

**Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, Alaska 99501**

**Total Maximum Daily Load (TMDL)
for Fecal Coliform in the Waters of
Little Rabbit Creek in Anchorage, Alaska**

March 2004

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Total Maximum Daily Load for Fecal Coliform in the Waters of Little Rabbit Creek in Anchorage, Alaska

TMDL AT A GLANCE:

<i>Water Quality-limited?</i>	Yes
<i>Hydrologic Unit Code:</i>	19020401
<i>Criteria of Concern:</i>	Fecal coliform
<i>Designated Uses Affected:</i>	Water supply and water recreation
<i>Major Source(s):</i>	Urban runoff
<i>Loading Capacity:</i>	1.98×10^{11} FC/year
<i>Wasteload Allocation:</i>	1.78×10^{11} FC/year (Section 6 includes seasonal allocations)
<i>Load Allocation:</i>	0 FC/year
<i>Margin of Safety:</i>	1.98×10^{10} FC/year
<i>Necessary Load Reductions (to meet WLA):</i>	Annual: 51 percent Winter: 0 percent Spring: 0 percent Summer: 65 percent

Executive Summary

Little Rabbit Creek is located in the Municipality of Anchorage (MOA), the urban center of the Anchorage Bowl in southcentral Alaska. The state of Alaska included Little Rabbit Creek on its 1998 303(d) list as water quality-limited due to fecal coliform, identifying urban runoff as the expected pollutant source. A Total Maximum Daily Load (TMDL) is established in this document to meet the requirements of Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130), which require the establishment of a TMDL for the achievement of water quality standards when a waterbody is water quality-limited. A TMDL is composed of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources 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. A TMDL represents the amount of a pollutant the waterbody can assimilate while maintaining compliance with applicable water quality standards.

Applicable water quality standards for fecal coliform in Little Rabbit Creek establish water quality criterion for the protection of designated uses for water supply, water recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. The TMDL is developed for the most stringent of these—the fecal coliform criteria for drinking, culinary, and food processing water supply

that states that in a 30-day period, the geometric mean may not exceed 20 FC/100 mL, and not more than 10% of the samples may exceed 40 FC/100 mL. (18 AAC 70.020(b)(2)(A)(i)).

Fecal coliform data indicate that Little Rabbit Creek does not meet the applicable water quality standards. The largest and most frequent exceedances of the water quality criteria occur during summer months, likely due to increased stormwater runoff and source activity (e.g., wildlife). Fecal coliform concentrations are lower during colder winter months that experience less stormwater runoff. Concentrations steadily increase during spring months, with increased surface runoff during spring thaw and breakup. Because of the substantial seasonal variation in fecal coliform levels, the Little Rabbit Creek TMDL is developed on a seasonal basis to isolate times of similar weather, runoff and instream conditions.

Because Little Rabbit Creek does not have a sufficient record of corresponding flow and water quality data, the TMDL was developed using a simple approach that uses an empirical equation to calculate pollutant loading in the absence of flow data. The Simple Method (Schueler, 1987) was used for the TMDL analysis. The Simple Method is a lumped parameter empirical model used to estimate stormwater pollutant loadings under conditions of limited data availability. The approach calculates pollutant loading using drainage area, event mean pollutant concentrations, precipitation and a runoff coefficient based on impervious area in the watershed. The method was used to calculate existing fecal coliform loading based on observed fecal coliform data and the loading capacity for the stream based on instream concentrations representing water quality standards.

The following table summarizes the results of the TMDL analysis. The MOS was included explicitly as 10 percent of the loading capacity. Because stormwater discharges in the MOA are regulated by a National Pollutant Discharge Elimination System (NPDES) stormwater permit for municipal separate storm sewer systems (MS4), watershed loads delivered to Little Rabbit Creek are addressed through the wasteload allocation component of this TMDL. Therefore, the load allocation for the Little Rabbit Creek fecal coliform TMDL is zero. The fecal coliform wasteload allocations for Little Rabbit Creek are provided as seasonal allocations for the entire watershed and are equal to the loading capacity minus the MOS.

Season	Loading Capacity (FC/season)	MOS (FC/season)	Wasteload Allocation (FC/season)	Percent Reduction (for Wasteload Allocation)
Winter	2.56E+10	2.56E+09	2.31E+10	N/A
Spring	4.63E+10	4.63E+09	4.17E+10	N/A
Summer	1.26E+11	1.26E+10	1.14E+11	65%
Total (FC/yr)	1.98E+11	1.98E+10	1.78E+11	51%

Implementation of the Little Rabbit Creek TMDL will be achieved through actions associated with the relevant MS4 permit. EPA recommends that for NPDES-regulated municipal and small construction stormwater discharges effluent limits should be expressed as best management practices (BMPs) or other similar requirements, rather than as numeric effluent limits. The policy recognizes the need for an iterative approach to control pollutants in storm water discharges and anticipates that a suite of BMPs will be used in the initial rounds of permits and that these BMPs will be tailored in subsequent rounds.

Follow-up monitoring will likely be conducted cooperatively by ADEC and MOA to track the progress of TMDL implementation and subsequent water quality response, track BMP effectiveness, and track the water quality of Little Rabbit Creek to evaluate future attainment of water quality standards.

1. Overview

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) implementing regulations (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state water quality standards when a waterbody is water quality-limited. A TMDL identifies the amount of pollution control needed to maintain compliance with standards and includes an appropriate margin of safety. The focus of the TMDL is reduction of pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices and/or effluent limits and monitoring required through National Pollutant Discharge Elimination System permits.

The state of Alaska included Little Rabbit Creek on its 1998 303(d) list as water quality-limited due to fecal coliform. The creek (Alaska ID Number 20401-024) was originally listed in 1994 and is included on the 1998 list as a Tier I water¹. The 303(d) list identifies urban runoff as the expected pollutant source. This document establishes a TMDL to address the fecal coliform impairment in Little Rabbit Creek.

The following sections provide general background information on the Little Rabbit Creek watershed.

1.1 Location

Little Rabbit Creek is located in the Municipality of Anchorage (MOA), the urban center of the Anchorage Bowl in southcentral Alaska (Figure 1-1). The Anchorage Bowl is a broad valley bordered by the Chugach Mountain Range on the east and the Turnagain Arm and Knik Arm of Cook Inlet to the southwest and northwest. The Little Rabbit Creek is located in the southeast portion of Anchorage and is the main tributary to Rabbit Creek, which drains to the Turnagain Arm (Figure 1-2).

1.2 Population

Based on 2000 Census data, the population of the MOA is 263,435. Census data in GIS format with population statistics by census blocks were clipped to the area of the Little Rabbit Creek watershed to estimate the watershed population. However, some Census blocks cross watershed boundaries. In this instance, a population density (people/acre) was calculated from the original block. These densities were assumed to be consistent across the Census block and were multiplied by the area contained within the watershed to estimate the population within the clipped portion of the Census block. Because population densities may vary spatially across the Census blocks with some portions of the blocks being more or less densely populated, the watershed populations calculated with the densities are considered estimates and are used as a reference of the relative magnitude of population in the watershed. The estimated population in Little Rabbit Creek watershed is 769. The Little Rabbit Creek Water Quality Assessment included an estimate of 975 for the watershed population; however, the date and population data for this estimate are unknown.

¹ Tier I: Water quality-limited waterbodies which require water quality assessments to verify the extent of pollution and what controls are in place or needed.

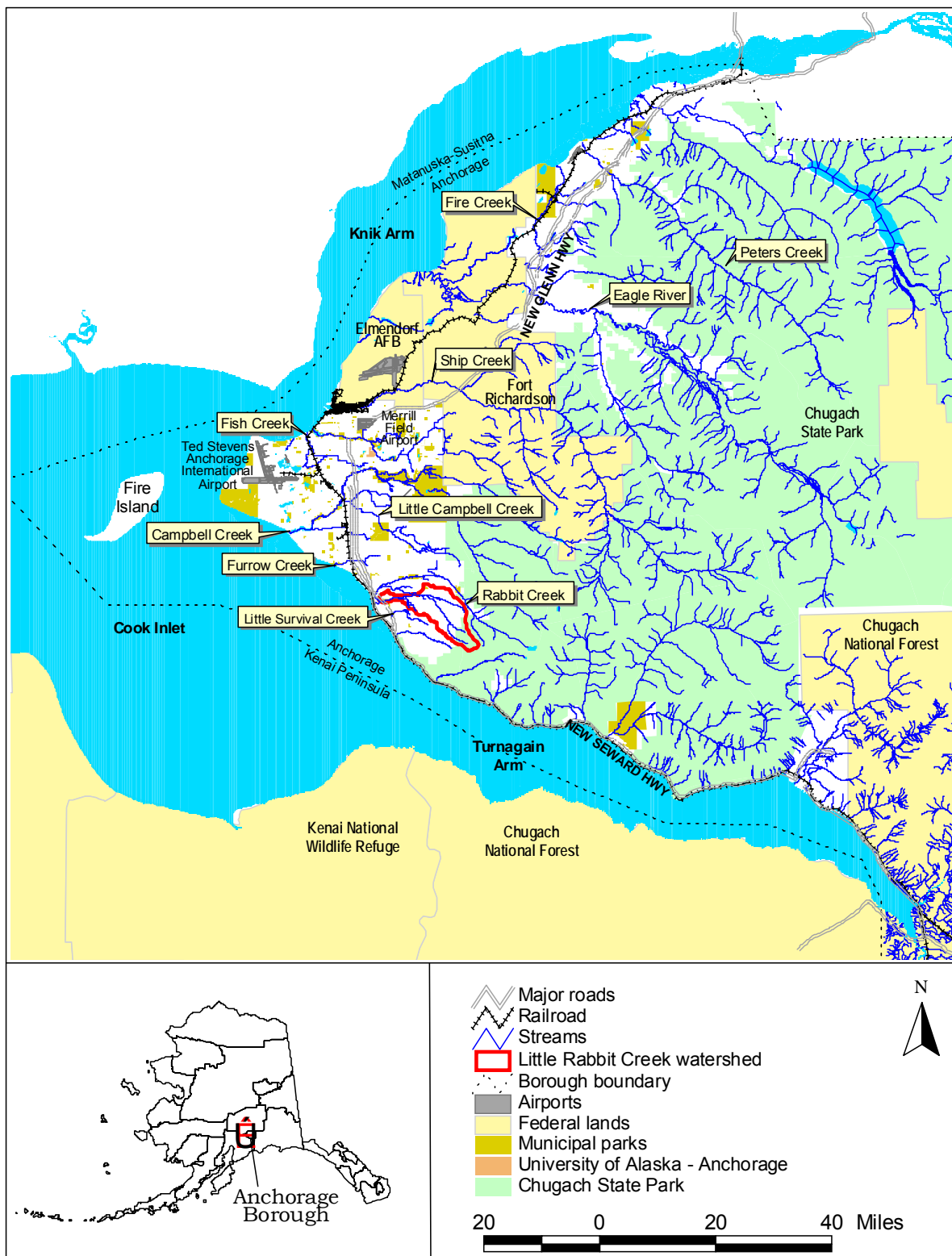


Figure 1-1. Location of Little Rabbit Creek watershed

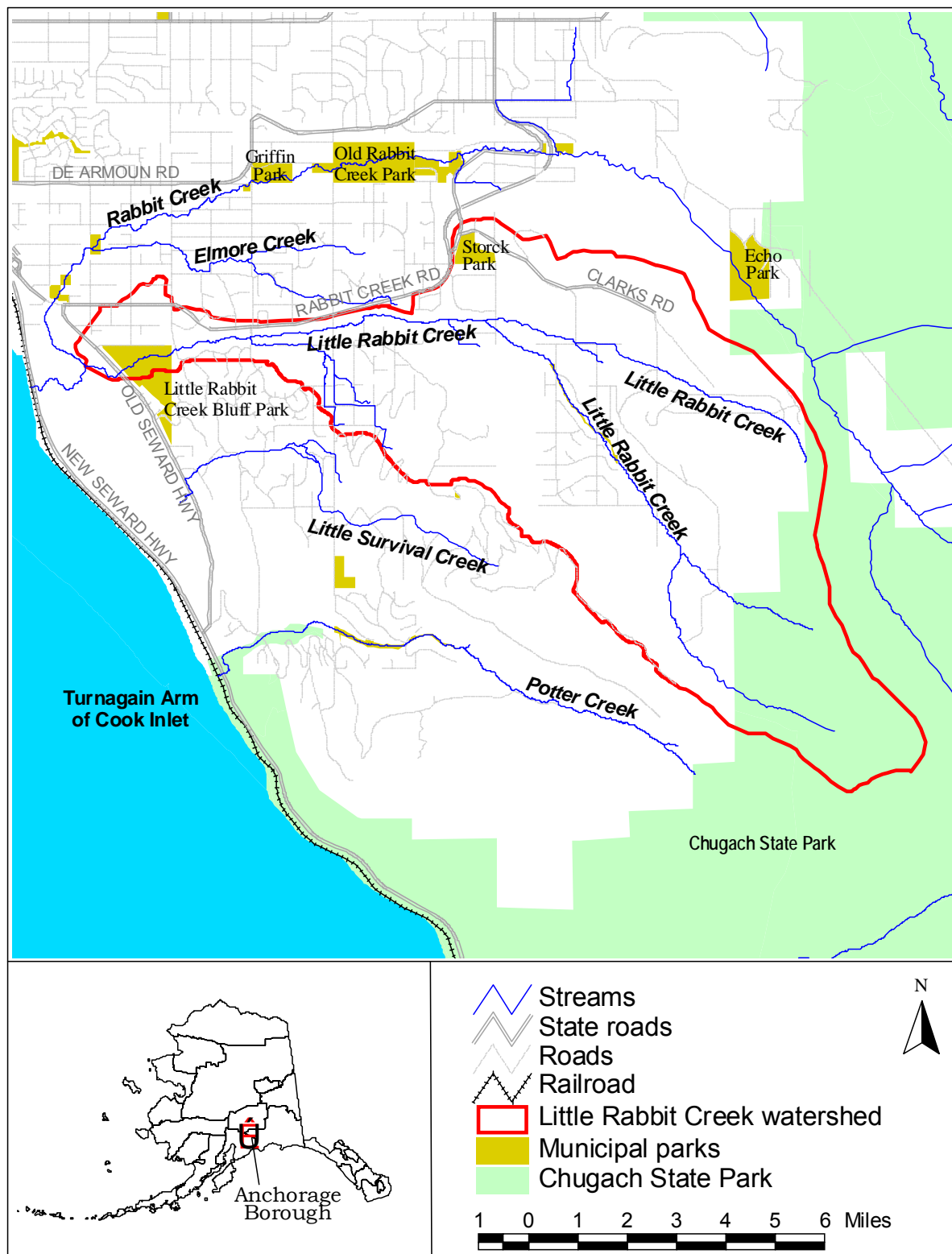


Figure 1-2. Little Rabbit Creek watershed

1.3 Topography

Anchorage is a broad valley bounded by the Knik Arm and Turnagain Arm of Cook Inlet. The terrain rises gradually to the east for about 10 miles, with marshes interspersed with glacial moraines, shallow depressions, small streams and knolls (AWSO, 1997). Beyond this valley area, the Chugach Mountains are situated in a north-northeast to south-southwest direction, with average elevations between 4,000 and 5,000 ft and peaks up to 10,000 ft. Elevations in the Little Rabbit Creek watershed vary, with the lower watershed just above sea level in the valley portion of the Anchorage Bowl and the headwaters in higher elevations and steeper topography in the Chugach Mountains. Little Rabbit Creek begins in the Chugach Mountains at an elevation of 4,200 ft and flows through the mountains to the valley where it discharges to Rabbit Creek at an elevation of 100 ft.

1.4 Landuse

Land cover and uses in the Little Rabbit watershed was determined based on GIS coverages available from MOA. MOA land use classifications include 8 major categories (e.g., residential) with more detailed subcategories (e.g., single family detached, mobile home on lot, etc.). Appendix A contains a listing of the subcategories associated with each major category and Table 1-1 and Figure 1-3 present the land use distribution by major category for the watershed.

The dominant landuse in the Little Rabbit Creek watershed is Vacant, including waterbody and intertidal areas. Little Rabbit Creek watershed is primarily open space (e.g., Chugach State Park) and residential areas with no commercial or industrial areas.

Table 1-1. Landuse distribution in Little Rabbit Creek watershed

Landuse	Area (acres)	Percent of total area
Residential	668.2	16%
Commercial	0.1	0%
Industrial	11.6	0%
Institutional	68.9	2%
Parks and Open Space	988.4	23%
Transportation	0.0	0%
Rights of Way	193.4	5%
Vacant/Intertidal	2,297.9	54%
Total	4,228.5	

1.5 Climate

The Anchorage area is contained in the “transition” climate zone of Alaska, between the maritime and continental zones. Temperatures in the transition zone typically range between zero and the low 60s degrees Fahrenheit (EF) (WWRC, 2002). The Chugach Mountains act as a barrier to the influx of warm, moist air from the Gulf of Alaska, resulting in annual precipitation amounts equal to 10 to 15 percent of that measured at weather stations located on the Gulf side of the Chugach Range. Annual snowfall varies from approximately 70 inches on the west side of Anchorage to about 90 inches on the east side. Snow totals increase steadily with increasing elevations in the Chugach Mountains where winter arrives a month earlier and stays a month longer at the 1,000 to 2,000 ft elevation (AWSO, 1997).

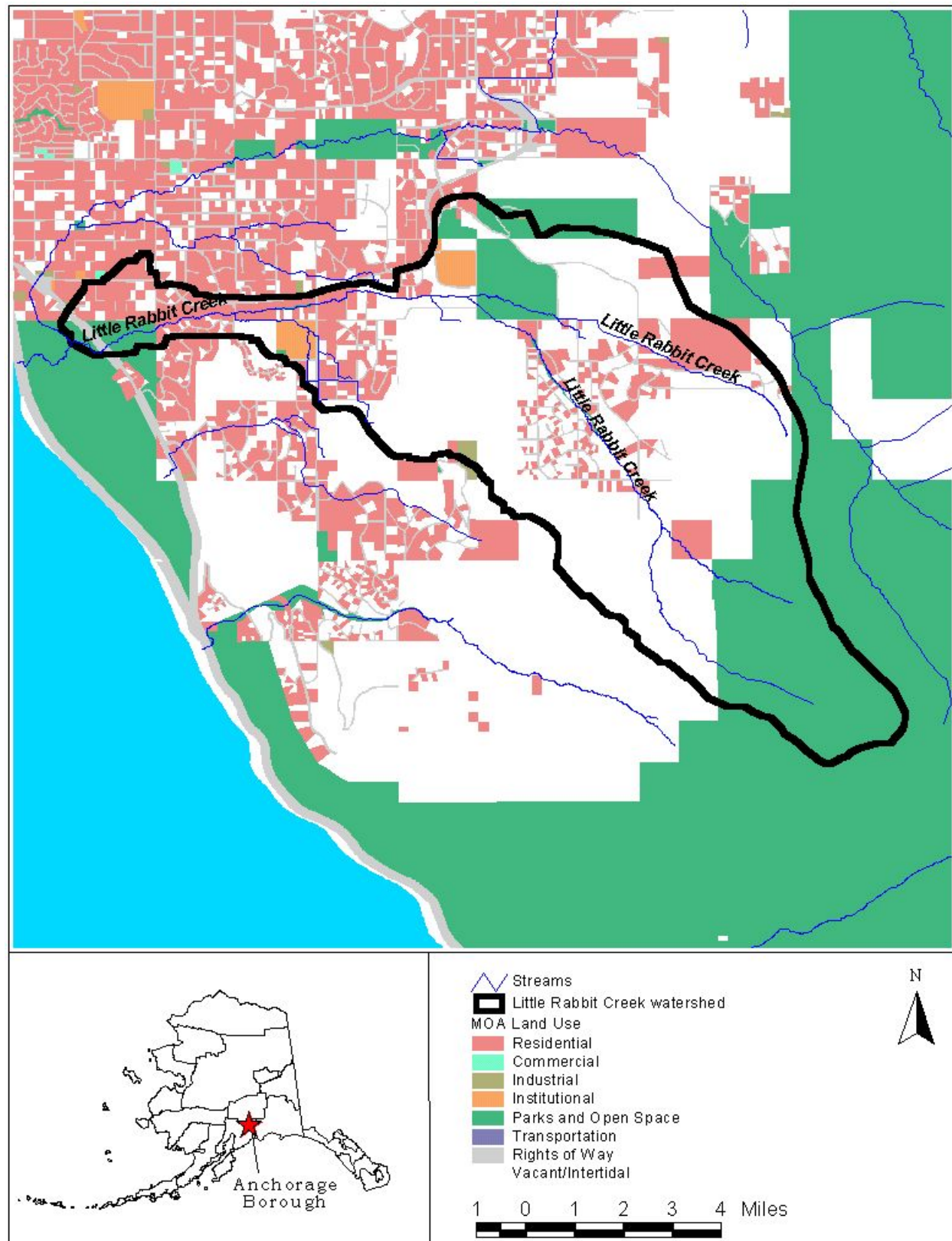


Figure 1-3. Landuse distribution in Little Rabbit Creek watershed

Summer temperatures average around 60°F. Autumn begins in early September and ends in mid-October with temperatures falling in September and snowfalls increasing in October (AWSO, 1997). Winter lasts from mid-October to early April, with the coldest temperatures typically occurring in January. Spring begins in late April and May with less precipitation and increasing temperatures. Figure 1-4 presents a summary of monthly averages for rainfall, snowfall and temperature at the Anchorage Ted Stevens International Airport (500280), based on the period of record at the station from April 1952 to December 2001.

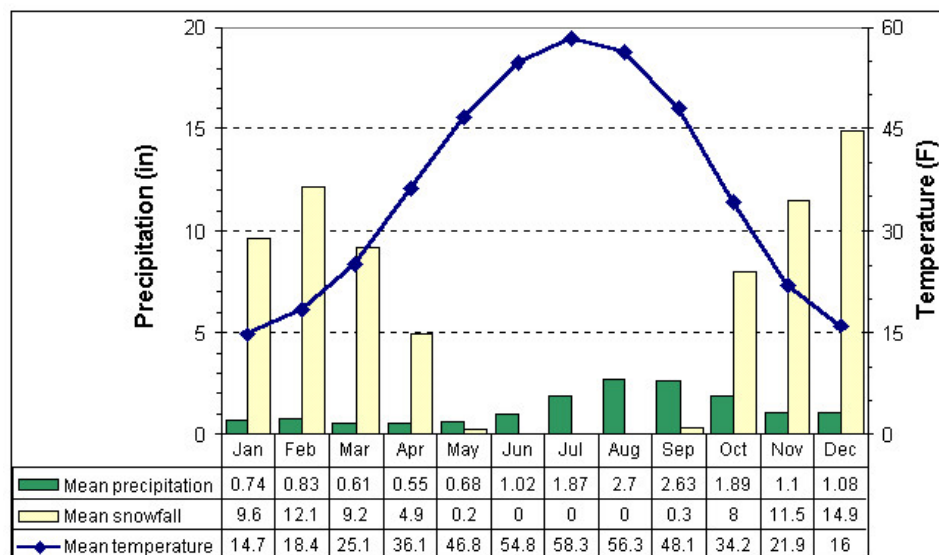


Figure 1-4. Monthly average precipitation and temperatures at Anchorage Ted Stevens International Airport

1.6 Hydrology

Little Rabbit Creek is approximately 7 miles long with a 4,228-acre watershed. The creek is one of three creeks that drain to Potter Marsh near Turnagain Arm. Its headwaters begin in the Chugach Mountains and flow northwesterly to the confluence with Rabbit Creek downstream of Little Rabbit Creek Bluff Park. There are no known storm drains discharging to the creek.

Two USGS gages with continuous streamflow data are located in the Little Rabbit watershed. USGS gage 15273095 is located on Little Rabbit Creek above Goldenview Drive and has data from 10/1/80 through 9/30/85. USGS gage 15273102 is located just upstream of the mouth of Little Rabbit Creek and has data from 5/1/79 through 9/30/80. Daily average flows for both gages are presented in Figure 1-5. The figure shows increasing flows during April and May due primarily to snowmelt. High flows also occur through the summer and again during the fall in response to summer and fall storms. Low flow occurs during the frozen winter months.

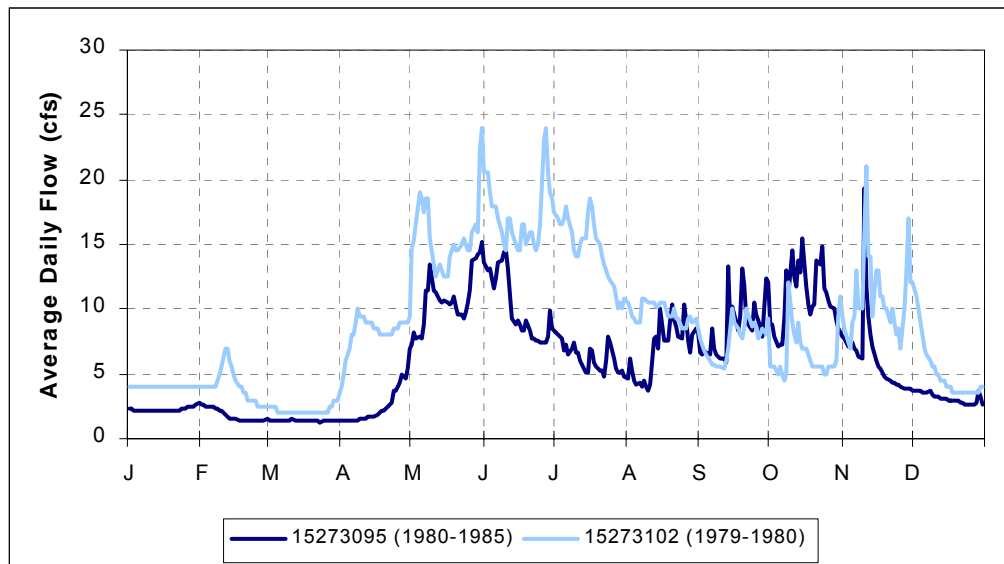


Figure 1-5. Average daily streamflow at USGS gages on Little Rabbit Creek

2. Water Quality Standards and TMDL Target

Water quality standards designate the “uses” to be protected (e.g., water supply, recreation, aquatic life) and the “criteria” for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). TMDLs are developed to meet applicable water quality standards, which may be expressed as numeric water quality criteria or narrative criteria for the support of designated uses. The TMDL target identifies the numeric goals or endpoints for the TMDL that equate to attainment of the water quality standards. The TMDL target may be equivalent to a numeric water quality standard where one exists, or it may represent a quantitative interpretation of a narrative standard. This section reviews the applicable water quality standards and identifies an appropriate TMDL target for calculation of the fecal coliform TMDL in Little Rabbit Creek.

2.1 Applicable Water Quality Standards

Title 18, Chapter 70 of the Alaska Administrative Code (ACC) establishes water quality standards for the waters of Alaska, including the designated uses to be protected and the water quality criteria necessary to protect the uses. Designated uses established in the State of Alaska Water Quality Standards (18 AAC 70.020) for fresh waters of the state include (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife, and are applicable to all fresh waters, unless specifically exempted. Fecal coliform water quality standards for each use and applicable to Little Rabbit Creek are presented in Table 2-1. The TMDL must be developed to meet all applicable criteria. The most stringent of these is the following criteria for drinking, culinary, and food processing water supply:

In a 30-day period, the geometric mean may not exceed 20 FC/100 mL, and not more than 10% of the samples may exceed 40 FC/100 mL. (18 AAC 70.020(b)(2)(A)(i))

2.2 Designated Use Impacts

Designated uses for Alaska’s waters are established by regulation and are specified in the State of Alaska Water Quality Standards (18 AAC 70.020). For fresh waters of the state, these designated uses include (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife. Little Rabbit Creek does not support its designated uses of water supply and water recreation due to elevated instream fecal coliform levels. The presence of fecal coliform indicates an increased risk of pathogen contamination in a waterbody. Consumption of or contact with pathogen-contaminated waters can result in a variety of gastrointestinal, respiratory, eye, ear, nose, throat and skin diseases.

2.3 TMDL Target

The TMDL target is the numeric endpoint used to evaluate the loading capacity and necessary load reductions and represents attainment of applicable water quality standards. Little Rabbit Creek has applicable numeric water quality criteria for fecal coliform, and the TMDL will be developed to meet the most stringent of these criteria—criteria for drinking, culinary, and food processing water supply (water supply). The water quality standard of a geometric mean of 20 FC/100 mL in a 30-day period will be used as the basis for this TMDL. The not-to-exceed criterion will not be used directly in the TMDL calculation because the available data does not support the use of an approach to link the frequency of exceedances (e.g., not to exceed in 10 percent of the samples) to fecal coliform loading. Using the geometric mean criterion results in a more stringent loading capacity and it is expected that maintenance of the geometric mean criterion will also result in maintaining the not-to-exceed criterion.

Table 2-1. Alaska water quality standards for fecal coliform

Water Use	Description of Standard
(A) Water Supply	
(i) drinking, culinary and food processing	In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml. For groundwater, the FC concentration must be less than 1 FC/100 ml, using the fecal coliform Membrane Filter Technique, or less than 3 FC/100 ml, using the fecal coliform most probable number (MPN) technique.
(ii) agriculture, including irrigation and stock watering	The geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked and for dairy sanitation of unpasteurized products, the criteria for drinking water supply, (1)(A)(i), apply.
(iii) aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml. For products not normally cooked, the criteria for drinking water supply, (1)(A)(i), apply.
(iii) industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 ml, and not more than 10% of the samples may exceed 400 FC/100 ml.
(B) Water Recreation	
(i) contact recreation	In a 30-day period, the geometric mean of samples may not exceed 100 FC/100 ml, and not more than one sample or more than 10% of the samples if there are more than 10 samples, may exceed 200 FC/100 ml.
(ii) secondary contact	In a 30-day period, the geometric mean of samples may not exceed 200 FC/100 ml, and not more than 10% of the total samples may exceed 400 FC/100 ml.
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	Not applicable

3. Data Analysis

The compilation and analysis of data and information is an essential step in understanding the general water quality conditions and trends in an impaired water. This section outlines and summarizes all of the data reviewed and includes the following information:

- Data inventory—describes the available data and information
- Data analyses—presents results of various data analyses evaluating trends in instream data

3.1 Data Inventory

Table 3-1 and the following discussion summarizes the available fecal coliform data for Little Rabbit Creek. Figure 3-1 presents the monitoring station locations.

Table 3-1. Summary of available fecal coliform data for Little Rabbit Creek

Site	Location Description	No. of Samples	Start Date	End Date	Min	Avg	Max	Over 40 FC/100 mL		Note ¹
								No.	%	
MOA stations										
LRC1	Little Rabbit at Old Seward Highway	87	1/5/89	6/26/90	0	155.6	10,600	25	29%	
LRC3	Little Rabbit at Nickleen	83	1/13/89	6/26/90	0	68.6	1,360	21	25%	
USGS stations										
15273090	L Rabbit C At Nickleen St	6	10/25/79	7/27/00	1	37.2	160	2	33%	4/67%
15273095	L Rabbit C Ab Goldenview Dr	5	11/28/83	6/29/84	1	4.8	17	0	0%	3/60%
15273097	L Rabbit C At Goldenview Dr	5	10/25/79	7/27/00	1	22.6	97	1	20%	3/60%
15273100	L Rabbit C Nr Anchorage	3	3/23/00	7/28/00	3	28.0	42	1	33%	1/33%
15273102	L Rabbit C At Anchorage	3	10/25/79	5/20/80	2	5.0	11	0	0%	3/100%
610449149433900	L Rabbit C Tr Nr Anchorage	2	10/25/79	3/26/80	1	1.5	2	0	0%	1/50%

¹ Number and percentage of measurements marked as “estimated value.”

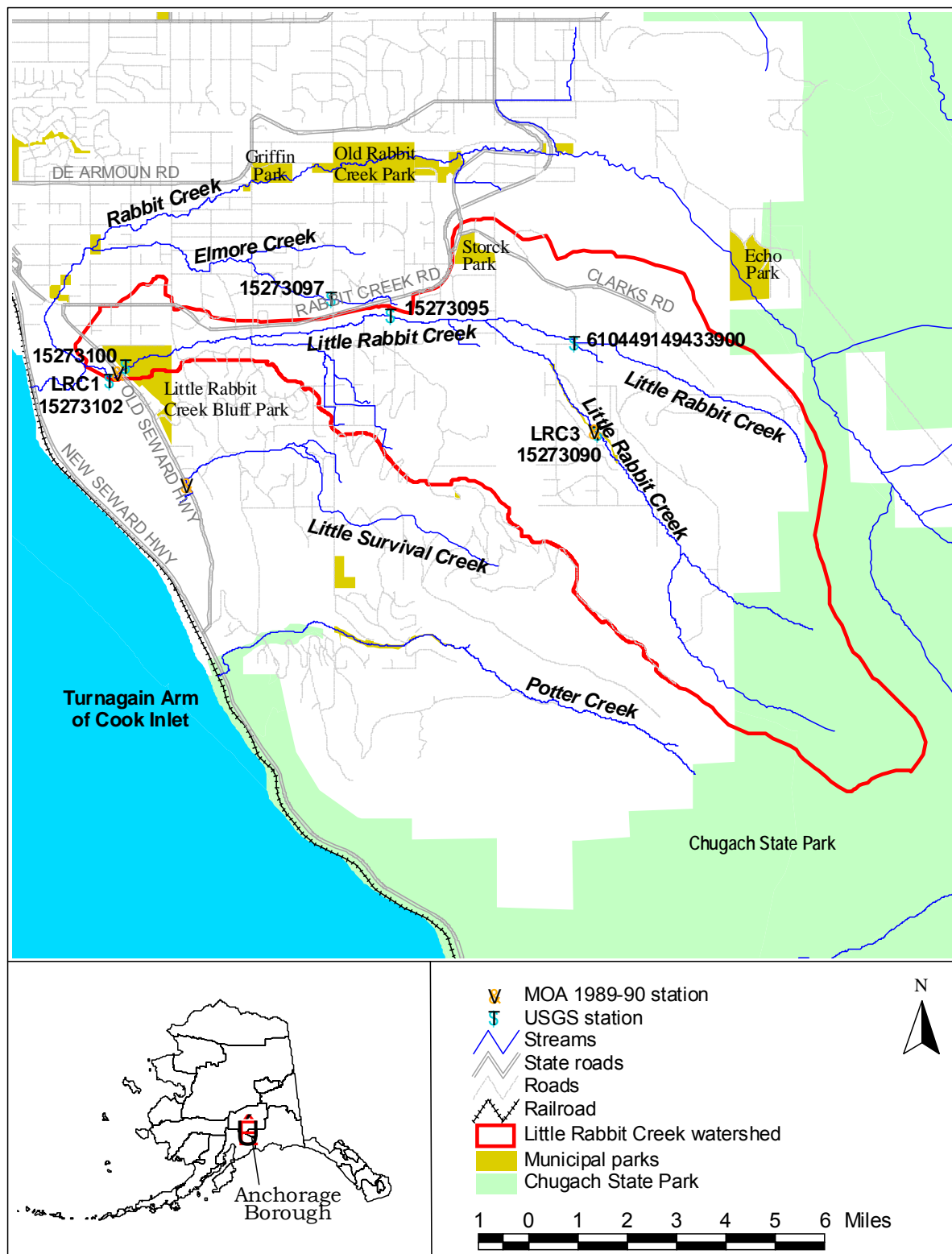


Figure 3-1. Locations of water quality monitoring stations in Little Rabbit Creek

3.2 Data Analysis

The following sections discuss data analyses conducted to evaluate any important trends or aspects of the fecal coliform levels in Little Rabbit Creek. Several sources of data were reviewed to characterize the water quality of Little Rabbit Creek; however, some of the data was used for general and background information rather than specific analyses and calculation of the TMDL. Many of the datasets available for Little Rabbit Creek contain limited number of samples, do not capture seasonal differences, are older than other available data, and/or contain estimated (rather than measured) values. The following analyses were based on the MOA data collected in at LRC1 in Little Rabbit Creek during the 1989-1990 water quality study of Anchorage Bowl streams. The MOA dataset is the most robust dataset available, representing extensive monitoring over an 18-month period, with sufficient data for meaningful analyses, and LRC1, located at the mouth of the creek, represents the overall watershed.

Impairment Analysis

An impairment analysis compares available instream data with applicable water quality standards to confirm the listed impairment (i.e., nonsupport of fecal coliform water quality standards). The analysis also evaluates the magnitude and frequency of water quality standards exceedances. Fecal coliform data collected by MOA at LRC1 in Little Rabbit Creek were compared to the geometric mean and not-to-exceed standards to evaluate impairment and water quality standards exceedances.

For comparison to the geometric mean criterion, geometric means were calculated for every possible 30-day period included in the dataset, based on all individual observations within that 30-day period. Table 3-2 and Figure 3-2 summarize the calculated geometric means and their comparison to the geometric mean criterion of 20 FC/100 mL. Table 3-2 includes the monthly average, median, minimum, maximum and 25th and 75th percentiles of all calculated geometric means. The table also presents a ratio and percentage of the number of 30-day geometric means included in each month that exceed the 20 FC/100 mL criterion ("Exceedances: Count" and "% of Exceedances"). A table listing all of the calculated exceedances of the geometric mean criterion is included in Appendix A with information on the 30-day period (start and end dates), the number of samples included in the calculation, the geometric mean value and exceedance percentage of the geometric mean.

The fecal coliform data at LRC1 in Little Rabbit Creek were also compared to the not-to-exceed standard (i.e., not to exceed 40 FC/100 mL in more than 10 percent of the samples in a 30-day period), as summarized in Table 3-3 and Figure 3-3. For a summary of the instantaneous concentrations, Table 3-3 includes the average, median, minimum, maximum, and 25th and 75th percentiles of all values within each month. For comparison to the criterion, samples within any possible 30-day period were compared to the not-to-exceed criterion and the calculated exceedances are summarized in Table 3-3 ("Exceedances: Count" and "% of Exceedances"). For example, there are 11 possible 30-day periods that include samples collected in January. In 1 of those 11 periods (or 9 percent), more than 10 percent of the values exceeded 40 FC/100 mL. A table listing all exceedances of the not-to-exceed criterion is included in Appendix A.

Table 3-2. Summary statistics of geometric means calculated using fecal coliform data at LRC1

Data: 1/5/89 to 6/26/90								
Month	Average ¹	Median ¹	Min ¹	Max ¹	25th ¹	75th ¹	Exceedances: Count ²	% of Exceedances ³
Jan	3	3	1	4	2	4	0:7	0%
Feb	3	1	1	15	1	3	0:8	0%
Mar	1	1	0	2	0	1	0:10	0%
Apr	4	3	1	18	2	4	0:10	0%
May	17	18	7	22	15	19	2:10	20%
Jun	27	26	20	37	24	30	11:12	92%
Jul	20	15	15	36	15	21	1:4	25%
Aug	85	59	38	173	51	111	7:7	100%
Sep	162	183	83	200	150	195	4:4	100%
Oct	42	41	27	65	34	45	5:5	100%
Nov	32	35	19	38	31	35	6:7	86%
Dec	16	16	14	18	15	17	0:3	0%
All Data	28	18	0	200	2	32	36:87	41%

¹ Average, median, minimum, maximum and 25th and 75th percentile values of all 30-day geometric means calculated for the month (i.e., using samples within the month).

² Ratio of number of calculated 30-day geometric means that exceed the water quality criterion to the number of calculated 30-day geometric means in the month.

³ Percentage of all calculated 30-day geometric means for the month that exceed the water quality criterion.

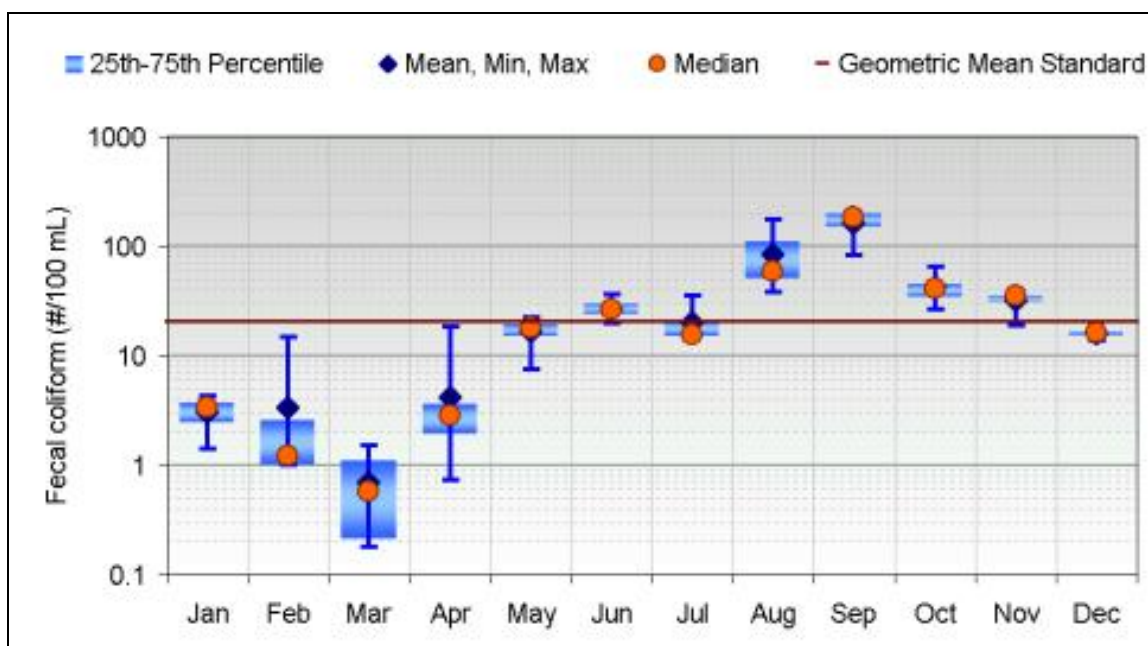


Figure 3-2. Summary of calculated geometric means of fecal coliform in Little Rabbit Creek (LRC1)

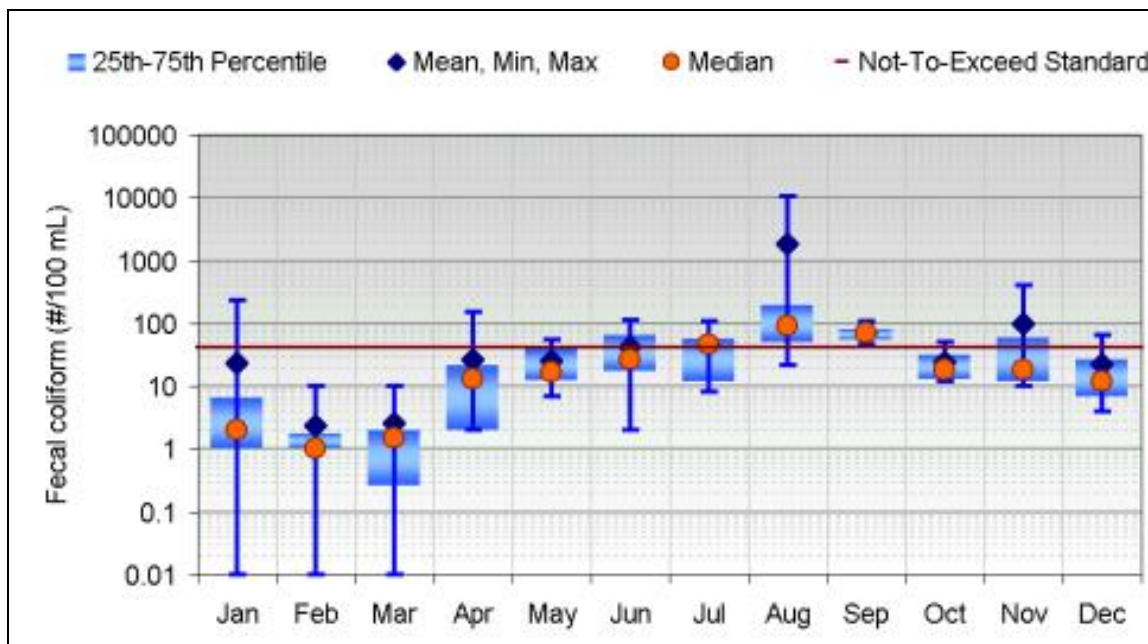
Table 3-3. Summary statistics for the evaluation of the not-to-exceed criterion at LRC1

Data: Data: 1/5/89 to 6/26/90								
Month	Average ¹	Median ¹	Min ¹	Max ¹	25th ¹	75th ¹	Exceedances: Count ²	% of Exceedances ³
Jan	24	2	0	230	1	7	1:11	9%
Feb	2	1	0	10	1	2	0:8	0%
Mar	3	2	0	10	0	2	0:10	0%
Apr	27	13	2	150	2	22	1:9	11%
May	26	17	7	56	12	40	3:10	30%
Jun	42	27	2	114	17	65	3:8	38%
Jul	46	46	8	106	12	58	3:5	60%
Aug	1,845	92	22	10,600	50	194	5:6	83%
Sep	71	70	46	106	54	80	5:5	100%
Oct	25	18	12	50	13	32	1:5	20%
Nov	100	18	10	400	12	60	2:5	40%
Dec	23	12	4	64	7	27	1:5	20%
All Data	156	12	0	10,600	2	46	25:87	29%

¹ Average, median, minimum, maximum and 25th and 75th percentile values of all fecal coliform samples for the month.

² Ratio of observed fecal coliform values that exceed the water quality criterion to the observed fecal coliform values in the month.

³ Percentage of all observed fecal coliform values for the month that exceed the water quality criterion.

**Figure 3-3. Summary of instantaneous fecal coliform levels in Little Rabbit Creek (LRC1)**

Temporal Variation

Evaluation of temporal patterns can assist in identifying potential sources in the watershed, seasonal variations or declining/improving water quality trends. Figure 3-3 presents a monthly distribution of fecal coliform observations at station LRC1 on Little Rabbit Creek. Flow data are not available with fecal coliform data to evaluate the relationship of seasonal flow differences on fecal coliform levels; however, some assumptions can be made based on fecal coliform distributions and likely flow patterns in the watershed. The highest levels of bacteria in Little Rabbit Creek occur during the summer months (July-September) due to the increased rain events and resulting stormwater runoff. Freezing temperatures during the winter months decrease surface runoff, resulting in lower instream bacteria levels. Runoff from the break-up and thaw result in increasing bacteria levels during spring months.

4. Pollutant Sources

The identification of sources is important to the successful implementation of a TMDL and the control of pollutant loading to a stream. Characterizing watershed sources can provide information on the relative magnitude and influence of each source and its impact on instream water quality conditions. This section discusses the potential sources of fecal coliform to Little Rabbit Creek, including point and nonpoint sources.

4.1 Point Sources

Stormwater runoff to Little Rabbit Creek is expected to be a primary source of fecal coliform. Stormwater is traditionally considered a nonpoint source, carrying pollutants to receiving waters through surface runoff. However, when stormwater is permitted and carried through conveyances to discrete discharges to streams, it is considered a point source. Unlike most constant point sources (e.g., WWTP discharges), stormwater is precipitation-driven.

4.2 Nonpoint and Natural Sources

The Alaska 303(d) list identifies urban runoff as the primary source of fecal coliform to Little Rabbit Creek. Snowmelt and rainfall transport bacteria that is deposited and accumulated on the surface of residential and urban areas. Likely sources of the accumulated bacteria are waterfowl, domestic animals (e.g., cats and dogs) and native animals (e.g., moose, bear, etc.). Animals can deposit fecal matter directly into the watershed streams or on the land surface where it is available for overland transport in surface runoff. MOA (1990) concludes that pet and waterfowl feces appear to be the major sources of fecal coliform for runoff in the Anchorage area. The water quality assessment for Little Rabbit Creek indicates that, of the potential animal sources of bacteria, waterfowl are likely not a source of fecal coliform due to heavy brush inhibiting the area.

Wildlife may be a considerable source of fecal coliform to Little Rabbit Creek, both through direct deposition and deposition on watershed surfaces; however, it is difficult to estimate fecal coliform contributions from wildlife in the Anchorage area. It is not feasible to isolate wildlife populations for area watersheds due to the mobility and large ranges of the wildlife throughout the area. Additionally, while fecal coliform production of many agricultural animals has been researched, there is little or no information on the bacteria production rates of wildlife species native to the Anchorage area.

Although the information is not available to quantify the direct loading from wildlife sources in the watershed, Alaska Department of Fish and Game (ADF&G) provided qualitative estimates of wildlife populations in the Anchorage area that are used to provide general background on the types of animals that may be contributing to the fecal coliform impairments in the area. The following summarizes the information provided by ADF&G (Rick Sinnott, personal communication, 1/30/03):

- Approximately 200-300 moose live in the Anchorage Bowl, not including moose that live solely in Fort Richardson or Chugach State Park, and as many as 1,000 moose are in the Anchorage Bowl in winter.
- About 2,000 Canada geese inhabit the Anchorage Bowl. Most of these geese are located west of Lake Otis Boulevard and north of Tudor Road (i.e., Fish Creek area) in grassy parks, school grounds, and athletic fields in April and July-October and in bogs, ponds, and lakes in May-July. Thousands more Canada and other geese fly through the area in spring and fall, primarily in the Anchorage Coastal Wildlife Refuge (located on the Turnagain Arm and including Potter Marsh).

- Anchorage may contain 2,000 or more mallards in the winter, with most located in open creeks (Ship Creek and Chester Creek).
- Anchorage also has several thousand pigeons, primarily downtown and midtown.
- At most, there are 100-150 beavers in the Anchorage Bowl.
- Latest counts showed no more than 6 brown bears and 30-40 black bears in the Anchorage Bowl.

Another potential source of fecal coliforms is failing septic systems. Septic systems have the potential to contribute fecal coliform to receiving waters through surface breakouts and subsurface malfunctions. Failing septic systems located in close proximity to receiving waterbodies are more likely to impact instream conditions. According to the water quality assessment for Little Rabbit Creek, failing septic systems are an unlikely source of fecal coliform to the streams. However, a summary of listing issues on the 1996 listing of Little Rabbit Creek indicate that septic systems are the primary means of sewage disposal in the watershed and that the citizens were concerned about the adequacy of the current systems. Although almost 100 percent of the homes in the watershed have onsite septic systems, because the majority of septic systems in the Anchorage area are located more than 100 feet away from any streams (Kevin Kleweno, ADEC, Division of Environmental Health, Drinking Water & Wastewater Program, personal communication to Timothy Stevens, ADEC, January 31, 2003), it is unlikely that any failing septic systems are significantly impacting instream water quality conditions in Little Rabbit Creek.

5. Analytical Approach

Developing TMDLs requires a combination of technical analysis, practical understanding of important watershed processes, and interpretation of watershed loadings and receiving water responses to those loadings. In identifying the technical approach for development of the fecal coliform TMDL for Little Rabbit Creek, the following core set of principles was identified and applied:

- ***The TMDLs must be based on scientific analysis and reasonable and acceptable assumptions.*** All major assumptions have been made based on available data and in consultation with appropriate agency staff.
- ***The TMDLs must use the best available data.*** All available data in the watershed were reviewed and were used in the analysis where possible or appropriate.
- ***Methods should be clear and as simple as possible to facilitate explanation to stakeholders.*** All methods and major assumptions used in the analysis are described. The TMDL document has been presented in a format accessible by a wide range of audiences, including the public and interested stakeholders.

The analytical approach used to estimate the loading capacity, existing loads, and allocations presented below relies on these principles and provides a TMDL calculation that uses the best available information to represent watershed and instream processes.

5.1 Analysis Background

When developing a TMDL based on instream observed data, existing loads can typically be estimated using corresponding observed flow and water quality data. Similarly, allowable loads can be calculated using observed flows and an appropriate TMDL target concentration. For example, a loading capacity curve can be developed by multiplying observed flow values by the water quality standard and graphing the resulting loads. An existing load curve can be developed by multiplying the observed flow values by the observed water quality data. Existing loads that plot above the TMDL curve therefore represent deviations from the water quality standard and those plotting below the curve represent compliance with standards. The area beneath the TMDL curve represents the loading capacity of the stream.

To conduct a load duration curve analysis it is necessary to have a continuous flow record or a dataset of flows covering a broad range of flow conditions during times of water quality sampling in the impaired stream. Although Little Rabbit Creek has a consistent record of fecal coliform data from the 1989-90 MOA study, it does not have flow data corresponding to the time and location of available fecal coliform data. Therefore, the TMDL development approach must be done using a simpler approach that uses an empirical equation to calculate pollutant loading in the absence of flow data.

The Simple Method (Schueler, 1987) was used to calculate existing fecal coliform loading based on watershed characteristics and observed fecal coliform data. The method was also used to calculate loading capacity for the stream, based on instream concentrations representing water quality standards.

Because Little Rabbit Creek experiences considerable seasonal variation in instream fecal coliform levels, the TMDL analysis calculates loads and reductions on a seasonal basis to isolate times of similar instream, weather, and flow conditions. The analysis is conducted for the three major seasons in the watershed—winter (October 1 - March 31), spring (April 1 - May 31), and summer (June 1 - September 30). During winter months, precipitation falls primarily as snow, resulting in little to no surface runoff.

Snow and ice accumulated during winter melts with the increasing temperatures during spring, creating increased surface runoff and steadily increasing instream flows. Summer experiences warmer temperatures and summer storms that produce peaks of high instream flows.

The following sections discuss the TMDL analysis in more detail, including the data inputs and results.

5.2 Evaluation of Existing Loads

The Simple Method (Schueler, 1987) was used to calculate fecal coliform loading in Little Rabbit Creek. The Simple Method is a lumped parameter empirical model to estimate stormwater pollutant loadings under conditions of limited data availability. The approach calculates pollutant loading using drainage area, pollutant concentrations, a runoff coefficient and precipitation. In the Simple Method, the amount of rainfall runoff is assumed to be a function of the imperviousness of the contributing drainage area. More densely developed areas have more impervious surfaces, such as rooftops and pavement, causing more stormwater to runoff rather than be absorbed into the soil. The Simple Method equation is:

$$L = CF \cdot P \cdot P_j \cdot R_v \cdot C \cdot A$$

where:

- L = Pollutant load (fecal coliform counts per time interval)
- CF = Conversion factor (1,028,270 mL/in-acre)
- P = Precipitation depth (inches) over desired time interval
- P_j = Fraction of rainfall that produces runoff (assumed to be 0.9 [Schueler, 1987])
- R_v = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
- C = Pollutant concentration (FC/100 mL)
- A = Area of the watershed (acres)

The following sections discuss the identification of the parameters for calculation of fecal coliform loading in Little Rabbit Creek using the Simple Method.

Precipitation (P)

Seasonal precipitation totals for use in the Simple Method were determined based on historical records at Ted Stevens International Airport, National Climatic Data Center Station 500280 (Figure 5-1). Precipitation totals measured at the NCDC station represent water-equivalent totals of rain, snow, and other forms of precipitation. Precipitation falling as snow during the winter months accumulates and does not result in surface runoff 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 more realistically reflect runoff patterns in the area.

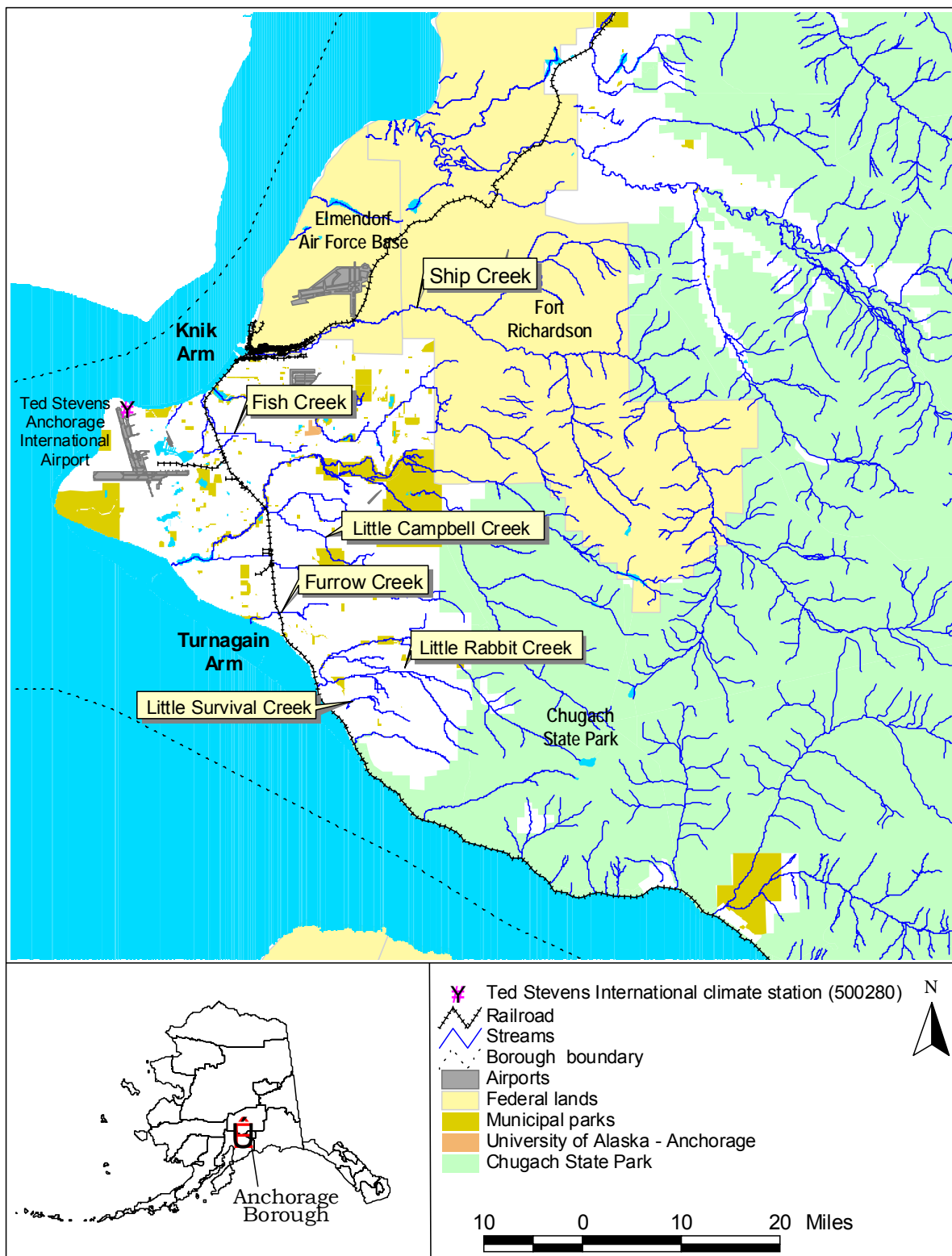


Figure 5-1. Location of Ted Stevens International Airport climate station (500280)

Precipitation during the winter months was divided into snow and rainfall to isolate the portion of measured precipitation that would result in runoff (i.e., rainfall) and that portion that would remain frozen on the watershed surface (i.e., snow). The snow portion was then added to the spring precipitation totals to reflect the time period that the accumulated snow would melt and contribute to surface runoff. To divide the precipitation into rainfall and snowfall portions, monthly snowfall totals from the airport were converted to water-equivalent precipitation and subtracted from the monthly precipitation totals also recorded at the airport.

To convert the snow to water-equivalent precipitation it was necessary to identify a conversion factor relating snow depth to water-equivalent depth. Monthly snowfall and total precipitation depths recorded at the Ted Stevens climate station for January, February and December of every year from 1980 through 1997 were evaluated to establish a relationship between the two measures. (Data from 1998 through 2002 were discarded due to periods of data gaps [e.g., missing days].) Monthly totals measured during months with average temperatures below 20° F were used to establish a correlation between snowfall and water-equivalent precipitation, as shown in Figure 5-2. The regression equation representing the relationship between the two parameters (also shown in Figure 5-2) was used to convert recorded winter snowfalls to water-equivalent precipitation.

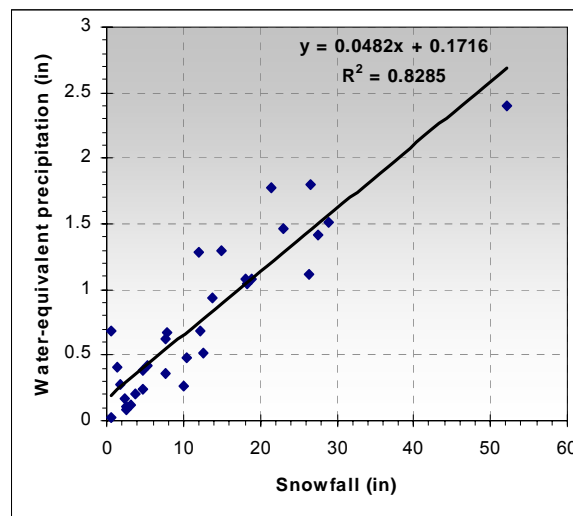


Figure 5-2. Relationship between snowfall and water-equivalent precipitation

Monthly average snowfall and rainfall precipitation values were then calculated for the period of record used in the TMDL analysis—January 1989 through June 1990, corresponding to available fecal coliform data. The monthly averages were summed to calculate the corresponding seasonal totals. Additionally, the average monthly snowfall totals for winter were summed and added to the spring totals to account for the effect of runoff during spring melt. Table 5-1 summarizes the seasonal precipitation totals and corrections for snowfall.

Table 5-1. Seasonal precipitation totals

Season	Total Measured Precip (in)	Snowfall correction (in)	Corrected Precip (in)
Winter	8.27	-4.63	3.64
Spring	1.95	4.63	6.57
Summer	17.91	0.00	17.91

¹Summer precipitation values include major storm events with above-average totals for August 1989. However, the values were not modified because they are representative of conditions during fecal coliform collection.

Runoff Coefficient (R_v)

Because site-specific runoff coefficients were not available for the Anchorage 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 Little Rabbit Creek watershed. Schueler (1987) used nationwide data collected for the Nationwide Urban Runoff Program study (USEPA, 1983) with additional data collected from Washington, DC, area watersheds to establish the relationship, represented by the following equation:

$$R_v = 0.05 + 0.9(I)$$

where:

I = Impervious fraction of the drainage area

An overall runoff coefficient for Little Rabbit Creek watershed was calculated based on the amount of impervious area in the watershed, determined using land cover data provided by MOA. MOA created a complete land cover classification to provide the foundation for mapping inland areas according to their common surface hydrologic and gross pollutant generation potential. The “Storm Water Runoff” grid was derived through analysis of IKONOS satellite imagery and other geographic datasets (especially landuse, streets, drainage, coastland and wetlands data). The dataset was built to provide information for storm water management applications and includes five major classes: Impervious, Barren Pervious, Vegetated Pervious, Snow and Ice, and Water. These land cover classes are further subdivided to reflect changes in perviousness due to different land development applications. For example, impervious surfaces are classified as either street surface, directly connected impervious, and indirectly connected impervious and vegetation classes are reclassified as either landscaped or forested. The MOA land cover classifications are described in Table 5-2 with corresponding areas in the Little Rabbit Creek watershed.

Any category classified as impervious is assumed to be 100 percent impervious, while all other classes are 0 percent impervious. The total impervious area in the watershed was calculated based on the land cover dataset and divided by the total watershed area to determine the overall impervious fraction of the watershed. This value (I) was used with the Schueler (1987) equation to determine the runoff coefficient (Rv) for Little Rabbit Creek watershed. Table 5-3 presents the total watershed area, total impervious area and the resulting I and Rv values.

Table 5-2. MOA land cover classification system

Land Cover	Land Cover Description	Area (acres)
<i>Impervious classes—Large paved areas, parking lots, rooftops.</i>		
Directly Connected Impervious	Impervious features (not including roads) that are immediately adjacent to paved roads and spatially intersect a 60-foot buffer from the edge of pavement. For example, a large parking lot that extends beyond 60 feet from the edge of a paved road will be categorized as directly connected impervious as long as a portion of that feature enters a 60-foot buffer from an adjacent roadway.	10
Indirectly Connected Impervious	Areas that do not intersect the 60-foot buffer from the edge of pavement. These include impervious areas that are adjacent and/or within the vicinity of dirt or unpaved roads.	42
Streets	Paved roadways.	135
<i>Pervious classes</i>		
Landscaped	Parks, open fields, residential yards, large areas of non-forested and non-wetland vegetation.	106
Forested	Areas of tree canopy—natural forest.	3,262
Barren	Includes areas of zero or little vegetation, exposed soil, non-active land-cover.	376
Wetland	Moist areas containing vegetation, marshes, bogs.	296
Lakes/Water	Areas of exposed water bodies, reservoirs.	
<i>Total</i>		<i>4,228</i>

Table 5-3. Information used in calculation of runoff coefficient for Little Rabbit Creek watershed

Total Area (acres)	Total Impervious Area (acres)	Overall Percent Imperviousness	Runoff Coefficient (Rv)
4,228	188	4%	0.09

Pollutant Concentration (C)

Observed fecal coliform data collected during MOA's 1989-90 study were used to calculate the C value for use in the Simple Method. The C value represents the average pollutant concentration, preferably the event mean concentration (EMC), which is a flow-weighted average concentration. Because concentrations of pollutants can widely vary throughout a storm event and between events, a flow-weighted average can account for variability and result in a more representative "average" concentration. Unfortunately, flow data are not available with available fecal coliform data, prohibiting the calculation of EMCs. To minimize the impact of variability of concentrations in the stream during and between storm events (and to be consistent with water quality standards), the geometric mean of observed fecal coliform samples is used as the C value. The seasonal C values were calculated as geometric means based on the MOA data and were calculated using all observations within a season. For example, the representative geometric mean of 14 FC/100 mL for spring was calculated using all samples collected in April and May during the period of record (i.e., 1989-1990). The resulting seasonal C values for Little Rabbit Creek are included in Table 5-4.

Calculation of Existing Load

Table 5-4 summarizes the information used to calculate the seasonal fecal coliform loads using the Simple Method and the resulting loads.

Table 5-4. Simple Method values and resulting fecal coliform loads for Little Rabbit Creek

Season	P (in)	Pj	Rv	C (FC/100 mL)	A (acres)	Existing Loading (FC/season)
Winter	3.64	0.90	0.09	4.88	4,228.46	6.25E+09
Spring	6.57	0.90	0.09	14.43	4,228.46	3.34E+10
Summer	17.91	0.90	0.09	51.81	4,228.46	3.27E+11
Total (FC/yr)						3.66E+11

5.3 Evaluation of Loading Capacity

The Simple Method was also used to calculate seasonal loading capacities. The parameters representing watershed characteristics (e.g., precipitation, runoff coefficients and area) remain the same for the loading capacity calculation; however, the pollutant concentration (C) is changed to reflect TMDL conditions—conditions meeting water quality standards. Therefore, the C value for calculation of loading capacities is equal to the geometric mean water quality criterion of 20 FC/100 mL. The calculated loading capacities are summarized in Table 5-5, along with the existing loadings and resulting load reductions.

Table 5-5. Seasonal fecal coliform loading capacities for Little Rabbit Creek

Season	Existing Loading (FC/season)	Loading Capacity (FC/season)	Percent Reduction
Winter	6.25E+09	2.56E+10	N/A
Spring	3.34E+10	4.63E+10	N/A
Summer	3.27E+11	1.26E+11	61%
Total (FC/yr)	3.66E+11	1.98E+11	46%

6. TMDL

A TMDL represents the total amount of a pollutant that can be assimilated by a receiving water while still achieving water quality standards. A TMDL is composed of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources 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. Conceptually, this definition is denoted by the equation

$$\text{TMDL} = \Sigma \text{WLAs} + \Sigma \text{LAs} + \text{MOS}$$

Table 6-1 summarizes the overall fecal coliform TMDL for Little Rabbit Creek.

This TMDL will be implemented using adaptive management and will be revised, as necessary, based on future information on sources and instream conditions. Adaptive management is an approach where monitoring and source controls are used 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 BMPs and reduced pollutant loading into a system. Information from an adaptive management process can then be used to refine a future TMDL, so that the future TMDL and allocations best represent how to improve water quality in a specific watershed.

Table 6-1. Summary of the Little Rabbit Creek fecal coliform TMDL

Source	Annual Existing Fecal Coliform Load	Percent Reduction	Annual Allocated Fecal Coliform Load
<i>Nonpoint Sources:</i>			
N/A (watershed covered by MS4 permit)	0 FC/yr	0%	0 FC/yr
<i>Point Sources:</i>			
Little Rabbit Creek watershed	3.66E+11 FC/yr	51%	1.78E+11 FC/yr
Total Existing Load	3.66E+11 FC/yr	Load Allocation	0 FC/yr
		Wasteload Allocation	1.78E+11 FC/yr
		Margin of Safety¹	1.98E+10 FC/yr
TMDL = Loading Capacity = 1.98E+11 FC/yr			

¹MOS was included explicitly as 10 percent of the loading capacity.

6.1 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 Little Rabbit Creek TMDL, the MOS was included explicitly as 10 percent of the loading capacity.

6.2 Load Allocation

Nonpoint sources are typically represented by loads carried to receiving waters through surface runoff resulting from precipitation events. However, because stormwater discharges in the MOA are regulated by a NPDES stormwater permit for municipal separate storm sewer systems (MS4), watershed loads delivered to Little Rabbit Creek are addressed through the wasteload allocation component of this TMDL. Therefore, the load allocation for the Little Rabbit Creek fecal coliform TMDL is zero. If data or information from future monitoring efforts can be used to identify and quantify stormwater or natural loads that are not delivered through the stormwater conveyances, the TMDL and its allocations will be revised accordingly.

6.3 Wasteload Allocation

The only permitted source of fecal coliform in the watershed of the impaired segment of Little Rabbit Creek is stormwater runoff. The MOA is subject to an MS4 permit that regulates stormwater discharges and EPA policy and regulation indicate that stormwater runoff regulated by the NPDES program through an MS4 permit must be addressed through wasteload allocations in a TMDL (USEPA, 2002). Therefore, the Little Rabbit Creek TMDL establishes wasteload allocations for watershed loads of fecal coliform.

The fecal coliform wasteload allocations for Little Rabbit Creek are provided as monthly allocations for the entire watershed. Because the load allocation is zero, the wasteload allocations are equal to the loading capacity minus the MOS, as summarized in Table 6-2 and Figure 6-1. Allocations are not established for future loads because ADEC does not anticipate any future permits for the discharge of fecal coliform to Little Rabbit Creek. Additionally, if data or information from future monitoring efforts can be used to identify and quantify stormwater or natural loads that are not delivered through the stormwater conveyances, the TMDL and its allocations will be revised accordingly.

Table 6-2. Fecal coliform wasteload allocations for Little Rabbit Creek

Season	Loading Capacity (FC/season)	MOS (FC/season)	Wasteload Allocation (FC/season)	Percent Reduction (for Wasteload Allocation)
Winter	2.56E+10	2.56E+09	2.31E+10	N/A
Spring	4.63E+10	4.63E+09	4.17E+10	N/A
Summer	1.26E+11	1.26E+10	1.14E+11	65%
Total (FC/yr)	1.98E+11	1.98E+10	1.78E+11	51%

6.4 Seasonal Variation

Fecal coliform concentrations and loading in Little Rabbit Creek vary seasonally, likely due to variations in weather and source activity. To account for this seasonality, this TMDL establishes seasonal allocations. Seasonal allocations represent loads allocated to time periods of similar weather, runoff, and instream conditions and can help to identify times of greatest impairment and focus TMDL implementation efforts by identifying times needing greater load reductions, as illustrated in Figure 6-2.

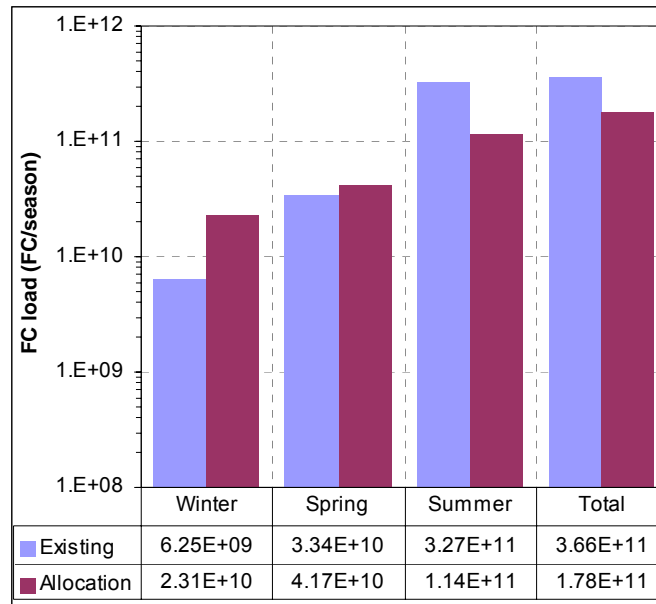


Figure 6-1. Summary of existing and allocated fecal coliform loads

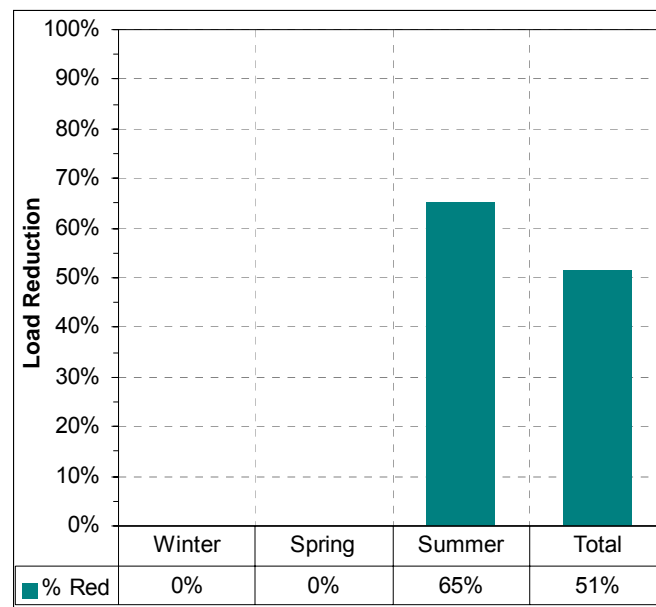


Figure 6-2. Seasonal variation in necessary load reductions

7. Implementation

According to EPA policy on addressing regulated stormwater in TMDLs (USEPA, 2002), wasteload allocations can be translated to effluent limitations in the applicable permit through the use of best management practices (BMPs). The following discussion summarizes information contained in USEPA (2002).

NPDES permits must contain effluent limits and conditions consistent with the requirements and assumptions of the wasteload allocations in the relevant approved TMDL. Typically, those effluent limitations to control the discharge of pollutants are expressed in numerical form. However, because storm water discharges are due to storm events that are highly variable in frequency and duration and are not easily characterized, EPA's policy recognizes that only in rare cases will it be feasible or appropriate to establish numeric limits for municipal and small construction storm water discharges. Therefore, EPA recommends that for NPDES-regulated municipal and small construction stormwater discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits. The policy recognizes the need for an iterative approach to control pollutants in storm water discharges. Specifically, the policy anticipates that a suite of BMPs will be used in the initial rounds of permits and that these BMPs will be tailored in subsequent rounds.

Appropriate BMPs will be identified for implementation in the Little Rabbit Creek watershed in the municipality's NPDES MS4 permit. Information on the applicability of the BMPs for removal of fecal coliform and on the feasibility of implementation in the Little Rabbit Creek watershed will be taken into account when identifying BMPs.

The National Stormwater Best Management Practices database (<http://www.bmpdatabase.org/>) provides access to BMP performance data in a standardized format for over 190 BMP studies conducted over the past fifteen years. The database was developed by the Urban Water Resources Research Council (UWRRC) of American Society of Civil Engineers (ASCE) under a cooperative agreement with the U.S. Environmental Protection Agency.

Some studies on BMP effectiveness have evaluated the ability of certain BMPs to remove fecal coliform and other bacteria. The Center for Watershed Protection has compiled a stormwater treatment database containing information from studies conducted from 1990 to the present. Schueler (2000) provides a summary of the information in the database. The included studies do not provide sufficient fecal coliform data to statistically evaluate the effectiveness of BMPs in removing bacteria from urban runoff, but Schueler (2000) indicates that mean fecal coliform removal rates typically range from 65 to 75 percent from ponds and wetlands and 55 percent for filters. Schueler (2000) and SMRC (2000) also reports that water quality swales (including biofilters and wet and dry swales) consistently exported bacteria. Although it is possible that the bacteria thrive in the warm swale soils, the studies do not account for potential sources of bacteria directly to the swales, such as wildlife and domestic pets. Table 7-1 provides examples of BMP removal efficiencies for bacteria. Because information on BMP efficiency for fecal coliform is limited, information in Table 7-1 should be applied with consideration of local knowledge of the environmental conditions and BMP performance in the Anchorage area.

CWP (1997) discusses the use and effectiveness of BMPs in cold climates. Due to the characteristics such as freezing temperatures and snowmelt events, some BMPs are not appropriate or require modifications for use in cold climates. Table 7-2 provides a summary of the applicability of BMPs to colder climates.

Table 7-1. Fecal coliform removal for various BMPs

BMP Type	Fecal Coliform Bacteria Removal (%)
Detention and Dry Extended Detention Ponds	78
Wet Ponds	70
Shallow Marsh Wetland	76
Submerged Gravel Wetland	78
Filters (excluding vertical sand filters)	37
Infiltration Basins	90
Water Quality Swales	-25
Ditches	5

Adapted from Schueler (2000) and SMRC (2000)

Table 7-2. Applicability of BMPs to cold climate conditions (CWP, 1997)

Type	BMP	Classification	Notes
Ponds	Wet Pond	▶	Can be effective, but needs modifications to prevent freezing of outlet pipes. Limited by reduced treatment volume and biological activity in the permanent pool during ice cover.
	Wet ED Pond	●	Some modifications to conveyance structures needed. Extended detention storage provides treatment during the winter season.
	Dry ED Pond	▶	Few modifications needed. Although this practice is easily adapted to cold climates, it is not highly recommended overall because of its relatively poor warm season performance.
Wetlands	Shallow Marsh	○	In climates where significant ice formation occurs, shallow marshes are not effective winter BMPs. Most of the treatment storage is taken up by ice, and the system is bypassed.
	Pond/Wetland System	▶	Pond/Wetland systems can be effective, especially if some ED storage is provided. Modifications for both pond and wetland systems apply to these BMPs. This includes changes in wetland plant selection and planting.
	ED Wetland	●	See Wet ED Pond. Also needs modifications to wetland plant species.
Infiltration	Porous Pavement	○	This practice is restricted in cold climates. It cannot be used on any pavement that is sanded, because the pavement will clog.
	Infiltration Trench	▶	Can be effective, but may be restricted by groundwater quality concerns related to infiltrating chlorides. Also, frozen ground conditions may inhibit the infiltration capacity of the ground.
	Infiltration Basin	▶	See infiltration trench.

Type	BMP	Classification	Notes
Filtering Systems	Surface Sand Filter	○	Frozen ground considerations, combined with frost heave concerns, make this type of system relatively ineffective during the winter season.
	Underground Sand Filter	●	When placed below the frost line, these systems can function effectively in cold climates.
	Perimeter Sand Filter	○	See Surface Sand Filter.
	Bioretention	▮	Problems functioning during the winter season because of reduced infiltration. It has some value for snow storage on parking lots, however.
	Submerged Gravel Wetlands	▮	Some concerns of bypass during winter flows. Has been used in relatively cold regions with success., but not tested in a wide range of conditions.
Open Channel Systems	Grassed Channel	▮	Reduced effectiveness in the winter season because of dormant vegetation and reduced infiltration. Valuable for snow storage.
	Dry Swale	▮	Reduced effectiveness in the winter season because of dormant vegetation and reduced infiltration. Very valuable for snow storage and meltwater infiltration.
	Wet Swale	▮	Reduced effectiveness in the winter season because of dormant vegetation. Can be valuable for snow storage.
	Vegetated Filter Strip	▮	See Dry Swale.

ED: Extended Detention

- Easily applied to cold climates; can be effective during the winter season.
- ▮ Can be used in cold climates with significant modifications; moderately effective during the winter season.
- Very difficult to use in cold climates. Generally not recommended.

8. 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 revisions and to track BMP effectiveness. Most importantly, monitoring will track the water quality of Little Rabbit Creek to evaluate future attainment of water quality standards.

USEPA (2002) outlines EPA regulatory requirements for and provides guidance on establishing WLAs for stormwater in TMDLs. The memorandum also provides information on the implementation of effluent limitations through NPDES permits consistent with the TMDL WLAs. The policy outlined affirms the appropriateness of an iterative, adaptive management BMP approach, whereby permits include effluent limits (e.g., a combination of structural and non-structural BMPs) that address stormwater discharges, implement mechanisms to evaluate the performance of such controls, and make adjustments (i.e., more stringent controls or specific BMPs) as necessary to protect water quality.

USEPA (2002) indicates that where BMPs are used to implement the WLAs, the NPDES permit should require the monitoring necessary to assess if the expected load reductions attributed to BMP implementation are achieved (e.g., BMP performance data), although the permitting authority has the discretion under EPA's regulations to decide the frequency of such monitoring. EPA recommends that such permits require collecting data on the performance of the BMPs. The monitoring data can provide a basis for revised management measures and indicate any necessary adjustments to the BMPs. Any monitoring for stormwater required as part of the permit should be consistent with the state's overall assessment and monitoring strategy.

9. Public Comments

EPA regulations [40 CFR §130.7(c)(1)(ii)] require public review consistent with the ADEC continuing planning process and public participation requirements. EPA TMDL guidance calls for a description of the public participation process, including a summary of significant comments and the responses to those comments (i.e. a responsiveness summary).

The following summarizes the comments and responses received on the public review draft of the six Anchorage Streams Total Maximum Daily Load (TMDL) documents developed by the Alaska Department of Environmental Conservation (ADEC).

A public notice for all six TMDLs was published in the Anchorage Daily News newspaper on Sunday, February 8, 2004, and included the meeting time and place, a description of issues to be discussed, the availability of the draft TMDLs and the schedule for comments. ADEC also published the notice and the draft TMDLs on their website www.state.ak.us/dec/water/wnpspc/anchorage_streams_tmdl.htm and the public notice appeared on the State of Alaska's public notice page at www.state.ak.us/dec/public_notices.htm. The notice was placed and appeared in "Whats up", a free e-mail newsletter published biweekly and widely subscribed to by government agencies, industry, environmental and education groups. Individual email invitations were also sent to key stakeholders and others who expressed interest.

The public comment period ran from February 8 through March 8, 2004. A public meeting was held in Anchorage on February 24, 2004, at the Alaska Department of Environmental Conservation Anchorage office to present the draft TMDLs. ADEC also made a presentation on the TMDLs at The Alaska Forum for the Environment on February 10, 2004.

No written comments were received during the 30-day public review period. Oral comments were received during the public meeting. Those comments and ADEC's responses are summarized in the attachment entitled **Six Anchorage Streams TMDLs Public Responsiveness**. In addition to the comments received at the public meeting, ADEC received numerous comments during the pre-public review of the February 28, 2003, TMDL draft from the Municipality of Anchorage. On March 4, 2003, the ADEC conducted a pre-public review of the draft TMDL with key stakeholders (Anchorage Municipality, USGS, Anchorage Waterways Council, and the University of Alaska, Anchorage, Environmental and Natural Resources Institute). ADEC received comments from the MOA based on discussions at the March 04, 2003, meeting. ADEC addressed all the comments received and incorporated many of them into the public review draft. Stakeholder comments, ADEC and Tetrattech's responses, and how comments were incorporated into the TMDL can be found in the attachment entitled **Anchorage FC TMDLs - Comments on Initial drafts - DEC Response**.

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Appendix A: Landuse Categories and Descriptions

CODE	MOA Description	MOA Secondary Description
1000	RESIDENTIAL	MAIN CATEGORY
1001	Single Family Detached	SINGLE FAMILY DETACHED
1002	Single Family Attached to one other unit on a diff	SINGLE FAMILY ATTACHED
1003	SF Attached to two or more other units on different lots	SINGLE FAMILY ATTACHED
1099	SF Structure that physically crosses lot lines	SINGLE FAMILY DETACHED
1102	Bldg.(s) with 2 units on the same lot	DUPLEX
1103	Bldg.(s) with 3 units on the same lot -- Triplex	MULTI FAMILY 3 & 4 Plex
1104	Bldg.(s) with 4 units on the same lot -- Fourplex	MULTI FAMILY 3 & 4 Plex
1105	Bldg.(s) with 5 to 9 units on the same lot	MULTI FAMILY 5+
1110	Bldg.(s) with 10 to 19 units on the same lot	MULTI FAMILY 5+
1120	Bldg.(s) with 20 to 49 units on the same lot	MULTI FAMILY 5+
1150	Bldg.(s) with 50 or more units on the same lot	MULTI FAMILY 5+
1199	Multi-Family Structure that physically crosses lot	MULTI FAMILY 3 & 4 Plex
1201	Mobile Home on Lot	MOBILE HOME
1220	Mobile Home Park (count is number of units in parc	MOBILE HOME
1240	Associated with mobile home park - no structure	MOBILE HOME
1299	Mobile Home that physically crosses lot lines	MOBILE HOME
1400	Group Quarters	INSTITUTIONAL
1500	Mixed Commercial/Residential	MULTI FAMILY 3 & 4 Plex
1600	Mixed Religious/Residential	SINGLE FAMILY DETACHED
1700	Mixed Industrial/Residential	SINGLE FAMILY ATTACHED
1800	Unsound Residential Structure	VACANT LAND
1920	Non-Residential structure assoc. with multi family	MULTI FAMILY 3 & 4 Plex
1930	Lot with no structure assoc. with adjoining duplex	DUPLEX
1940	Lot with no structure assoc. with adjoining multi	MULTI FAMILY 3 & 4 Plex
1950	Residential Structure Under Construction	RESIDENTIAL UNDER CONST.
1970	Open space (common/dedicated)	PRIVATE OPEN SPACE
1980	Non-Res. structure assoc. with adj. SF/duplex lot	SINGLE FAMILY ATTACHED
1990	Lot with no structure assoc. with adjoining single	SINGLE FAMILY ATTACHED
2000	COMMERCIAL	MAIN CATEGORY
2100	Commercial Retail	COMMERCIAL
2110	General Merchandise/Goods	COMMERCIAL
2120	Building Materials	COMMERCIAL
2130	Automobiles, Boats, Aircraft, Trailers	COMMERCIAL
2140	Retail Petroleum Products Sales	COMMERCIAL
2150	Food and Liquor	COMMERCIAL
2151	Supermarkets	COMMERCIAL

CODE	MOA Description	MOA Secondary Description
2152	Convenience stores	COMMERCIAL
2153	Liquor stores	COMMERCIAL
2160	Eating and Drinking Establishments	COMMERCIAL
2200	Commercial Office	COMMERCIAL
2210	Finance, Insurance, Real Est. Legal	COMMERCIAL
2220	Medical Services, (out-patient)	COMMERCIAL
2300	Other Commercial Services	COMMERCIAL
2310	Construction/Special-Trade	COMMERCIAL
2320	Repair Services	COMMERCIAL
2330	Commercial Transportation Services	COMMERCIAL
2340	Personal and Home Services	COMMERCIAL
2350	Commercial Education Services	COMMERCIAL
2351	day care and pre-schools	COMMERCIAL
2360	Commercial Recreation	COMMERCIAL
2361	Indoor commercial recreation	COMMERCIAL
2362	Outdoor commercial recreation	COMMERCIAL
2370	Transient Lodging	COMMERCIAL
2371	Overnight campground or recreational vehicle	COMMERCIAL
2380	Communication-Related	COMMERCIAL
2390	Commercial Parking Lots	COMMERCIAL
2391	Parking structures	COMMERCIAL
2400	Commercial Horticulture	COMM HORTICULTURE
3000	INDUSTRIAL	MAIN CATEGORY
3100	Truck and Heavy Equipment Repair, Automo	INDUSTRIAL
3200	Construction/Special Trade Contractors	INDUSTRIAL
3300	Manufacturing and Processing	INDUSTRIAL
3400	Natural Resource Extraction	INDUSTRIAL
3500	Bulk Products and Outdoor Storage	INDUSTRIAL
3510	Bulk building materials	INDUSTRIAL
3520	Junk and wrecked autos, salvage	INDUSTRIAL
3530	Bulk petroleum storage	INDUSTRIAL
3600	Warehousing, Wholesale Distribution	INDUSTRIAL
3610	Air Freight Terminals	INDUSTRIAL
3700	Motor Vehicle Transportation	TRANSPORTATION
3800	Utility-Related Facilities	UTILITIES
3810	Electric Utility Related	UTILITIES
3820	Natural Gas Utility related	UTILITIES
3830	Water Utility related	UTILITIES

CODE	MOA Description	MOA Secondary Description
3840	Sewer Utility related	UTILITIES
3850	Solid Waste Utility related	UTILITIES
3851	Hazardous waste incinerators	UTILITIES
3860	Storm Drainage Facilities	UTILITIES
3870	Snow Disposal Sites	UTILITIES
3880	Communications Facilities	UTILITIES
4000	INSTITUTIONAL	MAIN CATEGORY
4100	Educational Facilities	INSTITUTIONAL
4110	Public Elementary School	INSTITUTIONAL
4120	Public Jr. High School	INSTITUTIONAL
4130	Public High School	INSTITUTIONAL
4140	Public College or University	INSTITUTIONAL
4150	Other Public Schools	INSTITUTIONAL
4160	Private Elementary School	INSTITUTIONAL
4170	Private College or University	INSTITUTIONAL
4200	Government Facilities	INSTITUTIONAL
4210	Municipal Government-all	INSTITUTIONAL
4211	Municipal police	INSTITUTIONAL
4212	Municipal fire protection	INSTITUTIONAL
4220	State Government-all other	INSTITUTIONAL
4230	Federal Government-all other	INSTITUTIONAL
4231	Post office	INSTITUTIONAL
4300	Social/Civic/Fraternal Organizations	INSTITUTIONAL
4400	Churches, Synagogues, Temples, etc.	INSTITUTIONAL
4500	Social Service Facilities	INSTITUTIONAL
4600	Hospitals and Related Facilities	INSTITUTIONAL
4700	Cultural Facilities	INSTITUTIONAL
4800	Other Specific Institutional Uses	INSTITUTIONAL
4810	Correctional Facilities	INSTITUTIONAL
4820	Cemeteries	INSTITUTIONAL
5000	PARKS, OPEN SPACE AND RECREATION AREAS	MAIN CATEGORY
5100	Municipal Parks, Open Space	PARKS, OPEN SPACE
5200	Chugach State Park	STATE PARK
5300	Federal Parks and Recreation Areas	FEDERAL PARK
6000	TRANSPORTATION-RELATED	MAIN CATEGORY
6100	Aircraft Transportation	RR, PORT, AIRPORT
6200	Railroad Transportation	RR, PORT, AIRPORT
6300	Marine Transportation	RR, PORT, AIRPORT

CODE	MOA Description	MOA Secondary Description
7000	OTHER LAND USES	MAIN CATEGORY
7100	Street and Highway R.O.W.'s	ROAD ROW
7200	Railroad R.O.W.'s	RAILROAD ROW
7300	Military Reservation	MILITARY
8000	VACANT LAND	VACANT LAND
8100	Intertidal Areas	INTERTIDAL
8200	Waterbodies	WATER

Appendix B: Water Quality Standards Exceedances

Exceedances of Geometric Mean Criterion at LRC1 (Data: 1/5/89 to 6/26/90)					
Num	Exceedance Description	Value	Criterion	Exceedance Amount	% Exceedance
1	5/12/89 to 6/9/89 (5 samples)	25	20	5	125%
2	5/19/89 to 6/15/89 (5 samples)	29	20	9	147%
3	5/31/89 to 6/28/89 (5 samples)	22	20	2	109%
4	6/28/89 to 7/26/89 (6 samples)	36	20	16	178%
5	7/3/89 to 8/1/89 (6 samples)	38	20	18	191%
6	7/7/89 to 8/1/89 (5 samples)	48	20	28	241%
7	7/12/89 to 8/8/89 (5 samples)	59	20	39	295%
8	7/25/89 to 8/24/89 (6 samples)	60	20	40	300%
9	7/26/89 to 8/24/89 (5 samples)	53	20	33	267%
10	8/1/89 to 8/31/89 (6 samples)	161	20	141	806%
11	8/8/89 to 8/31/89 (5 samples)	173	20	153	864%
12	8/16/89 to 9/13/89 (6 samples)	193	20	173	966%
13	8/24/89 to 9/22/89 (7 samples)	172	20	152	860%
14	8/29/89 to 9/22/89 (6 samples)	200	20	180	999%
15	8/31/89 to 9/29/89 (6 samples)	83	20	63	414%
16	9/8/89 to 10/5/89 (6 samples)	65	20	45	324%
17	9/13/89 to 10/10/89 (6 samples)	45	20	25	225%
18	9/18/89 to 10/10/89 (5 samples)	41	20	21	206%
19	9/22/89 to 10/19/89 (5 samples)	34	20	14	172%
20	9/29/89 to 10/26/89 (5 samples)	27	20	7	133%
21	10/5/89 to 11/3/89 (6 samples)	35	20	15	174%
22	10/10/89 to 11/6/89 (6 samples)	36	20	16	180%
23	10/19/89 to 11/14/89 (6 samples)	38	20	18	192%
24	10/26/89 to 11/21/89 (6 samples)	32	20	12	158%
25	10/30/89 to 11/29/89 (6 samples)	31	20	11	156%
26	11/3/89 to 11/29/89 (5 samples)	35	20	15	175%
27	4/12/90 to 5/8/90 (6 samples)	22	20	2	112%
28	5/3/90 to 5/30/90 (5 samples)	20	20	0	101%
29	5/8/90 to 6/7/90 (5 samples)	32	20	12	158%
30	5/18/90 to 6/14/90 (5 samples)	24	20	4	121%
31	5/24/90 to 6/21/90 (5 samples)	28	20	8	140%
32	5/30/90 to 6/26/90 (5 samples)	37	20	17	183%
33	6/7/90 to 6/26/90 (4 samples)	33	20	13	166%
34	6/14/90 to 6/26/90 (3 samples)	22	20	2	110%
35	6/21/90 to 6/26/90 (2 samples)	26	20	6	132%

Exceedances of Not-to-exceed Criterion at LRC1 (Data: 1/5/89 to 6/26/90)					
Num	Exceedance Description	Value	Criterion	Exceedance Amount	% Exceedance
1	5/24/89 > 10% Limit in 5 30-day sets	43	40	3	108%
2	6/9/89 > 10% Limit in 5 30-day sets	62	40	22	155%
3	6/28/89 > 10% Limit in 5 30-day sets	74	40	34	185%
4	7/12/89 > 10% Limit in 6 30-day sets	46	40	6	115%
5	7/25/89 > 10% Limit in 5 30-day sets	106	40	66	265%
6	7/26/89 > 10% Limit in 6 30-day sets	58	40	18	145%
7	8/1/89 > 10% Limit in 6 30-day sets	114	40	74	285%
8	8/16/89 > 10% Limit in 5 30-day sets	43	40	3	108%
9	8/24/89 > 10% Limit in 6 30-day sets	70	40	30	175%
10	8/29/89 > 10% Limit in 5 30-day sets	10600	40	10560	26500%
11	8/31/89 > 10% Limit in 6 30-day sets	220	40	180	550%
12	9/8/89 > 10% Limit in 5 30-day sets	106	40	66	265%
13	9/13/89 > 10% Limit in 6 30-day sets	70	40	30	175%
14	9/18/89 > 10% Limit in 6 30-day sets	80	40	40	200%
15	9/22/89 > 10% Limit in 7 30-day sets	46	40	6	115%
16	9/29/89 > 10% Limit in 6 30-day sets	54	40	14	135%
17	10/5/89 > 10% Limit in 6 30-day sets	50	40	10	125%
18	11/3/89 > 10% Limit in 6 30-day sets	400	40	360	1000%
19	11/6/89 > 10% Limit in 6 30-day sets	60	40	20	150%
20	12/12/89 > 10% Limit in 5 30-day sets	64	40	24	160%
21	1/18/90 > 10% Limit in 5 30-day sets	230	40	190	575%
22	4/12/90 > 10% Limit in 6 30-day sets	150	40	110	375%
23	5/8/90 > 10% Limit in 6 30-day sets	56	40	16	140%
24	5/30/90 > 10% Limit in 5 30-day sets	54	40	14	135%
25	6/7/90 > 10% Limit in 5 30-day sets	114	40	74	285%