



MATANUSKA-SUSITNA BOROUGH

2026 LAKE LEVEL ANALYSIS REPORT



PREPARED FOR

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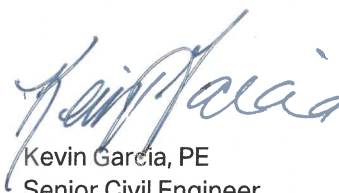
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EXECUTIVE SUMMARY

Changing lake water levels in the Matanuska-Susitna Borough (MSB) throughout recent decades have created issues, such as flooding, loss of recreation, and general safety concerns, for the infrastructure and residents near these waterbodies. To understand the current lake levels, project future levels, and scope reasonable solutions to the observed problems, MSB has contracted RESPEC Company, LLC (RESPEC) to perform a lake level analysis on several lakes within the borough.

For 11 lakes, RESPEC analyzed current and historical water levels through desktop investigation, site visits, and a hydrologic analysis. Recommended improvements and cost estimates were developed for these lakes, which included Upper Caswell, Horseshoe, Knik, Island, Blodgett, Swan, Golden, Kings/Anderson, Wolf, and Wolverine Lakes. Future climate models were used to inform which lakes may undergo significant increases in lake level due to projected increases in precipitation; it was found that Knik, Swan, Golden, and Wolf Lakes may be vulnerable. For these four lakes, infrastructure impacts due to possible future water levels were determined.

For nine lakes, survey benchmarks were established, and a generalized lake level monitoring plan was developed. These lakes included Kings/Anderson, Finger, Kepler, Bradley, Knik, Christiansen, Willow, and Rainbow Lakes. This report details the investigation and conclusions, including background research, hydrologic and lake level analyses, survey benchmarks and a monitoring plan, and recommendations and planning-level cost estimates.

TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 BACKGROUND.....	2
1.1.1 Upper Caswell Lake	2
1.1.2 Knik Lake.....	2
1.1.3 Blodgett, Golden, Swan, and Surrounding Lakes.....	3
1.1.4 Kings/Anderson Lakes.....	4
1.1.5 Wolf Lake	4
1.1.6 Wolverine Lake	4
1.2 DESIGN GUIDANCE	4
2.0 HYDROLOGIC ANALYSIS.....	5
2.1 LAKE LEVEL	6
2.2 DRAINAGE BASINS	8
2.2.1 Upper Caswell Lake.....	8
2.2.2 Horseshoe Lake.....	8
2.2.3 Knik Lake.....	8
2.2.4 Island Lake.....	8
2.2.5 Blodgett Lake.....	9
2.2.6 Swan Lake.....	9
2.2.7 Golden Lake	9
2.2.8 Kings/Anderson lakes.....	9
2.2.9 Wolf Lake	9
2.2.10 Wolverine Lake	10
2.3 PRECIPITATION	10
2.4 GROUNDWATER.....	13
2.5 AERIAL IMAGERY AND TOPOGRAPHY DATA	14
2.6 GENERAL TRENDS.....	14
3.0 SITE VISITS.....	16
3.1 UPPER CASWELL LAKE	16
3.2 HORSESHOE LAKE	17
3.3 KNIK LAKE.....	18
3.4 ISLAND LAKE.....	20
3.5 BLODGETT LAKE	21
3.6 SWAN LAKE	21
3.7 GOLDEN LAKE	21
3.8 KINGS/ANDERSON LAKES	22
3.9 WOLF LAKE.....	22
3.10 WOLVERINE LAKE.....	22
3.11 RAINBOW LAKE	22

4.0 SURVEY BENCHMARKS AND MONITORING PLAN.....	24
5.0 RECOMMENDATIONS AND COST ESTIMATES.....	25
5.1 UPPER CASWELL LAKE	25
5.2 HORSESHOE LAKE	26
5.3 KNIK LAKE.....	26
5.4 ISLAND LAKE.....	28
5.5 BLODGETT LAKE.....	28
5.6 SWAN LAKE	28
5.7 GOLDEN LAKE	28
5.8 KINGS/ANDERSON LAKES	29
5.9 WOLF LAKE.....	29
5.10 WOLVERINE LAKE.....	31
6.0 REFERENCES.....	33
APPENDIX A ADDITIONAL BACKGROUND INFORMATION.....	A-1
APPENDIX B LAKE LEVEL DATA.....	B-1
APPENDIX C HIGH WATER LEVEL FIGURES.....	C-1
APPENDIX D DRAINAGE BASINS	D-1
APPENDIX E PRECIPITATION DATA	E-1
APPENDIX F SITE VISIT PHOTOS	F-1
APPENDIX G SURVEY BENCHMARKS AND LAKE LEVEL MONITORING PLAN	G-1
APPENDIX H PLANNING-LEVEL COST ESTIMATES	H-1
APPENDIX I WOLVERINE LAKE WEIR - CONCEPT DESIGN	I-1

LIST OF TABLES

TABLE	PAGE
Table 2-1. Lake Level Analysis Summary.....	7
Table 2-2. Precipitation Station Data	11
Table 2-3. 2030–2099 Precipitation Increase Predicted by the Scenarios Network for Alaska and Arctic Planning	11
Table 2-4. Infrastructure Impacts from Theoretical Future Increases in Lake Level	12
Table 2-5. Matanuska-Susitna Borough Aerial Imagery and Topography Data Summary.....	14
Table 5-1. Upper Caswell Lake – Lower Culverts Cost Estimate	26
Table 5-2. Knik Lake Mitigation Alternatives Cost Estimates	28
Table 5-3. Anderson Lake Outlet Culvert Replacement Cost Estimate.....	29
Table 5-4. Wolf Lake Piped Outlet Cost Estimate	30
Table 5-5. Wolverine Lake Mitigation Cost Estimate	31

LIST OF FIGURES

FIGURE	PAGE
Figure 1-1. Project Lakes	1
Figure 2-1. Locations of Lakes in Hydrologic Analysis.....	5
Figure 2-2. Precipitation Station Locations	10
Figure 3-1. Upper Caswell Lake Outlet Culverts.....	16
Figure 3-2. Rock Weir at Upper Caswell Lake.....	17
Figure 3-3. Horseshoe Lake Outlet Channel.....	18
Figure 3-4. Knik Lake Outlet Channel – Looking Upstream	19
Figure 3-5. Knik Lake Outlet Channel - Looking Downstream	19
Figure 3-6. Knik Lake Outlet Channel – Upstream of Knik Bar & Grill Driveway.....	20
Figure 3-7. Island Lake Outlet Wetland.....	21
Figure 3-8. Rainbow Lake	23
Figure 5-1. Knik Lake Recommended Channel Alignment.....	27
Figure 5-2. Wolf Lake Outlet Configurations	30

1.0 INTRODUCTION

In the past two decades, the Matanuska-Susitna Borough (MSB) has received many public calls for assistance and complaints regarding changes in lake levels across the borough. MSB has received public input for the Palmer, Wasilla, Knik Goose Bay (KGB) Road Corridor, and Meadow Lakes areas—where most of the population and infrastructure is located—and for the northern reaches of the MSB, where residential and recreational lake properties are popular. To investigate lake level changes, MSB contracted with RESPEC Company, LLC (RESPEC) to conduct background research, perform a hydrologic investigation and analysis, identify historical natural and human changes, establish lake benchmarks and a monitoring plan, and develop recommendations. Figure 1-1 provides a map of the project extents, including the locations of the investigated lakes and established benchmarks.

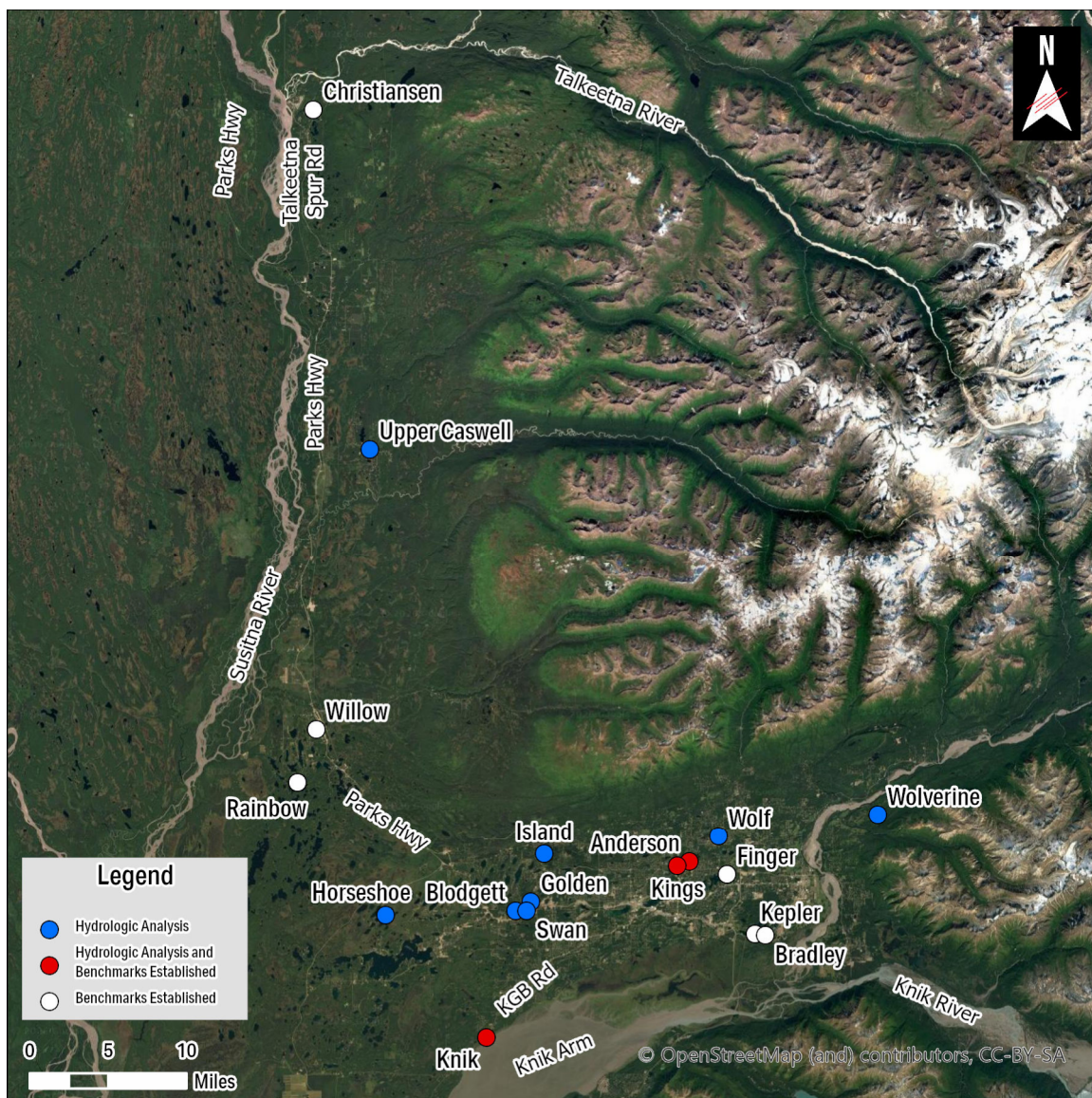


Figure 1-1. Project Lakes

1.1 BACKGROUND

Several of the lakes included in this report have been previously studied. RESPEC conducted a literature review of existing studies in the area to summarize current knowledge and support the lake level analysis presented in this report.

1.1.1 UPPER CASWELL LAKE

The outlet of Upper Caswell Lake flows through an embankment dam that functions as Caswell Lakes Road. In 2018, Shannon & Wilson, Inc. conducted a dam safety inspection. The inspection report notes that the lake's outlet consists of four corrugated steel pipe (CSP) culverts, one 48 inches in diameter and three 36 inches in diameter, that also act as the dam spillway. The culverts were in good condition at the time of the report [Shannon & Wilson, Inc., 2018].

To support the 2018 dam safety inspection report, Lounsbury & Associates, Inc. developed a hydraulic and hydrologic report, which determined flows to the Upper Caswell Lake outlet to be 38, 93, 196, 266, and 525 cubic feet per second (cfs) for the 2-, 10-, 50-, 100-, and 500-year floods, respectively. The report recommended replacing the four outlet culverts with two aluminum box culverts; one 16-foot, 10-inch span by 8-foot, 3-inch rise main channel culvert; and one 9-foot, 2-inch span by 3-foot, 3-inch rise overflow culvert [Lounsbury & Associates, Inc., 2018].

Lounsbury & Associates, Inc. inspected the dam again in 2022. After the 2018 inspection, the outlet culverts were replaced by the recommended design of two aluminum box culverts. These culverts function as the current outlet. The 2022 inspection report states that the box culvert design is conservative and capable of conveying approximately 700 cfs, which is greater than the calculated 500-year flow. The inspection report also notes that the embankment appears to be in a similar condition to its post-construction state, which indicates stability [Lounsbury & Associates, Inc., 2022].

On May 19, 2026, RESPEC conducted a periodic safety inspection at the dam. The draft report recommends clearing vegetation, installing additional survey monuments to enhance monitoring, installing signage, adhering to established maintenance and inspection policies, and reviewing and exercising the Emergency Action Plan [RESPEC, 2026].

1.1.2 KNIK LAKE

According to the Alaska Department of Fish and Game's (ADF&G's) Anadromous Waters Catalog (AWC) interactive mapper, Knik Lake is not designated as an anadromous waterbody [ADF&G, 2025]. However, an ADF&G lake survey conducted on August 13, 1959, documented a native population of stickleback and introduced populations of coho salmon and rainbow trout. The survey also identified a small intermittent outlet stream that drained directly to Knik Arm. This survey is included in Appendix A.

Following the introduction of coho salmon and rainbow trout, ADF&G installed a grate across the outlet stream to prevent downstream fish passage and to retain the stocked fish within the lake. Historical records indicate that significant losses of coho salmon occurred when the grate was not installed before spring freshet flows, which allowed fish to migrate downstream through the outlet channel. In 1995, the MSB Planning Department adopted a Lake Management Plan (LMP) for Knik Lake. The plan states that various stakeholders reported conflicting lake levels; some said the lake level was higher

than its historical average, but others said the lake level was not elevated. The LMP concludes by recommending a review of the need for and impact of efforts to lower lake levels, and, if no negative impacts are identified, the construction of a properly permitted redesign of the outlet channel [MSB, 1995].

In October 2022, the Alaska Department of Transportation and Public Facilities (DOT&PF) received a complaint that Knik Lake was experiencing higher-than-usual water levels, which threatened to flood several properties. These high water levels are believed to have been caused by above-average precipitation.

The following year, MSB inspected several culverts near the intersection of KGB Road and North Shore Drive to investigate whether development had contributed to elevated lake levels. The investigation identified a natural drainage pathway that historically conveyed water from Knik Lake toward North Shore Drive, where flow continued along the south side of North Shore Drive toward KGB Road. This drainage path appeared to have been obstructed by public and private development. A second potential drainage path was identified following an existing all-terrain vehicle trail. MSB recommended reestablishing this natural drainageway to provide some lake level relief [MSB, 2023a].

Following MSB's 2023 inspection, a swale was constructed adjacent to and parallel with KGB Road. The timing of the construction indicates it was likely intended to provide relief from elevated lake levels. Based on available information, the individual or entity responsible for constructing the swale is unknown. The work was completed without authorization from DOT&PF and without the applicable permits from DOT&PF, ADF&G, and USACE. Field observations indicate that additional improvements are needed to improve channel stability and address roadway safety considerations.

1.1.3 BLODGETT, GOLDEN, SWAN, AND SURROUNDING LAKES

In September 2022, Bluebird Lake overtopped Meadow Lakes Loop Road in the community of Meadow Lakes. 2022 experienced unusually high precipitation, and at the time of the flooding, lake water surface elevations (WSEs) were significantly higher than historical levels.

Prompted by this flooding, HDL Engineering Consultants, LLC (HDL) developed a memo analyzing flooding and drainage issues on Meadow Lakes Loop Road [HDL, 2023]. This memo studied Blodgett, Golden, Bluebird, Robin, and Teal Lakes. These five lakes may have been hydraulically connected before development. Today, Golden still drains into Bluebird through a small stream. Bluebird is connected to Robin by overland flow; for this connection to activate, however, WSEs must reach 252.0 feet, which was higher than the elevation of Meadow Lakes Loop Road at the time of the flooding. The overall drainage layout also demonstrates intent to direct outflow from these lakes into Blodgett, but this intended connection is blocked by damaged or missing culverts and fill. Therefore, the September 2022 flooding occurred as a result of unusually high precipitation and inflows into this lake system, coupled with the lake system's configuration that prevented release of the additional water without overtopping the road.

In 2024, MSB received a complaint about higher-than-usual water levels on Golden Lake. The resident believed the high water levels were caused by a blocked outlet; after investigation, the high water levels did not appear to be caused by a blockage but were rather attributed to the outlet swale's elevation.

MSB recommended that Golden Lake be further studied to determine historical lake levels and to alter the drainage swale to maintain these levels if necessary [MSB, 2024].

The analysis presented in this report does not include Bluebird, Robin, and Teal Lakes because they are outside the scope of the project.

1.1.4 KINGS/ANDERSON LAKES

Kings Lake drains into Anderson Lake through a culvert that runs through the thin strip of land separating the two waterbodies. In 2010, ADF&G investigated this culvert's fish passage adequacy. During the site visit, the culvert contained no flow, and the team was unable to inspect the entire interior of the pipe. The culvert was ultimately deemed to have a fish passage rating of Gray, which indicated that more analysis and investigation was needed. To improve fish passage and hydraulic connectivity, MSB is advancing two culvert replacement projects: one connecting Kings Lake and Anderson Lake, and one at the outlet of Anderson Lake. Construction for both is scheduled for 2027.

1.1.5 WOLF LAKE

In October 2025, PND Engineers, Inc. (PND) completed a drainage study that included Wolf Lake and calculated peak flows to the Wolf Lake outlet of 13.4, 25.3, and 51.5 cfs for the 10-, 25-, and 100-year floods, respectively. The study report notes that the lake is likely to have a significant amount of groundwater contribution and states that flooding in the area is primarily driven by development within the natural drainageways and high groundwater. The report also lists several recommendations for improving Wolf Lake's outlet, including upgrading and replacing several culverts in the drainage path, upgrading driveway culverts, relocating certain stretches of the drainage channel, and acquiring easements around drainage infrastructure [PND, 2025].

1.1.6 WOLVERINE LAKE

According to ADF&G [2025], Wolverine Lake is cataloged as an anadromous waterbody. The lake level is controlled by an unconventional weir constructed of logs, cobbles, boulders, brush, rebar, and wattles. Wolverine Lake and its outlet stream support populations of coho salmon, sockeye salmon, and rainbow trout. In 1997, ADF&G issued a fish habitat permit authorizing repairs to the outlet structure. The permit required that the maximum drop from the dam crest to the downstream step pool not exceed 6 inches to maintain fish passage and that disturbed areas be stabilized following construction [ADF&G, 1997]. The permit is included in Appendix A.

1.2 DESIGN GUIDANCE

For cost estimating purposes, analysis and design followed the *MSB Design Criteria Manual*, Chapter 1, Roads, and Chapter 2, Bridges & Crossing Culverts [MSB, 2025a; MSB, 2023b].

2.0 HYDROLOGIC ANALYSIS

A high-level hydrologic analysis was conducted to develop an initial understanding of watershed characteristics and historical water level conditions for Upper Caswell, Horseshoe, Knik, Island, Blodgett, Swan, Golden, Kings/Anderson, Wolf, and Wolverine Lakes. This analysis included documenting historical water levels; delineating drainage basins to understand their size, soil properties, land cover, and any notable features; analyzing historical precipitation and future precipitation projections; considering groundwater dynamics in the area; and determining public and private infrastructure at each lake that may be impacted by high lake levels. The locations of all lakes included in this analysis are provided in Figure 2-1.



Figure 2-1. Locations of Lakes in Hydrologic Analysis

Historical water levels are significant to the analysis because they describe the background of current conditions, reflect any active trends, and inform how water levels of each lake are connected to other hydrologic properties of the area, such as precipitation.

Drainage basin characteristics, including basin size, soils, land cover, groundwater, and any geomorphic features, highly influence lake levels. Larger basins receive precipitation from a larger area, which results in a larger volume of runoff and therefore higher inflow to the lake. Soil properties are directly connected to infiltration potential; higher infiltration potential means less runoff and less lake inflow, whereas lower infiltration potential results in more runoff and more lake inflow. Land cover also directly changes both runoff volume and timing; large impervious areas create increased amounts of surface flow that travels quickly to its outlet point, thereby increasing lake inflow rates. Conversely, pervious areas infiltrate more effectively and reduce surface flow volume. Areas of rougher land cover (e.g., forested areas) slow runoff timing and decrease lake inflow peak rates. Geomorphic features in the watershed (e.g., another lake) will change the path that runoff takes through the basin; if the path takes longer for runoff to travel, lake inflow rates decrease, whereas if runoff is able to travel the path quickly, lake inflow rates increase.

Precipitation has significant impacts to lake water levels because precipitation is a major water supply to lakes; more precipitation creates greater lake inflow, and less precipitation reduces lake inflow. Groundwater is another water source for many lakes; both groundwater and stormwater for the analyzed lakes are discussed in this section.

2.1 LAKE LEVEL

To determine historical lake levels, aerial imagery from 1985 through 2025 was analyzed. For each lake, the WSE was manually identified and digitized using the available imagery. To ensure consistency and accuracy, water surface locations were recorded at two representative locations along the bank line: near the inlet and near the outlet. Areas with steep banks, heavy vegetation, shading, or ice cover were avoided to minimize potential error. The selected points were then spatially correlated with the 2019 MSB LiDAR dataset to assign corresponding WSEs. LiDAR contains no underwater data; therefore, elevations for water level points that fell below the WSE shown on the 2019 LiDAR were estimated using bathymetric data. For each year, the average elevation of the two points was calculated and used as the representative water surface elevation for that year. Each year's imagery extents were slightly different; thus, some years were missing imagery for some lakes. Water levels at each lake were analyzed for all available years of imagery. All water levels collected for each lake are included in Appendix B.

High water level elevations for each lake were determined to inform potential impacts to infrastructure. These elevations were chosen based on observations at each lake, historical water levels, outlet structures and channels, and engineering judgment. These elevations are not the observed high water levels or theoretical maximum levels but rather are approximate high elevations that the lake may infrequently achieve. Figures of these high WSEs are included in Appendix C. The high water level for Kings Lake could not be determined because it is dependent on the elevation of its outlet culvert. There are current plans to replace the outlet culvert with an 8' diameter corrugated metal pipe (CMP), but no further information or plans were available to the project team while preparing this report.

Table 2-1 summarizes the lake level analysis results for each lake. All lake level elevations are given in North American Vertical Datum 1988 (NAVD 88).

Table 2-1. Lake Level Analysis Summary

Lake	Years of Available Imagery	Years of Available Bathymetric Data	Range of Average Observed Water Surface Elevations (ft)	High Water Surface Elevation (ft)	Impacted Infrastructure at High Water Surface Elevation
Upper Caswell	2004, 2011, 2017, 2020, 2023	1983	317.3–317.7	318	2 culverts, 1 septic system, 1 ramp
Horseshoe	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2020	160.3–161.2	161	1 culvert, 43 septic systems, 95 docks
Knik	2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2013, 2018	38.2–40.9	41	600 ft of South KGB Road, 190 ft of W Northshore Dr, 2 culverts, 1 driveway, 9 septic systems, 8 docks, 1 ramp, 2 structures
Island	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	N/A	369.8–372.3	373	1 culvert, 11 septic systems, 11 docks, 2 ramps
Blodgett	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2020	226.8–227.9	228	1 culvert, 10 septic systems, 22 docks
Swan	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	N/A	240.8–245.8	250	1 culvert, 1 septic system
Golden	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2013	288.0–289.2	290	4 docks, 1 ramp
Kings	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2016	436.3–438.7	Inconclusive	Inconclusive
Anderson	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2016	435.6–438.5	438	2 culverts, 9 septic systems, 20 docks
Wolf	1985, 2004, 2011, 2016, 2017, 2019, 2021, 2022, 2024, 2025	2013	541.0–542.2	543	1 culvert, 5 septic systems, 8 docks, 2 ramps
Wolverine	2004, 2011, 2017, 2019, 2021, 2022, 2024, 2025	2004	777.6–780.2	780*	1 septic system, 9 docks

*Wolverine Lake's high water level is based on the elevation of the top of the outlet structure. At the time of this report, it was approximately 780 ft. This will change as the outlet undergoes repairs and improvements.

2.2 DRAINAGE BASINS

To better understand the hydrology of each lake included in the analysis, their watersheds were delineated and characterized. A description of the watershed for each lake is included below. Figures of each watershed are included in Appendix D.

2.2.1 UPPER CASWELL LAKE

Upper Caswell Lake is the northernmost lake included in the analysis and is located approximately 17 miles northeast of Willow. Its watershed is the largest of all studied lakes at approximately 5,177 acres and largely consists of steep, undeveloped forests and wetlands that are primarily privately owned. The watershed is estimated to be 0.9 percent impervious: 0.3 percent of the area consists of roads and scattered structures near the lake, and 0.6 percent is the lake itself. Approximately two-thirds of soils in the watershed are in hydrologic soil group B (i.e., soils with moderately low runoff potential), and approximately one-third are in soil group D (i.e., soils with high runoff potential). The lake is fed by several unnamed tributaries to Caswell Creek, which are mapped as anadromous by the AWC [ADF&G, 2025].

2.2.2 HORSESHOE LAKE

Horseshoe Lake is located approximately 4.1 miles northwest of the community of Big Lake and is the second largest of the analyzed lakes. Horseshoe Lake's watershed comprises approximately 4,854 acres of wetlands and scattered brush. The watershed contains seven other lakes that drain into Horseshoe: Pear, Blanket, West, and Bottle Lakes, along with three unnamed lakes. These lakes drain into Horseshoe through various unnamed creeks and drainages, some of which are mapped as anadromous by ADF&G AWC. The watershed is largely undeveloped, although approximately 14.5 percent of the area is estimated to be impervious: 1 percent is attributed to roads and scattered structures near the lake, 9 percent is covered by Horseshoe Lake, and approximately 4.5 percent is covered by the other lakes within the watershed. Soils in the watershed are in hydrologic soil groups A (i.e., soils with low runoff potential), B, and D. The watershed comprises a combination of private, public, and Knikatnu Inc. land.

2.2.3 KNIK LAKE

Knik Lake is located approximately 11.7 miles northeast of Point MacKenzie, near Knik Arm, and its watershed is approximately 465 acres of primarily privately owned, forested land. The watershed is estimated to be 14 percent impervious: approximately 3 percent of the land is covered by roads and structures, and approximately 11 percent is the lake. Approximately half of the soils in the watershed are in hydrologic soil group A, and the other half are in soil groups B and D.

2.2.4 ISLAND LAKE

Island Lake is located approximately 3 miles north of Meadow Lakes, and its watershed is approximately 416 acres of both developed and forested land. Doubloon Lake is directly north of Island within the watershed. Island's watershed is estimated to be 26 percent impervious: approximately 3 percent of the watershed is developed, 20 percent is covered by Island Lake, and 3 percent is covered by Doubloon Lake. Approximately half of the soils in the watershed are hydrologic soil group B and approximately half are soil group D. Island's watershed is largely privately owned, except for the roads and the public park directly north of the lake.

2.2.5 BLODGETT LAKE

Blodgett Lake is located within the community of Meadow Lakes, and its watershed is approximately 114 acres of forested, residential, privately owned properties. The watershed is mostly impervious because of the size of Blodgett; approximately 65 percent is the lake, and 2 percent is covered by lakeside roads and properties. Soils in the watershed are primarily in hydrologic soil group A, with a small amount of group D soils on the eastern side.

2.2.6 SWAN LAKE

Swan Lake is located within the community of Meadow Lakes, approximately 0.4 miles southeast of Blodgett Lake. Swan Lake's watershed is approximately 13 acres and is the smallest of all the analyzed lakes. The watershed contains primarily developed land and is highly impervious; approximately 68 percent of the area is developed, and 15 percent is covered by the lake. Soils in the watershed are in hydrologic soil group A. The watershed is largely composed of privately owned parcels and the Parks Highway.

2.2.7 GOLDEN LAKE

Golden Lake is located within the community of Meadow Lakes, approximately 1 mile northeast of Blodgett Lake and approximately 0.75 mile northeast of Swan Lake. Golden Lake's watershed is approximately 289 acres and comprises forested areas, wetlands, developed areas, and another unnamed lake. The watershed is 14 percent impervious: roads and development comprise 3 percent of the watershed, 4.5 percent is covered by Gold Lake, and 6.5 percent is covered by the upstream lake. Soils in the watershed are a mix of hydrologic soil groups A, B, and D. The watershed is a mix of public and privately owned land, including parcels owned by the State of Alaska, MSB, and the Alaska Railroad.

2.2.8 KINGS/ANDERSON LAKES

Kings Lake is located approximately 4 miles northeast of Wasilla, directly west of Anderson Lake, and its watershed is approximately 595 acres of forested land with some development. The Kings Lake watershed is approximately 21 percent impervious: approximately 19.4 percent is the lake, and 1.6 percent is covered by roads and structures. Soils in the watershed are primarily hydrologic soil group B, with a small amount of group D soils. The watershed is a mix of private and public ownership, including some parcels owned by the MSB School District.

Anderson Lake is located directly east of Kings Lake, and its watershed is approximately 227 acres of privately owned, developed land with forested areas. The Anderson Lake watershed is approximately 49 percent impervious: 45.5 percent is the lake, and 3.5 percent is covered by roads and structures. Soils in the watershed are in hydrologic soil group B.

2.2.9 WOLF LAKE

Wolf Lake is located approximately 7 miles northeast of Wasilla, and its watershed is approximately 310 acres of a combination of developed and forested land. The watershed is approximately 22.4 percent impervious: approximately 20 percent is the lake, and 2.4 percent is covered by roads and structures. Soils in the watershed are primarily in hydrologic soil group B with some group D soils. The watershed is a mix of private and public ownership, including a parcel owned by ADNIR.

2.2.10 WOLVERINE LAKE

Wolverine Lake is the farthest east lake included in this analysis and is located approximately 6 miles northeast of Palmer. Its watershed is approximately 3,683 acres and is primarily composed of steep forested land, with a very small amount of development directly around the lake. The Wolverine Lake watershed is approximately 2.5 percent impervious: 2.4 percent is covered by the lake, and 0.1 percent is made up of roads and a few structures. Soils in the watershed are primarily in soil group B, with some group D soils. The watershed is largely owned by the Chickaloon-Moose Creek Native Association and contains some MSB land and a few private parcels.

2.3 PRECIPITATION

To understand how lake levels are affected by changes in precipitation, historical precipitation values were analyzed for each lake. The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information Climate Data Online database was used for seven different stations [NOAA, 2026]. The station locations are provided in Figure 2-2. Each station's available historical period and the corresponding lake(s) for each dataset are included in Table 2-2. All precipitation data are included in Appendix E.

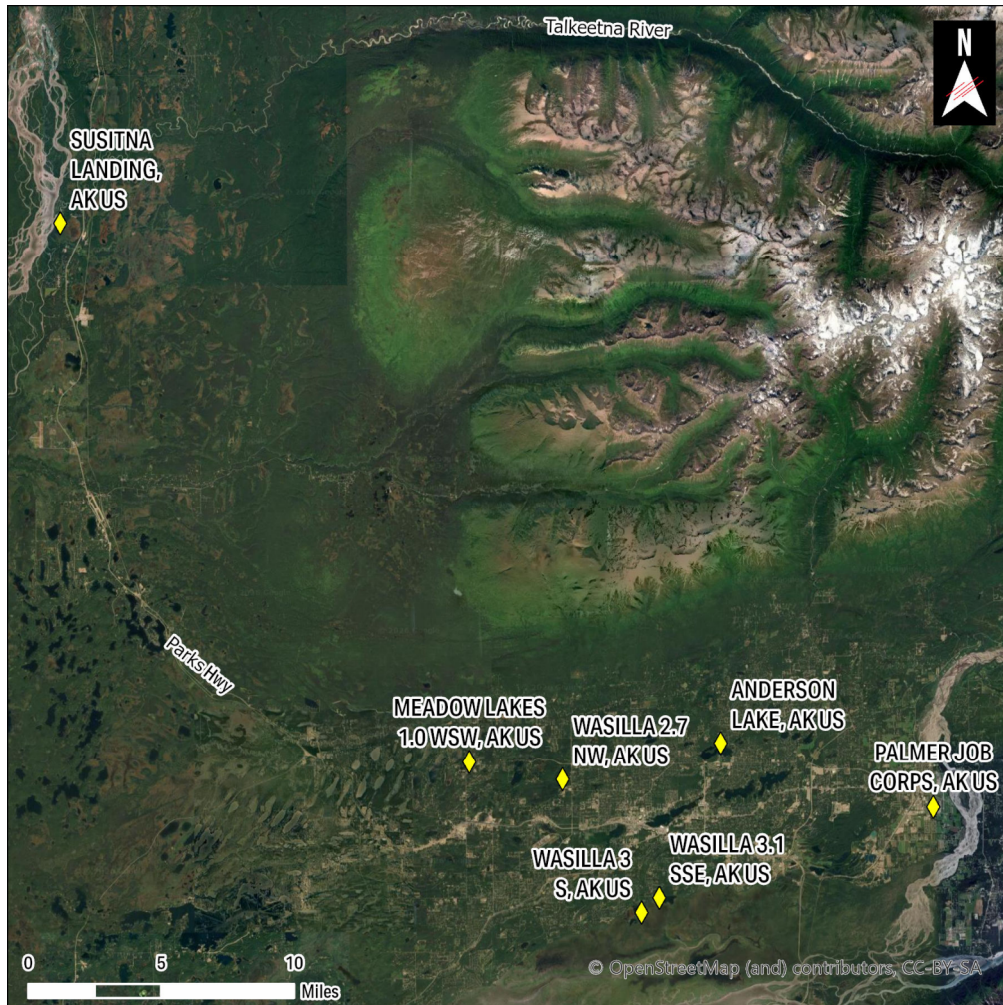


Figure 2-2. Precipitation Station Locations

Table 2-2. Precipitation Station Data

Precipitation Station	Years of Available Data	Corresponding Lakes
SUSITNA LANDING, AK US	2003–2017	Upper Caswell
MEADOW LAKES 1.0 WSW, AK US	2018–2025	Golden, Island, Swan, Blodgett, Horseshoe, Upper Caswell, and Knik
WASILLA 2.7 NW, AK US	2017–2026	Kings, Anderson, and Wolf
WASILLA 3 S, AK US	1985–1999	Golden, Island, Swan, Blodgett, Horseshoe, and Knik
WASILLA 3.1 SSE, AK US	2010–2011	Golden, Island, Swan, Blodgett, Horseshoe, and Knik
ANDERSON LAKE, AK US	1971–2010	Kings, Anderson, and Wolf
PALMER JOB CORPS, AK US	1985–2025	Wolverine

To predict how precipitation may change in the future and the anticipated effects on the lakes' water surface levels, the University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning (SNAP) climate model was examined for Wasilla. Table 2-3 provides the expected percent increase in precipitation projected from historical data for 2030–2099, predicted by SNAP.

Table 2-3. 2030–2099 Precipitation Increase Predicted by the Scenarios Network for Alaska and Arctic Planning

Month	Projected Precipitation Increase for 2030–2099 (%)
January	4.0
February	–7.4
March	4.5
April	12.5
May	12.0
June	14.9
July	28.3
August	16.2
September	18.7
October	9.4
November	10.0
December	21.2
Annual Average	14.4

The projected increase in precipitation indicates that the MSB may experience wetter conditions over the coming decades, which could contribute to increased runoff and higher seasonal lake levels. The greatest projected increases occur during the summer and early fall months, when rainfall most directly influences lake inflows. However, changes in precipitation alone cannot be used to quantify future lake levels. Individual lake elevations are governed by the combined effects of precipitation, watershed

runoff, groundwater exchange, evaporation, evapotranspiration, outlet capacity, and seasonal snowmelt patterns.

As part of this study, existing lake level trends, watershed characteristics, and outlet conditions were evaluated to identify lakes that may be susceptible to future water level increases and the potential implications for nearby infrastructure. Lakes with limited outlet capacity or restricted drainage include Knik, Golden, Swan, and Wolf lakes; these are expected to be more vulnerable to prolonged high-water conditions under a wetter climate, increasing the potential for impacts such as roadway overtopping, reduced culvert capacity, shoreline erosion, and flooding of adjacent infrastructure. Table 2-4 summarizes infrastructure impacts on Knik, Golden, and Swan Lakes under theoretical future increases to the high water surface elevations given in Table 2-1. Increases up to physical lake capacity are included. Wolf Lake is excluded since its theoretical high water elevation of 543 ft already approaches the maximum physical capacity of the lake; if the water level exceeds this, it is no longer contained by Wolf Lake and therefore higher water surface elevations are not realistic to include in the analysis.

Table 2-4. Infrastructure Impacts from Theoretical Future Increases in Lake Level

Lake	Theoretical Future Increase in Lake High Water Surface Elevation (ft)	Resulting Theoretical High Water Surface Elevation (ft)	Impacted Infrastructure
Knik	2	43	700 ft of South KGB Road, 250 ft of W Northshore Dr, 2 culverts, 1 driveway, 9 septic systems, 13 docks, 1 ramp, 5 structures
	4	45	800 ft of South KGB Road, 325 ft of W Northshore Dr, 2 culverts, 1 driveway, 9 septic systems, 13 docks, 1 ramp, 8 structures
	6	47	900 ft of South KGB Road, 350 ft of W Northshore Dr, 2 culverts, 1 driveway, 9 septic systems, 13 docks, 1 ramp, 12 structures
	8	49	985 ft of South KGB Road, 370 ft of W Northshore Dr, 2 culverts, 1 driveway, 9 septic systems, 13 docks, 1 ramp, 14 structures
Golden	1	291	4 docks, 1 ramp
	2	292	4 docks, 1 ramp, 165 ft of gravel access road
	3	293	4 docks, 1 ramp, 225 ft of gravel access road, 500 ft of Meadow Lakes Loop, 1 parking lot
Swan	1	251	1 culvert, 1 septic system
	2	252	1 culvert, 1 septic system
	3	253	1 culvert, 1 septic system
	4	254	1 culvert, 1 septic system
	5	255	1 culvert, 1 septic system

Lakes in this study with efficient outlets or substantial storage include Upper Caswell, Horseshoe, Island, Blodgett, and Anderson Lakes; these lakes are expected to better accommodate increased inflows with relatively minor changes in long-term water surface elevations. Wolverine Lake is not

anticipated to experience significant level changes with increased precipitation due to the controlled nature of its water level. Additionally, there are current plans to redo Kings Lake outlet, creating an unrestricted condition; Kings Lake is therefore also not expected to experience large increases in water level with increased future precipitation.

The climate projections presented in Table 2-3 provide regional context for evaluating future conditions but were not used to directly compute future average lake elevations. Predicting future lake levels would require detailed, watershed-specific hydrologic and hydraulic modeling such as water mass balance or lake stage-discharge analysis that incorporates projected precipitation, temperature, evapotranspiration, groundwater interactions, and outlet hydraulics. Accordingly, the recommendations presented in this report focus on identifying existing drainage limitations and infrastructure vulnerabilities that may become more significant under the wetter conditions projected by the SNAP climate model.

2.4 GROUNDWATER

Many lakes in the MSB receive groundwater inflow, lose water to the groundwater system, or exhibit a combination of both. Groundwater recharge occurs as precipitation and snowmelt infiltrate through permeable soils and unconsolidated glacial deposits into the underlying aquifer [Trainer, 1960]. The coarse-grained outwash deposits and glacial sediments common throughout much of the MSB promote infiltration, resulting in strong hydraulic connections between groundwater.

Under the projected increase in precipitation shown in Table 2-3, groundwater recharge is expected to increase in many watersheds, which may raise groundwater levels and increase groundwater discharge to hydraulically connected lakes. As a result, future lake level increases may occur not only from greater surface runoff but also from increased groundwater inflows. The magnitude of this response will vary among lakes depending on watershed characteristics, surficial geology, aquifer properties, and the degree of hydraulic connection between the lake and surrounding groundwater system.

Lakes can be categorized as either “submerged” or “perched”. Submerged lakes sit at least partially below the groundwater table and are directly recharged from groundwater input. Perched lakes sit above the groundwater table and have less of a direct connection to groundwater. Many of the lakes included in this study are likely submerged because they are located within the low-relief glacial outwash and alluvial deposits that characterize the core developed area of the Matanuska-Susitna Borough. These highly permeable sand and gravel deposits form a laterally extensive unconfined aquifer with a relatively shallow groundwater table. Numerous lakes in this setting occupy topographic depressions that intersect the groundwater table, resulting in direct groundwater exchange.

Wolverine Lake is the notable exception. Located at a substantially higher elevation in the surrounding mountains, it is likely a perched lake. Its watershed is dominated by precipitation, snowmelt, and local runoff, and the lake is less likely to be hydraulically connected to the regional groundwater system than the lakes located on the valley floor.

Because groundwater-lake interactions differ substantially across the borough and groundwater monitoring data are limited for most study lakes, groundwater contributions were evaluated

qualitatively rather than explicitly modeled. Consequently, groundwater is recognized as an important factor influencing observed and future lake levels, but the relative contribution of groundwater versus surface runoff for each lake could not be quantified within the scope of this study.

2.5 AERIAL IMAGERY AND TOPOGRAPHY DATA

Esri ArcGIS Pro (version 3.6) was used to spatially visualize MSB historical aerial imagery and topography. MSB historical aerial imagery from 1985 to 2025 and topographic data from 2019 were used [MSB, 2025b]. Some bathymetric data were publicly available from the ADF&G Alaska Lake Database and was georeferenced to supplement the 2019 MSB elevation data [ADF&G, 2026]. No other elevation or bathymetry data were available to conduct additional analyses. A summary of the data used is provided in Table 2-5.

Table 2-5. Matanuska-Susitna Borough Aerial Imagery and Topography Data Summary

Year	Notes
1949	Unknown
1985	Unknown
2004/2005	1-meter resolution
2011/2012	1-foot resolution; 6-inch resolution in MSB core area
2016	1-foot resolution; 6-inch resolution in MSB core area
2017	1-foot resolution; 6-inch resolution in MSB core area
2019	1-foot resolution; 6-inch resolution in MSB core area 1-foot contours, digital elevation model, and digital surface model
2020	1-foot resolution; 6-inch resolution in Talkeetna and Willow areas
2021	6-inch to 1-foot resolution
2022	6-inch to 1-foot resolution
2023	6-inch to 1-foot resolution
2024	6-inch resolution
2025	Unknown

2.6 GENERAL TRENDS

Historical data were analyzed to determine if emerging trends were present. Land cover changes associated with land development and urbanization are known contributors to drainage pattern impacts and increasing imperviousness in the MSB. Changes to land cover overtime were not analyzed for this study. Historical precipitation was analyzed using Matanuska Experimental Farm data because of its long data coverage from 1917 through 2026 [NOAA, 2026]. The observed long-term trend was stable, with the last 20 years showing a slightly increasing trend in precipitation and a notably high precipitation year in 2022. Changes in other basin characteristics, such as soils and groundwater, were immeasurable because of limited data and were therefore not analyzed.

Based on the historical WSE analysis, some emerging trends were observed. Increasing WSE trends were observed for several of the studied lakes, including Knik, Island, Swan, Golden, Kings/Anderson, Wolf, and Wolverine. A stable WSE trend was observed for Horseshoe and Blodgett Lakes, and a general trend could not be determined for Upper Caswell. Supporting data are provided in Appendix B. These trends are based on preliminary observation and require further observations and a longer analysis period to determine if they are long-term trends. Conducting lake level monitoring is recommended.

3.0 SITE VISITS

In May 2026, several RESPEC team members conducted site visits to investigate selected lakes in the MSB. The site visits helped the project team better understand the lake conditions, document any infrastructure of interest, and examine inlet and outlet structures at the lakes. Findings from the site visits are summarized in the following sections. Images from the site visits are included in Appendix F.

3.1 UPPER CASWELL LAKE

RESPEC team members and a representative of ADNR visited Upper Caswell Lake on May 19, 2026, at approximately 10:30 a.m. Some ice was present on the lake during the site visit, but the area near the outlet was thawed and allowed for good investigation of the outlet structure. Upper Caswell's outlet was identified as a 16-foot, 10-inch span by 8-foot, 3-inch rise aluminum box culvert, with an adjacent 9-foot, 2-inch span by 3-foot, 3-inch rise overflow aluminum box culvert. Both culverts outlet under East Caswell Lakes Road into Caswell Creek and subsequently to Middle Caswell Lake. The culverts are shown in Figure 3-1.



Figure 3-1. Upper Caswell Lake Outlet Culverts

visit photographs with the as-built drawings indicates that the culvert substrate remains largely intact but has been redistributed over time. This movement has resulted in the formation of at least one pool and altered the channel geometry from its original trapezoidal configuration to a more planar profile. Some minor erosion was observed near the inlets and outlets of the culverts. The most evident erosion was near the downstream end the overflow culvert, where the embankment on west side of the culvert had scoured. The observed erosion and scour are minor and will not affect the stability of the culvert and road embankment. The outlet of the spillway channel, connecting to Caswell Creek, was minorly obstructed with branches and rocks.

A high water mark was observed in the primary box culvert and approximately 4 feet, 8 inches below the crown of the pipe.

The primary control on the lake level is a rock weir located at the upstream end of the spillway channel. Comparison with post-construction photographs indicates that some rocks have been displaced since construction was completed. These changes may have altered the weir crest elevation and could be affecting the lake water level. The weir is shown in Figure 3-2.



Figure 3-2. Rock Weir at Upper Caswell Lake

3.2 HORSESHOE LAKE

The project team visited Horseshoe Lake on May 7, 2026, at approximately 10:30 a.m. The lake outlet was identified as a round CMP in good condition. This culvert outlets under South Horseshoe Lake Road into an outlet channel. The outlet channel and culvert are shown in Figure 3-3.



Figure 3-3. Horseshoe Lake Outlet Channel

3.3 KNIK LAKE

The project team visited Knik Lake on May 7, 2026, at approximately 2:25 p.m. Recent construction was observed at the lake outlet, including a newly excavated outlet channel approximately 7 feet wide extending parallel to KGB Road. The channel conveys flow from the lake to an existing 18-inch CMP beneath the Knik Bar & Grill driveway at Northshore Drive. Downstream of the driveway crossing, flow enters a second roadside ditch that continues parallel to KGB Road before crossing beneath KGB Road through an existing 36-inch CMP. The newly excavated channel consists primarily of exposed native gravel and cobble with steep side slopes and little to no established vegetation. No erosion protection, grade control features, or other channel stabilization measures were observed. Minor bank sloughing was evident at several locations, indicating the channel is susceptible to erosion until the banks become stabilized. In addition, the channel was excavated immediately adjacent to the KGB Road embankment, reducing the width of the roadside foreslope and creating steep side slopes between the roadway and the channel. These conditions present roadway safety concerns and may contribute to long-term embankment instability if left unaddressed.



Figure 3-4. Knik Lake Outlet Channel – Looking Upstream



Figure 3-5. Knik Lake Outlet Channel - Looking Downstream



Figure 3-6. Knik Lake Outlet Channel – Upstream of Knik Bar & Grill Driveway

3.4 ISLAND LAKE

Island Lake was visited by the project team on May 7, 2026, at approximately 1:20 p.m. Recent development around the lake has sparked concern with residents about future lower water levels, and the U.S. Army Corps of Engineers (USACE) is concerned about potentially raised future water levels.

During the site visit, no defined outlet channel was identified. Instead, surface water from the lake appeared to discharge into an adjacent wetland complex bordering the southern lobe of the lake. Based on field observations, no definitive conclusions could be drawn regarding the potential impacts of recent development on lake levels. Further monitoring and evaluation would be required to better understand the lake's hydrologic response and long-term water level trends.



Figure 3-7. Island Lake Outlet Wetland

3.5 BLODGETT LAKE

The project team visited Blodgett Lake on May 11, 2026, at approximately 9:00 a.m. Ice was present during the site visit but was confined to the middle of the lake. The lake outlet was identified as a 16-foot-span bridge with an approximately 12-foot-wide timber deck. Downstream of the bridge, flow is conveyed through a low-gradient channel characterized by organic-rich gravel substrate and densely vegetated banks. At the time of the site visit, the WSE closely matched the ordinary high water (OHW) elevation.

3.6 SWAN LAKE

Swan Lake was visited on May 21, 2026, to measure and inspect the outlet culvert, which was identified as an 18-inch CMP extending west under South Rainbow Street and draining into Mallard Lake.

3.7 GOLDEN LAKE

The project team visited Golden Lake on May 7, 2026, at approximately 12:50 p.m. Golden Lake is bisected by a railroad embankment. The team was able to see a culvert in the embankment connecting the two halves of the lake; the pipe was not measured but appeared to be 36 inches in diameter and rusted. Because of recent construction realigning North Meadow Lakes Drive, the original outlet was cut off and replaced with a new 12-inch CMP draining into a well-defined roadside ditch.

3.8 KINGS/ANDERSON LAKES

The project team visited Anderson Lake on May 11, 2026. A single 4-foot CMP outlet culvert was identified. The pipe's invert has experienced significant degradation caused by rusting, and vertical supports have been placed approximately halfway into the pipe. This outlet structure drains into a channel that ultimately leads to Dry Lake. The channel was measured to have a 4-foot bottom width, an OHW width of 8 feet, and a bankfull width of 11 feet. The water depth observed in the channel at the time of the site visit was 7 inches.

3.9 WOLF LAKE

The project team visited Wolf Lake on May 11, 2026, at approximately 11:45 a.m. Some ice was present in the middle of the lake during the site visit. The lake outlet was identified as a culvert draining west from the floatplane slip in the southwest portion of Wolf Lake. The outlet structure was underwater and inaccessible to the project team for further investigation. The overall drainage path was determined to be a series of 24-inch CMP culverts. The first pipe drains out of the floatplane slip; the second pipe crosses Beechcraft Cir; and the third pipe is very long, crosses under the Wolf Lake Airport runway, and has very limited cover. The third pipe's outlet was unable to be determined during the site visit. The fourth pipe crosses East Hart Lake Loop, and the final pipe crosses North Horizon View Drive.

3.10 WOLVERINE LAKE

The project team visited Wolverine Lake on May 11, 2026, at approximately 1:30 p.m. Some ice was present at the middle of the lake, but the outside edges and outlet were clear. Several nearby residents and an ADF&G representative also joined the project team to discuss the lake and its outlet.

The Wolverine Lake outlet is controlled by an unconventional weir constructed of logs, cobbles, boulders, brush, rebar, and wattles. The structure functions to maintain lake water levels for recreational use and to reduce the extent of near-shore vegetation growth. The original construction date is unknown; however, a long-term lake resident reported that the structure has existed since at least the 1960s. Fish passage is currently provided through a small orifice within the weir, which conveys flow under a range of lake levels but requires frequent maintenance to remain free of debris. During the site visit, the attending ADF&G representative indicated that the existing outlet structure would be classified as a fish passage barrier.

Weir maintenance is performed by the residents and consists primarily of restacking rocks and logs. The outlet structure was observed to be approximately 3.5 feet tall and 29 feet long. The downstream pool width was observed to be 21 feet wide, and the downstream channel was 16 feet wide. The residents expressed interest in alternative outlet structure designs and would prefer an additional 1 to 2 feet of lake level to support fish habitat. Because Wolverine Lake is relatively shallow, low water levels can contribute to winter fish mortality by reducing available overwintering habitat.

3.11 RAINBOW LAKE

Rainbow Lake was briefly visited by the project team to observe a fish passage culvert on the north side of the lake installed in 2008. While survey benchmarks were established for Rainbow Lake during this

project, it is not included in the scope of the H&H work, and therefore is not analyzed in this report. An image of Rainbow Lake is provided in Figure 3-8.



Figure 3-8. Rainbow Lake

4.0 SURVEY BENCHMARKS AND MONITORING PLAN

To assist future lake level monitoring, survey benchmarks and lake level monitoring plans were established in May 2026 for the following lakes: Kings, Anderson, Finger, Kepler, Bradley, Knik, Christansen, Willow, and Rainbow Lakes. Details about these benchmarks and the lake level monitoring plan are included in Appendix G.

5.0 RECOMMENDATIONS AND COST ESTIMATES

Mitigation measures were identified for various lakes in the analysis. The costs are rough order of magnitude estimates and include professional services for the design of the mitigation measures. The solutions were broken down into major work items, and approximate quantities were developed based on planning-level design. The costs for the major work items were developed using historical DOT&PF bid tab pricing for similar work. The costs for the following lakes are subject to change pending detailed design and quantity development. Further details on all cost estimates are provided in Appendix H.

5.1 UPPER CASWELL LAKE

Upper Caswell Lake is impounded by the Caswell Lakes Road Embankment Dam, with lake levels controlled by a rock weir and an outlet structure consisting of aluminum box culverts. According to RESPEC's dam inspection report, the dam is functioning as intended and requires only minor maintenance.

The MSB has requested an evaluation of options to eliminate the dam classification associated with the Caswell Lakes Road Embankment Dam. Based on RESPEC's preliminary assessment, declassification would likely require lowering the embankment crest (i.e., road profile) and associated outlet culvert invert elevations to reduce the structure's regulatory dam height.

Under ADNR (2017) dam safety criteria, an impoundment is generally subject to jurisdictional classification if it has a height of 10 feet or greater, measured from the lowest point at the downstream toe to the crest. The Caswell Lakes Road Embankment Dam is currently listed as 13.6 feet in height; therefore, the crest elevation would need to be reduced by approximately 3.7 feet to fall below the 10-foot threshold. For design and construction practicality, a conservative reduction of 4 feet in both the road profile and the outlet culvert elevations has been assumed for this conceptual cost estimate.

For planning-level cost estimating purposes, the road lowering would extend along the full length of the embankment dam, with vertical curves incorporated to maintain roadway functionality and appropriate design transitions. The total road reconstruction length is approximately 700 feet and would impact four existing driveway connections.

As part of the proposed configuration, the existing culverts would be relocated to better align with the downstream channel, thereby reducing the extent of channel realignment and shortening the overall construction footprint. This alignment refinement is intended to minimize the length of channel disturbance and reduce the quantity of new riprap required for outlet protection.

The conceptual approach assumes the existing culverts can be reused, and that suitable existing riprap can be salvaged and incorporated into the reconstructed outlet protection where feasible.

Table 5-1 summarizes the estimated cost for lowering the road embankment and reconstructing the associated culvert outlet system.

Table 5-1. Upper Caswell Lake – Lower Culverts Cost Estimate

Construction Cost (\$)	Professional Services (\$)	Contingency (\$)	Total
1,941,700	540,800	248,250	\$2,730,750

It is important to note that dam classification is not determined solely by structural height. A second governing criterion is the downstream hazard classification associated with a potential dam breach. As such, a dam breach and hazard potential analysis is recommended to evaluate downstream consequences and confirm whether reclassification or declassification is appropriate under ADNR dam safety regulations. This analysis would inform whether reducing structural height alone is sufficient to remove jurisdictional dam status.

5.2 HORSESHOE LAKE

The outlet for this lake appears to be functioning as intended, and the existing culvert is in fair condition. Therefore, no improvements are recommended. To determine the effect that future precipitation would have on the outlet, a hydraulic analysis should be performed using projected future precipitation data.

5.3 KNIK LAKE

Two mitigation alternatives were developed for Knik Lake: (1) outlet channel realignment and (2) improvement of the existing outlet channel.

The first alternative consists of realigning the outlet channel to better reflect historical drainage patterns. Under this alternative, flow would be directed north of the Knik Bar & Grill and then east toward KGB Road into an existing cross culvert. For a planning-level cost estimate, the proposed channel was assumed to be a 530-foot-long trapezoidal ditch. Based on current site conditions, LiDAR data, and other historical information, this alternative is recommended.

As part of further evaluation of this alternative, a hydrologic and hydraulic analysis is recommended to assess the capacity of the existing KGB Road cross culvert and confirm whether the proposed drainage pathway can be adequately conveyed without adverse upstream or downstream impacts. Because the proposed alignment crosses private property, acquisition of a drainage easement would also be required. In addition, the proposed channel alignment should be evaluated to verify adequate separation distances from existing private wells and septic systems and to identify any modifications necessary to avoid impacts to these facilities.

The recommended channel alignment is shown in Figure 5-1.

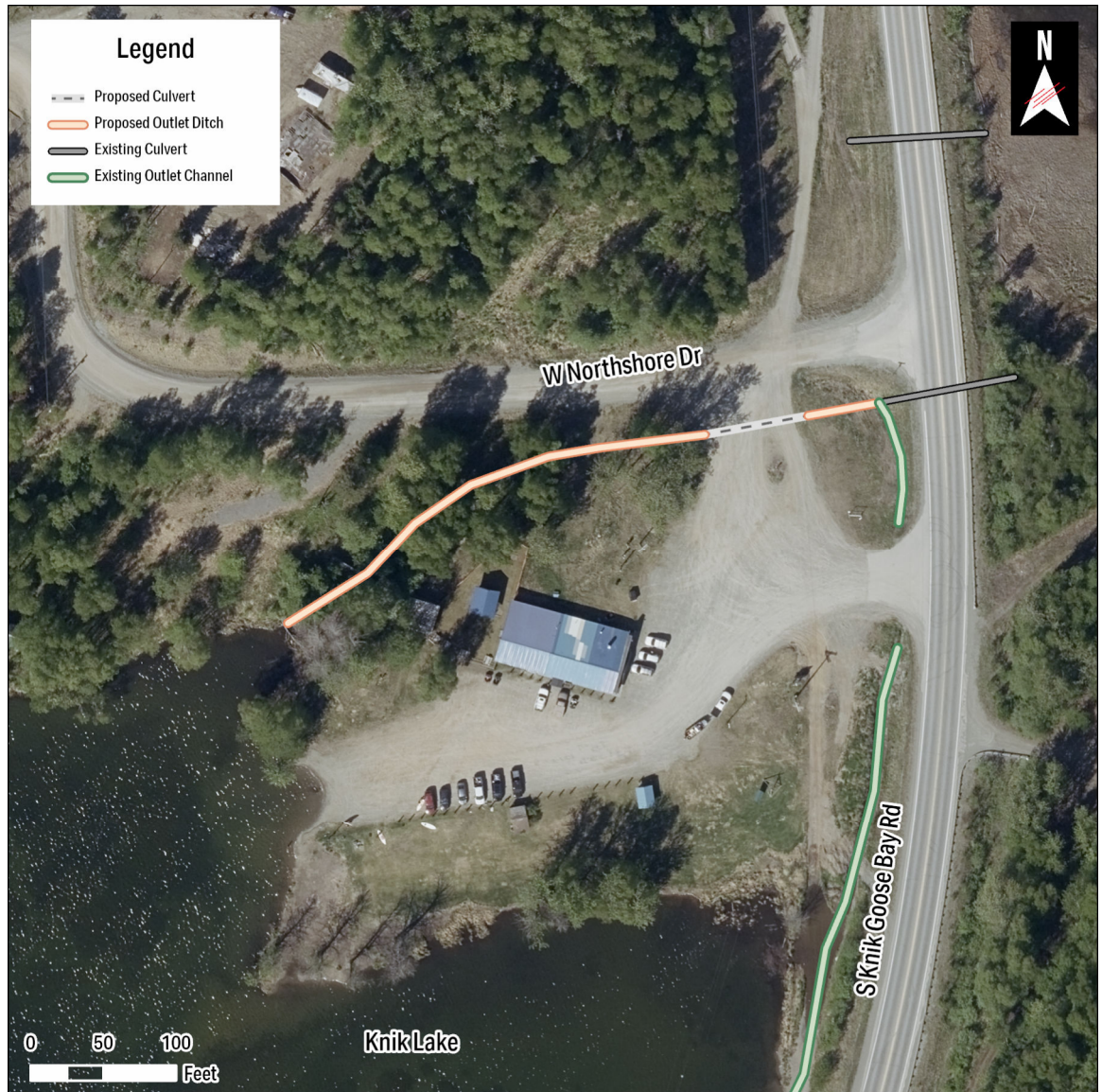


Figure 5-1. Knik Lake Recommended Channel Alignment

The second alternative involves armoring the recently constructed outlet channel and installing guardrail along KGB Road to improve roadway safety and protect motorists from the adjacent channel and steep slope. While this alternative was evaluated, it is not recommended. The existing channel alignment and geometry may continue to promote localized erosion and could increase long-term risk to roadway embankment stability, in addition to creating ongoing maintenance and traffic safety concerns.

Planning-level cost estimates for both alternatives are provided in Table 5-2.

Table 5-2. Knik Lake Mitigation Alternatives Cost Estimates

Alternative	Construction Cost (\$)	Professional Services (\$)	Contingency (\$)	Total
Alternative 1 (recommended)	177,200	50,300	22,750	\$250,250
Alternative 2	61,700	18,800	8,050	\$88,550

5.4 ISLAND LAKE

Surface water from the lake appears to discharge into an adjacent wetland complex bordering the southern lobe of the lake. Based on field observations, no definitive conclusions could be drawn regarding the potential impacts of recent development on lake levels. Further monitoring and evaluation would be required to better understand the lake's hydrologic response and long-term water level trends.

5.5 BLODGETT LAKE

RESPEC recommends further analysis of the existing bridge over the outlet of Blodgett Lake to determine its condition and adequacy. The bridge is on private property and may require an easement for inspection and maintenance. Along with the bridge inspection, the lake should be monitored in the future to document lake levels throughout the year over several years.

5.6 SWAN LAKE

No defined inlet channel was identified for Swan Lake during this study. Lake outflow is conveyed through an 18-inch culvert beneath South Rainbow Street, which provides the lake's primary outlet. Based on available topographic information, the lake level would need to rise more than 6 feet above the OHW elevation before overtopping either West Swan Drive or South Rainbow Street. RESPEC recommends monitoring lake levels over multiple years to better characterize seasonal and annual fluctuations and to evaluate the long-term performance of the existing outlet culvert.

5.7 GOLDEN LAKE

Recent reconstruction of Meadow Lakes Loop Road cut off the outlet of Golden Lake and therefore impacted its water surface elevation. During the site visit, a new outlet culvert, 12 inches in diameter, was identified under an all-terrain vehicle (ATV) trail. RESPEC recommends maintaining this culvert and its downstream ditch to preserve current lake levels; therefore, no cost estimate is included for Golden Lake.

Given the relatively small diameter of the outlet culvert, routine monitoring and periodic inspection are also recommended. The culvert is potentially susceptible to sedimentation and ice accumulation, which could reduce conveyance capacity over time. In addition, the 12-inch diameter may be insufficient to reliably convey higher magnitude lake outflows during peak runoff events, potentially resulting in episodic overtopping or localized backup of lake levels. Continued observation of performance during seasonal high-flow and freeze-thaw periods is recommended to verify long-term hydraulic adequacy and identify any maintenance needs.

5.8 KINGS/ANDERSON LAKES

The outlet culvert of Anderson Lake warrants replacement as a result of its poor condition. Because the lake and receiving stream are anadromous, the replacement structure should be designed to accommodate fish passage. The cost estimates presented in Table 5-3 are based on replacing the existing outlet culvert under North Charley Drive with a 13.5-foot-diameter structural steel plate culvert, embedded approximately 5.5 feet. This diameter was selected because it is approximately 20 percent wider than the measured bankfull channel width.

Table 5-3. Anderson Lake Outlet Culvert Replacement Cost Estimate

Construction Cost (\$)	Professional Services (\$)	Contingency (\$)	Total
862,000	271,600	56,680	\$1,190,280

MSB is advancing a culvert replacement project for the culvert that drains Kings Lake into Anderson Lake, with construction scheduled for 2027. Accordingly, recommendations are not provided for Kings Lake. MSB is also working with PND Engineers on the design of a replacement culvert under North Charley Drive.

5.9 WOLF LAKE

Based on field observations, RESPEC concluded that an excessively long culvert conveys flow from Wolf Lake south to the neighborhood south of the Wolf Lake runway. The culvert is more than 1,000 feet long. Because of the unknown alignment, length, and condition of the existing culvert, RESPEC recommends replacing it with a new piped outlet system that incorporates manholes at intervals not exceeding 300 feet to facilitate maintenance and inspection. The approximate existing outlet configuration, and the new recommended outlet configuration, are depicted Figure 5-2.

The proposed system would consist of an open channel south of Beechcraft Circle extending to the northern boundary of the airfield, where flow would be collected into a closed conveyance system. The closed system would convey flow southward beneath the runway and taxiways to the southern boundary of the airfield, where it would daylight.

At the daylight point, flow would be conveyed westward across Tract J-1 taxiway and into a culvert crossing. West of the Tract J-1 taxiway, the system would transition back to an open channel ditch that matches the alignment and geometry of the existing downstream channel.

A closed conveyance system was selected within the airfield to comply with Runway Safety Area (RSA) requirements, which require that the RSA remain free of hazardous irregularities, including open channels, steep drops, exposed structures, or other features that could compromise aircraft safety.

Because the proposed ditch crosses private property, acquisition of a drainage easement would also be required. In addition, the proposed ditch alignment should be evaluated to verify adequate separation distances from existing private wells and septic systems and to identify any modifications necessary to avoid impacts to these facilities.



Figure 5-2. Wolf Lake Outlet Configurations

Based on a previous report by PND, the existing 24-inch culverts are considered undersized, and a detailed hydraulic analysis is recommended to appropriately size the replacement conduits. For the purposes of this report, a preliminary pipe diameter of 4 feet was assumed to develop a rough order of magnitude construction cost for the proposed system.

Incorporation of a flow control structure, such as a weir or slide gate, is also recommended to support lake level management and prevent out-migration of stocked fish. The construction and professional services costs are depicted in Table 5-4.

Table 5-4. Wolf Lake Piped Outlet Cost Estimate

Construction Cost (\$)	Professional Services (\$)	Contingency (\$)	Total
1,633,700	270,200	95,195	\$1,999,095

A review of aerial imagery from 1972 suggests that Wolf Lake may have maintained a lower water surface elevation, below 541 feet, prior to construction of the floatplane base. However, the available information is insufficient to draw definitive conclusions regarding the magnitude of any long-term change in lake level or the extent to which construction of the seaplane base has influenced lake levels. The analysis is limited by the absence of detailed historical bathymetric data, uncertainty associated with georeferencing older aerial imagery, and the fact that historical water surface elevations were below the available LiDAR dataset. As a result, any quantitative estimate of lake level change would have a relatively high degree of uncertainty.

If restoration of historical lake levels is identified as a project objective, additional evaluation should be conducted to better define the pre-development outlet conditions and assess feasible restoration alternatives. Any proposed modifications should consider the operational requirements of the active floatplane base, potential impacts to adjacent property owners, environmental permitting requirements, and other stakeholders. Because changes to lake levels could affect aviation operations, shoreline properties, recreation, and ecological resources, a comprehensive engineering evaluation and robust public engagement process are recommended before advancing any restoration alternative.

5.10 WOLVERINE LAKE

Wolverine Lake supports coho and sockeye salmon and provides habitat for rainbow trout. The lake and stream are anadromous, so an outlet structure that supports fish passage should be constructed. Because of concerns about the long-term availability of resources to support maintenance of a new outlet structure, ADF&G has stated that any permissible solution would need to require as little maintenance as possible. The chosen mitigation measure was therefore a broad-crested weir with downstream step pools to allow juvenile fish to pass through the structure.

The planning-level design includes a 37-foot-long earthen embankment weir, approximately 80 feet of downstream channel improvements, and a permanent maintenance easement for the weir. The weir height would be 7.7 feet to allow for 2 feet of freeboard and an additional 2 feet of water level. An initial weir design is given in Appendix I.

Table 5-5 provides the estimated construction cost, design cost, and total project cost.

Table 5-5. Wolverine Lake Mitigation Cost Estimate

Construction Cost (\$)	Professional Services (\$)	Contingency (\$)	Total
459,400	152,000	30,570	\$641,970

If the project is funded and implemented by MSB, the weir will require provisions for long-term maintenance access. However, MSB funding is considered unlikely because of the limited recreational infrastructure associated with the lake, despite the presence of an undeveloped public access area on the north side of the lake. This area is low-lying and wet, which may limit its suitability for future development. A nearby resident has indicated that he would likely allow access for maintenance activities. Conversely, if the project is privately funded, long-term maintenance access provisions for MSB will not be required.



Anticipated permitting requirements include an ADF&G Fish Habitat Permit, a USACE Section 404 permit, and a dewatering permit during construction. Potential funding sources include MSB (unlikely), Trout Unlimited, the Mat-Su Salmon Partnership, tribal partners (potentially Chickaloon), and the U.S. Fish and Wildlife Service.

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