UNITED STATES AIR FORCE

Eielson AFB

Interim Feasibility Study for Community of Moose Creek, Alaska, Long-Term Drinking Water Treatment Systems

FINAL (DRAFT)

JUNE 2017

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FINAL (DRAFT)

Contract Number: FA8903-16-D-0032
Task Order: 0006

PREPARED BY:

MWH
725 EAST FIREWEED LANE, SUITE 200
ANCHORAGE, ALASKA 99503

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LIST OF ACRONYMS AND ABBREVIATIONS

″	inch(es)
°F	degrees Fahrenheit
µg/L	micrograms per liter
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
AFCEC	Air Force Civil Engineer Center
AFFF	aqueous film-forming foam
Air Force	U.S. Air Force
ANG	Air National Guard
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DERP	Defense Environmental Restoration Program
EAFB	Eielson Air Force Base
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
FS	feasibility study
FTA	Fire Training Area
GAC	Granular Activated Carbon
gpm	gallons per minute
GRA	General Response Action
IC	institutional control

IFS	interim feasibility study
IPP	interim proposed plan
IROD	interim record of decision
IRP	Installation Restoration Program
LF	linear feet
LHA	lifetime health advisory
LUC	land use control
M	million
MCL	maximum contaminant level
NCP	National Oil and Hazardous Substance Pollution Control Plan
NPL	National Priorities List
NPV	net present value
PA	Preliminary Assessment
PAL	preliminary action level
PFC	perfluorochemical
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PHA	provisional health advisory
ppm	part per million
ppt	part per trillion
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
SI	Site Investigation
TBC	to be considered
TCRA	time-critical removal action
USACE	U.S. Army Corps of Engineers
USC	United States Code
WTP	Water Treatment Plan
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

This Interim Feasibility Study (IFS) was prepared at the request of the Air Force Civil Engineer Center (AFCEC) under Contract Number FA8903-16-D-0032, Task Order 0006. This document was prepared as part of the U.S. Air Force (Air Force) Installation Restoration Program (IRP). The Air Force IRP is designed to identify, investigate, and clean up contamination associated with past Air Force activities at: active Air Force installations; government-owned, contractor-operated facilities; off-site locations where contamination may have migrated; third party sites; and sites that the Air Force formerly owned or used. The Air Force IRP is authorized by the Defense Environmental Restoration Program (DERP). DERP is the environmental restoration program military services use to conduct Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) response actions and satisfy CERCLA lead agency functions, as delegated by Executive Order 12580.

The Air Force discovered the presence of perfluorochemicals (PFCs) in the Community of Moose Creek, Alaska, drinking water wells, and is actively performing emergency and time-critical removal actions (TCRAs) at the impacted properties. These TCRAs are being performed to reduce exposure to these federally unregulated contaminants that have migrated into groundwater, following use of PFC-containing aqueous film-forming foam (AFFF) used for airfield firefighting at the adjacent Eielson Air Force Base (EAFB). The objective of this IFS is to develop and evaluate the feasibility of various potable water supply alternatives for the Community of Moose Creek while comprehensive PFC contamination source investigations and remedial actions are undertaken at EAFB. EAFB is currently conducting site inspections and time-critical response actions. Surface water impacts have been identified at Moose Creek (AFCEC, 2015a), but are not addressed under this IFS.

The U.S. Environmental Protection Agency (EPA) Office of Water has classified PFCs as contaminants of emerging concern; however, there are currently no federal Safe Drinking Water Act (SDWA) maximum contaminant levels or promulgated federal cleanup levels regarding PFC exposure levels. The Alaska Department of Environmental Conservation (ADEC) issued an update to 18 Alaska Administrative Code (AAC) 75 effective 6 November 2016 that sets cleanup levels for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) contamination in soil and groundwater. 18 AAC 80 currently sets Alaska drinking water standards for organic chemicals, such as PFOS and PFOA, by adopting the federal levels promulgated in 40 Code of Federal regulations (CFR) 141.61. Since 40 CFR 141.61 does not currently include drinking water standards for PFOS and PFOA, Alaska does not currently have established drinking water standards for PFOS and PFOA.

The EPA has established lifetime health advisory (LHA) values for two specific PFCs – PFOS and PFOA – as well as the combined total PFOS+PFOA concentration, that the Air Force is using as benchmarks to determine where alternative water supply alternatives are needed. The LHAs reflect health-based hazard concentrations above which action should be taken to reduce exposure to unregulated contaminants in drinking water. The individual and combined LHAs for PFOA and PFOS are 70 parts per trillion (ppt) or 0.07 micrograms per liter (µg/L).

Remedial Action Objectives (RAOs) and Preliminary Action Levels (PALs) were developed based on the EPA LHAs for drinking water at the Community of Moose Creek. The RAOs and PALs were used to identify General Response Actions (GRAs), which describe those actions that will satisfy the RAOs. For each GRA, potable water supply technologies and process options were developed and then formulated into potable water supply action alternatives. The potable water supply alternatives developed are appropriate to site-specific conditions, and are protective of human health and the environment, as far as can be determined with currently available data due to the emerging nature of the contaminants.

The identified potable water supply alternatives were developed using the EPA's *Guidance Document for Providing Alternative Water Supplies* (USEPA, 1988a) and screened against the EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988b). This has three broad screening criteria of effectiveness, implementability, and relative cost. Alternatives that passed the initial screening process were then evaluated in detail against seven of the nine CERCLA evaluation criteria. **Table ES-1** lists the alternatives that passed the initial screening and were evaluated against the CERCLA criteria.

Table ES -1 Potable Water Supply Alternatives Evaluated

Medium of Concern	Potable Water Supply Alternative	Applicable Contaminants
Potable Water	North Pole Municipal Water Supply to Community	PFOS, PFOA, total PFOS+PFOA
	EAFB Water Supply to Community	
	Water Tanks at each Property	
	Deep Wells at each Property	
	Develop New Community Deep Well	
	GAC Treatment at each Property	
	Retain Existing Systems (Water Tanks or GAC)	

Key:
EAFB – Eielson Air Force Base
GAC – granular activated carbon
PFOA – perfluorooctanoic acid
PFOS – perfluorooctanesulfonic acid

These potable water supply alternatives were evaluated, and the alternatives were rated based on multiple criteria, including cost and effectiveness.

The Air Force will use the results of this IFS, and ongoing base-wide site investigations, to develop an Interim Proposed Plan (IPP) and Interim Record of Decision (IROD). At an appropriate future time, the Air Force will also prepare a comprehensive Feasibility Study, Proposed Plan, and Record of Decision addressing PFC impacts and remediation for all sources identified as a result of the site investigations. The preferred alternative for potable water supply to the Community of Moose Creek will be evaluated for regulatory and community acceptance throughout the IFS, IPP, and IROD process.

1.0 INTRODUCTION

1.1 Objective and Scope

This Interim Feasibility Study (IFS) was prepared at the request of the Air Force Civil Engineer Center (AFCEC) under Contract Number FA8903-16-D-0032, Task Order 0006. This document was prepared as part of the U.S. Air Force (Air Force) Installation Restoration Program (IRP). The Air Force IRP is designed to identify, investigate, and clean up contamination associated with past contamination releases at: active Air Force installations; government-owned, contractor-operated facilities; off-site locations where contamination may have migrated; third party sites; and sites that the Air Force formerly owned or used. The Air Force IRP is authorized by the Defense Environmental Restoration Program (DERP). DERP is the environmental restoration program the military services use to conduct Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) response actions and satisfy CERCLA lead agency functions, as delegated by Executive Order 12580.

The Air Force discovered the presence of perfluorochemicals (PFCs) in the Community of Moose Creek, Alaska, drinking water wells, and is actively performing emergency and time-critical removal actions (TCRA) at the impacted properties to reduce exposure to these contaminants that have migrated into groundwater, following use of PFC-containing aqueous film-forming foam (AFFF) for airfield firefighting at the adjacent Eielson Air Force Base (EAFB). The objective of this IFS is to develop and evaluate the feasibility of various potable water supply alternatives for the Community of Moose Creek, while comprehensive PFC contamination source investigations and remediation actions are underway at EAFB. Surface water impacts have been identified at the Community of Moose Creek (AFCEC, 2015a), but are not addressed under this IFS.

Since it is currently unknown what specific PFC contamination source(s) at EAFB have migrated to the Community of Moose Creek, all documents regarding community of Moose Creek PFC contamination and removal actions are administratively tied to EAFB Site FT009 (Fire Department Training Area). Community of Moose Creek PFC documentation is currently available to the public on the Administrative Record for EAFB Site FT009. Depending on the results of ongoing PFC source investigations and selected remedies, the Community of Moose Creek documents may be administratively tied to another site or operating unit at a future time.

The U.S. Environmental Protection Agency (EPA) Office of Water has classified PFCs as contaminants of emerging concern; however, there are currently no federal Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) or promulgated federal cleanup levels regarding PFC exposure levels. The Alaska Department of Environmental Conservation (ADEC) issued an update to 18 Alaska Administrative Code (AAC) 75 effective 6 November 2016 that sets cleanup levels for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) contamination in soil and groundwater. 18 AAC 80 currently sets Alaska drinking water standards for organic chemicals, such as PFOS and PFOA, by adopting the federal levels promulgated in 40 Code of Federal Regulations (CFR) 141.61. Since 40 CFR141.61 does not currently include drinking water standards for PFOS and PFOA, Alaska does not currently have established drinking water standards for PFOS and PFOA under 18 AAC 80.

The EPA has established lifetime health advisory (LHA) values for two specific PFCs –PFOS and PFOA – as well as the combined total PFOS+PFOA concentration, that the Air Force is using as benchmarks to determine where alternative water supply alternatives are needed. The LHAs reflect health-based hazard concentrations above which action should be taken to reduce exposure to unregulated contaminants in drinking water. The individual and combined LHAs for PFOA and PFOS are 70 parts per trillion (ppt) or 0.70 micrograms per liter (µg/L).

This IFS has been prepared to document the evaluation process for remedial alternatives for supply of drinking water for the Community of Moose Creek, Alaska. The site is being assessed under the provisions of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The structure and content of this document is consistent with the Guidance for Conducting Remedial Investigations (RIs) and Feasibility Studies (FSs) under CERCLA (USEPA, 1988b).

1.2 Report Organization

This IFS is divided in to eight sections and four appendices, as follows:

- **Section 1.0 Introduction –** presents the objectives and scope for the IFS, and also the report organization.
- **Section 2.0 Site Description** – provides information about the Community of Moose Creek and EAFB.
- **Section 3.0 Investigation and Action Status** – summarizes the history and current status of PFC source investigations at EAFB and removal actions at the Community of Moose Creek.
- **Section 4.0 Human Health and Ecological Risk Assessment** – summarizes available information regarding health and ecological risks of PFCs.
- **Section 5.0 Remedial Action Objectives (RAOs) –** outlines the objectives of the remedial actions at the Community of Moose Creek, Alaska; identifies federal, state, and local regulations that would impact any potential action at the Community of Moose Creek; and provides the preliminary action levels (PALs) for PFCs in drinking water at the site.
- **Section 6.0 Identification and Screening of Potable Water Supply Technologies and Alternatives –** presents and screens the general response actions (GRAs) and identifies potential potable water supply alternatives for further consideration at the Community of Moose Creek.
- **Section 7.0 Detailed Analysis of Potable Water Supply Alternatives –** provides a detailed analysis of each potable water supply alternative that passed the initial screening process in Section 6.0, and compares all action alternatives against each CERCLA evaluation criteria.
- **Section 8.0 References –** contains references to documents used in preparing this IFS.
- **Appendix A Review of PFC Treatment Alternatives –** presents a current status on treatment technologies to removed PFCs from potable water.
- **Appendix B Figures of Alternatives, Moose Creek Potable Water Supply**
- **Appendix C Cost Estimates of Alternatives, Moose Creek Potable Water Supply**

- **Appendix D Regulatory Review Comments –** will present the EPA and ADEC review comments and Air Force responses. To be provided in final.

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2.0 SITE DESCRIPTION

2.1 Site Location and Vicinity

The Moose Creek community is located adjacent to the northern edge of EAFB (**Figure 2-1**). EAFB lies approximately 120 miles south of the Arctic Circle, 23 miles southeast of Fairbanks, and 9 miles southeast of the city of North Pole. EAFB is located in the Tanana River Valley along the northern bank of the river on a low, relatively flat, floodplain terrace approximately 2 miles from the active river channel. The Richardson Highway (Highway 2) passes through the western portion of EAFB, and the Alaska Railroad terminates within the base. The Trans-Alaska Pipeline, connecting Prudhoe Bay and Valdez, passes through EAFB – entering in the northwestern portion and exiting to the southeast.

2.2 Demography and Land Use

Approximately 750 people live in the Community of Moose Creek. Land use includes residential and industrial activities.

EAFB is an active military installation that has been used for military operations since its establishment in 1944. The mission of EAFB is to train and equip personnel for close air support of ground troops in an arctic environment. EAFB operations include: industrial areas, aircraft maintenance and operations, an active runway and associated facilities, administrative offices, and residential and recreational facilities. EAFB provides housing for resident military personnel and their dependents, and employment and services for civilians from the surrounding area. Surface water within 3 miles downslope of the base, is used for fishing. EAFB is located in the floodplain of the Tanana River.

2.3 Climate

EAFB is in the continental climatic zone that covers interior Alaska. The climate in this zone is characterized by large diurnal and annual temperature variations, low precipitation, and low humidity. The climate is semiarid because moist maritime air masses are blocked in the south by the Alaska Range and in the north by the Brooks Range (Pewe, 1982). Large annual variations in temperature and solar radiation occur because of the high latitude. Average summer temperatures range between 44 and 61 degrees Fahrenheit (°F). Average temperatures during the winter season range between -15°F and -10°F. Extreme temperatures recorded between 1944 and 1984 at EAFB were 93°F for July and -63°F for January. Annual precipitation in this area averages 14 inches, which includes 72 inches of snow. Average monthly precipitation ranges from 0.5 inch to 2.5 inches, with rainfall generally highest in July and August. The evaporation rate is approximately 14 inches per year, which equals the mean annual precipitation.

2.4 Site Geology

EAFB is located in the Tanana Basin of the Tanana River Valley, bordered on the north by the Yukon-Tanana Upland, which is characterized by rolling hills and small mountains, and the Alaska Range to the south. In this area, Quaternary sediments consisting of loess are found on the low hills and lower slopes, some of them reworked and redistributed downslope, and of alluvium found on the valley bottoms.

The consolidated rocks in the area of EAFB are part of the Birch Creek Schist of Precambrian age. This unit is primarily slaty to schistose although it includes quartzite and quartz veins (Cederstrom, 1963). The schist weathers to silt and clayey silt. The weathering product has been described as yellow clay in drill logs. The weathering zone may be relatively thick, 150 feet or greater. Because thick sediment accumulations are present in the Tanana Basin, bedrock is several hundred feet deep in the middle of the valley. The alluvium is thin or not present on the hill slopes and, in these areas, bedrock may be at or near the ground surface.

Sedimentary deposits overlie the Birch Creek Schist in much of the area surrounding EAFB. The most recent glaciation occurred during the Late Pleistocene (Wisconsinan glaciation), at which time the ice sheet advanced nearly to the Tanana River. During glacial retreat, outwash and alluvial fans were deposited to the south and west of the river. This glacial environment created extreme changes in surface-water flow rates: high flow created by melt water and low flow when no melt water was available. As a result, the Tanana River is braided with multiple channels that wander across the valley, leaving abandoned channel belts.

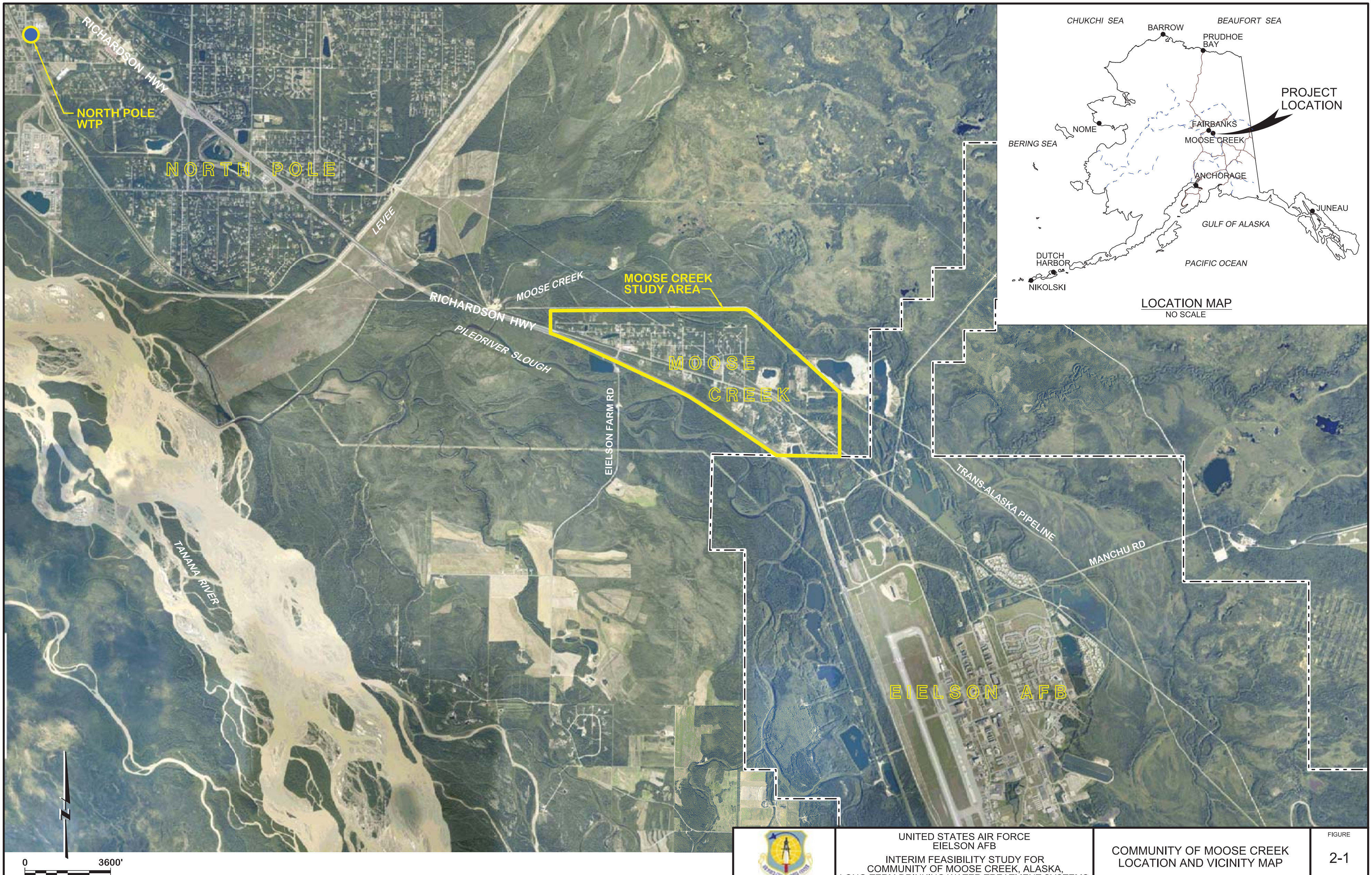
The prevailing wind direction appears to have been from the west, blowing silt-size particles from the alluvial fans and plastering them on the hill slopes of the Tanana Uplands, east of EAFB. These are well sorted, massive silt deposits with little jointing or stratification and are thickest near major rivers draining glaciated areas.

Along the hill slopes and underlying the loess are sediments deposited by solifluction occurring in periglacial settings where water-saturated soil is moved downslope with melt water. Weathered bedrock fragments may be included in the reworked material. This solifluction layer is widespread, inactive, and has been referred to as the Tanana Formation (Pewe and Bell, 1975).

Today, perennially frozen ground is not usually continuous over wide areas on the valley floor. The thick masses of permafrost (where present) may thin laterally, either gradually or abruptly – generally where a stream or the course of a former stream is approached. Where thick permafrost has been penetrated by wells in Fairbanks, the mass is ordinarily solid, and apparently unfrozen layers are absent. Near the edge of the frozen mass, however, lateral melting at different rates has produced a sawtooth pattern in cross section.

The valley-fill deposits of the Tanana Basin are complex and heterogeneous, consisting of alternating sand, gravel, and silt (Cederstrom, 1963). These braided river deposits are composed of variable gradations of fine and coarse material. Generally, individual lenses are less than 20 feet thick. Many structures found in these deposits are small-scale and cannot be correlated over great distances. Permafrost is present in many areas.

EAFB is in the area of an abandoned river-channel belt, and the subsurface underlying most of the base consists of braided river deposits. These deposits are complex in structure, but similar in lithology. In the Tanana River Valley, these deposits are 300 feet thick or greater. In the developed



UNITED STATES AIR FORCE EIELSON AFB INTERIM FEASIBILITY STUDY FOR COMMUNITY OF MOOSE CREEK, ALASKA, LONG-TERM DRINKING WATER TREATMENT SYSTEMS	COMMUNITY OF MOOSE CREEK LOCATION AND VICINITY MAP	FIGURE 2-1 10509506.06010401

TIME: 12-JUN-2017 10:11 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig 2-1 Location and Vicinity Map.dgn

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portion of EAFB, fill material, generally described as silty sand and gravelly sand, was used during construction. This material was quarried nearby and is lithologically similar to natural soil, although the sedimentary structures would have been obliterated. Only the upper part of the floodplain sediments has been explored, in some areas less than 30 feet. These sediments consist primarily of gravelly sand and sandy gravel (AECOM, 2013).

2.5 Site Hydrology

The sediments within the Tanana Basin provide large quantities of water to wells. The characteristics of the water-bearing units in the area are discussed in the sections below.

The Birch Creek Schist underlies the unconsolidated, sedimentary deposits in the vicinity of EAFB. However, the unconsolidated deposits do not extend far up the hill slopes. Groundwater flows down the hill slopes within the Birch Creek Schist and within the overlying sediments of the valley fill toward the basin.

Water supply wells in these areas tap into the schist, which is an inferior water-bearing formation, seldom yielding more than 10 gallons per minute (gpm). Of more significance in terms of well yield are the sediment-filled valleys along the mountain slopes. These valleys are commonly underlain with sand and gravel, and wells drilled into these deposits may yield 100 gpm or more (Cederstrom, 1963).

By contrast, the sands and gravels underlying the Tanana River Valley (braided river deposits) provide large quantities of water (1,000 gpm or more) to wells. This unit has been called the Tanana Basin aquifer. Well yields of up to 3,400 gpm, with minimal drawdown, have been reported. Recharge is predominantly from seepage into the aquifer from stream beds during periods of melt water, rather than from precipitation. During these times, the river elevations are higher than the groundwater levels.

Recharge to the Tanana Basin aquifer is from precipitation, snowmelt, and infiltration from stream beds. Historical water-level data indicate that recharge typically increases from April through May, often beginning in late March and continuing through mid-June, indicating recharge from snowmelt and from high water levels in the rivers and streams. Water-level declines begin in July or August. The largest recharge to the aquifer is from the river during periods of high flow. There is also recharge from the Birch Creek Schist from groundwater flowing down the hill slopes to the valley. The wetlands at the foot of the uplands, to the east of EAFB, are likely fed from this source and precipitation perched on permafrost. Therefore, the wetlands may also lose water to the Tanana Basin aquifer. The water within the Tanana Basin aquifer is a calcium bicarbonate or calcium magnesium bicarbonate type. The water quality is highly variable, suitable for most uses in many areas, but locally contains high iron and manganese and may not be usable for drinking water without treatment.

Water levels in the Tanana Basin aquifer vary seasonally, rising during snowmelt and declining in winter. Analysis of river stage elevations compared with groundwater levels indicates there is little separation between the two, less than 0.2 feet, although data are limited. Based on these data, the sloughs at or near EAFB are likely to be at the same elevation as the groundwater. EAFB is surrounded by wetland areas. On the eastern side of EAFB, these wetlands likely recharge groundwater.

Alluvial fans fine toward their distal ends. These fan deposits are typically much finer than the braided river deposits encountered at EAFB, causing the boundary effect. However, the thickness of the alluvial fans is unknown. It is likely that at least a portion of the fans has pushed out over older braided river deposits. If this is the case, the groundwater flow direction in the deep part of the aquifer could be more westerly than the shallow flow direction.

The Tanana Basin aquifer is composed of a heterogeneous mixture of gravelly sands and sandy gravels. Although very permeable, this heterogeneity causes local changes in groundwater flow velocity. Groundwater depths range from the ground surface in wetland areas to 10 feet below ground surface (bgs) in developed areas of EAFB, and groundwater flow is generally to the northwest. If contaminants were released in this environment, they would tend to migrate relatively slowly through the fill material near the ground surface and very rapidly in the aquifer sediments. The plume shapes would likely be complex, because of the changes in groundwater velocity on the scale of the bed forms encountered in braided river sediments.

Along the flightline the hydraulic gradient varies, but over a 3,750-foot distance, a decline in head of 4 feet has been observed, yielding a gradient of 0.0011. Using this gradient, a hydraulic conductivity of 240 feet per day (based on a transmissivity of 800,000 gallons per day per foot [Cederstrom, 1963]), a 450-foot thickness, and a porosity of 0.3, groundwater would flow approximately 320 feet in 1 year. However, it is likely that the groundwater velocity is highly variable.

The developed area of EAFB is located over a shallow, unconfined aquifer with groundwater often occurring at less than 10 feet bgs. The aquifer is greater than 250 feet thick, extends to the underlying bedrock, and has a regional gradient of about 5 feet per mile flowing to the north-northwest. The water table varies from the surface in adjacent wetlands to 10 feet bgs in developed areas. EAFB uses the local aquifer for its drinking water and monitors groundwater quality in a number of locations as part of its IRP. Localized contamination of the aquifer has been identified in the industrial area of the base, but the overall quality of groundwater at EAFB is good.

The community of Moose Creek is located within an area regionally characterized by discontinuous permafrost and therefore permafrost may be present in the subsurface. Data regarding the distribution of permafrost within the community is limited and what is available is biased to the shallow subsurface, between 40 and 100 feet bgs. Residential well logs on file at the Alaska Department of Natural Resources do not document the presence of permafrost in the community. More over two recent wells installed during the USAF investigation consisting deep borings did not encounter permafrost.

Eight groundwater drinking wells are located on EAFB, and a ninth well provides drinking water strictly for the military working dogs. Of the eight drinking water wells, five are primary and supply the base drinking water, a sixth is a standby/backup well to the main drinking water system, and two (one at Hursey Gate and one at the Bear Lake Family Camp) supply single facilities. The wells that supply the primary drinking water distribution system range in depth from 89 to 160 feet bgs and have pumps set at between 42 and 106 feet deep (although the depth of one pump is unknown). The wells are capable of producing 1,000 gpm, with the exception of Well F that is capable of producing 2,500 gpm.

The 2013 Five-Year Review for EAFB indicated that multiple private wells had been identified within 3.1 miles of EAFB, primarily in the Community of Moose Creek (USAF, 2014). Moose Creek is a community that stretches from approximately 1 to 3 miles downgradient of the northern end of EAFB. There are over 175 wells in the Community of Moose Creek.

2.6 Site Hydrogeology

Although much of the immediate area of EAFB has been built up with fill material, the installation is surrounded by large areas of forested wetland and numerous small lakes and ponds. The area is relatively flat, and stormwater drainage occurs as sheet flow across much of EAFB. Sheet flow primarily collects in low areas or drains into Garrison Slough. Garrison Slough flows south to north through the main area of EAFB, east of the flightline, and drains to the wetlands north of the base, which ultimately drain to the Tanana River.

2.7 Site Ecology

No officially designated federal wilderness area/wildlife preserve is on or near EAFB (EDR, 2015). Based on a biological survey conducted in 1993 of all installation lands, no state- or federally-designated threatened or endangered species are known to occur in the EAFB area (EA, 1994). No critical habitats are identified.

A variety of fish and wildlife species are present on EAFB. These include both permanent resident and migratory birds, as well as mammals. Many popular game species, such as ducks, ptarmigan, moose, and bear are present. Local lakes and streams also host a variety of both naturally-occurring and stocked fish species. As of 2008, the Alaska Department of Fish and Game (ADF&G) stocked rainbow trout, Arctic grayling, Arctic char, and Chinook salmon in nine lakes and one stream on EAFB (ADF&G, 2015).

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3.0 INVESTIGATION AND ACTION STATUS

3.1 Contamination Discovery

The USAF used AFFF, firefighting agents containing PFCs, to extinguish petroleum fires. AFFF may contain PFOS, and some PFC-based AFFF constituents may further degrade into PFOA. Releases of AFFF to the environment routinely occur during fire training, equipment maintenance, storage, and use. PFOS and PFOA were included on the EPA's third Contaminant Candidate List (CCL) in 2009.

In 2014, the Air Force conducted investigations at various installations, including EAFB, to determine the presence of PFCs and their relative concentrations. The site investigation report associated with that work was finalized in February 2015 (USACE, 2015). The site investigation discovered both PFOA and PFOS in concentrations in groundwater above their respective EPA provisional health advisory (PHA) levels that were in place at that time.

After reviewing the draft report, in January 2015 the EPA Region 10 requested that EAFB test the drinking water wells on base to determine if PFOA or PFOS was present. March, April, and July 2015 sampling by the Air Force found both chemicals in drinking water wells, with PFOS exceeding the PHA level that was in place at the time. Since PFCs are water soluble and there is the potential for migration, additional site inspection was conducted to determine whether contaminants had migrated in groundwater towards the northern base boundary and the nearby community of Moose Creek. In April 2015, the Air Force tested the water at the northern boundary which abuts the Community of Moose Creek. PFOS exceeding the PHA was identified near the base boundary. As a result, the Air Force coordinated with the community to test private drinking water wells in the Community of Moose Creek starting in May 2015 (AFCEC, 2015a).

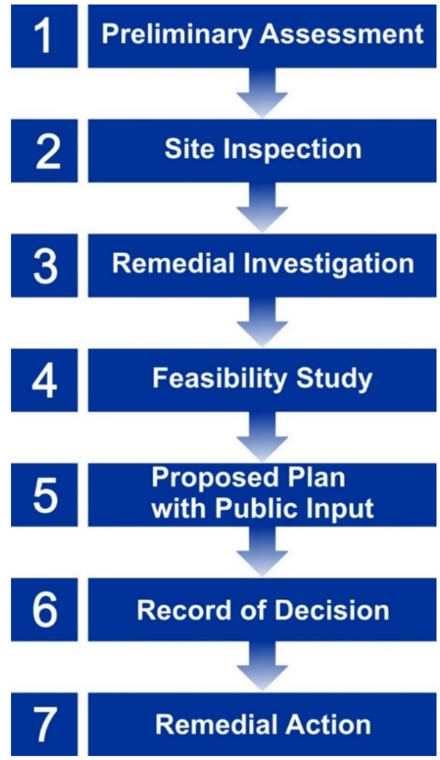
3.2 The CERCLA Process

Although PFOS and PFOA are not listed under CERCLA the Air Force will conduct investigations into these emerging contaminants at Eielson AFB and the Community of Moose Creek following the CERCLA process.

The main CERCLA process steps are presented in the following bullets and shown in the accompanying diagram:

- A PA and Site Inspection (SI) are conducted to identify if a site has contamination issues and develop an estimate of the magnitude of the issue.
- An RI will then be conducted of the site, this will accurately identify contamination and will also carry out a Human and Environmental risk assessment to assess their impact on people and plants and animals in the affected area.
- A FS will then be conducted to look at options for remediating the site. This can include cleaning up the site or preventing contact with the contamination to protect people and the environmental.

- A public consultation process will be conducted with regulators and local residents to ensure the selected process meets local concerns. As well as the FS, a Proposed Plan will also be circulated that highlights the key information for public participation.
- A Record of Decision will be produced of the agreed solution to be implemented. Based on this, the remedial action to achieve clean-up or necessary work to protect both humans and the environmental will be carried out.
- The Remedial Action is the implementation of the agreed solution.

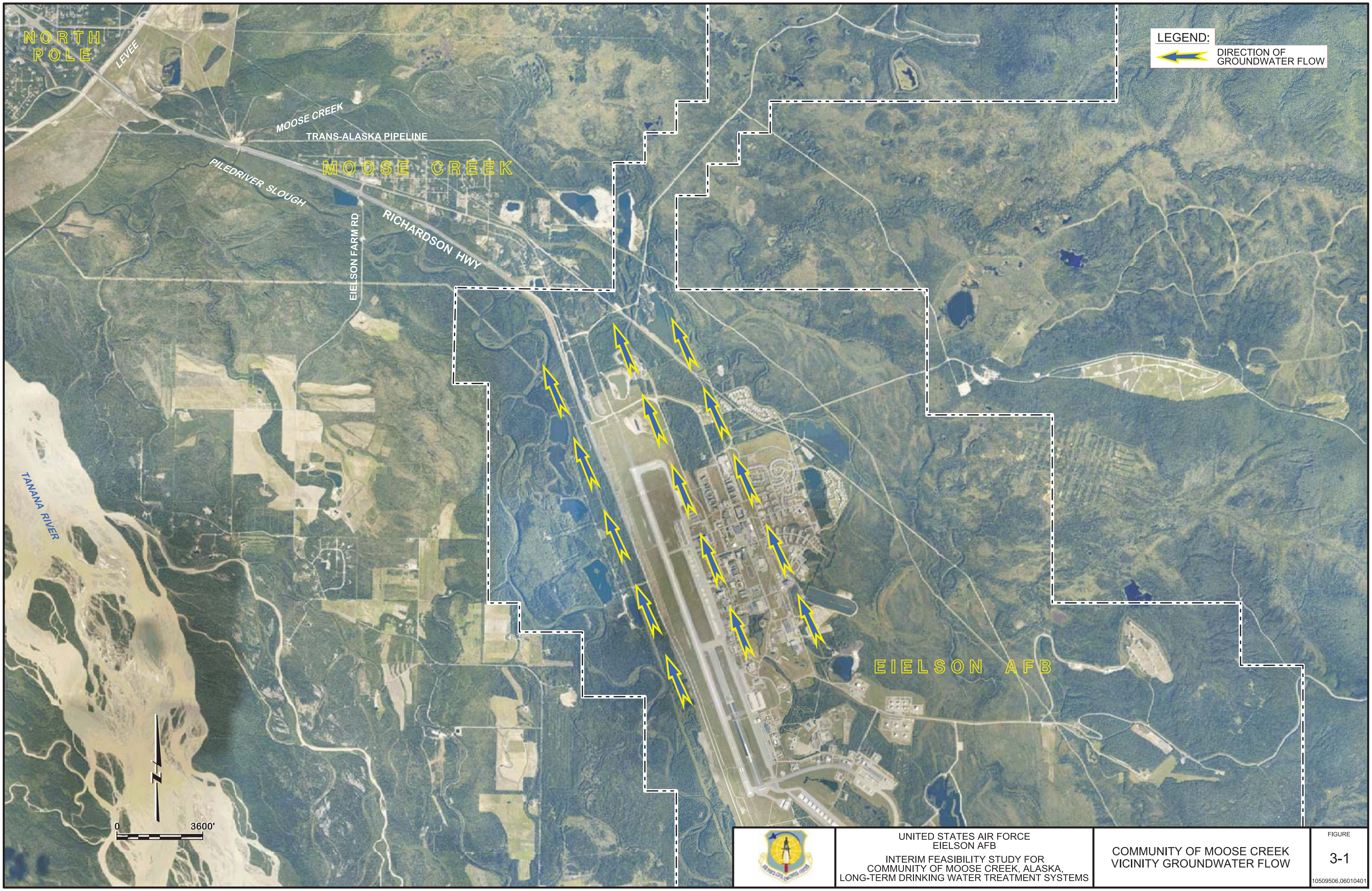


This process will produce an agreed long term solution for the contaminants at the site, which will protect humans and the environment. However, the process can take time and occasionally solutions, or partial solutions, must be implement more quickly, which can be done using a TCRA or an Interim Solution. The latter will use available information to develop an Interim Feasibility Study, followed by an Interim Proposed Plan, Interim Record of Decision and Interim Remedial Action. This will allow a long term solution to be developed and implemented for part of the contamination at a site before the whole process is complete

3.3 Contaminant Extent

Based on information collected as part of the Preliminary Assessment (PA) (AFCEC, 2015b) and subsequent water supply well and direct push sampling, the presence of PFOA and PFOS in community of Moose Creek groundwater is confirmation that a release of a contaminant has occurred. Groundwater flow at EAFB is approximately from south-east to north-west. Although delineation has not been completed, results of the Community of Moose Creek water well sampling program have identified a contaminant distribution pattern which is consistent with the groundwater flow direction (**Figure 3-1**).

The majority of individual private drinking water wells tested in community of Moose Creek exceed the current LHA for PFOS and for combined PFOS+PFOA, as well as the less stringent PHA for PFOS that was in place until May 2016 (AFCEC, 2015a). **Figure 3-2** depicts cumulative community of Moose Creek PFOA+PFOS sampling results, since the combined PFOS + PFOA level represents the most stringent LHA. The individual and combined LHAs for PFOA and PFOS are 70 ppt. ADEC introduced groundwater clean-up levels for PFOS and PFOA (ADEC), at a level of 400 ppt. The community of Moose Creek PFOS sampling results indicate that the PFOS levels are the more stringent for this area. **Figure 3-3** depicts the PFOS levels in the groundwater and indicates that the majority of wells exceed this level.



UNITED STATES AIR FORCE
EIELSON AFB

INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

COMMUNITY OF MOOSE CREEK
VICINITY GROUNDWATER FLOW

FIGURE 3-1

10509506.06010401

TIME: 08-JUN-2017 10:37 FILE: C:\DCAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig 3-1 Moose Creek Vicinity Groundwater Flow.dgn

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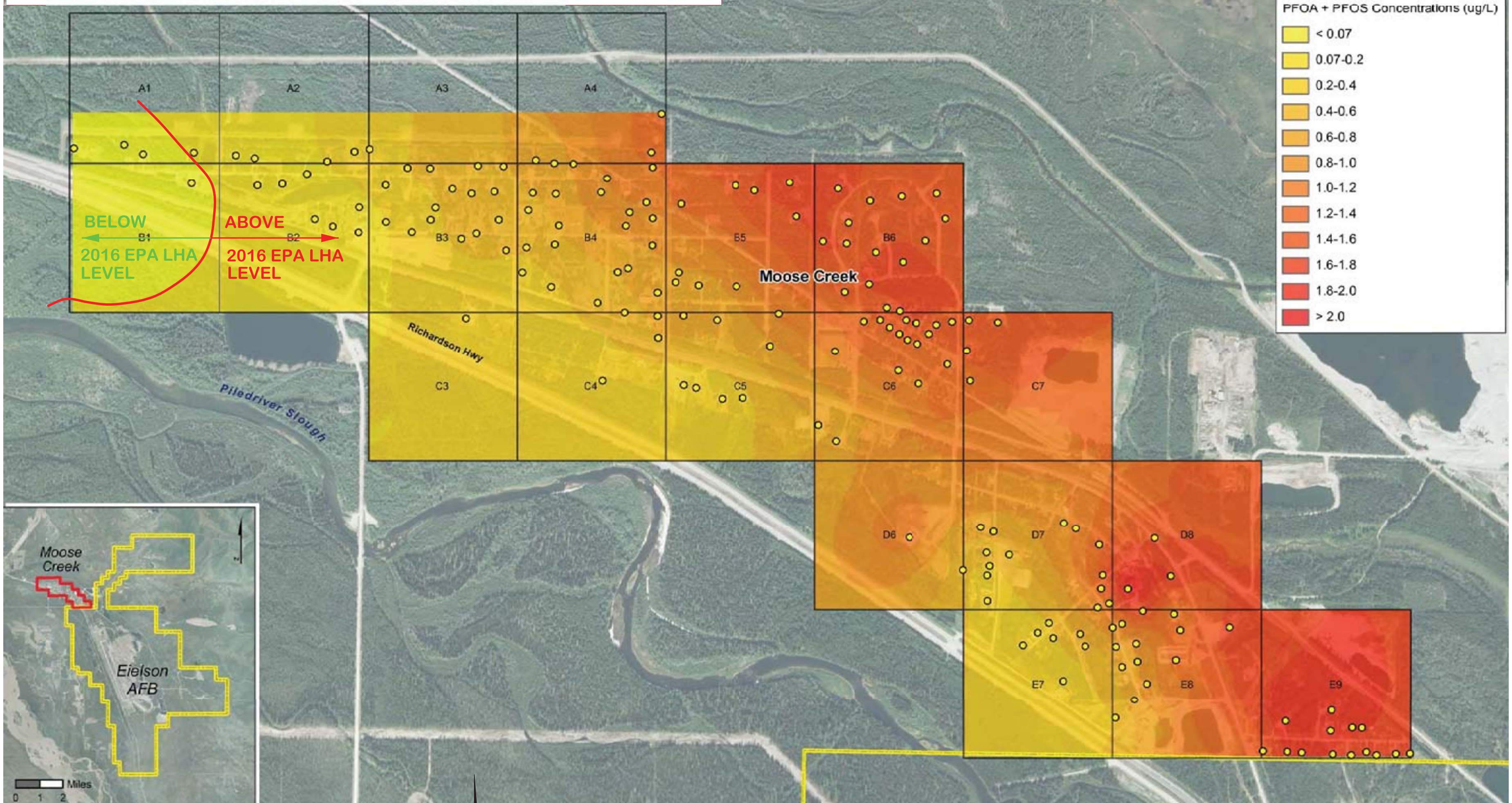
Note:
Concentrations above 0.07 ug/L exceed the EPA Lifetime Health Advisory (LHA) level (EPA 2016).

Data Sources:
Jacobs 2015; EA 2016; Imagery: Alaska Mapped, Geographic Information Network of Alaska 2007



Source:
EA Engineering Science, and Technology, Inc., PBC
2nd Quarter Report (2016) on Moose Creek Area Inspections, Sampling & Analysis, Treatment, and Construction
Moose Creek Area,
Figure 4- Moose Creek Cumulative PFOA+PFOS Results through 30 June 2016

UNITED STATES AIR FORCE
EIELSON AFB

INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

COMMUNITY OF MOOSE CREEK
PFOA AND PFOS RESULTS
UP TO 30 JUNE 2016

FIGURE
3-2

10509506.06010401

TIME: 08-JUN-2017 13:21 FILE: C:\DICAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig 3-2 Moose Creek _PFOA-PFOS results.dgn

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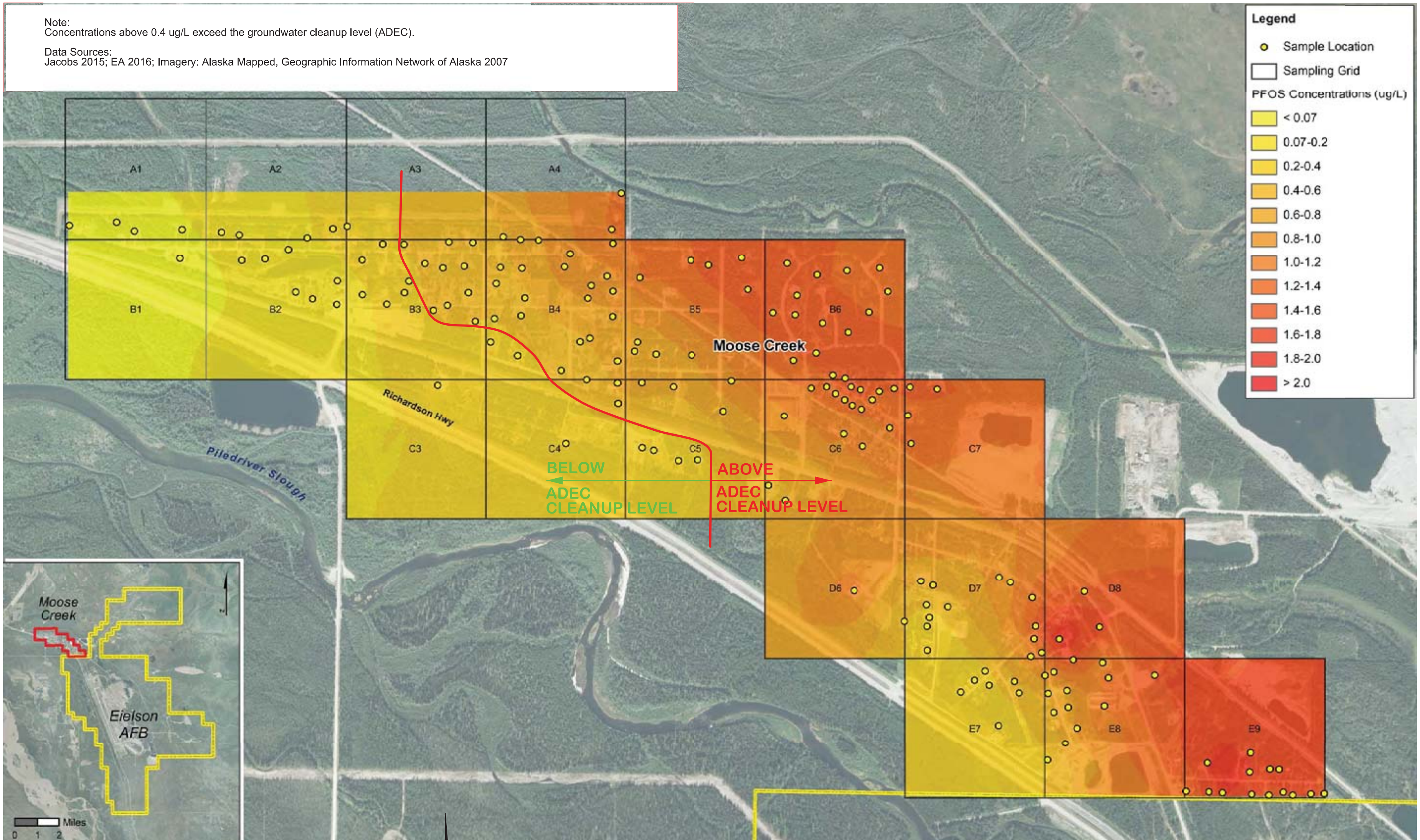
Note:
Concentrations above 0.4 ug/L exceed the groundwater cleanup level (ADEC).

Data Sources:
Jacobs 2015; EA 2016; Imagery: Alaska Mapped, Geographic Information Network of Alaska 2007



Source:
EA Engineering Science, and Technology, Inc., PBC
2nd Quarter Report (2016) on Moose Creek Area Inspections, Sampling & Analysis, Treatment, and Construction
Moose Creek Area,
Figure 3- Moose Creek PFOS Results through 30 June 2016

	UNITED STATES AIR FORCE EIELSON AFB INTERIM FEASIBILITY STUDY FOR COMMUNITY OF MOOSE CREEK, ALASKA, LONG-TERM DRINKING WATER TREATMENT SYSTEMS	COMMUNITY OF MOOSE CREEK PFOS RESULTS UP TO 30 JUNE 2016	FIGURE 3-3 10509506.06010401

TIME: 08-JUN-2017 11:36 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_18575071S\draft-June 2017\Fig 3-3 Moose Creek _PFOS results.dgn

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3.4 Contamination Source Inspections

The Air Force is presently implementing a nation-wide program of PA/SI of areas where a PFC release into the environment may have occurred. This is the first stage of the CERCLA process

The Final PA for PFCs at EAFB (AFCEC, 2015b) identified areas where it is possible that PFCs were released into the environment and recommended SIs for the following 19 locations:

- Current Fire Training Area (FTA) (FT09)
- Former FTAs by the Current Entomology Building (Building 4335)
- Former FTA near the Antenna Farm
- Thunderdome (Building 1140)
- Air National Guard (ANG) Hangar (Building 1171)
- ANG KC-135 Hangar (Building 1176)
- Hangar (Building 1344)
- Corrosion Control (Building 1348)
- Fire Station 1 (Building 1206) and Former Ball Field Spray Test Area
- Former Fire Station 1
- KC-135 Fire (1989)
- Foamed Runway and Biosolids Land Spreading Area
- Former Adak Building Fire
- South Ramp Spray Test Area
- Taxiway Charlie Spray Test Area
- Power Plant Cooling Pond
- Wastewater Treatment Plant (WWTP) and Biosolids Land Spreading Area
- Garrison Slough
- Fuel Pump House (Building 1246)

The following locations were either inspected in 2014, or associated with secondary use of groundwater at EAFB (USACE, 2016):

- Former Ball Field Spray Test Area
- KC-135 Fire (1989)
- Foamed Runway and Biosolids Land Spreading Area
- South Ramp Spray Test Area
- Taxiway Charlie Spray Test Area

Site inspection field work for the following 15 locations was conducted in 2016 (USACE, 2016), and final reports are expected to be available by early 2017:

- Current FTA (FT09)
- Former FTAs by the Current Entomology Building (Building 4335)
- Former FTA near the Antenna Farm

- Thunderdome (Building 1140)
- ANG Hangar (Building 1171)
- ANG KC-135 Hangar (Building 1176)
- Hangar (Building 1344)
- Corrosion Control (Building 1348)
- Fire Station 1 (Building 1206)
- Former Fire Station 1
- Former Adak Building Fire
- Power Plant Cooling Pond
- WWTP and Biosolids Land Spreading Area
- Garrison Slough
- Fuel Pump House (Building 1246)

SI results will provide a basis for determining which EAFB PFC contaminant releases are migrating to the Community of Moose Creek.

3.5 Previous Actions

In addition to the ongoing SI activities described above, the Air Force has taken specific actions to minimize exposure to PFC-contaminated water at the Community of Moose Creek, including:

- Pursuant to its CERCLA lead agency authority, the Air Force initiated an emergency and TCRA to provide impacted community of Moose Creek properties with individual, engineered treatment systems or water tanks for delivered potable water. As of December 2016, 175 systems have been installed – 100 storage tanks and 75 granular activated carbon (GAC) treatment systems.
- Provided clean, bottled water to impacted homes and businesses for drinking and cooking uses.
- Maintained close communications and coordination with the local community. Public meetings were held 15 June 2015, 22 July 2015, 26 August 2015, 26 October 2015, 14 December 2015, 25 January 2016, 18 April 2016, and 1 December 2016.
- Consulted with regulatory agencies.
- Consulted with local, state, and federal government representatives.

3.6 Planned Actions

Additional Air Force Planned Actions at the community of Moose creek include:

- Complete the installation of the PFC response action systems in the Community of Moose Creek.
- Conduct long-term operations and maintenance of the Community of Moose Creek PFOS and PFOA treatment systems, including performance sampling to ensure the systems are effective in removal of PFOS and PFOA to concentrations below the LHA levels.

- Conduct sampling of private wells not previously sampled as owners request the sampling and that are within the area thought to be at risk of PFCs.
- Continue providing bottled water, as needed.
- Conduct periodic resampling of wells that initially tested below the LHA The current well sampling frequency will continue as established in the TCRA
- Continue public participation throughout the CERCLA process.
- Continue regulatory engagement.
- Continue local, state, and federal government engagement.

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4.0 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

4.1 Human Health Risk

PFCs are a class of emerging contaminants. Neither PFOS nor PFOA are listed CERCLA hazardous substances (40 CFR Part 302, Table 302.4). However, ADEC has listed both PFOS and PFOA as hazardous substances under 18 AAC 75, both of which have a groundwater cleanup level of 0.40 µg/L (ADEC, 2017). Both the Air Force and regulators have determined that PFOS and PFOA are 'contaminants'. CERCLA defines a pollutant or contaminant as essentially any chemical that:

> "…upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformation in such organisms or their offspring…" (42 United States Code [USC] § 9601(33)).

The EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) have reviewed the large toxicity databases for both PFOA and PFOS, summarizing the adverse effects to animals and humans following exposure. The EPA concluded there is ample evidence of adverse effects, particularly in animals (USEPA, 2016).

In August 2016, the Air Force issued a Memorandum (USAF, 2016b) stating its commitment to the safety and well-being of its personnel and the general public, both on and off installations. It states that:

> "Consistent with on-going efforts, if the Air Force releases PFOA/PFOS into the environment, and has a reasonable basis to believe there is the potential for unacceptable risk to human health and the environment, we will take action under applicable Federal or state law, in cooperation with the appropriate regulatory agencies, to protect our personnel and the public."

At this time, there is limited PFC impact data available to allow a quantitative human health risk assessment to be conducted. The Air Force is using the reference dose (RfD) of 0.00002 milligrams per kilogram per day (mg/kg-day) that is used by EPA to derive a 70 ppt drinking water lifetime Health Advisory for PFOA and PFOS. This will be used as a Tier 3 human health toxicity value to calculate human health risk.

Based on the current sampling data, routes of exposure in the Community of Moose Creek area are limited to ingestion of groundwater. Soil exposures are not believed to be a concern for the following reasons: 1) the only soil impacted would be below the groundwater level, 2) dermal soil absorption from PFC is not a pathway of concern, and 3) soils exposed to groundwater with a maximum concentration of 2 parts per billion (ppb) would not result in a soil exceedance of 6 mg/kg, the EPA PFOS soil screening level (USEPA 1999). ADEC recently updated their human health risk-based soil cleanup level for PFOS and PFOA to 1.6 mg/kg. (ADEC).

Some epidemiological studies have been conducted as part of human occupational studies. These efforts attempted to correlate PFOS blood serum levels to health characteristics (e.g., cholesterol, thyroid function, and reproductive and developmental health). In all cases, the results were inconclusive, although suggestive that some relationship exists. Due to the limited extent of the studies and lack of sufficient data, the health effects from PFOS are not known in humans. Studies in animals have shown significantly different profiles between species. In general, there is evidence for immunological effects, increased liver weight, and a risk for low birth weight at exposures in the ppm range.

4.2 Ecological Risk

The ecological risk profile of PFCs is not yet known, as they are emerging contaminants. There is insufficient PFC impact data available at this time to perform a quantitative ecological risk assessment.

5.0 REMEDIAL ACTION OBJECTIVES

As described in the EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988b) and in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP – 40 CFR 300), a FS consists of three phases: identification and screening of technologies, development and screening of alternatives, and a detailed analysis of alternatives. The following steps were used in developing the potable water supply alternatives:

- Develop RAOs for drinking water at community of Moose Creek properties impacted by EAFB PFOS and PFOA contamination.
- Define remedial action goals, which include:
  - Developing PALs using chemical-specific to be considered (TBC) criteria.
  - Identifying a study area for contaminated media based on the PALs.
- Develop GRAs.
- Identify and screen GRAs for the medium of interest.
- Identify potable water supply alternatives utilizing GRAs that pass screening.
- Conduct a detailed analysis of potable water supply alternatives.
- Conduct a comparative analysis of potable water supply alternatives.

Development of RAOs and PALs for groundwater is provided in Section 5.3. Development of GRAs and identification and screening of potable water supply technologies and the development of potable water supply alternatives is provided in Section 6.0. A detailed analysis of the potable water supply alternatives and comparative analysis is presented in Section 7.0.

5.1 Federal, State and Local Roles

The Air Force issued a policy Memorandum on 11 August 2016 (USAF, 2016b) stating that they would address any PFOA/PFOS releases that pose unacceptable risk, including migration off-base, in accordance with CERCLA, and the NCP. Where drinking water samples indicate unacceptable risk to human health, as defined by exceeding the EPA's lifetime drinking water Health Advisory for PFOA and PFOS, the Air Force will take appropriate mitigation action for all sources on current and former Air Force installations, as well as public and private water sources reasonably believed to be contaminated by Air Force actions.

In November 1989, EAFB was listed on the National Priorities List (NPL) of Federal Superfund sites by the EPA. The Air Force, State of Alaska, and EPA then entered into a Federal Facilities Agreement (FFA) for EAFB under CERCLA Section 120, which was signed in 1991. The FFA established the procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions. An additional goal of the FFA was to integrate the Air Force's CERCLA response obligations and Resource Conservation and Recovery Act (RCRA) corrective action obligations.

The EPA has been involved in the Community of Moose Creek PFC investigation and TCRA, since discovery of the PFC contamination was initially made. Given that EAFB is a NPL site under a FFA, the EPA will continue to be involved throughout the investigation and remediation process.

The ADEC Contaminated Sites Program has been involved, along with the EPA. ADEC is also a signatory on the FFA and will continue to be involved in PFC investigation and remediation efforts. The Alaska Department of Health and Social Services is informed of the contamination and is supporting the Air Force, EPA, and ADEC by participating in the public meetings and providing fact sheets to the public. The ADEC Drinking Water section is also aware and involved.

ADF&G and the Alaska Department of Natural Resources have been notified and are working with the Air Force in evaluating a fish advisory in Garrison Slough.

Local authorities have been notified and include the Fairbanks North Star Borough and the Military Liaison Office, who have been supporting the Air Force by helping reserve public meeting locations, and speaking at some public meetings.

5.2 Regulatory Setting and Identification of ARARs and TBCs

PFOA and PFOS are not currently identified as hazardous chemicals as determined by CERCLA; however, application of CERCLA criteria suggests that it is appropriate to consider them to be pollutants and/or contaminants (AFCEC, 2015a).

The EPA has established individual and combined LHA levels for PFOA and PFOS at 70 ppt (USEPA, 2016). These LHA levels are believed to offer a margin of lifetime protection from adverse health effects resulting from exposure to PFOA and PFOS in drinking water (USEPA, 2016). The Air Force has agreed to follow the EPA's LHA guidance to the extent of PFC-contaminated ground water used for drinking water at Moose Creek and the resulting study area.

PFOS and PFOA have been detected in Moose Creek drinking water wells that exceed the EPA's LHA of 70 ppt for PFOS and for combined PFOS and PFOA. The concentrations of PFOS and PFOA in the groundwater at the site present a threat to public health or welfare or the environment.

Identification of potential Applicable or Relevant and Appropriate Requirements (ARARs) is required for site activities conducted in accordance with the IRP and CERCLA programs at U.S. Department of Defense (DoD) installations. ARARs are the basis for the development of RAOs for a site and include the laws, regulations, standards, criteria, and requirements that may apply to potable water supply alternatives developed for the Community of Moose Creek. ARARs in this Interim FS are limited to groundwater use and drinking water. Ultimately, a Final RI/FS and ROD will be needed that address the overall PFCs contamination. Additional ARARs may be identified therein..

A requirement or cleanup standard under state and federal law may be either "applicable" or "relevant and appropriate," but not both. Applicable and relevant and appropriate are defined according to the NCP (40 CFR 300.5) as follows:

- **Applicable requirements** are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by the state in a timely manner and that are more stringent than federal requirements may be applicable.

- **Relevant and appropriate requirements** are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations that are promulgated under federal or state environmental or facility siting laws that, while they may not be "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to a particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Additional standards and guidance to be considered (TBC) are non-promulgated guidance or advisories established by federal or state agencies and may also be identified to assist in implementing ARARs. TBCs are not legally enforceable or binding, but may be considered during the development and evaluation of remedial alternatives.

ARARs can be in the form of regulations enforceable by federal, state, or local laws, or by regulatory guidance. EPA guidance divides ARARs into the three categories described below and in the following subsections:

- ***Chemical-Specific ARARs*** are health or risk-based concentration limits or ranges for particular chemicals that may be found in, or discharged to, the ambient environment.
- ***Location-Specific ARARs*** are requirements that apply based on the location of the site (e.g., wetlands, floodplains, historic areas, native burial areas, wildlife refuges, etc.) or siting restrictions (e.g., industrial versus residential properties, native versus disturbed land, etc.).
- ***Action-Specific ARARs*** are requirements that govern particular technologies or activities. They typically set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities.

ARARs are not the only factors that determine what happens at a contaminated site; however, they represent the minimum requirements for which an action must be taken. In some instances, because of multiple contaminants or pathways, compliance with ARARs will not achieve an acceptable degree of protection. In other cases, non-promulgated criteria, advisories, and other forms of guidance need to be considered. Therefore, health-based risk levels, ARARs, environmental impacts, and (possibly) TBC criteria or guidelines, are used to set PALs, in accordance with 40 CFR § 300.400(g)(3).

The potential ARARs and TBCs for the Community of Moose Creek are identified in **Tables 5-1, 5-2,** and **5-3**.

5.2.1 Chemical-Specific ARARs and TBCs

There are no promulgated chemical-specific drinking water ARARs for PFCs. The 2016 LHA values issued by the EPA for both PFOA and PFOS are based upon the best available information. ADEC has state-promulgated cleanup levels for PFOA and PFOS in both soil and groundwater. Table C cleanup levels are State ARARs for groundwater, but may still use the LHA levels as more stringent TBCs for drinking water.

5.2.2 Location-Specific ARARs and TBCs

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include: sensitive habitats, floodplains, wetlands, endangered species habitats, and historic or archaeological resources. The community of Moose Creek is located adjacent to an active Air Force installation and access to the area is uncontrolled.

5.2.3 Action-Specific ARARs and TBCs

Action-specific ARARs are performance, design, or technical requirements applicable to remedial actions that may include the generation, transportation, treatment, or disposal of regulated hazardous wastes or contaminated environmental media.

Table 5-1 Potential Chemical-Specific ARARs and TBCs

Source	Standard, Requirement, Criterion, Limitation	Description of Standard	ARARs or TBC	Comments
EPA Fact Sheet. PFOA & PFOS Drinking Water Health Advisory	EPA-800-F-16-003. May 2016.	Establishes lifetime health advisory levels for PFOS and PFOA in drinking water at 70 ppt.	TBC	In the absence of promulgated cleanup levels, the EPA LHA levels can be used as trigger levels for actions at the Community of Moose Creek.
ADEC, Oil and Other Hazardous Substances Pollution Control	18 AAC 75 .340-.345	Provides for the reporting, investigation, and cleanup of hazardous substances, the regulation for PFOS and PFOA in soil is 1.6 mg/kg and groundwater at 0.4 µg/L	Applicable	In November 2016, the cleanup levels for PFOS and PFOA were promulgated in the revised edition of these regulations.
Resource Conservation and Recovery Act, Part C	40 CFR 261.20	Establishes requirements for characterization, classification, and disposal of hazardous wastes, but not a numeric PFC cleanup level.	Relevant & Appropriate	A material is a hazardous waste if it is either (1) specifically designated or listed as a hazardous waste, or (2) it exhibits any hazardous characteristics (corrosive, ignitable, reactive, or toxic). A state regulation (18 AAC 62.020) adopts these rules.
Safe Drinking Water Act (42 USC 3), National Primary Drinking Water Standards	40 CFR, Part 141	Establishes MCLs for public water systems, but not a numeric PFC cleanup level.	Relevant & Appropriate	The NCP defines MCLs as relevant and appropriate for groundwater determined to be a current or potential source of drinking water in cases where MCLGs are not ARARs. A state regulation (18 AAC 80.300) adopts these federal standards.
Safe Drinking Water Act (42 USC 3), MCLGs	40 CFR, Part 141	Establishes potable water quality goals.	Relevant & Appropriate	MCLGs that have non-zero values are relevant and appropriate for groundwater to be a current or potential source of drinking water. However, MCLGs have not been established for PFCs.

Table 5-1 (Cont.) Potential Chemical-Specific ARARs and TBCs

Source	Standard, Requirement, Criterion, Limitation	Description of Standard	ARARs or TBC	Comments
EPA Health-Based Guidelines for Air, Drinking Water and Soil (Regional Screening Levels)	Tables available at: http://www.epa.gov/region9/superfund/prg/	Human health risk-based screening levels for contaminants in soil and groundwater under different land use scenarios.	TBC	Possible screening and/or cleanup goals to use in the absence of ADEC values for specific contaminants. Standards for PFCs have not been established.

Key:
AAC – Alaska Administrative Code
ADEC – Alaska Department of Environmental Conservation
ARAR – Applicable or Relevant and Appropriate Requirements
CFR – Code of Federal Regulations
EPA – U.S. Environmental Protection Agency
LHA – lifetime health advisory
MCL – Maximum Contaminant Level
MCLG – Maximum Contaminant Level Goal
NCP – National Contingency Plan
PFC – perfluorochemical
PFOA – perfluorooctanoic acid
PFOS – perfluorooctanesulfonic acid
TBC – To Be Considered
USC – United States Code

Table 5-2 Potential Location-Specific ARARs and TBCs

Source	Standard, Requirement, Criterion, Limitation	Description of Standard	ARARs or TBC	Comments

Key:

No potential location specific ARAR's or TBC's have been identified for the alternatives being investigated. If location specific ARARs are identified during the project developmenet process, they will be added to the ROD for this site.

Table 5-3 Potential Action-Specific ARARs and TBCs

Source	Standard, Requirement, Criterion, Limitation	Description of Standard	ARARs or TBC	Comments
Clean Water Act (Section 402 – National Pollutant Discharge Elimination System (NPDES) Industrial Wastewater Discharge Permits)	40 CFR 122	Defines acceptable standards for discharges to receiving waters and pretreatment standards for discharge to a publicly owned treatment works.	Relevant & Appropriate	If a groundwater remedy includes effluent discharge to surface waters or to a publicly owned treatment works, this will be relevant, although a standard has not been established for PFCs.
Alaska Drinking Water Standards	18 AAC 80.200 -235)	Public Water System Review and Approval Requirements	Applicable	Extending an existing public water system or developing a new one will require approval
Occupational Safety and Health Administration	29 CFR 1910	Requires 40-hour HAZWOPER training and annual 8-hour refreshers for site workers.	Applicable	
Hazardous Material Transportation Act and Implementing Regulations	49 CFR 279	Regulates the transportation of hazardous materials, including requirements for certification of waste transporters. This act also includes regulations that specify procedures and requirements for waste containerization, labeling, marking, placarding, and manifesting.	Relevant & Appropriate	If groundwater is removed or transported from the Community of Moose Creek, these regulations will be relevant.

Key:
AAC – Alaska Administrative Code
ARAR – Applicable or Relevant and Appropriate Requirements
CFR – Code of Federal Regulations
HAZWOPER – Hazardous Waste Operations and Emergency Response
PFCs – perfluorochemicals
RCRA – Resource Conservation and Recovery Act
TBC – To Be Considered

5.3 Remedial Action Objectives

The EPA *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* (USEPA, 1988c) and the NCP define RAOs as medium-specific or site-specific goals for protecting human health and the environment that are established on the basis of the nature and extent of the contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure.

RAO development considers: medium-specific constituents of interest; potential exposure pathways; chemical-, location-, and action-specific ARARs; and TBCs (typically environmental cleanup standards, requirements, criteria, or limitations).

In this section, RAOs are developed for human receptors at the Community of Moose Creek. Test results have found that PFCs in groundwater are present at concentrations that exceed both the 2016 LHA values issued by the EPA and ADEC groundwater clean-up levels for PFOS and PFOA.

In the absence of promulgated standards for PFOS and PFOA in drinking water, RAOs established to protect human health and the environment at the Community of Moose Creek are based on the 2016 LHA values issued by the EPA and ADEC groundwater clean-up levels.

5.3.1 Human Health RAOs

The human health RAO for the Community of Moose Creek is to prevent human ingestion of PFOS or PFOA contaminated groundwater that exceeds the 2016 LHA value of 70 ppt and ADEC groundwater clean-up levels of 0.4 µg/L.

5.3.2 Ecological RAOs

There is insufficient data at this time to develop ecological RAOs for the Community of Moose Creek. However, since identified surface water impacts in the Community of Moose Creek study area are not addressed under this IFS, ecological RAOs are not required in order to evaluate potable water supply alternatives for the Community of Moose Creek.

5.4 Preliminary Action Levels and Study Area

PALs are chemical-specific concentration goals for specific media (e.g., soil, sediment, water, and air) and land use combinations at contaminated sites. They serve as a target to use during the initial development, analysis, and selection of action alternatives. These goals should both be protective of human health and the environment and comply with all ARARs for all exposure pathways being addressed.

To meet the RAOs defined in Section 5.3 for media of concern at the Community of Moose Creek, quantitative PALs were developed to define the extent of remedial action. This section presents the PALs and defines the extent of affected groundwater (areas of attainment) that will be addressed in this IFS. PALs establish concentrations of contaminants of concern that will not pose an unacceptable risk to human health and the environment, and are developed considering the following:

- RAOs representing concentration levels corresponding to the 2016 LHA values issued by the EPA.
- Factors related to technical limitations, uncertainties, and other pertinent information.

The study area defines the area over which concentrations of one or more contaminants in the groundwater are inferred to exceed the PALs, based on correlation of analytical results over multiple sample locations. For this IFS, the study area correlates with the estimated horizontal and vertical extent of concentrations exceeding PALs in the groundwater.

The PALs for PFOS and PFOA in groundwater at the Community of Moose Creek are summarized in **Table 5-4**.

Table 5-4 Preliminary Action Levels

Medium	Parameter	Lifetime Health Advisory[1]	Preliminary Action Level
Drinking Water	PFOS	70 ppt	70 ppt
	PFOA	70 ppt	70 ppt
	PFOS+PFOA	70 ppt	70 ppt
Groundwater	PFOS		0.4 μg/L
	PFOA		0.4 μg/L

Key:
1 – U.S. Environmental Protection Agency, 2016
PFOA – perfluorooctanoic acid
PFOS – perfluorooctanesulfonic acid
ppt – part per trillion

The study area for drinking water at the Community of Moose Creek is depicted on Figure 2-1. The study area was delineated based on sampling conducted to date at the Community of Moose Creek and encompasses sampling locations where concentrations in drinking water wells have exceeded, or are predicted to exceed, the PALs identified in Table 5-4.

6.0 IDENTIFICATION AND SCREENING OF POTABLE WATER SUPPLY TECHNOLOGIES AND ALTERNATIVES

This section identifies GRAs and potable water supply technologies that may potentially be utilized at the Community of Moose Creek while PFC-contamination source investigations and remediation actions are underway at EAFB. GRAs are basic actions that will satisfy RAOs. For each GRA, several possible potable water supply technologies may exist. Specific potable water supply technologies identified under each GRA were selected or arranged into potable water supply alternatives for each site. Each potable water supply alternative was then screened against three broad criteria: effectiveness, implementability, and cost. Those alternatives considered ineffective, too difficult to implement, or too costly for EAFB were eliminated from further analysis.

A list of GRAs is provided in Section 6.1. Initial screening of the GRAs against the three broad screening criteria is provided in Section 6.2. Specific potable water supply alternatives utilizing combinations of the GRAs that passed screening are described in Section 6.3. Further analysis of potable water supply alternatives that were retained after initial screening is provided in Section 7.

6.1 General Response Actions

GRAs are categories of actions that will satisfy the RAOs. The GRAs identified for the Community of Moose Creek are discussed below as outlined in EPA guidance for providing alternative water supplies (USEPA, 1988a).

6.1.1 No Action (Baseline)

The "No Action" response action consists of taking no additional steps to reduce or remove exposure to PFC contamination. Specifically, individual treatment systems installed to date would be left in place, but would not be maintained. Water quality sampling would not continue and land use controls (LUCs) would not be put in place to control use of the existing wells.

Pursuant to 40 CFR 300.403(e)(6) of the revised NCP (March 8, 1990) and the EPA's guidance for conducting a RI/FS (USEPA, 1988b), a 'No Action' option must be developed and examined as a potential remedial alternative for all sites. Therefore, this action is retained for detailed analysis as a baseline from which to compare the other technologies against the nine CERCLA criteria.

6.1.2 Connection with an Existing Municipal or Private Supply

This response action consists of providing uncontaminated water to the Community of Moose Creek study area either by connection of a water distribution system to an uncontaminated existing water supply or road delivery to individual water tanks at each property.

There are two existing drinking water treatment plants (WTPs) located in the proximity of the Community of Moose Creek: North Pole and EAFB. The North Pole connection would be approximately 5.5 miles and the EAFB would be approximately 3.5 miles. It would be necessary to develop local water distribution system for the Community of Moose Creek.

6.1.3 Develop New Uncontaminated Water Resources

This response action consists of providing uncontaminated water to the Community of Moose Creek study area by developing a new water source. For the Community of Moose Creek, uncontaminated water has been identified at depths of greater than 200 feet bgs. The current wells serving the properties are typically 50 feet bgs. This option could either be a new centralized well with a distribution system, or an individual well per property.

6.1.4 Removal of Contaminants by Treatment

This response action consists of installing, operating, and maintaining individual treatment systems for each of the existing water sources in the Community of Moose Creek. A review of technologies available to remove PFCs was conducted in late 2015 (USAF, 2016a) and concluded that only GAC was proven for public water supplies. A summary is provided in Appendix A.

Two additional GRA's were also considered for this study, as discussed below.

6.1.5 Land Use Controls

LUCs are legal and administrative actions to limit the potential exposure of the contaminants under both current and future land-use scenarios. LUCs use legal measures to restrict or regulate access to contaminated media. LUCs may include: prohibitions on well installation and groundwater use; encroachment permitting (i.e., dig permits) to eliminate contact with contaminated media; and deed restrictions or other land-use restrictions that prevent contact with and exposure to contaminated subsurface media. Contamination may also be periodically monitored to verify and determine potential impacts on human health and the environment. CERCLA describes four categories of LUCs, as follows:

- Governmental (e.g., zoning, land use designations).
- Proprietary (e.g., easements, fences).
- Administrative (e.g., consent orders, consent decrees).
- Informational (e.g., issued advisories, deed restrictions, deed notifications).

For the Community of Moose Creek, LUCs are likely to be necessary to prevent use of contaminated groundwater. Ground water use may be restricted through the use of deed restrictions, environmental covenants, permitting, contractual agreements or other mechanisms to prevent usage within the Moose Creek community. The AF is evaluating authorities and means to implement GW use restrictions upon private property owners in Moose Creek. This may also require existing wellhead equipment to be removed or locked.

6.1.6 Property Transfer

This response action consists of an agency purchase of all affected properties in the community of Moose Creek study area. Only FEMA has the authority to "buy out" affected property owner, however the Air Force can purchase property on the open market in order to effect a remedy.

6.2 Identification and Screening of GRAs

The available potable water supply GRAs described in Section 6.1 were screened against the three criteria, as shown in **Table 6-1**.

Each of the criteria were assigned a rating (Table 6-1) and, if the rating for either Effectiveness or Implementability was ○, then this alternative was eliminated and not carried forward to detailed analysis. The exception to this scoring process was the 'No Action' alternative, which must be carried forward.

The GRAs carried forward are:

- No Action (Baseline).
- Connection with an existing municipal or private supply.
- Develop a new uncontaminated water resource.
- Removal of contaminants via treatment.
- LUCs (as partial solution).

6.3 Identification of Potable Water Supply Alternatives for Further Evaluation

The potable water supply GRAs that passed initial screening were then assembled into specific action alternatives for the Community of Moose Creek study area. The action alternatives described in this section were carried forward for further evaluation in Section 7.

No Action (Baseline)

The "No Action" alternative consists of leaving the currently installed, individual GAC treatment systems and/or water tanks with delivery service for the Community of Moose Creek study area properties in place, but not maintaining them or performing water quality sampling. No LUCs would be put in place. This alternative provides a baseline against which the feasibility of all other alternatives can be evaluated.

Alternative 1 – Water Supplied from North Pole Municipal WTP

This alternative consists of running a new water main from the City of North Pole WTP to the Community of Moose Creek and installing a distribution system. LUCs would also be put in place to prevent use of contaminated groundwater.

Alternative 2 – Water Supplied from Eielson AFB WTP

This alternative consists of installing a new water main from an EAFB WTP to the Community of Moose Creek and installing a distribution system. LUCs would also be put in place to prevent use of contaminated groundwater.

Table 6-1 Potable Water Supply General Response Action Screening Analysis

Remedial Action Objective	General Response Action	Effectiveness	Implementability	Cost	Comments or Further Description	Result of Screening
Alternative Potable Water Supply Or Protect Human Health	No Action	○	●	●	Pursuant to 40 CFR 300.403(e)(6) of the revised NCP (March 8, 1990), this option must be evaluated.	**Retain** as Baseline
	Connect to Existing Municipal or private Water Supply	●	◑	○	Effectiveness: will supply safe drinking water. Implementability: Is a proven method of supplying drinking water, but remote from existing sources. Cost: likely have high capital but low O&M.	**Retain**
	Develop a New Uncontaminated Water Resource	◑	◑	◑	Effectiveness: all properties may not have access to uncontaminated aquifer. Implementability: proven technology to drill a deeper than 200 foot well, will require considerable number installed. Cost: Medium capital and O&M costs.	**Retain**
	Remove Contaminants via Treatment	●	◑	○	Effectiveness: effective in conjunction with ICs. Implementability: partial implementation in place. Cost: Some capital costs have been incurred. O&M costs remain until remediation is complete.	**Retain**
	Land Use Controls	◑	◑	●	Effectiveness: effective in conjunction with other technologies. Implementability: Large number of notices required. Cost: No significant capital or O&M costs.	**Retain** as partial solution
	Property Transfer	◑	○	○	Effectiveness: restricts future land use and reduces exposure risk. Implementability: The U.S. Air Force does not have authority to purchase properties, only FEMA has that purview. Cost: High capital cost to purchase land. O&M costs would be low.	**Eliminate**

Key
CFR – Code of Federal Regulations
FEMA – Federal Emergency Management Agency
ICs – institutional controls
NCP – National Contingency Plan
O&M – operation and maintenance

Rating:
○ – Low Effectiveness, Difficult Implementability, High Cost
◑ – Moderate Effectiveness, Moderate Implementability, Moderate Cost
● – High Effectiveness, Easy Implementability, Low Cost

Alternative 3 – Individual Property Potable Water Tanks

This alternative consists of installing new water tanks at each of the properties in the Community of Moose Creek. Potable water would be moved by road tanker from a local source, probably the City of North Pole, and LUCs would also be put in place to prevent use of contaminated groundwater.

Alternative 4 – Individual Property Potable Deep Wells

This alternative consists of installing new 250-foot deep wells at each property. At that depth, the groundwater water complies with drinking water requirements. Water supplied to apartment blocks may require treatment to remove secondary contaminants such as iron and manganese. The existing wells would decommissioned and LUCs implemented to prevent future installation of shallow wells.

Alternative 5 – Water Supplied from Community Deep Well

This alternative consists of developing a new water source in the Community of Moose Creek study area. A local treatment to remove iron and manganese and a distribution system would also be required. LUCs would also be put in place to prevent use of contaminated groundwater from shallow wells.

Alternative 6 – Individual Property GAC Treatment Systems

This alternative consists of continuing to install, operate, and maintain individual GAC treatment systems and/or water tanks with delivery service for the Community of Moose Creek study area properties until remediation efforts are complete, LUCs would be needed to prevent untreated contaminated groundwater from being used as drinking water.

Alternative 7 – Status Quo

This alternative consists of retaining the solution implemented as part of the TCRA, which is composite implementation of Alterative 3 and Alternative 6. This consisted of installing GAC water treatment or water tanks (for road tankered water) at all properties affected at the Moose Creek Study area. For this alternative, these remedies will continue and LUCs will be implemented to prevent human consumption of untreated well water, and groundwater that exceeds State groundwater cleanup levels should not continue to be used for potable or non-potable purposes.

7.0 DETAILED ANALYSIS OF POTABLE WATER SUPPLY ALTERNATIVES

The detailed analysis presents the relevant information needed to compare the potable water supply alternatives being considered for the Community of Moose Creek. This analysis follows the screening of the potable water supply technologies and process options considered in Section 6.0. The extent to which alternatives are fully evaluated during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were being analyzed during their development and screening.

Information provided in this section includes:

- A description of the evaluation criteria utilized to assess each alternative (Section 7.1).
- A description of assumptions made in order to evaluate each action alternative (Section 7.2).
- Engineering analysis of options (Section 7.3).
- Preliminary cost estimates for each action alternative (Section 7.4).
- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each of the nine evaluation criteria (Section 7.5).

7.1 Evaluation Criteria

Provisions of the NCP require that the action alternative for each site be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria provide grounds for comparison of the relative performance of the alternatives and identify their advantages and disadvantages. Evaluating against the nine criteria provides sufficient information to adequately compare the alternatives and to eventually select the most appropriate approach for a site.

The nine criteria are divided into three groups: threshold, balancing, and modifying criteria. Threshold criteria must be met by a particular alternative for it to be eligible for selection. Balancing and modifying criteria are used to establish the rationale for choosing the most appropriate alternative. A list of the nine evaluation criteria is provided in **Table 7-1**, and a detailed description for each evaluation criteria is provided in the following sections.

7.1.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria discussed below. There is little flexibility in meeting the threshold criteria; they are met by a particular alternative, or that alternative is not considered acceptable. If ARARs cannot be met, a waiver may be obtained in situations where one of the six exceptions listed in the NCP occurs (40 CFR 300.430 [f][1][ii][C][1 to 6]).

Preliminary ARARs and TBCs potentially applicable to groundwater use within the Community of Moose Creek are presented in Section 5. Tables 5-1, 5-2 and 5-3 present matrices indicating which of the ARARs have been identified as preliminary ARARs for each of the action alternatives presented herein.

Table 7-1 Evaluation Criteria for Potable Water Supply Alternatives

Criteria	Description
Threshold Criteria	
1	Overall protection of human health and the environment.
2	Compliance with applicable or relevant and appropriate requirements.
Balancing Criteria	
3	Long-term effectiveness and permanence.
4	Reduction in toxicity, mobility, or volume through treatment.
5	Short-term effectiveness.
6	Implementability
7	Cost
Modifying Criteria	
8	State acceptance.
9	Community acceptance.

7.1.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion is the basis for comparing action alternatives and establishing the extent to which each adequately protects human health and the environment. Evaluation of the overall protectiveness of an alternative during the RI/FS should focus on whether a specific alternative achieves adequate protection and should describe how site risks posed through each pathway being addressed by the IFS are eliminated, reduced, or controlled through treatment, engineering, or ICs. This evaluation also allows for consideration of whether an alternative poses any unacceptable, short-term or cross-media impacts.

7.1.1.2 Compliance with ARARs

Compliance with ARARs is one of the statutory requirements of action selection. ARARs are cleanup standards, standards of control, and other substantive environmental statutes or regulations which are either “applicable” or “relevant and appropriate” to the CERCLA cleanup action (42 USC 9621[d][2]).

"Applicable requirements" means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

“Relevant and appropriate requirements” means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. The assessment against this criterion describes how the alternative complies with ARARs, or presents the rationale for waiving an ARAR.

ARARs can be grouped into three categories:

- Chemical-specific ARARs. Chemical-specific ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, establish the amount or concentration of a chemical that may remain in or be discharged to the environment.
- Location-specific ARARs. Location-specific ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as flood plains, wetlands, historic places, and sensitive ecosystems or habitats.
- Action-specific ARARs. Action-specific ARARs include technology or activity-based requirements that set controls, limits, or restrictions on design performance of remedial actions, or management of hazardous constituents.

7.1.2 Balancing Criteria

The five balancing criteria upon which the comparative analysis of alternatives is based are discussed below.

7.1.2.1 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence criterion evaluates the ability of an alternative to prevent or minimize risk to public health and the environment after RAOs have been met. Components considered when evaluating the long-term effectiveness and permanence of an alternative include examining the magnitude of residual risk and the adequacy and long-term reliability of controls that may be required to manage this residual risk.

Residual risk, for example, may be the risk posed by treatment residuals and/or untreated wastes or contaminated areas. The demonstrated long-term effectiveness and permanence of equivalent alternatives(s) (under similar site conditions) at other sites can be considered in evaluating whether the alternative can be used effectively. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

The adequacy and reliability of controls assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site. It may include an assessment of containment systems and LUCs to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

7.1.2.2 Reduction in Toxicity, Mobility, and Volume through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies to permanently and significantly reduce toxicity, mobility, or volume of the hazardous substance(s) as their principal element (USEPA, 1988b). This preference is satisfied when treatment is used to reduce the principal threats at a site through: destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The fundamental objective of reducing the toxicity of a hazardous chemical is the protection of human health and the environment. This can be accomplished by reducing the contamination levels (thus, the risk of human or ecological exposure) and by limiting or preventing contaminants from reaching unimpacted areas. Mobility refers to the contaminant's ability to migrate to unimpacted areas or media. Volume reduction can be evaluated by assessing the amount of hazardous material destroyed or treated, the proportion of the contaminant plume that is remediated, and the amount remaining on site. In addition, the degree to which the treatment is reversible needs to be evaluated.

7.1.2.3 Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until action response objectives are met (e.g., a cleanup target has been met). Under this criterion, alternatives should be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The estimated time frame required to achieve the RAOs, the short-term reliability of the technology, and protection of the community and workers during implementation are considered under this criterion. Furthermore, the ability of an alternative to be protective of potential receptors during the failure of any one technology or uncontrollable changes at a site is considered.

7.1.2.4 Implementability

Implementability is used as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining an action alternative (USEPA, 1988b).

Technical feasibility refers to the following factors:

- Ability to reliably construct, operate, and maintain the components of the alternative during and after completion, as well as the ability to meet applicable technical regulatory requirements.
- Likelihood that technical problems associated with implementation will lead to schedule delays.
- Ability of equipment to undertake additional remedial actions (e.g., increased flows or volumes), and/or phase-in other remedial actions, if necessary.
- Ability to monitor the effectiveness of the implemented actions.

Administrative feasibility includes the following criteria:

- Ability to get permits and approvals from the appropriate agencies to implement the alternative.
- Availability of support services for the treatment, storage, and disposal of generated wastes.
- Availability of specialized equipment or technical experts to support the action.

7.1.2.5 Cost

This criterion considers the costs of construction and any long-term costs to operate and maintain an alternative. Costs that are grossly excessive compared to the overall effectiveness of an alternative may be considered as one of several factors used to eliminate an alternative. An alternative providing effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, may be eliminated. The main components of each alternative are sized prior to developing the cost estimates. Sizing is based on general guidelines found in technical literature, past experience, and general professional judgment.

To be selected, an action has to be cost-effective, provided that it first satisfies the threshold criteria set forth in 40 CFR 300.430(f)(1)(ii)(A) and (B). Cost-effectiveness is determined by evaluating the following three of the five balancing criteria noted in 40 CFR 300.430(f)(1)(i)(B) to determine overall effectiveness: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to ensure that the remedy is cost-effective. An alternative is considered cost-effective if its costs are proportional to its overall effectiveness. Cost estimates are intended to provide a basis for alternative evaluation and comparison purposes only, and should not be used for future budgeting, bidding, or construction purposes.

7.1.3 Modifying Criteria

The two modifying criteria address the need for stakeholder acceptance of the final action. The public participation step in the CERCLA process, the Interim Proposed Plan (IPP), was designed to inform the public as to a preferred action alternative and gather feedback regarding that alternative, and is executed following the IFS. Although state regulatory agencies are often involved in the CERCLA process from the beginning, the step that accommodates their acceptance of the preferred action alternative option is the Decision Document or IROD. Both the IPP and IROD are developed once the IFS is finalized. Therefore, modifying criteria are not included in the current analysis of alternatives.

7.1.3.1 State Acceptance

This criterion, which is an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. Although proposed action would occur under the IRP, with the Air Force as the lead agency, state approval is desired.

The state has not yet formally expressed an opinion regarding potential remedial options at the Community of Moose Creek; consequently, this criterion will not be scored.

Assessment of state concerns may not be completed until comments on the IFS are received, but may be discussed, to the extent possible, in the IPP issued for public comment. The state concerns that are assessed include:

- The state's position and key concerns related to the preferred alternative and other alternatives.
- State comments on ARARs or the proposed use of waivers.
- LUCs

7.1.3.2 Community Acceptance

This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. Community acceptance cannot be thoroughly evaluated until the IPP has been issued; consequently, any consideration of community acceptance will be limited to assumptions based on the use of the action alternative at other sites.

7.2 Assumptions Used for Developing of Potable Water Supply Alternatives

As described in Section 6.3, alternatives for providing potable water to the Community of Moose Creek study area were chosen for detailed analysis. Details regarding assumptions made for evaluation purposes are provided in the following subsections.

Several design assumptions were utilized to analyze potable water supply alternatives, including:

- A total of 200 properties are located in the study area, with a resident population of 750.
- 175 properties have had work conducted as part of the TCRA at Moose Creek study area. Of these, 100 have had water tanks installed to receive potable water deliveries by road tanker and 75 have GAC water filters on the property's well water.
- Potable water usage in the Community of Moose Creek study area will be between 60,000 and 75,000 gallons per day.
- No changes will be made to current fire protection service in the Community of Moose Creek study area (i.e., distribution systems will be sized for domestic water flow only, not fire flow). The current fire department well, will be retained for emergency use.
- LUCs to prevent use of contaminated ground water for potable use by residents, or non-potable uses if above ADEC groundwater protection values will be implemented.

7.3 Engineering Analysis of Options

7.3.1 No Action – Baseline

This option is included as required by the CERCLA process. It assumes no further work will be conducted to maintain the water supply systems installed as part of the TCRA.

7.3.2 Alternative 1 – Water Supplied from North Pole Municipal WTP

7.3.2.1 Description of Alternative 1

Potable water will be supplied by the North Pole Municipality from their WTP located in North Pole (Appendix B, Figure B-1). A new water main will carry water to a new holding tank located near the center of the Community of Moose Creek that will allow balancing of local demands on the existing North Pole WTP. The local distribution system will need to be pressurized and circulated with heat input to prevent freezing during winter (Appendix B, Figure B-2). Local connection will be made to all properties in the community. The new system will be maintained and operated by the North Pole Municipality.

7.3.2.2 Quantities Used for Estimate

The following engineering assumptions were made in order to evaluate Alternative 1:

- Increase capacity at North Pole WTP by installation of new sand filter unit in the space available at the plant.
- Water main North Pole to community of Moose Creek (Linear feet [LF] = 30,010, diameter = 6 inches [”]).
- Purchase land to locate reservoir and circulation PS (0.5 acre)
- Water Distribution Storage Tank (volume = 250,000-gallon).
- Pump Station (emergency generator, chlorination, and water heater).
- Local distribution system (LF = 47,640, Diameter = 4” and 6”).
- Local connections to properties (200 properties).
- Disposal of current GAC or water tanks (200 properties).
- LUCs will be required to prevent new wells, the AF is evaluating authorities and means to implement GW use restrictions upon private property owners in Moose Creek.
- Existing wells may be decommissioned

7.3.2.3 Design/ Construction Issues

North Pole will be required to apply for permission to supply water outside of its municipal boundary. The proposed route for the water supply main and local distribution system crosses numerous roads and railways lines, each of which will require permits, and the overall water supply system will require to be permitted by ADEC.

The crossing of the Chena Flood control area will be particularly difficult. Crossing this will require a Section 408 permit from the U.S. Army Corps of Engineers (USACE). This is a new permit and the approval process is still being developed. The crossing itself may require a directionally-drilled pipeline, or permission to use the Alaska Department of Transportation bridge as a route.

Currently, the North Pole WTP has enough spare capacity that it can provide water to the Community of Moose Creek without increasing capacity. Other projects within the North Pole municipality will also put demand on the WTP, so this situation may change.

7.3.2.4 Performance and Reliability

Performance and reliability for Alternative 1 includes:

- Water supplied by the North Pole WTP will comply with all water quality requirements, including those for manganese and iron.
- Regular water quality monitoring will be conducted as part of North Pole's regular requirements.
- The provision of a water tank at Moose Creek will mean that local peak demands can be met without requiring to add additional capacity at the WTP. The tank will be sized to cover short duration outages of water supply from North Pole.
- Distribution systems in this area can be prone to freezing in low flow conditions, therefore the design will require use of recirculation and heating to reduce/ eliminate this issue.

7.3.3 Alternative 2 – Water Supplied from Eielson AFB WTP

7.3.3.1 Description of Alternative 2

Potable water will be supplied by the Air Force from their WTP located on EAFB (Appendix B, Figure B-3). A new water main will carry water to a new holding tank located near the center of the Community of Moose Creek that will allow balancing of local demands on the existing EAFB WTP. The local distribution system will require to be pressurized and circulated with heat input to prevent freezing during winter (Appendix B, Figure B-2). An operating authority would be required to maintain and operate the system for the community.

7.3.3.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 2:

- Water main from EAFB to community of Moose Creek (LF = 17,480, Diameter = 6").
- Purchase land to locate reservoir and circulation PS (0.5 acre)
- Water Distribution Storage Tank (volume = 250,000-gallon).
- Pump Station (emergency generator, chlorination, and water heater).
- Local distribution system (LF = 47,640, Diameter = 4" and 6").
- Local connections to properties (200 properties).
- Disposal of current GAC or water tanks and well abandonment (200 properties).
- LUCs will be required to prevent new wells, the AF is evaluating authorities and means to implement GW use restrictions upon private property owners in Moose Creek.
- Existing wells may be decommissioned

7.3.3.3 Design/ Construction Issues

The EAFB WTP would become a supplier of water to the public outside the base boundary, and would have to change its operating status with ADEC. The proposed route for the water supply main and local distribution system crosses numerous roads and railways lines, each of which will require permits, and the overall water supply system will require to be permitted by ADEC.
The water distribution system would be operated and maintained by an operating authority that would be required to purchase water from EAFB.

7.3.3.4 Performance and Reliability

Performance and reliability for Alternative 2 includes:

- Water supplied by EAFB WTP complies with all water quality requirements, including those for manganese and iron.
- Water quality will be monitored as part of normal monitoring requirements.
- The provision of a water tank at Moose Creek will mean that local peak demands can be met, also the tank will be sized to cover short duration outages of water supply from the EAFB WTP
- Distribution systems can be liable to freezing in low flow conditions; therefore, design will require the use of recirculation and heating to reduce/ eliminate these issues.

7.3.4 Alternative 3 – Individual Property Potable Water Tanks

7.3.4.1 Description of Alternative

Currently, 100 properties have water tanks installed and 75 have GAC water filters. For Alternative 3, it is assumed that the 75 GAC water filters will be removed and water tanks installed at those and an additional 25 properties. All water deliveries would be by road tanker when the water tank level has dropped to allow a delivery.

7.3.4.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 3:

- New water tanks, pumps and ancillary equipment will be installed at each property and apartment location where one has not been installed.
- Disposal of current GAC filters to a regulated solid waste site.
- Water deliveries by road tanker will be made to all properties, as required.
- Water tanks and pumps will require periodic equipment maintenance and replacement at 25 years.
- LUCs will be required to prevent new wells, the AF is evaluating authorities and means to implement GW use restrictions upon private property owners in Moose Creek.
- Existing wells may be decommissioned

7.3.4.3 Design/ Construction Issues

Installation of water tanks has successfully been carried out at most properties, although some of the larger apartment blocks have not had this option installed to date.

7.3.4.4 Performance and Reliability

Performance and reliability for Alternative 3 includes:

- Water supplied by road complies with all water quality requirements, including those for manganese and iron.
- Water quality will require to be monitored by the Air Force if they maintain responsibility for deliveries.
- Dependence on water tanks at properties is vulnerable to road or tanker problems that could disrupt deliveries. Existing tanker deliveries are impacting roads, if all properties required road deliveries this would increase this issue
- Currently water quantities delivered are mainly for indoor household use, addition of non-potable use will increase frequency of road deliveries to properties.

7.3.5 Alternative 4 – Individual Property Potable Deep Wells

7.3.5.1 Description of Alternative

Currently, all properties in the Community of Moose Creek have wells that are approximately 50 feet deep. A test well has shown that water below 200 feet is uncontaminated with PFCs, so this alternative is to replace all the shallow wells at each property with a replacement well 250 feet deep. A new pump will be required, but all other piping should be reusable.

7.3.5.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 4:

- New deep wells (250 feet and 4" diameter) at each property and apartment location, with pumps. Top 200 feet will need to be 10" diameter and lined with bentonite to prevent infiltration by contaminated water.
- Pumps will require equipment maintenance and replacement at 25 years.
- Disposal of current GAC or water tanks and shallow well abandonment (200 properties).
- LUCs will be required to prevent new (shallow) wells being used the AF is evaluating authorities and means to implement GW use restrictions upon private property owners in Moose Creek.
- Existing wells may be decommissioned

7.3.5.3 Design/ Construction Issues

Installation of new wells lined with bentonite will require larger drilling equipment (10" diameter) different from that used for shallow wells. It is assumed, however, that the larger drilling rig can be accommodated without extensive work to access each property. A new pump will be required for the new well, but will be sized to give a similar flow rate and head to existing pumps.

7.3.5.4 Performance and Reliability

Performance and reliability for Alternative 4 includes:

- The new wells will be operated by the properties owners.
- There is limited water quantity and quality information available from the deep aquifer, however higher levels of dissolved metals (manganese and iron) currently experienced in the shallow wells are anticipated. Preliminary results have also shown higher levels of other metals (aluminum, arsenic and chromium) close to the EPA MCL values may be present, this would require to be investigated before proceeding with this option.
- It is possible that the aquifer below some properties may not have the required water quality and water quantity to supply the properties requirements. It is therefore possible this solution may not be possible for all properties.
- Over time, it is unknown if water contaminated with PFCs will migrate to lower levels and also contaminate these wells.
- Wells can be prone to freezing in low flow conditions; therefore, the design will need to use recirculation and heating to reduce/ eliminate this issue.

7.3.6 Alternative 5 – Water Supplied from a Community Deep Well

7.3.6.1 Description of Alternative

A new public water system would be developed to supply the Community of Moose Creek. A new, 250-foot deep well will provide water from below the PFC plume (Appendix B, Figure B-4). The water supplied would then be treated to remove manganese and iron and discharged into a local supply reservoir. The local distribution system will have to be pressurized and circulated with heat input to prevent freezing during winter (Appendix B Figure B-2). An operating authority would be required to maintain and operate the system for the community.

7.3.6.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 5:

- Moose Creek Community Well (250 feet deep and 10" diameter), top 200 feet will be bentonite lined to prevent infiltration by contaminated water.
- Well house, pumps, and associated equipment.
- WTP to remove manganese and iron to comply with secondary water quality standards (unless an exemption is granted by ADEC). Although PFC's are not currently present at this depth in the aquifer, space will be allowed for future installation of GAC.
- Water distribution storage tank (volume = 250,000 gallons).

- Distribution pump station (emergency generator, chlorination, and water heater).
- Local distribution system (LF = 47,640, Diameter = 4” and 6”).
- Local connections to properties (200 properties).
- Disposal of current GAC or water tanks and well abandonment (200 properties).
- LUCs will be required to prevent new wells, the AF is evaluating authorities and means to implement
- Existing wells may be decommissioned.

7.3.6.3 Design/ Construction Issues

Design/construction issues for Alternative 5 include:

- The new well will lined with bentonite for the top 200 feet. A new pump will be required for the new well, but will be sized to give similar flow rate and head to existing pumps.
- The water treatment and distribution system would be operated and maintained by an operating authority.
- The proposed route for the supply main and local distribution system crosses numerous roads and railways lines, each of which will require permits.
- The water supply system would be operated and maintained by the North Pole Municipality.

7.3.6.4 Performance and Reliability

Performance and reliability for Alternative 5 includes:

- Water supplied by a new Moose Creek Community WTP would be anticipated to comply with all water quality requirements, including those for manganese and iron due to water treatment being included in this alternative.
- Water quality will be monitored as part of operating permit requirements.
- The provision of a water tank at Moose Creek WTP will mean that local peak demands and recirculation requirements can be met without running the well pumps.
- Distribution systems can be prone to freezing in low flow conditions; therefore, the design will need to use recirculation and heating to reduce/ eliminate this issue.
- Over time, it is unknown if water contaminated with PFCs will migrate to lower levels of the aquifer and contaminate this well also. If this occurs, a GAC filtration stage would be required.

7.3.7 Alternative 6 – Individual Property GAC Treatment Systems

7.3.7.1 Description of Alternative

Currently, 75 properties have GAC water filters installed and 100 have water tanks. For Alternative 6, the 100 water tanks will be removed and GAC filters installed at those properties and an additional 25 properties. The Air Force would continue to monitor and maintain the systems.

7.3.7.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 6:

- Install GAC filters at each property and apartment location where one has not been installed.
- Modify pipework at all properties, so GAC treated water supplies all domestic uses.
- Disposal of current water tanks.
- Following completion, 200 GAC units will require to be maintained.
- GAC media will need replacement every 2 years.
- GAC mechanical and electrical equipment will need to be replaced every 25 years.

7.3.7.3 Design/ Construction Issues

During the TCRA, properties were given the choice of preferred system and the majority preferred water tanks. Alternative 6 will require installation at all locations, including those that have not requested it.

7.3.7.4 Performance and Reliability

The GAC water filters have to be tested regularly to check removal efficiency. This option will remove the requirement for road deliveries of water.

7.3.8 Alternative 7 – Status Quo

7.3.8.1 Description of Alternative

Currently, 75 properties have GAC water filters installed and 100 have water tanks. For Alternative 7, the remaining properties (assumed at 25) will have one of these solutions installed.

7.3.8.2 Quantities Used for Estimate

The following specific assumptions were made in order to evaluate Alternative 7:

- Provide a new GAC filter or water tank at each property and apartment location where one has not been installed.
- Approximately 80 GAC units will require maintenance.

- Approximately 120 Water tanks will require water deliveries.
- GAC media will need replacement every 2 years.
- GAC mechanical and electrical equipment will need to be replaced every 25 years.
- LUCs will be required to prevent well water being used without GAC filtration.

7.3.8.3 Design/ Construction Issues

Alternative 7 has largely been implemented already; therefore, few design or construction issues are anticipated. The larger apartment complex is the only major property that has not had a solution installed.

7.3.8.4 Performance and Reliability

The GAC water filters have to be tested regularly to check removal efficiency. The properties dependent on road deliveries will have to order water at regular intervals to maintain potable water on the premises. The high level of monitoring and maintenance required to maintain 200 separate systems within compliance will be a complex operation.

7.4 Preliminary Cost Estimates

Preliminary cost assumptions and estimates for each option were developed and are summarized in Table C-1 in Appendix C. These estimates were developed for option screening purposes and are based on the conceptual designs developed for this study, and are Class 5 Opinion-of-Probable-Construction-Cost (OPCC). The accuracy range limits for this specific OPCC class are defined by Association for the Advancement of Cost Engineering (AACE) International as follow: Low = -20 to -50 percent (%), and High = +30% to +100%, with a 90% confidence that the actual cost will fall within the bounds of these ranges after application of the appropriate contingencies.

The capital cost estimates for each option have an allowances for design and permitting, project administration and contingency based on their initial capital cost estimate.

To compare the Alternatives over their operating life Net Present Value (NPV) will be used to include anticipated operating cost over a 30 year period as recommended (USEPA. 1988b). The rate of return recommended for these projects is 5% however this applies to both all projects. For Federally funded projects it is recommended that the current Real Treasury Interest Rates published in Circular A-94 (Appendix C), which is 0.7% (for 2017, 30-Year) is used.

7.5 Evaluation of Options

The potable water supply alternatives for the Community of Moose Creek that were selected for evaluation will each be evaluated against the two threshold criteria and five balancing criteria described in Section 7.1. The potential benefits and challenges of each of the Alternatives outlined in Section 7.3 were considered.

7.5.1 No Action – Baseline

Protection of Human Health and the Environment – This alternative is not protective of human health. Remedial actions conducted to date would stop; therefore, human health and ecological risk levels would deteriorate. Although contaminants in the aquifer may decrease over time, the certainty and rate of this are unknown. Because this alternative does not protect human health and the environment, it "Fails" this criterion.

Compliance with ARARs – This alternative will not achieve ARARs and does not include any short term measures to comply with ARARs. This alternative "Fails" this criterion.

Long-Term Effectiveness and Permanence – This alternative does not effectively or permanently prevent human and ecological receptors from being exposed to PFOS or PFOA in drinking water. This alternative, therefore, does not provide long-term effectiveness and permanence, and rates "Low" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative does not involve treatment to reduce contaminants in the environment, so this criterion is not satisfied and rates "None."

Short-Term Effectiveness – The No Action alternative can be implemented immediately and poses no risks to the surrounding community, workers, or the environment as a result of the implementation. Although no short term detrimental impacts occur, there is no improvement in water quality to the community and no measurable duration until protection is achieved. Alternative 1 rates "Low" for this criterion.

Implementability – The No Action alternative can be implemented immediately with no issues to prevent it, this results in a "High" for this criterion.

Cost – No costs are associated with the No Action alternative which has the lowest cost of the alternatives considered for the Moose Creek Community.

State Acceptance – The No Action alternative does not ensure or verify protection of human health and the environment and is not likely to comply with ARARs in a reasonable time frame. State acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – The No Action Alternative does not ensure protection of human health and the environment and is not likely to comply with ARARs in a reasonable time frame. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – The No Action alternative will not achieve RAOs at the Community of Moose Creek.

7.5.2 Alternative 1 – Water Supply from North Pole Municipal WTP

Protection of Human Health and the Environment – This alternative will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment, it "Passes" this criterion.

Compliance with ARARs – Alternative 1 will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative "Passes" this criterion.

Long-Term Effectiveness and Permanence – The alternative provides water from a clean aquifer located in North Pole. The water supplied to Moose Creek would be further treated at the North Pole WTP that will be able to adapt to any future regulatory changes. North Pole Municipality has an administrative structure in place to reliably provide safe drinking water to the community and will do so into the future. This alternative, therefore, provides long-term effectiveness and permanence, and rates "High" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – Alternative 1 does not impact the chemicals present in the aquifer below the Community of Moose Creek. There will be no change in the quantities; therefore, this alternative rates "None" for this criterion.

Short-Term Effectiveness – Alternative 1 will take 2 to 3 years to implement due to the design and permitting process for a new water distribution system to be approved. However, once the system is installed and the local connections are made, the drinking water will immediately be in compliance. The existing water supply, as a result of the TCRA, will continue to operate until Alternative 1 is complete. This alternative rates "Medium" for this criterion.

Implementability – Alternative 1 will use well developed technology and is similar to other projects in the Fairbanks region. However, the route of the water main from North Pole to the Community of Moose Creek must cross the Chena Lakes Flood control area, which will involve negotiating with various permitting departments, and the exact requirements to comply are not known at this time. Following construction of the system and connection of the residences, this alternative will have the lowest long-term administrative requirements. Due to the uncertainty about this one aspect of the design, Alternative 1 rates "Medium" for this criterion.

Cost – The capital cost for Alternative 1 is the second highest of the alternatives evaluated; however, it has the second lowest net present value NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $40 million (M), which is in the middle of the range of resulting values.

State Acceptance – Alternative 1 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – Alternative 1 protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 1 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for the Community of Moose Creek.

7.5.3 Alternative 2 – Water Supply from Eielson AFB WTP

Protection of Human Health and the Environment – Alternative 2 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment; therefore, it "Passes" this criterion.

Compliance with ARARs – Alternative 2 will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative "Passes" this criterion.

Long-Term Effectiveness and Permanence – Alternative 2 provides water that is being treated at a modern WTP to industry standards, and should be able to adapt to any future regulatory changes. EAFB has an administrative structure in place to reliably provide safe drinking water to the community; however, the monitoring of publicly-supplied water may require an additional operating company. This alternative, therefore, provides long-term effectiveness and permanence, and rates "High" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative takes water from the aquifer below EAFB and treats it to remove PFCs. This will result in a reduction in PFC concentrations, although the impact compared to the overall plume will be small. Since this actively removes PFCs and allows water from existing wells to be utilized, this alternative rates "Low" for this criterion.

Short-Term Effectiveness – Alternative 2 will take 2 to 3 years to implement due to the design and permitting process for a new water distribution system to be approved. However, once the system is installed and the local connects made, the drinking water will immediately be in compliance. The existing water supply, as a result of the TCRA, will continue to operate until the alternative is complete. This alternative rates "Medium" for this criterion.

Implementability – Alternative 2 will use well developed technology and is similar to other projects in the Fairbanks region. The route of the water main from EAFB to Moose Creek Community should not present any significant issues. This alternative would require the Air Force to establish an operating authority and become a water purveyor, both of which are outside the Air Force's core missions and expose the Air Force to risk. Additional administrative and permitting burden as well as liability may be incurred. This alternative rates "Medium" for this criterion.

Cost – The capital cost for Alternative 2 is the third highest of the alternatives evaluated; however, it has the joint second lowest NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $36M, which is the second lowest of the resulting values.

State Acceptance – Alternative 2 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – Alternative 2 protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 2 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for the Community of Moose Creek.

7.5.4 Alternative 3 – Individual Property Water Tanks

Protection of Human Health and the Environment – Alternative 3 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment; therefore, it "Passes" this criterion.

Compliance with ARARs – This alternative will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative "Passes" this criterion.

Long-Term Effectiveness and Permanence – Alternative 3 provides water that is being treated at a modern WTP to industry standards and could be maintained for a long time. The delivery of water by road tanker will, however, require close monitoring and regulation to ensure water at all times complies with drinking water standards. The number of road tanker movements will increase as further development occurs in the community (only 100 properties are currently supplied by road tanker), which may become difficult to safely sustain. This alternative, although it provides long-term effectiveness and permanence, will require a high level of operation to maintain safe water deliver standards and road movements and, therefore, rates "Medium" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative does not impact the chemicals present in the aquifer below the Community of Moose Creek. There will be no change in the quantities; therefore, this alternative rates "None" for this criterion.

Short-Term Effectiveness – Alternative 3 could be implemented in under a year, since half the properties already have this alternative installed. The existing systems that are available as a result of the TCRA will continue to operate until the alternative is complete. This alternative rates "High" for this criterion.

Implementability – Alternative 3 will use the same approach used to install water tanks at other properties in the Community of Moose Creek and should not present any significant issues. Only large apartment blocks will require special solutions developed. This alternative rates “High” for this criterion.

Cost – The capital cost for Alternative 3 is the second lowest of the alternatives evaluated; however, it has the third highest NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $42M, which is in the middle of the range of resulting values.

State Acceptance – Alternative 3 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – Alternative 3 protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 3 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for the Community of Moose Creek.

7.5.5 Alternative 4 – Individual Property Potable Deep Wells

Protection of Human Health and the Environment – Alternative 4 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment; therefore, it “Passes” this criterion.

Compliance with ARARs – Alternative 4 will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative “Passes” this criterion.

Long-Term Effectiveness and Permanence – Alternative 4 provides water from an uncontaminated level in the aquifer and could for the foreseeable future. There is, however, a risk that the existing plume of contaminated ground water could spread, either by its own flow or by being drawn toward the pump inlet. Without tests conducted at different parts of the aquifer, there will be a risk that the water from these wells could become contaminated in a similar manner to the shallow wells. Water samples available from a well approximately 250 feet in the Moose Creek community area have indicated naturally occurring metal concentrations above EPA MCL values; therefore, this alternative rates “Medium” for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative does not impact the chemicals present in the aquifer below the Community of Moose Creek. There will be no change in the quantities. This alternative rates “None” for this criterion.

Short-Term Effectiveness – Alternative 4 could be implemented in 1 to 2 years. The existing systems available as a result of the TCRA will continue to operate until the alternative is complete. Uncertainty over water quality in the lower aquifer will require additional test wells to be developed. This alternative rates “Medium” for this criterion.

Implementability – This alternative will use a similar approach to install deep water wells to replace the shallow wells at each property. The drilling of 200 deep wells that require lining is a complex operation that may require more than one drilling rig, but this not regarded as a significant problem. The risk that water may not be available at all locations means it may not be implementable across the whole community. This alternative rates “Medium” for this criterion.

Cost – The capital cost for Alternative 4 is the highest of the alternatives evaluated; however, it has the lowest anticipated NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $33M, which is the lowest value.

State Acceptance – Alternative 4 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – This Alternative protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 4 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for Moose Creek Community.

7.5.6 Alternative 5 – Water Supply from New Community Deep Well

Protection of Human Health and the Environment – Alternative 5 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment; therefore, it “Passes” this criterion.

Compliance with ARARs – This alternative will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative “Passes” this criterion.

Long-Term Effectiveness and Permanence – Alternative 5 provides water from an uncontaminated level in the aquifer and could for the foreseeable future. There is, however, a risk that the existing plume of contaminated ground water could spread, either by its own flow or by being drawn toward the pump inlet. Without tests conducted at different parts of the aquifer, there will be a risk that the water from this well could become contaminated in a similar manner to the shallow wells. However, because only one well needs to be monitored and regularly tested, this alternative rates “Medium” for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative does not impact the chemicals present in the aquifer below the Community of Moose Creek. There will be no change in the quantities. This alternative rates “None” for this criterion.

Short-Term Effectiveness – This alternative could be implemented in 1 to 2 years. The existing systems available as a result of the TCRA will continue to operate until the alternative is complete. This alternative rates "Medium" for this criterion.

Implementability – Alternative 5 will use well developed technology and is similar to other projects in the Fairbanks region. The new deep well and well house would be located close to the storage tank and distribution pump station, and should not present any significant issues. This alternative rates "High" for this criterion.

Cost – The capital cost for Alternative 5 was in the middle of the alternatives evaluated; however, it has the third lowest anticipated NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $39M, which is in the middle range of the resulting values.

State Acceptance – Alternative 5 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – This alternative protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 5 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for Moose Creek Community.

7.5.7 Alternative 6 – Individual Property GAC Treatment Systems

Protection of Human Health and the Environment – Alternative 6 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment, it "Passes" this criterion.

Compliance with ARARs – This alternative will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative "Passes" this criterion.

Long-Term Effectiveness and Permanence – Alternative 6 provides water that is being treated using GAC to remove PFCs. Since there are 200 separate systems to monitor and maintain, there is an increased potential for issues with system failure and monitoring; therefore, this alternative rates "Medium" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative takes water from the aquifer below the Community of Moose Creek and treats it to remove PFCs. This will result in a reduction in PFC concentrations, although the impact compared to the overall plume will be small. Since this actively removes PFCs and allows water from existing wells to be utilized, this alternative rates "Low" for this criterion.

Short-Term Effectiveness – Alternative 6 could be implemented in under a year, since half the properties already have this alternative installed. The existing systems that are available as a result of the TCRA will continue to operate until the alternative is complete. This alternative rates "High" for this criterion.

Implementability – This alternative will use the same approach used to install GAC at other properties in the Community of Moose Creek, however, during the TCRA program it proved difficult to install these units at all properties. It is understood the issues can be overcome but makes it more difficult to apply this solution. The larger apartment blocks will require special solutions developed. This alternative rates "Medium" for this criterion.

Cost – The capital cost for Alternative 6 is the third lowest of the alternatives evaluated; however, it has the highest anticipated NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $67M, which is the highest value.

State Acceptance – Alternative 6 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – This alternative protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 6 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for Moose Creek Community.

7.5.8 Alternative 7 – Status Quo

Protection of Human Health and the Environment – Alternative 7 will supply water that complies with all ADEC drinking water standards and the EPA LHA for both PFOS and PFOA. This alternative protects human health and the environment, it "Passes" this criterion.

Compliance with ARARs – This alternative will comply with ARARs, including the action-specific ARARs, chemical-specific ARARs, and any location-specific ARARs governing actions in potentially sensitive habitat (if applicable). This alternative "Passes" this criterion.

Long-Term Effectiveness and Permanence – Alternative 7 provides water that is being treated using GAC to remove PFCs or water that is delivered by road tanker. Since there are 200 separate systems to monitor and maintain, is an increased potential for issues with system failure and monitoring; therefore, this alternative rates "Medium" for this criterion.

Reduction in Toxicity, Mobility, or Volume through Treatment – This alternative will take water from the aquifer below the Community of Moose Creek and treat it to remove PFCs, for the properties that have GAC treatment installed. This will result in a reduction in PFC concentrations, although the impact compared to the overall plume will be small. Since this actively removes PFCs and allows water from existing wells to be utilized, this alternative rates "Low" for this criterion.

Short-Term Effectiveness –Alternative 7 has already been implemented, as part of the TCRA, and will continue to operate. Properties receiving bottled water are anticipated to be changed to a GAC filter or water tank option in the near future. This alternative rates "High" for this criterion.

Implementability – This alternative has largely been implemented already, as part of the TCRA, and will continue to operate, but with additional pipework and LUC modifications. The remaining properties, including apartment complexes are anticipated to be completed soon. This alternative rates "High" for this criterion.

Cost – The capital cost for this alternative is the lowest of the alternatives evaluated; however, it has the second highest anticipated NPV (0.7%) recurring cost. This results in a NPV (0.7%) of approximately $50M, which is in the upper range of values.

State Acceptance – Alternative 7 protects human health and the environment and will comply with ARARs. Agency acceptance will be assessed after agency comments have been received on this IFS.

Community Acceptance – This alternative protects human health and the environment and will comply with ARARs. Community acceptance will be assessed after the public notification period has concluded and comments from the public have been received on the IPP.

Summary – Alternative 7 will eliminate human exposure to PFOS and PFOA in drinking water. This alternative will, thus, prevent human exposures to site contaminants and will achieve the RAOs for Moose Creek Community.

7.5.9 Comparative Evaluation Results of Potable Water Supply Alternatives

The potable water supply alternatives selected for the Community of Moose Creek were evaluated comparatively against the two threshold criteria and five balancing criteria described in Section 7.1. Evaluation against the two modifying criteria (state acceptance and community acceptance) will be conducted as part of the IPP and IROD.

Alternatives were rated based on their expected performance relative to each criterion. The following rating system was used to evaluate the performance of an action alternative:

- High – meets the requirements of the criterion.
- Medium – generally meets the requirements of the criterion, but with qualifiers.
- Low – does not meet the requirements of the criterion.
- None – For Reduction in TMV if no impact is anticipated by this alternative,

Evaluation results for the considered alternatives are presented in **Table 7-2**.

Table 7-2 Potable Water Supply Alternatives Comparative Evaluation

Item	Baseline	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
	No Action	Water Supply from North Pole WTP	Water Supply from EAFB WTP	Individual Property Water Tanks	Individual Property Deep Wells	Water Supply from Community Deep Well	Individual Property GAC Treatment	Status Quo
EVALUATION CRITERIA								
Protection of Human Health and Environment	Fail	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**
Compliance with ARARs/TBCs	Fail	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**
Long-Term Effectiveness and Permanence	Low	**High**	**High**	Medium	Medium	Medium	Medium	Medium
Reduction in TMV Through Treatment	None	None	Low	None	None	None	Low	Low
Short-Term Effectiveness	Low	Medium	Medium	**High**	Medium	Medium	**High**	**High**
Implementability	**High**	Medium	Medium	**High**	Medium	**High**	Medium	**High**
ESTIMATED COSTS								
Capital Costs	$0	$25,356,000	$21,683,000	$2,146,000	$26,905,000	$22,025,000	$1,753,000	$904,000
NPV of Recurring Costs at 0.7%	$0	$14,697,810	$14,697,810	$39,614,195	$5,720,927	$16,543,888	$65,669,500	$48,733,552
NPV at 0.7%	$0	$40,054,000	**$36,381,000**	$41,760,000	**$32,626,000**	$38,569,000	$67,423,000	$49,638,000

Key:
% – percent
ARARs – applicable or relevant and appropriate requirements
EAFB – Eielson Air Force Base
GAC – Granulated Activated Carbon
NPV – Net Present Value
TBC – To Be Considered
TMV – Toxicity, Mobility, and Volume
WTP – Water Treatment Plant

8.0 REFERENCES

Alaska Department of Fish and Game (ADF&G). 2015. Alaska Lakes Database. Available at: http://www.adfg.alaska.gov/index.cfm?adfg=fishingsportstockinghatcheries.lakesdatabase.

AECOM. 2013. Conceptual Site Model for Eielson Air Force Base, Alaska. May.

Alaska Department of Environmental Conservation (ADEC). 2017. 18 AAC 75 Oil and Other Hazardous Substances Pollution Control. March 23.

Air Force Civil Engineer Center (AFCEC). 2015a. Action Memorandum for a Time-Critical Removal Action of PFC-Contaminated Water at Moose Creek, Alaska. Final. November 18.

AFCEC. 2015b. Final Preliminary Assessment Report for Perfluorinated Compounds at Eielson Air Force Base, Alaska. Prepared by CH2M HILL. December.

Cederstrom, D. J. 1963. Ground-water Occurrence in an Area of Discontinuous Permafrost, Ground-Water Resources of the Fairbanks Area Alaska, Geological Survey Water-Supply.

Environmental Data Resources (EDR). 2015. EDR Offsite Receptor Report 4281494_3, EDR NEPACHECK 4281494.2s, EDR GEOCHECK 4281494_1.1s. May.

Pewe, T. L. 1982. Cited in AFCEC 2015b, but reference not found there.

Pewe, T. L. and J.W. Bell. 1975. Geologic Map of the Fairbanks D-2 SE Quadrangle, Alaska.

U.S. Army Corps of Engineers (USACE). 2015. Final Site Investigation Report for Site Investigations of Fire Fighting Foam Usage at Various Air Force Bases in the United States for Eielson Air Force Base. February.

USACE. 2016. Work Plan for Perfluorinated Compounds (PFCs) Site Inspections at Eielson Air Force Base, Alaska. Prepared by CH2M. July.

U.S. Air Force (USAF). 2014. U.S. Air Force Installation Restoration Program, 2013 Five-Year Review, Eielson Air Force Base, Alaska. February.

USAF. 2016. U.S. Air Force, Final Eielson Air Force Base Water Treatment Plant 9WTP) Design Report for GAC Treatment Intermediate Design Submission. March.

USAF. 2016. Memorandum: SAF/IE Policy on Perfluorinated Compounds (PFCs) of Concern, Department of the Air Force. August

U.S. Environmental Protection Agency (USEPA). 1988a. Guidance Document for Providing Alternative Water Supplies. Document EPA/540/G-87/006. February

USEPA. 1988b. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Document EPA/540/G-89/004. October

USEPA. 1988c. Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites. Document EPA/540/G-88/003. December.

USEPA. 1999, Soil Screening Levels for PFOA and PFOS. Memorandum. EPA Region 4, November.

USEPA. 2016. Fact Sheet. PFOA & PFOS Drinking Water Health Advisories. Document EPA-800-F-16-003. May.

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APPENDIX A

Review of PFC Treatment Alternatives

Review of PFC Treatment Alternatives

The treatment methods presented herein were evaluated for their feasibility to remove PFOA and PFOS from the existing groundwater supply and at a location near the existing WTP. Treatment capacities in the range of 1,000 to 3,000 gpm were considered as part of initial screening of options.

PFOA/PFOS are relatively large and stable organic molecules, which can affect the effectiveness of certain treatment technologies. This fact, coupled with lack of a large database of historical treatment performance at different locations, limits the ability to accurately assess all treatment options. But, there is available research and literature that provides the basis for most of the discussions herein. A review of possible treatment alternatives for the EAFB WTP is presented below.

Conventional Water Treatment Processes

Traditional/conventional water treatment processes commonly used to treat groundwater and surface water include:

- Coagulation, clarification, and filtration (using granular media filters or low-pressure membrane filters).
- Iron and manganese removal, using oxidation, clarification (sometimes), and filtration.
- Lime softening, using lime to raise the pH to remove dissolved Ca and Mg.

PFOA/PFOS are highly soluble at neutral pH levels and do not coagulate or settle out using traditional or conventional processes or chemicals. None of these processes have been demonstrated to be able to remove low concentrations of PFOA and PFOS. As mentioned previously, the existing iron/manganese removal process at the EAFB WTP (oxidation followed by greensand filtration) does not remove any PFCs.

Advanced Oxidation Processes

Advanced oxidation processes (**Figure A-1**) have become more-prevalent in the drinking water treatment industry over the past 20 years and include:

- Ozonation.
- Enhanced ozonation via addition of hydrogen peroxide.
- UV (ultraviolet) light.
- Enhanced UV oxidation via addition of hydrogen peroxide or chlorine.

These processes can create hydroxyl radicals that are capable of oxidizing and changing specific organic molecules, and are very good for reducing many trace organic contaminants. One benefit of this type of process is that it does not usually create a residual waste by-product that must be handled and disposed of. However, it does not appear that advanced oxidation processes can provide effective destruction of PFCs, presumably due to the strong molecular bond created by the fluorine. Literature indicates that PFCs are either inert to the oxidation process or the yield product of oxidation is just as recalcitrant (stable) as the initial compound. Therefore, none of these processes are able to remove low concentrations of PFOA and PFOS.

Example hydrogen peroxide feed tank and UV reactor

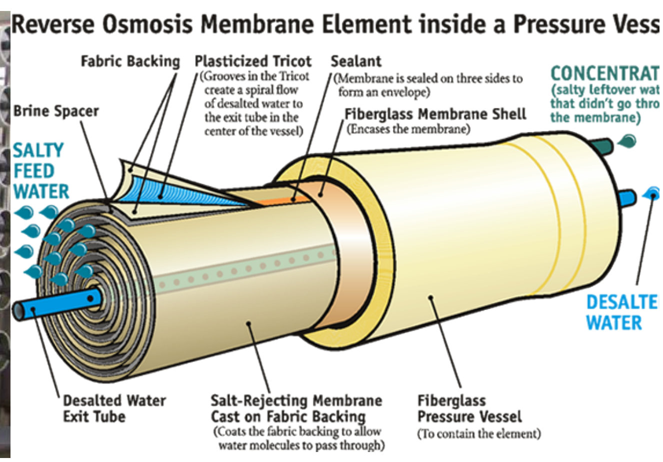
Example liquid oxygen tank and ozone generator system

Figure A 1 Examples of Advanced Oxidation Processes

High Pressure Membrane Processes

These processes use specially-designed membranes that exclude almost all dissolved molecules and require high pressures (upwards of 600 psi for seawater) to force the water through the membrane's tight pore spaces. Reverse osmosis (RO) is commonly used for desalination of seawater and brackish water to produce potable water (**Figure A-2**). Nanofiltration (NF) uses membranes with slightly larger pore spaces than RO membranes and is often used to remove large molecules such as Ca and Mg, as well as TOC. NF is commonly referred to as "membrane softening" and requires lower operating pressures compared to RO.

Example reverse osmosis membrane rack



Reverse osmosis cartridge graphical representation

Figure A 2 Examples of Reverse Osmosis

RO has become a viable alternative for removal of trace contaminants, including specific inorganic and organic compounds, and has demonstrated to successfully remove PFOA and PFOS. Because of the relatively-large molecular size of PFOA/PFOS, it is believed that NF will remove these contaminants also.

Membrane removal processes require high operating pressures and, therefore, require large horsepower booster pumps, thereby using large amounts of electrical energy. These processes also have a relatively low production efficiency, which means that a high percentage of feedwater is required to produce the desired volume of product water. For example, RO processes may require over 2 gallons of feedwater to produce 1 gallon of treated water. These processes also produce a continuous waste stream of reject water, which must be handled and disposed of. Additionally, if RO is used, the product water will be virtually free of any minerals and will, therefore, require chemical additions (such as lime, soda ash and/or carbon dioxide) to make the water non-corrosive and palatable, compared to the current treated water being distributed from the WTP.

RO and NF will be relatively expensive to construct and operate compared to other treatment alternatives, and should only be considered for the EAFB if there are no other viable alternatives.

Ion Exchange Process

Ion exchange (IX) uses specially-manufactured resins that are designed to remove certain dissolved compounds (**Figure A-3**). The resin beads eventually exhaust their exchange capacity and then must be regenerated with a specific chemical solution to bring the resin back to its original adsorptive state. Historically, IX has been used commonly for water softening (to remove Ca and Mg hardness) and uses brine (salt solution) as its regenerant. The high total dissolved solids (TDS) waste stream produced during regeneration must be handled and disposed of properly. IX is now used for a number of water treatment purposes besides softening, including nitrate removal and selective inorganic or organic contaminant removal.

Example photo of ion exchange resin beads

Example photo of ion exchange contactors

Figure A 3 Examples of Ion Exchange

IX resins are contained within pressure vessels, and the number of vessels depends on flowrate and the type/concentration of contaminants to be removed. The regenerant chemical is pumped through the vessel when exchange capacity has been exhausted and the waste stream must be collected and disposed of.

There are commercially available resins that have shown some promise of IX to remove various PFCs at the bench-scale level, but IX is not currently an industry-accepted long-term approach for treating PFOA or PFOS.

Adsorption Processes

Activated carbon has been demonstrated to be capable of removing PFOA/PFOS from drinking water supplies. There are two types of carbon adsorption processes that can be considered including: use of powdered activated carbon (PAC) and GAC.

PAC is a dry chemical delivered and stored in bulk or in sacks and fed to the flowstream continuously. PAC reacts with the water to remove dissolved organic compounds, with the dose and contact time dependent on the type and concentration of compounds to be removed. The PAC solids are then removed from the flowstream and must be properly handled and disposed of, similar to other liquid-solids waste streams created by a water treatment process. This process requires a mixing/contact stage, a clarification stage, and then a filtration stage to produce the desired treatment and potable water quality.

GAC is a granular material of similar size to traditional filter media, such as anthracite and sand. Treatment with GAC is achieved by passing the water through a fixed bed, either inside a pressure vessel or in a gravity contact basin. The GAC continues to remove the contaminant(s) until its adsorptive capacity is exhausted. Then, the GAC must be removed and replaced with fresh GAC. Sometimes, the GAC is regenerated off-site and then returned to the treatment plant for re-use. Examples of GAC are shown on **Figure A-4**.

Example granular activated carbon media

Example granular activated carbon pressure vessels

Figure A 4 Examples of GAC

Use of GAC at the EAFB WTP should be considered as one of the Best-Available Treatment options for PFC removal. The limited number of large-scale PFC treatment installations in the U.S.

are also using GAC treatment. GAC treatment can be integrated into the existing WTP processes, as discussed further below.

The use of PAC does not appear to be desirable for the EAFB WTP situation since it requires: a new chemical storage and feed system; use of contact basins, clarifiers, and filters; and produces a continuous waste stream to be handled and disposed of.

Research in the United Kingdom has been performed on chemical additives that can promote PFOA/PFOS to be more receptive to adsorption by GAC. These additives have not yet been National Science Foundation-approved in the U.S., but in the future may assist in increasing the life of GAC and/or removal efficiencies of GAC.

Summary and Recommendations

Table A2-1 summarizes the evaluation and comparison of treatment alternatives considered for the EAFB WTP to remove PFOA/PFOS. The use of a GAC contactor system is considered a Best Available Treatment, appears to be the most-viable alternative compared to other alternatives, and will also result in the lowest-cost treatment solution. Compared to other treatment alternatives, GAC adsorption offers the following benefits:

- Proven process at similar capacities with installed systems elsewhere.
- Relatively “benign” process with low level of complexity and O&M.
- No continuous residual stream to handle (versus RO, NF, and IX).
- Well-suited to integrate with existing WTP processes.
- Will provide other water quality benefits.
- Can remove other organic CECs, if needed.
- Will reduce chlorine demand and chlorine residual decay; reduces chlorine usage.
- Can reduce formation of disinfection by-products (DBPs).

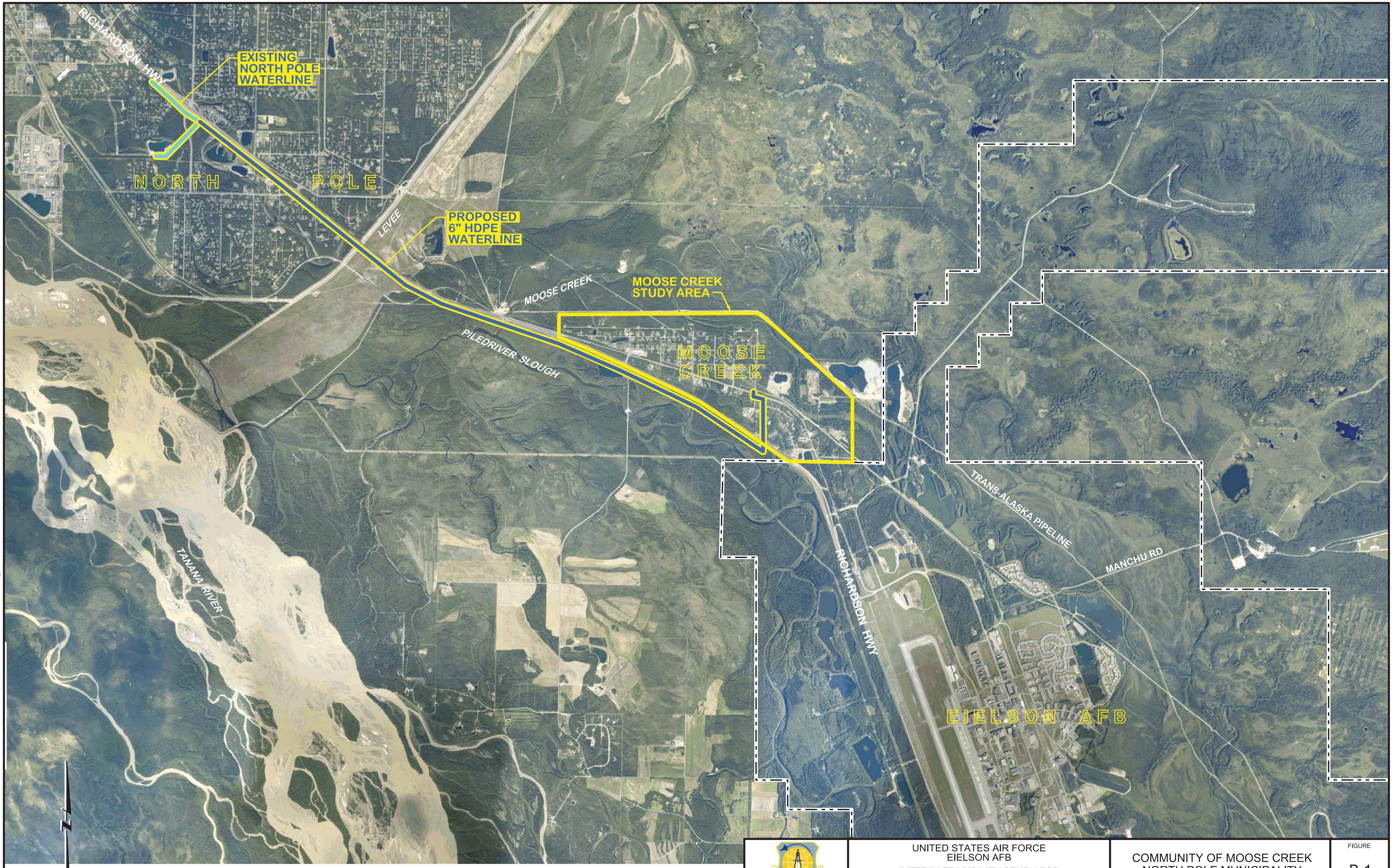
Table A2-1 Review of Potential Treatment Alternatives for PFCs

Alternative	Efficacy	Installed Systems	Residuals Handling	Power Required	Operation Impacts	Schedule to Implement	Relative Capital Cost	Relative O&M Cost	Comments
Iron and manganese treatment	None	No	N/A	N/A	N/A	N/A	N/A	N/A	Not a viable option.
Lime softening	None	No	N/A	N/A	N/A	N/A	N/A	N/A	Not a viable option.
Conventional treatment	None	No	N/A	N/A	N/A	N/A	N/A	N/A	Not a viable option.
Advanced Oxidation	Limited	No	N/A	N/A	N/A	N/A	N/A	N/A	Not a viable option.
Ion Exchange	Moderate	Unknown	Continuous	Low	Moderate	18 months	Moderate	Moderate	Requires regeneration system.
Nanofiltration	Moderate -High	Unknown	Continuous	High	High	18 months	High	High	Will soften water, but some TDS remains.
Reverse Osmosis	Moderate -High	Unknown	Continuous	High	High	18 months	High	High	Requires post-treatment chemical addition to increase TDS.
Enhanced coagulation + GAC	Moderate -High	Bench-Scale	Batch	Low	Low-Moderate	<12 months	Moderate	Low-Moderate	Additive from Europe not yet NSF approved in U.S.
Powdered Activated Carbon	Moderate -High	Unknown	Continuous	Low	High	18-24 months	High	High	Requires contact basin and filters; continuous PAC feed
GAC	Moderate -High	Yes	Batch	Low	Low	<12 months	Low	Low	Can consider pressure vessels or gravity filters.

Key:
< – less than
GAC – Granular Activated Carbon
N/A – not applicable
NSF – National Science Foundation
O&M – operation and maintenance
PAC – powdered activated carbon
TDS – total dissolved solids
PFC – perflourinated compound

APPENDIX B

Figures of Alternatives,
Moose Creek Potable Water Supply



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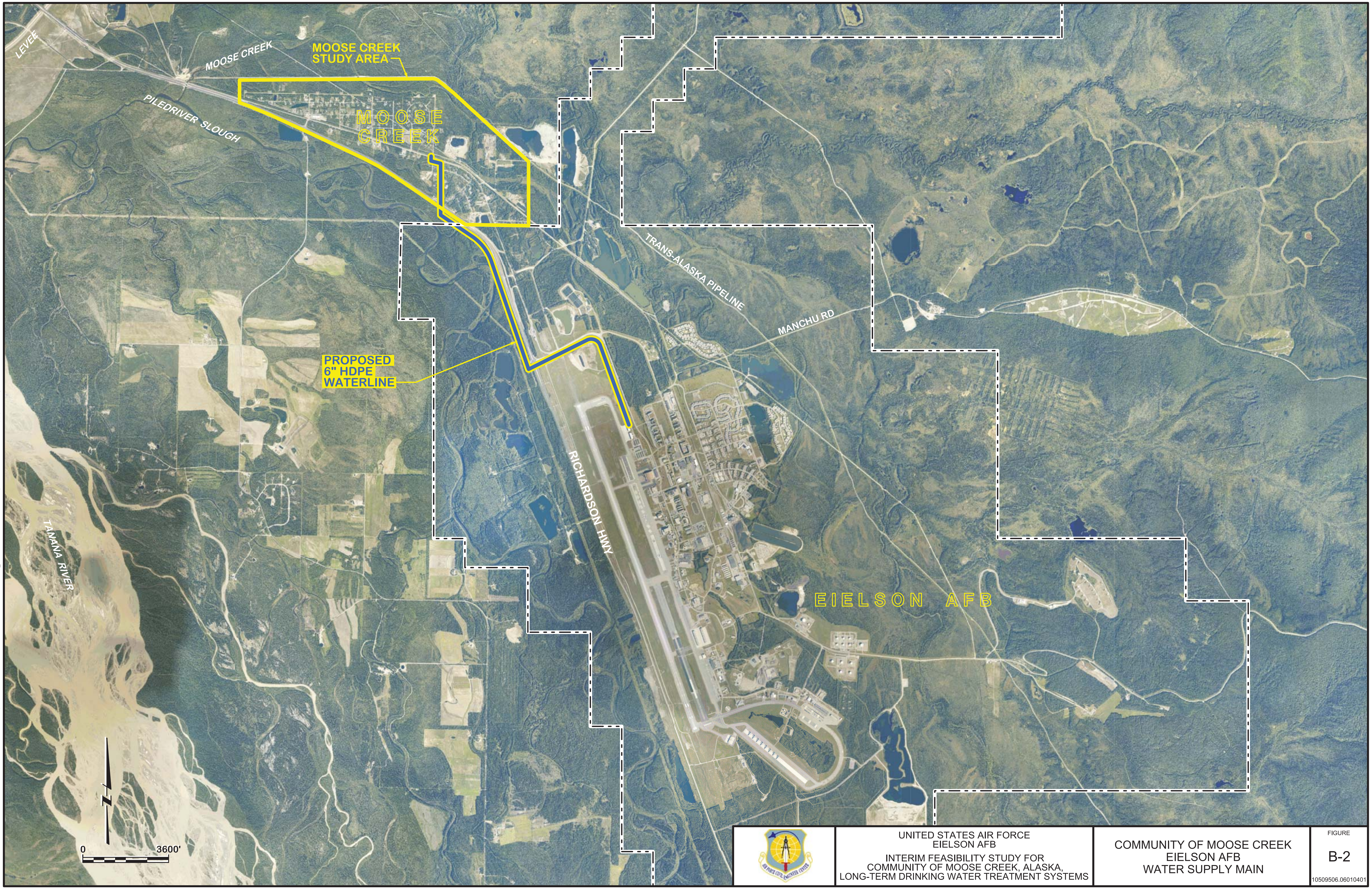
INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

COMMUNITY OF MOOSE CREEK
NORTH POLE MUNICIPALITY
WATER SUPPLY MAIN

FIGURE
B-1

10509506.06010401

TIME: 12-JUN-2017 10:09 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig B-1 North Pole Municipality Water System.dgn



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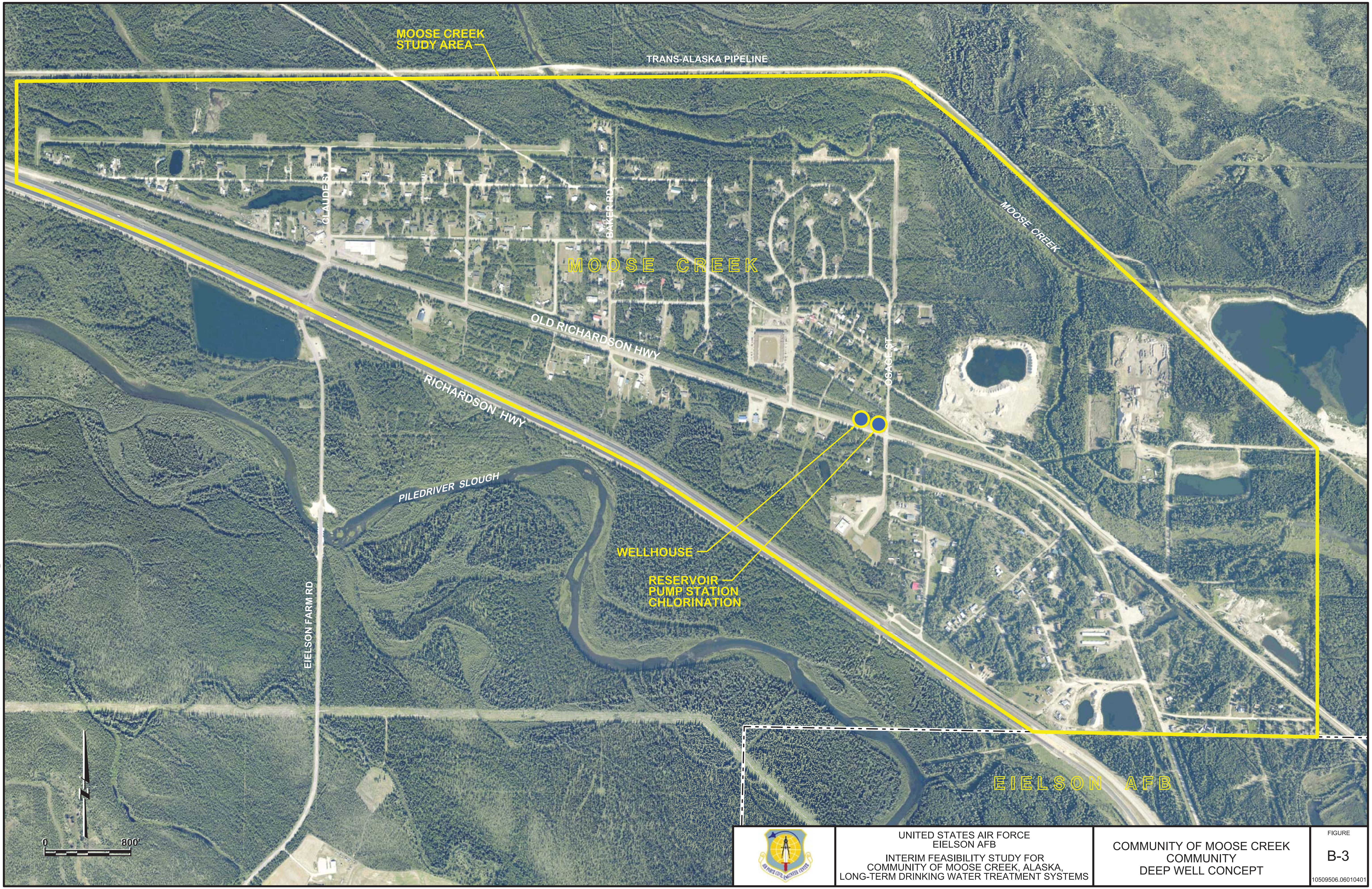
INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

COMMUNITY OF MOOSE CREEK
EIELSON AFB
WATER SUPPLY MAIN

FIGURE
B-2
10509506.06010401

TIME: 12-JUN-2017 10:04 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig B-2 Eielson AFB Water Supply Main.dgn



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INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

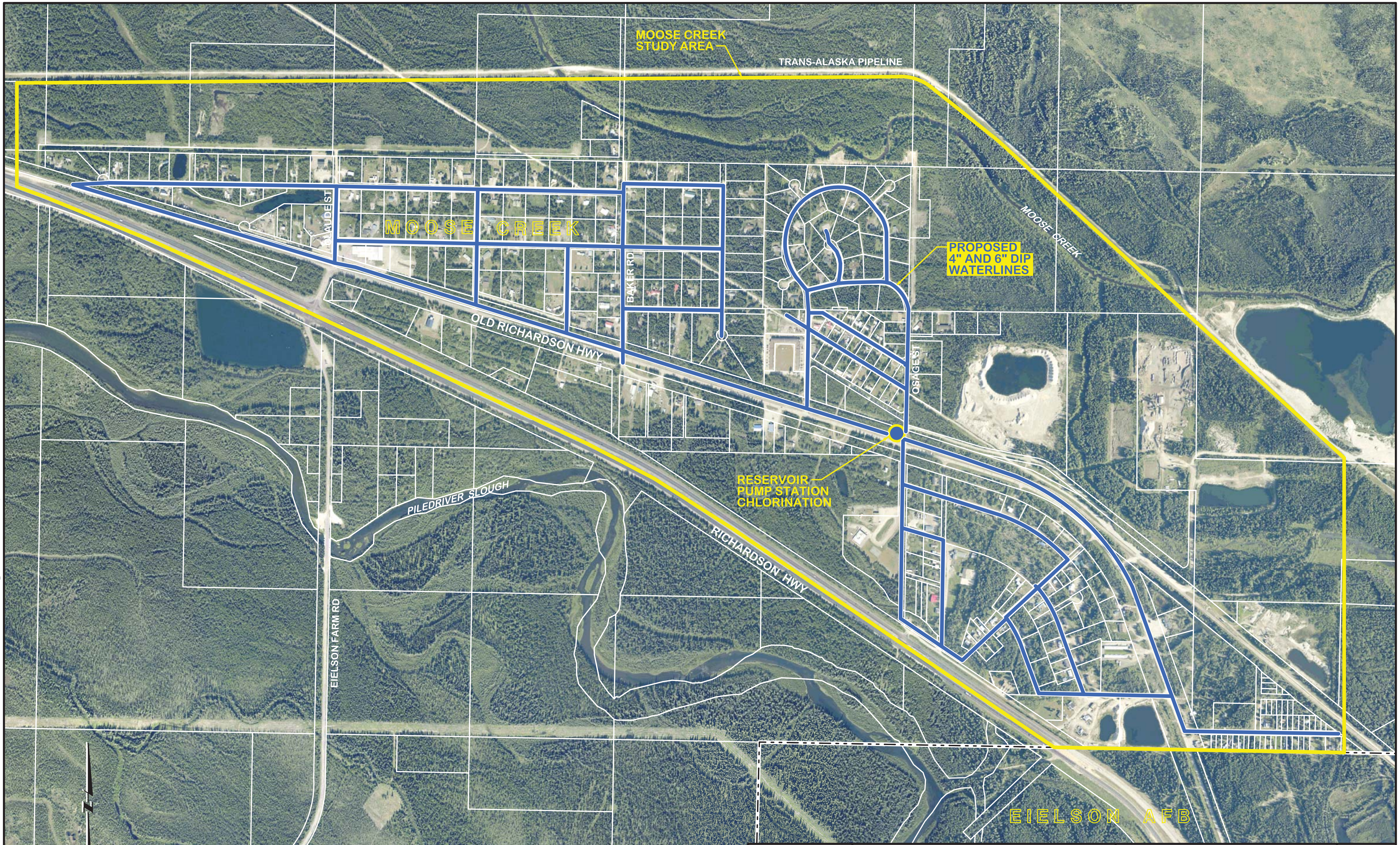
COMMUNITY OF MOOSE CREEK
COMMUNITY
DEEP WELL CONCEPT

FIGURE

B-3

10509506.06010401

TIME: 12-JUN-2017 09:59 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_185750715\draft-June 2017\Fig B-3 Moose Creek Community Deep Well Concept.dgn



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INTERIM FEASIBILITY STUDY FOR
COMMUNITY OF MOOSE CREEK, ALASKA,
LONG-TERM DRINKING WATER TREATMENT SYSTEMS

COMMUNITY OF MOOSE CREEK
LOCAL DISTRIBUTION
SYSTEM CONCEPT

FIGURE
B-4
10509506.06010401

TIME: 12-JUN-2017 09:54 FILE: C:\D\CAD\Proj\AFCEC\2016-2017 Eielson-Moose Creek FS (10509506)_18575071 5\draft-June 2017\Fig B-4 Moose Creek Local Distribution System Concept.dgn

APPENDIX C

Cost Estimates of Alternatives,
Moose Creek Potable Water Supply

Table C-1 Cost Estimates of Alternatives - Moose Creek Potable Water Supply

				Baseline		Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7	
				No Action		North Pole Supply		EAFB Supply		Individual Water Tanks		Individual Wells		New Community Well		Individual GAC		Status Quo	
Potable Water Supply Component		**Unit Cost**	**Units**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Capital Costs																			
Upgrade City of North Pole WTP		$280,000	lump sum	0	$0	1	$280,000	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
New Water Trans. Main	*	$100	per linear foot	0	$0	17,210	$1,721,000	17,480	$1,748,000	0	$0	0	$0	0	$0	0	$0	0	$0
New Water Trans. Main (DD Section)	+	$150	per linear foot	0	$0	12,800	$1,920,000	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
New Local Distribution Mains	*	$160	per linear foot	0	$0	47,640	$7,622,400	47,640	$7,622,400	0	$0	0	$0	47,640	$7,622,400	0	$0	0	$0
New Local Service Connections	*	$3,200	per property	0	$0	200	$640,000	200	$640,000	0	$0	0	$0	200	$640,000	0	$0	0	$0
New Local Storage Tank	*	$1,020,000	lump sum	0	$0	1	$1,020,000	1	$1,020,000	0	$0	0	$0	1	$1,020,000	0	$0	0	$0
New Distribution Pump Station	*	$880,000	lump sum	0	$0	1	$880,000	1	$880,000	0	$0	0	$0	1	$880,000	0	$0	0	$0
New Community Deep Well	*	$260,000	lump sum	0	$0	0	$0	0	$0	0	$0	0	$0	1	$260,000	0	$0	0	$0
New Community Wellhouse	*	$340,000	lump sum	0	$0	0	$0	0	$0	0	$0	0	$0	1	$340,000	0	$0	0	$0
New Community WTP	*	$1,350,000	lump sum	0	$0	0	$0	0	$0	0	$0	0	$0	1	$1,350,000	0	$0	0	$0
New Property Deep Well and Pump	x	$75,000	lump sum	0	$0	0	$0	0	$0	0	$0	200	$15,000,000	0	$0	0	$0	0	$0
Abandon/ Dispose: GAC/ Tank/ Well		$4,100	per property	0	$0	200	$820,000	200	$820,000	200	$820,000	200	$820,000	200	$820,000	70	$287,000	100	$410,000
New GAC Unit Installation		$5,000	per property	0	$0	0	$0	0	$0	0	$0	0	$0		$0	130	$650,000	25	$125,000
New Water Tank Installation		$5,000	per property	0	$0	0	$0	0	$0	70	$350,000	0	$0		$0	0	$0		$0
LUC - Deed Restrictions		$100,000	lump sum	0	$0	1	$100,000	1	$100,000	1	$100,000	1	$100,000	1	$100,000	1	$100,000	0	$0
CAPITAL SUBTOTAL					**$0**		**$15,003,400**		**$12,830,400**		**$1,270,000**		**$15,920,000**		**$13,032,400**		**$1,037,000**		**$535,000**
Engineering / Permitting / Survey / ROW		20%			$0		$3,000,680		$2,566,080		$254,000		$3,184,000		$2,606,480		$207,400		$107,000
Construction Administration		10%			$0		$1,500,340		$1,283,040		$127,000		$1,592,000		$1,303,240		$103,700		$53,500
Contingency		30%			$0		$5,851,326		$5,003,856		$495,300		$6,208,800		$5,082,636		$404,430		$208,650
CAPITAL TOTAL							**$25,355,746**		**$21,683,376**		**$2,146,300**		**$26,904,800**		**$22,024,756**		**$1,752,530**		**$904,150**
Operation and Maintenance																			
GAC unit replacement (25 years)		$200	per property	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	200	$40,000	70	$14,000
Well Pump Replacement (25 years)		$4,200	per property	0	$0	0	$0	0	$0	0	$0	200	$840,000	0	$0	0	$0	0	$0
GAC O&M (Annual)		$12,166	per property	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	200	$2,433,200	70	$851,620
Water Tank O&M (annual)		$7,343	per property	0	$0	0	$0	0	$0	200	$1,468,571	0	$0	0	$0	0	$0	130	$954,571
Individual Deep Well O&M (annual)		$925	per property	0	$0	0	$0	0	$0	0	$0	200	$185,000	0	$0	0	$0	0	$0
Cost of Water Purchase (North Pole)		$5.00	per 1000 gal	0	$0	27,375	$136,875	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Cost of Water Purchase (Eielson)		$5.00	per 1000 gal	0	$0		$0	27,375	$136,875	0	$0	0	$0	0	$0	0	$0	0	$0
Cost of Water Purchase (local)		$7.50	per 1000 gal	0	$0		$0	0	$0	0	$0	0	$0	27,375	$205,313	0	$0	0	$0
O&M Local Water Distribution System		$170	per property month	0	$0	200	$408,000	200	$408,000	0	$0	0	$0	200	$408,000	0	$0	0	$0
Net Present Value																			
NPV of Recurring Costs (30-yr)		0.7%			$0		$14,697,810		$14,697,810		$39,614,195		$5,720,927		$16,543,888		$65,669,500		$48,733,552
NPV of Recurring Costs (30-yr)		5.0%			$0		$8,376,064		$8,376,064		$22,575,542		$3,160,491		$9,428,116		$37,419,323		$27,770,866
SUMMARY																			
Capital		Total			**$0**		**$25,356,000**		**$21,683,000**		**$2,146,000**		**$26,905,000**		**$22,025,000**		**$1,753,000**		**$904,000**
NPV (30-yr)		0.7%			**$0**		**$40,054,000**		**$36,381,000**		**$41,760,000**		**$32,626,000**		**$38,569,000**		**$67,423,000**		**$49,638,000**
NPV (30-yr)		5.0%			**$0**		**$33,732,000**		**$30,059,000**		**$24,722,000**		**$30,065,000**		**$31,453,000**		**$39,172,000**		**$28,675,000**

Table C-1 (Cont.) Cost Estimates of Alternatives – Moose Creek Potable Water Supply

Definition of Alternatives:
No Action – Baseline
Alternative 1 – Water Supply from North Pole Municipal WTP
Alternative 2 – Water Supply from Eielson Air Force Base WTP
Alternative 3 - Individual Property Water Tanks
Alternative 4 – Individual Property Potable Deep Wells
Alternative 5 – Water Supply from New Community Deep Well
Alternative 6 – Individual Property GAC Treatment Systems
Alternative 7 – Status Quo

Assumptions:
* - Cost estimate form MWH estimators for conceptual design for Moose Creek Community Water Supply (summary sheet attached)
+ - Estimate for Directionally drilled water supply pipe to cross Chena Flood Control barrier (ROM Build up attached)
x – Cost supplied by Fairbanks based well installation contractors, with Prime Contractor cost added
** - Communication from North Pole Municipality indicated that an additional Green Sand filter installed in the planned extension to the WTP will be required to supply Moose Creek;
a - Quantity of water required to supply the Moose Creek community assumed as 27,375 thousand gallons/ annum (based on 75,000 gallons/ day)
b – Costs assumed to be financed as part of utility rate structure.
c – Includes O&M, sampling, electrical, GAC replacement, public relations and admin support.

Key:
% – percent
' – feet
" – inch
Dia – diameter
DD – directional drill
GAC – granular activated carbon
IC – institutional control
O&M – operation and maintenance
NPV – Net Present value
ROW – right of way
WTP – water treatment plant

WORK BREAKDOWN STRUCTURE

Project Name	Location	Date	Estimator	Version	Job #
Moose Creek Water Supply Alternatives	Moose Creek, AK	14-Oct-16	Jim Ward	000	10509506

WBS Items

Direct Costs — Costs are compilations of WBS coded items from DIVS 1-17 sheets

Cost-of-Work — Build-up methodology of these costs from direct costs is demonstrated in OPCC SUMMARY sheet

WBS	Description	ALLOCATE to Other WBS	CATEGORY Assignment	EXCLUDE from Allocations	MH	MH $	M&CE $	EQ $	DIRECT COST TOTAL	MH	MH $	M&CE $	EQ $	COST-OF-WORK (C-O-W) TOTAL	C-O-W with Proportional ALLOCATION of Checked (at left) WBS Items	CATEGORY TOTAL
	GENERAL		G													$0
0	Prime Contractor	✓	G											$7,471,297		
1	General Conditions	✓	G		4,180	$250,808	$726,700		$977,508	5,016	$378,086	$886,724		$1,264,810		
2	General Allowances	✓	G		1,587	$96,272	$140,183	$8,742	$245,197	1,905	$154,136	$175,718	$13,705	$343,560		
3	Power, Process, & Site Control EQ	✓	G		712	$44,883	$22,683	$412,851	$480,418	855	$79,797	$32,465	$647,248	$759,510		
4	**ALTERNATE 1**		2		0	$0	$0	$0	$0	0	$0	$0	$0	$0	$0	$14,254,962
	NR North Pole WTP Upgrades		2													
6	North Pole 6" HDPE Supply Main		2		7,228	$433,670	$1,433,470		$1,867,141	8,673	$653,745	$1,749,129		$2,402,874	$3,183,925	
7	Storage tank-40' Ø x 29'		2		4,681	$278,256	$181,581	$18,927	$478,764	5,617	$484,040	$255,607	$28,648	$768,295	$1,018,028	
8	Storage Tank PS		2		2,208	$134,920	$158,116	$146,552	$439,587	2,649	$231,325	$224,180	$204,601	$660,105	$874,672	
9	4" & 6" DIP Distribution Mains		2		21,944	$1,316,713	$3,141,804		$4,458,516	26,333	$1,984,904	$3,833,649		$5,818,552	$7,709,863	
10	Local Property Connections		2		3,200	$192,006	$160,000		$352,006	3,840	$289,444	$195,233		$484,677	$642,220	
11	Existing GAC's, Tanks, & Wells		2		4,800	$292,832	$120,000		$412,832	5,760	$468,700	$154,866		$623,565	$826,254	
12	**ALTERNATE 2**		3		0	$0	$0	$0	$0	0	$0	$0	$0	$0	$0	$12,837,908
	NR EAFB WTP Upgrades		3													
14	EAFB 6" HDPE Supply Main		3		3,953	$237,189	$799,741		$1,036,930	4,744	$357,556	$975,849		$1,333,405	$1,766,826	
15	Storage tank-40' Ø x 29'		3		4,681	$278,256	$181,581	$18,927	$478,764	5,617	$484,040	$255,607	$28,648	$768,295	$1,018,028	
16	Storage Tank PS		3		2,208	$134,933	$158,127	$146,552	$439,612	2,649	$231,345	$224,194	$204,601	$660,140	$874,717	
17	4" & 6" DIP Distribution Mains		3		21,944	$1,316,713	$3,141,804		$4,458,516	26,333	$1,984,904	$3,833,649		$5,818,552	$7,709,863	
18	Local Property Connections		3		3,200	$192,006	$160,000		$352,006	3,840	$289,444	$195,233		$484,677	$642,220	
19	Existing GAC's, Tanks, & Wells		3		4,800	$292,832	$120,000		$412,832	5,760	$468,700	$154,866		$623,565	$826,254	
20	**ALTERNATE 5**		4		0	$0	$0	$0	$0	0	$0	$0	$0	$0	$0	$13,016,196
21	Moose Creek Well-6" Ø		4		622	$37,752	$80,659	$26,550	$144,960	746	$59,005	$100,669	$38,207	$197,881	$262,202	
22	Moose Creek Well PS		4		1,241	$73,877	$84,187	$8,875	$166,939	1,489	$125,481	$118,752	$13,914	$258,147	$342,057	
23	Moose Creek WTP		4		3,115	$190,686	$223,717	$275,381	$689,784	3,738	$328,220	$317,111	$371,263	$1,016,594	$1,347,036	
24	Storage tank-40' Ø x 29'		4		4,681	$278,256	$181,581	$18,927	$478,764	5,617	$484,040	$255,607	$28,648	$768,295	$1,018,028	
25	Storage Tank PS		4		2,163	$132,227	$157,647	$146,552	$436,426	2,596	$227,265	$223,608	$204,601	$655,474	$868,535	
26	4" & 6" DIP Distribution Mains		4		21,944	$1,316,713	$3,141,804		$4,458,516	26,333	$1,984,904	$3,833,649		$5,818,552	$7,709,863	
27	Local Property Connections		4		3,200	$192,006	$160,000		$352,006	3,840	$289,444	$195,233		$484,677	$642,220	
28	Existing GAC's, Tanks, & Wells		4		4,800	$292,832	$120,000		$412,832	5,760	$468,700	$154,866		$623,565	$826,254	
	WBS TOTAL				133,094	$8,006,641	$14,795,382	$1,228,837	$24,030,860	159,713	$12,507,221	$18,346,463	$1,784,085	$40,109,066	$40,109,066	$40,109,066

APPENDIX D

Regulatory Review Comments
(To be provided in Final)