# Newtok-Mertarvik Relocation Energy Master Plan

Prepared For:

ALASKA ENERGY AUTHORITY

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**ABBREVIATIONS**

| | |
|---|---|
| % | percent |
| ADEC | Alaska Department of Environmental Conservation |
| ADOT&PF | State of Alaska Department of Transportation and Public Facilities |
| AEA | Alaska Energy Authority |
| AHFC | Alaska Housing Finance Corporation |
| ANTHC | Alaska Native Tribal Health Consortium |
| AVCP-RHA | Association of Village Council Presidents-Regional Housing Authority |
| AVEC | Alaska Village Electric Cooperative |
| BIA | Bureau of Indian Affairs |
| Btu | British thermal unit |
| CCHRC | Cold Climate Housing Research Center |
| CDR | Concept Design Report |
| cfs | cubic feet per second |
| CPC&N | Certificate of Public Convenience and Necessity |
| CRW | CRW Engineering Group |
| DCCED | State of Alaska, Department of Commerce, Community, and Economic Development |
| DCRA | State of Alaska, DCCED, Division of Community and Regional Affairs |
| DOWL | DOWL LLC |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FEMA | Federal Emergency Management Agency |
| GNE | Great Northern Engineering, LLC |
| HDL | HDL Engineering Consultants, LLC |
| IBC | International Building Code |
| IFC | International Fire Code |
| IRT | Military Innovative Readiness Training Program |
| kV | kilo-volt |
| kVA | kilo-volt-ampere |
| kW | kilo-watt |
| kWh | kilo-watt-hours |
| LKSD | Lower Kuskokwim School District |
| MEC | Mertarvik Evacuation Center |
| NEPA | National Environmental Policy Act |
| NFPA | National Fire Protection Association |
| NMFS | National Marine Fisheries Service |
| NNC | Newtok Native Corporation |
| NPG | Newtok Planning Group |
| NREL | National Renewable Energy Laboratory |

| | |
|---|---|
| NTC | Newtok Traditional Council |
| NVC | Newtok Village Council |
| NYC | Nunakauiak Yupik Corporation |
| O&M | Operations and Maintenance |
| PCE | Power Cost Equalization |
| PDC | PDC Engineers, Inc. |
| PV | photovoltaic |
| RCA | Regulatory Commission of Alaska |
| rpm | revolutions per minute |
| SCH | schedule |
| UL | Underwriters Laboratories |
| UPC | Ungusraq Power Company |
| U.S. | United States |
| USACE | United States Army Corps of Engineers |
| USFWS | US Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| V | volt |

## EXECUTIVE SUMMARY

This report has been prepared for the Alaska Energy Authority and its partners to provide a practical and efficient plan for phased development of power and bulk fuel infrastructure in the new community of Mertarvik and decommissioning of the existing power and bulk fuel systems in Newtok. The rapid rate of riverbank erosion in Newtok is threatening the community and efforts are underway to plan and facilitate relocation of the village to the nearby undeveloped area of Mertarvik. The Newtok Village Council and Alaska Native Tribal Health Consortium, in cooperation with other stakeholders, have prepared a Community Layout Plan depicting the proposed location of new homes and community infrastructure in Mertarvik. The relocation of the community is expected to be performed over six phases (Phase 1, 2A, 2B, 3A, 3B, and 4), with Phase 1 already complete and Phase 2A currently underway. Construction and implementation of bulk fuel and power plant facilities in Mertarvik to meet the demand of the phased community development is critical to the success of the village relocation. This report presents a comprehensive Energy Master Plan describing the action required under each phase to provide fuel storage, dispensing, power generation, and electrical distribution facilities to meet the anticipated demand. Special consideration has been given to incorporating fuel-efficient power generation equipment, recovered heat, and renewable energy into the final power plant concept. The plan also considers the actions required under each phase to decommission the existing dilapidated tank farm and power plant facilities in Newtok and incorporate reusable tanks into the new facilities in Mertarvik.

David Cooper, PE, of HDL Engineering Consultants LLC, Steven Stassel, PE, of Gray Stassel Engineering, Inc., and David Lockard, PE, of the Alaska Energy Authority traveled to Newtok with other stakeholders on March 21, 2017 to meet with residents and community leaders and inspect the existing power plant and tank farm infrastructure. The project team evaluated the condition of the existing power plant, power distribution system, fuel pipelines, and nine existing tank farms. The majority of the existing tanks and equipment were at or near the end of their useful life and only five tanks were identified for potential reuse in the new bulk fuel facilities in Mertarvik. The other facilities should be decommissioned and demolished as they reach end-of-life, are taken out of service due to reduced demand, or are threatened by riverbank erosion. The project team held a community meeting to discuss the recommendations of this Energy Master Plan and residents voiced general agreement with the phased approach described herein.

In general, this Energy Master Plan recommends the following bulk fuel and energy improvements in Mertarvik, which correspond to the phased relocation from Newtok and the new community development in Mertarvik:

- Phase 1: This phase took place between 2006 and 2016 and included construction of shallow and deep-water barge landings; pioneer roads and trails; seven homes; four storage buildings; the Mertarvik Evacuation Center foundation, well and septic system; and a rock quarry .

- Phase 2A: Install temporary tank farm and small mobile generator units to support construction and man-camp operations. This phase is anticipated to be complete in fall 2017.

- Phase 2B: Improve temporary tank farm and install a prime power modular power plant, with recovered heat, and limited electrical distribution system, to support a population of up to 35 year-round residents. This phase is anticipated to be complete in fall 2018.

- Phase 3A: Expand power distribution, and recovered heat systems as necessary to support a growing population of up to 100 year-round residents in Mertarvik. This phase is currently scheduled for completion by fall 2019, but construction is dependent on funding availability.

- Phase 3B: Construct permanent tank farm, install fuel transfer and dispensing equipment, expand power distribution and recovered heat systems to serve a population of 200 year-round residents (approximately half of Newtok's current population). This phase is currently scheduled for completion by fall 2020, but construction is dependent on funding availability.

- Phase 4: Add tanks to tank farm, increase power generation capacity, incorporate renewable energy, and expand distribution system to serve the entire population and infrastructure needs of the relocated community with additional capacity for anticipated growth. This phase is currently scheduled for completion by fall 2021, but construction is dependent on funding availability.

The phases are briefly described in Table 1 below. A more detailed graphical depiction of the Energy Master Plan is included in Appendix A.

**Table 1: Energy Master Plan Summary Table**

| Phase | Tank Farm | Diesel Capacity (Gallons) | Gasoline Capacity (Gallons) | Power Plant | Power Plant Capacity (kw) | Electrical Distribution System | Recovered Heat | Renewable Energy |
|---|---|---|---|---|---|---|---|---|
| 2A | Temporary (For Construction) by Goldstream Engineering | 38,000 | 5,000 | Temporary Generators for Construction | 150 kW<br>400 kW | No | No | No |
| 2B | Temporary | 48,000 | 15,000 | Full Size Module with Smaller Generators | 234 kW | Limited | Yes | No |
| 3A | Temporary | 48,000 | 15,000 | Full Size Module with Smaller Generators | 234 kW | Yes | Yes | No |
| 3B | Permanent w/ New Horiz. Tanks | 72,000 | 42,000 | Full Size Module with Smaller Generators | 234 kW | Yes | Yes | No |
| 4 | Permanent w/ New Horiz. Tanks | 207,000 | 96,000 | Full Size Module | 520 kW | Yes | Yes | Wind and Solar |

Dependent on the results of the geotechnical investigation of the preferred site, the permanent tank farm will likely consist of single-wall horizontal tanks installed in a lined gravel or pile-supported steel containment. The power plant will consist of an "Alaska Energy Authority-style" module with a double-wall intermediate tank. Tank farm capacity and power demand were determined by estimating population, housing, and infrastructure demand for each phase of community development and comparing them to existing trends in Newtok. In Phase 4, the ultimate tank farm shell capacity for 13 months of storage was determined to be 207,000 gallons of diesel, 96,000 gallons of gasoline, and the generator capacity was determined to be 520 kilo-watts.

## 1.0 INTRODUCTION

This report has been prepared for the Alaska Energy Authority (AEA) and its partners to provide a reasonable, cost effective plan for the phased implementation of power and bulk fuel infrastructure in the new community of Mertarvik and the decommissioning of existing power and bulk fuel systems in Newtok. The report includes a summary of the existing infrastructure in both Newtok and Mertarvik, a proposed project phasing plan for the community relocation, evaluation of potential renewable energy resources in Mertarvik, a Toksook Bay to Mertarvik intertie feasibility analysis, a phased power and bulk fuel storage development plan for Mertarvik, and the anticipated permitting requirements for the energy project development.

## 2.0 PROJECT NEED

Erosion of the north bank of the Ninglick River poses a significant hazard to the existing rural village of Newtok, threatening to displace residents and destroy homes, essential facilities, and utilities. An analysis of riverbank erosion rates conducted in 2003, as described in the 2015 *Newtok Village Tribal Hazard Mitigation Plan Update*, projected the river channel would begin impacting structures at the south end of the village as early as 2015 (Federal Emergency Management Agency [FEMA] 2015). Local observations during fall 2016 flooding events measured the riverbank at 86 feet from the nearest home. At the current rate of erosion of approximately 70 feet/year, the river is expected to threaten structures within two years and the village's critical infrastructure within four years. Figure 1 shows the Ninglick riverbank erosion from 1954 to 2007 and the erosion projections for 2012 to 2027.

In addition to the threat to infrastructure, erosion has altered hydrologic patterns of the Newtok River, which joins the Ninglick River immediately upstream of the village. The community discharges wastewater into the Newtok River and backwater from the Ninglick River can divert stagnant, sewage-laden water into the community.

In response to the increasing threat from erosion, the Newtok Village Council (NVC), with the assistance of the Alaska Department of Commerce, Community and Economic Development (DCCED), Division of Community and Regional Affairs (DCRA), the Denali Commission, and other state and federal agencies and non-government organizations, is undertaking an effort to relocate the community to a more stable location. A new location has been selected for the community on Nelson Island, approximately nine miles to the southeast of Newtok. The new village location is named Mertarvik, which in Yup'ik means "getting water from the spring". New infrastructure development is planned for Mertarvik including: airport; landfill; wastewater collection system and treatment lagoon; bulk fuel storage and dispensing facilities; power generation and distribution systems; water treatment plant, storage tank, and distribution lines; barge landing; housing developments; school; community buildings; and roads.

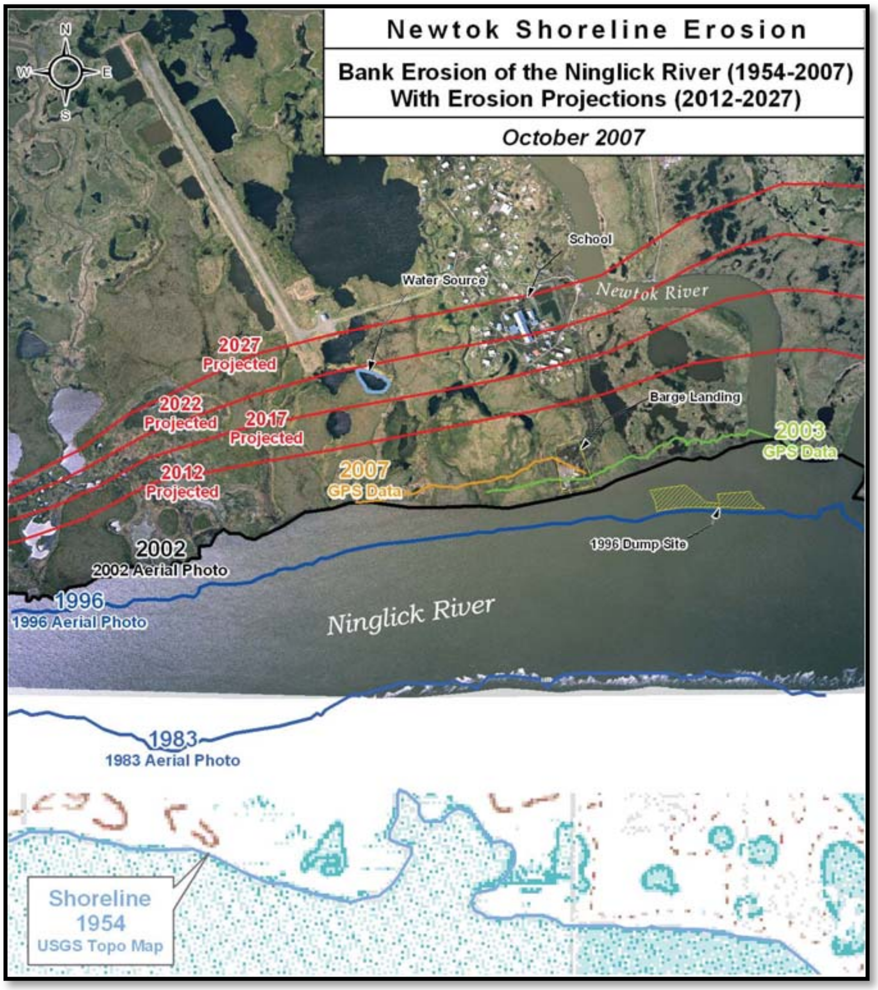


**Figure 1: Ninglick River Shoreline, 1954 – 2007, with predicted shoreline erosion to 2027**
***Source: CCHRC, Mertarvik Housing Master Plan (February 10, 2017)***

To date, numerous studies have documented the impact of erosion of the Ninglick River on Newtok, analyzed mitigation alternatives, and indicated the need to relocate the community to a stable site. The DCRA maintains a library of these documents on the Newtok Planning Group (NPG) website (DCRA 2017a).

## 3.0 PROJECT BACKGROUND

The first formal investigation of erosion along the bank of the Ninglick River was completed in 1984. This study assessed the erosion and evaluated alternatives to protect the riverbank from further migration toward the village. Based on riverbank locations from 1957 through 1983, the report estimated erosion would impact the village between 2008 and 2013. The report also determined that relocating the village would likely be more cost-effective than attempting to stop or slow the erosion (Woodward-Clyde 1984).

The former Newtok Traditional Council (NTC) began planning for relocating the community in 1994, with evaluation of six sites and the eventual selection of Mertarvik as the preferred location for the new village. Between 2000 and 2004, formal planning studies for the Mertarvik site were initiated and the U.S. Congress authorized a land exchange with the U.S. Fish and Wildlife Service (USFWS) for the Mertarvik site, which is within the Yukon Delta National Wildlife Refuge.

In 2006, the former NTC requested the assistance of Alaska DCRA to coordinate planning efforts between the numerous government agencies involved in funding, permitting, or carrying out activities related to the relocation effort. The Alaska DCRA formed the NPG to facilitate coordination efforts.

To date, the NPG and the NVC have completed the following projects in Mertarvik to prepare for the major effort to relocate residents and infrastructure:

- Constructed three Bureau of Indian Affairs (BIA) Housing Improvement Program houses (2006-2008)
- Drilled two water wells and developed one of the wells (2007)
- Constructed a shallow-draft barge landing and gravel and Dura-Base mat laydown area (2009)
- Constructed a gravel and Dura-Base mat access road from the barge landing to the anticipated location of the community, a gravel access trail to the deep water barge landing, and an unimproved pioneer trail to the anticipated gravel quarry site with approximately ¼ mile of the trail covered with a Dura-base mat (2011-2012)
- Constructed the Mertarvik Evacuation Center (MEC) foundation and deck (2011)
- Constructed three Department of Housing and Urban Development houses (2012)

In June 2016, NVC Retained DOWL LLC (DOWL) to provide planning and project management services. On behalf of NVC, DOWL is tracking and coordinating project funding, planning, design, and construction efforts associated with the move from Newtok to Mertarvik. DOWL frequently organizes planning meetings between representatives from the NVC, Denali Commission, AEA, other project stakeholders, and consultants to coordinate ongoing planning, design, and construction activities.

In March 2017, the Denali Commission, in cooperation with the U.S. Army Corps of Engineers (USACE), initiated the process to prepare an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) for the new infrastructure in Mertarvik (Denali Commission 2017). The EIS process is expected to conclude with a Record of Decision in late 2017.

Bulk fuel and power generation facilities are being planned and funded by the Denali Commission, in partnership with AEA. The AEA has developed this Energy Master Plan to provide a "road map" for development of energy infrastructure in Mertarvik and will oversee the design of the new bulk fuel and power generation systems.

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## 5.0 COMMUNITY INFORMATION

### 5.1 Newtok

#### A. Location and Access

Newtok is located 94 miles northwest of Bethel at the confluence of the Newtok and Ninglick Rivers, north of Nelson Island in the Yukon-Kuskokwim region of Alaska. Newtok is located at 60.9369° North Latitude and 164.6294° West Longitude (Sec. 24, T010N, R087W, Seward Meridian). The community is within the Bethel Recording District and is surrounded by the Yukon Delta National Wildlife Refuge (DCRA 2017b).

Newtok is accessed by air and water but there are no roads connecting the village to any other communities. Passenger, cargo, and private aircraft access the village via a 2,180-foot long gravel airstrip owned by the Alaska Department of Transportation & Public Facilities (ADOT&PF). There is barge access via the Ninglick River during ice-free conditions. The Newtok River is only navigable by smaller boats and skiffs. In the winter, snowmachines are used for local transportation throughout the community and between nearby villages.

#### B. Climate

Newtok is located within the transitional climate zone of Alaska, exhibiting characteristics of subarctic, arctic, and maritime climates. Winters are long and cold and summers are short and mild. Average summer temperatures range from 40°F to 60°F and winter temperatures range from 0°F to 20°F. Temperatures range from -48°F in the winter to 87°F in the summer. Annual precipitation is 16 inches, with 53 inches of snowfall.

### C. History and Culture

The Nelson Island region has been inhabited by the Qaluyaarmiut, or “dip net people”, for the last 2,000 years, with communities maintaining a traditional nomadic, subsistence lifestyle as late as 1936. The village of Newtok was established in its present location in 1949 when the community moved from the winter camp at the Old Kealavik site to escape flooding. Newtok was selected as the furthest point up the Ninglick River that a barge could safely navigate at the time. As recently as the 1960s, the majority of the population migrated to camps on the coast of the Bering Sea to harvest fish, marine mammals, and waterfowl during the summer months. By the 1970s, residents had transitioned from traditional sod houses heated with seal oil to more modern timber buildings. Today, modern means of travel such as snowmachines and boats allow villagers to access subsistence sites and return to Newtok on a daily basis, making Newtok a year-round home for the community (DCRA 2017a and DCRA 2017b).

According to U.S. Census data, the population of Newtok was 354 in 2010, with 96 percent (%) of the residents reported to be American Indian/Alaska Native. A total of 72 households in Newtok were occupied in 2010 (Census 2010).

## 5.2 Mertarvik

### A. Location and Access

Mertarvik is located approximately nine miles southeast of Newtok on Nelson Island at approximately 60.8099° North Latitude and 164.5004° West Longitude. Figure 2 below shows the Mertarvik village location in relation to Newtok.

There are no existing roads or runways that provide air or road vehicle access to Mertarvik, and the area is primarily accessed by small boats in the summer, by snowmachine in the winter, or by helicopter. During the summer barge season, barge access is available to the recently constructed shallow-draft and deep-water barge landings. The shallow-draft barge landing is only accessible during high tide.

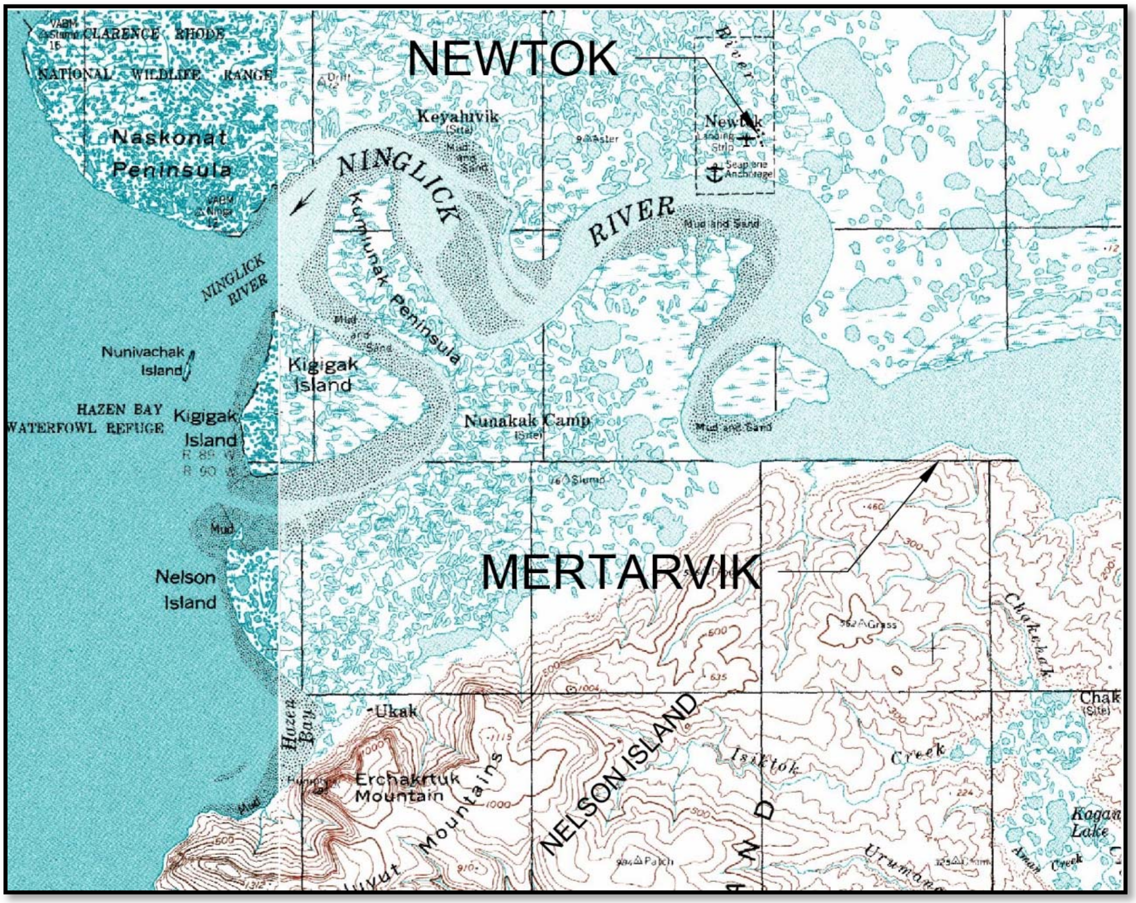


**Figure 2: Location Map**

## 6.0 EXISTING INFRASTRUCTURE

### 6.1 Newtok Infrastructure

#### A. Prime Power Generation

The Ungusraq Power Company (UPC) is owned and operated by NVC operating under Certificate of Public Convenience and Necessity (CPCN No. 375). The community has an isolated, above ground electrical power grid with no outside interties. A diesel electric plant provides community electric power.

The UPC power plant is located adjacent to the community water plant, about 300 feet northwest of the school and about 900 feet from the eroding shoreline. At the recent rate of erosion, riverbank erosion will impact the power plant in approximately 10 to 15 years. The power plant is a single story, wood frame structure, constructed in the 1980s on a post and pad foundation. The west side of the timber pad foundation has sunk into the tundra causing the floor of the power plant to tilt considerably. See Figure 3 below.

**Figure 3: UPC Newtok Power Plant**

The power plant has two 480-volt (V), three-phase John Deere generators. Unit #1 is a model 6068AFM75, Tier 2 marine engine, rated 150 kilo-watt (kW) Prime. Unit #3 is an older 6081AF001, non-certified engine, rated 120 kW Continuous. Unit #2 is vacant. See Table 2. Engine hours are unknown. Unit #1 was recently installed and is believed to be a low hour engine. The Unit #3 hour meter indicates 43,877 hours.

**Table 2: UPC Generators**

| GEN | kW | MAKE | MODEL | EPA | DATE | S/N |
|---|---|---|---|---|---|---|
| 1 | 150 | John Deere | 6068AFM75 | Tier 2 Marine | 8/23/2011 | PE6068G841045 |
| 2 | -- | -- | -- | -- | -- | -- |
| 3 | 120 | John Deere | 6081AF001 | Tier 0 | 2/7/2003 | RG6081A161323 |

The power plant has automatic paralleling switchgear, but it is operated in manual mode. The switchgear is equipped with one master and three generator sections. The master section contains the auto-synchronization/paralleling controls and demand meters in the upper cabinet, and the main community distribution and airport feeder breakers in the lower cabinet. Each generator section is equipped with metering, low voltage controls, indicator lights, and synchronization controls located in the upper cabinet, and the generator feeder breaker in the lower cabinet. The bus totalizer and station service meters are mounted on the wall adjacent to the switchgear.

Engine cooling is accomplished through a two-inch copper, common cooling system connected to a remote radiator attached to the exterior of the building. Each engine is equipped with a separate expansion tank and a shell and tube heat exchanger to recover engine jacket water heat. Recovered heat is piped approximately 60 feet to the adjacent water plant.

The power plant fuel system consists of a 300-gallon, single wall intermediate tank mounted on a wooden stand outside the plant. The intermediate tank feeds a 75-gallon Simplx autofill day tank inside the plant. The day tank is equipped with a Racor filter, float switches, and pump. Threaded steel pipe fuel oil supply and return piping is routed from the day tank along the perimeter of the plant to each generator.

Diesel fuel is transferred daily from the UPC bulk tank farm to the power plant intermediate tank. The power plant operator fills two 55-gallon drums daily and transports them via snowmachine and sled in the winter and four-wheeler and trailer during the summer.

### B. Electrical Distribution

A 400-amp main feeder breaker provides 480 V, three-phase power from the switchgear to the overhead electric distribution system. Electric power is distributed throughout the community at 480 V, three-phase. A separate, 40-amp feeder breaker provides single-phase power to the airport via a 25 kilo-volt-ampere (kVA), 240 V/7.2 kV pole-mounted transformer located adjacent to the power plant. The electrical distribution system is unique in that electricity is distributed at 480 V generation power, rather than the more conventional 7.2/12.47 kV power.

The existing electrical distribution system is in poor condition. The poles are direct-bury construction, and many are leaning due to the poor soil conditions. Many of the guy wires are loose and do not support the poles. The airport step-up transformer pole at the power plant is leaning at a 25 to 30-degree angle, and the conductor is hanging dangerously close to the ground, as is shown in Figure 4. A temporary support has been strung between the power plant and adjacent building to elevate the conductor. Once the ground thaws, the pole should be straightened and re-anchored.

**Figure 4: Newtok Electrical Distribution Pole**

The eroding riverbank is less than 200 feet from the nearest utility pole. At the recent rate of erosion, the eroding riverbank will reach the nearest power pole in as little as two to three years.

Pole mounted, dry pack transformers are located throughout the distribution system and stepdown the distribution voltage to 120/240 V power. As many as nine services are fed by one 10 to 15 kVA transformer. Due to limitations with transformer sizing and electrical distribution capacity, residents customarily coordinate with their neighbors to avoid simultaneously using high-demand electrical devices, such as electric clothes dryers, to prevent tripping a transformer fuse or knocking the power plant offline.

Residential customers use AMPY prepay electric meters. The prepay meters allow the utility to be paid in advance of energy consumption, which eliminates overdue accounts. Consumers receive real time feedback on electricity consumption, which helps with energy conservation and reduces the monthly cost of electricity.

### C. School Power Generation

The Lower Kuskokwim School District (LKSD) Ayaprun School generates its own prime power. The school power plant consists of two 1,800-revolutions per minute (rpm), 480 V, three-phase Cummins generators in a 40-foot insulated shipping container. The power plant is located about 350 feet from the eroding shoreline. At the recent rate of erosion, the eroding riverbank could reach the power plant in less than five years. The plant is set on wooden piles about five feet above grade. The generators are equipped with skid-mounted radiators, and each has its own day tank. Unit #1 is a 100 kW generator which was recently replaced in May 2016. Unit #2 is a

125-kW generator. Engine hours are unknown, but Unit #1 appears to have over 4,000 hours and Unit #2 over 11,500 hours. See Table 3 below. The power plant switchgear is manually operated and equipped with a non-auto transfer switch to transfer load between the generators. There is no recovered heat system.

**Table 3: Newtok LKSD Generators**

| GEN | kW | MAKE | MODEL | EPA | DATE | S/N |
|---|---|---|---|---|---|---|
| 1 | 100 | Cummins | 100DGDB | Replacement | 10/30/2014 | Engine: 6B: 60279357 |
| 2 | 125 | Cummins | 100DGDB | Tier 3 | 12/19/2013 | Engine: QSB 60275265 |

The power plant fuel system consists of a 2,000-gallon, double-wall, skid mounted, intermediate tank located adjacent to the power plant. The intermediate tank feeds two day tanks inside the plant. At the time of the site visit, the Unit #1 day tank was disassembled and inoperable. Unit #2 has a Simplx SST 50-gallon autofill day tank, equipped with filter, float switches, and pump. Fuel oil supply and return piping is routed from the day tank to both generators. Diesel fuel is transferred from the school tank farm to the power plant intermediate tank via a two-inch steel pipe.

### D. Renewable Energy

Current use of renewable energy in Newtok is limited to driftwood used to heat steam houses and for some home heating. The only other evidence of renewable energy identified in Newtok was an old, out of service Jacobs wind turbine thought to have been installed in the 1980s.

### E. Electrical Equipment Suitable for Reuse

Due to age and condition, there is little existing energy-related infrastructure that is suitable for reuse at Mertarvik or elsewhere. The power plant has a newer 150 kW John Deere 6068AFM75 marine generator that is in good condition. However, by the time Newtok relocates to Mertarvik, it is expected the engine could have 40,000 hours of runtime and be at or near the end of its useful life. There are two 25 kVA pole-mounted 480V/7.2kV transformers that feed the airport that could be reused. The residential AMPY pre-pay meters should be removed from abandoned houses and reinstalled at Mertarvik, or placed into inventory for future use.

It is expected the Lower Kuskokwim School District (LKSD) will recover useable infrastructure for use at other LKSD schools, or return it to Bethel for storage.

### F. Heat Recovery

The UPC power plant provides recovered heat to the adjacent water plant. Recovered heat is transferred from the power plant via a shell and tube heat exchanger, and piped through an at-grade utilidor approximately 60 feet to the water plant. The heat recovery piping is two-inch copper. A shell and tube heat exchanger is located in the water plant, along with the heat recovery circulating pump and expansion tank. The pump is a Grundfos UMC 65-40, operating on speed 2. The heat recovery system is equipped with isolation valves and pressure gauges. The system pressure gauge read 0 pounds per square inch at the pump inlet, indicating the heat recovery system requires additional antifreeze to pressurize the system for proper operation.

The water plant operator reported the heat recovery system is the sole source of heat for the water plant, and diesel fuel has not been used for many years. During a recent power outage that lasted several days, the water plant froze due to lack of recovered heat.

G. Bulk Fuel Storage and Dispensing

Newtok Bulk Fuel Assessment Reports prepared for AEA by CRW Engineering Group, LLC (CRW) in 2015 and Great Northern Engineering, LLC (GNE) in 2016 identified eight existing bulk fuel storage facilities (tank farms) in Newtok (TF1 – TF8) (CRW 2016 & GNE 2016). An additional tank farm, TF9, was identified at Tom's Store during HDL Engineering Consultant LLC's (HDL) March 21, 2017 site inspection and community meeting (HDL 2017).

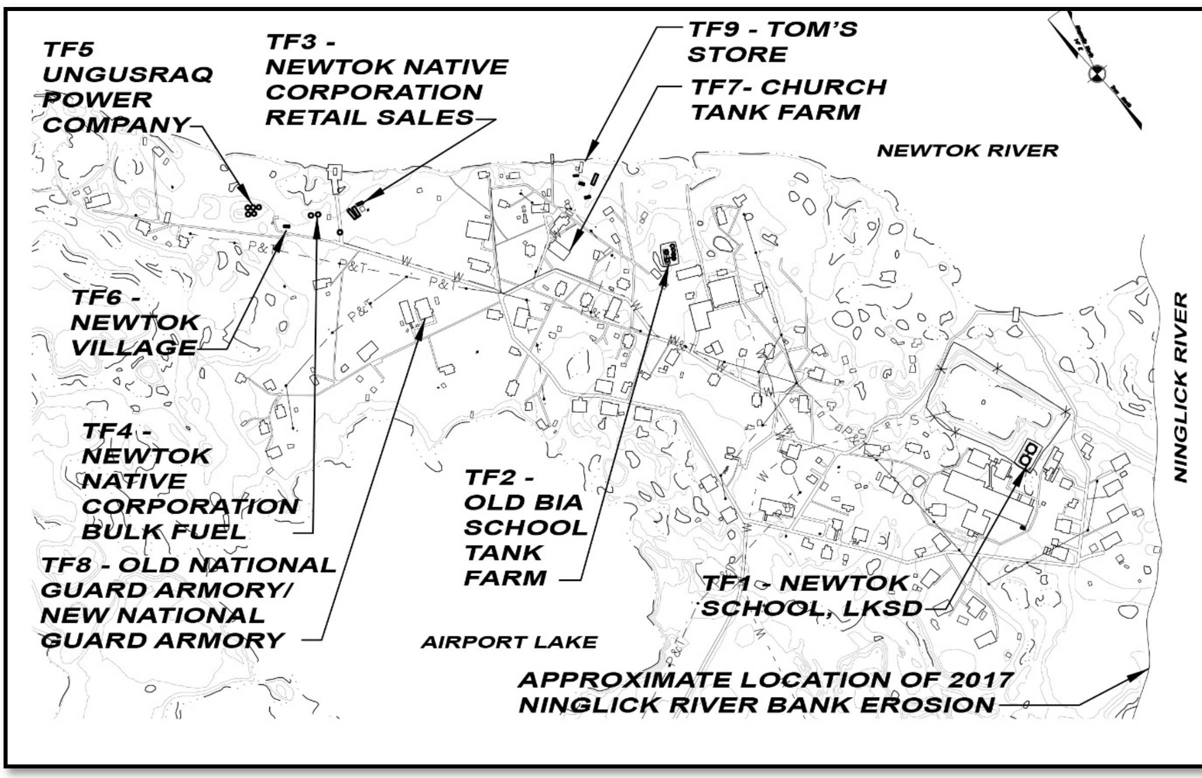


**Figure 5: Location of Existing Tank Farms in Newtok**

The following bulk fuel facilities exist in Newtok, as shown on Figure 5.

- TF1 - Newtok School, LKSD*
- TF2 - Old BIA School Tank Farm
- TF3 - Newtok Native Corporation (NNC), Retail Sales*
- TF4 - NNC, Bulk Fuel*
- TF5 - UPC*

- TF6 - NVC*
- TF7 - Church Tank Farm
- TF8 - Old National Guard Armory / New National Guard Armory *
- TF9 - Tom's Store
  *= active and currently in use

Tank farms TF1, TF3, TF4, TF5, TF6, & TF8 are active and currently used for bulk fuel storage and/or dispensing. The bulk fuel storage tank farms in Newtok provide 237,500 gallons of gross diesel storage and 33,025 gallons of gross gasoline storage in the community. Approximately 58,000 gallons of diesel tank storage and 11,125 gallons of gasoline tank storage are either abandoned or currently not in use. In general, the existing tank farms are old, deteriorating, non-code compliant, and nearing the end of their useful life. A detailed narrative describing the existing size and condition of each bulk fuel facility in Newtok is included in Appendix F. Private residences, community buildings, and commercial buildings use small tanks for on-site heating fuel storage. Residents generally store heating fuel in 55-gallon drums, while the fuel tank sizes for public buildings range between 300 and 500 gallons.

H. Fuel Pipelines

TF1, TF3, TF5, TF6, and TF9 are filled by temporary or permanent connection to the approximate 2,600-foot long, three-inch, above ground, schedule (SCH) 40 steel, common barge header pipeline. The header pipeline was reconstructed in 2008 and is in fair condition. The header begins on the bank of the Ninglick River near the school's teacher housing units and terminates at the UPC tank farm. The header consists of a single shared pipeline for gasoline and diesel barge filling operations. The header pipeline route is shown in Figure 6.

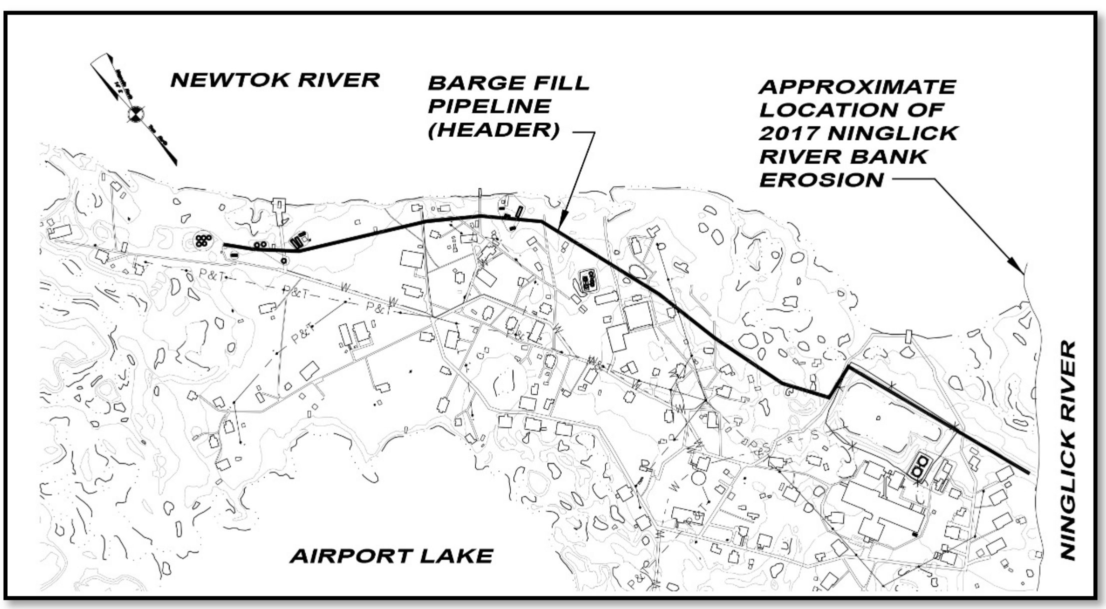


**Figure 6: Marine Header Pipeline Route**

### I. Barge Landings

Barges normally deliver cargo to Newtok twice a month during the summer barging season of July through September. The traditional village barge landing was lost to erosion in 2005, forcing the community to use a temporary barge landing located near the confluence of the Newtok and Ninglick Rivers. Recent sedimentation at the mouth of the Newtok River has caused shallow water in the area of the barge landing, making it difficult for barges to reach the community. In addition, the riverbank in this area continues to erode each season and village residents have voiced concern that barge delivery will be difficult during the 2017 season. The Ninglick River near the runway is reported to be deeper and this area may need to be used as a barge landing in 2017 and beyond (ADOT&PF 2012).

### J. Road System

Newtok is a boardwalk community and there are no permanent gravel roads. There are approximately 1.5 miles of boardwalks within the community that provide access for foot and all-terrain vehicle (ATV) traffic. These boardwalks generally consist of timber decking constructed on timber sleepers and pads that rest directly on wetlands and muskeg. The boardwalks are old and in need of repair (NPG 2011).

### K. Airport

An ADOT&PF-owned 2,180-foot by 35-foot gravel airstrip provides year-round aircraft access to the community. The runway width, safety area dimensions, and other separation distances do not meet Federal Aviation Administration (FAA) Standards. The runway, taxiway, and apron are in poor condition due to differential settlement and deterioration of surfacing in the air operations area. The primary wind cone and segmented circle are in poor condition and need to be replaced. The ADOT&PF is currently in the preliminary design phase of a project to improve the airport to provide safe airport operations until the village is relocated. Seaplane access is also available via the Ninglick River, but seaplanes are not routinely utilized to access the community (ADOT&PF 2008).

### L. Existing Community, Commercial, and Residential Buildings

The community of Newtok consists of residential, community, and commercial buildings. According to the 2010 U.S. Census, the population of Newtok in 2010 was 354 and the total number of occupied households in the community was 72 (Census 2010). The Cold Climate Housing Research Center (CCHRC) prepared a Housing Master Plan for the village in 2016, which determined that 78 homes existed in the community. The CCHRC determined that only 12 of the 78 houses were suitable for relocation to Mertarvik (CCHRC 2017).

The Newtok Ayaprun pre-kindergarten through grade 12 school building is owned by the LKSD and currently has an enrollment of 132 students (DCRA 2017b). The school building is equipped with its own tank farm, water and wastewater treatment plant, and generator. Eight teacher-housing units are located to the south of the school building. The teacher housing buildings are expected to be threatened by riverbank erosion as early as summer 2017. Riverbank erosion is anticipated to impact other school facilities by 2022 (FEMA 2015).

Other community buildings within the village include the old, abandoned BIA School building; village council office; community hall; health clinic; post office; church; old and new National Guard armory buildings; community water tank; and washeteria. Additionally, NNC owns a store and warehouse.

Commercial buildings in Newtok include Tom's Store and the UPC generator building, storage facility, office, and tank farm. Phone service is provided by United Utilities, which operates a small office in the community.

## 6.2 Mertarvik Infrastructure

### A. Barge Landing

The Mertarvik shallow-draft barge landing was the first significant infrastructure project constructed at Mertarvik. The DCCED partnered with ADOT&PF for the planning, design, and construction of the 16-foot wide by 230-foot long ramp/access road and 65-foot by 130-foot upland multi-use staging area. The project was constructed in 2009. The barge landing will only accommodate shallow draft vessels at high tide (ADOT&PF 2012).

Due to the need for deep-water access, a second barge landing was constructed in 2010 approximately 500 feet down river from the shallow-draft barge landing. The deep-water landing is 35 feet wide and connected by trail to the shallow-draft barge landing. The deep-water landing was constructed in a swift area of the river and barges require constant power to maintain position for loading and unloading.

### B. Road System

The existing road system in Mertarvik includes an approximately 0.3-mile access road from the barge landing to the MEC building site and an approximate two-mile trail from the barge landing to the quarry site. The MEC access road is approximately 14 feet wide constructed with Dura-Base mats over a thin layer of gravel. The quarry access trail consists of 0.25-mile Dura-Base mats leading to 1.75-mile unimproved pioneer trail over tundra. During the 2017 summer construction, NVC plans to complete the quarry access road and construct part of the village road system using crushed rock mined from the quarry. Figure 7 shows the existing village road system layout.

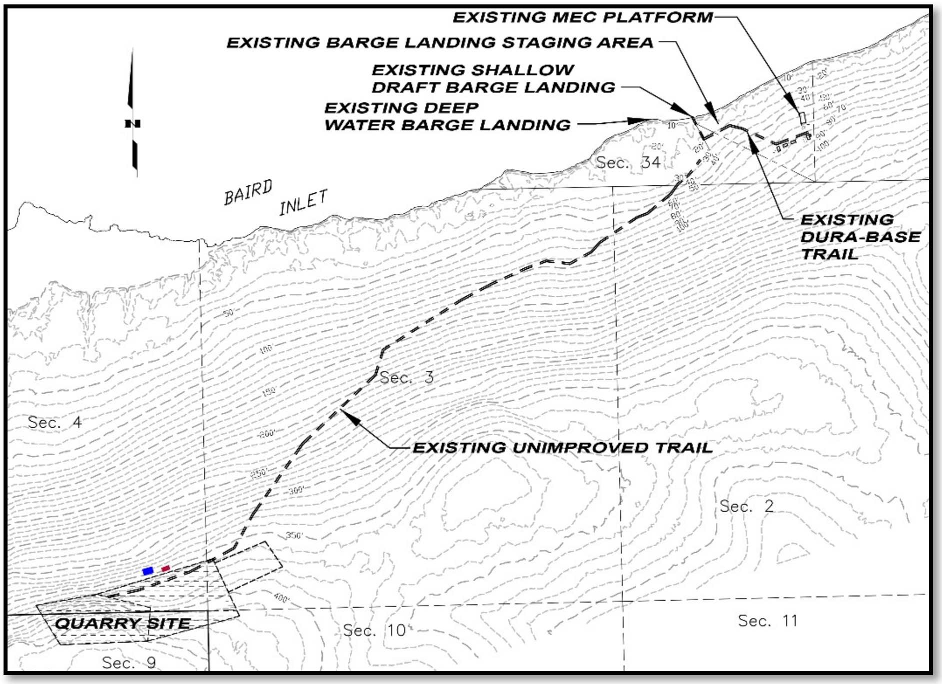


**Figure 7: 2017 Mertarvik Existing Road System Layout**

C. Airport

There is not an existing runway in Mertarvik and the site can only be accessed by air with helicopters. During the phased construction of the village road system, an approximate 1,400-foot long, 35-foot wide, straight section of the road is planned to be constructed that could be used as a temporary runway for charter flights.

In 2012, an Airport Site Selection Study was completed by PDC Engineers, Inc. (PDC) that identified the preferred site and orientation for the permanent village airport (PDC 2012). The preferred site is located on the ridge between the quarry site and the proposed village, approximately 345 feet above sea level. The Near-Term Airport plan includes construction of a 75-foot by 3,300-foot northwest/southeast runway. The Ultimate Airport layout plan includes a 75-foot by 4,000-foot northwest/southeast primary runway and a 75-foot by 4,000-foot northeast/southwest crosswind runway. Figure 8 shows the preferred site and the Mertarvik 2014 Airport Layout Plan.

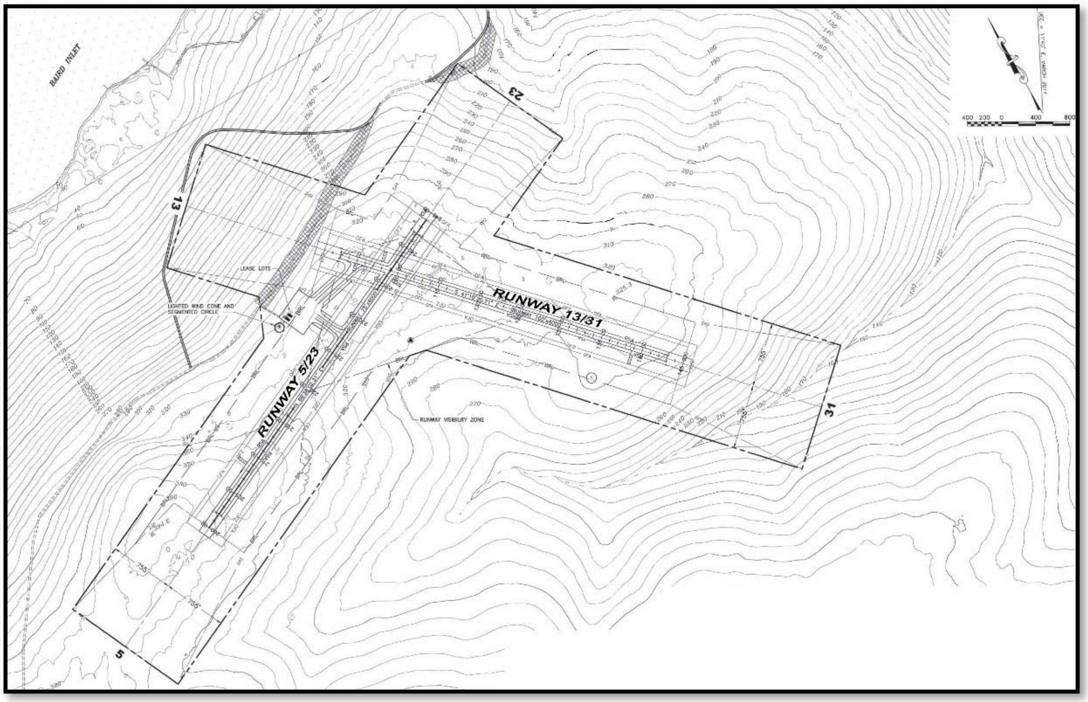


**Figure 8: 2014 Airport Layout Plan**

The Airport Layout Plan for the new airport has been reviewed and accepted by FAA and ADOT&PF (ADOT&PF 2014).

D. Gravel Source

The Mertarvik quarry site is located on top of the ridge, approximately two miles southwest of the new village site. Initial development, drilling, and blasting of the site was completed in 2011. The quarry area is estimated to have approximately 100,000 cubic yards of shot rock material available in stockpile (DCRA 2017a).

E. Existing Buildings

In 2006, Newtok residents constructed three BIA-funded 1,100-square foot homes west of the shallow-draft barge landing (CCHRC 2017). The homes are timber frame construction with batt insulation and post and pad foundations placed directly on the existing tundra. Piped water and sewer service are not available and occupants haul drinking water and utilize honey buckets for sewage disposal. Homes are heated with oil stoves and occupants use small portable generators to provide power. These homes are not located near the proposed village road system and will likely be relocated to lots within the proposed village subdivision. These homes are used as temporary camps for villagers and workers and are not occupied year-round.

In 2011, Cornerstone Construction constructed a 60-foot by 112-foot timber deck and pile foundation for the MEC building. The pile foundation consists of steel H-piles driven to refusal in bedrock. A small-scale septic system and water well were also installed to provide water and sewer service for the MEC building.

In 2011 and 2012, Newtok residents constructed three 1,100 square-foot Association of Village Council Presidents-Regional Housing Authority (AVCP-RHA)/BIA-style homes near the MEC building foundation. The homes are constructed with Structural Insulated Panel on post and pad foundations placed on a prepared gravel pad. The buildings are equipped with oil stoves and rely on hauled water, honey buckets, and small portable generators. These homes are used as temporary camps for villagers and workers and are not occupied year-round.

In 2013, The Military Innovative Readiness Training (IRT) program constructed one 32-foot by 64-foot timber building and three 16-foot by 32-foot timber buildings near the MEC foundation. These buildings have no windows and the interiors are unfinished. The buildings were constructed on post and pad foundations placed on a prepared gravel pad. The buildings are planned to be used as part of a man-camp to support future construction in Mertarvik.

In 2016, CCHRC constructed a 1,100 square-foot cold climate demonstration building in the deep-water barge landing laydown area. The building was constructed with timber truss framing and spray foam insulation in the floor, walls, and ceiling. The building foundation consists of a Triodetic space frame that can be re-leveled to account for differential settlement after construction. The building includes innovative on-site water treatment and waste disposal systems. The house is not currently occupied and will likely be relocated to a lot within the proposed village subdivision.

### F. Existing Fuel Storage in Mertarvik

Four bulk fuel storage tanks are currently located in Mertarvik, which have been used to provide temporary fuel storage in support of past construction projects (Goldstream 2017). Three single-wall tanks are located in the shallow-draft barge laydown area. The fourth double-wall tank is located by the MEC foundation. The tanks, their capacities, and condition are shown in Table 4 below.

**Table 4: Mertarvik Bulk Fuel Tanks**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7’-0” | 20’-0” | Horizontal | Single-Wall | Active | Reuse | Gasoline | Dispensing | 6,000 |
| 2 | 8’-0” | 32’-0” | Horizontal | Single-Wall | Active | Reuse | Diesel 1 | Dispensing | 12,000 |
| 3 | | | Horizontal | Double-Wall | Active | Reuse | Diesel 1 | Dispensing | 5,000 |
| 4 | 7’-0” | 32’-0” | Horizontal | Single-Wall | Inactive | Decommission | Unknown | Unknown | 9,200 |
| | | | | | | | | **Total Gallons** | **32,200** |

Tank numbers 1, 2, and 3 are reported to be in use and in good condition. Tank number 4 is described as a riveted tank that is likely over 40 years old, not code compliant, and should not be considered for permanent or temporary fuel storage in Mertarvik. See Figures 9 and 10 below.


**Figure 9: Existing Tanks in Shallow-Draft Barge Landing Laydown Area**


**Figure 10: 5,000-Gallon Double-Wall Tank Near MEC Foundation**

As part of the 2017 Phase 2A project in Mertarvik, NVC is planning to purchase and deliver one additional 20,000-gallon, single-wall bulk fuel storage tank to Mertarvik. Once this tank is on-site, there will be 44,000 gallons of diesel capacity available for temporary fuel storage during construction. During construction, all single-wall tanks need to be located in a code-compliant, liquid-tight, fuel resistant containment capable of retaining the volume of the largest tank, plus precipitation from the 25-year, 24-hour rain event, with an additional 12 inches of freeboard.

## 7.0 PROPOSED PROJECT PHASING

In 2011, the NPG developed a phased relocation plan as part of the Relocation Report: Newtok to Mertarvik (NPG 2011). The Report included the following four phases, described using

Newtok's native Yup'ik language: Uplluteng (Getting Ready); Upagluteng (Pioneering); Nass'paluteng (Transition); and Piciurlluni (Final Move). The phases were defined according to anticipated funding, construction schedule, and the estimated population levels in Mertarvik. For the purposes of this report, the phases have been further broken down into Phases 2A, 2B, 3A, and 3B to establish specific milestones related to bulk fuel and energy infrastructure development and to capture the anticipated schedule for 2017 and 2018 construction. The revised phases and their associated milestones are described in detail below.

Phase 1 is already complete and NVC has contracted to Goldstream Engineering to complete Phase 2A in summer 2017.

### 7.1 Phase 1: Uplluteng (Getting Ready) – Population: 0 year-round

This phase started in 2006 and continued through 2016. The work performed during this phase consisted of planning, research, community outreach, and construction of small projects in preparation of future phases of development. Planning and preliminary design work included, but was not limited to, a geotechnical investigation, surveying and mapping, Community Development Plan, Strategic Management Plan, Housing Master Plan, Harbor Feasibility Study, Airport Site Selection Study, and Airport Layout Plan.

The following infrastructure was constructed in Mertarvik during Phase 1:

- Three BIA Housing Improvement Program AVCP-RHA houses (2006-2008)
- Water well (2007)
- Shallow-draft barge landing and gravel and Dura-Base mat laydown area (2009)
- Deep-water barge landing and Dura-Base mat laydown area (2010)
- Gravel and Dura-Base mat access road from the barge landing to the anticipated location of the community (2011-2012)
- Dura-Base mat pioneer trail to the gravel quarry site (2011-2012)
- MEC foundation and deck platform (2011)
- Rock quarry material source development (2012)
- Three Department of Housing and Urban Development AVCP-RHA houses (2012)
- Village Safe Water MEC septic system (2012)
- Four Military IRT Program Storage Buildings (2013)
- One CCHRC demonstration house (2016)

### 7.2 Phase 2A: Upagluteng (Pioneering) – Population: 0 year-round

Phase 2A of the project is planned for summer 2017 construction and includes installation of a man-camp, construction of roads, material source development, and construction of four proto-typical housing units, as described below. The man-camp will be provided with its own generator, fuel tank, and heating system to self-generate power and heat. The man-camp will connect to the community well and MEC septic system installed under Phase 1. Power and fuel storage in

Mertarvik will be limited to what is needed to support construction and no community power system, electrical grid, fuel storage, or dispensing will be provided under this phase:

Phase 2A is anticipated to include the following:

- Improve road from barge landing to MEC
- Improve road from MEC to material source
- Develop material source
- Install 20-person man-camp adjacent to MEC
- Renovate IRT buildings to provide a cafeteria and washeteria for man-camp
- Construct exterior of four AVCP-RHA houses near MEC building
- Relocate existing fuel tanks into a temporary lined containment for fuel storage during construction

### 7.3 Phase 2B: Upagluteng (Pioneering) - Population: 0 to 35 year-round

Phase 2B of the project is planned to be completed by the fall of 2018 and includes renovation of existing buildings and construction of additional roads, houses, electrical distribution grid, and prime power plant. Completion of this phase will provide the necessary infrastructure to support a small community of year-round residents in Mertarvik.

Phase 2B is anticipated to include the construction of the following infrastructure in Mertarvik:

- Complete the interior of the four AVCP-RHA houses constructed under Phase 2A
- Construct one CCHRC Training House near MEC building
- Construct five AVCP-RHA houses
- Construct exterior of MEC building and renovate interior for a temporary school
- Construct community roads
- Furnish and install AEA-style modular power plant with a 10,000-gallon double-wall intermediate tank and limited electrical distribution, for prime power to the new homes and community buildings
- Relocate available, usable fuel tanks from Newtok and expand/improve temporary construction tank farm in Mertarvik to provide limited fuel storage for community use

The power plant and bulk fuel improvements constructed under this phase will include an AEA-style generator module and a small electrical distribution system to supply power to the houses, washeteria, and cafeteria building. The generator module will have automated switchgear and controls, and provide recovered generator heat to the adjacent community buildings via a small district heat loop. The houses will have continuous prime power and be suitable for year-round residence. Bulk fuel storage will consist of expanding and improving the temporary construction tank farm to accommodate usable tanks relocated from Newtok. A 10,000-gallon double-wall tank will be provided for the power plant intermediate tank. The power generation, distribution, and recovered heat loop systems will be designed and constructed to accommodate the future growth of the community.

This phase will provide sufficient infrastructure to support a small population of full-time residents in Mertarvik and allow the village relocation effort to move from the Pioneering phase to the Transition phase.

### 7.4 Phase 3A: Nass'paluteng (Transition) – Population: 100 year-round

Phase 3A consists of the first large-scale mobilization of families from Newtok to Mertarvik. This phase is scheduled for fall 2019 completion, but it could be delayed due to limited funding availability. Essential facilities will be relocated to Mertarvik, including a temporary school, post office, clinic, and washeteria constructed within the MEC. Approximately 10 new houses will be constructed and the electrical distribution system will be expanded to provide power to the new homes. A pioneer runway will be completed for year-round village access. Also, private companies and government agencies have expressed interest in implementing demonstration projects during this phase to explore new technologies for renewable and sustainable energy production and water and wastewater treatment. The infrastructure installed under this phase should be designed so it can be easily scaled to match the community's growth.

Phase 3A is anticipated to include the construction of the following infrastructure in Mertarvik:

- Erect temporary facilities in MEC (i.e., washeteria, clinic, classroom, post office, city office)
- Construct community roads
- Construct pioneer airport (unlighted)
- Construct sewage lagoon
- Construct 10 AVCP-RHA or CCHRC houses
- Provide haul system for water from the washeteria to houses and for sewage from houses to the lagoon
- Construct landfill

### 7.5 Phase 3B: Nass'paluteng (Transition) – Population: 200 year-round

This phase may be completed by the fall of 2020, or later (depending on funding availability), and continues development of essential community facilities in Mertarvik. Approximately 10 new homes will be constructed and the electrical distribution system will be expanded. The recovered heat system will be expanded to serve the MEC building. Bulk fuel improvements will include a diesel and gasoline fuel dispenser tank near the village store site, and construction of a new tank farm to provide a gross capacity for 72,000 gallons of diesel and 42,000 gallons of gasoline storage. A barge header pipeline will be constructed from the barge landings to the tank farm. Additionally, above-ground steel gasoline and diesel pipelines will be constructed from the tank farm to the generator intermediate tank and the store fuel dispenser. The tank farm will be sized to provide sufficient storage capacity to meet the near-term need for power generation, heating fuel, and gasoline and diesel dispensing. The tank farm dikes will be oversized to accommodate installation of additional tanks for future expansion.

Phase 3B is anticipated to include the construction of the following infrastructure in Mertarvik:

- Construct other community buildings
- Continue construction of community roads
- Construct 15 new AVCP-RHA or CCHRC houses
- Construct lighted airport
- Provide recovered heat from the generators to the MEC building and other new community buildings
- Construct a bulk diesel and gasoline tank farm with new tanks and retail dispensers in a preferred location. Construct the tank farm with oversized containment dike for future expansion
- Provide piped connection from the tank farm to the power plant intermediate tank and store dispensing tank
- Install new fuel header pipeline from deep-water barge landing to new tank farm, with optional connection at shallow draft barge landing

### 7.6 Phase 4: Piciurlluni (Final Move) **–** Population: over 400 year-round

This stage represents the final move of all Newtok residents to Mertarvik. Phase 4 is currently scheduled for fall 2021 completion, depending on funding availability. The tank farm will be expanded to provide a gross capacity of 207,000 gallons of diesel and 96,000 gallons of gasoline storage. The electrical distribution and district heating systems will be completed, and larger generators will be installed in the generator module. Wind turbines may be erected at a preferred site depending on funding availability and the quality of the wind resource. Wind energy will be integrated into the power generation and district heating systems. Additional community facilities, such as a large school and a new or relocated clinic will be completed.

The final phase of the relocation is anticipated to include construction of the following infrastructure in Mertarvik:

- Construct/relocate existing Newtok clinic
- Construct remaining community buildings
- Construct new school/relocate existing school from Newtok
- Construct remaining community roads
- Construct remaining new houses
- Construct piped water and sewer system and water treatment facilities
- Construct lighted crosswind runway
- Improve barge landing facilities

## 8.0 RECOVERED HEAT POTENTIAL

The electrical efficiency of a typical rural Alaska prime power diesel generator varies between 30% and 35%. This means about two-thirds of the energy content of the fuel consumed to generate electricity is unused. Using recovered heat to heat nearby facilities is a simple, effective method to nearly double the useful energy content of each gallon of fuel.

Available recovered heat is a function of the electric load and generator engine heat rejection. In the initial phase of prime power (Phase 2B), the average electric load will be about 15 kW. The generators will reject over 3,000 British Thermal Units (Btu)/kWh and provide about 50,000 Btu/hour of recovered heat. This is equivalent to one-half gallon/hour of heating fuel which can displace up to 2,000 gallons of heating fuel per year.

During subsequent phases, as electric loads grow and additional recovered heat is available, the recovered heat system will be expanded to serve additional facilities. During Phase 4, average loads will exceed 150 kW. At this load, the generators will reject about 450,000 Btu/hour, which is equivalent to 4.5 gallons/hour of heating fuel. Full utilization of this recovered heat will displace up to 20,000 gallons of heating fuel/year. See Table 5.

**Table 5: Mertarvik Heat Recovery**

| Phase | Average Load (kW) | Heat Rejection (Btu/hr) | Annual Heating Fuel Displaced (gallons) |
|---|---|---|---|
| 2B | 15 | 50,000 | 2,000 |
| 4 | 150 | 450,000 | 20,000 |

## 9.0 RENEWABLE ENERGY POTENTIAL

Affordable and reliable energy is essential to community sustainability. In isolated grids, such as Mertarvik, renewable energy will not completely replace diesel generated power, but it can reduce diesel fuel consumption. Renewables must be effectively designed, constructed, and maintained to reliably integrate with prime power diesel generation systems. Reliable power is key to end-user's satisfaction and poorly integrated renewables can adversely affect power quality and reliability, causing outages, brownouts, and damaged electronic components.

The purpose of the following sections is to evaluate potential options for integrating renewable energy into the new Mertarvik power generation system.

## 9.1 Wind Energy

### A. Wind Resource

Little information is known about the wind resource at Mertarvik. The National Renewable Energy Laboratory (NREL) Wind Map at 50 meters above ground level (AGL) shows Mertarvik region Wind Power ranging from a Class 3 to Class 5 wind resource. See Figure 11 (NREL 2011).

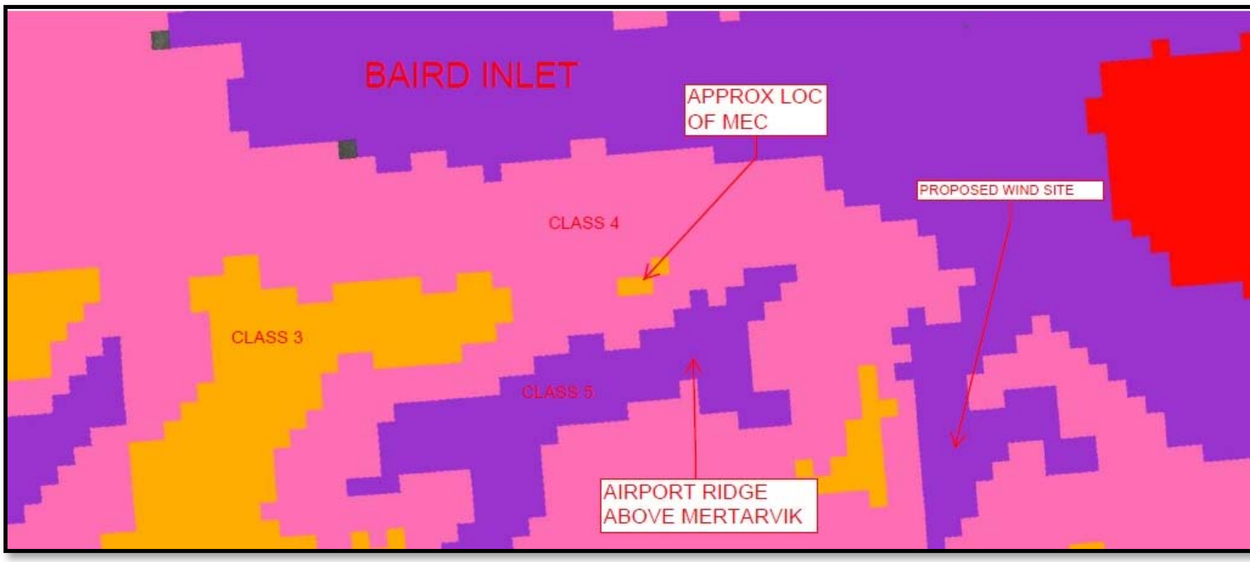


**Figure 11: NREL Mertarvik Wind Map at 50M AGL**

The ADOT&PF completed some wind monitoring as part of its airport design process, but this data does not readily translate into wind resource data. Site specific wind data is needed to determine the wind profile and effects of turbulence due to the surrounding topography.

Due to the proximity of the proposed airport, the location of a wind project is limited by the maximum allowable turbine height of 150 feet above the airport surface level. The proposed site for a potential wind project is located approximately 5,000 feet east of the existing MEC, near the proposed lagoon site. Based on a preliminary review of airport setback requirements and limited topography data, the estimated wind site location is latitude 60°48'18" N, longitude 164°27'04" W, at an approximate elevation of 276 feet. To assess the potential for a wind project, wind monitoring equipment should be installed during the summer of 2017, subject to funding availability for wind monitoring.

The performance of wind projects is routinely evaluated by capacity factor, which is calculated by dividing the wind power actually generated in a year by the total amount of wind energy that could be generated if the turbines are operated at 100% of rated capacity. In the absence of site specific data existing historical annual electric production was reviewed for eleven operating wind projects in Alaska to develop an estimate of the potential wind energy in Mertarvik. The historical annual capacity factor of these projects ranged widely from 9% to 28%, with an average capacity factor of 20%. For purposes of this initial wind analysis, a 20% capacity factor was assumed for Mertarvik. Additionally, existing projects in rural Alaska have shown that wind turbine operations and maintenance is challenging and costly. In this analysis, it is assumed that a skilled maintenance contractor will be hired for full service maintenance of the wind project. Since this cost has not yet been established at Mertarvik, AVEC's published $0.08/kWh wind maintenance cost was used.

Two metrics were used to assess wind power in Mertarvik: simple payback and cost of power. Two scenarios were evaluated for each metric. The first scenario included one Northern Power System (NPS) 100C turbine and the second included two NPS 100C turbines. In both scenarios, the wind turbines are located at the proposed location above the new community lagoon, and include a 2.5-mile intertie between the diesel power plant and wind site.

The cost analysis includes the following assumptions

- 20% Capacity Factor
- $30,000/kW Capital Cost of Construction for 1 turbine
- $20,600/kW Capital Cost of Construction for 2 turbines
- $2.97/gallon power plant diesel fuel
- 13.0 kWh/gallon diesel generator efficiency
- $0.08/kWh wind O&M costs (AVEC published rate)
- $0.23/kWh fuel cost component of diesel-generated electricity
- 20-year useful life of wind equipment

Simple payback is equal to the capital cost of construction divided by net annual savings. Net annual savings is equal to the value of diesel fuel saved less wind maintenance costs. Under both turbine scenarios, the simple payback was more than five-times the estimated useful life of the wind equipment.

Since wind power reduces diesel power plant fuel consumption, the cost of power analysis compares the cost of wind-generated power to the fuel cost component of diesel generated power. The cost of wind power equals the capital cost of construction divided by the total estimated wind kWh generated over a 20-year useful life, plus a $0.08/kWh maintenance cost. Based on the above assumptions, the cost of wind-generated power is $1.13/kWh for the single turbine alternative and $1.01/kWh for the two turbine alternative. See Table 6 below. $1.13/kWh is equivalent to $14.73/gallon power plant diesel fuel, and $1.01/kWh is equivalent to $13.15/gallon power plant diesel fuel. For comparison, the current diesel fuel cost of power is $0.23/kWh at $2.97/gallon power plant diesel fuel.

**Table 6: Wind Turbine Cost of Power**

| # of Turbines | 20% Capacity Factor | |
|---|---|---|
| | ($/kWh) | ($/gal) |
| 1-NPS | 1.133 | 14.73 |
| 2-NPS | 1.012 | 13.15 |

For wind energy to provide an economic benefit to Mertarvik, the capital cost of construction would need to be fully grant funded. Excluding the capital cost of construction, the cost of wind power would be reduced to the $0.08/kWh cost of maintenance, which is a net savings of $0.135/kWh compared to the current $0.215/kWh diesel fuel cost of power.

The Power Cost Equalization (PCE) program subsidizes the cost of electricity for eligible customers in rural Alaska. During the fiscal 2016 year, 68% of the power sold in Newtok was PCE eligible. Due to how the PCE program is structured, most of the benefit from renewable energy is retained by the PCE program, and little savings are passed on to residential and community facility customers. As an example: for a wind project that reduces diesel fuel costs by $0.10/kWh, the PCE rate is reduced by $0.095/kWh (95% of the diesel fuel cost savings), so the net reduction in electric rate after PCE is only one-half/kWh. Although residential and community facility customers would see a minimal effect, under this example, it is possible that commercial and government facilities, as well as other non-PCE eligible consumption could see the full $0.10/kWh rate reduction.

B. Turbine Alternatives

NPS100C-24: Northern Power Systems NPS100C-24 turbines are designed for lower wind speeds and a cut in speed of 7 miles per hour (mph). The NPS100C-24 would have a 30-meter hub height, permanent magnet, synchronous, direct drive wind generator and have a rated electrical power of 95 kW. AVEC Operations has a long history of experience with maintenance and operation of NPS turbines. AVEC's technical maintenance staff are skilled with troubleshooting and performing required maintenance on these units. The turbines are manufactured in Barre, Vermont, and replacement parts are readily available. AVEC has previously installed similar turbines with hub heights ranging from 30 to 37 meters in eleven Alaska villages.

Vestas Wind Systems A/S V17 turbines: The V17 is a 90 kW, fixed pitch turbine with active yaw and a high speed rotor with three blades. Vestas is an international turbine manufacturer based in Denmark, with their American operations based in Portland, Oregon. The V17s were commonly used as small scale industrial wind turbines in the 1980s and 1990s. More recently, these turbines have been replaced in wind farms with new large scale turbines with 1-megawatt capacity or greater. The decommissioned V17s were sold to independent contractors for refurbishment and resale. The V17 is a 26-meter (85-foot) high, 90 kW, induction generator. The turbines are equipped with a 17-meter diameter rotor. Installing one V17 would produce a maximum output of 90 kW at a wind speed of 33 mph. The generator power output can be controlled using a simple inverter and soft breaking or a variable speed drive complex inverter. V17 turbines are available from multiple vendors, and have been previously installed in Alaska at Kokhanok.

Windmatic 17S: The 17S is a fixed pitch turbine with a permanent magnet, synchronous, gearbox-driven generator rated at 95 kW. The 17S is equipped with a 17-meter diameter rotor, with a cut-in speed of 7 mph and rated speed of 33 mph. The generator power output is microprocessor controlled. The 17S is remanufactured and available through multiple vendors. A Windmatic 17S, provided by Talk Inc., located in Sauk Centre, Minnesota, is installed in St. George, Alaska.

### 9.2 Solar Energy

Alaska's high latitude presents the challenge of low solar energy corresponding to long, cold winter months when energy demand is greatest. On an annual basis, average solar insolation for Western Alaska is approximately 3.1 kilowatt-hours/square meter/day (kWh/m2/day), which is roughly one-half that of Southern California. Newtok residents have also reported that the Mertarvik area is frequently foggy, which would further decrease available solar energy (ASCG, January 2004).

Photovoltaic (PV) Watts calculator V1 was run using the closest weather data available in Bethel. PV Watts showed Bethel has a solar radiation of 3.12 kWh/m2/day. A 10 kW system would produce about 9,791 kWh/year, with an estimated energy value of $2,250, based on UPC's current fuel cost of $0.23/kWh.

AEA Rural Energy Fund funded projects in Eagle (2015) reported a capital cost of $261,000 for 24 kW ($11,000/kW) and Kaltag (2013) reported a capital cost of $120,000 for 9.6 kW($12,500/kW). AEA has recommended using approximately $10/watt for the solar PV capital cost for rural Alaska. Using $10/watt, the simple payback for a 10 kW solar PV array installed in Mertarvik is approximately 44 years (10 kW x 1000 watts/kW x $10/watt / $2,250/year), which exceeds the 25-year useful life of solar panels.

At current prices, solar PV should be installed in Mertarvik only if it is grant funded, because the energy production will not recoup the capital cost at current prices. Excluding the capital cost of construction, the cost of solar power would be reduced to maintenance cost, which is primarily the cost of periodically cleaning the solar panels.

If solar PV is installed, it should be no more than 10% of the peak load, or, if additional solar PV capacity is desired, additional cost to integrate the solar-diesel power systems should be budgeted. Additional information about storing excess renewable energy from solar or other renewable resources is included in Section 9.4, Battery Storage.

### 9.3 Hydroelectric Energy

Two potential hydroelectric sites have been identified in the vicinity of Mertarvik with limited U.S. Geological Survey (USGS) stream gauge data: Mertarvik Spring and Takikchak River. The Mertarvik Spring (Site Number 15304405) is the traditional water source for Newtok and is located approximately 1.3 miles east of the existing Mertarvik barge landing, in the vicinity of the proposed sewer lagoon. USGS data for seven months, over a period from May 2005 through September 2006, shows monthly mean flows ranging from 1 to 4 cubic feet/second (cfs). The drainage area for this site is estimated at 4.12 square miles. Due to the limited flow data, low flow rates, and small drainage area the potential to develop a commercially viable hydroelectric project at this site is considered low.

The Takikchak River (Site Number 15304400) is located approximately three miles southwest of the existing Mertarvik barge landing, about one mile west of the future landfill and gravel pit. This is an anadromous stream reportedly heavily used for subsistence. USGS data from June 2004 through September 2006 shows monthly mean flows ranging from 12 to 54 cfs. The drainage area for this site is estimated at 19.46 square miles. The Mertarvik Hydro Resource Assessment (AEA, May 2017), included in Appendix E, predicts a peak hydro output of about 90 kW and annual generation of 324,000 kWh/year. The estimated cost to develop the project is over $5 million. At the current cost of diesel fuel, the benefit cost ration is 0.34. Therefore, the project does not appear economical at this time.

Hydrokinetic energy (i.e., converting tidal, river current, or wave energy to electricity) is a developing industry. However, hydrokinetic power technology is not yet commercially viable and is not recommended for Mertarvik at this time.

### 9.4 Battery Storage

The purpose of battery storage is to store a low cost and abundant intermittent energy, such as electricity generated from solar or wind, to reduce generation from more expensive sources, such as diesel. Battery storage is an important tool to integrate high penetration renewables in remote grids. High penetration generally refers to renewables that generate more than 10% of a community's annual demand. In the absence of a low cost and abundant intermittent energy, battery storage is usually not an appropriate technology.

Few rural communities have battery storage in Alaska; however, lithium-ion batteries for community scale renewable energy systems is increasingly a technology of interest.

This analysis draws empirical data from Colville Lake, Northwest Territories, which recently installed 136.5 kW of solar and 200 kilo-watt-hours (kWh) of battery storage to serve their community of 160 residents (SAFT 2016). Battery costs totaled $1,483,000 Canadian dollar ($105,000 design, $1,378,000 construction). Based on this information, the cost of battery storage was $7,415 Canadian dollar/watt-hour capacity for a high penetration renewable energy system.

However, in Colville Lake, the greatest source of fuel displacement was not solar energy, but improved diesel efficiency. Some diesel efficiency was gained by newer, more efficient engines. Other gains were made by running the diesel engines at the highest efficiency and storing excess electricity, rather than running the generators to follow community demand. Mertarvik will also see diesel savings from new, more efficient diesel generators, switchgear, and distribution.

## 9.5 Biomass

### A. Biomass Resource

Mertarvik has little or no trees in the immediate area. Driftwood gathered from the Ninglick River is commonly used for home heating and sauna. Anecdotal interviews with Newtok community members suggest driftwood can be scarce and, therefore, should not be considered as a fuel source for commercial heating.

In the absence of local forests or abundant driftwood, the most likely biomass heating fuel considered viable for potential use in Mertarvik is wood pellets. Wood pellets could be barged in from the lower 48 and used for home heating in pellet stoves, or for commercial heating in pellet stoves or small pellet boilers.

A fuel switching analysis was completed to determine if wood pellets would offer savings over fuel oil. The fuel switching analysis is a preliminary analysis which compares fuel costs only, and does not include capital costs. See Tables 7 and 8. The fuel switching analysis uses the following metrics for comparison:

- $6.50/gal #1 diesel fuel retail cost (Site Visit March 21, 2017); 138,000 Btu/gal
- $200/ton wood pellets FOB Seattle/Tacoma barge landing (40 lb. bags, 1 ton pallets); 8,200 Btu/lb.
- Freight quotes of $0.68/pound from Seattle to Mertarvik

**Table 7: Pellets Cost**

| Pellets Cost ($/ton) | Freight ($/lb) | Freight ($/ton) | Total Cost ($/ton) |
|---|---|---|---|
| 200 | 0.50 | 1000 | 1200 |
| 200 | 0.60 | 1200 | 1400 |
| 200 | 0.70 | 1400 | 1600 |
| 200 | 0.80 | 1600 | 1800 |

**Table 8: Fuel Value Comparison**

| Fuel | Gross (btu/unit) | Net Boiler Efficiency | Net (btu/unit) | $/unit | Net ($/mmbtu) | Equiv Cost ($/gal) |
|---|---|---|---|---|---|---|
| Oil #1 (gal) (2) | 138,000 | 87% | 120,060 | 6.50 | 54.14 | 6.50 |
| Pellets (ton) (3) | 16,400,000 | 78% | 12,792,000 | 800.00 | 62.54 | 9.39 |
| Pellets (ton) (3) | 16,400,000 | 78% | 12,792,000 | 1200.00 | 93.81 | 11.26 |
| Pellets (ton) (3) | 16,400,000 | 78% | 12,792,000 | 1400.00 | 109.44 | 13.14 |
| Pellets (ton) (3) | 16,400,000 | 78% | 12,792,000 | 1600.00 | 125.08 | 15.02 |

(1) Freight Quotes are $.68/pound from Seattle, WA to Mertarvik, AK

(2) Toyostove estimated at 87% efficient, #1 diesel at 138,000 Btu/Gallon

(3) Premium pellets 8% MC. EPA-certified pellet stove is estimated 78% efficient, 8,200 Btu/Lb.

This fuel switching analysis shows pellets at $1,600/ton is equivalent to heating fuel at $15.02/gallon, which is more than twice the retail cost of $6.50/gallon. Similar to rural communities throughout western Alaska, the high cost of freight makes wood pellets unviable in Mertarvik.

Further analysis is not warranted due to lack of savings from fuel switching.

## 10.0 TOKSOOK BAY INTERTIE FEASIBILITY

The distance between Toksook Bay and Mertarvik is approximately 28.5 miles. Toksook Bay's power utility is owned and operated by AVEC and has 1,618 kW of diesel generator capacity and 400 kW of wind generator capacity. Based on a desktop study comparing the construction cost of the existing interties between the villages of Toksook Bay and Tununak and Toksook Bay and Nightmute, the estimated design and construction cost for an intertie between Toksook Bay and Mertarvik is between $13.5 to $16.5 million. The anticipated upgrades needed at the AVEC Toksook Bay power plant to support the intertie is estimated to cost an additional $1 to $2 million. The wind power at Toksook Bay is nearly fully utilized by the existing power demand. Power provided to Mertarvik via an intertie would be largely diesel-generated electricity. Although the Toksook Bay generation efficiency (kWh/gallon) will likely be marginally better than the diesel generation efficiency of power generated at Mertarvik (13.5 vs 13 kWh/gallon), any resulting fuel savings would be negated by the intertie transmission losses.

### 10.1 Existing Toksook Bay Infrastructure

Toksook Bay is a second-class city of 656 persons (2016 estimate) and is one of three villages located on Nelson Island (DLWD 2017). It is located on Kangirlvar Bay, which is navigable by barge from early June to mid-October.

Electric power is provided to Toksook, Tununak, and Nightmute by AVEC. In 2005, AVEC commissioned a new power generation system in Toksook Bay, which included a new power plant, bulk fuel tank farm, wind generation system, and electrical distribution interties to Tununak and Nightmute. The power plant consists of eight 11-foot wide by 30-foot long modules, set on a structural steel piling foundation and elevated steel deck. The combined generation capacity is 1,618 kW. Three generation modules house two Kohler/Detroit Diesel generation modules (363 kW & 756 kW) and a Cummins generator (499 kW). A fourth module houses controls and switchgear equipment. The other four modules include cold storage, warm storage, lubricating oil storage and emergency living quarters. The enclosed gross square footage of the AVEC power plant is 3,390 square feet.

The Toksook Bay wind generation project includes four 100 kW Northern Power System, Northwind 100A turbines supported on driven steel piles anchored to bedrock. Each foundation is equipped with a large concrete dampening mass and fabricated steel weldment attached to the top of the pile group. The wind turbines are connected to the Toksook Bay power plant via a three-phase primary electrical distribution line. Tununak and Nightmute are intertied to Toksook Bay, and receive prime power from the Toksook Bay power system. The renewable wind electric generation system, integrated with the electronically controlled power plant, reduces fuel oil for electric power generation and provides the economic benefits of renewable energy to residents of all three communities.

A fiber optic communication link provides communication and control of the wind turbines both at the power plant and from AVEC headquarters in Anchorage, maximizing operational stability and allowing remote trouble shooting. Use of electronic engine controls and fully automated switchgear at the power plant accommodate a seamless integration of the wind turbines, leveraging the technology to the fullest extent possible.

The consolidated bulk fuel storage facility provides fuel storage and handling for AVEC, LKSD, City of Toksook Bay, and Nunakauiak Yupik Corporation (NYC). The bulk fuel facility contains 615,000 gallons of diesel and gasoline fuel storage. Storage capacity by participant is 324,000 gallons of diesel for AVEC; 94,000 gallons of diesel for LKSD; 15,000 gallons of diesel for the City of Toksook Bay; and 182,000 gallons of diesel and gasoline for NYC. The tank farm consists of eighteen 27,000-gallon tanks; two 3,000-gallon tanks; two 4,000-gallon tanks; a 3,500-foot long, 4-inch diameter, welded SCH 80 marine header pipeline; 2-inch and 3-inch diameter distribution piping; and two dual product retail dispensers. All storage tanks are horizontal and are supported on a structural gravel pad, within a lined heavy timber dike containment system.

The Toksook Bay power plant generates approximately 3.5 million kWh/year, with 80% generated by diesel and 20% generated by wind. The annual diesel fuel consumption is about 210,000 gallons/year. Peak demand is estimated at about 700 kW, and diesel generation efficiency is approximately 13.5 kWh/gallon.

The estimated peak electric load and annual kWh consumption of the Phase 4 Mertarvik buildout, including the LKSD school, is 230 kW and 1.1 million kWh/year, respectively. At 13.5 kWh/gallon, approximately 81,500 gallons/year of diesel fuel is required to provide 1.1 million kWh/year to Mertarvik.

The existing AVEC bulk fuel storage facility has a gross tank capacity of 324,000 gallons. The net useful capacity, estimated at 90% of gross, is 292,000 gallons. The combined fuel requirement to meet Toksook's existing electric load, in addition to the estimated Mertarvik electric load is 291,500 gallons, which equals the net usable capacity of the AVEC Toksook Bay tank farm. The estimated Toksook Bay peak demand is 700 kW. Adding the projected Mertarvik peak demand of 230 kW results in a combined peak demand of 930 kW, which is well in excess of the 756 kW prime capacity of the largest Toksook Bay generator.

For Toksook Bay to provide long term, reliable prime power and meet Mertarvik's projected peak and annual electric needs, significant energy infrastructure upgrades would be required at the Toksook Bay power plant. These improvements would likely include increased generation capacity, new step-up transformers, and additional fuel storage capacity.

The 2016 AVEC Renewable Energy Fund annual report indicates the wind power output in Toksook Bay was not curtailed and was used in the existing grid (AVEC 2016). Therefore, there is no excess wind energy available and power provided to Mertarvik via an intertie would be largely diesel-generated. It is likely the fuel efficiency of the Toksook Bay power plant could be slightly better than the Mertarvik power plant, but most of any improved fuel efficiency would be lost in transmission line losses between Toksook Bay and Mertarvik.

### 10.2 Intertie Feasibility

The economic feasibility of an electrical intertie from Toksook Bay to Mertarvik appears poor. The high capital cost of constructing the intertie, in combination with the cost to upgrade the fuel storage and generation systems at Toksook Bay to meet Mertarvik's long term energy needs is estimated to be much greater than the cost of constructing a stand-alone power generation facility in Mertarvik.

Generating electric power locally in Mertarvik will provide efficient, reliable power, keep jobs in the community, provide valuable recovered heat, as well as support integration of future renewable energy resources after the final buildout in Phase 4. Although the Toksook Bay generation efficiency (kWh/gallon) may be marginally better than power generated at Mertarvik, any potential fuel savings would be offset by the intertie transmission losses.

## 11.0 PHASED POWER AND BULK FUEL STORAGE DEVELOPMENT PLAN

An AEA-style modular power plant is proposed to meet Mertarvik's long term power generation needs. The modular power plant will be equipped with auto start/stop and paralleling switchgear to select and operate the most efficient generator for the electric load, and to parallel the generators when necessary. The generators will be powered with John Deere Tier 2 and Tier 3 marine engines. The generators will be equipped with critical grade mufflers, and the ventilation ducts sound lined to minimize noise. The cooling system radiator fans will be equipped with variable frequency drives to minimize electric consumption, and maximize availability of recovered heat. An autofill day tank will receive fuel from the 10,000-gallon intermediate tank located adjacent to the plant. The module will be designed to accommodate larger generators as the electric loads increase to the final Phase 4 buildout. The power plant module will be constructed and fully tested in Anchorage prior to shipping to Mertarvik.

### 11.1 Mertarvik Power Generation and Bulk Fuel Siting Criteria

The Alaska Native Tribal Health Consortium (ANTHC) is charged with developing the final layout plan for the new community in Mertarvik. This includes working with NVC to determine the most suitable location for the school, housing subdivisions, roads, community buildings, water treatment plant, power plant, and other necessary infrastructure. See Figure 12. ANTHC requested assistance from AEA to evaluate possible locations for the new power plant and community tank farm. AEA and ANTHC worked together to identify alternative sites for the new power plant and bulk fuel facilities considering the siting criteria discussed below.

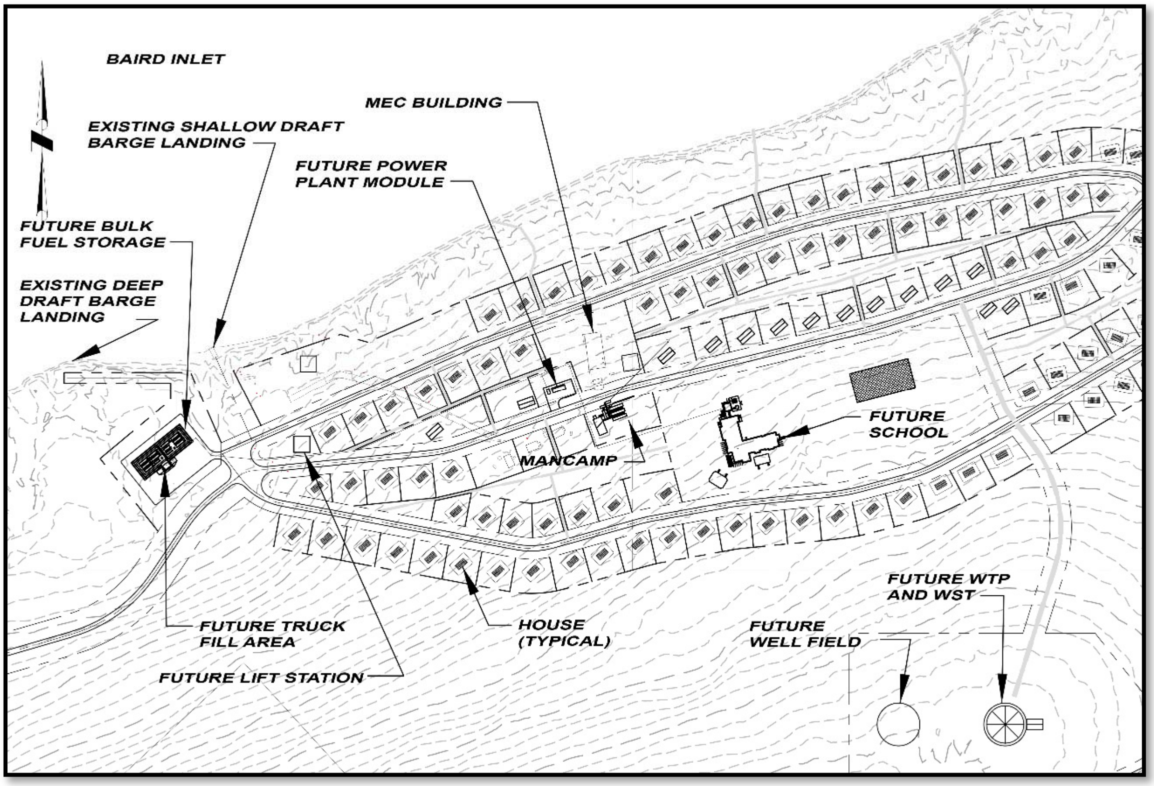


**Figure 12: New Community Layout**

Power Generation Siting Criteria:

*Code Required Setbacks:* The power plant will be located a minimum of 10 feet from the nearest property line which can be built upon, and a minimum of 20 feet from the nearest building on the same property. The International Building Code (IBC) requires a 10-foot minimum clearance from the new power plant to the nearest property line which is, or can be, built upon (refer to Table 9-Code Analysis).

The International Fire Code (IFC) requires a fire apparatus roadway to provide access to within 150 feet of every portion of the new power plant (IFC 2015).

The proposed 10,000-gallon double-wall intermediate fuel tank will be located a minimum of 30 feet from the nearest property line which can be built upon. The IFC requires 30 feet of clearance from 751 to 12,000-gallon bulk storage tanks to the nearest property line, which is, or can be, built upon.

The proposed 10,000-gallon double-wall intermediate fuel tank will be located a minimum of 5 feet from the nearest side of the road ROW and from the power plant. The IFC requires 5 feet of clearance from 751 to 12,000-gallon bulk storage tanks to the nearest side of a public way and the nearest important building on the same property.

**Table 9: Power Plant Building Code Analysis - 2009 Edition International Building Code**

| Section | Requirements | IBC Code Reference |
|---|---|---|
| Occupancy Classification | Group F-1 Factory Industrial Moderate Hazard - Generation Plant | Sec. 306.2 |
| Type of Construction | Type V-B (Non-Rated) | Table 601 and Sec. 602.5 |
| Building Heights and Areas | Allowed: 40'-0" 1 story 8500 S.F.<br>Provided: 16'-0" 1 story 600 S.F. | Table 503 |
| Fire Resistance Rating Requirements for Building Elements | Structural Frame: 0 HR Bearing Walls: 0 HR<br>Interior Partitions: 0 HR Floor: 0 HR Roof: 0 HR | Table 601 |
| Fire Resistance Rating Requirements for Exterior Walls | Exterior Walls 10' ≤ x ≤ 30' : 0 HR | Table 602 |
| Fire Protection System | Fire Protection Not Required.<br>Water Fire Suppression System Provided | Sec. 903.2.4 |
| Occupant Load | Mechanical/Storage = 300 S.F./Person<br>600 S.F./300 S.F. Per Occupant = 2 Occupants | Table 1004.1.1 |
| Means of Egress - Travel Distance | Required 200' Provided 30' | Table 1016.1 |

*Noise Abatement:* The power plant will be equipped with critical grade mufflers to minimize exhaust noise. The power plant structure will be insulated and ventilation ducts will be sound lined to minimize noise transmission from the plant to the surrounding environment.

*Recovered Heat Utilization:* The power plant should be located close to community buildings to provide recovered heat from the diesel generators to reduce the cost of heating the facilities. In other village communities, buildings typically served by recovered heat include the washeteria, water plant, city offices, and other village community supported facilities. If there is an abundance of recovered heat available, some village utilities have elected to sell recovered heat to the school and other commercial buildings in the village.

In Phase 2B, the power plant in Mertarvik is expected to include two 67 kW and one 100 kW marine generators. As the demand for electric power increases, these generators will be up-sized to meet the electric demand. The final build-out of the power plant will provide recovered heat to serve the MEC and other nearby community buildings, but it is unlikely the power plant will generate sufficient recovered heat to serve the new school. Therefore, the power plant should be located to provide recovered heat to the community buildings in the vicinity of the MEC.

*Site Selection:* The two sites considered for the power plant were located west and east of the existing MEC building foundation, respectively. Both of these locations allow recovered heat to be provided to the MEC, washeteria, water plant, village office, and other village community buildings that are planned for construction east of the MEC. The setback requirements from the existing MEC water well determined that the best location for the power plant would be west of the MEC building.

*Construction Considerations:* Soil conditions in the area of the preferred site are anticipated to consist of approximately 15 feet of silty, ice rich permafrost above bedrock. The site is sloped toward the Ninglick River at an approximate 10% grade. Large fills on the slope may have a potential for lateral creep of the upper soil layer in the downhill direction. Foundations need to be designed to resist creep, maintain the integrity of the underlying permafrost, or to account for differential settlement from thaw degradation of the permafrost over time. Foundation alternatives are anticipated to range from insulated gravel fills (with or without thermosyphons), helical piers, and/or driven piles. A site-specific soil investigation is required prior to final design to ensure that the power plant is constructed on a stable foundation.

Approximately 1,200 feet of fuel distribution line will be required to pump from the preferred location of the bulk fuel facility to the new power plant intermediate tank. The pipeline will be welded SCH 80 steel, installed above-grade on helical piers or timber sleeper supports, or buried below grade in an HDPE containment pipe.

Bulk Fuel Siting Criteria:

*General Considerations:* The following information was considered during evaluation of potential sites for a new bulk fuel facility in Mertarvik:

- Parcel of land large enough to accommodate the size and setback requirements of the new tank farm
- Fuel barge pumping limitations and proximity of the tank farm to the barge landing
- Transfer pumping limitations and the proximity of the tank farm to the power plant intermediate tank and store dispensing tank
- Other potential conflicting land uses at the proposed tank farm sites
- Anticipated soil conditions
- Susceptibility of the site to flooding
- Relatively level site

*Code Required Setbacks:* The tank farm will perform three functions: bulk storage, bulk transfer, and dispensing. All tanks are installed above ground, comply with the following setback requirements of the 2009 IFC, National Fire Protection Association (NFPA) publications NFPA 30 and NFPA 30A, the AEA/State of Alaska Division of Fire Prevention memorandum of agreement, and Federal Environmental Protection Agency (EPA) and Alaska Department of Environmental Conservation (ADEC) requirements. All protected aboveground tanks need to be listed and labeled in accordance with UL 2085 and unprotected aboveground tanks need to be listed and labeled in accordance with UL 142. The Setback/Separation Requirements are shown in Table 10 below.

**Table 10: Setback/Separation Requirements**

| Minimum Clearance Notes: | Code Reference: |
|---|---|
| No minimum distance from dispensing tank to dispenser required so long as the dispenser is used for fleet vehicle motor fueling | IFC 2206.2.3 |
| 15' from protected above ground dispensing tank with less than or equal to 6,000 gallon capacity to nearest property line which is or can be built upon | IFC 2206.2.3 |
| 5' from protected above ground dispensing tank with less than or equal to 6,000 gallon capacity to the nearest side of any public way | IFC 2206.2.3 |
| 25' from dispenser to fixed sources of ignition | IFC 2203.11 |
| 50' from the dispenser to all unprotected tanks | IFC 2206.2.3 |
| 3' minimum clearance between tanks | NFPA 30 22.4.2.1 |
| 40' from the bulk storage tanks to the nearest property line which can be built upon | NFPA 30 22.4.1.1 |
| 5' from the interior dike wall to tank | NFPA 30 4.3.2.3.2 |
| 10' from the outside base of dike to property line that can be built on | NFPA 30 4.3.2.3.2 |
| 10' from bulk storage tanks to nearest side of a public way | NFPA 30 22.4.1.1 |
| 25' from loading facility to property line that can be built upon | NFPA 30 28.4.1 |
| 25' from loading facility to above ground tanks | NFPA 30 28.4.1 |
| 25' from dispenser to protected above ground dispensing tank with less than or equal to 6,000 gallon capacity | IFC 2206.2.3 |
| 10' from dispenser to all property lines | NFPA 30A 6.2.1 |
| 50' from unprotected above ground tank to nearest important building on same property | IFC 2206.2.3 |
| 5' from protected above ground tank of less than or equal to 6,000 gallon capacity to nearest important building on same property | IFC 2206.2.3 |
| 100' from unprotected above ground dispensing tank to the nearest property line which is or can be built upon | IFC 2206.2.3 |
| Where fire fighting access is not possible due to terrain, or fire fighting equipment is not available, allow for placement of fills up to the property line | Memorandum of agreement #01-13 between the division of fire and life safety, and the Alaska Energy Authority |
| Allow installation of tank mounted dispensers when the entire system is a listed assembly or is comprised of listed components installed on a listed tank | |

*Site Selection and Preferred Alternative:* The ultimate tank farm site is anticipated to require a minimum of a 300-foot by 250-foot level area for containment and operations. The ANTHC, NPG, and Newtok residents expressed desire to locate the tank farm close to the barge landings and away from homes and community buildings. The design team reviewed the available land near the barge landings and determined the existing deep-water barge landing laydown area is the preferred tank farm location. This site is approximately 310 feet south from the riverbank and 30 feet above normal water and threats to the facility from erosion and flooding should be minimal. The site is located on a mostly flat area south of the deep-water barge landing and west of the shallow-draft barge landing. The site is relatively level and previously disturbed from its use as a staging area and CCHRC house construction. Currently the site is covered with Dura-Base mats that may need to be removed prior to construction.

The site locations were included in the community layout plans that ANTHC presented to the village for consideration. In March 2017, the village approved the ANTHC's Alternative 2 Community Layout Plan and the preferred locations for the power plant and bulk fuel facilities.

*Construction Considerations:* Soil conditions in the area of the preferred site are anticipated to consist of approximately 3 or more feet of silty, ice rich permafrost above bedrock. The site is relatively flat, but excavation may be required to expand the area into the hillside to the south to provide adequate room for tank farm development. Foundations will need to be designed to either remove the permafrost below the tank farm and backfill with compacted non-frost susceptible fill; maintain the integrity of the permafrost; or account for differential settlement from thaw degradation of the permafrost over time. Foundation alternatives are anticipated to range from removing the silty soil down to bedrock and backfilling with gravel, installing insulated gravel fills (with or without thermosyphons), helical piers, and/or driven piles. A site-specific soil investigation is required prior to final design to ensure that the power plant is installed on a stable foundation.

Approximately 1,475 feet of new three-inch SCH 80 steel fuel header pipeline will be required to transport fuel from barges docked at the deep-water and shallow-draft barge landings to the new tank farm. The header will include separate pipelines for diesel and gasoline unloading.

Figure 13 shows the preferred location for the Mertarvik Power Generation and Bulk Fuel facilities.

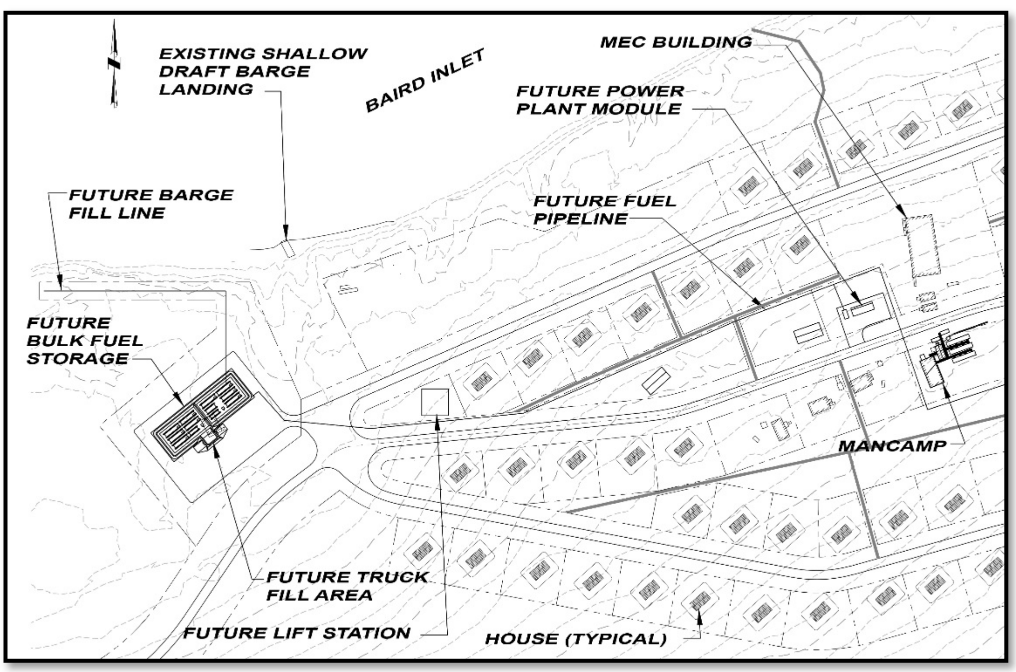


**Figure 13: Proposed Power Plant and Tank Farm Location**

### 11.2 Phase 2A Power and Bulk Fuel Upgrades:

#### A. Mertarvik Power and Bulk Fuel Demand

Phase 2A work is limited to installing a man-camp and constructing roads and houses, as described in Section 7 above. Goldstream Engineering will manage construction activities under contract with NVC. Some village residents are expected to temporarily relocate to Mertarvik during the 2017 construction season to work on the project, but year-round residents are not anticipated. Figure 14 shows Goldstream Engineering Construction Camp layout plan.

The man-camp will consist of three Atco style man camp housing units; a skid-mounted water treatment and storage plant; a skid-mounted generator and clothes drying unit; and a washeteria and kitchen/cafeteria located in the remodeled IRT buildings. The heating units in the tents and buildings, the water heater, and the clothes dryer will be electric and powered by the camp generator. The kitchen range and stove will run on propane.

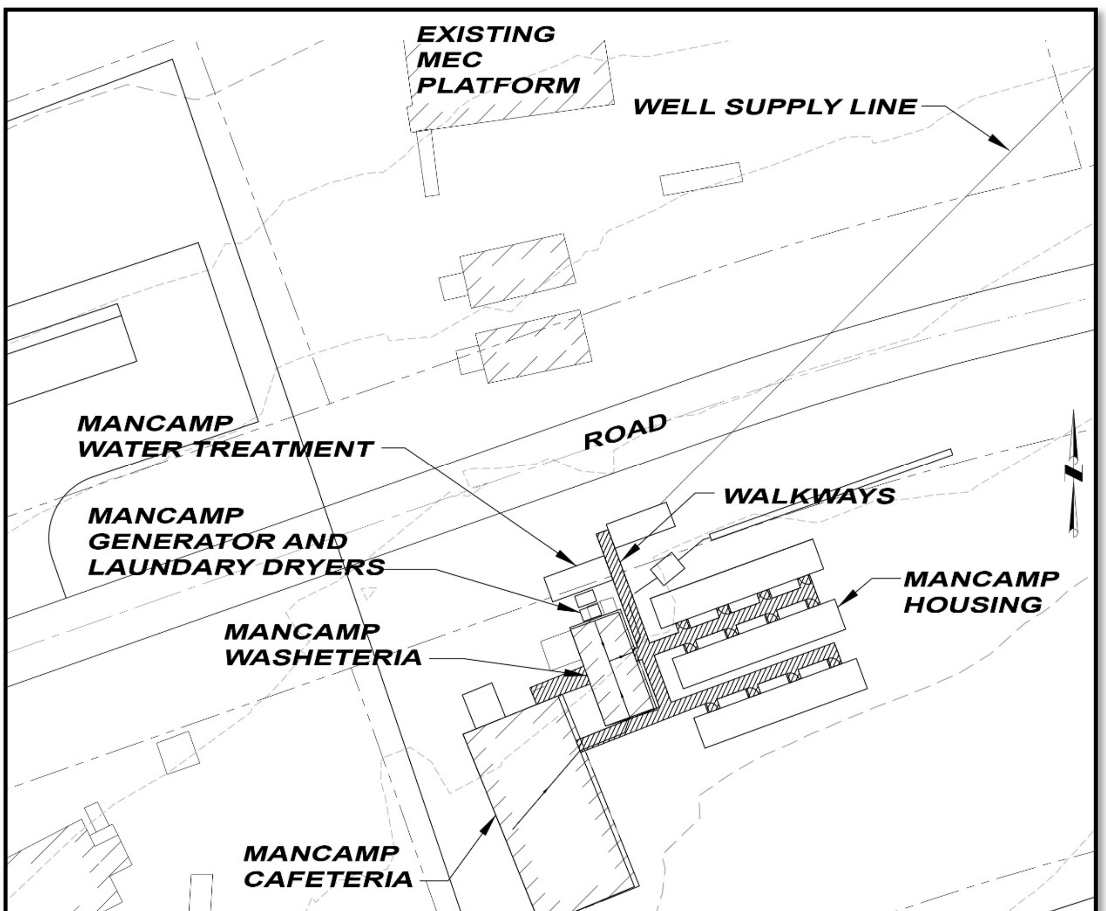


**Figure 14: Goldstream Engineering Construction Camp Layout Plan**

B. Mertarvik Power Systems

During Phase 2A, the man-camp will be equipped with a 150 kW generator to provide power and electric heat to the camp, washeteria, and kitchen. Prime power and electrical distribution will not be available to the new or existing homes. Therefore, village residents that elect to occupy the houses during this phase will be responsible for self-generating electricity.

A larger, 400 kW trailer-mounted electric generator will be mobilized to Mertarvik with the construction equipment and used for crushing rock at the quarry. This generator is part of the heavy equipment spread and excluded from the energy management plan for power planning purposes.

C. Mertarvik Bulk Fuel Storage and Dispensing

The camp generator will have an estimated fuel use of approximately 50 gallons/day. Therefore, approximately 5,000 gallons of diesel storage will be required on-site for power generation during the 90-day construction period. Additionally, Goldstream Engineering estimates that 35,000 gallons of diesel will be required to fuel the construction equipment. Goldstream plans to construct a temporary tank farm on the shallow-draft barge landing laydown area to store fuel for construction and man-camp power generation. The tank farm will include a code compliant, liquid tight containment constructed with gravel and a fuel resistant containment liner. The existing 12,000-gallon single-walled diesel tank and 5,000-gallon gasoline tank currently in Mertarvik will be relocated inside the new temporary containment. Goldstream is also planning to purchase and deliver a new 20,000-gallon single-wall diesel tank for storage during construction. This is an AEA surplus tank that was made available to the project. The tank will be installed in the temporary construction tank farm and incorporated into the new bulk fuel and power plant improvements constructed under a later phase. Fuel will be transferred from the tanks to the equipment and man-camp day tank using a dual-compartment fuel trailer (2,000-gallon diesel/200-gallon gasoline) mobilized to the site with the construction equipment.

Fuel for heating and vehicles will not be commercially available to residents. Therefore, village residents that elect to occupy the houses during this phase will be responsible for providing their own fuel for power, vehicles, and home heating.

11.3 Phase 2B Power and Bulk Fuel Upgrades:

A. Mertarvik Power and Bulk Fuel Demand

During Phase 2B, a small group of village residents in Newtok will begin transitioning to year-round residency in Mertarvik. At the completion of Phase 2B, up to 17 homes may be available for occupancy. The MEC building shell will be complete and part of the building will be used as a temporary school. The expected power and bulk fuel demand during Phase 2B will include the man-camp Military IRT buildings, homes, MEC building, and station service for the new power plant. Table 11 is the estimated annual fuel and power demand under this Phase.

*Residential Heating Fuel Demand:* The prime heating source for the new homes will be direct vent oil fired heaters and the heating demand for the new homes will vary based on the home's construction. The CCHRC homes are designed to a six-star Alaska Housing Finance Corporation (AHFC) energy rating and are expected to use approximately 160 gallons of fuel per year. The AVCP-RHA homes are designed to a five-star AHFC energy rating and are expected to use approximately 255 gallons of fuel per year (CCHRC 2017). If the homes include a direct vent oil fired domestic hot water heater, the houses could burn an additional 150 gallons of fuel per year. For planning purposes, the fuel demand per house is estimated to be 450 gallons per year. The CCHRC and AVCP-RHA home designs will also include wood stoves as a secondary heating source. The average fuel demand per house may be as low as 250 gallons per year depending on the utilization of wood stoves and domestic hot water heaters.

*Gasoline Demand:* Historical gasoline fuel deliveries to Newtok in the past five years have ranged from a high of 55,000 gallons to a low of 21,000 gallons. The average annual gasoline demand in Newtok is estimated to be approximately 31,000 gallons per year. Assuming that the 72 existing homes in Newtok use a similar amount of gasoline per year, the gasoline demand for each household ranges between 430 and 765 gallons/year. For planning purposes, the gasoline fuel demand per household is estimated to be 600 gallons/year for Phase 2B. Based on maximum occupancy of 35 people under this phase, it is likely that only eight or nine of the houses in Mertarvik will be occupied. Therefore, it is recommended that the temporary tank farm utilize the existing 5,800-gallon tank in Mertarvik for gasoline storage. If the demand for gasoline exceeds the 5,800-gallon capacity, Mertarvik residents can travel to Newtok to purchase additional fuel.

*Man-Camp Heating Fuel Demand:* The man-camp will likely be transformed into a community kitchen/meeting room and washeteria during this phase. Under Phase 2A, the facility will be constructed for summer occupancy and additional insulation and weather-proofing will be required for year-round use. The man-camp facility will require an estimated 1,500 gallons/year of fuel to heat the washeteria, kitchen/meeting room, and water treatment plant year-round.

*MEC Heating Fuel Demand:* The MEC building is planned to house a temporary school and village offices. The washeteria and post office may also be temporarily located in the MEC until separate buildings can be constructed during a future phase. LKSD has stated that a minimum 2,000-square foot area is required inside the MEC for the temporary school. The heating fuel demand for the MEC building is expected to change over time, depending on the use of the facility and availability of recovered heat from the new power plant. For planning purposes, an estimated 4,000 gallons/year of diesel will be required to heat the MEC, based on the initial reported heating design load of 140,000 Btu/hour.

*Power Plant Fuel Demand:* The average electric load during Phase 2B is estimated at 16 kW, and the annual power plant fuel consumption is estimated at 11,000 gallons/year of diesel.

**Table 11: Mertarvik Phase 2B Estimated Annual Fuel and Power Demand**

| Building Type | # | Estimated Annual Demand | | | | | |
|---|---|---|---|---|---|---|---|
| | | Diesel (gal/building) | Diesel Subtotal (Gal) | Connected Load (kW/building) | Connected Subtotal (kW) | Average Load (kW/hr building) | Average Subtotal (kW) |
| Village Home | 17 | 450 | 7650 | 12 | 204 | 0.5 | 8.5 |
| Man-Camp | 1 | 1500 | 1500 | 58 | 58 | 2.6 | 2.6 |
| MEC Building | 1 | 4000 | 4000 | 10 | 10 | 4.25 | 4.25 |
| Power Plant | 1 | 11,000 | 11,000 | 10 | 10 | 0.6 | .6 |
| **Total Estimated Demand** | | | **24,150** | | **282** | | **16** |

B. Mertarvik Power Systems

An AEA-style modular power plant will be provided to meet Mertarvik's long-term power generation needs. The modular power plant will be a steel building constructed and tested in Anchorage and shipped to Mertarvik. For reliability and increased available recovered heat, the proposed engines will be EPA Tier 2 or Tier 3 compliant marine engines. The steel module will have sound insulated construction and the engines will be equipped with critical grade disc silencers to reduce noise.

The following features are proposed for the new power plant:

- Sound insulated control room and separate generation room
- Three engine-generator sets with either new or fully remanufactured John Deere engines. Preliminary engine selections include two 67 kW and one 100 kW generators. The proposed engines have a good record of reliable performance, provide good fuel efficiency, and are equipped with marine jackets to increase heat available for recovery
- Three-phase 277/480V generation
- Programmable automatic paralleling switchgear with remote Supervisory Control and Data Acquisition (SCADA), capable of integrating with renewable energy sources
- New pad-mount step up transformer and community feeder connection to the overhead distribution system
- Heat recovery system to provide recovered heat to community buildings
- Water mist fire suppression system

- New 160-gallon interior day tank. Fuel system to include automatic fuel transfer from the power plant double-wall intermediate tank to the day tank. Fuel system to include redundant overfill prevention systems

- A used oil blending system to allow used engine lube oil to be filtered, blended, and burned in the engines

Figure 15 is the AEA style module power plant in Perryville.

**Figure 15: AEA Style Module Power Plant in Perryville**

C. Mertarvik Electrical Distribution

The electrical distribution during Phase 2B is expected to be minimal. The construction type depends on location of homes relative to the power plant, as well as geotechnical recommendations for utility pole foundations. At this time, it is presumed the electrical distribution will consist of a combination of at-grade and overhead construction. Power to the MEC and IRT cafeteria and washeteria will be run at-grade along with the recovered heat arctic piping. Depending on location of homes, the power lines will be run either at-grade or overhead. Power will be distributed at 7.2/12.47 kV. AMPY pre-pay meters, reused from Newtok, will be used for single-phase electric services.

D. Mertarvik Bulk Fuel Storage and Dispensing

Bulk fuel storage during Phase 2B will consist of utilizing existing gasoline and diesel tanks in the community and relocating additional usable tanks from Newtok to the temporary tank farm in Mertarvik. A temporary tank farm will be constructed at the shallow-draft barge landing laydown area during Phase 2A to store fuel for construction equipment and man-camp power generation. This phase will continue to utilize the temporary tank farm to store heating fuel and fuel for power generation. The 5,000-gallon double wall tank will be used for and gasoline storage. The tank farm will need to be improved to be code-compliant, provide security fencing, and ensure proper grounding. The liner and dike wall should be inspected and reconstructing the dike with sand bags and a new liner may be required to ensure it provides adequate liquid-tight containment. During this Phase, an additional 10,000-gallon double-wall tank will be needed for an intermediate tank at the power plant. If the 10,000-gallon double wall tank located at Tom's Store in Newtok is available, it will be relocated to Mertarvik. The following fuel tanks in Table 12 will be located in the temporary tank farm during Phase 2B:

**Table 12: Phase 2B Mertarvik Tank Farm**

| Tank No. | Dia (Ft) | Length (Ft) | Orientation | Description | Location | Diesel Capacity (Gal) | Gasoline Capacity (Gal) |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 20 | Horizontal | Single-wall (Black) | Temp Tank Farm | 6,000 | 5,000 |
| 2 | 8 | 32 | Horizontal | Single-wall | Temp Tank Farm | 12,000 | 0 |
| 3 | | | Horizontal | Double-Wall | Temp Tank Farm | | 5,000 |
| 4 | 10 | 20 | | Double-wall | Power Plant Intermediate Tank | 10,000 | |
| 5 | 12 | 23.6 | Horizontal | AEA Single-Wall - Purchased and Delivered under phase 2A | Temp Tank Farm | 20,000 | 0 |
| **Total Gross Capacity** | | | | | | 48,000 | 5,000 |
| | | | | | | **53,000** | |

The fuel trailer mobilized to Mertarvik during Phase 2A is not anticipated to be code-compliant and a new code-compliant trailer is required under this phase to transfer and dispense fuel. The fuel trailer will be set up with a gas powered fuel pump for transferring fuel from the bulk storage tanks to the power plant intermediate tank, heating fuel intermediate tanks, and commercial dispensing. Fuel dispensed from the trailer will be metered for accounting purposes, similar to the existing sales and accounting system in Newtok.

NVC will own the temporary tank farm and dispensing equipment. Before the facility is used to store fuel for commercial dispensing and power generation, it should be inspected and improved to ensure compliance with state and federal regulatory requirements. The facility will require Operation and Maintenance (O&M) Manuals, U.S. Coast Guard compliant Facility Response Plan, and a Spill Prevention, Control, and Countermeasure Plan meeting EPA and ADEC requirements.

NVC intends to enter into an agreement with NNC for fuel sales, operation, and maintenance of the tank farm facility. NNC operators and managers need be trained on the proper tank farm inspection, use, and maintenance procedures.

E. Mertarvik Recovered Heat

Available recovered heat is estimated to save up to 2,000 gallons of heating fuel per year. The initial buildings served by the district heating system will include a man-camp cafeteria, washeteria, and watering point, and will fully utilize the available recovered heat.

F. Newtok Power and Bulk Fuel Demand

*Newtok Current Power Demand:* Prime power to homes and community buildings in Newtok is provided by UPC's power plant and electrical distribution system. Prime power to the school is provided by a separate power plant owned and operated by LKSD. Current power demand for the UPC facilities was obtained from AEA's PCE program reports for fiscal years 2011 to 2016, included in Appendix C (AEA 2011-2016). These reports identify peak and average load data on a yearly basis. Power consumption data for the Newtok LKSD power plant was not available, but electric loads are estimated to be between 50 and 75 kW. Table 13 shows Newtok's Power Demand.

**Table 13: Newtok Power Demand**

| Fiscal Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|
| Ungusraq Power Company (kWh) | 409,595 | 439,069 | 451,968 | 431,224 | 430,272 | 427,010 |

*Newtok Current Fuel Demand:* Crowley Fuels, Vitus Marine, and Delta Western (Delta) fuel barge companies were contacted for Newtok fuel delivery information. Crowley Fuels and Vitus Marine provided fuel delivery information for the 2015 and 2016 summer delivery seasons and the volume of diesel and gasoline delivered to each entity in the community is shown in Table 14 below. Upon delivery, NNC sold fuel to fill the church, National Guard, and NVC tank farms.

**Table 14: 2015 and 2016 Newtok Fuels Deliveries**

| Entity | 2015 | | 2016 | |
|---|---|---|---|---|
| | Diesel (Gal/Year) | Gasoline (Gal/Year) | Diesel (Gal/Year) | Gasoline (Gal/Year) |
| Ungusraq Power Company (UPC) | 35,000 | 0 | 39,500 | 0 |
| Newtok Native Corporation (NNC) | 26,000 | 21,000 | 23,000 | 21,000 |
| Lower Kuskokwim School District (LKSD) | 62,274 | 0 | 49,583 | 0 |
| Total | 123,274 | 21,000 | 112,083 | 21,000 |

Delta was the only fuel provider to Newtok in 2012 and 2013. In 2012, Delta reported delivering 144,000 gallons of diesel and 55,000 gallons of gasoline to the community. In 2013, Delta reported delivering 170,000 gallons of diesel and 30,000 gallons of gasoline to the community. Delta's records do not track the volume delivered by entity and the volume delivered to each entity during this period is not known. For the four years of fuel delivery on record (2012, 2013, 2015, and 2016), an average of 137,000 gallons of diesel and 31,000 gallons of gasoline was delivered to Newtok per year. The PCE reports show a downward trend in the volume of fuel for power generation in Newtok per year, with a 3% percent decrease from 2013 to 2016. Similarly, Vitus Marine reported a 15% decrease in the average volume of diesel delivered to the Lower Kuskokwim Region over the last two years. Decreases in diesel consumption are likely due to the warmer temperatures experienced during the past two winters and may not reflect a long-term trend in reduced fuel consumption.

The volume of fuel reportedly delivered to UPC for power generation was compared to the data included in the AEA Newtok PCE reports included in Appendix C. Fuel for power generation was calculated using annual average generation efficiencies ranging from 12.6 kWh/gallon in 2011 to 14.4 kWh/gallon in 2016. Using this method, UPC consumed an estimated 44,743 gallons of diesel to generate power in 2015 and 41,839 gallons in 2016. These volumes are slightly higher than the reported volumes delivered to UPC during the same years. LKSD reported that they used approximately 35,000 gallons of diesel for power generation in 2016. This volume is slightly lower than the volume of fuel delivered to LKSD in 2016. Delivery and consumption of similar volumes of fuel for power generation are anticipated in Newtok during Phase 2A and Phase 2B and the improvements planned in Mertarvik during these phases will have little to no effect on the volume of fuel required for power generation.

Housing in Newtok is currently over-crowded. During the Phase 2B relocation from Newtok to Mertarvik the number of occupied homes in Newtok is not expected to decrease based on the number of new homes that are occupied in Mertarvik. As some families move to Mertarvik, other families in crowded homes in Newtok are expected to occupy the abandoned houses. A few homes in Newtok may be lost to the river erosion during Phase 2B and some homes may be relocated away from the riverbank. Therefore, the overall power and fuel demand in Newtok during Phase 2A and Phase 2B is not expected to differ from the levels experienced in 2016.

#### G. Newtok Power and Bulk Fuel Decommissioning Plan

The level of service currently provided by LKSD, UPC, NVC, and NNC in Newtok will not be reduced during Phase 2A and Phase 2B. The community power and bulk fuel facilities will maintain their current fuel through-put and power generation levels. One existing double-wall tank that is not currently in use at Tom's Store should be relocated to Mertarvik under Phase 2B. The other abandoned tanks in Newtok will be decommissioned as funding is available.

### 11.4 Phase 3A Power and Bulk Fuel Upgrades:

#### A. Mertarvik Power and Bulk Fuel Demand

During Phase 3A, more village residents in Newtok will move to Mertarvik as housing becomes available. Ten new CCHRC and/or AVCP-RHA homes are planned to be built during Phase 3A.

Currently, there is not an established plan for relocating existing homes and community buildings from Newtok to Mertarvik; however, future planning efforts may identify additional structures in Newtok that could be moved to Mertarvik during this phase. For planning purposes, the anticipated power and bulk fuel demand during Phase 3A will include the man-camp, up to 27 homes, the MEC building, and the power plant station service.

The Phase 3A power generator facility will continue to use the power generation equipment installed during Phase 2B. The generators have an estimated useful life of 40,000 hours of run time, and with properly scheduled maintenance should last up to 10 years. When additional generator capacity is needed, the generators can be replaced with up to a 210 kW generator to meet the then current and forecast future loads. The average electric load during phase 3A is estimated at 26 kW, and the annual power plant fuel consumption is estimated at 16,000 gallons per year of diesel.

Table 15 summarizes the estimated fuel and power demand during Phase 3A, based on previous described assumptions for heating fuel and power consumption.

**Table 15: Mertarvik Phase 3A Estimated Annual Fuel and Power Demand**

| Building Type | # | Estimated Annual Demand | | | | | |
|---|---|---|---|---|---|---|---|
| | | Diesel (gal/building) | Diesel Subtotal (Gal) | Connected Load (kW/building) | Connected Subtotal (kW) | Average Load (kW/building) | Average Subtotal (kW) |
| Village Home | 27 | 450 | 12,150 | 12 | 324 | 0.5 | 13.5 |
| Man-Camp | 1 | 1500 | 1500 | 58 | 58 | 2.9 | 2.9 |
| MEC Building | 1 | 4000 | 4000 | 10 | 10 | 4.25 | 8.5 |
| Power Plant | 1 | 16,000 | 16,000 | 10 | 10 | 0.6 | 0.6 |
| **Total Estimated Consumption** | | | **33,650** | | **402** | | **25.5** |

*Gasoline Demand:* Based on the historical average gasoline fuel demand in Newtok of approximately 600 gallons/year/household, the expected gasoline demand in Mertarvik is 16,200 gallons during Phase 3A.

B. Mertarvik Power Systems

The addition of 10 homes during Phase 3A is expected to increase the average load by about 10 kW to 26 kW/hour. At this average electric load, the generation efficiency will be about 11 kWh/gallon. The modular power plant generators will have sufficient generation capacity to meet the loads during this phase

C. Mertarvik Electrical Distribution

During Phase 3A, the electrical distribution system will be expanded to serve the 10 additional homes. The electrical distribution system will be 7.2/12.47 kV, 3-phase overhead construction to minimize line losses, and meet the long term needs of the community. Pole mounted transformers will stepdown the 7200 V distribution voltage and provide 120/240 V single-phase power to residential services. For larger customers, 208 V and 480 V 3-phase power will be provided, as required. The type of pole foundations, direct buried or pile, will be determined based on the outcome of the geotechnical investigation.

D. Mertarvik Bulk Fuel Storage and Dispensing

Bulk fuel storage and fuel dispensing during Phase 3A will continue to operate as outlined under Phase 2B. Diesel will continue to be stored in the Mertarvik temporary tank farm and in the double-wall 10,000-gallon power plant intermediate tank. The double-wall 5,000-gallon gasoline tank will not provide enough gasoline fuel storage during Phase 3A. Additional 10,000 gallons of gasoline fuel storage will be required. If one of the double-wall tanks from Tom's Store in Newtok is available, it should be cleaned and relocated to Mertarvik to increase the gasoline storage capacity to 15,000 gallons. If the tank is not available, a new double-wall tank will be required. If the demand for gasoline exceeds the 15,000 gallons, Mertarvik residents can travel to Newtok to purchase additional fuel. Table 16 below describes the capacity of the Phase 3A temporary tank farm.

**Table 16: Phase 3A Mertarvik Tank Farm**

| Tank No. | Dia (Ft) | Length (Ft) | Orientation | Description | Location | Diesel Capacity (Gal) | Gasoline Capacity (Gal) |
|---|---|---|---|---|---|---|---|
| 1 | 7 | 20 | Horizontal | Single-wall (Black) | Temp Tank Farm | 6,000 | 0 |
| 2 | 8 | 32 | Horizontal | Single-wall | Temp Tank Farm | 12,000 | 0 |
| 3 | | | Horizontal | Double-Wall | Temp Tank Farm | 0 | 5,000 |
| 4 | 10 | 20 | | Double-Wall | Power Plant Intermediate Tank | 10,000 | |
| 5 | 12 | 23.6 | Horizontal | AEA Single-Wall - Purchased and Delivered under phase 2A | Temp Tank Farm | 20,000 | 0 |
| 6 | 8 | 28 | Horizontal | New or Relocated Double-Wall | Gasoline Bulk Fuel Storage | | 10,000 |
| **Total Gross Capacity** | | | | | | 48,000 | 15,000 |
| | | | | | | **63,000** | |

The NVC will continue to own the temporary tank farm and NNC will operate and maintain the facility and sell fuel under an agreement with NVC. NNC will continue to use the fuel trailer provided under Phase 2B for dispensing and to transfer fuel to the power plant intermediate tank.

E. Mertarvik Recovered Heat

Available recovered heat is estimated to increase by 1,000 gallons to 3,000 gallons of heating fuel saved per year. The initial buildings served by the district heating system, consisting of the man-camp cafeteria, washeteria, and watering point, will continue to utilize most of the available recovered heat.

F. Newtok Power and Bulk Fuel Demand

The power and heating fuel demand in Newtok will continue to decline as more residents move to Mertarvik and homes are abandoned or relocated. Based on an average Newtok annual home heating fuel demand of 400 gallons/year, heating fuel demand in Newtok may decrease by approximately 4,000 gallons if approximately ten homes are abandoned, relocated to Mertarvik, or destroyed by erosion by the time Phase 3A is initiated. Under this scenario, a corresponding decrease in power demand of approximately 10 kW is anticipated due to the reduced population and housing electric load. The reduced power demand will reduce diesel consumption for power generation by approximately 5,000 gallons/year. Therefore, the total estimated decrease in Newtok diesel demand expected during this phase is 9,000 gallons/year. No appreciable decline in gasoline demand is anticipated.

G. Newtok Power and Bulk Fuel Decommissioning Plan

The existing bulk fuel storage and power generation facilities in Newtok will need to continue to operate and be maintained until the community is relocated to Mertarvik. Existing tanks that are abandoned or no longer used due to the reduced fuel demand described above need to be decommissioned as funding allows. Tanks and power plant facilities located within 50 feet of the riverbanks should be immediately relocated or decommissioned to mitigate the threat of a spill from rapid riverbank erosion. Tanks and piping should be cleaned of fuel and residual sludge, decommissioned in accordance with state and federal requirements, and rendered unusable. If funding allows, tanks should be cut into sections and neatly placed in an ADEC permitted Class III municipal landfill. Sludge and contaminated water should be stored in drums for transport out of the community and disposed of per EPA regulations. Electrical distribution equipment threatened by river erosion will need to be disconnected before it becomes a safety hazard to the community. Existing pre-pay meters should be removed from houses threatened by erosion and reused in Mertarvik. Existing tanks identified as suitable for re-use in Section 6.0 should be relocated to Mertarvik as they are taken out of service and reused in the temporary tank farm, if additional storage is required.

11.5 Phase 3B Power and Bulk Fuel Upgrades:

A. Mertarvik Power and Bulk Fuel Demand

At the conclusion of Phase 3B, more than half of Newtok's population will have relocated to Mertarvik. Fifteen additional new homes are planned for construction during this phase, increasing the total number of new homes in Mertarvik to approximately 42. This phase also includes construction of new or relocation of existing community buildings, such as the post office, NNC and NVC office building, small clinic, and permanent washeteria. For planning purposes, the expected power and bulk fuel demand during phase 3B will include the man-camp, up to 42 homes, the MEC building, the powerhouse, and four 2,000-square foot community buildings. During Phase 3B, the 67 and 100 kW generators will continue to meet the electric load of the community. The new bulk tank farm will be constructed in the preferred location with new horizontal, single-wall tanks installed in a lined gravel containment. The average electrical load during Phase 3B is estimated to increase to 38 kW and the annual power plant fuel consumption is estimated at 21,000 gallons/year of diesel.

Table 17 summarizes the estimated diesel fuel and power demand anticipated during Phase 3B based on previous described assumptions for heating fuel demand and generator efficiency in Mertarvik.

**Table 17: Mertarvik Phase 3B Estimated Annual Fuel and Power Demand**

| Building Type | # | Estimated Annual Demand | | | | | |
|---|---|---|---|---|---|---|---|
| | | Diesel (gal/building) | Diesel Subtotal (Gal) | Connected Load (kW/building) | Connected Subtotal (kW) | Average Load (kW/building) | Average Subtotal (kW) |
| Village Home | 42 | 450 | 18,900 | 12 | 504 | 0.5 | 21 |
| Man-Camp | 1 | 1,500 | 1,500 | 58 | 58 | 2.9 | 2.9 |
| MEC Building | 1 | 4,000 | 4,000 | 20 | 20 | 8.5 | 8.5 |
| Community Buildings | 4 | 1,500 | 6,000 | 10 | 40 | 1.19 | 4.75 |
| Airport | 1 | | | 2 | 2 | 0.25 | 0.25 |
| Power Plant | 1 | 21,000 | 21,000 | 10 | 10 | 0.6 | 0.6 |
| **Total Estimated Consumption** | | | **51,400** | | **634** | | **38** |

*Gasoline Demand*: The demand for gasoline fuel in Mertarvik is expected to increase due to the change from a boardwalk community in Newtok to a community road system in Mertarvik. However, the number of family members living in each new home in Mertarvik is expected to decrease significantly. Therefore, 600 gallons of gasoline/home/year will continue to be assumed to calculate the Phase 3B gasoline fuel demand in Mertarvik. Based on the number of homes in Mertarvik during this phase, the expected gasoline demand in Mertarvik is estimated to be 25,200 gallons/year.

B. Mertarvik Power Systems

The addition of 15 homes and 4 community buildings during Phase 3B is estimated to increase the average load to 38 kW/hour. At this average electric load, the generation efficiency will increase to 12.5 kWh/gallon.

C. Mertarvik Electrical Distribution

The electrical distribution system will be expanded to serve the additional homes and community buildings. Three to five pole-mounted transformers will be added to serve the new homes, and one to two additional transformers may be needed to serve the community buildings, depending on their locations.

D. Mertarvik Bulk Fuel Storage and Dispensing

Bulk fuel storage during Phase 3B will transition from the temporary diesel and gasoline tank farm constructed during Phase 2A to a new permanent, code compliant, fuel storage and dispensing facility constructed in the preferred location on the existing deep-water barge laydown area. A separate retail sales dispensing tank will be installed at the NNC village store so retail dispensing is centrally located in the community and can be easily monitored by store clerks.

*Tank Farm Capacity:* The Denali Commission recommends bulk fuel facilities receiving fuel by barge have the capability to store 13 months of fuel on-site. Additionally, the net capacity of the proposed horizontal tanks is assumed to be 90% of the total gross (shell) capacity. The proposed 13-month gross storage requirements to meet the projected yearly demand is shown in Table 18 below:

**Table 18: Proposed Capacity Requirements for Phase 3B**

| | Gasoline (Gal) | Diesel (Gal) |
|---|---|---|
| Annual Fuel Demand | 25,200 | 51,400 |
| Required 13 Month Net Capacity (Useable equal to 90% of shell capacity) | 27,300 | 55,600 |
| Required 13 Month Gross Capacity (Required shell capacity) | 30,400 | 61,700 |

The design gross capacity for the Phase 3B Mertarvik Bulk Fuel Facility is 92,100 gallons, assuming the projected fuel demand described above. The recommended tank farm storage capacity of the Phase 3B tank farm is designed to meet projected near-term fuel needs of the community, prior to the final phase of the Newtok relocation (Phase 4).

*Tank Farm:* The new bulk tank farm will likely consist of single-wall horizontal tanks installed in a lined gravel containment. The ability to use gravel containment berms will be highly dependent on the results of the site-specific geotechnical investigation of the proposed tank farm site and subsequent geotechnical foundation recommendations. Single-wall tanks are preferred over double-wall tanks due to their reduced construction cost and the availability of local gravel fill to construct the secondary containment berms. The lined gravel containment also allows the manifold piping and pump boxes to be installed within the secondary containment, which reduces the potential for minor spills reaching the environment. If the information from the geotechnical recommendations support a lined gravel containment, construction will likely consist of excavating the existing ice rich, silty-sand below the tank farm down to bedrock; placement and compaction of local fill material for pad construction; construction of gravel containment dikes; and installation of tank farm liner membrane, new bulk and intermediate fuel tanks, manifold and distribution piping, fencing, and a truck fill dispenser. The truck fill dispenser will be installed in a lined gravel containment adjacent to the tank farm. The dispenser will be used to transfer gasoline and diesel from the tank farm to the fuel trailer provided during Phase 2B. The tank farm design will allow for phased construction of the fuel containment dike system, tank installation, and fuel distribution piping such that the Phase 3B facility can be easily scaled to meet the estimated demand for the Phase 4 final build out.

The proposed Phase 3B tank farm will likely include one 20,000-gallon, horizontal, single-wall, diesel bulk tank (purchased during Phase 2A); one new 27,000-gallon, horizontal, single-wall, diesel bulk tank; one new 10,000-gallon, horizontal, double-wall diesel power plant intermediate tank; one new 12,000-gallon, horizontal, single-wall, diesel, intermediate tank; one new 27,000-gallon, horizontal, single-wall, gasoline bulk tank; one new 12,000-gallon gasoline dispensing tank; and one new 6,000 gallon diesel/gasoline double-wall duel dispensing tank. Table 19 below shows the tank farm shell capacity of 114,000 gallons, which is sufficient to meet the Phase 3B capacity requirements for the projected 13-month annual fuel demand described above.

**Table 19: Phase 3B Mertarvik Tank Farm**

| Tank No. | Dia (Ft) | Length (Ft) | Orientation | Description | Location | Diesel Capacity (Gal) | Gasoline Capacity (Gal) |
|---|---|---|---|---|---|---|---|
| 1 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 2 | 10 | 20 | Horizontal | Double-Wall, Bulk Power Plant Intermediate Tank | | 10,000 | 0 |
| 3 | 12 | 26.5 | Horizontal | Single-Wall, Bulk | | 20,000 | 0 |
| 4 | 10 | 20 | Horizontal | Single-Wall, Intermediate | | 12,000 | 0 |
| 5 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 0 | 27,000 |
| 6 | 10 | 20 | Horizontal | Single-Wall, Dispensing | | 0 | 12,000 |
| 7 | | | Horizontal | Double-Wall Duel Dispensing | Store | 3,000 | 3,000 |
| **Total Gross Capacity** | | | | | | 72,000 | 42,000 |
| | | | | | | **114,000** | |

Prior to construction of the Phase 3B tank farm, the remaining tanks in Newtok and the tanks in the Phase 2B temporary Mertarvik tank farm should be inspected to determine if any tanks are suitable for re-use in the new tank farm facility.

On-site storage of spill response equipment will be required by federal and state regulations for the facility. The spill response equipment will be stored in a connex within the gated tank farm area. The connex container will be anchored into the gravel pad to prevent movement. A six-foot tall chain-link fence will surround the perimeter of the tank farm. The gate will include a rolling vehicle gate and two man-gates with locks to provide vehicular and operational access control.

*Secondary Containment:* The tanks need to be installed in a liquid-tight, diesel and gasoline resistant, secondary containment capable of containing a spill from the largest tank and precipitation from the 25-year, 24-hour rainfall event. In addition, it is good engineering practice to provide capacity for a minimum of 12 inches of freeboard above the required storage volume. The containment should also be sufficient to contain snow and/or rainfall precipitation that accumulates between the routine pumping or snow removal operations defined in the O&M Manuals. Intermediate dike walls will be installed to contain minor spills for each 150,000-gallon area of aggregate storage capacity. The exterior dike walls will be designed to contain a major spill event, consisting of the entire spilled volume of a 27,000-gallon tank. The truck-fill dispenser/header will also be located in a lined containment area capable of containing a spill from the largest vessel planned to be filled at the site. The exterior containment dike walls are anticipated to be 2.5 feet tall and the intermediate dike walls are anticipated to be 18 inches tall. Additionally, stairs and walking areas will be designed to provide access to the tanks, pump boxes, piping, and valves.

The dikes will be constructed to a 3:1 slope for stability. The slopes will be stabilized with geotextile grid, concrete slurry, and/or sand bags to dissipate runoff velocity and prevent erosion. The containment areas will be lined with a continuous liner manufactured from fuel and UV resistant plastic geomembrane. The liner will be installed 12 inches below the surface of the containment area. Free draining material will be installed above the liner. A piped drainage collection system will be installed in the containment area to direct drainage to low point sumps for easy discharge.

*Retail Fuel Dispensing:* A separate retail fuel dispensing tank will be installed adjacent to the NNC store in the community. The retail fuel tank and dispenser will include a dual product, protected, double-wall dispensing tank with 3,000 gallons of diesel and 3,000 gallons of gasoline storage capacity. A protected above-ground dispensing tank will only require a 5 foot setback from buildings on the same property, 15 feet from property lines which can be built upon, and the dispenser could be placed directly on the tank. This option would allow the dispensing tank to be placed on a smaller lot. A dual product fuel dispenser will be installed in the store parking area, within view of the NNC sales clerk. The dispenser will include a credit card reader connected to the NNC village store sales counter. The dispenser will be housed in a metal frame structure with a metal shed roof, chain-link sidewalls, and a locking gate. The tank will be filled by a transfer pipeline connected to the new tank farm.

*Fuel Header Pipelines*: Approximately 490 feet of three-inch schedule 80, coated steel, buried primary marine header fuel pipeline will be constructed from the deep-water barge landing to the new tank farm. Approximately 500 feet of secondary marine header pipeline will be constructed from the shallow-draft barge landing and connect to the primary header. This configuration will allow the community to receive fuel from large barges and small lighters, to accommodate the variety of barge types that frequent the region.

*Fuel Distribution Pipelines:* Approximately 2,500 feet of aboveground, two-inch schedule 80 diesel pipeline will be installed from the new NNC tank farm to the power plant intermediate tank, retail sales dispensing tank, and school intermediate tank. An additional 1,900 feet of gasoline distribution pipeline will be constructed from the new NNC tank farm to the retail sales dispensing tank. Pipes will be routed to avoid truck, ATV, and snowmachine routes and marked with Carsonite reflective markers. Pipes will be installed on helical pier or timber sleeper pipe supports. Fuel will be transferred from the 12,000-gallon intermediate tank located in the tank farm to the intermediate and dispensing tanks using transfer pumps housed in a steel enclosure at the tank farm. Based on the findings of the geotechnical investigation and the desires of the community, the pipeline may also be buried to avoid traffic impacts. If buried, the pipe should be installed in a HDPE or PVC containment pipe to reduce the potential of fuel from underground spills impacting the Ninglick River.

*Tank Farm Ownership and Operation:* NVC is anticipated to be the recipient of the grant to construct the new Mertarvik fuel infrastructure described above and will own the fuel storage and dispensing facilities and equipment. NVC plans to enter into a fuel sale, maintenance, and operating agreement with NNC, which allows NNC to sell fuel and be responsible for operations and maintenance of the facility. This is similar to the current agreement between NVC and NNC for fuel storage and dispensing in Newtok.

E. Mertarvik Recovered Heat

As additional homes and community buildings are constructed, the available recovered heat will increase and the district heat loop will be expanded to serve additional end users. The recovered heat available during this phase is estimated to be able to offset up to 4,500 gallons of heating fuel, which may warrant extending the recovered heat system to the MEC.

F. Mertarvik Renewable Energy

The power generation system will be designed to fully integrate with a variety of renewable energy resources, including run-of-river hydro, wind, and photovoltaics (refer to Section 9).

G. Newtok Power and Bulk Fuel Demand

The power and heating fuel demand in Newtok will continue to decline as more village residents move to Mertarvik and homes in Newtok are abandoned or relocated. Based on an average Newtok annual home heating fuel demand of 400 gallons/year, heating fuel demand in Newtok may decrease by approximately 10,000 gallons if the total number of homes that are abandoned, relocated to Mertarvik, or destroyed by erosion in Newtok increase to approximately 25 homes. Under this scenario, a corresponding decrease in power demand of approximately 25 kW is anticipated due to the reduced population and housing electric load. The drop in power demand will reduce diesel consumption for power generation by approximately 10,000 gallons/year. Therefore, the total estimated decrease in Newtok diesel demand expected during this phase is 20,000 gallons/year. The gasoline demand in Newtok is anticipated to decline as more gasoline fuel storage is available in Mertarvik.

H. Newtok Power and Bulk Fuel Decommissioning Plan

During Phase 3B, the existing bulk fuel storage and power generation facilities in Newtok will continue to operate and be maintained. Existing tanks that are abandoned or no longer used due to the reduced fuel demand described above need to be decommissioned as funding levels allow. Tanks and power plant facilities located within 50 feet of the riverbanks should be immediately relocated or decommissioned to mitigate the threat of a spill due to rapid riverbank erosion.

Tanks and piping should be cleaned of fuel and residual sludge, decommissioned in accordance with state and federal requirements, and rendered unusable. If funding allows, tanks should be cut into sections and neatly stacked in an ADEC permitted Class III municipal landfill. Sludge and contaminated water should be stored in drums for transport out of the community and disposed of per EPA regulations. Electrical distribution equipment threatened by river erosion will need to be disconnected before it becomes a safety hazard to the community. Existing pre-pay meters should be removed from houses threatened by erosion and reused in Mertarvik. Existing tanks identified as suitable for re-use in Section 6.0 should be relocated to Mertarvik as they are taken out of service, if additional storage is required.

### 11.6 Phase 4 Power and Bulk Fuel Upgrades:

#### A. Mertarvik Power and Bulk Fuel Demand

During the transition from Phase 3B to Phase 4, the community's power generation and electrical distribution system will be upgraded and expanded to support the power demands of the new school building and the final build-out of the village. Upon conclusion of Phase 4, Newtok's entire population will be relocated to Mertarvik. The Village of Newtok currently includes 78 homes, the school, eight community buildings, two stores, and four commercial utility buildings. Per the 2010 Census, the village of Newtok currently has 354 full-time residents, with an average of 5.9 people in each household. The February 2017 CCHRC Mertarvik Housing Master Plan concluded that 105 new housing units will be needed in Mertarvik to house the current village residents. The ANTHC Community Layout Plan included in Appendix D includes 103 residential lots, four elder housing/four-plex lots, nine community building lots, the school, the MEC building, the man-camp, and the water treatment plant.

The Phase 4 power and fuel demand is based on the final build-out of the proposed houses and infrastructure shown on ANTHC's Community Layout Plan. Under the earlier phases, the estimated average hourly electric consumption (kWh) and annual power plant fuel consumption was estimated based on tabulated data for each identified electric service customer. This level of detail was necessary to confirm the power plant generation and fuel capacity will meet the loads while the community is growing and expanding. For sizing the final Phase 4 power generation and fuel capacity needs, Mertarvik's estimated population and number of electric customers was compared to other communities of similar population, geographic region, and customer base (Akiak, Kwigillingok, and Tununak). This provided actual historical operating data from which to size the final Phase 4 power generation capacity. The estimated fuel demand for the community and commercial buildings is based on historical data from similar buildings with the same use in Newtok and other village communities.

The power plant will be capable of providing power to all of the proposed residential lots and structures identified on the ANTHC Community Layout Plan and the proposed final airport. The estimated power plant generator efficiency will be about 13.0 kW/gallon with an annual fuel consumption of 82,000 gallons/year. The new bulk tank farm constructed in Phase 3B will be expanded to provide new horizontal, single-wall tanks constructed in the lined gravel containment.

Table 20 summarizes the estimated Phase 4 diesel fuel, based on previous described heating fuel demand and generator efficiency in Mertarvik.

**Table 20: Mertarvik Phase 4 Estimated Annual Fuel Demand**

| Building Type | # | Estimated Annual Demand | |
|---|---|---|---|
| | | Diesel (gal/building) | Diesel Subtotal (Gal) |
| Village Home | 103 | 450 | 46,350 |
| Teacher Housing | 1 | 450 | 450 |
| Four-Plex | 2 | 2,000 | 4,000 |
| VPSO Living Quarters | 1 | 450 | 450 |
| Elder Housing | 2 | 2,000 | 4,000 |
| Man-Camp | 1 | 1,500 | 1,500 |
| MEC Building | 1 | 4,000 | 4,000 |
| Power Plant | 1 | 82,000 | 82,000 |
| Corporation Office | 1 | 1,500 | 1,500 |
| CVRF Shop | 1 | 1,500 | 1,500 |
| Store | 1 | 2,000 | 2,000 |
| School | 1 | 6,000 | 6,000 |
| Post Office | 1 | 450 | 450 |
| Tribal Office | 1 | 1,500 | 1,500 |
| Clinic | 1 | 2,000 | 2,000 |
| Washeteria | 1 | 3,000 | 3,000 |
| **Total Estimated Consumption** | | | **160,700** |

*Gasoline Demand:* Based on the assumed annual gasoline demand of 600 gallons/household described in Phase 3B, the expected gasoline demand in Mertarvik is 61,800 gallons/year in Phase 4.

### B. Mertarvik Power Systems

To meet the anticipated electric load in Phase 4, the existing 67 kW generators will be replaced with 210 kW generators, for a combined generation capacity of 520 kW. The additional infrastructure is estimated to increase the average load to 150 kW/hour. At this average electric load, the generation efficiency will increase to about 13 kWh/gallon.

### C. Mertarvik Electrical Distribution

The electrical distribution system will continue to be expanded to serve the new school, additional homes, and community buildings. Additional pole-mounted transformers will be added as necessary.

D. Mertarvik Bulk Fuel Storage and Dispensing

*Tank Farm Capacity:* The proposed 13-month gross storage requirements to meet the projected yearly demand for the relocated community are shown in Table 21 below:

**Table 21: Proposed Capacity Requirements for Phase 4**

| | Gasoline (Gal) | Diesel (Gal) |
|---|---|---|
| **Annual Fuel Demand** | 61,800 | 160,700 |
| **Required 13 Month Net Capacity (Useable equal to 90% of shell capacity)** | 66,950 | 174,092 |
| **Required 13 Month Gross Capacity (Required shell capacity)** | 74,400 | 194,000 |

The design capacity for the Phase 4 Mertarvik Bulk Fuel Facility is 268,400 gallons assuming the projected fuel demand described above. The design shell capacity based on the tank design sizes in the proposed tank farm is 303,000 gallons. The recommended tank farm storage capacity is designed to meet the expected community size based on the ANTHC's approved Community Layout Plan.

Under this Phase, the tank farm constructed in Phase 3B will be enlarged to meet the estimated demand for the Phase 4 final build-out. Five new 27,000-gallon, horizontal, single-wall, diesel bulk tanks and two new 27,000-gallon, horizontal, single-wall, gasoline bulk tanks will be installed in the existing lined, gravel containments. Table 22 below shows the tank farm gross capacity of 303,000 gallons, which is sufficient to meet the Phase 4 capacity requirements for the projected 13-month annual fuel demand described above.

**Table 22: Phase 4 Mertarvik Bulk Fuel Tanks**

| Tank No. | Dia (Ft) | Length (Ft) | Orientation | Description | Location | Diesel Capacity (Gal) | Gasoline Capacity (Gal) |
|---|---|---|---|---|---|---|---|
| 1 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 2 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 3 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 4 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 5 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 6 | 12 | 26.6 | Horizontal | Single-Wall, Bulk | | 20,000 | 0 |
| 7 | 10 | 20 | Horizontal | Single-Wall, Intermediate | | 12,000 | 0 |
| 8 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 27,000 | 0 |
| 9 | | | | Double-Wall Duel Dispensing | Store | 3,000 | 3,000 |
| 10 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 0 | 27,000 |
| 11 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 0 | 27,000 |
| 12 | 11 | 40 | Horizontal | Single-Wall, Bulk | | 0 | 27,000 |
| 13 | 10 | 20 | Horizontal | Single-Wall, Dispensing | | 0 | 12,000 |
| 14 | 11 | 20 | Horizontal | Double-wall Power Plant Intermediate Tank | Power Plant | 10,000 | 0 |
| **Total Gross Capacity** | | | | | | 207,000 | 96,000 |
| | | | | | | **303,000** | |

### E. Mertarvik Recovered Heat

As community buildings are constructed or relocated, they will be connected to the heat recovery system loop. The estimated available recovered heat, based on marine generators and an average load of 150 kW, will displace up to 20,000 gallons of heating fuel per year.

### F. Mertarvik Renewable Energy

Depending on the outcomes of further evaluation, and funding availability, renewable energy options such as wind, PV or run-of-river hydro may be constructed and integrated with the new power plant.

### G. Newtok Power and Bulk Fuel Demand

Once the residents of Newtok have officially moved to Mertarvik, power and bulk fuel services in Newtok will no longer be available. The final transition to eliminate power service in Newtok will need to comply with the Regulatory Commission of Alaska (RCA) power utility service requirements for any existing service connection within the defined service area. Some of the current Newtok residents may decide to continue living at the Newtok village site after the village has officially relocated to Mertarvik. UPC may be obligated to provide service to all of their connected customers within their service area even if only a few customers remain in Newtok. Eventually the cost for providing power and bulk fuel services to only a few people that may remain in Newtok will be too expensive and the additional cost for providing power to any homes that remain in Newtok will need to be passed onto the customer.

H. Newtok Power and Bulk Fuel Decommissioning Plan

Upon Phase 4 relocation of the Newtok community, the bulk fuel storage and power generation facilities in Newtok need to be decommissioned as described in Phase 3A and 3B.

## 12.0 REGULATORY COMMISSION OF ALASKA REQUIREMENTS

The UPC currently operates under RCA CPC&N Certificate number 375. This certificate enables and requires UPC to provide power to Newtok residents within its service territory. This certificate is also a prerequisite to eligibility for the PCE program. The PCE program currently credits eligible UPC customers $0.4362/kWh.

One of the highest priorities for community migration is expansion of UPC's service territory so that "Pioneering" Newtok residents will continue to receive PCE upon arrival in Mertarvik. Additionally, as Mertarvik community buildings are constructed, applications for PCE Community Facility Certification and Eligibility Determination Requests should be filed.

To expand its service territory, UPC must demonstrate it is fit, willing, and able to provide service. An Application for an Amended Certificate must be filed with RCA. The application requires a public notice, service area maps, financial information, and other information detailing UPC's plans and capability. UPC's existing and new service territories need not overlap. An application must be reviewed by the RCA within 180 days per statute. To ensure the service territory has been expanded to include Mertarvik prior to Phase 2A (Fall 2018), the RCA application should be filed no later than Fall 2017.

As noted above, UPC is economically unregulated, and could therefore sell power at a different price in Newtok versus Mertarvik. UPC may find it useful to use electric prices to cue different phases. Indeed, such pricing may become necessary as the cost of providing service in both places fluctuates.

However, it is unlikely that UPC will be able to relinquish its obligation to serve customers who remain behind in Newtok. Nonetheless, the threat and realization of erosion is somewhat unprecedented, and the RCA may be amenable to UPC's request to cease providing service if it is no longer viable to do so.

## 13.0 ENVIRONMENTAL PERMITTING AND REGULATORY REQUIREMENTS

HDL conducted preliminary research using the most current available data from state and federal agencies to identify environmental resources that may be affected by the proposed project. The purpose of the research is to identify permitting and regulatory requirements, and to ensure environmental considerations are adequately addressed during development of the project.

### 13.1 National Environmental Policy Act Review

The Denali Commission, in cooperation with NVC and USACE is preparing an EIS for the Mertarvik Infrastructure Development Project. This EIS will address all activities associated with relocation of the community and the potential environmental impacts of reconstructing all required village infrastructure at the new village site of Mertarvik on Nelson Island. All impact assessment, consultation with federal and state agencies, public involvement, and permitting required for the proposed energy infrastructure described in this document will be addressed in the EIS.

### 13.2 Waters of the U.S., Navigable Waters, and Wetlands

Section 404 of the Clean Water Act requires any person, firm, or agency planning to place structures or conduct work in navigable waters of the U.S., or dump, place, or deposit dredged or fill material in waters of the U.S., including wetlands, to apply for and obtain a permit from USACE. A review of the USACE 2008 *Revised Environmental Assessment/Finding of No Significant Impact for Newtok Evacuation Center Mertarvik, Nelson Island, Alaska* (EA/FONSI), (USACE 2008) indicates wetlands are present throughout most of the project site. The project should be designed to avoid and minimize impacts to wetlands to the maximum extent practicable. A review of USACE list of Navigable Waters indicates the Ninglick River, located adjacent to the project area, is not currently regulated by USACE as a navigable water.

Pollutants entering waters of the U.S. as storm water discharges from construction sites are regulated under Section 402 of the Clean Water act and the Alaska Pollutant Discharge Elimination System. Construction of the project will involve discharge of construction storm water to waters of the U.S., including wetlands. Coverage under the ADEC Construction General Permit will be required.

### 13.3 Cultural, Historic, Pre-Historic, and Archaeological Resources

Consultation with the State Historic Preservation Officer pursuant to Section 106 of the National Historic Preservation Act will be required. Although unlikely, should historic sites that are listed or eligible for listing on the National Register of Historic Places be identified in the project's area of direct, indirect, or visual impacts, the project should be designed to avoid or minimize potential impacts to historic properties.

According to USACE's 2008 EA/FONSI, "Archaeological work in the Nelson Island area has been limited to a few sites outside the project vicinity...and to a few recent archaeological surveys near Nightmute and Toksook Bay mentioned in the Nelson Island Natural and Cultural Knowledge Project. The USACE Alaska District and USFWS archaeologists surveyed the Mertarvik area, including the project site, in 2002...They identified several archaeological sites near the mouth of Takikchak Creek, but did not find any sites that would be affected by the project described in the EA. The site nearest to the proposed project area consists of several shallow pits that were excavated for clay used in making pottery…The site is located approximately 1-mile northeast of the barge landing...”

### 13.4 Fish and Wildlife

#### A. Migratory Birds

Under the Migratory Bird Treaty Act, it is illegal for anyone to "take" migratory birds, their eggs, feathers, or nests. In order to avoid impacts to migratory bird species, USFWS recommends avoiding vegetation clearing activities from April 20 through July 25 in the area proposed for development.

#### B. Bald Eagles

Bald Eagles are protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, whereby the “taking” of bald eagles, their nests, or eggs is prohibited. The Acts define “take” to include any disturbance that causes, or is likely to cause, injury to an eagle, a decrease in productivity, or nest abandonment caused by interference with normal breeding, feeding, or sheltering behavior. According to the USFWS’s National Bald Eagle Guidelines, a minimum buffer of 660 feet, or as close as similar existing activities that are tolerated, should be maintained between the construction activity and the nest. Should eagles’ nests be identified within these zones, USFWS should be consulted on how to proceed.

#### C. Marine Mammals

Marine mammals are protected under the Marine Mammal Protection Act, which prohibits the “take” of marine mammals in U.S. waters, including the intentional or negligent release of toxic material and resultant exposure to marine mammals. The National Marine Fisheries Service (NMFS) Marine Mammal Protection Act interactive map indicates there are several species under NMFS jurisdiction found in marine waters adjacent to the project area. Mitigation measures such as constructing the tank farm in a secondary containment structure and implementing a Spill Prevention Control and Countermeasure Plan may be recommended.

### 13.5 Threatened and Endangered Species

Consultation with USFWS and/or NMFS under Section 7 of the Endangered Species Act will be required. Initial project scoping conducted using USFWS’s Information, Planning, and Conservation System tool indicated that one species listed as threatened, the Spectacled Eider (*Somateria fischeri*), is present in the vicinity of the project site. The project site is not within designated critical habitat. Measures to minimize impacts to Eiders would be developed in consultation with USFWS.

The NMFS threatened and endangered species interactive map indicates there are several ESA-listed species under NMFS jurisdiction found in the vicinity of the project site. However, no designated critical habitat has been identified. The risk of adverse impacts to marine mammals from rural energy projects is primarily from the accidental release of fuel into the environment during dispensing and transfer operations. No adverse impacts to threatened or endangered species, or their critical habitat, are expected as a result of this project; however, measures to reduce the likelihood of accidental releases will be required and incorporated into the final design.

### 13.6 Land Ownership, Management, and Special Use Areas

The entire Mertarvik village site is owned by NNC, an acquired site through a land exchange with USFWS, which was approved by the U.S. Congress in 2003.

### 13.7 Material and Disposal Sites

Should any dedicated material sites be developed for this project, they would need to be assessed in the Mertarvik Infrastructure Development Project EIS and included in state and federal permit applications.

### 13.8 Environmental Categories without Project Imposed Consequences

Environmental resource categories where no resources have been identified within the project vicinity, no impacts are foreseeable, or will not require mitigation include the following:

- Anadromous and resident fish streams: A review of the Alaska Department of Fish and Game's (ADFG) Anadromous Waters Catalog indicates there are no fish-bearing streams at the project site. However, the Takikchak River is an anadromous water, and any future hydropower project involving this stream would require coordination and permitting with ADF&G.
- Air quality: A review of the Environmental Protection Agency website indicates the project is not within an air quality non-attainment area.
- Water quality: A review of ADEC's impaired water bodies mapper indicated that none of the receiving waters for the proposed project are impaired.
- Floodplains: A review of FEMA flood maps indicate there are no mapped floodplains at the project site.
- Contaminated sites: A review of ADEC's Contaminated Sites Database indicates there are no active sites at the project site.

### 13.9 Federal Aviation Administration

In accordance with Code of Federal Regulations Title 14 Part 77, FAA regulations require an airspace study and filing form 7460-1 for proposed wind towers to determine if there is a hazard to air navigation. Coordination with FAA and ADOT&PF is recommended to coordinate published traffic procedures at the new airport to keep patterning aircraft away from any proposed towers.

### 13.10 Permits and Approvals

The Denali Commission and USACE are leading the development of NEPA documentation for the relocation of Newtok to Mertarvik. The Denali Commission and USACE will also be the agencies in responsible charge of obtaining all permits, agency authorizations, and consultation with local, state, and other federal agencies. Consultation with federal agencies under Section 7 of the ESA and Section 106 of the NHPA is required. Required permits include a Section 404 wetlands permit from USACE and coverage under the ADEC Construction General Permit. Table 23 below summarizes the anticipated approval requirements for the proposed project.

**Table 23: Permits**

| Regulatory Action | Authority | Regulatory Agency | Project Activity | Responsibility |
|---|---|---|---|---|
| Federal Agency Approvals | | | | |
| NEPA Document | NEPA | Denali Commission (Lead Agency) | Project is federally funded and requires federal permit | Denali Commission (Lead Agency) USACE |
| Wetlands Permit | Clean Water Act Section 404 | USACE | Discharge of fill or dredged material into waters of the U.S. | Denali Commission USACE |
| Threatened and Endangered Species Consultation | Endangered Species Act Section 7 | USFWS NMFS | Work potentially affecting threatened or endangered species or their habitat | Denali Commission USACE |
| State Agency Approvals | | | | |
| Water Quality Certification | Clean Water Act Section 401 | ADEC | Storm water Discharge review of USACE wetlands permit | Denali Commission USACE |
| Section 106 Review | National Historic Preservation Act Section 106 | ADNR State Historic Preservation Officer | Work potentially affecting significant cultural, historic, pre-historic, or archaeological resources | Denali Commission USACE |
| Construction General Permit | Clean Water Act Alaska Pollutant Discharge Elimination System | ADEC | Storm water discharges to waters of the U.S. from construction site | AEA/Contractor |

## 14.0 CONCLUSIONS AND RECOMMENDATIONS

The rapid rate of riverbank erosion in Newtok is threatening the community and efforts are underway to plan and facilitate relocation of the village to the nearby undeveloped area of Mertarvik. The NVC and ANTHC, in cooperation with other stakeholders, have developed a Community Layout Plan for the new homes and community infrastructure in Mertarvik. The relocation of the community is expected to be performed over six phases (Phase 1, 2A, 2B, 3A, 3B, and 4), with Phase 1 already complete and Phase 2A underway. Construction and implementation of bulk fuel and power plant facilities in Mertarvik to meet the demand of the phased community development is critical to the success of the village relocation. This Energy Master Plan describes the action required under each phase to provide fuel storage, dispensing, power generation, and electrical distribution facilities to meet the anticipated demand. Special consideration has been given to incorporating fuel-efficient power generation equipment, recovered heat, and renewable wind and solar energy into the final power plant concept. The plan also considers the actions required under each phase to decommission the existing dilapidated tank farm and power plant facilities in Newtok and incorporate reusable tanks into the new facilities in Mertarvik. A graphical depiction of the Energy Master Plan is included in Appendix A.

The following actions are recommended to continue the progress of planning, design, and construction of bulk fuel and power generation facilities in Mertarvik:

Recommendations:

1. Continue routine communication with NVC, NPG, ANTHC, the Denali Commission, Lower Kuskokwim School District, and other project stakeholders to ensure energy planning and development is closely coordinated with community priorities, relocation efforts, and funding levels.

2. Assist UPC with expanding the service area in its CPCN to assure the new homes in Mertarvik are PCE eligible to the greatest extent possible.

3. Gather site-specific survey and geotechnical information as required for the energy infrastructure design.

4. Complete Concept Design Reports (CDRs) to evaluate construction alternatives and preliminary costs for new tank farm and power plant upgrades in Mertarvik.

5. Coordinate planned energy improvements with USACE's ongoing permitting effort for the new development in Mertarvik.

6. Secure construction funding for the power plant, electrical distribution system, and temporary tank farm in Mertarvik to support a small population of year-round residents at the end of Phase 2B.

7. To assess the potential for a wind project, wind monitoring equipment should be installed during the summer of 2017, subject to funding availability for wind monitoring.

8. Complete final design of the power plant facility and electrical distribution system to be constructed during Phase 2B. The power plant should be designed such that generators can be replaced with larger units for additional capacity to meet Phase

4's projected energy demand, and to incorporate renewable wind and solar energy and energy storage alternatives.

9. Complete final design of the preferred alternative for a permanent tank farm planned for construction during Phase 3B. The tank farm should be designed so that tanks can be easily added for additional capacity to meet Phase 4's projected fuel demand.

10. Secure construction funding for generator upgrades, electrical distribution system, and tank farm expansion in Mertarvik to meet Phase 3B and Phase 4 energy demand.

11. Complete a CDR to analyze alternatives and costs for development of wind turbines and solar panels and incorporate renewable wind and solar energy into the new power plant design.

12. Finalize operating agreements with NNC and prepare a business plan for a new NVC-owned tank farm and fuel dispensing facilities in Mertarvik.

13. Construct tank farm, power plant, recovered heat, wind power, solar power, and electrical distribution improvements in Mertarvik, as funding levels allow, to meet the demand from the phased relocation of Newtok in accordance with this Energy Master Plan.

14. Decommission existing tank farms, power plant, and electrical distribution equipment in Newtok, as funding levels allow, and as facilities are taken out of service, reach the end their useful life, and are threatened by riverbank erosion.

## 15.0 REFERENCES

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# APPENDIX A

GRAPHICAL DEPICTION OF PHASED ENERGY PLAN

| Phase | Population, Homes, and New Facilities | Tank Farm Status | Tank Farm Location | Diesel Capacity (Gallons) | Gasoline Capacity (Gallons) | Fuel Dispensing | Piped Fuel Distribution | Power Plant Status | Power Plant Location | Power Pant Capacity (kw) | Electrical Distribution System | Recovered Heat | Renewable Energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A | 0 Year-round residents<br>20-person man-camp<br>Temporary cafeteria and washeteria for man-camp.<br>7 houses completed, 4 AVCP homes started | Temporary (For Construction) | Shallow-Draft Barge Landing Laydown Area | 37,000 | 5,800 | By Trailer for Construction | No | Temporary Generators for Construction | Man-Camp<br>Crusher | 125 kW<br>350 kW | No | No | No |
| 2B | Up to 35 year-round residents<br>17 houses completed<br>Construct Temporary School in Mertarvik Evacuation Center (MEC) | Temporary | Shallow-Draft Barge Landing Laydown Area | 47,000 | 5,800 | By Trailer | No | New Small, Temporary Module | West of MEC Building | 69 kW | Yes | Yes | No |
| 3A | Up to 100 year-round residents<br>27 houses completed<br>Construct Sewage Lagoon<br>Construct Landfill<br>Construct Additional temporary facilities in MEC (i.e. washeteria, clinic, classroom, post office, city office) | Temporary | Shallow-Draft Barge Landing Laydown Area | 47,000 | 15,800 | By Trailer | No | New Small, Temporary Module | West of MEC Building | 112 kW | Yes | Yes | No |
| 3B | Up to 200 year-round residents<br>42 houses completed<br>Construct Lighted Airport | Permanent w/ New Horz. Tanks | Deep-Water Barge Landing Laydown Area | 72,000 | 42,000 | 6,000 gallon Dispensing Tank at Store | To Power Plant and Store | New "AEA-Style" Module | West of MEC Building | 520 kW | Yes | Yes | No |
| 4 | Up to 350 year-round residents<br>103 houses<br>Construct new school/relocate existing school from Newtok<br>Construct new clinic<br>Construct remaining community buildings<br>Construct lighted crosswind runway<br>Construct Piped Water and Sewer System<br>Construct Water Treatment Building<br>Construct Sewage Treatment Facility | Permanent w/ New Horz. Tanks | Deep-Water Barge Landing Laydown Area | 207,000 | 96,000 | 6,000 gallon Dispensing Tank at Store | To Power Plant, Store, and School | New "AEA-Style" Module | West of MEC Building | 520 kW | Yes | Yes | Wind and Solar |

# APPENDIX B

Participants in Newtok Planning Group

# Participants in the Newtok Planning Group

## Native Village of Newtok

- Newtok Village Council
- Newtok Native Corporation

## State of Alaska

- Alaska Department of Commerce, Community, and Economic Development– *group coordinator*
- Alaska Department of Environmental Conservation (DEC)/Village Safe Water Program
- Alaska Department of Transportation and Public Facilities
- Alaska Department of Military and Veterans Affairs/Division of Homeland Security and Emergency Management
- Alaska Department of Education and Early Development
- Alaska Department of Health and Social Services
- Alaska Industrial Development and Export Authority/Alaska Energy Authority
- Alaska Governor's Office
- Alaska Legislative Representatives:
  - Senator Lyman Hoffman's Office
  - Representative Herron's Office

## Federal

- U.S. Army Corps of Engineers, Alaska District
- U.S. Department of Commerce, Economic Development Administration
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration
- U.S. Department of Defense, Innovative Readiness Training Program
- U.S. Department of Agriculture, Rural Development
- U.S. Department of Agriculture, Natural Resources Conservation Services
- U.S Department of Housing and Urban Development
- U.S. Department of the Interior, Bureau of Indian Affairs
- U.S Department of Transportation, Federal Aviation Administration
- U.S. Environmental Protection Agency
- Denali Commission
- Alaska Congressional Delegation
  - Senator Lisa Murkowski's Office
  - Representative Don Young's Office

## Regional Organizations

- Association of Village Council Presidents, Regional Housing Authority
- Alaska Native Tribal Health Consortium
- Coastal Villages Region Fund
- Lower Kuskokwim School District

| Graphical Depiction of Phased Energy Plan | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phase** | **Population, Homes, and New Facilities** | **Tank Farm Status** | **Tank Farm Location** | **Diesel Capacity (Gallons)** | **Gasoline Capacity (Gallons)** | **Fuel Dispensing** | **Piped Fuel Distribution** | **Power Plant Status** | **Power Plant Location** | **Power Pant Capacity (kw)** | **Electrical Distribution System** | **Recovered Heat** | **Renewable Energy** |
| 2A | 0 Year-round residents<br>Scheduled Completion Fall 2017<br>20-person man-camp<br>Temporary cafeteria and washeteria for man-camp.<br>7 houses completed, 4 AVCP homes started | Temporary (For Construction) | Shallow-Draft Barge Landing Laydown Area | 38,000 | 5,000 | By Trailer for Construction | No | Temporary Generators for Construction | Man-Camp<br>Crusher | 150 kW<br>400 kW | No | No | No |
| 2B | Up to 35 year-round residents<br>Scheduled Completion Fall 2018<br>17 houses completed<br>Construct Temporary School in Mertarvik Evacuation Center (MEC) | Temporary | Shallow-Draft Barge Landing Laydown Area | 48,000 | 5,000 | By Trailer | No | Full Size Module with Smaller Generators | West of MEC Building | 234 kW | Limited | Yes | No |
| 3A | Up to 100 year-round residents<br>Completion by fall 2019, construction is dependent on funding<br>27 houses completed<br>Construct Sewage Lagoon<br>Construct Landfill<br>Construct Additional temporary facilities in MEC (i.e. washeteria, clinic, classroom, post office, city office) | Temporary | Shallow-Draft Barge Landing Laydown Area | 48,000 | 15,000 | By Trailer | No | Full Size Module with Smaller Generators | West of MEC Building | 234 kW | Yes | Yes | No |
| 3B | Up to 200 year-round residents<br>Completion by fall 2020, construction is dependent on funding<br>42 houses completed<br>Construct Lighted Airport | Permanent w/ New Horz. Tanks | Military Base Camp Area | 72,000 | 42,000 | 6,000 gallon Dispensing Tank at Store | To Power Plant and Store | Full Size Module with Smaller Generators | West of MEC Building | 234 kW | Yes | Yes | No |
| 4 | Up to 400 year-round residents<br>Completion by fall 2021, construction is dependent on funding<br>103 houses<br>Construct new school/relocate existing school from Newtok<br>Construct new clinic<br>Construct remaining community buildings<br>Construct lighted crosswind runway<br>Construct Piped Water and Sewer System<br>Construct Water Treatment Building<br>Construct Sewage Treatment Facility | Permanent w/ New Horz. Tanks | Military Base Camp Area | 207,000 | 96,000 | 6,000 gallon Dispensing Tank at Store | To Power Plant, Store, and School | Full Size Module | West of MEC Building | 520 kW | Yes | Yes | Wind and Solar |

# APPENDIX C

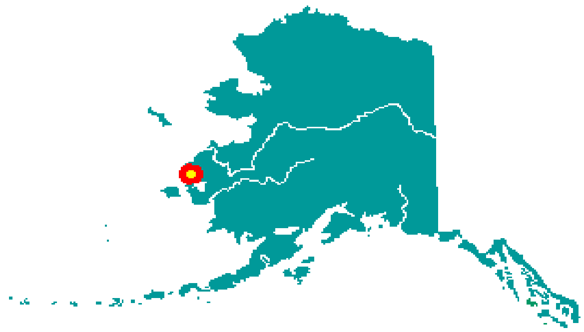
Newtok PCE Data Fiscal Year 2012 - 2016

# Newtok PCE

**Utility: UNGUSRAQ POWER COMPANY**

***Reporting Period: 07/01/15..06/30/16***

| | |
|---|---|
| Community Population | 380 |
| Last Reported Month | June |
| No. of Monthly Payments Made | 12 |
| Residential Customers | 71 |
| Community Facility Customers | 3 |
| Other Customers (Non-PCE) | 25 |
| **Fiscal Year PCE Payments** | **$136,125** |



| PCE Statistical Data | | | |
|---|---|---|---|
| PCE Eligible kWh - Residential Customers | 257,831 | Average Annual PCE Payment per Eligible Customer | $1,840 |
| PCE Eligible kWh - Community Facility Customers | 29,251 | Average PCE Payment per Eligible kWh | $0.47 |
| *Total PCE Eligible kWh* | *287,082* | Last Reported Residential Rate Charged (based on 500 kWh) | $0.80 |
| Average Monthly PCE Eligible kWh per Residential Customer | 303 | Last Reported PCE Level (per kWh) | $0.44 |
| Average Monthly PCE Eligible kWh per Community Facility Customer | 813 | Effective Residential Rate (per kWh) | $0.36 |
| Average Monthly PCE Eligible Community Facility kWh per Person | 6 | PCE Eligible kWh vs Total kWh Sold | 67.9% |

**Additional Statistical Data Reported by Community***

| Generated and Purchased kWh | | Generation Costs | |
|---|---|---|---|
| Diesel kWh Generated | 476,848 | Fuel Used (Gallons) | 41,839 |
| Non-Diesel kWh Generated | 0 | Fuel Cost | $137,869 |
| Purchased kWh | 0 | Average Price of Fuel | $3.30 |
| *Total Purchased & Generated* | *476,848* | Fuel Cost per kWh sold | $0.33 |
| | | Annual Non-Fuel Expenses | $152,492 |
| | | Non-Fuel Expense per kWh Sold | $0.36 |
| | | Total Expense per kWh Sold | $0.69 |

| Consumed and Sold kWh | | Efficiency and Line Loss | |
|---|---|---|---|
| Residential kWh Sold | 272,301 | Consumed vs Generated (kWh Sold vs Generated-Purchased) | 88.6% |
| Community Facility kWh Sold | 29,251 | Line Loss (%) | 10.5% |
| Other kWh Sold (Non-PCE) | 121,023 | Fuel Efficiency (kWh per Gallon of Diesel) | 11.40 |
| *Total kWh Sold* | *422,575* | PH Consumption as % of Generation | 0.9% |
| Powerhouse (PH) Consumption kWh | 4,435 | | |
| *Total kWh Sold & PH Consumption* | *427,010* | | |

**Comments**

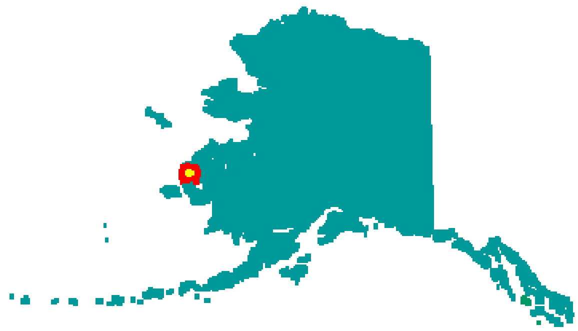
**The data contained in this report is primarily based on information submitted by the utility with their monthly PCE reports. Changes to the reported data and/or significant anomalies have been noted in the comments.*

# Newtok PCE

**Utility: UNGUSRAQ POWER COMPANY**

***Reporting Period: 07/01/14..06/30/15***

| | |
|---|---|
| Community Population | 400 |
| Last Reported Month | June |
| No. of Monthly Payments Made | 12 |
| Residential Customers | 68 |
| Community Facility Customers | 3 |
| Other Customers (Non-PCE) | 25 |
| **Fiscal Year PCE Payments** | **$161,156** |



| PCE Statistical Data | | | |
|---|---|---|---|
| PCE Eligible kWh - Residential Customers | 252,251 | Average Annual PCE Payment per Eligible Customer | $2,270 |
| PCE Eligible kWh - Community Facility Customers | 33,270 | Average PCE Payment per Eligible kWh | $0.56 |
| *Total PCE Eligible kWh* | *285,521* | Last Reported Residential Rate Charged (based on 500 kWh) | $0.80 |
| Average Monthly PCE Eligible kWh per Residential Customer | 309 | Last Reported PCE Level (per kWh) | $0.56 |
| Average Monthly PCE Eligible kWh per Community Facility Customer | 924 | Effective Residential Rate (per kWh) | $0.24 |
| Average Monthly PCE Eligible Community Facility kWh per person | 7 | PCE Eligible kWh vs Total kWh Sold | 67.3% |

**Additional Statistical Data Reported by Community***

| Generated and Purchased kWh | | Generation Costs | |
|---|---|---|---|
| Diesel kWh Generated | 442,280 | Fuel Used (Gallons) | 44,743 |
| Non-Diesel kWh Generated | 0 | Fuel Cost | $173,896 |
| Purchased kWh | 0 | Average Price of Fuel | $3.89 |
| *Total Purchased & Generated* | *442,280* | Fuel Cost per kWh sold | $0.41 |
| | | Annual Non-Fuel Expenses | $160,646 |
| | | Non-Fuel Expense per kWh sold | $0.38 |
| | | Total Expense per kWh sold | $0.79 |

| Consumed and Sold kWh | | Efficiency and Line Loss | |
|---|---|---|---|
| Residential kWh Sold | 267,789 | Consumed vs Generated (kWh Sold vs Generated-Purchased) | 95.9% |
| Community Facility kWh Sold | 33,270 | Line Loss (%) | 2.7% |
| Other kWh Sold (Non-PCE) | 123,081 | Fuel Efficiency (kWh per gallon of diesel) | 9.88 |
| *Total kWh Sold* | *424,140* | PH Consumption as % of generation | 1.4% |
| Powerhouse (PH) Consumption kWh | 6,132 | | |
| *Total kWh Sold & PH Consumption* | *430,272* | | |

**Comments**

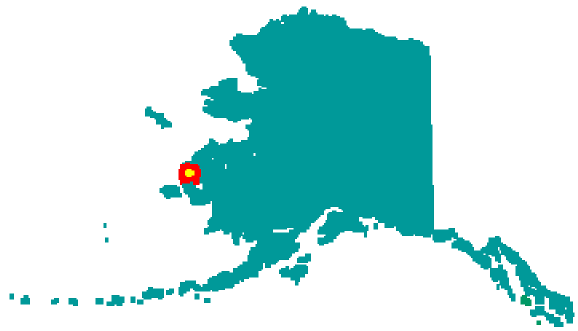
**The data contained in this report is primarily based on information submitted by the utility with their monthly PCE reports. Changes to the reported data and/or significant anomalies have been noted in the comments.*

# Newtok PCE

**Utility: UNGUSRAQ POWER COMPANY**

***Reporting Period: 07/01/13..06/30/14***

| | |
|---|---|
| Community Population | 377 |
| Last Reported Month | June |
| No. of Monthly Payments Made | 12 |
| Residential Customers | 68 |
| Community Facility Customers | 3 |
| Other Customers (Non-PCE) | 25 |
| **Fiscal Year PCE Payments** | **$164,276** |



| PCE Statistical Data | | | |
|---|---|---|---|
| PCE Eligible kWh - Residential Customers | 252,423 | Average Annual PCE Payment per Eligible Customer | $2,314 |
| PCE Eligible kWh - Community Facility Customers | 33,101 | Average PCE Payment per Eligible kWh | $0.58 |
| *Total PCE Eligible kWh* | *285,524* | Last Reported Residential Rate Charged (based on 500 kWh) | $0.80 |
| Average Monthly PCE Eligible kWh per Residential Customer | 309 | Last Reported PCE Level (per kWh) | $0.57 |
| Average Monthly PCE Eligible kWh per Community Facility Customer | 919 | Effective Residential Rate (per kWh) | $0.23 |
| Average Monthly PCE Eligible Community Facility kWh per person | 7 | PCE Eligible kWh vs Total kWh Sold | 67.2% |

| Additional Statistical Data Reported by Community* | | | |
|---|---|---|---|
| **Generated and Purchased kWh** | | **Generation Costs** | |
| Diesel kWh Generated | 446,009 | Fuel Used (Gallons) | 44,165 |
| Non-Diesel kWh Generated | 0 | Fuel Cost | $177,209 |
| Purchased kWh | 0 | Average Price of Fuel | $4.01 |
| *Total Purchased & Generated* | *446,009* | Fuel Cost per kWh sold | $0.42 |
| | | Annual Non-Fuel Expenses | $146,654 |
| | | Non-Fuel Expense per kWh sold | $0.35 |
| | | Total Expense per kWh sold | $0.76 |

| Consumed and Sold kWh | | Efficiency and Line Loss | |
|---|---|---|---|
| Residential kWh Sold | 272,602 | Consumed vs Generated (kWh Sold vs Generated-Purchased) | 95.3% |
| Community Facility kWh Sold | 33,101 | Line Loss (%) | 3.3% |
| Other kWh Sold (Non-PCE) | 119,141 | Fuel Efficiency (kWh per gallon of diesel) | 10.10 |
| *Total kWh Sold* | *424,844* | PH Consumption as % of generation | 1.4% |
| Powerhouse (PH) Consumption kWh | 6,380 | | |
| *Total kWh Sold & PH Consumption* | *431,224* | | |

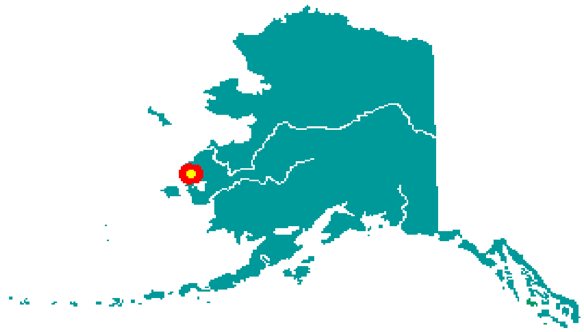
**Comments**

**The data contained in this report is primarily based on information submitted by the utility with their monthly PCE reports. Changes to the reported data and/or significant anomalies have been noted in the comments.*

# Newtok PCE

**Utility: UNGUSRAQ POWER COMPANY**

***Reporting Period: 07/01/12..06/30/13***



| | |
|---|---|
| Community Population | 370 |
| Last Reported Month | June |
| No. of Monthly Payments Made | 12 |
| Residential Customers | 66 |
| Community Facility Customers | 3 |
| Other Customers (Non-PCE) | 23 |
| **Fiscal Year PCE Payments** | **$174,283** |

| PCE Statistical Data | | | |
|---|---|---|---|
| PCE Eligible kWh - Residential Customers | 253,549 | Average Annual PCE Payment per Eligible Customer | $2,526 |
| PCE Eligible kWh - Community Facility Customers | 33,438 | Average PCE Payment per Eligible kWh | $0.61 |
| *Total PCE Eligible kWh* | *286,987* | Last Reported Residential Rate Charged (based on 500 kWh) | $0.80 |
| Average Monthly PCE Eligible kWh per Residential Customer | 320 | Last Reported PCE Level (per kWh) | $0.62 |
| Average Monthly PCE Eligible kWh per Community Facility Customer | 929 | Effective Residential Rate (per kWh) | $0.18 |
| Average Monthly PCE Eligible Community Facility kWh per person | 8 | PCE Eligible kWh vs Total kWh Sold | 64.0% |

**Additional Statistical Data Reported by Community***

| Generated and Purchased kWh | | Generation Costs | |
|---|---|---|---|
| Diesel kWh Generated | 462,408 | Fuel Used (Gallons) | 42,851 |
| Non-Diesel kWh Generated | 0 | Fuel Cost | $192,650 |
| Purchased kWh | 0 | Average Price of Fuel | $4.50 |
| *Total Purchased & Generated* | *462,408* | Fuel Cost per kWh sold | $0.43 |
| | | Annual Non-Fuel Expenses | $152,169 |
| | | Non-Fuel Expense per kWh sold | $0.34 |
| | | Total Expense per kWh sold | $0.77 |

| Consumed and Sold kWh | | Efficiency and Line Loss | |
|---|---|---|---|
| Residential kWh Sold | 276,720 | Consumed vs Generated (kWh Sold vs Generated-Purchased) | 97.0% |
| Community Facility kWh Sold | 34,057 | Line Loss (%) | 2.3% |
| Other kWh Sold (Non-PCE) | 137,729 | Fuel Efficiency (kWh per gallon of diesel) | 10.79 |
| *Total kWh Sold* | *448,506* | PH Consumption as % of generation | 0.7% |
| Powerhouse (PH) Consumption kWh | 3,462 | | |
| *Total kWh Sold & PH Consumption* | *451,968* | | |

**Comments**

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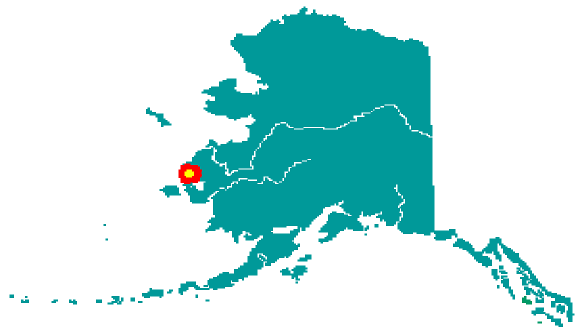
# Newtok PCE

**Utility: UNGUSRAQ POWER COMPANY**

***Reporting Period: 07/01/11..06/30/12***

| | |
|---|---|
| Community Population | 354 |
| Last Reported Month | June |
| No. of Monthly Payments Made | 12 |
| Residential Customers | 66 |
| Community Facility Customers | 3 |
| Other Customers (Non-PCE) | 23 |
| **Fiscal Year PCE Payments** | **$143,685** |



| PCE Statistical Data | | | |
|---|---|---|---|
| PCE Eligible kWh - Residential Customers | 243,114 | Average Annual PCE Payment per Eligible Customer | $2,082 |
| PCE Eligible kWh - Community Facility Customers | 36,173 | Average PCE Payment per Eligible kWh | $0.51 |
| *Total PCE Eligible kWh* | *279,287* | Last Reported Residential Rate Charged (based on 500 kWh) | $0.80 |
| Average Monthly PCE Eligible kWh per Residential Customer | 307 | Last Reported PCE Level (per kWh) | $0.56 |
| Average Monthly PCE Eligible kWh per Community Facility Customer | 1,005 | Effective Residential Rate (per kWh) | $0.24 |
| Average Monthly PCE Eligible Community Facility kWh per person | 9 | PCE Eligible kWh vs Total kWh Sold | 64.5% |

**Additional Statistical Data Reported by Community***

| Generated and Purchased kWh | | Generation Costs | |
|---|---|---|---|
| Diesel kWh Generated | 497,892 | Fuel Used (Gallons) | 44,253 |
| Non-Diesel kWh Generated | 0 | Fuel Cost | $180,849 |
| Purchased kWh | 0 | Average Price of Fuel | $4.09 |
| *Total Purchased & Generated* | *497,892* | Annual Non-Fuel Expenses | $160,848 |
| | | Non-Fuel Expense per kWh sold | $0.37 |

| Consumed and Sold kWh | | Efficiency and Line Loss | |
|---|---|---|---|
| Residential kWh Sold | 262,020 | Consumed vs Generated (kWh Sold vs Generated-Purchased) | 87.0% |
| Community Facility kWh Sold | 36,173 | Line Loss (%) | 11.8% |
| Other kWh Sold (Non-PCE) | 134,736 | Fuel Efficiency (kWh per gallon of diesel) | 11.25 |
| *Total kWh Sold* | *432,929* | | |
| Powerhouse (PH) Consumption kWh | 6,140 | | |
| *Total kWh Sold & PH Consumption* | *439,069* | | |

**Comments**

**The data contained in this report is primarily based on information submitted by the utility with their monthly PCE reports. Changes to the reported data and/or significant anomalies have been noted in the comments.*

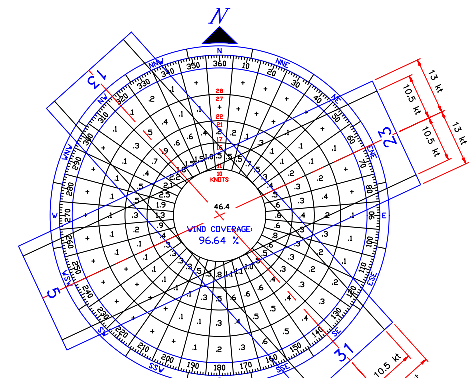
# APPENDIX D

ANTHC 95% Mertarvik Community Layout Plan

1 2 3 4

# 95% LAYOUT
# NOT FOR CONSTRUCTION

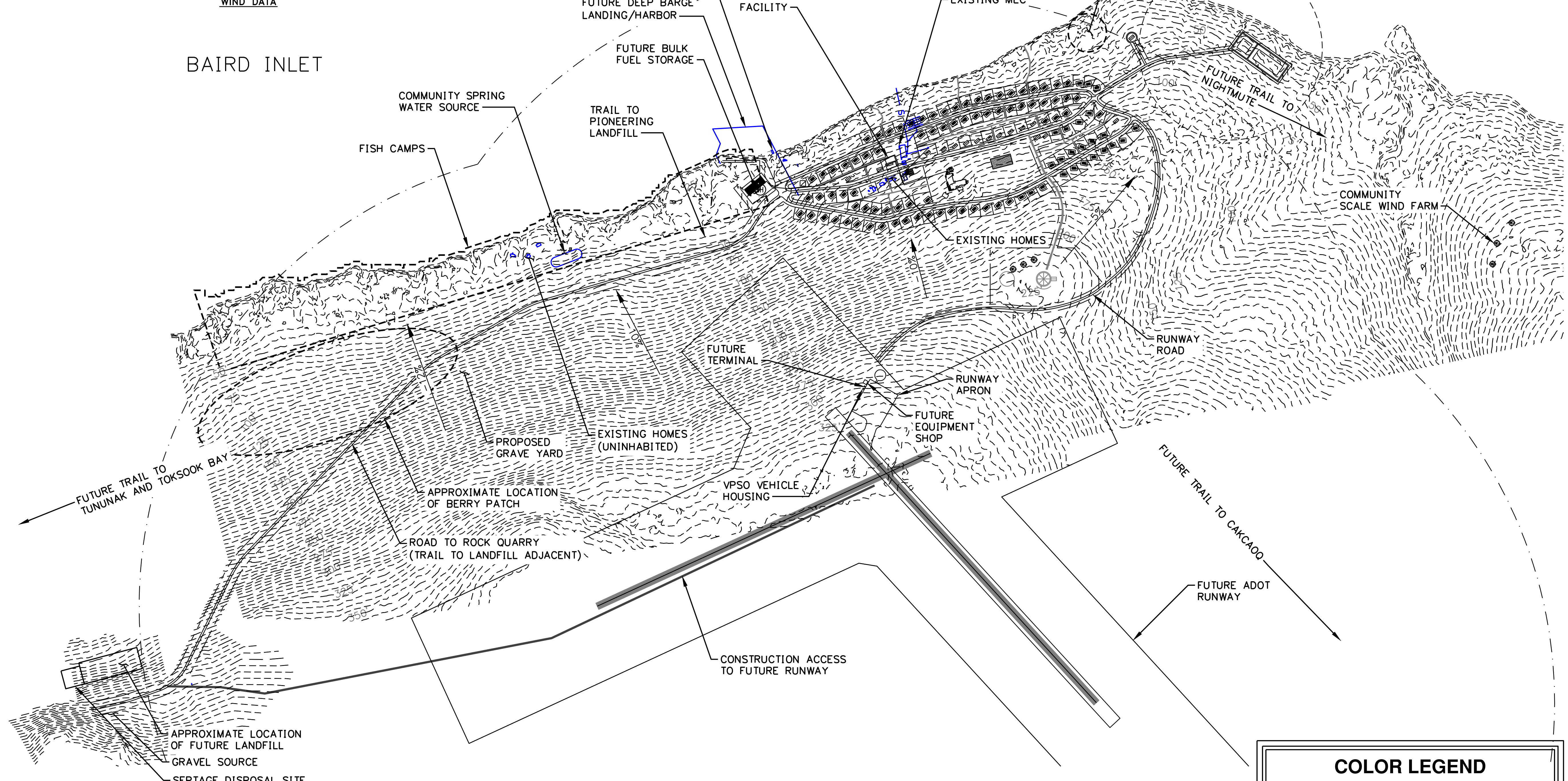
| WIND DATA TABLE | | |
|---|---|---|
| RUNWAY | 13 kt | 16 kt |
| 13/31 | 89.26% | 94.76% |
| 5/23 | 77.35% | – |
| COMBINED | 96.64% | – |
| | | |




DATA SOURCE: DRYDEN INSTUMENTATION, COLLECTED FOR THIS PROJECT

PERIOD: FEBRUARY 2007 – JANUARY 2009

WIND DATA




## COLOR LEGEND

EXISTING INFRASTRUCTURE

## (A1) OVERALL SITE PLAN

1" = 600'

D C B A

Division of Environmental Health and Engineering
4500 Diplomacy Drive
Anchorage, Alaska 99508
(907) 729-3600

0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING, IF NOT ADJUST SCALES ACCORDINGLY

MERTARVIK, AK
COMMUNITY LAYOUT
CONCEPTUAL

| MRK | DATE | DESCRIPTION | INIT |
|---|---|---|---|
| | | | |

| | |
|---|---|
| PLAN SET: | MTV-00-000 |
| PROJ MGR: | GND |
| PROJ ENG: | JEH |
| DRUMS ENG: | ---- |
| DRAWN BY: | ---- |

SHEET TITLE

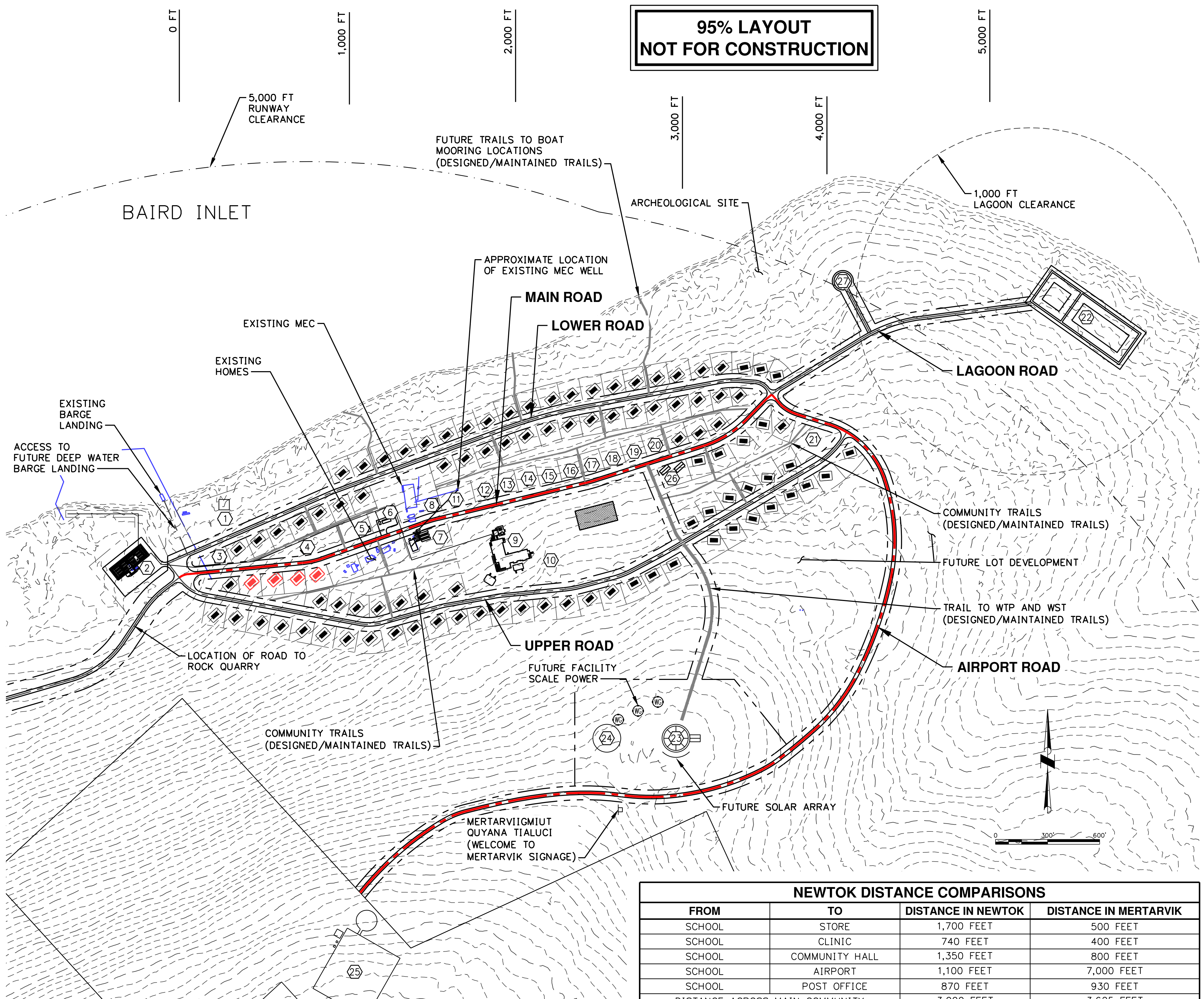
OVERALL PLAN

C-100

SHEET 1 OF 5

1 | 2 | 3 | 4

**95% LAYOUT**
**NOT FOR CONSTRUCTION**




## FUTURE ROAD LENGTHS

| | |
|---|---|
| MAIN ROAD | 3,625 LF |
| AIRPORT ROAD | 5,300 LF |
| LOWER ROAD | 3,685 LF |
| UPPER ROAD | 4,150 LF |
| LAGOON ACCESS | 1,625 LF |
| DESIGNED/MAINTAINED TRAILS | 8,750 LF |
| WTP AND WST TRAIL | 1,600 LF |
| LIGHTING SHALL BE PROVIDED FOR PRIMARY ROADS | |

## FUTURE INFRASTRUCTURE KEY

| | |
|---|---|
| 1 | BARGE UNLOADING AREA AND BOAT STORAGE FISHERIES SUPPORT CENTER |
| 2 | BULK FUEL STORAGE |
| 3 | LIFT STATION |
| 4 | CORPORATION OFFICE |
| 5 | STORE AND FUEL STATION |
| 6 | POWER FACILITY |
| 7 | MAN CAMP AND WST |
| 8 | CVRF SHOP |
| 9 | SCHOOL |
| 10 | SCHOOL BULK STORAGE |
| 11 | TOM'S STORE |
| 12 | FUTURE WASHETERIA |
| 13 | CHURCH |
| 14 | CLINIC |
| 15 | ELDER HOUSING |
| 16 | ELDER HOUSING |
| 17 | TRIBAL OFFICE |
| 18 | POST OFFICE |
| 19 | FOUR-PLEXES |
| 20 | FOUR-PLEXES |
| 21 | VPSO OFFICE AND LIVING QUARTERS |
| 22 | LAGOON |
| 23 | WTP AND WST |
| 24 | WELL FIELD |
| 25 | RUNWAY AND APRON |
| 26 | TEACHER HOUSING |
| 27 | TELECOMMUNICATION BUILDING |

## PROPERTY INFORMATION

| | |
|---|---|
| RESIDENTIAL LOT SIZE | 3/8 ACRE |
| SCHOOL LOT SIZE | 12 1/4 ACRES |
| NEW RESIDENTIAL LOTS | 100 |
| EXISTING RESIDENCES | 3 |

## NEWTOK DISTANCE COMPARISONS

| FROM | TO | DISTANCE IN NEWTOK | DISTANCE IN MERTARVIK |
|---|---|---|---|
| SCHOOL | STORE | 1,700 FEET | 500 FEET |
| SCHOOL | CLINIC | 740 FEET | 400 FEET |
| SCHOOL | COMMUNITY HALL | 1,350 FEET | 800 FEET |
| SCHOOL | AIRPORT | 1,100 FEET | 7,000 FEET |
| SCHOOL | POST OFFICE | 870 FEET | 930 FEET |
| DISTANCE ACROSS MAIN COMMUNITY | | 3,000 FEET | 3,625 FEET |

DISTANCES IN MERTARVIK ARE TAKEN BY NAVIGATING A COMBINATION OF ROAD AND TRAILS

## COLOR LEGEND

EXISTING INFRASTRUCTURE

## SYMBOL LEGEND

HOMES TO BE CONSTRUCTED IN 2017/2018

A1 **COMMUNITY LAYOUT**
1" = 300'

Division of Environmental Health and Engineering
4500 Diplomacy Drive
Anchorage, Alaska 99508
(907) 729-3600

0 1"
BAR IS ONE INCH ON ORIGINAL DRAWING, IF NOT ADJUST SCALES ACCORDINGLY

**MERTARVIK, AK COMMUNITY LAYOUT CONCEPTUAL**

MRK | DATE | DESCRIPTION | INIT

| | |
|---|---|
| PLAN SET: | MTV-00-000 |
| PROJ MGR: | GND |
| PROJ ENG: | JEH |
| DRWNS ENG: | ---- |
| DRAWN BY: | ---- |

SHEET TITLE
COMMUNITY LAYOUT

C-103
SHEET 4 OF 5

# APPENDIX E

AEA Mertarvik Hydro Resource Assessment

## Memorandum

To: David Lockard, Alaska Energy Authority

From: Daniel Hertrich

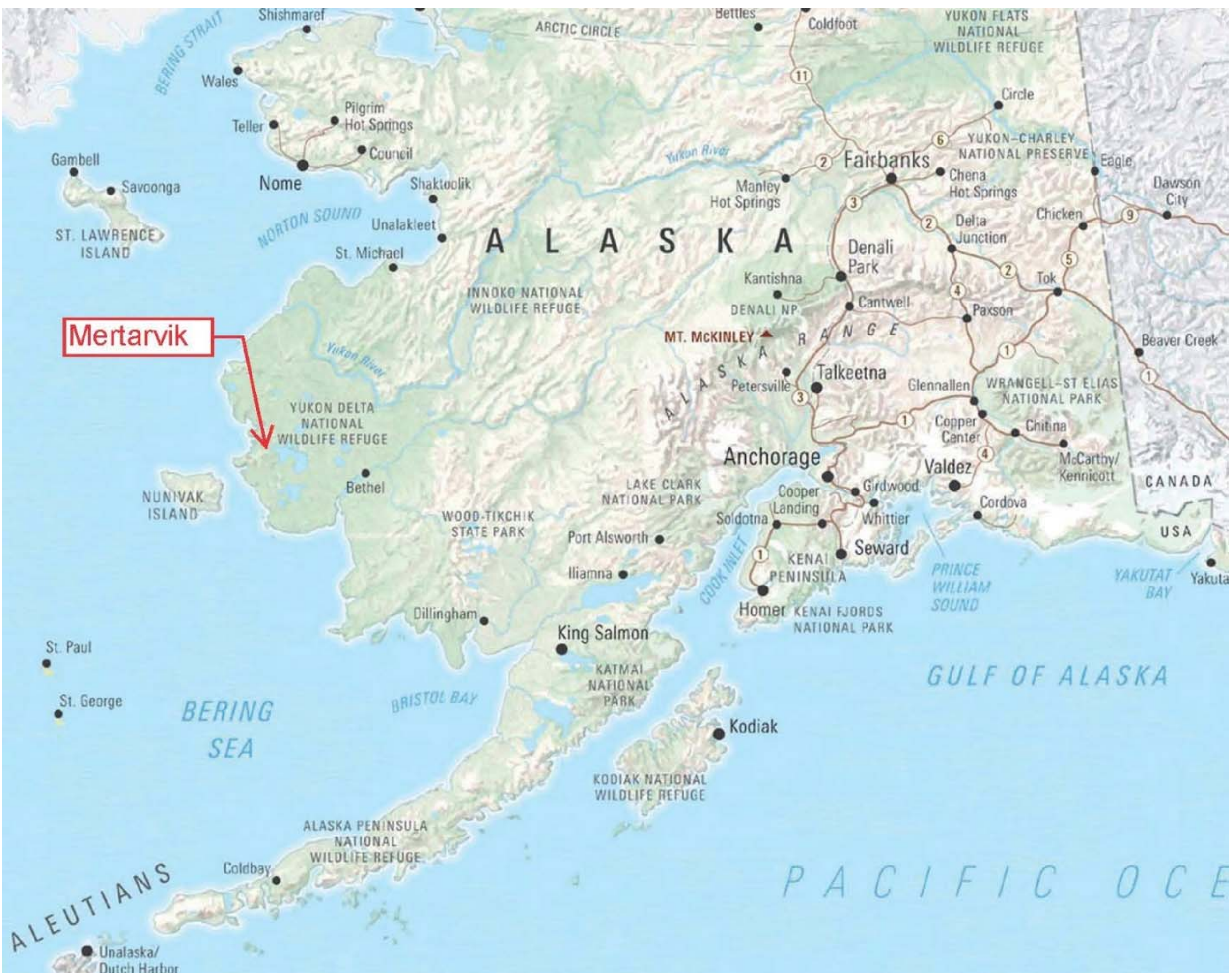
Subject: Mertarvik Hydro Resource Assessment

Date: May 11, 2017

## Introduction

This memo presents the analysis of conventional hydroelectric alternatives for the future community of Mertarvik (the chosen name and location for Newtok to relocate to). This analysis is prepared in response to, and as a supplement to, the energy analysis report titled “Mertarvik 2017 Energy Master Plan, Draft”, April 2017, prepared by Gray Stassel Engineering and HDL Engineering Consultants.

*Figure 1 - Vicinity Map*






813 West Northern Lights Boulevard Anchorage, Alaska 99503 T 907.771.3000 Toll Free (Alaska Only) 888.300.8534 F 907.771.3044

## Hydrology

The USGS operated a stream gauge on the Takikchak River near Newtock. The USGS also performed flow measurements at Spring Creek. Neither of the creeks are named on the USGS 63k scale quad map. The available data for the 2 sites is summarized below.

USGS 15304400 TAKIKCHAK R NR NEWTOK AK
Latitude 60°48'23.71", Longitude 164°35'45.86" NAD27
Bethel Census Area County, Alaska, Hydrologic Unit 19030502
Drainage area: 19.56 square miles
Datum of gage: 12.5 feet above NGVD29.

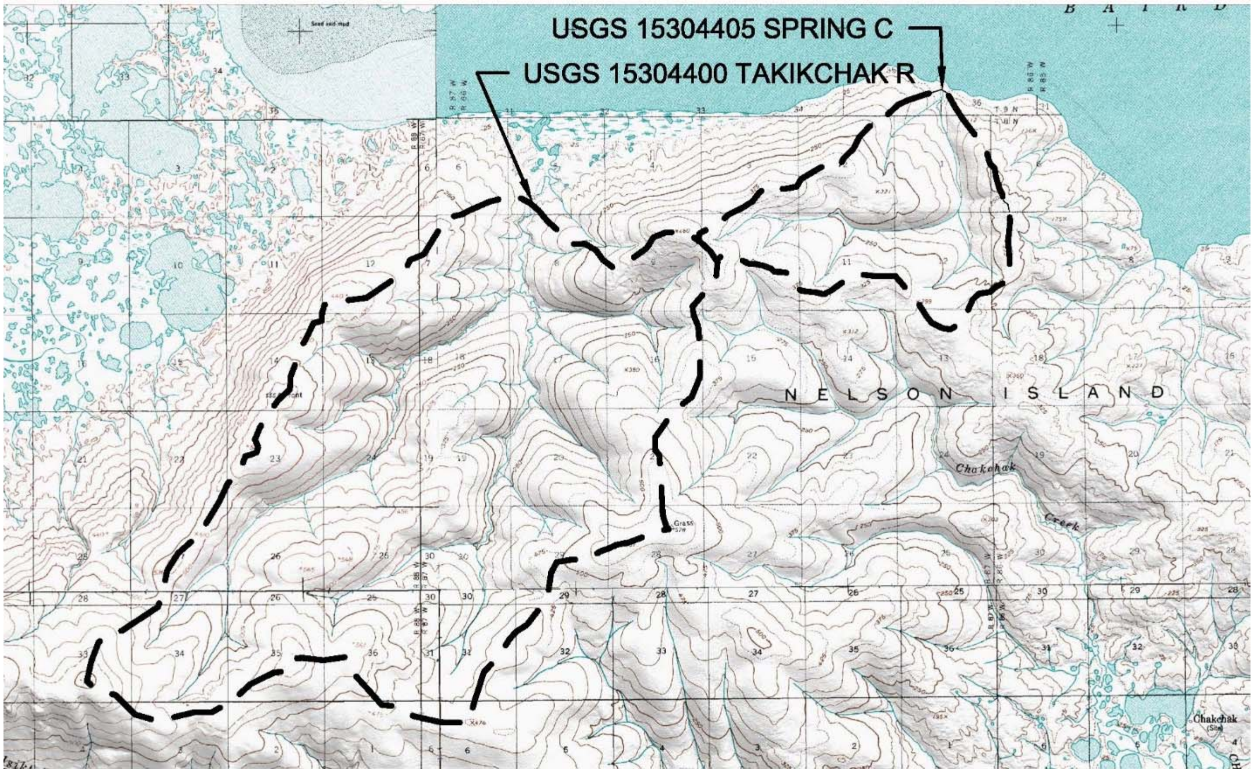
| | | |
|---|---|---|
| Daily Data, Discharge, cubic feet per second | 2004-05-21 to 2006-09-30 | 853 |
| Field measurements | 2004-05-21 to 2006-09-29 | 12 |
| Field/Lab water-quality samples | 2004-05-21 to 2005-09-28 | 38 |

USGS 15304405 MERTARVIK SPRING C NR NEWTOK AK
Latitude 60°49'33", Longitude 164°28'08" NAD27
Bethel Census Area County, Alaska, Hydrologic Unit Code 19030502
Drainage area: 4.12 square miles
Gage datum: 12.5 feet above NGVD29

| | | |
|---|---|---|
| Field measurements | 2005-05-27 to 2006-09-29 | 7 |

The gauge sites along with the drainage area drawn, based on the arctic 2 meter digital elevation model (DEM), is shown in the figure below (USGS 63k quad map textured with 2 DEM). The drainage area calculated for the USGS Takikchak River using the 2 meter DEM is 19.46 square miles.

*Figure 2 – Watershed Map*



The daily data for the unit discharge, cfs/sq mi (discharge divided by basin area) is shown in the chart below followed by the median monthly unit discharge.

*Figure 3 – Takikchak River Unit Discharge*

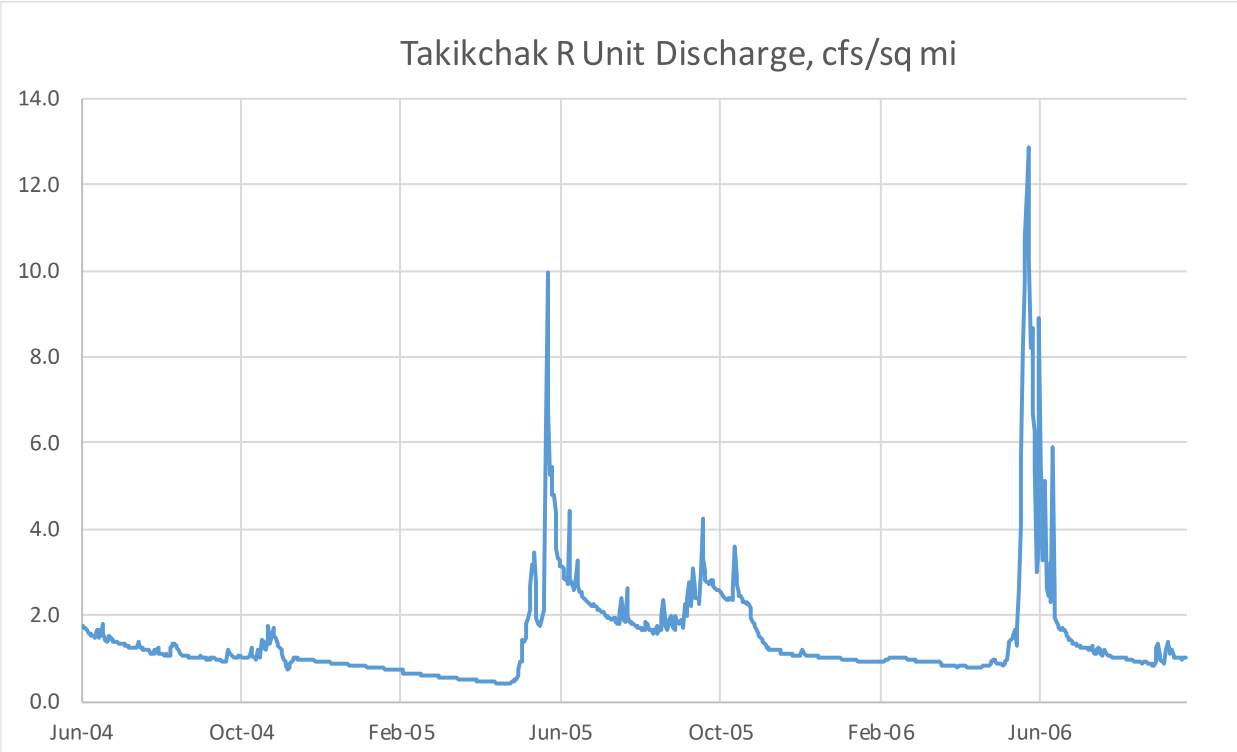


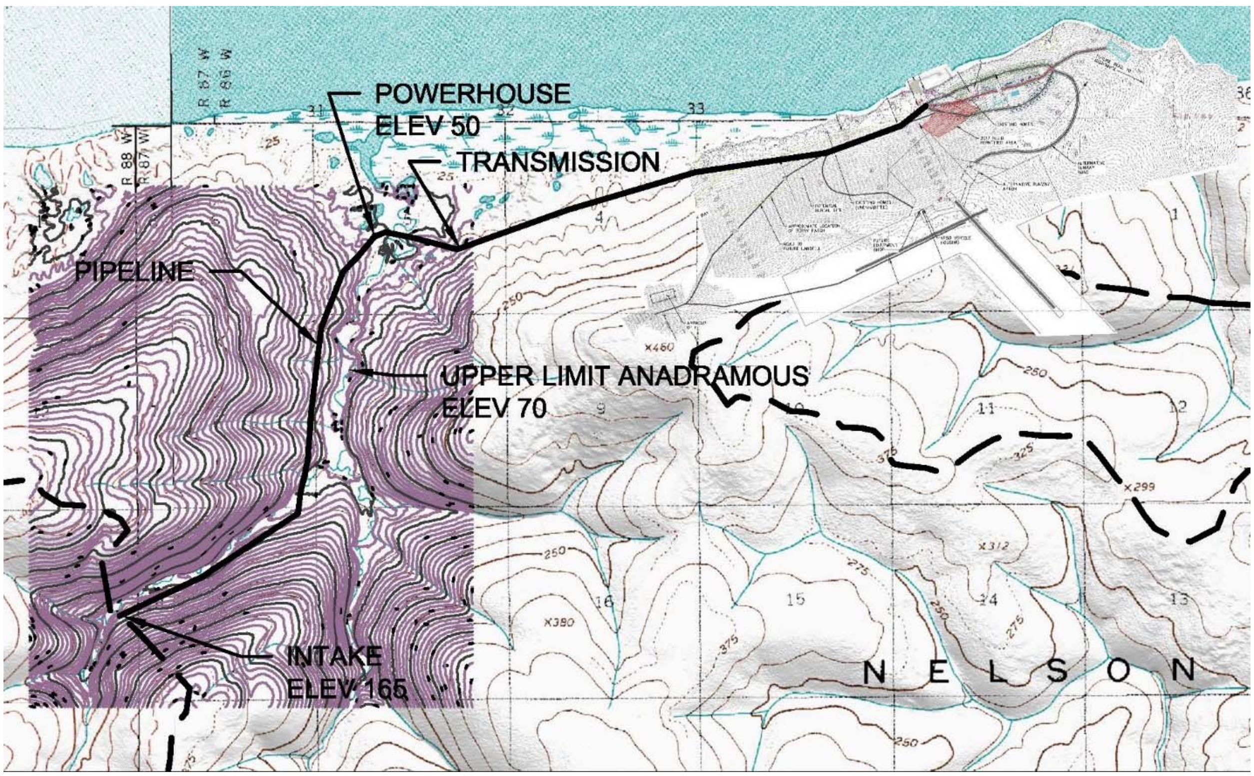

*Table 1 - USGS 15304400 TAKIKCHAK R NR NE, Median Unit Discharge, cfs / sq mi*

| Month | 2004 | 2005 | 2006 | Average |
|---|---|---|---|---|
| 1 | | 0.77 | 0.98 | 0.87 |
| 2 | | 0.67 | 1.00 | 0.84 |
| 3 | | 0.57 | 0.92 | 0.75 |
| 4 | | 0.46 | 0.82 | 0.64 |
| 5 | | 1.95 | 1.28 | 1.62 |
| 6 | 1.54 | 2.72 | 2.88 | 2.38 |
| 7 | 1.23 | 2.00 | 1.23 | 1.49 |
| 8 | 1.08 | 1.70 | 0.98 | 1.25 |
| 9 | 1.03 | 2.42 | 1.03 | 1.49 |
| 10 | 1.18 | 2.42 | | 1.80 |
| 11 | 0.98 | 1.18 | | 1.08 |
| 12 | 0.87 | 1.08 | | 0.98 |
| Average | | 1.49 | | 1.27 |

## Project Concept

The project concept that is expected to produce the most energy utilizes the west fork of Takikchak River with an intake located at about elevation 165' and a powerhouse located near the mouth at an elevation of about 50'. The drainage area contributing to the intake is approximately 6.75 square miles. The pipeline conveyance distance from the intake to the powerhouse is about 13,450'. The layout of the project would reduce flows in the presumed anadramous reach (based on ADF&G catalog) but the significant drainage area remaining that is not diverted is assumed to be sufficient to meet the needs of habitat and fish passage.

*Figure 4 - Project Layout*




## Energy Analysis

Sizing of the project was optimized to maximize the hydro energy generation using the full daily Takikchak River hydrology record and the average monthly demand of Newtok as reported from AEA's Power Cost Equalization data from 7/2012 through 3/2017 with a correction made to the month of 9/2015.

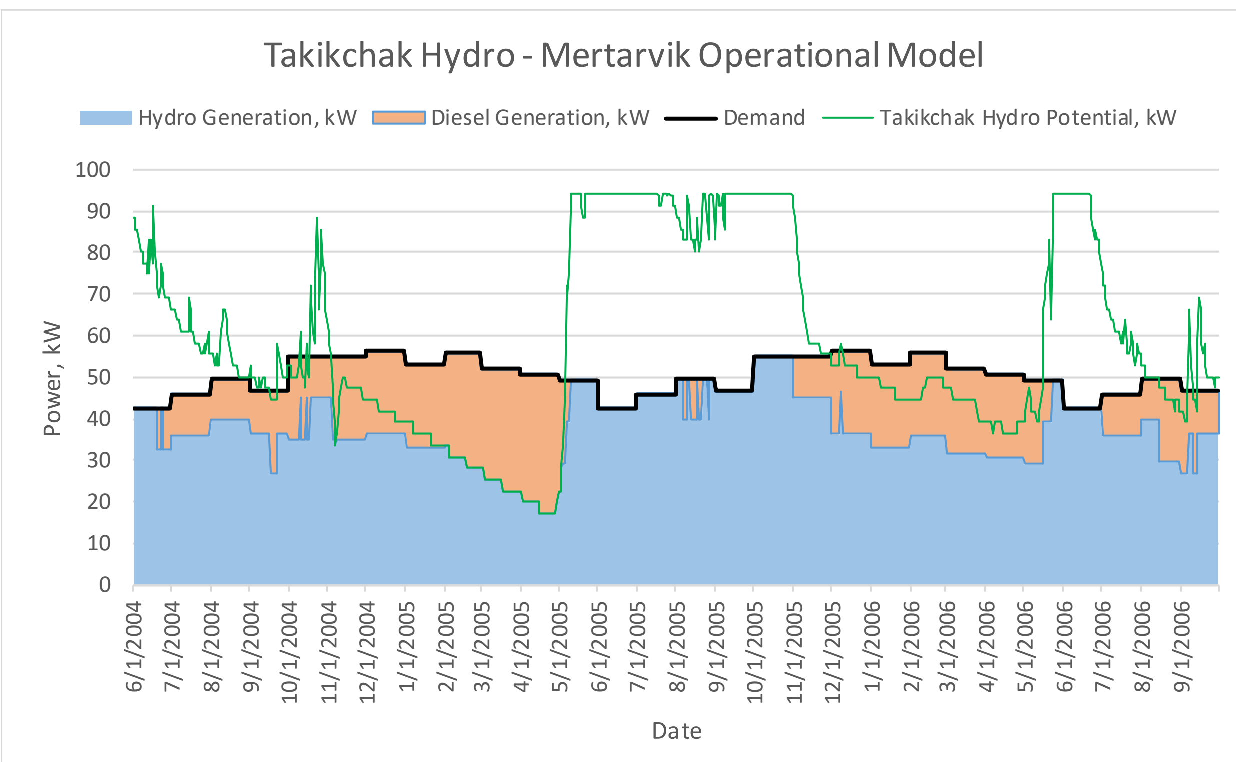
The analysis showed the a project with a hydraulic capacity of about 12.5 cfs would displace the most diesel generation. For this flow a pipeline diameter of about 28" is assumed. The peak project output would be about 90 kW. If load growth were considered a slightly larger project might be better.

A significant factor in the modeling was the peak diesel generation for each month. Peak demand reported in PCE average about 1.9 times the average daily load. For the modeling, a slightly lower peak to average demand ratio of 1.7 was used. The model logic dispatches a diesel at its minimum operating load (assumed to be 20% of 100 kW) for 12 hours if the hydro potential is above the average demand but below the peak demand. If the hydro is below the average demand a diesel is dispatched for 24 hours at the greater of the minimum diesel operating load or the average demand less the hydro potential. Results of the modeling are shown in the table and figure below.

*Table 2 – Monthly Hydro Generation*

| Month | Hydro Generation, kWh | Diesel Generation, kWh | Total Demand, kWh |
|---|---|---|---|
| 1 | 24,706 | 14,880 | 39,586 |
| 2 | 22,132 | 15,366 | 37,499 |
| 3 | 20,918 | 17,649 | 38,567 |
| 4 | 17,841 | 18,717 | 36,558 |
| 5 | 30,176 | 6,410 | 36,586 |
| 6 | 29,860 | 720 | 30,580 |
| 7 | 29,210 | 4,960 | 34,170 |
| 8 | 29,504 | 7,360 | 36,864 |
| 9 | 27,638 | 5,920 | 33,558 |
| 10 | 35,411 | 5,520 | 40,931 |
| 11 | 29,157 | 10,457 | 39,614 |
| 12 | 27,243 | 14,640 | 41,883 |
| Total | 323,797 | 122,599 | 446,396 |

*Figure 5 – Operational Model*



## Economics

The Takikchak River hydro would be very costly for its size. The main issue would be the length of access roads and the pipeline. An approximate estimate of the cost of construction is shown below. An HDPE pipeline is assumed with a material cost of $2/lb.

| Item | Cost |
|---|---:|
| Pipeline | $1,500,000 |
| Equipment | $650,000 |
| Powerhouse | $200,000 |
| Turbine | $450,000 |
| Transmission | $450,000 |
| Diversion and Intake | $350,000 |
| Access Roads | $700,000 |
| Mobilization | $600,000 |
| Design and Permitting | $400,000 |
| Total | $5,300,000 |

Using a 30 year 3% discount rate analysis with an initial fuel cost of $3/gallon and a 1.5% escalation factor with a diesel efficiency of 13 kWh/gal the net present value of the hydro generation would be $1,800,000 giving a benefit to cost ratio of 0.34.

## Conclusion

The project does not appear potentially economical without a significant reduction in access road and transmission length and/or cost, lower cost mobilization and equipment, and lower cost pipeline construction using alternative materials, and lower design and permitting costs. Coupled with a significant reduction in construction costs, a higher cost of fuel and/or value of local renewable hydroelectric generation could make the project beneficial and worth pursuing.

## Recommendation

Consider the hydro resource as a potential future development in the planning for the future community of Mertarvik.

# APPENDIX F

Newtok Bulk Fuel Facilities Description, Size and Condition

# Newtok Bulk Fuel Facilities Description, Size and Condition

## ***TF1 - Newtok School, Lower Kuskokwim School District***

TF1 (Tank Farm 1) is owned and operated by LKSD. The tank farm provides fuel for power generation to the school power plant and heating fuel to the Ayaprun School building, school water and wastewater treatment plant, and eight teacher housing units. The tank farm is supplied with fuel from the common marine barge header pipeline. The tank farm consists of two 40,600-gallon, single-wall, vertical storage tanks supported on wood cribbing inside of a containment dike. The dike walls have experienced differential settlement and the containment is no longer liquid-tight. The vertical tanks provide fuel to a double-wall, horizontal intermediate tank at the school power plant and a double-wall, horizontal day tank at the school building. The school building's day tank is equipped with a hose dispenser and used to fill the tanks at the teacher housing units. The tank farm fuel tank descriptions and gross capacities are located in the table below.

**Tank Farm 1 - School Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active / Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 23'-6" | 12'-0" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 40,600 |
| 2 | 23'-6" | 12'-0" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 40,600 |
| 3 | 5'-4" | 12'-3" | Horizontal | Double - Wall | Active | Modify/Reuse | Diesel 1 | Interm. Tank | 2,000 |
| 4 | 4'-9" | 10'-6" | Horizontal | Double - Wall | Active | Modify/Reuse | Diesel 1 | Day Tank | 1,500 |
| | | | | | | | | **Total Gallons** | **84,700** |

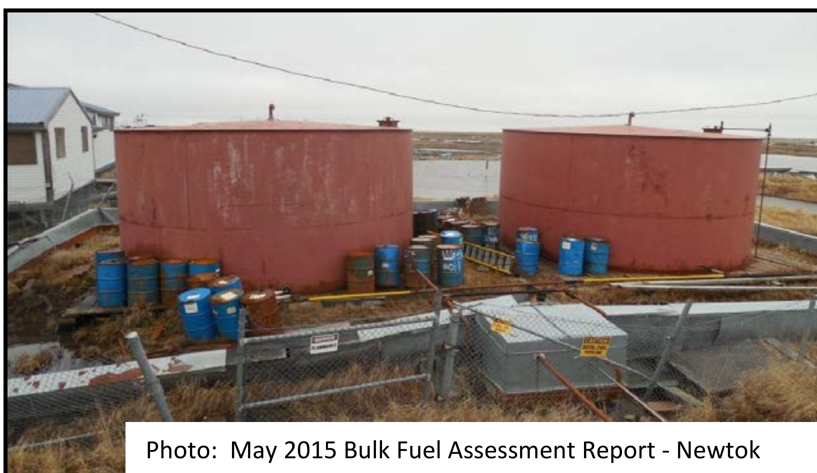


Photo: May 2015 Bulk Fuel Assessment Report - Newtok

**TF1 - School Tank Farm**

### ***TF2 - Old BIA School Tank Farm***

TF2 is also owned by LKSD. The tank farm is currently out of service and in poor condition. It contains six BIA-style, single-wall, 14-foot tall vertical bulk fuel storage tanks ranging from 8 to 11 feet in diameter. The tanks are supported on wood cribbing inside of a failed fuel containment dike. The tank farm is connected to the common marine barge header pipeline. The tank descriptions and gross capacities are shown in the table below. All tanks are in poor condition, are unusable, and should be decommissioned.

**TF2 - Old School Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8'-0" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 5,200 |
| 2 | 8'-0" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 5,200 |
| 3 | 8'-6" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 5,900 |
| 4 | 9"-0" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 6,600 |
| 5 | 10'-0" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 8,200 |
| 6 | 11'-0" | 14 | Vertical | Single-Wall | Inactive | Decommission | Diesel | Bulk | 9,900 |
| | | | | | | | | **Total Gallons** | **41,000** |

**TF2 - Old School Tank Farm**

### TF3- Newtok Native Corporation, Retail Sales

TF3 is owned by NNC and contains three single-wall, skid-mounted, horizontal tanks for diesel and gasoline storage and dispensing. The tank farm consists of one gasoline bulk storage tank, one gasoline dispensing tank, and one diesel dispensing tank. The tanks are installed in a lined containment with timber supported dike walls. The dike is not level and does not appear structurally sound. The tank skids are installed directly on the ground inside the containment. The fuel dispensers consist of "fill-rite style" pumps plumbed to the bottom tank penetrations with threaded piping and a short length of dispensing hose. The dispensing equipment is enclosed within plywood structures built on the ends of the tanks. A temporary fuel hose connected to the common marine header pipeline during barge deliveries fills the tanks. Tank descriptions and gross capacities are shown in the table below. According to the previous bulk fuel assessment reports, the gasoline and diesel fuel dispensing tanks are Underwriters Laboratories (UL) listed. These two tanks are in fair condition but are not equipped with code-compliant venting, fill control, or fuel level monitoring appurtenances. If code compliant appurtenances are installed, these tanks could be relocated to a lined containment in Mertarvik to provide temporary bulk fuel storage.

**TF3 - Newtok Native Corporation Retail Sales Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7'-9" | 13'-9" | Horizontal | Single-Wall | Active | Modify/Reuse | Gasoline | Dispensing | 4,500 |
| 2 | 7'-9" | 27'-9" | Horizontal | Single-Wall | Active | Decommission | Gasoline | Bulk | 9,000 |
| 3 | 7'-9" | 27'-9" | Horizontal | Single-Wall | Active | Modify/Reuse | Diesel 1 | Dispensing | 9,000 |
| | | | | | | | | **Total Gallons** | **22,500** |


**TF3 - Newtok Native Corporation Retail Sales Tank Farm**

## TF4 - Newtok Native Corporation Bulk Storage Tank Farm

TF4 is also owned and operated by NNC for diesel and gasoline bulk storage. The tank farm consists of one gasoline bulk storage tank and two diesel bulk storage tanks. All of the tanks are single-wall vertical tanks supported on wood cribbing inside a lined timber containment with timber supported dike walls. The tanks are filled by a temporary fuel hose connected to the common marine header pipeline during barge deliveries. This hose is also used to transfer fuel between TF3 and TF4. The tanks are at the end of their useful life and should be decommissioned when no longer in service. Tank descriptions and gross capacities are shown in the table below.

**TF4 - Newtok Native Corporation Bulk Storage Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 11'-0" | 13'-10" | Vertical | Single-Wall | Active | Decommission | Gasoline | Bulk | 8,400 |
| 2 | 10'-10" | 13'-10" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 8,100 |
| 3 | 10'-0" | 13'-10" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 6,900 |
| | | | | | | | | **Total Gallons** | **22,400** |

Photo: May 2016 Bulk Fuel Assessment Report - Newtok

**TF4 - Newtok Native Corporation Bulk Storage Tank Farm**

## ***TF5 - Ungusraq Power Company***

TF5 consists of five vertical, single-wall tanks and one horizontal, single-wall tank for diesel storage for power generation. The vertical tanks are supported on wood cribbing inside of a lined containment dike with timber supported dike walls. The skid mounted horizontal tank is placed directly on the tundra outside of the containment. Fuel is drawn from the tanks via a flexible hose connected to the bottom penetrations. The hose connects to a transfer pump housed in a plywood shed within the diked area. The operator uses the pump to transfer from the tanks into a fuel trailer, which is then trucked to the power plant and transferred to the power plant day tank. The horizontal tank serves as additional diesel fuel storage. Fuel is transferred from the horizontal tank to the vertical tanks on an as-needed basis using a portable pump and flexible hose. The tanks are filled by a temporary fuel hose connected to the common marine header pipeline during barge deliveries. All tanks are nearing the end of their useful life and should be decommissioned when no longer in service. Tank descriptions and gross capacities are shown in the table below.

**T5 - Ungusraq Power Company Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 12’-0” | 12’-0” | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 8,500 |
| 2 | 11’-9” | 18’-0” | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 13,000 |
| 3 | 12’-0” | 17’-0” | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 12,600 |
| 4 | 11'-9" | 17'-0" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 12,100 |
| 5 | 11'-9" | 12'-0" | Vertical | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 8,100 |
| 6 | 8'-0" | 30’-0” | Horizontal | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 7,500 |
| | | | | | | | | **Total Gallons** | **61,800** |

Photo: May 2016 Bulk Fuel Assessment Report - Newtok

**TF5 - Ungusraq Power Company Tank Farm**

## ***TF6 - Newtok Village Council***

ffTF6 is owned and operated by NVC. The tank farm consists of one 3,000-gallon, horizontal, single-wall diesel storage tank. The tank is supported by timber blocking and is located adjacent to the power plant tank farm. There is a liner spread beneath the tank, but the liner does not provide fuel containment. The tank is equipped with a “fill-rite” type pump and a dispensing hose. The dispensing system is used to fill portable fuel containers that are transported to village-owned buildings for heating oil. The tank is filled by a temporary fuel hose connected to the common marine header pipeline during barge deliveries. The tank description is shown in the table below. This tank should be decommissioned as soon as practical.

**TF6 - Newtok Village Council Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6’-4” | 15’-0” | Horizontal | Single-Wall | Active | Decommission | Diesel 1 | Bulk & Dispensing | 3,000 |
| | | | | | | | | **Total Gallons** | **3,000** |


**TF6 - Newtok Village Council Tank Farm**

## ***TF7 – Agayuvik Holy Family Church Tank***

TF7 is one single-wall, 3000-gallon, horizontal diesel tank located next to the church building on elevated wood cribbing with no fuel containment. The tank is not API 650 or UL 142 labeled and is not code compliant. The tank is hard piped to the building heating system day tank. The tank should be decommissioned as soon as practical. The tank description is shown in the table below.

**TF7 - Agayuvik Holy Family Church Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6'-4" | 15'-0" | Horizontal | Single-Wall | Active | Decommission | Diesel 1 | Bulk | 3,000 |
| | | | | | | | | **Total Gallons** | **3,000** |

## ***TF8 - National Guard Armory***

TF8 consists of one 1500-gallon, horizontal, single-wall tank located adjacent to the old armory building and one 1500-gallon, horizontal, self-diked tank located adjacent to the new armory building. The old National Guard Armory building is currently not in use. The new National Guard Armory building is constructed adjacent to the old armory. The new building is currently used to house the village administrative offices. The single-wall tank appears to be in fair condition, but has been inactive for many years and reuse is not recommended. The self-diked tank was constructed in 2003, is UL 142 listed, and is in good condition. This tank could be relocated to Mertarvik to provide fuel storage for community buildings. Tank descriptions and gross capacities are shown in the table below.

**TF8 - National Guard Armory Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5’-4” | 9’-0” | Horizontal | Single-Wall | Inactive | Decommission | Diesel 1 | Bulk | 1,500 |
| 2 | 5’-4” | 9’-0” | Horizontal | Self-Diked | Active | Modify/Reuse | Diesel 1 | Bulk | 1,500 |
| | | | | | | | | **Total Gallons** | **3,000** |

**TF8 - Old National Guard Armory Fuel Tank**

**TF8 - New National Guard Armory Fuel Tank**

***TF9 – Tom’s Store***

The Tom’s Store tank farm consists of five horizontal, single-wall tanks and two horizontal, double-wall tanks. Three of the single-wall tanks are supported on wood cribbing with no fuel containment. The other two single-wall tanks appear to be small, 500-gallon tanks that are stored at the site and not used for fuel storage. The two skid-mounted, double wall, horizontal tanks are placed directly on the ground. One of the single-wall tanks and one of the double-wall tanks have top mounted suction pumps for fuel dispensing. The tank is filled by a temporary fuel hose connected to the common marine header pipeline during barge deliveries. The community reported that the tank farm has not received a fuel delivery in the past three years and is currently not in use. The product historically stored in each tank could not be verified at the time of inspection. However, it is assumed that at least one of the double-walled tanks was used for diesel storage.

The two double-wall tanks were constructed in 2001, are UL listed, and appear to be in fair condition. These tanks could be relocated to Mertarvik and temporarily used for bulk fuel storage or as the power plant intermediate tank until a new tank farm is constructed. The single-wall tanks are old and should be permanently taken out of service and decommissioned.

**TF9 - Tom's Store Tank Farm**

| Tank No. | Dia. | Height/ Length | Orientation | Tank Type | Active/ Inactive | Reuse / Decommission | Product | Tank Function | Gross Capacity (Gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 4’-0” | 12’-0” | Horizontal | Single-Wall | Inactive | Decommission | Gasoline | BF/D | 1,125 |
| 2 | 6’-0” | 12’-0” | Horizontal | Single-Wall | Inactive | Decommission | Unknown | BF | 3,000 |
| 3 | 6’-0” | 12’-0” | Horizontal | Single-Wall | Inactive | Decommission | Unknown | BF/D | 3,000 |
| 4 | 4’-0” | 6’-0” | Horizontal | Single-Wall | Inactive | Decommission | Unknown | BF | 500 |
| 5 | 4’-0” | 6’-0” | Horizontal | Single-Wall | Inactive | Decommission | Unknown | BF | 500 |
| 6 | 8’-0” | 28’-0” | Horizontal | Double-Wall | Inactive | Modify/Reuse | Gasoline | BF | 10,000 |
| 7 | 8'-0” | 28’-0” | Horizontal | Double-Wall | Inactive | Modify/Reuse | Diesel 1 | BF/D | 10,000 |
| | | | | | | | | **Total Gallons** | **28,125** |


**TF9 - Tom’s Store 10,000-Gallon Double Wall Fuel Tank**