Integrated Aquatic Vegetation Management Plan 2009

REVIEW ONLY

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By

Moses Lake Irrigation & Rehabilitation District

Acknowledgements

The following people are acknowledged for their contributions to the collection of data, photos, and/or other important input to this document. Each has generously contributed their time and effort to ensure the management plan will reflect and fulfill the restoration and future health of the waterbody of Moses Lake.

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Curt J. Carpenter, General Manager of Moses Lake Irrigation and Rehabilitation District. Curt's early background was in horticulture as a field man at the Moses Lake Conservation District Nursery. He served seven years with the Conservation District, propagating, maintaining, harvesting, and sales of all types of landscape and habitat plant species. Curt has fifteen years service with the City of Moses Lake Engineering Division with responsibilities of construction plan reviews, plat reviews, and providing public utility information. During tenure Curt was involved in several projects, such as; concept design of the third avenue revitalization project, design of Dogwood Court Project. One of the founding members of Moses Lake Activity Trail Committee, and author, publisher of The Moses Lake Activity Trail Master Plan. Curt was the lead in acquiring a grant from the State of Washington WWRP for the Heron Trail Project. In all, Curt has served over 24 years serving the public.

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Clyde Carpenter is a science educator with 30 years experience teaching high school physiology and biology. Clyde was awarded the Biology Teacher of the Year for the State of Washington. He earned a Presidential Award for Excellence in Science and Mathematics and has authored numerous science articles, curricula, and biology textbook for the State of Washington. He served as a Board member on the Eisenhower Mathematics and Science for Northwest Schools. Clyde wrote several pieces of curriculum relating to the Nature of Water Power. For six years he had a major role in Washington State Water Quality Institutes. Clyde is experienced in water quality sampling and clean water projects. Also, Clyde continues to serve as a science consultant and has for the past 17 years.

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B.S., Physical Science, M.A. Science Education

Jack Horne is a Geoscientist with experience at science and mathematics teacher training at Washington State University. He has organized, planned and delivered a number of science teacher workshops, nationally and internationally. Jack is well known as an excellent grant writer, and manager. Jack authored a grant which provided the establishment of Washington State water quality teacher institutes over a six year period. Jack is a former NSTA Board/Council member. Jack participated in writing several science curriculum pieces, including the Nature of Water Power. Jack is experienced in water quality testing and clean water projects and is in his 27th year as a science consultant.

Ryan Walker, Biologist

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Ryan Walker is a Biologist with experience in forestry, wetland biology, riparian restoration and code administration. His background includes natural resource management, land-use planning and Shoreline Management Act permitting. He is a U.S. Army Corps of Engineers-certified wetlands delineator and has completed the Department of Ecology's training course for the *Washington State Wetland Rating Form for Eastern Washington*. In addition, Ryan has training in stream typing and ordinary high water mark identification from the Washington Departments of Natural Resources and Fish and Wildlife. He has worked with state and federal agencies in north-central Washington on environmental permitting issues for over nine years. Ryan is based in Wenatchee.

Glenn Grette, Senior Biologist & Company Principal

M.S., Fisheries, University of Washington
B.S., Zoology, Washington State University

Glenn Grette is a Company Principal and Senior Fisheries Biologist with experience in the consulting field in fisheries ecology, habitat restoration and mitigation, impact assessment, study design, environmental documentation, and permitting assistance since 1984. Glenn has been involved in permitting numerous large-scale marine-oriented projects. He has extensive experience with design, implementation, and monitoring of mitigation projects developed to offset aquatic impacts in accordance with Section 404(b) of the Clean Water Act and the Washington Hydraulic Code. Glenn also manages our Wenatchee office.

David L. Kluttz, Managing Member, Applicator

B. S. Agronomy, California State University, 7 years Idaho Professional applicator, 3 years as Washington Professional applicator

Dave Kluttz has 13 years experience in aquatic weed control, including both application and survey work in lakes, rivers and delta systems. In addition he has 17 years of experience in crop production, consultation, and diagnosis/treatment of landscape pest problems, including noxious weed eradication and environmental restoration. Dave is actively involved in the industry. He regularly attends regional conferences as both and attendee and presenter for the purposes of continuing education.

JEFF KOERTHE: Department of Fish and Wildlife (To Be Inserted Later)

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INTRODUCTION

The Moses Lake Irrigation & Rehabilitation District is committed to improve the water quality of Moses Lake. It is our goal to enhance the recreational aspects of the lake and to rehabilitate the lake to further the health, welfare and quality of life of the citizens that surround it.

The Moses Lake Irrigation and Rehabilitation District (MLIRD) is the primary agency for planning and implementation of efforts to revitalize Moses Lake, grant County, Washington. The Moses Lake Irrigation District was formed in 1928 and authorized to manage irrigation water distribution in the Moses lake region. MLIRD has held a Certificate of Water Right for storage of 50,000 acre feet since 1952.

In 1962, the state of Washington authorized certain irrigation districts to convert to irrigation and rehabilitation districts (RCW 87.84.010)-legislation specifically enacted for the district. The Moses Lake Irrigation and Rehabilitation District (MLIRD) was formed and is authorized to "further the rehabilitation or improvement of inland lakes as shorelines, and the modification or improvement of existing or planned control structures located in the district in order to further the health, recreation, and welfare of the residents in the area" (RCW 87.84.050).

In 2004 the Moses Lake Irrigation and Rehabilitation District (MLIRD) received a grant (number G0600278) from the Washington State Department of Ecology (DOE) to develop an integrated lake aquatic plant plan for the lake body of Moses Lake. In May of 2008, a grant extension request was made to the Department of Ecology and the extension was granted in June 2008, to expire on June 30, 2009.

Moses Lake is a 6,800 acre (surface area) water body with approximately 120 miles of shoreline, and is located in Grant County, Washington. At a water surface elevation of 1047 feet, the depth ranges from 2 to 35 feet deep. Moses Lake's water shed is inclusive of portions of Lincoln, Adams, Grant, and Spokane Counties and receives perennial flows from Crab Creek and Rocky Ford Creek. Rocky Ford Creek contributes substantial flow but is a spring-fed stream with a very small surface drainage area. The Crab Creek drainage is approximately 2,200 square miles as measured upstream of the U.S. Bureau of Reclamation (USBR) gage located at Road 7 NE (3-miles upstream of Moses Lake). Rocky Coulee Wasteway drains to Crab Creek approximately 1.5-miles below the USBR gage on Crab Creek.

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Fig 1. Aerial View of Moses Lake Waterbody.

Table 1. Physical Characteristic of Moses Lake (Bain 1990) (based on water surface elevation of 1046 ft).

Moses Lake	
Surface Area	6,800 acres
Maximum Depth	38 feet
Mean Depth	18.5 feet
Volume	126,000 acre-feet
Total Length	20.5 miles
Parker Horn	
Mean depth	12.6 feet
Area	758 acres
Volume	9,520 acre-feet
Pelican Horn	
Mean Depth	15.6 feet
Area	1,600 acres
Volume	25,000 acre-feet

The purpose of an integrated aquatic vegetation management plan is to create a working model design for the Moses Lake Irrigation and Rehabilitation District can use to mobilize effective

actions that will rehabilitate the waterbody and protect the beneficial uses of Moses Lake. This model will refer to the waterbody as a "system" dealing with existing conditions and processes of the waterbody which must exhibit change in response to planned rehabilitation activities. The model will be a plan to promote beneficial uses of the lake, including wildlife habitat, water quality, increase the reservoir volume and provide water saving measures.

GOALS & OBJECTIVES

This project has several goals and objectives to be attained. Moses Lake Irrigation & Rehabilitation District has the responsibility to maintain and enhance the water quality and usability of the fresh water reservoir known as Moses Lake. In order to attain additional goals or objectives we need to determine the primary goal which is exactly what plant life, existing water quality, and existing or potential outside influences exist.

- Survey and map the existing aquatic vegetation
- Establish the lake bottom existing conditions
- Determine the most effective and efficient means of managing aquatic plants
- Ascertain possible funding opportunities

The general goals of this management plan are to:

- Define, describe and map aquatic vegetation data using appropriate GPS mapping techniques.
- Describe management of aquatic vegetation.
- Describe management of lake's water temperature.
- Describe management of sedimentation in eight specific areas.
- Describe management of blue-green algal blooms
- Describe management of trapped phosphates and nitrates
- Describe management of water quality improvement
- Describe aeration water features and their efficacy.

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The objectives of this plan are to:

- Map and apply the water quality results (data) to the management plan, data from the "2006-Summary of water sampling for Moses Lake" by Peter S. Buragoon, PhD., PE, Principal Environmental Scientist.
- Map and apply aquatic vegetation and bottom sampling (data) to the management plan, data from by the GPS "2008 Survey Mapping of the aquatic vegetation and bottom sampling" by Dave Klutz, Managing Member of Lakeland Restoration Services.
- Map and integrate sedimentation into the management plan from the "2008 Moses Lake Management Plan" by Grette Associates, Environmental Consultants.
- Apply relevant shoreline data provided by the "2005 Final Draft of the City of Moses Lake, Shoreline Inventory and Characterization" by the Department of Geography and Land Studies, Central Washington University.
- Apply relevant flora and fauna data provided the Washington State Fish and Wildlife.
- Apply relevant data provide by the U.S. Bureau of Reclamation.
- Develop a "Use Map" with legends for the waterbody of Moses Lake.

HISTORY OF THE MOSES LAKE IRRIGATION AND REHABILITATION DISTRICT

The following is a list of past and ongoing contributions of the MLIRD to rehabilitation of the waterbody of Moses Lake.

- Water management actions to control nutrient input from agricultural lands through partnering with farmers and adjacent conservation districts via the Clean Lakes project in the 1980's. This has improved water quality and recreational opportunities in Moses Lake.
- Constructed a pumping station, using grants from the Washington Department of Ecology and the U.S. Environmental Protection Agency that pumps water

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between Parker Horn and Pelican Horn. This has improved water quality in Pelican Horn.

- Developed an ongoing program to harvest and dispose of nuisance submerged vegetation using mechanical weed harvesters. This has maintained open channels free of excessive vegetation, debris and foreign material and has improved fish habitat and recreational opportunities.
- In cooperation with Washington Department of Fish and Wildlife (WDFW), installation and maintenance of a screened carp barrier in Pelican Horn, increasing the amount of rearing habitat available for key sport fish species.
- Conducted water quality studies in Moses Lake waterbody in collaboration with the Washington Department of Ecology and the University of Washington.
- Sponsors annual lakeshore clean-up efforts by volunteers, involving trash removal of 30 to 50 cubic yards per year.
- Manages the operation of Connelly Park, formerly Airman's Beach, on Rocky Ford Arm for the benefit of recreational users and area residents.
- Coordinates irrigation water flow management through Moses Lake waterbody to major Potholes Reservoir with the Bureau of Reclamation. These inputs have a major beneficial effect on water quality in the lake. Supports efforts to control the carp population
- Through cooperative efforts from the Washington State Department of Fisheries and Wildlife, Drumheller Dam was constructed to improve Rocky Ford Creek Carp infestation and through sedimentation at the dam to slow and reduce the entrance of phosphates into the waterbody of Moses Lake

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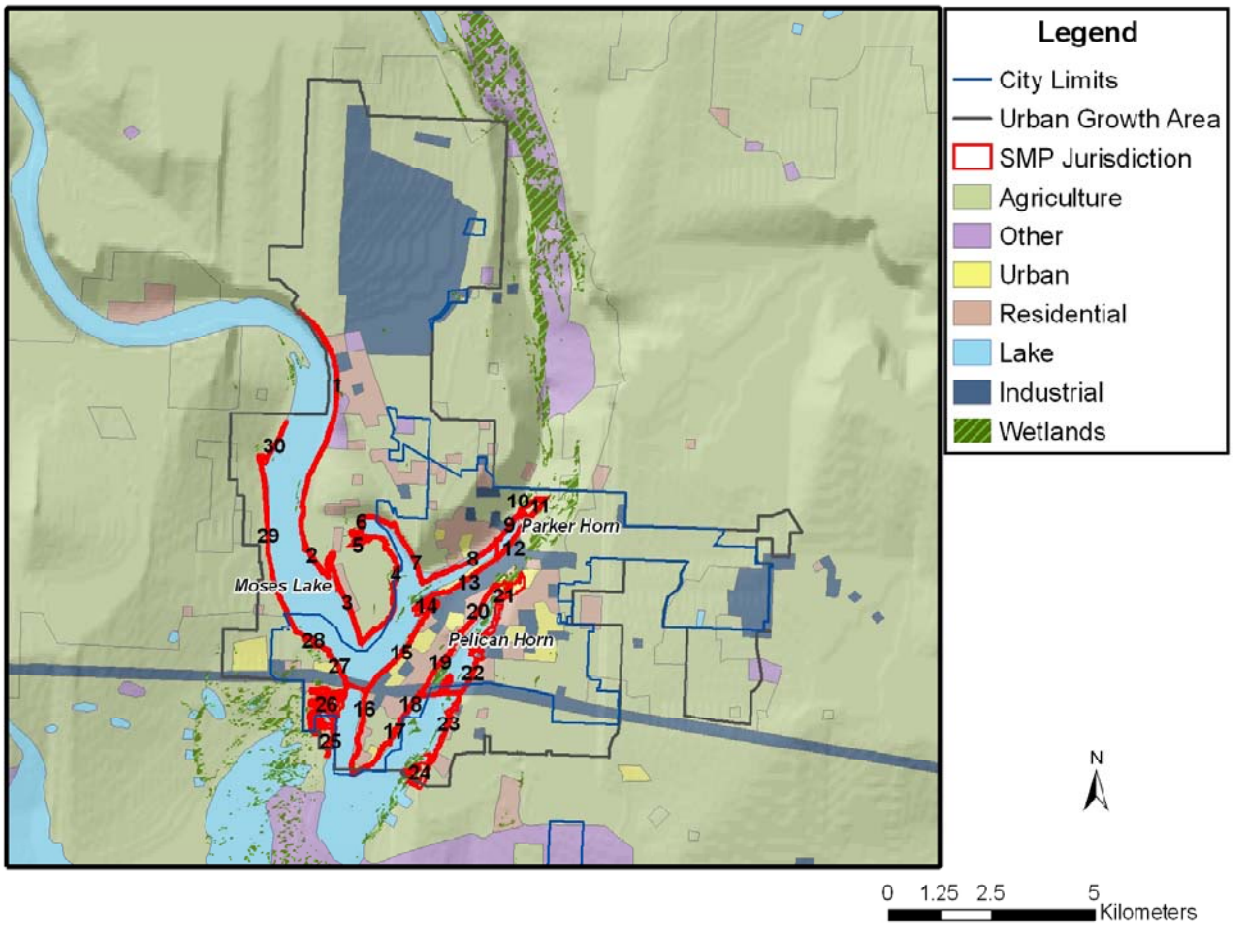

Figure 2. City Jurisdiction of Moses Lake Shoreline

Historically the City of Moses Lake has had responsibility for the shoreline management. The city shoreline management plan is reflected in the MLIRD lake management plan.

PROBLEMS AND IMPLICATIONS

Moses Lake's landowners, business owners, general public, steering committee, and Moses Lake Irrigation & Rehabilitation District (MLIRD) employees have identified problems and implications of invasive and non-indigenous aquatic vegetation. Problems were identified through public complaints reported directly to MLIRD and through public meetings. The original problem focus was Eurasian Milfoil (Myriophylhum spicatum L.) and has been the focus of the harvester program since the 1980's.

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Eurasian water milfoil (*Myriophylhum spicatum L.)* is an exotic, submersed aquatic plant, considered one of the most aggressive and troublesome species in North America. Current evidence suggests it to be native to Europe, Asia, and northern Africa; it was introduced in the United States near Washington, DC in the early 1940s (Couch and Nelson 1985). Since that time, it has spread throughout much of United States and now occurs in southern provinces of Canada, in British Columbia, Quebec, and Ontario (Sheldon and Creed 1995, Jacono and Richerson 2003, Washington State Department of Ecology 2003). The success of Eurasian watermilfoil in a wide range of aquatic systems is attributable mainly to two important plant characteristics: the plant's ability to photosynthesize at low temperatures, allowing it to grow rapidly to the surface in spring and increasing its ability to compete with other plant species at high latitudes (Barko and Smart 1981; Barko et al. 1982); and its propensity for generating a large number of propagules (fragments) that disperse to other areas to establish new colonies (Kimbel 1982; Nichols and Shaw 1986; Madsen et al. 1988). Stem fragments may result from mechanical breakage (allofragments) or through natural processes associated with plant senescence (autofragments). Stolons or underground runners provide additional means of expanding the plant bed as well as serving as primary structures for perennation (Madsen et al. 1988). Although the role of seeds in the dispersal of this species has not been rigorously studied, its seeds have shown high viability in the laboratory but are seldom observed growing in nature (Aiken et al. 1979; Madsen and Boylen 1988, 1989; McFarland and Rogers 1998).

The spread of non-indigenous aquatic vegetation causes significant economic and ecological problems throughout North America. Invasive, non-indigenous species are one of the leading threats to the ecological integrity of forests, grasslands, and water bodies. Identifying the threat to western aquatic ecosystems and water delivery systems caused by nuisance exotics has raised concerns with representatives from local, state, and federal agencies as well as private water communities.

Aquatic vascular vegetation consists of flowering plants and ferns that cultivate submersed in water float on the surface, or have basal segments flooded with foliage and upper parts immersed. Dissimilar in form and habitat, many aquatic plant species have become established in the United States outside of their normal range. Introduced intentionally or non-intentionally non-indigenous vegetation can colonize aquatic communities where they compete

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with and often displace indigenous species. Eurasian Milfoil and Brazilian elodea (Egeria densa) are examples, well known for their ability to modify physical and biological denotation of aquatic environments. They influence water quality, fisheries, recreation, and development. Pondweeds (Potomogeton spp.) species can interfere with irrigation and drainage ways. Planktonic algae and filamentous can block waterways, influence water quality, and produce toxic blooms in lakes and ponds.

The Moses Lake community has recently undertaken an extensive evaluation of their community, including the lake and associated lake front property. This evaluation was for better utilization of the lake with associated economic and recreational opportunities. This effort is identified as the "VISION 2020" project. The potential exists in Moses Lake with its long shoreline and shallow depths to become over-run with invasive species of aquatic weeds and to suffer major losses of recreational tourism in the area and cause economic hardship in an already stressed economy. Property values are impacted by environmental conditions. Aquatic vegetation both non-indigenous and indigenous vegetation has become a nuisance to boating by becoming intertwined with propellers, to fisherman by tangling fishing gear, and to swimmers and water skiers with similar entanglements.

The waterbody of Moses Lake has developed an infestation of Eurasian watermilfoil that has established itself in the shallow areas of the lake. This has affected the fish habitat, boating navigation and dissolved oxygen levels of the lake water. For the past several years the watermilfoil has been harvested throughout the summer growth season, as a management practice. The lake is a shallow lake and responds to temperature changes much more rapidly than a deeper lake. This can result in eutrophic algal blooms during the warmer temperature season. In addition, Curly Leaf Pondweed can become a serious waterbody problem and must be monitored carefully.

An additional problem is sedimentation in Moses Lake due to natural and human-accelerated processes. Specific impacts of accumulated sediment are: 1) decreased open water habitat for fish and wildlife; 2) blocked access to boating facilities; 3) limited open water for recreation boating; 4) degraded water quality; and 5) nuisance growth of submerged aquatic vegetation. In the absence of active management actions, many portions of the lake will proceed through a

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process of succession that reduces the value of the lake as a community resource and as habitat for important species of fish and wildlife.

Urban Growth-the expansion of urban growth exacerbates the ecological concerns of the waterbody.

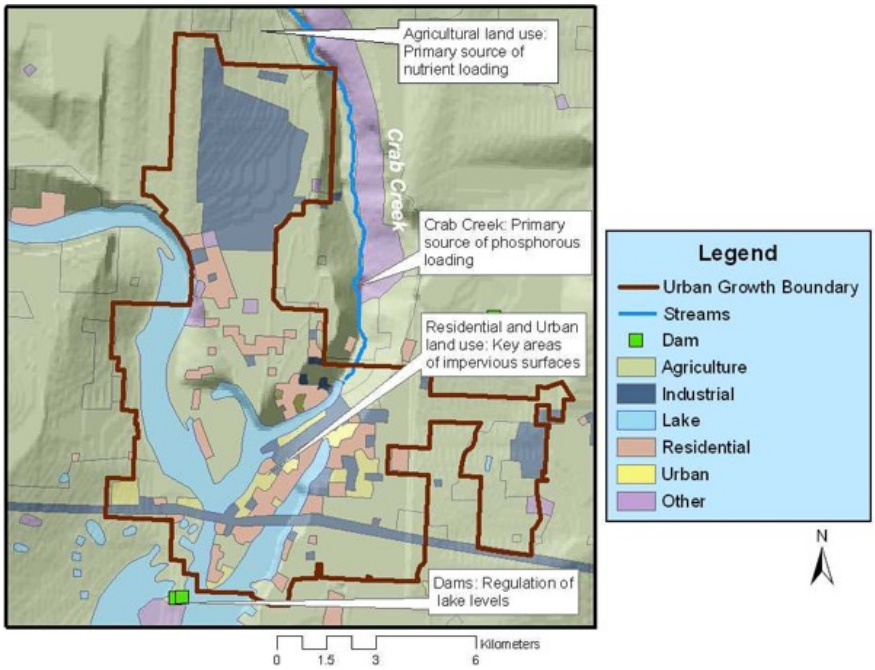

Figure3. Urban Growth 2005

Riparian habitat: The lake, once a premier crappie, bass, bluegill, sunfish and trout fishery in central Washington, began to decline in the late 1970's. Annual drawdown of the lake may affect fish habitat by dewatering aquatic vegetation and exposing root structures to wave erosion and freezing. Residents along the shoreline have also been identified as removing aquatic vegetation. Development activities also affect the quality of freshwater habitat through removal of upland and wetland vegetation and increasing silt, organic debris, and other stormwater contaminants that enter the natural drainage system. The greatest risk to the habitat is the continued pace of urban land conversions, land development patterns; especially that remove riparian cover and erode productive topsoil. Urban tolerant species, like raccoons and crows, invade the remaining habitat from the urban edges, supplanting and driving out remaining native species. Exotic species of plants and animals can become a nuisance when they reduce the amount of habitat and resources used by native species. In addition, stabilization

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methods such as bulkheads often associated with residential development disconnect the critical ecological linkages between the water and land environments.

Specific Riparian issues:

- New development can be regulated to ensure protection of riparian habitat and migration corridors.
- Use zoning and shoreline regulations to prevent encroachment of riparian and wetland habitat by new development within the SMP jurisdiction, including the use of buffers and adequate shoreline setbacks for new construction.
- Protect wetland and riparian vegetation within SMP jurisdiction to mitigate effects of upland nonpoint pollution sources, both by maintaining natural shoreline and aquatic plants was well as preventing their removal.
- Prevent protection of shoreline with hard structures.

Fish: Moses Lake does not support anadromous fish. The Moses Lake Fishery Restoration Project has increased recreational angling for resident fish stocks to compensate for the loss of similar opportunity in the region due to hydropower development and operation with the mainstream Columbia River, where the habitat has been so severely altered that opportunities for compensation cannot be realized.

New Development: Permits for new development and setback legislation can be used to mitigate stormwater flows. New developments should be required to use Stormwater Best Management Practices.

Water quality:

- Wetlands and riparian vegetation within SMP jurisdiction can be protected by mitigate effects of upland sources.
- Public education on fertilizer and pesticide impacts may be useful, especially for shoreline residents.
- Slow runoff from construction sites with proper erosion controls.
- Avoid development on hydric or highly erodible soils.
- Identify neighboring jurisdictions for coordination of water quality management plans.

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Restoration Actions

Hydrology issues: Work with Bureau of Reclamation to alter dam and irrigation operations, such as timing drawdown to limit impacts to aquatic vegetation.

Water quality issues: Effects on lake from upland developments can be addressed through integration with GMA planning. Direct storm runoff away from waterways or install containment ponds. Highlight locations for most effective stormwater retrofitting. Reduce fertilizer (phosphates) use on agricultural and residential land near shoreline.

Riparian habitat issues: Implement a program (City of Moses Lake) to protect lakeside terrestrial and emergent vegetation; retrofit shore protection structures with bioengineered approaches; restore riparian vegetation and function. Maintain vegetative buffer along shoreline zones to help limit nonpoint source pollution. Maintain and enhance the biological and physical functions and values of wetlands. Provide for reasonable buffers around wetlands in order to provide a local habitat for wetland plant and animal communities, and to reduce or minimize intrusions from humans and domestic animals. Stewardship strategies should be implemented for the long term management of wetlands. Maintain the natural value of wetlands to control and filter storm water runoff.

WATERSHED AREA

Moses Lake's waterbody has approximately 120 miles of shoreline and a surface area of approximately 6,800 acres, is over 20 miles in length, and is located in Grant County, Washington. At the water surface elevation is 1047 feet and the depth ranges from 2 to 35 feet deep.

The waterbody of Moses Lake is shallow and was originally created by ice age glacial floods that covered much of Eastern Washington. During this period the Missoula Floods periodically discharged large volumes of water, some of which reached Upper Crab Creek by overtopping the divide between the Columbia drainage and the Crab Creek drainage, and some diverted into the Columbia River to enter Crab Creek at Moses Lake. As a result, substantial coulees and scablands were created in the Upper Crab Creek drainage.

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The Moses Lake watershed includes portions of Lincoln, Adams, Grant, and Spokane counties and receives perennial flow from Crab Creek and Rocky Ford Creek (Figure 4). Rocky Ford Creek contributes substantial flow but is a spring-fed stream with a very small surface drainage area. The Crab Creek drainage is approximately 2,200 square miles as measured upstream of the U.S Bureau of Reclamation (USBR) gage at Road 7 (located 3 miles upstream of Moses Lake). Rocky Coulee Wasteway drains to Crab Creek approximately 1 ½ miles below the USBR gage on Crab Creek (Figure 4).

The Rocky Coulee Wasteway, a concrete channel, was constructed in 1954 by the USBR to provide a means to divert water from the East Low Canal into Crab Creek, Moses Lake, and Potholes Reservoir. The upstream end of this concrete wasteway begins at a 0.35 mile-long rock dam that diverts surface flows from Rocky Coulee to the wasteway. Approximately 0.6 miles downstream of the diversion dam, the gated diversion channel from the East Low Canal converges with the wasteway and flows approximately 4 miles to Crab Creek.

Prior to construction of the wasteway, Rocky Coulee drained south to Lind Coulee and not to Moses Lake. During spring runoff a temporary lake would form in the area of Rocky Coulee near the location of the diversion dam. The drainage area of Rocky Coulee contains a high proportion of dryland wheat farms and a much smaller area of irrigated lands. There is no defined stream channel in the reach of Rocky Coulee immediately upstream of the diversion dam due to tilling of the entire width of the coulee. However, during infrequent surface flow events in the coulee, a channel is cut through the tilled fields by flowing water. The construction of Rocky Coulee Wasteway added approximately 185 square miles to the natural drainage area of Crab Creek and Moses Lake. Before the Wasteway was constructed, the flow of any spring or seasonal runoff would flow to Lind Coulee and form a collective lake near the area of the dam at Rocky Coulee.

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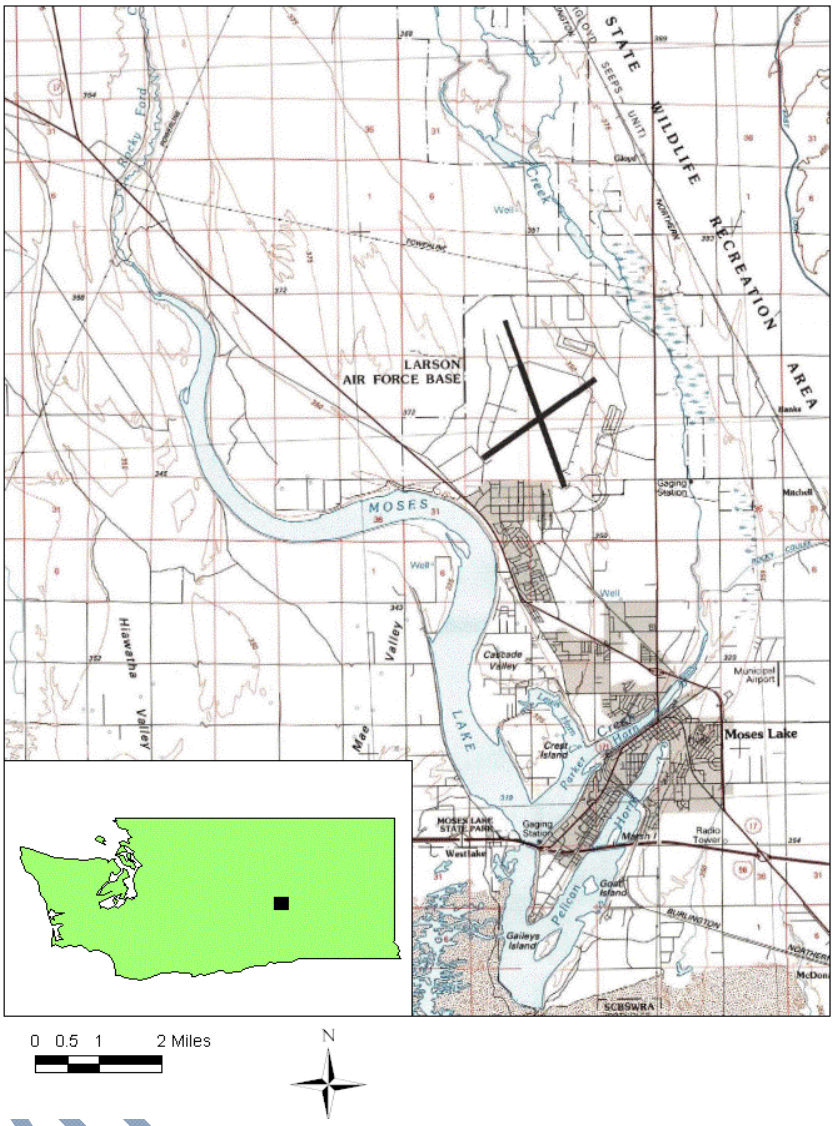

Figure 4. Moses Lake Watershed

Despite all the work and benefits of the Clean Lakes Project (Bain 1990) Washington State Department of Ecology placed Moses Lake, Rocky Ford, and Crab Creek on the 2004 303(d). The lake was listed with a Category 5 listing for Total phosphorus. The lake outlet was also placed on the 303(d) for pH based on samples collected from 1993 – 2001. In addition to the water quality listings the lake was listed for elevated concentrations of 2,3,7,8 TCDD and PCBs in fish tissue (WA DOE 2005). Crab Creek was listed for high pH and temperature at several locations (mouth to Moses Lake, at USGS gage station, Road 16 crossing) (WA DOE 2005).

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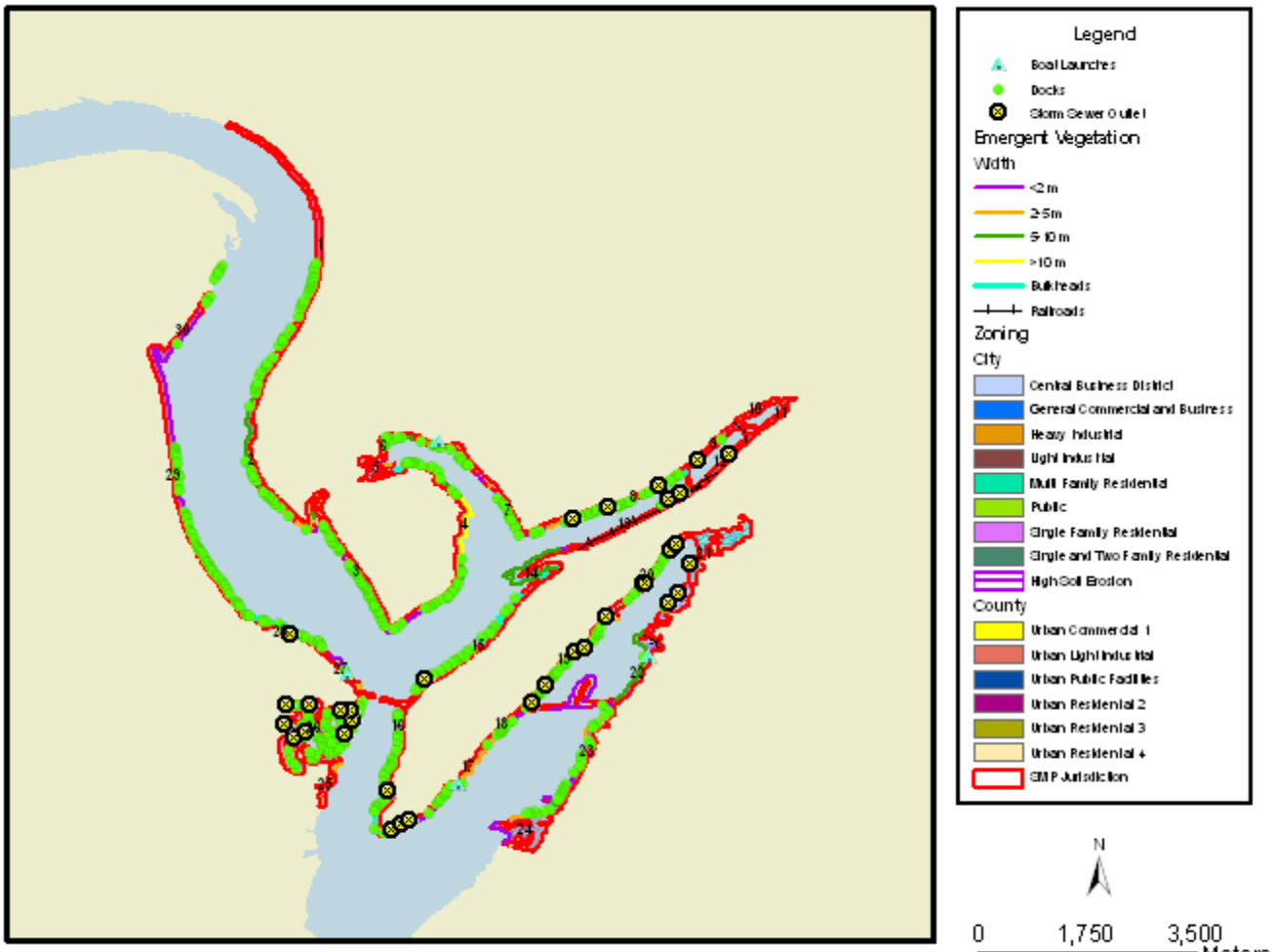

Opportunities for Restoration

Figure 5. Illustrates the City Storm Sewer Outlets of the waterbody.

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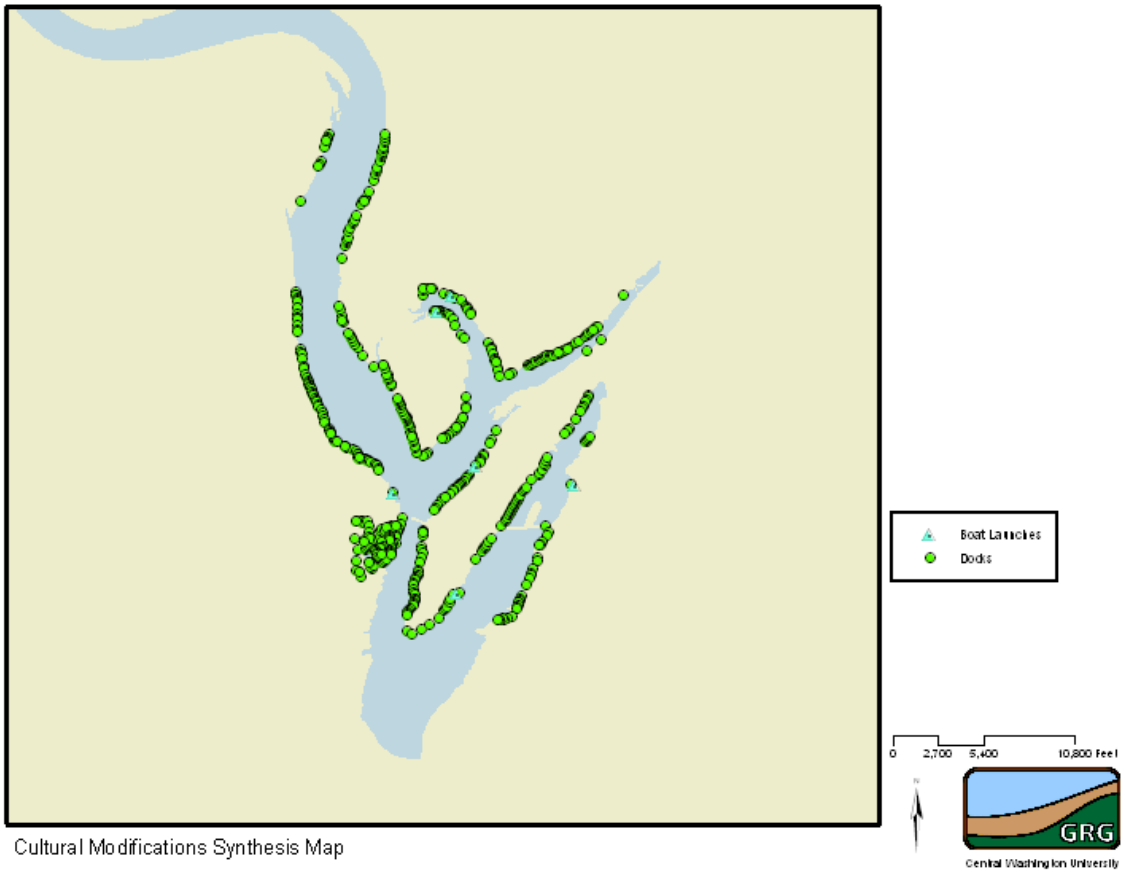

Figure 6. Locations of City Shoreline Boat Launches and Docks

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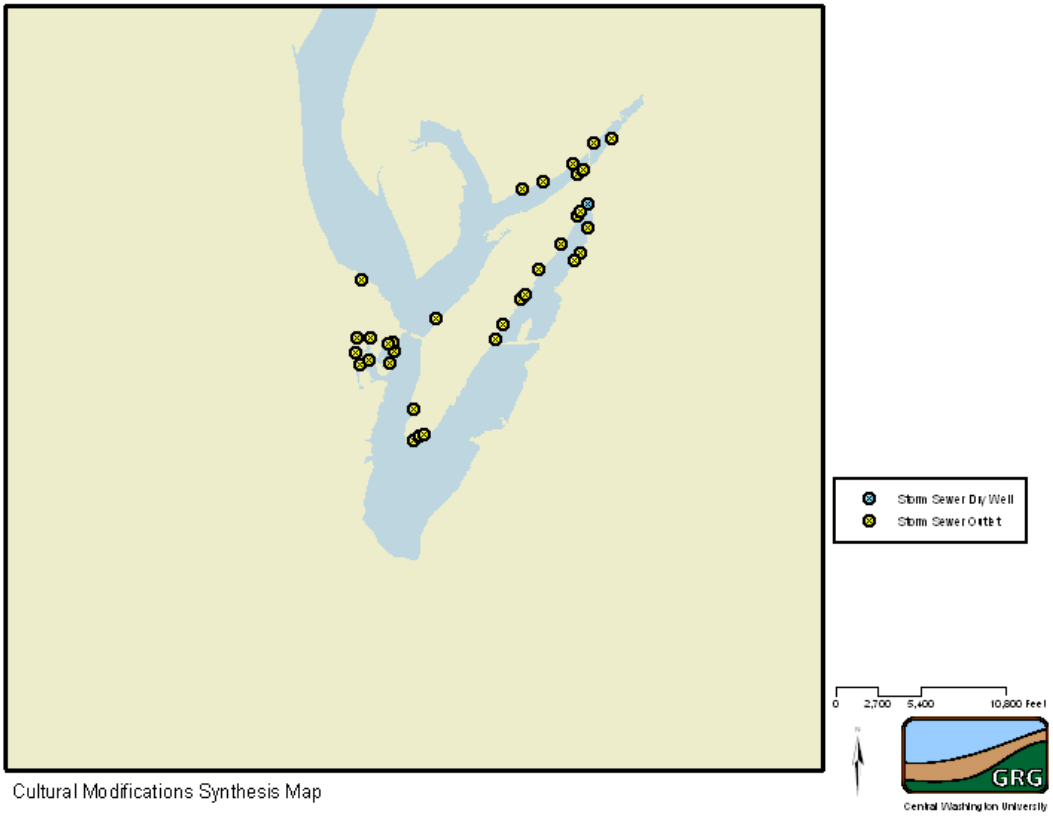

Figure 7. Storm Sewer Dry Wells and Storm Sewer Outlets

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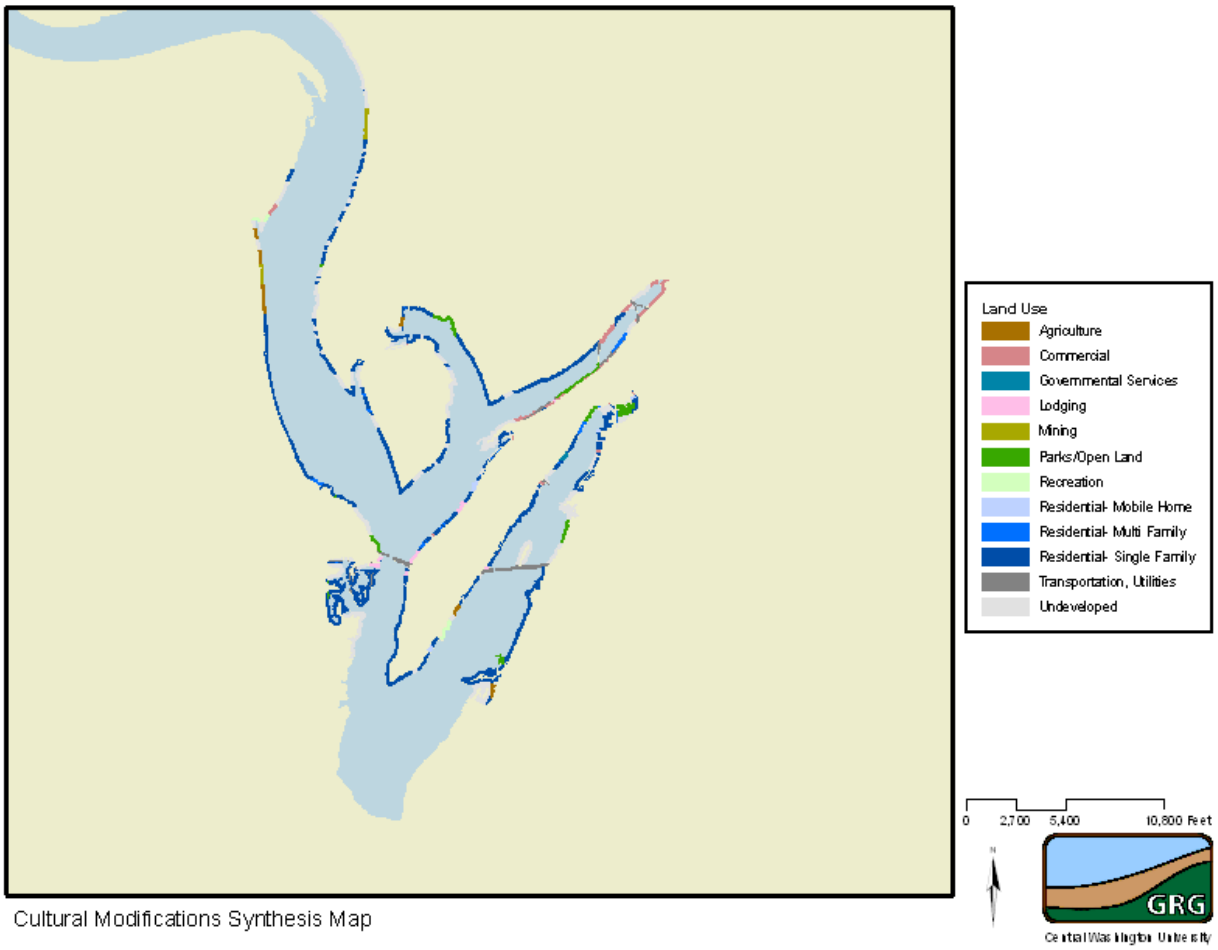

Figure 8. Multiple Family Homes on Lake Shore.

The above maps (arc view) indicate the land use activities surrounding the waterbody. The data represented was from 2005 and was developed by Central Washington State College for the City of Moses Lake.

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REGIONAL LAND USES

The land in the lower Crab Creek watershed is agricultural in nature. There is rangeland (630,00 acres), irrigated cropland (130,500 acres) and dryland farming (781,000 acres in the upper watershed). (Bain, Jr., 1990) There is considerable irrigated cropland to the west, southeast, east and northeast of the lake, including low density rural development and irrigated agricultural land. The urban and suburban shoreline has residential development extending along much of the lake shoreline, with considerable activity along the southern shorelines of the lake. A dense area of development exists along the peninsula between Parker and Pelican Horn. In total, more than 27,000 people reside around the lake, the majority are found in and around the city. The

area has seen considerable growth and development beyond the city boundaries into unincorporated areas during the past 19 years. The waterbody of Moses Lake has also experienced rapid growth along the shoreline.

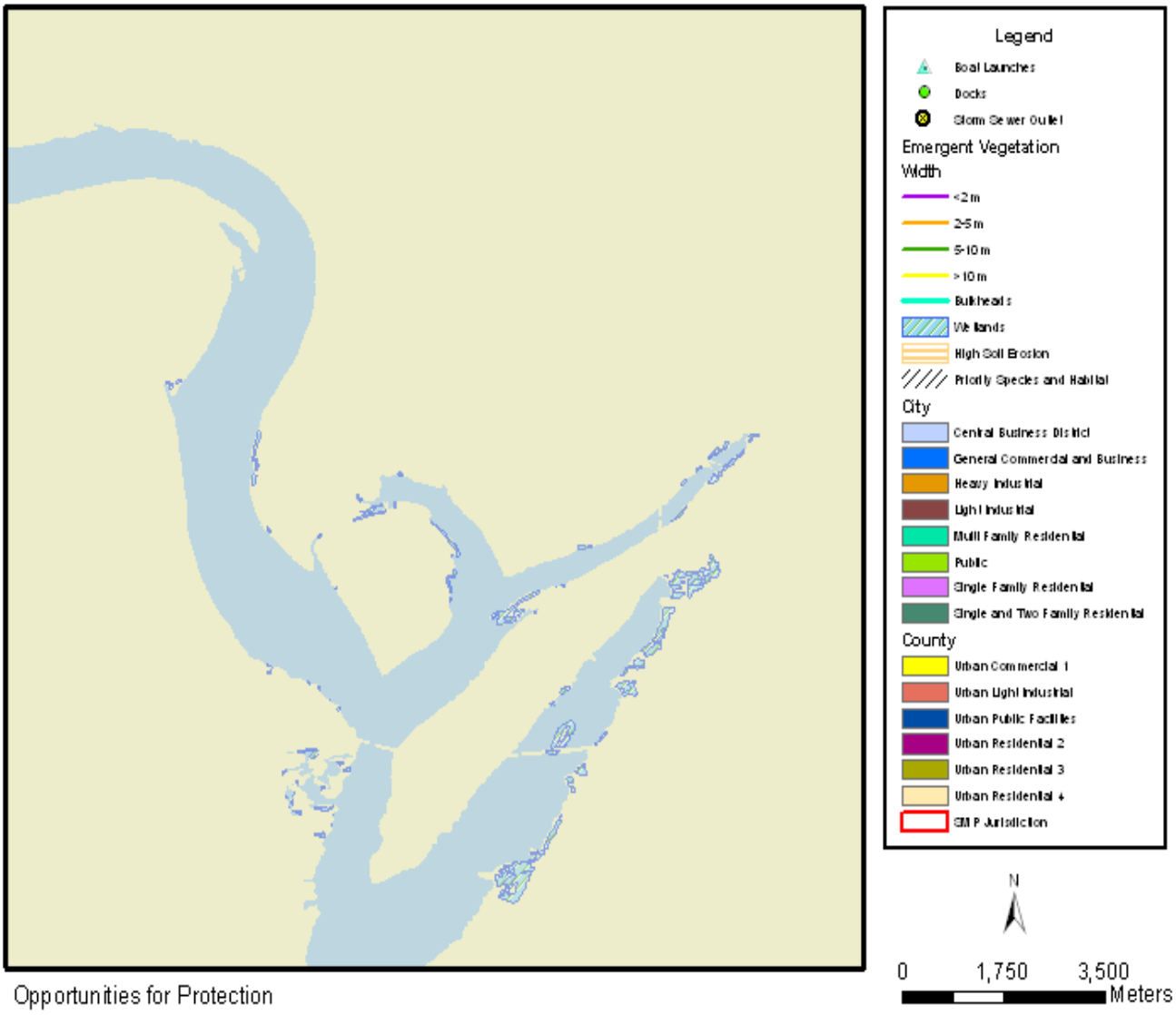

Figure 9. Wetland locations-This map illustrates the location of the many wetlands adjacent to the waterbody. Wetlands are addressed in Management Plan.

Nonpoint nutrient source locations

Residential growth in the Moses Lake area has increased 12.3% in the past five years. This represents an increase of about 1200 people. A significant portion of the growth is occurring in the Cascade Valley and on the eastern shore of Moses Lake south of interstate 90. Both areas are outside the City limits but inside the Urban Growth Boundary. Figure 10 shows the areas in the Urban Growth Area (UGA) that are not currently on the City Sewer system. Currently there are about 3,156 acres of land available for residential development in the Cascade Valley. About 917 acres of that total has 491 dwelling units with septic systems. There may be more septic systems than this since Grant County Health District does not have systems installed prior to 1993 in their electronic data base.

The City will annex parcels and provide sewer upon request from the owners (personal communication, Grant County Planning 2006). The load of phosphorous from septic systems could increase significantly as the available lakeside land is developed prior to annexation and installation of a sewer collection system. Phosphorous in septic system effluent can be expected to average about 8,000 ug/L TP. Approximately 20 – 30% of the phosphorous is removed in the septic tank (Lombardi 2006). Assuming an average septic tank wastewater, the approximate load to the drain field from 491 houses with an average of 3 people per house and 80 gpd/kg soil can estimate the total phosphorous.

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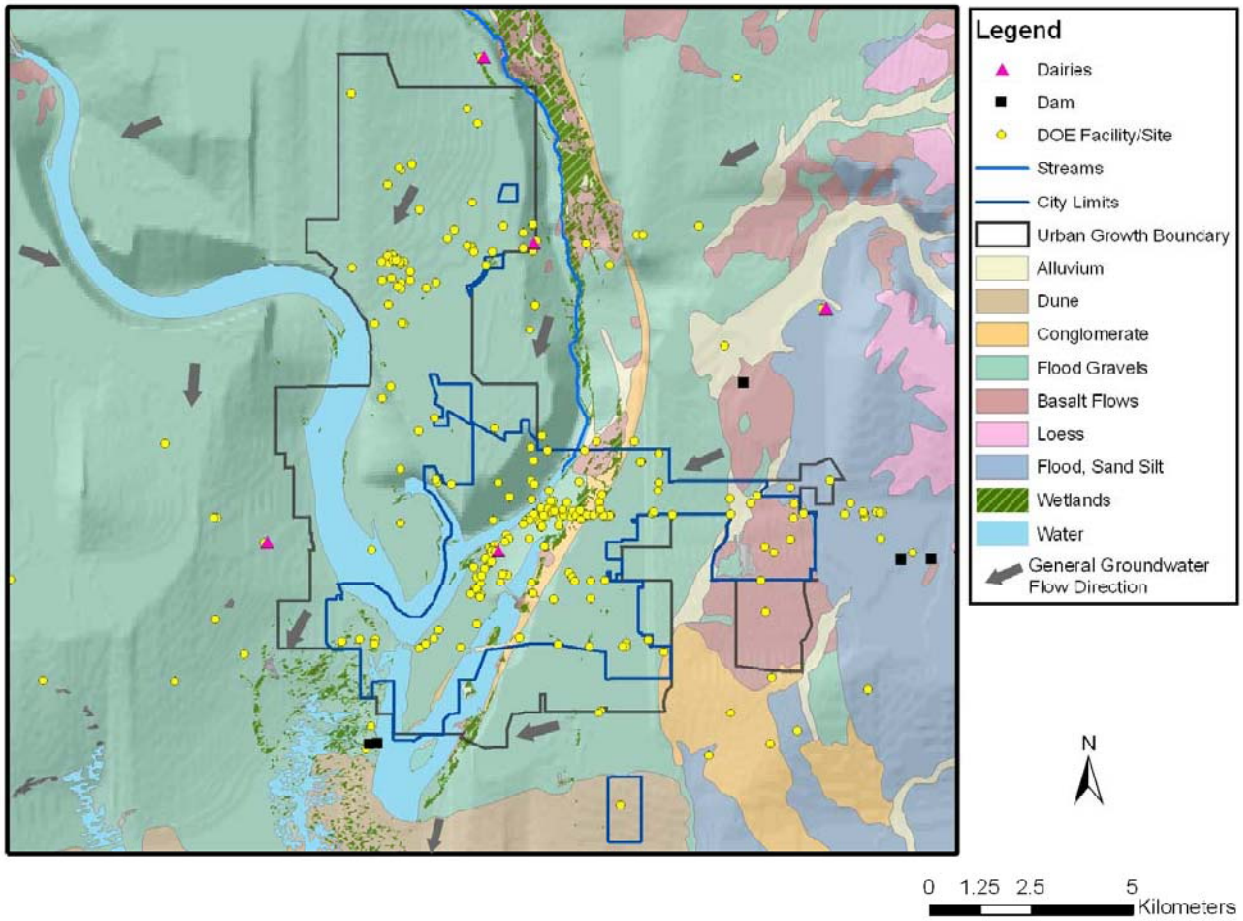

Figure 10 Septic Tank in Cascade Area and General Groundflow Direction

Regional Context for Moses Lake indicating the location of septic systems – also city limits is shown as well as the urban growth boundary.

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Figure 11. Well and ground water sampling sites

WATER LEVELS , INFLOW, OUTFLOW, AND MANAGEMENT

Although Moses Lake was originally a natural lake, it was designated for irrigation water storage and distribution for the Columbia Basin irrigation project by the USBR in the 1950's and is thereby a managed waterbody. Moses Lake is connected to Potholes Reservoir, a USBR facility to the southwest. The water level in Moses Lake is controlled at the southern end of the lake by two outflow structures, one owned by the MLIRD and one owned by the USBR. The current operating scheme entails drawing the water level of Moses Lake down to an elevation of 1042 feet in November to allow off-season access for maintenance and construction and to provide flood storage to Potholes Reservoir. The water level naturally increases starting in

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February or March, and by April, it reaches an elevation of 1047 +/-feet to store and convey irrigation water and support recreation and all other beneficial uses.

The two major sources of inflow to Moses Lake are Crab Creek, which flows into the northern tip of Parker Horn, and Rocky Ford Creek, which flows into the north end of the lake (Figure 1). Overall, Crab Creek where it enters Moses Lake exhibits a highly unusual flow regime that is sustained by groundwater, affected by flood episodes fed by snowmelt in the watershed, and by Bureau of Reclamation feed route releases through Rocky Coulee Wasteway just above Moses Lake. Most of the annual discharge volume of Crab Creek is contributed by Rocky Coulee Wasteway during several months of the spring and summer. The wasteway enters Crab Creek approximately one and one-half miles above Moses Lake and contributes approximately 85% of the total inflow to the lake from all sources. The Columbia Basin irrigation project's East Low Canal is the source of water for Rocky Coulee Wasteway except during infrequent winter storms. Rocky Ford Creek and the mainstem of Crab Creek (Gloyd Seeps springs) contribute approximately 10% and 5% respectively of the total flow into Moses Lake (WDOE 2002).

The Bureau of Reclamation recently studied options for increasing the overall flow rate year-round via Crab Creek from the Billy Clapp Reservoir through Moses Lake to provide supplemental feed water to Potholes Reservoir for use by the South Columbia Irrigation District (U.S. Department of the Interior 2007). This would involve discharges from Lake Billy Clapp through the natural channel of Crab Creek, increasing the flow in Crab Creek by 100 to 500 cfs. During late summer and fall of 2006, the USBR tested this feed route with discharge of approximately 150 cfs. During the test period, flow at the mouth of Crab Creek was attenuated by entrance of the feed water into the ground. No appreciable increases in discharge at the mouth of Crab Creek were noted during the Fall 2006 feed route test. A NEPA Environmental Assessment for all proposed supplemental feed options has been prepared by USBR. In contrast to Crab Creek, Rocky Ford Creek exhibits a typical stable flow pattern as seen for most spring-fed streams. Annual mean flow in Rocky Ford Creek is approximately 78.2 cfs (WDOE 2000).

Flows through Moses Lake vary substantially on a seasonal basis. In early April, Rocky Coulee Wasteway (and therefore Crab Creek) is at its peak annual flow (2238 cfs, April 1st average 2000-2001) and is used to transfer water from the USBR's East Low Canal through Moses Lake into Potholes Reservoir for use by irrigators in the South Columbia Basin Irrigation District.

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Flows from the wasteway are reduced to 20-100 cfs from the springs and outflow of Gloyd Seeps, along the bluff area. The 100-year flood peak discharge for Crab Creek is predicted to be 14,100 cfs. By December, Crab Creek typically reaches its annual low flow (20 cfs, 2000-2001 average).

As previously mentioned the northern or main arm of the Moses Lake waterbody is fed by a small spring fed tributary known as Rocky Ford Creek. A small dam was constructed in 1987 at the lower end of Rock Ford Creek as part of the Moses Lake Clean Lake Project; the dam is Drumheller Dam. This dam was designed to prevent upstream migration of carp into the creek system as part of the program to enhance water quality within the Creek and Moses Lake waterbody. High phosphorous concentrations are associated with the Rocky Ford Creek system and were aggravated by carp activity within the Creek. This barrier provided a carp holding area and made efforts to rehabilitate the creek feasible. Carp were eroding the banks and uprooting vegetation within the creek. The remaining Carp in the Creek were eliminated by the Department of Fish and Wildlife and a trout fishery was established. In 1966 vandals removed the stop logs on the dam and compromised the dam's water quality control. The detention or holding area was eliminated and Carp were allowed to migrate upstream into Rocky Ford Creek. The State Department of Fisheries and Wildlife repaired the dam and rehabilitated Rocky Ford Creek during 1998.

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Figure 12. Drumheller Dam at Rocky Ford Confluence

The Moses Lake Clean Lake Project also focused on nitrogen sources, particularly the deep percolation of nitrates from irrigation of agricultural lands within Blocks 40 and 41 of the USBR Columbia Basin Project. On-farm assistance to local irrigators was provided cost share assistance for irrigation system upgrades and for irrigation water management plans. The Clean Lake Project activities provided funding improvements on 36 farms totaling 5,346 acres. Other Project spin-offs benefitted approximately 7350 cropland acres by the 1989 irrigation season. Nutrient loss savings and overall benefits of the Clean Lake Project were summarized in a March 1990 Final Report (Bain 1998). Following the Clean Lake Project, the lake and surrounding wells have been monitored on a 5 year cycle to provide a historical database and records on water quality in the lake since the completion of the Clean Lakes Project.

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Managing Water Flow

Although Moses Lake waterbody was natural in origin, a dam was constructed at the tributary of Crab Creek (at the south end of the lake) to control water levels. Water lost to irrigation and water flowing into the waterbody produces a flow through the waterbody and reduces hyper-eutrophism. Additional water flow is created through a controlled flushing action and further reduces the eutrophic nature of the waterbody. The outlets to control the additional flow are regulated by the Bureau of Reclamation and the Moses Lake Irrigation Rehabilitation District.

LAKE QUALITY

Moses Lake is classified as a Lake class under Washington State water quality standards (Chapter 173-210A WAC). Rocky Ford Creek is classified as Class A, and Crab Creek as Class B. Lake class and Class A waters are required to meet or exceed the requirements for all or substantially all, of the following characteristic uses: domestic, industrial, and agricultural water supply, stock watering, salmonid and other fish migration, rearing, spawning, and harvesting; wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment); and commerce and navigation. Class B waters are required to meet or exceed the requirements for most of the preceding uses (Carroll 2006).

Moses Lake exhibited hyper-eutrophic conditions prior to the Clean Lakes Project in the 1980s. During the Clean Lakes Project, with grant funding from EPA and DOE, about $8 million dollars in projects were implemented to clean the lake. Key projects that significantly improved lake water quality in the lake were: 1) eliminating direct disposal of wastewater in the lake; 2) Columbia River water diversion from East Low Canal down Rocky Coulee Wasteway and into Moses Lake; and 3) conversion of rill irrigation to center pivot irrigation on surrounding agricultural land. The MLIRD was the lead agency managing these projects and the lake.

Large algal mats that were common and contributed to fish kills were eliminated. However, as is common in lakes, the clear water provided a better habitat for submerged aquatic plants. Both native and invasive aquatic plants became well established due to the clearer water coupled with the ever increasing sediment deposits on the lake bottom. The MLIRD owns and

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operates two weed harvesters to remove excessive growth of aquatic plants that hinder recreation and boating in the lake.

Despite improvements to lake quality, the phosphorus concentrations still exceed state water quality standards. Therefore Moses Lake was placed on the Clean Water Act 303(d) list in 2004 for elevated concentrations of phosphorus.

Annual inflows of feed water from Rocky Coulee Wasteway during the summer months continue to have positive impacts on water quality in Moses Lake by mitigating the water quality concerns for significant parts of the year. This is a successful program worth continuing. The efforts of the MLIRD, such as the water pumping station from Parker Horn to Pelican Horn and the weed harvesting program, have also contributed to improvement of water quality in the lake. This project is addressed in detail as a demonstration project in the Management Plan.

In 2006 sampling efforts were focused on determining sources of phosphorous that may be entering the waterbody of Moses Lake. Two of the primary sources evaluated was the wastewater to groundwater at the Larson Wastewater Treatment and from residential septic systems. These were chosen as the point of focus for 2006 since they are known sources of relatively high loads of phosphorous to the groundwater. The resulting data would determine if it would be necessary to control via available wastewater treatment technology. The goal was to estimate phosphorous loads to the lake from these sources and compare them to load reductions recommended in the Washington State Department of Ecology TMDL assessment (see Summary of Water Sampling For Moses Lake, by Peter Burgoon).

GEOLOGY OF THE MOSES LAKE AREA

The subsurface stratigraphy of the Moses Lake area consists of a series of thick Miocene-age basalt lava flows and interbedded sediments is known as the Columbia River Basalt Group (CRBG). The most recent basalts underlying most of the Moses Lake area are Roza, member of the Wanapum Basalt formation of the CRBG.

Throughout much of the area, the basalts are directly overlain by fine-grained deposits known as the Ringold Formation. Ringold sediments in the Moses Lake area are primarily comprised of lacustrine, clay, silt and fine sand. These sediments are thicker to the west and thin out east of

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the lake waterbody approximately one mile west of Crab Creek. Previous research indicates the Ringold sediments separate Moses Lake from the underlying basalt units for much of the area between the airport and the City of Moses Lake.

Overlying the Ringold sediments are a sequence of Pleistocene-age flood deposits that surround the majority of the lake. These flood deposits, known as the Hanford Formation, consist of large, well-stratified boulder to granule-sized basaltic gravel with some deposits of sand, silt and non-basalt gravel.

The Hanford Formation flood deposits are highly permeable and can allow rapid groundwater movement. Reported hydraulic conductivities in this formation range from 2,800 to 28,000 ft/day. In addition, because of the coarse nature of these deposits, infiltration rates through the vadose zone are considered to be quite rapid with little attenuation capacity for pollutants (Pitz, 2003; MWH, 2003).

Moses Lake has been described as a regional discharge feature for shallow groundwater within the Columbia Basin. Groundwater elevation data in the Hanford and Ringold deposits just east of the lake indicate the main direction of groundwater flow in this area is in a south to southwest direction, with groundwater discharging to the lake along the eastern shoreline (Figure 13). Groundwater discharge volumes to the lake from the lower permeability Ringold deposits is at a limited rate but significant (Pitz 2003; MWH, 2001).

Table 2. External TP load contributions to Moses Lake (May through September) during critical load conditions and TP loads following 35% load reductions (Carroll 2006).

External Source	TP load, kg	TP load after 35% reduction(kg)	TP Load reduction (kg)
Crab Creek	1765	1147	591
Rocky Coulee Wasteway	687	447	240
Groundwater	2150	1398	752
Columbia Basin Hatchery[1]	77	50	22
Columbia Basin Hatchery Spring	1582	1028	554
Troutlodge Hatcheries[1]	398	259	139
Rocky Ford Creek	3089	2008	1081
TOTAL			3379

[1]Hatcheries contributions based on 2001 production levels.

Recharge for both the unconsolidated aquifers and the basalt aquifer is primarily from irrigation. Primary creeks entering Moses Lake, Rocky Ford Creek and Crab Creek are both groundwater discharge areas. The recharge to the Rocky Ford stream area comes from the northwest

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(Ephrata), and north (Soap Lake), and the northeast (Adrian). Recharge to the portion of Crab Creek between Adrian and Moses Lake is primarily from the east and northeast. Direct groundwater recharge to Moses Lake is from both east and west (Figure 13).

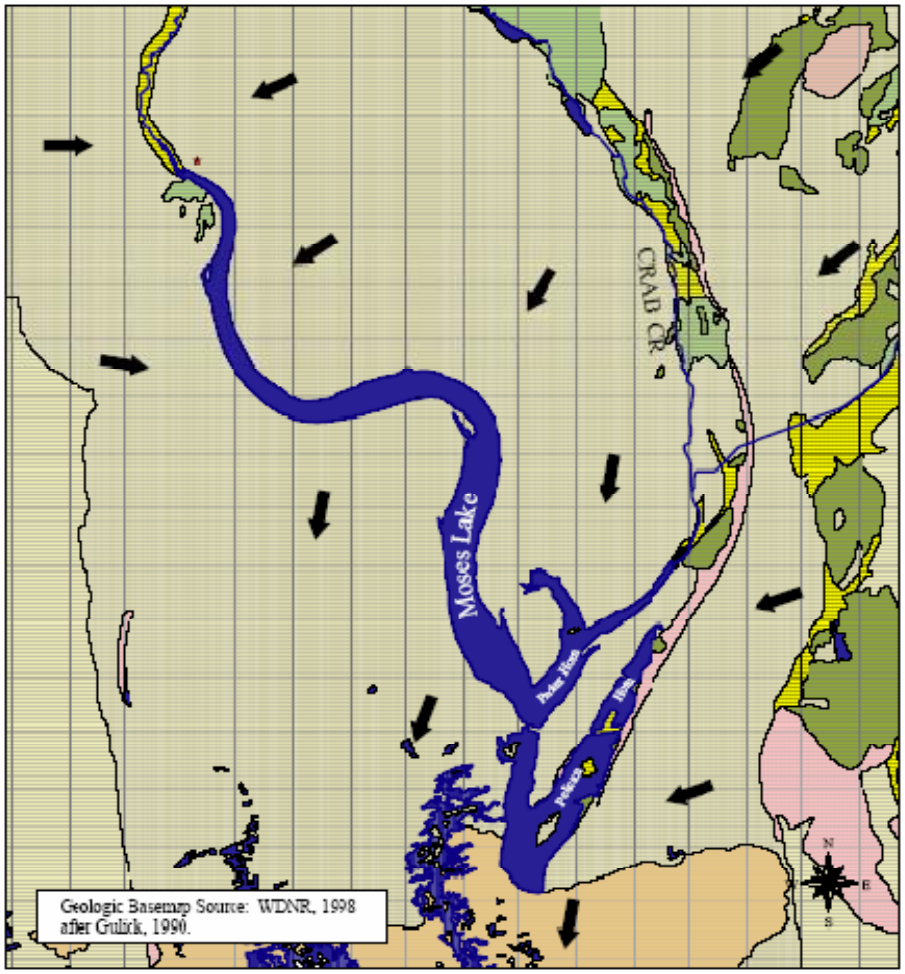

Figure 13. Groundwater flow direction in the Moses Lake basin (arrows). Tan areas around lake are Pleistocene gravel and sand flood deposits (from Pitz 2003).

GROUNDWATER QUALITY

A historical median TP concentration of 20ug/l has been reported from wells sampled between 1942 and 1992 in the central Columbia Plateau (Pitz, 2003). These data showed no clear trend in

TP concentration with depth as might be expected from a buried geologic source. Reported TP concentrations averaged 35 ug/L as P in groundwater from wells less than 150 feet in the Moses Lake area since 1980 (Pitz 2003).

NATURAL CONDITION OF PHOSPHOROUS IN AREA GROUNDWATER

Existence of surface or subsurface geologic deposits containing phosphate minerals were suggested to cause elevated phosphorous concentrations in the groundwater in the Moses Lake area. Detailed mineralogical descriptions of the Hanford and Ringold Formations are limited in literature but there are not references to the presence of significant phosphate mineral deposits in these formations in published geologic reports of the area. In addition, the sediments of the Ringold Formation underlying Moses Lake are thought to originate in granitic and volcanic regions northeast of the Columbia Basin. Such sediments are not likely to be a significant source of phosphate-rich sediments (2006 Summary of Groundwater and Lake Sampling).

The slightly higher OP concentrations in the Moses Lake area (35 ug/L) compared to the central Columbia Plateau (20 ug/L) may possibly be due to a natural mineral contribution; however, previous research suggests human impacts (Pitz 2003)

Rocky Ford Creek provides an anomaly to the presumed groundwater phosphorous levels of 35ug/L. Fed by a spring, Rocky Ford Creek has had historically elevated levels of phosphorous. Carroll (2006) reported an average concentration of 91ug/L TP in the spring water entering Rocky Ford Creek. Pitz (2003) and Bain (2002, 1997, 2002) speculate that the spring is fed with shallow groundwater originating from the flood deposits northeast of the springs. Using trilinear analysis of water samples and historical geological evaluations, reasoned that the spring water was not connected to Soap Lake (a lake north of the springs which has phosphorous concentrations as high as 6300 ug/LTP)

Bain (1987) determined that phosphorus may originate from Brook Lake and Round Lake. Nutrients in these lakes apparently originate from agricultural activities in the upper Crab Creek Basin and upper Grant and Lincoln Counties. Bain found no available evidence for a natural stratigraphic source of phosphorus that could explain the elevated concentrations present in the groundwater.

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Anthropogenic Sources of Phosphorous Contributing to Groundwater

Usual sources of phosphorus in groundwater are disposal of municipal, residential and agricultural wastewater. In 2006 the source focus evaluation was municipal and residential wastewater in the Cascade Valley area. This area and sources were carefully evaluated since many findings imply that this may be a significant source of groundwater phosphorus. The study led to circumstances which are: the hydrology, gravelly soils, the rapid increase in the area development, the close proximity to the lake, and the long term practices of wastewater disposal in the area (2006 Summary of Groundwater and Lake Sampling).

CRAB CREEK SAMPLING

The Columbia River Water Management Program is evaluating alternative methods to develop new water supplies for the Columbia River Basin. One of the alternative methods considered is to move water from Brooks Lake down Crab Creek and into Potholes Reservoir (WA DOE 2006). An early implementation study was started by United States Bureau of Reclamation in August 2006. A sampling program was established in 2006 to monitor impacts or additional flows in Crab Creek (2006 Summary of Groundwater and Lake Samplings).

LAKE SAMPLE STATISTICS

The RPD for each set of lake samples is presented in table 3. During analysis of the July samples the RPD of 10% was exceeded for ortho P during analysis of the known standard and for Total N during analysis of the sample spike. During September the average RPD for the laboratory analysis were all less than the 10% target (Table 3).

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Table 3. Summary of QA|QC Statistics (relative percent difference, RPD) for the two sets of lake samples.

	Ortho P	Total P	Total N	pH
July Sample				
Lab Duplicate	4%	8%	0%	FM
Sample spike	6%	3%	79%	FM
Known standard	**29%**	3%	2%	FM
Average RPD	**13%**	5%	**27%**	FM
September Sample				
Lab Duplicate	0%	**14%**	0%	3%
Sample spike	3%	3%	0%	na
Known standard	0%	3%	0%	1%
Average RPD	1%	6%	0%	2%

FM = Field measurement

GROUND WATER SAMPLE STATISTICS

The average RPD summaries for groundwater samples are presented in tables 4 through 6. These include samples collected from wastewater effluent and monitoring wells at the Larson Wastewater Treatment Plant and those collected from domestic private wells.

The 2005/2006 winter was very wet and consequently dilution flows from Rocky Coulee Wastewater were expected to be very low in 2006. Since the critical season for TMDL is for low flow years the plans were to sample the lake during this critical time.

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Table 4. Summary of Average RPD for Larson Wastewater Effluent Samples

Date	Total P	Ortho P	Sodium	Chloride	Boron
7/19/2006	4%	6%	3%	2%	5%
7/26/2006	4%	13%	3%	9%	5%
8/2/2006	4%	1%	3%	3%	3%
8/9/2006	4%	1%	3%	3%	3%
8/16/2006	5%	2%	1%	1%	4%
8/23/2006	5%	1%	1%	1%	4%
8/30/2006	3%	2%	2%	2%	4%
9/6/2006	3%	1%	2%	2%	4%
9/13/2006	6%	2%	2%	0%	4%
9/20/2006	6%	25%	2%	0%	4%
9/27/2006	4%	1%	2%	3%	4%
10/4/2006	3%	1%	1%	2%	5%
10/11/2006	12%	9%	1%	1%	5%
10/18/2006	5%	2%	1%	1%	4%
11/8/2006	1%	2%	2%	1%	4%

Water Quality Survey 2006

Peter Burgoon conducted a water quality survey of the waterbody of Moses Lake in 2006 and compiled extensive data supporting the historical data previously tested. The data as noted throughout this document speaks clearly about the : 1) phosphate and nitrate loading, 2) the sedimentation concerns, 3) the low dissolved oxygen levels, 4) the eutrophic conditions, and 5) the Eurasian watermilfoil vegetation problem. All of these concerns need addressing in this integrated aquatic vegetation management plan.

Lake Sampling sites are shown in figures 14 and 15. These sites are consistent with the 2001 TMDL lake assessment and other historic sampling records (MLIRD 2005).

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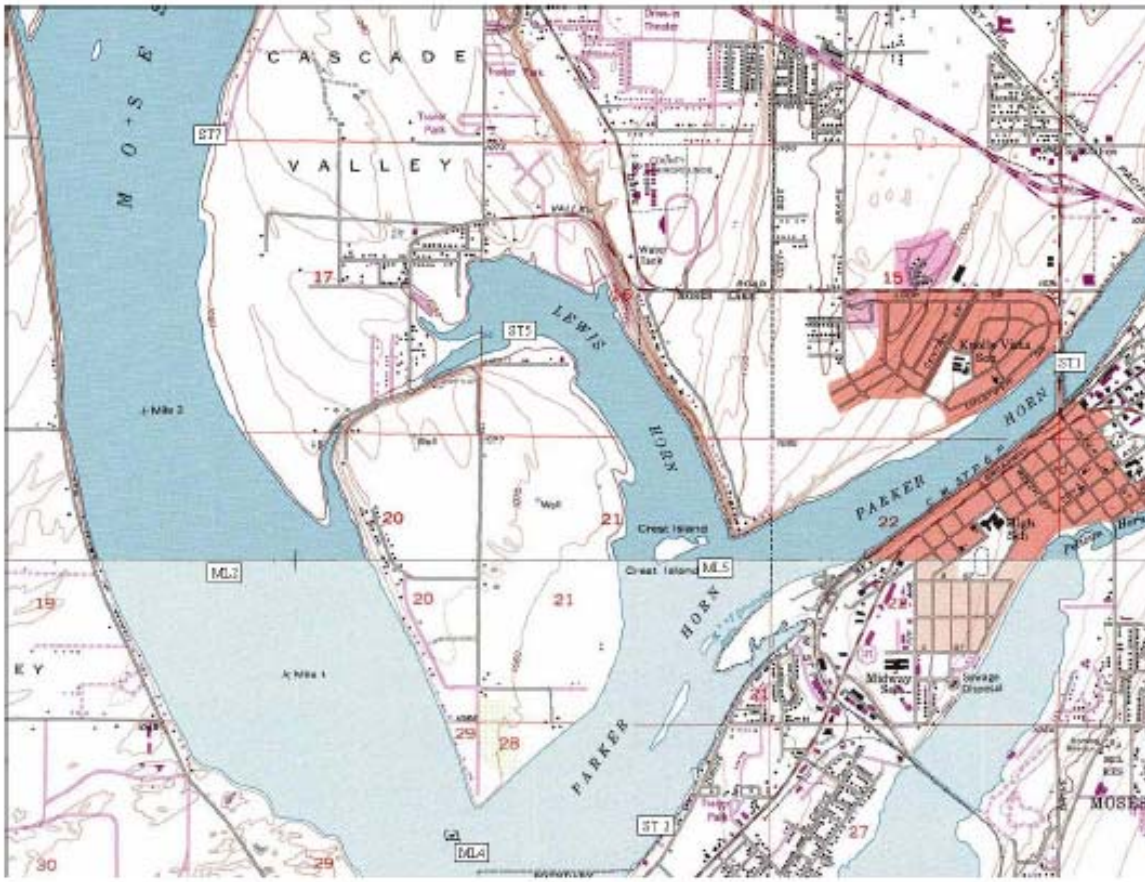

Figure 14. Cascade Valley Sampling Sites (Burgoon, 2008)

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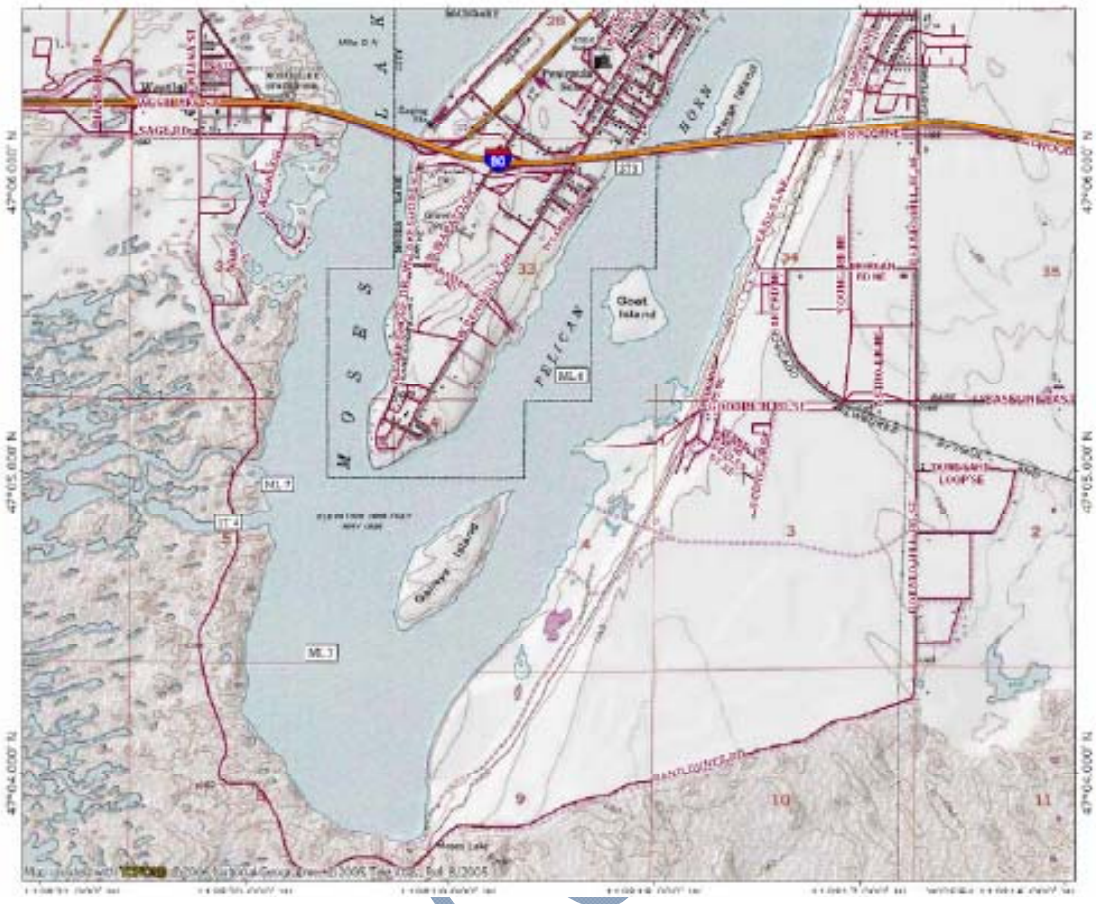

Figure 15. Vicinity of Pelican Horn Sampling Sites (Burgoon, 2008)

Water Flow

Flows from Rocky Coulee (Rocky Coulee flows into Crab Creek) have significant impacts on nutrient levels and water quality in the lake. Total flow to Moses Lake in 2006 was 194,802 acre-feet. This was significantly less than flow added in six previous years (Table 5). From 2002 through 2005 total annual flow was greater than 316,900 acre-feet for each year.

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Table 5 Moses Lake Dilution Water Release Record

Year	Dilution Release (ac-ft)
1976	64,070
1977	150,630
1978	81,840
1979	214,540
1980	19,540
1981	56,050
1982	144,180
1983	73,250
1984	0
1985	154,350
1986	106,230
1987	137,770
1988	207,300
1989	207,300
1990	229,980
1991	286,098
1992	267,846
1993	120,976
1994	289,356
1995	132,211
1996	60,685
1997	25,886
1998	111,026
1999	117,928
2000	***243,072***
2001	***242,039***
2002	***316,900***
2003	***340,418***
2004	***372,315***
2005	***326,875***
2006	194,802
90th percentile	316,900
75th percentile	***242,556***
50th percentile	150,630

Total annual flow is not always a good indicator of lake quality during summer since significantly less dilution flow is available in the summer months. Figure 16 shows that in 2006 most of the dilution flow were added before July 1; of 194,000 acre-feet added in 2006 only 87% of the annual flow was released before July 1. Thus dilution flows in July, August, and September were very low in 2006. This was a major factor in high concentrations of TP and algae in the September lake samples.

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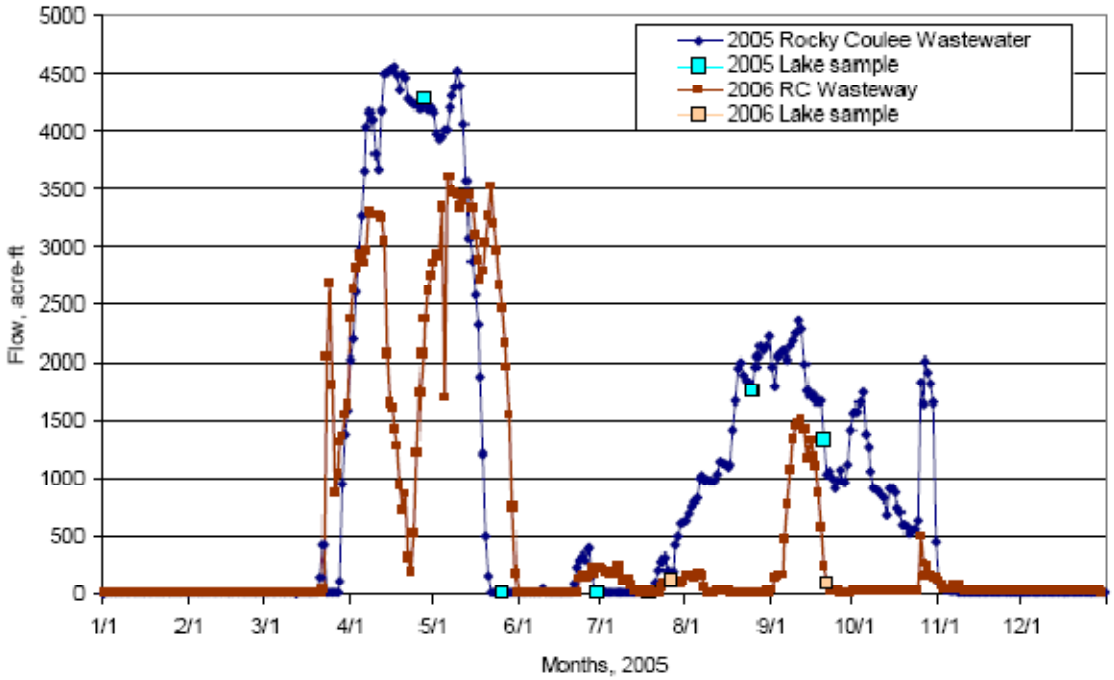

Figure 16. Comparison of Dilution flows from Rocky Coulee Wasteway in 2005 and 2006

Lake Water Quality- Phosphorus

The lake was sampled on July 26, 2006 and on September 21, 2006. Both samples were taken from the surface and were collected at all lake stations (Table 6). Samples showed that less than 40ug/L at all locations in July. September sample results were above 50ug/L TP at three of the 7 stations. The average TP for the entire lake was 26 + or – 12 ug/L in July and 54 + or – 14 ug/L in September.

September's elevated TP occurred for several reasons, 1) TP release from the sediment increase in the summer due to development of anoxic sediment conditions, 2) a uniform temperature gradient facilitates mixing of the entire water column, and 3) dilution flow was low in August and September. Elevated TP and eutrophic conditions resulted from combination of all three reasons stated above.

Surface water samples were analyzed for algae type and chlorophyll a. Chlorophyll a (Table 6) and algae densities (Table 7) were significantly elevated in September over July. The algae

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populations were dominated by toxic blue-green algae during July and September. Concentrations were highest in September and toxic blue-green algae were at levels that have moderate to high probability of negative health effects. The World Health Organization considers concentrations greater than 1000,000 counts/100 ml a moderate risk (WHO 2006). During this type of condition, the WHO recommendations are to discourage swimming and post on-site risk advisory signs. The risks are greatest from the toxic blue-green algae Microcystistis. This alga was at elevated concentrations throughout the lake in September.

Concentrations were at the highest in the southern portion of the lake, reaching concentrations of 554,000 counts/ml at site ML3.0 and 704,000 counts/ml at site ML7.0 (Figure 15 and Table 7). It is common that these algae species drift with the winds and become concentrated in downwind sections of the lake. The high concentrations in September are most likely due to strong northerly winds the day before sampling.

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Table 6. Summary of lake sampling 2006 (Burgoon, 2006)

	MLCC0	ML2.0	ML2.5	ML3.0	ML4.0	ML5.0	ML6.0	ML7.0
TP, ug/L								
7/26/06	35	12	46	39	9	17	32	15
9/21/06	29	59	ns	69	49	37	47	62
Ortho - P, ug/L								
7/26/06	34	5	0	17	4	5	18	5
9/21/06	6	9	ns	13	9	5	8	12
Total N, mg/L								
7/26/06	<0.7	<0.7	1.95	1.3	<0.7	<0.7	0.7	<0.7
9/21/06	<0.7	<0.7		<0.7	<0.7	<0.7	<0.7	<0.7
pH								
7/26/06	8.3	8.76	7.98	8.6	8.55	8.61	8.77	8.71
9/21/06	7.9	8.6	ns	8.7	8.5	8.8	8.7	6.99
Temperature, oC								
7/26/06	23.3	26.1	23.8	25.9	26.7	27.5	27	26.3
9/21/06	13.8	18.0	ns	18.1	17.8	16.2	17.5	18.0
Dissolved oxygen, mg/L								
7/26/06	7.15	9.16	7.98	8.2	8.67	10.56	7.99	8.03
9/21/06	8.3	10.7	ns	8.4	10.4	10.0	9.7	9.5
Secchi depth, ft								
7/26/06	5.2	6.8		12.2	6.3	4.5	6.5	10.8
9/21/06	7.0	3.3	ns	2.3	3.9	5.2	ns	2.3
Chlorophyll a, ug/L								
7/26/06	ns	5	ns	5	6	7	5	14
9/21/06	4	20	ns	29	16	12	27	9

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Table 7. Densities of algae in the lake in July and September (Burgoon 2006)

		21-Jul-06		9/21/2006	
		ML2.0		**ML2.0**	
Phytoplankton		counts/mL		counts/mL	
	Total	220,400		544,000	
	Bluegreen (Toxic)	220,000	Aphanizomenon (87%), Microcystis (13%)	500,000	Microcystis (59%), Lyngbya (33%), Aphanizomenon (3%), Anabaena (5%)
		ML3.0		**ML3.0**	
Phytoplankton		counts/mL		counts/mL	
	Total	4,100		800,400	
	Bluegreen (Toxic)	2,000	Microcystis (100%)	730,000	Microcystis (76%), Lyngbya (6%), Aphanizomenon (3%),
		ML4.0			
Phytoplankton		counts/mL		counts/mL	
	Total	61,900		625,900	Ulothrix
	Bluegreen (Toxic)	59,500	Aphanizomenon (66%), Microcystis (30%), Anabaena (4%)	600,000	Anabaena (58%), Microcystis (31%), Lyngbya (3%), Aphanizomenon (8%),
		ML5.0		**ML5.0**	
Phytoplankton		counts/mL		counts/mL	
	Total	31,800		626,100	
	Bluegreen (Toxic)	7,100	Anabaena	600,000	Anabaena (65%), Microcystis (28%), Aphanizomenon (6%), Lyngbya (1%)
		ML6.0		**ML6.0**	
Phytoplankton		counts/mL		counts/mL	
	Total	14,600		269,600	
	Bluegreen (Toxic)	10,100	Microcystis (100%)	200,000	Microcystis (87%), Anabaena (9%), Aphanizomenon (4%)
		ML7.0		**ML7.0**	
Phytoplankton		counts/mL		counts/mL	
	Total	160,000		867,300	
	Green	<200		<200	
	Bluegreen (Toxic)	160,000	Aphanizomenon (93%), Microcystis (7%)	800,000	Microcystis (88%), Anabaena (11%), Lyngbya (1%)
		CC 0		**CC 0**	
Phytoplankton		counts/mL		counts/mL	
	Total	ns		7,100	
	Bluegreen (Toxic)	ns		700	Microcystis (100%)

ns = no sample

The liver toxins from these algae can cause skin irritations, gastrointestinal illness and potential long term illness. Pets are most vulnerable due to potential ingestion from drinking or licking the algae off their fur.

These blue-green algae are associated with lakes with elevated concentrations of phosphorus. In September, the average concentration of TP in the surface water samples of the lake was 5ug/L. Elevated concentrations of phosphorus contribute to elevated concentrations of blue-green algae.

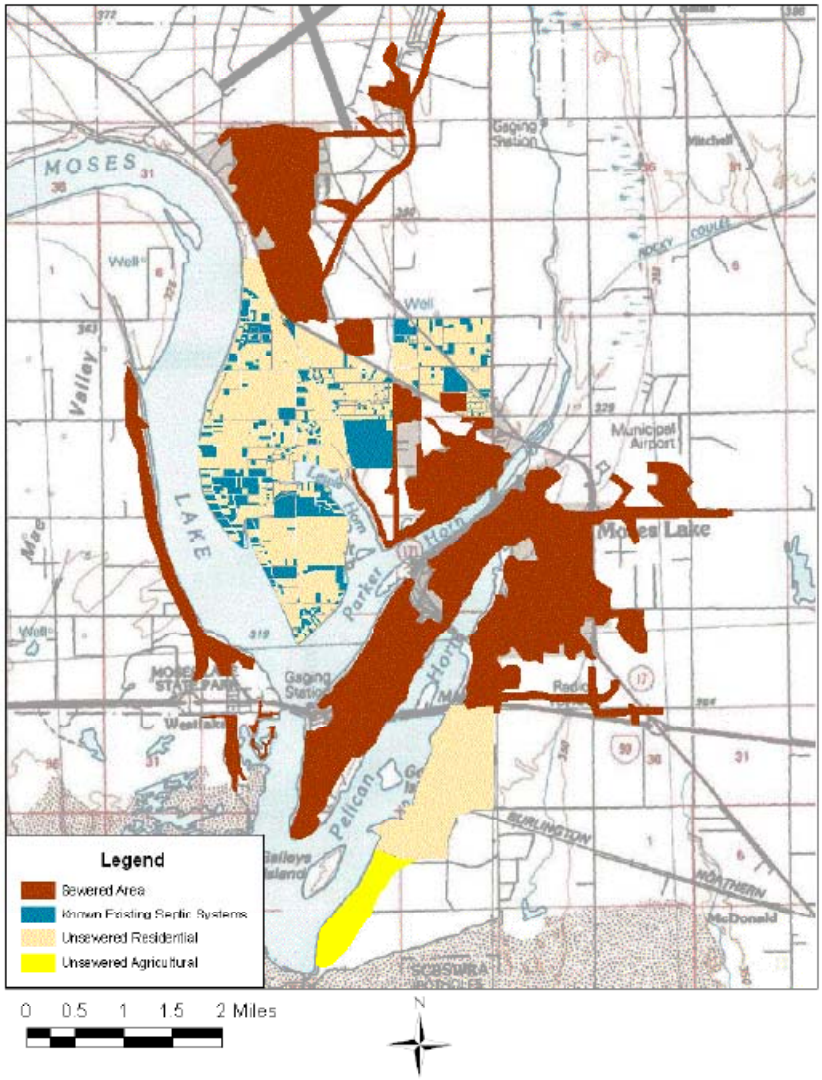

Figure 17. Current and potential development of Cascade Valley using drain fields for disoposal of the residential wastewater. (Burgoon, 2006)

LAKE SEDIMENT SAMPLING

Site specific sediment samples and depths were taken from Laguna and Wild Goose inlets on September 21, 2006. The depth of sediment above cobbles was measured with a steel rod. The rod was forced into the sediment until it would stop with the force of two men pushing down on the rod. The point at which it stopped was considered the depth of the cobbles. Sites and depth samples are shown in Table 10. Both analysis samples were taken from Laguna. The sample taken in the Laguna channel was a silt loam; with 65% silt and 15% clay. The sample had strong sulfide odors, implying anoxic sediment. Phosphorus levels in the sediment were 1000 mg/kg. The sample collected at the inlet of the Laguna channel was loamy sand, which also had about 1000 mg/kg of TP. This sample was not anoxic.

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Table 8. Sediment sampling sites in Laguna and Wild Goose Inlets on 9/21/06 (Burgoon, 2006).

Site	Description	Coordinates		
1	Laguna/Pier 4 Channel	47	6.051	
		119	19.717	
	Water Depth		3.8	ft
	Probe depth (to water surface)		12	ft
	Depth of sand and silt sediment		8.2	ft
	One sediment sample collected	ponar grad, strong sulfide smell, fine sediment and roots, OM?		
2	Laguna/Pier 4 Channel - west of dock	47	6.057	
		119	19.653	
	Water Depth		2.6	
	Probe depth (to water surface)		12	
	Depth of sand and silt sediment		9.4	
	No sample			
3	Laguna/Pier 4 Channel - east of end of dock	47	6.058	
		119	19.601	
	Water Depth		3	
	Probe depth (to water surface)		7.6	
	Depth of sand and silt sediment		4.6	
	No sample			
4	Laguna/Pier 4 Channel - between east end of dock and inlet	47	6.051	
		119	19.54	
	Water Depth		3	
	Probe depth (to water surface)		7	
	Depth of sand and silt sediment		4	
	No sample			
5	Laguna/Pier 4 Channel - south side of inlet	47	6.048	
		119	19.52	
	Water Depth		2.8	
	Probe depth (to water surface)		12	
	Depth of sand and silt sediment		9.2	
	One sediment sample			no odor from sample, coarse
6	Wild Goose	na	na	
		na	na	
	Water Depth		3	
	Probe depth (to water surface)		6	
	Depth of sand and silt sediment		3	
	No sample, DO less than 1 mg/L			

Figure 18. Lake Sediment Sampling (Klutz, 2008 survey)

Survey crew categorized the soil types and is shown by color on the legend, figure 19. The weed rack used made the soils easily determined as it was pulled along the lake bottom.

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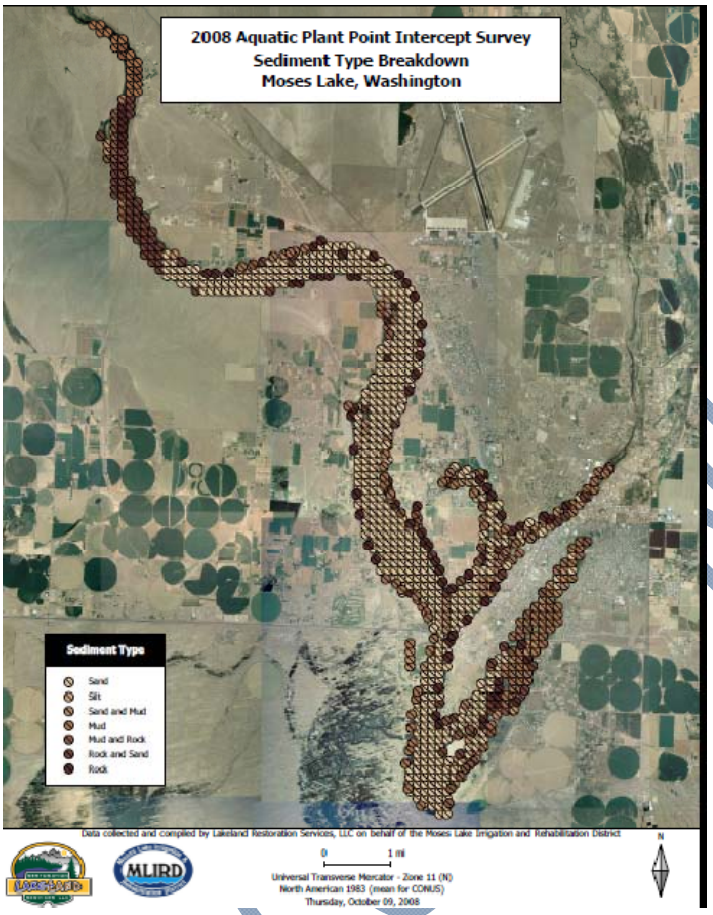

Figure 19. Sediment Type Breakdown (Klutz2008 survey)

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FISHERIES AND WILDLIFE

Fishing is a major recreational activity on Moses Lake and fishermen utilize the lake primarily April through November. At times hundreds are fishing-especially for Walleye and Bass. Common fish species table 9 furnished by Department of Fish and Wildlife.

Table 9. Common Fish species in Moses Lake waterbody (WDFL).

Black crappie (Pomoxis nigromaculatus)
Blue gill (Lepomis macrochirus)
Bullhead
Common carp (Cyprinus carpio)
Largemouth bass (Micropterus salmoides)
Pumpkinseed sunfish (Lepomis gibbosus)
Rainbow trout (Oncorhynchus mykiss)
Sculpin (Catostomus spp.)
Smallmouth bass (Micropterus dolomieui)
Sucker (Catostomus spp.)
Walleye (Stizostedion vitreum)
Whitefish (Coregonus clupeaformis; Prosopium williamsoni)
Yellow perch (Perca flavescens)

Wildlife live in abundance in and around the lakebody. Bird watchers, school children, and others often come to the lake to make a chance sighting of wildlife. Wildlife viewing sites are located in several places along the lakeshore. Very limited hunting occurs in special areas.

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Table 10. List of Audubon Society Bird Species in Moses Lake (1998-2003)

Species Name	Species Name	Species Name
Accipiter sp.	Glaucous-winged Gull	Savannah Sparrow
American Coot	Golden-crowned Kinglet	Sharp-shinned Hawk
American Crow	Gray Partridge	Short-eared Owl
American Goldfinch	Great Blue Heron (Blue form)	Snowy Owl
American Green-winged Teal	Great Egret	Song Sparrow
American Kestrel	Great Horned Owl	Sora
American Robin	Greater White-fronted Goose	Spotted Towhee
American Tree Sparrow	grebe sp.	Swamp Sparrow
American White Pelican	gull sp.	Tundra Swan
American Wigeon	Herring Gull	Varied Thrush
Bald Eagle	Hooded Merganser	Virginia Rail
Barn Owl	Horned Grebe	Western Grebe
Belted Kingfisher	Horned Lark	Western Meadowlark
Bewick's Wren	House Finch	White-throated Sparrow
Black-billed Magpie	House Sparrow	white-winged gull sp.
blackbird sp.	Killdeer	Wood Duck
Black-crowned Night-Heron	Lapland Longspur	Yellow-headed Blackbir
Blue-winged Teal	Lesser Scaup	Yellow-rumped Warbler
Bohemian Waxwing	Lesser Yellowlegs	
Bonaparte's Gull	Long-billed Dowitcher	
Brewer's Blackbird	Mallard	
Brown Creeper	Marsh Wren	
Brown-headed Cowbird	Merlin	
Bufflehead	Mourning Dove	
Burrowing Owl	Northern (Red-shafted) Flicker	
Buteo sp.	Northern (Yellow-shafted) Flicker	
California Gull	Northern Flicker	
California Quail	Northern Harrier	
Canada Goose	Northern Pintail	
Canvasback	Northern Shoveler	
Carpodacus sp.	Northern Shrike	
Cedar Waxwing	peep sp.	
Common Goldeneye	Pied-billed Grebe	
Common Merganser	Pine Siskin	
Common Raven	Prairie Falcon	
Common Snipe	Red-breasted Nuthatch	
Cooper's Hawk	Red-breasted Sapsucker	
Dark-eyed (Oregon) Junco	Redhead	

Species Name	Species Name
Dark-eyed (Slate-colored) Junco	Red-tailed Hawk
Double-crested Cormorant	Red-winged Blackbird
Downy Woodpecker	Ring-billed Gull
duck sp.	Ring-necked Duck
Dunlin	Ring-necked Pheasant
Eared Grebe	Rock Dove
European Starling	Rough-legged Hawk
Gadwall	Ruby-crowned Kinglet
Glaucous Gull	Ruddy Duck

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Table 11. WDFW GAP analysis avian species list for Moses Lake area (WDFW, 1997

Species Common Name	Species Scientific Name
Spotted Sandpiper	Actitis macularia
Clark`s Grebe	Aechmophorus clarkii
Western Grebe	**Aechmophorus occidentalis**
Red-winged Blackbird	Agelaius phoeniceus
Greater white-fronted goose	Anser albifrons
Northern Shoveler	Anas clypeata
Green-winged Teal	Anas crecca
Cinnamon Teal	Anas cyanoptera
Mallard	Anas platyrhynchos
Gadwall	Anas strepera
Great Blue Heron	Ardea herodias
Short-eared Owl	Asio flammeus
Long-eared Owl	Asio otus
Redhead	Aythya americana
Canada Goose	Branta canadensis
Red-tailed Hawk	Buteo jamaicensis
Swainson`s Hawk	Buteo swainsoni
Great Horned Owl	Bubo virginianus
California Quail	Callipepla californica
House Finch	Carpodacus mexicanus
Great Egret	Ardea alba
American Goldfinch	Carduelis tristis
Belted Kingfisher	Ceryle alcyon
Common Nighthawk	Chordeiles minor
Killdeer	Charadrius vociferus
Northern Harrier	Circus cyaneus
Marsh Wren	Cistothorus palustris
Northern Flicker	Colaptes auratus
Common Raven	Corvus corax
Rock Dove	Columba livia
Horned Lark	Eremophila alpestris
Brewer`s Blackbird	Euphagus cyanocephalus
Prairie Falcon	Falco mexicanus
American Kestrel	Falco sparverius
American Coot	Fulica americana
Common Snipe	Gallinago gallinago
Black-necked Stilt	Himantopus mexicanus
Cliff Swallow	Hirundo pyrrhonota
Barn Swallow	Hirundo rustica
Bullock`s Oriole	Icterus bullockii
California Gull	Larus californicus
Ring-billed Gull	Larus delawarensis

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Species Common Name	Species Scientific Name
Song Sparrow	Melospiza melodia
Brown-headed Cowbird	Molothrus ater
Black-crowned Night-Heron	Nycticorax nycticorax
Ruddy Duck	Oxyura jamaicensis
Lazuli Bunting	Passerina amoena
Deer Mouse	Peromyscus maniculatus
Double-crested Cormorant	Phalacrocorax auritus
Black-headed Grosbeak	Pheucticus melanocephalus
Wilson`s Phalarope	Phalaropus tricolor
Black-billed Magpie	Pica pica
Downy Woodpecker	Picoides pubescens
Pied-billed Grebe	Podilymbus podiceps
Sora	Porzana carolina
American Avocet	Recurvirostra americana
Bank Swallow	Riparia riparia
Rock Wren	Salpinctes obsoletus
Say`s Phoebe	Sayornis saya
Caspian Tern	Sterna caspia
Forster`s Tern	Sterna forsteri
Northern Rough-winged Swallow	Stelgidopteryx serripennis
European Starling	Sturnus vulgaris
Violet-green Swallow	Tachycineta thalassina
American Robin	Turdus migratorius
Barn Owl	Tyto alba
Eastern Kingbird	Tyrannus tyrannus
Western Kingbird	Tyrannus verticalis
Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Mourning Dove	Zenaida macroura

Table 12. WDFW GAP analysis terrestrial species list for Moses Lake area (WI 1997). Bold text indicates priority species

Common Name	Scientific Name
Tiger Salamander	Ambystoma tigrinum
Pallid Bat	Antrozous pallidus
Coyote	Canis latrans
Rubber Boa	Charina bottae
Painted Turtle	Chrysemys picta
Big Brown Bat	Eptesicus fuscus
Porcupine	Erethizon dorsatum
Western Skink	Eumeces skiltonianus
Hoary Bat	Lasiurus cinereus
Bobcat	Lynx rufus
Striped Skunk	Mephitis mephitis
Montane Vole	Microtus montanus
Meadow Vole	Microtus pennsylvanicus
Long-tailed Weasel	Mustela frenata
Long-eared Myotis	Myotis evotis
Small-footed Myotis	Myotis ciliolabrum
Fringed Myotis	Myotis thysanodes
Yuma Myotis	**Myotis yumanensis**
Bushy-tailed Woodrat	Neotoma cinerea
Mule Deer	Odocoileus hemionus
Muskrat	Ondatra zibethicus
Townsend`s Big-eared Bat	**Plecotus townsendii**
Raccoon	Procyon lotor
Pacific Treefrog	Hyla regilla
Bullfrog	Rana catesbeiana
Northern Leopard Frog	**Rana pipiens**
Western Harvest Mouse	Reithrodontomys megalotis
Vagrant Shrew	Sorex vagrans
Nuttall`s Cottontail	Sylvilagus nuttallii
Western Terrestrial Garter Snake	Thamnophis elegans
Common Garter Snake	Thamnophis sirtalis

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Western Grebe Nesting(Department of Fish and Wildlife)

The department of Fish and Wildlife conducted a study on the Western Grebe's nesting sites of Moses Lake, and provided data and photos on the location of the Western Grebe's nesting sites. This will be valuable in developing the management plan to provide conservation concern and aid to this species that is now on the alert for possibly being placed on the endangered species.

The Department of Fish and Wildlife also provided and verified data on plant and animal species and habitats of the lake. They will participate in the dredging process and the management plan

Figure 20. Gailey's Island Grebe Nesting (Dept. Fish and Wildlife)

Figure 21. Goat Island Recent Grebe Nesting (Dept. Fish and Wildlife).

Figure 22. Marsh Island Grebe Nesting (Dept. Fish and Wildlife).

Figure 23. Crescent Island Historical Grebe Nesting (Dept Fish and Wildlife).

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Figure 24. Mae Valley Grebe Nesting (Dept. Fish and Wildlife)

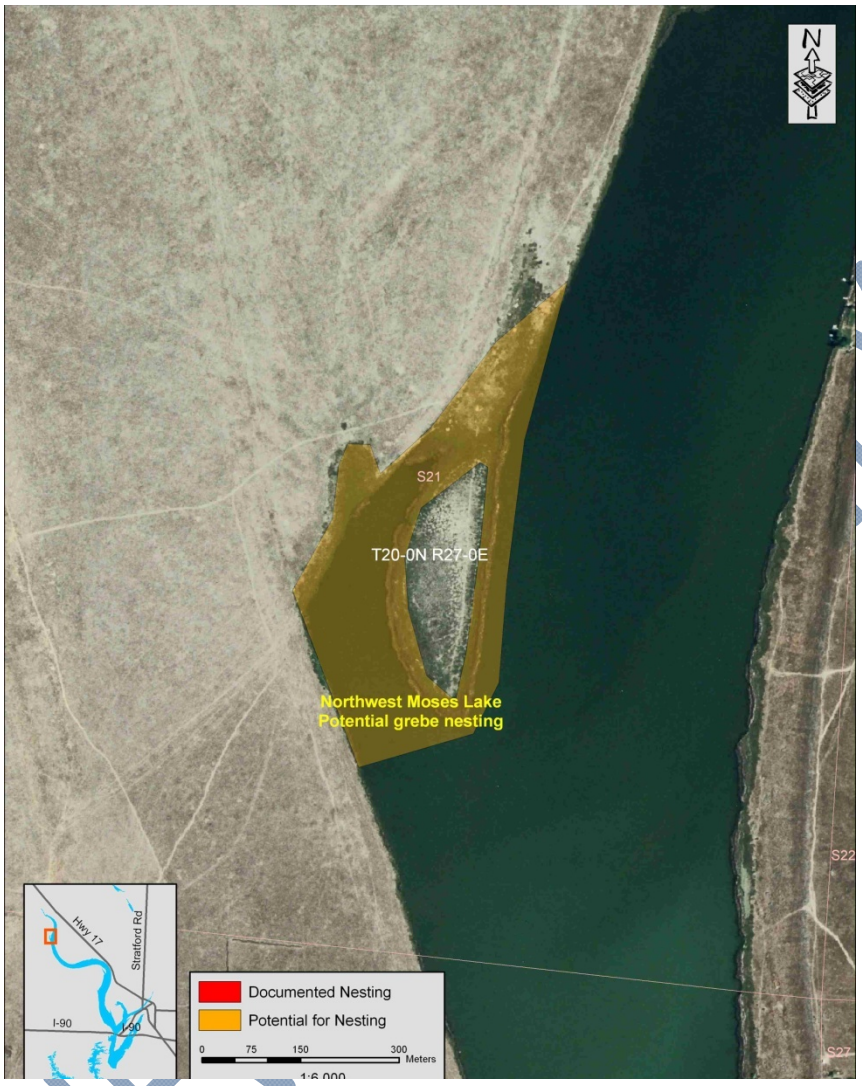

Figure 25. Northwest Moses Lake Grebe Nesting (Dept. Fish and Wildlife)

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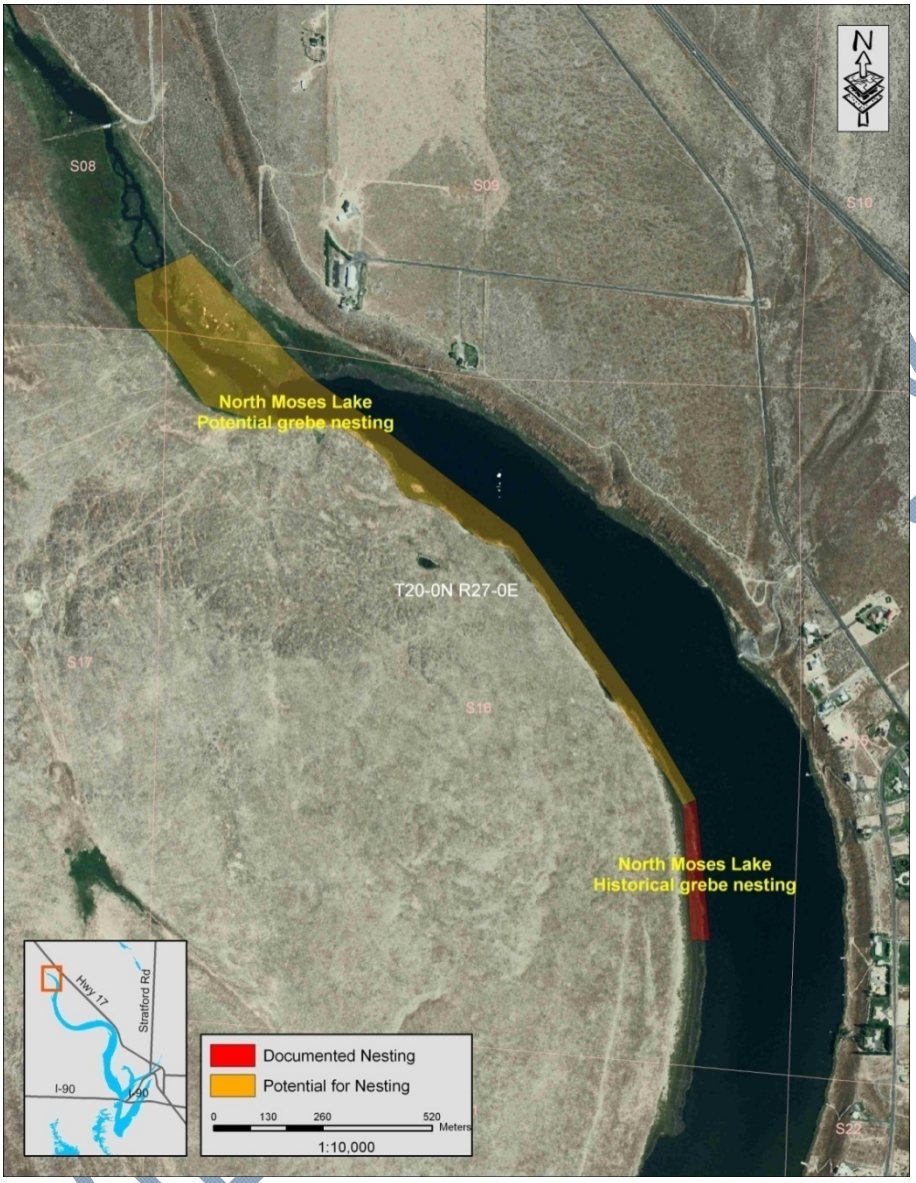

Figure 26. North Moses Lake Grebe Nesting. (Dept. of Fish and Wildlife)

REVIEW

RECREATIONAL USES OF THE WATERBODY

Figure 27. – Beneficial and recreational uses of the Moses Lake waterbody

The proposed "Use Map" is a compilation boating areas, harvest, special projects (fish rearing area, youth/senior fishing pond) nutrient sources and Grebe nesting areas

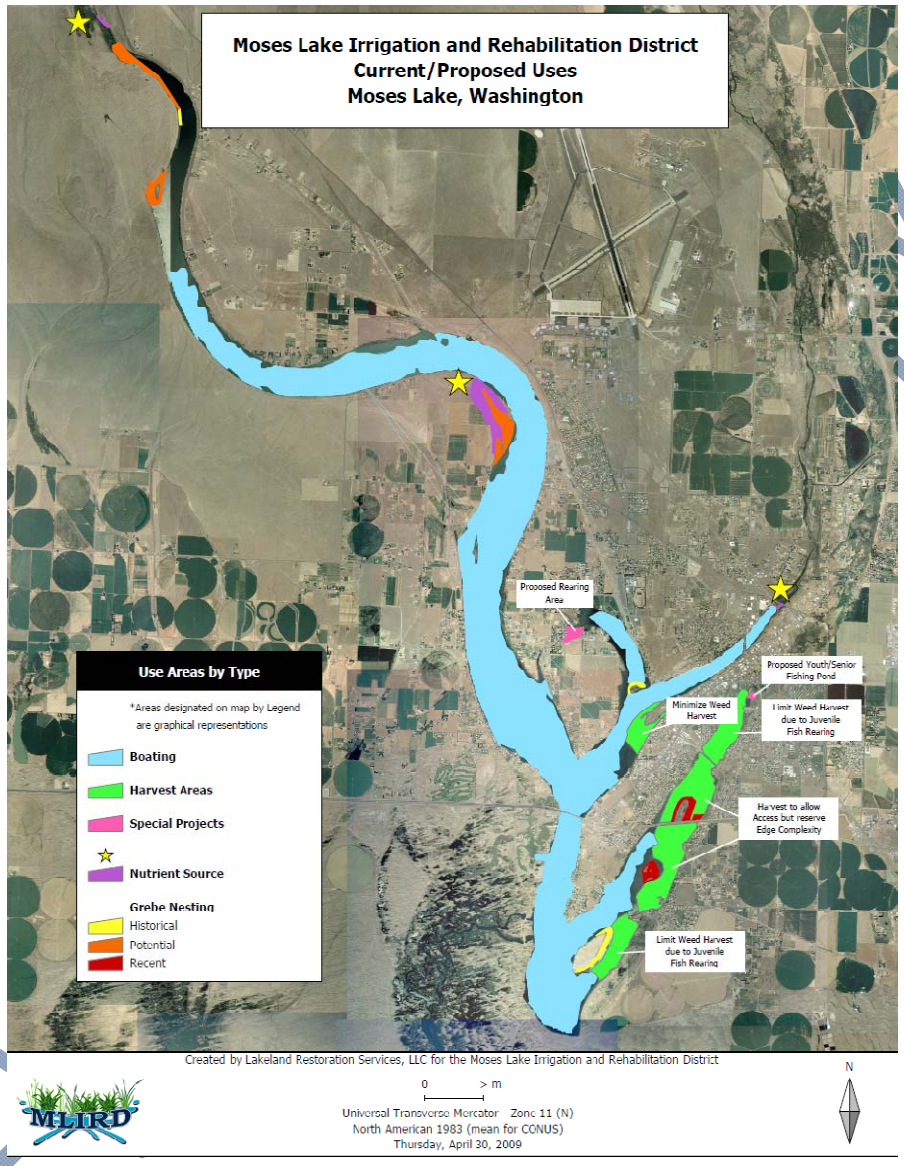

Figure 28. A Proposed Use Map for Moses Lake Waterbody

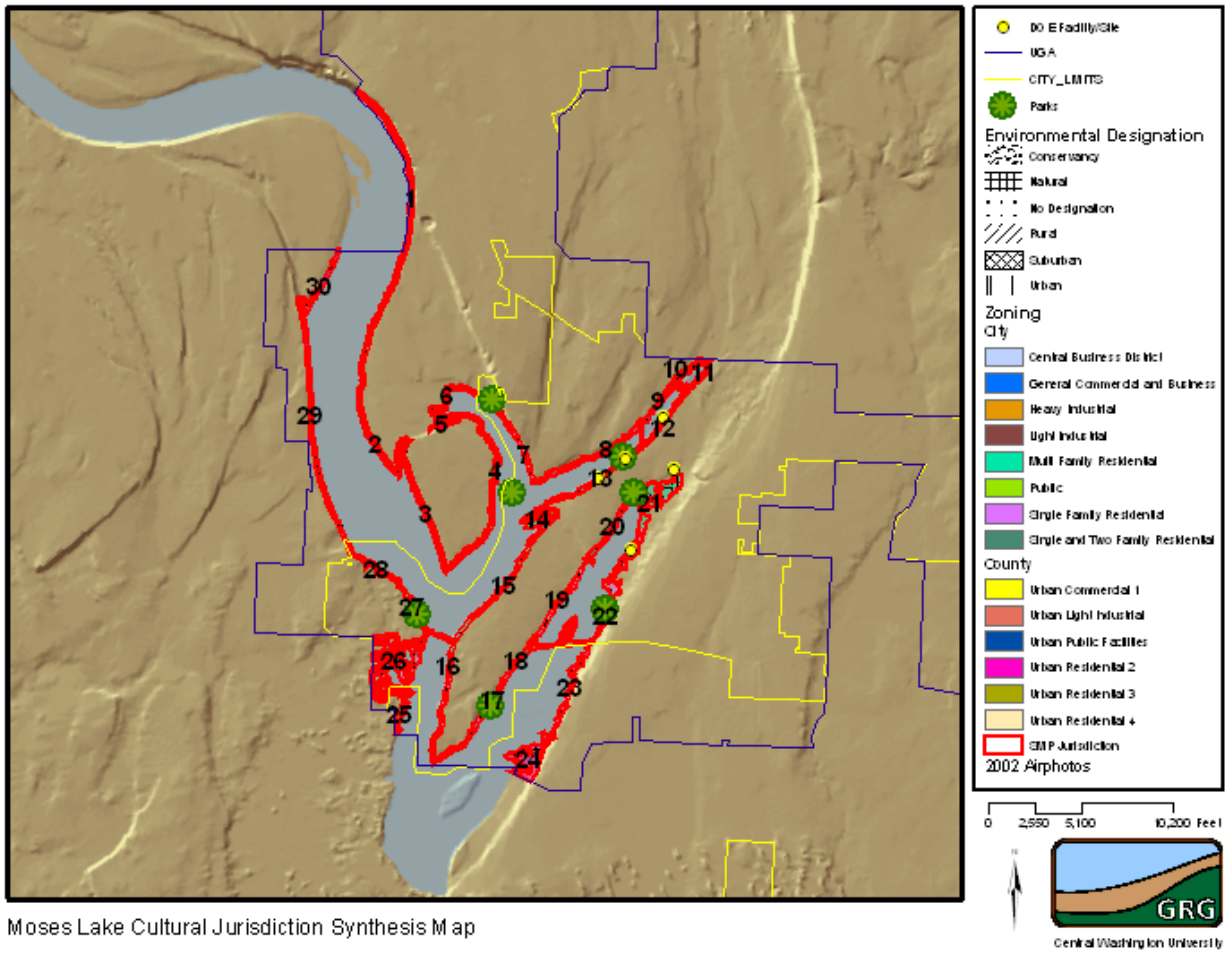

Figure 29. Parks located within Moses Lake.

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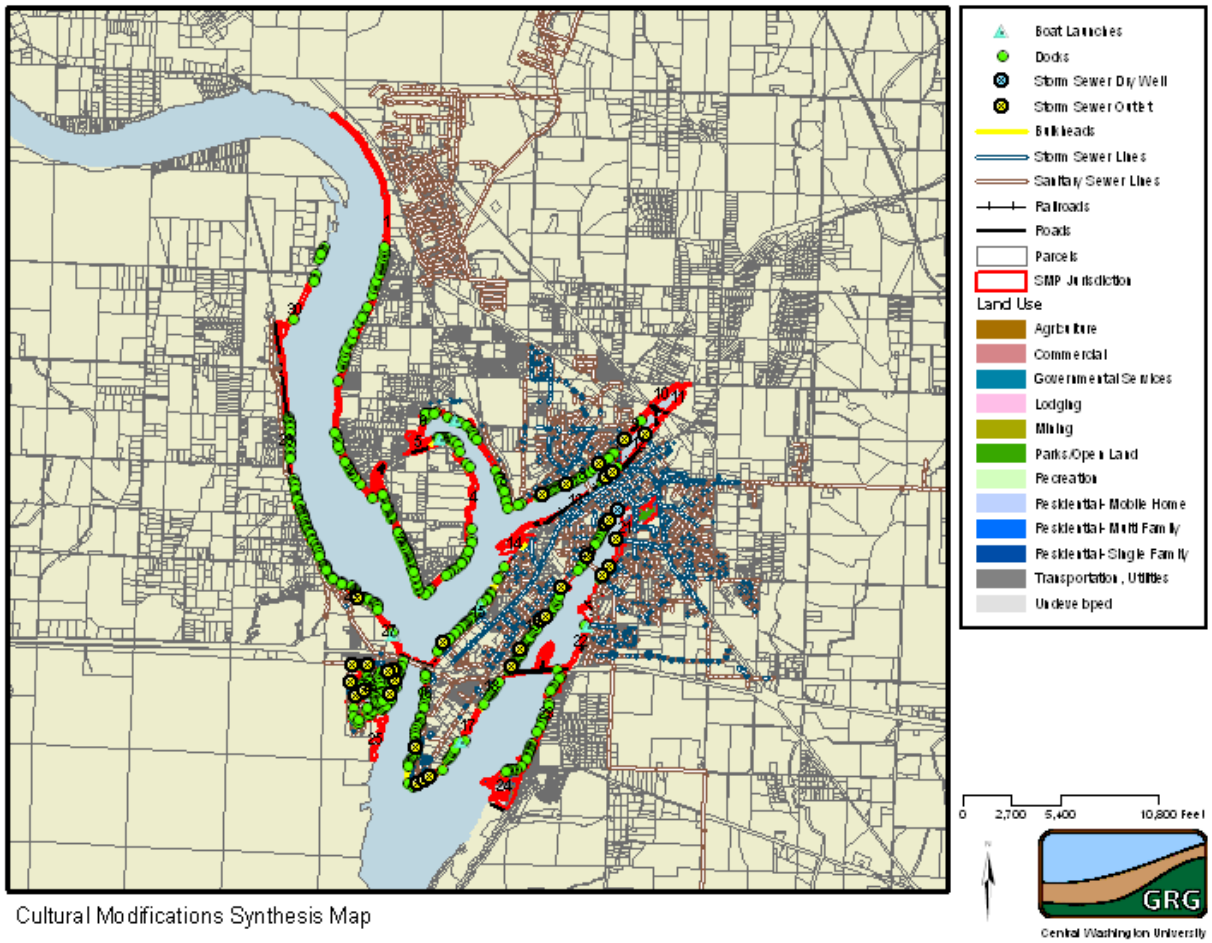

Figure 30. Private Docks and Public Boat Launches (City of ML)

LAKE VEGETATION SURVEY 2008

Dave Klutz of Lakeland Restoration Services conducted a vegetation survey, mapping the entire waterbody of Moses Lake. The survey inventoried the variety of plant types, their population density, their identity and their location via GPS (global Positioning System) map readings. During the same survey, bathymetry mapping of the water depths, and the sediment areas were also mapped with GPS readings. The findings support all previous data with a high degree of significance and provided data that will have an impact on the treatment application of the vegetation in the lake.

REVIEW

Survey of Aquatic plants

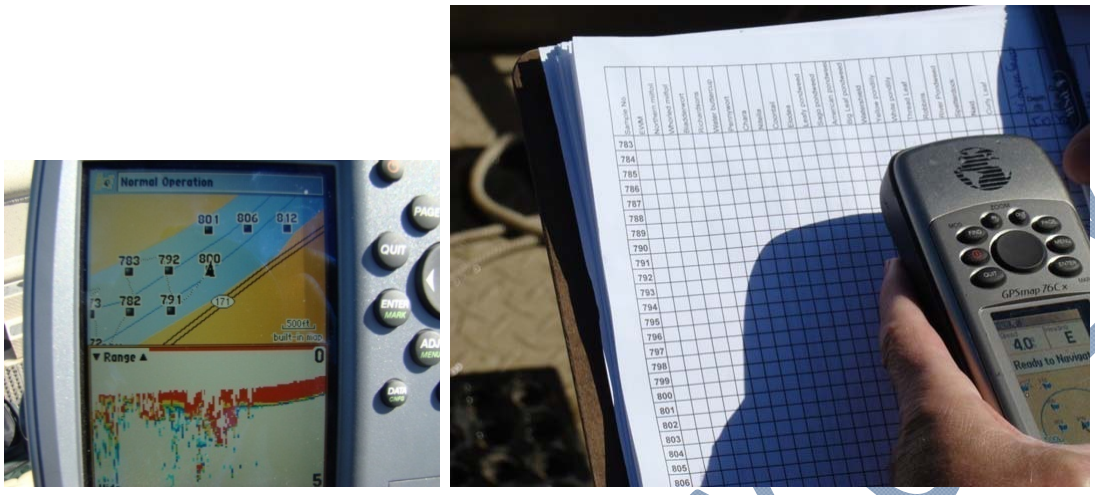

Figure 31. Lakebody survey (Kluttz, 2008 survey)

Dave Kluttz (Lakeland Restoration Services) and crew visited every site shown on the subject map. With the use of a Garmin GPS, Rake, water testing equipment, and depth/GPS finder in an airboat. The crew established elevations, aquatic vegetation, water temp., dissolved oxygen levels, and Lake Bottom makeup.

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Figure 32. Plant Sampling (Kluttz, survey 2008)

The use of an Airboat allowed the survey crew to easily traverse shallow areas in addition to providing a good platform for identification.

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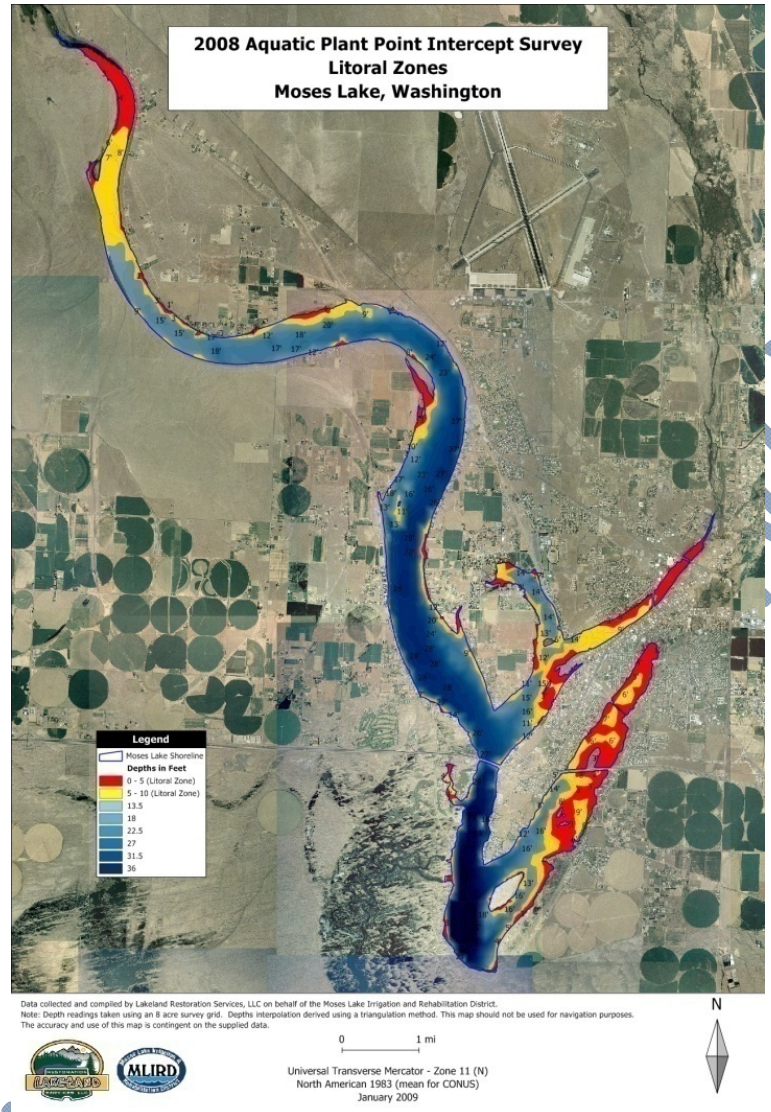

Figure 33. 2008 Aquatic Plant Point Intercept Survey Littoral Zones (Kluttz, 2008 survey)

Map Aquatic Plants

The following maps and captions illustrate and describe areas of concentration of Aquatic Plants (The survey was completed on October 11, 2008):

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American Pondweed found in few locations and primarily in the lower part of the waterbody in Pelican Horn

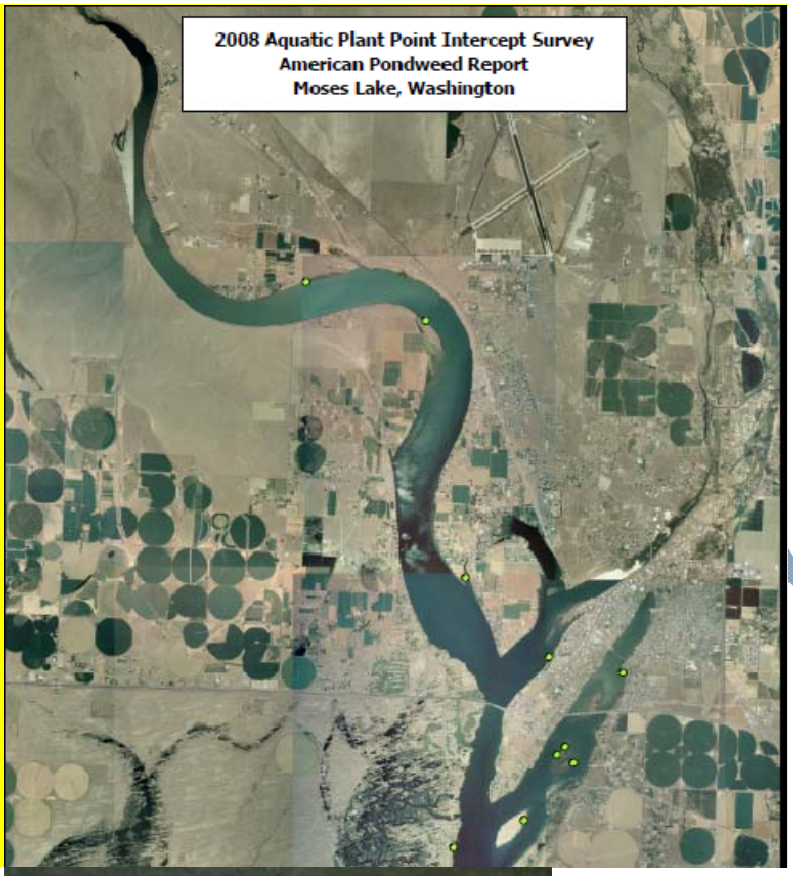

Figure 34. American Pondweed Report (Kluttz, 2008 survey

Potamogeton nodosus

American pondweed is a perennial plant that has both floating and a few submerged leaves in an alternate pattern. The floating leaves are elliptical to oval 4 to 7 inches long and 1 to 2 inches wide on long petioles. Submerged leaves are not abundant and are blade-like, somewhat transparent and smaller than floating leaves. Fruits are on spikes that often stand above the water's surface and are brownish to reddish 3 to 2 1 inches long and 1/8 to ¼ inches wide.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food (called "detritus") or many aquatic invertebrates. American pondweed is highly utilized as food by ducks and some other types of wildlife.

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Big Leaf Pondweed was found along the shoreline and in lake fingers throughout the lake.

Figure 35. Big Leaf Pondweed (Kluttz, 2008 survey)

Big Leaf Pondweed

Leaf: Alternate leaves of two types. Submersed leaves: bright to dark green, translucent, 8-20 cm long and 2-7.5 cm wide, folded along the midrib, curved backwards into a banana-shape, and sometimes with wavy margins. They have short stalks (1-2cm) and 19-45 lengthwise veins. These leaves often decay in late summer. Floating leaves: often absent. The opaque, leathery, oval leaves taper at both ends and are 5-10 cm long and 2.5-5 cm wide. They have 25-45 veins and 3-

10 cm long stalks that are generally longer than the floating leaves. Sheaths (stipules) are up to 10 cm long, whitish, translucent, occur at leaf bases, but are not attached to the leaves. They become stringy with age. **Stem:** Few or un-branched stem to 3mm thick to 5m long.

Flower: Small flowers have 4 petal-like lobes. Up to 16 whorls of tightly clustered flowers are arranged into an up to 5 cm long spike on stalks rising above the water. The flower stalks are thicker than the stem and are 5-15 cm long.

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Bulrush was found in varying concentrations throughout most of the lake-some shoreline without evidence of Bulrush. Growth was along the shoreline.

Figure 36. Bulrush Report (Kluttz, 2008 survey)

Description

Rushes are grass-like herbaceous plants with cylindrical or flattened, solid stems. At their bases, leaves are tightly sheathed around the stem, and leaves are sometimes absent or little more than bladeless sheaths on green stems. Flowers are small, greenish-brown to purplish-brown, and borne in clusters near or at the ends of small flower stems.

Habitat

Generally found growing in clumps in wet soils or shallow, standing water. Rushes are widely-distributed, and there are more than 20 rush species in Western Washington.

Advantages

Rushes provide excellent soil-binding and erosion resistance. They also provide cover for small mammals and marsh birds. Seeds of bulrushes are consumed by ducks and other birds while geese, muskrats, and nutria consume the rhizomes and early shoots.

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Coontail

Coontail was found in the upper reaches of the North end of the waterbody and Parker Horn. These area are primarily the inlets to the lake. Coontail are growing in very shallow water depths, 0'-5'.

Figure 37. Coontail Report (Kluttz, 2008 survey)

Coontail – A Freely Floating Native Plant

Coontail (*Ceratophyllum demersum*) is a completely submersed plant commonly seen in Washington lakes with moderate to high nutrient levels. It is also known by the common name hornwort. The common names refer to its full, bottle-brush-like growth form and its forked, antler-shaped leaves. The Latin name *Ceratophyllum* pertains to the horned leaf edges – Cerato derives from the Greek word "keras" (horn, as in rhinoceros). Phyllum means leaf.

The serrated, forked leaves of Coontail are arranged on the stems in whorls, with usually 5-12 leaves in each whorl. It is generally a dark, olive green color, and is often rather hard and crusty

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to the feel. This is especially true where it grows in hard water lakes (the calcium in the water becomes deposited on the leaf surface, making it seem crunchy)

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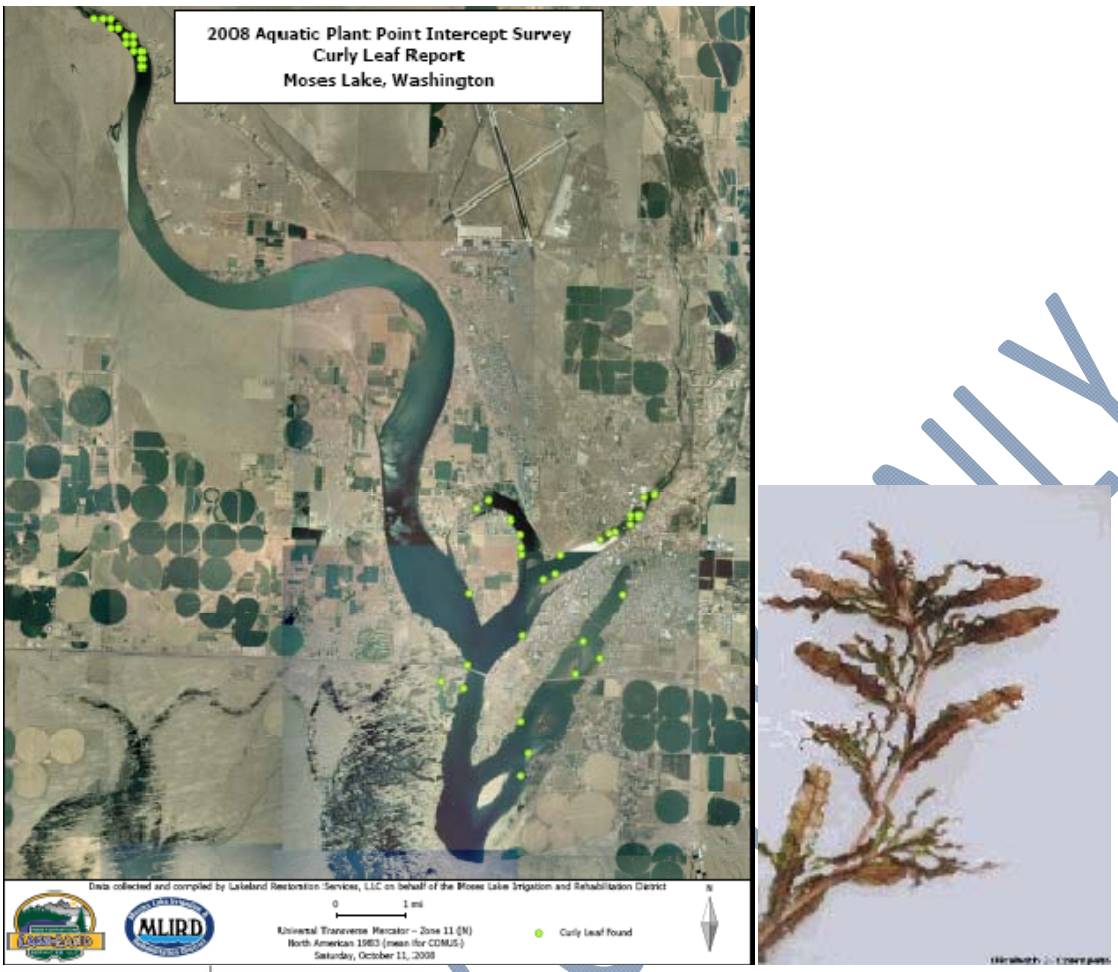
Curly Leaf was found in mainly shallow areas of the lake, especially at the inlets. The growth is in very shallow area of the lake, 0'-5'.



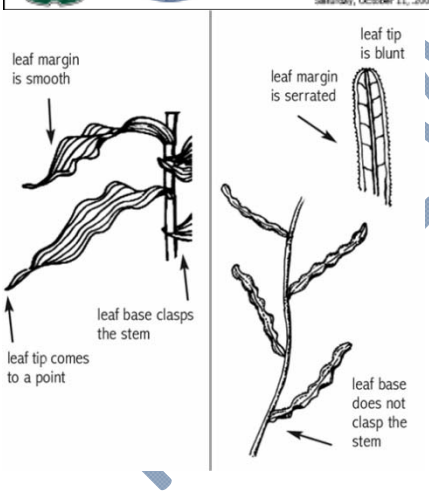


Figure 38. Curly Leaf Pondweed Report (Kluttz, 2008 survey)

Figure 39. Curly Leaf Pondweed

Description: Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early July Duckweed were found in low concentrations only in Parker Horn just above the confluence of Parker Horn and the main waterbody. The duckweed was found in very shallow water.

Distribution and Habitat: Curly-leaf pondweed is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine

Invasion: Curly-leaf pondweed spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring.

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants

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are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation.

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Duckweed was found in low concentrations only in Parker Horn just above the confluence of Parker Horn and the main waterbody. The duckweed was found in very shallow water. Figure 40.

Figure 40. Duckweed Report (Kluttz, 2008 survey)

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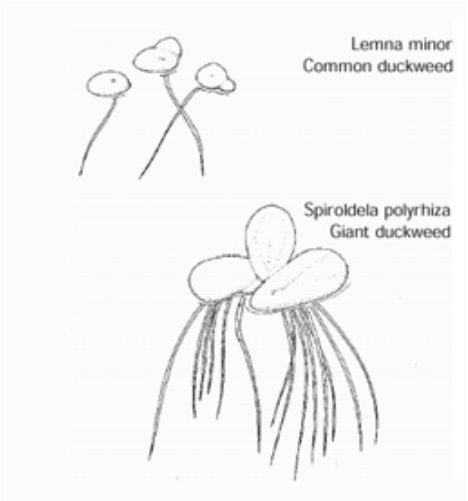

Lemna minor

Figure 41. Duckweed

Common duckweed is a very small light green free-floating, seed bearing plant. Duckweed has 1 to 3 leaves, or fronds, of 1/16 to 1/8 inch in length. A single root (or root-hair) protrudes from each frond. Duckweeds tend to grow in dense colonies in quiet water, undisturbed by wave action. Often more than one species of duckweed will be associated together in these colonies. Duckweeds can be aggressive invaders of ponds/lakes and are often found mixed in with mosquito fern or watermeal. If colonies cover the surface of the water, then oxygen depletions and fish kills can occur. These plants should be controlled before they cover the entire surface of the pond.

Duckweed colonies provide habitat for micro invertebrates but if duckweed completely covers the surface of a pond/lake for an extended period it will cause oxygen depletions. These colonies will also eliminate submerged plants by blocking sunlight penetration. Many kinds of ducks consume duckweed and often transport it to other bodies of water.

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Elodea

Elodea was found in small concentrations in Lewis Horn and Pelican Horn with a trace amount on the edge of Pogo Island. The elodea was found in shallow water, 0'-5'. Figure 42.

Figure 42. Elodea Report (Kluttz, 2008 survey)

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Elodea is a genus of aquatic plants often called the water weeds. *Elodea* is native to North America. It is also widely used as aquarium vegetation. The introduction of some species of *Elodea* into waterways in parts of Europe, Australia, Africa, Asia, and New Zealand has created a significant problem, and it is now considered a noxious weed in these areas *Elodea canadensis*, sometimes called American or Canadian water weed/pond weed is widely known as the generic water weed. The use of these names causes it to be confused with similar-looking plants, like Brazilian elodea (*Egeria densa*) or hydrilla (*Hydrilla verticillata*). American water weed is an attractive aquarium plant, and is a good substitute for Brazilian elodea. It can be used for science experiments in classrooms as it can show how plants use carbon dioxide with the usage of bromothymol blue (BTB).

The American water weed lives entirely underwater with the exception of small white flowers which bloom at the surface and are attached to the plant by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. It also often overwinters as an evergreen plant in mild climates. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is the American water weed's most important method of spreading, with seed production playing a relatively minor role.

Silty sediments and water rich in nutrients favor the growth of American water weed in nutrient-rich lakes. However, the plant will grow in a wide range of conditions, for example, from very shallow to deep water, and in many sediment types. It can even continue to grow unrooted, as floating fragments. It is found throughout temperate North America, where it is one of the most common aquatic plants.

American water weed is an important part of lake ecosystems. It provides good habitat for many aquatic invertebrates and cover for young fish and amphibians. Waterfowl, especially ducks, as well as beaver and muskrat eat this plant. Also, it is of economic importance as an attractive and easy to keep aquarium plant.

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High concentrations of Watermilfoil were found in various locations on the waterbody; the highest concentration in Pelican Horn in 5'-10' water levels, figure 43.

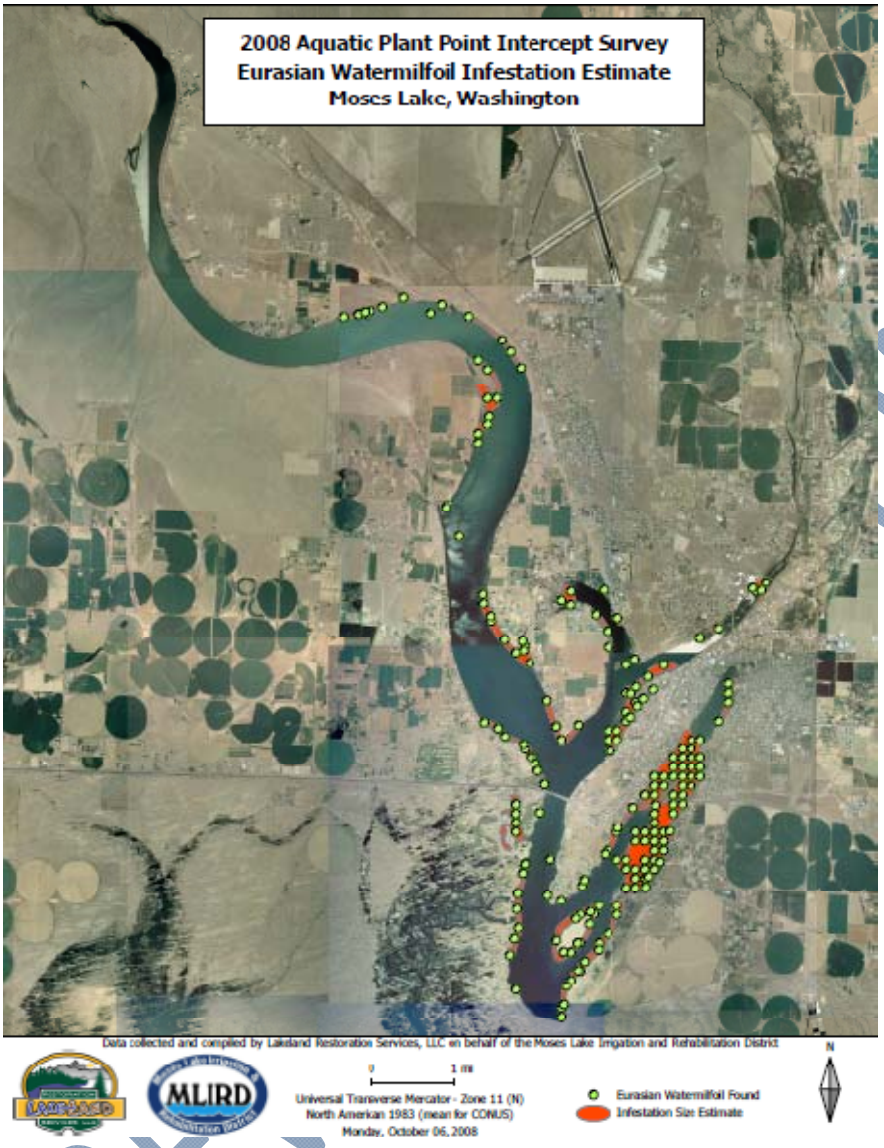

Figure 43. Eurasian Watermilfoil Infestation Estimate in Moses Lake (Kluttz, 2008 survey)

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Figure 44. Eurasian Watermilfoil

Myriophyllum spicatum--Non-Native

Eurasian watermilfoil is a perennial plant native to Europe, Asia, and Africa and was probably brought to the U.S. as an aquarium plant. Today it is considered one of the most aggressive and problematic plants in the U.S. because of the dense colonies which it forms. The stems are multi-branched, somewhat reddish in color, with gray-greenish feather-like leaves. The leaves are in whorls of 3 to 5 around the stem with each leaf divided into 12 or more pairs of thin thread-like leaflets. Reddish flowers are borne on leafless spikes that rise above the surface a few inches. Eurasian watermilfoil can spread from seeds or by fragmentation.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food (called "detritus") for many aquatic invertebrates. Eurasian watermilfoil seeds are consumed by ducks, while muskrats and nutria will consume the stems. Eurasian watermilfoil is a non-native and should not be spread (*Agri*LIFE EXTENSION-Texas A & M).

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This second Milfoil map is a good indicator of the density and location of Milfoil in the waterbody, figure 45.

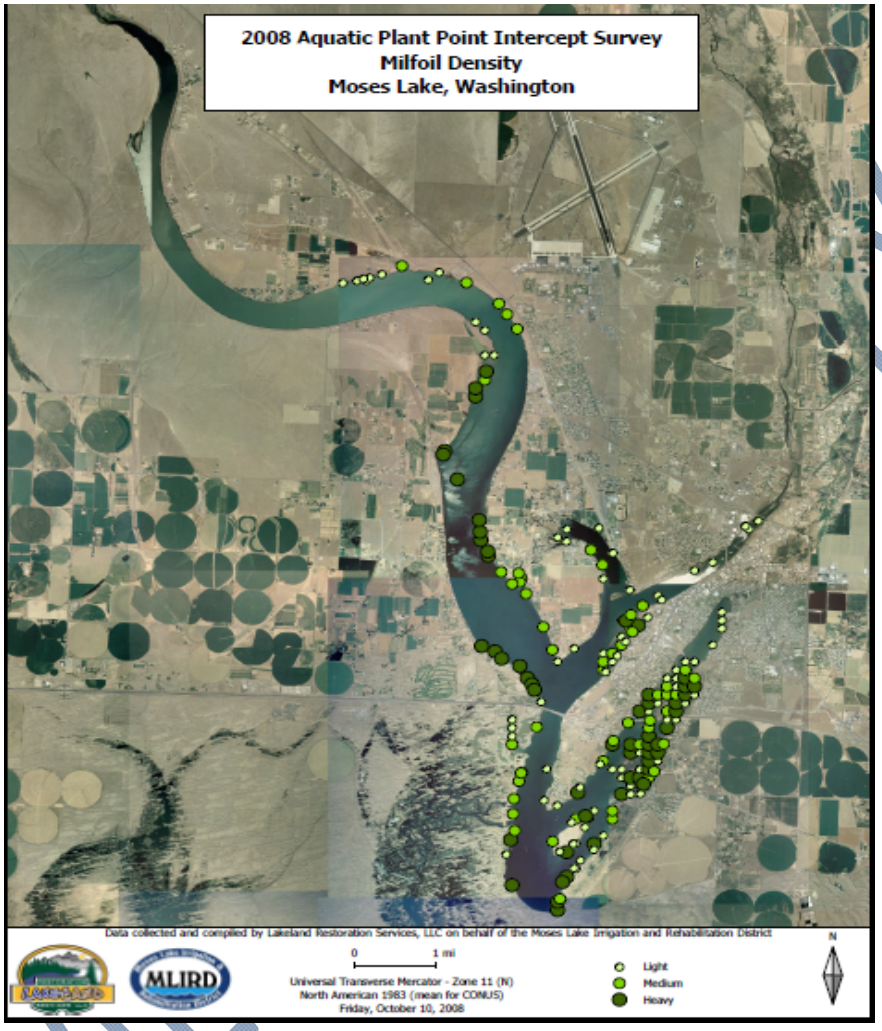

Figure 45. Milfoil Density (Kluttz, 2008 survey)

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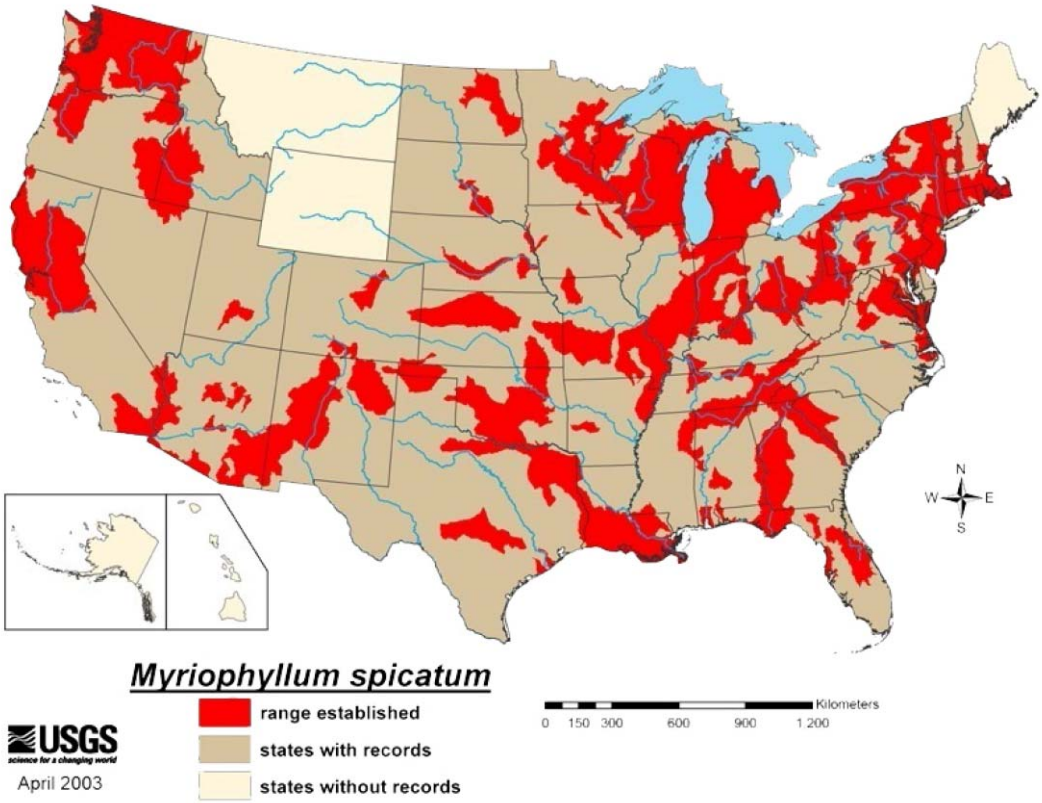

Figure 46. Areas of United States with recorded Eurasian watermilfoil infestation.

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Floating Algae is concentrated primarily in two areas with smaller concentrations along the shoreline. The water depth varied from virtually 0' to 30', figure 47.

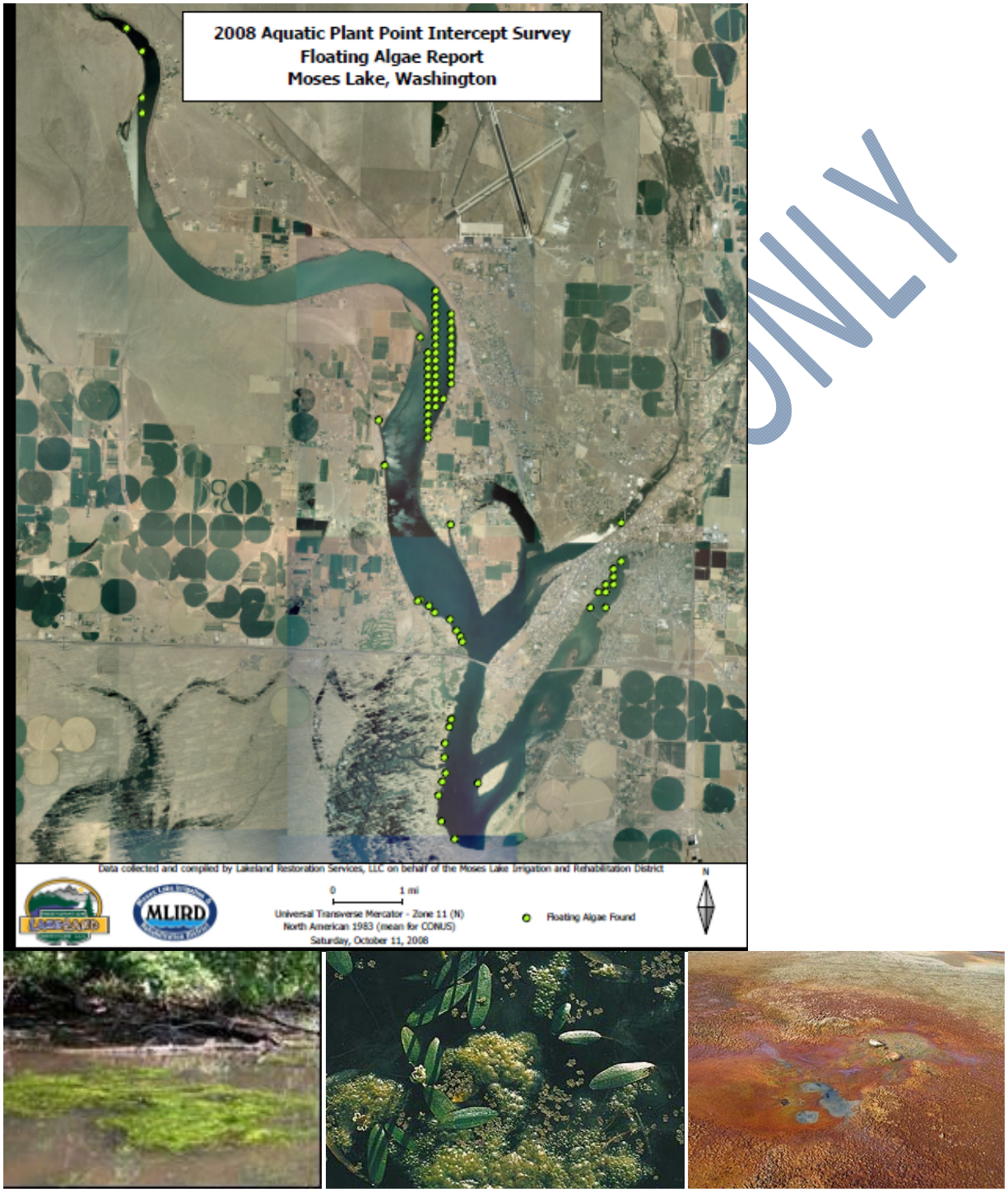

Figure47. Floating Algae (Kluttz 2008 survey)

The arrival of spring often presents a problem for pond owners as the beautiful, clear green water of their ponds/lakes disappears beneath a blanket of lime green, slimy, stinky pond scum. "Pond scum" is actually a popular term for aquatic algae, which tend to "bloom," or grow excessively in the early months of spring, spreading over the surface of the pond in unsightly and odorous mats of green and brown.

Aquatic algae are primitive plants, having no true roots, stems, or leaves. Pond/lake algae can be found either floating on the pond/lake surface or attached to other plants, bottom sediments or other hard surfaces. There are thousands of species of aquatic algae, but for simplicity they can be classified in three categories: microscopic algae, filamentous algae, and attached-erect algae.

Microscopic algae, also called phytoplankton, are tiny, free-floating algae that give the pond water its characteristic green color. Microscopic algae are the primary producers of dissolved oxygen in pond water. The presence of a healthy

level of microscopic algae in a pond is important for maintaining good water quality and health of the aquatic organisms in the pond, such as fish. Microscopic algae can undergo excessive blooms during mid-summer months, rising to the surface of the pond as a layer of yellow-green or reddish scum. A sudden die-off of microscopic algal blooms, caused by a change in water temperature or a stretch of several overcast days, can deplete dissolved oxygen levels in ponds to a critical level for the survival of aquatic organisms.

The clue for the pond owner in the control of microscopic algae is to look for a change in the color of the water that might signal that a bloom of microscopic algae is taking place. This color change would be from the clear green water of the healthy pond to a bright, pea-soup green.

To quickly check the density of microscopic algae in a pond, nail a light-colored object, such as a coffee can lid or aluminum pie pan, to the bottom of a yardstick. Place the yardstick in the water and observe the depth at which the light-colored object disappears. In a healthy pond, the light-colored object should be visible at a depth of 24 inches. If the object disappears before a depth of 24 inches is reached, a bloom of microscopic algae is taking place in the pond. If sight of the light-colored object is lost in less than 10 inches of water, the bloom is heavy and the pond owner may want to seek advice about control of microscopic algae.

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Attached-erect algae are a less common problem for pond owners, but excessive blooms of submerged attached-erect algae may occur across pond bottoms causing difficulties for anglers or swimmers. Attached-erect algae, commonly called stonewort or muskgrass, is often mistaken for more advanced pond plants because it resembles a higher plant with leaf-like structures arranged about a long stem-like structure. Attached-erect algae have a gritty texture due to surface calcium deposits. A positive identification of attached-erect algae is important for chemical treatment because chemicals used to treat many submerged aquatic plants often do not provide good control of algal species.

Green filamentous algae are the last category of pond/lake algae and the one which gives the most headaches. Many species of green filamentous algae are tolerant of cold water temperatures and undergo blooms in early spring. Typically, ponds/lakes having recurring problems with filamentous algae begin to exhibit algal blooms as early as March, although some blooms in late February have been reported. Blooms of filamentous algae begin in clear water in shallow areas where sunlight can penetrate the water to reach the soil of the pond bottom. Algal cells join together in long stands resembling green hairs, which grow in fur-like clumps along the pond bottom and edges, breaking off and floating to the surface to form dense mats. Sudden die-offs of dense blooms of filamentous algae can create serious water quality problems, not to mention unattractive and odorous conditions as the dead algae decays.

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Floating Leaf Pondweed was found in few areas and in shallow water, 0'-5', figure 48.

Figure 48. Floating Leafy Pondweed (Kluttz, 2008 survey)

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Leafy pondweed was found in the upper reaches of a finger (spy glass bay) off of the lower main waterbody and in Parker Horn and Stonebridge Harbor. Map49.

Leafy Pondweed

Figure 49. Leafy Pondweed (Kluttz, 2008 survey)

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Leaf: Submersed, alternate, stalk less. Small pondweed: linear leaves, 2-7 cm long, 0.5-2 mm wide, have pointed to rounded tips and 3 veins. Membranous tubular or open sheaths (stipules) are 1-3 cm long, free of the leaf base, and usually disintegrate before the leaves. Leafy pondweed: linear leaves, 2-10 cm long, 1-2.5 mm wide, have pointed tips and 1-5 veins. Sheaths (stipules) are free of the leaf-base with the lower portion forming a tube that eventually ruptures as new branches emerge. **Stem:** Slender and profusely branched. Small pondweed: often with small paired yellowish glands at leaf base,. Leafy pondweed: slightly flattened, paired glands lacking.

Flower: Small pondweed: in 1-4 whorls on spikes measuring 3-15 mm long; spikes not always above the water; on stalks to 5 cm long, often curved at the base. Leafy pondweed: in 2-4 whorls on an initially crowded spike (1 cm) that elongates as the season progresses; stalk 1-3 cm long.

Fruit: Achenes. Small pondweed: 1.5-3 mm long, rounded back, straight beak to 0.5 mm long. Leafy pondweed: To 2 mm long, with distinctively wavy ridged achene, beak 0.5 mm long.

Root: Small pondweed: Fibrous, from base of plant; often non-rhizomatous. Leafy pondweed: fibrous, emerging from threadlike rhizomes.

Propagation: Seeds and winter buds form at lateral branch tips and near leaf bases. Leafy pondweed also has rhizomes.

Importance of plant: Seeds and vegetation provide cover and food for aquatic animals.

Distribution: Small pondweed: widespread in northern hemisphere. Leafy pondweed: widespread in North and Central America.

Habitat: Small pondweed: wide tolerance of habitats, including brackish conditions. Leafy pondweed: marshes and shallow standing water.

Leafy and small pondweed may be confused with: each other and other narrow leaved submersed plants. Careful examination of the glands at the leaf bases, leaf characteristics, and fruits is required to distinguish them. The wavy keel of the achene of leafy pondweed is particularly distinctive.

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Naid is found primarily in the southern portion of the waterbody, concentrating in Parker Horn and Pelican Horn with plants found along the shoreline on the main waterbody, figure 50.

Figure 50. Naid (Kluttz, 2008 survey)

Najas minor

Brittle naiad or marine naiad occurs in fresh or brackish waters. It is a rooted submerged annual plant that resembles southern naiad except the leaves are highly toothed (3 – 12 teeth). Leaves are up to 1 ¼ inch long and 3/16 wide with several leaves at each node. Flowers (1/8 to 3/16 inch long) are found during summer, in the leaf axis.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food (called "detritus") for many aquatic invertebrates. Brittle naiad is readily consumed by ducks.

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Nitella was found in small concentrations at six sites, five of which are in the southern portion of the waterbody, figure 51.

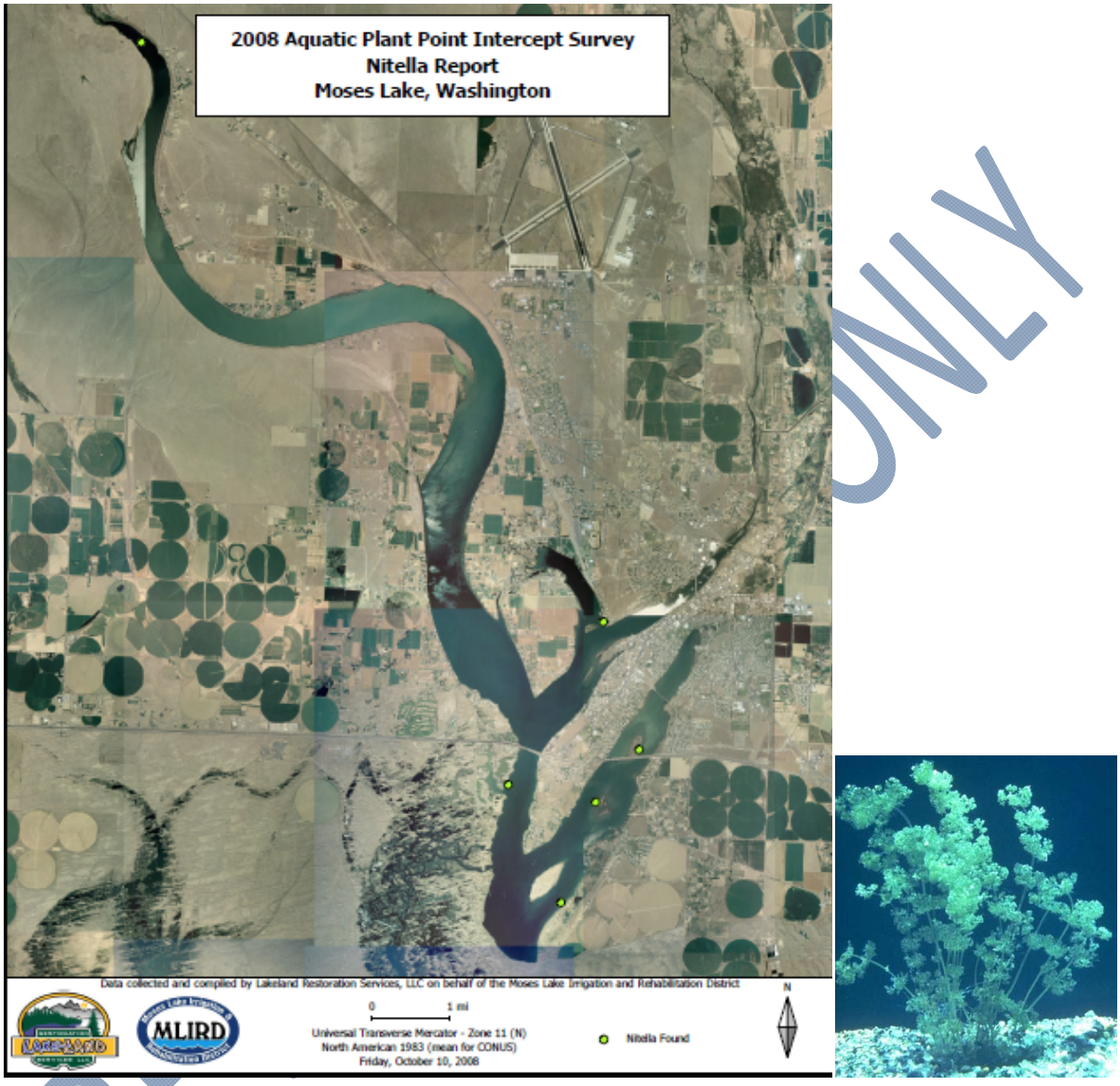

Figure 51. Nitella (Kluttz, 2008 survey)

Nitella spp.

Stoneworts are branched multicellular algae that are often confused with submerged flowering plants. However, stonewort has no flower and will not extend above the water surface. Nitella has no odor and are soft to the touch, unlike Chara. Stoneworts are light to dark green in color with forked, bushy branches 1/16 to 1/8 inches in diameter.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food called detritus-E for many aquatic invertebrates. Stonewort's have no known direct food value to wildlife.

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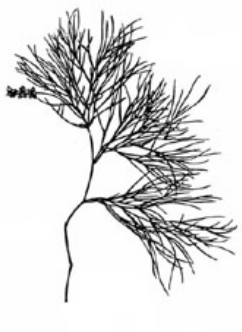
Sago Pondweed, figure 52.



Potamogeton pectinatus

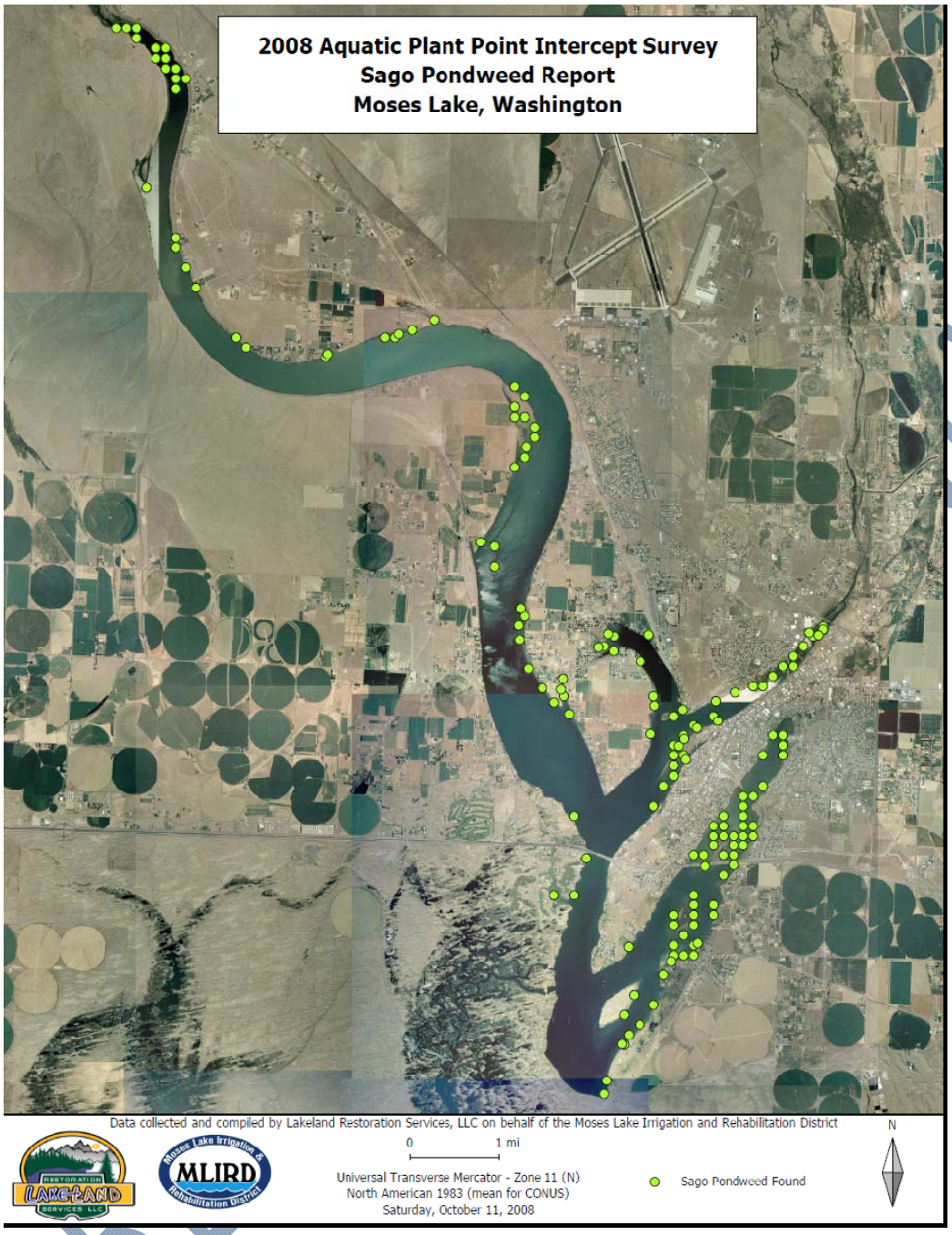


Figure 52. Sago Pondweed (Kluttz, 2008 survey)

Sago pondweed is a perennial plant that arises from thickly matted rhizomes and has no floating leaves. The stems are thin, long and highly branching with leaves very thin and filament-like, about 1/16 of an inch wide and 2 to over 12 inches long tapering to a point. The leaves grow in thick layers and originate from a sheath. The fruit is nut-like 1/8 to ¼ inches long and 1/10 to 1/8 inches wide.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food (called "detritus") for many aquatic invertebrates. Sago pondweed is an excellent food for waterfowl which eat both the fruits and the tubers.

Spatterdock –A single location was found in Pelican Horn and noted on figure 53.

Figure 53. Spatterdock (Kluttz, 2008 survey)

Thread Leaf was primarily found in Pelican Horn, Parker Horn, Lewis Horn and Spyglass Bay- also, found in small concentrations in sparse areas, figure 54.

Figure 54. Thread Leaf (Kluttz, 2008 survey)

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Threadleaf pondweed

Suckenia filiformis (Pers.) Boerner (formerly *Potamogeton filiformis*): Threadleaf pondweed, fineleaf pondweed, slender-leaved pondweed. Potamogetonaceae (pondweed family).

Native perennial. Whole plant is very slender and thread-like, to 20 in (50 cm) tall, growing submersed and with only one type of leaf. Stems emerge from a network of rhizomes that can form tubers at their tips. Stems to 0.04 in (1 mm) wide, and slightly flattened, branching into two near the base of the plant. Leaves are very thin, 2 – 4.75 in (5 – 12 cm) long; they have one main vein. The lower part of the stipule sheathes the stem and the base of the leaf blade; the upper part is free of the stem and up to 0.2 in (0.5 cm) long. The stipule can be pulled away from the stem to reveal the lower part of the leaf blade. Flower spike stalks are slender to thread-like; the flowers and later nut-like fruits are spaced rather than crowded along the stalk.

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White Pondlily was found at a single location on the Pelican Horn as noted on the map, figure 55.

Figure 55. White Pond Lily (Kluttz 2008 survey)

Widgeon grass is sparse and was found at four sites as noted on the map, figure 56.

Figure 56. Widgeon Grass (Kluttz, 2008 survey)

Widgeon grass is a completely submerged perennial plant with single or multi-branched stems up to 3 feet long. Leaves are alternate, simple, and thread-like (less than 1/32 of an inch wide) up to 4 inches long with sheaths. The flowers and fruits in clusters are at the end of individual stalks. Fruits are small (< 1/32 inches), dark-green and pear-shaped. Widgeon grass can live in fresh or brackish water to 10 ppt (parts per thousand) salinity or higher.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food (called "detritus") for many aquatic invertebrates. Widgeon grass is a very important wildlife plant with the stems and leaves being heavily utilized by many duck species.

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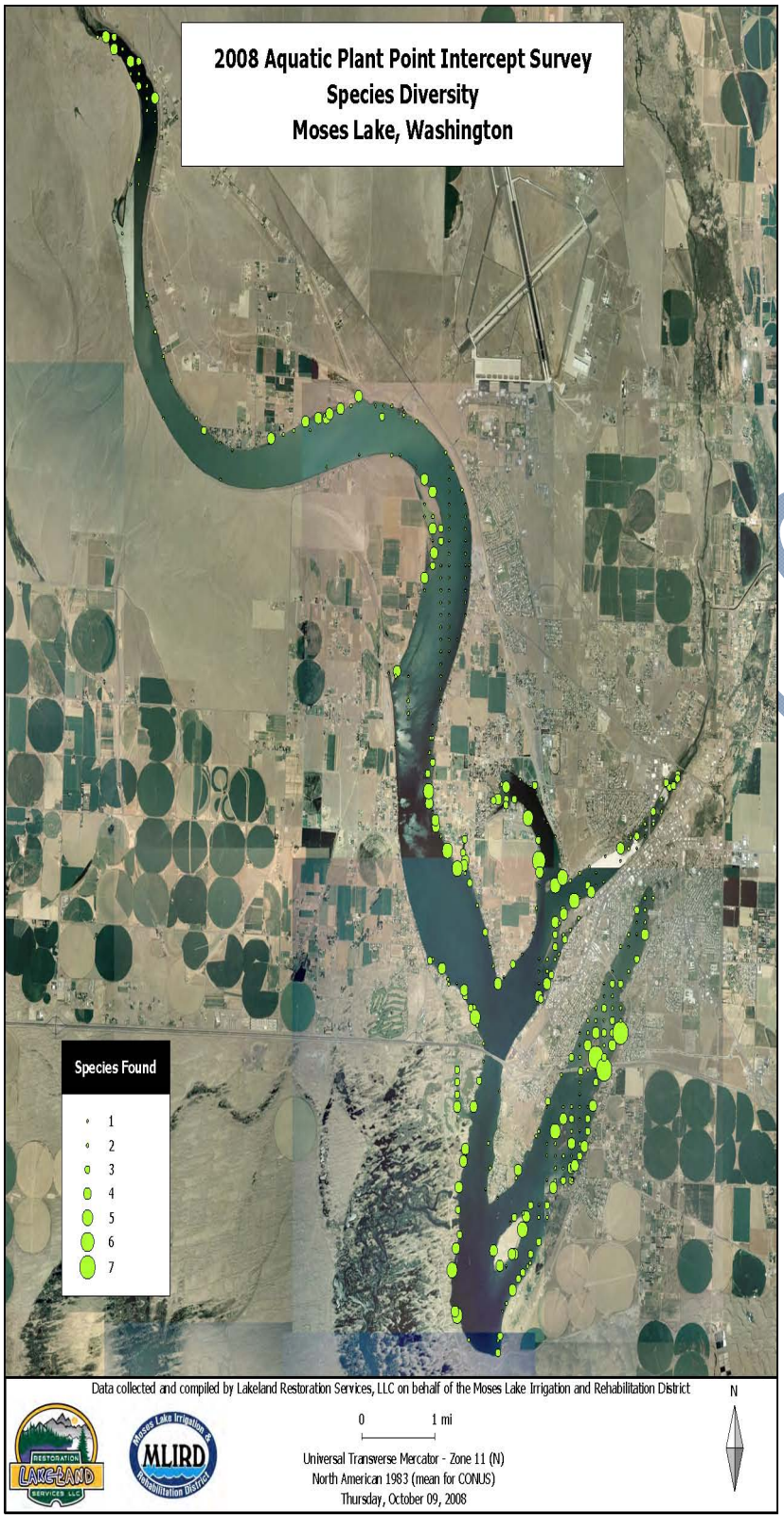

Figure 57. Species Diversity (Kluttz, 2008 survey)

These photos represent several of the diverse species in the Moses Lake waterbody.

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Terrestrial/Riparian Plants

Areas of high plant diversity are indicated on the map. It should be noted that the highest diversity of plant species are located in the Pelican Horn and in shallow water, 0'-10', figure 58.

Figure 58. Yellow Flag Iris (Kluttz, 2008 survey)

Yellow Flag Iris is found primarily in the southern sections of the waterbody with the greatest density in the southern main waterbody and Pelican Horn. The map indicates the various densities of plants found, figure 51.

Description: The plants are 4-6 ft. in height, and are spaced from about 36-48 in. apart. The plant is the only yellow iris specie found in the United States. The yellow flag iris has a robust stalk, and the plant has a long blooming season.

Impacts: Yellow-flag-iris is a fast growing and fast spreading weed. It creates thickets in water just like cattails.

Native Range/probable entry into N. America: It is native to Europe, British Isles, North Africa and the Mediterranean region; unfortunately yellow flag iris is sold over the internet on gardening web sites. Yellow-flag iris entered the U.S. from Canada as an ornamental plant in the early 1900's.

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Tree of Heaven was found at two locations in the Pelican Horn, figure 59.

Figure 59. Tree of Heaven (Kluttz, 2008 survey)

- Aggressive root growth – can spread long distances
- High evaporative transpiration rate
- Reproduces asexually and sexually

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It is noted on the map that Salt Cedar was found in one location on the waterbody, figure 60.

Figure 60. Salt Cedar (Kluttz, 2008 survey)

Salt Cedar

- Escaped ornamental tree
- Planted in semi-arid areas
- Prolific seed production
- High evaporative transpiration rate
- Can extract water from unsaturated soils which increases competitive ability
- Pulls salt out of the soil and concentrates it below the canopy

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Purple Loosestrife was found in low density and location along the shoreline, especially in the southern portion of the waterbody, figure 61.

Figure 61. Purple Loosestrife (Kluttz, 2008 survey)

Purple Loosestrife Origin:

L. salicaria, a plant of European origin, has spread and degraded temperate North American wetlands since the early nineteenth century. The plant was introduced both as a contaminant of European ship ballast and as medicinal herb for treatment of diarrhea, dysentery, bleeding, wounds, ulcers and sores.
Ecology: L. salicaria is a herbaceous, wetland perennial that grows in a wide range of habitats. Established plants can reach heights of 2m with 30-50 stems forming wide-topped crowns that dominate the herbaceous canopy. One mature plant can produce more than 2 million seeds annually. Seeds are easily dispersed by water and in mud adhered to aquatic wildlife, livestock and people. High temperatures (>20°C) and open, moist soils are required for successful germination and seedling densities can approach 10,000-20,000 plants/m^2. A woody rootstock serves as a storage organ, providing resources for growth in spring and regrowth if the above-ground shoots are cut or damaged.

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Map indicates density of the Russian Olive trees along the shoreline of the waterbody. Several areas indicate a high density of trees, figure 62.

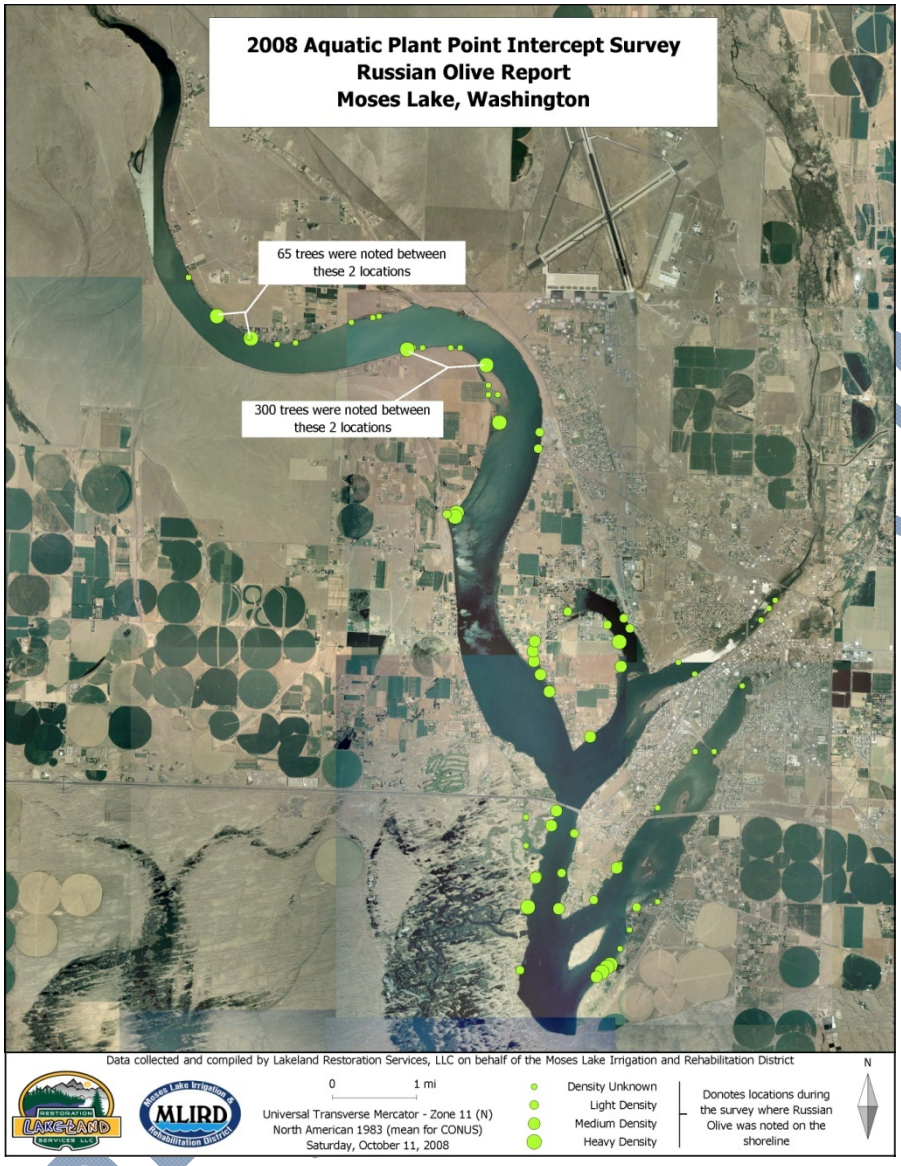

Figure 62. Russian Olive (Kluttz, 2008 survey)

The Russian Olive plants are vigorous growing plants that require little water to grow. These plants were brought to the Moses Lake area by cattlemen seeking quick shade and shelter for their livestock. The lake waterbody and wildlife have enabled the scattering of seed and infestation of large areas surrounding the lake shore. The olive trees have become a risk to the health of the lake.

Phragmities was located along the shoreline of Pelican Horn, south of I-90, figure 63.

Figure 63. Fragmites (Kluttz, 2008 survey)

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Phagmites photograph illustrating population density in wetland in Pelican Horn.

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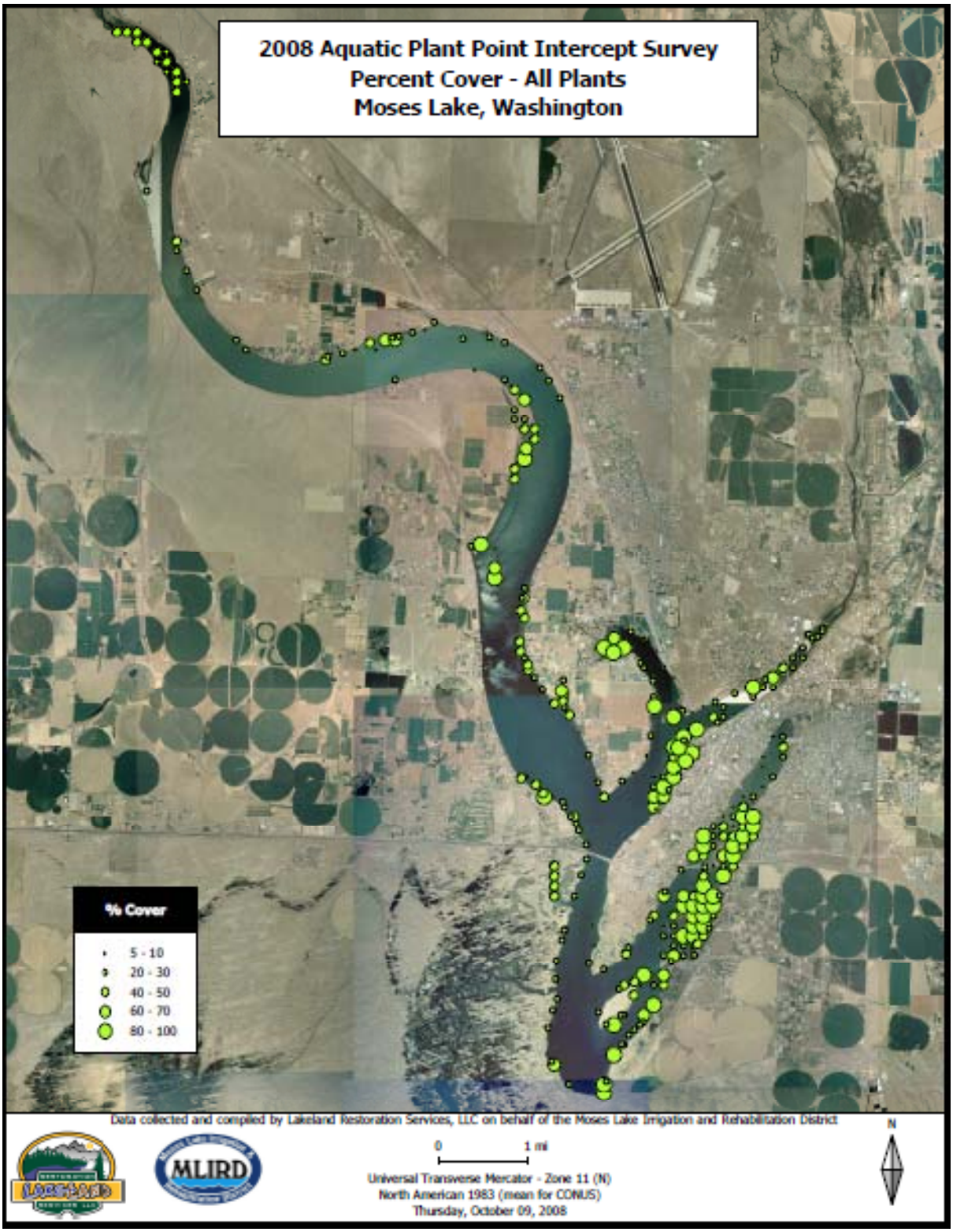

Figure 64. Percent coverage of all plants in Moses Lake (Kluttz, 2008 survey)

Figure 65, the native plant population illustrates where the vast number of native plants are located.

Figure 65. Native Plant Population (Kluttz, 2008 survey)

Aquatic Vegetation Survey Summary

- Littoral Zone: 10 feet or less with no milfoil growth at deeper areas.
- 60% of the lakebody is deeper than 10 feet which eliminates approximately 60% of the lake for plant presence and the need for treatment.

This map illustrates the extent of vegetation survey using GPS points to document the coverage of the waterbody and shorelines. All sites can be accurately revisited to determine the efficacy of treatment, figure 66.

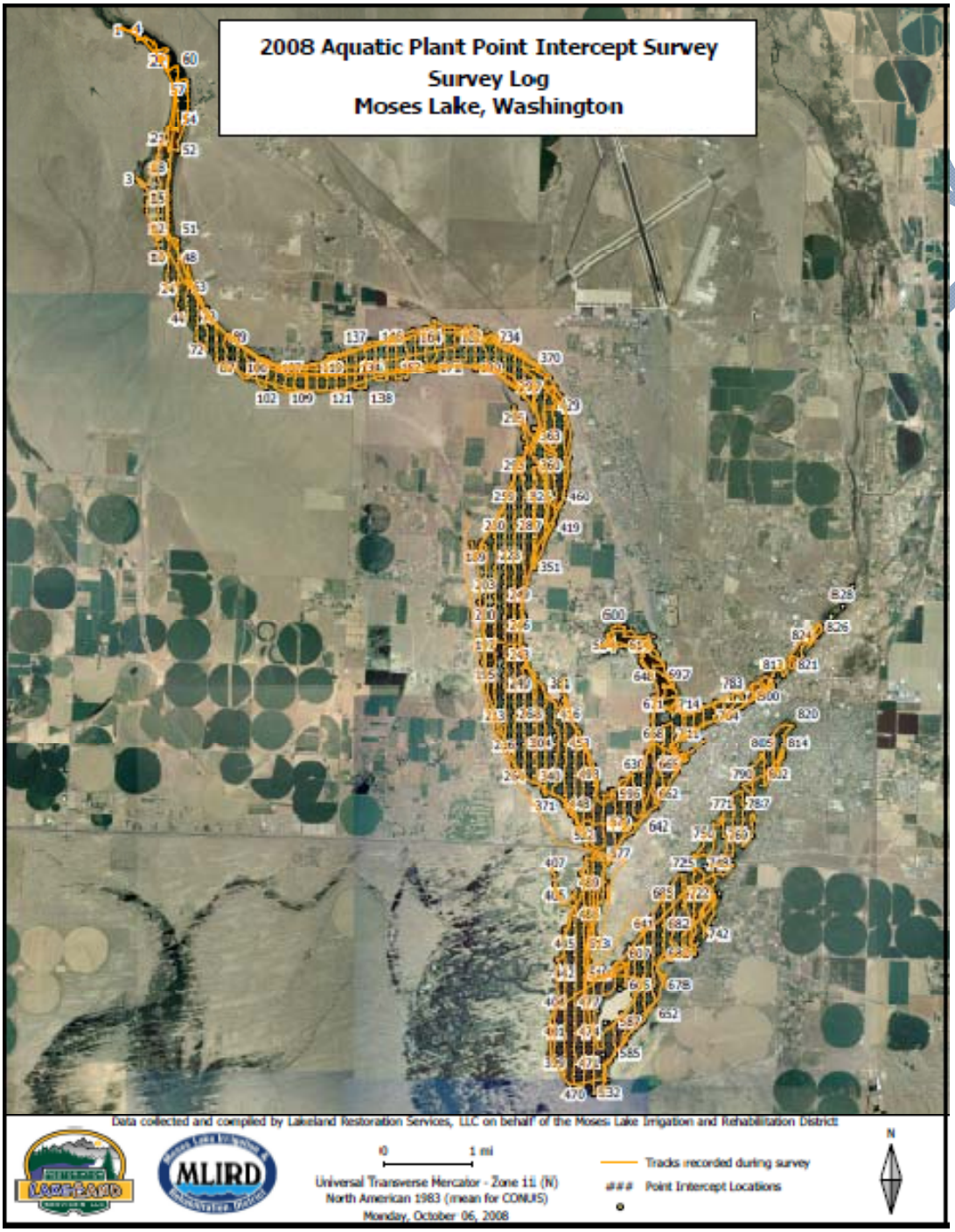

Figure 66. GPS location documentation (Kluttz, 2008 survey)

BATHYMETRY

This map clearly illustrates the depth throughout the lake. The littoral zone is shown in the zero to 10 foot depth range where the growing plant species are located.Figure 67.

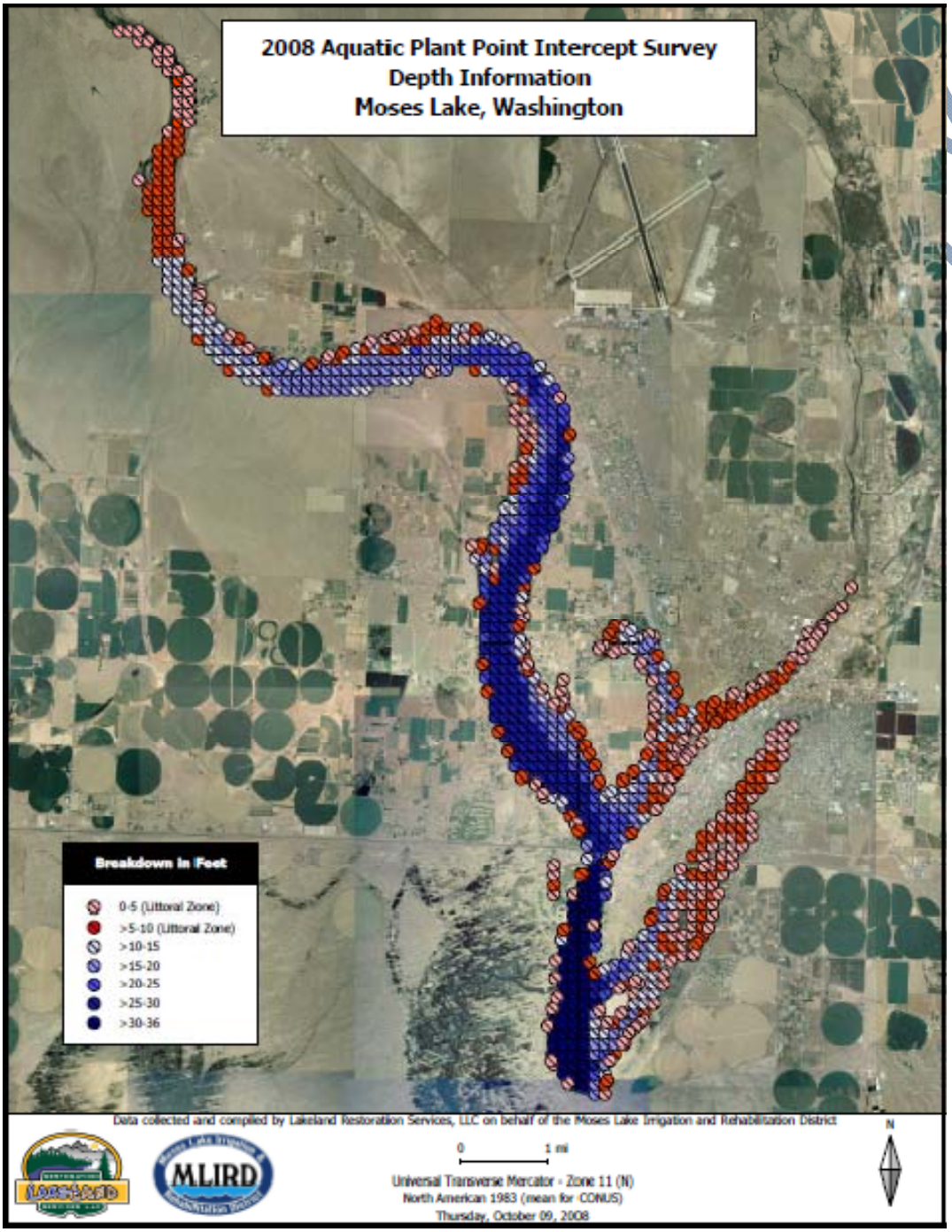

Figure 67. Waterbody Depth Information (Kluttz, 2008 survey)

Figure 68, illustrates the bathymetry of the bottom depths of the waterbody.

Figure 68. Waterbody bottom depth contour readings (Kluttz, 2008 survey)

Figure 69. Graphic waterbody bottom contour in multiple legend colors.

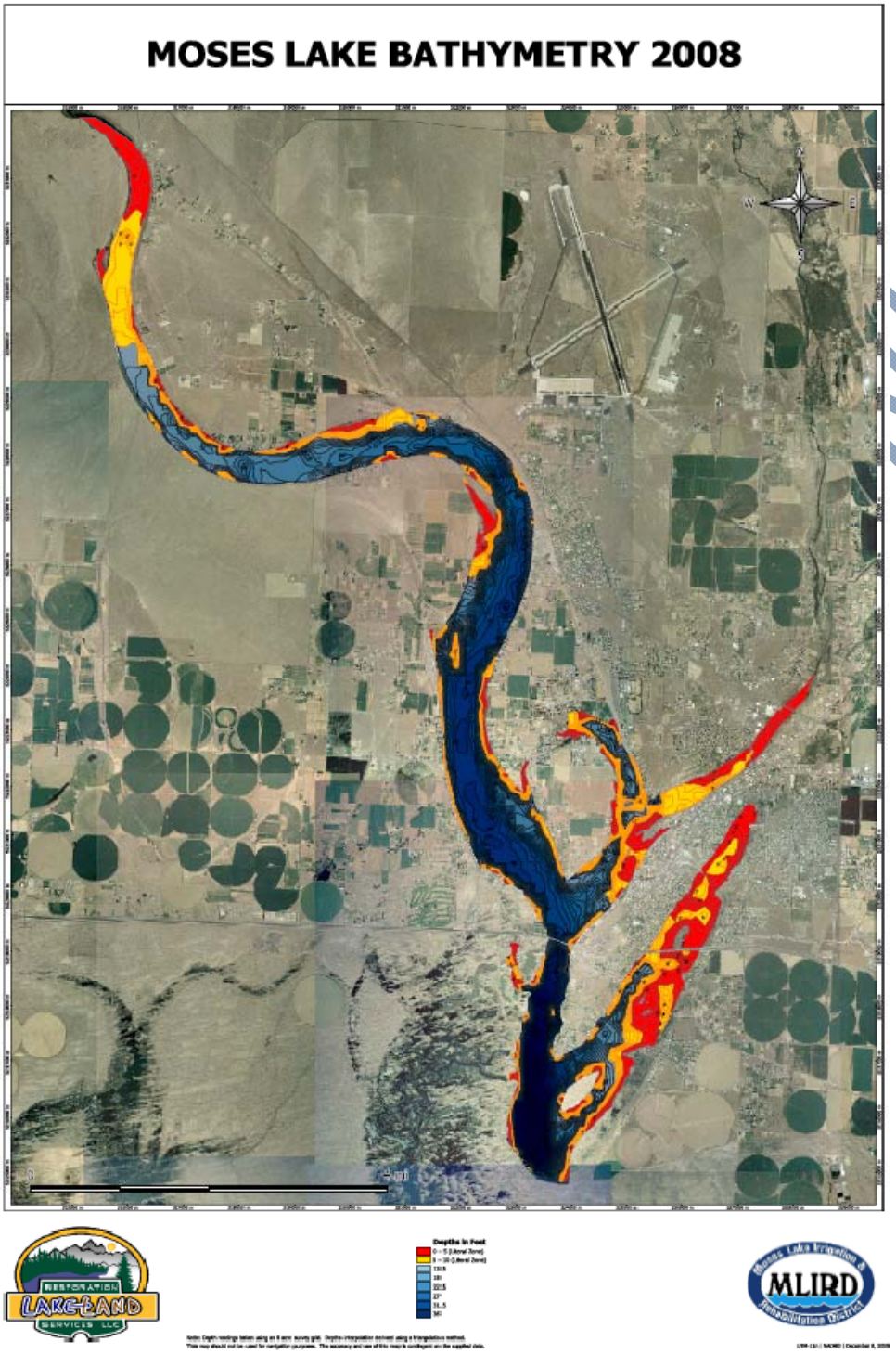

Figure 69. Graphic bathymetric recorded waterbody bottom depths (Kluttz, 2008 survey)

Integrated Vegetation Management Plan

Demonstration Project

The spring/summer of 2007 a project to test control of increased water flow through the lakebody during high temperature peaks to reduce waterbody temperature in order to affect eutrophic plant growth. The results were very favorable as the lakebody showed reduced eutrophic growth over past years with comparable air temperatures. The outcome of this project proved so positive that MLIRD will continue the practice of increased lakebody water flow during spring/summer.

Ecosystem-Wide Management Issues Moses Lake

Current ecosystem issues relate to the accumulation of sediment in the Rocky Ford and Crab Creek confluences, as agricultural erosion enters the watershed and are deposited behind Drumheller Dam reservoir as the water enters Moses Lake from Rocky Ford Creek. The sediment has accumulated behind Drumheller Dam to a point where it now flows over the dam and deposits in the confluence area of the lakebody. At the Crab Creek entrance there is heavy sedimentation due to the heavy flow from Crab Creek and agricultural erosion across the watershed.;

The accumulation of sediment reduces the volume of water in the reservoir and contains contaminants such as phosphates and nitrates which affect the water quality and the ecosystem of lakebody's vegetation succession. As the at risk plant vegetation increases in population, it consumes oxygen and nutrients from the lakebody negatively affecting the fish habitat and breeding practices.

Pelican Point, Cascade Marina, and Parker Horn wild life habitat enhancement areas will have the development of island wetlands as a part of this plan. Cascade Marina and across from Connelly Park are two areas that need to be developed for fisheries. The department of fish and wildlife has targeted these areas and will provide the lead to develop these areas in partnership cooperation with the Moses Lake Irrigation and Rehabilitation District the management plan.

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Another ecosystem concern is the Western Grebe nesting areas in the waterbody of Moses Lake. The nesting areas have been identified by the fish and wildlife personnel, and continue monitoring the Grebe. The Grebe constructs their nests on top of pondweed and/or milfoil so their nest is supported on top of the water by the vegetation. However, the boats passing near nesting may create enough water disturbances to break the nests loose causing them to float away from the original nest site by wind or other water disturbances. Commonly the grebe will not come back to tend that nest, resulting in loss of the hatch. With the successful elimination of the milfoil and pondweed, the Grebe will nest on other more stable floating vegetation and boating will be restricted from these areas during nesting times.

Shoreline Management Jurisdiction

Shoreline management will be the responsibility of the City of Moses Lake and Grant County, who is in the process of developing a shoreline management plan. The Moses Lake Irrigation and Rehabilitation District plan will support and work in cooperation with the City of Moses Lake and Grant County in the management of the shoreline.

The terrestrial/riparian plant vegetation has been identified, given location and populations by the Survey of the lakebody in 2008. The survey was completed by Lakeland Restoration and submitted to MLIRD by Dave Klutz. The survey and this plan submitted will provide means of controlling or eliminating riparian vegetation that is a risk to the waterbody of Moses Lake. The vegetation that is identified in the survey as a risk are; Yellow flagged Iris, Salt Cedar, Russian Olive and Atlantis (tree of heaven). These will be referred to the City of Moses Lake, Grant County, and Grant County Noxious Weed Board with treatment methods to control these threatening species of terrestrial/riparian vegetation.

The tree of heaven has been identified only in Pelican Horn, near the border of McCosh Park. See figure 59. Salt Cedar is on figure 60. Yellow Flag Iris is on figure 58. Phragmites is only found along the shoreline of Pelican Horn and is figure 63. Purple loosestrife is found on figure 61 and is located in inlets where minimal flow occurs. Russian Olive is found on figure 62 and infests many areas of the shoreline. It was introduced in the early years of Moses Lake by

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cattlemen to provide quick shade for their animals, and has since quickly spread its infestation along the shoreline areas. Russian Olive does threaten the life of the waterbody of Moses Lake.

Environmental Manipulation

The water flow through the waterbody of Moses Lake is controlled at the south end of the lake. Currently the MLIRD extends the time flow six weeks during spring season to help keep the lakebody temperature lower. This started in 2007. This keeps the flow time six weeks longer and therefore keeps the water temperature lower which shortens the plant growth season. Dredging will be a way to manipulate the ecosystem. Removal of sediment from specific permitted areas of the lakebody will indeed change the size of the reservoir and in deepening areas of the lakebody it will help control the spread EMF, enhance boating and recreational use, as well benefit the fish and fish brooding areas.

Reduce sources of nutrients to the waterbody

Currently the inflow is providing considerable phosphate and nitrate loading from both the Crab Creek and the Rocky Ford inlets. Each inflow presents some unique problems when considering reduction of phosphate and nitrate loading. The most common problem stems from phosphates and nitrates entering the creek in runoff and ground water from both residential and agricultural areas in the watershed. The most effective approach to this would be to limit the use of phosphate containing fertilizers and to adopt practices that prevent large runoff from irrigation. It is difficult to surround the problem of seasonal runoff due to snow melt or heavy rains.

Mechanical Control Methods

Hand Pulling

Hand pulling is not a viable option for the control of EMF and pond weed since the size of the waterbody and the numerous identified areas and dense infestations. This would be expensive require a large trained work force to accomplish this. Also any fragments of EMF that are broken loose during the hand pulling generate new growth and new areas of infestation. The turbidity of the waterbody is so poor that hand pulling would not be effectively used. This method is not appropriate for Moses Lake due the cost, water turbidity and the size of the infestation.

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Advantages of Hand Pulling

- Can be a very selective process
- Viable in very small infestation areas.

Disadvantages of Hand Pulling

- Very labor intensive.
- Special labor certification requirement therefore creates an expensive labor force.
- Potential for plant fragmentation and further infestation.
- A short-term solution.

Hand Pulling Costs

- $1200 - $1600 per day for two for divers and support boat and operator.
- Typical coverage range is from 400 – 2000 square feet per day.

Bottom Barriers

Bottom barriers may be synthetic (geo-textile) fabrics, burlap, sand gravel, polypropylene, synthetic rubber, polyethylene fiberglass screens and nylon film. The materials are used to cover lake sediments and existing plants to prevent plant growth in these areas. The method is a non-selective control which may eliminate plant vegetation necessary to support fish habitat. Even though this method is considered 100% effective, if installed and maintained properly, the size of Moses Lake's waterbody proves this too expensive. Yearly maintenance is required by a dive team to remove any sediment build up and/or replace barrier material.

The use of bottom barriers is a method that proves very expensive for a lake of this size and characteristics. The cost is at $100,000 per acre and the barriers must be serviced each year and require permitting. The high maintenance and the disturbance of fish habitat seriously limit the employment of bottom barriers. The limited possible areas may only be around boat docks and hard to access areas.

Advantages of Bottom Barrier

- No toxic chemicals
- Provides complete removal of plant vegetation, where placed.
- Easy to install in small dock areas or inlets.
- Not visible
- Some materials can be reclaimed for use.

Disadvantages of Bottom Barrier

- Very high cost for materials
- Excessive cost for diver labor
- High maintenance costs
- Not selective to vegetation

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- Permit restrictions impact use.
- May require removal too allow native plants to re-establish.

Bottom Barrier Costs

- $0.50 - $1.05 per square foot per year.
- $0.45- $0.75 per square foot for installation
- $0.35 - $0.60 per square foot to remove

Sediment Management

Glen Grette and Associates of Wenatchee are designing the dredging plan and taking care of the permitting (sedimentation report 2008).

The practice of dredging will be limited to specified areas (permitted). Specific sedimentation areas will be scheduled for dredging over a period of years, as per sediment plan. The objective is to remove inflow sediment accumulation to: 1) increase waterbody depth, 2) increase reservoir capacity, 3) increase flow to slow sediment accumulation, 4) establish lake habit areas for birds and other wildlife, 5) aid in water quality improvement of lake, 6) reduce opportunity for Eurasian watermilfoil growth, 7) aid in reduction of water temperature during warm season, and 8) reduce eutrophic algal accumulation and blooms.

Construct a sediment trap at the Crab Creek, Moses Lake waterbody confluence.

An alternative is dredging targeted areas which will not need chemical herbicide treatment or minimal spot treatment. Dredging will be used as specified by the sedimentation plan of Grette Associates, with maps and permitting.

Nuisance weed concentrations would be managed using a cutter-head hydraulic dredge on a floating barge. A cutter comprised of steel blades appropriate for the sediment type/consistency would be used to dislodge the weeds and sediments. The cutter-head would be mounted on a boom at the front of the barge and swung through the substrate to cut it. As the cutter head dislodged the sediment and weeds, a centrifugal pump would be used to "vacuum up" the slurry (sediment/water mix) and weeds, which would be piped to a dewatering site on land. Here, the water would be drained off and the sediment and weeds would be left to dry. Removing the

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plant fragments from the lake is a key advantage for control of undesirable weeds such as milfoil because it limits their spread to other parts of the waterbody.

During dredging, the barge would be stabilized through the use of spuds. After a cutter-head swing was completed, the dredge would "walk" forward, using the spuds.

Use of a hydraulic dredge is preferable for Moses Lake because hydraulic dredging is faster than mechanical dredging, creates less turbidity than wet mechanical dredging, and can effectively remove loose, watery sediments (greater than 70 percent water). Potential effects of turbidity would be further minimized through use of a pipeline to transport the slurry to an upland dewatering/disposal site. A cutter-head dredge in particular is proposed because these dredges are able to work where there is debris and weeds, and remove all aquatic weed parts and roots. The dredge operator is able to closely control the cutting depth to achieve target depths and species control. By controlling the target depth, weeds can be managed by dredging to certain depths where desired species would be preferred, or by dredging to depth to eliminate all aquatic growth depending on management objectives (Grette Sediment Plan, 2008).

Over 200,000 cubic yards of sediment transported from the Crab Creek water shed and Columbia Basin irrigation feed water.

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Figure 70. Launching dredge

The sediment plan will be phased in based on specific priorities: priority one is to dredge the in-flows of Crab Creek. Parker Horn (confluence of Crab Creek) has a water feature located at a site just west of the "Alder Street fill" highway crossing. The water feature has lost much of its effectiveness due to the accumulated sediment. Simultaneously with the removal of the sediment from Parker Horn part of the sediments will be used to develop wetland islands to enhance wildlife habitat.

Priority two: Rocky Ford Creek inflows have a recent accumulation of sediment in the most northerly tip of the Moses Lake water body. Presently the water is less than five feet deep due to the sediments. The area could be used for boating and fishing subsequent to sediment removal.

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Priority three: Montlake area water body. When culverts were initially installed under interstate 90 the bottom of the culverts were twelve feet above lake bottom, today the top of the culverts are at the same level as the lake bottom as a result of waterbody sedimentation. The plan is to remove the area sediments back to the original level to increase water flow from Montlake to Pelican Horn.

Please to the Moses Lake Sediment Management Plan prepared for MLIRD by Grette Associates, October 2008. Each phase will be project specific and implemented as resources and time permits. Listed in the report are several projects that will enhance the removal of Eurasian Milfoil, increase fishing habitat, enhance boating and increase the available volume of water in Moses Lake.

Advantages of Sediment Removal and Habitat Renewal

- Removal of nutrient rich sediments.
- Fines deposited from irrigation flow.
- Re-establishes water depth at targeted sedimentation areas (below littoral zone).
- Increases the volume of the reservoir.
- Enhances fish rearing area (exposes cobble)
- Long term lake enhancement.

Disadvantages of Sediment Removal

- Operation costs are typically expensive and labor intensive.
- Potential for short-term turbidity.
- Permitting requirements

Cost of Sediment Control

Capital Costs

- Equipment purchase (dredge) $260,000
- Upgrade dredge $40,000
- Piping network for sediment removal $40,000
- Support barge $30,000

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- Support equipment $360,000 (equipment is used for other district projects)

Project Parker Horn Specific Costs

- Fuel cost $22,000
- Cubic yards to be removed, Parker Horn project 200,000
- Handling lake sediment to dewatering area $80,000 (6200 gallons @ $3.50/gal)
- Transporting dewatered sediments $150,000
- Wildlife habitat restoration to be determined

Costs for Future Projects

- Project by project costs to be determined
    - Wildlife habitat restoration
    - Rocky Ford Creek
    - Montlake/Pelican Horn

Harvesting

A harvester is the basic machine built on stainless pontoons with cycle/mower as a cutting bar with a series of conveyors to transport cut material from the cycle to the hopper for later transport onshore off-load sites by way of a conveyer to trailer. The material is then transported to composting site. This process involves two harvesters, one being a model 250 having a 5 foot cutting head and a model 450 has an 8 foot cutting head.

Typically the harvesters are used for three months each year to maintain the growth of the Eurasian watermilfoil. The harvesters are operated on an 8 hour schedule or less due to weather, environmental and/or mechanical conditions. The fuel, fluids, and grease are all biodegradable marine grade. The harvesters are equipped with GPS units to give location sites where they operate to provide data as management tool.

Mechanical harvesting will continue as a practice to maintain areas of active vegetation growth and will be included in the integrated aquatic vegetation plan. The harvesting will continue this maintenance of the lake both pre-aquatic herbicide treatment and post-aquatic herbicide

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treatment of lake areas of warranted need. Currently the harvesters operate on a scheduled plan to cover the entire lake areas where Eurasian watermilfoil, along with many other vegetative species are established. Harvesting could become a much more selective process, once the integrated aquatic vegetation, management plan is established and the aquatic vegetation becomes manageable. Harvesting could be used more as an administrative tool, rather than a maintenance tool, etc helping to maintain shoreline habitat and removal of undesirable floating bio-mass.

Advantages of Mechanical Harvesting

- Control open water pathways for boating.
- Immediate of removal of plants.
- Minimal bottom disturbance.
- Harvested plants can be used as compost.
- No chemicals added to the lake.

Disadvantages of Mechanical Harvesting

- Labor and equipment intensive, involves plant cutting and handling of plant material.
- Requires repeat cutting during the season.
- Non-selective and could destroy non-target plants.
- Slow process.
- High cost for machines, maintenance and operator.
- Creates fragments which have potential to spread and re-establish

Cost of Mechanical Harvesting

- $700 - $800 per acre.
- $180,000 capital purchase of the harvester.
- $30.00 - $40.00 per cubic yard for handling plant disposal.

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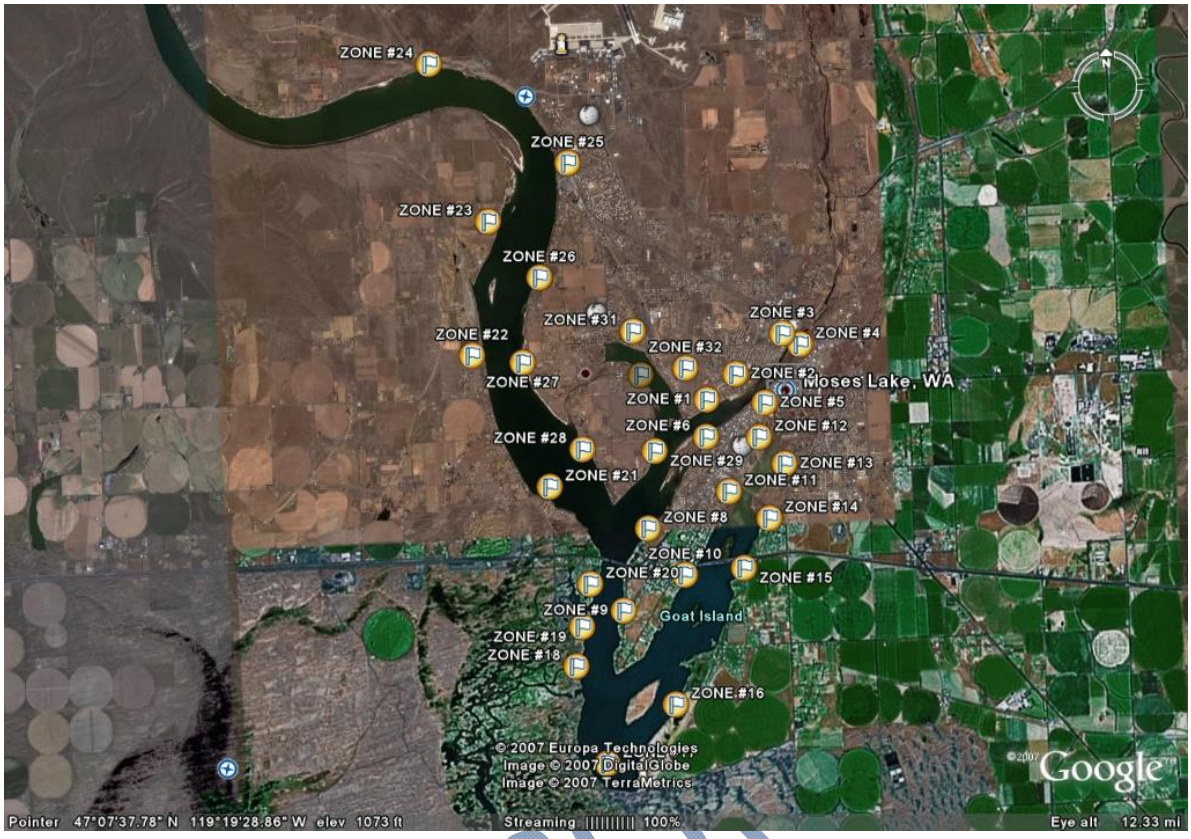

Figure 71 Harvest Map 2007 (zones prior to survey)

Water Features

The lake has one water feature located in Parker Horn, west of the Alder Street lake crossing. The feature was placed at this site for aesthetic value and in the spirit of friendship of Japan Airlines with the community of Moses Lake. However, during the lake survey completed in 2008, it was observed that the area surrounding the water feature was; 1) higher in dissolved oxygen, 2) exhibited better water clarity, 3) no signs of algal growth,4) increased water flow, and 5) absence of Eurasian watermilfoil 6) the most diverse desirable aquatic vegetative environment was observed surrounding the water feature..

By increasing the number of water features in a heavily impacted areas or areas, a much larger area of the lake could be aided. The water features that would not only provide improved aesthetics for the lake, but would serve in lake water quality improvement. Once again, the cost of selecting, purchasing, installing, and maintaining the water features would be of concern and would require priority ranking.

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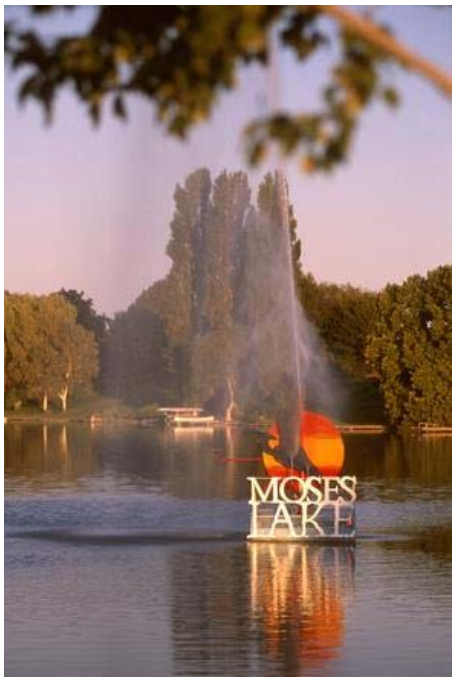

Water Feature, west of Alder Street Lake Crossing

Advantages of Water Features

- Assists in local aeration and oxygenation.
- Greater water clarity in the area
- Reduces algal growth in the area

Disadvantages of Water Features

- Capital cost of water feature
- Installation cost.
- Maintenance cost

Water Feature Costs

- Purchase price $35,000 - $85,000 depending on design and capacity (amortization over 5 year life expectancy $10,000/year)
- Installation cost varies, depending upon complexity system
- Cleaning, filters, and servicing $7,000 - $10,000 for 1 unit. (additional units reduce cost per unit)

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Water Level Drawdown

Historically the waterbody is drawn down in November of each year to maintain a level with the southern water body behind O'Sullivan Dam. The water was often drawn down at a rate of 800 cubic feet per second. This rate of draw down did not maintain an adequate flow of water to cause water temperature to lower significantly, so in 2007 a program was initiated to keep the water flow at 2800 cubic feet per second which significantly kept the water temperatures lower for a longer period of time. With the lower water temperatures the plant growing season is reduced and therefore the lake has fewer problematic plants to contend with. The reason for the drawdown is two-fold; 1) maintain level with the south reservoir and 2) to have adequate space for flood control.

Hand Cutting

This technique involves cutting of plants below the water surface, however the roots are often not removed. Tools for cutting include scythes, rakes, thin wire cables or other specialized devices which can be towed through the weed beds by boat or by a vehicle on shore. A popular device is two single-sided stainless steel blades forming a "V" shape for cutting and is connected to a four foot handle and tied to a rope.

Hand cutting is not a viable option for use in Moses Lake, since the District already owns and operates two harvesting machines, which are much more efficient in cutting and handling the large amounts of aquatic vegetative growth that infests the large waterbody of Moses Lake.

Advantages of Hand Cutting:

- Ability to remove nuisance submerged vegetation immediately
- Equipment costs are minimal
- Repetition of hand cutting will be performed throughout the growing season.

Disadvantages of Hand Cutting:

- Highly labor intensive
- Not species specific

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- Disturbs waterbody and creates turbidity and visibility problems.
- A short-term method of plant control, requiring multiple times a growing season.
- Difficult to contain and handle plant material as well as floating plant fragments.

Rotovation

Under water cultivation or rotovation is a concept of non-specific aquatic plant control providing a longer term control of some aquatic plants. This method can remove plants to greater depths (approximately 12 feet) as these underwater rototillers churn the bottom sediments to a depth of 12 inches. The action tills up plants and root crowns embedded in the bottom sediment.

As plant material comes to the surface, it must be collected, and removed. Rotovation should not be considered in lake or river systems where plants are in the pioneering stages of an infestation and/or spread by fragmentation. This technique is not expected to control non-rooted plants such as Coontail (Ceratophyllum demersum).

This method is not an option for use in the large rocky bottomed waterbody of Moses Lake, as it would be too expensive and too damaging to the fish and wildlife habit.

Advantages of Rotovation:

- Technique removes plant and roots.
- Longer effectiveness than Hand Cutting or Harvesting.
- Successive treatments tend to reduce aquatic plant density.

Disadvantages of Rotovation:

- Difficult or not possible to collect all the plants and fragments which are tilled up.
- Damages bottom habitat and fish spawning areas.
- Increases turbidity with potential release of nutrients.

Cost of Rotovating:

- **$1500 – $2800 per acre**

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Diver Directed Suction Removal

A technique of diver suction hand removal has been employed where sparse colonies of milfoil exist. The technique employs a small barge or boat loaded with portable suction pumps and hoses directed by SCUBA divers. Divers use the suction hoses to dislodge plant and root system from the bottom sediment, vacuuming the material back to the barge. After screening the water and sediment back into the water, the plant parts are then taken to land for proper disposal.

Diver suction removal can be highly effective under appropriate conditions. Efficiency of removal is dependent on sediment condition, plant size and density, and underwater visibility. It is most effective for small localized infestations of low plant density, where plant fragmentation must be minimized. This technique also allows the diver to target specific species within a mixed population area.

An environmental issue with diver suction removal is turbidity and nutrient release from the sediments. Light, organic sediments which often settle out in heavy weed beds are most desirable for this method. Divers typically attempt to prevent suction intake from disturbing sediment materials. Sediment curtains can be used to minimize drift of sediment materials and escape of plant fragments. There is no way of controlling the release of nutrients during the employment of diver suction.

Diver operated suction does not have applicability at Moses Lake's waterbody as it is too expensive for the large area and dense populations of milfoil above the littoral zone. This technique is far too expensive to employ in the large rocky waterbody of Moses Lake. Therefore this technique is not included in the integrated aquatic vegetation plan.

Advantages of Diver Suction Removal:

- It is species selective and site-specific.
- Minimal disruption of sediments and habitat in preferred target areas.

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- Minimal release of plant fragments.
- Effective in areas difficult to enter because of obstacles or deep water.
- Effective in large areas where there is very light plant growth.

Disadvantages of Diver Suction Removal:

- Expensive and labor intensive
- Not appropriate for large waterbody or dense plant infestations.
- Short term turbidity
- Potential release of nutrients from disturbed sediments.
- Rocky or gravelly bottoms prevent removal of all root fragments.

Cost of Diver Suction Removal

- $1500 -$2400 a day for two divers and support boat
- Typical coverage is from 0.25 to 1.0 acre per day

Water Column Dyes

Dark colored dyes are added to the lakebody attempting to suppress aquatic growth by shading vegetation or algae from sunlight. The dyes can be a blend of blue and yellow to absorb part of the visible light spectrum that plants use to promote photosynthesis by submersed plants and algal cells. The use of dyes apparently is most effective at depths of two feet or more. Use of this technique is limited to lakes or ponds which have minimal dilution with clear water and no outflow.

This technique is not viable for use in Moses Lake, (a reservoir) since there is dilution with clear water as the flow passes through from Crab Creek, and Rocky Ford Creek to O'Sullivan Dam. This technique will not be a part of the options to use in the IAVMP for Moses Lake waterbody.

Advantages of Water Column Dyes:

- Potential to control both aquatic plants and algae.
- Water use restrictions not required.

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- Treatment will not harm fish, wildlife or pets.
- No special equipment or applicator certification required.

Disadvantages of Water Column Dyes:

- Not species specific (can affect all aquatic plants and algae)
- Not effective to plants or algae near the surface.
- Dilution from inflow sources would reduce effectiveness and need frequent reapplication.
- Dyes may not be allowed due outflow and domestic water rights.

Cost for Water Column Dyes

- $12.00 to $15.00 per acre foot for materials.

Biological Control Methods

The control of aquatic vegetation through the means of biological organism is a technique that has an impact on the growth of a target plant. This technique is expensive and must be considered only a backup technique to be employed when other planned techniques fail to control target plant populations. Many of the biological control techniques have not yet proven to have scientific data to support their use on a large scale. Some success has been reported with the use of some organisms in the control of aquatic weeds. Also there have been some undesirable effects from the introduction of some biological controls.

Biological control agents are often of two types. There are general agents like grass carp that will consume most aquatic vegetation. As such, they are of limited use when trying to target specific plants. The second types of "biocontrol" agents are those that are target-specific for problematic plant species. Typically research focuses upon the area of the world where the plants have come from and then researches the organisms that keep the plant species in check. Organisms identified are brought through quarantine protocol into this country for further research to determine if there is the potential for control desired. Currently there are no other biological agents in the State of Washington which are considered effective against Milfoil, other than grass carp, and recently the Milfoil Weevil.

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Developing Techniques

There are a number of techniques under investigation as proposed control agents; primarily biological agents. Included are plant pathogens, herbivorous insects, competitive plants and plant growth regulators. Research with these agents has a primary focus on noxious submersed plants such as Eurasian watermilfoil and hydrilla.

Grass Carp

Grass carp (or White Amur) are plant consuming fish native to China and Siberia. These fish eat a large variety of aquatic plants, but have very definite feeding preferences. Stocking rates are dependent upon climate, water temperature, type and extent of plant species and other site-specific conditions. It is recommended that 25 fish per acre by (Bonar et al. 1996) and 9 fish per acre by (Hamel 2002) be the guide to follow. Apparently the grass carp used in Washington have had either minimal effect or have consumed all aquatic vegetation.

It is necessary to periodically restock fish lost to predation or disease, and to maintain a strong population of young fish with active appetites. Only triploid (sterile) fish can be planted in Washington and only by permit. Grass carp must be imported by approved suppliers who certify the fish to be disease and Zebra mussel free and sterile. The body of water must have all inlets and outlets screened off and approved by WDFW biologists prior to stocking.

Water quality is seen to generally improve following introduction of grass carp; with the elimination of large mats of vegetation, bottom dissolved oxygen levels generally increase from levels lethal to fish and pH generally decreases with decreases in photosynthesis **(WDFW)**. Water turbidity does increase where grass carp stir up the bottom sediments. Effectiveness of grass carp depends upon feeding preferences and fish metabolism which vary from region to region. Some preferred plant species appear to be pondweed species, Coontail, and Elodea. Plant control effectiveness is site specific and significant control of vegetation may not be apparent until two to four years following introduction.

Grass carp are not a viable option for the control of Milfoil in Moses Lake for a number of reasons: 1) the lake has a population of sport fish which promotes heavy fishing activity; 2) not a

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proven control for Milfoil which is a targeted plant in Moses Lake; 3) turbidity is already a concern and grass carp would add to the issue; 4) may destroy plants which support fish brooding and habitat areas.

Grass carp will not be included as an option in the Moses Lake Integrated Vegetation Management Plan.

Advantages of Grass Carp:

- Non-toxic

Disadvantages of Grass Carp:

- Not known to control Milfoil which is problematic in Moses Lake
- Possibly destroy submersed aquatic plants and increase algal problems.
- Possibly damage native fish habitat
- Inlet, outlet screens must be constructed and must allow passage of native salmonid fishes.
- Potential for carp to cause increased turbidity while foraging by disturbing bottom sediment.

Cost of Grass Carp:

- $12.00 to $18.00 per fish (plus delivery)
- Stocking rate is 9-15 fish per acre
- Installation cost of effective inlet and outlet screens. (cost site specific)

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Milfoil Weevils

The following description is taken from the website of the Washington Cooperative Fish & Wildlife Research Unit.
(http://depts.washington.edu/wacfwru/recent/Weevil_Life_History.shtml)

Eurasian watermilfoil (Myriophyllum spicatum) is an aquatic plant native to Europe, Asia and northern Africa. This plant was introduced into North America in the 1940's and has spread rapidly across the United States and Canada. In Washington State, Eurasian watermilfoil is present in over 100 lakes and rivers, particularly along the Columbia and Okanogan Rivers and the Interstate 5 corridor. Eurasian watermilfoil has become a nuisance in many lakes and rivers. The plant reproduces quickly and can spread easily into new locations through fragmentation. In addition, it can create dense mats that can interfere with water circulation, increase the rate of lake sedimentation, change water chemistry, displace native plants, and create aquatic habitats that may be unsuitable for fish and invertebrates. Eurasian watermilfoil can also hinder boating, swimming and fishing and is considered by many property owners as undesirable.

Several methods are being used in Washington State to control Eurasian watermilfoil. These include mechanical harvesting, chemical treatment and biological control (grass carp). Since 1996, we have been evaluating the milfoil weevil Euhrychiopsis lecontei as a potential biological control. This weevil has been associated with declines of Eurasian watermilfoil in the United States (e.g. Vermont, Minnesota, Wisconsin). Studies in Vermont found that both adults and larvae negatively impact Eurasian watermilfoil by reducing its biomass and causing the plant to lose buoyancy and collapse. Furthermore, research in Minnesota has shown that the weevil is a watermilfoil specialist. Surveys conducted in Washington in 1993 indicated that the weevil was present in the state. During 1996-1997, we conducted a comprehensive survey of 50 waterbodies in Washington to determine 1) the weevil's distribution and 2) environmental factors related to that distribution. Overall, including the 1993 results, weevils were found in 21 lakes and rivers; two of which were in western Washington (Lake Meridian and Sawyer Lake, King County) and the remainder in eastern Washington. Weevils were associated with both Eurasian and northern watermilfoil (M. sibiricum). The water quality data collected in 1996 and 1997, suggested that in Washington the weevil was primarily present in waterbodies with pH >= 8.2 and specific conductance >= 0.2 mS cm-1 (i.e., hard-water lakes and rivers). Furthermore, we found that weevil presence was correlated with waterbody location (eastern versus western Washington) and surface water temperature (Logistic regression: Chi-square=24.3, P<=0.001).

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Currently our evaluation has focused on 1) estimating weevil abundance in 13 lakes, 2) characterizing the weevil's terrestrial and aquatic habitat, 3) comparing the weevil's developmental performance (egg to adult development) among watermilfoil plants (Eurasian and northern) from different lakes, and 4) developing criteria for selecting lakes that may be suitable for weevil treatments. To date, our abundance estimates range from undetectable levels to 0.6 weevils (eggs, larvae, and adults) per stem. In addition, we are currently processing and analyzing data collected in 1999 and 2000 in order to characterize the weevil's habitat, compare the weevil's developmental performance, and develop guidelines for selecting potential weevil treatment lakes.

In Washington State, the milfoil weevil is present primarily in eastern Washington (including Fan and Sacheen Lakes) and occurs on both Milfoil and northern watermilfoil (M. sibiricum), which is native to the State (Tamayo et. Al. 1999) During the summer of 1999, researchers from the University of Washington determined the abundance of the Milfoil weevil in 11 lakes in Washington. They found that weevil abundance ranged from undetectable levels to 0.3 weevils (adults and larvae) per stem. Fan Lake, Pend Oreille County has the greatest density per stem as 0.6 weevils)adults, larvae and eggs per stem) although the weevils there were present on northern watermilfoil not Milfoil. These abundance results are well below the recommendation made by other researchers in Minnesota, Ohio, Vermont and Wisconsin of having at least 1.5-2.0 weevils per stem in order to control milfoil.

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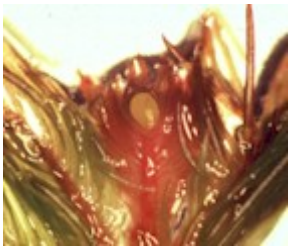
Milfoil Weevil

Eurasian Milfoil



Weevil eggs and larvae

Research information does not support the use of weevils in the State of Washington as a viable alternative for the control of Milfoil. Moses Lake waterbody contains populations of spiny rays, which are known to feed on weevils. The lake is a reservoir with water flowing through the lake and would not be able to contain the weevils. The Moses Lake Integrated Aquatic Vegetation Management Plan will not include Milfoil Weevils as treatment option.

Advantages of Milfoil Weevil:

- Non-toxic
- Potential long-term effectiveness

Disadvantages of weevils:

- Weevils may not control Milfoil in lakes with populations of native watermilfoil.
- Weevil densities may be reduced below effective levels due to predation by sunfish and other environmental factors.

Cost of Milfoil weevils:

- Milfoil weevils currently cost in excess of $1.00 each from commercial producers.

Chemical Control Methods

One of the leading methods of effectively controlling, eliminating noxious aquatic plant growth is the use of chemical herbicides. The herbicides which are approved for aquatic use by the US EPA are well reviewed and considered compatible with the aquatic environment when used according to label directions. In addition to the review and regulations provided by the EPA, the Washington Department of Ecology completed an Environment Impact Statement (EIS) in 1992 for the aquatic plant management program which allows for the introduction of a number of compounds into state waters. This EIS was recently updated by WDOE and information contained in the Supplemental EIS documents **(WDOE 2001c, 2003)** has been used in the preparation of this IAVMP. Note that the application of chemicals for aquatic pest control can only be performed by a licensed pesticide applicator with an aquatics endorsement.

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There are two general types of aquatic herbicides in use; referred to as "contact" and "systemic" products. Contact herbicides kill susceptible plant leaves and stems, generally leaving roots and some reproductive structures alive and capable of regrowth. As such, a contact herbicide is generally considered a maintenance tool, one that can provide relief from aquatic plant problems, but not something that can eliminate the problem from the lake system. Systemic herbicides are absorbed and carried throughout the plant structural system, thereby making them capable of killing the entire plant.

Aquatic Herbicides *(the following excerpt is taken from the Dept of Ecology web page 4/30/2009)*
www.ecywa.gov/programs/wq/plants/management/aqua028.html

Ecology currently issues permits for seven aquatic herbicides and two algaecides (as of 2006 treatment season) for aquatic plant treatment for lakes, rivers, and streams. Plant control in irrigation canals is covered under another permit. The chemicals that are permitted for use in 2006 under the Aquatic Plant and Algae Control Permit and the Noxious Weed Permit are:

Glyphosate

Trade names for aquatic products with glyphosate as the active ingredient include Rodeo®, AquaMaster®, and AquaPro®. This systemic broad spectrum herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife. It is generally applied as a liquid to the leaves. Glyphosate does not work on underwater plants such as Eurasian watermilfoil. Although glyphosate is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants can take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

Fluridone

Trade names for fluridone products include Sonar® and Whitecap®. Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where

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there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose. When used to manage Eurasian watermilfoil in Washington, fluridone is applied several times during the spring/summer to maintain a low, but consistent concentration in the water. Granular formulations of fluridone are proving to be effective when treating areas of higher water exchange or when applicators need to maintain low levels over long time periods. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

2,4-D

There are two formulations of 2,4-D approved for aquatic use. The granular formulation contains the low-volatile butoxy-ethyl-ester formulation of 2,4-D (Trade names include AquaKleen® and Navigate®). The liquid formulation contains the dimethylamine salt of 2,4-D (Trade names include DMA*4IVM). 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species. Both the granular and liquid formulations can be effective for spot treatment of Eurasian watermilfoil. 2,4-D has been shown to be selective to Eurasian watermilfoil when used at the labeled rate, leaving native aquatic species relatively unaffected.). By court-order the butoxy-ethyl-ester formulation of 2,4-D cannot be used in waters with threatened and endangered salmon-bearing waters in the Pacific Northwest.

Endothall

A trade name for the dipotassium salt of endothall is Aquathol®. Endothall is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but generally does not kill the roots. Endothall may be applied in a granular or liquid form. Typically endothall compounds are used primarily for short term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, endothall can be used to selectively remove exotic weeds; leaving some native

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species unaffected. Because it is fast acting, endothall can be used to treat smaller areas effectively. Endothall is not effective in controlling Canadian waterweed (*Elodea 145rogram145en*) or Brazilian elodea.

Diquat

A trade name for diquat is Reward®. Diquat is a fast-acting non-selective contact herbicide which destroys the vegetative part of the plant but does not kill the roots. It is applied as a liquid. Typically diquat is used primarily for short term (one season) control of a variety of submersed aquatic plants. It is very fast-acting and is suitable for spot treatment. However, turbid water or dense algal blooms can interfere with its effectiveness. Diquat was allowed for use in Washington in 2003 and Ecology collected information about its efficacy against Brazilian elodea in 2003. A littoral zone treatment in Battle Ground Lake in Clark County Washington in 2003 resulted in nearly complete removal of Brazilian elodea in that water body.

Triclopyr-TEA

A trade name for triclopyr is Renovate3®. There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. Triclopyr can be effective for spot treatment of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate. Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. When applied directly to water, Ecology has imposed a 12-hour swimming restriction to minimize eye irritation. Triclopyr received its aquatic registration from EPA in 2003 and was allowed for use in Washington in 2004.

Imazapyr

A trade name for imazapyr is Habitat®. This systemic broad spectrum, slow-acting herbicide, applied as a liquid, is used to control emergent plants like spartina, reed canarygrass, and phragmites and floating-leaved plants like water lilies. Imazapyr does not work on underwater plants such as Eurasian watermilfoil. Although imazapyr is a broad spectrum, non-selective

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herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Imazapyr was allowed for use in Washington in 2004.

Adjuvants

There are a number of adjuvants (surfactants, stickers, sinking agents) allowed for use under the NPDES permits.

Algaecides

Endothall – Amine Salt

A trade name for the amine formulation of endothall is Hydrothol 191®. Hydrothol 191® is a rapidly acting non-selective contact herbicide or algaecide. In Washington Hydrothol 191® may only be used at very low concentrations for filamentous algae control or cyanobacteria control (blue-green algae) in selected waterbodies. Several treatments each season may be needed to control algae/cyanobacteria. Hydrothol 191® has a high acute toxicity to fish and must be used with extreme care. Because of fish impacts, Ecology does not allow concentrations higher than 0.2mg a.e./L of Hydrothol 191®. Unlike copper compounds that are also used for algae control, Hydrothol 191® does not accumulate in sediments and breaks down rapidly. There are water use restrictions associated with the use of Hydrothol 191® in Washington.

Peroxygen-based Granular Algaecide

Trade names include GreenClean® and Pak27®. These are peroxygen-based granular algaecides used for the prevention and control of algae in ponds, streams, irrigation systems, ornamental pools, and fountains. Areas being treated with these products must be closed to recreational activities during and for two-hours after treatment.

Copper Compounds

Copper compounds are no longer allowed for aquatic use in Washington state waters except under the NPDES permit for Irrigation Districts.

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Advantages

- Aquatic herbicide application can be less expensive than other aquatic plant control methods, especially when used in controlling wide-spread infestations of state-listed noxious aquatic weeds.
- Aquatic herbicides are easily applied around docks and underwater obstructions.
- Washington has had some success in eradicating Eurasian watermilfoil, a state listed noxious weed, from some smaller lakes (350 acres or less) using aquatic herbicides.

Disadvantages

- Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions (check the label and general permit).
- Herbicide use may have unwanted impacts to people who use the water and to the environment.
- Non-targeted plants as well as nuisance plants may be controlled or killed by some herbicides.
- Depending on the herbicide used, it may take several days to weeks or several treatments during a growing season before the herbicide controls or kills treated plants.
- Rapid-acting herbicides like endothall and diquat may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills.
- To be most effective, generally herbicides must be applied to rapidly-growing plants, although sometimes fall applications of perennial plants can also be effective..
- Some expertise in using herbicides is necessary in order to be successful and to avoid unwanted impacts.
- Many people have strong feelings against using chemicals in water. Find out what your neighbors think about chemical use before deciding to treat your water plants with herbicides.
- Some cities or counties may have policies forbidding or discouraging the use of aquatic herbicides. Check before hiring an aquatic herbicide applicator.

Treatment Plan for MLIRD –Herbicide

Planned treatment of the lake waterbody shallow areas (less than 10 feet deep) where Eurasian watermilfoil has established dense growth and is categorized as a nuisance area and of high priority will receive treatment with aquatic herbicides. The cost of aquatic herbicide application will serve as a factor in site selection and treatment schedule. The district MLIRD will need to assist in meeting the costs through careful budgeting and supporting grants that may be available. The 2008 lake survey by Lakeland Restoration provided all of the established

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aquatic vegetation sites on the lake with GPS locations, density of growth, and vegetative types that will be invaluable in determination of site selection for treatment and evaluative monitoring of treatment results.

District Funding

MLIRD (Moses Lake Irrigation and Rehabilitation District) is a subdivision of the State of Washington operating under RCW 87.84.050. The District receives funding via a special taxing district established many years ago around Moses Lake. Currently property owners within the District are assessed $1.00 per thousand of tax assessed value on their real property.

Property owners within the District receive value for their dollars by tapping into the District's surface irrigation rights, and MLIRD is devoted to improve the water quality of Moses Lake, enhance the recreational aspects and rehabilitate the lake to further the health, welfare and quality of life of the citizens that surround it.

Property owners may at any time petition to become a part of the special taxing district in order to obtain the important benefits MLIRD has provided to the citizens of Moses Lake since the District was formed in 1928.

District Staffing

MLIRD staff consists of four full time members and three working Board Members. In addition, approximately 3 temporary seasonal staff is hired during the busy season to meet the needs and demands of managing all aspects of the District.

Web Page

Information for public input with GPS updates of sites to be treated as well as dredging sites. Shoreline residents will be able to access information on any and all herbicides that will be used, schedule of treatment, and permitted areas to be treated, along with all safety information for those shoreline residents and or agricultural shoreline owners.

The MLIRD Website will be advertised on notices in the Columbia Basin Herald, local radio, released printed documents, and public meetings.

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No control

Lake management will practice no control on bird nesting and wildlife sanctuaries. The long-range plan is to develop additional wildlife habitat.

Low level of control

The long-rang plan is to enhance boating, swimming and fishing by increasing the depth of the lake by sediment removal in targeted areas (please see sediment management plan, Grette2008).

Moses Lake is a waterbody which the inflow and outflow can be controlled providing a situation in which herbicides can be contained in a targeted area. Any chemical application will be in accordance with all government guidelines and product specifications.

The implementation of sedimentation and/or herbicide treatment will be scheduled for late August through October. This is nearing the time of the fall reservoir draw down. During this time there is reduced irrigation.

During each phase of sediment removal, downstream barriers will be in place to catch any floating materials. The sediment is directly pumped to a dewatering site as it is dredged from the waterbody.

Public Involvement:

Public meetings; Spring clean-up; water quality institute involving high, middle, and elementary students; youth fishing derby; 3 hydro/inboard/outboard races each year at Connelly Park; Morning Rotary has adopted Neppel landing as a community shoreline maintenance region; Grant County Sheriff use inmates from Grant County Jail to clean and maintain the south end of lake shore, known as sand dunes; the local Job Corp is involved in several lakebody projects.

Identify interested parties

To date there have been no significant concerns voiced by lake shore residents and/or general public concerning the lake management plan. The City of Moses Lake is actively supporting the lake management plan, as it will provide improved aesthetics and recreation. The Grant County

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Noxious Weed Board is supportive, as it will leverage their efforts for shoreline weed control. With the improved fishing conditions the Walleye and Bass fishermen will be supportive of the project. The local Audubon Society is supportive since the management plan compliments their goals. The Department of Fish and Wildlife have been active in developing the fish and wildlife in conjunction with the lake management plan.

Conduct public meetings (See appendix)

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PROJECT EVALUATION LOGIC MA

	Management Plan	Milfoil & Sago pondweed	Sediment Parker Horn	Sediment Rocky Ford	Sediment Montlake/Pelican Horn	Eurasian Milfoil
Initial Start-up	May-05	Parker Horn removal during dredging Project August 2009 as permitting allows	August 2009 as permitting allows	Will not commence until Parker Horn is completed and permits have been secured	Starting date is dependent upon completion of Rocky Ford and partial funding	This will be initiate on a project by project basis a funding is availabl
Progress (formative)	Work with Department of Ecology for Revision	Plant Resurvey following sediment removal	Dredging equipment purchased & updated 2008 Check compliance with Sediment Plan	Equipment on site permits secured, monitoring depth of dredging and removal	Equipment on site permits secured, dewatering site established. Monitor sediment removal in relationship to culverts. Plant barrier at culverts.	Monitor and ensur compliance with current regulation and product specifications of herbicide applicataion
Funding Source	Dept. of Ecology Grant # 0600278	MLIRD General Fund	MLIRD General Fund	Bureau of Reclammation will assist in funding	MLIRD General Funding and secure additional grant funding	Seek available gran funding to finance targeted project
Completion (summative)	6/30/2009	10/30/2010	New Waterbody depth with sediment trap established Oct-10	The depth has been increased and the sediment has dewatered and removed	The sediment level is a minimum of 12 feet below the culvert. Increased water flow through culvert	Survey the targeted area in compare to the original plant survey
Notes	Due to unforseen circumstances the completion date of the grant was extended to 2009	A plant barrier will placed down flow during dredging	Sediment removal is again in compliance with the sediment plan	The sediment collection in Rocky Ford and Behind Drumheller Dam is a responsibility of the Bureau of Reclammation	Sediment removal will take place outside of Grebe nesting season.	Eurasian milfoil is problematic and is targeted noxious plant of the management plan

MLIRD TIMELINE

[----------] **Herbicide Treatment**
[----------] **Dredging Sediment**
[----------] **Harvest Milfoil**
Lake Inflow [----------] **Lake Draw down**
[----------} **Connelly Park**

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec

Public Involvement activities

- **Fishing Derby**
- **Lake Cleanup**
- **Water Quality Institute**
- **Board Meetings**
- **Budget Due**
- **Boat Races**
- **Wake Board Competition**
- **Public Meetings**

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APPENDICES

APPENDIX A

Public Notice

The Moses Lake Irrigation and Rehabilitation District (MLIRD) is the recipient of an Aquatic Plant Plan Grant from the State of Washington, Department of Ecology. The purpose of the Grant is to study, map and manage noxious weeds that are a detriment to the recreational and aesthetic values of Moses Lake.

The goal of the project is to protect the waters, shorelines, wetlands, and aquatic plant communities of Moses Lake from invasive non-native freshwater plants, and develop an integrated aquatic plant management plan that will target Eurasian and hybrid milfoil, and other noxious weeds. Alternatives to current weed harvesting activities including dredging, installing bottom barriers, manual methods and aquatic herbicides will be reviewed. The suitability of each method for use in Moses Lake will be evaluated, including impacts on fish and wildlife, water quality, and other environmental parameters.

MLIRD is holding an open meeting December 9, 2008 at 5:00 p.m. at the Moses Lake Irrigation and Rehabilitation District, 932 E. Wheeler, Moses Lake WA. MLIRD cordially invites the public to attend.

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Agenda

Public Meeting

December 9, 2008

Introduction and overview
Slide Presentation on weeds in Moses Lake
Education plan for public awareness and assistance with lake weed problem.
Discuss need for herbicide treatment and permits.
Discuss time line for lake survey by Dave Klutz.
Question (concerns) and answer time

Aquatic Weed Grant

Public Meeting Minutes

December 9, 2008

Richard Teals opened meeting at 5:00 pm

Curt Carpenter introduced special guest David Klutz with Lakeland Restoration Services Inc. See attached list of meeting attendees.

Curt Carpenter presented slides on different kinds of weeds that are present in Moses Lake. Dave Klutz spoke of his August survey and showed a map of Moses Lake sharing there is no Milfoil below 10' deep. Dave and Curt both talked on the different weeds present in Moses Lake. Weeds in the lake tend to increase based upon water flow and settling.

Curt spoke on the need to get education for public to help with the weed problems not to add to the lake problems.

There will be a need to get herbicide permits.

Dave Klutz said he could have the lake covered in 7-10 days.

Jeff Powell stated that many homeowners are willing to help they just don't know how or what to do.

Curt spoke about creating strategic zones in the lake for designated habitat and recreation.

Next meeting will be held on January 27, 2009 at 7:30 pm

Meeting was closed at 6:10

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MLIRD is holding an open meeting January 27, 2009 at 7:00 p.m. at the Moses Lake Fire Department, 701 E. Third, Moses Lake WA. MLIRD cordially invites the public to attend.

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Agenda

Public Meeting

January 27, 2009

- Introduction and overview
- Presentation (PowerPoint) of 2008Aquatic Weed Survey results
    - GPS mapping of every site visited.
    - Large maps posted on walls for audience review
    - Use of survey in the development of the management plan
    - Question (concerns) and answer time

Aquatic Weed Grant Public Meeting Minutes 1/27/09

A published public meeting was held at the Moses Lake Fire Department on 3rd street to discuss the survey of the lake and shoreline in conjunction with the Aquatic Weed Grant. Curt Carpenter opened the meeting at 7:05 p.m.

19 survey maps were available for the public to see where the weed concentrations were in the lake. Curt explained that there were no plants findings below 10' deep.

Dave Klutz explained the survey encompassed 6800 acres surveyed at random points approximately every 8 acres that included 680 locations. The survey measured water depth, types of sediment, water clarity and plants at each location. The shoreline was also surveyed at the same time for plants. Dave said there is approximately 1200 acres of lake bottom in Moses Lake where the plants flourish. He added that aeration of the water, such as with the water feature, positively affects the health of the lake, helps with clarity and, promotes good plant growth. Dave pointed out there are approximately 500 – 600 acres of Eurasian Milfoil that need to be treated. Controlling the milfoil promotes growth of native plants.

Dave talked about using different techniques to control aquatic weeds such as dredging, using herbicide treatments that are safe for fish but would kill the milfoil, creating habitat areas in the lake, and the use of harvesting machines for cleaning up certain areas. He said stated the best herbicide is 2,4-D which can be applied in liquid or granular form. Proper timing and application of chemicals allows for healthy fish. In addition, Dave mentioned that the sandier the soil, the less the plant density.

The survey of the shoreline revealed noxious weeds that need to be treated. Curt stated the Noxious Weed Board may have some money for applying treatment of these shoreline plants and he will be working towards coordinating that effort with them.

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Mr. Cargo mentioned there were not as many weeds throughout the summer of 2008. Curt explained the change in the flow of water which was coordinated with the Bureau of Reclamation to allow the water to run longer, keeping the temperature of the lake cooler, which inhibited some of the undesirable plant growth. Curt also explained that Moses Lake has a high concentration of oxygen in the water which allows the consideration of herbicide treatment of plants, as well as keeping the fish healthy.

Mrs. Cargo asked about the dredging project MLIRD has planned for Parker Horn later this year. Curt pointed out that there is a lot more sediment than this time last year and part of the project will be to create fish habitat in that area.

Dave Klutz explained that all programs would be ongoing for the treatment of undesirable plant growth whether it be dredging, chemical treatments or harvesting. The timeline for chemical treatment would depend on the availability of money. Dave would like to get a start with chemical treatment on a few acres to show the community how safe and effect this type of treatment can be. He stated the cost could range from $500 - $800 per acre.

The Department of Fish & Wildlife has expressed willingness to work with MLIRD through these processes.

Curt and Dave mentioned they are willing to working with homeowners and/or homeowner associations around the lake if they are interested in controlling noxious weeds on their shorelines.

On February 7, 2009 Curt and Dave will be making a presentation on the history and survey findings of Moses Lake at the Eastern Washington Lake Conference in Spokane at the SCC campus at 3:00 p.m. Everyone is invited.

Meeting adjourned 8:30 p.m

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APPENDIX B

References

Shoreline Inventory and Characterization for the City of Moses Lake, prepared by Geo-Ecology Research Group, Department of Geography and Land Studies, Central Washington University, 400 E. University Way, Ellensburg, WA 98926-7420.

Grette Sedimentation Plan Prepared for: Moses Lake Irrigation and Rehabilitation District, by Grette Associates 151 South Worthen Street, Suite 101,Wenatchee, WA 98801.

2008 Aquatic Plant Point Intercept Survey, prepared for Moses Lake Irrigation and Rehabilition District, by Lakeland Restoration Services LLC, Dave Kluttz, 78 E. River Spur Rd., Priest River, ID 83856.

WRIA 41 Lower Crab Creek; 2006—Summary of Water Samplng for Moses Lake Irrigation and Rehabilitation District, prepared by: Peter Burgoon, PhD, PE,Water Quality Engineering, Inc.; 103 Palouse Street, Suite 2, Wenatchee, WA 98801

*All References within the document are accounted for in the above studies.

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APPENDIX C

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Figure 4. Moses Lake Watershed

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Figure 49. Leafy Pondweed

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Table 10. List of Audubon Society Bird Species in Moses Lake

Table 11. WDFW GAP analysis avian species list for Moses Lake area

Table 12. WDFW GAP analysis terrestrial species list for Moses Lake area

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