Appendix D: Economics

Nome Harbor
Navigation Improvements
Appendix D: Economics

Nome, Alaska

US Army Corps
of Engineers
Alaska District

CITY OF NOME
INC. APRIL 9, 1901

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1. INTRODUCTION

This document presents the economic evaluations performed for the Nome Harbor Modifications project. The current federally authorized project depth for Nome Harbor is -22 feet mean lower low water (MLLW) in the outer harbor and -10 feet MLLW in the inner harbor. In 2017, the U.S. Army Corps of Engineers (USACE) Alaska District was approved by the Office of Management and Budget (OMB) to begin the multi-year feasibility study to determine if modifying Nome Harbor is both economically beneficial and environmentally acceptable to the nation. The Deep Draft Navigation Planning Center of Expertise (DDNPCX) performed the economic analyses contained within this document in support of the feasibility study.

1.1. Study Purpose and Scope

The purpose of this study is to evaluate the problems and opportunities for improved navigation in Nome Harbor and to identify the plan that best satisfies the environmental, economic, and engineering criteria. The scope of this feasibility study involves analyzing existing conditions and requirements, identifying opportunities for improvement, preparing economic analyses of alternatives, identifying environmental impacts, and analyzing the National Economic Development (NED) plan.

This feasibility study is being conducted under authority granted by Section 204 of the Flood Control Act of 1948, as amended, which authorizes a study of the feasibility for development of navigation improvements in various harbors and rivers in Alaska. Nome is a coastal community of Northwestern Alaska. Section 204 states:

"The Secretary of the Army is hereby authorized and directed to cause preliminary examinations and surveys for flood control and allied purposes, including channel and major drainage improvements…to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its Territorial Possessions, which include the following-named localities…Provided, that after the regular or formal reports made on any examination, survey, project, or work under way or proposed are submitted to Congress; Harbors and Rives in Alaska, with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power, and related water uses."

In addition to contributions to NED, a Federal project at Nome may be justified with regional benefits as outlined in Section 2006 of WRDA 2007 "Remote and Subsistence Harbors" or national security benefits as outlined by Section 1202(c)(3) of WRDA 2016 "Additional Studies, Arctic Deep Draft Port Development Partnerships." This allows for the consideration of benefits to communities located within the region served by a remote and subsistence harbor when evaluating navigation improvements for the harbor. This provision allows the approval for such harbors without the need to demonstrate justification solely on NED benefits, if the long-term viability of a community located within the region served by the project would be threatened without the navigation improvements.

2. BACKGROUND

2.1. History and Location

Nome is located on the southern coast of the Seward Peninsula in western Alaska. The western half of the Seward Peninsula is generally treeless, wet coastal tundra at low elevations and alpine tundra at higher elevations. Some trees exist in protected locations along the rivers, and the few forested areas are limited to inland rivers. The vegetation consists primarily of grasses, mosses sedges, dwarf shrubs, and lichens. Agricultural production does not exist.

The entire study area lies south of the Arctic Circle. Average summer temperatures are from 30-50 degrees Fahrenheit, and include 77 frost-free days. Sea ice is generally present from late November to May, though there is significant variation in ice formation from year to year. Wind is a feature of the local climate as well. The area has near constant daylight at the height of the summer and long hours of twilight in the winter, when the sun is low in the sky during the short days.

The Norton Basin does not hold significant oil reserves, although it is estimated to contain valuable natural gas reserves. This area is rated as high to moderate in environmental sensitivity. No leases have been scheduled for the 2007-2012, 2012-2017, or 2017-2022 Outer Continental Shelf Oil and Gas Leasing Programs.[1]

True to its rich gold mining history, several small gold mines are still present in the Nome area.[2] There are operating gold mines in areas offshore of Nome in the Norton Sound, as well as small onshore mines. The Alaska Department of Natural Resources (DNR) created two public mining areas for suction dredge use in Nome: the West Beach and East Beach Public Recreational Mining Areas. These are the only public mining areas currently available near Nome. DNR also held an offshore lease sale in fall 2011 that will expire in 2021.[3] This is the only permitted area for commercial operations.

The Rock Creek Mine is located along the west coast of Alaska on the Seward Peninsula, 6 miles north of Nome, on private lands owned by Sitnasuak Native Corporation (surface rights), Bering Straits Native Corporation (BSNC) (subsurface rights), and Alaska Gold Company, LLC (AGC) (land). The mine was operated by Alaska Gold Company, LLC (AGC), under the ownership of NOVAGOLD Resources Inc. (NOVAGOLD), from September 2008 to November 2008 when Rock Creek Mine was placed into care and maintenance. Phase I Reclamation was completed by AGC in October 2012. Bering Straits Native Corporation purchased Alaska Gold Company, LLC and all its interests, including the Rock Creek Mine, from NOVAGOLD in November 2012. Final phases of reclamation were completed by AGC (under BSNC) in 2015 and 2016.[4]

In 2010, Cedar Mountain Exploration Inc. staked almost 150 gold mining claims on the Seward Peninsula, NANA Regional Corporation conducted exploration of a zinc-lead-silver prospect, and at least 28 individuals or other companies reported to have engaged in placer mining efforts for gold, tin, and polymetallic mineralization in the area.

The federally authorized Nome Harbor navigation project, consisting of the inner and outer harbors, is located at the mouth of the Snake River, on the south coast of the Seward Peninsula, facing Norton Sound and the Bering Sea. The Figure 1 shows the current charted depths for the project.

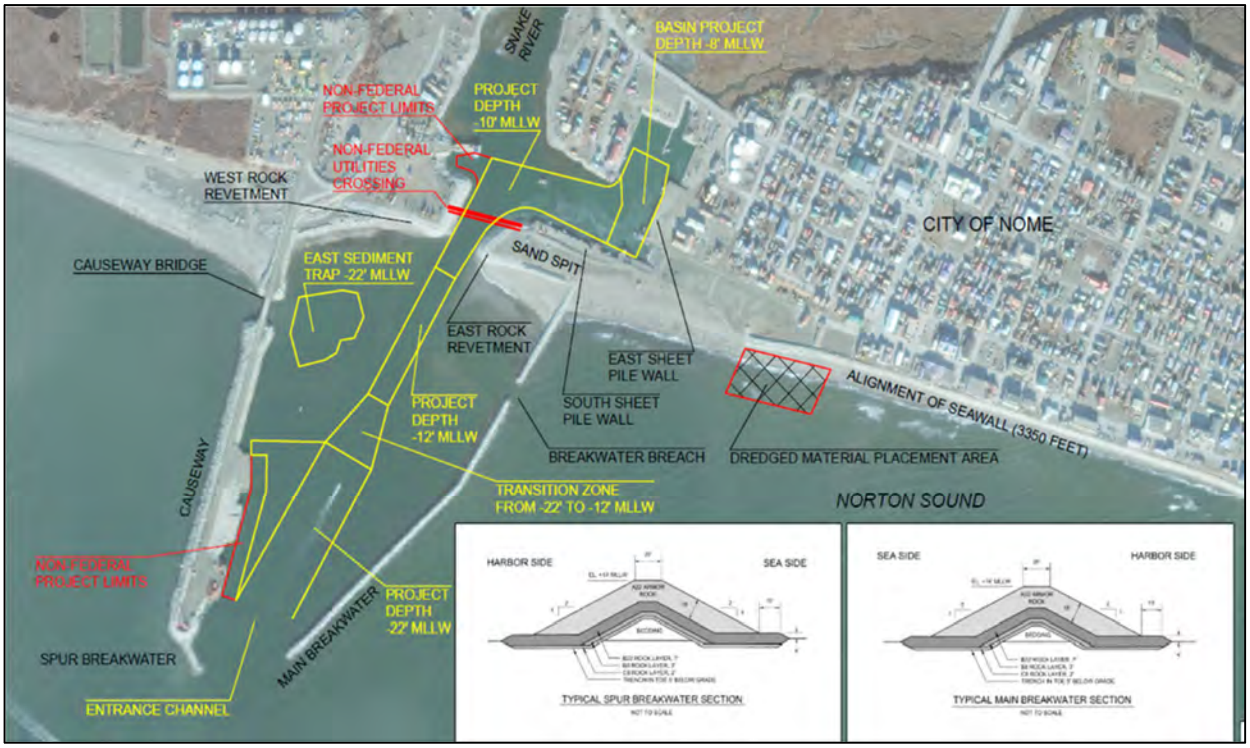

Figure 1. Federally Authorized Harbor and Channel at Nome

3. SOCIOECONOMIC CONDITIONS

3.1. Demographic Profiles

Inupiat Eskimo occupancy of the area began at least 4,000 years ago. Prior to the gold rush of 1899, Inupiat people had seasonally inhabited the Nome townsite. Twenty inhabitants were recorded in the 1880 census, and 10 persons inhabited a nearby site at the mouth of the Nome River. The principle settlement at the time was at Cape Nome, 15 miles east, with a population of 60. Small settlements like those at the Nome location occurred along the coast at productive locations for food gathering. The settlements were largely independent of Europeans socially and economically until 1899, when the gold rush began.

Nome was founded on October 28, 1898, as a mining district on the Snake River. The first reports of the discovery of gold in the area date to 1865, when Western Union surveyors entered the area seeking a route across Alaska and the Bering Sea. The Nome gold rush officially began with the gold strike on tiny Anvil Creek in 1898. This strike brought thousands of miners to the area, which was termed the "Eldorado." Almost overnight, the isolated stretch of tundra fronting the beach was transformed into a tentand-log cabin city of *20,000* prospectors, gamblers, claim jumpers, saloon keepers, and prostitutes. The gold-bearing creeks had already been almost completely staked when an entrepreneur discovered the "golden sands of Nome." With nothing more than shovels, buckets, rockers and wheel barrows, thousands of idle miners descended upon the beaches. Two months later the golden sands had yielded one million dollars in gold (at $16 an ounce). A narrow-gauge railroad and telephone line from Nome to Anvil Creek was built in 1900. The City of Nome was incorporated in 1901, and the city has been inhabited continuously ever since. By 1902, the more easily reached gold claims were exhausted and large mining companies with better equipment took over the mining operations. Since the first strike on tiny Anvil Creek, Nome's gold fields have yielded a total of $136 million. The gradual depletion of gold, a major influenza epidemic in 1918, the Great Depression, and World War II each influenced Nome's population since then.[5] Figure 2 is a graph of factors that have influenced Alaska's population since the end of World War II.

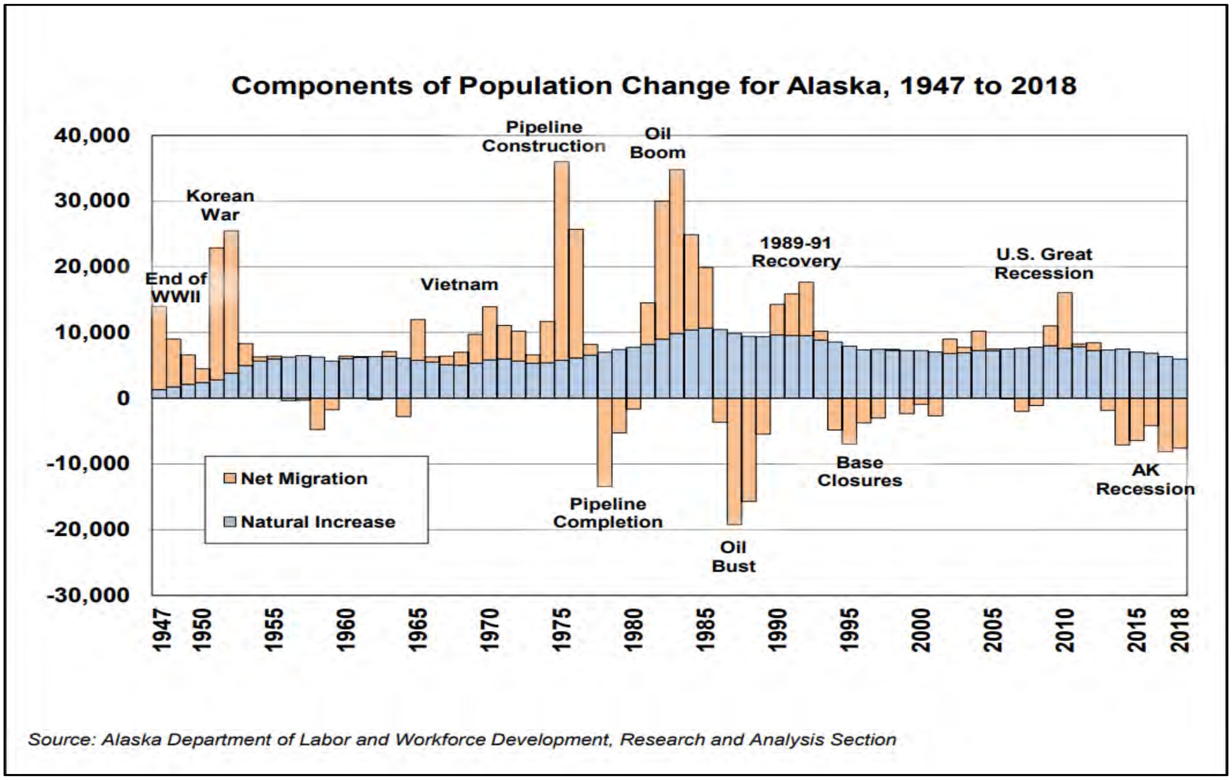

Figure 2. Net Migration in Alaska since 1947

The Native people of Nome were severely impacted by the gold rush population boom. In 1918 the Native population in the Nome area was estimated at 250, and 200 of those died in an influenza epidemic. The epidemic decimated the population over a wide area, and many communities were abandoned.

By 2010, there were 3,598 residents in Nome, ranking it as the 30th largest of 352 communities in Alaska with recorded populations that year. Between 1990 and 2010, the population of Nome stayed relatively stable, increasing by 2.8 percent overall. This stability continues as of 2018, as the City of Nome had a population of 3,662 people in 2018[6]. This reflects an increase of 64 people since the 2010 Census, or 1.7 percent. According to Alaska Department of Labor estimates, the 2011 and 2017 populations of permanent residents were exactly the same. However, the average annual growth rate over this period was slightly positive (0.39 percent), reflecting small increases and decreases from year to year and an overall slight upward population trend. According to a survey conducted by the Alaska Fisheries Science Center (AFSC) in 2011, community leaders reported that an additional 500 individuals are present in Nome as transient seasonal workers. The leaders indicated that seasonal workers are present in Nome in various industries throughout the year, and that Nome's population typically peaks in July. They indicated that the peak is somewhat driven by employment in the fishing industry, and that seasonal workers are also employed in construction and gold mining industries, and at the local hospital. In addition to transient seasonal workers, community leaders estimated that 15-30 permanent residents work seasonally in the local shore-side seafood processing facility.[7]

In 2016, almost half of the population of Nome identified themselves as American Indian or Alaska Native (48.5 percent), along with 31.5 percent who identified as White, 1.5 percent as Asian, 2.0 percent as Black or African American, 0.6 percent as Native Hawaiian or Other Pacific Islander, 0.2 percent as "some other race," and 15.7 percent who identified with two or more races. In addition, 4.9 percent of Nome residents identified themselves as Hispanic in 2016. The percentage of the population that identified themselves as White decreased over time, from 45 percent in 1990, 37.9 percent in 2000, 30.4 percent in 2010, to 31.5 percent in 2016. The percentage of the population that identified themselves as American Indian or Alaska Native decreased between 1990 and 2000, from 52.1 percent to 51 percent, increased to 54.8 percent in 2010, then decreased again to 48.5 percent in 2016. The change in population from 1990 to 2017 is provided in Table 1, and changes in racial and ethnic composition from 2010 to 2016 are shown in Figure 3.

Table 1. Population in Nome from 1990 to 2018 by Source

Year	U.S. Decennial Census[8]	Alaska Dept. of Labor Estimate of Permanent Residents[9]
1990	3,500	
2000	3,505	
2010	3,598	
2011		3,691
2012		3,744
2013		3,648
2014		3,730
2015		3,815
2016		3,773
2017		3,691
2018		3,662

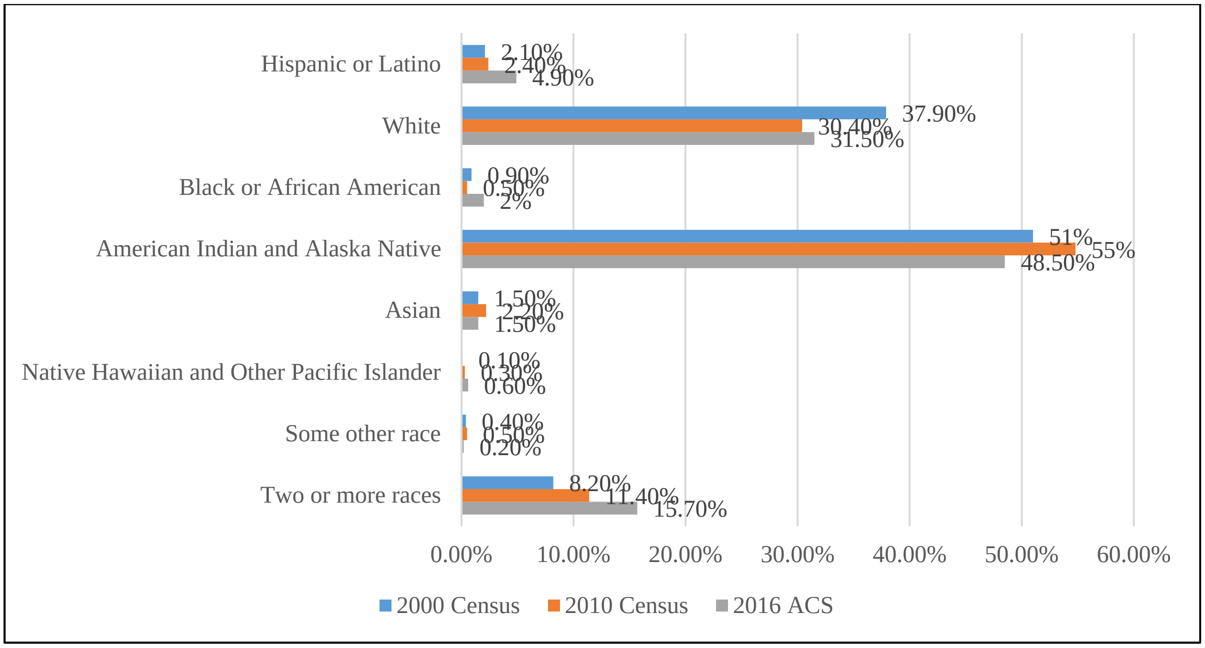

Figure 3. Racial and Ethnic Composition, Nome: 2000-2017 (U.S. Census).

In terms of educational attainment, according to the 2012-2016 American Community Survey (ACS), 89.9 percent of Nome residents aged 25 and over were estimated to hold a high school diploma or higher degree in 2016, compared to 90.7 percent of Alaskan residents overall.[10]

Figure 4. Nome Census Area

Outside of the City of Nome, the Nome Census Area, as shown in Figure 4, contains the cities of: Brevig Mission, Diomede, Elim, Gambell, Golovin, Koyuk, Port Clarence, St. Michael, Savoonga, Shaktoolik, Shishmaref, Stebbins, Teller, Unalakleet, Wales, and White Mountain. The following tables and analysis of the population, migration, and cost of living are conducted at the regional level using census area data in order to highlight regional trends that extend beyond the city of Nome itself. This area is not the same as the economic study area that is mentioned later in this appendix. The total estimated population of the Census area in 2018 was 9,988 people. Between 1990 and 2010, the Census area population increased by 14.5 percent overall. However, from 2010 to 2017, the rate of growth slowed to 5.4 percent, but still outpaced both the City of Nome itself (2.5 percent) and the State of Alaska (3.8 percent) over the same time period. The average annual growth rate for the Census area over this period was slightly positive as well (0.76 percent), reflecting small increases and decreases from year to year and an overall slight upward population trend[11]. The change in population from 1990 to 2018 is provided in Table 2.

Table 2. Population in Nome Census Area from 1990 to 2018 by Source

Year	U.S. Decennial Census[12]	Alaska Dept. of Labor Estimate of Permanent Residents[13]
1990	8,288	
2000	9,196	
2010	9,492	
2011		9,718
2012		9,852
2013		9,869
2014		9,986
2015		10,058
2016		10,070
2017		10,006
2018		9,988

3.2. Migration

The movement of native peoples amongst communities in Alaska has been occurring for hundreds of years. Multiple studies have investigated the causes of migration going back to the 1800s. These efforts tend to use Alaska Permanent Fund Dividend (PFD) applications for individuals combined with counts of births and deaths from the Alaska Division of Vital Statistics to track the movements of people. In addition to movement from rural areas, there is movement into rural areas as well. Additionally, there appears to be evidence that movements occur from rural communities to regional hubs, like Nome, and back.

Migration data are not available at the community level. Instead data provided by the Alaska Division of Labor and Workforce Development (AKDOL&WD) at the borough (county) level was used. Figure 5 shows a chart of net in-state migration to the region as well as regional population change from 2010-2017. It shows that over the eight year period, the region lost 643 more people than they gained within the state of Alaska, or about 6 percent of the total regional population. The city of Anchorage and surrounding regions were the largest net recipients of people from the region, while the regions to the north were the largest donors. Despite the growing numbers of people migrating out of the region, the overall regional population increased by 5 percent from 2010-2017.

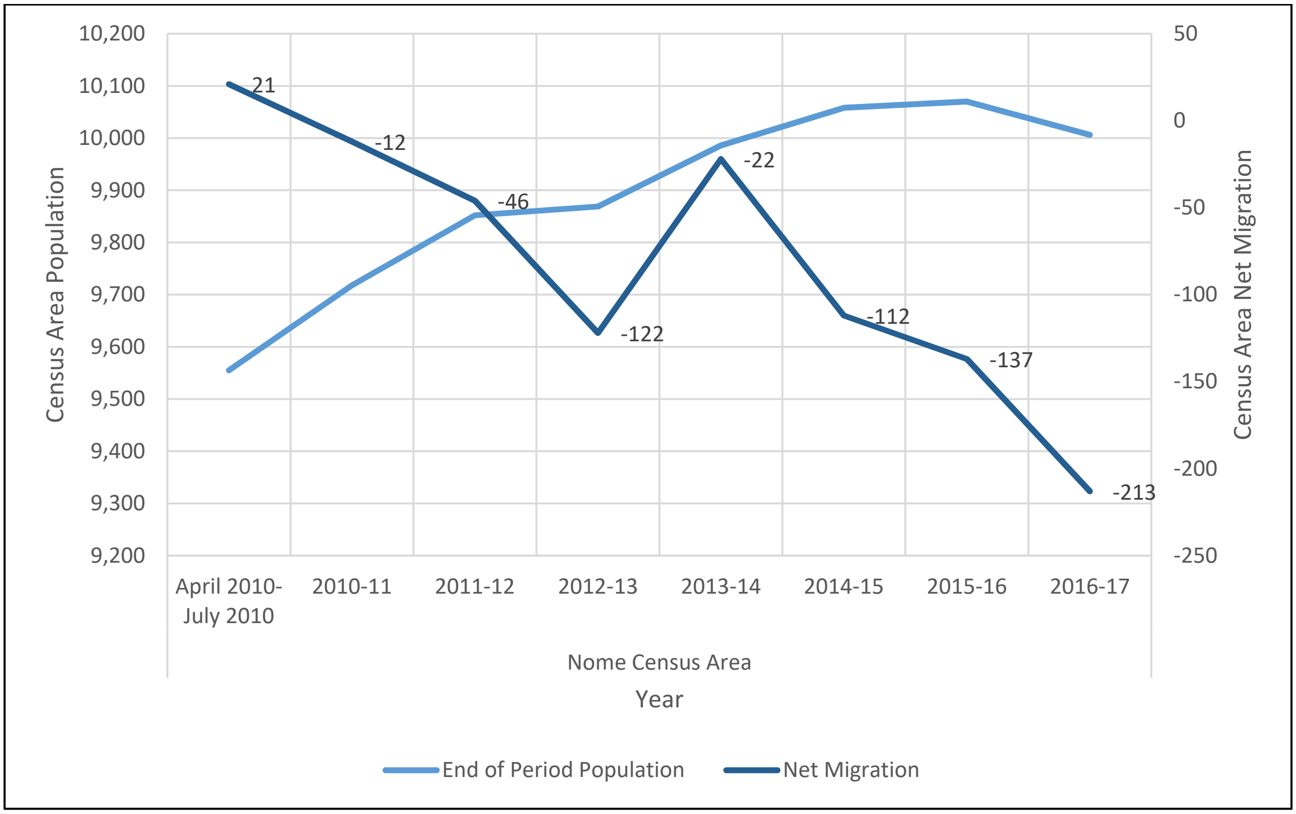

Figure 5. Net Migration (people) in Nome Census Area vs. Population from 2010-2017
Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section

Martin, Killorin, and Colt of the Institute of Social and Economic Research (ISER) at the University of Alaska-Anchorage put forth many observations and hypotheses surrounding rural-urban migration in Alaska over the last 20 years.[14] Low employment, fuel costs, and public safety are all listed reasons for why people left rural areas. However, the same phenomenon exists in their data that is highlighted in this section: a negative net migration occurring at the same time as positive overall population growth. This could be attributed to migration into the region from outside the State of Alaska, immigration from other countries, or natural population increases. They leave the question unanswered to rely on more data over time to see if this was a one-time occurrence or not.

Another study from the ISER in 2017 downplayed the effect of fuel prices on migration:

“The study found that high fuel prices were associated with more rural Alaska residents moving to urban Alaska, but the size of the effect was relatively small: less than 40 adults each year for each $1 rise in fuel prices…Other factors besides fuel prices that change over time also affect migration decisions. The study found that local labor market conditions, as well as the individual’s employment status and earnings had much stronger effects on out-migration than fuel prices.” (Berman 2017)[15]

While it is clear that out-migration (net negative migration) is occurring, it is not clear what factors have the most impact, or how significant migration is relative to overall population trends.

3.3. Income and Cost of Living

Using census data from 2013, median household income for the Nome census area is $51,563. This figure is 69 percent of the Alaska state average of $74,444 and 93 percent of the national median household income of $55,322[16]. Conclusions about economic well-being based on household income need to be tempered by the fact that the cost of living in the Nome area is about twice the cost of living outside the state.

The University of Alaska conducts their Alaska Food Cost Survey every quarter each year. This compares weekly food costs for a basket of goods in various areas of Alaska with USDA information for the U.S. as a whole. This could be a reasonable proxy comparison for the cost of living between a place like Nome, and other areas both in and outside of Alaska. A typical male, aged 19-50, can expect to spend approximately $42.60 a week on food in the U.S. as a whole, on average. This compares to $62.50 per week in Anchorage, Alaska, an increase of 47 percent. When the sample moves more rural, to a place like Nome, the costs increase further to $103.75 a week. That is 66 percent higher than Anchorage and 144 percent higher than the U.S. average[17]. Now, revisit the household income comparisons from before. Residents of the Nome region now have to pay double the U.S. average for the same amount of goods, but with less household income than the national average. This means that households have less cushion to equip themselves to survive systemic problems such as interruptions to the transportation system.

4. EXISTING CONDITIONS

The existing conditions are defined in this report as the project conditions that existed in 2017, plus any changes that are expected to occur prior to project year one, anticipated in 2030, which is referred to as the base year for comparison of alternatives to the without project condition and among proposed alternatives. It is the year the project is expected to be operational and accrue benefits. The year 2017 is the most recent year for which complete data was obtained for commercial cargo volumes and is used as the baseline for the commodity forecast. The year 2017 data, along with historical data dating back to 2012, was thought to be the most reasonable data to use in the development of fleet and commodity forecasts described later in this appendix given the completeness and relevancy of data obtained to date and to capture economic highs and lows during that timeframe.

4.1. Regional Center

Nome is characterized as a regional center because it provides services, government, commerce and transportation for a geographic region containing a group of smaller communities. According to representatives of the transportation industry at Nome, the town serves 50 communities in the western Alaska region, linking them to the outside world. All goods must travel through Nome by air or water. Major government functions are administered from Nome. Social and medical services center on Nome resources. The importance of the regional center function is highlighted by harsh weather conditions that close down water and road transportation for about half the year. The regional center functions as a year-round nerve center, but activity is at a peak in summer when weather allows outside activities to prepare for freeze-up. Any interruption to the transportation system at Nome creates the prospect of delays in delivery to outlying villages, or perhaps even going without needed supplies for the duration of the winter.

The villages are scattered over a large land area, but each of them has a landing strip adjacent to the village. The communities have differing amounts of local infrastructure, but all of them share the use of Nome-based resources to make the community whole. In that sense, because of the lifeline it provides, Nome is not separable from activities in its dependent villages.

Some of the dependent villages are situated along the coast but lack a suitable harbor to accommodate deep-draft vessels that sail between the Seattle-Tacoma area and Nome. Villages that depend on Nome as a regional center must therefore arrange to lighter their supplies using smaller boats from Nome, or use charter air flights. All of the villages are accessible by aircraft, though the length and condition of the landing strips limit the type and size of aircraft. The villages vary in size, but all have a population of less than 1,000. Typically, the population is primarily native, and a subsistence lifestyle is essential to survival, as there are few opportunities for career employment.

4.2. Economy

The term “mixed economy” has special implications in rural areas of Alaska. In the Alaska-style mixed economy, households typically follow a pattern of activity that combines employment for cash with traditional fishing and hunting. Subsistence gathering contributes to the household food supply and also provides building material, fuel, and raw material for tools, clothing, and arts and crafts.

Cash income from employment (most often limited to seasonal income) is used to obtain modern technology to support the gathering of wild resources. Use of modern equipment, such as snow machines, power boats, nets, rifles, and traps, enables individuals to continue to participate successfully in traditional activities across greater distances. In some villages, however, subsistence harvest still depends on the use of traditional methods.

The presence of a mixed economy is more obvious in the smaller villages, where the economic base is essentially absent. In contrast, Nome, the regional center, presents a mixed economy with a stable and prominent economic base and year-round jobs that yield cash income. Unlike the smaller villages, a conventional lifestyle in Nome is similar to that in cities elsewhere. In Nome, more than the villages that depend on it, cash employment is more common. The type of wage employment found in Nome is influenced by the town's function as a service center to the Bering Straits-Norton Sound area.

Government services provide the major source of Nome's employment. Of the total work force of 1,814, Federal, State, and local government employ 542. Of the 1,136 people employed in the private sector, the single largest class of employment is educational, health care and social assistance, accounting for 662 jobs. This is followed by the retail trade with 176 jobs, transportation with 169, and other services with 118.[18] Thus, it is clear from the employment profile that Nome serves as a regional center for government, trade, health, and education support.

4.3. Economic Study Area and Hinterlands

Nome lies on the southern shore of the Seward Peninsula. The area near Nome is treeless arctic tundra except for intermittent trees in the Fish River drainage. Most of the rivers that drain into Norton Sound near Nome are small. The Snake River is about 123 miles long, the Nome River about 140 miles, the Eldorado River about 105 miles, and the Sinuk River about 170 miles. During normal water conditions, the rivers are navigable by outboard skiffs for only a few miles above their mouths. The smaller streams are accessible only by jet- or hand-powered watercraft.

The economic study area has an area of approximately 191,000 square miles, from Utqiagvik (Barrow) in the north, to Kuskokwim Bay in the south. Figure 6 shows the study area.

Figure 6. Nome Economic Study Area

Economically, western Alaska relies on a few ports for the transshipment of goods: Anchorage, Nome, Dutch Harbor, Dillingham, and Naknek. At these ports, larger cargo shipments arrive from Seattle and are re-distributed for smaller vessels that make final delivery to villages and communities along the coast and upriver. The Nome economic study area extends from the northernmost accessible communities in western Alaska to approximately 330 nautical miles south of the port. At that point, it is assumed that goods are more efficiently transshipped at Anchorage, Dutch Harbor, Dillingham, or Naknek to ports along Bristol Bay and the Aleutian Islands. The commodities that are distributed to the locations inside the area in Figure 6 are transshipped through Nome. So, the levels of commodities delivered to that region are accounted for as they pass through the port of Nome. This allows for the effects of those goods shipped to the remote villages and communities of western Alaska to be captured by analyzing cargo volumes at Nome.

While some goods can make their way via air transport, the majority of goods are moved via line-haul or smaller barges, and landing craft. Road or rail transport is not a realistic mode given the present level of infrastructure.

Under ideal conditions, village residents in western Alaska would elect to use water transportation at every opportunity. It promises to be the cheapest delivery mode, and since most villages are located directly on the beach, water transportation has the advantage of being the least complex. The major disadvantage is that goods shipped by water must first be delivered to Nome, where they are shuffled and reshipped to their final destination. Reshipping involves delivery of the cargo to land-based staging areas in Nome, where it is sorted into units for delivery to the receiving villages. Sorting the cargo at Nome involves several pieces of machinery, several storage areas, and a number of personnel. It is a necessary operation to minimize time, confusion, risk, and breakage when the lighter making the final delivery beaches itself to unload at the village destination. The lighters minimize time spent in conditions that put the hull and machinery at risk of damage. The motivation for performing the make-break operation at Nome is that it is speedier to do it at a location where modern handling equipment and a protected moorage is available. Speed is of the essence, because deliveries late in the season run the risk of being delayed by weather while ice is forming at the delivery location. In the past, freeze-out events have prevented cargo from being delivered from Nome to the villages.

4.3.1. Port Facilities

Nome's outer harbor is composed of a 3,000-foot causeway, three sheet pile docks, and a breakwater to the east. Shipping companies use these docks for loading and unloading dry cargo, gravel, and refined petroleum products. The shallower inner harbor is located at the mouth of the Snake River and includes the Small Boat Harbor and Snake River development. This harbor supports smaller vessels, including gold dredging operations, commercial fishing, and recreational travelers. In general, the outer harbor is used for incoming cargo and fuel, outgoing gravel, and ship traffic exceeding the shallow depth of the inner harbor. The inner harbor facilitates redistribution of these and other supplies to outlying communities through landing crafts and smaller village delivery tug and barge sets.

The Port of Nome and associated infrastructure for the port and small boat harbor is shown in Figure 7.

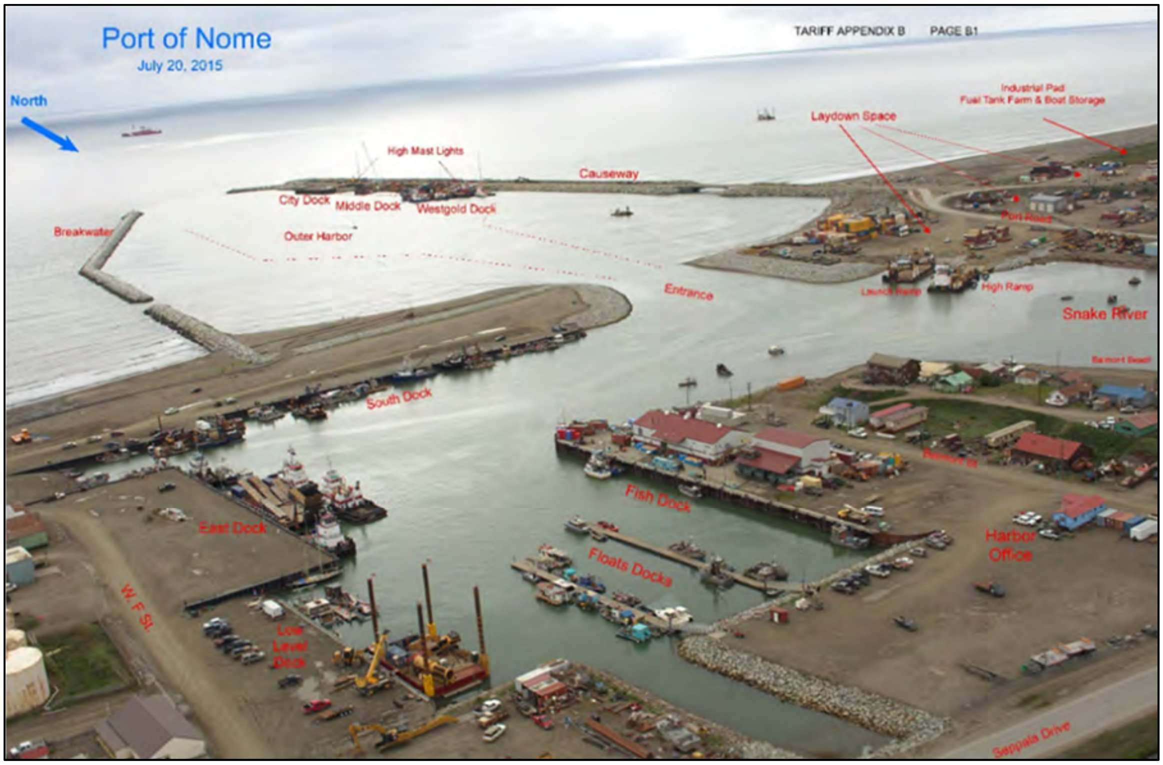

Figure 7. Port of Nome Aerial Image
Source: City of Nome

The City Dock (south) on the causeway is equipped with marine pipeline headers to handle the community's bulk fuel deliveries, and is also the primary dock for unloading the mainline cargo barges. The City Dock is approximately 200 feet in length with a depth of minus 22.5 feet MLLW.

The Middle Dock is 210 feet in length with the same depth of minus 22.5 feet MLLW. Previously, one of the challenges the port faced was that gravel ramps had to be built for roll-on/roll-off (RO/RO) equipment with frequent conflicts occurring due to differing heights of the barge and the fixed height of the dock. The Middle Dock was completed in 2016 with a ramp built in to address this issue. It is the primary location to load or unload heavy equipment.

The Westgold Dock (north) is 190 feet in length with the same depth of minus 22.5 feet MLLW and handles nearly all of the exported and imported rock and gravel for this region (Figure 8).

Figure 8. City, Middle, and Westgold Docks (looking west)
Source: City of Nome

The sheetpile for these three docks was driven to a depth of 34 feet MLLW at construction. There are currently no plans to expand these docks in the future; both with and without an improvement project.

The opening between the breakwater and the causeway (outer harbor entrance) is approximately 500 feet in width and serves as access to both causeway deep water docks and the Snake River entrance that leads into the Inner Harbor. Buoys outline the minus 12-foot MLLW navigation channel from the outer harbor entrance into the inner harbor.

For flexibility in assigning berths for vessel calls in the HarborSym economic model, the three docks on the Causeway were combined into one "Causeway" dock with the capacity to hold multiple vessels at once. This allows the model to more accurately reflect actual conditions of traffic management at the port.

The Nome Inner Harbor, shown in Figure 9, has a depth of minus 10-feet MLLW and offers protected mooring for small vessels alongside sheetpile and floating docks. Smaller cargo vessels and landing craft load and unload cargo, equipment and gravel at the inner harbor sheetpile docks, high ramp dock, and concrete ramp. The barge ramp and the high ramp dock are located just inside the inner harbor, west of the Snake River entrance. The ramps provide the bulk cargo carriers with suitable locations closer to the causeway and industrial pad to trans-load freight to landing crafts and roll-on/roll-off (RO/RO) equipment barges. This location also has approximately 2 acres of uplands for container, gravel, vessel, and equipment storage. Diesel, gasoline, and aviation gasoline is discharged and loaded at the harbor's East Dock for export to surrounding villages.

The concrete ramp is primarily used for launching and hauling out vessels at the beginning and end of the season.

Norton Sound Economic Development Corporation operates a fish processing facility in Nome, running tenders that bring cod, herring, salmon, crab, and halibut across the Fish Dock in the Inner Harbor. The fishing fleet consists of about 22 to 25 local and regional vessels.

Figure 9. Inner Harbor Aerial View
Source: City of Nome

4.3.2. Port and Facility Capacities

Fuel deliveries occur via fuel headers at the City and East Docks and are transferred to or from local tank farms via fuel pipeline. Four separate tank farms represent three different companies at the port. The western tanks that service the City Dock have a capacity of approximately 12 million gallons. They are connected by three pipelines with flow rates ranging from 50-100k gallons an hour. The 3-4 acres of land north of the west tank farm is available for expansion, if the need arises. In 2018, the terminal operators added fill dirt and drainage to the site in anticipation of future expansion. The timeframe of expansion will be dictated by fuel demand in the region. In order to realize NED benefits associated with the proposed alternatives presented in this study, fuel storage capacity will need to be increased. Most likely, it would have to be added to the storage connected to the causeway piers in order to accommodate deeper draft vessels as the east tank farm is connected to the small boat harbor. The east tank farm that services the East Dock has a capacity of about 5 million gallons. There are currently no plans in place at this time to expand the east tank farm.

Dry cargo deliveries occur at the causeway docks as well. The lighter fuel barges can carry some cargo if space allows and will transfer it inside the Small Boat Harbor occasionally. Also, fishing tenders transfer equipment and smaller cargo at the seafood processing plant during the seasons as well. Causeway dock cargo is typically offloaded using forklifts in a “pass-pass” configuration, where a forklift on a barge passes cargo to a forklift on the dock, but there are occasions where a cargo barge will carry a crane to Nome to offload specialty cargo. Figure 10 is a photo of forklifts using the “pass-pass” technique to unload cargo containers.

Figure 10. Forklifts using “pass-pass” technique to unload cargo containers
Source: City of Nome

Some cargo and equipment offloading is roll-on-roll-off, depending on the delivery company and the types of cargo or equipment being loaded. Typically, up to two forklifts can operate on the causeway docks at a time, but only one on the vessel, due to the amount of space available for maneuvering.

In general, vessel operators provide their own offloading equipment, either brought on-board the vessel or stored at Nome. The City of Nome does not provide offloading equipment. Figure 11 is the typical barge configuration with its own crane for cargo on-load and off-load operations.

Figure 11. Typical Cargo Barge with organic crane at the Port of Nome Westgold Dock
Source: City of Nome

While the use of this equipment, combined with limited storage space on the docks themselves, limits the cargo handling capacity of the port, the City of Nome has limited ability to change this configuration. Nome can utilize additional trucks for cargo handling during times of peak cargo volumes to speed up onloading and offloading. This cargo handling configuration is also consistent with offloading practices in other communities in Alaska. This is particularly true for remote Alaskan communities – many of which have no marine infrastructure, so vessels must provide their own cargo transfer equipment. This fact is a primary driver for the selection of the future cargo fleet in this analysis. Typically, the only cargo vessels able to carry their own forklifts/cranes to a variety of remote ports are barges. They have the flexible deck configurations and low freeboard relative to the dock face that larger general cargo vessels won't have.

Gravel loading typically occurs at the Westgold Dock via a portable conveyor system. Other gravel loading occurs at the Barge Ramp via front-end loader or excavator. There, gravel is loaded onto small barges and landing craft that utilize low freeboard or bow ramps for loading/unloading. Again, vessel operators, or construction companies, provide their own loading equipment that is stored in Nome. Until demand and volumes increase, it is likely that this methodology for moving gravel and rock will continue.

Commodity transfer rates were estimated in previous studies based on gross rates that include other dock-related activities such as fuel bunkering, inspections, repairs and similar activities. Many vessels that transit the Port of Nome do not transfer cargo. They enter the port to escape bad weather, change or rest crews, effect repairs and/or provision their vessel. For this study these vessels are defined as layberth vessels. It is important that the HarborSym model properly accounts for layberth vessel operations, including the time they spend occupying dock space. For this purpose a layberth “commodity” is defined in the model. One unit of this layberth “commodity” is intended to keep a vessel at the dock for 0.5 hour; thus 48 units equals 1 day.

Cargo transfer rates are displayed in Table 3and are stated in metric tons per hour (MTPH).

Table 3. Cargo Transfer Rates, in metric tons per hour (MTPH)

Dock	Commodity	Vessel Class	Minimum (MTPH)	Most Likely (MTPH)	Maximum (MTPH)
Causeway	Dry Cargo	All classes	6	46	114
	Fuel	Tanker Tug & Barge	62	123	199
	Fuel	All others	10	79	211
	Gravel	All classes	29	50	111
	Layberth	All classes	2	2	2
Lightering Area	Layberth	All classes	2	2	2

The Port of Nome currently has approximately 34 acres of uplands available for vessel haul out, storage, and other uses by commercial users. A wide array of vessels, including gold dredges, commercial fishing vessels, tenders, and landing crafts, are pulled from the water using trailers or airbags to over winter on shore. As port activity has increased, and as more vessels have been hauled out, additional uplands have been sought. The city is in the process of acquiring 7 acres of land, previously owned by the Air Force, to expand uplands. Additional uplands will also be developed from the second half of an 18-acre site located north of the large fuel storage facility located northwest of the port.

4.3.3. Waterway conditions

USACE conducts annual dredging of the navigation channels and maneuvering basins. The city is responsible for dredging of berthing areas in front of the sheet pile docks. Vessel activity at the outer harbor typically occurs following the breakup of sea ice in May and concludes in November. The inner harbor usually freezes over in late October or early November and in recent years, the outer harbor has not iced-in until late December or mid-January.

While currents in Norton Sound do not typically exceed a normal speed of 1 knot, there is a strong cross current at the entrance to the Nome Outer Harbor between the causeway and breakwater. Nome is impacted by both astronomical and meteorological tidal fluctuations. The published tide data for Nome, Alaska (in feet) is as follows:

Highest Observed Water Level (10/19/04)………….. +9.80
Mean Higher High Water (MHHW) .... +1.52
Mean High Water (MHW)... +1.33
Mean Low Water (MLW)... +0.30
Mean Lower Low Water (MLLW)............................... 0.0 (datum)
Lowest Observed Water Level (11/11/05)................. -6.69

Although there is a NOAA tide station at Nome, the HarborSym Economic model used for this analysis does not contain tidal information for Nome specifically. The closest available station to Nome within HarborSym is for Carolyn Island, Golovnin Bay, approximately 62 nautical miles from Nome.

The predicted tide data (in feet) for Carolyn Island, Golovnin Bay is as follows:

Mean Higher High Water (MHHW) .... +1.80
Mean Tide Level (MTL)... +0.90
Mean Lower Low Water (MLLW)................................. 0.0 (datum)

Based on this information, the tide range is slightly higher at Golovnin Bay by less than three tenths of a foot compared to Nome. For purposes of the HarborSym modeling, the Golovnin Bay data are considered representative of Nome, and have been used in previous studies. Figure 12 shows the historic tide levels measured at Golovnin Bay.

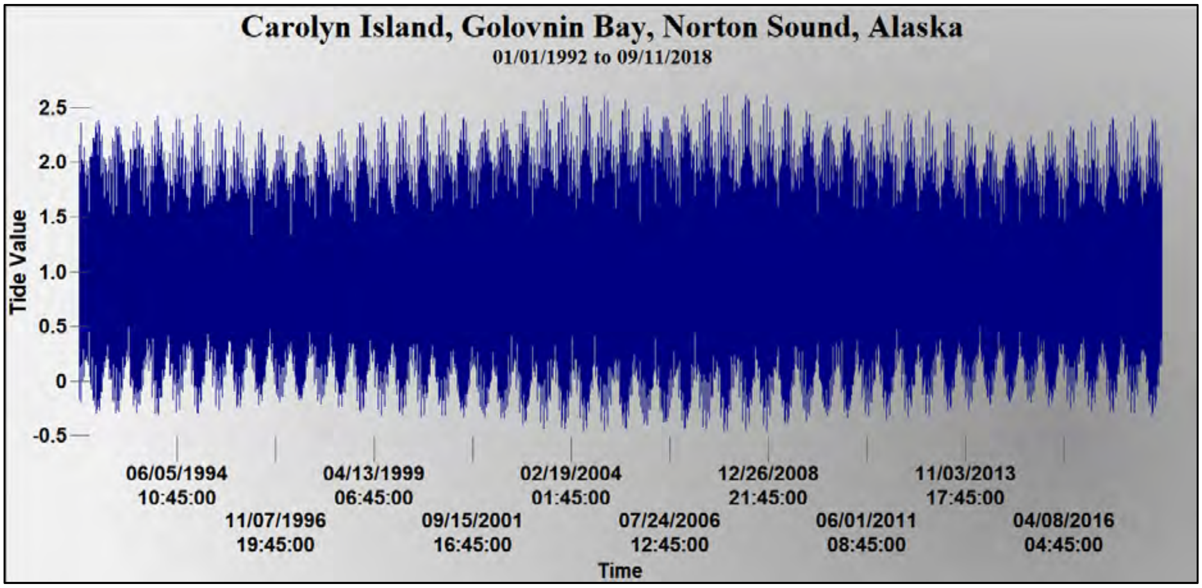

Figure 12. Tidal Ranges in Norton Sound, 1993-2018

There are narrow tidal ranges at the port; generally around 1.5 feet. However, during storm events, tidal surges can significantly affect water levels. During heavy southerly and southeasterly storms, vessels are prevented from mooring at causeway docks because of severe wave action. The water level at the port fluctuates significantly depending on the direction and duration of the wind. A sustained southerly wind can increase water levels in the port by 6 feet, while a northerly wind can reduce water levels by the same amount. Historically, these storm events occur in the fall season, and only occur once a year, or once every other year.

The weather over the Bering Sea is generally bad and very changeable. Good weather is the exception, and it does not last long when it does occur. Wind shifts are both frequent and rapid. The summer season has much fog and considerable rain. In early winter, the gales increase, the fogs lessen, and snow is likely any time after mid-September. Winter is the time of almost continuous storminess. Heavy winds from any direction are usually accompanied by precipitation.

The month of June, with less severe winds, appears to be the best month for navigation. July is about the same, but the rainy season and southwest winds pick up in the latter part of the month and continue through August and part of September. September is usually somewhat drier, with more frequent winds from the north. Prevailing winds during October are north to northwest; the general weather is clearer and colder. Fog is typically a problem in the Bering Sea in general; however Norton Sound is spared much of that dense fog. On entering the sound with thick weather in the Bering Sea, a vessel will find that the fog almost always thins out and gradually clears as the vessel proceeds up the sound.[19]

These conditions result in weather-related delays for a variety of reasons. Sometimes, the transshipment of cargo from oceangoing barge to a smaller lighter involves storing the cargo at the harbor to await arrival of the lighter. Ideally, the lighters schedule themselves to be available when the barges arrive at Nome. They are sometimes delayed due to sea conditions. Weather delays cause the tug and barge to incur non-productive time, waiting of the dock crew, waiting of the lighter, delay at the village destination, and waiting for final delivery by the end user. The port has kept records of vessel delays due to weather since 2012. These delays were not related to a specific condition; i.e. fog, sea state, inadequate water levels, etc. However, they do offer an idea of how the weather effects the already shortened ice-free shipping season. Table 4 shows weather delays, in hours, since 2012.

Table 4. Total Weather-Related Delays in Nome (hours) from 2012-2017

Year	2012	2013	2014	2015	2016	2017	Average
Total Delays (hrs.)	120	120	48	48	24	216	96

Source: Port of Nome Workbooks; Provided by Port of Nome May 2018.

4.4. Existing Vessel Fleet Composition

Existing vessel traffic was provided by the port of Nome from 2015 through 2017 to establish a representative port call list in the harbor. The three principle commodities moved through Nome and the rest of the study area were fuels, dry cargo, and gravel. For this analysis, vessels were divided into different vessel classes based on type and similarity of their dimensions. Based on the data collected, 11 different vessel classes carry the three main commodities. The previous Arctic Deep Draft Ports report published in 2015 listed characteristics for each of these vessel classes. Since that data is relatively recent, the same characteristics were carried forward to this study. The most recent data available for the 2015 study was from 2013. In most instances, the same vessels that were calling on Nome in 2013 are still calling in 2017. The breakdown of existing vessel classes and their respective characteristics are presented in Table 5.

Table 5. Characteristics by Vessel Class

Vessel Type	Vessel Class	Length (ft.)	Beam (ft.)	Draft (ft.)	Capacity (Metric Tons)	Commodities Carried
Cruise Ship	Medium Cruise Ship	464	59	16.1	1,177	Layberth
Cruise Ship	Small Cruise Ship	234	42	14.8	620	Layberth
Cruise Ship	Large Cruise Ship	820	106	25	10,810	Layberth
Government	Buoy Tender	225	46	13.0	350	Layberth
Government	Cutter	378	43	18	2,328	Layberth
Government	Ice Breaker	420	82	30.0	3,250	Layberth
Landing Craft	Small Landing Craft	78	24	3.5	300	Layberth Cargo
Landing Craft	Large Landing Craft	152	50	9.8	500	Layberth Cargo Gravel
Research	Medium Research Vessel	269	56	18.4	2,808	Layberth Cargo
Research	Small Research Vessel	180	40	15.0	730	Layberth Cargo
Research	Large Research Vessel	500	70	25	9,500	Layberth Cargo
Tanker	Tanker	417	67	28.5	11,611	Layberth Fuel
Tug & Barge	Large Tug & Barge	380	96	18.0	14,157	Layberth Fuel Cargo Gravel
Tug & Barge	Medium Tug & Barge	376	78	18.0	10,653	Layberth Fuel Cargo Gravel
Tug & Barge	Small Tug & Barge	299	54	14.0	4,400	Layberth Fuel Cargo Gravel
Tugboat	Tugboat	76	32	5.0	170	Layberth

Vessel capacities are the cargo amounts (in metric tons) that can be carried by each vessel. The primary source for capacity information was the U.S. Coast Guard Port State Information Exchange, with supplemental data from shipper's websites. Three classes of tug and barge were established, based on general groupings of vessel sizes. The length, beam, draft, and capacity for these classes were defined based on the dimensions of the barge alone, as tugs typically disconnect from barges prior to mooring in order to maneuver the barge into the dock.

The vast majority of the vessels that called at Nome were sailing under the U.S. flag. This is primarily due to Jones Act restrictions on "coastwise" trade; or trade between U.S. ports. It stipulates that any vessel that transfers cargo from one U.S. port to another must be a U.S. flagged vessel. Since many supplies are shipped from Seattle and many shipments from Nome go to communities on the U.S. coast of Alaska, vessels involved in this trade must be Jones Act compliant. However, all of the tanker and cruise ship calls at Nome are vessels sailing under foreign flags. In addition, many of the research vessels, cutters, ice breakers, and tugboats are foreign flagged. Foreign flagged vessels typically have significantly lower operating costs than U.S. flagged vessels. Figure 13 shows a cruise ship docked at the Middle and City Docks.

Figure 13. Medium Cruise Ship docked at the Middle and City Docks
Source: City of Nome

Table 6 displays the total number of vessel calls from 2015-2017 by vessel class. A combination of data from USACE's Waterborne Commerce Statistics Center and the Port of Nome was used to determine the ultimate count.

Table 6. Total Vessel Calls to Nome by Class, 2015-2017

Year	2015	2016	2017
Vessel Class	**Number of Calls**	**Number of Calls**	**Number of Calls**
Buoy Tender	2	1	2
Cutter	8	4	10
Ice Breaker	4	3	4
Large Cruise Ship	0	1	1
Large Landing Craft	33	34	43
Large Research Vessel	0	2	2
Large Tug & Barge	16	18	16
Medium Cruise Ship	3	3	3
Medium Research Vessel	9	6	17
Medium Tug & Barge	51	44	40
Miscellaneous	10	44	17
Small Landing Craft	1	3	1
Small Research	29	12	16
Small Tug & Barge	47	62	67
Tanker	11	11	9
Tugboat	5	6	2
Grand Total	**229**	**254**	**250**

4.5. Vessel Operations

All vessel traffic into and out of the port is managed by the Nome Harbormaster. Any foreign-flagged vessel is required to have a domestic pilot, usually provided by Alaska Marine Pilots. The pilots typically embark/debark vessels approximately 2-3 nautical miles outside the harbor entrance. Nome currently has no harbor tugs to provide docking/undocking assistance, but is planning to acquire private contract tug services for hire. Pilots have suggested that larger vessels have twin propellers or bow thrusters to dock at the causeway, unless an assist tug is available. Foreign tanker vessels are usually under charter of one of the regional fuel distributors. They sometimes will have their own tug/barge sets in the vicinity for lightering and barge operations, so they typically assist tankers in docking and undocking in Nome. Figure 14 below shows two tugs owned by regional fuel distributors assisting a small tanker in docking on the causeway.

Figure 14. Private tugs assisting chartered tanker in docking at Causeway
Source: City of Nome

Other smaller vessels, such as U.S. Coast Guard vessels, foreign government vessels, cruise ships, and research vessels also call on the port, as shown in Figure 15 below. These are typically small enough, or equipped with bow thrusters, to not require any additional assistance moving into and out of the port. Any foreign vessel is required to have a U.S. pilot, but will typically not require tugboat assistance. However, these operators would prefer to have an assist tug in and out of the facility. The majority of the remaining fleet of vessels calling on Nome are a mix of tug/barge combinations and landing craft. These smaller, domestic vessels are more maneuverable and do not require pilot assistance or additional tugboats to dock and undock, unless wind, swell or current plays a factor.

Figure 15. USCG Cutter, Research Vessel and Small Tug and Barge Docked at Nome Causeway Docks.
Source: City of Nome

Due to the narrow entrance (500 feet between the causeway and breakwater), traffic is restricted to one ship movement at a time in the outer harbor. This means that two large commercial vessels will not pass each other inside the harbor. The narrow entrance also poses navigational challenges during times of large swells or wind. There are no charted anchorage areas inside the harbor, but occasionally, vessels will anchor in the outer harbor to avoid rough weather in Norton Sound or wait for available dock space. Multiple gold dredges will also anchor along the west bank of the Snake River, and in the shallow mud flats below the Fish Dock once dredging operations are complete.

Docking and undocking times vary with conditions and vessel traffic in the harbor. Typically, the largest determinant is vessel size, given the small space for maneuverability inside the harbor. Vessels will enter and exit the harbor just fast enough to maintain steering controls, but no faster. The larger the vessel, the farther away the slowdown must occur, which takes more time. For example, smaller research vessels and landing craft that are fairly maneuverable can dock relatively quickly, or in about 15 minutes. Barges that are being towed into the harbor must change their configuration to dock. The tugboat will shift from towing the barge via cable, to pushing the barge alongside (called getting into the push configuration) into the dock, adding more time. Smaller gravel barges can do this in around 20 minutes. Larger cargo barges (over 400 feet) will take much longer—typically 45 minutes to an hour to dock. These larger barges will have very tall loads of various configurations, as Figure 16 shows.

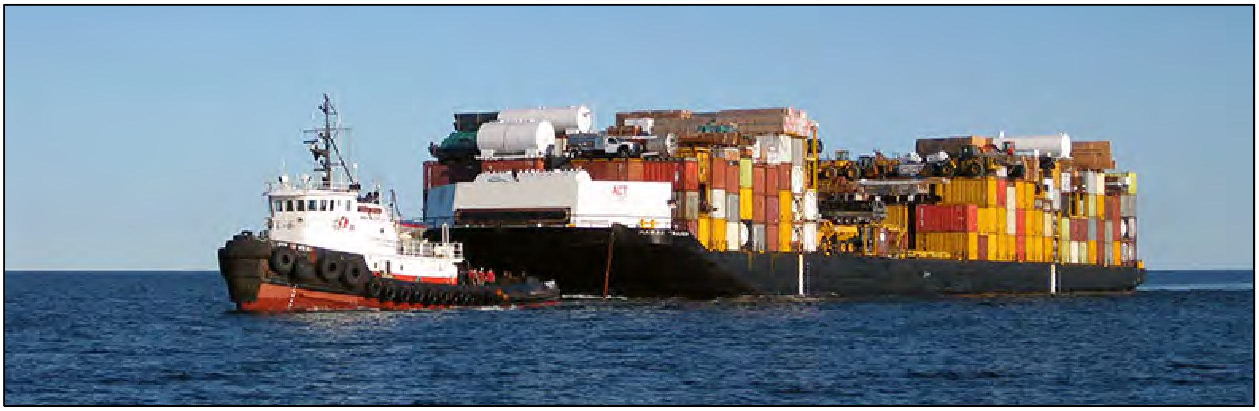

Figure 16. Large Cargo Barge used for Western Alaska Re-supply
Credit: Alaska Marine Lines

With the prevailing windy conditions at Nome, the heights of the loads on these barges create a "sail area" that makes docking operations more difficult as well. This is another consideration shippers must make before navigating the narrow entrance to the harbor, made already difficult by its cross-currents. The opposite condition exists for heavily loaded fuel barges with little freeboard, which are more strongly affected by the cross-currents. Larger vessels, like tankers or cruise ships, must consider this sail area problem as well. That issue, combined with their size and slow approach, will cause more delays in waiting for ideal conditions and longer docking times. These vessels take around 45 minutes to an hour (or more) to dock.

As the Port of Nome is a seasonal facility, the general intent is to work as many vessels as feasible to accomplish the necessary work in a short time period. However, certain types of vessels are restricted to entering the harbor at times when onshore staff or facilities are available. For example, vessels making fuel deliveries to the City Dock can only enter the port or tie up to the dock between 5:00AM and 10:00PM. These vessels are considered regulated vessels by the Coast Guard and need security personnel and line handlers to facilitate docking and loading or unloading, as well as sufficient staff present at the receiving tank farm; these personnel are only available during this time frame. Fuel vessels can undock and leave the port at any time, as personnel are not needed for oversight. Similarly, vessels delivering dry cargo typically only enter the port and dock between 6:00AM and 10:00PM to ensure company personnel are available to secure and work the vessel, as well as coordinate with Nome harbor staff to establish secure operational areas and verify other vessels can also operate safely. This window can be expanded during periods of heavy congestion or delayed arrival, provided sufficient crew is available. Foreign-flagged research and cruise vessels using a dock at Nome can only enter the harbor or access a dock between 5:00AM and 10:00PM because, line handling and port security are required, and U.S. Customs officials must be present to board and clear the vessel before disembarkation.

If vessels arrive outside these timeframes, they must wait offshore. There are no timing restrictions on barges delivering equipment or loading gravel, government vessels (unless they request line handlers), smaller research vessels, or tugboats not towing a barge.

Typical sailing draft assumptions were determined based on detailed data from Waterborne Commerce of the United States from 2004-2016. A total of approximately 1,600 records were reviewed. The data indicated that the vast majority of vessels calling at Nome sail very near to their maximum drafts on load-carrying legs. It is believed this practice is mostly due to the fact that the vast majority of vessels that call at Nome are smaller in size, and not constrained by draft. Also, the potential for rough weather causes the need to adequately ballast vessels that operate in the region. Based on the available data, arrival drafts were plotted in Figure 17 from 2004-2016. As shown in the figure, 95 percent of all vessel traffic arrived at 18 feet or less. Those that arrived deeper used high tides to dock in the outer harbor.

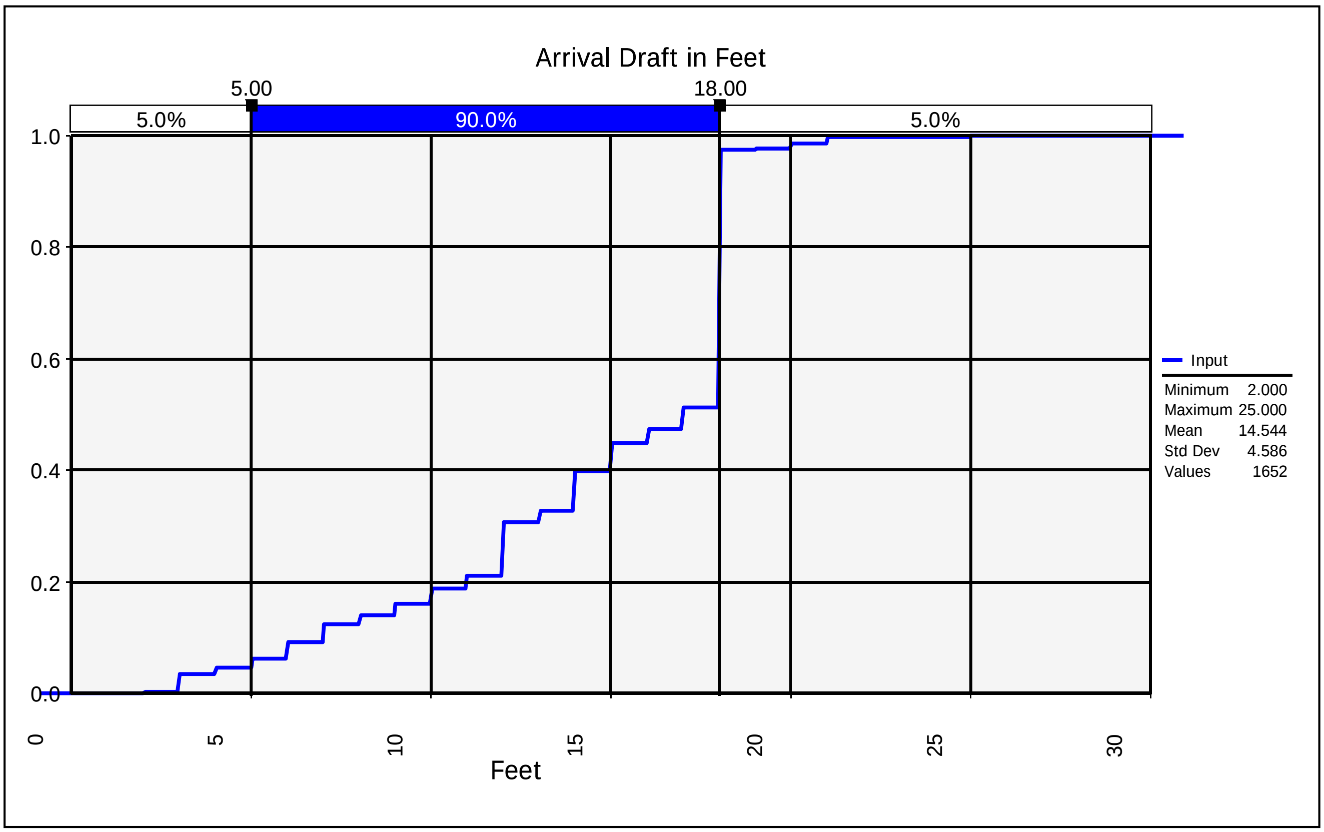

Figure 17. Cumulative Distribution Function (CDF) for Arrival Drafts into Nome, 2004-2016

In contrast, the drafts of the largest vessels that utilized the causeway docks were limited by channel constraints, and their sailing drafts were not approaching their maximum. For example, tankers calling at the dock were limited to 17 feet and large tug/barge combinations were limited to 18 feet. Arrival drafts for tankers and large tug & barge combos were plotted in Figures 18 and 19 below. Tankers arrival drafts included those that anchored offshore of Nome. The upper delimiter in Figure 18 is set to 22.5 to signify the current depth of the Outer Harbor. The CDF shows that only 15 percent of the tankers in the vicinity of Nome were able to pull into the Outer Harbor at its current depth. Figure 19 shows that 95 percent of the large tug & barge combos were limited to 18 feet. The rest of those calls were assisted by a favorable tide.

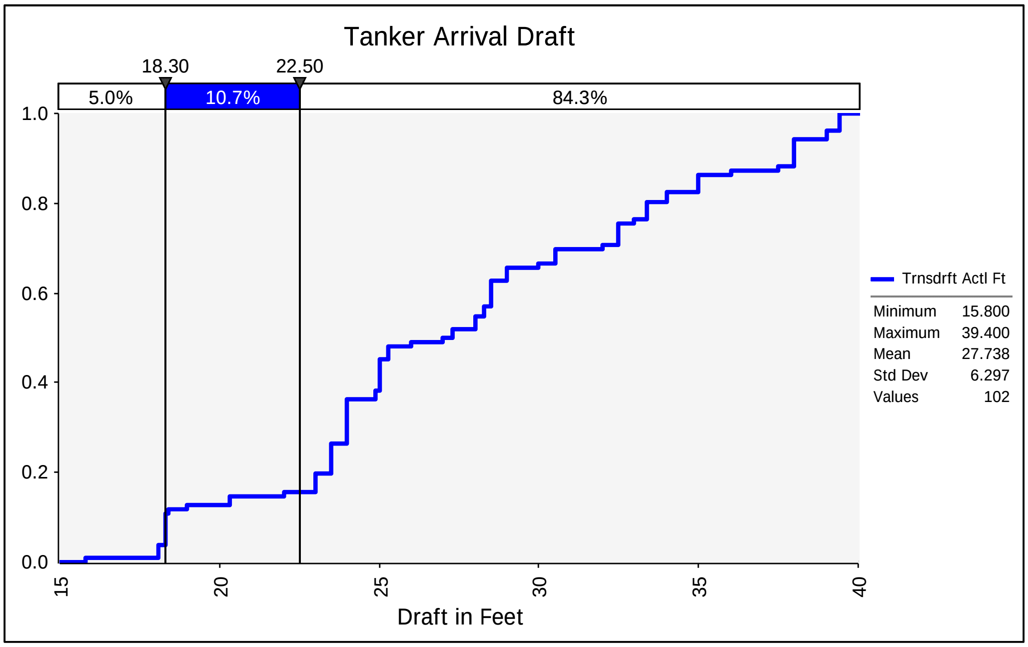

Figure 18. CDF for Tanker Arrival Drafts into Nome 2003-2017

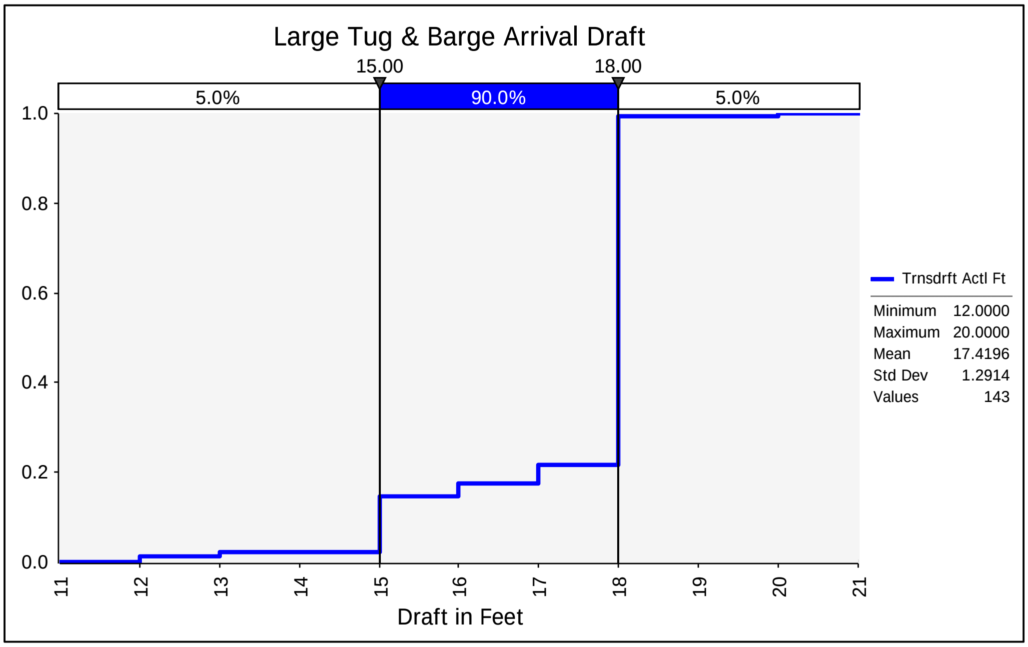

Figure 19. Figure 19 CDF for Large Tug & Barge combos Arrival Drafts into Nome 2003-2017

Based on the available data and feedback from multiple sources, the underkeel clearance for most vessel classes is estimated at 5 feet. The margin of safety is ultimately decided by the vessels themselves and their risk tolerance given the prevailing conditions. The safety clearance also varies depending on the type and size of vessel. Smaller vessels and barges with flat bottoms may require as little as 2 feet in favorable conditions. Larger vessels, or vessels with specialized bottom equipment, like research or government vessels, may require up to 6 feet. Rough wind and wave conditions can cause the clearance desired to increase from there as well.

4.5.1. Lightering

The use of lighter vessels occurs in connection with two commodities in Nome: dry cargo and fuel. The first is for shifting dry cargo from larger barges to smaller ones using the docks inside the port itself. The second is the use of tankers and lighters transferring fuel at sea, outside of the port.

When a dry cargo barge arrives at Nome, cargo bound for villages close to Nome is unloaded, trucked to the staging area, sorted, and reloaded onto a fleet of lighters. The lighters, like the landing craft shown in Figure 20 below, are capable of operating in shallower waters, and all of them are equipped to land on the beach and unload with use of a bow ramp.

Figure 20. Typical Landing craft trans-shipping cargo at Nome
Source: Port of Nome

Communities that depend on waterborne delivery must order goods for an entire year, and deliveries must be made during the ice-free months. The vessels are either idle in the winter or working at ice-free locations. These vessels range in size from 100-300 feet long, and draw up to 12.5 feet at their maximum draft.

The other lightering situation at Nome is using fuel vessels. Fuel vessels traditionally conduct lightering operations all over the western Alaska coastline, including in the vicinity of the Port of Nome. Similar to dry cargo operations, fuel lighters are capable of operating in shallow water or landing on the beach to deliver fuel, as shown in Figure 21 below. The use of these vessels is critical to remote villages and their fuel supplies, because they are Jones Act compliant and they are small and specialized enough to navigate the shallow waters and tidal conditions of upriver villages and coastal unimproved beaches.

Figure 21. Fuel lighter delivering fuel over the shore via hose connection
Source: Port of Nome

Since 2012, western Alaska fuel distributors have been utilizing medium-range (MR) class tanker vessels to deliver a large portion of the fuel to the region by acting as a "floating gas station." These tankers are typically 500-600 feet long, have a draft of 40 feet, and have a capacity of 40,000 deadweight tons (DWT). They bring large loads (335,000-360,000 barrels (bbls)) of fuel from Northern Asia to the western Alaska region at a fraction of the cost (usually ½ to 1/3) of domestic suppliers. This is because tankers from domestic refineries, like ones in Kenai, Alaska, would require Jones Act compliance to move product, and the only Jones Act compliant tankers in Alaskan waters are in the south, traveling from Valdez to Puget Sound in the continental U.S. Alaskan refineries also do not have the capacity sufficient for the demand of western Alaska fuel. The Kenai refinery, for example, can produce only 72,000 bbls a day. This lack of capacity would require more frequent barge transits that could cost up to 19-20 days during the ice-free season. Using larger vessels results in economies of scale by buying and selling fuel in larger quantities. Also, the Cook Inlet, where the Kenai refinery is located, is very congested for the fleet that operates there, so dock space is limited. This causes more delays and increases cost for transportation to shippers and higher prices to consumers. Chartering vessels from Asia limits the amount of transit time needed to get to western Alaska markets.

Another reason that this “floating gas station” model has developed over the last 5 years is a change in oil spill prevention regulations. In 1989, the Exxon Valdez hit a reef and spilled 10.8 million gallons of crude oil in Prince William Sound, causing irreparable environmental and financial harm to the region. Subsequently, Congress made oil spill prevention plans a requirement for all vessels operating in U.S. waters, including out to the 200 nautical mile Exclusive Economic Zone (EEZ). These National Planning Criteria (NPC), as they are called in 33 CFR § 155, set minimum requirements for a vessel’s oil spill response equipment and identification of oil response resources within a given response time. These are based on the type of vessel, the amount of oil carried, and the location of operations. While these regulations were feasibly met in the continental U.S., locations like Alaska, Hawaii, and the U.S. Virgin Islands could not comply. In these remote areas, the response resources are simply not available due to the high cost of maintenance, or the available commercial resources will not meet the NPC response time requirements. As shown in Figure 22 below, in Alaska specifically, NPC criteria could only be met in the Cook Inlet (near Anchorage) and the Prince William Sound (the terminus of the Trans Alaska Pipeline and site of the Exxon Valdez spill).

Figure 22. Graphic of NPC compliance
Source: Alaska Maritime Prevention & Response Network

So, in 1990, a special provision was made for these areas in 33 CFR § 155.5067. They could request from the Coast Guard to operate under Alternative Planning Criteria (APC), which could mitigate the lack of recovery assets available in Alaska and delayed on-scene arrival time with more aerial observation, enhanced shoreline cleanup, and greater sustainment of response.[20] By 1994, Alaskan fuel barge operators were submitting APCs as part of their required response plans to allow them to operate in western Alaska. However, these APCs did not cover tankers. By 2006, barge operators were pushing the USCG to allow APCs for fuel tankers in western Alaska as well. Utilizing these larger vessels could offer savings of $0.20-$0.25 per gallon of fuel. Also, the aging single-hull fleet of Jones Act-compliant barges was being phased out. These barges would typically over-winter in the ice-free areas of southern Alaska, and were no longer cost effective to operate for only half the year. So, barge operators were having to decide how many and what size of new double-hulled Jones Act-compliant barges to build. Also, oil companies performing exploration and production in the Chukchi and Beaufort Seas relied on support vessels for fuel and logistics during drilling operations. These support vessels carried enough fuel to be classified as tankers, thus falling under the NPCs. They also pushed the USCG to accept APCs for tanker vessels to operate in western Alaska. Relying on fuel tankers would reduce these operators' overall capital and maintenance costs. In 2013, the Alaska Maritime Prevention & Response Network proposed Network APCs for tankers and secondary oil cargo carriers. By relying on the Alaska Marine Exchange's Automated Identification System (AIS) to track vessels in distress and available response assets, the network could monitor APC compliance and manage the locations of response assets, like tugboats, 24/7. This was accepted by the USCG, with certain limitations, and tankers were subsequently allowed to operate with APCs in western Alaska. This change in regulations, combined with the economies of scale available in tanker movements, ushered in the use of the "floating gas station" model in western Alaska fuel distribution.

Figure 23. MR Tanker lightering to small local delivery barge
Source: Crowley Maritime

The above Figure 23 is an example of the “floating gas station” model in action, as a Tanker delivers fuel to a small regional delivery barge alongside. Vessels are typically be chartered by regional fuel distributors 2-3 times a season. These vessels anchor in central locations like Togiak Bay, Goodhope Bay, and approximately 4 miles offshore of the port of Nome. They provide fuel deliveries to smaller tankers or different sizes of barges. Small tankers and large barges are used if the anchored location is farther than 3-5 miles from the final destination. This does not happen often in western Alaska; however, this is the predominant activity offshore of Nome, as Figure 24, a photo provided by the Port of Nome, demonstrates.

Figure 24. MR Tanker lightering to smaller "pocket" tanker offshore of Nome
Source: Port of Nome

If the destination is close enough to the anchored location, which is usually the case, the tankers will lighter directly to the smaller delivery barges. This distance criteria is in place because the delivery leg of the supply chain that goes to the remote villages requires a small and specialized barge. This barge is typically very slow, especially in open water. During the ice-free season, time is at a premium to ensure villages get their required fuel deliveries, so shortening their transits saves time and money. Anchoring as close to the beach as possible is the most cost-effective strategy.

4.6. Waterborne Commerce

The city of Nome provided detailed waterborne commerce information for this analysis. The harbor records are used as support for use fees, and the harbormaster has records for every pound of commerce and for every shipper. Since fees are based on number of pounds, there is reason to believe any error in the data would surface. The period from 2012-2017 was used in this analysis. Typically, a 3-5 year data range is used to establish a baseline for forecasts into the future. However, the variability in cargo volumes suggests that using a larger range provides greater opportunity to smooth the baseline levels of cargo movements. Figure 25 shows the cargo tonnage that moved through Nome from 2012-2017.

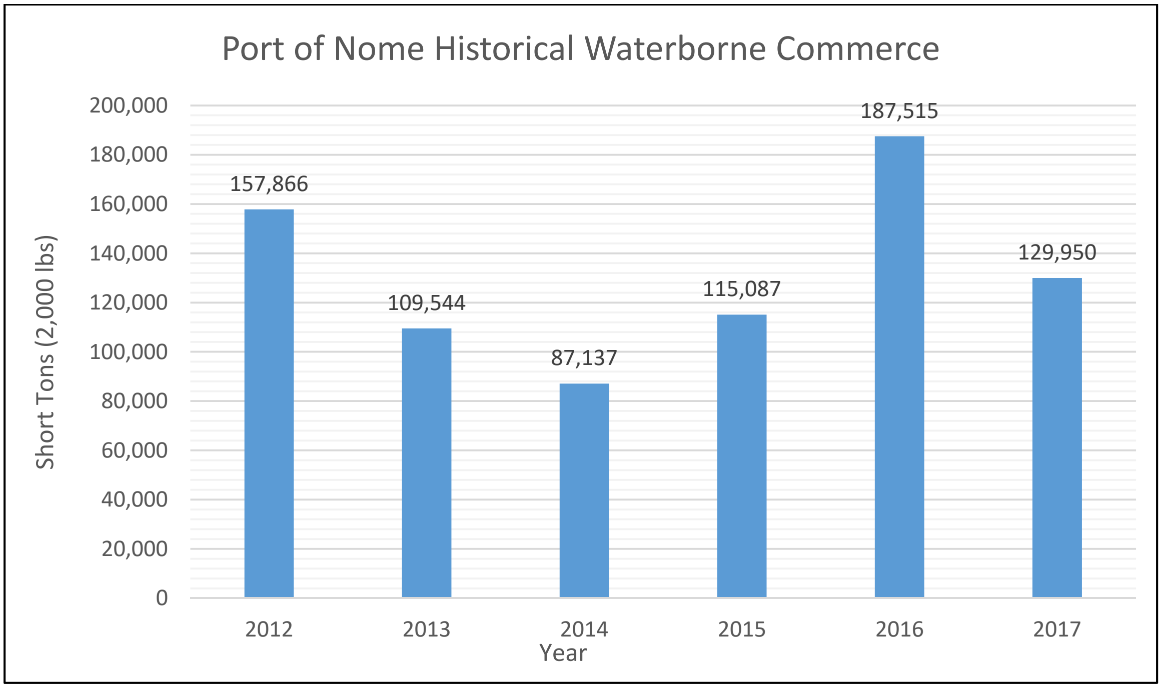

Figure 25. Nome Historical Waterborne Commerce by tons, 2012-2017.
Source: Port of Nome Season Commodity Report by Vessel, 2012-2017

Cargo is composed primarily of three commodities: petroleum products (fuels), gravel, and dry cargo goods. The movements of these goods from 2012-2017 are captured in Figure 26.

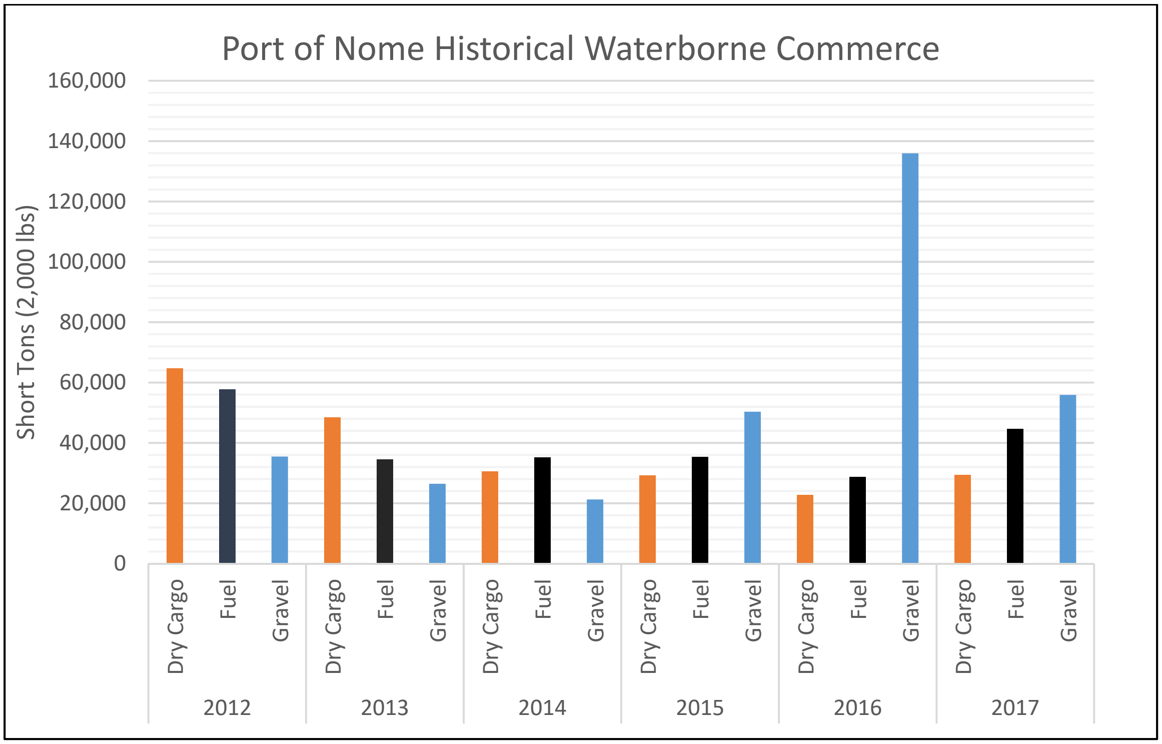

Figure 26. Nome Historical Waterborne Commerce by Commodity and Year, 2012-2017.
Source: Port of Nome Season Commodity Report by Vessel, 2012-2017

Commodity volumes for each respective category can vary significantly over a 2 or 3 year period. There are multiple reasons for this. First and foremost, the weather and ice conditions around the port of Nome induce large variability in the amount and schedule of goods shipped in and out of Nome. The port is typically iced over from November/December to April/May every year. Most shippers make anywhere from 5-8 voyages to western Alaska inside of that ice-free window each year. If shipping schedules slip too frequently, this can cause shipments from Anchorage or farther away to be cancelled entirely if the full delivery can't be completed before the ice arrives. This can leave Nome, and communities that rely on Nome, with a very difficult situation—either ship the needed goods by air, or go without.

Another cause in the variability of shipments, especially for the export of gravel, is the pace of infrastructure spending within the region and state. Rock exported from Nome is mined at the nearby Cape Nome quarry and gravel is crushed in local pits around Nome and sent around the state via barge as construction material. The levels of rock and gravel exported from Nome are directly related to the number and scope of public construction projects around the state that require these materials. Years where those projects are more numerous or larger, like 2016, result in large fluctuations in volumes of rock and gravel shipped.

Finally, shipments are often affected by adverse weather and sea state conditions. This can be a problem at hub communities like Nome, as well as more remote communities "down the line" for ultimate freight delivery. Weather or condition delays at transshipment hubs compound problems with shipping timelines by delaying not just final deliveries, but also back-haul voyages to Anchorage or beyond for re-supply. An accumulation of these effects can cancel entire voyages later in the season.

4.6.1. Fuel

There are typically six different types of fuel moved through the port of Nome: diesel #1, diesel #2, aviation gasoline (Avgas), regular unleaded gasoline (RUL), jet fuel (Jet A), and heating fuel. The two types of diesel fuels and heating fuel are used for heavy equipment fuel, municipal and private power generation, and heating purposes. Jet fuel and aviation gasoline are delivered to the airport for the variety of planes operating there. Regular unleaded gasoline is used for vehicle/miscellaneous fuel at service stations in town. Movements are dominated by receipts, even though regular shipments do occur, as shown in Figure 27. Shipments are typically captured by the vessels that call on Nome to refuel via pipeline at the causeway docks. That includes the regular barge vessel traffic as well as the many ancillary vessels that call each year. Examples of these are U.S. and foreign government vessels, research vessels, cruise ships, and miscellaneous support vessels. Smaller vessels can also be re-fueled by tanker trucks supplied by local fuel distributors. These trucks typically deliver approximately 250,000 gallons of fuel each year, in addition to what is delivered by pipeline to the docks.

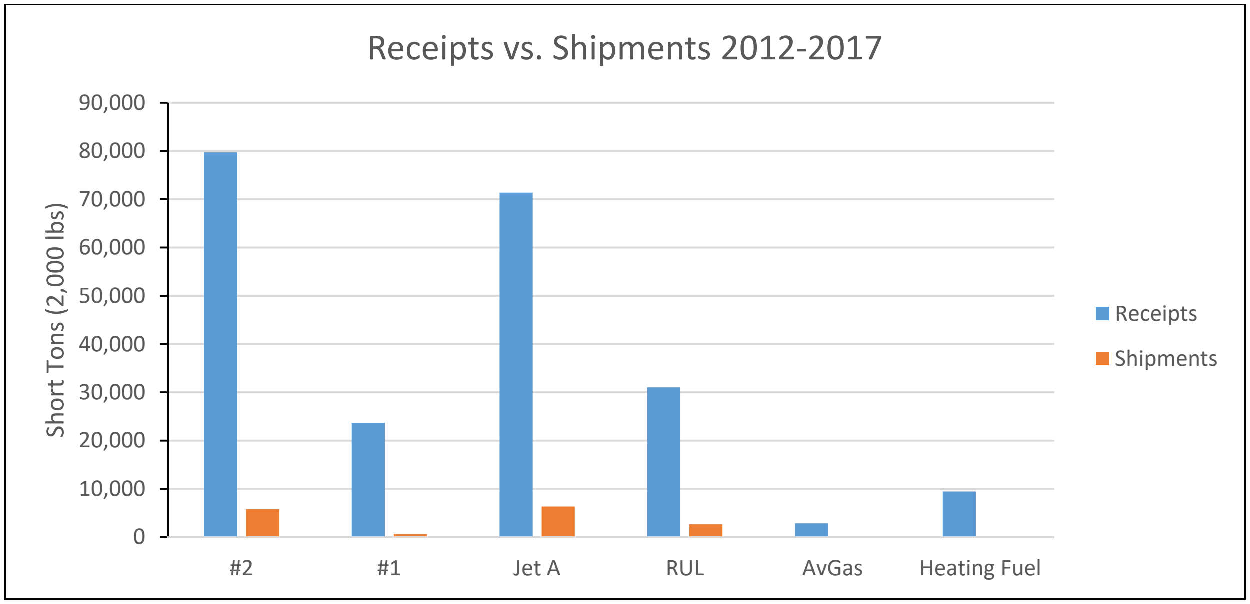

Figure 27. Nome Historical Fuel Volumes by Type and Direction, 2012-2017
Source: Port of Nome Season Commodity Report by Vessel

Total fuel receipts vary significantly from year to year, for reasons discussed in previous sections. Each year, anywhere from 25-50 thousand tons of fuel come into Nome, as Figure 28 shows. Shipments do still occur, albeit at decreasing levels, even after the rise of the “floating gas station” model came into effect in 2013.

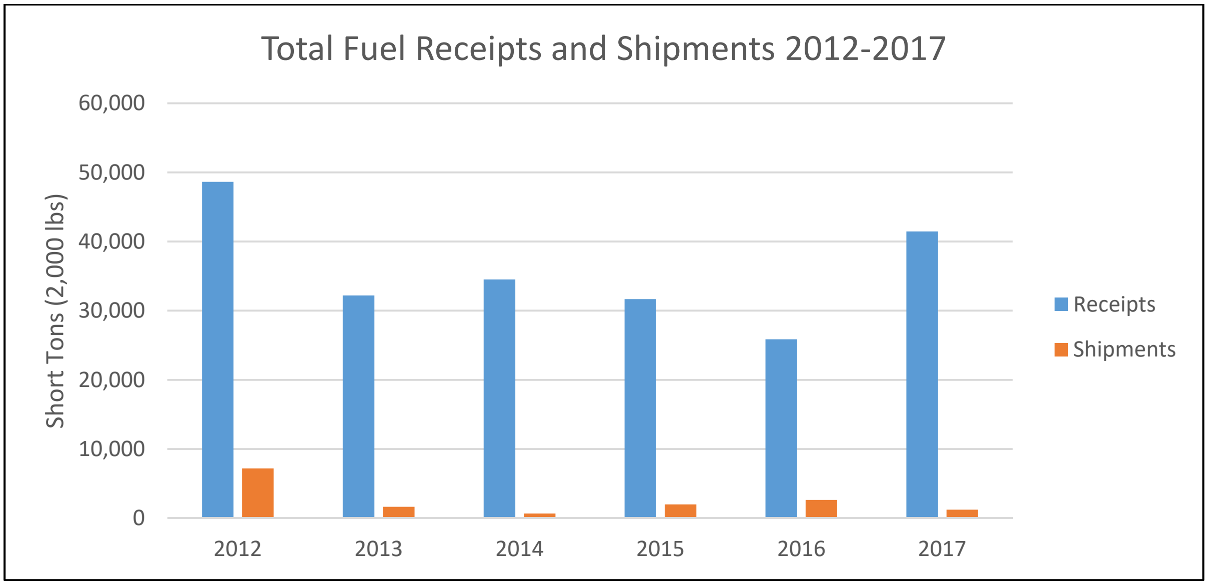

Figure 28. Nome Total Historical Fuel Volumes (short tons) by Direction, 2012-2017
Source: Port of Nome Season Commodity Report by Vessel

4.6.2. Gravel and Quarry Stone

The Cape Nome quarry (12 miles east of Nome) is a source of industrial grade armor stone and rip rap commonly used on seawalls, causeways, and breakwaters. It can also be crushed for gravel and used as construction material for airport runways and roads. The nearest alternative quarry is located on St. Paul Island, about 1,700 miles from Nome. Figure 29 below shows the typical setup on the causeway for gravel loading operations onto a delivery barge.

Figure 29. Gravel loading operation at the Westgold dock via conveyor
Source: Port of Nome

The receipts and, primarily, shipments of gravel and stone from Nome since 2012 is shown in Figure 30 shows. As explained earlier, the volumes of gravel and stone shipped can be quite variable, depending on the amount of local and regional construction happening that year. In 2016, for example, there was a very large project in Hooper Bay, about 180 miles south of Nome. The state conducted extensive relocations and repairs on their airport and its access road. This project accounted for much of that year's volume.

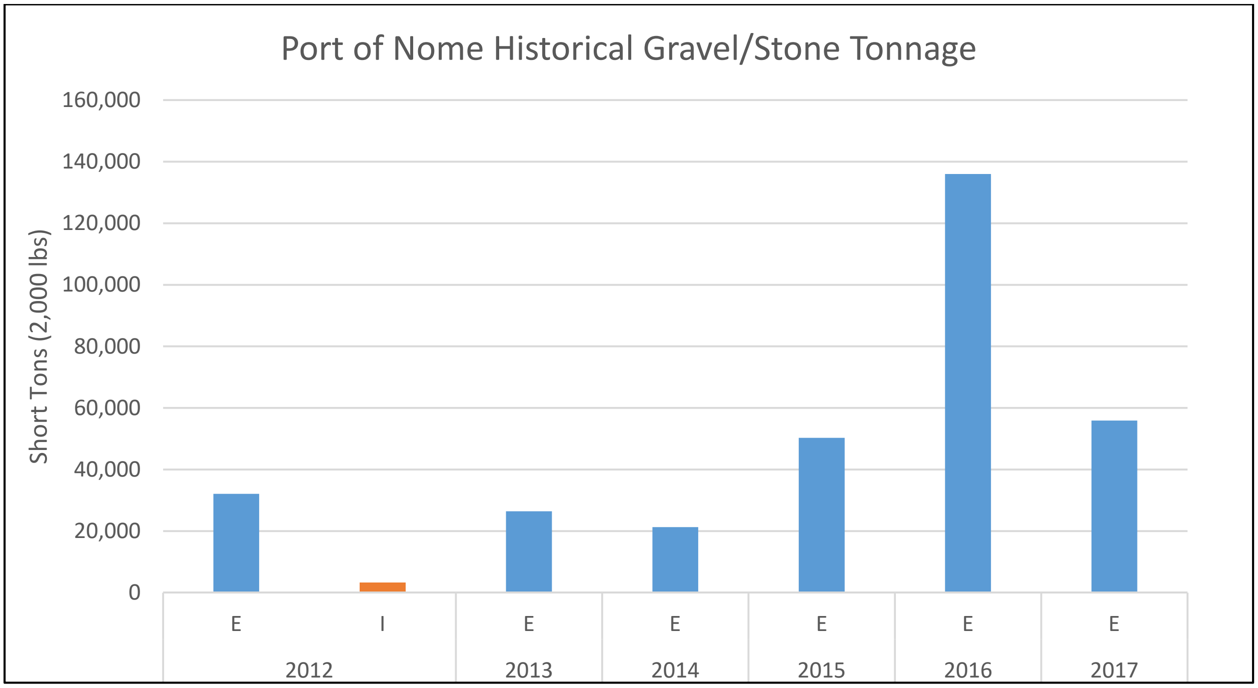

Figure 30. Gravel/Stone Receipts and Shipments through Nome, 2012-2017
Source: Port of Nome Seasonal Commodity Report by Vessel

4.6.3. Dry Cargo

All other cargo shipped into and out of Nome is classified by the port as dry cargo, or simply, cargo. The volumes of cargo delivered to Nome are for local consumption in Nome as well as to be transshipped to remote villages along the western Alaska coast. Figure 31 shows the types of items that are shipped to and from Nome on cargo barges, including containerized cargo and fuel, vehicles, construction equipment, municipal and industrial building materials, windmills, modular/manufactured housing, etc.

Figure 31. Typical Large Cargo Barge Docking at Nome Middle Dock
Source: City of Nome

Cargo receipts and shipments have decreased significantly over the last 6 years. The weather and ice have played their traditional role in minor variations in volumes, but Alaska is also in the midst of a recession. Economic output in Alaska has been on the decline since 2012, but the drop in oil prices in 2015 ushered in steeper declines in output and employment state-wide. The significance of these drops are displayed in Figure 32.

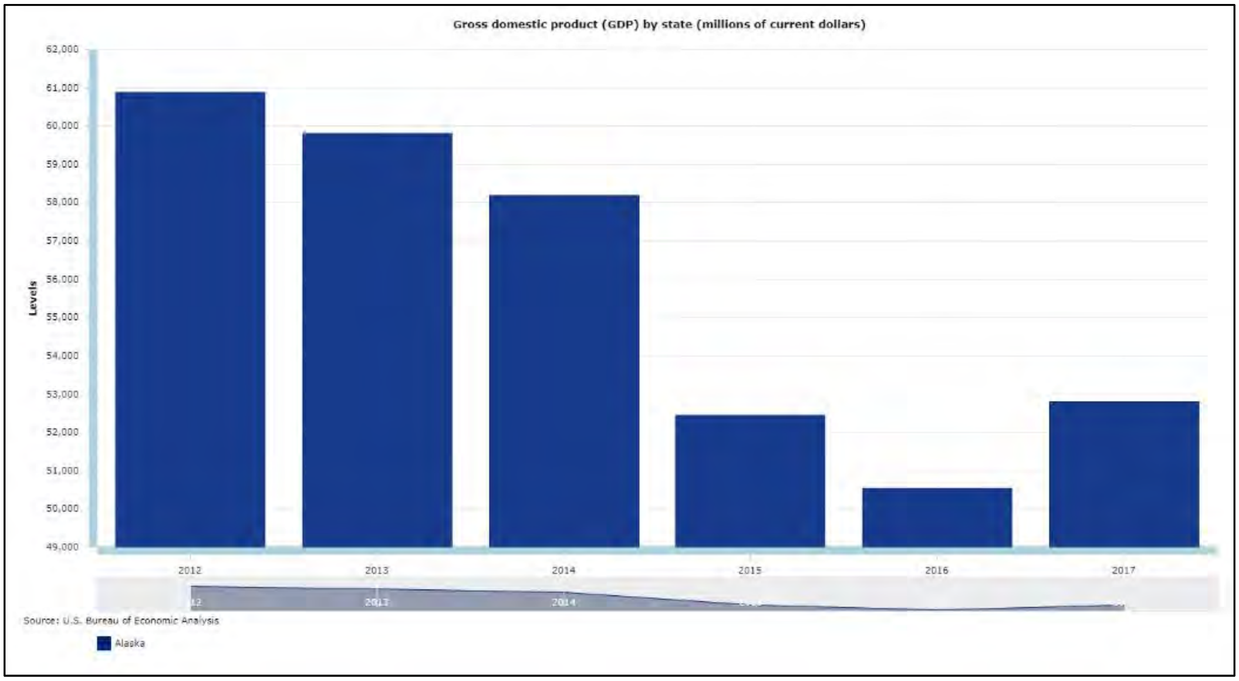

Figure 32. Alaska Gross Domestic Product (million$) 2012-2017.

According to discussions with port personnel, this recession directly impacted regional construction projects such as roads, airports, schools, clinics, and seawalls. Although some work periodically occurred through federal funds, there was a significant drop in the volume of projects due to limited state funding. The volumes of cargo moved in western Alaska, and Nome specifically, reflect these changes, as shown in Figure 33.

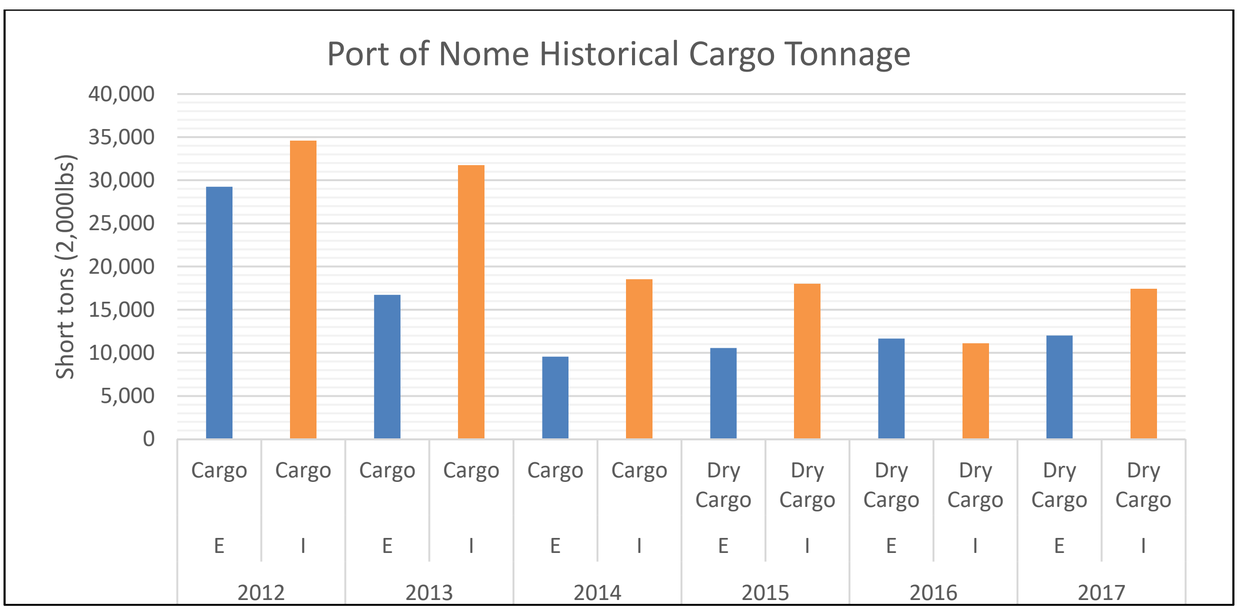

Figure 33. Cargo Receipts and Shipments through Nome, 2012-2017
Source: Port of Nome Seasonal Commodity Report by Vessel

4.6.4. Layberth

Many vessels that transit the Port at Nome do not transfer cargo. They enter the port to escape bad weather, change or rest crews, effect repairs and/or provision their vessel. For this study these vessels are defined as layberth vessels. Since no transfers are logged with this "commodity," there are no volumes to analyze. What can be chronicled in the existing condition is how many vessels historically call on Nome for layberth purposes. Table 7 presents the layberth calls from 2015-2017. Included in this count are the vessels that anchor offshore of Nome as opposed to pulling into a dock.

Table 7. Layberth Calls from 2015 -2017

Year	**Draft**	**2015**	**2016**	**2017**
Cutter	15.0 - 22.5	7	3	9
Large Landing Craft	4.0 - 12.5	5	2	6
Large Tug & Barge	16 - 17.5	6	8	3
Medium Cruise Ship	15.7 - 17.0	3	2	3
Medium Research Vessel	15.5 - 27.5	7	4	15
Medium Tug & Barge	8.5 - 17.5	20	9	14
Miscellaneous	3.0 - 33.0	6	37	14
Small Landing Craft	4.0 - 8.0	1	0	1
Small Research Vessel	5.0 - 20.0	29	12	14
Small Tug & Barge	5.0 - 22.0	22	17	20
Tanker	20.0 - 43.8	9	10	9
Tugboat	5.0 - 20.7	5	6	2
Ice Breaker	19.0 - 30.0	4	3	4
Buoy Tender	13.0 – 20.0	2	1	2
Large Cruise Ship	25.0	0	1	1
Large Research Vessel	19.0 - 29.0	0	2	2
Total		**126**	**117**	**119**
% of Total Vessel Calls		**55%**	**46%**	**48%**

4.7. Route Groups

A route group is a set of typical port itineraries that are applicable to a particular class or classes of vessels. Route groups are defined to include the minimum, most likely, and maximum travel distances for the previous port of call, the next port of call, and the remaining voyage distance. HarborSym develops triangular distributions from this data and selects a distinct distance for each voyage segment of each call and model iteration. For this study a set of six route groups were defined. These route groups and their associated distances are shown in Table 8.

Each route groups is associated with particular sets of vessels as follows: the Large and Medium Tug & Barge class and the Tankers were associated with a West Coast United States – Nome (WCUS-Nome) service area. Ninety percent of the small Tug & Barge class calls were associated with the Nome Service Area and 10 percent were with the Nome-Lightering service area. The Tugboat class was associated with the Nome Service Area. Research Vessels were associated with a Bering Sea Research service area, Government Vessels were associated with a Bering Sea Patrol service area and Cruise Ships were associated with a Bering Sea Cruise Ship service area. Small Landing Craft were associated with the Nome Service Area while Large Landing Craft were associated 90 percent with the Nome Service Area and 10 percent with the Nome-Lightering service area. The basis for the distances defined in each route group is explained in the following sections.

Table 8 Route Groups and Associated Distances

Route Group	Distance to Previous Port (nautical miles)		
	Minimum	Most Likely	Maximum
West Coast US-Nome	620	634	659
Nome Service Area	74	238	566
Nome Lightering	0.4	0.8	1.2
Bering Sea Patrol	100	250	1,000
Bering Sea Research	337	1,010	2,878
Bering Sea Cruise	225	225	470
Far East Tanker	1,518	3,055	3,055

Route Group	Distance to Next Port (nautical miles)		
	Minimum	Most Likely	Maximum
West Coast US-Nome	280	832	2,290
Nome Service Area	74	238	566
Nome Lightering	0.4	0.8	1.2
Bering Sea Patrol	100	250	1,000
Bering Sea Research	337	1,010	2,878
Bering Sea Cruise	225	348	1,700
Far East Tanker	3,055	3,055	6,398

Route Group	Additional Sea Distance (nautical miles)		
	Minimum	Most Likely	Maximum
West Coast US-Nome	-	1,944	2,570
Nome Service Area	74	238	566
Nome Lightering	-	-	-
Bering Sea Patrol	2,000	3,500	5,000
Bering Sea Research	337	1,010	2,878
Bering Sea Cruise	1,000	3,587	4,510
Far East Tanker	700	1,923	4,652

4.7.1. West Coast US – Nome

The West Coast US – Nome route group sailing distances are based upon available sailing schedules for the "mainline" barges and tankers serving Nome. Sailing schedules were obtained from the vessel companies which serve Nome: Alaska Logistics, Alaska Marine Lines, and Crowley Maritime. These mainline barge services typically originate in the Pacific Northwest (Seattle or Tacoma area) and stop in several Alaskan communities before or after arriving at Nome. Alaska Logistics sailing schedules include stops in Bethel, Naknek, Kotzebue, and Dillingham. Alaska Marine Lines voyages include these same communities with stops in Dutch Harbor for some trips. An example of a sailing schedule for these companies is Seattle, Seward, Bethel, Nome, Kotzebue, Naknek, Dillingham, and Seattle.

Crowley Maritime reports that their large tugs and barges are filled from an offshore tanker (which originates in Asia). The distances for the West Coast US route group are equal to the averages of the distances between these ports and Nome, based on available sailing schedules. Averages of these distances are believed representative given a lack of data available on exact sailing routes for each vessel call in 2012. Similarly, future vessel trips may take different routes, so average values address some of the uncertainty.

4.7.2. Nome Service Area

The Nome Service Area route group represents the rural communities near Nome which receive transshipment services from Nome. More specifically, a mainline tug and barge (or tanker) will deliver cargo or fuel to Nome. At Nome, these commodities will be transferred to a smaller vessel for delivery to rural communities. Gravel products from the Cape Nome Quarry are also shipped to rural communities for construction projects. Data provided by the Port of Nome lists 50 communities in western Alaska which have been served from the Port of Nome. These communities range from as far south as Platinum (507 nautical miles south of Nome) to as far north as Utqiatvik (566 nautical miles from Nome). Distances between Nome and these 50 communities are based on NOAA's Distances between United States Ports, as available, with further estimates conducted using Google Earth. Again, average values of the distances between Nome and these outlying communities were utilized to address the uncertainty in the exact origin and destination of each vessel call.

4.7.3. Nome Lightering

The Nome Lightering route group represents the distances which must be traveled to conduct lightering operations to the Port of Nome from a vessel anchored offshore. The exact location of vessels anchored offshore of Nome is dependent upon weather conditions and the preferences of the captains, so the values utilized in HarborSym provide reasonable estimates of lightering distances.

4.7.4. Bering Sea Patrol

Available data on the sailing schedules of research vessels calling at Nome in 2012 were used to estimate the Bering Sea research route group distances. In some cases, specific research vessels maintain websites which list their schedules and ports of call. In other cases, Alaska Marine Exchange data provides some information on destination ports. Research vessels traveled from as far as Incheon, South Korea (approximately 3,700 nautical miles from Nome) to as near as Port Clarence, Alaska (approximately 119 nautical miles from Nome). For this category, the ports of call of research vessels were placed into three distance categories, and the average of each category is set equal to the minimum, most likely, and maximum route group distances for HarborSym.

4.7.5. Bering Sea Cruise

The route group for cruise ships is based upon the available sailing schedules of the two cruise ships which called upon Nome in 2012: the Hanseatic and The World. The website for the cruise ship Hanseatic listed four sailing schedules with stops primarily in the

Russian, Alaskan, Canadian, and Scandinavian Arctic. The voyage for The World in 2012 in the vicinity of Nome included stops in Vancouver, Ketchikan, Wrangell, Petersburg, Haines, Kodiak, Dutch Harbor, St. Paul Island, Provideniya, Nome, and St. Anthony, Canada. The World is essentially a floating condominium complex where the on-board passengers/owners decide at which ports to stop each year. Therefore, the routes will vary each year. The distances for the Bering Sea Cruise route group is based on taking the average values of the ports of call listed for these cruise ships.

4.7.6. Far East Tanker

The route group for tankers from Asia is based upon the available sailing schedules of six tanker vessels that anchored offshore of Nome from 2015-2017. The Waterborne Commerce Statistics Center (WCSC) data listed all of their origins and destinations as South Korea (approximately 3,050 nautical miles from Nome). This was corroborated by conversations with Vitus Marine and Crowley, the two fuel distributors in western Alaska. All of these tankers were spot charter voyages, meaning they did not repeat their trips in successive years; however some did make multiple trips across the Pacific in one year. The WCSC data showed that the tankers would anchor near the areas of Nome, Nunavak, St. Lawrence, and Togiak. These anchorage locations were also confirmed with the shippers. The distances for the Far East Tanker route group is based on the shortest, average, and longest combination of traveling to those anchorage areas from South Korea.

5. FUTURE WITHOUT PROJECT CONDITION

ER 1105-2-100 states: "The without project condition is the most likely condition expected to exist over the planning period in the absence of a plan, including any known change in law or public policy. It provides the basis for estimating benefits for alternative with project conditions. Assumptions specific to the study should be stated and supported," (USACE, 2000).

5.1. Assumptions

For this particular Nome study, all non-structural measures that are currently in place are assumed to remain in place over the period of analysis. For instance, all vessel lightering and transshipment activities will continue in the manner they currently occur. Vessels that draft more than 18 feet will still have to await favorable tides to call at the causeway docks.

There are currently some plans to improve the harbor or channels being undertaken by the port of Nome. The Inner Harbor has an ongoing Feasibility Study to deepen it to 12 feet to achieve navigation efficiencies. It is assumed that this project will be completed by the base year of 2030. Any cargo movements or vessel calls in this analysis are restricted to the Outer Harbor and any newly constructed harbors, not the Inner Harbor. Additional uplands have already been acquired for cargo storage and vessel overwintering, and that is assumed to continue into the future.

The fuel storage facilities at Nome have sufficient capacity at their respective locations for the amount of fuel moved in and out of the port at this time. However, future volumes of fuel will require an increased level of fuel storage over the period. Since existing customers are already preparing for storage expansion, it is safe to assume that the existing storage will be expanded as demand dictates, and without consideration to project alternatives.

The period of analysis is 50 years, beginning with the base year of 2030, the project effective date, to 2079. The FY 2020 Federal discount rate of 2.75 percent is used to discount benefits and costs. The report uses methodology from ER 1105-2-100, transportation savings accruing to deep draft vessels.

5.2. Commerce

In order to project volumes of commerce into the future, each commodity was examined in detail. All commodity volumes were provided by the port in short tons (2,000 lbs.), but the volumes were converted to metric tons for the subsequent analysis. All graphs from this point are in metric tons. Generally, specific commodity studies are of limited value for projections beyond approximately 20 years. Given this limitation, it is preferable to hold the traffic projections constant to the end of project life from the 20-year point. Table 9 below shows the baseline average tonnage for 2018, projected over the forecast period in the without-project condition.

Table 9 Baseline and future estimated tonnages by Commodity

Commodity	2018	2019	2020	2030	2033	2043	2053	2063	2079
Layberth (calls)	124	128	131	177	193	260	349	349	349
Fuel Receipts	32,097	32,341	32,586	35,149	35,957	38,785	41,836	41,836	41,836
Fuel Shipments	4,432	4,432	4,432	4,432	4,432	4,432	4,432	4,432	4,432
Gravel	58,361	58,612	58,864	61,444	62,240	64,969	67,817	67,817	67,817
Cargo Receipts	30,049	30,278	30,508	32,907	33,663	35,495	39,167	39,167	39,167
Cargo Shipments	5,474	5,515	5,557	5,994	6,132	6,614	7,134	7,134	7,134
Total Tons	**130,537**	**131,306**	**132,078**	**140,103**	**142,617**	**150,555**	**160,735**	**160,735**	**160,735**

5.2.1. Fuel

Historical fuel volumes were provided by the port of Nome dating back to 2012 for this study effort. Data from 2008-2011 was retrieved from previous port submissions for the 2015 Arctic Deep Draft Ports Study. Fuel movements were separated into receipts and shipments given that the volumes for each are significantly different.

In the future without-project condition, fuel receipts are not assumed to grow. As shown in Figure 34, a linear trend line of historical receipt volumes results in a downward slope. As mentioned previously, Alaska is currently in a recession, so the low volumes over the past five years are expected to rise eventually. The Anchorage Economic Development Corporation estimates that the state will begin to exit recession by the first quarter of 2019.[21] Volumes in 2017 already approached the previous highs achieved in 2012, so a no growth forecast was used. A baseline volume of fuel receipts was calculated using a 10-year average of the 2008-2017 historical volumes. From there, volumes are forecasted to remain constant for 20 years.

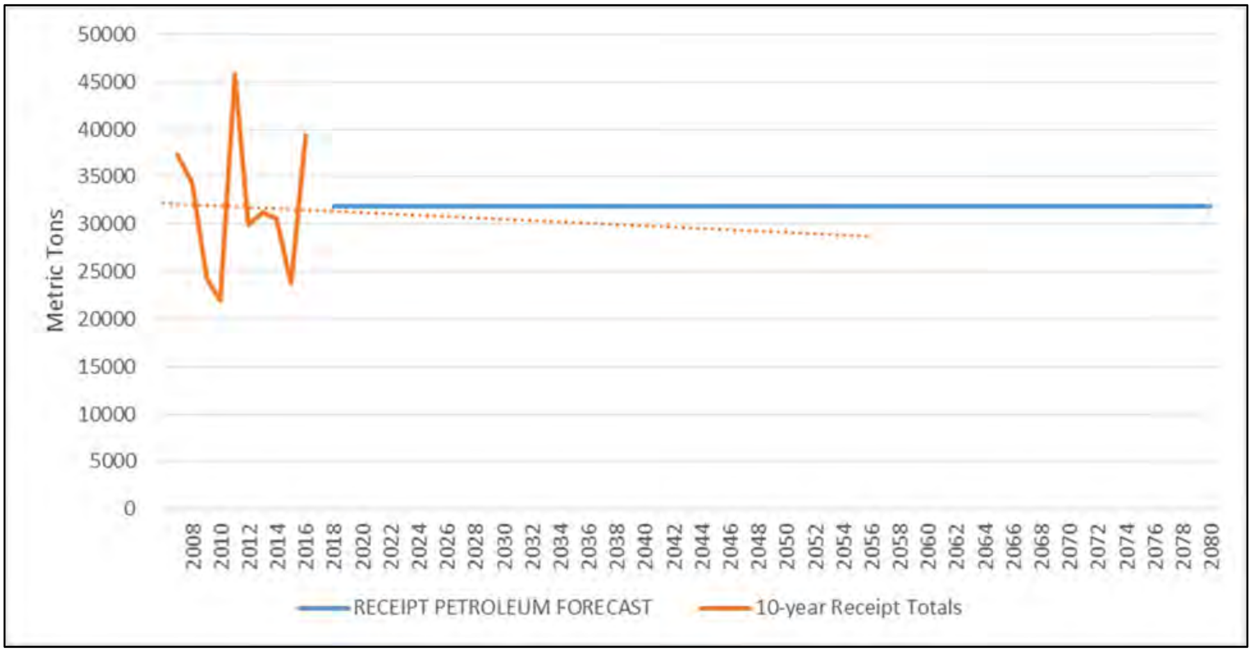

Figure 34. Historical and Projected Fuel Receipts at Nome

A similar situation exists when examining future fuel shipments. Volumes have varied significantly over the past 10 years, as Figure 35 shows. The historical trend is quite negative. In the future without-project condition, fuel receipts are not assumed to grow. As mentioned previously, Alaska is currently in a recession, so the low volumes over the past five years are expected to rise eventually. A baseline volume of fuel receipts was calculated using a 10-year average of the 2008-2017 historical volumes. From there, volumes are forecasted to remain constant for 20 years.

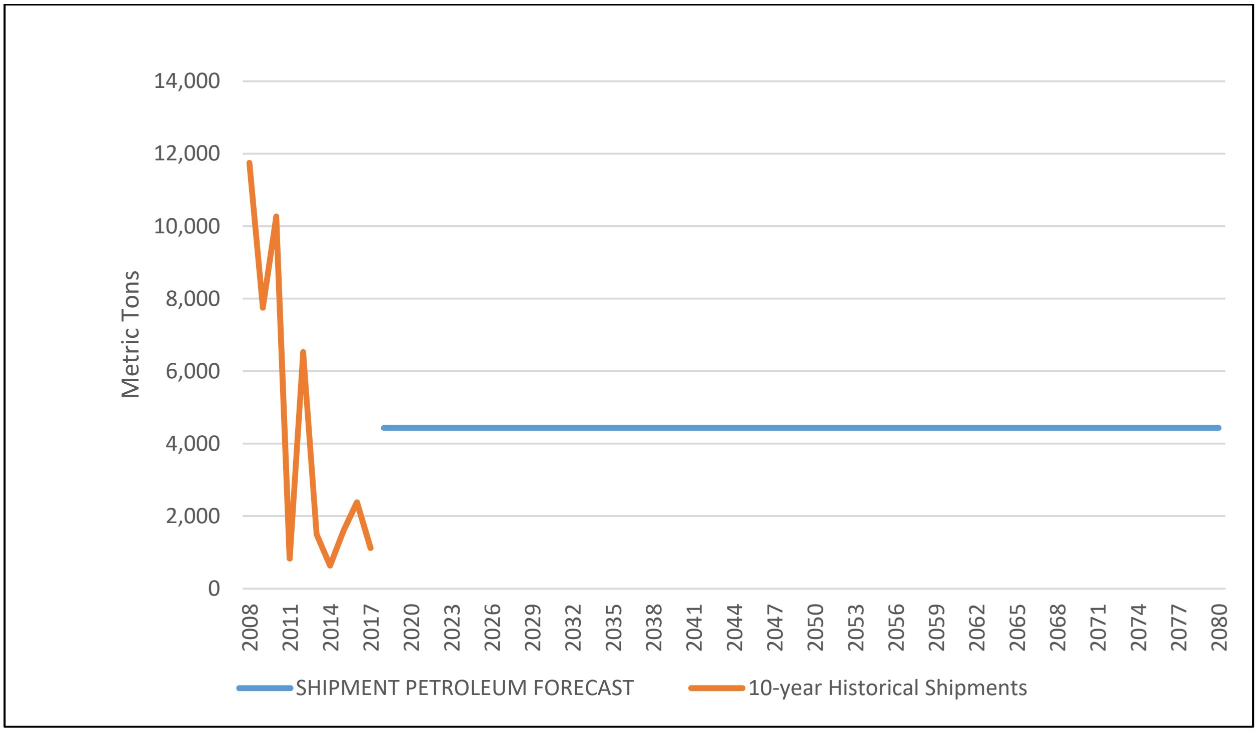

Figure 35. Historical and Future Fuel Shipments at Nome

5.2.2. Gravel, Stone, and other Minerals

Historical gravel and stone volumes were provided by the port of Nome dating back to 2012 for this study effort. Data from 2008-2011 was retrieved from previous port submissions for the 2015 Arctic Deep Draft Ports Study. Gravel and stone movements are export-only, and no receipts are expected to appear over the forecast period. As previously discussed, gravel volumes are extremely volatile and dependent on public infrastructure spending in the region. Large projects were completed in 2010 and 2016, driving growth in those years. However, predicting the rate of public spending is beyond the scope of this analysis. Therefore, a linear regression of the last 10 years of export data was used as a forecast for the period. A growth rate of 0.43 percent was used as a proxy for gravel export growth in the study area over the period of forecast. A baseline volume of gravel shipments was calculated using a 10-year average of the 2008-2017 historical export volumes. From there, volumes are forecasted to grow by 0.43 percent a year. Figure 36 below shows the forecasted gravel shipments from Nome.

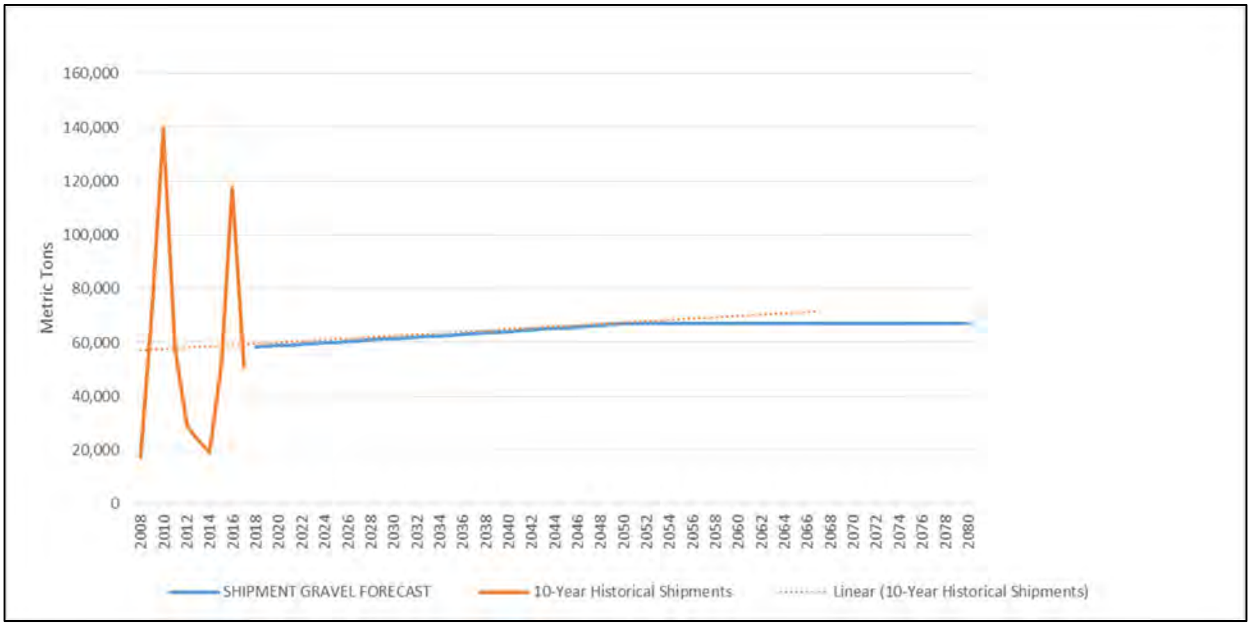

Figure 36. Historical and Future Gravel Shipments at Nome

One variable that is not in place currently is the development of the nearby Graphite Creek Project. This would include America's highest grade and largest known, large flake graphite deposit, located about 37 miles north of Nome. Industry continues to work towards completion of its project's pre-feasibility and feasibility studies with a construction decision targeted for 2022. The company was scheduled to complete its 2018 summer field program in October. This program includes about 1,000 meters of drilling, a review of access road options, continued baseline fish and water monitoring, and continued outreach to the Alaska Native communities closest to the project site. The road options reviewed included connecting from the project site to the Kougarok Road and to the Nome-Teller Highway. Both route options provide access to the Port of Nome.

In July 2017, the company released its preliminary economic analysis report (PEA) which concluded that the company's graphite resources have the potential to be economically viable. The PEA assumed a mine life of 40 years shipping 60,000 metric tons per year of graphite concentrate (from the 6th year onwards) by truck to the Port of Nome for seasonal loading onto barges. The concentrate would be loaded at the mine into containers in 1 ton super sacks. Each container would hold 18 tons of concentrate and have a gross weight of about 20 tons. On this basis, the annual number of containers shipped would be approximately 3,333.[22]

Conversations with Graphite One Resources found that the company is in initial discussions with barge operators at Nome to transport mined graphite from Nome via back haul on returning barges; however no firm plans are in place at this time.

This analysis assumes the graphite will be shipped from Nome aboard cargo barges that already call at Nome. Considering the capacity of these vessels and the expected amount of outbound dry cargo from Nome on each call, there is assumed to be adequate capacity on board these barges for the expected 3,333 annual additional containers of graphite. No additional barges have been added to future scenarios for mine operations, therefore graphite would not be a benefiting commodity from a project in Nome. Exploration of different scenarios around this assumption are explored further in the Sensitivity analysis section of this appendix. Figure 37 is an updated chart of shipments including the graphite tonnage from the mine over its 40-year service life.

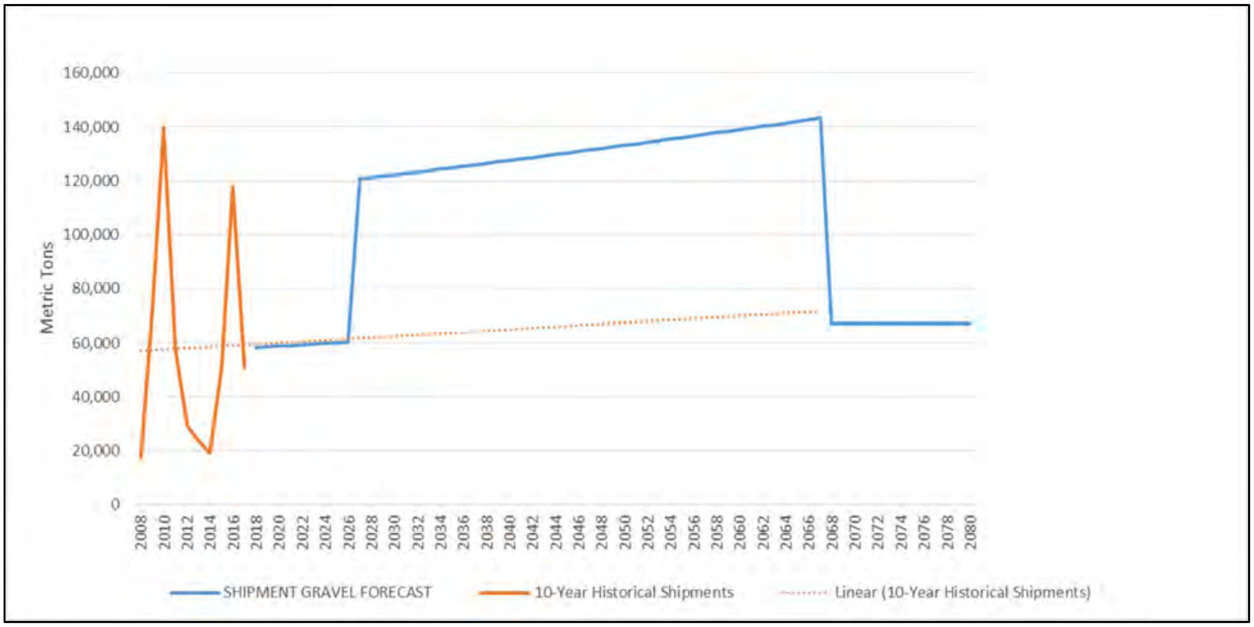

Figure 37. Historical and Future Gravel and Stone Shipments at Nome, including graphite

5.2.3. Cargo Volumes

Historical cargo volumes were provided by the port of Nome dating back to 2012 for this study effort. Data from 2004-2012 was gathered from USACE's Waterborne Commerce Statistics Center databases as well. Cargo movements were separated into receipts and shipments given that the volumes for each are significantly different.

In the future without-project condition, cargo receipts are not assumed to continue as they have historically. As shown in Figure 38, a linear trend line of historical import volumes results in a downward slope. As mentioned previously, Alaska is currently in a recession, so the low volumes over the past 5 years are expected to rise eventually. Volumes in 2017 already began to increase towards more moderate levels, so a positive forecast is not unreasonable. Also, as highlighted earlier, fluctuations in cargo volumes closely resemble movements in Alaska State GDP because of the tie in state funding to project cargo that is shipped throughout western Alaska. For this reason, the 0.02 percent growth rate in Alaska GDP from 2012-2018 was a reasonable proxy for import growth in this scenario. A baseline volume of receipts was calculated using a 10-year average of the 2008-2017 historical import volumes. From there, import volumes are forecasted to grow by 0.02 percent a year for 20 years.

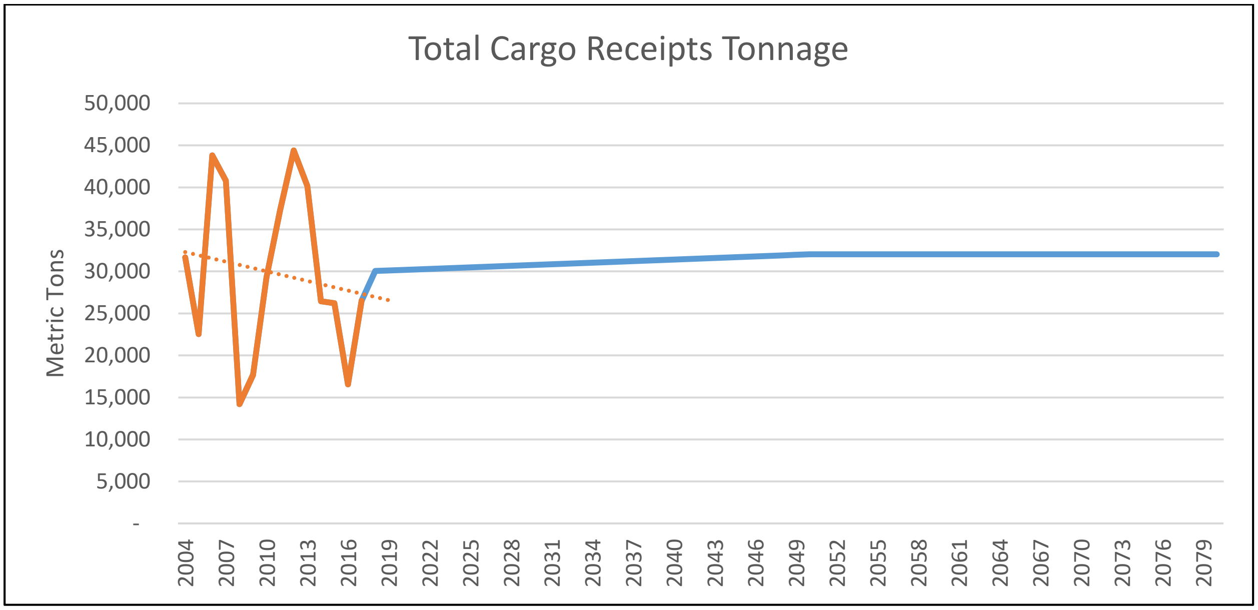

Figure 38. Historical and Future Cargo Receipts at Nome

Cargo shipments are assumed to behave in a similar manner. As shown in Figure 39 below, volumes in 2016 showed an increase towards more moderate levels, so a positive forecast is not unreasonable. The positive GDP growth in the State of Alaska was a reasonable proxy for export growth in this scenario. A baseline volume of shipments was calculated using a 10-year average of the 2008-2017 historical volumes. From there, volumes are forecasted to grow by 0.02 percent a year for 20 years.

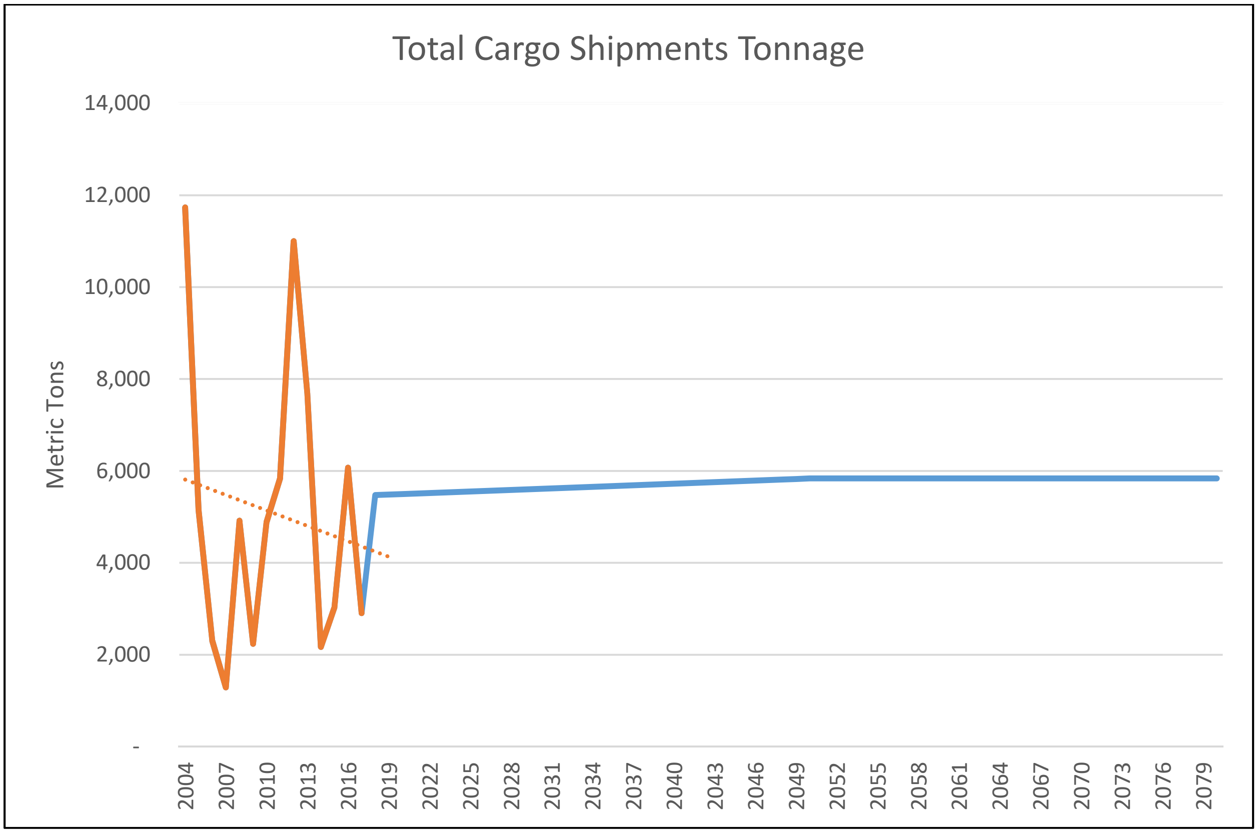

Figure 39. Historical and Future Cargo Shipments at Nome

5.2.4. Layberth

Historical layberth calls were provided by the port of Nome dating back to 2015 for this study effort. Separation into receipts and shipments was not necessary for this commodity.

Call volumes have varied slightly over the last three years, as Figure 40 shows. The historical trend is also negative. However, future volumes are not expected to mirror this trend into the future.

Layberth calls are driven by vessels needing to refuel in small quantities via tanker truck, conduct personnel or crew transfers, conduct logistical re-supply, and seek refuge in the protected harbor from storms. The state of Alaska has been in a recession since 2012. This decrease in statewide revenue has directly translated to decreases in commodity volumes over that time period. At the same time, overall vessel traffic has increased into the port of Nome. This is due to increases in layberth vessel traffic not associated with large-scale commerce, such as Arctic research vessels, government patrol vessels, cruise ships, and commercial support vessels. Also, Arctic shipping in general is projected to increase over the forecast period as more users conduct resource exploitation and research in the area. This type of traffic was modeled by the Committee on the Marine Transportation System (CMTS) as part of their study on future Arctic maritime transportation in 2015. CMTS modeled the levels of this traffic using global GDP as a proxy. Growth rates for global gross domestic product (GDP) have been used traditionally as proxies for shipping growth.[23] This is due to the strong correlation found between global shipping activity as measure in ton-miles and measures of global GDP. Recent forecasts for global GDP have predicted average growth rates of 3 percent over the next 5 years. This is due to views that world growth momentum will continue to be strong, financial markets will continue to be bullish, and major economies will continue pro-growth policies, including accommodative monetary policies.

These factors will place more upward pressure on the demand for dock space as more vessels will be looking to operate in the area. Growth rates for global gross domestic product (GDP) will be used as a proxy for overall layberth traffic growth in the study area over the period of forecast. A baseline number of layberth calls was calculated using a 3-year average of the 2015-2017 historical calls. From there, call numbers are forecasted to grow by 3.0 percent a year for 20 years.

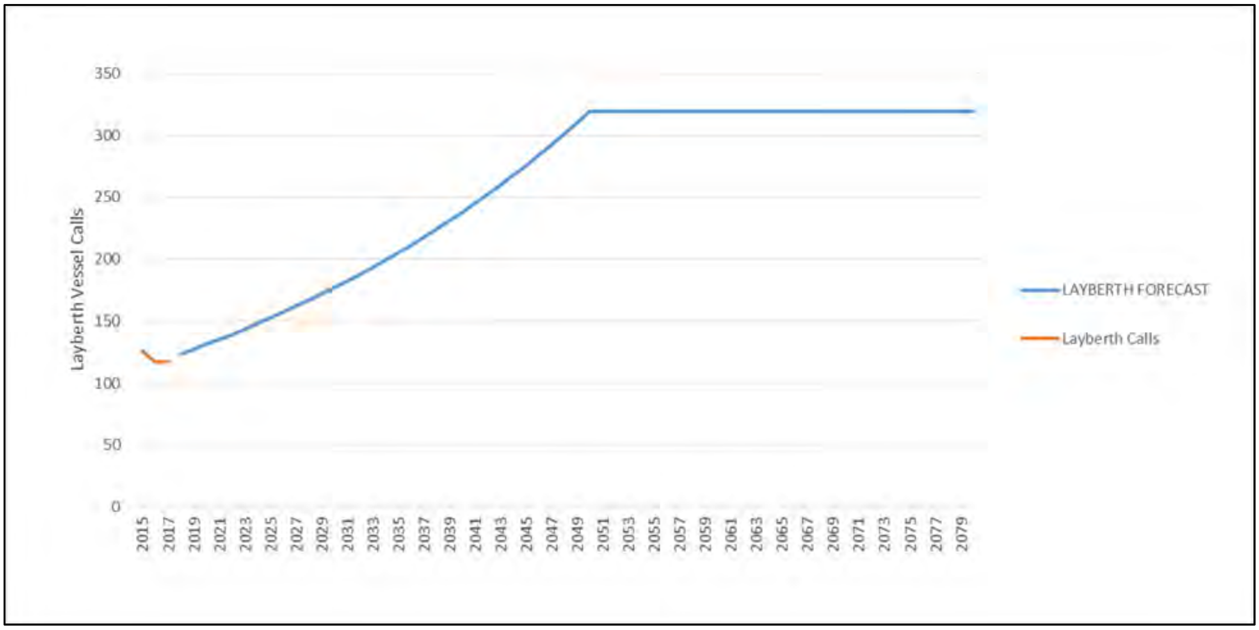

Figure 40. Historical and Future Layberth Vessel Calls at Nome

5.3. Vessel Fleet and Calls

Typically, a 3-year historical vessel call list is used in navigation studies to create a baseline for future vessel forecasts. This study continued this in order to capture the upper potential limit of increased traffic (in 2016) and two additional years of steady traffic. This approach best captures the variability present in Nome traffic from year to year. Figure 41 presents a graph of vessel calls by type from 2015-2017.

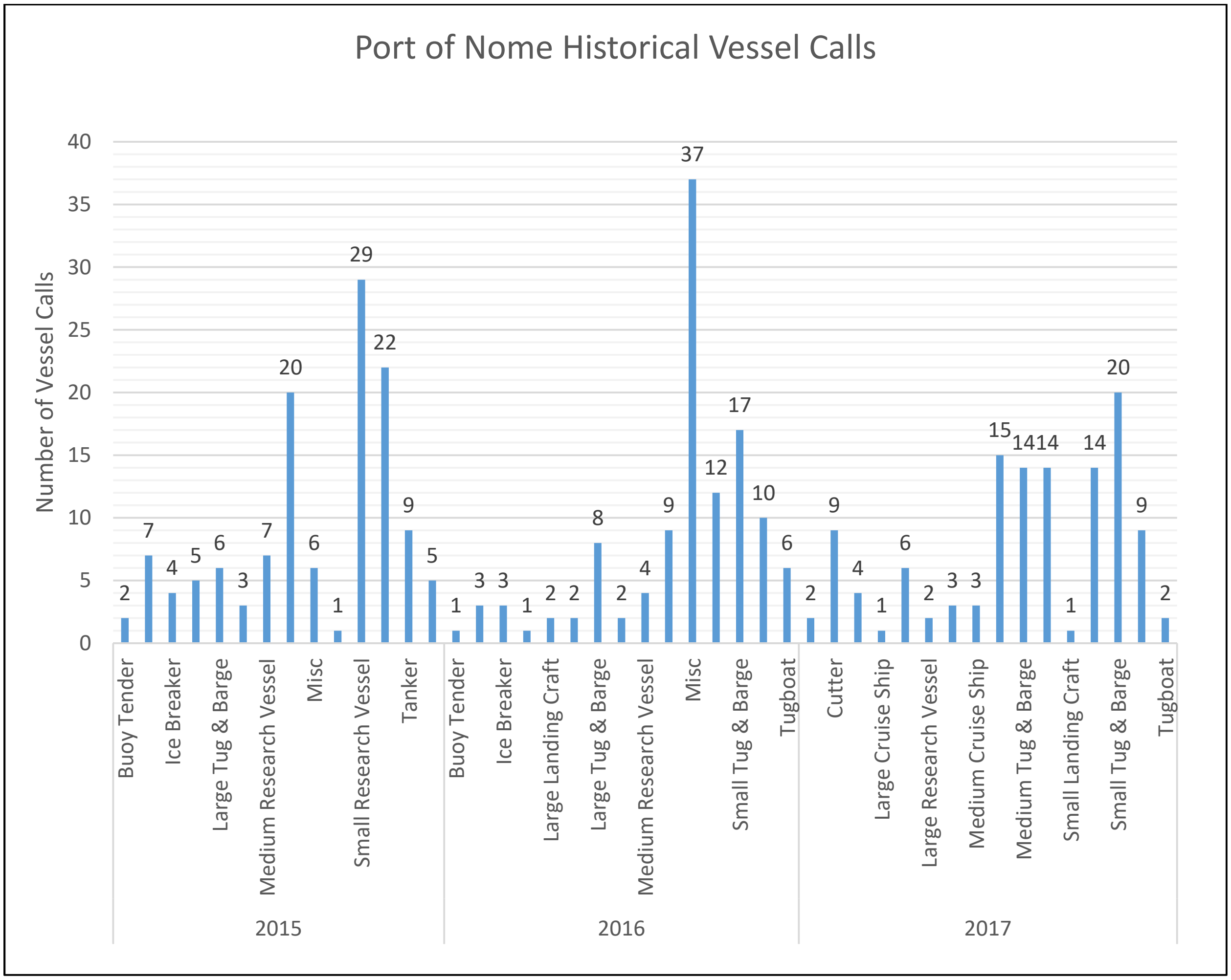

Figure 41. Historical Vessel Calls at Nome by Type, 2015-2017

Using the totals from 2015-2017, a 3-year average was used to calculate the estimated number of vessel calls, by class, for the 2018 season. Those estimates are shown in Table 10 as compared to the totals from each of the previous three years. These totals include vessels that anchored off-shore of Nome to conduct re-supply or transfer fuel, as they were too large to call inside the outer basin.

Table 10 Historical and Projected Calls at Nome by Class

Year	2015	2016	2017	2018(Est)
Vessel Class	**Number of Calls**	**Number of Calls**	**Number of Calls**	**Number of Calls**
Buoy Tender	2	1	2	2
Cutter	8	4	10	8
Ice Breaker	4	3	4	4
Large Cruise Ship	0	1	1	1
Large Landing Craft	33	34	43	37
Large Research Vessel	0	2	2	2
Large Tug & Barge	16	18	16	17
Medium Cruise Ship	3	3	3	3
Medium Research Vessel	9	6	17	11
Medium Tug & Barge	51	44	40	45
Miscellaneous	10	44	17	24
Small Landing Craft	1	3	1	2
Small Research	29	12	16	19
Small Tug & Barge	47	62	67	59
Tanker	11	11	9	10
Tugboat	5	6	2	5
Grand Total	**229**	**254**	**250**	**249**

Next, the future vessel fleet was forecasted by conducting a load factor analysis for each vessel class and each commodity that they moved through the port. This analyzes how fully loaded each vessel was when it imported or exported a certain commodity. Or, in the case of the commodity layberth, where no loading takes place, what fraction of total layberth calls are attributed to each vessel class. There is no reason to suspect that vessels will alter the ways in which they load goods in the future without-project condition. In discussions with the various shippers that use the port of Nome, none have indicated a pending shift to larger or different kinds of vessels. Low population growth and historic demand for fuel and cargo lead them to believe that the current fleet is sufficient for the foreseeable future. There is currently no new technology on the horizon that could alter the way these vessels operate either. There are policies being debated at the international level about the use of certain types of fuels in the Arctic region, of which Nome is a part. These fuels include types of heavy fuels and high-viscosity oils used in larger commercial shipping fleets. These fleets are currently making plans to install conversion equipment on existing vessels and build new vessels that no longer require heavy fuels. However, the fleet currently calling on Nome does not use these heavy fuels to operate. They use diesel or gasoline to operate their propulsion and auxiliary systems, so these rule changes will not drive vessel changes in this scenario.

Consequently, the load factor analysis of the current fleet can be used to inform vessel behavior into the future. This analysis was based on the historical vessel information and commodity movements provided by port personnel. Specific vessel capacity data was gathered from various online databases that house vessel specifications, such as IHS Maritime and the USCG Port State Information Exchange. Once initial loading percentages were estimated, loading practices were tested in the HarborSym planning tool to validate that percentages were reflective of actual operations. This was done by testing if the existing vessel fleet could sufficiently move the historic commodity level given the estimated load factors. If the fleet could not, factors were adjusted until they were able to move all the historical volumes. This process acts as a calibration of sorts for the HarborSym model to make sure it can accurately portray existing conditions before attempting future condition simulations.

The results of the load factor analysis for the Port of Nome are displayed in Table 11. For each class, a minimum, maximum, and average (or most likely) loading percentage (factor) was calculated.

Table 11. Load Factors by Commodity and Vessel Class

Fuel Receipts

MIN		**MOST LIKELY**		**MAX**		TPI	Add 'l tonnage/foot
Small Tug & Barge	10%	Small Tug & Barge	34%	Small Tug & Barge	90%	20.0	240.0
Medium Tug & Barge	10%	Medium Tug & Barge	34%	Medium Tug & Barge	90%	43.0	516.0
Large Tug & Barge	10%	Large Tug & Barge	34%	Large Tug & Barge	90%	66.0	792.0
Tanker	8%	Tanker	21%	Tanker	40%	77.4	928.8

Fuel Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	4%	Small Tug & Barge	13%	Small Tug & Barge	29%	20.0	240.0

Medium Tug & Barge	14 %	Medium Tug & Barge	17%	Medium Tug & Barge	19 %	43.0	516.0
Large Tug & Barge	4%	Large Tug & Barge	4%	Large Tug & Barge	4%	66.0	792.0
Tugboat	32 %	Tugboat	32%	Tugboat	32 %	-	N/A
Cutter	3%	Cutter	8%	Cutter	12 %	-	N/A
Medium Cruise Ship	15 %	Medium Cruise Ship	18%	Medium Cruise Ship	21 %	-	N/A
Medium Research Vessel	9%	Medium Research Vessel	9%	Medium Research Vessel	10 %	-	N/A
Large Landing Craft	6%	Large Landing Craft	6%	Large Landing Craft	6%	15.0	180.0
Miscellaneous	7%	Miscellaneous	9%	Miscellaneous	10 %	-	N/A

Gravel Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	15 %	Small Tug & Barge	29%	Small Tug & Barge	46 %	20.0	240.0
Medium Tug & Barge	15 %	Medium Tug & Barge	46%	Medium Tug & Barge	74 %	43.0	516.0
Large Tug & Barge	58 %	Large Tug & Barge	70%	Large Tug & Barge	77 %	66.0	792.0
Large Landing Craft	45 %	Large Landing Craft	66%	Large Landing Craft	78 %	15.0	180.0

Cargo Receipts

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	10 %	Small Tug & Barge	34%	Small Tug & Barge	90 %	20.0	240.0
Medium Tug & Barge	10 %	Medium Tug & Barge	34%	Medium Tug & Barge	90 %	43.0	516.0
Large Tug & Barge	12 %	Large Tug & Barge	34%	Large Tug & Barge	90 %	66.0	792.0
Small Landing Craft	1%	Small Landing Craft	23%	Small Landing Craft	23 %	10.0	120.0
Large Landing Craft	17 %	Large Landing Craft	31%	Large Landing Craft	56 %	15.0	180.0

Cargo Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	15 %	Small Tug & Barge	15%	Small Tug & Barge	15 %	20.0	240.0
Medium Tug & Barge	1%	Medium Tug & Barge	16%	Medium Tug & Barge	57 %	43.0	516.0
Large Tug & Barge	1%	Large Tug & Barge	7%	Large Tug & Barge	22 %	66.0	792.0
Small Landing Craft	1%	Small Landing Craft	19%	Small Landing Craft	19 %	10.0	120.0
Large Landing Craft	13 %	Large Landing Craft	47%	Large Landing Craft	97 %	15.0	180.0

Layberth Fractions by Class							
Cutter	5%	Medium Research Vessel	7%	Small Tug & Barge	16 %	-	N/A
Large Landing Craft	4%	Medium Tug & Barge	12%	Tanker	8%	-	N/A
Large Tug & Barge	5%	Misc.	16%	Tugboat	4%	-	N/A
Large Cruise Ship	0%	Small Landing Craft	1%	Ice Breaker	3%	-	N/A
Large Research Vessel	1%	Small Research Vessel	15%	Buoy Tender	1%	-	N/A
Medium Cruise Ship	2%					-	N/A

Once this analysis was completed for each class and each commodity, then a requisite number of vessels were calculated to move the forecasted amounts of commodities, per the commodity forecasts highlighted in the previous section. These results for each vessel class over the forecast period are shown in Table 12. Total numbers of vessel calls were estimated over the 50-year forecast period. Similar to the commodity forecasts, after the initial 20-year period, growth was held constant for the remaining 30 years. So, the level of vessels in 2050-2080 will remain unchanged.

Table 12. Future Without-Project Vessel Fleet Calling at the Port of Nome by Class and Year

Vessel Class	2030	Vessel Class	2040	Vessel Class	2050
Small Tug & Barge	68	Small Tug & Barge	79	Small Tug & Barge	92
Medium Tug & Barge	39	Medium Tug & Barge	47	Medium Tug & Barge	57
Large Tug & Barge	21	Large Tug & Barge	24	Large Tug & Barge	28
Tanker	18	Tanker	22	Tanker	29
Tugboat	9	Tugboat	12	Tugboat	14
Cutter	13	Cutter	16	Cutter	21
Buoy Tender	2	Buoy Tender	3	Buoy Tender	4
Ice Breaker	5	Ice Breaker	7	Ice Breaker	10
Large Cruise Ship	1	Large Cruise Ship	2	Large Cruise Ship	2
Medium Cruise Ship	6	Medium Cruise Ship	7	Medium Cruise Ship	8
Small Research Vessel	27	Small Research Vessel	36	Small Research Vessel	49
Medium Research Vessel	18	Medium Research Vessel	22	Medium Research Vessel	28
Large Research Vessel	2	Large Research Vessel	3	Large Research Vessel	4
Small Landing Craft	1	Small Landing Craft	1	Small Landing Craft	2
Large Landing Craft	18	Large Landing Craft	21	Large Landing Craft	23
Miscellaneous	35	Miscellaneous	45	Miscellaneous	54
Total	**285**	**Total**	**347**	**Total**	**425**

Table 13. FWOP Vessel Calls by Route Group

Route Group	Years			
	2030	2040	2050	2079
Bering Sea Cruise	7	9	10	10
Bering Sea Patrol	18	30	35	35
Bering Sea Research	49	59	81	81
FE Tanker Route	18	22	29	29
Nome Service Area	131	155	179	179
WCUS-Nome	63	73	91	91
Total	**285**	**347**	**425**	**425**

The vessel fleet calling on the Port of Nome in the future without-project condition is assumed to grow with the natural increases in global shipping over the forecast period. Arctic shipping is forecasted to follow the increasing trend of global economic growth, and as mentioned before, state GDP growth will also drive the need for increased levels of cargo shipped in the future.

5.4. Future Without-Project Transportation Costs

The estimated future vessel fleet and number of vessel calls was run through the HarborSym planning model to calculate the transiting times and costs for the forecast period for each of the increments evaluated (2030, 2040, 2050). HarborSym represents a port as a tree-structured network of reaches, docks, anchorages, and turning areas. The representation of the port of Nome as a nodal network is shown in Figure 42 below. It shows how docks and other navigation features are connected in the model and how vessels are allowed to move in the model along specified reaches.

Figure 42. Port of Nome HarborSym network for Future without Project Condition

Vessel movements are simulated along the reaches, moving from the entrance to one or more docks, and then exiting the port. One limitation of the model is that weather (wind or fog) is not a factor.

5.4.1.1. Inputs

The data required to run HarborSym are separated into six categories:

- Simulation Parameters. Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay. These inputs were included in the model runs for this study. For this analysis, 50 iterations were run to determine the economic benefits associated with transit cost reductions.

- Specific physical and descriptive characteristics of Nome. These data inputs include the specific networks of the port such as the node location and type; reach length, width, and depth, in addition to tide and current stations. This includes information about the docks in the harbor such as length and the maximum number of vessels the dock can accommodate at any given time. This also includes any vessel transit rules in place for the harbor overall, any specific reaches, or any particular vessel types specifically. A brief description of the rules for this study are captured below:
    - (Overall rule) Draft Exceeds Depth Using Tide / Underkeel clearance: The model will not allow movement if vessel draft plus underkeel clearance (class-specific) is greater than depth plus minimum tide
    - (Overall rule) Turning Basins block channel: Each turning basin (yellow dots in Figure 42 above) blocks the channel while it's in use. Each turning basin allowed 6 minutes for any vessel to be turned before docking. This blocked the channel until turning was complete. This was consistent with Port operations as discussed with the Port as vessels were not typically entering/exiting the channel while docking operations at the Causeway were underway.
    - (Reach rule) Combined Beam Width: If the combined beam width of the vessels in the reach is greater than the half the reach width, two-way traffic is not allowed. This essentially forces there to be one-way traffic to and from the current Outer Harbor. But, this is consistent with current Port operations. This rule will not apply to reaches leading to the Inner Harbor, or any new docks in the with-project condition alternatives.
- General Information. General information used as inputs to the model include: specific vessel and commodity classes, and commodity transfer rates at each dock.
- Vessel speeds. With the assistance of the Port of Nome, the speeds at which vessels operate in the harbor, by vessel class both loaded and light loaded, were determined for each channel segment.
- Underkeel clearance requirements are used along with tide to determine whether a vessel can enter the system. These clearances varied by vessel class.
- Vessels calls. The vessel call lists are made up of vessel calls forecast for a given year. Each call is given a movement number based on its date and time of entry into the harbor. The vessel call list for the current condition was imported into HarborSym using an Excel spreadsheet. The vessel call lists for the future without-project and future

with-project conditions were projected based on forecasted commodities and the available fleet required based on the load factor analysis previously discussed.

5.4.1.2. Outputs

A number of parameters are collected and stored in HarborSym after the model runs are completed. Among these parameters are the number of vessels entering/exiting the harbor, the average time a vessel class spends in the system (hours), the average transit cost of a vessel for each class, the total transit cost of the annual fleet, vessel time and location (e.g., entry, dock, turning basin, etc.) spent waiting in the system, vessel times in anchorage areas, vessel times docking and undocking, vessel times loading and unloading, commodity quantities transferred, and total commodity statistics at the port. These outputs are then used to quantify delay reduction benefits.

Once the transiting times were calculated, the model calculated total vessel transportation costs allocated to the port in a given year based on vessel operating costs. HarborSym requires vessel minimum, most likely, and maximum vessel operating costs at sea and in port for each vessel class. IWR determines deep draft vessel operating costs (DDVOCs) [24] for many of the most common vessel types, and these costs are issued as guidance by HQUSACE.

Information for Tanker and Cruise Ship vessel classes are included in the IWR costs. However, the tankers and cruise ships that call upon Nome are smaller than those listed by IWR so tankers and cruise ships at Nome are based upon extrapolation of the IWR VOCs.

Vessels costs for the other vessel classes are estimated based on available data, either by extrapolating costs for vessels that are similar, or apportioning costs for vessels where some type of relationship can be determined. Where data is unavailable, operating costs in port are assumed to be 67 percent of operating costs at sea. Maximum and minimum costs are defined as plus or minus 10 percent of the most likely value for this study. Operating costs for foreign-flagged vessels are set at 50 percent of domestic vessel VOCs, if no other data is available. These assumptions, while general, are necessary to translate IWR's published VOCs into rates usable in HarborSym. These assumptions and resultant VOCs are believed to be based on the best available data.

Most likely Tug & Barge and Landing Craft operating costs at sea and in port are extrapolated from the vessel operating costs for General Cargo vessels with similar deadweight tonnage contained in the Deep Draft Vessel Operating Cost guidance issued by IWR.

Vessel operating costs for government and research vessels are based upon the US Coast Guard's published Reimbursable Standard Rates. Rates for Coast Guard vessels are assumed representative of research vessels and foreign government vessels given their similar vessel characteristics and missions.

The total transportation costs in the without project condition, for the base year, year 10, and year 20 of the period of analysis, are displayed in Table 14. These are outputs of the HarborSym model for the without project condition. Model outputs for the with-project condition are provided in the with-project section of this report.

Table 14. Total Transportation Costs by Vessel Class and Year in Without Project Condition

Vessel Class	2030	2040	2050
Small Tug & Barge	$1,195,000	$1,454,000	$1,756,000
Medium Tug & Barge	$703,000	$711,000	$843,000
Large Tug & Barge	$13,000	$13,000	$10,000
Small Cruise Ship	$60,000	$120,000	$120,000
Medium Cruise Ship	$525,000	$1,079,000	$1,238,000
Small Landing Craft	$52,000	$84,000	$103,000
Large Landing Craft	$90,000	$82,000	$102,000
Small Research	$1,132,000	$1,464,000	$2,066,000
Medium Research	$347,000	$675,000	$1,256,000
Large Research	$344,000	$511,000	$681,000
Tanker	$265,000	$367,000	$484,000
Miscellaneous	$361,000	$480,000	$722,000
Total	**$5,088,000**	**$7,041,000**	**$9,381,000**

6. FUTURE WITH PROJECT CONDITION

The with-project condition is the one expected to exist over the forecast period if a project is undertaken. The following sections provide the with-project conditions for each of the proposed alternatives.

6.1. Proposed Alternatives

There are six different alternatives under consideration for this project. Each alternative contains a combination of measures, including channel deepening, widening, breakwater construction, and berth additions.

Given the current configuration of the existing breakwaters around the entrance to the port of Nome, the Outer Harbor is exposed to persistent southerly waves. This wave action can cause vessels to remain at anchor offshore of Nome in order for conditions to improve before docking or undocking. All of the alternatives presented have breakwaters constructed to eliminate weather delays entering or exiting the port. There are also instances where vessels have anchored offshore in order to wait out incidents of bad weather before continuing their voyages. If a breakwater were constructed to protect the port from the southerly wave action, these vessels would call on the port to take refuge from the weather.

The current depth of the Outer Harbor is limiting the current fleet from calling on the port. Currently, there are five types of vessels utilizing the offshore anchorage area whose draft is too deep for the proposed deepened Outer Harbor. They are listed in Table 15 below with their maximum dimensions.

Table 15. Vessel Types and Characteristics of the Anchored Fleet due to Draft Constraints

Vessel Type	**Maximum LOA (ft.)**	**Maximum Beam (ft.)**	**Maximum draft (ft.)**
Research Vessel	421.9	62.4	32.5
Cruise Ship	820.3	106.3	29.85
Tanker	610	106	43.86
Miscellaneous	460.5	77.2	34
Government	420	82	31

Source: Port of Nome Vessel Calendars, 2012-2017

Of those five vessel types, the research, cruise, and miscellaneous vessels would be able to call on the port to conduct operations like personnel transfers and crew re-supply instead of at anchor. The tanker vessels would be able to call on the port and deliver fuel rather than have to lighter it into port by barge.

Each alternative for the Deepwater basin would create vessel benefits by alleviating weather delays for vessel calls, allowing larger vessels to take refuge from weather, conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port.

6.1.1. Alternative 3a

This alternative involves the extension of the existing causeway resulting in a deep-water basin, and the re-alignment of the existing breakwater to the east. Figure 43 below shows the preliminary design for this alternative.

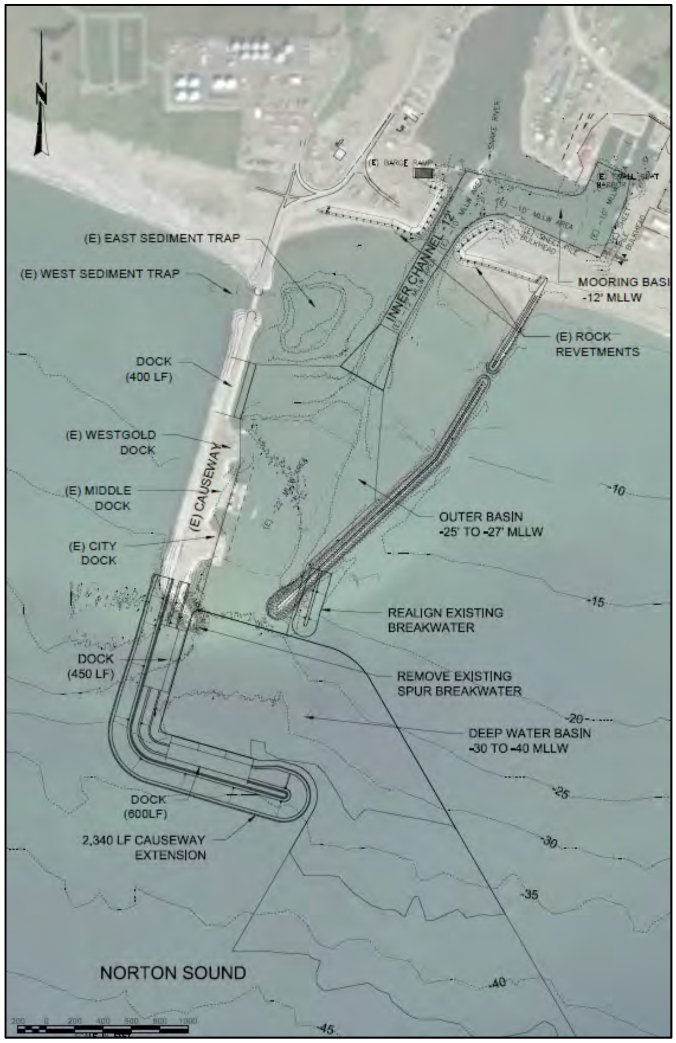

Figure 43. Alternative 3a

There are multiple deepening options being evaluated for this alternative. The existing Outer Basin could be deepened from -22 feet MLLW to either -25 feet or -28 feet. The newly created deep-water basin could be deepened to -30 feet, -35 feet, or -40 feet.

This alternative also includes the construction of three new docks. One 400-foot dock would be constructed to the north of the existing Westgold Dock on the causeway. The other two docks would be constructed on the causeway extension. The east-facing dock would be 450 feet long and the north-facing dock would be 600 feet long.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port. The amount of new dock space created would be enough to accommodate the increase in vessel traffic with additional depth, leading to congestion relief benefits as well.

6.1.2. Alternative 3b

This alternative includes the same deepening and breakwater features as Alternative 3a, but does not include construction of a third dock. The only two docks that would be constructed are in the deep-water basin. Figure 44 below shows the preliminary design for this alternative.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port. The amount of new dock space created would be enough to accommodate the increase in vessel traffic with additional depth, leading to congestion relief benefits as well.

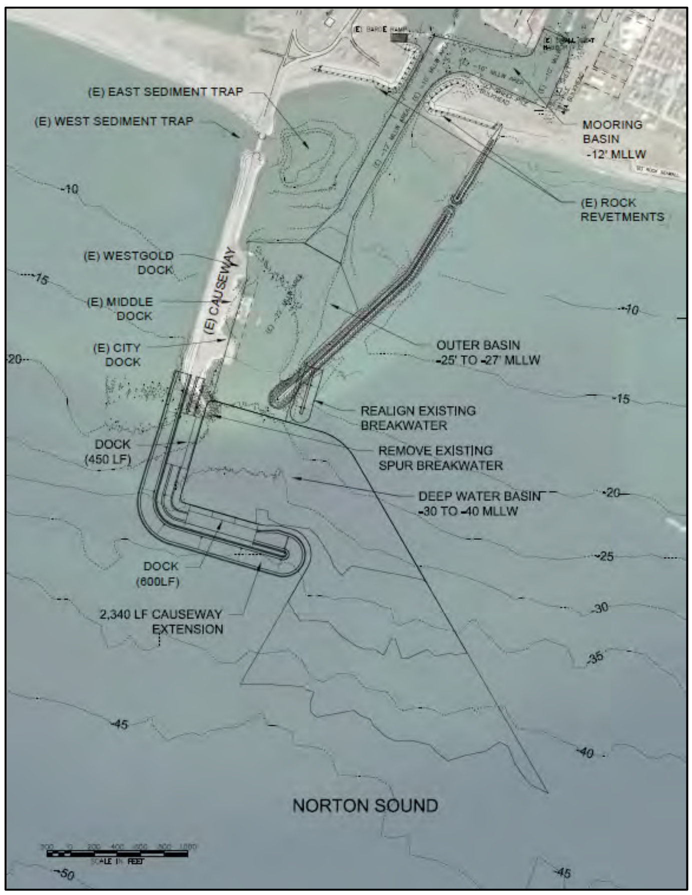

Figure 44. Alternative 3b

6.1.3. Alternative 3c

This alternative includes the same deepening and breakwater features as Alternatives 3a and 3b, but only includes the construction of one 600-foot dock in the deep-water basin. Figure 45 below shows the preliminary design for this alternative.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port. The amount of new dock space created would be enough to accommodate the increase in vessel traffic with additional depth, leading to congestion relief benefits as well.

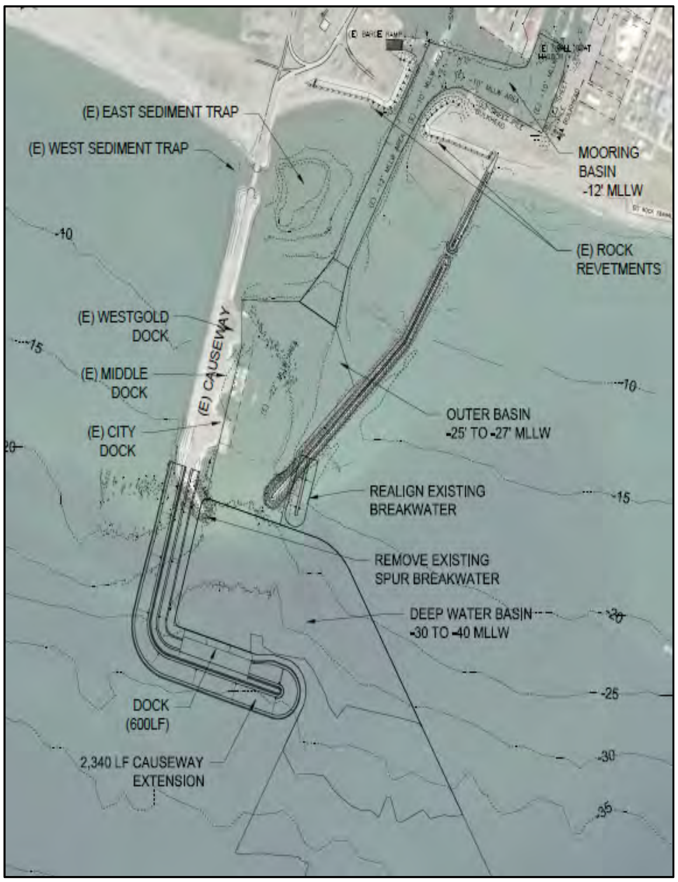

Figure 45. Alternative 3c

6.1.4. Alternative 4a

This alternative involves the same causeway extension as Alternative 3, but adds a rebuilt east breakwater that would widen the opening to the outer harbor. Figure 46 below shows the preliminary design for this alternative.

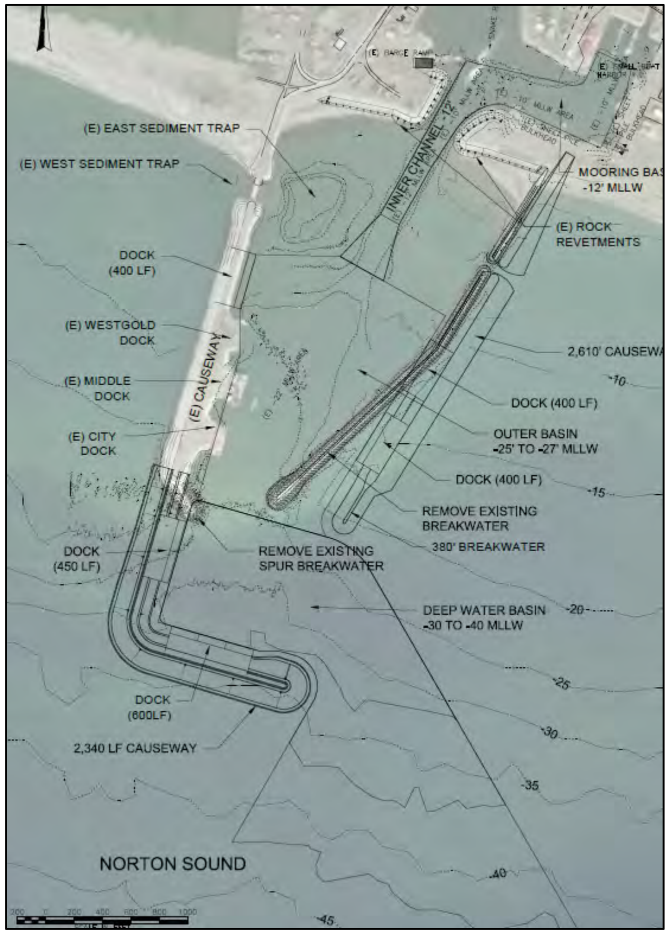

Figure 46. Alternative 4a

The same deepening options apply to this alternative as Alternative 3. This option also includes all of the additional docks as Alternative 3, but adds one more 400-foot dock on the newly constructed east breakwater.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port.

6.1.5. Alternative 8a

This alternative involves an extension of the existing causeway south into Norton Sound beyond the -40-foot MLLW depth contour, creating a larger deep-water basin than in the previous alternatives. This configuration also includes a new east breakwater constructed further to the east than the current location. Figure 47 shows below shows the preliminary design for this alternative.

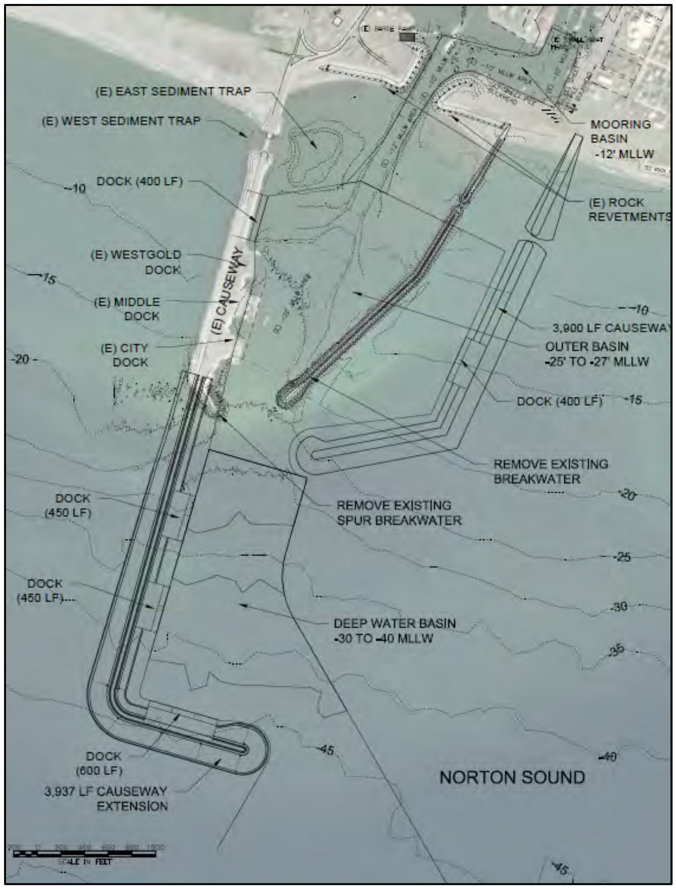

Figure 47. Alternative 8a

The same deepening options apply to this alternative as well. The relocation of the east breakwater would widen the outer harbor. This option also includes the addition of five new docks. One 400-foot dock would be on the existing causeway, north of the Westgold Dock, and one 400-foot dock would be built on the east breakwater. The causeway extension would have three new docks. The two furthest docks from shore would be 600 feet long, the remaining would be 450 feet long.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port.

6.1.6. Alternative 8b

This alternative involves an extension of the existing causeway south into Norton Sound beyond the -40-foot MLLW depth contour, but not as long as alternative 8a. This configuration also includes a new east breakwater constructed further to the east than the current location, and all six of the same new docks listed in alternative 8a. Figure 48 below shows the preliminary design for this alternative.

The additional depth of this alternative would allow vessels that currently anchor off-shore the ability to call at the existing causeway docks or the new Deepwater basin docks. This would eliminate vessel delays due to weather, allow larger vessels to take refuge from bad weather, allow more and larger vessels to conduct personnel operations in-port, and reduce the amount of fuel lightering needed to the port.

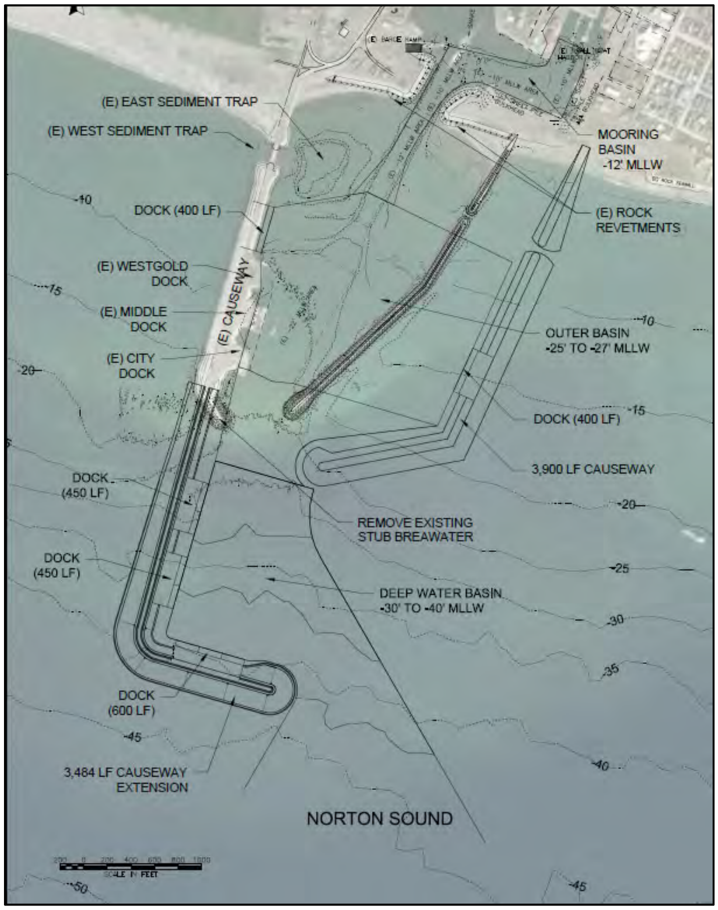

Figure 48. Alternative 8b

6.2. Separable Elements

ER 1105-2-100 states that "a separable element is any part of a project which has separately assigned benefits and costs, and which can be implemented as a separate action (at a later date or as a separate project)." (USACE, 2000). As separable elements may need to be incrementally justified in some cases, benefits and costs for each of them will be analyzed. For each alternative, there are two separable elements to be studied: the deepening of the existing Outer Harbor; and the creation and deepening of the Deepwater basin and addition of docks. Each of the six project alternatives listed previously demonstrate differences in the last element -- the changes in the Deepwater basin and docks. In each of those alternatives, the Outer Harbor was assumed to have been deepened from -22 to -28 feet MLLW. However, to ensure that this remaining element was analyzed per USACE guidance, benefits and costs were calculated for deepening the existing Outer Harbor to -25 feet and -28 feet alone.

Given the current dimensions of the Outer Harbor, the general navigation features (GNF) are limiting the current fleet that call on the port. The largest tug & barge combo calling on the port has a loaded draft of 17.5 feet. With 2 feet of UKC and 1.5 feet of tide, that is approaching, but not exceeding, the 22.5 feet available in the outer harbor. Arrival draft data for the port of Nome shows that all the barges of this class arrive at 18 feet or less. Therefore, the current fleet of barges is not limited by the depth of the outer harbor. The largest tanker to call at the City Dock (which has the fuel headers) since 2012 was the SICHEM EDINBURGH. Her dimensions are 422 feet long by 67 feet wide, with a max draft of 38 feet. Ships of this size must be light-loaded in order to call at the port at around 19 feet of draft, since her minimum draft is listed as 18 feet. Typically, tankers will wait until the end of their Far East trade route to call on Nome to be as light as possible. The SICHEM EDINBURGH only called on Nome one time in 2016, and in 2017, no tankers called at the Outer Harbor at all. This depends on which fuel distributor gets the local contract and if they only have enough delivery barges to facilitate a small tanker bringing the fuel from Asia. If that smaller tanker arrives, then it can be lightered, light-loaded, and then call at the Outer Harbor. If a larger tanker arrives because the delivery barge fleet consists of more, larger assets, then that tanker will remain offshore and cannot call on the Outer Harbor. The largest of the tankers that remain offshore has a max draft of 44 feet. The minimum draft of that class of tanker is approximately 27 feet, so deepening the Outer Harbor to its proposed depth of 28 feet wouldn't allow enough underkeel clearance to call.

In order for tankers to benefit from deepening the Outer Harbor, they would need to be small enough to call at around 21-24 feet, like the SICHEM EDINBURGH. If it is assumed that the tanker called once a year, it would be able to load more with a deeper harbor. That would eliminate fuel barge trips needed to lighter fuel into the port. The immersion factor for that tanker is 53.8 tons/inch. So, with an additional 2.5 to 5.5 feet of depth at the Outer Harbor, that would allow the tanker to load an additional 1,614 to 3,551 tons of fuel per visit. This translates to approximately 1,180,000 additional gallons of fuel delivered per visit. The average fuel barge load into Nome in 2017 was 1,890 tons of fuel per visit. Therefore, every fully loaded small tanker could eliminate one lightering barge call in the 25-foot alternative, and two lightering barge calls in the 28-foot alternative. The Nome Lightering route would be affected by this change. Fuel barges on that route travel approximately 0.8 miles to and from their destination. At an average speed of 5 knots, that transit would take about 10 minutes. So, at an average load of 1,890 tons, and a pumping rate of 800 gallons per minute, a lightering trip would take approximately 12 hours, including transit time. Based on the current VOC for a fuel barge, the 25-foot alternative would produce approximately $15,000 in annual benefits by eliminating one lightering call. The 28-foot alternative would produce approximately $30,000 in annual benefits by eliminating two lightering calls.

The Far East Tanker route would not be affected by any deepening of the Outer Harbor, since these tankers are estimated to only call once a year. Therefore, no origin-to-destination benefits would occur for this class of vessel from a potential reduction in vessel calls.

6.3. Assumptions

ER1105-2-100 states "Since benefits attributable to each alternative will generally be equal to the difference in the total transportation costs with and without the project, the assumptions stated for the without project condition are used to establish the with-project condition for each alternative," (USACE, 2000).

Beginning with non-structural measures, there are changes in the assumptions from the future without-project condition. For instance, not all vessel lightering and transshipment activities would continue in the manner they currently occur. Cargo vessels would continue to lighter and transship cargo at docks inside the Port of Nome. But, fuel lightering operations that are currently occurring offshore would be somewhat affected by the project.

Lightering currently exists offshore of Nome for two reasons. First, tankers making deliveries to the region, including Nome, are draft restricted at the Nome City Dock. Deliveries to the City Dock are shipped to the Nome Joint Utility System for power generation, Bonanza Fuel Inc., and Crowley Fuels, LLC for local retail sales, which is also trucked to the airport.

If the draft of the port were increased, this lightering to the port would be affected. Table 16 compares the number of fuel import calls to the port over the last three years with the number of lightering calls. Modifications to the Outer Harbor are assumed to reduce these lightering calls to the port as previously discussed. This reduction will be replaced by tanker import calls. Alternatives that create a Deepwater basin will reduce these lightering calls further. The number of tanker calls will depend on where else the tankers go on their voyage, and the structure of the annual refueling contract with the various communities in western Alaska.

Table 16. Port of Nome Fuel Import and Lightering Calls, 2015-2017

	2015	2016	2017		2015	2016	2017
Fuel Import Calls	16	16	23	Lightering Calls	12	10	16

Source: Port of Nome Seasonal Commodity Report by Vessel

The second reason fuel lightering occurs around Nome is for delivery of fuel from large tankers to either smaller tankers or regional delivery barges, depending on their distance from the final delivery destination, as part of the "floating gas station" model. According to the shippers in the region, this operation does not consider the depth of the port a factor in its operations at this time. It is uncertain if this consideration would change with a project in place. This operation could be negatively affected if a tanker was forced to pull into port, taking valuable time away from deliveries to remote locations. If regional delivery barges had to pull into the Port of Nome for fuel shipments, instead of receiving it offshore, this could increase their travel time as well, which would increase transportation costs and, ultimately, fuel prices at remote delivery points in the region. There are also additional financial costs incurred by using Nome as a hub, instead of continuing the offshore lightering operation. The city charges a 3.5¢ per gallon inbound fee on receipts and 1.2¢ on shipments of fuel, which would increase the transportation cost of regional fuel deliveries by adding another handling location to the process. Any new tugboat or pilotage fees would impact transportation costs as well.

However, it is not certain if vessels would conduct fuel transfers faster offshore than they could pier side. Many factors play a role in how quickly these operations can be conducted, including weather, sea state, crew proficiency, increased safety considerations, type and age of equipment, etc. So, it could possibly save both tankers and more local regional delivery vessels time by conducting their transfers via the Port of Nome, even if the financial costs of doing so are increased with port fees. In that case, port modifications would have an impact on the “floating gas station” model, and some offshore lightering tankers would call on the port of Nome instead to conduct their business on shore.

In light of this uncertainty, this analysis presents a range of cost savings that capture two scenarios.

The first assumes that the only vessels that would be enticed to transfer fuel ashore are those who were lightering to the port itself, not transshipping fuel to remote locations in the “floating gas station.” This is not an unreasonable scenario given the feedback from multiple shippers in the Nome area. They do not see a port expansion as affecting their operations at this time.

The second scenario assumes that some tankers would be enticed to transfer fuel ashore, rather than at anchor. “Floating gas station” tankers typically carry over 9 million gallons of fuel to be transshipped around the Nome area. For example, the GLENDA MERYL, a 47,000 DWT tanker that was anchored offshore of Nome for 44 days in 2016, offloaded 9.6 million gallons to other vessels during that time. The port has a total of 12.4 million gallons of storage capacity for fuel, therefore it is unlikely that tankers would offload their entire cargo ashore. Historically, Nome receives about 6 million gallons of fuel each summer to satisfy its various demands. The number of tankers that may be enticed to transfer fuel ashore is assumed to be 6 per summer, at 1 million gallons each call. This would not be the tanker’s full delivery to the region, but would represent an estimate of the efficiency they would gain due to the project modifications and expected landside capacity. Tankers would still need to transfer fuel at anchor around the region to meet existing demand.

Vessels that are approaching their underkeel clearance tolerances will still need to wait for favorable tides in order to call on the port. This tolerance will remain at 5 feet, but the arrival drafts will deepen with the corresponding change in with project depths.

There are currently the aforementioned plans to alter the Inner Harbor being undertaken by the port of Nome. There are also plans to acquire additional uplands for cargo storage and vessel overwintering, and that is assumed to occur in the future.

The fuel storage facilities at Nome have sufficient capacity at their respective locations for the amount of fuel moved in and out of the port at this time. However, future volumes of fuel will require an increased level of fuel storage over the period. Since existing customers are already preparing for storage expansion, it is safe to assume that the existing storage will be expanded as demand dictates, and without consideration to project alternatives.

The period of analysis is 50 years, beginning with the base year of 2030, the project effective date, to 2079. The FY 2020 Federal discount rate of 2.75 percent is used to discount benefits and costs. The report uses methodology from ER 1105-2-100, transportation savings accruing to deep draft vessels.

Vessels may experience a time savings “with” project in the form of the reduction in transit time delays. Other costs and practices, such as land side handling costs, would not change as a result of the project and are assumed to remain constant.

6.4. Commerce

The volume of commerce through the Port of Nome is expected to remain the same as forecasted in the future without project condition. Regional economic growth will drive the need for increased levels of cargo shipped in the future; however, the proposed alternatives are not estimated to further affect the demand for fuel, gravel, or dry cargo in the region. Current forecasted rates of growth for each of these commodities take into account normal business cycle fluctuations and reflect long-term trends. Table 17 below shows the baseline average tonnage and forecasted tonnages by commodity over the forecast period.

Table 17 FWP Baseline Tonnage and Forecast by Commodity

Commodity	2019	2020	2030	2040	2050	2060	2070	2079
Layberth (calls)	128	131	177	237	319	319	319	319
Fuel Receipts	31,855	31,855	31,855	31,855	31,855	31,855	31,855	31,855
Fuel Shipments	4,702	4,843	6,509	8,748	11,756	11,756	11,756	11,756
Gravel	58,612	58,864	61,444	64,138	66,950	66,950	66,950	66,950
Cargo Receipts	30,109	30,170	30,778	31,400	32,033	32,033	32,033	32,033
Cargo Shipments	5,485	5,496	5,606	5,720	5,835	5,835	5,835	5,835
Total Metric Tons	**130,763**	**131,228**	**136,192**	**141,861**	**148,429**	**148,429**	**148,429**	**148,429**

6.5. Vessel Fleet and Calls

In the with-project condition, the deepening and widening of the port and its berths will drive additional changes in the vessel fleet calling on Nome. Currently, multiple government vessels, large cruise ships, and larger research vessels conduct business in Nome while anchored offshore in deeper water. This business includes the transfer of personnel and equipment to and from the ships. The airport and various retail locations in town help facilitate these much-needed logistical stops offshore. With the project in place, these vessels would be able to conduct their business pier side, instead of offshore. These vessels include a fleet of ice breakers used by public and private entities to conduct polar research or commercial ice breaking for oil and gas traffic through the Northern Sea Route. These vessels spent over 1200 hours at anchor offshore of Nome in 2017 alone. These vessels also include a large class of cruise vessels. Nome already receives multiple calls from medium size cruise ships each summer that tour the Alaskan coast for whale watching, glacier visits and other opportunities. In 2016 and 2017, a larger class of vessel transited the Northwest Passage around Canada from the U.S. East Coast as part of a destination cruise package. With a project in place, this type of destination cruise would become more frequent as passenger transfer can occur on a much larger scale inside the port of Nome via the airport. The reduction in sea ice through the Northwest Passage will also help facilitate these types of cruises. The breakdown of future vessel classes and their respective characteristics are presented in Table 18 below.

Table 18. Characteristics of Future With-project Fleet by Vessel Type and Class

Vessel Type	Vessel Class	Length (ft.)	Beam (ft.)	Draft (ft.)	Capacity (Metric Tons)	Commodities Carried
Cruise Ship	Medium Cruise Ship	464	59	16.1	1,177	Layberth
Cruise Ship	Small Cruise Ship	234	42	14.8	620	Layberth
Cruise Ship	Large Cruise Ship	820	106	25	10,810	Layberth
Government	Buoy Tender	225	46	13.0	350	Layberth
Government	Cutter	378	43	18	2,328	Layberth
Government	Ice Breaker	420	82	30.0	3,250	Layberth
Landing Craft	Small Landing Craft	78	24	3.5	300	Layberth Cargo
Landing Craft	Large Landing Craft	152	50	9.8	500	Layberth Cargo Gravel
Research	Medium Research Vessel	269	56	18.4	2,808	Layberth Cargo
Research	Small Research Vessel	180	40	15.0	730	Layberth Cargo
Research	Large Research Vessel	500	70	25	9,500	Layberth Cargo
Tanker	Tanker	600	105	34	50,000	Layberth Fuel
Tug & Barge	Large Tug & Barge	380	96	18.0	14,157	Layberth Fuel Cargo Gravel
Tug & Barge	Medium Tug & Barge	376	78	18.0	10,653	Layberth Fuel Cargo Gravel
Tug & Barge	Small Tug & Barge	299	54	14.0	4,400	Layberth Fuel Cargo Gravel
Tugboat	Tugboat	76	32	5.0	170	Layberth

Typically, a three-year historical vessel call list is used in navigation studies to create a baseline for future vessel forecasts. Just as in the without-project condition, a 3-year average was used to calculate the baseline number of vessel calls, by class, for the 2018 season (Table 19).

Table 19. Historical and Projected Calls at Nome by Class

Year	2015	2016	2017	2018(Est)
Vessel Class	**Number of Calls**	**Number of Calls**	**Number of Calls**	**Number of Calls**
Buoy Tender	2	1	2	2
Cutter	8	4	10	8
Ice Breaker	4	3	4	4
Large Cruise Ship	0	1	1	1
Large Landing Craft	33	34	43	37
Large Research Vessel	0	2	2	2
Large Tug & Barge	16	18	16	17
Medium Cruise Ship	3	3	3	3
Medium Research Vessel	9	6	17	11
Medium Tug & Barge	51	44	40	45
Miscellaneous	10	44	17	24
Small Landing Craft	1	3	1	2
Small Research	29	12	16	19
Small Tug & Barge	47	62	67	59
Tanker	11	11	9	10
Tugboat	5	6	2	5
Grand Total	**229**	**254**	**250**	**249**

Just as in the without-project condition, the future vessel fleet was forecasted by conducting a load factor analysis for each vessel class and each commodity that they moved through the port. In discussions with the fuel and cargo shippers that use the port of Nome, none have indicated a pending shift to larger or different kinds of vessels. Low population growth and historic demand for fuel and cargo lead them to believe that the current fleet is sufficient for the foreseeable future. This fleet would not benefit from an increase in depth, therefore, their load factors are not expected to change with a project.

The exception to this would be fuel tanker receipts. Tankers are anticipated to increase the load factor for fuel receipts with a project in place. This is because the additional depth will allow them to eliminate some of the lightering calls into the port by loading deeper.

Also, the addition of newly available classes of vessels were included in the with-project load factor analysis. These three classes were Ice Breakers, Large Cruise Ships, and Large Research Vessels. These vessels will only be refueling inside the port of Nome. Load factors for these shipments were matched with the most similar vessel class already calling at Nome. For example, Ice Breakers were matched with the Government Cutter fleet, Large Cruise Ships with Medium Cruise Ships, and Large Research Vessels with Medium Research Vessels. There is no reason to assume that these new classes will be loaded much differently than those already calling on Nome.

There is currently no new technology on the horizon that could alter the way these vessels operate either. Just as in the without-project condition, rule changes for vessel fuels will not drive vessel changes in this scenario.

Table 20 presents the results of the load factor analysis for the port of Nome. For each class, a minimum, maximum, and average (or most likely) loading percentage (factor) was calculated. Changes or additions for the with-project condition are in italics.

Table 20. Load Factors by Commodity and Vessel Class

Fuel Receipts

MIN		**MOST LIKELY**		**MAX**		TPI	Add 'l tonnage /foot
Small Tug & Barge	10%	Small Tug & Barge	34%	Small Tug & Barge	90%	20.0	240.0
Medium Tug & Barge	10%	Medium Tug & Barge	34%	Medium Tug & Barge	90%	43.0	516.0
Large Tug & Barge	10%	Large Tug & Barge	34%	Large Tug & Barge	90%	66.0	792.0
Tanker	8%	Tanker	***40%***	Tanker	40%	77.4	928.8

Fuel Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	4%	Small Tug & Barge	13%	Small Tug & Barge	29%	20.0	240.0
Medium Tug & Barge	14%	Medium Tug & Barge	17%	Medium Tug & Barge	19%	43.0	516.0
Large Tug & Barge	4%	Large Tug & Barge	4%	Large Tug & Barge	4%	66.0	792.0
Tugboat	32%	Tugboat	32%	Tugboat	32%	-	N/A
Cutter	3%	Cutter	8%	Cutter	12%	-	N/A
Medium Cruise Ship	15%	Medium Cruise Ship	18%	Medium Cruise Ship	21%	-	N/A
Medium Research Vessel	9%	Medium Research Vessel	9%	Medium Research Vessel	10%	-	N/A
Large Landing Craft	6%	Large Landing Craft	6%	Large Landing Craft	6%	15.0	180.0

Miscellaneous	7%	Miscellaneous	9%	Miscellaneous	10%	-	N/A
Ice Breaker	***3%***	***Ice Breaker***	***8%***	***Ice Breaker***	***12%***	-	N/A
Large Cruise Ship	***15%***	***Large Cruise Ship***	***18%***	***Large Cruise Ship***	***21%***	-	N/A
Large Research Vessel	***9%***	***Large Research Vessel***	***9%***	***Large Research Vessel***	***10%***	-	N/A

Gravel Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	15%	Small Tug & Barge	29%	Small Tug & Barge	46%	20.0	240.0
Medium Tug & Barge	15%	Medium Tug & Barge	46%	Medium Tug & Barge	74%	43.0	516.0
Large Tug & Barge	58%	Large Tug & Barge	70%	Large Tug & Barge	77%	66.0	792.0
Large Landing Craft	45%	Large Landing Craft	66%	Large Landing Craft	78%	15.0	180.0

Cargo Receipts

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	10%	Small Tug & Barge	34%	Small Tug & Barge	90%	20.0	240.0
Medium Tug & Barge	10%	Medium Tug & Barge	34%	Medium Tug & Barge	90%	43.0	516.0
Large Tug & Barge	12%	Large Tug & Barge	34%	Large Tug & Barge	90%	66.0	792.0
Small Landing Craft	1%	Small Landing Craft	1%	Small Landing Craft	1%	10.0	120.0
Large Landing Craft	6%	Large Landing Craft	11%	Large Landing Craft	90%	15.0	180.0

Cargo Shipments

MIN		**MOST LIKELY**		**MAX**			
Small Tug & Barge	15%	Small Tug & Barge	15%	Small Tug & Barge	15%	20.0	240.0
Medium Tug & Barge	1%	Medium Tug & Barge	16%	Medium Tug & Barge	57%	43.0	516.0
Large Tug & Barge	1%	Large Tug & Barge	7%	Large Tug & Barge	22%	66.0	792.0
Small Landing Craft	1%	Small Landing Craft	1%	Small Landing Craft	1%	10.0	120.0
Large Landing Craft	5%	Large Landing Craft	17%	Large Landing Craft	90%	15.0	180.0

Layberth Fractions by Class

Cutter	5%	Medium Research Vessel	7%	Small Tug & Barge	16%	-	N/A
Large Landing Craft	4%	Medium Tug & Barge	12%	Tanker	8%	-	N/A
Large Tug & Barge	5%	Misc.	16%	Tugboat	4%	-	N/A
Large Cruise Ship	0%	Small Landing Craft	1%	Ice Breaker	3%	-	N/A
Large Research Vessel	1%	Small Research Vessel	15%	Buoy Tender	1%	-	N/A

Medium Cruise Ship	2%					-	N/A

Once this analysis was completed for each class and each commodity, a requisite number of vessels were calculated to move the forecasted amounts of commodities, per the commodity forecasts highlighted in the previous section. Total numbers of vessel calls were estimated over the 50-year forecast period. Similar to the commodity forecasts, after the initial 20-year period, growth was held constant for the remaining 30 years. So, the level of vessels in 2050-2079 will remain unchanged. The results are presented in Table 21.

Table 21. Future With-Project Vessel Fleet Calling at the Port of Nome by Class and Year

Vessel Class	2030	Vessel Class	2040	Vessel Class	2050
Small Tug & Barge	68	Small Tug & Barge	79	Small Tug & Barge	92
Medium Tug & Barge	39	Medium Tug & Barge	47	Medium Tug & Barge	57
Large Tug & Barge	21	Large Tug & Barge	24	Large Tug & Barge	28
Tanker	18	Tanker	22	Tanker	29
Tugboat	9	Tugboat	12	Tugboat	14
Cutter	13	Cutter	16	Cutter	21
Buoy Tender	2	Buoy Tender	3	Buoy Tender	4
Ice Breaker	5	Ice Breaker	7	Ice Breaker	10
Large Cruise Ship	1	Large Cruise Ship	2	Large Cruise Ship	2
Medium Cruise Ship	6	Medium Cruise Ship	7	Medium Cruise Ship	8
Small Research Vessel	27	Small Research Vessel	36	Small Research Vessel	49
Medium Research Vessel	18	Medium Research Vessel	22	Medium Research Vessel	28
Large Research Vessel	2	Large Research Vessel	3	Large Research Vessel	4
Small Landing Craft	1	Small Landing Craft	1	Small Landing Craft	2
Large Landing Craft	18	Large Landing Craft	21	Large Landing Craft	23
Miscellaneous	35	Miscellaneous	45	Miscellaneous	54
Total	**285**	**Total**	**347**	**Total**	**425**

The vessel fleet calling on the Port of Nome in the future with-project condition is also assumed to grow with the natural increases in global shipping over the forecast period. Arctic shipping is forecasted to follow the increasing trend of global and regional economic growth.

6.6. Dock Operations and Calls

When the commodity and fleet forecasts are combined, they can help estimate the volume of calls that will be made at a port in the future. However, these alone will not predict which dock a vessel will visit inside a port. Typically, USACE uses the HarborSym model to help estimate these movements by using the Bulk Loading or Container Loading tools inside the model. These require dock-specific forecasts, vessel class load factors, and an available fleet of vessels to mix-and-match dock-vessel pairs until all the commodities have been moved over the required time period. The loading tools in HarborSym use regression analysis to mix-and-match loaded vessels to docks over the required time period. To build this regression, each vessel class must have a minimum number of calls entered into the loading tool. Unfortunately, at the Port of Nome, most of the vessel classes do not have enough calls to build a regression for their class. So, using the Bulk or Container Loading tools did not capture the full volume of calls occurring at the port, which does not capture all of the vessel congestion effects that this particular study requires. Subsequently, vessel calls to different docks had to be changed manually in the respective vessel call list for each Alternative and simulation year group (2030, 2040, and 2050). Table 16 presents the procedures for adjusting calls to different docks for each alternative. Table 22 presents the resultant changes in vessel call numbers by vessel class and dock.

Table 22. Dock Call Changes Made per Alternative

Alternative	Dock Call Changes Made
Outer Harbor 25	- Changed all FWOP Lightering Area calls with a draft of 12-22 feet to calls at causeway docks
Outer Harbor 28	- Changed all FWOP Lightering Area calls with a draft of 23-25 feet to calls at causeway docks
Alternative 3a Deepwater basin 30	-Started with Outer Harbor 28 call list -Changed Lightering Area calls with draft of 25-26 feet to new Deepwater Dock (600LF)
Alternative 3a Deepwater basin 35	-Same changes as 3a 30 feet -Changed Lightering Area calls with draft of 27-31 feet to Deepwater Dock
Alternative 3a Deepwater basin 40	-Same changes as 3a 35 feet -Changed Lightering Area calls with draft of 32-36 feet to Deepwater Dock
Alternative 3b Deepwater basin 30	-Same changes as 3a 30 feet
Alternative 3b Deepwater basin 35	-Same changes as 3a 35 feet
Alternative 3b Deepwater basin 40	-Same changes as 3a 40 feet
Alternative 3c Deepwater basin 30	-Same changes as 3a 30 feet
Alternative 3c Deepwater basin 35	-Same changes as 3a 35 feet
Alternative 3c Deepwater basin 40	-Same changes as 3a 40 feet
Alternative 4a Deepwater basin 30	-Start with Alternative 3a 30 call list -Shifted all non-cargo layberth calls (cruise, research, and government) to east breakwater dock -Changed Lightering Area calls with draft of 25-26 feet to Deepwater Dock
Alternative 4a Deepwater basin 35	-Same changes as 4a 30 feet -Changed Lightering Area calls with draft of 27-31 feet to Deepwater Dock
Alternative 4a Deepwater basin 40	-Same changes as 4a 35 feet -Changed Lightering Area calls with draft of 32-36 feet to Deepwater Dock
Alternative 8a Deepwater basin 30	-Same changes as 4a 30 feet
Alternative 8a Deepwater basin 35	-Same changes as 4a 35 feet
Alternative 8a Deepwater basin 40	-Same changes as 4a 40 feet
Alternative 8b Deepwater basin 30	-Same changes as 4a 30 feet
Alternative 8b Deepwater basin 35	-Same changes as 4a 35 feet
Alternative 8b Deepwater basin 40	-Same changes as 4a 40 feet

6.7. Future With-Project Transportation Costs

The estimated future vessel fleet and number of vessel calls was run through the HarborSym planning model to calculate the transiting times and costs for the forecast period for each of the increments evaluated (2020, 2030, 2040). HarborSym concentrates on specific vessel movements and transit rules on the waterway. HarborSym represents a port as a tree-structured network of reaches, docks, anchorages, and turning areas. Figure 49 shows the Port of Nome HarborSym network for the Future With-Project condition.

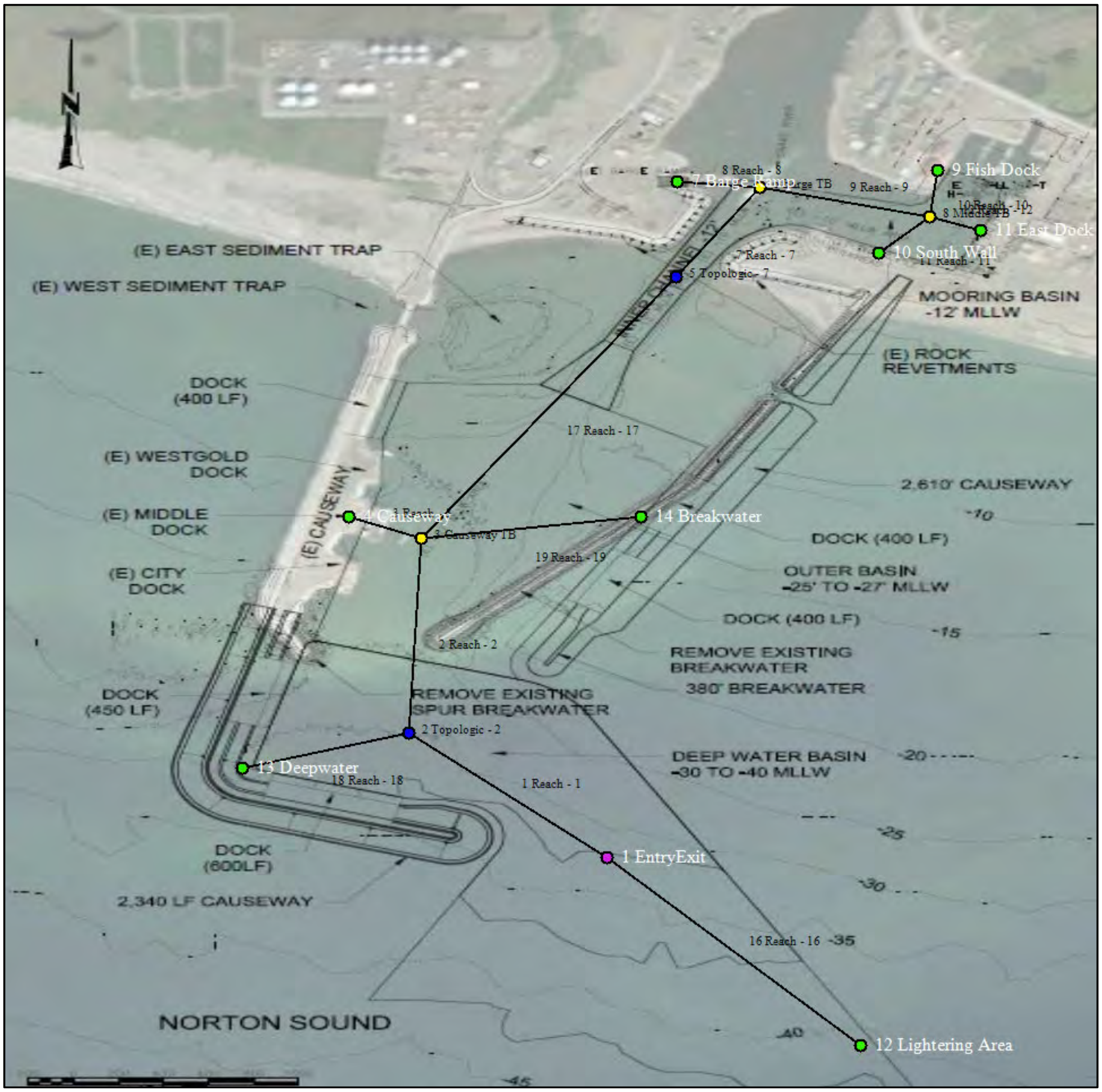

Figure 49. Port of Nome HarborSym network for Future With-Project Condition, Alternative 4a

Vessel movements are simulated along the reaches, moving from the entrance to one or more docks, and then exiting the port. One limitation of the model is that weather (wind or fog) is not a factor. The driving parameter for the HarborSym model is a vessel call at the port. A HarborSym analysis revolves around the factors that characterize or affect vessel movement within the harbor.

6.7.1.1. Inputs

The data required to run HarborSym are separated into six categories: simulation parameters, physical characteristics, general information such as commodity transfer rates at the docks, vessel speeds, transit rules, and vessel calls. For all but vessel calls, these input parameters are the same that were used in the without-project condition. Vessel calls were adjusted as discussed in the previous section. Table 23 below shows the changes in vessel calls by dock for each alternative.

Table 23 Vessel Calls by Dock by FWP Alternative

FWOP				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	269	339	427	427
Lightering Area	18	30	42	42
Total	287	369	469	469

Outer Harbor 25				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	276	346	436	436
Lightering Area	11	23	33	33
Total	287	369	469	469

Outer Harbor 28				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	7	17	27	27
Total	287	369	469	469

Alternative 3a_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Total	287	369	469	469

Alternative 3a_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Total	287	369	469	469

Alternative 3a_40				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Total	287	369	469	469

Alternative 3b_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Total	287	369	469	469

Alternative 3b_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Total	287	369	469	469

Alternative 3b_40				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Total	287	369	469	469

Alternative 3c_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Total	287	369	469	469

Alternative 3c_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	280	352	442	442
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Total	287	369	469	469
Alternative 3c_40				

Dock	2030	2040	2050	2079
Causeway	280	352	442	442
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Total	287	369	469	469

Alternative 4a_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 4a_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 4a_40				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Breakwater	57	77	103	103

Total	287	369	469	469

Alternative 8a_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 8a_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 8a_40				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 8b_30				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	7	17	27	27
Deepwater	0	0	0	0
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 8b_35				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	6	16	25	25
Deepwater	1	1	2	2
Breakwater	57	77	103	103
Total	287	369	469	469

Alternative 8b_40				
Dock	**2030**	**2040**	**2050**	**2079**
Causeway	223	275	339	339
Lightering Area	5	9	16	16
Deepwater	2	8	11	11
Breakwater	57	77	103	103
Total	287	369	469	469

6.7.1.2. Outputs

A number of parameters were collected and stored in HarborSym after the model runs are completed for each scenario. Among these parameters are the number of vessels entering/exiting the harbor, the average time a vessel class spends in the system (hours), the average transit cost of a vessel for each class, and the total transit cost of the annual fleet. These outputs were used to quantify delay reduction benefits if a project was in place.

Once the transiting times were calculated, the model calculated total vessel transportation costs allocated to the port in a given year based on 2016 Deep Draft Vessel Operating Costs. The total vessel transportation costs for each alternative at the base year, year 10, and year 20 of the period of analysis, are displayed graphically in Figure 50. The following totals are in FY20 dollars.

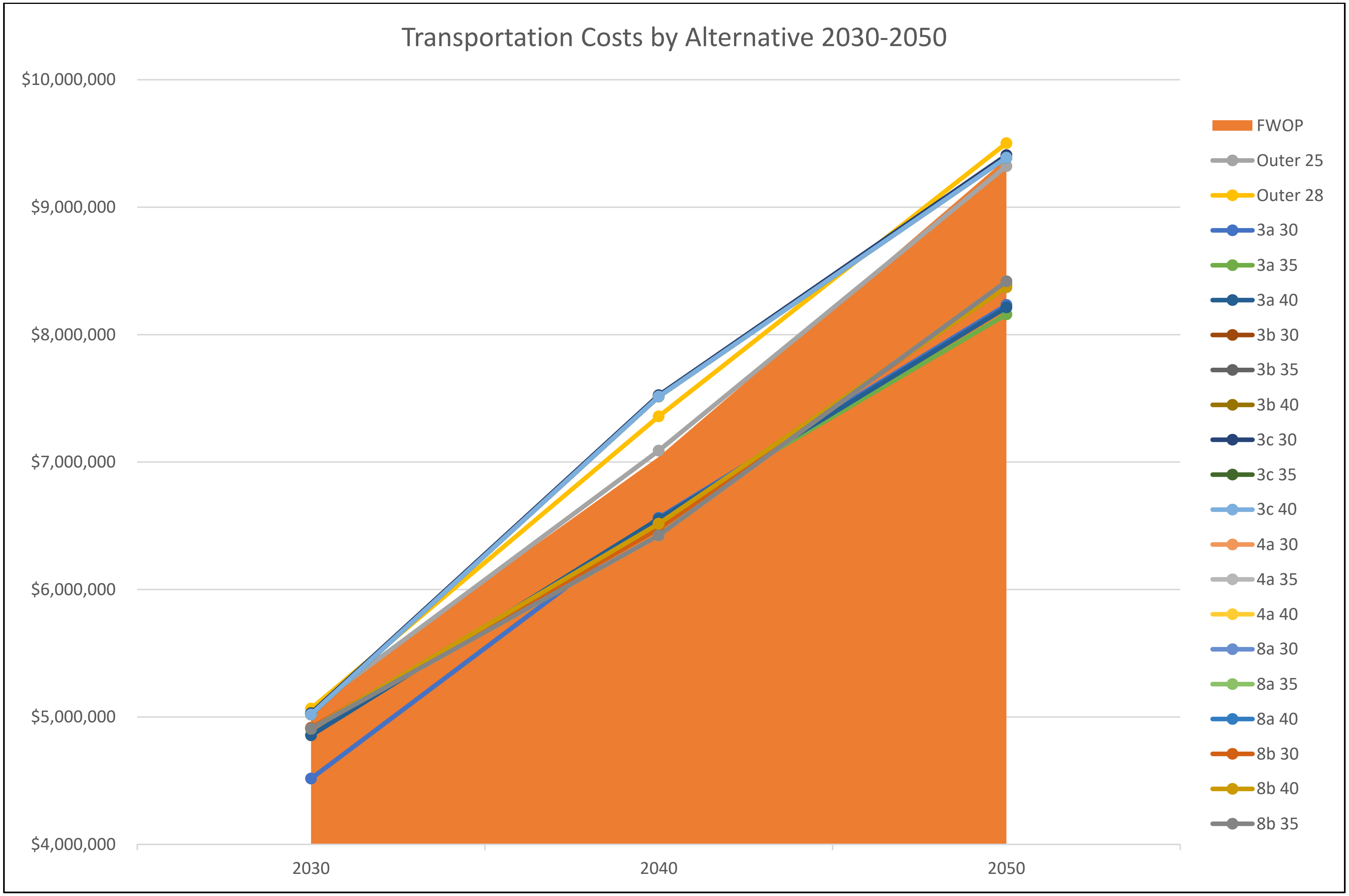

Figure 50. Total Transportation Costs by Alternative

7. PROJECT BENEFITS

ER 1105-2-100 states that “the basic economic benefit from navigation management and development plans are the reduction in transportation costs for commodities and the increase in the value of output for goods and services,” (USACE, 2000). The combination of HarborSym scenarios has produced results for savings to the future fleet based on reduced delays, improved loading practices and greater accessibility.

As listed in Section 6.2, deepening the Outer Harbor to 25 feet would produce approximately $15,000 in annual benefits by eliminating one lightering call. The 28-foot alternative would produce approximately $30,000 in annual benefits by eliminating two lightering calls.

Benefits from the deepwater basin are grouped into three categories: breakwater construction, deepening, and congestion relief.

7.1. Breakwater Construction Benefits

Given the current configuration of the existing breakwaters around the entrance to the port of Nome, the Outer Harbor is exposed to persistent southerly waves. This wave action can cause vessels to remain at anchor offshore of Nome in order for conditions to improve enough to dock. Based on data provided by the port, there were 528 hours of delays from 2012-2017. Those delays are broken down by vessel class in Table 24 below. Benefits to Government class vessels are captured separately in the Other Government Benefits section of the Appendix.

Table 24 Vessel Delays due to weather by Class, 2012-2017

Vessel Class	Delays (hours)	VOC x delay
Fuel Tug & Barge	48	$60,000
Cargo Tug & Barge	216	$307,000
Gravel Tug & Barge	144	$205,000
Government	120	-

Source: Port of Nome Vessel Calendars, 2012-2017

If a breakwater were constructed to completely eliminate weather delays due to the southerly wave action present at the port, it would save approximately $95,000 a year in delay cost prevented.

There are also instances where vessels anchored offshore of the port of Nome in order to wait out incidents of bad weather before continuing their voyages. If a breakwater were constructed to protect the port from the southerly wave action, these vessels would call on the port to take refuge from the weather. Based on data provided by the port, there were 312 hours of time at anchor in this situation from 2012-2017. Those durations at anchor are broken down by vessel class in Table 25 below.

Table 25 Vessels seeking refuge time at anchor and In-port Cost Savings by Class, 2012-2017

Vessel Class	Time at anchor (hours)	Savings x time at anchor
Fuel Tug & Barge	144	$62,000
Cargo Tug & Barge	24	$12,000
Tanker	144	$9,500

Source: Port of Nome Vessel Calendars, 2012-2017

If a breakwater were constructed to completely eliminate weather delays due to the southerly wave action present at the port, it would save approximately $14,000 a year in operating costs at sea.

7.2. Deepening Benefits

Based on the current depth of the outer harbor, the GNF's there are limiting the potential fleet from calling on the port. Currently, there are five types of vessels utilizing the offshore anchorage area whose draft is too deep for the proposed deepened Outer Harbor. They are listed in Table 26 below with their maximum dimensions.

Table 26 Vessel Types at Anchor due to Draft, 2012-2017

Vessel Type	Maximum LOA (ft.)	Maximum Beam (ft.)	Maximum draft (ft.)
Research Vessel	422	63	33
Cruise Ship	820	106	30
Tanker	610	106	44
Miscellaneous	461	77	34
Government	420	82	31

Source: Port of Nome Vessel Calendars, 2012-2017

Of those five vessel types, the research, cruise, and miscellaneous vessels would be able to call on the port to conduct operations like personnel transfers and crew re-supply instead of at anchor. Benefits to Government class vessels are captured separately in the Other Government Benefits section of the Appendix.

7.2.1. Tanker Deepening Benefit Scenarios

Lightering occurs in Nome for two reasons: to deliver fuel to the port itself for local consumption; and to deliver fuel to smaller tankers or regional delivery barges as part of the "floating gas station" model. As previously discussed in Section 6.3, this analysis presents two scenarios.

The first assumes that the only vessels that would be enticed to transfer fuel ashore are those who were lightering to the port itself. With a project, the tankers would be able to call on the port and deliver fuel rather than have to lighter it into port by barge. The deepest tanker to utilize the anchorage since 2012 was the HIGH PROGRESS. Her dimensions are 600 feet long, by 106 feet wide, by 44 feet deep. The three-year average number of lightering calls from 2015-2017 is 13 per year. It is assumed that the ability of these tankers to call at the Deepwater basin would completely eliminate the need to lighter fuel into the port. Using a 12-hour lightering trip and the fuel barge hourly VOC, creating a Deepwater basin would produce approximately $195,000 in annual benefits by eliminating thirteen calls.

The second scenario assumes that not only would lightering be eliminated, but some additional tankers from the “floating gas station” would be enticed to transfer fuel ashore, rather than at anchor. “Floating gas station” tankers typically carry over 9 million gallons of fuel to be transshipped around the Nome area. As outlined previously, the number of additional tankers that may be enticed to transfer fuel ashore is assumed to be 6 per year, at 1 million gallons each call. This would not be the tanker’s full delivery to the region, but would represent an estimate of the efficiency they would gain due to the project modifications and expected landside capacity. Those 6 tankers would still need to transfer fuel at anchor around the region to meet existing demand, and would still need to be light-loaded prior to entering Nome in the 40-foot alternative.

This time savings at anchor benefit to tankers cannot be captured in the HarborSym congestion model at this time. The transition of vessels from the Lightering Area to the Deepwater basin docks does not result in time or cost savings as seen by the model. This is because only 11 vessels have a deep enough draft to shift to the Deepwater Basin in the FWP condition. If only 11 vessels use the Deepwater basin a year, they will encounter no delays. As the model is currently designed, they also experience no delays moving to and from the Lightering Area, because in the model, it’s a dock with unlimited reach and dock capacity. So, there is no reduction in congestion by moving those 11 vessels from the Lightering Area to the Deepwater basin. It is safe to assume that adding the 6 more tanker calls from this scenario to the Deepwater basin will not induce any delays either. Therefore, any cost savings are not captured by the model. The only effect of moving tankers ashore from anchorage is the operating costs they’d save in-port versus at sea.

A tanker call to deliver 1 million gallons of fuel pier side is assumed to take 12 hours, based on the cargo transfer rates of the landside infrastructure and time to moor, make connections and conduct typical housekeeping functions. A “floating gas station” transfer of 1 million gallons of fuel while at anchor is assumed to require two barge calls of 500,000 gallons each. Using a pumping rate of 800 gallons per minute, these two barge calls would take approximately 12 hours each; 24 hours total. This would be consistent with the duration of a lightering call from earlier in the analysis. If each tanker call at the port saves 12 hours over transfers at anchor, the 6 calls annually will save 72 hours each year.

Using the hourly tanker vessel operating cost, the annual additional cost savings from these 6 tankers would be approximately $30,000, at a depth of 40 feet.

The remaining four vessel types were forced to anchor to conduct personnel transfers and crew re-supply. From 2012-2017, these four classes of vessel were at anchor for the durations shown in Table 27 below. Benefits to Government class vessels are captured separately in the Other Government Benefits section of the Appendix.

Table 27 Vessels time at anchor due to draft and In-port Cost Savings by Class, 2012-2017

Vessel Type	Time at anchor (hrs.)	Number of Calls	Savings x time at anchor
Research Vessel	1,056	16	$2,380,000
Cruise Ship	264	9	$264,000
Miscellaneous	864	11	$1,950,000
Government	1,464	28	N/A

Source: Port of Nome Vessel Calendars, 2012-2017

It is assumed that calls take the same amount of time in-port as they do at anchor. While it is likely that in-port calls would be faster for all but cruise vessels (maximizing passengers' time ashore), how much faster is uncertain. Given the lack of examples of this comparison and the limited effect this would have to overall levels of NED benefits, the assumption was left as-is. It is acknowledged that this may understate the cost savings benefits of these classes of vessels from the deepening alternatives.

The annual cost savings from cruise vessels calling in-port by constructing a deeper outer harbor would be $44,000, but only at depths exceeding 30 feet. In order to capture the additional $720,000 in annual cost savings, the basin would need to be deeper to accommodate all vessel types at anchor now. The research and miscellaneous types would only be able to call at 40 feet.

The combination of annual benefits for the Deepwater basin in each tanker scenario for breakwater construction and deepening are listed in Table 28 below.

Table 28 Benefits from the Deepwater basin by Category

	Tanker Scenario 1			Tanker Scenario 2		
Category	**30 feet**	**35 feet**	**40 feet**	**30 feet**	**35 feet**	**40 feet**
Breakwater Construction	$109,000	$109,000	$109,000	$109,000	$109,000	$109,000
Deepening						
- Lightering Savings	$195,000	$195,000	$195,000	$195,000	$195,000	$195,000
- Anchorage savings	$0	$44,000	$770,000	$0	$44,000	$800,000
Total	**$304,000**	**$348,000**	**$1,074,000**	**$304,000**	**$348,000**	**$1,104,000**

7.3. Congestion Relief Benefits

The changes in transportation costs from vessel congestion at the port were modeled using HarborSym. Each deepening alternative allowed more vessels access to the port instead of waiting or conducting business at anchor. This translated into increased vessel activity in the port, leading to increases or decreases in congestion, based on the size of the alternative and the number of docks proposed. This effect is independent of delays from bad weather, reductions in lightering, and operating cost differences between in port and at anchor (at sea). Congestion relief benefits took into account vessel calls shifting from at anchor to in port as well as the overall forecasted increase in vessel traffic over time. No origin-to-destination benefits were assumed to occur as a result of the deepening alternatives, since future fleets were not expected to grow larger. Thus, the only effect captured by HarborSym was the differences in harbor congestion in each FWP alternative, given the increase in traffic and the increase in dock space; i.e. how long vessels had to wait for a dock to enter or leave. The congestion relief cost changes are shown in Figure 51 below.

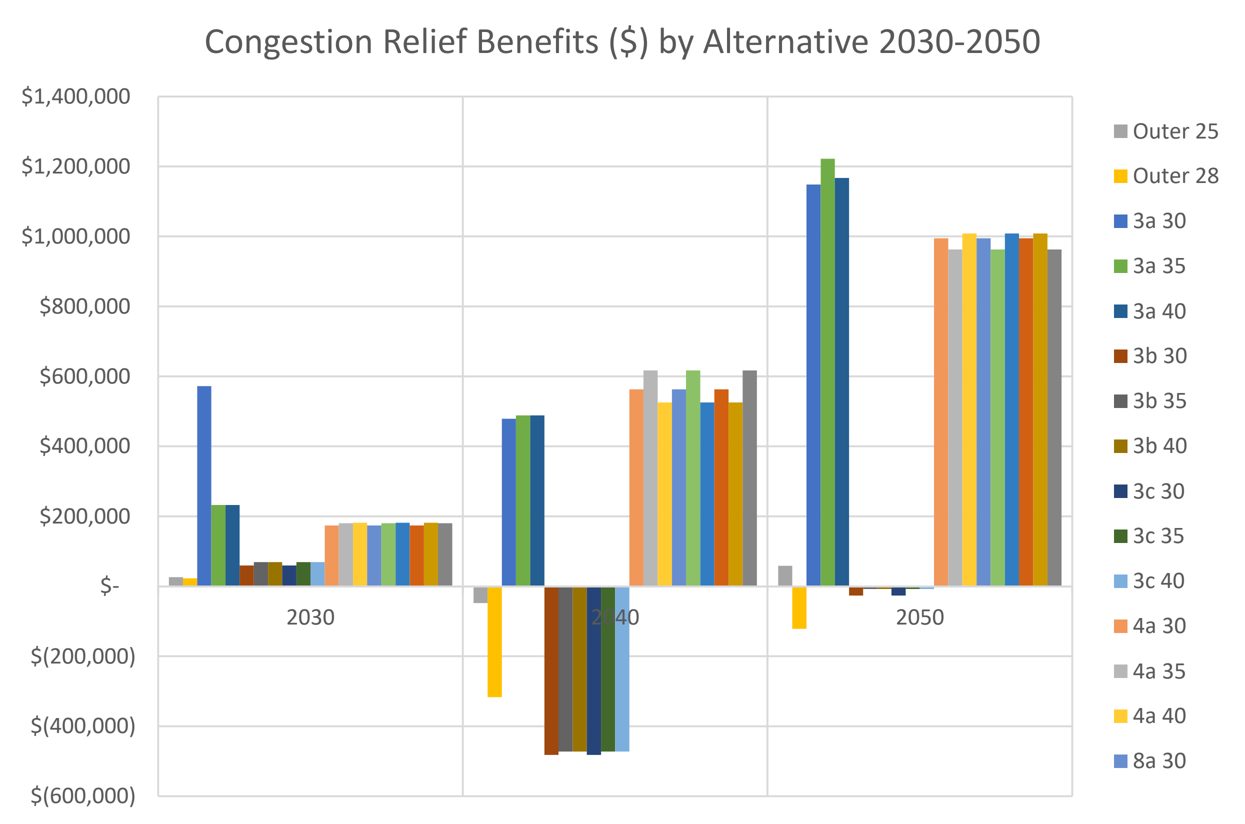

Figure 51. Congestion Relief Benefits

Positive costs are showing congestion relief from the respective alternative. Negative costs are indicative of increased congestion over and above the without-project condition. In other words, the congestion is made worse by enticing more vessels to come into the port with the increased depth, and there is not enough dock capacity added in that alternative to accommodate the new vessels. For example, look at alternatives 3a, 3b, and 3c. Alternative 3a contains three new docks: one in the existing outer harbor and two in the new Deepwater harbor. 3b and 3c do not contain a new outer harbor dock, and just one or two Deepwater docks, respectively. Alternative 3a has positive benefits, while

3b and 3c have negative totals. The reason is that 3b and 3c are trying to fit 15 deeper vessels into the Outer Harbor from the Lightering Area with one less dock than 3a, as shown in Table 29 below. The transition of vessels from the Lightering Area to the Deepwater basin docks does not have a significant counter-effect on this. If only 11 vessels use the Deepwater basin a year (because there's only 11 vessels deep enough to need it), they will encounter no delays. As designed, they also experience no delays moving to and from the Lightering Area. So, there is no reduction in congestion by moving those 11 vessels from the Lightering Area to the Deepwater basin. Therefore, the positive totals seen in 3a are more due to an additional dock in the Outer Harbor, and the lack of this dock has a negative effect on traffic in 3b and 3c.

Table 29. Vessel Calls by Alternative and Dock, 2079

FWOP	
Dock	**2079**
Causeway	427
Lightering Area	42 (16+11+15)
Total	469

Alternative 3a_40	
Dock	**2079**
Causeway	442
Lightering Area	16
Deepwater	11
Total	469

Alternative 3b_40	
Dock	**2079**
Causeway	442
Lightering Area	16
Deepwater	11
Total	469

Alternative 3c_40	
Dock	**2079**
Causeway	442
Lightering Area	16
Deepwater	11
Total	469

7.4. Other Government Benefits

Next, any previous categories of benefits calculated for the existing activities of other government agencies must be calculated.

7.4.1. Breakwater Construction Benefits to the U.S. Coast Guard

Southerly wave action causes weather delays to USCG calls to Nome as well. The construction of a breakwater would eliminate these delays. Table 30 below shows the 6-

year total of delays to government vessels due to weather and the resultant operating cost savings by eliminating those delays.

Table 30. Government Vessel Delays due to Weather 2012-2017

Vessel Class	**Delays (hours)**	**VOC x delay**
Government	120	$466,000

Source: Port of Nome Vessel Calendars, 2012-2017

If a breakwater were constructed to completely eliminate weather delays due to the southerly wave action present at the port, it would save approximately $78,000 a year in delay cost prevented.

7.4.2. Deepening Benefits to the U.S. Coast Guard

Based on the current depth of the outer harbor, the GNF's there are limiting the government fleet from calling on the port. Currently, some vessels are utilizing the offshore anchorage area when their draft is too deep for the proposed deepened Outer Harbor. They are listed in Table 31 below with their maximum dimensions.

Table 31. Government Vessels at Anchor due to Draft, 2012-2017

Vessel Type	**Max LOA (ft.)**	**Max Beam (ft.)**	**Max draft (ft.)**
Government	420	82	31

Source: Port of Nome Vessel Calendars, 2012-2017

The government vessels were forced to anchor to conduct personnel transfers and crew re-supply. From 2012-2017, these vessels were at anchor for the durations shown in Table 32 below.

Table 32. Government Vessels time at anchor due to draft and In-port Cost Savings, 2012-2017

Vessel Type	**Time at anchor (hrs.)**	**Number of Calls**	**Savings x time at anchor**
Government	1,464	28	$11,250,000

Source: Port of Nome Vessel Calendars, 2012-2017

If it is assumed that calls take the same amount of time in-port as they do at anchor, then the annual cost savings from government vessels calling in-port by constructing a deeper outer harbor would be $1,875,000, but only at depths exceeding 40 feet to maintain the 5-foot underkeel clearance requirement. As in-port Reimbursable rates are not available, they were assumed to be 67 percent of the at-sea rate, to be consistent with previous cost assumptions. While it is likely that in-port calls would be faster for government vessels, how much faster is uncertain. Given the lack of examples of this comparison and the limited effect this would have to overall levels of NED benefits, the assumption was left as-is. It is acknowledged that this may understate the cost savings benefits of these classes of vessels from the deepening alternatives.

The combination of annual benefits to Coast Guard for breakwater construction and deepening are listed in Table 33 below.

Table 33. U.S. Coast Guard Benefits from the Deepwater basin by Category

Category	**30 feet**	**35 feet**	**40 feet**
Breakwater Construction	$78,000	$78,000	$78,000
Deepening			
- Anchorage savings	$0	$0	$1,875,000
Total	**$78,000**	**$78,000**	**$1,953,000**

Finally, any benefits from proxy savings to government agencies that were estimated must be included.

7.4.3. Proxy Savings to the Department of Defense

A deep draft port on the western coast of Alaska benefits Maritime Homeland Defense (MHD). Some of the benefits can be represented with quantitative data, other benefits can only be represented qualitatively. U.S. Northern Command (USNORTHCOM) provided a series of MHD vignettes in the Arctic which represent a plausible future course of this mission. These were analyzed and a quantitative benefit to the Department of Defense was estimated here. The qualitative benefits to Maritime Homeland Defense are discussed in the Main Report.

These benefits are to the Joint Force's surface vessels deploying to perform MHD in the Arctic portions of the USNORTHCOM Area of Responsibility (AOR). The frequency and extent of these operations are based on current capability requirements as communicated by USNORTHCOM. Exercise and real-world scenarios were provided by USNORTHCOM to assist USACE in development of these benefits. In order to estimate total benefits to the Nome Project, benefits were estimated for each USNORTHCOM-provided scenario. In order to estimate benefits for each scenario, a future without- and with-project condition must be formulated. The comparison between these two conditions was the basis for quantitative economic benefits.

Exercise Benefits

Arctic Maritime Homeland Defense (AMHD) Capability Requirements (CR) lay out four different exercise scenarios applicable to the Nome feasibility study that would repeat over the 50-year period of analysis. Quantitative benefits to the fleet would be in the form of proxy savings to the DOD for increased mission efficiencies from reduced costs during refueling operations.

2022 Exercise

Without a refueling capability in western Alaska, vessels would need to return to Dutch Harbor for refueling, since that is the closest deep-water port that vessels could access for fuel. This would represent the future-without project condition.

Future Without-Project Condition

Vessels would leave Dutch Harbor and proceed to the operating area (OPAREA) for the exercise. They would need to return to Dutch Harbor to refuel. Once refueling was complete, they would return to the OPAREA to finish the exercise. Once the exercise was complete, they would return to Dutch Harbor to refuel on their way home.

Future With-Project Condition

The 35 and 40 foot alternatives from the Nome Harbor Improvements project would allow vessels to refuel inside the port. This would represent the future with-project conditions. In this scenario, vessels would arrive in the OPAREA with about 84 percent fuel on board. They would be able to refuel at Nome, approximately 5.5 days after arrival.

They would arrive in Dutch Harbor with 75 percent fuel on board and refuel prior to returning home. Operating this way would save vessels one additional trip to Dutch Harbor to refuel. It is approximately a 1,320-nautical mile round trip from Dutch Harbor to Nome. At a speed of 20 knots (NM/hour), the trip would take approximately 66 hours, so the total scenario benefit would be approximately $1,580,000.

2026 Exercise

In this scenario, some refueling option must be available north of Dutch Harbor. The three options currently being considered are refueling by a new single-point mooring buoy, refueling by DOD combat logistics force (CLF), and refueling by existing commercial barges. Single-point mooring buoys can cost upwards of $25 Million. In order to ensure DOD combat logistics force (CLF) assets are available for this tasking, additional assets would need to be constructed and allocated to the Arctic AOR. The GAO estimated that one new T-AO class CLF vessel costs approximately $525 million in 2018. The timetable for completion of these assets is uncertain at this time. The contracting of existing western Alaska commercial fuel barges would be simpler to implement and less expensive. These conditions suggest that the preferred means is via CLF, but the most likely method to be used would be commercial barge. Barge operators have already stated in discussions with USNORTHCOM that the preferred location to refuel by barge would be inside the protected waters of Pt. Clarence, about 60NM from Nome. Figure 52 below shows the relationship between Nome, Dutch Harbor and Port Clarence. This would provide protection from Bering Sea weather conditions and is assumed to provide anytime refueling operations. This would represent the future-without project condition.

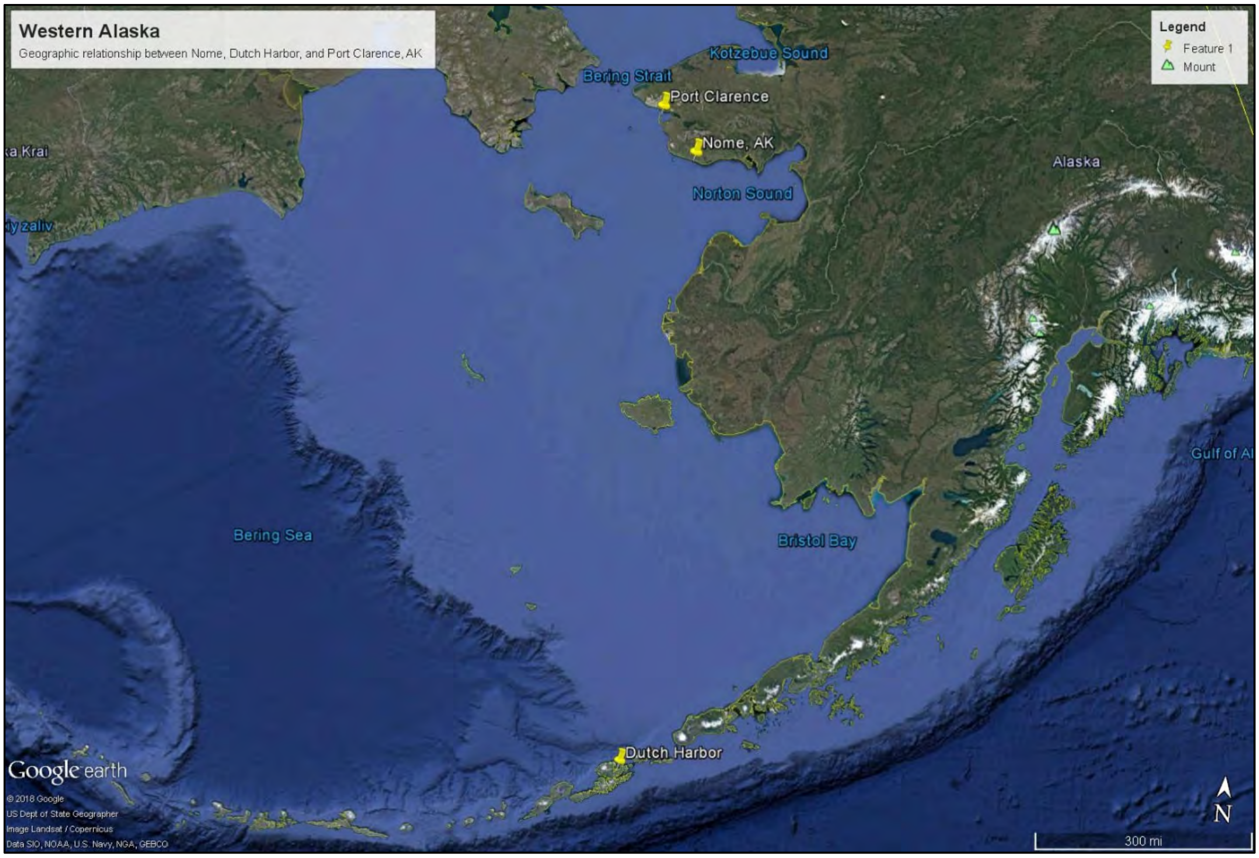

Figure 52. Western Alaska highlighting Nome, Dutch Harbor, and Port Clarence

Future Without-Project Condition

Vessels would leave Dutch Harbor and proceed to Pt. Clarence to refuel by barge approximately 720 NM away. They would then proceed to the OPAREA, then return to Dutch Harbor before reaching their 50 percent minimum fuel on board threshold. They would not need to top off with fuel via barge before their return trip to Dutch Harbor. They would then refuel prior to returning home.

Future With-Project Condition

Vessels would leave Dutch Harbor and proceed to Nome to refuel in-port, approximately 660 NM away. They would proceed to the OPAREA, then return to Dutch Harbor before reaching minimum fuel threshold. They would then refuel prior to returning home. The benefit to refueling in Nome versus via barge would be the reduced cost of fuel in-port as compared to the cost of fuel from the barge.

The benefit from this scenario would be approximately $290,000.

2028 Exercise

Future Without-Project Condition

Vessels would leave Dutch Harbor and proceed to Pt. Clarence to refuel via barge, a transit of approximately 720 NM. After refueling, they would proceed to the OPAREA.

They would need to refuel via barge at Pt. Clarence again prior to their transit to Dutch Harbor in order to stay above required minimum fuel on board thresholds.

Future With-Project Condition

Vessels would leave Dutch Harbor and proceed to Nome to refuel in port, a transit of approximately 660 NM. After refueling, they would proceed to the OPAREA. They would need to re-fuel again at Nome prior to returning to Dutch Harbor as well. The benefit to refueling in Nome versus via barge would be the reduced cost of fuel in-port as compared to the cost of fuel from the barge.

13,900 barrels (bbls) of fuel at the port of Nome would cost approximately $2,650,000, including any associated fees for utilizing the port. 13,900 bbls of fuel delivered via barge would cost approximately $3,890,000. The benefit from this scenario would be $1,240,000.

2030 Exercise

Future Without-Project Condition

Vessels would leave Dutch Harbor and proceed to Pt. Clarence to refuel via barge. Once refueled, they would proceed to the OPAREA. In order to meet the mission requirements, vessels must return to Pt. Clarence three more times to refuel prior to their return to Dutch Harbor.

Future With-Project Condition

Vessels would leave Dutch Harbor and proceed to Nome to refuel in port, a transit of approximately 660 NM. After refueling, they would proceed to the OPAREA. The vessels would need to make two additional intermediate refueling stops prior to completing the exercise. They would need to re-fuel again at Nome prior to returning to Dutch Harbor as well. The benefit to refueling in Nome versus via barge would be the reduced cost of fuel in-port as compared to the cost of fuel from the barge.

52,300 bbls of fuel at the port of Nome would cost approximately $10,000,000, including any associated fees for utilizing the port. 52,300 bbls of fuel delivered via barge would cost approximately $14,680,000. The benefit from this scenario would be $4,680,000.

Exercise Benefits

The four scenarios outlined above provided the opportunity for economic benefits with a project at Nome. They would begin in 2022 and repeat every ten years over the 50-year period of analysis. Table 35 below shows the total annual benefits for each year.

Table 34. Annual Exercise Scenario Benefits

Year	Benefit ($)
2022	$1,580,000
2026	$290,000
2028	$1,240,000
2030	$4,680,000
2032	$1,580,000
2036	$290,000
2038	$1,240,000
2040	$4,680,000
2042	$1,580,000
2046	$290,000
2048	$1,240,000
2050	$4,680,000
2052	$1,580,000
2056	$290,000
2058	$1,240,000
2060	$4,680,000
2062	$1,580,000
2066	$290,000
2068	$1,240,000
2070	$4,680,000
2072	$1,580,000
2076	$290,000
2078	$1,240,000
2080	$4,680,000

Real-World Response Scenario Benefits

Arctic Maritime Homeland Defense (AMHD) Capability Requirements (CR) lay out three different real-world events and the potential USNORTHCOM response scenarios applicable to the Nome feasibility study. These scenarios would occur every other year over the 50-year period of analysis. Benefits to the fleet would be in the form of proxy savings to the DOD for increased mission efficiencies from reduced costs during refueling operations.

Real-World Scenario One

In this real world scenario, vessels would have to refuel in western Alaska on their northbound transit from Dutch Harbor to the OPAREA. They would return to western Alaska to refuel. They would then return to the OPAREA and complete their patrol, prior to heading home. They would top off with fuel in Dutch Harbor on the transit out of the OPAREA, on the way home.

Future Without-Project Condition

Similar to the 2028 exercise scenario, vessels would leave Dutch Harbor and proceed to Pt. Clarence to refuel via barge, a transit of approximately 720 NM. After refueling, they would proceed to the OPAREA. They would need to refuel via barge at Pt. Clarence again to complete their patrol in the OPAREA. They would depart the OPAREA and transit to Dutch Harbor in order to refuel and return home.

Future With-Project Condition

Vessels would leave Dutch Harbor and proceed to Nome to refuel in port, a transit of approximately 660 NM. After refueling, they would proceed to the OPAREA. They would return to Nome to refuel and continue their patrol in the OPAREA once further tasking was provided. There would be no need to re-fuel again at Nome prior to returning to Dutch Harbor. The benefit to refueling in Nome versus via barge would be the reduced cost of fuel in-port as compared to the cost of fuel from the barge.

8,500 bbls of fuel at the port of Nome would cost approximately $1,620,000, including any associated fees for utilizing the port. 8,500 bbls of fuel delivered via barge would cost approximately $2,380,000. The benefit from this scenario would be $760,000.

Real-World Scenario Two

This scenario would be similar to the 2028 exercise, but the OPAREA would be farther away. There would also be another additional refueling stop in western Alaska in order to return to the OPAREA to finish the patrol; which the 2028 exercise did not need.

Future Without-Project Condition

Similar to the 2028 exercise scenario, vessels would leave Dutch Harbor and proceed to Pt. Clarence to refuel via barge, a transit of approximately 720 NM. After refueling, they would proceed to the OPAREA. They would need to refuel via barge at Pt. Clarence two more times to complete their patrol in the OPAREA, which is one more than the 2028 exercise. They would depart the OPAREA and transit to Dutch Harbor in order to refuel and return home.

Future With-Project Condition

Vessels would leave Dutch Harbor and proceed to Nome to refuel in port, a transit of approximately 660 NM. After refueling, they would proceed to the OPAREA. They would return to Nome to refuel and continue their patrol. They would return to Nome again to refuel and await further tasking. Once further tasking was provided, they would proceed to Dutch Harbor, and then home. The benefit to refueling in Nome versus via barge would be the reduced cost of fuel in-port as compared to the cost of fuel from the barge.

12,000 bbls of fuel at the port of Nome would cost approximately $2,330,000, including any associated fees for utilizing the port. 12,000 bbls of fuel delivered via barge would cost approximately $3,420,000. The benefit from this scenario would be $1,110,000.

Real-World Scenario Three

The vessels would need to refuel in Dutch Harbor twice in order to maintain the desired OPAREA presence.

Future Without-Project Condition

Without a refueling capability in western Alaska, vessels would need to return to Dutch Harbor for refueling, since that is the closest deep-water port that vessels could access for fuel.

Future With-Project Condition

The vessels would depart Dutch Harbor and proceed to the OPAREA. They would need to refuel twice in Nome prior to returning to the OPAREA to continue operations. They would return to Dutch Harbor with 75 percent fuel on board and refuel prior to returning home. Operating this way would save vessels two additional trips to Dutch Harbor to refuel. It is approximately a 1,320-nautical mile round trip from Dutch Harbor to Nome. At a speed of 20 knots (NM/hour), the trip would take approximately 66 hours. Therefore, the scenario benefit would be approximately $6,340,000.

Real-World Scenario Benefits

The three scenarios outlined above provided the opportunity for economic benefits with a project at Nome. They would begin in 2022 and repeat every other year over the 50-year period of analysis. Given the frequency of these historical occurrences, it is reasonable to assume that some combination of these scenarios would occur every other year. Therefore, the total annual benefit of the three scenarios was calculated and an average of the three years was used to represent that real-world annual benefit provided by the project. Table 36 below shows the total benefits from the three scenarios and the resulting average benefit for the real-world scenarios.

Table 35. Total and Average Real-World Scenario Benefits

Year	Benefit ($)
Scenario 1	$760,000
Scenario 2	$1,110,000
Scenario 3	$6,340,000
Total Benefit	$8,210,000
Average Benefit	$2,737,000

Total Combined Benefits

Once the total annual benefits were calculated for the exercises and real-world scenarios, they were combined into a single scenario benefit total for each year of the 50-year period of analysis. Table 37 shows this calculation below. Totals may not add up due to rounding.

Table 36 Annual Combined Benefits

Year	Exercise Benefits ($)	Real-World Benefits ($)	Total Benefits ($)
2022	$1,580,000	$1,670,000	$3,250,000
2024		$1,670,000	$1,670,000
2026	$290,000	$1,670,000	$1,960,000
2028	$1,240,000	$1,670,000	$2,900,000
2030	$4,680,000	$1,670,000	$6,330,000
2032	$1,580,000	$1,670,000	$3,250,000
2034		$1,670,000	$1,670,000
2036	$290,000	$1,670,000	$1,960,000
2038	$1,240,000	$1,670,000	$2,900,000
2040	$4,680,000	$1,670,000	$6,330,000
2042	$1,580,000	$1,670,000	$3,250,000
2044		$1,670,000	$1,670,000
2046	$290,000	$1,670,000	$1,960,000
2048	$1,240,000	$1,670,000	$2,900,000
2050	$4,680,000	$1,670,000	$6,330,000
2052	$1,580,000	$1,670,000	$3,250,000
2054		$1,670,000	$1,670,000
2056	$290,000	$1,670,000	$1,960,000
2058	$1,240,000	$1,670,000	$2,900,000
2060	$4,680,000	$1,670,000	$6,330,000
2062	$1,580,000	$1,670,000	$3,250,000
2064		$1,670,000	$1,670,000
2066	$290,000	$1,670,000	$1,960,000
2068	$1,240,000	$1,670,000	$2,900,000
2070	$4,680,000	$1,670,000	$6,330,000

2072	$1,580,000	$1,670,000	$3,250,000
2074		$1,670,000	$1,670,000
2076	$290,000	$1,670,000	$1,960,000
2078	$1,240,000	$1,670,000	$2,900,000
2080	$4,680,000	$1,670,000	$6,330,000
		Average Annual Benefit	**$1,683,000**

This benefit would accrue to any project alternative at 35 feet or deeper.

7.5. Annual Project Benefits

First, any additional annual project benefits outside of the HarborSym model were determined by adding breakwater construction, deepening, and government benefits for each alternative at FY20 price levels. Table 38 shows the annual benefits generated by each alternative and tanker scenario for breakwater construction, deepening and government agencies.

Table 37 Average Annual Benefits by Category and Alternative

Average Annual Benefit by Alternative									
Alternative	Breakwater	Deepening	Deepening w/ 6 tankers	Subtotal	Sub w/6 Tankers	USCG Benefit	DOD Benefit	Sum With Government	Sum w/ Government & 6 Tankers
Outer Harbor 25	$0	$15,000	$15,000	$15,000	$15,000	$0	$0	$15,000	$15,000
Outer Harbor 28	$0	$30,000	$30,000	$30,000	$30,000	$78,000	$0	$108,000	$108,000
Alt 3a_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 3a_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 3a_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000
Alt 3b_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 3b_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 3b_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000
Alt 3c_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 3c_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 3c_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000
Alt 4a_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 4a_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 4a_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000
Alt 8a_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 8a_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 8a_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000
Alt 8b_30	$109,000	$195,000	$195,000	$304,000	$304,000	$78,000	$0	$382,000	$382,000
Alt 8b_35	$109,000	$239,000	$239,000	$348,000	$348,000	$78,000	$1,683,000	$2,109,000	$2,109,000
Alt 8b_40	$109,000	$965,000	$995,000	$1,074,000	$1,104,000	$1,953,000	$1,683,000	$4,710,000	$4,740,000

Next, the annualized congestion relief benefits from the HarborSym model were calculated. The annualized benefits were calculated using the total benefit for each alternative evaluated, discounted to FY20 price levels using the Federal discount rate of 2.75 percent, over a 50-year period of analysis. Alternatives that show a negative AAEQ benefit mean that transportation costs increased from the without-project condition to the with-project condition. Alternatives with negative benefits did not expand enough in the areas that needed to accommodate increases in vessel traffic, and the result was increasing vessel congestion at the entry to the port. This increase in congestion resulted in longer vessel wait times than in the without-project condition, translating into increased vessel operating costs. These totals were then added to the categories of additional benefits, and then to the government benefits separately. Benefit totals are shown in Table 39 below.

Table 38. Annualized Benefits by Alternative

Alternative	**Congestion Relief Benefits**	**Additional Benefits**	**Total Benefits**	**Total Benefits with Gov't**
Outer Harbor 25	$45,000	$15,000	$60,000	$60,000
Outer Harbor 28	-$128,000	$30,000	-$98,000	-$20,000
Alternative 3a_30	$879,000	$304,000	$1,183,000	$1,261,000
Alternative 3a_35	$859,000	$348,000	$1,207,000	$2,968,000
Alternative 3a_40	$830,000	$1,104,000	$1,934,000	$5,540,000
Alternative 3b_30	-$115,000	$304,000	$189,000	$267,000
Alternative 3b_35	-$101,000	$348,000	$247,000	$2,008,000
Alternative 3b_40	-$101,000	$1,104,000	$1,003,000	$4,609,000
Alternative 3c_30	-$115,000	$304,000	$189,000	$267,000
Alternative 3c_35	-$101,000	$348,000	$247,000	$2,008,000
Alternative 3c_40	-$101,000	$1,104,000	$1,003,000	$4,609,000
Alternative 4a_30	$746,000	$304,000	$1,050,000	$1,128,000
Alternative 4a_35	$745,000	$348,000	$1,093,000	$2,854,000
Alternative 4a_40	$745,000	$1,104,000	$1,849,000	$5,455,000
Alternative 8a_30	$746,000	$304,000	$1,050,000	$1,128,000
Alternative 8a_35	$745,000	$348,000	$1,093,000	$2,854,000
Alternative 8a_40	$745,000	$1,104,000	$1,849,000	$5,455,000
Alternative 8b_30	$746,000	$304,000	$1,050,000	$1,128,000

Alternative 8b_35	$745,000	$348,000	$1,093,000	$2,854,000
Alternative 8b_40	$745,000	$1,104,000	$1,849,000	$5,455,000

7.6. Project Costs

Rough Order of Magnitude (ROM) costs were developed for the initial construction of each alternative. The period of construction varies for each alternative, and are shown in Table 22 below. Landside ancillary costs are any costs estimated to construct local service facilities, or additional docks, associated with each Deepwater basin alternative. Other GNF costs are the costs estimated to construct the breakwaters needed for the Deepwater basin alternatives. Project costs were developed without escalation and are at the October 2019 price level. Based on the knowledge of other projects in Nome, operations and maintenance dredging would need to be accomplished every year, and those O&M costs were also included. The combination of these costs were used to determine the average annual cost of each project. Table 40 displays the ROM costs for each channel alternative. Subsequent updates to O&M costs were estimated for the 30- and 40-foot depths for each alternative. Those updated costs are reflected in Table 40. Alternatives at 35-feet were not updated due to preliminary screening as not cost effective, and the exclusion of these costs had no impact on plan selection.

Table 39 ROM Costs for all alternatives (FY2020 dollars)

Alt	Duration (months)	Dredging	IDC	Landside Ancillary	Other GNF Construction	PED	Contingency	Total Investment	OMRR&R (PV)
Outer Harbor 25	3	$6,479,000	$29,000	$0	$0	$648,200	$2,527,000	$9,683,000	$33,444,000
Outer Harbor 28	4	$8,210,000	$37,000	$0	$0	$820,000	$3,202,000	$11,532,000	$33,444,000
Alternative 3a Deepwater basin 30	5	$15,548,000	$1,649,000	$43,967,000	$151,140,000	$2,107,000	$82,156,000	$296,567,000	$41,263,000
Alternative 3a Deepwater basin 35	7	$24,402,000	$2,972,000	$43,967,000	$151,140,000	$2,163,000	$84,473,000	$306,145,000	$126,750,000
Alternative 3a Deepwater basin 40	12	$36,891,000	$5,593,000	$43,967,000	$151,140,000	$2,320,000	$90,479,000	$330,390,000	$64,539,000
Alternative 3b Deepwater basin 30	3	$11,158,000	$3,179,000	$37,043,000	$150,628,000	$1,988,000	$77,544,000	$281,540,000	$47,424,000
Alternative 3b Deepwater basin 35	6	$19,665,433	$4,288,000	$37,043,000	$150,628,000	$2,204,000	$85,947,000	$299,775,000	$128,774,000
Alternative 3b Deepwater basin 40	11	$33,988,000	$5,603,000	$37,043,000	$150,628,000	$2,217,000	$86,447,000	$315,925,000	$70,700,000
Alternative 3c Deepwater basin 30	3	$11,158,351	$3,025,000	$24,753,000	$153,301,000	$1,892,000	$73,793,000	$267,923,000	$47,424,000
Alternative 3c Deepwater basin 35	6	$19,011,000	$3,981,000	$24,753,000	$153,301,000	$2,046,128	$78,799,009	$281,892,000	$143,623,000
Alternative 3c Deepwater basin 40	11	$33,988,000	$5,360,000	$24,753,000	$153,301,000	$2,120,000	$82,696,000	$302,219,000	$70,700,000
Alternative 4a Deepwater basin 30	7	$25,652,000	$2,546,000	$56,474,000	$173,524,000	$2,546,000	$99,313,000	$361,408,000	$60,626,000
Alternative 4a Deepwater basin 35	10	$33,505,000	$4,735,000	$56,474,000	$173,524,000	$2,962,000	$115,512,000	$386,712,000	$126,750,000
Alternative 4a Deepwater basin 40	15	$46,359,000	$7,632,000	$56,474,000	$173,524,000	$2,764,000	$107,779,000	$394,531,000	$83,902,000
Alternative 8a Deepwater basin 30	12	$55,034,000	$6,328,000	$69,513,000	$337,901,000	$4,624,000	$180,355,000	$653,754,000	$80,293,000
Alternative 8a Deepwater basin 35	13	$45,304,000	$8,599,000	$69,513,000	$337,901,000	$4,699,000	$182,263,000	$648,279,000	$126,750,000
Alternative 8a Deepwater basin 40	16	$67,539,000	$15,539,000	$69,513,000	$337,901,000	$4,750,000	$185,232,000	$680,283,000	$92,826,000
Alternative 8b Deepwater basin 30	12	$55,034,000	$6,974,000	$63,964,000	$314,203,000	$4,396,000	$171,463,000	$622,303,000	$80,293,000
Alternative 8b Deepwater basin 35	13	$45,300,000	$8,864,000	$63,964,000	$314,203,000	$4,556,000	$177,675,000	$617,559,000	$103,427,000
Alternative 8b Deepwater basin 40	16	$66,112,000	$4,507,000	$70,413,000	$314,203,000	$4,507,000	$175,784,000	$635,525,000	$94,616,000

Average annual costs were developed by combining the initial construction costs with the annual Operations and Maintenance costs for each potential alternative using the FY20 Federal Discount Rate of 2.750 percent along with a period of analysis of 50 years. Results are presented in Table 41.

Table 40 Average Annual Cost Summary Information per Alternative

Alternative	AAEQ Construction Cost	AAEQ OMRR&R	Total AAEQ Cost	Incremental AAEQ Cost
Outer Harbor 25	$359,000	$1,238,800	$1,597,000	
Outer Harbor 28	$427,000	$1,238,800	$1,666,000	$69,000
Alternative 3a Deepwater basin 30	$10,985,000	$1,528,000	$12,514,000	
Alternative 3a Deepwater basin 35	$11,450,000	$4,695,000	$16,145,000	$3,631,000
Alternative 3a Deepwater basin 40	$12,238,000	$2,391,000	$14,629,000	$2,115,000
Alternative 3b Deepwater basin 30	$10,429,000	$1,757,000	$12,185,000	
Alternative 3b Deepwater basin 35	$11,104,000	$4,770,000	$15,874,000	$3,689,000
Alternative 3b Deepwater basin 40	$11,702,000	$2,619,000	$14,321,000	$2,136,000
Alternative 3c Deepwater basin 30	$9,924,000	$1,757,000	$11,681,000	
Alternative 3c Deepwater basin 35	$10,442,000	$5,320,000	$15,761,000	$4,080,000
Alternative 3c Deepwater basin 40	$11,194,000	$2,619,000	$13,813,000	$2,132,000
Alternative 4a Deepwater basin 30	$13,387,000	$2,246,000	$15,633,000	
Alternative 4a Deepwater basin 35	$14,324,000	$4,695,000	$19,019,000	$3,386,000
Alternative 4a Deepwater basin 40	$14,614,000	$3,108,000	$17,722,000	$2,089,000
Alternative 8a Deepwater basin 30	$24,216,000	$2,974,000	$27,190,000	
Alternative 8a Deepwater basin 35	$24,013,000	$4,695,000	$28,708,000	$1,518,000
Alternative 8a Deepwater basin 40	$25,198,000	$3,438,000	$28,637,000	$1,447,000
Alternative 8b Deepwater basin 30	$22,878,000	$2,974,000	$25,852,000	

Alternative 8b Deepwater basin 35	$22,875,000	$3,831,000	$26,706,000	$854,000
Alternative 8b Deepwater basin 40	$23,795,000	$3,505,000	$27,300,000	$594,000

7.7. Benefit Cost Ratio

The benefit-cost ratio is determined using the average annual benefits and average annual costs for each project alternative. A benefit cost ratio was calculated for each of the six alternatives, as well as the other separable elements, and with and without the benefits to the government agencies. Table 42 shows the BCR for each project alternative along with the net benefits.

Table 41 Net Benefits and Benefit Cost Ratios by Alternative

Alternative	AAEQ Benefits	Benefits w/ Gov't	AAEQ Costs	Net Benefits	Net Benefits w/ Gov't	BCR	BCR w/ Gov't
Outer Harbor 25	$60,000	$60,000	$1,597,000	-$1,537,000	-$1,537,000	0.0	0.0
Outer Harbor 28	-$98,000	-$20,000	$1,666,000	-$1,764,000	-$1,686,000	0.0	0.0
3a 30	$1,183,000	$1,261,000	$12,514,000	-$11,331,000	-$11,253,000	0.1	0.1
3a 35	$1,207,000	$2,968,000	$16,145,000	-$14,938,000	-$13,177,000	0.1	0.2
3a 40	$1,934,000	$5,540,000	$14,629,000	-$12,695,000	-$9,089,000	0.1	0.4
3b 30	$189,000	$267,000	$12,185,000	-$11,996,000	-$11,918,000	0.0	0.0
3b 35	$247,000	$2,008,000	$15,874,000	-$15,627,000	-$13,866,000	0.0	0.1
3b 40	$1,003,000	$4,609,000	$14,321,000	-$13,318,000	-$9,712,000	0.1	0.3
3c 30	$189,000	$267,000	$11,681,000	-$11,492,000	-$11,414,000	0.0	0.0
3c 35	$247,000	$2,008,000	$15,761,000	-$15,514,000	-$13,753,000	0.0	0.1
3c 40	$1,003,000	$4,609,000	$13,813,000	-$12,810,000	-$9,204,000	0.1	0.3
4a 30	$1,050,000	$1,128,000	$15,633,000	-$14,583,000	-$14,505,000	0.1	0.1
4a 35	$1,093,000	$2,854,000	$19,019,000	-$17,926,000	-$16,165,000	0.1	0.2
4a 40	$1,849,000	$5,455,000	$17,722,000	-$15,873,000	-$12,267,000	0.1	0.3
8a 30	$1,050,000	$1,128,000	$27,190,000	-$26,140,000	-$26,062,000	0.0	0.0
8a 35	$1,093,000	$2,854,000	$28,708,000	-$27,615,000	-$25,854,000	0.0	0.1
8a 40	$1,849,000	$5,455,000	$28,637,000	-$26,788,000	-$23,182,000	0.1	0.2
8b 30	$1,050,000	$1,128,000	$25,852,000	-$24,802,000	-$24,724,000	0.0	0.0
8b 35	$1,093,000	$2,854,000	$26,706,000	-$25,613,000	-$23,852,000	0.0	0.1
8b 40	$1,849,000	$5,455,000	$27,300,000	-$25,451,000	-$21,845,000	0.1	0.2

7.8. Risk, Uncertainty, and Sensitivity

7.8.1. Risk

The specific economic risk for this project is the opportunity to realize uncertain transportation cost savings by making modifications to the port. This opportunity is triggered by the local sponsor's desire for a larger port with deeper basins and more docks that can produce the cost savings benefit. The consequence of this opportunity being realized is a cost savings to western Alaska shippers and the Nation. In order for these cost savings benefits to be realized, certain events must occur. First, vessel traffic volumes must remain steady or increase over the foreseeable future. Second, modifications must be made to the port to allow enhanced maneuverability or delay reductions. This would include changes that increase dock space sufficiently, maintain cargo handling capability and capacity, maintain or improve pilot and tugboat assistance, and offer improved mitigation for times of severe weather. These are all necessary steps to realize these cost savings.

7.8.2. Uncertainty

The benefits to modifying the Port of Nome are uncertain. One uncertain aspect of the opportunity for gains itself lies in the future vessel fleet. Traffic would continue to get less efficient if the same types of vessels simply increased in number over time. However, many shippers change vessel type after 15-20 years, as their existing vessels age. Even though, shippers involved in the Nome trade have denied any intent of upgrading away from Jones Act-compliant barges. If shippers shifted to newer, or larger, or more fuel efficient vessels to move the existing commodities into and around Nome, they could increase efficiencies, and take advantage of economies of scale available to them. This would not negate the cost savings opportunity from a project in Nome, but it is a source of uncertainty around the magnitude of the cost savings opportunity available. Another source of uncertainty around the future vessel fleet is the amount of time between the existing condition and the selected base year. Existing fleet conditions were investigated in 2017, but the future without-project condition does not begin until 2030. It is possible to have a very different fleet mix if the start of a project is significantly further into the future than the existing conditions. As previously noted, much of the fleet has remained the same between the previous Nome study conducted in 2013, and this study in 2017, so the likelihood that a drastic change would occur over the next 11 years is small. Again, a newer, larger fleet would not negate the cost savings opportunity from a project in Nome, but it could reduce the magnitude of the benefits available.

There are many sources of uncertainty in the consequences, or transportation cost savings to western Alaska shippers and the Nation. The Nation could be missing out on many different things, depending on how conditions materialize over the study period. There is a great deal of uncertainty surrounding the development of offshore oil and gas resources in the Arctic region. Price fluctuations, changing environmental conditions, and changing regulations influence how much and how often companies search for oil and gas. Whether they do or not will heavily influence the consequences of uncertain cost savings in the region. If those benefits are realized, and oil and gas development occurs, then the cost savings could be very large. However, if those benefits are not realized and no development occurs, the consequences could be as forecasted in this report--much less significant.

Another large assumption that was made in this analysis was that a few vessels would prefer to do their business in port at Nome, rather than at anchor off-shore. They simply cannot at the present time, due to the current depth of the port. This assumption contains a great deal of uncertainty around the future change in behavior of the fleet at Nome. It is possible that improvements to the port make larger differences than predicted in the behavior of the anchored fleet—especially the tankers and delivery vessels involved in the "floating gas station" model. If that occurs, then the magnitude of the cost savings realized could be more than reported here.

7.8.3. Sensitivity analyses

Congestion costs in the HarborSym model appear to be mostly driven by, and most sensitive to, time loading and unloading at the dock. This is shown in Figure 53, which is an example output graph from the model. For brevity purposes, only one alternative simulation is listed, but it is indicative of all other alternatives.

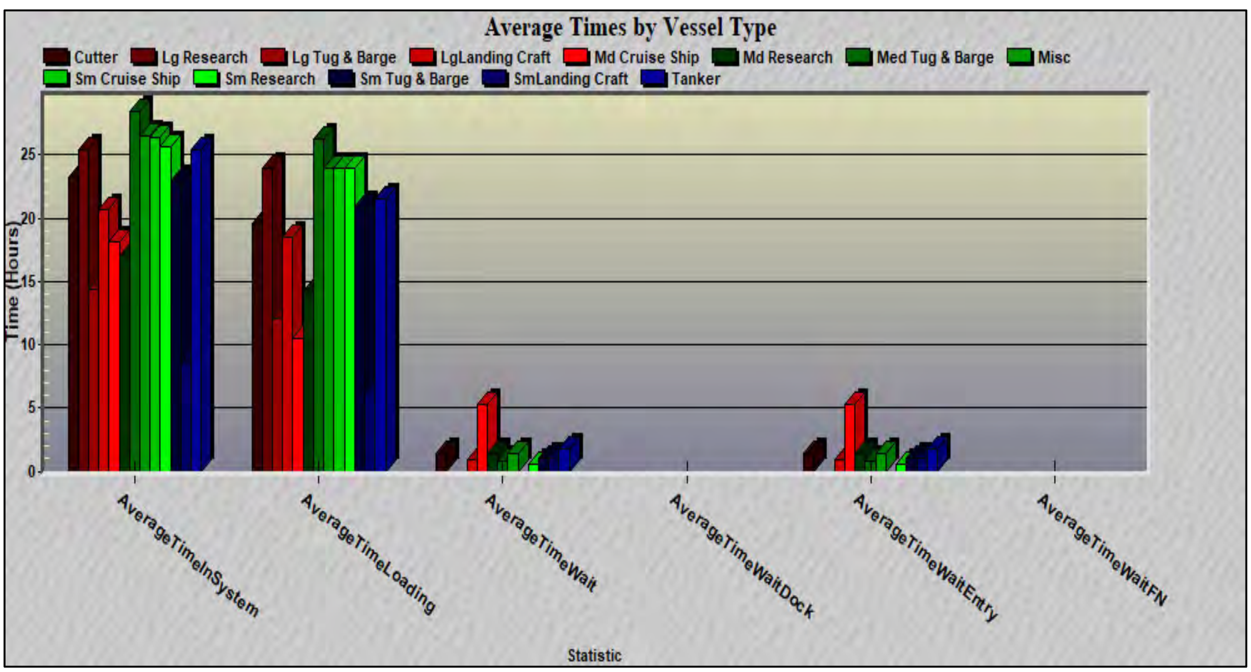

Figure 53. Average Time Statistics from HarborSym, Alternative 8a 40 feet

Therefore, any variable that affects how long vessels spend loading or unloading will have a significant effect on benefits. So, vessel traffic volumes or dock numbers will not impact benefits as much as commodity volumes or fleet composition will. This is part of the reason why there are minimal levels of congestion relief benefits associated with all of the alternatives—no matter the number or location of docks. That being said, it would take a very significant, possibly unreasonable, increase in commodity or vessel movements over the forecast period to result in enough additional benefits to justify any project alternative. Since no origin-to-destination transportation cost savings exist for these alternatives, the cost savings via congestion relief and other means cannot justify any project alternatives, in any foreseeable scenario. The only possibility would be the resurgence of natural resource activity outlined in the 2015 Alaska Deep Draft Arctic Ports Study.

Sensitivity scenario:

Oil and gas development scenario

In the previous Alaska Deep Draft Arctic Port System Feasibility Study, a scenario was analyzed that included significant growth in the oil and gas industry in the Chukchi and Beaufort Sea regions of the U.S. Arctic. The key underlying assumption to including oil and gas activities in the analysis of Nome was that offshore oil and gas exploration activities were ongoing and would continue in the Arctic in the near future. This assumption was supported by oil and gas companies' significant investment and continued interest in the region at the time. Figure 54 is a map of the active leases in the Chukchi Sea in 2013, which shows how many companies were interested and investing in resource development.

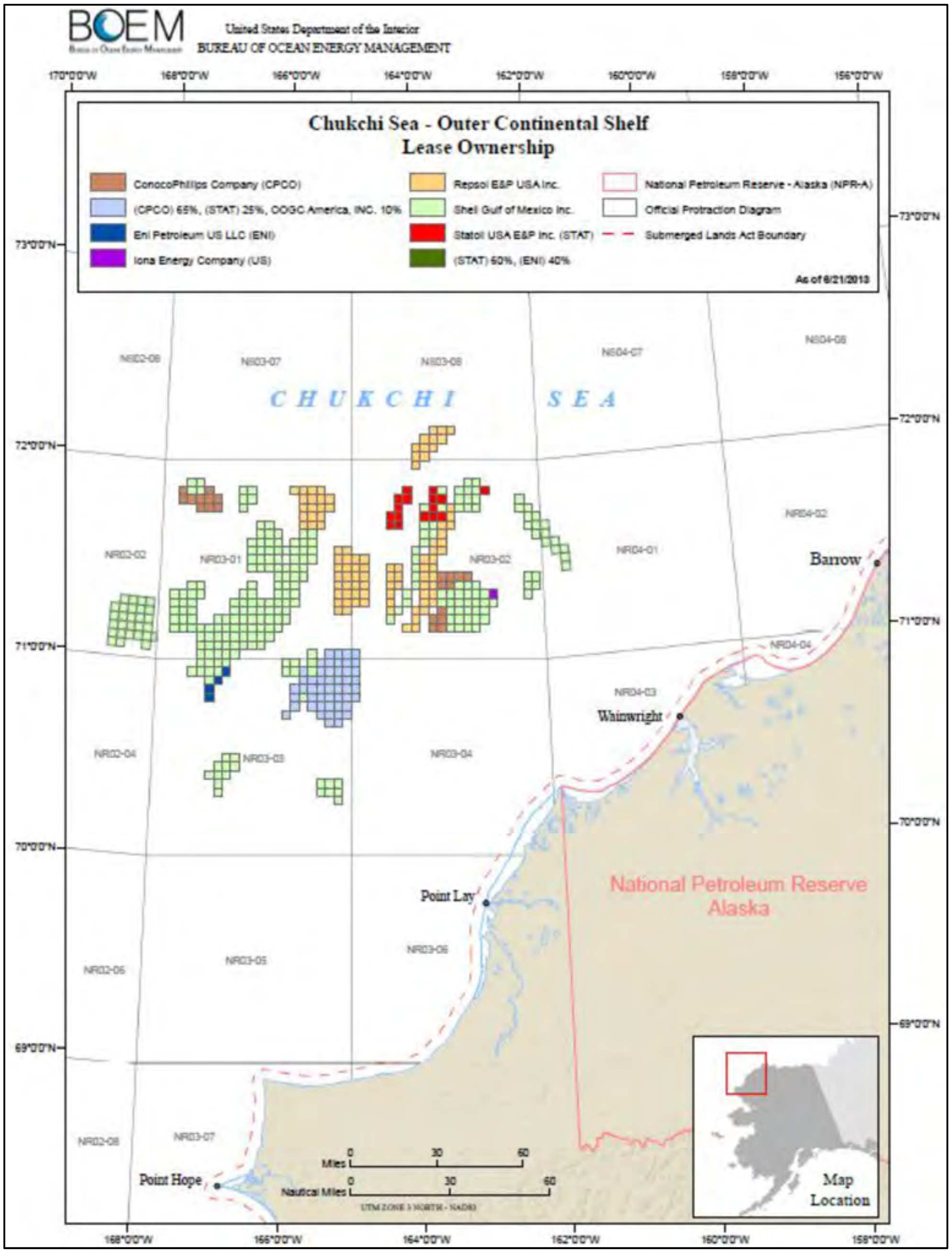

Figure 54. Chukchi Sea Offshore Oil and Gas Lease Ownership, 2013

Conditions quickly changed. On September 28, 2015, Shell announced that it ended its exploratory oil drilling in the Arctic for the “foreseeable” future, citing poor results and high costs. On October 16, the U.S. Department of the Interior announced that it would cancel two potential offshore lease sales in the Beaufort and Chukchi Sea that were scheduled for 2016 and 2017 “in light of current market conditions and low industry interest.” By October 23, USACE had suspended the Alaska Deep Draft Study. By 2017, Shell had relinquished their last remaining federal lease in the Chukchi Sea and have no further plans for frontier exploration in offshore Alaska. With the exception of two remaining positions in the long-established North Slope area, they have exited all other leases[25]. Other companies followed suit. Figure 55 is a map of the remaining leases still active in Alaska. All are located in the Cook Inlet and Beaufort Seas (essentially onshore).

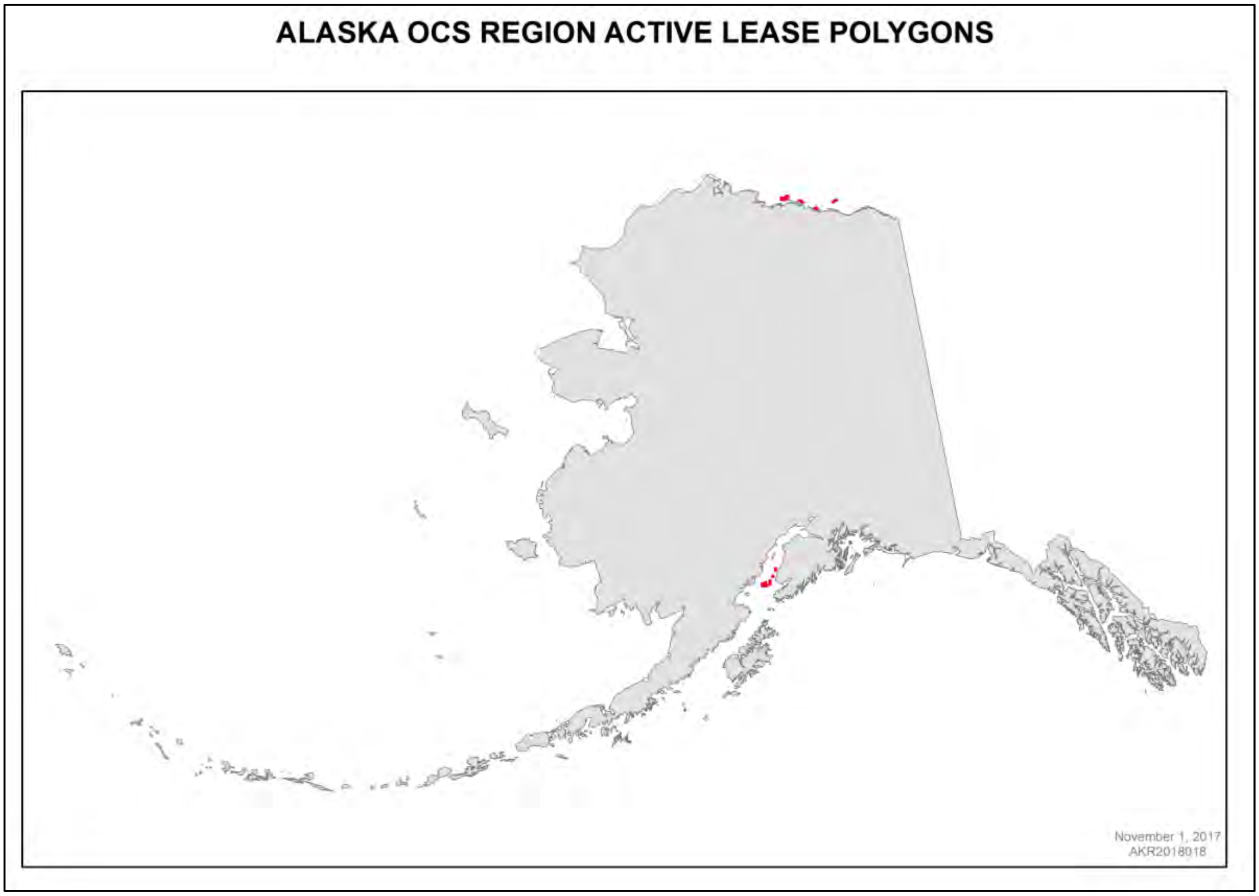

Figure 55. Active Outer Continental Shelf Oil and Gas Leases in 2017

Oil and gas exploration activities since then have been restricted to the Beaufort Sea area, mainly consisting of oil-and-gas producing artificial islands currently operating in the near-shore areas around Prudhoe Bay. The latest of these developments was approved by BOEM in October 2018 for Hilcorp Alaska LLC's Liberty Project. BOEM may conduct more lease sales in the Beaufort Sea as part of the 2019-2024 National Outer Continental Shelf Oil and Gas Leasing Draft Proposed Program (DPP). The 2017-2022 Program did not include any new leases for the Arctic, only Cook Inlet. The 2019-2024 National OCS Oil & Gas Leasing Program is expected to be finalized in 2019.[26]

However, the potential for future development still exists. The Chukchi Sea still holds an estimated 15.4 billion barrels of oil, despite Shell's failure to exploit it. Exploration activities are ultimately driven by costs and potential returns with a given price of oil. The U.S. Energy Information Administration (EIA) estimates that while prices dipped in late 2018, they may stabilize and rise over the next two years. Figure 56 shows the forecasted monthly price of two different types of benchmark crude oil from 2015 through 2020.

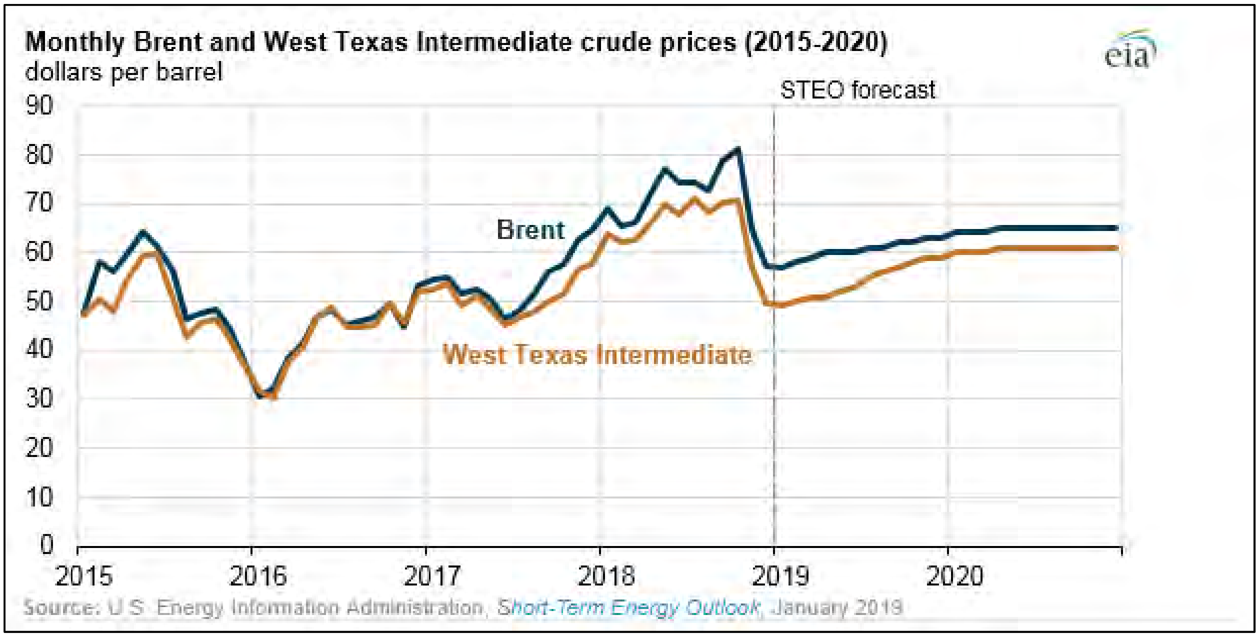

Figure 56. EIA Monthly Crude Oil Forecasts 2015-2020

Prices over the 20-year forecast period may reach a level where firms can profit from Chukchi exploration. If they do, offshore vessels would benefit from port expansions in Nome, as previously analyzed.

The benefit results of that previous analysis are shown in Table 43. They have been compared to an updated cost estimate for a comparable alternative. Alternative 3c Deepwater basin 30 feet was used for the AAEQ Costs since it was the alternative that most closely resembled the single alternative recommended by the Deep Draft Arctic Study. This level of benefits would also justify other 30-foot alternatives: 3a and 3b.

Table 42. Economic Analysis of Resource Development Scenario

Alternative	AAEQ Benefits	AAEQ Costs	Net Benefits	BCR
Alternative 3c Deepwater basin 30	$16,300,000	$15,019,000	$1,281,000	1.08

It would be possible to justify multiple project alternatives on NED benefits should the previous assumptions on oil and gas resource development re-surface. Should conditions in the oil and gas industry change in the future, there would be an opportunity to capture NED benefits from a port expansion project.

Graphite One additional barge scenario

Earlier in the Future Without-Project section of the report, it was assumed that the additional 60,000 tons and 3,333 containers of graphite from the Graphite One mine project outside of Nome would have no net increase in barge traffic on the port of Nome. In order for the existing barge fleet to achieve this, they would require 556 vacant container spaces (equivalent to one entire medium tug & barge combo) a month on their backhaul voyages to the U.S. West Coast. This may or may not exist in the future, so the impact of bringing new barge trips into Nome to ship the graphite needs to be captured. Only the medium and large tug & barge combos return to the U.S. West Coast on their backhaul voyages, where the graphite would need to be shipped. These barges have container capacities between 500-950 containers each. At the projected weight of each loaded graphite container, the largest barges calling on Nome presently could only carry approximately 600 containers before reaching their weight capacity. Using these assumptions, approximately 7 new barges, solely dedicated to graphite movements, would be needed each year at the port. Even the largest of these barges would not receive origin-to-destination benefits from deepening any element of the harbor because their maximum draft is around 18 feet. So, the only benefits they could receive would be in the form of congestion relief. As demonstrated in the previous congestion relief sections, the addition of even dozens of vessels to the system does not result in significant savings in the with-project condition, therefore it is assumed to have an insignificant effect in this scenario as well.

It is possible for Graphite One to forego the use of the existing barge fleet for graphite shipments from Nome in favor of larger container vessels in the future. There is a possibility to see the profit-maximizing opportunity of economies of scale by doing this. Because they would be shipping graphite from Alaska to the U.S. West Coast, they would require Jones Act-compliant container vessels. They would also require "geared" vessels, which come equipped with the capability to load the containers onto their own decks with built-in cranes. The largest Jones Act shipper in the Pacific, Matson Lines, has 3 Jones Act-compliant, "geared" container vessels. The largest of which has a 2,000 container capacity and a maximum draft of 30 feet. If this vessel were used to ship graphite from Nome to the U.S. West Coast in the with-project condition, it would replace 7 barge trips with 2 container trips. The distance from Seattle, WA to Nome, AK by sea is 2,272 nautical miles[27]. At a speed of 15 knots, the trips would take about 150 hours, or 6 days. The addition of 2 container vessel trips, using the latest Deep Draft Vessel Operating Costs is approximately $272,000. The elimination of 7 barge trips, using the barge operating costs from earlier in this appendix is approximately $2,000,000, given a transit time of approximately 9 days at a speed of 10 knots (barges are slower than containerships). Therefore, the origin-to-destination benefit to graphite vessels in this scenario could be approximately $1,728,000 in all alternatives.

8. REGIONAL ECONOMIC DEVELOPMENT

The long-term viability of remote and subsistence communities is dependent upon affordable, reliable, and timely cargo transshipment and barge delivery services provided by Nome. More reliable movement of goods throughout the region would contribute to the health of the regional economy and support expanded local and regional economic opportunities. The reliable delivery of essential goods to regional communities is significant to the health and welfare of the local population, as well as being a factor in residents' participation in subsistence activities and the ability to maintain the region's unique cultural heritage.

For remote communities in western and northern Alaska, Nome is an essential component of the transportation system that annually delivers the fuel and equipment which powers communities year-round; but is especially vital in winter. This project would increase the resilience of the waterborne transportation system at Nome against the ever-present threat of severe weather and poor marine conditions. As it stands now, voyages are routinely delayed or canceled due to conditions. These delays have severe consequences, including some communities having to go without certain supplies during the harsh winter months. Having a larger, more protected harbor would reduce the likelihood of these delays or cancellations. The viability of the region in inextricably linked to waterborne shipments. Lowering the risk of needed supplies failing to reach their destinations, despite the frequent bad weather, is a valuable benefit to the western Alaska region.

8.1. RECONS

USACE provides estimates of jobs and other economic measures such as labor income, value added, and sales that are supported by the Nome project. USACE's Institute for Water Resources, the Louis Berger Group and Michigan State University has developed a regional economic impact modeling tool called RECONS (Regional ECONomic System) to provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Work program spending and stem-from effects for Ports, Inland Waterway, FUSRAP and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations. These multipliers were then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates.

These following estimates of regional impacts from the Nome project were created using spending profiles and local purchase coefficients (LPC) of construction and O&M funds spent by the project. The spending profiles used for each alternative in the Nome Project are listed in Table 44. They were the same percentages for each alternative.

Table 43. Spending Profiles for Construction and O&M Expenditures at Nome

	Spending Category (Construction)	Construction Percentage (%)	O&M Percentage (%)
1	Dredging Fuel	6%	10%
2	Metals and Steel Materials	5%	2%
3	Dredging Consumables -- Textiles, Lubricants, and Metal Valves and Parts	2%	4%
4	Machinery Materials	1%	1%
5	Electrical Materials	4%	1%
6	Dredge Equipment (Depreciation and Capital Expenses)	6%	12%
7	Insurance (bond) and Workman's Comp	2%	2%
8	Construction of Other Nonresidential Structures	23%	6%
9	Cement Materials	3%	1%
10	Architectural, Design, and Engineering Services	1%	-
11	Environmental Compliance, Planning, and Technical Services	1%	1%
12	USACE Overhead	4%	8%
13	Industrial Machinery and Equipment Repair and Maintenance	10%	19%
14	USACE Wages and Benefits	7%	15%
15	Private Sector Labor or Staff Augmentation	23%	14%
16	Dredging Consumables -- Food and Beverages	2%	3%
17	Dredging Consumables – Restaurants	-	1%

The LPC for the Nome project are listed in Table 45. The percentages are cumulative as you progress from Local to State to U.S. They are the same across all alternatives.

Table 44. LPC for Construction and O&M Expenditures at Nome

Industry	Local Purchase Coefficients (Construction)			Local Purchase Coefficients (O&M)		
	Local	State	US	Local	State	US
Construction of other new nonresidential structures	87%	99%	100%	87%	99%	100%
All other food manufacturing	0%	1%	91%	0%	1%	91%
Petroleum refineries	0%	75%	81%	0%	75%	81%
Cement manufacturing	0%	0%	87%	0%	0%	87%
Iron and steel mills and ferroalloy manufacturing	0%	0%	74%	0%	0%	74%
Valve and fittings, other than plumbing, manufacturing	0%	0%	52%	0%	0%	52%
All other industrial machinery manufacturing	0%	0%	69%	0%	0%	69%
Switchgear and switchboard apparatus manufacturing	0%	0%	54%	0%	0%	54%
Ship building and repairing	0%	22%	98%	0%	22%	98%
Wholesale trade	0%	51%	100%	0%	51%	100%
Retail - Food and beverage stores	1%	79%	100%	1%	79%	100%
Air transportation	74%	80%	80%	74%	80%	80%
Rail transportation	0%	0%	99%	0%	0%	99%
Water transportation	0%	100%	100%	0%	100%	100%
Truck transportation	19%	74%	99%	19%	74%	99%
Insurance carriers	0%	23%	87%	0%	23%	87%
Architectural, engineering, and related services	1%	95%	96%	-	-	-
Environmental and other technical consulting services	0%	100%	100%	0%	100%	100%
Office administrative services	0%	87%	100%	0%	87%	100%
Commercial and industrial machinery and equipment repair and maintenance	4%	100%	100%	4%	100%	100%
Employment and payroll of federal govt, non-military	75%	100%	100%	75%	100%	100%
Private Labor	87%	99%	100%	87%	99%	100%
Limited Service Restaurants	-	-	-	0%	79%	100%

All expenditures associated with construction and O&M work at the Port of Nome were estimated for each alternative. Of this total expenditure, some will be captured within the Nome Census Area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in Tables 46 through 51. The regional economic effects are shown for the local, state, and national impact areas. Construction effects would occur over the expected duration of the construction period. O&M effects are assumed to occur every year. Total effects are the sum of all construction and O&M effects over the 50-year study period. All jobs effects are calculated and displayed in full-time equivalents (FTE). Construction period durations in Section 7.6, ROM costs, reflect the latest cost updates. The following RED tables show durations in years, not months, because construction must start up and stop each year around the presence of sea ice. So, for example, a 21-month duration is actually 6 seasons, or 6 years. While RED durations are based on previous duration estimates, they are within a margin of significance for plan evaluation, given their negligible effect on plan selection. Based on the regional economic development outputs estimated for each alternative, Alternative 8a provides the most regional economic benefits per category over the period of study.

Table 45. Regional Economic Development Impacts from Construction Spending by Type and Alternative (3a-3c)

Alt 3a Construction: Period of 33 months (8 years 1 month)					**Alt 3b Construction: Period of 21 months (5 years 1 month)**					**Alt 3c Construction: Period of 21 months (5 years 1 month)**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$162,922	512.5	$50,263	$62,019	Direct	$149,971	471.8	$46,268	$57,089	Direct	$140,759	442.8	$43,426	$53,582
Secondary	$9,614	38.8	$1,973	$5,561	Secondary	$8,850	35.8	$1,816	$5,119	Secondary	$8,306	33.6	$1,705	$4,805
Total	$101,220	551.4	$52,237	$67,581	Total	$93,173	507.5	$48,084	$62,208	Total	$87,450	476.4	$45,130	$58,387
State					**State**					**State**				
Direct	$269,600	1319.3	$101,721	$125,970	Direct	$248,167	1214.4	$93,635	$115,956	Direct	$232,924	1139.8	$87,883	$108,833
Secondary	$116,960	659.5	$37,753	$70,321	Secondary	$107,662	607.0	$34,751	$64,731	Secondary	$101,049	569.8	$32,617	$60,755
Total	$305,089	1978.8	$139,474	$196,291	Total	$280,836	1821.5	$128,386	$180,686	Total	$263,586	1709.6	$120,500	$169,588
US					**US**					**US**				
Direct	$336,073	1646.7	$118,896	$151,946	Direct	$309,356	1515.8	$109,444	$139,867	Direct	$290,354	1422.7	$102,722	$131,276
Secondary	$410,461	2066.8	$126,864	$215,269	Secondary	$377,831	1902.5	$116,779	$198,155	Secondary	$354,623	1785.6	$109,606	$185,984
Total	$664,457	3713.5	$245,760	$367,214	Total	$611,635	3418.3	$226,223	$338,022	Total	$574,067	3208.3	$212,328	$317,260

Table 46. Regional Economic Development Impacts from Construction Spending by Type and Alternative (4a-8b)

Alt 4a Construction: Period of 28 months (7 years)					**Alt 8a Construction: Period of 30 months (7 years 2 months)**					**Alt 8b Construction: Period of 21 months (5 years 1 month)**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$198,297	623.8	$61,177	$75,485	Direct	$307,116	966.1	$94,749	$116,909	Direct	$241,967	761.2	$74,649	$92,109
Secondary	$11,702	47.3	$2,402	$6,769	Secondary	$18,123	73.2	$3,720	$10,483	Secondary	$14,279	57.7	$2,931	$8,259
Total	$123,197	671.1	$63,578	$82,254	Total	$190,803	1039.3	$98,468	$127,392	Total	$150,328	818.9	$77,580	$100,368
State					**State**					**State**				
Direct	$328,136	1605.7	$123,807	$153,321	Direct	$508,207	2486.9	$191,748	$237,458	Direct	$400,400	1959.4	$151,072	$187,086
Secondary	$142,355	802.7	$45,950	$85,590	Secondary	$220,475	1243.1	$71,165	$132,558	Secondary	$173,705	979.4	$56,069	$104,439
Total	$371,331	2408.4	$169,757	$238,910	Total	$575,106	3730.0	$262,914	$370,017	Total	$453,108	2938.8	$207,141	$291,524
US					**US**					**US**				
Direct	$409,042	2004.3	$144,711	$184,937	Direct	$633,511	3104.1	$224,124	$286,424	Direct	$499,123	2445.6	$176,580	$225,664
Secondary	$499,581	2515.5	$154,409	$262,008	Secondary	$773,736	3896.0	$239,144	$405,790	Secondary	$609,601	3069.5	$188,414	$319,709
Total	$808,726	4519.8	$299,121	$446,945	Total	$1,252,529	7000.1	$463,269	$692,214	Total	$986,827	5515.2	$364,995	$545,373

Table 47. Regional Economic Development Impacts from O&M Spending by Type and Alternative (3a-3c)

Alt 3a O&M					**Alt 3b O&M**					**Alt 3c O&M**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$1,834	6.2	$734	$930	Direct	$1,856	6.3	$743	$941	Direct	$2,018	6.9	$808	$1,024
Secondary	$112	0.4	$21	$66	Secondary	$113	0.4	$21	$67	Secondary	$123	0.5	$23	$73
Total	$1,188	6.6	$755	$997	Total	$1,202	6.7	$764	$1,008	Total	$1,307	7.3	$831	$1,096
State					**State**					**State**				
Direct	$4,617	30.3	$2,217	$2,767	Direct	$4,672	30.7	$2,244	$2,800	Direct	$5,080	33.4	$2,440	$3,044
Secondary	$2,209	12.2	$706	$1,353	Secondary	$2,235	12.3	$714	$1,369	Secondary	$2,430	13.4	$776	$1,488
Total	$5,960	42.5	$2,923	$4,120	Total	$6,031	43.0	$2,958	$4,169	Total	$6,557	46.7	$3,216	$4,533
US					**US**					**US**				
Direct	$5,886	37.3	$2,617	$3,312	Direct	$5,956	37.8	$2,649	$3,351	Direct	$6,476	41.1	$2,880	$3,643
Secondary	$7,526	38.2	$2,355	$3,991	Secondary	$7,616	38.6	$2,383	$4,039	Secondary	$8,280	42.0	$2,591	$4,391
Total	$12,540	75.5	$4,972	$7,303	Total	$12,689	76.4	$5,031	$7,390	Total	$13,796	83.1	$5,470	$8,034

Table 48. Regional Economic Development Impacts from O&M Spending by Type and Alternative (4a-8b)

Alt 4a O&M					**Alt 8a O&M**					**Alt 8b O&M**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$1,834	6.2	$734	$930	Direct	$1,826	6.2	$731	$926	Direct	$1,475	5.0	$590	$748
Secondary	$112	0.4	$21	$66	Secondary	$112	0.4	$21	$66	Secondary	$90	0.3	$17	$53
Total	$1,188	6.6	$755	$996	Total	$1,183	6.6	$752	$993	Total	$955	5.3	$607	$802
State					**State**					**State**				
Direct	$4,617	30.3	$2,217	$2,767	Direct	$4,598	30.2	$2,208	$2,756	Direct	$3,714	24.4	$1,784	$2,226
Secondary	$2,209	12.2	$705	$1,353	Secondary	$2,200	12.1	$703	$1,347	Secondary	$1,777	9.8	$567	$1,088
Total	$5,960	42.5	$2,923	$4,120	Total	$5,936	42.3	$2,911	$4,103	Total	$4,794	34.2	$2,351	$3,314
US					**US**					**US**				
Direct	$5,886	37.3	$2,617	$3,311	Direct	$5,862	37.2	$2,607	$3,298	Direct	$4,734	30.0	$2,105	$2,664
Secondary	$7,525	38.2	$2,355	$3,991	Secondary	$7,495	38.0	$2,345	$3,975	Secondary	$6,053	30.7	$1,894	$3,210
Total	$12,538	75.5	$4,972	$7,302	Total	$12,488	75.2	$4,952	$7,273	Total	$10,086	60.7	$3,999	$5,874

Table 49. Total Regional Economic Development Impacts from All Spending by Type and Alternative (3a-3c)

Alt 3a Total					**Alt 3b Total**					**Alt 3c Total**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$254,622	822.5	$86,963	$108,519	Direct	$242,771	786.8	$83,418	$104,139	Direct	$241,659	787.8	$83,826	$104,782
Secondary	$15,214	58.8	$3,023	$8,861	Secondary	$14,500	55.8	$2,866	$8,469	Secondary	$14,456	58.6	$2,855	$8,455
Total	$160,620	881.4	$89,987	$117,431	Total	$153,273	842.5	$86,284	$112,608	Total	$152,800	841.4	$86,680	$113,187
State					**State**					**State**				
Direct	$500,450	2,834.3	$212,571	$264,320	Direct	$481,767	2,749.4	$205,835	$255,956	Direct	$486,924	2,809.8	$209,883	$261,033
Secondary	$227,410	1,269.5	$73,053	$137,971	Secondary	$219,412	1,222.0	$70,451	$133,181	Secondary	$222,549	1,239.8	$71,417	$135,155
Total	$603,089	4,103.8	$285,624	$402,291	Total	$582,386	3,971.5	$276,286	$389,136	Total	$591,436	4,044.6	$281,300	$396,238
US					**US**					**US**				
Direct	$630,373	3,511.7	$249,746	$317,546	Direct	$607,156	3,405.8	$241,894	$307,417	Direct	$614,154	3,477.7	$246,722	$313,426
Secondary	$786,761	3,976.8	$244,614	$414,819	Secondary	$758,631	3,832.5	$235,929	$400,105	Secondary	$768,623	3,885.6	$239,156	$405,534
Total	$1,291,457	7,488.5	$494,360	$732,364	Total	$1,246,085	7,238.3	$477,773	$707,522	Total	$1,263,867	7,363.3	$485,828	$718,960

Table 50. Total Regional Economic Development Impacts from All Spending by Type and Alternative (4a-8b)

Alt 4a Total					**Alt 8a Total**					**Alt 8b Total**				
Region	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**	**Region**	**Output ($000)**	**Jobs***	**Labor Income ($000)**	**Value Added ($000)**
Local					**Local**					**Local**				
Direct	$289,997	933.8	$97,877	$121,985	Direct	$398,416	1,276.1	$131,299	$163,209	Direct	$315,717	1,011.2	$104,149	$129,509
Secondary	$17,302	67.3	$3,452	$10,069	Secondary	$23,723	93.2	$4,770	$13,783	Secondary	$18,779	72.7	$3,781	$10,909
Total	$182,597	1,001.1	$101,328	$132,054	Total	$249,953	1,369.3	$136,068	$177,042	Total	$198,078	1,083.9	$107,930	$140,468
State					**State**					**State**				
Direct	$558,986	3,120.7	$234,657	$291,671	Direct	$738,107	3,996.9	$302,148	$375,258	Direct	$586,100	3,179.4	$240,272	$298,386
Secondary	$252,805	1,412.7	$81,200	$153,240	Secondary	$330,475	1,848.1	$106,315	$199,908	Secondary	$262,555	1,469.4	$84,419	$158,839
Total	$669,331	4,533.4	$315,907	$444,910	Total	$871,906	5,845.0	$408,464	$575,167	Total	$692,808	4,648.8	$324,691	$457,224
US					**US**					**US**				
Direct	$703,342	3,869.3	$275,561	$350,487	Direct	$926,611	4,964.1	$354,474	$451,324	Direct	$735,823	3,945.6	$281,830	$358,864
Secondary	$875,831	4,425.5	$272,159	$461,558	Secondary	$1,148,486	5,796.0	$356,394	$604,540	Secondary	$912,251	4,604.5	$283,114	$480,209
Total	$1,435,626	8,294.8	$547,721	$812,045	Total	$1,876,929	10,760.1	$710,869	$1,055,864	Total	$1,491,127	8,550.2	$564,945	$839,073

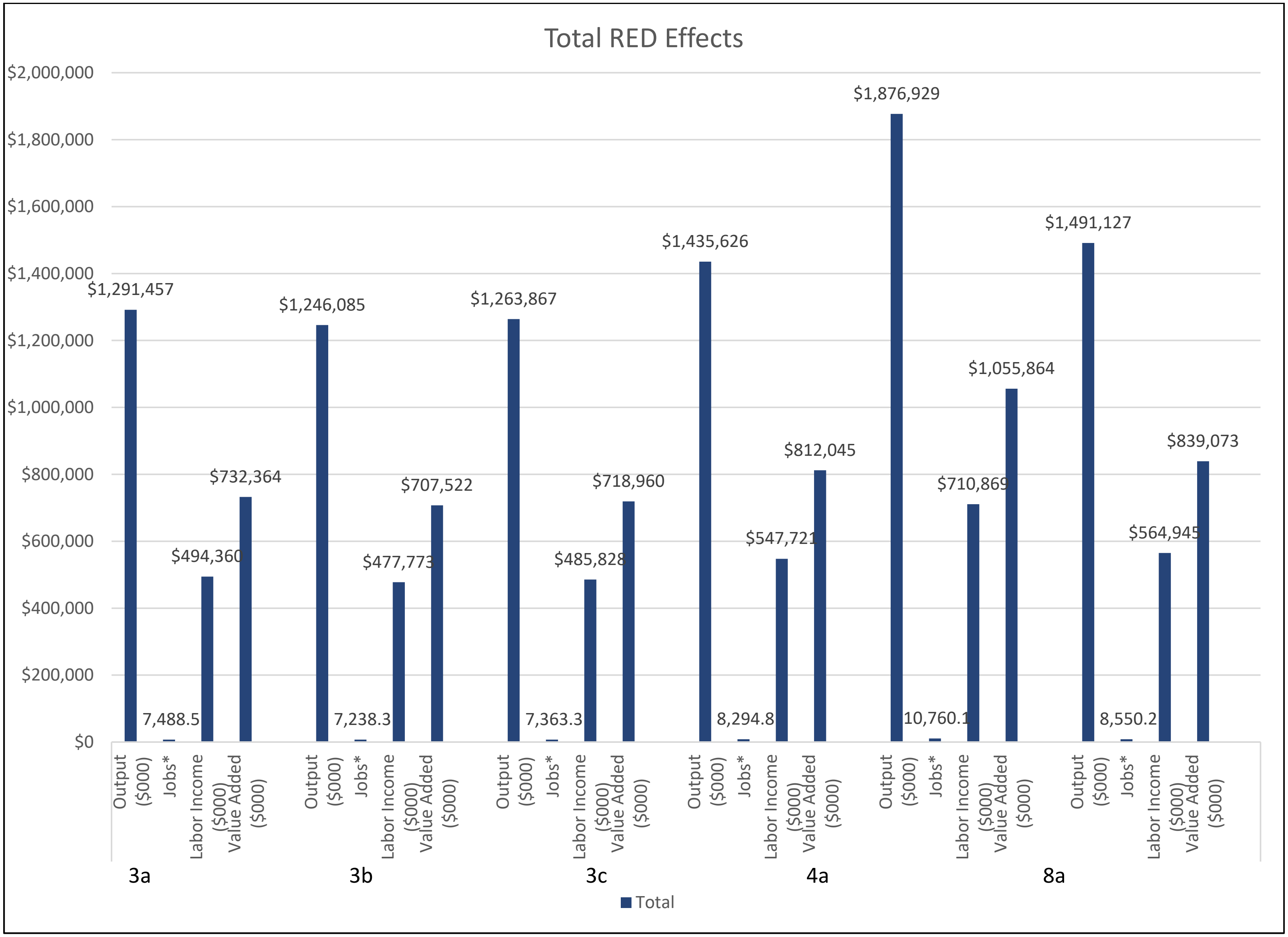

Figure 57. Total Regional Economic Development Effects by Type and Alternative

9. ADDITIONAL BENEFITS ANALYSIS

9.1. Remote and Subsistence Community Viability

In addition to contributions to NED, a Federal project at Nome may be justified with regional benefits as outlined in Section 1105 of WRDA 2016. This allows for the consideration of benefits to communities located within the Nome region when evaluating navigation improvements for Nome's harbor. This provision allows the approval for such harbors without the need to demonstrate justification solely on NED benefits if the long-term viability of a community located within the region served by the project would be threatened without the navigation improvements.

For the Nome project, Section 1105 provides an opportunity to consider the additional benefits in the RED, OSE, and EQ accounts through a Cost Effectiveness/Incremental Cost Analysis (CE/ICA). Corps implementation guidance for this legislation calls for an assessment of project benefits, including:

- Public health and safety of the local community, including access to facilities designed to protect public health and safety;
- Access to natural resources for subsistence purposes;
- Local and regional economic opportunities;
- Welfare of the local population; and
- Social and cultural value to the community.

Section 1105 benefit categories were identified that represent issues of importance to the Nation, the State of Alaska, to project stakeholders in Nome, and to the region served by the port. To facilitate characterization of long-term community viability at Nome and other communities served by the port, (collectively referred to simply as community viability from here on), the PDT developed a community viability unit (CVU) to consider such benefits. More detail on the methodology and evaluation of these categories is contained in Attachment 1, Documentation of the CE/ICA.

9.2. National Security

Proposed navigation improvements at Nome may also support National Security needs in the Arctic. The Nome project also has the opportunity to include consideration of benefits to National Security. Section 1202(c)(3) of WRDA 2016 expands the feasibility justification of an Arctic deep draft harbor and related navigation improvements to include consideration of benefits associated with National Security and homeland protection. Corps implementation guidance for this legislation states that identification of a recommended plan can be supported by a CE/ICA. The Corps provided additional guidance on consideration of National Security benefits in a July 2018 memorandum from a meeting of the NWD/POD Regional Integration Team.

This authorization follows recent research and literature on a need for an expanded U.S. presence in the Arctic. The most recent Arctic Strategy from the Department of Defense (2016) highlights the need for an improved Arctic presence. The need for an Arctic deep draft port is identified specifically in the infrastructure needs assessment published by the U.S. Committee on the Marine Transportation System Arctic Marine Transportation Integrated Action Team (2016).

National Security contributions of alternative plans will be evaluated in terms of a unit referred to as National Security Units (NSUs). The framework could support evaluation of NSUs by themselves, as well as in combination with the CVUs discussed above. For the purpose of the main alternatives evaluation, NSUs are considered separately from CVUs. More detail on the methodology and evaluation of these categories is contained in Attachment 1, Documentation of the CE/ICA.

9.3. CE/ICA Inputs and Results

The PDT developed variables to capture community viability and national security for which there was a difference in expected output among the alternatives. Figure 58 provides the collection of variables and their relationships. The Community Viability Unit (CVU) is derived from the outputs of five variables. The National Security Units (NSUs) were maintained as a separable element.

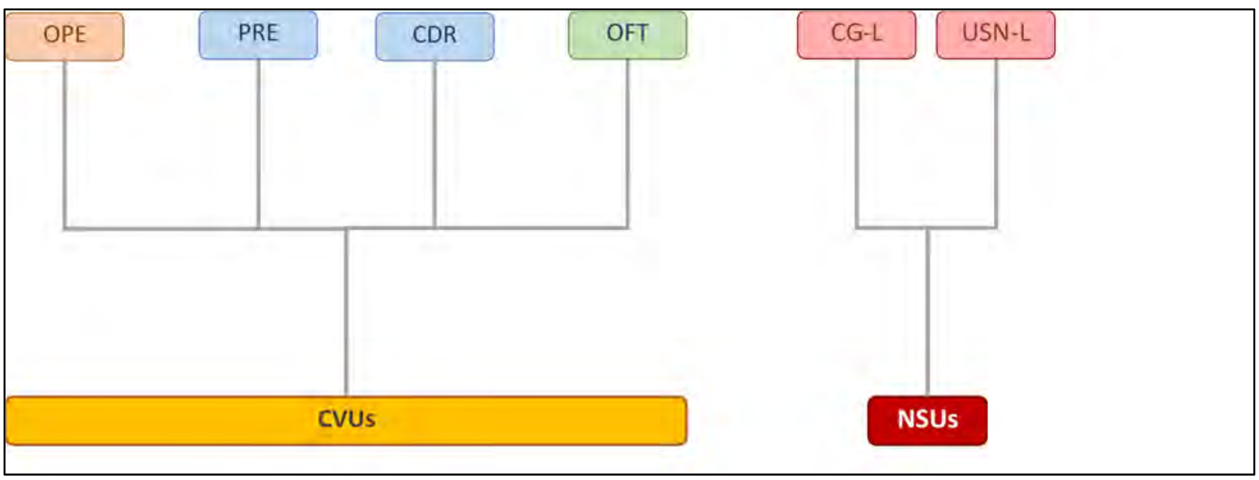

Figure 58. Final Nome CE/ICA Framework

<u>Note: Variable Names:</u> OPE (other port economic effects); PRE (port of refuge effects); CDR (cargo delivery reliability); OFT (overwater fuel transfer);CVU (community viability units); CG-L (Coast Guard Logistics); USN-L (U.S. Navy Logistics); NSU (national security units)

9.3.1. Variable Explanations

9.3.1.1. OPE: Other Port (Economic) Effects

The OPE output variable was included to describe expected permanent growth in local economic opportunities at the port and related local businesses from increased business at the port. Such growth would result in benefits to two of the areas identified in the Section 1105 implementation guidance. Economic growth in Nome from additional port activity and the city's related industries would result in increases in economic opportunities, both locally in Nome and in the region. As a relatively large community, regional wage employment opportunities are affected by the health of the Nome economy. A healthy regional economy would in turn contribute to the welfare of the local and regional population by increasing the economic viability of the subsistence culture in the region. Additional vessel traffic and support for larger vessels would be expected to increase sales for existing ships services, such as expanded fuel, water, waste, and mechanical/machine/diving services at the port. These opportunities were determined to not be duplicative with effects of with-project construction and O&M expenditures that were modeled in the RED section. Inclusion of the variable contributes to the consideration of community welfare and regional economic opportunities which are critical to viability of rural and subsistence communities in the Arctic. These employment and income opportunities associated with port operations under with project conditions are available to individuals throughout the region and allow financial support of family members in the regional community to continue to support their desired cultural subsistence lifestyle.

9.3.1.2. PRE: Port of Refuge Effects

The PRE output variable addresses the safety of vessels and crews in inclement weather. The port currently serves as a port of refuge during inclement weather; however, not all vessels that operate in the Nome area are able to take refuge if necessary. Crews on vessels unable to seek refuge, due to vessel size or lack of available space inside the port, could be at greater risk of injury. Data on operational injuries due to inclement weather in the Nome area are not available, so the likelihood of an incident and the subsequent risk to vessels and personnel is unknown at this time. Project alternatives would increase the port's capacity to provide shelter to vessels during inclement weather conditions. Alternatives would also reduce the wave action inside the modified harbor, reducing the opportunity for injury. The PDT considered how each alternative would improve refuge opportunity by both reducing existing wave climate inside the harbor and expanding the port's refuge capacity in the development of scores.

9.3.1.3. CDR: Cargo Delivery Reliability

The long-term viability of local communities is dependent upon affordable, reliable, and timely cargo transshipment and barge delivery services provided by Nome. More reliable movement of goods throughout the region would contribute to the health of the regional economy and support expanded local and regional economic opportunities. The reliable delivery of essential goods to regional communities is significant to the health and welfare of the local population.

For remote communities in western and northern Alaska, Nome is an essential component of the transportation system that annually delivers the fuel and equipment which powers communities year-round; but is especially vital in winter. The CDR variable considers how alternatives would support increased reliability of and capacity for cargo transshipment services. The port and PDT found that alternatives with increased dock numbers are expected to improve transshipment and barge turn-around times. More space could potentially allow for cargo movements to be made quicker. This could allow for both a delayed or additional barge to still deliver to regional communities each open water season. This additional flexibility would reduce any risk of fuel or supply shortages in remote communities due to shortened barge seasons from inclement weather or other factors.

9.3.1.4. OFT: Overwater Fuel Transfer

The CE/ICA framework includes the OFT variable to represent EQ benefits. Some vessels are too large to enter port for refueling service and need to take on fuel at anchor under without project conditions. Other vessels that participate in the “floating gas station” model conduct their primary refueling business overwater. Refueling overwater increases the opportunity for broad environmental contamination resulting from a marine fuel spill. This region is dependent upon subsistence and marine resources. Therefore, environmental quality is important from a cultural and an economic perspective. The region’s subsistence culture is inextricably tied to environmental quality, with participants dependent upon access to high quality natural resources. Data on spills during overwater fuel transfers in the Nome area are not available, so the likelihood of an incident and the subsequent risk to the environment is unknown at this time. An increase in dock space and depth for refueling vessels could reduce the need for overwater fuel transfers, reducing the opportunity for environmental contamination.

9.3.1.5. NSU: National Security Units

As shown above in Figure 3, NSUs were maintained as separate output type. NSUs are representative of likely benefits to National Security, consistent with Section 1202(c)(3) and related implementation guidance, which supports consideration of benefit stemming from an Arctic deep draft harbor and related improvements at Nome. The principal sources of national security benefits identified for consideration in this analysis were benefits to the U.S. Coast Guard and U.S. Navy, both of which could call at Nome for refueling, resupply, and other services. Support of U.S. Coast Guard logistics was captured in the U.S. Coast Guard Logistics (CG-L) variable, and support of U.S. Navy logistics was captured in the U.S. Navy Logistics (USN-L) variable.

9.3.1.5.1. CG-L Coast Guard Logistics

The U.S. Coast Guard and its fleet provide critical services in the Arctic, and improved infrastructure at Nome would benefit existing and future U.S. Coast Guard activities and vessels. The two types of U.S. Coast Guard vessels likely to call at Nome are cutters and icebreakers. Cutters typically have a draft of 15-21 feet. The icebreaker Healy requires a draft of 38 feet, and current designs for the planned Polar Security icebreaker will require nearly 40 feet of draft (USACE 2019). Identification of relative output among the alternatives considers whether calling cutters and icebreakers would be able to enter the harbor and dock.

9.3.1.5.2. USN-L: United States Navy Logistics

U.S. Navy operations in the Arctic require fuel north of Dutch Harbor, AK in order to perform its Homeland Defense mission. An improved Port of Nome, capable of receiving auxiliary support ships could improve logistic support in the region. In addition to providing fuel for forces operating in the northern Bering, southern Chukchi, and western Beaufort Seas, an accessible port would provide unique benefits to Homeland Defense including a port of refuge, logistics support, and a location to loiter as the maritime situation unfolds.

Based upon coordination with U.S. Northern Command, the two vessel types (surface combatant and auxiliary support ships) were representative of potential U.S. Navy calls at Nome.

Surface combatants include the DDG-51 (Arleigh Burke-class guided missile destroyer), which requires a 36-foot draft and is 505 feet long. Additionally, the U.S. Navy is developing a new Large Surface Combatant that will be the successor to DDG-51 and CG-47 (Ticonderoga-class guided missile cruiser) and is expected to enter the fleet in the late 2020's or early 2030's. This vessel is expected to be 10% longer, marginally wider, and have approximately the same draft as the DDG-51 (USACE 2019).

Several types of auxiliary support ships were identified. The T-AO (Henry-Kaiser-class fleet replenishment oiler) is 677.5 feet in length and requires 38 feet of draft. The T-AO successor design, T-AO-205 (John Lewis-class), is a similar design to the Kaiser-class but is slightly longer, at 745.7 feet. And the T-AKE (Lewis and Clark-class dry cargo/ammunition ship) is 689 feet long and requires 33 feet of draft.

9.3.2. Output Quantification by Variable

Scoring of outputs on a scale of 1 to 10 (10 being the highest) for each combination of alternative and variable scenario was performed by the PDT in order to facilitate group discussion and consensus. The following subsections document the scores developed and the rationale for the point selections. Table 52 provides a summary of the scores. The scores were reviewed and judged by the team to be representative of changes in conditions from the FWOP condition for each variable with each alternative and depth considered. For NSUs, scores were developed with input from representatives of the U.S. Coast Guard and U.S. Navy Northern Command. For the purpose of the NSU evaluation, only Alternatives 4 and 8 were considered, as Alternative 3 options did not provide adequate maneuverability in the outer harbor to be viable.

Table 51. Score by Alternative and Variable

Alternative	Depth	CVU Variable Scores				NSU Variable Scores			
						CG-L		USN-L	
		OPE	PRE	CDR	OFT	Ice-breaker	Cutter	Surface Comb.	Aux. Support
No Action	-	0	0	0	0	0	0	0	0
Alt 3a	30 feet	4	1	3	3				
	35 feet	6	2	4	4				
	40 feet	7	3	5	5				
Alt 3b	30 feet	3	1	2	2				
	35 feet	4	2	3	3				
	40 feet	5	3	4	4				
Alt 3c	30 feet	2	1	1	2				
	35 feet	3	2	2	2				
	40 feet	4	3	3	3				
Alt 4a	30 feet	6	6	5	6	0	8	0	0
	35 feet	8	7	6	8	0	9	0	0
	40 feet	10	8	7	10	8	10	8	8
Alt 8a	30 feet	6	8	8	6	0	8	0	0
	35 feet	8	9	9	8	0	9	0	0
	40 feet	10	10	10	10	10	10	10	10
Alt 8b	30 feet	6	7	7	6	0	8	0	0
	35 feet	8	8	8	8	0	9	0	0
	40 feet	10	9	9	10	10	10	10	10

9.3.2.1. OPE: Other Port (Economic) Effects

The port drives the Nome economy, enabling it to act as a regional hub in the provision of goods and services across many industries. In the future without project condition, the growth potential for the regional economy would be limited as compared to its potential with the project in place. Scores for the OPE variable were informed by the number of docks that would be provided by each of the alternatives and the configuration of the causeways. With additional docks, more fuel, water, supply, or waste services could be delivered concurrently, which would increase the volume of business that the port could perform per unit time. Additionally, inclusion of the east causeway would further increase delivery capacity and flexibility, especially in that refueling by truck could be supported at docks even if not all docks have dedicated fuel headers. Finally, the depth of the basin was judged to be an important factor in whether larger vessels would be able to maximize use of port services, such as being able to come into or out of the harbor fully loaded. This was reflected by substantial point decreases for shallower depth scenarios. Similarly, support for larger vessels would maximize the additional business to related port industries. Given these considerations, Alternatives 4a, 8a, and 8b all had maximum scores, and Alternatives 3c, 3b, and 3a had lower scores based upon their configuration.

9.3.2.2. PRE: Port of Refuge Effects

In the without project condition, there would continue to be limitation on the port's ability to provide optimal refuge in terms of the number of vessels and the sizes which could be served. Discussion of refuge include two components, refuge capacity (size of protected area that would be provided), and wave climate (how the configuration would handle typical storms). The PDT engineer determined that all alternatives would perform better than the existing condition, but that differences in performance between the alternatives regarding wave climate was negligible. As such, the PDT focused discussion on refuge capacity, as the various alternatives and depths would allow for different quantity and size of vessels to be sheltered. Factors that increased the score for an alternative include the size of the turning basin (allowing for more vessels to be sheltered), the length of the causeways (which could be used to raft vessels even if there are no available docks), and the number of docks (which allows more vessels to be docked during storms). The consideration of depth focused on the extent to which deeper depths would decrease the likelihood that a vessel couldn't be sheltered due to draft, which was judged to be a small benefit, reflected by small decreases in scores for shallower depths. Given these considerations, Alternative 8a ranked the highest due to its long causeways, followed closely by Alternatives 8b and 4a.

9.3.2.3. CDR: Cargo Delivery Reliability

In the without project condition, the existing operational constraints would remain, including harbor depth, port throughput limits (congestion and cargo handling speed), and port configuration (dock size, turning basin, etc.). The alternatives provide an opportunity to reconfigure the port to support more reliable and efficient operations. This would benefit the region's communities that depend on Nome for life-sustaining supplies and fuel. Scoring of the CDR variable focused on how the alternative configurations and depths would affect the efficiency and throughput for cargo transshipment activity, which is the essential service provided by the port in the provision of goods by barge to regional communities. The PDT determined that the number of docks provided by the alternative would be a driving factor, as it would allow more cargo to be processed concurrently, reducing wait time for vessels. The port noted that operationally, it would prefer to keep industrial activity on the west causeway and its docks, and therefore additional docks on the east causeway would be less desirable than on the west causeway for this variable. Additionally, alternatives with wider entrance channels would likely improve efficiency and the ability for multiple vessels to move in and out of the harbor while maintaining safe navigation. The consideration of depth focused on the extent to which deeper depths would improve efficiency. Because of the size of barges typically used to deliver regional goods, depth was judged to have only minor benefit as compared to the alternative configuration and is reflected by small decreases in scores for shallower depths. Given these considerations, Alternative 8a ranked the highest, given large causeway and dock configuration, followed closely by 8b. Alternative 4a ranked well, but somewhat below 8a and 8b given its focus on extra docks on the east causeway. The lowest ranking alternatives were 3a, 3b, and 3c, respectively.

9.3.2.4. Overwater Fuel Transfer

In the without project condition, overwater fuel transport would be expected to continue due to continued lack of dockside options in the region. The alternatives provide an opportunity to meet additional refueling need at the dock and reducing risk to contamination of marine resources upon which subsistence participants depend for food and cultural value. In the discussion of the OFT variable, the PDT concurred that the number of docks was the key driver, as more docks meant more fuel volume could be delivered per unit time, allowing a greater proportion of demand to be met at the Port. The configuration of the docks (east vs west causeway) was judged to be a minor factor for the OFT variable, as the Port currently offers trucked fuel for small vessels and would continue to offer trucked fuel at and docks not equipped with a permanent fuel header. Depth was judged to play an important role but was less a driver of scores than the number of docks. Regarding the depth scenarios, the PDT noted that at shallower depths, the largest vessels accommodated might be unable to take a full load of fuel, resulting in moderate point reductions for successively shallower depth scenarios. Given these considerations, alternatives 4a, 8a, and 8b all received the same high scores, with alternatives 3c, 3b, and 3a receiving substantially lower scores due to the reduced number of docks.

9.3.2.5. National Security Units

In the without project condition, medium and large vessel classes, such as U.S. Coast Guard cutters and icebreakers, are unable to enter the Port due to their draft. The alternatives would provide an opportunity to support medium and/or large size vessels; offering opportunity for refueling, supply provisioning, crew shifts, and other logistics support.

Scoring for NSUs was based upon input from the U.S. Coast Guard and U.S. Navy Northern Command. Representatives of both agencies participated in a scoring meeting with the PDT to document the types of vessels that should be considered and the rationale for point selections. To generate a single NSU output value, scores across the four vessels types were averaged.

For the CG-L variable, two representative vessel types were discussed: icebreakers and cutters. The current U.S. Coast Guard icebreaker that serves the Arctic is the Healy, which requires 38 feet of draft. As such, the 30- and 35-foot depth options scored zero points. At 40 feet, Alternative 4A scored 8 points and alternatives 8A and 8B each scored the maximum 10 points. Alternative 4A scored lower due to smaller size of the turning basin in the Deepwater basin, which might limit maneuverability. It was also judged that the same scores would apply to the planned Polar Security Cutter/Icebreaker. For cutters with around 20 feet of draft, scoring reflected that these vessels could dock at any of the alternative depths, though increased depth and capacity in the Deepwater harbor would yield additional flexibility in operation of the port to meet the needs of the calling vessel.

Similarly, for the USN-L variable, two vessel types were discussed: surface combatants and auxiliary support vessels. For surface combatants, only the 40-foot depth alternative provided sufficient draft. Additionally, these long vessels would require the use of a 600-foot dock. The relatively small size of the turning basin in the Deepwater harbor was also judged to adversely affect the score for Alternative 4A 40-feet, whereas Alternatives 8A and 8B both received maximum scores. For auxiliary support vessels, the 40-foot depth alternatives would also be required, and their even longer length again resulted in a preference for alternatives 8A and 8B due to maneuverability concerns with 4A.

9.3.3. CE/ICA Results

The derived CVUs and NSUs were calculated based on the scores. For CVUs, each of the five component variables are equally weighted by averaging the scores across the variables. A scale factor of 100 is then applied to the resulting average scores to yield CVUs. A sensitivity analysis was performed which confirmed that equal weighting of these variables was appropriate. For NSUs, the NSU variable is the only component variable, and this score is multiplied by a scale factor of 100. Details of that are contained in Attachment 1. Table 53 presents the computed CVUs and NSUs for each alternative and depth scenario. Figure 59 shows the computed CVUs for the range of alternatives, and Figure 60 shows the range of scores across alternatives for NSUs.

Table 52. CVUs by Alternative

Alternative	Depth Scenario	CVUs	NSUs
No Action	-	0	0
Alt 3a	1 (30ft)	275	
Alt 3a	2 (35ft)	400	
Alt 3a	3 (40ft)	500	
Alt 3b	1 (30ft)	200	
Alt 3b	2 (35ft)	300	
Alt 3b	3 (40ft)	400	
Alt 3c	1 (30ft)	150	
Alt 3c	2 (35ft)	225	
Alt 3c	3 (40ft)	325	
Alt 4a	1 (30ft)	575	200
Alt 4a	2 (35ft)	725	200
Alt 4a	3 (40ft)	875	900
Alt 8a	1 (30ft)	700	200
Alt 8a	2 (35ft)	850	200
Alt 8a	3 (40ft)	1000	1,000
Alt 8b	1 (30ft)	650	200
Alt 8b	2 (35ft)	800	200
Alt 8b	3 (40ft)	950	1,000

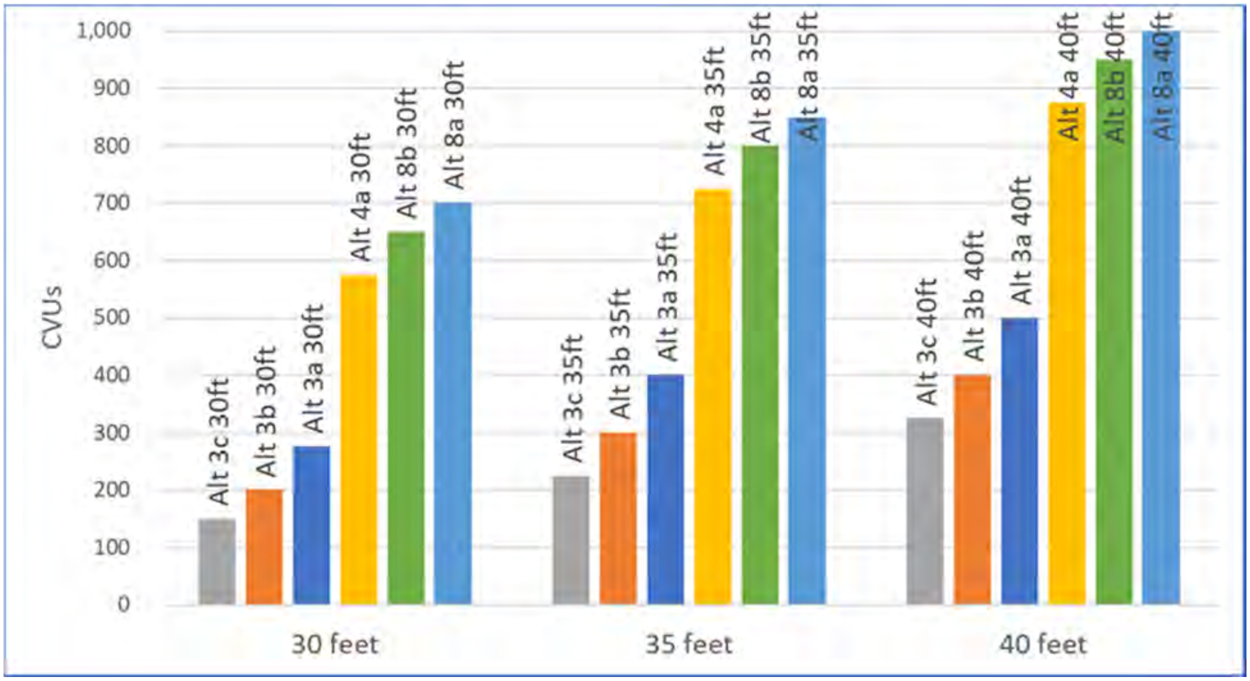

Figure 59. CVUs by Alternative

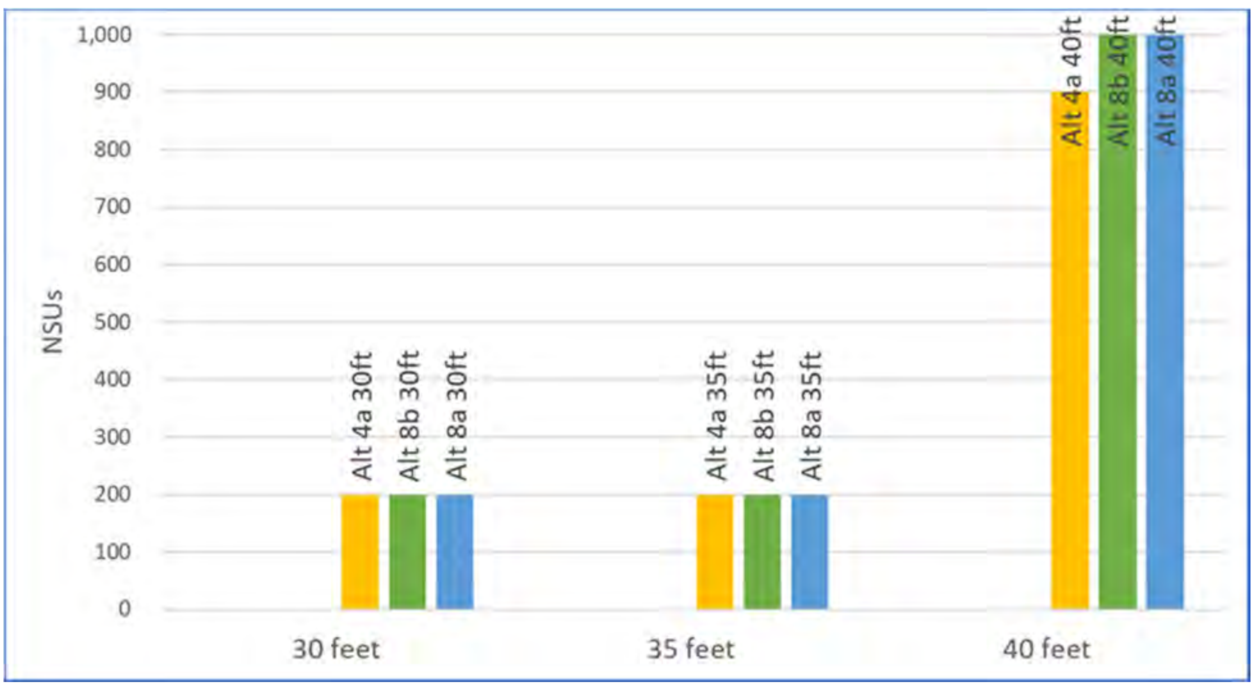

Figure 60. NSUs by Alternative

A CE/ICA model run was then performed using CVUs as the output. Previously developed costs were used for each alternative. Table 54 presents the input data which was fed into IWR Planning Suite. Because each of the alternatives are mutually exclusive, alternatives are entered as Measures, each with three Scales, one for each of the three depth scenarios. Combinability rules are specified such that no measures are combinable. This results in a CE/ICA which ranks complete alternatives according to their cost effectiveness and incremental cost. Table 55 presents the ranking of alternatives produced from the model. Of the total possible 19 plans, including the No Action, there were eight plans which were not cost effective, eight which were cost effective but not best buys, and three which were best buys. Best buy plans over the No Action, in order of total output, were 4A (40ft) and 8A (40ft). Table 56 presents the incremental cost calculations for the best buy plans. Figure 61 presents all these plans according to their output and cost. Figure 62 presents the incremental cost box plot for the best buy plans.

Table 53 CE/ICA Input Data, CVUs

Measure	Scale	Annualized Cost $1000	Output
No Action	-	$0	0
Alt 3a	1 (30ft)	$12,514	275
Alt 3a	2 (35ft)	$16,145	400
Alt 3a	3 (40ft)	$14,629	500
Alt 3b	1 (30ft)	$12,185	200
Alt 3b	2 (35ft)	$15,874	300
Alt 3b	3 (40ft)	$14,321	400
Alt 3c	1 (30ft)	$11,681	150
Alt 3c	2 (35ft)	$15,761	225
Alt 3c	3 (40ft)	$13,813	325
Alt 4a	1 (30ft)	$15,633	575
Alt 4a	2 (35ft)	$19,019	725
Alt 4a	3 (40ft)	$17,722	875
Alt 8a	1 (30ft)	$27,190	700
Alt 8a	2 (35ft)	$28,708	850
Alt 8a	3 (40ft)	$28,637	1,000
Alt 8b	1 (30ft)	$25,852	650
Alt 8b	2 (35ft)	$26,706	800
Alt 8b	3 (40ft)	$27,300	950

Table 54 CE/ICA Outputs, CVUs

Plan	Annualized Cost $1000	Output	Cost/Output $1000	Type
No Action	**$0**	**0**	**-**	**Best Buy**
3a - 30ft	$12,514	275	$46	Cost Effective
3a - 35ft	$16,145	400	$40	Non-Cost Effective
3a - 40ft	$14,629	500	$29	Cost Effective
3b - 30ft	$12,185	200	$61	Cost Effective
3b - 35ft	$15,874	300	$53	Non-Cost Effective
3b - 40ft	$14,321	400	$36	Cost Effective
3c - 30ft	$11,681	150	$78	Cost Effective
3c - 35ft	$15,761	225	$70	Non-Cost Effective
3c - 40ft	$13,813	325	$43	Cost Effective
4a - 30ft	$15,633	575	$27	Cost Effective
4a - 35ft	$19,019	725	$26	Non-Cost Effective
4a - 40ft	$17,722	875	**$20**	**Best Buy**
8a - 30ft	$27,190	700	$39	Non-Cost Effective
8a - 35ft	$28,708	850	$34	Non-Cost Effective
8a - 40ft	$28,637	1000	**$27**	**Best Buy**
8b - 30ft	$25,852	650	$40	Non-Cost Effective
8b - 35ft	$26,706	800	$33	Non-Cost Effective
8b - 40ft	$27,300	950	$29	Cost Effective

Table 55. Incremental Cost Summary, CVUs

Best Buy	Alternative	Annualized Cost $1000	Incremental Cost $1000	Total Output	Incremental Output	Incremental Cost/Output $1000
1	No Action	$0	$0	0	0	$0
2	Alt 4a, 40ft	$17,722	$17,722	875	875	$20
3	Alt 8a, 40ft	$28,637	$10,915	1000	125	$87

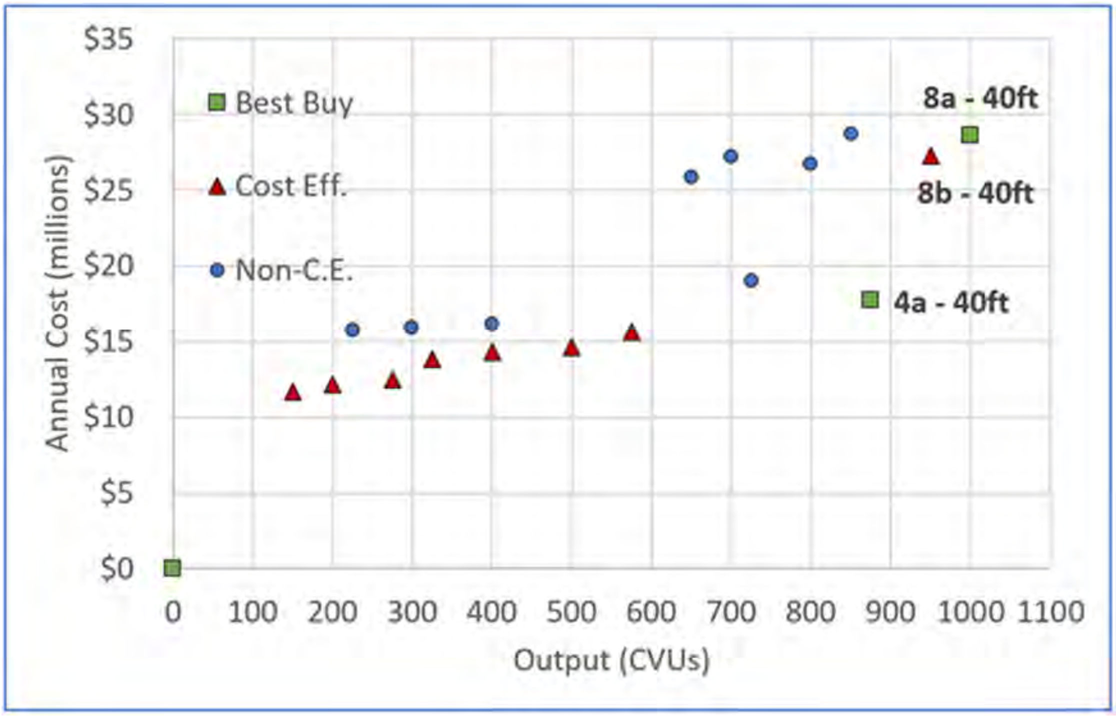

Figure 61. All Possible Plans, CVUs

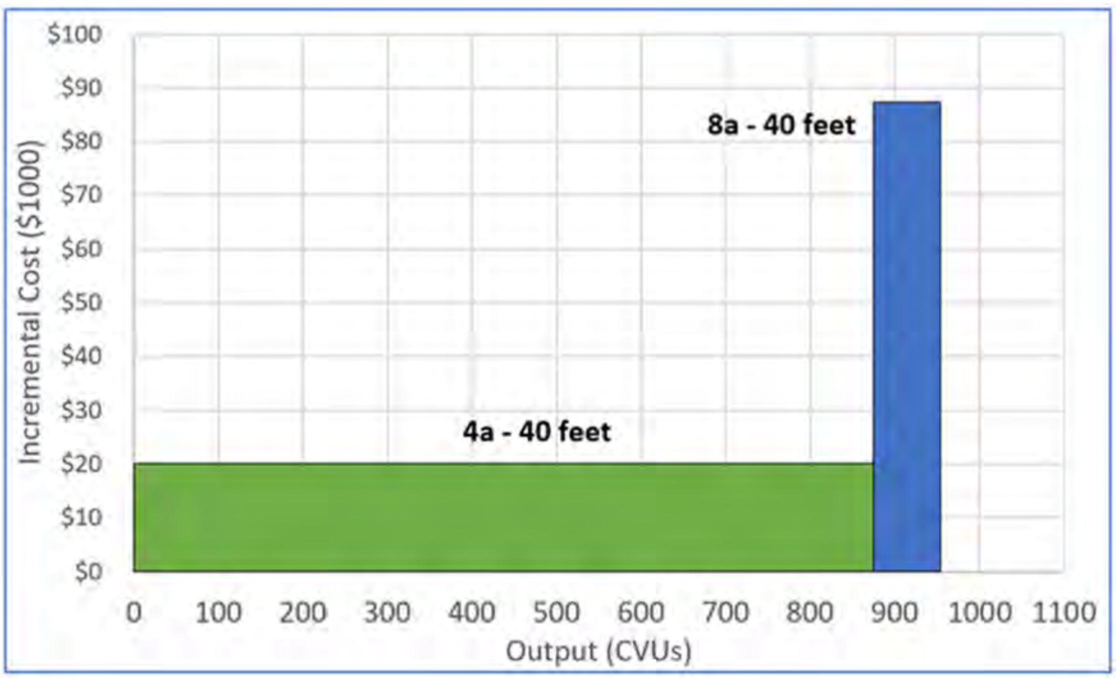

Figure 62. Incremental Cost, CVUs

9.3.4. Addition of NSUs

As discussed in the previous section, the framework was developed to be able to run CE/ICA analyses in multiple configurations to be able to keep evaluation of national security outputs (NSUs) as a separable incidental benefit category, or to include NSUs in addition to CVUs in a combined derived unit. This section presents both options, first the results of a CE/ICA analysis based only on the NSUs, and then an analysis where NSUs and CVUs have been combined via summation. A series of table and figures follow that present the results of these two runs. Table 57 presents the input data for these two models.

For the NSUs-only run, Table 58 and Figure 63 present the output results for all plans, and Table 59 and Figure 64 present the incremental cost for the best buy plans. For combined CVU+NSU, Table 60 and Figure 65 present the output results for all plans, and Table 61 and Figure 66 present the incremental cost for the best buy plans.

Table 56 – CE/ICA Input Data, CVUs

Measure	Scale	Annualized Cost $1000	CVUs	NSUs	CVUs + NSUs
No Action	-	$0	0	0	0
Alt 3a	1 (30ft)	$12,514	275		275
Alt 3a	2 (35ft)	$16,145	400		400
Alt 3a	3 (40ft)	$14,629	500		500
Alt 3b	1 (30ft)	$12,185	200		200
Alt 3b	2 (35ft)	$15,874	300		300
Alt 3b	3 (40ft)	$14,321	400		400
Alt 3c	1 (30ft)	$11,681	150		150
Alt 3c	2 (35ft)	$15,761	225		225
Alt 3c	3 (40ft)	$13,813	325		325
Alt 4a	1 (30ft)	$15,633	575	200	775
Alt 4a	2 (35ft)	$19,019	725	200	925
Alt 4a	3 (40ft)	$17,722	875	900	1,775
Alt 8a	1 (30ft)	$27,190	700	200	900
Alt 8a	2 (35ft)	$28,708	850	200	1,050
Alt 8a	3 (40ft)	$28,637	1,000	1,000	2,000
Alt 8b	1 (30ft)	$25,852	650	200	850
Alt 8b	2 (35ft)	$26,706	800	200	1,000
Alt 8b	3 (40ft)	$27,300	950	1,000	1,950

Table 57 – CE/ICA Outputs, NSUs-only

Plan	Annualized Cost $1000	Output	Type
No Action	**$0.00**	0	**Best Buy**
3a - 30ft	$12,514		
3a - 35ft	$16,145		
3a - 40ft	$14,629		
3b - 30ft	$12,185		
3b - 35ft	$15,874		
3b - 40ft	$14,321		
3c - 30ft	$11,681		
3c - 35ft	$15,761		
3c - 40ft	$13,813		
4a - 30ft	$15,633	200	Cost Effective
4a - 35ft	$19,019	200	Non-Cost Effective
4a - 40ft	$17,722	900	Best Buy
8a - 30ft	$27,190	200	Non-Cost Effective
8a - 35ft	$28,708	200	Non-Cost Effective
8a - 40ft	$28,637	1000	Non-Cost Effective
8b - 30ft	$25,852	200	Non-Cost Effective
8b - 35ft	$26,706	200	Non-Cost Effective
8b - 40ft	$27,300	1000	Best Buy

Table 58. Incremental Cost Summary, NSUs-only

Best Buy	Alternative	Annualized Cost $1000	Incremental Cost $1000	Total Output	Incremental Output	Incremental Cost/Output $1000
1	No Action	$0	$0	0	0	$0
2	Alt 4a, 40ft	$17,722	$17,722	900	900	$20
3	Alt 8b, 40ft	$27,300	$9,578	1000	100	$96

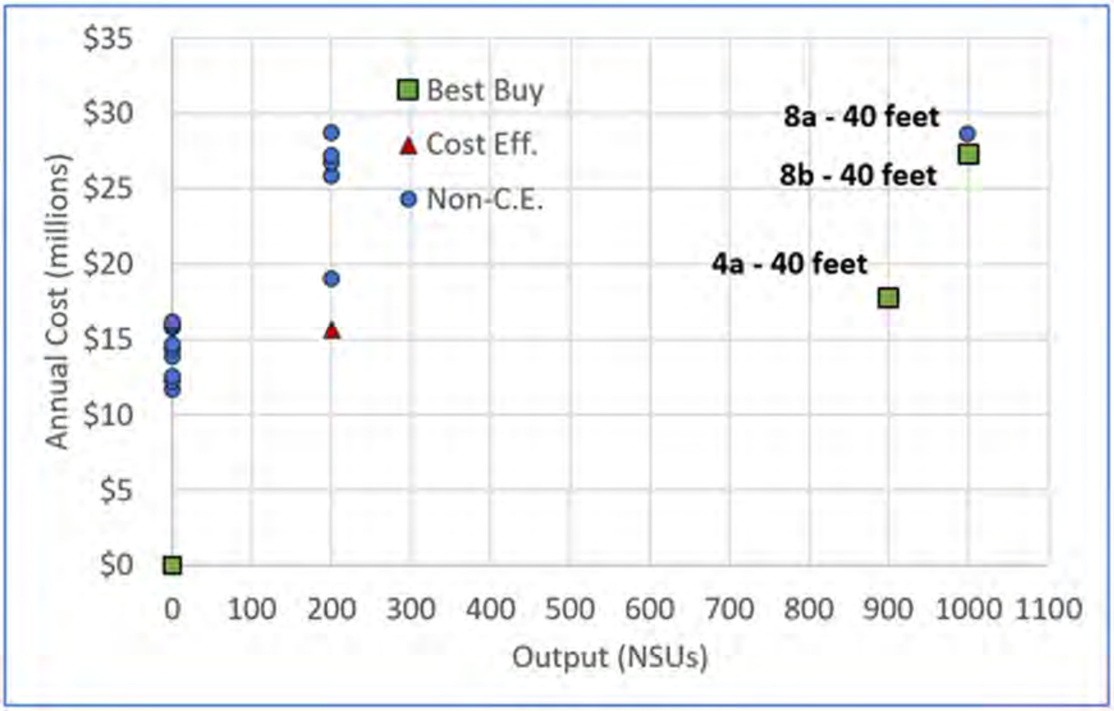

Figure 63. All Possible Plans, NSUs-only

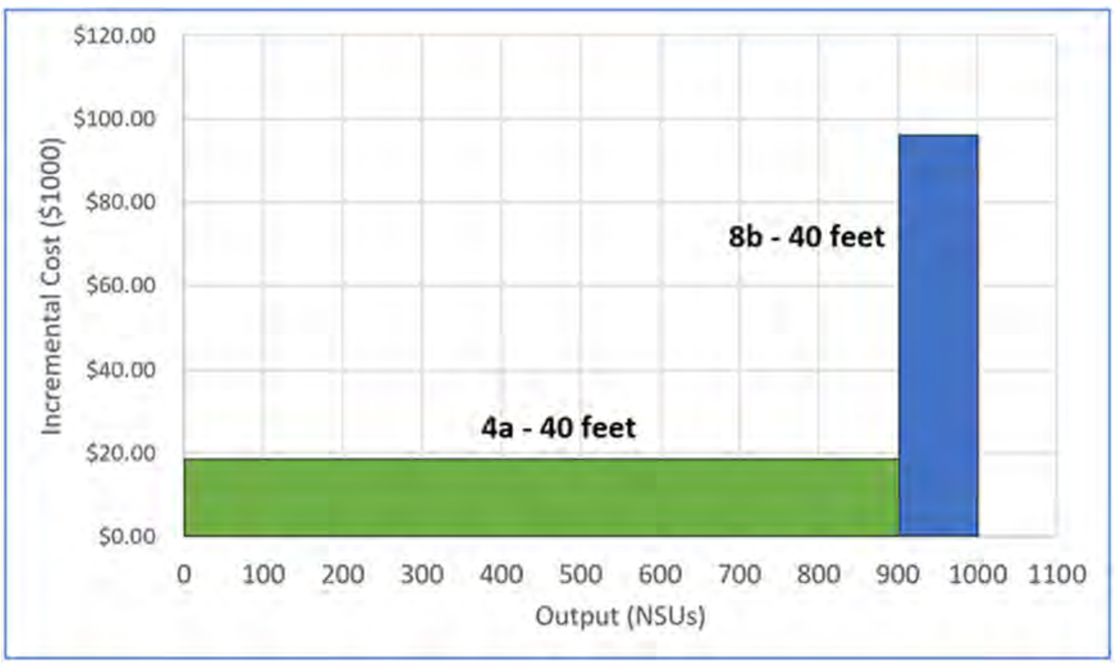

Figure 64. Incremental Cost, NSUs-only

Table 59. CE/ICA Outputs, CVUs + NSUs

Plan	Annualized Cost $1000	Output	Type
No Action	**$0.00**	**0**	**Best Buy**
3a - 30ft	$12,514	275	Cost Effective
3a - 35ft	$16,145	400	Non-Cost Effective
3a - 40ft	$14,629	500	Cost Effective
3b - 30ft	$12,185	200	Cost Effective
3b - 35ft	$15,874	300	Non-Cost Effective
3b - 40ft	$14,321	400	Cost Effective
3c - 30ft	$11,681	150	Cost Effective
3c - 35ft	$15,761	225	Non-Cost Effective
3c - 40ft	$13,813	325	Cost Effective
4a - 30ft	$15,633	775	Cost Effective
4a - 35ft	$19,019	925	Non-Cost Effective
4a - 40ft	**$17,722**	**1775**	**Best Buy**
8a - 30ft	$27,190	900	Non-Cost Effective
8a - 35ft	$28,708	1050	Non-Cost Effective
a - 40ft	**$28,637**	**2000**	**Best Buy**
8b - 30ft	$25,852	850	Non-Cost Effective
8b - 35ft	$26,706	1000	Non-Cost Effective
8b - 40ft	$27,300	1950	Cost Effective

Table 60 – Incremental Cost Summary, CVUs + NSUs

Best Buy	Alternative	Annualized Cost $1000	Incremental Cost $1000	Total Output	Incremental Output	Incremental Cost/Output $1000
1	No Action	$0	$0	0	0	$0
2	Alt 4a, 40ft	$17,722	$17,722	1,775	1,775	$10
3	Alt 8a, 40ft	$28,637	$10,915	2,000	225	$49

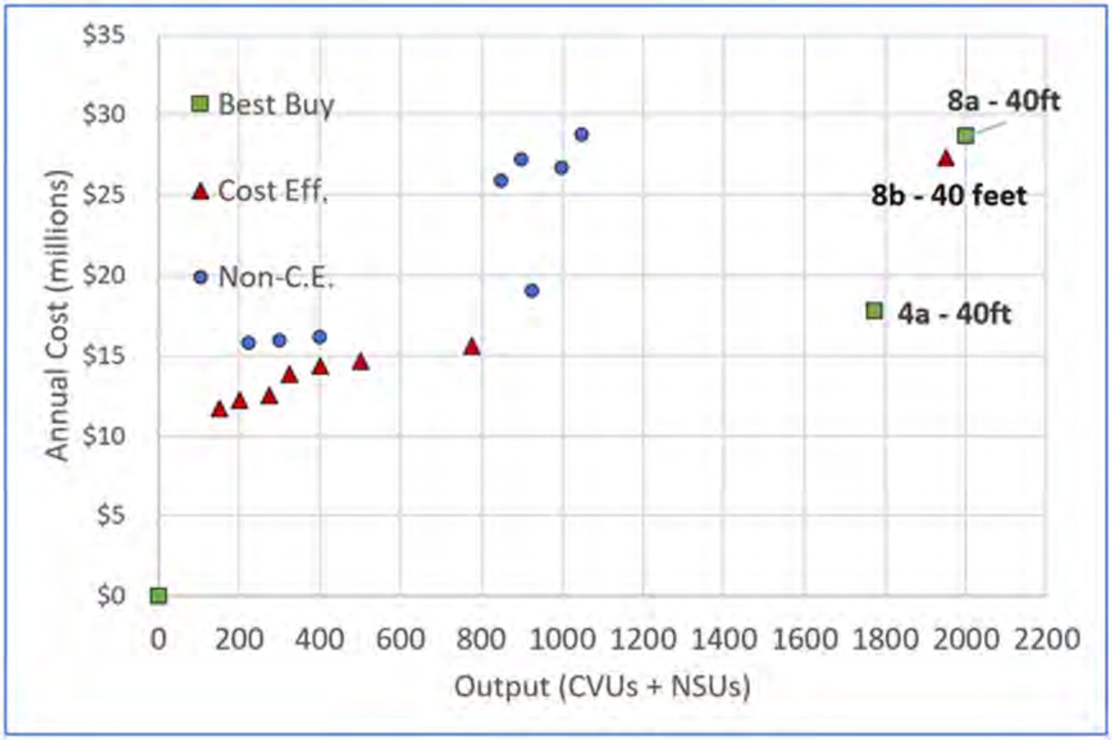

Figure 65. All Possible Plans, CVUs + NSUs

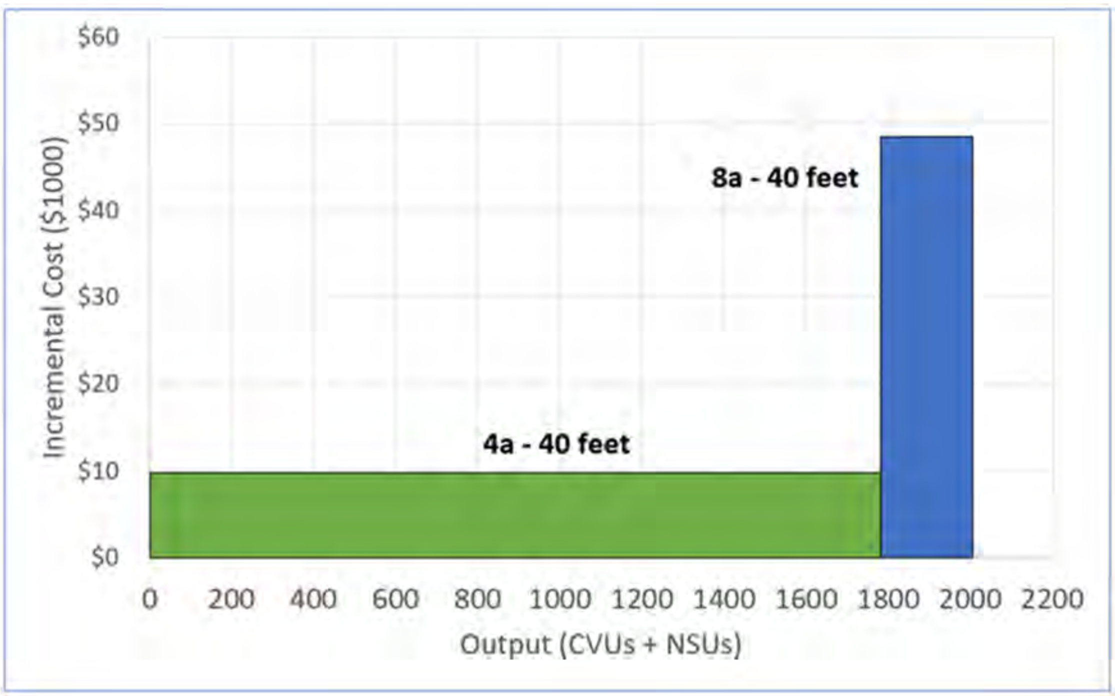

Figure 66. Incremental Cost, CVUs + NSUs

9.3.5. Summary

In the CVU analysis, the best buy plans were 4a and 8a, both at the 40-foot depth scenario. Plan 8b (40ft) ranked between these two best buy plans and was cost effective. Figure 61 shows that 4A (40ft) was the most efficient (cost per unit) alternative in generating CVUs over the No Action.

To buy up to the next best buy plan, 8A (40ft), would incur a cost of $87,300 per additional CVU as compared to the cost of $20,300 per unit for the first best buy. This buy-up would generate 125 additional CVUs, or a 14% increase in output. Alt 8A (40ft) scored similar to Alt 4A (40ft) in the OPE and OFT variables given that they would both maximize the number docks at the Port. Alt 8A (40ft) scored better in the PRE and CDR variables, reflecting the expanded outer harbor size as a result of the east causeway relocation and the inclusion of four docks on the west causeway, which was judged to have greater benefit to cargo and industrial operations than inclusion of two docks on the east breakwater.

Alternative 8B (40ft) scored only marginally lower than 8A (40ft) in the PRE and CDR variables, owing to the longer causeway for the deep-water basin in 8A (40ft), which maximizes available refuge area, including for large vessels, and would maximize the size and quantity of vessels that could be served simultaneously for cargo transshipment and other industrial activities. Because the incremental cost of buying up from 4A (40ft) to 8A (40ft) was less than the incremental cost of buying up to 8B (40ft), 8B (40ft) is cost effective, but not a best buy.

9.3.6. National Security

The output associated with the NSU variable, representative of potential national security benefits, were considered. The analysis focused on potential incidental benefits to the U.S. Coast Guard and U.S. Navy in terms of the port’s ability to provide logistics support to vessels in the region.

In the model run which included only the NSU output, alternatives 4A (40ft) and 8B (40ft) were both best buy plans. Alternative 8A (40ft) had the same output as 8B (40ft) at a higher cost, and so was not cost effective. These results reflect the input of the U.S. Coast Guard and U.S. Navy, which indicated that 40-feet of depth was required to provide adequate logistics support. It also reflects a preference for maximizing the size of the deep-water basin to provide the most capacity, flexibility, and maneuverability for large vessels.

In the model run where CVUs and NSUs were added together, the results mimic those of the CVU-only run, where the best buy plans are 4A (40ft) and 8A (40ft), with 8B (40ft) being cost effective and falling between the two best buys.

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Attachment 1
Documentation of the Cost Effectiveness and Incremental Cost Analysis

Port of Nome Navigation Improvements Study

Prepared for

U.S. Army Corps of Engineers Alaska District

Prepared by

Tetra Tech, Inc.

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Contents

Attachments

1 – Weighting Sensitivity Results

Tables

Figures

1. INTRODUCTION

The purpose of this attachment is to document the Cost Effectiveness and Incremental Cost Analysis (CE/ICA) developed and implemented for the study.

The framework was designed with flexibility to address various elements of the four Corps plan evaluation accounts (National Economic Development (NED), Other Social Effects (OSE), Regional Economic Development (RED), and Environmental Quality (EQ)); as well as National Security, in response to supplemental legislative direction and associated Corps implementation guidance that have been published to allow consideration of *Community Viability* and *National Security* in project evaluation and justification. As the study evolved and the framework passed through the USACE model review and approval process, specific model elements were approved to be carried forward for evaluating plan effects in this study.

The CE/ICA evaluation framework has been approved for one-time use in accordance with EC 1105-2-412, Assuring Quality of Planning Models. This document summarizes the development of the framework, including revisions and refinements made through the model approval process, and documents implementation of the framework in support of plan formulation for the study.

The results of the CE/ICA provide comparative information on the accomplishments and costs of alternative plans under consideration. The CE/ICA analysis is consistent with established evaluation procedures in the Corps Planning Guidance Notebook (ER 1105-2-100), Appendix E and with published implementation guidance specific to the project.

2. STUDY-SPECIFIC AUTHORIZATIONS AND IMPLEMENTATION GUIDANCE

Formulation of USACE navigation projects typically focus on NED benefits associated with transportation cost savings. For this study, two additional legislative authorizations and associated USACE implementation guidance memoranda allow for consideration of additional project accomplishments in terms of non-NED benefits in evaluating alternatives and to support identification of a recommended plan.

2.1.1. Section 1105 of Water Resource Development Act (WRDA) of 2016

For the Nome project, Section 1105 of WRDA 2016 provides an opportunity to consider the additional benefits in the RED, OSE, and EQ accounts through a CE/ICA. In accordance with this authorization, the Corps may recommend this Nome Harbor Modification project without the need to demonstrate that the project is justified solely by NED benefits. Corps implementation guidance for this legislation calls for an assessment of project benefits, including:

- Public health and safety of the local community, including access to facilities designed to protect public health and safety;
- Access to natural resources for subsistence purposes;
- Local and regional economic opportunities;
- Welfare of the local population; and
- Social and cultural value to the community.

The implementation guidance allows for the effects associated with alternative plans to be compared through CE/ICA. Section 1105 benefit categories were identified that represent issues of importance to the Nation, to project stakeholders in Nome, and to the region served by the Port of Nome. To facilitate characterization of *long-term Community Viability at Nome and other communities served by the Port of Nome,* (collectively referred to simply as *Community Viability* in this document), the framework develops a Community Viability Unit (CVU) to consider such benefits.

2.1.2. Section 1202(c)(3) of WRDA 2016

Proposed navigation improvements at Nome may also support National Security needs in the Arctic. The Nome project also has the opportunity to include consideration of benefits to National Security. Section 1202(c)(3) of WRDA 2016 expands the feasibility justification of an Arctic deep draft harbor and related navigation improvements to include consideration of benefits associated with National Security and homeland protection. Corps implementation guidance for this legislation states that identification of a recommended plan can be supported by a CE/ICA. The Corps provided additional guidance on consideration of National Security benefits in a July 2018 memorandum from a meeting of the NWD/POD Regional Integration Team.

This authorization follows recent research and literature on a need for an expanded U.S. presence in the Arctic. The most recent Arctic Strategy from the Department of Defense (2016) highlights the need for an improved Arctic presence. The need for an Arctic deep draft port is identified specifically in the infrastructure needs assessment published by the U.S. Committee on the Marine Transportation System Arctic Marine Transportation Integrated Action Team (2016).

National Security contributions of alternative plans will be evaluated in terms of a unit referred to as National Security Units (NSUs). The framework could support evaluation of NSUs by themselves, as well as in combination with the CVUs discussed above. For the purpose of the main alternatives evaluation, NSUs are considered separately from CVUs.

3. CE/ICA FRAMEWORK OVERVIEW

This goal of utilizing the framework is to provide a means of consistently and systematically assessing the contribution of each alternative to Community Viability and National Security as compared to the without project condition. The CE/ICA framework structures the development of derived output units that are based upon consideration of benefits which accrue across the RED, OSE, and EQ accounts (CVUs); with the capability to also assess the incidental benefits to national security (NSUs).

3.1. Potential Benefit Categories

The PDT initially identified a range of potential benefit categories which might result from implementation of the project and as such could be used to describe the relative performance of the alternatives. **Figure 1** highlights these benefit categories and categorizes them in terms of the four Corps evaluation accounts and National Security. The benefit categories identified in **Figure 1** were intended to be representative of the major types of benefits that the alternatives would provide for modeling purposes, but are not an exhaustive list. Instead, the categories chosen are those which best captured the types of benefits of importance to this study, including navigation benefits typical to a Corps navigation study, as well as benefits specifically called out in the Section 1105 and Section 1202(c)(3) authorizations. The goal was to identify a range of applicable benefit categories across all accounts to allow for the consideration of multiple types of effects during the model review and approval process.

Figure 1 – Potential Benefit Categories by Evaluation Account

NED Account

- Transportation cost savings

RED Account

- Construction and operations spending effects
- New/expanded Port services and associated employment opportunities that support community welfare

OSE Account

- Human Health and Safety (HH&S) improvement from safer Port operations
- HH&S improvement for vessels requiring refuge during severe weather
- Consideration of local subsistence access and reduced risk of resource degradation via contamination

EQ Account

- Reduced risk of environmental contamination during Port operations, such as offshore fuel transfers
- Improved response capabilities and speed for oil spill and other contamination hazards in the Arctic

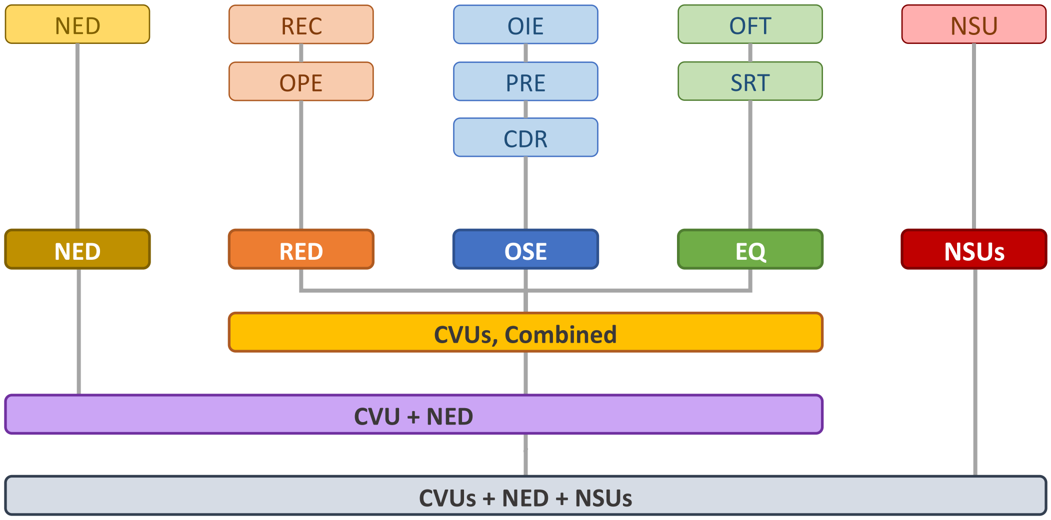
National Security

- Improved U.S. Coast Guard and U.S. Navy refueling capabilities in close proximity to the Arctic
- Support for U.S. Coast Guard and U.S. Navy operational logistics in the Arctic region

3.2. Initial Framework and Variables

Next, these categories were considered in more detail to define a quantifiable output variable that would describe the associated benefit and provide information about the relative performance of the alternatives. In the initial iteration of the planning process, a total of nine variables were identified. Each variable was mapped to one of the four accounts (and national security), in order to develop a flowchart of how the variable outputs might be combined into one or more derived units for the purpose of the CE/ICA modeling. **Figure 2** presents the first iteration variable definition and framework specification. This initial iteration was designed for flexibility, supporting analysis at multiple levels, from individual variables to a single derived unit. The variables named in the figure will be further described in subsequent sections.

Figure 2 – Nome CE/ICA Framework, Iteration 1



Variable Names: *NED (National Economic Development); REC (regional effects of construction); OPE (other port economic effects); RED (Regional Economic Development); OIE (operational injury effects); PRE (port of refuge effects); CDR (cargo delivery reliability); OSE (Other Social Effects); OFT (overwater fuel transfer); SRT (spill response time); EQ (Environmental Quality); NSUs(national security units); CVUs (community viability units)*

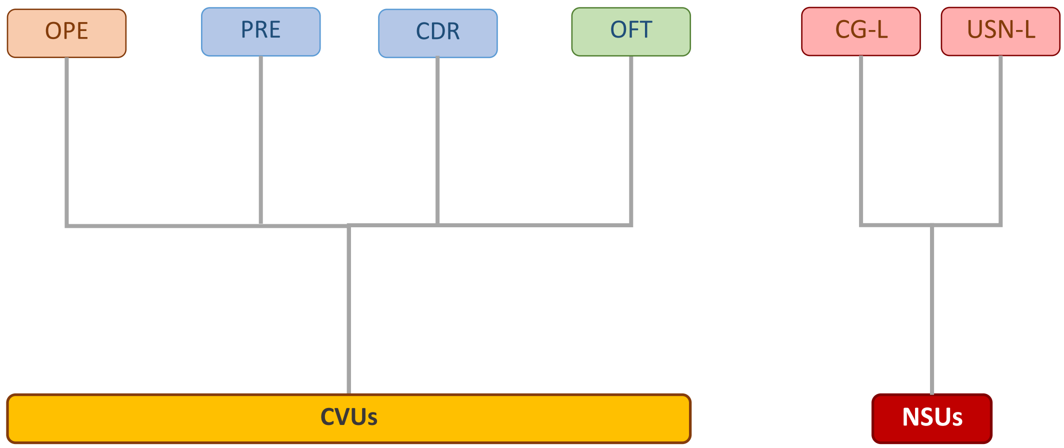
3.3. Final Framework and Variables

During subsequent iterations of formulation, sensitivity analysis, and through the model approval process, the PDT refined and simplified this flowchart to include only those variables which provided useful information for the plan formulation and evaluation process – those variables for which there was a difference in expected output among the alternatives being considered and whose outputs would be acceptable to include in the decision-making process. **Figure 3** provides the final iteration of the framework flowchart.

As illustrated, the NED account was removed, as it is being considered in a separate analysis. Similarly, the REC variable, which was driven by outputs of the RECONS model being used as part of the separate Regional Economic Development analysis, was removed. The OPE variable, an indicator of other economic impacts, was maintained. The OIE variable was removed during model review and approval because the project was not being formulated for the purposes of removing potential pedestrian and land use conflicts associated with locally led project operations. The remaining variables describing benefits in the OSE account were maintained. In the EQ account, the OFT variable was maintained, but the SRT variable was removed as it did not provide useful information on differences in performance across the alternatives.

The resulting framework includes the Community Viability Unit (CVU) which is derived from the outputs of four variables. The National Security Units (NSUs) were maintained as a separable element.

Figure 3 – Final Nome CE/ICA Framework



<u>Variable Names:</u> OPE (other port economic effects); PRE (port of refuge effects); CDR (cargo delivery reliability); OFT (overwater fuel transfer); CVUs (community viability units); CG-L (Coast Guard Logistics); USN-L (U.S. Navy Logistics); NSUs(national security units)

3.4. Variable Definitions

The following subsections expand upon the definition and quantification of the output variables, including those which were considered initially but subsequently screened.

3.4.1. Variables Considered then Removed

The follow variables were included in the initial framework development but were removed following additional consideration.

3.4.1.1. NED: National Economic Development

The NED output was defined as a function of the separately completed NED analysis, which considers navigation benefits to the nation, principally measured in terms of transportation cost savings using the HarborSym model. Because it was determined that the best approach for use of the CE/ICA results in the plan selection process was to use the CE/ICA to consider the benefits of the project over and above the NED benefits already being computed, the NED variable was not necessary in the CE/ICA framework, and was removed during the model review and approval process.

3.4.1.2. REC: Regional Effects of Construction

Similar to the NED variable, the REC variable was defined as a function of the RECONS model outputs which were being developed as part of the separate Regional Economic (RED) analysis. The RECONS model outputs describe regional economic impacts of construction and OMRR&R expenditures. Because these impacts are a function of cost, and because they are already described in this separate analysis, the REC variable did not provide any additional information to describe the relative differences among the alternatives being considered, and the variable was removed during the model review and approval process.

3.4.1.3. SRT: Spill Response Time

The SRT variable was defined to addresses the project's ability to improve mobilization and response speed for oil spill and other environmental disaster response to the Arctic. Sensitivity analysis conducted during an initial iteration of the CE/ICA found that attempts to quantify this variable did not result in significant differences in output among the alternatives. Given that the variable was unlikely to affect plan selection, and due to the extensive effort, that would have been required to elicit better information from spill response operators, it was determined that this variable should be removed from the analysis during the model review and approval process.

3.4.1.4. OIE: Operational Injury Effects

The OIE output variable aimed to address human health and safety at the Port. Current Port facilities and operations often require that industrial and non-industrial vessels and their passengers pass through or occupy the same areas on the docks as industrial users. This intersection introduces injury and life safety risk due use of heavy equipment and machinery where pedestrians move across the port to reach town. It was initially thought that the extent to which an alternative would help alleviate this risk would represent a public health and safety benefit to the community and the region, consistent with the Section 1105 implementation guidance. Any such reduction of risk to public health and safety would contribute to the welfare of the local and regional population. The OIE variable considered the extent to which each alternative would allow for would the separation of non-worker pedestrians from dangerous work areas when moving through the Port, such that an alternative's ability to separate pedestrians from work areas would constitute a reduction in the risk of injury (i.e. an increase in safety). During model review and approval, it was determined that this variable should be removed from the analysis as plans were not being formulated for the purpose of providing this incidental benefit. It was also determined that reduction of the potential conflict is a local operational responsibility.

3.4.2. Final Output Variables

The following variables are those which are included in the final CE/ICA framework (see **Figure 3**).

3.4.2.1. OPE: Other Port (Economic) Effects

The OPE output variable was included to describe expected permanent growth in local economic opportunities at the Port and related local businesses from increased business at the Port. Such growth would result in benefits to two of the areas identified in the Section 1105 implementation guidance. Economic growth in Nome from additional Port activity and the city's related industries would result in increases in economic opportunities, both locally in Nome and in the region. As a relatively large community, regional wage employment opportunities are affected by the health of the Nome economy. A healthy regional economy would in turn contribute to the welfare of the local and regional population by increasing the economic viability of the subsistence culture in the region. These opportunities were determined to not be duplicative with effects of with-project OMRR&R costs that are being modeled in the separate RED analysis. Additional vessel traffic and support for larger vessels would be expected to increase sales for existing ships services, such as expanded fuel, water, and waste services at the Port, increased tug and pilot service, increased mechanical/machine/diving services, and increased activity for businesses serving passengers and crew in town. Inclusion of the variable contributes to the consideration of community welfare and regional economic opportunities which are critical to viability of rural and subsistence communities in the Arctic. These employment and income opportunities associated with port operations under with project conditions are available to individuals throughout the region and allow financial support of family members in the regional community to continue to support their desired cultural subsistence lifestyle.

3.4.2.2. PRE: Port of Refuge Effects

The PRE output variable addresses safety of vessel crews at the Port. Current Port facilities do not have optimal facilities to serve as a port of refuge during inclement weather, both in terms of vessel size restrictions, and in terms of raw capacity. Crew on vessels unable to seek refuge are at greater risk of injury. Project alternatives can provide opportunity to improve the Ports capacity to provide shelter to vessels during inclement weather conditions. Such improvements would reduce the risk to human health and safety. Like the previous variable, consideration of local and regional public health and safety effects are consistent with identified benefit categories in the Section 1105 implementation guidance. Any such reduction of risk to public health and safety would contribute to the welfare of the local and regional population. The PDT considered the how each alternative would improve refuge in terms of both wave climate and refuge capacity in the development of scores.

3.4.2.3. CDR: Cargo Delivery Reliability

The long-term viability of remote and subsistence communities is dependent upon affordable, reliable, and timely cargo transshipment and barge delivery services provided by Nome. Such increases in reliability would address multiple benefit categories in the Section 1105 implementation guidance. More reliable movement of goods throughout the region would contribute to the health of the regional economy and support expanded local and regional economic opportunities. The health of the regional economy and the reliability and deliver of essential goods and services to regional communities are significant drivers of the health and welfare of the local population, as well as being a significant factor in the extent to which residents have the resources to participate in subsistence activity and maintain the region's unique cultural heritage.

For remote subsistence communities in western and northern Alaska, Nome is an essential component of the transportation system which annually delivers the fuel and equipment which powers communities year-round and is especially vital in winter. The CDR variable considers how alternatives would support increased reliability of and capacity for cargo transshipment services. The Port and PDT found that some alternatives are expected to improve transshipment and barge turn times to allow for an additional barge run to regional communities each open water season. This additional flexibility would reduce any risk of fuel or supply shortages in remote communities due shortened barge seasons from inclement weather.

3.4.2.4. OFT: Overwater Fuel Transfer

The CE/ICA framework includes the OFT variable to be representative of benefits falling under the EQ account. The OFT variable specifically addresses a known environmental risk associated with current Port operations. Currently, the Port's fueling dock is routinely congested. Rather than wait, many vessels are opting to perform overwater fuel transfers. Additionally, some vessels are too large to enter port for refueling service and need to take on fuel via overwater transfer under without project conditions. Refueling overwater has a substantially higher risk of environmental contamination from fuel spillage. As a region dependent upon subsistence and marine resources, environmental quality is important from sociocultural and economic perspectives as well. Regarding benefits consistent with the Section 1105 implementation guidance, the OFT variable addresses multiple areas. The region's subsistence culture is inextricably tied to environmental quality, with participants dependent upon access to high quality natural resources. Reduction in overwater fuel transfers would reduce the risk of environmental contamination which could affect public health and safety as well as the availability of high-quality natural resources which are a critical component of the subsistence culture. The OFT variable considers the extent to which each alternative would maximize the capacity for fuel transfer at the docks, thereby minimizing environmental risks associated with overwater transfer.

3.4.2.5. NSU: National Security Units

As shown above in Figure 3, NSUs were maintained as separate output type. NSUs are representative of likely benefits to National Security, consistent with Section 1202(c)(3) and related implementation guidance, which supports consideration of benefit stemming from an Arctic deep draft harbor and related improvements at Nome. The principal sources of national security benefits identified for consideration in this analysis were benefits to the U.S. Coast Guard and U.S. Navy, both of which could call at Nome for refueling, resupply, and other services. Support of U.S. Coast Guard logistics was captured in the U.S. Coast Guard Logistics (CG-L) variable, and support of U.S. Navy logistics was captured in the U.S. Navy Logistics (USN-L) variable.

3.4.2.5.1. CG-L: Coast Guard Logistics

The U.S. Coast Guard and its fleet provide critical services in the Arctic, and improved infrastructure at Nome would benefit existing and future U.S. Coast Guard activities and vessels. The two types of U.S. Coast Guard vessels likely to call at Nome are cutters and icebreakers. Cutters typically have a draft of 15-21 feet. The icebreaker Healy requires a draft of 38 feet, and current designs for the planned Polar Security icebreaker will require nearly 40 feet of draft (USACE 2019). Identification of relative output among the alternatives considers whether calling cutters and icebreakers would be able to enter the harbor and dock.

3.4.2.5.2. USN-L: United States Navy Logistics

U.S. Navy operations in the Arctic require fuel north of Dutch Harbor, AK in order to perform its Presidentially assigned Homeland Defense mission. An improved Port of Nome, capable of receiving auxiliary support ships could improve logistic support in the region. In addition to providing fuel for forces operating in the northern Bering, southern Chukchi, and western Beaufort Seas, an accessible port would provide unique benefits to Homeland Defense including a port of refuge, logistics support, and a location to loiter as the maritime situation unfolds.

Based upon coordination with U.S. Northern Command, the two vessel types (surface combatant and auxiliary support ships) were representative of potential U.S. Navy calls at Nome.

Surface combatants include the DDG-51 (Arleigh Burke-class guided missile destroyer), which requires a 36-foot draft and is 505 feet long. Additionally, the U.S. Navy is developing a new Large Surface Combatant that will be the successor to DDG-51 and CG-47 (Ticonderoga-class guided missile cruiser) and is expected to enter the fleet in the late 2020’s or early 2030’s. This vessel is expected to be 10% longer, marginally wider, and have approximately the same draft as the DDG-51 (USACE 2019).

Several types of auxiliary support ships were identified. The T-AO (Henry-Kaiser-class fleet replenishment oiler) is 677.5 feet in length and requires 38 feet of draft. The T-AO successor design, T-AO-205 (John Lewis-class), is a similar design to the Kaiser-class but is slightly longer, at 745.7 feet. And the T-AKE (Lewis and Clark-class dry cargo/ammunition ship) is 689 feet long and requires 33 feet of draft.

3.5. Variable Quantification Approach

To quantify outputs for each of variables in the framework, a scoring system was developed. The scoring system relies upon elicitation of scores from the PDT and Sponsor (including Port of Nome operations managers) based upon expert opinion and informed by available data. A standardized rubric was developed based upon a 10-point scale, as shown below in **Figure 4**. As noted in the figure, scores for each variable were developed where 0 points corresponded to no change as compared to the No Action alternative, and 10 points corresponded to the best-performing alternative in that category. This approach provides a relative ranking of the alternatives in terms of their output for a given variable.

Figure 4 – Scoring Rubric

Output (points)					
None	**Minimum**	**Low**	**Moderate**	**High**	**Maximum**
No change from No Action	*Min output from the alternatives under consideration*	*Increasingly larger output*	*Increasingly larger output*	*Increasingly larger output*	*Max output from the alternatives under consideration*
0	**1-2**	**3-4**	**5-6**	**7-8**	**9-10**

To derive CVUs, scores from each variable are equally weighted and combined. The equal-weighting approach was considered in a sensitivity analysis using preliminary scores developed by the PDT. The sensitivity analysis considered two alternative weighting scenarios, one with socio-economic priority (OPE and CDR strongly weighted) and one with a social-environmental priority (PRE and OFT strongly weighted). The sensitivity found that while the computed incremental cost changed between these weighting schemes, the alternatives which were identified as best buy plans did not. As such, it was determined that an equal weighted scheme was appropriate for the final model iteration. Results from this sensitivity are provided in **Attachment 1**.

4. ANALYSIS OF ALTERNATIVES

The following narrative documents the analysis of the final array of alternatives using this CE/ICA framework. The following subsections are organized according to the main steps performed in the analysis.

1. **Output Quantification by Variable:** For each alternative and dredge depth scenario, score each output variable in terms of change in output relative to the future without project condition (No Action).
2. **Calculate Derived CVUs and NSUs:** Tabulate scores to generate CVUs and NSUs.
3. **Run CE/ICA Model for CVUs:** Use IWR Planning Suite to conduct CE/ICA.
4. **Run Separate NSU Analysis:** Run separate CE/ICA in IWR Planning Suite for NSUs to describe national security outputs.
5. **Present Results:** Format and present results to be provided to decision-makers to inform plan selection.

4.1. Step 1 – Output Quantification by Variable

Scoring of outputs for each combination of alternative, variable, and depth scenario was performed by the entire PDT (including the Sponsor and Port operations staff) in order to facilitate group discussion and consensus. The following subsections document the scores developed by the PDT and the rationale for the point selections. **Table 1** provides a summary of the scores. The scores were reviewed and judged by the team to be objective and representative of changes in conditions from those under no-action for each variable with each alternative and depth considered. For NSUs, scores were developed with input from representatives of the U.S. Coast Guard and U.S. Navy Northern Command. For the purpose of the NSU evaluation, only Alternatives 4 and 8 were considered, as Alternative 3 options did not provide adequate maneuverability in the outer harbor to be viable.

Table 1 – Score by Alternative and Variable

Alternative	Depth	CVU Variable Scores				NSU Variable Scores			
						CG-L		USN-L	
		OPE	PRE	CDR	OFT	Ice-breaker	Cutter	Surface Comb.	Aux. Support
No Action	-	0	0	0	0	0	0	0	0
Alt 3a	30 feet	4	1	3	3				
	35 feet	6	2	4	4				
	40 feet	7	3	5	5				
Alt 3b	30 feet	3	1	2	2				
	35 feet	4	2	3	3				
	40 feet	5	3	4	4				
Alt 3c	30 feet	2	1	1	2				
	35 feet	3	2	2	2				
	40 feet	4	3	3	3				
Alt 4a	30 feet	6	6	5	6	0	8	0	0
	35 feet	8	7	6	8	0	9	0	0
	40 feet	10	8	7	10	8	10	8	8
Alt 8a	30 feet	6	8	8	6	0	8	0	0
	35 feet	8	9	9	8	0	9	0	0
	40 feet	10	10	10	10	10	10	10	10
Alt 8b	30 feet	6	7	7	6	0	8	0	0
	35 feet	8	8	8	8	0	9	0	0
	40 feet	10	9	9	10	10	10	10	10

4.1.1. OPE: Other Port (Economic) Effects

The Port drives the Nome economy, enabling it to act as a regional hub in the provision of goods and services across many industries. In the future without project condition, the growth potential for the regional economy would be limited as compared to its potential with the project in place. Scores for the OPE variable were informed by the number of docks that would be provided by each of the alternatives and the configuration of the causeways. With additional docks, more fuel, water, supply, or waste services could be delivered concurrently, which would increase the volume of business that the Port could perform per unit time. Additionally, inclusion of the east causeway would further increase delivery capacity and flexibility, especially in that refueling by truck could be supported at docks even if not all docks have dedicated fuel headers. Finally, the depth of the basin was judged to be an important factor in whether larger vessels would be able to maximize use of Port services, such as being able to come into or out of the harbor fully loaded, reflected by substantial point decreases for shallower depth scenarios. Similarly, support for larger vessels would maximize the additional business to related port and town industries. Given these considerations, alternatives 4a, 8a, and 8b all had maximum scores.

4.1.2. PRE: Port of Refuge Effects

In the without project condition, there would continue to be limitation on the Port's ability to provide optimal refuge in terms of the number of vessels and the sizes which could be served. Discussion of refuge include two components, refuge capacity (size of protected area that would be provided), and wave climate (how the configuration would handle typical storms). After evaluation by the engineering component of the PDT, it was determined that difference in performance regarding wave climate was that all alternatives would perform better than the existing condition, but that differences in performance between the alternatives regarding wave climate was negligible. As such, the PDT focused discussion on refuge capacity, as the various alternatives and depths would allow for different quantity and size of vessels to be sheltered. Factors that increased the score for an alternative include the size of the turning basin (allowing for more vessels to be sheltered), the length of the causeways (which could be used to raft vessels even if there are no available docks), and the number of docks (which allows more vessels to be docked during storms). The consideration of depth focused on the extent to which deeper depths would decrease the likelihood that a vessel couldn't be sheltered due to draft, which was judged to be a small benefit, reflected by small decreases in scores for shallower depths. Given these considerations, Alternative 8a ranked the highest due to its long causeways, followed closely by 8b and 4a.

4.1.3. CDR: Cargo Delivery Reliability

In the without project condition, the existing operational constraints would remain, including harbor depth, Port throughput limits (congestion), and Port configuration (dock size, turning basin, etc.). The alternatives provide an opportunity to reconfigure the Port in a manner that would support more reliable and efficient operations, in turn benefiting the region's communities that depend on Nome for life sustaining supplies and fuel. Scoring of the CDR variable focused on how the alternative configurations and depths would affect the efficiency and throughput for cargo transshipment activity, which is the essential service provided by the Port in the provision of goods by barge to regional communities. The PDT determined that the number of docks provided by the alternative would be a driving factor, as it would allow more cargo to be processed concurrently, reducing wait time for vessels. The Port noted that operationally, it would prefer to keep industrial activity on the west causeway and its docks, and therefore additional docks on the east causeway would be less desirable than on the west causeway for this variable. Additionally, alternatives with wider entrance channels would likely improve efficiency and the ability for multiple vessels to move in and out of the harbor while improving navigation safety. The consideration of depth focused on the extent to which deeper depths would improve efficiency. Because of the barges typically used to deliver regional goods, depth was judged to have only minor benefit as compared to the alternative configuration and is reflected by small decreases in scores for shallower depths. Given these considerations, alternative 8a ranked the highest, given large causeway and dock configuration, followed closely by 8b. Alternative 4a ranked well, but somewhat below 8a and 8b given its focus on extra docks on the east causeway.

4.1.4. OFT: Overwater Fuel Transfer

In the without project condition, overwater fuel transport would be expected to continue due to continued lack of dockside options in the region. The alternatives provide an opportunity to meet additional refueling need at the dock and reducing risk to contamination of marine resources upon which subsistence participants depend for food and cultural value. In the discussion of the OFT variable, the PDT concurred that the number of docks was the key driver, as more docks meant more fuel volume could be delivered per unit time, allowing a greater proportion of demand to be met at the Port. The configuration of the docks (east vs west causeway) was judged to be a minor factor for the OFT variable, as the Port currently offers trucked fuel for small vessels and would continue to offer trucked fuel at and docks not equipped with a permanent fuel header. Depth was judged to play an important role but was less a driver of scores than the number of docks. Regarding the depth scenarios, the PDT noted that at shallower depths, the largest vessels accommodated might be unable to take a full load of fuel, resulting in moderate point reductions for successively shallower depth scenarios. Given these considerations, alternatives 4a, 8a, and 8b all received the same high scores.

4.1.5. NSU: National Security Units

In the without project condition, medium and large vessel classes, such as U.S. Coast Guard cutters and icebreakers, are unable to enter the Port due to their draft. The alternatives would provide an opportunity to support medium and/or large size vessels; offering opportunity for refueling, supply provisioning, crew shifts, and other logistics support.

Scoring for NSUs was based upon input from the U.S. Coast Guard and U.S. Navy Northern Command. Representatives of both agencies participated in a scoring meeting with the PDT to document the types of vessels that should be considered and the rationale for point selections. To generate a single NSU output value, scores across the four vessels types were averaged.

For the CG-L variable, two representative vessel types were discussed: icebreakers and cutters. The current U.S. Coast Guard icebreaker that serves the Arctic is the Healy, which requires 38 feet of draft. As such, the 30- and 35-foot depth options scored zero points. At 40 feet, Alternative 4A scored 8 points and alternatives 8A and 8B each scored the maximum 10 points. Alternative 4A scored lower due to smaller size of the turning basin in the deepwater basin, which might limit maneuverability. It was also judged that the same scores would apply to the planned Polar Security Cutter/Icebreaker. For cutters with around 20 feet of draft, scoring reflected that these vessels could dock at any of the alternative depths, though increased depth and capacity in the deepwater harbor would yield additional flexibility in operation of the port to meet the needs of the calling vessel.

Similarly, for the USN-L variable, two vessel types were discussed: surface combatants and auxiliary support vessels. For surface combatants, only the 40-foot depth alternative provided sufficient draft. Additionally, these long vessels would require the use of a 600-foot dock. The relatively small size of the turning basin in the deepwater harbor was also judged to adversely affect the score for Alternative 4A 40-feet, whereas Alternatives 8A and 8B both received maximum scores. For auxiliary support vessels, the 40-foot depth alternatives would also be required, and their even longer length again resulted in a preference for alternatives 8A and 8B due to maneuverability concerns with 4A.

4.2. Step 2 – Calculate Derived CVUs and NSUs

The derived CVUs and NSUs were calculated based on the scores. For CVUs, each of the five component variables are equally weighted by averaging the scores across the variables. A scale factor of 100 is then applied to the resulting average scores to yield CVUs. As discussed in **Section 3.4**, a sensitivity analysis was performed which confirmed that equal weighting of these variables was appropriate. For NSUs, the NSU variable is the only component variable, and this score is multiplied by a scale factor of 100. **Table 2** presents the computed CVUs and NSUs for each alternative and depth scenario. **Figure 5** shows the computed CVUs for the range of alternatives, and **Figure 6** shows the range of scores across alternatives for the NSUs.

Table 2 – CVUs and NSUs by Alternative

Alternative	Depth Scenario	CVUs	NSUs
No Action	-	0	0
Alt 3a	1 (30ft)	275	
Alt 3a	2 (35ft)	400	
Alt 3a	3 (40ft)	500	
Alt 3b	1 (30ft)	200	
Alt 3b	2 (35ft)	300	
Alt 3b	3 (40ft)	400	
Alt 3c	1 (30ft)	150	
Alt 3c	2 (35ft)	225	
Alt 3c	3 (40ft)	325	
Alt 4a	1 (30ft)	575	200
Alt 4a	2 (35ft)	725	200
Alt 4a	3 (40ft)	875	900
Alt 8a	1 (30ft)	700	200
Alt 8a	2 (35ft)	850	200
Alt 8a	3 (40ft)	1,000	1,000
Alt 8b	1 (30ft)	650	200
Alt 8b	2 (35ft)	800	200
Alt 8b	3 (40ft)	950	1,000

Figure 5 – CVUs by Alternative

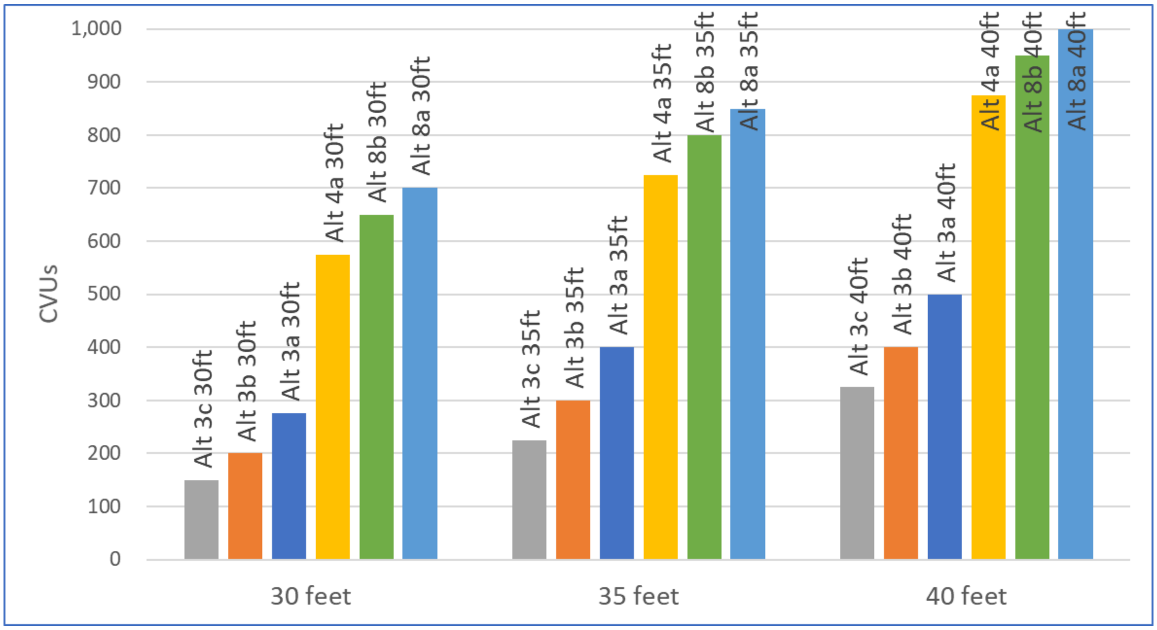
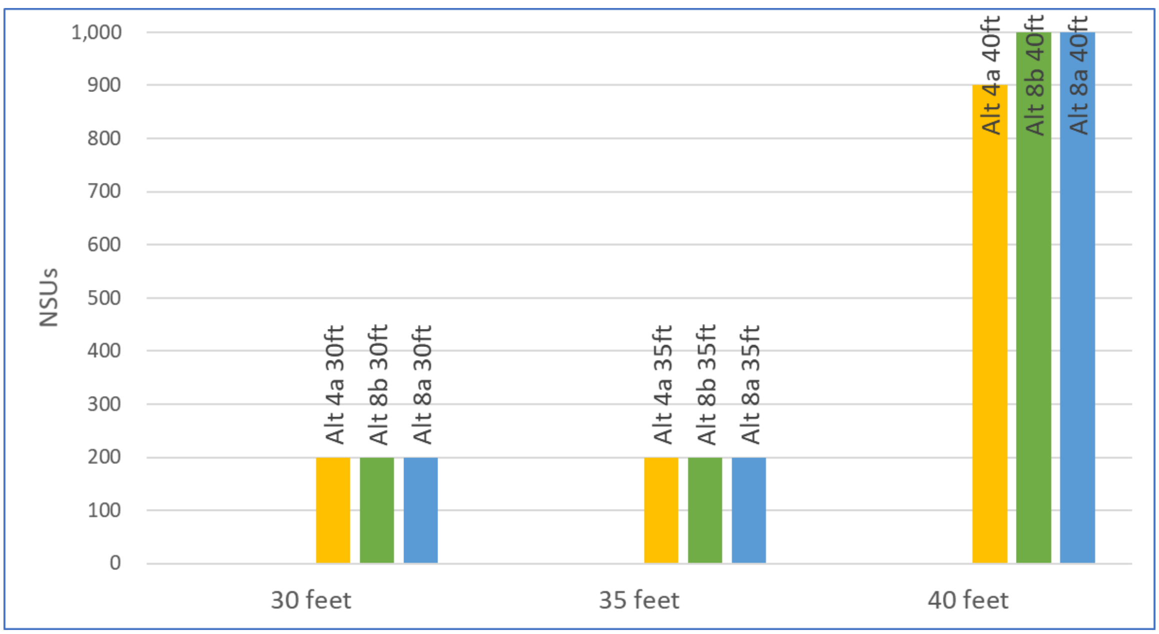


Figure 6 – NSUs by Alternative



4.3. Step 3 – Run CE/ICA Model for CVUs

CVUs are identified as the main derived unit for the analysis and applied to support plan evaluation and recommendation, as discussed in **Section 3.3**. A CE/ICA model run was performed using CVUs as the output. Costs were developed for each alternative and depth scenario by the District, at FY20 price levels, and using the FY20 discount rate of 2.75%. **Table 3** presents the input data which was fed into IWR Planning Suite. Because each of the alternatives are mutually exclusive, alternatives are entered as Measures, each with three Scales, one for each of the three depth scenarios. Combinability rules are specified such that no measures are combinable. This results in a CE/ICA which ranks complete alternatives according to their cost effectiveness and incremental cost. **Table 4** presents the ranking of alternatives produced from the model. Of the total possible 19 plans, including the No Action, there were six plans which were not cost effective, nine which were cost effective but not best buys, and four which were best buys. Best buy plans over the No Action, in order of total output, were 4A (40ft), 8B (40ft), and 8A (40ft). **Table 5** presents the incremental cost calculations for the best buy plans. **Figure 7** presents all these plans according to their output and cost. **Figure 8** presents the incremental cost box plot for the best buy plans.

Table 3 – CE/ICA Input Data, CVUs

Measure	Scale	Annualized Cost $1000	Output
No Action	-	$0	0
Alt 3a	1 (30ft)	$12,514	275
Alt 3a	2 (35ft)	$16,145	400
Alt 3a	3 (40ft)	$14,629	500
Alt 3b	1 (30ft)	$12,185	200
Alt 3b	2 (35ft)	$15,874	300
Alt 3b	3 (40ft)	$14,321	400
Alt 3c	1 (30ft)	$11,681	150
Alt 3c	2 (35ft)	$15,761	225
Alt 3c	3 (40ft)	$13,813	325
Alt 4a	1 (30ft)	$15,633	575
Alt 4a	2 (35ft)	$19,019	725
Alt 4a	3 (40ft)	$17,722	875
Alt 8a	1 (30ft)	$27,190	700
Alt 8a	2 (35ft)	$28,708	850
Alt 8a	3 (40ft)	$28,637	1,000
Alt 8b	1 (30ft)	$25,852	650
Alt 8b	2 (35ft)	$26,706	800
Alt 8b	3 (40ft)	$27,300	950

Table 4 – CE/ICA Outputs, CVUs

Plan	Annualized Cost $1000	Output	Type
No Action	**$0**	**0**	**Best Buy**
3a - 30ft	$12,514	275	Cost Effective
3a - 35ft	$16,145	400	Non-Cost Effective
3a - 40ft	$14,629	500	Cost Effective
3b - 30ft	$12,185	200	Cost Effective
3b - 35ft	$15,874	300	Non-Cost Effective
3b - 40ft	$14,321	400	Cost Effective
3c - 30ft	$11,681	150	Cost Effective
3c - 35ft	$15,761	225	Non-Cost Effective
3c - 40ft	$13,813	325	Cost Effective
4a - 30ft	$15,633	575	Cost Effective
4a - 35ft	$19,019	725	Non-Cost Effective
4a - 40ft	$17,722	875	**Best Buy**
8a - 30ft	$27,190	700	Non-Cost Effective
8a - 35ft	$28,708	850	Non-Cost Effective
8a - 40ft	$28,637	1000	**Best Buy**
8b - 30ft	$25,852	650	Non-Cost Effective
8b - 35ft	$26,706	800	Non-Cost Effective
8b - 40ft	$27,300	950	Cost Effective

Table 5 – Incremental Cost Summary, CVUs

Best Buy	Alternative	Annualized Cost $1000	Total Output	Incremental Cost $1000
1	No Action	$0	0	$0
2	Alt 4a, 40ft	$17,722	875	$20
3	Alt 8a, 40ft	$28,637	1000	$87

Figure 7 – All Possible Plans, CVUs

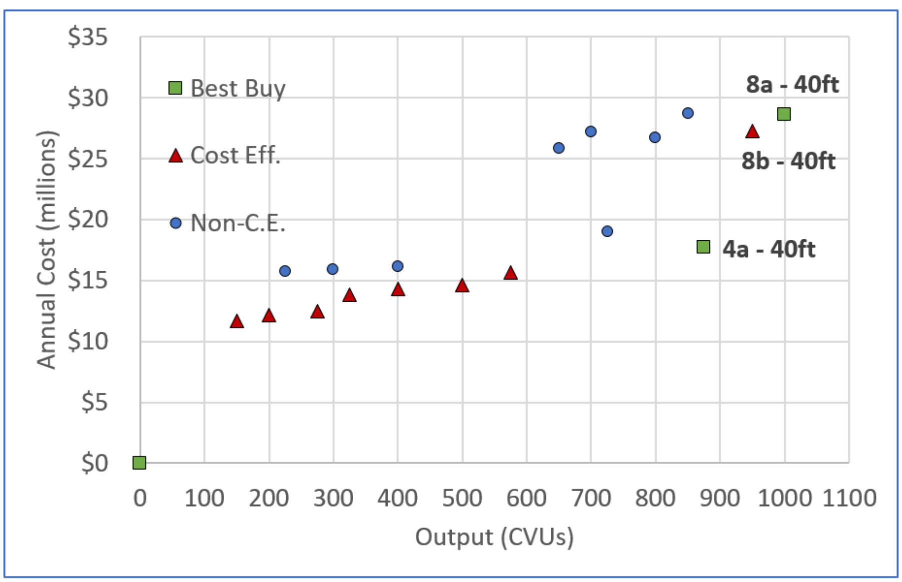
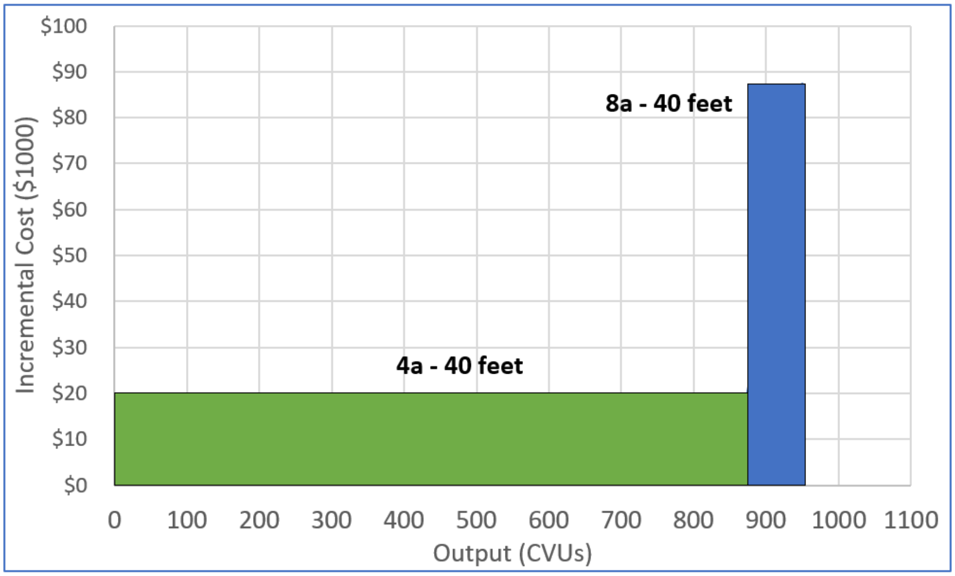


Figure 8 – Incremental Cost, CVUs



4.4. Step 4 – Consider Addition of NSUs

As discussed in **Section 3**, the framework was developed to be able to run CE/ICA analyses in multiple configurations to be able to keep evaluation of national security outputs (NSUs) as a separable incidental benefit category, or to include NSUs in addition to CVUs in a combined derived unit. This section presents both options, first the results of a CE/ICA analysis based only on the NSUs, and then an analysis where NSUs and CVUs have been combined via summation. A series of table and figures follow that present the results of these two runs. **Table 6** presents the input data for these two models.

For the NSUs-only run, **Table 7** and **Figure 9** present the output results for all plans, and **Table 8** and **Figure 10** present the incremental cost for the best buy plans. For combined CVU+NSU, **Table 9** and **Figure 11** present the output results for all plans, and **Table 10** and **Figure 12** present the incremental cost for the best buy plans.

Table 6 – CE/ICA Input Data, CVUs

Measure	Scale	Annualized Cost $1000	CVUs	NSUs	CVUs + NSUs
No Action	-	$0	0	0	0
Alt 3a	1 (30ft)	$12,514	275		275
Alt 3a	2 (35ft)	$16,145	400		400
Alt 3a	3 (40ft)	$14,629	500		500
Alt 3b	1 (30ft)	$12,185	200		200
Alt 3b	2 (35ft)	$15,874	300		300
Alt 3b	3 (40ft)	$14,321	400		400
Alt 3c	1 (30ft)	$11,681	150		150
Alt 3c	2 (35ft)	$15,761	225		225
Alt 3c	3 (40ft)	$13,813	325		325
Alt 4a	1 (30ft)	$15,633	575	200	775
Alt 4a	2 (35ft)	$19,019	725	200	925
Alt 4a	3 (40ft)	$17,722	875	900	1,775
Alt 8a	1 (30ft)	$27,190	700	200	900
Alt 8a	2 (35ft)	$28,708	850	200	1,050
Alt 8a	3 (40ft)	$28,637	1,000	1,000	2,000
Alt 8b	1 (30ft)	$25,852	650	200	850
Alt 8b	2 (35ft)	$26,706	800	200	1,000
Alt 8b	3 (40ft)	$27,300	950	1,000	1,950

Table 7 – CE/ICA Outputs, NSUs-only

Plan	Annualized Cost $1000	Output	Type
No Action	**$0.00**	0	**Best Buy**
3a - 30ft	$12,514		
3a - 35ft	$16,145		
3a - 40ft	$14,629		
3b - 30ft	$12,185		
3b - 35ft	$15,874		
3b - 40ft	$14,321		
3c - 30ft	$11,681		
3c - 35ft	$15,761		
3c - 40ft	$13,813		
4a - 30ft	$15,633	200	Cost Effective
4a - 35ft	$19,019	200	Non-Cost Effective
4a - 40ft	$17,722	900	Best Buy
8a - 30ft	$27,190	200	Non-Cost Effective
8a - 35ft	$28,708	200	Non-Cost Effective
8a - 40ft	$28,637	1000	Non-Cost Effective
8b - 30ft	$25,852	200	Non-Cost Effective
8b - 35ft	$26,706	200	Non-Cost Effective
8b - 40ft	$27,300	1000	Best Buy

Table 8 – Incremental Cost Summary, NSUs-only

Be st Buy	Alternati ve	Annualiz ed Cost $1000	Tot al Output	Increment al Cost $1000
1	No Action	$0	0	$0
2	Alt 4a, 40ft	$17,722	900	$20
3	Alt 8b, 40ft	$27,300	1000	$96

Figure 9 – All Possible Plans, NSUs-only

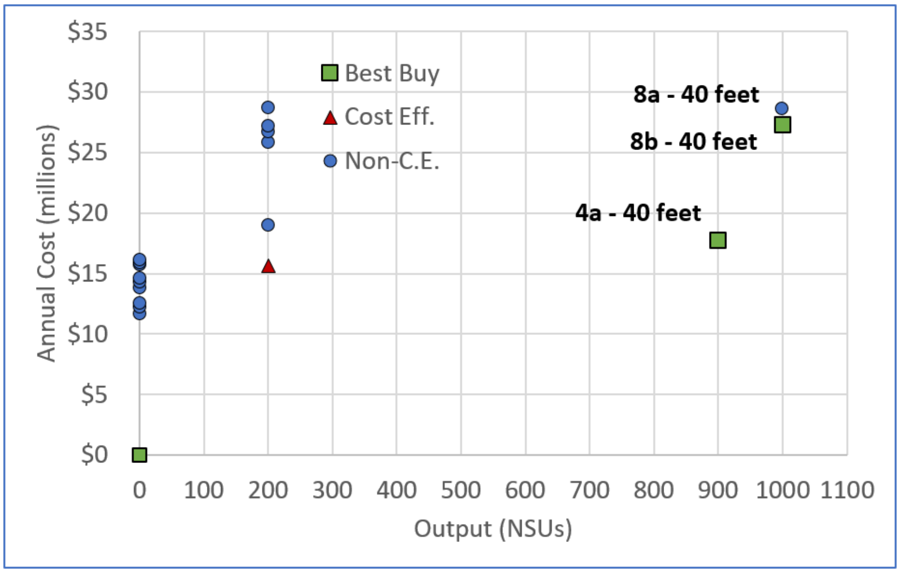


Figure 10 – Incremental Cost, NSUs-only

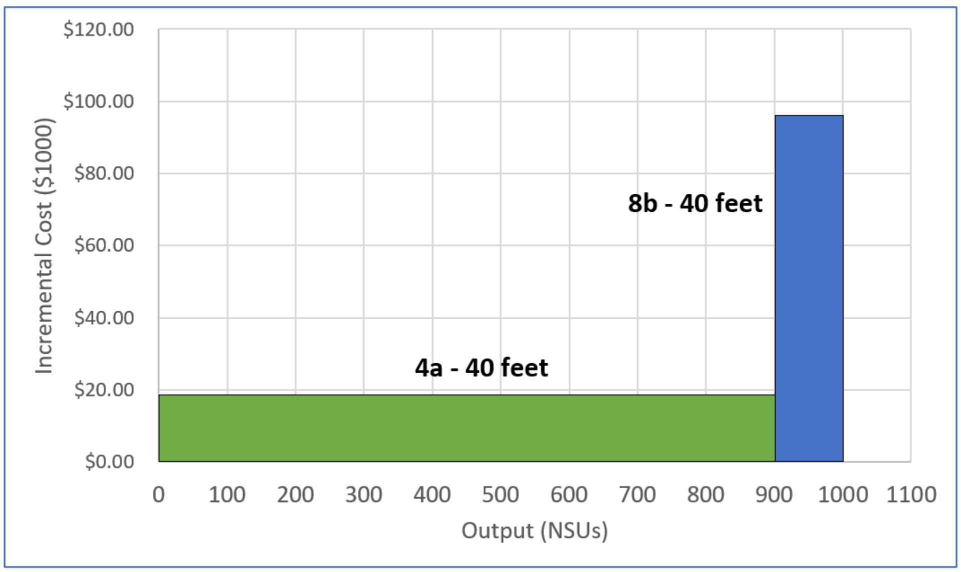


Table 9 – CE/ICA Outputs, CVUs + NSUs

Plan	Annualized Cost $1000	Output	Type
No Action	**$0.00**	**0**	**Best Buy**
3a - 30ft	$12,514	275	Cost Effective
3a - 35ft	$16,145	400	Non-Cost Effective
3a - 40ft	$14,629	500	Cost Effective
3b - 30ft	$12,185	200	Cost Effective
3b - 35ft	$15,874	300	Non-Cost Effective
3b - 40ft	$14,321	400	Cost Effective
3c - 30ft	$11,681	150	Cost Effective
3c - 35ft	$15,761	225	Non-Cost Effective
3c - 40ft	$13,813	325	Cost Effective
4a - 30ft	$15,633	775	Cost Effective
4a - 35ft	$19,019	925	Non-Cost Effective
4a - 40ft	**$17,722**	**1775**	**Best Buy**
8a - 30ft	$27,190	900	Non-Cost Effective
8a - 35ft	$28,708	1050	Non-Cost Effective
8a - 40ft	**$28,637**	**2000**	**Best Buy**
8b - 30ft	$25,852	850	Non-Cost Effective
8b - 35ft	$26,706	1000	Non-Cost Effective
8b - 40ft	$27,300	1950	Cost Effective

Table 10 – Incremental Cost Summary, CVUs + NSUs

Best Buy	Alternative	Annualized Cost $1000	Total Output	Incremental Cost $1000
1	No Action	$0	0	$0
2	Alt 4a, 40ft	$17,722	1,775	$10
3	Alt 8a, 40ft	$28,637	2,000	$49

Figure 11 – All Possible Plans, CVUs + NSUs

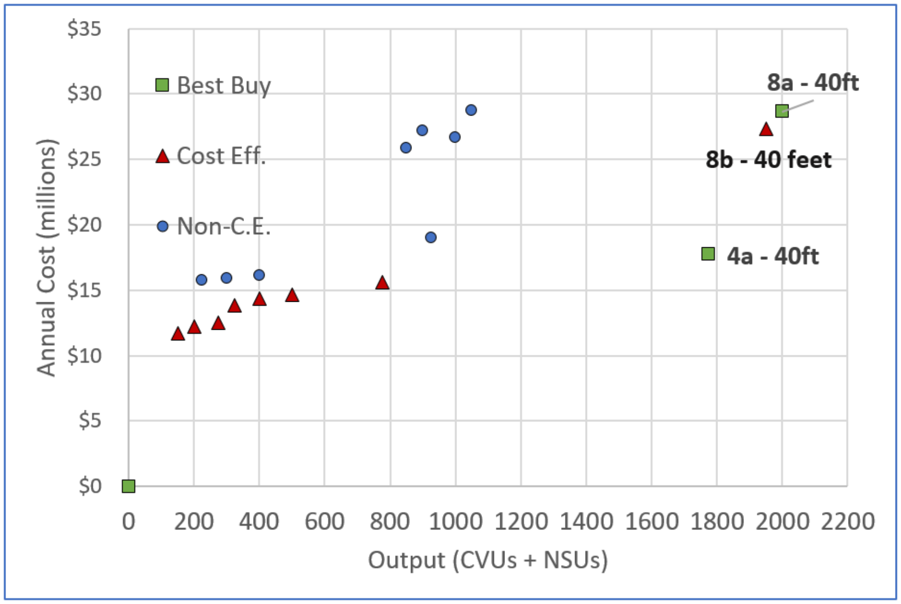
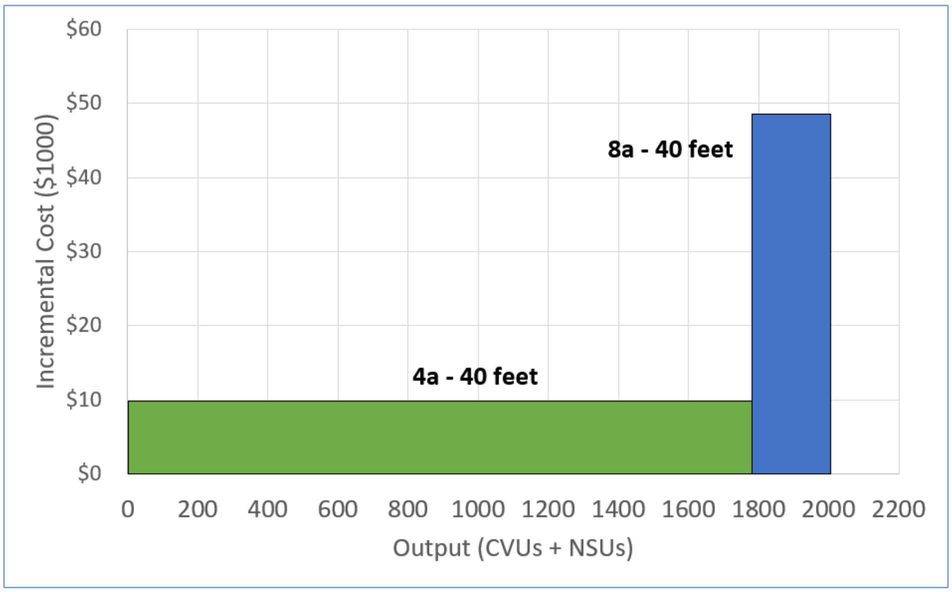


Figure 12 – Incremental Cost, CVUs + NSUs



4.5. Step 5 – Summary of Results

The following narrative discusses the best buy plans from the model runs previously presented. The discussion focuses on the differences between the outputs provided for each successive plan.

4.5.1. CVUs Only

In the CVU analysis, the best buy plans were 4a and 8a, both at the 40-foot depth scenario. Plan 8b (40ft) ranked between these two best buy plans and was cost effective. **Figure 7** shows that 4A (40ft) was the most efficient (cost per unit) alternative in generating CVUs over the No Action.

To buy up to the next best buy plan, 8A (40ft), would incur a cost of $87,300 per additional CVU as compared to the cost of $20,300 per unit for the first best buy. This buy-up would generate 125 additional CVUs, or a 14% increase in output. Alt 8A (40ft) scored similar to Alt 4A (40ft) in the OPE and OFT variables given that they would both maximize the number docks at the Port. Alt 8A (40ft) scored better in the PRE and CDR variables, reflecting the expanded outer harbor size as a result of the east causeway relocation and the inclusion of four docks on the west causeway, which was judged to have greater benefit to cargo and industrial operations than inclusion of two docks on the east breakwater.

Alternative 8B (40ft) scored only marginally lower than 8A (40ft) in the PRE and CDR variables, owing to the longer causeway for the deep-water basin in 8A (40ft), which maximizes available refuge area, including for large vessels, and would maximize the size and quantity of vessels that could be served simultaneously for cargo transshipment and other industrial activities. Because the incremental cost of buying up from 4A (40ft) to 8A (40ft) was less than the incremental cost of buying up to 8B (40ft), 8B (40ft) is cost effective, but not a best buy.

4.5.2. National Security

In Section 4.4, the output associated with the NSU variable, representative of potential national security benefits, were considered. The analysis focused on potential incidental benefits to the U.S. Coast Guard and U.S. Navy in terms of the port’s ability to provide logistics support to vessels in the region.

In the model run which included only the NSU output, alternatives 4A (40ft) and 8B (40ft) were both best buy plans. Alternative 8A (40ft) had the same output as 8B (40ft) at a higher cost, and so was not cost effective. These results reflect the input of the U.S. Coast Guard and U.S. Navy, which indicated that 40-feet of depth was required to provide adequate logistics support. It also reflects a preference for maximizing the size of the deep-water basin to provide the most capacity, flexibility, and maneuverability for large vessels.

In the model run where CVUs and NSUs were added together, the results mimic those of the CVU-only run, where the best buy plans are 4A (40ft) and 8A (40ft), with 8B (40ft) being cost effective and falling between the two best buys.

5. REFERENCES

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(USACE) U.S. Army Corps of Engineers. Jul 06 2017. Implementation Guidance for Section 1105 of the Water Resources and Development Act (WRDA 2016), Remote and Subsistence Harbors. CECW-NWD. Department of the Army.

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(USDOT) U.S. Department of Transportation, prepared by the U.S. Committee on the Marine Transportation System Arctic Marine Transportation Integrated Action Team. April 15 2016. A Ten-Year Prioritization of Infrastructure Needs in the U.S. Arctic, National Strategy for the Arctic Region Implementation Plan Task 1.1.2. U.S. Department of Transportation.

U.S. Department of Defense. December 2016. Report to Congress on Strategy to Protect United States National Security Interests in the Arctic Region. OUSD (Policy).

Attachment 1

Weighting Sensitivity Results

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Introduction

The following series of slides provides the results of the sensitivity analysis which determined it was appropriate to use equal weighting of the four variables included in the final CE/ICA framework from which CVUs are derived.

Findings of Sensitivity Analysis

The sensitivity analysis considered two alternative weighting scenarios, one with socio-economic priority (OPE and CDR strongly weighted) and one with a social-environmental priority (PRE, and OFT strongly weighted). The sensitivity found that while the computed incremental cost changed between these weighting schemes, the top performing alternatives did not.

When socioeconomic output is weighted more heavily, Alt 4A (40ft) and 8A (40ft) are the top performers. In this scenarios, Alt 8B (40ft) is cost effective but not a best buy.

When social-environmental output is weighted more heavily, the same pattern is observed. Alternatives 4A (40ft) and 8A (40ft) are best buy plans, and alternative 8B (40ft) is cost effective but not a best buy.

Based on these results it was determined that an equal weighted scheme was appropriate for the final model iteration.

Socioeconomic Priority (strongly weight OPE and CDR)

<u>Weights</u>

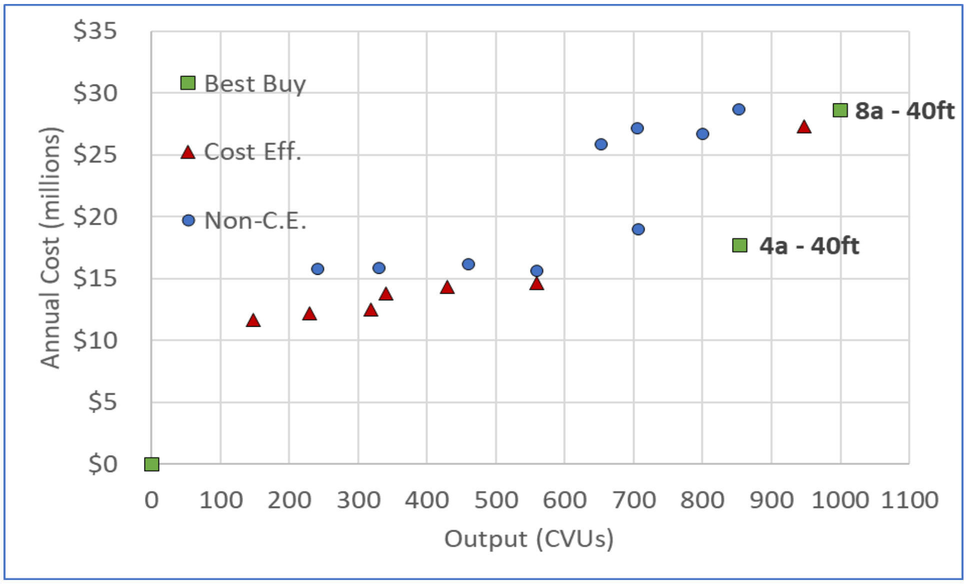
AHP Weights

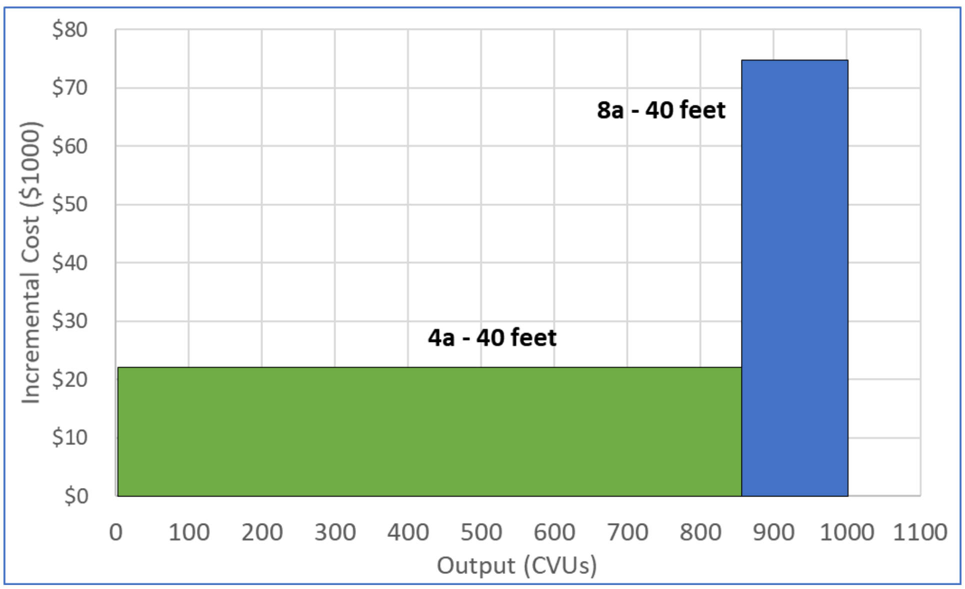
	OPE	PRE	CDR	OFT
OPE	N/A	(5) Strongly More Important	(1) Equally Important	(5) Strongly More Important
PRE	(-5) Strongly Less Important	N/A	(-5) Strongly Less Important	(3) Slightly More Important
CDR	(1) Equally Important	(5) Strongly More Important	N/A	(5) Strongly More Important
OFT	(-5) Strongly Less Important	(-3) Slightly Less Important	(-5) Strongly Less Important	N/A
Weight	41.137	11.314	41.137	6.412

Best Buy Plans

Best Buy	Alt	Ann Cost ($1000)	Total Output (CVU)	Inc. Cost ($1000)
1	No Action	$0	0	$0
2	4a - 40ft	$17,722	854	$21
3	8a - 40ft	$28,637	1,000	$75

Figures





Social-Environmental Priority (strongly weight PRE and OFT)

Weights

AHP Weights

	OPE	PRE	CDR	OFT
OPE	N/A	(-3) Slightly Less Important	(1) Equally Important	(-3) Slightly Less Important
PRE	(3) Slightly More Important	N/A	(5) Strongly More Important	(1) Equally Important
CDR	(1) Equally Important	(-5) Strongly Less Important	N/A	(-3) Slightly Less Important
OFT	(3) Slightly More Important	(1) Equally Important	(3) Slightly More Important	N/A
Weight	12.011	41.312	10.645	36.032

Best Buy Plans

Best Buy	Alt	Ann Cost ($1000)	Total Output (CVU)	Inc. Cost ($1000)
1	No Action	$0	0	$0
2	4a - 40ft	$17,722	885	$20
3	8a - 40ft	$28,637	1,000	$95

<u>Figures</u>