FINAL Total Maximum Daily Loads (TMDL) for Lead, Zinc, and Polycyclic Aromatic Hydrocarbon in Lakebed Sediments for Lake Lucile in Wasilla, Alaska

And Informational TMDL for Copper in Lakebed Sediments for Lake Lucile in Wasilla, Alaska

April 29, 2020

Alaska Department of Environmental Conservation
1700 East Bogard Road, Building B, Suite 103
Wasilla, AK 99654

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 155
Seattle, WA 98101-3188

WATER
DIVISION

May27, 2020

Mr. Randy Bates, Director
Water Division
Alaska Department of Environmental Conservation
P.O. Box 111800
Juneau, Alaska 99811

Re: Approval of the Total Maximum Daily Loads for Lead, Zinc, and Polycyclic Aromatic Hydrocarbons in the Lakebed Sediments for Lake Lucile in Wasilla, Alaska

Dear Mr. Randy Bates:

The Alaska Department of Environmental Conservation (ADEC) submitted the Total Maximum Daily Loads (TMDLs) for Lake Lucile (also known as Lake Lucille) to address lead (Pb), zinc (Zn), and polycyclic aromatic hydrocarbons (PAHs) in the lakebed sediments (Lake Lucile TMDL) via a letter, transmitted electronically, from Nancy Sonafrank (ADEC) to Dave Croxton (EPA) on April 30, 2020. Following our review, the Environmental Protection Agency (EPA) is pleased to approve the Lake Lucile TMDL for the pollutants listed in table below.

EPA-Approved TMDLs

Water Body Name	Assessment Unit Number	Pollutant
Lake Lucile	AK- 20505-409	Lead
Lake Lucile	AK- 20505-409	Zinc
Lake Lucile	AK- 20505-409	Polycyclic Aromatic Hydrocarbons

Since Copper (Cu) did not reach the level of impairment but was elevated in lakebed sediments, ADEC developed an informational TMDL and protection plan for copper in lakebed sediments for Lake Lucile in Wasilla, Alaska. Although the EPA does not act on informational TMDLs, the EPA is pleased with ADEC's inclusion of Cu into its planning, prevention and restoration efforts for Lake Lucile.

Lake Lucile is included in Alaska's 2014/2016 303(d) list ("list") of impaired waters for Pb and Zn. This list is Alaska's most recently EPA-approved list. Lake Lucile is not included in this list for PAH but during the TMDL development process ADEC found this waterbody to be impaired for this pollutant and submitted it as a TMDL for the EPA's action. Therefore, the EPA considers it to be unlisted but impaired.

The EPA's review indicates that these allocations have been established at a level that, when fully implemented, will lead to the attainment of the water quality standards in Lake Lucile for the pollutants shown in the above table. Therefore, ADEC does not need to include Lake Lucile on the next 303(d) list of impaired waters for the pollutants covered by the Lake Lucile TMDL.

We greatly appreciate the opportunity to work with your staff, especially Laura Eldred and Chandra McGee, throughout the development of these TMDLs. We are impressed with their collaboration and dedication during Lake Lucile TMDL's development and their commitment towards the implementation through inclusion of implementation targets and recommendations.

By the EPA's approval, the TMDLs shown in the above table are now incorporated into the State's Water Quality Management Plan under §303(e) of the CWA.

If you have any comments or questions, please feel free to call me at (206) 553-1855, or have your staff call Jayne Carlin of my staff at (206) 553-8512.

Sincerely,

DANIEL OPALSKI
Digitally signed by DANIEL OPALSKI
Date: 2020.05.27 12:50:10 -07'00'

Daniel D. Opalski
Director

cc: Ms. Terri Lomax, Acting Manager, Water Quality Standards, Assessment and Restoration Program, ADEC (ecopy)
Ms. Chandra McGee, Manager, Nonpoint Source Water Pollution Control Section, ADEC (ecopy)

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ACRONYMS AND ABBREVIATIONS

18 AAC 70	Title 18, Chapter 70, of the *Alaska Administrative Code*
ADEC	Alaska Department of Environmental Conservation
APDES	Alaska Pollutant Discharge Elimination System
ARRI	Aquatic Restoration and Research Institute
BMP	Best Management Practice
Cu	Copper
CAD	Computer Aided Design
CGP	Construction General Permit
COV	Coefficient of Variance
CWA	Clean Water Act
CWP	Center for Watershed Protection
DOT&PF	Alaska Department of Transportation and Public Facilities
GHCN	Global Historical Climate Network
GIS	Geographic Information System
GPS	Global Positioning System
g	Gram
kg	Kilogram
LC	Loading Capacity
LA	Load Allocation
mg	Milligram
mg/L	Milligrams Per Liter
MRLC	Multi-Resolution Land Consortium
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MSGP	Multi-Sector General Permit
NCDC	National Climatic Data Center
ND	Non-Detects
NHD	National Hydrologic Dataset
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSQD	National Stormwater Quality Database
NURP	Nationwide Urban Runoff Program
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PDF	Portable Document Format
PEL	Probable Effects Level
SQuiRT	NOAA Screening Quick Reference Tables
TAH	Total Aqueous Hydrocarbons
TEL	Threshold Effects Level
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
µg	Micrograms
EPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQS	Water Quality Standards
Zn	Zinc

TOTAL MAXIMUM DAILY LOAD AT A GLANCE

Water Quality Limited:	Yes
Alaska ID Number:	20505-409
Contaminant of Concern:	Lead, Zinc, Polycyclic Aromatic Hydrocarbon, and Copper
Designated Uses Affected:	Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife; Water Supply Aquaculture
Major Source(s):	Urban runoff
Loading Capacity:	See following table
Wasteload Allocation:	See following table
Load Allocation:	Outfall dependent; see following table
Margin of Safety:	Implicit through conservative assumptions
Necessary Reductions:	Outfall dependent; see following table

TMDLs for Lead (Pb), Zinc (Zn), and Polycyclic Aromatic Hydrocarbon (PAH)

Pollutant	g/year						East Outfall Reduction Required, %	West Outfall Reduction Required, %	Margin of Safety	Percent, %
	Existing Load	Load Capacity	WLA_{CGP}	LA_{NB}	LA_E	LA_W				Total Reduction
Lead	713.2	279.9	13.3	37.6	137.4	91.6	71	0	Implicit	61
Zinc	16,520	1,120.0	53.2	191.2	461.4	414.2	96	73	Implicit	93
PAH	13.8	2.4	0.1	0.0	1.2	1.1	86	77	Implicit	83

g = gram; WLA_{CGP} = Waste Load Allocation for the Construction General Permit; LA_{NB} = Load Allocation for natural background; LA_E= Load Allocation for east outfall; LA_W= Load Allocation for west outfall

Note that LA_E and LA_W would become WLAs if and when the MS4 permit is issued.

Informational TMDL for Copper (Cu)

Copper TMDL is included for informational and protection planning purposes only. While monitoring showed elevated copper levels, they were not considered by ADEC to be causing a water quality impairment.

Pollutant	g/year						Margin of Safety
	Existing Load	Load Capacity	WLA_{CGP}	LA_{NB}	LA_E*	LA_W*	
Copper	996.4	325.1	15.4	75.0	123.6	111.0	Implicit

g = gram; WLA_{CGP} = Waste Load Allocation for the Construction General Permit, LA_{NB} = Load Allocation for natural background, LA_E= Load Allocation for east outfall, LA_W= Load Allocation for west outfall

EXECUTIVE SUMMARY

Lake Lucile (also spelled Lucille) is a 365-acre lake located in Wasilla, Alaska, in the Matanuska-Susitna Borough. Alaska added Lake Lucile to Alaska's 2014/2016 Clean Water Act (CWA) Section 303(d)/Category 5 list of impaired waters for failing to meet the Alaska Water Quality Standards (WQS) for lead (Pb) and zinc (Zn) in lakebed sediments. The U.S. Environmental Protection Agency (EPA) approved this list on April 12, 2019. The impairment listing determination was based on sediment sampling that the Alaska Department of Environmental Conservation (ADEC) conducted in 2011–2013 surrounding two stormwater discharge outfalls at Lake Lucile. The impaired areas of the lake are approximately 4.5 acres in the northeast area surrounding the east stormwater outfall and approximately 1.1 acres in the northwest area surrounding the west stormwater outfall.

The CWA requires Total Maximum Daily Loads (TMDL) to be developed for pollutants causing water quality impairment. Although polycyclic aromatic hydrocarbon (PAH) was not originally listed as a cause of impairment, Alaska determined that Lake Lucile was impaired for PAH in the lakebed sediments during this TMDL development process and has included a TMDL for this impairment with the Pb and Zn. Copper (Cu) did not reach the level of impairment but was elevated in lakebed sediments. An informational TMDL is included for Cu to serve as a protection plan.

This is the second TMDL restoration plan for Lake Lucile. In 1998, Lake Lucile was added to the CWA Section 303(d)/Category 5 list of impaired waters for failing to meet the WQS for dissolved oxygen criteria (18 AAC 70) due to excess phosphorus. The EPA approved a TMDL for the lake on March 18, 2002, and implementation actions have occurred to increase dissolved oxygen concentrations by reducing anthropogenic phosphorus lake inputs. The lake remains impaired (Category 4a) for low dissolved oxygen.

A TMDL represents the amount of a pollutant the waterbody can assimilate while maintaining compliance with applicable WQS. A TMDL is composed of the sum of individual wasteload allocations (WLAs) for point sources of pollution and load allocations (LAs) for nonpoint sources of pollution and natural background loads. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs must be developed that address seasonal variation and critical conditions associated with pollutant loadings, waterbody response, and impairment conditions. Consideration of seasonal variation and critical conditions provides assurance that the waterbody will maintain WQS under all expected conditions.

Fresh waters of the State of Alaska are protected by criteria for (1) water supply; (2) water recreation; and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. All designated uses must be addressed unless specifically exempted in Alaska. Therefore, these TMDLs use the most stringent of the criteria among all the uses (as outlined in 18 AAC 70.020[b]).

For WQS Toxic and Other Deleterious Organic and Inorganic Substances for Fresh Water Uses, Lake Lucile does not support the designated uses for the Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife and for Water Supply Aquaculture, due to elevated levels of Pb, Zn, and PAH in lakebed sediments. Because the water quality criteria for these designated uses is narrative, these TMDLs use the National Oceanic and Atmospheric Administration (NOAA) Threshold Effects Levels (TELs) and Probable Effects Levels (PELs) to evaluate sediment quality (presented as milligrams per kilogram [mg/kg]) and effects to aquatic life exposed to those sediments.

The PEL sediment assessment values were used to determine impairment of Lake Lucile based on exceedance of the PEL values for Pb and Zn. Cu was not identified as a cause of impairment because it only exceeded TEL values; however, this does indicate the levels are elevated and should be addressed. PAH, which does not have a NOAA PEL value, is not currently on the impairment list; however, during TMDL development, ADEC determined that the magnitude of the PAH exceedances (6 times greater than the TEL value) in lakebed sediments is an impairment and needs a TMDL.

Based on a review of available data, ADEC determined that runoff from urban land uses in the watershed, delivered to the lake through two stormwater outfalls (i.e., “east” and “west”), contributes the majority of the metals and PAH pollutant loading to Lake Lucile. The metals and PAH attach to sediments and move to Lake Lucile through stormwater runoff, so the overall approach to developing these TMDLs links the metals and PAH concentrations in the lakebed near the outfalls to the sediment loads transported via stormwater runoff. The sediment loading also can be used as a surrogate to measure progress during and after implementation of the TMDLs.

The MOS was included implicitly through conservative assumptions outlined in the TMDL. Most of the loading capacity is assigned to nonpoint sources draining to the east and west outfalls as the LA with a WLA for current and future construction general permit (CGP) loadings. However, it is anticipated that in the near future, stormwater discharges to Lake Lucile will be regulated by an Alaska Pollutant Discharge Elimination System (APDES) stormwater permit for municipal separate storm sewer systems (MS4). In that scenario when the future permit is issued, the LA for Pb, Zn, and PAH, delivered to Lake Lucile from the MS4 area will automatically convert to a WLA without having to revise this TMDL for ease of implementation. The load capacity includes a natural background load allocation because with the exception of PAH, there is a background level of metals expected to be found in the lakebed sediment in the absence of the stormwater outfalls.

The most effective way to address these sources of pollution is to prevent the pollutants from entering the drainage collection system that discharges to Lake Lucile through the two outfalls. ADEC does not recommend lake dredging for pollutant removal nor capping the polluted lakebed sediments (see Section 7.1). The City of Wasilla and the Alaska Department of Transportation and Public Facilities (DOT&PF) will be the primary parties implementing the Lake Lucile TMDLs by focusing on:

- ❖ Pollutant source control and stormwater interception prior to lake discharge (key implementation factor);
- Implementing stormwater management practices related to control of runoff from construction sites, particularly practices that result in greater control of sediment erosion and those that result in greater disconnected impervious areas;
- Improving maintenance and management of stormwater best management practices (BMPs) to reduce sediment availability as well as PAH and metals concentrations;
- Pollution prevention public education;
- Identifying and restoring suspected pollutant source hotspots.

Under the future expected MS4 permit, addressing the potential contribution of pollutant loads from stormwater is typically expressed as BMPs or other similar requirements, rather than as numeric effluent limits. ADEC recognizes the need for an iterative approach to control pollutants in stormwater discharges and anticipates that a suite of BMPs will be used in the initial permit issuance; subsequent permit issuances may become more tailored based on BMP effectiveness and performance.

Follow-up monitoring is recommended to track the progress of TMDL implementation and subsequent water quality response, track BMP implementation and effectiveness, and track the water quality of Lake Lucile to evaluate future attainment of WQS.

1. OVERVIEW

Lake Lucile (also spelled Lucille) is a 365-acre lake located in Wasilla, Alaska, in the Matanuska-Susitna Borough. Alaska added Lake Lucile to Alaska's 2014/2016 Clean Water Act (CWA) Section 303(d)/Category 5 list of impaired waters for failing to meet the Alaska Water Quality Standards (WQS) for lead (Pb) and zinc (Zn) in lakebed sediments (Table 1-1). The U.S. Environmental Protection Agency (EPA) approved this list on April 12, 2019. The impairment listing determination was based on sediment sampling that the Alaska Department of Environmental Conservation (ADEC) conducted in 2011–2013 surrounding two stormwater discharge outfalls at Lake Lucile. TMDLs are required by the CWA to be developed for these metals.

This is the second TMDL restoration plan for Lake Lucile. In 1998, Lake Lucile was added to the CWA Section 303(d)/Category 5 list of impaired waters for failing to meet the WQS for dissolved oxygen criteria (18 AAC 70) due to excess phosphorus. The EPA approved a TMDL for the lake on March 18, 2002, and some implementation actions have occurred to increase dissolved oxygen concentrations by reducing anthropogenic lake inputs of phosphorus. The lake remains impaired (Category 4a) for low dissolved oxygen.

Table 1-1. Lake Lucile Section CWA 2014/2016 303(d)/Category 5 impairment listing from Alaska's 2014/2016 Integrated Water Quality Monitoring and Assessment Report (ADEC, 2018b)

Alaska ID Number	Waterbody	Area of Concern	Water Quality Standard	Pollutant	
				Parameters	Sources
20505-409	Lake Lucile	4.5 acres in northeast area of lake and 1.1 acres in northwest area of lake	Toxic & Other Deleterious Organic and Inorganic Substances	Metals – lead and zinc	Stormwater discharges

The location of high concentrations of Pb and Zn in lakebed sediments near two stormwater outfalls in Lake Lucile supports a conclusion that increased metal concentrations are the result of runoff from urban and commercial development within this drainage area. Exceedances of the National Oceanic and Atmospheric Administration (NOAA) Threshold Effects Level (TEL) and Probable Effects Level (PEL) benchmarks (NOAA, 2008) occur during times of active stormwater discharges and during times of dry weather with no discharge (ADEC, 2018a). Exceedances occur in the lake in the area coincident with the stormwater discharge outfalls located along the north shore in the east and west ends of the lake.

Copper (Cu) levels also exceed the TEL but not the PEL at these locations. Like Pb and Zn, the source of Cu contamination is stormwater runoff. While Cu contamination did not result in the listing of any impaired waters, this pollutant was addressed in this analysis because of the elevated levels and for consistency in implementation of best management practices (BMPs). ADEC considers the TMDL for Cu as informational for protection planning purposes. Polycyclic aromatic hydrocarbon (PAH), which does not have a NOAA PEL value, is not currently on the impairment list; however, during TMDL development, ADEC determined that the magnitude of the PAH exceedances (6 times greater than the TEL value) in lakebed sediments is an impairment and needs a TMDL.

The areas listed as impaired are 4.5 acres in the northeast area of the lake near the east stormwater discharge outfall and 1.1 acres in the northwest area of the lake surrounding the west stormwater discharge outfall.

As part of the metals and PAH TMDL development, available data and studies were compiled, and a data inventory was developed (Appendix A). The primary purpose of the data compilation effort was to identify and review any relevant information to support an understanding of historical conditions and trends, possible sources, and activities that have occurred or are planned.

The following subsections summarize key information and findings from available reports and datasets available for the Lake Lucile watershed, focusing on the local climate, surface and groundwater hydrology, infrastructure with respect to the two stormwater outfalls, population and growth, land use and land cover, and geology and soils.

1.1 Location and Description

Lake Lucile is located in Wasilla, Alaska, approximately 45 miles (72 kilometers) north of Anchorage in south-central Alaska (see Figure 1-1). The lake was formed through glacial activity, likely from the most recent glacial retreat, approximately 10,000 years ago (Eilers, 1993). The lake is part of a 2,812-acre watershed and is the headwaters for Lucile Creek. The lake is a popular recreational destination and includes Lake Lucile Park, an 80-acre park on the southern shores of the lake, with swimming, camping, hiking trails, athletic fields, and lake access as well as a smaller public park and boat launch on the eastern shore. The lake is stocked with Coho salmon and rainbow trout and is a popular destination for anglers.

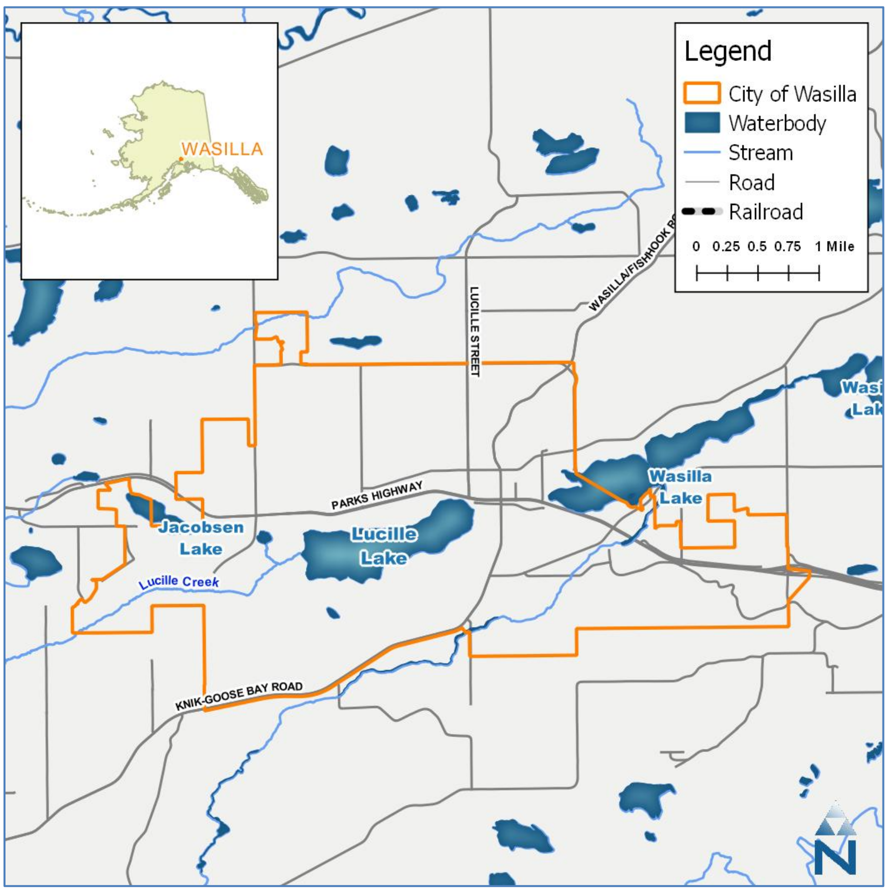

Figure 1-1. Location of Lake Lucile in Alaska's Matanuska-Susitna Borough

Lake Lucile has an east-west orientation (see Figure 1-2). The lake's fetch is approximately 1.6 miles (2.6 kilometers) and width is 0.5 miles (0.8 kilometers). The lake is relatively shallow, with a mean depth of 5.5 feet (1.7 meters) and a maximum depth of 22 feet (6.7 meters). The lake's surface area is 365 acres, and approximately 95% of its surface area is less than 15 feet (5 meters) deep. The maximum depth is located close to the east stormwater outfall. The lake substrate is almost entirely covered by aquatic vegetation (Eilers and Bernert, 1993). Its watershed-to-lake ratio is approximately 4:1, meaning the lake's watershed area is approximately four times the lake's surface area. Lake Lucile has a volume of approximately 2,000 acre-feet (651,702,854 gallons) and a shoreline length of 4.3 miles (6.9 kilometers).

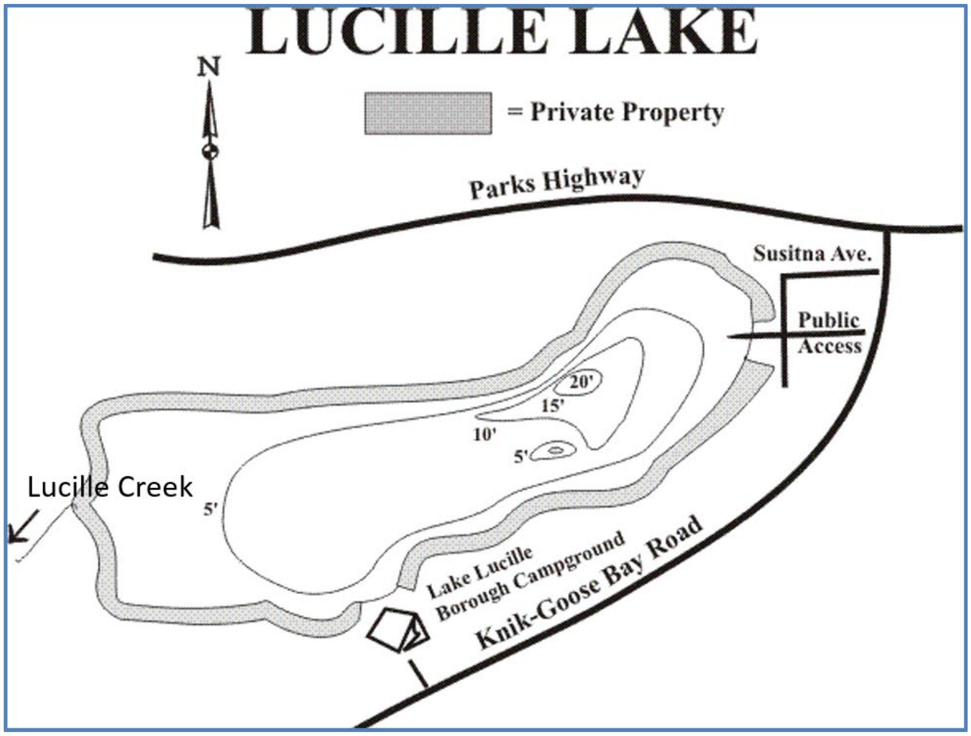

Figure 1-2. Lake Lucile location and bathymetry

Source: Modified from Alaska Department of Fishing and Game figure
(http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportLakeData.lakeDetail&LakeID=145).

1.2 Hydrology

Lake Lucile and most of its watershed are within the City of Wasilla boundaries in the Matanuska-Susitna Borough in south-central Alaska. Northern portions of the watershed are not within city limits and instead are under Matanuska-Susitna Borough jurisdiction. The lake is primarily groundwater-fed with no surface water stream inflows (ADEC, 2002; City of Wasilla, 1984). Other than groundwater, other sources of water to the lake are direct precipitation and runoff from the surrounding area. A hydrologic budget from the 2002 dissolved oxygen TMDL estimated that 58.9% of the inflows are from groundwater, 23.6% are from precipitation directly to the lake's surface, and 17.5% are from runoff (ADEC, 2002).

The only outlet of the lake, Lucile Creek, originates at the western end of the lake and flows about 12 miles to its confluence with Little Meadow Creek. The United States Geological Survey (USGS) operates a gage on Lucile Creek (Lucile Creek below Lucile Lake near Wasilla AK; USGS-15286400), which collected 42 streamflow data measurements between May 1984 and November 2013. Two additional gages located 2 miles downstream recorded limited data in 1984.

Due to the lack of surface inflows and limited precipitation in the area, the lake has a long water residence time (Eilers, 1993). The Lake Lucile Waterbody Assessment (HDR, 1995) estimated the lake's water residence time to be 1.2 years. This means that sediment and other pollutants washed into the lake will remain for long periods. Sediment and any associated pollutants would likely settle to the bottom of the lake, thereby increasing their time in the lake and their chances of being resuspended and recirculated into the lake. Additionally, wind direction and fetch length can impact sediment resuspension in shallow lakes (Sheng and Lick, 1979). High wave conditions on Lake Lucile and associated increases in bottom shear stresses also may result in significant resuspension of sediments.

A wooden dam/weir at the outlet of the lake was installed in the 1960s to stabilize the lake level and enhance fish habitat. Improvements to the dam were made in 2013, with the wooden structure replaced by sheet piles (A. Giddings, personal communication, June 5, 2019). Less than one mile to the east of Lake Lucile is Wasilla Lake. Although there is no current surface hydrology connection between the two waterbodies, there is some historic anecdotal evidence that the lakes used to have a connection through a wetland complex prior to area development.

The impaired areas are coincident with the location of the two stormwater outfalls presented in Figure 1-3 (ADEC, 2018a).

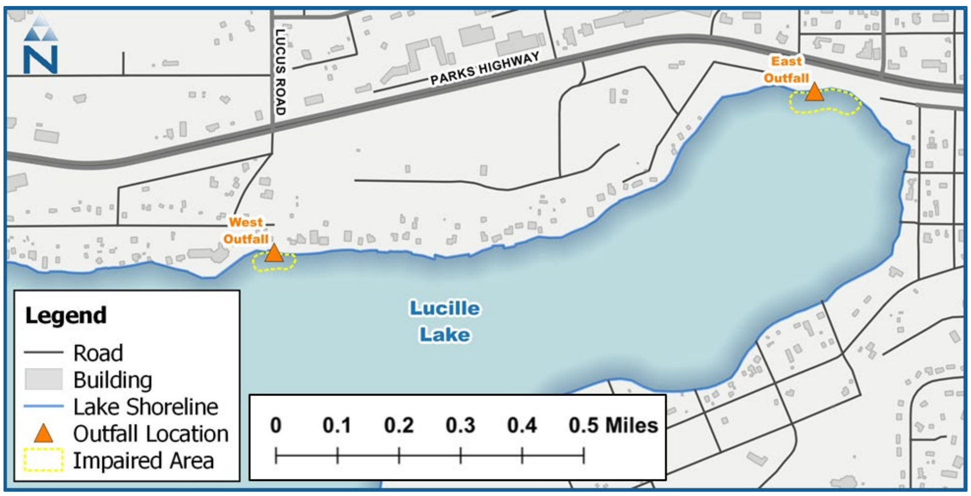

Figure 1-3. Location of CWA 2014/2016 303(d)/category 5 listed areas and stormwater outfalls

The City of Wasilla (2001) assessed the drainage system as part of a strategy to upgrade and improve public infrastructure through a period of rapid growth. Using a combination of digital elevation model data, city information on the stormwater infrastructure system, and field assessments, the *Storm Water Master Plan: 2000–2015* identified drainage basins contributing runoff to Lake Lucile. The plan indicated that much of the area along the northern border of the city likely did not produce runoff that entered the lake. While these areas may contribute groundwater to Lake Lucile, runoff was managed entirely by infiltration through local depressions in the landscape (City of Wasilla, 2001).

Because of the unique groundwater–surface water interactions and the amount of disconnected impervious cover, topography was not used to delineate the watershed used for this TMDL assessment. Instead, the watershed area draining to the lake was determined using locally developed information from a study sponsored by ADEC (ARRI, 2019). The study was conducted to measure the impervious surface area of roads and other development contributing stormwater flows to storm drains leading to Lake Lucile. The study estimated that 142 acres contributed stormwater flows to the two outfalls (ARRI, 2019).

1.3 Population and Growth

The Lake Lucile watershed was undeveloped until 1916 when the Alaska Railroad was extended through the Matanuska Valley (ADEC, 2002). The population grew very slowly to 300 persons by 1970. Between 1970 and 2010, the population grew by an average annual rate of 8.5%. Wasilla was listed in the 2010 decadal census with a population of 7,831, making it the largest city in Matanuska-Susitna Borough and the sixth largest city in Alaska by population (U.S. Census, 2012). Figure 1-4 shows Wasilla's population growth from 1970 through 2010, highlighting the rapid growth through the latter part of the 20th century that has continued over the past two decades.

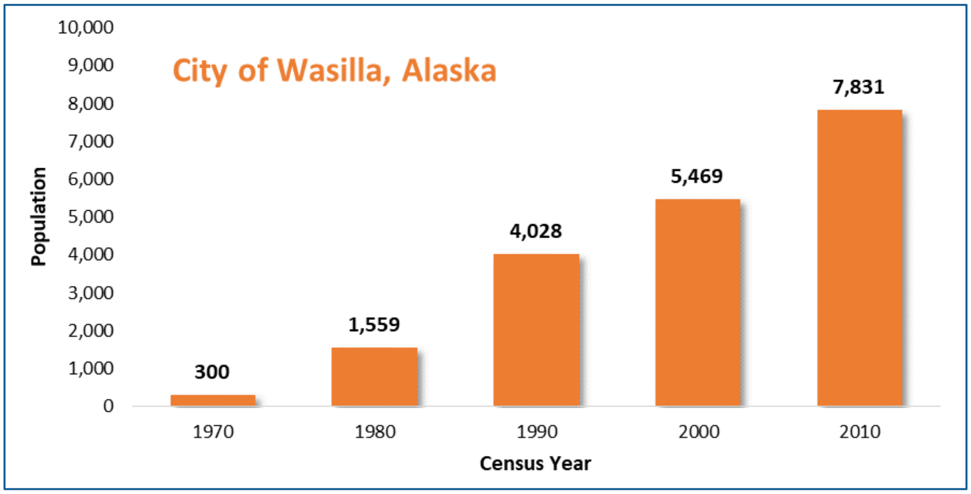

Figure 1-4. City of Wasilla decadal census population (1970–2010)

Today, virtually the entire length of the northern shoreline has been developed into single-family residences and one large motel (ADEC, 2002). The south shore has also been developed into single-family residences and a public park. The east shore adjacent to downtown Wasilla is the site of a public park, boat launch, and several residences, while the west shore is primarily residential and is the location of the weir outflowing to Lucile Creek.

1.4 Zoning and Land Use

It is important to include impervious cover and differentiate land use types to represent the existing urbanizing landscape for developing a reasonable pollutant source characterization. The City of Wasilla provided maps of the current land use zoning in PDF and CAD formats (City of Wasilla, 2019). The CAD layer was converted to a geographic information system (GIS) format consistent with the other datasets evaluated in this section. The city has seven zoning categories: four categories of *Residential* (*Rural Residential, Residential, Single-Family Residential, Multi-Family Residential*), *Commercial, Industrial,* and *Public*. Figure 1-5 presents a map of the Lake Lucile area showing the surrounding zoning categories.

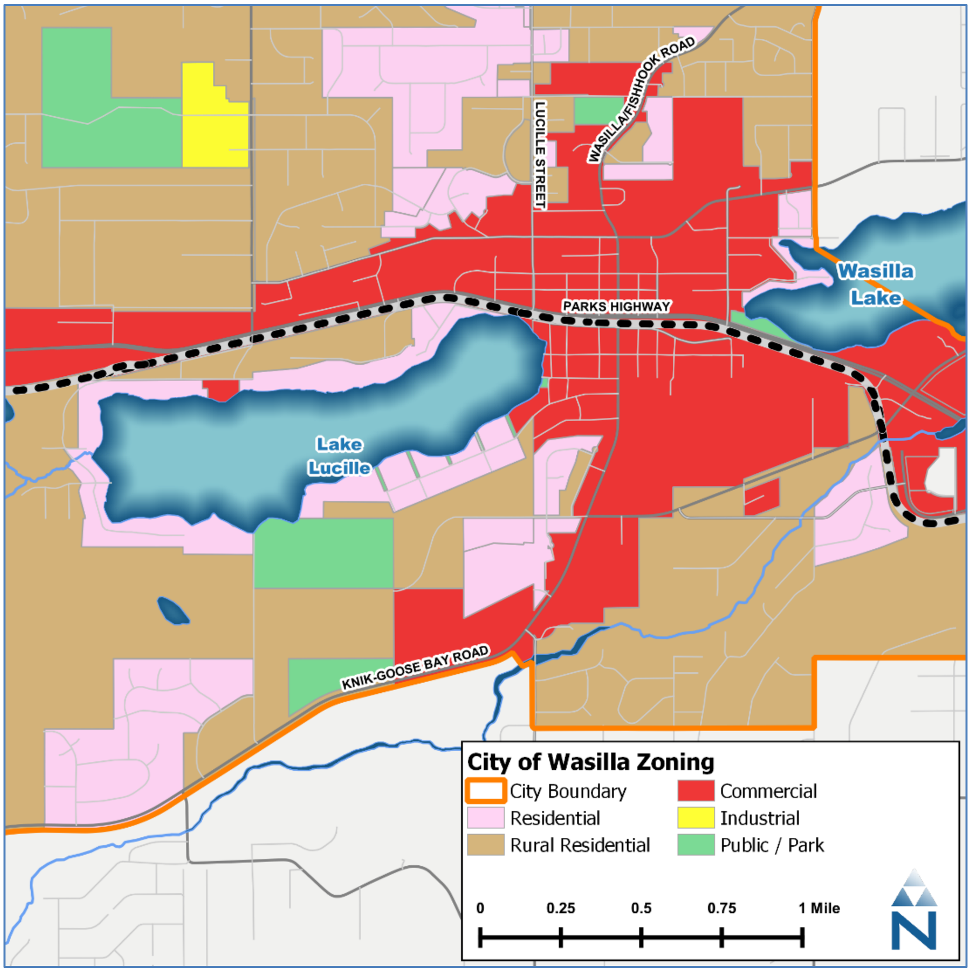

Figure 1-5. City of Wasilla zoning categories surrounding Lake Lucile (City of Wasilla, 2019)

Much of the area to the east of the lake is zoned Commercial, and most of the area to the north is zoned Single-Family Residential or Rural Residential. There is limited industrial zoning within the Lake Lucile drainage area.

1.5 Roads

Several major roads surround Lake Lucile, including the Parks Highway, located on the north side of the lake parallel and adjacent to the railroad right-of-way on the east side before diverging toward the western side of the lake. Smaller and less-traveled roads are immediately adjacent to the lake, including West Lake Lucile Drive, which loops around the northwestern, western, and southwestern sides of Lake Lucile. Small, gridded road networks along the eastern shore (South Lake Street) and southern shore (West Lake View Drive) primarily service commercial and residential areas, respectively. Another nearby major road includes Knik Goose Bay Road to the east. This road is currently being redesigned. Figure 1-6 presents the road network surrounding Lake Lucile, highlighting the major arterial roads and secondary roads.

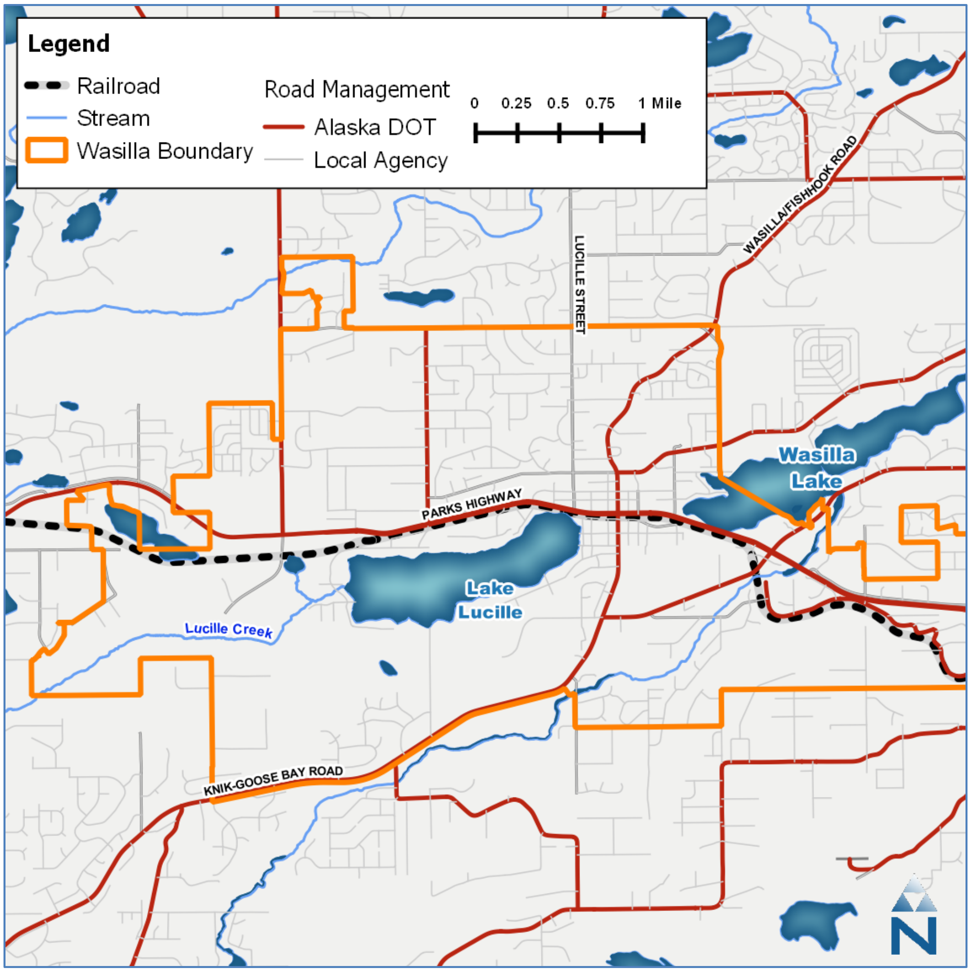

Figure 1-6. Lake Lucile with adjacent roads and road management responsibility

1.6 Soils and Geology

The following description of local soils was taken from the previous version of the TMDL document (ADEC, 2002, p. 3):

> The geology of the watershed can be described as a ground moraine with complex till stratigraphy and artesian aquifers. The glacial drift reaches a depth of approximately 21 meters (70 feet). Steep hills rise to a height of approximately 40 meters (150 feet) to the north of the lake. The remainder of the watershed around the lake can be described as gently sloping. Predominant soils are Knik silt loams (Kn) and organic peat. Knik loams are found in upland areas and are subject to high winds from the east, resulting in an erosion hazard. Other soils in the watershed include Kashwitna, Wasilla, and Jacobson. Kashwitna and Wasilla are silt loams and Jacobson is a very stony silt loam. The silt loams have high rates of permeability, and moderate or high-density housing may cause pollution to the water table. The low-lying areas are organic (peat) soils with low permeability. Frost depth may reach 2 meters (6 feet) and may be in the ground until July.

Suspended sediment often plays an important role in the transport of metals that have accumulated on the ground surface or in soils. The accumulation in soils is the result of the process of adsorption (process where metal [or other elements/compounds] ions in water adhere to the surface of soil particle). Metal adsorption to soil particles is a function of the concentration of metal ions in solution and the properties of specific soils. Clay soils typically have the greatest potential for metal adsorption (sand has the lowest), although organic matter and even living organisms such as bacteria and algae can adsorb metals (Fein and Delea, 1999; Jahan et al., 2004). Soils can also adsorb PAH, and the presence of heavy metals can even enhance PAH sorption to soils (Liang et al., 2016). The fate and transport of metals and PAH in the environment can therefore be largely dependent on the mobilization of soil particles.

1.7 Climate

Wasilla is approximately 45 miles north of Anchorage, Alaska, with a similar climate; however, Wasilla is inland and less influenced by coastal weather patterns. Average temperatures range from a high of just under 70° F (21° C) in the summer (i.e., July) to a low around 8° F (-13° C) in the winter (i.e., January). Precipitation occurs throughout the year and typically falls as snow during the winter months. Climate data were obtained to characterize local trends and conditions through 2018.

The National Climatic Data Center's (NCDC) Global Historical Climate Network (GHCN) dataset describes total precipitation, rainfall, snowfall, snow depth, and air temperature. These data were evaluated to characterize the climate trends in the region surrounding Lake Lucile and the City of Wasilla. Five monitoring stations were near the Lake Lucile watershed. Table 1-2 summarizes the stations found in the GHCN dataset and the available climate data for each station.

Table 1-2. Summary of available NCDC climate stations with data near Wasilla, Alaska

		Date			Daily Climate Parameter				
Station Name	Station ID	Start	End	Appx. Distance from Lake Lucile (mi.)[a]	Precipitation	Evaporation	Temperature	Snowfall	Snow Depth
Anderson Lake, AK, US	USC00500302	1/1/1999	2/28/2010	5.9	●	—	●	●	●
Matanuska Experimental Farm, AK US	USC00505733	1/1/1999	1/31/2019	8.3	●	●	●	●	●
Meadow Lakes, AK US	USC00505780	12/1/2006	3/31/2008	3.5	●	—	●	●	●
Wasilla 3 S, AK US	USC00509759	2/1/1999	6/30/1999	3.0	●	—	●	●	●
Wasilla 4 N, AK US	USC00509767	4/1/2006	11/30/2006	5.1	●	—	●	●	●

[a] Distance estimated as measurement between reported station locations and centroid of Lake Lucile.

Of the five stations, the Matanuska Experimental Farm (GHCN-USC00505733) station has the longest available climate record, spanning a full 20 years. Over the 20-year period from January 1, 1999, through December 31, 2018, this station showed an annual average precipitation depth of 14.7 inches (see Figure 1-7) with variability of approximately ± 4 inches.

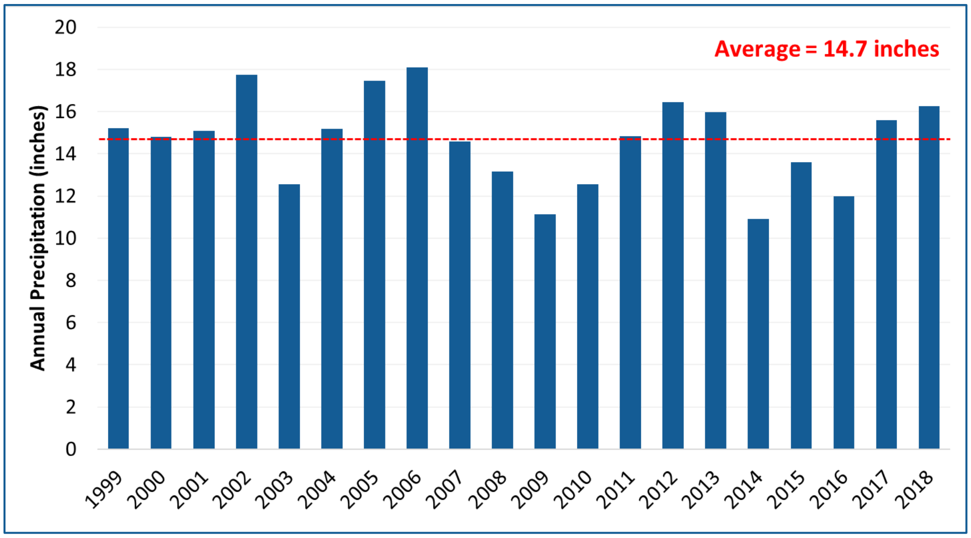

Figure 1-7. Annual precipitation at Matanuska Experimental Farm (1/1/1999–12/31/2018)

The seasonal variations in precipitation, snowfall, and temperature are presented in Figure 1-8 as the monthly average values at Matanuska Experimental Farm from January 1, 1999, through December 31, 2018. Note that the snowfall data in Figure 1-8 represent snow depth as reported by the climate station, not snow-water equivalent, and therefore show values higher than total precipitation.

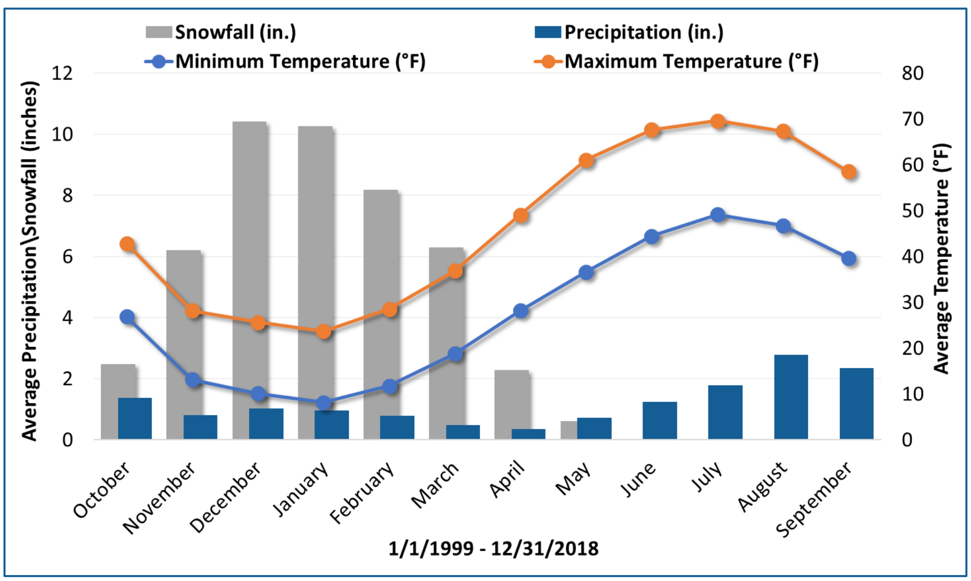

Figure 1-8. Average monthly precipitation, snowfall, and temperature at Matanuska Experimental Farm (1/1/1999–12/31/2018)

Monthly precipitation data show drier months in the spring with less than 0.5 inches of total precipitation (i.e., April and May). However, these months coincide with spring break-up and snow melt, which likely generates runoff to the lake. Wetter periods include the late summer and fall months of July, August, and September when precipitation (i.e., rainfall) is driven by a higher frequency of storm events. Wasilla typically sees snowfall starting in October and ending in May (see Figure 1-8). The highest periods of accumulation tend to be December through February, which are also the coldest months. Snowfall rapidly decreases in the spring and typically ends by the middle of May.

1.8 Plant and Animal Life

The watershed is a combination of northern mesic hardwood forest and sphagnum bogs. Dominant trees in mesic hardwood forests include white spruce, cottonwood, willow, aspen, and birch. Sphagnum bogs are found in low-lying areas and are dominated by black spruce. Small non-forested wetlands contain shrubs, such as bog rosemary, leatherleaf, blueberry, Labrador tea, and bog laurel (ADEC, 2002). Chara, a species of algae, is the dominant macrophyte (vascular plant and macro algae) in Lake Lucile. The remaining macrophytic population is composed of only three other species of submerged vascular plants: sago and whitestem pondweed (*Potamogeton pralongus* and *P. pectinatus*) and northern watermilfoil (*Myriophyllum exalbescens*) (ADEC, 2002).

Coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and threespine stickleback (*Gasterosteus aculeatus)* are the three dominant species of fish in the lake. Lake Lucile is a natural lake, but its outlet has a weir with a fish pass. Maintained by the City of Wasilla, the weir allows fish to pass from Lake Lucile and travel 11 miles down Lucile Creek into Meadow Creek and finally on to Big Lake. The Alaska Department of Fish and Game (ADFG) began stocking the lake with steelhead and rainbow trout in 1954. In later years, ADFG stocked Coho salmon and rainbow trout. In March 2002, there was a winter kill on Lake Lucile, but the ADFG restocked the lake with rainbow trout in May of that year (https://www.lakelubbers.com/lake-Lucile-655/). The die-off was likely due to low dissolved oxygen. Periods of anoxia during winter months are common in ice- and snow-covered shallow lakes when photosynthesis decreases but oxygen use continues or increases due to ongoing respiration and decay (ADEC, 2002). Lake Lucile is a popular summer and winter fishery.

2. WATER QUALITY STANDARDS AND TMDL TARGETS

WQS define the water quality goals of a waterbody and include designated uses, criteria to protect these uses, and antidegradation requirements. TMDLs are developed to achieve WQS, which can be expressed as numeric or narrative criteria to support designated uses. TMDLs use numeric WQS, when applicable, or a numeric interpretation of a narrative standard when explicit numeric criteria do not exist.

This section reviews the applicable WQS and identifies the TMDL target to be used in calculating the TMDLs to address Pb, Zn, and PAH impairments in Lake Lucile lakebed sediments. Because Cu only exceeded the TEL but not the PEL, the TMDL analysis, along with the entire document, will be considered an informational TMDL and protection plan for Cu.

2.1 Applicable WQS

The AAC establishes WQS for the waters of Alaska (Title 18 AAC Chapter 70; ADEC, 2018c). WQS define the water quality goals of a waterbody by designating the use or uses to be made of the water and criteria for protecting those uses. State water quality criteria apply to both fresh and marine waters, but only the freshwater criteria apply to Lake Lucile.

2.1.1 Designated Uses and Criteria

Designated uses for Alaska's waters are specified in 18 AAC 70.020(a). State fresh water is protected by criteria for (1) water supply; (2) water recreation; and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. All designated uses must be addressed unless specifically exempted. Therefore, the TMDL must use the most stringent use criteria (as outlined in 18 AAC 70.020[b]). Alaska added Lake Lucile to its list of impaired waters due to its exceedance of the Toxic and Other Deleterious Organic and Inorganic Substances standard.

For WQS *Toxic and Other Deleterious Organic and Inorganic Substances for Fresh Water Uses*, Lake Lucile does not support the designated uses for the Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife and for Water Supply Aquaculture, due to elevated levels of Pb, Zn, and PAH in lakebed sediments, which led to the development of this TMDL.

Table 2-1 lists the related narrative criteria in 18 AAC 70 (ADEC, 2018c) with the most appropriate and stringent criteria highlighted in bold text. The focus of this TMDL is on the narrative portion of the criteria regarding concentrations in bottom sediments that cause adverse effects for aquatic life.

Table 2-1. Summary of WQS and targets (ADEC, 2018c)

Pollutant and Water Use	Criteria
(11) TOXIC AND OTHER DELETERIOUS ORGANIC AND INORGANIC SUBSTANCES, FOR FRESH WATER USES	
(A) Water Supply Drinking, culinary, and food processing	The concentration of substances in water may not exceed the numeric criteria for drinking water and human health for consumption of water and aquatic organisms shown in the Alaska Water Quality Criteria Manual. Substances may not be introduced at concentrations that cause, or can reasonably be expected to cause, either singly or in combination, odor, taste, or other adverse effects on the use.
Water Supply Agriculture, including irrigation and stock watering	The concentration of substances in water may not exceed the numeric criteria for drinking and stockwater and irrigation water shown in the Alaska Water Quality Criteria Manual. Substances may not be introduced at concentrations that cause, or can reasonably be expected to cause, either singly or in combination, odor, taste, or other adverse effects on the use.
Water Supply Aquaculture	**Same as 11(C)**
Water Supply Industrial	Concentrations of substances that pose hazards to worker contact may not be present.
(B)Water Recreation Contact recreation	The concentration of substances in water may not exceed the numeric criteria for drinking water shown in the Alaska Water Quality Criteria Manual. Substances may not be introduced at concentrations that cause, or can reasonably be expected to cause, either singly or in combination, odor, taste, or other adverse effects on the use.
Water Recreation Secondary recreation	Concentrations of substances that pose hazards to incidental human contact may not be present.
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	The concentration of substances in water may not exceed the numeric criteria for aquatic life for fresh water and human health for consumption of aquatic organisms only shown in the Alaska Water Quality Criteria Manual, or any chronic and acute criteria established in this chapter, for a toxic pollutant of concern to protect sensitive and biologically important life stages of resident species of this state. **There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, adverse effects on aquatic life** or produce undesirable or nuisance aquatic life, except as authorized by this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests.

2.2 TMDL Targets

The TMDL target is the numeric endpoint that represents attainment of applicable WQS and is used to evaluate the loading capacity and necessary load reductions and allocations. As noted above, the TMDL must use the most stringent criteria among all designated uses. For these parameters, the most stringent criteria are for *Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife* (see highlight in Table 2-1).

The State of Alaska has not adopted freshwater numeric sediment criteria in the state WQS at 18 AAC 70. However, the state has adopted in 18 AAC 70 narrative criteria for toxic and other deleterious organic and inorganic substances as shown in Table 2-1. To implement narrative criteria for toxic substances in fresh and marine sediments, ADEC currently uses the NOAA Screening Quick Reference Tables (SQuiRT) as sediment quality guidelines for protection of aquatic life.

These sediment quality guidelines are scientific tools that synthesize information regarding the relationships between the sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals. The SQuiRT values were developed to support the evaluation of potential risks from contaminated water, sediments, or soil and represent statistical relationships between sediment chemical concentrations and adverse biological effects resulting from exposure. The SQuiRT tables present a range of risk tolerance levels for inorganic and organic substances in sediment, soil, and water (in freshwater and marine environments). Previous ADEC impairment decisions used applicable thresholds from the NOAA SQuiRT. The ADEC Contaminated Sites Program issued the *Sediment Quality Guidelines* (ADEC, 2013), which recommend the use of TELs and PELs from the most current NOAA SQuiRT. The TEL represents the concentration below which adverse biological effects are expected to occur rarely, and the PEL defines the level above which adverse effects are expected to occur frequently. The TEL and PEL values for the pollutants of concern are presented in Table 2-2.

Table 2-2. NOAA SQuiRT freshwater sediment assessment values used as sediment criteria

Parameter	TEL (µg/kg)	PEL (µg/kg)
Copper	35,700	197,000
Lead	35,000	91,300
Zinc	123,000	315,000
Total PAH	264.1	—

Source: NOAA, 2008

Section 3 summarizes the data available for the impairment assessment.

The TMDL targets for these pollutants will be set at the TEL value because it represents a conservative screening value assumed to be protective of aquatic life (see Table 2-2). The approach for applying these criteria is presented in Section 5.

2.3 Antidegradation

Alaska's WQS also include an antidegradation policy (18 AAC 70.015), which states that existing water uses and the level of water quality necessary to protect the existing uses must be maintained and protected unless the State of Alaska finds that lower water quality is necessary to accommodate important economic or social development in the surrounding area. When allowing such degradation or lower water quality, the state must ensure that water quality is adequate to fully protect existing uses of the water.

The most effective and reasonable methods of pollution prevention, control, and treatment then will be applied to all discharges. All discharges will be treated and controlled to achieve the highest statutory and regulatory requirements for point sources and all cost-effective and reasonable BMPs for nonpoint sources. Actions that could cause further degradation of Lake Lucile from metals and PAH in the lakebed sediments will be reviewed using Alaska's Antidegradation Policy and the requirements therein for making these kinds of decisions.

3. DATA REVIEW AND ANALYSIS

Available data and information were analyzed to provide a better understanding of general water quality conditions, spatial and temporal trends, and confirmation of the impairment of Lake Lucile. Appendix A includes an inventory and brief summary of all studies reviewed.

The development of this TMDL relied heavily on two studies (Davis et al., 2013a, 2013b) conducted for ADEC by the Aquatic Restoration and Research Institute (ARRI) for information on the magnitude and extent of metal and PAH contamination in Lake Lucile lakebed sediment. The reports include wet weather sample concentrations collected from stormwater discharge from the east outfall in 2011–2012 (Davis et al., 2013a) and dry weather lake sediment samples collected near the east and west outfalls in 2013 (Davis et al., 2013b). Water being discharged out of the east outfall was sampled during storm events in 2011 – 2012 and met all applicable WQS. No additional water samples were collected in 2013.

The 2013 dry weather sediment study collected twenty-seven samples during the first sampling event on June 4, 2013. Results from this initial sampling were used to inform the 17 sampling locations during the second sampling event on June 20 and 21, 2013. The study collected lakebed sediment samples during dry weather only. Sampling locations for the east and west outfalls were distributed on a 100-meter (328-foot) interval grid from the east outfall to determine the extent of contaminated sediments (locations are presented in Figure 3-1). No samples were taken within 25 meters (82 feet) of either outfall during the 2013 study.

The PEL sediment assessment values were used to determine impairment of Lake Lucile based on exceedance of the PEL for Pb and Zn. Cu was not identified as a cause of impairment because it only exceeded TEL values; however, this does indicate the levels are elevated and should be addressed. PAH, which does not have a NOAA SQuiRT PEL value, is not currently on the impairment list; however, during TMDL development, ADEC determined that the magnitude of the PAH exceedances (6 times greater than the TEL value) in lakebed sediments is an impairment and needs a TMDL.

The sediment sample results from these studies are presented in Sections 3.1 through 3.4.

In addition to the sampling efforts and characterization of in-lake sediment concentrations, ADEC sponsored an additional study (ARRI, 2019) that provided an improved measure of the impervious surface area of roads and other development contributing sediment and runoff to the stormwater outfalls discharging to Lake Lucile.

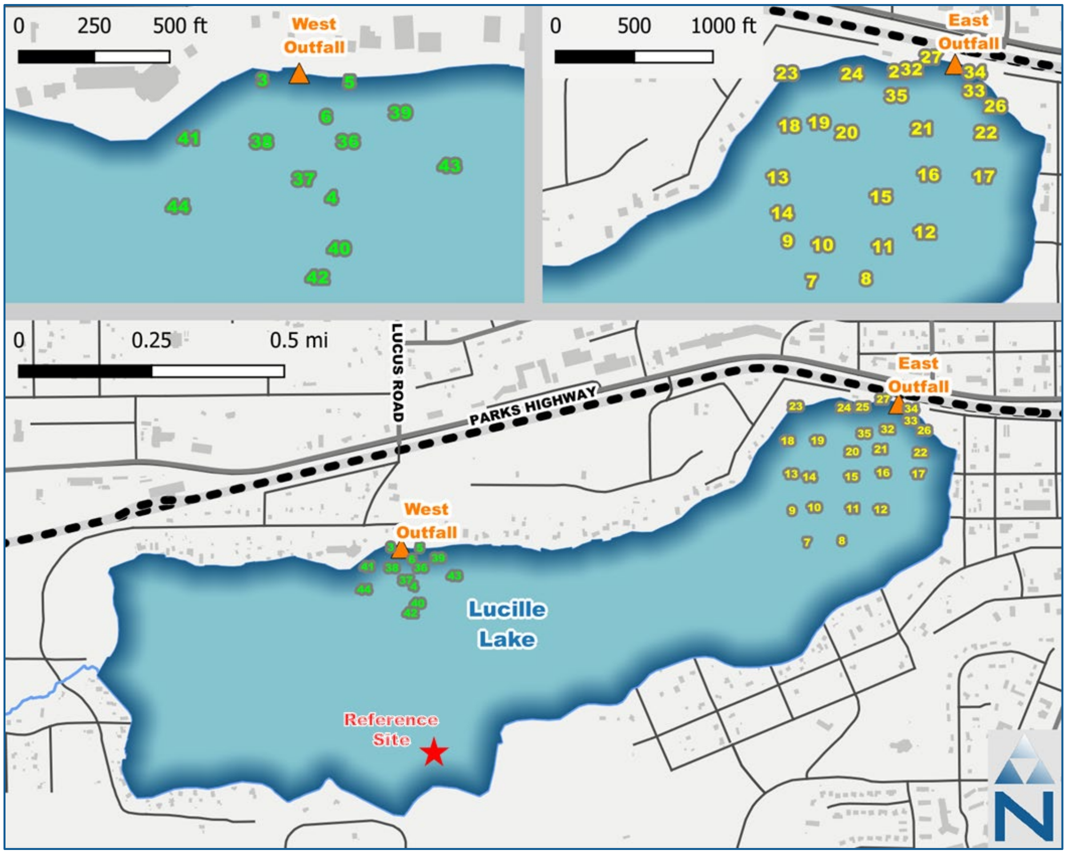

Figure 3-1. Location and site ID of lakebed 2013 sediment sampling sites (Davis et al., 2013b)

During dry weather, the sampling sites nearest the west outfall, sites 6 and 37, recorded among the highest constituent concentrations for all tested parameters and locations, while sites 2 and 3 had concentrations exceeding TEL values. The sites nearest the east outfall, sites 25, 27, and 32, also recorded high constituent concentrations, some exceeding corresponding TEL and PEL values (as noted in Table 2-2). In general, as distance from the outfall increased, concentrations decreased for all parameters. This suggests that sediment-bound metals are transported to the lake by stormwater runoff through the two outfalls (Davis et al., 2013b).

One sample was collected from a reference site, located near the south shore, approximately 1,000 feet (300 meters) from the next furthest sampling location for the west outfall and approximately 3,000 feet (900 meters) from the next furthest sampling location for the east outfall. Data from this site are used to represent natural background within this TMDL but ADEC acknowledges it is not a true natural background as it is unlikely there is no human influence at the location. However, as the impairment listings for Lake Lucile are in the vicinity of the stormwater outfalls (as described in Section 1) and the reference site is in an area of the lake not directly influenced by the outfall discharges, it is intended to represent background concentrations in the lakebed sediment in the absence of the outfalls. The same reference site location was used by ADEC in a 1989 Wasilla-area storm drainage study (ADEC, 1990) that included water column and lakebed sediment samples that were analyzed for Pb concentrations.

Table 3-1 presents the summarized sediment data for Cu, Zn, Pb, and PAH with comparisons to corresponding TEL and PEL values. The data presented in the table are from the ADEC sampling events (Davis et al., 2013b) conducted in June 2013 during dry weather and 2011–2012 during wet weather (Davis et al., 2013a). These data are presented because they are the most recent sediment data collected, and they provide an overview of the spatial patterns observed relative to the outfalls. The sediment data collected by ADEC in 2011 and 2012 (Davis et al., 2013a) were limited to three samples from directly below the east outfall collected during times of active stormwater discharge. No wet weather samples were taken at the west outfall. Of note is Site 13X that showed anomalous high PAH values in June 2013, inconsistent with nearby samples. The site was resampled during a second sampling event later that same month with PAH result values below detection limits, so was not included in subsequent area calculations of elevated PAH concentrations. The following subsections provide an overview of the lakebed sediment data for each of the pollutants of concern used in the assessment.

Table 3-1. Results of Lake Lucile 2013 dry weather sediment sampling (east and west outfalls) and 2011-2012 wet weather sediment sampling (east outfall)

Site ID	Location	µg/kg				Distance from outfall (ft)
		Copper	Zinc	Lead	PAH	
2013 Dry Weather Sediment Sampling (Davis et. al., 2013b)						
1	Reference Site	8,240	21,000	4,705	< DL	2,136 (west) 5,667 (east)
3	West Outfall	31,100	47,400	12,350	< DL	187.2
4	West Outfall	16,400	42,200	10,450	< DL	208.1
5	West Outfall	27,300	112,000	19,220	< DL	407.0
6	West Outfall	**43,100**	**460,000***	22,980	**1,125.5**	2,295.2
36	West Outfall	29,200	103,000	22,650	< DL	265.7
37	West Outfall	**60,900**	**399,000***	33,020	< DL	144.6
37 X	West Outfall	**57,400**	**167,000**	22,830	< DL	
38	West Outfall	32,900	89,500	13,420	< DL	121.7
39	West Outfall	9,800	23,100	4,824	< DL	733.4
39 X	West Outfall	15,400	34,900	7,771	< DL	
40	West Outfall	21,200	46,800	11,900	< DL	321.8
41	West Outfall	28,500	55,200	13,400	< DL	423.5
42	West Outfall	17,100	35,400	9,211	—	513.3
43	West Outfall	17,400	49,300	10,550	—	1,085.9
44	West Outfall	15,900	33,000	4,884	—	879.8
36	West Outfall	29,200	103,000	22,650	< DL	265.7
7	East Outfall	19,600	60,100	10,480	< DL	1,790.7
8	East Outfall	9,230	20,400	5,566	< DL	2,409.9
9	East Outfall	11,000	39,600	6,392	< DL	2,061.6
10	East Outfall	18,800	50,500	10,500	< DL	1,463.1
11	East Outfall	7,690	32,400	5,116	< DL	1,190.8
12	East Outfall	2,910	20,300	2,215	< DL	2,242.7

(continued)

Table 3-2. Results of Lake Lucile 2013 dry weather sediment sampling (east and west outfalls) and 2011-2012 wet weather sediment sampling (east outfall) (continued)

Site ID	Location	µg/kg				Distance from outfall (ft)
		Copper	Zinc	Lead	PAH	
13	East Outfall	11,300	44,300	4,368	< DL	2,295.2
13 X	East Outfall	7,950	29,000	3,371	*302 (sample error)*	2,295.2
13 b	East Outfall	—	—	—	< DL	2,295.2
14	East Outfall	7,390	42,800	3,551	< DL	2,005.2
15	East Outfall	24,800	42,800	19,690	< DL	1,252.4
16	East Outfall	17,600	25,500	19,780	< DL	828.4
17	East Outfall	12,000	21,900	3,848	< DL	899.7
18	East Outfall	15,400	21,800	3,294	< DL	2,102.3
19	East Outfall	12,700	56,800	5,116	< DL	1,715.7
20	East Outfall	13,000	25,300	16,540	< DL	1,089.9
21	East Outfall	11,600	70,500	11,850	< DL	608.3
22	East Outfall	5,980	43,200	4,175	< DL	607.9
23	East Outfall	23,800	47,400	7,086	< DL	1,759.1
24	East Outfall	17,800	28,200	4,226	< DL	995.6
24 X	East Outfall	**39,400**	82,100	7,459	< DL	
25	East Outfall	14,500	**159,000**	5,865	< DL	282.8
26	East Outfall	10,700	32,100	6,556	< DL	705.8
27	East Outfall	27,800	**428,000***	21,820	**1,530**	152.4
32	East Outfall	33,100	**417,000***	21,220	< DL	226.3
33	East Outfall	**43,100**	**732,000***	27,680	**559.4**	497.9
34	East Outfall	30,900	**339,000***	20,340	< DL	382.7
35	East Outfall	26,800	**139,000**	18,450	< DL	764.6
2011–2012 Wet Weather Sediment Sampling (Davis et al., 2013a)						
OF1-Storm 2	East Outfall	**153,000**	**3,030,000***	**119,000***	**1,664**	0
OF1-Storm 3	East Outfall	34,200	**344,000***	**51,600**	125	0
OF1 Storm 4	East Outfall	**146,000**	**2,460,000***	**73,400**	1,870	0

DL is detection limit. Site 1 is the reference location on the south shore. Results in exceedance of TEL values are bolded. Results in exceedance of PEL values are bolded and asterisked (*). In site name, "X" indicates replicate measures. At Site 13X, initial sampling occurred on June 4, 2013, and only PAH was resampled (13 b) on June 21, 2013 (Davis et al., 2013b). The original anomalous PAH result at 13X was not used in subsequent data analysis.

3.1 Copper

Copper is not included on the CWA 2014/2016 303(d)/Category 5 list because none of the collected samples exceeded the PEL value, which was the basis for the impairment determination. However, it is considered a pollutant of concern because concentrations exceeding the TEL value were observed at three sediment monitoring sites near the west outfall (collected during dry weather), and at four monitoring sites near the east outfall (collected during wet and dry weather conditions). Figure 3-2 shows the location of all monitoring stations with measured Cu concentrations, the location of the observations that exceeded the TEL (orange coloring), and their proximity to the east or west outfall.

For the west outfall, dry weather results for Sites 6 and 37 exhibited the highest Cu sample concentrations of 43,100 and 60,900 µg/kg, respectively. No wet weather samples were collected at the west outfall.

Near the east outfall, dry weather results for Sites 24X and 33 had the highest Cu concentrations of 39,400 and 43,100 µg/kg, respectively. East outfall wet weather sampling had the highest overall Cu results at 153,000 and 146,000 µg/kg. These results were above the TEL but did not exceed the PEL of 197,000 µg/kg.

The figure also includes radial distance from the outfall for each station. Both sample locations near the west outfall that exceeded the TEL were within 300 feet of the outfall. For the east outfall, the two dry weather observations that exceeded the TEL were ~500 and 1,000 feet from the outfall. The two wet weather exceedances were at the east outfall discharge point into the lake. For Cu, 37 of 42 samples (86%) were above the reference site concentrations (8,240 µg/kg).

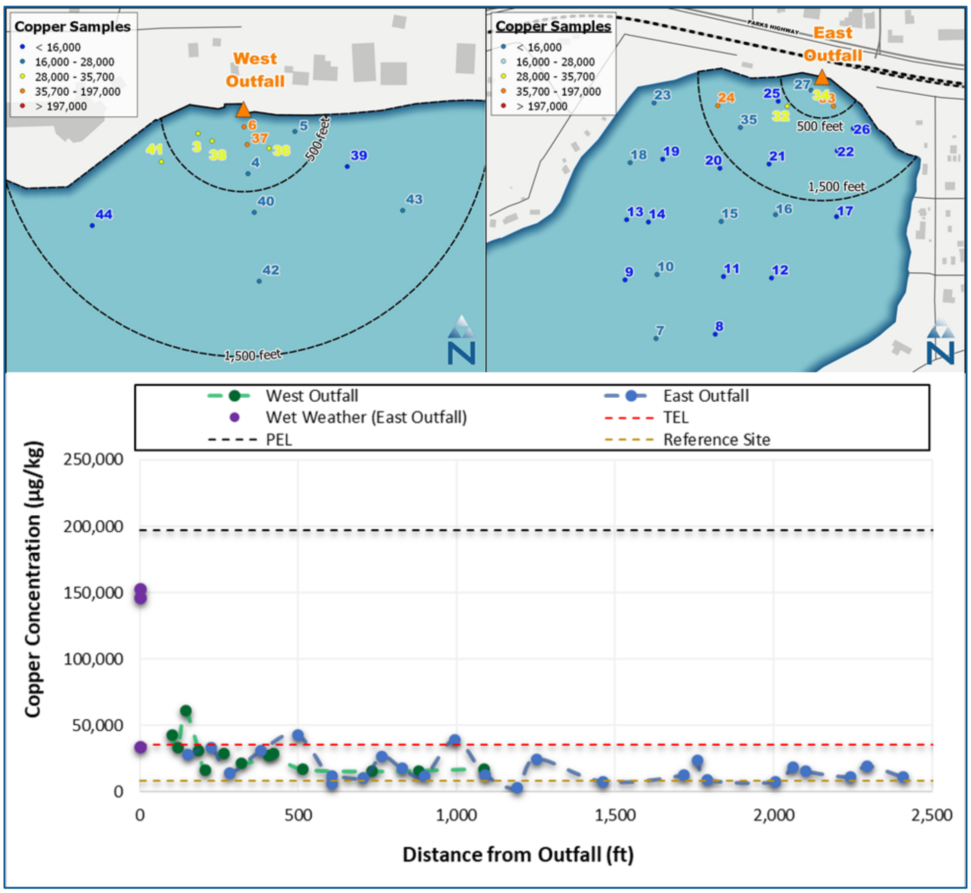

Figure 3-2. Locations and concentrations at copper sampling sites 2011-2013 (Davis et al., 2013b)

Figure 3-3 presents the results of the east outfall wet weather monitoring (Davis et al. 2013a) for Cu compared to the TEL value. During wet weather monitoring two of the three samples exceeded the TEL while the third sample was slightly below. None of the samples exceeded the PEL values.

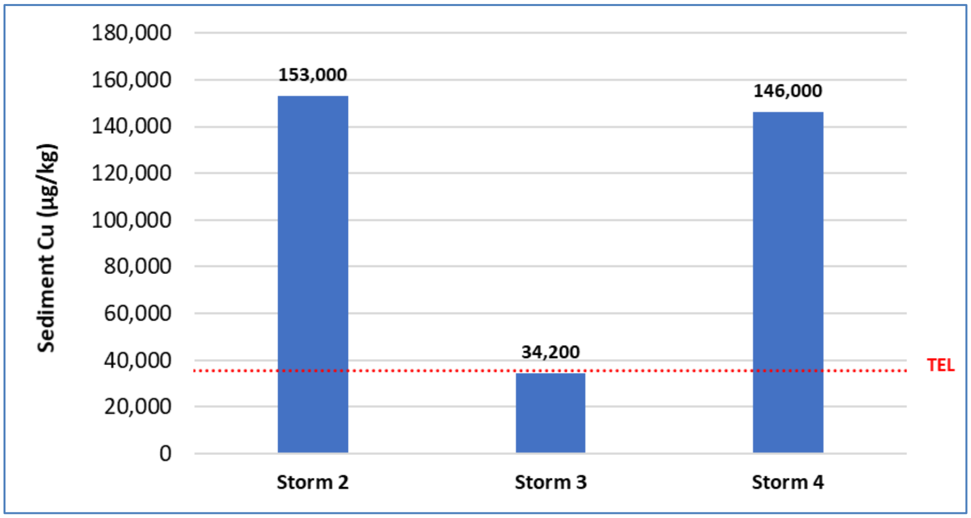

Figure 3-3. Wet weather copper sediment sampling at the east outfall 2011-2012 (Davis et al., 2013a)

3.2 Lead

Lead concentrations in samples collected at the east outfall during wet weather in August 2011 and 2012 exceeded TEL and PEL values (Davis et al., 2013b). The PEL exceedance resulted in the impairment listing. During dry weather sampling in June 2013, all Pb sediment concentrations from sites surrounding both outfalls were less than TEL value of 35,000 µg/kg and the PEL value of 91,300 µg/kg (Davis et al., 2013b). Historic sampling conducted by ADEC in 1989 (ADEC, 1990) revealed Pb sediment concentrations as high as 40,000 µg/kg at the east outfall.

Figure 3-4 shows the sampled Pb sediment concentrations at both outfalls and illustrates a distinct trend of decreasing Pb concentrations as distance from the outfalls increases. For Pb, 34 of 42 samples (81%) were above the reference site concentrations (4,705 µg/kg).

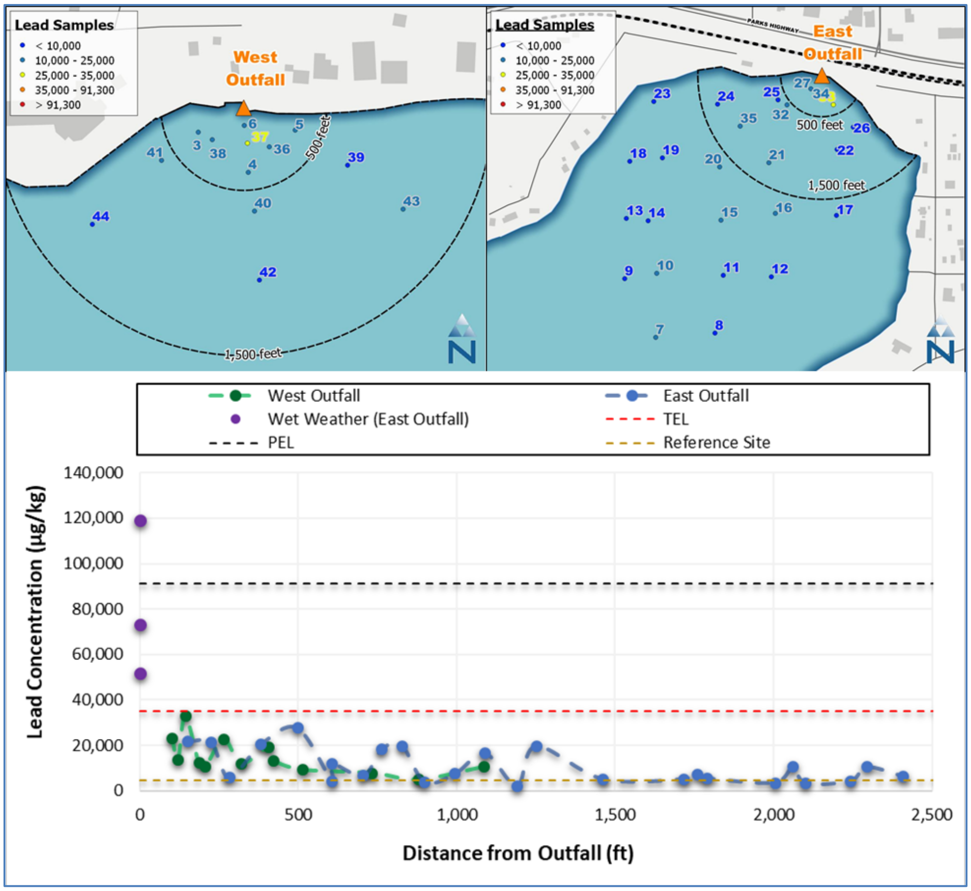

Figure 3-4. Locations and concentrations at lead sediment sites 2011–2013 (Davis et al., 2013b)

Figure 3-5 presents the wet weather Pb sediment results at the east outfall (2011–2012) (Davis et al., 2013a) compared to the TEL and PEL values. During wet weather monitoring, two of the three samples significantly exceeded the TEL, while the third exceeded the PEL. Although Pb did not exceed either the TEL or PEL during the dry weather sediment sampling study (June 2013), the wet weather results suggest impairment of the lakebed sediments.

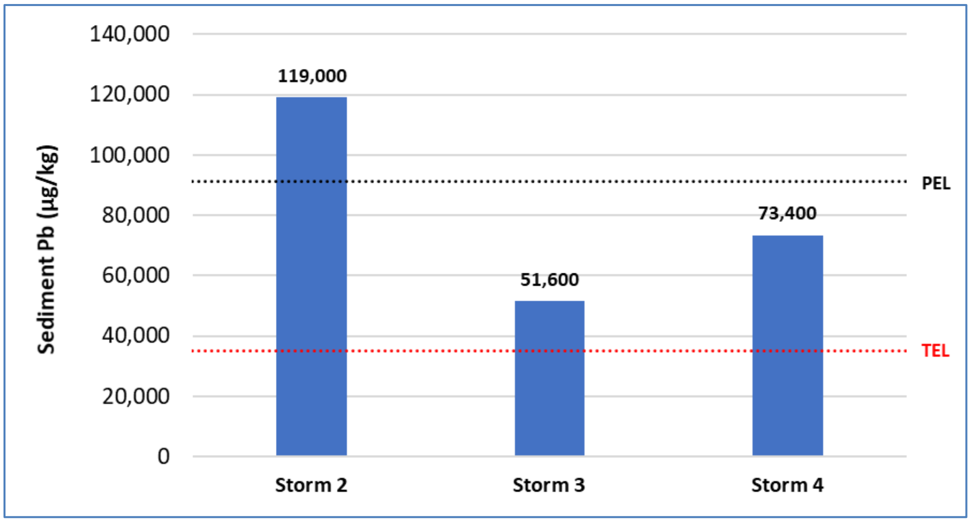

Figure 3-5. Wet weather lead sediment sampling at the east outfall 2011–2012 (Davis et al., 2013a)

3.3 Zinc

During dry weather sampling in June 2013, Zn sediment concentration values were found to be above the PEL value of 315,000 µg/kg at six sites (two near the west outfall and four near the east outfall; shown in red in Figure 3-6) and above the TEL value of 123,000 µg/kg at eight sites (six near the east outfall and two near the west outfall; shown in orange in Figure 3-6) (Davis et al., 2013b). As with the other pollutants, a decrease in concentrations was observed further from the outfall. This trend was especially pronounced for the west outfall, with a spike observed at Site 33 (~500 feet from the outfall). Concentrations were significantly lower at a distance greater than 500 feet from both outfalls. For Zn, 40 of 42 samples (95%) were above the reference site concentrations (2,100 µg/kg).

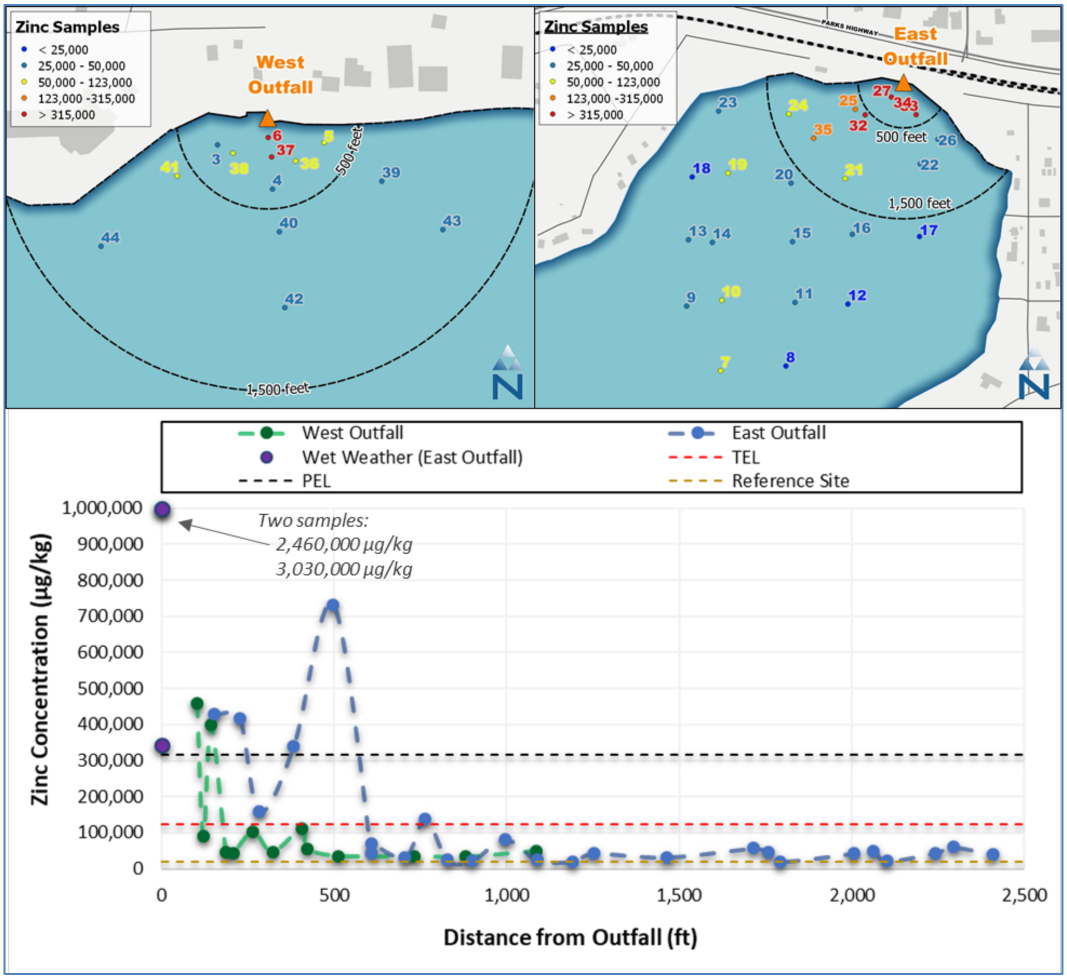

Figure 3-6. Locations and concentrations at zinc sampling sites 2011–2013 (Davis et al., 2013b)

Figure 3-7 presents the results of the east outfall wet weather monitoring (2011–2012) (Davis et al., 2013a) for Zn compared to the TEL and PEL values. During wet weather monitoring, all samples were above the PEL with the concentration during Storm 2 increasing to an order-of-magnitude larger than the PEL value.

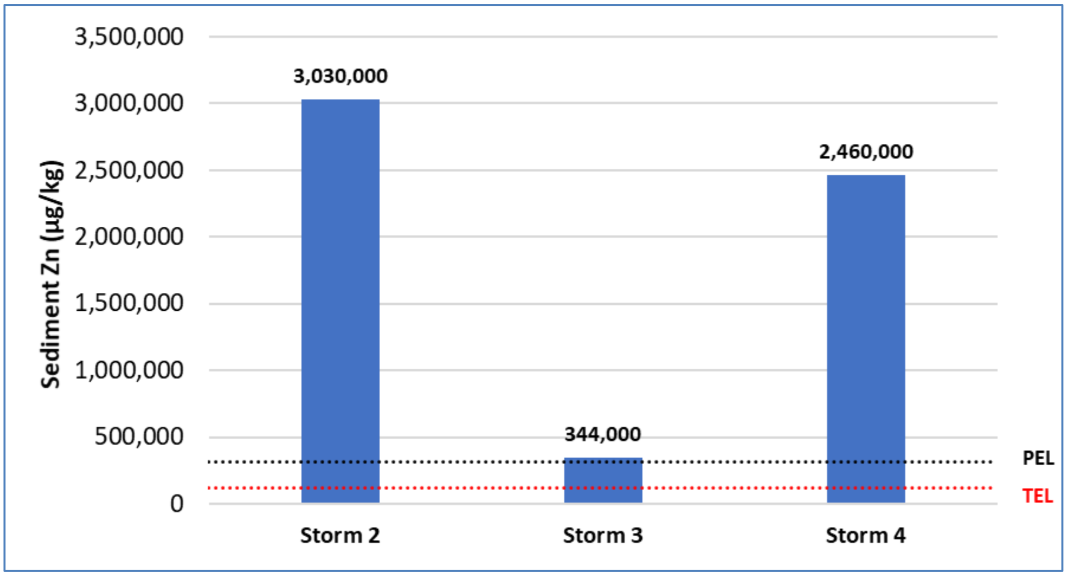

Figure 3-7. Wet weather zinc sediment sampling at the east outfall 2011–2012 (Davis et al., 2013a)

3.4 PAH

During dry weather sampling (June 2013), PAH concentrations above the TEL value of 264.1 µg/kg were observed at three sites (6, 27, and 33). All other samples collected were below the analytical detection limit as shown in Figure 3-8. The area exhibiting TEL exceedance near the east outfall (three sites) was estimated to be 1.6 acres, and the area exhibiting TEL exceedance near the west outfall (one site) was estimated to be 0.11 acres (Davis et al., 2013b). During dry weather sampling, Site 6 exhibited the highest PAH sample concentration, 1,125.5 µg/kg, which is considerably above the PAH TEL value. The reference site sample was below the detection limit.

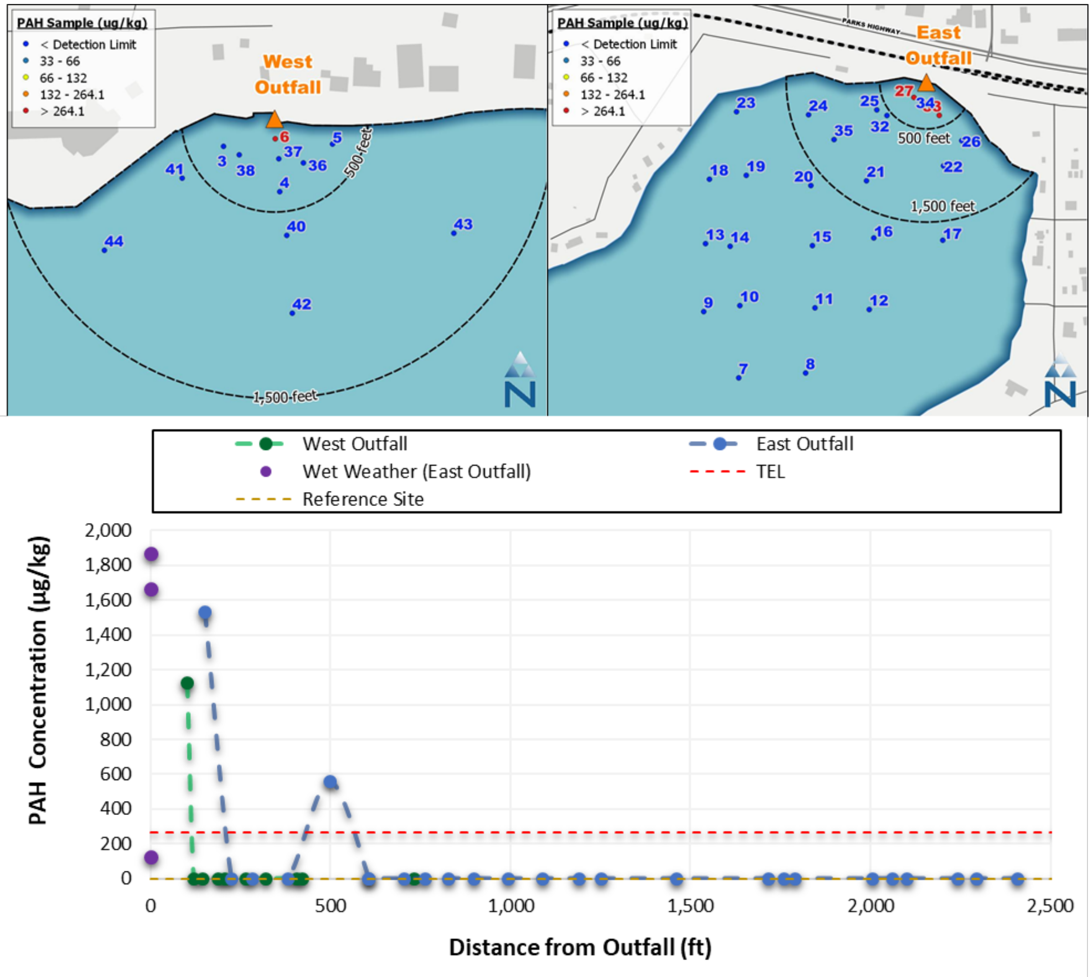

Figure 3-8. Locations and concentrations at PAH sediment sites 2011–2013 (Davis et al., 2013b)

Figure 3-9 presents the results of the wet weather monitoring (Davis et al., 2013a) for PAH compared to the TEL value. During wet weather monitoring, two of the three samples exceeded the TEL value, while the third sample remained below the TEL value. There is no PEL for PAH. Based on the magnitude of the exceedances (six times the TEL value), Alaska determined that Lake Lucile is impaired for PAH in the lakebed sediments and a TMDL needs to be completed.

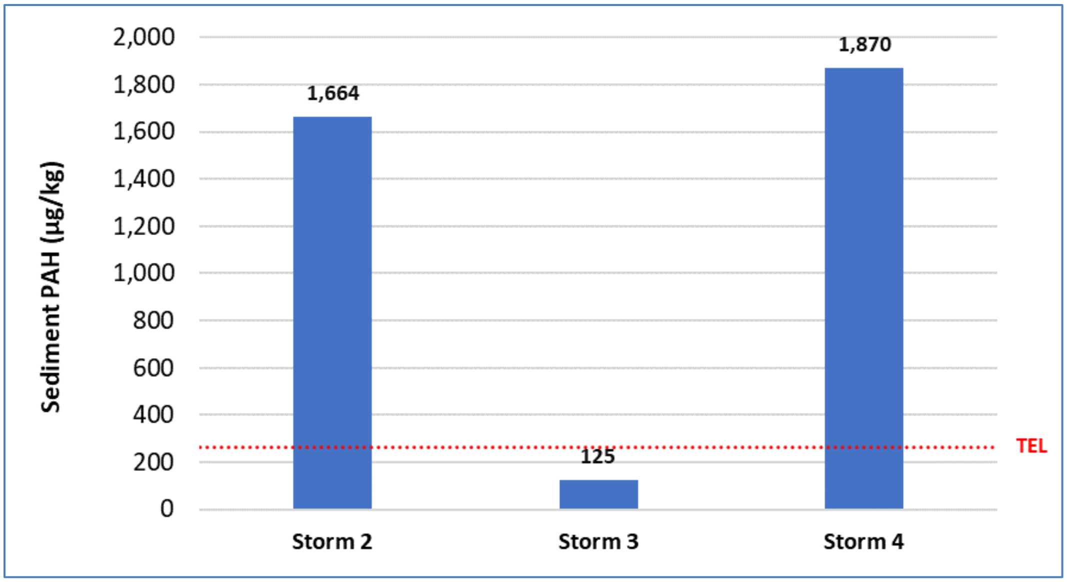

Figure 3-9. Wet weather PAH sediment sampling at the east outfall 2011–2012 (Davis et al., 2013a)

3.5 Conclusions

Based on the sediment sampling data collected during both wet weather (Davis et al., 2013a) and dry weather (Davis et al., 2013b), it is reasonable to conclude that the lake is impaired by Zn, Pb, and PAH. Although Cu did not exceed the PEL, there are sufficient exceedances of the TEL to warrant developing an informational TMDL and protection plan for Cu. The determination that pollutants are primarily coming from the outfalls is supported by many of the highest observed pollutant concentrations occurring near the outfalls with decreasing concentrations observed further from them. These data also provide assurance that the TMDL technical approach, which is focused on the outfalls and the sources draining to them, is appropriate (Section 5).

4. POTENTIAL SOURCES OF POLLUTANTS

An understanding of pollutant loading sources and the amounts and timing of pollutant discharges is vital to the development of effective TMDLs. Alaska's 2014/2016 CWA Section 303(d)/Category 5 lists stormwater discharges from urban and commercial development as the primary sources of metals and PAH to Lake Lucile (ADEC, 2018b). This section further summarizes potential nonpoint and point sources of Cu, Pb, Zn, and PAH to Lake Lucile.

4.1 Nonpoint Sources

Pollutants accumulate on impervious surfaces such as roadways and parking lots, get picked up by runoff water moving across the landscape from rain or snow melt, and in the case of Lake Lucile, get transported to the lake via the stormwater system where they sink to the bottom of the lake, building up over time. This type of pollution is called nonpoint source and is not covered by a permit. The following subsections summarize specific information known about probable nonpoint pollutant sources to Lake Lucile.

4.1.1 Stormwater

Stormwater runoff is generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets/highways, parking lots, and building rooftops, and does not soak into the ground. The runoff picks up pollutants like trash, chemicals, metals, oils and hydrocarbons, and dirt/sediment. Communities, construction companies, industries, and others, use stormwater controls, known as best management practices (BMPs) to filter out pollutants or prevent pollution by controlling it at its source.

The stormwater runoff coming out of the pipes into Lake Lucile has minimal pretreatment prior to discharging to the lake. At the west outfall, the Alaska Department of Transportation and Public Facilities (DOT&PF) maintains an oil/grit separator at Hallea Lane designed to remove floating debris and heavy particulates prior to reaching the lake. The east outfall has a stormwater collection system (Tommy Moe system) that takes part of the stormwater from the Parks Highway and pumps it north to the Iditapark infiltration basins. The remaining portion of the stormwater directly discharges to the lake out of the east outfall pipe.

In 2019, under the direction of ADEC, ARRI performed an outfall drainage area and source assessment to identify all areas of impervious surface that could potentially contribute stormwater to the east and west outfalls to Lake Lucile. This assessment involved combining several resources ranging from desktop analyses using ArcMap and Google Maps with the results of a field survey conducted on foot (ARRI, 2019). The study area generally included all roads and businesses between Parks Highway to the south and Nelson Avenue to the north and between Deskas Road to the west and Main Street to the east. Main Street was not included because topography and the locations of drains indicated that stormwater is diverted toward the Cottonwood Creek drainage (ARRI, 2019).

Figure 4-1 shows the areas identified as draining to the east and west outfalls. Each area in the map was assigned a corresponding land use category based on the City of Wasilla zoning data (see Table 4-1). The identified impervious areas primarily follow the main commercial corridor along Parks Highway. Very little residential or park area was identified during this drainage area assessment. While the drainage area study focused on identifying impervious surfaces that would most likely contribute runoff to the east and west outfalls, it is likely overestimated as some portion of the stormwater runoff likely drains to vegetated swales, the Iditapark sedimentation basins, or toward the Cottonwood Creek drainage (ARRI, 2019).

Commercial land uses may be a source of metals and PAH pollution depending on the activity involved and any on-site treatment works designed to reduce runoff pollution coming from a site. Although commercial land uses cover more than 50% of the Lake Lucile watershed, roads and highways are considered the more significant contributing source of metals and PAH pollution because they are directly connected to the piped stormwater system.

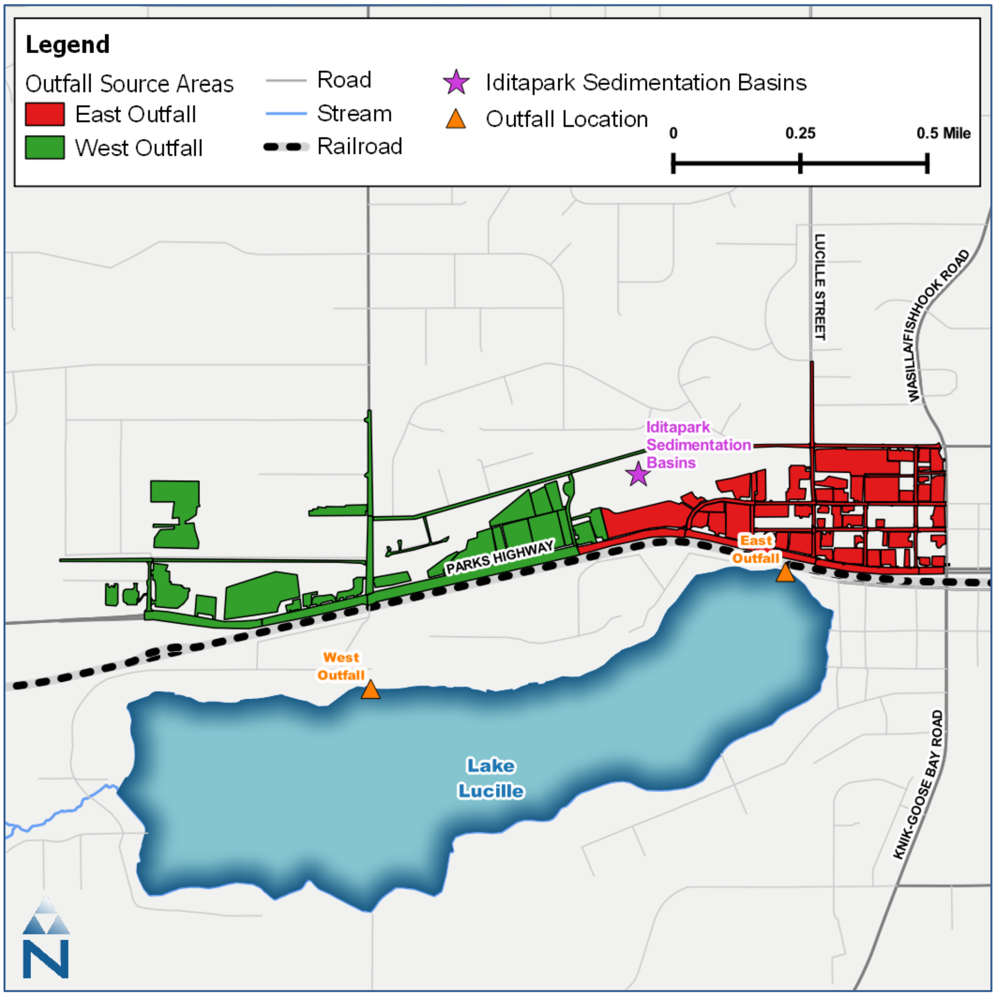

Figure 4-1. Land areas draining to the east and west Lake Lucile outfalls (ARRI, 2019).

Table 4-1. Summary of source land use areas (acres) by outfall.

Land Use Classification	Outfall (acres)	
	West	East
Highway	13.32	8.51
Road	11.03	11.98
Commercial	38.37	48.35
Residential	9.44	—
Public Park	—	1.13
Total	72.2	70.0

The Alaska Pollutant Discharge Elimination System (APDES) stormwater program regulates stormwater discharges to waters of the United States from three potential sources: municipal separate storm sewer systems (MS4s) serving urban population areas; construction activities disturbing one or more acres (Construction General Permit); and certain industrial activities as defined in federal regulations (Multi-Sector General Permit). The APDES permitting mechanism is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters.

Permits are automatically required for MS4s located in urbanized areas as defined by the latest U.S. census. MS4s serving communities with populations greater than 10,000 and with a density greater than 1,000 people per square mile can also be designated as an MS4 needing permit coverage by ADEC. It appears likely that the Cities of Wasilla and Palmer and the surrounding area in the Matanuska-Susitna Borough will be considered an urbanized area as a result of the year 2020 census. Once the census is finalized, and population density established, the Cities of Wasilla and Palmer, the Matanuska-Susitna Borough, and the DOT&PF would be required to obtain an MS4 permit (as co-permitees) from ADEC at that time.

This TMDL includes analyses and allocations under the current regulatory environment as well as TMDL allocations under a future MS4 permit scenario. When the MS4 permit is issued, the LAs for the area covered by the permit automatically will be changed to WLAs without having to revise this TMDL. This decision does not impact the background analyses or the need to understand possible sources of each pollutant within the watershed. The following summarizes each pollutant addressed by this TMDL, the possible sources, and differences based on land use.

Copper (informational TMDL)

The primary source of Cu reaching Lake Lucile is from the wearing of automobile brake pads. Numerous scientific studies have identified the dust generated by vehicle brakes as the most significant source of Cu in urban runoff (Donigian et al., 2009; Washington Department of Ecology, 2011). In fact, studies in California found that brake pad Cu comprised more than 60% of all Cu in runoff from urban watersheds (California Stormwater Quality Association [CASQA]), 2014). This finding triggered the enactment of a 2010 California state law that established a program for nearly eliminating Cu from brake pads. The state of Washington followed with its own restrictions on brake pad Cu content. In 2015, a national memorandum of understanding between EPA and several motor vehicle and parts manufacturers aimed to reduce heavy metals and other pollutants from stormwater runoff from roads and highways by facilitating the phase out of Cu, Pb, and other harmful constituents from vehicle brake pads. The voluntary practices and approaches are modeled after laws and regulations currently in place in the states of Washington and California. Other potential sources that can contribute Cu to surface waters include pesticides, herbicides, and fungicides; Cu roofing and metal plating; mining activity; anti-fouling paints and chemicals; and natural deposits (Kenai Watershed Forum, 2017). However, these sources are considered minor relative to brake pads.

Lead

Historically, the principal source of Pb in highway and street stormwater runoff in urban areas and near highways was the use of Pb as an additive in gasoline. Although reductions of leaded gasoline have diminished this source, crude oil still has a natural amount of Pb that remains in gasoline and can cause stormwater runoff from highways and streets to have excessive concentrations of Pb compared to ambient water quality criteria/standards. Originally, leaded gasoline contained about 250 mg/L Pb, whereas today unleaded gasoline can contain on the order of 15 mg/L Pb (Lee et al., 1997). In addition, many soils near highways and urban streets still contain high concentrations of Pb from when it was used as a gasoline additive. Another source of Pb in Lake Lucile is the fuel used for private planes and other recreational vehicles. Based on the information presented on airnav.com for the Wasilla airport (located west of the lake), the fuel available is 100LL JET-A, which contains tetraethyl Pb. This could also be a source of Pb to the lake via emissions or small spills. Lake Lucile is a seaplane base designated 4A3 with a 5,000-foot runway (airnav.com). Information on the number of planes and their possible impact is unknown. Other recreational vehicle owners could also be using leaded gasoline or octane boosters (that often contain tetraethyl Pb). No information is available on this possible source. However, because Pb concentrations are highest closest to the outfalls, it is unlikely that plane or recreational vehicles are a major source outside of spills and that the major Pb source is coming from road runoff.

Zinc

The primary source for Zn in Lake Lucile is likely tire wear on the adjacent paved roadways. A secondary source may be galvanized metal. Studies have identified the major sources of Zn in urban runoff as outdoor Zn surfaces (primarily galvanized surfaces) and outdoor rubber materials (primarily tire wear) (CASQA, 2015; Washington Department of Ecology, 2011). These studies identified other potential Zn sources as Zn-containing paint, tire shred and crumb products, brake pad dust, industrial air emissions, Zn-rich soils, and mining (CASQA, 2015). Each of these sources can result in the accumulation of Zn, with the concentrations varying by land use. Wasilla likely does not have many of these other potential sources contributing to the stormwater system. Zinc contributed by the wearing of tire rubber is likely to be greatest from road and parking lot surfaces where significant vehicular traffic exists such as the adjacent Parks Highway.

Polycyclic Aromatic Hydrocarbon

PAH are a wide and varied group of compounds whose sources include incomplete combustion of fossil fuels, organic materials and wood, tire particles, leaking motor oil, vehicle exhaust, crumbling asphalt, atmospheric deposition, coal gasification, and parking lot sealants, as well as sources inside the home (e.g., tobacco smoke, wood fire smoke, grilling or charring meat). PAH are also commonly found in particulate matter of air pollution. PAH can also leach from creosote pilings in docks and wells as creosote railroad ties. PAH tend to adhere to surfaces, attaching readily to sediment particles and leading to elevated concentrations in sediments (Hwang and Foster, 2006; Urban Waterways, 2012). Input of PAH from stationary sources has been decreasing since the 1940s due to changes in fuel usage from coal to petroleum and enhanced emission control (USEPA, 1999). PAH from mobile sources such as vehicle operation, however, may be responsible for the recent increase of PAH input to aquatic sediment, especially from the early 1980s in most urban areas (Rice et al., 2008). Recreational boating or personal water craft (jet ski) that use two-stroke motors can be another direct source of PAH to lakes due to the incomplete combustion in this motor design. Water monitoring conducted by ADEC did not find PAH exceedances in the water column as one would expect if the source was coming from boats or jet skis. No evidence or data suggest that the boat launch is a primary source of PAH or other pollutants.

4.1.2 Winter Road Maintenance

As discussed above, roads and highways are a likely source of all pollutants addressed in this document. This is largely due to automobile use, but they may also be a more direct source because of winter road maintenance. Road maintenance in the Lake Lucile watershed is completed by DOT&PF, the Matanuska-Susitna Borough, and the City of Wasilla. The Parks Highway, adjacent to Lake Lucile, is maintained by DOT&PF, which uses a salt/sand blend mixed at 10% sodium chloride to sand ratio. According to DOT&PF, very little salt brine is used as an anti-ice pretreatment to the road surface. When it is used, the brine is mixed at a 23.3% salt solution. Use of a salt brine treatment has to be done at road surface temperatures above 18°F. The brine is more corrosive to vehicles and other materials it contacts.

Sanding and plowing roads are also important components of road maintenance. Estimates on the exact amount of salt/sand applied to roads in the Lake Lucile watershed were not available. Sanding could be a source of sediment available to transport metals and PAH to the lake, although sands typically have a low adsorption ability. An additional potential concern is the impact of the salt brine on the corrosion of Cu, Pb, and Zn found on vehicles or other infrastructure. Because of the lack of information and data to link salt treatments to metals concentrations, this is not included as a pollutant source. However, in developing event mean concentrations (EMCs) for roads and highways, an attempt was made to select EMCs from locations where winter treatment of roads is common. Therefore, the contributions from winter road maintenance activities are included with the land use analysis and allocations, primarily with the setting of EMCs for highway and secondary and local road land uses.

4.1.3 Atmospheric Deposition

In many parts of the United States, the atmospheric deposition of pollutants to a watershed or waterbody can represent a significant source of pollution. For this TMDL, no data were available to identify specific sources or to quantify any atmospheric sources of the pollutants of concern. Therefore, no load allocation will be developed for atmospheric deposition. Note that the approach selected for this TMDL uses national literature-based pollutant concentrations for specific land uses to develop watershed loadings to the lake, which implicitly incorporates any atmospheric deposition that falls on the land. In addition, as highlighted in Table 3-2 and Figure 3-2 through Figure 3-9, the concentrations of the pollutants in lake sediment decrease at sampling locations located further from the outfalls. This is strong evidence that the primary and largest sources of the pollutants in the lake are entering through the outfall discharges and not through atmospheric deposition. The small surface area of the lake relative to the watershed size also provides some assurance that any loading directly to the lake will be *de minimis*.

4.1.4 Natural Background

Many metals occur naturally in the environment including Cu, Pb, and Zn. While a true natural background level may not be known for Lake Lucile prior to human settlement, there is a reference monitoring site in the southern part of the lake located away from the outfall discharge points. This reference site was monitored in previous studies (ADEC, 1990) and more recently (Davis et al., 2013b) to compare the results to those from potentially impacted areas in the lake. For the TMDL calculations, the reference monitoring location results (Table 3-2) are used as the natural background levels for Cu, Pb, and Zn. As PAH is man-made, there is no natural source. This document may refer to the reference site as a natural background site interchangeably.

4.2 Point Sources

There is currently no MS4 permit regulating stormwater runoff to Lake Lucile. In addition, there are no facilities with individual permits or facilities regulated by the industrial multi-sector general permit (MSGP) that discharge to the outfall drainage areas. Activities associated with the construction general permit (CGP) are likely to take place and their contributions are included in this TMDL. The following describes the types of point sources investigated and any relevant discharge permits.

4.2.1 Individual Permits

Industrial and construction activities regulated by an individual APDES permit can also generate contaminated stormwater. Both the EPA Enforcement and Compliance History Online (ECHO) database and ADEC Water Permit Search database were queried for permitted facilities discharging within the City of Wasilla. No individual permitted facilities were identified within the Lake Lucile watershed boundary; therefore, no WLAs for individual NPDES or APDES dischargers will be included in this TMDL.

4.2.2 General Permits

Statewide general permits for construction (CGP AKR100000) and industrial activities (MSGP AKR060000) are potentially applicable to pollutant sources within the Lake Lucile watershed.

APDES General Permit for Discharges from Large and Small Construction Activities Permit Number AKR100000

The Alaska General Permit for Discharges from Large and Small Construction Activities (aka CGP) (ADEC, 2016) authorizes stormwater discharges from large and small construction-related activities that result in a total land disturbance equal to or greater than 1 acre and where those discharges enter U.S. waters (directly or through a stormwater conveyance system) or a MS4 leading to U.S. waters. This permit also authorizes stormwater discharges from certain construction support activities and some non-stormwater discharges commonly associated with construction sites. The primary pollutant of concern generated by activities covered under this permit is sediment, but the fact sheet for the 2016 CGP also discusses that other pollutants such as metals may be attached to sediment particles. Therefore, the goal of the permit is to minimize erosion and reduce or eliminate stormwater pollution from construction activity through implementation of appropriate control measures (i.e., BMPs).

A review of ADEC's Water Permit Search online database found two projects authorized under the CGP have been issued in the past 3 years within the Lake Lucile watershed. It was unclear on the Notice of Intent (NOI) if the projects include any discharges to the City of Wasilla stormwater collection system. Because the CGP only authorizes discharges associated with construction activities, they are relatively short-term in nature and the total number of permitted construction projects in the Lake Lucile watershed will change over time.

APDES Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activities Permit Number AKR060000

The 2015 Multi-Sector General Permit (MSGP) (ADEC, 2015b) authorizes and sets conditions on the discharge of pollutants from certain industrial activities to U.S. waters through stormwater discharges. The MSGP specifies 10 categories of regulated industry, which are divided into 29 sectors based on Standard Industrial Classification (SIC) code or narrative activity. To ensure protection of water quality and human health, the 2015 MSGP requires eligible industrial facilities to implement BMPs and develop site-specific stormwater pollution prevention plans (SWPPPs) to comply with APDES requirements.

A construction sand and gravel facility (registry service number 110070517220) is currently the only permittee within the City of Wasilla regulated under this permit. However, the facility lies outside of the drainage to Lake Lucile and is not included in the TMDL pollutant loading calculations.

5. TECHNICAL APPROACH

A TMDL represents the total amount of a pollutant that can be assimilated by a receiving waterbody while still achieving WQS (also known as the loading capacity). The analytical approach used to estimate the loading capacity and allocations for Lake Lucile is based on the best available information to represent the impairment and expected sources. As additional data is collected or information becomes available, the TMDL calculations may be revisited in the future. The following are known data limitations used in the technical approach:

- The actual measured amount or load of sediment reaching Lake Lucile in the storm drain system is unknown;
- The volume of stormwater that discharges to the lake from the pipes has not been measured;
- The west outfall has a more limited dataset compared to the east outfall resulting in the analysis likely underestimating the actual pollutant load in the lakebed sediments surrounding the west outfall.

5.1 Analysis Approach

The approach to developing these TMDLs is based on meeting the sediment metals and PAH concentration targets, but because TMDLs must be expressed as loads and the source of impairment is stormwater-associated loading, a simple stormwater loading model was used in conjunction with lakebed data to identify the reductions necessary to meet the TMDL. The approach is summarized here and presented in more detail in the following sections.

The analytical method summary is as follows:

1. Because water quality and sediment data (as discussed in Section 3) indicated the sediment impairments in Lake Lucile are the result of stormwater loading, the TMDL analysis focused on stormwater. ADEC assumed metals and PAH, which are commonly sorbed to sediment, primarily enter the lake along with sediment. To estimate the sediment load (kg) transported to Lake Lucile, a simple stormwater loading tool called the Simple Method (CWP, 2003; Schueler, 1987) was used. Since there is little to no runoff in the winter, the "annual" sediment load associated with stormwater entering the lake was based on spring break-up (which captures pollutants deposited in the winter) and runoff during wet weather events in the spring (April 1–May 31) and summer (June 1–September 30).
2. There was limited local stormwater data to directly calculate current metals and PAH loads to Lake Lucile, so recent lakebed sediment metals and PAH concentration data were used in conjunction with the sediment load (from Step 1) to approximate the loads entering the lake from the east and west outfall. The maximum sediment metals and PAH concentration (µg/kg) near each outfall was multiplied by the annual sediment load delivered to each outfall (kg) to estimate the annual load of Cu, Pb, Zn, and PAH going to each outfall (µg).
3. To determine the annual loading capacity, the TEL target for each parameter (in µg/kg) was multiplied by the annual sediment load (kg) from Step 1 and converted from µg to grams. The reductions needed to meet the TMDL target can be calculated based on the difference between the existing load (Step 2) and the load capacity. The reduction needed also corresponds to the percent reduction between the maximum metal or PAH concentration and the corresponding target.
4. The allocation scheme includes a WLA for the CGP, a LA to natural background nonpoint sources, and separate LAs to the east and west outfalls for human nonpoint sources of Cu, Pb, Zn, and PAH to Lake Lucile. The WLA is based on the loads associated with the land disturbance currently permitted under the CGP, as well as a 10% buffer for additional construction activities. The allocation to natural background sources is based on data from the reference site in Lake Lucile; although it may reflect some level of loading to the lake from recreation or diffuse stormwater, it is referred to as natural

background because it represents the background load expected in the absence of the east and west outfalls. The remaining available load is allocated to human nonpoint sources draining to the east and west outfalls based on their relative contribution to existing loads.

5. Although annual loading is more practical for implementation, daily loads are required. Daily loads were calculated by distributing the load capacity across the year based on when most of the loading occurs. Ninety percent of the load capacity was equally divided over the days from April 1 through the end of September, and the remainder was equally divided over the remaining months when there is little to no snowmelt or runoff draining to Lake Lucile.

5.2 Existing Loads

As described above, the Simple Method was used to determine the existing sediment loads going to the Lake Lucile east and west outfalls, and then those loads were combined with the lakebed sediment metals and PAH concentration data to estimate annual loads for those parameters to the east and west outfalls.

5.2.1 Sediment Loads

The Simple Method is an approach for developing pollutant load estimates for small, urban watersheds that relies on local climate and land use information. The Simple Method was developed by the Center for Watershed Protection (CWP) to quickly estimate stormwater pollutant loads for small urban catchments and watersheds and has been used in Alaska TMDLs previously (CWP, 2003; Schueler, 1987). The Simple Method was selected for this TMDL primarily due to limited data availability and the lack of continuous flow data and sediment data, which would be required for calibrating a watershed model or developing a load-duration curve-based approach.

In the Simple Method, pollutant loads are calculated as a function of drainage area, pollutant concentrations, a runoff coefficient, and precipitation. This method assumes that runoff is a function of the imperviousness of the contributing drainage area, where areas with more development have greater intensity of impervious areas and therefore allow for greater runoff volumes as opposed to absorption in the soil. The critical conditions for precipitation (P) span both spring (including winter build up) and summer, which based on the climate information presented in Section 1.7, is anticipated to capture periods when runoff and snowmelt are contributing metals and PAH loading to Lake Lucile.

Pollutant loads are represented using runoff concentration data that can be found in literature or derived from local monitoring data if available. In the absence of local data, literature values for sediment runoff concentration are used based on contributing land use, as characterized in Table 5-1. Load estimates are the product of annual runoff volume and pollutant concentration using the following equation:

$$L = 0.1028 * P * P_j * Rv * C * A \qquad \text{EQ. 1}$$

where:

L = annual loading rate (kg per acre per year),

0.1028 = conversion factor for expressing (L) in kilograms [(kg*L)/(inch*acre*mg)],

P = precipitation depth for the critical condition period (inches) from University of Fairbanks (see Section 1.7)

P_j = fraction of annual rainfall events that produce runoff, assumed to equal 0.9 (Schueler, 1987),

Rv = runoff coefficient by land use from the National Land Cover Database (Schueler, 1987),

C = average sediment concentration (mg/L) by land use from the National Stormwater Quality Database, and

A = watershed area (acres) based on Lake Lucile Stormwater Outfall Source Area Estimates (ARRI, 2019).

The average sediment concentration in runoff varies by land use, so the land use acreages delineated as part of the 2019 source assessment study (see Table 4-1) were used along with national stormwater data broken out by land use to estimate the "annual" sediment load contributed to each outfall by each land use (Table 5-1). Additional details about the Simple Method and stormwater data reviewed are presented in Appendix B.

Table 5-1. Existing annual stormwater sediment loads by land use reaching each outfall to Lake Lucile

Land use	Estimated stormwater sediment concentration (mg/L)	Outfall (kg)		
		East	West	Both
Residential	103.5	0.0	520.7	520.7
Commercial	102.0	3,308.9	2,409.8	5,718.7
Highways	108.5	689.5	975.7	1,665.2
Road	108.5	773.2	400.8	1,174.0
Park/Open Space	32.5	26.6	0.0	26.6
Total	--	4,798.2	4307.0	9,105.2

5.2.2 Metals and PAH Loads

Although the Simple Method can be used to estimate metals loads in stormwater, ADEC decided to only use the Simple Method to estimate sediment loads to Lake Lucile associated with stormwater. This approach was taken because stormwater pollutant concentrations tend to be highly variable and limited local stormwater data were available, and because there is quite a bit of sediment data collected near the outfalls, which is reflective of loading via the outfalls from the contributing area. The lake sediment metals and PAH concentrations are associated with sediment delivered to the lake in stormwater and snowmelt runoff, so the sediment loads estimated by the Simple Method were used to provide an estimate of the existing Cu, Pb, Zn, and PAH loads delivered to the lake annually.

For each outfall, the estimated annual sediment load shown in Table 5-1 was multiplied by the maximum concentration value shown in Table 5-2, which is excerpted from the results of samples collected between 2011 and 2013 presented in Table 3-2. This resulted in an annual load of Cu, Pb, Zn, and PAH (Table 5-3). As the metals and PAH data used to develop these loads integrate land uses in the contributing area and implementation will largely focus on stormwater BMPs on land uses contributing the most sediment, the metals and PAH load assessments are not broken out by land use.

Table 5-2. Concentration values (µg/kg) used to calculate existing metals and PAH loads by outfall

Pollutant	Outfall	
	East	West
Copper	153,000	60,900
Lead	119,000	33,020
Zinc	3,030,000	460,000
PAH	1,870	1125.5

Note: Copper concentrations are provided for informational purposes only.

Table 5-3. Existing annual load by outfall for each parameter

Pollutant	Outfall (g)		Total (g)
	East	West	
Copper	734.1	262.3	996.4
Lead	571.0	142.2	713.2
Zinc	14,538.8	1,981.3	16,520.1
PAH	9.0	4.8	13.8

Note: After values in Tables 5-1 and 5-2 were multiplied, loads were converted from kg to g. Copper loads are provided for informational purposes only.

5.3 Loading Capacity

The loading capacity is the greatest amount of a given pollutant that a waterbody can receive without exceeding the applicable WQS, as represented by the TMDL water quality target.

The loading capacity for each pollutant by outfall was calculated by multiplying the respective target and the existing sediment load (Table 5-1). The existing Cu, Pb, Zn, and PAH loads (Table 5-3) were compared against the corresponding loading capacities to calculate the percent reduction required to meet each target (Table 5-4).

Table 5-4. Loading capacities and percent reduction required for the east outfall and west outfalls

Pollutant	Sediment Target[a] (µg/kg)	East Outfall Loading Capacity (g/year)	East Outfall Reduction, %	West Outfall Loading Capacity (g/year)	West Outfall % Reduction	Total Loading Capacity (g/year)	Total Reduction, %
Copper	35,700	171.3	N/A	153.8	N/A	325.1	N/A[b]
Lead	35,000	167.9	71	112.0	0	279.9	61
Zinc	123,000	590.2	96	529.8	73	1,120.0	93
PAH	264.1	1.3	86	1.1	77	2.4	83

[a]Source: NOAA SQuiRT Tables (https://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf) TEL values;
[b]N/A – as copper is not considered an impairment, reductions are not required but information is provided for protection planning.

6. TMDL ALLOCATION ANALYSIS

TMDLs represent the total amount of a pollutant that can be assimilated by a receiving waterbody and still achieve WQS. TMDLs are composed of the sum of WLAs for point sources and the sum of LAs for nonpoint sources and natural background loads. The TMDL must include an explicit and/or implicit margin of safety (MOS) that accounts for the uncertainty in the analysis and relationships between pollutant loading and in-stream water quality. Finally, the TMDL can provide a reserve allocation to account for future growth. The basic TMDL equation is commonly expressed using these three components as follows:

$$TMDL = \sum WLA + \sum LA + MOS \qquad \text{EQ. 2}$$

The remainder of this section identifies these components and presents the allocation analysis and daily pollutant loads for the contributing areas to the east outfall and west outfall of Lake Lucile for each pollutant.

6.1 Wasteload Allocation

The WLA is the portion of the loading capacity allocated to point source discharges. In the Lake Lucile watershed, there are no individual point sources of Cu, Pb, Zn, or PAH. The Alaska General Permit for Discharges from Large and Small Construction Activities (CGP) (ADEC, 2016) authorizes stormwater discharges from large and small construction-related activities that result in a total land disturbance equal to or greater than 1 acre and where those discharges enter U.S. waters (directly or through a stormwater conveyance system) or an MS4 leading to U.S. waters. This permit also authorizes stormwater discharges from certain construction support activities and some non-stormwater discharges commonly associated with construction sites.

Polluted runoff and erosion from construction sites could contribute metals and PAH to Lake Lucile. Authorizations under the CGP are ephemeral in nature and the total number of permitted construction projects in the watershed will change over time. This TMDL establishes a WLA for activities occurring under the CGP (WLA_{CGP}) to account for these activities. The WLA_{CGP} is intended to apply to existing and future activities permitted under the CGP within the contributing area to Lake Lucile.

As presented in Section 4.2.2, a search of ADEC's Water Permit database identified two projects authorized under the CGP in the past 3 years within Lake Lucile's watershed:

- Permit Number AKR10FU40, Yuyan Subdivision Developments. This application was filed for the development of the Yuyan subdivision, new driveways, and a well house, and is anticipated to take 2 years. The location listed in the application is West Lucas Rd. and W. Cache Dr. in Wasilla. The size of the disturbed area is 9 acres. Pollutants of concern included diesel fuel, gasoline, hydraulic oil, antifreeze, and fertilizer. BMPs were identified to limit the site activities from impacting areas adjacent to the development.
- Permit Number AKR10GA09, Wasilla McDonald's Rebuild, located at 810 East Parks Highway in Wasilla. The project involves the demolition of an existing structure, foundations, and site finishes; and the preparation of a new building foundation, site preparation, and construction of a new building per designs provided. The project site is 1.64 acres. A SWPPP was not available for review, but the design documents indicated that silt fencing would be installed before any construction and stabilization.

It is uncertain if either or both of these projects will drain to Lake Lucile, but they were used to develop the WLA_{CGP} because they represent all recent projects in the watershed with permit coverage under the CGP and are anticipated to represent the level of disturbance in the future after the current projects are completed. Since construction could occur on any land use within the contributing area, the WLA_{CGP} is a percentage of the load capacity corresponding to the percent of acres permitted to be disturbed under the CGP, plus a 10% buffer, relative to all acreage in the area contributing to both outfalls to the lake.

Permit Number AKR10FU40 development project spans 2 years with a total land disturbance of 9 acres. The annual load capacity was calculated by taking half of the 9 acres to be disturbed (i.e., 4.5 acres), the total estimated acres draining to Lake Lucile 142.2 (see Table 4-1), and the area of disturbance permitted under the CGP within the Lake Lucile watershed plus a buffer of 10% equals 6.75 acres (i.e., 4.5 + 1.64 + 0.62), which is 4.75%. This percentage of the load capacity was used to derive the WLA_{CGP} for each parameter shown in Table 6-1. For Cu for example, 4.75% of the Loading Capacity (LC) of 325.1 g is 15.4 g, which is the WLA_{CGP} for the informational TMDL.

Table 6-1. Lake Lucile WLA_{CGP} (g/year)

Total			
Copper	Lead	Zinc	PAH
15.4	13.3	53.2	0.1

Note: Copper wasteload is provided for informational purposes only.

Information from DOT&PF for the upcoming Wasilla Fishhook Road – Main Street Reconstruction project includes plans for two new sedimentation and infiltration basins that will be installed at the intersection of Railroad Avenue and Lake Street to improve stormwater quality prior to discharge to Lake Lucile. The current design models 100% of the 50-year storm event will be detained in the basins (HDR, 2019), meaning there will not be associated discharge to Lake Lucile a majority of the time. The project is scheduled for construction in 2021 and will need to receive authorization under the CGP and meet requirements ADEC deems to be consistent with the WLA_{CGP} for metals and PAH.[1]

After the construction phase, post-construction discharges and will be required under 18 AAC 72.600 to acquire ADEC engineering plan review for a permanent stormwater management control plan to meet the LA. In the event that the area falls under a future MS4 permit, the LA (for areas within the permit boundary) will switch to a WLA.

6.2 Load Allocation

The LA is the portion of the loading capacity allocated to nonpoint source discharges to the waterbody, including natural background. Nonpoint sources are typically represented by loads carried to receiving waters through surface runoff resulting from precipitation or other runoff-producing events (e.g., snowmelt).

The concentrations measured at the reference site (see Table 3-2) were used to establish the load allocation to natural background sources (LA_{NB}). As noted previously, it is acknowledged that this load may contain some level of human contribution, but because the impairment and reductions are associated with loading to the lakebed sediment via the outfalls, the natural background load is intended to present the background load in the lakebed sediment in the absence of the stormwater outfalls.

[1] 40 C.F.R. § 122.44(d)(1)(vii)(B): Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7.

PAH, which are man-made and were below the detection level at the reference site, are given a LA_{NB} of zero because there is no natural background level of PAH. For Cu, Pb, and Zn, the LA_{NB} to natural background is based on the percentage of the reference concentration of each parameter relative to the target. For example, for Pb, the reference concentration of 4,705 µg/kg is 13% of the target of 35,000 µg/kg, and 13% of LC of 279.9 g is 37.6 g. After subtracting the natural background LA_{NB} and the CGP_{WLA} (Table 6-1) from the LC, the remaining capacity is allocated to nonpoint loads associated with human activity. The LA is presented as a total LA (LA_{TOT}) and as separate LAs for each outfall to potentially aid in implementation, with the portion being allocated to human nonpoint sources draining to each outfall matching the percentage of the LC for each outfall relative to the LC for the entire contributing area (Table 5-4). Table 6-2 summarizes the load allocations, including separate allocations for each outfall (LA_E and LA_W) and the associated reductions required.

Table 6-2. Lake Lucile TMDL load allocation summary

Pollutant	g/year			East Outfall Reduction Required, %	LA_W (g/year)	West Outfall Reduction Required, %
	LA_{NB}	LA_{TOT}	LA_E			
Copper	75.0	234.6	123.6	N/A	111.0	N/A
Lead	37.6	229.0	137.4	71	91.6	0
Zinc	191.2	875.6	461.4	96	414.2	73
PAH	0.0	2.3	1.2	86	1.1	77

g = gram; LA_{NB} = Load Allocation for natural background;; LA_E= Load Allocation for east outfall, LA_W= Load Allocation for west outfall; WLA_{CGP} = Waste Load Allocation for the Construction General Permit; copper is included for informational purposes only

When the required reductions are viewed by outfall, it is apparent that more reductions are required for all parameters in the area contributing to the east outfall. The available data used for the west outfall calculations likely underrepresent the actual metals and PAH concentrations because no wet weather samples were collected and no samples were collected within 25 meters of the outfall discharge point. This data difference means the higher sample results at the east outfall (collected during wet weather at the discharge point) led to greater required reductions. Additionally, the area draining to the east outfall has a greater portion of roads and commercial land than the west side (see Table 5-1).

The entire contributing area to the east and west outfalls is within the City of Wasilla, so if the city is designated in the future as an MS4 requiring permit coverage, the LA_{TOT} will be deemed a WLA, and revisions to the TMDL will not necessarily be required.

6.3 TMDL

The TMDLs are presented in Table 6-3. Total Zn has the highest required reduction necessary to meet the TMDL. Because the reductions are associated with sediment loading, the Zn load reductions will ensure that all other pollutant reductions exceed those necessary to meet the criteria. The sediment reductions achieved through TMDL implementation (Sections 6.6.1 and 7) can also be used as a TMDL implementation target to measure progress in meeting WQS.

Table 6-3. Summary of Loads Lake Lucile TMDLs (g/year)

Pollutant	Existing Load	Load Capacity	WLA_{CGP}	LA_{NB}	LA_{E} *	LA_{W}*	Total Reduction, %
Copper	996.4	325.1	15.4	75.0	123.6	111.0	N/A
Lead	713.2	279.9	13.3	37.6	137.4	91.6	61
Zinc	16,520	1,120.0	53.2	191.2	461.4	414.2	93
PAH	13.8	2.4	0.1	0.0	1.2	1.1	83

g = gram; WLA_{CGP} = Waste Load Allocation for the Construction General Permit, LA_{NB} = Load Allocation for natural background, LA_{E}= Load Allocation for east outfall, LA_{W}= Load Allocation for west outfall. Note that LA_{E} and LA_{W} would become WLAs if and when the MS4 permit is issued (Appendix C). Copper is not impaired and does not require a reduction. The loads were included for informational purposes only.

6.3.1 Daily Load

TMDLs must be expressed as daily loads, which are presented in Table 6-4. While the primary analysis focused on the critical loading period from April through September, there may be some loading that occurs on other days from October through March as a result of rain-on-snow events, episodic melting, and other causes. To address this, ADEC calculated daily loads by distributing 90% of the load capacity equally across the critical season (calculated at 183 days) when a majority of the sediment and associated metal and PAH loading occurs and distributing the remaining 10% of the load capacity across the remaining months (182 days). Daily loads were calculated by assigning 90% and 10% of the total load capacity to these periods and dividing by the number of days during each period (e.g., critical period daily WLA_{CGP} Pb = (.9*13.3)/183 = 0.07 g/day). As it is not practical to implement LAs for the east and west outfalls on a daily basis, the daily loads are presented for the LA_{TOT}, which is the sum of the LA to human nonpoint sources contributing to each outfall.

Table 6-4. Seasonal and daily load calculations for Pb, Zn, and PAH

Pollutant	Season	Seasonal (g/year)				Daily (g/day)		
		Loading Capacity	LA_{TOT}	LA_{NB}	WLA_{CGP}	WLA_{CGP}	LA_{TOT}	LA_{NB}
Lead	Critical Season (Apr-Sept)	251.95	206.11	33.87	11.97	0.07	1.13	0.19
	Off-season (Oct-Mar)	27.99	22.90	3.76	1.33	0.01	0.13	0.02
Zinc	Critical Season (Apr-Sept)	1,007.97	788.00	172.09	47.87	0.26	4.31	0.94
	Off-season (Oct-Mar)	112.00	87.56	19.12	5.32	0.03	0.48	0.11
PAH	Critical Season (Apr-Sept)	2.16	2.06	0.0	0.10	0.001	0.01	0.0
	Off-season (Oct-Mar)	0.24	0.23	0.0	0.01	0.0001	0.001	0.0

g = gram; WLA_{CGP} = Waste Load Allocation for the Construction General Permit, LA_{NB} = Load Allocation for natural background, LA_{TOT}= Total Load Allocation for both outfalls. A daily load was not included for copper at this time.

6.4 Margin of Safety

The MOS accounts for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loading) or a combination of both.

For the Lake Lucile TMDLs, the MOS was included implicitly through the following conservative assumptions:

- The water quality targets are based on the TELs (adverse biological effects rarely occur) rather than PELs (adverse biological effects likely). By setting the water quality targets at the TEL, it provides more assurance that aquatic life will not be negatively affected by the levels of metals or PAH being discharged to the lake and accumulating in lakebed sediment.
- The maximum concentration measured from lakebed sediment near each outfall was used to calculate the existing load and percent reductions necessary for each parameter.
- For both outfalls, total Zn needs the highest required reduction. Because the reductions are associated with sediment loading, meeting the Zn load reductions will ensure that all other pollutant reductions exceed those necessary to meet the criteria; thereby providing additional MOS for Pb, Cu, and PAH.
- The land surface area contributing stormwater to the outfalls is likely overestimated as some portion of the stormwater runoff drains to vegetated swales, the Iditapark sedimentation basins, or toward the Cottonwood Creek drainage (ARRI, 2019). Overestimating the land area contributing to the stormwater system increases the number of acres used in calculating the existing sediment load.

6.5 Seasonal Variation and Critical Conditions

TMDLs must be developed that address seasonal variation and critical conditions associated with pollutant loadings, waterbody response, and impairment conditions. Consideration of seasonal variation and critical conditions ensures that the waterbody will maintain WQS under all expected conditions.

Metals and PAH loading to Lake Lucile are expected to vary seasonally primarily due to variations in weather conditions and source activity. The two periods considered are:

- Critical Season: open water including spring melt when the snowpack melts and becomes runoff and summer when most rainfall occurs. The critical open water season is when the majority of runoff is expected to occur. ADEC calculated the open water critical period as 183 days (April – September).
- Fall/Winter Off-season: fall and winter when the lake may still have some open water but is largely frozen, or the amount of rain or rain on snow is anticipated to cause a limited amount of runoff and loading to the lake. This season includes road sanding, wind dispersal, and winter rain events. The off-season is calculated as 182 days (October – March).

ADEC assigned 90% of the load to the critical season. This period is considered the critical condition for the Lake Lucile TMDLs because it accounts for the two critical event types that drive metals and PAH loading to the lake through stormwater (spring break-up and summer rains). This is also when most construction takes place in the watershed and the increased likelihood of sediment-laden runoff and associated metals and PAH occurs. During the winter off-season, ADEC assigned 10% of the load to take into account runoff that may occur during this period but to a much lesser extent than during open water season.

6.6 Reasonable Assurance

EPA requires a reasonable assurance that a mixed-source TMDL (one developed for waters that are impaired by both point and nonpoint sources) can be implemented (USEPA, 1991). Reasonable assurance is necessary to determine that the combination of a TMDL's WLAs (assigned to point sources) and LAs (assigned to nonpoint sources) are established at levels that provide a high degree of confidence that the goals outlined in the TMDL can be achieved. This TMDL was developed as a mixed-source TMDL because it includes a WLA assigned to construction general permit activities (WLA_{CGP}). In addition, it is likely that an MS4 permit will be developed in the future. The allocation for the stormwater sources is currently expressed as an LA, contingent on the source remaining unpermitted. However, if the stormwater discharge of the portion of the LA is required to obtain MS4 permit coverage in the future, then this portion of the LA will be deemed a WLA (Appendix C).

Education, outreach, technical and financial assistance, permit administration, and permit enforcement will all be used to ensure that the goals of this TMDL are met. Implementation will be focused on the activities described in the following sections to reduce polluted runoff in the watershed from reaching Lake Lucile.

6.6.1 Programs to Achieve Load Reductions

Activities and actions designed to reduce polluted runoff and clean it prior to lake discharge should be implemented on a regular and consistent basis to improve the lake's water quality. Many area plans, guidance documents and manuals, and stormwater guidance contain Alaska-specific BMP and stormwater reduction actions. A few key plans and potential funding sources to consider include.

- The Matanuska-Susitna Borough (in collaboration with local governments, state agencies, and private industry) has developed a Stormwater Management Plan (Mat-Su, 2013) designed to meet the requirements of a future MS4 permit but includes voluntary activities until the MS4 permit is issued. The borough has also developed rain garden, rain barrel, and other low-impact development resources for homeowners and contractors (Mat-Su Rain Garden Resources). The continued promotion, implementation, and incentivizing of the types of BMPs outlined in the Stormwater Management Plan will reduce stormwater runoff that flows to Lake Lucile and reduce pollutants from stormwater that reaches the lake.
- The City of Wasilla Comprehensive Plan outlines numerous priorities, including development that promotes healthy and active living and support for stricter code enforcement to clean up properties within the city. There was also citizen support for improving Lake Lucile Park (City of Wasilla, 2011), indicating the public's awareness and willingness to adopt stormwater practices that improve the health of the lake.
- The Alaska Storm Water Guide (ADEC, 2011) provides detailed guidance on the implementation of stormwater BMPs to comply with WQS. The guide addresses some of the unique challenges posed by Alaska's diverse climate, soils, and terrain, and recommends design and selection of stormwater BMPs to optimize their effectiveness.
- The City of Wasilla Lake Lucile Lake Management Plan is being developed starting in July 2019 and is scheduled for completion by June 2020. The Lake Management Plan will document and evaluate stormwater management options for reducing the pollutants (especially sediment) entering Lake Lucile from stormwater discharges.
- The Mat-Su Salmon Habitat Partnership Strategic Plan (2013) was developed with input from state and federal resource agencies, local governments, nongovernmental organizations, and the public. The strategy outlines several actions that would improve water quality in Lake Lucile as well as other area waterways.
- The Clean Water State Revolving Fund program may be a funding source for large-scale stormwater reduction projects.
- Alaska Clean Water Action (ACWA) grants provide funding for small-scale actions and BMPs to address nonpoint source pollution in high priority watersheds for activities not associated with permit requirements.

ADEC's stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from regulated construction activities and MS4s. Due to the variability of storm events (and snowmelt) and discharges from various stormwater infrastructure, it is difficult to establish numeric limits on stormwater discharges that accurately address projected loadings. As a result, ADEC regulations and EPA guidance recommend expressing APDES permit limitations for MS4s as BMPs and only using numeric limits in unique instances. A BMP plan should accompany monitoring plans that test the performance of BMPs and provide a basis for revised management techniques. This iterative strategy allows for an implementation plan where realistic goals can be set to improve water quality through the use of BMPs throughout the watershed. The intention is to implement BMPs with the ultimate goal of achieving the TMDL allocations and water quality standards (USEPA, 2002).

6.6.2 Follow-Up Actions

ADEC's legal authorities allow for the possibility of requiring more stringent permit limits or more effective nonpoint controls if there is insufficient progress in the expected nonpoint source control implementation. While ADEC is authorized under Alaska Statutes Chapter 46.03 to impose strict requirements or issue enforcement actions to achieve compliance with state WQS, it is the goal of all participants in the Lake Lucile TMDL process to achieve clean water through cooperative efforts.

To provide additional assurance beyond existing programs and planned activities, the actions described in Section 7 are provided to better understand how implementing various BMPs and stormwater management techniques could help toward achieving the goals in the TMDL and improving Lake Lucile's water quality.

7. IMPLEMENTATION AND MONITORING RECOMMENDATIONS

This TMDL will be implemented using adaptive management and will be revised, as necessary, based on future information on sources and in-lake conditions. Adaptive management uses monitoring and source controls to provide more information for future review and revision of a TMDL. This process recognizes that water quality monitoring data and knowledge of watershed dynamics may be insufficient at the time a TMDL is developed, but that the TMDL uses the best information available during its development. An adaptive management strategy seeks to collect additional monitoring data to understand better how systems react to best management practices (BMPs) and reduced pollutant loading into a system. Information can then be used to refine future TMDL revisions so that allocations best represent how to improve water quality in a specific watershed.

Implementing BMPs in the Lake Lucile watershed is necessary to improve water quality to the point where the lake can support its designated uses. Additional future monitoring is desired to verify TMDL assumptions and measure water quality progress. This section presents recommendations for implementation and monitoring to assist in meeting the numeric targets and achieving Lake Lucile's WLAs and LAs.

7.1 Recommended Implementation Activities

TMDL implementation focuses on reducing and preventing pollutants from entering the drainage collection system discharging to Lake Lucile through the two outfalls. The City of Wasilla and the DOT&PF will be the primary parties implementing the Lake Lucile TMDL. The activities outlined below are designed to reduce or eliminate pollutant sources in the Lake Lucile watershed.

1. Pollutant source control and stormwater interception prior to lake discharge

The Alaska Storm Water Guide (ADEC, 2011) contains details on design and considerations for temporary and permanent stormwater BMPs designed to intercept and clean stormwater runoff prior to discharge into a waterbody. The primary goals of any BMP design in the watershed would be to reduce runoff from the site, retain, and infiltrate water to the extent practical. This includes reducing polluted runoff coming from commercial land uses, parking lots, construction sites, and roadways.

One cost-effective approach is using green infrastructure (GI) techniques that use designed natural systems for stormwater retention, treatment, and infiltration. The Lake Lucile drainage area has several opportunities for designing and installing various types of GI including bioswales, flow-through boxes, rain gardens, bioretention areas, pervious pavers in certain areas such as walkways, and others. A BMP as simple as a vegetated swale or grassed median strips can provide places for stormwater infiltration and allow pollutants to drop out of runoff prior to lake discharge. Several successful GI techniques have been used in the Matanuska-Susitna Borough and other communities in Alaska.

Coordinating planned activities across multiple agencies within a jurisdiction helps leverage resources and limits community disruptions. For example, opportunities to schedule GI installation at the same time as planned road construction, improvements, or maintenance can help leverage resources and project timing. The Complete Streets projects along Cushman Street in Fairbanks, Alaska is a good example of coordinating road projects and GI installation.

The City of Wasilla operates a stormwater collection system (Tommy Moe system) and three sedimentation basins in the Iditapark north of Lake Lucile that feed into the east outfall stormwater pipes. In discussions with City and DOT&PF representatives, this system may currently be underused and has capacity to accept and treat greater stormwater volume. Using the design capacity of this stormwater treatment system to a greater extent may be a relatively inexpensive and simple implementation action that could result in significant water quality improvement at the east outfall discharge point.

Prior to the MS4 permit being required, the City of Wasilla could develop a sediment and erosion control ordinance to implement source control and reduce polluted runoff. There are many example ordinances from other communities available to use as a template. Many communities offer incentives for businesses to implement GI and other stormwater control measures.

2. Improve maintenance and management of stormwater BMPs

Reducing sediment transport to the lake is critical to improving water quality. Maintaining stormwater BMPs so that they function as designed is a key feature of any stormwater management program. Catch basins and stormwater BMP sediment traps should be vacuumed or otherwise have sediment, litter, and debris removed annually or more frequently if design capacity has fallen below 50%. Regular scheduling of street sweeping, particularly sweepers that vacuum versus mechanically broom, can significantly reduce sediment, and the pollutants attached to the sediment particles, from road systems. Additionally, sweeping should occur anytime sediment accumulation is visible on paved surfaces or at least twice per year: in early spring to remove sand and other deicing materials and in the fall after leaf drop.

DOT&PF maintains an oil/grit separator (OGS) near the Parks Highway and Hallea Lane intersection. This OGS is an older model and may not be functioning as efficiently or effectively as newer OGS designs. Implementation recommendations include replacing the current OGS with a newer system that is more effective at treating stormwater. In the meantime, ADEC recommends DOT&PF establish a regular maintenance schedule for cleaning out the current OGS.

3. Construction site stormwater best management practices

The Alaska General Permit for Discharges from Large and Small Construction Activities (CGP) (AKR1000000) (ADEC, 2016) authorizes stormwater discharges from large and small construction-related activities that result in a total land disturbance equal to or greater than 1 acre and where those discharges enter U.S. waters (directly or through a stormwater conveyance system). The CGP requires the development of a Storm Water Pollution Prevention Plan (SWPPP) to manage materials, equipment, and runoff from construction sites. To ensure compliance with the TMDL, construction sites need to implement stormwater controls described in their SWPPP and maintain erosion and sediment controls as necessary.

ADEC and DOT&PF websites provide a wealth of information on construction site BMPs and options for monitoring and inspections to ensure that management measures are performing to design specifications. Additionally, the Alaska Storm Water Guide (ADEC, 2011) contains details on design and considerations for temporary and permanent stormwater BMPs designed to intercept stormwater runoff and clean it up prior to discharge into a waterbody. These resources provide valuable information on all land uses and sources of sediment in the Lake Lucile watershed with recommended BMPs to reduce pollution.

4. Identifying and restoring suspected pollutant source hotspots

The Lake Lucile watershed may have land-based pollutant hot spots that serve as major sources of metals or PAH pollution draining to the piped stormwater system. The surface hydrology of the Lake Lucile watershed is complicated and traditional methods of delineating watersheds do not accurately define the extent of the area contributing runoff to the lake. A recent ADEC study (ARRI, 2019) identified and mapped the basic drainage network to the lake, particularly the two stormwater outfalls and identified parcels that likely contribute to the piped stormwater system. This information will support public education efforts about the impacts of activities that include drainage to the lake and may also support implementing actions in specific hot spots of potentially higher pollutant concentrations for cleanup prioritization and BMP installation.

5. Pollution prevention public education

Public interest in water quality and having a healthy community provides opportunity for an outreach and education program that highlights how pollutants enter the lake and activities the public can support to reduce pollutant generation and transport. Some key aspects of a public and business education program could include an improved understanding of how metals, PAH, nutrients, trash, and other pollutants are transported to the lake and activities that can reduce the transport, such as low-impact development and GI options, street cleaning, and trash management. Public outreach through presentations, social media, online materials, and other venues can help foster public participation and support for restoring Lake Lucile's water quality.

Under the future expected MS4 permit, addressing the potential contribution of pollutant loads from stormwater is typically expressed as BMPs or other similar requirements, rather than as numeric effluent limits. ADEC recognizes the need for an iterative approach to control pollutants in stormwater discharges and anticipates that a suite of BMPs will be used in the initial permit issuance; subsequent permit issuances may become more tailored based on BMP effectiveness and performance.

7.2 Recovery Activities Not Recommended

ADEC supports natural recovery of lake water quality that relies on natural processes to decrease pollutant concentrations in sediment to acceptable levels within a reasonable period. Essential to this approach are pollutant reduction activities in the stormwater drainage area as described above to prevent additional lake pollution during recovery. Natural recovery is the least disruptive in-lake approach but is likely to have the longest time required for improvement. Natural recovery will be aligned with a monitoring program to assess progress. ADEC does not recommend lake dredging for pollutant removal nor capping the polluted lakebed sediments for the following reasons:

Dredging for pollutant removal. Dredging can be effective in certain situations for mass removal of pollutant hot spots, but its effectiveness can be offset by resuspension, redeposition, and spread of the contamination. In addition to the pollutants addressed by this TMDL, the 2002 Dissolved Oxygen TMDL (ADEC, 2002) identified internal lake phosphorus as a major contributor to low dissolved oxygen levels. Dredging would likely lead to the resuspension of bioavailable phosphorus from the bottom sediments and reduce dissolved oxygen concentrations in the lake. It is also one of the costliest practices and would require approved disposal of the contaminated sediment.

Capping the contaminated areas. This practice involves placing a clean layer of sand, sediments, or other material over contaminated sediments to mitigate risk, depending on the objective (e.g., stabilization, isolation of the hot spot). Typically, capping works best in deeper waters and waters not subject to erosive forces (e.g., wave effects, prop wash). The process of capping can also disturb bottom sediments, leading to resuspension and redistribution. Lastly, capping is not recommended without first reducing or even eliminating the stormwater pollutant loading reaching Lake Lucile.

7.3 Monitoring

Follow-up monitoring for a TMDL is important in tracking the progress of TMDL implementation and subsequent water quality response, as well as in evaluating any assumptions made during TMDL development. Monitoring results can be used to support any necessary future TMDL revision or to determine whether BMPs should be added or modified. ADEC expects water quality to be monitored after sufficient BMPs have been implemented to determine whether improvements in water quality are observed through reductions in Cu, Pb, Zn, and PAH in lakebed sediments.

In the Lake Lucile watershed, several targeted monitoring efforts by ADEC have provided some information characterizing the water quality conditions in Lake Lucile. In addition, a study conducted by ADEC at the time of this TMDL preparation has provided improved estimates for the drainage areas contributing to the two stormwater outfalls. Future sampling events should focus on specific areas or sources of concern and on tracking progress of water quality improvement as BMPs are implemented.

Monitoring efforts should consider activities that address current data limitations and uncertainties as track BMP effectiveness at improving Lake Lucile water quality:

- Runoff water quality at each stormwater outfall during storm events and spring break-up (non-precipitation runoff). The monitoring should include water column and sediment quality sampling. The monitoring would ideally include flow, hardness, sediment, metals, PAH, and nutrients (in support of the dissolved oxygen TMDL post-TMDL monitoring efforts). Data from multiple storm events and spring break-up discharges would be preferable.

- Further refinement and understanding of drainage patterns. As noted throughout the TMDL, the delineation of the drainage areas of the outfalls was estimated from the best available information. Better information would provide a more accurate representation of source loadings.

- Land use–specific monitoring to locate and better characterize sources of metals and PAH in the drainage areas. The TMDL sediment loading was developed using literature-based Event Mean Concentration (EMC) values that may not be completely representative of local conditions.

- Additional water column sampling in the lake for metals and PAH as only limited data exist now.

- Measure BMP effectiveness at reducing stormwater pollutants in Lake Lucile.

This implementation plan assumes that the activities described in Section 7.1 will yield water quality improvement. The adaptive management feedback loop (Figure 7-1) is a mechanism for evaluating the success of this plan and whether the goal of improving water quality is being achieved. Adaptive management recognizes the dynamic nature of pollutant loading and water quality response to remediation.

Additional monitoring and resulting refinements to loading can improve our understanding of Lake Lucile water quality. The TMDL may be revised in the future, as needed, based on additional information.

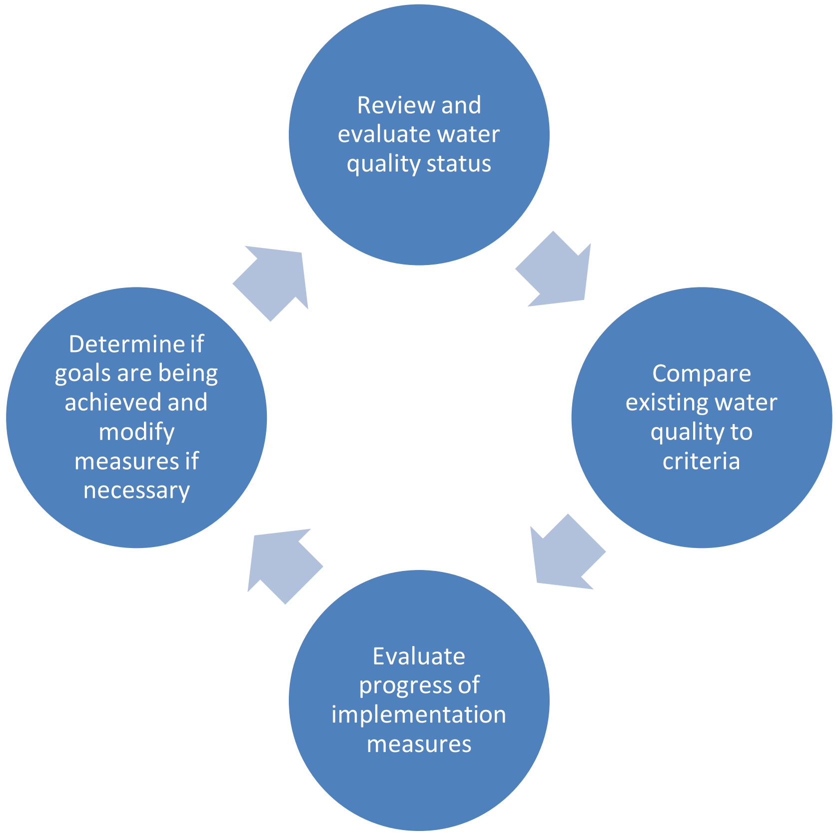

Figure 7-1. Adaptive management feedback loop

8. PUBLIC PARTICIPATION

The notice for the public review period was posted on March 24, 2020, and the review period closed on April 28, 2020. The public notice was posted in the local newspaper, Mat-Su Valley Frontiersman, on ADEC’s website, and on the State of Alaska’s Public Notice website. A fact sheet was also available on ADEC’s website.

One comment was received during the public review period expressing concern for general lake pollution issues. This comment did not change the TMDL and will be addressed through other methods as appropriate.

9. REFERENCES

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APPENDIX A: DATA INVENTORY AND STUDIES REVIEWED FOR THE LAKE LUCILE TOTAL MAXIMUM DAILY LOADS

Numerous studies published in 1978 or later were reviewed for the Lake Lucile Total Maximum Daily Load (TMDL). Early studies mostly focused on nutrients and pathogens. Several studies recorded pH levels above the water quality criteria of 8.5; the alkaline nature of the lake has been attributed to the calcium carbonate substrate in some areas of the lake and from aquatic plant photosynthesis. A monitoring study focused on Alaska Department of Transportation & Public Facilities (DOT&PF) drains and the lake outlet was the first to analyze metals (copper [Cu], lead [Pb]) (ADEC, 1985)[1], followed by a study that sampled sediment near the outlet and the water column in the deepest part of the lake for metals, including Cu and zinc (Zn) (ADEC, 1986). A 2004 study was the first to assess polycyclic aromatic hydrocarbon (PAH) and total aromatic hydrocarbons (TAH), although all PAH levels were below reporting limits (OASIS Environmental, Inc., 2004). The studies reviewed for the Lake Lucile TMDL are presented in Table A-1. Key information from each of these studies is presented below and in the TMDL document.

- Matanuska-Susitna Stormwater Assessment (2011–2012) (Davis et al., 2013a). This regional stormwater study was conducted by the Alaska Department of Environmental Conservation (ADEC) between 2011 and 2012. In addition to samples collected at other locations, outfall discharge water and lakebed sediment samples were collected at the east outfall. Parameters sampled included outfall metal concentrations, petroleum hydrocarbons, and general field chemistry. Lakebed sediments directly below the east outfall discharge point were sampled for metal concentrations (Cu, Pb, and Zn) and PAH during wet weather events.
- Lake Lucile Sediment Quality Sampling: Spatial Extent of Impaired Sediment Due to Outfall Stormwater Inputs (Davis et al., 2013b). This 2013 study was a follow-up to the regional stormwater study and focused on lakebed sediments in Lake Lucile. Dry weather samples were collected around the east and west stormwater outfalls extending outward into the lake to determine the spatial extent of pollutants in lakebed sediments. Parameters measured included Cu, Pb, Zn, and PAH.
- Wasilla Storm Drains Investigation (ADEC, 1990). This project characterized road runoff entering the storm drain system. Samples were collected at manholes and two outfalls on Lake Lucile. Lake sediment samples were collected at the outfalls and analyzed for metals. Outfall samples were analyzed for total petroleum hydrocarbons; trace metals (e.g., Cu, Pb, Zn); benzene, toluene, and xylene; and chloride. The study included a reference site in Lake Lucile analyzed for sediment concentrations of Pb. This is the same reference site used in the 2013 Lake Lucile Sediment Quality study.

Table A-1. Inventory of Lake Lucile water quality studies reviewed

Title	Year	Authors	Sample Location (# of Samples, if applicable)*	Pollutants Sampled*
Lake Assessment Project in the Palmer-Wasilla Area, Alaska Lucile, Wasilla, Cottonwood, and Finger Lakes	1978	Unknown	Water column and surface water	NA
Alaska Water Quality Status Report	1979	ADEC	Water column	NA
The Domestic Wastewater Receiving Capacity of Four Lakes Near Wasilla, Alaska	1979	Short	NA; Estimate of future wastewater additions	NA

(continued)

[1] See Table A-1 for references.

Table A-1. Inventory of Lake Lucile water quality studies reviewed (continued)

Title	Year	Authors	Sample Location (# of Samples, if applicable)*	Pollutants Sampled*
Lake Lucile Water Pollution Control Analytical Report	1985	ADEC	Grab samples from Lake Lucile ADOT drains and lake outlets (2)	Cu, Pb
Lakes Lucile and Wasilla Water Quality Report	1986	ADEC	Sediment and water column (2)	Cu, Zn
Wasilla Storm Drains Investigations	1990	ADEC	Grab samples from manholes Sediment samples from outfalls (3) and reference sites (2)	Pb, Zn
Lake Lucile Water Quality Study	1990	Gilfilian Engineering, Inc.	Water column	NA
Final Report. Lake Lucile, Alaska. A Phase-I Diagnostic and Feasibility Study	1993	Eilers and Bernert	Water column, lake outlet, and select groundwater wells	NA
Waterbody Assessment of Lake Lucile	1995	HDR Engineering, Inc.	NA; Review of other studies	NA
Big Lake and Lake Lucile Water Quality Monitoring Final Report	2004	OASIS Environmental, Inc.	Water column (4); all PAH samples were below reporting limits	TAH, PAH
Lake Lucile Water Quality Monitoring Report, 2005	2006	OASIS Environmental, Inc.	Water column (12)	TAH
Matanuska-Susitna Stormwater Assessment, May–September 2011	2012	Davis and Davis	Stream grab samples from Wasilla, Cottonwood, and Meadow Creek	Cu, Pb, PAH
Matanuska-Susitna Stormwater Assessment, 2011–2012	2013a	Davis et al.	Discharge grab samples and sediment samples for 3 storm events from east outfall (6)	Cu, Pb, Zn, PAH
Lake Lucile Sediment Sampling: Spatial Extent of Impaired Sediment Due to Outfall Stormwater Inputs. Final Report for Alaska Department of Environmental Conservation	2013b	Davis et al.	Water column and sediment from east outfall (28), west outfall (15), and reference site (1)	Cu, Pb, Zn, PAH
Category 5/303(d) List Waterbody Determination	2018	ADEC	NA; 303(d), including review of other studies	NA
Lake Lucile Stormwater Outfall Source Area Estimates	2019	ARRI	Outfall drainage area estimates	NA

ADEC = Alaska Department of Environmental Conservation; DOT&PF = Alaska Department of Transportation and Public Facilities; ARRI = Aquatic Restoration & Research Institute; Cu = copper; NA = not applicable; PAH = polycyclic aromatic hydrocarbon; Pb = lead; TAH = total aqueous hydrocarbon; Zn = zinc.

*Pollutants and sample number reported only for studies that included information on one or more of the following: Cu, Pb, Zn, TAH, or PAH.

APPENDIX B: SIMPLE METHOD

The Simple Method was used to develop loading estimates for each of the three contributing drainage areas to Lake Lucile (east outfall, west outfall, and direct to lake). The Simple Method is an approach for developing pollutant load estimates for small, urban watersheds that relies on local climate and land use information. It was developed by the Center for Watershed Protection (CWP) as a tool to estimate stormwater pollutant loads quickly for small urban catchments and watersheds (CWP, 2003; Schueler, 1987). The Simple Method was used in 2004 and 2006 to develop several fecal coliform bacteria Total Maximum Daily Loads (TMDLs) for the Anchorage Bowl–Campbell Creek (ADEC, 2006), Ship Creek, Fish Creek, Furrow Creek, Little Campbell Creek, Little Rabbit Creek, and Little Survival Creek (ADEC, 2004). In 2015, the Simple Method was used to develop the Cottonwood Creek TMDL for fecal coliform bacteria (ADEC, 2015a).

The local climate is characterized by using the annual precipitation, and land use is characterized based on land use categories and percentage of impervious cover. Pollutants are represented using runoff concentration data that can be found in the literature or derived from local monitoring data if available and representative of single land uses. Load estimates are the product of annual runoff volume and pollutant concentration using the following set of equations:

$$L = 0.1028 * P * P_j * Rv * C * A \qquad \text{EQ. 1}$$

where

L = annual loading rate (kg per acre per year),

CF = conversion factor for expressing (L) in kilograms (0.1028) [(kg*L)/(inch*acre*mg)],

P = precipitation depth for the critical condition period (inches),

P_j = fraction of annual rainfall events that produce runoff assumed to equal 0.9 (Schuler, 1987),

Rv = runoff coefficient,

C = average pollutant concentration (mg/L or µg/L), and

A = watershed area (acres).

The sources of values used to represent precipitation (P), runoff coefficient (R_v), and pollutant concentration (C) in the Simple Method (Eq. 1) are presented in the following sections, providing additional detail on how each of these values was derived.

Precipitation (P)

In the Simple Method, precipitation (P) represents the primary precipitation (rainfall or snowfall) input that is used to calculate runoff. Runoff will never be larger than precipitation. Therefore, the total precipitation sets the limit on the amount of runoff that can be generated.

Precipitation totals for this TMDL analysis were based on historical records at the University of Fairbanks's Matanuska Agriculture and Forestry Experiment Station (AFES), located approximately 8.3 miles to the east of Lake Lucile (see Section 1.7). Precipitation totals measured at AFES represent water-equivalent totals of rain, snow, and other forms of precipitation.

An important factor in the Lake Lucile watershed is accounting for rainfall and snowfall. Precipitation falling as snow during the winter months accumulates and does not result in surface runoff in the same manner as rainfall would. Therefore, if precipitation totals from winter months are used in the Simple Method, the calculations result in unrealistic surface runoff and loading to the stream. To account for this, precipitation totals were modified to reflect more realistic runoff patterns in the area using a similar approach as the Cottonwood Creek fecal coliform bacteria TMDL (ADEC, 2015a). This approach involves converting snowfall during the winter months to an equivalent precipitation depth that can be represented as runoff in the spring, accounting for the process of snow accumulation and melt consistent with the spring break-up period. Figure B-1 presents a regression analysis relating monthly snow depth to liquid precipitation for December, January, and February from 1999 through 2018. The analysis was limited to this 3-month period because average temperatures are at or below 20°F, ensuring that any precipitation that does fall is in the form of snow. Table B-1 applies this regression relationship and presents this seasonal precipitation analysis for AFES.

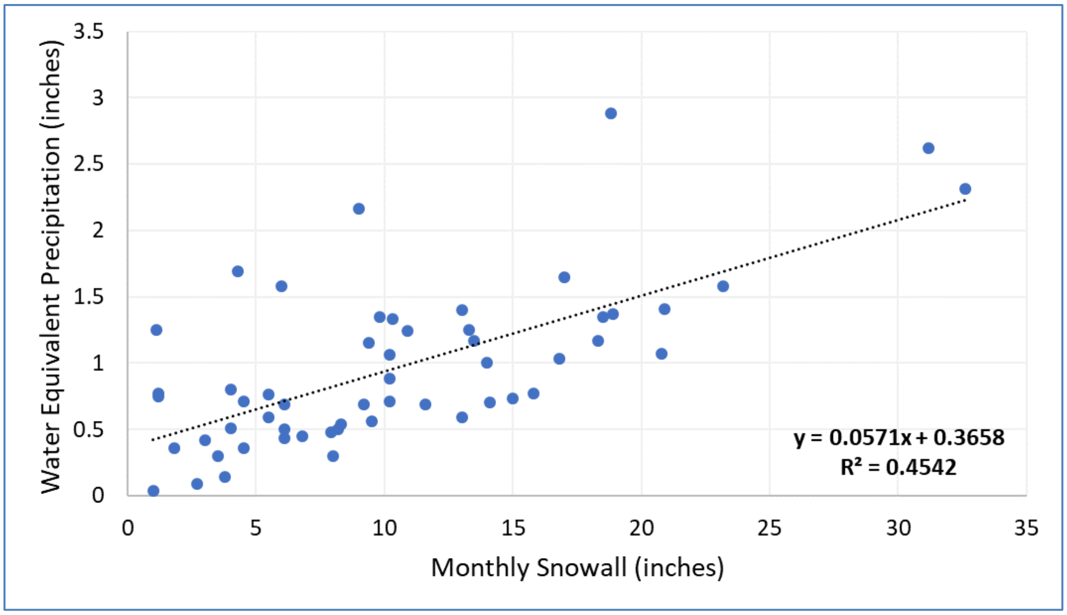

Figure B-1. Relationship between snowfall and water-equivalent precipitation (1999–2018)

Table B-1. Seasonal precipitation totals for the Matanuska Agriculture and Forestry Experiment Station

Season	Inches			
	Total		Snowfall Snow-Water Equivalent	Adjusted Precipitation
	Precipitation	Snowfall		
Winter (October 1–March 31)	5.46	43.85	2.87	2.591[1]
Spring (April 1–May 31)	1.06	2.91	0.53	3.932[2]
Summer (June 1–September 30)	8.14	0.00	0.37	8.14
Annual Average	14.66	46.76	—	14.66

[1] Equal to Total Precipitation (inches) less Snowfall Snow-Water Equivalent (inches).

[2.] Equal to Total Precipitation (inches) plus Winter Snowfall Snow-Water Equivalent (inches).

Runoff Coefficient (Rv)

The runoff coefficient (R_v) is an adjustment factor used to convert precipitation into runoff based on landscape characteristics, such as impervious cover and interception storage. Precipitation (P) from the previous section is multiplied by R_v to calculate a depth of runoff.

Because site-specific runoff coefficients were not available for the Wasilla area, a relationship between watershed imperviousness and the storm runoff coefficient (R_v) developed by Schueler (1987) was used to determine the runoff coefficient (R_v) for the Lake Lucile watershed. Schueler (1987) used nationwide data collected for the Nationwide Urban Runoff Program study with additional data collected from Washington, DC-area watersheds to establish the relationship, represented by the following equation:

$$Rv = 0.05 + (0.9 * Ia) \qquad \text{EQ. 2}$$

where

Ia = Impervious fraction.

A unique impervious fraction (Ia) value was calculated by subwatershed and land use for the Lake Lucile watershed using the 2011 National Land Cover Database (NLCD) impervious cover dataset (Homer et al., 2015). The NLCD impervious cover data include estimates of impervious cover as a fraction ranging between 0.0 and 1.0 using the same 30-meter grid. This layer of impervious cover was sampled using the Lake Lucile watershed land use categories (see the geographic information system [GIS] dataset to estimate impervious cover by subwatershed and land use category).

Table B-2 presents the impervious fraction (Ia) and runoff coefficient (Rv) values by subwatershed and land use category for the Lake Lucile watershed.

Table B-2. Impervious fraction (Ia) and runoff coefficient (Rv) by subwatershed and land use category

Land Use Category	Outfall			
	Impervious Fraction (Ia), %		Runoff Coefficient (R_v)	
	East	West	East	West
Residential	—	47.5	—	0.477
Commercial	61.2	55.7	0.601	0.551
Public Park	66.5	—	0.649	—
Highway	68.7	61.6	0.669	0.604
Local Roads	53.6	27.8	0.533	0.300

Pollutant Concentration (C)

Average pollutant concentrations (C) are used in conjunction with the runoff to characterize pollutant loads expressed as mass. In the Simple Method, this information is used to develop unit loads (mass/acre/time), which are used with the land use category areas to develop loads.

Local monitoring studies and national datasets were reviewed to identify representative concentration values for sediment, Cu, Pb, Zn, and PAH for each of the land use categories present in the Lake Lucile watershed. Table B-3 summarizes the studies reviewed to support selection of the most representative average pollutant concentrations.

Table B-3. Summary of studies reviewed for pollutant concentration data

Study Name	Study Location	Available Concentration Data				
		Sediment	Total Copper	Total Lead	Total Zinc	Total PAH
Matanuska-Susitna Stormwater Assessment, 2011–2012	Matanuska-Susitna Borough, Alaska	—	●	●	●	—
Anchorage MS4 Stormwater Outfall Monitoring (2016, 2017)	City of Anchorage, Alaska	—	●[1]	—	—	●
National Urban Runoff Program (NURP)	National	●	●	●	●	—
National Stormwater Quality Database (NSQD)	National	●	●	●	●	—

[1] Available copper data are dissolved only.

Ideally, the average pollutant concentration data available would be calculated as flow-weighted averages to account for the high variability in concentrations during individual events. The data available in the Matanuska-Susitna Stormwater Assessment 2011–2012 and the 2016 and 2018 Anchorage MS4 Stormwater Outfall Monitoring contain some of the parameters required for characterizing the existing loading to Lake Lucile; however, the data are limited to a small number of storm events and represent single "grab samples" rather than flow-weighed EMCs.

Because the sample data available from local studies are limited and are primarily grab samples, data from the NSQD were used to develop average pollutant concentrations for the existing load and TMDL analysis. This dataset represents peer-reviewed, comprehensive data available by land use category. Concentration values were derived by filtering the NSQD data for each pollutant and land use to include locations with cold weather climates where winter maintenance and deicing occur to better reflect conditions in the Lake Lucile watershed. Specifically, data were extracted for the states of Idaho, Minnesota, Washington, Oregon, and Wisconsin. Additional East Coast states were included from the Open Space category for deriving Public Park concentrations because limited data were available.

Table B-4 presents the 25th percentile, median, and 75th percentile sediment concentration by land use calculated to be representative of existing conditions based on the raw data from the NSQD query.

Table B-4. Representative pollutant concentrations by land use category

Land Use Category	States Represented	Sample Count	Sediment Concentration (mg/L)		
			25th Percentile	Median	75th Percentile
Residential	ID, MN, OR, WA, WI	318	64.0	103.5	185.8
Commercial	NH, OR, WI	167	47.0	102.0	202.5
Highway & Roads	OR	26	62.5	108.5	238.5
Park & Open Space	KY, MA, MD, NC, TN, VA	42	10.0	32.5	82.75

Existing Load (L)

Tables B-5 and B-6 present summaries of the Simple Method input parameters and calculations used to develop existing loads reaching the east and west outfalls for sediment (using total suspended solids [TSS]).

Table B-5. Simple Method calculations of total sediment existing loads by land use reaching the east outfall

Season	Land use category	P (in.)	Pj	Rv	C	A (ac.)	TSS load (kg/season)
Spring April 1 – May 31	Residential	3.932	0.9	—	—	—	—
	Commercial			0.601	102.0	48.35	1,077.53
	Highways			0.669	108.5	8.51	224.55
	Road			0.533	108.5	11.98	251.80
	Park & Open Space			0.649	32.5	1.13	8.67
Summer June 1 – Septembe r 30	Residential	8.14	0.9	—	—	—	—
	Commercial			0.601	102.0	48.35	2,231.4
	Highways			0.669	108.5	8.51	465.0
	Road			0.533	108.5	11.98	521.4
	Park & Open Space			0.649	32.5	1.13	17.9

P = precipitation depth for the critical condition period (inches); Pj = fraction of annual rainfall events that produce runoff; Rv = runoff coefficient; C = average pollutant concentration (mg/L or µg/L); and A = watershed area.

Table B-6. Simple Method calculations of total sediment existing loads by land use reaching the west outfall

Season	Land use category	P (in.)	Pj	Rv	C	A (ac.)	TSS load (kg/year)
Spring April 1 – May 31	Residential	3.932	0.9	0.477	103.5	9.44	169.6
	Commercial			0.551	102.0	38.37	784.7
	Highways			0.604	108.5	13.32	317.7
	Road			0.300	108.5	11.03	130.5
	Park & Open Space			—	—	—	—
Summer June 1 – September 30	Residential	8.14	0.9	0.477	103.5	9.44	351.1
	Commercial			0.551	102.0	38.37	1,625.1
	Highways			0.604	108.5	13.32	658.0
	Road			0.300	108.5	11.03	270.3
	Park & Open Space			—	—	—	—

APPENDIX C: WASTELOAD AND LOAD ALLOCATIONS UNDER MS4 PERMIT SCENARIO

Urbanized areas as defined by the latest U.S. census may be required to obtain Alaska Pollutant Discharge Elimination System (APDES) stormwater permit coverage as a municipal separate storm sewer system (MS4). MS4 permits are required for communities with populations greater than 10,000 and with a density greater than 1,000 people per square mile. It appears likely that the Cities of Wasilla and Palmer and the surrounding area in the Matanuska-Susitna Borough will be considered an urbanized area as a result of the year 2020 census. Once the census is finalized, and population density established, the Cities of Wasilla and Palmer, the Matanuska-Susitna Borough, and the DOT&PF would be required to obtain an MS4 permit (as co-permittees) from ADEC at that time. The MS4 permit is designed to prevent stormwater runoff from washing harmful pollutants into local surface waters.

This TMDL includes analyses and allocations under the current regulatory environment as well as TMDL allocations under a future MS4 permit scenario (Table C-1). When the MS4 permit is issued, the LAs for the area covered by the permit automatically will be changed to WLAs without having to revise this TMDL.

Table C-1. Lake Lucile TMDLs under MS4 permit scenario (g/year)

Pollutant	Existing Load	Load Capacity	LA_{NB}	WLA_{CGP}	WLA_{E} *	WLA_{W}*	Total Reduction, %
Copper	996.4	325.1	75.0	15.4	123.6	111.0	N/A
Lead	713.2	279.9	37.6	13.3	137.4	91.6	61
Zinc	16,520	1,120.0	191.2	53.2	461.4	414.2	93
PAH	13.8	2.4	0.0	0.1	1.2	1.1	83

g = gram; LA_{NB} = Load Allocation for natural background; WLA_{CGP} = Waste Load Allocation for the Construction General Permit; WLA_{E}= Waste Load Allocation for east outfall; WLA_{W}= Waste Load Allocation for west outfall. Copper is not considered impaired but is provided for information purposes.