



Mountain Lake Study Sites in the North Coast and Cascades Network

Version 1.1

Natural Resource Data Series NPS/NCCN/NRDS—2012/364.1



ON THE COVER

Heather Lake, Olympic National Park

Photograph by: Bill Baccus

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Contents

	Page
Figures.....	vii
Tables.....	xv
Abstract.....	xix
Acknowledgments.....	xxi
Introduction.....	1
Methods.....	3
Geological Setting	3
Bathymetry & Lake Features.....	3
Physical/Chemical Water Properties	4
Water samples.....	4
Lake Profiles	5
Water clarity.....	5
Primary Productivity	5
Biological Data	5
Amphibians	5
Non-native Fish.....	6
Summary of NCCN Lake Characteristics.....	7
Elevation	7
Surface Area	7
Maximum Depth.....	8
Precipitation.....	9
Acid Neutralizing Capacity	9
Non-Native Fish.....	10

Contents (continued)

	Page
Lake Descriptions: Mount Rainier National Park.....	11
Lake Allen (LN03)	12
Upper Palisades Lake (LH14)	18
Lake LP19.....	24
Lake LH15	30
Upper Deadwood Lake (LW32)	36
Blue Lake (LZ35)	42
Lake Descriptions: North Cascades National Park Service Complex	49
Bowan Lake (MR-12-01)	50
Lower Silent Lake (MA-03-01).....	56
Lower East Lake (MC-14-02)	62
Upper Triplet Lake (SM-02-02)	68
Easy Ridge Lake (MC-03-01)	74
Lower Blum Lake (LS-07-01).....	80
Lake Descriptions: Olympic National Park	87
Ferry Lake (138)	88
Gladys Lake (106)	94
Heather Lake (263)	100
Milk Lake (498).....	106
Crazy Lake (426)	112
Lake La Crosse (520).....	118
Lake Sunup (623)	124
Lake Connie (627)	130

Contents (continued)

	Page
Literature Cited	137

Figures

	Page
Figure 1. Northwestern salamander larvae swimming in Lake Allen, Mount Rainier. An adult Long-toed salamander netted at Ferry Lake, Olympic National Park.	6
Figure 2. Elevation distribution of core NCCN sampling lakes.	7
Figure 3. Size distribution of core NCCN sampling lakes.	8
Figure 4. Maximum lake depth of core NCCN sampling lakes.	8
Figure 5. Annual precipitation at core NCCN sampling lakes.	9
Figure 6. Acid-neutralizing capacity values for core NCCN sampling lakes.	10
Figure 7. Proportion of fish free lakes among the core NCCN sampling lakes.	10
Figure 8. Location of the 6 core monitoring lakes at Mount Rainier National Park.	11
Figure 9. Lake Allen from talus slope northwest of lake.	12
Figure 10. Lake Allen watershed and surrounding area.	13
Figure 11. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake Allen sampling station.	14
Figure 12. Bathymetry, shoreline features and sampling locations at Lake Allen.	15
Figure 13. Lake Allen watershed panoramic photo from Photo Point 1.	16
Figure 14. Lake Allen watershed panoramic photo from Photo Point 2.	16
Figure 15. Cross country hiking route to Lake Allen.	17
Figure 16. Upper Palisades Lake looking northwest from open meadows on hillside above.	18
Figure 17. Upper Palisades Lake watershed and surrounding area.	19
Figure 18. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Palisades Lake sampling station.	20
Figure 19. Bathymetry, shoreline features and sampling locations at Upper Palisades Lake.	21
Figure 20. Upper Palisades Lake watershed panoramic photo from Trail Photopoint.	22

Figures (continued)

	Page
Figure 21. Upper Palisades Lake panoramic photo from Talus Photopoint.	22
Figure 22. Hiking route to Upper Palisades Lake.	23
Figure 23. Lake LP19 from shoreline northeast of the lake outlet.	24
Figure 24. Lake LP19 watershed and surrounding area.....	25
Figure 25. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake LP19 sampling station.....	26
Figure 26. Bathymetry, shoreline features and sampling locations at Lake LP19.....	27
Figure 27. Lake LP19 watershed panoramic photo from Photo Point 1.....	28
Figure 28. Lake LP19 watershed panoramic photo from Photo Point 2.....	28
Figure 29. Hiking route to Lake LP19, including main trails and cross country route.....	29
Figure 30. Lake LH15 from lakeshore wetlands south of lake.	30
Figure 31. Lake LH15 watershed and surrounding area.	31
Figure 32. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake LH15 sampling station.....	32
Figure 33. Bathymetry, shoreline features and sampling locations at Lake LH15.....	33
Figure 34. Lake LH15 watershed panoramic photo from Photo Point 1.	34
Figure 35. Lake LH15 watershed panoramic photo from Photo Point 2.	34
Figure 36. Hiking route to Lake LH15, including main trails and cross country route.	35
Figure 37. Upper Deadwood Lake as seen from the ridge top southeast of lake.....	36
Figure 38. Upper Deadwood Lake watershed and surrounding area.	37
Figure 39. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Deadwood Lake sampling station.....	38
Figure 40. Bathymetry, shoreline features and sampling locations at Upper Deadwood Lake.	39
Figure 41. Upper Deadwood Lake watershed panoramic photo from Photo Point 1.	40

Figures (continued)

	Page
Figure 42. Upper Deadwood Lake watershed panoramic photo from Photo Point 2.	40
Figure 43. Hiking route to Upper Deadwood Lake, including main trails and cross country route.	41
Figure 44. Blue Lake from the mountainside above.	42
Figure 45. Blue Lake watershed and surrounding area.	43
Figure 46. Dissolved oxygen, temperature and pH depth profiles from the deep-point Blue Lake sampling station.	44
Figure 47. Bathymetry, shoreline features and sampling locations at Blue Lake.	45
Figure 48. Blue Lake watershed panoramic photo from Photo Point 1.	46
Figure 49. Blue Lake watershed panoramic photo from Photo Point 2.	46
Figure 50. Hiking route to Blue Lake, including main trails and cross country route.	47
Figure 51. Location of the 6 core monitoring lakes at North Cascades National Park Service Complex.	49
Figure 52. Bowan Lake from slope north of lake.	50
Figure 53. Bowan Lake watershed and surrounding area.	51
Figure 54. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Bowan Lake sampling station.	52
Figure 55. Bathymetry, shoreline features and sampling locations at Bowan Lake.	53
Figure 56. The western shore of Bowan Lake from Photo Point 1.	54
Figure 57. Hiking route to Bowan Lake, including main trails and cross country route.	55
Figure 58. Lower Silent Lake from upper slopes west of the lake.	56
Figure 59. Lower Silent Lake watershed and surrounding area.	57
Figure 60. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lower Silent Lake sampling station.	58

Figures (continued)

	Page
Figure 61. Bathymetry, shoreline features and sampling locations at Lower Silent Lake.....	59
Figure 62. Lower Silent Lake watershed panoramic photo from Photo Point 1.....	60
Figure 63. Hiking route to Lower Silent Lake, including main trails and cross country route.	61
Figure 64. Lower East Lake from slope Northwest of lake.	62
Figure 65. Lower East Lake watershed and surrounding area.	63
Figure 66. Continuous temperature profile and dissolved oxygen at upper, middle and bottom depths, from the deep-point Lower East Lake sampling station.....	64
Figure 67. Bathymetry, shoreline features and sampling locations at Lower East Lake.....	65
Figure 68. Lower East Lake watershed panoramic photo from Photo Point 1.	66
Figure 69. Lower East Lake watershed panoramic photo from deepest point of lake.....	66
Figure 70. Hiking route to Lower East Lake, including main trails and cross country route.	67
Figure 71. Upper Triplet Lake from a ridge, north of the lake.	68
Figure 72. Upper Triplet Lake watershed and surrounding area.	69
Figure 73. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Triplet Lake sampling station.	70
Figure 74. Bathymetry, shoreline features and sampling locations at Upper Triplet Lake.....	71
Figure 75. Upper Triplet Lake watershed panoramic photo from Photo Point 1.....	72
Figure 76. Upper Triplet Lake watershed panoramic photo from Photo Point 2.....	72
Figure 77. Upper Triplet Lake watershed panoramic photo from Photo Point 3.....	72
Figure 78. Hiking route to Upper Triplet Lake, including main trails and cross country route.	73
Figure 79. Easy Ridge Lake from northeast shore of lake.....	74

Figures (continued)

	Page
Figure 80. Easy Ridge Lake watershed and surrounding area.	75
Figure 81. Dissolved oxygen and temperature depth profiles from the deep-point Easy Ridge Lake sampling station.	76
Figure 82. Bathymetry, shoreline features and sampling locations at Easy Ridge Lake.....	77
Figure 83. Easy Ridge Lake watershed panoramic photo from Photo Point 1.	78
Figure 84. Hiking route to Easy Ridge Lake, including main trails and cross country route.	79
Figure 85. Lower Blum Lake from slope northeast of lake.	80
Figure 86. Lower Blum Lake watershed and surrounding area.	81
Figure 87. Continuous temperature depth profile and dissolved oxygen samples at upper, middle and bottom depths, from the deep-point Lower Blum Lake sampling station.	82
Figure 88. Bathymetry, shoreline features and sampling locations at Lower Blum Lake.....	83
Figure 89. Lower Blum Lake watershed panoramic photo from Photo Point 1.	84
Figure 90. Hiking route to Lower Blum Lake, including main trails and cross country route.	85
Figure 91. Location of the 8 core monitoring lakes at Olympic National Park.	87
Figure 92. Ferry Lake from the mountainside above.	88
Figure 93. Ferry Lake watershed and surrounding area.....	89
Figure 94. Dissolved oxygen, temperature and pH depth profiles from the deep-point Ferry Lake sampling station.....	90
Figure 95. Bathymetry, shoreline features and sampling locations at Ferry Lake.....	91
Figure 96. Ferry lake watershed panoramic photo from Photo Point 1.	92
Figure 97. Ferry lake watershed panoramic photo from Photo Point 2.	92
Figure 98. Hiking route to Ferry Lake, including main trails and cross country route.....	93

Figures (continued)

	Page
Figure 99. Gladys Lake from a nearby ridge.	94
Figure 100. Gladys Lake watershed and surrounding area.	95
Figure 101. Dissolved oxygen, temperature and pH depth profiles from the deep-point Gladys Lake sampling station.	96
Figure 102. Bathymetry, shoreline features and sampling locations at Gladys Lake.	97
Figure 103. Gladys Lake watershed panoramic photo from Photo Point 1.	98
Figure 104. Gladys Lake watershed panoramic photo from Photo Point 2.	98
Figure 105. Hiking route to Gladys Lake.	99
Figure 106. Heather Lake viewed from the ridge east of lake.	100
Figure 107. Heather Lake watershed and surrounding area.	101
Figure 108. Dissolved oxygen, temperature and pH depth profiles from the deep-point Heather Lake sampling station.	102
Figure 109. Bathymetry, shoreline features and sampling locations at Heather Lake.	103
Figure 110. Heather Lake watershed panoramic photo from Photo Point 1.	104
Figure 111. Heather Lake watershed panoramic photo from Photo Point 2.	104
Figure 112. Hiking route to Heather Lake, including main trails and cross country route.	105
Figure 113. Milk Lake with Mt. Bretherton in background.	106
Figure 114. Milk Lake watershed and surrounding area.	107
Figure 115. Dissolved oxygen, temperature and pH depth profiles from the deep-point Milk Lake sampling station.	108
Figure 116. Bathymetry, shoreline features and sampling locations at Milk Lake.	109
Figure 117. Milk Lake watershed panoramic photo from Photo Point 1.	110
Figure 118. Milk Lake watershed panoramic photo from Photo Point 2.	110
Figure 119. Hiking route to Milk Lake, including main trails and cross country route.	111

Figures (continued)

	Page
Figure 120. Crazy Lake looking south toward Mt. Skokomish.	112
Figure 121. Crazy Lake watershed and surrounding area.	113
Figure 122. Dissolved oxygen, temperature and pH depth profiles from the deep-point Crazy Lake sampling station.	114
Figure 123. Bathymetry, shoreline features and sampling locations at Crazy Lake.	115
Figure 124. Crazy Lake watershed panoramic photo from Photo Point 1.	116
Figure 125. Crazy Lake watershed panoramic photo from Photo Point 2.	116
Figure 126. Hiking route to Crazy Lake, including main trails and cross country route.	117
Figure 127. Lake La Crosse and the upper La Crosse Basin.	118
Figure 128. Lake La Crosse watershed and surrounding area.	119
Figure 129. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake La Crosse sampling station.	120
Figure 130. Bathymetry, shoreline features and sampling locations at Lake La Crosse	121
Figure 131. Lake La Crosse watershed panoramic photo from Photo Point 1.	122
Figure 132. Lake La Crosse watershed panoramic photo from Photo Point 4.	122
Figure 133. Hiking route to Lake LaCrosse, including main and way trails.	123
Figure 134. Lake Sunup from western shore.	124
Figure 135. Lake Sunup watershed and surrounding area.	125
Figure 136. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake Sunup sampling station.	126
Figure 137. Bathymetry, shoreline features and sampling locations at Lake Sunup.	127
Figure 138. Lake Sunup watershed panoramic photo from Photo Point 1.	128
Figure 139. Lake Sunup watershed panoramic photo from Photo Point 2.	128

Figures (continued)

	Page
Figure 140. Hiking route to Lake Sunup, including main trails, shortcut and cross country routes.....	129
Figure 141. Lake Connie from the northwest shoulder of Mt. Hoquiam.....	130
Figure 142. Lake Connie watershed and surrounding area.....	131
Figure 143. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake Connie sampling station.	132
Figure 144. Bathymetry, shoreline features and sampling locations at Lake Connie.....	133
Figure 145. Lake Connie watershed panoramic photo from Photo Point 1.....	134
Figure 146. Lake Connie watershed panoramic photo from Photo Point 2.....	134
Figure 147. Lake Connie watershed panoramic photo from Photo Point 3.....	135
Figure 148. Lake Connie watershed panoramic photo (2010) from Photo Point 4.	135
Figure 149. Hiking route to Lake Connie, including main trails, shortcut and cross country routes.....	136

Tables

	Page
Table 1. Lake Allen morphometric data.....	13
Table 2. Water quality and productivity parameters for Lake Allen.	14
Table 3. Amphibian species observed at Lake Allen.	15
Table 4. Introduced fish species observed at Lake Allen.....	15
Table 5. Upper Palisades Lake morphometric data.....	19
Table 6. Water Quality and productivity parameters for Upper Palisades.....	20
Table 7. Amphibian species observed at Upper Palisades Lake.	21
Table 8. Introduced fish species observed at Upper Palisades Lake.....	21
Table 9. Lake LP19 Morphometric data	25
Table 10. Water Quality and productivity parameters for Lake LP19.....	26
Table 11. Amphibian species observed at Lake LP19.	27
Table 12. Introduced fish species observed at Lake LP19.....	27
Table 13. Lake LH15 Morphometric data.....	31
Table 14. Water Quality and productivity parameters for Lake LH15	32
Table 15. Amphibian species observed at Lake LH15.....	33
Table 16. Introduced fish species observed at Lake LH15.	33
Table 17. Upper Deadwood Lake Morphometric data.....	37
Table 18. Water Quality and productivity parameters for Upper Deadwood Lake.	38
Table 19. Amphibian species observed at Upper Deadwood Lake.....	39
Table 20. Introduced fish species observed at Upper Deadwood Lake.	39
Table 21. Blue Lake Morphometric data	43
Table 3. Water Quality and productivity parameters for Blue Lake..	44
Table 23. Amphibian species observed at Blue Lake.	45

Tables (continued)

	Page
Table 24. Introduced fish species observed at Blue Lake.	45
Table 25. Bowan Lake Morphometric data.....	51
Table 26. Water Quality and productivity parameters for Bowan Lake	52
Table 27. Amphibian species observed at Bowan Lake.....	53
Table 28. Introduced fish observed at Bowan Lake.....	53
Table 29. Lower Silent Lake Morphometric data	57
Table 30. Water Quality and productivity parameters for Lower Silent Lake.....	58
Table 31. Amphibian species observed at Lower Silent Lake	59
Table 32. Introduced fish species observed at Lower Silent Lake.....	59
Table 33. Lower East Lake Morphometric data.....	63
Table 34. Water Quality and productivity parameters for Lower East Lake	64
Table 35. Amphibian species observed at Lower East Lake.....	65
Table 36. Upper Triplet Lake Morphometric data	69
Table 37. Water Quality and productivity parameters for Upper Triplet Lake.....	70
Table 38. Amphibian species observed at Upper Triplet Lake	71
Table 39. Introduced fish species observed at Upper Triplet Lake.....	71
Table 40. Easy Ridge Lake Morphometric data.....	75
Table 41. Water Quality and productivity parameters for Easy Ridge Lake	76
Table 42. Amphibian species observed at Easy Ridge Lake.....	77
Table 43. Introduced fish species observed at Easy Ridge Lake.	77
Table 44. Lower Blum Lake Morphometric data.....	81
Table 45. Water Quality and productivity parameters for Lower Blum Lake	82
Table 46. Amphibian species observed at Lower Blum Lake.....	83

Tables (continued)

	Page
Table 47. Ferry Lake Morphometric data	89
Table 48. Water Quality and productivity parameters for Ferry Lake	90
Table 49. Amphibian species observed at Ferry Lake.	91
Table 50. Introduced fish species observed at Ferry Lake.	91
Table 51. Gladys Lake Morphometric data.....	95
Table 52. Water Quality and productivity parameters for Gladys Lake	96
Table 53. Amphibian species observed at Gladys Lake.....	97
Table 54. Introduced fish species observed at Gladys Lake.	97
Table 55: Heather Lake Morphometric data	101
Table 56. Water Quality and productivity parameters for Heather Lake.....	102
Table 57. Amphibian species observed at Heather Lake.	103
Table 58. Introduced fish species observed at Heather Lake.	103
Table 59. Milk Lake Morphometric data	107
Table 60. Water Quality and productivity parameters for Milk Lake.....	108
Table 61. Amphibian species observed at Milk Lake.	109
Table 62. Introduced fish species observed at Milk Lake.....	109
Table 63. Crazy Lake Morphometric data	113
Table 64. Water Quality and productivity parameters for Crazy Lake	114
Table 65. Amphibian species observed at Crazy Lake.	115
Table 66. Introduced fish species observed at Crazy Lake.	115
Table 67. Lake La Crosse Morphometric data	119
Table 68. Water Quality and productivity parameters for La Crosse Lake	120
Table 69. Amphibian species observed at Lake La Crosse.....	121

Tables (continued)

	Page
Table 70. Introduced fish species observed at Lake La Crosse.	121
Table 71. Lake Sunup Morphometric data.....	125
Table 72. Water Quality and productivity parameters for Lake Sunup	126
Table 73. Amphibian species observed at Lake Sunup.....	127
Table 74. Introduced fish species observed at Lake Sunup.	127
Table 75. Lake Connie Morphometric data	131
Table 76. Water Quality and productivity parameters for Lake Connie.....	132
Table 77. Amphibian species observed at Lake Connie.	133
Table 78. Introduced fish species observed at Lake Connie.	133

Abstract

This report provides a baseline characterization of 20 mountain lakes monitored annually as part of the North Coast and Cascades Network (NCCN) Mountain Lakes Monitoring Protocol (Glesne et al. 2012). Of the 20 “core” reference lakes, six lakes each are at Mount Rainier National Park (MORA) and North Cascades National Park Service Complex (NOCA), and eight lakes are at Olympic National Park (OLYM). The location of each lake is presented, along with a descriptive map of the lake’s watershed and associated environs. These help to present each lake in the context of surrounding topography and the park’s climatic gradients. Physical characteristics such as size, elevation, aspect and depth are described for each lake, along with representative physical/chemical data from the 2010 sampling year. A list of observed amphibian and introduced fish species are also provided. Finally, a description of the access route used by sampling crews is provided. This information will aid in the interpretation of future sampling results, support the planning of additional research components at these lakes, and serve as a reference for NCCN and park staff involved in long term monitoring efforts.

The reference lakes characterized here span an elevational gradient from 4,105 ft to 6,713 ft. Lake elevations are generally higher at NOCA and lower at OLYM, reflecting differing geographic and climatic conditions. The reference lakes span a surface area gradient from 0.4 ha to 6 ha. While lake size is well distributed across parks, sample lakes in MORA tend to have larger surface areas, while the NOCA lakes generally have smaller surface areas. The maximum depths of reference lakes span a range from 3.6 m to 16.2 m. MORA reference lakes are generally deeper, while the majority of shallow lakes are sampled within NOCA. The precipitation gradient across the reference lakes is greatest at OLYM (196-559 cm/yr), while the gradient at MORA spans from 162-304 cm/yr and the gradient at NOCA spans from 157-379 cm/yr. Differences exist within the NCCN reference lakes in their ability to buffer atmospheric acid deposition based on differences in the bedrock geology of their watersheds. OLYM lakes are generally more buffered, while MORA and NOCA lakes tend to be more poorly buffered. All three parks have introduced fish in some of their previously fishless mountain lakes. A total of three species have been found in the NCCN reference lakes. All three species are found in the MORA and OLYM reference lakes with fish, while the single NOCA reference lake with fish has only one species. A total of eight amphibian species have been found in the NCCN reference lakes. The MORA and NOCA lakes have six species each, while the NOCA lakes have three species.

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Introduction

The NCCN Mountain Lakes Monitoring Program (Glesne et al. 2012) was developed to characterize and detect substantive trends within a representative set of subalpine lakes in each of the three NCCN parks. The primary focus of this program centers on the detailed monitoring of physical, chemical and biological trends in the same 20 “core” reference lakes sampled annually. Of the 20 core lakes funded by the NCCN, six lakes are at MORA, six are at NOCA, and eight are at OLYM. A secondary focus of the program is to determine the status of a broader population of park lakes through the less frequent (once per decade) sampling of 40-50 lakes. This report pertains to only the 20 core lakes. All core lakes were selected randomly from a subset of the entire population of similar lakes at each park. The subset, or sample frame includes lakes found entirely within park boundaries, ranging in size from 0.4 to 6.0 hectares, occurring at elevations from 1220 meters (4000 ft.) extending to the upper limit of the subalpine zone at each park, and which are not heavily influenced by glacial runoff. Lakes were also required to have a maximum depth greater than 2.5 meters, be accessible within a two-day hike from a trailhead, and have low densities of fish. An additional sampling design objective was to disperse sample lakes across the wide range of annual precipitation categories found within these mountainous NCCN parks.

While lake selection criteria were designed to standardize the type of lakes to be monitored, lakes within the sample frame exhibit differences in their physical setting that may affect individual lake dynamics. These differences include bedrock geology, lake aspect, hydrology, watershed size, topography and vegetation.

The purpose of this report is to provide a gazetteer of the core NCCN lakes to characterize the landscape, morphometric, physical/chemical, and biological context of each core lake. This report is an extension of the NCCN Mountain Lake Protocol (Glesne et al. 2012), and is essentially a “field guide” to the core lakes, providing background information that characterizes each lake. The majority of this information will not be presented in subsequent standardized annual reports. This information will aid in the interpretation of future sampling results, support the planning of additional research components at these lakes, and serve as a reference for NCCN and park staff involved in long term monitoring efforts.

This report is divided into two sections. The first section briefly describes the methods used for characterizing and sampling at NCCN lake study sites. The second section is subdivided by NCCN Park, and uses a standard format to describe each lake and its watershed, and presents representative physical/chemical and biological data from the 2010 sampling season.

Methods

The methods described below are general, abbreviated descriptions of the methods used in data and sample collection. Full descriptions of protocol methodology are contained in the Protocol for Long Term Monitoring of Mountain Lakes in the North Coast and Cascades Network of National Parks (Glesne et al. 2012).

Geological Setting

The geology of lake basins and their associated watersheds is a key factor influencing physical and chemical processes in lakes. Nutrient fluxes, dissolved solids (ions), acid neutralizing capacity, groundwater interactions, and thermal dynamics are all shaped by the underlying geological structure. For each core lake, the basin and watershed geology were describe based on previous geological mapping, soil inventories and previous site visits. Currently, a soil inventory is only available for NOCA.

Bathymetry & Lake Features

Lake bathymetry data were collected by field staff using inflatable boats and handheld sonar devices to record depths systematically along transects across lakes. A geographical information system (GIS) was then used to derive a bathymetric map. Mapped lake features include late season inlets, outlets, and important sampling points (e.g. permanent photo points, lake level measurement sites, air temperature sensor location, and the maximum lake depth sampling location).

Lake locations are reported as UTM coordinates using the NAD83 datum. The UTM region for all locations was Region 10N. Lake morphometric features were derived from bathymetric data and digitized shorelines and watersheds (derived from high resolution aerial photography topographic maps) via GIS. Morphometric parameters presented in the lake descriptions in this document are defined as:

Lake elevation is the height (m) of the water body above sea level. Lake elevation for NCCN lakes was determined via GIS. Elevation influences temperature, precipitation, ice-on/ice-off patterns, and the length of growing season.

Lake aspect is the predominant direction the lake catchment basin faces (e.g. northeast). Aspect influences precipitation patterns, snowmelt, wind exposure, duration of solar warming, and ice-on/ice-off timing. North-facing lakes generally have later season snowmelt and ice-off timing.

Watershed area is the surface area (ha) of the landscape around a lake that drains into the lake. The size of the watershed influences the amount of runoff and terrestrially derived chemicals entering a lake.

Surface area is the area (ha) of the surface of the lake. Surface area influences the direct water and chemical flux to a lake via atmospheric deposition and evaporation.

Volume is the amount of water (m^3) within the lake basin.

Maximum depth is the depth of the deepest point in a lake. In deeper lakes, water column processes are less dependent upon littoral and benthic processes.

Mean depth is the lake volume (m^3) divided by the surface area (m^2). Increased mean depth decreases the influence of the littoral and benthic zones on water column processes and increases the potential for water column stratification.

Relative depth is the ratio, expressed as a percentage, of the maximum depth to the diameter of a circle with the same area as the lake. Relative depth is an index of the depth/surface area relationship between lakes and describes water column stability against wind mixing. Lakes that are deep relative to their surface area (e.g. relative depths > 4%) tend to exhibit greater stability. In the NCCN, mountain lakes with relative depths > 4% are unlikely to become strongly stratified during the brief ice-free summer season.

Shoreline length is the length (m) of the perimeter of a lake.

Lake length is the length (m) of the longest uninterrupted axis along the surface area of a lake. Together with Lake Width, this measure describes the shape of the lake basin.

Lake width is the width (m) of the longest uninterrupted axis along the surface area perpendicular to the lake length axis. Together with Lake Length, this measure describes the shape of the lake basin.

Watershed area: lake area is a ratio that describes the area of a lake relative to its watershed. A larger ratio denotes an increased influence of watershed processes (i.e. water and chemical inputs) on a lake.

Shoreline development is the ratio of the length of the shoreline (m) to the length of the circumference of a circle (m) with an area equal to that of the lake. Shoreline development describes the degree of departure of lake surface shape from that of a circle. Circular lakes have a shoreline development closer to 1, while lakes > 1 have more distorted or crenulated shapes that reflect the potential for more developed littoral plant communities.

Index of basin permanence is the ratio of lake volume (m^3) to shoreline length (km) and is another measure of the littoral effect on basin volume. Lakes with an index of basin permanence <0.1 are likely to be dominated by rooted aquatic vegetation.

Physical/Chemical Water Properties

Water quality data presented in this report are derived from collected water samples, vertical profiles taken *in situ* with a YSI datasonde, and water clarity measurements derived from Secchi disk observations. All water quality measurements and samples were taken using similar equipment between parks, at the same time of day (between 10:00 AM and 2:00 PM) at the deepest point in the lake.

Water samples

Water samples were collected to measure a suite of water chemistry variables including nutrients, dissolved organic carbon (DOC), anions/cations, pH, specific conductance, total dissolved solids (TDS), and acid neutralizing capacity (ANC). When the water column was

unstratified (the normal situation), water samples were taken at mid-depth at the deepest point in the lake. When the water column was stratified, two sets of samples were collected, one just below the water surface and the other 1 m above the bottom. The exception was DOC samples, which were always taken at the 1 m depth. The water chemistry of mountain lakes is a fundamental component of lake ecosystems, from biogeochemical cycles to the regulation of biological communities. Characteristics of water chemistry are also key indicators of ecosystem change due to the effects of global climate change, atmospheric deposition, and visitor impacts. The various analytical procedures for measuring water chemistry properties require laboratory conditions and equipment not available in the field. Water samples are processed in the field and transported back to the park laboratory for analysis, or shipped to commercial analytical labs (Cooperative Chemical Analytical Lab/ Corvallis, OR; Central Washington University Johansen Environmental Chemistry Laboratory). Reported water chemistry parameters whose measured sample values fall below the method detection limit are flagged in the report tables with an asterisk.

Lake Profiles

Vertical profiles of physical and chemical parameters were taken with a YSI 600XLM datasonde that continuously measures and records temperature, dissolved oxygen, specific conductance, and pH. These data provide key information on the vertical structure of the water column and provide insight into the fundamental processes that govern lake ecosystem dynamics.

Temperature profiles illustrate the degree of thermal stratification occurring between the warmer upper water layer (epilimnion) and the colder lower water layer (hypolimnion). Dissolved oxygen profiles illustrate the amount of oxygen available for organism respiration. Specific conductance and pH provide indices of the ionic strength and concentration of dissolved ions that affect organismal growth and metabolism.

Water clarity

Water clarity is an index of light transmission through lake water. Transparency of mountain lakes water is affected by the cumulative concentrations of dissolved solids, pigments, phytoplankton and suspended sediments. The depth of transparency is determined as the mean depth of the point where a weighted black & white 20-cm diameter “Secchi” disk disappears when viewed from the lake surface, and the point where it reappears upon raising it after it has been lowered beyond visibility.

Primary Productivity

Chlorophyll-a concentration is derived from phytoplankton in water samples collected and filtered in the field. Filters retaining all sample phytoplankton are transported to a laboratory where the chlorophyll-a is extracted and quantified fluorometrically. Chlorophyll-a is the major photosynthetic pigment used by phytoplankton and is a standard index of algal biomass, itself a useful indicator of the trophic status and productivity of mountain lakes.

Biological Data

Amphibians

Amphibians are an important top predator in many mountain lake ecosystems. They are also an organism of interest due to documented declines in many ecosystems around the world (Alford

and Richards 1999). Finally, they provide an important indicator of ecosystem health, due to their susceptibility to many anthropogenic and stressors. At each core sample lake, a visual encounter survey is conducted by a crew of two during the day. Surveyors walk the entire perimeter of the lake continuously searching for amphibians and stopping every 50 m to search more intensively. Species, developmental life stage and the size of individuals (when possible) are recorded.



Figure 1. Northwestern salamander larvae swimming in Lake Allen, Mount Rainier (left). An adult Long-toed salamander netted at Ferry Lake, Olympic National Park (right).

Non-native Fish

While historically absent from NCCN mountain lakes, fish were later introduced into many of the sample lakes, originally for the purpose of recreational fishing. Introduced fish populations can alter the composition of native aquatic communities by predation on amphibians (Bradford et al. 1993, Knapp and Matthews 2000, Pilliod and Peterson 2001), zooplankton (Anderson 1980, Stoddard 1987, Carlisle 1995), and benthic macroinvertebrates (Carlisle 1995, Rowan 1996, Bradford et al. 1998). Fish introductions into mountain lakes can also initiate trophic cascades (Carpenter et al. 1985) that can greatly alter lake productivity (Leavitt et al. 1994). The presence or absence of fish is determined at each site visit through shore based observation, angling or gill netting. Additionally, gill nets are deployed in each core lake every 5 years.

Summary of NCCN Lake Characteristics

While core lakes in each NCCN park have been randomly selected from a sub-population of lakes of similar size, depth and elevation in order to reduce signal variation, variation in these features still exists. In this section summary core lake physiographic data are presented.

Elevation

All core lakes range between 1220 m and 2100 m in elevation (Figure 2). Core lakes are generally at a higher elevation in NOCA and lower elevation in OLYM, reflecting differences in the elevation of subalpine zones in these parks due to geographic and climatic conditions. The highest elevation lake is Lower Silent Lake (NOCA) at 2046 m (6713 ft). The lowest elevation lake is Lake Sunup (OLYM) at 1224 m (4015 ft).

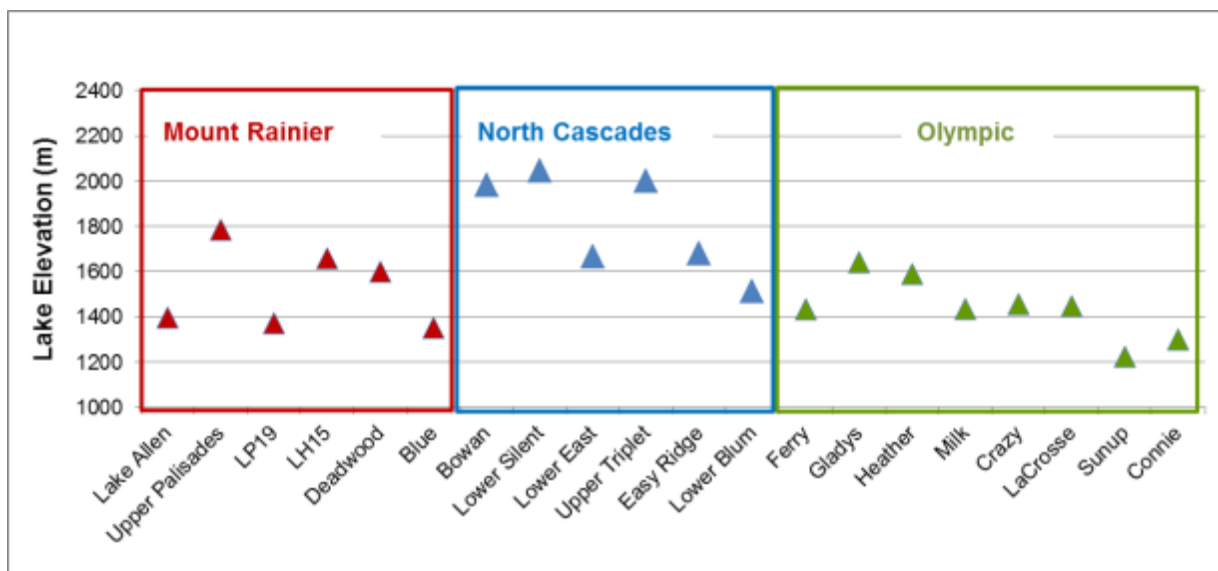


Figure 2. Elevation distribution of core NCCN sampling lakes. The highest elevation lake is Lower Silent Lake, at 2046 meters (6713 ft.) in North Cascades. The lowest elevation lake is Lake Sunup at 1224 meters (4015 ft.) in Olympic. Sample lakes are generally highest at the North Cascades and lowest in Olympic, a direct reflection of the geographic & climatic characteristics of these parks.

Surface Area

The core lakes span a surface area gradient (Figure 3) from 0.4 ha (Heather Lake, OLYM) to 6.0 ha (Blue Lake, MORA). While lake size is well distributed across parks, sample lakes in MORA tend to have larger surface areas, while NOCA lakes generally have smaller surface areas.

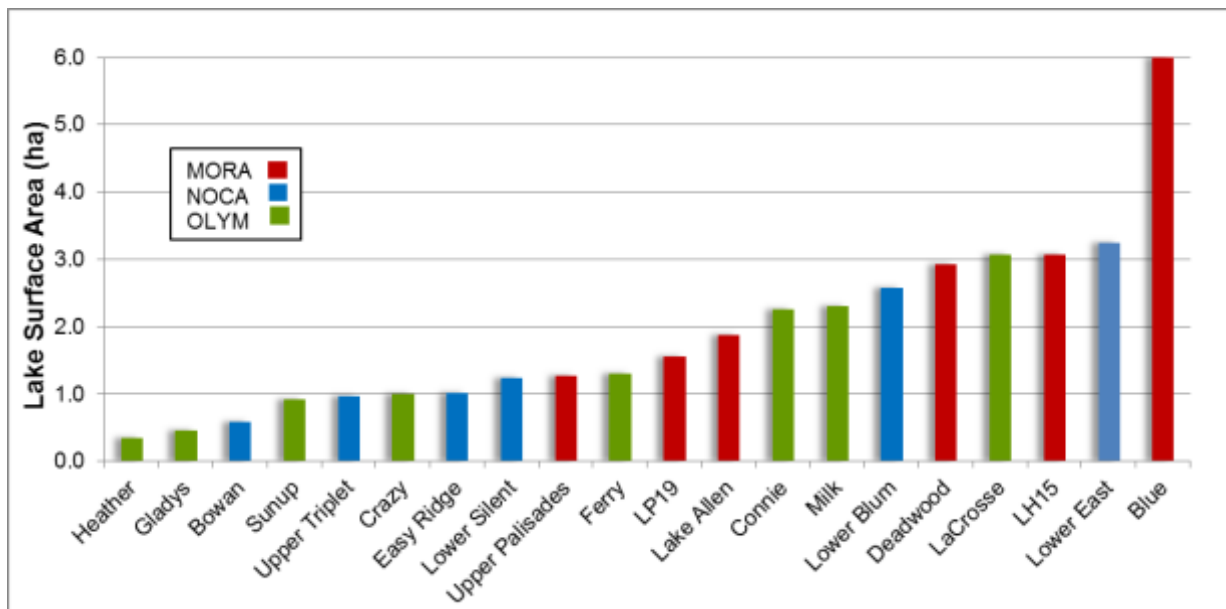


Figure 3. Size distribution of core NCCN sampling lakes. Mt. Rainier's Blue Lake, at 6.0 hectares, is the largest lake sampled. Heather Lake at Olympic is the smallest at .4 hectares. While lake size is generally well distributed across parks, Mt. Rainier tends towards larger lakes, and North Cascades sample lakes are generally on the smaller size.

Maximum Depth

NCCN core lakes also span a range of maximum depths (Figure 4) from 3.6 m (Bowan Lake, NOCA) to 16.2 m (Lower East Lake, NOCA). MORA core lakes are generally deeper, while the majority of shallow lakes (less than 4 meters) are within NOCA.

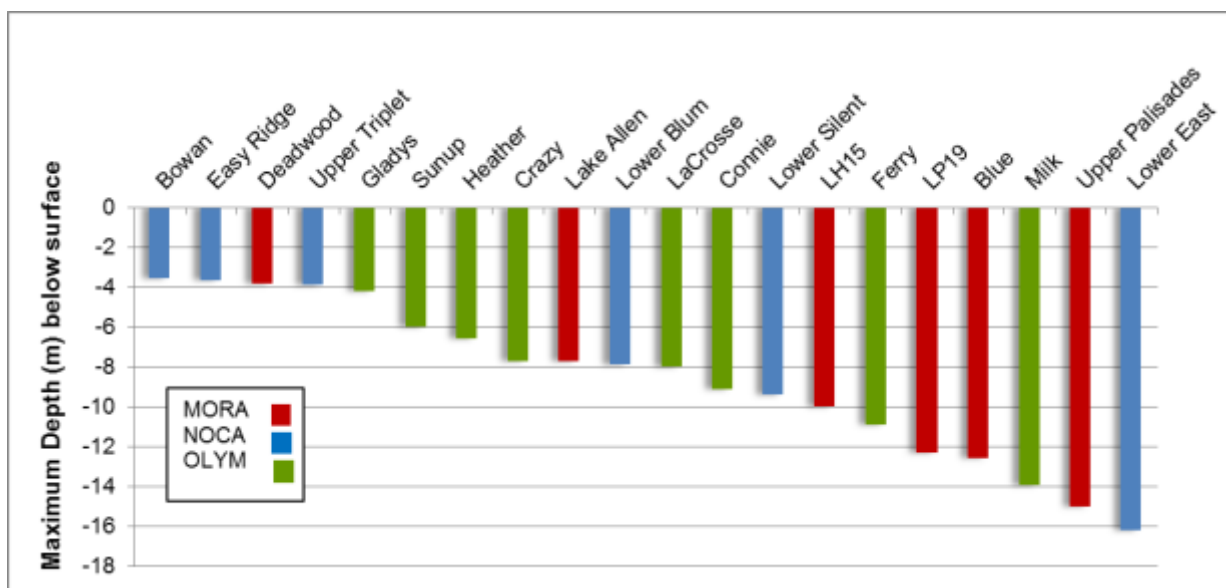


Figure 4. Maximum lake depth of core NCCN sampling lakes. The deepest lake is Lower East Lake, in North Cascades, with a depth of 16.2 meters. Mt. Rainier sample lakes are generally deeper and the majority of shallow lakes (less than 4 meters) are found at North Cascades.

Precipitation

Core lakes span the precipitation gradients found in each NCCN park (Figure 5). The greatest gradient is seen at OLYM (196-559 cm/yr), while the gradient at MORA spans from 162-304 cm/yr and the gradient at NOCA spans from 157-379 cm/yr. The lowest precipitation lake (Upper Triplet at 140 cm/yr) is found in the eastern portion of NOCA. The highest precipitation lake (Lake Connie at 559 cm/yr) occurs in the southwestern corner of OLYM. Precipitation data is based on 1971-2000 PRISM data

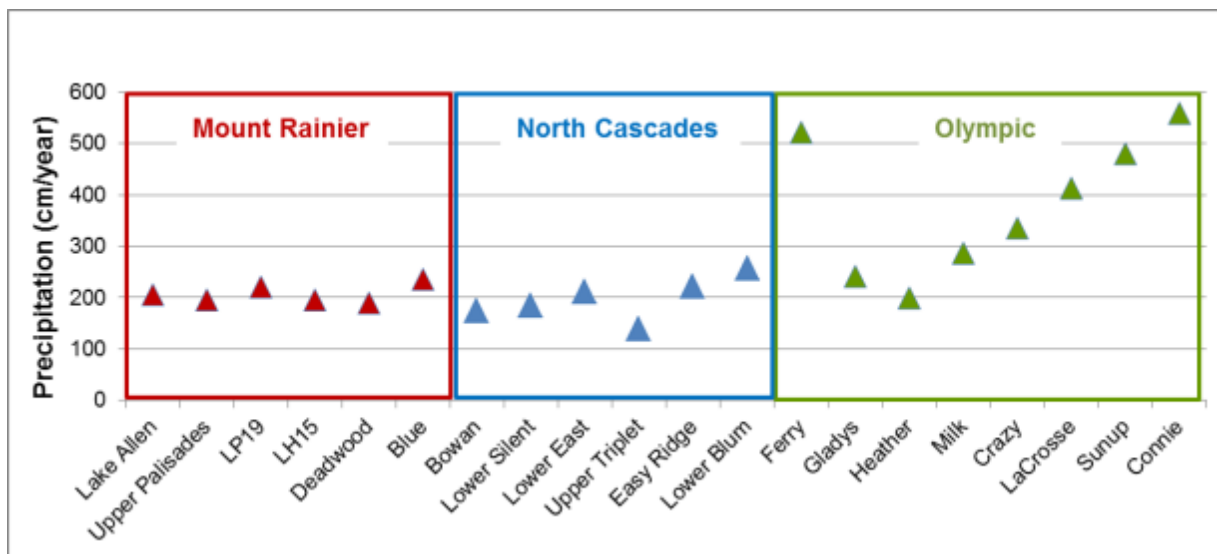


Figure 5. Annual precipitation at core NCCN sampling lakes. The greatest precipitation gradient is seen at Olympic National Park where Heather Lake receives 200 cm/year while Lake Connie receives 559 cm/year. The lowest precipitation lake is found in the eastern portion of North Cascades, with Upper Triplet receiving 140 cm/year. Precipitation data is based on 1971-2000 PRISM data.

Acid Neutralizing Capacity

NCCN lakes are potentially sensitive to atmospheric deposition of compounds (e.g. sulfur, nitrogen) that can reduce lake pH with devastating effects on lake biota (NPS 1995a, 1995b, 1999). Core lakes vary in their buffering, or acid neutralizing capacity due to differences in the bedrock geology of their watersheds (Figure 6). OLYM lakes are generally more buffered, while MORA and NOCA lakes tend to be more poorly buffered.

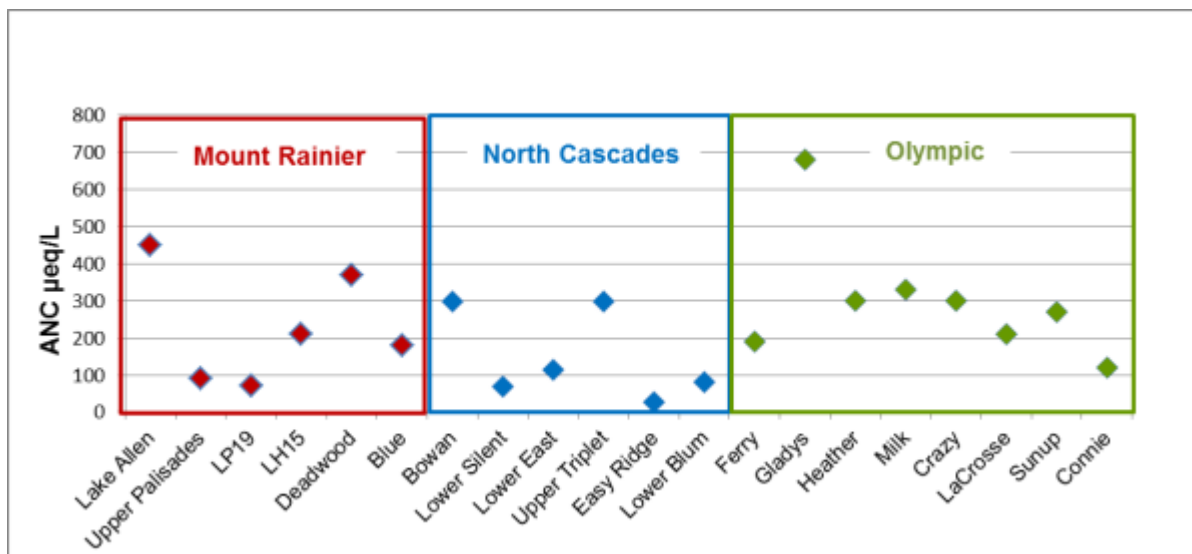


Figure 6. Acid-neutralizing capacity (ANC) values (µeq/L) for core NCCN sampling lakes. The majority of low ANC lakes are found in North Cascades and Mt. Rainier National Parks.

Non-Native Fish

All three NCCN mountain lake parks have a history of exotic fish stocking (Glesne et al. 2012) although complete inventories are lacking. In each park, some portion of the selected core lakes contains exotic fish (Figure 7). MORA has the highest percentage of core lakes with fish (67%), while OLYM has 37%, and NOCA has the lowest with 17%.

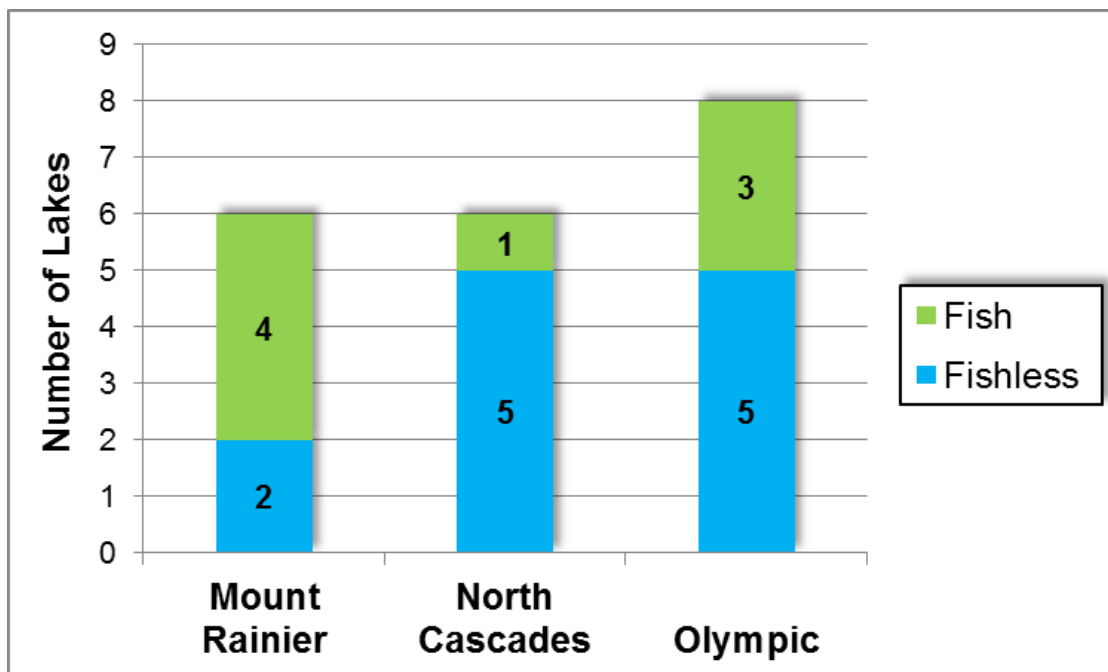


Figure 7. Proportion of fish free lakes among the core NCCN sampling lakes. At North Cascades 83% of the study lakes are fish free. At Olympic, 63% are fish free. At Mount Rainier only 33% are free of fish.

Lake Descriptions: Mount Rainier National Park

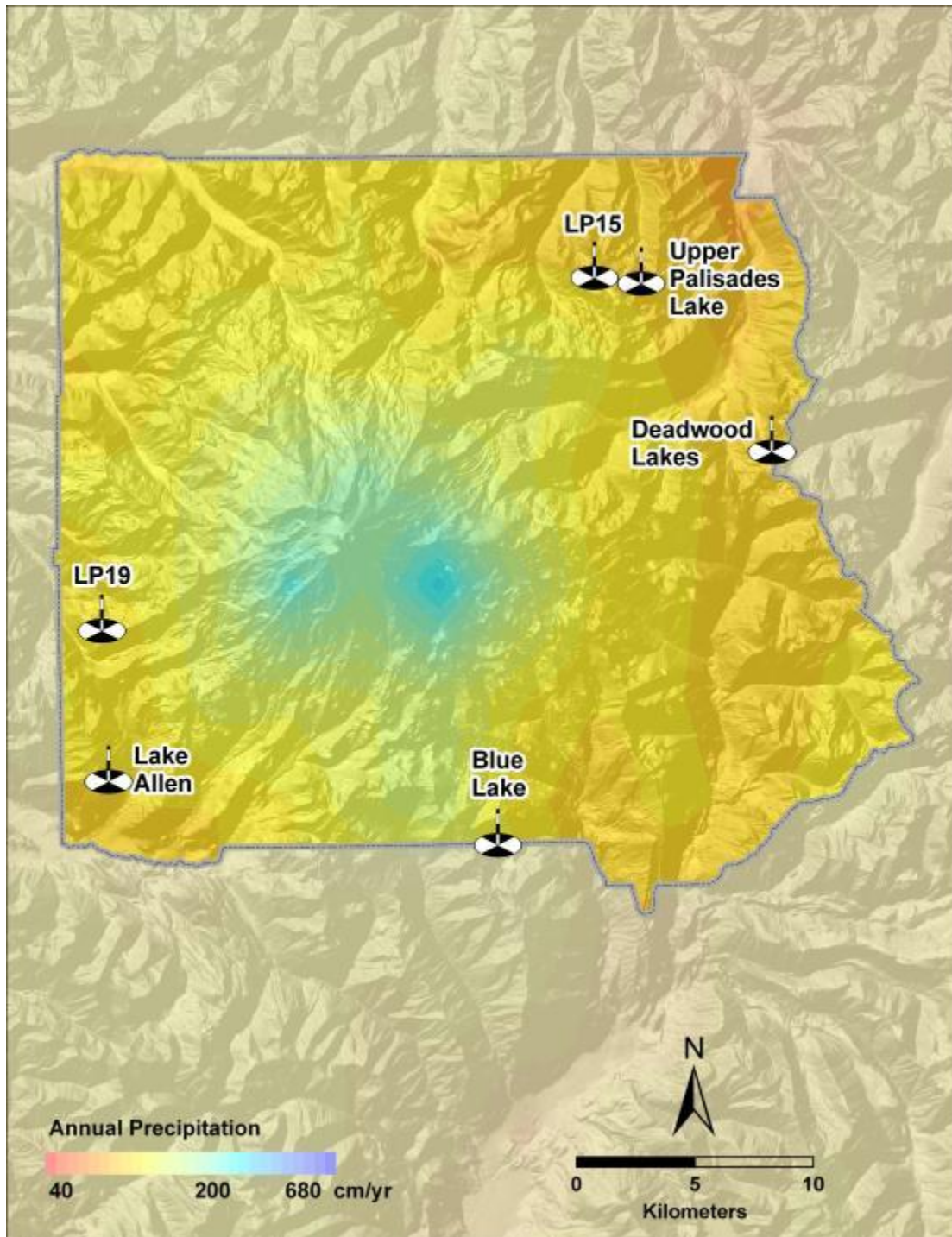


Figure 8. Location of the 6 core monitoring lakes at Mount Rainier National Park. Background shading indicates precipitation gradient derived from PRISM model.

Lake Allen (LN03)

Mount Rainier National Park

UTM Coordinates (NAD83): 584537 m E / 5179649 m N



Figure 9. Lake Allen from talus slope northwest of lake.

Geologic Setting

Lake Allen is located within the Ohanapecosh Formation, which is basaltic andesite, a volcanic rock that formed between 27 and 37 million years ago (Fisk et al. 1988). The lake rests in a small glacial cirque basin carved along the valley wall of Tahoma Creek. Hummocky topography at the outlet of the lake and on the lake bed may indicate that the lake was created by a landslide, which blocked the cirque basin with a debris dam (Riedel et al. in press). The age of the landslide is unknown, but it clearly would have occurred after the last glaciation ended. The lake shore is composed of talus, bedrock, colluvium (hillslope sediments), and alluvial gravel deposited on the north and west sides of the lake. Snow and small debris avalanches likely enter the lake at its west end, and contribute to the relatively high lakeshore development.

Watershed Description

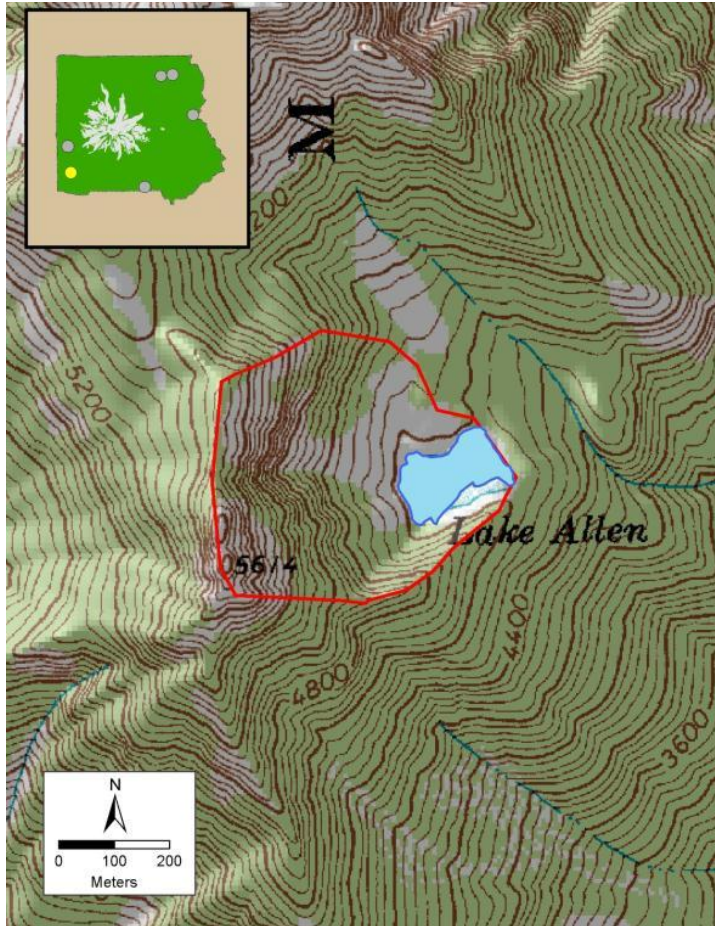


Figure 10. Lake Allen watershed and surrounding area.

Table 1. Lake Allen morphometric data

Lake Parameter	Value
Elevation	1397 m (4583 ft)
Aspect	Northeast
Watershed Area	19.8 ha
Surface Area	1.9 ha
Volume	64,157 m ³
Depth (maximum)	7.7 m
Depth (mean)	3.4 m
Depth (relative)	2.7%
Shoreline length	668 m
Lake length (maximum)	210 m
Lake width (maximum)	133 m
Watershed area: Lake Area (ratio)	10.6
Shoreline Development	1.38
Index of Basin Permanence	0.10

Physical/ Chemical Water Properties

Table 2. Water quality and productivity parameters for Lake Allen, August 4, 2010. Water samples collected at multiple depths due to lake stratification. Chlorophyll was sampled at mid-depth.

Parameter	Units	2010 1 m	2010 6.5 m
Water Chemistry			
Total Nitrogen	mg/l	0.03	0.05
Total Phosphorus	mg/l	*0.002	*0.002
Nitrogen & Phosphorus Ratio	N/A	15	25
NO3+NO2-N	mg/l	*0.000	*0.000
NH3-N	mg/l	*0.001	*0.004
Anion & Cation Ratio		N/A	N/A
Acid Neutralizing Capacity	µeq/L	450	530
pH	None	6.48	6.33
Specific Conductance	µS/cm	61	67
Dissolved Organic Carbon	mg/l	0.89	
Total Dissolved Solids	mg/l	37	38
Water Clarity			
Depth of Transparency	m	Bottom (7.5)	
Chlorophyll			
Chlorophyll-a	µg/L	0.172	

*Below Detection Limit

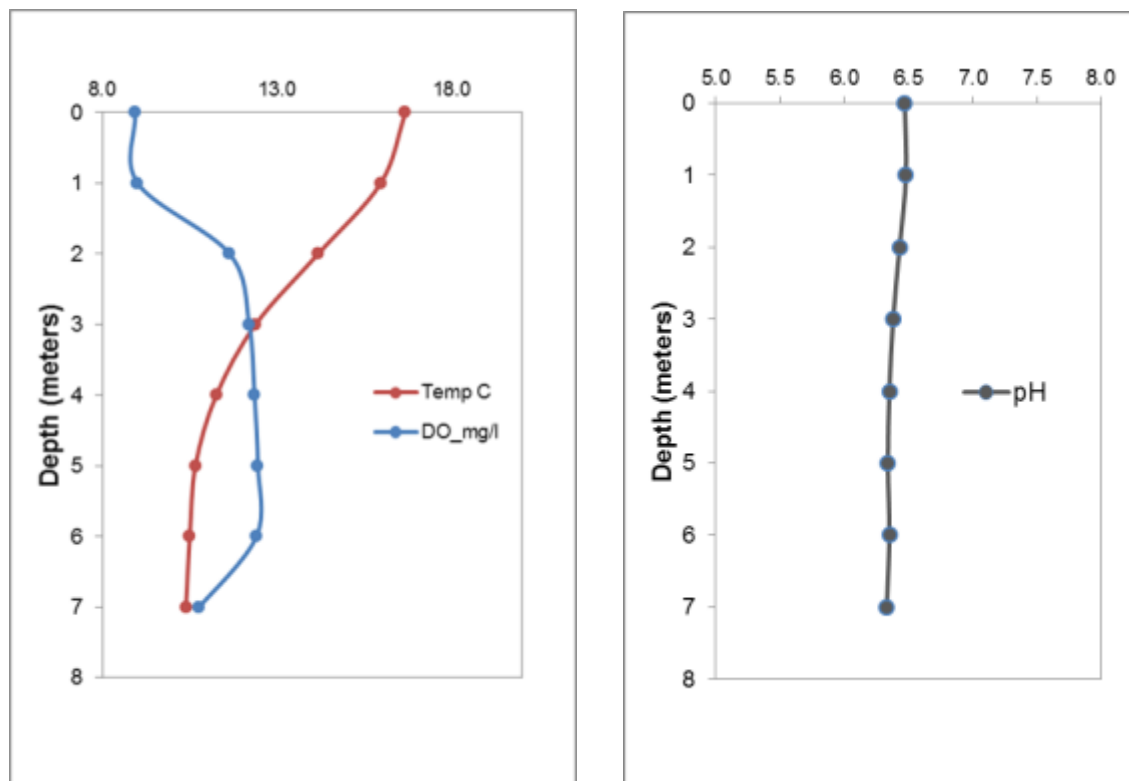


Figure 11. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake Allen sampling station August 4, 2010.

Bathymetry & Shoreline Features

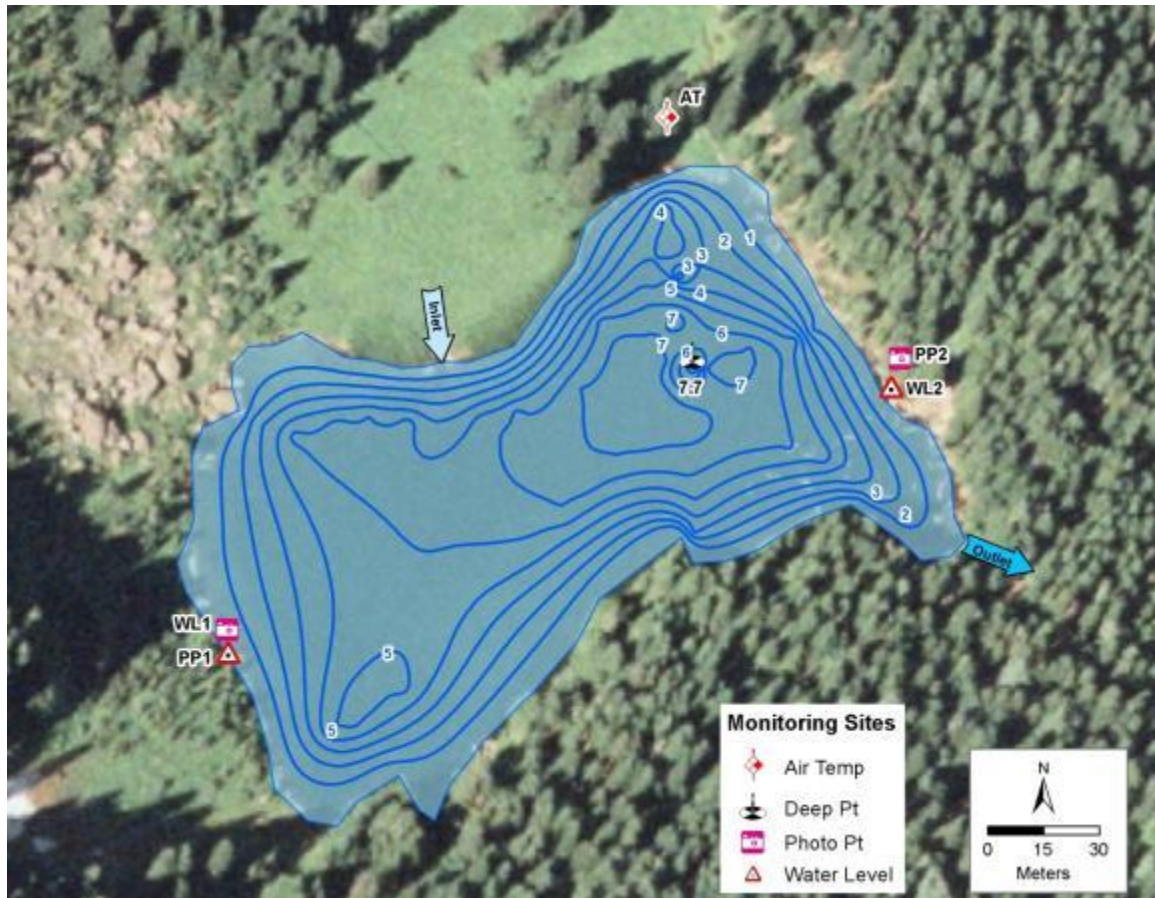


Figure 12. Bathymetry, shoreline features and sampling locations at Lake Allen.

Amphibian & Fish Species

Table 3. Amphibian species observed at Lake Allen (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Larvae	484
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Egg Mass	42
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Dead	12
<i>Taricha granulosa</i>	Rough-skinned Newt	TAGR	Adult	1

Table 4. Introduced fish species observed at Lake Allen (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 13. Lake Allen watershed panoramic photo (2010) from Photo Point 1 (see Figure 12).

16



Figure 14. Lake Allen watershed panoramic photo (2010) from Photo Point 2 (see Figure 12).

Lake Access

A sampling trip to Lake Allen requires 1 day. Drive or hike the Westside Road to mile 1.8. Ascend 0.6 miles cross country up the steep southwest shoulder of Mt. Wow. At 4440 feet in elevation, begin traversing southwest, cross a stream in the bottom of the drainage, then climb into the Lake Allen basin. Total hiking time is approximately 2 hours.

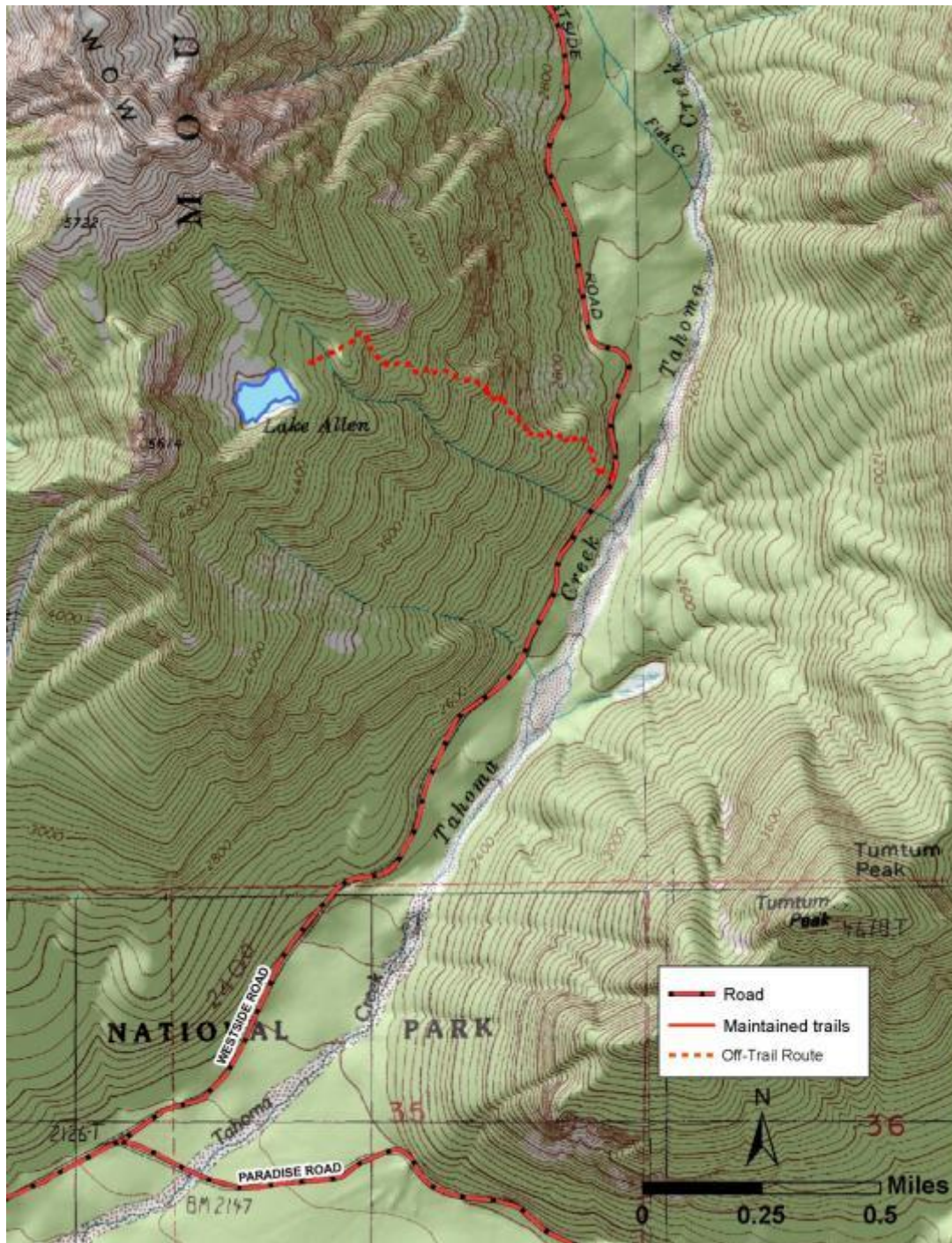


Figure 15. Cross country hiking route to Lake Allen.

Upper Palisades Lake (LH14)

Mount Rainier National Park

UTM Coordinates (NAD83): 588661 m E / 5198683 m N

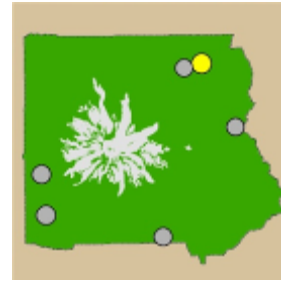


Figure 16. Upper Palisades Lake looking northwest from open meadows on hillside above.

Geologic Setting

Upper Palisades Lake is formed in a unit of the Ohanapecosh Formation, whose bedrock is comprised of volcanic breccia, sandstone and siltstone (Fisk et al. 1988). The lake is located in a small pass that likely acted as an ice-shed between adjacent cirque basins. The lake is dammed by landslide debris, and the outlet is composed primarily of large blocks of talus deposited by rock-falls from the cliffs on the west side of the lake (Riedel et al. in press). Moraines on the northeast and southwest date to the end of the last ice age 12,000 years ago, while a glacier may have drained into the lake from the basin to the southwest between the 5th and 19th centuries AD. Bedrock, talus, colluvium, and alluvial gravel from a small stream entering the lake from the southeast form the remainder of the shoreline. While no detailed soils mapping has been completed, the moraines likely host well-developed soils (Spodosols), while volcanic ash from Mount Rainier and Mount St. Helens has created young soils rich in nutrients (Andosols) in the meadows and slopes around the lake.

Watershed Description

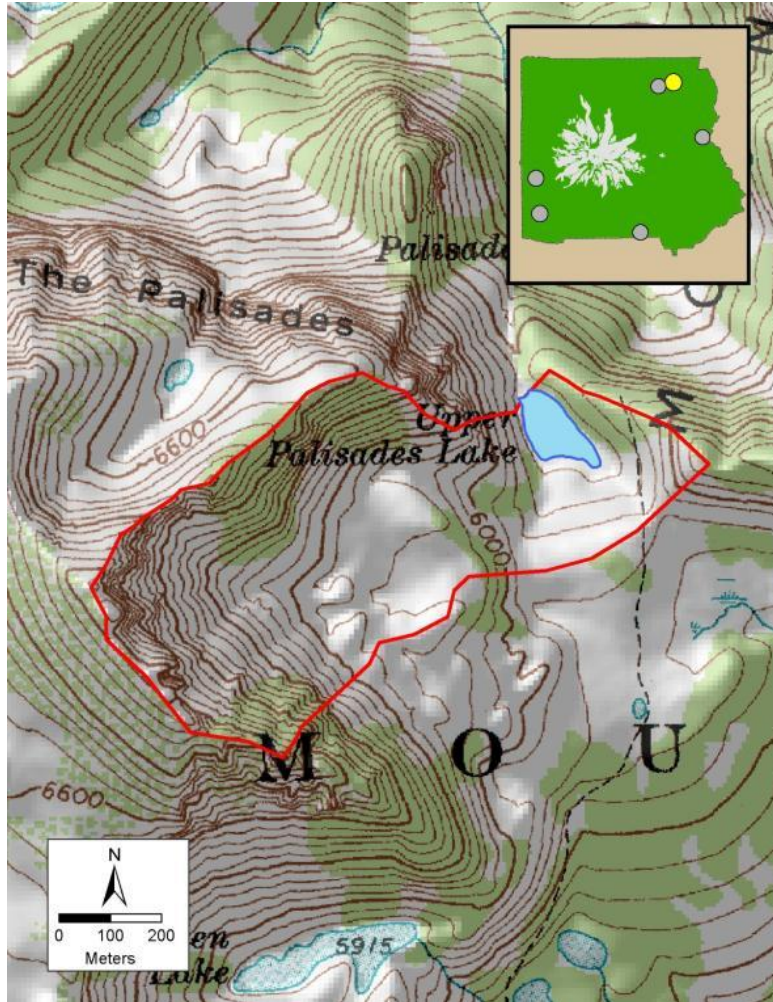


Figure 17. Upper Palisades Lake watershed and surrounding area.

Table 5. Upper Palisades Lake morphometric data.

Lake Parameter	Value
Elevation	1785 m (5857 ft)
Aspect	East
Watershed Area	46.6 ha
Surface Area	1.3 ha
Volume	57,218 m ³
Depth (maximum)	15.0 m
Depth (mean)	4.5 m
Depth (relative)	5.6%
Shoreline length	498 m
Lake length (maximum)	206 m
Lake width (maximum)	97 m
Watershed area: Lake Area (ratio)	36.8
Shoreline Development	1.25
Index of Basin Permanence	0.11

Physical/ Chemical Water Properties

Table 6. Water Quality and productivity parameters for Upper Palisades, August 11, 2010. Water samples collected at multiple depths due to lake stratification. Chlorophyll was sampled at mid-depth.

Parameter	Units	2010 1 m	2010 14.5 m
Water Chemistry			
Total Nitrogen	mg/l	0.03	0.04
Total Phosphorus	mg/l	0.003	0.003
Nitrogen & Phosphorus Ratio	N/A	10	13.3
NO3+NO2-N	mg/l	*0.000	*0.000
NH3-N	mg/l	*0.002	*0.004
Anion & Cation Ratio		N/A	N/A
Acid Neutralizing Capacity	µeq/L	90	70
pH	None	5.82	6.14
Specific Conductance	µS/cm	15	14
Dissolved Organic Carbon	mg/l	0.88	
Total Dissolved Solids	mg/l	19	17
Water Clarity			
Depth of Transparency	m	Bottom (15.5)	
Chlorophyll			
Chlorophyll-a	µg/L	0.033	

*Below Detection Limit

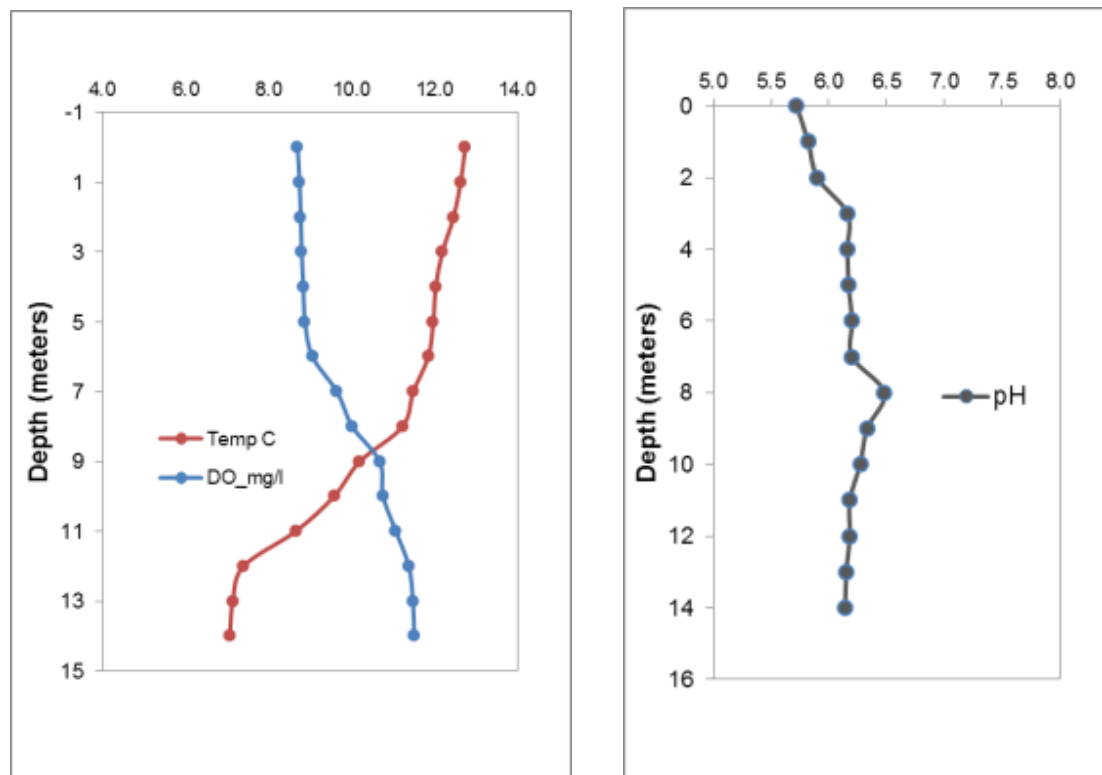


Figure 18. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Palisades Lake sampling station August 11, 2010.

Bathymetry & Shoreline Features

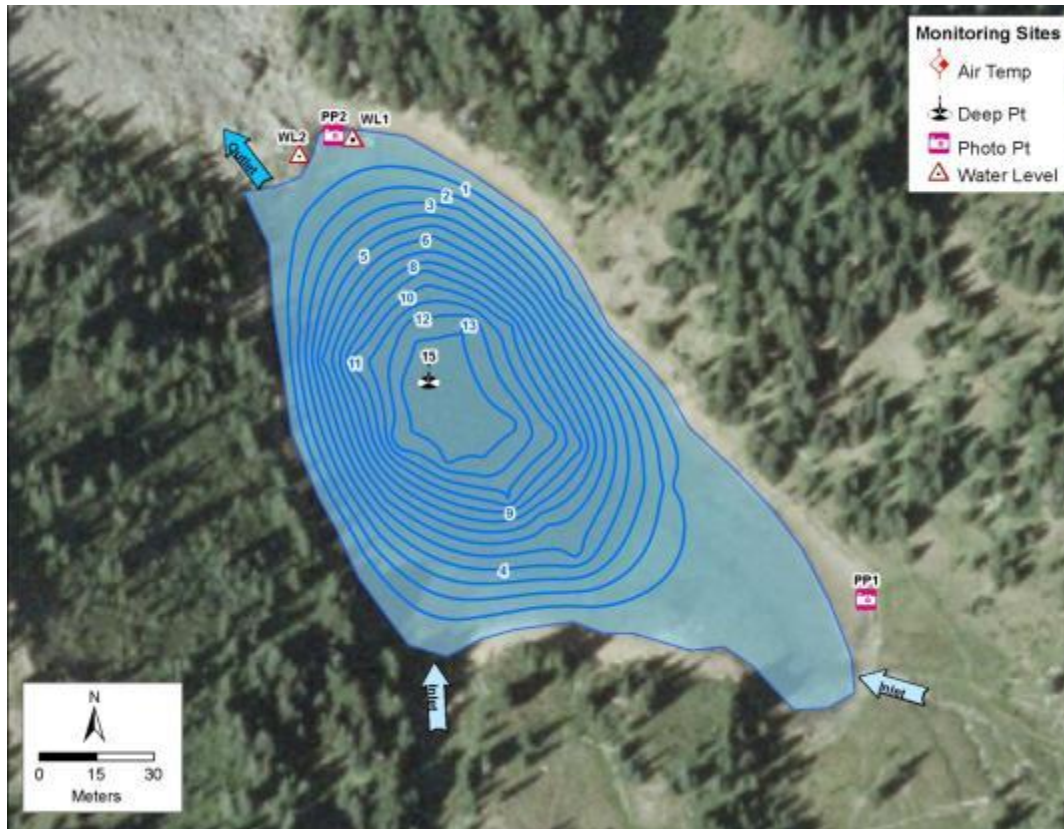


Figure 19. Bathymetry, shoreline features and sampling locations at Upper Palisades Lake.

Amphibian & Fish Species

Table 7. Amphibian species observed at Upper Palisades Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Paedomorph	15
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Larvae	95
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Adult	4
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Egg	31
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	7

Table 8. Introduced fish species observed at Upper Palisades Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 20. Upper Palisades Lake watershed panoramic photo (2010) from Trail Photopoint (see Figure 19).

22



Figure 21. Upper Palisades Lake panoramic photo (2010) from Talus Photopoint (see Figure 19).

Lake Access

A sampling trip to Upper Palisades Lake requires 1-2 days. Starting from Sunshine Point on Sunrise Road, hike the Palisades Lakes trail 3.2 miles to Upper Palisades Lake. Total hiking time is approximately 1.5 hours.

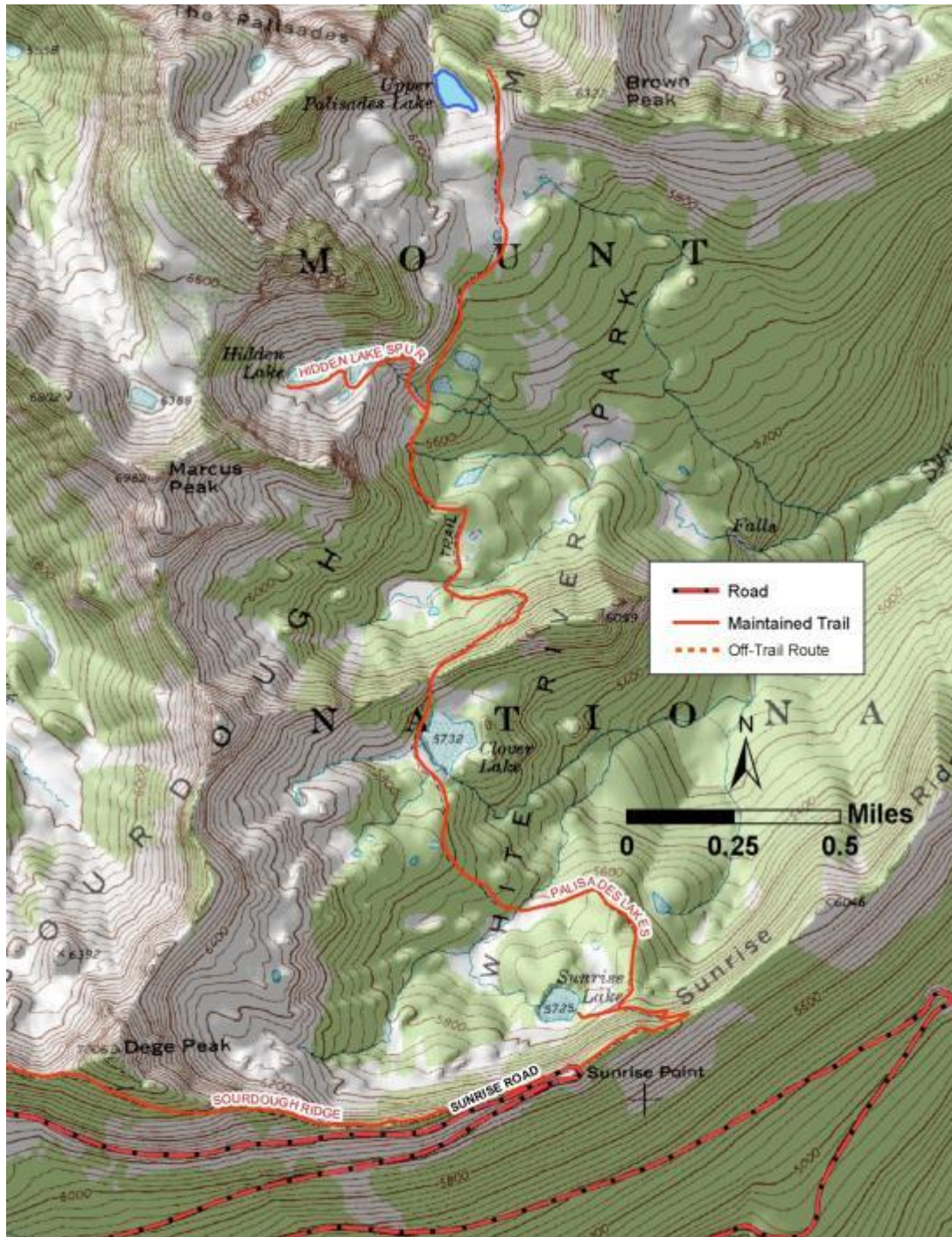


Figure 22. Hiking route to Upper Palisades Lake.

Lake LP19

Mount Rainier National Park

UTM Coordinates (NAD83): 584279 m E / 5186067 m N



Figure 23. Lake LP19 from shoreline northeast of the lake outlet.

Geologic Setting

The bedrock surrounding Lake LP 19 is Mount Rainier andesite, a volcanic rock formed within the last 2 million years (Fisk et al. 1988). The lake basin appears to have been formed by glacial scouring of a shallow cirque basin in upper St. Andrews Creek during multiple ice age glaciations. Given the relatively low elevation of the lake, however, it is unlikely that it has been glaciated for 15,000 years. The lake rests in a shallow basin between streamlined bedrock ridges that form a prominent bench on the west side of the lake (Riedel et al. in press). The shoreline of the lake is likely composed of glacial sediments, with some colluvial material on the south and west shores.

Watershed Description

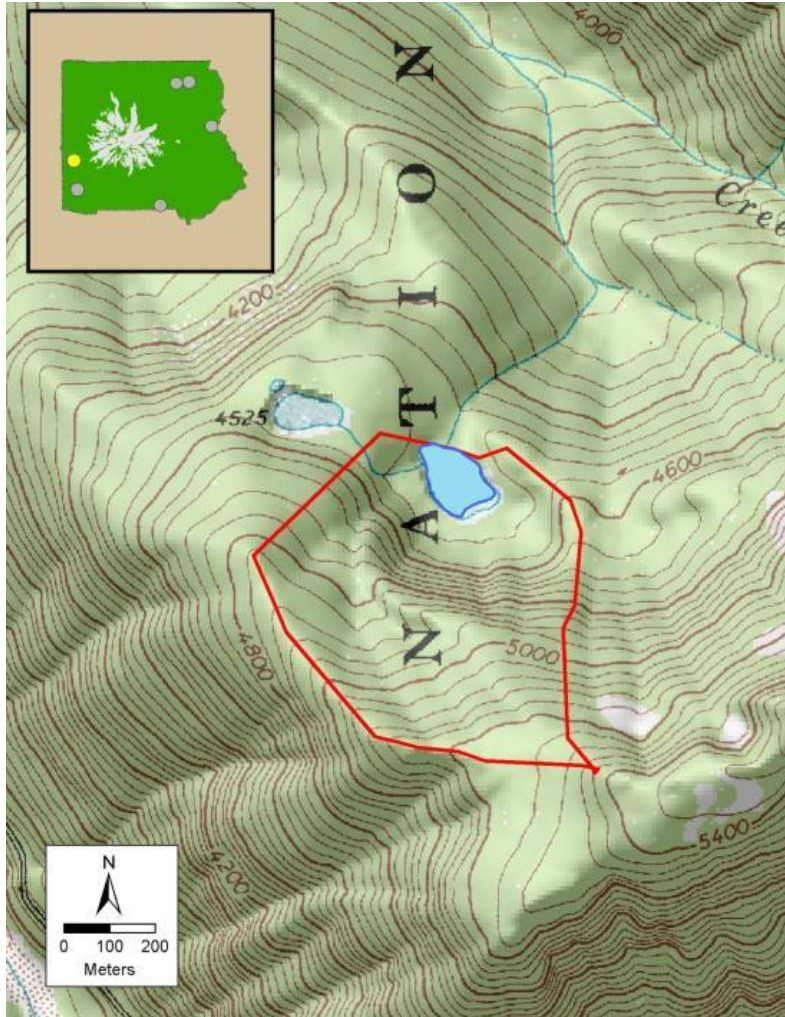


Figure 24. Lake LP19 watershed and surrounding area.

Table 9. Lake LP19 Morphometric data

Lake Parameter	Value
Elevation	1372 m (4502 ft)
Aspect	North
Watershed Area	37.9 ha
Surface Area	1.6 ha
Volume	71,651 m ³
Depth (maximum)	12.3 m
Depth (mean)	4.6 m
Depth (relative)	4.1%
Shoreline length	507 m
Lake length (maximum)	193 m
Lake width (maximum)	123 m
Watershed area: Lake Area (ratio)	24.3
Shoreline Development	1.14
Index of Basin Permanence	0.14

Physical/ Chemical Water Properties

Table 10. Water Quality and productivity parameters for Lake LP19, August 2, 2010. Water samples collected at multiple depths due to lake stratification. Chlorophyll was sampled at mid-depth.

Parameter	Units	2010 1 m	2010 11.0 m
Water Chemistry			
Total Nitrogen	mg/l	0.10	0.09
Total Phosphorus	mg/l	*0.002	*0.002
Nitrogen & Phosphorus Ratio	N/A	*50	*45
NO3+NO2-N	mg/l	0.008	0.038
NH3-N	mg/l	*0.003	*0.002
Anion & Cation Ratio		N/A	N/A
Acid Neutralizing Capacity	µeq/L	70	90
pH	None	6.18	5.29
Specific Conductance	µS/cm	11	15
Dissolved Organic Carbon	mg/l	1.88	
Total Dissolved Solids	mg/l	10	12
Water Clarity			
Depth of Transparency	m	Bottom (12.3)	
Chlorophyll			
Chlorophyll-a	µg/L	0.200	

*Below Detection Limit

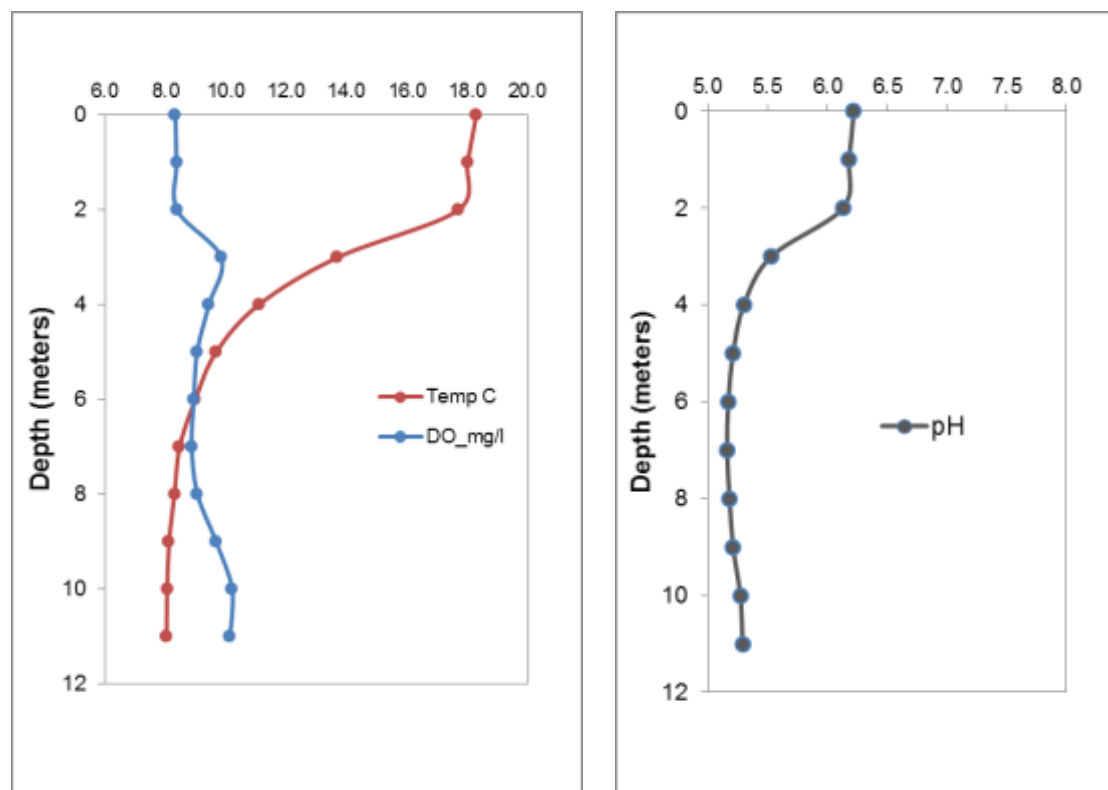


Figure 25. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake LP19 sampling station August 2, 2010.

Bathymetry & Shoreline Features

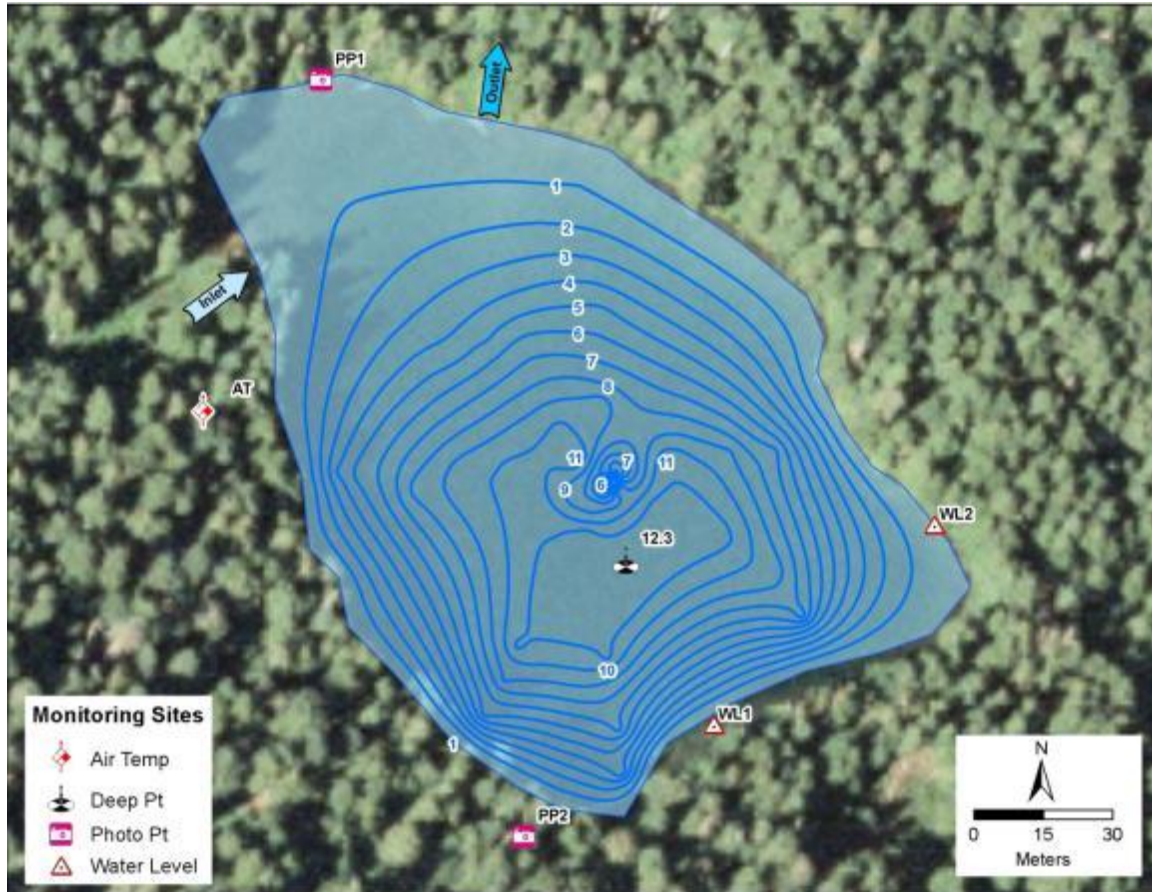


Figure 26. Bathymetry, shoreline features and sampling locations at Lake LP19.

Amphibian & Fish Species

Table 11. Amphibian species observed at Lake LP19 (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Adult	1
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Metamorph	2
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Larvae	38
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Egg Mass	33
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Egg	1
<i>Ambystoma spp</i>	Mole Salamander Species	AMSP	Larvae	11
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	19
<i>Rana cascadae</i>	Cascades Frog	RACA	Juvenile	2
<i>Taricha granulosa</i>	Rough-skinned Newt	TAGR	Adult	3

Table 12. Introduced fish species observed at Lake LP19 (2010).

Species	Common Name	Species Code
<i>Salvelinus fontinalis</i>	Brook Trout	BRK

Watershed Panoramic Photos



Figure 27. Lake LP19 watershed panoramic photo (2010) from Photo Point 1 (see Figure 26).

28



Figure 28. Lake LP19 watershed panoramic photo (2010) from Photo Point 2 (see Figure 26).

Lake Access

A sampling trip to Lake LP19 requires 1 to 2 days. Drive or hike the Westside Road to mile 11, just before the St. Andrews Ranger Patrol Cabin. Climb cross country, up a steep wooded ridge (.9 miles) and into Lake LP19. Total hiking time is approximately 1.5 hours.

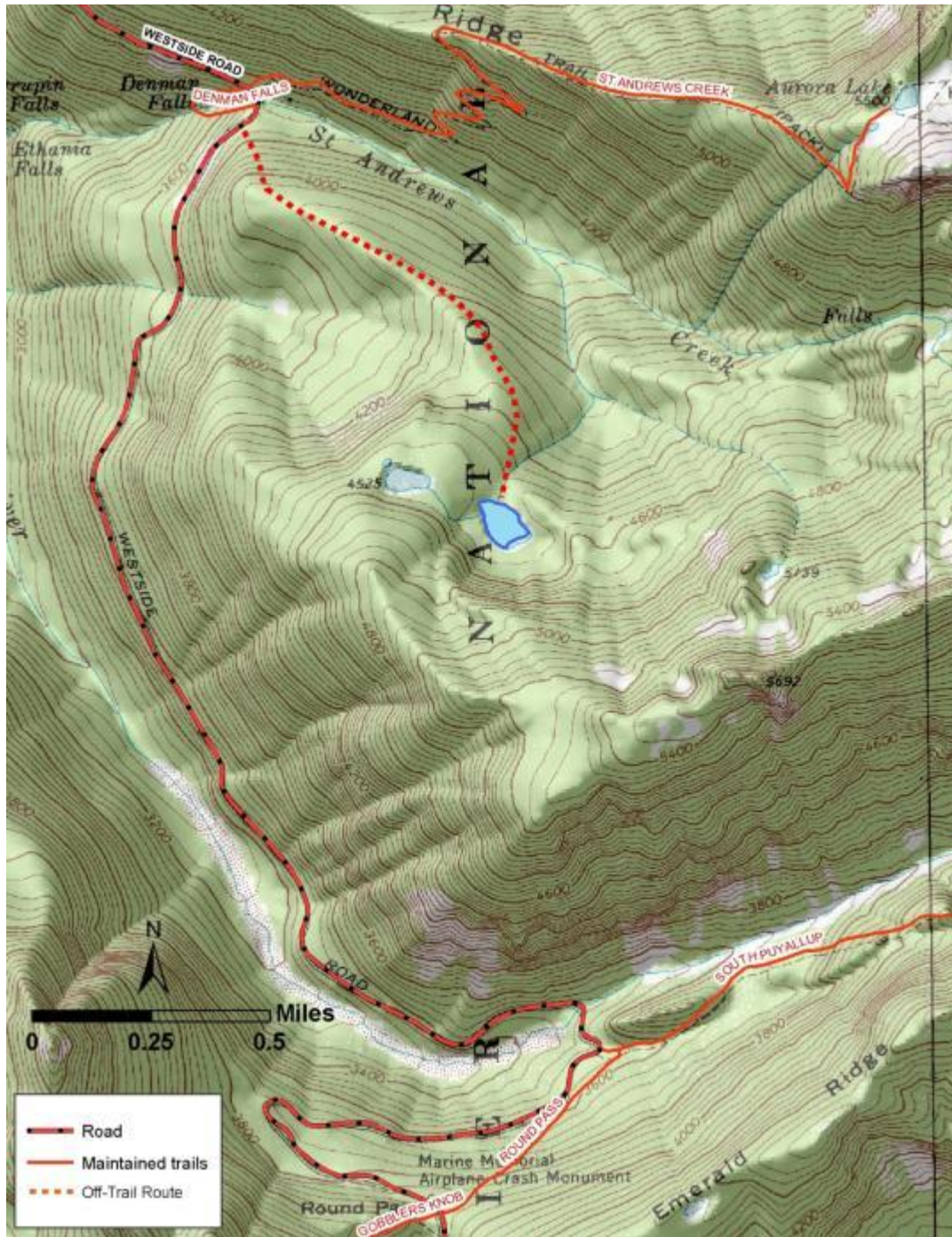


Figure 29. Hiking route to Lake LP19, including main trails and cross country route.

Lake LH15

Mount Rainier National Park

UTM Coordinates (NAD83): 605082 m E / 5200913 m N

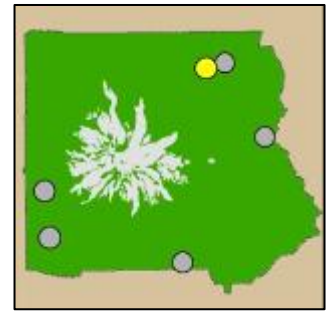


Figure 30. Lake LH15 from lakeshore wetlands south of lake.

Geologic Setting

Lake LH 15 is formed in volcanic breccia, sandstone and siltstone of the Ohanapecosh Formation on the northeast side of Mount Rainier at the base of Green Park (Fisk et al. 1988). The lake rests in a glacially scoured basin on the floor of Josephine Creek Valley, which is stair-stepped below the northwest face of Marcus Creek (Riedel et al. in press). This lake has not been glaciated since the last ice age, but several moraines in the cirque basin above provide evidence that glaciers did provide melt water to the lake in the last few centuries. The shorelines of this lake are eroded into glacial sediments, colluvium, or at the southeast end, alluvial gravels from the creek. The outlet to the lake is cut across a small bedrock bench.

Watershed Description

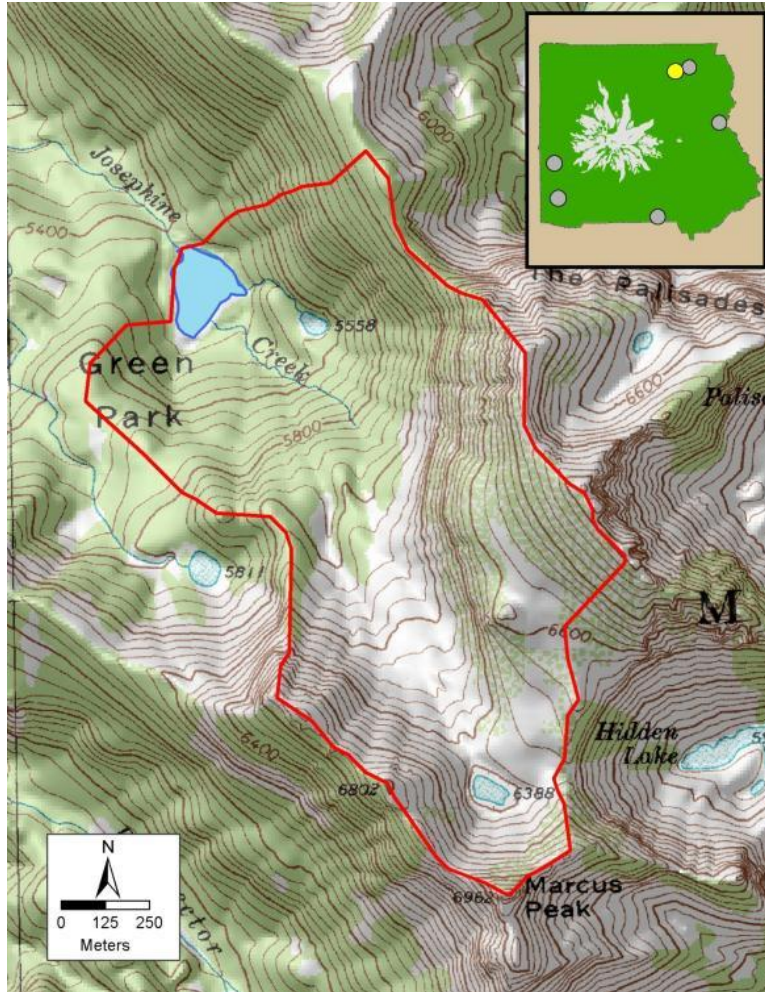


Figure 31. Lake LH15 watershed and surrounding area.

Table 13. Lake LH15 Morphometric data

Lake Parameter	Value
Elevation	1659 m (5443 ft)
Aspect	Northwest
Watershed Area	158.6 ha
Surface Area	3.1 ha
Volume	102,633 m ³
Depth (maximum)	10.0 m
Depth (mean)	3.4 m
Depth (relative)	2.8%
Shoreline length	772 m
Lake length (maximum)	261 m
Lake width (maximum)	201 m
Watershed area: Lake Area (ratio)	51.8
Shoreline Development	1.24
Index of Basin Permanence	0.13

Physical/ Chemical Water Properties

Table 14. Water Quality and productivity parameters for Lake LH15, August 12, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.04
Total Phosphorus	mg/l	*0.002
Nitrogen & Phosphorus Ratio	N/A	20
NO3+NO2-N	mg/l	*0.000
NH3-N	mg/l	*0.002
Anion & Cation Ratio		N/A
Acid Neutralizing Capacity	µeq/L	210
pH	None	6.64
Specific Conductance	µS/cm	25
Dissolved Organic Carbon	mg/l	0.86
Total Dissolved Solids	mg/l	22
Water Clarity		
Depth of Transparency	m	Bottom (9.3)
Chlorophyll (7.75 m)		
Chlorophyll-a	µg/L	0.078

*Below Detection Limit

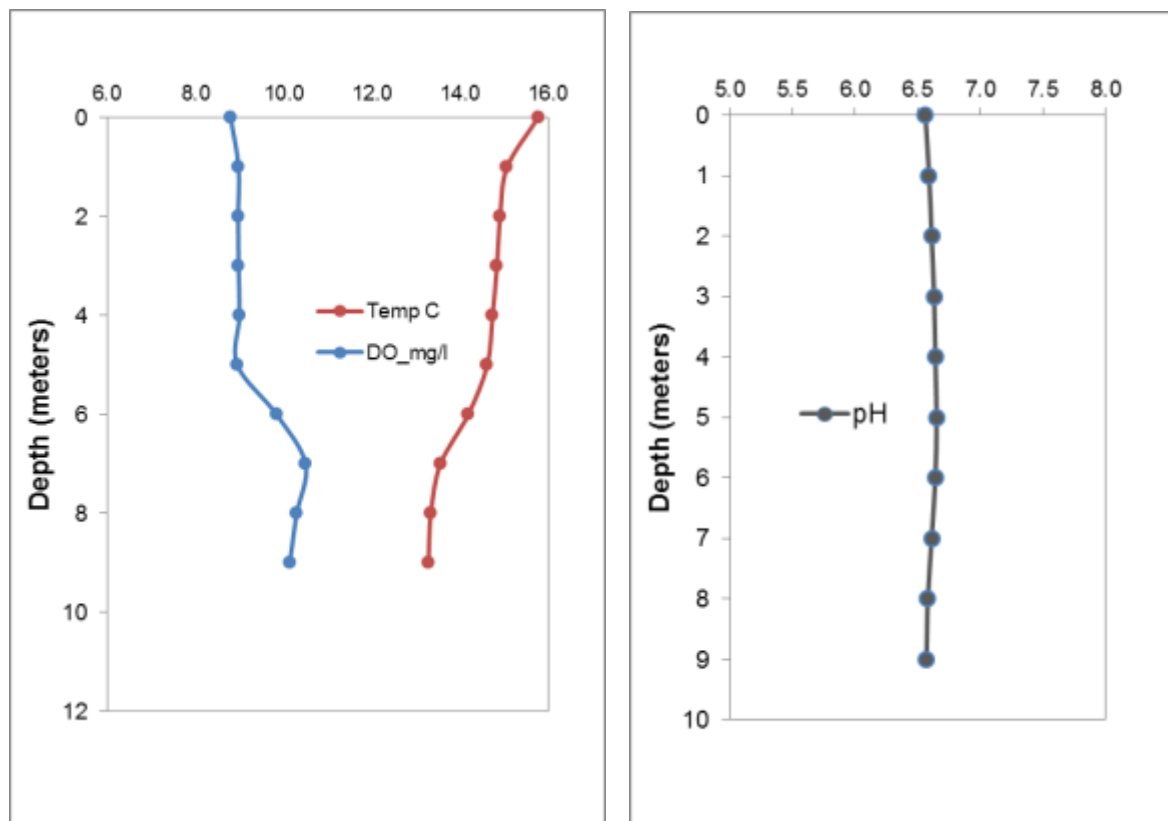


Figure 32. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lake LH15 sampling station August 12, 2010.

Bathymetry & Shoreline Features

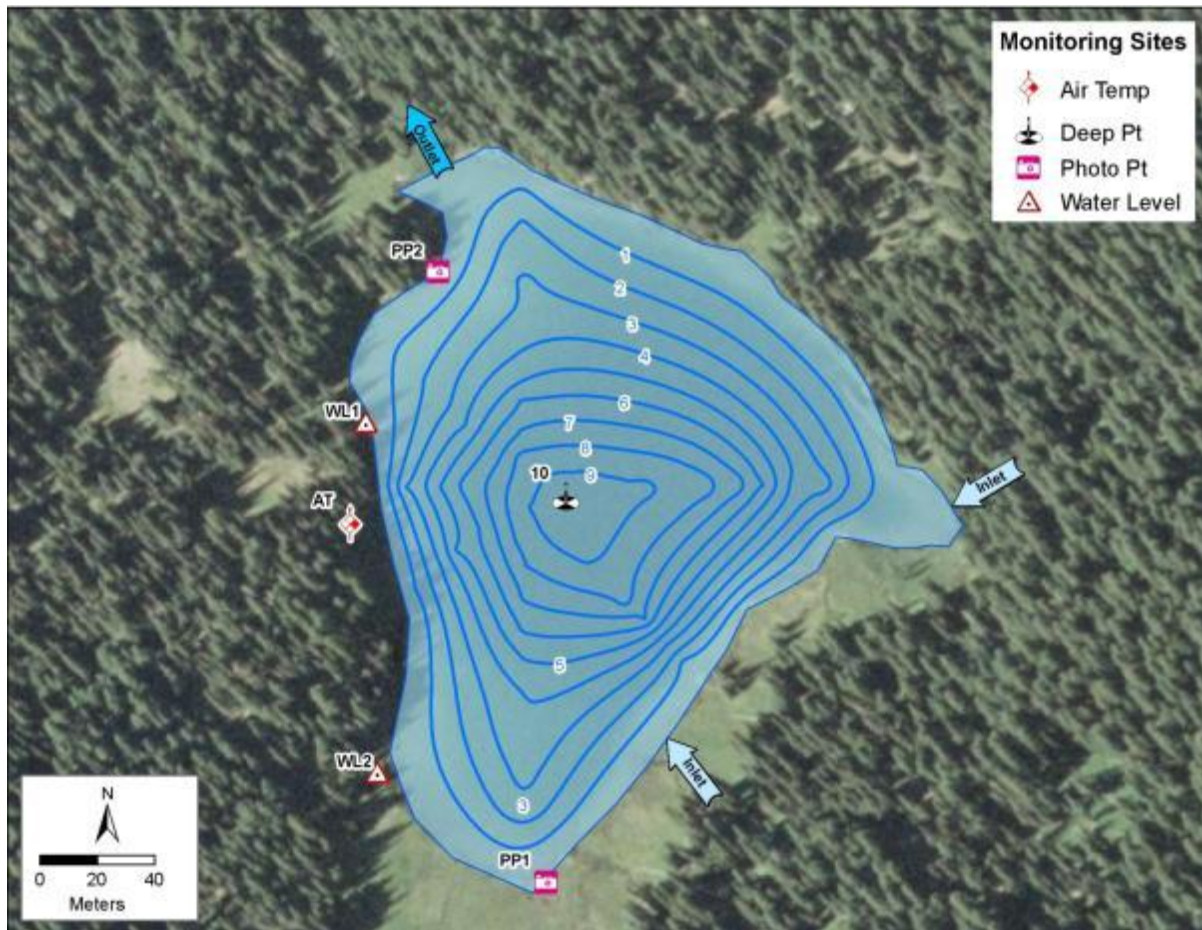


Figure 33. Bathymetry, shoreline features and sampling locations at Lake LH15.

Amphibian & Fish Species

Table 15. Amphibian species observed at Lake LH15 (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Egg Mass	18
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Larvae	3
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	19
<i>Rana cascadae</i>	Cascades Frog	RACA	Juvenile	1
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	738
<i>Rana cascadae</i>	Cascades Frog	RACA	Dead	1

Table 16. Introduced fish species observed at Lake LH15 (2010).

Species	Common Name	Species Code
<i>Oncorhynchus clarki</i>	Westslope Cutthroat	WCT

Watershed Panoramic Photos



Figure 34. Lake LH15 watershed panoramic photo (2010) from Photo Point 1 (see Figure 33).



Figure 35. Lake LH15 watershed panoramic photo (2010) from Photo Point 2 (see Figure 33).

Lake Access

A sampling trip to Lake LH15 requires 1-2 days. Starting from Sunshine Point on the Sunrise Road, hike the Palisades Lakes trail 2.6 miles to the junction with the Hidden Lake Trail. Hike .5 miles to Hidden Lake. Follow an established way trail to the ridge top saddle west of Hidden Lake. Descend 1.0 miles into Green Park and Lake LH15. Total hiking time is approximately 2.5 hours.

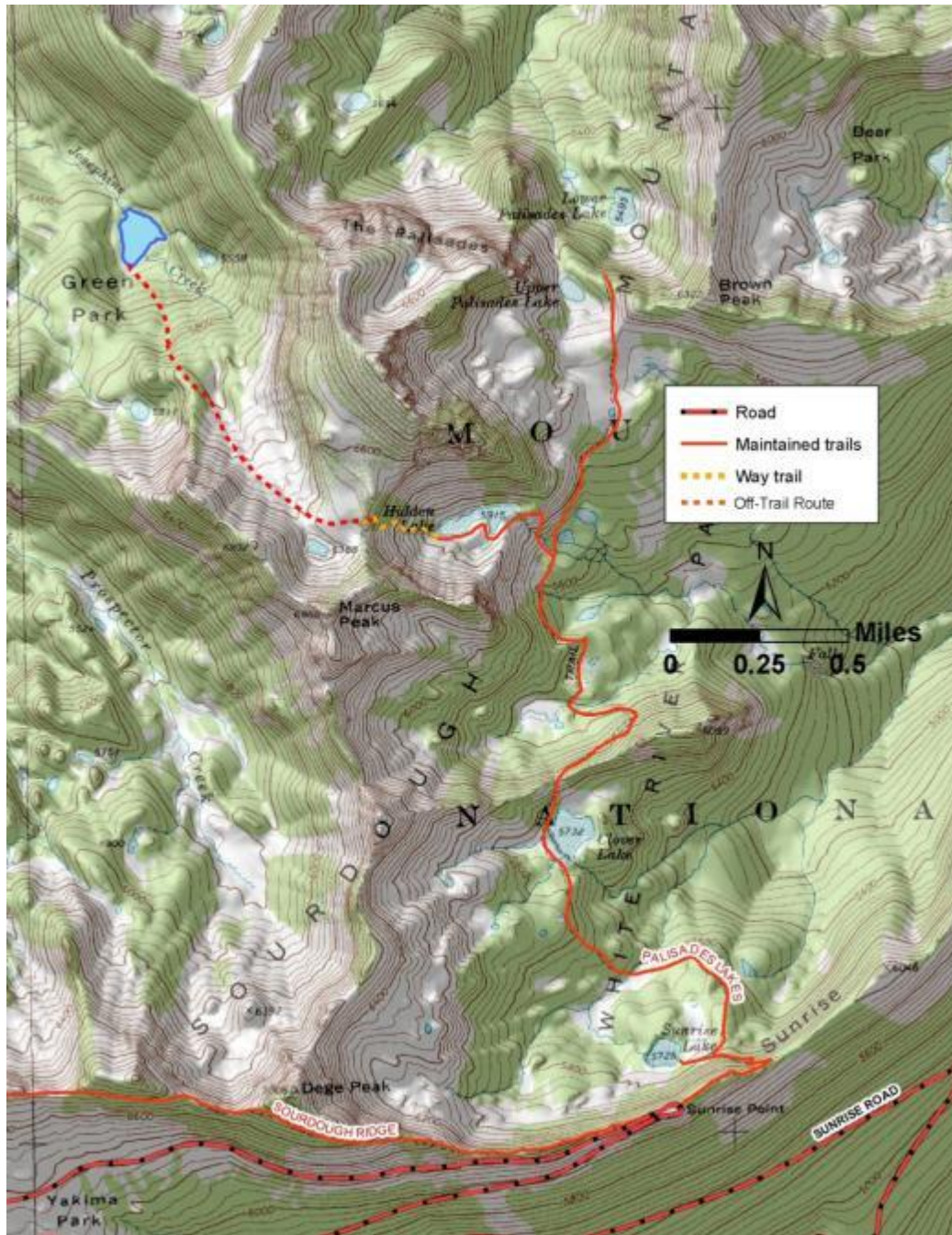


Figure 36. Hiking route to Lake LH15, including main trails and cross country route.

Upper Deadwood Lake (LW32)

Mount Rainier National Park

UTM Coordinates (NAD83): 612597 m E / 5193616 m N

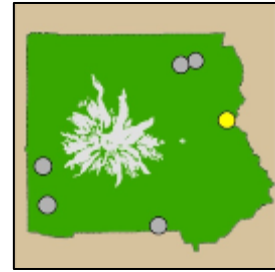


Figure 37. Upper Deadwood Lake as seen from the ridge top southeast of lake.

Geologic Setting

The Deadwood Lake basin was eroded from volcanic breccia, sandstone and siltstone of the Ohanapecosh Formation (Fisk et al. 1988). The lake rests on the floor of a cirque in upper Deadwood Creek Valley, which has a northeast aspect and a stair-stepped longitudinal profile characteristic of glaciated valleys. Shorelines are composed of glacial sediments, colluviums, and alluvial gravel deposited by two streams that enter the lake at its south end (Riedel et al. in press). The outlet is bedrock-controlled and plunges steeply down to Lower Deadwood Lake. Snow avalanches may occasionally enter the lake from steep slopes at the lake's west end.

Watershed Description

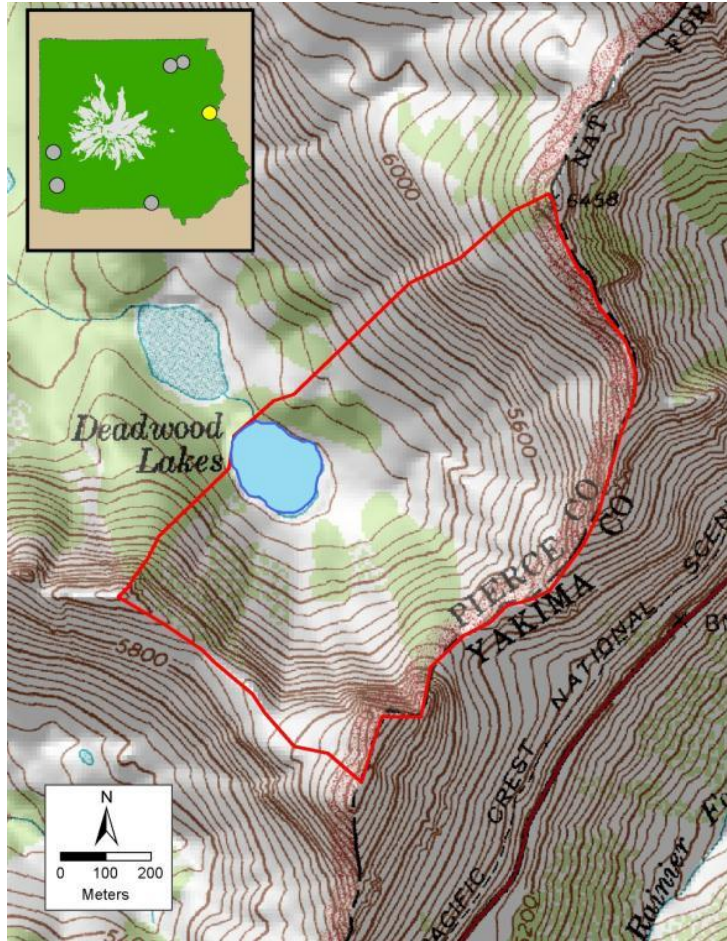


Figure 38. Upper Deadwood Lake watershed and surrounding area.

Table 17. Upper Deadwood Lake Morphometric data

Lake Parameter	Value
Elevation	1600 m (5249 ft)
Aspect	Northwest
Watershed Area	74.8 ha
Surface Area	2.9 ha
Volume	48,922 m ³
Depth (maximum)	3.8 m
Depth (mean)	1.7 m
Depth (relative)	1.5%
Shoreline length	645 m
Lake length (maximum)	220 m
Lake width (maximum)	187 m
Watershed area: Lake Area (ratio)	25.6
Shoreline Development	1.06
Index of Basin Permanence	0.08

Physical/ Chemical Water Properties

Table 18. Water Quality and productivity parameters for Upper Deadwood Lake, August 18, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.05
Total Phosphorus	mg/l	0.004
Nitrogen & Phosphorus Ratio	N/A	12.5
NO ₃ +NO ₂ -N	mg/l	*0.000
NH ₃ -N	mg/l	*0.003
Anion & Cation Ratio		N/A
Acid Neutralizing Capacity	µeq/L	370
pH	None	6.45
Specific Conductance	µS/cm	41
Dissolved Organic Carbon	mg/l	0.97
Total Dissolved Solids	mg/l	30
Water Clarity		
Depth of Transparency	m	Bottom (3.8)
Chlorophyll		
Chlorophyll-a	µg/L	.0679

*Below Detection Limit

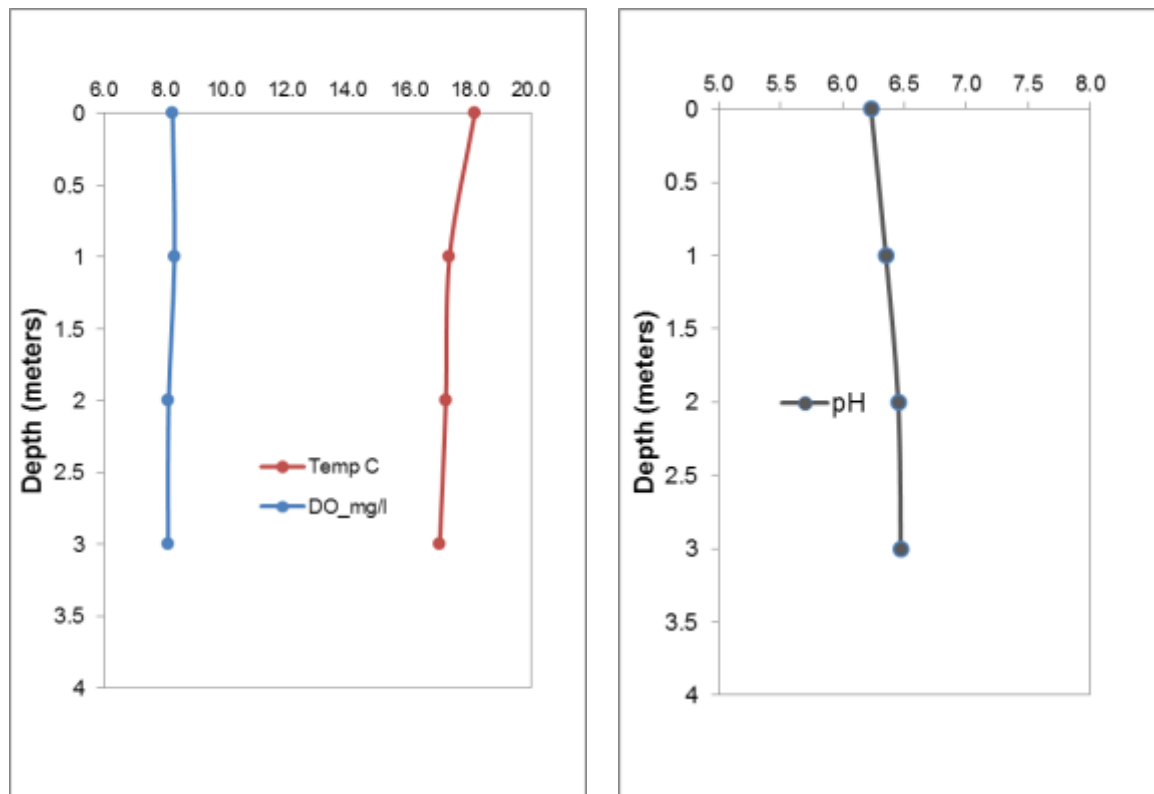


Figure 39. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Deadwood Lake sampling station August 18, 2010.

Bathymetry & Shoreline Features

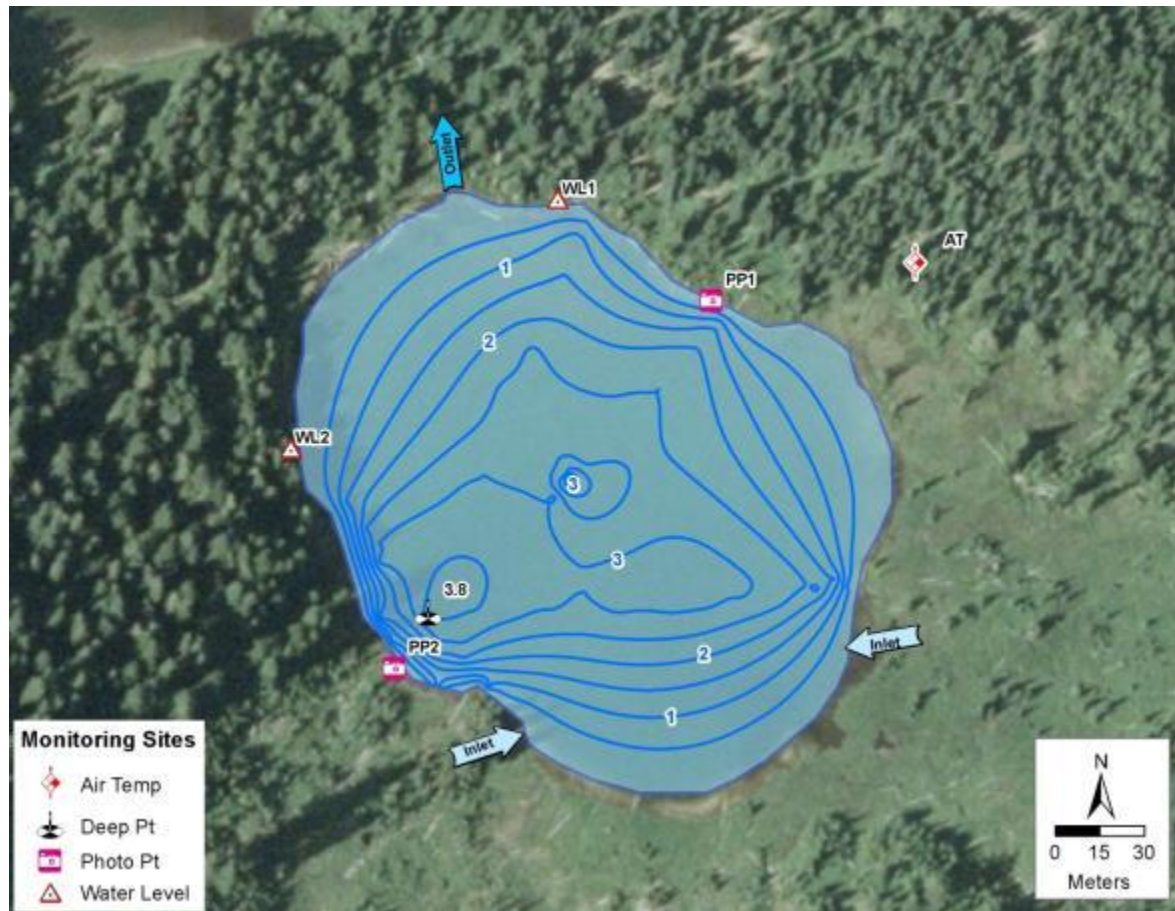


Figure 40. Bathymetry, shoreline features and sampling locations at Upper Deadwood Lake.

Amphibian & Fish Species

Table 19. Amphibian species observed at Upper Deadwood Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Larvae	52
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Egg Mass	1
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Adult	5
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Larvae	12
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Egg	2
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Larvae	24
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	51
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	991

Table 20. Introduced fish species observed at Upper Deadwood Lake (2010).

Species	Common Name	Species Code
<i>Oncorhynchus mykiss</i>	Rainbow Trout	RBT

Watershed Panoramic Photos



Figure 41. Upper Deadwood Lake watershed panoramic photo (2010) from Photo Point 1 (see. Figure 40).

40



Figure 42. Upper Deadwood Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 40).

Lake Access

A sampling trip to Upper Deadwood Lake requires one day. From Hwy 410 at Chinook Pass, hike the Pacific Crest Trail .5 miles to the junction with the Deadwood Lakes Way Trail. Follow the way trail 0.75 miles to Upper Deadwood Lake.

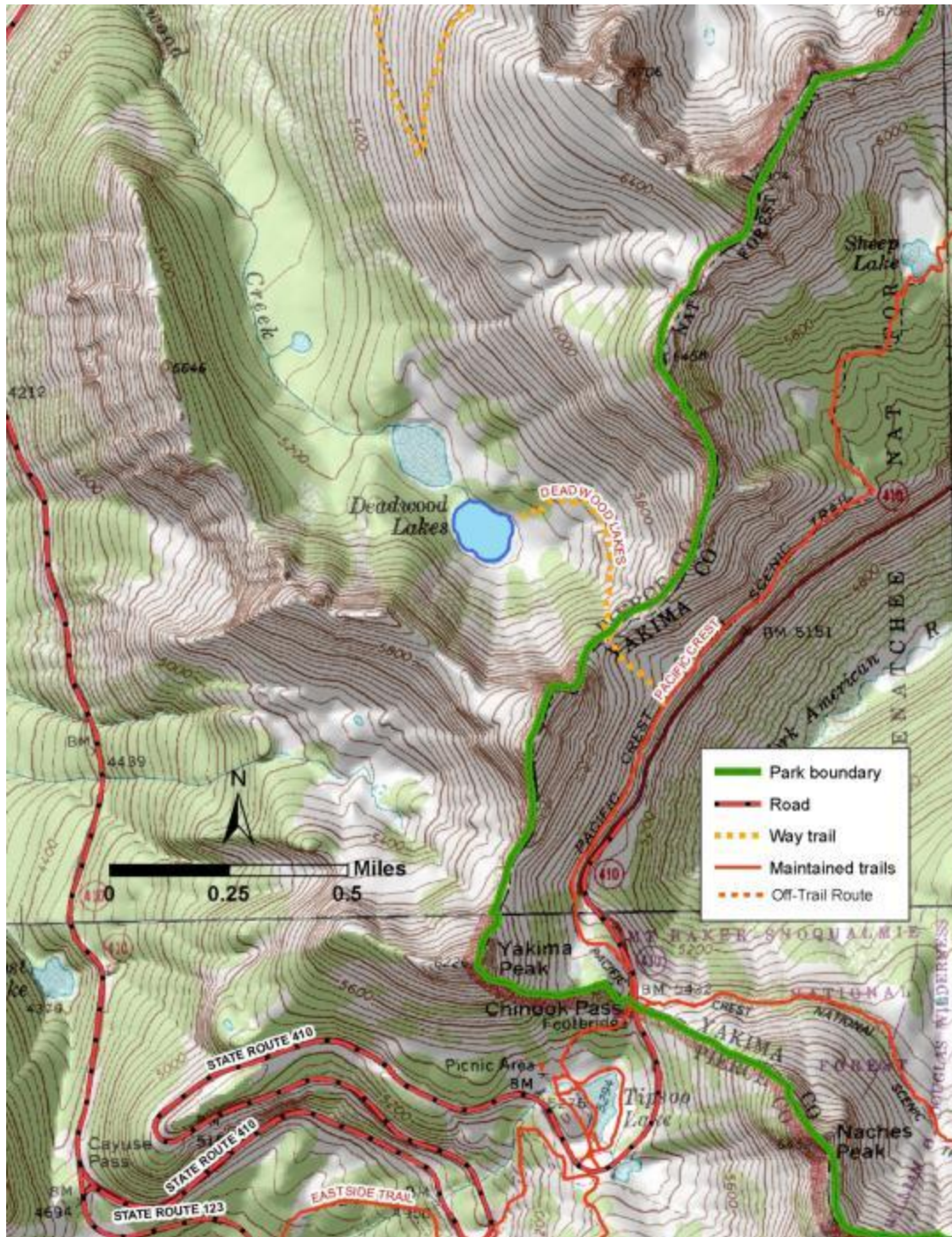


Figure 43. Hiking route to Upper Deadwood Lake, including main trails and cross country route.

Blue Lake (LZ35)

Mount Rainier National Park

UTM Coordinates (NAD83): 48921 m E / 5176890 m N



Figure 44. Blue Lake from the mountainside above.

Geologic Setting

The Blue Lake watershed drains a deep cirque basin cut from basaltic andesite of the Ohanapecosh Formation (Fisk et al. 1988). The basin was eroded from the slopes of Boundary Peak by alpine glaciers during the past two million years. Shorelines are composed mainly of bedrock and talus, but two small inlet streams entering from the west have built small debris cones into the lake (Riedel et al. in press). The outlet is bedrock controlled, and plunges through a canyon into the valley below. Snow avalanches and rock falls occasionally transport coarse sediment and woody debris from steep slopes to the north, west and south sides of the lake.

Watershed Description

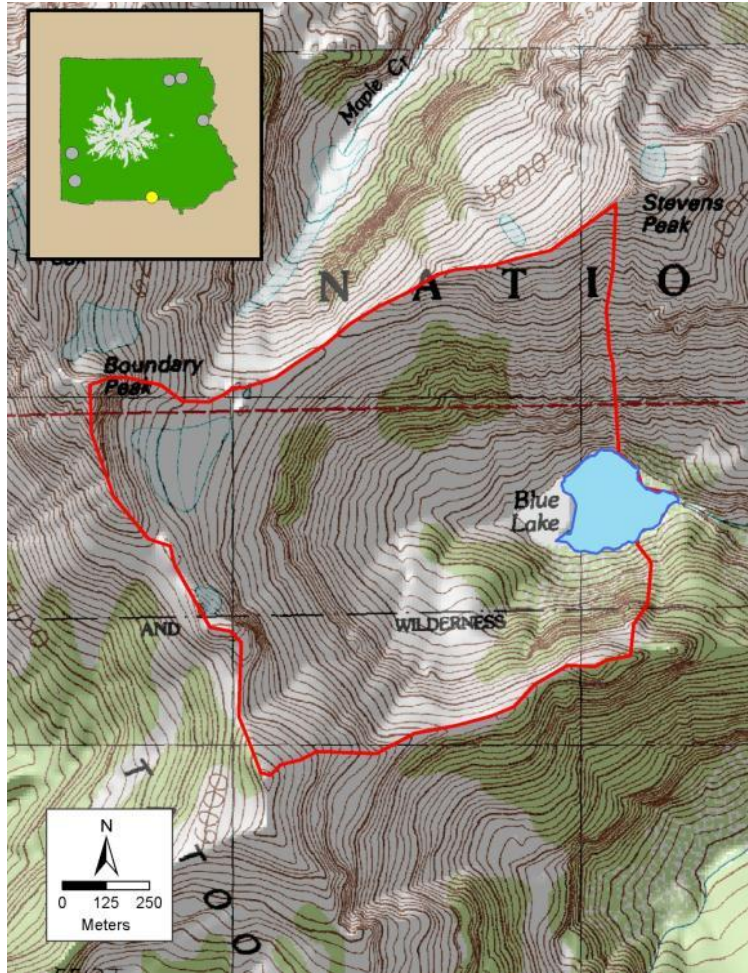


Figure 45. Blue Lake watershed and surrounding area.

Table 21. Blue Lake Morphometric data

Lake Parameter	Value
Elevation	1352 m (4436 ft)
Aspect	East
Watershed Area	158.3 ha
Surface Area	6.0 ha
Volume	237,032 m ³
Depth (maximum)	12.6 m
Depth (mean)	3.9 m
Depth (relative)	2.3%
Shoreline length	1117 m
Lake length (maximum)	373 m
Lake width (maximum)	283 m
Watershed area: Lake Area (ratio)	26.1
Shoreline Development	1.28
Index of Basin Permanence	0.21

Physical/ Chemical Water Properties

Table 3. Water Quality and productivity parameters for Blue Lake, August 24, 2010. Water samples collected at multiple depths due to lake stratification. Chlorophyll was sampled at mid-depth.

Parameter	Units	2010 1 m	2010 11.0 m
Water Chemistry			
Total Nitrogen	mg/l	0.03	0.08
Total Phosphorus	mg/l	0.003	0.005
Nitrogen & Phosphorus Ratio	N/A	10	16
NO ₃ +NO ₂ -N	mg/l	*0.000	0.005
NH ₃ -N	mg/l	*0.002	0.022
Anion & Cation Ratio		N/A	N/A
Acid Neutralizing Capacity	µeq/L	180	180
pH	None	5.69	5.68
Specific Conductance	µS/cm	12	26
Dissolved Organic Carbon	mg/l	0.75	
Total Dissolved Solids	mg/l	0.03	0.08
Water Clarity			
Depth of Transparency	m	9.4	
Chlorophyll			
Chlorophyll-a	µg/L	0.372	

*Below Detection Limit

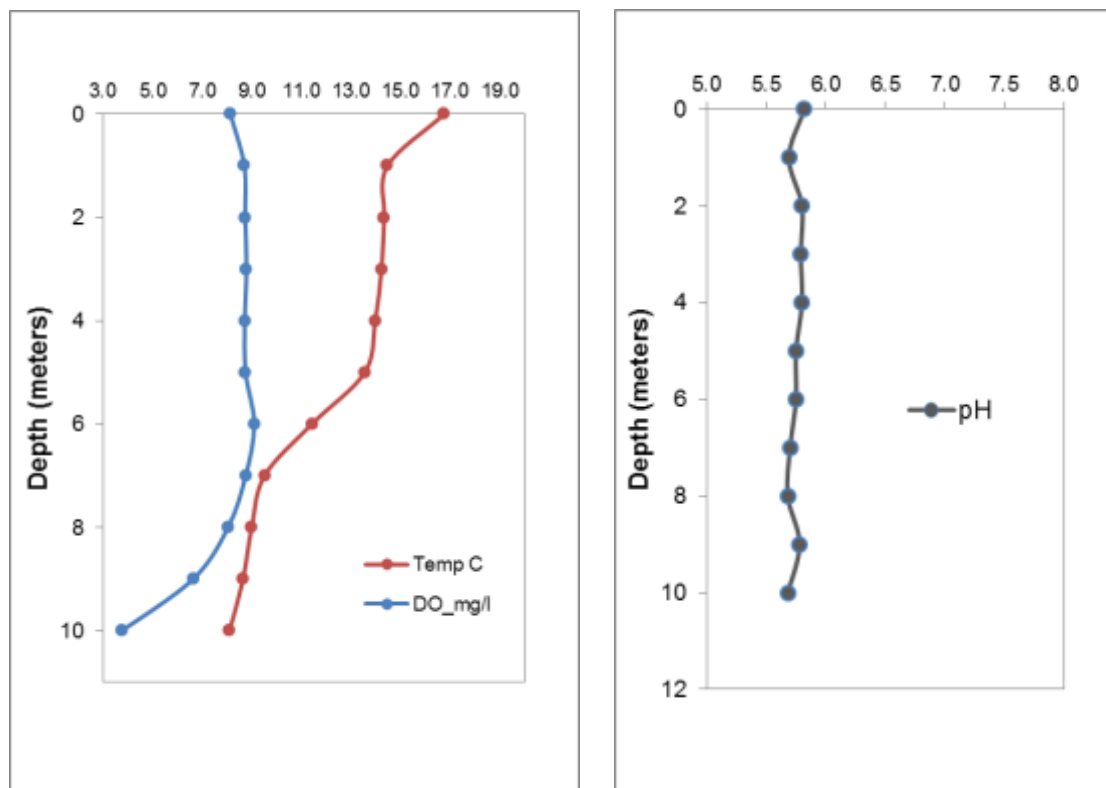


Figure 46. Dissolved oxygen, temperature and pH depth profiles from the deep-point Blue Lake sampling station August 24, 2010.

Bathymetry & Shoreline Features

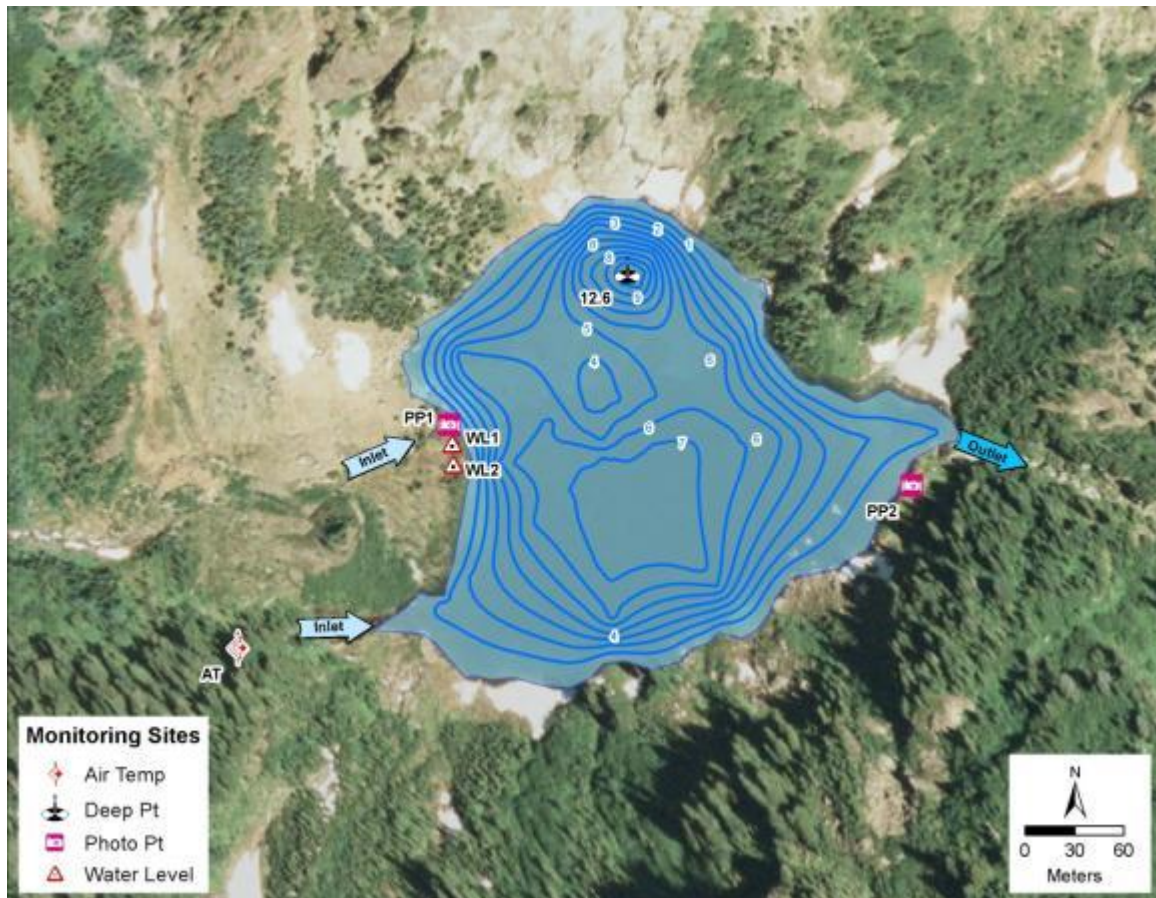


Figure 47. Bathymetry, shoreline features and sampling locations at Blue Lake.

Amphibian & Fish Species

Table 23. Amphibian species observed at Blue Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Larvae	4
<i>Ascaphus truei</i>	Coastal Tailed Frog	ASTR	Larvae	1
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	1
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	391

Table 24. Introduced fish species observed at Blue Lake (2010).

Species	Common Name	Species Code
<i>Oncorhynchus mykiss</i>	Rainbow Trout	RBT

Watershed Panoramic Photos



Figure 48. Blue Lake watershed panoramic photo (2010) from Photo Point 1 (see Figure 47).



Figure 49. Blue Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 47).

Lake Access

A sampling trip to Blue Lake requires 3 days. Day 1: Drive 7 miles on the USFS Road 5270, located off Skate Creek Road, to the Tatoosh Lakes Trailhead. Hike the Tatoosh Lake trail (#161B) 3.0 miles, past the junction with the Tatoosh trail (#161). Continue .1 mile toward Tatoosh Lake. Just below the ridge, follow an established route to the left and traverse northwest along the western slope of Tatoosh Ridge. After 0.3 miles, turn north and follow the ridge approximately 1.3 miles to the crest of the ridge above Blue Lake. Descend 1.4 miles down into Blue Lake taking extra caution when descending the steep gully into the Blue Lake basin. An established route is apparent the majority of the distance. Total travel time to lake is approximately 7.0 hours.

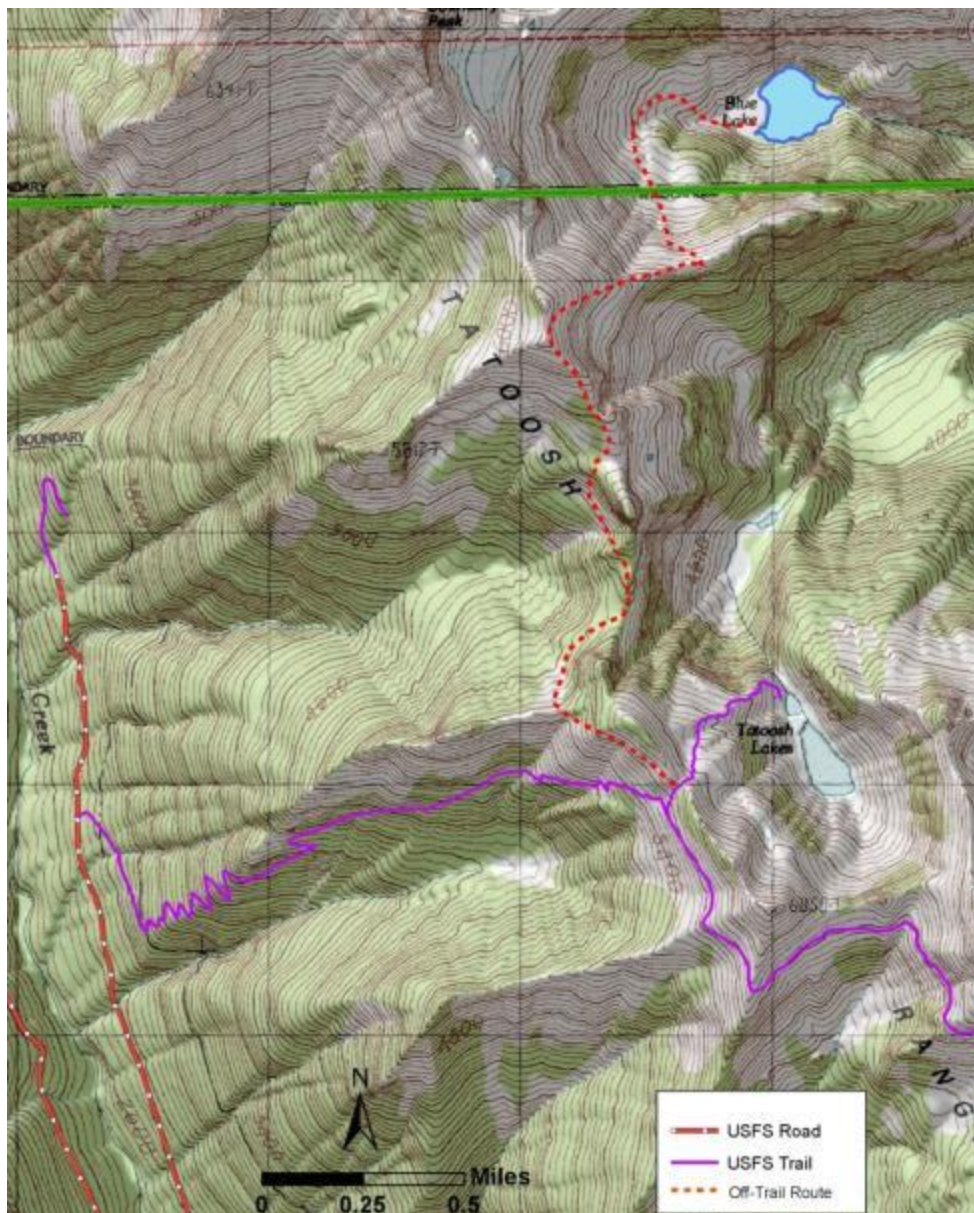


Figure 50. Hiking route to Blue Lake, including main trails and cross country route.

Lake Descriptions: North Cascades National Park Service Complex

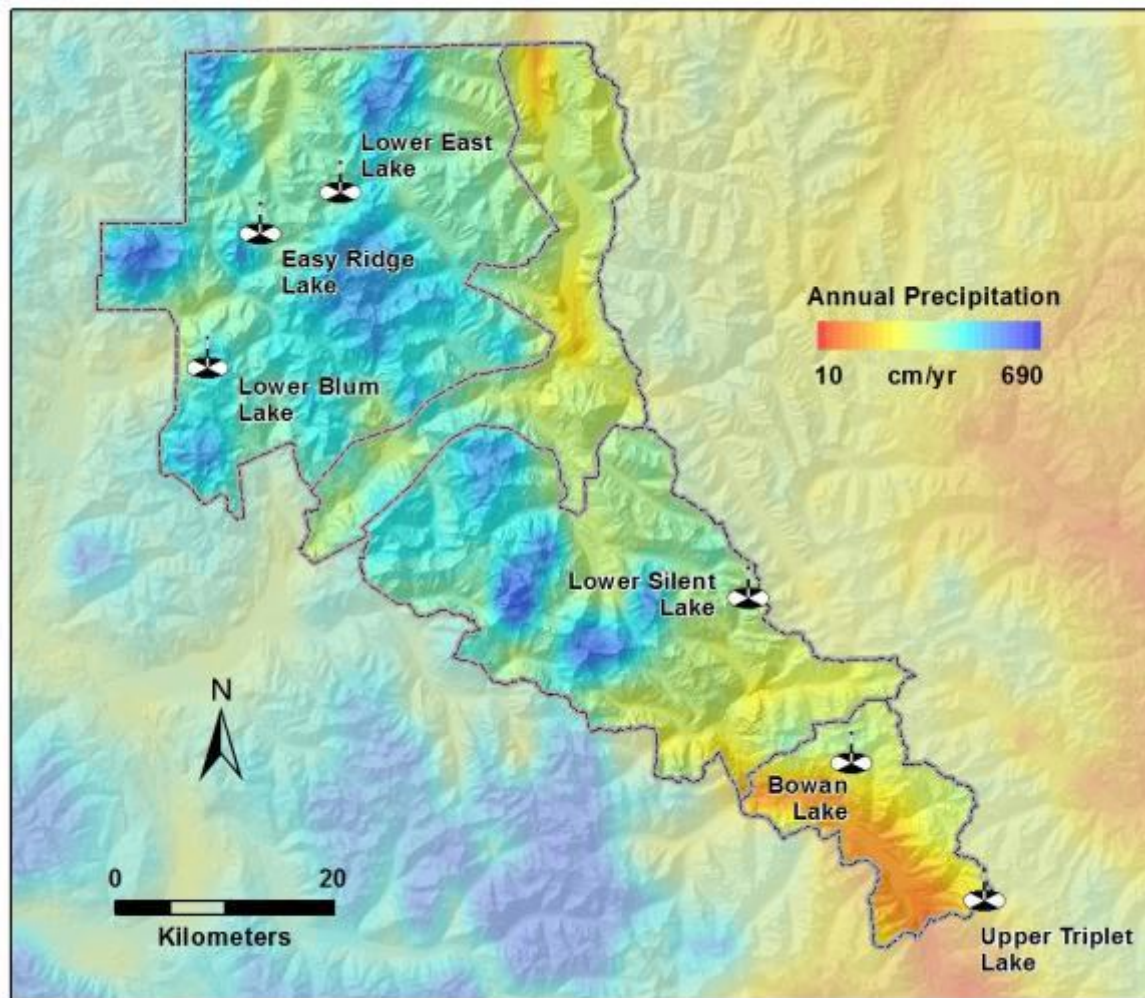


Figure 51. Location of the 6 core monitoring lakes at North Cascades National Park Service Complex. Background shading indicates precipitation gradient derived from PRISM model.

Bowan Lake (MR-12-01)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 669306 m E / 5364200 m N

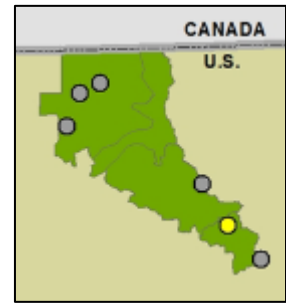


Figure 52. Bowan Lake from slope north of lake.

Geologic Setting

This shallow lake drains a cirque basin cut into resistant orthogneiss bedrock on the south side of Rainbow Ridge. The gneiss has a chemical composition similar to granite (Tabor and Haugerud 2009). Glacially-scoured bedrock slopes and talus surround the lake, which has not been glaciated in at least 11,500 years (Riedel et al. 2012). The inlet stream has built an extensive delta into the lake, while the lake drains into Rainbow Creek via a stable bedrock outlet at the south end of the lake. Soils in the surrounding watershed are the Kimtah-Bacon-Yawning Complex, a cobbly, sandy loam, and the Doubtful-Treen Rock Outcrop Complex, a sandy loam (Rodgers and Roberts 2012).

Watershed Description

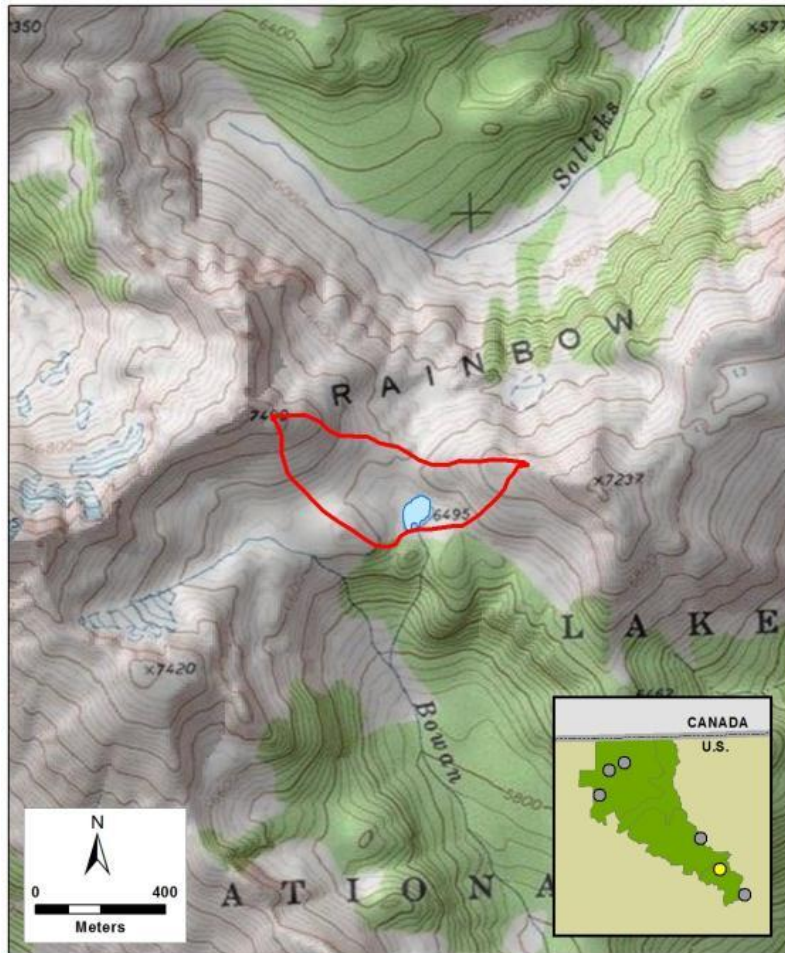


Figure 53. Bowan Lake watershed and surrounding area.

Table 25. Bowan Lake Morphometric data

Lake Parameter	Value
Elevation	1982 m (6503ft)
Aspect	South
Watershed Area	14.4 ha
Surface Area	0.6 ha
Volume	8,672 m ³
Depth (maximum)	3.6 m
Depth (mean)	1.5 m
Depth (relative)	3.4%
Shoreline length	328 m
Lake length (maximum)	117 m
Lake width (maximum)	76 m
Watershed area: Lake Area (ratio)	24.4
Shoreline Development	1.20
Index of Basin Permanence	0.03

Physical/ Chemical Water Properties

Table 26. Water Quality and productivity parameters for Bowan Lake, August 19, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.07
Total Phosphorus	mg/l	0.003
Nitrogen & Phosphorus Ratio	N/A	23.3
NO ₃ +NO ₂ -N	mg/l	N/A
NH ₃ -N	mg/l	*0.002
Anion & Cation Ratio	N/A	0.054
Acid Neutralizing Capacity	µeq/L	298
pH	None	7.5
Specific Conductance	µS/cm	35
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	30
Water Clarity		
Depth of Transparency	m	Bottom (3.6)
Chlorophyll		
Chlorophyll-a	µg/L	0.30

*Below Detection Limit

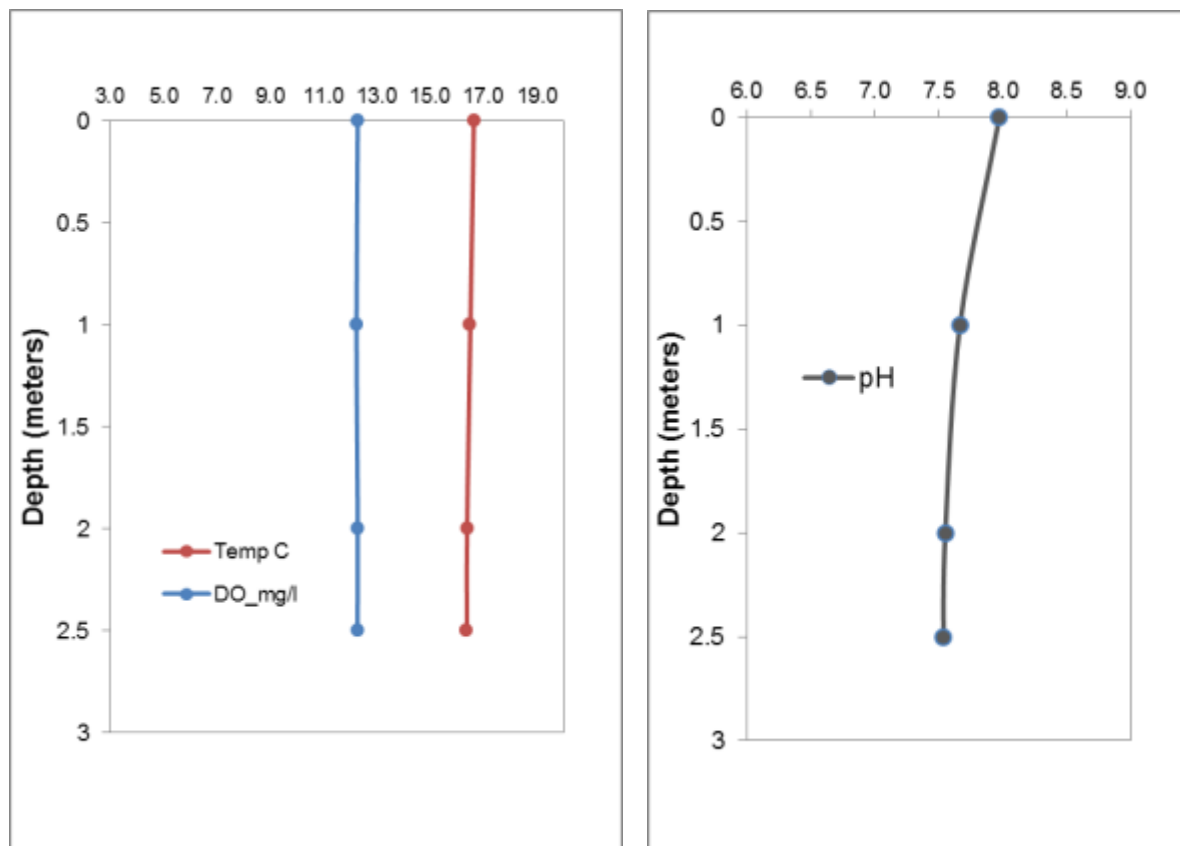


Figure 54. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Bowan Lake sampling station, August 19, 2010.

Bathymetry & Shoreline Features

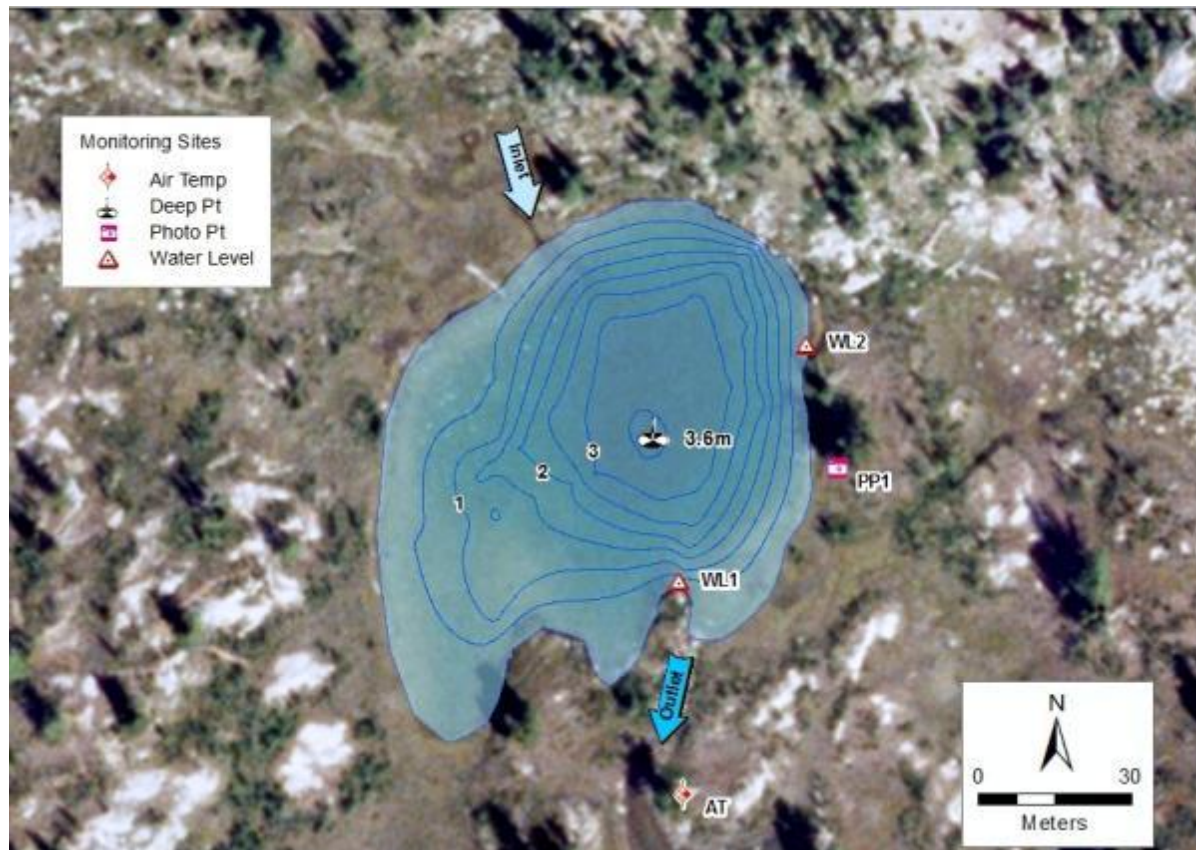


Figure 55. Bathymetry, shoreline features and sampling locations at Bowan Lake.

Amphibian & Fish Species

Table 27. Amphibian species observed at Bowan Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Larvae	3

Table 28. Introduced fish observed at Bowan Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 56. The western shore of Bowan Lake (2009) from Photo Point 1 (see Figure 55)

Lake Access

Bowan Lake requires 4 to 5 days to sample. Day 1: Take the Bridge Creek Trail (also Pacific Crest Trail - PCT) starting at the trail head off Highway 20 (HWY 20). Continue for 3.5 miles to the McAlaster Creek Trail. Follow the McAlaster Creek Trail up to McAlaster Pass (6000 ft) and camp at High Camp. The first day has 2 hours of driving from NOCA headquarters in Sedro-Woolley and 5 hours of moderate to strenuous hiking on 8.8 miles of maintained trail. Day 2: From High Camp, head down the Rainbow Creek Trail for 0.25 miles. Exit the main trail here, before the trail drops in elevation, and traverse around the base of the peak at the eastern end of Rainbow Ridge. Continue west along the south side of the ridge on the relatively flat bench (absolute elevation change is under 300 ft.) until you reach the small lake set in a semi-steep bowl. Navigate around to the southwest side of the lake, and continue heading southwest out of the bowl. Once out of the bowl link up with an informal trail that leads to a large wide flat pass with many small ponds. Continue southwest up towards the west peak of Rainbow Ridge. At 6800 ft., traverse around the south side of the peak reaching the ridge that runs directly south. Descend this ridge to the pass/bench at 6400 ft. and follow it northwest for 0.45 miles to reach camp at Bowan Lake. Day two will roughly take 3 hours, hiking 2.94 miles cross-country.



Figure 57. Hiking route to Bowan Lake, including main trails and cross country route.

Lower Silent Lake (MA-03-01)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 659850 m E / 5379294 m N



Figure 58. Lower Silent Lake from upper slopes west of the lake.

Geologic Setting

Lower Silent Lake rests on the floor of a stair-stepped glacial valley in the lowest of two basins eroded from tonalite of the Black Peak Batholith (Tabor and Haugerud 2009). Both Silent lakes are relatively young features, having been formed behind two rocky moraines left as glaciers receded in the last century (Riedel et al. 2012). The shoreline is primarily talus, scree and bedrock. Soils are thin and discontinuous in the basin surrounding the lake and are classified as the Harlequin Complex, which includes sandy loam soils, bedrock and ice (Rodgers and Roberts 2012).

Watershed Description

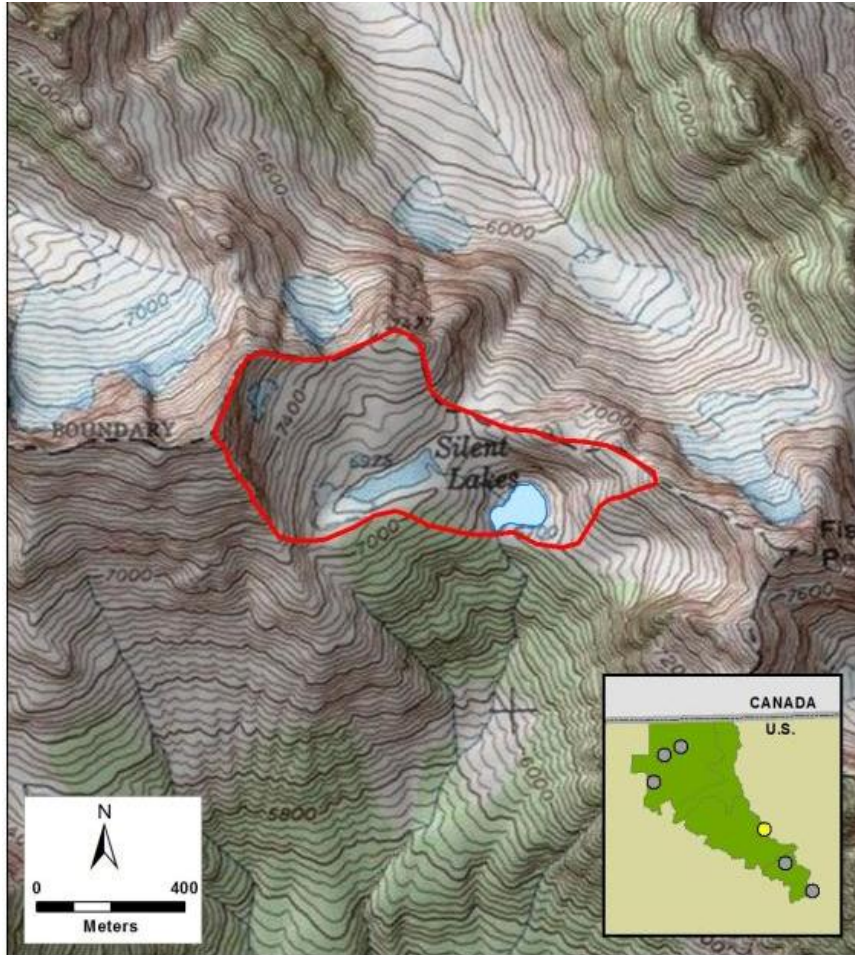


Figure 59. Lower Silent Lake watershed and surrounding area.

Table 29. Lower Silent Lake Morphometric data

Lake Parameter	Value
Elevation	2046 m (6713 ft)
Aspect	Southwest
Watershed Area	8.3 ha
Surface Area	1.2 ha
Volume	56,204 m ³
Depth (maximum)	9.4 m
Depth (mean)	4.5 m
Depth (relative)	3.5%
Shoreline length	481 m
Lake length (maximum)	158 m
Lake width (maximum)	121 m
Watershed area: Lake Area (ratio)	6.7
Shoreline Development	1.22
Index of Basin Permanence	0.12

Physical/ Chemical Water Properties

Table 30. Water Quality and productivity parameters for Lower Silent Lake, August 17, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.03
Total Phosphorus	mg/l	*0.002
Nitrogen & Phosphorus Ratio	N/A	*N/A
NO ₃ +NO ₂ -N	N/A	N/A
NH ₃ -N	mg/l	*0.002
Anion & Cation Ratio	N/A	0.130
Acid Neutralizing Capacity	µeq/L	69
pH	None	6.7
Specific Conductance	µS/cm	10
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	13
Water Clarity		
Depth of Transparency	m	Bottom (9.2)
Chlorophyll		
Chlorophyll-a	µg/L	0.31

*Below Detection Limit

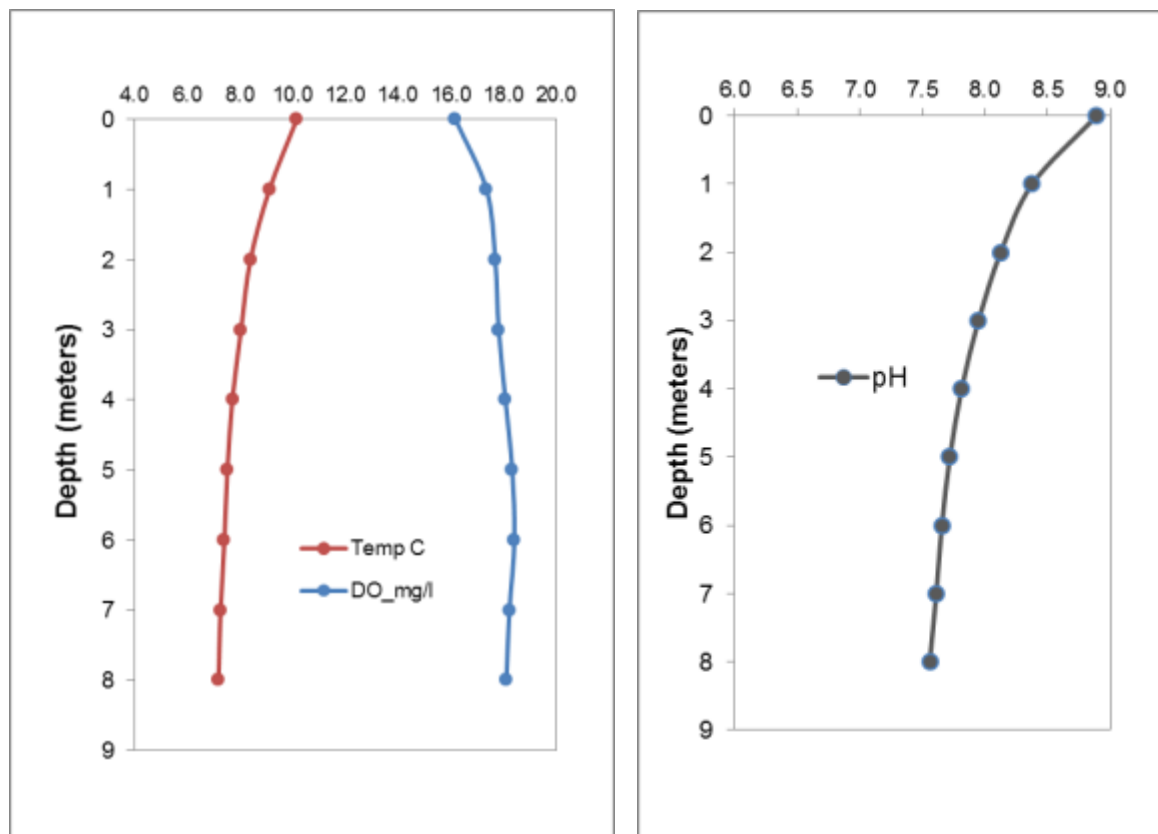


Figure 60. Dissolved oxygen, temperature and pH depth profiles from the deep-point Lower Silent Lake sampling station August 17, 2010.

Bathymetry & Shoreline Features

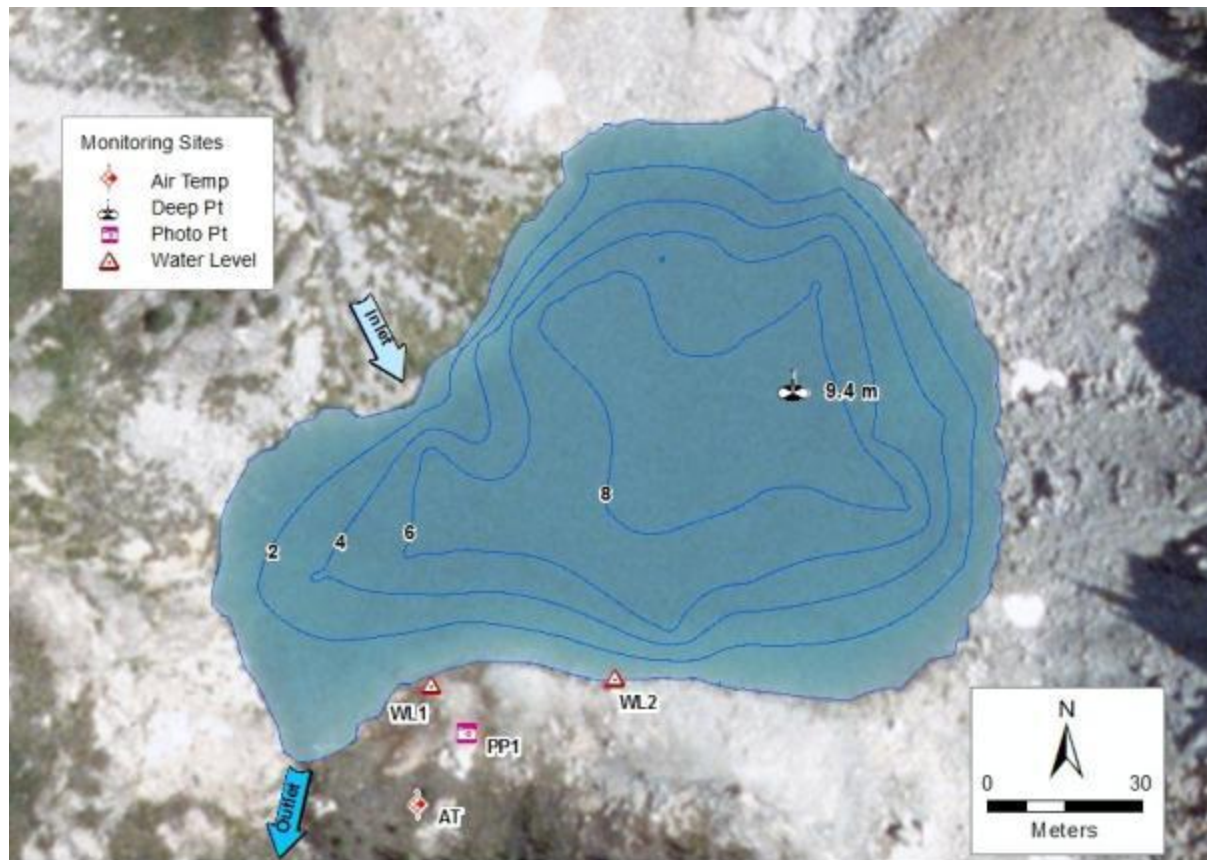


Figure 61. Bathymetry, shoreline features and sampling locations at Lower Silent Lake.

Amphibian & Fish Species

Table 31. Amphibian species observed at Lower Silent Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
None	--	--	--	--

Table 32. Introduced fish species observed at Lower Silent Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 62. Lower Silent Lake watershed panoramic photo (2011) from Photo Point 1 (see Figure 61).

Lake Access

Lower Silent Lake will require 3 to 4 days to sample. Day 1: From HWY 20, at the Easy Pass/Fisher Creek Trailhead, climb to Easy Pass and descend down to Fisher Creek (3.7 miles). Leave the main trail at Fisher Creek and travel cross-country, along the drainage all the way to the headwater basin (1.4 miles). Set up base-camp in the Fisher Creek Basin. Day one has 2 hours of driving from NOCA headquarters in Sedro-Woolley, 3 hours of strenuous hiking on 3.7 miles of maintained trail and at least 2 hours of cross-country hiking on boulder through brush. Sample Day: Climb up the second southern facing gully (lowest angle approach), cross the saddle and descend down to Lower Silent Lake. Day trips into the lake for sampling are 0.6 miles and take about 1 hour. Minimize bulky and un-balanced backpacks, taking extreme care ascending and descending the gully.



Figure 63. Hiking route to Lower Silent Lake, including main trails and cross country route.

Lower East Lake (MC-14-02)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 622345 m E/ 5416597 m N

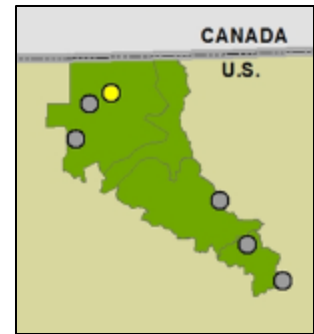


Figure 64. Lower East Lake from slope northwest of lake.

Geologic Setting

Lower East Lake is located in a stair-stepped cirque basin carved from resistant granite of the Chilliwack Composite Batholith. The glaciers that created this small valley probably exploited a weakness in the contact between two bedrock types, tonalite and granodiorite. A small remnant glacier feeds upper East Lake, and eventually Lower East Lake. Shorelines are composed of bedrock, talus, colluvium, and glacial deposits (Riedel et al. in prep). Erosion into thick glacial deposits at the southwest end of the lake has created a steep, unstable slope. Several small inlet streams and the flow from Upper East Lake have deposited small alluvial fans into the north end of the lake. Soils mapped in the basin surrounding the lake include the Stetattle-Doubtful-Arriva Complex, a sandy loam, and the Doubtful-Treen-Rock Outcrop complex (Rodgers and Roberts 2012).

Watershed Description

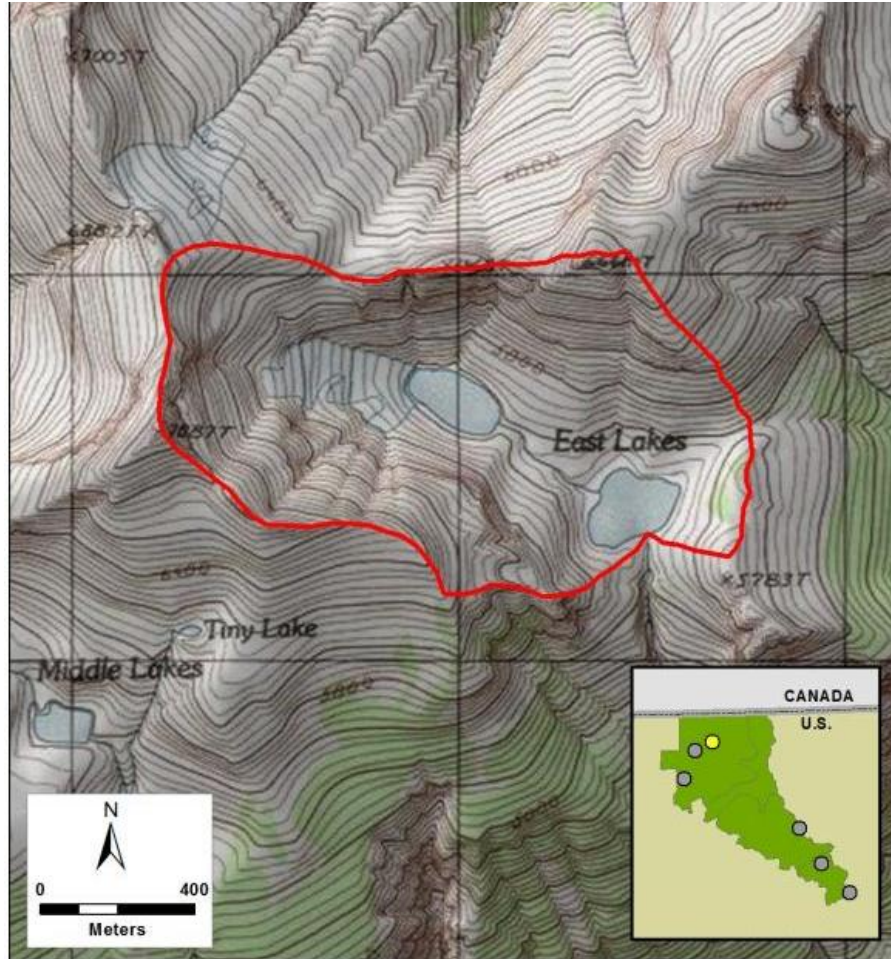


Figure 65. Lower East Lake watershed and surrounding area.

Table 33. Lower East Lake Morphometric data

Lake Parameter	Value
Elevation	1664 m (5459 ft)
Aspect	South
Watershed Area	44.1 ha
Surface Area	3.6 ha
Volume	193,435 m ³
Depth (maximum)	16.2 m
Depth (mean)	6.0 m
Depth (relative)	3.3%
Shoreline length	745 m
Lake length (maximum)	262 m
Lake width (maximum)	184 m
Watershed area: Lake Area (ratio)	13.6
Shoreline Development	1.17
Index of Basin Permanence	0.36

Physical/ Chemical Water Properties

Table 34. Water Quality and productivity parameters for Lower East Lake, September 2, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.02
Total Phosphorus	mg/l	*0.002
Nitrogen & Phosphorus Ratio	N/A	*N/A
NO3+NO2-N	mg/l	N/A
NH3-N	mg/l	*0.000
Anion & Cation Ratio	N/A	0.683
Acid Neutralizing Capacity	µeq/L	114
pH	None	6.5
Specific Conductance	µS/cm	38
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	33
Water Clarity		
Depth of Transparency	m	12.8
Chlorophyll		
Chlorophyll-a	µg/L	0.04

*Below Detection Limit

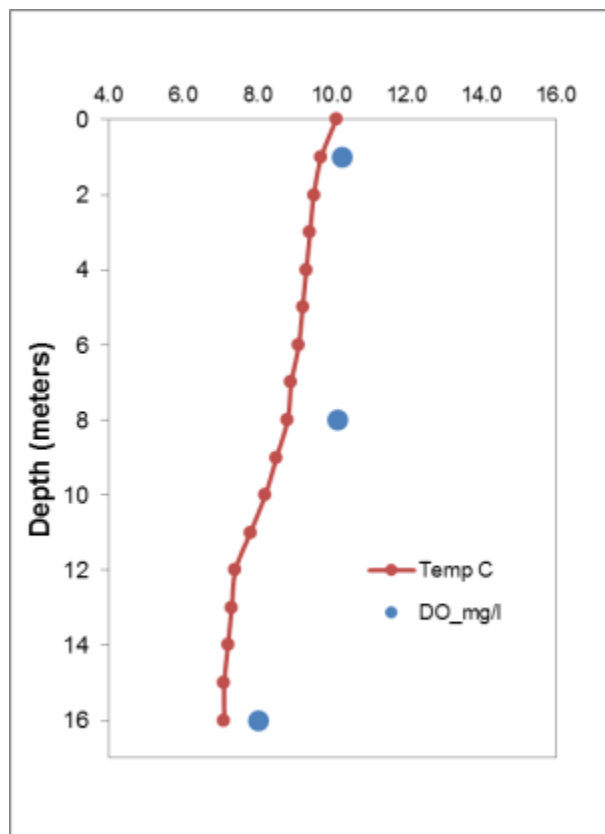


Figure 66. Continuous temperature profile and dissolved oxygen at upper, middle and bottom depths, from the deep-point Lower East Lake sampling station September 2, 2010.

Bathymetry & Shoreline Features

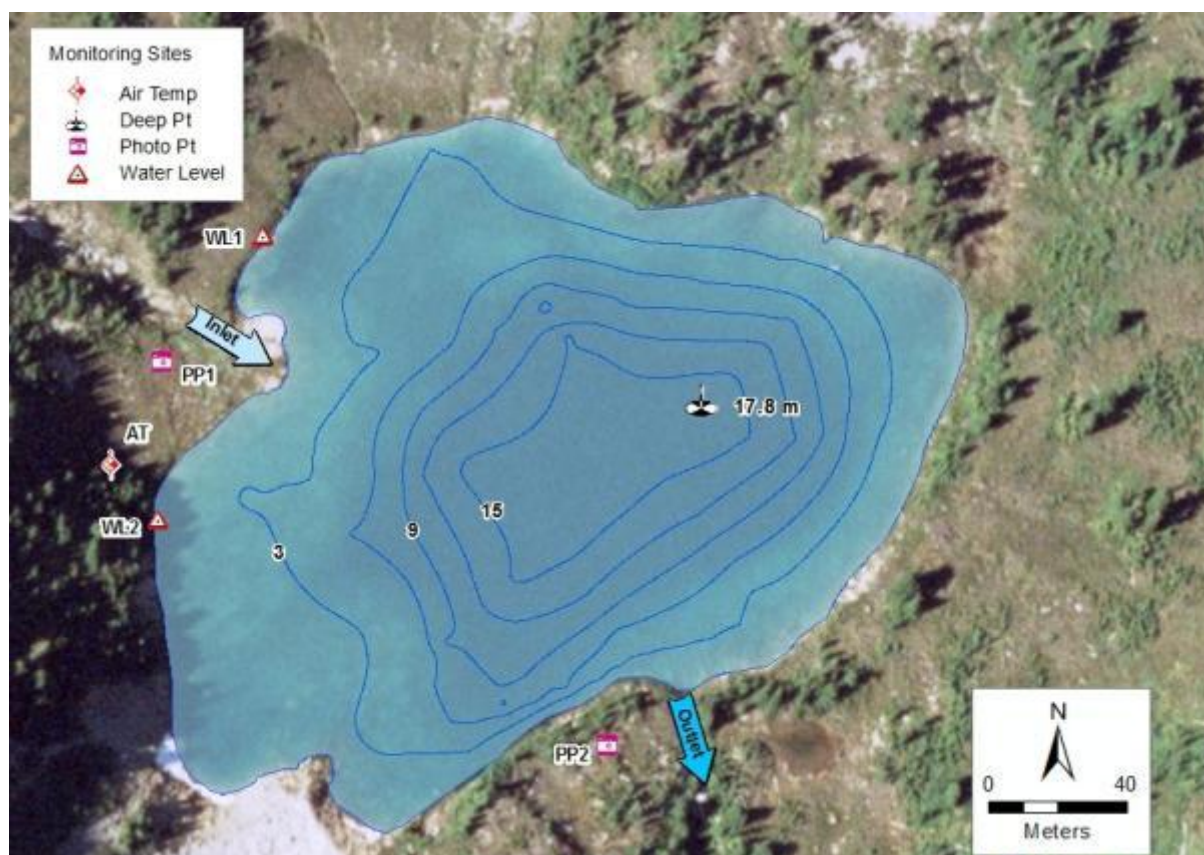


Figure 67. Bathymetry, shoreline features and sampling locations at Lower East Lake.

Amphibian & Fish Species

Table 35. Amphibian species observed at Lower East Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ascaphus truei</i>	Tailed Frog	ASTR	Adult	1

Table 36. Introduced fish species observed at Lower East Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos

66



Figure 68. Lower East Lake watershed panoramic photo (2009) from Photo Point 1 (See Figure 67).



Figure 69. Lower East Lake watershed panoramic photo (2010) from deepest point of lake (See Figure 67).

Lake Access

A Lower East Lake sampling event will take 6 days to complete. Day 1: The Hannegan Pass trailhead starts at the end of NFD 32, accessed from HWY 542, 15 miles east outside of Glacier, WA. Take the Hannegan Pass trail up and over the pass until you reach the U.S. Cabin Camp for the night (10.2 miles). Day one has a 1 hour drive from NOCA headquarters in Sedro-Woolley, and more than 5 hours of strenuous hiking on 10 miles of maintained trail. Day 2: Continue to the Chilliwack/Brush Creek Trail junction and on to Whatcom Pass to camp. Day two covers 7.2 miles of strenuous trail estimated to take 5 hours. Crew must acquire a camping permit and reservation from the Wilderness Information Center well in advance of a planned trip. Day 3: From Whatcom Pass, climb north up to 5600ft. Begin traversing east toward Middle Lakes. Pass between the Middles Lakes, towards Tiny Lake. From Tiny Lake, traverse east, staying above tree line, wrapping around to the north and the East Lakes can be seen below. Drop into the East Lakes, aiming for the reach of stream between the two lakes to camp. Day three totals about 2.5 miles of cross-country travel, which takes more than 3 hours.

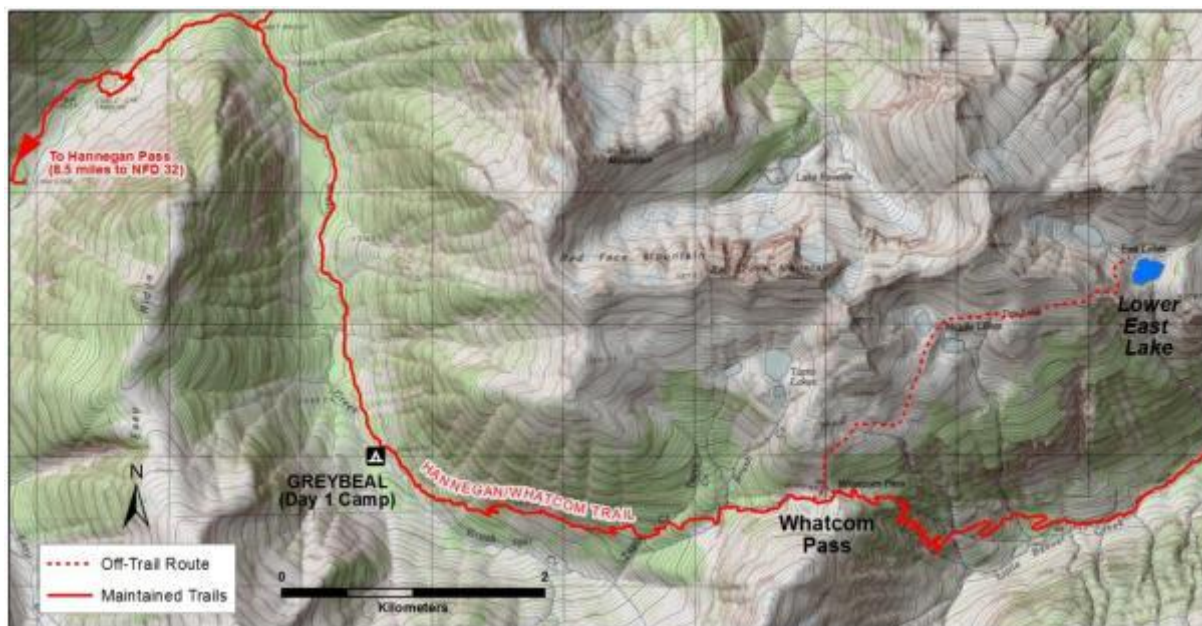


Figure 70. Hiking route to Lower East Lake, including main trails and cross country route.

Upper Triplet Lake (SM-02-02)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 681548 m E / 5351548 m N

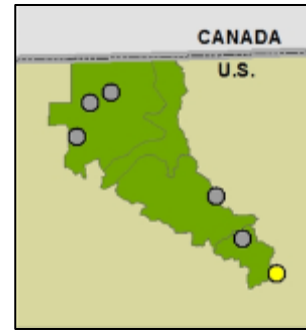


Figure 71. Upper Triplet Lake from a ridge, north of the lake.

Geologic Setting

Upper Triplet Lake drains an area of Skagit Gneiss, a gneiss bedrock found on the dry eastern slopes of the North Cascades (Tabor and Haugerud 2009). The lake lies on the valley floor at the upper end of a stair -stepped valley that was eroded out of the north slope of Twin Peaks by glaciers. No recent glacial moraines are mapped near the lake, which was likely formed at the end of the last ice age more than 12,000 years ago (Riedel et al. in prep). Shorelines include broad talus fields on the south end of the lake, with the remainder formed in glacial debris and bedrock. Soils mapped in the surrounding terrain include sandy loams of the Despair and Doubtful-Triumph-Perfect complexes (Rodgers and Roberts 2012).

Watershed Description

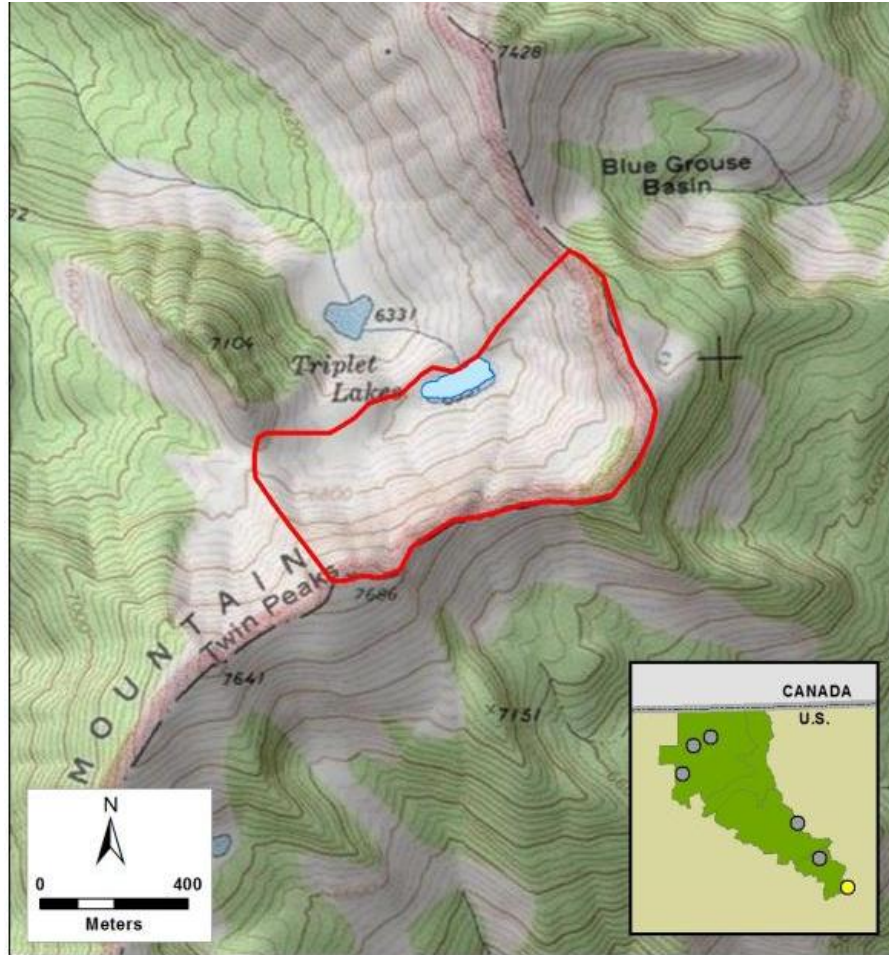


Figure 72. Upper Triplet Lake watershed and surrounding area.

Table 36. Upper Triplet Lake Morphometric data

Lake Parameter	Value
Elevation	1998 m (6555 ft)
Aspect	Southeast
Watershed Area	29.1 ha
Surface Area	0.1 ha
Volume	16,238 m ³
Depth (maximum)	3.9 m
Depth (mean)	1.7 m
Depth (relative)	2.7%
Shoreline length	507 m
Lake length (maximum)	205 m
Lake width (maximum)	73 m
Watershed area: Lake Area (ratio)	30.3
Shoreline Development	1.46
Index of Basin Permanence	0.03

Physical/ Chemical Water Properties

Table 37. Water Quality and productivity parameters for Upper Triplet Lake, August 17, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.07
Total Phosphorus	mg/l	*0.001
Nitrogen & Phosphorus Ratio	N/A	*N/A
NO ₃ +NO ₂ -N	mg/l	N/A
NH ₃ -N	mg/l	*0.002
Anion & Cation Ratio	N/A	0.072
Acid Neutralizing Capacity	µeq/L	298
pH	None	7.5
Specific Conductance	µS/cm	35
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	30
Water Clarity		
Depth of Transparency	m	Bottom (4.1)
Chlorophyll		
Chlorophyll-a	µg/L	0.12

*Below Detection Limit

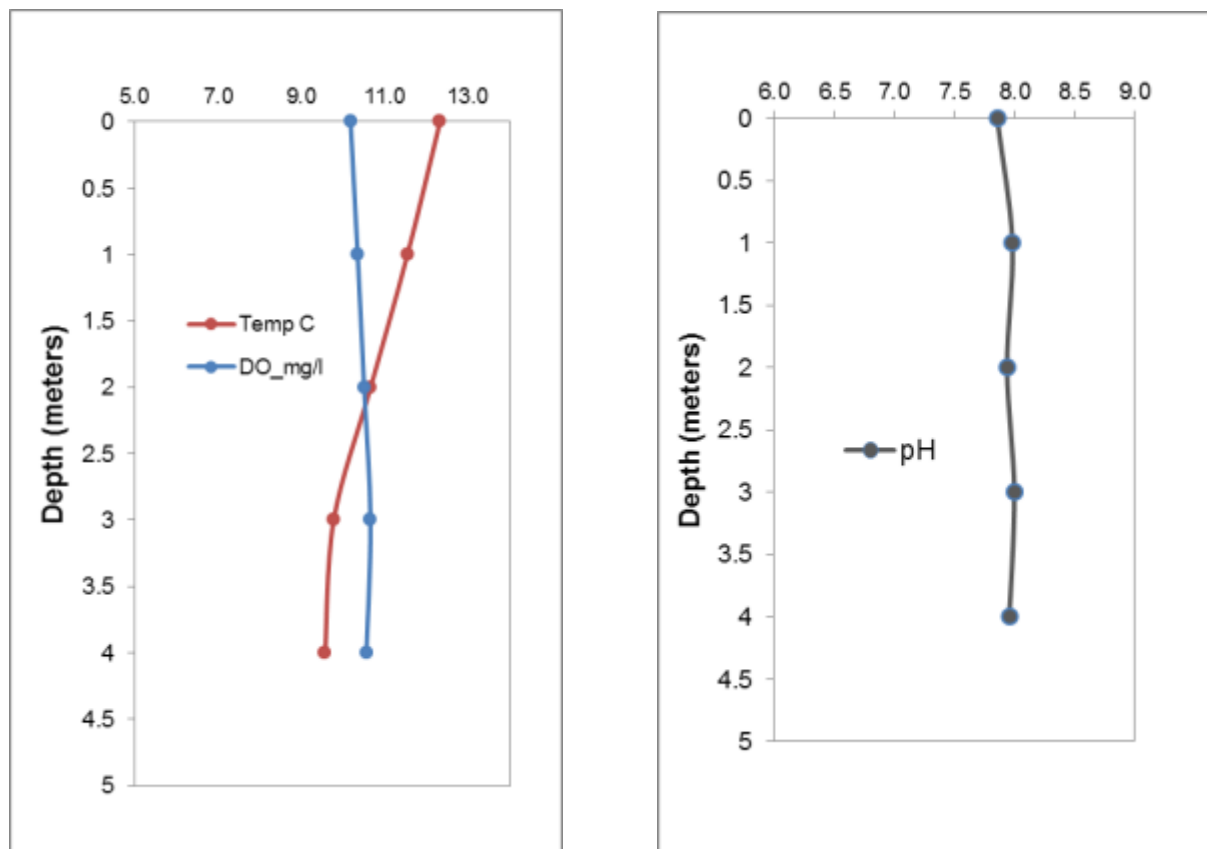


Figure 73. Dissolved oxygen, temperature and pH depth profiles from the deep-point Upper Triplet Lake sampling station August 17, 2010.

Bathymetry & Shoreline Features

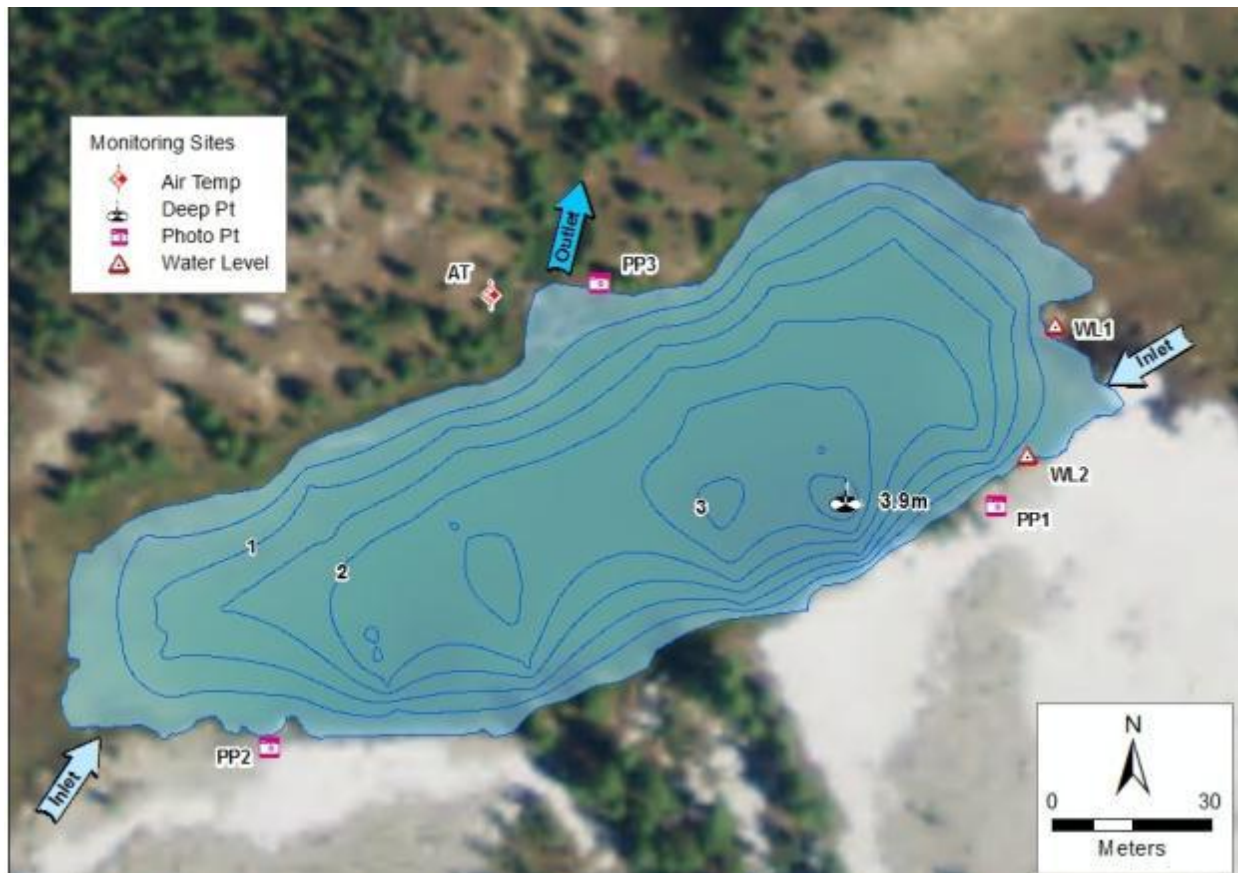


Figure 74. Bathymetry, shoreline features and sampling locations at Upper Triplet Lake. [Note: contours in this figure are in .5 meter increments].

Amphibian & Fish Species

Table 38. Amphibian species observed at Upper Triplet Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Larvae	2

Table 39. Introduced fish species observed at Upper Triplet Lake (2010).

Species	Common Name	Species Code
<i>Oncorhynchus clarkii</i>	Cutthroat Trout	UCT

Watershed Panoramic Photos



Figure 75. Upper Triplet Lake watershed panoramic photo (2011) from Photo Point 1 (see Figure 74).



Figure 76. Upper Triplet Lake watershed panoramic photo (2011) from Photo Point 2 (see Figure 74).



Figure 77. Upper Triplet Lake watershed panoramic photo (2011) from Photo Point 3 (see Figure 74).

Lake Access

An Upper Triplet sampling event will require 4 to 5 days to complete. To reach the trail head, follow West 2nd street out of Twisp, WA, continue to follow on to Twisp River Rd for 14.1 miles to National Forest Developed Rd (NFD) 4430, to NFD 4420 and Finally Eagle Creek Trail trailhead is located at the end of NFD 80. Day 1: Follow Eagle Creek trail for 1.5 miles, taking the right fork to Eagle Pass to camp (6 miles), camp in existing areas if available, and out of sight of the trail. Day one has a 2.5 hour drive from NOCA headquarters in Sedro-Woolley, 5 hours of strenuous hiking on 7.5 miles of maintained trail. Day 2: Continue over Eagle Pass to the junction with Summit trail, keeping right (1 mile). Keeping right, continue on Summit Trail until you reach the ridge above Triplet Lakes. This will be 5 miles of maintained trail hiking, and take 3 hours. Finally, head south on the ridge for just under 1 mile to the low point above Triplet Lakes. The lakes will be visible from most of the ridge. Descend down to camp at Upper Triplet Lake. Day two has a total of 3 hours of strenuous hiking on 4 miles of maintained trail and 1 hour of cross-country hiking to traverse the ridge and drop into the lake.



Figure 78. Hiking route to Upper Triplet Lake, including main trails and cross country route.

Easy Ridge Lake (MC-03-01)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 615007 m E / 5412756 m N

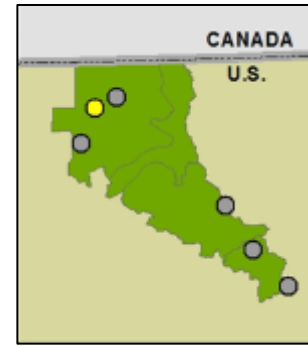


Figure 79. Easy Ridge Lake from northeast shore of lake.

Geologic Setting

Easy Ridge Lake is located in a cirque basin cut from biotite hornblend, tonalite and granodiorite of the Chilliwack Batholith (Tabor and Haugerud 2009). The topography around the lake consists of glacially-scoured, minimally weathered bedrock benches and a thin, patchy cover of glacial debris (Riedel et al. in prep). Scarce soils in the surrounding terrain include sandy loams of the Despair and Doubtful-Triumph-Perfect complexes (Rodgers and Roberts 2012). The lake outlet is bedrock-controlled.

Watershed Description

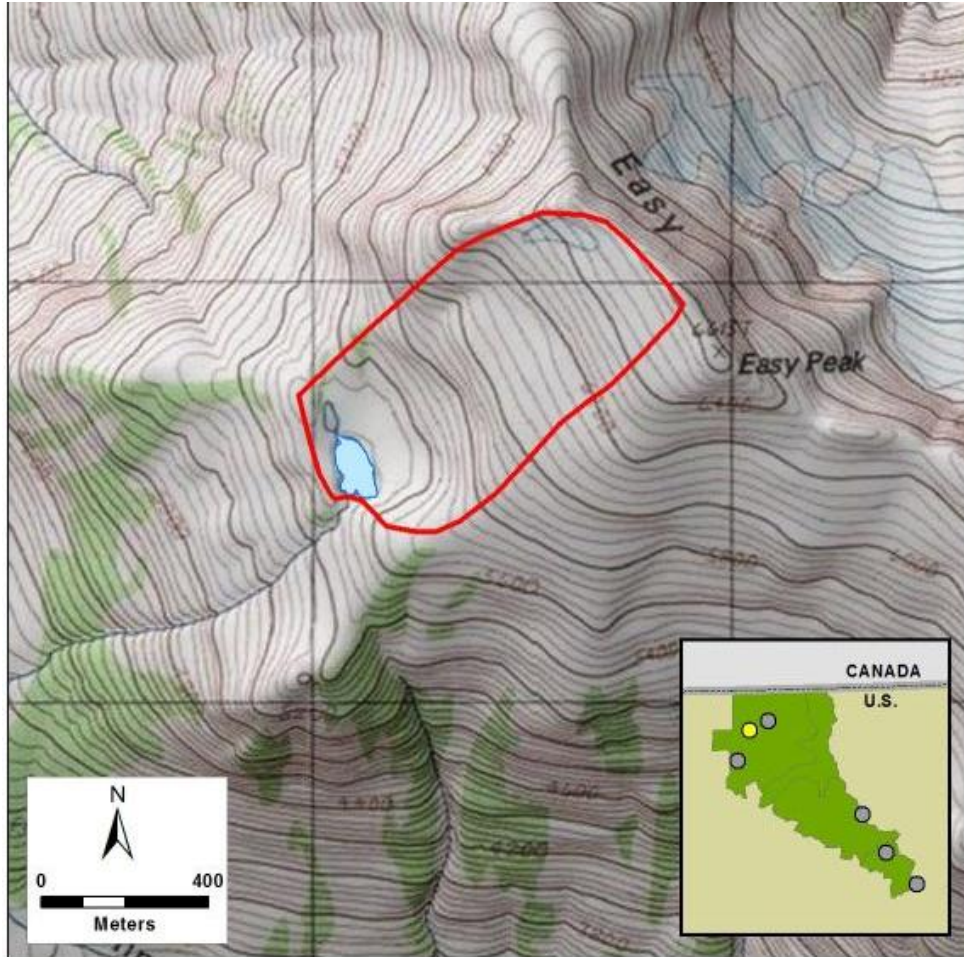


Figure 80. Easy Ridge Lake watershed and surrounding area.

Table 40. Easy Ridge Lake Morphometric data

Lake Parameter	Value
Elevation	1680 m (5512 ft)
Aspect	West
Watershed Area	37.1 ha
Surface Area	1.0 ha
Volume	13,583 m ³
Depth (maximum)	3.65 m
Depth (mean)	1.3 m
Depth (relative)	2.8%
Shoreline length	455 m
Lake length (maximum)	175 m
Lake width (maximum)	158 m
Watershed area: Lake Area (ratio)	36.8
Shoreline Development	1.28
Index of Basin Permanence	0.03

Physical/ Chemical Water Properties

Table 41. Water Quality and productivity parameters for Easy Ridge Lake, September 2, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	*0.01
Total Phosphorus	mg/l	*0.000
Nitrogen & Phosphorus Ratio	N/A	*N/A
NO3+NO2-N	mg/l	N/A
NH3-N	mg/l	*0.001
Anion & Cation Ratio	N/A	0.626
Acid Neutralizing Capacity	µeq/L	27
pH	None	5.7
Specific Conductance	µS/cm	6
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	15
Water Clarity		
Depth of Transparency	m	Bottom (3.9)
Chlorophyll		
Chlorophyll-a	µg/L	0.03

*Below Detection Limit

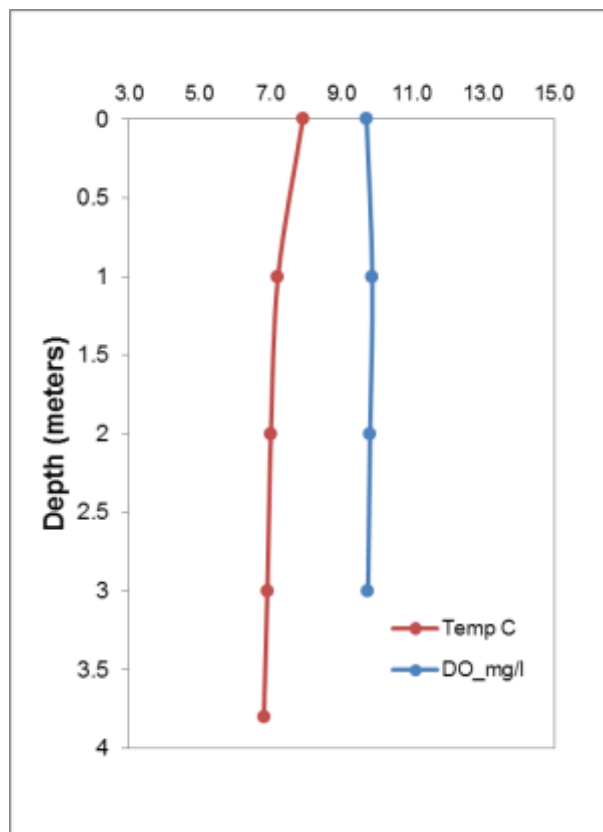


Figure 81. Dissolved oxygen and temperature depth profiles from the deep-point Easy Ridge Lake sampling station September 2, 2010.

Bathymetry & Shoreline Features

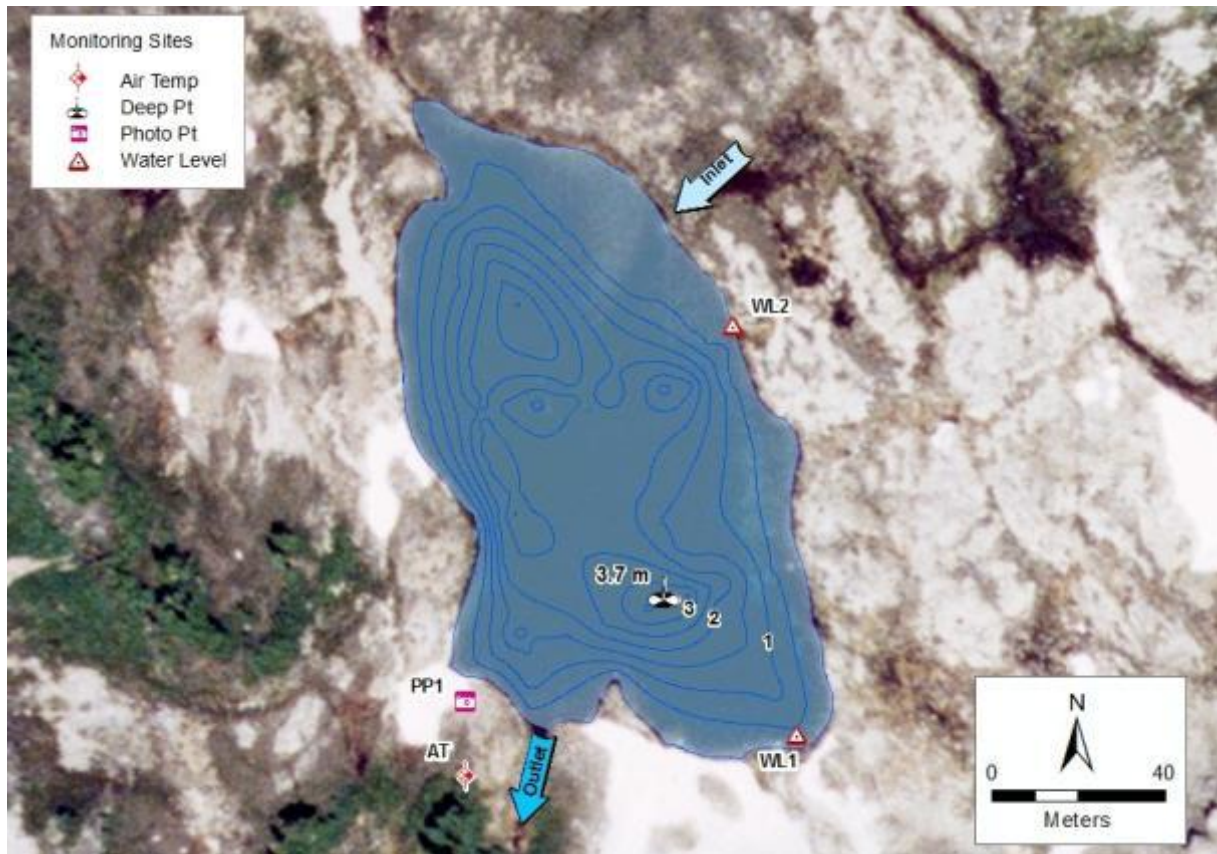


Figure 82. Bathymetry, shoreline features and sampling locations at Easy Ridge Lake.

Amphibian & Fish Species

Table 42. Amphibian species observed at Easy Ridge Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma spp</i>	Unknown	--	Larvae	1

Table 43. Introduced fish species observed at Easy Ridge Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 83. Easy Ridge Lake watershed panoramic photo (2011) from Photo Point 1 (see Figure 82).

Lake Access

A minimum of 5 days are required to sample Easy Ridge Lake. Day 1: The Hannegan Pass trailhead starts at the end of NFD 32, accessed from HWY 542, 15 miles east outside of Glacier, WA. Take the Hannegan Pass trail up and over the pass until you reach Copper Camp for the night (7 miles). Day one has a 1 hour drive time from NOCA headquarters in Sedro-Woolley, and three hours of strenuous hiking on 7 miles of maintained trail. Day 2: Two miles past Copper Creek Camp where you can first see the Chilliwack River, locate the obvious but unsigned trail that departs to the right and leads down to the river. Safely ford the river, which is only ankle deep in the late season, and pick up the abandoned Easy Ridge Trail directly on the other side. Climb up the trail to a saddle on Easy Ridge, a climber's trail follows the ridge, though becomes scarce approaching Easy Peak. Navigate to the top of Easy Peak and Easy Ridge Lake can be seen below to the west. Descend directly to the lake, approaching the southern end of the lake to camp. Day two has 2 miles of maintained trail and 3.8 miles of cross-country travel that will take more than 5 hours.

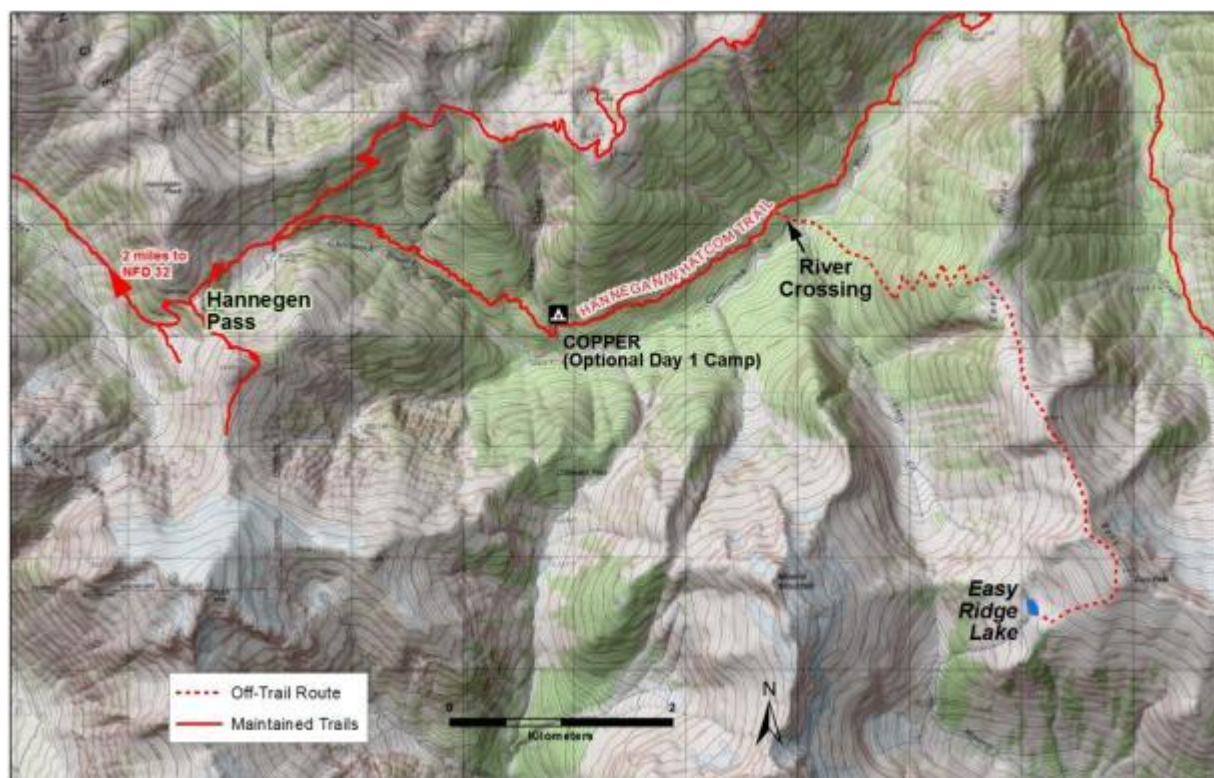


Figure 84. Hiking route to Easy Ridge Lake, including main trails and cross country route.

Lower Blum Lake (LS-07-01)

North Cascades National Park Service Complex

UTM Coordinates (NAD83): 610186 m E / 5400526 m N

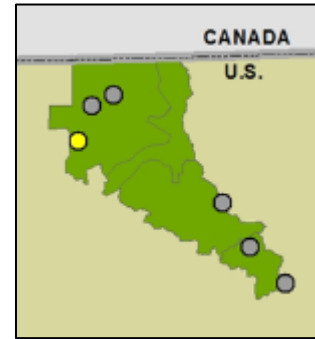


Figure 85. Lower Blum Lake from slope northeast of lake.

Geologic Setting

The Blum Lakes rest in an exceptionally deep cirque basin on the southwest side of Mount Blum. The lake's drainage basin is composed of biotite hornblend and granodiorite bedrock (Tabor et al. 2003, Tabor and Haugerud 2009). The lake is contained by three recent moraines that likely formed at the end of the 20th century (Riedel et al. in prep). Shorelines are made primarily of glacial deposits, talus, and colluvium. Soils mapped in the basin are sandy loams from the Stetattle-Doubtful-Arriva Complex (Rodgers and Roberts 2012).

Watershed Description

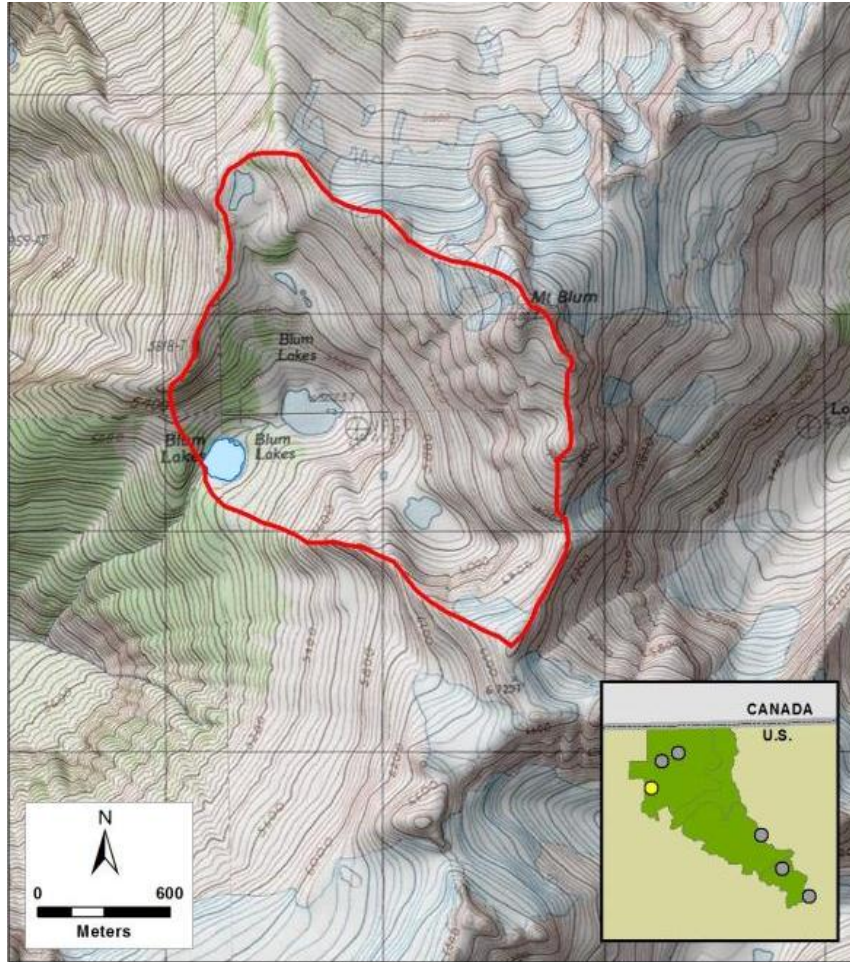


Figure 86. Lower Blum Lake watershed and surrounding area.

Table 44. Lower Blum Lake Morphometric data

Lake Parameter	Value
Elevation	1511m (4957 ft)
Aspect	Southwest
Watershed Area	30.4 ha
Surface Area	2.6 ha
Volume	116, 924m ³
Depth (maximum)	7.9 m
Depth (mean)	4.5 m
Depth (relative)	2.0%
Shoreline length	662 m
Lake length (maximum)	201 m
Lake width (maximum)	164 m
Watershed area: Lake Area (ratio)	11.8
Shoreline Development	1.16
Index of Basin Permanence	0.18

Physical/ Chemical Water Properties

Table 45. Water Quality and productivity parameters for Lower Blum Lake, September 14, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.02
Total Phosphorus	mg/l	0.006
Nitrogen & Phosphorus Ratio	N/A	3.3
NO3+NO2-N	mg/l	N/A
NH3-N	mg/l	*0.001
Anion & Cation Ratio	N/A	0.225
Acid Neutralizing Capacity	µeq/L	81
pH	None	6.7
Specific Conductance	µS/cm	15
Dissolved Organic Carbon	mg/l	N/A
Total Dissolved Solids	mg/l	12
Water Clarity		
Depth of Transparency	m	7.0
Chlorophyll		
Chlorophyll-a	µg/L	0.05

*Below Detection Limit

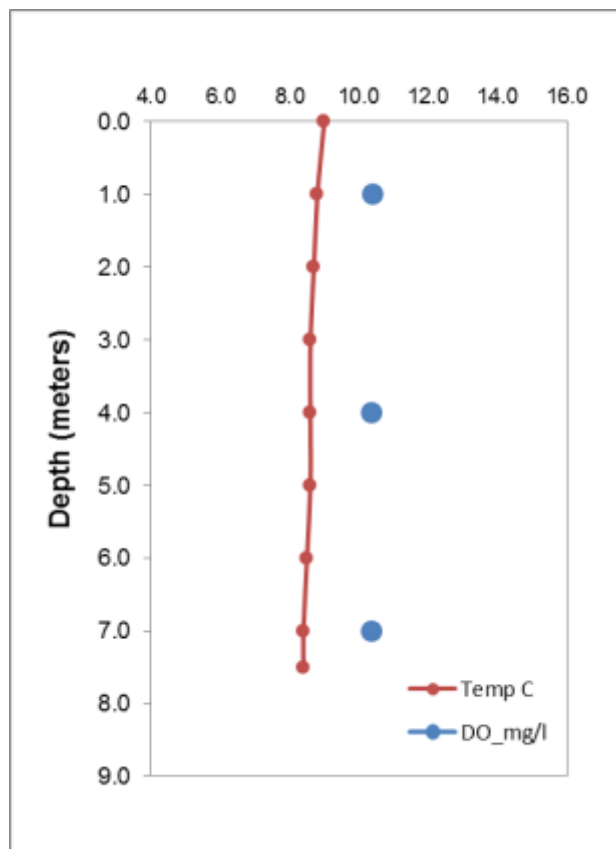


Figure 87. Continuous temperature depth profile and dissolved oxygen samples at upper, middle and bottom depths, from the deep-point Lower Blum Lake sampling station September 14, 2010.

Bathymetry & Shoreline Features

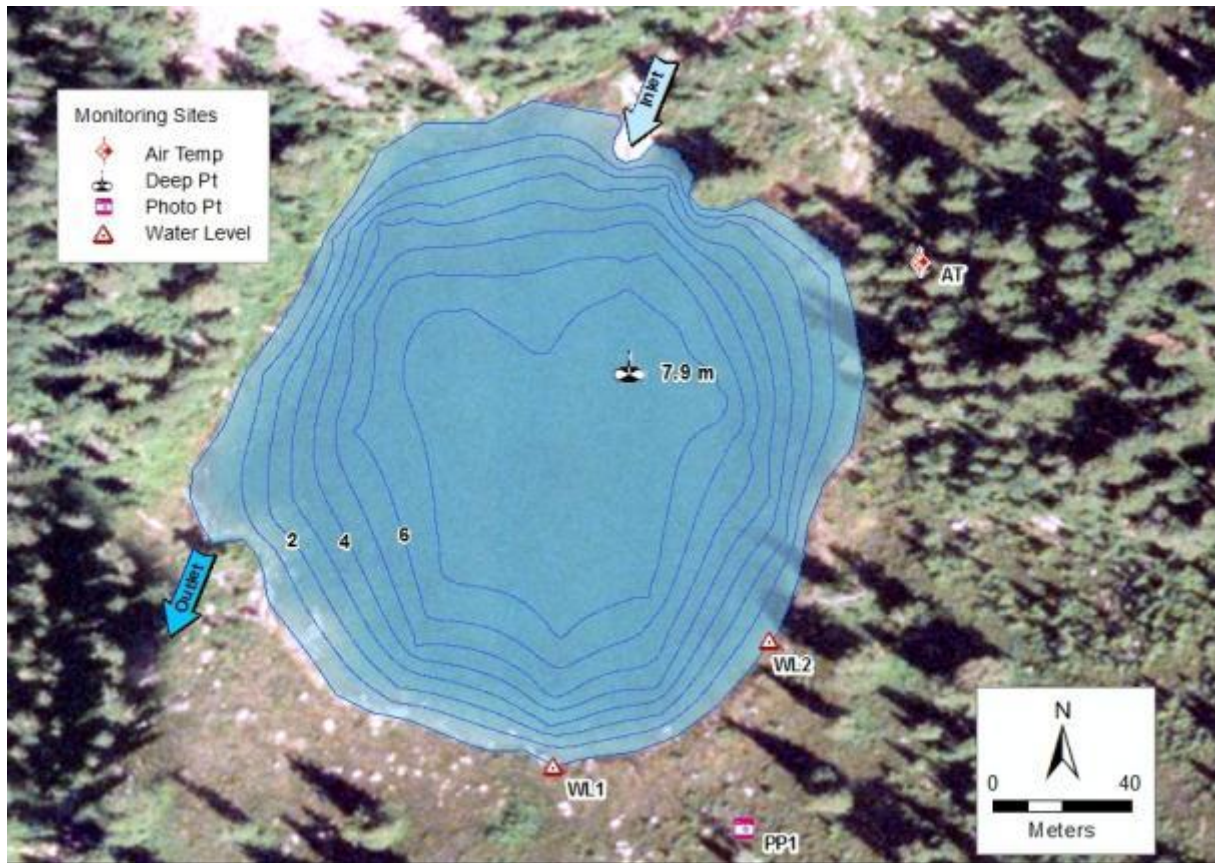


Figure 88. Bathymetry, shoreline features and sampling locations at Lower Blum Lake.

Amphibian & Fish Species

Table 46. Amphibian species observed at Lower Blum Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ascaphus truei</i>	Tailed Frog	ASTR	Adult	1

Table 47. Introduced fish species observed at Lower Blum Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 89. Lower Blum Lake watershed panoramic photo (2009) from Photo Point 1 (see Figure 88).

Lake Access

A sampling event on Lower Blum Lake will take a minimum of 3 days. Advisory: Travel to Lower Blum Lake must be done in 1 day. There is no water or camping options once cross-country travel begins. An early morning start is recommended and weather depending, crew members may need to carry up to 5 liters of water. Camping at the trailhead the night before is an option. Day 1: The Baker River Trailhead is at the end of the Baker Lake Road, 20 miles off HWY 20. Follow the Baker Lake trail approximately 1 mile, to the Baker River crossing (bridge crossing). A climbers trail is accessed approximately 200 yards south, past the Baker River Bridge, just before the Blum Creek Bridge. Not historically marked, the climbers trail was illegally marked in 2011 with small orange spray paint circles on three trees. For the first half mile, traverse north towards the ridge that extends east from the Blum Lakes area. Continue east up the ridge. This portion of the cross-country travel is extremely steep with many areas that turn into cliffs. Safely navigate up the ridge staying to the south. Continue east along the talus slope to 5,200 ft.; from here traverse east until the Blum Lakes are in view. Descend into the Blum Lakes Basin to camp. Day one has a 2 hour drive from NOCA headquarters in Sedro-Woolley, 30 minutes on a maintained trail and more than 6 hours of cross-country travel over 3 miles of extremely steep and brushy terrain.

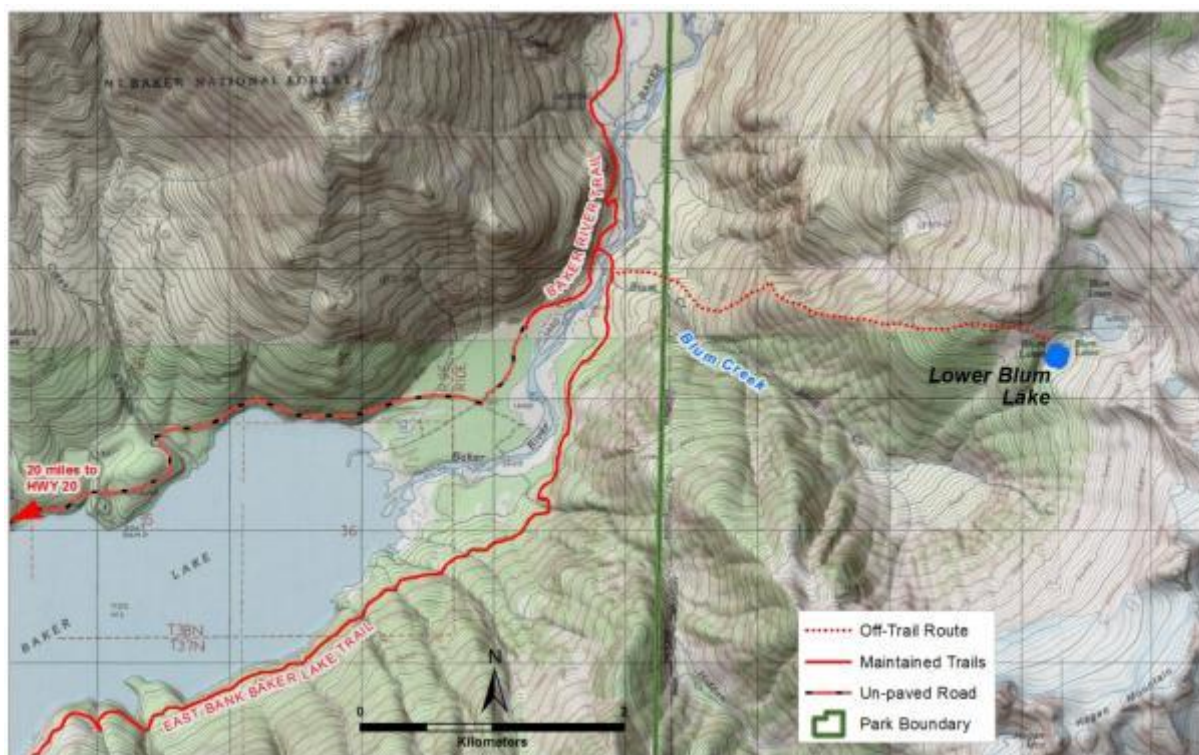


Figure 90. Hiking route to Lower Blum Lake, including main trails and cross country route.

Lake Descriptions: Olympic National Park

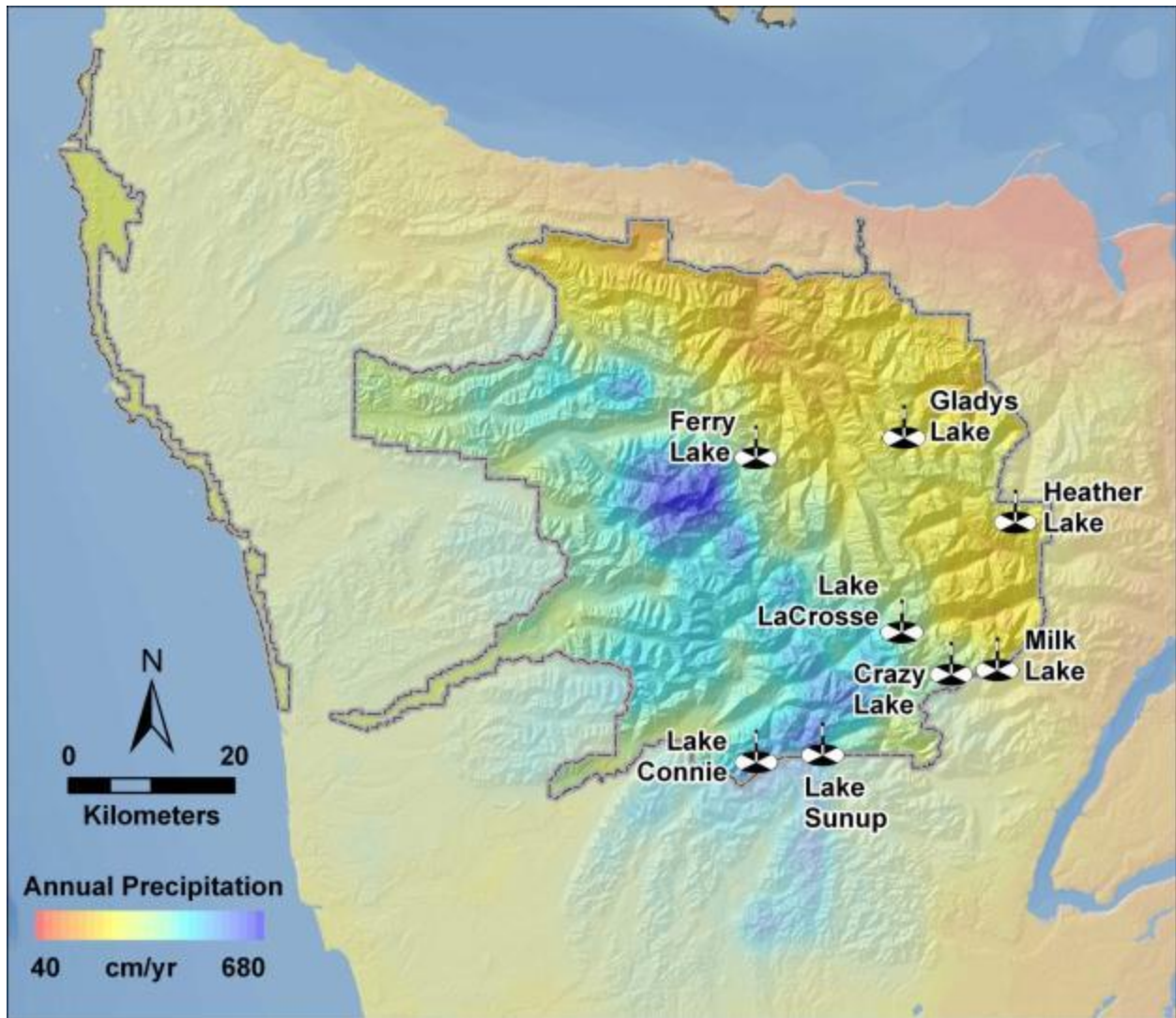


Figure 91. Location of the 8 core monitoring lakes at Olympic National Park. Background shading indicates precipitation gradient derived from PRISM model.

Ferry Lake (138)

Olympic National Park

UTM Coordinates (NAD83): 455307 m E / 5300225 m N

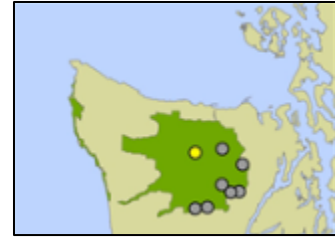


Figure 92. Ferry Lake from the mountainside above.

Geologic Setting

The Ferry Lake watershed drains part of the central Bailey Range and is composed of sandstone from the Western Olympic lithic assemblage (Tabor and Cady 1978). The lake itself rests in a north-facing cirque basin that was occupied by glacial ice during the last ice age. Cliffs and glacially-scoured bedrock benches surround the lake. Shorelines are steep and rocky, and composed of talus, bedrock, and glacial sediments. The lake's outlet is bedrock-controlled and plummets rapidly from the bedrock bench down into Cream Lake Basin below (Riedel and Dorsch in prep).

Watershed Description

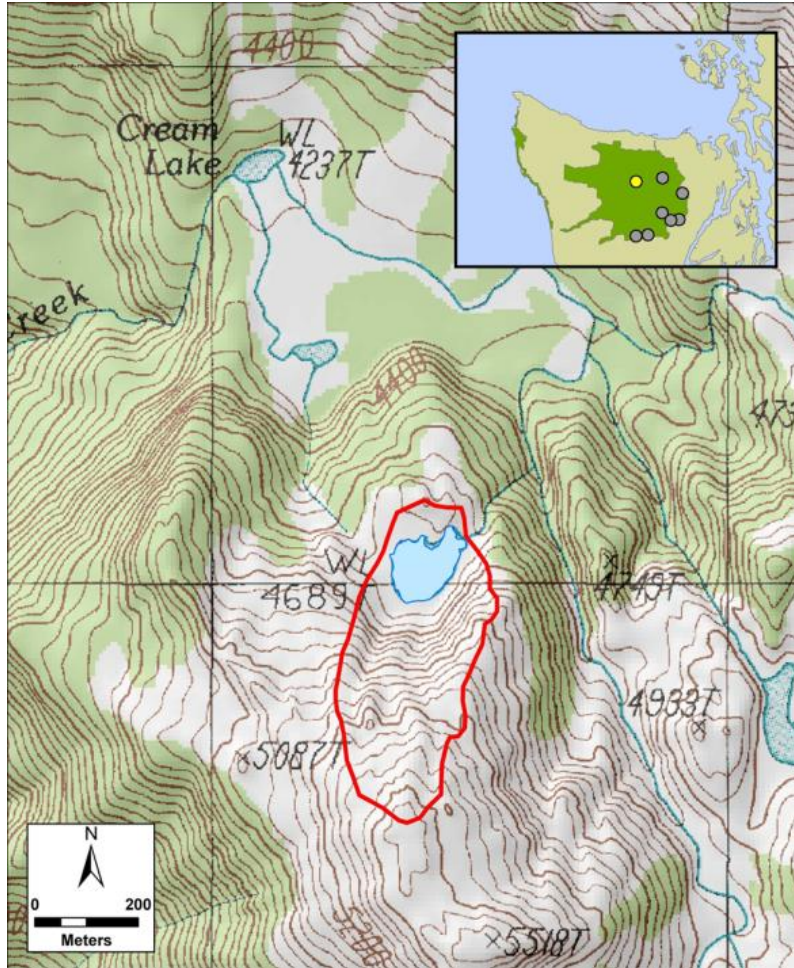


Figure 93. Ferry Lake watershed and surrounding area.

Table 47. Ferry Lake Morphometric data

Lake Parameter	Value
Elevation	1434 m (4705 ft)
Aspect	North
Watershed Area	12.7 ha
Surface Area	1.3 ha
Volume	60,843 m ³
Depth (maximum)	10.9 m
Depth (mean)	4.7 m
Depth (relative)	8.4%
Shoreline length	464 m
Lake length (maximum)	174 m
Lake width (maximum)	120 m
Watershed area: Lake Area (ratio)	9.7
Shoreline Development	1.15
Index of Basin Permanence	0.13

Physical/ Chemical Water Properties

Table 48. Water Quality and productivity parameters for Ferry Lake, September 22, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.04
Total Phosphorus	mg/l	0.002
Nitrogen & Phosphorus Ratio	N/A	20
NO ₃ +NO ₂ -N	mg/l	0.0
NH ₃ -N	mg/l	0.004
Anion & Cation Ratio	N/A	0.180
Acid Neutralizing Capacity	µeq/L	190
pH	None	6.0
Specific Conductance	µS/cm	26
Dissolved Organic Carbon	mg/l	0.59
Total Dissolved Solids	mg/l	17
Water Clarity		
Depth of Transparency	m	Bottom (10.9)
Chlorophyll		
Chlorophyll-a	µg/L	0.29

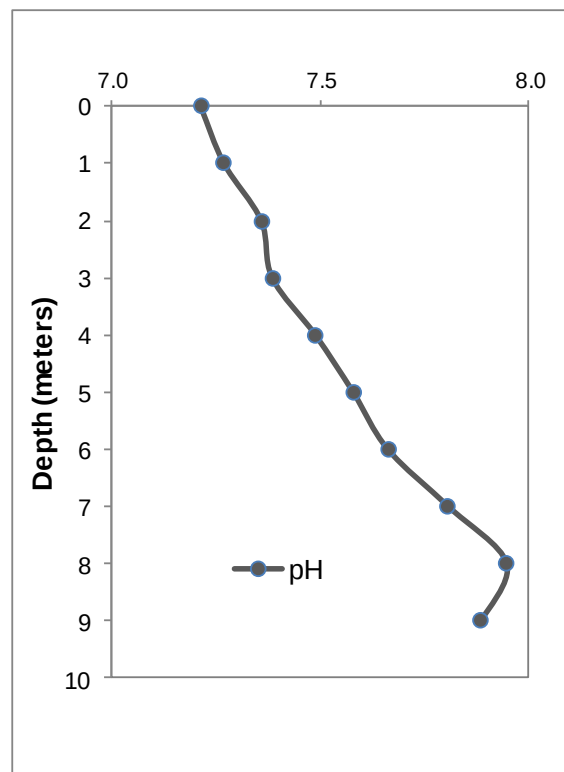
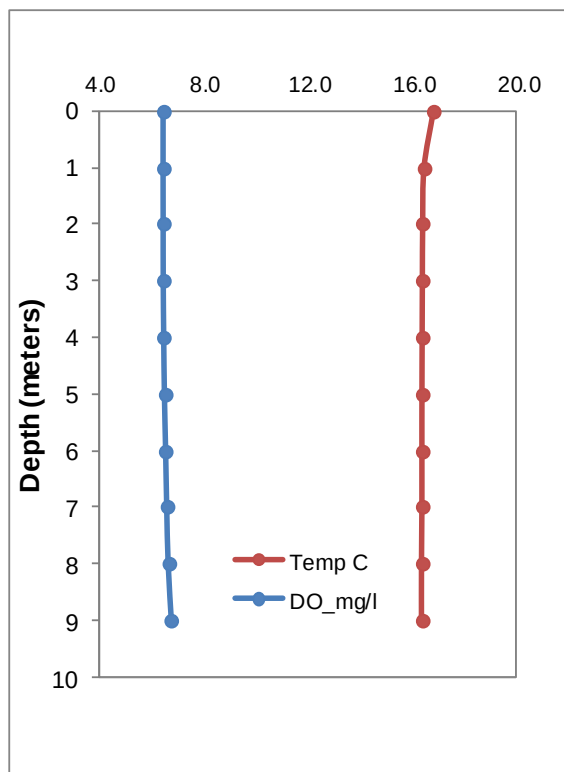


Figure 94. Dissolved oxygen, temperature and pH depth profiles from the deep-point Ferry Lake sampling station September 22, 2010.

Bathymetry & Shoreline Features

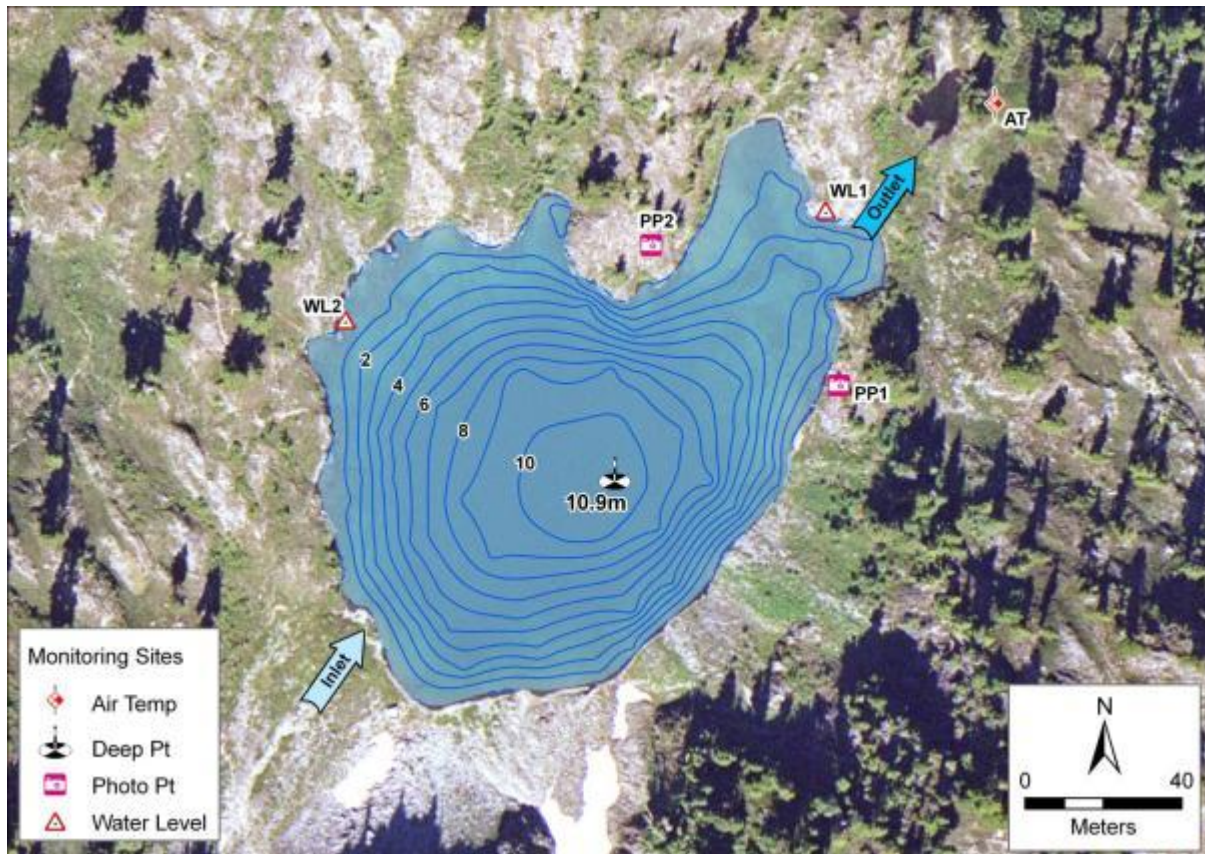


Figure 95. Bathymetry, shoreline features and sampling locations at Ferry Lake.

Amphibian & Fish Species

Table 49. Amphibian species observed at Ferry Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Adult	2
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Paedomorph	9
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Larvae	3
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Larvae	24
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	7
<i>Rana cascadae</i>	Cascades Frog	RACA	Juvenile	1

Table 50. Introduced fish species observed at Ferry Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 96. Ferry lake watershed panoramic photo (2010) from Photo Point 1 (see Figure 95).

92



Figure 97. Ferry lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 95).

Lake Access

A sampling trip to Ferry Lake requires a minimum of 5 days. Day 1: From the Whiskey Bend Trailhead, hike 13.5 miles to the Dodger Point Fire Lookout (6 hrs). A camp can be set in the meadows near the trail junction or crews can camp in the historic lookout. Water must be carried to the lookout. Day 2: Follow the abandoned trail 1.9 miles to Ludden Peak. At the trails end, drop steeply then traverse, following GPS way points to the Scott Ludden saddle. From this point ascend through dense brush back to the ridgetop. Follow the ridge to the shoulder of Mt. Ferry, then descend into a barren basin. Camp 2 is located on a sheltered ledge overlooking the Elwha Valley (4-5 hrs). Day 3: Descend into Ferry Basin, travelling northeast to the steep gorge west of the basin. Cross the creek, climb talus slope and traverse bedrock benches to the eastern end of lake (2 hrs).

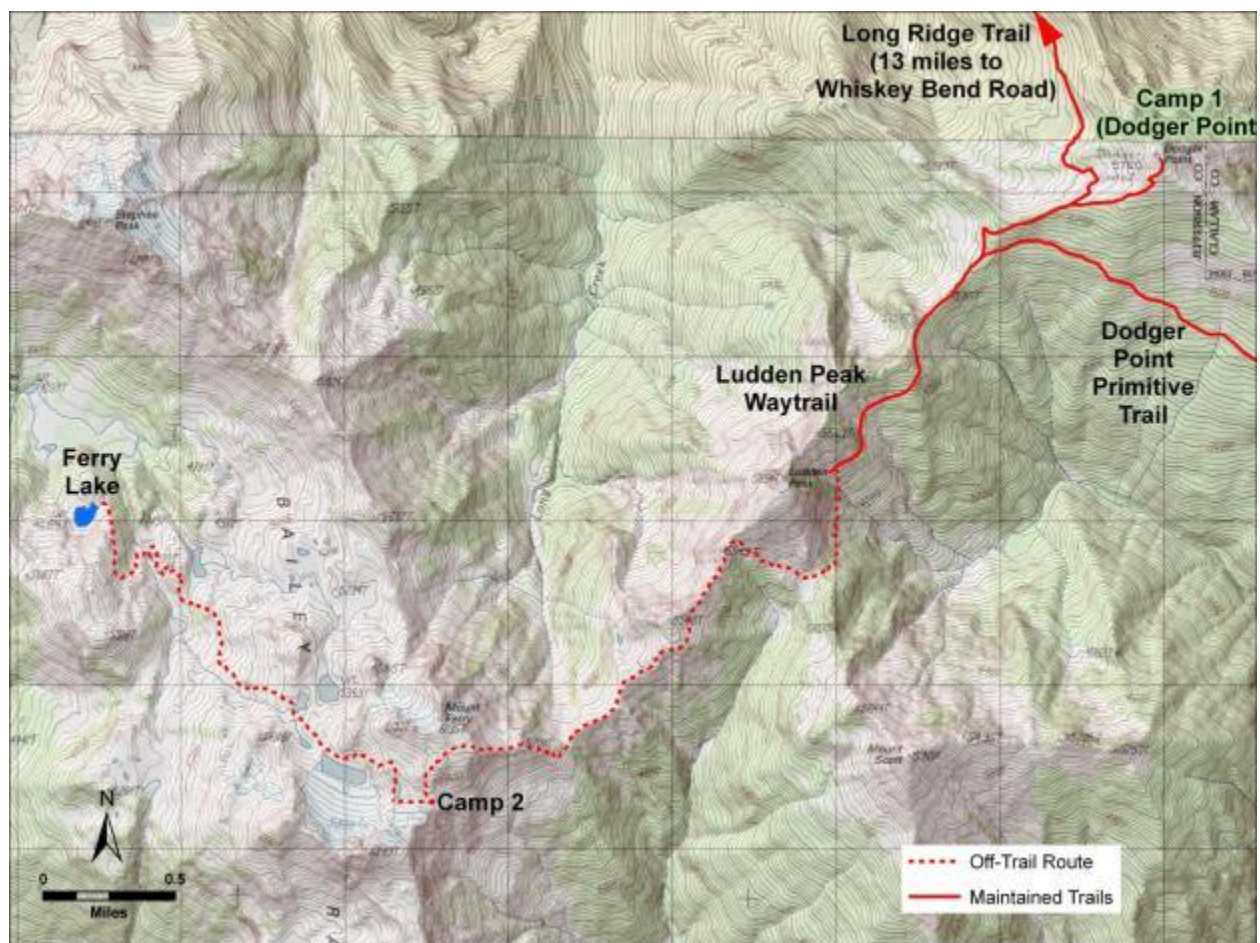


Figure 98. Hiking route to Ferry Lake, including main trails and cross country route.

Gladys Lake (106)

Olympic National Park

UTM Coordinates (NAD83): 473243 m E / 5302663 m N

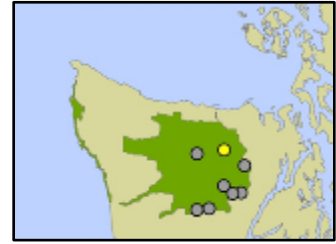


Figure 99. Gladys Lake looking northeast from a nearby ridge.

Geologic Setting

Gladys Lake is located in a cirque basin in the upper reaches of Grand Valley, a stair-stepped glacial trough, and is the highest in a chain of three lakes (Riedel and Dorsch in prep). The bedrock surrounding the lake is the Grand Valley lithic assemblage, which is composed of layered sandstone, semi-schist and shales (Tabor and Cady 1978). The lake is dammed by a glacial moraine on its northwest side; a feature which probably dates to the end of the last ice age. Along the southeast side of the lake, from the lake inlet to its outlet, the shoreline is composed of talus and scree. The outlet drains across a low point between the moraine and the talus field. Snow avalanches regularly reach the lake from the southeast but these events deposit little woody debris due to the lack of forested slopes above.

Watershed Description

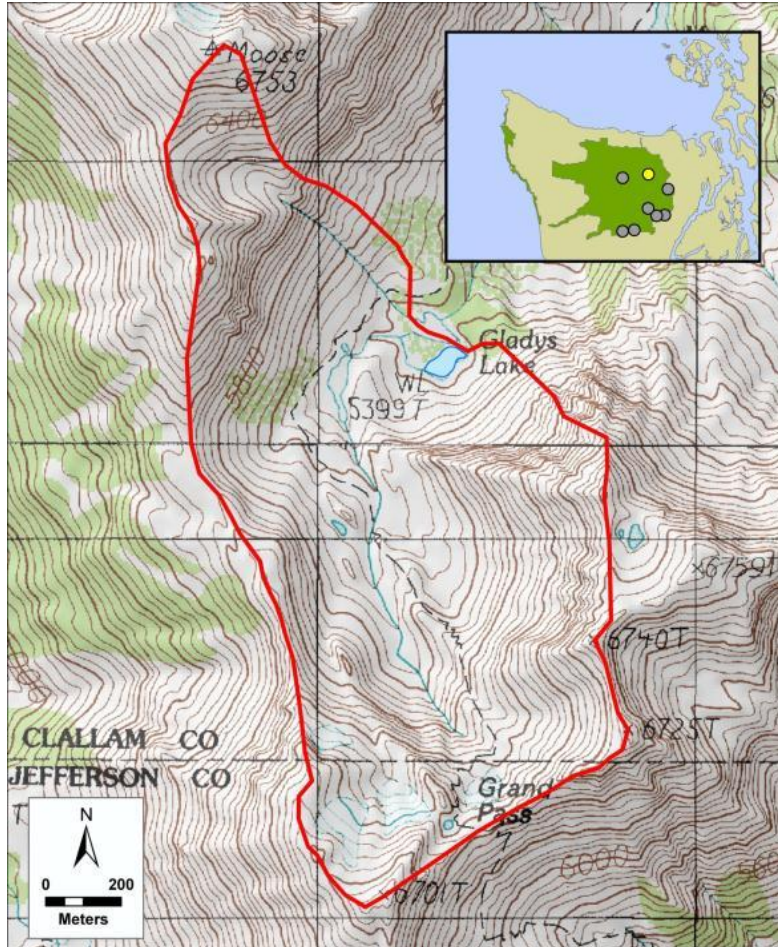


Figure 100. Gladys Lake watershed and surrounding area.

Table 51. Gladys Lake Morphometric data

Lake Parameter	Value
Elevation	1383 m (5387 ft)
Aspect	Northwest
Watershed Area	149.0 ha
Surface Area	.5 ha
Volume	6,633 m ³
Depth (maximum)	4.2 m
Depth (mean)	1.4 m
Depth (relative)	5.5%
Shoreline length	316 m
Lake length (maximum)	115 m
Lake width (maximum)	58 m
Watershed area: Lake Area (ratio)	324.0
Shoreline Development	1.31
Index of Basin Permanence	0.02

Physical/ Chemical Water Properties

Table 52. Water Quality and productivity parameters for Gladys Lake, September 30, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.04
Total Phosphorus	mg/l	0.001
Nitrogen & Phosphorus Ratio	N/A	40
NO ₃ +NO ₂ -N	mg/l	0.001
NH ₃ -N	mg/l	0.004
Anion & Cation Ratio	N/A	0.173
Acid Neutralizing Capacity	µeq/L	680
pH	None	7.6
Specific Conductance	µS/cm	110
Dissolved Organic Carbon	mg/l	0.50
Total Dissolved Solids	mg/l	70
Water Clarity		
Depth of Transparency	m	Bottom (4.6)
Chlorophyll		
Chlorophyll-a	µg/L	0.32

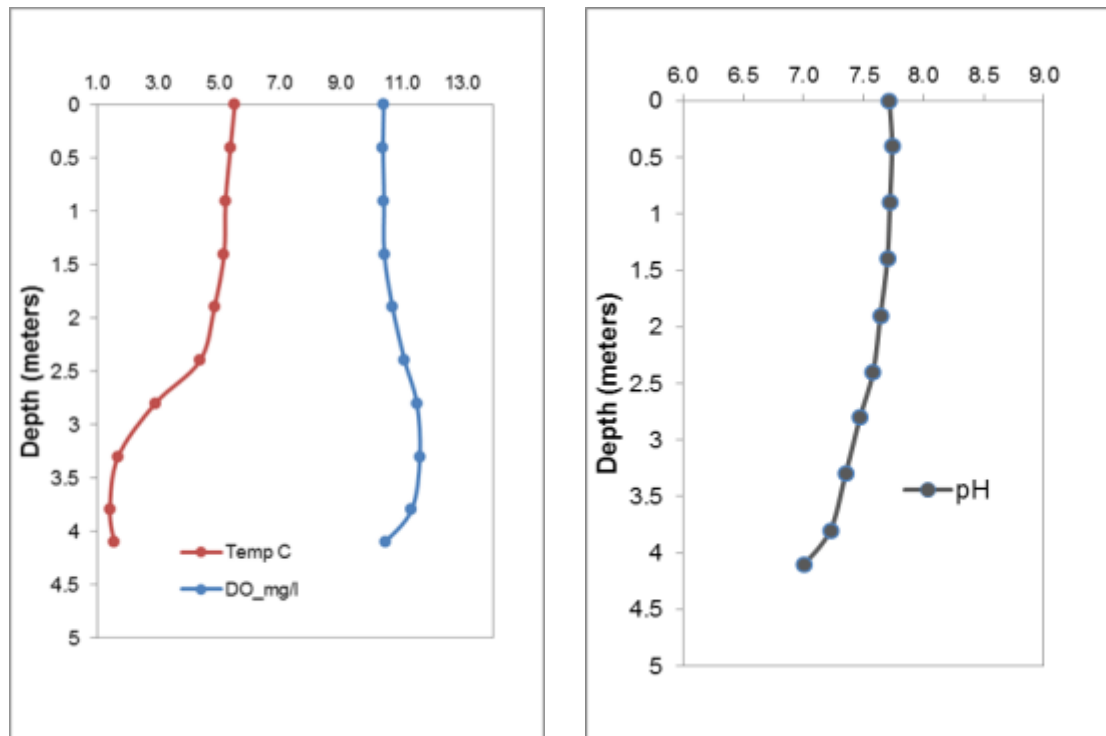


Figure 101. Dissolved oxygen, temperature and pH depth profiles from the deep-point Gladys Lake sampling station September 30, 2010.

Bathymetry & Shoreline Features

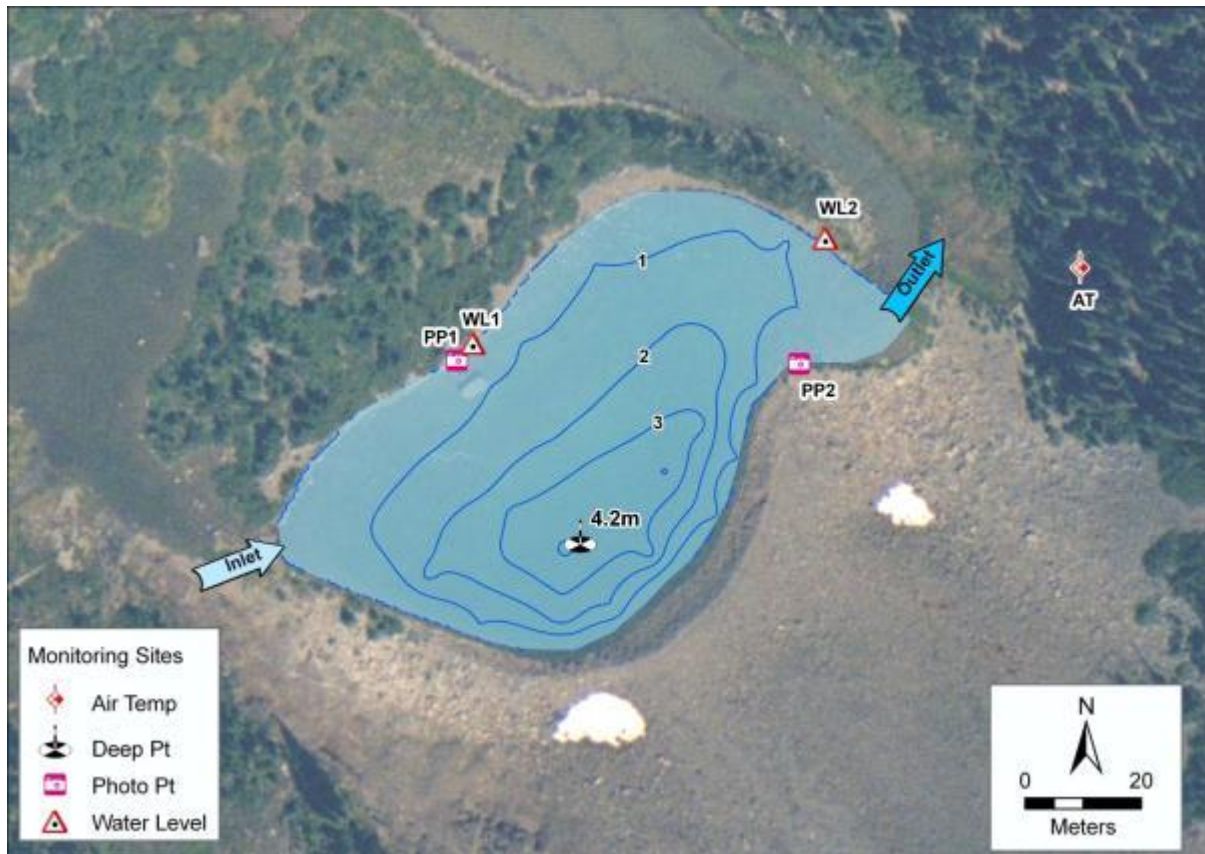


Figure 102. Bathymetry, shoreline features and sampling locations at Gladys Lake.

Amphibian & Fish Species

Table 53. Amphibian species observed at Gladys Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	2
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	5

Table 54. Introduced fish species observed at Gladys Lake (2010).

Species	Common Name	Species Code
<i>Salvelinus fontinalis</i>	Brook Trout	BRK

Watershed Panoramic Photos



Figure 103. Gladys Lake watershed panoramic photo (2010) from Photo Point 1 (see Figure 102).

98



Figure 104. Gladys Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 102).

Lake Access

A sampling trip to Gladys Lake generally requires 3 days. Day 1: Drive from Port Angeles to the Obstruction Point Trailhead (1 hr.). Hike 4.2 miles to Gladys Lake (2-3 hrs.). NOTE: Gladys Lake within Grand Valley, is a popular hiking destination with an established use quota. Crew must acquire a camping permit and reservation from the Wilderness Information Center well in advance of a planned trip.

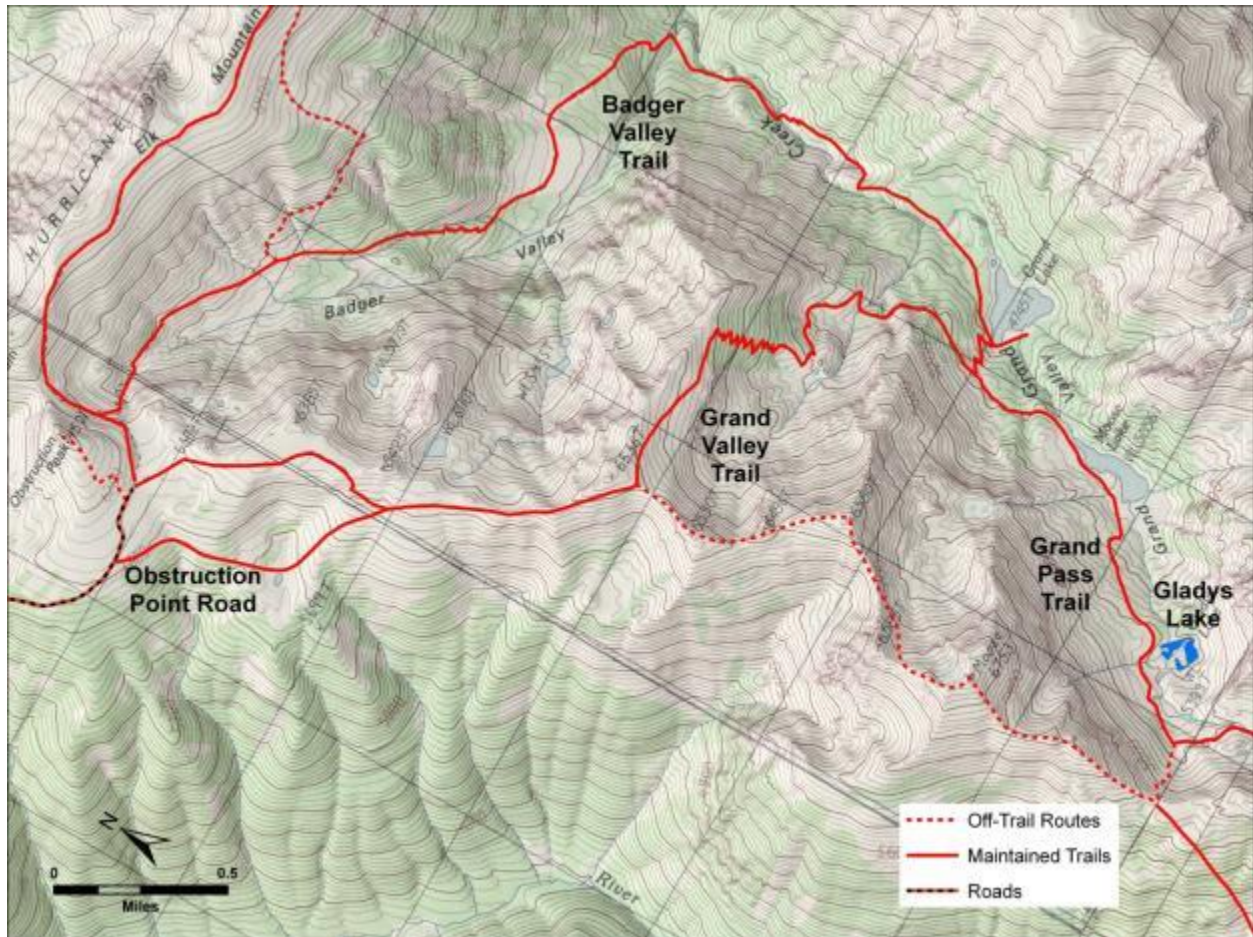


Figure 105. Hiking route to Gladys Lake.

Heather Lake (263)

Olympic National Park

UTM Coordinates (NAD83): 486670 m E / 5292448 m N

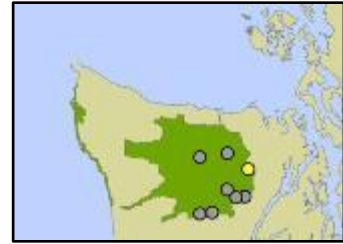


Figure 106. Heather Lake viewed from the ridge east of lake.

Geologic Setting

Heather Lake is the lower of two lakes which rest in a large, north-facing cirque basin in the headwaters of the Dungeness River. This cirque, containing extensive snow fields was carved by glaciers out of sedimentary rocks of the Grand Valley and Needles-Gray Wolf lithic assemblages (Tabor and Cady 1978). Surrounding bedrock is mostly thick sequences of semi-schist and sandstones. The lake shoreline is composed of glacial sediments that contain large boulders on the east side of the lake, a small alluvial fan/delta at the inlet on the south shore of the lake, and bedrock and colluvium slopes on the western side. The lake outlet is bedrock controlled and drains through a narrow bedrock notch, eventually flowing into Heather Creek (Riedel and Dorsch in prep).

Watershed Description

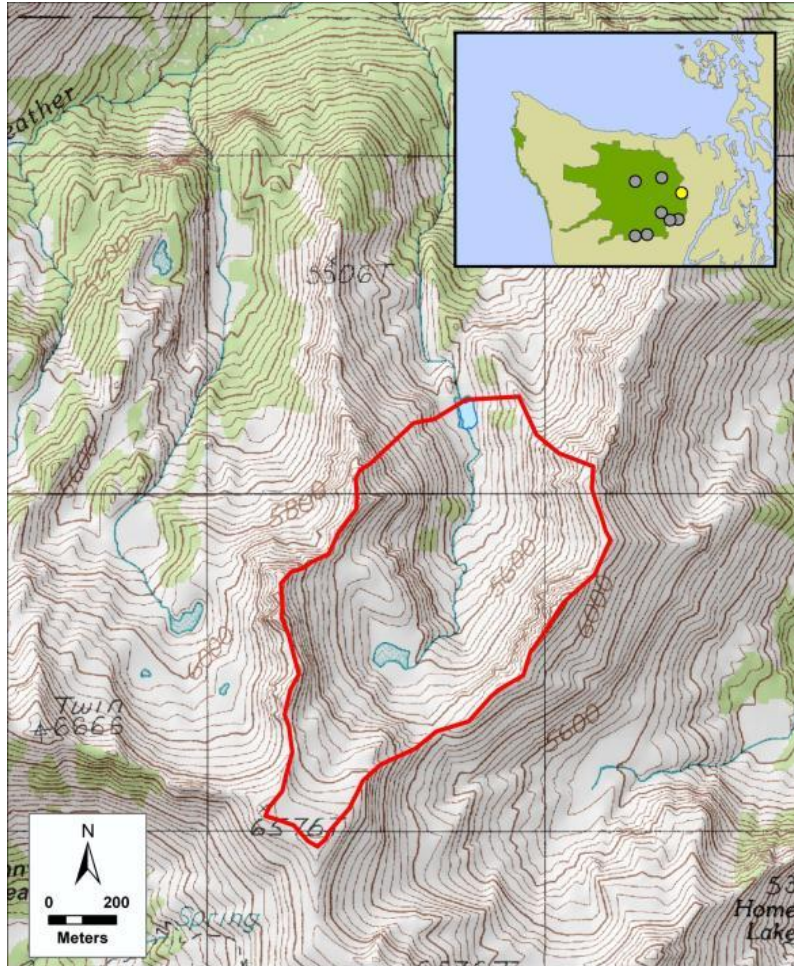


Figure 107. Heather Lake watershed and surrounding area.

Table 55: Heather Lake Morphometric data

Lake Parameter	Value
Elevation	1589 m (5215 ft)
Aspect	North
Watershed Area	73.9 ha
Surface Area	0.4 ha
Volume	8,087 m ³
Depth (maximum)	6.6 m
Depth (mean)	2.3 m
Depth (relative)	9.8%
Shoreline length	266 m
Lake length (maximum)	93 m
Lake width (maximum)	49 m
Watershed area: Lake Area (ratio)	210.6
Shoreline Development	1.26
Index of Basin Permanence	0.03

Physical/ Chemical Water Properties

Table 56. Water Quality and productivity parameters for Heather Lake, September 22, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.03
Total Phosphorus	mg/l	0.004
Nitrogen & Phosphorus Ratio	N/A	7.5
NO3+NO2-N	mg/l	0.010
NH3-N	mg/l	0.015
Anion & Cation Ratio	N/A	0.257
Acid Neutralizing Capacity	µeq/L	300
pH	None	8.1
Specific Conductance	µS/cm	50
Dissolved Organic Carbon	mg/l	0.12
Total Dissolved Solids	mg/l	35
Water Clarity		
Depth of Transparency	m	Bottom (6.6)
Chlorophyll		
Chlorophyll-a	µg/L	-0.01

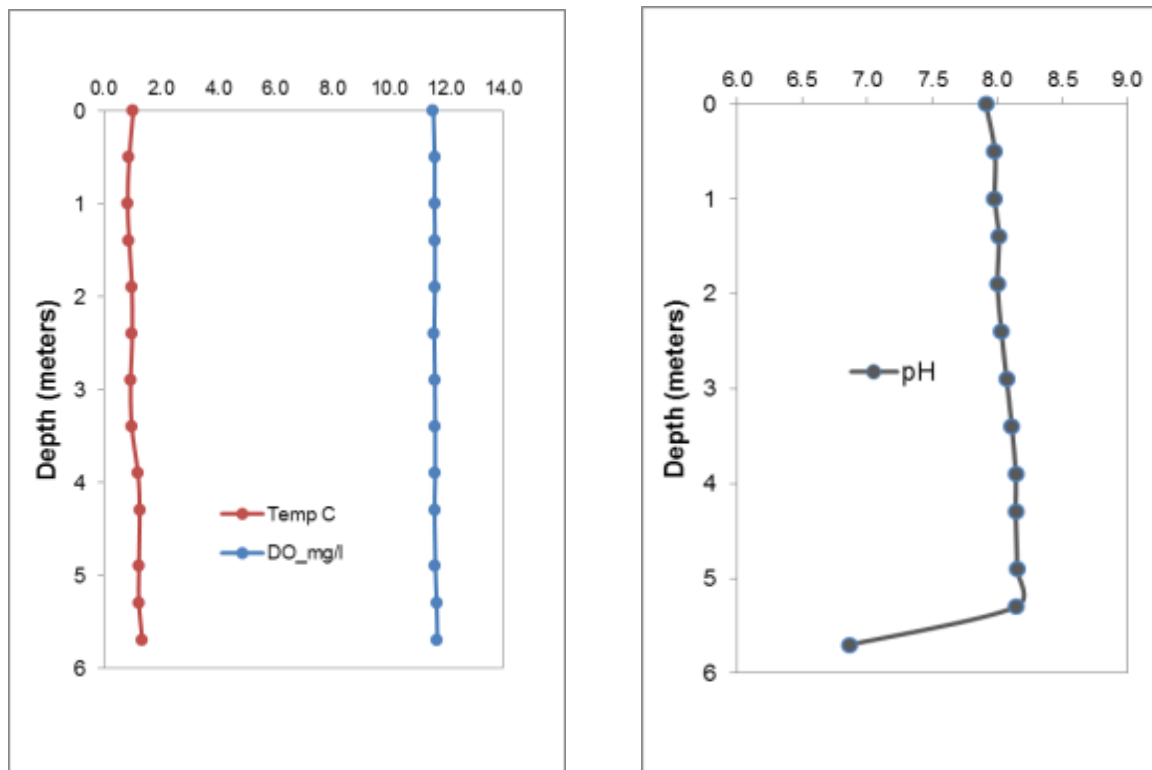


Figure 108. Dissolved oxygen, temperature and pH depth profiles from the deep-point Heather Lake sampling station September 22, 2010.

Bathymetry & Shoreline Features

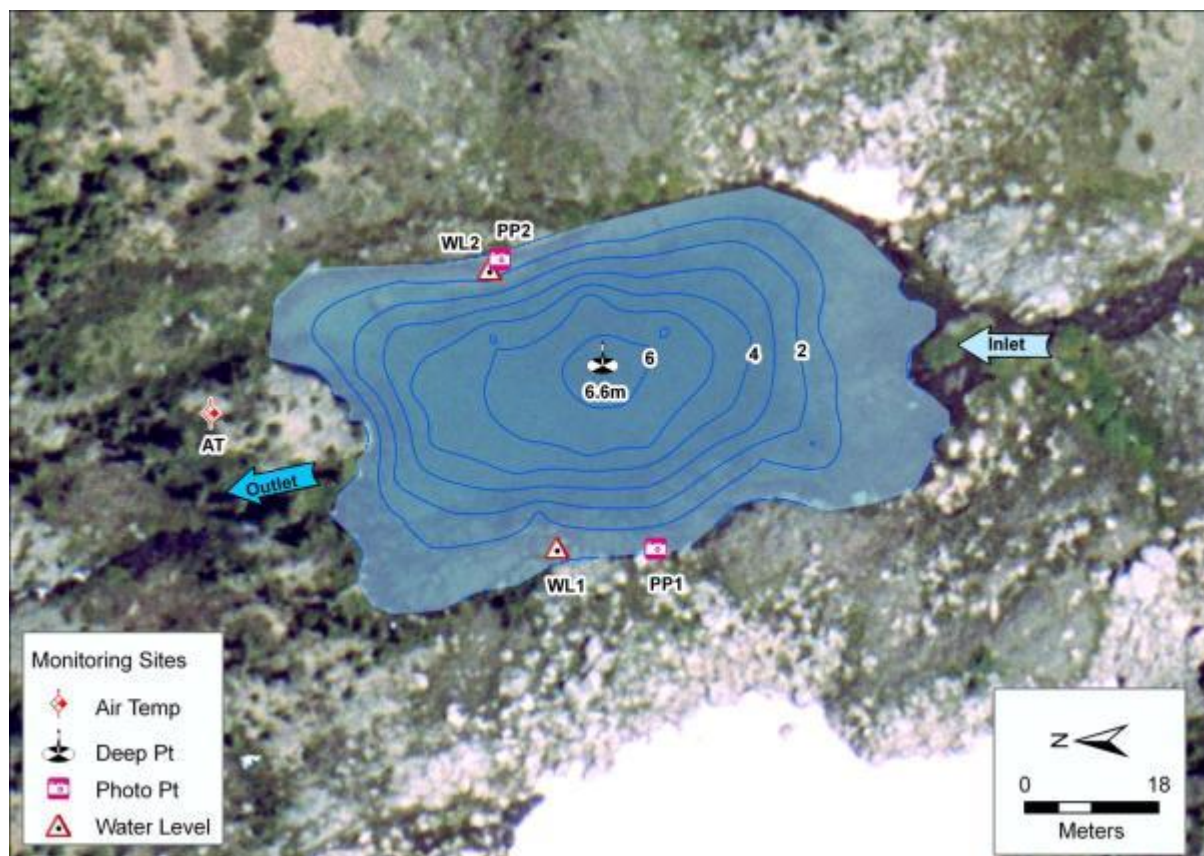


Figure 109. Bathymetry, shoreline features and sampling locations at Heather Lake.

Amphibian & Fish Species

Table 57. Amphibian species observed at Heather Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
None	--	--	--	--

Table 58. Introduced fish species observed at Heather Lake (2010).

Species	Common Name	Species Code
Oncorhynchus mykiss	Rainbow Trout	RBT

Watershed Panoramic Photos



Figure 110. Heather Lake watershed panoramic photo (2010) from Photo Point 1 (see. Figure 109).



Figure 111. Heather Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 109).

Lake Access

A sampling trip to Ferry Lake requires a minimum of 3 days. Day 1: From the Dungeness Forks Trailhead on the USGS Road 2860, hike 1 mile to the Dungeness River (.5 hrs). Follow the trail 2.4 miles to Camp Handy (1 hr.). At .3 miles beyond Camp Handy, watch to the right for a junction with the Heather Creek way trail. Follow this way trail 3.8 miles to a large meadow just beyond the National Park Service boundary (3 hours). An established campsite is adjacent to the creek on the east side of the meadow. Total hiking time is 4 to 5 hours. Day 2: Ford Heather Creek at the campsite and climb a steep cross-country route to Heather Lake (2 hrs.).

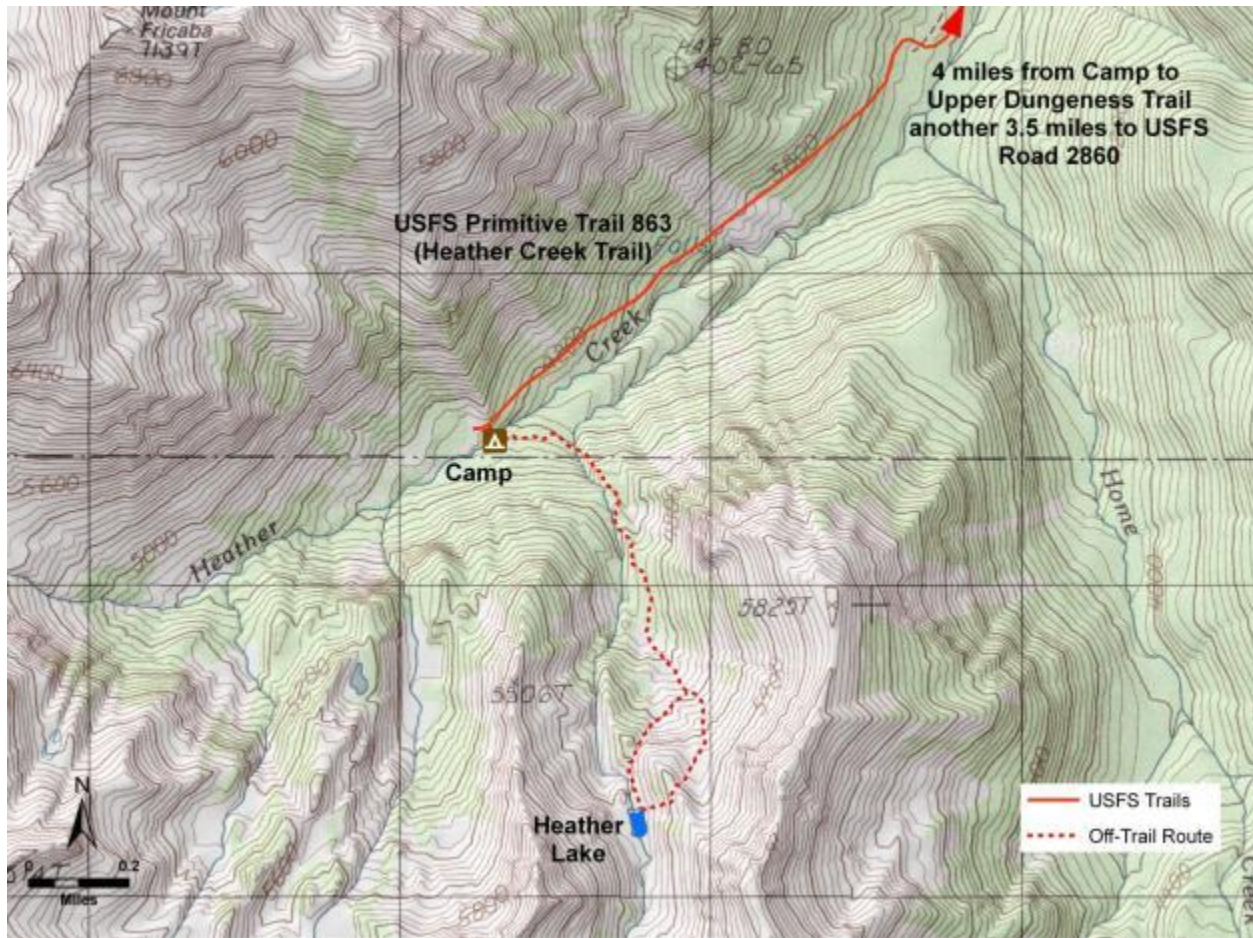


Figure 112. Hiking route to Heather Lake, including main trails and cross country route.

Milk Lake (498)

Olympic National Park

UTM Coordinates (NAD83): 484442 m E / 5274562 m N

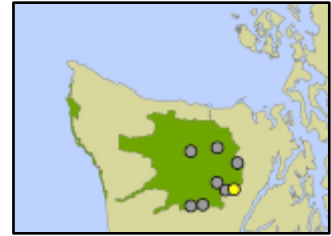


Figure 113. Milk Lake with Mt. Bretherton in background.

Geologic Setting

Milk Lake lies in a deep, narrow cirque basin on the north face of Mount Bretherton. The bedrock of the lake watershed is composed of pillow basalts typical of the Crescent Formation, as well as sandstone and argillite of the Blue Mountain unit (Tabor and Cady 1978). The inlet to the lake drains a perennial snowfield that was likely a glacier at the end of the last ice age (Riedel and Dorsch in prep). This glacier descended into the lake basin and appears to have left a moraine on a resistant bedrock ridge that splits the lake bed into two separate basins. This forested ridge can be traced from the lake bed along the east shore at the southeast end of the lake. Shorelines of the lake are thin glacial sediments and bedrock along the northern two thirds of the lake, and talus and scree at the south end. The lake's outlet cuts through a glacial moraine at the north end, then cascades downward to Upper Lena Lake lower in the basin.

Watershed Description

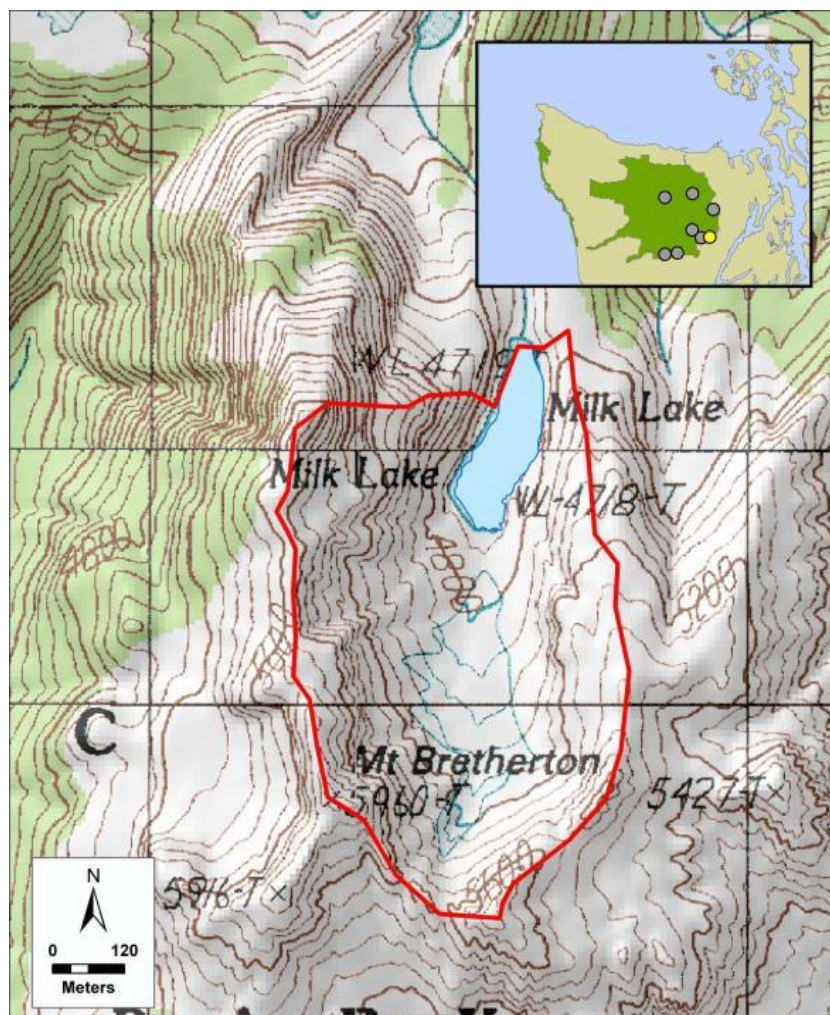


Figure 114. Milk Lake watershed and surrounding area.

Table 59. Milk Lake Morphometric data

Lake Parameter	Value
Elevation	1435 m (4708 ft)
Aspect	North
Watershed Area	40.9 ha
Surface Area	2.3 ha
Volume	129,854 m ³
Depth (maximum)	13.9 m
Depth (mean)	5.6 m
Depth (relative)	8.1%
Shoreline length	456 m
Lake length (maximum)	314 m
Lake width (maximum)	98 m
Watershed area: Lake Area (ratio)	17.7
Shoreline Development	0.84
Index of Basin Permanence	0.29

Physical/ Chemical Water Properties

Table 60. Water Quality and productivity parameters for Milk Lake, September 15, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.07
Total Phosphorus	mg/l	0.006
Nitrogen & Phosphorus Ratio	N/A	11.7
NO ₃ +NO ₂ -N	mg/l	0.0
NH ₃ -N	mg/l	0.007
Anion & Cation Ratio	N/A	0.052
Acid Neutralizing Capacity	µeq/L	330
pH	None	7.3
Specific Conductance	µS/cm	50
Dissolved Organic Carbon	mg/l	0.36
Total Dissolved Solids	mg/l	30
Water Clarity		
Depth of Transparency	m	1.4
Chlorophyll		
Chlorophyll-a	µg/L	0.32

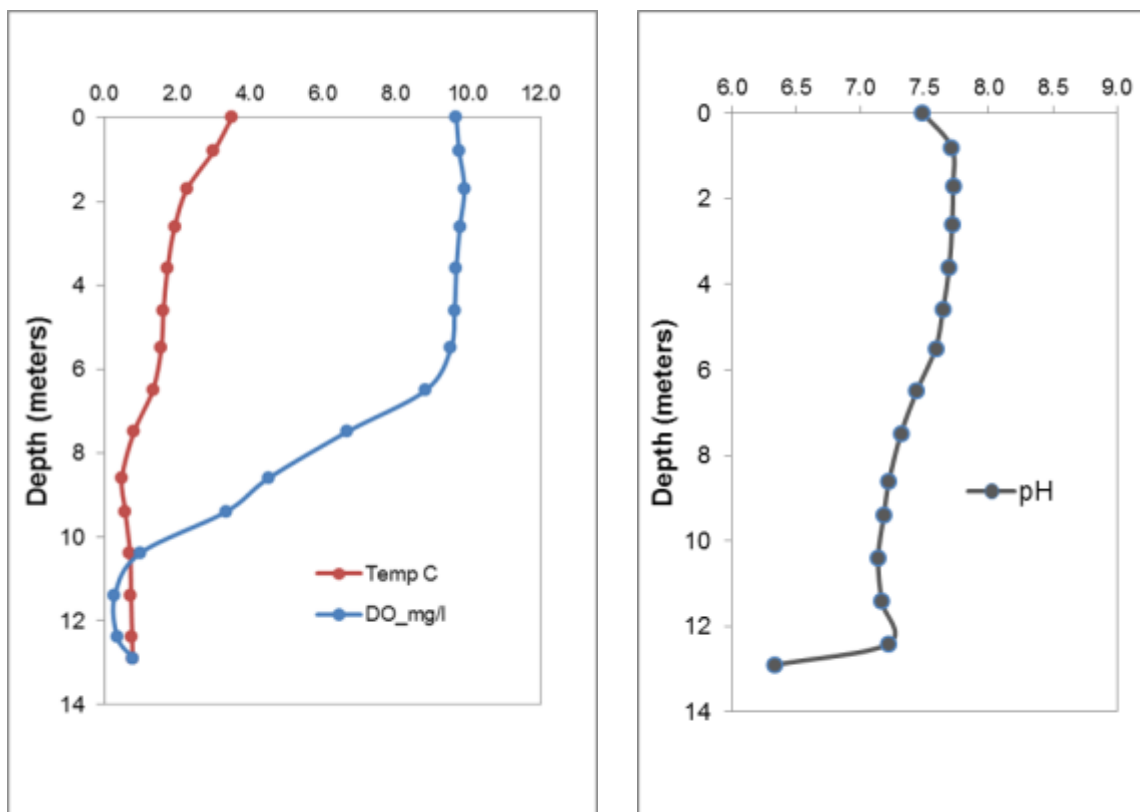


Figure 115. Dissolved oxygen, temperature and pH depth profiles from the deep-point Milk Lake sampling station September 15, 2010.

Bathymetry & Shoreline Features

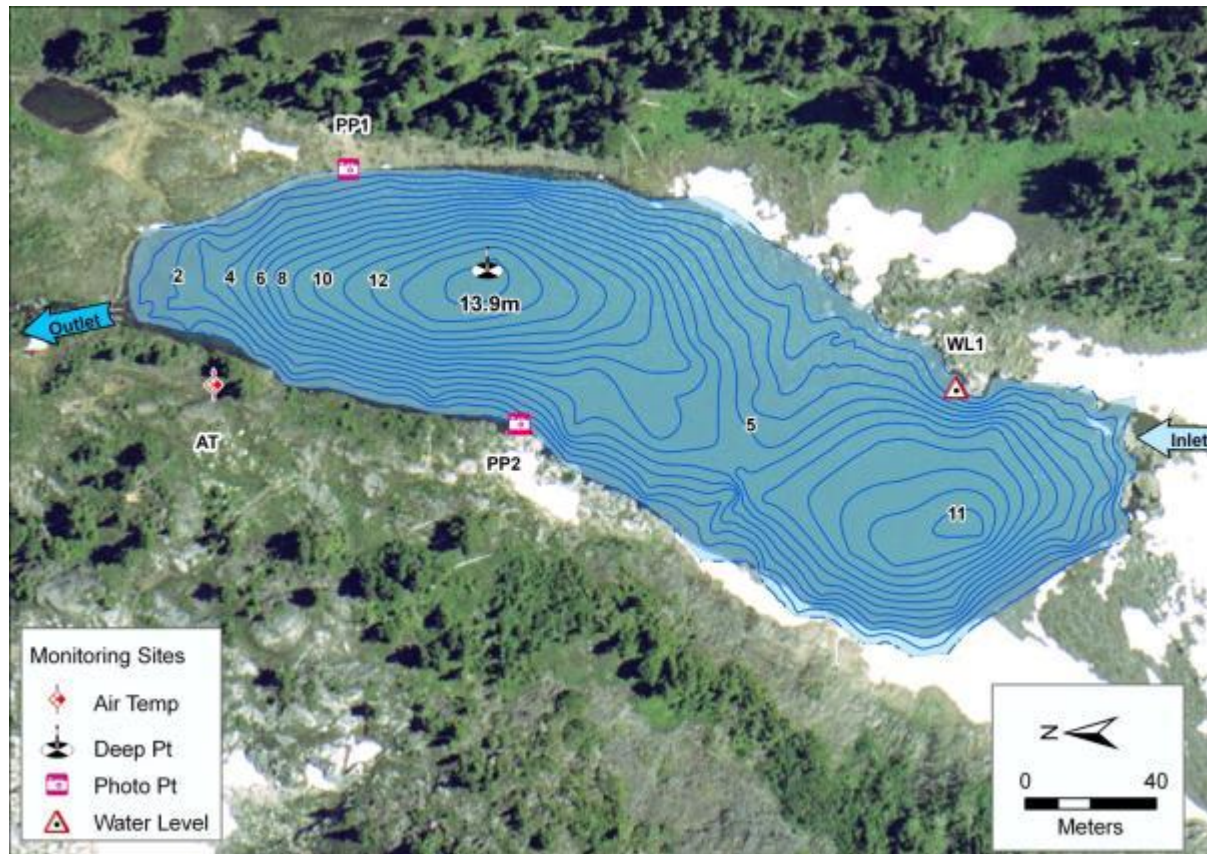


Figure 116. Bathymetry, shoreline features and sampling locations at Milk Lake.

Amphibian & Fish Species

Table 61. Amphibian species observed at Milk Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	6

Table 62. Introduced fish species observed at Milk Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 117. Milk Lake watershed panoramic photo (2010) from Photo Point 1 (see Figure 116).



Figure 118. Milk Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 116).

Lake Access

A sampling trip to Milk Lake requires a minimum of 3 days. Day 1: From the Lena Lake Trailhead on the USFS Road 25, hike 3 miles to the trail junction above Lena Lake (1.5 hrs.). Follow the left branch of the trail 3.9 miles to Upper Lena Lake (3 hrs.). Camp at one of the established campsites on the east side of the lake. Total hiking time is 4 to 5 hours. Day 2: From the southeast corner of Upper Lena Lake, follow a short way trail adjacent to a creek, up to Milk Lake (.5 hrs.). NOTE: Upper Lena Lake is a popular hiking destination with an established use quota. Crew must acquire a camping permit and reservation from the Wilderness Information Center well in advance of a planned trip.

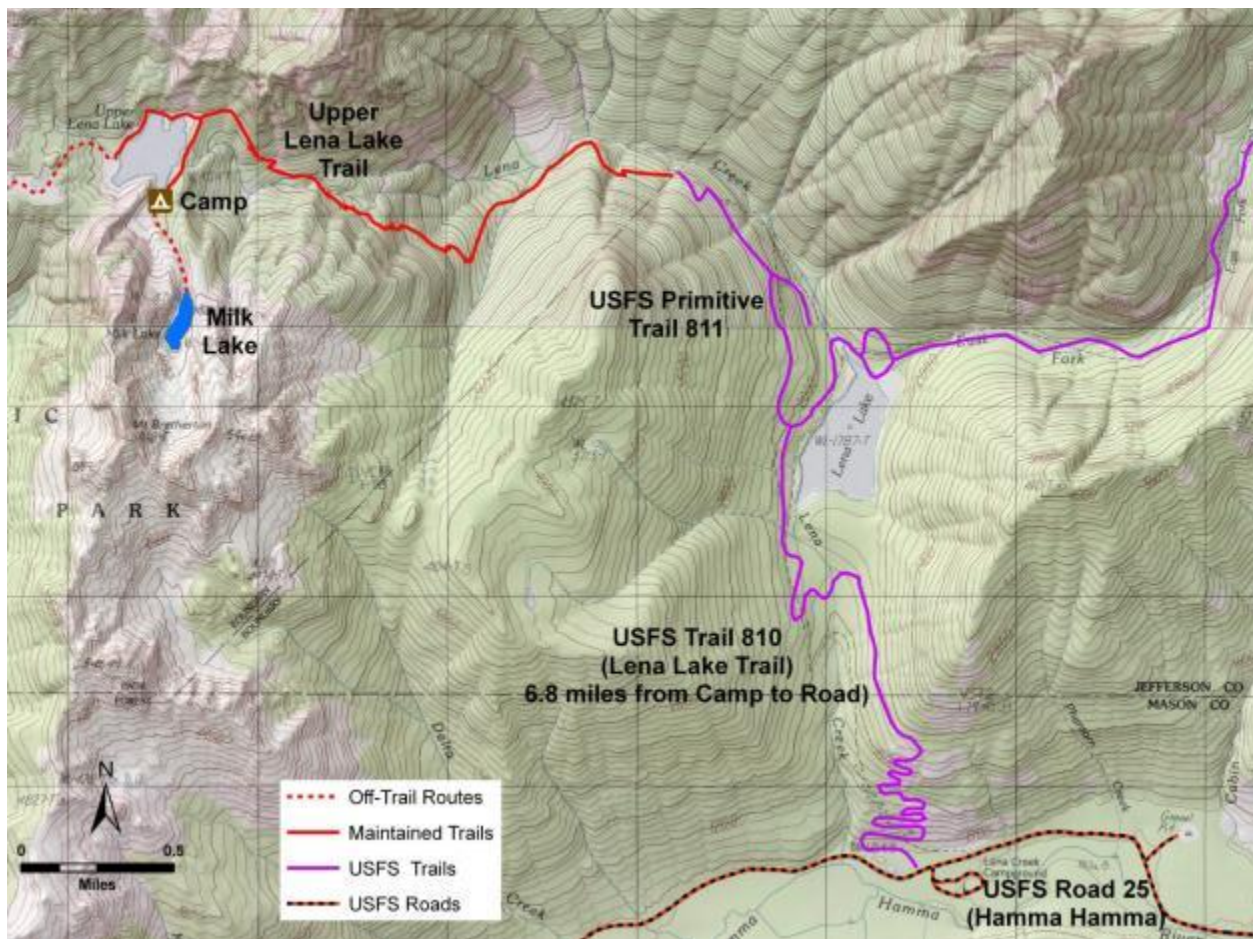


Figure 119. Hiking route to Milk Lake, including main trails and cross country route.

Crazy Lake (426)

Olympic National Park

UTM Coordinates (NAD83): 478933 m E / 5274073 m N

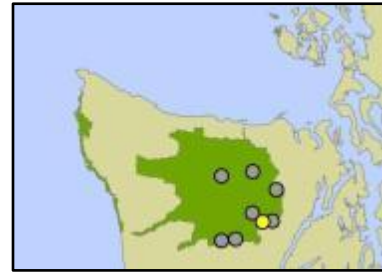


Figure 120. Crazy Lake looking south toward Mt. Skokomish. The haze is from a wildfire burning in the Duckabush Valley in September 2011.

Geologic Setting

Crazy Lake occurs in a long, narrow cirque cut along the Southern Fault Zone from the thickly bedded sandstones and semi-schist rocks of the Southern Core (Tabor and Cady 1978). Glaciers have probably not occupied this cirque since the last ice age. Shorelines are composed mainly of bedrock, talus and colluvium, although there appear to be thinly deposited glacial sediments on the bedrock lip controlling the outflow of the lake (Riedel and Dorsch in prep). The lake has no distinct inlet, but is fed from snowmelt and subsurface streams flowing beneath the coarse talus hillsides.

Watershed Description

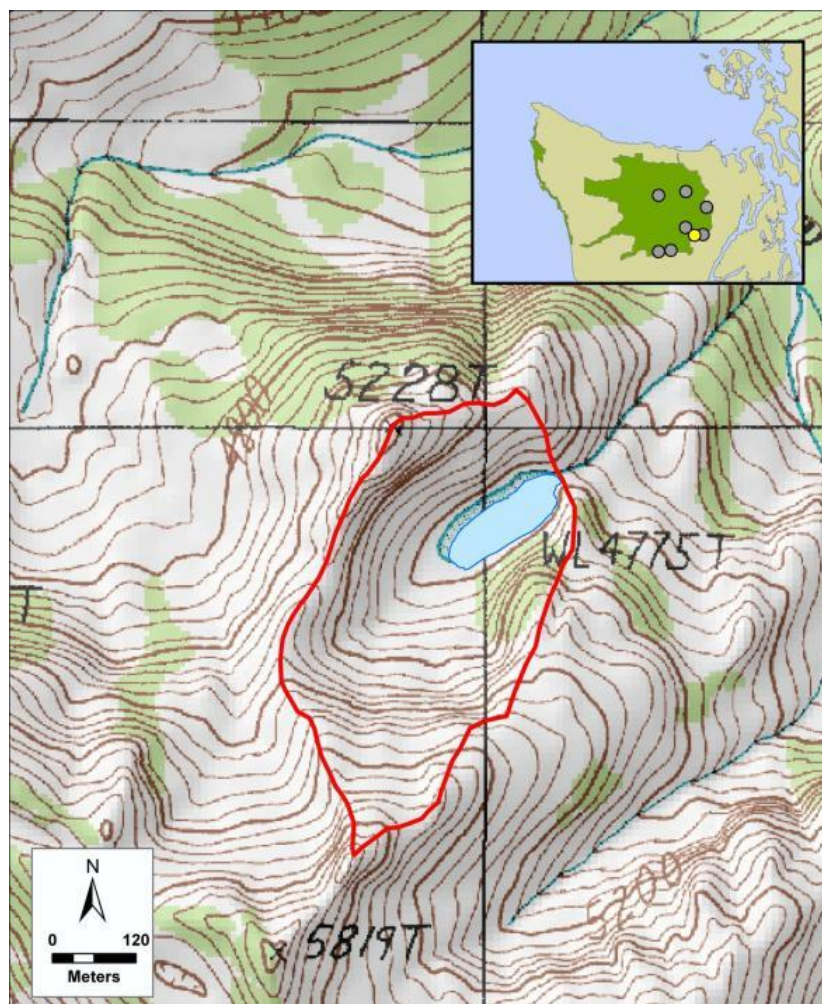


Figure 121. Crazy Lake watershed and surrounding area.

Table 63. Crazy Lake Morphometric data

Lake Parameter	Value
Elevation	1457 m (4779 ft)
Aspect	Northeast
Watershed Area	16.8 ha
Surface Area	1.0 ha
Volume	37,924 m ³
Depth (maximum)	7.7 m
Depth (mean)	3.8 m
Depth (relative)	6.8%
Shoreline length	439 m
Lake length (maximum)	195 m
Lake width (maximum)	62 m
Watershed area: Lake Area (ratio)	16.8
Shoreline Development	1.24
Index of Basin Permanence	0.09

Physical/ Chemical Water Properties

Table 64. Water Quality and productivity parameters for Crazy Lake, August 18, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.03
Total Phosphorus	mg/l	0.002
Nitrogen & Phosphorus Ratio	N/A	15
NO ₃ +NO ₂ -N	mg/l	0.0
NH ₃ -N	mg/l	0.005
Anion & Cation Ratio	N/A	0.056
Acid Neutralizing Capacity	µeq/L	300
pH	None	7.3
Specific Conductance	µS/cm	40
Dissolved Organic Carbon	mg/l	0.27
Total Dissolved Solids	mg/l	26
Water Clarity		
Depth of Transparency	m	Bottom (7.6)
Chlorophyll		
Chlorophyll-a	µg/L	0.14

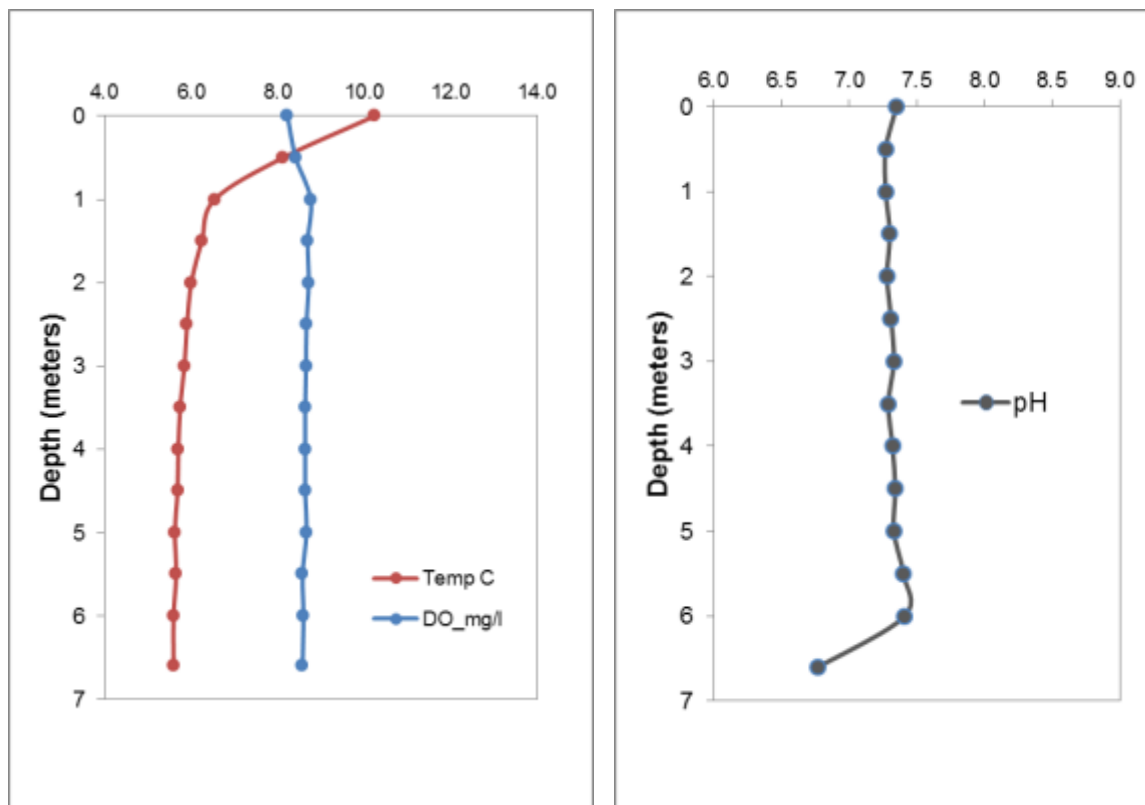


Figure 122. Dissolved oxygen, temperature and pH depth profiles from the deep-point Crazy Lake sampling station August 18, 2010.

Bathymetry & Shoreline Features

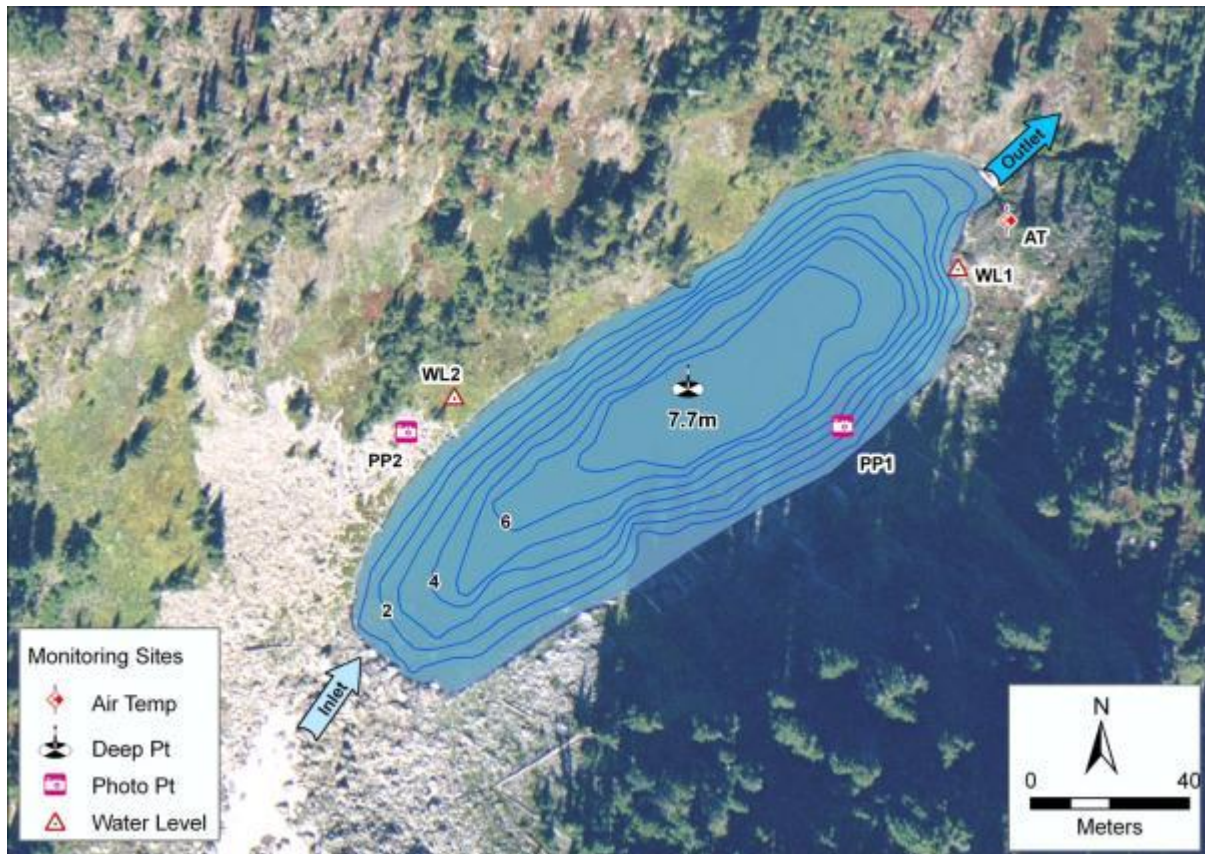


Figure 123. Bathymetry, shoreline features and sampling locations at Crazy Lake.

Amphibian & Fish Species

Table 65. Amphibian species observed at Crazy Lake (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMMA	Paedomorph	20
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	5
<i>Hyla regilla</i>	Pacific Tree Frog	HYRE	Egg Mass	2

Table 66. Introduced fish species observed at Crazy Lake (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 124. Crazy Lake watershed panoramic photo (2010) from Photo Point 1 (see Figure 123).



Figure 125. Crazy Lake watershed panoramic photo (2010) from Photo Point 2 (see Figure 123).

Lake Access

A sampling trip to Crazy Lake requires a minimum of 3 days. Day 1: From the Lake of the Angels (Putvin Way Trail) trailhead on the USFS Road 25, hike 3.6 miles steep miles to Lake of the Angels (3.5 hrs.). Continue to climb and cross over the low saddle between Mt. Skokomish and Mt. Stone, and traverse talus slopes north to Stone Arrow Pass (1 hr.). Glissade steep snow fields to Hagen Lake and camp in established campsites (.5 hr.). Day 2: Follow discernible way trails west first to a small lake, then beyond to Crazy Lake (1 hr.).

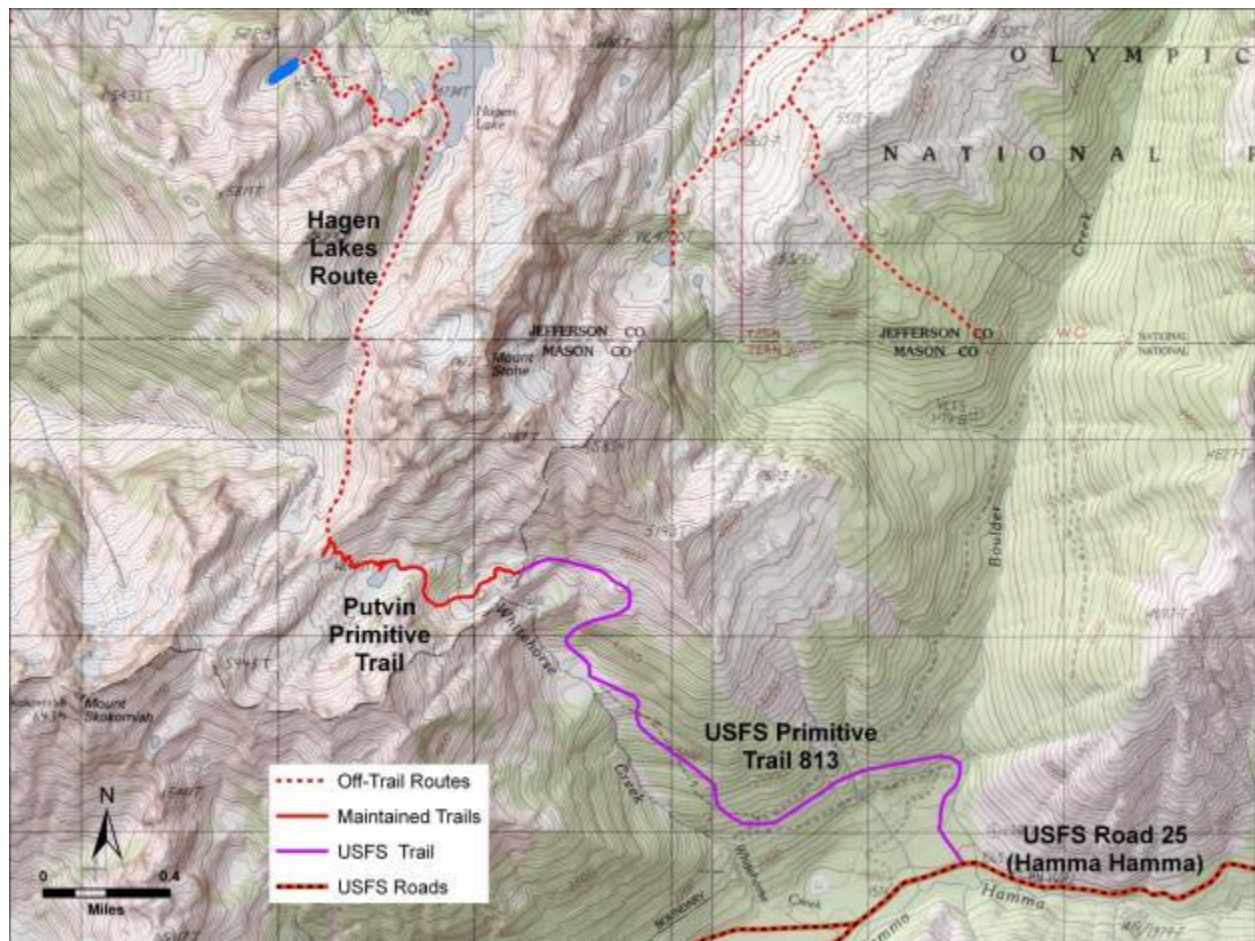


Figure 126. Hiking route to Crazy Lake, including main trails and cross country route.

Lake La Crosse (520)

Olympic National Park

UTM Coordinates (NAD83): 472944 m E / 5279102 m N

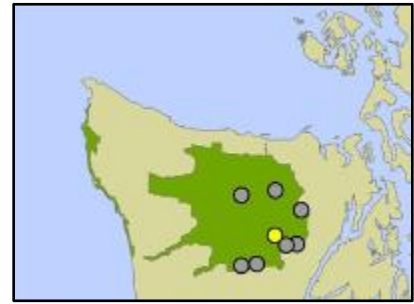


Figure 127. Lake La Crosse and the upper La Crosse Basin.

Geologic Setting

Lake LaCrosse is located in the headwaters of the Duckabush River, in an area of slate and phyllite bedrock that are a part of the Elwha Lithic Assemblage (Tabor and Cady 1978). Ice age glaciers carved the broad cirque that contains the lake basin (Riedel and Dorsch in prep). A glacial moraine that dams the basin to create the lake is therefore likely late-glacial in age, or about 12,000 years old. Shorelines are composed mainly of glacial till on the eastern shore, and bedrock and colluvium on the west side of the lake. The lake inlet has formed a prominent alluvial fan/delta at the north end of the lake, which is flat and stands as a low terrace above the lake. The outlet to the lake cuts across a low point in a moraine then exits the basin as a shallow, meandering stream.

Watershed Description

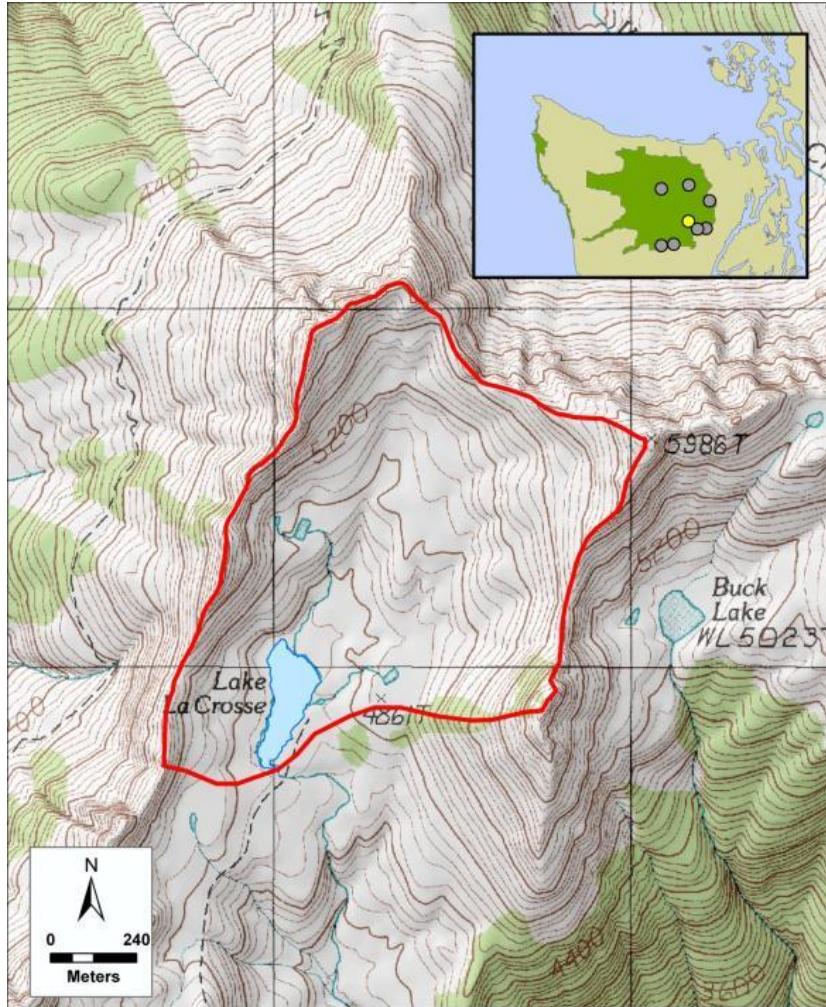


Figure 128. Lake La Crosse watershed and surrounding area.

Table 67. Lake La Crosse Morphometric data

Lake Parameter	Value
Elevation	1447 m (4749 ft)
Aspect	Southwest
Watershed Area	107.1 ha
Surface Area	3.1 ha
Volume	107,073 m ³
Depth (maximum)	8.0 m
Depth (mean)	3.5 m
Depth (relative)	4.1%
Shoreline length	851 m
Lake length (maximum)	362 m
Lake width (maximum)	143 m
Watershed area: Lake Area (ratio)	35.0
Shoreline Development	1.37
Index of Basin Permanence	0.13

Physical/ Chemical Water Properties

Table 68. Water Quality and productivity parameters for La Crosse Lake, September 9, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.03
Total Phosphorus	mg/l	0.002
Nitrogen & Phosphorus Ratio	N/A	15
NO ₃ +NO ₂ -N	mg/l	0.0
NH ₃ -N	mg/l	0.006
Anion & Cation Ratio	N/A	0.185
Acid Neutralizing Capacity	µeq/L	210
pH	None	7.8
Specific Conductance	µS/cm	40
Dissolved Organic Carbon	mg/l	0.28
Total Dissolved Solids	mg/l	23
Water Clarity		
Depth of Transparency	m	Bottom (8.0)
Chlorophyll		
Chlorophyll-a	µg/L	0.1

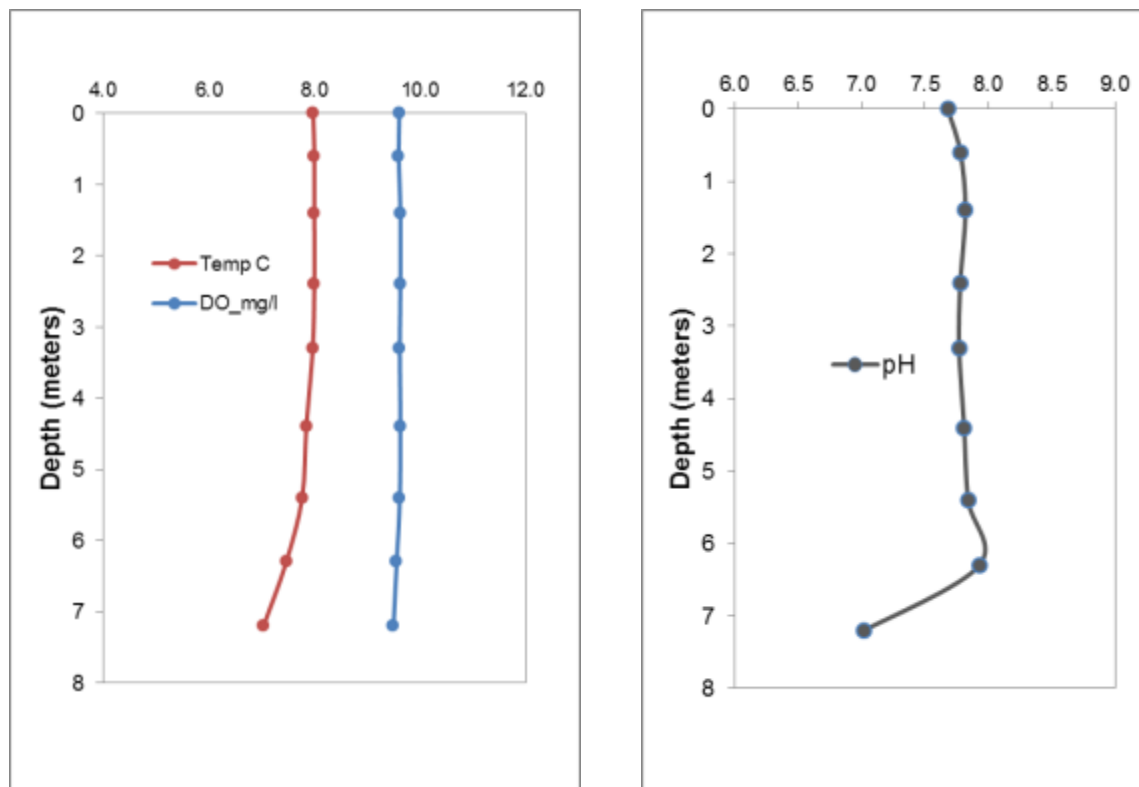


Figure 129. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake La Crosse sampling station September 9, 2010.

Bathymetry & Shoreline Features

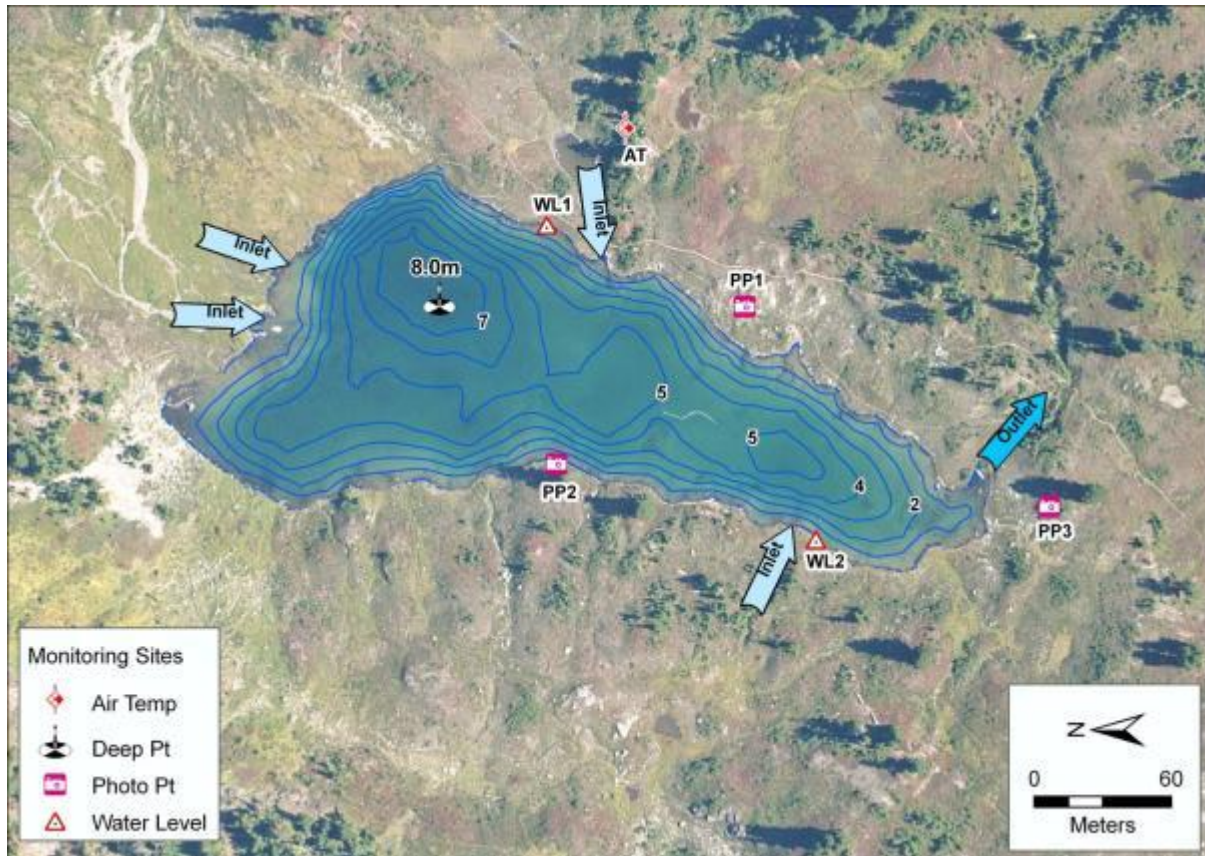


Figure 130. Bathymetry, shoreline features and sampling locations at Lake La Crosse.

Amphibian & Fish Species

Table 69. Amphibian species observed at Lake La Crosse (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Paedomorph	6
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Larvae	3
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Adult	1
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Paedomorph	2
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	7
<i>Rana cascadae</i>	Cascades Frog	RACA	Juvenile	1
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	43
<i>Bufo boreas</i>	Western Toad	BUBO	Dead	1

Table 70. Introduced fish species observed at Lake La Crosse (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 131. Lake La Crosse watershed panoramic photo (2011) from Photo Point 1 (see. Figure 130).

122



Figure 132. Lake La Crosse watershed panoramic photo (2011) from Photo Point 4 (see Figure 130).

Lake Access

A sampling trip to Lake La Crosse requires 4-5 days. Day 1: From the Graves Creek Trailhead at the Quinault, hike 13.3 miles to the Enchanted Valley (5-6 hrs.) and camp. Day 2: Climb 3.2 miles to the junction with the O'Neil Pass trail. Hike less than a mile past White Creek, then take the Ranger Pass way trail south over the low saddle and into La Crosse Basin. Descend to Lake La Crosse (4 hrs.).

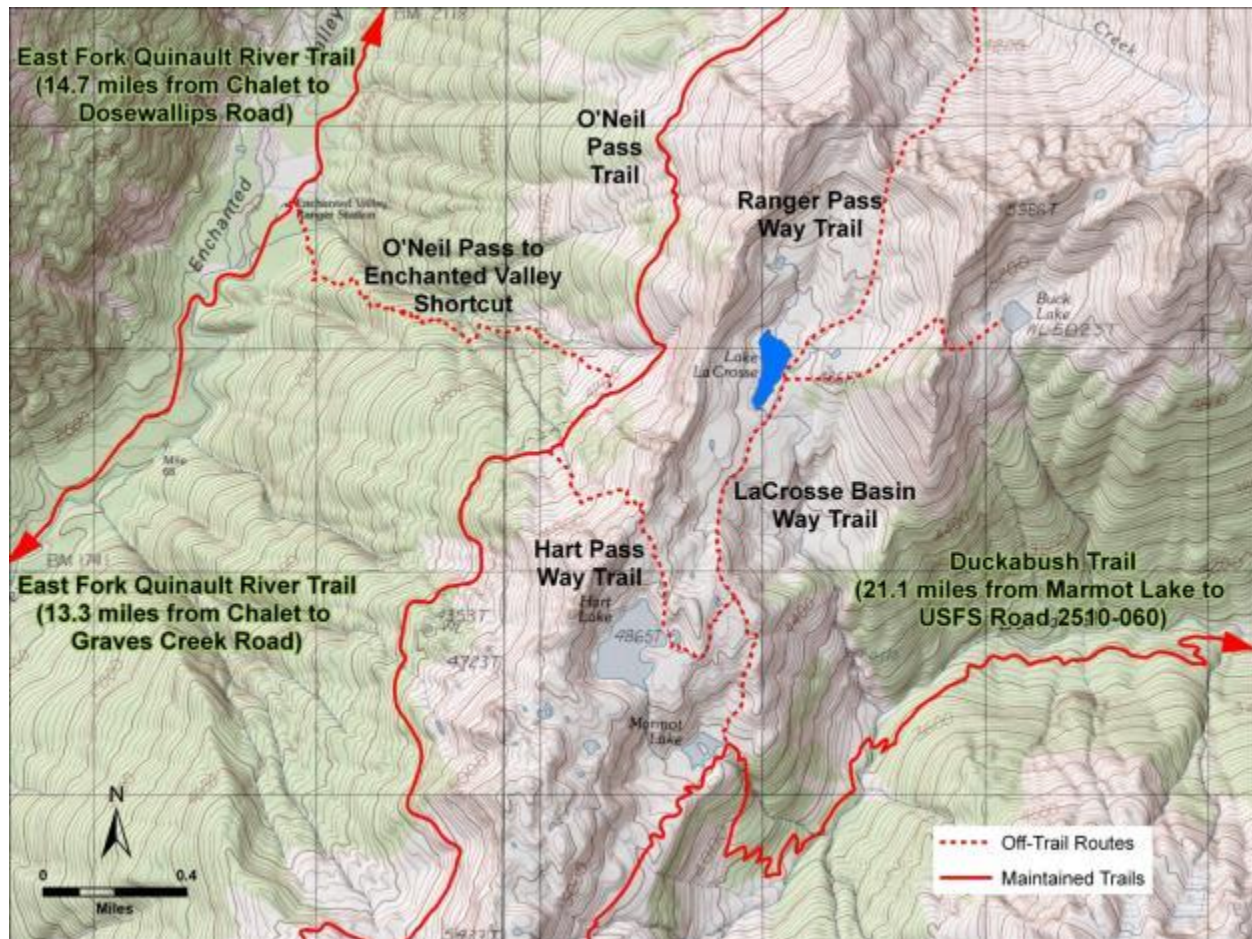


Figure 133. Hiking route to Lake LaCrosse, including main and way trails.

Lake Sunup (623)

Olympic National Park

UTM Coordinates (NAD83): 463405 m E / 5264336 m N

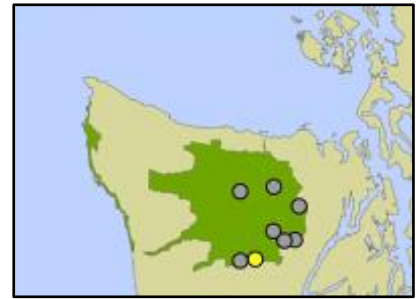


Figure 134. Lake Sunup from western shore.

Geologic Setting

The Lake Sunup watershed drains an area of basalt and basaltic sandstones (Tabor and Cady 1978). The lake rests in a small cirque basin cut by glaciers during multiple ice ages, but which has not been occupied by glacial ice for at least 12,000 years (Riedel and Dorsch in prep). Lake shores are composed mainly of bedrock and colluvium, and small patches of glacial sediment. There is a poorly developed alluvial/fan where small inlets drain a shallow, wet slope on the south shore of the lake. The lake outlet is controlled by a bedrock lip, where a stream plunges over a steep drop into Six Stream and eventually the North Fork Skokomish River.

Watershed Description

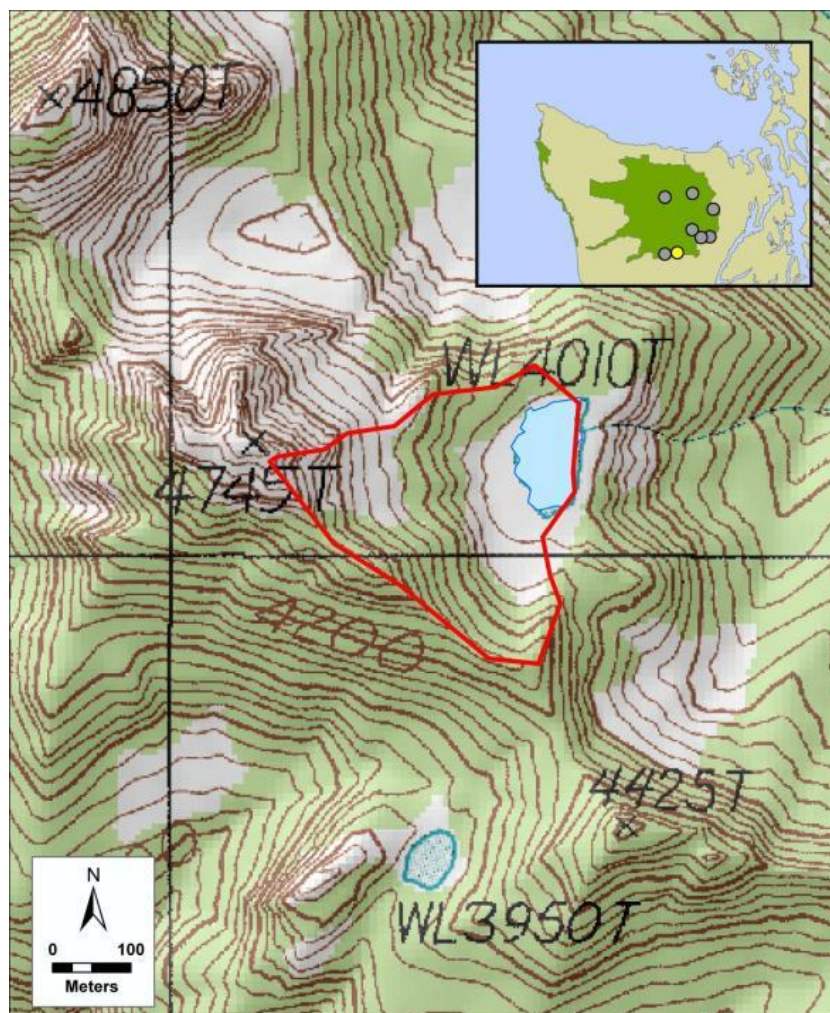


Figure 135. Lake Sunup watershed and surrounding area.

Table 71. Lake Sunup Morphometric data

Lake Parameter	Value
Elevation	1224 m (4015 ft)
Aspect	East
Watershed Area	9.8 ha
Surface Area	0.9 ha
Volume	26,586 m ³
Depth (maximum)	6.0 m
Depth (mean)	2.9 m
Depth (relative)	5.5%
Shoreline length	406 m
Lake length (maximum)	155 m
Lake width (maximum)	85 m
Watershed area: Lake Area (ratio)	10.6
Shoreline Development	1.19
Index of Basin Permanence	0.07

Physical/ Chemical Water Properties

Table 72. Water Quality and productivity parameters for Lake Sunup, August 12, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.06
Total Phosphorus	mg/l	0.002
Nitrogen & Phosphorus Ratio	N/A	30
NO ₃ +NO ₂ -N	mg/l	0.0
NH ₃ -N	mg/l	0.013
Anion & Cation Ratio	N/A	0.123
Acid Neutralizing Capacity	µeq/L	270
pH	None	7.1
Specific Conductance	µS/cm	30
Dissolved Organic Carbon	mg/l	0.65
Total Dissolved Solids	mg/l	22
Water Clarity		
Depth of Transparency	m	Bottom (5.8)
Chlorophyll		
Chlorophyll-a	µg/L	0.12

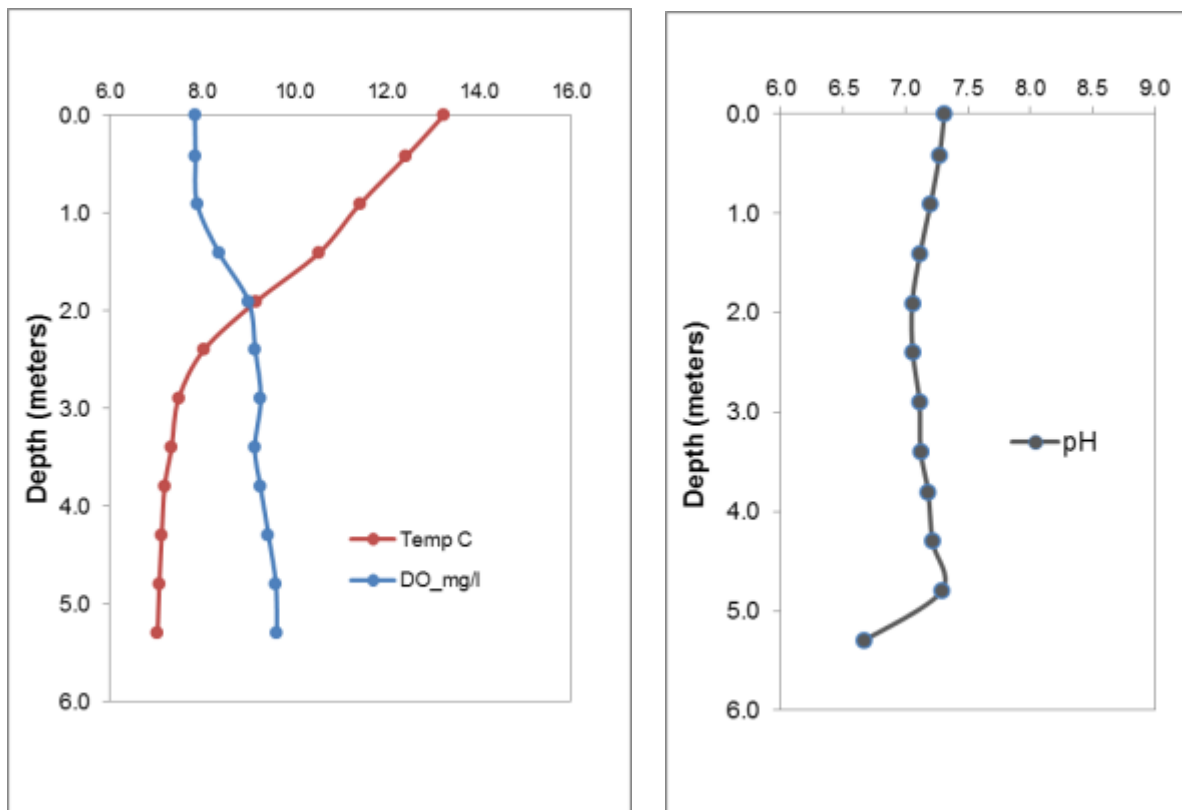


Figure 136. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake Sunup sampling station August 12, 2010.

Bathymetry & Shoreline Features

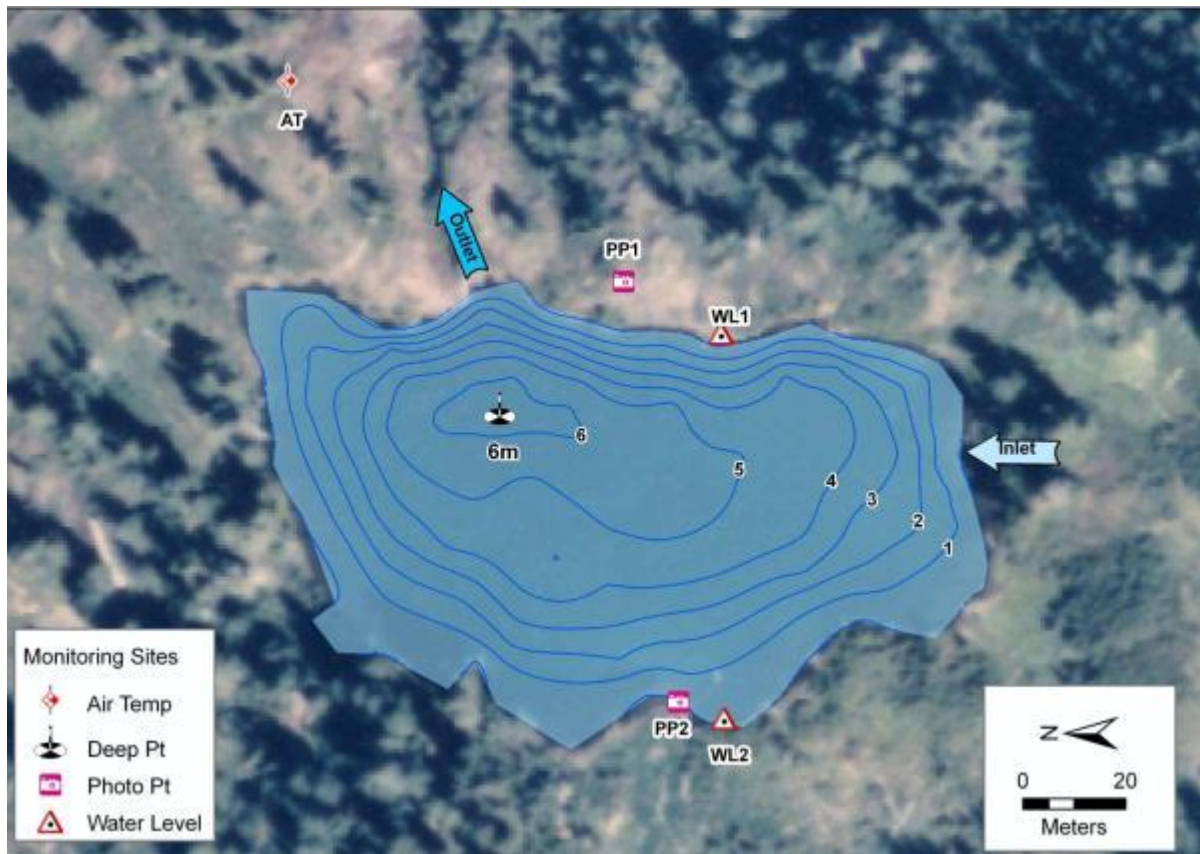


Figure 137. Bathymetry, shoreline features and sampling locations at Lake Sunup.

Amphibian & Fish Species

Table 73. Amphibian species observed at Lake Sunup (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Egg Mass	18
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Paedomorph	1
<i>Ambystoma macrodactylum</i>	Long-toed Salamander	AMMA	Egg Mass	2
<i>Ambystoma spp</i>	Mole salamander species	AMSP	Dead	1
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	2

Table 74. Introduced fish species observed at Lake Sunup (2010).

Species	Common Name	Species Code
<i>Oncorhynchus clarkii</i>	Cutthroat Trout	UCT

Watershed Panoramic Photos



Figure 138. Lake Sunup watershed panoramic photo (2010) from Photo Point 1 (see Figure 137).



Figure 139. Lake Sunup watershed panoramic photo (2010) from Photo Point 2 (see Figure 137).

Lake Access

A sampling trip to Lake Sunup requires 3 days. Day 1: From Port Angeles, drive to the USFS 400 Road (3.5 hrs). NOTE: Check road conditions prior to planning this trip. Access to the 400 road is often closed due to slides and washouts. The 2270 road which accesses the 400 road is gated and locked after October 1st. From the end of the USFS 400 road, hike 2.4 miles to Wynoochee Pass (2 hrs.). Descend from the pass and take the Sundown Shortcut route (.7 miles / 1 hour), traversing high around the headwaters of Graves Creek until intersecting with the top of the Graves Creek trail just above steep switchbacks. Continue traversing on the main trail to the junction of the South Fork Skokomish Trail then descend to Lake Sundown (.6 miles / .5 hr.). Camp at at Lake Sundown. Day 2: Hike the Six Ridge Trail 1.4 miles east towards McGravey Lakes. At a designated GPS waypoint, leave the maintained trail traversing above the headwaters of Six Stream and travel cross country 1.6 miles to Lake Sunup. (2.5 hours).

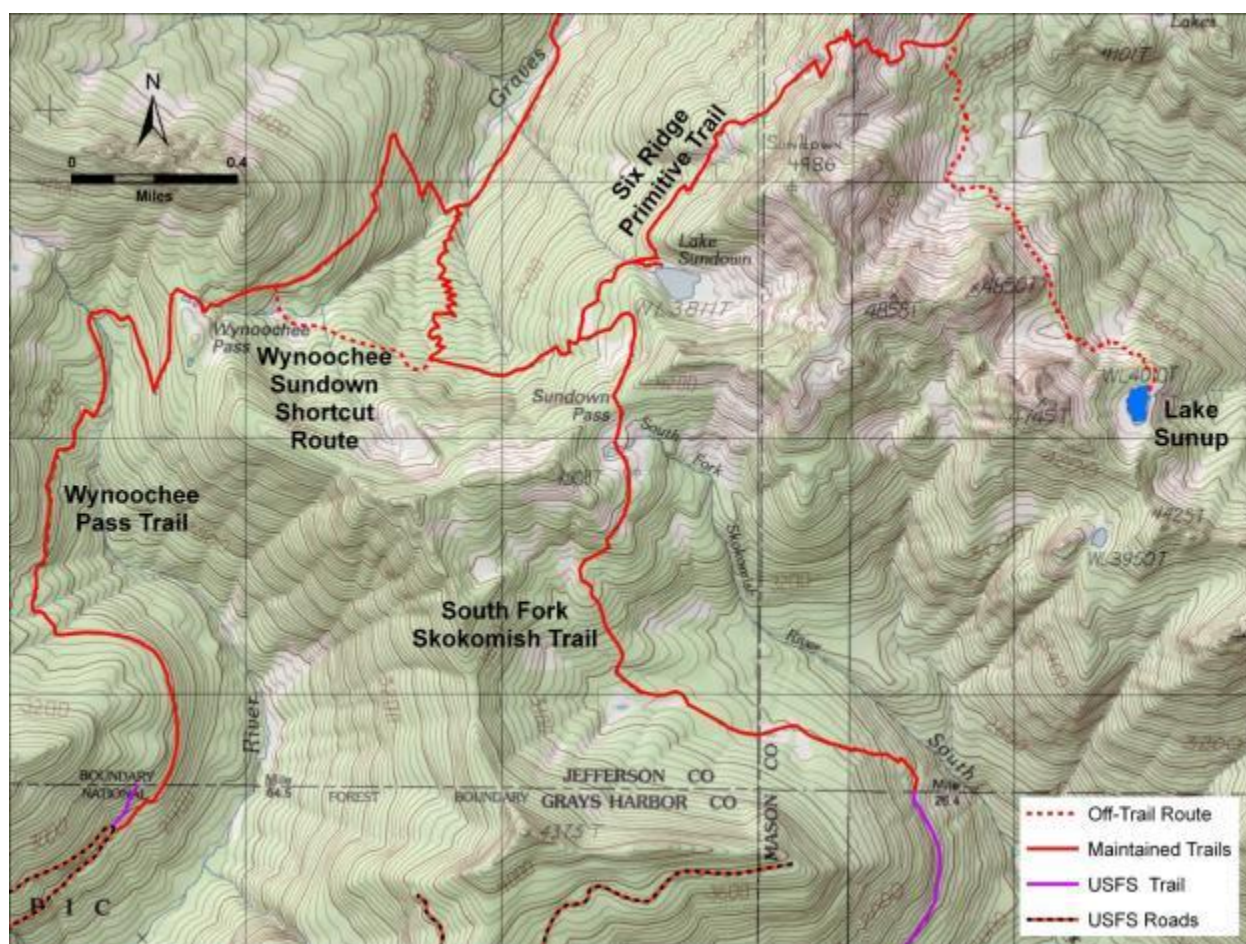


Figure 140. Hiking route to Lake Sunup, including main trails, shortcut and cross country routes.

Lake Connie (627)

Olympic National Park

UTM Coordinates (NAD83): 455346 m E / 5263487 m N

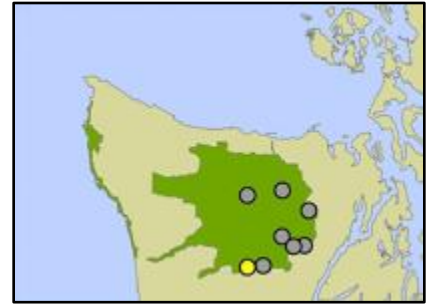


Figure 141. Lake Connie from the northwest shoulder of Mt. Hoquiam. The small object in lake's center is an inflatable boat with park scientists.

Geologic Setting

Lake Connie is located on the floor of a cirque basin that drains into Litchy Creek, and eventually into the Quinault River. The lake basin is carved within sandstone and conglomerate bedrock, however much of the upper watershed consists of basalts and basaltic sandstones that form Mount Hoquiam and the surrounding ridges (Tabor and Cady 1978). Glaciers have not occupied this basin for at least 12,000 years since the end of the last ice age. Shorelines of Lake Connie are composed mainly of scoured sedimentary bedrock, with small patches of colluvium and glacial sediments (Riedel and Dorsch in prep). The lake has many small inlet streams, the larger of which have built small alluvial fans/deltas into the lake. The lake outlet is controlled by bedrock.

Watershed Description

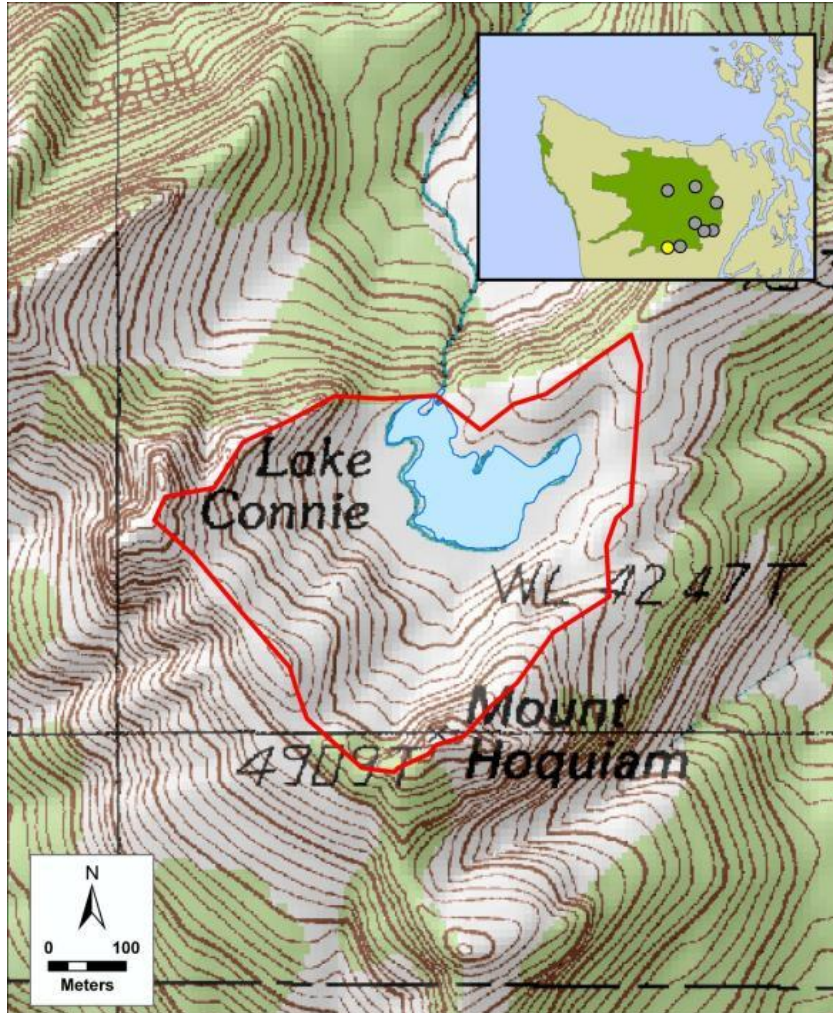


Figure 142. Lake Connie watershed and surrounding area.

Table 75. Lake Connie Morphometric data

Lake Parameter	Value
Elevation	1300 m (4265 ft)
Aspect	Northeast
Watershed Area	20.0 ha
Surface Area	2.3 ha
Volume	69586 m ³
Depth (maximum)	9.1 m
Depth (mean)	3.1 m
Depth (relative)	5.4%
Shoreline length	843 m
Lake length (maximum)	236 m
Lake width (maximum)	208 m
Watershed area: Lake Area (ratio)	8.9
Shoreline Development	1.58
Index of Basin Permanence	0.08

Physical/ Chemical Water Properties

Table 76. Water Quality and productivity parameters for Lake Connie, August 25, 2010.

Parameter	Units	2010
Water Chemistry		
Total Nitrogen	mg/l	0.04
Total Phosphorus	mg/l	0.002
Nitrogen & Phosphorus Ratio	N/A	20
NO3+NO2-N	mg/l	0.0
NH3-N	mg/l	0.028
Anion & Cation Ratio	N/A	0.210
Acid Neutralizing Capacity	µeq/L	120
pH	None	8.2
Specific Conductance	µS/cm	24
Dissolved Organic Carbon	mg/l	0.30
Total Dissolved Solids	mg/l	15
Water Clarity		
Depth of Transparency	m	Bottom (9.2)
Chlorophyll		
Chlorophyll-a	µg/L	0.06

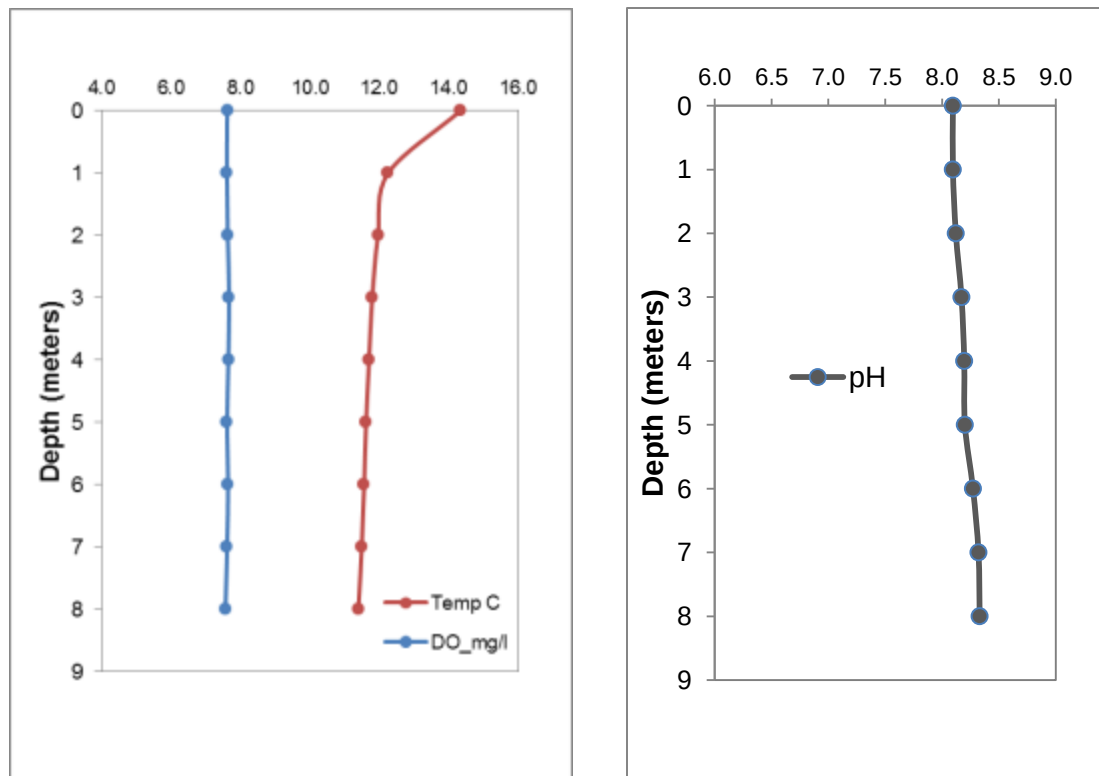


Figure 143. Dissolved oxygen, temperature and pH depth profiles from the deep-point of Lake Connie sampling station August 25, 2010.

Bathymetry & Shoreline Features

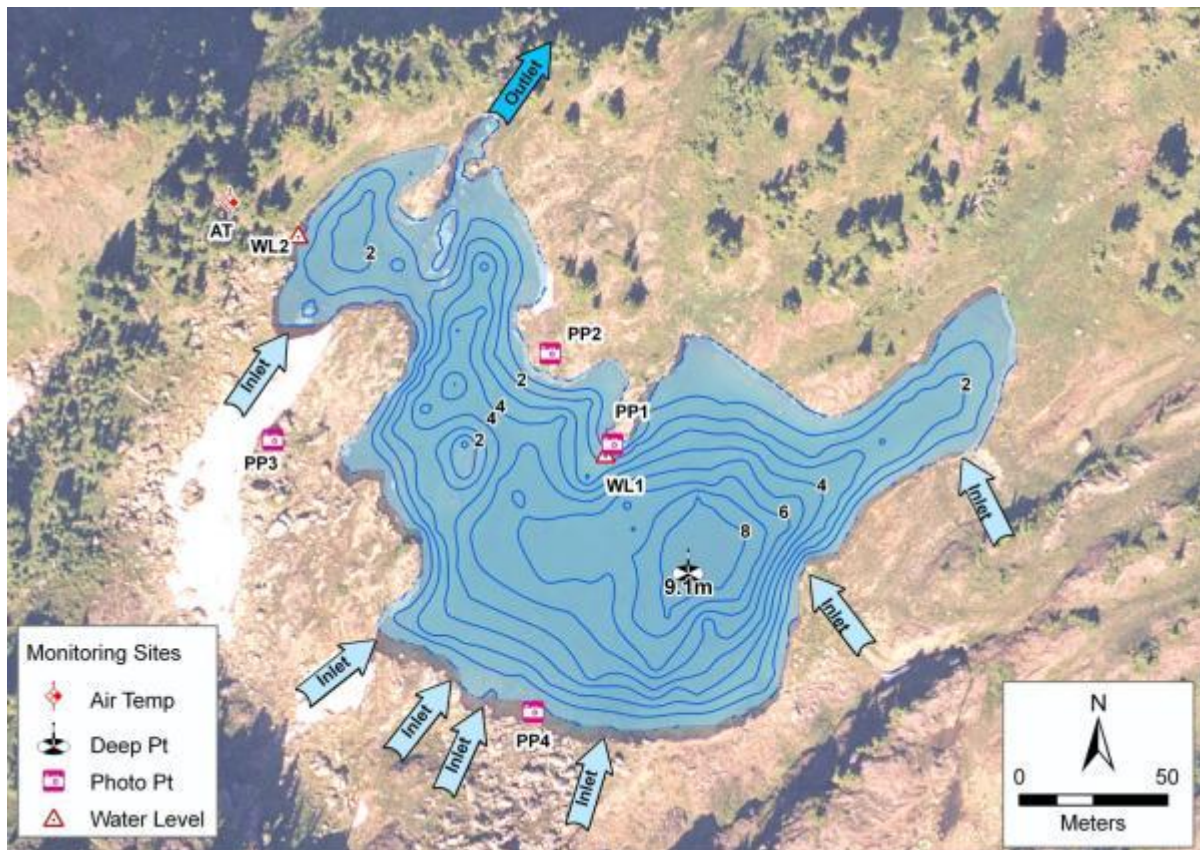


Figure 144. Bathymetry, shoreline features and sampling locations at Lake Connie.

Amphibian & Fish Species

Table 77. Amphibian species observed at Lake Connie (2010).

Species	Common Name	Species Code	Developmental Stage	Count
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Adult	63
<i>Ambystoma gracile</i>	Northwestern Salamander	AMGR	Paedomorph	165
<i>Rana cascadae</i>	Cascades Frog	RACA	Adult	12
<i>Rana cascadae</i>	Cascades Frog	RACA	Larvae	50
<i>Hyla regilla</i>	Pacific Tree Frog	HYRE	Egg Mass	2

Table 78. Introduced fish species observed at Lake Connie (2010).

Species	Common Name	Species Code
None	--	--

Watershed Panoramic Photos



Figure 145. Lake Connie watershed panoramic photo (2010) from Photo Point 1 (see Figure 144).



Figure 146. Lake Connie watershed panoramic photo (2010) from Photo Point 2 (see Figure 144).



Figure 147. Lake Connie watershed panoramic photo (2010) from Photo Point 3 (see Figure 144).



Figure 148. Lake Connie watershed panoramic photo (2010) from Photo Point 4 (see Figure 144).

Lake Access

A sampling trip to Lake Connie requires 3 days. Day 1: From Port Angeles, drive to the USFS 500 Road (3.5 hrs). NOTE: Check road conditions prior to planning this trip. Access to the 500 road is often closed due to slides and washouts. The 2270 road which accesses the 500 road is gated and locked after October 1st. Hike along the abandoned section of the USFS 500 road to a marked GPS point. Ascend steeply through regrowth and clearcuts, travelling .5 miles to a ridgetop saddle west of the Discovery Lakes (1 hr.). Descend and traverse the headwaters of Litchy Creek, following an intermittent way trail .7 miles to a saddle just south of Mt. Hoquiam (.5 hr.). Cross the saddle and traverse the southwest slope below the ridge to a broad shoulder northwest of Mt. Hoquiam. Camp on the shoulder or descend to Lake Connie.

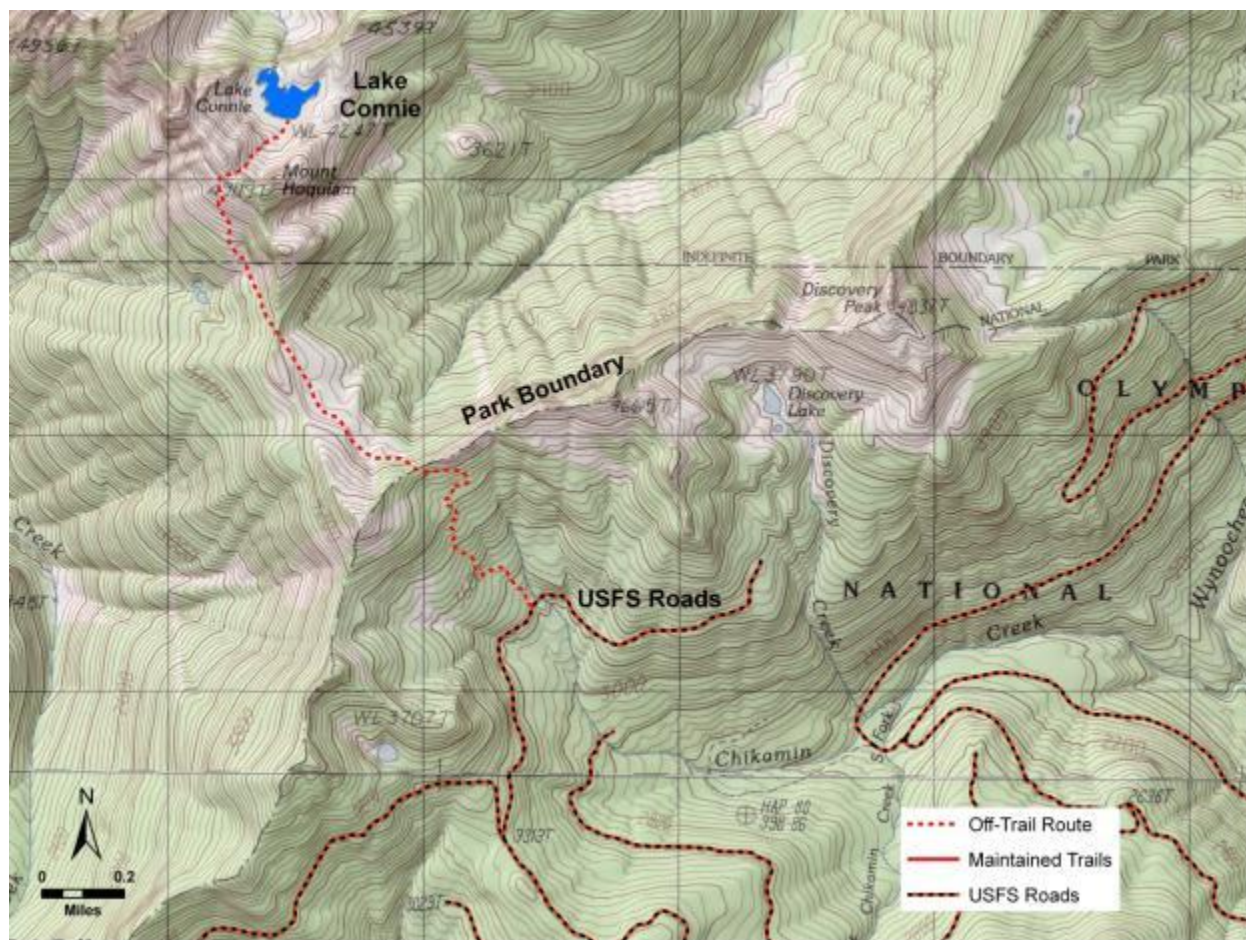


Figure 149. Hiking route to Lake Connie, including main trails, shortcut and cross country routes.

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NPS 963/117180, October 2012

National Park Service
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