation is chosen by the agency, the agency requests and USFWS prepares and issues a Biological Opinion (BO) which completes the consultation.

3b. If the BA concludes that the project is "likely to adversely affect" listed species or critical habitat, the agency must request formal consultation and a BO.

4. If the USFWS prepares a BO, it utilizes information contained in the BA on whether the project is:

4a. "Likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat" (a "jeopardy" biological opinion). If the USFWS issues a "jeopardy" opinion, it must include any "reasonable and prudent alternatives" to the project that would avoid jeopardy; *or*

4b. "Not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat" (a "no jeopardy" biological opinion). If the USFWS issues a "no jeopardy" opinion, it may include discretionary "conservation recommendations," which are steps the USFWS believes could be taken to further minimize potential effects on listed species or critical habitat (previous from USDA Forest Service and WA Department of Ecology 1997).

This BA assesses potential impacts of the proposed Amendment on fish, wildlife, bird, and plant species listed as Endangered, Threatened, or Proposed by the USFWS and ensures compliance with the provisions of the Endangered Species Act of 1973, P.L. 93-205 (87 Stat. 884) as amended.

# 2.0 PROJECT LOCATION AND DESCRIPTION

## 2.1 PROJECT LOCATION

The Box Canyon Hydroelectric Project is located on the Pend Oreille River in the northeast corner of Washington state, near the town of Ione. The Project is an existing facility licensed by the Federal Energy Regulatory Commission (FERC) as Project No. 2042. The Project was originally licensed in 1952 and began operation in 1955.

The Box Canyon Dam is located on the Pend Oreille River, 34.4 river miles from its confluence with the Columbia River. The Pend Oreille River serves as a 55.7-mile long run-of-the-river reservoir upstream of the dam. The reservoir begins at the dam spillway at river mile (RM) 34.4, and extends upstream to the Albeni Falls Dam at RM 90.1. The reservoir has a surface area of approximately 8,850 acres, with mean depths ranging from 9 ft to 40 ft, at a water surface level of El. 2030.6 at Box Canyon Dam when flow is 30,000 cfs. Mean annual flow is 26,243 cfs (1955 - 1995) (Bennett and Liter 1991). The deepest part of the reservoir (110 ft) occurs in Box Canyon, near the dam just upstream of the spillway at RM 34.84. The narrowest part (125 ft wide) occurs just upstream from that point at RM 34.84. The widest part of the river occurs at RM 63.60 where the river is 2,540 ft. wide (Figure 2.1-1).

## 2.2 PROJECT DESCRIPTION

### 2.2.1 Purpose of Amendment

The proposed Amendment and the reason(s) why the proposed changes are necessary, are to amend the Exhibit K (now known as Exhibit G) drawings to show the project boundary around the entire 55-mile-long reservoir from Box Canyon Dam to the foot of the U.S. Army Corps of Engineers' (COE) Albeni Falls Dam near the Washington/Idaho border. The original license describes the reservoir as 55-miles-long from Box Canyon Dam (River Mile [RM] 34.4) to the COE's Albeni Falls Dam (RM 90.1) but the associated Exhibit K drawings K-1 through K-9, approved by the Federal Power Commission (FPC) on October 3, 1956 (sheets K-1 through K-5 were revised and approved by the FPC on March 18, 1963) only included the reservoir area from Box Canyon Dam to Ruby, Washington (RM 58.0).

The Amendment includes drawings G-11 through G-29 which show the rest of the boundary line between Ruby and Albeni Falls Dam. No other changes to the original license application are proposed other than revising these Exhibit G (previously Exhibit K) project drawings. There are no changes being proposed to project operations. They will continue as they have for the past 34 years, in accordance with Exhibit I backwater curve drawings 1 through 4 (see Appendix A in the Amendment Application), and an application for Amendment of license submitted to the FPC on June 5, 1961 that was subsequently approved on March 18, 1963. This proposed Amendment adds the boundary line maps from Ruby to Albeni Falls Dam to the License No. 2042 document. The backwater curves on drawings I-1 through I-4 from the 1961 license Amendment application were utilized to establish the water surface elevations at the project boundary along the shoreline as shown on the new Exhibit G maps, included in the Amendment Application.

A portion of the project reservoir between Ruby and Albeni Falls Dam occupies lands within the Kalispel Indian Reservation (established by Executive Order dated March 23, 1914). Because the project uses and occupies Tribal and allotted lands within the Kalispel Indian Reservation, the Licensee requested a determination be made by the FERC regarding the Application with respect to Section 4(e) and 10(e) of the Federal Power Act. The District and Tribe have been in litigation on this issue for over ten years. After filing of the amendment application, a variety of disagreements still remained between the District, the Tribe,

PLACE HOLDER FOR PEND OREILLE RIVER MAP

U.S. Department of Interior (DOI), U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS) and the Washington Department of Fish and Wildlife (WDFW). Most of the disagreements revolved around the level of payments, environmental study and mitigation that should be associated with the amendment application. Beginning in January of 1996, the parties entered into negotiations in an attempt to reach resolution of all outstanding issues. After nearly two years of negotiations and with the assistance of the FERC, the Licensee has entered into an Offer of Settlement (Settlement) with all parties on May 14, 1998, and intends that Settlement to be considered part of the Amendment.

The Settlement Agreement has been filed with FERC as an integral part of the Amendment application, and all parties have requested that FERC adopt it in its entirety as part of any amendment order issued by FERC. The Settlement Agreement contains provisions for conducting studies, establishing funds, and performing a variety of enhancement and mitigation projects as part of a package of measures designed to address the concerns of all parties. Under the Settlement Agreement, a Technical Committee is established, with representatives from the District and each involved agency, to oversee and administer all aspects of the Settlement Agreement. The Settlement contains provisions for cultural resource studies, payments to the Tribe and USFS, and a variety of studies of aquaculture, recreation, and other project-related studies. As part of the Offer of Settlement, the District also agrees, in part, to fund the following:

- Tributary habitat assessment projects
- Tributary habitat enhancement projects
- Habitat Evaluation Procedure (HEP)
- Habitat acquisition, protection and enhancement projects
- Erosion control measures

These aspects of the Settlement could have impacts to fish and wildlife resources in the Project Area, and therefore the Biological Assessment will include analysis of these aspects of the Settlement. Additional environmental analyses are also being conducted during relicensing of this Project No. 2042. License No. 2042 expires January 31, 2002, and activities associated with relicensing, including environmental analysis, are already underway.

### 2.2.2 Project Operation

#### 2.2.2.1 Description Of Reservoir Operation

Box Canyon Hydroelectric Project is a run-of-river facility located on the Pend Oreille River (RM 34.1) in northeastern Washington State near the City of Ione. The Project has a rated capacity of 60 megawatts at a flow of 27,500 cubic feet per second (cfs). The Project does not store water behind its 46-foot-high dam, but the dam backs-up the Pend Oreille River approximately 55 miles to the Albeni Falls Dam (RM 90.1) in Idaho which does store water for power generation. All waters released from Albeni Falls Dam are passed downstream of Box Canyon Dam with no active storage.

The Pend Oreille River flows northwesterly from Albeni Falls Dam to Box Canyon Dam. Albeni Falls Dam regulates almost the entire flow in the river upstream of Box Canyon. The drainage area above Box Canyon Dam is 24,930 square miles and all but about 700 square miles of the drainage area lie above Albeni Falls Dam. Because there is little inflow, the flow passing the Box Canyon Project is virtually the same as the flow released from Albeni Falls Dam. The flow rate down the river above Box Canyon Dam is not under the control of Box Canyon Dam in any way.

#### 2.2.2.2 Effect of Project Operation on Water Levels

FERC License No. 2042 issued for the project in 1952, and an application for Amendment of license filed in 1961 and approved in 1963, describe operating procedures for the dam and power plant. The District plans to continue to utilize these same operating procedures throughout the remaining term of license No. 2042, and also to continue these same procedures in any new license issued for the project. No changes in these operating procedures are planned.

Although the flow rate cannot be controlled by Box Canyon Dam, the water levels in the Pend Oreille River can be controlled to a limited extent by Box Canyon Dam through the operation of the gates within the dam. In general, water levels are primarily controlled by the flow rate of water in the river; the higher the flowrate, the higher the level. Following is a description of the operating procedures and resulting water levels in the Pend Oreille River under various flow conditions.

The normal elevation of the water surface at Box Canyon Dam is El. 2030.6. The water surface is controlled by raising the spillway gates whenever the flow in the river exceeds the Project hydraulic capacity (turbine capacity) of 27,500 cfs. The backwater caused by Box Canyon Dam is also affected by lowering or raising the spillway gates. "Backwater" is the difference between the natural water surface elevation (without the dam) and the raised water surface elevation caused by the dam. There is a pronounced backwater effect in the river near the dam and less effect further away upstream from the dam. The river water surface (backwater) can be raised or lowered somewhat by controlling the release of water at the dam with either turbines and/or spillway gates. Generally, the spillway gates at Box Canyon Dam are raised when the river flowrate increases, and lowered (put back in place) when the flowrate decreases.

The spillway gates at Box Canyon Dam are operated to meet two constraints for backwater. The first constraint requires that the water surface elevation at Cusick (RM 70.1) caused by project-induced backwater, not exceed El. 2041.0. The second constraint requires that the encroachment (backwater) on the tailwater of Albeni Falls Dam Hydroelectric Project not exceed 2 feet above natural levels at that point. (Note: Prior to March 1963, the allowable encroachment was 1 foot.) At the calculated flow of 68,000 cfs, both constraints are simultaneously at their limit. For flows less than 68,000 cfs, a 2-foot encroachment at Albeni Falls is maintained with a water surface at Cusick of El. 2041.0 or less. When flows exceed 68,000 cfs, backwater encroachment at Albeni Falls is reduced below 2 feet to maintain a water surface at Cusick of El. 2041.0 or less. These constraints are met by either raising (removing) or lowering (put back in place) the spillway gates, which also decreases or increases the water surface elevation at the dam. When all spillway gates are completely removed, the water surface at Cusick reaches its limit of El. 2041.0 when the flow in the river reaches about 90,000 cfs. The power plant is shutdown at this time because there is no or very little head (difference between headwater and tailwater levels) at the dam to operate the turbines. At flows greater than 90,000 cfs, the river becomes regulated by a naturally-occurring narrow entrance to Box Canyon located about one-half mile upstream from the dam, and there is no longer any backwater effect due to the project. The canyon's natural entrance is simply not wide enough to pass all of the flow greater than 90,000 cfs without backing-up water. Whenever river flows are above 90,000 cfs with the spillway gates completely removed, upstream water levels are the same as before the dam was constructed, there is no "backwater effect" from the Project and the water elevation at Cusick exceeds El. 2041.0.

It is evident from the above description that water levels in the Pend Oreille River, and specifically at Cusick, are dependent to a large extent on river flow rate. The river level at Cusick is below El. 2041.0 at flows up to 68,000 cfs, is at or slightly below El. 2041.0 at flows between 68,000 and 90,000 cfs, and is above El. 2041.0 (and beyond control of Box Canyon Dam) at flows above 90,000 cfs. Exhibit I, sheets 1 through 4 (in the license Amendment) provide backwater curves that tell what the river level will be at any point on the river at any flow rate. These curves are a part of the existing License No. 2042 for the Project, and these same curves will be proposed to be included in any new license application for the Project. These curves completely define expected Project operations, but they are somewhat cumbersome.

Table 2.2-1 shows the expected water level at the Cusick gage at various river flow rates. If one knows the river flowrate on any particular day, Table 2.2-1 can be utilized to calculate what the corresponding river level will be at Cusick that day, and therefore is an excellent way to check that the project is operating normally. This table was derived from the Amendment Exhibit I, sheets 1 through 3 backwater curves.

**TABLE 2.2-1**
**EXPECTED RIVER LEVELS AT CUSICK GAGE FOR VARIOUS FLOW RATES**

| Flow Rate (cfs) | Expected River Level (elevation, ft.) |
|---|---|
| 10,000 | 2031.4 |
| 20,000 | 2033.1 |
| 30,000 | 2034.9 |
| 40,000 | 2036.5 |
| 50,000 | 2038.1 |
| 60,000 | 2039.9 |
| 70,000 | 2041.0 |
| 80,000 | 2041.0 |
| 90,000 | 2041.0 |
| above 90,000 | above 2041.0 |

# 3.0 LIST OF SPECIES

The District requested a USFWS listing of threatened, endangered, or proposed species potentially occurring within the project area on July 24, 1998. The USFWS list of potential species was provided in response on July 28, 1998 (See Appendix A - FWS Reference 1-9-98-SP-201 [503.1000]). The USFWS response did not designate any areas of critical habitat potentially affected by project development but did indicate that potential effects on seven species would need to be addressed. Table 3.0-1 lists the species identified in the USFWS response that are analyzed in this BA.

**TABLE 3.0-1.**
**THREATENED AND ENDANGERED SPECIES EVALUATED FOR THE BOX CANYON HYDROELECTRIC PROJECT LICENSE AMENDMENT**

| Common Name | Scientific Name | USFWS Status |
|---|---|---|
| **FISH** | | |
| Bull trout | *Salvelinus confluentus* | Threatened |
| **MAMMALS** | | |
| Gray wolf | *Canis lupus* | Endangered |
| Grizzly bear | *Ursus arctos* | Threatened |
| Canada lynx | *Lynx canadensis* | Proposed |
| **BIRDS** | | |
| Peregrine Falcon | *Falco peregrinus* | Endangered |
| Bald eagle | *Haliaeetus leucocephalus* | Threatened |
| **PLANTS** | | |
| Ute ladies'-tresses | *Spiranthes diluvialis* | Threatened |

## 3.1 BULL TROUT

### 3.1.1 Description of species and habitat

#### 3.1.1.1 Description of Species

Bull trout are native salmonids found in the Columbia River Basin and the Pend Oreille River. Bull trout closely resemble Dolly Varden *(Salvelinus malma)* and were long considered an inland form of that coastal anadromous trout until Cavender (1978) identified them as a distinct species. They were officially recognized as *Salvelinus confluentus* by the American Fisheries Society in 1980.

Bull trout appear to have two distinct life history forms, resident and migratory. Resident fish spend their entire lives in small headwater streams, living upstream from natural barriers and increasing numbers of human-caused barriers. Migratory stocks of bull trout rear in tributary streams for one to four years before moving to larger river systems (fluvial), or lake systems (adfluvial). These fluvial and adfluvial bull trout then spend several years in larger rivers or lakes before returning to the smaller tributaries to spawn. Resident and migratory forms may inhabit the same areas and are suspected to have offspring which exhibit either resident or migratory behavior (Rieman and McIntyre 1993).

Bull trout reach sexual maturity between 4 and 7 years, and typically spawn from August to November in second to fourth order tributary streams (Rieman and McIntyre 1995). Spawning migrations into tributaries appear to be triggered by the onset of warmer temperatures (Swanberg 1996). Spawning areas are typically low gradient streams characterized by presence of groundwater infiltration, cold-water springs, and loose gravels with low percentages of fines (Fraley and Shephard 1989; Rieman and McIntyre 1995). Bull trout are reported to have repeat and alternate year spawning (Shephard et al. 1984; Allen 1980).

Bull trout growth appears to vary with life history strategy, with resident adults ranging from 150 to 200 mm total length and migratory adults reaching 600 mm or more (Pratt 1985; Goetz 1989). In 1949 a world record bull trout weighing 32 pounds was caught in Lake Pend Oreille (Simpson and Wallace 1982).

Primary prey items for juvenile bull trout are terrestrial and aquatic insects. Larger bull trout feed on insects and fish, including sculpins, salmon fry and other bull trout (Pratt 1992). Studies show adult bull trout to prey upon whitefish (*Prosopium williamsoni*), yellow perch *(Perca flavescens)*, kokanee (*Oncorhynchus nerka*) and mysids (Pratt 1992).

### 3.1.1.2 Description of Habitat

Cover and Channel Complexity

Bull trout appear to have more specific habitat requirements than other salmonids (Rieman and McIntyre 1993). Preferred habitats include streams with complex forms of cover and stable channels. Water temperatures above 15°C (59°F) are believed to be a major factor limiting the distribution of bull trout. Channel stability, high winter flows, low summer flows, substrate, cover, cool water temperatures in summer and the presence of migration corridors all appear to influence distribution and/or abundance of bull trout. Disruption of migratory corridors can block access to over-wintering, foraging or spawning, adversely impacting population numbers (Leathe and Enk 1985; Rieman and McIntyre 1993; Swanberg and Burns 1997; Ziller 1992).

Bull trout usually associate with complex forms of cover and with pools (Rieman and McIntyre 1993). Juveniles live close to in-channel wood, substrate or undercut banks (Goetz 1991; Pratt 1985, 1992). Woody debris correlated highly with densities of bull trout in the Bitterroot National Forest (Rieman and McIntyre 1993). Although in-stream wood correlates with the distribution and abundance of bull trout, habitat complexity in any form can be important (Mullan et al. 1992 cited by Rieman and McIntyre 1993). Cover is important in winter and is thought to limit populations of other trout species (Chapman 1966; Cunjak and Power 1986). Saffel and Scarnecchia (1995) found bull trout density and abundance closely correlated to the number of pools as well as temperature. Rieman and McIntyre (1993) suggests that stable channels and relatively stable stream flows favor the persistence of bull trout populations.

Bull Trout Temperature Requirements

Regulatory agencies cite several review articles providing a basis for temperature criteria for bull trout (Shepard et al 1984; Carl 1985; Pratt 1985, 1992; Fraley and Shepard 1989; Goetz 1989; Buchanan and Gregory 1997). While it is not the only factor, temperature has been recognized most often by researchers as a critical factor in determining bull trout distribution and abundance (Goetz 1994; Rieman and McIntyre 1993; Saffel and Scarnecchia 1995). In studies by Saffel and Scarnecchia (1995) bull trout were found in Northern Idaho streams with maximum summer temperatures above 13.9°C, but not in high densities. This conclusion is consistent with research by Goetz (1991), Pratt (1985) and Ratliff (1992) who stated that temperatures of 15°C limited bull trout distribution. Fraley et al. (1981) reported the mean monthly maximum temperatures ranged from 11.5°C to 19.0°C for five streams in the Upper Flathead River Basin, while Saffel and Scarnecchia (1995) found bull trout in 20°C water in a tributary to Lake Pend Oreille.

Rieman and McIntyre (1993) reported that Jensen (1981) suggests a maximum temperature of 14°C controlled the distribution of arctic char (*Salvelinus alpinus*), a closely related species to bull trout (as cited in Pratt 1992). Meisner (1990) and others report that the maximum temperature of 24°C presents a thermal barrier to brook trout, which are more tolerant of warm temperatures than bull trout.

Swanberg (1996) reported adult bull trout migration occurring over a range of temperatures from 12°C to 20°C; 73% of observed bull trout migrated during peak temperatures of 18°C to 20°C (64.4°F - 68°F).

Bull trout appear to select groundwater upwelling zones for spawning (Fraley and Shepard 1989). Buchannan and Gregory (1997) suggested that optimal temperatures for bull trout spawning range from 4°C to 10°C. Others have noted spawning occurring when mean weekly temperatures dropped below 13°C (Fraley and Graham 1981). Buchannan and Gregory (1997) suggested a suitable range for egg incubation temperatures of 13°C to 4°C.

Saffel and Scarnecchia (1995) suggested that high water temperatures may be physiologically constraining on juvenile bull trout. The report states that although summer is the season in which maximum growth of fish would be expected, at temperatures above the optimal range, increased metabolic processes may result in most or all of the food being used for maintenance. Although temperature is recognized as a critical factor influencing bull trout distribution, the evidence is mostly correlative, leaving critical thresholds poorly defined (Rieman and McIntyre 1993). Saffel and Scarnecchia (1995) reported the highest densities of juvenile bull trout in their study coincided with a maximum temperature range of 11°C to 14°C. Adams (1994) found juvenile and adult bull trout in water temperatures up to 20.5°C. Maximum temperatures in bull trout streams reported by Fraley and Graham (1981) ranged from 14.4°C to 18.9°C, a temperature range considerably higher than that recommended by the EPA (40 CFR 131.E.1 - 1997).

### 3.1.2 <u>On site inspection</u>

**Bull Trout Distribution in BCR**

At the time the Box Canyon Dam was constructed, migration by anadromous fish species in the upper Columbia and lower Pend Oreille rivers had been eliminated by the prior construction of the Grand Coulee Dam in 1939 and subsequent construction of Chief Joseph Dam on the Columbia River above its confluence with the Okanogan River, Waneta and Seven-Mile dams on the Pend Oreille River in British Columbia as well as the Boundary Dam (in the 1960s), located downstream of Box Canyon Dam on the Pend Oreille River in Washington. Dominant species in the Pend Oreille River and tributaries in the vicinity of Box Canyon Reservoir were likely resident species of brown trout, rainbow trout, cutthroat trout and mountain whitefish (Barber et al. 1989). Many of these populations were the result of plants by state fisheries managers.

Historically adfluvial, fluvial, and resident populations of bull trout were common in the Pend Oreille and Clark Fork River drainages (as cited in Pratt and Huston 1993; Suckley 1860; Everman 1893; Chalfant 1974; Malouf 1982). Adfluvial trout from Lake Pend Oreille likely migrated far upstream and downstream to tributaries of the Pend Oreille and Clark Fork rivers (CES 1998).

The Kalispel Tribe fished for bull trout along with other species of native trout including westslope cutthroat trout in the Pend Oreille River. Principal fishing locations for trout in the BCR were Ruby, Le Clerc, Tacoma, Calispell, and Cee Cee Ah creeks, as well as other streams in the Cusick area (Smith 1985; 1986 as cited in Nenema 1997).

Albeni Falls Dam, located at RM 90.1 on the Pend Oreille River, began operation in 1955. The construction of Albeni Falls Dam without fish passage facilities precludes fish migration into and from Lake Pend Oreille except when the spillway gates are open in the spring flood period to pass flood flows. Currently, existing populations of bull trout in the BCR are generally limited to resident populations which spawn in the tributaries to the Pend Oreille River.

Current Population Size

The population size of bull trout in BCR is small. Few bull trout were found (6 of 81,763 fish captured) in surveys of the reservoir by Eastern Washington University and the University of Idaho (Ashe and Scholz 1992; Bennett and Liter 1991). In electrofishing surveys conducted by Plum Creek Timber in 1993, 2 juvenile bull trout were found in the East Branch 2 miles upstream of the confluence of the Middle Fork and the East Branch; in addition Plum Creek also found a single juvenile bull trout in the West Branch on State land approximately 1.5 miles upstream from the confluence of the West and East Branches. The Kalispel Tribe also found 2 juvenile bull trout in the East Branch in 1995 while snorkeling and a single juvenile in 1998 at the confluence of Fourth of July Creek and the E Branch. The presence of juvenile bull trout are indicative of a spawning population in the vicinity. During snorkeling surveys, the Kalispel Tribe found a single bull trout in Mill Creek in 1995, and another single bull trout in Indian Creek in 1997 (about 0.5 miles upstream from its confluence with the Pend Oreille River on private land). One adult bull trout was found behind the municipal dam at Ione on Cedar Creek by the Kalispel Tribe during snorkeling surveys in 1995, indicating the possible presence of a resident population on that stream (USFS 1998; T. Shuhda, USFS pers. comm. Oct. 16, 1998).

This lack of adfluvial bull trout in the reservoir is reflected by capture results in the adfluvial fish traps. The District and the Kalispel Tribe have cooperatively operated an adfluvial fish trapping program on the major tributaries to BCR since 1997. Although trapping efforts in 1997 were sporadic, none of the 71 fish captured in the traps during 1997 was a bull trout (Table 3.1-1). Of the over 400 fish captured in the adfluvial traps through September 20, 1998, no bull trout were found in any of the tributaries sampled (Table 3.1-2). Although these records are not total numbers of fish passing through the traps (weather, flow and physical stream conditions preclude absolute counts) the data indicate that bull trout, if present, are there in extremely small numbers.

Cover and Channel Complexity

Habitat for bull trout in the BCR is poor, due to silt and sand substrates, lack of habitat diversity, and warm water temperatures (Box Canyon ICD, 1997). Ashe and Scholz (1992) estimated that only 15% of the total riverine area of the reservoir provide habitat preferable to salmonids.

The District is currently conducting habitat mapping of Box Canyon Reservoir and sloughs. Over 100 transects have been measured in the reservoir, recording depth, velocity, cover and substrate along each transect; similar measurements were taken at over 20 transects in the sloughs. Data have not been extensively analyzed; however, preliminary analysis indicates that the habitat is most riverine immediately downstream of Albeni Falls Dam. Substrates found in the vicinity of Ruby and downstream may also be those preferred by salmonids, although depths and velocities would not be as reflective of riverine conditions at this location when compared to habitat near Albeni Falls. Pools are generally lacking; most LWD in the system appears to be remnants of old commercial docks and logging/rafting operations. Habitat complexity is limited in the reservoir.

**TABLE 3.1-1**
**SUMMARY OF FISH CAPTURED IN DOWNSTREAM AND UPSTREAM MIGRANT TRAPS, BOX CANYON TRIBUTARIES, 1997. DATA ARE PRELIMINARY AND INCOMPLETE.**

| Creek | Species | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | BLL | BRN | CT | EB | LSS | RB | SC | SQW | WF | |
| Big Muddy | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 23 |
| Cee Cee Ah | 0 | 7 | 0 | 17 | 0 | 0 | 1 | 0 | 3 | 28 |
| Indian | 0 | 1 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 6 |
| LeClerc | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 6 | 8 |
| Mill | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Skookum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tacoma | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 5 |
| | | | | | | | | | | |
| Total | 0 | 10 | 2 | 43 | 1 | 3 | 2 | 1 | 9 | 71 |

| | | | |
|---|---|---|---|
| BLL | Bull Trout | | |
| BRN | Brown Trout | RB | Rainbow Trout |
| CT | Cutthroat Trout | SC | Sculpin |
| EB | Eastern Brook Trout | SQW | Squawfish |
| LSS | Large Scale Sucker | WF | Whitefish |

Surveys conducted in 1995 by Washington Department of Fish and Wildlife (WDFW) and the Kalispel Tribe (KNRD 1995) estimated that within the 22 tributaries of the Box Canyon Reservoir, there were approximately 136.4 miles of bull trout habitat available. Although the tributaries are outside of the Project boundary and the scope of this Amendment, the opinion has been expressed that enhancement of salmonid populations in Box Canyon Reservoir can best be accomplished in the tributaries, given the limitations in the river itself. For this reason, the District will be funding habitat surveys of the tributaries to BCR beginning in 1999 as part of the Settlement. Information from these surveys will be used to identify those areas which may potentially be improved through habitat restoration and enhancement efforts. Tributaries and stream reaches will then be selected for restoration and enhancement activities; these activities will be funded by the District as part of the Settlement.

Temperature Regimes in Box Canyon Reservoir

The Box Canyon Reservoir is a cool-water mesotrophic system based on nutrients (maximum August temperature based on a two year average from 1989-1990 of 71.2•F [21.75•C]) (Falter et al. 1991). Water quality is good (Pelletier and Coots 1990; Bennet et al. 1990; Falter et al. 1991; EPA 1993). The reservoir is characteristic of a riverine environment. Annual mean reservoir flushing time during summer low flows is approximately 4.2 days and less during high water (Falter et al. 1991). The short flushing time and shallow depth do not allow vertical temperature stratification and the river is fully saturated for dissolved oxygen (D.O.) having an orthograde pattern (no difference top to bottom of water column). Nutrients appear to be a limiting factor for productivity. The WDOE shows exceedence of water quality standards to be limited to occasional high water temperatures and elevated pH (WDOE 1996). The river is moderately hard-water with a total alkalinity ranging from 93 mg/l $CaCO_3$ (Falter et al. 1991) to 98 mg/l $CaCO_3$ (Soltero et al. 1988). Aquatic macrophytes, particularly the proliferation and control of Eurasian Water-milfoil (*Myriophyllum spicatum spicatum*), are the major identified water quality concern (EPA 1993).

Data for maximum water temperatures and seasonal temperature regimes in the BCR are well documented (Pelletier and Coots 1990; Falter et al. 1991; Coots and Willms 1991; Skillingstad 1993; EPA 1993; District 1998; miscellaneous District records). River temperatures are above 50°F (10°C) from late May through October. Bennett and Garrett (1994) suggested that summer water temperatures are defined by the surface flow out of Lake Pend Oreille and that temperatures changed little due to the construction of Box Canyon Dam. The

Box Canyon Reservoir can best be described as favoring warm and cool-water fish species (Bennett and Liter 1991).

The sloughs of Pend Oreille River are mesotrophic (moderate nutrients) to eutrophic (high nutrients) (Falter et al. 1991). The sloughs warm earlier in the spring than the river with the exception of Trimble Slough which was 7.8• C in April 1990. By June, surface waters of the sloughs are 6• C warmer than the river except Trimble Slough (Falter et al. 1991). The situation is reversed by August. The sloughs and the river are near homothermous November through early April. The major sloughs weakly stratify in the July and August; however, only Tiger Slough is known to remain strongly stratified throughout the summer.

Dissolved oxygen (D.O.) is extremely important for most aquatic organisms. Coldwater salmonids are less tolerant of depressed oxygen levels and generally require 7 - 9 mg/l while warmwater species, including largemouth bass, can tolerate dissolved oxygen levels as low as 3 - 4 mg/l. Fish response to low D.O. levels in the sloughs has not been characterized. Juvenile and adult fish can avoid waters with depressed oxygen levels. Decay of organic matter in the sediment creates anaerobic (lacking oxygen) conditions when the sloughs are stratified. Surface waters, however, can be supersaturated for oxygen due to photosynthesis of macrophytes (aquatic plants). Indian, Davis, and Tiger sloughs were anaerobic near the bottom in July and August 1989. Trimble and Cusick sloughs did not show low D.O. levels except for isolated measurements.

**TABLE 3.1-2**
**SUMMARY OF FISH CAPTURED IN ADFLUVIAL FISH TRAPS, BOX CANYON TRIBUTARIES, 1998 (THROUGH NOVEMBER 1).**

| | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Creek** | **BLS** | **BRK** | **BRN** | **BULL** | **LSS** | **MTW** | **RBW** | **SCU** | **SQW** | **WSC** | **TOTAL** |
| **Indian Cr.** | | | | | | | | | | | |
| Down | 1 | 41 | 31 | 0 | 0 | 0 | 3 | 9 | 0 | 3 | 88 |
| Up | 0 | 4 | 4 | 0 | 0 | 0 | 2 | 1 | 0 | 4 | 15 |
| Total | 1 | 45 | 35 | 0 | 0 | 0 | 5 | 10 | 0 | 7 | 103 |
| **Skookum - Main** | | | | | | | | | | | |
| Down | 0 | 11 | 22 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 66 |
| Up | 0 | 22 | 22 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 51 |
| Total | 0 | 33 | 44 | 0 | 0 | 0 | 2 | 38 | 0 | 0 | 117 |
| **Skookum - NF** | | | | | | | | | | | |
| Down | 0 | 18 | 4 | 0 | 0 | 1 | 0 | 9 | 0 | 0 | 32 |
| Up | 0 | 2 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| Total | 0 | 20 | 12 | 0 | 0 | 1 | 0 | 9 | 0 | 0 | 42 |
| **Cee Cee Ah Cr.** | | | | | | | | | | | |
| Down | 0 | 10 | 16 | 0 | 0 | 2 | 0 | 13 | 3 | 0 | 44 |
| Up | 0 | 5 | 4 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 14 |
| Total | 0 | 15 | 20 | 0 | 0 | 2 | 0 | 18 | 3 | 0 | 58 |
| **Mill Cr.** | | | | | | | | | | | |
| Down | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 |
| Up | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 |
| Total | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 14 |
| **Middle Cr.** | | | | | | | | | | | |
| Down | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 17 |
| Up | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 13 |
| Total | 0 | 19 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 7 | 30 |
| **E. Br. LeClerc Cr.** | | | | | | | | | | | |
| Down | 0 | 16 | 8 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 27 |
| Up | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 |
| Total | 0 | 20 | 11 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 35 |
| **W. Br. LeClerc Cr.** | | | | | | | | | | | |
| Down | 0 | 7 | 2 | 0 | 0 | 4 | 3 | 2 | 0 | 2 | 20 |
| Up | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 7 |
| Total | 0 | 9 | 5 | 0 | 0 | 4 | 3 | 4 | 0 | 2 | 27 |
| **Cedar Cr.** | | | | | | | | | | | |
| Down | 0 | 1 | 1 | 0 | 0 | 13 | 1 | 3 | 0 | 1 | 20 |
| Up | 0 | 5 | 0 | 0 | 0 | 1 | 13 | 0 | 0 | 1 | 20 |
| Total | 0 | 6 | 1 | 0 | 0 | 14 | 14 | 3 | 0 | 2 | 40 |

**TABLE 3.1-2**
**SUMMARY OF FISH CAPTURED IN ADFLUVIAL FISH TRAPS, BOX CANYON TRIBUTARIES, 1998 (THROUGH NOVEMBER 1).**

| | Species | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Creek | BLS | BRK | BRN | BULL | LSS | MTW | RBW | SCU | SQW | WSC | TOTAL |
| **Big Muddy Cr.** | | | | | | | | | | | |
| Down | 0 | 29 | 0 | 0 | 0 | 0 | 1 | 9 | 0 | 0 | 39 |
| Up | 0 | 9 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 14 |
| Total | 0 | 38 | 0 | 0 | 0 | 0 | 2 | 11 | 0 | 2 | 53 |
| **Ruby Cr.** | | | | | | | | | | | |
| Down | 1 | 23 | 1 | 0 | 1 | 19 | 3 | 1 | 0 | 4 | 53 |
| Up | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| Total | 1 | 23 | 3 | 0 | 1 | 19 | 4 | 1 | 0 | 4 | 56 |
| **TOTAL** | | | | | | | | | | | |
| **Down** | 8 | 165 | 86 | 0 | 1 | 40 | 11 | 80 | 4 | 18 | 413 |
| **Up** | 5 | 64 | 46 | 0 | 0 | 1 | 19 | 17 | 0 | 10 | 162 |
| **Total** | 13 | 229 | 132 | 0 | 1 | 41 | 30 | 97 | 4 | 28 | 575 |

BLS Bridgelip Sucker
BRK Brook Trout — LSS Largescale Sucker — SCU Sculpin
BRN Brown Trout — MTW Mtn. Whitefish — SQW Squawfish
BULL Bull Trout — RBW Rainbow Trout — WSC Westslope Cutthroat Trout

Data collected in summer, 1997 (District 1998) showed mean daily temperatures were nearly identical throughout the mainstem river portion of the Box Canyon Reservoir. Maximum daily temperatures varied longitudinally along the river; the river upstream of Tacoma Creek (Left Bank LB) had the highest recorded hourly water temperature value (76.9°F = 24.9°C) compared to a maximum daily temperature downstream of Albeni Falls of 71.1°F (21.7°C). Although water temperatures were slightly warmer downstream of Albeni Falls, the river does not show a continually increasing temperature pattern as it flows down through the Box Canyon Reservoir. Longitudinal variability in riverine water temperatures appears to be a function of water depth, an observation which is consistent with the literature on the physics of stream heating (Sullivan et al. 1990). Deeper water columns tend to be less responsive to diurnal fluctuation in ambient air temperatures. The warmest riverine temperatures were recorded in the broad, shallow Reach 3 upstream of Riverbend. Water temperature regimes downstream at Ione began to cool as the river deepens and temperatures more closely resembled those at the head of the reservoir at Albeni Falls. Falter et. al. (1991) report similar findings; temperatures recorded throughout the reservoir in July/August 1990 were within a $\pm$ 0.5°C range of the same day temperature immediately downstream of Albeni Falls Dam.

Maximum instantaneous temperatures for the 1997 period of record were observed on August 5 and 6, 1997. Generally, daily temperatures peaked throughout the river in mid afternoon with minimum daily temperatures occurring between 4 and 10 a.m.

Simple regression analyses of temperature (dependent variable) with discharge and/or reservoir water surface elevation did not show any meaningful correlations. Water temperatures recorded in 1997 throughout the river were highly correlated with receiving water temperatures coming out of Albeni Falls.

The water quality criteria of 20°C was exceeded daily throughout the reservoir including water releases from Albeni Falls for the entire period of record in July, August, and the first week of September, 1997. Maximum daily temperatures showed a gradually cooling trend following a seasonal peak in early August.

Summer slough temperature regimes were intermediary between adjacent riverine and tributary temperatures, a result explained by the mixing of cooler tributary water with the Pend Oreille River. The 1997 data suggest that the sloughs may act as important temperature buffers for fish migrating between the tributaries and river. Sloughs showed a greater diurnal range in temperature than either the adjoining tributary or the river. The greatest diurnal range was observed in Skookum Slough where it averaged nearly 10°F in August, 1997. River diurnal ranges in August were less than 2°F and tributaries had typical diurnal ranges of 7-9°F (smaller diurnal ranges in cooler groundwater dominated tributaries.) The greater diurnal range in the sloughs could be attributable to cool tributary water dominating the nighttime temperature regimes as well as the open bank vegetation canopy character of the sloughs which are generally shallower than the river.

### 3.1.3 Analysis of effects

The June 10, 1998 listing of bull trout populations as a threatened species cites factors contributing to the decline of populations in the Columbia River population segment. Among those listed are the construction of dams, forest management practices, livestock grazing, agricultural practices, road construction and maintenance, mining and residential development (Federal Register Vol. 63, No.111) . The Amendment Application does not alter the existing flow or hydraulic dynamics of the reservoir or the tributaries. The Amendment Application itself does not involve change in operation of the Box Canyon Dam, nor will it involve activities pertaining to any of the other factors listed above. Therefore no effects to existing bull trout habitat, foraging or prey species habitat or populations are anticipated. No mitigation measures to avoid adverse impacts to *Salvelinus confluentus* are proposed.

Under the Settlement Agreement, the District will fund habitat restoration efforts in Box Canyon tributaries in areas identified during stream habitat surveys; these surveys will be conducted during 1999. Depending upon the location of the targeted restoration activities, enhancement activities may directly benefit bull trout habitat; however, there may be short-term adverse impacts associated with these enhancement/restoration activities (i.e., temporary siltation due to instream activities). When habitat restoration measures are proposed in tributaries to BCR under the Settlement, the District will enter into consultation with the USFWS to discuss any measures required to mitigate for short term adverse impacts that may be associated with restoration/enhancement activities.

<u>Cover and Channel Complexity</u>

Analysis of habitat in the reservoir is ongoing, and detailed habitat investigations in tributaries to BCR which have not been previously surveyed will begin in 1999. As mentioned above, habitat for bull trout in the BCR is currently poor, due to silt and sand substrates, lack of habitat diversity, and warm water temperatures. Lower reaches of inundated creeks and water temperatures in sloughs have not proven to preclude adfluvial fish migration, as evidenced by adfluvial trap returns. There are no changes in reservoir elevations proposed in the Amendment, and therefore, no effect from current operations.

As part of the Settlement, the District will be funding enhancement and restoration activities in tributaries to BCR. Since the data have not been collected nor are specific enhancement activities known at this time, it is premature to determine the effects of these efforts on bull trout populations or habitat. When specific habitat enhancement projects are proposed in these tributaries (which could potentially affect migratory and/or resident populations of bull trout), the District will enter into informal consultation with the USFWS on a tributary and site-specific basis.

<u>Temperature as a Limiting Factor in Box Canyon Reservoir</u>

Summer water temperatures in the Box Canyon Reservoir remain above 20°C, an upper limit of temperatures reported in the literature for bull trout occupancy. Temperatures in 1997 never dropped below 20°C during August; averaged above 20°C during the second half July, and exceeded 20°C for 7-10 days in September. Tributary temperatures were monitored from mid July through October 1997. Monitoring in 1998 has been expanded to April through November; however, that data is not yet available. Tributaries monitored in 1997 included Indian, Skookum, Cee Cee Ah, Tacoma, LeClerc, and Big Muddy Creeks. Coolest water temperatures in the lower tributaries were observed in Indian Creek (annual maximum 13.6°C) and LeClerc Creek (13.1°C). Maximum temperature in Skookum Creek near the fish trapping site was 15.6°C. Other tributaries were cooler than the river but maximum observed temperatures were in the upper range of bull trout tolerance as reported in the literature based on occurrence. It can be concluded that, if fluvial or adfluvial bull trout populations occur in the BCR, it is unlikely they remain year round in the river. Summer water temperatures are not considered suitable.

### 3.1.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impacts to *Salvelinus confluentus* are proposed. When habitat restoration measures are proposed in tributaries to BCR under the Settlement, the District will enter into consultation with the USFWS to discuss any measures required to mitigate for short term adverse impacts that may be associated with restoration/enhancement activities.

### 3.1.5 Conclusion

This District concludes that the Amendment, as proposed, coupled with the terms of the Settlement, will result in an action which **may effect, not likely to adversely affect** bull trout populations and habitat within BCR. Continued operation of Box Canyon Dam will result in no change to BCR, and no effect on bull trout or their habitat. Habitat restoration efforts may, depending upon tributary system, location within the tributary, and method(s) of enhancement/restoration used, result in short-term adverse impacts; in the long-term, however, efforts should prove beneficial to bull trout populations and/or habitat.

## 3.2 GRAY WOLF (*Canis lupus*)

### 3.2.1 Description of species and habitat

Extirpation of gray wolves in much of the lower 48 United States has primarily been the result of a relentless program of extermination and less a result of loss of habitat (USFWS 1987). Since being federally listed as an Endangered species, wolf populations have steadily increased, particularly in wild and remote areas in proximity to areas with viable wolf populations. Wolves are present at low densities in the Selkirk Mountains, which are contiguous with wolf habitat in Canada. Gray Wolves are very wide-ranging and can use diverse habitats, including those in the study area.

Historically, wolves utilized a broad spectrum of habitats. These habitats had two specifics in common: an abundance of natural prey and, more recently, minimal conflict with human interests/uses.

The USFWS (1987) Recovery Plan for gray wolf states the key components of habitat as fairly simple and requiring: (1) a sufficient, year-round prey base of ungulates (big game) and alternate prey; (2) suitable and somewhat secluded denning and rendezvous sites; and (3) sufficient space with minimal exposure to humans. Because the needs of wolves relate so directly to ungulates, and because the habitat needs of different ungulate species are variable between regions, it is difficult to characterize wolf habitat with specificity.

Riparian habitats will often be used as travel corridors and can provide wolves with an alternative prey source (beaver, small mammals) during ice-free times (spring-fall). On a biomass basis, however, ungulates comprise the bulk (more than 90%) of the wolves' diet during the summer and fall in the Rocky Mountains (USFWS 1987).

Most wolves are particularly sensitive to human activity near den sites and may abandon them if disturbed. Wolf rendezvous sites are characterized by matted vegetation in a meadow, a system of well used trails through adjacent forest and across the meadow, and resting beds adjacent to trees. Den and rendezvous sites are also characterized by having forested cover and being distant from human activity. "The wolf's need for cover is also related indirectly to the cover requirements of its principle prey in a particular area (USFWS 1987)." For the Pend Oreille River watershed, that prey source would most likely be white-tailed deer, which is the most abundant ungulate in the region. Elk may also provide a food source for wolves, however the elk herds in the Pend Oreille River watershed are not found in the Project area. Wolves prey upon the newborns and young of moose, bison, elk, and deer in calving/fawning areas during May and June (USFWS 1987). Since most ungulates show high site fidelity, the location of these calving/fawning areas is critical to the establishment of home range and recovery for the gray wolf.

### 3.2.2 On-Site Inspection

WDFW (1996) reported six recent (1990-1994), reliable sightings of wolves within two miles of the Pend Oreille River, including three sightings less than a mile east of the USFS campground near Ione, Washington. There is also a record of a radio-tagged wolf which was found dead near Calispel Lake in 1994 (pers. comm., Steve Zender, WDFW Sept. 28, 1998). These records suggest at least incidental use of the river corridor, with occasional presence more likely in the northeastern quadrant of the river corridor, closest to the western foothills of the Selkirk Mountains. The existing level of human activity, including hunting, logging, and road-use, limits the suitability of this area for wolves (pers. comm., Steve Zender, WDFW Sept. 28, 1998; Mike Herrin, USFS, Sept. 23, 1998, and Ray Entz, Kalispel Tribe Sept. 22, 1998).

### 3.2.3 Analysis of Effects

The proposed operation of Box Canyon Dam will not alter suitable habitats for gray wolf along the river corridor. Annual peak flows and flooding, which could effect plant communities and structure are not influenced by the Project. The most significant impacts to wolves include changes in road density, habitat fragmentation due to development and increased human activities in the Project area. It is anticipated that these non-project impacts will continue to create problems for gray wolf in the area; however these impacts are not controlled by Box Canyon Dam or the Licensee and therefore are not included in the analysis of effects of the proposed Amendment.

### 3.2.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impacts to gray wolf are proposed.

### 3.2.5 Conclusion

Agency consultation, literature search, and habitat analysis show that the gray wolf occurs within the Project area infrequently. Elk is not a species commonly found along the Box Canyon Reservoir and there are no known ungulate calving/fawning areas in the Project area. Implementation of the Box Canyon License Amendment would not adversely affect existing populations of gray wolf, or its principle prey (white-tailed deer), because individuals or home ranges will not be influenced by the proposed operation of the Project. White-tailed deer do occur in the Project area, however, the increased amount of human activity along the river corridor is viewed as a significant deterrent for gray wolf. Nonetheless, the fact that gray wolves have been sighted in the Pend Oreille River Valley and near the reservoir in several places suggests that the proposed Amendment will have a **may effect/not likely to adversely effect** determination for gray wolf.

## 3.3 GRIZZLY BEAR (*Ursus arctos horribilis* )

### 3.3.1 Description of species and habitat

The grizzly bear is listed as Threatened Federally, and Washington State listed as Endangered. These listings are based on historical mortality due to predator control and hunting, and a loss of habitat with the encroachment of civilization. Surviving populations continue to be threatened by illegal poaching and conflicts with human use of critical habitats; however, the grizzly bear is slowly returning to certain suitable regions, particularly in wilderness and roadless areas. This species persists in the Selkirk Mountains, which span the Washington-Idaho border and extend northward into Canada. The Selkirk population is one of only five known populations in the lower 48 states, and the supporting ecosystem has been designated as the Selkirk Grizzly Bear Recovery Zone. Recovery will require reducing illegal mortality, maintaining and improving habitat quality through management, reducing land-use conflicts, and increasing public acceptance of this species (USFWS 1993).

Preferred habitats of grizzly bears include sub-alpine meadows and open or semi-open forests. Dens are typically located far away from human activity on steep slopes where snow accumulation is deep and persistent. Grizzly bears are very wide-ranging and can be found in diverse habitats, including habitats in the study area.

Grizzly bears are opportunistic feeders and will prey or scavenge on almost any available food source including; ground squirrels, ungulates, carrion, roots, bulbs, tubers, fungi, tree cambium, berries, nuts, fish, and garbage (Murie 1944, Hamer 1974, Craighead and Craighead 1972, Blanchard 1978 as cited in USFWS 1993).

The relative importance of forest cover to grizzly bears has been documented by Blanchard (1978) in studies conducted within the Yellowstone ecosystem. The majority (90%) of radio-collared bears tracked in this 4-year study were observed in dense forest cover areas less than 1 kilometer from an opening. Thus the importance of an interspersion of open parks as feeding sites with dense forest cover for denning was a critical component of grizzly bear habitat suitability. Elevations and locations of dens vary geographically, but generally most den sites were found at higher elevations well away from development or human activity (Blanchard 1978). The author was uncertain whether this selection was out of innate preference or avoidance to humans; however, the low ambient air temperatures inherent with higher elevations have been documented by Craighead and Craighead (1972) as important to successful hibernation and reduced metabolic rates.

### 3.3.2 On-Site Inspection

The Selkirk Recovery Zone is situated on the Colville National Forest east of the Pend Oreille River, completely outside of the Box Canyon Project area. WDFW (1996b) reported an unverified sighting of a grizzly sow with two cubs less than about 0.5 mile from the river on a recently logged hillside in the Colville National Forest in 1986. Verified sightings have occurred further to the east in the west branch of Le Clerc Creek and Dry Canyon areas. Recently a sub-adult male grizzly was killed on the Kalispel Indian Reservation (August, 1998), suggesting that this species may occasionally venture into the study area. (pers. comm., Steve Zender, WDFW Sept. 28, 1998). The existing level of human activity, including hunting, logging, and road-use, is likely to limit future occurrences of grizzly bear in the Project area (pers. comm., Steve Zender, WDFW Sept. 28, 1998, Mike Herrin, USFS, Sept. 23, 1998, and Ray Entz, Kalispel Tribe Sept. 22, 1998).

### 3.3.3 Analysis of Effects

The grizzly bear has never been documented within the Project study area and historical records show the closest observations being several miles outside of the Project boundary. The recent sighting of a sub-adult male on the Kalispel Reservation suggests a single individual attempting to emigrate through the area as opposed to a bear establishing a home territory. The operation of Box Canyon Dam will not alter suitable habitats for grizzly bear along the river corridor and the Project does not include acreage in the Selkirk Grizzly Bear Recovery Zone.

### 3.3.4 Mitigation measures that avoid adverse impacts

Mitigation measures to avoid adverse impacts to grizzly bear are not being proposed.

### 3.3.5 Conclusion

Agency consultation, literature search, and habitat analysis show that grizzly bear does not typically occur in the Project area. Implementation of the Box Canyon License Amendment would not adversely affect existing populations of grizzly bear because no individuals or home ranges have been documented within the Project boundary or Project study area, and existing habitats will not be influenced by the proposed operation of the Project. Since a grizzly bear was recently encountered on the Kalispel Reservation, however, it suggests that the proposed Amendment will have a **may effect/not likely to adversely effect** determination for grizzly bear.

## 3.4 CANADA LYNX (Lynx canadensis)

### 3.4.1 Description of species and habitat

The Canada lynx is proposed for federal listing, and recognized as a state Threatened species. The lynx still occurs in Washington, but its range has retracted northward, principally in the higher elevations of the northeastern Cascades and the Okanogan Highlands. Remote high elevation areas appear to be important to the lynx as they provide a preferred prey base and lack of human activity. Structurally, lynx habitat reflects a mosaic of forest successional stages such as early successional forests that contain high numbers of prey for foraging, and late successional forests that contain cover for kittens and denning. Limiting factors for lynx may include a lack of plentiful prey base (snowshoe hair), elevation and topographic boundaries, fragmented or non-continuous coniferous forest cover, road density and recreational activities (eg. snowmobiles), snow conditions, and competition with the more adapted bobcat or cougar (USDA Gen. Tech. Report 1994).

### 3.4.2 On-Site Inspection

There have been no sightings of lynx in the Project study area or within the Project boundary. The closest confirmed sightings have been up the Paupac Road near Harvey Creek and Coyote Hill approximately 3.5 miles east of the reservoir and the town of Tiger. Additional lynx tracks have been observed on the west side of the Pend Oreille Valley near the Little Pend Oreille Lakes area, approximately 5 miles from the Pend Oreille River and completely outside of the Box Canyon Project area (pers. comm., Steve Zender, WDFW September 28, 1998). Based on literature review and consultation with species experts, the Project area does not contain lynx habitat (pers. comm. John Weaver, Wildlife Conservation Society, September 30, 1998, and Steve Zender, WDFW September 28, 1998).

### 3.4.3 Analysis of Effects

Canada lynx is not present in the Project area. Human activity levels likely preclude occupation within the project area or boundaries. Therefore, the Amendment is viewed to not effect this species.

### 3.4.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impacts to Canada lynx are proposed.

### 3.4.5 Conclusion

Canada lynx is not known to inhabit the Project study area; therefore, the Project has **no effect** on this species.

## 3.5 PEREGRINE FALCON (*Falco peregrinus anatum*)

### 3.5.1 Description of species and habitat

The peregrine falcon is a state and federally-listed Endangered species. Once relatively secure even in urban settings, peregrine falcon populations plummeted throughout the U.S. beginning about 1950. These declines closely correspond to the introduction and widespread use of organochlorine pesticides such as DDT. The number of peregrine falcons has steadily increased since the use of DDT was stopped and recovery plans were instituted. These have included aggressive intervention with captive-breeding, and hatching impaired eggs under protected conditions. Hundreds of nestlings have been raised and placed in appropriate habitat where there are suitable natural or artificial nest sites. Natural recolonization has also occurred. Populations are still relatively small, but are approaching numbers that may warrant down-listing to Threatened in the near future. These birds nest on cliff ledges, or less commonly on large trees or snags. Nests are also found under high bridges, and on skyscrapers that simulate natural eyries. Principal prey are other birds. Peregrines are known to migrate along the coast or elsewhere following migrating waterfowl and shorebirds.

There are reliable sight records of a single peregrine falcon in the Campbell Slough area in the spring of 1993, 1994, and 1995 (pers. comm., M. Herrin, USFS Newport Ranger District, October 3, 1996). There is no indication that this species nests within the study area. USFS (1996) had no records of breeding peregrine falcons on National Forest land in the region. A cliff immediately upstream from the Box Canyon Dam has a moderate potential for use by this species and will be surveyed during proposed relicensing studies.

### 3.5.2 On-Site Inspection

The procedures for determining the presence or absence of peregrine falcons within the study area will follow the survey protocol developed by the USDA Forest Service (Pagel 1992). Surveys of cliff sites are necessary to document the full extent of the recovery of peregrine falcon populations in the Pacific Northwest (Pagel 1992). The combination of cliff habitat (albeit limited), high waterfowl and neotropical bird concentrations, and historical sighting (USFS Newport R.D.) in the study area suggests that suitable habitat for peregrine falcons exists. Thus, surveys are warranted to determine if any project related impacts are occurring to this state and federally endangered species.

<u>Presence/Absence Survey</u>

The potential nesting habitat found on a cliff immediately upstream of Box Canyon Dam will be surveyed to determine whether the site is being used by peregrine falcons. This cliff is easily observed from the west side of the river and will be surveyed continuously on three separate visits in 1998 and 1999 using binoculars and a spotting scope. Surveys will occur during the nesting season which extends from January 15 through July 30.

Nesting chronologies of specific falcons vary depending upon elevation, aspect, microclimate of the nest cliffs and availability of prey. The optimum time of the year to search for new eyries is during the post-hatch period (April-August) of the nesting chronology. Surveyors will establish a sufficient number of observation stations to adequately survey all areas of suitable nesting habitat. A total of three survey visits staggered throughout the post-hatch period of April, May and June will begin at dawn and continue for a minimum of four hours under favorable viewing conditions. The three viewing periods will occur at least 25-30 days apart from each other to maximize opportunities for detecting falcons within the post-hatch period.

1998 surveys conducted by Duke Engineering and Services, Inc. (DE&S) have failed to locate nesting peregrines in the Pend Oreille River Valley. The observations of a single peregrine near the town of Newport and again on the Flying Goose Ranch in the spring of 1993, 1994, and 1995, suggest that there may be a resident bird occasionally foraging in the Project area, or more likely an individual falcon following the same migratory rout as many of the waterfowl species (pers. comm., M. Herrin, USFS Newport Ranger District, October 3, 1996).

### 3.5.3 Analysis of Effects

Limited nesting habitat has been identified within ¼ mile of the project area; however, the local cliff and rock outcropping habitats lack the crevice and overhanging structure typical of falcon eyries. Foraging opportunities would not be limited by the Project Amendment. Waterfowl and neotropical migrant birds, identified as the primary food sources of inland peregrine falcons (USFWS, 1982), are plentiful around the reservoir and have not been adversely effected by Project operations.

### 3.5.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impacts to peregrine falcons are considered necessary based upon their limited use of the area and analysis of effects. Continued monitoring of suitable cliff sites in the valley and high foraging habitats (example: Flying Goose Ranch), however, will help identify the recovery status of this species in Pend Oreille County.

### 3.5.5 Conclusion

Literature review, agency and tribe consultation, aerial photo interpretation, and field investigations indicate that peregrine falcons do not nest in the immediate vicinity of the Project, and nesting and foraging habitat will not be affected by the proposed License Amendment. Therefore, the proposed Amendment will have **may effect/not likely to adversely affect** on peregrine falcon.

## 3.6 BALD EAGLE (*Haliaeetus leucocephalus*)

### 3.6.1 Description of species and habitat

The bald eagle is listed as Threatened by USFWS in Washington and Idaho, but has experienced dramatic increases in numbers throughout the state since DDT use ceased, and recovery management plans were instituted (USFWS 1986). Bald eagles typically nest within one mile of water in nests placed on large-diameter trees (Stalmaster et al. 1985, Rodrick and Milner 1991). Eagles prey primarily on fish, and opportunistically on carrion and waterfowl, especially where waterfowl are present in large concentrations. The Project is located within Zone 7 (Upper Columbia Basin) of the Pacific Recovery area. The recovery population goal for the Zone is 69 breeding pairs (USFWS 1986).

### 3.6.2 On-Site Inspection

The goals of ongoing eagle surveys are to assess the current status of bald eagles within the Project study area, monitor reproduction success over a two year period, and evaluate the effects of the project on the species. Studies of this species emphasize up-dating information on active nest locations and nest productivity. Active and potential nest sites were surveyed in spring of 1998 to record nest activity and the number of young produced. Eagles were viewed from a boat and other locations using binoculars and spotting scopes to minimize disturbance to the birds. These surveys were coordinated with WDFW, USFS, USFWS, and the Kalispel Tribe to avoid duplication of survey efforts. Surveys for bald eagles include three levels of effort: 1) winter population counts to document the number of migratory bald eagles; 2) summer surveys to document the number of resident eagles; and 3) surveys of all known or suspected eagle nests to document annual productivity of the species.

Winter Population Counts

After preliminary identification of potential nesting and roosting habitat from aerial photographs and vegetation maps, biologists employed non-random, ground-based surveys to detect winter concentrations of bald eagles. Eagles were identified through a complete two day boating survey and additional road overlook stations. Since wintering bald eagles tend to congregate along the shorelines and open water areas overlooking foraging habitat, the total number of eagles in the study area was easily counted. These surveys were performed around all suitable habitat, with a total of three visits completed during the winter migratory season (November-February) in 1997/98 and 1998/99. This approach ensured that the study area received complete survey coverage and that winter population densities were quantified.

Summer Population Counts

The procedure for counting summer resident bald eagle population within the study area was the same methodology used for the winter population counts. A two day continuous boating survey was the principle means of collecting population, age, distribution, and behavioral data. These surveys involved three complete visits conducted in May, June and July 1998. A second year of summer population data will be collected in 1999.

Nest Visits

Nest visits were performed for all bald eagle nest sites known or suspected within the study area. The locations of nests sites were identified through consultations (agencies, tribes, and/or private), previous eagle nesting records, and field survey data. The current number of occupied nest sites were recorded and mapped along with the number of offspring hatched and successfully fledged. Inactive nests (including alternate nests) and abandoned nests were also noted. A total of three visits were staggered over the nesting-fledgling period (April-August). Information collected was used to document reproductive success and annual production for 1998 and will be duplicated again in 1999.

Results

There were three active bald eagle nests documented in the vicinity of the Reservoir in 1989, two in 1990, four in 1992 and 1993, and five in 1994 (Reese et al. 1993, Landua and Reese 1995, WDFW 1996). Surveys conducted in 1997 and 1998 documented seven active bald eagle nests in the Project area with two additional nesting pairs in the vicinity of the reservoir (Table 3.6-1). The active nests were each associated with areas of known spring-summer waterfowl concentrations. All nine active nests in the vicinity of the project produced between two and three fledglings per nest, demonstrating maximum nest productivity for 1998. Data over a ten-year period shows an increase in the average annual population of eagles.

The maximum number of eagles observed in any year was a winter count of thirty six birds in 1997. The number of bald eagles observed during the 1997 winter surveys suggests that the breeding population does not migrate during winter.

### 3.6.3 Analysis of Effects

Reese et al. (1993) concluded that human activity (particularly the presence of homes and well-traveled roads) is the primary limiting factor for bald eagles along the Box Canyon Reservoir; however, the distribution and number of active nests in the study area, along with annual productivity counts, indicate that habitats in and around the Project area are maintaining a healthy and viable population of bald eagles.

| TABLE 3.6-1<br>ACTIVE NEST SITES FOR BALD EAGLE | |
|---|---|
| Indian Island | Lost Creek |
| Everett Island | Kalispel Reservation |
| Trimble Creek | Fountain's Ranch |
| Loop Creek/USFS land | |
| 1 mile north of Box Canyon Dam<br>*(not in Project area)* | Calispel Lake<br>*(not in Project area)* |

There have been no adverse effects associated with the construction and/or operation of the Project. Foraging does not appear to be a limiting factor based on the increases in population of eagles along the reservoir and the high number of eaglets successfully fledged each year. Furthermore, nesting, roosting and perching habitats have not been significantly altered as a result of the project, based upon aerial photo interpretation from pre-project photos and current habitat conditions. There has been a considerable increase in the number of homes and human activities occurring along the reservoir; however, development is not attributable to the Amendment.

### 3.6.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impact to bald eagle are currently being proposed; however, continued monitoring of resident populations and existing nests sites will be important to document population stability over time. The bald eagle is a target species for the HEP analysis currently being conducted as part of the Settlement Offer. If an adverse impact is determined to have occurred to the bald eagle, mitigation for this species may be provided via land acquisition. A monitoring program may be implemented to address the short and long term effects of increased human activity and development along the reservoir and the effect this will have on bald eagle populations and habitat conditions.

The Washington State Department of Fish and Wildlife (WDFW) has historically been charged with the task of monitoring nest productivity for bald eagles in the state. The USFS Colville National Forest and the Kalispel Tribe of Indians have also been pro-active in documenting nest productivity and population trends for bald eagles along the reservoir. Provided funding is available and allocated for these agencies and landowners, reliable data should be available to monitor the future recovery of bald eagles in the Project area.

### 3.6.5 Conclusion

Literature review, agency consultation, aerial photograph interpretation, and field investigations demonstrate that bald eagle has been a common species in the Project area with better recovery today than historic records indicate. Implementation of the Box Canyon License Amendment would not adversely affect existing populations of bald eagle because this species has already established itself to the present conditions and operation of the reservoir. Therefore, the proposed Amendment will have **may effect/not likely to adversely affect** on bald eagle.

## 3.7 UTE LADIES'-TRESSES

### 3.7.1 Description of species and habitat (following from USFWS, July 28, 1998 - Appendix A)

*Spiranthes diluvialis* (Orchid family - Orchidaceae) is a perennial, terrestrial orchid with stems 20 to 50 cm (8 to 20 in) tall, arising from tuberously thickened roots. Its narrow leaves are about 28 cm (11 in) long at the base of the stem, and become reduced in size up the stem. The inflorescence consists of 7 to 32 small (5.5 to 15 mm (3/8 to 5/8 in)) white or ivory flowers clustered into a spike arrangement at the top of the stem. The sepals and petals, except for the lip, are rather straight, though the lateral sepals are variably oriented, with these often spreading abruptly from the base of the flower. Sepals are sometimes free to the base.

Because the non-blooming plants are very similar to those of the widespread species, *Spiranthes romanzoffiana*, it is normally possible to positively identify Ute ladies'-tresses only when it is flowering. *S. romanzoffiana* has a tight helix of flowers around the spike and laterally appressed sepals. *S. diluvialis* has flowers facing directly away from the stalk, neither ascending nor nodding, and appressed or free lateral sepals. Ute ladies'-tresses generally bloom from late July through September, depending upon location and climatic conditions. In some areas, this species may bloom in early July or as late as early October.

Mature plants may remain dormant for one or more growing seasons, without producing above ground shoots, or may exhibit vegetative shoots only. Orchids generally require symbiotic associations with mycorrhizal fungi for seed germination. Many plants of some *Spiranthes* species are initially saprophytic, persisting underground for several years before emerging above ground (USFWS 1995). Bumblebees are apparently required for germination.

Because *Spiranthes diluvialis* was first described in 1984 (Sheviak 1984), it is not found in many of the older written dichotomous keys commonly used for plant identification.

*Spiranthes diluvialis* typically inhabits wetland and riparian areas, including perennial springs habitats, mesic to wet meadows, river meanders and floodplains. It is found above 1500 feet, below the lower margin of montane forests, generally in wet areas in open shrub or grassland, or in the transitional zone.

### 3.7.2 ON-SITE INSPECTION

Rare plant surveys have been conducted for the relicensing of Box Canyon Dam for the District, beginning in 1996. Surveys for the entire reservoir and associated habitats were completed in 1998. The reservoir and adjacent habitats were surveyed at the appropriate time of year of this three-year period, including all potential habitat for *Spiranthes diluvialis*. *Spiranthes diluvialis* were specifically targeted during 1997 and 1998 field surveys. No *Spiranthes diluvialis* were identified during any surveys. It has been concluded that *Spiranthes diluvialis* is not present in the Box Canyon Amendment area.

### 3.7.3 Analysis of effects

*Spiranthes diluvialis* is not present in the Project area; therefore, the project has no effect on this species.

### 3.7.4 Mitigation measures that avoid adverse impacts

No mitigation measures to avoid adverse impacts to *Spiranthes diluvialis* are proposed.

### 3.7.5 Conclusion

Extensive field investigations indicate that *Spiranthes diluvialis* does not exist in the project area. Implementation of the Box Canyon License Amendment would not adversely affect existing populations of *Spiranthes diluvialis* because no populations of this species occur within the analysis area. Therefore, the proposed Amendment will have **no effect** on *Spiranthes diluvialis*.

# 4.0 CUMULATIVE EFFECTS

## 4.1 INTRODUCTION

For the purposes of this analysis, cumulative effects are defined as the effects on the environment which result from the incremental impact of the proposed action when added to other reasonably foreseeable future *non-federal* actions (from Kreske 1996); this analysis must assess what actions are likely to occur through private interests, the state, county and tribes (pers. comm., L. Halleck, USFWS, Spokane Office, November 19, 1998).

Table 4.1-1 describes the ownership of lands on Box Canyon Reservoir. The overwhelming majority of the land is in private ownership (nearly 77%). The District and the Box Canyon Hydroelectric Project have no control over actions that take place on 97% of the lands surrounding Box Canyon Dam.

**TABLE 4.1-1**
**OWNERSHIP OF LANDS SURROUNDING BOX CANYON RESERVOIR.[1/]**

| Ownership | Acreage | Percent |
|---|---|---|
| Private | 2,469.3 | 76.5% |
| Tribal | 403.9 | 12.5% |
| Federal | 145.7 | 4.5% |
| County | 92.6 | 2.9% |
| PUD | 82.4 | 2.6% |
| State | 27.6 | 0.9% |
| Unknown | 5.2 | 0.2% |
| | | |
| Total | 3,226.7 | 100.0% |

[1/] From County Assessor's Office, 1998

## 4.2 AREAS EXAMINED FOR CUMULATIVE EFFECTS ANALYSIS

The following section details those investigations made by the District to determine foreseeable future *non-federal* actions in the vicinity of the Box Canyon Project. Information gathered from private, county and District sources are summarized below. Telephone interviews were held with individuals knowledgeable about county planning activities, county growth, state plans along the Pend Oreille River, and plans produced by the Kalispel Tribe for future recreational activities for the Kalispel Indian Reservation were examined.

### 4.2.1 Pend Oreille County

There is currently no anticipated large increase in growth in the cities or rural areas within Pend Oreille County; unemployment remains high. Washington State census figures indicate that Pend Oreille County experienced negative growth from 1980 - 1990; annual growth rate since 1990 is approximately 3% (WOFM 1998). There have been no changes in zoning within the county recently, and none are proposed (pers. comm., Paul R.

Wilson, Public Works Director, Public Works Department, November 13, 1998). A six-year road program has been prepared for Pend Oreille County and approved by the Pend Oreille County Commissioners on October 26, 1998. Within the project area, approval has been secured to improve the following roads:

- Widen the LeClerc Road from the Washington/Idaho border (Milepost - MP 0.0) to MP 12.0 in 1999, 2001, 2002 and 2004 in approximately three-mile increments.
- 2.32 miles of the RiverBend Loop Road will be widened to 24 ft in 1999.
- The Skookum Creek Road will be widened to 24 ft from MP 0.00 to MP 1.81.
- Ashenfelter Bay Road will be graded and surfaced from MP 0.00 to MP 1.50
- Indian Creek Road will be widened to 26 ft from MP 0.00 to 1.40 in 2001. (Pend Oreille County 1998)

Best Management Practices (BMP's) will be followed while improving these roads; improvements will also be contingent upon securing the proper permits which will stipulate the required environmental protection measures to be undertaken during road improvements. These projects are not likely to impact any of the species in the Endangered Species List.

### 4.2.2 Pend Oreille County Public Utility District

There are currently no changes planned to current operation at Box Canyon Dam. There are currently no projections of growth in the county, and no one has inquired into the availability of additional power to accommodate any such growth (pers. comm., Bob Geddes, Regulatory Affairs Manager, Pend Oreille Public Utility District, November 13, 1998).

### 4.2.3 Kalispel Tribe of Indians

The Kalispel Tribe developed a Kalispel Tribal Recreation Plan in 1996 (KNRD 1996). This plan calls for the development of the following for the time period 1996 - 2000:

- Pow Wow Grounds Improvements
- Boat Launch and Bass Tournament Facility
- Bike Trail
- Baseball Field Improvements
- Playgrounds Improvement
- Playgrounds Improvements
- Interpretive Center
- Manressa Grotto Improvements

Although the status of these projects is uncertain at this time, these projects are not likely to impact any of the species in the Endangered Species List.

### 4.2.4 Washington State

Washington State Parks had previously planned to develop state lands along the Pend Oreille River into a Park (SW 1/4 of the SE 1/4 of Section 33 T. 32 N. R. 45 E, downstream of Indian Island). Due to wetlands and local resident concerns, the State has decided not to develop this site (pers. comm., Debby Howe, Howe Consulting, Inc. November 25, 1998).

### 4.2.5 Private Interests

The only identifiable, foreseeable future action within the County with the potential to impact the Pend Oreille River is the proposed reopening of the Pend Oreille Mine. This lead and zinc mine, owned by Cominco

American, is located just north of the town of Metaline Falls and is immediately adjacent to the Pend Oreille River about 8 river miles downstream of Box Canyon Dam. An Environmental Impact Statement (EIS) is currently being developed for the mine reopening. Water quality issues are being addressed within that forum, and Washington Department of Ecology will be setting standards for mine water discharge into the Pend Oreille River. Cominco will be required to comply with State water quality and dilution standards for their effluent before the mine will be permitted and allowed to reopen.

Due to the strict water quality standards that the mine will be required to meet, as well as the location of the mine downstream of the Box Canyon Project, cumulative effects of this mine will be negligible.

## 4.3 CONCLUSION

The extent of cumulative impacts on the Federally Listed Threatened and Endangered species will be contingent upon the implementation of Best Management Practices. The extent to which these Threatened or Endangered Species would be impacted depends on the magnitude, timing, and proximity of the potential impact on habitat. The cumulative impacts are expected to be low.

## 5.0 REFERENCES

Adams, S.B. 1994. Bull trout distribution and habitat use in the Weiser River drainage, Idaho. Master's Thesis. University of Idaho, Moscow, Idaho.

Allen, J.H. 1980. Life history notes on the Dolly Varden char *(Salvelinus malma)* in the upper Clearwater River, Alberta. Alberta Energy and Natural Resources, Fish and Wildlife Division, Red Deer, Alberta, Canada.

Ashe, B.L., and A.T. Scholz. 1992. Assessment of the Fishery Improvement Opportunities in the Pend Oreille River. Final Report. Upper Columbia United Tribes Fisheries Center, Dept. Of Biology, Eastern Washington Univ., Cheney. Prepared for U.S. Dept. Energy, Bonneville Power Administration, Div. Of Fish and Wildlife. Project No. 88-66, Agreement DE-179-88BP39339, March 1992. 295 pp.

Barber, M.R., R.A. Williams, A.T. Scholz, L.O. Clark, B.L. Renberg, K. O'Laughlin, K.L. Woodward, and R.D. Heaton. 1989. Assessment of the Fishery Improvement Opportunities on the Pend Oreille River: 1988 annual report. Upper Columbia United Tribal Fisheries Center, Eastern Washington University. Final report submitted to U.S. Dept. Energy, Bonneville Power Administration. Project No. 88-66. Contract No. DE-179-88B 39339.

Bennett, D.H., and J.W. Garrett. 1994. Abundance and Habitat Use of Box Canyon Reservoir, Pend Oreille River, Washington and Tributaries by Trout with Emphasis on Brown Trout. Completion Report 1992-1993. Dept. of Fish and Wildlife Res., College of Forestry, Wildlife and Range Sci., Univ. of Idaho, Moscow. Prepared for the Public Utility District No. 1 of Pend Oreille County, Washington. Sept. 1994.

Bennett, D.H., and M. Liter. 1991. Water Quality, Fish and Wildlife Characteristics of Box Canyon Reservoir, Washington. Completion Report 1989 - 1990, Section 3: Fish, Dept. of Fish and Wildlife Res., College of Forestry, Wildlife and Range Science., Univ. of Idaho, Prepared for the Public Utility District No. 1 of Pend Oreille County, Washington. July 1991. 94 pp.

Blanchard, B.1978. Grizzly bear distribution in relation to habitat areas and recreational use: Cabin Creek Hilgard Mountains. M.S. Thesis Montana State University. 8:85-92.

Buchanan, D.V. and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species. *In* W.C. Mackay, M.K. Brewin, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings. Alberta, Canada.

Carl. L. 1985. Management plan for bull trout in Alberta. *In* D. McDonald, ed. Proceedings of the Flathead River Basin bull Trout Biology and Population Dynamics modeling Information Exchange. Fisheries Branch, British Columbia Ministry of Environment. Cranbrook B.C. Canada.

Cascades Environmental Services, Inc. 1998. Historic and Current Resources for the Washington Water Power Cabinet Gorge and Noxon Rapids Hydroelectric projects. Final Report prepared for Washington Water Power Company, Spokane, WA.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus* (Suckley) from the American Northwest. Calif. Fish and Game 3:139-174

Chapman, D. W. 1966. Food and space as regulators of salmonid populations in streams. Americ a n

Natural
i s t .
100:34
5-357.

Chalfant, S.A. 1974. Aboriginal territory of the Kalispel Indians. A report based on ethnohistoric research and filed inquiry in reference to the Kalispel Tribe of Indians v. The United States, Docket No. 94 before the Indian Claims Commission *in* E.O. Fuller. Interior Salish and eastern Washington Indians, II. Garland Publishing. New York, NY.

Coots, R. and R. Willms. 1991. Pend Oreille River Primary Productivity and Water Quality of Selected Tributaries. Washington Dept. of Ecology. Olympia, WA.

Craighead, F.C., Jr. and Craighead J.J. 1972. Data on grizzly bear denning activities and behavior obtained by using wildlife telemetry. Pages 94-106 in S. Herrero, ed. Bears-their biology and management. IUCN Publ. New Series 40.

Cunjak, R. A. and G. Power. 1986. Winter habitat utilization by stream resident brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*). Canadian Journal of fisheries and Aquatic Sciences. 43:1970-1981.

District (Public Utility District No. 1 of Pend Oreille County). 1998. Study Plan Updates, Box Canyon Hydroelectric Project Relicensing. FERC No. 2042.

Environmental Protection Agency (EPA). 1993. Clark Fork - Pend Oreille basin water quality study: a summary of findings and a management plan. EPA 910/R-93-006. Region 10. Seattle, WA

Entz, Ray. September 22, 1998, Personal Communication with Ray Entz, Wildlife Biologist for the Kalispel Tribe of Indians.

Evermann, B.W. 1893. A reconnaissance of the streams and lakes of Western Montana and Northwestern Wyoming. United States Fish Commission. Fort Collins, Colorado.

Falter, C.M., C. Baines, J.W. Carison. 1991. Water Quality, Fish and Wildlife Characteristics of Box Canyon Reservoir, WA: Section 2 Water Quality. University of Idaho. Moscow, Id.

Fraley, J. J. and P. Graham. 1981. Flathead River fishery study: April 1981. Montana Dept. Fish, Wildlife, and Parks. Kalispell, MT

Fraley, J.J., and B.B. Shephard. 1989. Life History, Ecology and Population Status of Migratory Bull Trout (Salvelinus confluentus) in the Flathead Lake River System, Montana. Northwest Science 63(4):133-143

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, a literature review. U.S.D.A. Forest Service, Willamette National Forest, Eugene Oregon.

Goetz, F. 1991. Bull Trout Life History and Habitat Study. Oregon State University, Corvallis, OR. MS Thesis. 49 p

Goetz, F. A. 1994. Distribution and juvenile ecology of bull trout (*Salvelinus confluentus*) in the Cascade Mountains. M.S. Thesis. Oregon State University. 173 p.

Hamer, J.D. 1974. Distribution, abundance and management implications of the grizzly bear and mountain caribou in the Mountain Creek watershed of Glacier National Park, British Columbia. M.S. Thesis. Univ. of Calgary, Alberta. 164 pp.

Herrin, Mike, September 23, 1998. Personal Communication with Mike Herrin, Wildlife Biologist for the Newport Ranger District, Coville National Forest.

Jensen, J. W. 1981. Anadromous arctic char *Salvelinus alpinus*, penetrating southward on the Norwegian coast. Canadian Journal of Fisheries and Aquatic Sciences 38:247-249.

KNRD 1996. Kalispel Tribal Recreation Plan. Prepared by Kalispel Natural Resource Department

Klavano, W.C. 1960. Creel census and limnological studies, Lake Pend Oreille. 1951 to 1958. Federal Aid to Fish Restoration Final Report. Project F 3-R-10. Biological and economic survey of fishery resources in Lake Pend Oreille. Idaho Department of Fish and Game, Boise.

Kreske, D.L. 1996. Environmental impact statements: a practical guide for agencies, citizens, and consultants. John Wiley & Sons, Inc. New York.

Landua, G.K. and K.P. Reese. 1995. Fish and Wildlife Management Options for the Box Canyon Reservoir, Washington. Department of Fish and Wildlife Resources, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, Idaho.

Leathe, S.A. and M.D. Enk. 1985. Cumulative effects of microhydro development on the fisheries of the Swan River Drainage, Montana. Vol. 1. Summary report prepared for the BPA, US Dept. of Energy, Contracts DE-A179-82BP36717 and DE-A179-83BP39802, Project 92-19.

Malouf, C.I. 1982. A study of the prehistoric and historic sites along the lower Clark Fork River valley, western Montana. Contributions to Anthropology, Number 7. University of Montana. Missoula, MT.

Meisner, J. D. 1990. Potential loss of thermal habitat for brook trout, due to climatic warming, in two southern Ontario steams. Transactions of the American Fisheries Society 119:282-291.

Murie, A. 1944. The wolves of Mount McKinley. U.S. Government Printing Office. Washington, D.C. 238pp.

Nenema, G. 1997. Letter to Mr. Jack Snyder, Northrop, Devine & Tarbell, Inc. January 24, 1997

Oliver, G. 1979. A final report on the present fisheries of the Wigwam River with emphasis on the migratory life history and spawning behavior of Dolly Varden char *Salvelinus malma*. Fisheries investigation in tributaries of the Canadian portion of the Libby Reservoir. Victoria, B.C: British Columbia Fish and Wildlife Branch. 27 p.

Pagel, J.E. 1992. Protocol for observing known and potential peregrine falcon eyries in the Pacific Northwest, pp. 83-96. *In:* J.E. Pagel (editor). Symposium on Peregrine Falcons in the Pacific Northwest, 16-17 January 1991. Rogue River National Forest, Medford, Oregon

Pelletier, G. And R. Coots. 1990. Progress Report No. 1 Pend Oreille River water quality study. Washington Dept. of Ecology. Olympia, WA.

Pend Oreille County. 1998. Six Year Road Program Adoption.

Pratt, K. L. 1985. Habitat preferences of juvenile bull trout in the Flathead River Basin. *In* D. McDonald, ed. Proceedings of the Flathead River Basin bull Trout Biology and Population Dynamics modeling Information Exchange. Fisheries Branch, British Columbia Ministry of Environment. Cranbrook B.C. Canada.

Pratt, K.L. 1992. A Review of Bull Trout Life History. *In:* Howell, P.J. and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. (August) Oregon Chapter, American Fisheries Society, Corvallis, OR. p.5-9

Pratt, K.L. and J.E. Huston. 1993. Status of bull trout (*Salvelinus confluentus*) in Lake Pend Oreille and the lower Clark Fork River: DRAFT. Prepared for Washington Water Power Company. Spokane, WA.

Ratliff, D. E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. In: Howell, P.J.; Buchanan, D.V., eds. Proceedings of the Gearhart Mountain bull trout workshop; 1992 August; Gearhart Mountain, OR. Corvallis, OR: Oregon Chapter of the American Fisheries Society: 10-17.

Rieman, B.W., J.D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull trout. Gen. Tech. Rep. INT-302. Ogden, UT: U.S. Department of Agriculture, Intermountain Research Station. 38 p.

Rieman, B.W., J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society. Vol. 124 (3): p. 285-296

Reese, K.P. and J. Hall. 1991. Water Quality, Fish, and Wildlife Characteristics of Box Canyon Reservoir, Washington. Completion Report 1989-1990. Section 4: Wildlife and Riparian. Department of Fish and Wildlife Resources, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, Idaho.

Reese, K.P., G.K. Landua, and A. Rockledge. 1993. Water Quality, Fish, and Wildlife Characteristics of Box Canyon Reservoir, Washington. Phase II Completion Report: Wildlife and Riparian. Department of Fish and Wildlife Resources, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, Idaho.

Rodrick, E. and R. Milner (eds.). 1991. Management Recommendations for Washington's Priority Habitats and Species. Washington Department of Wildlife, Wildlife Management, Fish Management, and Habitat Management Divisions, Olympia, Washington.

Saffel, P. D. and D. L. Scarnecchia. 1995. Habitat use by juvenile bull trout in Belt-Series geology watersheds of Northern Idaho. Northwest Science. 69(4):304-317.

Shephard, B.B., S.A. Leathe, T.M. Weaver, and M.D. Enk. 1984. Monitoring levels of fine sediment within tributaries of Flathead Lake and impacts of fine sediment on bull trout recruitment. Proceedings of the Wild Trout III Symposium, Yellowstone National Park, WY.

Sheviak, C.J. 1984. *Spiranthes diluvialis* (Orchidaceae), a new species from the western United States. Brittonia 36(1):8-14.

Simpson, J.C. and R.L. Wallace. 1982. Fishes of Idaho. University Press of Idaho. Moscow, Idaho.

Skillingstad, T.H. and A.T. Scholz. 1993. Trends in Water Quality in the Box Canyon Reservoir of the Pend Oreille River Adjacent to the Kalispel Indian Reservation. Fisheries Tech. Rep. No. 44. Upper Columbia United Tribes Fisheries Center. Eastern Washington Univ. Cheney, WA.

Soltero, R.A., L.A. Campbell, R.W. Plotnikoff, and L. Sexton. 1988. A baseline investigation of selected water quality characteristics for a reach of the Pend Oreille river, WA, before the introduction of thermomechanical pulp mill effluent. Eastern Washington University, Dept. of Biology. Cheney, WA.

Stalmaster, M. V., R. l. Knight, B. L. Holder, and R. J. Anderson. Bald eagles, pp. 270-290. *In:* E. R. Brown (editor). Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington, Part 1. U.S. Forest Service, Pacific Northwest Region. Publication R6-FNWL-192-1985.

Suckley, G. Dr. 1860. Report upon the fishes collected on the survey. Pages 307-349 *in* Report: Explorations and surveys, ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, Volume XII, Book II. House of Representatives, 36th Congress, Ex. Doc. 56. Washington, D.C.

Sullivan, K., J. Tooley, K. Doughty, J.E. Caldwell, and P. Knudsen, 1990. Evaluation of Prediction Models and Characterization of Stream Temperature Regimes in Washington. Washington Dept. of Natural Resources Timber/Fish/Wildlife Report TFW-WQ3-90-006. Olympia, WA

Swanberg. T. 1996. The movement and habitat use of fluvial bull trout in the Upper Clark Fork River drainage. MS Thesis, University of Montana, Missoula, MT.

Swanberg, T. and L. Burns. 1997. Movement and Habitat Use of Radio-tagged Bull Trout in the Upper Blackfoot River Drainage. Montana Fish, Wildlife and Parks, Missoula, MT. 20p

USDA Forest Service, WA Dept of Ecology. 1997. Crown Jewel Mine, Final Environmental Impact Statement. Appendix H: Wildlife Biological Assessment and Biological Evaluation.

U.S. Fish and Wildlife Service (USFWS). 1995. Ute ladies'-tresses (*Spiranthes diluvialis*) Agency Review Draft Recovery Plan. Prepared by the Ute ladies'-tresses Recovery Team for Region 6, USFWS, Denver, Colorado.

U.S. Forest Service (USFS). 1998. Stimson Cost Share Road Project. Addendum Number 3 for the Biological Evaluation for the Proposed Bull Trout. February 11, 1998. Colville National Forest., Colville, WA.

U.S. Forest Service General Technical Report, 1994. The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in Western States. 184 pp.

United States Fish & Wildlife Service (USFWS). 1987. Northern Rocky Mountain Wolf Recovery Plan. U.S. Fish and Wildlife Service, Denver, Colorado. 119pp.

United States Fish & Wildlife Service (USFWS). 1993. Grizzly Bear Recovery Plan. U.S. Fish and Wildlife Service, Missoula, MT. 181pp.

United States Fish & Wildlife Service (USFWS). 1986. Recovery Plan for the Pacific Bald Eagle. U.S. Fish and Wildlife Service, Portland, Oregon. 160pp.

United States Fish & Wildlife Service (USFWS). 1982. The Pacific Coast American Peregrine Falcon Recovery Plan, U.S. Fish and Wildlife Service, Denver, Colorado. 87pp.

USFS (U.S. Forest Service). 1996. Data search for Threatened and Endangered wildlife records, 11 January 1996. Unpublished material.

Washington Office of Financial Management (WOFM). 1998. Populations of cities, towns, and counties.

WDFW. 1996. Data search of Priority Habitats and Species, 25 September 1996. Unpublished material.

Washington Dept. Of Ecology (WDOE). 1996. Section 303(d) listing - May 1996.

Weaver, John., September 30, 1998. Personal Communication with John Weaver, Lynx Wildlife Biologist for the Wildlife Conservation Society.

Zender, Steve, September 28, 1998. Personal Communication with Steve Zender, Regional Wildlife Biologist for the Washington Department of Fish and Wildlife. Spokane, WA.

Ziller, J.S. 1992. Distribution and relative abundance of bull trout in the Sprague River subbasin, Oregon. In: Howell, P.J. and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop (August). Oregon Chapter, American Fisheries Society, Corvallis, OR

# APPENDIX A

## CONSULTATION WITH US FISH AND WILDLIFE SERVICE

# APPENDIX I

# WDOE WATER QUALITY MONITORING DATA

WASHINGTON STATE DEPT. OF ECOLOGY

/ Conditions & Trends / River and Stream WQ Monitoring

AMBIENT MONITORING DATA

# Station 62A150
# Six Year Water Quality Data Summary

*Last updated 29-May-1998*

| Station name | Class | Latitude | Longitude | Elevation (ft) | River mile | Watershed (s) | External mapping links | |
|---|---|---|---|---|---|---|---|---|
| Pend Oreille R @ Newport | A | 48 11 07.0 | 117 02 02.0 | 2030 | 88.2 | Pend Oreille | Tiger Mapping Service | MapBlas |

Years-monitored history *Note: Data for years not presented here are available on request. See Requesting additional data.*

| 98 | 97 | 96 | 95 | 94 | 93 | 92 | 91 | 90 | 89 | 88 | 87 | 86 | 85 | 84 | 83 | 82 | 81 | 80 | 79 | 78 | 77 | 76 | 75 | 74 | 73 | 72 | 71 | 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 | 59 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | | | | | | | | | | • | • | • | • | • | • | • | • |

| 1997 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 09/09/1997 | 1140 | 16300 | 18.4 | 143 | 8.6 | 98.1 | 8.6 | 1u | 2 | 0.059 | 0.012 | 0.026 | 0.005u |
| 08/04/1997 | 1130 | 23700 | 23.0 | 142 | 8.6 | 105.0 | 8.4 | 1 | 2 | 0.040 | 0.011 | 0.033 | 0.005u |
| 07/08/1997 | 1115 | 46400 | 16.5 | 150 | 10.6 | 115.8 | 8.2 | 1 | 3 | 0.081 | 0.010u | 0.016 | 0.005u |
| 06/03/1997 | 1350 | 125000 | 13.1 | 109 | 11.4 | 116.4 | 7.9 | 11 | 15 | 0.121 | 0.034 | 0.051 | 0.005u |
| 05/06/1997 | 1150 | 68100 | 8.6 | 145 | 11.9 | 109.0 | 7.8 | 1u | 8 | 0.138 | 0.025 | 0.051 | 0.005u |
| 04/08/1997 | 1120 | 32100 | 5.6 | 138 | 12.0 | 101.9 | 7.7 | 1 | 8 | 0.111 | 0.010u | 0.135j | 0.005u |
| 03/04/1997 | 1100 | 26200 | 2.9 | 163 | 13.0 | 102.9 | 7.9 | 1 | 3 | 0.108 | 0.010u | 0.026 | 0.005u |
| 02/04/1997 | 1125 | 21500 | 3.0 | 123 | 12.3 | 96.8 | 7.8 | 1u | 3 | 0.135 | 0.010u | 0.010u | 0.005u |
| 01/14/1997 | 1150 | 20700 | 3.1 | 171j | 12.3 | 95.3 | 7.7 | | 7 | 0.131 | 0.010u | 0.040 | 0.005uj |

result fails water quality criteria     Data qualifiers: u, j - estimated value  k - actual value known to be less  s - spreader  x - high backgrou

| 1996 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/03/1996 | 1115 | 13600 | 3.4 | 159j | 11.9 | 96.0 | 7.9 | 1u | 1u | 0.088j | 0.010u | 0.032j | 0.005u |
| 11/05/1996 | 1100 | 16000 | 8.0 | 148 | 11.0 | 98.9 | 8.2 | 1 | 2 | 0.088 | 0.010u | 0.010u | 0.005u |
| 10/08/1996 | 1130 | 25800 | 15.1 | 155 | 9.5 | 100.2 | 8.4 | 1u | 1 | 0.090 | 0.010u | 0.010u | 0.005u |
| 09/03/1996 | 1245 | 16400 | 22.8 | 147 | 8.7 | 108.1 | 8.7 | 1 | 2 | 0.096 | 0.010u | 0.011 | 0.005u |
| 08/05/1996 | 1140 | 19400 | 21.2 | 146 | 8.6 | 103.7 | 8.4 | 1 | 1 | 0.095 | 0.010u | 0.010u | 0.005u |
| 07/08/1996 | 1340 | 41000 | 18.3 | 141 | 9.8 | 112.2 | 8.2 | 1 | 3 | 0.092 | 0.010u | 0.010u | 0.005u |

| (62A150) | | | (C) | (umhos/25c) | (mg/L) | tion (%) | | (colonies/100ml) | Solids (mg/L) | Nitrogen (mg/L) | (mg/L) | (mg/L) | Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/07/1993 | 1035 | 18600 | 2.9 | 159 | 11.8 | 94.8 | 8.0 | 1 | 1k | 0.107 | 0.010k | 0.012 | 0.010k |
| 11/02/1993 | 1035 | 24700 | 10.2 | 155 | 10.2 | 96.1 | 8.4 | 1 | 2 | 0.092 | 0.010k | 0.010k | 0.010k |
| 10/05/1993 | 1025 | 34700 | 15.0 | 158 | 9.1 | 96.5 | 8.4 | 1 | 2 | 0.094 | 0.010k | 0.010k | 0.010k |
| 09/08/1993 | 0830 | 22400 | 18.8 | 149 | 9.0 | 102.4 | 8.5 | 1k | 1k | | 0.010k | 0.010k | 0.010k |
| 08/04/1993 | 0820 | 24000 | 18.8 | 142 | 9.1 | 103.8 | 8.5 | 2 | 2 | | 0.010k | 0.010k | 0.010k |
| 07/07/1993 | 0820 | 36500 | 16.0 | 139 | 10.0 | 108.0 | 8.4 | 9 | 4 | | 0.010k | 0.010k | 0.010k |
| 06/09/1993 | 0930 | 28500 | 15.4 | 123 | 9.6 | 102.0 | 7.6 | 1 | 3 | | 0.011 | 0.010k | 0.010k |
| 05/05/1993 | 0900 | 20800 | 8.9 | 134 | 11.7 | 107.3 | 8.0 | 1 | 5 | | 0.015 | 0.010k | 0.010k |
| 04/07/1993 | 0755 | 17500 | 5.6 | 127 | 11.9 | 100.9 | 8.1 | 1k | 3 | | 0.010k | 0.010k | 0.010k |
| 03/03/1993 | 0740 | 17400 | 0.0 | 157 | 12.9 | 93.9 | 8.4 | 1k | 3 | | 0.027 | 0.010k | 0.010k |

■ result fails water quality criteria    Data qualifiers: u, j - estimated value  k - actual value known to be less  s - spreader  x - high backgrou

| 1992 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/03/1992 | 0840 | 16400 | 4.1 | 162 | 11.4 | 92.2 | 8.1 | 1 | 3 | | 0.023 | 0.010 | 0.010k |
| 11/04/1992 | 0800 | 26200 | 9.9 | 120 | 9.8 | 91.7 | 8.2 | 1k | 2 | | 0.010k | 0.010k | 0.010k |
| 10/07/1992 | 0800 | 25000 | 13.7 | 155 | 9.1 | 92.2 | 8.4 | 1k | 3 | | 0.010k | 0.073 | 0.010k |
| 09/10/1992 | 0800 | 15200 | 16.8 | 158 | 8.7 | 94.9 | 8.4 | 1 | 1 | | 0.010k | 0.011 | 0.010k |
| 08/05/1992 | 0800 | 7890 | 22.1 | 143 | 8.7 | 106.0 | 8.6 | 1k | 3 | | 0.010 | 0.010k | 0.010k |
| 07/08/1992 | 0750 | 17800 | 18.2 | 147 | 8.9 | 100.5 | 8.4 | | 3 | | 0.010k | 0.010k | 0.010k |
| 06/03/1992 | 0750 | 8290 | 17.0 | 153 | 9.1 | 100.6 | 8.3 | 7 | 4 | | 0.010k | 0.013 | 0.010k |
| 05/06/1992 | 0745 | 26200 | 11.8 | 136 | 10.9 | 107.4 | 8.3 | 5 | 4 | | 0.010k | 0.010k | 0.010k |
| 04/08/1992 | 0755 | 13200 | 8.2 | 152 | 11.0 | 99.2 | 7.8 | 2 | 3 | | 0.010k | 0.010k | 0.010k |
| 03/04/1992 | 0805 | 10800 | 4.7 | 157 | 12.0 | 100.1 | 8.1 | 1k | 3 | | 0.010k | 0.010k | 0.010k |
| 02/05/1992 | 0825 | 15000 | 3.2 | 150 | 12.3 | 98.8 | 7.9 | 1k | 4 | | 0.010k | 0.010k | 0.010k |
| 01/08/1992 | 0835 | 15700 | 2.9 | 160 | 12.0 | 94.3 | 8.1 | 1k | 2 | | 0.010k | 0.016 | 0.010k |

■ result fails water quality criteria    Data qualifiers: u, j - estimated value  k - actual value known to be less  s - spreader  x - high backgrou

| 1991 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/04/1991 | 0820 | 17000 | 4.1 | 211 | 11.6 | 95.3 | 7.9 | 5 | 3 | | 0.010k | 0.010k | 0.010k |
| 11/06/1991 | 0825 | 25100 | 5.3 | 199 | 11.1 | 93.1 | 8.2 | 1 | 2 | | 0.010k | 0.010k | 0.010k |
| 10/09/1991 | 0820 | 25500 | 13.8 | 170 | 8.8 | 89.2 | 8.2 | 1 | 2 | | 0.018 | 0.011 | 0.010k |

■ result fails water quality criteria    Data qualifiers: u, j - estimated value  k - actual value known to be less  s - spreader  x - high backgrou

Washington State Department of Ecology
Please send comments to stba461@ecy.wa.gov

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/03/1996 | 1235 | 94400a | 12.2 | 144 | 12.0 | 119.7 | 7.8 | 1u | 10 | 0.134 | 0.010u | 0.010u | 0.005u |
| 05/06/1996 | 1115 | 60200 | 10.5 | 146 | 11.8 | 113.2 | 8.2 | 1u | 8 | 0.100 | 0.010u | 0.010 | 0.005u |
| 04/09/1996 | 1115 | 35900 | 7.5 | 160 | 12.9 | 116.2 | 8.4 | 1u | 4 | 0.106 | 0.010u | 0.010u | 0.005u |
| 02/05/1996 | 1055 | 21000a | 0.5 | 154 | 12.9 | 96.1 | 7.8 | 1u | 3 | 0.125 | 0.010u | 0.010u | 0.005u |
| 01/08/1996 | 1130 | 25600 | 2.6 | 158 | 13.6 | 107.2 | 7.8 | 1u | 3 | 0.111 | 0.010u | 0.010u | 0.005u |

☒ *result fails water quality criteria* Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgrou

| 1995 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/04/1995 | 1115 | 46300 | 6.6 | 160 | 11.8 | 103.3 | 8.0 | 1u | 6 | 0.108 | 0.010u | 0.010u | 0.005u |
| 11/06/1995 | 1100 | 24600 | 8.9 | 155 | 10.5 | 97.3 | 8.3 | 1u | 2 | 0.069 | 0.010u | 0.010u | 0.005u |
| 10/02/1995 | 1145 | 17100 | 15.3 | 166 | 9.0 | 95.3 | 8.3 | 1 | 2 | 0.157 | 0.079 | 0.010u | 0.005u |
| 09/05/1995 | 0950 | 11700 | 19.8 | 161 | 9.2 | 105.5 | 8.5 | 6 | 2 | 0.095 | 0.010u | 0.010u | 0.005u |
| 08/07/1995 | 1205 | 15400 | 20.7 | 160 | 8.7 | 104.1 | 8.5 | 1u | 1 | 0.046 | 0.013 | 0.010u | 0.011 |
| 07/10/1995 | 1010 | 40000 | 19.8 | 167 | 10.3 | 118.6 | 8.2 | 3 | 4 | 0.097 | 0.010u | 0.015 | 0.005u |
| 06/05/1995 | 1050 | 40500 | 17.2 | 144 | 10.8 | 119.7 | 8.2 | 4 | 5 | 0.138 | 0.016 | 0.010u | 0.005u |
| 05/02/1995 | 1235 | 18300 | 10.0 | 139 | 10.3 | 98.4 | 8.1 | 1 | 5 | 0.110 | 0.010u | 0.011 | 0.005u |
| 04/03/1995 | 1240 | 9520 | 5.7 | 137 | 12.2 | 104.1 | 8.1 | 1u | 4 | 0.121 | 0.010u | 0.010u | 0.005u |
| 03/06/1995 | 1245 | 23800 | 1.7 | 154 | 13.0 | 99.8 | 8.1 | 1u | 5 | 0.112 | 0.010u | 0.010u | 0.005u |
| 02/06/1995 | 1215 | 7000 | 2.4 | 145 | 13.2 | 102.9 | 8.0 | 1 | 4 | 0.100 | 0.010u | 0.010u | 0.005u |
| 01/09/1995 | 1150 | 17700 | 0.0 | 160 | 13.0 | 96.8 | 8.2j | 1u | 2 | 0.089 | 0.010u | 0.020 | 0.005u |

☒ *result fails water quality criteria* Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgrou

| 1994 (62A150) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/05/1994 | 1315 | 16600 | 1.9 | 156 | 11.9 | 92.4 | 8.1 | 1u | 2 | 0.030 | 0.010u | 0.014 | 0.005u |
| 11/07/1994 | 1205 | 26500 | 7.8 | 159 | 10.6 | 95.4 | 8.0 | 1u | 3 | 0.084 | 0.010k | 0.010u | 0.010k |
| 10/10/1994 | 1215 | 19400 | 14.5 | 159 | 9.3 | 97.7 | 8.2 | 1 | 1 | 0.084 | 0.010k | 0.010k | 0.010k |
| 09/06/1994 | 1130 | 4450 | 19.6 | 162 | 8.9 | 103.3 | 8.3 | 63 | 2 | 0.101 | 0.010k | 0.014 | 0.010k |
| 08/02/1994 | 1130 | 6200 | 24.9 | 127 | 9.1 | 117.2 | 8.5 | 1 | 1 | 0.122 | 0.010k | 0.010k | 0.010k |
| 07/06/1994 | 1125 | 12700 | 18.0 | 145 | 9.0 | 100.7 | 8.0 | 1 | 2 | 0.076 | 0.010k | 0.010k | 0.010k |
| 06/07/1994 | 1120 | 31000 | 14.5 | 138 | 9.8 | 102.2 | 8.0 | 3 | 4 | 0.063 | 0.010k | 0.015 | 0.010k |
| 05/03/1994 | 1135 | 35800 | 8.9 | 138 | 11.3 | 104.3 | 8.4 | 1k | 5 | 0.048 | 0.010k | 0.010k | 0.010k |
| 04/05/1994 | 1115 | 19400 | 6.0 | 148 | 12.0 | 103.5 | 8.3 | 2 | 3 | 0.097 | 0.010k | 0.010k | 0.010k |
| 03/08/1994 | 1050 | 30600 | 2.2j | 168 | 12.4 | 96.1 | 8.1 | 1k | 3 | 0.122 | 0.010k | 0.010k | 0.010k |
| 02/08/1994 | 1055 | 14200 | 0.4 | 179j | 12.7 | 94.0 | 8.0 | 1k | 4 | 0.145 | 0.010k | 0.010k | 0.010k |
| 01/04/1994 | 1050 | 16500 | 2.8 | 162 | 11.9 | 95.5 | 8.0 | 1k | 5 | 0.108 | 0.010k | 0.010k | 0.010k |

☒ *result fails water quality criteria* Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgrou

| 1993 (62A150) | Time | Flow (CFS) | Temperature | Conductivity (umhos/ | Oxygen (mg/L) | Oxygen Satura- | pH | Fecal Coliforms (colonies/ | Suspended Solids | Total Persulfate Nitrogen | Ammonia Nitrogen | Total Phosphorus | Dissolved Soluble Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

AMBIENT MONITORING DATA

# Station 62A090
# Six Year Water Quality Data Summary

*Last updated 29-May-1998*

| Station name | Class | Latitude | Longitude | Elevation (ft) | River mile | Watershed (s) | External mapping links | |
|---|---|---|---|---|---|---|---|---|
| Pend Oreille @ Metaline Falls | A | 48 51 54.0 | 117 22 20.0 | 2020 | 27 | Pend Oreille | Tiger Mapping Service | MapBlas |

"Years-monitored history" *Note: Data for years not presented here are available on request. See Requesting additional data.*

| 98 | 97 | 96 | 95 | 94 | 93 | 92 | 91 | 90 | 89 | 88 | 87 | 86 | 85 | 84 | 83 | 82 | 81 | 80 | 79 | 78 | 77 | 76 | 75 | 74 | 73 | 72 | 71 | 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 | 59 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| • | | | • | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | • |

| 1995 (62A090) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) | T d ( |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 09/06/1995 | 1230 | 15600 | 19.4 | 159 | 9.6 | 108.9 | 8.7 | 1 | 2 | 0.099 | 0.010u | 0.010u | 0.005u | |
| 08/08/1995 | 1335 | 16300 | 20.9 | 156 | 8.6 | 102.5 | 8.5 | 4 | 2 | 0.114 | 0.010u | 0.010u | 0.009 | |
| 07/11/1995 | 1215 | 39800 | 19.5 | 163 | 10.2 | 117.0 | 7.9 | 4 | 7 | 0.157 | 0.010u | 0.014 | 0.005u | |
| 06/06/1995 | 1245 | 37700 | 16.9 | 132 | 10.3 | 113.5 | 7.7 | 6 | 5 | 0.146 | 0.024 | 0.010u | 0.005u | |
| 05/03/1995 | 1335 | 22100 | 11.2 | 134 | 10.0 | 97.3 | 8.0 | 1 | 5 | 0.105 | 0.010u | 0.012 | 0.005u | |
| 04/04/1995 | 1335 | 25000 | 6.5 | 140 | 12.2 | 107.4 | 8.2 | 1u | 3 | 0.109 | 0.010u | 0.010u | 0.005u | |
| 03/07/1995 | 1320 | 25800 | 2.0 | 148 | 12.8 | 98.8 | 8.2 | 1u | 5 | 0.108 | 0.010u | 0.010u | 0.005u | |
| 02/07/1995 | 1345 | 11200 | 1.7 | 149 | 13.3 | 101.9 | 8.0 | 1u | 2 | 0.122 | 0.016 | 0.010u | 0.005u | |
| 01/10/1995 | 1355 | 13900 | -0.2 | 171 | 13.3 | 98.9 | 8.0 | 1 | 2 | 0.052 | 0.010u | 0.022 | 0.005u | |

■ *result fails water quality criteria* Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgroun

| 1994 (62A090) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) | T d ( |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/06/1994 | 1530 | 10100 | 0.8 | 160 | 12.2 | 91.6 | 8.0 | 1u | 5 | 0.010u | 0.010u | 0.010u | 0.005u | |
| 11/08/1994 | 1345 | 27200 | 7.1 | 164 | 10.7 | 95.3 | 8.2 | 1 | 2 | 0.074 | 0.010k | 0.010u | 0.010k | |
| 10/11/1994 | 1350 | 20400 | 14.3 | 159 | 9.6 | 99.9 | 8.5 | 68 | 1 | 0.070 | 0.010k | 0.010k | 0.010k | |
| 09/07/1994 | 0940 | 10700 | 19.4 | 160 | 8.8 | 101.6 | 8.6 | 7 | 1k | 0.125 | 0.012 | 0.012 | 0.010k | |
| 08/03/1994 | 0925 | 6320 | 24.9 | 127 | 8.6 | 110.6 | 8.7 | 3 | 2 | 0.099 | 0.010k | 0.010k | 0.010k | |
| 07/07/1994 | 1000 | 12500 | 18.7 | 146 | 9.1 | 103.5 | 8.3 | 1u | 1 | 0.092 | 0.010k | 0.010k | 0.010k | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/08/1994 | 1255 | 31400 | 14.8 | 137 | 9.7 | 101.6 | 7.7 | 2 | 4 | 0.056 | 0.010k | 0.010k | 0.010k | |
| 05/04/1994 | 0950 | 27900 | 9.4 | 142 | 10.7 | 99.7 | 8.2 | 1 | 3 | 0.067 | 0.010k | 0.010k | 0.010k | |
| 04/06/1994 | 0940 | 12500 | 6.2 | 156 | 11.6 | 97.5 | 8.3 | 1 | 2 | 0.077 | 0.010k | 0.010k | 0.010k | |
| 03/09/1994 | 0945 | 22800 | 1.6j | 161 | 12.6 | 96.2 | 8.1 | 1k | 3 | 0.110 | 0.011 | 0.014 | 0.010k | |
| 01/05/1994 | 0955 | 14200 | 1.8 | 162 | 12.4 | 96.1 | 8.0 | 1 | 2 | 0.098 | 0.010 | 0.010k | 0.010k | |
| result fails water quality criteria | | | | | Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgroun | | | | | | | | | |
| 1993 (62A090) | Time | Flow (CFS) | Temperature (C) | Conductivity (umhos/25c) | Oxygen (mg/L) | Oxygen Saturation (%) | pH | Fecal Coliforms (colonies/100ml) | Suspended Solids (mg/L) | Total Persulfate Nitrogen (mg/L) | Ammonia Nitrogen (mg/L) | Total Phosphorus (mg/L) | Dissolved Soluble Phosphorus (mg/L) | T d ( |
| 11/02/1993 | 0950 | 26500 | 9.9 | 157 | 10.1 | 96.0 | 8.1 | 1k | 1 | 0.092 | 0.010k | 0.010k | 0.010k | |
| 10/06/1993 | 1020 | 24900 | 15.3 | 158 | 9.2 | 98.0 | 8.4 | 2 | 2 | 0.091 | 0.010k | 0.010k | 0.010k | |
| result fails water quality criteria | | | | | Data qualifiers: u, j - estimated value k - actual value known to be less s - spreader x - high backgroun | | | | | | | | | |

Washington State Department of Ecology
Please send comments to stbu461@ecy.wa.gov

# Appendix B

# Rotovator and Harvester Impact Assessment Reports

# ASSESSMENT OF ROTOVATION IMPACTS AND SUGGESTED OPERATING PROCEDURES FOR THE INTERIM AQUATIC PLANT MANAGEMENT PLAN BOX CANYON RESERVOIR

*Prepared by*

**PUBLIC UTILITY DISTRICT NO. 1 OF PEND OREILLE COUNTY**
**NEWPORT, WASHINGTON**

**June, 30 2010**

# Executive Summary

Aquatic plant removal through rotovation and harvesting is the primary aquatic weed management tool used by the District to prevent the spread of Eurasian Water Milfoil (EWM) to surrounding bodies of water and provide safe, ascetically pleasing public recreation areas in Box Canyon Reservoir. To assess the potential environmental impacts (both positive and negative) and develop a list of Best Management Practices for rotovator operation the district designed and implemented five specific impact studies. They included: rotovation caused turbidity, fish injury or mortality, plant fragmentation, on-shore fragment viability and remobilization, and re-contouring the river bed.

Of the five studies detailed in this document, the study of Rotovator-caused fragmentation and that of Rotovator-caused re-contouring of the river bed, showed either no impact or that the rotovator caused fragmentation was less than auto-fragmentation of the same area if the plants were left in place. For the remaining three studies the district has identified the degree of rotovator impacts and developed a list of recommended mitigation measures and Best Management Practices as shown below.

### Recommended Mitigation Measures and Best Management Practices

***Turbidity***

The rotovator occasionally causes short-term localized turbidity exceedances in bays and backwater sloughs and routinely causes similar exceedances in turbidity at mainstem higher flow sites. The following Best Management Practices were developed to reduce or eliminate these exceedances.

- During the warmer summer months when many aquatic organisms are under increased stress due to high water temperatures, the District will use the harvester in place of the rotovator. Recent turbidity tests of the new harvester indicate it produces far less turbidity than the rotovator. By using the new harvester instead of the rotovator during the summer months total number and duration of turbidity exceedances and associated impacts will be reduced by 50% annually when compared to previous years.

- Higher turbidity values recorded at the mainstem sites during rotovation cannot be completely avoided; however, at higher velocity sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" containing the turbid water and reducing the movement of cloudy water outside the work area. This strip will then be removed after upstream work is completed.

- To reduce potential for rotovation to impact whitefish spawning, the District recommends rotovation be avoided in areas immediately upstream of creek mouths and higher-velocity gravel bars during the period of November 15 to February 1.

- To minimize exceeding state turbidity criteria in small bays or low velocity sloughs (300 ft in width or less), the District recommends that rotovation be limited in duration to no more than 30 minutes of continuous rotovation, with a minimum of one hour between rotovation sessions. This restriction will allow turbidity levels to return to normal between rotovating sessions and eliminate exceedances in bay habitats.

- The rotovator no longer tills the substrate, instead the operators back spin the blades on, or just above the substrate, winding plants up on the tines and pulling plant roots instead of digging them.

***Fish Mortality***

Overall fish mortality due to rotovation was extremely low. On average total rotovator mortality was 9.22 fish per acre. With an estimated maximum treatment area of 100 acres per year, total associated fish mortality would be 922 fish with an average fish length of about 2" (50mm).

- As a result of this low mortality rate, the District plans to only use the rotovator in locations (i.e. around cold water sources or creek mouths) and during times of the year when native salmonids, or other species of concern, are more likely to be encountered (October through June).

- To reduce impact on whitefish and bass spawning, rotovation will be avoided in areas immediately upstream of creek mouths and high-velocity gravel bars during the period of November 15 to February 1, and in sloughs during spring spawning.

***Fragment Viability and Remobilization***

Milfoil fragments were found to remain viable for extended periods of time when left in thick piles 18 to 28 inches thick regardless of treatment type. These piles are not typical but often left on private land owner's property, who request that most of their shore line be left clean and all rotovator spoils condensed into a single location on the property.

- To reduce the possibility that EWM deposited on shore will be returned to the river the height of vegetation piles, placed below the high water line by the rotovator will be less than 5 inches. When rotovation efforts occur within 2 weeks of the annual high water events, work should focus on areas where spoils can be placed above the high water.

- The District and Pend Oreille County will post the relevant results of this study on their web sites. The posting will include photos documenting both viable and unviable fragments, the piles during different stages of decomposition or desiccation, and the length of time that fragments remained viable. The site will also include suggestions as to how best to management EWM fragment piles deposited on private shorelines.

## 1.0 INTRODUCTION

Pend Oreille County Public Utility District (the District) has adopted an Interim Aquatic Plant Management Plan (IAPMP) that guides the management of aquatic plants in Box Canyon Reservoir (BCR). The IAPMP provides baseline data on aquatic plant distribution within BCR, describes resource effects and provides a foundation for the implementation of management strategies. Harvesting/rotovation has been identified as a primary containment measure. Operation of this equipment requires the District to secure a Hydraulic Project Approval (HPA). Washington Department of Fish and Wildlife (WDFW) issued a one year HPA and the County issued a 5-year Shoreline Permit, both with the condition that several studies be conducted to better assess the impacts of harvesting/rotovation on aquatic life. The requested studies include an assessment of:

- Turbidity levels relative to the water quality standards;
- Fish mortality due to rotovation;
- Fragmentation due to rotovation;
- Viability of Eurasian Watermilfoil fragments, and
- Re-contouring the river bed.

The use of rotovation and harvesting of aquatic weed beds is common across the country for systems that have wide-spread aquatic weed infestations. Rotovation has been used in the BCR to control Eurasian water milfoil (EWM) since the 1980s; recently a new harvester machine was purchased to use with the rotovator when conditions allow. Each of the two machines works to remove milfoil in different ways. A brief description of how each machine works is listed below:

- Rotovation functions by entangling and pulling the underwater plants; starting near the upstream end of a weed bed, the rotovator moves from shore toward mid-channel. Working perpendicular to the flow, it pulls up plant root wads by entangling the stem and leaves winding them up on the rotovator head, which is rotating on or slightly above the substrate. The rotovator head is lowered, as needed, as the water deepens and the slow revolution of the rotovator head pushes the rotovator away from the shore. As the rotovator head and rakes fill with plant material, the rotovator returns to shore and back-spins the material off the rotovator heads onto the shore. This process continues, swath by swath, until the work area has been cleared.

- The harvester functions exactly like a land-based crop harvester. It starts either at the upstream end of the test plot, working perpendicular to the flow from mid-channel toward shore, or by moving parallel to the shore either working back and forth upstream to down. The harvester sickle head can be positioned up to 6' under water and is raised hydraulically to follow as closely as possible the bottom contours. The harvester sickle bar cuts the submerged plant material; conveyer belts load the cut material onto the storage conveyer on the vessel. When the harvester is fully loaded, it returns to shore and back-spins the material off the storage deck onto shore. This process continues, swath by swath, until the test patch has been completed.

Due to the different modes of operation of the two milfoil removal machines, the new harvester was studied independently and will not be discussed in detail this report. This document describes the study approach, results, and recommended Best Management Practices and/or standard operating procedures for each of the requested studies related to the rotovator.

This document will be incorporated into the IAPMP. All studies were managed and supervised by Mr. Scott Jungblom, Resource Biologist for Public Utility District No. 1 of Pend Oreille County (District). This report is broken into sections that detail the study area, methods and materials, measurements, results, and discussion for each of these assessments. **Figure 1** shows the general location for all study areas by season. **Appendix A** provides a list of all the study sites within each seasonal study area, including which tests were completed at each site.

## 2.0 ROTOVATION TURBIDITY TESTING STUDY

*Question: Do turbidity levels at the compliance point meet water quality standards?*

Rotovation has the potential to temporarily increase localized water turbidity in the Pend Oreille River during and immediately after operation. To investigate this potential, or the extent of water quality standard exceedance, the District monitored the level of turbidity before, during, and after rotovation. For the Pend Oreille River, the acceptable exceedance value and point of compliance for turbidity is 10 NTU above background level at a point 300 ft downstream of the rotovator.

### 2.1 Study Area and Site Selection

The study area for this assessment is BCR of the Pend Oreille River (WRIA 62), located in Pend Oreille County. Six specific study areas were determined in the field; site selection was based on water velocity. Three sites were located in backwater sloughs or sheltered bays with little or no detectible water velocity. The remaining three sites were located in the mainstem Pend Oreille River in areas that produced velocities representative of main-channel weed-bed conditions at the time of sampling. Four of the six test were completed during the November sample session, two each main-channel and bay sites, in the Blueslide area between River Mile (RM) 49.5 and 51.5. **Figure 2** shows the selected sites and associated placement of the turbidity meters for the fall turbidity tests. The remaining two sites, one bay and one main-channel, were studied in April 2009 in the Lost Creek area at RM 48. **Figure 3** shows the selected sites and associated placement of the turbidity meters for the two spring turbidity tests.

### 2.2 Methods and Materials

Turbidity was measured using a turbidity meter/datalogger of one or more of the following designs: Hydrolab DataSonde 4; DataSonde 5, or Eureka - Manta water quality sampler. Prior to beginning of the daily study, the instruments were calibrated according to the manufacturer's instructions. A nephelometer or desktop grab sample turbidity meter was first calibrated relative to four known standards. The calibrated nephelometer was then used to measure the turbidity of a grab sample from the river. A concurrent in-situ turbidity measurement was recorded by each instrument (Hydrolab or Manta). The instruments were considered properly calibrated when instrument readings were within 10% or 0.5 NTU (whichever was greater) of the standardized reading (calibrated nephelometer). Turbidity levels downstream of the rotovation site were recorded at 5-minute intervals for a period of up to two hours prior to the start of rotovation to establish baseline or background turbidity values.

### *2.2.1 Turbidity Instrument Placement*

One instrument was located 300 ft downstream of the middle of each 100 ft study site, to represent the end of a mixing zone as established by WAC 173-201A-200(1)(e)(i). Instruments were deployed 1 meter (m) below the surface. Instrument locations were monitored throughout each study and moved laterally, when needed, to ensure the instruments location was in the center of any visible plume. Distances from the work area were measured by GPS (with differential correction - dGPS).

### *2.2.2 Instrument Measurements*

Turbidity was measured and recorded every five minutes at each station. Monitoring extended up to four hours after the conclusion of the rotovation, or to a time when the downstream turbidity measurements were 10 NTU or less from background levels (levels typical for the Pend Oreille River are < 5 NTU).

## 2.3 Results

Sampling occurred during both fall, 2008 and spring, 2009 sampling sessions. Four tests (two bay and two mainstem sites) were completed in November 2008 during the fall sampling period (**Figure 2**). The remaining two tests, one bay site and one main cannel site, were completed in April 2009 (**Figure 3**).

Mean background levels for the three bay sites were 0.36 NTU (SE = 0.19, n=14) at Fall Site #3, 7.97 NTU (SE = 0.22, n=16) at Fall Site #6, and 27.29 NTU (SE = 0.94 NTU, n = 9) at Spring Site #5. Experimental maximum values for the three bay sites were 5.2 NTU, 16.2 NTU and 39.5 NTU respectively (see **Figures 4, 5** and **6**). Of these three study sites only the spring bay site #5 exceeded the state standard of 10 NTU over baseline. Turbidity values at this site exceeded the standard by 2.2 NTU and lasted 10 minutes.

Mean background levels for the three mainstem sites were 0.05 NTU (SE = 0.01, n = 22) at Fall Ste #4, 0.06 NTU (SE = 0.02, n = 11) at Fall Site #5 and 2.49 NTU (SE = 0.48 NTU, n = 12,) at Spring Site #6. Experimental maximum values for the three mainstem sites were 22.4, 15.0 NTU and 107.5 NTU respectively (see **Figures 7, 8** and **9**); all three of these values exceeded the 10 NTU above background level criteria. Values exceeding the 10 NTU criteria ranged between a low of 5 NTU for a time of 5 minutes to a high of 95 NTU for 30 minutes. During the larger 30 minute exceedance period, the average turbidity was 54.6 NTU (SE = 16.6, n = 6).

## 2.4 Discussion

While turbidity increased at all sites during rotovation, two of the three bay sites remained within the state threshold at the mixing zone; the third exceeded the state criteria by only 2 NTU for 10 minutes. Although higher velocities at the mainstem sites carried suspended solids past the mixing zone before they could dissipate, the turbidity cleared the active site of rotovation in a shorter period of time than the bay sites. At no time did a turbidity plume appear to affect both shorelines.

## 2.5 Conservation Measures

Current permits prevent rotovation during the period in the spring when largemouth bass spawn in and around the bays and sloughs. To minimize exceeding state criteria in bay habitats, the District recommends that rotovation be limited in duration to no more than 30 minutes of continuous rotovation, with a minimum of one hour between rotovation sessions, in small bays or low velocity sloughs (300 ft in width or less). This will allow the turbidity levels to return to normal between rotovation sessions and eliminate turbidity exceedance values in bay habitats. These limitations should be implemented at all times, regardless of season.

Higher turbidity values recorded at the mainstem sites during rotovation cannot be completely avoided; however, at higher velocity sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and concentration of turbid water outside the work area. This strip will then be removed after upstream work is completed.

Of the three native salmonid species in the BCR (mountain whitefish, westslope cutthroat and bull trout), mountain whitefish is the only species which may be affected by rotovation-caused turbidity during spawning and egg incubation (November – January) (Wydoski 2004). To reduce potential for rotovation to impact whitefish spawning, the District recommends rotovation be avoided in areas immediately upstream of creek mouths and higher velocity gravel bars during the November 15 to February 1 period.

During the warmer summer months from July through October when many aquatic organisms are under increased stress due to high water temperatures, the District will use the new harvester in place of the rotovator. Recent turbidity tests of the new harvester indicate it produces far less turbidity than the rotovator. By using the new harvester, in place of the rotovator during the summer months, total number and duration of turbidity exceedances and associated impacts will be reduced by 50% annually when compared to previous years.

## 3.0 ROTOVATION AND FISH MORTALITY STUDY

*Question: To what extent does rotovation cause fish injury or mortality?*

The extent of potential mortality to fish populations caused by rotovation is unknown. It has been suggested that fish, especially young of the year, could be trapped in the aquatic vegetation as it is collected on the tiller heads and deposited on the shoreline. To evaluate the potential for entrainment in the vegetation, the District sub-sampled the affected vegetation and quantified fish presence as a result of the rotovation process.

### 3.1 Study Area and Site Selection

The study area for this assessment is BCR of the Pend Oreille River (WRIA 62) from RM 46.7 to 62, located in Pend Oreille County. The District sampled two different habitat types on the BCR:

1. Backwater slough or sheltered bay with little or no detectible water velocity, and
2. Primary channel or mainstem Pend Oreille River, where higher velocities are present.

Sampling occurred over a one-year period. To determine if particular life stages were vulnerable to the rotovation process, the District selected three similar sites per habitat type listed above for each of the four seasons (summer, fall, and winter of 2008 and spring before flooding of 2009). Seasonal study area locations can be seen on **Figure 1**. The District did not randomly select sampling sites due to the predetermined work schedule, slow travel/transport speed of the rotovator and the short time frame of the study. Site selection was further limited to near shore areas deep enough to allow the rotovator within 10 ft of the bank so spoils could be deposited on shore for sorting. Once the areas meeting the above restrictions were identified in the location the rotovator was working during each seasonal sample session, final sites were selected which had the largest and densest aquatic vegetation beds. Sample site locations selected during each season are shown on **Figures 10** through **Figure 13**.

### 3.2 Methods and Materials

#### *3.2.1 Fish Presence in the Vegetation*

Little data existed on fish species, distribution and populations utilizing weed bed habitat of the Pend Oreille River seasonally. To establish a baseline data, the District boat electrofished weed beds and margins the week before or after rotovation adjacent to or across from study area plots. Depending on weed bed density, time sampled per study area varied from 500 and 1100 shocking seconds. Larger, denser weed beds were electrofished for longer periods of time.

#### *3.2.2 Determination of Sample Area and Estimated Mortality*

Sample areas were delineated with buoys and shoreline stakes prior to the start of each study. The area ($m^2$) of the test plot for small weed beds or subsection of larger weed beds was calculated by using a dGPS with sub-meter accuracy. Any fish mortality observed was expressed as the number of fish /$m^2$ of weed bed rotovated.

The aquatic plant bed was removed using standard methods established for rotovation as described below:

Rotovation starts at the upstream end of the test plot, moving from shore toward mid-channel, working perpendicular to the flow.

- All vegetation removed from the sample plot was deposited in a single pile or single layer strip along the shore. Direct shoreline fish mortality (fish trapped in the vegetation piled on shore) was measured by:
    - Visual inspection of the surface of the pile and shore for any fish that may have been deposited outside the pile; and
    - Physical sorting and visual evaluation of two, randomly-selected, 10% subsamples of the deposited aquatic vegetation from each site.
- The vegetation from each subsample was triple-rinsed with water in a white bottom tote or buckets to free any trapped fish. The vegetation was then visually inspected on a white sorting table before disposal. Any dead fish or fish fragments collected were preserved in 85% ethanol and returned to the lab for identification. Live fish were identified on site and released immediately.

### *3.2.3 Netting*

A seine was deployed during one or more mainstem test sites per season to detect the presence of fish which may have become injured or killed and drifted downstream from the test site during rotovation. The net was deployed immediately downstream from the project area and extended from the shore out toward the middle of the river past the influence of the test plot. The barrier seine was 18 ft deep *X* 100 ft long with ¼" mesh size. The net was deployed prior to initiation of rotovation and was left in place for up to four hours after the test area had been rotovated.

## 3.3 Results

All fish collected were identified to the lowest possible taxa and summarized as the number of organisms/$m^2$/taxa by habitat type and season. Site-specific measurements of seasonal ambient fish presence and species composition using the weed bed habitat are presented in Total Number Collected, Catch per Unit Effort, and Relative Abundance seasonally for bay and mainstem habitats and total combined values in **Appendix B**. Fish mortality results for both shoreline and net samples are presented by season below.

### 3.3.1 Summer 2008

Summer samples included six shoreline samples (three bay sites and three mainstem sites) and two drift samples (an extra drift sample was taken in conjunction with the plant fragmentation netting). **Figure 10** shows the locations of each summer sample site. Summer shoreline mortality samples yielded eight fish total. All eight came from two of the six shoreline samples. Six fish were collected from one bay site and two fish were collected from a mainstem site. **Table 1** shows mortality rates for each species at each site during summer sampling.

**Table 1. Summer 2008 fish mortality rates for drift and shoreline mortality studies.**

| Site | Habitat type | Sample type | Area sampled ($m^2$) | Species | Number collected | Gallons of vegetation processed | Mortality (fish/$m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | Mainstem | Drift | 1107 | none | 0 | NA | 0 |
| 2 | Bay | Shoreline | 645 | yellow perch | 3* | 40 | 0.0233/$m^2$ |
| | | | | large mouth bass | 2* | 40 | 0.0155/$m^2$ |
| | | | | pumpkinseed | 1* | 40 | 0.0076/$m^2$ |
| 3 | Bay | Shoreline | 1267 | yellow perch | 1* | 30 | 0.0039/$m^2$ |
| | | | | large mouth bass | 1* | 30 | 0.0039/$m^2$ |
| 4 | Bay | Shoreline | 596 | none | 0 | 43 | 0 |
| 5 | Mainstem | Shoreline | 684 | none | 0 | 74 | 0 |
| 6 | Mainstem | Shoreline | 964 | none | 0 | 86 | 0 |
| 6 | Mainstem | Drift | 964 | none | 0 | NA | 0 |
| 7 | Mainstem | Shoreline | 886 | none | 0 | 37 | 0 |
| Total | All | Shoreline | 5042 | All | 8 | 310 | .0079/ $m^2$ |

* Fork length for yellow perch ranged from 38 to 55 mm, large mouth bass from 27 to 34 mm, and pumpkinseed 85mm.

### 3.3.2 Fall 2008

Fall samples included six shoreline samples (three bay sites and three mainstem sites) and two drift samples (an extra drift sample was taken in conjunction with the plant fragmentation netting). **Figure 11** shows the locations of each fall sample site. No fish were recovered from the fall sampling. **Table 2** shows results for both shoreline and drift fish mortality studies at each site during fall sampling.

**Table 2. Fall 2008 fish mortality rates for drift and shoreline mortality studies.**

| Site | Habitat type | Sample type | Area sampled ($m^2$) | Species collected | Number collected | Gallons of vegetation processed | Mortality ($fish/m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | Mainstem | Shoreline | 1265 | none | 0 | 73 | 0 |
| | | Drift | 1265 | none | 0 | | 0 |
| 2 | Bay | Shoreline | 1010 | none | 0 | 24 | 0 |
| 3 | Bay | Shoreline | 474 | none | 0 | 15 | 0 |
| 4 | Mainstem | Shoreline | 703 | none | 0 | 27 | 0 |
| | | Drift | 703 | none | 0 | | 0 |
| 5 | Mainstem | Shoreline | 722 | none | 0 | 11.5 | 0 |
| 6 | Bay | Shoreline | 535 | none | 0 | 10 | 0 |
| Total | All | Shoreline | 4790 | none | 0 | 160.5 | 0 |

**Note:** Two yellow perch (89 mm and 100 mm long), one from each of two separate fall mainstem samples, were recovered from outside the randomly selected subsamples. This indicates there was some mortality during fall rotovation, but the seasonal mortality rate was too low for our sampling protocol to detect.

### *3.3.3 Winter 2008*

Winter samples included six shoreline samples (three bay sites and three mainstem sites) and one drift net sample. **Figure 12** shows the locations of each winter sample site. No fish were recovered from the winter sampling. **Table 3** shows results for both shoreline and drift fish mortality studies at each site during winter sampling.

**Table 3.** Winter 2008 fish mortality rates for drift and shoreline mortality studies.

| Site | Habitat type | Sample type | Area sampled ($m^2$) | Species collected | Number collected | Gallons of vegetation processed | Mortality ($fish/m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | Bay | Shoreline | 667 | none | 0 | 10 | 0 |
| 2 | Mainstem | Shoreline | 762 | none | 0 | 30 | 0 |
| 3 | Bay | Shoreline | 753 | none | 0 | 29 | 0 |
| 4 | Mainstem | Shoreline | 813 | none | 0 | 34 | 0 |
| | | Drift | 813 | none | 0 | | 0 |
| 5 | Bay | Shoreline | 514 | none | 0 | 12 | 0 |
| 6 | Mainstem | Shoreline | 954 | none | 0 | 17 | 0 |
| Total | All | Shoreline | 4463 | All | 0 | 132 | 0 |

### *3.3.4 Spring 2009*

Spring samples included six shoreline samples (three bay sites and three mainstem sites) and one drift net sample. **Figure 13** shows the locations of each spring sample site. No fish were recovered from the spring sampling. **Table 4** shows results for both shoreline and drift fish mortality studies at each site during spring 2009 sampling.

**Table 4.** Spring 2009 fish mortality rates for drift and shoreline mortality studies.

| Site | Habitat type | Sample type | Area sampled ($m^2$) | Species collected | Number collected | Gallons of vegetation processed | Mortality ($fish/m^2$) |
|---|---|---|---|---|---|---|---|
| 1 | Mainstem | Shoreline | 445 | none | 0 | 10 | 0 |
| | | Drift | 445 | none | 0 | | 0 |
| 2 | Bay | Shoreline | 396 | none | 0 | 10 | 0 |
| 3 | Bay | Shoreline | 837 | none | 0 | 20 | 0 |
| 4 | Mainstem | Shoreline | 524 | none | 0 | 24 | 0 |
| 5 | Bay | Shoreline | 487 | none | 0 | 6 | 0 |
| 6 | Mainstem | Shoreline | 652 | none | 0 | 14 | 0 |
| Total | All | Shoreline | 3341 | All | 0 | 84 | 0 |

### 3.4 Discussion

When looking at the full years sampling at 24 100 foot long shoreline sites, a total of 17555 $m^2$ or 4.3 acres were sampled providing an overall mortality rate of $0.0023/m^2$ or 9.22 fish/acre of rotovated shoreline. Since each sample area was 100 feet long you can also roughly estimate a mortality rate per length of shoreline at 16.6 fish per 1000 feet of shoreline rotovated.

The new duty cycle of the rotovator is to operate primarily during the months from November to June with the new harvester operating from July through October. During these eight months of rotovator operation, ice on the river and high flows will limit the rotovator to approximately four months of on-the-water-work equaling approximately 100 acres of weed bed rotovation per ear. By using the total average mortality rate of 9.22 fish/acre estimated annual rotovator caused mortality is roughly 922 fish per year with an average fish length of 50mm.

When comparing fish collected in shoreline samples to ambient fish population from electroshocking during the Summer sample session, the three species collected in Summer shoreline samples (yellow perch, largemouth bass and pumpkinseed) are the among the four most abundant fish occupying the habitat and all but one pumpkinseed were age 0 - 1 (See **Appendix B** for a summary of the ambient fish population assessment). Based on length to age ratios taken from Divens and Osborne 2010 all of the fish mortality observed were of the size or species making them prey fish in this historically prey dominant system (Bennett and Liter 1991; Ashe and Scholz 1992; and Divens and Osborne 2010).

### 3.5 Conservation Measures

Overall fish mortality due to rotovation was extremely low. As a result, the District recommends that the county use the rotovator in locations (i.e. around cold water sources or creek mouths) and during times of the year when native salmonids or other species of concern, are more likely to be encountered (October through June).

Both summer sample sites which resulted in mortalities were very shallow with low water exchange; neither site had been previously rotovated. These conditions led to what appeared to be higher than normal turbidity during rotovation. The elevated turbidity may have contributed to the increased mortality at these sites by disorienting fish that otherwise would have been able to avoid the machine. Sections 2.4 and 2.5 discuss recommendations for reducing turbidity during rotovation. If these measures are implemented, they may further reduce rotovation-induced fish mortality.

## 4.0 DURATION OF FRAGMENT VIABILITY OF DEPOSITED EURASIAN WATERMILFOIL

*Question: How long do Eurasian water milfoil fragments stay viable after being deposited on shore?*

Several studies have been done on the effects of freezing and desiccation on EWM plant beds after dewatering. Little if any information, however, is available on the length of time a plant fragment stays viable after being harvested and deposited on shore after rotovation. Duration of viability becomes important at times of year when the water is expected to rise (i.e., spring flood season and in the fall when water is released from Lake Pend Oreille) and milfoil recently deposited on shore has the potential to be returned to the river.

The rotovator cannot operate during periods of extended freezing weather due to ice in the river. Hot, dry weather desiccates rooted weed mats in about one week (WAPMS 2004 http://www.wapms.org/plants/milfoil.html), while laboratory tests showed individual cuttings lost viability in as little as 7 to 9 hours (in the open air, shade with no wind) (Cooke 2005). For these reasons, the District focused on the amount of time plant fragments remained viable in temperate and/or wet conditions. This study was developed to assist the District in estimating the maximum plant fragment viability when the fragments were deposited in piles by the rotovator in areas of heavy aquatic vegetation or where landowners request all the spoils from their shoreline be put in a single pile. The study was also designed to indicate whether covering piles with black plastic would reduce the time period plant fragments remain viable during temperate weather.

## 4.1 Study Area

This study was performed at the LeClerc Creek Wildlife Area in Pend Oreille County, BCR, at RM 58, on the Pend Oreille River (WRIA 62).

## 4.2 Methods and Materials

### *4.2.1 Treatment Types*

The District evaluated fragment viability under two treatment types. The first treatment type (control) was a heavy vegetation rotovator pile without manipulation. For the second treatment type (experimental), the District covered the heavy vegetation rotovator piles with black plastic immediately after rotovation. This treatment was selected to evaluate the potential of mulching to reduce the duration of plant fragment viability during temperate weather.

### *4.2.2 Setup and Sample Collection*

The treatment piles were deposited September 11, 2008, as high on the bank as possible, at a flow of approximately 12,000 cfs. Both the control and experimental treatment piles were taller than normally deposited by the rotovator (about 2 ft thick at the crest compared to 2 in to 5 in thick with standard piles) to represent an area of heavy vegetation or a pile similar to what is deposited when a landowner requests the vegetation be put in a single pile. Both treatment piles were deposited on shore at the same time from vegetation collected along the 100 ft of shoreline. **Figure 14** shows both experimental and control piles the day they were deposited, before and after the experimental pile was covered with 6 Mil black plastic. The edge of the plastic was held in place with landscaping staples and rocks.

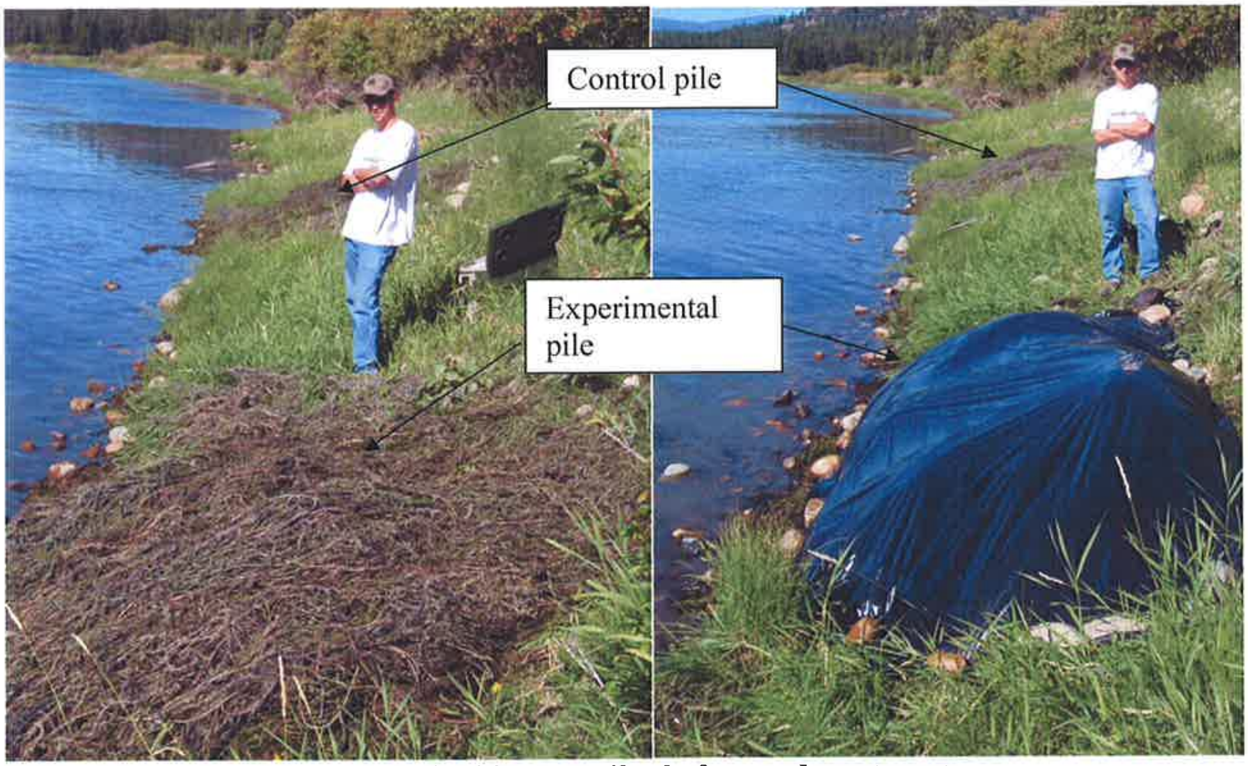



**Figure 14. Photos of fragment viability test piles before and treatment.**

Immediately after the two treatment piles were deposited on shore, 15 pre-test fragments were collected: five from the water surface and five from the top of each treatment pile. These first pre-test samples were collected for use in the lab aquarium to verify adequate growing conditions were maintained for the duration of the study.

The District collected 15 samples per collection date, and treatment type: five from the top of each treatment pile, five from the middle of each pile, and five from the bottom. Samples were pooled per treatment type for each collection date and transported back to the lab in a cooler of river water. To verify viability, all samples collected were marked with the date of harvest, rinsed and placed in an aquarium of filtered river water, with a grow light for observation, until viability was determined.

At one to three week intervals after the piles were deposited, 15 sample fragments were collected from each pile and returned to the lab. Each fragment was labeled and put in aquarium filled with river water to be held until signs of growth or total decomposition appeared (which usually occurred two to three weeks after collection). As soon as signs of new growth were observed on a leaf, stem, or root, the fragment was considered viable and discarded. If growth was questionable, a fragment was photographed and returned to the aquarium for an additional amount of time so that photos taken at different times could be compared. Samples fragments were declared unviable when the stem lost all rigidity, color turned from green or red to brown and advanced decomposition was apparent. Sample collection ended December 8, prior to a severe cold snap and heavy snowfall that occurred on December 15, 2008.

## 4.3 *Results*

Nine sets of samples were collected over a thirteen week period from September 18 to December 8. The first six samples were collected at one-week intervals; the last three were spread two then three weeks apart. The number of fragments remaining viable, out of the 15 collected for each treatment type on each collection date, can be seen in **Figure 15.**

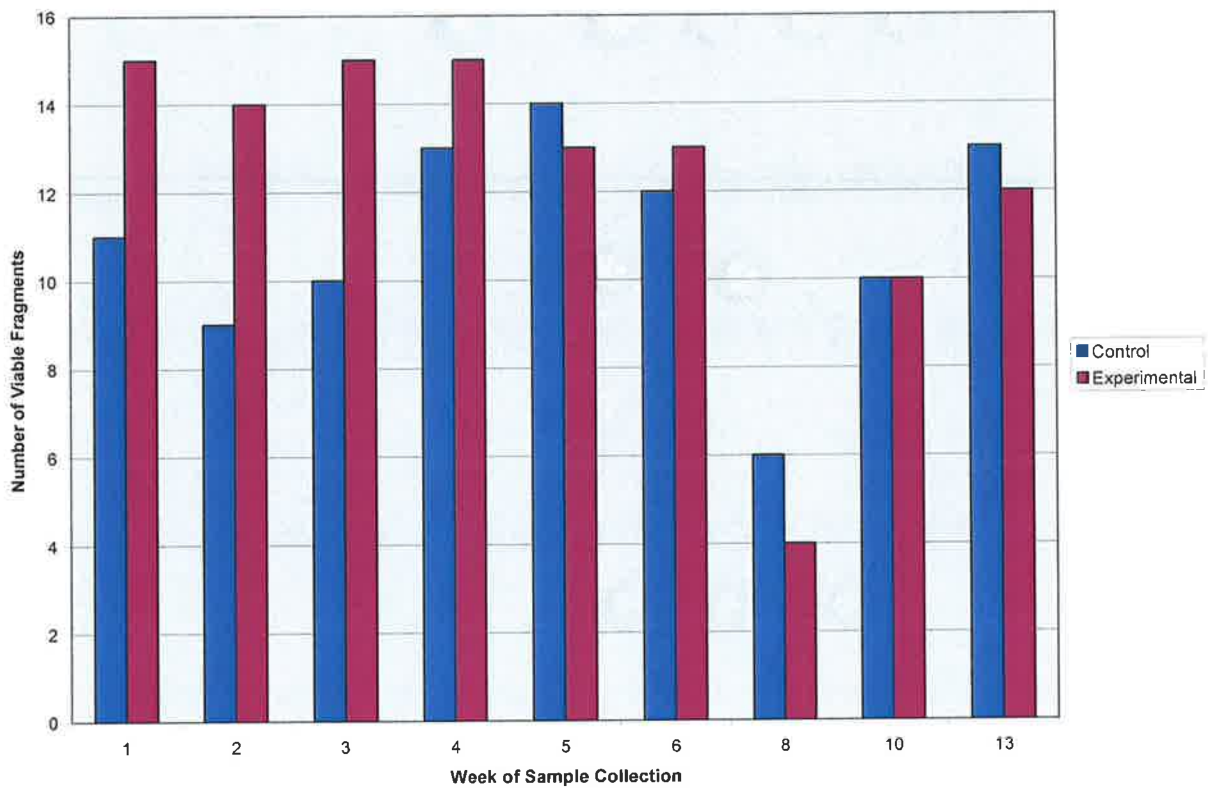



**Figure 15. Results of weekly fragment viability sample collection for control and experimental treatment types.**

All 15 original pre-test fragments collected to verify adequate growing conditions were maintained in the aquarium with the experimental and control samples; they remained viable, showing new growth throughout the study.

## 4.4 Discussion

By the fourth week of the study, both treatment piles were showing from 40 to 60 percent of the original material actively decomposing; the control or uncovered pile had lost around 15 percent of its mass to desiccation from the exposed top. The desiccated material from the top layer of the control pile would crumble to pieces when collected, making it difficult to recover intact fragments from the top for each subsample. Under the top 2 – 5 in of piled material, however, the remaining fragments were actively producing new roots and shoots. By the eighth week post-treatment, most of the remaining viable material left in either treatment pile was in the new growth sections. These new growth sections were loosely connected by the decomposing parent stems. This is reflected in the net increase in total number of viable fragments in the pile, between sample week 8 and 10 since each original foot-long fragment produced as many as five new shoots. **Figure 15** shows examples of new growth on decomposing stems.

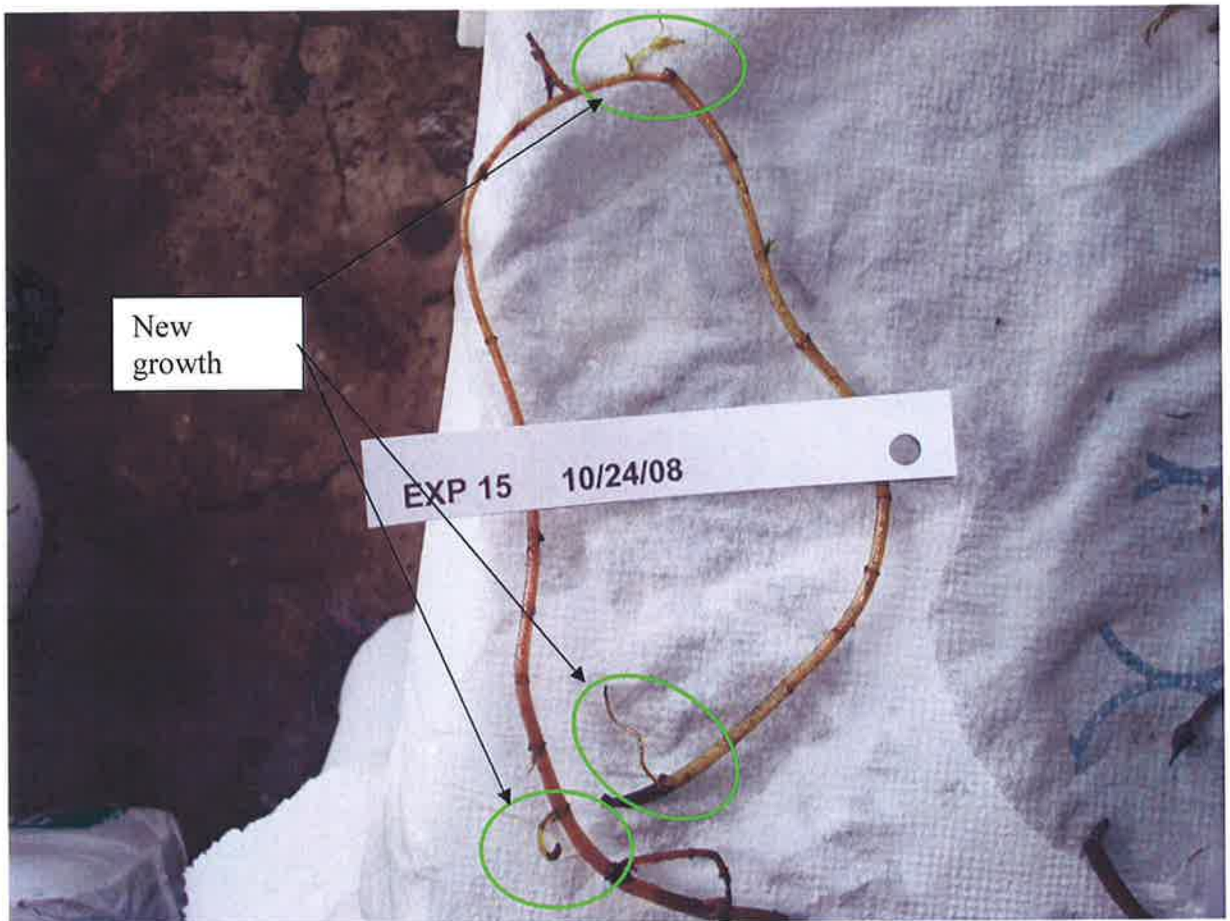



**Figure 15. Decomposing Milfoil stem with new shoots and root growth.**

During October, Albeni Falls Dam released water from Lake Pend Oreille to reach its low winter pool elevation. This increased flows from 12,000 cfs to approximately 28,000 cfs. The associated increase in stage (approximately 2.2 feet) inundated over 50% of both study piles. The majority of the both piles remained intact and in-place when the water receded after November 4. Both the experimental and control piles, however, were noticeably deflated from what appeared to be the loss of decomposed or desiccated material. The bulk of the viable material remained in place, possibly due to the new root and stem development.

A final visit was made to the site the following year on September 24, 2009 to check the remains of both treatment piles and search for viable fragments. By September 24, the control pile was completely gone (**Figure 16).** And, while the black plastic was largely intact covering the area over the experimental site, there was no sign of the experimental pile beneath it (**Figure 17**).

**Figure 16**. Photo showing the remains of the control pile site one year after placement.

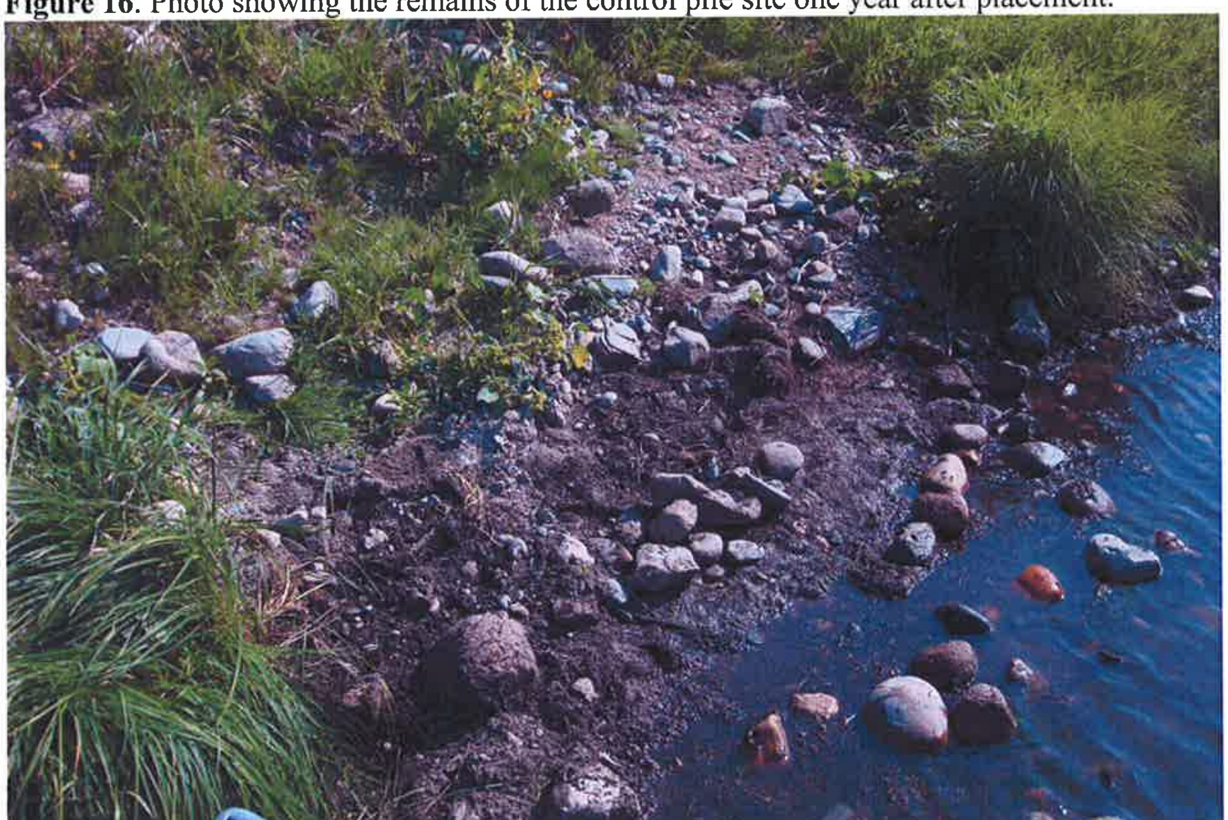


**Figure 17.** Photo showing remains of experimental pile site one year after placement.

The District took photographs to provide photo documentation of both individual Eurasian water milfoil (EWM) stems and piles before and after mortality for use in future public education activities.

Neither treatment type reduced or eliminated plant viability during temperate weather through time. While the over-sized piles studied in this test stayed in place during a flood event, there were as many or more viable fragments in the piles for remobilization at the end of this study as at the start. Total fragment mortality was not observed unless piles were frozen or desiccated.

### 4.5 Conservation Measures

The District and Pend Oreille County will post the relevant results of this study on their web sites. The posting will include photos documenting both viable and unviable fragments, the piles during different stages of decomposition or desiccation, and the length of time that fragments remained viable. The site will also include suggestions as to how to management EWM fragment piles deposited on private shorelines.

Based on the results of this study, future rotovation efforts should limit the depth of vegetation piles placed below the high water line by the rotovator, to less than 5 in to accelerate the drying process. When rotovation efforts occur within two weeks of the annual spring runoff, or Lake Pend Oreille drawdown, work should focus on areas where spoils can be placed above high water.

## 5.0 Fragmentation Rates during Rotovation

*How much plant material (EWM) floats away during Rotovation?*

The amount of EWM that is released during rotovation (e.g., not collected by tillers for shore disposal) was compared to natural autofragmentation rates.

It is generally believed that the fragments released by harvest are fewer than those that would have been released had the bed been left intact or those created by adjacent, untreated EWM beds autofragmenting over time (Zisette 1983; Cooke et al. 1993). This hypothesis has not been tested in the field, but appears reasonable, given the high background levels of fragments in EWM-infested systems (Aquatic Research Incorporated 1986). To address this question five samples were collected at four different sites for the purpose of quantifying the amount of rotovator caused fragmentation. Samples were composed of three control samples to determine auto fragmentation rates and two experimental samples.

### 5.1 Study Area and Sample Selection

The study area for this assessment is BCR of the Pend Oreille River (WRIA 62) from river mile 48 to 51, located in Pend Oreille County. Three control and three experimental sites were selected and studied during fall and spring sampling sessions; one fall experimental site failed during testing and was omitted. The remaining sites, two control and one experimental sampled in the fall are shown on **Figure 2** and one each control and experimental samples were taken from the same site in the spring 2009 is shown on **Figure 3**.

## 5.2 Methods and Materials

Two seines 18 ft deep *X* 100 ft long, with ½" size mesh, were deployed: one upstream and one downstream of each 100 ft stretch of shoreline to be rotovated or used as a control site (**Figure 18**). For control sets, the nets were deployed for approximately 24 hours; at this time, the downstream net only was retrieved and sampled. At the experimental sites, the net was deployed prior to initiation of rotovation and remained in place for a time sufficient for all suspended fragmented material to reach the downstream net.

**Figure 18.** Photo showing seines set for a fragmentation Control site sample collection.

For samples too large to send to the lab in their entirety, sub-samples of plant material were collected from six randomly selected subsections of the seine net. Each subsection was 3 ft wide at the water surface and extended to the depth of the net. Four of the subsections were located within the central half of the net's length; the other two subsections were located on the outer quarter ends of the net. These subsections locations were generated through an Excel TM random number generator. Plant materials from the six sub-sections were aggregated into a single 18% subsample for lab analysis.

All EWM fragments trapped on the net were collected and stored on ice for later laboratory processing.

The total seasonal biomass for fragmentation from the control sites was calculated as the weight of the 24 hour sample *X* the number of days remaining in the growing season (April 1 though September 30) or auto-fragmentation period (October 1 to March 31) after the date of the rotovation.

The rationale for multiplying the weight of the 24 hour sample by either the number of days remaining in the growing season or auto-fragmentation period was that fragmentation from rotovation is temporarily elevated during treatment, but plants are then absent from the site for the remainder of the growing season and during auto fragmentation producing no auto fragmentation during the remainder of these times.

The amount of fragmentation for both experimental and background samples are presented as gross volume and total mass (dry weight)/m$^2$.

## 5.3 Results

Seasonal fragmentation rates were greater for both fall control sites than the rotovator-caused fragmentation at the fall experimental site. Values were 19g/m$^2$ and 15.7g/m$^2$ vs. 2.7 g/m$^2$, respectively. Similar but more pronounced results were found during spring sample collection, with control seasonal fragmentation rate of 164.6 g/m$^2$ as compared to rotovator-caused fragmentation of 3.2 g/m$^2$. See **Table 6**.

**Table 6**. Results from Control and Experimental fragmentation sampling.

| Sample Type and Number | Date | Study Area Size (m$^2$) | Sample size | Sample Dry Weight | Gross Volume in gallons | Daily Fragmentation Rate | Days Remaining in Season | Total Seasonal Fragmentation |
|---|---|---|---|---|---|---|---|---|
| **Control 1** | 10/28/2008 | 1265 | Full Sample | 156.25g | 2 | 0.1235g/m$^2$ | 154 | 19.0g/m$^2$ |
| **Control 2** | 10/30/2008 | 1010 | Full Sample | 103.87g | 1.7 | 0.1028g/m$^2$ | 152 | 15.7g/m$^2$ |
| **Exp. 2** | 11/6/2008 | 535 | 18% Sub | 206.37g | 5 | 2.7g/m$^2$ | NA | 2.7g/m$^2$ |
| **Control 3** | 4/22/2009 | 445 | Full Sample | 465.2g | 5 | 1.02g/m$^2$ | 161 | 164.6 g/m$^2$ |
| **Exp. 3** | 4/23/2009 | 445 | Full Sample | 1390.3g | 14 | 3.2g/m$^2$ | NA | 3.2g/m$^2$ |

## 5.4 Discussion

This study showed that calculated seasonal auto fragmentation per m$^2$ of EWM bed exceeded the one time, rotovator-related fragmentation event for the same surface area. This effect is likely reduced when operating the rotovator in the rapid growing season of mid summer, when milfoil plants are growing strong and auto fragmentation rates are presumably lower. Another consideration during the summer season is that, when rotovating, the tiller head fills more quickly with healthy plant material, which increases the potential for large sections of the plant to drift away. This tendency for tiller heads to fill quickly in thick summer weed beds also reduces the rotovator's ability to remove the root stock, which increases the potential for re-growth and auto fragmentation later in the growing season.

### 5.5 Conservation Measures

The District proposes to limit the use of the rotovator from July – September, when its effectiveness may be reduced and the potential for increased fragmentation is the higher. During this time, the District proposes to use the harvester, which is better suited to handle the large volume of dense and rapidly-growing vegetation encountered during this time of year.

## 6.0 ROTOVATOR DREDGE AND FILL INVESTIGATION

*Question: Does rotovation cause a net movement of substrate if so how much?*

Anecdotal comments provided by the County suggested rotovation activities may cause the development of furrows or sand bars through repeated treatments in areas of low velocity. This activity could lead to navigational hazards or an alteration of hydraulic function. To address this issue, the District preformed a before- and after-rotovation inspection of the substrate of two different, low-velocity study areas.

### 6.1 Study Area and Site Selection

The study area for this assessment is BCR of the Pend Oreille River (WRIA 62) at river miles 51.2 and 52.0, located in Pend Oreille County. Two study sites were selected in the Ruby Creek area. The first site was a bay with heavy silt deposits recently rotovated for the first time. The second site had areas of mixed silt and sand, and areas dominated by gravel located at the mouth of Ruby Creek, which had not been previously been rotovated. **Figure 11** shows the site location and **Figure 19** shows the position of marker transects at each site.

### 6.2 Methods and Materials

Both study sites were observed visually prior to treatment, using SCUBA equipment, and substrate contour conditions were recorded by sketching and underwater photography. A marker line of colored gravel was placed perpendicular to the path of rotovation to identify the treatment area after rotovation had occurred. The sites were rotovated using a single pass from shore toward mid channel as described in the standard methods in Section 3.2.2. Sites were then examined post-treatment to identify any gross movement of bed material. Post-treatment contour conditions were recorded in the same manner as pre-treatment. Where observed, width, depth, and length measurements were made of furrows or piles when observed to the nearest cm.

### 6.2 Results

This study was completed November 19, 2008. Photos of before and after treatment were taken by divers to show effects of rotovator operation. The effects varied significantly based on substrate type and whether or not the site had been tilled previously.

### 6.3.1 Pre-treatment Site Descriptions

**Site 1**

Site 1 was a bay site with heavy silt deposits which had been rotovated for the first time one week prior to the study. Substrate was a smooth evenly sloped, slightly cupped silt bed. This silt layer was from 22 - 30 cm deep covering a gravel and clay hard bottom (**Figure 20**).

**Figure 20.** Photo showing rotovation dredge and fill at site one pre-rotovation

**Site 2**

Site 2 was a bay site with mixed sand and gravel and patches of vegetated silt deposits directly in front of the mouth of Ruby Creek. This area had never been rotovated, but was free of vegetation in several spots, apparently due to spring high flows in both the Pend Oreille River and Ruby Creek. Two monitoring transects were established for this site. The first was near shore dominated by sand and silt the second was off shore and dominated by gravel (**Figure 19**). The two separate open patches, about 17 m apart, were photographed and measured independently.

Transect 1, immediately downstream of the confluence of the river and Ruby Creek, was primarily sand (**Figure 21**). The second open patch (Transect 2; **Figure 22**) was dominated by small and medium gravel located about 20 m towards the middle of the river from the mouth of the creek.

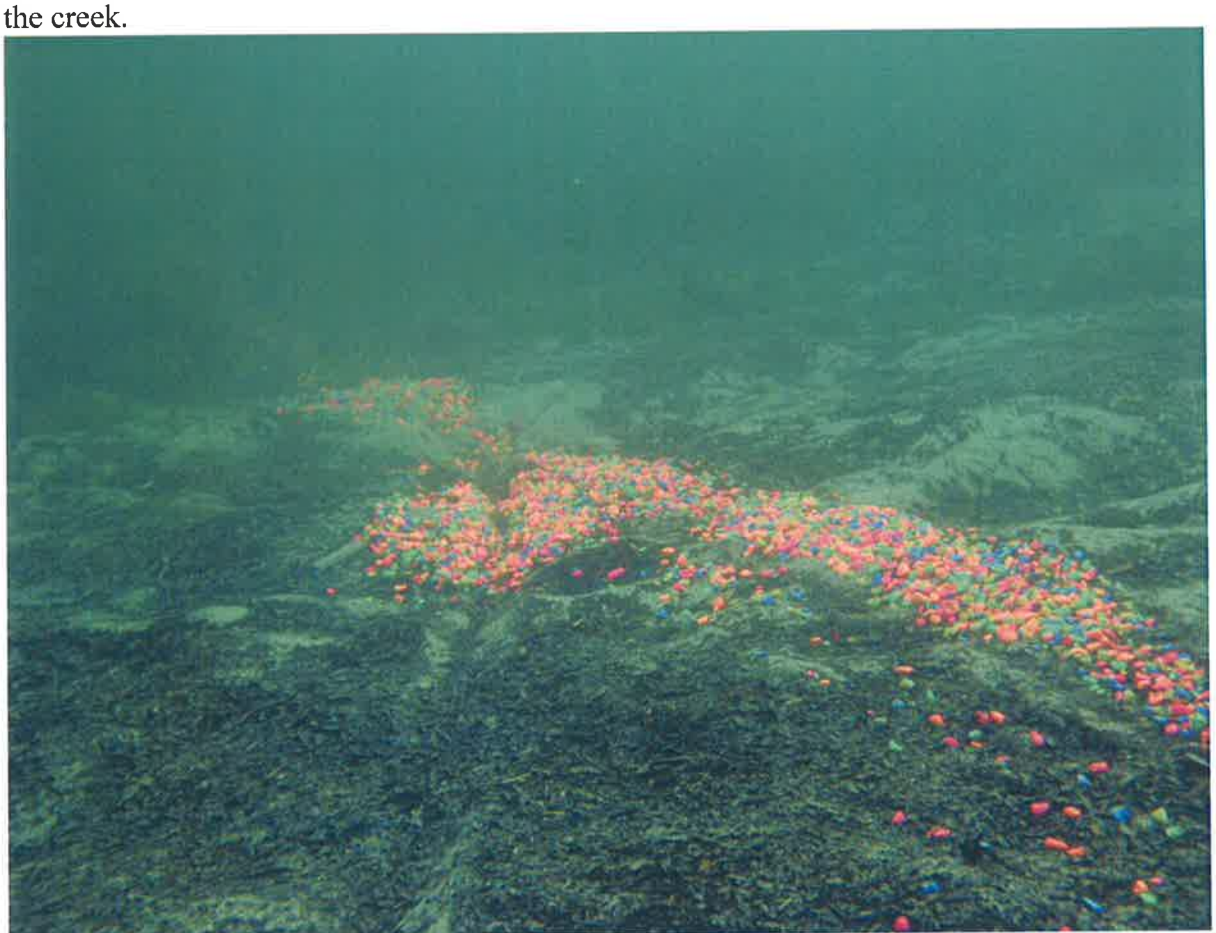


**Figure 21.** Photo showing rotovation dredge Site 2, Transect 1 (near shore transect) pre-rotovation.

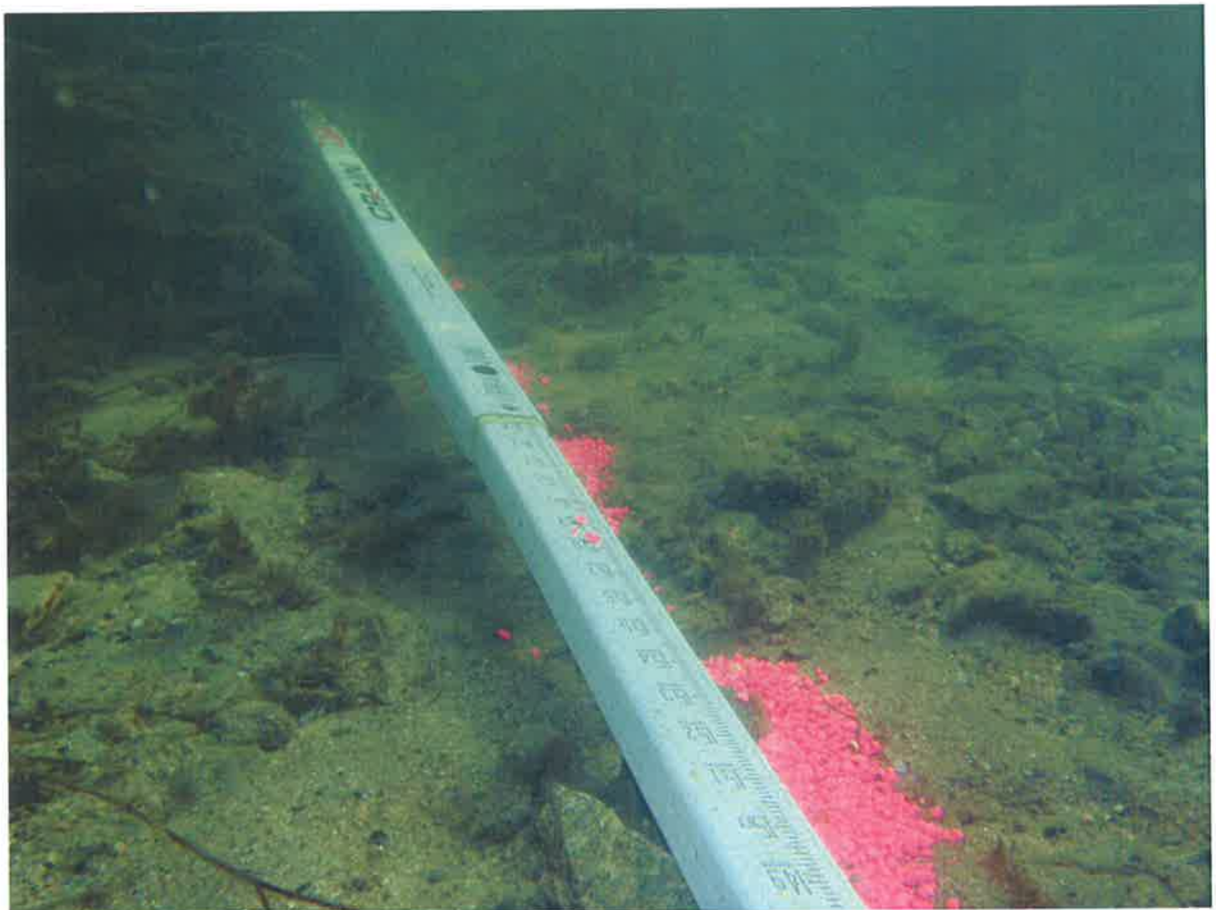


**Figure 22.** Photo of rotovation dredge Site 2, Transect two (off shore transect) pre-rotovation, showing sand and gravel substrate.

Pre-treatment, slope and contour were smooth, evenly-sloped, with a pronounced cupping at the upstream margin of the rotovator path on Transect 1. The sand and gravel patch farther off shore (Transect 2) was also smooth in texture; however, the contour was rounded and bowl shaped with the deep spot about 22 cm lower than the edges (**Figure 23**).

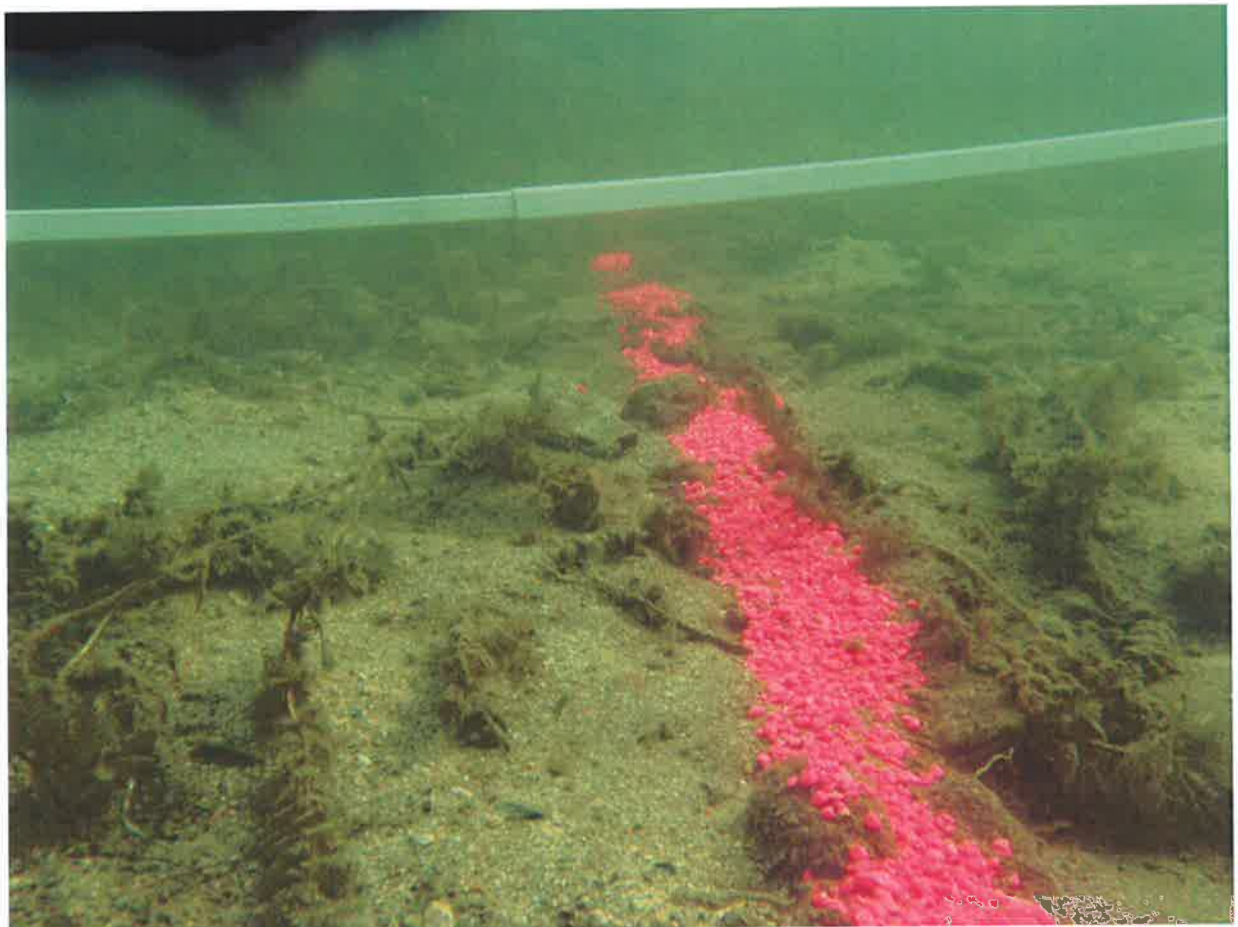


**Figure 23.** Photo of rotovation dredge Site 2, Transect 2 (off shore transect) pre-rotovation, contour.

### *6.3.2 Post-treatment Site Descriptions*

**Site 1**

After rotovation at Site 1, the slope and contour of the site were unchanged. However, the texture was roughened after rotovation, like sod, but loose and spongy to the touch (**Figure 24**). There was no noticeable movement of substrate either vertically or horizontally, and no sign of a mound or pile at the lower extent of the rotovator swath. While inspection indicated no net substrate movement, there were signs of depressions left by the rotovator during the previous week of tilling. Those areas which were missed by the rotovator head the week before leaving the plant bed intact, were elevated from 15 - 30 cm above adjacent tilled areas. This depth corresponded to the amount of root material and associated silt removed during initial rotovation.

**Figure 24.** Photo showing rotovation dredge and fill site 1 post-treatment.

**Site 2**

Post-treatment observations at Site 2 showed two noticeable features. The first was a 15 cm row of raised substrate near the upstream edge of the rotovator path as it crossed Transect 1. This raised furrow, composed of sand and silt, followed the path of the tiller head away from shore roughly 7 m (**Figure 25**). The furrow was not at the outside of path left by the tiller head but was left by the space between two sets of tiller blades. The furrow ended as the substrate changed from sand/silt to gravel.

**Figure 25.** Photo showing the 15 cm raised furrow found at Site 2, Transect 1 post-treatment.

The current at Site 2 pushed the rotovator downstream of the gravel marking Transect 2 while tilling the first swath at Site 2. This caused the rotovator operator to deviate from standard operating procedures (starting at the shore and working out), because he had to start a second swath or pass with the rotovator tiller head mid channel between Transects 1 and 2 in order to rotovate only transect 2 on the second pass. This mid-channel start caused formation of the second feature identified post treatment described below.

The second feature identified post-treatment was a depression produced by the tiller head as it was lowered down in the middle of the swath between Transects 1 and 2. The depression was 45 cm deep, the full width of the tiller head, with the substrate from the depression deposited immediately up the bank, or up-slope from the hole. There were no other piles of substrate to either side of the transects or at the bottom of either of the Site 2 rotovator passes.

## 6.4 Discussion

Normal operation of the rotovator left from no noticeable change in substrate profile to a 15 cm high furrow of loose silt that ceased when substrate size increased to sand. This feature did not constitute major movement of bed material and due to its small substrate size would not have remained in place or increased during an additional treatment.

Of the two post-treatment observations mentioned above at Site 2, the only observation that could represent a significant movement of bed material or substrate was the 45 cm depression caused by starting a rotovation pass at depth or away from shore. This is not standard operating procedure for the rotovator; study methods dictated a procedure outside the norm, which resulted in the furrow. The District proposes that all future swaths made during rotovation start in the shallows, working to deeper water, as the standard procedure stipulates. No additional mitigation or conservation measures are recommended at this time.

## 7.0 General Summary

Through the described studies the District has identified the degree to which the rotovator has the potential to impact, either positively and negatively, water quality, fish mortality, bed load movement, fragmentation and fragment viability. Below is a bulleted list of the conservation/mitigation measures and suggested Best Management Practices identified to address rotovation related impacts throughout this report. For detailed information on any bulleted item, please refer to the chapter of this report at the end of each bulleted item.

## 7.1 Recommended Mitigation Measures and Best Management Practices

### *7.1.1 Turbidity*

- To minimize exceeding state turbidity criteria in small bays or low velocity sloughs (300 ft in width or less), the District recommends that rotovation be limited in duration to no more than 30 minutes of continuous rotovation, with a minimum of one hour between rotovation sessions,. This restriction will allow the turbidity levels to return to normal between rotovating sessions and eliminate exceedances in bay habitats. These limitations should be implemented at all times, regardless of season.

- Higher turbidity values recorded at the mainstem sites during rotovation cannot be completely avoided; however, at higher velocity sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and concentration of turbid water outside the work area. This strip will then be removed after upstream work is completed.

- To reduce potential for rotovation to impact whitefish spawning, the District recommends rotovation be avoided in areas immediately upstream of creek mouths and higher-velocity gravel bars during the period of November 15 to February 1.

- During the warmer summer months when many aquatic organisms are under increased stress due to high water temperatures, the District will use the harvester in place of the rotovator. Recent turbidity tests of the new harvester indicate it produces far less turbidity than the rotovator. By switching the rotovator for the new harvester during the summer months, total number and duration of turbidity exceedances and associated impacts will be reduced by 50% annually when compared to previous years.

- The rotovator no longer tills the substrate; instead the blades spin backwards on, or just above, the substrate winding plants up on the tines and pulling plant roots instead of digging them.

### 7.1.2 Fish Mortality

- Overall fish mortality due to rotovation was extremely low. As a result, the District recommends that the County use the rotovator in locations (i.e. around cold water sources or creek mouths) and during times of the year when native salmonids, or other species of concern, are more likely to be encountered (October through June).

- Both summer sample sites where fish mortality was documented were very shallow with low water exchange and neither had been previously rotovated. These conditions led to what appeared to be higher than normal turbidity during rotovation. This increased turbidity may have contributed to the increased mortality at these sites. Conservation measures discussed in the section above specifically address methods to reduce turbidity in areas such as this and may be affective in further reducing rotovation caused fish mortality.

- To reduce impact on whitefish and bass spawning, rotovation will be avoided in areas immediately upstream of creek mouths and high-velocity gravel bars during the period of November 15 to February 1, and in sloughs during spring spawning.

### 7.1.3 Fragment Viability and Remobilization

- The District and Pend Oreille County will post the relevant results of this study on their web sites. The posting will include photos documenting both viable and unviable fragments, the piles during different stages of decomposition or desiccation, and the length of time that fragments remained viable. The site will also include suggestions as to how to management EWM fragment piles deposited on private shorelines.

- Based on the results of this study, future rotovation efforts should limit the depth of vegetation piles, placed below the high water line by the rotovator, to less than 5 in to accelerate the drying process. When rotovation efforts occur within 2 weeks of the annual spring runoff, or Lake Pend Oreille drawdown, work should focus on areas where spoils can be placed above the high water.

### 7.1.4 Rotovator Caused Fragmentation

- Since rotovation caused fragmentation was less than seasonal auto fragmentation for all sites studied the District proposes only to limit the use of the rotovator when its effectiveness may be reduced and potential for increased fragmentation is the higher during the period from July – September. During this time, the District proposes to use the harvester, which is better suited to handle the large volume of dense and rapidly growing vegetation encountered during this time of year.

## 8.0 LITERATURE CITED


Aquatic Research Incorporated. 1986. Field Test of Mechanical Harvesting of Aquatic Macrophytes. Final Report prepared for the Municipality of Metropolitan Seattle, Water Quality Planning Division, Seattle, Washington.

Ashe, B. L. and A. T. Scholz. 1992. Assessment of the fishery improvement opportunities on the Pend Oreille River: Recommendations for Fisheries Enhancement. Final Report. Upper Columbia United Tribes Fisheries Center; Department of Biology, Eastern Washington University, Cheney. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project Number 88-66, Agreement Number DE-A179-88BP39339, March 1992.

Bennett, D. H. and M. Liter. 1991. Water quality, fish and wildlife characteristics of Box Canyon Reservoir, Washington. Completion Report 1989 – 1990, Section 3: Fish, Department of Fish and Wildlife Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho. Prepared for the Public Utility District No. 1 of Pend Oreille County, Washington. July 1991.

Cooke, G. D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers, Boca Raton, Florida.

Cooke, D. G. 2005. Restoration and Management of Lakes and Reservoirs. CRC Press, ISBN 1566706254, p.344

EES Consulting, Inc. 2008. Box Canyon Hydroelectric Project (No. 2042) Aquatic Plant Management Plan - Annual Report of Activities in 2007.

PUD No. 1 of Pend Oreille County (District). 2000. Box Canyon Hydroelectric Project, Application for New License, FERC No. 2042. Volume II of XIII, Exhibit E, Section 2.0.

Western Aquatic Plant Management Society (WAPMS). 2004. http://www.wapms.org/plants/milfoil.html

WDOE. 2008. http://www.ecy.wa.gov/programs/wq/plants/management/rotovation_strategies.html

Zisette, R.R. 1983. Milfoil Control Method Evaluation. Prepared by Aquatic Control, Ltd. for the Municipality of Metropolitan Seattle Water Quality Planning Division, Seattle, Washington.

Wydoski, R. S. and R.R. Whitney. 2003. Inland Fishes of Washington Second Edition. American Fisheries Society and U of W press. p. 88-89

# Appendix A

# Sample Site Information

**Appendix A**. Site specific information for each season and test.

| Season | Site number | Date | Habitat type | Studies performed | Size (m2) | Volume processed in gallons |
|---|---|---|---|---|---|---|
| Summer | 1 | 8/4/2008 | Mainstem | Drift mortality | 1107 | NA |
| Summer | 2 | 8/4/2008 | Bay | Shoreline mortality | 645 | 40 |
| Summer | 3 | 8/4/2008 | Bay | Shoreline mortality | 1267 | 30 |
| Summer | 4 | 8/5/2008 | Bay | Shoreline mortality | 596 | 43 |
| Summer | 5 | 8/5/2008 | Mainstem | Shoreline mortality | 684 | 74 |
| Summer | 6 | 8/5/2008 | Mainstem | Shoreline mortality | 964 | 86 |
| Summer | 6 | 8/5/2008 | Mainstem | Drift mortality | 964 | NA |
| Summer | 7 | 8/6/2008 | Mainstem | Shoreline mortality | 886 | 37 |
| Fall | 1 | 10/28/2008 | Mainstem | Fragmentation Control | 1265 | 73 |
| Fall | 1 | 11/4/2008 | Mainstem | Shoreline mortality | 1265 | NA |
| Fall | 1 | 11/4/2008 | Mainstem | Drift mortality | 1265 | NA |
| Fall | 2 | 10/30/2008 | Mainstem | Fragmentation Control | 1010 | 24 |
| Fall | 2 | 11/7/2008 | Bay | Shoreline mortality | 1010 | NA |
| Fall | 3 | 11/5/2008 | Bay | Shoreline mortality | 474 | 15 |
| Fall | 3 | 11/5/2008 | Bay | Turbidity | 474 | NA |
| Fall | 4 | 11/6/2008 | Mainstem | Shoreline mortality | 703 | 27 |
| Fall | 4 | 11/6/2008 | Mainstem | Turbidity | 703 | NA |
| Fall | 4 | 11/6/2008 | Mainstem | Fragmentation Experimental | 703 | NA |
| Fall | 4 | 11/6/2008 | Mainstem | Drift mortality | 703 | NA |
| Fall | 5 | 11/13/2008 | Mainstem | Shoreline mortality | 722 | 11.5 |
| Fall | 5 | 11/13/2008 | Mainstem | Turbidity | 722 | NA |
| Fall | 6 | 11/13/2008 | Bay | Shoreline mortality | 535 | 10 |
| Fall | 6 | 11/13/2008 | Bay | Turbidity | 535 | NA |
| Winter | 1 | 12/9/2008 | Bay | Shoreline mortality | 667 | 10 |
| Winter | 2 | 12/9/2008 | Mainstem | Shoreline mortality | 762 | 30 |
| Winter | 3 | 12/9/2008 | Bay | Shoreline mortality | 753 | 29 |
| Winter | 4 | 12/10/2008 | Mainstem | Shoreline mortality | 813 | 34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Winter | 4 | 12/10/2008 | Mainstem | Drift mortality | 813 | NA |
| Winter | 5 | 12/10/2008 | Bay | Shoreline mortality | 514 | 12 |
| Winter | 6 | 12/11/2008 | Mainstem | Shoreline mortality | 954 | 17 |
| Spring | 1 | 4/21/2009 | Mainstem | Fragmentation Control | 445 | NA |
| Spring | 1 | 4/22/2009 | Mainstem | Fragmentation Experimental | 445 | NA |
| Spring | 1 | 4/22/2009 | Mainstem | Shoreline mortality | 445 | 10 |
| Spring | 1 | 4/22/2009 | Mainstem | Drift mortality | 445 | NA |
| Spring | 2 | 4/21/2009 | Bay | Shoreline mortality | 396 | 10 |
| Spring | 3 | 4/21/2009 | Bay | Shoreline mortality | 837 | 20 |
| Spring | 4 | 4/21/2009 | Mainstem | Shoreline mortality | 524 | 24 |
| Spring | 5 | 4/22/2009 | Bay | Shoreline mortality | 487 | 6 |
| Spring | 5 | 4/22/2009 | Bay | Turbidity | 487 | NA |
| Spring | 6 | 4/22/2009 | Mainstem | Shoreline mortality | 652 | 14 |
| Spring | 6 | 4/22/2009 | Mainstem | Turbidity | 652 | NA |

# Appendix B
# Ambient Fish Summery

Appendix B. Ambient fish population assessment electroshocking results for bay and mainstem habitats by season.

Summer 2008

| SPECIES | BAY TOTAL NUMBERS | RIVER TOTAL NUMBERS | TOTAL | BAY CPUE | RIVER CPUE | TOTAL SUMMER CPUE | BAY RELATIVE ABUNDANCE | RIVER RELATIVE ABUNDANCE | TOTAL RELATIVE ABUNDANCE |
|---|---|---|---|---|---|---|---|---|---|
| Black Crappie | 1 | 1 | 2 | 2.20 | 3.60 | 2.73 | 1.03 | 1.22 | 1.12 |
| Brown Bullhead | 2 | 0 | 2 | 4.39 | 0.00 | 2.73 | 2.06 | 0.00 | 1.12 |
| Large Mouth Bass | 12 | 4 | 16 | 26.34 | 14.40 | 21.82 | 12.37 | 4.88 | 8.94 |
| Long Nose Sucker | 1 | 1 | 2 | 2.20 | 3.60 | 2.73 | 1.03 | 1.22 | 1.12 |
| Northern Pikeminnow | 2 | 4 | 6 | 4.39 | 14.40 | 8.18 | 2.06 | 4.88 | 3.35 |
| Pumpkin Seed | 36 | 24 | 60 | 79.02 | 86.40 | 81.82 | 37.11 | 29.27 | 33.52 |
| Tench | 18 | 10 | 28 | 39.51 | 36.00 | 38.18 | 18.56 | 12.20 | 15.64 |
| Yellow Perch | 25 | 37 | 62 | 54.88 | 133.20 | 84.55 | 25.77 | 45.12 | 34.64 |
| Large Scale Sucker | 0 | 1 | 1 | 0.00 | 3.60 | 1.36 | 0.00 | 1.22 | 0.56 |
| TOTAL | 97 | 82 | 179 | 212.93 | 295.20 | 244.09 | 100.00 | 100.00 | 100.00 |

Fall 2008

| SPECIES | BAY TOTAL NUMBERS | RIVER TOTAL NUMBERS | TOTAL | BAY CPUE | RIVER CPUE | TOTAL SUMMER CPUE | BAY RELATIVE ABUNDANCE | RIVER RELATIVE ABUNDANCE | TOTAL RELATIVE ABUNDANCE |
|---|---|---|---|---|---|---|---|---|---|
| Black Crappie | 27 | 28 | 55 | 45.63 | 33.41 | 38.47 | 5.33 | 10.18 | 7.03 |
| Brown Bullhead | 0 | 4 | 4 | 0.00 | 4.77 | 2.80 | 0.00 | 1.45 | 0.51 |
| Large Mouth Bass | 150 | 34 | 184 | 253.52 | 40.57 | 128.70 | 29.59 | 12.36 | 23.53 |
| Small Mouth Bass | 2 | 1 | 3 | 3.38 | 1.19 | 2.10 | 0.39 | 0.36 | 0.38 |
| Long Nose Sucker | 3 | 12 | 15 | 5.07 | 14.32 | 10.49 | 0.59 | 4.36 | 1.92 |
| Northern Pikeminnow | 28 | 7 | 35 | 47.32 | 8.35 | 24.48 | 5.52 | 2.55 | 4.48 |
| Pumpkin Seed | 198 | 87 | 285 | 334.65 | 103.81 | 199.34 | 39.05 | 31.64 | 36.45 |
| Tench | 20 | 15 | 35 | 33.80 | 17.90 | 24.48 | 3.94 | 5.45 | 4.48 |
| German Brown trout | 0 | 1 | 1 | 0.00 | 1.19 | 0.70 | 0.00 | 0.36 | 0.13 |
| Yellow Perch | 78 | 85 | 163 | 131.83 | 101.43 | 114.01 | 15.38 | 30.91 | 20.84 |
| Large Scale Sucker | 1 | 1 | 2 | 1.69 | 1.19 | 1.40 | 0.20 | 0.36 | 0.26 |
| TOTAL | 507 | 275 | 782 | 856.90 | 328.14 | 546.96 | 100.00 | 100.00 | 100.00 |

Appendix B. (Continued) Ambient fish population assessment electroshocking results for bay and mainstem habitats.

Winter 2008

| SPECIES | BAY TOTAL NUMBERS | RIVER TOTAL NUMBERS | TOT AL | BAY CPUE | RIVER CPUE | TOTAL SUMMER CPUE | BAY RELATIVE ABUNDANCE | RIVER RELATIVE ABUNDANCE | TOTAL RELATIVE ABUNDANCE |
|---|---|---|---|---|---|---|---|---|---|
| Black Crappie | 42 | 14 | 56 | 49.03 | 28.03 | 41.60 | 8.94 | 5.88 | 7.91 |
| Brown Bullhead | 3 | 1 | 4 | 3.50 | 2.00 | 2.97 | 0.64 | 0.42 | 0.56 |
| Large Mouth Bass | 54 | 38 | 92 | 63.04 | 76.08 | 68.35 | 11.49 | 15.97 | 12.99 |
| Small Mouth Bass | 1 | 0 | 1 | 1.17 | 0.00 | 0.74 | 0.21 | 0.00 | 0.14 |
| Long Nose Sucker | 3 | 3 | 6 | 3.50 | 6.01 | 4.46 | 0.64 | 1.26 | 0.85 |
| Northern Pikeminnow | 17 | 2 | 19 | 19.84 | 4.00 | 14.11 | 3.62 | 0.84 | 2.68 |
| Pumpkin Seed | 259 | 130 | 389 | 302.33 | 260.29 | 288.98 | 55.11 | 54.62 | 54.94 |
| Tench | 26 | 15 | 41 | 30.35 | 30.03 | 30.46 | 5.53 | 6.30 | 5.79 |
| Eastern Brook Trout | 3 | 0 | 3 | 3.50 | 0.00 | 2.23 | 0.64 | 0.00 | 0.42 |
| Yellow Perch | 62 | 35 | 97 | 72.37 | 70.08 | 72.06 | 13.19 | 14.71 | 13.70 |
| TOTAL | 470 | 238 | 708 | 548.64 | 476.53 | 525.96 | 100.00 | 100.00 | 100.00 |

Appendix B. (Continued) Ambient fish population assessment electroshocking results for bay and mainstem habitats.

| Spring 2009 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SPECIES | BAY TOTAL NUMBERS | RIVER TOTAL NUMBERS | TOT AL | BAY CPUE | RIVER CPUE | TOTAL SUMMER CPUE | BAY RELATIVE ABUNDANCE | RIVER RELATIVE ABUNDANCE | TOTAL RELATIVE ABUNDANCE |
| Black Crappie | 1 | 2 | 3 | 1.24 | 2.10 | 1.71 | 2.56 | 2.04 | 2.19 |
| Brown Bullhead | 1 | 1 | 2 | 1.24 | 1.05 | 1.14 | 2.56 | 1.02 | 1.46 |
| Large Mouth Bass | 1 | 20 | 21 | 1.24 | 21.00 | 11.96 | 2.56 | 20.41 | 15.33 |
| Small Mouth Bass | 0 | 6 | 6 | 0.00 | 6.30 | 3.42 | 0.00 | 6.12 | 4.38 |
| Long Nose Sucker | 0 | 1 | 1 | 0.00 | 1.05 | 0.57 | 0.00 | 1.02 | 0.73 |
| Pumpkin Seed | 3 | 40 | 43 | 3.73 | 42.01 | 24.49 | 7.69 | 40.82 | 31.39 |
| Tench | 2 | 2 | 4 | 2.49 | 2.10 | 2.28 | 5.13 | 2.04 | 2.92 |
| Rainbow trout | 0 | 2 | 2 | 0.00 | 2.10 | 1.14 | 0.00 | 2.04 | 1.46 |
| Mountain Whitefish | 1 | 0 | 1 | 1.24 | 0.00 | 0.57 | 2.56 | 0.00 | 0.73 |
| German Brown trout | 0 | 2 | 2 | 0.00 | 2.10 | 1.14 | 0.00 | 2.04 | 1.46 |
| Yellow Perch | 26 | 20 | 46 | 32.35 | 21.00 | 26.20 | 66.67 | 20.41 | 33.58 |
| Large Scale Sucker | 4 | 2 | 6 | 4.98 | 2.10 | 3.42 | 10.26 | 2.04 | 4.38 |
| TOTAL | 39 | 98 | 137 | 48.53 | 102.92 | 78.03 | 100.00 | 100.00 | 100.00 |

# ASSESSMENT OF HARVESTER IMPACTS AND SUGGESTED OPERATING PROCEDURES FOR THE INTERIM AQUATIC PLANT MANAGEMENT PLAN BOX CANYON RESERVOIR

**PUBLIC UTILITY DISTRICT NO. 1 OF PEND OREILLE COUNTY**
**NEWPORT, WASHINGTON**

**June 30, 2010**

# Executive Summary

Aquatic plant removal through rotovation and harvesting is the primary aquatic weed management tool used by the Pend Oreille County PUD (the District) to prevent the spread of Eurasian Water Milfoil (EWM) to surrounding bodies of water and provide safe, ascetically pleasing public recreation areas in Box Canyon Reservoir. To assess the potential environmental impacts (both positive and negative) and develop a list of Best Management Practices for the operation of the milfoil harvester the district designed and implemented three harvester specific impact studies. They included: harvester caused increases in turbidity, fish injury or mortality and plant fragmentation.

A brief summary of the impacts identified by each study and a list of recommended mitigation measures and Best Management Practices developed to address them are shown below.

**Recommended Mitigation Measures and Best Management Practices (BMP's)**

## *1.0 Turbidity*

While turbidity was slightly increased at three sites during harvesting, three of the four test sites remained below the state criteria for turbidity. The fourth, a main channel site, exceeded the state criteria by only 23 NTU for 20 minutes. Due to the small size and angular shape of the study plots these results reflect a worst case scenario of harvester caused turbidity. It is expected that under normal operation and by following the BMPs listed below, turbidity exceedances will be extremely rare. While periodic turbidity exceedances may not be completely avoided, operating the harvester in place of the rotovator under the following BMP's will reduce or eliminate turbidity exceedances throughout the warmer, summer months.

- Harvester operators will run the machine parallel to the shoreline, whenever possible to reduce prop-wash directed toward shore. When the harvester is operated perpendicular to the shoreline it will be done carefully as to limit the duration and force of near-shore prop wash.
- GIS and dGPS will be used to the full extent possible, to mark shallow areas when encountered, thus reducing repeat bottom contact thought the years of operation.
- At higher velocity sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and concentration of turbid water outside the work area. This strip will then be removed after upstream work is completed.

## *2.0 Fish Mortality*

Fish mortality caused by the harvester was studied for each species seasonally in both bay and mainstem habitat types. Mortality rates were compared to ambient species population composition and estimated total annual mortality was calculated per species. Total seasonal mortality for all species combined ranged from a high, during summer sampling, of 0.36 fish/m$^2$ (±0.27 SD) to a low, in late fall, of 0.15 fish/m$^2$ (±0.15 SD). Total annual mortality rate for all seasons and habitats combined was 0.23 fish/m$^2$ (±0.20 SD). The harvester is estimated to treat a maximum of 227,700 m$^2$/year, assuming 69 days of operation. Using the average total mortality rate (0.23 fish/m$^2$ or 931 fish /acre) provides an estimated daily maximum mortality of 796 fish /

day along with up to 153,000 pounds of milfoil/day harvested (9 hauls). Monthly mortality is approximately 15,920 fish that are approximately two inches in size or smaller.
The study indicated that the harvester is "selecting" the smaller individuals within each species affected. Likely this is due to its area of operation and swimming speed of small fish. The harvester's impact on all native fish species is very low compared to their relative abundance in the reservoir as a whole. Yellow perch and pumpkinseed comprised 61.5 % of the fish entrained by the harvester during these studies. No native salmonids were harvested during the tests.

Concerns addressed by the following BMP's regarding harvester induced fish mortality focus on the following priorities: First priority is to avoid any impacts to native salmonids (bull trout, westslope cutthroat trout and mountain whitefish). The second priority is reducing impacts to, or enhancing non-native sports fisheries through improved habitat complexity.

- To avoid contact and potential take of native salmonids, specifically ESA-listed bull trout, the District will operate the harvester only during the warm summer months, from July to mid–October, when it is extremely unlikely trout will be using the weed bed habitat.
- Harvester operators will continuously observe the conveyer belt to identify, recover and release any salmonid or other species of concern, if brought aboard. The crew will be instructed in fish identification and proper fish handling techniques and fish handling equipment will always be aboard the harvester and in good working condition.
- "Travel lanes" can be cut in dense beds of milfoil which may provide more escape opportunities for small fish during the milfoil harvest operation.
- Because fish mortality of the **rotovator** is extremely low, the District will use only the **rotovator** in locations (e.g. creek mouths) and during times of the year when native salmonids, or other species of concern, are more likely to be encountered (November through June).
- If at any time during operation, salmonids or other species of concern are collected, entrained, injured or killed, the fish will be photographed, and its location, date of capture and water temperature will be documented. These observations will be reported annually as part of the Aquatic Plant Management Plan annual report and submitted for agency and public review.
- To reduce impacts to bass spawning, harvesting will be avoided in sloughs, bays and back water areas during spring spawning.

### *3.0 Harvester induced Fragmentation*

Harvester caused fragmentation was studied at several sites and compared to the amount of naturally occurring auto-fragmentation that would have been produced at the same site for the duration of the season if the plant community had been left in place. The study showed that at all sites the harvester caused fragmentation was less than seasonal auto-fragmentation of an intact weed bed. The following BMP's are recommended to further reduce effects of both harvester caused fragmentation and auto- fragmentation.

- All aquatic vegetation removed by the harvester will be placed as far above the wetted perimeter of the reservoir as possible at the time of harvesting. The large pile size produced by the harvester keeps the piles stationary during normal reservoir fluctuations and through several seasons.
- The harvester has the ability to remove large amounts of milfoil every year from the Pend Oreille River with a relatively low level of operation-caused fragmentation. The District recommends the use of the harvester as much as possible targeting EWM and other non-native species, during the warm summer months when the risk of impacting native salmonid populations is low and bulk of the weed biomass is at/near the surface.
- One additional use of the harvester which may be employed in future years to combat the spread of milfoil through auto fragmentation is to operate the machine mid reservoir during the fall and spring peaks of auto fragmentation. The machine would passively pick up drifting rafts of aquatic vegetation as they floated down river before the free floating fragments have a chance to re-infest downstream habitats.
- As to the issue of turbidity, at higher velocity sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and fragmentation outside the work area. This strip will then be removed after upstream work is completed.

# TABLE OF CONTENTS

## TABLE OF TABLES



## TABLE OF FIGURES

# 1.0 INTRODUCTION

Pend Oreille County PUD #1(the District) has adopted an Interim Aquatic Plant Management Plan (IAPMP) that guides the management of aquatic plants in Box Canyon Reservoir (BCR). The IAPMP provides baseline data on aquatic plant distribution within BCR, describes the effects of past rotovation and harvesting efforts on aquatic resources by the County, and provides a foundation for the implementation of management strategies. Harvesting and rotovation have been identified as primary containment measures for aquatic plant management. Operation of these machines requires the District to secure a Hydraulic Project Approval (HPA). Washington Department of Fish and Wildlife (WDFW) issued a-one year renewable HPA and the County issued a five-year Shoreline Permit, both with the condition that studies be conducted to more completely assess the impacts of harvesting/rotovation on aquatic life. The requested studies include an assessment of:

- Turbidity levels relative to the water quality standards;
- Fish mortality due to harvesting, and
- Fragmentation of aquatic weeds due to harvesting;

The use of rotovation and harvesting of aquatic weed beds is common across the country for systems that have wide-spread aquatic weed infestations. Rotovation has been used in the BCR to control Eurasian water milfoil (EWM) since the 1980s. Recently, the County purchased a harvester machine to use with the rotovator when conditions allow. Each of the two machines works to remove milfoil in a different way. A brief description of how each machine works is provided below:

- Rotovation functions by entangling and pulling the underwater plants; starting near the upstream end of a weed bed, the rotovator moves from shore toward mid-channel. Working perpendicular to the flow, it pulls up plant root wads by entangling the stem and leaves winding them up on the rotovator head, which is rotating on or slightly above the substrate. The rotovator head is lowered, as needed, when the water deepens and the slow revolution of the rotovator head pushes the rotovator away from the shore. As the rotovator head and rakes fill with plant material, the rotovator returns to shore and back-spins the material off the rotovator heads onto the shore. This process continues, swath by swath, until the work area has been cleared.

- The harvester functions exactly like a land-based crop harvester. It starts either at the upstream end of the test plot, working perpendicular to the flow from mid-channel toward shore, or by moving parallel to the shore either upstream or downstream. The harvester sickle head can be positioned up to 6 ft under water, and is raised hydraulically to follow as closely as possible the bottom contours. The harvester sickle bar cuts the submerged plant material; conveyer belts load the cut material onto the storage platform conveyer on the back end of the vessel. When the harvester is fully loaded, it returns to shore and a conveyer off-loads the material in a single haystack-shaped pile onto shore. This process continues, swath by swath, until the work area has been cleared.

Due to different modes of operation of the two milfoil removal machines, the rotovator and harvester were studied independently. This report addresses the studies associated with the harvester; a separate report is being prepared for the rotovator studies.

This document will be incorporated into the IAPMP. All studies were managed and supervised by Mr. Scott Jungblom, Resource Biologist for Public Utility District No. 1 of Pend Oreille County. This report is broken into sections that detail the study area, methods and materials, measurements, results, and discussion for each of these assessments. Figure 1 shows the general location for all study areas by season. Appendix A provides a list of all the study sites within each seasonal study area, including which tests were completed at each site.

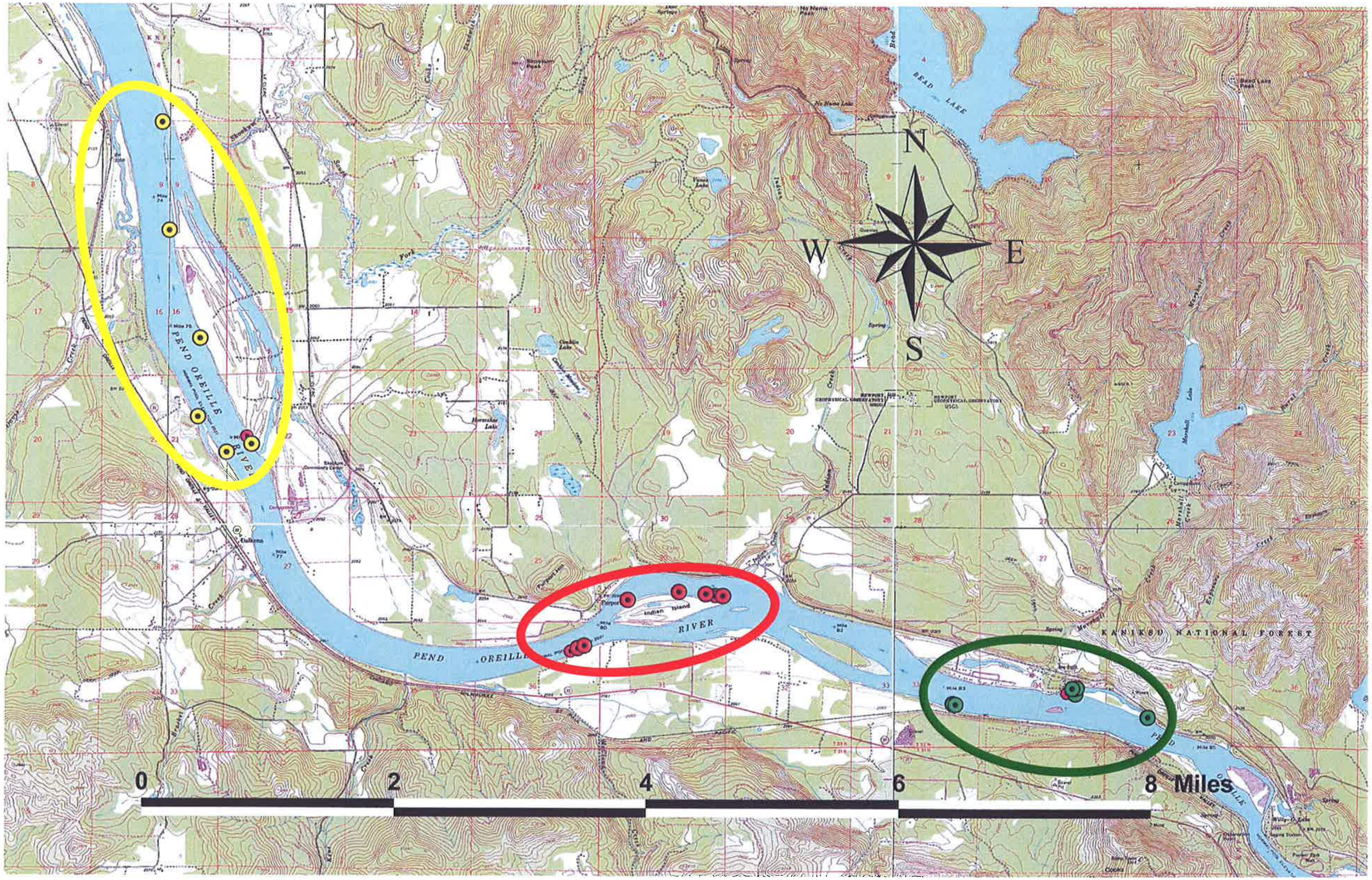



**Figure 1. Map showing seasonal sampling areas. Summer sample area shown in yellow, fall sample area shown in green, and late fall sample area shown in red.**

## 2.0 HARVESTER TURBIDITY STUDY

Aquatic harvesting has the potential to temporarily increase localized water turbidity in the Pend Oreille River during and immediately after operation. Turbidity levels were monitored before, during and after the harvesting process to analyze the potential for water quality exceedances. Washington State water quality standards provide for a temporary mixing zone subject to constraints specified in the Washington Administrative Code (**WAC 173-201a-200(1)(e)(i)).** For the Pend Oreille River, the acceptable exceedance value and point of compliance for turbidity is 10 NTU above background level as measured at a point 300 ft downstream of the harvester.

### 2.1 Study Area and Site Selection

The study area for this assessment is the BCR on the Pend Oreille River (WRIA 62), located in Pend Oreille County. Four specific study areas were determined in the field; site selection was based upon water velocity. Two sites were located in backwater sloughs or sheltered bays with little or no detectible water velocity. The remaining two sites were located in the mainstem Pend Oreille River in areas that produced velocities representative of main-channel weed-bed conditions at the time of sampling. One mainstem test was completed during the summer sample session near Everett Island at River Mile (RM) 76 (Figure 2). One bay site was completed during the fall sample session east of Sandy Shores at RM 84 (Figure 3). The remaining two sites, one bay and one main-channel, were studied in late fall around Indian Island at RM 80. Figure 4 shows the selected sites and associated placement of the turbidity meters for the two late fall turbidity tests.

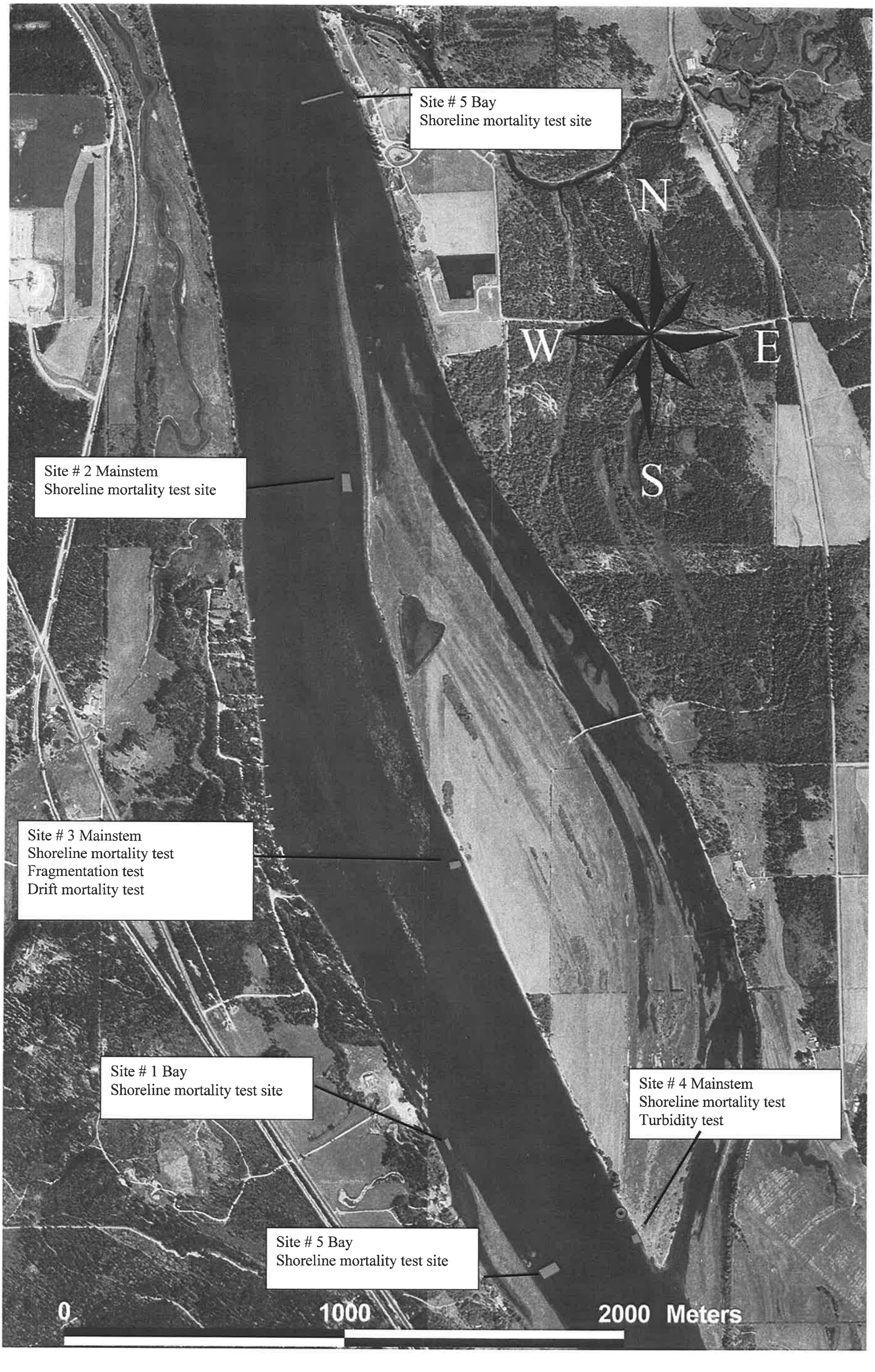



**Figure 2 Ortho photo showing the harvested area and specific tests completed for each sample site during summer sampling (green polygons). Pink points show locations of turbidity meters placed during summer turbidity testing.**

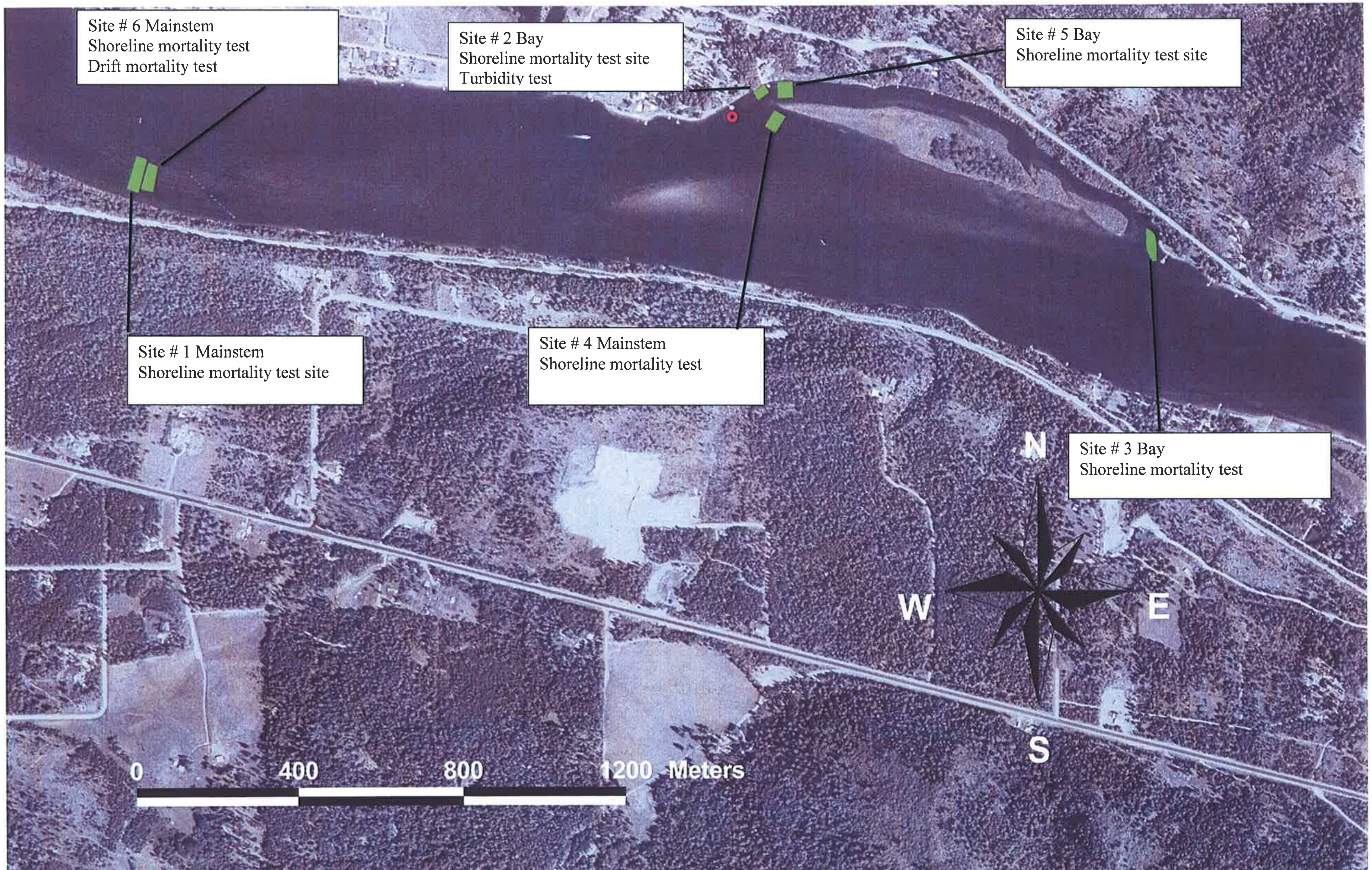



**Figure 3. Ortho photo showing the harvested area and specific tests completed for each sample site during fall sampling (green polygons). Pink points show locations of turbidity meters placed during fall turbidity testing.**


**Figure 4. Ortho photo showing the harvested area and specific tests completed for each sample site during late fall sampling (green polygons). Pink points show locations of turbidity meters placed during late fall turbidity testing.**

## 2.2 Methods and Materials

Turbidity was measured using a Hydrolab DataSonde 5 water quality sampler. Prior to beginning of the daily study, the instrument was calibrated according to the manufacturer's instructions. A nephelometer or desktop grab sample turbidity meter was first calibrated relative to four known standards. The calibrated nephelometer was then used to measure the turbidity of a grab sample from the river. A concurrent in-situ turbidity measurement was recorded by the Hydrolab. The instrument was considered properly calibrated when instrument readings were within 10% or 0.5 NTU (whichever was greater) of the standardized reading (calibrated nephelometer). Turbidity levels downstream of the harvester test site were recorded at 5-minute intervals for a period of up to two hours prior to the start of harvesting to establish baseline or background turbidity values.

### *2.2.1 Turbidity Instrument Placement*

One instrument was located 300 ft downstream of the middle of each 100-ft study site to represent the end of a mixing zone, as established by WAC 173-201A-200(1)(e)(i). Instruments were deployed approximately 3 ft below the surface. Instrument locations were monitored throughout each study and moved laterally, or perpendicular to the shore line when needed, to ensure the instrument's location was in the center of any visible plume. Distances from the work area were measured by GPS (with differential correction - dGPS).

### *2.2.2 Instrument Measurements*

Turbidity was measured and recorded every five minutes at each station. Monitoring extended up to four hours after the conclusion of harvesting the test site, or to a time when the downstream turbidity measurements were 10 NTU or less from background levels (levels typical for the Pend Oreille River are < 5 NTU).

## 2.3 Results

Four turbidity tests, (two bay and two main channel sites) were completed in 2009. One main channel site was harvested during the summer sample session on August 26, one bay site in the fall sample period on September 22, and two test sites (one bay and one main channel) during the late fall sampling on October 14. Mean background levels for the bay sites were 0.88 NTU (SE = 0.06, n=13) and 1.26 NTU (SE = 0.06, n=7). Experimental maximum values for the two bay sites were 1.0 and 5.5 NTU respectively, neither of which exceeded the 10 NTU above background level criteria (See Figures 5 and 6).


**Figure 5. Turbidity measured at Bay Site #2 during fall 2009 sampling. Light grey box indicates time of harvesting.**

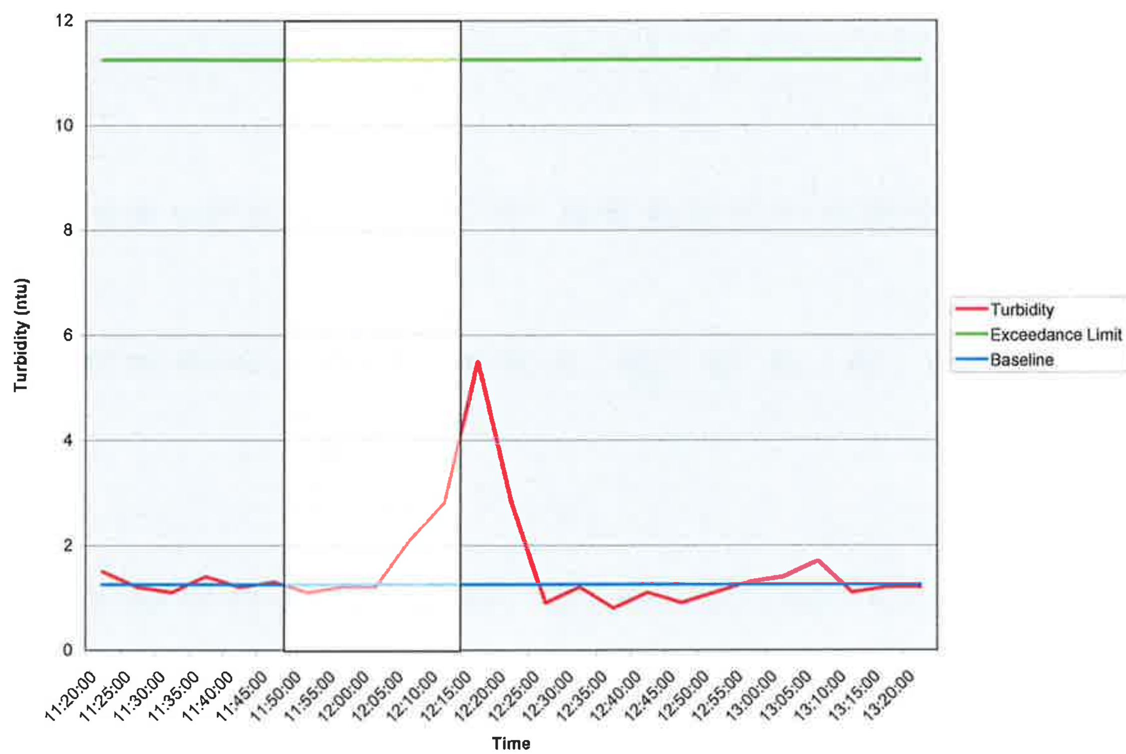



**Figure 6. Turbidity measured at Bay Site # 6 during late fall 2009 sampling. Light grey box indicates time of harvesting.**

Mean background levels for the mainstem sites were 0.46 NTU (SE = 0.09, n=30) and 3.01 NTU (SE = .29, n=13) (see Figures 7 and 8). Experimental maximum values for the two main channel sites were 3.4 and 34.9 NTU respectively. Of the samples taken, only the late fall sample exceeded the 10 NTU above background level criteria. This exceedence level started 36 min after the harvester started work in the study area, and turbidity levels remained elevated for a total of 20 minutes before dropping back below 10 NTU above base line. During this 20-minute period of exceedance, the average turbidity was 22.9 NTU (SE=3.8, n=5).

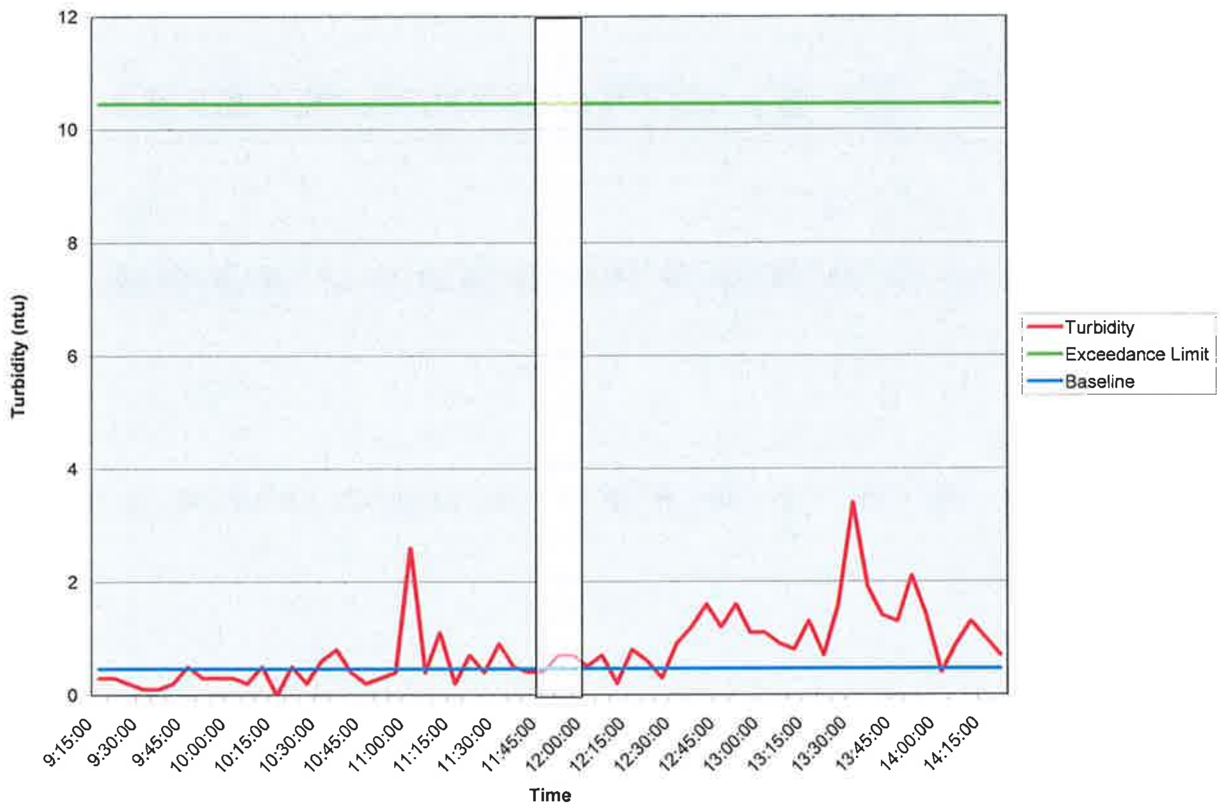



**Figure 7. Turbidity measured at Mainstem Site # 4 during summer 2009 sampling. Light grey box indicates time of harvesting.**

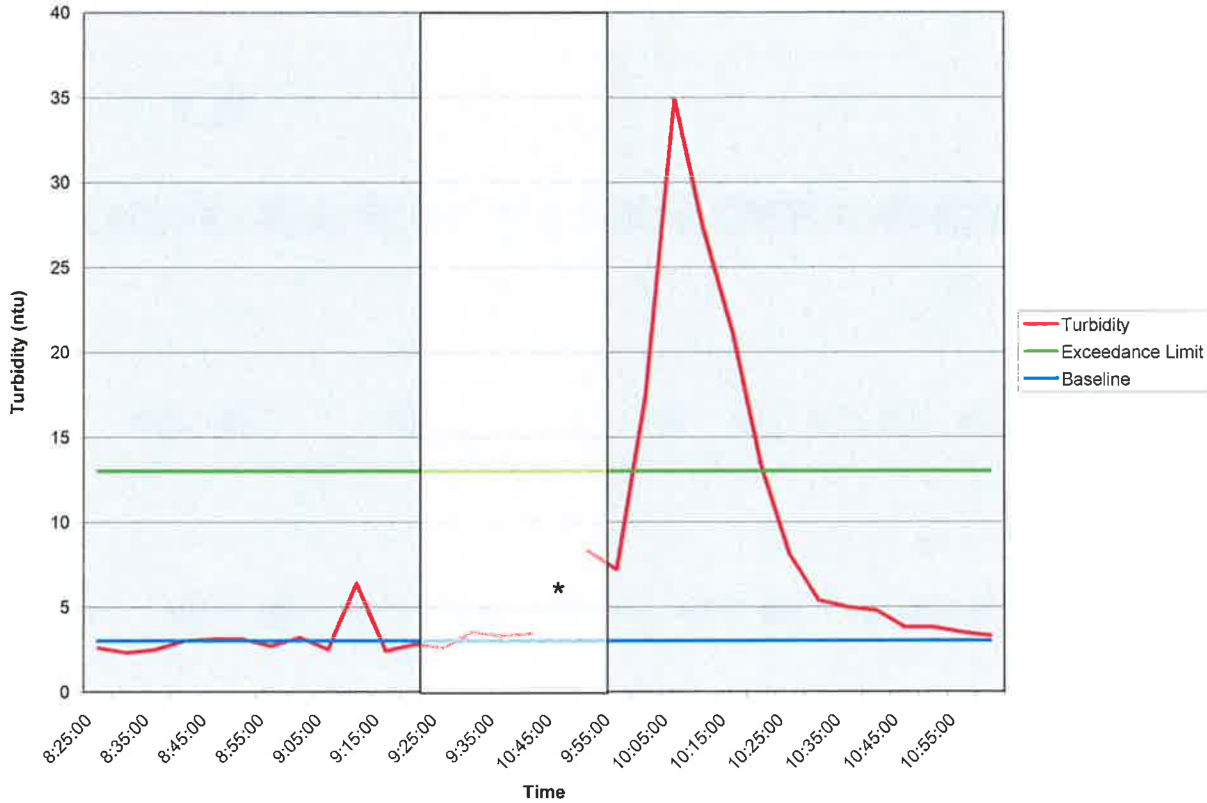



**Figure 8. Turbidity measured at Mainstem Site # 6 during late fall 2009 sampling. Light grey box indicates time of harvesting. The * shows a missing data point reflecting when the meter was moved**

## 2.4 Discussion

Due to the small size and angular shape of the study plots these results reflect a worst case scenario of harvester caused turbidity. It is expected that under normal operation turbidity exceedances will be extremely rare.

While turbidity was slightly increased at all sites during harvesting, three of the four test sites remained below the state criteria at the mixing zone. The fourth, a main channel site, exceeded the state criteria by 23 NTU for 20 minutes. Although higher velocities at the mainstem sites carried suspended solids past the mixing zone before they could dissipate, the turbidity cleared the active site of harvesting in a shorter period of time than the bay sites. At no time did a turbidity plume appear to affect both shorelines.

Localized turbidity increased visibly during two different activities while the harvester operated. When the harvester sickle made contact with the channel bottom, turbidity would increase. Regardless of location or study site type, sediment was lifted up the conveyer belt and released higher in the water column when contact with the substrate was made. As bottom contact puts the harvester in jeopardy of severe damage, the crew is working with new equipment specifically, real time DGPS tracking and GIS data logging to mark bottom profiles and flow dependent depths to enable them to better avoid bottom contact in future years. The second action contributing to elevated turbidity levels was halting the forward momentum of the harvester by reversing the paddle direction at the end of each pass, if running perpendicular to the shore. This action sends prop wash toward shore and near-shore substrate.

### *2.4.1 Turbidity Reduction Measures*

Higher turbidity values observed at main channel sites cannot be completely avoided. Exceedances should be reduced by operating the harvester parallel to the shore whenever possible. Also care should be taken when operating perpendicular to the shoreline where necessary (i.e. boat launches, docks set close together, or around water hazards) so as to limit the duration and force of near-shore prop wash. The drawbacks to harvesting parallel to shore are that a strip of vegetation is often left untreated due to shallow water, and parallel swaths are not always a viable option in areas smaller than 300 feet in length due to the limits of maneuverability of the machine.

At higher velocity mainstem sites a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and concentration of turbid water passing outside the work area. This strip will then be removed after upstream work is completed.

## 3.0 HARVESTING AND FISH MORTALITY STUDIES

The extent of mortality to fish populations caused by aquatic harvesting was widely unknown. It has been suggested that fish could be: 1) trapped in the aquatic vegetation as it is collected on the harvester and deposited on the shoreline, or 2) injured by the machine and drift away from the work site. To evaluate injury and mortality during harvesting, the District sampled both the harvested vegetation and the water flowing away from the worksite.

### 3.1 Study Area and Site Selection

For the fish mortality studies, the District sampled the same two habitat types on the BCR as described above in the turbidity study:

1. Backwater slough or sheltered bay with little or no detectible water velocity; and
2. Primary channel or mainstem Pend Oreille River, where higher velocities are present.

Sampling occurred over a three-month period, in order to determine the vulnerability of particular life stages to the harvesting process. The District selected three similar sites per habitat type for each of three seasonal sample sessions (summer, July – August, Figure 2; fall, September, Figure 3; and late fall, October, Figure 4). Due to the mechanical limitations of the harvester (primarily frozen conveyer belts) and its limited operating depth of 6 feet, the harvester only functions appropriately after spring runoff subsides and new aquatic growth approaches the water surface(mid June to July). Plant beds die back substantially in the late fall. This die-off marks the end of the harvesting window typically around the end of October.

## 3.2 Methods and Materials

### *3.2.1 Fish Presence in Vegetation*

Little data existed on seasonal fish species, distribution, and populations utilizing weed bed habitat of the Pend Oreille River. To establish baseline data, the District electrofished weed beds and margins the week before or after harvesting adjacent to, or across from, study area plots. Depending on weed bed density, time sampled per study area varied from 750 - 2042 shocking seconds. Larger, denser, weed beds were electrofished for longer periods of time. Boat electrofishing started at the downstream end of a weed bed and progressed upstream, spending roughly one third of the shocking time on each of the outer and inner weed bed margins and the last third shocking back and forth across the middle of the weed bed.

### *3.2.2 Determination of Sample Area and Estimated Mortality*

Sample areas were delineated with buoys and/or shoreline stakes prior to the start of each study. The area ($m^2$) of the test plot for small weed beds or subsection of larger weed beds was calculated by using a dGPS with sub-meter accuracy. Any fish mortality observed was expressed as the number of fish /$m^2$ of weed bed harvested. The aquatic plant bed was removed using standard methods established for the harvester, as described in Section 1.

### *3.2.3 Netting (Drift Mortality)*

A barrier seine was deployed during one primary channel site test per season to detect the presence of fish that may have become injured or killed, and drifted away from the harvester during treatment rather than being deposited on shore. The net was deployed immediately downstream from the project area. It extended from the shore out toward the middle of the river, past the influence of the test plot. The block net was 18' deep *X* 100' long with ¼" mesh size. The net was deployed prior to initiation of harvesting and remained deployed up to four hours after the area was harvested. After the harvested area had cleared and all drifting debris had reached the net, the net was hauled into shore and the contents inspected for dead or injured fish. All fish collected were inspected for signs of injury or abnormal behavior before release. All dead or injured fish collected were identified to species, and fork length was recorded.

### *3.2.4 Shoreline Mortality*

All vegetation removed from each site or sample plot was deposited in a pile or single layer strip along the shore. Fish mortality was measured by the physical sorting and visual evaluation of the full shore line vegetation pile or a randomly selected, subsample of the deposited vegetation from each site.

The vegetation processed from each site was rinsed in a white bottom tote or bucket filled with water to free any loose fish, then visually inspected by spreading the vegetation out in a thin layer on a white sorting table. Before disposal all rinse water was strained through ¼" mesh net and the contents inspected for fish and fish fragments. Species and fork length were recorded for all fish (live or dead) or fish fragments collected from the shoreline samples. The volume of aquatic weeds sorted at each site was measured in gallons.

Varying width, depth, and shape of the weed bed make expressing mortality for a given length of shoreline harvested impractical. All fish collected were identified to species and presented as the average number of organisms entrained/m$^2$ by species, habitat type, and season. The following example describes how this value was calculated.

Example:

**Table 3.1 Example Calculations for Fish Mortality at Each Site**

| Species Entrained | Subsample 1 | Subsample 2 |
|---|---|---|
| Largemouth Bass | 5 | 2 |
| Northern Pikeminnow | 3 | 7 |
| Total Sample Area (m$^2$) | 200 | |
| % of Total Sample | 10 | 10 |

1) The total number of largemouth bass entrained in the sample area is calculated as follows:

   Total Number of largemouth bass/sample = (5 + 2)/(.1 + .1) = 35

2) The number of largemouth bass per square meter is calculated by dividing the number calculated in step 1 by the total area of the site:

   Number of largemouth bass/m$^2$ = 35/200 = 0.175 largemouth bass/m$^2$

Species compositions of these samples were compared to the site-specific measurements of seasonal ambient fish species composition using the weed bed habitat use data collected prior to harvesting. Only measures of % species composition or relative abundance were compared between ambient populations and harvester mortality because it was not possible to accurately estimate population densities per species seasonally, in each project area, during this study.

3.2.4.1 Shoreline Mortality Visual Estimates

A visual estimate of total mortality was made for each shoreline mortality sample site by counting all the fish visibly entrained or brought up the conveyer belt and deposited in the vegetation pile. This visual total mortality estimate was made by the copilot from the pilot house and was not enumerated by species or length.

## 3.3 Results

### *3.3.1 Fish Presence in Vegetation*

Boat electroshocking was completed for both the summer and fall sample sessions on August 27, and September 23, respectively. Collection occurred at three bay and three mainstem weed beds adjacent to harvester test sites during each of the two sample dates. No ambient fish data were collected during the late fall sample session due to its proximity, both geographic and temporal, to the fall sample session. Total number, catch per unit effort (CPUE) and relative abundance of each species are shown in Table 3.2. Fork lengths of fish collected at each site are listed by season and habitat type in Appendix B.

**Table 3.2 Species composition of fish collected during electroshocking by season.**

| Summer Summary | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Number Collected | | | Catch Per Unit Effort (#/Hour) | | | Relative Abundance (% Species Composition) | | |
| Species | Bay | Mainstem | Total | Bay | Mainstem | Total | Bay | Mainstem | Total |
| Black Crappie | 5 | 2 | 7 | 5.22 | 2.57 | 4.03 | 1.16 | 0.67 | 0.96 |
| Brown Bullhead | 1 | 0 | 1 | 1.04 | 0.00 | 0.58 | 0.23 | 0.00 | 0.14 |
| Large Mouth Bass | 56 | 17 | 73 | 58.50 | 21.80 | 42.03 | 12.99 | 5.69 | 10.00 |
| Northern Pike | 6 | 1 | 7 | 6.27 | 1.28 | 4.03 | 1.39 | 0.33 | 0.96 |
| Pumpkin Seed | 97 | 23 | 120 | 101.33 | 29.50 | 69.09 | 22.51 | 7.69 | 16.44 |
| Small Mouth Bass | 1 | 3 | 4 | 1.04 | 3.85 | 2.30 | 0.23 | 1.00 | 0.55 |
| Tench | 23 | 7 | 30 | 24.03 | 8.98 | 17.27 | 5.34 | 2.34 | 4.11 |
| Yellow Perch | 242 | 246 | 488 | 252.81 | 315.50 | 280.95 | 56.15 | 82.27 | 66.85 |
| Summer Total | 431 | 299 | 730 | 450.26 | 383.47 | 420.28 | 100.00 | 100.00 | 100.00 |

| Fall Summary | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Number Collected | | | Catch Per Unit Effort | | | Relative Abundance (% Species Composition) | | |
| Species | Bay | Mainstem | Total | Bay | Mainstem | Total | Bay | Mainstem | Total |
| Black Crappie | 33 | 6 | 39 | 45.85 | 11.34 | 31.23 | 6.61 | 4.38 | 6.13 |
| Bridge Lipped Sucker | 1 | 0 | 1 | 1.39 | 0.00 | 0.80 | 0.20 | 0.00 | 0.16 |
| Brown Bullhead | 8 | 0 | 8 | 11.12 | 0.00 | 6.41 | 1.60 | 0.00 | 1.26 |
| Large Mouth Bass | 50 | 20 | 70 | 69.47 | 37.80 | 56.05 | 10.02 | 14.60 | 11.01 |
| Large Scale Sucker | 9 | 28 | 37 | 12.50 | 52.91 | 29.63 | 1.80 | 20.44 | 5.82 |
| Long Nosed Sucker | 3 | 0 | 3 | 4.17 | 0.00 | 2.40 | 0.60 | 0.00 | 0.47 |
| Northern Pike | 2 | 0 | 2 | 2.78 | 0.00 | 1.60 | 0.40 | 0.00 | 0.31 |
| Pumpkin Seed | 140 | 9 | 149 | 194.52 | 17.01 | 119.31 | 28.06 | 6.57 | 23.43 |
| Small Mouth Bass | 1 | 1 | 2 | 1.39 | 1.89 | 1.60 | 0.20 | 0.73 | 0.31 |
| Tench | 57 | 14 | 71 | 79.20 | 26.46 | 56.85 | 11.42 | 10.22 | 11.16 |
| Yellow Perch | 193 | 40 | 233 | 268.16 | 75.59 | 186.57 | 38.68 | 29.20 | 36.64 |
| Northern Pike Minnow | 2 | 19 | 21 | 2.78 | 35.91 | 16.81 | 0.40 | 13.87 | 3.30 |
| Fall Total | 499 | 137 | 636 | 693.32 | 258.89 | 509.25 | 100 | 100 | 100 |

### *3.3.2 Fish Mortality in the Drift*

No dead or injured fish were recovered from the drift net sets during any sample, regardless of season.

### *3.3.3 Shoreline Mortality*

3.3.3.1 Summer Sample Period

Shoreline mortality samples were collected during the week of August 24. Three bay sites and three main channel sites were processed for shore mortality (Figure 2). The average mortality for bay sites was 0.26 fish/m$^2$ ± 0.32 SD, the maximum mortality of shoreline samples was 0.63 fish/m$^2$. The average mortality for main channel sites was 0.47 fish/m$^2$ (± 0.22 SD), with a maximum of 0.67 fish/m$^2$. The average mortality for all summer sites was 0.36 fish/m$^2$ (± 0.27 SD). A summary of shoreline mortality in fish/m$^2$ and relative abundance of summer bay, mainstem and all combined habitat shoreline mortality per species is shown in Table 3.3.

**Table 3.3 Summer 2009 shoreline mortality by habitat type.**

| | Fish/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| **Species** | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| **Summer Bay Sites** | | | | | |
| Brown Bullhead | 0.0027 | 0.0046 | 0.0080 | 0.0080 | 0.86 |
| Black Crappie | 0.0063 | 0.0057 | 0.0110 | 0.0110 | 3.02 |
| Large Mouth Bass | 0.0413 | 0.0158 | 0.0294 | 0.0527 | 21.12 |
| Northern Pike | 0.0027 | 0.0046 | 0.0080 | 0.0080 | 0.86 |
| Pumpkin Seed | 0.0243 | 0.0242 | 0.0452 | 0.0518 | 10.34 |
| Small Mouth Bass | 0.0007 | 0.0013 | 0.0022 | 0.0022 | 0.43 |
| Tench | 0.0214 | 0.0333 | 0.0598 | 0.0598 | 7.33 |
| Yellow Perch | 0.1619 | 0.2534 | 0.4413 | 0.4545 | 56.03 |
| Bay Total | 0.2612 | 0.3267 | 0.5822 | 0.6379 | 100.00 |
| **Summer Mainstem Sites** | | | | | |
| Black Crappie | 0.0051 | 0.0089 | 0.0154 | 0.0154 | 1.19 |
| Large Mouth Bass | 0.1473 | 0.2288 | 0.3965 | 0.4116 | 28.06 |
| Pumpkin Seed | 0.0389 | 0.0326 | 0.0610 | 0.0760 | 7.91 |
| Tench | 0.0106 | 0.0183 | 0.0317 | 0.0317 | 1.98 |
| Yellow Perch | 0.2715 | 0.1494 | 0.2825 | 0.4408 | 60.87 |
| Mainstem Total | 0.4733 | 0.2171 | 0.4322 | 0.6775 | 100.00 |
| **Summer All Sites** | | | | | |
| Brown Bullhead | 0.0013 | 0.0033 | 0.0080 | 0.0080 | 0.41 |
| Black Crappie | 0.0057 | 0.0067 | 0.0154 | 0.0154 | 2.06 |
| Large Mouth | 0.0943 | 0.1563 | 0.3965 | 0.4116 | 24.74 |

| | Fish/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| **Species** | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| Bass | | | | | |
| Northern Pike | 0.0013 | 0.0033 | 0.0080 | 0.0080 | 0.41 |
| Pumpkin Seed | 0.0316 | 0.0269 | 0.0694 | 0.0760 | 9.07 |
| Small Mouth Bass | 0.0004 | 0.0009 | 0.0022 | 0.0022 | 0.21 |
| Tench | 0.0160 | 0.0248 | 0.0598 | 0.0598 | 4.54 |
| Yellow Perch | 0.2167 | 0.1955 | 0.4413 | 0.4545 | 58.56 |
| Summer Total | 0.3673 | 0.2739 | 0.6219 | 0.6775 | 100.00 |

During summer shoreline mortality testing, only 8 fish had a fork length $\geq$150 mm; the largest fish collected was a brown bullhead (254 mm) (Appendix C). No salmonids were collected or observed at any time during summer sampling. Appendix C provides a list of all fish recovered from shoreline samples sorted by season, habitat type, site, species and fork length.

A comparison of % species composition or relative abundance of fish collect in the shoreline mortality samples and ambient fish collections (electroshocking) is shown in Figure 9. A complete list comparing relative abundance of species present in shoreline samples to the relative abundance of species present in ambient populations is shown by habitat type in Table 3.4.

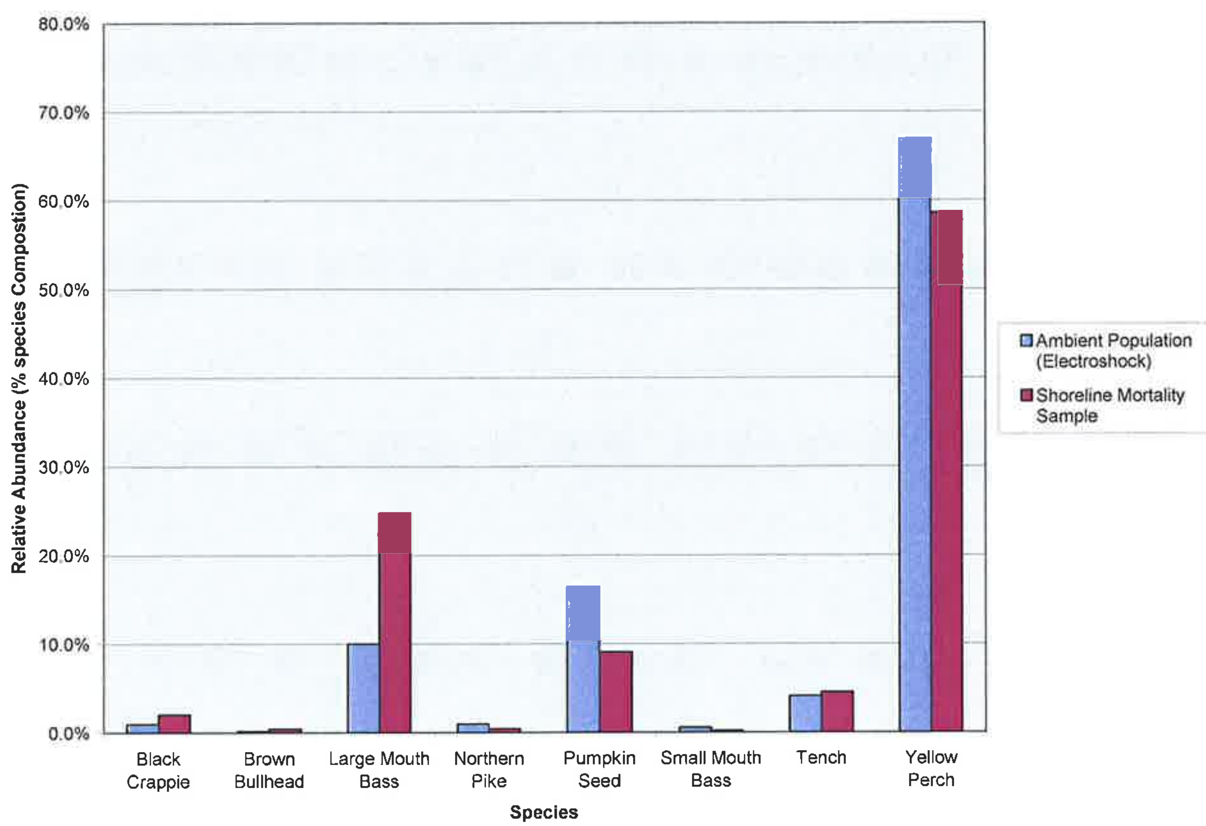



**Figure 9. Relative abundance of pooled bay and mainstem shoreline mortality samples and adjacent ambient fish populations, summer 2009.**

The top three most abundant fish in both electroshocking samples and shoreline mortality samples were yellow perch, pumpkin seed and large mouth bass.

**Table 3.4 Relative Abundance of fish collected in summer shoreline samples and associated electrofishing.**

| Species | Bay Ambient Population | Bay Shoreline Mortality | Mainstem Ambient Population | Mainstem Shoreline Mortality | Total Ambient Population | Total Shoreline Mortality |
|---|---|---|---|---|---|---|
| Black Crappie | 1.16 | 3.02 | 0.67 | 1.19 | 0.96 | 2.06 |
| Brown Bullhead | 0.23 | 0.86 | 0.00 | 0.00 | 0.14 | 0.41 |
| Large Mouth Bass | 12.99 | 21.12 | 5.69 | 28.06 | 10.00 | 24.74 |
| Northern Pike | 1.39 | 0.86 | 0.33 | 0.00 | 0.96 | 0.41 |
| Pumpkin Seed | 22.51 | 10.34 | 7.69 | 7.91 | 16.44 | 9.07 |
| Small Mouth Bass | 0.23 | 0.43 | 1.00 | 0.00 | 0.55 | 0.21 |
| Tench | 5.34 | 7.73 | 2.34 | 1.98 | 4.11 | 4.54 |
| Yellow Perch | 56.15 | 56.03 | 82.27 | 60.87 | 66.85 | 58.56 |

3.3.3.2 Fall Sample Period

Shoreline mortality samples were collected during the week of September 22. Three bay sites and three main channel sites were processed for shore mortality (Figure 3). The average mortality for bay sites was 0.19 fish/m$^2$ (± 0.11 SD), with a maximum of 0.31 fish/m$^2$. The average mortality for mainstem sites was 0.16 fish/m$^2$ (± 0.11 SD), with a maximum of 0.28 fish/m$^2$. The average mortality for all fall sites was 0.17 fish/m$^2$ (± 0.10 SD). A summary of shoreline mortality in fish/m$^2$ and relative abundance of fall bay, mainstem and all combined habitat shoreline mortality per species is shown in Table 3.5.

**Table 3.5. Fall 2009 shoreline mortality by habitat type.**

| | Mortality/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| | Mean | Standard Deviation | Range | Maximum | % by Number |
| Fall Bay Sites | | | | | |
| Brown Bullhead | 0.0166 | 0.0183 | 0.0363 | 0.0363 | 8.72 |
| Black Crappie | 0.0329 | 0.0174 | 0.0324 | 0.0527 | 18.12 |
| Large Mouth Bass | 0.0175 | 0.0099 | 0.0196 | 0.0264 | 10.07 |
| Pumpkin Seed | 0.0145 | 0.0120 | 0.0239 | 0.0271 | 6.04 |
| Tench | 0.0416 | 0.0188 | 0.0357 | 0.0560 | 23.49 |
| Yellow Perch | 0.0630 | 0.0615 | 0.1221 | 0.1285 | 32.89 |
| Small Mouth Bass | 0.0023 | 0.0039 | 0.0068 | 0.0068 | 0.67 |

| | Mortality/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| | Mean | Standard Deviation | Range | Maximum | % by Number |
| Bay Total | 0.1884 | 0.1105 | 0.2101 | 0.3131 | 100 |
| **Fall Mainstem Sites** | | | | | |
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| Brown Bullhead | 0.0009 | 0.0015 | 0.0027 | 0.0027 | 0.60 |
| Black Crappie | 0.0398 | 0.0376 | 0.0695 | 0.0828 | 23.95 |
| Large Mouth Bass | 0.0209 | 0.0154 | 0.0303 | 0.0345 | 12.57 |
| Largescale Sucker | 0.0067 | 0.0075 | 0.0149 | 0.0149 | 5.39 |
| Pumpkin Seed | 0.0231 | 0.0112 | 0.0201 | 0.0361 | 16.77 |
| Tench | 0.0321 | 0.0057 | 0.0113 | 0.0379 | 21.56 |
| Yellow Perch | 0.0368 | 0.0637 | 0.1104 | 0.1104 | 19.16 |
| Mainstem total | 0.1604 | 0.1067 | 0.1950 | 0.2829 | 100 |
| **Fall All Sites** | | | | | |
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| Brown Bullhead | 0.0087 | 0.0145 | 0.0363 | 0.0363 | 4.43 |
| Black Crappie | 0.0364 | 0.0264 | 0.0695 | 0.0828 | 21.20 |
| Large Mouth Bass | 0.0192 | 0.0117 | 0.0303 | 0.0345 | 11.39 |
| Largescale Sucker | 0.0034 | 0.0060 | 0.0149 | 0.0149 | 2.85 |
| Pumpkin Seed | 0.0188 | 0.0114 | 0.0328 | 0.0361 | 11.71 |
| Tench | 0.0368 | 0.0134 | 0.0357 | 0.0560 | 22.47 |
| Yellow Perch | 0.0499 | 0.0578 | 0.1285 | 0.1285 | 25.63 |
| Small Mouth Bass | 0.0011 | 0.0028 | 0.0068 | 0.0068 | 0.32 |
| Fall Total | 0.1744 | 0.0983 | 0.2253 | 0.3131 | 100 |

No fish were collected during fall shoreline mortality testing with a fork length ≥150 mm, and the largest fish collected was a yellow perch at 120 mm (Appendix C). No salmonids were collected or observed at any time during fall sampling.

A comparison of % species composition or relative abundance of fish collected in the shoreline mortality samples and ambient fish collections (electroshocking) is shown in Figure 10.

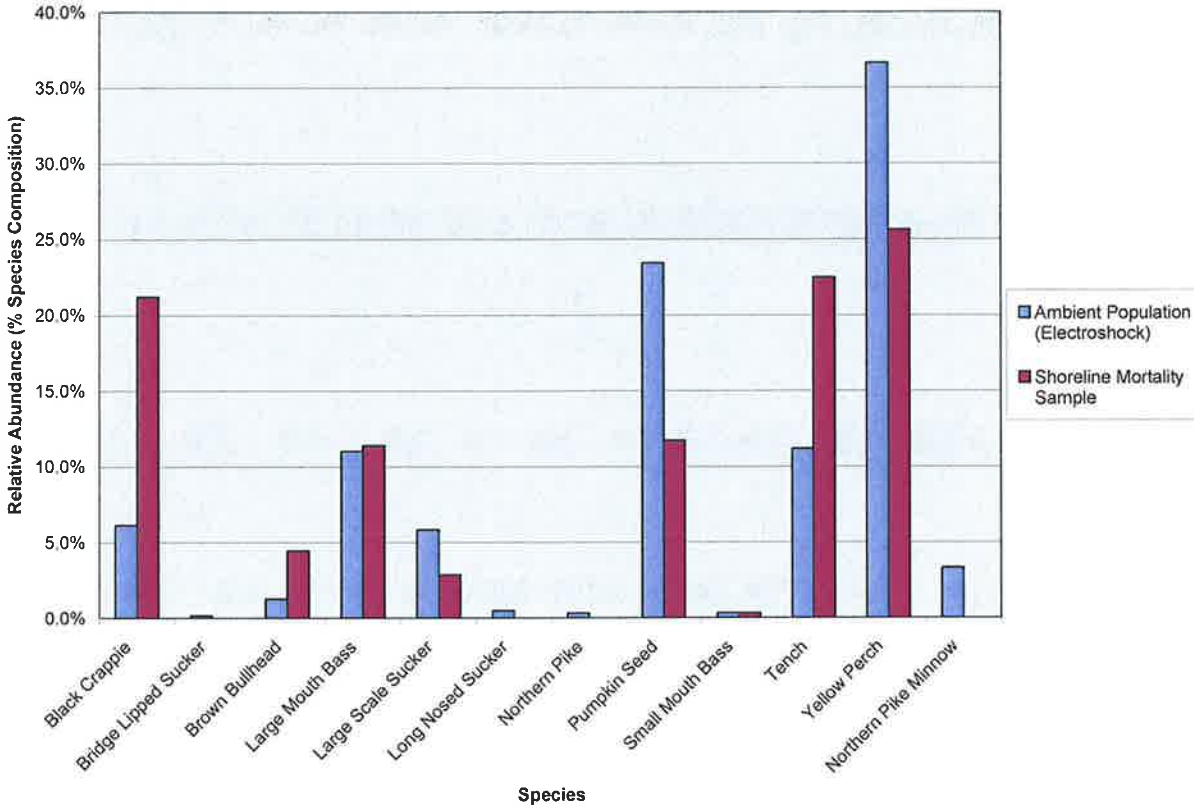



**Figure 10. Relative abundance of pooled bay and mainstem shoreline mortality samples and adjacent ambient fish populations, for fall 2009.**

The three most abundant fish in fall shoreline mortality samples were yellow perch, black crappie and tench; ambient fish populations in fall bay habitats were composed mostly of yellow perch, pumpkinseed and tench. The three most abundant species in ambient mainstem habitats were yellow perch, largemouth bass and large scale suckers. A complete list comparing relative abundance of species present in shoreline samples to the relative abundance of ambient populations collected during electroshocking is shown by habitat type in Table 3.6.

**Table 3.6 Relative Abundance of fish collected in fall 2009 shoreline samples and associated electrofishing.**

| Species | Bay Ambient Population | Bay Shoreline Mortality | Mainstem Ambient Population | Mainstem Shoreline Mortality | Total Ambient Population | Total Shoreline Mortality |
|---|---|---|---|---|---|---|
| Black Crappie | 6.61 | 18.12 | 4.38 | 23.95 | 6.13 | 21.20 |
| Bridgelip Sucker | 0.20 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 |
| Brown Bullhead | 1.60 | 8.72 | 0.00 | 0.60 | 1.26 | 4.43 |
| Large Mouth Bass | 10.02 | 10.07 | 14.60 | 12.57 | 11.01 | 11.39 |

| Species | Bay Ambient Population | Bay Shoreline Mortality | Mainstem Ambient Population | Mainstem Shoreline Mortality | Total Ambient Population | Total Shoreline Mortality |
|---|---|---|---|---|---|---|
| Largescale Sucker | 1.80 | 0.00 | 20.44 | 5.39 | 5.82 | 2.85 |
| Longnose Sucker | 0.60 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 |
| Northern Pike | 0.40 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 |
| Pumpkin Seed | 28.06 | 6.04 | 6.57 | 16.77 | 23.43 | 11.71 |
| Small Mouth Bass | 0.20 | 0.67 | 0.73 | 0.00 | 0.31 | 0.32 |
| Tench | 11.42 | 23.49 | 10.22 | 21.56 | 11.16 | 22.47 |
| Yellow Perch | 38.68 | 32.89 | 29.20 | 19.16 | 36.64 | 25.63 |
| Northern Pike Minnow | 0.40 | 0.00 | 13.87 | 0.00 | 3.30 | 0.00 |

3.3.3.3 Late Fall Sample Period

Late fall shoreline mortality samples were collected during the week of October 13. Three bay sites and three main channel sites were processed for shore mortality (Figure 4). The average mortality for bay sites was 0.26 fish/m$^2$ (± 0.14 SD), with a maximum of 0.34 fish/m$^2$. The average mortality for mainstem sites was 0.03 fish/m$^2$ (± 0.02 SD), with a maximum of 0.05 fish/m$^2$. The average mortality for all late fall sites was 0.15 fish/m$^2$ (± 0.15 SD). A summary of shoreline mortality in fish/m$^2$ and relative abundance of late fall bay, mainstem and combined habitat shoreline mortality per species is shown in Table 3.7.

**Table 3.7 Late Fall 2009 shoreline mortality by habitat type.**

| | Mortality/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| **Late Fall Bay Sites** | | | | | |
| *Brown Bullhead* | 0.0057 | 0.0052 | 0.0101 | 0.0101 | 2.24 |
| *Black Crappie* | 0.0196 | 0.0083 | 0.0163 | 0.0270 | 7.17 |
| *Large Mouth Bass* | 0.0176 | 0.0074 | 0.0148 | 0.0254 | 6.28 |
| *Longnose Sucker* | 0.0014 | 0.0024 | 0.0042 | 0.0042 | 0.45 |
| *Pumpkinseed* | 0.1540 | 0.1080 | 0.2138 | 0.2520 | 58.74 |
| *Small Mouth Bass* | 0.0014 | 0.0024 | 0.0042 | 0.0042 | 0.45 |
| *Tench* | 0.0252 | 0.0237 | 0.0472 | 0.0472 | 9.87 |
| *Yellow Perch* | 0.0385 | 0.0275 | 0.0547 | 0.0674 | 14.80 |

| | Mortality/m$^2$ | | | | Relative Abundance |
|---|---|---|---|---|---|
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| *Bay Total* | 0.2635 | 0.1365 | 0.2383 | 0.3442 | 100.00 |
| **Late Fall Mainstem Sites** | | | | | |
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| *Black Crappie* | 0.0015 | 0.0025 | 0.0044 | 0.0044 | 4.00 |
| *Large Mouth Bass* | 0.0077 | 0.0068 | 0.0132 | 0.0132 | 20.00 |
| *Pumpkinseed* | 0.0205 | 0.0078 | 0.0147 | 0.0294 | 52.00 |
| *Tench* | 0.0015 | 0.0025 | 0.0044 | 0.0044 | 4.00 |
| *Yellow Perch* | 0.0077 | 0.0068 | 0.0132 | 0.0132 | 20.00 |
| *Mainstem Total* | 0.0388 | 0.0210 | 0.0380 | 0.0527 | 100.00 |
| **Late Fall All Sites** | | | | | |
| | **Mean** | **Standard Deviation** | **Range** | **Maximum** | **% by Number** |
| *Brown Bullhead* | 0.0029 | 0.0045 | 0.0101 | 0.0101 | 2.02 |
| *Black Crappie* | 0.0105 | 0.0113 | 0.0270 | 0.0270 | 6.85 |
| *Large Mouth Bass* | 0.0126 | 0.0084 | 0.0254 | 0.0254 | 7.66 |
| *Longnose Sucker* | 0.0007 | 0.0017 | 0.0042 | 0.0042 | 0.40 |
| *Pumpkinseed* | 0.0873 | 0.1002 | 0.2373 | 0.2520 | 58.06 |
| *Small Mouth Bass* | 0.0007 | 0.0017 | 0.0042 | 0.0042 | 0.40 |
| *Tench* | 0.0133 | 0.0199 | 0.0472 | 0.0472 | 9.27 |
| *Yellow Perch* | 0.0231 | 0.0246 | 0.0674 | 0.0674 | 15.32 |
| *Late Fall Total* | 0.1511 | 0.1509 | 0.3295 | 0.3442 | 100.00 |

During late fall shoreline mortality testing, only 9 fish had a fork length ≥150 mm and the largest fish collected was a brown bullhead at 310 mm (Appendix C). No salmonids were collected or observed at any time during late fall sampling. A comparison of species composition, or relative abundance, between late fall shoreline fish mortality and late fall ambient fish collections is shown in Figure 11.

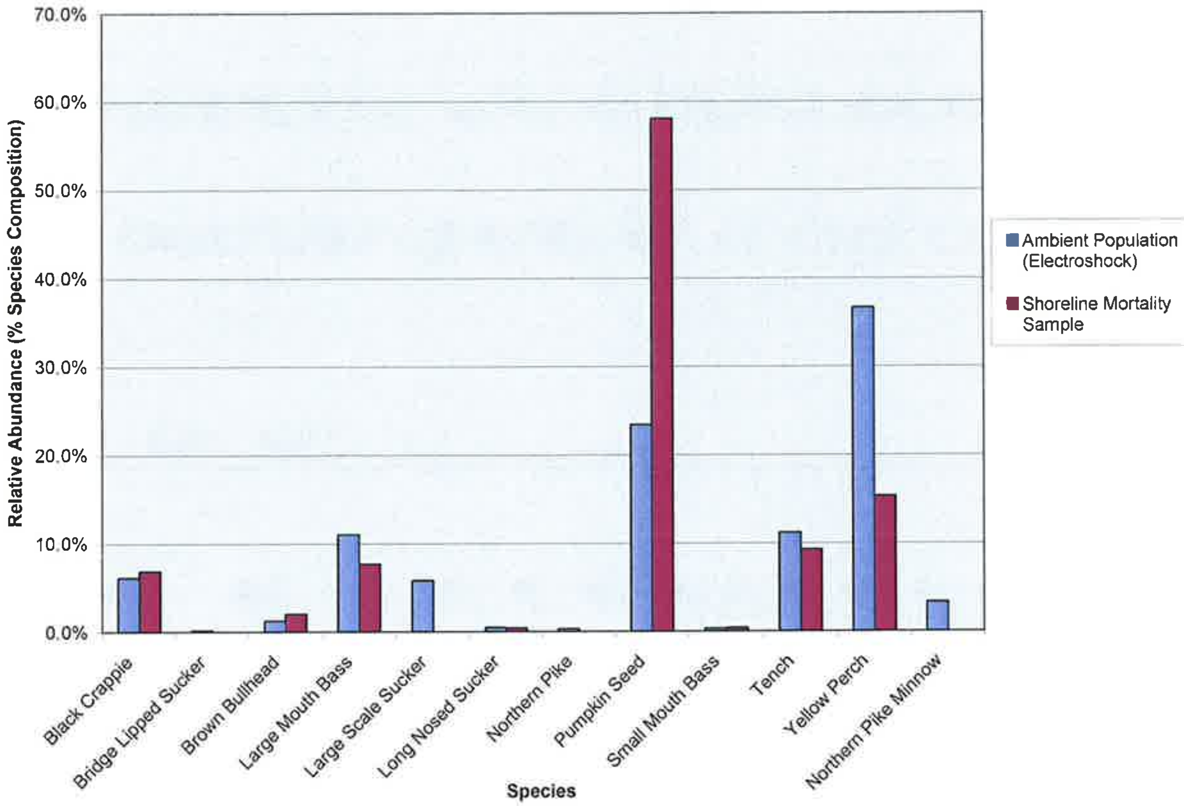



**Figure 11. Relative abundance of pooled bay and mainstem shoreline mortality samples and adjacent ambient fish populations, for late fall 2009.**

The three most abundant fish in late fall bay and combined shoreline mortality samples and late fall ambient fish populations, were yellow perch, pumpkin seed and tench. However the three most abundant species found in mainstem habitats were largemouth bass, large-scale sucker and yellow perch. Table 3-8 summarizes fish collected during the late fall, 2009, period.

**Table 3.8 Relative Abundance of fish collected in late fall 2009 shoreline samples and associated electrofishing.**

| Species | Bay Ambient Population | Bay Shoreline Mortality | Mainstem Ambient Population | Mainstem Shoreline Mortality | Total Ambient Population | Total Shoreline Mortality |
|---|---|---|---|---|---|---|
| Black Crappie | 6.61 | 7.17 | 4.38 | 4.00 | 6.13 | 6.85 |
| Bridge Lipped Sucker | 0.20 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 |
| Brown Bullhead | 1.60 | 2.24 | 0.00 | 0.00 | 1.26 | 2.02 |
| Large Mouth Bass | 10.02 | 6.28 | 14.60 | 20.00 | 11.01 | 7.66 |

| Species | Bay Ambient Population | Bay Shoreline Mortality | Mainstem Ambient Population | Mainstem Shoreline Mortality | Total Ambient Population | Total Shoreline Mortality |
|---|---|---|---|---|---|---|
| Large Scale Sucker | 1.80 | 0.00 | 20.44 | 0.00 | 5.82 | 0.00 |
| Long Nosed Sucker | 0.60 | 0.45 | 0.00 | 0.00 | 0.47 | 0.40 |
| Northern Pike | 0.40 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 |
| Pumpkin Seed | 28.06 | 58.74 | 6.57 | 52.00 | 23.43 | 58.06 |
| Small Mouth Bass | 0.20 | 0.45 | 0.73 | 0.00 | 0.31 | 0.40 |
| Tench | 11.42 | 9.87 | 10.22 | 4.00 | 11.16 | 9.27 |
| Yellow Perch | 38.68 | 14.80 | 29.20 | 20.00 | 36.64 | 15.32 |
| Northern Pike Minnow | 0.40 | 0.00 | 13.87 | 0.00 | 3.30 | 0.00 |

### *3.3.4 Shoreline mortality Visual estimates*

Visual estimates of total shoreline mortality were made during each of the 18 harvester test sites. One fall site's visual estimates were lost, leaving 17 estimates of shoreline mortality to compare to those fish found while sorting shoreline vegetation. The ratio of visual estimate to actual sub-sample count was calculated for each sample, producing an average ratio of 0.81 ±0.59 (SD), with a maximum value of 2.67 and a minimum of 0.18.

## 3.4 Discussion

When comparing relative abundance of fish entrained by the harvester to relative abundance of ambient fish populations, it appears the harvester is capturing fish in proportion to their ambient abundance. The harvester, however, is selecting smaller individuals within those populations. This can be seen when comparing the total size range of fish caught while electrofishing the adjacent weed beds (18 mm to 770 mm, with 15% of the total number ≥150 mm), to those found in shoreline samples (8 mm to 310 mm, with only 1.6% of the total ≥150 mm). The average length of all fish collected in shoreline samples regardless of species was 55 mm (Appendix C).

The rate of fish entrainment by the harvester is inconsistent. Occasionally, large numbers of fish are entrained quickly. This most often occurs when the river bottom shallows unexpectedly under the harvester, causing the depth of the sickle bar and angle of the conveyer belt to be reduced quickly. When this occurs, it is usually possible for the operator to stop the harvester and back the conveyer belt back down into the water, returning most of the fish to the water. The largest disadvantage of this technique is increased fragmentation of the aquatic weed material.

When forward momentum is lost and the conveyer is reversed to release fish, plant material previously built up on each side sickle and the primary conveyer is pushed back into the open water by the back thrust of the paddlewheels. Because of these negative impacts, this practice is used as little as possible.

Likely due to its area of operation the harvesters impact on all native fish species is very low compared to there relative abundance in the reservoir as a whole. Less than 0.6% of all the fish entrained by the harvester during these studies were native species compared to a reservoir wide native species composition of 21.8% as reported by Diviens and Osborne 2010.

Currently, it is estimated that the harvester can cut and deposit 10 loads/day under ideal conditions (i.e., where a suitable unload location is nearby and the weed beds are dense and easily accessible). This amount varies, depending on the location on the BCR and environmental conditions, such as wind, flow, vegetation type and visibility. By using 10 loads/day as a maximum and 330 $m^2$ area of vegetation to represent an average load (personal observation during testing, Scott Jungblom 2009 POPUD), a rough estimate of the amount of area the harvester will cover in a given summer is calculated as 227,700 $m^2$/year, assuming 69 days of operation. Multiplying this area by the average total mortality rate (0.23 fish/$m^2$ or 931 fish /acre) provides an estimated annual maximum mortality of 52,580 fish per year. This estimated maximum annual mortality is broken down by species in the table below.

**Table 3.9 Estimated maximum annual harvester-caused mortality by species**

| Species | Estimated Maximum Annual Mortality |
|---|---|
| Brown Bullhead | 982 |
| Black Crappie | 3,995 |
| Large Mouth Bass | 9,573 |
| Long Nosed Sucker | 54 |
| Large Scale Sucker | 255 |
| Northern Pike | 101 |
| Pumpkin Seed | 10,445 |
| Small Mouth Bass | 167 |
| Tench | 5,021 |
| Yellow Perch | 21,988 |
| **Total** | **52,580** |

Another way to assess estimated total mortality is the number of fish/ton of aquatic vegetation harvested. If the value of average area per load of 330 $m^2$ in the equation above is switched with an average weight per load of 8.5 tons/load, about 5,865 tons of vegetation/ year or about 9 fish/ ton of vegetation is removed from the system.

Multiple past studies have described the BCR as a prey-dominated system (Bennett and Liter 1991; Ashe and Scholz 1992). Recent data collected in 2004 (Divens and Osborne 2010) and during this study, have indicated that condition has not changed. These studies attribute the lack of quality-sized pan fish and the low growth rate/survival of young largemouth bass to a number of factors. These include high numbers of yellow perch and pumpkinseed competing for resources with young bass and each other, and dense aquatic vegetation, reducing the success of predation from adult predators on over-abundant prey fish (Bennett and Liter 1991; Ashe and Scholz 1992). Harvesting has the potential to reduce local densities of pan fish competing with young large mouth bass, and to increase aquatic vegetation complexity, improving predation by adult fish.

## 3.5 Fish Conservation Measures

The primary concern with harvester-associated fish mortality is the possible impact on native species in the Pend Oreille River (e.g., bull trout, westslope cutthroat trout and mountain whitefish). The best method for preventing entrainment of these target fish is avoidance. By operating the harvester only during the warmest part of the year (e.g., July through October), and in shallow, slow-moving water, harvesting operations are less likely to encounter species of concern or salmonids of any kind.

To reduce impacts to bass spawning, harvesting will be avoided in sloughs, bays and back water areas during spring spawning.

On average the harvester crew can visual observe over 80% of the fish being entrained while harvesting, and estimates are likely much higher for fish over 200 mm (personal observation during testing, Scott Jungblom POPUD staff ). This observation increases the likelihood that most adult and sub-adult salmonid species, if captured, could be identified, removed from the harvester, and placed back in the water a safe distance away from the project immediately following entrainment. To assist in this process going forward, the crew will be instructed in fish identification and proper fish handling techniques. The crew will have fish handling equipment, including a knot-less dip net and temporary holding tank on board at all times during operation. If at any time during operation, salmonids or other species of concern are collected, entrained, injured or killed, the fish will be photographed, and its location, date of capture and water temperature will be documented. These observations will be reported annually as part of the Aquatic Plant Management Plan annual report and submitted for review publicly.

Since the rotovator is able to treat all boat launches and other high-use public areas primarily during spring and fall low flow times the summer harvesting efforts can now target dense stands of noxious weeds throughout BCR. The rotovator was less effective at treating these dense weed areas in the summer because the low capacity rotovator head could not handle the volume of aquatic weeds which need removed. The harvester crew has been trained to identify aquatic plants, specifically EWM and curly leaf pond weed. The goal of the harvester program will be to remove as much non-native vegetation as possible prior to the time of increased auto-fragmentation in the fall, while increasing weed bed habitat structure for adult predators throughout the summer.

## 4.0 FRAGMENTATION RATES DURING HARVESTING

The District was required to quantify the amount of EWM actively dispersed (i.e., cut or broke loose during harvesting but not collected for shore disposal) during operation of the harvester. This quantity was compared to natural auto-fragmentation rates.

It is generally believed that the fragments released by using the harvester are fewer than those that would have been released had the bed been left intact, or those created by adjacent, untreated EWM beds auto-fragmenting over time (Zisette 1983, Cooke et al. 1993). Although this hypothesis has not been tested in the field, it appears reasonable, given the high background levels of fragments in EWM-infested systems (Aquatic Research Incorporated 1986). To address this question, four samples were collected at two different sites for the purpose of quantifying the amount of harvester-caused fragmentation. The four samples were composed of two control samples to determine auto-fragmentation rates, and two experimental samples to quantify the amount of EWM fragments released during harvesting.

### 4.1 Study Area and Sample Selection

Two control and two experimental sites were selected and studied. One control and one experimental test were completed during the summer sampling at Site 3 (Figure 2), and one each during late fall sampling at Site 4 (Figure 4).

### 4.2 Methods and Materials

Two seines 18 ft deep *X* 100 ft long, with ½" size mesh, were deployed: one upstream and one downstream of each 100 ft stretch of shoreline to be harvested or used as a control site (Figure 12). For control sets, the nets were deployed for approximately 24 hours; at this time, the downstream net only was retrieved and sampled. At the experimental sites, the net was deployed prior to initiation of harvesting and remained in place for a time sufficient for all suspended fragmented material to reach the downstream net.

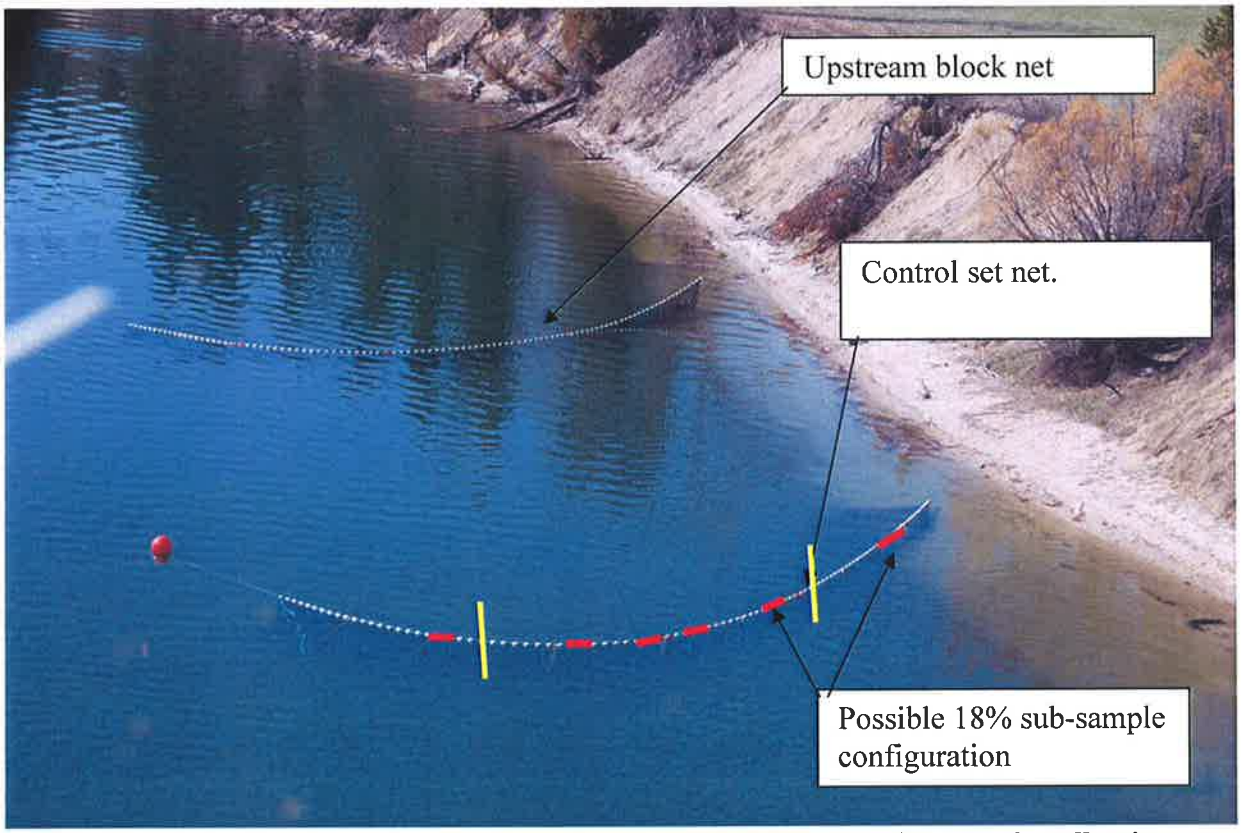



**Figure 12. Photo showing seines set for a fragmentation Control site sample collection.** Red lines are examples of possible random subsection locations to form an 18% subsample. Four of the subsamples were located inside the yellow lines indicating the middle ½ of the net, with one each on the outer quarter of the net.

For samples too large to send to the lab in their entirety, sub-samples of plant material were collected from six randomly-selected subsections of the seine net. Each subsection was 3 ft wide and extended from the water surface to the depth of the net. When combined the six subsamples, three-foot wide subsamples totaled produced an 18% subsample of the 100 ft net. Four of the subsections were located within the central half of the net's length; the other two subsections were located on the outer quarter ends of the net (Figure 12). These sub-section locations were generated through an Excel™ random number generator. Plant materials from the six sub-sections were aggregated into a single 18% sub-sample for lab analysis.

All EWM fragments trapped on the net were collected and stored on ice for later laboratory processing.

The total seasonal biomass for fragmentation from the control sites was calculated as:

> Weight of the 24 hour sample *X* the number of days remaining in the growing season (April 1 though September 30) or auto-fragmentation period (October 1 to March 31) after the date of the treatment.

The amounts of fragmentation for both experimental and background samples are presented as gross volume gallons and total mass (dry weight)/$m^2$.

## 4.3 Results

The results of the fragmentation study are summarized in Table 4.1.

**Table 4.1. Results from control and experimental fragmentation sampling.**

| Sample Type and Number | Date | Study Area Size ($m^2$) | Sample size | Sample Dry Weight (g) | Gross Volume (gallons) | Daily Fragmentation Rate ($g/m^2$) | Days Remaining in Season ($g/m^2$) | Total Seasonal Fragmentation ($g/m^2$) |
|---|---|---|---|---|---|---|---|---|
| **Control 1** | 8/24/2009 | 929 | Full Sample | 83.1 | 1 | .09 | 38 | 3.42 |
| **Exp. 1** | 8/24/2009 | 929 | 18% Sub | 503 | 5 | 3.01 | NA | 3.01 |
| **Control 2** | 10/13/2009 | 3716 | Full Sample | 2896 | 32 | .78 | 169 | 132 |
| **Exp. 2** | 10/13/2009 | 1022 | Full Sample | 2339 | 26 | 2.29 | na | 2.29 |

The volume of material for the October control and experimental sites prohibited dry mass analysis. As a result, dry mass was calculated for these samples by using a regression of past dry weight measurements performed as part of this and the 2008 rotovator fragmentation study (PUD No. 1, 2010). **Figure 13** shows the regression and $r^2$ value associated with the equation used.

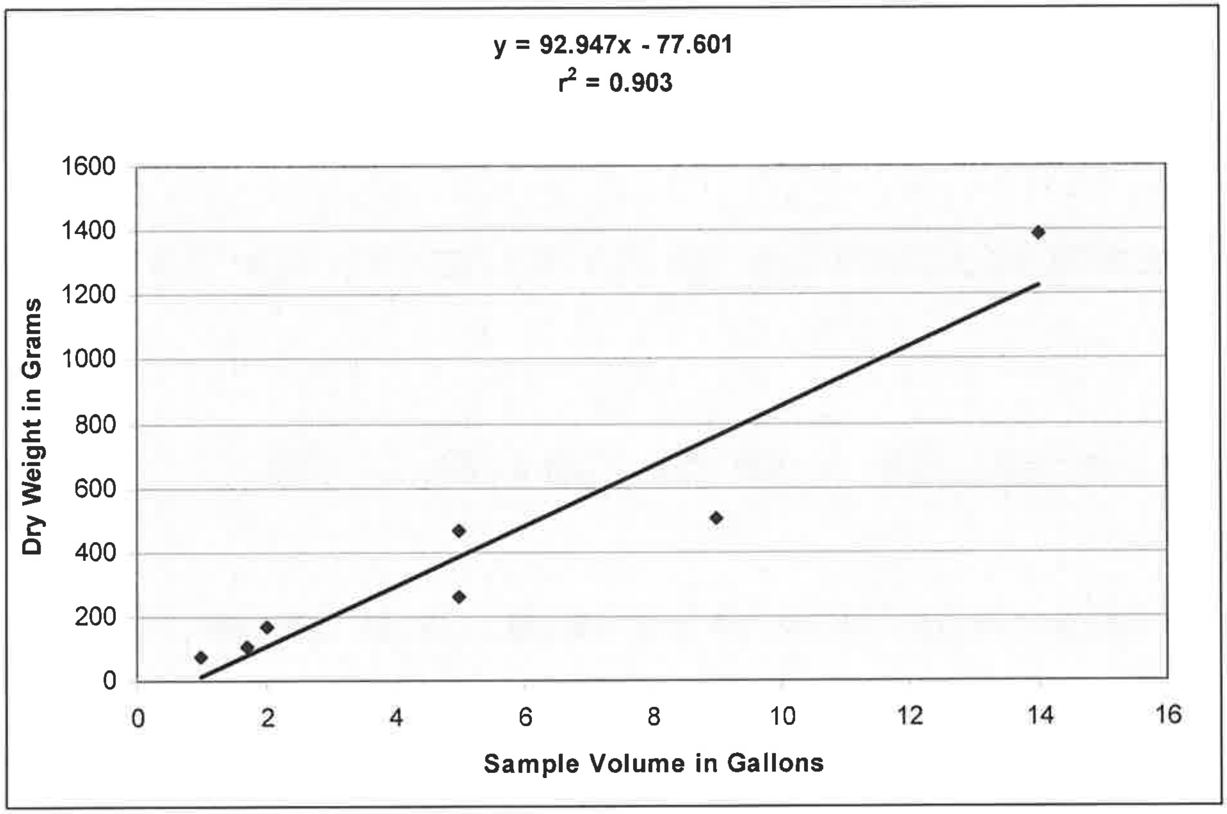



**Figure 13. Scatter plot with regression of dry weight (g) vs. gross volume (gallons) for 2008 and 2009 EWM fragment samples.**

## 4.4 Discussion

The study showed that calculated seasonal auto-fragmentation of EWM is greater per unit surface area than the one time harvester-related fragmentation event. This difference in total fragmentation is reduced when operating the harvester during the mid-summer growing season, when EWM plants are growing rapidly and auto-fragmentation rates are lower. The time of accelerated growth, however, is also the period when the harvester is most effective at removing large amounts of milfoil from the river. For this reason, the harvester should be used primarily during the months of July – October when its effectiveness is maximized and the potential to reduce fall fragmentation is the highest.

Using the same calculations for harvester production as described in the fish mortality study (10 loads/day, 8.5 tons / load and 69 work days/season), it is estimated that 5, 865 tons of harvested aquatic vegetation/year can be removed from BCR.

## 4.5 Conservation measures

The harvester has the ability to remove large amounts of milfoil every year from the Pend Oreille River with a relatively low level of operation-caused fragmentation. The District recommends the use of the harvester as much as possible, targeting EWM and other non-native species, during the warm summer months when the risk of impacting native salmonid populations is low.

One additional use of the harvester which may be employed in future years to combat the spread of milfoil through auto fragmentation is to operate the machine mid reservoir during the fall and spring peaks of auto fragmentation. The machine would passively pick up drifting rafts of aquatic vegetation as they floated down river before the free floating fragments have a chance to re-infest downstream habitats.

As with turbidity, at higher velocity sites, a strip of vegetation will be left in place downstream of the work area to act as a "catcher's mitt" reducing the movement and fragmentation outside the work area. This strip will then be removed after upstream work is completed.

# 5.0 SUMMARY

Through the described studies the District has identified the extent to which the harvester has the potential to impact (either positively or negatively) water quality and fish mortality, and to cause fragmentation of aquatic weeds. The section below describes the conservation or mitigation measures and suggested Best Management Practices proposed to address harvester-related impacts discussed throughout this report.

## 5.1 Recommended Mitigation Measures and Best Management Practices

### *5.1.1 Turbidity*

While periodic turbidity exceedances cannot be completely avoided, operating the harvester in place of the rotovator will greatly reduce turbidity impacts throughout the warm, summer months.

Harvester operators will run the machine parallel to the shoreline, whenever possible to reduce prop-wash directed toward shore suspending shoreline sediments. When the harvester is operated perpendicular to the shoreline (i.e. boat launches, docks set close together, or around water hazards), it will be done carefully as to limit the duration and force of near-shore prop wash.

GIS and dGPS will be used to the full extent possible, to mark shallow areas when encountered.

### *5.1.2 Fish Mortality*

To avoid contact and potential take of native salmonids, specifically ESA-listed bull trout, the District plans to operate the harvester only during the warm summer months, from July to mid–October, when it is extremely unlikely trout will be using any weed bed habitat.

When ever possible, both pilot and copilot will watch the harvester conveyer belt to identify and recover any salmonid or other species of concern, if brought aboard. To assist in this process going forward, the crew will be instructed in fish identification and proper fish handling techniques. The following fish handling equipment will always be aboard the harvester and in good working condition:

- A knot-less dip net and
- Temporary holding tank
- Fish identification sheet
- Hand held thermometer
- Camera

If at any time during operation, salmonids or other species of concern are collected, entrained, injured or killed, the fish will be photographed, and its location, date of capture and water temperature will be documented. These observations will be reported annually as part of the Aquatic Plant Management Plan annual report and submitted for agency and public review.

Because overall fish mortality associated with the county rotovator was extremely low, the District recommends that the County use the rotovator in locations (i.e. around cold water sources or creek mouths) and during times of the year when native salmonids, or other species of concern, are more likely to be encountered (October through June).

### *5.1.3 Harvester-Caused Fragmentation*

Due to the ability of the harvester to remove large amounts of EWM every day from the Pend Oreille River with a relatively low amount of operation-caused fragmentation, The District recommends the use of the harvester as much as possible, targeting EWM and other non-native aquatic plants, during the warm summer months while risk of impacting native salmonid populations is low.

### *5.1.4 Placement of Harvested Vegetation*

All aquatic vegetation removed by the harvester will be placed as far above the wetted perimeter of the reservoir as possible at the time of harvesting. It is not necessary to remove harvested vegetation entirely from the shoreline, because the size of the piles produced by the harvester prevents them from being remobilized during normal reservoir level fluctuations from July until winter cold weather freezes any remaining viable fragments.

## 6.0 LITERATURE CITED

Aquatic Research Incorporated. 1986. Field Test of Mechanical Harvesting of Aquatic Macrophytes. Final Report prepared for the Municipality of Metropolitan Seattle, Water Quality Planning Division, Seattle, Washington.

Ashe, B. L. and A. T. Scholz. 1992. Assessment of the fishery improvement opportunities on the Pend Oreille River: Recommendations for Fisheries Enhancement. Final Report. Upper Columbia United Tribes Fisheries Center; Department of Biology, Eastern Washington University, Cheney. Prepared for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Project Number 88-66, Agreement Number DE-A179-88BP39339, March 1992.

Bennett, D. H. and M. Liter. 1991. Water quality, fish and wildlife characteristics of Box Canyon Reservoir, Washington. Completion Report 1989 – 1990, Section 3: Fish, Department of Fish and Wildlife Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho. Prepared for the Public Utility District No. 1 of Pend Oreille County, Washington. July 1991.

Cooke, G. D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and Management of Lakes and Reservoirs, Second Edition. Lewis Publishers, Boca Raton, Florida.

EES Consulting, Inc. 2008. Box Canyon Hydroelectric Project (No. 2042) Aquatic Plant Management Plan - Annual Report Of Activities In 2007.

PUD No. 1 of Pend Oreille County. 2010 Assessment of Rotovation Impacts and suggested Operating Procedures for the Interim Aquatic Plant Management Plan Box Canyon Reservoir.

Western Aquatic Plant Management Society (WAPMS). 2004. http://www.wapms.org/plants/milfoil.html

WDOE. 2008. http://www.ecy.wa.gov/programs/wq/plants/management/rotovation_strategies.html

Zisette, R.R. 1983. Milfoil Control Method Evaluation. Prepared by Aquatic Control, Ltd. for the Municipality of Metropolitan Seattle Water Quality Planning Division, Seattle, Washington.

# APPENDIX A

# SITE SPECIFIC INFORMATION FOR EACH SEASON AND TEST

**Appendix A. Site specific information for each season and test.**

| Season | Site number | Date | Habitat type | Studies performed | Percent of site sampled | Size (m2) | Volume processed in gallons |
|---|---|---|---|---|---|---|---|
| Summer | 1 | 8/24/2009 | Bay | Shoreline mortality | 100 | 557.4 | 480 |
| Summer | 2 | 8/24/2009 | Mainstem | Shoreline mortality | 10 | 1951 | 1650 |
| Summer | 3 | 8/25/2009 | Mainstem | Shoreline mortality | 21.5 | 929 | 540 |
| Summer | 3 | 8/25/2009 | Mainstem | Drift mortality | 100 | 929 | NA |
| Summer | 3 | 8/25/2009 | Mainstem | Fragmentation control | 100 | 929 | 1 |
| Summer | 3 | 8/25/2009 | Mainstem | Fragmentation Experimental | 18 | 929 | 9 |
| Summer | 4 | 8/25/2009 | Mainstem | Shoreline mortality | 20 | 790 | 360 |
| Summer | 4 | 8/25/2009 | Mainstem | Turbidity | Na | 790 | NA |
| Summer | 5 | 8/26/2009 | Bay | Shoreline mortality | 20 | 1254 | 500 |
| Summer | 6 | 8/26/2009 | Bay | Shoreline mortality | 20 | 2276 | 700 |
| Fall | 1 | 9/22/2009 | Mainstem | Shoreline mortality | 20 | 2357 | 445 |
| Fall | 2 | 9/22/2009 | Bay | Shoreline mortality | 20 | 739 | 215 |
| Fall | 2 | 9/22/2009 | Bay | Turbidity | Na | 739 | NA |
| Fall | 3 | 9/22/2009 | Bay | Shoreline mortality | 20 | 1552 | 185 |
| Fall | 4 | 9/22/2009 | Mainstem | Shoreline mortality | 20 | 1449 | 440 |
| Fall | 5 | 9/23/2009 | Bay | Shoreline mortality | 20 | 1516 | 330 |
| Fall | 6 | 9/23/2009 | Mainstem | Shoreline mortality | 20 | 1878 | 380 |
| Fall | 6 | 9/23/2009 | Mainstem | Drift Mortality | 100 | 990 | NA |
| Late Fall | 1 | 10/13/2009 | Mainstem | Shoreline mortality | 20 | 1022 | 220 |

**Appendix A. Site specific information for each season and test.**

| Season | Site number | Date | Habitat type | Studies performed | Percent of site sampled | Size (m2) | Volume processed in gallons |
|---|---|---|---|---|---|---|---|
| Late Fall | 2 | 10/13/2009 | Mainstem | Shoreline mortality | 20 | 1138 | 180 |
| Late Fall | 3 | 10/13/2009 | Bay | Shoreline mortality | 20 | 1484 | 320 |
| Late Fall | 4 | 10/14/2009 | Mainstem | Shoreline mortality | 20 | 1022 | 92 |
| Late Fall | 4 | 10/14/2009 | Mainstem | Drift mortality | 100 | 1022 | NA |
| Late Fall | 4 | 10/14/2009 | Mainstem | Turbidity | Na | 1022 | NA |
| Late Fall | 4 | 10/14/2009 | Mainstem | Fragmentation control | 100 | 3716 | NA |
| Late Fall | 4 | 10/14/2009 | Mainstem | Fragmentation Experimental | 100 | 1022 | NA |
| Late Fall | 5 | 10/14/2009 | Bay | Shoreline mortality | 20 | 1180 | 210 |
| Late Fall | 6 | 10/14/2009 | Bay | Shoreline mortality | 20 | 1409 | 245 |
| Late Fall | 6 | 10/14/2009 | Bay | Turbidity | 100 | 1409 | NA |

# APPENDIX B

# AMBIENT FISH DATA FROM BOAT ELECTROSHOCKING

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Black Crappie | 42 |
| Summer | Bay | Black Crappie | 50 |
| Summer | Bay | Black Crappie | 56 |
| Summer | Bay | Black Crappie | 96 |
| Summer | Bay | Black Crappie | 282 |
| Summer | Bay | Brown Bullhead | 124 |
| Summer | Bay | Large Mouth Bass | 42 |
| Summer | Bay | Large Mouth Bass | 44 |
| Summer | Bay | Large Mouth Bass | 45 |
| Summer | Bay | Large Mouth Bass | 46 |
| Summer | Bay | Large Mouth Bass | 46 |
| Summer | Bay | Large Mouth Bass | 50 |
| Summer | Bay | Large Mouth Bass | 50 |
| Summer | Bay | Large Mouth Bass | 51 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 53 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 57 |
| Summer | Bay | Large Mouth Bass | 59 |
| Summer | Bay | Large Mouth Bass | 59 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 61 |
| Summer | Bay | Large Mouth Bass | 61 |
| Summer | Bay | Large Mouth Bass | 62 |
| Summer | Bay | Large Mouth Bass | 62 |
| Summer | Bay | Large Mouth Bass | 63 |
| Summer | Bay | Large Mouth Bass | 65 |
| Summer | Bay | Large Mouth Bass | 68 |
| Summer | Bay | Large Mouth Bass | 70 |
| Summer | Bay | Large Mouth Bass | 80 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Large Mouth Bass | 82 |
| Summer | Bay | Large Mouth Bass | 107 |
| Summer | Bay | Large Mouth Bass | 109 |
| Summer | Bay | Large Mouth Bass | 119 |
| Summer | Bay | Large Mouth Bass | 128 |
| Summer | Bay | Large Mouth Bass | 130 |
| Summer | Bay | Large Mouth Bass | 130 |
| Summer | Bay | Large Mouth Bass | 152 |
| Summer | Bay | Large Mouth Bass | 152 |
| Summer | Bay | Large Mouth Bass | 160 |
| Summer | Bay | Large Mouth Bass | 168 |
| Summer | Bay | Large Mouth Bass | 187 |
| Summer | Bay | Large Mouth Bass | 195 |
| Summer | Bay | Northern Pike | 110 |
| Summer | Bay | Northern Pike | 215 |
| Summer | Bay | Northern Pike | 225 |
| Summer | Bay | Northern Pike | 235 |
| Summer | Bay | Northern Pike | 450 |
| Summer | Bay | Northern Pike | 515 |
| Summer | Bay | Pumpkin Seed | 24 |
| Summer | Bay | Pumpkin Seed | 25 |
| Summer | Bay | Pumpkin Seed | 53 |
| Summer | Bay | Pumpkin Seed | 56 |
| Summer | Bay | Pumpkin Seed | 62 |
| Summer | Bay | Pumpkin Seed | 79 |
| Summer | Bay | Pumpkin Seed | 80 |
| Summer | Bay | Pumpkin Seed | 81 |
| Summer | Bay | Pumpkin Seed | 82 |
| Summer | Bay | Pumpkin Seed | 82 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 87 |
| Summer | Bay | Pumpkin Seed | 88 |
| Summer | Bay | Pumpkin Seed | 88 |
| Summer | Bay | Pumpkin Seed | 89 |
| Summer | Bay | Pumpkin Seed | 89 |
| Summer | Bay | Pumpkin Seed | 90 |
| Summer | Bay | Pumpkin Seed | 91 |
| Summer | Bay | Pumpkin Seed | 92 |
| Summer | Bay | Pumpkin Seed | 92 |
| Summer | Bay | Pumpkin Seed | 93 |
| Summer | Bay | Pumpkin Seed | 93 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 95 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 104 |
| Summer | Bay | Pumpkin Seed | 104 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 106 |
| Summer | Bay | Pumpkin Seed | 106 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 112 |
| Summer | Bay | Pumpkin Seed | 113 |
| Summer | Bay | Pumpkin Seed | 114 |
| Summer | Bay | Pumpkin Seed | 114 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 116 |
| Summer | Bay | Pumpkin Seed | 118 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 123 |
| Summer | Bay | Pumpkin Seed | 124 |
| Summer | Bay | Pumpkin Seed | 125 |
| Summer | Bay | Pumpkin Seed | 129 |
| Summer | Bay | Pumpkin Seed | 129 |
| Summer | Bay | Pumpkin Seed | 132 |
| Summer | Bay | Pumpkin Seed | 136 |
| Summer | Bay | Pumpkin Seed | 140 |
| Summer | Bay | Pumpkin Seed | 170 |
| Summer | Bay | Pumpkin Seed | 171 |
| Summer | Bay | Pumpkin Seed | 180 |
| Summer | Bay | Small Mouth Bass | 87 |
| Summer | Bay | Tench | 44 |
| Summer | Bay | Tench | 114 |
| Summer | Bay | Tench | 125 |
| Summer | Bay | Tench | 125 |
| Summer | Bay | Tench | 143 |
| Summer | Bay | Tench | 150 |
| Summer | Bay | Tench | 152 |
| Summer | Bay | Tench | 163 |
| Summer | Bay | Tench | 190 |
| Summer | Bay | Tench | 209 |
| Summer | Bay | Tench | 230 |
| Summer | Bay | Tench | 268 |
| Summer | Bay | Tench | 372 |
| Summer | Bay | Tench | 374 |
| Summer | Bay | Tench | 377 |
| Summer | Bay | Tench | 390 |
| Summer | Bay | Tench | 393 |
| Summer | Bay | Tench | 405 |
| Summer | Bay | Tench | 420 |
| Summer | Bay | Tench | 421 |
| Summer | Bay | Tench | 425 |
| Summer | Bay | Tench | 425 |
| Summer | Bay | Tench | 440 |
| Summer | Bay | Yellow Perch | 46 |
| Summer | Bay | Yellow Perch | 47 |
| Summer | Bay | Yellow Perch | 50 |
| Summer | Bay | Yellow Perch | 51 |
| Summer | Bay | Yellow Perch | 52 |
| Summer | Bay | Yellow Perch | 52 |
| Summer | Bay | Yellow Perch | 52 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 53 |
| Summer | Bay | Yellow Perch | 54 |
| Summer | Bay | Yellow Perch | 54 |
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 57 |
| Summer | Bay | Yellow Perch | 58 |
| Summer | Bay | Yellow Perch | 59 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 63 |
| Summer | Bay | Yellow Perch | 64 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 66 |
| Summer | Bay | Yellow Perch | 70 |
| Summer | Bay | Yellow Perch | 70 |
| Summer | Bay | Yellow Perch | 75 |
| Summer | Bay | Yellow Perch | 83 |
| Summer | Bay | Yellow Perch | 88 |
| Summer | Bay | Yellow Perch | 88 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 95 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 98 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 103 |
| Summer | Bay | Yellow Perch | 103 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 106 |
| Summer | Bay | Yellow Perch | 106 |
| Summer | Bay | Yellow Perch | 106 |
| Summer | Bay | Yellow Perch | 107 |
| Summer | Bay | Yellow Perch | 107 |
| Summer | Bay | Yellow Perch | 109 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 113 |
| Summer | Bay | Yellow Perch | 113 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 116 |
| Summer | Bay | Yellow Perch | 116 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 121 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 123 |
| Summer | Bay | Yellow Perch | 123 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 126 |
| Summer | Bay | Yellow Perch | 127 |
| Summer | Bay | Yellow Perch | 127 |
| Summer | Bay | Yellow Perch | 128 |
| Summer | Bay | Yellow Perch | 128 |
| Summer | Bay | Yellow Perch | 129 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 131 |
| Summer | Bay | Yellow Perch | 131 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 133 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 135 |
| Summer | Bay | Yellow Perch | 135 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 137 |
| Summer | Bay | Yellow Perch | 137 |
| Summer | Bay | Yellow Perch | 138 |
| Summer | Bay | Yellow Perch | 139 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 142 |
| Summer | Bay | Yellow Perch | 142 |
| Summer | Bay | Yellow Perch | 144 |
| Summer | Bay | Yellow Perch | 144 |
| Summer | Bay | Yellow Perch | 145 |
| Summer | Bay | Yellow Perch | 146 |
| Summer | Bay | Yellow Perch | 147 |
| Summer | Bay | Yellow Perch | 149 |
| Summer | Bay | Yellow Perch | 151 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 153 |
| Summer | Bay | Yellow Perch | 156 |
| Summer | Bay | Yellow Perch | 157 |
| Summer | Bay | Yellow Perch | 157 |
| Summer | Bay | Yellow Perch | 162 |
| Summer | Bay | Yellow Perch | 162 |
| Summer | Bay | Yellow Perch | 163 |
| Summer | Bay | Yellow Perch | 170 |
| Summer | Bay | Yellow Perch | 171 |
| Summer | Bay | Yellow Perch | 182 |
| Summer | Channel | Black Crappie | 89 |
| Summer | Channel | Black Crappie | 120 |
| Summer | Channel | Large Mouth Bass | 49 |
| Summer | Channel | Large Mouth Bass | 50 |
| Summer | Channel | Large Mouth Bass | 53 |
| Summer | Channel | Large Mouth Bass | 55 |
| Summer | Channel | Large Mouth Bass | 58 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 61 |
| Summer | Channel | Large Mouth Bass | 64 |
| Summer | Channel | Large Mouth Bass | 150 |
| Summer | Channel | Large Mouth Bass | 159 |
| Summer | Channel | Large Mouth Bass | 192 |
| Summer | Channel | Large Mouth Bass | 390 |
| Summer | Channel | Large Mouth Bass | 427 |
| Summer | Channel | Northern Pike | 205 |
| Summer | Channel | Pumpkin Seed | 50 |
| Summer | Channel | Pumpkin Seed | 56 |
| Summer | Channel | Pumpkin Seed | 70 |
| Summer | Channel | Pumpkin Seed | 73 |
| Summer | Channel | Pumpkin Seed | 81 |
| Summer | Channel | Pumpkin Seed | 81 |
| Summer | Channel | Pumpkin Seed | 82 |
| Summer | Channel | Pumpkin Seed | 90 |
| Summer | Channel | Pumpkin Seed | 92 |
| Summer | Channel | Pumpkin Seed | 95 |
| Summer | Channel | Pumpkin Seed | 96 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 102 |
| Summer | Channel | Pumpkin Seed | 105 |
| Summer | Channel | Pumpkin Seed | 105 |
| Summer | Channel | Pumpkin Seed | 107 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 120 |
| Summer | Channel | Pumpkin Seed | 124 |
| Summer | Channel | Small Mouth Bass | 60 |
| Summer | Channel | Small Mouth Bass | 94 |
| Summer | Channel | Small Mouth Bass | 140 |
| Summer | Channel | Tench | 131 |
| Summer | Channel | Tench | 178 |
| Summer | Channel | Tench | 295 |
| Summer | Channel | Tench | 321 |
| Summer | Channel | Tench | 378 |
| Summer | Channel | Tench | 389 |
| Summer | Channel | Tench | 395 |
| Summer | Channel | Yellow Perch | 42 |
| Summer | Channel | Yellow Perch | 43 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 46 |
| Summer | Channel | Yellow Perch | 46 |
| Summer | Channel | Yellow Perch | 47 |
| Summer | Channel | Yellow Perch | 47 |
| Summer | Channel | Yellow Perch | 48 |
| Summer | Channel | Yellow Perch | 48 |
| Summer | Channel | Yellow Perch | 49 |
| Summer | Channel | Yellow Perch | 49 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 59 |
| Summer | Channel | Yellow Perch | 59 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 61 |
| Summer | Channel | Yellow Perch | 61 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 69 |
| Summer | Channel | Yellow Perch | 69 |
| Summer | Channel | Yellow Perch | 70 |
| Summer | Channel | Yellow Perch | 71 |
| Summer | Channel | Yellow Perch | 73 |
| Summer | Channel | Yellow Perch | 82 |
| Summer | Channel | Yellow Perch | 83 |
| Summer | Channel | Yellow Perch | 84 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 86 |
| Summer | Channel | Yellow Perch | 88 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 97 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 99 |
| Summer | Channel | Yellow Perch | 99 |
| Summer | Channel | Yellow Perch | 100 |
| Summer | Channel | Yellow Perch | 101 |
| Summer | Channel | Yellow Perch | 102 |
| Summer | Channel | Yellow Perch | 103 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 106 |
| Summer | Channel | Yellow Perch | 106 |
| Summer | Channel | Yellow Perch | 107 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 111 |
| Summer | Channel | Yellow Perch | 112 |
| Summer | Channel | Yellow Perch | 112 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 121 |
| Summer | Channel | Yellow Perch | 121 |
| Summer | Channel | Yellow Perch | 122 |
| Summer | Channel | Yellow Perch | 123 |
| Summer | Channel | Yellow Perch | 124 |
| Summer | Channel | Yellow Perch | 125 |
| Summer | Channel | Yellow Perch | 125 |
| Summer | Channel | Yellow Perch | 126 |
| Summer | Channel | Yellow Perch | 126 |
| Summer | Channel | Yellow Perch | 128 |
| Summer | Channel | Yellow Perch | 129 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 133 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 135 |
| Summer | Channel | Yellow Perch | 136 |
| Summer | Channel | Yellow Perch | 137 |
| Summer | Channel | Yellow Perch | 138 |
| Summer | Channel | Yellow Perch | 140 |
| Summer | Channel | Yellow Perch | 140 |
| Summer | Channel | Yellow Perch | 141 |
| Summer | Channel | Yellow Perch | 141 |
| Summer | Channel | Yellow Perch | 142 |
| Summer | Channel | Yellow Perch | 145 |
| Summer | Channel | Yellow Perch | 146 |
| Summer | Channel | Yellow Perch | 146 |
| Summer | Channel | Yellow Perch | 155 |
| Summer | Channel | Yellow Perch | 155 |
| Summer | Channel | Yellow Perch | 158 |
| Summer | Channel | Yellow Perch | 160 |
| Summer | Channel | Yellow Perch | 160 |
| Fall | Bay | Black Crappie | 18 |
| Fall | Bay | Black Crappie | 30 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 55 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 60 |
| Fall | Bay | Black Crappie | 60 |
| Fall | Bay | Black Crappie | 60 |
| Fall | Bay | Black Crappie | 65 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 100 |
| Fall | Bay | Black Crappie | 110 |
| Fall | Bay | Black Crappie | 115 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 130 |
| Fall | Bay | Black Crappie | 140 |
| Fall | Bay | Black Crappie | 150 |
| Fall | Bay | Black Crappie | 160 |
| Fall | Bay | Black Crappie | 165 |
| Fall | Bay | Black Crappie | 180 |
| Fall | Bay | Black Crappie | 185 |
| Fall | Bay | Black Crappie | 190 |
| Fall | Bay | Black Crappie | 210 |
| Fall | Bay | Black Crappie | 290 |
| Fall | Bay | Bridge Lipped Sucker | 262 |
| Fall | Bay | Brown Bullhead | 65 |
| Fall | Bay | Brown Bullhead | 70 |
| Fall | Bay | Brown Bullhead | 75 |
| Fall | Bay | Brown Bullhead | 90 |
| Fall | Bay | Brown Bullhead | 100 |
| Fall | Bay | Brown Bullhead | 160 |
| Fall | Bay | Brown Bullhead | 252 |
| Fall | Bay | Brown Bullhead | 299 |
| Fall | Bay | Large Mouth Bass | 45 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 55 |
| Fall | Bay | Large Mouth Bass | 55 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 70 |
| Fall | Bay | Large Mouth Bass | 75 |
| Fall | Bay | Large Mouth Bass | 80 |
| Fall | Bay | Large Mouth Bass | 80 |
| Fall | Bay | Large Mouth Bass | 85 |
| Fall | Bay | Large Mouth Bass | 85 |
| Fall | Bay | Large Mouth Bass | 110 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 135 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 145 |
| Fall | Bay | Large Mouth Bass | 145 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 160 |
| Fall | Bay | Large Mouth Bass | 160 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 190 |
| Fall | Bay | Large Mouth Bass | 230 |
| Fall | Bay | Large Mouth Bass | 240 |
| Fall | Bay | Large Mouth Bass | 280 |
| Fall | Bay | Large Mouth Bass | 330 |
| Fall | Bay | Large Scale Sucker | 50 |
| Fall | Bay | Large Scale Sucker | 50 |
| Fall | Bay | Large Scale Sucker | 70 |
| Fall | Bay | Large Scale Sucker | 190 |
| Fall | Bay | Large Scale Sucker | 195 |
| Fall | Bay | Large Scale Sucker | 240 |
| Fall | Bay | Large Scale Sucker | 480 |
| Fall | Bay | Large Scale Sucker | 480 |
| Fall | Bay | Large Scale Sucker | 770 |
| Fall | Bay | Long Nosed Sucker | 153 |
| Fall | Bay | Long Nosed Sucker | 165 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Long Nosed Sucker | 262 |
| Fall | Bay | Northern Pike | 325 |
| Fall | Bay | Northern Pike | 580 |
| Fall | Bay | Northern Pike Minnow | 40 |
| Fall | Bay | Northern Pike Minnow | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 65 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 78 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 83 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 88 |
| Fall | Bay | Pumpkin Seed | 90 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Pumpkin Seed | 104 |
| Fall | Bay | Pumpkin Seed | 105 |
| Fall | Bay | Pumpkin Seed | 105 |
| Fall | Bay | Pumpkin Seed | 105 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 112 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 125 |
| Fall | Bay | Pumpkin Seed | 140 |
| Fall | Bay | Pumpkin Seed | 140 |
| Fall | Bay | Small Mouth Bass | 155 |
| Fall | Bay | Tench | 35 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Tench | 35 |
| Fall | Bay | Tench | 45 |
| Fall | Bay | Tench | 45 |
| Fall | Bay | Tench | 50 |
| Fall | Bay | Tench | 90 |
| Fall | Bay | Tench | 120 |
| Fall | Bay | Tench | 125 |
| Fall | Bay | Tench | 130 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 160 |
| Fall | Bay | Tench | 165 |
| Fall | Bay | Tench | 180 |
| Fall | Bay | Tench | 180 |
| Fall | Bay | Tench | 195 |
| Fall | Bay | Tench | 195 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 205 |
| Fall | Bay | Tench | 205 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 220 |
| Fall | Bay | Tench | 230 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 240 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 270 |
| Fall | Bay | Tench | 270 |
| Fall | Bay | Tench | 280 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 290 |
| Fall | Bay | Tench | 300 |
| Fall | Bay | Tench | 300 |
| Fall | Bay | Tench | 365 |
| Fall | Bay | Tench | 380 |
| Fall | Bay | Tench | 400 |
| Fall | Bay | Tench | 410 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Tench | 410 |
| Fall | Bay | Tench | 410 |
| Fall | Bay | Tench | 430 |
| Fall | Bay | Tench | 430 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Yellow Perch | 30 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 59 |
| Fall | Bay | Yellow Perch | 59 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 61.5 |
| Fall | Bay | Yellow Perch | 63 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 85 |
| Fall | Bay | Yellow Perch | 90 |
| Fall | Bay | Yellow Perch | 100 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 114 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 116 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 125 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 131 |
| Fall | Bay | Yellow Perch | 135 |
| Fall | Bay | Yellow Perch | 135 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 145 |
| Fall | Bay | Yellow Perch | 152 |
| Fall | Bay | Yellow Perch | 155 |
| Fall | Bay | Yellow Perch | 160 |
| Fall | Bay | Yellow Perch | 160 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 175 |
| Fall | Bay | Yellow Perch | 175 |
| Fall | Bay | Yellow Perch | 180 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 180 |
| Fall | Bay | Yellow Perch | 180 |
| Fall | Bay | Yellow Perch | 185 |
| Fall | Bay | Yellow Perch | 225 |
| Fall | Channel | Black Crappie | 55 |
| Fall | Channel | Black Crappie | 60 |
| Fall | Channel | Black Crappie | 170 |
| Fall | Channel | Black Crappie | 195 |
| Fall | Channel | Black Crappie | 230 |
| Fall | Channel | Black Crappie | 315 |
| Fall | Channel | Large Mouth Bass | 50 |
| Fall | Channel | Large Mouth Bass | 50 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 60 |
| Fall | Channel | Large Mouth Bass | 70 |
| Fall | Channel | Large Mouth Bass | 70 |
| Fall | Channel | Large Mouth Bass | 90 |
| Fall | Channel | Large Mouth Bass | 110 |
| Fall | Channel | Large Mouth Bass | 145 |
| Fall | Channel | Large Mouth Bass | 150 |
| Fall | Channel | Large Mouth Bass | 150 |
| Fall | Channel | Large Mouth Bass | 240 |
| Fall | Channel | Large Mouth Bass | 240 |
| Fall | Channel | Large Mouth Bass | 285 |
| Fall | Channel | Large Mouth Bass | 420 |
| Fall | Channel | Large Scale Sucker | 50 |
| Fall | Channel | Large Scale Sucker | 50 |
| Fall | Channel | Large Scale Sucker | 60 |
| Fall | Channel | Large Scale Sucker | 60 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 75 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Channel | Large Scale Sucker | 75 |
| Fall | Channel | Large Scale Sucker | 80 |
| Fall | Channel | Large Scale Sucker | 85 |
| Fall | Channel | Large Scale Sucker | 90 |
| Fall | Channel | Large Scale Sucker | 100 |
| Fall | Channel | Large Scale Sucker | 180 |
| Fall | Channel | Large Scale Sucker | 195 |
| Fall | Channel | Large Scale Sucker | 300 |
| Fall | Channel | Large Scale Sucker | 510 |
| Fall | Channel | Northern Pike Minnow | 50 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 60 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 75 |
| Fall | Channel | Northern Pike Minnow | 85 |
| Fall | Channel | Northern Pike Minnow | 90 |
| Fall | Channel | Pumpkin Seed | 65 |
| Fall | Channel | Pumpkin Seed | 65 |
| Fall | Channel | Pumpkin Seed | 75 |
| Fall | Channel | Pumpkin Seed | 80 |
| Fall | Channel | Pumpkin Seed | 95 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Small Mouth Bass | 70 |
| Fall | Channel | Tench | 140 |
| Fall | Channel | Tench | 155 |
| Fall | Channel | Tench | 155 |
| Fall | Channel | Tench | 165 |
| Fall | Channel | Tench | 200 |
| Fall | Channel | Tench | 210 |
| Fall | Channel | Tench | 255 |
| Fall | Channel | Tench | 290 |
| Fall | Channel | Tench | 380 |
| Fall | Channel | Tench | 385 |
| Fall | Channel | Tench | 390 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Channel | Tench | 390 |
| Fall | Channel | Tench | 400 |
| Fall | Channel | Tench | 435 |
| Fall | Channel | Yellow Perch | 30 |
| Fall | Channel | Yellow Perch | 50 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 60 |
| Fall | Channel | Yellow Perch | 65 |
| Fall | Channel | Yellow Perch | 65 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 75 |
| Fall | Channel | Yellow Perch | 85 |
| Fall | Channel | Yellow Perch | 90 |
| Fall | Channel | Yellow Perch | 90 |
| Fall | Channel | Yellow Perch | 100 |
| Fall | Channel | Yellow Perch | 110 |
| Fall | Channel | Yellow Perch | 115 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 135 |
| Fall | Channel | Yellow Perch | 140 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 155 |
| Fall | Channel | Yellow Perch | 155 |
| Fall | Channel | Yellow Perch | 175 |
| Fall | Channel | Yellow Perch | 175 |
| Fall | Channel | Yellow Perch | 185 |
| Fall | Channel | Yellow Perch | 220 |
| Fall | Channel | Yellow Perch | 255 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Black Crappie | 42 |
| Summer | Bay | Black Crappie | 50 |
| Summer | Bay | Black Crappie | 56 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Black Crappie | 96 |
| Summer | Bay | Black Crappie | 282 |
| Summer | Bay | Brown Bullhead | 124 |
| Summer | Bay | Large Mouth Bass | 42 |
| Summer | Bay | Large Mouth Bass | 44 |
| Summer | Bay | Large Mouth Bass | 45 |
| Summer | Bay | Large Mouth Bass | 46 |
| Summer | Bay | Large Mouth Bass | 46 |
| Summer | Bay | Large Mouth Bass | 50 |
| Summer | Bay | Large Mouth Bass | 50 |
| Summer | Bay | Large Mouth Bass | 51 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 52 |
| Summer | Bay | Large Mouth Bass | 53 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 54 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 55 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 56 |
| Summer | Bay | Large Mouth Bass | 57 |
| Summer | Bay | Large Mouth Bass | 59 |
| Summer | Bay | Large Mouth Bass | 59 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 60 |
| Summer | Bay | Large Mouth Bass | 61 |
| Summer | Bay | Large Mouth Bass | 61 |
| Summer | Bay | Large Mouth Bass | 62 |
| Summer | Bay | Large Mouth Bass | 62 |
| Summer | Bay | Large Mouth Bass | 63 |
| Summer | Bay | Large Mouth Bass | 65 |
| Summer | Bay | Large Mouth Bass | 68 |
| Summer | Bay | Large Mouth Bass | 70 |
| Summer | Bay | Large Mouth Bass | 80 |
| Summer | Bay | Large Mouth Bass | 82 |
| Summer | Bay | Large Mouth Bass | 107 |
| Summer | Bay | Large Mouth Bass | 109 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Large Mouth Bass | 119 |
| Summer | Bay | Large Mouth Bass | 128 |
| Summer | Bay | Large Mouth Bass | 130 |
| Summer | Bay | Large Mouth Bass | 130 |
| Summer | Bay | Large Mouth Bass | 152 |
| Summer | Bay | Large Mouth Bass | 152 |
| Summer | Bay | Large Mouth Bass | 160 |
| Summer | Bay | Large Mouth Bass | 168 |
| Summer | Bay | Large Mouth Bass | 187 |
| Summer | Bay | Large Mouth Bass | 195 |
| Summer | Bay | Northern Pike | 110 |
| Summer | Bay | Northern Pike | 215 |
| Summer | Bay | Northern Pike | 225 |
| Summer | Bay | Northern Pike | 235 |
| Summer | Bay | Northern Pike | 450 |
| Summer | Bay | Northern Pike | 515 |
| Summer | Bay | Pumpkin Seed | 24 |
| Summer | Bay | Pumpkin Seed | 25 |
| Summer | Bay | Pumpkin Seed | 53 |
| Summer | Bay | Pumpkin Seed | 56 |
| Summer | Bay | Pumpkin Seed | 62 |
| Summer | Bay | Pumpkin Seed | 79 |
| Summer | Bay | Pumpkin Seed | 80 |
| Summer | Bay | Pumpkin Seed | 81 |
| Summer | Bay | Pumpkin Seed | 82 |
| Summer | Bay | Pumpkin Seed | 82 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 86 |
| Summer | Bay | Pumpkin Seed | 87 |
| Summer | Bay | Pumpkin Seed | 88 |
| Summer | Bay | Pumpkin Seed | 88 |
| Summer | Bay | Pumpkin Seed | 89 |
| Summer | Bay | Pumpkin Seed | 89 |
| Summer | Bay | Pumpkin Seed | 90 |
| Summer | Bay | Pumpkin Seed | 91 |
| Summer | Bay | Pumpkin Seed | 92 |
| Summer | Bay | Pumpkin Seed | 92 |
| Summer | Bay | Pumpkin Seed | 93 |
| Summer | Bay | Pumpkin Seed | 93 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 94 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 95 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 96 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 96 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 97 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 100 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 102 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 103 |
| Summer | Bay | Pumpkin Seed | 104 |
| Summer | Bay | Pumpkin Seed | 104 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 105 |
| Summer | Bay | Pumpkin Seed | 106 |
| Summer | Bay | Pumpkin Seed | 106 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 109 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 110 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 111 |
| Summer | Bay | Pumpkin Seed | 112 |
| Summer | Bay | Pumpkin Seed | 113 |
| Summer | Bay | Pumpkin Seed | 114 |
| Summer | Bay | Pumpkin Seed | 114 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 115 |
| Summer | Bay | Pumpkin Seed | 116 |
| Summer | Bay | Pumpkin Seed | 118 |
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 120 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Pumpkin Seed | 120 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 121 |
| Summer | Bay | Pumpkin Seed | 123 |
| Summer | Bay | Pumpkin Seed | 124 |
| Summer | Bay | Pumpkin Seed | 125 |
| Summer | Bay | Pumpkin Seed | 129 |
| Summer | Bay | Pumpkin Seed | 129 |
| Summer | Bay | Pumpkin Seed | 132 |
| Summer | Bay | Pumpkin Seed | 136 |
| Summer | Bay | Pumpkin Seed | 140 |
| Summer | Bay | Pumpkin Seed | 170 |
| Summer | Bay | Pumpkin Seed | 171 |
| Summer | Bay | Pumpkin Seed | 180 |
| Summer | Bay | Small Mouth Bass | 87 |
| Summer | Bay | Tench | 44 |
| Summer | Bay | Tench | 114 |
| Summer | Bay | Tench | 125 |
| Summer | Bay | Tench | 125 |
| Summer | Bay | Tench | 143 |
| Summer | Bay | Tench | 150 |
| Summer | Bay | Tench | 152 |
| Summer | Bay | Tench | 163 |
| Summer | Bay | Tench | 190 |
| Summer | Bay | Tench | 209 |
| Summer | Bay | Tench | 230 |
| Summer | Bay | Tench | 268 |
| Summer | Bay | Tench | 372 |
| Summer | Bay | Tench | 374 |
| Summer | Bay | Tench | 377 |
| Summer | Bay | Tench | 390 |
| Summer | Bay | Tench | 393 |
| Summer | Bay | Tench | 405 |
| Summer | Bay | Tench | 420 |
| Summer | Bay | Tench | 421 |
| Summer | Bay | Tench | 425 |
| Summer | Bay | Tench | 425 |
| Summer | Bay | Tench | 440 |
| Summer | Bay | Yellow Perch | 46 |
| Summer | Bay | Yellow Perch | 47 |
| Summer | Bay | Yellow Perch | 50 |
| Summer | Bay | Yellow Perch | 51 |
| Summer | Bay | Yellow Perch | 52 |
| Summer | Bay | Yellow Perch | 52 |
| Summer | Bay | Yellow Perch | 52 |
| Summer | Bay | Yellow Perch | 53 |
| Summer | Bay | Yellow Perch | 54 |
| Summer | Bay | Yellow Perch | 54 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 55 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 56 |
| Summer | Bay | Yellow Perch | 57 |
| Summer | Bay | Yellow Perch | 58 |
| Summer | Bay | Yellow Perch | 59 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 60 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 61 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 62 |
| Summer | Bay | Yellow Perch | 63 |
| Summer | Bay | Yellow Perch | 64 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 65 |
| Summer | Bay | Yellow Perch | 66 |
| Summer | Bay | Yellow Perch | 70 |
| Summer | Bay | Yellow Perch | 70 |
| Summer | Bay | Yellow Perch | 75 |
| Summer | Bay | Yellow Perch | 83 |
| Summer | Bay | Yellow Perch | 88 |
| Summer | Bay | Yellow Perch | 88 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 92 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 93 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 94 |
| Summer | Bay | Yellow Perch | 95 |
| Summer | Bay | Yellow Perch | 96 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 96 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 97 |
| Summer | Bay | Yellow Perch | 98 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 100 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 101 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 102 |
| Summer | Bay | Yellow Perch | 103 |
| Summer | Bay | Yellow Perch | 103 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 104 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 105 |
| Summer | Bay | Yellow Perch | 106 |
| Summer | Bay | Yellow Perch | 106 |

Appendix B. Ambient Fish Data From Boat Electroshocking

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 106 |
| Summer | Bay | Yellow Perch | 107 |
| Summer | Bay | Yellow Perch | 107 |
| Summer | Bay | Yellow Perch | 109 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 110 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 111 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 112 |
| Summer | Bay | Yellow Perch | 113 |
| Summer | Bay | Yellow Perch | 113 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 114 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 115 |
| Summer | Bay | Yellow Perch | 116 |
| Summer | Bay | Yellow Perch | 116 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 119 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 120 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 121 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 121 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 122 |
| Summer | Bay | Yellow Perch | 123 |
| Summer | Bay | Yellow Perch | 123 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 124 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 125 |
| Summer | Bay | Yellow Perch | 126 |
| Summer | Bay | Yellow Perch | 127 |
| Summer | Bay | Yellow Perch | 127 |
| Summer | Bay | Yellow Perch | 128 |
| Summer | Bay | Yellow Perch | 128 |
| Summer | Bay | Yellow Perch | 129 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 130 |
| Summer | Bay | Yellow Perch | 131 |
| Summer | Bay | Yellow Perch | 131 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 132 |
| Summer | Bay | Yellow Perch | 133 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 134 |
| Summer | Bay | Yellow Perch | 135 |
| Summer | Bay | Yellow Perch | 135 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 136 |
| Summer | Bay | Yellow Perch | 137 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Bay | Yellow Perch | 137 |
| Summer | Bay | Yellow Perch | 138 |
| Summer | Bay | Yellow Perch | 139 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 140 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 141 |
| Summer | Bay | Yellow Perch | 142 |
| Summer | Bay | Yellow Perch | 142 |
| Summer | Bay | Yellow Perch | 144 |
| Summer | Bay | Yellow Perch | 144 |
| Summer | Bay | Yellow Perch | 145 |
| Summer | Bay | Yellow Perch | 146 |
| Summer | Bay | Yellow Perch | 147 |
| Summer | Bay | Yellow Perch | 149 |
| Summer | Bay | Yellow Perch | 151 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 152 |
| Summer | Bay | Yellow Perch | 153 |
| Summer | Bay | Yellow Perch | 156 |
| Summer | Bay | Yellow Perch | 157 |
| Summer | Bay | Yellow Perch | 157 |
| Summer | Bay | Yellow Perch | 162 |
| Summer | Bay | Yellow Perch | 162 |
| Summer | Bay | Yellow Perch | 163 |
| Summer | Bay | Yellow Perch | 170 |
| Summer | Bay | Yellow Perch | 171 |
| Summer | Bay | Yellow Perch | 182 |
| Summer | Channel | Black Crappie | 89 |
| Summer | Channel | Black Crappie | 120 |
| Summer | Channel | Large Mouth Bass | 49 |
| Summer | Channel | Large Mouth Bass | 50 |
| Summer | Channel | Large Mouth Bass | 53 |
| Summer | Channel | Large Mouth Bass | 55 |
| Summer | Channel | Large Mouth Bass | 58 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 60 |
| Summer | Channel | Large Mouth Bass | 61 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Large Mouth Bass | 64 |
| Summer | Channel | Large Mouth Bass | 150 |
| Summer | Channel | Large Mouth Bass | 159 |
| Summer | Channel | Large Mouth Bass | 192 |
| Summer | Channel | Large Mouth Bass | 390 |
| Summer | Channel | Large Mouth Bass | 427 |
| Summer | Channel | Northern Pike | 205 |
| Summer | Channel | Pumpkin Seed | 50 |
| Summer | Channel | Pumpkin Seed | 56 |
| Summer | Channel | Pumpkin Seed | 70 |
| Summer | Channel | Pumpkin Seed | 73 |
| Summer | Channel | Pumpkin Seed | 81 |
| Summer | Channel | Pumpkin Seed | 81 |
| Summer | Channel | Pumpkin Seed | 82 |
| Summer | Channel | Pumpkin Seed | 90 |
| Summer | Channel | Pumpkin Seed | 92 |
| Summer | Channel | Pumpkin Seed | 95 |
| Summer | Channel | Pumpkin Seed | 96 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 100 |
| Summer | Channel | Pumpkin Seed | 102 |
| Summer | Channel | Pumpkin Seed | 105 |
| Summer | Channel | Pumpkin Seed | 105 |
| Summer | Channel | Pumpkin Seed | 107 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 115 |
| Summer | Channel | Pumpkin Seed | 120 |
| Summer | Channel | Pumpkin Seed | 124 |
| Summer | Channel | Small Mouth Bass | 60 |
| Summer | Channel | Small Mouth Bass | 94 |
| Summer | Channel | Small Mouth Bass | 140 |
| Summer | Channel | Tench | 131 |
| Summer | Channel | Tench | 178 |
| Summer | Channel | Tench | 295 |
| Summer | Channel | Tench | 321 |
| Summer | Channel | Tench | 378 |
| Summer | Channel | Tench | 389 |
| Summer | Channel | Tench | 395 |
| Summer | Channel | Yellow Perch | 42 |
| Summer | Channel | Yellow Perch | 43 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 45 |
| Summer | Channel | Yellow Perch | 46 |
| Summer | Channel | Yellow Perch | 46 |
| Summer | Channel | Yellow Perch | 47 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 47 |
| Summer | Channel | Yellow Perch | 48 |
| Summer | Channel | Yellow Perch | 48 |
| Summer | Channel | Yellow Perch | 49 |
| Summer | Channel | Yellow Perch | 49 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 50 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 51 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 52 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 53 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 54 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |

Appendix B. Ambient Fish Data From Boat Electroshocking

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 55 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 56 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 57 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 58 |
| Summer | Channel | Yellow Perch | 59 |
| Summer | Channel | Yellow Perch | 59 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 60 |
| Summer | Channel | Yellow Perch | 61 |
| Summer | Channel | Yellow Perch | 61 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 62 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 63 |
| Summer | Channel | Yellow Perch | 64 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 64 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 65 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 66 |
| Summer | Channel | Yellow Perch | 69 |
| Summer | Channel | Yellow Perch | 69 |
| Summer | Channel | Yellow Perch | 70 |
| Summer | Channel | Yellow Perch | 71 |
| Summer | Channel | Yellow Perch | 73 |
| Summer | Channel | Yellow Perch | 82 |
| Summer | Channel | Yellow Perch | 83 |
| Summer | Channel | Yellow Perch | 84 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 85 |
| Summer | Channel | Yellow Perch | 86 |
| Summer | Channel | Yellow Perch | 88 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 90 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 91 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 92 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 93 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |
| Summer | Channel | Yellow Perch | 94 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 95 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 96 |
| Summer | Channel | Yellow Perch | 97 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 98 |
| Summer | Channel | Yellow Perch | 99 |
| Summer | Channel | Yellow Perch | 99 |
| Summer | Channel | Yellow Perch | 100 |
| Summer | Channel | Yellow Perch | 101 |
| Summer | Channel | Yellow Perch | 102 |
| Summer | Channel | Yellow Perch | 103 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 105 |
| Summer | Channel | Yellow Perch | 106 |
| Summer | Channel | Yellow Perch | 106 |
| Summer | Channel | Yellow Perch | 107 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 110 |
| Summer | Channel | Yellow Perch | 111 |
| Summer | Channel | Yellow Perch | 112 |
| Summer | Channel | Yellow Perch | 112 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 114 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 115 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 120 |
| Summer | Channel | Yellow Perch | 121 |
| Summer | Channel | Yellow Perch | 121 |
| Summer | Channel | Yellow Perch | 122 |
| Summer | Channel | Yellow Perch | 123 |
| Summer | Channel | Yellow Perch | 124 |
| Summer | Channel | Yellow Perch | 125 |
| Summer | Channel | Yellow Perch | 125 |
| Summer | Channel | Yellow Perch | 126 |
| Summer | Channel | Yellow Perch | 126 |
| Summer | Channel | Yellow Perch | 128 |
| Summer | Channel | Yellow Perch | 129 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 130 |
| Summer | Channel | Yellow Perch | 133 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 134 |
| Summer | Channel | Yellow Perch | 135 |
| Summer | Channel | Yellow Perch | 136 |
| Summer | Channel | Yellow Perch | 137 |
| Summer | Channel | Yellow Perch | 138 |
| Summer | Channel | Yellow Perch | 140 |
| Summer | Channel | Yellow Perch | 140 |
| Summer | Channel | Yellow Perch | 141 |
| Summer | Channel | Yellow Perch | 141 |
| Summer | Channel | Yellow Perch | 142 |
| Summer | Channel | Yellow Perch | 145 |
| Summer | Channel | Yellow Perch | 146 |
| Summer | Channel | Yellow Perch | 146 |
| Summer | Channel | Yellow Perch | 155 |
| Summer | Channel | Yellow Perch | 155 |
| Summer | Channel | Yellow Perch | 158 |
| Summer | Channel | Yellow Perch | 160 |
| Summer | Channel | Yellow Perch | 160 |
| Fall | Bay | Black Crappie | 18 |
| Fall | Bay | Black Crappie | 30 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 55 |
| Fall | Bay | Black Crappie | 60 |
| Fall | Bay | Black Crappie | 60 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Black Crappie | 60 |
| Fall | Bay | Black Crappie | 65 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 80 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 90 |
| Fall | Bay | Black Crappie | 100 |
| Fall | Bay | Black Crappie | 110 |
| Fall | Bay | Black Crappie | 115 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 120 |
| Fall | Bay | Black Crappie | 130 |
| Fall | Bay | Black Crappie | 140 |
| Fall | Bay | Black Crappie | 150 |
| Fall | Bay | Black Crappie | 160 |
| Fall | Bay | Black Crappie | 165 |
| Fall | Bay | Black Crappie | 180 |
| Fall | Bay | Black Crappie | 185 |
| Fall | Bay | Black Crappie | 190 |
| Fall | Bay | Black Crappie | 210 |
| Fall | Bay | Black Crappie | 290 |
| Fall | Bay | Bridge Lipped Sucker | 262 |
| Fall | Bay | Brown Bullhead | 65 |
| Fall | Bay | Brown Bullhead | 70 |
| Fall | Bay | Brown Bullhead | 75 |
| Fall | Bay | Brown Bullhead | 90 |
| Fall | Bay | Brown Bullhead | 100 |
| Fall | Bay | Brown Bullhead | 160 |
| Fall | Bay | Brown Bullhead | 252 |
| Fall | Bay | Brown Bullhead | 299 |
| Fall | Bay | Large Mouth Bass | 45 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 50 |
| Fall | Bay | Large Mouth Bass | 55 |
| Fall | Bay | Large Mouth Bass | 55 |
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 60 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Large Mouth Bass | 60 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 65 |
| Fall | Bay | Large Mouth Bass | 70 |
| Fall | Bay | Large Mouth Bass | 75 |
| Fall | Bay | Large Mouth Bass | 80 |
| Fall | Bay | Large Mouth Bass | 80 |
| Fall | Bay | Large Mouth Bass | 85 |
| Fall | Bay | Large Mouth Bass | 85 |
| Fall | Bay | Large Mouth Bass | 110 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 130 |
| Fall | Bay | Large Mouth Bass | 135 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 140 |
| Fall | Bay | Large Mouth Bass | 145 |
| Fall | Bay | Large Mouth Bass | 145 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 150 |
| Fall | Bay | Large Mouth Bass | 160 |
| Fall | Bay | Large Mouth Bass | 160 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 165 |
| Fall | Bay | Large Mouth Bass | 190 |
| Fall | Bay | Large Mouth Bass | 230 |
| Fall | Bay | Large Mouth Bass | 240 |
| Fall | Bay | Large Mouth Bass | 280 |
| Fall | Bay | Large Mouth Bass | 330 |
| Fall | Bay | Large Scale Sucker | 50 |
| Fall | Bay | Large Scale Sucker | 50 |
| Fall | Bay | Large Scale Sucker | 70 |
| Fall | Bay | Large Scale Sucker | 190 |
| Fall | Bay | Large Scale Sucker | 195 |
| Fall | Bay | Large Scale Sucker | 240 |
| Fall | Bay | Large Scale Sucker | 480 |
| Fall | Bay | Large Scale Sucker | 480 |
| Fall | Bay | Large Scale Sucker | 770 |
| Fall | Bay | Long Nosed Sucker | 153 |
| Fall | Bay | Long Nosed Sucker | 165 |
| Fall | Bay | Long Nosed Sucker | 262 |
| Fall | Bay | Northern Pike | 325 |
| Fall | Bay | Northern Pike | 580 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Northern Pike Minnow | 40 |
| Fall | Bay | Northern Pike Minnow | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 60 |
| Fall | Bay | Pumpkin Seed | 65 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 70 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 75 |
| Fall | Bay | Pumpkin Seed | 78 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 80 |
| Fall | Bay | Pumpkin Seed | 83 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 85 |
| Fall | Bay | Pumpkin Seed | 88 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 90 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 95 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 100 |
| Fall | Bay | Pumpkin Seed | 104 |
| Fall | Bay | Pumpkin Seed | 105 |
| Fall | Bay | Pumpkin Seed | 105 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Pumpkin Seed | 105 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 110 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 111 |
| Fall | Bay | Pumpkin Seed | 112 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 115 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 120 |
| Fall | Bay | Pumpkin Seed | 125 |
| Fall | Bay | Pumpkin Seed | 140 |
| Fall | Bay | Pumpkin Seed | 140 |
| Fall | Bay | Small Mouth Bass | 155 |
| Fall | Bay | Tench | 35 |
| Fall | Bay | Tench | 35 |
| Fall | Bay | Tench | 45 |
| Fall | Bay | Tench | 45 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Tench | 50 |
| Fall | Bay | Tench | 90 |
| Fall | Bay | Tench | 120 |
| Fall | Bay | Tench | 125 |
| Fall | Bay | Tench | 130 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 150 |
| Fall | Bay | Tench | 160 |
| Fall | Bay | Tench | 165 |
| Fall | Bay | Tench | 180 |
| Fall | Bay | Tench | 180 |
| Fall | Bay | Tench | 195 |
| Fall | Bay | Tench | 195 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 200 |
| Fall | Bay | Tench | 205 |
| Fall | Bay | Tench | 205 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 210 |
| Fall | Bay | Tench | 220 |
| Fall | Bay | Tench | 230 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 235 |
| Fall | Bay | Tench | 240 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 250 |
| Fall | Bay | Tench | 270 |
| Fall | Bay | Tench | 270 |
| Fall | Bay | Tench | 280 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 285 |
| Fall | Bay | Tench | 290 |
| Fall | Bay | Tench | 300 |
| Fall | Bay | Tench | 300 |
| Fall | Bay | Tench | 365 |
| Fall | Bay | Tench | 380 |
| Fall | Bay | Tench | 400 |
| Fall | Bay | Tench | 410 |
| Fall | Bay | Tench | 410 |
| Fall | Bay | Tench | 410 |
| Fall | Bay | Tench | 430 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Tench | 430 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Tench | 440 |
| Fall | Bay | Yellow Perch | 30 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 55 |
| Fall | Bay | Yellow Perch | 59 |
| Fall | Bay | Yellow Perch | 59 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 60 |
| Fall | Bay | Yellow Perch | 61.5 |
| Fall | Bay | Yellow Perch | 63 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 65 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 70 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 75 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 80 |
| Fall | Bay | Yellow Perch | 85 |
| Fall | Bay | Yellow Perch | 90 |
| Fall | Bay | Yellow Perch | 100 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 110 |
| Fall | Bay | Yellow Perch | 114 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 115 |
| Fall | Bay | Yellow Perch | 116 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 120 |
| Fall | Bay | Yellow Perch | 125 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 130 |
| Fall | Bay | Yellow Perch | 131 |
| Fall | Bay | Yellow Perch | 135 |
| Fall | Bay | Yellow Perch | 135 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 140 |
| Fall | Bay | Yellow Perch | 145 |
| Fall | Bay | Yellow Perch | 152 |
| Fall | Bay | Yellow Perch | 155 |
| Fall | Bay | Yellow Perch | 160 |
| Fall | Bay | Yellow Perch | 160 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 165 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 170 |
| Fall | Bay | Yellow Perch | 175 |
| Fall | Bay | Yellow Perch | 175 |
| Fall | Bay | Yellow Perch | 180 |
| Fall | Bay | Yellow Perch | 180 |
| Fall | Bay | Yellow Perch | 180 |
| Fall | Bay | Yellow Perch | 185 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Bay | Yellow Perch | 225 |
| Fall | Channel | Black Crappie | 55 |
| Fall | Channel | Black Crappie | 60 |
| Fall | Channel | Black Crappie | 170 |
| Fall | Channel | Black Crappie | 195 |
| Fall | Channel | Black Crappie | 230 |
| Fall | Channel | Black Crappie | 315 |
| Fall | Channel | Large Mouth Bass | 50 |
| Fall | Channel | Large Mouth Bass | 50 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 55 |
| Fall | Channel | Large Mouth Bass | 60 |
| Fall | Channel | Large Mouth Bass | 70 |
| Fall | Channel | Large Mouth Bass | 70 |
| Fall | Channel | Large Mouth Bass | 90 |
| Fall | Channel | Large Mouth Bass | 110 |
| Fall | Channel | Large Mouth Bass | 145 |
| Fall | Channel | Large Mouth Bass | 150 |
| Fall | Channel | Large Mouth Bass | 150 |
| Fall | Channel | Large Mouth Bass | 240 |
| Fall | Channel | Large Mouth Bass | 240 |
| Fall | Channel | Large Mouth Bass | 285 |
| Fall | Channel | Large Mouth Bass | 420 |
| Fall | Channel | Large Scale Sucker | 50 |
| Fall | Channel | Large Scale Sucker | 50 |
| Fall | Channel | Large Scale Sucker | 60 |
| Fall | Channel | Large Scale Sucker | 60 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 65 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 70 |
| Fall | Channel | Large Scale Sucker | 75 |
| Fall | Channel | Large Scale Sucker | 75 |
| Fall | Channel | Large Scale Sucker | 80 |
| Fall | Channel | Large Scale Sucker | 85 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Channel | Large Scale Sucker | 90 |
| Fall | Channel | Large Scale Sucker | 100 |
| Fall | Channel | Large Scale Sucker | 180 |
| Fall | Channel | Large Scale Sucker | 195 |
| Fall | Channel | Large Scale Sucker | 300 |
| Fall | Channel | Large Scale Sucker | 510 |
| Fall | Channel | Northern Pike Minnow | 50 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 55 |
| Fall | Channel | Northern Pike Minnow | 60 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 70 |
| Fall | Channel | Northern Pike Minnow | 75 |
| Fall | Channel | Northern Pike Minnow | 85 |
| Fall | Channel | Northern Pike Minnow | 90 |
| Fall | Channel | Pumpkin Seed | 65 |
| Fall | Channel | Pumpkin Seed | 65 |
| Fall | Channel | Pumpkin Seed | 75 |
| Fall | Channel | Pumpkin Seed | 80 |
| Fall | Channel | Pumpkin Seed | 95 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Pumpkin Seed | 100 |
| Fall | Channel | Small Mouth Bass | 70 |
| Fall | Channel | Tench | 140 |
| Fall | Channel | Tench | 155 |
| Fall | Channel | Tench | 155 |
| Fall | Channel | Tench | 165 |
| Fall | Channel | Tench | 200 |
| Fall | Channel | Tench | 210 |
| Fall | Channel | Tench | 255 |
| Fall | Channel | Tench | 290 |
| Fall | Channel | Tench | 380 |
| Fall | Channel | Tench | 385 |
| Fall | Channel | Tench | 390 |
| Fall | Channel | Tench | 390 |
| Fall | Channel | Tench | 400 |
| Fall | Channel | Tench | 435 |

**Appendix B. Ambient Fish Data From Boat Electroshocking**

| Season | Habitat Type | Species | Fork length (mm) |
|---|---|---|---|
| Fall | Channel | Yellow Perch | 30 |
| Fall | Channel | Yellow Perch | 50 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 55 |
| Fall | Channel | Yellow Perch | 60 |
| Fall | Channel | Yellow Perch | 65 |
| Fall | Channel | Yellow Perch | 65 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 70 |
| Fall | Channel | Yellow Perch | 75 |
| Fall | Channel | Yellow Perch | 85 |
| Fall | Channel | Yellow Perch | 90 |
| Fall | Channel | Yellow Perch | 90 |
| Fall | Channel | Yellow Perch | 100 |
| Fall | Channel | Yellow Perch | 110 |
| Fall | Channel | Yellow Perch | 115 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 120 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 130 |
| Fall | Channel | Yellow Perch | 135 |
| Fall | Channel | Yellow Perch | 140 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 150 |
| Fall | Channel | Yellow Perch | 155 |
| Fall | Channel | Yellow Perch | 155 |
| Fall | Channel | Yellow Perch | 175 |
| Fall | Channel | Yellow Perch | 175 |
| Fall | Channel | Yellow Perch | 185 |
| Fall | Channel | Yellow Perch | 220 |
| Fall | Channel | Yellow Perch | 255 |

# APPENDIX C

# SHORELINE MORTALITY SAMPLE DATA BY SEASON

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Large Mouth Bass | 50 | Bay | 1 |
| Summer | Large Mouth Bass | 50 | Bay | 1 |
| Summer | Large Mouth Bass | 50 | Bay | 1 |
| Summer | Large Mouth Bass | 55 | Bay | 1 |
| Summer | Large Mouth Bass | 55 | Bay | 1 |
| Summer | Large Mouth Bass | 60 | Bay | 1 |
| Summer | Large Mouth Bass | 65 | Bay | 1 |
| Summer | Large Mouth Bass | 65 | Bay | 1 |
| Summer | Large Mouth Bass | 65 | Bay | 1 |
| Summer | Large Mouth Bass | 70 | Bay | 1 |
| Summer | Large Mouth Bass | 70 | Bay | 1 |
| Summer | Large Mouth Bass | 75 | Bay | 1 |
| Summer | Large Mouth Bass | 75 | Bay | 1 |
| Summer | Pumpkinseed | 55 | Bay | 1 |
| Summer | Pumpkinseed | 60 | Bay | 1 |
| Summer | Pumpkinseed | 65 | Bay | 1 |
| Summer | Pumpkinseed | 70 | Bay | 1 |
| Summer | Pumpkinseed | 70 | Bay | 1 |
| Summer | Pumpkinseed | 70 | Bay | 1 |
| Summer | Pumpkinseed | 75 | Bay | 1 |
| Summer | Pumpkinseed | 75 | Bay | 1 |
| Summer | Yellow Perch | 65 | Bay | 1 |
| Summer | Yellow Perch | 70 | Bay | 1 |
| Summer | Yellow Perch | 70 | Bay | 1 |
| Summer | Yellow Perch | 75 | Bay | 1 |
| Summer | Yellow Perch | 75 | Bay | 1 |
| Summer | Yellow Perch | 80 | Bay | 1 |
| Summer | Yellow Perch | 80 | Bay | 1 |
| Summer | Yellow Perch | 80 | Bay | 1 |
| Summer | Yellow Perch | 85 | Bay | 1 |
| Summer | Yellow Perch | 100 | Bay | 1 |
| Summer | Black Crappie | 80 | Mainstem | 2 |
| Summer | Black Crappie | 80 | Mainstem | 2 |
| Summer | Black Crappie | 80 | Mainstem | 2 |
| Summer | Large Mouth Bass | 75 | Mainstem | 2 |
| Summer | Large Mouth Bass | 75 | Mainstem | 2 |
| Summer | Large Mouth Bass | 75 | Mainstem | 2 |
| Summer | Pumpkinseed | 70 | Mainstem | 2 |
| Summer | Pumpkinseed | 70 | Mainstem | 2 |
| Summer | Pumpkinseed | 70 | Mainstem | 2 |
| Summer | Pumpkinseed | 75 | Mainstem | 2 |
| Summer | Pumpkinseed | 75 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Yellow Perch | 65 | Mainstem | 2 |
| Summer | Large Mouth Bass | 50 | Mainstem | 3 |
| Summer | Large Mouth Bass | 50 | Mainstem | 3 |
| Summer | Large Mouth Bass | 50 | Mainstem | 3 |
| Summer | Pumpkinseed | 75 | Mainstem | 3 |
| Summer | Pumpkinseed | 75 | Mainstem | 3 |
| Summer | Pumpkinseed | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 50 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 75 | Mainstem | 3 |
| Summer | Yellow Perch | 100 | Mainstem | 3 |
| Summer | Yellow Perch | 100 | Mainstem | 3 |
| Summer | Yellow Perch | 100 | Mainstem | 3 |
| Summer | Yellow Perch | 105 | Mainstem | 3 |
| Summer | Yellow Perch | 110 | Mainstem | 3 |
| Summer | Yellow Perch | 110 | Mainstem | 3 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 30 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 60 | Mainstem | 4 |
| Summer | Large Mouth Bass | 65 | Mainstem | 4 |
| Summer | Large Mouth Bass | 65 | Mainstem | 4 |
| Summer | Large Mouth Bass | 65 | Mainstem | 4 |
| Summer | Large Mouth Bass | 65 | Mainstem | 4 |
| Summer | Large Mouth Bass | 65 | Mainstem | 4 |
| Summer | Pumpkinseed | 60 | Mainstem | 4 |
| Summer | Pumpkinseed | 60 | Mainstem | 4 |
| Summer | Pumpkinseed | 60 | Mainstem | 4 |
| Summer | Pumpkinseed | 60 | Mainstem | 4 |
| Summer | Pumpkinseed | 75 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Pumpkinseed | 100 | Mainstem | 4 |
| Summer | Tench | 100 | Mainstem | 4 |
| Summer | Tench | 110 | Mainstem | 4 |
| Summer | Tench | 110 | Mainstem | 4 |
| Summer | Tench | 110 | Mainstem | 4 |
| Summer | Tench | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 70 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 90 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Yellow Perch | 110 | Mainstem | 4 |
| Summer | Brown Bullhead | 254 | Bay | 5 |
| Summer | Brown Bullhead | 254 | Bay | 5 |
| Summer | Black Crappie | 60 | Bay | 5 |
| Summer | Black Crappie | 60 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 25 | Bay | 5 |
| Summer | Large Mouth Bass | 50 | Bay | 5 |
| Summer | Large Mouth Bass | 50 | Bay | 5 |
| Summer | Large Mouth Bass | 70 | Bay | 5 |
| Summer | Large Mouth Bass | 70 | Bay | 5 |
| Summer | Large Mouth Bass | 70 | Bay | 5 |
| Summer | Nothern Pike | 175 | Bay | 5 |
| Summer | Nothern Pike | 175 | Bay | 5 |
| Summer | Pumpkinseed | 45 | Bay | 5 |
| Summer | Pumpkinseed | 45 | Bay | 5 |
| Summer | Pumpkinseed | 50 | Bay | 5 |
| Summer | Pumpkinseed | 70 | Bay | 5 |
| Summer | Pumpkinseed | 70 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 100 | Bay | 5 |
| Summer | Pumpkinseed | 150 | Bay | 5 |
| Summer | Tench | 45 | Bay | 5 |
| Summer | Tench | 45 | Bay | 5 |
| Summer | Tench | 45 | Bay | 5 |
| Summer | Tench | 45 | Bay | 5 |
| Summer | Tench | 60 | Bay | 5 |
| Summer | Tench | 120 | Bay | 5 |
| Summer | Tench | 120 | Bay | 5 |
| Summer | Tench | 120 | Bay | 5 |
| Summer | Tench | 125 | Bay | 5 |
| Summer | Tench | 125 | Bay | 5 |
| Summer | Tench | 125 | Bay | 5 |
| Summer | Tench | 140 | Bay | 5 |
| Summer | Tench | 140 | Bay | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Tench | 140 | Bay | 5 |
| Summer | Tench | 175 | Bay | 5 |
| Summer | Yellow Perch | 45 | Bay | 5 |
| Summer | Yellow Perch | 45 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 50 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 60 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 65 | Bay | 5 |
| Summer | Yellow Perch | 75 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 100 | Bay | 5 |
| Summer | Yellow Perch | 120 | Bay | 5 |
| Summer | Yellow Perch | 125 | Bay | 5 |
| Summer | Yellow Perch | 125 | Bay | 5 |
| Summer | Yellow Perch | 125 | Bay | 5 |
| Summer | Yellow Perch | 125 | Bay | 5 |
| Summer | Yellow Perch | 150 | Bay | 5 |
| Summer | Yellow Perch | 150 | Bay | 5 |
| Summer | Black Crappie | 25 | Bay | 6 |
| Summer | Black Crappie | 25 | Bay | 6 |
| Summer | Black Crappie | 25 | Bay | 6 |
| Summer | Black Crappie | 25 | Bay | 6 |
| Summer | Black Crappie | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 45 | Bay | 6 |
| Summer | Large Mouth Bass | 45 | Bay | 6 |
| Summer | Large Mouth Bass | 45 | Bay | 6 |
| Summer | Large Mouth Bass | 45 | Bay | 6 |
| Summer | Large Mouth Bass | 45 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 50 | Bay | 6 |
| Summer | Large Mouth Bass | 70 | Bay | 6 |
| Summer | Large Mouth Bass | 71 | Bay | 6 |
| Summer | Large Mouth Bass | 72 | Bay | 6 |
| Summer | Large Mouth Bass | 73 | Bay | 6 |
| Summer | Large Mouth Bass | 74 | Bay | 6 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Summer | Large Mouth Bass | 75 | Bay | 6 |
| Summer | Large Mouth Bass | 75 | Bay | 6 |
| Summer | Large Mouth Bass | 75 | Bay | 6 |
| Summer | Large Mouth Bass | 85 | Bay | 6 |
| Summer | Pumpkinseed | 25 | Bay | 6 |
| Summer | Pumpkinseed | 50 | Bay | 6 |
| Summer | Pumpkinseed | 75 | Bay | 6 |
| Summer | Small Mouth Bass | 50 | Bay | 6 |
| Summer | Tench | 50 | Bay | 6 |
| Summer | Tench | 50 | Bay | 6 |
| Summer | Yellow Perch | 50 | Bay | 6 |
| Summer | Yellow Perch | 50 | Bay | 6 |
| Summer | Yellow Perch | 50 | Bay | 6 |
| Summer | Yellow Perch | 75 | Bay | 6 |
| Summer | Yellow Perch | 75 | Bay | 6 |
| Summer | Yellow Perch | 75 | Bay | 6 |
| Fall | Black Crappie | 20 | Mainstem | 1 |
| Fall | Black Crappie | 20 | Mainstem | 1 |
| Fall | Black Crappie | 25 | Mainstem | 1 |
| Fall | Black Crappie | 25 | Mainstem | 1 |
| Fall | Black Crappie | 25 | Mainstem | 1 |
| Fall | Black Crappie | 25 | Mainstem | 1 |
| Fall | Black Crappie | 30 | Mainstem | 1 |
| Fall | Black Crappie | 30 | Mainstem | 1 |
| Fall | Black Crappie | 30 | Mainstem | 1 |
| Fall | Black Crappie | 30 | Mainstem | 1 |
| Fall | Black Crappie | 35 | Mainstem | 1 |
| Fall | Large Mouth Bass | 40 | Mainstem | 1 |
| Fall | Large Mouth Bass | 60 | Mainstem | 1 |
| Fall | Largescale Sucker | 40 | Mainstem | 1 |
| Fall | Largescale Sucker | 45 | Mainstem | 1 |
| Fall | Largescale Sucker | 50 | Mainstem | 1 |
| Fall | Largescale Sucker | 50 | Mainstem | 1 |
| Fall | Largescale Sucker | 50 | Mainstem | 1 |
| Fall | Largescale Sucker | 55 | Mainstem | 1 |
| Fall | Largescale Sucker | 60 | Mainstem | 1 |
| Fall | Pumpkinseed | 15 | Mainstem | 1 |
| Fall | Pumpkinseed | 20 | Mainstem | 1 |
| Fall | Pumpkinseed | 20 | Mainstem | 1 |
| Fall | Pumpkinseed | 20 | Mainstem | 1 |
| Fall | Pumpkinseed | 20 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 25 | Mainstem | 1 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Fall | Tench | 30 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 35 | Mainstem | 1 |
| Fall | Tench | 40 | Mainstem | 1 |
| Fall | Tench | 40 | Mainstem | 1 |
| Fall | Tench | 45 | Mainstem | 1 |
| Fall | Tench | 45 | Mainstem | 1 |
| Fall | Tench | 50 | Mainstem | 1 |
| Fall | Tench | 55 | Mainstem | 1 |
| Fall | Tench | 60 | Mainstem | 1 |
| Fall | Tench | 60 | Mainstem | 1 |
| Fall | Brown Bullhead | 65 | BAY | 2 |
| Fall | Brown Bullhead | 75 | BAY | 2 |
| Fall | Black Crappie | 45 | BAY | 2 |
| Fall | Black Crappie | 48 | BAY | 2 |
| Fall | Black Crappie | 105 | BAY | 2 |
| Fall | Large Mouth Bass | 53 | BAY | 2 |
| Fall | Pumpkinseed | 82 | BAY | 2 |
| Fall | Pumpkinseed | 82 | BAY | 2 |
| Fall | Pumpkinseed | 85 | BAY | 2 |
| Fall | Pumpkinseed | 100 | BAY | 2 |
| Fall | Small Mouth Bass | 50 | BAY | 2 |
| Fall | Tench | 33 | BAY | 2 |
| Fall | Tench | 42 | BAY | 2 |
| Fall | Tench | 45 | BAY | 2 |
| Fall | Yellow Perch | 55 | BAY | 2 |
| Fall | Yellow Perch | 56 | BAY | 2 |
| Fall | Yellow Perch | 65 | BAY | 2 |
| Fall | Yellow Perch | 69 | BAY | 2 |
| Fall | Yellow Perch | 70 | BAY | 2 |
| Fall | Yellow Perch | 70 | BAY | 2 |
| Fall | Yellow Perch | 75 | BAY | 2 |
| Fall | Yellow Perch | 75 | BAY | 2 |
| Fall | Black Crappie | 20 | BAY | 3 |
| Fall | Black Crappie | 20 | BAY | 3 |
| Fall | Black Crappie | 20 | BAY | 3 |
| Fall | Black Crappie | 30 | BAY | 3 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Black Crappie | 45 | BAY | 3 |
| Fall | Black Crappie | 55 | BAY | 3 |
| Fall | Black Crappie | 55 | BAY | 3 |
| Fall | Black Crappie | 75 | BAY | 3 |
| Fall | Large Mouth Bass | 25 | BAY | 3 |
| Fall | Large Mouth Bass | 50 | BAY | 3 |
| Fall | Large Mouth Bass | 55 | BAY | 3 |
| Fall | Large Mouth Bass | 55 | BAY | 3 |
| Fall | Large Mouth Bass | 55 | BAY | 3 |
| Fall | Large Mouth Bass | 55 | BAY | 3 |
| Fall | Pumpkinseed | 20 | BAY | 3 |
| Fall | Tench | 25 | BAY | 3 |
| Fall | Tench | 25 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 30 | BAY | 3 |
| Fall | Tench | 35 | BAY | 3 |
| Fall | Tench | 35 | BAY | 3 |
| Fall | Tench | 40 | BAY | 3 |
| Fall | Tench | 40 | BAY | 3 |
| Fall | Tench | 50 | BAY | 3 |
| Fall | Yellow Perch | 60 | BAY | 3 |
| Fall | Yellow Perch | 70 | BAY | 3 |
| Fall | Black Crappie | 15 | Mainstem | 4 |
| Fall | Black Crappie | 15 | Mainstem | 4 |
| Fall | Black Crappie | 15 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 20 | Mainstem | 4 |
| Fall | Black Crappie | 25 | Mainstem | 4 |
| Fall | Black Crappie | 25 | Mainstem | 4 |
| Fall | Black Crappie | 25 | Mainstem | 4 |
| Fall | Black Crappie | 25 | Mainstem | 4 |
| Fall | Black Crappie | 30 | Mainstem | 4 |
| Fall | Black Crappie | 30 | Mainstem | 4 |
| Fall | Black Crappie | 30 | Mainstem | 4 |
| Fall | Black Crappie | 30 | Mainstem | 4 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Black Crappie | 35 | Mainstem | 4 |
| Fall | Black Crappie | 40 | Mainstem | 4 |
| Fall | Black Crappie | 54 | Mainstem | 4 |
| Fall | Black Crappie | 55 | Mainstem | 4 |
| Fall | Black Crappie | 65 | Mainstem | 4 |
| Fall | Large Mouth Bass | 48 | Mainstem | 4 |
| Fall | Large Mouth Bass | 50 | Mainstem | 4 |
| Fall | Large Mouth Bass | 50 | Mainstem | 4 |
| Fall | Large Mouth Bass | 50 | Mainstem | 4 |
| Fall | Large Mouth Bass | 55 | Mainstem | 4 |
| Fall | Large Mouth Bass | 58 | Mainstem | 4 |
| Fall | Large Mouth Bass | 60 | Mainstem | 4 |
| Fall | Large Mouth Bass | 70 | Mainstem | 4 |
| Fall | Large Mouth Bass | 70 | Mainstem | 4 |
| Fall | Large Mouth Bass | 70 | Mainstem | 4 |
| Fall | Pumpkinseed | 30 | Mainstem | 4 |
| Fall | Pumpkinseed | 30 | Mainstem | 4 |
| Fall | Pumpkinseed | 30 | Mainstem | 4 |
| Fall | Pumpkinseed | 55 | Mainstem | 4 |
| Fall | Pumpkinseed | 110 | Mainstem | 4 |
| Fall | Tench | 25 | Mainstem | 4 |
| Fall | Tench | 25 | Mainstem | 4 |
| Fall | Tench | 30 | Mainstem | 4 |
| Fall | Tench | 34 | Mainstem | 4 |
| Fall | Tench | 35 | Mainstem | 4 |
| Fall | Tench | 35 | Mainstem | 4 |
| Fall | Tench | 35 | Mainstem | 4 |
| Fall | Tench | 35 | Mainstem | 4 |
| Fall | Tench | 40 | Mainstem | 4 |
| Fall | Tench | 40 | Mainstem | 4 |
| Fall | Tench | 42 | Mainstem | 4 |
| Fall | Yellow Perch | 48 | Mainstem | 4 |
| Fall | Yellow Perch | 53 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 55 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 60 | Mainstem | 4 |
| Fall | Yellow Perch | 62 | Mainstem | 4 |
| Fall | Yellow Perch | 62 | Mainstem | 4 |
| Fall | Yellow Perch | 64 | Mainstem | 4 |
| Fall | Yellow Perch | 65 | Mainstem | 4 |
| Fall | Yellow Perch | 65 | Mainstem | 4 |
| Fall | Yellow Perch | 65 | Mainstem | 4 |
| Fall | Yellow Perch | 65 | Mainstem | 4 |
| Fall | Yellow Perch | 70 | Mainstem | 4 |
| Fall | Yellow Perch | 70 | Mainstem | 4 |
| Fall | Yellow Perch | 70 | Mainstem | 4 |
| Fall | Yellow Perch | 75 | Mainstem | 4 |
| Fall | Yellow Perch | 75 | Mainstem | 4 |
| Fall | Yellow Perch | 80 | Mainstem | 4 |
| Fall | Yellow Perch | 120 | Mainstem | 4 |
| Fall | Brown Bullhead | 45 | BAY | 5 |
| Fall | Brown Bullhead | 55 | BAY | 5 |
| Fall | Brown Bullhead | 55 | BAY | 5 |
| Fall | Brown Bullhead | 55 | BAY | 5 |
| Fall | Brown Bullhead | 55 | BAY | 5 |
| Fall | Brown Bullhead | 60 | BAY | 5 |
| Fall | Brown Bullhead | 60 | BAY | 5 |
| Fall | Brown Bullhead | 60 | BAY | 5 |
| Fall | Brown Bullhead | 65 | BAY | 5 |
| Fall | Brown Bullhead | 65 | BAY | 5 |
| Fall | Brown Bullhead | 65 | BAY | 5 |
| Fall | Black Crappie | 20 | BAY | 5 |
| Fall | Black Crappie | 20 | BAY | 5 |
| Fall | Black Crappie | 30 | BAY | 5 |
| Fall | Black Crappie | 30 | BAY | 5 |
| Fall | Black Crappie | 35 | BAY | 5 |
| Fall | Black Crappie | 50 | BAY | 5 |
| Fall | Black Crappie | 55 | BAY | 5 |
| Fall | Black Crappie | 55 | BAY | 5 |
| Fall | Black Crappie | 55 | BAY | 5 |
| Fall | Black Crappie | 60 | BAY | 5 |
| Fall | Black Crappie | 60 | BAY | 5 |
| Fall | Black Crappie | 60 | BAY | 5 |
| Fall | Black Crappie | 60 | BAY | 5 |
| Fall | Black Crappie | 60 | BAY | 5 |
| Fall | Black Crappie | 65 | BAY | 5 |
| Fall | Black Crappie | 100 | BAY | 5 |
| Fall | Large Mouth Bass | 15 | BAY | 5 |
| Fall | Large Mouth Bass | 50 | BAY | 5 |
| Fall | Large Mouth Bass | 55 | BAY | 5 |
| Fall | Large Mouth Bass | 55 | BAY | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Large Mouth Bass | 55 | BAY | 5 |
| Fall | Large Mouth Bass | 55 | BAY | 5 |
| Fall | Large Mouth Bass | 60 | BAY | 5 |
| Fall | Large Mouth Bass | 65 | BAY | 5 |
| Fall | Pumpkinseed | 95 | BAY | 5 |
| Fall | Pumpkinseed | 95 | BAY | 5 |
| Fall | Pumpkinseed | 100 | BAY | 5 |
| Fall | Pumpkinseed | 110 | BAY | 5 |
| Fall | Tench | 25 | BAY | 5 |
| Fall | Tench | 25 | BAY | 5 |
| Fall | Tench | 30 | BAY | 5 |
| Fall | Tench | 30 | BAY | 5 |
| Fall | Tench | 30 | BAY | 5 |
| Fall | Tench | 35 | BAY | 5 |
| Fall | Tench | 35 | BAY | 5 |
| Fall | Tench | 35 | BAY | 5 |
| Fall | Tench | 35 | BAY | 5 |
| Fall | Tench | 40 | BAY | 5 |
| Fall | Tench | 40 | BAY | 5 |
| Fall | Tench | 40 | BAY | 5 |
| Fall | Tench | 40 | BAY | 5 |
| Fall | Tench | 45 | BAY | 5 |
| Fall | Tench | 45 | BAY | 5 |
| Fall | Tench | 45 | BAY | 5 |
| Fall | Tench | 50 | BAY | 5 |
| Fall | Yellow Perch | 45 | BAY | 5 |
| Fall | Yellow Perch | 50 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 55 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 60 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 65 | BAY | 5 |
| Fall | Yellow Perch | 70 | BAY | 5 |
| Fall | Yellow Perch | 70 | BAY | 5 |
| Fall | Yellow Perch | 70 | BAY | 5 |
| Fall | Yellow Perch | 70 | BAY | 5 |
| Fall | Yellow Perch | 75 | BAY | 5 |
| Fall | Brown Bullhead | 55 | Mainstem | 6 |
| Fall | Black Crappie | 15 | Mainstem | 6 |
| Fall | Black Crappie | 20 | Mainstem | 6 |
| Fall | Black Crappie | 30 | Mainstem | 6 |
| Fall | Black Crappie | 30 | Mainstem | 6 |
| Fall | Black Crappie | 40 | Mainstem | 6 |
| Fall | Large Mouth Bass | 20 | Mainstem | 6 |
| Fall | Large Mouth Bass | 20 | Mainstem | 6 |
| Fall | Large Mouth Bass | 25 | Mainstem | 6 |
| Fall | Large Mouth Bass | 35 | Mainstem | 6 |
| Fall | Large Mouth Bass | 40 | Mainstem | 6 |
| Fall | Large Mouth Bass | 55 | Mainstem | 6 |
| Fall | Large Mouth Bass | 70 | Mainstem | 6 |
| Fall | Large Mouth Bass | 70 | Mainstem | 6 |
| Fall | Large Mouth Bass | 70 | Mainstem | 6 |
| Fall | Largescale Sucker | 85 | Mainstem | 6 |
| Fall | Largescale Sucker | 85 | Mainstem | 6 |
| Fall | Pumpkinseed | 25 | Mainstem | 6 |
| Fall | Pumpkinseed | 27 | Mainstem | 6 |
| Fall | Pumpkinseed | 30 | Mainstem | 6 |
| Fall | Pumpkinseed | 35 | Mainstem | 6 |
| Fall | Pumpkinseed | 35 | Mainstem | 6 |
| Fall | Pumpkinseed | 100 | Mainstem | 6 |
| Fall | Tench | 15 | Mainstem | 6 |
| Fall | Tench | 30 | Mainstem | 6 |
| Fall | Tench | 35 | Mainstem | 6 |
| Fall | Tench | 35 | Mainstem | 6 |
| Fall | Tench | 35 | Mainstem | 6 |
| Fall | Tench | 35 | Mainstem | 6 |
| Fall | Tench | 40 | Mainstem | 6 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Fall | Tench | 40 | Mainstem | 6 |
| Fall | Tench | 40 | Mainstem | 6 |
| Fall | Tench | 50 | Mainstem | 6 |
| Late Fall | Large Mouth Bass | 60 | Mainstem | 1 |
| Late Fall | Large Mouth Bass | 130 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 25 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Late Fall | Pumpkinseed | 30 | Mainstem | 1 |
| Late Fall | Yellow Perch | 110 | Mainstem | 1 |
| Late Fall | Yellow Perch | 110 | Mainstem | 1 |
| Late Fall | Black Crappie | 130 | Mainstem | 2 |
| Late Fall | Large Mouth Bass | 50 | Mainstem | 2 |
| Late Fall | Large Mouth Bass | 60 | Mainstem | 2 |
| Late Fall | Large Mouth Bass | 110 | Mainstem | 2 |
| Late Fall | Pumpkinseed | 15 | Mainstem | 2 |
| Late Fall | Pumpkinseed | 20 | Mainstem | 2 |
| Late Fall | Pumpkinseed | 25 | Mainstem | 2 |
| Late Fall | Pumpkinseed | 40 | Mainstem | 2 |
| Late Fall | Tench | 40 | Mainstem | 2 |
| Late Fall | Yellow Perch | 30 | Mainstem | 2 |
| Late Fall | Yellow Perch | 50 | Mainstem | 2 |
| Late Fall | Yellow Perch | 70 | Mainstem | 2 |
| Late Fall | Brown Bullhead | 100 | BAY | 3 |
| Late Fall | Brown Bullhead | 100 | BAY | 3 |
| Late Fall | Brown Bullhead | 310 | BAY | 3 |
| Late Fall | Black Crappie | 10 | BAY | 3 |
| Late Fall | Black Crappie | 12 | BAY | 3 |
| Late Fall | Black Crappie | 15 | BAY | 3 |
| Late Fall | Black Crappie | 15 | BAY | 3 |
| Late Fall | Black Crappie | 15 | BAY | 3 |
| Late Fall | Black Crappie | 25 | BAY | 3 |
| Late Fall | Black Crappie | 60 | BAY | 3 |
| Late Fall | Black Crappie | 90 | BAY | 3 |
| Late Fall | Large Mouth Bass | 55 | BAY | 3 |
| Late Fall | Large Mouth Bass | 60 | BAY | 3 |
| Late Fall | Large Mouth Bass | 65 | BAY | 3 |
| Late Fall | Large Mouth Bass | 70 | BAY | 3 |
| Late Fall | Large Mouth Bass | 100 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | BAY | 3 |
| Late Fall | Pumpkinseed | 12 | BAY | 3 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 15 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 20 | BAY | 3 |
| Late Fall | Pumpkinseed | 25 | BAY | 3 |
| Late Fall | Pumpkinseed | 25 | BAY | 3 |
| Late Fall | Pumpkinseed | 25 | BAY | 3 |
| Late Fall | Pumpkinseed | 25 | BAY | 3 |
| Late Fall | Pumpkinseed | 25 | BAY | 3 |
| Late Fall | Pumpkinseed | 30 | BAY | 3 |
| Late Fall | Pumpkinseed | 30 | BAY | 3 |
| Late Fall | Pumpkinseed | 30 | BAY | 3 |
| Late Fall | Pumpkinseed | 35 | BAY | 3 |
| Late Fall | Pumpkinseed | 40 | BAY | 3 |
| Late Fall | Pumpkinseed | 40 | BAY | 3 |
| Late Fall | Pumpkinseed | 50 | BAY | 3 |
| Late Fall | Pumpkinseed | 50 | BAY | 3 |
| Late Fall | Pumpkinseed | 80 | BAY | 3 |
| Late Fall | Pumpkinseed | 90 | BAY | 3 |
| Late Fall | Pumpkinseed | 100 | BAY | 3 |
| Late Fall | Tench | 15 | BAY | 3 |
| Late Fall | Tench | 20 | BAY | 3 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Late Fall | Tench | 30 | BAY | 3 |
| Late Fall | Tench | 30 | BAY | 3 |
| Late Fall | Tench | 30 | BAY | 3 |
| Late Fall | Tench | 35 | BAY | 3 |
| Late Fall | Tench | 35 | BAY | 3 |
| Late Fall | Tench | 35 | BAY | 3 |
| Late Fall | Tench | 40 | BAY | 3 |
| Late Fall | Tench | 40 | BAY | 3 |
| Late Fall | Tench | 40 | BAY | 3 |
| Late Fall | Tench | 40 | BAY | 3 |
| Late Fall | Tench | 45 | BAY | 3 |
| Late Fall | Tench | 50 | BAY | 3 |
| Late Fall | Yellow Perch | 10 | BAY | 3 |
| Late Fall | Yellow Perch | 10 | BAY | 3 |
| Late Fall | Yellow Perch | 15 | BAY | 3 |
| Late Fall | Yellow Perch | 20 | BAY | 3 |
| Late Fall | Yellow Perch | 20 | BAY | 3 |
| Late Fall | Yellow Perch | 25 | BAY | 3 |
| Late Fall | Yellow Perch | 35 | BAY | 3 |
| Late Fall | Yellow Perch | 40 | BAY | 3 |
| Late Fall | Yellow Perch | 45 | BAY | 3 |
| Late Fall | Yellow Perch | 45 | BAY | 3 |
| Late Fall | Yellow Perch | 45 | BAY | 3 |
| Late Fall | Yellow Perch | 50 | BAY | 3 |
| Late Fall | Yellow Perch | 50 | BAY | 3 |
| Late Fall | Yellow Perch | 50 | BAY | 3 |
| Late Fall | Yellow Perch | 50 | BAY | 3 |
| Late Fall | Yellow Perch | 60 | BAY | 3 |
| Late Fall | Yellow Perch | 100 | BAY | 3 |
| Late Fall | Yellow Perch | 150 | BAY | 3 |
| Late Fall | Yellow Perch | 150 | BAY | 3 |
| Late Fall | Yellow Perch | 160 | BAY | 3 |
| Late Fall | Pumpkinseed | 10 | Mainstem | 4 |
| Late Fall | Pumpkinseed | 15 | Mainstem | 4 |
| Late Fall | Pumpkinseed | 15 | Mainstem | 4 |
| Late Fall | Black Crappie | 10 | BAY | 5 |
| Late Fall | Black Crappie | 10 | BAY | 5 |
| Late Fall | Black Crappie | 20 | BAY | 5 |
| Late Fall | Black Crappie | 20 | BAY | 5 |
| Late Fall | Black Crappie | 35 | BAY | 5 |
| Late Fall | Large Mouth Bass | 40 | BAY | 5 |
| Late Fall | Large Mouth Bass | 50 | BAY | 5 |
| Late Fall | Large Mouth Bass | 60 | BAY | 5 |
| Late Fall | Large Mouth Bass | 60 | BAY | 5 |
| Late Fall | Large Mouth Bass | 100 | BAY | 5 |
| Late Fall | Large Mouth Bass | 100 | BAY | 5 |
| Late Fall | Longnose Sucker | 150 | BAY | 5 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Late Fall | Pumpkinseed | 10 | BAY | 5 |
| Late Fall | Pumpkinseed | 10 | BAY | 5 |
| Late Fall | Pumpkinseed | 15 | BAY | 5 |
| Late Fall | Pumpkinseed | 20 | BAY | 5 |
| Late Fall | Pumpkinseed | 20 | BAY | 5 |
| Late Fall | Pumpkinseed | 20 | BAY | 5 |
| Late Fall | Pumpkinseed | 30 | BAY | 5 |
| Late Fall | Pumpkinseed | 30 | BAY | 5 |
| Late Fall | Pumpkinseed | 30 | BAY | 5 |
| Late Fall | Small Mouth Bass | 150 | BAY | 5 |
| Late Fall | Yellow Perch | 90 | BAY | 5 |
| Late Fall | Yellow Perch | 90 | BAY | 5 |
| Late Fall | Yellow Perch | 100 | BAY | 5 |
| Late Fall | Brown Bullhead | 100 | BAY | 6 |
| Late Fall | Brown Bullhead | 100 | BAY | 6 |
| Late Fall | Black Crappie | 20 | BAY | 6 |
| Late Fall | Black Crappie | 20 | BAY | 6 |
| Late Fall | Black Crappie | 160 | BAY | 6 |
| Late Fall | Large Mouth Bass | 35 | BAY | 6 |
| Late Fall | Large Mouth Bass | 60 | BAY | 6 |
| Late Fall | Large Mouth Bass | 80 | BAY | 6 |
| Late Fall | Pumpkinseed | 8 | BAY | 6 |
| Late Fall | Pumpkinseed | 10 | BAY | 6 |
| Late Fall | Pumpkinseed | 10 | BAY | 6 |
| Late Fall | Pumpkinseed | 10 | BAY | 6 |
| Late Fall | Pumpkinseed | 10 | BAY | 6 |
| Late Fall | Pumpkinseed | 10 | BAY | 6 |
| Late Fall | Pumpkinseed | 11 | BAY | 6 |
| Late Fall | Pumpkinseed | 11 | BAY | 6 |
| Late Fall | Pumpkinseed | 11 | BAY | 6 |
| Late Fall | Pumpkinseed | 12 | BAY | 6 |
| Late Fall | Pumpkinseed | 12 | BAY | 6 |
| Late Fall | Pumpkinseed | 12 | BAY | 6 |
| Late Fall | Pumpkinseed | 13 | BAY | 6 |
| Late Fall | Pumpkinseed | 13 | BAY | 6 |
| Late Fall | Pumpkinseed | 13 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

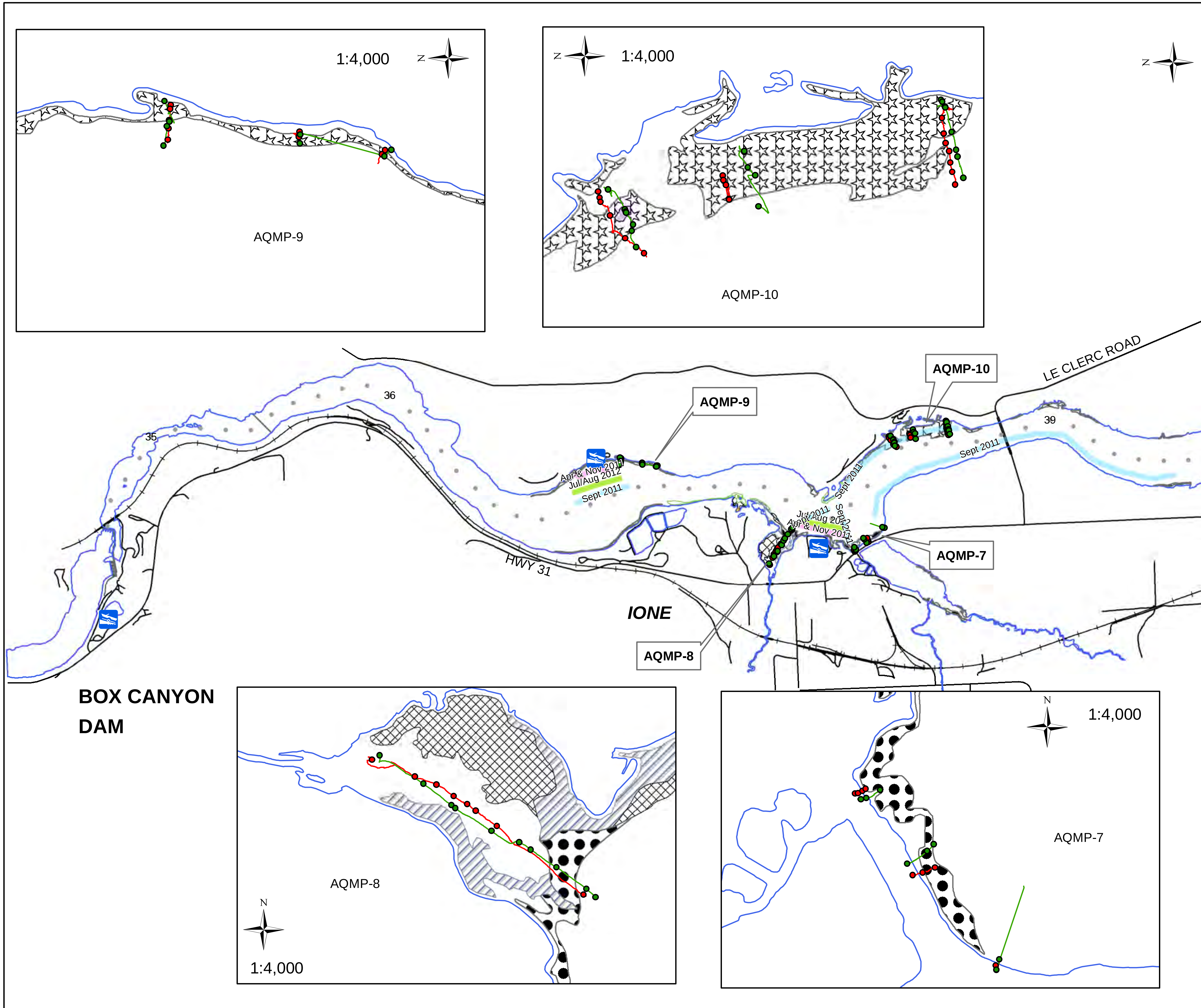
| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 15 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 20 | BAY | 6 |
| Late Fall | Pumpkinseed | 25 | BAY | 6 |
| Late Fall | Pumpkinseed | 25 | BAY | 6 |
| Late Fall | Pumpkinseed | 25 | BAY | 6 |
| Late Fall | Pumpkinseed | 25 | BAY | 6 |
| Late Fall | Pumpkinseed | 180 | BAY | 6 |
| Late Fall | Pumpkinseed | 180 | BAY | 6 |
| Late Fall | Tench | 20 | BAY | 6 |
| Late Fall | Tench | 25 | BAY | 6 |

**Appendix C. Shoreline Mortality Sample Data By Season.**

| Season | Species | Fork Length | Habitat Type | Site # |
|---|---|---|---|---|
| Late Fall | Tench | 30 | BAY | 6 |
| Late Fall | Tench | 30 | BAY | 6 |
| Late Fall | Tench | 30 | BAY | 6 |
| Late Fall | Tench | 30 | BAY | 6 |
| Late Fall | Tench | 40 | BAY | 6 |
| Late Fall | Tench | 50 | BAY | 6 |
| Late Fall | Yellow Perch | 30 | BAY | 6 |
| Late Fall | Yellow Perch | 30 | BAY | 6 |
| Late Fall | Yellow Perch | 31 | BAY | 6 |
| Late Fall | Yellow Perch | 50 | BAY | 6 |
| Late Fall | Yellow Perch | 50 | BAY | 6 |
| Late Fall | Yellow Perch | 60 | BAY | 6 |
| Late Fall | Yellow Perch | 70 | BAY | 6 |
| Late Fall | Yellow Perch | 80 | BAY | 6 |
| Late Fall | Yellow Perch | 80 | BAY | 6 |
| Late Fall | Yellow Perch | 90 | BAY | 6 |

# Appendix C

# Maps of Index Site Monitoring




## Legend

- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Rotovation
- 2011 Harvester
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

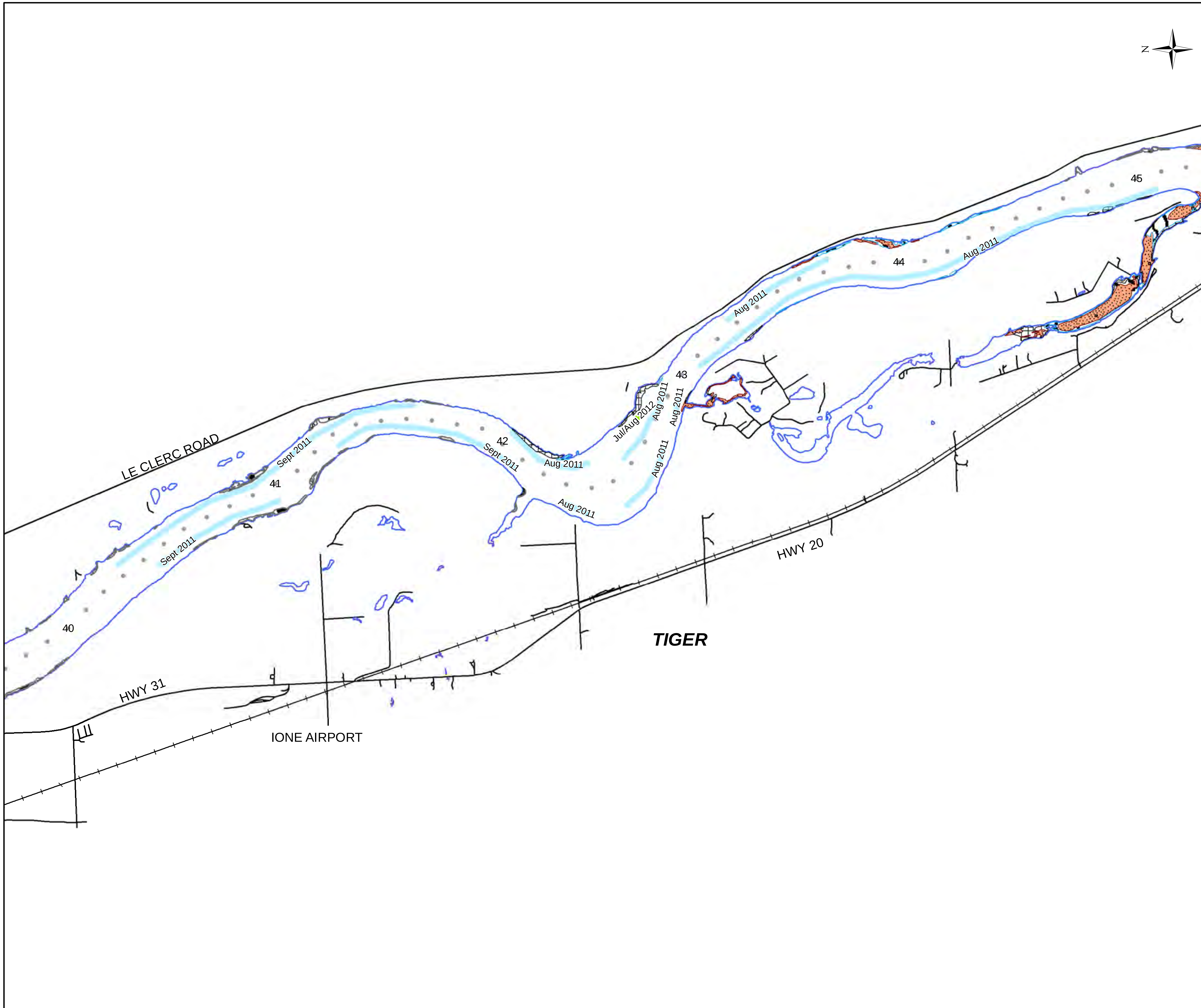
0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 1 of 11

Pend Oreille Public Utility District




## Legend

- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Rotovation
- 2011 Harvester
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

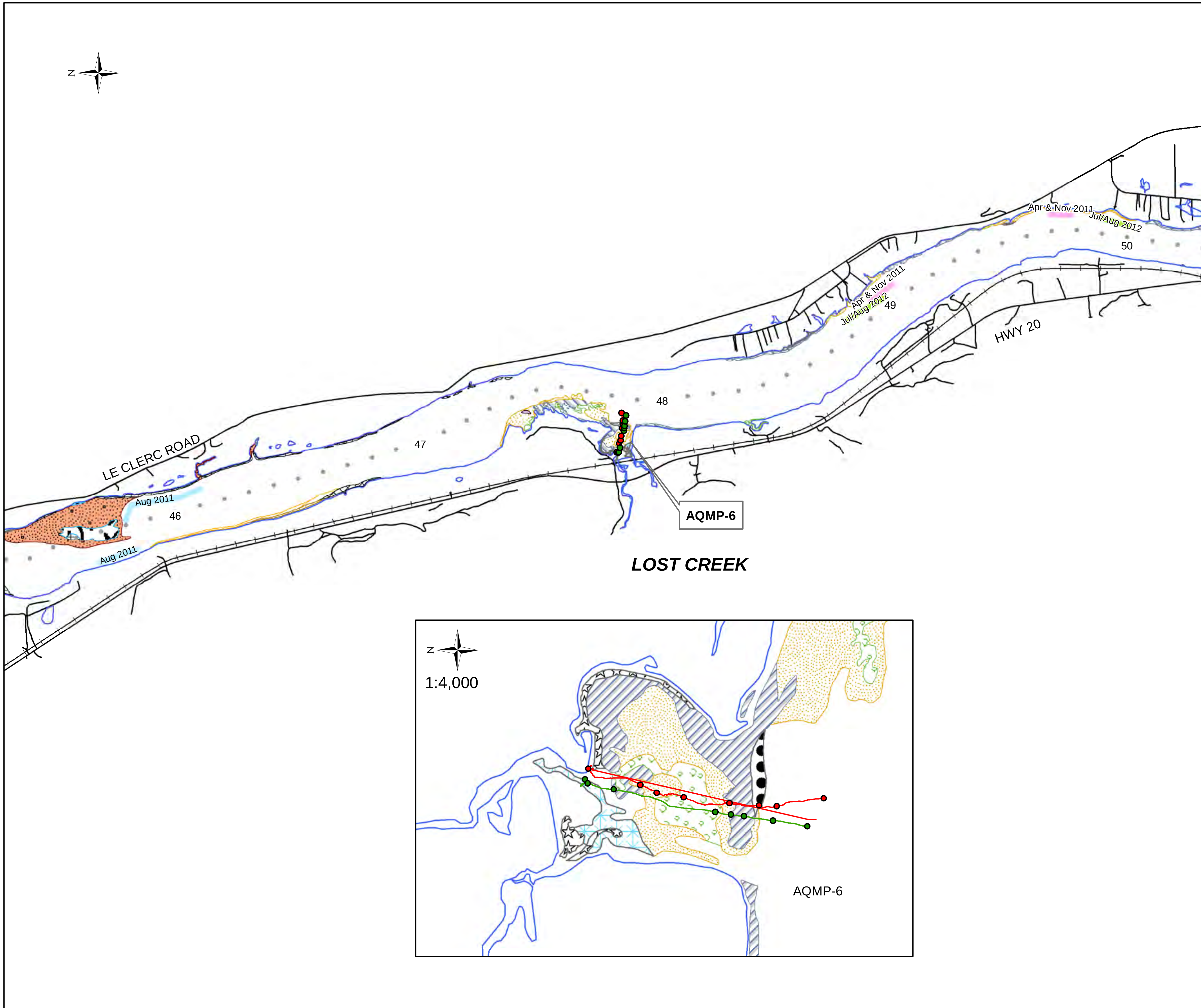
0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 2 of 11

Pend Oreille Public Utility District




## Legend

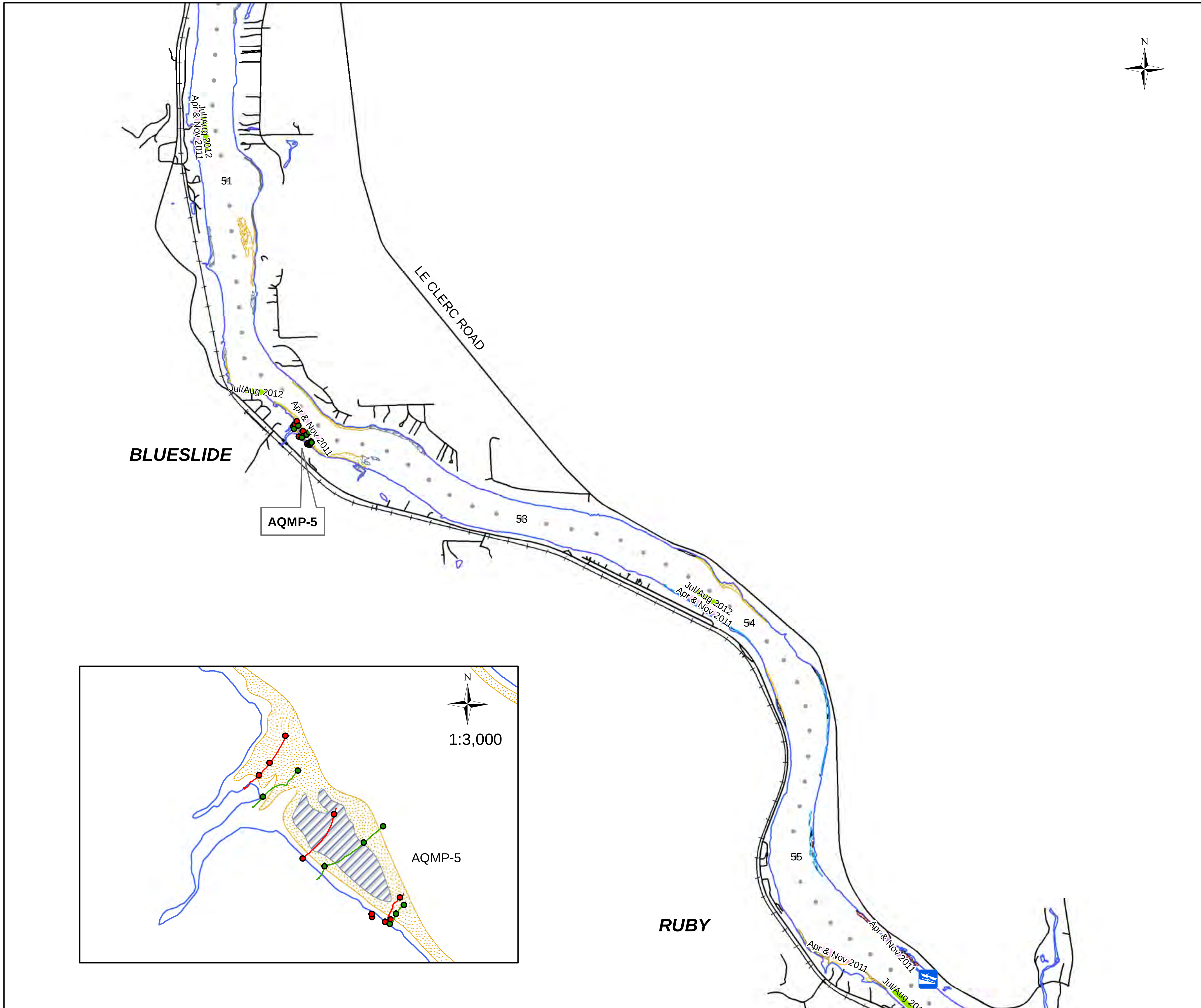
- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Rotovation
- 2011 Harvester
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 3 of 11




## Legend

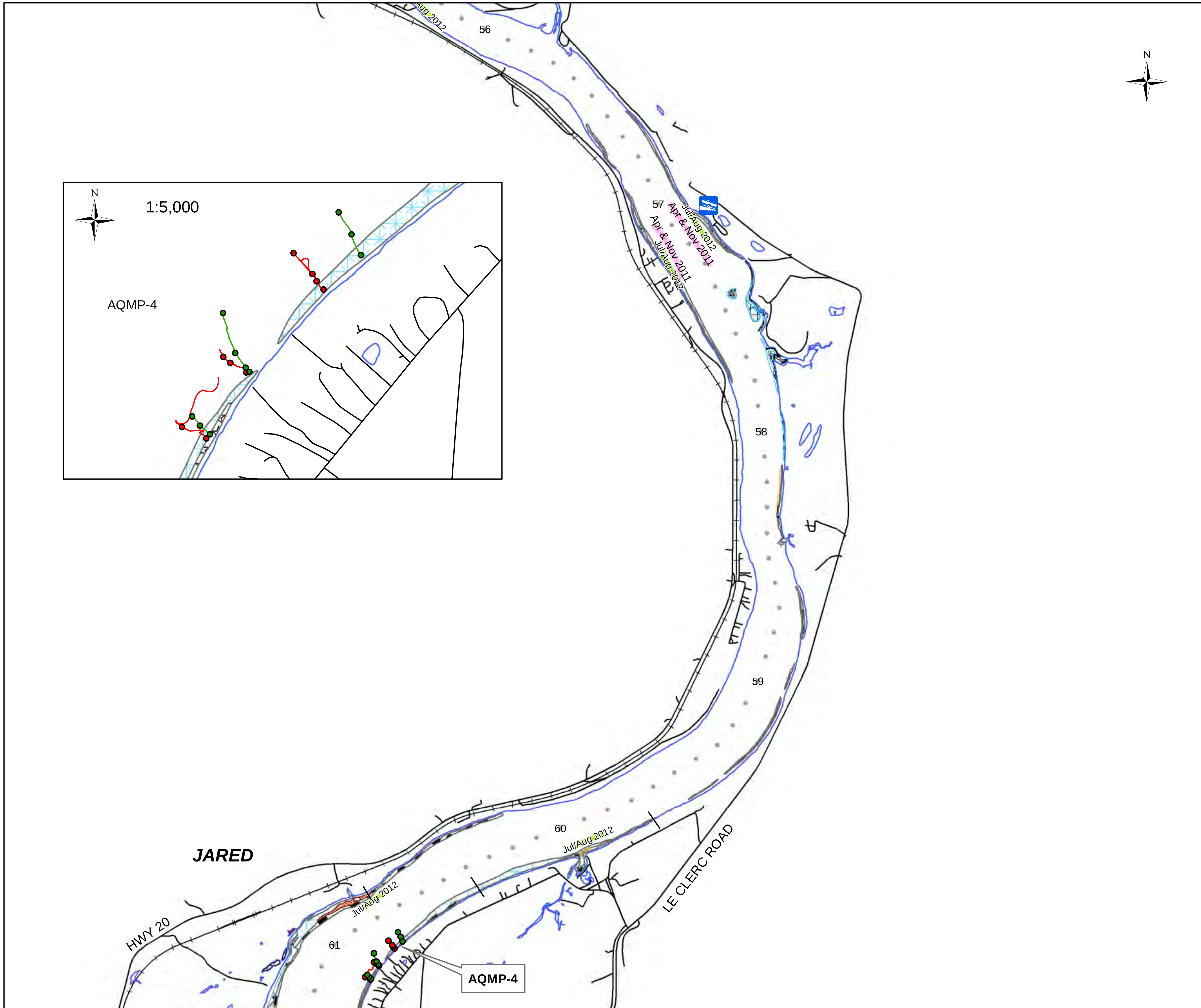
- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Harvester
- 2011 Rotovation
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 4 of 11




## Legend

- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Rotovation
- 2011 Harvester
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

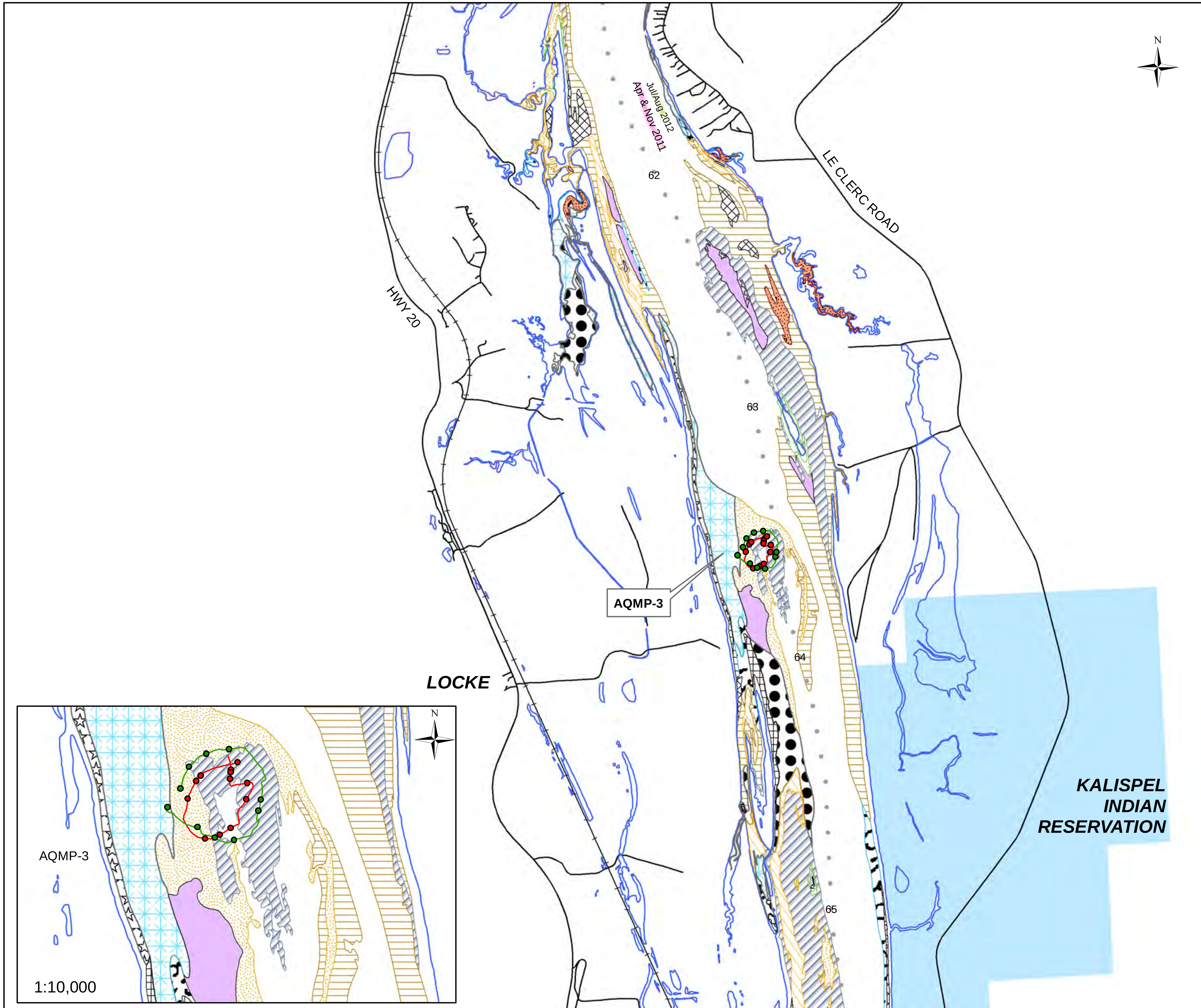
0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 5 of 11

Pend Oreille Public Utility District




## Legend

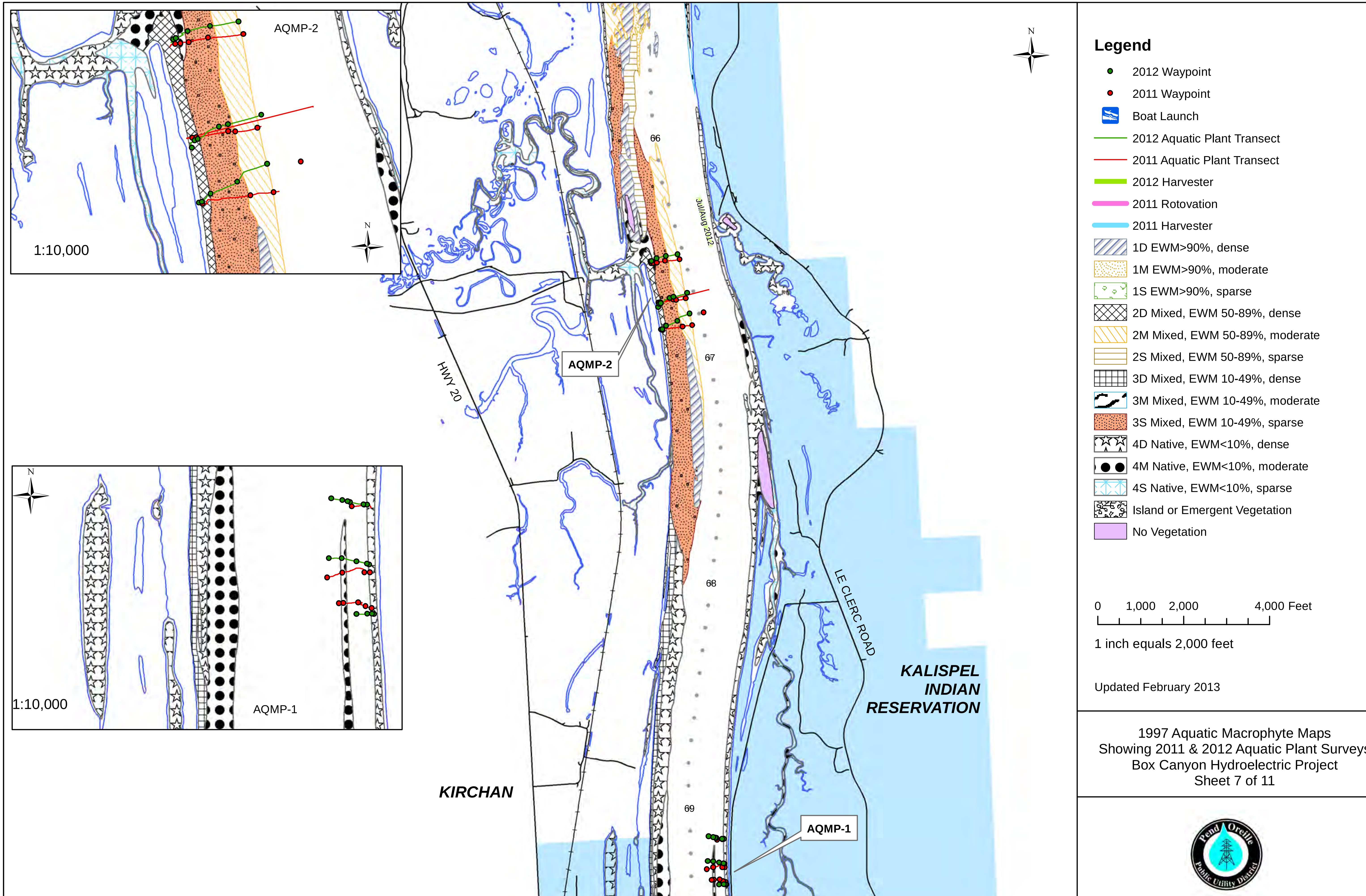
- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Harvester
- 2011 Rotovation
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

0 1,000 2,000 4,000 Feet

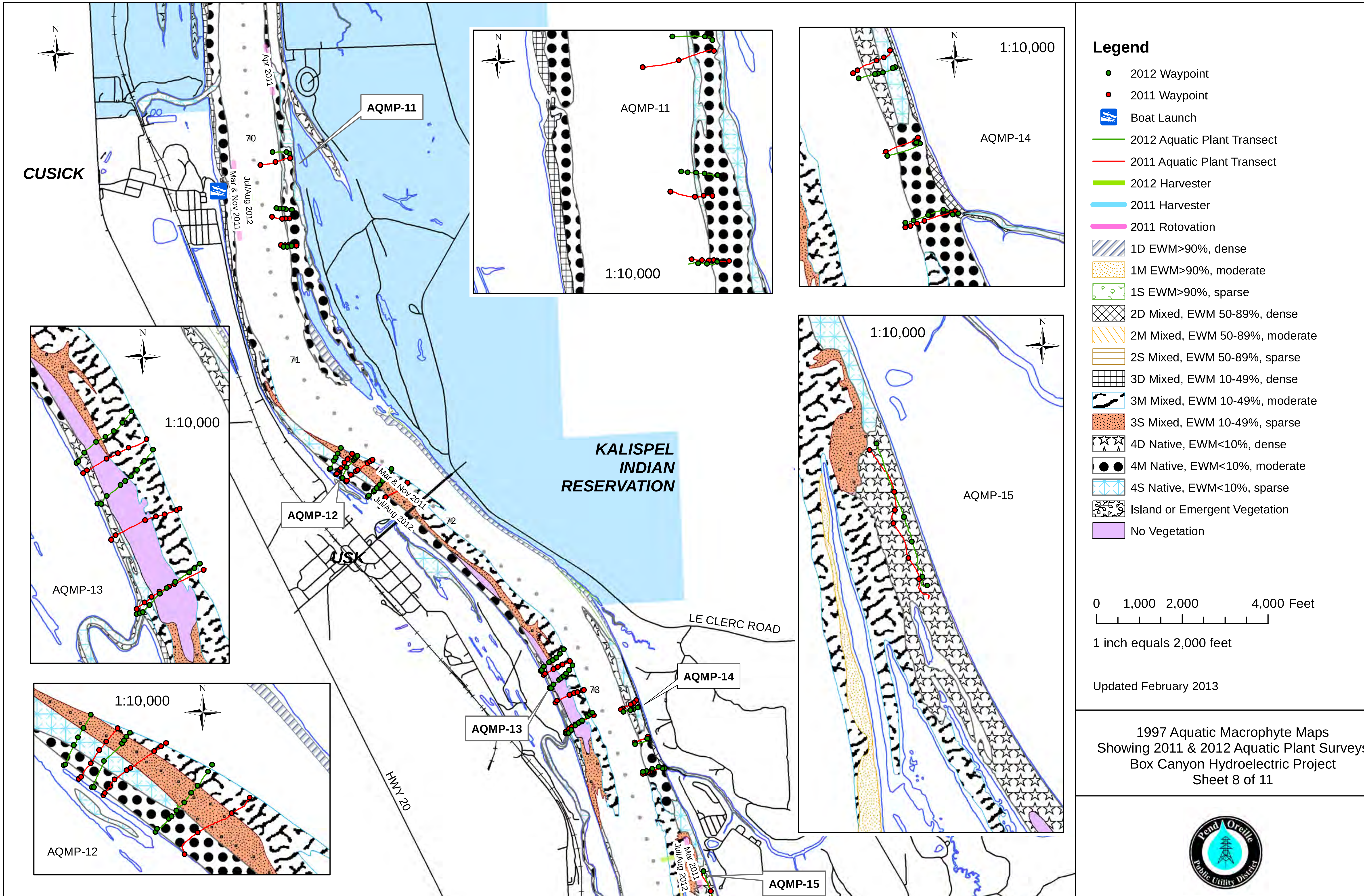
1 inch equals 2,000 feet

Updated February 2013

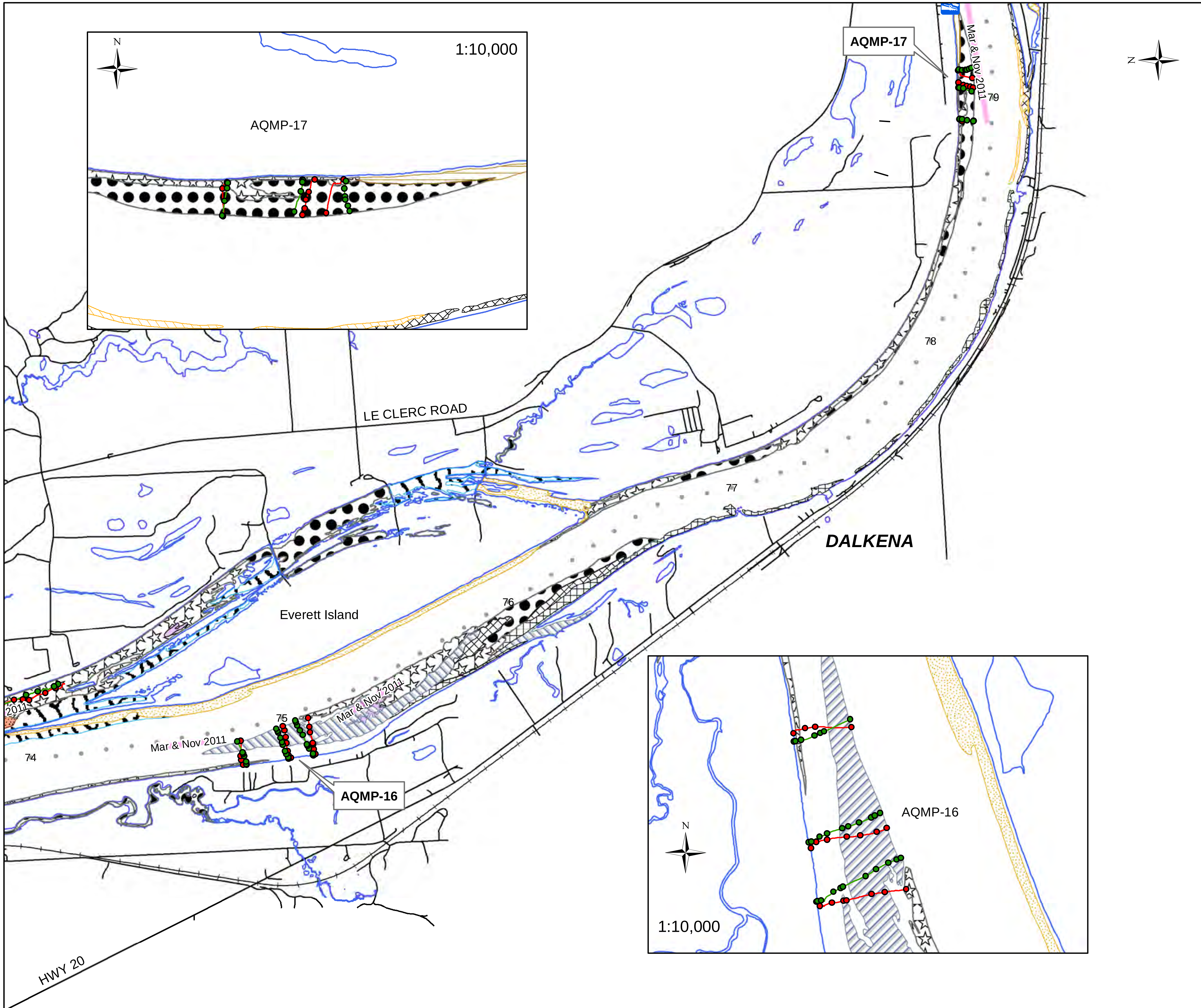
1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 6 of 11




1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 7 of 11



CUSICK
KALISPEL INDIAN RESERVATION
USK
LE CLERC ROAD
HWY 20
AQMP-11
AQMP-12
AQMP-13
AQMP-14
AQMP-15
Apr 2011
Mar & Nov 2011
Jul/Aug 2012
70
71
72
73
1:10,000
N
Legend
2012 Waypoint
2011 Waypoint
Boat Launch
2012 Aquatic Plant Transect
2011 Aquatic Plant Transect
2012 Harvester
2011 Harvester
2011 Rotovation
1D EWM>90%, dense
1M EWM>90%, moderate
1S EWM>90%, sparse
2D Mixed, EWM 50-89%, dense
2M Mixed, EWM 50-89%, moderate
2S Mixed, EWM 50-89%, sparse
3D Mixed, EWM 10-49%, dense
3M Mixed, EWM 10-49%, moderate
3S Mixed, EWM 10-49%, sparse
4D Native, EWM<10%, dense
4M Native, EWM<10%, moderate
4S Native, EWM<10%, sparse
Island or Emergent Vegetation
No Vegetation
0 1,000 2,000 4,000 Feet
1 inch equals 2,000 feet
Updated February 2013
1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 8 of 11
Pend Oreille Public Utility District




## Legend

- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Rotovation
- 2011 Harvester
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

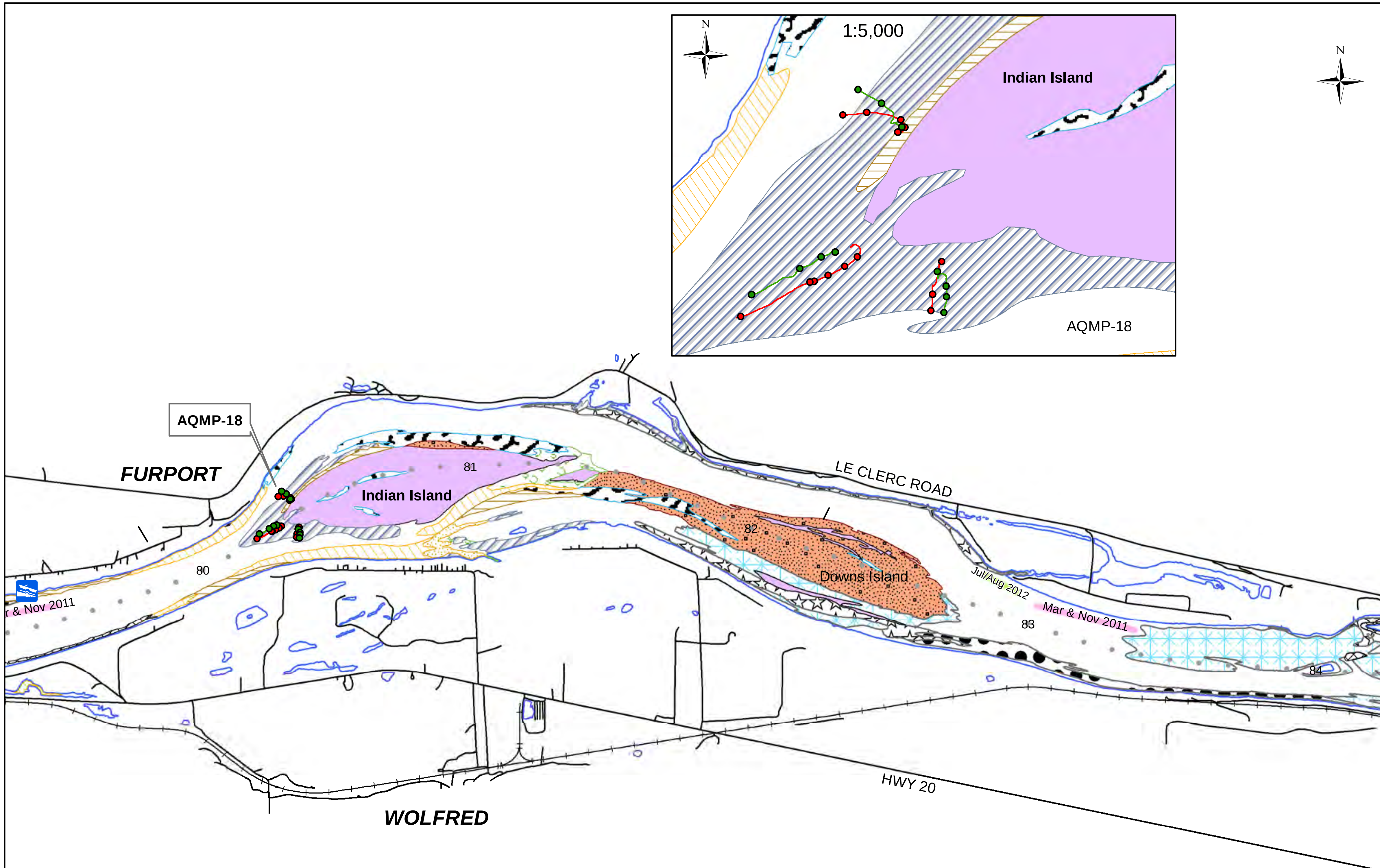
0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 9 of 11

Pend Oreille Public Utility District




## Legend

- 2012 Waypoint
- 2011 Waypoint
- Boat Launch
- 2012 Aquatic Plant Transect
- 2011 Aquatic Plant Transect
- 2012 Harvester
- 2011 Harvester
- 2011 Rotovation
- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

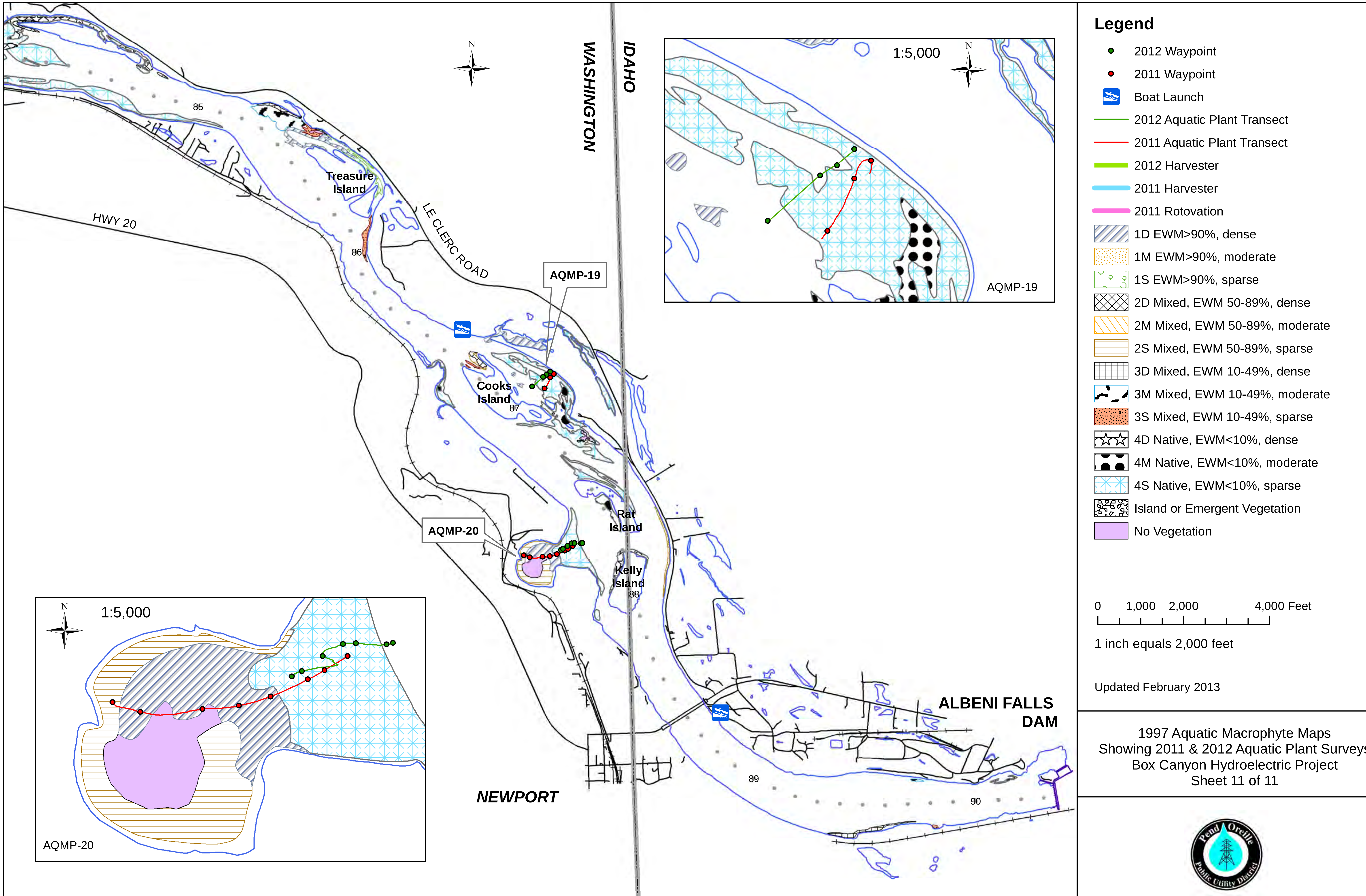
0 1,000 2,000 4,000 Feet

1 inch equals 2,000 feet

Updated February 2013

1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 10 of 11

Pend Oreille Public Utility District


WASHINGTON
IDAHO
HWY 20
LE CLERC ROAD
Treasure Island
Cooks Island
Rat Island
Kelly Island
AQMP-19
AQMP-20
NEWPORT
ALBENI FALLS DAM
85
86
87
88
89
90
N
1:5,000
AQMP-19
1:5,000
AQMP-20
Legend
2012 Waypoint
2011 Waypoint
Boat Launch
2012 Aquatic Plant Transect
2011 Aquatic Plant Transect
2012 Harvester
2011 Harvester
2011 Rotovation
1D EWM>90%, dense
1M EWM>90%, moderate
1S EWM>90%, sparse
2D Mixed, EWM 50-89%, dense
2M Mixed, EWM 50-89%, moderate
2S Mixed, EWM 50-89%, sparse
3D Mixed, EWM 10-49%, dense
3M Mixed, EWM 10-49%, moderate
3S Mixed, EWM 10-49%, sparse
4D Native, EWM<10%, dense
4M Native, EWM<10%, moderate
4S Native, EWM<10%, sparse
Island or Emergent Vegetation
No Vegetation
0 1,000 2,000 4,000 Feet
1 inch equals 2,000 feet
Updated February 2013
1997 Aquatic Macrophyte Maps
Showing 2011 & 2012 Aquatic Plant Surveys
Box Canyon Hydroelectric Project
Sheet 11 of 11
Pend Oreille Public Utility District

# Appendix D

# Boat Launch Survey/Treatment Areas

Edgewater FSCG
Write a description for your map.
Legend
Edgewater FSCG
N
Google Earth
200 ft

Ione Boat Launch
Google earth
Google earth
feet
800
meters
200


Tiger County Access
Google earth
feet
300
meters
100


Sunset
Google earth
Google earth
feet
200
meters
60


feet 400
meters 100


Alaska Lane
Google earth
feet 200
meters 70


Blue Slide
Google earth
Google earth
feet
300
meters
100


Holiday Shores
Google earth
feet
300
meters
90

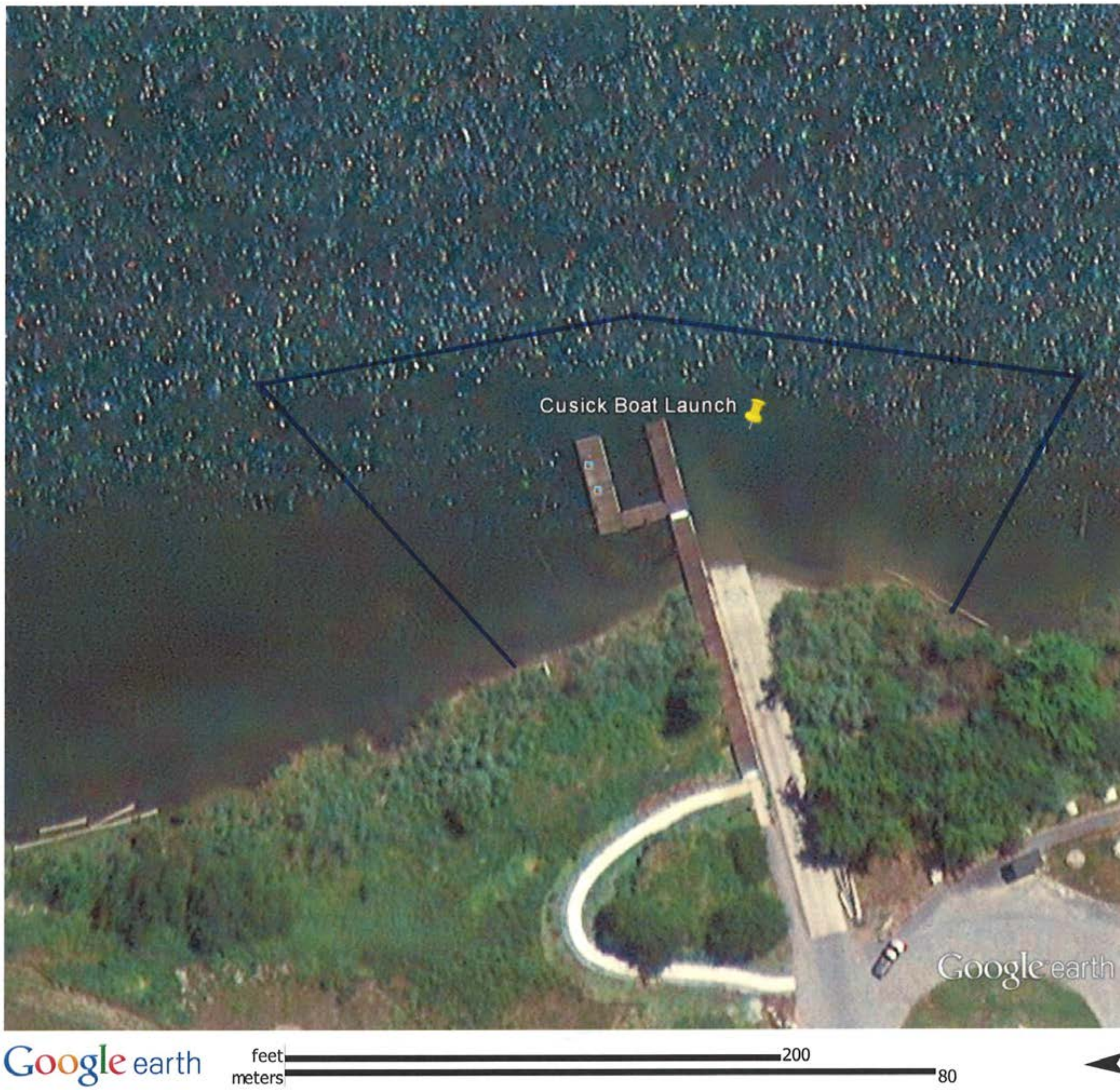
Ruby Ferry Landing Boat Launch
Google earth
Google earth
feet
300
meters
100

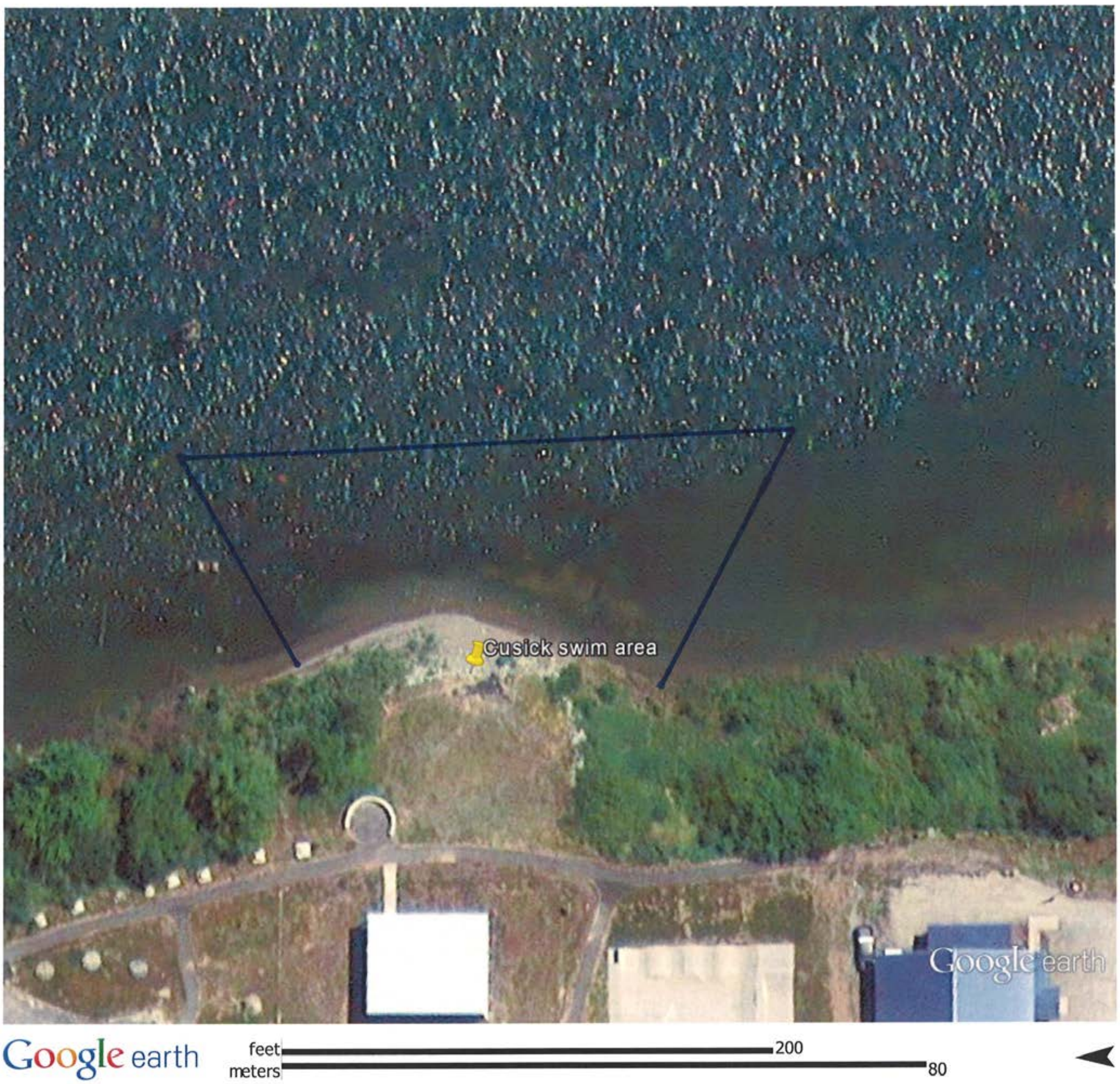

Panhandle FSCG
Write a description for your map.
Legend
Edgewater FSCG
Google Earth
N
200 ft


River Bend Boat Launch
Google earth
feet
300
meters
100


Manresa Grotto Boat Launch
Google earth
Google earth
feet
200
meters
80


Kalispel Boat Launch
Google earth
feet
300
meters
90
Google earth


Cusick Boat Launch
Google earth
Google earth
feet
200
meters
80


Cusick swim area
Google earth
feet
200
meters
80


Usk Boat Launch
Google earth
Google earth
feet
300
meters
100

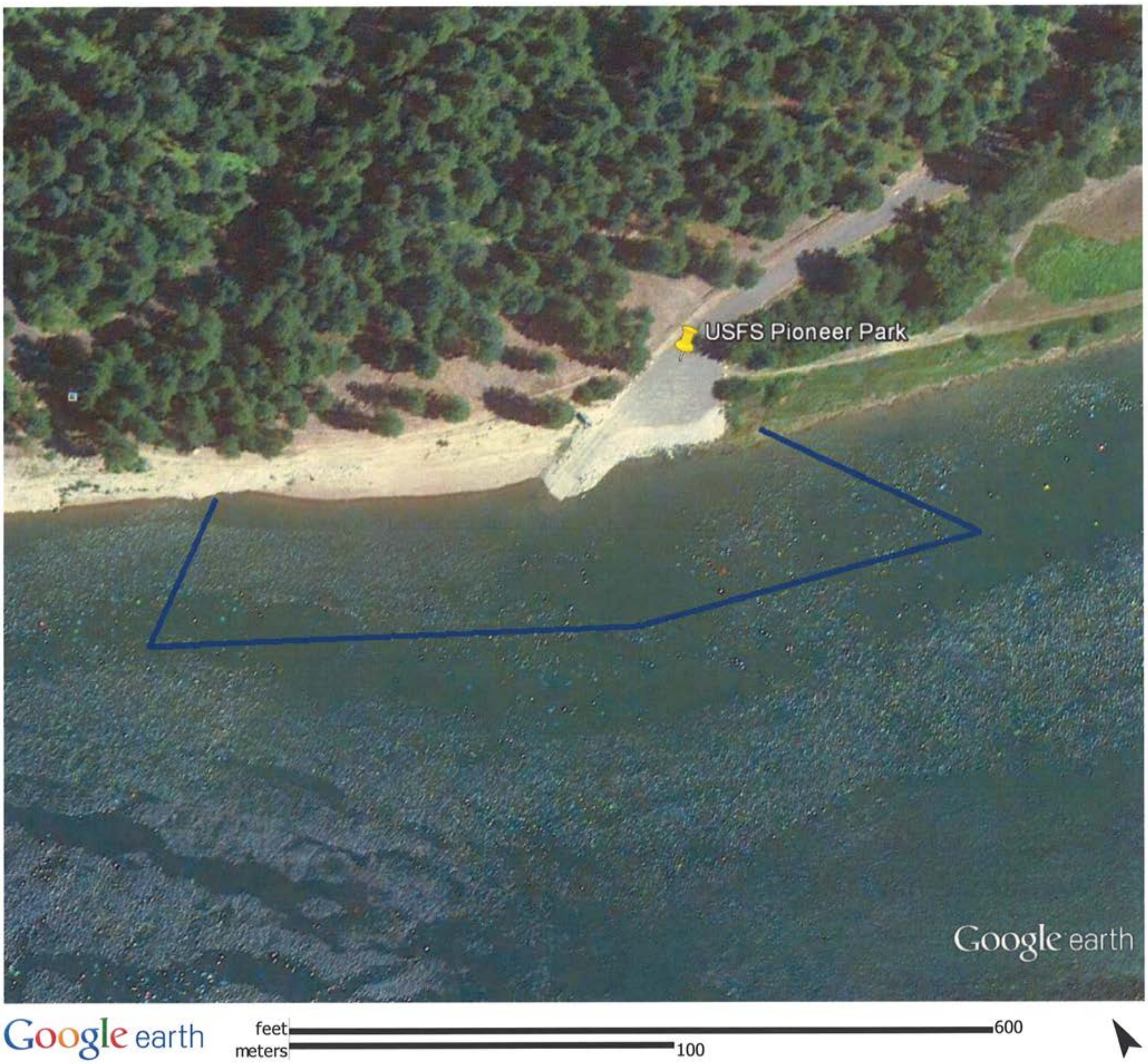
Davis Ests North
Google earth
feet
400
meters
100

Davis Ests Boat Launch South
Google earth
Google earth
feet
300
meters
100


Open Skies-Pondoray Shores Boat Launch
Google earth
Google earth
feet
100
meters
50

Greggs Addition Boat Launch
Google earth
feet
100
meters
40


Sandy Shores Boat Launch
© 2014 Google
Google earth
Google earth
feet
200
meters
70



USFS Pioneer Park
Google earth
Google earth
feet
600
meters
100


Oldtown Boat Launch
Google earth
Google earth
feet
200
meters
80

**MAXIMUM OF 50 PEOPLE ALLOWED. NO WALK INS WILL BE ACCEPTED**

**FREE EVENT!**


## Aquatic Plant ID

Let's take a hands on look at Pend Oreille County's aquatic nuisances, look alikes and the best way to eradicate them! Tool demo available after workshop.

## Bank Stabilization

Learn to safeguard both the natural resources we enjoy in a rural lifestyle while also guarding your property from the erosional forces of Mother Nature!

## Weed Management

Herbicides? Mechanical Control? What is the best option for you to control your problem weeds? Let's find the right management practice for you!

# FRIDAY JULY 24TH 9AM- 3PM

# AT THE CAMAS CENTER IN USK WA

## FREE LUNCH, DOOR PRIZES & PESTICIDE CREDITS!

REGISTER BY EMAIL, PHONE, OR ON OUR WEBSITE AT
NOXWEEDINFO@PENDOREILLE.ORG OR 509 447-6451

# WWW.TINYURL.COM/POCAQUATIC

# Appendix E

# Rotavator and Harvester Operating Permits

Washington Department of
Fish & Wildlife
PO Box 43234
Olympia, WA 98504-3234
(360) 902-2200

# HYDRAULIC PROJECT APPROVAL

Issued Date: July 20, 2020
Project End Date: July 19, 2025

Permit Number: 2020-1-160+01
FPA/Public Notice Number: N/A
Application ID: 22206

| PERMITTEE | AUTHORIZED AGENT OR CONTRACTOR |
|---|---|
| Public Utility District #1 of Pend Oreille County<br>ATTENTION: Scott Jungblom<br>PO Box 190<br>Newport, WA 99156-0190 | |

**Project Name:** Mechanical Aquatic Weed Control in Box Canyon Reservoir

**Project Description:** This project provides for the mechanical removal of aquatic noxious weeds and nuisance vegetation from the Pend Oreille River at 23 public and high-use private boat launches and associated swim areas to help prevent the spread of Milfoil and other noxious aquatic weeds to area lakes as part of the Aquatic Plant Management Plan for Pend Oreille County PUD #1 and FERC License 2042.

## PROVISIONS

1. TIMING LIMITATION: The harvester and aquamog may operate between July 20, 2020 and July 19, 2025 provided: The Rotovator will only operate when water temperatures are below 65F and the harvester will only operate when water temperatures are above 65F. The machines shall not operate within 300ft of the mouths of tributaries and high velocity gravel bars between November 1, and February 1. The harvester and rotovator shall not operate in active fish spawning areas.

2. APPROVED PLANS: Except for the provisions below, you must follow all of the requirements for mechanical harvest and cutting found in the current edition of the Washington Department of Fish and Wildlife (WDFW) Aquatic Plants and Fish Pamphlet (http://wdfw.wa.gov/licensing/aquatic_plant_removal/index.html). You must also work under the plans and specifications in your Hydraulic Project Approval (HPA) application, June 25, 2020, and approved by WDFW, except as modified by this HPA. The Aquamog shall also be operated in accordance with the recommended mitigation measures and BMP's as outlined in the June 30, 2010 'Assessment of Rotovator Impacts and Suggested Operating Procedures for the Interim Aquatic Plant Management Plan, Box Canyon Reservoir'. You must have a copy of this HPA, the pamphlet, and application with you or on the job site while you work.

3. Removal of detached plants and plant fragments from the watercourse in boat ramp areas shall be as complete as possible. All plant materials shall be placed in an upland disposal site to prevent re-entry into state waters. Plants and plant fragments removed in other parts of the reservoir shall be placed above the current waterline to minimize re-entry into state waters.

4. Extreme care shall be taken to ensure that no petroleum products, hydraulic fluid or other deleterious material from equipment used are allowed to enter or leach into the watercourse. The Aquamog shall be well-maintained and where practicable, food-grade oil in the hydraulic systems should be used.

5. If at any time, as a result of project activities or water quality problems, fish life are observed in distress or a fish kill occurs, operations shall cease and both the Washington Department of Fish and Wildlife and the Washington Military Department's Emergency Management Division at 1-800-258-5990 shall be notified of the problem immediately. The project shall not resume until further approval is given by the Washington Department of Fish and Wildlife. Additional

measures to mitigate impacts may be required.

6. Existing fish habitat components such as logs, stumps, and large boulders may be relocated within the watercourse if necessary to operate the equipment. These habitat components shall not be removed from the watercourse.

7. The Aquamog and Harvester shall be operated at all times to cause the least adverse impact to fish life.

8. The harvester shall only operate in high use recreational areas such as public boat ramps, public swimming areas, marinas, resorts and high use boating areas. Operation shall occur when water temperatures are above 65 degrees Fahrenheit.

9. Every effort shall be made to avoid the spread of plant fragments through equipment contamination. Persons or firms using any equipment to remove or control aquatic plants shall thoroughly remove and properly dispose of all viable residual plants and viable plant parts from the equipment prior to the equipment's use in a body of water.

10. The Aquamog shall only operate in high use recreational areas such as public boat ramps, public swimming areas, marinas, resorts and high use boating areas. Operation shall occur when water temperatures are below 65 degrees Fahrenheit.

11. INVASIVE SPECIES CONTROL: Thoroughly clean all equipment and gear before arriving and leaving the job site to prevent the transport and introduction of aquatic invasive species. Properly dispose of any water and chemicals used to clean gear and equipment. You can find additional information in the WDFW Invasive Species Management protocols (http://wdfw.wa.gov/ais/youcanhelp.html).

12. NOTIFICATION PRIOR TO STARTING WORK: You, your agent, or contractor must contact WDFW by e-mail at HPAapplications@dfw.wa.gov; mail to PO Box 43234, Olympia WA 98504-3234; or fax to (360) 902-2946 at least three business days before starting work each season. The notification must include the permittee’s name, project location, starting date, and the HPA permit number.

13. ANNUAL REPORTING: A calendar year annual report must be uploaded as a post permit requirement to Application ID 22206 in the Aquatic Protection and Permitting System (APPS; http://wdfw.wa.gov/licensing/hpa/) by February 28 of the following year. In the final year of the HPA, the report must be submitted prior to the HPA expiration date. An annual report is required even if no work was conducted. The annual report must include:
a. Application ID number (22206), HPA permit number, permittee, contact person, address, telephone, date of report, time period covered in report.
b. Total number of projects implemented under the HPA.
c. Problem(s) encountered.
d. List of individual projects completed, including location, date and duration of work, and description of work.

| | | | | | | |
|---|---|---|---|---|---|---|
| LOCATION #1: | , , WA | | | | | |
| WORK START: | July 20, 2020 | | | WORK END: | July 19, 2025 | |
| WRIA | | Waterbody: | | | Tributary to: | |
| | | | | | | |
| 1/4 SEC: | Section: | Township: | Range: | Latitude: | Longitude: | County: |
| | | | | | | |

Washington Department of
Fish & Wildlife
PO Box 43234
Olympia, WA 98504-3234
(360) 902-2200

# HYDRAULIC PROJECT APPROVAL

Issued Date: July 20, 2020
Project End Date: July 19, 2025

Permit Number: 2020-1-160+01
FPA/Public Notice Number: N/A
Application ID: 22206

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | Pend Oreille |
| Location #1 Driving Directions | | | | | | |
| | | | | | | |

## APPLY TO ALL HYDRAULIC PROJECT APPROVALS

This Hydraulic Project Approval pertains only to those requirements of the Washington State Hydraulic Code, specifically Chapter 77.55 RCW. Additional authorization from other public agencies may be necessary for this project. The person(s) to whom this Hydraulic Project Approval is issued is responsible for applying for and obtaining any additional authorization from other public agencies (local, state and/or federal) that may be necessary for this project.

This Hydraulic Project Approval shall be available on the job site at all times and all its provisions followed by the person(s) to whom this Hydraulic Project Approval is issued and operator(s) performing the work.

This Hydraulic Project Approval does not authorize trespass.

The person(s) to whom this Hydraulic Project Approval is issued and operator(s) performing the work may be held liable for any loss or damage to fish life or fish habitat that results from failure to comply with the provisions of this Hydraulic Project Approval.

Failure to comply with the provisions of this Hydraulic Project Approval could result in civil action against you, including, but not limited to, a stop work order or notice to comply, and/or a gross misdemeanor criminal charge, possibly punishable by fine and/or imprisonment.

All Hydraulic Project Approvals issued under RCW 77.55.021 are subject to additional restrictions, conditions, or revocation if the Department of Fish and Wildlife determines that changed conditions require such action. The person(s) to whom this Hydraulic Project Approval is issued has the right to appeal those decisions. Procedures for filing appeals are listed below.

Washington Department of
Fish & Wildlife
PO Box 43234
Olympia, WA 98504-3234
(360) 902-2200



MINOR MODIFICATIONS TO THIS HPA: You may request approval of minor modifications to the required work timing or to the plans and specifications approved in this HPA unless this is a General HPA. If this is a General HPA you must use the Major Modification process described below. Any approved minor modification will require issuance of a letter documenting the approval. A minor modification to the required work timing means any change to the work start or end dates of the current work season to enable project or work phase completion. Minor modifications will be approved only if spawning or incubating fish are not present within the vicinity of the project. You may request subsequent minor modifications to the required work timing. A minor modification of the plans and specifications means any changes in the materials, characteristics or construction of your project that does not alter the project's impact to fish life or habitat and does not require a change in the provisions of the HPA to mitigate the impacts of the modification. If you originally applied for your HPA through the online Aquatic Protection Permitting System (APPS), you may request a minor modification through APPS. A link to APPS is at http://wdfw.wa.gov/licensing/hpa/. If you did not use APPS you must submit a written request that clearly indicates you are seeking a minor modification to an existing HPA. Written requests must include the name of the applicant, the name of the authorized agent if one is acting for the applicant, the APP ID number of the HPA, the date issued, the permitting biologist, the requested changes to the HPA, the reason for the requested change, the date of the request, and the requestor's signature. Send by mail to: Washington Department of Fish and Wildlife, PO Box 43234, Olympia, Washington 98504-3234, or by email to HPAapplications@dfw.wa.gov. You should allow up to 45 days for the department to process your request.

MAJOR MODIFICATIONS TO THIS HPA: You may request approval of major modifications to any aspect of your HPA. Any approved change other than a minor modification to your HPA will require issuance of a new HPA. If you originally applied for your HPA through the online Aquatic Protection Permitting System (APPS), you may request a major modification through APPS. A link to APPS is at http://wdfw.wa.gov/licensing/hpa/. If you did not use APPS you must submit a written request that clearly indicates you are requesting a major modification to an existing HPA. Written requests must include the name of the applicant, the name of the authorized agent if one is acting for the applicant, the APP ID number of the HPA, the date issued, the permitting biologist, the requested changes to the HPA, the reason for the requested change, the date of the request, and the requestor's signature. Send your written request by mail to: Washington Department of Fish and Wildlife, PO Box 43234, Olympia, Washington 98504-3234. You may email your request for a major modification to HPAapplications@dfw.wa.gov. You should allow up to 45 days for the department to process your request.

## APPEALS INFORMATION

If you wish to appeal the issuance, denial, conditioning, or modification of a Hydraulic Project Approval (HPA), Washington Department of Fish and Wildlife (WDFW) recommends that you first contact the department employee who issued or denied the HPA to discuss your concerns. Such a discussion may resolve your concerns without the need for further appeal action. If you proceed with an appeal, you may request an informal or formal appeal. WDFW encourages you to take advantage of the informal appeal process before initiating a formal appeal. The informal appeal process includes a review by department management of the HPA or denial and often resolves issues faster and with less legal complexity than the formal appeal process. If the informal appeal process does not resolve your concerns, you may advance your appeal to the formal process. You may contact the HPA Appeals Coordinator at (360) 902-2534 for more information.

A. INFORMAL APPEALS: WAC 220-660-460 is the rule describing how to request an informal appeal of WDFW actions taken under Chapter 77.55 RCW. Please refer to that rule for complete informal appeal procedures. The following information summarizes that rule.

A person who is aggrieved by the issuance, denial, conditioning, or modification of an HPA may request an informal appeal of that action. You must send your request to WDFW by mail to the HPA Appeals Coordinator, Department of Fish and Wildlife, Habitat Program, PO Box 43234, Olympia, Washington 98504-3234; e-mail to HPAapplications@dfw.wa.gov; fax to (360) 902-2946; or hand-delivery to the Natural Resources Building, 1111 Washington St SE, Habitat Program, Fifth floor. WDFW must receive your request within 30 days from the date you receive notice of the decision. If you agree, and you applied for the HPA, resolution of the appeal may be facilitated through an informal conference with the WDFW employee responsible for the decision and a supervisor. If a resolution is not reached through the informal conference, or you are not the person who applied for the HPA, the HPA Appeals Coordinator or designee may conduct an informal hearing or review and recommend a decision to the Director or designee. If you are not satisfied with the results of the informal appeal, you may file a request for a formal appeal.

B. FORMAL APPEALS: WAC 220-660-470 is the rule describing how to request a formal appeal of WDFW actions taken under Chapter 77.55 RCW. Please refer to that rule for complete formal appeal procedures. The following information summarizes that rule.

A person who is aggrieved by the issuance, denial, conditioning, or modification of an HPA may request a formal appeal of that action. You must send your request for a formal appeal to the clerk of the Pollution Control Hearings Boards and serve a copy on WDFW within 30 days from the date you receive notice of the decision. You may serve WDFW by mail to the HPA Appeals Coordinator, Department of Fish and Wildlife, Habitat Program, PO Box 43234, Olympia, Washington 98504-3234; e-mail to HPAapplications@dfw.wa.gov; fax to (360) 902-2946; or hand-delivery to the Natural Resources Building, 1111 Washington St SE, Habitat Program, Fifth floor. The time period for requesting a formal appeal is suspended during consideration of a timely informal appeal. If there has been an informal appeal, you may request a formal appeal within 30 days from the date you receive the Director's or designee's written decision in response to the informal appeal.

C. FAILURE TO APPEAL WITHIN THE REQUIRED TIME PERIODS: If there is no timely request for an appeal, the WDFW action shall be final and unappealable.

| | | | |
|---|---|---|---|
| Habitat Biologist | Renee.Kinnick@dfw.wa.gov | | for Director |
| Renee Kinnick | 509-892-1001, Ext:318 | | WDFW |