Final Report

Lake Kapowsin Biological Inventory

Prepared for:
Washington Department of Natural Resources
Aquatic Reserves Program
1111 Washington Street SE, PO Box 47016
Olympia, WA 98504-7016

Prepared by:
Hamer Environmental L.P.
P.O. Box 2561
Mount Vernon, WA 97273
www.HamerEnvironmental.com

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EXECUTIVE SUMMARY

The biological inventory of Lake Kapowsin was conducted with the goal of providing a baseline snapshot of lake conditions, and of the habitats and wildlife associated with the lake system. Lake Kapowsin is the first freshwater aquatic system to be considered for enrollment in the state Aquatic Reserves Program. The intent of this report is to provide baseline information on the lake to Washington State Department of Natural Resources (WDNR) for development of lake management and monitoring plans.

Highlighted Findings

- **Limnology:**
    - **Physical habitat:** The riparian canopy along the banks of Lake Kapowsin was varied, dominated by deciduous forest along the western shores and conifer or mixed forest along the eastern shores. Within the lake there was a large amount of tree stumps, floating logs and macrophytic vegetation. The littoral substrate cover at the physical habitat sampling stations was dominated by silt, clay or muck, followed by woody debris and organic material.
    - **Water chemistry:** Preliminary data suggest that Lake Kapowsin is a mesotrophic to eutrophic lake system that thermally and chemically stratifies in the spring and summer potentially leading to anoxic and low pH conditions in the deeper portions of the lake. Additional sampling during summer and fall months is recommended to test these hypotheses.
- **Macroinvertebrates:** Twenty-seven unique invertebrate taxa in 7 orders were documented at Lake Kapowsin, including one non-native aquatic mollusk, the Chinese mystery snail (*Cipangopaludina chinensis malleata*). Seventy-six percent of the macroinvertebrates collected were crustaceans: among these, the isopod *Caecidotea* sp. and the amphipod *Crangonyx* sp. were the dominant taxa. Macroinvertebrate communities found in the lake were dominated by detritivores, due to the large amounts of woody debris found in the lake.
- **Aquatic plants:** No aquatic invasive or rare plants were documented on Lake Kapowsin, though this effort was not a complete survey. A total of 45 aquatic plant species (submerged, floating & emergent) were documented, indicating high species diversity.
- **Wetlands:** Several wetland sites at the north end of the lake and Jaybird Island, contained plant communities exclusive to bogs, but only a portion of one wetland met the plant cover requirements to be rated as a bog. However, these wetlands are in the process of becoming bogs, which are specialized habitats containing unique species, acidic water conditions, and are highly susceptible to degradation from human impacts. Lake fringe wetlands dominated by common cat-tail (*Typha latifolia*), yellow flag iris (*Iris pseudoacorus*), and yellow pond lily (*Nuphar lutea*) were also documented along all shores of the lake.
- **Fish:** Lake Kapowsin and adjacent Kapowsin and Ohop Creeks support a variety of cold and warm water fish species, including: Coho salmon (*Oncorhynchus kisutch*), Chinook salmon

(*Oncorhynchus tshawytscha*), pink salmon (*Oncorhynchus gorbuscha*), steelhead (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), and cutthroat trout (*Oncorhynchus clarki*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and numerous other warmwater fish species.

- **Amphibians:** Five amphibian species were identified at Lake Kapowsin during the March and April visual encounter surveys and included two native frog species (Pacific treefrog [*Pseudacris regilla*] and northern red-legged frog [*Rana aurora aurora*]); one non-native frog (American bullfrog [*Lithobates catesbeianus*]); and two native salamanders (northwestern salamander [*Ambystoma gracile*] and rough-skinned newt [*Taricha granulosa*]). The northern red-legged frog is listed as a federal species of concern. Additional survey efforts are recommended for verifying presence or absence of Oregon spotted frog (*Rana pretiosa*) and western toad (*Bufo boreas*).
- **Mammals:** A total of 51 mammals were predicted to occur within the Lake Kapowsin region by the 2004 Pierce County Biodiversity Network Assessment. The state and federal-listed mammal species predicted to occur in this region included the brush prairie pocket gopher (*Thomomys mazama douglasii*), fisher (*Martes pennanti*), long-eared myotis (*Myotis septentrionalis*), long-legged myotis (*Myotis volans*), Pacific water shrew (*Sorex bendirii*), Townsend's big-eared bat (*Corynorhinus townsendii*), and Yuma myotis (*Myotis yumanensis*). This region had the third highest predicted mammal diversity of any of the mapped 17 biodiversity management areas in Pierce County. Beaver lodges and river otter scat were documented on the Lake. WDFW priority species documentations for the lake and adjacent habitats included state endangered, federally threatened grizzly bear (*Ursus arctos*), migratory elk (*Cervus elaphus*) and other species.
- **Birds:** A total of 116 avian species (or species groups) have been documented on Lake Kapowsin during Christmas bird counts, including numerous with federal and/or state conservation status: Bald Eagle (*Haliaeetus leucocephalus*), Peregrine Falcon (*Falco peregrinus*), Western Grebe (*Aechmorphorus occidentalis*), Pileated Woodpecker (*Dryocopus pileatus*), Purple Martin (*Progne subis*), Wood Duck (*Aix sponsa*), Osprey (*Pandeon haliaetus*), and Great Blue Heron (*Ardea Herodias*). When comparing the number of bird species detected at the lake itself during the summer and during the Christmas Bird Counts, the Lake Kapowsin area had 127 overall species compared to the predicted 113 species identified by the 2004 Pierce County Biodiversity Network Assessment for this region. The Lake Kapowsin area had the 2nd highest predicted number of bird species in the Biodiversity Network Assessment Region of Pierce County, out of the 17 biodiversity regions assessed.

Potential Management Concerns

Eutrophic Lake Conditions

Several different measurements and observations at Lake Kapowsin indicate this is a mesotrophic to eutrophic lake system, with high nutrient inputs (woody detritus, aquatic vegetation) and shallow water depths as contributory factors. Eutrophic lakes have high nutrient levels, high plant production rates, and an abundance of plant life. They are naturally occurring and can be biologically diverse with abundant fish, plant and wildlife. Human activities, such as lakeshore development and poorly managed agriculture, however, can result in excessive nutrient concentrations, accelerated eutrophication and can cause undesirable effects such as nuisance algae, excessive plant growth, murky water, odor and fish kills.

- Water chemistry: Lake Kapowsin was mesotrophic in October 2014 and eutrophic in April 2015 based on chlorophyll-*a* concentration (algal productivity) and water clarity measurements. Based on total phosphorus concentrations in both October 2014 and April 2015, the lake would be considered eutrophic. Additional sampling during the summer growing season is recommended to better understand biological productivity in Lake Kapowsin.
- Macroinvertebrates: macroinvertebrate community composition suggests that Lake Kapowsin: 1) has relatively high organic nutrient concentrations and is dominated by a detrital-based food web; 2) water temperatures are warm; 3) water is mildly acidic; and 3) benthic substrates may be hypoxic.
- Algae blooms: several small algae blooms were identified in still water areas during June 2015. These blooms are likely filamentous green algae, which is not toxic to humans, but is indicative of high nutrients in the lake.

Invasive Species

- Six Class C noxious weed species were documented on Lake Kapowsin, which included Himalayan blackberry (*Rubus armeniacus*), yellow flag iris (*Iris pseudoacorus*) most commonly, as well as evergreen blackberry (*Rubus laciniatus*), reed canary grass (*Phalaris arundinacea*), common St. Johnswort (*Hypericum perforatum*) and Canada thistle (*Cirsium arvense*) in small or isolated infestations. As Class C noxious weeds, these species are considered widespread and well established in Washington, so management is recommended but not required.
- A non-native aquatic mollusk, the Chinese mystery snail was documented and regularly observed throughout Lake Kapowsin. This snail, while very abundant at Lake Kapowsin, is considered to be a mostly benign species (non-invasive) where it has been studied in the Great Lakes region.
- American bullfrog (*Lithobates catesbeianus* or *Rana catesbeiana*) was commonly encountered on Lake Kapowsin. Exotic species such as bullfrogs, and nonnative, warmwater fish species act as aquatic predators and have played a role in losses of Oregon spotted frog and northern red-legged frog populations in the Pacific Northwest.

Fishery Management

- Warmwater fish, especially largemouth bass (*Micropterus salmoides*) and rock bass (*Ambloplites rupestris*), provide a popular and apparently significant recreational sport fishery on Lake Kapowsin. This makes managing for successful juvenile coho lake and side-channel rearing, and outmigration of juvenile coho, steelhead, and possibly sea-run cutthroat trout and bull trout through the lake difficult. Warmwater fish predation on salmonid juveniles, particularly from largemouth bass, is potentially significant on the lake. The amount of predation on juvenile salmonids in Lake Kapowsin is not known, however, based on studies in other similar western Washington lakes (Downen 1999, Wydoski and Whitney 2003, Bonar et al. 2004) this predation could be significant.

Recreational Use

- Dispersed recreational use was commonly noted along the shorelines of Lake Kapowsin, particularly along the western shore of the lake, where walk-in access was easiest from nearby Orville Road E. Dispersed recreation resulted in trash, fire rings and small trails along the shore.
- Recreational fishing, typically of stocked trout and warm water species, is the dominant activity on the Lake, with both boat and land-based anglers. Stumps found throughout the lake at or just below the surface ensure boats move slowly through the lake waters and operate primarily with electric trolling motors, though gas motors were observed regularly.

Recommendations for Additional Monitoring to Address Information Gaps

- **Temperature, dissolved oxygen and pH depth profiles:** Additional monitoring of Lake Kapowsin's temperature, dissolved oxygen and pH levels throughout the water column, especially during the summer and early fall, are recommended for determining the extent and duration of thermal and chemical stratification and low dissolved oxygen and pH levels within the lake.
- **Nutrient sampling:** to determine if internal phosphorus loading is occurring in Lake Kapowsin, it is recommended that surface and bottom nutrient samples are collected while the lake is stratified in the summer.
- **Trophic State:** To better understand biological productivity in Lake Kapowsin, it is recommended that trophic state is measured during the summer growing season.
- **Algae bloom:** Collection of algae bloom sample and lab analysis for toxicity is recommended to determine potential health risk and better characterize presence during summer temperatures when algae blooms will peak.
- **Wetland plant communities:** Additional botanical inventory of wetlands on Jaybird Island and south-end of Lake Kapowsin are recommended to document presence of rare plants and better document plant communities within these wetlands.

Table of Contents

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

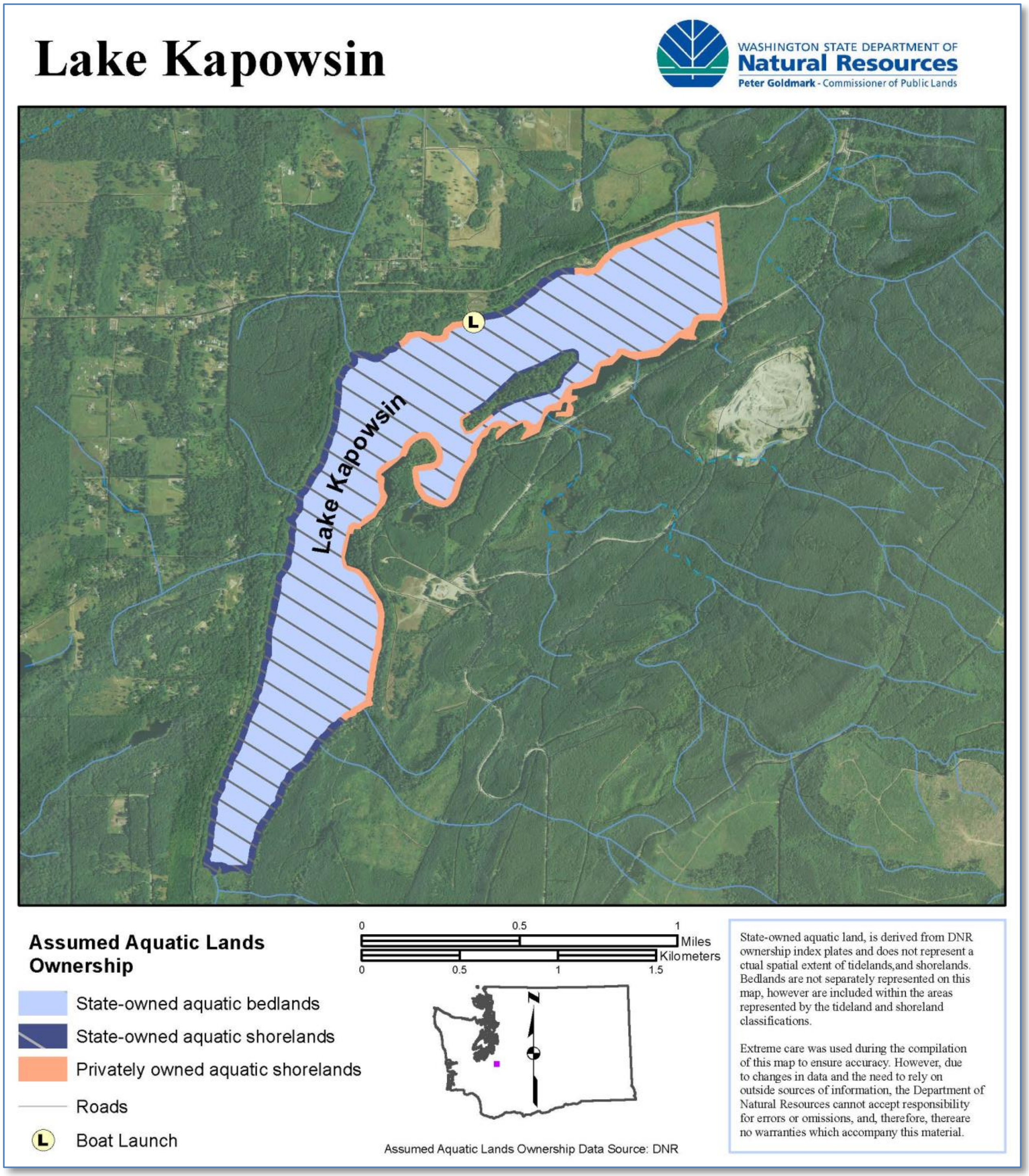
1.0 INTRODUCTION

Lake Kapowsin is located approximately 25 miles south east of Tacoma in Pierce County, Washington. Lake Kapowsin is a large lake covering 512 surface acres and is located at an elevation of 600 feet. The lake reaches depths of about 58 feet but most of the lake is quite shallow. The lake was formed 500 years ago by the Electron mudflow originating on Mt. Rainier, which flowed down the Puyallup River valley, and up a tributary approximately one mile to the present day north end of Lake Kapowsin. The dammed creek backed-up and drowned an old growth forest. These trees were then cut at the lake surface water level, which left thousands of large stumps in the lake bed. Lake is fed by Ohop Creek at the southern end and is drained by Kapowsin Creek at the northern end (eventually flowing into the Puyallup River at RM 27.6).

The WDNR is interested in protecting the historic, ecological, and geologic resources of the lake for research, education, and public uses. The Aquatic Reserves Program was established by WDNR Aquatic Resources Division in an effort to promote preservation, restoration, and enhancement of state-owned aquatic lands that provide benefits to the health of native aquatic habitats and species in the state of Washington. The program was created to establish aquatic reserves on selected state-owned lands to help protect important native aquatic ecosystems. Aquatic reserves are lands of special educational or scientific interest or of special environmental importance. The program was also designed to help meet the need for site-based conservation management of state-owned aquatic land.

WDNR currently has seven aquatic reserves located throughout the marine waters of Puget Sound and the Straits of Georgia and Juan de Fuca. Presently, WDNR is proposing to establish Lake Kapowsin as an Aquatic Reserve which would be composed of existing state-owned bed-lands and shore-lands (Figure 1.1). Lake Kapowsin has a unique combination of geological, biological, and historical attributes, and offers a rare opportunity for conservation of a distinctive Puget Trough lowland freshwater ecosystem that merits its consideration for designation as a freshwater aquatic reserve. If designated, Lake Kapowsin would be the first freshwater WDNR aquatic reserve in Washington State.

The primary objective of this study is to provide a baseline biological inventory and associated habitat data to assist WDNR in the development of a Lake Kapowsin management plan to meet their Aquatic Reserve Program Implementation and Designation Guidance requirements (WDNR 2005). This study will support the planning for the proposed Lake Kapowsin Aquatic Reserve by providing key biological information on species and communities of the lake. The study involved collecting and assimilating all available biological information on the primary biological resources found at the site. This data will be summarized in the Lake Kapowsin management plan and integrated with existing information to develop conservation targets, goals and objectives for lake management. The physical and biological resources include a description of the limnological parameters of the lake, sediments, water quality, benthic macroinvertebrates, plants, wetlands, fish, mammals, birds, and amphibians. Climatic conditions are also summarized along with an assessment of human impacts at the lake. In the literature the lake is referred to as Lake Kapowsin and Kapowsin Lake. In this report Lake Kapowsin is used.



State-owned aquatic land, is derived from DNR ownership index plates and does not represent a ctual spatial extent of tidelands,and shorelands. Bedlands are not separately represented on this map, however are included within the areas represented by the tideland and shoreland classifications.

Extreme care was used during the compilation of this map to ensure accuracy. However, due to changes in data and the need to rely on outside sources of information, the Department of Natural Resources cannot accept responsibility for errors or omissions, and, therefore, thereare no warranties which accompany this material.

Figure 1.1. Map of Lake Kapowsin showing land ownership of aquatic lands.

2.0 LIMNOLOGY (PHYSICAL CHARACTERISTICS AND WATER CHEMISTRY)

2.1 Introduction

Hamer Environmental employed methods developed for the US EPA National Lakes Assessment (NLA) program (USEPA 2009, USEPA 2011, USEPA 2012) to measure limnological parameters in Lake Kaposwin. The NLA allows for the assessment of trophic status, ecological integrity, human use value and lake characteristics.

2.2 Methods

2.2.1 Field Sampling

The NLA is designed to be completed during the summer growing season (June – Sept). However, due to the deadlines for this project, sampling was completed in Fall 2014, Winter 2015 and Spring 2015. Over this period of time, a variety of trophic status, water quality indicators and ecological integrity indicators were measured by three different groups:

- University of Washington, October 2014,
- WDNR, 5 visits (monthly) December 2014 to April 2015, and
- Hamer Environmental April 2015.

On 24 October 2014, Dr. Jim Gawel, Associate Professor of Environmental Chemistry and Engineering with the Environmental Science and Studies School, University of Washington (UW), Tacoma, and his students measured several parameters at three locations in Lake Kapowsin. Temperature, dissolved oxygen, pH and specific conductance depth profile data were collected with a multi-probe sonde. Water transparency was measured with a Secchi disk. Nutrients (total phosphorus, total nitrogen, and ammonia [NH_4-N]) and chlorophyll-*a* concentrations were determined in the UW laboratory from water samples collected at multiple depths along the water column. Specific laboratory analytical methods and detection limits were not provided for these data and are not presented in this report. For best comparisons and due to project constraints, only UW data collected at the sampling station closest to our 2015 Index station (UW2; Figure 2.1), and only water chemistry data collected at 1 meter below the water's surface were used.

WDNR completed temperature and dissolved oxygen depth profiles with a multi-probe sonde at one to three locations in Lake Kapowsin on 4 December 2014, 6 January 2015, 3 February 2015, 5 March 2015 and 13 April 2015. Water transparency was also measured using a Secchi disk. Due to the budget constraints of this project, and to best compare these data to sampling conducted in April 2015; we only used data collected at the sampling station closest to our Index station (Scout Site; Figure 2.1) on 6 January 2015.

On 29 and 30 April 2015, Hamer Environmental, with the assistance of WDNR biologists, collected a variety of trophic status and water quality indicators and ecological integrity indicators. Specific measurements were taken at stations located at the deepest point in the lake (Index) and ten stations located along the littoral zone around the shoreline of the lake (Figure 2.1). All measurements taken and samples collected were done so following the US EPA NLA program protocols (USEPA 2009, USEPA 2011, USEPA 2012).

At the Index station, depth profiles for temperature, pH and dissolved oxygen were taken with a calibrated multi-probe sonde. These vertical profile measurements were used to determine the extent of stratification, the availability of the appropriate temperature regime and level of available oxygen necessary to support aquatic life. A Secchi disk was used to measure water transparency and depth at which light penetrates the lake. A single, integrated water chemistry sample was collected from just below the water surface to a depth of 2 meters using a sampling tube. An additional surface water sample was collected to measure chlorophyll-*a* (algal density).

At ten evenly spaced physical habitat sampling stations around the lake, Hamer Environmental collected several physical habitat characterization measurements within the littoral, shoreline, and riparian areas of the lake that affect habitat suitability (Figures 2.1, 2.2). These parameters included: vertical and horizontal distances between present and normal high water line as a measure of lake level fluctuations, bank angle, substrate characteristics and cover, aquatic macrophyte cover, fish habitat cover, cover and type of riparian and drawdown zone vegetation, evidence of human influence and presence of invasive plants and invasive invertebrates (e.g. zebra mussel). Benthic macroinvertebrate samples were also collected at each of the ten stations (see Chapter 3. Benthic Macroinvertebrate Sampling). At one of the ten stations (Station J), we collected a chlorophyll-*a* sample as an additional measure of ecological integrity and human use in the littoral zone of the lake. Aquatic macrophyte results from these efforts are presented in Chapter 5. Aquatic Plants; Fish habitat cover results are presented in Chapter 7. Fish; and human influence results are presented in Chapter 8. Human Influence.

2.2.2 Laboratory Analyses

Water chemistry and chlorophyll-*a* and benthic macroinvertebrate samples were processed and analyzed in accordance with NLA Protocols (USEPA 2009, USEPA 2011, USEPA 2012). Water chemistry and chlorophyll-*a* samples were analyzed by the CCAL Water Analysis Laboratory, Oregon State University and the Institute for Watershed Studies, Western Washington University. A total of 15 parameters were determined from each water chemistry sample collected: total phosphorus (TP), ammonia (NH3), Nitrate-Nitrite (NO3-NO2), total nitrogen (TN), major anions and cations (chloride [Cl]), sulfate (SO4), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K)), alkalinity (CaCO3), total suspended solids (TSS), turbidity, conductivity, and silica. Samples were processed in accordance with NLA protocols and best use practices of the labs (Appendix 2.A). In addition, chlorophyll-*a* was determined from a separate, discrete sample following the same performance-based methods approach as proposed for water chemistry analytes (USEPA 2012).

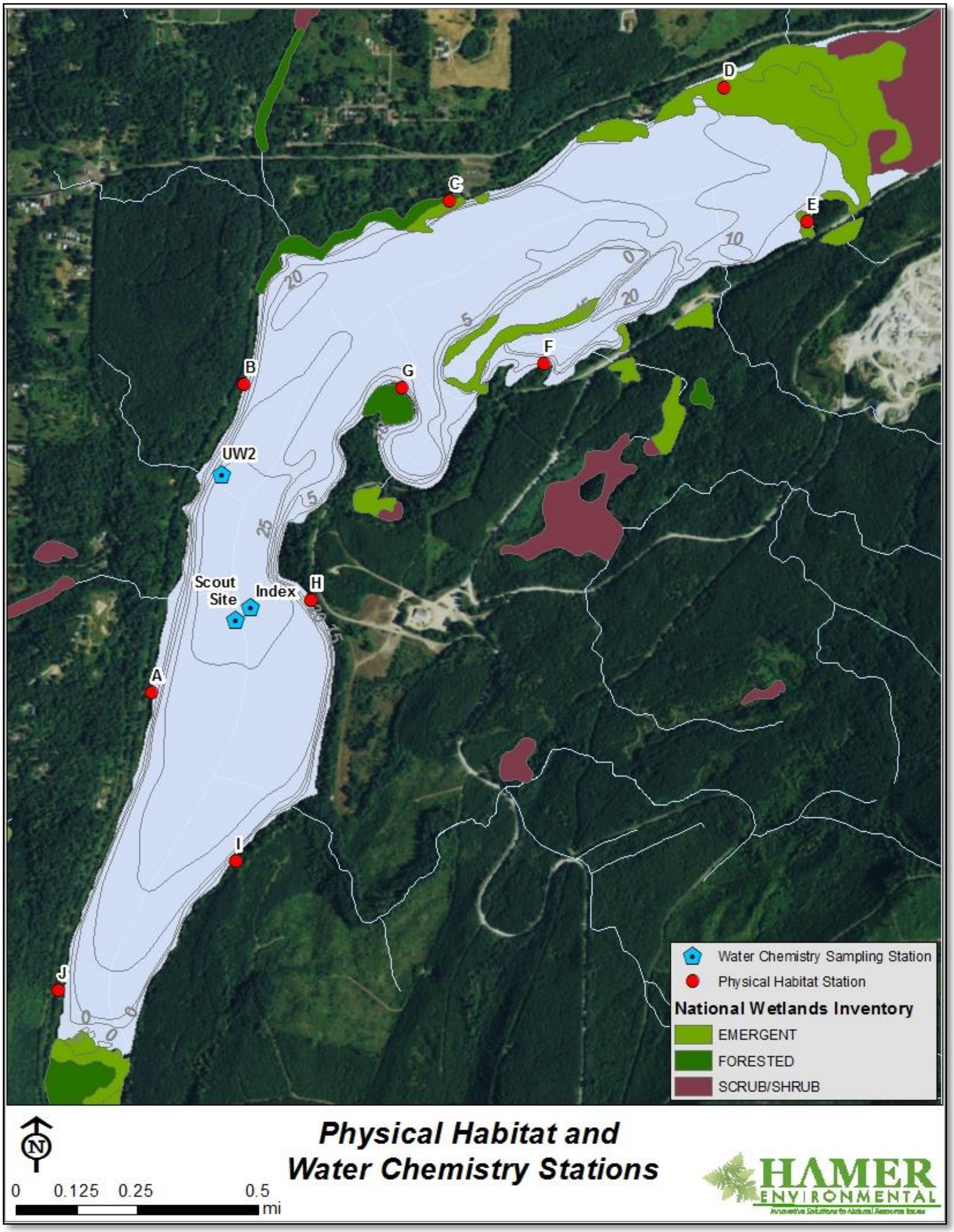


Figure 2.1. Lake Kapowsin physical habitat and water chemistry sampling stations.

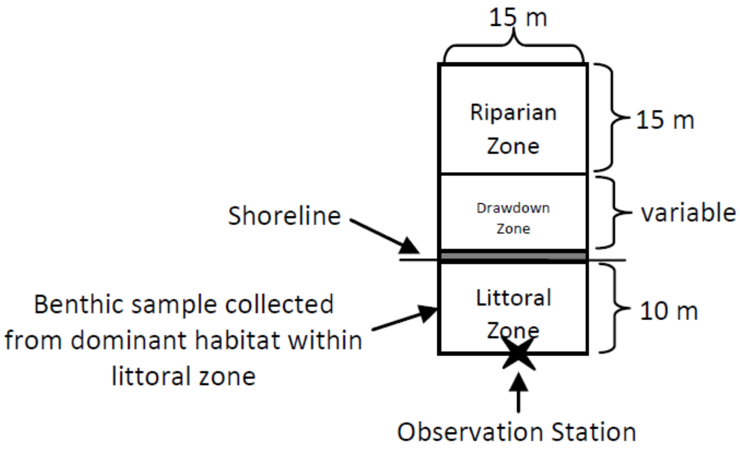


Figure 2.2. Schematic of Physical Habitat Station (from USEPA 2012).

2.3 Results and Discussion

2.3.1 Physical Habitat

Photographs of some of the physical habitat stations can be found in Appendix 2.B.

Riparian Vegetation

Forty percent of the physical habitat stations were dominated by a canopy (trees >5 meters tall) of mixed forest, containing both coniferous and deciduous trees within the riparian area (Table 2.1, Figure 2.3). Thirty percent of the physical habitat stations were dominated by coniferous trees and the final thirty percent were dominated by deciduous trees. On average, big trees (trunk >0.3 m DBH), represented 40-75% of the canopy cover when present. Small trees (trunk <0.3 m DBH) were sparse on average and represented <10% of the canopy when present.

The riparian understory (vegetation 0.5-5 m tall) was dominated by deciduous trees at 60% of the physical habitat stations. Forty percent of the physical habitat stations were dominated by mixed forest. On average, woody shrubs and saplings, represented 40-75% of the understory cover when present and tall herbs, grasses and forbs represented <10% of the understory cover when present.

The riparian groundcover (vegetation <0.5 m tall), was dominated by herbs, grasses and forbs, representing on average, 10-40% of the ground cover when present. Other ground cover only represented <10% on average, and when present, consisted of: woody shrubs and saplings, standing water or inundated vegetation, bare dirt, and/or leaf litter or duff.

Of the vegetation present within the riparian area, 90-100% was native at 9 out of 10 physical habitat stations (Table 2.1). Non-native vegetation species found at these stations included yellow flag iris (*Iris pseudacorus*). At one station (D), 50% of the vegetation present within the riparian area was native and 50% was invasive Himalayan blackberry (*Rubus armeniacus*). Generally, shoreline areas along Lake Kapowsin, outside of wetlands, consisted of a narrow fringe of understory emergent vegetation before grading into upland habitats. Shoreline zones contained a mix of native and non-native species, with higher concentrations of non-native and invasive species found along the southwest and northwest shoreline, including yellow flag iris and non-native redtop grass (*Agrostis gigantea*), with Himalayan blackberry frequently dominant in the understory areas upland from the shore. Native, common cat-tail (*Typha angustifolia*) was found throughout the lake shorelines, frequently as the dominant plant cover, particularly along eastern shoreline areas. Riparian habitats along Lake Kapowsin were also varied, but tended to be deciduous forest along the south, southwest and northwest banks, and were mixed conifer-deciduous or conifer forest along Jaybird Island and the east banks of the Lake.

Figure 2.3. Mixed forest canopy.

Table 2.1. Riparian vegetation summary for physical habitat stations. Measured 29-30 April 2015.

	Canopy (>5m) % Cover			Understory (0.5-5m) % Cover			Ground Cover (<0.5m) % Cover					
Station	**Dominant Forest**	**Big Tree (trunk >0.3m**	**Small Tree (trunk <0.3m**	**Dominant Forest**	**Woody Shrubs & Saplings**	**Tall Herbs, Grasses &**	**Woody Shrubs &**	**Herbs, Grasses &**	**Standing Water or Inundated**	**Barren, Bare Dirt, Litter**	**% Native Veg**	**% Non-Native Veg**
A	Mixed	10-40	10-40	Deciduous	>75	<10	<10	<10	<10	0	90	10
B	Deciduous	40-75	10-40	Deciduous	40-75	10-40	<10	10-40	<10	10-40	95	5
C	Deciduous	40-75	10-40	Deciduous	40-75	<10	<10	>75	<10	<10	95	5
D	Mixed	40-75	<10	Deciduous	>75	<10	<10	<10	inaccessible	<10	50	50
E	Coniferous	40-75	<10	Mixed	<10	<10	>75	<10	0	<10	100	0
F	Mixed	40-75	<10	Mixed	10-40	<10	<10	10-40	0	<10	98	2
G	Coniferous	40-75	0	Mixed	40-75	<10	<10	40-75	10-40	0	96	4
H	Mixed	40-75	<10	Deciduous	40-75	<10	10-40	<10	0	<10	100	0
I	Coniferous	40-75	0	Mixed	<10	0	<10	10-40	0	10-40	100	0
J	Deciduous	10-40	<10	Deciduous	>75	<10	0	<10	<10	0	98	2

Physical Characteristics

Physical habitat stations located on the northwest shoreline of the lake were characterized by flat bank angles (<5°), while those stations located on the southeast shoreline were characterized by gradual (5-30°) to steep (30-75°) bank angles (Table 2.2, Figure 2.4). There was evidence of drawdown at each of the physical habitat stations (Table 2.2). The average drawdown distance from the normal high water line was 1.4 meters (SD = ± 1.0). The average drop in water height from the normal high water line was 0.3 meters (SD = ± 0.2). The average water depth 10 meters off-shore at the physical habitat stations was 2.1 meters (SD = ± 1.5 m).


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Figure 2.4 Physical Habitat Station G. Coniferous forest canopy, steep bank.

Table 2.2. Physical Habitat Station characteristics. Measured 29 – 30 April 2015.

Station	Depth (m) 10 m off-shore	Drawdown Vertical Height (m)	Drawdown Distance (m)	Bank Angle
A	1.3	0.1	1.2	Flat (<5°)
B	0.7	0.2	1.6	Flat (<5°)
C	0.9	0.2	3.7	Flat (<5°)
D	4.2	inaccessible	inaccessible	inaccessible
E	0.7	0.5	2.1	Gradual (5-30°)
F	2.8	0.3	0.8	Gradual (5-30°)
G	0.7	0.4	1.2	Steep (30-75°)
H	3.9	0.4	0.2	Steep (30-75°)
I	4.0	0.8	0.8	Steep (30-75°)
J	1.6	0.2	1.1	Gradual (5-30°)
Mean	2.1	0.3	1.4	-
SD	1.5	0.2	1.0	-

Substrate/Sediment

The littoral substrate cover at the physical habitat stations was dominated by silt, clay or muck, followed by woody debris and organic material (Figure 2.5, Table 2.3). The average cover class for silt, clay or muck at physical habitat stations was heavy, representing 40 – 75% of the substrate when present. On average, woody debris and organic material cover was moderate, representing 10-40% of the substrate when present. Overall, sediment composition was organic for most physical habitat stations. Three out of four sediment samples (Stations E, G and J) were of a dark brown hue (5YR – 10YR, yellow-red) with the darkest value and lowest chroma, consistent with organic muck soils. Sediment sampled at station H was of a gray hue (5Y) with a mid-color value and low chroma consistent with sandy soils developed from bedrock (Munsell 2000). We recorded surface scum at only one of the physical habitat stations. At a couple of the stations we detected a hydrogen sulfide odor. These results reflect the large amount of wood stumps, floating logs and macrophytic vegetation within the lake.

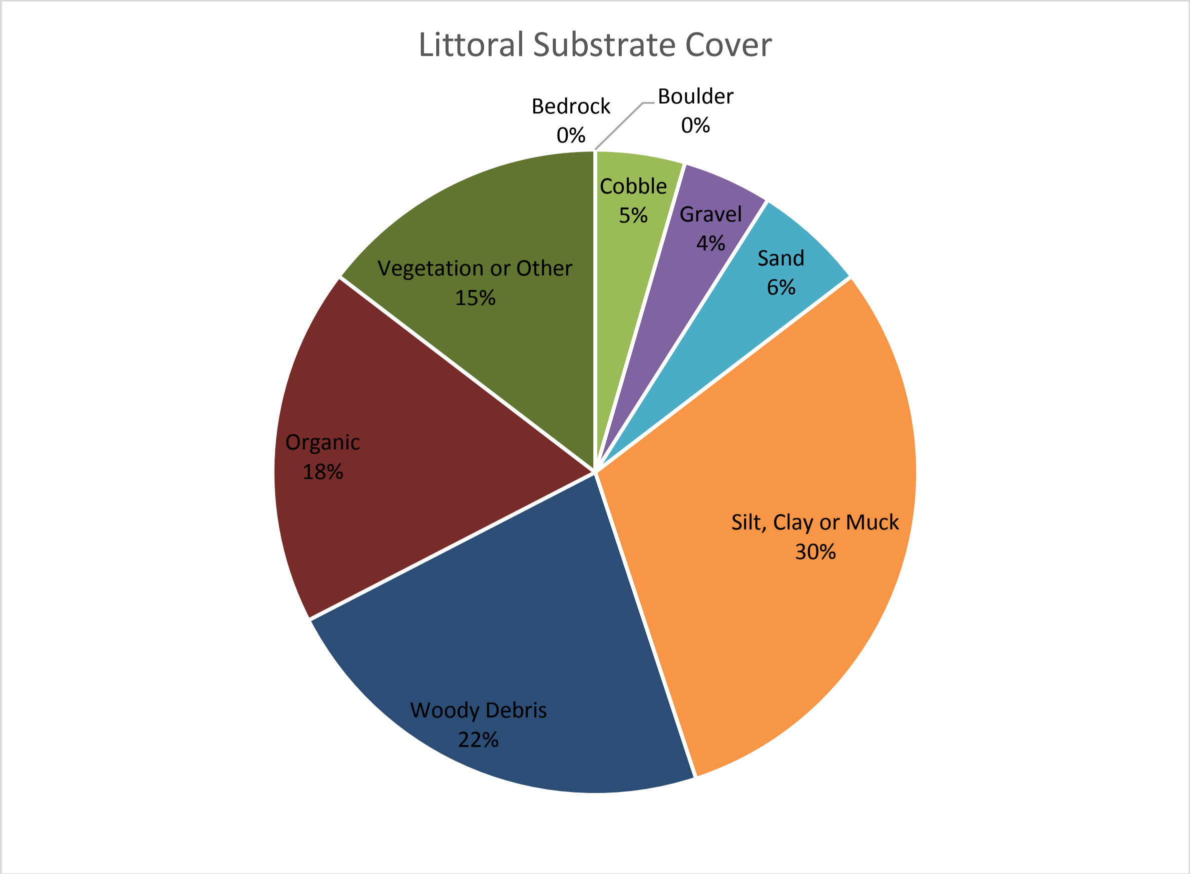

Figure 2.5. Littoral substrate cover of physical habitat stations. Measured 29 - 30 April 2015.

Table 2.3. Littoral substrate and sediment sample summary for each physical habitat station. Measured 29 - 30 April 2015.

Station	Dominant Substrate	Composition	Substrate Color	Munsell Color	Surface Film	Substrate Odor
A	Woody Debris	organic	Brown	-	None	None
B	Silt, Clay or Muck	high organic	Brown	-	None	None
C	Woody Debris	organic	Brown	-	Scum	None
D	Woody Debris	organic	Brown	-	None	None
E	Silt, Clay or Muck	high organic	Brown	5YR 2.5/1	None	None
F	Silt, Clay or Muck and Woody Debris	organic	Brown	-	None	H2S
G	Woody Debris	organic, fibric	Brown	10YR 2/1	None	None
H	Cobble and Gravel	sandy	Gray	5Y 5/1	None	None
I	Silt, Clay or Muck	organic	Brown	-	None	None
J	Silt, Clay or Muck	organic	Brown	7.5YR 2.5/2	None	H2S

2.3.2 Water Chemistry

Previous Studies

Jackson and Caromile (2000) reported that the water quality in Lake Kapowsin is within optimal limits for most warmwater fish, however, below 6 meters the lake becomes quite anoxic with DO levels below 1 ppm. They indicated that the anoxic conditions are the result of decomposition of abundant woody debris on the lake bottom. Jackson and Caromile (2000) found conductivity readings to be low (<100 us/cm) throughout the water column, which was below the optimum range (100-400 us/cm) for electrofishing efficiency and indicated that low conductivity could have affected their electrofishing sampling.

Sumioka and Dion (1985) described the trophic classification of Lake Kapowsin as having a trophic state index (TSI) (Carlson 1977) of 47, calculated from Secchi-disc depth and total phosphorus and chlorophyll, and a characteristic value (Bortleson 1976 of 39. According to Sumioka and Dion (1985) the mean TSI value of 41 is the upper limit of "oligotrophy" and 51 is the lower limit of "eutrophy" so the trophic state of Lake Kapowsin can be described as being between "oligotrophy" or unproductive and "eutrophy." or productive. Please refer to the Trophic State section at the end of this chapter for a more detailed description and implications.

Pierce County Surface Water Management Division has been conducting annual water quality monitoring in Kapowsin Creek since 2006 (Pierce County 2010-2013). A Water Quality Index (WQI) score is calculated for each parameter measured along with an overall score for the stream. The stream monitoring WQI is a unitless number ranging from 1 to 100, where a higher score indicates better water quality relative to expectations. For temperature, pH, fecal coliform bacteria and dissolved oxygen, scores are indicative of water quality relative to the criteria in Washington's Water Quality Standards, WAC 173-01A. For nutrient and sediment measurements, the WQI is relative to expected conditions in a given region. Scores below 40 do not meet water quality expectations and are of "highest concern," scores 40 – 80 indicate "marginal concern," and scores 80 and above meet expectations.

In Kapowsin Creek, water quality indices have ranged from a low of ~ 35 in 2006 to a high of 88 in 2007 (Figure 2.6), although it is important to note that the WQI was not implemented until 2008 and any score reported before this year may not be scored using the same parameters as after this date. Except for 2006, when Kapowsin Creek was rated as "Poor," all other years the creek has been rated "Moderate" or "Good." Between 2008 and 2010, the overall WQI decreased slightly each year. Between 2010 and 2013, there has been an overall increase in the WQI.

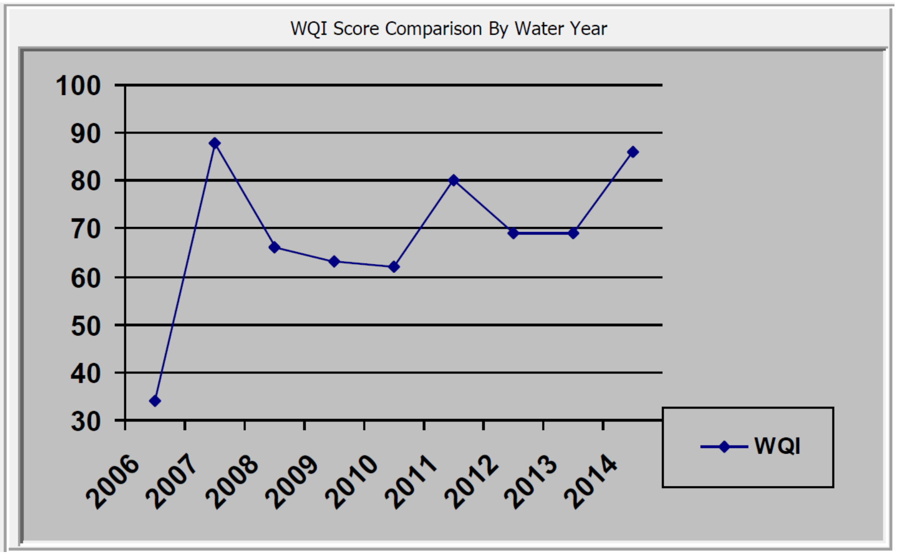

Figure 2.6 Kapowsin Creek Water Quality Index score comparison by water year (figure from Pierce County 2013).

Water Quality Index Scores for Kapowsin Creek were reported for individual parameters in years 2010 – 2013 (Pierce County 2010-2013; Appendix 2.C.). Surface water temperature was the water quality parameter with the lowest overall WQI score and was rated as "Moderate" every year between 2010 and 2013. Dissolved oxygen and total phosphorus were each rated as "Moderate" in 3 out of 4 years and "Good" in one year. Total nitrogen, fecal coliform bacteria, and pH were rated as "Good" in 3 out of 4 years and "Moderate" in one year. Turbidity and total suspended sediment (TSS) were rated as "Good" in all 4 years.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles showed that Lake Kapowsin was vertically unstratified in Fall 2014 and Winter 2015 and stratified in Spring 2015.

Lake stratification typically occurs in the spring when the surface of the lake begins to warm due to solar radiation (Wetzel 2001, Matthews et al. 2006). As the lake warms, the surface water becomes less dense than the underlying cold water and eventually stratifies into the epilimnion, a warm layer that is physically separated from the colder, denser, lower layer, the hypolimnion. After the lake has stratified, there is little exchange of dissolved chemicals between the epilimnion and hypolimnion. The metalimnion, the transition zone between these layers, is where temperature changes the most rapidly with depth. Algae and bacteria often accumulate in the metalimnion, where light is sufficient for photosynthesis and nutrients are often more available than at the surface. Since the primary source of dissolved oxygen in lakes is from the atmosphere, stratification may lead to oxygen depletion in hypolimnion, because it is isolated from the lake's surface. This effect is more pronounced in nutrient-rich lakes, where bacteria decompose organic matter from dead algae or aquatic plants and use up dissolved oxygen. Low oxygen conditions in lakes may be associated with a number of water quality issues, including: loss of aquatic organisms (Table 2.4) and habitat, release of phosphorus and nitrogen from sediments, increased rates of algal production due to release of nutrients, unpleasant odors during lake overturn, fish kills, particularly during lake overturn and release of metals and organics from sediments (Wetzel 2001, Matthews et al. 2006, Jones 2011).

Table 2.4. General dissolved oxygen concentration guidelines for aquatic organisms (Jones 2011).

Dissolved Oxygen Concentration (mg/L)	Impacts to Aquatic Organisms
0-2 mg/L	not enough oxygen to support life
2-4 mg/L	only a few kinds of fish and insects can survive
4-7 mg/L	acceptable for warmwater fish
7-11 mg/L	very good for most stream fish including cold water fish

As the lake surface begins to cool in the fall or winter, the density difference between the epilimnion and hypolimnion begin to decrease, losing their pronounced boundary, and becoming increasingly uniform (Wetzel 2001, Matthews et al. 2006). Eventually, the density between the surface and bottom waters are sufficiently similar that wind-generated internal waves mix the entire water column. This process is called “turn-over” and is often completed within a few days or hours during the first major wind storm in the fall (Wetzel 2001, Matthews et al. 2006).

On 24 October 2014, the surface water temperature of Lake Kapowsin was 14.6° C and remained relatively consistent throughout the water column before decreasing slightly between 6.5 and 7 meters depth (Figure 2.7), suggesting that the lake had already turned-over for the season. Dissolved oxygen concentrations were low (< 6 mg/L) and uniform throughout the water column. While acceptable for warmwater fish, this dissolved oxygen concentration was below ideal conditions for cold water fish (Table 2.4).

By 6 January 2015, the surface water temperature had cooled to 6.6° C, decreased to 5.3° at a depth of 1 meter and was nearly uniform from 1 meter to the lake bottom (Figure 2.8). Dissolved oxygen concentrations had increased to above 10 mg/L throughout the water column, levels good for all aquatic organisms.

On 29 April 2015, the surface water temperature had increased to 14.2° C and the lake had begun to thermally stratify (Figure 2.9). The epilimnion of the lake extended from the water surface to 1 meters depth, where water temperatures were relatively similar. The metalimnion and zone of largest temperature change occurred between 1 and 3 meters depth. Water temperature continued to decrease slightly throughout the hypolimnion to 10.4° C, just above the bottom of the water column. There were some signs of oxygen depletion within the metalimnion and hypolimnion in April 2015, although dissolved oxygen levels were still near or above oxygen saturation (9.78 – 14.31 mg/L) throughout the water column. Dissolved oxygen “supersaturation” can occur when oxygen is produced by algae and aquatic plants more quickly than it can escape into the atmosphere (Jones 2011). In lakes with algae and dense aquatic vegetation, similar to Lake Kapowsin, dissolved oxygen can become supersaturated during the day as algae and plants produce oxygen and under-saturated during the night as bacteria consume oxygen.

Continued temperature and dissolved oxygen profile measurements, especially during summer months, and from year to year, are recommended to determine:

- if thermal and chemical stratification continues throughout the summer growing season,
- if there is adequate oxygen for fish and other aquatic organisms,
- how oxygen concentrations vary with depth or in different areas of the lake during the day,
- if internal phosphorus loading into the lake is expected,
- where photosynthesis and respiration dominate within the lake and whether this could have impacts on biota or chemistry, and
- whether lake conditions are improving or degrading over time (Jones 2011).

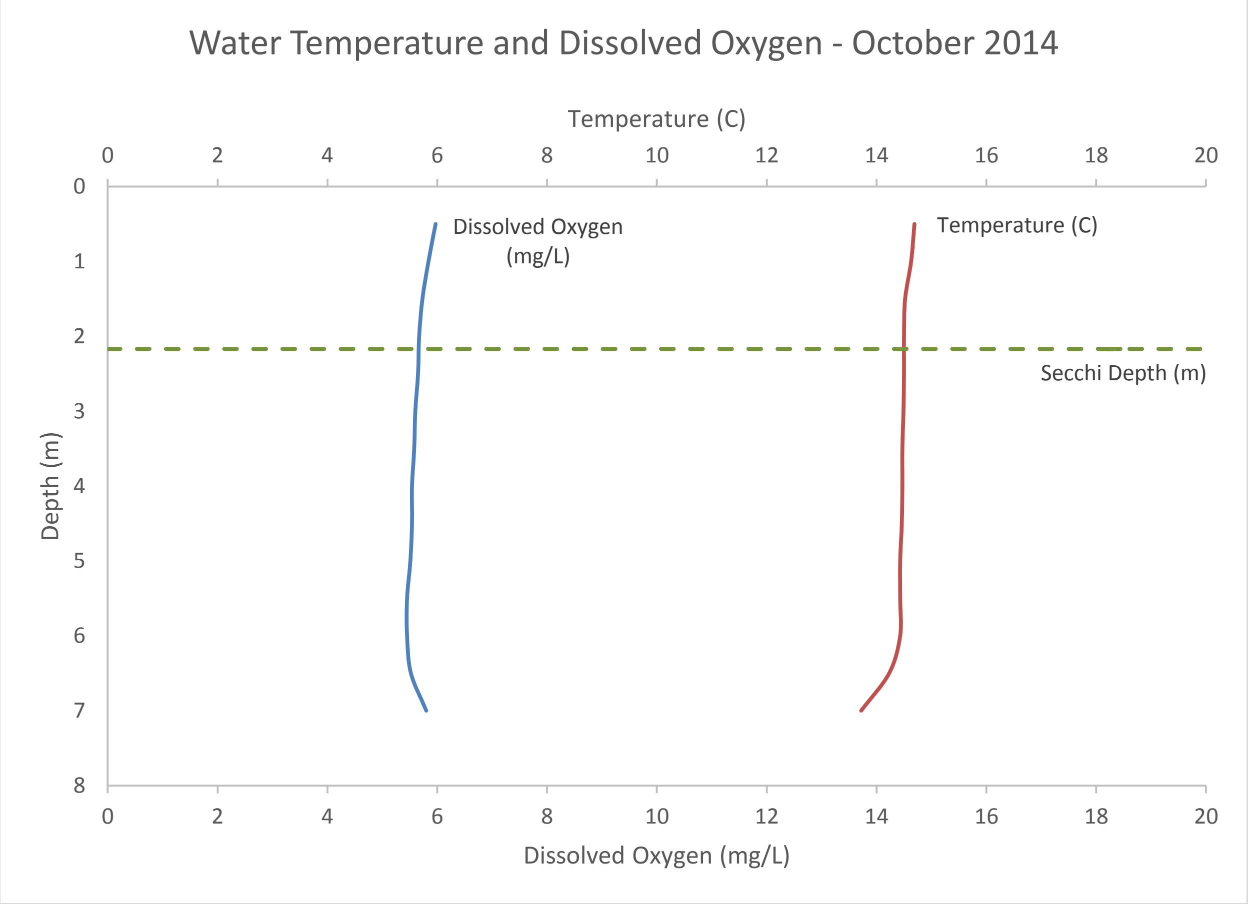

Figure 2.7 Lake Kapowsin water temperature and dissolved oxygen vertical profile on 24 October 2014. Secchi depth shown.

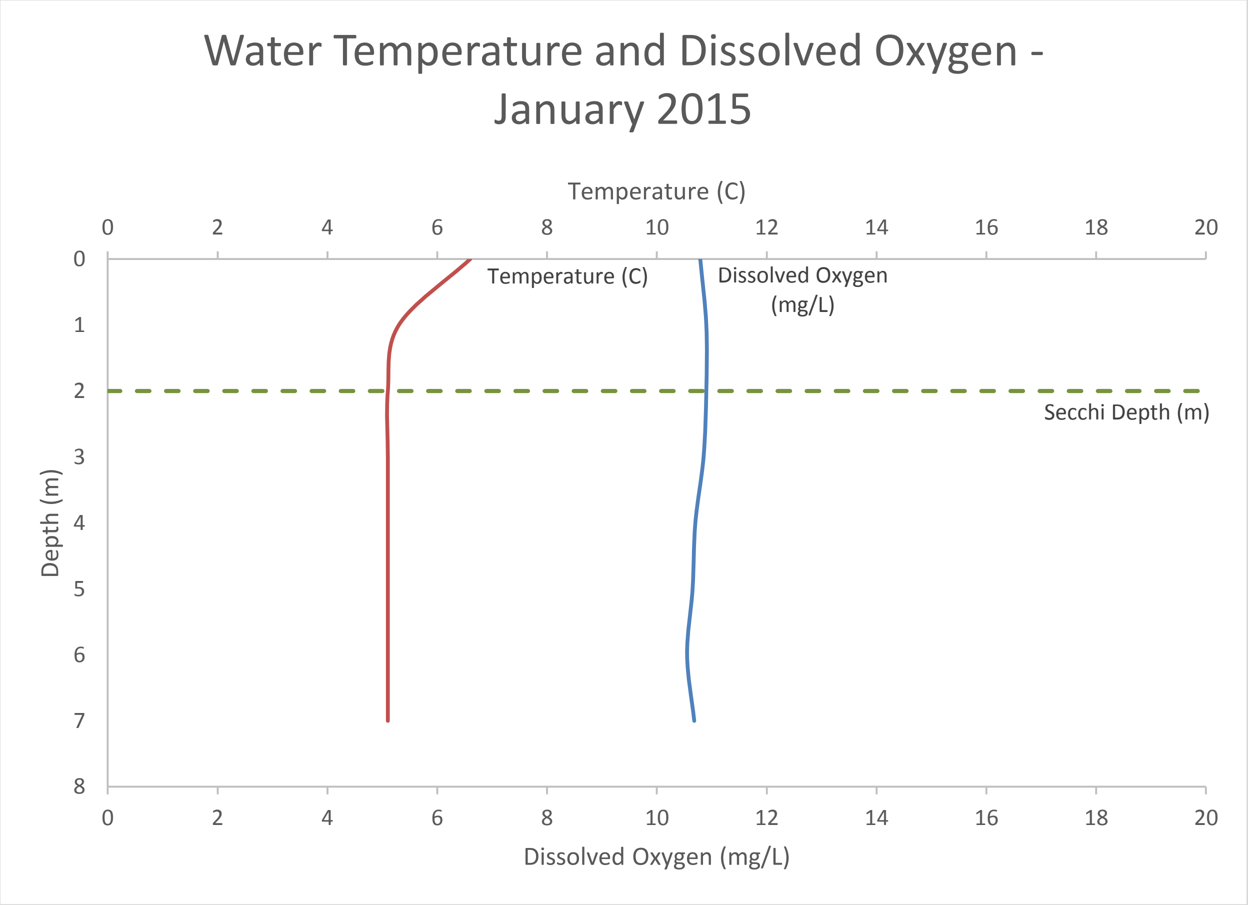

Figure 2.8 Lake Kapowsin water temperature and dissolved oxygen vertical profile on 6 January 2015. Secchi depth shown.

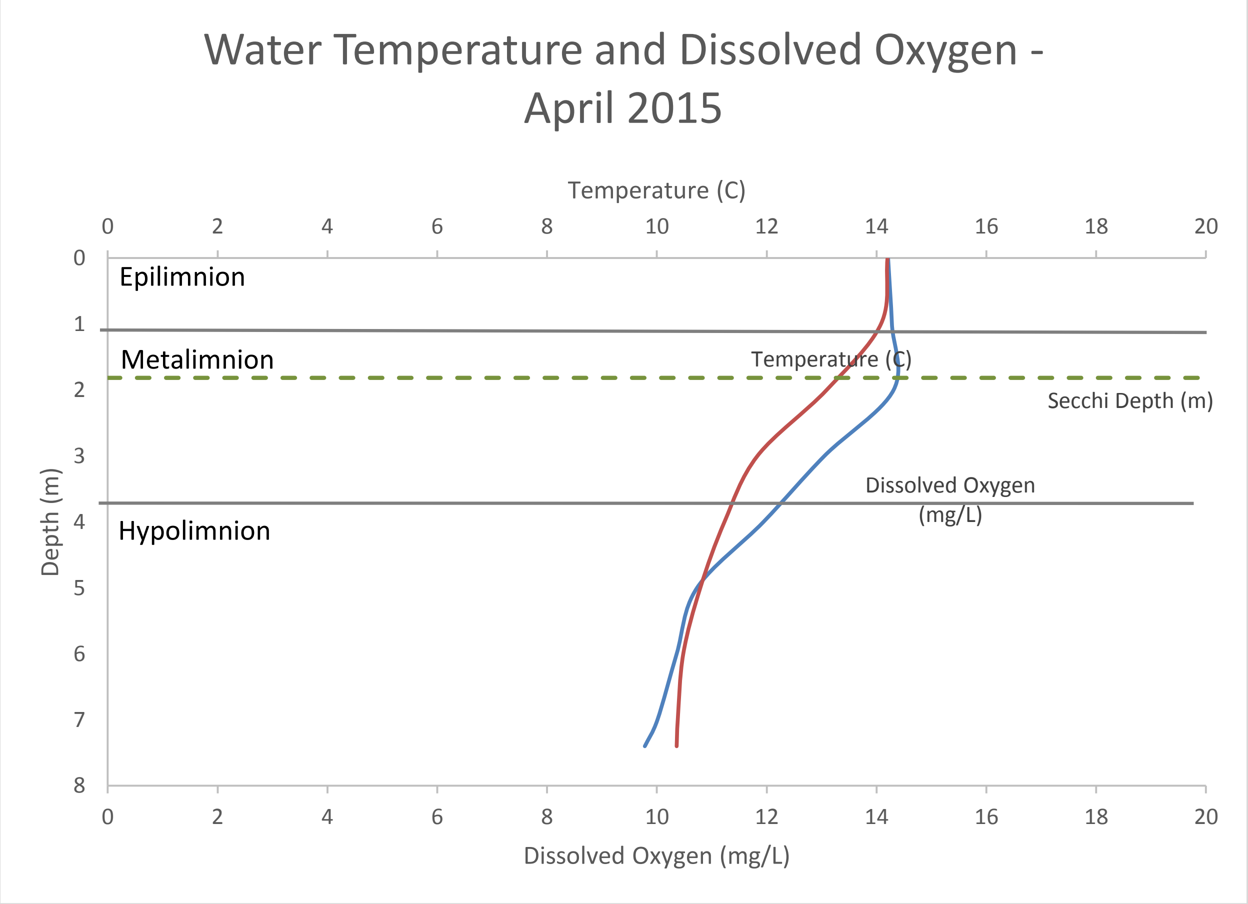

Figure 2.9 Lake Kapowsin water temperature and dissolved oxygen vertical profile on 29 April 2015. Secchi depth shown. Epilimnion, metalimnion and hypolimnion shown based on thermal stratification.

Alkalinity, pH and Specific Conductance

Alkalinity, pH, and conductivity are related in aquatic systems (Matthews et al. 2006). Conductivity and pH are measures of dissolved ions in the water. Conductivity measures the ability of a solution to carry an electrical flow (Wetzel 2001). Acidity, reported as pH, is determined by measuring the proton activity of hydrogen ions in a solution (National Research Council 1983). Alkalinity is the ability of a solution to neutralize (buffer) acids and is usually related to the levels of carbonate ions (carbonic acid, carbonate and bicarbonate) in the water. Higher carbonate levels in water result in a higher buffering capacity (Wetzel 2001).

A pH profile measured on 24 October 2014 showed a relatively uniform pH of 6.75 throughout the water column of Lake Kapowsin (Figure 2.10). By 29 April 15, the pH throughout the water column had decreased below 6 and showed evidence of vertical stratification. The pH of the lake's surface water was 5.5 and steadily increased to 5.9 at 2 meters depth before decreasing relatively quickly to a pH of 5.3 at a 4 meters depth. Below 4 meters depth, the pH continued to decrease to 4.9 at 7.4 meters depth. The increase of pH within the epilimnion indicated the influence of photosynthesis and bacterial decomposition in the lake as CO_2 was removed, resulting in a temporary reduction in the concentration of dissolved carbonic acid (Matthews et al. 2006). Concurrently, the pH level decrease in the hypolimnion is an indication of the accumulation of acidic decomposition products broken down by bacteria and settling to the bottom of the lake (Matthews et al. 2006).

The pH of natural waters ranges from < 2 to 12, where pH 7 is neutral, values below 7 are increasingly acidic and values above 7 increasingly basic (Wetzel 2001). In natural waters, lethal effects of acidity typically occur at a pH of 4.5 (Wetzel 2001), although negative effects in biological communities are seen starting at pH values just below 6.0 (Mills and Schindler 1986). Additional monitoring of Lake Kapowsin's pH levels are recommended to determine the extent and duration of low pH within the lake.

In April 2015, the alkalinity of Lake Kapowsin was fairly low (19.93 mg CaCO3/L; Table 2.5), indicating that it is not well buffered against pH changes. These results correspond to the lower pH levels measured in the lake.

On 24 October 2015, the average specific conductance within the upper two meters of Lake Kapowsin was 57.7 uS/cm (± 0.16 SD), measured in-situ with a multi-parameter probe. On 29 April 2015, specific conductance within the upper 2 meters of the lake was 49.3 uS/cm.

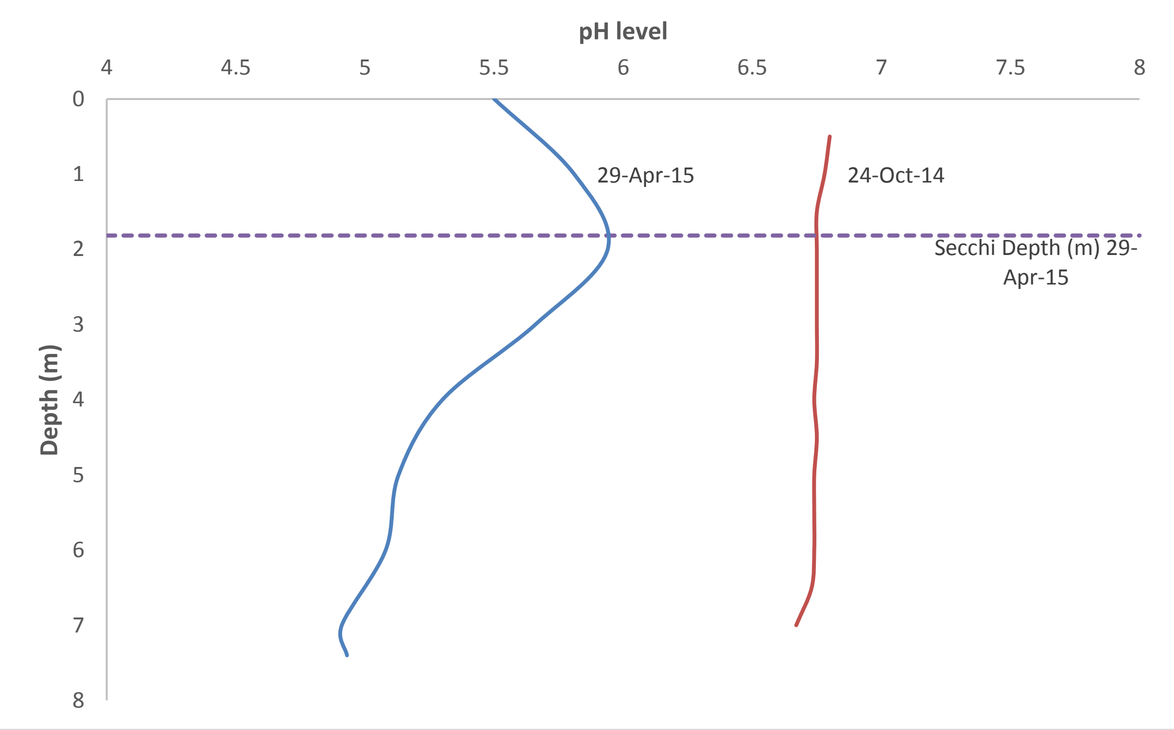

Figure 2.10. Lake Kapowsin pH vertical profile for 24 October 2014 and 29 April 2015. Secchi depth on 24 April 2015 also shown.

Table 2.5 Lake Kapowsin water chemistry results on 24 October 2014 and 29 April 2015.

Analyte	**24 Oct 2015 (UW2)**	**29 April 2015 (Index)**
Alkalinity (mg CaCO3/L)	-	19.93
Conductivity (uS/cm)	57.7	49.3
Total Suspended Sediment (mg/L)	-	3.20
Turbidity (NTU)	-	3.07
Ammonium (NH3-N mg/L)	-	*0.007
Nitrate/Nitrite (NO3-N mg/L)	-	0.041
Total Nitrogen (mg N/L)	396.8	390.0
Total Phosphorus (ug P/L)	97.9	30.0
Silica (Si mg/L)	-	8.01
Chloride (Cl mg/L)	-	2.18
Sulfur (SO4-S mg/L)	-	0.68
Sodium (Na mg/L)	-	3.52
Potassium (K mg/L)	-	0.68
Calcium (Ca mg/L)	-	4.15
Magnesium (Mg mg/L)	-	1.60
Chlorophyll-a (Index) (ug/L)	5.3	13.5
Chlorophyll-a (Littoral St J) (ug/L)	-	16.2

*Below detection limits

Nutrients: Nitrogen and Phosphorus

Nitrogen and phosphorus were measured in the laboratory from water samples collected at Lake Kapowsin on 24 October 2014 and 29 April 2015. Samples were analyzed to measure total dissolved nitrogen, nitrate-nitrogen (NO3), ammonia-nitrogen (NH4) and total dissolved phosphorus.

Nitrogen and phosphorus are important nutrients supporting the primary algal production necessary to support lake food webs. Though nitrogen rarely limits algal growth in lakes, the type available often determines which species of algae will be abundant (Matthews et al. 2006). Most algae can only use dissolved inorganic nitrogen for growth. During the summer, as algae take up dissolved nitrogen, dissolved inorganic nitrogen concentrations may fall so low that nitrogen becomes a limiting factor to algal productivity. These conditions favor the growth of toxic cyanobacteria (bluegreen "algae") because they can convert dissolved nitrogen gas into usable forms of inorganic nitrogen (Matthews et al. 2006).

In Lake Kapowsin, total nitrogen concentrations were 396.8 µg N/L in October 2014 and 390.0 µg N/L in April 2015 (Table 2.5). Nitrate/nitrite concentration was 40 µg N/L in April 2015. Nitrate/nitrite was not measured in October 2014. Ammonia (NH4 – N) was below detection limits

(<0.01 mg N/L) in April 2015. We could not verify the methodology used to measure ammonia in October 2014 and are therefore, not presenting these data here. A progressive reduction of total nitrogen and nitrate/nitrite throughout the summer is expected, due to uptake by algae, lasting until lake turnover in the fall. Additional sampling during summer and fall months is recommended to confirm or reject this hypothesis and to determine if nitrogen is limited in Lake Kapowsin during the summer.

In many lakes, phosphorus is the nutrient primarily limiting biological productivity, because it is required by all algae and the concentration of biologically available phosphorus for algal growth is typically quite low in lakes (Wetzel 2001, Matthews et al. 2006). This also means that small increases in biologically available phosphorus can result in very rapid increases in algal growth (USEPA 2012). Phosphorus tends to bind to the surface of small inorganic and organic matter and is often moved from terrestrial to aquatic environments through runoff (Wetzel 2001). To become available for algae, phosphorus must be released into soluble forms. During stratification, when dissolved oxygen concentrations are low in the hypolimnion, soluble phosphorus will be released from the sediment surface, becoming available for algae.

In Lake Kapowsin, the total phosphorus concentration was 97.9 µg P/L in October 2014 and 30.0 µg P/L in April 2015. These concentrations are associated with eutrophic, or biologically productive, lakes. Total phosphorus concentrations may have been lower in April 2015 due to increased algal uptake during this time (see chlorophyll-*a* results and discussion). Additional sampling during summer and fall months is recommended to measure how phosphorus levels change during summer stratification.

Water Clarity: Secchi Depth, Chlorophyll-a, Turbidity and Total Suspended Solids

Water clarity refers to the transparency or clearness of the water and is important in determining the depth-of-penetration of sunlight within a lake. Light penetration is especially important for submerged aquatic plants. Suspended materials like sediment (silt or clay, inorganic material), or organic matter (algae, plankton and decaying material), can all reduce water clarity. Dissolved organic matter, such as humus, peat or decaying plant matter, can produce a yellow or brown color and also reduce water clarity.

Secchi depth is a measurement of water transparency and determines the approximate depth at which light conditions favor photosynthesis (aka. photic zone) (Matthews et al. 2006). Chlorophyll-*a* is a measure of algal productivity. Turbidity and total suspended solids (TSS) are both measures of suspended solids in the water column, which includes algae as well as inorganic particles and non-living organic matter. Turbidity measures the amount of light scattered from a sample (more suspended particles cause greater scattering), whereas TSS measures the weight of the particles per volume of water (Wetzel 2001). High chlorophyll-*a*, turbidity, and TSS can reduce primary production by limiting the penetration of light into the water column.

In Lake Kapowsin, Secchi depths decreased 0.2 meters between each survey date: October 2014 (2.2 m), January 2015 (2.0 m), and April 2015 (1.8 m) (Figures 2.7-2.9). While taking Secchi depth readings, the water appeared tea-colored, which contributed to reduced water clarity. Decaying plants and other organisms can release natural dissolved organic acids such as tannins and lignins, which give water a tea color, also known as humic stain.

Lake Kapowsin turbidity and total suspended solids levels were low in April 2015 (Table 2.5). Turbidity and total suspended sediment was not measured in October 2014 and January 2015.

Chlorophyll concentration in Lake Kapowsin was lower in October 2014 (5.3 ug/L), than in April 2015 (13.5 ug/L). No chlorophyll measurements were taken in January 2015. Chlorophyll is the most direct measurement of algal productivity, which typically is at its highest during the summer. An additional chlorophyll measurement was collected in the littoral zone of the lake (at Physical Station J). In the littoral zone, chlorophyll concentration was higher (16.2 ug/L) than at the deepest point in the lake. This is likely due to warmer water temperatures and increased algal productivity in the shallower littoral zone of the lake.

Based on these results, the reduction in water clarity between October 2014 and April 2015 may be due to an increase in algal production in April, although with limited sampling, cause and effect cannot be determined conclusively. In most lakes, Secchi depth begins to decrease in the spring and continues decreasing until algal growth peaks in the summer. As algal growth decreases in fall and winter, Secchi depth increases again. In Lake Kapowsin, however, the humic stain of the lake water may contribute to year-round reduced water clarity.

Trophic State

Carlson's Trophic State Index (TSI) (Carlson 1977) is a method widely used to classify lakes based on biological productivity and is utilized by the US EPA as part of their NLA Program (USEPA 2012). Lakes are usually classified as one of three possible trophic classifications: oligotrophic, mesotrophic or eutrophic. Oligotrophic lakes are typically cool and clear and have low concentration of nutrients and low rates of productivity. Eutrophic lakes have high nutrient levels, high plant production rates, and an abundance of plant life. Lakes that fall in between these classifications are mesotrophic. Lakes on the extreme ends of the scale may be considered hypereutrophic or ultra-oligotrophic. All lakes naturally fall into each of these categories and therefore, there is no ideal trophic state for lakes as a whole. Trophic state indices can be used to compare the biological productivity between lakes and to also measure change in biological productivity over time at a single lake.

Trophic state may be calculated using chlorophyll-*a* concentrations (algal biomass), Secchi depth (water transparency), or total phosphorus concentrations (usually the nutrient limiting algal growth). Chlorophyll is the most direct measurement of algal productivity, and when available, should be the primary basis for a trophic index (Carlson 1977). Chlorophyll-*a* is also used by the US EPA NLA Program to determine trophic state (USEPA 2012).

TSI (chlorophyll-*a* concentration ug/L) = 9.81 (chlorophyll-*a* concentration ug/L) + 30.6

Typically, unproductive or oligotrophic lakes have TSI values lower than 30, moderately productive mesotrophic lakes have TSI values of 40 - 50, while productive or eutrophic lakes have TSI values higher than 50.

Based on chlorophyll-*a* concentration, Lake Kapowsin was mesotrophic in October 2014 (TSI 46.9) and eutrophic in April 2015 (TSI 56.1). It is not unusual for a lake to have different trophic states throughout the year as biological productivity changes. Eutrophic lakes are naturally occurring and can be biologically diverse with abundant fish, plant and wildlife. Human activities, such as lakeshore development and poorly managed agriculture, however, can result in excessive nutrient concentrations, accelerated eutrophication and can cause undesirable effects such as nuisance algae, excessive plant growth, murky water, odor and fish kills (USEPA 2012). To better understand biological productivity in Lake Kapowsin, it is recommended that trophic state is measured during the summer growing season.

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3.0 MACROINVERTEBRATE SAMPLING

3.1 Introduction

The objective of the benthic macroinvertebrate sampling effort was to characterize the biological condition, or health and productivity of Lake Kapowsin in terms of the presence, number and diversity of benthic macroinvertebrates that serve as a direct measure of the lake's overall well-being. These results will serve as a baseline condition for the lake and with additional monitoring can be used to determine changes and trends over time.

3.2 Methods

3.2.1 Field Sampling

Macroinvertebrate sampling was conducted on April 29th and 30th, 2015. Macroinvertebrates were collected in the littoral zone of each of the ten, evenly spaced physical habitat stations (see 2.3.1 Physical Habitat) located around the perimeter of the lake (USEPA 2012a). After identifying the dominant littoral habitat type at each station, a 500 µm D-frame kick net was used to sweep through 1 linear meter of the dominant habitat type. To disturb the substrate and dislodge organisms, we used our feet or the frame of the net. After completing the 1 meter sweep, all organisms were removed from the net and placed into a 500 µm mesh sieve bucket, placed inside a larger bucket full of lake water. Larger predaceous invertebrates were immediately placed into a sample bottle and preserved with ethanol. At the end of each sampling day, benthic macroinvertebrates were transferred from the sieve bucket to sampling jars and preserved with ethanol. Samples were kept in a cool, dark location until shipped to Rhithron Associates, Inc. for identification and enumeration.

3.2.2 Laboratory Analyses

A full technical summary of the laboratory analyses methods and quality assurance procedures can be found in Appendix 3.A.

Standard sorting procedures were applied to achieve a random subsample of a minimum of 500 organisms. A Caton sub-sampling device (Caton 1991), divided into 30 grids, each approximately 6 cm by 6 cm was used. The sample was thoroughly mixed in its jar(s), poured out and evenly spread into the Caton tray, and individual grids were randomly selected. The contents of each grid were examined under stereoscopic microscopes using 10x-30x magnification. All aquatic invertebrates from each selected grid were sorted from the substrate, and placed in 80% ethanol for subsequent identification. Grid selection, examination, and sorting continued until at least 500 organisms were sorted. The final grid was completely sorted of all organisms.

After the target number of organisms was obtained in the subsample, a large/rare search was performed: the Caton tray was scanned for additional organisms that were not collected in the subsample. No unique organisms were found in the large/rare search. All unsorted sample fractions were retained and stored at the Rhithron laboratory.

Organisms were examined individually by certified taxonomists, using 10x – 80x stereoscopic dissecting scopes (Leica S8E) and identified to the lowest practical level, using appropriate published taxonomic references and keys. Identification, counts, life stages, and information about the condition of specimens were recorded on electronic bench sheets. Organisms that could not be identified to the taxonomic targets because of immaturity, poor condition, or lack of complete current regionally-applicable published keys were left at appropriate taxonomic levels that were coarser than those specified. To obtain accuracy in richness measures, these organisms were designated as "not unique" if other specimens from the same group could be taken to target levels. Organisms designated as "unique" were those that could be definitively distinguished from other organisms in the sample. Identified organisms were preserved in 80% ethanol in labeled vials, and archived at the Rhithron laboratory.

Chironomids and oligochaetes were carefully morphotyped using 10x – 80x stereoscopic dissecting microscopes (Leica S8E) and representative specimens were slide mounted and examined at 200x – 1000x magnification using an Olympus BX 51 or Leica DM 1000 compound microscope. Slide mounted organisms were archived at the Rhithron laboratory.

Internal quality control procedures for initial sample processing and subsampling involved checking sorting efficiency (Appendix 3.A).

3.2.3 Data Analysis

Measurements of biotic integrity for lakes have not been established, so it is not possible to give numeric scores or assessment classifications for the lake based on the macroinvertebrate assemblages. Nor is it possible to provide comparisons with a reference condition, because of the unique habitat represented by Lake Kapowsin.

3.3 Results and Discussion

3.3.1 Physical Habitat Characteristics

Substrates at 8 of the 10 locations were characterized by muck, woody debris, and fines (sand, mud, organic material). The other 2 locations had cobble/gravel substrates. A detailed analysis of the physical habitat characteristics of each macroinvertebrate sampling station can be found in section see 2.3.1 Physical Habitat of this report.

3.3.2 Invertebrate assemblage: taxonomic composition

Twenty-seven unique invertebrate taxa in 7 orders were identified in the composite sample (Appendix 3.B). A low-resolution depiction of the taxonomic composition of the sample is given in Figure 3.1. Seventy-six percent of the animals collected in these samples were crustaceans: among these, the dominant taxon was the isopod *Caecidotea* sp., which accounted for 52.3% of the collected invertebrates. The other crustacean present in significant numbers was the amphipod *Crangonyx* sp. (22.1%). Amphipods and isopods are frequently the most abundant taxa in shallow-water lentic systems. The relatively low value for the Shannon Diversity index (1.65) reflects the strong dominance of these taxa. The homogeneous fauna of the littoral zones of Lake Kapowsin may be related to the simple habitat structure of the sampled littoral zones, the relative instability associated with fine sediments, and relatively monotonous food resources, which may have been dominated by detritus. All of these factors appear to be consistent with a shallow, warm-water, tannic lake that supports a warm-water fishery.

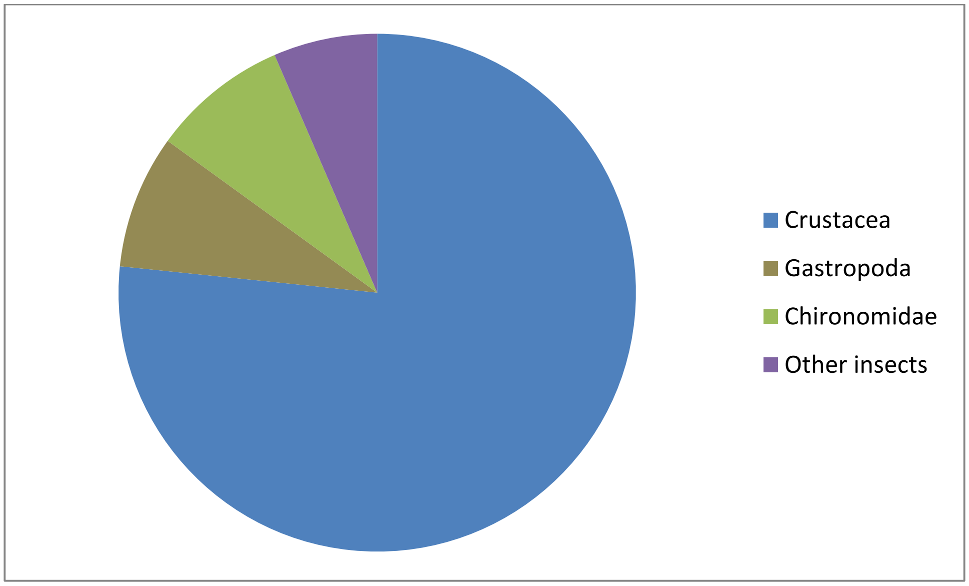

Figure 3.1. Taxonomic composition of Lake Kapowsin benthos.

The dominance of the isopod *Caecidotea* sp. suggests warmwater temperatures and relatively high organic nutrient concentrations. This is consistent with other studies which found that *Asellus,* (also in the Asellidae family), was usually absent in soft, unproductive waters (Wetzel 2001).

Seven hemoglobin-bearing chironomid taxa, accounting for 12.2% of sampled animals, were counted in the composite sample. These included *Chironomus* sp., *Microtendipes* sp., *Polypedilum* sp., *Clinotanypus* sp., and others. The presence of hemoglobin in the circulating fluids of these animals allows them to tolerate low oxygen conditions; their abundance in the Lake Kapowsin sample suggests that benthic substrates are hypoxic. Several chironomid taxa characteristic of stained water with lower pH conditions were collected: these included *Chironomus* sp., *Ablabesmyia* sp., and *Psectrocladius* sp. Not a single mayfly specimen was collected. The absence of mayflies may be related to the mildly acidic conditions.

The gastropod fauna included an individual specimen of *Cipangopaludina chinensis*, the Chinese mystery snail, which is an invasive species. This snail prefers mud and silt substrates and a thermal range of 20-28°, which suggests that Lake Kapowsin may be vulnerable to increases in its population. To date, this species has exerted no recorded impacts in the Great Lakes, where it was first recorded about 70 years ago, and is considered relatively "benign" with respect to its potential to greatly change or influence ecosystems and native species. However, it may act as a vector for the transmission of parasites and disease, and may also be implicated in negative interactions with native gastropods. Because the snail can survive for weeks in a desiccated condition, dispersal overland by means of boats is of concern (Kipp et al. 2015). Other snails in the lake were native, and included the planorbid *Micromenetus* sp., and snails in the family Physidae.

3.3.3 Function/Food webs

By far, the most abundant functional group were detritivores (Figure 3.2). Both *Caecidotea* sp. and *Crangonyx* sp. are included in this feeding group. Both amphipods and isopods are generally omnivorous substrate feeders that consume detritus composed of bacteria, algae, fungi, and dead animal and plant material (Wetzel 2001; Dodds and Whiles 2010). The detrital material can come from inside the lake system itself, as when the ample macrophytes of Lake Kapowsin die and decompose, or from outside the lake system, as when terrestrial plant material falls into the lake and decomposes. The amphipods and isopods may, in turn, be fed on by fish and other predatory invertebrates. For example, sunfish and yellow perch, which are found in Lake Kapowsin, often selectively feed on larger amphipods (Wetzel 2001). It is probable that other fish species commonly found in Lake Kapowsin consume amphipods and isopods as well. The fact that these benthic detritivores/omnivores are so abundant in the lake suggests that detritus may be a large component of its basal trophic level and that detritrivory by the amphipods and isopods may play a large role in energy transfer in this food web.

Ecologists often separate food webs into those in which the basal trophic level is composed of primary producers (algae, living macrophytes in Lake Kapowsin), often referred to as “green food webs,” and food webs in which the basal trophic level is composed of detritus (the dead material consumed by the amphipods and isopods of Lake Kapowsin), often referred to as “brown food webs” (Mittelbach 2012). Although these food webs are often considered separately when ecologists study ecosystems, recent work highlights the interplay between these two food webs (Wolkovich et al. 2014) and the importance and positive effects of detritus in food webs (Hagen et al. 2012). In addition, the contribution of benthic communities and the importance of this pathway in the food webs of lakes is inversely proportional to lake size (Vadeboncoeur et al. 2002) suggesting that the small size of Lake Kapowsin makes it more likely that the benthic detritivores are an important component of the food web. Although further study would be needed to understand the relative importance of the green and brown food webs In Lake Kapowsin, the abundance of the detritivores in the littoral zone and the small size of the lake suggest that the brown food web contributes substantially to the overall lake food web.

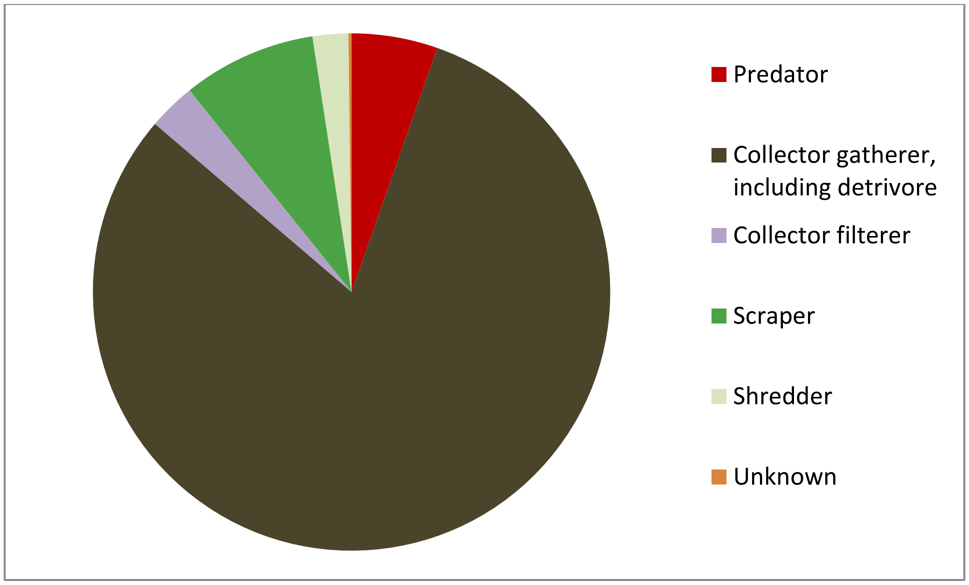

Figure 3.2. Functional composition of Lake Kapowsin benthos.

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4.0 CLIMATE CONDITIONS

4.1 Methods

Monthly average weather data was summarized to help establish a reference climate condition for Lake Kapowsin. The weather station at McMillin Reservoir Complex in Puyallup Washington was used as the source of data as it was the closest weather station to Lake Kapowsin with long term weather data. The McMillin Reservoir weather station has been collecting data since 1941 and is operated through the Western Regional Climate Center (WRCC) through the National Oceanic and Atmospheric Administration (NOAA). At 588 feet of elevation, the McMillin Reservoir Complex is similar in elevation to Lake Kapowsin (600 feet) and is only 10 miles due north of the lake. We summarized the average monthly temperature (maximum and minimum) and precipitation at McMillin Reservoir for the last 73 years to establish the expected climate conditions for Lake Kapowsin. Only temperature and precipitation (rain and snow) data were available from the weather station. Wind data was not available.

4.2 Results and Discussion

The average annual maximum temperature at McMillin Reservoir was 59.4° Fahrenheit (F), while the average annual minimum temperature was 40.6° F. The warmest average monthly maximum temperature was 75.4° F, which occurred in August, while the coldest average monthly minimum temperature was in January at 31.4° F. The total yearly precipitation was 41.34 inches. The wettest month of the year was November with an average of 6.04 inches of precipitation. The driest month of the year was in July with an average of 0.97 inches of precipitation. The average annual snowfall at McMillin Reservoir was 8.6 inches. A summary of the average monthly minimum and maximum temperatures and monthly precipitation can be found in Table 4.1.

Table 4.1. Average monthly maximum and minimum temperatures and precipitation at McMillin Reservoir Complex in Puyallup (WRCC 2015).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annu
Average Max. Temperature (F)	44.6	48.5	52.5	57.9	64.3	69.1	75.2	75.4	70	60.1	50.4	45.3	59.4
Average Min. Temperature (F)	31.4	32.9	34.9	38.2	43.2	47.8	50.7	51	47	41.4	36	32.6	40.6
Average Total Precipitation (in.)	5.64	4.28	3.96	3.22	2.43	2.13	0.97	1.24	1.93	3.7	6.04	5.79	41.34
Average Total SnowFall (in.)	3	1.4	1.4	0.1	0	0	0	0	0	0	1	1.8	8.6

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5.0 AQUATIC VEGETATION

5.1 Methods

An aquatic plant species inventory was conducted with special emphasis on the identification of invasive and rare aquatic plant species at Lake Kapowsin. This inventory followed the Washington Department of Ecology's (Ecology), Aquatic Plant Sampling Protocol (Parsons 2001) and the National Lakes Survey Assessment Field Operations Manual (USEPA 2011). Surveys were conducted by boat with an experienced botanist documenting plants visible at and below the lake surface. Eight randomly selected 20-40 m long transects on the lake were surveyed to capture floating and submerged vegetation at different depths along each transect. Two additional survey transects were strategically placed at the boat launch and near the former Erickson's Boat Rental property (north shore ~650 meters WNW of boat launch), as public access areas are most likely to contain noxious weed species (Figure 5.1).

The boat generally followed transects beginning at the shoreline and running 25 to 40 meters through the littoral zone toward the center of the lake. Aquatic plant information was collected at 5 to 6 points along each transect, noting plant species observed, water depth (meters) and distance from shoreline (meters). In shallower reaches, aquatic plants were readily observed from the surface and samples of submerged aquatic plants could be reached by hand for species identification. In deeper areas, a double handled rake attached to a rope (rake) was dropped from the boat to pull up pieces of submerged aquatic plants for documentation. When utilizing the rake, it was lowered from the boat three to five times per sample point location to increase the likelihood of collecting aquatic vegetation.

All aquatic plants were identified to species, unless it was not possible to do so without microscope or chemical analyses, or due to lack of flowering or other identifying structures. If not possible to identify to species, the aquatic plant was identified to the lowest taxonomic class possible. Any rare aquatic plants (WNHP 2014) or aquatic noxious weeds (WNWCB 2014) were documented by GPS and photographed. Aquatic plant inventory surveys were conducted 8 June 2015 to meet the timing requirements of the project contract.

Three additional data sources of aquatic vegetation were collected on Lake Kapowsin:

- Wetland Inventory: aquatic plant species lists and relative cover from 10 wetland inventory sites (conducted 9-11 June 2015)
- Physical Habitat: General aquatic plant cover information from physical habitat data forms completed at 20 sites on the lake, including: 10 wetland inventory sites (June) and 10 invertebrate stations (29-30 April 2015)
- Lake Inventory: Aquatic plant monitoring was conducted by Ecology (9 Sept. 2000 and 15 July 2001)

Wetland inventory surveys conducted at 10 sites on Lake Kapowsin included documentation of aquatic plant species present in the littoral zone of each wetland site. Aquatic plant species at wetland sites were identified and their relative cover within the littoral zone throughout the wetland site was determined.

Physical habitat plots were conducted at 10 invertebrate stations and 10 wetland inventory sites on the Lake. Data collection included general information on aquatic plants in the littoral zone. Physical habitat forms were completed following the National Lakes Assessment methodology (USEPA 2011). Presence of aquatic plants was noted, and then presence and relative abundance of aquatic plant species by type (submerged, emergent, floating, total aquatic plants) was recorded. Aquatic plants were not identified to species during this exercise.

An inventory of Lake Kapowsin was conducted by Ecology personnel on 20 September 2000 and 15 June 2001 with a specific focus of monitoring for noxious weeds (Ecology 2014). A Lake Report was downloaded from the Ecology website although their survey methods were not specified. In addition to creating a species list, a distribution value (estimate of density) was assigned to each plant species.

5.2 Results and Discussion

5.2.1 Aquatic Plant Transects

Ten aquatic plant transects (25 to 40 m length) were conducted on Lake Kapowsin on 8 June2015 (Figure 5.1). Aquatic plant transects were conducted by boat, beginning near the shoreline (when accessible) and continuing 25 to 40 meters toward the center of the lake. Aquatic plant information was collected at 5 to 6 points along each transect, noting plant species observed, water depth (meters) and distance from shoreline (meters). The sampling effort included 10 transects and 54 plant sampling points. A total of 24 aquatic plant species were documented, which included 3 floating, 12 submerged and 9 emergent aquatic plant species (Appendix 5.A).

Aquatic plant transect J was located at the northwest corner of the lake, and had the highest number of plant occurrences (22) and unique plant species (13) (Figure 5.1). Transects C and H, also had high numbers of aquatic plant occurrences (17) and unique plant species (9) observed. Transects with the highest aquatic plant occurrence and plant species diversity (J, C and H) were associated with large wetland systems. Conversely, transects (A, D, G and I) which contained 6 or fewer plant occurrences of 3 or fewer unique species were located in areas with steeper bathymetry (deeper littoral zone) and were not associated with wetlands (Figure 5.1). One aquatic plant species, common bladderwort (*Utricularia macrorhiza* [was *U. vulgaris*]), was only observed along Transect C, with 3 occurrences. Common bladderwort is a submerged aquatic plant with unique carnivorous bladder-like traps found along the leaf stems and is found exclusively in bog habitats, with acidic waters (Ecology 2001, Hruby 2014).

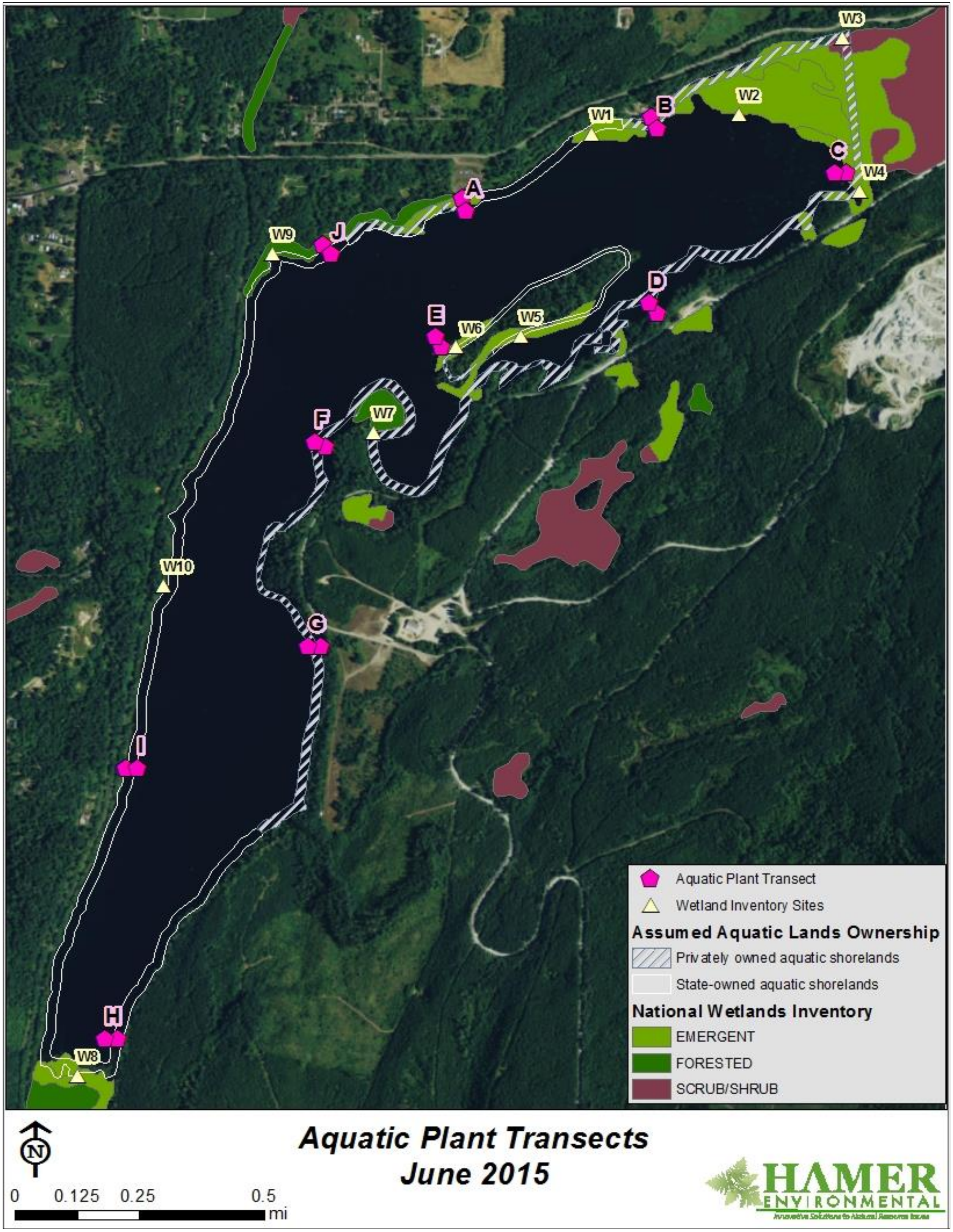

Figure 5.1. Aquatic Plant Transects (Ten) and Wetland Inventory Sites (Ten) on Lake Kapowsin.

The two most commonly observed plants were submerged aquatic pondweeds: Robbins' pondweed (*Potamogeton robbinsii*) and large-leaf pondweed (*Potamogeton amplifolius*) with 16 and 15 occurrences, respectively (Table 5.1). Other frequently encountered plant species included yellow pond lily (*Nuphar lutea* [was *N. polysepala*]) and common elodea (*Elodea canadensis*) with 15 and 10 occurrences, respectively. Some aquatic plant species were observed infrequently during transect surveys (excluding emergent plant species, which occurred more commonly above the lake shoreline). Those aquatic plants with only 1 occurrence, included: pond water starwort (*Callitriche stagnalis*), water moss (*Fontinalis antipyretica*), common duckweed (*Lemna minor*), common naiad (*Najas flexilis*), swaying bulrush (*Schoenoplectus subterminalis* [was *Scirpus s.*]) and Sago pondweed (*Stuckenia pectinata* [was *Potamogeton pectinatus*] (Table 5.1).

Table 5.1. Aquatic Plant Species Observed During Transect Surveys on Lake Kapowsin, Excluding Emergent Plants.

Scientific Name	Common Name	Plant Habit	No. of Occurrences	Depth Range (m)
Brasenia schreberi	watershield	Aquatic (Float)	6	0.3 - 1.6
Callitriche stagnalis	pond water starwort	Aquatic (Subm)	1	0.3
Ceratophyllum demersum	Coontail, hornwort	Aquatic (Subm)	3	0.5 - 2.6
Elodea canadensis	common elodea	Aquatic (Subm)	10	0.3 - 1.6
Fontinalis antipyretica	water moss	Aquatic (Subm)	1	1.7
Lemna minor	common duckweed	Aquatic (Float)	1	1.3
Najas flexilis	common naiad	Aquatic (Subm)	1	1.4
Nitella sp.	stonewort	Aquatic (Subm)	3	0.3 - 2.2
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Aquatic (Float)	15	0.2 - 2.1
Potamogeton amplifolius	large-leaf pondweed	Aquatic (Subm)	15	0.3 - 3.1
Potamogeton pusillus	small pondweed	Aquatic (Subm)	3	0.4 - 0.9
Potamogeton robbinsii	Robbins' pondweed	Aquatic (Subm)	16	0.3 - 3.1
Potamogeton zosteriformis	flatstem pondweed	Aquatic (Subm)	5	0.3 - 2.6
Schoenoplectus subterminalis	swaying bulrush	Aquatic (Emerg/Subm)	1	0.3
Stuckenia pectinata (was *Potamogeton pectinatus*)	Sago pondweed	Aquatic (Subm)	1	0.3
Utricularia macrorhiza (was *U. vulgaris*)	common bladderwort	Aquatic (Subm)	3	0.8 - 1.4

Aquatic plant occurrences and number of species observed were compared across different water depths sampled on the lake (Figure 5.2). The most plant occurrences (29) and unique species (18) were encountered within the shallowest areas of the lake (0.1 to 0.5 m depth). This result was expected, as emergent plant species were only documented in the shallowest depths and plants were easiest to observe in shallow waters. Excluding emergent plant species, 21 occurrences and 12 unique species were observed at 0.1 to 0.5 m depth, which was still higher than any other water depth category. The most common two submerged plant species observed, Robbins' and large-leaf pondweeds, were also the only plants to occur across all lake depth profiles where plants were found (0.1 to 3.5 m) (Figure

5.2). Generally, plant species and number of plant occurrences declined as water depths increased, with no plants observed below 3.1 m depths, though sampling continued to depths of 5.3 m (Figure 5.2).

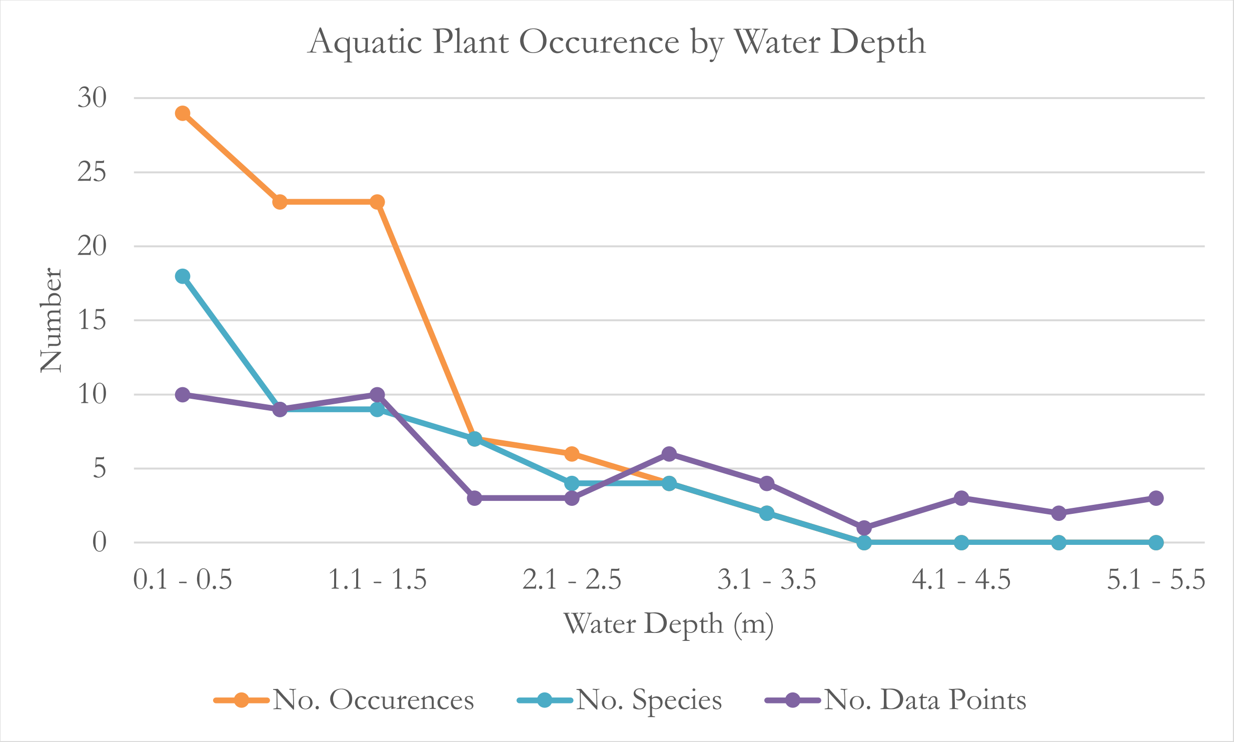

Figure 5.2. Aquatic plant occurrences and number of species observed by water depth at Lake Kapowsin.

Multiple Secchi disk measurements of water transparency conducted at Lake Kapowsin resulted in an average depth of 2.0 m where the disk disappeared, indicating the maximum depth light could reach (see Limnology Chapter 2.0). Below this depth (2.0 m) light conditions are not suitable to photosynthesis and become a limiting factor to plant presence. This was consistent with depth ranges of most aquatic plants observed on the lake, occurring at 2.0 m or shallower (Table 5.1). Aquatic species found in depths below two meters exhibited growth habits that allowed leaf structures to grow in shallower areas where photosynthesis could occur, including yellow pond lily, with floating leaves and pondweeds (*Potamogeton* spp.) and other submerged species that exhibited tall growth habits allowing leaves to reach shallower water depths while still being rooted in deeper waters (Table 5.1).

5.2.2 Limitations

The timing of aquatic plant surveys required to meet the project deadline (June) was initially deemed a limitation for the aquatic plant inventory, since surveys are typically conducted in late July to September. Late summer timing ensures aquatic plants are at the end of the plant growing season and that many have flowers necessary for species identification. However, the mild winter and warm spring weather in the region sped up the growing season, so the June inventory surveys encountered water levels and plant growth more typical of July conditions.

Aquatic plant transects, when conducted by boat (surface inventory), are deemed by Ecology as having a lower level of data reliability than when diver inventory surveys are conducted (Parsons 2001). Several factors made diver surveys impractical at Lake Kapowsin, including: lake characteristics (many stumps/underwater obstacles, low water visibility), additional cost, and project time limitations. In water too deep to see subsurface, boat-based surveys attempted to capture submerged plant presence through use of a double sided rake lowered from the boat. This method worked well in some areas of the lake, but was problematic in areas with high stump/tree root density where the rake could get stuck on underwater features. Floating logs along the lake shore margins created another barrier to access the shoreline edge of the aquatic plant transects. When floating logs were encountered, the surveyor attempted to access shallower littoral zone in an adjacent area not blocked by floating logs, and also spent more time meandering through the littoral zone in adjacent accessible areas.

5.2.3 Aquatic Plants in Wetland Sites

Ten wetland sites were inventoried at Lake Kapowsin on 9-11 June 2015 to document dominant vegetation and classify and rate the wetlands. As part of this inventory effort, aquatic plants found within the littoral zone of the wetland sites were inventoried (Figure 5.1). Emergent plants (cat-tails and the like) were included in this assessment of aquatic plants only if they were found within the littoral zone (below OHWM). Proportion of cover was collected for dominant aquatic plant species as part of the wetland inventory, but weren't reported separately for the littoral zone (see Wetland Inventory Section 6.0).

For all wetland sites combined, a total of 43 aquatic plant species were documented in the littoral zones, which included 13 submerged, 5 floating and 25 emergent plant species (Appendix 5.1). The highest aquatic plant diversity was found at Wetland Site 8 (25 total, 9 submerged, 3 floating, 13 emergent) and Site 1 (24 total, 9 submerged, 3 floating, 12 emergent). Wetland Site 8, located at the south end of the lake, had a sizeable, gradual littoral zone, and contained the largest total area of aquatic plant cover on the lake. Several emergent plant species, such as spikerushes (*Eleocharis* spp.) were unique to this site and grew along the shoreline edge of the littoral zone (below OHWM). Wetland Site 1 was at the north end of the lake and consisted of vegetated floating logs interspersed with open water habitat and a beaver lodge. Aquatic plant cover at this wetland was diverse, but not unique to the site. Wetland Site 3 contained the lowest number of aquatic plants, but was located within a scrub/shrub area with only small pools of water and no littoral zone. Wetland Sites 5, 7 and 10 also contained lower aquatic plant species diversity relative to other wetland sites. These wetland sites were all lake-fringe wetlands of limited size, with narrow bands of both emergent and aquatic plant cover.

The aquatic plant component of the wetland inventory was a good complement to the boat-based survey transects, as shallower emergent and littoral zones with floating log cover were more easily accessed and viewed by land. Several aquatic species not documented during the boat-based aquatic plant inventory were documented during the wetland surveys. During the wetland inventory an additional 17 emergent plant species were documented in the shallow littoral zone below OHWM (ordinary high water mark) (Appendix 5.1). Aquatic plant species unique to the wetland inventory sites included 3 submersed and 2 floating aquatic species (Table 5.2).

Table 5.2. Aquatic Plant Species Documented Only at Wetland Inventory Sites, Excluding Emergents, on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced
Ludwigia palustris	water purslane	Forb	Aquatic (Float)	Nat
Azolla microphylla (was *A. mexicana*)	Mexican water fern	Fern	Aquatic (Float)	Nat
Potamogeton epihydrus	ribbonleaf pondweed	Forb	Aquatic (Subm)	Nat
Potamogeton praelongus	whitestem pondweed	Forb	Aquatic (Subm)	Nat
Limosella aquatica	water mudwort	Forb	Aquatic (Subm)	Nat

5.2.4 Department of Ecology Aquatic Plant Inventory

Aquatic plants were monitored by Ecology personnel in 2000 and 2001, with a particular focus on documenting any aquatic noxious weed species. Aquatic plants were identified by species and a distribution value (estimate of abundance) of 1 to 5 was determined: 1) few plants in only 1 or a few locations, 2) few plants, but with a wide patchy distribution, 3) plants growing in large patches, codominant with other plants, 4) plants in nearly monospecific patches, dominant and, 5) thick growth covering the substrate at the exclusion of other species (Ecology 2014). A total of 20 plant species were documented, including vascular plant and plant-like nonvascular moss species (Appendix 5.B). The most abundant aquatic plants, both with a distribution value of 3, included muskgrass (*Chara spp.*) and Robbins pondweed (*Potamogeton robbinsii*). Muskgrass, a plant-like algae, was not documented on Lake Kapowsin during the June 2015 aquatic plant transect or wetland inventory surveys. In 2000 narrow leaf cat-tail (*Typha angustifolia*), a Class C noxious weed, was documented on the lake. However, a subsequent visit in 2001 noted no other aquatic plant species except for common cat-tail (*Typha latifolia*) with a note that narrow leaf cat-tail was not found, implying this subsequent visit may have been to verify the identification and presence of the noxious weed. Narrow leaf cat-tail was not observed during 2015 field surveys.

5.2.5 Physical Habitat Assessment

Aquatic plant presence and abundance by aquatic plant type (submerged, emergent, or floating) was assessed at 20 different stations on the lake (Table 5.3). Late April surveys included 10 physical habitat sites at invertebrate stations, though aquatic plant cover was absent from 2 sites (see Invertebrates Section 3). June surveys of 10 wetland inventory sites, included 10 physical habitat sites (Figure 5.1). Proportion of aquatic plant cover by plant type was assessed using a range: 1) Sparse (<10%), 2)

Moderate (10-40%), 3) Heavy (41-75%) and, 4) Very Heavy (>75%), and assumed total aquatic plant cover and open water combined was 100%.

Table 5.3. Aquatic Plant Cover by Plant Type at 20 Physical Habitat Stations on Lake Kapowsin.

Stations	**Aquatic Plant Cover**			
	Submerged	**Emergent**	**Floating**	**Total Cover**
All Stations (20 stns.)	**Moderate** (10-40%)	**Moderate** (10-40%)	**Moderate** (10-40%)	**Moderate** (10-40%)
Invert only (10 stns.)	**Sparse** (<10%)	**Sparse** (<10%)	**Sparse** (<10%)	**Moderate** (10-40%)
Wetland only (10 stns.)	**Moderate** (10-40%)	**Heavy** (41-75%)	**Moderate** (10-40%)	**Heavy** (41-75%)

At all 20 surveyed stations combined, total aquatic plant cover was Moderate (10-40%), and all types of aquatic plants were present in Moderate amounts (10-40%) (Table 5.3). Aquatic plant cover was greatest when associated with wetland sites (Table 5.3). This result was expected, as lake fringe wetlands contained emergent vegetation along the shoreline-littoral zone interface. Submerged and floating aquatic vegetation cover was also higher at wetland sites than at the invertebrate sites assessed. This may be a result of shallower littoral zones associated with the wetland sites, which are conducive to both wetland and aquatic plant community formation. Emergent vegetation at wetlands is also beneficial to other aquatic plant communities as the emergent plants grow into the shallow littoral zone, slowing water flow and retaining sediments and nutrients.

For all physical habitat sites combined, emergent plants, such as common cat-tail (*Typha latifolia*), comprised the largest portion of aquatic vegetation (39%), while floating (33%) and submerged (27%) vegetation were slightly lower (Figure 5.3). Submerged vegetation may have comprised the lowest proportion of aquatic vegetation, due to the difficulty of viewing plants under water. Submerged vegetation cover may also have been under represented because the total cover could not exceed 100% for all vegetation in the littoral zone. Submerged vegetation grows in a separate layer from emergent and floating vegetation (essentially growing underneath other types of vegetation), which may lead to undercounting.

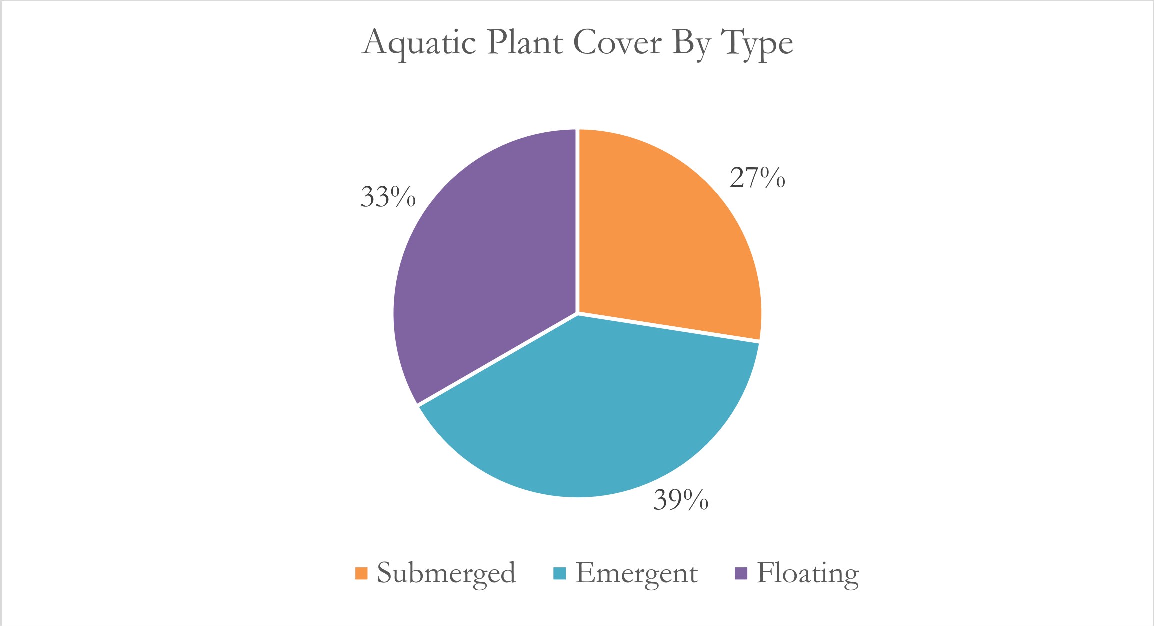

Figure 5.3. Aquatic plant cover by Plant type at 20 Stations combined on Lake Kapowsin.

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6.0 LACUSTRINE FRINGE AND EMERGENT WETLANDS

6.1 Methods

6.1.1 Wetland Site Selection and Data Collection

This inventory followed the National Lakes Survey Assessment Field Operations Manual (USEPA 2011) to inventory a subsample of lake-fringe and emergent wetlands on Lake Kapowsin. Ten wetland sites within the littoral and emergent zones of the lake were selected for inventory (Figure 6.1). Lacustrine fringe and emergent wetland inventory sites were selected based on aerial photo interpretation, existing maps of Lake Kapowsin wetlands, including National Wetland Inventory (NWI) maps and from existing knowledge of wetland habitats from a previous site visit in April 2015. Random stratified wetland site selection was attempted whenever possible, but access to areas was also an important consideration for site selection, particularly at large floating log wetland complex at the northeast end of Lake Kapowsin. The wetland plots were 15 m wide and extended from the upland border between emergent and upland vegetation (or shrub/forested wetland edge) to the lower littoral zone. The wetland sites were inventoried in detail, documenting dominant vegetation and relative cover, wetland classification, wetland quality rating (Hruby 2014), and susceptibility to degradation from potential impacts. Wetland inventory surveys were conducted concurrently with aquatic vegetation surveys 8-11 June 2015 to meet the timing requirements of the project contract.

6.1.2 Wetland Rating

Each wetland site was classified into Categories I – IV, with Category I wetlands rated as the highest quality/highest importance for preservation, to Category IV wetlands, which are typically disturbed and perform wetland functions at a low level. The intent of the Washington wetland rating system is to "differentiate among wetlands based on their sensitivity to disturbance, their significance, their rarity, our ability to replace them and the functions they provide" (Hruby 2014). Wetland ratings resulted from scoring a wetland's water quality, hydrologic and habitat functions. Wetland ratings were performed by a wetland scientist trained in the updated wetland rating methodology. Each of ten wetland sites were rated to provide information on wetland quality on Lake Kapowsin and to highlight those wetlands with higher functions, uniqueness, priority for further protection, enhancement, and/or further study.

Additional rationale to perform the wetland rating was to determine whether bog-like wetlands at the northeast end of Lake Kapowsin, and the southwest shore of Jaybird Island met the requirements to be rated as a bog (acidic peat wetland). Wetlands must meet criteria for soils (organic: peats or mucks) and plant species composition (moss layer, plant species associated with bogs/acidic fens) (Hruby 2014). The plants and animals found in bogs are adapted to the acidic conditions, soils and hydrologic regime of bog habitats. Those wetlands that meet criteria to classify as bogs are rated as Category I wetlands, due to their sensitivity to disturbance, uniqueness within Washington State and the extreme difficulty to restore or recreate bog habitats. Category I bog wetlands are not common, and protection of these areas is important as restoration or recreation of bog habitats is not successful due to their slow rate of formation (1 inch of organic soil in a bog takes 40 years to form in western Washington

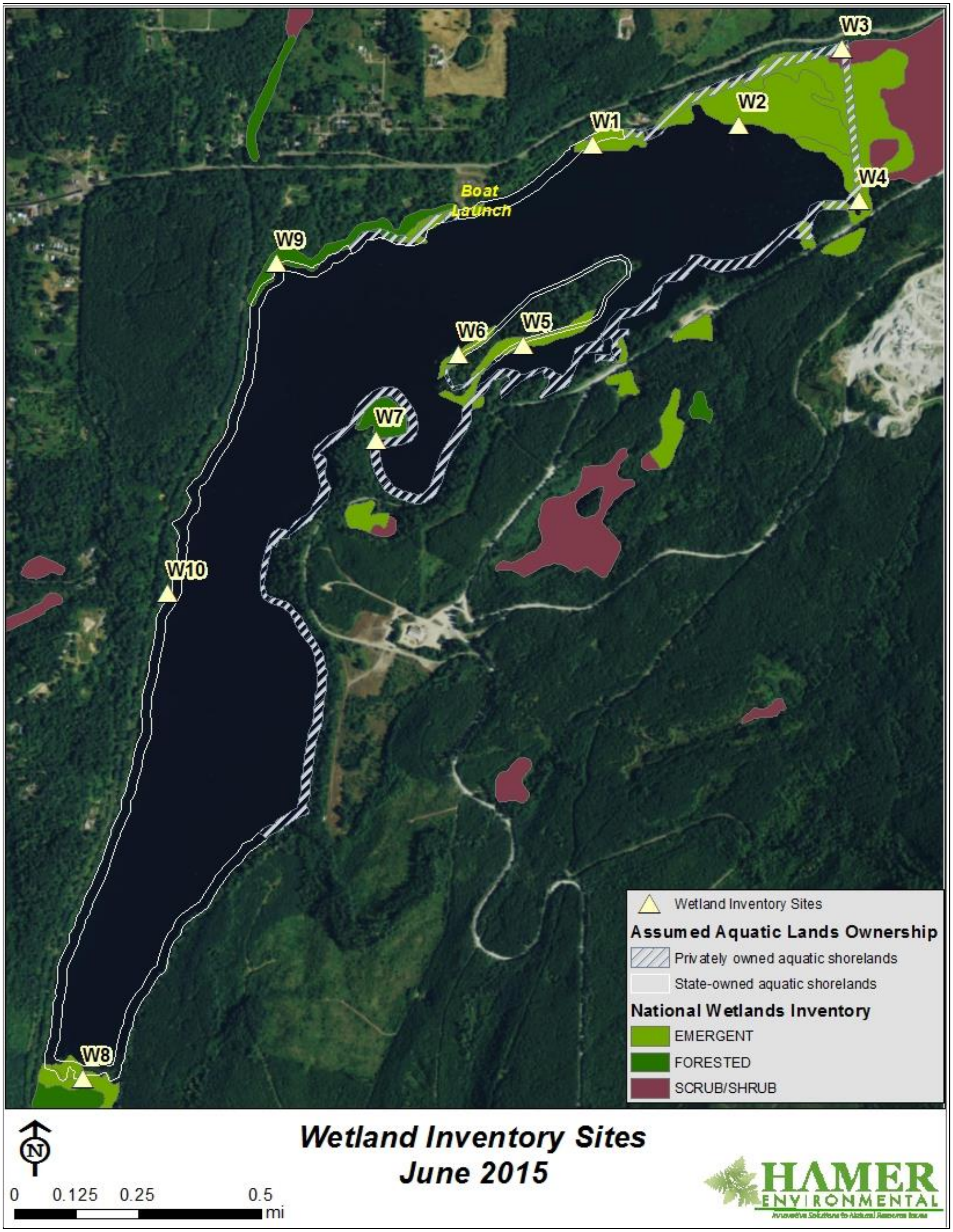

Figure 6.1. Wetland Inventory and Rating Sites on Lake Kapowsin.

[Rigg 1958]) and delicate balance of abiotic and biotic factors, which can be hugely impacted by small changes in water regime or nutrient inputs (Hruby 2014).

6.1.3 Wetland Mapping of Non-Sampled Lake Fringe Wetlands

A brief field and GIS exercise was conducted to document presence of other lacustrine fringe and emergent wetlands at sites on the lake that were not sampled in this study. This exercise was conducted by boating along the shoreline of the lake and documenting the shoreline extent of all lacustrine fringe wetlands and relying on wetland obligate plants as indicators of wetland presence. The inland extent of these wetlands was not determined as part of this exercise. Wetlands comprising a length along the shoreline of less than 25 meters were not mapped. The wetlands identified/confirmed were then digitized in GIS to provide a complete map of lake fringe wetlands on Lake Kapowsin.

6.1.4 Rare Plants and Noxious Weeds

Any state and/or federally listed rare plants (Washington Natural Heritage Program 2015) and noxious weeds identified during the wetland or aquatic plant surveys were documented by GPS and photographed. Rare plants listed with potential range in Pierce County were closely reviewed to eliminate those rare species with no habitat or an elevation profile that did not overlap with the Lake Kapowsin study area. Those rare plants with potential to occur in the study area included 13 emergent plants, 3 aquatic plants and 4 moss species (Appendix 6.A). Moss species were not included in the rare plant search effort at each wetland site, due to the additional time required to thoroughly inventory and identify non-vascular plants.

Noxious weeds included those species listed by the Washington Noxious Weed Control Board (NWCB) for Pierce County (Appendix 6.A). Noxious weeds were classified as A, B or C by the NWCB depending on their overall distribution within the state. Class A weeds have a limited distribution within Washington, so eradication of infestations is most critical. Class C weeds are well established throughout the state, so eradication of infestations is recommended, but not required.

6.2 Results and Discussion

6.2.1 Wetland Habitats and Composition

Wetland habitats were documented within each of ten wetland site that comprised ten percent or greater coverage of the entire wetland area (Table 6.1). Aquatic bed habitat included those wetlands with aquatic plants in the littoral zone or ponded habitat within the emergent zone. Forest wetland habitat required that trees both comprise 30 percent or higher canopy cover and be rooted within the wetland area. Wetlands with forest canopy cover shading a portion of the wetland area, but not rooted in the wetland, were not included as forested wetland.

All wetland sites, and nine of ten wetland sites, contained emergent and aquatic bed habitats respectively, typical of lacustrine fringe wetlands (Table 6.1). Wetland site 3 was located away from the lake shore edge, within scrub/shrub habitat, and didn't contain ten percent of ponded habitat within the site to count as aquatic bed. Scrub/shrub habitats were commonly found along the wetland/upland edge of the lake-fringe wetlands, but comprised a more significant habitat layer at wetland sites 2, 3, 4, 6 and 8. Scrub/shrub habitat at sites 2 and 4 was intermixed with emergent plants found growing on floating logs. Scrub/shrub habitat at sites 3, 6 and 8 comprised 30 percent or more of the entire wetland area. Forest wetland habitat, where it occurred, was deciduous and primarily comprised of red alder (*Alnus rubra*), though at wetland site 9 large Oregon ash (*Fraxinus latifolia*) was dominant in the forest canopy layer.

Table 6.1. Wetland habitats at ten wetland sites on Lake Kapowsin.

Wetland Habitats[1]	W - 1	W - 2	W - 3	W - 4	W - 5	W - 6	W - 7	W - 8	W - 9	W - 10
Aquatic bed	x	x		x	x	x	x	x	x	x
Emergent	x	x	x	x	x	x	x	x	x	x
Scrub/shrub	x	x	x	x	x	x	x	x	x	
Forest[2]			x			x		x	x	

[1]Wetland habitats: Must comprise ≥ 10% of wetland area; [2]Forest: Canopy cover must be ≥ 30%

Wetland composition was determined based on the plot conducted at each wetland site which was 15 m wide, extending from shoreline to wetland/upland edge and from shoreline to littoral aquatic vegetation edge. Composition was not possible to determine for the entire wetland area, without a more intensive plant inventory effort. Wetland composition was divided into four categories totaling 100 percent. These categories included:

1) vegetation (including emergent & scrub/shrub vegetation found on floating logs)
2) aquatic vegetation (littoral zone or within ponded areas)
3) floating logs (unvegetated)
4) water

Wetland sites 1, 2 and 4, where sampled, were dominated by vegetated and non-vegetated floating logs within open water habitat (Table 6.2). These wetland sites contained lower proportions of vegetation and higher proportions of water and floating logs. Wetlands 5, 7 and 10 were narrow lacustrine fringe wetlands with a limited band of emergent and aquatic vegetation comprising an overall moderate (50 to 60%) vegetative cover. Wetlands 3, 6 and 8 were all unique sites, but contained a substantial scrub/shrub component in addition to emergent vegetative cover, and are discussed in detail in the following section (6.2.2 Wetland Descriptions).

Table 6.2. Wetland composition at ten wetland site survey plots on Lake Kapowsin.

Wetland	Percent Cover (%)									
Composition	W - 1	W - 2	W - 3	W - 4	W – 5	W - 6	W - 7	W - 8	W - 9	W - 10
Vegetation[1]	40	35	95	20	50	70	60	70	70	60
Aquatic Veg.	8	4	3	28	26	10	10	26	10	27
Floating Logs	20	25	0	10	10	5	2	0	5	5
Water	32	36	2	40	40	15	28	4	15	8

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[1] Includes vegetation on floating logs.

6.2.2 Wetland Descriptions

Wetland Descriptions were completed for each of ten wetland sites, noting the habitat types, dominant vegetation, total plant species documented, wildlife use and human disturbance observed. Site photos of each wetland and additional photos of prominent features were also taken to aid in the description of the wetlands (Appendix 6.B).

Wetland 1

This lake fringe wetland consisted of many vegetated and non-vegetated logs interspersed with open water habitat, with logs becoming both more densely spaced and vegetated closer to the shoreline. A well-established emergent plant community was narrowly present along the shoreline, becoming scrub-shrub dominant before quickly transitioning to upland shrub and deciduous forest. Vegetated logs in the wetland contained variable vegetation including dwarf shrubs and emergent plants: Labrador tea (*Ledum groenlandicum* [*was Rhododendron g.*]), common cat-tail (*Typha latifolia*), salal (*Gaultheria shallon*), twinberry (*Lonicera involucrata*), yellow flag iris (*Iris pseudoacorus*), roundleaf sundew (*Drosera rotundifolia*) and purple marshlocks (*Comarum palustre* [was *Potentilla palestra*]) (Table 6.3). The wetland contained little aquatic vegetation, though many aquatic species were sparsely present. Primary aquatic species included yellow pond lily (*Nuphar lutea* [was *N. polysepala*)] and water purslane (*Ludwigia palustris*). Within the wetland, 39 emergent and 13 aquatic species were documented (Appendix 6.C). The wetland contained a large beaver lodge within the floating logs (~13 meters from the shoreline) and was located immediately adjacent (west) of the only structured development on Lake Kapowsin, the former Erickson's Boat Rental facility (Appendix 6.B). The development consisted of two buildings, a lake-side shed, dock, and a lagoon surrounding the property of chain-tied floating logs.

Table 6.3. Dominant plant species of Wetland Site 1 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Ledum groenlandicum (was *Rhododendron g.*)	bog Labrador tea	Shrub	Emergent	Nat.	10
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	10
Gaultheria shallon	salal	Shrub	Emergent	Nat.	10
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	8
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	5
Drosera rotundifolia	roundleaf sundew	Forb	Emergent	Nat.	3

Wetland 2

This wetland site was part of the large bog-like wetland found at the northeast end of Lake Kapowsin (Figure 6.1). Two other wetland sites were surveyed within this large wetland. These included Wetland 3 – located in scrub/shrub habitat furthest inland from the lake shore, and Wetland 4 – located in vegetated log and emergent wetland habitat close to the southeast edge of the large bog-like wetland. Wetland 2 consisted of vegetated logs interspersed with unvegetated logs and areas of open water with very few aquatic plants. Vegetated floating logs contained a variety of emergent species, most commonly: bog Labrador tea, common cat-tail, yellow flag iris, roundleaf sundew, twinberry, salal, and western swamp laurel (*Kalmia microphylla*) (Table 6.4). Within the wetland, 44 emergent and 8 aquatic species were documented (Appendix 6.C).

Table 6.4. Dominant plant species of Wetland Site 2 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Ledum groenlandicum (was *Rhododendron g.*)	bog Labrador tea	Shrub	Emergent	Nat.	5
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	5
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	5
Drosera rotundifolia	roundleaf sundew	Forb	Emergent	Nat.	5
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	5
Gaultheria shallon	salal	Shrub	Emergent	Nat.	3
Kalmia microphylla	western swamp laurel	Shrub	Emergent	Nat.	3

Wetland 3

This wetland site was part of the large bog-like wetland found at the northeast end of Lake Kapowsin (Figure 6.1). Two other wetland sites were surveyed within this large wetland. These included Wetland 2 – located in located in vegetated log and open water habitat, and Wetland 4 – located in vegetated log and emergent wetland habitat close to the southeast edge of the large bog-like wetland. Wetland site 3 was a dense scrub/shrub wetland with sparse, young deciduous trees, and interspersed with vegetated logs, patches of common cat-tail and small open water areas. Tree species included red alder, Sitka willow [*Salix sitchensis*], and coastal willow [*Salix hookeriana*]). Scrub/shrub species, specifically hardhack (*Spirea douglasii*), provided the dominant plant cover along with twinberry and common snowberry (*Symphoricarpos albus*) (Table 6.5). Dominant forbs included common cat-tail and true forget-me-not, which grew on logs and shallow (2 inches deep) open water/mud areas. Within the wetland, 23 emergent and 2 aquatic species were documented (Appendix 6.C).

Table 6.5. Dominant plant species of Wetland Site 3 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	30
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	15
Myosotis scorpioides	true forget-me-not	Forb	Emergent	Int.	15
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	14
Salix sitchensis	Sitka willow	Shrub	Emergent	Nat.	5
Symphoricarpos albus	common snowberry	Shrub	Emergent	Nat.	5
Alnus rubra	red alder	Tree	Emergent	Nat.	5
Scirpus microcarpus	small-fruited bulrush	Sedge	Emergent	Nat.	3

Wetland 4

This wetland site was part of the large bog-like wetland found at the northeast end of Lake Kapowsin (Figure 6.1). Two other wetland sites were surveyed within this large wetland. These included Wetland 2 – located in located in vegetated log and open water habitat, and Wetland 3 – located in scrub/shrub habitat furthest inland from the lake shore. Wetland site 4 consisted of a large vegetated floating log complex interspersed with unvegetated logs and areas of open water with aquatic plants. Vegetated floating logs contained a variety of emergent species, most commonly: bog Labrador tea, awlfruit sedge (*Carex stipata*), yellow flag iris and roundleaf sundew (Table 6.6). The dominant aquatic plant was yellow pond lily, with common bladderwort (*Utricularia macrorhiza*), and common elodea (*Elodea canadensis*) also present. Within the wetland, 20 emergent and 9 aquatic plant species were documented (Appendix 6.C).

Table 6.6. Dominant plant species of Wetland Site 4 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Ledum groenlandicum (was *Rhododendron g.*)	bog Labrador tea	Shrub	Emergent	Nat.	5
Carex stipata	awlfruit sedge	Sedge	Emergent	Nat.	5
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	3
Drosera rotundifolia	roundleaf sundew	Forb	Emergent	Nat.	2
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	20
Utricularia macrorhiza (was *U. vulagris*)	common bladderwort	Forb	Aquatic (Subm)	Nat.	3

Wetland 5

This narrow lake fringe wetland was located along the southern shore of Jaybird Island (Figure 6.1) and consisted of a narrow strip of aquatic and emergent vegetation backed by upland conifer forest with a scrub/shrub layer in between. Common cat-tail dominated the emergent vegetation cover, with hardhack, Oregon crab apple (*Malus fusca*), and salal in the scrub/shrub layer (Table 6.7). Yellow pond lily was the dominant aquatic plant in the littoral zone, with water purslane also present and growing closer to shore near the common cat-tail. Awlfruit sedge and purple marshlocks were also present in lesser amounts within the emergent layer along the shoreline and littoral interface. The conifer forest immediately upland of the wetland site contained mid-succession and mature trees with co-dominants including western red cedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*). Within the wetland, 12 emergent and 7 aquatic plant species were documented (Appendix 6.C).

Table 6.7. Dominant plant species of Wetland Site 5 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	37
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	10
Malus fusca	Oregon crab apple	Tree	Emergent	Nat.	3
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	20
Ludwigia palustris	water purslane	Forb	Aquatic (Float)	Nat.	3

Wetland 6

This wetland site was located along the southwestern shore of Jaybird Island (Figure 6.1). This was a bog-like wetland containing plant species consistent with acidic bog plant communities. Yellow pond lily was dominant in the littoral layer and found in open water habitats interspersed with vegetated floating logs (Table 6.8). Toward the shoreline, the vegetated logs were densest grading into emergent plant and sphagnum bog habitat. Emergent species included common cat-tail as the dominant with Pacific jewelweed (*Impatiens* x *pacifica*), northern bugleweed (*Lycopus uniflorus*), yellow flag iris, common rush (*Juncus effusus*), awlfruit sedge and lady fern (*Athyrium filix-femina*). Red peatmoss (*Sphagnum rubellum*) formed a dense ground cover throughout the emergent vegetation, shallow pools of water and scrub/shrub wetland areas. This lake fringe bog-like wetland mixes with scrub/shrub where bog Labrador tea and hardhack were dominant. This scrub/shrub region of the wetland was rated separately from the other portions of the wetland (see Wetland Rating section). Salal and red alder (*Alnus* rubra) were present in lesser amounts. The bog-like wetland was contiguous with a conifer forest slope wetland further inland. A small stream bisected the wetland. In the littoral layer the dominant aquatic plant was yellow pond lily, with watershield and many other aquatic species found in smaller amounts. Within the wetland, 27 emergent and 7 aquatic plant species were documented (Appendix 6.C).

Table 6.8. Dominant plant species of Wetland Site 6 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	30
Ledum groenlandicum (was *Rhododendron g.*)	bog Labrador tea	Shrub	Emergent	Nat.	10
Impatiens x pacifica	Pacific jewelweed	Forb	Emergent	Nat.	8
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	5
Lycopus uniflorus	northern bugleweed	Forb	Emergent	Nat.	3
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	3
Juncus effusus	common rush	Rush	Emergent	Nat.	3
Carex stipata	awlfruit sedge	Sedge	Emergent	Nat.	3
Athyrium filix-femina	lady fern	Fern	Emergent	Nat.	3

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Sphagnum rubellum	red peatmoss	Moss	Emergent	Nat.	–
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	20
Brasenia schreberi	watershield	Forb	Aquatic (Float)	Nat.	3

Wetland 7

This narrow lake fringe wetland was located in a still-water cove just south of Jaybird Island and consisted of aquatic and emergent vegetation with sparse mature trees and shrubs intermixed (Figure 6.1). Hardhack was dominant with common cat-tail and twinberry along the shoreline (Table 6.9). Mature red alder, western red cedar and western hemlock were sparsely intermixed. In the littoral zone, aquatic vegetation was patchy with yellow pond lily dominant and common cat-tail in the shallower reaches. The wetland exhibited a wide lake draw-down area due to the shallow topography of the lake shore in this area. A small algal bloom was observed in the still, shallow water nearby, a filamentous green algae filling the water column to the surface and covering a 1 m^2 area (see 6.2.6 Noxious Weeds section). Within the wetland, 22 emergent and 2 aquatic plant species were documented (Appendix 6.C).

Table 6.9. Dominant plant species of Wetland Site 7 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	30
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	10
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	5
Gaultheria shallon	salal	Shrub	Emergent	Nat.	5
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	8

Wetland 8

This wetland was located at the southern end of Lake Kapowsin and contained a large aquatic bed/mudflat, emergent and scrub/shrub wetland plant communities (Figure 6.1). The extensive and diverse aquatic vegetation community was partially due to the shallow lake shore topography forming extensive shallow littoral zone habitat and mudflats. Aquatic vegetation was dense and dominated by yellow pond lily, with large patches of other aquatics including common elodea and swaying bulrush (*Schoenoplectus subterminalis*) in shallow areas and patches of three pondweed species in the deeper reaches (large-leaf [*Potamogeton amplifolius*], ribbonleaf [*P. epihydrus*] and flatstem pondweeds [*P. zosteriformis*]) (Table 6.10). Along the east and west shoreline edges, mudflats contained American bulrush (*Schoenoplectus americanus*), a variety of sedges (*Carex* spp., *Eleocharis* spp.) and water horsetail (*Equisetum fluviatile*). The majority of the shoreline was dominated by a dense cover of redtop grass (*Agrostis gigantea*) with common cat-tail present in patches as well as many narrow channels bisecting the wetland. A large portion of the central and southern reaches of the wetland was scrub/shrub dominated by hardhack and Sitka willow, with a dense layer of redtop grass in the understory. Within the wetland, 23 emergent and 12 aquatic plant species were documented (Appendix 6.C). A small wooden hunting blind/shack and remnant dock pilings were found within the wetland.

Table 6.10. Dominant plant species of Wetland Site 8 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Agrostis gigantea	redtop grass	Grass	Emergent	Int.	58
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	5
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	4
Salix sitchensis	Sitka willow	Shrub	Emergent	Nat.	3
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	11
Elodea canadensis	common elodea	Forb	Aquatic (Subm)	Nat.	3
Potamogeton amplifolius	large-leaf pondweed	Forb	Aquatic (Subm)	Nat.	3
Potamogeton epihydrus	ribbonleaf pondweed	Forb	Aquatic (Subm)	Nat.	3
Potamogeton zosteriformis	flatstem pondweed	Forb	Aquatic (Subm)	Nat.	3
Schoenoplectus subterminalis	swaying bulrush	Sedge	Emergent/ Floating	Nat.	3

Wetland 9

This is a high quality lake fringe wetland with abundant submersed and floating aquatic vegetation in the littoral zone, a dense emergent community, with vegetated floating logs near the shoreline grading into shrub and deciduous forested wetland. It is bisected by a 0.8-meter wide stream. The lake fringe wetland was located at the northwest corner of Lake Kapowsin, approximately 800 meters west of the boat launch (Figure 6.1). In the littoral zone, yellow pond lily was dominant with flatstem pondweed and many other aquatic plants present in lesser amounts (Table 6.11). Emergent species were present along the shoreline and growing on vegetated floating logs near the shore and included common cat-tail, true forget-me-not (*Myosotis scorpioides*), redtop grass and yellow flag iris. A dense shrub layer was present immediately inland which graded into a deciduous forested slope wetland. Within the lake fringe wetland the dominant shrub was hardhack with twinberry also present and canopy cover from large Oregon ash trees. Within the wetland, 18 emergent and 8 aquatic plant species were documented (Appendix 6.C).

Table 6.11. Dominant plant species of Wetland Site 9 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Fraxinus latifolia	Oregon ash	Tree	Emergent	Nat.	38
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	20
Myosotis scorpioides	true forget-me-not	Forb	Emergent	Int.	15

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	10
Agrostis gigantea	redtop grass	Grass	Emergent	Int.	10
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	3
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	3
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	11
Potamogeton zosteriformis	flatstem pondweed	Forb	Aquatic (Subm)	Nat.	3

Wetland 10

This narrow and small lake fringe wetland was located along the southwestern shore of Lake Kapowsin, approximately 800 meters west of the old lumber mill property (Figure 6.1). This wetland consisted of a narrow aquatic and emergent vegetation zone which quickly graded into an upland deciduous forest with a narrow scrub/shrub interface. Common cat-tail was dominant with hardhack, twinberry and redtop grass also common (Table 6.12). Red alder in the upland provided some canopy cover over the lake fringe wetland. In the littoral zone, aquatic vegetation was patchy with yellow pond lily dominant, common cat-tail in the shallower reaches and Robbins' pondweed (*Potamogeton robbinsii*) common in the deeper littoral zone. In addition, numerous other aquatic plants were present in smaller quantities. Within the wetland, 13 emergent and 8 aquatic plant species were documented (Appendix 6.C).

Table 6.12. Dominant plant species of Wetland Site 10 on Lake Kapowsin.

Scientific Name	Common Name	Plant Type	Plant Habitat	Native or Introduced	% Cover
Alnus rubra	red alder	Tree	Emergent	Nat.	40
Typha latifolia	common cat-tail	Forb	Emergent	Nat.	18
Spirea douglasii	hardhack, rose spirea	Shrub	Emergent	Nat.	20
Lonicera involucrata	twinberry	Shrub	Emergent	Nat.	10
Agrostis gigantea	redtop grass	Grass	Emergent	Int.	6
Iris pseudoacorus	yellow flag iris	Forb	Emergent	Int. - Weed	3
Nuphar lutea (was *N. polysepala*)	yellow pond lily	Forb	Aquatic (Float)	Nat.	25
Elodea canadensis	common elodea	Forb	Aquatic (Subm)	Nat.	3
Potamogeton robbinsii	Robbins' pondweed	Forb	Aquatic (Subm)	Nat.	3

6.2.3 Wetland Rating

Ten wetland sites were rated following the Washington State Wetland Rating System for Western Washington using the 2014 Update (Hruby 2014). The rating resulted in a range of Category I to Category III wetlands found at Lake Kapowsin (Table 6.13). Wetland 6 received a dual rating as both Category I and Category III wetland, due to a portion of the wetland meeting the criteria to be classified as a bog (Category I, detailed in subsequent section of this report). Wetland sites 1 and 2 were rated as Category II wetlands. Category II wetlands perform all wetland functions well, or one group of functions very well, and are difficult to replace. The remaining eight wetland sites (3 - 10) were rated as Category III wetlands, which typically perform wetland functions moderately well, have likely been disturbed or degraded somehow, may be less diverse than other wetlands, and are more likely to be replaceable through mitigation efforts.

All wetland sites received moderate to high scores for improving water quality and high scores for providing important wildlife habitat and habitat functions. However all wetland sites received low to moderate scores for hydrologic function, which indicates whether a wetland is able to reduce shoreline erosion. According to the Wetland Rating System, lake-fringe wetlands can receive a maximum score of 6 for hydrologic functions compared to a maximum score of 16 for riverine or depressional wetlands (Hruby 2014). The hydrologic functions of a lake-fringe wetland are deemed less critical for erosion control and peak water flow reduction than other types of wetland systems (Hruby 2014).

Table 6.13. Wetland Ratings of Ten Wetland Sites on Lake Kapowsin, Pierce County, WA.

Wetland Site ID	Wetland Function			Total Wetland Score	Wetland Category[1]
	Improving Water Quality	Hydrologic	Habitat		
W - 1	7	5	8	20	II
W - 2	7	5	8	20	II
W - 3	6	4	7	17	III
W - 4	6	5	7	18	III
W - 5	5	4	8	17	III
W - 6	7	3	8	18	III
W - 6		Dual Rating – bog			I
W - 7	6	4	8	18	III
W - 8	7	5	7	19	III
W - 9	6	4	8	18	III
W - 10	5	4	8	17	III

[1] Wetland Category (based on Score): Category I (23-27), Category II (20-22), Category III (16-19), Category IV (9-15).

6.2.3.1 Bog and Bog-like Wetlands

Several wetland sites on Lake Kapowsin exhibited soils, moss layer and plant species composition consistent with bog (acidic fen) wetlands. However, these wetland sites (1, 2, 3, 4 and most of 6), didn't meet the minimum plant cover (30 percent of plant species exclusive to bogs) requirement to be rated as Category I bog (Hruby 2014). Typically, these sites contained three or more plant species exclusive to bogs and acidic fen habitats in Western Washington, but in lesser amounts (Hruby 2014, referenced from J. Rocchio, Washington Natural Heritage Program). Only a portion of one wetland (Wetland 6) met the minimum criteria to be classified and rated as a Category I bog (Table 6.13).

Wetland 1 did not meet the criteria to be classified as bog habitat, but did contain four species exclusive to bogs and acidic fen habitats in Western Washington (Hruby 2014). Those species included roundleaf sundew, western swamp laurel, bog Labrador tea and common bladderwort, an aquatic plant.

Wetland sites 2, 3 and 4 were all part of one large wetland complex at the northeast end of Lake Kapowsin. While none of these three sampled sites met the minimum criteria to rate as bog habitat, sites 2 and 4 contained four and six plant species found exclusively in bogs, respectively. Bog species included star sedge (*Carex echinata* ssp. *echinata*), roundleaf sundew, three-way sedge (*Dulichium arundinaceum*), western swamp laurel, bog Labrador tea, bog cranberry (*Vaccinium oxycoccos*) and common bladderwort. These sites (2 and 4) were both located along accessible portions of the wetland and lake interface, with the vegetated area consisting of emergent vegetated floating logs. Wetland site 3 was located at the accessible northern edge of the scrub/shrub wetland area, and did not exhibit bog characteristics other than organic soils. Many areas of this northeast wetland were not accessible due to the large matrix of vegetated floating logs along the open lake water (southern) wetland edge, and dense shrub intermixed with open water, cat-tail and floating logs on the northern edge of the lake. Habitat that meets the criteria to be rated as bog would likely be found at the floating log and scrub/shrub interface, but that area was not accessible to assess and rate. This shoreline floating log and scrub/shrub interface area is likely bog habitat due to denser vegetation cover and spacing of floating logs and incorporation of these logs into shoreline areas with bog soils, dense moss cover and scrub/shrub habitat as seen at Wetland 6.

Wetland 6, located along the southwest shore of Jaybird Island was rated dually as both Category I – bog and Category III lacustrine fringe wetland (Figure 6.1, Table 6.13). Only a portion of the wetland met the plant cover minimums required to be rated as a bog, and was scrub/shrub dominated by bog Labrador tea and hardhack, with a dense groundcover of red peatmoss (*Sphagnum rubellum*) (Hruby 2014). The remaining area of the wetland, while meeting soils and moss layer requirements, did not meet the plant cover requirements to be rates as a bog. However, this area of the wetland contained four species exclusive to bogs and acidic fen habitats in Western Washington (Hruby 2014). Those bog species included star sedge, three-way sedge, Chamisso's cottongrass (*Eriophorum chamissonis*) and bog Labrador tea.

6.2.4 Wetland Mapping of Non-sampled Lake Fringe Wetlands

A brief field and GIS exercise was completed, which documented all lacustrine fringe wetlands along the Lake Kapowsin shoreline. Of particular emphasis was noting the shoreline extent of wetlands not sampled as part of the wetland inventory and assessment efforts. In the field, all wetlands were denoted simply as a horizontal line along the lake shore, based on the presence of emergent vegetation along the shoreline (and usually aquatic vegetation in the littoral zone). The shoreline extent of the lake fringe wetland had to be a minimum of 25 meters (parallel to the lake shore) to be mapped. The resulting wetland map can be used for future focused survey efforts of wetland affiliated species (amphibians, invertebrates, etc.) and/or additional wetland inventory efforts (Figure 6.2).

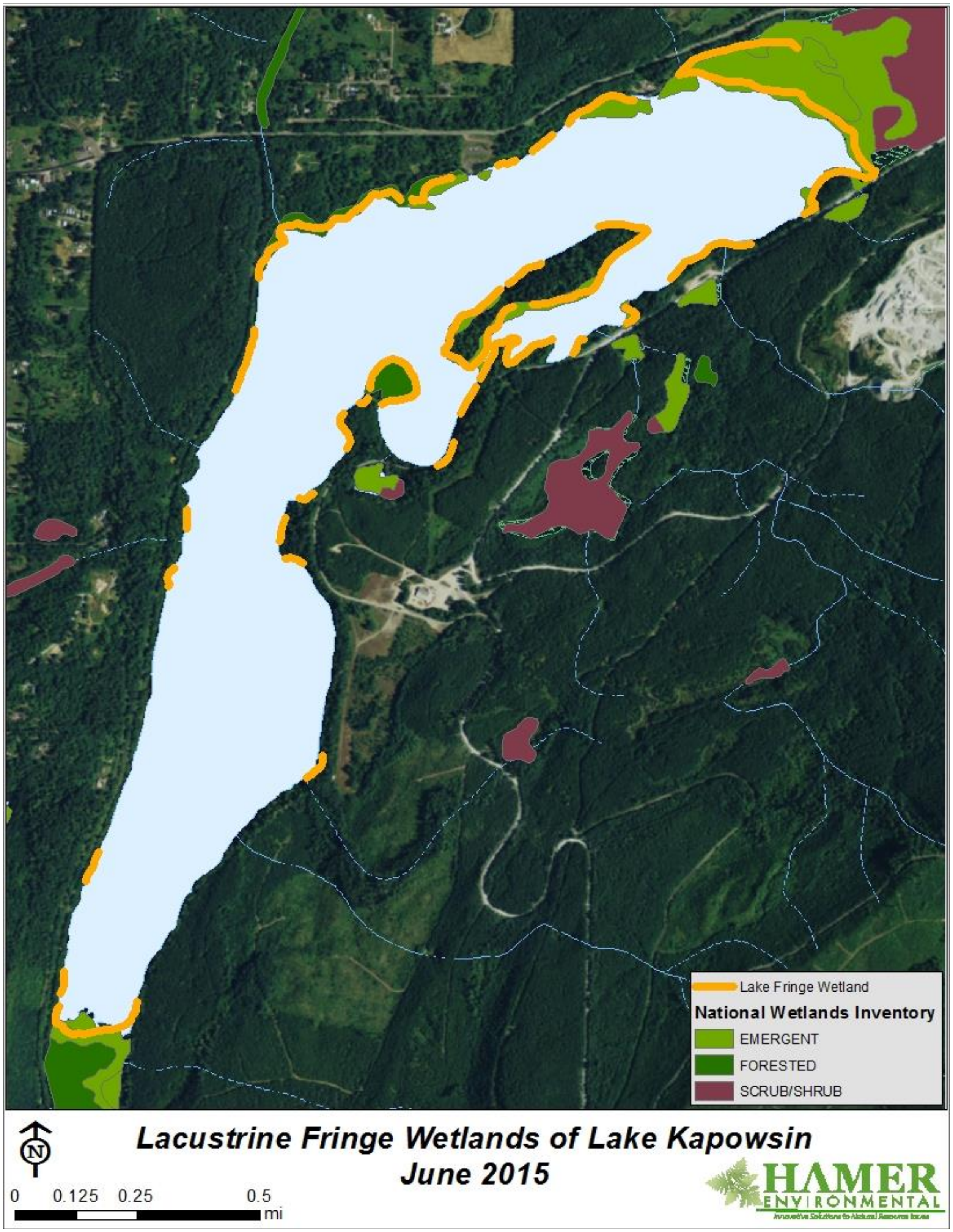

Figure 6.2. Lake Fringe Wetlands on Lake Kapowsin, which comprise 48% of total lake shoreline.

A total of 28 lake fringe wetlands were mapped on Lake Kapowsin, comprising approximately 48 percent of all shoreline areas. Wetlands were minimal to absent along the most of the western and southeastern shores of the lake where DNR has shoreland ownership (Figure 6.1). However, DNR shoreland ownership does include Jaybird Island and the northern shorelands of Lake Kapowsin which had extensive, well established lake fringe wetlands.

6.2.5 Rare Plants

No rare plants were identified during aquatic plant or lacustrine fringe wetland field assessments conducted June 8-11, 2015. One plant species was vouchered and sent to the Washington Natural Heritage Program for species verification. This plant was identified as Northwest Territory sedge (*Carex utriculata*), but is very similar to the state listed Sensitive rare plant, bristly sedge (*Carex comosa*).

Detection of rare plant species was limited to those incidentally encountered during the aquatic plant and wetland subsampling field efforts. Only rare vascular plant species were searched for due to time limitations and project scope, though four species of rare mosses have potential to occur within the study area (Appendix 6.A). Detections of rare plants were further limited to those plants that were identifiable (in flower) during the June survey effort, the accessibility of selected survey sites (frequently limited by floating logs) and overall survey coverage of the Lake Kapowsin study area. Additional botanical surveys are recommended to be conducted during a different period of the growing season (August-September) at targeted sites with suitable habitat for particular rare plants.

6.2.6 Noxious Weeds

Six species of noxious weeds, all Class C, were identified during aquatic plant and lake-fringe wetland surveys (Table 6.14). Treatment of Class C weeds is recommended but not mandatory, due to their widespread establishment throughout Washington State (Washington NWCB 2015). However, new and small infestations of Class C noxious weeds should be treated to avoid the development of large infestations. A total of 22 noxious weed infestations were documented during April and June field survey efforts (Figure 6.3). Of note, no observations of noxious aquatic plant species such as Eurasian watermilfoil (*Myriophyllum spicatum*), Brazilian elodea (*Egeria densa*), curly-leaf pondweed (*Potamogeton crispus*) or fragrant water lily (*Nymphaea odorata*) were made. However, lack of observation does not mean probable absence, as many areas of the lake were not thoroughly surveyed for noxious weeds and most detections were incidental to other data being collected.

Table 6.14. Noxious Weed species identified at Lake Kapowsin and Weed Class.

NRCS Code	Scientific Name	Common Name	Weed Class
IRPS	*Iris pseudoacorus*	yellow flag iris	C
PHAR3	*Phalaris arundinacea*	reed canarygrass	C
RULA	*Rubus laciniatus*	evergreen blackberry	C
RUAR9	*Rubus armeniacus* (was *R. discolor*)	Himalayan blackberry	C
HYPE3	*Hypericum perforatum*	common St. Johnswort	C
CIAR4	*Cirsium arvense*	Canada thistle	C

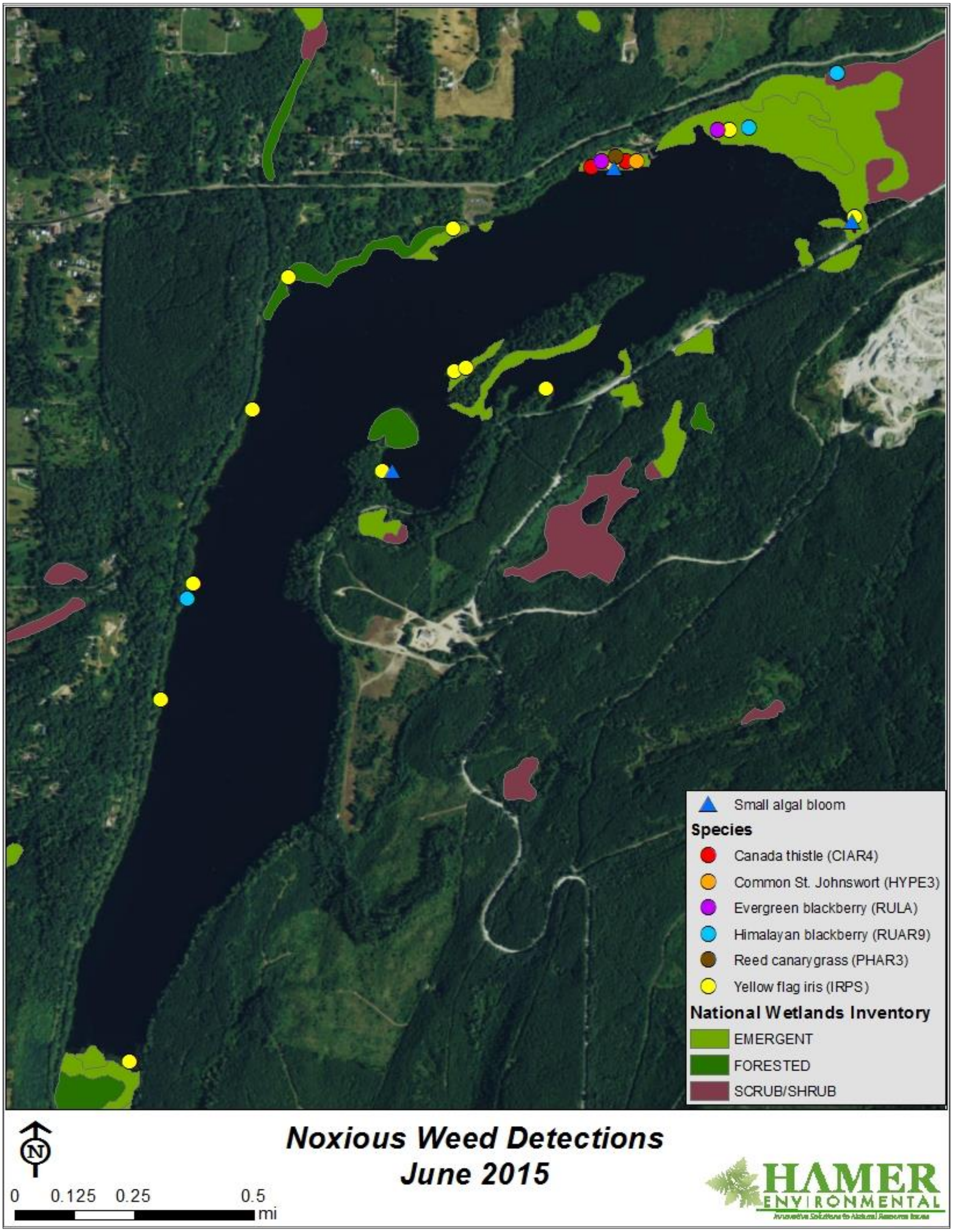

Figure 6.3. Noxious weed infestations detected on Lake Kapowsin, Pierce County, WA.

Yellow flag iris infestations were the most commonly encountered weed in the Lake Kapowsin study area. Iris were found in patches amongst other emergent plant species, particularly common cat-tail, with single infestations ranging from 30 to 600 or more plants. Yellow flag iris infestations were also documented on vegetated floating log habitats at the north and northeastern areas of Lake Kapowsin (Figure 6.3). Himalayan (*Rubus armeniacus*) and evergreen blackberry (*R. laciniatus*) were documented in small patches, mostly within the northeastern area of Lake Kapowsin. However, dense patches of Himalayan blackberry, sometimes intermixed with evergreen blackberry, dominated understory vegetation along the west and northern upland portions of the lake. Infestations of reed canarygrass (*Phalaris arundinacea*) were limited to two small infestations at the northern end of the lake. Reed canarygrass is typically found more abundantly along the shoreline (lake margins) of lakes in western Washington. However, at Lake Kapowsin, redtop grass (*Agrostis gigantea* [an introduced species not considered a noxious weed]) fills this disturbed shoreline niche. Canada thistle (*Cirsium arvense*) and common St. Johnswort (*Hypericum perforatum*) were each limited to a single, small infestation on vegetated floating logs in the northeastern wetland area of Lake Kapowsin.

6.2.6.1 Algal Blooms

Several small (less than 3 m^2) algal blooms were observed on Lake Kapowsin during June 2015 field surveys. The algal blooms were noted in shallow areas of the lake, where the water was particularly still such as in backwater areas and within floating log complexes (Figure 6.3). The algal blooms appeared to be a type of filamentous green algae (Figure 6.4). These algal blooms were the widest at the lake surface with bubbling texture and filaments that completely filled the water column below. Filamentous algae blooms (if identified correctly) are not harmful to people, but can be harmful to lake biota (particularly fish) as the algae deplete oxygen where the bloom occurs.

Figure 6.4. Algal bloom (1 square meter in size) observed near Wetland Site 7, Kapowsin Lake.

6.3 Literature Cited

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7.0 FISH

7.1 Introduction

Lake Kapowsin (Figures 7.1 and 7.2) has a unique combination of geological, biological and historical attributes, and offers a rare opportunity for conservation of a unique Puget Trough lowland freshwater ecosystem that merits consideration for designation as a freshwater aquatic reserve. Coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*), which move through Lake Kapowsin, and Chinook salmon (*Oncorhynchus tshawytscha*), pink salmon (*Oncorhynchus gorbuscha*), bull trout (*Salvelinus confluentus*), and cutthroat trout (*Oncorhynchus clarki*), have been identified in Kapowsin and/or Ohop Creeks.

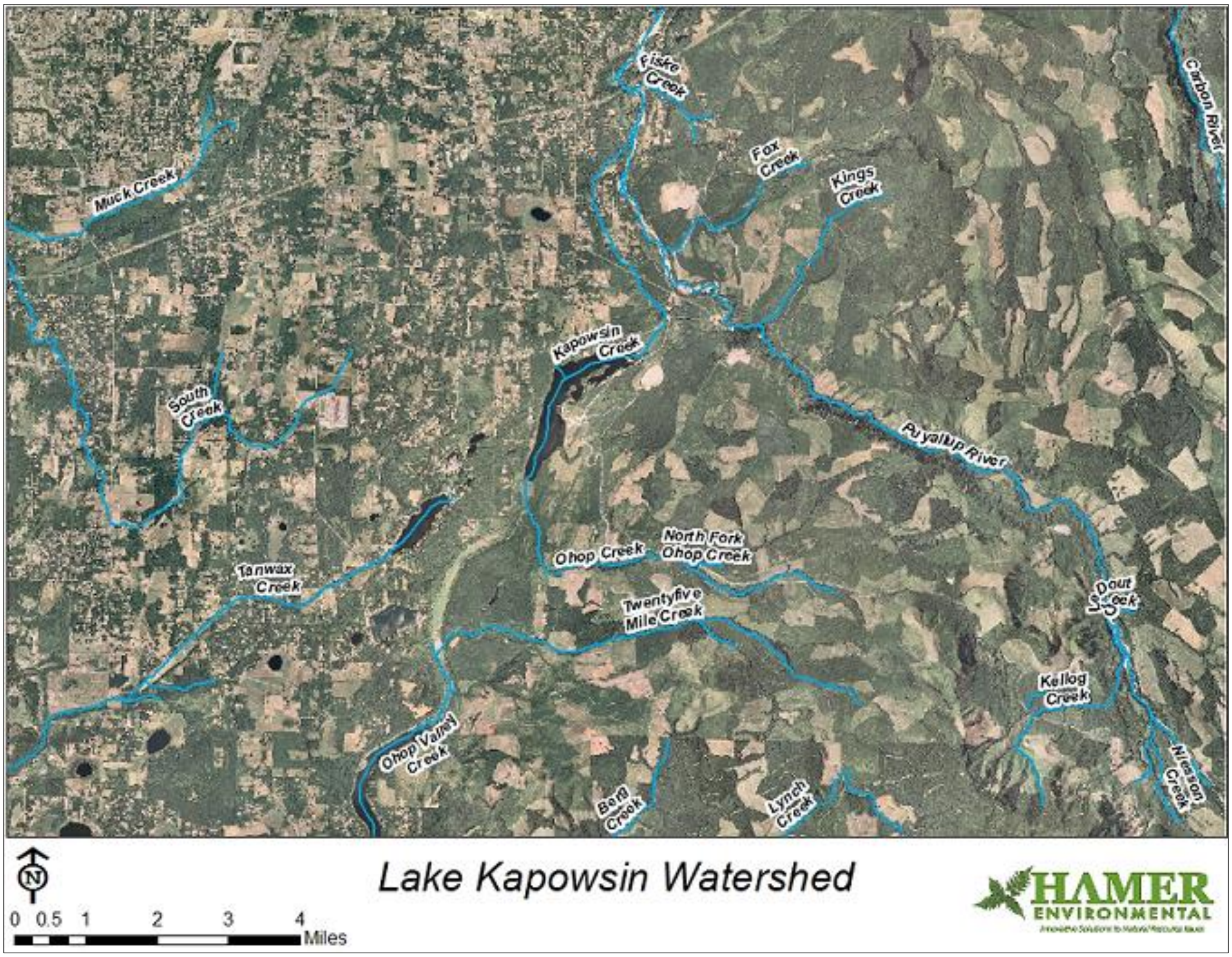


Figure 7.1. Map of Lake Kapowsin watershed, including Kapowsin Creek and Ohop Creek.

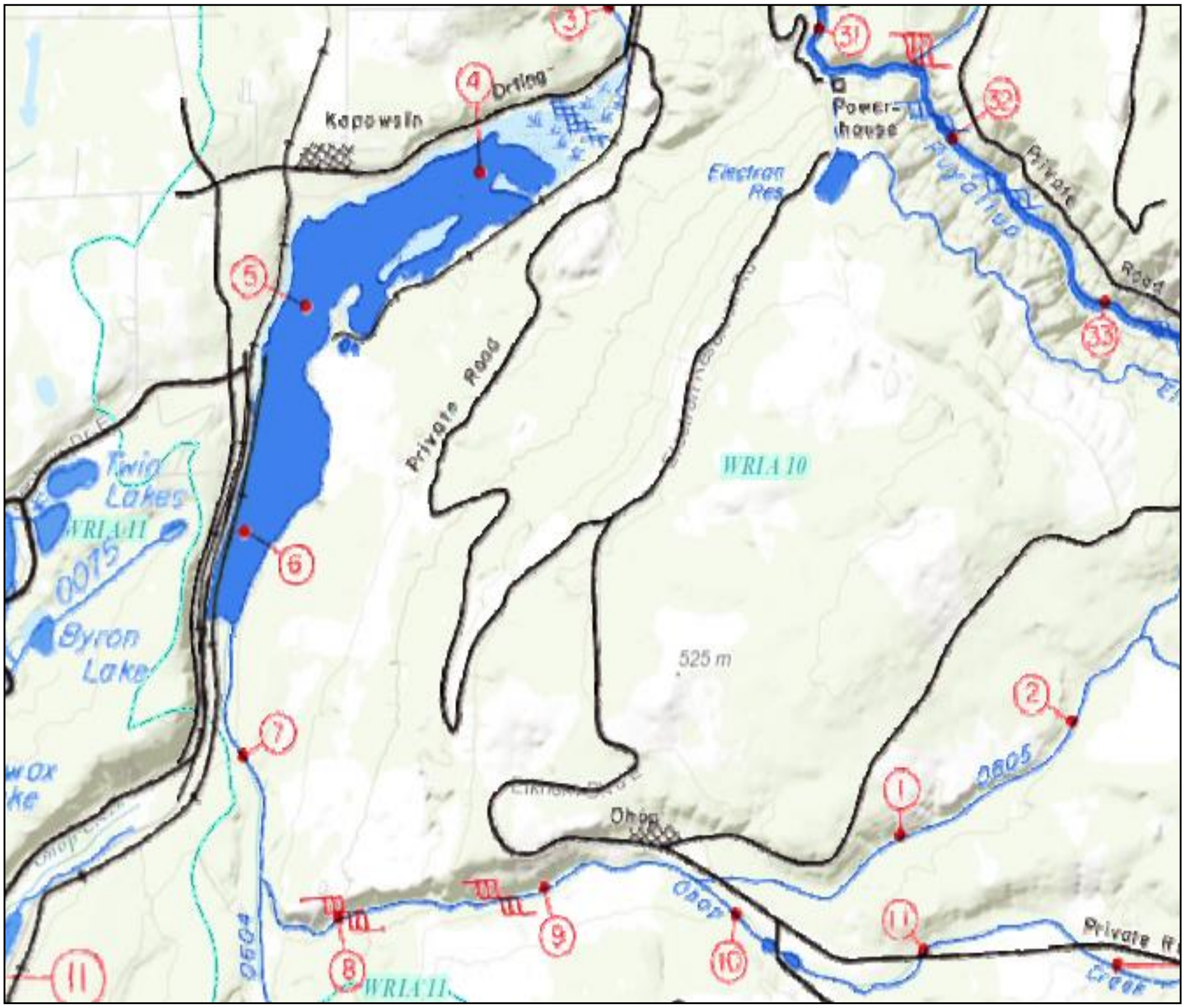


Figure 7.2. Lake Kapowsin stream catalogue map from WDFW showing river miles.

The primary objective of this Chapter is to provide fish inventory and habitat data to assist WDNR in the development of the Lake Kapowsin management plan. This Chapter is based on the review of all pertinent fisheries and fish habitat related inventories, literature, reports, etc., for the Lake Kapowsin watershed, including tributaries Kapowsin Creek and Ohop Creek and the greater Puyallup River Basin. A list of fisheries/aquatic habitat information gaps and recommendations are at the end of this Chapter.

Information on life histories, habitat requirements, and distribution of many salmonids in the Watershed Resource Inventory Area (WRIA) 10, which includes Lake Kapowsin, is fairly extensive. Some warmwater fisheries assessment work (Jackson and Caromile 2000) and creel census work (Cummings 1976, Livingood 2015) has been conducted on Lake Kapowsin, with a focus on the warmwater fish community. Some basic physical, cultural and water quality data is available for Lake Kapowsin (Bortleson et al. 1976). Salmonid spawning count survey information is available for Kapowsin Creek starting in 1943 up until the present (WDFW 2015a). WDFW hatchery releases into

Lake Kapowsin and Kapowsin Creek are available from 1906 through 2014 (WDFW 2015b). The Puyallup Tribe conducts annual salmon, steelhead and bull trout surveys for the Puyallup River system, which includes Kapowsin Creek, Lake Kapowsin and Ohop Creek (Marks et al. 2013). Water quality data from 2006 to 2013 is available from the Pierce County Surface Water Management Division for Kapowsin Creek (Pierce County, 2010-2013).

7.2 Methods

The following analysis is based completely on available aerial photos, maps, reports, studies, e-mails, and other information sources. Due to limited project funding and time constraints, no site visit to collect fisheries information were made to Lake Kapowsin. The focus was to review, synthesize, and summarize all available pertinent fish and aquatic habitat surveys, studies, investigations, and reports and other data related to Lake Kapowsin and the adjacent watershed. This included examining all available salmonid spawning ground surveys, fish habitat, creel census, and other data from the WDFW, Puyallup Tribe, Muckleshoot Tribe, Tacoma City (PUD, Water Dept., etc.), South Sound Fisheries Enhancement Group, and other agencies and groups. All available warmwater fisheries studies, creel census, and other warmwater fish inventories were reviewed. In addition, a strong effort was made to contact appropriate public agency, tribal, and other representatives to locate fisheries-related information pertinent to Lake Kapowsin. Through this analysis gaps in fisheries and fish habitat information were identified and recommendations made for additional fisheries data needs.

The analysis included using the latest aerial and orthophotos, USGS topographic maps, and WDFW fish habitat maps for the area from Salmon Scape (WDFW 2015c), as well as other pertinent information sources. General references consulted for the Puyallup River basin, Lake Kapowsin, Kapowsin Creek and its tributaries included:

- Salmonids: Salmon, steelhead, and bull trout: WDF and WWTIT (1993), WDFW and WWTIT (1994), WCC (1999), WSRCO GSRO (2012), Marks et al. (2013), WDFW (2014a), WDFW (2014c), WDFW (2015a, 2015b), Berger et al. (2014, 2015).
- Cutthroat trout: WDFW (1988), Blakley et al. (2000).
- Bull trout: WDFW (1997b), WDFW (1998), WDFW (2004).
- Warmwater Fish Species: Jackson and Caromile (2000), Livingood (2015).
- Water Quality: Wolcott (1973), Bortleson et al. (1976), Sumioka and Dion (1985), Pierce County (2010-2013).

Additional references are also cited in the body of this report.

In addition, an attempt was made to identify water projects, adjacent land uses, outfalls, road run-off, and other waste inputs that may impact Lake Kapowsin and to contact appropriate land owners to evaluate their potential risks. An attempt was also made to contact warmwater fishing groups that might use Lake Kapowsin to find out how much warmwater-related fishing recreation is occurring and the relative importance of the lake to these groups.

7.3 Results and Discussion

7.3.1 Puyallup River Basin Overview

Lake Kapowsin is located within the Puyallup River basin (Figure 7.3). In order to properly describe Lake Kapowsin, and its tributaries, and the relative importance of their fisheries resources, it is necessary to describe their context in relation to the Puyallup River basin as a whole.

The Puyallup River Basin was one of the earliest areas settled in the Puget Sound area (WCC 1999). Homesteads and settlements began appearing as early as 1850 and the new arrivals initiated a series of actions to modify the landscape to fit their needs. Prior to the construction of the Electron Diversion Dam at River Mile (RM) 41.5 in 1904, salmon spawned naturally throughout the entire Puyallup River Basin, however, the dam eliminated access to 21.5 miles of salmonid spawning habitat (Berger et al. 2014, 2015).

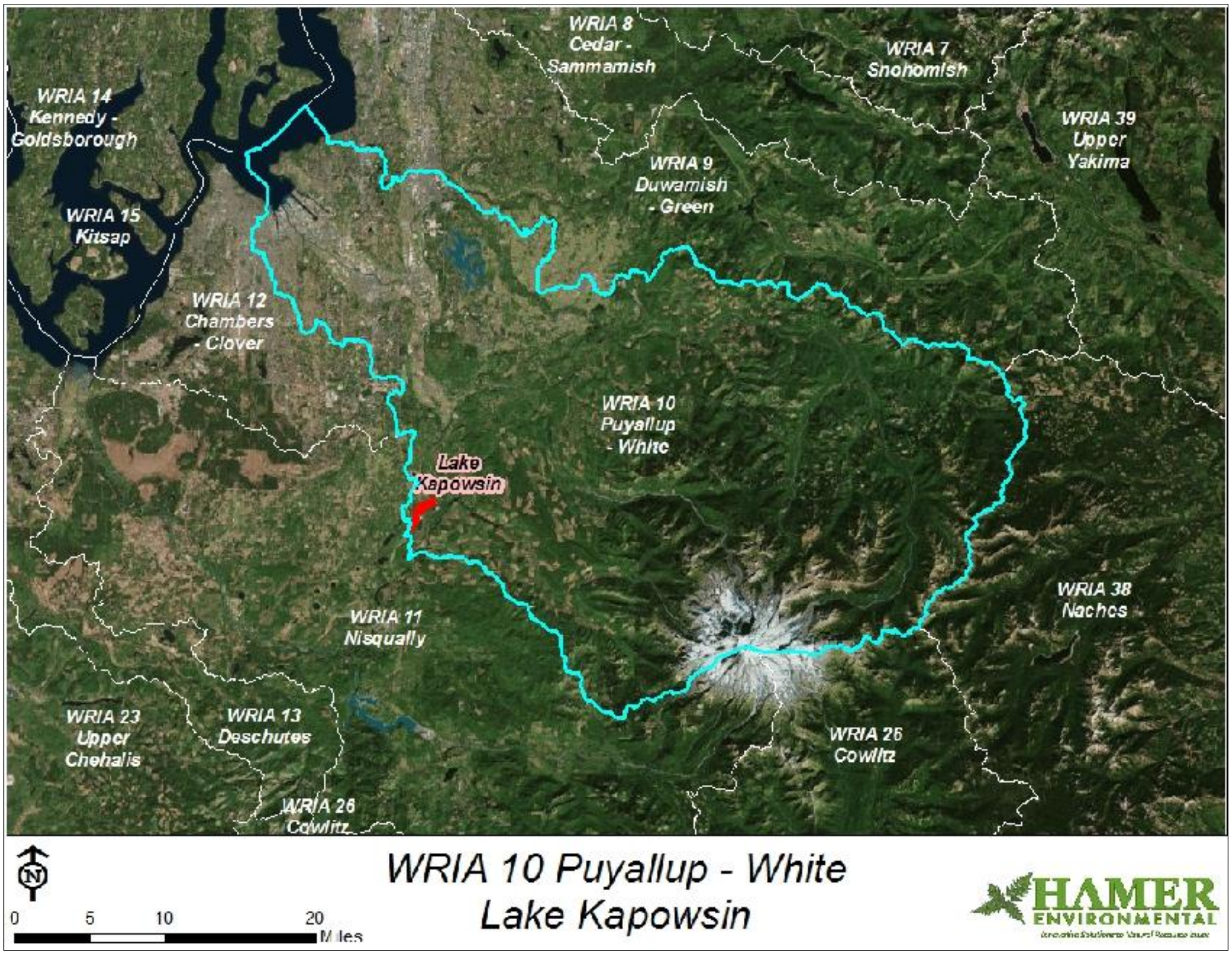


Figure 7.3. Puyallup River basin map (WRIA 10) showing Lake Kapowsin in red.

According to the WCC (1999), in spite of the widespread habitat degradation within the Puyallup River basin, the opinion of the Puyallup River Technical Advisory Group (an interagency watershed/fisheries group) is that functioning and productive areas still exist in the systems that are capable of naturally producing self-sustaining runs of salmonids.

In the fall of 2000, the Puyallup Tribe reopened access to the 21.5 miles of salmonid spawning habitat by installing a fish ladder at the Electron Dam at RM 41.5 on the Puyallup River (Berger et al. 2015). The upper Puyallup watershed suffers from past and present timber harvest practices that reduce the ability for riparian areas to provide wood recruitment and shade to the river and stream channels, and continues to contribute fine sediments from road construction and landslides, which adversely impact natural salmonid production (WCC 1999).

The lower reaches of the mainstem Puyallup River currently are lacking in the coniferous riparian habitat that was present historically and the habitat that remains is comprised of disconnected areas that do not meet the properly functioning categories of the National Marine Fisheries Service ESA matrix of habitat pathways and indicators (WCC 1999).

According to WCC (1999), based on aerial photos, less than 5% of the lower Puyallup River mainstem has what can be considered high quality riparian habitat and that habitat is fragmented into small segments often separated by distances of over a mile with late seral stage forests absent, or minimal, with the following category percentages: Late Seral 0%, Mid-seral 6.4%, Early Seral 1.7%, Other 23.2%, Water 1.8%, and 66.9% Non-Forested. The Electron area adjacent to Lake Kapowsin has higher percentages of all seral stages, particularly Mid-seral at 46.9%, Early Seral at 6.4% and only 7.2% Non-Forested.

Lake Kapowsin, Kapowsin Creek, and Ohop Creek, are part of the lower Puyallup River basin and are located below the Puget Sound Energy Electron Power House (RM 0.0 to 31.2) which is located about 1 mile to the west of Lake Kapowsin. Average annual rainfall nearby at Electron Dam is about 70 inches (WCC 1999). The Puyallup River flows have shown a continuous decline despite the establishment of instream flows in 1980. This can be attributed to increased demand for groundwater water withdrawal through unregulated wells and increased impervious surfaces, which led to a decline in groundwater and base surface water flow (WDOE 1995).

7.3.2 Lake Kapowsin, Kapowsin Creek, and Ohop Creek Fisheries & Aquatic Habitat Conditions, Water Quality, Recreation & Fishing Regulations

Lake Kapowsin has been stocked with fish starting in 1906 and through 2015 (Appendices 7.A and 7.B) (WDFW 2015). Warmwater fish species were stocked in the lake from 1907 and until 1939. Since then various rainbow trout stocks have been the primary species stocked in Lake Kapowsin. Other salmonids listed as having been stocked in the lake include coho, chinook and pink salmon, steelhead trout and mountain whitefish (*Prosopium williamsoni*).

Jackson and Caromile (2000) described Lake Kapowsin as being relatively deep (maximum depth of 8.8 meters) with steep sloping shorelines and littoral zones located at the northern and southern ends of the lake, with many shoreline irregularities. Emergent vegetation covers 10% of the shoreline; however, the lake is littered with logs, snags, and pilings (Jackson and Caromile 2000). Walcott (1973) described Lake Kapowsin as being "Used partially for log storage" and Bortleson et al. (1976) stated that "The north end of the lake is choked with floating logs and snags extending 1,000-2,000 feet from shore" and "the next 1,000 feet into the lake was covered with submersed plants interspersed with stumps and snags." According to Jackson and Caromile (2000) this mixture of aquatic vegetation and timber provides optimal habitat conditions for largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and other warmwater fish.

Lake Kapowsin receives a relatively high level of pressure from anglers, as it is a favored and popular area for recreational fisheries (Jackson and Caromile 2000). A WDFW creel survey conducted in 2000 estimated 3,324 shore angler trips and 5,862 boat angler trips (3,234 boats) between May and October (Livingood pers. comm. 2015).

In 2006, at the northern end of Lake Kapowsin, WDFW developed a boat launch ramp and parking area, and in 2008, WDFW upgraded the boat ramp and float at the northern end, improving public access (Figure 1.1). In 2008, WDFW conducted a creel survey to assess use that estimated 12,330 shore angler trips and 14,094 boat angler trips (5,604 boats) between January and December, and between May and October, their creel survey estimated 11,803 shore angler trips and 10,564 boat angler trips (5,314 boats) (Livingood, pers. comm. 2015).

The Puyallup Tribe is interested in maintaining the lake as a high quality recreational fishery and protecting the unique productivity of the lake. The Puyallup Tribe has lands adjacent to Lake Kapowsin, supports the aquatic reserve designation and wishes to assist in any action that further protects the last large undeveloped lake in Pierce County (Ladley, pers. comm. 2015). According to Ladley, the Muckleshoot Tribe owns approximately 40 acres of land, adjacent to the Puyallup Tribe holdings, along the eastern shore of Lake Kapowsin. Attempts to contact Muckleshoot Tribe fisheries personnel to get information about how these lands are managed were unsuccessful (via phone calls and e-mails).

7.3.3. Lake Kapowsin Fishing Regulations

Fishing in Lake Kapowsin is allowed year-round for trout with no minimum size, a daily limit of 5, and up to 2 fish over 14 inches in length (WDFW 2014e). Fishing for other game fish, including crappie (*Pomoxis nigromaculatus*), perch (*Perca flavescens.*), sunfish (*Lepomis gibbosus*), catfish (*Ictalurus punctatus*) and rock bass (*Ambloplites rupestris*), is allowed year-round with no minimum size limit. Regulations (WDFW 2014e) state that "Only largemouth bass less than 12 inches may be retained, except 1 over 17 inches may be retained. Daily limit of 5 bass may be caught, retained, and released from a livewell until a daily limit is in possession." All fishing is closed in the Puyallup River above the confluence with the Carbon River at RM 17.9 (WDFW 2014e). This fishing closure includes Kapowsin Creek, which enters the Puyallup River at RM 27.6.

The Puyallup Tribe has their own Puyallup River system fishing regulations for subsistence and ceremonial purposes that requires tribal fishers (approximately 100 tribal fishers) report total catch, days fished, and gear type to the Puyallup Tribal Fisheries Office weekly (Puyallup Tribe of Indians 2010). The seasons run from August 1 to July 31 in all waters of the Puyallup Tribe in their usual and accustomed fishing area. Daily bag limits are 8 salmon per fisher per day and or 2 hatchery steelhead and 6 salmon (Puyallup Tribe of Indians 2010).

7.3.4 Fish Species and Fisheries Management

7.3.4.1 Warmwater Fish Species

Lakes and rivers in the western US were stocked en-mass with nonnative fishes, including centrarchids, ictalurids, percids and salmonids, during the late 19th and early 20th century, by European settlers and the US Fish Commission (Lampman 1946, Wydoski and Whitney 2003). The introductions and subsequent movement of these warmwater fishes were widespread and virtually all lowland lakes and many river systems in the Pacific Northwestern region of the US now contain some introduced fish Bonar et al. 2004). Zook (1999) estimated that introduced warmwater fishes and extensive use of nonnative trout strains in stocking lowland lakes account for over 80% of the total inland fishing opportunities in Washington. Largemouth bass are widespread, present in 85%, of the lowland warmwater public-access lakes of Washington (WDFW 2003). Many non-native, warmwater fish species have been introduced into Lake Kapowsin.

Jackson and Caromile (2000) reported collecting eight species of fish from Lake Kapowsin. Of those, largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) were the most abundant numerically at 32.6% and 42.5%, respectively, and together they accounted for 54% of the total biomass (32.7% and 21.8%, respectively). Other fish sampled during the survey, in order of highest to lowest abundance, included: yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), pumpkinseed (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), brown bullhead (*Ictalurus nebulosus*), and coho salmon (*Oncorhynchus kisutch*). Although Jackson and Caromile (2000) did not report collecting walleye (*Sander vitreus*), WDNR (2015) lists walleye for Lake Kapowsin. Jackson and Caromile (2000) reported that similar to species composition, largemouth bass and bluegill exhibited the highest catch per unit effort (CPUE) at 31 fish/hour and 232 fish/hour, respectively. With the exception of yellow perch, gill and trap nets were ineffective at capturing warmwater fish (Jackson and Caromile 2000).

Jackson and Caromile (2000) conducted fish surveys in Lake Kapowsin from 7-9 September 1999, using multiple gear types (electrofishing, gill nets and trap nets) to reduce the sampling bias associated with each sampling method. Fish data analysis by Jackson and Caromile (2000) included metrics such as species composition, relative abundance, catch per unit effort, length frequency, stock density indices, relative weight, and age and growth. This analysis also included a general description of Lake Kapowsin habitat and water quality conditions in 1999.

Jackson and Caromile (2000) indicated that due to a combination of factors (steep sloping shorelines, low conductivity and season) that the size structure of fish collected, especially largemouth bass and bluegill, was dominated by smaller sized fish, unlike information from anglers and area fish biologists suggesting that the lake has a large population of big bass. In addition, Jackson and Caromile (2000) stated that in the 1970's, "Fishing and Hunting News reported on Kapowsin Lake's tremendous black crappie fishery with individuals reaching a pound or greater." Other possible explanations for the smaller stock size of the largemouth bass collected suggested by Jackson and Caromile (2000) were the presence of abundant bluegill and yellow perch populations, made space limited, and that it could simply be that Lake Kapowsin has a short growing season (for warmwater species).

According to Jackson and Caromile (2000) Lake Kapowsin is managed as a mixed-species water providing fishing for bass, bluegill, black crappie, yellow perch and rainbow trout and has received annual plants of legal-sized rainbow trout since the 1960's. A creel survey performed by Jim Cummings in Lake Kapowsin in 1976 revealed that 59% of the catch was warmwater fish and the remainder trout. Informal creel reports suggest that the majority of anglers are targeting warmwater fish (Jackson and Caromile 2000).

Fish condition results reported by Jackson and Caromile (2000) were as follows:
1) Largemouth bass condition was good with nearly all individuals ranging between 90-110 mm,
2) Condition for bluegill was good with nearly all individuals ranging between 90-120 mm,
3) Condition for yellow perch was fair,
4) Condition for rock bass was poor,
5) Pumpkinseed condition was high,
6) Black crappie condition was high,
7) Condition and growth calculations were not performed on brown bullhead and coho salmon.

7.3.4.2 Lake Kapowsin Warmwater Fish Species Habits and Habitat

Following is a brief summary of habits and habitats for key warmwater fish species in Lake Kapowsin:

Largemouth Bass – The largemouth bass is tolerant of warmwater and does best in shallow, weedy lakes and backwaters of rivers and prefers clear water with bottoms of mud, sand, and organic material (Wydoski and Whitney 2003). Generally the fish occupy shallow areas and are seldom found much deeper than the deepest areas where rooted plants grow (about 10 to 20 feet, depending on water clarity) and are found usually in association with objects that provided cover, such as brush, logs, piling, submerged trees, reeds and lily pads (Wydoski and Whitney 2003). At night, they may move into open waters to feed, but return to cover during the day (Wydoski and Whitney 2003).

Water temperatures of about 50 to 80°F appear to be optimal for the growth and well-being of largemouth bass and they can live to a rather old age, as long as 16 years in northern states, and 15 years in Washington, but few live longer than 10 years (Wydoski and Whitney 2003). In nearby Lake Washington, largemouth bass spawning occurs from mid-May until the end of June, with a peak during the last two weeks of June, with water temperatures reported between 60 and 65°F during the spawning season (Wydoski and Whitney 2003). They generally spawn in water 1 to 4 feet deep over a sand, gravel, or rubble bottom. Spawning occurs first in shallow bays, where the water warms earlier than in the main lake (Wydoski and Whitney 2003). The male digs the nest, a depression that may be 2 feet in diameter and 6 inches deep, and defends it against intruders until the fry disperse, and he is especially vulnerable to angling, because he tends to strike at anything that comes near the nest (Wydoski and Whitney 2003).

The diet of largemouth bass fry is composed principally of small crustaceans and insects and when they reach 3 to 4 inches, they begin to eat fishes. Largemouth bass in Lake Sammamish also fed extensively on fish, with 42% of their diet composed of salmonids, 15% sculpin, 23% unidentified fish, and 5% crayfish (Wydoski and Whitney 2003).

According to Wydoski and Whitney (2003) migrating juvenile salmonids are highly susceptible to predation by largemouth bass. The largemouth bass is one of the most popular spiny-rayed fish in Washington (Wydoski and Whitney 2003). It is most common to manage for trout and bass in the same water, with trout found in the deeper water where the water temperature is more suitable for them when lakes stratify during the summer, while bass will be found in the warmer littoral zone (Wydoski and Whitney 2003). Although trout can be overharvested from a lake, it is much more difficult to fish out bass (Bennett 1962). Angling pressure on largemouth bass has increased in different parts of the US in concert with the increased numbers of fishing tournaments and mortality of bass from angling and handling during such tournaments was reported to be as high as 98% (May 1974). Lake Kapowsin largemouth bass receive fishing pressure from bass fishers but it is not known if bass tournaments take place there. Introductions of largemouth bass should be made only after a thorough review of the biology of other species present and the possible effects of the introduction (Wydoski and Whitney 2003).

Bluegill – Bluegill usually inhabit warm, shallow lakes with rooted vegetation and all sizes exhibit a strong orientation to habitat with cover or structure. They grow fastest at water temperatures between 60 and 80°F, but also grow well at water temperatures to 85 °F. High turbidity is probably detrimental to successful reproduction and good growth in this species (Wydoski and Whitney 2003). Bluegill often become stunted in some lakes, particularly in waters that are infertile or have dense vegetation (Wydoski and Whitney 2003).

Bluegill spawn in the spring when the water temperature is above 67°F and spawning may occur throughout their growing season. Males generally form hollows for nest on a sandy bottom in shallow water, vigorously protect the nest, keep eggs clean and aerated by fanning them with their fins and protect the fry for several days until they disperse from the nest (Wydoski and Whitney 2003).

Bluegill fry eat zooplankton and as they increase in size, they eat increasing proportions of various aquatic insects, mollusks, small crayfish, amphipods, fish eggs, larval or small juvenile fish and terrestrial insects such as grasshoppers and crickets (Wydoski and Whitney 2003). During the summer, bluegill may eat plants such as algae as well as rooted aquatic vegetation (Wydoski and Whitney 2003). Because of its fine table quality, good fighting ability and ease of capture, the bluegill is eagerly sought by anglers in certain parts of the US (Wydoski and Whitney 2003).

Yellow Perch – In 1999, yellow perch were considered to be one of the most abundant fishes in Lake Washington (Warner 2000). Yellow perch usually travel in loose schools that often are composed of fish of the same sex, size, or age and prefer lakes with a modest amount of vegetation and clear water (Wydoski and Whitney 2003). Adult Yellow perch generally live near the bottom and move shoreward in spring for spawning and may linger in the shallow water for a while after spawning. Spawning usually occurs in April or May when water temperatures reach 45 to 52°F, takes place on vegetation or submerged brush and other objects over various types of bottom (sand, gravel, or rubble) and eggs are deposited in a ribbonlike gelatinous mass. As the water warms in late spring they move into deeper water and prefer a temperature of about 70°F during the summer.

Young perch feed in shallow areas on zooplankton, particularly copepods and cladocerans, feeding on immature insects as they grow, with large perch feeding on forage fish when they are available (Wydoski and Whitney 2003). The flesh of perch is firm, white and mild in flavor, making it a choice table item (Wydoski and Whitney 2003).

Rock Bass - Rock bass spawning generally occurs during May or June when the water temperature reaches about 70 °F and continues until the temperature reaches about 79°F. Immediately preceding and during the spawning period, adult females congregate in pools of streams until they become ripe (Wydoski and Whitney 2003). The males make a nest by digging a depression in gravel (sometimes in sand) where the current is slow and they may also make a nest in shallow water along the shoreline (Wydoski and Whitney 2003). Consequently, Kapowsin Creek and Ohop Creek may be important spawning areas for rock bass that inhabit Lake Kapowsin.

Rock bass are opportunistic feeders and eat a variety of food items, including aquatic insect larvae, mollusks, crustaceans such as crayfish and small fishes (Wydoski and Whitney 2003). In Washington, as in most US waters, rock bass seldom reach 10 inches in length. However, the species is a good gamefish, since it is voracious feeder and will strike a lure nearly as large as itself, and the white flesh is very tasty but a number of fish are generally required to make a meal (Wydoski and Whitney 2003). Rock bass are eaten by predatory fishes such as bass.

According to Kurt Perry (pers. comm.), the rock bass fishery in Lake Kapowsin is unique, in that there apparently aren't many other lakes in Washington where you can catch rock bass. WDNR (2015) states "The distribution of rock bass in Washington state is mostly confined to a few lakes and small tributary streams in Pierce and Thurston counties; Lake Kapowsin has a wealth of prime rock bass habitat."

Pumpkinseed – Pumpkinseed prefer clear, quiet water with dense aquatic vegetation and are found in weedy ponds and lakes as well as sloughs and backwaters of slow-moving rivers (Wydoski and Whitney 2003). Pumpkinseed do not grow well in waters where summer temperatures do not reach at least 70°F, and generally spawn in late spring and early summer, when the water temperature reaches about 60 °F (Wydoski and Whitney 2003). As with other sunfishes, the male constructs the nest, a shallow depression about a foot in diameter, in gravel, sand or mud bottom, and the nests are defended by the male until the young leave the nest (Wydoski and Whitney 2003).

The principal foods of pumpkinseed are aquatic insects, small mollusks, and crustaceans and because this species grows slowly in the relatively cool waters of the Pacific Northwest, it usually does not reach an acceptable size for anglers (Wydoski and Whitney 2003). Pumpkinseed provide some forage for larger predators like largemouth bass and yellow perch, and they hybridize with other sunfishes such as bluegill and green sunfish found in the same Washington waters (Wydoski and Whitney 2003).

Black Crappie – Black crappie are generally found in clear waters of large streams, reservoirs, and in medium-sized lakes and prefer dense aquatic vegetation over bottoms of sand, muck or organic debris (Wydoski and Whitney 2003). Crappie feed most actively in spring, when it is found in weedy areas with water usually less than 10 feet deep and during summer it moves into deeper water and does not seem to be as available to anglers as in the spring (Wydoski and Whitney 2003). Black crappie apparently move about in lakes or reservoirs and do not remain very long in one location (Wydoski and Whitney 2003).

Crappie spawn in spring, during May or early June in most of their range, when water temperatures reach 58 to 64°F, and males dig a shallow depression of about 10 inches to 2 feet in diameter in soft mud bottoms at depths usually less than 8 feet (Wydoski and Whitney 2003). Young crappie feed principally on zooplankton and as they grow feed more on small larval aquatic insects and large fish generally depend on fishes for food (Wydoski and Whitney 2003). It is easy to catch crappie and their white flesh has an excellent flavor (Wydoski and Whitney 2003).

Brown Bullhead – Brown bullhead inhabit warmwater ponds, lakes, sloughs, and sluggish areas in streams and adults are usually in deeper water along the shoreline of lakes during daylight, but move into shallow, weedy areas to feed and spawn at night (Wydoski and Whitney 2003). Brown bullhead are tolerant of high temperatures (up to 97°F) and low dissolved oxygen levels (0.2 parts per million) (Wydoski and Whitney 2003).

Brown bullhead spawn from April through June, when the water temperature is about 70 °F, excavate a circular depression about 1 foot in diameter in the mud or sand, and choose nesting sites (most often in dense aquatic vegetation, shaded areas or near objects such as logs or stumps), usually in shallow water, a few inches to several feet deep (Wydoski and Whitney 2003). Brown bullhead feed on the bottom, primarily at night, although they also readily feed on dark, cloudy days, particularly in turbid waters (Wydoski and Whitney 2003). Young bullhead feed primarily on zooplankton and midge larvae, and larger fish feed on midges, mayflies, worms, and crustaceans, and adults feed on many food items, such as insect larvae, mollusks, worms, leeches, terrestrial insects, algae, other aquatic plants and fishes (Wydoski and Whitney 2003). Although brown bullhead are abundant in many lakes in Washington, only a limited sport fishery exists (Wydoski and Whitney 2003).

7.3.4.3 Salmonid Fish Species

Puyallup River Basin Salmonids

As a glacier-fed system, the Puyallup River typically experiences two seasonal peaks in runoff, a large, long duration peak in summer in response to snowmelt and smaller peaks in winter in response to rainfall (Mudd and Leigh 2008). Native salmonids have adapted to these flow conditions.

Wydoski and Whitney (2003) provided an excellent summary of salmonid species biology, habits and habitats and Groot and Margolis (1995, 2003) present more detailed information on salmon physiological ecology and life histories. Figure 7.4 displays the life histories of Puyallup River salmonids (except cutthroat trout and mountain whitefish). Figures 7.5 to 7. show distribution of Chinook, coho, pink and chum salmon (*Oncorhynchus keta*), and winter steelhead in WRIA 10.

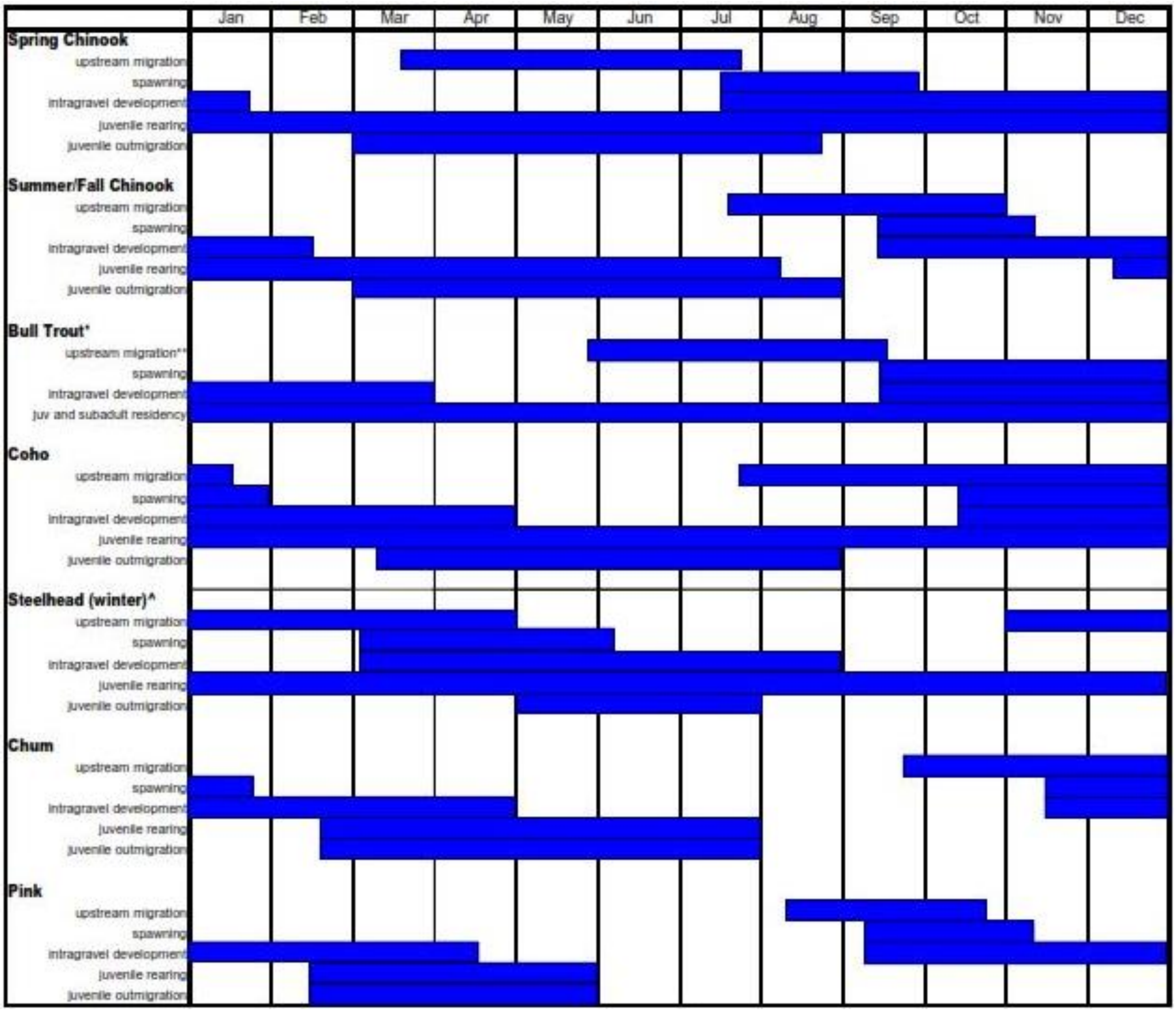


Figure 7.4. Life history of Puyallup River salmonid species (From Bates et al. 2008).

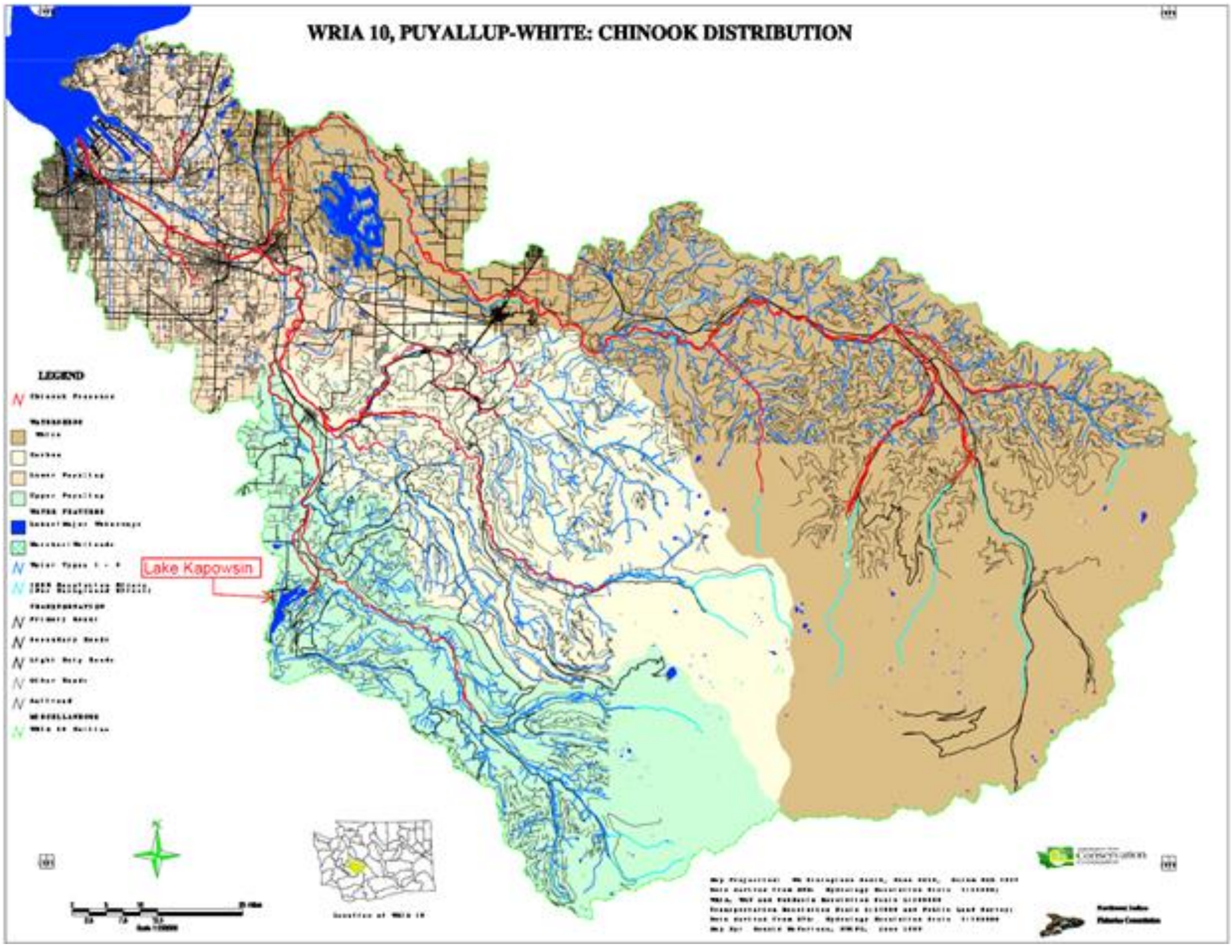
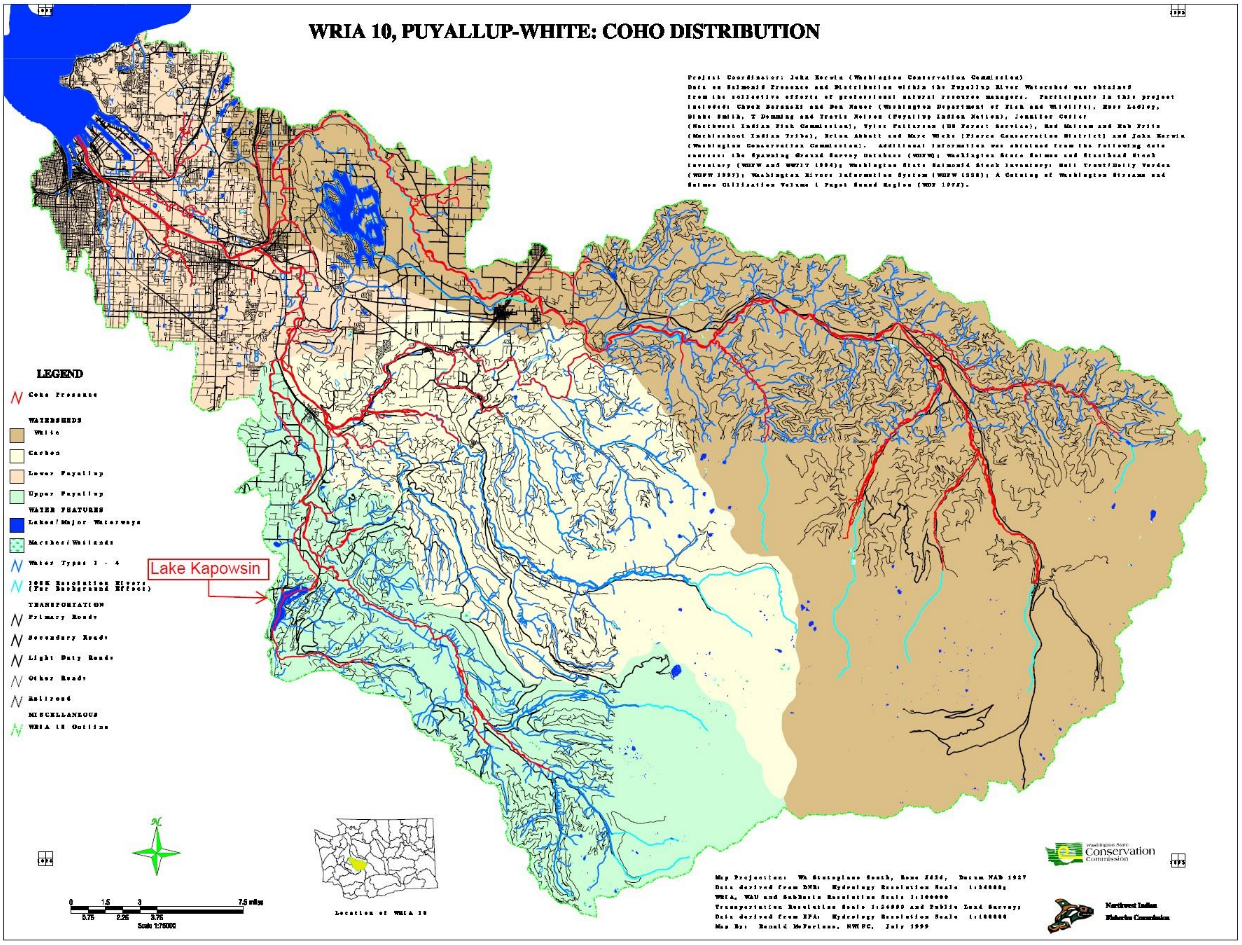


Figure 7.5. WRIA 10. Puyallup-White: Chinook distribution.



Project Coordinator: John Kerwin (Washington Conservation Commission)
Data on Salmonid Presence and Distribution within the Puyallup River Watershed was obtained from the collective efforts of professional natural resource managers. Participants in this project included: Chuck Baranski and Dan Mauer (Washington Department of Fish and Wildlife), Russ Ladley, Blake Smith, T Demming and Travis Nelson (Puyallup Indian Nation), Jennifer Cutler (Northwest Indian Fish Commission), Tyler Patterson (US Forest Service), Ned Malcom and Bob Fritz (Muckleshoot Indian Tribe), Brian Abbott and Marc Weeks (Pierce Conservation District) and John Kerwin (Washington Conservation Commission). Additional information was obtained from the following data sources: the Spawning Ground Survey Database (WDFW); Washington State Salmon and Steelhead Stock Inventory (WDFW and WWTIT 1994); Washington State Salmonid Stock Inventory: Bull Trout/Dolly Varden (WDFW 1997); Washington Rivers Information System (WDFW 1998); A Catalog of Washington Streams and Salmon Utilization Volume 1 Puget Sound Region (WDF 1975).

Map Projection: WA Stateplane South, Zone 5626, Datum NAD 1927
Data derived from DNR: Hydrology Resolution Scale 1:24000;
WRIA, WAU and SubBasin Resolution Scale 1:100000
Transportation Resolution Scale 1:24000 and Public Land Survey;
Data derived from EPA: Hydrology Resolution Scale 1:100000
Map By: Ronald McFarlane, NWIFC, July 1999

Figure 7.6. WRIA 10. Puyallup-White: coho distribution.

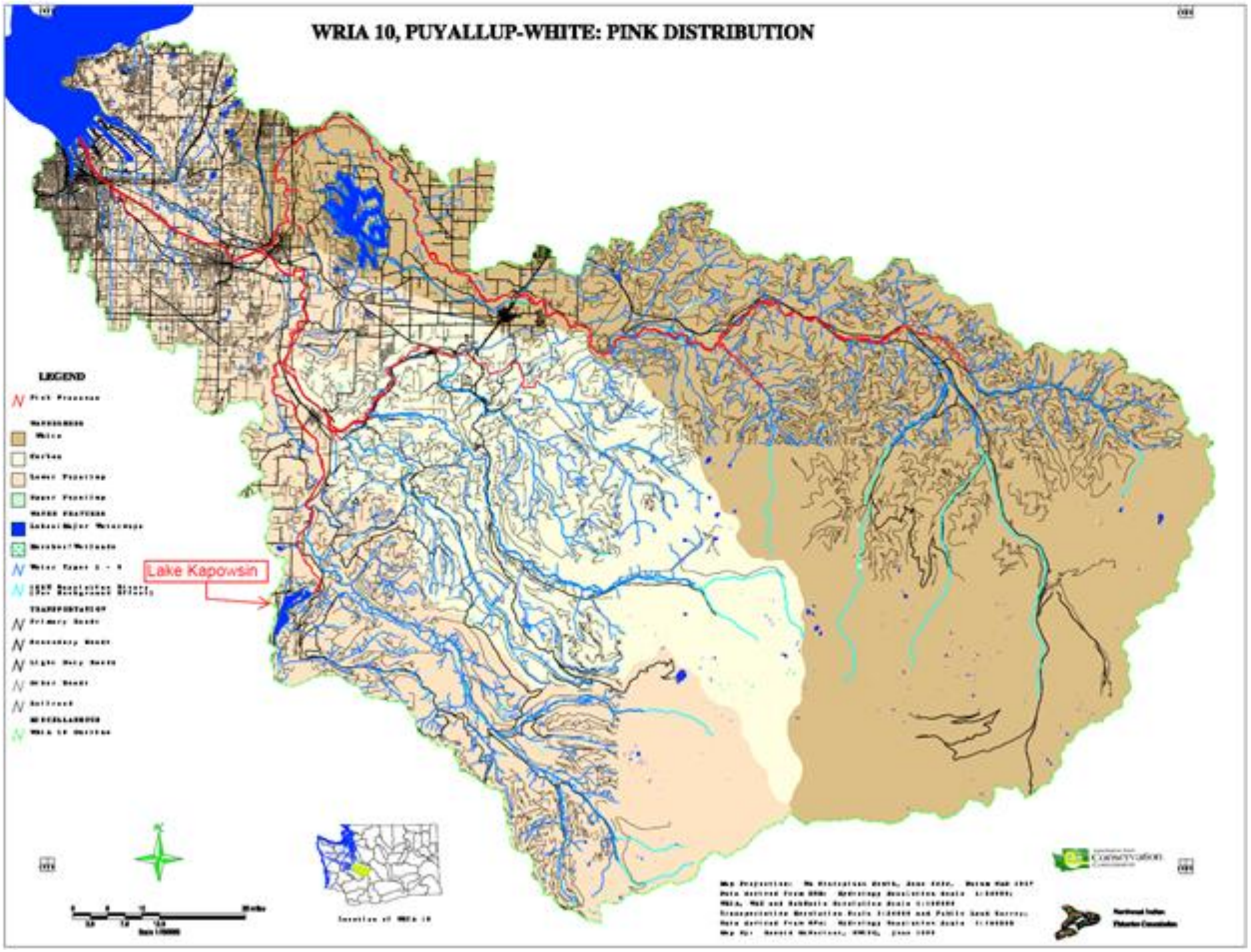


Figure 7.7. WRIA 10. Puyallup-White: pink distribution.

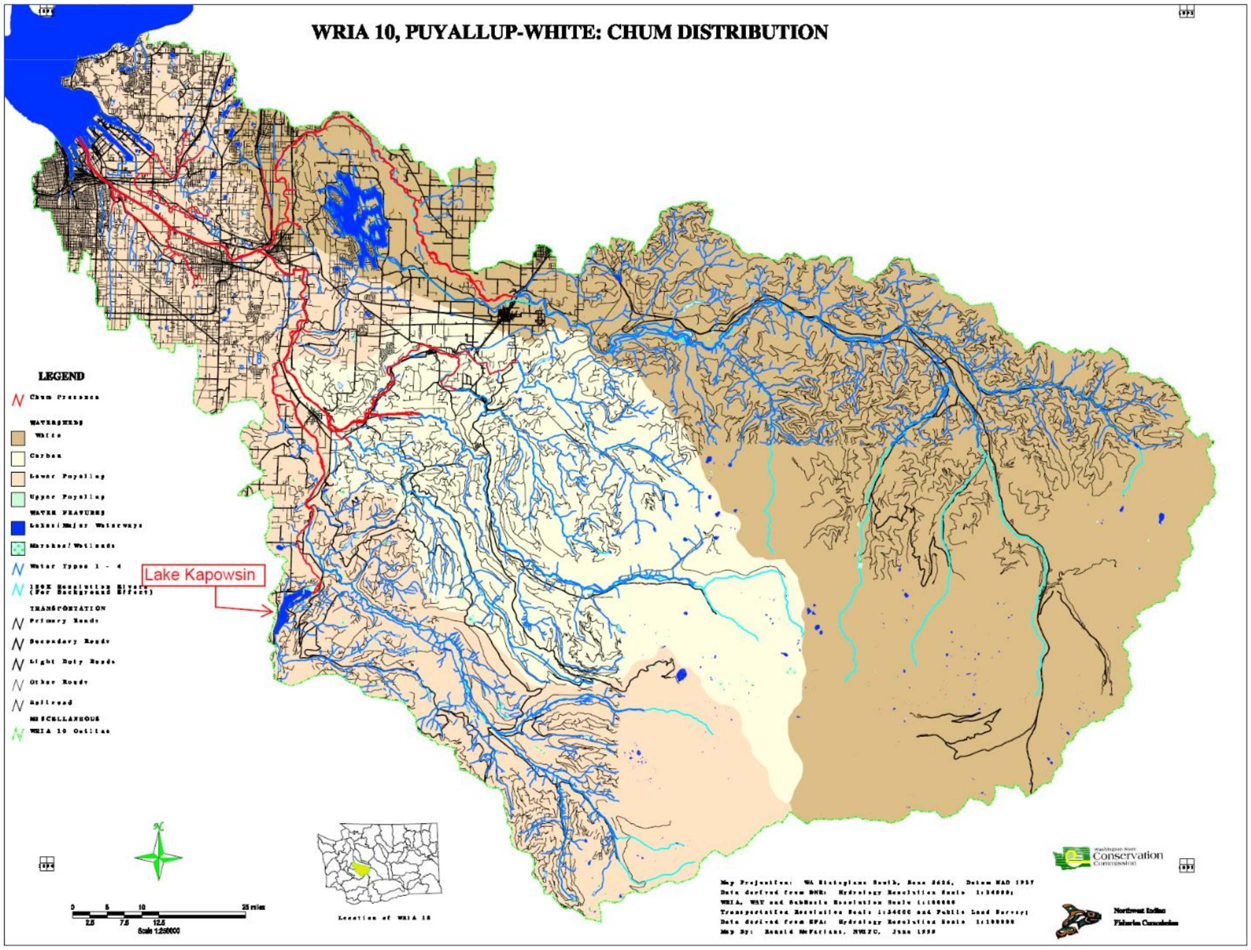


Figure 7.8. WRIA 10. Puyallup-White: chum distribution.

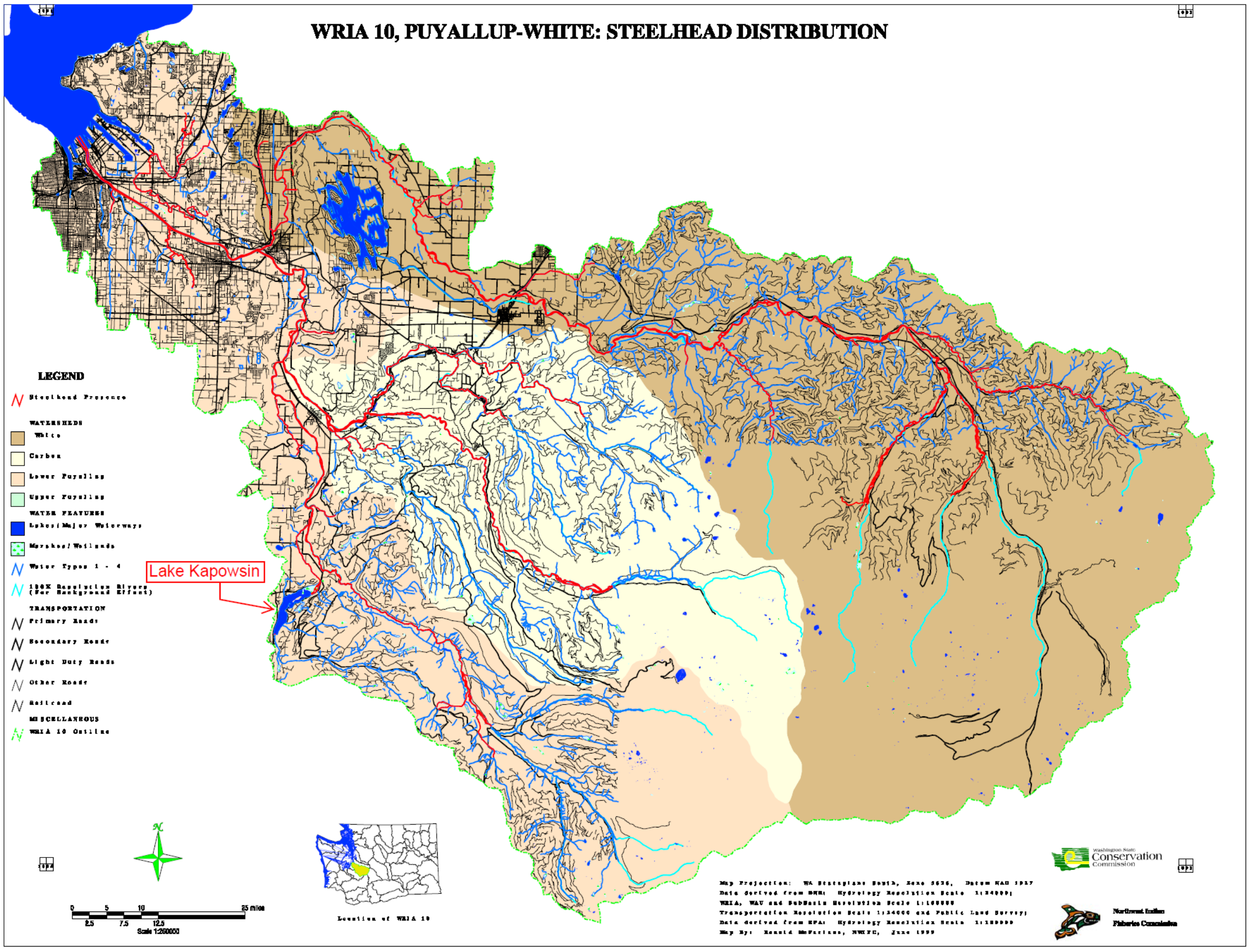


Figure 7.9. WRIA 10. Puyallup-White: winter steelhead distribution.

The majority of the salmonid information found was focused on rivers and streams in Water Resource Inventory Area (WRIA) 10: Puyallup/White River Watershed, which includes Kapowsin Creek, Ohop Creek, and the adjacent Puyallup River. There was not much information for Lake Kapowsin specifically. Following is a summary of this information.

According to Berger et al. (2014, 2015) the Puyallup River watershed supports eight species of anadromous fish, including six species of Pacific salmon (*Oncorhynchus spp.*), coastal cutthroat trout (*Oncorhynchus clarki*), and bull trout (*Salvelinus confluentus*). WCC (1999) reported that "There is no reliable source of information on salmonid species abundance in the Puyallup River basin of record." Historically, runs of Chinook (fall and spring stocks), pink, coho, chum salmon, winter steelhead and cutthroat trout were present in the Puyallup River system and there is limited evidence that sockeye salmon (*Oncorhynchus nerka*) also spawned in the Puyallup River system (WCC 1999). WCC (1999) states that "Adult sockeye are reported spawning annually but there is no information that suggests these fish are successful in their reproduction." However, Ladley (pers. comm. 2015) stated "We do observe adult sockeye spawning in lower Kapowsin Creek occasionally but that's all we know." Mudd and Leigh (2008) also reported that there was mountain whitefish in the Puyallup River system.

Since 1967, run sizes of fall Chinook, coho, pink, chum and winter steelhead have been highly variable, and escapement trends for fall Chinook and chum have trended upwards, while coho have decreased significantly (WCC 1999). The stock status for Puyallup summer/fall Chinook are unknown but the National Marine Fisheries Service (NMFS) includes this population in the Puget Sound Ecological Significant Unit (ESU) and has listed that ESU as Threatened under the Endangered Species Act (ESA) in 1999 (WCC 1999). Puyallup River fall Chinook were classified as a distinct stock by the 1992 State Salmon and Steelhead Stock Inventory (SASSI) on the basis of geographic distribution (Berger et al. 2014, 2015). Nelson et al. (1991) considered Puyallup River spring Chinook extinct and the Puyallup River fall Chinook as a stock of special concern.

Fall chum stocks in the Puyallup River are isolated from other Puget Sound stocks by geographic distribution and are separated into three stocks based on differences in spawning distribution and genetic composition. The Puyallup/Carbon fall chum stock is considered native (WCC 1999) and spawns in the mainstem reaches of the Puyallup River. Spawning usually begins in December and continues through most of January (WDF, WDW and WWTIT 1993).

Pink salmon have remained relatively stable and their stock status is considered healthy (SASSI 1994). Puyallup River pink salmon have been considered native and healthy (WCC 1999). Puyallup River pink salmon stocks are isolated from other Puget Sound stocks by geographic separation of the spawning grounds and in addition, genetic studies have shown them to be distinct from other Washington pink salmon stocks (WDF, WDW & WWTIT 1993). Puyallup River pink salmon spawning begins about the first week in September and may continue through October (WDF, WDW and WWTIT 1993).

Puyallup coho were identified as a stock due to their distinct spawning distribution (WDFW 2014b). Puyallup River coho were listed as depressed in 1992 (WDFW and WWTIT 1994) but, between 1992 and 2001, had considerably higher numbers and the stock status was upgraded to a healthy (WDFW 2014b). Coho spawning takes place though out much of the Puyallup River basin, including lower portions of Kapowsin Creek, and spawning occurs from mid-October through January (WDFW 2014b). Coho occasionally move through Lake Kapowsin into Upper Ohop Creek to spawn (Marks et al. 2013).

The Puyallup River winter steelhead stock is considered native with wild production, and had a healthy status until 1992 (WDFW 2014b). Wild winter steelhead in the mainstem Puyallup River and tributaries are native and are a distinct stock based on the geographic isolation of the spawning population (WDFW and WWTIT 1994). However, as run sizes have decreased and have not recovered their stocks status was downgraded to depressed (WDFW 2014b). Since that time Puget Sound steelhead, which includes Puyallup River steelhead stocks, were listed as threatened under ESA in 2007. According to WSRCO GSRO (2012) there was insufficient data to determine a Puyallup\Carbon winter steelhead recovery goal at that time. According to the PSSTRT (2013) the extinction risk of Puyallup River winter steelhead is high (about 90% within 25-30 years). There is little life history information on Puyallup River winter-run steelhead stocks other than spawn timing (WDFW 2002). Spawning takes place in the mainstem Puyallup River, and tributaries like Kapowsin Creek, from early March through mid-June (WDFW 2014b).

The Puyallup coastal cutthroat stock complex is thought to be of native origin, sustained by wild production, and is distinct based on geographic distribution of its spawning grounds (Blakely et al. 2000). Coastal cutthroat occur in virtually all perennial tributaries and mainstem reaches in the Puyallup River system in one or more life-history forms (Blakely et al. 2000). There is very little data available, for any life history stage for anadromous cutthroat trout (WCC 1999). The number of anadromous cutthroat in the Puyallup River system is not large, but a few (probably fewer than 50) are caught by anglers each year and the fluvial form is present throughout the system but in relatively small numbers within the mainstem anadromous zones (Blakely et al. 2000). The anadromous form of coastal cutthroat trout inhabits Kapowsin Creek and adfluvial cutthroat trout may be present in Lake Kapowsin (Blakely et al. 2000). Anadromous spawning is probably from February through May and fluvial, adfluvial and resident spawning is probably from January through mid-June (Blakely et al. 2000). Berger et al. (2014, 2015) reported catching some cutthroat trout each year in their screw trap that has been in operation since 2000, on the lower Puyallup River at RM 10.6.

Puyallup River bull trout/Dolly Varden are native and are maintained by wild production (WDFW 2004). The stock status of native populations of bull trout/Dolly Varden in the Puyallup River basin is unknown due to insufficient information and spawn timing and locations have not been determined (WDFW 2004). Only limited bull trout/Dolly Varden data exists from sporadic electrofishing and angler catch reports (WCC 1999). Bull trout/Dolly Varden in the Puyallup River have been identified as a distinct stock based on their geographic distribution (WDFW 2004). Their life histories are unknown, but habitat is available for anadromous, fluvial and resident forms (WDFW 2004).

Following is a summary of salmonids and their habitats found in Kapowsin Creek that flows out of Lake Kapowsin into the Puyallup River and Ohop Creek, the major tributary stream flowing into Lake Kapowsin.

7.3.5 Lake Kapowsin Fish Species, Streams & Habitat Conditions

7.3.5.1 Kapowsin Creek (WRIA 10.0600)

Kapowsin Creek is a tannic stream originating at the north shore of Lake Kapowsin (Marks et al. 2013), located approximately 3.6 miles upstream from its confluence with the Puyallup River at RM 27.6 (Figures 7.1 and 7.2). Marks et al. (2013) described the lower segment (RM 0-0.2) of the creek as being “a low gradient channel flowing within the open migration zone of the Puyallup River, and is repeatedly occupied by mainstem river incursions.” A large, mostly scrub/shrub and forested wetland complex exists along Kapowsin Creek just north of the lake, and extends along the lake shore and into the lake with vegetated floating logs.

According to Sullivan et al. (1990) Kapowsin Creek has a basin area of 67.34 square kilometers (26 sq. miles) and an average flow of 0.59 square meters per second (16 cubic feet/sec.). According to Marks et al. (2013) Kapowsin Creek supports Chinook, pink, coho, steelhead and occasionally chum salmon. Figures 7.6 to 7.9 show the distribution of coho, pink, and fall chum salmon, winter steelhead and Dolly Varden/bulltrout in the Lake Kapowsin area.

Salmon spawning ground surveys (Appendix 7.C, Figure 7.10) have been conducted in Kapowsin Creek starting as early as 1943 and continuing through 2014 (WDFW 2015). Up until the 1990's, most of these surveys were conducted by the WDFW (WDF and WDG), and since then they have been conducted exclusively by the Puyallup Tribe (WDFW 2015). These foot surveys collect data on live and dead fish numbers and redd counts and have focused primarily on coho, Chinook and pink salmon, with a few chum surveys (WDFW 2015). Steelhead spawning ground surveys have only been conducted in Kapowsin Creek since 1999 (WDFW 2015).

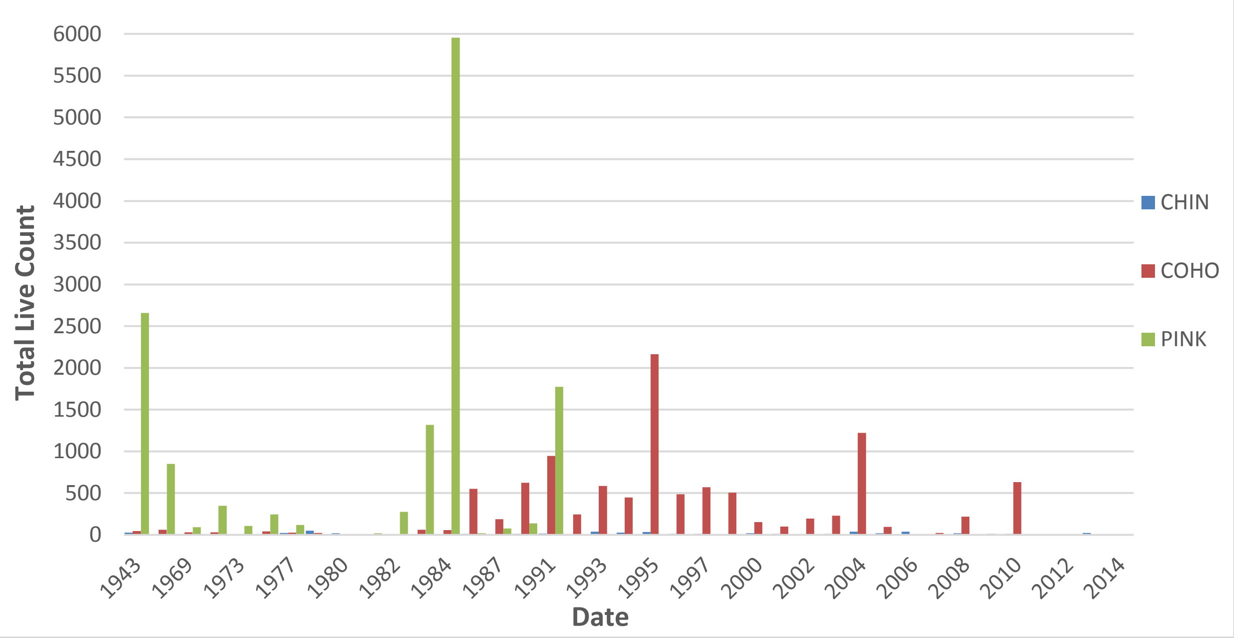


Figure 7.10. Historical live counts of coho, pink, and Chinook from WDFW spawning ground survey database 1943-2014 (WRIA 10) (WDFW 2015).

Marks et al. (2013) stated that "Chinook have not been observed beyond the top of Kapowsin Creek where it enters the lake," meaning Chinook haven't been observed in the lake, beyond where Kapowsin Creek originates or terminates. Chinook spawning ground surveys conducted between 1993 and 2012, show maximum counts of 38 live Chinook in 2004 and 2006, and 28 and 26 redds, respectively, in 1995 and 2001 (Marks et al. 2013). In October 2011, 100 adult Chinook were released into Kapowsin Creek (Marks et al. 2013).

Coho, and occasionally a few steelhead move through Lake Kapowsin into Ohop Creek to spawn (Marks et al. 2013). Ohop Creek, which enters the south end of the lake, is technically considered the continuation of Kapowsin Creek. According to Marks et al. (2013) steelhead escapement in the Kapowsin system is low, however, this drop in escapement is widespread as winter steelhead stocks in the Puyallup basin have been declining since 1990. Steelhead redd counts conducted in Kapowsin Creek between 1995 and 2013, ranged from 0 (1997, 1999, 2001 and 2012) up to 11 in 1998 (Marks et al. 2013).

Coho are the predominate salmonid in Kapowsin Creek and recovered coded wire tag (CWT) data has shown that many of the coho spawning in the creek are fish that were released a few years ago from upper Puyallup River acclimation ponds or are descendants of the net-pen acclimation project in Lake Kapowsin. From 1993 to 1997, the Puyallup Tribe fisheries staff transported juvenile coho from WDFW's Voights Creek Hatchery to four net-pens in Lake Kapowsin to acclimate (Marks et al. 2013). Ladley (pers. comm. 2015) reported that the Puyallup Tribe operated a coho net pen program in Lake Kapowsin for a five year period in the 1990's, and that it was so successful that the tribe abandoned the program. Spawning coho were prolific in most of the lake tributaries and Ohop Creek for a short period of time after the coho net pens were operated. According to Marks et al. (2013) "Prior to this fish restoration project few or no coho were observed in Kapowsin Creek or Ohop Creek." Between 1993 and 2011 annual live adult coho counts ranged from 21 in 2010 (survey data incomplete due to extreme high water and poor visibility) to a maximum of 2,023 in 2002 (Marks et al. 2013).

According to WCC (1999) and WDFW (2014c) there is known chum salmon spawning and presence/migration up to RM 1.0 (Figure 7.2).

According to WCC (1999) and WDFW (2014c) there is known pink salmon juvenile rearing up to RM 3.5, and spawning and presence/migration up to RM 3.75 (Figure 7.2). Pink salmon spawning ground live adult counts conducted between 2001 and 2011, ranged from 0 in 2001 to 3,361 in 2009 (Marks et al. 2013).

According to WCC (1999) and WDFW (2014c) there is known native char (Dolly Varden/bull trout) presence/migration up to RM 6.5, which is the upper end of Lake Kapowsin (Figure 7.2). Since coho salmon utilize Ohop Creek up to RM 12, it seems reasonable to assume that native char can at least access habitat that far due to their ability to ascend fairly steep gradient headwater streams. Ladley (pers. comm. 2015) stated "We've not seen bull trout in the lake but I suspect adults would venture in to forage during cooler months. Our genetics analysis has not revealed the presence of any dolly's, only bull trout."

Marks et al. (2013) stated that "Suitable spawning gravel is available throughout the 3.6 mile survey reach of Kapowsin Creek, although much of it is sporadic" and that "A number of downed trees within the channel along with several sizable logjams create complexity throughout the stream." Cattle and other livestock have been allowed access to the stream channel around RM 1.7, homes and outbuilding are frequent along the creek between RM 0.5 and 2.0, and human-made rock dam structures and sill logs span the creek and alter channel hydrology which results in upstream migration problems for adult salmon during summer and fall low flow periods (Marks et al. 2013). In addition, Marks et al. (2013) reported that beaver dams in the creek can also prevent upstream fish migration during summer/fall low flow periods.

Marks et al. (2013) described the riparian zone along Kapowsin Creek as being dense "consisting of fir, cedar, alder, cottonwood, and salmon-berry." Marks et al. (2013) indicate that Pierce County completed construction of the new Oroville Road Bridge over the head of Kapowsin Creek in early 2006 and that a 2006 flood event destroyed extended portions of the levee along Oroville Road near the creek. WCC (1999) identified flood connectivity, large woody debris, pools, side channel habitat, riparian habitat, and Lake Kapowsin as important habitat limiting factors for salmonids in Kapowsin Creek.

7.3.5.2 Ohop Creek (WRIA 10.0600)

Ohop Creek is the main feeder stream to Lake Kapowsin and is considered a continuation of Kapowsin Creek and therefore shares the same WRIA designation (Marks et al. 2013) (Figures 7.1 and 7.2). Ohop Creek continues for approximately 8.5 miles beyond (upstream from) Lake Kapowsin and currently primarily supports coho and likely also supports a limited number of steelhead (Marks et al. 2013).

According to Sullivan et al. (1990) Ohop Creek has a basin area of 90.65 square kilometers (35 Sq. miles) and an average flow of 0.34 square meters per second (7.0 cubic feet/sec.). Marks et al. (2013) described the lower 0.2 miles of Ohop Creek as flowing through a narrow and incised wetland boundary at the southern end of Kapowsin Lake that is nonconductive to spawning and is heavily vegetated with reed canary grass and has a lot of beaver activity. From RM 6.5 to 7.0, the creek has a low gradient pool-riffle structure, containing excellent spawning gravel, with several deep pools and moderate amounts of woody debris according to Marks et al. (2013).

From RM 6.5 to 8.0 the channel meanders through a fairly dense forested (cedar, fir, alder and maple) riparian zone with several side channels that branch off and offer additional spawning and rearing habitat (Marks et al. 2013). High water flood events often re-establish some significantly long, complex, side channels above RM 0.4 that are often used by coho (Marks et al. 2013). Cattle occasionally access the creek but have had minor impacts (Marks et al. 2013).

Upper reaches of Ohop Creek extend well into the Kapowsin Tree Farm, currently managed by the Hancock Timber Resource Group (Marks et al. 2013). Logging roads and timber harvest have impacted several stream reaches, with sedimentation, windthrow, increased solar exposure, as well as channel confinement and constriction (Marks et al. 2013). We were not able to determine if these logging roads, including culverts, and other stream crossings, have been surveyed recently to determine road condition and maintenance and improvement needs.

In Ohop Creek, coho are the only fish species surveyed for on a consistent basis according to Marks et al. (2013). According to WCC (1999) and WDFW (2014c), there is known coho presence/migration and spawning in Ohop Creek (WRIA # 0607) up to RM 12 and presence/migration up to RM 0.5 in North Fork Ohop Creek (WRIA # 0605) (Figure 7.6). Over the last few years, adult coho escapement has dropped significantly in Ohop Creek as well as in Kapowsin Creek, despite the 5-year coho net-pen project operated by the Puyallup Tribe during the 1990's, and despite the surplus adult plants from Voights Creek (Marks et al. 2013). Ohop Creek coho spawning ground surveys conducted between 1995 and 2012, ranged from 2 live adults in 2007 to 638 in 2012. In 2001, an additional 393 adult surplus coho from the Voights Creek Hatchery were planted in North Fork Ohop Creek, approximately 3 miles upstream of the survey area, and 720 coho were planted in 2012 (Marks et al. 2013). In 2008 and 2009, 93,000 and 21,000 juvenile coho outplants, respectively, were released into Lake Kapowsin from the Voights Creek acclimation pond (Marks et al. 2013).

According to Marks et al. (2013) steelhead surveys in Ohop Creek have been reduced to periodic spot checks during the spring since none have been observed for several years now, however, it is likely that a small number of steelhead may continue to spawn in the creek above the survey areas since they are consistently observed in Kapowsin Creek. According to WCC (1999) and WDFW (2014c) there is known steelhead presence/migration in Ohop Creek (WRIA # 0607) up to RM 8.0.

Although documented in Kapowsin Creek, Chinook, chum and pink salmon have not been observed in Ohop Creek (Marks et al. 2013). According to WCC (1999) and WDFW (2014c) distribution maps for resident rainbow and cutthroat trout do not show any use of the Kapowsin Creek/Ohop Creek system. This is very difficult to understand since rainbow and cutthroat trout are found in many systems that have steelhead. Also, according to WDFW (2014d) rainbow trout are routinely stocked in Lake Kapowsin and some would have been expected to survive and establish naturally spawning populations over time. Berger et al. (2014, 2015) reported collecting cutthroat trout regularly in the rotary screw trap incidental catch since 2000 that is operated in lower Puyallup River at RM 10.6.

WCC (1999) identified bank stability, large woody debris, pools, and fine sediment as important habitat limiting factors for salmonids in Ohop Creek. However, WCC (1999) did not specify specific locations where these problems occurred.

Three other unnamed streams are associated with Lake Kapowsin (Figure 1.1). These are described as follows: 1) Unnamed stream # 1 (approximately 1 mile long) flows out of some pot hole ponds along the western edge of the town of Kapowsin and south into the northwest side of Lake Kapowsin, near the middle of the lake; 2) Unnamed stream # 2 (2.5 miles long) is located just southwest of the Electron Reservoir (for the Electron Power House), and flows in a northwesterly direction (parallel to the Electron Flume) into the lower end of Lake Kapowsin; 3) Unnamed stream #3 (approximately 3 miles long) flows in a westerly direction into the east side of Lake Kapowsin near Jaybird Island.

7.3.5.3 Other Fish Species

Jackson and Caromile (2000) report capturing sculpin (Cottidae), but not identified to the species, as well as carp (Cyprinidae). Berger et al. (2014, 2015) report catching western brook lamprey (*Lampetra richardsoni*), Pacific lamprey (*Lampetra tridentata)*, sculpin (*Cottus spp*.), long-nosed dace (*Rhinichthys cataractae*) and sticklebacks (Gasterosteidae) as incidental catch in their rotary screw trap operated in the lower Puyallup River at RM 10.6, located just downstream from the mouth of Kapowsin Creek (RM 27.6). It is assumed that all of these non-salmonid species captured in the lower Puyallup River, could also occur in Lake Kapowsin and/or it's tributary streams. Other fish species that could occur in Lake Kapowsin and/or its tributaries, based on their known distribution in Washington and habitats (Wydoski and Whitney 2003) include: mountain whitefish (*Prosopium williamsoni*), river lamprey (*Lampetra ayresi*), peamouth (*Mylocheilus caurinus*), northern pikeminnow (*Ptychocheilus oregonensis*), speckled dace (*Rhinichthys osculus),* redside shiner *(Richardsonius baleatus),* Salish sucker (*Catastomus sp*.), largescale sucker (*Catostomus macrocheilus),* three-spine stickleback (*Gasterosteus aculeatus*).

7.3.6 Interactions Between Warmwater Fish Species and Native Salmonids in Lake Kapowsin & Adjacent Stream Systems

Most of the hundreds of lakes and ponds in the Pacific Northwest contain introduced fish and many of these water bodies are also important for salmonid production, especially coho salmon (Bonar et al. 2004). Although popular with anglers (Zook 1999), introduced fishes have contributed to declines of native fishes in many regions of the American West (Minckley and Deacon 1991, Gunckel et al. 2002).

Most studies of interactions among introduced fishes and Pacific salmon have been conducted in large deep lakes, reservoirs, or large river systems (Poe et al. 1991, Tabor et al. 1993, Fayram and Sibley 2000, Nowak et al. 2004). However, the most common introduced fishes found in the freshwaters of the Pacific Northwest evolved in warm, shallow waters of the eastern US and prefer shallow, off-channel sites such as ponds, sloughs, marshes, and the littoral zones of lakes (Bonar et al. 2004). These same areas are also important for salmon and these habitats are reported to contribute 15-62% of the total production of juvenile salmon in various watersheds (Bustard 1983, Brown and Hartman 1988, Beechie et al. 1994). The vast majority of these lakes and ponds throughout the Pacific Northwest are small and shallow, yet almost no information is available regarding the impacts of introduced fishes on the numerous small salmon runs that use these lake systems (Bonar et al. 2004).

Interaction between transplanted warmwater fish communities, and native salmonid communities, has become an important area of research, yet little is known about the structure of these transplanted communities or possible competitive and trophic interactions between warmwater fish and salmonids in systems outside of the Columbia Basin (Downen 1999). Downen (1999) observed trophic interaction between juvenile largemouth bass and coho salmon fry in both pond (Sunset Pond) and stream habitats in Squalicum Creek, a western Washington tributary to Bellingham Bay (Whatcom County), where juvenile largemouth bass preyed upon coho salmon fry. Downen (1999) indicated that if the largemouth population size was large then bass are probably a mortality factor during coho smolt outmigration and that yellow perch may also interact trophically with salmonids in the Squalicum Creek system. Downen cited studies (Paszkowski and Tom 1994) conducted on yellow perch in Lake Erie and stated that "These studies suggest yellow perch are capable of preying on salmonid fry under circumstances in which both groups overlap spatially, temporally, and metabolically." Downen (1999) found that growth rates for largemouth bass and yellow perch in the Squalicum Creek-Sunset Pond system were above the Washington State average, suggesting system productivity is effectively transferred to warmwater populations. Although Sunset Pond along Squalicum Creek, is a much smaller water body than Lake Kapowsin, similar interactions between warmwater fish species and juvenile salmonids could be expected, although on a different scale.

Over a two-year period, Bonar et al. (2004) examined predation impacts of ten common introduced warmwater fish species on wild juvenile coho salmon in three shallow western Washington lakes, all located in different watersheds. Warmwater fish studied included largemouth bass, bluegill, yellow perch, pumpkinseed, black crappie, brown bullhead catfish, as well as others, and found that fish predation was a significant source of mortality of coho salmon juveniles (Bonar et al. 2004). Of the ten warmwater species, largemouth bass were responsible for an average of 98% of the predation on coho salmon in all lakes, but total impact to each run varied among lakes and years. Largemouth bass predation varied by season and occurred most in the spring when coho salmon smolts were migrating through lakes to the sea, or when coho fry were moving from creeks into lakes. Few coho salmon were captured in any of the lakes in summer or early fall; consequently, predation was usually low at this time of year. Bonar et al. (2004) found no evidence that a particular size group, or age class of largemouth bass was responsible for more predation on coho salmon than others and that almost all of the predation by largemouth bass on coho salmon was likely confined to the lakes. Bonar et al. (2004) indicated that predation impacts to salmon seemed greatest when there was a small coho salmon run passing through a lake containing a large littoral zone supporting many largemouth bass versus a large run passing through a small lake. This is very similar to the largemouth bass and coho salmon situation in Lake Kapowsin. Bonar et al. (2004) found that very few coho salmon were eaten by black crappie, brown bullhead catfish, yellow perch, and cutthroat trout, while the remaining species were not observed to eat coho salmon. Juvenile coho salmon growth in all lakes was higher than in nearby streams. Other warmwater species primarily targeted insects and zooplankton as food, so food competition between coho salmon and introduced warmwater fishes in lakes was probably not limiting coho salmon populations.

Attempts to transplant, or increase largemouth bass numbers in lakes important to coho salmon, would be counterproductive to coho salmon enhancement efforts (Bonar et al. 2004). Berger et al. (2014, 2015) reported catching bass and sunfish each year as incidental catch in their rotary screw trap operated in the lower Puyallup River at RM 10.6. Ladley (pers. comm. 2015) reported that the Puyallup Tribe's screw trap intercepts a variety of centrarchids and warmwater fish species that they assume to have emigrated, escaped, or have been flushed from Lake Kapowsin into the Puyallup River. This is an indication as to how entrenched these warmwater fish are in Lake Kapowsin and the difficulty in being able manage these warmwater fish populations in order to reduce their impacts on the native salmonid fish populations in the Lake Kapowsin system.

A major fishery management challenge in Lake Kapowsin is that warmwater fish, especially largemouth bass and rock bass, provide a popular and apparently significant recreational sport fishery. This makes managing for successful juvenile coho lake and side-channel rearing, and juvenile coho, steelhead, and possibly sea-run cutthroat trout and bull trout out-migration through the lake difficult, considering the high potential for warmwater fish predation, especially from largemouth bass, on salmonid juveniles. The amount of predation on juvenile salmonids in Lake Kapowsin is not known, however, based on studies in other similar western Washington lakes (Downen 1999, Wydoski and Whitney 2003, Bonar et al. 2004) this predation could be significant.

7.3.7 Summary of Average Discharge & Flow Data for Kapowsin Creek

According to the USGS (2015) Kapowsin Creek does not have an operating stream gage that measures stream discharge. USGS historical data shows that a stream gage (USGS #12093000 Kapowsin Creek, Near Kapowsin, WA) was operated on Kapowsin Creek from 1927 to 1957. This gage collected stream discharge data during that time period and some field peak flow measurements were made in 1970, and in 2001. The graph of these historic data shows daily mean discharge in Kapowsin Creek ranging from about 1 cfs up to about 600 cfs (USGS 2015). This gage site was located on Kapowsin Creek at about RM 2.9 (Lat. 46°59'44", Long. 122°11"44"), at 561 feet above mean sea level, with a reported drainage area of 25.9 square miles (Figure 7.2). Kapowsin Creek enters the Puyallup River at RM 27.6.

The two nearest active gaging stations are USGS #12093500 (Puyallup River near Orting, WA), located about 1.2 miles downstream from the mouth of Kapowsin Creek at RM 26.4, and USGS #12092000 (Puyallup River near Electron, WA), located about 14.4 miles upstream from the mouth of Kapowsin Creek at RM 42.0 (Figure 7.11). USGS Gage #12093500 has a period of record from 1931 to the present, a listed flood stage of 4,500 cfs, and a drainage area of 172 square miles, while USGS Gage #12092000 is newer, with a period of record from 2007 to the present, with no flood stage yet established, and a drainage area of 92.8 square miles (USGS 2015). However, contradictory to this information, Mudd and Leigh (2008) reported that USGS Gage #12092000 has been in operation since 1909 and that daily discharge at this gage typically varies from less than 200 cfs to more than 2,000 cfs in a year.

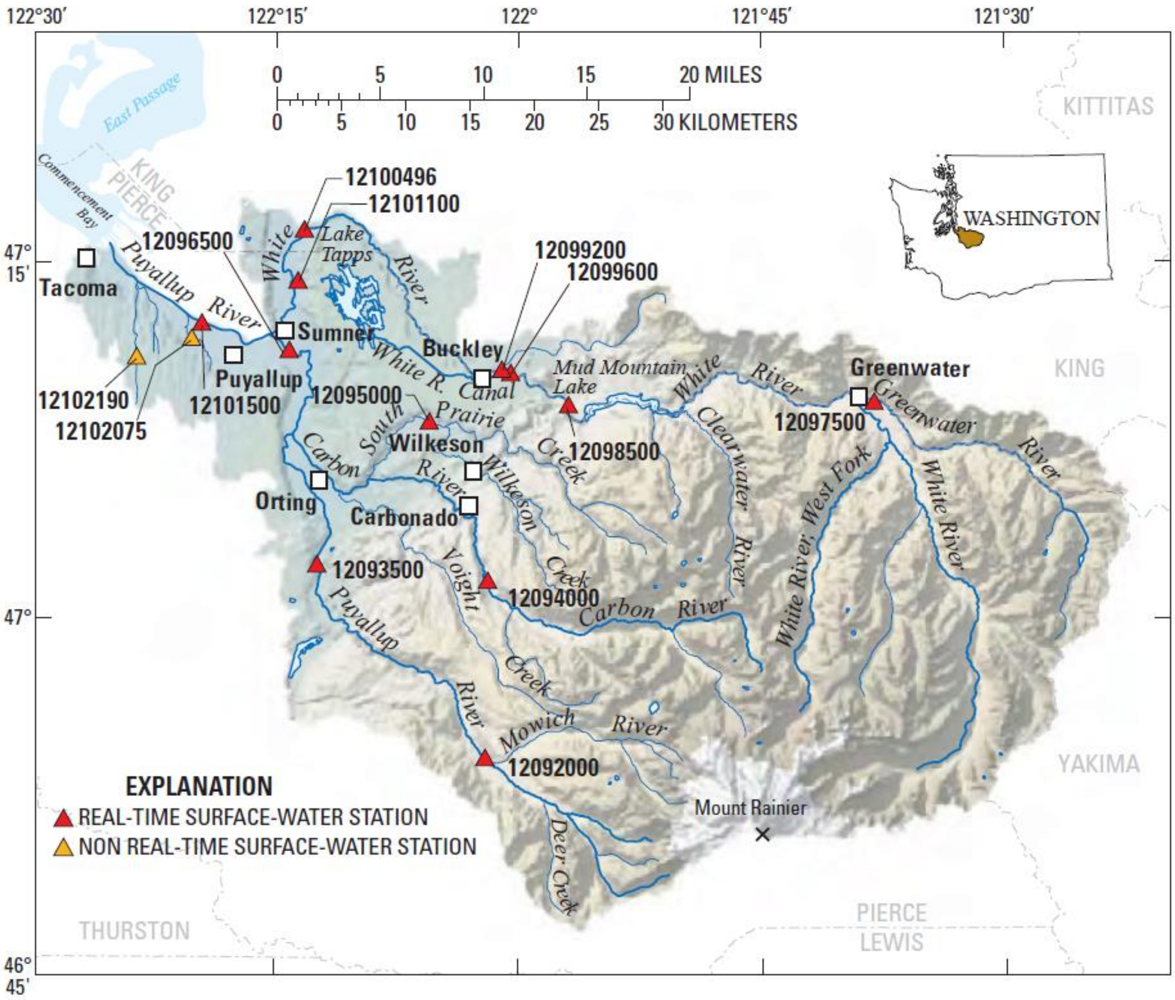


Figure 7.11. Puyallup River basin USGS gage site map.

7.4 Fisheries and Aquatic Habitat Information Gaps and Recommendations

1) Determine impacts of warmwater fish species, especially largemouth bass, on juvenile coho salmon moving through the Lake Kapowsin system.
2) Determine if there are wild coastal cutthroat trout populations in Lake Kapowsin, Kapowsin Creek and Ohop Creek, and which life history forms are present (anadromous, resident, fluvial and adfluvial).
3) Determine if there are wild rainbow trout populations in Lake Kapowsin, Kapowsin Creek and Ohop Creek.
4) Evaluate existing spawning ground survey data to determine inter annual trends in salmonid redd counts in Kapowsin Creek and Ohop Creek.

5) Analyze annual salmonid spawner survey data (spawn timing, etc.) to delineate salmonid populations in Lake Kapowsin, and its tributaries, and to provide an understanding of the life history variability.
6) If determined to be present, conduct genetic analysis of wild rainbow and cutthroat trout populations in Lake Kapowsin, Kapowsin Creek, and Ohop Creek, to determine the number of trout populations, and compare those genetic differences to other western Washington trout populations.
7) Determine spatial and temporal variability of spawning patterns and timing of incubation and emergence for salmonids (coho, pink, chum and Chinook salmon, steelhead, rainbow and cutthroat trout) in Kapowsin Creek and Ohop Creek.
8) Determine the extent of interspecific hybridization (in rainbow and cutthroat trout) in Lake Kapowsin, Kapowsin Creek and Ohop Creek.
9) Determine management and conservation implications associated with observed life history patterns for coho, rainbow and cutthroat trout, and other salmonids.
10) Implement an integrated and comprehensive monitoring program in Lake Kapowsin, Kapowsin Creek and Ohop Creek to assess the status and life history diversity among the salmonid population and to better understand the effects of past fisheries management actions.
11) Conduct adult capture and tagging studies (i.e., PIT or telemetry) to help elucidate patterns of fish movements between Lake Kapowsin, Kapowsin Creek and Ohop Creek, and provide current information on age, size structure, growth, and extent of repeat spawning (rainbow, steelhead, cutthroat, and possibly bull trout) with each population.
12) Resurvey Lake Kapowsin in the spring to obtain a truer account of size structure. According to Jackson and Caromile (2000) few largemouth bass of quality size or larger were sampled from Lake Kapowsin and they recommended that the lake be resurveyed in the spring. (As far as we know the recommended follow-up spring fish re-sampling and creel survey were not conducted by the WDFW).
13) Conduct a year-long creel survey on Lake Kapowsin, as recommended by Jackson and Caromile (2000), to assess angler preference, pressure, harvest, and satisfaction, as it relates to the warmwater fish community in the lake.
14) Apply the full three-point lake evaluation program used by Garn and Parrott (1977) to classify the trophic state and sensitivity of Lake Kapowsin that provides basic resource information questions in qualitative terms for making general management decisions for the lake.
15) Evaluate the condition of septic systems in the town of Kapowsin and other homes and recreation facilities around the lake to determine if water quality is being impacted.
16) Contact private timber land owners to get the latest forest road condition survey, culvert/bridge inventory information to evaluate potential risks to Lake Kapowsin water quality.
17) Consider conducting a watershed cumulative effects analysis for Lake Kapowsin watershed, as recommended by Marcus et al. (1990).

18) Determine the amount of warmwater-related fishing recreation use occurring on Lake Kapowsin and the relative importance of this fishery to local and statewide fishing groups. Develop a questionnaire and use the "Washington Fishing website" (Washington Fishing 2015), or other means, to query fishers to gather this information.

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8.0 HUMAN INFLUENCE AND IMPACTS AT LAKE KAPOWSIN

This analysis was based primarily on available aerial photos, maps, reports, studies and other information sources. Incidental observations of human impacts due to recreation along Lake Kapowsin were also noted during 2015 site visits for other studies (aquatic plants, amphibians, wetlands, etc.). Following is a summary of the land uses (timber management) and other resources (recreation, urban, etc.) in the Lake Kapowsin watershed and an attempt was made to evaluate their potential impacts.

8.1 Land Use and Ownership

8.1.1 Puyallup Tribe

The Puyallup Tribe owns lands some acreage along the east side of the lake (shown on Puyallup Tribal Planning and Land Services 6/20/2012 map [Figure 8.1]). On the map, for Tribal parcels on the eastern shoreline (in blue), the captions states that the "Parcels in blue are for coho salmon, treaty access or preservation activities" and "Parcels in fuchsia are Designated Forest Lands."'

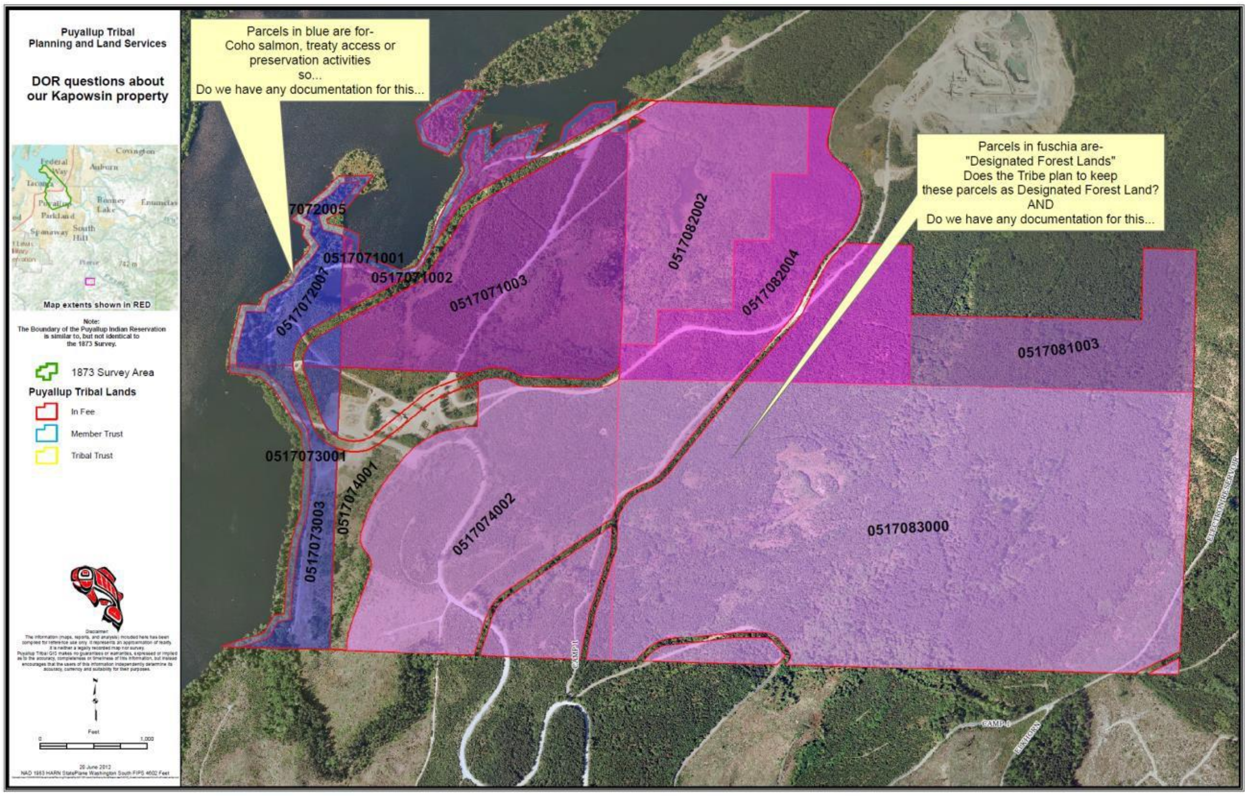

Figure 8.1. Puyallup Tribe Lake Kapowsin forest lands map.

8.1.2 Muckleshoot Tribe

The Muckleshoot Tribe owns second class shorelines within the lake on Jaybird Island. According to Ladley (pers. comm. 2015) the Muckleshoot Tribe owns about 40 acres of land, located just north of the Puyallup Tribal holdings, which, to his knowledge, was given to them by the City of Tacoma as part of a settlement. The Muckleshoot Tribe has not taken any management actions in Lake Kapowsin to date.

8.1.3 Washington State Lands

WDNR owns the bedlands of Lake Kapowsin in their entirety (WDNR 2015) which is approximately 561 acres (WSPLI 2015). The proposed aquatic reserve would be composed of existing state-owned bedlands and shorelands (WDNR 2015). WDNR continues to own and manage all second class shorelands along the southern portion of the lake, over half the western shoreline, and over half of the shoreline surrounding Jaybird Island, a small forest-shrub island in the center of the lake (Figure 1.1). There are no upland tracts owned by WDNR directly adjacent to the lake. There is a parcel of Charitable Education, Penal and Reformatory Institution Trust (HCP CEP & RI) land in the NE Corner of Section 6 (T17, R5E) just west of the town of Kapowsin. Coho salmon and steelhead, which move through Lake Kapowsin, and Chinook salmon, pink salmon, bull trout, and cutthroat trout, have been identified in tributary creeks, Kapowsin and Ohop Creeks (WDFW 2015).

8.1.4 Pierce County & Pierce County PUD

The shoreline of Lake Kapowsin is classified as “Conservancy” in the Pierce County Shoreline Master Program (Pierce County 2014). Pierce County (2014) maps show the majority of Lake Kapowsin shoreline as being designated “Conservancy” with small portions designated as “Natural” and Kapowsin Creek and Ohop Creek are mostly designated “Natural” with short sections being designated as “Conservancy.” Pierce County has identified multiple priority habitats associated with Lake Kapowsin, including wetlands and riparian habitat (2014). Based on the Washington State Public Lands Inventory Map Pierce County PUD has approximately 12 acres and Pierce County has approximately 9 acres of land in the Lake Kapowsin watershed (WSPLI 2015).

8.1.5 City of Tacoma & Tacoma PUD

Based on the Washington State Public Lands Inventory Map, the Tacoma City Water Dept. has approximately 93 acres and Tacoma PUD has approximately 33 acres in the Lake Kapowsin watershed (WSPLI 2015). The City of Tacoma may be using Lake Kapowsin as a water source according to comments received at a public meeting (WDNR 2014).

Tacoma Public Utilities, Tacoma Rail-Mountain Division, operates the section of track that runs along the west side of the lake. Utilization rates of the rail line and impacts to the Lake Kapowsin watershed are not known.

8.1.6 Town of Kapowsin

The town of Kapowsin, located on the northwest side of Lake Kapowsin, was founded in 1901 when the Kapowsin Lumber Company built a sawmill there and was a thriving lumber town in the early part of the 20th century of about 10,000 people (Wikipedia 2015). After the decline in the timber industry, and a devastating fire, the town diminished in size into a neighborhood center, with a store, tavern, post office, fire station and grange hall, elementary school, and according to the 2010 Census, the town had a population 333 (Wikipedia 2015). According to a resident at the Oct. 2, 2014, WDNR public meeting, the town had a serious fire earlier in its history (WDNR 2014).

It is assumed that most of the town's residents have septic sewer systems and that typical of septic systems, some fail and seep/overflow into Lake Kapowsin that can create water quality problems. The extent of this problem is not known. The impact of failed septic systems is a high risk to Lake Kapowsin water quality (Ladley pers. comm. 2015).

8.1.7 Railroads

WDFW PHS maps (2014) show Burlington Northern Railroad tracks running along much of the east side of Lake Kapowsin and Chicago-Milwaukee-St. Paul and Pacific Railroad tracks running along most of the west side of the lake. Impacts of the railroad operation on Lake Kapowsin are unknown.

8.1.8 Private Lands

The amount of private land ownership in the Lake Kapowsin watershed was not available. Adjacent private owners of the remaining second-class shorelands along Lake Kapowsin, not owned by WDNR, include Hancock Timber (east and north of Lake Kapowsin), Rayonier Timber, and Tacoma PUD (north Lake Kapowsin). WDFW has a non-exclusive easement with the City of Tacoma for the second-class shorelands and upland parcels where the public boat launch is located.

Marks et al. (2013) report "that homes and outbuildings are frequent along Kapowsin Creek between RM 0.5 and 2.0, and human-made rock dam structures and sill logs span the creek and alter channel hydrology which results in upstream migration problems for adult salmon during summer and fall low flow periods."

Based on recent aerial photos (Figure 7.1) much of the land to the east of Lake Kapowsin is private forest land that is obviously being actively managed for timber harvest. The highest risk to Lake Kapowsin water quality is road runoff from both black top and logging roads (Ladley pers. comm. 2015).

Bortleson et al. (1976) categorized land uses (% area by category) in the Lake Kapowsin watershed, based on an August 10, 1973 survey, calling it "Cultural Data" and is summarized as follows: Residential development 1%, Number of nearshore houses 2%. Land Use in the Lake Kapowsin drainage basin: Residential Urban <1%, Residential Suburban 1%, Agricultural 4%, Forest or Unproductive 91%, Lake (Lake Kapowsin) Surface 4%. This information gives a general idea of what land use conditions were like in 1973 around Lake Kapowsin.

A cursory review comparing aerial photos of the Lake Kapowsin area (Bortleson et al. 1976) with recent ones (WDFW 2014), reveals a significant amount of new timber harvest (mostly clear-cuts) and road systems located on the eastern side of Lake Kapowsin (Figure 7.1). These clear-cuts crisscross an extensive road system located along Ohop Creek, unnamed stream #2, and unnamed stream #3 (Figures 7.1). Clear-cutting is potentially more disruptive of natural watershed processes than other logging methods because virtually all vegetation is removed and soil is usually highly disturbed (Spence et al. 1996). Significant changes resulting from these new clear-cuts are expected in runoff patterns into these streams draining into Lake Kapowsin, as well as a corresponding increase in the number of stream crossings along these new roads. In addition, the extensive roads system on the east side of Lake Kapowsin needs to be maintained adequately, or decommissioned, or else road failures will occur more frequently and increase the amount of sediment entering area streams and Lake Kapowsin.

Roads built in forests can impact salmonids and their habitat primarily through two mechanisms (Marcus et al. 1990). 1) Forest roads increase erosion rates and sediment loads in streams, potentially affecting salmonids by reducing respiration and ion exchange rates across gills and by clogging spawning areas and; 2) Improperly constructed road culverts and bridges can block migration routes. In addition, there is evidence to suggest that road networks alone can accelerate peak flows in small watersheds because roads effectively increase drainage networks in watersheds (Chamberlin 1982).

Forest harvest and reforestation practices can also affect salmonid habitats by altering patterns for erosion and deposition of sediment, streamflows, fish migrations, structural habitat cover, water temperatures, nutrient cycles, and potentials for exposure to toxicants (Marcus et al. 1990, MacDonald et al. 1991, Spence et al. 1996). Fertilizers, herbicides, and insecticides are commonly used in forest environments to prepare sites for planting, to release and stimulate growth of conifers, and to control disease and pests (Spence et al. 1996).

8.2 Livestock Grazing

According to Marks et al. (2013) cattle and other livestock have been allowed access to Kapowsin Creek around RM 1.7.

8.3 Recreation Use

Water-related recreation use of Lake Kapowsin obviously plays a significant role in the watershed. Although the primary influence of recreation on salmonids is fishing; there are also indirect effects related to boating, log removal, parks, and campgrounds (Spence et al. 1996). Stream and lake banks, riparian vegetation, and spawning redds are disturbed wherever human use is concentrated (Johnson and Carothers 1982); however, these effects are generally localized (Spence et al. 1996).

Human concentrations at campgrounds or vacation areas may also lead to impaired water quality by elevating coliform bacteria and nutrients in streams (Aukerman and Springer 1976, Potter et al. 1984). Recreational boaters, kayakers, and rafters have less obvious, but more far-reaching effects, by removing snags from rivers and lakes and removal of wood potentially affects salmonids by reducing habitat complexity (Spence et al. 1996).

8.4 Evidence of Human Influence

Evidence of human influence was documented at 10 physical habitat and 10 wetland sites conducted on Lake Kapowsin in 2015 (20 sites total) and was not documented for the entire lake shoreline (Figures 2.1, 6.1). Indicators of human influence were observed within or adjacent to the riparian area at 75% of the 20 physical habitat and wetland stations. Trash was the most commonly encountered evidence of human influence, found within or adjacent to the riparian area at 40% of the stations. Most of the trash found was small (e.g. wrappers, cans, bottles, plastic bags, etc.), but an abandoned car was found on the slope of the riparian area in Physical Station D (Figure 2.1). Roads and railroads were the next most encountered evidence of human influence and were within or adjacent the riparian area at 30% of the stations. There are roads and/or railroad tracks around the perimeter of most of the lake that are often visible from the lake shoreline (Figure 8.2). Other types of human influence observed at the 20 sites included buildings (at 5% of stations), docks (10%), powerlines (5%), and other (20%; including an unofficial campsite, hunting blind, fishing spot, and trails). Based on field observations, areas with highest impacts from dispersed recreation were portions of the shoreline with the easiest walk-in access from a nearby road, including: the southwest side of the lake, all areas immediately surrounding the boat launch and portions of the east side of the lake where access was gained through logging road or tribal lands. Boaters also used shoreline areas of Lake Kapowsin, as evidenced by dispersed recreation on Jaybird Island adjacent to Wetland Site 5, which included trash, a campfire ring and a trail (Figure 6.1). Dispersed recreation areas often contained trash, small trails along the shoreline and/or fire rings.

Figure 8.2. Beaver dam on the southeast shoreline of the lake with road visible in the background.

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9.0 MAMMALS

9.1 Methods

Data found in the 2014 Pierce County Biodiversity Network Assessment (Brooks et al. 2004) was reviewed and summarized to compile a likely comprehensive mammal species list predicted to occur for the Lake Kapowsin area based on the habitat types present in the area. We also reviewed the Washington State PHS database (WDFW 2014) to identify any sensitive, threatened or endangered mammal species that may be located within a 3 mile buffer around the lake. In addition, field crews working on the amphibian, wetland, aquatic vegetation, and limnology field studies at the lake also noted and recorded any signs of mammal use found in and around the lake using a standard sighting form. This information included documentation and location data of any mammal seen in the field, along with documenting any tracks, scat and possible nests or dens observed.

9.2 Results and Discussion

9.2.1 Biodiversity Analyses

The Pierce County Biodiversity Management Plan (Pierce County 2000) was an effort to evaluate and map the lands within Pierce County that provided for the greatest biological diversity of terrestrial species (mammals, birds, amphibians and reptiles). The methodology used to identify these biodiversity areas was based on the principles of conservation biology and landscape ecology (GAP Analysis) for species richness and representation as predicted by primary land cover (habitat types) derived from review of satellite imagery. Gap Analysis is the process of locating habitat for individual species or groups of species not adequately protected through land ownership or management. Gap Analysis is used as a tool in wildlife conservation efforts to identify gaps in protected areas and nature reserves or other wildlands where significant plant and animal species and their habitats or important ecological features occur.

In 2004, the Washington Department of Fish and Wildlife, University of Washington and Pierce County conducted an assessment (Brooks et al. 2004) of the Pierce County Biodiversity Network which was a part of the Pierce County Biodiversity Management Plan. The assessment was conducted to examine the accuracy of predicted habitats and species contained within the original Biodiversity Network analysis conducted in 2000. The original modeling (Pierce County 2000) was conducted using watershed boundaries and thus also represented lands that were located within adjacent counties. The current assessment (Brooks et al. 2004) was conducted based on the core Biodiversity Management Area polygons (BMA's) and buffered connection areas mapped within Pierce County only. The assessment conducted by Brooks et al. (2004) used a combination of GIS review and on-the-ground field inspections to assess accuracy. The results of this review were used to modify biodiversity areas and the associated connecting corridors to more precisely reflect the actual current on-the-ground conditions as of 2004.

The minimum mapping unit used in the analysis by Brooks et al. (2004) was 100 hectares. The analysis classified land cover types over the landscape using satellite imagery and obtained historical and current species location records to build a habitat relationship model. Over 360,000 records were collected and mapped (Brooks et al. 2004). The species locations were then used to assess predicted habitats for individual species based on the satellite imagery. The final model generated areas across the landscape that were identified for species richness and representation. These areas became the primary driver habitat core polygons for each of the taxonomic groups in the study. The taxonomic groups used in the analyses included mammals, birds, amphibians, and reptiles. These core polygons were then enclosed by a standard ¼-mile buffer to create Biodiversity Management Areas (BMAs). The BMAs were connected using riparian channels and other linear habitat features to promote movement corridors that would be adequate to promote dispersal of species and help prevent the negative effects of isolation that can be detrimental to the protection of biodiversity. These connection corridors, also known as buffered connector areas, were buffered ¼-mile on either side of their linear boundaries (Brooks et al. 2004).

Once the model identified BMAs across the county, this information was checked against actual wildlife records. Confirmation of species predicted to inhabit the Biodiversity Network was based on data sets including WDFW known species locations and use areas from PHS and Wildlife Heritage databases, citizen scientist species record locations, museum records, Breeding Bird Atlas records, Breeding Bird Survey records, Monitoring for Avian Population and Status (MAPS) records, Audubon Christmas Bird Count records, research project datasets, and private databases. With only a few exceptions overlap between the wildlife records and predicted habitats within the BMAs was reported to be significant by Brooks et al. (2004).

Lake Kapowsin was mapped within a buffered connection area. Although not mapped within a BMA, Lake Kapowsin was located ~8 miles southeast of BMA 8b, also known as an Upland BMA. Lake Kapowsin has similar primary driver habitats surrounding the lake as BMA 8b, which included habitat types such as lakes, marsh, shrub, hardwood and hardwood/conifer mixed forests. BMA 8 was mapped within the Puget Sound Douglas-fir Vegetation Zone in the Puget Trough Eco-region. BMA 8b was identified as a one of the areas that represented some of the most biologically rich habitats within Pierce County (Brooks et al. 2004).

For BMA 8, for all species (including birds, mammals, amphibians and reptiles), there were 10 predicted at-risk species, 20 state or federal-listed species and 24 PHS species (Brooks et al. 2004). The federal and state listing status codes provided after each species (Table 9.1) were defined as: FE: Federal Endangered, FT: Federal Threatened, FC: Federal Candidate, FCo: Federal Species of Concern, SE: State Endangered, ST: State Threatened, SC: State Candidate, SS: State Sensitive and SM: State Monitor.

The state and federal-listed mammal species predicted to occur in BMA 8 included the Brush Prairie pocket gopher (*Thomomys mazama douglasii*) (SC), fisher (*Martes pennanti*) (SE), long-eared myotis (*Myotis septentrionalis*) (FCo, SM), long-legged myotis (*Myotis volans*) (FCo, SM), Pacific water shrew (*Sorex bendirii*) (SM), Townsend's big-eared bat (*Corynorhinus townsendii*) (FCo, SC), western gray squirrel (*Sciurus griseus*) (FCo, ST), Yuma myotis (*Myotis yumanensis*) (FCo) and sharptailed snake (*Contia tenuis*) (SC) (Brooks et al. 2004) (Table 9.1). A total of 51 mammals were predicted to occur within this BMA. BMA 8 had the third highest mammal diversity of any of the mapped BMA's in Peirce County. Since grassland and oak woodland habitats are not present near Lake Kapowsin, but are found further west, the lake area likely has a lower diversity of mammals than that predicted for BMA 8. The western gray squirrel and sharptailed snake are unlikely to occur near the lake since they require oak woodland habitats more common in the Fort Lewis area, which is part of the BMA 8 mapped polygons. A list of the likely mammals found in BMA 8 can be found below (Table 9.1).

Table 9.1. Predicted Mammal Species for the Upland Biodiversity Management Area (BMA 8) (Brooks et al. 2004).

Beaver
Big brown bat (4)
Black bear
Black rat
Black-tailed deer (4)
Bobcat
Brush prairie pocket gopher (3,5)
Bushy-tailed woodrat
California myotis (4)
Coast mole
Coyote
Creeping vole
Deer mouse
Dusky (Montane) shrew
Eastern cottontail
Ermine
Fisher (2,3,4)
Hoary bat
Little brown myotis (4)
Long-eared myotis (3,4)
Long-legged myotis (3,4)
Long-tailed (Forest) deer mouse
Long-tailed vole
Long-tailed weasel
Mink (4)
Mountain beaver
Mountain lion
Muskrat
Northern flying squirrel
Norway rat
Pacific jumping mouse
Pacific water shrew (3)
Porcupine
Raccoon
Red fox
River otter
Shrew-mole
Silver-haired bat (2)
Snowshoe hare
Southern red-backed vole
Spotted skunk
Striped skunk
Townsend's big-eared bat (2,3,4)
Townsend's mole
Townsend's vole
Trowbridge's shrew
Vagrant shrew
Virginia opossum
Western gray squirrel (1,2,3,4)
Yuma myotis

Footnotes: (1) Trigger Species - Species that needed additional mapped land cover units to ensure representation within the network; (2) At-Risk - Washington Gap Analysis Project (WAGAP) selected species considered to be most as risk of continued or future population declines due to human activities; (3) Listed (State or Federal) - Species listed as State endangered, threatened, sensitive, candidate or monitor, as well as species listed or proposed for listing by the US Fish and Wildlife Service; (4) PHS - a species defined as priority under the WDFW Priority Habitats and Species (PHS) Program and; (5) Included based on species significance under the WDFW PHS/Heritage database, although not predicted to occur (Brooks et al. 2004

9.2.2 Priority Habitats and Species Database

An examination of the WDFW Priority Habitats and Species (PHS) Program database showed two additional mammals near or adjacent to Lake Kapowsin. These two mammal species were found near Lake Kapowsin, but were not predicted to occur here in the biodiversity analysis described above. One adult, 1 young, and 1 unknown age grizzly bear (*Ursus arctos*) were recorded by WDFW biologists on 21 June 1993, ~3 miles east of the lake (Figure 9.1). The animals were identified by taking plaster castes of their tracks. The verification level of the record was labeled as "high probability". In addition, a region east of the lake has been mapped in the PHS database as an area used by resident winter and migrating elk (*Cervus elaphus*) (Figure 9.1). This is a general locality only, as no PHS records of elk have been mapped within 10 miles of the lake to date. Although we could not find any records of elk within 10 miles of the lake, there was an area 12.7miles southwest of the lake that was reported by WDFW to be repeatedly damaged by elk. Thus elk likely occur in the area of the lake. Elk were not predicted to occur in BMA 8 in the biodiversity analyses by Brooks et al. (2004).

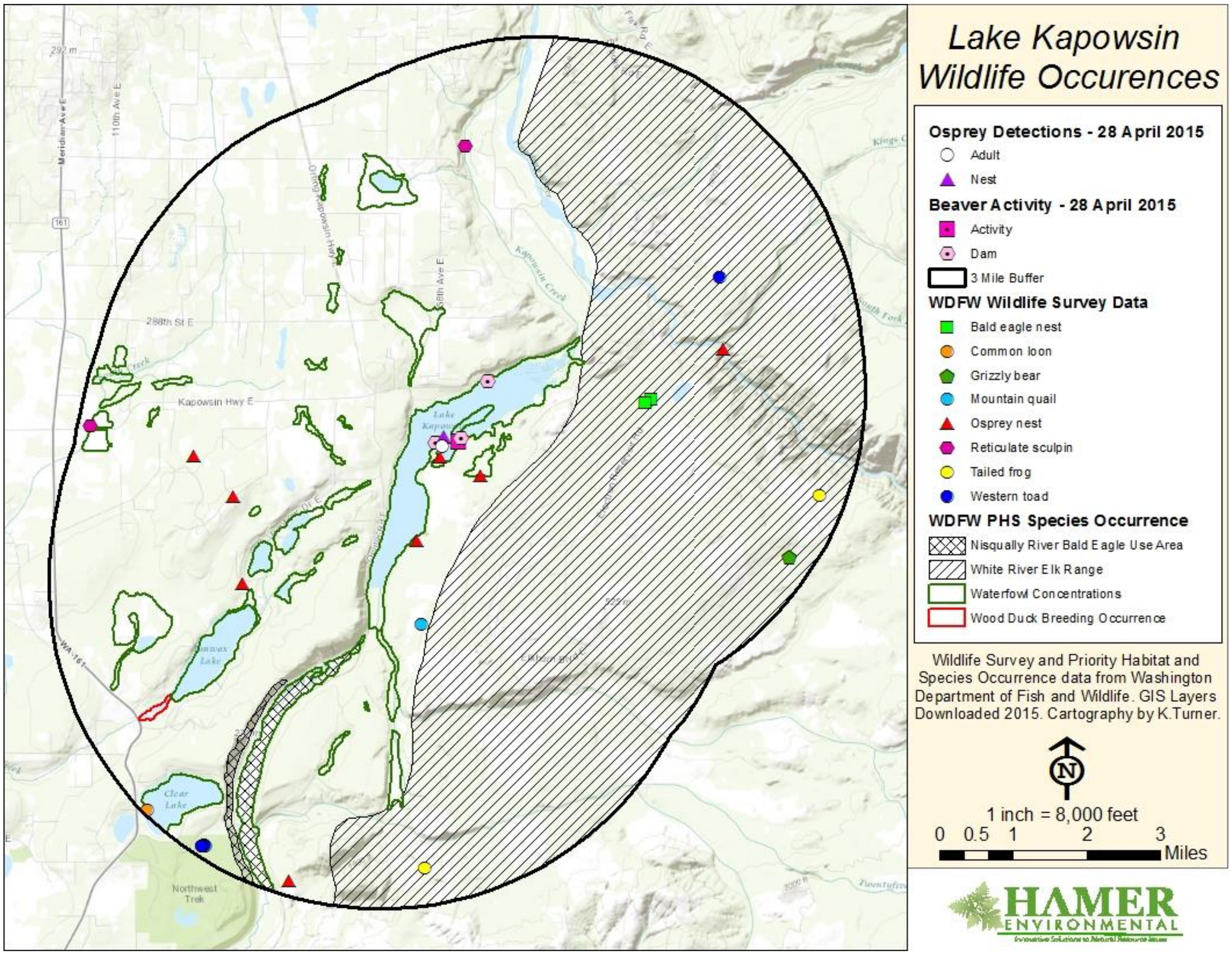

Figure 9.1. Map of wildlife records within a 3 mile radius of Lake Kapowsin from the WDFW PHS database, 2014.

9.2.3 Field Records

Two species of mammals were documented to occur at the lake during the field work for this study. river otter (*Lutra Canadensis*) scat was seen on the lake shoreline east of Jaybird Island. In addition, three different American beaver (*Castor Canadensis*) lodges were observed near the center of the lake. Two lodges were located on the east side of the lake and one was located on the west side of the lake (Figure 9.1). Beaver sign (chewed tree trunks) was also observed on the east side of the lake near one of the beaver lodges (Figure 9.1). Both of these species were predicted to occur in BMA 8 by the biodiversity analyses conducted by Brooks et al. (2004). In addition, in a conversation with biologist Tim McBride of Hancock Forest Management (Tim McBride, pers. comm.), which is the forest landowner just northeast of the lake, he has observed elk on Hancock property in the vicinity of the lake.

In summary, the biodiversity of mammals in the Lake Kapowsin area is expected to be high.

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10.0 BIRDS

10.1 Methods

Data on the species of birds present at Lake Kapowsin and the surrounding vicinity was summarized for the breeding season along with a summary of birds utilizing the area during the winter. Fortunately, information on the presence of birds in the Lake Kapowsin area was fairly extensive and readily available due to avian surveys that had been conducted previously. We summarized local data from the previous 5 years of eBird's breeding bird survey reports (http://ebird.org/ebird/eBirdReports) conducted at Lake Kapowsin. The organization eBird is a real-time, online checklist program, that has greatly improved the way that the birding community reports and accesses information about birds. Launched in 2002 by the Cornell Lab of Ornithology and National Audubon Society, eBird provides rich data sources for basic information on bird abundance and distribution at a variety of spatial and temporal scales. For the winter period, we summarized the three most recent years of avian survey results available (2011-2013) from the Audubon Society Christmas Bird Counts for the survey route closest to Lake Kapowsin (Tahoma Audubon Society). The Tahoma Audubon Society Christmas Bird Count Route is made up of areas surrounding Lake Kapowsin along with nearshore and marine areas located along the Puget Sound in Pierce County. We removed any marine dependent bird species from the Christmas Bird Count data that would not be likely found at Lake Kapowsin, to be able to compare Christmas Bird Count data to data gathered from other sources. We were also provided with waterfowl survey data that was collected by WDFW between 1991 and 2015. The waterfowl data collected by WDFW did not include exact survey dates other than the years collected, so we could not discern what season the data was collected in. In addition, bird observations were recorded by Hamer Envronmental biologists during the 2015 field effort when collecting amphibian, botanical, and water quality data. Lastly, any survey data on birds form the 2004 Pierce County Biodiversity Network Assessment (Brooks et al. 2004) and the Washington's PHS database were also summarized for the lake. Using all this data, a comprehensive avian species list for the Lake Kapowsin was created, along with information regarding any sensitive, threatened or endangered bird species present in and around the lake.

10.2 Results and Discussion

10.2.1 Lake Kapowsin Survey Data

Survey data from Lake Kapowsin was summarized from multiple sources. We used eBird's avian sighting report data from 2010 through 2015 to summarize the probable breeding birds found at the lake. The data that was summarized from the breeding bird surveys was collected between March and June and was comprised of 44 species of birds, including 34 species of songbirds, 7 species of waterfowl, and 3 species of raptors (Table 10.1). Three of the 44 species identified in the breeding season records were state or federal species of concern. Bald Eagles (*Haliaeetus leucocephalus*) are a Federal Species of Concern along with being a State Sensitive species. Pileated Woodpeckers *(Dryocopus pileatus)* are a State Candidate Species. Wood Ducks (*Aix sponsa*) were also seen on the lake and are listed as a WDFW PHS priority species.

WDNR provided waterfowl count data collected by WDFW for Lake Kapowsin. Random surveys were conducted for waterfowl between the years of 1991 and 2015, though data was not collected every year. The data collected was not associated with any specific dates, so we could not relate the data to a specific time of year. Seven species or species groups were detected during the 25 years of waterfowl counts at Lake Kapowsin. These 7 species or species groups were Green-winged Teal (*Anas crecca*), Northern Shoveler (*Anas clypeata*), Ringed-neck Duck (*Aythya collaris*), Common Goldeneye (*Bucephala clangula*), Bufflehead (*Bucephala albeola*), scaup (*Aythya*) and mergansers (*Mergus*) species (Table 10.1).

Hamer Environmental biologists also collected incidental observations of birds during their field visits in the spring of 2015. Fifteen species of birds were identified during the amphibian, botanical, and water quality field surveys. These species include Purple Martin (*Progne subis*), which is a State Candidate species, Osprey (*Pandeon haliaetus*), and Great Blue Heron (*Ardea Herodias*), which are State Monitored species. Bald Eagles and Wood Ducks were also observed by Hamer Environmental Biologists (Table 10.1). An active Osprey nest was also seen along the east-central shore of Lake Kapowsin (Figure 9.1).

In summary, a total of 53 bird species or species groups were detected at Lake Kapowsin during field surveys conducted by WDFW staff, Hamer Environmental Biologists, and eBird sighting reports (Table 10.1). Six species of concern, Bald Eagle (Federal Species of Concern, State Sensitive Species), Great Blue Heron (State Monitored Species), Osprey (State Monitored Species), Pileated Woodpecker (State Candidate Species), Purple Martin (State Candidate Species), and Wood Duck (PHS Priority Species), were identified during field surveys. The lake itself and the surrounding environment provide an abundance of potential nesting habitat for all of the bird species encountered in the field. The only active nest observed in the field was of an Osprey in April, 2015, located along the east-central shore of the lake. Known Bald Eagle nests have also been documented near the northeast shoreline of the lake, according to the WDFW PHS Database (Figure 9.1).

10.2.2 Christmas Bird Counts

We summarized the three most recent years of avian survey results available (2011-2013) from the Tahoma Audubon Society Christmas Bird Counts. The survey route for these annual bird counts included areas that are near Lake Kapowsin along with sites that are close to and along the Puget Sound. After removing any marine dependent bird species that would likely not occur as far inland as Lake Kapowsin, a 116 bird species or species groups were identified during the 3 years of bird count data that was analyzed (Table 10.1). This included 66 song bird species, 38 waterfowl and shorebird species, and 12 species of raptors. The 3 years of Christmas Bird Count data included 6 state or federal species of concern. Peregrine Falcons *(Falco peregrinus)* are a State Sensitive Species and a Federal Species of Concern. Western Grebe *(Aechmorphorus occidentalis)* are also a State Candidate Species. Other state or federal species of concern detected include Bald Eagle, Great Blue Heron, Pileated Woodpecker, and Wood Duck.

10.2.3 Biodiversity Analyses

We also examined the 2004 Pierce County Biodiversity Network Assessment (Brooks et al. 2004) for Biodiversity Management Area 8 (BMA 8) to identify the species of birds predicted to occur in and around Lake Kapowsin (see mammals section for a description of methodology used by Brooks et al. 2004) based on the habitat types present in the area. Lake Kapowsin is located ~8 miles southeast of Biodiversity Management Area 8b, also known as an Upland BMA. The Biodiversity Network Assessment (Brooks et al. 2004) identified 113 species of birds that were predicted to occur in the Lake Kapowsin area based on the habitats that were identified. This included 80 species of song birds, 18 species of waterfowl and shorebirds, and 15 species of raptors. Most of the species that were predicted by the Pierce County Biodiversity Network Assessment were also detected during field surveys conducted at Lake Kapowsin and during the 3 years of Christmas Bird Counts that were analyzed for this inventory report. Overall, BMA 8 had the 2nd highest predicted total number of bird species for the 17 BMA units identified in Peirce County. Only BMA 10, which was the Nisqually Delta, had a higher predicted number of bird species.

In summary, Lake Kapowsin has an abundant number of bird species utilizing the lake, its near-shore environment, and surrounding habitats. Multiple State and/or Federally listed bird species were identified during field surveys at the lake, including Bald Eagles, Great Blue Heron, Osprey, Pileated Woodpecker, Purple Martin, and Wood Duck. Peregrine Falcon and Western Grebe were detected during the Christmas Bird Counts. When comparing the number of species detected at the lake itself and during the Christmas Bird Counts, the Lake Kapowsin area had 127 overall species compared to the predicted 113 species identified by the 2004 Pierce County Biodiversity Network Assessment for BMA 8, which had the 2nd highest predicted number of bird species in the Biodiversity Network Assessment Region of Pierce County.

Table 10.1. Bird Species Identified in and Around Lake Kapowsin.

- American Coot (4)
- American Crow (1,3,4)
- American Goldfinch (4)
- American Kestrel (4)
- American Robin (1,4)
- American Widgeon (4)
- Anna's Hummingbird (4)
- Bald Eagle (1,3,4)
- Band-tailed Pigeon (4)
- Barn Owl (4)
- Barn Swallow (1)
- Barred Owl (4)
- Barrow's Goldeneye (4)
- Belted Kingfisher (1,4)
- Bewick's Wren (1,4)
- blackbird sp. (4)
- Black-capped Chickadee (1,4)
- Brewer's Blackbird (4)
- Brown Creeper (1,4)
- Brown-headed Cowbird (4)
- Bufflehead (1,2,4)
- Bushtit (4)
- Cackling Goose (4)
- California Gull (4)
- California Quail (4)
- Canada Goose (1,3,4)
- Canvasback (4)
- Cedar Waxwing (4)
- Chestnut-backed Chickadee (1,3,4)
- Common Goldeneye (1,2,4)
- Common Loon (4)
- Common Merganser (1,4)
- Common Raven (1,4)
- Cooper's Hawk (4)
- Dark-eyed Junco (1,4)
- Double-Crested Cormorant (3,4)
- Downy Woodpecker (4)
- Eurasian Collared-Dove (4)
- Eurasian Widgeon (4)
- European Starling (4)
- Evening Grosbeak (4)
- Fox Sparrow (4)
- Gadwall (4)
- Glaucous-winged Gull (4)
- Golden-crowned Kinglet (1,4)
- Golden-crowned Sparrow (4)
- Great Blue Heron (3,4)
- Great Horned Owl (1,4)
- Greater Scaup (4)
- Green-winged Teal (2,4)
- Hairy Woodpecker (1,4)
- Harlequin Duck (4)
- Harris's Sparrow (4)
- Hermit Thrush (4)
- Hooded Merganser (1,4)
- House Finch (4)
- House Sparrow (4)
- Hutton's Vireo (1,4)
- Killdeer (4)
- Lesser Scaup (4)
- Lincoln's Sparrow (4)
- Long-tailed Duck (4)
- Mallard (1,3,4)
- Marsh Wren (4)
- Merganser spp (2)
- Merlin (4)
- Mourning Dove (1,3,4)
- Northern Flicker (1,4)
- Northern Harrier (4)
- Northern Pintail (4)
- Northern Shoveler (2,4)
- Northern Shrike (4)
- Orange-crowned Warbler (4)
- Osprey (3)
- Pacific Loon (4)
- Pacific Wren (1,4)
- Pelagic Cormorant (4)
- Peregrine Falcon (4)
- Pied-billed Grebe (4)
- Pileated Woodpecker (1,3,4)
- Pine Grosbeak (4)
- Pine Siskin (1,4)
- Purple Finch (1,4)
- Purple Martin (3)
- Red Crossbill (4)
- Red-breasted Merganser (4)
- Red-breasted Nuthatch (1,4)
- Red-breasted Sapsucker (1,4)
- Redhead (4)
- Red-shouldered Hawk (4)
- Red-tailed Hawk (1,4)
- Red-winged Blackbird (1,3,4)
- Ring-billed Gull (4)
- Ring-necked Duck (1,2,4)
- Rock Pigeon (4)
- Rough-legged Hawk (4)
- Ruby-crowned Kinglet (4)
- Ruddy Duck (4)
- Ruffed Grouse (4)
- Rufous Hummingbird (1)
- Savannah Sparrow (4)
- Scaup spp (2)
- Sharp-shinned Hawk (4)
- Song Sparrow (1,4)
- Spotted Sandpiper (4)
- Spotted Towhee (4)
- Steller's Jay (1,4)
- Swainson's Thrush (1)
- Townsend's Warbler (4)
- Tree Swallow (1)
- Trumpeter Swan (4)
- Varied Thrush (1,4)
- Violet-green Swallow (1,3)
- Virginia Rail (4)
- Western Grebe (4)
- Western Meadowlark (4)
- Western Sandpiper (3)
- Western Screech-Owl (4)
- Western Scrub-Jay (4)
- White-breasted Nuthatch (4)
- White-crowned Sparrow (1,4)
- White-throated Sparrow (4)
- Willow Flycatcher (1)
- Wilson's Warbler (4)
- Wood Duck (1,3,4)
- Yellow Warbler (1)
- Yellow-rumped Warbler (1,4)

Footnotes: (1) eBird sightings species from 2010-2015 at Lake Kapowsin; (2) WDFW Waterfowl Counts from 1991-2015; (3) Birds detected by Hamer Environmental during Spring 2015 field work at Lake Kapowsin; (4) Tahoma Christmas Bird Count data from 2011-2013.

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11.0 AMPHIBIANS

11.1 Introduction

The objective of the amphibian inventory was to generate information on the habitat used, locations, distribution and relative abundance of the amphibians using Lake Kapowsin.

11.2 Methods

11.2.1 Literature Review

Prior to conducting field surveys, we compiled a potential species list for Lake Kapowsin using known breeding habitat requirements for amphibians in Western Washington and predicted occurrence data from the 2014 Pierce County Biodiversity Network Assessment final report (Brooks et al. 2004). We also searched for any existing amphibian observation records for Lake Kapowsin by reviewing the WDFW PHS database on amphibian locations and species present in the area (WDFW 2015) and reaching out to biologists with WDNR, WDFW and Northwest Trek.

11.2.2 Field Surveys

To maximize survey efforts, we coordinated with WDNR biologists to develop and implement an amphibian survey plan for the Spring 2015 breeding season. We completed amphibian surveys using the Washington Department of Fish and Wildlife Final Pilot Citizen Science Amphibian Survey Protocol (WDFW 2010). This protocol utilizes visual encounter survey methodology to survey still water habitats and has been used by state agencies and conservation groups to survey dozens of lakes throughout western Washington over the course of several years.

Visual encounter surveys have been used for rapid evaluation of large areas, where habitats are uniform and visibility is good. These surveys can also be used for species that inhabit easily identifiable habitats, such as logs and near- shore riparian zones including the wetlands north and south of the lake and along the shorelines of the lake itself. (Heyer et al., 1994). This method has been effective at documenting western toads, red-legged frogs, and Cascades frogs, as well as Oregon spotted frogs (Mohagen and Kruger 2001).

Four visual encounter surveys were completed along the shoreline of Lake Kapowsin between March 4th and April 28th, 2015. WDNR biologists completed the first three surveys and Hamer Environmental and WDNR biologists completed the fourth survey together. WDNR focused their survey efforts on the state-owned aquatic shorelands along the perimeter of the lake and Jaybird Island (Figure 11.1). Surveys were completed in one or two days depending on personnel availability and area covered. Jaybird Island was not surveyed on the March 4th and April 28th surveys. On April 28th, WDNR and Hamer Environmental surveyed both state-owned and privately owned aquatic shorelands along the perimeter of the lake.

Visual encounter surveys were completed in a circuit around the perimeter of the lake within the shallow water zone when accessible and the shore/water zone when the shallow water was inaccessible (e.g. too deep to safely enter or blocked). The shallow water zone is an area within approximately 2 meters (~ 6 feet) of the waterline with a maximum water height of 1 m (~3 feet). The shore/water zone is the location where water meets the shore. Due to the size of the lake and the inaccessibility of much of the shoreline due to floating logs, soft substrate, and steep banks, surveys were conducted using a combination of boating and walking. When possible, biologists slowly walked along the shallow water zone searching for amphibian egg masses and other life stages. When inaccessible, biologists used a canoe or small drift boat with an electric motor to slowly survey the shallow water zone for amphibians. In locations where floating log rafts limited accessibility to the shallow water zone, we surveyed from the boat along the edge of the floating logs. When found, amphibians were identified to species, life stage was determined (egg mass, tadpole, or adult/juvenile) and the total number was counted. Habitat information was recorded and included up to 10 possible habitat codes (1 = In water < 1 ft; 2 = In water 1-3 ft; 3 = In water > 3 ft; 4 = terrestrial vegetation; 5 = Reed Canary grass; 6 = Herbaceous vegetation; 7 = Sedges; 8 = Rushes; 9 = Cattails; 10 = Open water). Multiple habitat codes were selected if present. The location of each amphibian was recorded using GPS.

11.3 Results and Discussion

11.3.1 Literature Review

There are ten known amphibian species in Western Washington that utilize lakes and/or wetland as their primary or secondary breeding habitat (Brown 1985). Three of these species are state or federally-listed. The northern red-legged frog is listed as a federal species of concern and currently has no state listing. Western toad are listed as federal species of concern and is a candidate for state listing. The Oregon spotted frog is a candidate for federal listing and a Washington state endangered species (WDFW 2008). Of these ten species, seven are predicted to occur within the Pierce County Biodiversity Management Area 8, which is located 4 miles west of Lake Kapowsin and contains similar habitat (Table 11.1; Brooks et al. 2004). Summaries of the breeding chronologies and general habitat associations of all ten species can be found in Appendices 11.A and 11.B. A summary of the life history, habitat associations, potential stressors, and observations at or around Lake Kapowsin of the three state or federally listed species are below.

Table 11.1. Predicted amphibian species for the Upland) Biodiversity Management Area (BMA 8) (Brooks et al. 2004).

Common Name	Species Name
Long-toed salamander	*Ambystoma macrodactylum*
Northwestern salamander	*Ambystoma gracile*
Pacific giant salamander	*Dicamptodon tenebrosus*
Pacific treefrog (Chorus frog)	*Pseudacris regilla*
Northern Red-legged frog (3)	*Rana aurora aurora*
Roughskin newt	*Taricha granulosa*
Western Toad(3)	*Anaxyrus boreas*

(3) = Listed (State of Federal) Species listed as State endangered, threatened, sensitive, candidate or monitor, as well as species listed or proposed for listing by the US Fish and Wildlife Service.

11.3.1.1 Northern Red-legged Frog (Rana aurora aurora)

Federal Species of Concern

Red-legged frogs inhabit moist and riparian forests, usually below 2,790 feet (850 m) in elevation in the Pacific Northwest (Nussbaum *et al.* 1983, Stebbins 1985). This species is generally found near permanent water, including small ponds, quiet pools along streams, reservoirs, springs, lakes, and marshes (Gordon 1939, Nussbuam *et al.* 1983, Stebbins 1985). Breeding areas for this species vary greatly; red-legged frogs may breed in small temporary ponds, relatively large lakes, in potholes, in overflows of lakes and rivers, or in slow-moving portions of rivers (Storm 1960, Licht 1969, Licht 1971, Calef 1973, Brown 1975, Nussbaum *et al.* 1983). Breeding in Western Washington typically occurs February through April (Brown 1985; Appendix 11.A).

Several biologists suggest that populations of this species are dwindling. Nussbuam *et al.* (1983) stated that the red-legged frog is less common than it once was in the Willamette Valley of Oregon. This species has also declined greatly in California, presumably due to exploitation by humans and introduced bullfrogs (Jennings and Hayes 1985, Hayes and Jennings 1986). The red-legged frog was included in a list of Pacific Northwest species of concern compiled by Lehmkuhl and Ruggiero (1991), and its populations were considered to be at moderately high risk. Potential stressors to northern red-legged frog include predation by non-native American bullfrogs and non-native fish and water quality degradation and altered hydrological regimes associated with agriculture and urbanization (Lannoo 2005).

We could not find record of any Northern red-legged frog observations at Lake Kapowsin, though it is predicted to occur within the Pierce County BMA Area 8.

11.3.1.2 Oregon Spotted Frog (Rana pretiosa)

Federal Candidate and State Endangered

Historically, Oregon spotted frogs ranged from southwest British Columbia, south to the northeast corner of California. In Washington, the Oregon spotted frog was historically found in the Puget Trough from the Canadian border to the Columbia River Gorge. In 2012, only 46 known populations occured in British Columbia, Washington and Oregon (WDFW 2013). Of these, there are six known Washington populations. One of the Washington populations is located in the South Puget lowlands of Thurston County, two populations exist in the Columbia River Gorge (Klickitat & Skamania Counties), and in 2011 and 2012, three more populations were found in Whatcom County on the South Fork Nooksack (Black Slough), Samish River, and Sumas River (McAllister and Leonard 1997, WDFW 2013). Populations in California have likely been extirpated (McAllister and Leonard 1997), and populations in British Columbia have declined, with at least three of six known sites containing this species having lost their populations (Vancouver Aquarium 2003). Conservative estimates indicate that the Oregon spotted frog has lost 76% of its habitat over their former range. Invasive species have acted to reduce habitat for the Oregon spotted frog (McAllister and Leonard 1997). Reed canary grass (*Phalaris arundinacea*) has reduced habitat quality in marshes. Exotic species such as bullfrogs (*Lithobates catesbeianus* or *Rana catesbeiana*), and nonnative fish such as largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavenscens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), and brown bullhead (*Ameiurus nebulosus*) act as aquatic predators and have played a role in losses of Oregon spotted frog populations (McAllister and Leonard 1997).

Oregon Spotted frogs inhabit emergent wetlands within forested landscapes. They are highly aquatic and seldom outside of areas with standing water. Sites frequently used are wetlands, lakes, or slow moving streams that include zones of shallow water with emergent or aquatic plants suitable for basking (McAllister and Leonard 1997). Oregon spotted frogs breed in very shallow ponds (2-10" [5-25 cm] deep), sometimes along the margins of flowing water. They usually breed where vegetation is sparse and often lightly grazed by cows. Plant species present at these sites may include soft rush (*Juncus effusus*), slough sedge (*Carex obnupta*), and creeping buttercup (*Ranunculus repens*) (McAllister and Leonard 1997).

Oregon spotted frog, identified for coverage under the DNR Aquatics HCP, utilize habitat areas of western Washington that include Lake Kapowsin. We could not find records of any Oregon spotted frog observations at Lake Kapowsin, nor is Oregon spotted frog predicted to occur within the Pierce County BMA Area 8. However, there is a historic observation of Oregon spotted frog two miles from the lake (McAllister et al. 1993). Additionally, there is an active Oregon spotted frog reestablishment program in Pierce County led by the Washington Oregon Spotted Frog Working Group that includes biologists from state and federal agencies and several private, non-profit and conservation groups (WDFW 2013). Since 2008, these partners have raised thousands of frogs from fertilized eggs and released them into Pierce County wetlands.

11.3.1.3 Western Toad (Anaxyrus boreas)

Federal Species of Concern and State Candidate Listing

The western toad occurs from northeast Mexico through the western U.S. and Canada into southeast Alaska (Stebbins 1985). The western toad is known to occur from near sea level to 6,522 feet (1,988 m) near Harts Pass (Chelan County, Washington) (Leonard *et al.*, 1993). Western toads are common near marshes and small lakes, but adults may wander great distances through dry forests or shrubby thickets. Nussbaum *et al.* (1983) noted that a multitude of western toad tracks were seen in the sand dunes of the Oregon coast. Outside of the breeding season, western toads are nocturnal, spending the day buried in the soil, concealed under woody debris, or in the burrows of other animals. Breeding may occur from February to April at low elevations west of the Cascades and from May to early July at higher elevations in the Cascade Mountains (Leonard *et al.*, 1993). Western toad tadpoles form huge aggregations in many parts of their range, with millions of individuals often compromising a school. The tadpoles grow to about one inch (2.5 cm) in length before completing their development in late summer or early fall. Late in the summer, large concentrations of tiny toadlets may be encountered as they roam about the forest floor or as they cross roads. They may also use ephemeral, seasonal, or intermittent ponds (G. Stagner, personal communication).

Western toad populations have been declining rapidly throughout the western United States (AmphibiaWeb 2015). In the Puget Sound lowlands of Washington and other lower elevations in the

Pacific Northwest, they are now rare. Surveys conducted in the 1990s found western toads present at only 22% of the sites surveyed (Lannoo 2005). Western toads are vulnerable to road traffic as adults move to and from breeding sites in the spring and metamorphosed juveniles move away from breeding sites in the summer and fall (WHCWG 2010). Breeding sites are vulnerable to habitat degradation and destruction, and habitat conversion from open wetlands to scrub-shrub wetlands that provide unsuitable breeding habitat. Additional factors suspected to be contributing to the decline of western toads include fungal infections, such as *Saprolegnia ferax* (Blaustein *et al.* 1994), along with acid and mineral pollution from mine water drainage (Lannoo 2005).

Western toads has been identified for coverage under the DNR Aquatics HCP. Lake Kapowsin is within the forage buffer and predicted core habitat of western toad, although we could not find record of western toad observations at Lake Kapowsin. In reviewing the Washington State Priority Habitat Species Occurrence List (WDFW 2015), we found that Tanwax Lake, ~4 miles southwest of Lake Kapowsin, had a population of breeding western toad as recently as 2012. In addition, a western toad was observed in a clearcut ~3 miles northeast of Lake Kapowsin in 1992.

11.3.2 Field Survey Results

Five amphibian species were identified at Lake Kapowsin during the March and April visual encounter surveys conducted by WDNR and Hamer Environmental (Table 11.2). These five species included two native frog species (pacific chorus frog and northern red-legged frog); one non-native frog (American Bullfrog); and two native salamanders (northwestern salamander and rough-skinned newt). There were also 9 unidentified amphibian egg masses and 36 unidentified tadpoles.

Egg masses represented 64% of the detections, tadpoles 26%, and individuals (adults or juveniles) 9%. In total, 174 amphibians were counted over the four survey visits. Amphibian abundance increased throughout the survey season, with the highest number of amphibians counted during the April 28th survey.

Amphibians were found along the south, southeast, southwest, and northwest shoreline of Lake Kapowsin and along the shoreline of Jaybird Island (Figure 11.1). Overall, 60% of amphibians were found within the emergent wetland on the southern portion of the lake. Forty-five percent of amphibians were found in shallow water (< 1 foot), 25% in water 1 – 3 feet deep, and 10% in shallow water and terrestrial vegetation (Figure 11.2). Other habitats where amphibians were found included: shallow water and cattails, shallow water and herbaceous vegetation, water 1 – 3 feet deep and herbaceous vegetation, water 1 – 3 feet deep and sedges, water > 3 feet deep, water > 3 feet deep and sedges, and terrestrial vegetation.

Table 11.2. Lake Kapowsin March and April 2015 survey results from surveys conducted by WDNR and Hamer Environmental. Counts by species and life stage per survey visit.

	March 4th	March 10th - 11th	April 14 - 15th	April 28th	
Northern Red-legged Frog *(Rana aurora aurora)*					**Total**
Egg Mass			4		**4**
Adult/juvenile				1	**1**
Tadpole			10		**10**
Pacific Treefrog aka. Pacific Chorus Frog *(Pseudacris regilla)*					
Egg Mass	3		2	5	**10**
Adult/juvenile				1	**1**
American Bullfrog *(Lithobates catesbeianus or Rana catesbeiana)*					
Adult/juvenile				1	**1**
Northwestern Salamander *(Ambystoma gracile)*					
Egg Mass	11	26	35	17	**89**
Rough-skinned Newt *(Taricha granulosa)*					
Adult/juvenile	4	4	3	2	**13**
Unknown Amphibian					
Egg Mass				9	**9**
Tadpole				36	**36**
Survey Visit Total	**18**	**30**	**54**	**72**	***148***

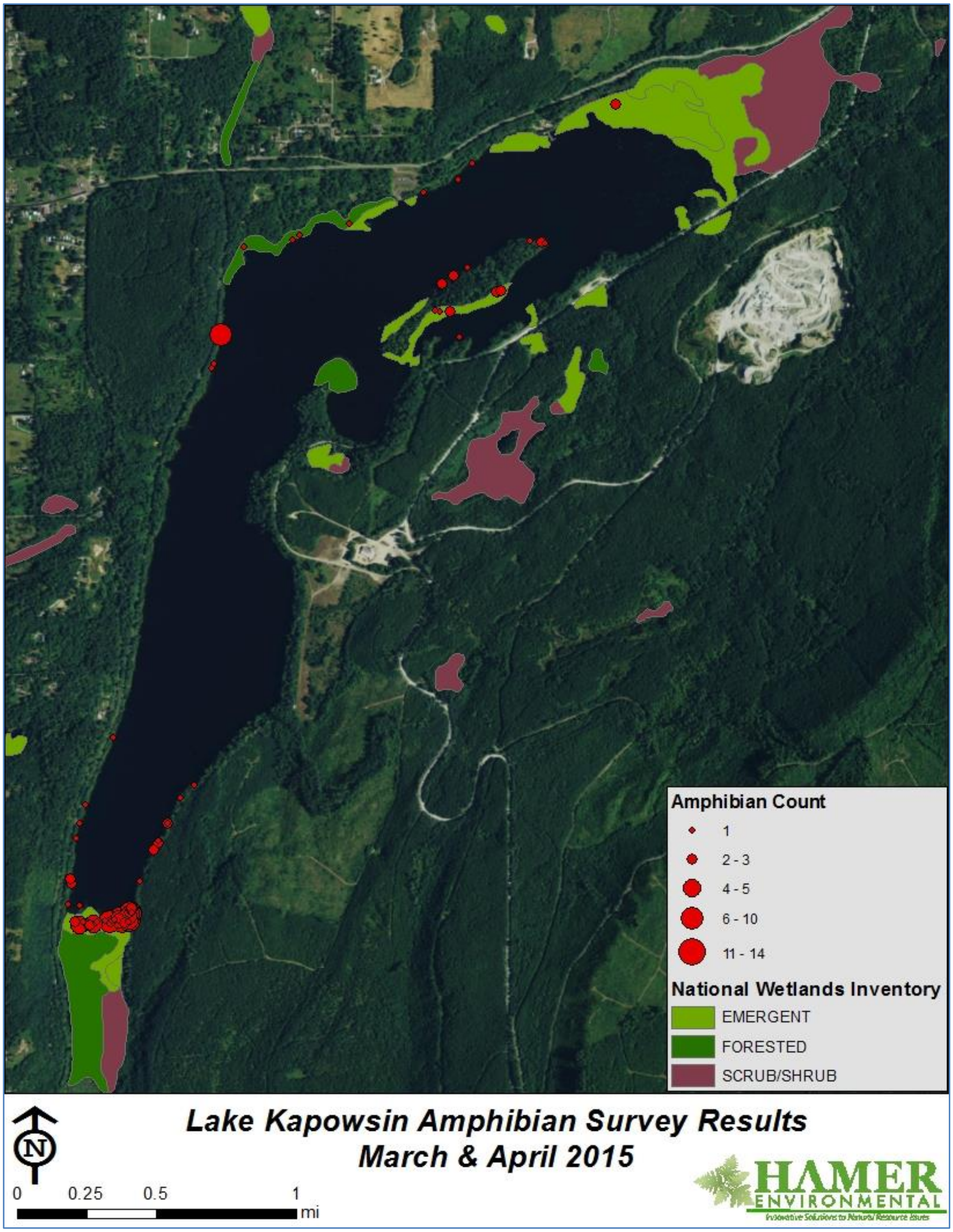

Figure 11.1. Distribution and abundance of amphibian detections at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

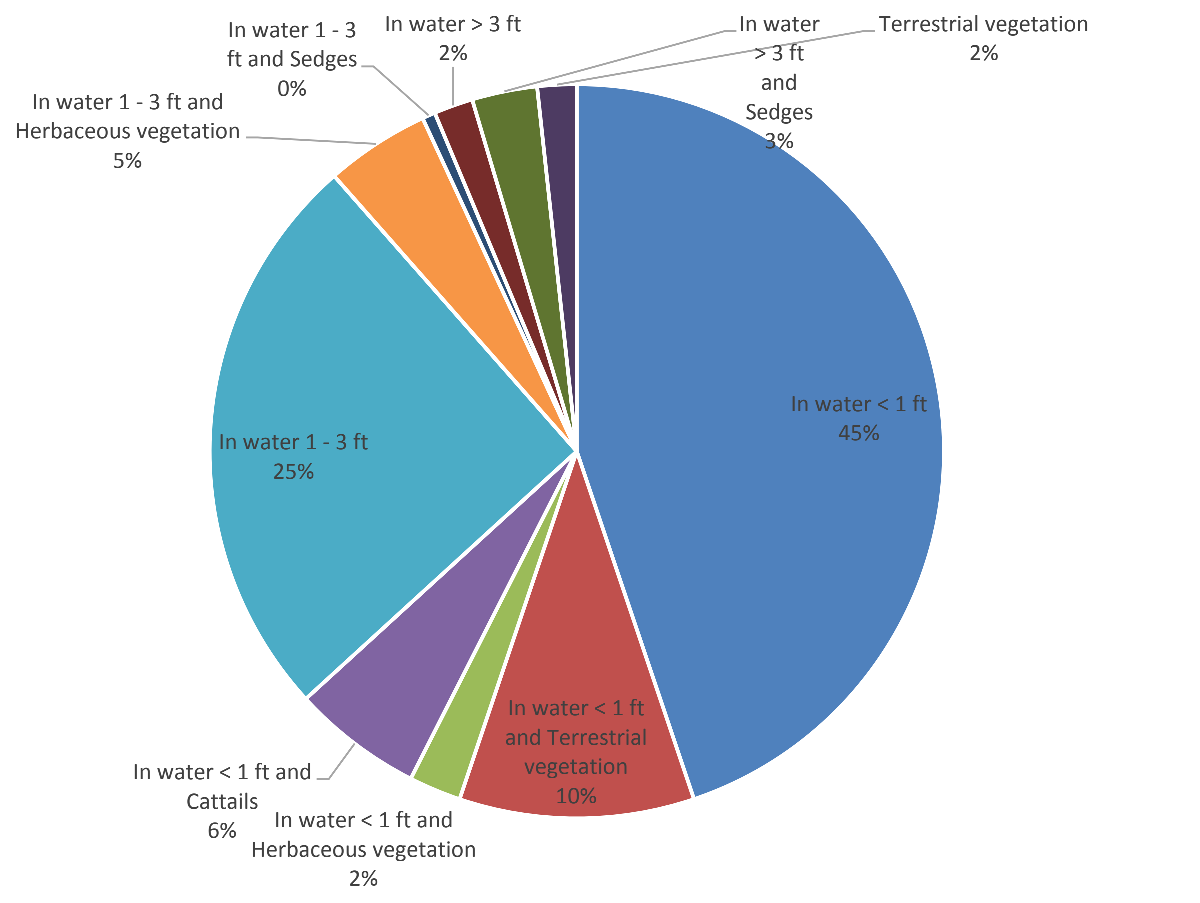

Figure 11.2. Percent occurrence of habitat types where amphibians were observed during March and April 2015 visual encounter surveys at Lake Kapowsin.

11.3.2.1 Northern Red-legged Frog (Rana aurora aurora)

Federal Species of Concern

During our March and April surveys, 15 northern red-legged frogs were found: 1 adult, 10 tadpoles, and 4 egg masses (Table 11.2). Egg masses and tadpoles were only observed during the April 14 – 15th survey. The one adult was observed during the April 28th survey.

All northern red-legged frog egg masses and tadpoles were observed in the emergent wetland on the southern edge of the lake (Figure 11.3). Northern red-legged frog egg masses were found in 1- 3 feet of water and tadpoles were found in water less than 1 foot deep. The one adult detected was observed along the northwest shoreline of the lake, jumping off a log raft with sedges into water 1 - 3 feet deep. During our wetland survey on June 9th, one additional northern red-legged frog adult was observed jumping into the water at an emergent wetland along the shoreline of Jaybird Island (wetland station W6).

11.3.2.2 Pacific Treefrog aka. Pacific Chorus Frog (Pseudacris regilla)

During our March and April surveys, 11 pacific treefrogs were found: 1 adult and 10 egg masses (Table 11.2). Egg masses were observed during the March 4th, April 14 – 15th and April 28th surveys, though those egg masses found on April 28th were old. The one adult frog was heard calling during the April 28th survey. Pacific treefrog egg masses were found along the northeast, northwest, south, southeast and southwest shoreline of Lake Kapowsin (Figure 11.4). Fifty percent of pacific treefrog egg masses were found along the edges of floating log rafts with sedges growing on the top of them in water > 3 feet deep. These log rafts with vegetation are along much of the shoreline of Lake Kapowsin. Thirty percent of the egg masses were found in shallow water (< 1 ft) and cattails and 20% were found in water 1 – 3 feet deep. The one adult frog detected was heard calling ~40 meters inland, in terrestrial vegetation, from the northwest shoreline of the lake.

11.3.2.3 American Bullfrog (Lithobates catesbeianus or Rana catesbeiana)

On April 28th, one American Bullfrog adult was observed sitting on a lilypad in 1-3 feet of water in the southwest corner of the lake (Table 11.2; Figure 7.5). During our wetland surveys in June, American bullfrogs were commonly heard around the lake, indicating larger numbers than those observed during the March and April surveys.

American bullfrogs are an introduced species to Washington State, they were originally found only to the east of the Rocky Mountains. They have successfully spread throughout the low elevations of Washington and are believed to have contributed both directly and indirectly to the drastic decline of native amphibians and reptiles. They have non natural enemies due to the toxicity of secretions from their paratoid glands. In addition to outcompeting and predating on native amphibians, American bullfrogs are often carriers of the chytrid fungus, which is a major factor in many frog species declines. They are also resistant to the effects of the chytrid fungus (Burke Museum of Natural History and Culture 2005 and WDFW 2005).

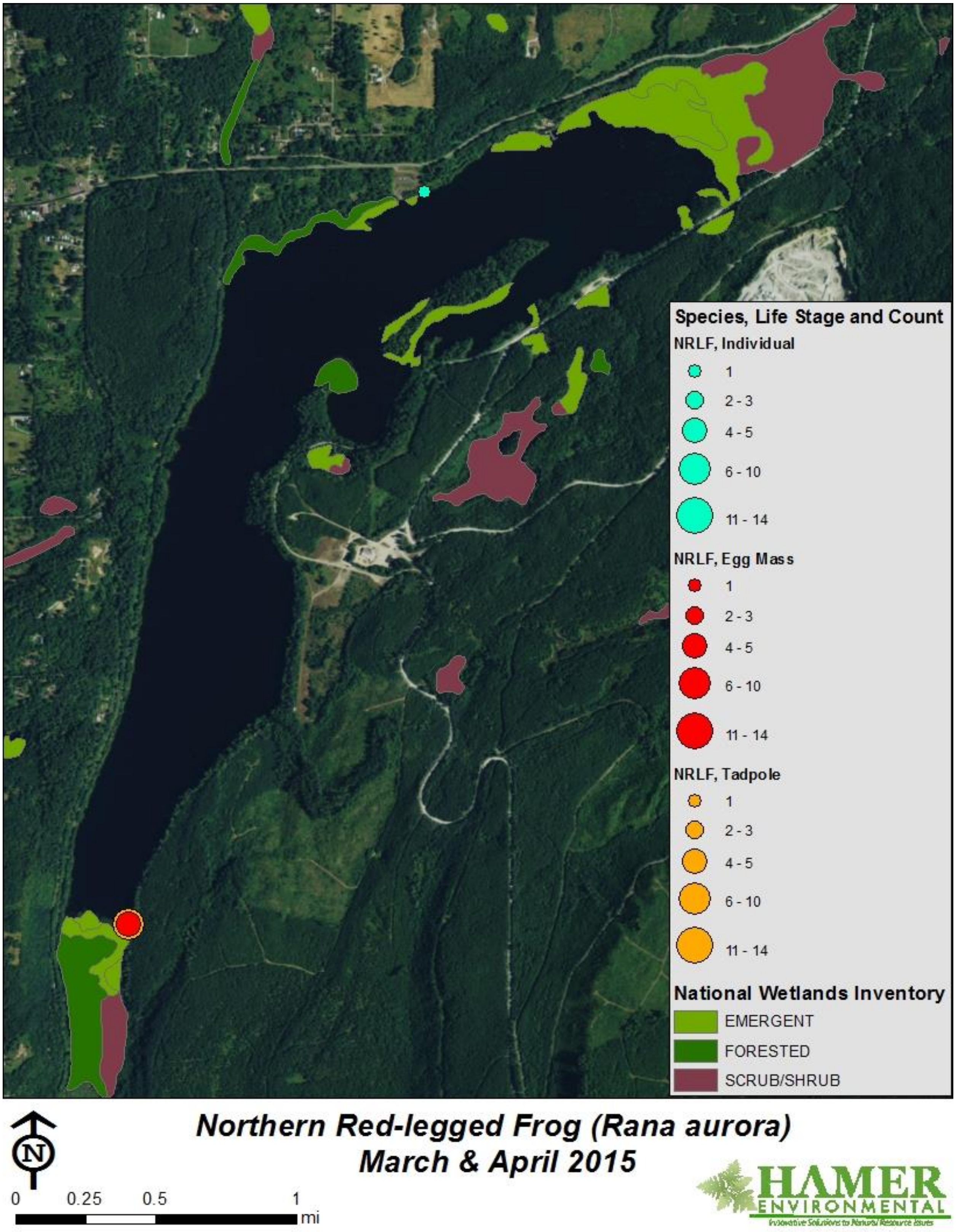

Figure 11.3. Distribution and abundance of red-legged frog at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

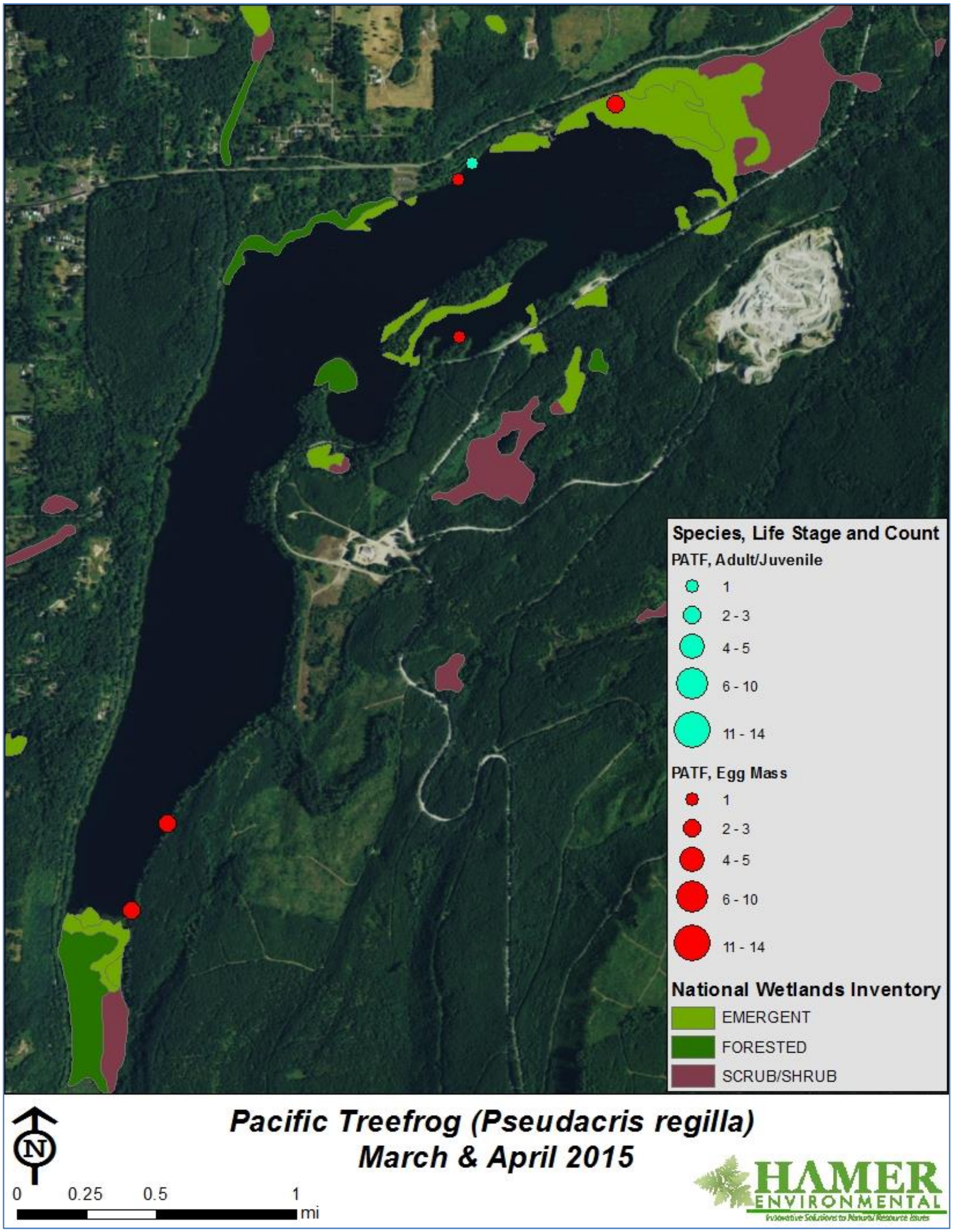

Figure 11.4. Distribution and abundance of Pacific treefrog at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

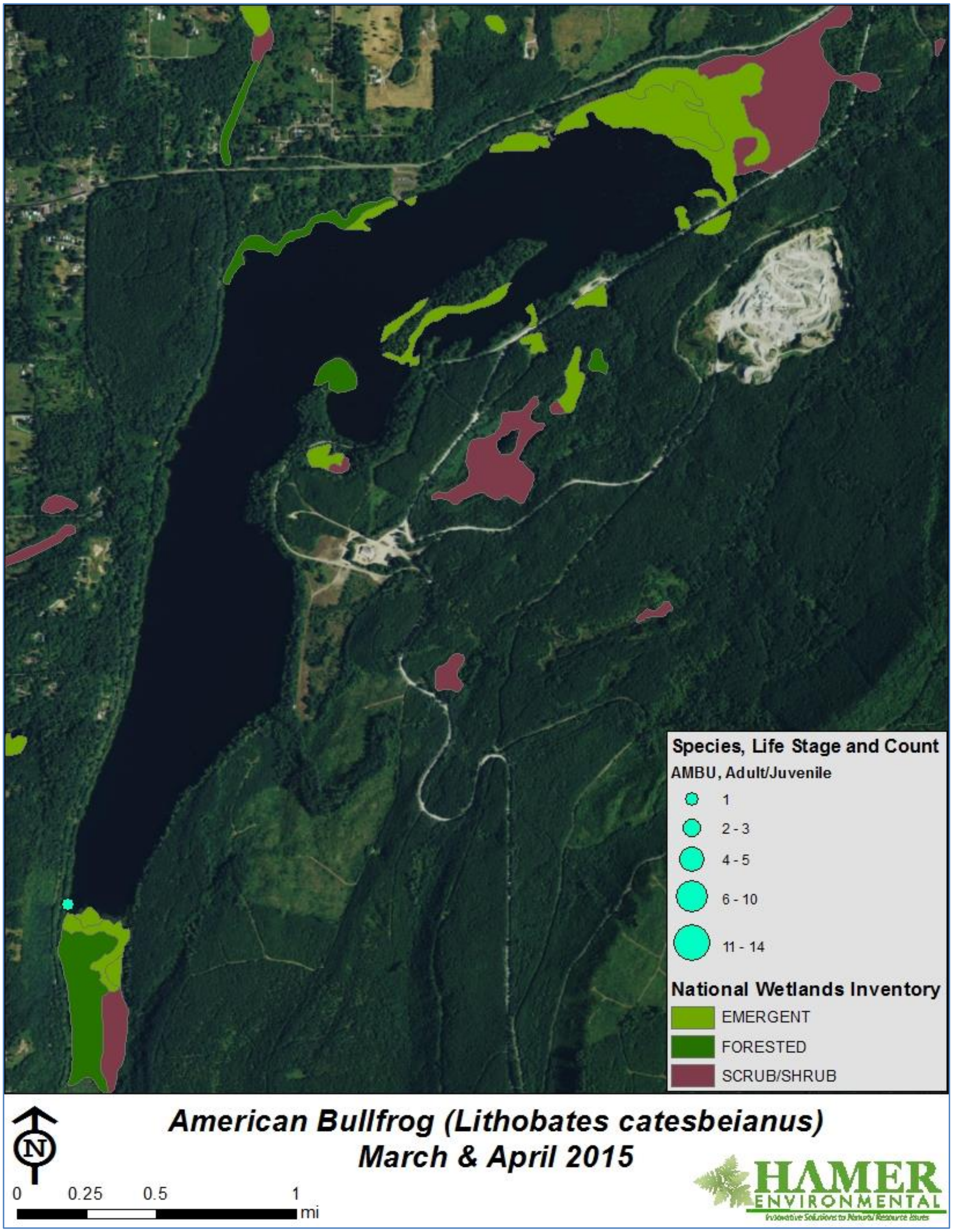

Figure 11.5. Distribution and abundance of American bullfrog at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

11.3.2.4 Northwestern Salamander (Ambystoma gracile)

Northwestern salamander was the most abundant amphibian encountered over the two month survey period, with a total of 89 egg masses, representing 52% of all amphibian detections (Table 11.2). Northwestern Salamander egg masses were observed during all four visual encounter surveys, with the highest count of 35 egg masses during the April 14 – 15th survey.

Northwestern Salamander egg masses were found along the south, southeast, southwest, and northwest shoreline of Lake Kapowsin and along the shoreline of Jaybird Island (Figure 11.7). Sixty-four percent of the egg masses were recorded in Lake Kapowsin's southern wetland. Thirty-five percent of Northwestern Salamander egg masses were found in 1- 3 feet of water, 20% in shallow water (< 1 foot), and 20% in shallow water and terrestrial vegetation. Other habitats included: shallow water and cattails, water 1 – 3 feet deep and herbaceous vegetation, shallow water and herbaceous vegetation, and water > 3 feet deep and terrestrial vegetation (Figure 11.6).

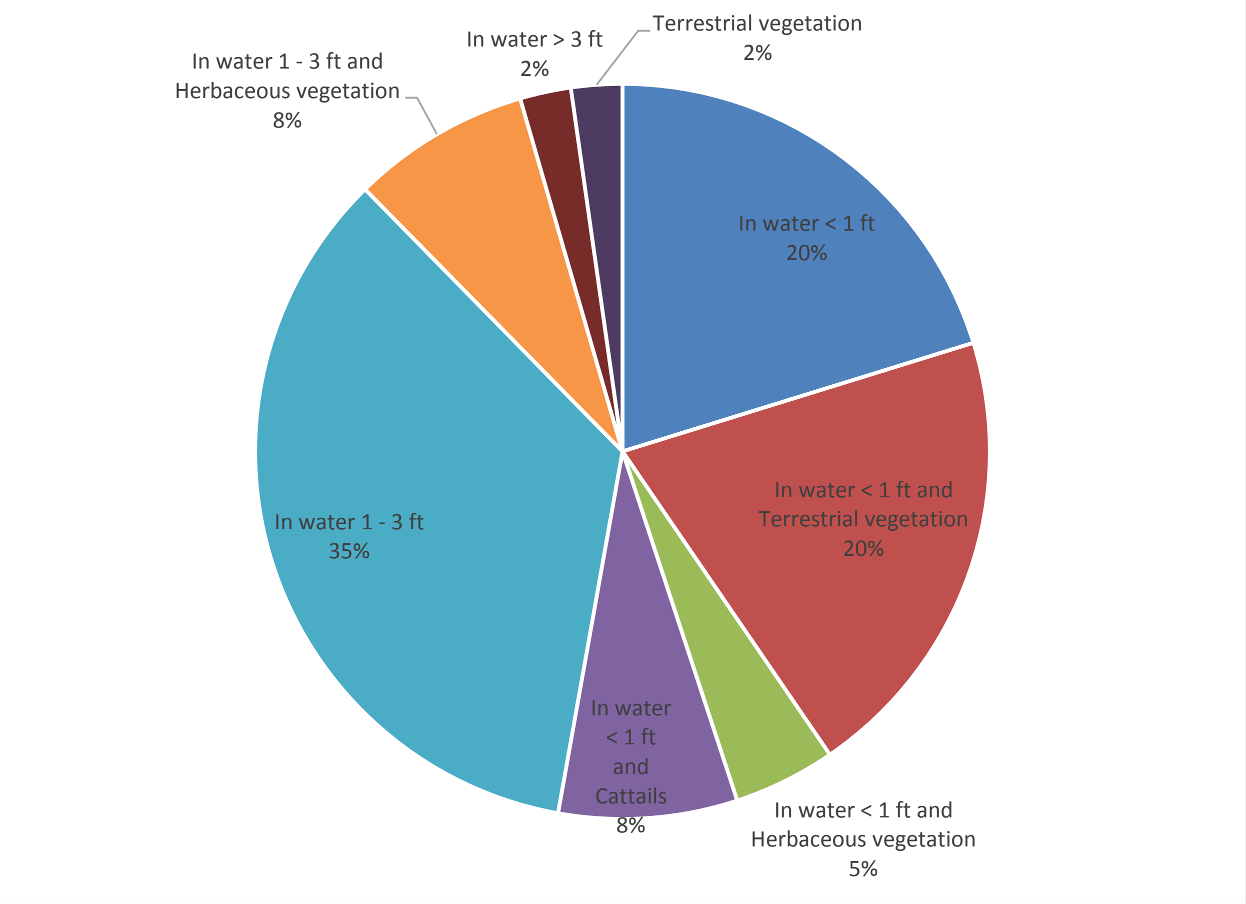

Figure 11.6. Percent occurrence of habitat types where northwestern salamanders were observed during March and April 2015 visual encounter surveys at Lake Kapowsin.

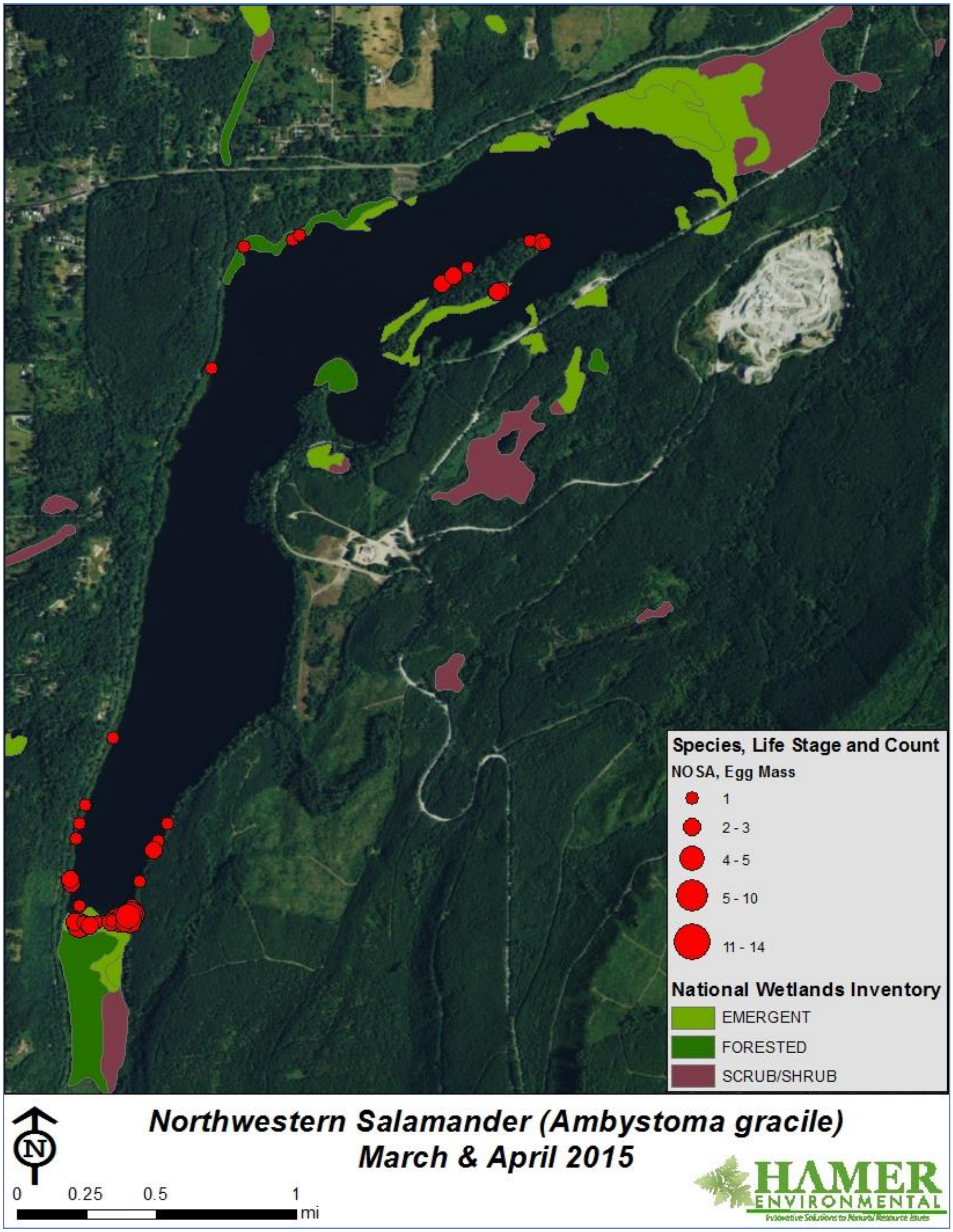

Figure 11.7. Distribution and abundance of Northwestern salamander at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

11.3.2.5 Rough-skinned Newt (Taricha granulosa)

Thirteen rough-skinned newts were observed during the March and April surveys (Table 11.2). All observations were of adult/juvenile newts. Abundance was fairly consistent throughout the survey period, but did slowly decrease over time. Four adult/juvenile rough-skinned newts were detected during each survey in March, three were detected during the April 14 – 15th survey, and two were detected during the April 28th survey.

Rough-skinned newts were found along the northwest, south, southeast shoreline of Lake Kapowsin and along the southeast shoreline of Jaybird Island (Figure 11.8). Fifty-four percent of adults/juveniles were found in water 1 – 3 feet deep, 38% were found in shallow water < 1 foot deep, and 8% were found in water greater than 3 feet deep.

11.3.2.6 Oregon Spotted Frog (Rana pretiosa)

Federal Candidate and State Endangered

We did not observe any Oregon spotted frog during our survey efforts. We started surveys in the first half of March to target the known Oregon spotted active breeding season for Western Washington based on the elevation of Lake Kapowsin (Brown 1985 and Marc Hayes, personnel comm.). Oregon spotted frogs begin to lay eggs when surface water temperatures are at 8° C (46.4 F) during the day (Marc Hayes personal communication). The average surface water temperature of Lake Kapowsin on March 5th was 8.7° C (± 0.58 SD, n = 3), indicating that surveys were conducted during ideal conditions for breeding Oregon spotted frogs. During the March and April surveys, the majority of the suitable habitat around the lake was surveyed. However, due to inaccessibility, we did not extensively survey the emergent wetland on the northern shoreline of the lake. Additional survey efforts in this area are recommended for verifying presence or absence of Oregon spotted frog.

Oregon spotted frog is declining through its historical range, and several factors that have been cited as contributing to this decline are present at Lake Kapowsin. We observed non-native American bullfrogs during our surveys and there are several non-native fish present in Lake Kapowsin that may be contributing to the absence of this species from the study area.

11.3.2.7 Western Toad (Bufo boreas)

Federal Species of Concern and State Candidate Listing

We did not observe any western toads during our survey efforts. Based on the elevation of Lake Kapowsin, it was recommended that the surveys be conducted during the latter half of April (Marc Hayes, personnel comm.). We conducted two surveys during the latter half of April; however, surface water temperatures may not have been warm enough at that time for breeding activity to have started. Western toads do not begin to lay eggs until surface water temperatures are around 14° C (57.2 F). The average surface water temperature during our first survey in April was 11.9° C (± 0.29 SD, n = 3). Two weeks later, the surface water temperature during our April 28th survey was 14.2° C. Though water temperatures were ideal during this survey effort, we may have been too early to observe breeding activity. Additional survey efforts starting in mid-April and running through May are recommended for verifying presence or absence of western toad.

Oregon spotted frog is declining through its historical range, and several factors that have been cited as contributing to this decline are present at Lake Kapowsin. We observed non-native American bullfrogs during our surveys and there are several non-native fish present in Lake Kapowsin that may be contributing to the absence of this species from the study area.

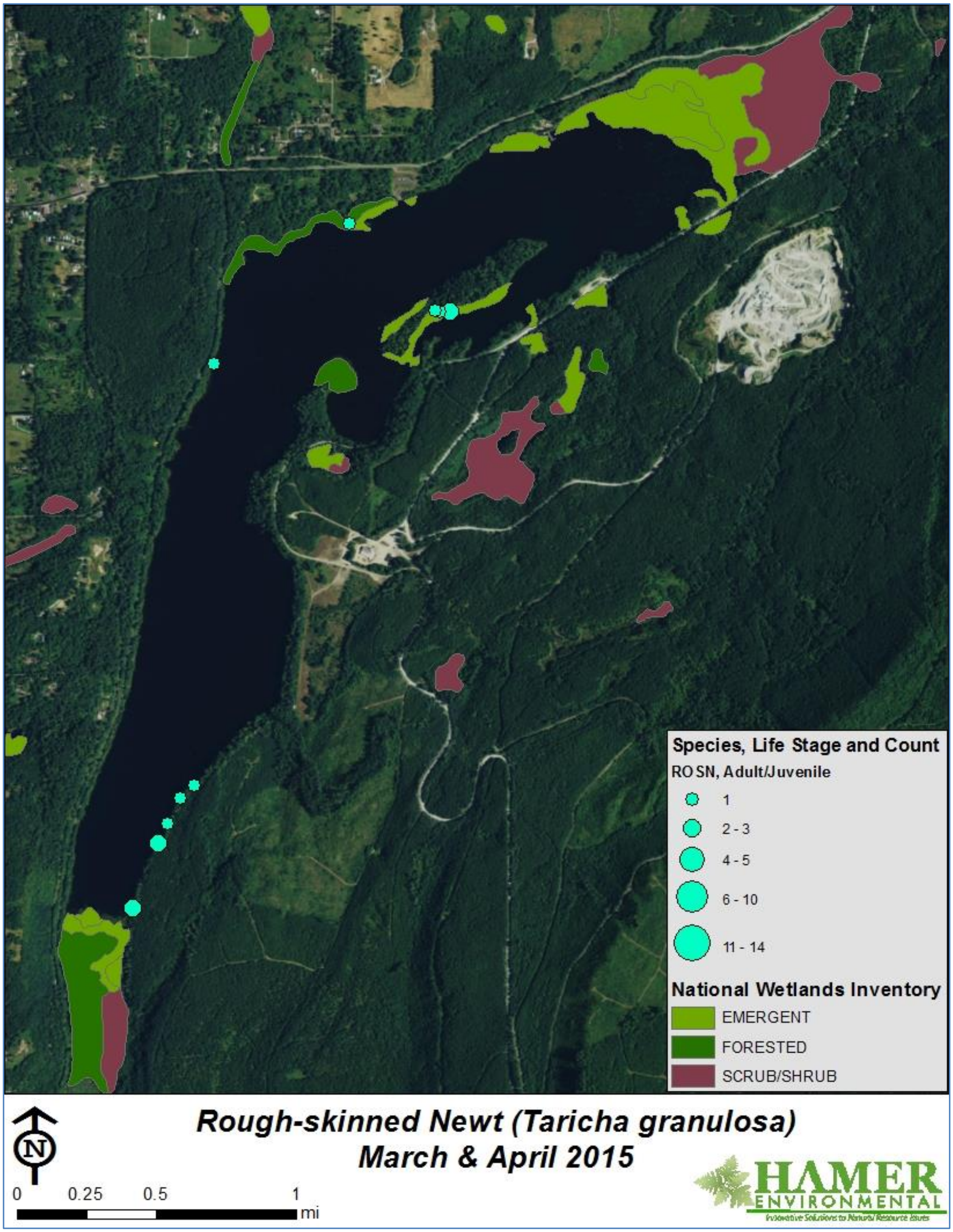

Figure 11.8. Distribution and abundance of rough-skinned newt at Lake Kapowsin during March and April 2015 visual encounter surveys by WDNR and Hamer Environmental.

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