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NAVIGATION IMPROVEMENTS
FINAL INTERIM FEASIBILITY REPORT

NOME, ALASKA

APPENDIXES

A – Hydraulic Design

B – Economic Analysis

C – Geotechnical Analysis (Woodward-Clyde)

D – Cost Estimate

E – Real Estate Requirements

F -- Correspondence

APPENDIX A
HYDRAULIC DESIGN

APPENDIX A
HYDRAULIC DESIGN

NAVIGATION IMPROVEMENTS FEASIBILITY REPORT
NOME, ALASKA

CONTENTS

Page

1. INTRODUCTION A-1
   1.1 Appendix Purpose A-1
   1.2 Project Purpose and Needs Assessment A-1
   1.3 Use of English Units A-3

2. EXISTING NAVIGATION/REVETMENT FEATURES A-4
   2.1 Background A-4
   2.2 Small Boat Harbor A-4
   2.3 Causeway A-4
   2.4 Seawall A-7
   2.5 Entrance Channel A-8
   2.6 Project Problems A-8

3. SITE CHARACTERISTICS A-9
   3.1 Climatology A-9
   3.2 Water Levels and Currents A-9
      3.2.1 Tides. A-9
      3.2.2 Sea-Level Rise. A-11
      3.2.3 Storm Surge. A-11
      3.2.4 Set-Down. A-11
      3.2.5 Currents. A-12
      3.2.6 Wave Climate. A-13
   3.3 Hydrology A-14
      3.3.1 Rivers. A-14
      3.3.2 Dry and Bourbon Creeks. A-14
      3.3.3 Estuary A-14
      3.3.4 Ice Conditions. A-17

4. TECHNICAL FINDINGS AND DESIGN A-19
   4.1 Wave Studies A-19
      4.1.1 General. A-19
      4.1.2 Wave Hindcast. A-19
   4.2 Sedimentation A-24
      4.2.1 Littoral Drift. A-29
      4.2.2 Depth of Closure. A-30
      4.2.3 Sediment Trap A-30

CONTENTS--Continued

Page

4.2.4 Snake River Sediment A-45
4.2.5 Ice Studies. A-50

5. DESIGN CRITERIA A-54
5.1 Design Vessel and Fleet A-54
5.2 Allowable Wave Heights A-55
5.2.1 Entrance Channel A-55
5.2.2 Dock Approach Channel. A-55
5.2.3 Inner Harbor Access Channel A-55
5.2.4 Inner Harbor. A-55
5.3 Channel Width and Depth A-55
5.3.1 Entrance Channel A-55
5.3.2 Dock Approach Channel. A-56
5.3.3 Inner Harbor Access Channel A-56
5.4 Flushing A-57
5.5 Breakwaters A-57
5.5.1 Main Breakwater. A-58
5.5.2 Spur Breakwater. A-58
5.6 Channel Usability A-58
5.7 Dredging Requirements A-59

6. MODEL STUDIES A-62
6.1 Purpose of 3-D Model Study A-62
6.2 Model Design A-62
6.3 Model Test Procedure A-64
6.4 Model Results A-66
6.4.1 Base Condition Currents and Sedimentation. A-66
6.4.2 Base Condition Waves. A-66
6.4.3 Main Breakwater. A-66
6.4.4 Causeway Extension. A-67
6.4.5 Sediment Trap. A-67
6.4.6 Final Test Series. A-67
6.4.7 Model Conclusions. A-70

7. DEVELOPMENT OF RECOMMENDED PLAN A-71
7.1 Project Objectives A-71
7.2 Comparison of Alternative Plans A-71
7.3 Selection of Recommended Plan A-73

8. THE RECOMMENDED PLAN A-86
8.1 General Description A-86
8.2 Channels A-86
8.2.1 General. A-86
8.2.2 Entrance Channel A-89

CONTENTS--Continued

Page

8.2.3 Dock Approach Channel. A-89
8.2.4 Inner Harbor Access Channel. A-89
8.2.5 Wave Height Criteria. A-89
8.3 Breakwaters A-89
8.3.1 General Description. A-89
8.3.2 Main Breakwater A-91
8.3.3 Spur Breakwater. A-91
8.4 Existing Project Features A-91
8.5 Circulation A-91
8.6 Shoaling A-93
8.7 Construction Dredging and Excavation A-94
8.8 Operation, Maintenance, Repair, Replacement, and Rehabilitation A-96
8.8.1 General. A-96
8.8.2 Federal Inner Harbor Channel Maintenance. A-96
8.8.3 Federal Causeway Dock Maintenance Dredging. A-97
8.8.4 Major Maintenance. A-97
8.8.5 Non-federal Sponsor's O&M Cost. A-97
8.9 Effects on Downstream Beaches A-98
8.10 Aids to Navigation A-98
8.11 Detailed Quantity and Cost Estimates A-98
8.12 Construction Schedule A-98
8.13 Effects of Project Construction A-100

REFERENCES A-101

Figures

Figure No.	Title	Page
1-1	Location and vicinity map	A-2
2-1	Project site features (foldout)	A-5
4-1	Level 1 grid, wave hindcast	A-21
4-2	Level 2 grid, wave hindcast	A-22
4-3	Level 3 depth contours, wave hindcast	A-23
4-4	Wave frequency, Nome, Alaska, 0 ft MLLW	A-27
4-5	Wave conditions by direction	A-28
4-6	West and east areas for beach profiles – 1986, 1990 and 1997	A-31
4-7	Beach profiles – 1986, 1990, and 1997, west of causeway, station 0+00	A-33
4-8	Beach profiles – 1986, 1990, and 1997, west of causeway, station 5+00	A-34

CONTENTS--Continued

FIGURES—Continued

Figure No.	Title	Page
4-9	Beach profiles – 1986, 1990, and 1997, west of causeway, station 10+00	A-35
4-10	Beach profiles – 1986, 1990, and 1997, west of causeway, station 15+00	A-36
4-11	Beach profiles – 1986, 1990, and 1997, west of causeway, station 20+00	A-37
4-12	Beach profiles – 1986, 1990, and 1997, west of causeway, station 25+00	A-38
4-13	Beach profiles – 1986, 1990, and 1997, east of causeway, station 0+00	A-39
4-14	Beach profiles – 1986, 1990, and 1997, east of causeway, station 5+00	A-40
4-15	Beach profiles – 1986, 1990, and 1997, east of causeway, station 10+00	A-41
4-16	Beach profiles – 1986, 1990, and 1997, east of causeway, station 15+00	A-42
4-17	Beach profiles – 1986, 1990, and 1997, east of causeway, station 20+00	A-43
4-18	Beach profiles – 1986, 1990, and 1997, east of causeway, station 25+00	A-44
4-19	Snake River sediment discharge v. water discharge	A-45
4-20	Snake River suspended sediment discharge v. water discharge, regression best-fit line	A-46
4-21	Snake River bedload sediment discharge v. water discharge, regression best-fit line	A-47
4-22	Nome Small Boat Harbor sediment classification sampling locations	A-48
4-23	Sediment classification sample 1	A-48
4-24	Sediment classification sample 2	A-49
4-25	Sediment classification sample 3	A-49
4-26	Sediment classification sample 4	A-50
4-27	Sediment classification sample 5	A-50
6-1	Wave gauge initial locations	A-65
6-2	Model study results (1)	A-68
6-3	Model study results (2)	A-69
7-1	Alternative A, new channel next to existing with spending beach	A-74
7-2	Alternative B, new channel off causeway with breakwater	A-75
7-3	Alternative C, harbor outside riverbed in spit	A-76
7-4	Alternative D, major rehabilitation	A-77
7-5	Alternative E, channel through spit with breakwater/revetment	A-78

CONTENTS—Continued

FIGURES—Continued

Figure No.	Title	Page
7-6	Alternative F, channel through spit	A-79
7-7	Alternative H, channel through spit with new breakwaters extending past depth of closure	A-80
7-8	Alternative I, channel through spit with breakwater extending past depth of closure	A-81
7-9	Alternative J, plan I but with –22' depth at causeway	A-82
7-10	Alternative K, plan J but with causeway extension	A-83
7-11	Alternative L, plan K but with a sand bypass added	A-84
7-12	Alternative M, plan L but with breakwater crest height 17'	A-85
8-1	Recommended plan (foldout)	A-87
8-2	Typical channel cross sections	A-90
8-3	Typical breakwater cross sections	A-92
8-4	EPA-approved disposal sites	A-95

Tables

Table No.	Title	Page
3-1	Nome meteorological data	A-10
3-2	Recorded tidal data for Nome, Alaska	A-9
3-3	Wind data for Nome, 1945-1990	A-12
3-4	Discharges of Snake River near Nome, 1965-1991	A-15
3-5	Spot discharges from Bourbon and Dry Creeks	A-17
4-1	Comparison of hindcast wave heights to measurements from buoys	A-22
4-2	Comparison of hindcast wave periods to measurements from buoys	A-23
4-3	Wave occurrence frequency, 0 ft MLLW	A-25
4-4	Wave heights for various return periods	A-24
4-5	Littoral drift at Nome, east and west of causeway	A-29
4-6	Sediment discharge analysis	A-32
4-7	Variation in ice force from ice thicknesses of 3.0 and 4.5 feet	A-52
5-1	Entrance channel depth	A-56
5-2	Inner harbor access channel depth	A-57
5-3	Historical dredging costs, Nome Harbor	A-59
6-1	Relationships of the 3-D model to prototype	A-63
8-1	Dredging and excavation quantities	A-94
8-2	Inner harbor costs without contingencies	A-99
8-3	Causeway dock improvement costs without contingencies	A-99

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June 15, 1998

APPENDIX A
HYDRAULIC DESIGN

NAVIGATION IMPROVEMENTS FEASIBILITY REPORT
NOME, ALASKA

1. INTRODUCTION

1.1 Appendix Purpose

This appendix describes the technical aspects of proposed improvements to the navigation features of Nome Harbor. (See figure 1-1 for the project location.) This appendix provides the background for determining the Federal interest in the major construction features, including the breakwaters and channel improvements. A three-dimensional hydraulic model was used to evaluate the relative differences in harbor wave action, currents, and sedimentation between existing conditions and proposed alternatives.

1.2 Project Purpose and Needs Assessment

The objectives listed below were identified as possible navigation improvements before beginning the engineering analysis.

a. Restore the project as authorized by performing a major rehabilitation.

b. Improve inner harbor access by improving the channel alignment and by deepening.

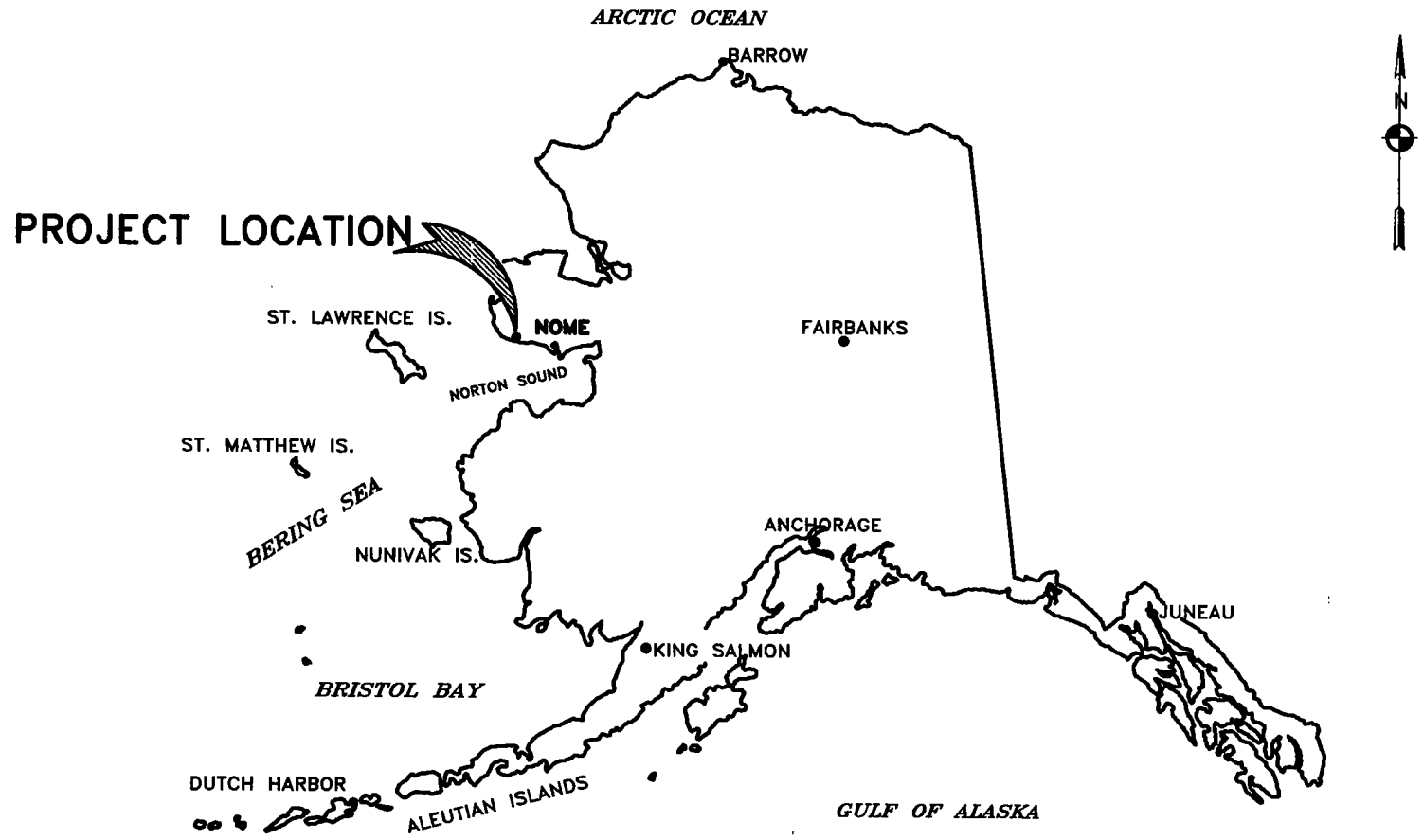
c. Develop a maintainable inner harbor access channel with adequate dimensions to handle the user fleet.

d. Improve the effective use time of the causeway docks. Potential improvements include decreased wave activity and increased depths. Develop a protected zone to allow tugs to change from towing mode to docking configuration.

e. Identify littoral sediment transport and Snake River sediment transport trends to minimize operation and maintenance of a new navigation channel and optimize usage at project depths. Combined with this, develop a realistic maintenance plan that allows project benefits to be realized.

f. Determine the effects of a new navigation channel on circulation and wave action as related to the city of Nome's harbor expansion plans.

g. To the extent possible, minimize dredging and maintenance costs. Cost would be minimized by several possible methods, which include decreasing dredging and



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LOCATION AND VICINITY MAP

NAVIGATION IMPROVEMENTS, NOME, ALASKA

1 – 1

establishing a program that reduces lost time due to weather or wave delays. Where cost-effective, develop structural controls for sedimentation.

h. Minimize any negative environmental impacts of the existing or new project.

1.3 Use of English Units

Most measurements in this appendix are in English (inch-pound) units, rather than in metric (SI) units. Metric units predominate in the main report and in Appendix B, Economic Analysis. The rationale for using English units here is explained in the following paragraphs.

Nome has been an active Corps of Engineers project since 1919 and was designed and constructed in English units. Maintenance dredging and project surveys dating back as far as 1977 were used in this analysis. Integral to the study was analyzing past beach surveys dating back to 1986, then comparing them to bathymetric survey data obtained from the 1997 survey. The 1986 and 1990 surveys were completed in English units based on State plane horizontal control in English units. By using English units in this analysis, the surveys could be readily contoured, and it was not necessary to go through the laborious process of converting to integer metric contours.

It followed that the most cost-effective survey approach to use for the 1997 survey was to match the State plane grid system and use survey monuments from the previous surveys to preclude additional field and office survey costs. The interpretation of beach contours to obtain sediment budgets along the coastline of Nome was a major design consideration used in project development.

Additionally, the causeway, an integral feature of longshore transport and hydrodynamics in the project area, was designed in English units and the as-built drawings are in English units. Converting more than 30 past survey drawings into metric so that actual contouring would be metric (not a conversion) could easily have taken a year and $100,000. The wave hindcast was performed in metric units, since this is commonly done and the data is easily converted to English units.

2. EXISTING NAVIGATION/REVETMENT FEATURES

2.1 Background

The Nome Federal navigation project was first authorized by the River and Harbor Act of August 8, 1917. The authorization was to construct jetties, dredge a channel, and revet the banks of the Snake River. The original jetties that defined the Snake River mouth entrance were timber and concrete structures, the east jetty 335 feet long and the west 460 feet. The jetties were completed in 1923. They were reconstructed in 1940 with reinforced concrete and modified to 240 feet long for the east jetty and 400 feet long for the west. The authorized width of the channel is 75 feet (ft) at a depth of -8 ft Mean Lower Low Water (MLLW) from Norton Sound through the Snake River, ending in a turning basin of the same depth. The basin is 250 feet wide and 600 feet long. The entrance channel, 1,925 feet long, was constructed with an abrupt 90-degree turn without widening and has not been maintainable with dredging efforts applied since construction. The channel and riverbanks were originally stabilized with timber piling. The timber piling was severely damaged during a storm in 1945. The timber piles were completely refaced with steel sheet pile in 1952. The total length of sheet pile is 3,815 feet. Figure 2-1 shows the existing navigation features.

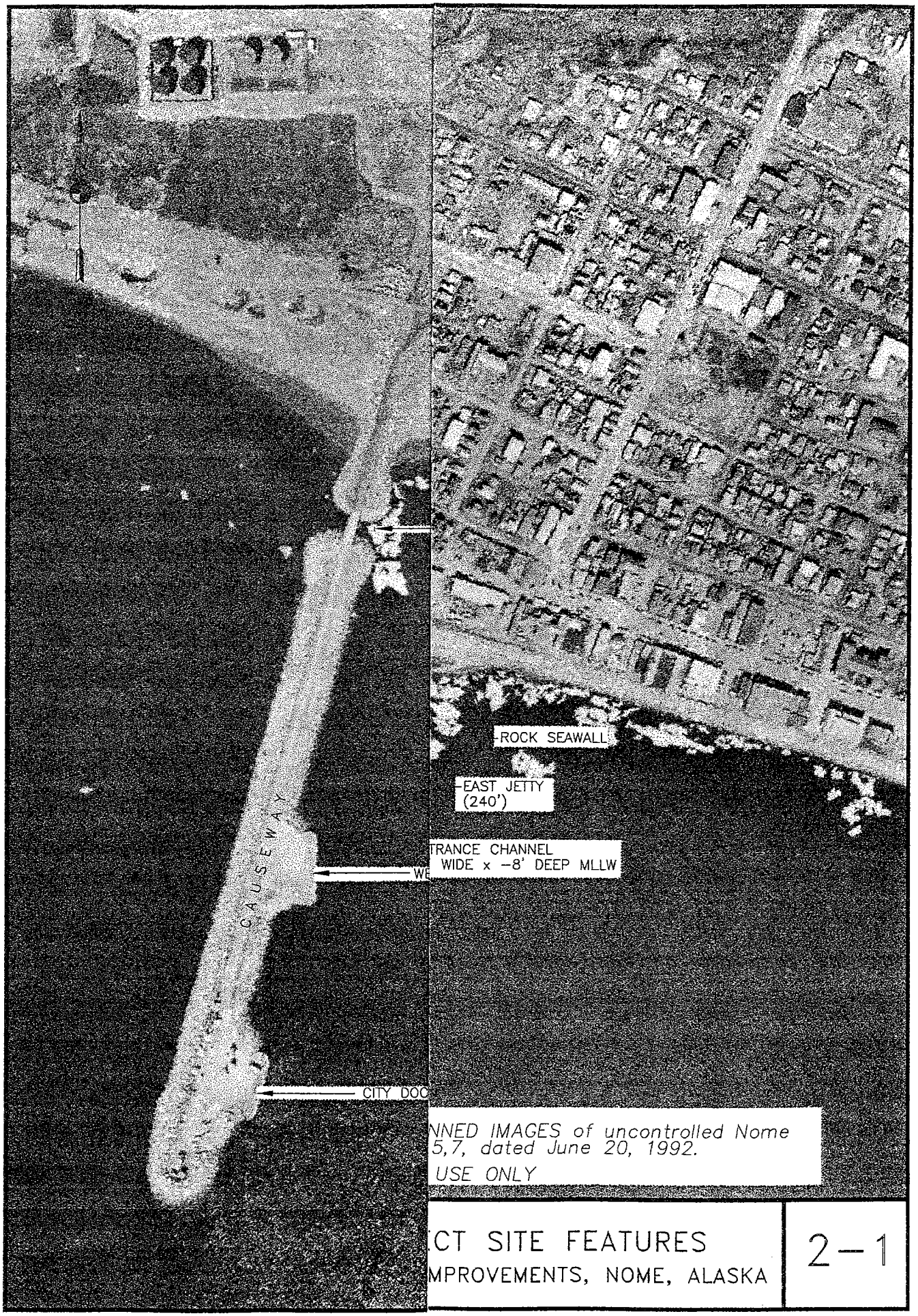
2.2 Small Boat Harbor

The City of Nome has begun to upgrade and expand the Nome small boat harbor and its facilities. The area of upgrade is adjacent to the northern portion of the existing federally authorized turning basin. The upgrade project includes constructing sheet pile bulkheads, dredging existing material to achieve depths of –8 to –10 feet MLLW, filling an area of approximately 6 acres for uplands, constructing floating docks and ramps, and placing riprap along the shoreline. The city started construction in April 1997 by dredging the west half of the harbor and plans to construct the project in phases, with completion scheduled for December 2000.

2.3 Causeway

A causeway was constructed to replace the historic open-water lightering system used for resupply of Nome and outlying villages. The city of Nome began construction of the causeway in November 1985. Construction history and other information is contained in the "1989 Annual Report of Nome Littoral Drift Monitoring and Shore Protection Program," prepared by the city of Nome. This report chronicles the construction sequence as follows.

In November 1985, 700 linear feet of the causeway was constructed. Causeway construction was shut down for the winter season on November 21, 1985. In mid-June 1986, construction of the causeway resumed, with work proceeding until



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MPROVEMENTS, NOME, ALASKA

2-1

November 1, 1986, when the causeway reached its Phase I length of 2,700+ linear feet. Final armor stones were placed in June 1987. The causeway was constructed with 22-ton, 16-ton, and 8-ton armor rock on the west side of the trunk, 22-ton rock at the head, and 8-ton rock on the east side of the trunk. The side slope of the west side and head is 2H:1V; the side slope on the east is 1.5H:1V. The top elevation of the west face varies from +20 to +28 ft MLLW. The east face top elevation is +15 ft MLLW. The core of the causeway is pit run tailings, a clean gravel with a maximum unit weight of 100 lb and not more than 5 percent by weight passing a 200 sieve. Adequate mass was placed to resist up to 110 kips per linear foot of lateral ice thrust.

A breach was left in the causeway for passing fish and other marine life. The breach was established at the -7-ft MLLW depth contour and bridged to allow cargo transfer. Since construction, however, the breach has filled in to an approximate depth of -2.5 ft MLLW.

After completion of the causeway, two earth-filled circular sheet pile docks were constructed on its west side. The inner or northernmost cell, West Gold Dock, was completed in the fall of 1989. The outer cell, City Dock, was completed in August 1991. The outer dock is used by the large petroleum barges and has the pipeline and headers for this type of cargo transfer.

The causeway structure is in excellent condition. There is no known movement of stone, and ice has not presented a problem. Cargo handling is curtailed to some degree because the bridge across the fish passage breach controls loads on the causeway road. As already noted, the fish passageway has shoaled to –2.5 ft MLLW.

2.4 Seawall

Construction of a federally authorized seawall began in 1949 to protect the Nome shoreline from pounding Bering Sea storms. The seawall, completed in 1951, extends 3,350 feet from the existing entrance channel to the east. The seawall consists of a rock-revetted slope with a crest height of +18 ft MLLW. The crest width is 16 feet, and the upper limit of the armor rock is in the 12-ton range. The city of Nome has responsibility for maintaining the seawall.

The federally constructed seawall remains in good condition overall, though it has been reported that sand has been removed from the toe or stone is missing. It rests on a fairly non-erodible surface. East of the Federal seawall, extensive erosion has occurred. The State of Alaska constructed a 3,750-foot eastern extension beginning in September 1993. The State extension was completed in 1995. Prior to the State's revetment extension, an August 1993 storm with an accompanying surge caused significant erosion on the eastern edge of the Nome shoreline where the revetment is now constructed.

2.5 Entrance Channel

The seaward portion of the channel is entirely within the active littoral transport zone and is therefore subject to continuous sediment deposition. Channel controlling depths are frequently shoaled to -3 ft MLLW. The zone between the jetties and the first channel turn is blocked from alongshore currents when the jetties are in good condition and is the collection area for sediments fluxing around the end of the jetties. At present, it is also the collection area for sediments passing under the jetties. Maximum Corps dredging effort has not been able to maintain a continuously open system at the -8-ft-MLLW authorized depth. That effort has included a continuous active dredge presence through the open navigation season and the removal of up to 10,000 cubic yards (yd^3) of material per year. The jetties are in a failed condition, as they are perched above the sand bed and sediment is transferred through them to the channel.

The inner portion of the channel, which lies between sheet pile walls, is now maintained to the full 120-foot width between walls to maximize accessibility for the 50-by-200-foot barges using the system. The steel sheet-pile revetment is corroded and in danger of failing. Numerous piles have holed through at the water line, and sand passes through whenever free water is present on the land side. The pilings are held in place by those piles not totally corroded and by the waler and tieback system. Immediate replacement is needed if present use is to continue, as large segments could fail during any major storm. A failure could curtail most harbor activity because the large tugs and barges rely on the sheet pile for guidance during adverse conditions. Channel alignment includes a 90-degree turn without widening, and a reflective wall that creates a surfing condition for vessels when waves are present.

2.6 Project Problems

The difficulties, described by the project sponsor and verified by research and technical analysis, are twofold. First, large delays in accessing inner harbor facilities are caused by inadequate channel depths, widths, and widening at bends, combined with surfing conditions in the access channel under moderate wave conditions. The problems are compounded by deteriorated structures that allow sediment to transfer to the channel, and a maintenance program that has not been able to retain project depths except for extremely short periods. Also, increased harbor use has pushed user vessel sizes beyond the limits of safe use within the authorized harbor dimensions.

Constraints on use of the causeway docks cause the second major difficulty. These constraints are partially due to the inability of vessels to stay at the docks under somewhat adverse wave conditions. Local interests state that they are unable to make dock landings when waves are about 1 meter in height and greater. Reviews of shipping records indicate that the outer dock is not usable about 40 percent of the time and the inner dock is unusable 30 percent of the time due to the excessive wave heights.

3. SITE CHARACTERISTICS

3.1 Climatology

Nome is located at the northern edge of Norton Sound, approximately 545 miles by air northwest of Anchorage. The wave conditions and climate are influenced by both the Norton Sound and Bering Sea oceanographic conditions. Nome is affected moderately by the influence of Norton Sound open water, typically from early June to about the middle of November. Storms within this area during these months result in extended periods of cloudiness and rain. During the summer months, the daily temperature variation is very slight. The freezing of Norton Sound, in November on average, causes a rather abrupt change from a maritime to a continental climate. Temperatures generally remain well below freezing from the middle of November to the latter part of April, with January usually the coldest month of the year. Precipitation reaches its maximum in late summer and drops to a minimum in April and May. See table 3-1 for meteorological data for Nome published by the National Oceanographic and Atmospheric Administration (NOAA).

3.2 Water Levels and Currents

3.2.1 Tides.

The tidal influence at Nome is minimal, and the tides are chiefly diurnal. Much larger sea level fluctuations occur at Nome due to storm surges than are shown below. Tidal data, referenced to Mean Lower Low Water, are shown in table 3-2.

TABLE 3-2.—*Recorded tidal data for Nome, Alaska (ft)*

Mean Higher High Water (MHHW)	+1.6
Mean High Water (MHW)	+1.4
Mean Low Water (MLW)	+0.4
Mean Lower Low Water (MLLW)	0.0 (datum)
Extreme Low Water	-2.5

Source: NOAA Chart 16206, 6th ed., July 21, 1990.

From the above data, the mean tide, the arithmetic average of the Mean High Water (MHW) and the Mean Low Water (MLW), is 0.9 feet. The mean range is the difference between MHW and MLW of 1.0 feet.

TABLE 3-1.—*Nome meteorological data*

LATITUDE: 64° 30' N LONGITUDE: 165° 26' W ELEVATION: FT. GRND 13 BARO 19 TIME ZONE: ALASKA WBAN: 26617

	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE °F														
Normals														
-Daily Maximum		14.7	12.2	17.4	25.5	42.0	52.9	57.7	56.1	48.7	33.7	22.5	15.1	33.2
-Daily Minimum		-0.7	-4.5	-0.3	9.7	29.2	38.8	45.2	44.1	36.3	22.2	9.3	-0.5	19.1
-Monthly		7.0	3.9	8.6	17.6	35.6	45.9	51.5	50.2	42.5	28.0	15.9	7.3	26.2
Extremes														
-Record Highest	49	43	48	43	51	78	81	86	81	71	59	45	43	86
-Year		1977	1986	1984	1988	1981	1957	1977	1977	1979	1954	1983	1969	JUL 1977
-Record Lowest	49	-54	-42	-46	-30	-11	23	30	26	9	-10	-39	-41	-54
-Year		1989	1978	1971	1968	1949	1974	1994	1994	1992	1966	1948	1961	JAN 1989
NORMAL DEGREE DAYS:														
Heating (base 65 °F)		1798	1711	1748	1422	911	573	423	459	675	1147	1473	1789	14129
Cooling (base 65 °F)		0	0	0	0	0	0	0	0	0	0	0	0	0
% OF POSSIBLE SUNSHINE	40	40	55	54	54	50	43	37	32	36	35	31	34	42
MEAN SKY COVER(tenths)														
Sunrise - Sunset	49	6.2	5.4	5.7	6.1	6.6	6.8	7.6	8.1	7.5	6.9	6.8	6.2	6.7
MEAN NUMBER OF DAYS:														
Sunrise to Sunset														
-Clear	49	10.1	11.6	11.2	9.2	7.2	5.9	3.9	2.9	4.7	7.0	7.6	10.0	91.3
-Partly Cloudy	49	4.3	3.6	5.1	6.2	7.6	8.9	6.8	5.8	5.6	5.5	4.3	3.9	67.6
-Cloudy	49	16.6	13.1	14.6	14.6	16.2	15.3	20.2	22.3	19.7	18.4	18.2	17.1	206.2
Precipitation														
.01 inches or more	49	10.9	8.2	9.5	8.8	8.1	8.9	12.5	15.7	13.9	10.8	12.1	10.4	129.8
Snow,Ice Pellets,Hail														
1.0 inches or more	49	3.1	2.2	2.6	2.1	0.7	0.*	0.0	0.0	0.2	1.5	3.7	3.4	19.5
Thunderstorms	49	0.0	0.0	0.0	0.0	0.*	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.7
Heavy Fog Visibility														
1/4 mile or less	49	1.8	1.4	1.4	1.3	2.9	3.8	3.1	1.4	0.5	0.4	1.1	1.6	20.9
Temperature °F														
-Maximum														
70° and above	29	0.0	0.0	0.0	0.0	0.3	2.1	3.6	1.0	0.*	0.0	0.0	0.0	7.0
32° and below	29	28.0	25.1	27.6	20.0	3.9	0.0	0.0	0.0	0.2	12.0	24.6	27.2	168.6
-Minimum														
32° and below	29	31.0	28.0	30.9	29.1	18.7	3.1	0.3	1.6	9.8	25.1	29.1	30.9	237.5
0° and below	29	15.9	16.3	15.2	8.1	0.3	0.0	0.0	0.0	0.0	0.6	7.8	15.4	79.6
AV. STATION PRES.(mb)	23	1007.0	1011.6	1009.1	1010.3	1009.5	1010.5	1011.4	1009.5	1006.8	1005.4	1005.0	1004.6	1008.4
RELATIVE HUMIDITY (%)														
Hour 03	32	75	73	74	79	82	84	88	89	83	80	77	75	80
Hour 09 (Local Time)	32	74	72	73	76	76	76	82	83	80	79	77	74	77
Hour 15	32	74	71	70	74	73	73	78	79	73	72	75	74	74
Hour 21	32	75	73	74	78	76	75	80	84	82	79	77	74	77
PRECIPITATION (ins):														
Water Equivalent														
-Normal		0.79	0.60	0.54	0.68	0.62	1.12	2.17	2.71	2.43	1.35	1.04	0.83	14.88
-Maximum Monthly	49	2.10	2.11	1.95	2.15	2.02	4.15	4.66	7.82	7.46	3.84	4.39	2.16	7.82
-Year		1957	1989	1954	1961	1989	1978	1990	1951	1986	1972	1979	1951	AUG 1951
-Minimum Monthly	49	T	T	T	0.01	0.04	0.04	0.25	0.40	0.39	T	0.03	0.03	T
-Year		1970	1979	1971	1992	1994	1964	1964	1971	1968	1974	1962	1956	FEB 1979
-Maximum in 24 hrs	49	1.23	0.77	0.65	0.75	0.75	2.03	1.77	2.99	1.49	2.28	1.15	1.09	2.99
-Year		1963	1975	1954	1995	1989	1953	1954	1976	1978	1957	1994	1951	AUG 1976
Snow,Ice Pellets,Hail														
-Maximum Monthly	49	23.7	23.2	19.7	23.3	10.0	2.5	0.0	0.1	3.5	13.6	30.9	29.7	30.9
-Year		1950	1989	1954	1961	1977	1982		1965	1992	1958	1994	1994	NOV 1994
-Maximum in 24 hrs	49	7.8	9.0	7.0	6.3	5.3	1.7	0.0	0.1	2.6	6.6	8.7	9.3	9.3
-Year		1947	1975	1993	1961	1952	1982		1965	1948	1948	1979	1994	DEC 1994
WIND:														
Mean Speed (mph)	48	11.2	10.8	10.2	10.2	10.0	9.7	9.7	10.4	11.0	10.7	11.6	10.4	10.5
Prevailing Direction through 1963		E	NE	E	N	N	WSW	WSW	SW	N	N	N	E	N
Fastest Obs. 2 Min.														
-Direction (!!)	38	09	04	02	05	09	04	24	26	18	20	24	05	24
-Speed (mph)		54	51	44	45	44	35	35	40	44	52	55	54	55
-Year		1967	1971	1991	1964	1966	1971	1973	1964	1973	1960	1965	1958	NOV 1965
Peak Gust														
-Direction (!!)	12	SE	NE	NE	NE	E	W	S	SE	NE	SE	E	E	NE
-Speed (mph)	12	59	66	59	52	46	35	39	56	52	59	59	53	66
-Date		1987	1988	1985	1984	1985	1991	1984	1993	1991	1992	1989	1992	FEB 1988

Source: NOAA.

3.2.2 Sea-Level Rise.

The Alaska landmass in general is rebounding since glaciation. Therefore, sea-level rise is not a design consideration.

3.2.3 Storm Surge.

The Nome coastline is subject to positive storm surges due to its exposure to a long southwest fetch. Contributing to surge are the effects of the Bering Sea, Norton Sound, and mildly sloping shallow depths, which amplify surges. Positive surges are distinguished from negative storm surges as an increase in water level from the normal tidal elevation as compared to a decrease. A storm surge consists of the water surface response to wind-induced surface shear stress and pressure fields. Storm-induced surges can produce short-term increases in water levels to an elevation considerably above mean water levels. As table 3-2 shows, the small range of diurnal tidal fluctuation at Nome is not a significant factor in the increase of the water level during severe storms.

The "Great Bering Sea" storm of November 12, 1974, was the most severe to hit Nome in the town's recorded history, which dates back to 1898. The storm surge or rise in water level was the greatest on record, about 12 feet above MLLW, with tide levels and atmospheric pressure estimated at about 2 feet of the total (Fathauer 1978). The storm coincided with the highest tides of the month. This storm generated waves that overtopped the +18-ft-MLLW seawall fronting Nome. Fathauer documented this storm as follows: "This storm moved north-northeast from the central Aleutian Islands up through the Bering Strait. Winds of 50 to 75 knots occurred within 12 hours of the frontal passage. The southerly fetch in the Bering Sea was about 1,000 miles long. Winds persisted over this fetch for about 36 hours. Along with damaging Nome, this storm also caused other flooding along the Bering Sea coastline."

Typically, the major storm surges occur during the fall. In this century, there have been at least 14 occurrences of flooding in Nome (Blier *et al.* 1996); all except two occurred in the fall season (Wise *et al.* 1981).

NOAA installed a tide gauge off the causeway in Nome in June of 1992. NOAA has not released the water level data due to pending quality control checking, so it could not be used during this study.

3.2.4 Set-Down.

Negative surges (set-downs) occur with offshore or alongshore winds and at times are accompanied by high atmospheric pressure. The reduced depths could affect operation of vessels.

Nome residents report that set-down of the water surface occurs in the existing harbor area, typically in the fall as a result of north winds. The wind stress on the water surface results in a pushing or piling up of water in the downwind direction and a lowering of the water surface in the upwind direction. The duration of set-downs is typically 2 or 3 days. Set-downs occur only with northerly winds, and northerly winds of 22 knots and above are infrequent for the ice-free months. Table 3-3 provides a compilation of wind data from Nome for 1945-1990. The data are summarized for cases of winds cumulatively from the northwest, north-northwest, north, north-northeast, and northeast (NW, NNW, N, NNE, and NE) and with speeds of 22 knots and above.

TABLE 3-3.—*Wind data for Nome, 1945-1990*

Month	% from specified directions*	% at speed of more than 22 knots
Jan	40.3	2.7
Feb	41.1	3.1
Mar	43.1	2.6
Apr	35.5	1.9
May	31.3	0.8
Jun	19.2	0.1
Jul	16.3	0.1
Aug	25.1	0.2
Sep	42.1	0.7
Oct	54.7	0.9
Nov	47.8	1.9
Dec	43.0	1.8

* NW, NNW, N, NNE, and NE.

From the table, it is evident that winds from the NW to NE sector increase toward the fall. For the ice-free season, the cumulative percentage is 4.7 percent for winds exceeding 22 knots.

According to a longtime maritime official, a set-down of 2.5 to 3 feet occurs every September due to northerly winds. The set-down caused by the northerly winds has been especially critical during August and September, when fuel is shipped out of Nome to surrounding villages for the winter season. Protection of the causeway docks will allow topping off of fuel barges serving outlying villages. No special depth allowance has been made for these conditions at the inner harbor location.

3.2.5 Currents.

Data on Nome currents are not available in the *Tidal Current Tables* (NOAA 1997). The nearest location listed to Nome is Sledge Island, with a maximum flood of 1.0 knot at 305 degrees and a maximum ebb of 0.5 knots at 119 degrees. Sledge Island is approximately 23 nautical miles west of Nome.

Coastal currents at Nome vary depending upon wind and wave direction, wave height, wave period, and surface pressure patterns. According to Hood *et al.* (1974), observations in August and September showed current speeds of 0.3 to 0.5 knots with occasional peaks up to 0.8 knots.

Wave-generated currents near shore control sediment deposition and transport. Deposition around the causeway and in the present navigation channel indicates that wave-generated current and the accompanying sedimentation have a major impact on use of facilities at Nome. The direction and strength of those currents depend upon the still water level, wave direction, and wave height. The detailed results are displayed in section 6 of this appendix, Model Studies.

3.2.6 Wave Climate.

Nome is exposed to waves from the Bering Sea and Norton Sound, with the waves generally occurring during the ice-free season, between May and November. Of the fetch exposures, the southwest window between St. Lawrence Island and the mainland is the longest. The wave climate at Nome, generally moderate, is subject to short-period wind-generated waves. In addition, swell propagates through the window between St. Lawrence Island and the mainland. The predominant wave direction is from the southwest to southeast. The presence of swell has caused shutdown of dredging operations in the outer portion of the existing entrance channel. Waves and shoaling are influenced by the relatively shallow bathymetry of Norton Sound, with maximum depths in the range of 80 feet. The wave hindcast section of this appendix, subsection 4.1.2, describes the wave climate in detail.

The wave climate at Nome is generally moderate, with heights less than 6 feet and periods less than 12 seconds. Those waves present a problem only because of shallow depths in Norton Sound and at the harbor location. Vessel maneuvering, docking and cargo handling are impaired or stopped when wave heights exceed a 3-foot threshold. Severe storms accompanied by extremely high storm surges occur often enough to be of concern for the survival of facilities. Swell with up to a 25-second period arrives from the south and appears to be associated with typhoons and other severe weather well south of the Aleutian Island chain.

Fetches. The coastline of Nome is oriented at approximately a 105-degree azimuth west of north. Fetches for wave generation are limited, except that the fetch from the southwest approach passes through the window between St. Lawrence Island and the Alaska mainland. Wave generation from the west and east-southeast is limited when compared to the other fetch directions.

Swells. Long-period waves have been measured at the NOAA buoy located at latitude 56.91° N., longitude 177.81° W., about 900 nautical miles southwest of Nome. Swells have also been reported at the harbor complex at Nome and have delayed dredging operations on more than one occasion. Those swells are expected to have periods similar to those observed farther to the south at St. Paul Island, and an

upper-limit period has been estimated at 25 seconds. Heights are probably minor as they enter Norton Sound but become larger as the waves steepen over the shallow Norton Sound approaches to Nome Harbor.

Nome residents have indicated that long-period swell creates problems at Nome. This was confirmed by the wave hindcast and also by reviewing maintenance records for dredging of the existing federally authorized project. The records showed that the contractor had been delayed due to long-period swell.

Earthquake/Tsunami. Because of their relatively large mass, the breakwaters of the recommended plan are not designed to withstand severe earthquake ground accelerations and their associated forces. The foundation materials beneath the proposed breakwaters are sound to withstand moderate earthquakes, however. The breakwaters are designed to withstand the design wave as described in the Design Criteria section of this appendix, section 5.

3.3 Hydrology

3.3.1 Rivers.

Rivers in the vicinity of Nome include the Snake, Nome, and Penny. The Snake River follows a meandering route, flowing through the currently authorized turning basin and then passing through the existing sheet-pile-lined navigation channel and out into Norton Sound. The approximate drainage area of the Snake River is 86 square miles. The discharges of the Snake River for the water years of 1965 –1991 are shown in table 3-4, excerpted from the U.S. Geological Survey Water-Data Report AK-91-1. As shown in the table, the discharge of the Snake River is less than 500 cubic feet per second (ft^3/s) on average, except for the month of June. The highest daily mean recorded was 3,770 ft^3/s during June 1966.

3.3.2 Dry and Bourbon Creeks.

These creeks merge and then flow through existing culverts beneath Seppala Drive into the northern portion of the city of Nome's harbor basin. The discharge patterns are probably similar to those of the Snake River due to the close proximity. As shown in table 3-5, the spot discharge measurements show small discharges. Therefore, these creeks have a minor influence on the upper basin under average flow conditions and would not facilitate circulation in the new harbor area. These creeks may contribute to the fine sediment deposition found in the present harbor location, but that contribution is small.

3.3.3 Estuary.

The lower reach of the Snake River and Norton Sound form an estuary. Because of the minimal freshwater flow during most of the year, the system is stratified, with most of the fresh water passing near the surface and salt water intruding landward along the bottom. Flow strengths are minor, and little mixing occurs due to

TABLE 3-4.—*Discharges of Snake River near Nome, 1965-1991*

LOCATION.—Lat. 64°33'51", long. 165°30'26", in NW¼SE¼ sec. 5, T.11S., R.34 W., Hydrologic Unit 19020002, on downstream side of bridge on Nome-Teller Highway, 5.4 mi northwest of Nome.

DRAINAGE AREA.—85.7 mi^2, approximately.

PERIOD OF RECORD.—September 1965 to September 1981, October 1981 to September 1982 (discharge measurements and fragmentary gage-height record), October 1982 to September 1991 (discontinued as a continuous-record station, converted to a crest-stage partial record station).

GAGE.—Water-stage recorder and crest-stage gage. Datum of gage is 8.58 ft above National Geodetic Vertical Datum of 1929 (USC&GS data furnished by Alaska Department of Transportation, Nome). Sept. 1, 1965, to Apr. 24, 1968, and July 12, 1979, to Aug. 26, 1988, nonrecording gage at same site and datum.

REMARKS.—Gage heights during spring ice breakup and formation of ice in the autumn provided by twice-daily observer radings. Records good except for estimated daily discharges, which are poor.

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	212	e140	e28	8.0	e4.5	e3.5	e9.0	e130	569	221	117	64
2	212	e130	e28	e7.5	e4.0	e3.5	e9.0	e170	567	202	123	62
3	208	e120	e26	e7.5	e4.0	e4.0	e9.5	e220	520	188	104	61
4	327	e110	e24	e7.5	e4.0	e4.0	e10	e300	726	178	93	60
5	355	e110	e24	e7.0	e4.0	e4.0	e10	e450	982	167	88	62
6	385	e100	e22	e7.0	e4.0	e4.5	e11	e700	841	155	85	65
7	410	e100	e22	e7.0	e4.0	e4.5	e11	e2000	865	146	115	68
8	435	e95	e20	e7.0	e4.0	e4.5	e12	e1800	822	138	120	70
9	405	e90	e20	e6.5	e3.5	e4.5	e12	e1400	810	131	101	69
10	375	e85	e19	e6.5	e3.5	e4.5	e13	e1100	750	123	95	81
11	365	e80	e18	e6.5	e3.5	e4.5	e13	e900	642	115	92	77
12	360	e75	e17	e6.0	e3.5	e5.0	e14	e800	509	113	90	69
13	355	e70	e17	e6.0	e3.5	e5.0	e14	e700	431	114	91	65
14	355	e65	e16	e6.0	e3.5	e5.5	e15	e600	403	110	88	63
15	340	e65	e15	e6.0	e3.5	e5.5	e16	549	459	105	84	62
16	340	e60	e15	e6.0	e3.5	e5.5	e16	575	633	104	84	62
17	358	e60	e14	e5.5	e3.5	e5.5	e17	500	715	104	82	75
18	350	e55	e13	e5.5	e3.5	e6.0	e18	463	551	99	81	96
19	320	e50	e13	e5.5	e3.5	e6.0	e19	478	487	120	78	129
20	295	e50	e12	e5.5	e3.5	e6.0	e20	384	454	128	75	107
21	281	e48	e12	e5.0	e3.5	e6.5	e20	324	431	109	75	93
22	e260	e46	e11	e5.0	e3.5	e6.5	e22	350	441	99	78	86
23	e240	e44	e11	e5.0	e3.5	e6.5	e24	501	406	92	82	83
24	e220	e42	e10	e5.0	e3.5	e7.0	e26	794	401	85	78	84
25	e220	e40	e10	e5.0	e3.5	e7.0	e28	959	372	80	72	108
26	e200	e38	e9.5	e4.5	e3.5	e7.5	e38	1080	332	77	70	126
27	e190	e36	e9.0	e4.5	e3.5	e7.5	e50	766	301	80	70	109
28	e180	e34	e8.5	e4.5	e3.5	e8.0	e60	751	278	78	69	100
29	e170	e32	e8.5	e4.5	---	e8.0	e76	825	260	93	68	98
30	e160	e30	e8.5	e4.5	---	e8.5	e100	771	240	161	67	97
31	e150	---	e8.0	e4.5	---	e8.5	---	595	---	135	66	---
Total	9033	2100	489.0	182.0	102.5	177.5	712.5	21935	16198	3850	2681	2451

e = Estimated.

TABLE 3-4.—*Discharges of Snake River near Nome, 1965-1991--Continued*

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1990 TO SEPTEMBER 1991
DAILY MEAN VALUES

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Mean	291	70.0	15.8	5.87	3.66	5.73	23.7	708	540	124	86.5	81.7
MAX	435	140	28	8.0	4.5	8.5	100	2000	982	221	123	129
MIN	150	30	8.0	4.5	3.5	3.5	9.0	130	240	77	66	60
Ac-Ft	17920	4170	970	361	203	352	1410	43510	32130	7640	5320	4860
CFSM	3.40	.82	.18	.07	.04	.07	.28	8.26	6.30	1.45	1.01	.95
In.	3.92	.91	.21	.08	.04	.08	.31	9.52	7.03	1.67	1.16	1.06

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1965-91, BY WATER YEAR (WY)#

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Mean	212	72.6	38.2	28.3	23.4	21.4	22.9	418	642	227	244	298
MAX	534	156	74.2	56.6	45.4	40.0	41.6	973	1655	527	657	1183
(WY)	1986	1983	1979	1979	1979	1979	1979	1981	1989	1989	1979	1986
MIN	62.9	28.1	15.8	5.87	3.66	1.00	1.00	55.5	98.0	80.2	69.1	81.7
(WY)	1971	1971	1991	1991	1991	1971	1971	1967	1970	1983	1971	1991

Summary statistics	**For 1990 calendar year**		**For 1991 water year**		**Water years 1965-91#**	
Annual total	71101.0		59911.5			
Annual mean	195		164		187	
Highest annual mean					284	1989
Lowest annual mean					97.6	1976
Highest daily mean	1890	Aug 26	2000	May 7	3770	Jun 2 1966
Lowest daily mean	8.0	Dec 31	a3.5	Feb 9	b1.0	Feb 25 1971
Annual 7-day minimum	8.9	Dec 25	3.5	Feb 9	1.0	Feb 25 1971
Instantaneous peak flow			(c)		4200	Jun 2 1966
Instantaneous peak stage					11.90	Jun 2 1966
Instantaneous peak stage			df10.17	May 7	f13.59	May 15 1975
Annual runoff (ac-ft)	141000		118800		135400	
Annual runoff (CFSM)	2.27		1.92		2.18	
Annual runoff (inches)	30.86		26.01		29.63	
10% exceeds	570		492		462	
50% exceeds	65		69		65	
90% exceeds	12		4.5		20	

See period of record.
a From Feb. 9 to Mar. 2
b From Feb. 25 to May 15, 1971, but may be no flow at times during some winters.
c Not determined; see highest daily mean.
d Maximum observed.
f Backwater from ice.

Source: U.S. Geological Survey.

TABLE 3-5.—*Spot discharges from Bourbon and Dry Creeks (ft^3/s)*

Date	Bourbon Creek	Dry Creek
5/29/97	1.8	6.9
7/14/97	1.0	1.2
10/1/97	2.0	5.3

stratification. Modest tides also limit flushing within the estuary. Spring freshets combined with ice overlays force saltwater intrusion to beyond the mouth of the river, temporarily reducing the salinity of the estuary. Those freshets, combined with an ice overlay at the seaward end of the project and on the shore area, can create a scouring condition, increasing navigation depths.

Saltwater intrusion does not appear to play an important part in estuary sedimentation. Density currents tend to move marine sediments upstream along the bottom, and marine sediments entering the estuary may become trapped. The region that experiences heavy shoaling is well downstream of the point of no net flow because of the low velocities and lack of upstream transport capability. The apparent location of marine sediment entrapment at Nome is in the first few hundred feet inside the jetties. Some of the smaller fraction of upland suspended sediments appears to deposit in the vicinity of or within the mooring basin. The slightly denser dirty water is driven to these locations by density differences, and although it creates a chronic shoaling problem, removal history places the phenomenon in the nuisance range. Ice on the river melts prior to ice on Norton Sound and the lower segment of the river. The remaining ice cover creates a larger than normal head difference between the upstream ice limits and the sound. Because of the large head differences and the high velocities created, it is believed that most of the coarse suspended sediments and bed load pass to Norton Sound.

The extent of saltwater advance up the Snake River has not been measured. Saltwater advance up the Snake River will, however, occur until the tidal flow can no longer overcome the riverflow in conjunction with the riverbed elevation. This location at most ice-free times will be well upstream of the harbor complex.

3.3.4 Ice Conditions.

Norton Sound Ice. The project is within an area of sea ice formation and therefore will interact with ice and the associated forces. Fast ice is present to some degree each winter at Nome. Fast ice is sea ice of any origin which remains fast (attached with little horizontal motion) along a coast or to some other fixed object. Fast ice may be formed by freezing of sea water or freezing of drifting ice. According to LaBelle *et al.* (1983), the average date of ice formation is November 10, with the earliest freezeup of record on October 13, 1942, and the latest on December 26, 1950, for the period from 1936 to 1952. Extreme dates for ice breakout are April 28 and June 28, with the average falling on May 29. Sea Ice Consultants, Inc., for Tetra

Tech, Inc. (1981) performed the most recent ice study in the area for the causeway design. The period of record used for the study was June 1967 to December 1979. Analysis of satellite imagery for these 13 years shows that fast ice formation at Nome has occurred as early as November 12 and as late as December 30. The extreme dates for fast ice breakout were May 6 and June 12.

Fast ice extends out from the shore from one-half mile to 7 miles, dependent upon seasonal conditions. Near shore, the ice is relatively smooth to about 1,000 feet out, where the ice surface typically becomes more buckled with ridges. Beyond the fast ice is the pack ice zone consisting of drifting pack ice, which may have a grounded ice zone as well as open leads within the ice pack.

An early winter ice sheet thickness of about 1 foot is typical. A maximum ice sheet thickness of approximately 4.5 feet is predicted from computed freezing-degree-day estimates of ice growth.

Snake River Ice. The Snake River at the existing turning basin typically freezes up around the end of November but has frozen as early as September, according to some residents. The upstream portion of the river, with a smaller cross-sectional area, is more susceptible to freezing than the area near the existing turning basin. Spring breakup of the Snake River occurs prior to the Norton Sound ice breakout, with the river discharge helping clear the area of Norton Sound ice at the exit into Norton Sound. At the existing sheet-pile-faced dock just east of the existing turning basin, vessels on average are placed in the water by May 15.

4. TECHNICAL FINDINGS AND DESIGN

4.1 Wave Studies

4.1.1 General.

A 10-year wave hindcast was developed using winds analyzed from pressure field data from the National Center of Environmental Prediction (NCEP) and the National Center of Atmospheric Research (NCAR) Reanalysis Products (Kalnay 1996).

Wise *et al.* (1981) developed a surge height – frequency interval curve for the northern coast of Norton Sound and other areas in western Alaska based on analysis of historical storm surge events. This information is the basis of storm surge heights and frequencies used for this study. The Wise report separated the Alaska coast into 8 areas and 25 sectors, with sectors 7 and 8 applicable to Nome with a surge height of +13 feet for a 100-year frequency interval. This was designated the extreme high water event for this study.

Other research on storm surge was undertaken by Blier *et al.* (1996), who conducted an observational and numerical modeling investigation of three Bering Sea storms and the associated storm surges, one of which was a negative surge. The numeric model results were compared to the tide gauge data. Overall, the numeric model performed well, with some limitations. One of the storms analyzed was the storm of October 5-6, 1992, which caused the most significant flooding since the November 1974 storm. The operational numeric model implemented for use in Alaska has been modified from the original version.

4.1.2 Wave Hindcast.

The wave hindcast was developed to define the annual wave climate and to verify the extreme events for this project. Prior to the hindcast, only limited information for extreme wave events was available. A separate part of the study entailed analyzing the local wind climate by month from 1945 to 1990 for January through December. The winds were categorized by windspeed and direction over each month of the year. The wave hindcast and local wind analysis were completed in December 1997 by Applied Coastal Modeling of Vicksburg, Mississippi.

The objective of the hindcast was to define the general range of wave heights, periods, directions, and frequencies of occurrence at a depth of 10 meters, and 1 kilometer from the project site. Standard analytical practices were used to develop the wave information. The wave hindcast information was then used with appropriate adjustments in the physical model during test conditions. The hindcast was also ground-truthed to use history at the causeway docks so the incremental benefits of navigation improvements could be estimated.

As stated earlier, the 10-year wave hindcast was developed based on winds analyzed from pressure field data from the NCEP and NCAR Reanalysis Products, (Kalnay

1996). Among the data was the global surface wind (10 meters above ground level), considered the most accurate readily available source of winds for this hindcast project. Another part of the wave hindcast task was to develop a frequency analysis of storm events for return periods ranging from 0 to 50 years.

Each part of the wave hindcast was performed at water levels of 0 ft MLLW and 13 ft MLLW. The higher water level was chosen based on the November 1974 storm as an extreme high water-level condition. According to NOAA Technical Memorandum NWS AR-23, (Fathauer 1978), the rise in water level at Nome was the greatest on record and the storm was the most severe in the recorded history of Nome, which goes back to 1898. A number of different sources have stated that the water elevation ranged from +12 ft to about +13 ft MLLW. As previously stated, the higher water level of +13 ft MLLW was shown as the extreme boundary condition for this study.

At these two water levels, the waves were propagated with the U.S. Army Corps of Engineers wave model WISWAVE 2.0 (Hubertz 1992) and the data input into the wave model STWAVE (Resio 1988) for wave transformation to a depth of 10 meters, 1 kilometer from the shoreline. The STWAVE computer model solves for refraction, shoaling, and diffraction. The results were saved as a series of wave heights, periods, and directions for use in the physical model.

The wave hindcast was developed using three grids, Levels 1, 2, and 3, which are shown in figures 4-1, 4-2, and 4-3. The wave data from each grid level was input into the next grid level, with the final results saved at the Level 3 grid point of 10 meters at the 1-kilometer location described above. The Level 1 grid was applied in deep water over the Bering Sea on the same grid as the NCEP/NCAR winds. A nested grid with a resolution four times that of Level 1 was used over the region to the east of St. Lawrence Island, which is referred to as the Level 2 grid. This Level 2 grid spectral wave information was then transformed from a point about 22 kilometers offshore of the project site in the Level 2 grid to a point 1 kilometer from shore at a depth of 10 meters, using the computer model STWAVE.

The wave hindcast results from the Level 1 grid were compared to the output from the NOAA-maintained buoy 46035, using data from 1987 to1996. Trends of the results compared well, but the wave model underpredicted peak periods and shifted wave heights downward as much as 0.5 meter in the smaller wave fields. The underestimation of heights is not critical in evaluating extremes but does become a critical element in average events in the modest wave climate at Nome. The quantitative indication of model performance is shown in tables 4-1 and 4-2. Note that the maximum height and period for each year's values do not necessarily occur at the same time. The third and fifth columns, designated as "No.," indicate a data record. The measure of annual mean difference between model and buoy, regardless of sign, is provided as the root mean square difference (RMSD).

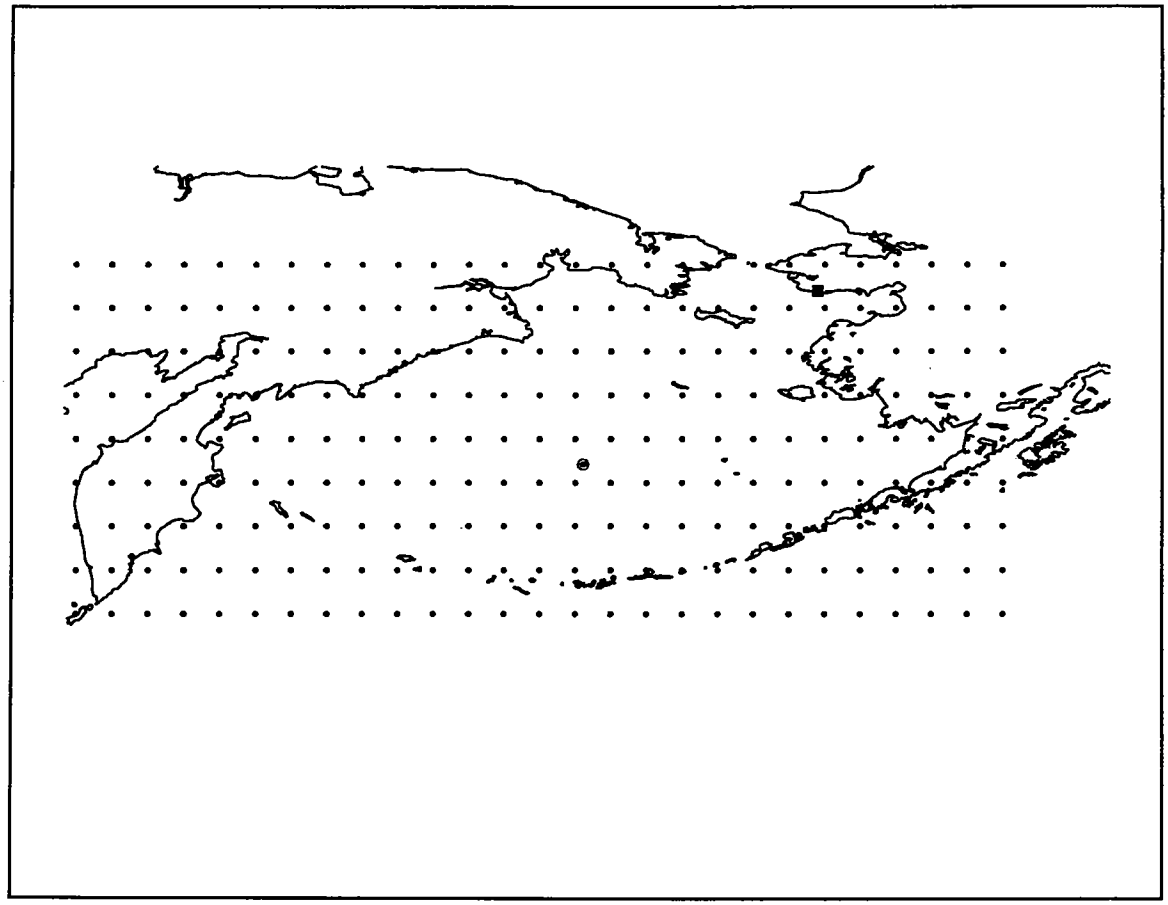


FIGURE 4-1.--Level 1 grid. Circled point is location of buoy 46035; filled box is location of Nome.

The underprediction of wave period has been accounted for in the development of extreme events by using known outer boundary values from St. Paul Island. To conduct physical model testing, heights of the annual wave climatology were first shifted upward to reflect buoy history and then further adjusted to boundary conditions defined by use history at the causeway docks. The second adjustment, defined by history at the causeway docks, is well within the range of error that occurs from not using wind fields lower than 10 knots to add energy after the waves leave the principal generating field. The practice of eliminating these minor winds is common and makes little difference when large waves are being generated, but can make a significant difference in small wave fields. The choice to ignore them here was due to cost and the fact that there was a use history to weigh and to use for adjusting the hindcasts.

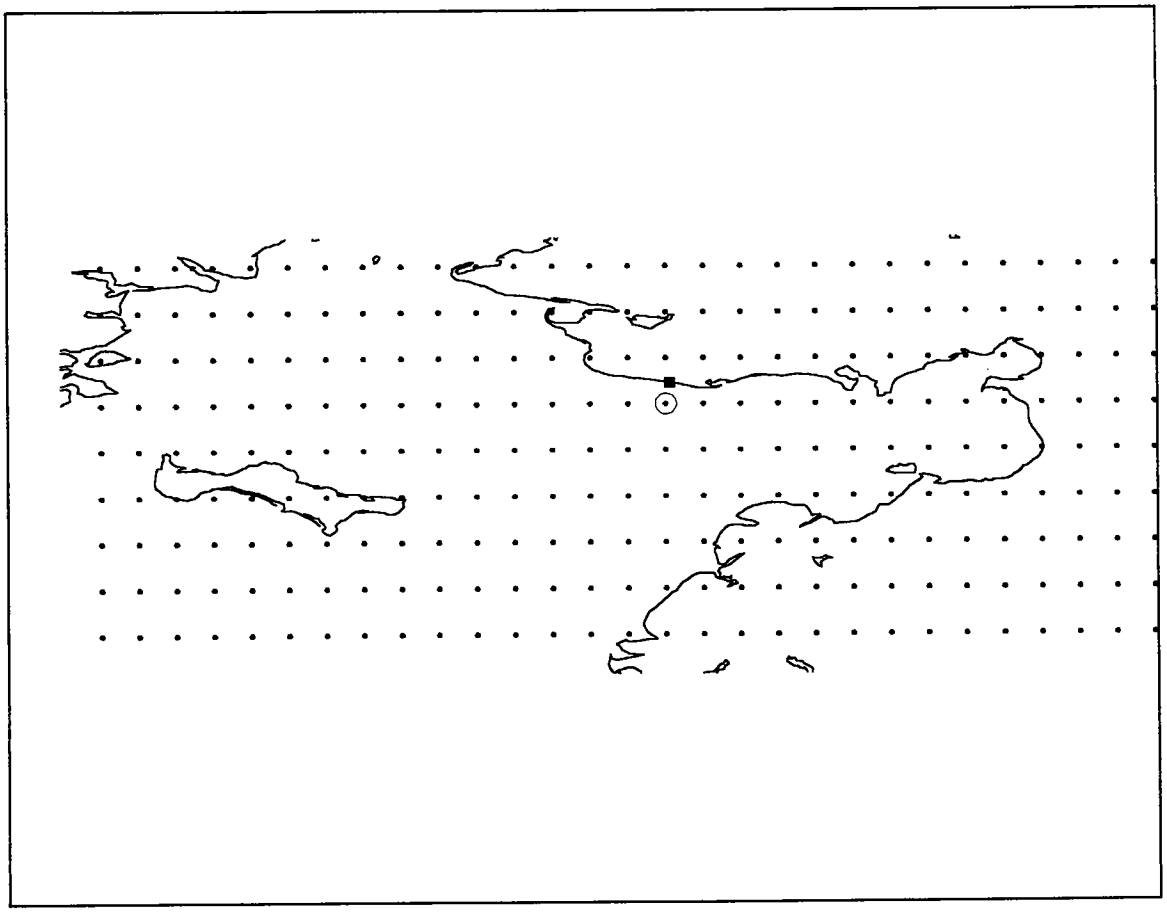


FIGURE 4-2.--Level 2 grid. Results were saved at circled point for input to Level 3.

TABLE 4-1.--*Comparison of hindcast wave heights (m) to measurements from buoys*

Year	Mean				Bias[1]	RMSD	Maximum	
	Buoy	No.	Model	No.			Buoy	Model
1987	2.91	2334	2.72	2920	-0.19	0.55	13.0	12.5
1988	2.42	2810	2.52	2928	0.10	0.44	10.2	9.3
1989	2.72	2734	2.80	2920	0.02	0.53	12.1	11.6
1990	2.51	2870	2.60	2920	0.09	0.52	11.4	12.7
1991	3.08	1720	2.64	2920	-0.44	0.53	10.8	10.2
1992	2.56	2489	2.68	2928	0.12	0.49	9.7	9.8
1993	2.54	2457	2.62	2920	0.08	0.48	11.3	10.0
1994	2.96	1958	2.90	2920	-0.06	0.68	11.4	12.3
1995	2.04	2143	2.48	2920	0.44	0.42	9.1	10.1
1996	2.66	1651	2.71	2441	0.05	0.72	9.2	10.0
All Years	2.64		2.67		0.03	0.54	10.8	10.8

[1] Model - buoy.

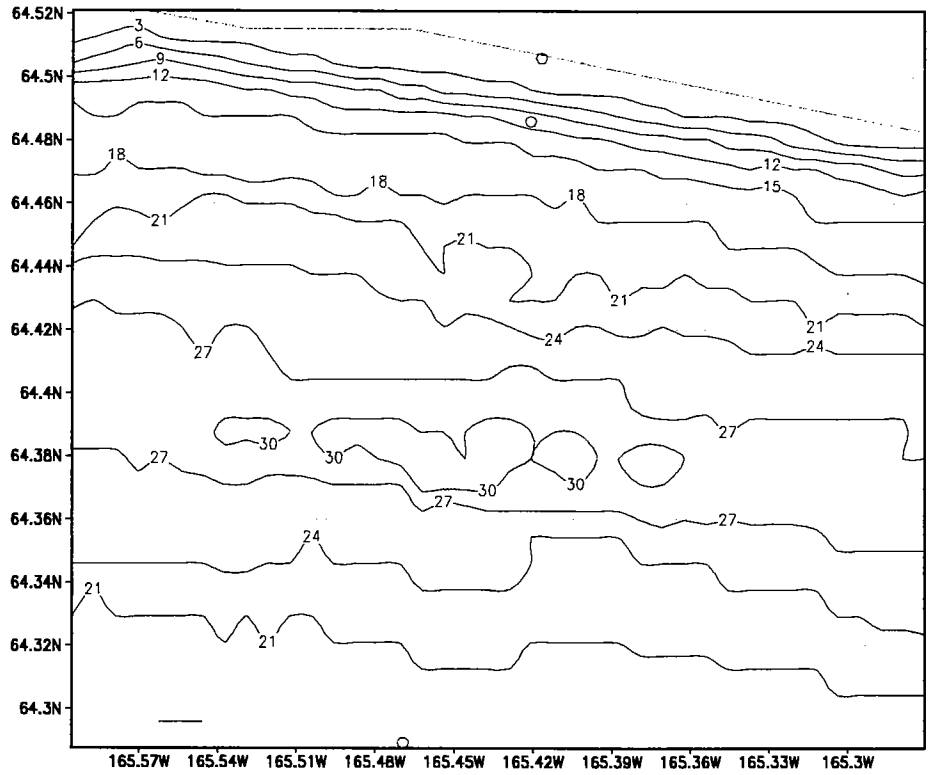


FIGURE 4-3.--Level 3 depth contours (m). Level 2 input is at circled point offshore. Results were saved at circled point near shore. Project site is circled point on shore.

TABLE 4-2.--*Comparison of hindcast wave periods (sec) to measurements from buoys*

	Mean						Maximum	
Year	Buoy	No.	Model	No.	Bias[1]	RMSD	Buoy	Model
1987	9.4	2334	8.3	2920	-1.1	5.0	20.0	16.0
1988	8.7	2810	8.0	2928	-0.7	4.4	16.7	13.0
1989	9.1	2733	8.4	2920	-0.7	4.3	20.0	15.0
1990	9.0	2870	8.1	2920	-0.9	5.5	20.0	16.0
1991	9.5	1720	8.2	2920	-1.3	5.2	20.0	15.0
1992	8.9	2489	8.2	2928	-0.7	6.4	20.0	15.0
1993	9.1	2457	8.2	2920	-0.9	6.4	20.0	14.0
1994	9.3	1958	8.4	2920	-0.9	4.8	25.0	15.0
1995	8.3	2143	8.0	2920	-0.3	6.4	25.0	15.0
1996	9.3	1651	8.3	2441	-1.0	6.6	20.0	16.0
All Years	9.1		8.2		-0.9	5.5	20.7	15.0

[1] Model - buoy.

The Alaska District adjusted the wave heights upward by 0.5 meter and categorized them by wave period and by six wave directions. See table 4-3 and figure 4-4 for the wave frequencies at a 0-ft-MLLW water level.

Wave directions were then consolidated into three groups. The percent time of occurrence for each directional group during the 7-month ice-free or nearly ice-free season was determined using two different water levels. Wave conditions by direction for the 0-ft-MLLW level are shown in table 4-3 and figure 4-5. The predominate wave directions, after accumulating them into the directional bins used for modeling, are from 15° east and 30° west. Waves exceed 1 meter in height about 48 percent of the time and are increased in height by up to 30 percent at the causeway due to focusing on the shoal adjacent and southwest of the causeway head in both the 15° east and the 30° west direction. The height increase occurs 46 percent of the time during the navigation season. The percent of time waves exceed 1 meter is approximately the same duration as the non-usable time documented at the outer causeway, or dock facility.

The wave hindcast study also identified extremal wave heights using the sample range of 1976-1996 for storm events. The values for the Level 3 output point 1 km from shore in 10 m of water are shown in table 4-4.

TABLE 4-4.--*Wave heights for various return periods (ft)*

Return period (yr)	**H_s @ 0 ft MLLW**	**H_s @ 13 ft MLLW**
2	8	11
5	10	14
10	12	15
25	14	18
50	16	19

The design wave height of 19 feet is used in the design criteria section of this appendix (section 5) for the breakwaters.

4.2 Sedimentation

The causeway has had a large impact on sedimentation in its immediate zone of influence and possibly for an extended area. The contours along this beach were nearly parallel to shore prior to causeway construction. Those contours now indicate extensive accumulations of sediment both east and west of the causeway. The seaward bulge west of the causeway, compared to that to the east, indicates a sizable west-to-east littoral transport dominance. Modeling of wave refraction differences across the present seaward protuberance of the west side shoal identifies up to a 30-percent increase in wave heights at dock facilities due to wave focusing on the causeway-developed shoal. The causeway, in the 2,500-foot zone east and west, has caused the accumulation of 738,000 cubic yards west and 216,000 cubic yards east of its location. The time history of those accumulations indicates a net west-to-east transport in the range of 60,000 cubic yards per year. Gross transport rates are

Table 4-3
Nome, Alaska
Wave Occurrence Frequency, 0' MLLW

OVERALL INFORMATION

MAY - NOVEMBER (1987 - 1996)
Total Hours = MAY(31 days) +JUNE(30 days) + JULY(31 days) +AUGUST(31 days) + SEPTEMBER(30 days) + OCTOBER(31 days) + NOVEMBER(30 days)

Total Hours = **214** day/year x 10 years x 24 hour/day = **51,360.0** hours

MAY	31 days x 10 years x 24 hour/day = 7440 hrs/10 yr period
JUNE	30 days x 10 years x 24 hour/day = 7200 hrs/10 yr period
JULY	31 days x 10 years x 24 hour/day = 7440 hrs/10 yr period
AUGUST	31 days x 10 years x 24 hour/day = 7440 hrs/10 yr period
SEPTEMBER	30 days x 10 years x 24 hour/day = 7200 hrs/10 yr period
OCTOBER	31 days x 10 years x 24 hour/day = 7440 hrs/10 yr period
NOVEMBER	30 days x 10 years x 24 hour/day = 7200 hrs/10 yr period

TOTAL SHEET

ANGLE BAND	hr/band	1m, 6s wave	1m, 9s wave	1m, 12s wave	1m, 15s wave	1m, 18s wave	2m, 6s wave	2m, 9s wave	2m, 12s wave	2m, 15s wave	3m, 6s wave	3m, 9s wave	3m, 12s wave	4m, 6s wave	4m, 9s wave	4m, 12s wave	5m, 6s wave	5m, 9s wave	5m, 12s wave	6m, 6s wave	6m, 9s wave	6m, 12s wave
		hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr	hr
1 (90-120 deg)	153	120	27	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 (120-150 deg)	2085	840	396	153	0	0	336	198	18	6	0	99	0	0	27	6	0	0	6	0	0	0
3 (150-180 deg)	6066	1041	2610	1215	87	0	300	477	93	6	0	192	15	0	18	9	0	0	3	0	0	0
4 (180-210 deg)	16314	3693	7866	3702	744	24	9	204	36	9	0	12	15	0	0	0	0	0	0	0	0	0
5 (210-240 deg)																						
6 (240-270 deg)																						
subtotal	24618	5694	10899	5073	831	24	648	879	147	21	0	303	30	0	45	15	0	0	9	0	0	0

ANGLE BAND	1m, 6s wave	1m, 9s wave	1m, 12s wave	1m, 15s wave	1m, 18s wave	2m, 6s wave	2m, 9s wave	2m, 12s wave	2m, 15s wave	3m, 6s wave	3m, 9s wave	3m, 12s wave	4m, 6s wave	4m, 9s wave	4m, 12s wave	5m, 6s wave	5m, 9s wave	5m, 12s wave	6m, 6s wave	6m, 9s wave	6m, 12s wave	TOTAL
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1 (90-120 deg)	0.23%	0.05%	0.01%			0.01%																0.30%
2 (120-150 deg)	1.64%	0.77%	0.30%			0.65%	0.39%	0.04%	0.01%		0.19%			0.05%	0.01%			0.01%				4.06%
3 (150-180 deg)	2.03%	5.08%	2.37%	0.17%		0.58%	0.93%	0.18%	0.01%		0.37%	0.03%		0.04%	0.02%			0.01%				11.81%
4 (180-210 deg)	7.19%	15.32%	7.21%	1.45%	0.05%	0.02%	0.40%	0.07%	0.02%		0.02%	0.03%										31.76%
5 (210-240 deg)																						
6 (240-270 deg)																						
Total % per wave type based on 51, 360 hrs.	11.09%	21.22%	9.88%	1.62%	0.05%	1.26%	1.71%	0.29%	0.04%		0.59%	0.06%		0.09%	0.03%			0.02%				47.93%

ANGLE BAND		1m, 6s wave	1m, 9s wave	1m, 12s wave	1m, 15s wave	1m, 18s wave	2m, 6s wave	2m, 9s wave	2m, 12s wave	2m, 15s wave	3m, 6s wave	3m, 9s wave	3m, 12s wave	4m, 6s wave	4m, 9s wave	4m, 12s wave	5m, 6s wave	5m, 9s wave	5m, 12s wave	6m, 6s wave	6m, 9s wave	6m, 12s wave	TOTAL
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1 (90-120 deg)	60 DEG EAST	1.87%	0.82%	0.30%	0.00%	0.00%	0.66%	0.39%	0.04%	0.01%	0.00%	0.19%	0.00%	0.00%	0.05%	0.01%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	4.36%
2 (120-150 deg)																							
3 (150-180 deg)	15 DEG EAST	2.03%	5.08%	2.37%	0.17%	0.00%	0.58%	0.93%	0.18%	0.01%	0.00%	0.37%	0.03%	0.00%	0.04%	0.02%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	11.81%
4 (180-210 deg)																							
5 (210-240 deg)	30 DEG WEST	7.19%	15.32%	7.21%	1.45%	0.05%	0.02%	0.40%	0.07%	0.02%	0.00%	0.02%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	31.76%
6 (240-270 deg)																							
Total % per wave type based on 51, 360 hrs.		11.09%	21.22%	9.88%	1.62%	0.05%	1.26%	1.71%	0.29%	0.04%		0.59%	0.06%		0.09%	0.03%			0.02%				47.93%

NOTES:

1. The above values are based on the months of May through November over a 10-year time period for a total of 51,360 hrs.

2. The 24, 618 hours reflects total sampling hours for the months of May through November for a ten year time period. This total is based on a three hour recorded event.

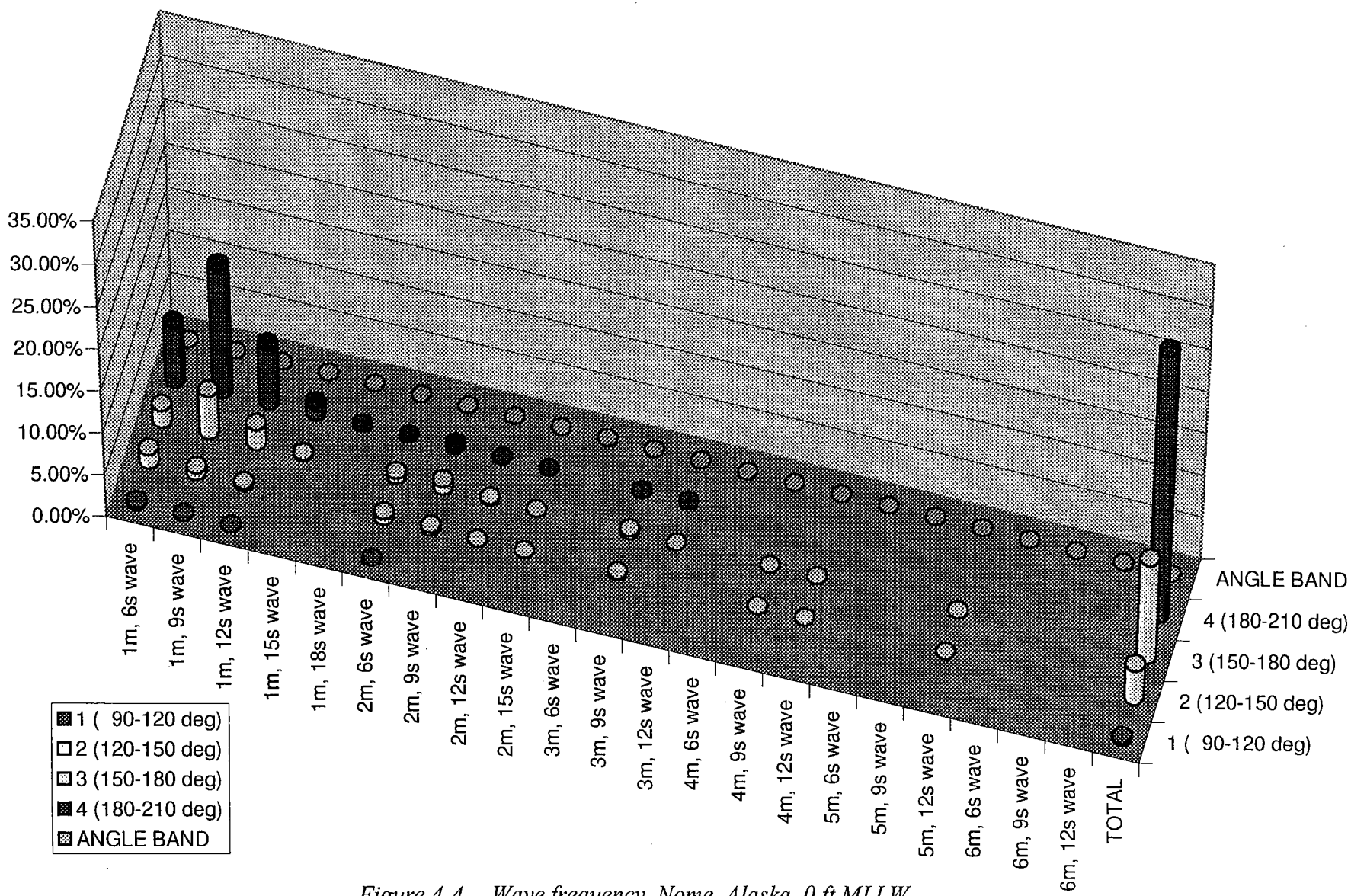


Figure 4-4.-- Wave frequency, Nome, Alaska, 0 ft MLLW.

estimated at 120,000 cubic yards to the east and 60,000 cubic yards to the west. These transport rates are not immense, but go a long way in defining the futility of attempting to maintain an unprotected channel in the active transport zone (landward of the depth of closure). Repetitive cross sections outside the locations of active rip currents within the shoaled area depict active onshore-offshore sediment movement, ceasing at about the -22-ft-MLLW contour, or the "depth of closure." West of the causeway, the same series of cross sections show a deposition zone controlled by rip currents well seaward of the causeway tip. The sections also show an area with a tendency to scour just west of the seaward tip of the causeway. These deposit and scour patterns were also observed during model testing.

4.2.1 Littoral Drift.

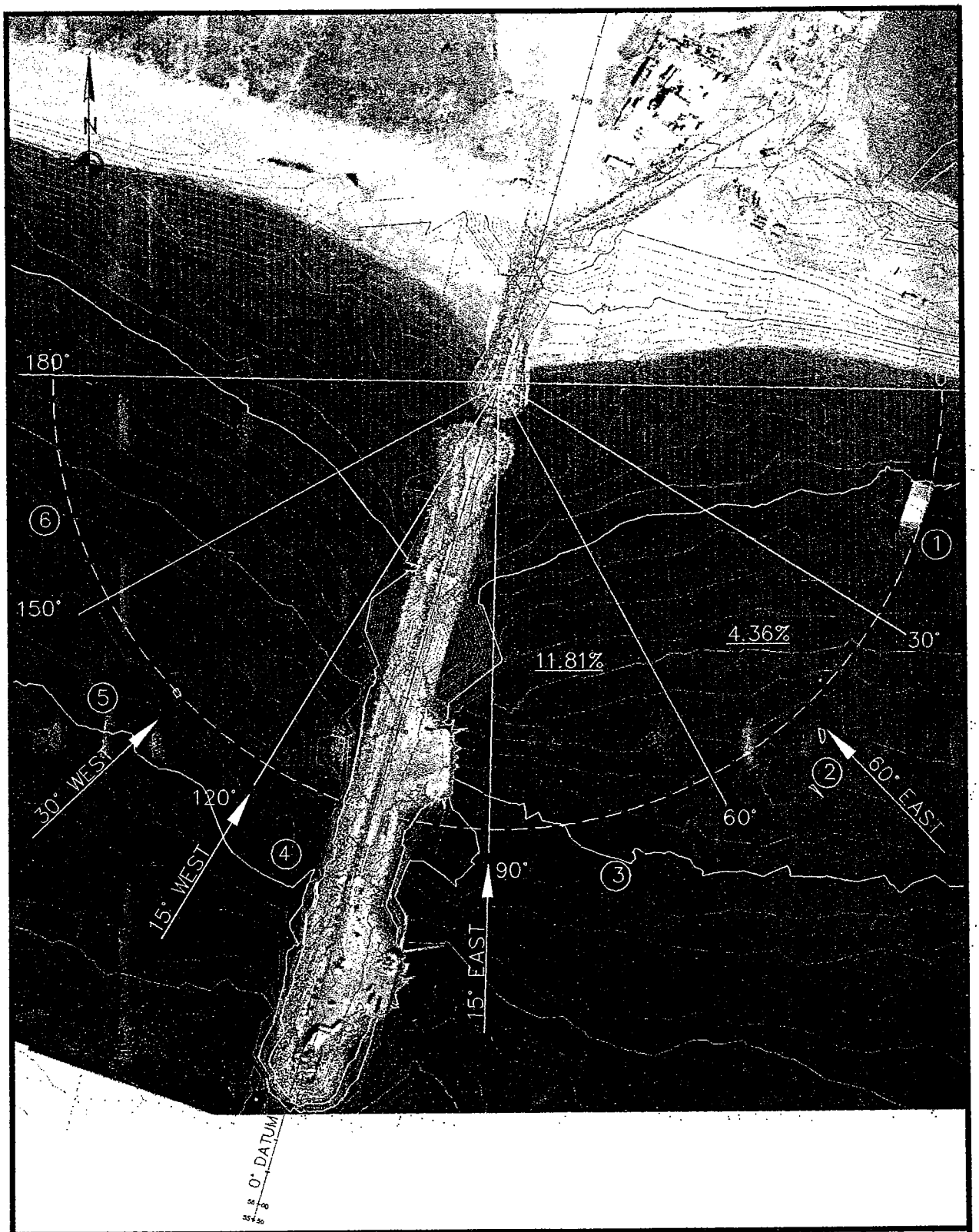
Sediments move in both directions along the reach under study; however, movement from west to east dominates the deposition pattern. The direction and magnitude of sediment transport have been determined from comparing hydrographic survey areas of similar extent east and west of the causeway. Aerial photographs and local knowledge were used to ground-truth rip currents adjacent to the causeway and the extent of fillet development on either side of the causeway.

A hydrographic survey conducted by Peratrovich, Nottingham & Drage, Inc., from June 24 to July 14, 1997, was used as a base to compare surveys from 1986 and 1990. The 1986 survey was performed by the Corps of Engineers and titled "Beach Erosion Study Condition Survey, 26-30 June 1986." The 1990 survey, titled "Beach Erosion Study Condition Survey, June 1990," was performed by Alaska Rim Engineering for the city of Nome. The 1986 and 1990 surveys were scanned from the paper plots into an computerized image and then converted to three-dimensional points in an "x", "y", "z" format. Following this, "Softdesk Earthworks" software was used to compute the volumes based on the average-end area method.

Sedimentation was analyzed using the net difference between the 1986/1990 surveys and the 1990/1997 surveys in an area extending 2,500 feet west and 2,500 feet east of the causeway. Distances east and west were controlled to some degree by the extent of the surveys, but were determined primarily by where the contours appeared to still be parallel to shore in the 1997 survey. The length of comparisons certainly does not capture the total change, but is indicative of quantities and magnitudes of annual sediment transport. The causeway is functioning as a littoral barrier, impeding alongshore sediment transport in both the west and east directions. Table 4-5 shows results of the analysis.

TABLE 4-5.—*Littoral drift at Nome, east and west of causeway*

Survey	Net vol. stored west of causeway (yd^3)	West – average annual storage (yd^3)	Net vol. stored east of causeway (yd^3)	East – average annual storage (yd^3)
1986-1990	225,000	56,000	216,000	54,000
1990-1997	513,000	73,000	-56,000	-8,000



ALASKA DISTRICT CORPS OF ENGINEERS CIVIL WORKS BRANCH	WAVE CONDITIONS BY DIRECTION NAVIGATION IMPROVEMENTS, NOME, ALASKA	4-5

It is assumed that storage to the east of the causeway stabilized after 1990 and that the average annual east-side storage in the 1986-1990 period represents the east-to-west system transport. It is also assumed that the average annual storage experienced west of the causeway since 1990 represents the net system transport. With those assumptions in place, the gross east-to-west transport is about 60,000 cubic yards per year. The gross west-to-east transport is about 120,000 cubic yards per year, and the net accumulation west of the causeway is expected to be about 60,000 cubic yards per year.

Erosion east of the Corps seawall supports the premise of west-to-east transport dominance. Another qualitative observation that supports net west-to-east transport is Corps construction staff reports of wood pilings adjacent to the west side of the existing west jetty becoming exposed since construction of the causeway.

The common areas of comparison, shown east and west of the causeway, are in figure 4-6.

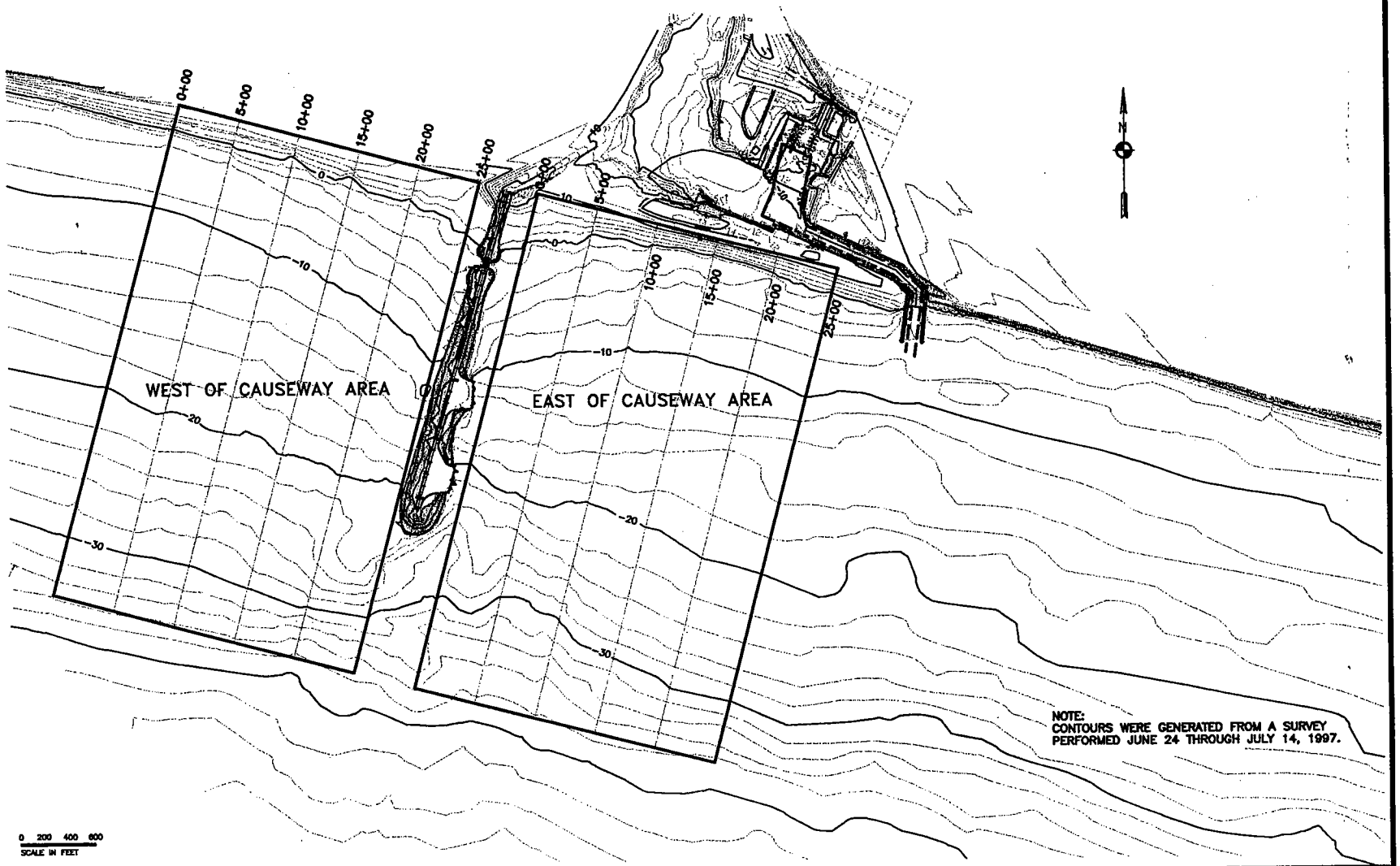
4.2.2 Depth of Closure.

Cross sections have been analyzed to determine the zone of active alongshore transport and the areas where sediment deposition is controlled by rip currents. The active alongshore and onshore-offshore area occurs inside the –22-ft-MLLW depth. Cross sections used in arriving at this depth are shown in figures 4-7 to 4-18. The depth where onshore-offshore and alongshore transport due to wave activity ceases is commonly known as the depth of closure. Rip currents west of the causeway have carried sediments seaward well beyond the depth of closure. Deposition is evident to at least the 30-foot depth. Once deposited in the offshore rip current stream, the sediments form shoals that act as wave focal points, thus negatively impacting project use. It is expected that little if any alongshore transport will occur in the deposition zones until elevations rise above closure depth.

4.2.3 Sediment Trap.

Management of sediments is one of the more critical factors in developing a successful project at Nome. The responsibility for managing sediments accreting along the west side of the causeway falls within the purview of the Corps project, since management of material would have to take place if the causeway were not in place and were being proposed as a west breakwater in a new system. The project capitalizes on the existence of an in-place structure; therefore, the management of sediments accreting against that structure is part of the Federal project.

Sediment management would be accomplished by a sediment trapping and bypass system to prevent the tip shoal at the end of the causeway from growing larger. An increase in the size of this shoal would intensify the degree of wave focusing at the end of the causeway, further reducing the usability of the outer causeway cell. Therefore, management of sediments accreting on the west side of the causeway is necessary to prevent increased wave activity and loss of function at the docks under existing as well as proposed project conditions.



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WEST AND EAST AREAS FOR BEACH PROFILES 1986, 1990 & 1997

NAVIGATION IMPROVEMENTS, NOME, ALASKA

4–6

A sediment trap arrangement was tested in the physical model. The trap was dimensioned to contain 60,000 cubic yards below the –10-ft-MLLW depth. The actual configuration will be shown in figure 8-1, Recommended Plan. Model studies indicate that with an expanded causeway gap, wave-generated velocities in the gap are about 2 feet per second (fps) for 30 percent of the navigation season, and about 1.5 fps for another 10 percent of the time. The velocity direction is from west to east (littoral zone to trap) at least 40 percent of the time during the ice-free season, not reversing. For the remaining period of time, there is no flow through the breach, because either the system is quiescent and has no forcing mechanism, or waves come from far enough east not to influence this location.

The gap and the seaward approach to the gap are almost continuously within the surf zone. Suspended sediment concentrations are expected to be near or above 250 mg/liter (mg/L) during wave-active days that generate the alongshore currents. Based on these values, a sensitivity analysis was conducted to assess the potential of the sediment trap. That analysis, summarized in table 4-6, looked at concentrations between 150 mg/L to 350 mg/L and found that the collection could vary from 35,000 to 85,000 tons annually, with the expectation being 60,000 tons.

TABLE 4-6.--*Sediment discharge analysis*

QS = Sediment discharge, tons/day
k = 0.0027 when other variables are expressed in designated units
C = Concentration, mg/L
Q = Water discharge, ft^3/s

QS = kCQ

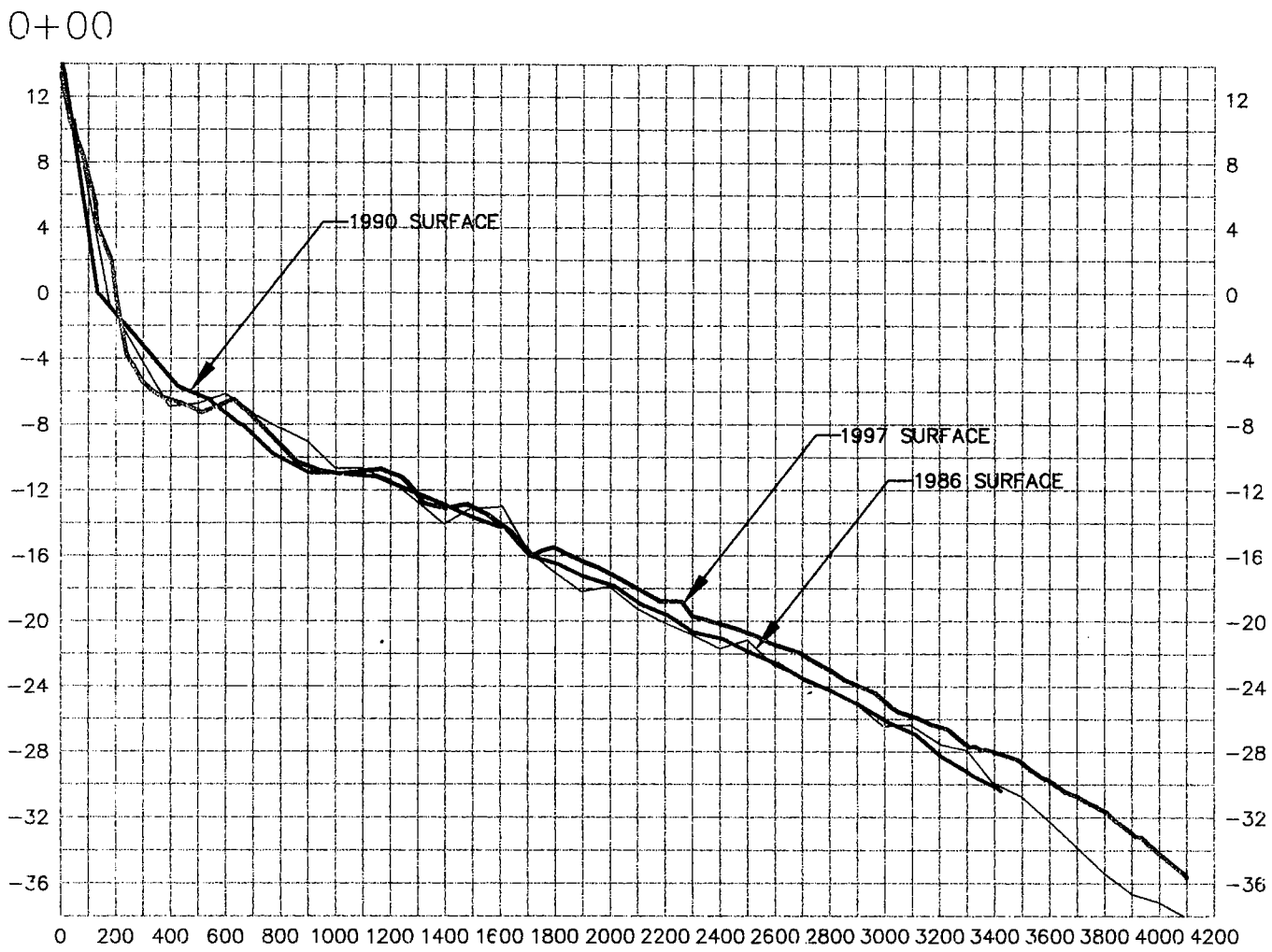
INPUT VARIABLES

Side slope =	1.5
Water level =	0.9 ft MLLW
Bottom channel elev.=	-8 ft
Velocity =	1.5 fps or 2 fps
C = concentration, varies	
K =	0.0027 Constant

Channel bottom width (ft)	Velocity (ft/s)	Effective channel area (ft^2)	Water Discharge (ft^3/s)	Suspended sediment concentration (mg/L)	Tons/ day	Days	Cumul. tons
60	2	653	1,306	150	529	54	28,554
60	2	653	1,306	250	881	54	47,590
60	2	653	1,306	350	1,234	54	66,626
60	1.5	653	979	150	397	18	7,139
60	1.5	653	979	250	661	18	11,898
60	1.5	653	979	350	925	18	16,657

Summary of cumulative tons for 150 mg/L, 250 mg/L, & 350 mg/L concentrations from the table above:

150 mg/L	35,693
250 mg/L	59,488
350 mg/L	83,283



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BEACH PROFILES 1986, 1990, & 1997
WEST OF CAUSEWAY, STATION 0+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-7

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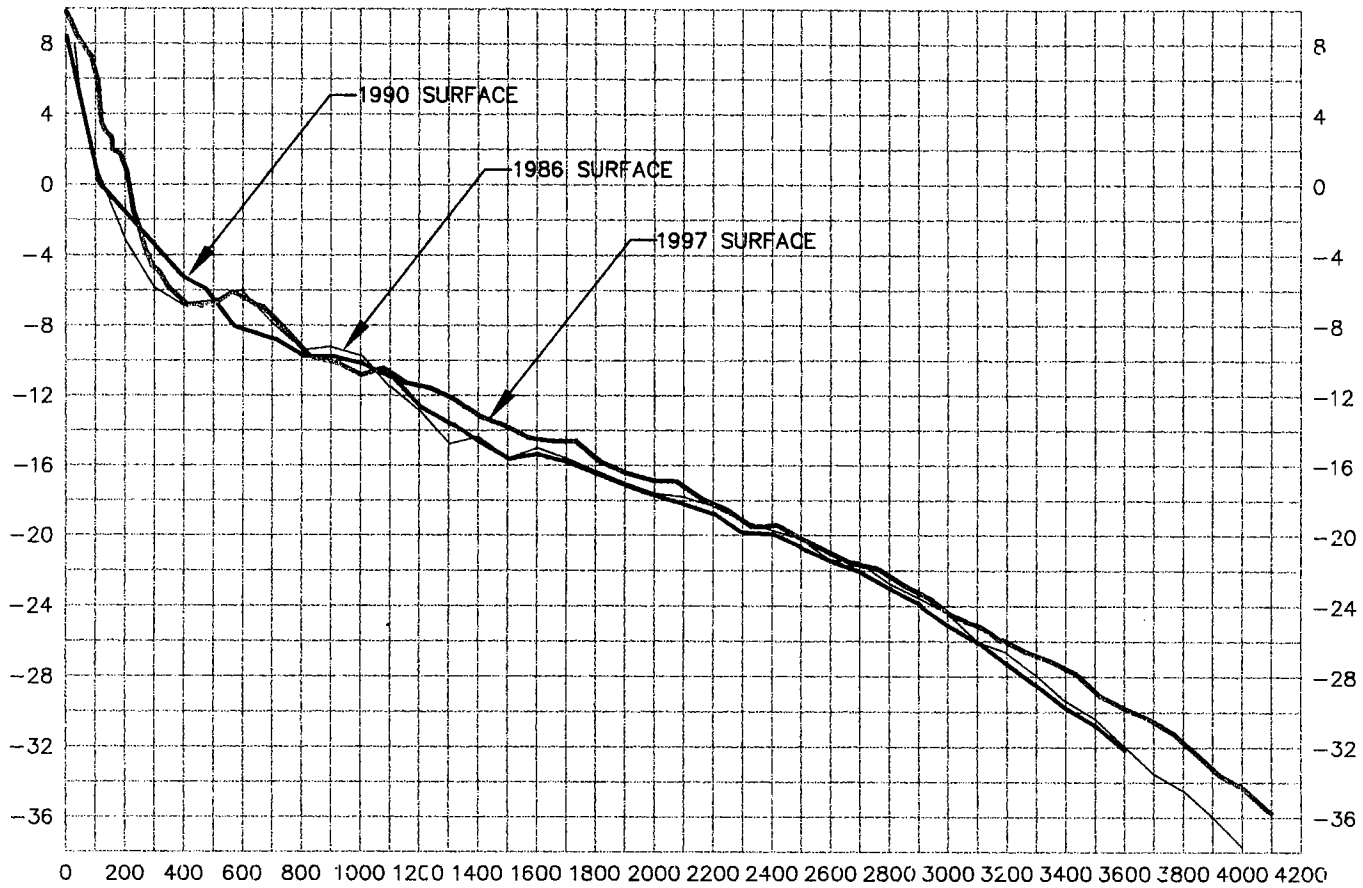

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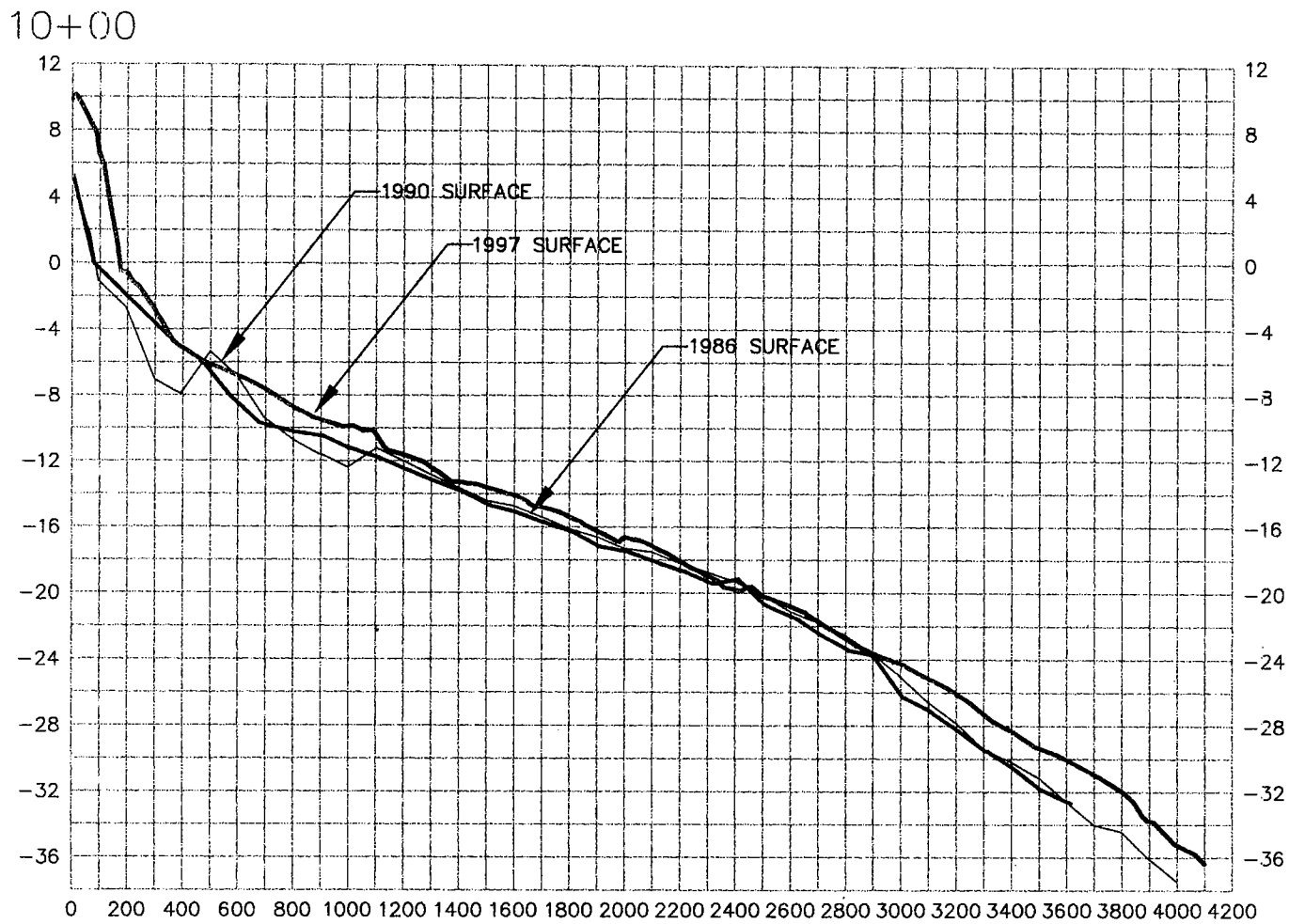
BEACH PROFILES 1986, 1990, & 1997
WEST OF CAUSEWAY, STATION 5+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-8



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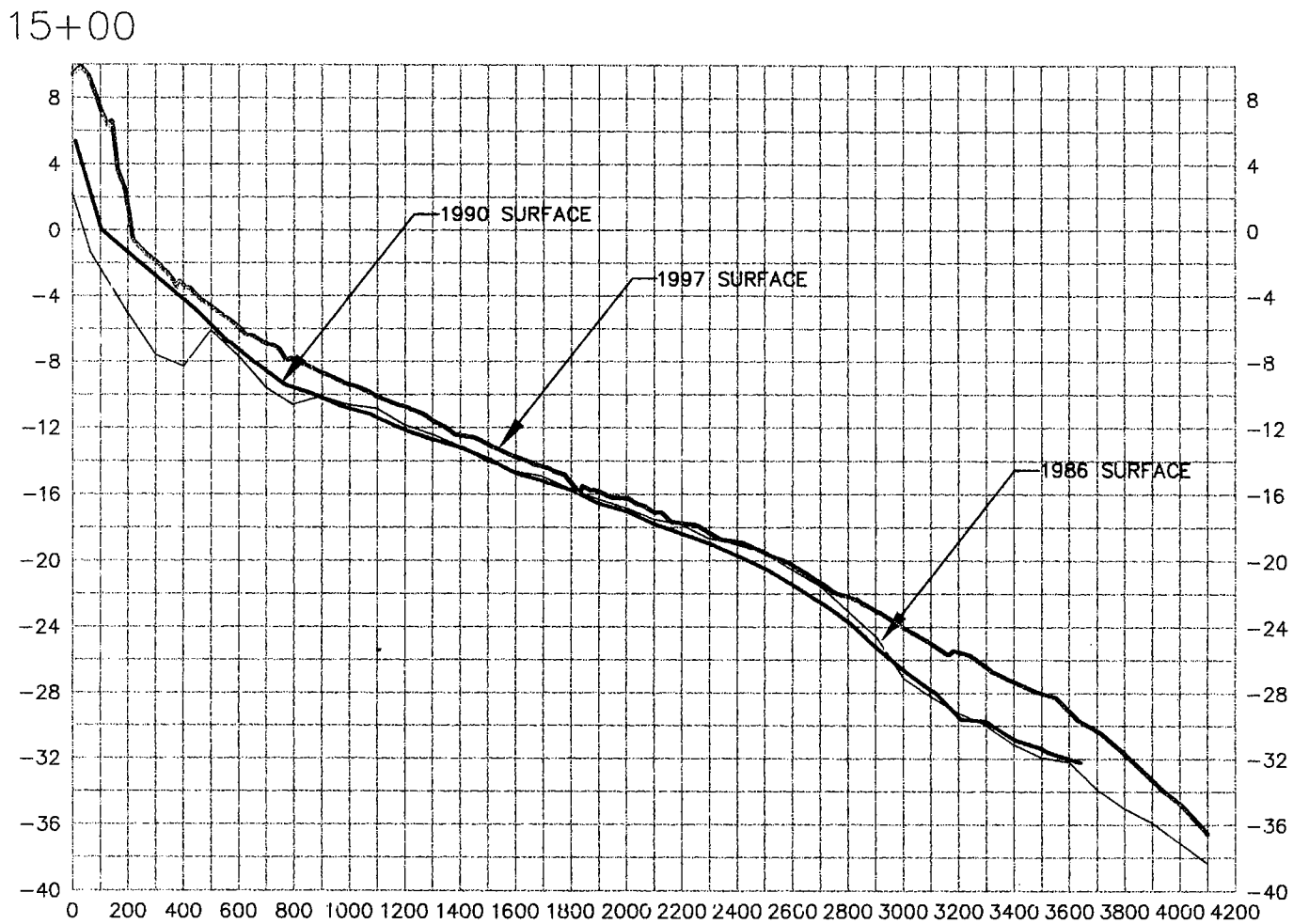
BEACH PROFILES 1986, 1990, & 1997
WEST OF CAUSEWAY, STATION 10+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-9



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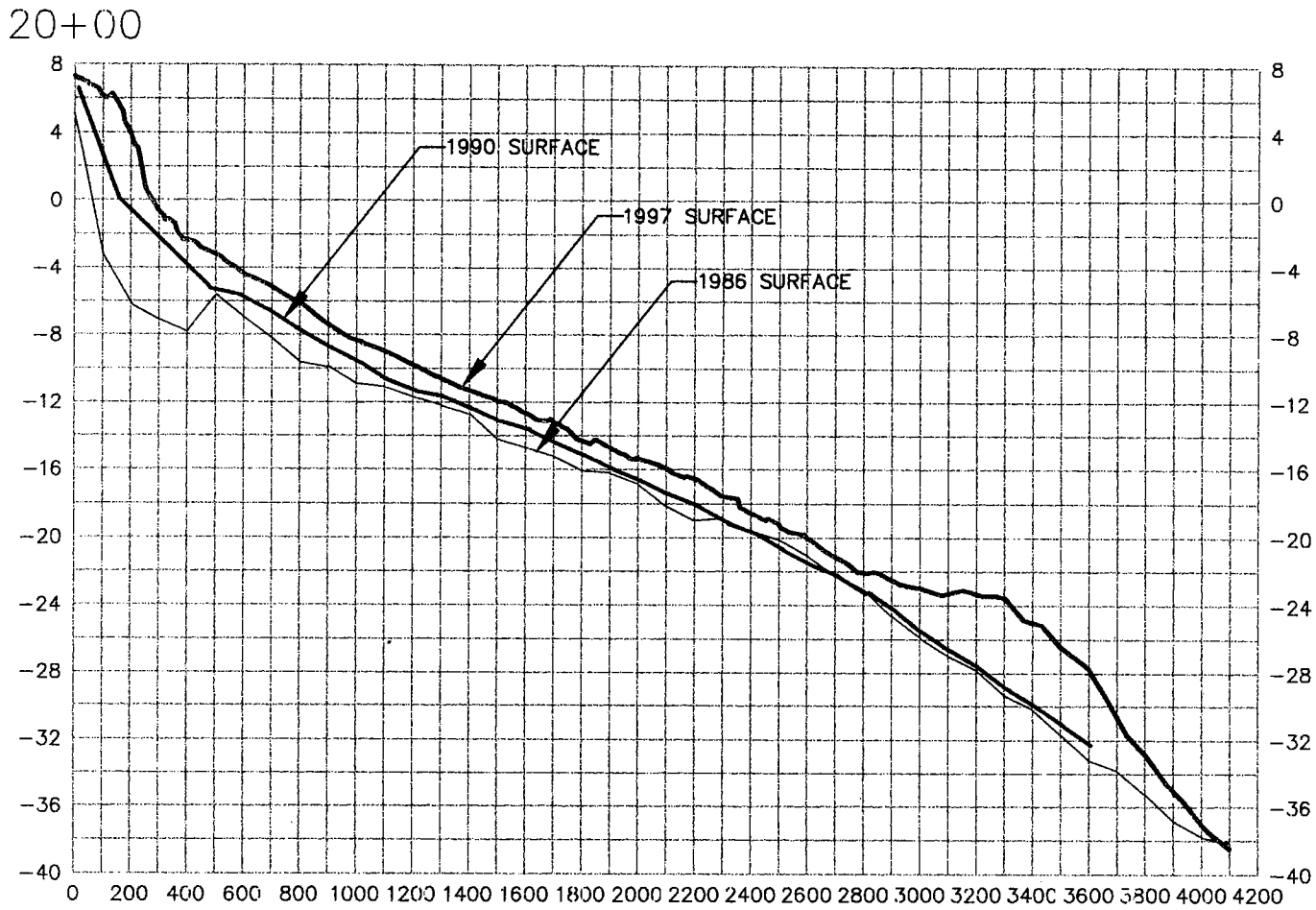
BEACH PROFILES 1986, 1990, & 1997
WEST OF CAUSEWAY, STATION 15+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-10



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

BEACH PROFILES 1986, 1990, & 1997
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NAVIGATION IMPROVEMENTS, NOME, ALASKA

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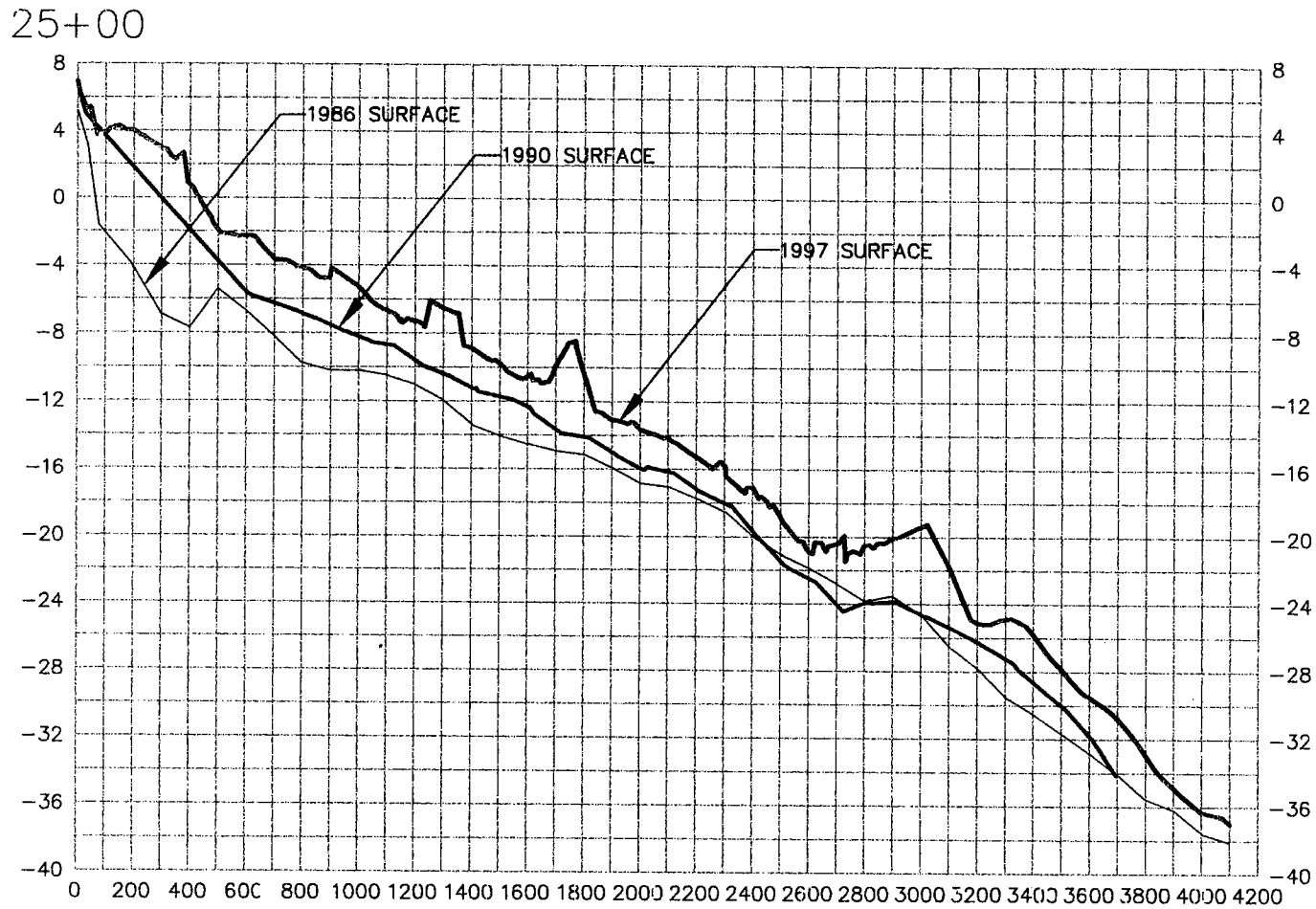

ALASKA DISTRICT
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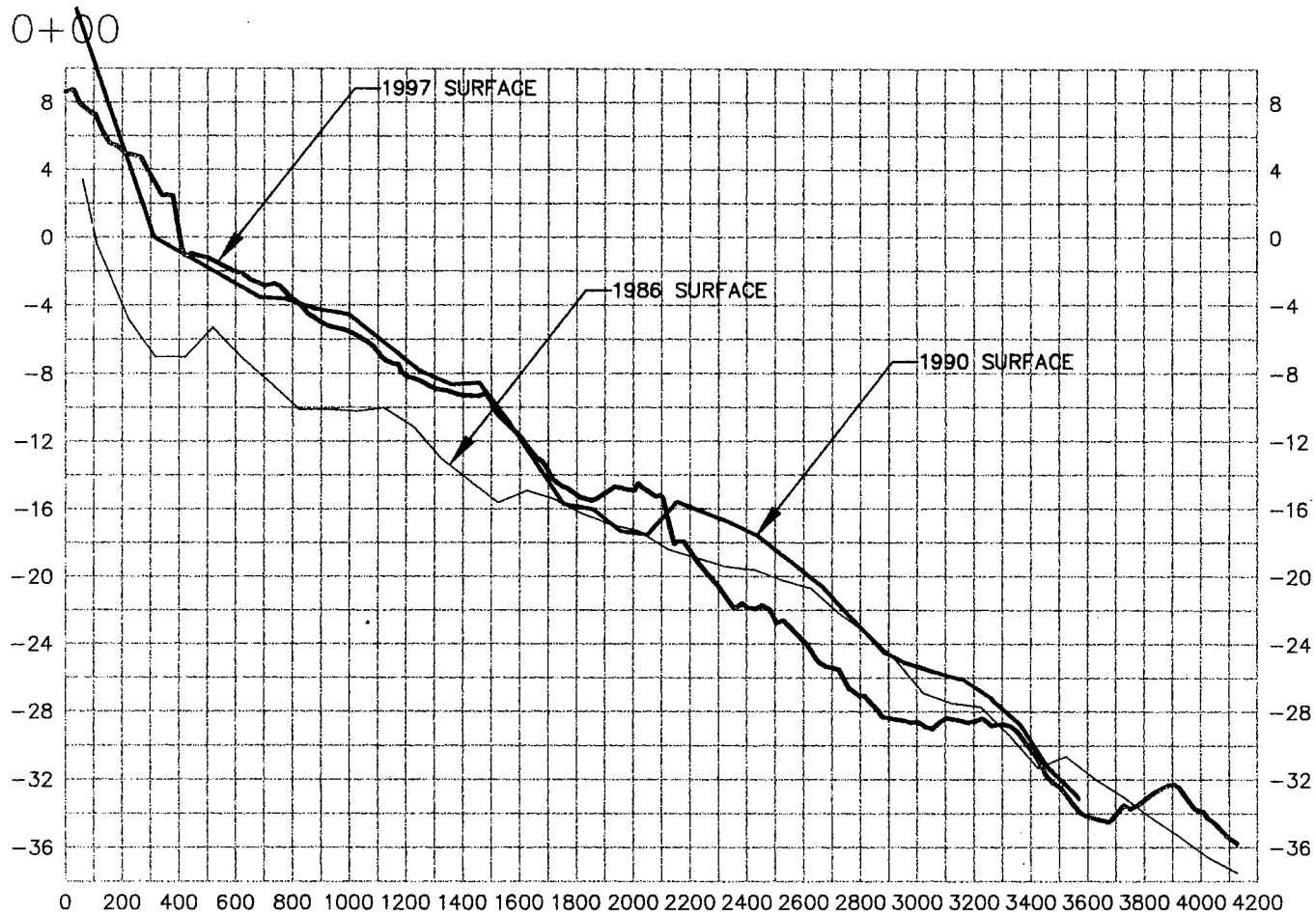

ALASKA DISTRICT
CORPS OF ENGINEERS
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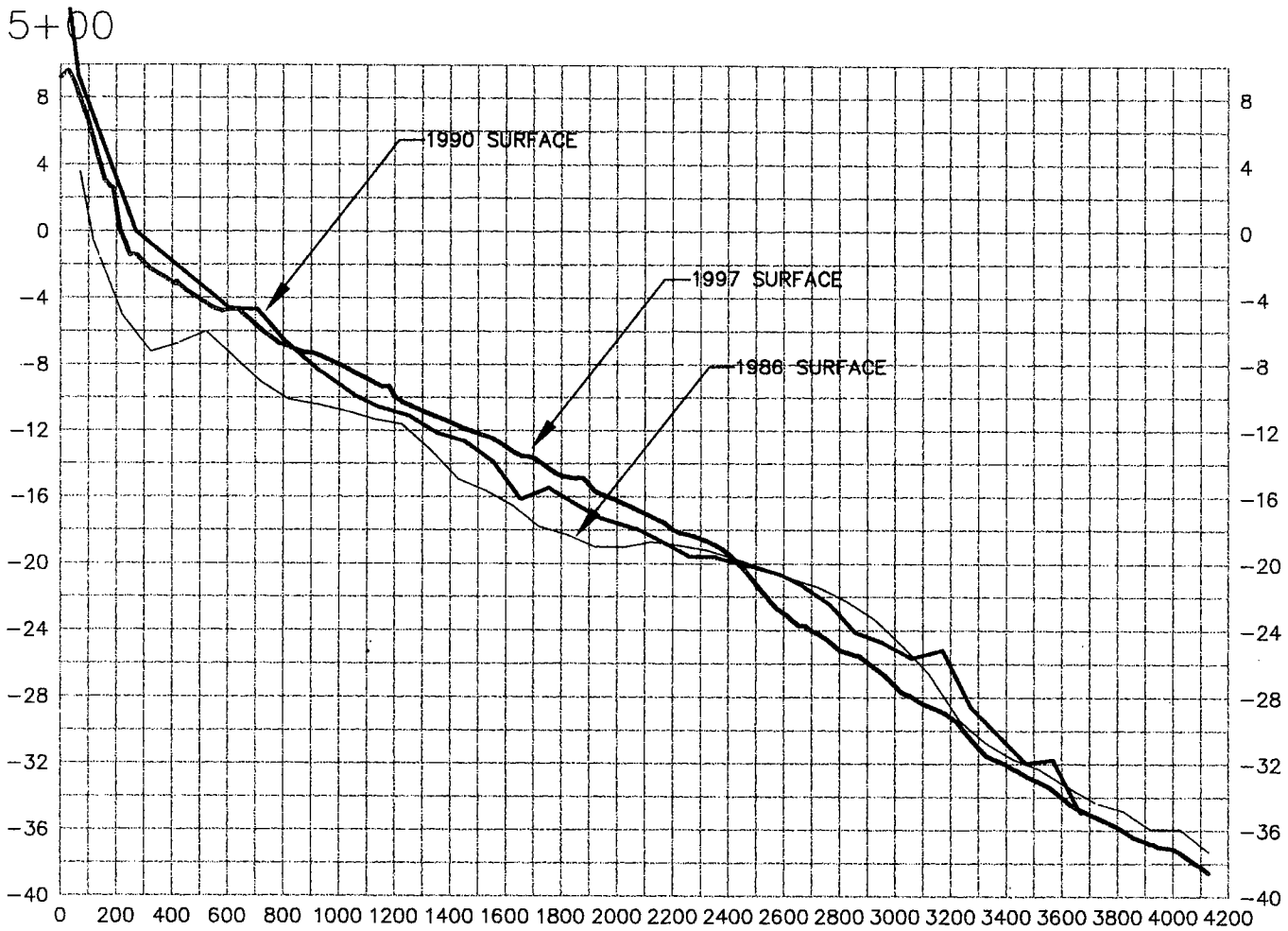
4-13



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

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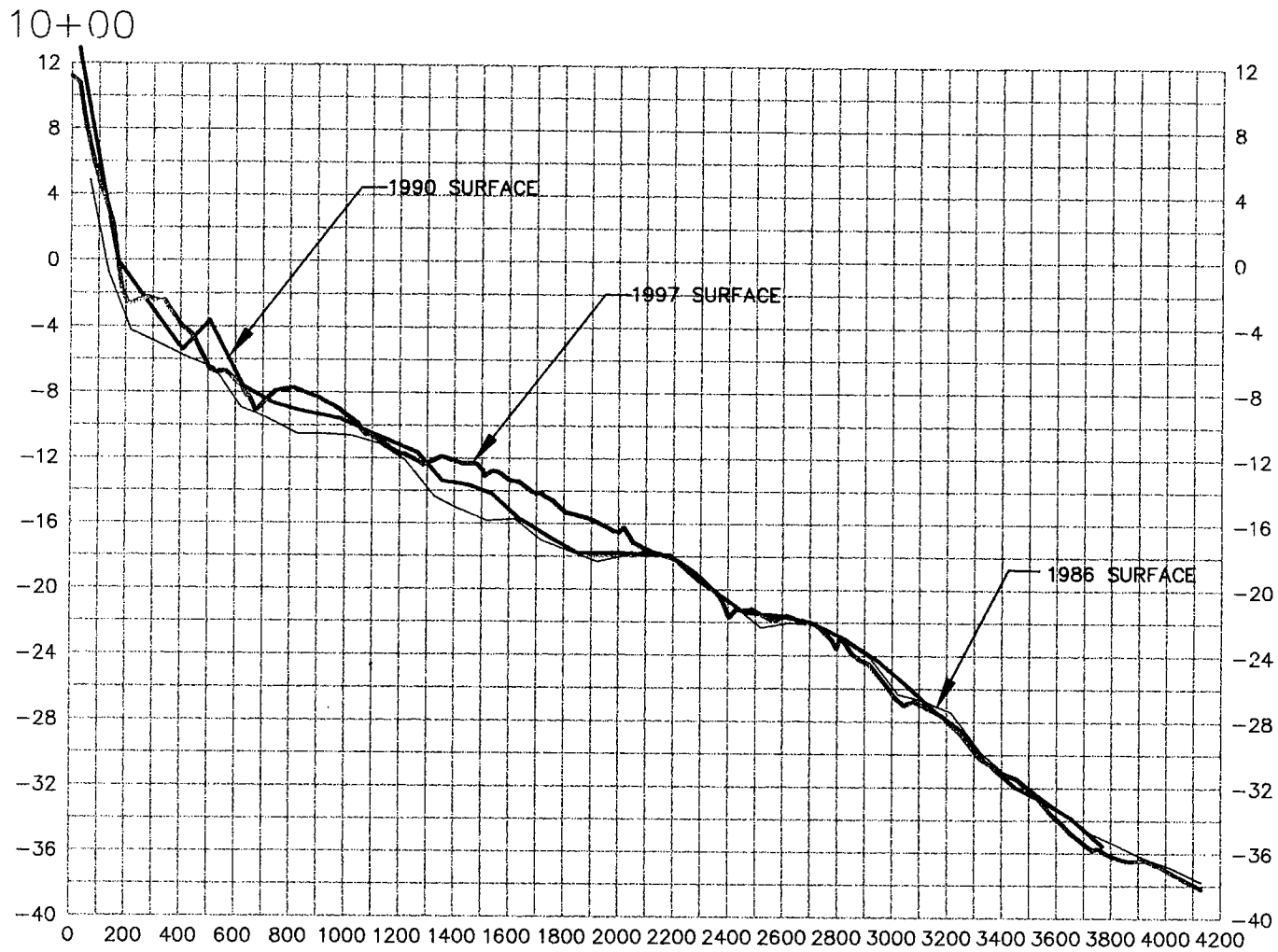
4-14



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

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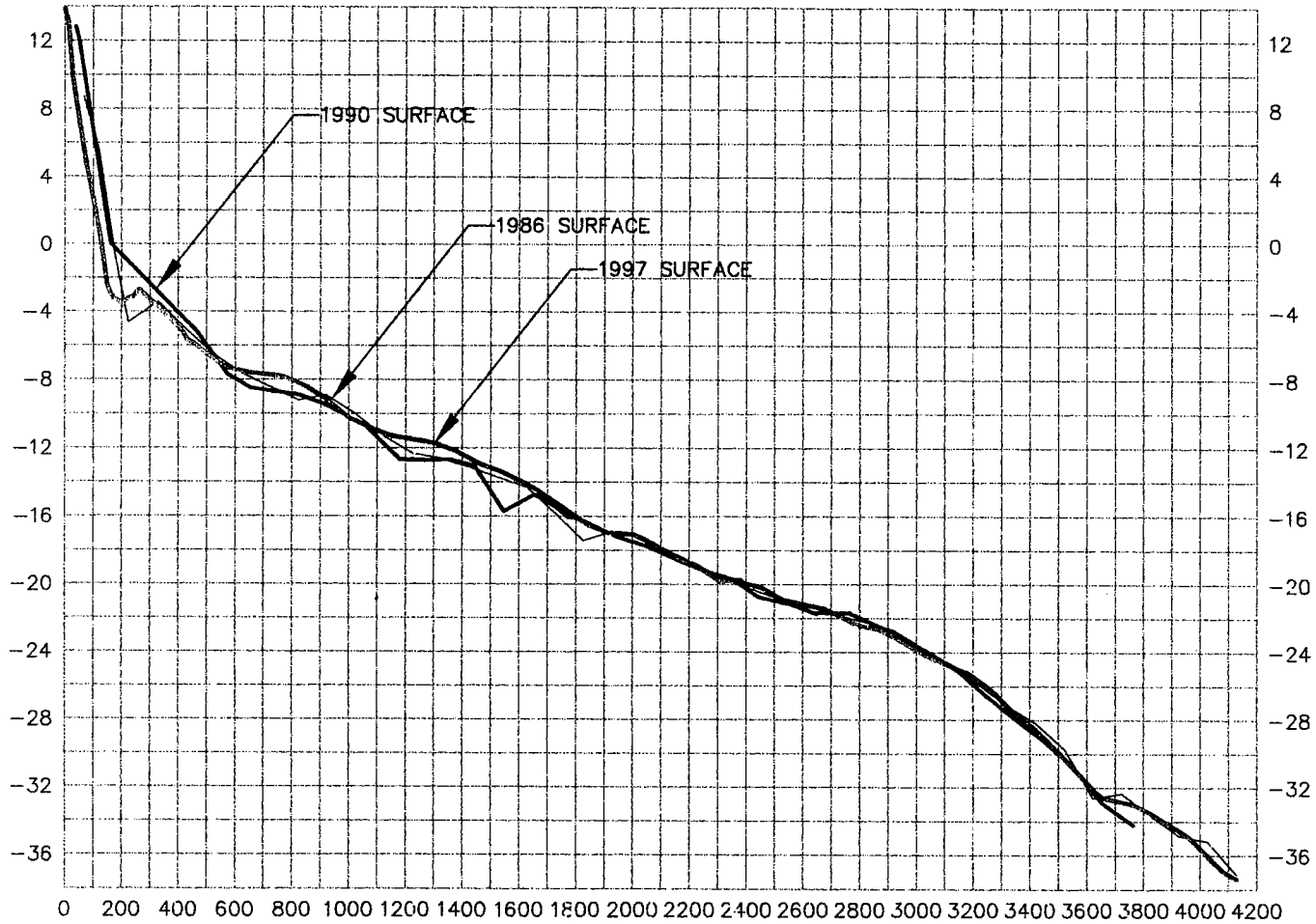
4-15

15+00



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

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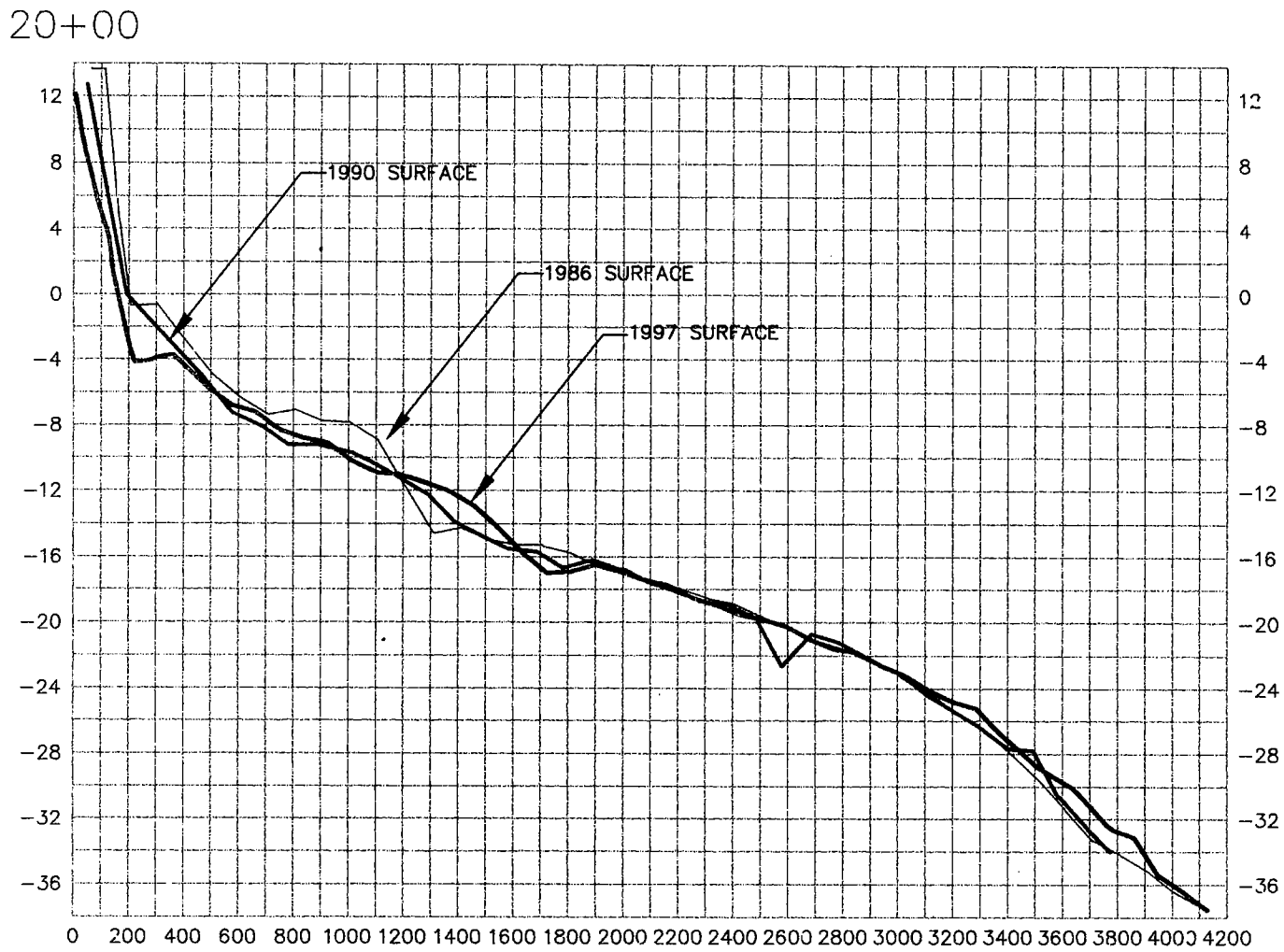
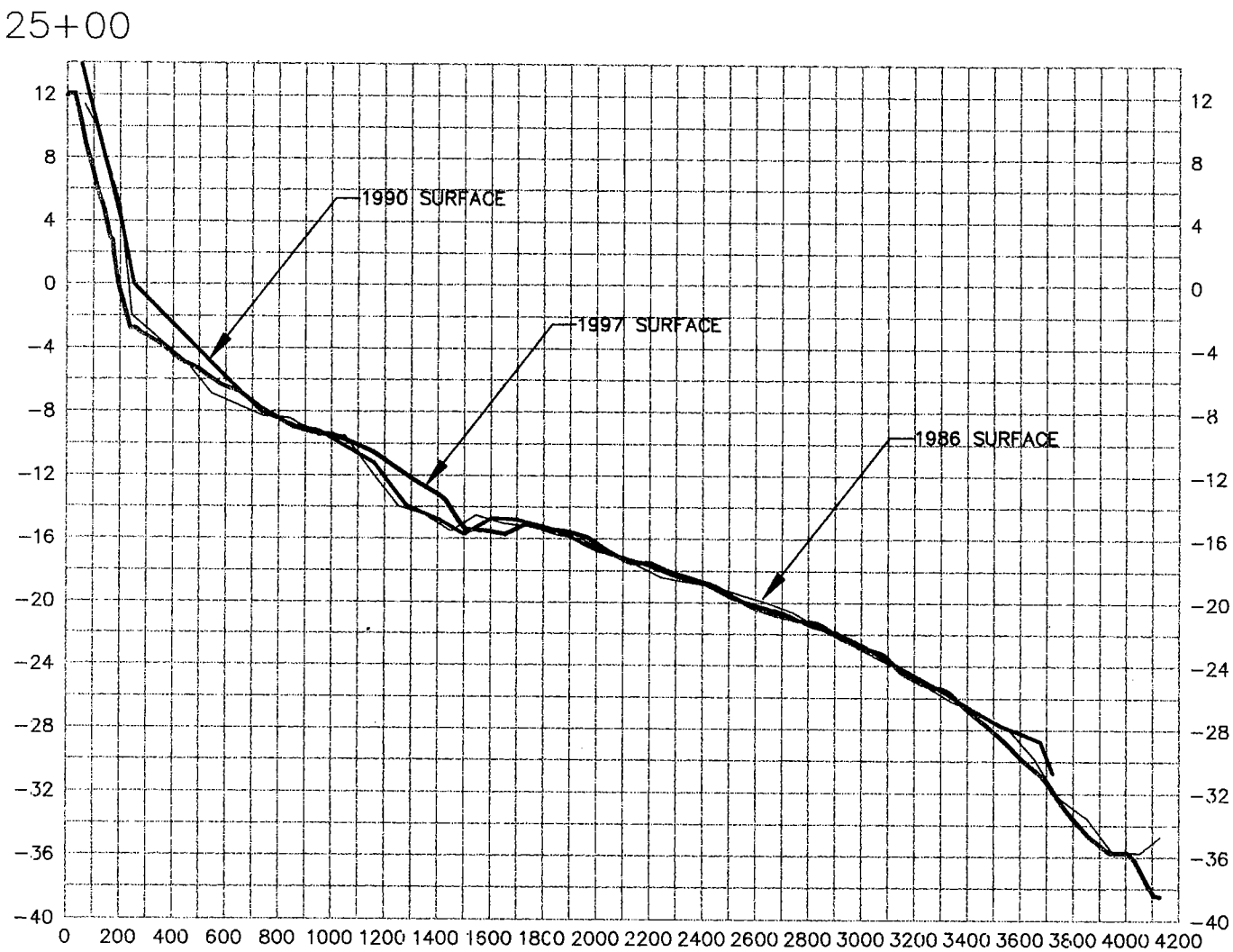
4-16



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

BEACH PROFILES 1986, 1990, & 1997
EAST OF CAUSEWAY, STATION 20+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-17



ALASKA DISTRICT
CORPS OF ENGINEERS
CIVIL WORKS BRANCH

BEACH PROFILES 1986, 1990, & 1997
EAST OF CAUSEWAY, STATION 25+00
NAVIGATION IMPROVEMENTS, NOME, ALASKA

4-18

4.2.4 Snake River Sediment.

The total rate of sediment transported by a river is the sum of the contributions from bed load and suspended load. Bed load sediment is the material moving on or near the bed, with particles moving intermittently by rolling, sliding, or jumping. Load rates often are proportional to river velocity and the corresponding shear stress. Shear stress can be related to the square of the velocity.

Data for the Snake River was obtained from the U.S. Geological Survey (USGS). The data included yearly sediment discharge correlated with water discharge and grain size distribution for 1997 and for 1963-1972, and daily water discharge for October 1990 to September 1991. Figure 4-19 shows the yearly data for both suspended sediment and bed load sediment versus water discharge on a logarithmic scale. The daily data is shown in table 3-4 in section 3 of this appendix.

A regression analysis was performed on the yearly data to determine a relationship between the water discharge and the sediment loading. Figure 4-20 is a plot of the best-fit line generated from the regression analysis for the yearly suspended sediment data. There was a break in the distribution of data around 300 ft^3/s, so separate slopes

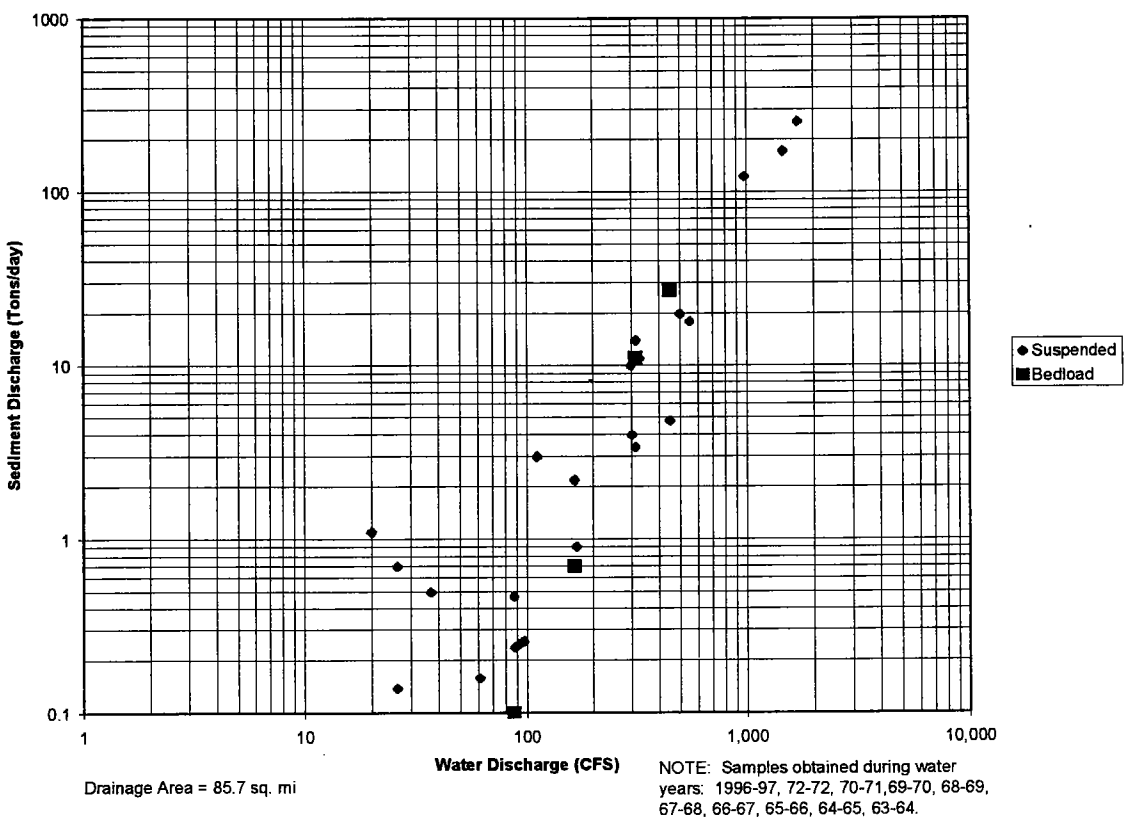


FIGURE 4-19.—Snake River sediment discharge v. water discharge.

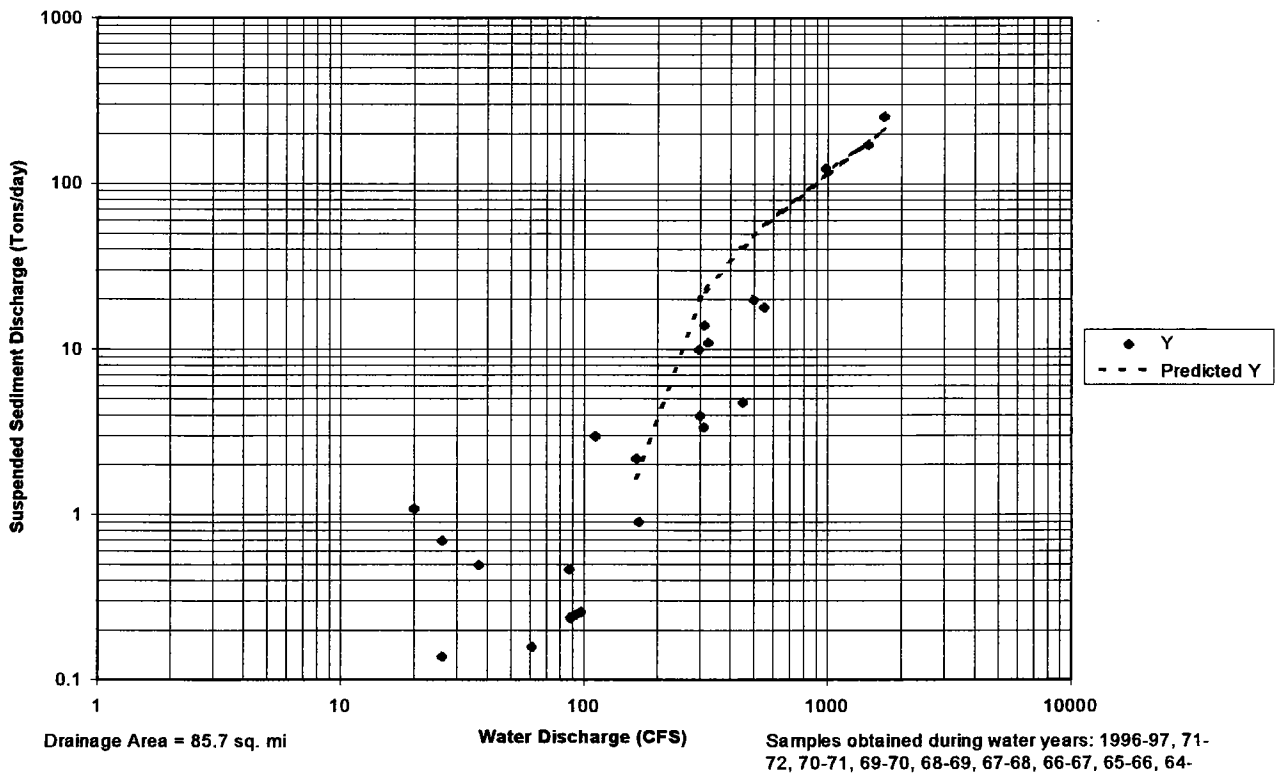


FIGURE 4-20.—Snake River suspended sediment discharge v. water discharge, regression best-fit line.

were computed for the data above 300 ft^3/s and for that below. Those slopes were used to find the corresponding suspended sediment discharge from the daily discharge data. The results were compared to the best-fit line plot of the yearly data to see how close the extrapolated daily data was to the yearly data. Most of the results were in the correct range, except for river discharge data that was between 300 ft^3/s and 400 ft^3/s. For a water discharge of 320 ft^3/s, the suspended sediment would be approximately 60 tons/day using the slope for data above 300 ft^3/s. If the slope for data below 300 ft^3/s was applied, the sediment discharge was approximately 10 tons/day. The 10 tons/day was much closer to the best fit line plot, so slopes were recomputed with the yearly data separated by that below and greater than 400 ft^3/s. The resulting daily values then corresponded more closely to the best fit line plot. The same procedure was applied to the bed load sediment discharge data.

Figure 4-21 is a plot of the best-fit line generated by regression analysis of the bed load data. The daily values of sediment discharge were summed up to provide the yearly sediment discharge. Suspended sediment discharge was computed to be 7,500 tons per year, and the bed load sediment discharge was 4,500 tons per year.

In the yearly data obtained from USGS, approximately 70 percent of the suspended sediment was finer than 0.062 millimeters (mm) under normal flow conditions. Thus the suspended load is composed of relatively fine material as compared to materials

on the bed. The information from the yearly data was compared with data from the "Sediment Characterization for Nome Turning Basin and Entrance Channel Sediments," done by the Alaska District Corps of Engineers Geotechnical Branch in July 1995 (see figures 4-22 through 4-27).

Note that the sediment load finer than 0.062 mm is not significant in bed material except in the stagnation areas of the harbor. Therefore, only approximately 2,250 tons of 7,500 tons of suspended sediment is expected to be involved in channel bed exchange per year. If the sediment is assumed to weigh 85 lb/ft^3, then the quantity involved in channel bed exchange (suspended and bed load) is 5,900 yd^3/yr. Most of the sediment discharge occurs during the spring freshet when there is an ice cover over the lower river and Norton Sound. River sediments are expected to flush through the system at this time, as no severe deposits are found in the channel unless storms wash over the spit. These quantities and history indicate that the Snake River does not now contribute a significant amount of sediment to the navigation segment of the channel, nor is it a significant source when littoral transport values are at least 20 times as large.

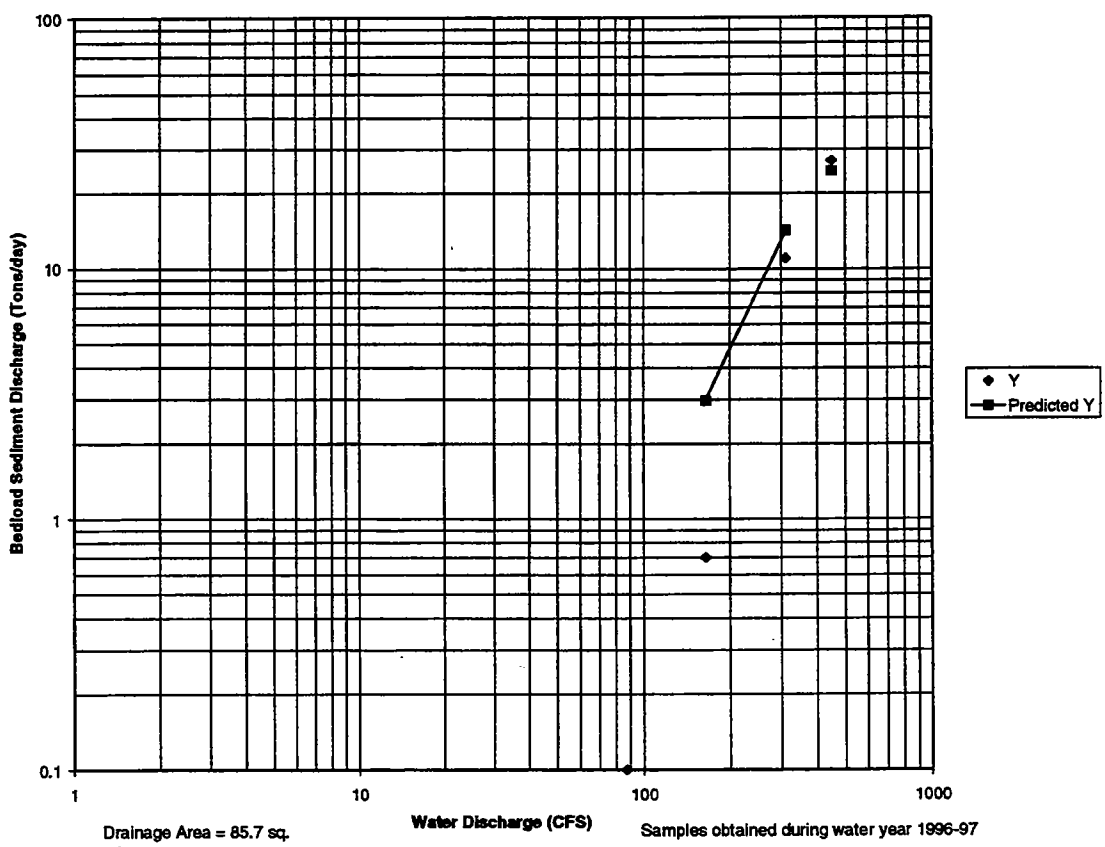


FIGURE 4-21.—Snake River bed load sediment discharge v. water discharge, regression best-fit line.

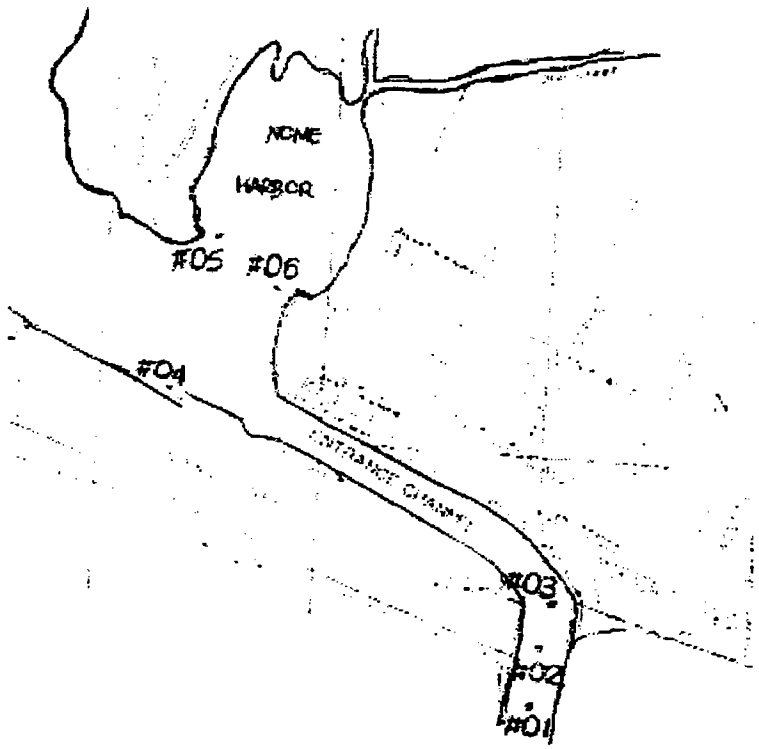


FIGURE 4-22.–Nome Small Boat Harbor sediment classification sampling locations.

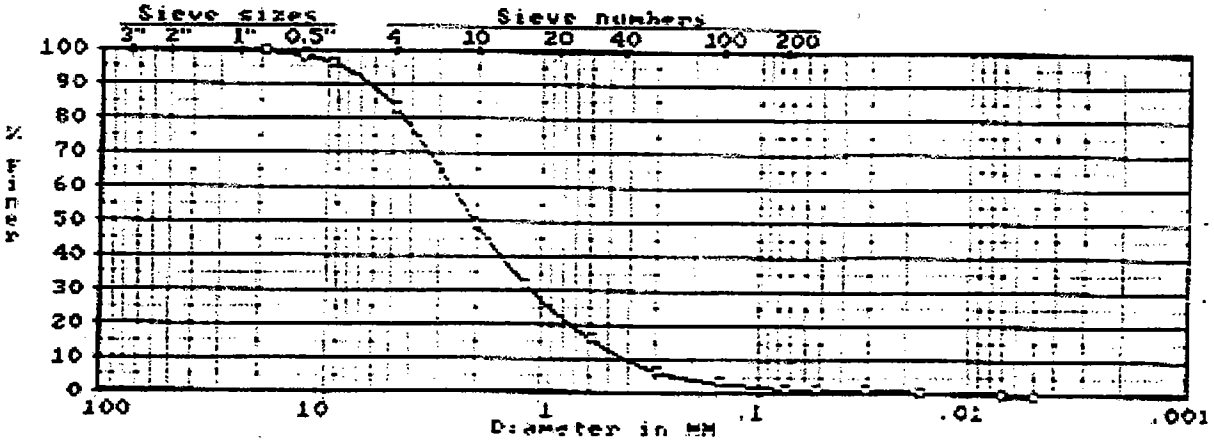


FIGURE 4-23.–Sediment classification sample #1.

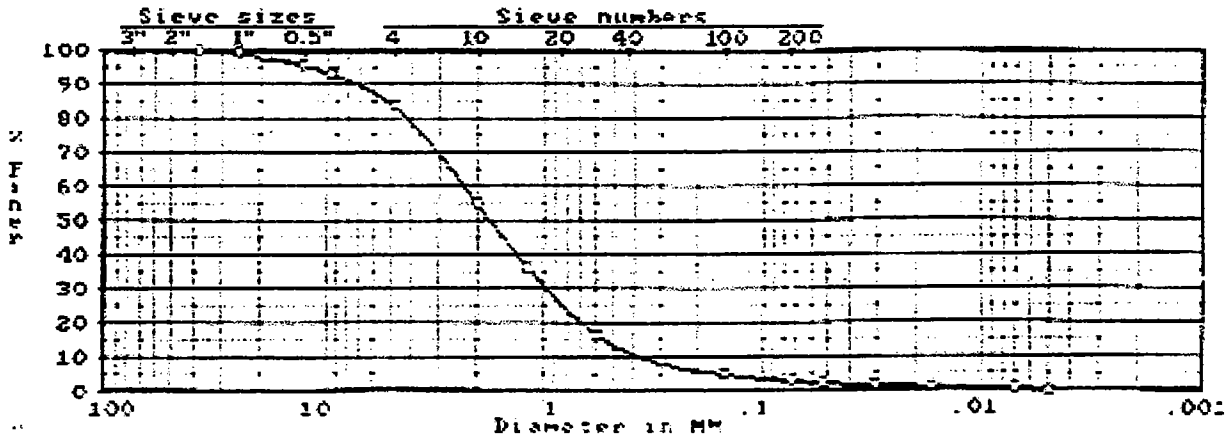


FIGURE 4-24.–Sediment classification sample #2.

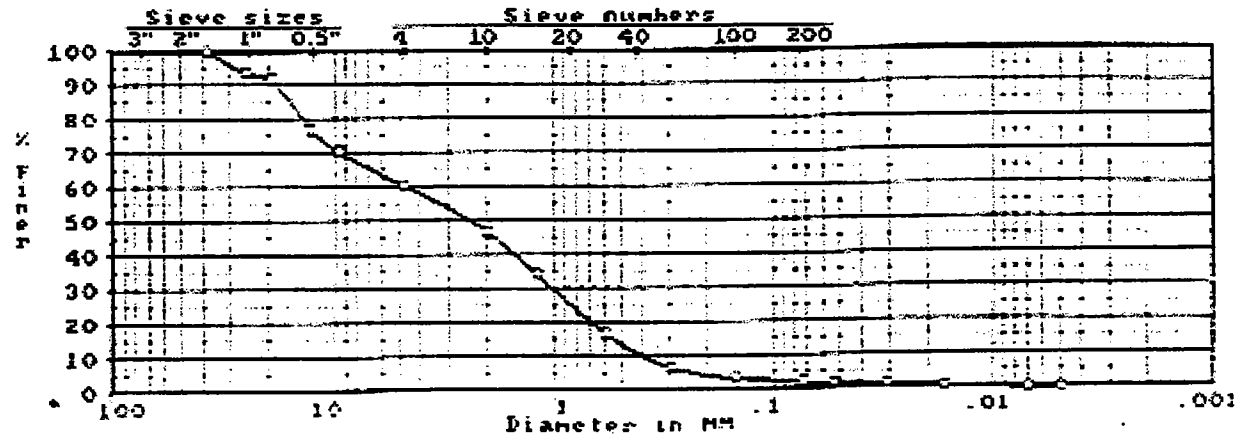


FIGURE 4-25.–Sediment classification sample #3.

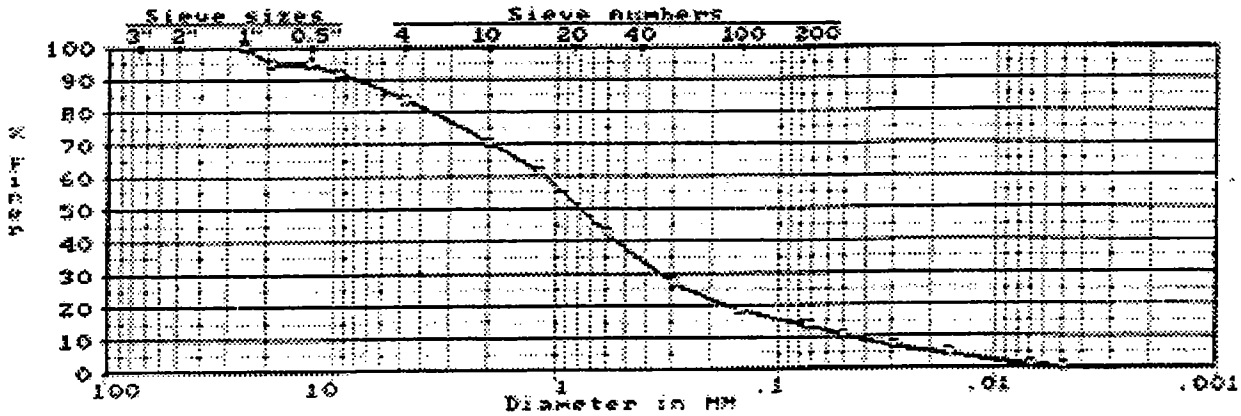


FIGURE 4-26.--Sediment classification sample #4.

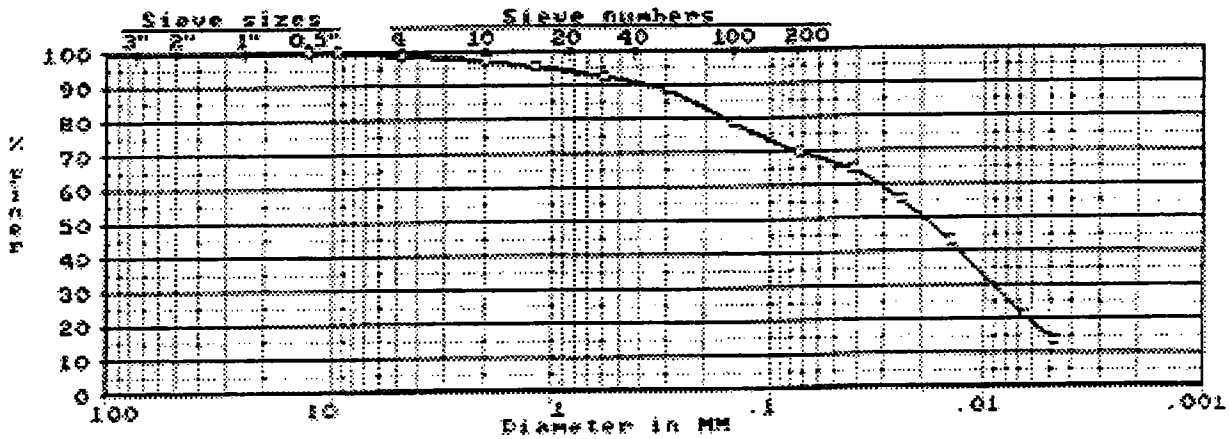


FIGURE 4-27.--Sediment classification sample #5.

4.2.5 Ice Studies.

The ice design parameters for the causeway will be applied to the recommended plan in this report because the causeway structure has soundly withstood ice forces since its completion. The minimum-sized armor rock used in the causeway is 8-ton, which was sized for ice forces. Ice ride-up apparently has been infrequent also. Of the Nome residents asked about ice ride-up on the causeway, only one has seen this, which occurred at the head of the causeway.

TAMS (1982) describes the causeway ice design parameters. As part of the design, the Iowa Institute of Hydraulic Research (IIHR) conducted an ice-engineering study by testing ice forces against scaled model sections of the causeway.

The causeway side-slope length modeled had a slope of 1:1.5 and used a model-scaled 8-ton armor rock. From the model study, it was found that randomly placed 8-ton armor remained generally stable during the ice ride-up on the causeway.

The ice forces imparted on structures are a function of the ice strength. Ice strengths of compressive, tensile, and bending modes depend upon temperature, strain rate, grain size, porosity, salinity, crystallographic structure, etc.

To estimate design loads on a structure, ice forces can be separated into two broad categories: static and dynamic (Neill 1976, Sanderson 1988). Static loading is identified if ice is in stationary contact with a structure, and then the structure is subjected to ice sheet-transmitted loads caused by wind drag, water movement, pressure from surrounding ice sheets, and thermal strain. Dynamic loading, in contrast, is identified if a structure is not in initial contact with an ice feature, but is impacted by it with some velocity.

The three modes of ice failure that can occur when an ice sheet impinges on a side slope are flexural, buckling, or crushing. Due to uncertainty in estimating environmental forces transmitted to ice sheets, such as wind exerting a shear stress on the top of an ice sheet, a typical method used in ice design is to estimate the loads generated during the different ice-failure modes.

TAMS used the following recommendation for causeway ice design:

> *A design ice loading of 110 kip/ft is recommended for the causeway and causeway head. This load is commensurate with the ductile crushing of a 4.5-foot-thick ice sheet against ice rubble frozen to the causeway and small strain rates. The 188 kip/ft and 120 kip/ft loads, due to the collision of mobile ice sheets on the causeway head and causeway and the resulting brittle fracture, are unlikely to develop along significant lengths of the causeway or its head. A mobile ice sheet failing against the side-slopes of the causeway causes ice rubble to accumulate along the structure. As observed in the model tests, the presence of ice rubble leads to the nonsimultaneous failure of relatively short sections of the ice sheet along the causeway and so precludes the generation of the full impact (buckling or crushing) load. The forces required to buckle or crush ice against the causeway are considerably greater than those required for the flexural failure or ride-up of ice.*

For the recommended plan for the main and spur breakwaters, which is explained later in the report, the minimum armor rock size and resisting mass against ice forces were investigated. From the causeway prototype and the ice model testing performed

by IIHR, 8-ton will be used as the minimum armor rock size since it has been proven to function successfully.

The seaward end of the 3,000-foot main breakwater has the greatest ice fetch exposure to static and dynamic ice forces because the causeway and ice between the breakwater and causeway are not providing a buttress to counteract ice forces. In contrast, the trunk of the causeway is protected from large, environmentally caused ice forces by the causeway and ice between the causeway and the 3,000-foot main breakwater.

For the resisting mass, the head of the 3,000-foot breakwater was sized for ice by determining the mass per linear foot using an average dry density of 1.4 tons/yd^3 for the armor, secondary, core, and bedding material. The bedding layer and existing sea bottom were chosen as having the least shear resistance. This presumes that the friction forces among the breakwater rock pieces are greater than the bedding layer – sand sea bottom interface, and the breakwater acts as a unit mass.

At station 39+00 (the shoreward end of the breakwater begins at station 10+00), near the southern end of the breakwater, the mass was computed at 258,000 pounds per foot. Applying a coefficient of 0.41 to this results in a resisting friction force of 106,000 pounds per linear foot, which is in the range of the causeway design ice loading of 110,000 pounds per foot. The 110,000 pounds-per-foot causeway design ice load exceeds the ice design force suggested by Gute and Nottingham (1974) of 50,000 pounds per foot for a dock or breakwater.

The *Shore Protection Manual* (1984) recommends that structures subject to blows from floating ice should be capable of resisting 139 to 167 pounds per square inch on the area exposed to the greatest thickness of exposed ice. Table 4-7 shows the variation in ice force, using ice thicknesses of 3.0 and 4.5 feet and converting the 139 and 167 pounds per square inch to pounds-per-square-foot units:

TABLE 4-7.—*Variation in ice force from ice thicknesses of 3.0 and 4.5 feet*

	Pounds per square foot	
	20,016	24,048
Ice thickness (ft)	Ice load per linear foot using the loadings above	
3.0	60,048	72,144
4.5	90,072	108,216

The mass of the 3,000-foot main breakwater progressively decreases shoreward due to the decreasing sea bottom elevation, given a constant crest height of 14 ft MLLW. As described previously, the ice between the causeway and the new main breakwater

would buttress the new breakwater on the east side, eliminating the need for increased mass to resist ice forces. Additionally, placement of dredged material against the east side of the breakwater would buffer the ice forces.

For the spur breakwater, the breakwater mass at station 53+00 is 299,000 lb/ft, and applying a coefficient of 0.41 results in a resisting friction force of 122,000 lb/ft, which exceeds the 110 kips/ft design ice load.

For the recommended plan, the spur and the outer reach of the main breakwater sections were designed to resist ice forces. However, the risk does exist that ice loading can be focused on local areas or portions of the breakwaters, causing localized failure. The other potential location for failure is the inner reach of the main breakwater, where the mass progressively decreases as compared to the breakwater in the deeper waters.

5. DESIGN CRITERIA

5.1 Design Vessel and Fleet

Two design vessels were identified, with one using the causeway part of the navigation system and the other using the inner harbor. The design vessel for inner harbor access is described in section 5.3.3. The design vessel using the causeway is one of the larger barges now using the system. That barge is approximately 400 feet in length overall (LOA) with a beam of 100 feet. The design draft is 19 feet, and because it is used as a petroleum carrier, the actual draft may be only 18 feet. A combination tug/oil barge with a length of 625 feet, a beam of 105 feet, and a draft of more than 30 feet has been identified as a possible future user. An economic analysis for developing harbor depths to accommodate this vessel was not performed because NED criteria indicated a vessel of this size and draft could not be used economically at this site with or without the project. Harbor dimensions other than the 22-foot depth were, however, examined so as not to preclude future use by such a vessel. Because of wave action and a nominal safety allowance, a minimum of 4 feet of bottom clearance is needed. This design vessel is the largest projected oil barge now in the Nome fleet. The aforementioned 625-ft barge/tug combination is under design, but its deployment date has not yet been set.

Local users have indicated that the no-damage and no-delay depth requirement should include 2 feet of underkeel clearance to prevent vessel porpoising and skating in quiet waters, and about two-thirds the wave height to accommodate wave activity at the docks, the dock approach channel, and the inner harbor channel. They have also indicated that an allowance is needed to accommodate depth decreases from shoaling. The 2 feet of underkeel clearance parallels minimum safe practices recommended by the Corps, and the clearance for wave action parallels practices used by the Corps when the wave climate is moderate. More severe wave climates may require in excess of one wave height clearance, as vessel mass may force the excursion beyond the horizontal distance covered by the forcing function. Local experience dictates the tolerances used, but as they parallel Corps guidance, the Corps' Engineer Manuals (EM) are referenced.

The entrance channel design for this project is described in the following paragraphs for the four distinct sections: the entrance channel proper, the dock approach channel, the interior harbor access channel outside the 0-ft-MLLW contour, and the interior harbor access channel within the 0-ft-MLLW contour. The channel dimensions, alignment, and depths were configured based on recommendations of harbor users and fall within the Corps' recommended practices. The local sponsor had several onsite representatives during initial configuring of the system in the hydraulic model. Don Stultz of Crowley Marine was the principal navigation adviser during this process.

5.2 Allowable Wave Heights

5.2.1 Entrance Channel.

Immediately seaward of the causeway and the proposed breakwater, focused waves can approach 6 feet in height even in the absence of an extreme storm. Depths are presently available to allow passage of the design fleet under this condition. Waves at the outer fringes of the –22-foot-MLLW channel need to be reduced to 4 feet to allow unrestricted use. Wave heights need to be further reduced to 3 feet in the channel where tugs need to uncouple from barges and shift to a pushing mode to dock barges at the causeway loading/offloading cells.

5.2.2 Dock Approach Channel.

Users have indicated that waves in excess of 3 feet curtail docking operations at the existing facility. Therefore, a 3-foot wave at the docks and in the approach channel was used as the upper limit allowed with navigational improvements in place.

5.2.3 Inner Harbor Access Channel.

The approach channel in the region seaward of the spit, where a channel would be dredged to a bottom elevation of -12 ft MLLW, requires waves to be reduced to less than 3 feet. For channel depths of -10 ft MLLW, the wave height should be less than 1 foot.

5.2.4 Inner Harbor.

The design wave height within the Nome harbor is 1 foot. This design wave height is based on the criteria contained in EM 1110-2-1615, "Hydraulic Design of Small Boat Harbors" (USACE 1984).

5.3 Channel Width and Depth

Navigational channel criteria are contained in EM 1110-2-1613, "Hydraulic Design of Deep-Draft Navigation Projects" (USACE 1994). Channel dimensions are set to provide for the safe and efficient movement of the design vessels. The minimum channel width required depends upon the size and maneuverability of the vessels, channel shape and alignment, traffic congestion, wind, waves, currents, visibility, quality and spacing of navigation aids, and whether traffic is one-way or two-way.

5.3.1 Entrance Channel.

Width. Channel width was determined by criteria given in EM 1110-2-1613 (USACE 1994). For one-way ship traffic and a trench cross-section channel with 0.5-to-1.5-knot currents, the width should be approximately 3.25 times the beam of the design vessel. With a design vessel beam of 100 feet, this formula yields 325 feet of channel bottom width. Because of the effects of wave focusing that would occur at the entrance to the project and the asymmetrical bank conditions for this portion of the channel, an additional 25 feet is used, bringing the channel width to 350 feet.

Depth. The proposed channel depth was determined based on the criteria in table 5-1.

TABLE 5-1.—*Entrance channel depth*

Factor	Feet
Design vessel draft	18
Pitch, roll, and heave*	2
Safety clearance	2
Squat	0
Tide allowance	0
Total depth	**22**

* Taken as 2/3 of the maximum operating interior wave height in the channel.

Because the tidal range is only 1.6 feet and the vessels in the channel travel at slow speeds, the allowances for tide and squat were considered negligible. This resulted in a design depth of –22 ft MLLW.

5.3.2 Dock Approach Channel.

Width. A vessel using this portion of the channel would be pulled into the dock access channel by a tug, which would then uncouple from the vessel and maneuver to the dock by pushing the vessel sideways through the approach channel. The beam for the vessel would then be 400 feet. Using the criteria given in EM 1110-2-1613 (USACE 1994) for one-way ship traffic and a trench cross-section channel with decreased currents, the width should be approximately 3 times the 400-foot beam of the design vessel, giving 1,200 feet of channel bottom width. The vessels require about 100 feet of overhang on the 200-foot-long dock and an additional 100 feet of bank clearance to arrive at the dock. This corresponds to a bank clearance of 200 feet (25% of the beam = 100 feet of overhang) on the outward side of the two docks. The area between docks is a common use area for vessels going to either dock and is incorporated into the channel width requirement of both docks.

Depth. The design depth in the dock approach channel is –22 ft MLLW, the same as the entrance channel. The same design criteria were used for this portion of the channel.

5.3.3 Inner Harbor Access Channel.

Width. Channel width was determined by criteria given in EM 1110-2-1613 (USACE 1994). For one-way ship traffic and a trench cross-section channel with minimal currents, a design ship beam multiplier of 2.75 to 3.5 is applicable. Using 3 times the 50-foot beam of the design vessel applicable to this portion of the channel results in a channel width of 150 feet. This width applies to both straight portions of the inner harbor access channel.

Additional width in the turn of the channel was determined by using the minimum criteria given in EM 1110-2-1613. The total length of the tug and barge design vessel is 250 feet. Therefore, channel widths approach 335 feet in the area of the turn, allowing sufficient channel space for the design vessel. The currents on the north side of the spit are negligible, and a channel in this location would fall in the lee of the sand spit. Therefore, the use of the minimum criteria for the turn is sufficient for navigation.

Depth. The proposed channel depth was determined based on the criteria in table 5-2.

TABLE 5-2.—*Inner harbor access channel depth*

Factor	Feet
Design vessel draft	8
Pitch, roll, and heave*	2
Safety clearance	2
Squat	0
Tide allowance	0
Total depth	**12**

* Taken as 2/3 of the maximum operating interior wave height in the channel.

Because the tidal range is only 1.6 feet and the vessels in the channel travel at slow speeds, the allowances for tide and squat were considered negligible. This resulted in a design depth of –12 ft MLLW. This depth would be used outward of the 0-ft-MLLW contour for the interior harbor channel. Inward from this point, the depth would decrease to –10 ft MLLW as a result of the decrease of interior wave height reducing the effects of pitch, roll, and heave.

No allowance was made for set-down conditions in the harbor, as oil barges can receive partial loading in the interior harbor and be topped off at the causeway docks.

5.4 Flushing

The flushing characteristics of the existing harbor are at an appropriate level for a new facility. A criterion for flushing is not to decrease the capabilities of the present system.

5.5 Breakwaters

Criteria from the *Shore Protection Manual (SPM)* (USACE CERC 1984) were used for the breakwaters. These criteria included applying the Hudson equation using a breaking wave with a significant wave height (H_s) of 19 feet with a 50-year design return period. The alignments and lengths of the breakwaters were determined by examining their impact on offshore/onshore and longshore sediment transport along with reducing wave action in the channels.

5.5.1 Main Breakwater.

This breakwater would be constructed from the sand spit and extend southwest, terminating east of the entrance channel in a water depth of approximately -24 ft MLLW.

Using 1V:1.5H side slopes, 165 pounds per cubic foot unit weight of stone, and the wave height of 19 feet resulted in a K_D value of 12.0 for the armor rock on the structure head with a breaking wave. This value for K_D is reasonable with the use of special placement for the armor rock. Armor rock layer thickness would be 10.0 feet, with a crest width of 12 feet calculated based on an armor rock size of 8 tons. From the model testing performed at the Corps' Waterways Experiment Station (WES), it was determined that the optimum crest height is +14 ft MLLW. The remaining layer rock sizes were determined for the breakwater using the methods described in the *SPM*.

5.5.2 Spur Breakwater.

The spur breakwater extends from the causeway head, at a 50-degree angle from the causeway alignment, toward the new entrance channel. The causeway has 22-ton armor rock at the head where the spur would begin, and this material has performed well since project inception. Therefore, 22-ton rock was evaluated for use in the spur, using the methods described in the *SPM* by applying the Hudson equation, and was determined to be acceptable.

Using 1V:1.5H side slopes, 165 pounds per cubic foot unit weight of stone, and a wave height of 19 feet resulted in a K_D value of 4.4 for the armor rock on the structure head with a breaking wave. This value for K_D is reasonable with the use of special placement for the armor rock. The armor layer thickness would be 15.0 feet and the crest width would be 29 feet, based on the armor rock size. From the model testing performed at WES, it was determined that the optimum crest height is +14 ft MLLW. The remaining layer rock sizes for the breakwater were determined using the methods described in the *SPM*.

5.6 Channel Usability

The channel is expected to be usable about 98 percent of the time for inner harbor users, with closure occurring only during extreme storm events or during periods of depressed water level. The causeway dock approach channel would be closed during extreme events about 2 percent of the time, and occasionally outer dock access would be limited under 60-degree-east wave activity. Total lack of access to the outer dock is expected about 6 percent of the time and to the inner dock about 2 percent of the time.

5.7 Dredging Requirements

Sediments dredged from the existing project are almost exclusively of marine origin. They are circulated to the channel through alongshore currents and rip currents along the jetties. Typically, dredging efforts are scheduled for June each year. Effective dredge time on the project has been controlled by wave and weather conditions and is reflected in the extreme unit costs of dredging. For many years, a project-dedicated dredge was kept on the site to minimize mobilization cost and to try to control the almost continuous channel infill. The historical dredging costs and quantities are shown in table 5-3.

TABLE 5-3. — *Historical dredging costs, Nome Harbor*

Year dredged	Dredging cost	Quantity dredged (yd^3)
1919-1920	$20,212	20,625[a]
1923-1933	113,735	65,690
1933-1964	281,897	120,750
1964-1972	490,576	120,240
1973	169,158	14,350
1974	287,304	13,510
1975	513,175	6,000
1976	183,381	17,250
1977	288,290	12,120
1979	351,250	13,000
1980	384,055	17,647
1981	335,405	17,100
1982	315,845	12,337
1983	358,476	14,305
1984	466,400	15,200
1985	247,669	15,200
1986	374,155	7,200
1987	310,671	2,869
1988	205,000	2,200
1989	202,000	0[b]
1990	74,544	0[b]
1991	193,305	0[b]
1992	241,890	7,600[c]
1993	173,548	4,224[c]
1994	116,773	3,545[c]
1995	680,824	14,267[d]
1996	430,973	10,760[d]

[a] New project.

[b] No dredging occurred in these years because of contaminated materials in the turning basin. Incurred cost was due to standby time as per contract specifications when there were holdups in the work.

[c] During these 3 years, dredging occurred in the entrance channel only.

[d] The substantial increase in quantity in these years is mostly due to dredging the upper turning basin that had not been dredged since 1988. Excavation quantities for the hole in the turning basin to bury the contaminated material are also included. Final pay estimate (1995-96, on file in the Alaska District Operations office) has the quantity breakout.

Research of emergency dredging operations for the existing channel found that emergency channel dredging of 60,000 cubic yards of sand was required after the great Bering Sea storm of November 1974. The emergency channel dredging was done between November 1974 and April 1975. At that point in time, the channel had filled in to several hundred feet landward of the channel bend. The infill was due to overwash of the sand spit by waves.

According to Blier *et al.,* the most significant coastal flooding to occur after the 1974 event was on October 5-6, 1992. The waves again overtopped the sand spit into the existing entrance channel. The expectation was that more dredging than average would be required. A review of the dredging quantities shows that this was not the case. According to a Nome resident, sand did wash into the existing channel, but presumably the large amount of Snake River ice scoured the sediment out during breakup.

Sediment transport analyses indicate that about 120,000 yd^3 of material moves along the shoreline from west to east, and about 60,000 yd^3 passes from east to west. The existing channel prior to causeway construction was impacted by this total sediment load, or gross transport. Now the channel sees reduced sediment volumes because of blockage by the causeway. The channel probably receives only the westerly flow of sediment and its backpass to the east, or a total of 120,000 yd^3 per year.

Historical dredging has been unable to maintain project depths during the navigation season, with depths decreasing to as little as –3-ft MLLW. The inability to maintain project depths is understandable given the alongshore sediment transport rates. Because of the almost continuous transport in one direction or another, sediment removal would need to be almost continuous to maintain the authorized depth of –8 ft MLLW.

For sediment management to be effective, efforts must either incorporate equipment that is capable of operating in inclement conditions or isolate the maintenance operation from those adverse sea conditions. Three approaches are available to do this. The first is a sediment bypass system protected by structures. A second approach is to develop long-term storage in deep enough water for an available hopper dredge to transfer sediment on an infrequent basis. A third option is to develop a project dredge that is capable of operating efficiently in these shallow depths and constrained widths under adverse weather conditions. None of these solutions are practical for the existing facility.

An improved project that incorporates a two-breakwater channel protection system to depth of closure can be an initial step in developing a functional maintenance program. An added east breakwater in combination with the causeway allows protected sediment transfer from shoaling areas subject to riverine sedimentation and isolation from marine sedimentation. It is a total solution for inner harbor sediment management. The Snake River and marine sediments expected to need removal annually are estimated at 10,000 yd^3 per year within the protected channel. Annual removal would preserve the12- and 10-foot depths almost 100 percent of the time during the navigation season.

Another 1,000 yd^3 of fine-grained sediments are expected to accumulate in the channel and harbor area each year. These are similar to sediments that have accumulated historically in the harbor and turning basin. Fine sediment removal has been on about a 10-year cycle, and that cycle is expected to continue.

The incorporation of the causeway dock use enhancement into the project requires management of the shoal growth to the west of the causeway. The shoal growth involves about 60,000 yd^3 of material per year. Sediment management can be obtained by development of a sediment trap on the east side of the present causeway breach area. Trapped sediment would be transferred east of the existing breakwaters, where it would nourish the downdrift beach.

The second option for management is afforded by the propensity of the sediment transport system on the west side of the causeway to transfer material to the deep-water shoal off the tip of the causeway. Storage in the tip shoal is probably adequate for a 4- or 5-year period without a bypass system. The shoal can be used as an added storage location with a partially effective bypass system on a 10-year basis. Hopper dredge transfer is, however, less environmentally favorable than the bypass. Sediment return to the downdrift shoreline with a hopper dredge operation would be in deeper water and at a much higher volume than with an annual bypass, and could affect benthic organisms.

6. MODEL STUDIES

6.1 Purpose of 3-D Model Study

A three-dimensional physical model was constructed to analyze the navigation difficulties being described by the project sponsor and to develop and optimize a basis for design. The model reproduced waves, wave-induced current patterns, and sediment transport patterns along several thousand feet of shoreline with and without improvement components. A 1-to-90-scale model was constructed and operated at the Corps' Waterways Experiment Station (WES) at Vicksburg, Mississippi, in 1997, with model runs beginning in January 1998. The model tests were conducted at different still water levels and different wave heights and periods. Specifically, the model was utilized to:

a. Analyze and assess conditions in the existing navigation channel including wave heights, currents, and sedimentation trends.

b. Develop a basis for design to optimize the use of the existing harbor and causeway docks.

c. Analyze the effects of various alternatives on wave-induced current patterns, sediment transport patterns, and wave activity in channels and the harbor area.

d. Optimize lengths and heights of structures needed to control sediments and waves.

6.2 Model Design

The Nome Harbor model was constructed at WES in 1997 to an undistorted linear scale of 1:90 (model to prototype). Scale selection was based principally on the following factors:

- Depth of water required in the model to prevent excessive bottom friction
- Absolute size of model waves
- Available shelter dimensions and area required for model construction
- Efficiency of model operation
- Available wave-generating and wave-measuring equipment
- Model construction costs

A geometrically undistorted model was necessary to ensure accurate reproduction of wave and current patterns. Following selection of the linear scale, the model was designed and operated in accordance with Froude's Model Law (Stevens *et al.* 1942). The scale relations used for design and operation of the model are shown in table 6-1.

TABLE 6-1.--*Relationships of the 3-D model to prototype*

Characteristic	Dimension*	Scale relations
Length	L	$L_r = 1:90$
Area	L^2	$A_r = L_r^2 = 1:8,100$
Volume	L^3	$V_r = L_r^3 = 1:729,000$
Time	T	$T_r = L_r^{1/2} = 1:9.49$
Velocity	L/T	$V_r = L_r^{1/2} = 1:9.49$
Discharge	L^3/T	$Q_r = L_r^{5/2} = 1:76,818$

* Dimensions are in terms of length (L) and time (T).

The causeway and seawall adjacent to the existing entrance channel are rubble-mound structures. Experience and experimental research have shown that considerable wave energy passes through the interstices of this type of structure; thus, the transmission and absorption of wave energy became a matter of concern in the design of the 1:90-scale model. In small-scale hydraulic models, rubblemound structures reflect relatively more and absorb or dissipate relatively less wave energy than geometrically similar prototype structures (LeMehaute 1965). Also, the transmission of wave energy through a rubblemound structure is relatively less for the small-scale model than for the protoytpe.

Consequently, some adjustment in small-scale model rubblemound structures is needed to ensure satisfactory reproduction of wave-reflection and wave-transmission characteristics. In past investigations (Dai and Jackson 1966, Brasfield and Ball 1967) at WES, this adjustment was made by determining wave-energy transmission characteristics of the proposed structure in a two-dimensional model using a scale large enough to ensure negligible scale effects. A cross section then was developed for the small-scale, three-dimensional model that would provide essentially the same relative transmission and reflection of wave energy. Therefore, from previous findings for structures and wave conditions similar to those at Nome, it was determined that a close approximation of the correct wave-energy transmission and reflection characteristics could be obtained by increasing the size of the rock used in the 1:90-scale model to approximately two times that required for geometric similarity. Accordingly, in constructing the rubblemound structures in the Nome model, rock sizes were computed linearly by scale, then multiplied by 2 to determine the actual sizes to be used in the model.

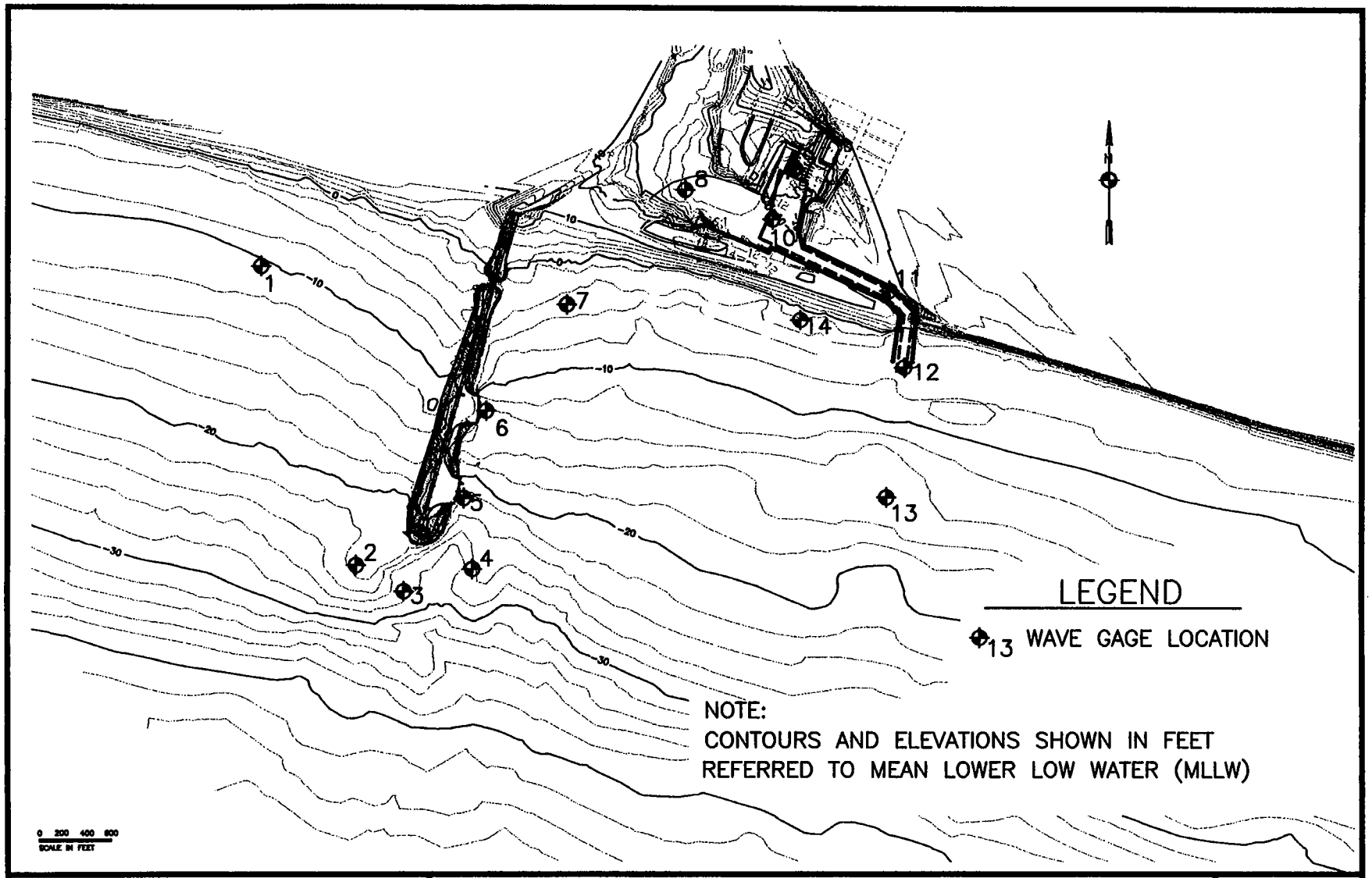
The model was constructed in cement mortar (fixed-bed), and a coal tracer material was used to qualitatively determine sediment transport patterns. The fixed-bed model reproduced approximately 11,000 feet of the shoreline, the existing harbor and lower reaches of the Snake River, and bathymetry in Norton Sound to an offshore depth of -40 ft MLLW, with a sloping transition to the wave generation pit elevation of -90 feet. The total area reproduced in the model was approximately 13,200 square feet, representing about 3.8 square miles in the prototype. Vertical control for model construction was based on mean lower low water (MLLW). Horizontal control was referenced to the Alaska State Plane grid system.

An 80-foot-long, electrohydraulic, unidirectional spectral wave generator reproduced model waves with a trapezoidal-shaped, vertical motion plunger with the vertical motion of the plunger controlled by a computer-generated command signal. For the selected waves used in the model, unidirectional wave spectra were generated based on Joint North Sea Wave Project (JONSWAP) parameters for the selected waves and used throughout the model investigation.

6.3 Model Test Procedure

Model testing was conducted in a systematic manner beginning with existing conditions in place, as is shown in figure 6-1, and confirmation of described problems. A no-action base condition was tested so the impacts of alternative plans could be measured against existing conditions found. A second series of tests was run without channel modifications to assess the relative importance of an added east side breakwater. These tests were limited in scope, with concrete blocks used as breakwaters. The third series of tests was conducted with the interior and causeway channels in place, the east breakwater positioned at various depths and lengths, and the causeway at various lengths. Next, a sediment trap with an expanded causeway breach was tested. The final series of tests was conducted as a cross-check of the hypotheses developed during the other tests.

Waves were applied, and currents and their impact on sedimentation were analyzed. Sediment modeling was accomplished with waves that exceed normal values to obtain similitude with the coal tracer sediments used in the model. The increase in wave height to obtain movement is normal in a model of this scale. Actual sediment deposition zones may be somewhat under- or overstated in the model because of the distortion. Waves from three directions were applied to each modeling operation. Wave periods used were 9 and 12 seconds for general testing and outer boundary values of 25 seconds for survivability tests. Wave heights for general testing were limited to 1 and 2 meters. Water depths were generally at MHHW, except that the design storm was tested at the highest estimated surge, +13 ft MLLW. A design wave height of 5.8 meters, or the 50-year event, was used.



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WAVE GAUGE INITIAL LOCATIONS

NAVIGATION IMPROVEMENTS, NOME, ALASKA

6—1

6.4 Model Results

6.4.1 Base Condition Currents and Sedimentation.

Current measurements indicate that alongshore currents develop in both directions based on incident wave direction. The alongshore currents are redirected seaward at the causeway, with the most severe rip currents developing along the west side of the causeway. The prototype hydrographic survey is ground truth of this severe rip current condition, as sediments have built up to the west of the causeway to at least the 30-foot depth contour. The base test condition also indicates that the present navigation channel receives sediment under practically all wave conditions. Current patterns and sediment movement demonstrated in the model indicate that any channel constructed in the active sediment transport zone (shallower than the depth of closure, which is -22 ft MLLW) would be filled in rapidly and have the same maintenance and delay problems as the present channel. The results of this testing allowed the design team to conclude that any viable alternative needs to include sediment management for both transport directions.

6.4.2 Base Condition Waves.

Waves for the base condition were applied from locations beginning with 15 degrees west of the causeway to 60 degrees east of the causeway. Wave gauges were placed at various locations to obtain ground truth and verification of conditions reported by local residents. The 15-degree west direction was shifted to 30 degrees west during this exercise to get the appropriate approach angles at the causeway. Wave gauge locations for this initial base condition are shown in figure 6-1.

In the third phase of testing, a number of wave gauges were shifted to the causeway approach channel area so the testing could focus on reaching preferred criteria for landing vessels at the docks.

6.4.3 Main Breakwater.

In the second series of tests, the waves and wave-induced currents seemed to be influenced to the maximum beneficial effect with the proposed breakwater extended to the 22-foot depth and the causeway extended by 325 feet.

During the third series of tests, these features remained constant: the proposed breakwater extended to the –22-ft depth contour, the entrance channel at –22 ft MLLW, and the interior channel at –12 ft to –10 ft MLLW. This configuration was then tested with and without the spur breakwater added to the causeway head. Breakwater and causeway extensions were scaled to proper permeability and reflectivity so false reflections could be eliminated. The breakwater top elevation in this series of tests was initially set at + 17 ft MLLW. The breakwater length was somewhat indeterminate by model study and was resolved by reviewing depth-of-closure information that could be obtained from cross sections and through a literature search on depth of closure on other coastlines (Larson and Kraus 1993). The breakwater was extended to the 22-foot depth contour for all tests used in the

comparisons. Later refinements of breakwater height indicated that the east breakwater crest elevation could be lowered to +14 ft MLLW without adversely impacting navigation or sedimentation. Lower elevations were not tested because dropping the core below 0 ft MLLW would have adversely affected wave transmission.

6.4.4 Causeway Extension.

Two lengths of causeway extension were examined: a 185-foot length and a 235-foot length. Both would intersect the causeway at the +14-ft contour elevation. The 185-foot spur breakwater had little impact on waves in dock approaches. The 235-foot spur put the wave activity in this region within desired design conditions.

6.4.5 Sediment Trap.

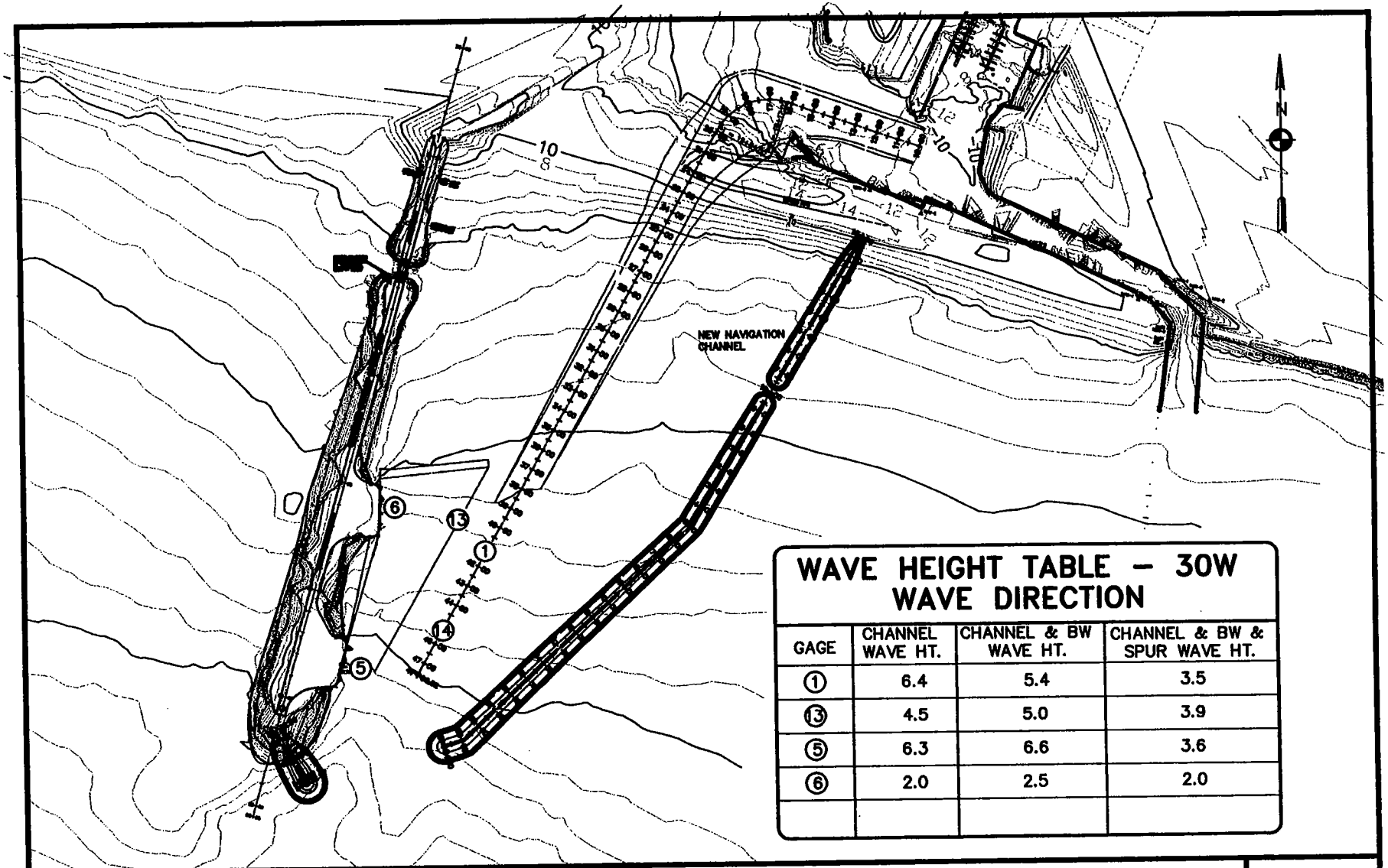
It was determined from the model that the sediment trap should collect up to 60,000 yd^3 per year. The success of the sediment trap relies heavily on bifurcating the rip current stream at the causeway breach and diverting the more heavily sediment-laden bottom water into the trap on the east side of the causeway. Study of the model bottom currents indicates that this does occur and an effective trap can be developed. The east breakwater, improved channel depths, and causeway extension were being modeled throughout the modeling of the sediment trap system.

6.4.6 Final Test Series.

The final series of tests were conducted with the main breakwater and causeway extension removed and only the channels in place. This series of tests duplicated the earlier base condition testing, with the differing placement of wave gauge locations mentioned earlier. The testing results are displayed in figure 6-2 as the without-project condition when comparing the system's reaction to waves from 30 degrees west (1) with the east breakwater in place and (2) with both the east breakwater and causeway extension in place. The new interior harbor approach channel and causeway channel were developed to full dimensions and the shoaling and wave activity measured.

Waves at dockside were slightly decreased over base test conditions because the increased depth allowed some lateral transfer of energy. This series of tests was used as the base condition for measuring impacts of the east breakwater and the causeway extension on dock use. A wave height table for the 30 degrees west, 15 degrees east, and 60 degrees east directions is displayed for the causeway dock and channel area of concern on figure 6-3.

The wave heights displayed are the average conditions expected and are the results of averaging the impacts of a 1-meter and a 2-meter applied wave. In all cases, there is a dramatic decrease at gauges 1 and 13, where tows would uncouple and enter a dock approach configuration. Also, dockside wave activity is greatly decreased except during 60-degree-east activity, which occurs less than 4 percent of the time.



WAVE HEIGHT TABLE – 30W WAVE DIRECTION

GAGE	CHANNEL WAVE HT.	CHANNEL & BW WAVE HT.	CHANNEL & BW & SPUR WAVE HT.
1	6.4	5.4	3.5
13	4.5	5.0	3.9
5	6.3	6.6	3.6
6	2.0	2.5	2.0

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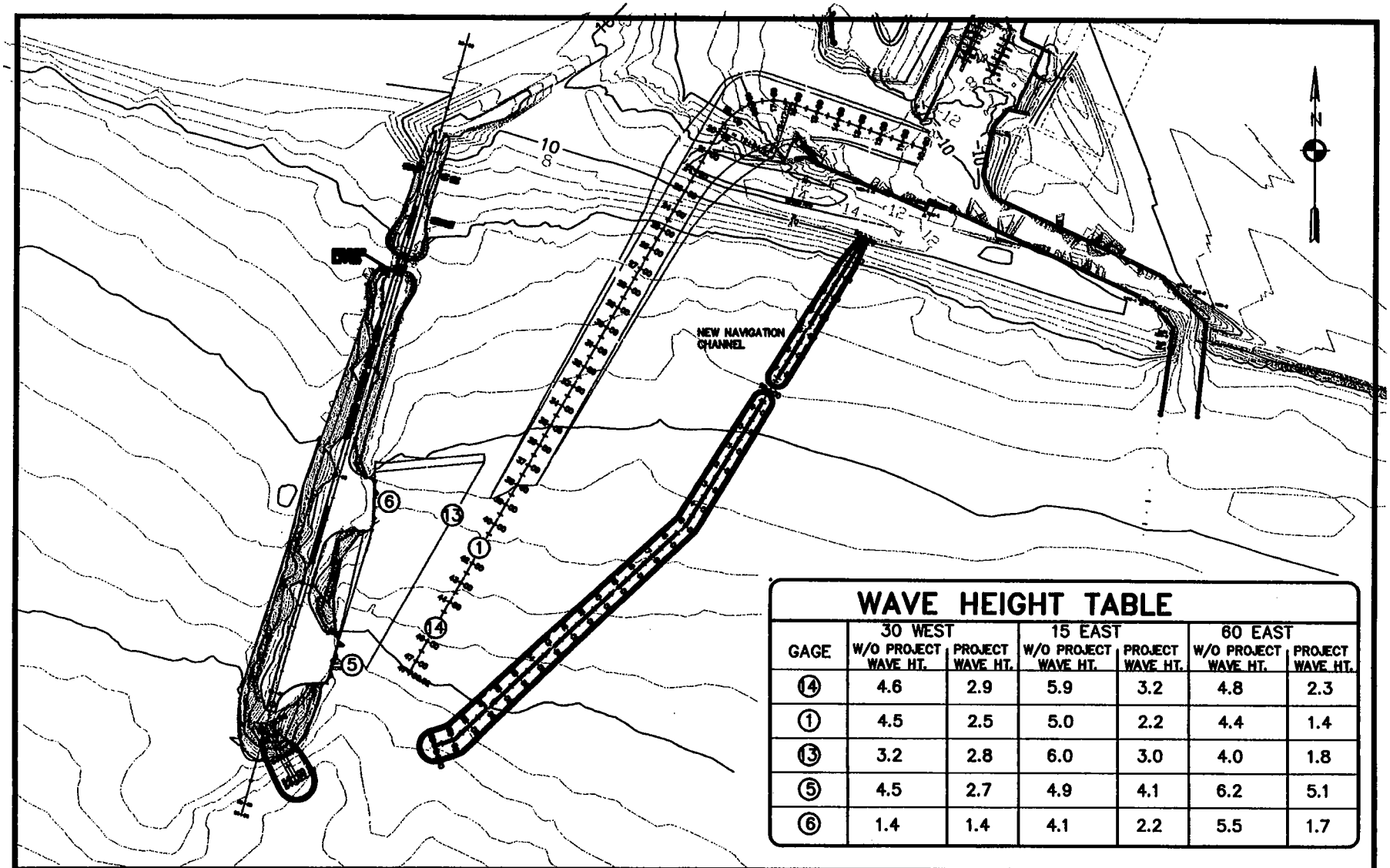
MODEL STUDY RESULTS (1)
NAVIGATION IMPROVEMENTS, NOME, ALASKA

6–2



WAVE HEIGHT TABLE

GAGE	30 WEST W/O PROJECT WAVE HT.	30 WEST PROJECT WAVE HT.	15 EAST W/O PROJECT WAVE HT.	15 EAST PROJECT WAVE HT.	60 EAST W/O PROJECT WAVE HT.	60 EAST PROJECT WAVE HT.
14	4.6	2.9	5.9	3.2	4.8	2.3
1	4.5	2.5	5.0	2.2	4.4	1.4
13	3.2	2.8	6.0	3.0	4.0	1.8
5	4.5	2.7	4.9	4.1	6.2	5.1
6	1.4	1.4	4.1	2.2	5.5	1.7

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MODEL STUDY RESULTS (2)
NAVIGATION IMPROVEMENTS, NOME, ALASKA

6-3

6.4.7 Model Conclusions.

Modeling and associated analysis show that a major decrease in wave activity can be realized in the dock approach channel and at dockside by extending the causeway. Desired threshold values for waves approaching from 30 degrees west of the causeway and 15 degrees east of the causeway could be obtained with the 235-foot extension. The adverse shoaling that was indicated at all locations occurred in the channel system when the east side breakwater was not in place. Both the east side breakwater and the causeway extension are required to reduce waves and currents to desirable levels in the causeway dock approaches and control sedimentation within the channels.

7. DEVELOPMENT OF RECOMMENDED PLAN

7.1 Project Objectives

Study objectives, identified at the beginning of the feasibility study, are presented in section 1.2 of this appendix.

7.2 Comparison of Alternative Plans

With the list of objectives as an indication of needs, a group judgment process that screened out alternatives clearly not applicable to the site was used for initial filtering. Fundamental coastal engineering concepts were used in combination with site conditions and local needs to eliminate numerous types of alternatives. With the general magnitude of sediment transport known, all structures that would exacerbate the already difficult maintenance potential were eliminated. Knowledge of wave periods required that other alternatives be removed from consideration. Ice forces put demands on other solutions, and these were also eliminated from further study. This is a partial listing of options eliminated:

- Detached breakwater structures
- Articulated mat
- Floating breakwaters
- Submerged groins
- An array of wave power generators
- Low-mass or thin-walled structures
- Development of unique dredging plant
- Shifting or relocation of dredged material disposal areas

Following the elimination of those alternatives clearly having little to no application at the project site, an array of more likely alternatives was left. A matrix showing improvements versus their impacts was developed for these alternatives. This matrix is shown in table 3 in the main report. (The same table appears in appendix B, in this volume, as table B-21.) The alternative plans are shown in figures 7-1 through 7-12. Initially, only alternatives A through J and N were rated. Alternatives K, L and M are extended developments of J and are products of physical model refinements. The top row of table 3 designates the improvement alternative. The alternatives are evaluated relative to alternative D, the major rehabilitation option. Alternative D was used as the base for engineering rating in lieu of N, the no-action option, as it was evident that allowing the project to continue to deteriorate would have astronomical impacts on Nome and its service area. Ratings are based on 1 being the best possible impact and 10 being the worst impact. Navigation use under the no-action alternative would deteriorate beyond present conditions. Present conditions could be maintained with a rehabilitated project. Because of the expected continued deterioration, the no-action alternative is rated a 10+ for navigation use.

The major rehabilitation option D is also given poor rankings across the board, as it is the present project condition. The present project has a history of poor performance with the current inner harbor fleet. In addition, rehabilitation does not benefit the causeway dock portion of the fleet. Inner harbor use is plagued with many problems. One of the more serious is the lack of reliable navigation depths. The analysis of alongshore transport makes it abundantly evident that reliable depth improvements cannot be obtained without either an astronomical increase in maintenance dredging effort or protection of the access channel to the depth where alongshore transport is not a critical element.

The massive increase in dredging effort would be required for all options that do not protect the inner harbor access channel to at least the depth of closure. The combination of shallow depths, intense littoral transport, and chronic wave activity has historically been too much for the maintenance plant and equipment to overcome on the present project, which has an open environment similar to plans A through F. Alternatives A through F can be eliminated on the basis that an effective plan for maintaining project depths cannot be developed. Harbor use can be increased only as much as alignment and width adjustment allow.

Plan G, the addition of another causeway cell landward of the present cells, can also be eliminated, as it adds nothing to the interior harbor and little to the causeway dock system. The causeway, with its open exposure and shallow depths, does not see much improvement until it receives wave protection.

Alternative H has many of the positive aspects of the preferred plan. By placing the breakwaters out past the depth of closure, the navigation channel can be retained in an open condition, with only the Snake River and minor amounts of marine sediments to manage. The plan does not, however, benefit the causeway docks, and there is obviously a less expensive method of obtaining a two-breakwater system. The use of the causeway as a second breakwater appears to be the best method of obtaining increased navigation use and developing a maintainable channel.

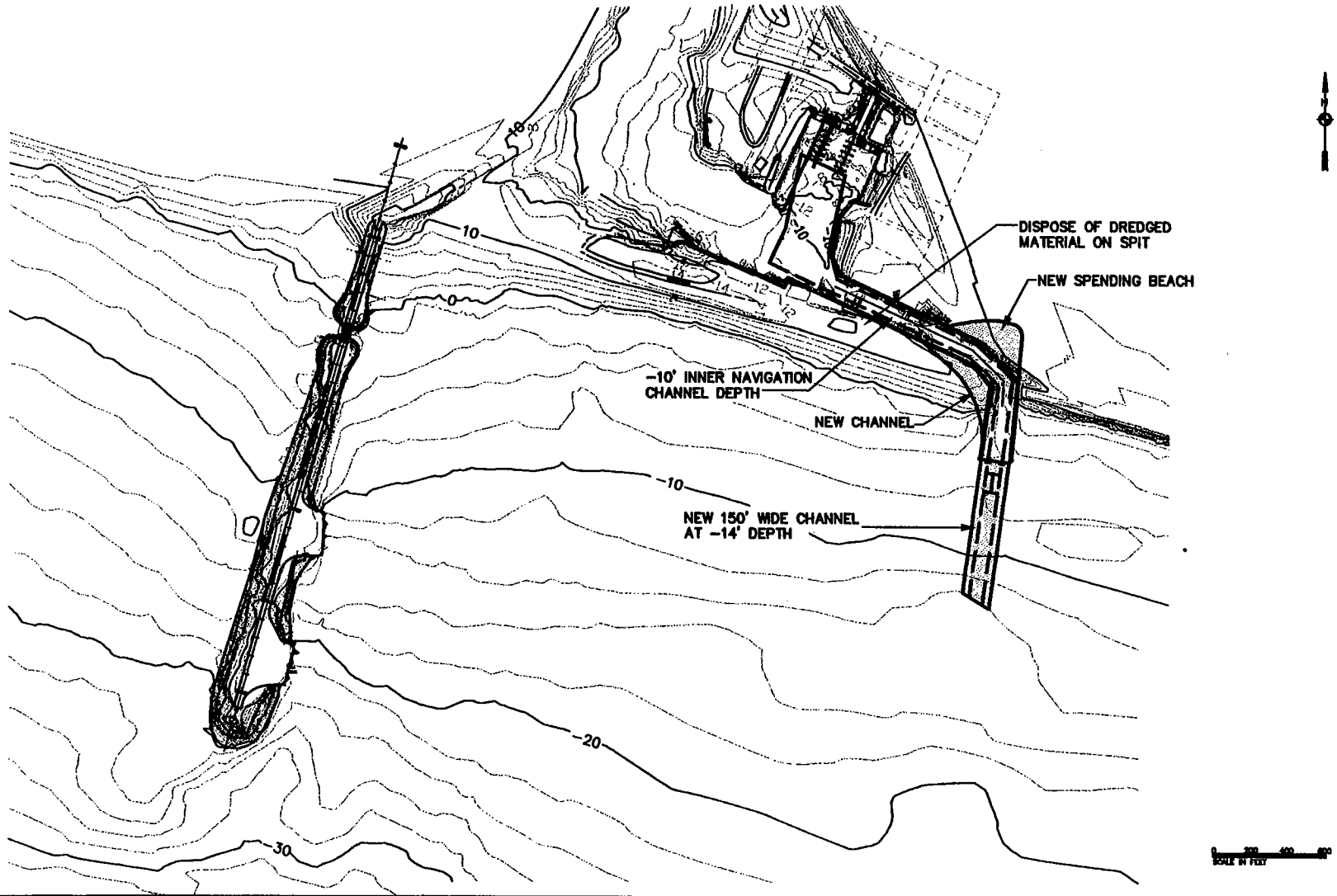
Alternative I extends the breakwaters beyond the depth of closure, which in turn offers a manageable maintenance program. The breakwater can be sited so causeway access is not limited and ship debris can be avoided. The breakwater root would be far enough east so as not to preclude future harbor use and would allow for the development of a sediment bypass system when that is needed for causeway dock use. The inner harbor navigation channel was situated so as to miss known petroleum, oil, and lubricant hazard areas, although some minor contact is still expected. The system still has the problem of encountering arsenic, but all of the alternatives have this problem to some degree. The arsenic rating for I and all other options that anticipate filling the revetted portion of the existing channel is 4, as the filling allows a locally acceptable disposal in lieu of off-site disposal.

Alternatives J through M are variations of alternative I. They optimize alternative I to maximize the benefits for both the interior harbor and the causeway docks. Several elements were analyzed when going from I through M. Project depth requirements for the user fleet were adjusted. The causeway was extended to the southeast to obtain

wave protection and sediment management, which prevents added wave focusing and loss of dock use in the future. The elevation of the new east breakwater is also adjusted to its minimum useful level.

7.3 Selection of Recommended Plan

Of the alternatives analyzed, plan L best satisfies the design criteria and optimizes the economic benefits. This plan is discussed in the next section and is referred to as the Recommended Plan in the main report.



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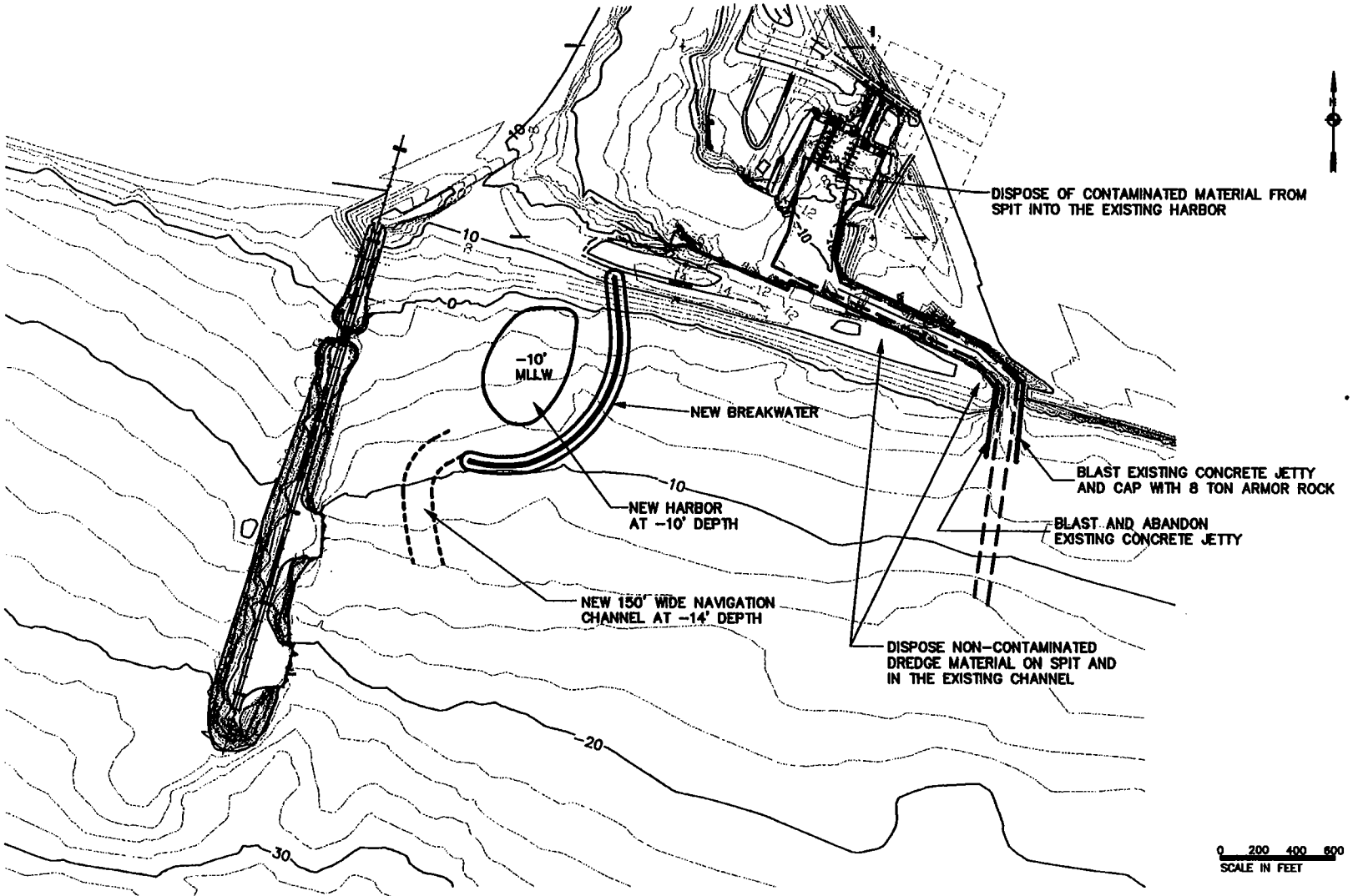
ALTERNATIVE A
NEW CHANNEL NEXT TO EXISTING W/SPENDING BEACH
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—1



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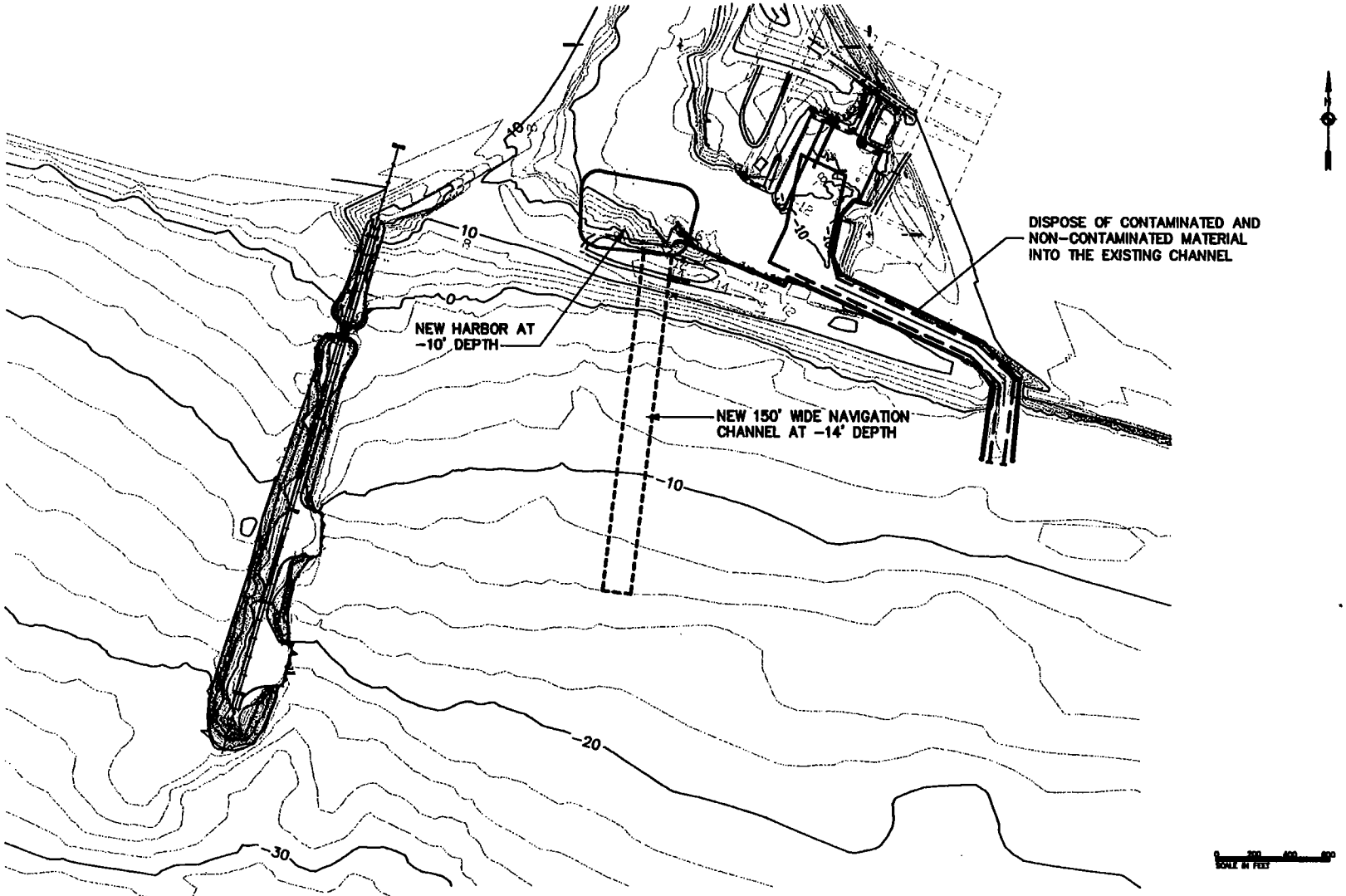
ALTERNATIVE B
NEW CHANNEL OFF CAUSEWAY W/BREAKWATER
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-2



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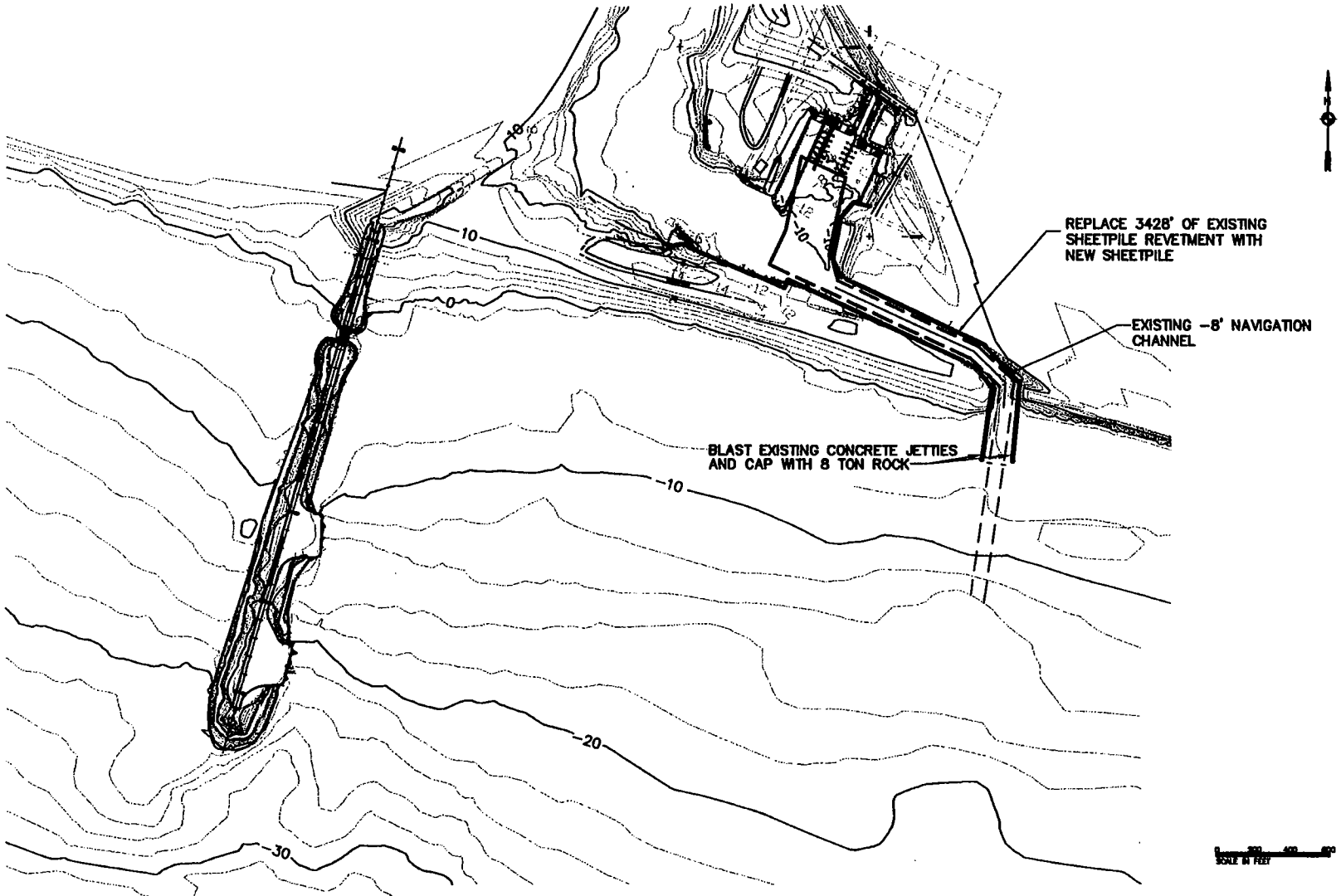
ALTERNATIVE C
HARBOR OUTSIDE RIVER BED IN SPIT
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-3



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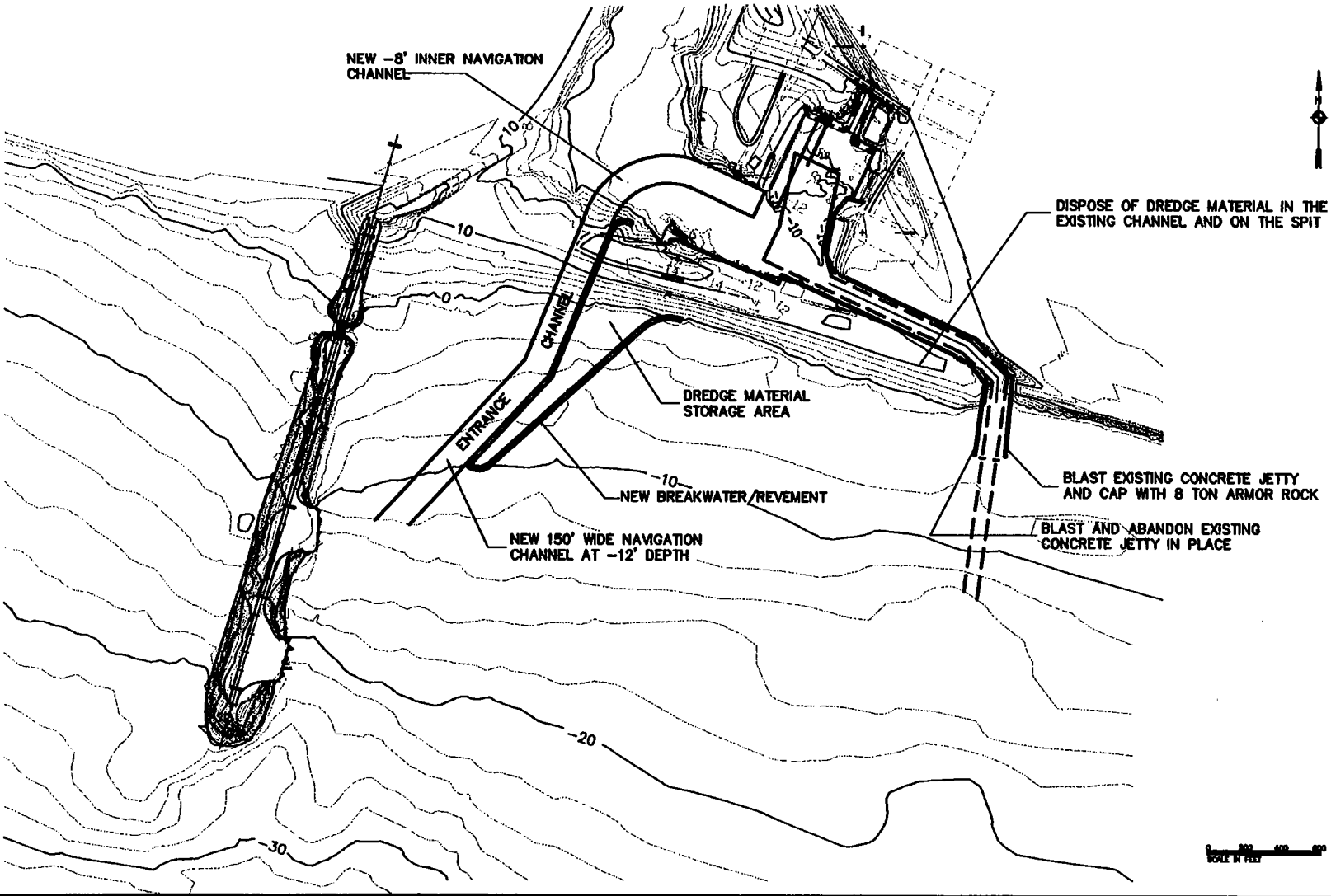
ALTERNATIVE D
MAJOR REHABILITATION
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—4



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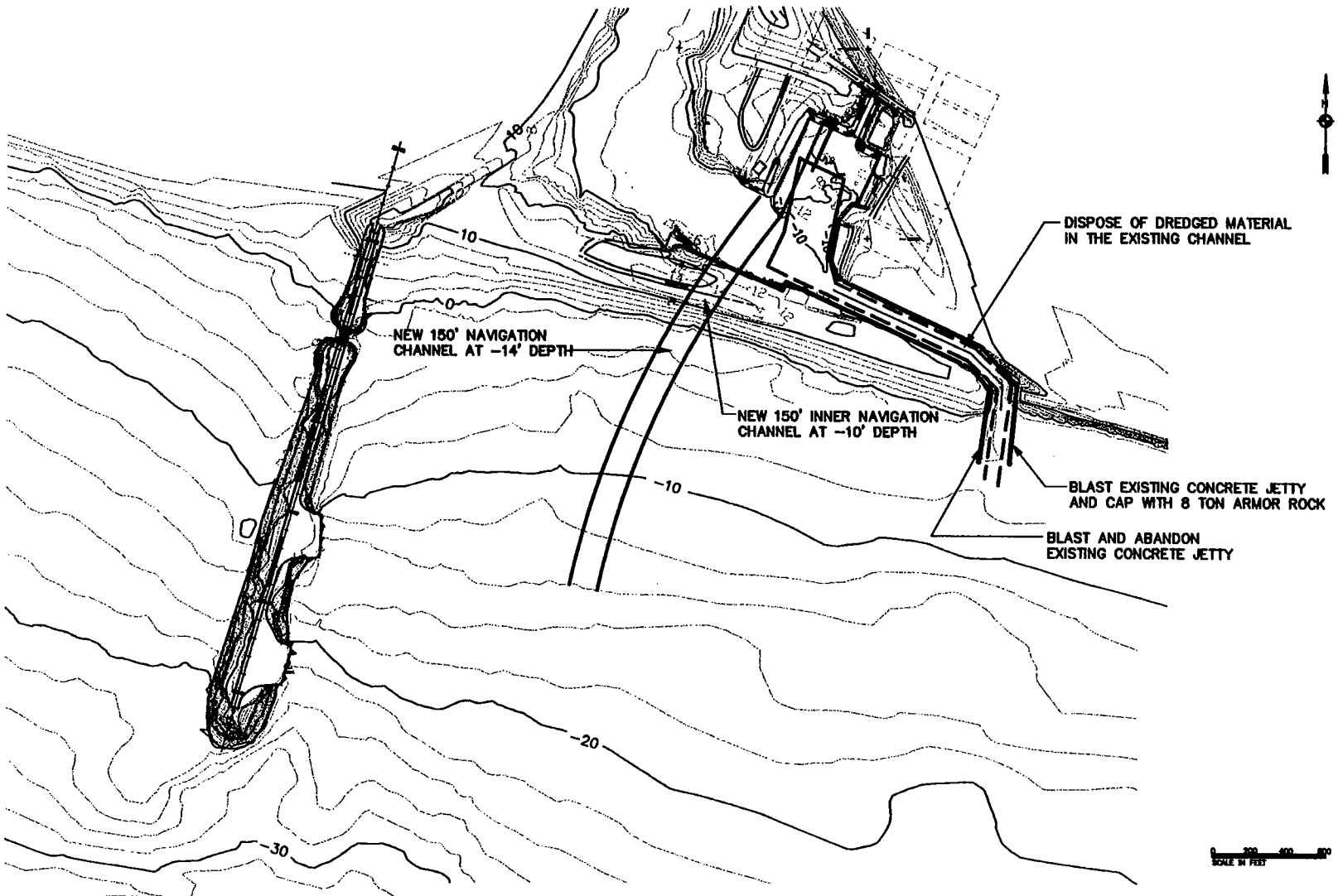
ALTERNATIVE E
CHANNEL THROUGH SPIT WITH BREAKWATER/REVETMENT
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-5



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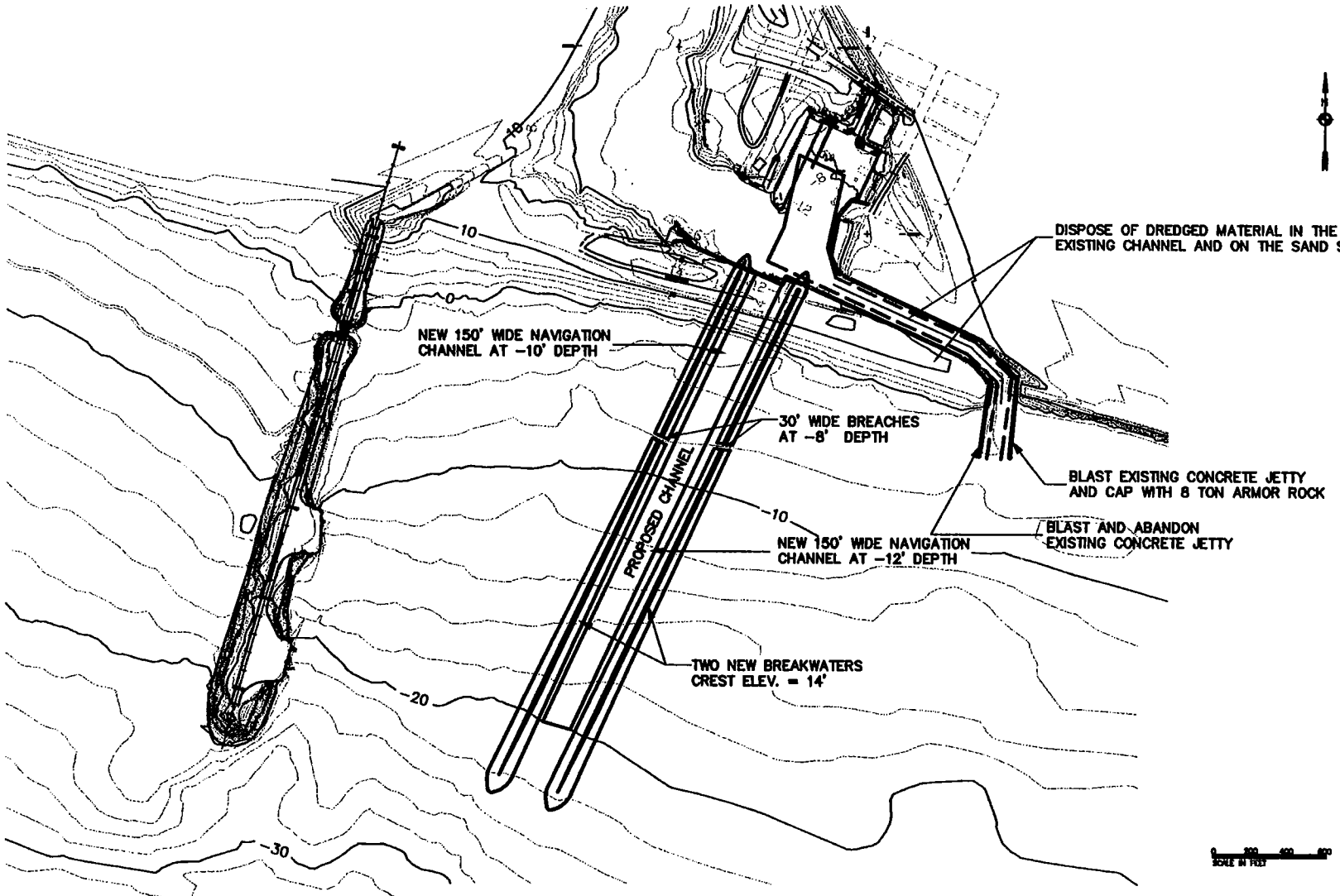
ALTERNATIVE F
CHANNEL THROUGH SPIT
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-6



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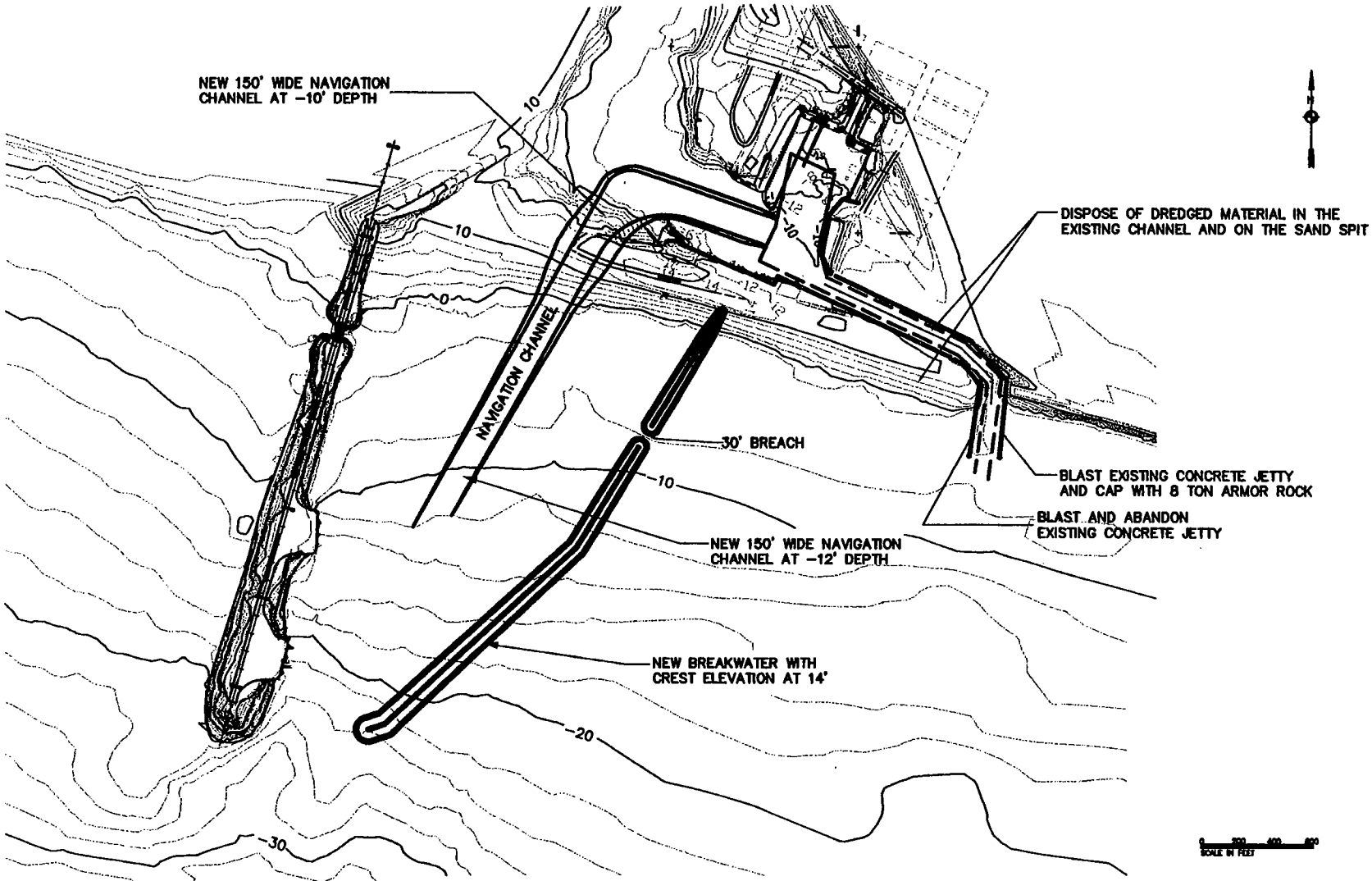
ALTERNATIVE H
CHANNEL THROUGH SPIT WITH BREAKWATERS EXTENDING PAST DEPTH OF CLOSURE
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-7



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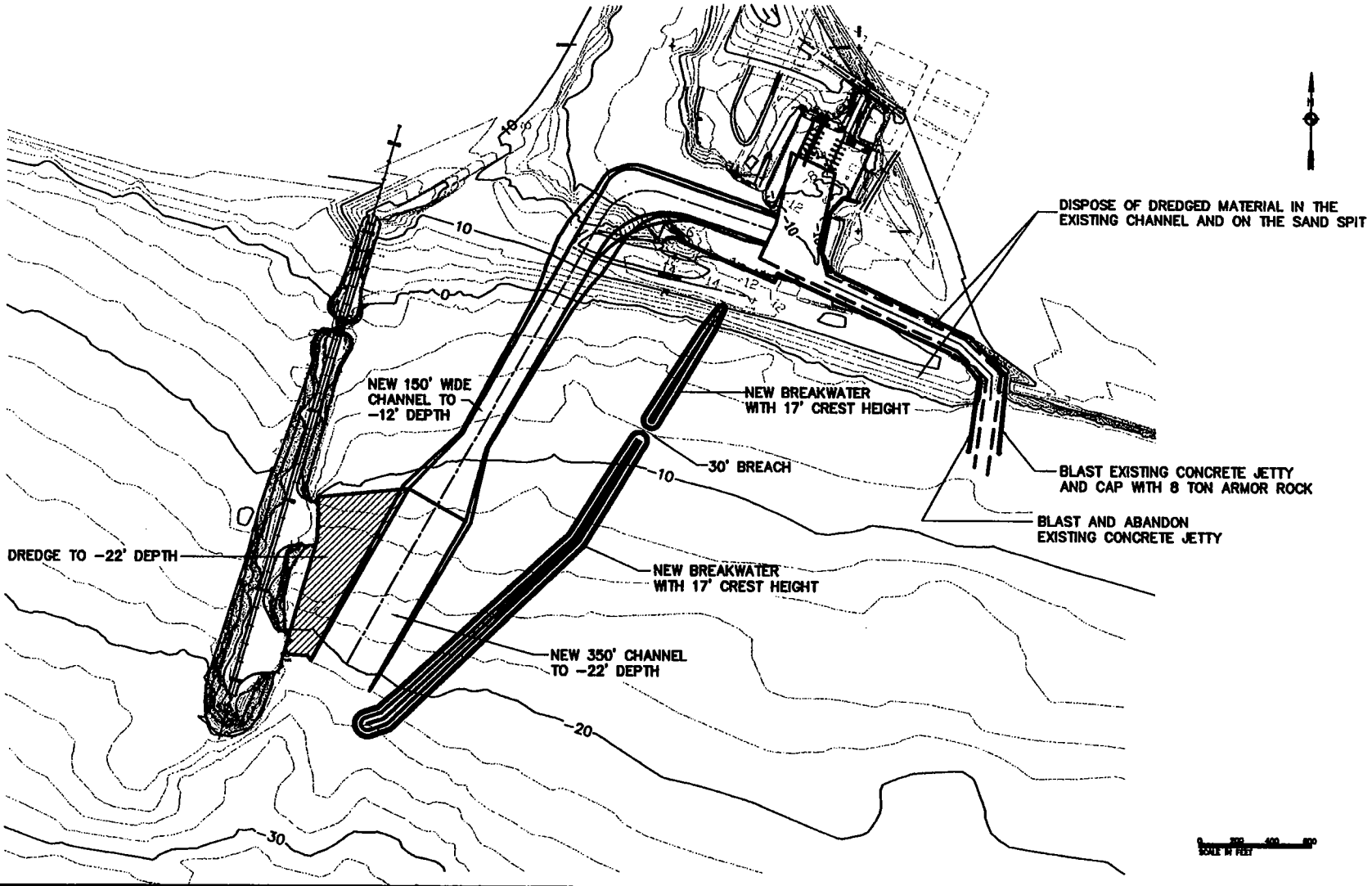
ALTERNATIVE I
CHANNEL THROUGH SPIT WITH BREAKWATER EXTENDING PAST DEPTH OF CLOSURE
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7-8



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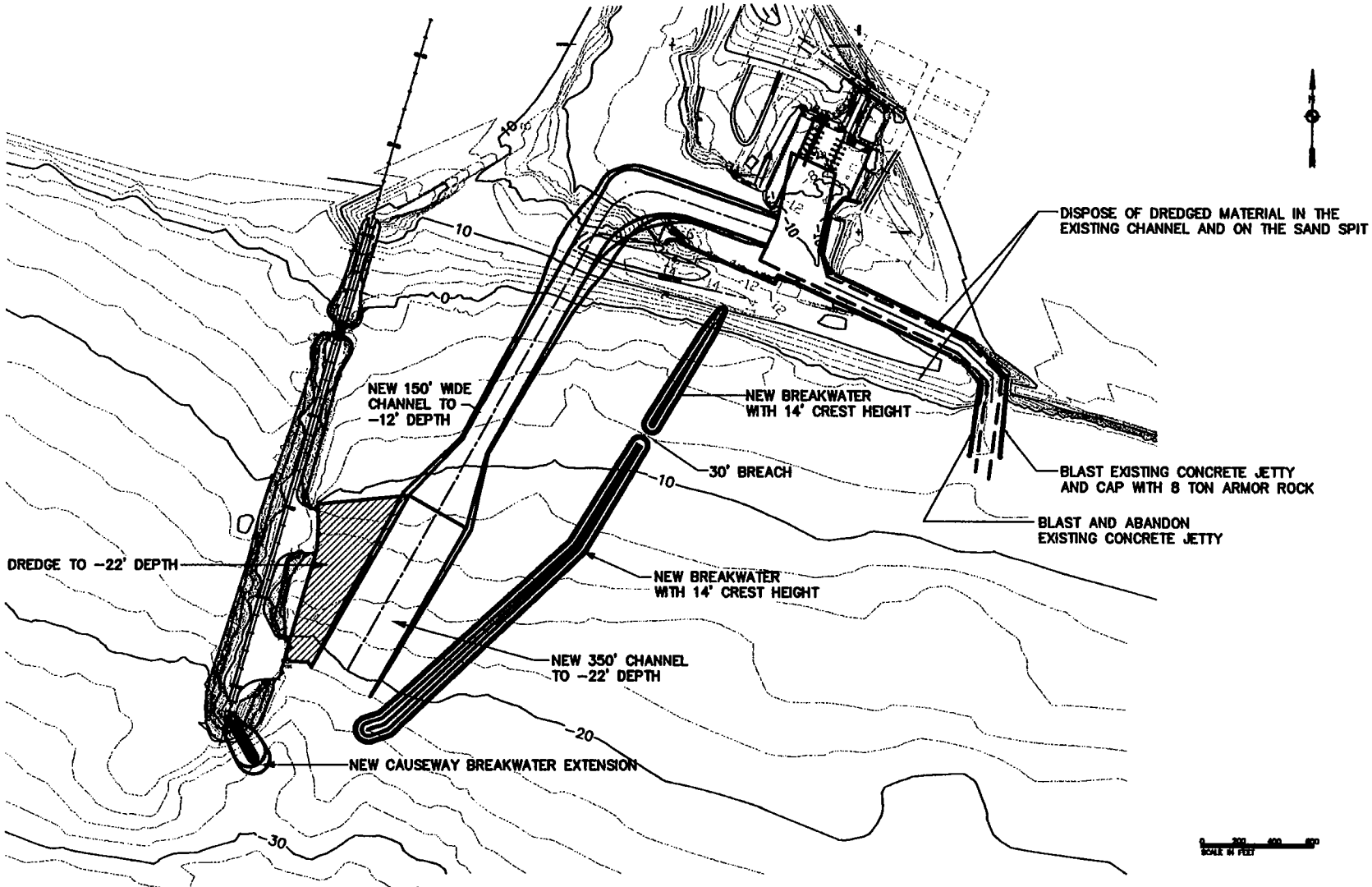
ALTERNATIVE J
PLAN I BUT WITH -22' DEPTH AT CAUSEWAY
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—9



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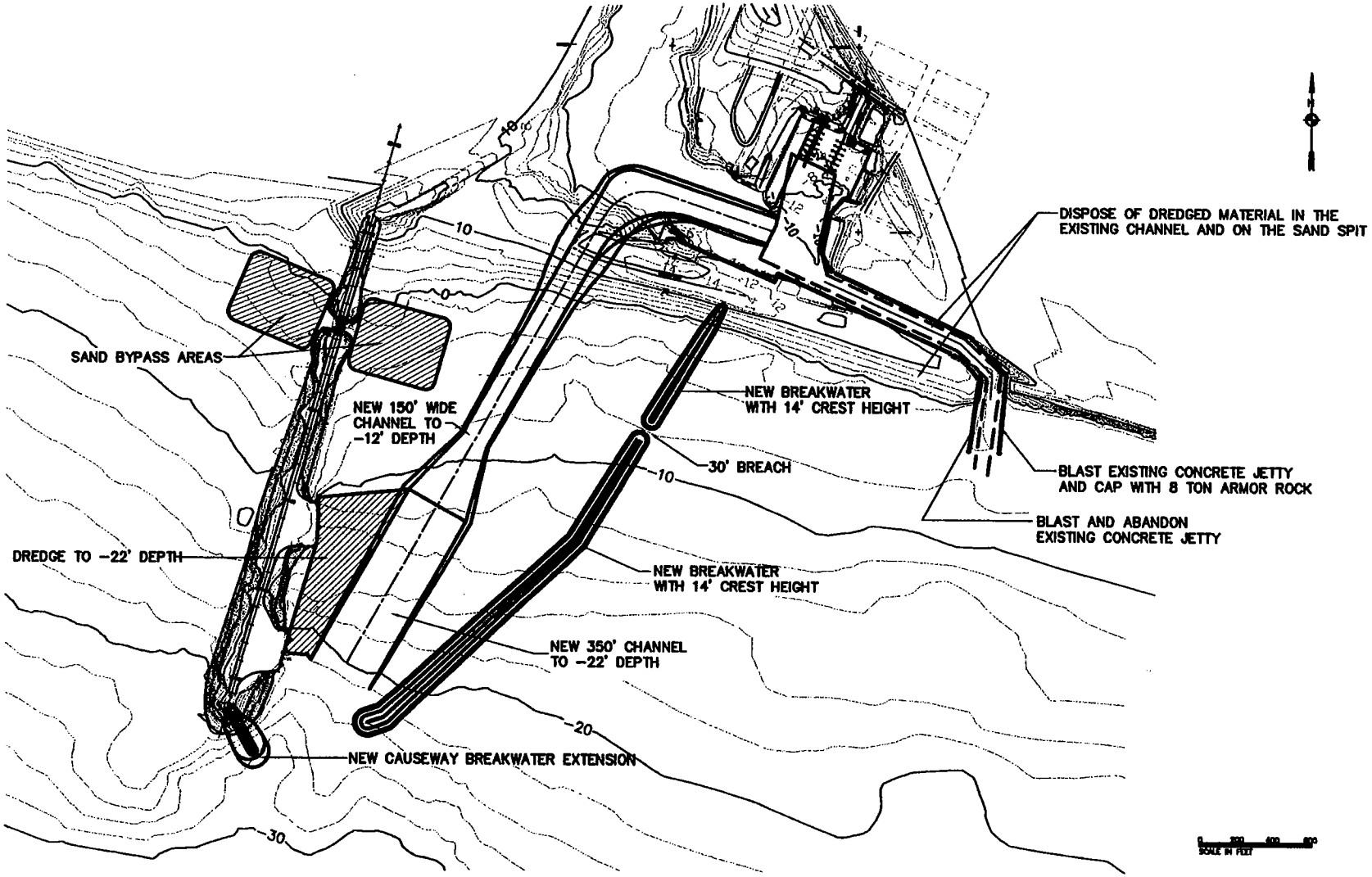
ALTERNATIVE K
PLAN J BUT WITH CAUSEWAY EXTENSION
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—10



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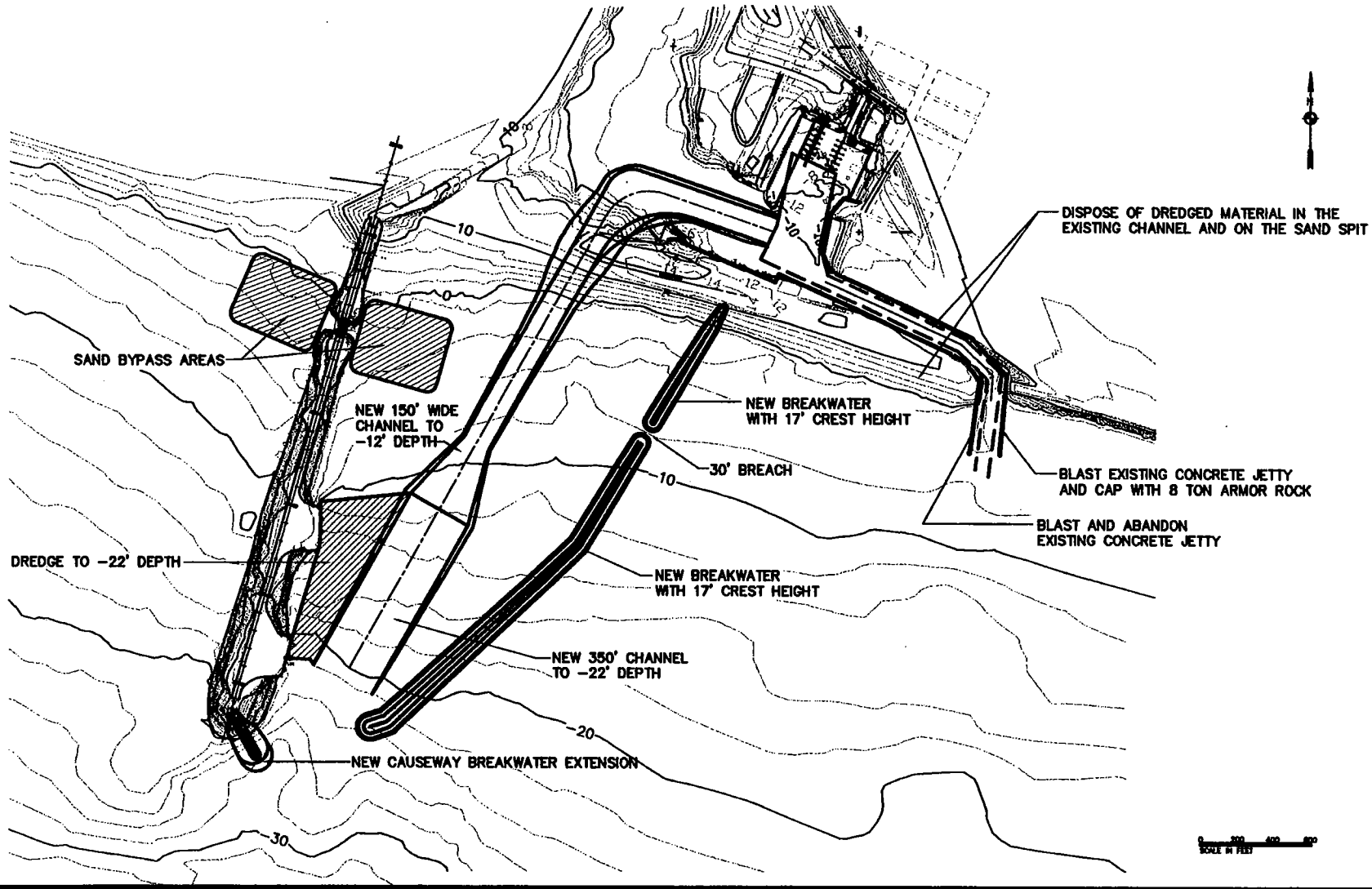
ALTERNATIVE L
PLAN K BUT WITH A SAND BYPASS ADDED
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—11



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ALTERNATIVE M
PLAN L BUT WITH 17' BREAKWATER CREST HEIGHT
NAVIGATION IMPROVEMENTS, NOME, ALASKA

7—12

8. THE RECOMMENDED PLAN

8.1 General Description

The recommended plan, alternative L, consists of four major features, as shown in figure 8-1. The first feature is a relocated, deeper, wider, extended access channel to the inner harbor. The channel would be protected from sediment infill by the second major feature, a new east breakwater 2,985 feet long. The existing causeway would serve as a west breakwater.

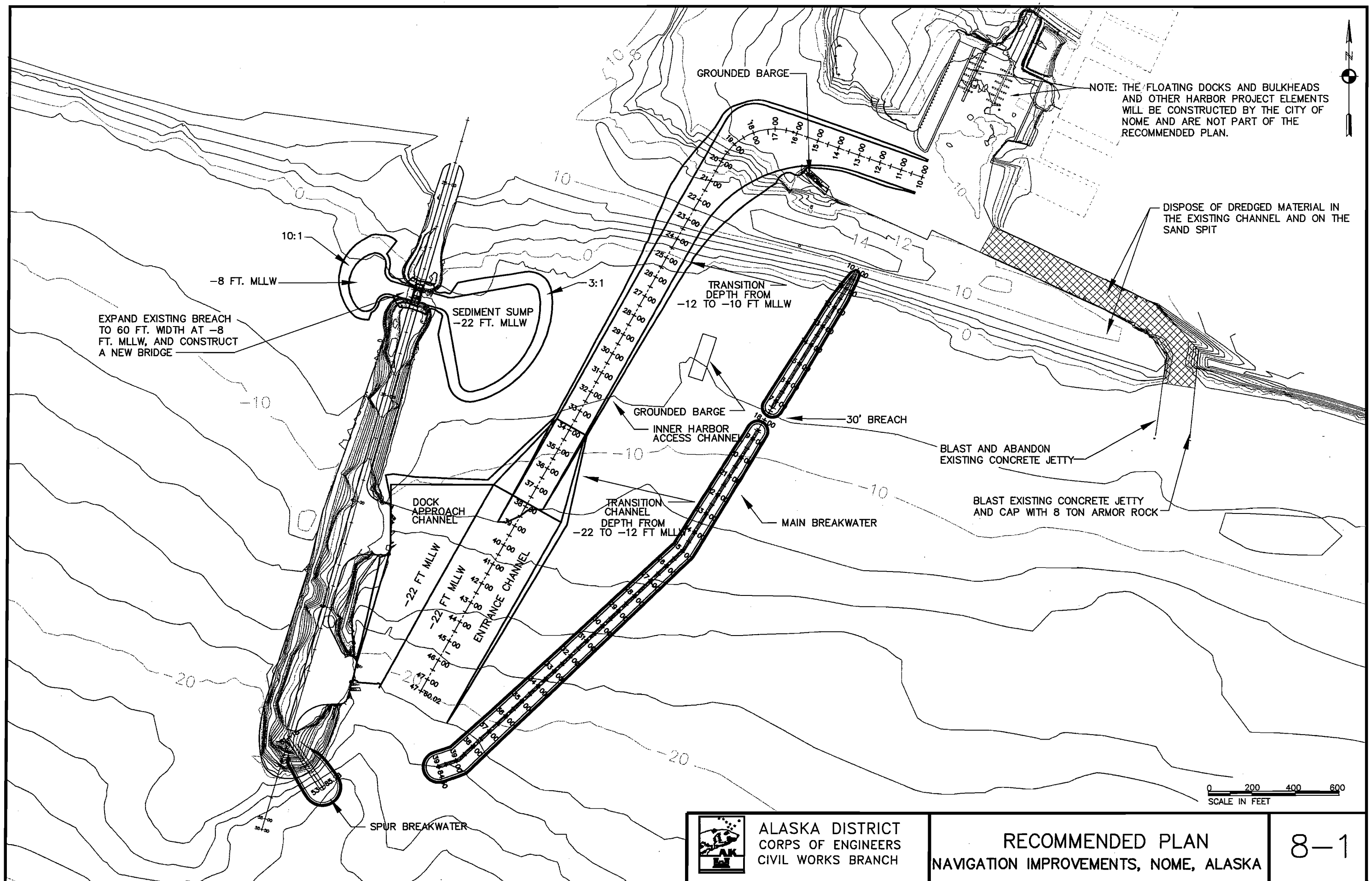
The third feature is a 235-foot spur breakwater added to the head of the causeway. This would provide added wave protection for the causeway dock facilities and deeper access channels leading to them. The improved dock access and protection consist of a 350-foot-wide channel to the inner dock and an approach channel to both the inner and outer docks.

This fourth major feature is management of about 60,000 yd^3 per year of sediments to prevent wave focusing at the causeway head and increased wave activity in the channel and at dockside. Management consists of expanding the breach in the causeway to 60 feet in width at an –8-ft-MLLW elevation, excavating a seaside approach to the breach at an –8-ft-MLLW elevation, and constructing a 450-foot-radius sediment trap for collection to the east of the causeway. Annual removal and transfer of 60,000 yd^3 per year of sediments to the eastern beach line would occur. Sediment not collected in the trap would accumulate on the shoal west of the causeway, primarily in water depths greater than 22 feet. Sediments stored on the shoal can be removed by hopper dredge at about 10-year or greater intervals without significantly degrading causeway dock use.

8.2 Channels

8.2.1 General.

Natural bottom elevations offshore from the end of the proposed entrance channel are -28 ft MLLW. The proposed entrance channel would be dredged to -22 ft MLLW at a width of 350 feet for a distance of approximately 1,050 feet shoreward from the -22-ft-MLLW contour. From this point, the dredging depth would linearly transition a distance of 400 feet to the design depth of –12 ft MLLW and to a channel width of 150 feet. The channel then would continue to route shoreward for a distance of approximately 900 feet to the existing 0-ft-MLLW elevation at a dredged depth of -12 ft MLLW and at the 150-ft width. The rest of the channel would be dredged to the design depth of –10 feet MLLW for approximately 1,460 feet. The width would vary through the turn, becoming 150 feet wide in the straight portion after the turn, with dredging ending at the existing harbor.



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RECOMMENDED PLAN
NAVIGATION IMPROVEMENTS, NOME, ALASKA

8-1

8.2.2 Entrance Channel.

The channel's width of 350 feet and depth of –22 ft MLLW were determined by criteria described in the Design Criteria section of this report (section 5). The side slopes of the channel are 1 vertical to 3 horizontal (1V:3H). Cross sections of the proposed channel and the other channels of the project are shown in figure 8-2. The approximately 1,050-foot-long entrance channel provides necessary access to the dock approach channel and the inner harbor access channel.

8.2.3 Dock Approach Channel.

The design depth in the dock approach channel is –22 feet MLLW, the same as the entrance channel, using the same criteria for this portion of the channel. The 1,200-foot channel would allow vessels to maneuver to the City and West Gold Docks from the entrance channel.

8.2.4 Inner Harbor Access Channel.

The approximately 725-foot inner harbor access channel is connected to the entrance channel by a transition area over a length of 400 feet, where the bottom elevation transitions from the –22 ft MLLW of the entrance channel to –12 ft MLLW. The channel width correspondingly decreases from 350 feet to 150 feet. The 150-foot-wide inner harbor access channel transitions from a 12-foot depth to a 10-foot depth at the seaside 0-ft-MLLW contour due to a decrease of the interior wave height. The reduced depth reduces dredging and excavation volumes through the sand spit. At the channel turn, the width is increased to 300 feet and transitions back to the straight channel width of 150 feet. The channel terminates at the inner harbor.

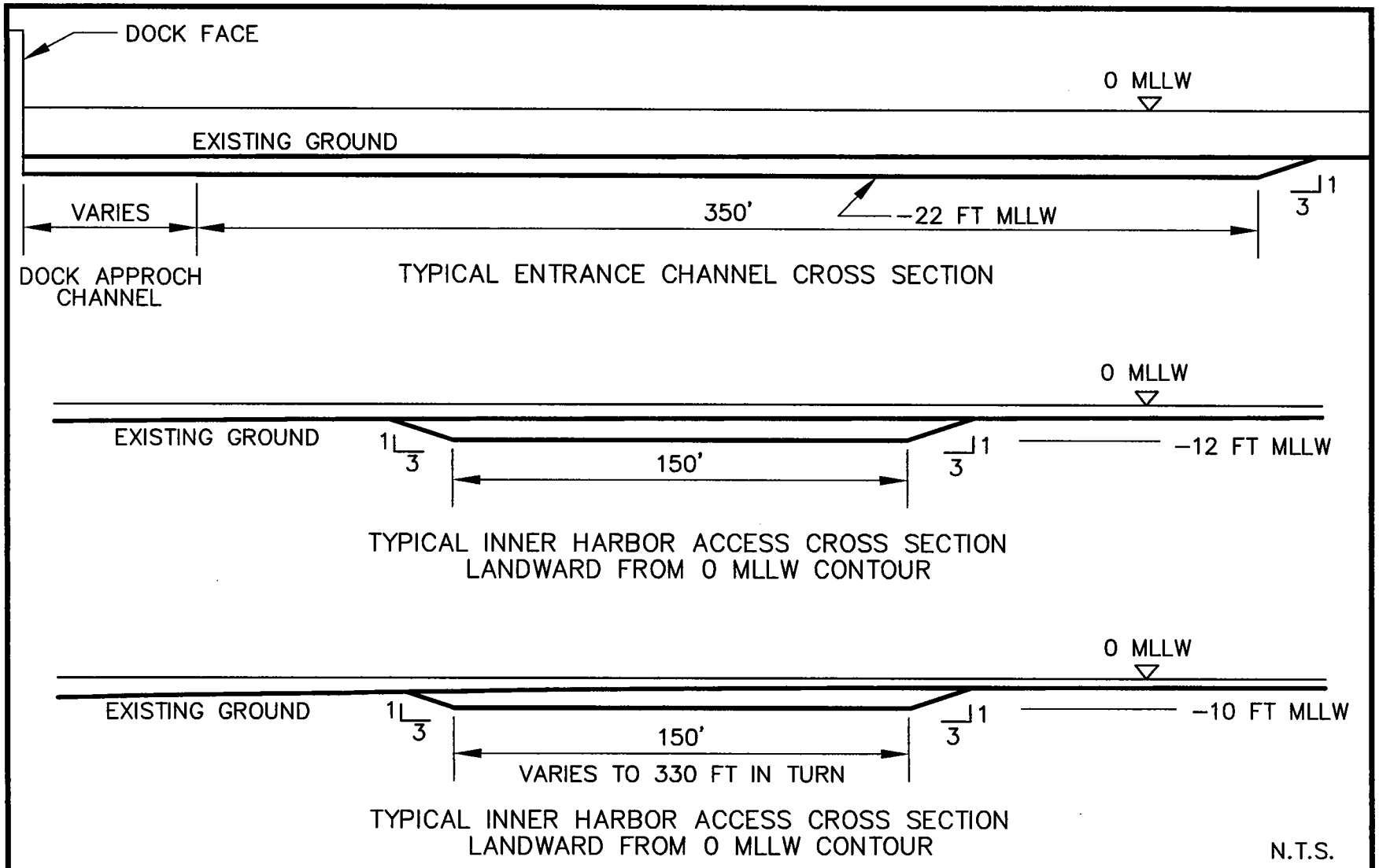
8.2.5 Wave Height Criteria.

Wave height criteria were explained in the Design Criteria section (section 5.2, Allowable Wave Heights) and evaluated against alternatives tested in the model studies.

8.3 Breakwaters

8.3.1 General Description.

A 2,985-foot-long rubblemound main breakwater would be constructed from the sand spit and extend southwest to a depth of approximately -24 ft MLLW, terminating east of the entrance channel. The main breakwater has a 30-foot breach at the -8-ft-MLLW contour, approximately 800 feet from the shoreward end of the structure. The breach would facilitate fish passage. A 235-foot-long rubblemound spur breakwater would be extended from the causeway head 50 degrees from the causeway alignment to the southeast. The channel width, toe to toe, from the head of the main and spur breakwaters would be 380 feet. The width was optimized for wave reduction and vessel navigation during physical model testing. Maximum depths of water are -30 ft MLLW at the outward end of the spur breakwater. Foundation



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TYPICAL CHANNEL CROSS SECTIONS
NAVIGATION IMPROVEMENTS, NOME, ALASKA

8-2

materials are sand, gravel, and cobbles, which would serve as suitable base material for both rubblemound breakwaters.

8.3.2 Main Breakwater.

Using 1V:1.5H side slopes, the 8-ton armor rock would range from plus or minus 2 tons and 10 feet thick, with a crest width of 12 feet and height of +14 ft MLLW. The 5-foot-thick secondary rock layer would range from 2,000 lb maximum to 800 lb minimum. Core material would be 650 lb maximum to 1 lb minimum.

A total of 79,500 cubic yards of armor rock, 23,000 cubic yards of secondary rock, 18,000 cubic yards of core rock, and 47,500 cubic yards of filter material would be required for main breakwater construction. The structure would be built on a 4-foot-thick filter layer consisting of quarry run material. The typical breakwater sections for the main and spur breakwaters are shown in figure 8-3.

8.3.3 Spur Breakwater.

Using 1V:1.5H side slopes, the 22-ton armor rock would range from +5 to –3 tons and 15 feet thick with a crest width of 29 feet and height of +14 feet MLLW. The 7-foot thick secondary rock layer would range from 5,500 lb maximum to 3,000 lb minimum. Core material would be 650 lb maximum to 1 lb minimum. The structure would be built on a 4-foot-thick filter layer consisting of quarry run material.

A total of 16,000 cubic yards of armor rock, 4,000 cubic yards of secondary rock, 2,900 cubic yards of core rock, and 5,500 cubic yards of filter material would be required for spur breakwater construction.

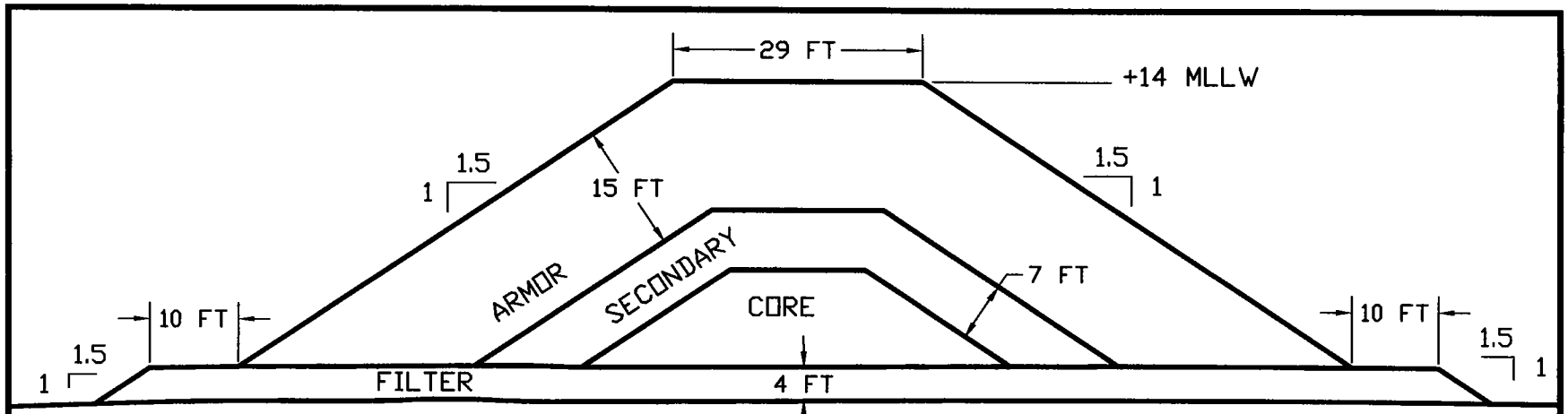
8.4 Existing Project Features

With the recommended plan, the existing concrete jetties would be broken up or blasted. The debris of the west jetty would be abandoned in place, and the concrete rubble on the east jetty would be shaped and capped with 8-ton rock to function as groin to capture longshore sediment transport at the boundary between the seawall and the sand spit.

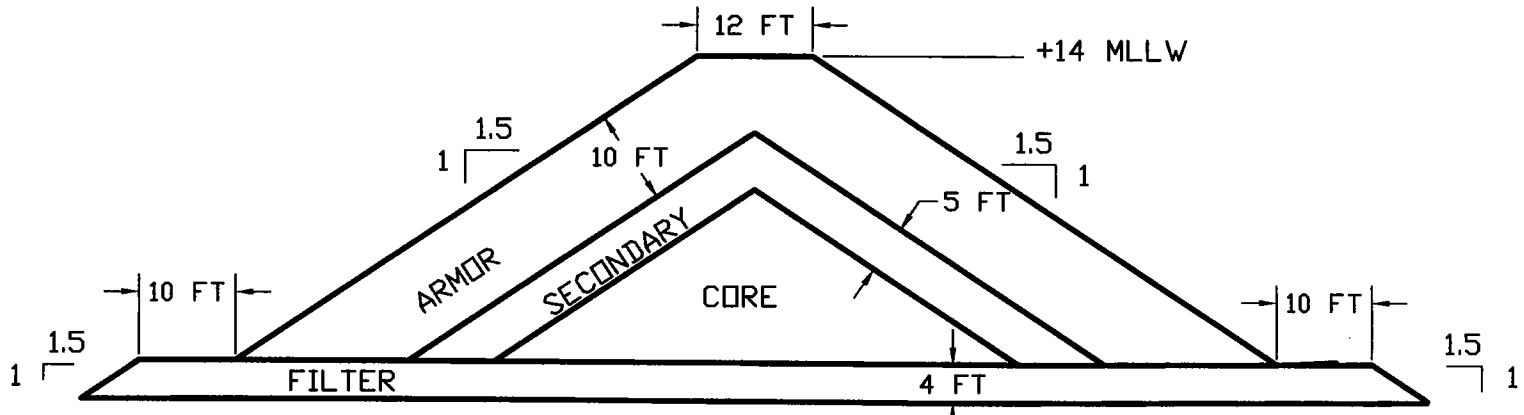
Of the 3,815 feet of existing sheet-pile revetment, approximately 2,365 linear feet would be abandoned by placing dredged material against the vertical face in the existing entrance channel. The balance, 1,450 linear feet, would be abandoned in place. The result of these activities would be the Federal deauthorization of all of the sheet-pile revetment.

8.5 Circulation

Circulation offshore of Nome Harbor is to a large part a function of the prevailing wave activity. The circulation is from west to east when waves approach the beach line from the west and from east to west when waves approach the beach line from the east. Superimposed on this general circulation are the impacts of the existing



TYPICAL SPUR BREAKWATER CROSS SECTION



TYPICAL MAIN BREAKWATER CROSS SECTION

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TYPICAL BREAKWATER CROSS SECTIONS
NAVIGATION IMPROVEMENTS, NOME, ALASKA

8-3

entrance channel and the causeway. Another additive factor would be the new east breakwater. However, that breakwater is more an east offset of the causeway's existing impact on circulation. Circulation patterns are well demonstrated in the WES model study simulations.

When alongshore currents approach the existing breakwaters, they are shunted seaward and form rip currents. The upflow rip current is usually quite strong and is capable of moving sediments to the tip of the obstruction; this is the source of much of the sedimentation entering the channel with the present short jetties. The downflow side of the obstructions is almost always the location of a gyre that circulates from the shore seaward along the obstruction. Velocities in the gyre are modest and transport little sediment, but they enhance the turnover of water as they entrain some new water.

Waves occur from one direction or another nearly 50 percent of the time during the ice-free season, so the turnover of waters at the present and future harbor entrance is excellent. Vertical mixing from wind activity further enhances water quality at the ocean. In the shallow depths of the near-shore area in Norton Sound, mixing should be almost continuous. Currents at the causeway form gyres and rip currents similar to those at the existing entrance jetties, with one distinct difference that affects sediment transport much more than water quality. The difference is that the causeway extends beyond the depth where longshore currents can transport bottom sediments; therefore, the causeway forms a sediment transport block in both the east and west direction. Addition of a breakwater to the east of similar length does not change the impact of the causeway on circulation or sediment transport.

Interior harbor circulation goes through a number of perturbations each year. Those perturbations include massive exchanges during storm setup and set-down incidents, and flushing of saltwater intrusions during major spring flow periods. The major perturbations probably have some influence on water quality, as they are capable of flushing the system in a very short period of time. The period of the perturbations is short, and the dominant influence on circulation and water quality is the day to day modest tidal exchange. That tidal exchange and the major perturbations are not modified by the new project. There should be no change in exchange or circulation caused by the new harbor configuration.

8.6 Shoaling

The three-dimensional modeling of wave refraction differences across the present seaward protuberance of the west side shoal identifies an increase of up to 30 percent in wave heights at dock facilities due to wave focusing on the causeway-developed shoal off the southwest end of the nose. Therefore, a sediment trap arrangement was tested in the model with dimensions to contain 60,000 cubic yards below the -10-ft-MLLW depth. Because the causeway is functioning as a groin, impeding longshore sediment transport in both the west and east directions, the sediment trap (or another type of sand bypass system, such as annual dredging from the west side) is necessary.

For the sediment trap to function properly, the bridge length of 100 feet over the existing causeway breach would need to be reconstructed to allow a 60-foot bottom width along the alignment of the causeway at a bottom elevation of –8 ft MLLW.

8.7 Construction Dredging and Excavation

Dredging quantities were computed using baseline data from the survey performed in July 1997 by Peratrovich, Nottingham, & Drage, Inc. The dredging and excavation quantities are summarized in table 8-1.

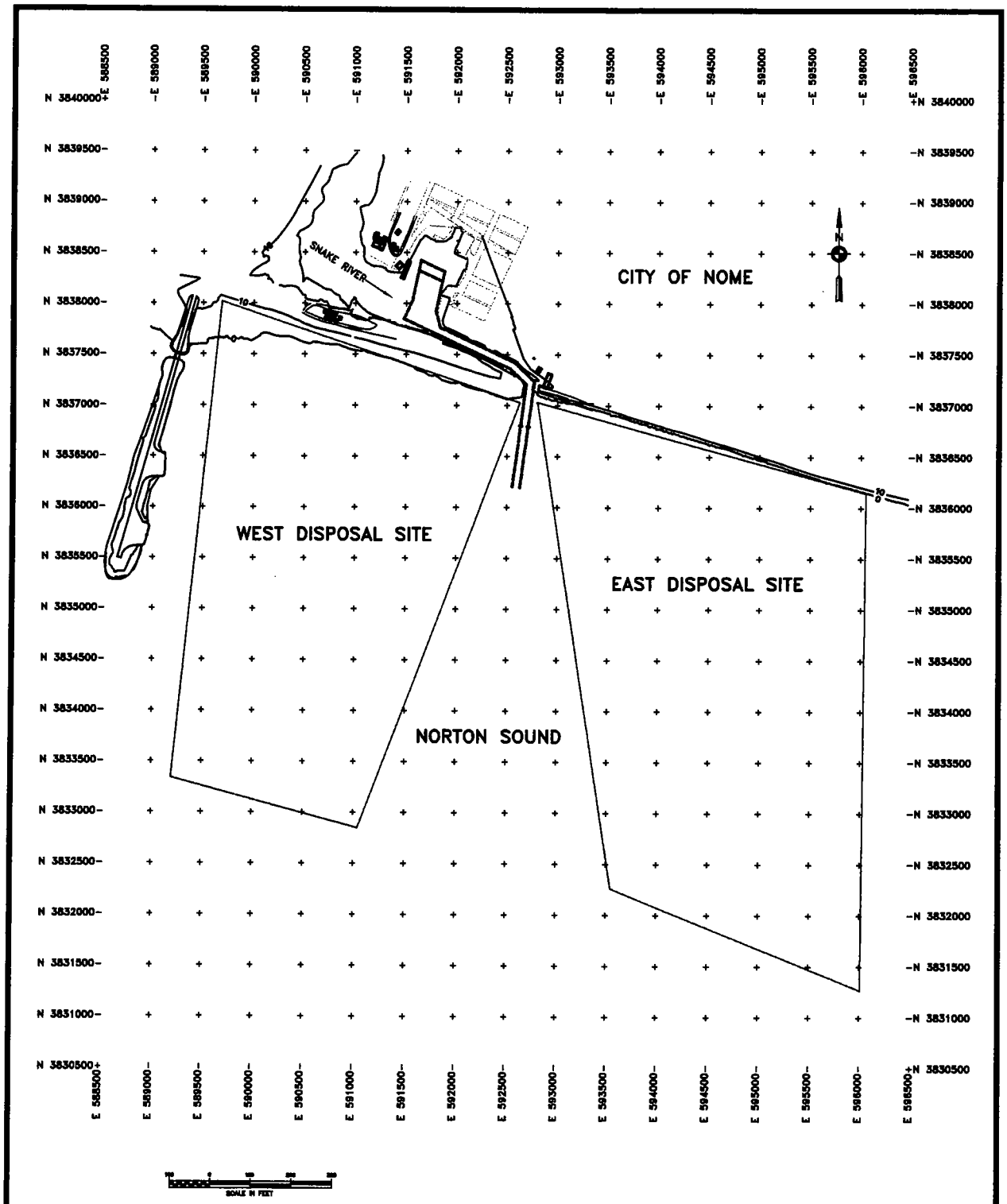
TABLE 8-1.—*Dredging and excavation quantities*

Item	Quantity (yd^3)
Entrance channel (-22 ft) and transition (-22 to –12 ft)	113,000
Inner harbor access channel (-12 ft to –10 ft)	
Uncontaminated material	158,000
Arsenic-laden material	21,000
	179,000
Dock approach channel	
Federal	58,000
Non-federal	26,000
	84,000
Sediment sump	141,000

Dredging material is expected to consist of sands and gravels with cobbles to project limits, based on the available geotechnical information. Side slopes for the channels would be dredged to 1V:3H. The slopes would not require armor protection. The entrance channel dredged material quantity of 113,000 cubic yards would be placed on the sand spit and seaward between the new main breakwater and the capped east jetty from the existing project. There is an Environmental Protection Agency-approved dredge disposal site seaward of the spit, shown in figure 8-4.

All of the inner harbor access channel arsenic-laden material (21,000 cubic yards) and 81,000 cubic yards of the noncontaminated material would be placed in the existing entrance channel. The balance of the noncontaminated material would be placed on the sand spit and seaward between the new main breakwater and the capped east jetty. The dock approach channel material (84,000 cubic yards) and the sediment sump material (141,000 cubic yards) would be placed on the sand spit and seaward also.

The construction dredging could be accomplished with a large clamshell dredge, since sand and gravel would be encountered during construction. However, an excavator could be utilized for material on the sand spit.



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EPA APPROVED DISPOSAL SITES
NAVIGATION IMPROVEMENTS, NOME, ALASKA

8—4

8.8 Operation, Maintenance, Repair, Replacement, and Rehabilitation

8.8.1 General.

Maintenance-dredged material would be composed of Snake River and marine sediments. This dredging is not expected to create any detrimental effects on water quality or other aspects of the project. Disposal of maintenance dredging and bypass material for the proposed project lies east of the existing entrance, where the potential for transport is not under the influence of the causeway. That disposal site is far enough from the proposed harbor complex to realize the full potential of 92,000 cubic meters per year of west-to-east transport afforded by the wave climate on the unencumbered shoreline. This moves the system to a near-natural balance with the littoral transport system.

Also, the ocean disposal site is under the management and jurisdiction of the U.S. Environmental Protection Agency (EPA). The site was established under the Marine Protection, Research and Sanctuaries Act (MPRSA), with the Environmental Impact Statement finalized in 1995. Establishing a new ocean dumping disposal site under MPRSA would require EPA approval and an explanation of why the existing disposal site is not adequate. Present regulations do not allow relocation of ocean dumping sites.

8.8.2 Federal Inner Harbor Channel Maintenance.

Maintenance dredging for the interior harbor channel without improvements for the causeway docks would consist of all the Snake River bed load and about 30 percent of the suspended load, for a total of about 6,000 yd^3 per year. Added to that would be some recirculated sediments derived from east breakwater overtopping, and also some windblown sediments. It is estimated that less than 10,000 yd^3 would need to be handled annually. If a pipeline dredge is used for the removal, the project would have to absorb either the annual mobilization or the amortization cost of the plant.

Winter or summer clamshell or backhoe equipment options would be available with all the sedimentation in protected waters. With these alternatives, the unit cost for removal should be \$6.00/yd^3 or less in the shallow cuts anticipated. Preconstruction engineering and design studies should consider alternative dredging plans. The cost of maintenance must also include periodic removal of some fine sediment in the interior channel area adjacent to the harbor. It is expected that about 1,000 yd^3 of fine-grained sediment, similar to sediments now found in the turning basin, would accumulate annually in the inner channel turn and harbor approaches. Removal is expected to occur on the cycle experienced with the present harbor configuration, about every 10 years. The inner harbor maintenance dredging cost is calculated thus:

Federal inner harbor maintenance dredging cost

Mobilization	$104,000
Navigation aids	1,000
Surveys	$20,000
Annual channel dredging, 10,000 yd3 @ $5.00/yd^3	$50,000
Inner harbor turn dredging, 10,000 yd^3 @ years 10, 20, 30, & 40 @ $6.00/yd^3. Average annual cost for inner harbor =	$4,100
Total	**$179,100**

8.8.3 Federal Causeway Dock Maintenance Dredging.

Maintenance dredging with the added project feature of an improved dock requires management of the 60,000 yd^3 of material arriving and being stored west of the causeway. The report has been developed around constructing a sediment trap and transfer operation for that management. Annual removal and transfer of 60,000 yd^3 per year of sediments to the eastern beach would occur. Alternatives to the sediment trap are available, such as making a periodic transfer with a hopper dredge or transferring during the winter from the west side of the breakwater. None of the alternatives have been looked at in detail to see which may be the most cost-effective. A value engineering study during preconstruction engineering and design that uses the WES model for many of the input parameters would be beneficial.

The causeway dock maintenance dredging cost is calculated thus:

Causeway dock maintenance dredging cost

Mobilization and surveys (absorbed by inner harbor dredging)	0
Annual removal of 60,000 yd^3 from trap @ $4.00/yd	$240,000
Total	**$240,000**

8.8.4 Major Maintenance.

Major repair would consist of periodic reconstruction of the new 3,000-foot main or east breakwater and the causeway extension. Historically, damages to rubblemound breakwaters in Alaska have been almost nonexistent. History elsewhere in the Nation approaches in some cases 1 percent damage a year, with repairs occurring on a 20- to 35-year cycle. In recognition of expectation of need, the major maintenance cycle for the structures has been placed near the outer boundary of that experienced in more severe wave conditions, or at a 35-year cycle. The estimate considers a 25-percent replacement of new work and equivalent new work mobilization cost of $500,000.

Annualized cost of major maintenance	$21,400
Annual cost of all maintenance	**$440,000**

8.8.5 Non-federal Sponsor's O&M Cost.

The non-federal sponsor is responsible for maintenance dredging in the small boat harbor and in the 30-meter-wide by 400-meter-long strip adjacent to the causeway

docks. The harbor dredging is expected to be on the same dredging cycle as the 10-year interior harbor channel Federal dredging. Dredging is expected to be undertaken with a backhoe off the ice in the non-use season with local equipment. Annual costs of $4,100 are expected. No dredging requirement is expected at the causeway docks.

8.9 Effects on Downstream Beaches

The project should have no added impact on downdrift beaches. The existing causeway has introduced a sediment block that prevents about 60,000 yd^3 per year of sediment from reaching the beaches east of the causeway. If sand bypassing is undertaken, that impact would be minimized. If sand bypassing is not undertaken, those beaches would continue to be deprived of those sediments. The actual impact of the deprivation is unknown, although the post-causeway erosion east of the Federal seawall could be an indication of the impact.

8.10 Aids to Navigation

It is anticipated that navigation marker lights would be installed at both seaward ends of the spur and main breakwaters.

8.11 Detailed Quantity and Cost Estimates

Quantity and cost estimates are in the main report, and the detailed cost estimate is in appendix D. Costs of the inner harbor are listed in table 8-2, and costs of the causeway dock improvement are listed in table 8-3.

8.12 Construction Schedule

Construction of the recommended plan would require two construction seasons. The most likely quarry for breakwater materials is the Cape Nome quarry, due to its proximity to the project site and high quality of rock. If this quarry is used, it is anticipated that the breakwater rock would be barged from Cape Nome to the project site, with the rock material for the main and spur breakwater processed prior to the first construction season.

During the first construction season, which would start in April and extend through December, the main and spur breakwaters would be completely constructed. Quarrying should begin 30 days after contract award. Rock placement is expected to begin as soon as the Norton Sound ice leaves to take advantage of the better weather and calmer waters that extend to mid- to late summer. The causeway bridge construction would be initiated in the fall of the first year, immediately after major use of the causeway was over for the season. Causeway bridge construction would extend into the winter months so causeway use would not be impacted the following spring. During the second spring and summer construction season, the channels and sediment sump would be constructed. Removal of any portions or other work on the existing project would probably be accomplished in the fall of the second construction season.

TABLE 8-2.—*Inner harbor costs without contingencies*

Item	Amount	Subtotal
Relocations		
Utilities sewer line	$120,000	
		$120,000
Existing jetties		
Break up jetties	41,797	
Armor rock cap	103,025	
		144,822
Breakwaters and seawalls		
Mobilization & demobilization	526,459	
Main breakwater	8,652,938	
Foundation for 2 navigation aids	10,132	
Hydrographic surveys (3)	45,596	
		9,235,125
Navigation ports and harbors		
Entrance channel	2,803,419	
Hydrographic surveys (2)	30,937	
		2,834,356
Hazardous & toxic waste		
Mobilization & demobilization	18,998	
Institutional actions	31,664	
Containment for waste	668,250	
		718,912
Total inner harbor to 10-ft depth		**$13,053,215**

TABLE 8-3.—*Causeway dock improvement costs without contingencies*

Item	Amount	Subtotal
Relocation		
Bridge construction and breach expansion		$1,675,000
Breakwaters and seawalls		
Breakwater stub		1,415,982
Navigation ports and harbors		
Dock approach	$852,829	
Hydrographic surveys (2)	1,231,517	
		2,084,546
Total for causeway docks		**$5,175,328**

8.13 Effects of Project Construction

There are at least five main areas or items potentially affected by the navigational improvements described in the recommended plan. First, the city of Nome's inner harbor expansion is not expected to be impacted by construction of the recommended plan, because the city's new bulkhead and float system are outside the project limits of the recommended plan.

Second, before filling the existing channel with dredged material, the new inner harbor access channel would have to be dredged through the sand spit to provide access from the harbor area to Norton Sound.

Third, construction of the main and spur breakwaters as well as dredging of the entrance and dock approach channels must be coordinated with vessel traffic using the causeway docks.

Fourth, environmental windows for blasting of the existing east and west jetties would have to be complied with. Navigation and environmental conflicts may place this blasting into the second winter of construction.

Fifth, access to the causeway docks would have to be maintained during the navigation season.

APPENDIX B
ECONOMIC ANALYSIS

NAVIGATION IMPROVEMENTS
NOME, ALASKA

APPENDIX B
ECONOMIC ANALYSIS

CONTENTS

Page

CONTENTS ..... B-i
Figures ..... B-v
Tables ..... B-v

1. OVERVIEW OF REGION AND COMMUNITY B-1
1.1 Location and Climate B-1
1.2 History B-1
1.3 Economic History B-3
1.4 Population B-3
1.5 Nome as Regional Center B-4
1.6 Economy B-5
1.7 Income B-6
1.8 Subsistence and Use of Wild Resources B-6
1.9 Cost of Living B-8
1.10 Villages Serviced Through Nome B-9
1.10.1 Alakanuk B-9
1.10.2 Brevig Mission B-10
1.10.3 Chevak B-11
1.10.4 Council B-11
1.10.5 Deering B-11
1.10.6 Diomede B-12
1.10.7 Elim B-12
1.10.8 Emmonak B-12
1.10.9 Gambell B-13
1.10.10 Golovin B-13
1.10.11 Hooper Bay B-14
1.10.12 Kotlik B-14
1.10.13 Koyuk B-15
1.10.14 Marshall B-15
1.10.15 Mountain Village B-16
1.10.16 St. Marys B-16
1.10.17 St. Michael B-16
1.10.18 Savoonga B-17
1.10.19 Scammon Bay B-17

CONTENTS—Continued

Page

1.10.20 Shaktoolik B-18
1.10.21 Sheldon Point B-18
1.10.22 Shishmaref B-18
1.10.23 Stebbins B-19
1.10.24 Teller B-19
1.10.25 Unalakleet B-20
1.10.26 Wales B-20
1.10.27 White Mountain B-21

2. WATERBORNE COMMERCE B-22
2.1 General B-22
2.2 Gravel and Quarry Stone Shipments B-22
2.3 Modular Housing Shipments B-24
2.4 Fuel Oil B-25

3. WITHOUT-PROJECT CONDITIONS FOR THE NOME-BASED FISHING INDUSTRY B-26
3.1 The Nome-Based Fishing Industry B-26
3.2 Community Development Quota B-26
3.2.1 Potential Development Impacts B-27
3.2.2 Early Results of the CDQ Program at Norton Sound B-28
3.3 Norton Sound "Super-Exclusive" Crab Fishery B-29
3.4 Salmon Fishing Developments B-31
3.5 Crab Fishery in the Adjacent Bering Sea Waters B-31
3.6 Halibut Fishery and Controlled Access B-32
3.7 Halibut Harvest Opportunities B-33
3.8 Pollock Harvest B-34

4. WITHOUT-PROJECT CONDITIONS FOR NOME-BASED COMMERCIAL FISHING FLEET, PRESENT AND FUTURE B-35
4.1 Commercial Fishing Income to Nome-Based Operators B-35
4.2 Average Operator's Income B-36
4.3 Equilibrium Fleet B-36

5. WITHOUT-PROJECT CONDITION FOR COMMERCIAL TRANSPORTATION FLEET CALLING AT NOME B-38
5.1 Fleet Characteristics B-38
5.2 Causeway Fleet B-38
5.3 Inner Harbor Commercial Transportation Fleet B-40

CONTENTS—Continued

Page

6. TRANSPORTATION PROBLEMS B-41
6.1 Village Transportation Options B-41
6.2 Lighter Operations B-41
6.3 Transportation Delay B-42
6.4 Delay Cost B-43
6.5 Delays for Fishing Boats B-44
6.6 Threshold Entrance Conditions B-45
6.7 Delay for Lighters B-47
6.8 Long-Term Delay B-48
6.9 Air Transportation Options B-48
6.10 Other Modes B-49

7. ECONOMIC ISSUES OF PLAN FORMULATION B-50
7.1 Without-Project Condition B-50
7.2 Alternatives B-51

8. BENEFIT METHODOLOGY B-52
8.1 Evaluation Criteria B-52
8.2 Evaluation Framework B-52
8.3 Risk and Uncertainty B-52
8.4 Fishing Fleet Projection Procedure B-53
8.5 Commercial Fishing B-53
8.6 Transportation Savings B-53
8.7 Opportunity Cost of Time B-54
8.8 Operation and Maintenance Cost Savings B-56
8.9 Other Effects B-56

9. ESTABLISHMENT OF MAJOR REHABILITATION AS THE MOST LIKELY WITHOUT-PROJECT CONDITION B-57
9.1 Major Rehabilitation: the Most Likely Future B-57
9.2 Economic Justification of Major Rehabilitation B-57
9.2.1 Shipping Cost B-58
9.2.2 Queuing Cost B-59
9.2.3 Commercial Benefits for the Norton Sound King Crab Fishery B-61
9.2.4 Subsistence B-64
9.2.5 Halibut Fishery Harvest Savings B-66
9.2.6 Salmon Fishery Harvest Savings B-67
9.2.7 Benefit Summary B-69
9.2.8 Viability of Major Rehabilitation B-70
9.3 Without-Project Condition Conclusion B-70

CONTENTS—Continued

Page

10. BENEFIT EVALUATION FOR IMPROVEMENT OF THE ENTRANCE..B-71
10.1 Without-Project Condition....B-71
10.2 Entrance Problems Remaining After Major Rehabilitation....B-71
10.3 Proposed Improvements....B-72
10.4 Damages From Anchoring Out During Storms....B-72
10.4.1 Minor Damage....B-73
10.4.2 Serious Damage....B-73
10.4.3 Severe Damage....B-73
10.4.4 Maximum Damage....B-73
10.4.5 Damage Summary....B-74
10.5 Project-Related Fishing Fleet Damages....B-75
10.6 Commercial Tug and Barge Damages at Entrance....B-79
10.7 Light Loading....B-80
10.8 Long-Term Delay....B-81
10.9 Reduced Annual Dredging Cost....B-82
10.10 Saved Major Rehabilitation Cost....B-83
10.11 Land Creation....B-83
10.12 Summary of Benefits for Improving the Entrance....B-85

11. BENEFIT EVALUATION FOR IMPROVED CONDITIONS AT THE CAUSEWAY....B-86
11.1 Without-Project Condition....B-86
11.2 Potential Savings for Delivery of Crab to Nome....B-86
11.3 Damage to Lighters....B-92
11.4 Vessel Delay Reduction....B-92
11.5 Cruise Ship Benefits....B-93
11.6 Summary of Benefits for Improving the Causeway....B-93

12. INCREMENTAL BENEFITS FOR ADDING A CELL TO THE CAUSEWAY....B-95

13. PROJECT MAXIMIZATION....B-97
13.1 Incremental Evaluation....B-97
13.2 NED Project Depth....B-97
13.3 Evaluation Procedure....B-97
13.4 Present Operating Practice....B-98
13.5 Inner Harbor Depth Evaluation....B-98
13.6 Incremental Cost of Entrance Improvement....B-100
13.7 Causeway Depth Evaluation....B-101
13.8 Incremental Cost of Causeway Improvement....B-102
13.9 Comparison of the NED Plan With Other Alternatives....B-104

CONTENTS--Continued

Page

14. LOCAL IMPACTS AND OTHER SOCIAL EFFECTS B-106
14.1 Purpose B-106
14.2 Impact Analysis Compared to Benefit/Cost Analysis B-106
14.3 Transportation Impacts B-107
14.4 Evaluation Procedure B-107
14.5 Major Rehabilitation B-109
14.6 Impacts of the NED Plan B-109
14.7 Short-Term Construction Impacts B-110
14.8 Other Social Effects B-111

15. SENSITIVITY OF NED PLAN TO SELECTED VARIABLES B-112
15.1 Sensitive Variables B-112
15.2 Range of Benefits Generated B-115

SOURCES B-117

Figures

Figure No.	Title	Page
B-1	Economics study area	B-2
B-2	Entrance optimization	B-101
B-3	Causeway channel optimization	B-103

Tables

Table No.	Title	Page
B-1	Nome harbor activity	B-23
B-2	Norton Sound Economic Development Corporation Economic Development Program	B-29
B-3	Nome-based fishing fleet	B-37
B-4	Nome causeway fleet: unadjusted sample data from 38 percent of days during 1995 season	B-39
B-5	Nome inner harbor commercial transportation fleet	B-40
B-6	Lighter operating cost	B-44
B-7	Threshold entrance conditions	B-46
B-8	Average annual wages of respondents	B-55
B-9	Causeway use: harbormaster data for specific years	B-59

TABLES—Continued

Page

B-10 Causeway use: simulation results B-60
B-11 Benefit summary, major rehabilitation B-69
B-12 Annual benefits, major rehabilitation, with assumed loss-of-service dates B-70
B-13 Frequency integration, vessel damages B-74
B-14 Summary, incremental benefits from improvements to the entrance B-85
B-15 Statistical description of average vessel (crab boat) represented in study B-89
B-16 Average vessel operating cost profile B-89
B-17 Benefits for improving the causeway B-94
B-18 Entrance optimization B-100
B-19 Causeway optimization B-102
B-20 NED plan incremental justification, Nome Harbor B-104
B-21 Comparison of alternatives for Nome Harbor and facilities B-105
B-22 Job loss impact from shutdown of inner harbor and entrance B-109
B-23 Employment impacts of the NED plan B-110
B-24 Distribution of job impacts B-110
B-25 Display of range of benefits generated B-116

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June 18, 1998

NAVIGATION IMPROVEMENTS
NOME, ALASKA

APPENDIX B
ECONOMIC ANALYSIS

1. OVERVIEW OF REGION AND COMMUNITY

1.1 Location and Climate

Nome lies on the southern shore of the Seward Peninsula. The area near Nome is treeless arctic tundra except for intermittent spruce trees in the Fish River drainage. Most of the rivers that drain into Norton Sound near Nome are small. The Snake River is about 56 km long, the Nome River about 64 km, the Eldorado River about 48 km, and the Sinuk River about 77 km. 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.

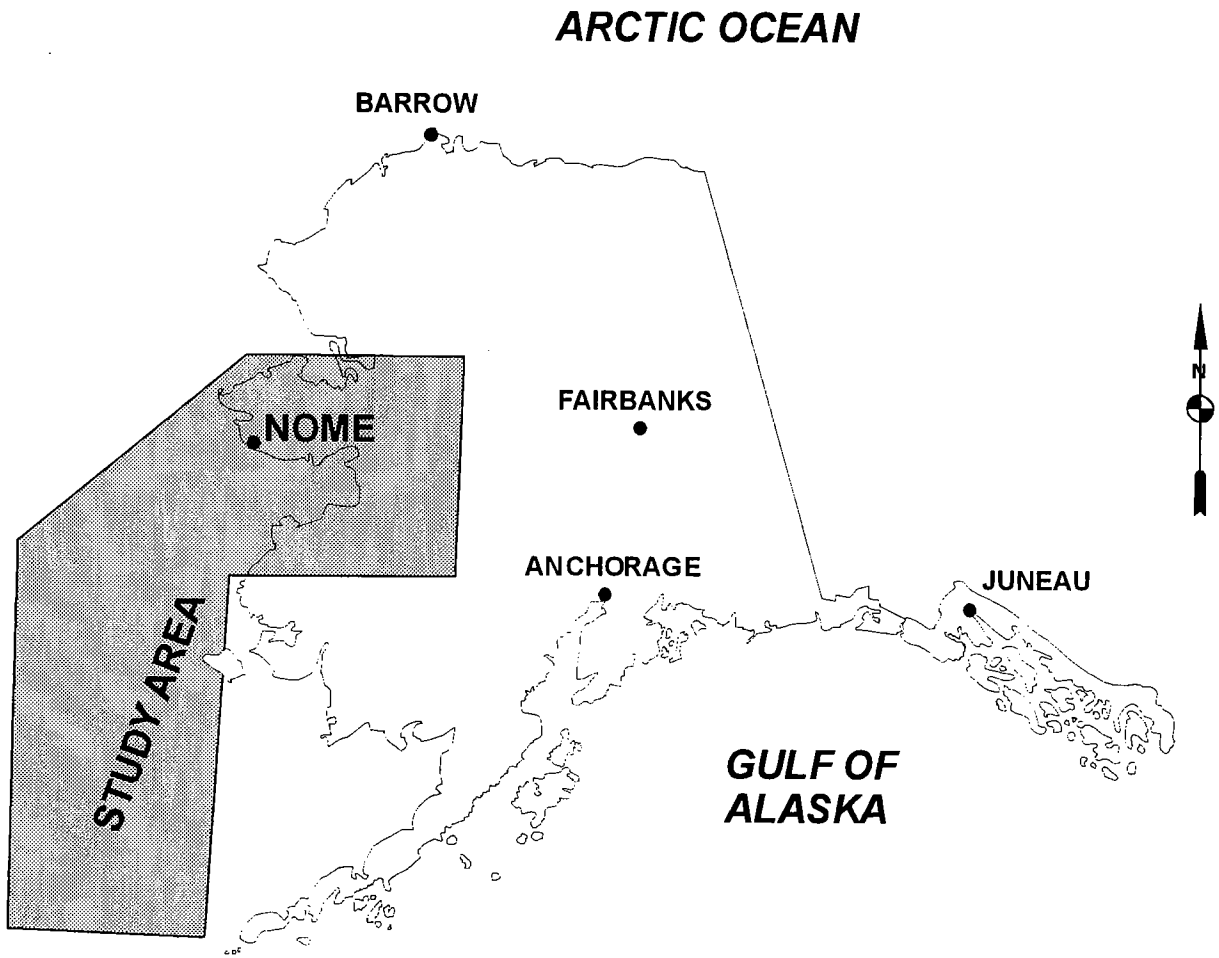
The study area, generally referred to as the Bering Strait-Norton Sound region, has an area of approximately 258,000 km^2, encompassing all watersheds draining into Norton Sound and Bering Strait, from Shishmaref in the north to Hooper Bay in the south. Figure B-1 shows the study area.

The western half of the Seward Peninsula is generally treeless, wet coastal tundra at low elevations and alpine tundra at higher elevations. Willows 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.

The entire study area lies south of the Arctic Circle. Average summer temperatures are from -2 to 10 °C (30-50 °F), and include 77 frost-free days. Sea ice is generally present from late November to June, though there is significant variation in ice formation from year to year. Wind is a feature of the local climate. One experiences near constant daylight at the height of summer and long hours of twilight in the winter, when the sun is low in the sky during the short days.

1.2 History

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 principal settlement at the time was



ALASKA DISTRICT
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ECONOMICS STUDY AREA

NAVIGATION IMPROVEMENTS, NOME, ALASKA

B-1

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. In 1899 nearly 3,000 miners arrived at Nome, and the following year 20,000 more arrived. Residents voted to incorporate Nome in 1901, and the city has been inhabited continuously ever since.

The Native people of Nome were severely impacted by the gold rush population boom and ceased to exist as separate Native societies by the early 20th century. 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.

1.3 Economic History

From the early days, Nome attracted Natives from the surrounding area. Labor was needed for longshoring, mining, and services. Some Natives from outlying areas made wage labor part of their seasonal round of subsistence. World War II temporarily boosted the local economy when Nome became a refueling stop for the lend-lease program that provided aircraft to the Soviet Union. Defense-related civilian job opportunities attracted more Natives from the surrounding areas; however, the military boom was temporary.

Despite Alaska's rich mineral and marine resources, residents of the study area have not shared richly in the economic gains made in other parts of the State. Nome has gradually developed as a regional service hub for surrounding villages, with government becoming the main source of income and employment. Nome provides administrative, educational, medical, and social services to the Seward Peninsula and Norton Sound area. In 1990, State and local government employed 526 Nome residents, compared to only 303 in 1969.

1.4 Population

By Alaska standards, Nome is a community of moderate population size. The city population of 3,656 includes 40 percent of the people in the census area. The census area, with a population of 8,800, is the 10th largest in the State.

Only 23 communities in Alaska have populations between 1,000 and 10,000. Twenty-one percent of the State's people reside in communities smaller than 1,000, while about 63 percent reside in the State's three largest cities, Anchorage, Fairbanks, and Juneau.

1.5 Nome as Regional Center

The Alaska National Interest Lands Conservation Act of 1981 gave five examples of Alaska communities that Congress considered to be rural: Dillingham, Barrow, Bethel, Kotzebue, and Nome. These communities share four general characteristics:

- Moderate population size
- Regional center function
- Mixed economy of cash and wild resource use
- Diverse population

The five "rural" communities are characterized as regional centers. As such, they provide 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 27 communities in the Norton Sound-Bering Straits 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 freezeup. 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.

Only a few of the outlying communities are accessible by road, and only during the summer months. 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 air charter 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.

1.6 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. Some villages are more traditional than others. In several, the Native language is used daily, and hunters employ traditional methods such as the use of open boats covered with walrus hide.

Families engage in a seasonal round of subsistence activities, and it is common for them to move short distances as hunting, berry picking, or fishing draws them. The wild resources used for food and raw materials are distributed by an informal network. The distribution system does not necessarily require that exchange take place, as the fundamental purpose is to share the harvest. This sharing ensures that no one goes without. Generally, about half or more of the villagers are actively involved in subsistence harvests in a major way, while all of the village is involved in use of the harvest.

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, subsistence harvest still depends on use of traditional methods that pre-date modern technology.

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 in the smaller villages, a conventional lifestyle in Nome is similar to that in cities elsewhere. Woven into the fabric of the community is a working, productive population, more than 50 percent Native people. 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 1,570, Federal, State, and local government employ 526. Of the 1,018 persons employed in the private sector, the single largest class of employment is retail trade, accounting for 308 jobs. Health care, with 198 jobs, is second, and education with 144 is third. Thus it is clear from the employment profile that Nome serves as a regional center for government, trade, health, and education support.

Fishing does not provide year-round employment locally, but it is important to the local food supply and the mainstay of a regional economy that depends on summertime activity for cash income. Registered for use within the greater area of Norton Sound, there are 281 commercial fishing permits, and an additional 57 halibut permits are registered to residents of the Nome census area. Of this total of 338 permits, 72 belong to Nome residents.

Fishing in the Bering Sea during winter is possible only for large vessels that stay far out to sea for weeks at a time. None of these deep-sea trawlers or crabbers are home-ported at Nome. With harbor improvements and a local seafood processing plant, Nome would be an attractive alternative offloading and reprovisioning stop for the fleet that fishes near Nome. These vessels now make the long haul to Dutch Harbor or St. Paul Island for support.

1.7 Income

Using census data from 1990, updated to 1994 by the State, per capita personal income for the Nome census area is $16,573. This figure ranked 23rd in the State and was 71 percent of the State average of $23,437 and 76 percent of the national average of $21,696. Conclusions about economic well-being based on per capita personal 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.

In 1994 the census area had a total personal income of $145,846,000. This ranked 14th in the State and accounted for 1 percent of the State total. Total personal income includes earnings (wages, salaries, and proprietors' income), dividends, interest, rent, and transfer payments. Earnings were 66 percent of total personal income, transfer payments were 28 percent, and dividends, interest, and rent were 6 percent.

Using earnings as a measure of industry size, the largest industries were State and local government with 38 percent of earnings, services with 27 percent, and transportation and public utilities with 8 percent.

1.8 Subsistence and Use of Wild Resources

The office of Alaska's Governor recognizes that rural communities depend substantially on fish and game for nutrition and other subsistence uses. State law allows the use of subsistence harvests for customary trade but not as a commercial enterprise. The Governor supports a proposed constitutional amendment that could ensure effective State authority over fish and game management of all lands and waters of Alaska. A basic purpose of the amendment is to recognize the paramount importance of the subsistence way of life to Alaskans.

The Nome community includes a group of Native people who migrated from King Island during the past few decades. They have maintained a cultural identity and live

in a community outside of Nome. They rely on subsistence gathering to a greater extent than the Nome population in general. Nome is the largest community in the study area, and patterns of subsistence use are combined with wage activities.

Within the study area, fish, wildlife, and plant growth change throughout the seasons. From a subsistence standpoint, marine resources are especially important. The harvest is used for food, clothing, crafts, and trade. Wild resources are not harvested only for food. Wild resources are substitutes for many non-food items that would otherwise have to be purchased. Subsistence activity takes place in all seasons. The most commonly used wild resources gathered by Nome residents are seals, salmon, berries, ptarmigan, and moose. As the distance from Nome increases, villagers' reliance on wild resources emphasizes the taking of sea mammals, seals being a major share of the harvest.

Ringed seals, generally available throughout the winter, are hunted at breathing holes and open leads in the sea ice. Other seals are present near open water at the edge of the ice and can be hunted most successfully in spring and fall during migrations. Bearded seals weighing about 350 kg are the preferred take. Virtually the whole animal is used, whether it is bearded seal, spotted, or ringed. The meat and organs are eaten fresh or dried, blubber is rendered into oil, and hides are used for footwear, clothing and crafts. Some of the harvest may be used for dog food.

During winter, seal hunters usually use a snow machine to travel up to 80 km (50 miles) along the coast. As spring arrives, hunters began to rely on boats as soon as open water is available.

Polar bear and walrus are considered economically important to subsistence gathering. Walrus are hunted in open boats up to 65 km offshore. Polar bears are hunted in the spring and winter along the coast and on the ice pack. Virtually all of the animal is used for food, clothing, or crafts.

Boats are important to all fishing activities and to marine mammal hunts that occur from spring through fall. Boats are the only means available to scour the coastal area during the months when water is free of ice. The local road system is usable after the spring thaw, but it is limited, consisting of three short gravel roads leading to inland villages.

Nome residents harvest wild resources throughout Norton Sound, west to Bering Strait, and in all watersheds draining the south portion of the Seward Peninsula between Golovin Bay and Port Clarence. Harvest participation rates are high. A random sample by the Alaska Department of Fish and Game (ADF&G) in 1982 indicated that 95 percent of households use wild resources, and 43 percent of households depend on 10 or more different ones.

Based on a partial survey by ADF&G, Nome's total annual subsistence harvest fluctuates between 9,000 and 30,000 salmon and includes about 500 walrus, more than 200 moose, and about 8,000 king crab each year. There is no statistically reliable current estimate of total subsistence harvest for the community, but ADF&G did an excellent study in 1993 for Kotzebue, about 325 km north of Nome--a similar coastal regional center, with similar economic structure and similar demographics. There, the average household harvest was 634 kg and the average per-capita harvest was 182 kg, adjusted to usable weight.

Crab is a major commercial and subsistence fishery. During the summer when most of the harvest takes place, a boat is necessary to set and retrieve pots. About half the population participates in harvest of crab for subsistence purposes. Those with access to boats share the harvest with other members of the community. Virtually 100 percent of the population benefits from this traditional generosity.

1.9 Cost of Living

Two types of cost-of-living measurements are available for Alaska. The Consumer Price Index measures inflation, or how costs change over time. However, another type of measurement is necessary to find out how the cost of living in one area compares to that in another--Seattle to Nome, for example. The American Chamber of Commerce Research Association (ACCRA), and Runzheimer International (RI) studies are two sources of measurements sometimes used to compare the cost of living in one area against the cost of living in another. Also, Alaska's Cost of Food at Home Study (ACFHS), by the University of Alaska, measures the cost of feeding families of various sizes at different locations in Alaska. The surveys use different methods, so show somewhat different results. All three, however, support the idea that living in rural Alaska is far more costly than living in urban areas.

The ACFHS food basket provides a minimum level of nutrition to a family at the lowest possible cost. It uses widely dispersed locations over a long period of time, but measures only food and utility cost. The study has consistently shown that the highest food costs are found in isolated communities supplied primarily by air, such as Bethel, Dillingham, and Nome. Food costs are consistently 50 to 70 percent higher than in Anchorage.

The ACCRA study reviewed a list of 59 items over a fixed period of time. The average price in each urban area was converted to an index for the expenditure category. The study has been criticized for its limited number of sample items and the fact that it does not take State and local taxes into account.

Four Alaska cities are included in the latest ACCRA study for the 4th quarter of 1995: Anchorage, Juneau, Fairbanks, and Kodiak. Results show that Anchorage, Fairbanks, and Juneau all have a cost of living 25 to 35 percent higher than the average of all 24 cities in the nationwide study. Kodiak was 50 percent higher.

Runzheimer International (RI), under contract to the Alaska Department of Labor Workers Compensation Division, looked at comparable income necessary to maintain a certain standard of living for different areas of the country in 1995. In this study, a "base" family was created with two parents and two children. They recently purchased a 1,500-square-foot home with three bedrooms and 1.5 baths. They drive a 1992 car 16,000 miles per year. Family income is $32,000. RI indicates the cost of living in Anchorage, Fairbanks, or Juneau is up to 16.3 percent higher than non-Alaska cities surveyed.

ACCRA and RI indicate that the cost of living in Anchorage is at least 16 to 25 percent higher than in cities outside Alaska, and ACFHS puts Nome 50 to 70 percent higher than Anchorage. Field observations, and casual remarks of Nome residents that imply living in Nome is about twice the cost of living in Seattle, are taken seriously.

Unfortunately, incomes are not twice as high in Nome. Per capita income is about 12 percent higher among Nome residents than it is for the United States as a whole. This means that households have less cushion to equip them to survive systemic problems such as interruptions to the transportation system or other cost-imposing disruptions.

Another significant implication for this report is that the subsistence lifestyle is essential to human survival and plays a major non-cash role in the social and economic maintenance of the community.

1.10 Villages Serviced Through Nome

Nome has an airport capable of year-round jet service. It also has a protected boat harbor open about 6 months of the year. Because it has transportation infrastructure, Nome has developed as a regional center upon which villages in the region depend. Villages scattered through the interior and coast are not able to accommodate oceangoing barges that deliver supplies from Puget Sound ports; therefore, goods are transferred to lighters at Nome, where machinery, a work area, and warehousing exist. These villages receive shipments through Nome by water or air: Alakanuk, Brevig Mission, Chevak, Council, Deering, Diomede, Elim, Emmonak, Gambell, Golovin, Hooper Bay, Kotlik, Koyuk, Marshall, Mountain Village, Savoonga, Scammon Bay, Shaktoolik, Sheldon Point, Shishmaref, St. Marys, St. Michael, Stebbins, Teller, Unalakleet, Wales, and White Mountain.

1.10.1 Alakanuk.

Alakanuk is located in the southern channel of the Yukon Delta, 24 km inland from the Bering Sea. The presence of the village was first reported in 1899. The village and its population of 633, of which 96 percent are Natives, are scattered over a 5-km

stretch of the Yukon River. Villagers have always depended on subsistence as a way of life. The only year-round employment is in government jobs and a few retail services.

In the 1990 census there were 140 housing units, and the official unemployment rate was 27 percent. Sixty-one percent of the adults were not in the work force, and 29 percent of the residents were living below the poverty level. Seventy-four residents hold commercial fishing permits. Salmon make up the majority of the fish harvested. None of the harvest is processed at Alakanuk.

Alakanuk has an airstrip, and most passengers and mail arrive by air. There are no roads connecting Alakanuk with other villages, but the village is easily accessible from the Yukon River and Bering Sea. As with other isolated villages, people who live in the bush come into the village to wait for arrival of barges when delivery is expected. Delivery schedules are very uncertain, as weather delays and complications of reshipping can add many days to the schedule. Reshipping at Nome involves transfer of cargo to a smaller vessel, or lighter, which makes other stops in addition to Alakanuk.

Goods delivered by air are shipped through Nome. Even if goods are ordered from Anchorage, they must be reshipped from Nome, as the Alakanuk airstrip cannot accommodate the large air freighters that fly the Anchorage-to-Nome route.

1.10.2 Brevig Mission.

Brevig Mission is 105 km northwest of Nome on the shore of the Bering Sea at the mouth of Shelman Creek. Originally established in 1892 as a U.S. Government reindeer station, the Norwegian Lutheran mission became a dominant influence on the settlement as reindeer herding declined, and the village became known as Teller Mission or Brevig Mission.

Historically the Eskimos in the area lived in migratory communities and traded furs with Siberia, Little Diomede, and King Island. Between 1892 and 1974, reindeer herding provided the community with an economic base. The industry has since declined, and Brevig Mission, with its population of 261, recorded an unemployment rate of 35 percent in the 1990 census. At that time 54 percent of the adults were not in the labor force, and 25 percent of the population were living below the poverty level. The community had 64 housing units in 1990.

The residents, of whom 92 percent are Natives, subsist on moose, fish, reindeer, seal, and beluga whales. There are few year-round jobs; the school and city are the largest employers. One resident has a commercial fishing permit, and Native arts and crafts provide some cash income.

Brevig Mission is accessible by air and sea. One cargo delivery is scheduled annually by sea, and the airstrip allows year-round access by air. The nearest community is Teller, 8 km away by boat.

1.10.3 Chevak.

Chevak is located on the north bank of the Ninglikfak River, 27 km east of Hooper Bay in the Yukon-Kuskokwim delta. It has a population of 708. Eskimos have inhabited the area for thousands of years. Chevak is primarily an Eskimo village, with commercial fishing and subsistence important to its local culture and economy.

Employment in Chevak is at a peak in summer and declines to a few full-time positions during winter. Sixteen residents hold commercial fishing permits. There are 154 persons in the work force. The local unemployment rate is 18 percent. Local employment data shows 96 persons employed by government and 56 in the private sector.

The community has a State-owned airstrip, although Chevak is located near the Bering Sea where heavy rains and winds can preclude air access. The community has made relocation of the airport a local priority. There is no local road system, so people depend on skiffs in the summer and snow machines in the winter.

1.10.4 Council.

Council is 97 km northeast of Nome at the end of a gravel road usable in summer. The village was originally a summer fish camp used by the Fish River Tribe. When gold was discovered in the area in 1897, the population began to grow rapidly, reaching 15,000 at the peak. After the gold rush, the population began a decline; the Council post office finally closed in 1953. By the 1990 census there were 32 housing units in the community, but the population had become almost entirely seasonal subsistence gatherers. During winter months, only a few people live at the site.

1.10.5 Deering.

Deering, with its population of 141, is located on the north side of the Seward Peninsula about 180 km north of Nome. It is situated on a spit about 0.8 km long.

The village was established in 1901 as a supply station for gold miners. A nearby Eskimo village, now abandoned, pre-dated establishment of the supply station. The village of Deering is 94 percent Native, and the inhabitants depend heavily on subsistence. Handicrafts and trapping provide some cash income. In 1990 there were 141 people, with 42 percent not in the labor force. Twenty-two percent of the residents were living below the poverty level.

There are no roads linking Deering with any other village. There is a 797-m gravel airstrip. Goods are delivered to the village by a lighterage service during summer months.

1.10.6 Diomede.

Diomede is on Little Diomede Island, 218 km northwest of Nome and about 1.7 km from the international boundary with Russia. The population was 172 in 1990. It is a traditional village with a subsistence lifestyle dependent upon sea mammals, cod, crab, and birds. Seal and walrus hides are used to make personal clothing items and parkas, hats, mukluks, and furs for trade. Traditional clothing is still worn and skin-covered boats are still used there. The Native language is still in common use. Some mainland Natives go to Diomede during the winter to hunt polar bears.

Regular employment is limited to the city and school. Ivory carving is an active cottage industry. The island has neither an airport nor a boat harbor. Mail service is once per week by helicopter. Some float-equipped airplanes have landed on the open sea, and in winter ski-equipped planes land on the sea ice. A cargo barge stops at Diomede no more than once per year; lighterage service is available from Nome.

1.10.7 Elim.

Elim is on Norton Sound 155 km east of Nome. It has a population of 284, of which 92 percent are Native. The village is at the site of an original Eskimo village called Nuviakchak where a church and mission school were located in 1914. When the Alaska Native Settlement Claims Act was passed in 1971, the village decided not to participate and opted for title to 298,000 acres of land.

Today the economy is undeveloped, and most of the people depend on a subsistence lifestyle relying on fish, seal, beluga whale, reindeer, moose, and plant harvest. The only cash employment is fishing, city government, and the school. Forty-one residents hold commercial fishing permits. The village has 81 housing units. The unemployment rate is 36 percent, with 66 percent of the adults not in the work force. About 25 percent of the residents are living below the poverty level.

The village has a recently upgraded airport; air service between Nome and Elim is reliable. Though the village is located on Norton Sound, there is no dock. Freight is either flown in or delivered by lighter from Nome.

1.10.8 Emmonak.

Located near the mouth of the Yukon River, 16 km from the Bering Sea, Emmonak is within the Yukon Delta National Wildlife Refuge. The village is a center for commercial fishing, purchasing, and processing. Locally there are 104 commercial fishing permits. There are two fish processing plants. The processing industry is very

seasonal, as it is based on the salmon harvest. Salmon is also the main element of the subsistence harvest. During the summer, many residents move to fish camps nearer their traditional harvest areas, where they catch and air-dry the salmon to preserve them for winter consumption. Residents rely on trapping for other cash income.

Emmonak has a population of 784, and 92 percent are Native. There are 172 housing units. The unemployment rate is 35 percent, with 62 percent of the adults not in the labor force. Twenty-one percent are living below the poverty level. In this fairly large village, all goods must be brought in by air or water, as no roads connect Emmonak with other areas. All goods brought in by water are delivered by lighter.

1.10.9 Gambell.

Gambell is located on St. Lawrence Island, 323 km southwest of Nome and 58 km from Siberia. The island has been inhabited intermittently for 10,000 years or longer. In the 18th and 19th centuries, more than 4,000 people lived there in 35 villages. In 1990, the census showed a population of 636 in 132 housing units.

St. Lawrence Island, with 1.136 million acres, is jointly owned by the island's two villages of Gambell and Savoonga. They gained ownership by opting not to participate in the Alaska Native Claims Settlement Act in 1971. Ninety-six percent of the population are Native people, and they maintain their traditional language and lifestyle. Subsistence is based on harvest of marine mammals. Boats are made from driftwood covered with walrus hide. Subsistence supplies materials for construction, transportation, clothing, and crafts, as well as the kitchen table.

Seventy-one percent of Gambell adults are not in the work force, unemployment is at 17 percent, and 46 percent of the residents are living below the poverty level. There are few opportunities for year-round employment. Many of the Natives depend on fox trapping and ivory carving for cash income. One resident holds a commercial fishing permit. The island does not have a deep-draft harbor, so there is heavy reliance on lighters for cargo delivery. Air transport from Nome must be used when needs are urgent.

1.10.10 Golovin.

Golovin is 113 km east of Nome on Norton Sound. At the historical site of an Eskimo village, Golovin became a supply point for miners during the gold rush days. In 1887, the Mission Covenant of Sweden established a mission and school and began to run a reindeer herding operation. The herding operation continues as part of the community economic base, with fish processing and commercial fishing making up the balance.

Ninety-three percent of the population of 163 are Natives, and the traditional subsistence lifestyle prevails. Fish, beluga whale, moose, and reindeer are the main

sources of meat. Residents have 13 commercial fishing permits. Of the 49 housing units, about half are plumbed. Unemployment is 15 percent, and 44 percent of the adults are in the labor force. Eight percent of the residents live below the poverty level.

The community is located on the seacoast but it does not have a harbor, and no roads connect it with other areas. Goods are either flown in from Nome or delivered by a lighter that picks them up at Nome and unloads them on the beach at Golovin.

1.10.11 Hooper Bay.

The relatively large community of Hooper Bay is located 32 km south of Cape Romanzof and 40 km south of Scammon Bay in the Yukon-Kuskokwim Delta. The current population is 996.

Ninety-six percent of Hooper Bay residents are Natives. Commercial fishing and subsistence activities are the primary means of support. The 1990 U.S. Census counted 203 total housing units, and 13 of these were vacant. One hundred fifty-eight jobs were estimated to be in the community. The official unemployment rate at that time was 41.7 percent; 66.3 percent of all adults were not in the work force. The median household income was $18,125, and 43.5 percent of residents were living below the poverty level.

Most employment in Hooper Bay is seasonal, with peak economic activity in the summer and little income-producing activity during the winter. Forty-one residents hold commercial fishing permits. The 1992 Community Development Quota (CDQ) program has increased the pollock harvest. Residents of Hooper Bay rely on air and water transportation. The airstrip is owned and operated by the State. Barge lines deliver shipments of fuel and other bulk supplies throughout the summer. A commercial fishing dock is under construction.

1.10.12 Kotlik.

Kotlik, an Eskimo village practicing a fishing, trapping, and subsistence lifestyle, is located on the east bank of the Kotlik Slough, 56 km northeast of Emmonak in the Yukon-Kuskokwim Delta. Current population is 517. Ninety-seven percent of the population is Native. Residents of Hamilton, a nearby summer fish camp, also live in Kotlik. During the 1990 U.S. Census, there were 109 total housing units. Ninety-four jobs were estimated to be in the community. The official unemployment rate at that time was 36.6 percent, with 65.2 percent of all adults not in the work force. The median household income was $20,417, and 17.7 percent of residents were living below the poverty level.

Kotlik has a seasonal economy with most activity during the summer. Fishing and fish processing are the primary income generators. Seventy-seven residents hold

commercial fishing permits. Kotlik's residents rely heavily on subsistence foods. Income is also derived from trapping.

Air transportation of passengers, cargo, and mail is provided via the State-owned airstrip. There is no road access, though Kotlik is easily accessible by barge. The 50 or so commercial and private boats owned by residents use the river.

1.10.13 Koyuk.

Koyuk is located at the mouth of the Koyuk River at the northeastern end of Norton Bay on the Seward Peninsula, 145 km northeast of Nome. Current population is 280, with 94.8 percent of the population Native. The site of "Iyatayet" to the south has traces of early human occupation that are 6,000 to 8,000 years old. Prior to 1900 the village was nomadic, ranging within 32 km of the present site. Two boomtowns grew up in the Koyuk region around 1914: Dime Landing and Haycock. In addition to gold, coal was mined a mile upriver to supply steamships and for export to Nome. During the 1990 U.S. Census, there were 70 total housing units. Fifty-two jobs were estimated to be in the community. The official unemployment rate at that time was 37.3 percent, with 64.6 percent of all adults not in the work force. The median household income was $18,750, and 30.0 percent of residents were living below the poverty level.

The Koyuk economy is based on subsistence supplemented by limited part-time jobs. There is a small amount of commercial fishing, and some income is derived from reindeer herding. Eleven residents hold commercial fishing permits. The main sources of meat are fish, reindeer, seal, beluga whale, and moose. There are no roads connecting Koyuk with other villages, although a 29-km road to Six Mile Point is under construction. Access is limited to air and sea. There is a State-owned 615-m gravel runway, recently improved. Regular flight service from Nome and Unalakleet is available. Supplies arrive in Nome and are lightered to shore. There is no dock in the village, although the city has requested funds for a small boat harbor feasibility study.

1.10.14 Marshall.

Located on the east bank of the Yukon River, Marshall has a population of 318. The lower Yukon is ice-free from mid-June through October. Unemployment at the time of the 1990 census was 19 percent, and 17 percent of the residents were living below the poverty level.

The community has a school with 112 students. The economy revolves around summer employment opportunities in fish processing. Thirty-three residents hold commercial fishing permits. Subsistence activities are essential to residents.

Access to the community is by air or water, as there are no roads. The community has a 700-m airstrip. In winter, snow machines and dog teams are used.

1.10.15 Mountain Village.

Mountain Village, with a population of 738, is on the north bank of the Yukon River. The unemployment rate was reported in the 1990 census as 37 percent, with 24 percent of the residents living below the poverty level.

Eighty Mountain Village residents hold commercial fishing permits, with fish processing a summer employment opportunity. A road links Mountain Village with St. Marys, Andreafsky, and Pitka's Point. Cargo and passengers must be brought in from other locations by plane or boat.

1.10.16 St. Marys.

St. Marys is on the north bank of the Andreafsky River, 6 km inside Pitka's Point in the Yukon-Kuskokwim Delta. It has a population of 504. The river is ice-free from June through October. Unemployment has been reported at 19 percent, and 17 percent of the residents have been reported as living below the poverty level.

Seventy St. Marys residents hold commercial fishing permits, and the community has a cold storage facility. The community is served by barge; an expansion of the dock is under construction. A 1,800-m airstrip provides year-round access. A local road system links St. Marys with three other villages.

1.10.17 St. Michael.

St. Michael is located on the eastern coast of St. Michael Island in Norton Sound, 202 km southeast of Nome. The community has a current population of 351. Natives make up 91.2 percent of the population. St. Michael is largely an Eskimo population today, with strong historical Russian influences. Seal, beluga whale, moose, caribou, fish, and berries are important staples. During the 1990 U.S. Census, there were 78 total housing units. Seventy-four jobs were estimated to be in the community. The official unemployment rate at that time was 22.9 percent, with 60.6 percent of all adults not in the work force. The median household income was $23,194, and 20.9 percent of residents were living below the poverty level.

The St. Michael economy is based on subsistence food harvests, supplemented by part-time wage earning. Most cash positions are found in city government, the Indian Reorganization Act (IRA) council and village corporation, schools, and local stores. Eight residents hold commercial fishing permits, primarily for the herring fishery. Stebbins and St. Michael jointly manage a herd of reindeer.

St. Michael is accessible by air and sea only. The State owns an airstrip, and a seaplane base is available. Regular and charter flights are available from Nome and Unalakleet. St. Michael is near the Yukon River delta and has a good natural harbor, but no dock. Lighterage service is provided on a frequent basis from Nome, and St. Michael receives at least one annual shipment of bulk cargo. A 17-km road exists to Stebbins.

1.10.18 Savoonga.

Savoonga is located on the northern coast of St. Lawrence Island in the Bering Sea, 264 km west of Nome. The current population is 615, of which 95.2 percent is Native. It is a traditional Eskimo village with a subsistence lifestyle surrounding walrus and whale hunting. Most residents are bilingual. During the 1990 U.S. census, there were 129 total housing units, and 13 of these were vacant. Ninety-four jobs were estimated to be in the community. The official unemployment rate at that time was 14.7 percent, but 72.2 percent of all adults were not in the work force. The median household income was $11,339, and 50.9 percent of residents were living below the poverty level.

The economy of Savoonga is largely based upon subsistence hunting of walrus, seal, fish, and beluga whale, with some cash income. Fourteen residents hold commercial fishing permits, and a fish processing facility was recently completed. Reindeer harvest occurs, but the herd is not managed. Fox are trapped as a secondary source of income. Islanders are known for their quality ivory carvings. Birdwatchers provide some tourism.

Savoonga's isolated location, with no seaport and iced-in conditions during the winter, means a dependence on air transport. The State-owned airstrip is undergoing major improvements. Regular air service is available from Nome and Unalakleet. There is no dock, so supplies must be lightered from Kotzebue to Shishmaref and offloaded on the beach. Savoonga residents want a small boat harbor and dry dock.

1.10.19 Scammon Bay.

Scammon Bay is located to the north of the Askinuk Mountains on the Yukon-Kuskokwim Delta, 1 km from the Bering Sea. Current population is 425, of which 96.5 percent is Native. Scammon Bay is an Eskimo community that relies on fishing and subsistence activities. During the 1990 U.S. Census, there were 99 housing units. Seventy-three jobs were estimated to be in the community. The official unemployment rate at the time was 18.4 percent, with 60.1 percent of all adults not in the work force. The median household income was $15,179, and 40.7 of the residents were living below the poverty level. Employment in Scammon Bay focuses on commercial fishing, firefighting for the Bureau of Land Management, and various construction projects. Forty-nine residents hold commercial fishing permits. Subsistence activities provide fish, beluga whale, walrus, seal, birds, and berries.

Scammon Bay is accessible by air and water. A State-owned airstrip and city-owned seaplane base serve air traffic. Barges bring in bulk supplies each summer. Winter trails connect Scammon Bay with Hooper Bay.

1.10.20 Shaktoolik.

Shaktoolik is located on the east shore of Norton Sound, 202 km east of Nome. The current population is 231, of which 94.4 percent is Native. It is an Eskimo village with a fishing and subsistence lifestyle. Resources include seal, beluga whale, caribou, reindeer, moose, and fish. The 1990 U.S. Census found 58 housing units. Forty-seven jobs were estimated to be in the community. The official unemployment rate at that time was 31.9 percent, with 54.4 percent of all adults not in the work force. The median household income was $18,438, and 22.8 percent of residents were living below the poverty level.

The Shaktoolik economy is based on subsistence supplemented by part-time wage earning. Commercial fishing is increasing and provides a major source of income. Development of a new fish processing facility is a village priority. Thirty-six residents hold commercial fishing permits. Reindeer herding also provides income.

Shaktoolik is accessible primarily by air and sea. A State-owned airstrip allows regular air service from Nome, and plans are under way to relocate the airport. Summer travel is by motorbike, truck, and boat; winter travel is by snow machine and dog team. Cargo is barged to Nome, then lightered to shore. The community has no docking facilities.

1.10.21 Sheldon Point.

Sheldon Point, with a population of 177, is on a south fork of the Yukon River. In the 1990 census, unemployment was 13 percent, and 56 percent of the residents were living below the poverty level.

Commercial fishing is the economic foundation, with 27 residents holding commercial fishing permits. Sheldon point has boat and barge access. It also has a 700-m airstrip and floatplane landing sites at Kwemeluk Pass and Swan Lake. In winter, snow machines serve as the primary mode of inter-village transportation.

1.10.22 Shishmaref.

Shishmaref is located on Sarichef Island about 8 km from the mainland. The island is 203 km north of Nome and about 161 km southwest of Kotzebue. Shishmaref is surrounded by the 2.6-million-acre Bering Land Bridge National Reserve. It has been proposed as part of the Beringian National Heritage Park. Archeological evidence exists that the site has been inhabited for several centuries. In 1900 a supply center

was established at Shishmaref to serve gold mining activities on the Seward Peninsula. Originally named Keekektuk, the village was renamed by the Russians in 1816.

Population of the traditional Eskimo village is 537. The people depend on a fishing and subsistence lifestyle. There are few year-round jobs, and only one resident holds a commercial fishing permit. Villagers rely on sea mammal harvests and management of two reindeer herds. Reindeer skins are tanned locally, and meat is available from the village store.

The village's primary transportation link is by air, with charter and freight service coming from Nome. Local boats are used for trips to the mainland, but there is no improved local boat harbor.

1.10.23 Stebbins.

Stebbins is located on the northwest coast of St. Michael Island, 193 km southeast of Nome. The current population is 507. During the 1990 U.S. Census, there were 87 total housing units. Ninety-six jobs were estimated to be in the community. The official unemployment rate at that time was 39.2 percent, with 64.0 percent of all adults not in the work force. The median household income was $23,333, and 32.3 percent of residents were living below the poverty level.

The Stebbins economy is based on subsistence harvests supplemented by part-time wage earnings. The city government and schools provide the only full-time positions. Reindeer herding was important in the past, and there is still an unmaintained herd on Stuart Island. The commercial herring fishery has become increasingly important, including fishing on the lower Yukon. Twenty-one residents hold commercial fishing permits. Residents subsist upon fish, seal, reindeer, and beluga whale.

Stebbins is accessible by air and sea. There is a State-owned 701-m turf runway. Regular flights, charters, and freight services are available from Bethel. A cargo ship brings supplies annually. There is no dock, and lighterage of goods to shore is provided out of Nome. Overland travel in the winter is by snow machine.

1.10.24 Teller.

Teller is located on the Seward Peninsula, 116 km northwest of Nome. The current population is 278, of which 86.6 percent is Native. Teller is a traditional Eskimo village with a subsistence lifestyle derived from seal and beluga, fish, reindeer, and other resources. In the past, caribou roamed the area. During the 1990 U.S. Census, there were 88 total housing units, and 20 of these were vacant. Fifty-eight jobs were estimated to be in the community. The official unemployment rate at that time was 3.3 percent, but 38.9 percent of all adults were not in the work force. The median

household income was $20,000, and 32 percent of residents were living below the poverty level.

Teller has a road link to Nome from May to September and is easily accessible by sea and air. There is a State-owned 800-m gravel runway with regular flights from Nome. There is no dock; goods are lightered from Nome and offloaded on the beach.

1.10.25 Unalakleet.

Unalakleet is located on Norton Sound at the mouth of the Unalakleet River, 239 km southeast of Nome and 637 km northeast of Anchorage. The current population is 798. The village site has dated house remains from 200 B.C. The village was a historic trading center as the terminus for the Kaltag Portage, an important winter route connecting to the Yukon River. The community has an active economy that centers on commercial fishing and subsistence. One hundred twenty-one residents hold commercial fishing permits. A fish processing plant is under construction. Government and school employment provides stability for the economic base. A herd of musk oxen is maintained near Unalakleet, and the wool is spun and hand-knit by Natives into garments.

Unalakleet has a State-owned runway with regular flights from Anchorage. Cargo is delivered by water using lighters from Nome. There are no road connections with other villages, and most overland travel is by all-terrain vehicles, snow machines, and dogsleds in the winter.

1.10.26 Wales.

Wales is located on Cape Prince of Wales at the western tip of the Seward Peninsula, 179 km northwest of Nome. Current population of Wales is 154, of which 88.8 percent is Native. Wales has a strong traditional Eskimo whaling culture. Ancient songs, dances, and customs are still practiced. In the summer, Diomede residents travel between the two villages in large, traditional skin boats. During the 1990 U.S. Census, there were 66 total housing units, and 17 of these were vacant. Forty-six jobs were estimated to be in the community. The official unemployment rate at that time was 19.3 percent, with 53.5 percent of all adults not in the work force. The median household income was $15,000, and 35.2 percent of residents were living below the poverty level.

The economy of Wales is based on subsistence hunting, fishing, trapping, Native arts and crafts, and some mining. A private reindeer herd is managed out of Wales, and local residents are employed to assist in the harvest.

Wales can be reached by air and sea only. There is a State-owned 800-m gravel airstrip, and planes frequently use the ice on the straits in winter. Scheduled and charter flights are available. A cargo ship delivers goods to Nome which are then

lightered to Wales. Skin boats are still a popular method of sea travel, and snowmobiles are used in winter.

1.10.27 White Mountain.

White Mountain is located on the west bank of the Fish River on the Seward Peninsula, 102 km east of Nome. The current population of White Mountain is 212, of which 87.8 percent is Native. White Mountain is an Eskimo village, with historical influences from the gold rush. Subsistence activities are prevalent. During the 1990 U.S. Census there were 69 total housing units, with 11 of them vacant. Thirty-five jobs were estimated to be in the community. The official unemployment rate at that time was 36.4 percent, with 67.3 percent of all adults not in the work force. The median household income was $15,893, and 38.3 percent of residents were living below the poverty level.

The population of White Mountain depends on subsistence hunting and fishing, and most spend the entire summer at fish camps. The school, Native store, and White Mountain Lodge provide the only local employment. Construction outside of town and firefighting provide seasonal employment. Five residents hold commercial fishing permits. Ivory and bone carvings contribute some cash.

Access to White Mountain is by air and sea. There are no roads. The airport is operated by the State, and scheduled flights are available daily from Nome. The village has no dock. Supplies are lightered from Nome and offloaded on the beach. Cargo barges cannot currently land at White Mountain. Residents are interested in a road to Golovin to permit fuel deliveries, or the construction of a docking facility for barges.

2. WATERBORNE COMMERCE

2.1 General

The city of Nome and the harbormaster 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 post-1990 period was used in this analysis because the fee structure, harbor management, and records for that period appeared to be in excellent shape.

During the 1990-to-1996 period, annual tonnage through Nome Harbor averaged 51,070 tons. This included 22,100 tons of non-fuel cargo and 28,970 tons of fuel. In years when fuel deliveries have been reshipped from Nome, this includes about 1,500 tons of fuel that is transferred to a tank farm at Nome and reshipped to villages. The amount of fuel reshipped to villages has varied from zero to about 2,100 tons during the last 5 years. The variation is explained in three ways:

- A lighter accompanies some of the large line-haul barges that deliver fuel, and the lighter offloads at each village, eliminating the need to transfer fuel at Nome.

- The line-haul shipments or lighter connections are delayed and arrive late, so village delivery cannot be made before freezeup.

- Air transportation is used in anticipation of delivery problems due to weather or equipment situations.

Table B-1 shows a summary of activity at the Nome inner harbor. It includes an estimate of fishing fleet activity based on one trip per day during the season, less 30 percent for weather days. There were 43 docking permits for the season. On some occasions, fishing boats tie up to the causeway when tug-and-barge activity requires available inner harbor space.

2.2 Gravel and Quarry Stone Shipments

Nome is a source of gravel and quarried stone construction materials for western Alaska. It is the site of a high-quality quarry located within 19 km of the harbor on a haul road with little other traffic. The nearest alternative quarry is located at St. Paul Island, about 800 km from Nome. The Nome quarry has recently provided rock for projects at Shemya, Diomede, Emmonak, Alakanuk, Point Hope, and McGrath.

TABLE B-1.-- *Nome harbor activity (annual average for 1994, 1995, 1996)*

Vessel category	Number of trips
Bulk cargo and fuel	33
Construction equipment and supplies	26
Tugs only	7
Fishing fleet	3,600
Miscellaneous non-permitted	24
Cruise ships	1
Government	1
Total trips	**3,692**

The quarry produces granite, and the rock source is known to be at least 8 km long at the surface. The quarry is able to produce stone in the 20-30 ton range. The land is owned by Sitnasuak Native Corporation, the subsurface rights are owned by Bering Straits Native Corporation, and Knik Construction has a royalty lease on production rights. The Nome quarry is a likely competitive source for coastal construction throughout western Alaska.

The quarry operator has a business plan that includes development of a barge loading facility when tonnage reaches the 20,000-30,000-ton level. At that point, it will become cheaper to construct the facility than to haul to the Nome causeway at $5-$7 per ton, plus $3 for handling and loading at the causeway and $1 for port fees. The potential quarry barge loading site is in a weather-exposed setting and would likely require breakwater protection. One oceangoing barge recently caught at the site by bad weather sank before it could be moved to a protected moorage. Use of the Nome harbor in the long run becomes an attractive alternative even at high tonnage levels only if it can be developed as an all-weather facility.

The haul road from the quarry to Nome is a handicap to shipping stone out of the Nome harbor, as the bridges have a practical load limit of about 35 to 36 tons. Also, in wet conditions the road becomes difficult to maintain over the entire 19-km distance.

In 1997, about 11,000 tons of quarry stone was hauled out from the causeway. In some years, quarry stone shipments are zero. Quarry production depends on construction needs, and it is impractical to stockpile intentionally in anticipation of winning a bid, since stone specifications vary from one job to another.

Annual shipments of 6,300 tons of gravel were made over the 1991-1995 period. These production levels may rise, as indicated by an Alaska Department of Transportation and Public Facilities (ADOT&PF) analysis of future transportation needs related to harbor and airport development in western Alaska. ADOT&PF has developed a priority list of projects that could be potential users of quarry stone and/or gravel from the Nome area.

Of 160 airport construction or reconstruction jobs listed as future workload by ADOT&PF, eight in the priority 1 classification fall within the Northwest Arctic Borough, the political subdivision that includes Nome. Also within the borough are six State-funded port and harbor projects. In addition to the 14 "local" projects, many of the others are at coastal locations that could be reached using barges out of Nome. Actual estimates of requirements for stone and gravel are not available, nor have actual construction sources been identified. The nature of arctic construction in permafrost zones is that gravel blankets are needed, and therefore gravel requirements are greater than for similar projects in less severe climates.

The State's list of projects is the result of interagency review and evaluation, so the projects have survived a prioritization process. There are numerous challenges and financial restraints in implementation of any of the projects; they are expected to develop over a number of years. In addition, ADOT&PF is reviewing and updating the list of projects, and it is anticipated that coastal port improvements in western Alaska will be prominent on the list. The current ADOT&PF list of potential projects includes numerous opportunities in western Alaska. Clearly, the State has established development of transportation infrastructure as a priority. The emphasis on transportation projects that will be heavy users of gravel and stone supports a projection of stable, long-term shipping of stone and gravel, generally equivalent to 12,600 tons per year of gravel and 22,000 tons per year of quarry stone.

Another local source of gravel has been a popular supply of construction material for outlying villages. This year two shipping companies have been delivering gravel to Bethel, Hooper Bay, and Chevak from Nome. The gravel, tailings from past dredging operations, is owned by Alaska Gold. The tailings are in convenient piles a very short haul from the causeway. Local contractors deal with the shippers, and Alaska Gold sells the tailings.

2.3 Modular Housing Shipments

Housing stock among the villages served from Nome is characteristically different from housing found in urban areas such as Anchorage. Typically the houses are very small, due to the high heating cost and high cost of materials. Because of permafrost conditions, which make construction and maintenance of modern water systems very costly, a relatively high percentage of them lack inside plumbing. Because replacement costs are high and population growth has been low, the housing stock has expanded very little from year to year.

State, Federal, and local government agencies have implemented effective programs for improving the quality of housing. The cost-effective solution that seems to work best is to import modular units by barge. The units are shipped into Nome, transferred to lighters, and shipped to the villages. The Bering Straits Housing Authority, the main agency providing public housing in the study area, has established a long-term projection for replacement modular housing. The projection is essential to

formulating the agency budget and coordinating the regional program with the State and Federal programs. The coordinated projection identifies "annual needs being met" at 20 units annually, all of which will be shipped through Nome.

2.4 Fuel Oil

Each year about 8 to 11 million gallons of fuel come into Nome. About 600,000-800,000 gallons of it is reshipped to the villages by water. The cost of shipping it by water includes dock transfer fees and transshipping via lighter. The cost of transportation between Puget Sound and Nome is about equal to the cost of transportation from Nome to the villages. Fuel requirements are expected to grow at the rate of 1 percent annually as a result of long-term population trends. Upgrading of housing stock will conserve some of the future energy needs, but future economic growth and higher living standards will introduce greater energy demands.

3. WITHOUT-PROJECT CONDITIONS FOR THE NOME-BASED FISHING INDUSTRY

3.1 The Nome-Based Fishing Industry

Historically Nome has not been a commercial fishing port, with the exception of a local small-boat fleet of subsistence fishermen. For subsistence purposes, salmon harvest can take place from the beach or inside the river mouths, so large boats have not been a requirement. In the past, Nome has had no processing stations, so when there have been local commercial harvests, they have been flown out. Lack of a local processing station and the high cost of air transportation have discouraged formation of a local small-boat commercial salmon operation. Regarding harvest of other species, such as halibut, sablefish, cod, and crab, the local fleet has been in competition with larger catcher-processor vessels. The situation is now changing with construction of a local processing plant and introduction of fishing regulations that reserve quotas for the local fleet.

The new fish processing plant is just one of many changes resulting from a new quota program that gives communities a flow of capital from the fishing industry. The quota situation changed drastically for many Western Alaska coastal communities, including those of Norton Sound, in three significant ways between 1992 and 1995:

- Creation of a Community Development Quota (CDQ) program.
- Creation of an exclusive Norton Sound crab fishery, referred to as a "super exclusive" zone.
- Creation of individual fishing quotas (IFQ) for halibut and blackcod.

3.2 Community Development Quota

Prospects for commercial fishing activity began to change in 1992 when a Community Development Quota (CDQ) was implemented. The CDQ program thrust participating western Alaska communities into a partnership with the multi-million-dollar Bering Sea groundfish industry. In contrast to their traditional subsistence and small-boat commercial fisheries, western Alaska residents were suddenly extended the opportunity to work aboard the fishing boats and in the factories as partners with the industry.

Leverage for the communities to participate in the industry was established by granting harvest rights to the communities. The potential economic value of the pollock quotas allowed the structuring of partnerships between corporations established to represent the communities on one side, and experienced harvesters and processors on the other. The partnerships allowed a flow of capital to the participating

communities, and the capital has been used to establish and expand fishing fleets and local support facilities.

The concept of CDQ's emerged in the mid-1980's as the Bering Sea groundfish, which had long been dominated by foreign nations, finally became profitable for the domestic fishing industry. The CDQ idea is a regulatory concept implemented through the North Pacific Fisheries Management Council. The Department of Commerce structures the CDQ program to give the Governor lead responsibility in recommending who would receive quotas, with final approval.

The Norton Sound Economic Development Corporation (NSEDC) is a private corporation formed for the purpose of administering CDQ for 15 Norton Sound communities. The objective of the NSEDC is to provide fishing opportunities, jobs, and income to develop self-sustaining economies. The CDQ program is administered under a combination of State and Federal rules involving the office of the Secretary of Commerce and the Governor. These are the 15 NSEDC communities:

Brevig Mission, Gambell, Nome, Shaktoolik, Unalakleet, Diomede, Golovin, St. Michael, Stebbins, Wales, Elim, Koyuk, Savoonga, Teller, and White Mountain.

The total population of these communities in 1990 was 7,621 in 2,238 households. To be eligible for the CDQ program, communities must meet these criteria:

- Be located within 50 miles of the Bering Sea coast
- Be identified as a Native village in accordance with the Alaska Native Claims Settlement Act
- Conduct more than 50 percent of their commercial and subsistence fishing in waters of the Bering Sea
- Have not previously developed harvesting and groundfish processing capability in groundfish fisheries of the Bering Sea

3.2.1 Potential Development Impacts.

The Bering Sea pollock fishery is one of the largest in the world. Annual harvest is 1.3 billion kg, with a value of more than $200 million. Prior to implementation of the program, 94 percent of the value of the fishery was accrued by non-Alaskans, and western Alaskans captured virtually none of the value. By setting aside 7.5 percent of the quota for harvest by those regions bordering the Bering Sea, the CDQ program has capital for development in an economically depressed region.

The economic impacts of the CDQ program must be assessed in the context of life in western Alaska. Within the State, 56 communities meet criteria for participation in the CDQ program, representing a population of 21,037. According to 1990 census data, 76 percent are Natives. Poverty and unemployment are chronic. In 1990, more than 25 percent of the population of the CDQ communities lived below the poverty level, more than twice the State rate. Unemployment ranged as high as 31 percent. In

many of the communities income is half the State level, but the cost of living can be twice as high.

Non-economic standards also portray the regions under development. Much of the housing is substandard, and utilities that most U.S. citizens take for granted, such as water, sewer, and telephones, are in short supply. In more than half the communities, 5-gallon buckets or outhouses remain the primary means of sewage disposal. Three-quarters of the locations do not have piped water and sewer available to at least half the homes in the community. The results of these conditions are poor health conditions, high rates of infectious disease, and low living standards. This profound state of underdevelopment is the background for this economic evaluation.

3.2.2 Early Results of the CDQ Program at Norton Sound.

Since its inception in 1992, Norton Sound Economic Development Corporation (NSEDC) has administered the CDQ program to the clear benefit of the communities involved, creating or enhancing direct opportunities for employment in 674 jobs, with direct earned income of $6,073,486. The NSEDC plan is designed to manage opportunities of the CDQ program to produce future employment gains at least equal to those of the past.

Programs that support development and/or increased reliance on Nome Harbor are related to education and training, retention and addition of permits, fisheries rehabilitation and enhancement, development of local infrastructure, and revolving loan programs for fleet development. NSEDC has loaned out $400,000 among 75 local fishermen to help them purchase gear and permits, and has invested $489,000 in community infrastructure. The NSEDC has provided $1,350,000 for a fund to be used for purchase of Individual Fishing Quotas (IFQ) as they become available. NSEDC has also purchased a 42-m long-line/freezer vessel, and is actively involved in development of a processing vessel in partnership with Glacier Fish Company.

Salmon restoration has been allocated $250,000 of NSEDC funds, and NSEDC is proposing to contribute another $507,000. Education endowments for the purpose of increasing employment opportunities have received $2.9 million, which has grown to $3.3 million. To complete the transition to self-sustaining fisheries in Norton Sound, NSEDC has established a separate, wholly owned entity called Norton Sound Seafood Processors, and will invest an additional $1 million to cover working capital demands of expansion. The company conducts commercial seafood activities including salmon, herring, halibut, winter and summer king crab, and bait fisheries.

The largest dollar activity for NSDC is establishment of a fund for purchase of equity ownership in firms already having business operations in the Bering Sea. This activity calls for an investment of $7.5 million.

NSEDC is planning to distribute funds from the CDQ operations to development programs and subsidiaries over the remaining years of this century. The NSEDC economic development program is outlined in table B-2.

TABLE B-2.—*NSEDC Economic Development Program*

Program	Amount (Rounded $000)
Fisheries development	300
Education, employment, training	804
Revolving loan program	300
Shoreside infrastructure	1,350
Salmon restoration	507
Education endowment	1,095
CDQ harvest	994
Administration	780
Norton Sound Seafoods	1,000
Harvesting capital investment fund	6,500
Fund for equity purchase	7,500
TOTAL	**$21,780**

Immediate fleet expansion plans include addition of two vessels: a harvesting/ tendering vessel that would target open-access crab and then harvest CDQ stocks during other periods, and a deep-water trawl vessel. During salmon seasons, the harvest/tender vessel would operate exclusively as a tender. The vessel's overall length will be 45.7 m, and its capacity is 159,000 to 227,000 kg. During the crab harvest, it will carry a 6-person crew and work 250 pots. Cost is estimated at $4,000,000, including $500,000 for gear. The trawler will have an overall length of 61 m and a holding capacity of 591,000 kg. It will carry 40 crewmembers and is expected to cost $7,000,000 including gear.

3.3 Norton Sound "Super-Exclusive" Crab Fishery

In addition to the CDQ, the North Pacific Fisheries Management Council has developed a regulatory amendment creating what is referred to as a "super-exclusive" crab fishery in Norton Sound. Generally the regulation forbids boats to harvest in more than one area, with all of Norton Sound being identified as one area. The effect is to keep crab boats fishing in the waters that are most productive to them.

Crab stocks are denser in the deeper waters outside Norton Sound, so large crab boats tend to be more profitable in those waters. Prior to the initiation of the "super-exclusive" concept, the larger boats would occasionally fish in Norton Sound, setting a huge number of pots over a wide area. They could home in on the areas where the take was best. Now, with the "super-exclusive" rule, the fishery is reserved for the smaller shore-based boats (usually 9.9-12.9 m), as they do not fish the waters far offshore preferred by the large boats. The effect is to reserve Norton Sound king crab for boats that fish out of Nome Harbor. The "super-exclusive" concept does not keep boats from calling at Nome; it merely forces them to choose the waters they wish to

fish. If they elect to fish in Norton Sound, they are not allowed to fish other waters, and if they fish other waters, they cannot fish in Norton Sound.

In 1994 and 1995, NSEDC processed 38,200 kg and 25,900 kg of red king crab respectively. The ADF&G has been managing the resource in a way that will allow it to recover from recent stock declines. The management strategy is paying off in higher stocks, and the ADF&G 5-year outlook for crab harvest in Norton Sound is 150,000 kg annually. Beyond 5 years, the Norton Sound outlook is for a harvest of 227,000 kg annually.

In 1994 and 1995, all crab processed in the Norton Sound area were supplied by local NSEDC fishermen. Processing capacity has been a limiting factor in production, and most of the crab is iced and flown out to fresh markets. New facilities are being planned at Nome to ensure continued involvement in crab processing, and funds have been allocated by NSEDC to start construction.

The planned processing facility is being developed as a shoreside plant for multi-species processing. It will be equipped to handle crab processing based on assumed rebound of Norton Sound stocks to the 227,000-kg harvest level as anticipated by ADF&G, plus up to 1.36 million kg of blue king crab from the Bering Sea fishery. A site selection evaluation has been completed, and arrangements have already been made to locate the facility at Nome Harbor.

The plant will be completed prior to modification of Nome Harbor. The larger harvest boats that fish farther out for *bairdi* tanner and blue king crab later in the year will access the plant by offloading at the causeway. They will expect to incur added handling cost compared to the with-project condition because vessels will be exposed to sea conditions at the causeway, and offloading will be interrupted. Interruptions will impact other boats in the queue, all of which will be required to wait for an open, usable space at the dock. Waiting cost per boat is estimated at $7,450-$7,980 per day.

In 1996 and 1997, a Russian fleet harvested crab in Russian waters, and in the opinion of ADF&G, serious over harvesting has occurred. The activity has put so much crab on the market that prices have settled in the range of $4.40/kg, down from as high as $9.90. Prices generally have averaged about $8.80 in recent years. In the opinion of ADF&G, the market is expected to revert to its historical price structure in the next year or two, because Russian crab cannot continue to be harvested in sufficient quantity to continue to influence prices without endangering the fishery. Either the government will need to apply some control to the industry, or numbers harvested will naturally decline. Either way, the harvest will stabilize to a long-term equilibrium, and long-run prices will again prevail.

The Norton Sound crab fishery is a limited entry fishery, with the number of permitted vessels limited to 86. A long-run harvest of 227,000 kg annually, as predicted by ADF&G, and a stabilized price of $8.80/kg will provide the NSEDC fleet with gross income of $2,000,000.

3.4 Salmon Fishing Developments

For the Norton Sound area, the annual commercial salmon harvest by all harvesters averaged 328,079 fish during 1980-94, according to NSEDC. None of it was locally processed for commercial sale. The average harvest for the 1990-94 period was 372,092 fish. NSEDC devised a four-part program to develop a self-sustaining salmon fishing and processing industry in Norton Sound, including:

- A first-year incentive system
- Gear loans, supplies, and coordination support
- Required icing, bleeding, and careful handling
- Development of new markets

NSEDC created a new market by producing frozen fillets and blocks from pink salmon, previously treated as a noncommercial species in Norton Sound. In 2 years, the market for locally processed pinks developed from zero to $446,000 for 77 local fishermen. By the end of 1995, NSEDC was processing all salmon commercially caught in Norton Sound. Local processing of the harvest is expected to happen rapidly under the NSEDC plan and stabilize at sustainable levels. For this report, the sustained production is estimated at $1,000,000 annually, due to a doubling under the auspices of NSEDC initiatives. Because of location advantages, Nome has become a seasonal home port for a significant share of the salmon fleet. It has also become a candidate site for development of a salmon smoking facility that will target a retail and catalogue niche market. The smoking facility will add jobs to the community and bring in dollars from outside sales.

3.5 Crab Fishery in the Adjacent Bering Sea Waters

In the area known as "the St. Matthew Island section of the Northern District of the Bering Sea," the annual king crab harvest for 1990-1995 has been 1,454,000 kg per year. This is a deep-water fishery too far from shore for the Nome-based day fleet to target. The resource is of great potential economic value to Nome, however, as with suitable harbor improvements and processing infrastructure, Nome can serve as an alternative port to Dutch Harbor and St. Paul for vessels that fish waters closer to Nome.

Both St. Paul and Dutch Harbor serve as ports for the red king crab fishery in the St. Matthew Island section of the northern Bering Sea. The next fishery targeted by these boats is Bering Sea *bairdi* tanner crab, which opens about November 1, or St. Matthew Island blue king crab, which begins at the same time. Stocks of blue king crab are known to exist at the far northern limits of the region in the vicinity of King Island, and this fishery is very close to Nome.

The ADF&G controls the location of the *bairdi* tanner crab fishery. Based on data from ADF&G,[1] an anticipated annual harvest is 2.5 million kg for a season that will last about 7 days. The harvest will involve half of the approximately 180 boats that fish for crab during November; the other half target blue king crab. The *bairdi* tanner season may involve either the eastern or the western subdistrict of the Bering Sea. The eastern subdistrict reaches to Norton Sound and farther north to the Bering Straits. Boats that intend to fish in the northern half of the eastern subdistrict for either *bairdi* tanner or blue king crab will be closer to Nome than to either St. Paul or Dutch Harbor. The possibility of delivery to a processor at Nome, therefore, would present an option allowing the vessels to finish the season at the northern limit of their harvest area. This would cut additional time from the delivery run and minimize deadloss during transit. It would also provide a time and cost saving over delivery to Dutch Harbor or St. Paul Island.

The fleet's annual harvest of *bairdi* tanner crab has ranged in size during 1992-1996 from a high of 15.6 million kg to a low of 0.85 million kg. Fishing regulations currently in effect are designed to keep the long-term average harvest in the range of 2.5 million kg for the foreseeable future. Harvest of blue king crab in the St. Matthew fishery produces about 1.36 million kg annually. This is in addition to the Norton Sound red king crab, projected to be stable at 227,000 kg annually.

3.6 Halibut Fishery and Controlled Access

The two most common methods of controlling access to commercial fishing are limited entry, which limits the number of permits issued but not the catch per vessel, and IFQ, which assigns a specific share to each operator. Other less common methods include taxes and fees to force less efficient vessels out, restrictions on type of gear allowed, and restrictions on vessel size.

The halibut fishery is better tailored for an IFQ system than some other fisheries such as salmon, which must be harvested during brief concentrated runs with less predictability. The program has the following advantages for halibut:

- Stock levels can be predicted well in advance.
- Short seasons can be eliminated, and harvest can take place throughout much of the year.
- Expanded fishing windows introduce improved safety.
- Less rush means better quality.

About 85 percent of the world's halibut comes from Alaska waters. Annual ex-vessel value has ranged from $50 million to $100 million.

In the 1940's, the season lasted about 200 days. By the 1960's, it was down to about 100 days, and during the 1980's it shrunk to about a week in length. During the late

[1] "Bering Sea and Aleutian Islands King and Tanner Crab Management Historic Overview and Preliminary Summary of 1995/1996 Fisheries," ADF&G.

1980's and early 1990's, there were times when the season was only 2 or 3 days long, because that is all the time the large number of vessels needed to harvest the stocks.

Over the last 20 years the number of vessels in the fishery has doubled, and the number of the most efficient boats, "long-liners," has tripled, though boats under 12.3 m still make up more than half the fleet. Without IFQ, the large number of boats (about 5,484) would take the allowable harvest in a matter of hours.

The rush to be involved in the harvest sometimes means venturing out in hazardous conditions. Even in the best conditions, the short seasons result in jams at the processing stations while boats compete to unload their catch while it is still fresh.

3.7 Halibut Harvest Opportunities

Harvest opportunities are expected to change drastically. With IFQ, the season length jumps from a few days to several months. Holders of IFQ are able to fish anytime during the year, and there is no particular time that favors catching halibut. In the introduction of the IFQ program, windfalls were avoided by allocating IFQ to everyone who fished during the 1988-90 period. Using a scheme that resulted in relatively small quota shares encouraged a large initial fleet. Because IFQ can be bought and sold, and because there are economies to be achieved in fishing larger blocks of IFQ, the fleet will almost certainly consolidate to some degree. Programs such as the NSEDC IFQ Investment Fund will provide fishermen the capital necessary to purchase IFQ to enhance local fleet operations.

Based on an established market in Canadian IFQ's, which has existed since 1991, a unit of IFQ is worth about three times the value of the fish it can bring aboard the boat in a year. There are ownership caps to prevent excessive consolidation, so the traditional size makeup of the fleet is not expected to change drastically, except that the total number of vessels will be reduced.

The halibut IFQ's issued to vessels in the Bering Sea are all for vessels below 12.9 m. The area quota is 350,000 kg, but it is distributed among vessels home-ported at other places as well. In this report, predictions of gross income are tied to an IFQ purchase program initially funded at $1,350,000. With provisions for continuation, it could provide Nome fishermen with $2,700,000 for the purchase of halibut IFQ in the next 5-10 years. By the time an improved Nome harbor is in operation, the halibut IFQ program would be bringing in an estimated $900,000 in ex-vessel value to Nome-based operators.

Since the Nome fleet will fish on unsheltered waters of the Bering Sea but generally less than 2 days from Nome, it is anticipated the active fleet will consist of existing combination boats generally less than 12.9 m in length.

3.8 Pollock Harvest

Based on harvest history and prices during the 1992-95 period, NSEDC predicts an annual 33,000-ton harvest and expects to receive $7,260,000 annually for its allocation. The business plan is based on a total CDQ allocation of 100,000 metric tons annually, of which NSEDC is allowed 44 percent. Royalty payments have been established at $220 per metric ton each year.

NSEDC has an agreement with Glacier Fish Company, which allows use of the company's equipment and expertise for the harvest and provides employment opportunities for local residents. The agreement has proven effective in harvesting 100 percent of the CDQ allocation.

The pollock harvest will provide a flow of income to NSEDC. This is the primary source of funding for expansion of the fishing industry at Nome. The pollock fleet, however, is a deep-water, distant shore fishery, and will not need support from Nome Harbor.

4. WITHOUT-PROJECT CONDITIONS FOR NOME-BASED COMMERCIAL FISHING FLEET, PRESENT AND FUTURE

4.1 Commercial Fishing Income to Nome-Based Operators

Operating budgets for fishing boats vary depending on the type of boat and number and type of fisheries in which it is used. There are no known published studies of operating cost specifically for vessels using Nome Harbor, so rather than create a new data base we have elected to use reliable data from a very large population having fleet characteristics similar to the Nome fleet. Specifically, the Nome-based fleet is similar to the statewide halibut fleet in size, distribution, design, and target fisheries. Halibut boats are designed for use in multiple fisheries because the historically short duration of halibut seasons has created the practical requirement that boats must be able to harvest in other fisheries to cover costs and produce net income. The boats typically spend part of the season fishing for crab, herring, cod, or salmon.

Total fleet size is drastically different, with the overall halibut fleet outnumbering the Nome fleet by about 100 to 1, but it is the large number of halibut vessels that allows a greater measure of confidence in data. Fleet size distributions are similar in that 84 percent of the halibut fleet ranges in size downward from 12.3 m, while all of the Nome fleet ranges in size downward from 12.9 m. About 14 percent of the halibut fleet is less than 8 m, compared to 8 percent for the Nome fleet. Of the total 3,457 boats in the halibut fleet, the size distribution is:

- Over 17.2 m = 16 percent
- 12.3-17.2 m = 30 percent
- 8-12.3 m = 40 percent
- Under 8 m = 14 percent

In 1994, the University of Alaska selected a sample of commercial fishing boats from the halibut fleet and interviewed the permit holders. Of the 3,457 boats, there were 391 interviews completed, which was 69 percent of the number attempted. Based on vessel operating cost data publicly available from those interviews, gross income is sorted out as follows:

- **Operating Expense** - 24 percent, including fuel, gear, bait, food, and special payments to hired captains and boat owners

- **Crew Share** - 49 percent, including crew payments net of expenses shared by the crew

- **Operator's Share** - 27 percent, including fixed costs such as license, insurance, moorage, maintenance, and boat payments

- **Net Operator's Share -** 12 percent, excluding deductions for fixed cost estimated at 15 percent

Because of similarities to the makeup of the Nome-based fleet, and quality of the research, expense data from halibut fleet studies is used here as a means of estimating income and expense for the fleet at Nome. Using 12 percent as a basis for estimating operators' income, the Norton Sound crab resource available to Nome-based boats would provide a net income of $240,000. Salmon would provide a net income of $120,000, halibut a net income of $108,000, and Bering Sea crab $151,800. The total annual operators' net income is estimated at $619,800, not including income from other species.

4.2 Average Operator's Income

Based on vessels active in 1997, interviews with NSEDC, harbor records, and review of limited entry permit data, an estimated 65 commercial fishing vessels use Nome Harbor. With an active fishing fleet of 65 boats, and fleet operators' income of $619,800, the average operator's net cash income from one season operating out of Nome would be $9,500.

Compared to an average yearly income of $14,000 for other non-farm proprietors in the census area, this appears low; however, a fishing season does not represent a full year of income. The $9,500 cash income from one season is multiplied by 2 in order to represent a 1-year equivalent = $19,000. When adjusted to an annual equivalent, a 65-boat fleet is able to provide operators with an annual equivalent cash income of $19,000, which is higher than the $14,000 average earnings of other proprietors.

While average proprietors in the Nome census district earn $14,000 annually, they are less well off than persons who do not own a business. Average earnings among non-proprietors in Nome, according to census data for 1994, were $27,000 per year. Wage earners outnumber proprietors by over 5:1. Opportunities for alternative employment for fishing boat operators appear to be primarily as wage earners, as opposed to owners/operators of businesses other than commercial fishing.

The threshold at which some operators will begin to leave the commercial fishing business has been established at $27,000 annually based on alternative wage earning possibilities. If this were the only alternative wage level available, a fleet of 45 boats would be the practical economic maximum. Beyond this number, average net income per operator would begin to fall below the average of other income opportunities for employment as a wage earner.

4.3 Equilibrium Fleet

Based on the number of people in the census area employed as proprietors (592), and those employed in other jobs (3,281), the income threshold needs to be adjusted to realistically reflect that alternative earning possibilities are best represented as a mix

of the two. A weighted average of the two is $24,600, and with this as a threshold, the long-term equilibrium fleet is 50 boats. The balance of forces at play against the number of vessels is expected to produce a steady-state equilibrium fleet, with low expectation of small changes from year to year.

The NSEDC strategy is to maximize the number of boats and persons employed in the harvest activity, so its programs support development of the maximum-sized fleet that can maintain economic viability. This will be done by low-cost loans, grants, and quota programs that will act in a way that distributes the resources without placing a handicap on more efficient operators. In time, the more effective boats will be able to produce their share of the harvest in less time due to higher success rates.

The fleet will spend the ice-free months using Nome as a base of operations. The vessels will generally be targeting the same fisheries, so patterns of harbor use will mirror fishing seasons and weather windows. Prospects for a single berth providing moorage for more than one vessel (hot-berthing) are nonexistent, as the fleet will be fishing near Nome on trips of very short duration.

The Nome-based fishing fleet is profiled in table B-3.

TABLE B-3.—*Nome-based fishing fleet*

Vessel Design	Draft (m)	LOA[a] (m)	Beam (m)	No. of vessels
Combo/crab	1.3	12.9	4.9	15
Combo/long-liner	1.1	9.8	3.8	29
Combo/gill-netter	1.1	9.8	4.0	2
Skiff	0.3	8	2.6	2
Skiff	0.3	6	2.1	2
Subsistence skiffs with partial commercial use	0.3	6	2.1	120
TOTAL NEEDING MOORAGE SPACE				50
TOTAL NEEDING LAUNCH FACILITY				120
TOTAL NOME-BASED FISHING FLEET				170

[a] Length overall.

5. WITHOUT-PROJECT CONDITION FOR COMMERCIAL TRANSPORTATION FLEET CALLING AT NOME

5.1 Fleet Characteristics

The commercial transportation fleet is made up of two groups:

- Users of the causeway
- Users of the inner harbor

The groups are distinctly different because of the limits of each aspect of the project. The causeway is suited to short-term use by oceangoing equipment, but does not offer protected moorage for smaller fishing boats or for smaller commercial lighters that need the protection offered by the inner harbor. Therefore, the causeway fleet is made up of larger vessels, primarily oceangoing tug-and-barge combinations. On some occasions smaller vessels use the causeway, but rougher conditions can cause damage and delay.

5.2 Causeway Fleet

The causeway fleet includes more than 30 different vessels with 10 different owners. About 90 percent of the use is by oceangoing barges and their tugs, 6 percent is by fishing support vessels, and 3 percent is by cruise lines. The deepest vessel is the tug-and-barge combination *Vigilant/416,* which drafts 5.79 m. The shallowest is the *Redoubt*, which drafts 2.13 m. A sample of the fleet is summarized in table B-4, using vessel calls from data representing about 38 percent of the 1995 season. Harbor logs for 1993 and 1994 indicated repeat calls by these same vessels.

The largest tug-and-barge combination now in use is 121.95 m overall. There has been interest in introducing an integrated tug/barge unit using a 130-m barge into which a 46-m tug would tuck about 15.3 m of its length. This would create an integrated unit with about 160 m overall length. When dockside, the combination could be separated, leaving a 130-m barge.

This type of equipment is ordinarily used on long hauls with high capacity and short turnaround times. This type of operation is not typical of Nome or other Norton Sound or Bering Sea ports. When fully loaded, the unit would carry 180,000 barrels and draft 10.1 m. With its 20,000-30,000 ton displacement, it would be comparable to a Panamax tanker ship. The economic advantages of its use at Nome would be difficult to justify. However, according to one company now serving Nome, they would be able to use the vessel occasionally. Use in a light-loaded condition is consistent with the design of channel width. The plan of improvement does not rule out the prospect of future incremental depth increases not presently justified.

TABLE B-4.—*Nome causeway fleet: unadjusted sample data from 38 percent of the days during the 1995 season*

Vessel	Draft (m)	LOA[a] (m)	Dock	No. of trips
Seneca/250-10	3.66	76.22	2	1
Sea Vixen/Malol	4.27	121.95	2	1
Vigilant/416	5.79	121.95	2	1
Mercury/250-6	3.66	76.22	2	3
Bulwark/450-7	5.18	121.95	2	1
Bulwark/101	5.18	91.46	2	3
Baranof Trader	3.66	70.12	2	1
Drew Foss/Naknek	3.05	87.50	2	2
M O'Leary/Kvic	3.66	76.22	2	1
P Challenger/3	5.49	100.61	2	1
P Challenger/1	5.49	54.88	2	1
World Discoverer	5.49	86.89	2	3
Double Eagle/24	3.35	73.17	1	7
Redoubt	2.13	48.78	1	2
Amatull	4.27	34.15	1	2
Muir Milach	3.05	25.61	1	10
Arctic Bear/Pro	3.66	76.22	1	2
Arctic Star	4.57	80.79	2	1
Impala	3.05	50.30	1	1
Croatian Turn	2.44	19.82	1	1

[a] Length overall.

5.3 Inner Harbor Commercial Transportation Fleet

The inner harbor fleet consists of the Nome-based fishing fleet plus a share of the commercial transportation vessels that call on Nome and are able to be accommodated within the harbor. These commercial transportation vessels are in addition to the fleet that uses the causeway. The inner harbor is draft-limited. It is authorized only to -2.4 m, and the entrance shoals to lesser depths during the season. Therefore, the fleet using the inner harbor is made up of vessels designed to draft less than 2.3 m and rarely drafting more than 1.7 m when in use. They are smaller tugs matched with smaller barges, and self-powered lighters. This fleet is profiled in table B-5.

TABLE B-5.—*Nome inner harbor commercial transportation fleet*

Vessel	LOA[a] (m)	Design	Design draft (m)	Visits per year
Sam Talak	46	LC[b]	1.9	3
Quyaq	57	Barge	2.3	3
Unnamed	45.1	Barge	2.3	13
Nunaniq	45.7	MV[c]	2.3	15
BC152	24.4	Barge	2.3	10
160-1	24.4	Barge	2.3	7
Kavik	22.9	Tug	2.3	4
St. Michael	22.6	MV	2.3	6
Siku	22.6	Tug	2.3	8
Sinuk	21.9	Tug	2.3	3
Sadie Brower	20.7	MV	2.3	5
Postouk	19.5	LC	1.1	15
Kuparuk River	31.1	Tug	2.1	9

[a] Length overall. [b] Landing craft. [c] Motor vessel.

6. TRANSPORTATION PROBLEMS

6.1 Village Transportation Options

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 of the 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 be delivered first to Nome, where they are shuffled and re-shipped to the final destination. Reshipping involves delivery of the cargo to land-based staging areas at 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.

6.2 Lighter Operations

There are other problems with the transfer operation to move cargo at Nome from the oceangoing barge to the dock. Movement to the lighter sometimes 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 that keep them out of the harbor or keep them from leaving the harbor. In other instances, rough conditions within the harbor have interfered with cargo transfer. 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 motivation for performing the make-break operation at Nome is that it is speedier to do it at a location where modern handling equipment is available and a moorage is available in protected waters. 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 destination. In the past, freezeout events have prevented cargo from being delivered from Nome to the villages.

If cargo cannot be delivered to a village late in the shipping season because of freezeout, the residents have two choices: use airfreight or go without.

To the village residents, the option of going without creates hardships they can avoid only by having freight delivered by air. Goods shipped from Seattle are often late being delivered to Nome because of weather conditions, especially in the late summer and fall. As the seasons begin to change, fall brings serious storm conditions. It is at this time of year that vessel delays are a serious worry.

6.3 Transportation Delay

According to Northland Services, Inc., and Crowley Marine Services, Inc., the ideal length of time to get a barge into Nome, unload and load, and depart for the next port of call is 12 hours. The practicality of this ideal operation is not supported by harbormaster logs, which show numerous instances where barges require 1 to 3 days at Nome. Operators admit the ideal 12-hour stay is regularly exceeded due to unanticipated situations. The port logs for 1995, described by operators as a good weather year, show 42 vessel days of weather delay. Visits of 12 hours were uncommon. On an annual basis, barge delay has been estimated at 55 days.

When the barge arrives at Nome, cargo bound for villages close to Nome is unloaded, sorted, and reloaded onto a fleet of lighters. The lighters are capable of operating in shallower waters, and some of them are equipped to land on the beach and unload with use of a bow ramp. The lighter operations from Nome to the destination villages are owned by companies including Crowley Marine with five lighters, Kelley Ryan with two lighters, Bowhead Transportation with two, and Tidemark with one, for a total lighter fleet of 10 vessels. Goods that arrive at Nome by water are reshipped to 27 destinations. Of the 27 destinations, 17 are served by water from Nome. Communities that depend on water delivery must order goods for an entire year, and deliveries must be made during the ice-free months. The lighters are busy throughout the summer. They are either idle in the winter or working at ice-free locations.

The lighters range in size from about 21 to 45 m. Typically they have two or three screws and 500 or more horsepower per shaft. The vessels draw up to 2.3 m at their design draft. They cannot always be loaded to their maximum, as they need to be able to deliver to draft-restricted areas. Also, with the exception of bulk fuel oil, typically the cargo is not of sufficient mass to use all of the vessel space or weight capacity, even when there are no draft restrictions.

The project entrance is authorized to a depth of -2.4 m MLLW. It is maintained in the spring, but by midseason, when oceangoing barges are making deliveries to the causeway and cargo is transferred from there to the inner harbor, the channel has shoaled. Sometimes fuel shipments are lightered or pumped from the causeway to a storage facility at the inner harbor. The fuel is later delivered from the inner harbor to village destinations in less than full loads because of draft limits at the entrance.

Local shippers describe situations in which supply barges arrive at Nome but must hold offshore or seek shelter in the lee of Sledge Island, about 32 km from Nome, or in Golovin Bay, 113 km from Nome. Storms are likely to last several days and often signal that seasonal weather changes are coming. A late arrival at Nome by itself, or coupled with a delay in the cargo handling operation, has been enough to cancel the final leg of the village delivery until the following season.

6.4 Delay Cost

Northland Services, Inc., a marine transportation company, owns most of the fleet of oceangoing barges that service Nome. The company contracts for all of its tugboat services and lighters. The company pays by the hour for the boats and crews. Northland provides the barges, insurance, and loading and unloading services. For the oceangoing equipment, the daily cost for equipment, crews, supplies and insurance is $12,000 to $14,000, depending on the tug-and-barge combination. Barges in use range in size from 88 x 24 m to 100 x 27.8 m. New replacement cost of barges is $3.2 million to $4.0 million.

When the barge is delayed, the shore crews are kept available to work as soon as the barge is able to tie up. The labor time includes machine operators for a crane, truck/trailer, and fork lift. The opportunity cost of tying up dock labor is $450 per person per day, or $1,350 per day for the crew. The company estimated the total cost for its oceangoing equipment lost time at Nome to be $14,000 per day.

The above delays reflect direct increases in transportation cost. The oceangoing barge calls at Nome are timed to connect with lighter operators that transship cargo to the villages. The lighter operators travel shorter distances and can arrange to be at Nome in anticipation of the barge arrival. In the late summer and fall, it is especially important for the lighters to be in Nome prior to the barge arrival to minimize any chance of delay. The consequence of delay is more serious later in the year, as the destination harbors freeze quickly, generally before freezeup at Nome. Thus lighter operators attempt to arrive early and leave the Nome harbor as soon as possible. In some cases, late-season shipments have not reached the villages because of ice, forcing residents to use airfreight (substantially more expensive) or go without.

If weather is severe and the forecast does not indicate moderation, the barge can bypass Nome in favor of other destinations in hopes it will be able to make a call at Nome on the return leg. This does not happen frequently, as bypassing Nome may cause lighters to be eventually frozen out of the village ports. It also means the lighters already waiting at Nome will wait longer, perhaps as long as 2 or 3 weeks. During the delay there is a daily cost for the crew, which must still be paid and fed; a cost of capital tied up in equipment which is not earning a return; and a maintenance cost, which will increase if lighters must sail through the forming ice pack. For purposes of this study, the delay cost for lighters (a tug-and-barge combination) is placed at $6,300 per day. If the lighters leave to escape freezeup, the cargo is left in storage at Nome or delivered to the villages by air. The cost basis used to estimate the cost of delivery by water is summarized in table B-6.

TABLE B-6.—*Lighter operating cost*[a]

Item	Amount
Value fully equipped, in good operating condition	$5,000,000
Fuel for a 300-day active season, 75% of the time making way under power, with 65 days reserved for layup	340,000
Maintenance @ 5% of value	250,000
Hull and machinery insurance	175,000
Property and Indemnity (P&I) insurance	100,000
Crew salary	600,000
Business expense	50,000
Opportunity cost of capital	368,000
TOTAL ANNUAL COST	**$1,883,000**
AVERAGE DAILY COST	**$6,300**
AVERAGE HOURLY COST, 300 DAYS/24 HOURS	**$261**

[a] Vessel length 45.7 m, powered by diesel engine, 1,500 hp, two or three screws.

6.5 Delays for Fishing Boats

The commercial and subsistence fleets at Nome are day-use boats. They range in size up to 12.9 m. The commercial crab boats are in the 9.9-12.9-m class, and the subsistence fleet is smaller. The harbor is necessary for all sizes of boats because the only other choice is to anchor offshore or beach the boat. Neither is an attractive choice, as anchoring in Norton Sound would leave the challenge of getting ashore in a small boat, and beaching the boat on Nome's beaches could cause unacceptable risk of damage.

Virtually the entire commercial fishing fleet uses the inner harbor. The smallest boats are launched from trailers into the protected water of the harbor and motored out to the fishing grounds through the protection of the jetties. The larger boats are kept tied to the docks and to each other, behind the protection of the breakwater. The protected harbor is used to offload the catch, provision the boats, make repairs, and wait out periods closed to fishing.

There are many days during open fishing periods when the water at the entrance to the harbor is too rough for boats of any size to challenge. If this happens when the fleet is inside, the fleet captains use their judgment and wait for conditions to

improve. If the fleet is outside, the vessels seek shelter in the lee of Sledge Island while conditions improve, trading off the cost of spoilage and lost time against the risk of damage or loss of the vessel.

Based on interviews with commercial fishermen who operate out of Nome, operators are forced to risk entry during conditions they would prefer to avoid. Some of the forced entries are explained as due to having an injured person on board, being low on fuel, taking on water, failing equipment, spoiling catch, or worsening weather. In these cases, the operators risk the entry in borderline conditions because they expect the consequences of staying out to exceed the possible losses associated with the risk of entry. They do not expect to incur a zero-loss situation and are motivated by a need to minimize adverse effects. For example, if a boat is in bad condition and taking on water with clogged or broken pumps, it will likely risk near-certain loss during the entry since the boat and probably the crew would be lost outside the harbor anyway. If the boat survives the entry, some damages will need to be repaired, but if it does not risk the entry, the expected loss is total. Local records indicate 39 vessels (not including skiffs), have been lost within 16 km of Nome Harbor. People who use the harbor regularly have been known to refer to the entrance as "jaws of death" during storms.

The introduction of quota programs allows Nome-based operators to terminate fishing activities on bad-weather days without the prospect that others will harvest the resource. This does not change the amount of time lost due to weather conditions, nor does it eliminate the times a vessel may be caught outside the harbor in an approaching storm, but, overall, it does reduce the risk of vessel loss or damage. Operators lose time whether the vessel is jogging at sea or tied to the dock. The major economic difference from the operator's point of view is that lost time at sea incurs variable operating cost unless the vessel is at anchor, while lost time waiting in the harbor does not.

6.6 Threshold Entrance Conditions

There are generally understood threshold conditions which operators prefer not to risk if they are not compelled to do so. Some of these conditions, which cause delays for the fishing fleet, are described in the following paragraphs.

- **Shoaling of the project to less than the authorized 2.4-m depth.** This begins after the project is dredged in the spring and progresses through the summer, until by the end of the season, shoaling has robbed half the depth from the channel. A shallower entrance increases the chances of striking bottom or of encountering breaking waves.

- **Sustained winds from onshore "set-down" which cause the waters of Norton Sound to become shallower, giving less than the authorized depth, and subsequently limiting vessel underkeel clearance.** This situation is present about three times per year with 2–3 days' duration.

- **Wind-driven surge that causes waves and swells to submerge the jetty and make the entrance difficult to locate.** This condition is present about 36 times per year.

- **Steep or breaking waves at the entrance coupled with a following sea.** This situation, associated with winds from the southwest to the southeast, is hazardous even when not accompanied by a storm surge. Therefore, it can be associated with shorter, more localized storm events and can be of lesser duration. Generally these events last from 12 to about 36 hours. Data does not allow sufficient information to statistically separate this type of event from storm surges, which may accompany it. Steep waves make the entrance hazardous even when the jetty is not submerged.

- **Waves greater than 1 meter under any condition.** Generally these conditions last 12 to 24 hours. This type of situation is present in excess of 40 percent of the time during the ice-free period, increasing in the fall.

- **Strong winds perpendicular to the channel, which interfere with ability to control the vessel.** These winds can make it nearly impossible to maintain tight control of a vessel, especially a vessel under tow. Collisions with the jetty and sheet pile and damages to the sides of the vessels are most common under these conditions. Winds generally parallel with the shoreline are common 10 percent of the navigation season. Crosswinds above 20 knots, generally regarded as creating the high-risk situation, are present about 2 percent of the time during the navigation season.

Table B-7 summarizes the undesirable threshold entrance conditions at the Nome harbor.

TABLE B-7.—*Threshold entrance conditions*

PROBLEM	OCCURRENCE
Shoaling	Often happens at the beginning of the season and gets worse as the season progresses.
Set-down	About 3 times per year with 2 - 3 day duration.
Swell	About 36 times per year during about 20 percent of the navigation season.
Waves in excess of 1 meter	About 48 percent of the time.
Perpendicular winds above 20 knots	About 2 percent of the time during the season.

6.7 Delay for Lighters

Lighters can be single vessels, or combinations of tugs and barges up to 46 m. Many of them are draft-limited, in the sense that they often will not load to their maximum draft due to limitations at destinations. Also, with the exception of fuel lighters, they often do not have adequate cargo to load fully to capacity on some legs of their trips. Overall, however, they draft deeper than the fishing fleet, and ideally they need to load to 2.3 m whenever the opportunity is presented. Also, they need adequate depth to include regular safety clearances. Lighters are most fully loaded when leaving Nome. At each destination, they drop off some cargo, generally returning to Nome empty.

The required operating depth for various vessels in the lighter fleet can be somewhat misleading, as some of the lighters are equipped with a bow ramp and are designed to be landed with the bow on the beach. Even though some of these vessels may be beached at the bow, it is essential that appropriate operating clearance be maintained under the rest of the vessel to avoid damage to rudders, shafts, cooling systems, and props. Attempts to beach the vessel in heavy sea conditions can result in hull damage, loss of control, and possibly sinking.

For the boats designed to operate by running up against a beach and letting down a bow ramp, the operation requires a bottom that is smoothly sloped, free of reefs, and well charted. Even the lighters with bow doors, which are designed to beach themselves, can be damaged or sunk by running aground in foul conditions. Harbor entry conditions at Nome and other ports are therefore closely watched by all of the lighter fleet. Despite awareness of the hazards, incidents are common, and annual damages are high.

Lighters can operate only during the months when they are not restricted by sea ice. Therefore, they are less inclined to wait for improved entrance conditions while the short season slips away. In contrast, commercial fishing boats are less averse to waiting, because individual quotas and community quotas tend to protect their harvest prospects. In addition, when Nome is frozen over, typically some of the larger commercial fishing boats move their harvest operations to target different species in other areas open to fishing in a way that keeps them busy and productive during the winter months.

The larger oceangoing tugs and barges also lack an incentive to operate in high-risk situations. They can and do jog slowly at sea until conditions at the causeway improve. Despite weather delays, their itinerary keeps them steaming from deep-water port to deep-water port, all year as much as possible. So it is the fleet of lighters, competing for freight to and from the villages during the ice-free season, that incurs the greatest risk of damage and delay, and suffers the highest damages because of collisions with the bottom, the jetty, the sheet pile, or other vessels at Nome.

Not all of the lighters use the inner harbor exclusively, since some cargo transfer can take place at the causeway. The causeway, however, is weather-impacted, and sometimes delays happen because lighters find it too risky to dock there when other space is not available. Also, lighters sometimes begin transfer operations at the causeway and must terminate the activity and sometimes even pull away from the dock until the weather and sea conditions moderate. Serious damages have occurred when winds and waves have set vessels against the causeway.

6.8 Long-Term Delay

With the goods delivered as far as Nome, and the final leg impossible to complete until the following summer, arrangements must be made for storage or transport by air. A 1-year arrangement for storage at Nome can be made for $224,000 per hectare.

Since villages rely on barge shipments for heating fuel, fuel for local generating plants, groceries, medical supplies, boats and motors, snow machines, clothing and other essentials, and technology they are not able to gather from wild resources, delivery is sometimes an absolute requirement. Air transportation then becomes the obvious choice.

6.9 Air Transportation Options

There have been times when water shipment has been unsuccessful and air has had to be substituted, even for high-cost bulk items such as fuel oil. Some of the village airstrips are adequate to accommodate a scheduled carrier from Nome. The advantage of scheduled flights allows the operator to more reliably estimate the cost per pound of cargo delivery. Generally the cost for freight on Bering Air, one of the scheduled carriers, is between $0.66 and $1.80 per kg, depending on which village is used as the destination.

Cost of airfreight is not a subsidized operation, except for some infrastructure comparable to what the truck, rail, and inland waterway systems enjoy in other States. In Alaska, as in other States, the government assists in the cost of establishing and maintaining airports and air traffic control systems. Aside from this, the carriers must charge an amount adequate to cover all of their own capital and operating cost.

Some air carriers also deliver to the villages under charter arrangements. Charter service is not scheduled, so a trip rate structure is not in use. Cost of cargo delivery varies according to the village being served, weight of the shipment, and the type of cargo and aircraft. It is a cost rather than a rate. There is ample competition at Nome for major charter services to the villages, and a variety of small aircraft is also available to compete for smaller loads. Charges are based on recovery of the long-run incremental cost of each operation, with competition driving each operator to the margin. A review of the cost of serving six of the villages found the cost per kg by unscheduled charters to vary from $1.10 to $2.42, depending on the distance to be

traveled. Cost increases as load factors decline. Costs were comparable for two different aircraft presently in service as charters from Nome.

In the rare event a load is perfectly matched with an aircraft, and a maximum payload can be carried on a short route, cost can be reduced significantly. Such occasions are rare even when customers work together to charter a complete aircraft. The most efficient airplanes are those that carry the biggest payloads, are easy to load and unload, and have high cruising speed and good fuel economy. An additional factor is that the airplane must be available at Nome. This restricts the type of aircraft but does not necessarily rule out use of a DC-6, which can operate out of Nome to some of the regional airports. A DC-6 is the largest practical charter aircraft that can be considered, while a Cessna Caravan, DeHavilland, or Casa 312 are among the mid-size carriers available from Nome by charter. A number of smaller planes are used for charter cargo and passenger delivery, but they are too small to consider as deliverers of crates of goods and bulk items such as building materials, or large shipments such as machine parts or snow machines.

6.10 Other Modes

In winter, snow machines are used for local transportation. The winter is harsh, but people do make solo trips on the machines for many miles. It is possible to tow a toboggan behind one of the machines and use it for small payloads. This is not often done because of problems with stability and the life-and-death consequences of an accident on the trail. Snow machines are therefore not considered to be an option for transport of bulk commodities in winter.

In summer, a local road system is open to regular car traffic. The road system reaches none of the villages served by the water transportation system. The roads are not passable in winter.

7. ECONOMIC ISSUES OF PLAN FORMULATION

The benefit evaluation is tied to six plan formulation issues:

- Because of obvious deterioration of the existing project, it is at the point of needing major rehabilitation. Is the major rehabilitation economically justified?
- In addition to replacement in kind, revision of the entrance is an option. Are improvements in design of the entrance and jetties justified?
- Regardless of future work on the inner harbor and entrance, protection of vessels at the causeway can be improved. Is protection to vessels at the causeway economically justified?
- Is an additional causeway cell justified?
- Which project elements should be included in the National Economic Development (NED) plan?
- What depth is indicated for the NED plan?

Each of these issues presents a need to evaluate proposed plan increments on a separable basis, to the extent possible. Therefore, the evaluation isolates the analysis of benefits for preserving the existing project, for improving the entrance, and for improving protection to the causeway. Analysis of major rehabilitation allows support to be established for projection of major rehabilitation as the most likely without-project condition. Beyond major rehabilitation, the incremental approach allows use of the benefit/cost analysis in a decision framework designed to evaluate the merits of including each identifiable increment in the overall project. The NED plan includes increments that produce maximum net benefits.

7.1 Without-Project Condition

The without-project condition is based on major rehabilitation as the most likely future condition. Major rehabilitation is demonstrated as being economically justified. Economic support for major rehabilitation is demonstrated by comparison against loss of service of the inner harbor, which would result from continued deterioration of the sheet-pile entry if major rehabilitation does not take place. This report demonstrates that the benefits of major rehabilitation are very high, and that it is a rational course of action to continue service provided by the project through major rehabilitation.

Rehabilitation of the existing project therefore serves as the "without-project condition" against which improvements to the entrance and protection of the causeway cells are evaluated. These separable aspects of the overall proposal are presented as incrementally justified. As a means of providing reduced delays and improved service, an additional moorage cell was evaluated in the near-shore area of

the causeway. The cell is presented as an increment to rehabilitation of the existing project, but falls out on the grounds of high dredging cost and low benefits.

7.2 Alternatives

Numerous alternatives considered in the early stages of planning included offshore breakwaters and other ideas that proved to be impractical and/or economically unjustified. During advanced stages of planning, the alternatives were narrowed down to 14. These alternatives depict five general concepts:

- **Concept A -** Cut a channel through the spit off the Snake River and expand the basin.
- **Concept B -** Create a new channel next to the old one and fill the old one in with dredged material; include a spending beach.
- **Concept C -** Build a harbor off the causeway.
- **Concept D -** Build a harbor outside the riverbed, possibly in the spit.
- **Concept E -** Build a new entrance with a jetty and modified causeway.

The alternatives are designed to be responsive to the same basic needs for increased operational efficiency of the commercial fishing and commercial transportation fleets. Regarding improved access to the inner harbor, they all provide benefits of similar magnitude. The plans differ significantly in their ability to reduce operation and maintenance (O&M) cost and wave activity at the causeway. Therefore, plan selection, consistent with the NED criteria, is based on a comparison of net benefits, using reduction in O&M as one benefit category.

Major differences in plan benefits relate primarily to activity at the causeway. There is wide variation in costs among the various plans. The major influence on plan selection, however, is that some plans must be discarded because of adverse environmental impact associated with presence of contaminated materials. A more complete list of alternatives and a summary evaluation is included in table B-21 at the end of section 13 of this appendix.

8. BENEFIT METHODOLOGY

8.1 Evaluation Criteria

The identification of project benefits under the National Economic Development (NED) criteria is based on increases in the net value of national output of goods and services, expressed in monetary units. It includes value of goods and services that are marketed and those that are not. Benefit/cost analysis is the technique used to identify and value the effects.

8.2 Evaluation Framework

Corps planning is conducted in a with-project and without-project context. By comparing forecasts of future conditions in a study area without a project, to forecasts of conditions with a project, the differences in costs incurred by the study area and benefits accruing to it as a result of the project are more readily identified. To ensure that plan alternatives are economically efficient, it is necessary to impose the condition of economic rational behavior on individuals and firms in both the with-project and the without-project condition. The result of the evaluation is identification of a theoretical willingness to pay for the project outputs. This evaluation is used to express the NED benefit, regardless of who will actually pay. In this project analysis, four alternative techniques are used to estimate willingness to pay:

- **Actual Market Prices -** Used to determine ex-vessel harvest values
- **Changes in Net Income -** Used to estimate increased productivity and establish a fleet size
- **Cost of the Most Likely Alternative -** Used to estimate benefits due to project-caused improvements in harbor efficiency, travel cost, and subsistence harvest
- **Administratively Established Values -** Used to estimate opportunity cost of time and to apply discount rate effects at 7-1/8%

8.3 Risk and Uncertainty

All of the techniques present information from which it is impossible to pick an absolute figure to represent all situations. Therefore, the economic evaluation under each approach presents a range of values in cases where results are sensitive to use of a single number and where there is notable uncertainty regarding use of a single number.

8.4 Fishing Fleet Projection Procedure

In this report, the benefit evaluation starts with a willingness-to-pay analysis to determine the need for additional moorage. Willingness to pay is estimated based on income from fishing opportunities. Harvest value is turned into net income for the operator, and the size of the fleet is established in increments by adding boats to the fleet until the average income of operators is equal to the average income from opportunities in non-fishing employment.

A range of fleet sizes was considered to select an NED project scope, but the benefit evaluation herein is based primarily on one fleet size, 50 vessels. The different-sized fleets range from 45 to 65 vessels. The fleet projection was verified with the harbormaster and local commercial fishing boat operators.

Identification of the local subsistence fleet was based on an informal interview process and review of ADF&G reports detailing harvest practices. The fleet is considered to be an unrefined estimate, but one to which the benefit evaluation is not sensitive.

Identification of the commercial transportation fleet was done by direct contact with the shippers and owners of tug and barge equipment using Nome Harbor. They also provided vessel descriptions, operating scenarios, logs, damage and delay anecdotes, and information regarding operating cost which was reconciled with other sources.

8.5 Commercial Fishing

With the regional resource available to no others because of a quota system, local boats enjoy a location advantage to stocks in Norton Sound and the Bering Sea. Reduction of costs associated with damages, delay, deadloss, and travel operations produce NED benefits in the form of a lower overall harvest cost. Effects of the CDQ program, super-exclusive fishing zones, development of an IFQ halibut fishery, processing opportunities, and marketing new products from underutilized species are discussed in the evaluation of harvest opportunities. There are no new harvests, increased catches, or impacts on price. Benefits are based on Nome being the least-cost location for delivery, or least-cost home port. The "least-cost" aspect of the operation allows estimation of overall savings, and these savings make up the NED benefits associated with commercial fishing activities. The least-cost aspect of the benefit derivation is reflected in reduced damages to vessels, reduced deadloss, reduced vessel operating cost, and reduced lost crew time.

8.6 Transportation Savings

With Nome as a transportation nerve center for 27 surrounding villages (see section 1.10), any improvement in harbor conditions provides opportunities for savings in time and possibly reduction in damages. An unreliable harbor at Nome creates a situation in which villagers and Nome residents must rely increasingly on

costly aircraft transportation as the only alternative. This report establishes the practices involved in cargo transportation, the areas served, equipment used, problems encountered, and economic consequences. To the extent the consequences may be avoided due to harbor improvements, they serve as a basis for estimating transportation savings.

In general, transportation savings are most obvious in damage reductions, cost savings over the alternative mode, and reduced delay. Because Nome can be closed by ice for nearly half the year, and since no roads connect the Seward Peninsula communities with the rest of Alaska, shipment by air is the only practical alternative to bring goods into Nome. It is also the only practical alternative means of delivering cargo to the villages. Problems with waterborne commerce at Nome impact delivery to at least 27 villages in the surrounding area.

8.7 Opportunity Cost of Time

Some of the benefits are based on a value for increased leisure time. The reasoning is that to gain leisure time, one gives up the opportunity for other earnings. So if an individual enjoys the advantage of being a worker in an industry with increasing efficiency, he/she can produce more output in the same amount of time or the same output in less time. In the fishing industry, quota programs generally fix output. Technology, however, continues to find ways of achieving that output with less and less time.

Time saved is valued by the increased earnings that could take place if the time were used for income-generating purposes. When time saved is used for leisure enjoyment, economic evaluations value that leisure time at a fraction of the income possibility. Either way, the evaluation requires that a case be made for alternative earning possibilities.

Harbor improvements at Nome would result in time saved for commercial fishermen and commercial shippers. The nature of each industry is that most of the workers move from place to place as fishing seasons, and seasons of the year, may require. For example, it is not unusual for persons working in the fishing or shipping industries in Alaska to have homes in Washington or Oregon. Their alternative earning possibilities are therefore not necessarily in Nome or even near Nome. This is an important consideration because earning opportunities in the Nome area are well below the pay scale of opportunities available to the industry in Alaska as a whole, or in the Pacific Northwest.

Typically, day fleets, such as the majority of commercial fishing operators out of Nome, produce less income than deep-water fleets that stay on the grounds for weeks at a time. The lower financial income of day fleets is accompanied by non-cash incentives such as being able to come home every night, having a regular family life, staying at home when sea conditions are dangerous, working with the same crew on a long-term, regular basis, and so on. For many fishermen of the day fleet, alternative

income opportunities in the deep-water fleet are significantly higher than what they earn in their Nome-based operations.

It appears that many persons working the day fleet from Nome already have made a conscious choice to give up higher earnings to maintain their lifestyle. Since they already have made this choice, the argument cannot be made that time saved for them has a value higher than their normal earning opportunity as workers in the day fleet. This is despite the fact that it can be clearly shown they can earn at a rate two to three times higher by letting go of their chosen lifestyle. The value of leisure time for operators and crew of the day fleet is therefore based on one-third (adjustment consistent with Corps policy guidance) of their estimated hourly equivalent earning opportunities, or $27,000/2,080 hours/3 = $3.00 per hour.

For operators and crew of oceangoing equipment, alternate earning possibilities are different. These workers have not elected to give up higher earnings to stay at Nome. Their earning possibilities are based on a 1997 study of industry earnings. In the survey of the industry, excluding floating processors, the study shows their average annual wages as displayed in table B-8.

TABLE B-8.—*Average annual wages of respondents*

Species harvested	Minimum wages	Maximum wages	Average wages
Pollock	$25,000	$125,000	$70,000
Crab	15,000	120,000	68,000
All other	20,000	45,000	30,000

The study gathered information on hours worked and income produced. It estimated pollock fishers earn an average of $44 per hour, crab fishers earn an average of $56 per hour, and all other categories of fishers earn an average of $25 per hour. By weighting earnings according to the number of vessels and crew in each of the fisheries, the average hourly wage of all fisheries was found to be $44. Given that there is always a demand for experienced crew in the offshore fishery, potential employment within the deep-water fleet is taken as the alternative earning opportunity for operators of oceangoing equipment, and the value of leisure time for them is evaluated at one-third of that hourly rate = $15.

Crews do not work a 5-day week of 8-hour days, so actual hours worked need to be taken into account when calculating equivalent hourly earnings. For example, crab fishers interviewed spent an average of 32.5 days fishing, 7.9 days at port or anchor, and 3.9 days steaming, for a total trip length of 42.5 days. Given the likely trip length and open seasons, it was determined that a crew could make 1.5 trips during the year, excluding brown king and hair crab seasons. The crab fishers said they worked an average of 19.3 hours per day while fishing, 14.5 hours a day while in port, and 6 hours a day when steaming. Taking into account the number of season days worked per day of each activity, the time involvement for the sample 1995 season was 1,155 hours, and average hourly earnings were $59.00. Similar support is available for other target species.

8.8 Operation and Maintenance Cost Savings

The existing harbor has been plagued with high cost. The proposed alternatives will require less dredging, and what dredging they might need will be able to be done at a lower cost per unit. To the extent each alternative will reduce dredging cost when compared to the project history, NED benefits are included.

8.9 Other Effects

Many of the beneficial effects mentioned in the text are not quantified as benefits in this report. Data limits presented too large of a band of uncertainty to estimate dollar values of some effects, and in others where dollar values could be estimated, causal ties to the proposed improvements were loose associations. The benefit evaluation is followed by a presentation of the NED plan and a discussion of risk and uncertainty. The risk and uncertainty discussion provides some additional supporting material for the benefit evaluation.

9. ESTABLISHMENT OF MAJOR REHABILITATION AS THE MOST LIKELY WITHOUT-PROJECT CONDITION

9.1 Major Rehabilitation: the Most Likely Future

The existing Nome harbor project has deteriorated and is in danger of immediate failure. This study assumes that the most likely future condition will be major rehabilitation of the project rather than its abandonment. Reasons for this assumption are discussed in the following paragraphs.

- The project was authorized in 1917 and constructed in 1923. The Federal Government has maintained it with jetty reconstruction in 1940 and major repairs to the jetties and entrance area in 1954, 1965, 1985, and 1986.

- The city of Nome has begun upgrading and expanding the Nome small boat harbor and facilities adjacent to the northern portion of the existing federally authorized turning basin.

- The existing harbor is essential to the area.

- It is a federally authorized project, with no deauthorization foreseen.

- The reconnaissance report gave no indication that the project would be abandoned.

- The analyses in this report demonstrate that major rehabilitation is economically justified. Strong economic arguments favor extending the service that has been provided by the project since the 1920's. The economic rationale is that even with all of the current problems associated with the project's high O&M cost and outdated design, the potential annual benefits from major rehabilitation exceed costs by a ratio of 2.4 to 1.

9.2 Economic Justification of Major Rehabilitation

Major rehabilitation is treated as the most likely future largely because of economic arguments in favor of extending the service provided by the project historically. The economic argument is that even with all of the problems associated with the project's high O&M cost and outdated design, the annual benefits that would be provided by major rehabilitation would exceed costs by 2.4 to 1, as will be shown in the following paragraphs.

Without major rehabilitation, the project depth would become so shallow that none of the commercial fleet would be able to use the inner harbor entrance. Benefits are evaluated by identifying increases in transportation costs, which would be incurred due to closure of the entrance and inner harbor. Without a harbor, there would be no

local commercial fishing fleet at Nome, so benefits to the commercial fishing operation are based on harvest of the resource by operation from an alternative port.

Benefits associated with commercial transportation use of Nome's inner harbor and the entrance are based on the cost of delivering cargo to the causeway and moving it overland to areas where it can be stored or sorted for later reloading and reshipment by lighters operating from the causeway.

9.2.1 Shipping Cost.

Presently the inner harbor is used by tugs, barges, and lighters. It offers a protected area where 3,000 tons of cargo is staged for transshipment. All of it comes into the inner harbor to be rehandled, and it makes up 24 percent of the total tonnage that uses the inner harbor. Since 1990, average annual tonnage through the inner harbor has amounted to 3,000 tons of dry cargo and 9,200 tons of fuel. Tonnage is based on actual measurements used to calculate port use fees.

Typically, the shipments are miscellaneous items destined for Nome, its outlying areas, or some of the 27 villages using Nome as a transportation hub. Because of the numerous destinations involved and the lack of bulk shipments, reshipment is handled on an item-by-item basis unlike the practice at most other shipping terminals.

Without major rehabilitation, cargo destined for the inner harbor will be offloaded at the causeway, taken to a staging area and sorted for final delivery, and shipped by air or water to the villages. The causeway does not have adequate space to land and sort cargo, so use of that location as a regular reshipping area is not viable. It is possible to land the cargo at the causeway, truck it to a staging area and sort it, then haul it back to the causeway to load it onto lighters for shipping to the villages. Two major problems here are that the causeway does not offer adequate protection to allow the lighters to work alongside the dock for extended periods, and the causeway needs to be available for larger incoming shipments handled by oceangoing line-haul tugs and barges. These oceangoing combinations need the entire area and incur very high costs for delay. At the only docking facility for oceangoing equipment hauling supplies for Nome and 27 villages, congestion must be minimized. Taken together, shipping cost and increased delay cost associated with using the causeway as a shipping substitute for the inner harbor are estimated to be less than the cost of air transportation to the villages.

Based on rates of scheduled carriers, shipping 1 ton of air cargo costs $600 to $1,600, depending on the village destination. Information based on actual cost of shipping by air is available from charter arrangements. Cost of cargo delivery varies according to the village being served and the weight of the shipment. For many of the aircraft choices, 1 ton represents the maximum practical load, though cargo capacity varies with type of plane, number of passengers also on board, and distance to be flown. Cost of each charter is estimated based on weight and distance for the specific type of aircraft for each trip, and in that sense it is a cost rather than a rate. There is ample competition at Nome for charter services to the villages, and a variety of small

aircraft are available. Charges are based on recovery of the long-run incremental cost of each operation, with competition driving each operator to the margin. Review of the cost of serving six of the villages determined the cost per kg by unscheduled charters to vary from $1.10 to $2.42, depending on the distance. Costs were comparable for two different aircraft presently in service as charters from Nome. Overall, the alternative cost of air transportation for purposes of this evaluation is $1.32/kg, or $1,320 per metric ton.

The cost of delivery by air at $1.32/kg exceeds the cost of water delivery, including the $261-per-hour cost of the lighter. Allowing 48 hours for a charter, a ton of waterborne chartered cargo delivery costs $12,600, or $13.80/kg. Waterborne commerce is at a cost disadvantage until the quantity shipped approaches 10.5 tons. Ordinarily, lighters deliver greater loads to multiple destinations, and single-destination trips with low load factors are highly unusual.

On average, the delivery of 3,000 tons of dry cargo to the 27 villages, using as many as six deliveries per year through the village circuit, works out to be 22 tons per trip. At 22 tons, and 48 hours per trip, the cost per ton is $570. Occasionally the load factors are greater, especially if liquid fuel is being hauled.

With liquid fuel taken into account, total annual tonnage shipped to the villages is 12,200, and the average load is 88 tons. Cost per ton is reduced to $140.

9.2.2 Queuing Cost.

Without major rehabilitation, there would be added handling of cargo, added congestion at the causeway facility, and lost time at destinations. On average, moorage would be adequate, but there would be times when more vessels were present than the moorage space could accommodate. Since there is no master schedule for use of the harbor, and weather determines to a large extent when it is usable, delays are random. A simple simulator based on calculation of a series quasi-random numbers generator was used to estimate delay.

Table B-9 shows harbor information used as a basis for the model. Data for the simulation was gathered from harbormasters' notes for 1993 through 1996.

TABLE B-9.—*Causeway use: harbormaster data for specific years*

Item	1993	1994	1995	1996
Dock use days (180 days less weather closure)	140	153	131	140
Capacity factor (arrival days out of a 180-day season)	0.39	0.51	0.36	0.39
Weather days	**37**	**26**	**42**	**58**
Delay days	**66**	**55**	**47**	**61**

Many of the users require more than a day at dockside, and only two locations are available at the causeway. Based on interviews with operators and local officials, the

season lasts usually about 180 days. On some days, sea conditions interrupt use of the causeway, closing the outer cell 40 percent of the time and closing the inner cell 30 percent of the time. During closed conditions, arrivals sometimes stack up, compounding delay problems. The outer cell is more exposed, and for that reason it is less frequently used. The 30-percent and 40-percent closure factors are estimates based on vessel and harbor logs.

The simulator selected arrival based on a 50-percent chance of any day during a 180-day period of consecutive days. Each arrival was assigned a moorage cell with an equal chance. A service condition (cell 1 closed 30 percent of the time and cell 2 closed 40 percent) was selected. A vessel service time varying between 12, 24, and 36 hours with equal probability (33 percent) was assigned. If a vessel arrived and was assigned to a cell that was closed, but the following day either cell was open, both cells were treated as open the following day. In other words, when causeway conditions improve after a storm adequately to service a vessel at either cell, the other cell will be open at nearly the same time. These conditions were established because storms build over a fairly short time period, but they can be long lasting. Results of this simulation model for causeway use are presented in table B-10.

TABLE B-10.—*Causeway use: simulation results*

Item	Without inner harbor	With inner harbor
Causeway use days (180 days less weather closure)	238	133
Capacity factor (arrival days out of a 180-day season)	0.70	0.46
Weather days	**55**	**59**
Delay days	**106**	**55**

The simulation revealed that the vessel delay of oceangoing equipment at the causeway over the course of a season could be expected to be 55 days under existing conditions. Existing conditions include service of the inner harbor. Cost of delay due to vessel waiting time with the inner harbor in service is 55 vessel days, at a cost of $14,000 per day for oceangoing equipment = $770,000.

Inner harbor fleet records indicate that about 100 dockings would be displaced to the causeway if the inner harbor were not usable. Thus, without the inner harbor, 100 additional vessel calls would need to be absorbed at the causeway cells. This estimate is based on displacement of inner harbor users that would have occurred in years with traffic as reported for the 1994-96 seasons.

The simulation predicted that the 70-percent increase in causeway use would result in a 51-day increase in vessel delay. The 51-day increase in delay would impact both lighters and oceangoing equipment, because with the inner harbor out of service, the causeway would be used by both oceangoing equipment and lighters. Lighter delay cost is $6,300 per day, and delay cost for oceangoing equipment is $14,000. The

delay impacts both types of vessels, but delay cost for the incremental impact of taking the inner harbor out of service is evaluated at $6,300. The impact of the increased 51 vessel days of waiting time is estimated at **$321,000**.

Waiting time for dock crews includes the labor cost of three machine operators, possibly a crane operator, a truck/trailer driver, and a forklift driver. The opportunity cost of tying up dock labor is $450 per person per day, or an added $1,350 per day for the crew. With the inner harbor in service and vessel delay days estimated at 55 per year, associated dock delay cost is 55 days x $1,350 = $74,200. With the inner harbor out of service, the associated cost of dock delay increases by 51 days = **$68,800**.

Cost of lost time at destination harbors was estimated based on a leisure time loss of $3 per hour, and one person delayed for each destination. Sometimes many persons wait for delivery, but we have assumed one person could be assigned responsibility to wait for the cargo and provide security when it is delivered on the beach at each village. Daily lost time at the villages is therefore $3 x 24 x 10 = $2,160. With the inner harbor estimated to reduce delay days from 106 to 55, benefits associated with reduced cost at the destination villages are $2,160 x 51 = **$110,200**.

All of the villages served from Nome have a total population of approximately 8,000. Average annual waterborne commerce to Nome and all of the villages is 51,070 tons per year. The added cost imposed by delay adds about $9.80 per ton. Without the non-cash opportunity cost of villagers' time involved, the cost increase is $389,800, or $7.60 per ton. So, with the cost of delay included in the cost of delivery by water, delivery by air is still the more expensive mode. Air is estimated at $1,200 per ton and water at $140 + $9.80 per ton = $150.

9.2.3 Commercial Benefits for the Norton Sound King Crab Fishery.

Without major rehabilitation, the Nome Harbor depth would become so shallow that none of the commercial fleet could use the harbor entrance. In this scenario, the most likely nearest alternative port for harvest of the crab stock in Norton Sound would be a small boat harbor planned for construction at St. Paul Island in the Bering Sea, 800 km from Nome. Planned improvements at St. Paul will be able to accommodate vessels at least as large as those that would work out of Nome in the with-project condition.

Actual Norton Sound operations from a base at St. Paul would be expected to require a larger vessel because of the open-ocean distance from the fishing grounds. The nature of a super-exclusive zone, however, will work to keep the very large vessels of the deep-water crab fleet (31-62 m) out of Norton Sound. The resource would attract newer-design combination boats up to 17.7 m, and possibly some older-design, similar displacement hulls with overall lengths greater than 17.7 m.

Because the number of crab pots per vessel is restricted in some Bering Sea waters to 40 pots for vessels under 38.3 m, and only 10 additional pots for vessels exceeding 38.3 m, smaller vessels are gaining favor. The main constraint on size is the smallest

vessel that can efficiently and safely fish 40 pots. According to a consensus from a meeting with 15 local Bering Sea fishermen, vessels in the 12-to-17.7-m class are ideal. Ability of vessels in this class to fish 40 to 50 pots was verified with two West Coast boat builders.

For years, the 17.7-m vessels have been in great demand because of salmon fishing profits and rules that establish this as the maximum-size vessel allowed in some salmon fisheries. In many cases, larger vessels have been selling at lower prices. In recent years, success of fish farms has driven salmon prices down, and these 17.7-m boats are no longer as desirable as they once were for exclusive salmon fishing. Some of the formerly exclusive salmon boats are now routinely outfitted for multi-use fisheries.

A fleet operating out of St. Paul would be made up of larger vessels than the fleet operating out of Nome. Therefore, catch per vessel would be greater, and there would be fewer boats. Two other effects of a St. Paul-based fleet would be added travel time and increased deadloss, both of which would reduce net income.

The estimated reduction in net income caused by operating out of St. Paul was estimated for a fleet sized so that net income of the vessel operator would equal income from other opportunities at St. Paul. Given a projected Norton Sound harvest of 227,000 kg, an ex-vessel value of $8.80, operator's return at 12 percent, and average earned income at St. Paul of $24,000 based on census data, there would be room for 10 boats in the Norton Sound super-exclusive fishery. Expansion of the fleet beyond 10 boats would create a situation at St. Paul in which other earning opportunities on the island were more attractive than venturing to sea.

These combination boats that venture into the super-exclusive crab fishery will generally be 17.7 m in length. However, some older hull designs are comparable to the smaller boats in terms of displacement because of narrower beam and round chine design. Some of these boats range in size to nearly 30.7 m. The 17.7-30.7-m vessels have replacement cost between $0.5 and $2 million and will cost about $0.5 to $0.6 million annually to operate. Their total annual cost, including a return to capital, ranges from $537,000 to $747,000. To break even in the long run, this cost must be recovered.

Vessels that cannot produce annual income above this threshold will not be able to survive as businesses. If the vessel fishes in all available fisheries, it can be active about 209 days per year. This would include 106 days of pollock or other groundfish, up to 64 days of crab, and 39 days in other fisheries. Preparation, reprovisioning, offloading, and travel time are included in the time allowance. Based on 209 days of fishing per year, the daily cost of the vessel is $2,600-$3,600. Each trip from St. Paul instead of Nome would increase travel distance by a 1,600-km round trip, requiring an additional 86 hours of travel time at a maximum speed of 18.5 km/hour. The additional travel cost would amount to $9,300-$12,900, not including the value of

crew time as lost leisure time. For the 10 boats involved, the annual savings from using Nome would amount to **$93,000 - $129,000**.

Each of the 10 boats has a crew of at least four persons. With value of leisure time established at $15 per hour for this distant-water fishery (fishing out of St. Paul requires an 800-km open-ocean trip each direction), the savings in leisure time would add **$51,600**.

In addition to the travel cost, a run to St. Paul, the alternative home port, would expose the catch (which must be kept alive aboard the vessel) to the increased mortality associated with an additional 86 hours of travel time. Deadloss begins to become a significant concern at 36 hours, and an additional 86 hours of rough travel could be so damaging as to ruin the entire catch.

Larger vessels, generally well over 30.7 m, are equipped with live-crab holding tanks with constantly circulating sea water. These vessels are able to keep the crabs alive for longer periods of time, enabling delivery to processors every 5-7 days. When sea conditions are rough, even boats with live tanks shorten delivery times, as mortality rates increase under rough conditions. The smaller vessels, such as those that presently fish Norton Sound from Nome, hold the live crabs in dry totes. They must deliver to a processor every 2 days, or every day if fishing success is excellent or if sea conditions are rough. With a harbor at Nome, the fleet would deliver to the harbor, but without a harbor at Nome, a floating processor would need to be available in Norton Sound so the 17.7-m vessels fishing out of St. Paul can minimize deadloss. A floating processor in Norton Sound would be needed in the without-project condition to prevent total mortality loss. The floating processor would be on the grounds for the duration of the season. During the season, each boat would deliver about 22,700 kg of crabs. At each delivery, some of them would have been on board 24-48 hours, and trapped in the pot up to 48 hours before that. By the end of a trip to St. Paul, deadloss would be total. By the end of a trip to a floating processor within Norton Sound, deadloss would be approximately 25 percent. Deadloss estimates are based on discussions with vessel operators at Nome, NSEDC, and the Nome area manager for ADF&G. Seventy-five percent of the catch is worth $1,500,000 for the 10 vessels involved.

With an ex-vessel harvest value of $1.5 million at stake, the option of bringing in a floating processor makes sense. Total cost for the season for a 61-m floating processor capable of processing 1,500 pounds of crab per hour is **$225,400 - $450,800,** depending on the time allotted for the harvest. Harvest season varies from 2 to 5 weeks, depending on weather days and success rates. Cost of keeping the floating processor on the grounds is saved if Nome is kept open. In the with-project case, the processor is free to work in other locations, or if it cannot operate above the break-even point without processing in Norton Sound, it will go out of business. In either scenario, improvements to Nome harbor dispense with the cost of running it to service the Norton Sound harvest and produce an NED saving.

Total economic effect is estimated at **$370,000 to $631,100** annually.

9.2.4 Subsistence.

Historically, subsistence fishermen have launched skiffs from Nome area beaches and rivers. Beaches are convenient to practically all area residents. The problems associated with their use, and use of the rivers, arise from launching and landing boats under unprotected circumstances. Boats are often fishing when the weather changes, increasing the risk of landing the boat in bad conditions.

The prospect of being unable to use the boat because of bad conditions reduces the number of subsistence trips and shortens overall subsistence fishing time. The impact on the community is to decrease the amount of subsistence harvest available. The economic consequence is that households are required to use scarce cash reserves for store-bought substitutes for food and nonfood items traditionally available from wild harvests.

The local fleet of skiffs, ranging in size up to 7.4 m, is maintained at approximately 120 vessels. They are primarily outboard-equipped open boats used in a near-shore day fishery for crab, salmon, trout, halibut, cod, and seal. The vessels are also used as transportation to areas used for gathering berries and setting up fish camps and base camps for hunting large land mammals.

Most of the vessels are stored on trailers or racks until their time of use, when they are launched from the beach. When the boat basin is not too busy and there is available area for them, they are launched from the protected inner area off a sloping gravel bank. The area used as a launch is not maintained or designated as a launch area. The use of the launch area within the inner harbor is preferred to launching and retrieving from the unprotected beach.

The ADF&G Department of Subsistence has gathered subsistence harvest data for 122 communities. They show that the annual harvest (all in usable weight) varies from about 4.5 kg per person in Anchorage to 680 kg per person in small, remote villages. The median statewide per-capita harvest is about 114 kg per person. Of the communities that have been studied, five are communities in or close to the Nome census area. The communities and their per-capita harvests are Kaktovik, 136 kg; Kotlik, 227 kg; Emmonak, 273 kg; Alakanuk, 340 kg; Stebbins, 454 kg; and Kotzebue, 182 kg.

Kotzebue, a coastal community 324 km north of Nome, is very similar to Nome in terms of size, ethnic composure, economic base, climate, and location with regard to availability of wild resources. Like that of Kotzebue, Nome's population contains a relatively large share of non-Native people (41 percent), and because it functions as a regional center, it cannot be considered isolated. Neither place is accessible by highway, and both are cut off by sea ice half the year. Per-capita subsistence harvest at Kotzebue is 182 kg. In comparison, the average American uses 623 kg of all foods in a year, of which 116 kg are meat, fish, or poultry.

Harvests vary among communities depending on personal income and location. Generally, Native communities harvest more than non-Native communities. Community income levels are strongly associated with settlement entry, so that statistically a community's non-Native population and mean income increase together. Isolation is another factor, in that the less connection a community has with others, the more it needs to rely on wild harvests.

Food is an important use of the subsistence harvest. Other important uses include the following:

- **Clothing** - Wild furs and hides still make the best materials for ruffs, mitts, parkas, kuspuks, and mukluks.
- **Home Goods** - Hides are used for sleeping mats. Sealskins are used as pokes to store food. Wild grasses are made into baskets and mats.
- **Ceremony** - Traditional items are used in funerals, potlatches, marriages, Native dances, and other ceremonial occasions.
- **Sharing** - Harvests are widely distributed to support neighbors who cannot harvest for themselves because of age, disability or other circumstance.
- **Customary Trade** - Specialized products like seal oil are bartered and exchanged in traditional trade networks between communities. Furs sold to outside markets provide a source of income.
- **Arts and Crafts** - Items are crafted for use and sale.
- **Fuel** – Wood, a major source of energy in rural homes, is used for smoking, preserving, and cooking.
- **Transportation** - Fish, seals, and other products are used to feed dog teams. Walrus hides are used for boat coverings.

The value of the subsistence harvest within the State economy as a whole has been estimated, but no known documented studies have established the economic value of the subsistence harvest at Nome proper. Reports generated by the State generally apply a value ranging from $6.60/kg to $11/kg. Persons with resources to trade frequently advertise wares on local radio programs. The following is a sample of such advertisements made on the Kotzebue Swap-N-Shop program. The list would translate roughly to $24.20 per kg.

- Gunny sack of whitefish, $1.00 per pound
- Five-to-six-pound blocks of black muktuk, $15.00 per pound. First come, first served.
- Plain seal oil for sale, $2.00 per pound

- Dried ugruk meat, $3.50 per pound
- Paniqtuq mixed with cooked meat, $2.50 per pound
- One whole ugruk skin for mukluk bottoms, $105.00
- Beluga muktuk for sale, $4.00 per pound
- Blueberries and cranberries for sale, $100.00 for 5 gallons
- Five marten skins for sale from Huslia, $50.00 each
- One large dark wolverine skin with long hair for sale, $500.00
- 70 muskrats from Noorvik for sale. Also a wolf and wolverine skin (no price mentioned)

With major harbor rehabilitation, launch and retrieval of boats would be faster, require fewer persons, and result in less damage to boats and equipment. There are definite savings in time, wear and tear, and stress, but the major beneficial effect is that weather windows that are used for subsistence harvests will be more effectively used.

It is anticipated that major harbor rehabilitation would prevent at least a 50-percent decrease in subsistence harvest operations out of Nome Harbor. Subsistence harvest that depends on use of the harbor is estimated to represent 10 percent of all subsistence activity. The estimate is based on sector population harvest success and cultural characteristics of users. A 5-percent change in per-capita subsistence harvest, at a value of $6.60-$11.00/80 kg, would produce an annual benefit lower range of $6.60 x 9 kg x 3,500 population = **$207,900**, and a higher range of $11.00 x 9 kg x 3,500 population = **$346,500**.

9.2.5 Halibut Fishery Harvest Savings.

The ex-vessel value of the Nome halibut fleet harvest is estimated at $900,000 annually. The harvest is done with long-line equipment, with numerous baited hooks strung out along the bottom. As fish are brought aboard the boat, they are bled and iced. Boats deliver the catch to processors daily, if possible, to avoid deterioration of quality.

In the absence of major harbor rehabilitation, the fleet would relocate, as the boats need a sheltered harbor. One possible alternative would be St. Paul Island, though the island fishermen are organized into a different Community Development Association called Central Bering Sea Fishermen's Association (CBSFA). The halibut fishery is the subject of an IFQ program, so the quota moves with the fishermen. Halibut range through large areas, so IFQ is not location-specific. The practical aspect of the relocation proposal, however, is that the halibut fishery is basically a small-boat day fishery, and St. Paul is too far from the Norton Sound area to expect St. Paul-based boats to harvest and deliver a marketable product while making a profit in the process. The obvious consequence to the halibut fleet of a shutdown of Nome Harbor

would be that $900,000 of ex-vessel halibut would go unharvested until the IFQ could be sold or until the IFQ holders could relocate to places where the IFQ could be used.

Historically, persons involved in the fishing industry do not leave the industry when hard times hit. Typically, the industry is overcapitalized in any fishery, indicating operators at the margin do not exit. Although IFQ is marketable, a harbor shutdown is not likely to precipitate a sudden selling of permits. Therefore, the NED benefit from keeping the harbor open would be ex-vessel value forgone during the period that IFQ is not transferred and the individual quota is not harvested. Ex-vessel values are used because capital to establish the fleet is a sunk cost. With the fleet already in existence and able to be productive in other fisheries in the absence of a halibut harvest, halibut harvest forgone represents NED effects.

Some of the IFQ would be immediately transferred on at least a temporary basis to other vessel operators who are qualified to accept the transfer and capable of harvesting the halibut. The rest of the IFQ would be retained by the owners as part of a strategy to gain access to the resource, or because of unwillingness to dispose of an asset that represents their livelihood. The period of retention is very uncertain. In studies of similar situations where the workers are in extractive, resource-based industries (logging interruptions in the Pacific Northwest due to Endangered Species Act listing of the spotted owl, fishing interruptions in Oregon and Washington coastal towns because of Endangered Species Act salmon listings, mining interruptions due to Appalachian closures, farm closures due to debt issues and weather cycles), researchers assume that recovery periods last many years. In some cases, the studies evaluate effects of dislocation as if adjustments are never made. This seems extreme, but a casual observation of some of the impacted communities easily discloses that the landscape is littered with fishing, logging, mining, and farming equipment that could have been put to work elsewhere but was not. A review of regional economic data discloses chronic unemployment rates of 30 percent in some fishing communities.

It could not be ascertained whether an adjustment in the halibut fishery would take place if Nome Harbor were to close, or if one did, how long it would take. For this evaluation, it is assumed that an adjustment would take place and that it would represent a 100-percent transfer of IFQ over a period of 10 years. The transfers would be to new operators, or to old operators working from new locations. During the adjustment period, it is assumed that public agencies already operating support programs would provide retraining, relocation, and income maintenance. By the 10th year, this transfer would reduce the $900,000 loss to an annual equivalent of **$442,000**.

9.2.6 Salmon Fishery Harvest Savings.

Historically, markets for Norton Sound salmon have been small and sporadic. Typically, wholesale buyers would come to Unalakleet or Shaktoolik and buy whole chinook and coho and fly them out on ice. The most plentiful fish, pinks, would be left to rot.

The quality of pink salmon deteriorates very quickly. The fish must be harvested in top condition and processed immediately. NSEDC has developed harvesting procedures, processing methods, and new food products that present the fish as attractive in the retail market, so the local fishery is now active. It is basically a river-mouth fishery and therefore ideal for a fleet of small boats. The boats deliver daily directly to processors, or to buyers that transport the catch to Unalakleet, or to the floating processors *Northern Glacier* and *Norton Sound.* A smoking facility is planned for Nome or another nearby Norton Sound community, and that will also be a delivery point.

Seventy-seven Nome-area boats fish for salmon. Their projected long-term harvest is $1,000,000 annually. A market analysis and resource management program supports the projection. In 1994, the second year of a pink salmon harvesting and marketing program, 77 local boats harvested $446,000 in pinks. That year the fishermen established themselves as providers of a very high-quality fish to the processors. Historically, processors working with Norton Sound fish have been handicapped by low-quality deliveries and high spoilage rates. As a result, low prices are paid to fishermen; however, this is expected to change.

The small boats require a protected harbor for moorage, and if they are launched from trailers, they require a protected launch area away from ocean swells. The existing Nome Harbor and the river above the city are popular launch areas because of the protection during launch and retrieval operations, and because the entrance allows a safer transit to deeper water.

For tender operators that function as buyers on the fishing grounds and transport the catch to a floating processor, or a processor at Nome, a reliable harbor entrance is essential. The consequence of not being able to deliver the catch to a processor without delay is total loss. Unlike other species, pink salmon do not have a holding time. They must be processed immediately or the quality loss is so serious that the catch has no human food value. The harvest time is also a very small window, as the quality of fish deteriorates rapidly upon entering the rivers. The tenders and harvesters must be able to be on location on a schedule dictated by product quality guidelines. Therefore, a protected harbor is essential.

The new markets served by the NSEDC strategy for product development depend on a reliable long-term supply. Therefore, without a protected inner harbor and entrance channel, survival of the fledgling industry is at risk. Some part of the industry would adjust to survive from the harvest that would be taken by a beach-launched fleet of small skiffs, but this is expected to be as insignificant in the future as it has been historically. The fleet would be inactive on many days when surf conditions make it impossible or impractical to launch small boats safely, and on other days when conditions on Norton Sound are uninviting to fishermen in small open boats.

Some analysts argue that the Norton Sound pink salmon industry would not survive at all. They support the argument with history showing that in the absence of local supporting infrastructure since 1900, a locally operated commercial pink salmon fishery did not develop, even though salmon were present in greater numbers historically. A safe port for the fleet, a protected entrance, and a convenient processing facility are all essential to industry survival. The effect of delays at the entrance would drive up the average cost of the harvest. Also, delay in harvest or delivery translates to increased spoilage, and a spoiled catch is cast overboard.

Fishermen would ordinarily incur the financial cost of additional trips to provide replacements for the discarded spoiled catch. But in the pink salmon fishery, the window of opportunity for a makeup catch is very small because of quality problems in a delayed harvest. If the window of opportunity were not small, the actual number of fish delivered to the processor would not change. The impact on the resource would then be that a greater number of fish would be taken to make up for spoilage, and the cost of the increased resource extraction would be the NED effect.

The economic effect of a project at Nome is the difference in product value. With the project, long-term harvest is anticipated to be in the $0.5-to-$1-million range. Without the project, quality problems created by delay and subsequent discarding of catch are expected to bring the pink salmon harvest in Norton Sound back to its average over the past 5 years, or $115,000. Benefits associated with Nome Harbor are **$385,000** at the lower range and **$885,000** at the higher range.

9.2.7 Benefit Summary.

The inner harbor produces annual benefits estimated at **$1,787,000** to **$2,578,400,** as shown in table B-11.

TABLE B-11.—*Benefit summary, major rehabilitation*

	Annual benefits ($000)	
Benefit category	**Lower range estimate**	**Upper range estimate**
Shipping delay cost	$321.0	$321.0
Dock delay cost	68.8	68.8
Leisure time (villages)	110.2	110.2
Travel cost savings	93.0	129.0
Crab harvest travel saved	90.0	120.0
Leisure time (crew)	51.6	51.6
Crab deadloss	225.4	450.8
Subsistence	207.9	346.5
Halibut harvest	442	442
Salmon harvest	385.0	885.0
TOTAL	**$1994.9**	**$2924.9**

The above analysis is based on a without-project condition reflecting loss of service provided by the inner harbor. The loss of service has been treated as imminent due to

the deteriorated condition of the harbor entrance. If the projected loss of service were extended to year 2005, or year 2010, benefits would be as shown in table B-12. For the "immediate" column, an in-service date of 2000 is assumed.

TABLE B-12.—*Annual benefits, major rehabilitation ($000), with assumed loss of service dates*

	Loss of service		
Benefit range	**Immediate**	**2005**	**2010**
Higher	$2,924.9	$2,050.7	$1,437.8
Lower	$1,994.9	$1,398.6	$980.7

9.2.8 Viability of Major Rehabilitation.

The benefit-to-cost ratio is sensitive to the expected loss-of-service date for the existing project. Engineering studies indicate risk of loss of service is imminent. Benefits represent a median value of the high and low range. Benefits, after adjusting for residual effects of set-down and remaining wave activity, are **$2,336,000** annually, cost is **$969,000,** and the benefit-to-cost ratio is 2.4 to 1. Annual cost is derived from an M-CACES estimate of a major rehabilitation project, dated January 1998.

9.3 Without-Project Condition Conclusion

Economic impacts of allowing the project to deteriorate to the point of non-use would be severe. Major rehabilitation is justified, with a benefit/cost ratio of 2.4. Major rehabilitation is the most likely future in the absence of other work.

10. BENEFIT EVALUATION FOR IMPROVEMENT OF THE ENTRANCE

10.1 Without-Project Condition

As demonstrated in this report, major rehabilitation is the most likely future for obvious economic and policy reasons. Though major rehabilitation would result in renewal of an outdated design not supported by the sponsor, Corps policy requires that it be used as the base condition for evaluation of improvements beyond replacement in kind.

10.2 Entrance Problems Remaining After Major Rehabilitation

Despite annual dredging, shoaling of the entrance channel and inner harbor have historically restricted vessel draft to less than the authorized depth of 2.4 m. Tugs and barges regularly using the inner harbor have drafts of 2.3 m, landing craft draft 1.5 m, and fishing boats draft 1.5 m. Even immediately after the channel is dredged in the spring, commercial vessels cannot load to their maximum potential without risk of bottoming out in the 2.4-m channel. Before the end of the navigation season, the channel shoals to about 1 m.

Impassability of the entrance impacts commercial fishermen and commercial shippers. During periods when the entrance is not usable, potential users must wait in the harbor or at sea. Frequently boats running low on fuel or anticipating worse conditions, such as ice or breaking seas, will risk the entry. Often the entrance is negotiated, but not without the vessel striking the jetty or a wing wall, or bottoming out in the channel. Economic costs associated with the entrance, even after major rehabilitation, would be high, because it is not uncommon for the same vessel to incur repeated bottom strikes and also ram the sheet pile when using the channel in adverse conditions. The entrance is at less than the authorized depth a major part of every year. Therefore, more than half of the trips are made through an under-depth channel, even when storm conditions are not present.

Events at the entrance result in damages in the following categories, each of which is presented separately:

- Fishing fleet damage from anchoring out
- Fishing fleet damage using Nome Harbor
- Tug and barge damage
- Light loading and delay

10.3 Proposed Improvements

Alternatives for improvement of the entrance to the inner harbor include jetty extension, channel realignment, channel widening, and channel deepening. Each alternative evaluated is shown in table B-21 at the end of section 13 in this appendix. The economic evaluation summarized here pertains primarily to the NED plan, plan L.

10.4 Damages From Anchoring Out During Storms

When storm conditions make it impossible to enter the harbor, owners have adopted a practice of moving boats to other locations and anchoring or otherwise staying with the vessel throughout the storm. Even with a crew on board, vessels are plagued by conditions that cause dislodged anchors, failed moorage arrangements, loss of power, steering problems, mechanical difficulties, and electrical failures.

Operators may risk the entry during severe conditions. The number of boats caught outside will vary from none to nearly all. When a storm catches the fleet outside, some of the boats that return early may be able to enter the harbor. Late arrivals are more likely to stay outside and wait out the storm.

Damage scenarios were developed from discussions with vessel operators, repair yard operators, and marine surveyors. Four levels of damages were identified. There is an implied relation between extent of damage and a given storm frequency. The relationship characterizes minor damage as being associated with annual events, serious damage associated with 2-year events, severe damage with 3-year events, and maximum damage with 4-year and greater events. This relationship is supported by discussions with vessel operators, repair yard operators, harbor officials, and residents.

The relationship is generally thought to be an understatement, as there are numerous accounts of vessels being sunk near Nome during storms. U.S. Coast Guard (USCG) data specifically for the Bering Sea and Norton Sound indicate an average of just over three vessel losses each year, based on incidents of record from 1990 to 1996. The number of serious distress incidents annually within the Bering Sea-Norton Sound area is estimated at 30 per year, and incidents of a less serious nature are estimated to outnumber serious incidents by 10 to 1. These vessels are typically not confined to one fishery or one area, so there are some vessels with multiple incidents during any year.

The Nome fleet is made up primarily of aluminum-hull vessels. Typical damage identified during interviews was specifically related to hull material. Damages from similar events differ considerably, with aluminum being more capable of withstanding impact damage. Only damage typical of aluminum hulls is described here. Each type of damage is described in the following paragraphs.

10.4.1 Minor Damage.

Minor damage consists primarily of cosmetic damage to hulls. Typically, watertight integrity is maintained, and mechanical systems are workable but in need of repair due to inboard-outboard stress and prop damage. For vessels with inboard motors, shaft, skeg, or rudder damage is evident, but the boat can be refloated and moved under its own power. Repairs should be made and haul-out may be needed prior to the boat being fully serviceable. Hull damage is not structural, but damages are obvious, and mechanical systems need service. Damage, up to 5 percent of replacement cost, may consist largely of lost or damaged equipment, gear, or tackle. Damage may also include the value of catch that cannot be delivered.

10.4.2 Serious Damage.

Hull scratches and dents are obvious but not large enough to impact vessel displacement, stability, or handling. Sharp edges and evidence of stretched metal are present to a minor degree. The hull is serviceable without repair, but haul-out is needed for hull inspection, and repair of underwater mechanical systems must be done out of the water. The boat may be able to be moved under its own power, but the drive system needs immediate repair. Damages are 5 to 15 percent of replacement cost and may include lost or damaged equipment, gear, or tackle. Damage may also include value of catch that cannot be delivered.

10.4.3 Severe Damage.

Hull dents may impact displacement and performance. Hull is watertight even with damage below the water line; however, obvious sharp edges and stretched metal indicate hull repair is required before use. Internal mechanical and electrical systems do not suffer water damage, providing the boat remains upright during the grounding. Drive units are unusable without major repair. Boat can be towed without repair, but cannot be used. Damage is 15 to30 percent of replacement cost and can include lost or damaged equipment, gear, or tackle. Damage also includes the value of catch that cannot be delivered.

10.4.4 Maximum Damage.

This category covers catastrophic hull damage, such as can be caused by being rolled in the surf onto a rocky shore. Hull displacement and stability are compromised through changes in the hull geometry. Mechanical and electrical systems suffer damage from water and impact. Mechanical systems require replacement. Hull repair requires welded sections. Damages are 30 to 100 percent of replacement cost. Damages can exceed 100 percent if negligence or environmental damage is involved, or if catch is lost.

10.4.5 Damage Summary.

The expected percentage of annual loss was estimated using damages related to aluminum hulls, as shown in table B-13.

TABLE B-13.—*Frequency integration, vessel damages*

Damage range	Frequency	Average % damage	Frequency of interval	Weighted %
0 - 5%	.99	2.5	.01	0.02
5 - 15%	.50	5.0	.44	2.2
15 - 30%	.33	7.5	.17	1.3
30 - 100%	.25	35	.08	2.8
			TOTAL	**6.3**

Historically, vessels driven aground, striking bottom, or sunk during storms in Norton Sound are combination fishing boats. Typical replacement cost of the 9.8-12.9-m combination boats of the day fleet using Nome in the summer of 1997 was $260,000, not including electronics and fishing gear, so the estimated annual expected storm damage for the commercial fishing fleet is .063 x $260,000 x (50-boat fleet less 4 skiffs) x 33% caught outside once annually = **$248,700**.

As an upper limit to the benefit, it is assumed that damage factors based on vessel values have not adequately recognized the value of lost catch. Seasonal harvest per boat is $103,300 during about 74 days of active commercial fishing, allowing for an average of 55 weather days, days between seasons, maintenance, and travel. Average daily gross income from operations is $1,400. In the event boats are caught outside the harbor by storms, they will be unable to off load their catch, so they will dispose of it. Since a quota system prevails, the discard does not financially damage them, but the nature of NED economics is that part of a resource has been used up, and an opportunity cost must be recognized. The opportunity cost incurred by disposal of the catch is based on ex-vessel prices. $1,400 discard x 15 boats + $248,700 = **$269,700**.

This calculation does not include time required of the operators and caretakers who must tend boats during storms or move them to other locations where they are less subject to damage. Those damages amount to a loss of leisure time required to tend all boats moored at Nome. Licensed captains at Nome maintain that such activity, expected several times each year, is essential to preventing damages. For this analysis, the time lost is based on the following assumptions:

- Fifty-five weather-restricted days occur each season.
- Each storm day requires 12-24 hours of attention to vessels closed out of the harbor.
- One-third of the boats (excluding fast skiffs) are caught outside at least once annually.

- Two crewmembers are aboard each boat.
- Opportunity cost of time is valued at $3.00 per hour.

Annual prevented lost-time damages to the fishing fleet at the higher range are (55 storm days x 24 hours x 15 vessels x 2 crew x $3) = **$118,800,** and at the lower range are (55 storm days x 12 hours x 15 vessels x 2 crew x $3) = **$59,400**.

10.5 Project-Related Fishing Fleet Damages

Typically, the event leading to damage during use of the entrance or harbor is a storm of fairly long duration from the southeast or southwest. When seas develop to a combination of surge, swells, and steep, short-interval waves, the harbor entrance becomes invisible from the outside. The jetty can become overtopped with spray and breakers, and vessel captains are not able to accurately locate the entrance. There is usually a following sea, and vessels are highly likely to broach during the entry. As vessels move closer to the beach line, they are more subject to increased energy from breaking waves. Wave action within the harbor is also damaging to boats tied to docks and to each other.

According to 46 CFR Ch. 1 (10-1-88 edition) subpart 4.05-1, the owner, agent, master or person in charge of a vessel shall give notice as soon as possible to the nearest USCG Marine Safety or Marine Inspection Office whenever incidents involve accidental grounding, loss of main propulsion or steering or any associated control system, any occurrence materially affecting the vessel's seaworthiness, loss of life, injury causing incapacitation for more than 72 hours, OR events causing damage in excess of $25,000.

Since the regulations are oriented toward disclosure of serious incidents, those events that could be considered minor by some standards ordinarily go unreported. No statistical research was conducted to verify the number of incidents involving damage less than $25,000, but discussions with industry officials, including vessel owners, disclose that they expect to accumulate $25,000 in visible, above-waterline damage during any year from multiple events. This amount of annual expected damage may seem high at first presentation, however, the rule of thumb among old-timers in the industry has been that a new boat should be able to pay for itself in 3 years of successful operation. Given a 3-year recovery of the investment, with annual damages of $25,000 (10 percent of vessel value), the vessel still has a substantial liquidation value should the owner elect to replace it at the end of 3 years. Theoretically, the upper limit on expected damages would allow them to accrue at an annual rate sufficient to erode liquidation value to zero at the end of 3 years.

Damage to commercial fishing boats happens with practically every trip. The boats are extremely durable, and damage that appears serious is often of a cosmetic nature. Hull scratches, dents, and scrapes may not impact the performance or seaworthiness of a boat but do change the esthetics and consequently the price at which the boat can later be sold. Visible damages are so common and difficult to avoid that owners

generally accept the cumulative scars as part of the commercial fishing environment and take no initiative to repair for appearance unless a boat is put up for sale. Still, the damage impacts retail value of the boat, as any new owner wants a vessel that shows pride of ownership and is shipshape and seaworthy by appearance as well as survey. The cosmetic damage, therefore, does have a significant economic cost equivalent in cost to an annual refurbishing of the hull.

Commercial fishing boats are not required to be hauled out annually for hull maintenance, so cosmetic damage is allowed to accumulate until the vessel is put on the market. At that point, the seller assesses his choices between selling at a discount or refurbishing in order to obtain a premium price. The economic cost of cumulative damage is estimated by comparing known sales value of similar boats in drastically different condition.

For this report, price data was obtained from *BUC Price Guide*, *ABOS Marine Blue Book*, and discussions with boatbuilders. The guides are similar to automobile blue books. They compile information from actual sales of used boats and note the variation in price due to condition. The guides are based primarily on pleasure boat sales. However, the data base is extensive, and adequate information exists on specialized fishing boats to use the guides for reference. There is no known similar guide specifically for commercial fishing boats. The guides describe average value, extreme variations, and standard deviation. The most recent *BUC Price Guide* available is for 1996. It reviews sales of boats built from 1991 to 1996.

Several of the boats in the Nome CDQ fleet were manufactured by Kvichak Marine and put into service during the price period under study. The boats are typical of smaller combination vessels in use in the Bering Sea and Norton Sound. A representative of the company provided information for this report.

Larger combination boats range up to 17.7 m, but those commonly used on Norton Sound are 9.8-12.9 m overall, 4.9 m wide, and draw about 1.8 m. The boats are welded aluminum with 3/16" hull side shells, ¼" bottom plate, and ½" rudders. They are diesel powered and drive a 4-bladed propeller through a 2-inch shaft.

All seams on the boats are welded, creating an extremely durable hull. Compared to wood or fiberglass, the hulls are able to withstand more abuse while maintaining seaworthiness. Aluminum hulls are more expensive, but the tradeoff for reduced risk of serious damage has encouraged owners to pay the premium.

An estimate of the economic impact on a boat's value of one season's wear and tear was arrived at by use of three procedures. The damages were considered to be minor annual damage, usual and customary, but repairable and preventable:

- Differences in the price of comparable boats when differences are explainable by condition, based on data from *BUC Used Boat Price Guide* and *ABOS Marine Blue Book*

- An examination of boats in service at Nome to document actual hull appearance and damage
- Manufacturer's estimate of annual cost of restoring a boat to new-condition appearance

Nine boats in the Nome harbor were examined. Two had been hauled out, and the complete hull was viewable. All nine had been in service less than three seasons. They were of similar design and of aluminum construction. All of them showed numerous scratches, dents, and gouges to the hull, especially the front third of the hull visible above the waterline. The second most common damage was to the gunwale area, where dents were present. Thirdly, scratches and abrasions were showing along the vessel side, amidships.

Such damage is common on Alaska fishing boats, and it is rare for a boat with one or two seasons on it not to show serious effects of use. The boats were considered to be in good/average condition with an upgrade to very good, hinging on the performance of cosmetic work to make damage from fishing operations less obvious.

A manufacturer's representative described damages to be of two separate types: minor damages, which are cosmetic and are generally not repaired (damages of this type are expected to be obvious above the waterline); and major damages, which could impact performance and are generally repaired (most likely to be in evidence below the waterline). The manufacturer does not generally perform cosmetic repair as the owners often elect to put up with the damage, expecting to take the loss when the boat is sold, or less often, repair in preparation for sale. The impact of appearance on price is generally less than the costs of cosmetic repair to put the boat back in like-new condition. The reason for the difference is that with the damages present, the boat can still provide its income function as well as it could with the damages repaired.

Repair of all cosmetic damages would normally require filling dents and scratches. The procedure changes the appearance of the hull, so the aluminum must be painted to make the boat look new again. This is a very expensive undertaking. The process is sometimes done for pleasure hulls but generally not for fishing boats, as the boats become damaged again as soon as they are put back in service.

The manufacturer estimated that above-waterline cosmetic renovation of the boats at Nome could be done annually at a cost from $10,000 to $40,000 (up to 15 percent of value). If the aluminum were filled and painted, cost would be significantly higher. Total renovation including filling and painting could cost $70,000 (up to 27 percent of value), but would not likely be done, as the fishing community accepts above-waterline damage as ordinary and customary. The manufacturer's position is that annual damages could be repaired for between $10,000 and $40,000, with the higher figure being able to cover almost any type of above-waterline annual repair an owner would be likely to order. The cost does not include lost time from fishing for the boat or its crew. Also not included is the cost to transport the boat from the Bering Sea to Seattle or another location where the work could be performed.

Damages from one season's activity are impossible to identify without monitoring a number of boats during the season. For this analysis, damages were documented by inspection of nine boats at Nome and discussions with operators. It was not possible even for the vessel operators interviewed to separate the damage by event or season. With damages grouped together in a small area of the hull, the manufacturer believed it would probably cost little more to fix damages of 2 years' worth of fishing than it would for 1 year.

Based on review of the damages at the scene, discussion with a local marine surveyor, discussion with the manufacturer who also operates a repair service, and judgment based on BUC and ABOS guides, accumulated effects of seasonal damages from normal operations are estimated at 15 percent.

For purposes of the benefit evaluation, damages were assigned to harbor-related incidents based on the percentage of time fished from a given harbor. Regarding the Nome fleet, the combination boats fish from Nome at least 50 percent of the season. Above-waterline damages related to experiences at Nome Harbor equal average vessel value ($260,000) x damages (15%) x location factor (50%) x number of vessels fishing from Nome Harbor based on the equilibrium fleet (50 - 4 skiffs) = **$897,000**.

Improvements to the entrance would reduce the number of incidents when vessels contact one another, the jetty, the sheet pile, or the docks. It is impossible to say exactly how many incidents would be prevented. However, operators claim there is a direct relation between severity of water conditions at the entrance and damages to vessels using the project. Therefore, project effects on reduced wave activity within the channel have been used as a basis for estimating benefits for above-waterline damage reduction. Some of the fleet is expected to use other harbors in addition to Nome, so benefits have been reduced to recognize the possibility that 50 percent of the fleet would be active in other fisheries involving other ports 6 months of the year. The estimate of fleet activity is based on discussions with local operators.

A project with a relocated entrance and a jetty extension to deeper water is anticipated to eliminate impassable days. A 100-percent reduction has been used as a basis for estimating potential benefits. The reduction in damaging conditions is applied to damages incurred in the entrance and also within the harbor. Benefits for improving the entrance are estimated to range between a high of **$897,000** and a low of **$672,700,** after making a 25-percent allowance for significant uncertainty surrounding the tie between proposed improvements and reduction in damaging wave events. The 25 percent includes a judgment allowance for residual damages, and the fact that even under perfect conditions it is still possible for an inattentive or inexperienced operator to get into trouble.

10.6 Commercial Tug and Barge Damages at Entrance

Problems at Nome Harbor are a cause of excessive damages to tugs and barges operating out of Nome. Review of maintenance and budget information for the *Kuparuk River*, a 31-m, three-screw tugboat stationed at Nome, disclosed higher than normal repair costs due to hull impacts and related wear and tear. The *Kuparuk River* was selected because it is stationed at Nome and because the owner, Crowley Maritime, also has comparable budget and maintenance records on other vessels not based at Nome.

Maintenance of the *Kuparuk River* is significantly higher compared to those sister vessels because of damages incurred at Nome. In many cases, fishing boat damages go unrepaired if they are cosmetic, but in the case of a commercial tugboat hull, inspections are required and dents are fixed, especially if they involve sharp edges or stretched metal. The industry is subject to strict safety standards and inspection programs. The companies that own the boats therefore have good records on vessel repair.

When a tug bottoms out, often the barge does not hit bottom because the drafts are different. Usually, however when a tug is in difficulty, the barge will have problems as well. A bottom strike with prop, shaft, bearing or rudder damage to the tug will often involve the barge either breaking loose or hitting the jetty or breakwater. A rule of thumb in the industry is that tugs experience bottom damage and barges experience side damage. Barge damages that appear minor, such as loss of a fender, can be extremely expensive to repair, especially if the barge is used for fuel hauling. Repairs usually require welding, and the entire barge must be made gas-free. Cost of repair to a single fender can exceed $6,000.

For 1997, a year the owner considers "normal," the owner budgeted $130,000 for repairs for *Kuparuk River*. In 1996, repairs amounted to nearly $200,000 because of an unusually high number of bottom strikes at Nome, and the maintenance budget was exceeded. For the *Kuparuk River*, records show about 70 percent of the budgeted repair cost is attributed to bottom damage, with only 30 percent related to upkeep of machinery. For other vessels owned by the company, which do not operate in and out of Nome Harbor, only 20 to 30 percent of budgeted maintenance is related to hull damage, so their overall cost is much lower. Conditions at Nome Harbor are responsible for a 40-to-50-percent historical increase in cost, about $52,000 to $65,000 per tug-and-barge combination every year over similar equipment that does not call at Nome. In addition to Crowley's *Kuparuk River*, three other operators out of Nome Harbor have one tug apiece: Bowhead Transportation, Utana Barge Lines, and Delta Western. The three tugs draft 0.2 m more than the *Kuparuk River*.

Based on detailed review of damages incurred by the *Kuparuk River* due to bottom strikes in the channel, fleet total damages related to bottom strikes are estimated to range between $208,000 and $260,000 annually. This estimate is based on the assumption that damages to other tugs with slightly deeper draft but less frequent use

are similar to damages incurred by *Kuparuk River*. The estimate discounts damages to the rest of the lighter fleet on the grounds they are not coupled to barges and hence more easily maneuvered. It is possible for them to back down and reverse direction, or turn sharply when entering shallows, options not available to tugs with barges in tow. With the proposed project, the channel would provide adequate depth through the entire navigation season. All of the tug damages are considered preventable, so benefits are estimated at **$208,000 - $260,000** annually.

Improving conditions for the tugs would allow them to maintain better control of the tow and reduce the number of incidents resulting in damages to barges in tow. Barge damage from collisions with the project happen several times each year. The collisions usually happen when seas are rough and strong cross-channel winds are present. Under these conditions, tows are difficult to control. Barges sometimes break loose under tow or break loose from their moorage.

Though there have been incidents of major damages to barges at Nome in recent years, including sinking, the incidents do not appear to be related to bottom strikes. Some problems would still be associated with crosswinds during use of the entrance, so the problem of collision with the project is not eliminated. It may be reduced somewhat by providing improved maneuvering conditions for the tug, but benefits for improved operating conditions and improved underkeel clearance for the tug are already presented. Damages to barges are considered to be present in the without-project and with-project conditions. The amount these damages would be reduced by the project has not been estimated.

10.7 Light Loading

As the season progresses and the entrance channel begins to shoal, the lighter fleet must light-load on every trip in and out of the harbor. This is not a critical factor on most trips when dry cargo is being hauled, as the vessels rarely draft to their maximum. When fuel is delivered to and from the inner harbor, less than full loads are taken two-thirds of the year. This light loading drives unit delivery costs up, and adds trips and time when hauling fuel to village destinations.

The average number of gallons of fuel through the jetty each year between 1990 and 1996 was 3,257,000. According to Crowley, delivery to the inner harbor requires the use of lighters. The oceangoing barges dock at the causeway and transfer fuel by pipeline to a local tank farm or transfer it to lighters that deliver it into the inner harbor. The lighters are capable of taking 250,000 gallons per trip but under light loading requirements can take no more than 150,000. During a year like 1996, when the project was shoaled up the entire season, every fuel lighter had to be light-loaded, causing a 65-percent increase in number of trips and a corresponding increase in cost. Each extra trip required an extra 5 hours of pumping time at each end, which tied up the equipment an additional 90 hours, adding $23,500 not counting cost incurred for additional dock crew time.

Fuel shippers expect to have to light-load in and out of the harbor every year, but in most years the channel does not develop a shoal until the last two-thirds of the season. For that reason, the annual cost of light loading is estimated at $23,500 x 0.66 = **$15,500**.

10.8 Long-Term Delay

Sea conditions often slow deliveries to Nome during the fall. Time is especially important as the weather turns foul and harbors served from Nome began to freeze. With the goods delivered as far as Nome, and the final leg impossible to complete until the following summer, arrangements must be made for storage or delivery by air. If delivery is not urgent, and the goods can be secured against the winter and vandalism, outside storage is possible at $2.08 per square foot per year, approximately $224,000 per hectare annually. To this one must add the cost of movement to the site, preparation for storage, administration of arrangements, insurance and other overheads, and all of the expenses related to getting the shipment ready to move again after the thaw of the following spring.

For a shipment such as housing units, delivery contracts in the past have added liquidated damages in the amount of $50 per day per unit, not including the arrangements that must be made at the destination for interim housing. Also lost when delivery of housing units is delayed is the return on investment for up to a year's worth of capital tied up in unusable inventory. For goods such as housing units, the cost of lost return on investment is substantial. One extreme case involved delivery of 40 housing units that got delayed a season, half of them nearly a year. At a cost of $200,000 per unit (cost of new housing by grants for similar housing units), the capital tied up in 40 units is $8,000,000. The cost of 1 year's lost opportunity at 7-3/8 percent is $588,800; liquidated damages were $347,000; and interim housing is estimated at $280,000 = $1,215,800 delay cost.

If a weather delay at Nome threatens to be of long duration, an oceangoing barge will sometimes call first at Bethel or Kotzebue, hoping that by the time it arrives at Nome it will be able to unload with a weather break. But this can happen only if the barge has been loaded with cargo destined for Bethel or Kotzebue, and this does not happen on every trip.

One of the reasons for bypassing Nome is to ensure that Bethel or Kotzebue can be serviced prior to freezeup. Freshwater flow of the river at Bethel freezes before the Nome harbor, but even if things go perfectly, the lighters bypassed at Nome are delayed there until a connection can be made. If the barge is able to get into Nome on the return leg of its journey, the lighters may still be able to operate. The major problem they face, even if the barge is not delayed again by weather at Nome, is that the barge cargo must be broken apart for reshipment aboard the lighters. This takes time, and each hour is an hour closer to freezeup. There have been times when the barge was at Nome and the lighters could not make their final leg due to ice.

Since villages rely on barge shipments for heating fuel, fuel for local generating plants, groceries, medical supplies, boats and motors, snow machines, clothing and other essentials, and technology they are not able to gather from wild resources, delivery is sometimes an absolute requirement. Air transportation then becomes the obvious choice. The difference in cost between shipping by air and shipping by water is $1,150 per ton.

According to the Alaska Department of Transportation and Public Facilities, Statewide Aviation, air cargo departing from Nome, excluding passengers and mail, was 4,900 tons in 1995. Air cargo out of Nome has increased steadily by 1 to 2 percent each year and is anticipated to hold that rate of growth at least until 2010, but for this report a level annual shipment of 4,900 tons was used. Waterborne cargo shipped out of the inner harbor has averaged 3,000 tons annually over the last 5 years.

We have used the relation between tons shipped out of the inner harbor by water (3,000), and tons shipped out of Nome by air (4,900) as a means of estimating the probability that any shipment arriving at Nome by water will be shipped out by air or water. Out of the 51,000 tons arriving annually, 6 percent will be reshipped to villages by air, and 10 percent will be delivered by lighter.

If the inner harbor were not available, lighter operations would be plagued by excessive queuing problems, encouraging people to rely increasingly on air delivery. With closure of the inner harbor there is an increased possibility that added waiting at the causeway would delay deliveries into Nome. Delay in November is most likely to interrupt lighter delivery to villages or displace cargo delivery to aircraft. It is assumed that at least one additional oceangoing barge trip per year coming into Nome would be too late to allow delivery to villages by lighter. Based on estimates from number of causeway trips and annual average load during the period, cargo loads can be expected to vary from a low of 233 tons to a high of 1,133 tons. If half the load ordinarily delivered by water is displaced to air and half is stored at Nome for later delivery by water, the range of increased cost would be:

Air = Lower range, 233 tons x 10% x 50% x $1,200 = $14,000; Upper range, 1,133 tons x 10% x 50% x $1,200 = $68,000

Storage = Assume 0.25 hectare for any storage problem = $56,000

Lower range benefits, then, are **$70,000,** and higher range benefits are **$124,000.**

10.9 Reduced Annual Dredging Cost

Based on historical dredging since 1973, the average quantity of material dredged each year is 9,950 cubic yards. Between 1986 and 1996, annual dredging cost ranged from $74,500 to $795,500. The minimum cost reflects a year in which there was no dredging due to environmental restraints, so only dredge standby cost was incurred. In most years, the bulk of dredging cost at Nome is due to a combination of standby

cost and the cost of getting the equipment to and from Nome. During actual productive work periods, unit costs are relatively low.

A project based on replacement in kind would continue to incur dredging, including dredging of the entrance as experienced in 1992, 1993 and 1994. Since 1964, only two years had less dredging than in 1992-94. This is a recent period and captures modern production technology. A minor price level adjustment based on the Civil Engineering Works Index (CEWI) was applied. The resulting annual dredging cost for the lower range is estimated at $202,800.

For the higher range, the dredging costs of 1987, 1988, and 1989 were used. These years appear to have been "normal" entrance maintenance, judging by quantities removed. Adjusting the annual cost based on the CEWI, the upper-range annual dredging cost is $512,800.

Proposed improvements to the entrance would realign the channel, add a jetty, and provide a deeper channel. The new alignment is anticipated to produce essentially a self-maintaining channel, which would save the dredging cost anticipated in the without-project condition.

Realignment of the project, including addition of a jetty west of the causeway, is anticipated to reduce annual dredging cost over the without-project condition by **$202,800 - $512,800**. The median value used for the benefit estimate is $357,800.

10.10 Saved Major Rehabilitation Cost

Major rehabilitation is demonstrated as the most likely future condition. An M-CACES cost estimate for major rehabilitation indicated a construction cost of $8,018,000. Including interest during construction, the annualized investment cost is $611,200. Since major rehabilitation is the most likely future without-project condition, all of the cost is saved by any of the plans for improvement beyond replacement in kind. The annual benefit is **$611,200.**

10.11 Land Creation

Project formulation and cost sharing must recognize that land creation benefits cannot to be used in formulation of the NED plan, and that special cost sharing is required for land creation. The formula for special cost sharing requires sharing general navigation costs in proportion to the magnitude land creation benefits have to total navigation benefits.

Land creation benefits exist when filling provides a usable area that can provide increased net income to the owner, or a windfall gain in property value that can be recouped through sale.

Improvement of the entrance includes filling in the old navigation channel, which is subject to navigation servitude. The area is yet to be specifically determined, but has been estimated as having the potential to create 3.4 acres of usable area. As part of the project a new channel is created, to which 5 acres of fast land (including easements) is dedicated. Close proximity of the parcels, similar values, potential uses, and development cost indicate an overall net economic NED loss of land resources due to the project.

With regard to the filled land, the created land parcel will be newly present in the with-project condition. A gross appraisal indicated it would have a potential market value of $440,000 in a contaminant-free state. It is created largely from contaminated material taken from the new channel, and the presence of contaminants may influence marketability.

The filled parcel is not served by utilities. Cost of developing the parcel may exceed the potential market value of the highest and best use. Development would require construction of underground utility corridors at a cost ranging between $500 and $700 per foot. The cost of slope stabilization and any special measure or restriction to compensate for the presence of contaminated material should also be considered development costs. If cost of development exceeds potential market value, there is no potential for net economic gain, basis for identification of NED benefits, or basis for identification of windfall gain to the owner.

The near-term use of the land will most likely remain as an area to keep dog teams, as much of the adjacent area is now used. In the long term, it may be possible to use the land as a support area for marine-related industries. Such use, however, would be in the distant future, as waterborne commerce through Nome is not projected to undergo significant growth, and support infrastructure already exists adjacent to the harbor.

Given that there are other parcels of land not burdened with a navigation servitude title defect and not a disposal site for contaminated material, the filled land is not considered a candidate location for future construction.

Land values represent capitalized future income. Projected land needs are met in the near term by other parcels, and effects of development cost and navigation servitude constrain future net income prospects. It is not likely that the land would be sold for profit as a construction site in the foreseeable future. Indications are that special cost sharing is not required.

Nome is not a rapidly growing economy, and it is not constrained in land supply. Creation of the land is not related to any potential future industrial use, marketing plan, or economic gain. It is merely the least-cost means of disposing of contaminated material. There are other undeveloped land parcels with lower development cost and lower risk, so given the slow rate of economic growth at Nome, prospects for developing and marketing the filled land as a construction site in the foreseeable future would be nil.

10.12 Summary of Benefits for Improving the Entrance

Benefits that would result from improving the Nome harbor entrance are listed in table B-14.

TABLE B-14.—*Summary, incremental benefits from improvements to the entrance ($000)*

Benefit category	Low range	High range
Fishing fleet damage, anchoring out	$248.7	$260.7
Fishing fleet damage, project-related	672.7	897.0
Lost time	59.4	118.8
Tug and barge damage	208.0	260.0
Light loading	15.5	15.5
Reduced long-term delay	70.0	124.0
Reduced O&M dredging	202.8	512.8
Saved major rehabilitation cost	611.2	611.2
TOTAL	**$2,088.3**	**$2,800.0**

Most of the benefits for improvement of the entrance can be achieved by providing improved authorized channel depths all season, and by improved conditions to avoid entrance problems for vessels. In effect, the improvements would allow unhindered use up to 95 percent of the navigation season. Providing this objective can be achieved and all related damages can be prevented, median annual benefits would be **$2,321,900,** including an adjustment for residual effects of a set-down. Benefits for varying degrees of improvement are presented in the discussion of project maximization.

11. BENEFIT EVALUATION FOR IMPROVED CONDITIONS AT THE CAUSEWAY

11.1 Without-Project Condition

The causeway, and any proposed improvements to it, stands alone as a separable element. The causeway can be left alone or modified, with identifiable impacts on engineering, economic, or environmental aspects of the existing harbor or other proposed improvements to it. It is therefore possible to evaluate the merits of causeway improvements on a next-added basis.

The appropriate "without-project condition" for evaluation of the causeway as an increment is a project with a reconstructed inner harbor, including a modified entrance with a jetty to provide improved entrance conditions. Those aspects of the proposed plan have benefits clearly in excess of cost, and have merit regardless of improvements to the causeway. Improvements to the causeway would have economic effects on oceangoing line haul barges and deep-water fishing boats that would use the causeway as a transfer station. Lighters would benefit little from causeway improvements, as their needs are met by first-added improvements to the entrance channel and inner harbor.

The without-project condition includes a processing facility, but it would be used only by vessels able to use the inner harbor facility to unload. This rules out inner harbor use by deeper-draft vessels in the +30.7-m size that make up the bulk of the deep-water offshore crab fleet and have drafts deeper than the depth of the channel and inner harbor. At present, the causeway is open to wave conditions that interrupt its use by the offshore crab fleet and oceangoing commercial transportation equipment. During the end of the season, the prospect of delay due to wave activity at the causeway is so great that shippers and fishing boats avoid using it.

11.2 Potential Savings for Delivery of Crab to Nome

Improvements that result in less interruption in use of the causeway would produce economic savings in the form of reduced operating cost. The prospect of using the causeway as a means of access to the inner harbor processing facility would provide a part of the crab fleet with a lower-cost alternative port for offloading at the end of the season.

Of the estimated 180 vessels involved in the two Bering Sea deep-water crab fisheries, vessels are evenly split between the *bairdi* tanner and blue crab fisheries that open the first week of November. November usually marks the end of regular commercial traffic at Nome, due to worsening weather and sea conditions, but the causeway is still available for use. Ordinarily, by this time of the season, all of the planned commercial shipping has taken place and Norton Sound fisheries have been

closed. The Bering Sea deep-water fisheries are open but not fished by the Nome-based fleet, so harbor activity is quiet.

The ADF&G controls the location of the *bairdi* tanner crab fishery. Based on data in the "Bering Sea and Aleutian Islands King and Tanner Crab Management Historic Overview and Preliminary Summary of 1995/1996 Fisheries" by ADF&G, the anticipated annual harvest is 2.5 million kg. The season lasts from 7 to 21 days and involves half of the approximately 180 boats that fish for crab during November. The other half target blue king crabs.

The *bairdi* tanner season may involve either the eastern subdistrict of the Bering Sea or the western subdistrict. The eastern subdistrict reaches to Norton Sound and farther north to the Bering Straits. Boats fishing in the northern half of the eastern subdistrict for either *bairdi* tanner or blue king crab are closer to Nome than to either St. Paul or Dutch Harbor. Delivery to a processor at Nome therefore would allow the vessels to finish the season in the northern limit of their harvest area. If the end-of-season delivery is made to Nome, this would cut time from the delivery run and minimize deadloss during transit. It would also provide a time and cost saving over delivery to Dutch Harbor or St. Paul Island.

Bairdi tanner crabs generally dwell in the deeper water in the southern half of the Bering Sea, while king crabs also inhabit shallower waters of the northern half and Norton Sound. Tanner crabs gather into mounds of hundreds of crabs per mound, so capture rates can be very high when pots are set at or near a mound. Blue crabs are solitary, so capture rates are lower. This is balanced somewhat by the fact that king crabs are more likely to be located in shallower waters, and the fact that the average weight of king crab is much higher than the average weight of *bairdi* tanner crab. Still, at any time during the season, boats are more likely to be concentrated in the southern half of the subdistrict.

There is no readily available hard data to determine where crabs are harvested at a particular time. Only boats with processors on board are required to carry official observers to document activities and record harvest locations. Almost none of the boats in these fisheries carry observers, so they do not disclose to those with whom they compete, or the public at large, exactly where and how they fish. Therefore, one is left to estimate vessel dispersion patterns based on what is known about stocks and general harvest locations to account for vessels that may be closer to Nome than other delivery points.

NMFS surveys of abundance of blue king crab in the Northern District of the St. Matthew Island fishery, between 1978 and 1994, average 7.8 million. A 1996 research report, sponsored by Norton Sound Seafood Products, included an interpretation of a Norton Sound trawl survey, and estimated population of blue king crabs in Norton Sound at about 1.7 million. The NMFS estimate is based on 17 years of data, while the Norton Sound Economic Development Corporation (NSEDC)

estimate is based on trawl surveys in only one season. The NMFS data is therefore more reliable and not directly comparable with the NSEDC study.

The data from NMFS shows a 39-percent difference between the calculated mean of the trawl samples and ± one standard deviation. Providing these properties hold true for the sample taken at Norton Sound, and a normal distribution can be hypothesized, the data implies that a population estimate of 1.7 million ± 39 percent (a range of 1.0 to 2.4), is within a 68-percent confidence interval. Of the blue king crab population in the Northern District and Norton Sound, we are reasonably confident that Norton Sound stocks represent 15 to 20 percent of the total.

To estimate the economic savings that would result from delivery of the harvest to Nome instead of to more distant ports, a fleet must be identified. The estimate is based on use of a decay function depicting a fleet split evenly between the November tanner crab fishery and the blue king fishery. This vessel distribution is supported by NMFS harvest data.

To estimate the number of vessels closest to Nome at the end of the season, half of the blue crab fleet is allocated to operations close to St. Matthew Island, and half is dispersed more widely around the island. Most of the second group would be operating within a distance of approximately 325 km. Related to the widely dispersed part of the fleet is a group of vessels that would operate in Norton Sound as far north as within 16 km of King Island, providing they would be able to deliver catch nearby. Based on abundance of crab populations, this places up to 15-20 percent of the 90 blue crab harvesters, or 13-18 vessels, closer to Nome than to any other port.

A crab vessel using Nome as an offloading and reprovisioning station would save 1,600 km or more on each fishing trip of the season. Only one or two of the vessels are equipped to stay on the fishing grounds all season, processing the crab on board the boat to reduce deadloss and minimizing fishing time lost during delivery to a processor. The smaller combination boats are not equipped to process on board and must hold the crabs live after they are caught. These boats often fish steadily for 1 to 3 days, then deliver the catch to a shore-based or floating processor and return to continue the harvest.

The savings in travel distance by delivery to Nome is countered somewhat by the longer final-market delivery distance from Nome to Japan, compared against the distance from St. Paul Island to Japan. The processed crabs would be shipped in freezer vans from Nome to St. Paul, where they would be picked up by a freighter and taken to Japan. The processed crab has less bulk than the live product. When it is shipped in freezer vans, a single vessel can ship the catch of all 13-18 fishing vessels to St. Paul at a cost of about $20,000 (allowing 44 hours for the trip and 28 hours for cargo transfer). The result is minimum overall lay-down cost at the destination.

Combination boats that venture into the deep-water offshore crab fishery are generally less specialized smaller vessels under 30.7-39.9 m. They have a

replacement cost of $2 million to $4 million and cost about $0.7 million to $1.3 million annually to operate. Their total annual cost that needs to be recovered, including a return to capital, ranges from $702,000 to $1,099,000.

The vessel cost data in this section were reported in a fleet survey project prepared in June 1997. The report is based on detailed interviews with successful operators, and the findings appear to be statistically significant. The two vessel classes used to bracket the above operating costs were crab boats less than 30.7 m and crab boats in the 30.7-to-39.9-m class. Actual data presented in the report is summarized in tables B-15 and B-16.

TABLE B-15.—*Statistical description of average vessel (crab boat) represented in the study*

Size class	**Larger (<30.7 m)**	**Smaller (30.7-39.9 m)**
Average length	28 m	35 m
Average beam	7.6 m	9.2 m
Average draft	3.4 m	3.8 m
Value in $ millions	1.2	2.7
Age	23 years	20.8 years
Horsepower	582	1,121
Max. speed	17.2 km	18.2 km

TABLE B-16.—*Average vessel operating cost profile (costs in $000)*

Size class	**Larger (<30.7 m)**	**Smaller (30.7-39.9 m)**
Fuel, lube hydraulic	$34.7	$57.2
Vessel & machine maintenance	66.2	113.6
Fishing gear maintenance	32.3	36.3
Bait	15.7	23.6
Food	11.3	14.1
Stores & supplies	3.4	11.7
Licenses	2.0	2.4
Freight cost	1	1.6
Hull insurance	54.6	70.1
Moorage & storage	6.7	10
Crew share	261.1	410.6
Salary/benefits	46.4	53.5
P&I	27.4	36
Business expense	58.9	59.3
TOTAL	**$621.7**	**$900**

To break even during the course of a year, the vessel must recover its fixed and variable cost. Vessels that cannot produce annual income above this threshold cannot compete in the long run. If the vessel fishes in all available fisheries, it can be active about 209 days per year. This would include 106 days of pollock or other groundfish,

up to 64 or more days of crab, and 39 days in other fisheries. Preparation, re-provisioning, offloading, and travel time are included. Based on 209 days of fishing per year, the daily cost of the vessel is $3,360-$5,260, and the hourly cost range is from $140 to $219. At a maximum speed of 17.2 km/h to 18.2 km/h, each call at Nome instead of St. Paul could save a 1,600-km round trip. This would save 88-93 hours of travel time and $13,000-$19,300 in cost, not including the value of crew time as lost leisure time, and not including savings due to reduced deadloss.

Since the crab stocks inhabit the ocean floor in a way that distributes them in patterns but with lack of predictability with regard to location, the boats that harvest them space themselves and their crab pots accordingly. This pattern of harvest is maintained throughout the season, with the pattern of boats becoming more localized as concentrations are discovered and the unit success rate increases.

Smaller boats that do not process on board tend to fish closer to the processing station. They minimize non-fishing time, and will trade off travel time and distance against success in an attempt to maximize net income during the short season. Therefore, the result is that the smaller boats are closer to the processing station at any time during the harvest. At the close of the season, the boats needing to offload their live catch will do so immediately.

The non-processing boats, which could plan to end the season close to Nome, would save the alternative travel cost of delivering their catch to St. Paul or Dutch Harbor. There are about 13-18 of these boats, with an average of 7,750 kg of crab on board (half of the average per-vessel blue crab harvest reported in NMFS data over a 17-year period). This represents a travel cost savings of $169,000-$347,400, from which one bulk delivery of freezer vans from Nome to St. Paul must be subtracted at a cost of $20,000. Benefits of travel saved are estimated to range from **$149,000** to **$327,000** annually.

The actual saving is expected to be less, as there would be some lost time due to queuing at the offloading facility, and in some cases a stop at Dutch Harbor or St. Paul might fit more effectively with the vessel itinerary. There is inadequate data to simulate what might happen, so it has been estimated that the 13-18 vessels would be accommodated at the two causeway cells on a first come-first served basis, that they would arrive over a 48-hour period, and that they would require 6 hours to unload. The 13-18 vessels would require a total of 78-106 dock hours A total of 108 dock hours would be available during the arrival period, including the 6 hours following. Still, some vessels would need to wait, as they would not arrive at a controlled, uniform rate, and unloading times would vary. The operators would attempt to balance cost of waiting time and related deadloss against leaving for the processor early. Among operators there is also expected to be some exchange of information regarding end-of-season activity, so all of the boats would probably never actually depart at the same time.

Two simulations of arrivals were conducted to determine the relation between arrival patterns and waiting times. The first simulation, based on random arrivals of 13 vessels during each of eight 6-hour periods, demonstrated repeatedly that half or more of the vessels would arrive during the first 6 hours, and the balance during the next 12 to 18 hours. This results in fleet waiting time of about 426 hours.

A second simulation was based on the assumption that vessel arrivals would be random, but that the fleet would be self-directed to minimize waiting. As input to the simulation, it was stipulated that half the vessels would arrive randomly in the first 24 hours and half in the second 24 hours. Total waiting time was reduced to 144 hours under this scenario.

The difference in fleet waiting time between 426 hours and 144 hours (estimated to have a value in excess of $60,000) is a strong incentive for the fleet to exchange information with the intention of managing arrivals to minimize waiting. For this analysis, it is assumed the fleet would act in a rational manner and be self-directed, resulting in minimizing randomness in the arrival procedure. Within the practical restraints of a specific window for the season, wide dispersion of fishing vessels, variation in success rates, differences in holding capacity, differences in vessel speed, and a desire by some operators to be independent, self-reliant, and possibly skeptical, we have assumed:

- 25 percent of the vessels would experience zero waiting
- 25 percent would wait 6 hours
- 25 percent would wait 12 hours
- 25 percent would wait 18 hours

This would result in a total waiting time of 108 hours for 13 vessels and 162 hours for 18 vessels, not including unloading time. On the surface, the effect of waiting is to create a reduction in the range of transportation savings by 108 to 162 hours. However, those boats unloading at St. Paul or Dutch Harbor (72-77 vessels) are forced to wait for longer periods than the boats that would unload at Nome. The total fleet waiting time of 108 hours to 162 hours at Nome is therefore, to some extent, a beneficial effect compared to the without-project condition.

To some extent, this incidental gain would be augmented by a smaller deadloss through Nome delivery. Deadloss is a function of the time the crabs are on board and how rough sea conditions are. A shorter trip can reduce deadloss substantially. Also, adjustments are required to recognize the value of leisure time effects and reduced exposure to risk of vessel damage or loss at sea.

By saving running time to St. Paul and instead heading to Nome, a reduction in running time of at least 44-46 hours is expected. A reduction in deadloss of about 10 percent for saving 44-46 hours of wet holding time is estimated, using mortality between 36 hours and 78 hours. With ex-vessel harvest on board at time of delivery

estimated at $68,000, the value of reduction in deadloss is $6,800 per vessel, or **$88,400-$122,400** for 13 and 18 vessels respectively.

With four persons aboard each vessel, net travel time savings of 93 and 88 hours, and leisure time valued at $15 (deep-water fishery), savings for the 13-18 vessels amount to **$72,500-$95,000** respectively.

11.3 Damage to Lighters

To load and unload, lighters must pull alongside a fixed dock or larger vessel, or ground themselves on a beach. When seas are rough, the lighter runs a high risk of damage in all three cargo-handling scenarios. When tied to a fixed dock, the lighter can surge against its moorings and impact the mooring cell. The mooring cells have zero give against forces carried by the lighter. When the vessel rebounds, energy not absorbed by the lines and fenders can cause damage to the mooring cell or the vessel. The lighters are of less solid construction, and the effect of impact against the moorage cell is most visible as scratches, dents, and tears in the hull.

Historically, there have been numerous sinkings of lighters just off the beach at Nome. Many of these incidents took place prior to the construction of the causeway, which provides some shelter from wave effects but does not make them disappear. Vessels now in use as lighters display numerous scars from hull impacts. Not all of the vessel damages observed are caused by incidents at Nome, as there are other destinations that require the lighters to transfer cargo while tied along the lee side of larger vessels. Many of the lighters are fuel tankers, and a serious event could be environmentally disastrous.

Rough conditions result in unusual wear and tear on moorage equipment, including stretching and fraying of moorage lines, which cuts life expectancy in half. Line replacement is expected to add **$18,000** annually to the lighter operation for the entire fleet. Damage to vessels has been effectively minimized by stout mooring arrangements.

11.4 Vessel Delay Reduction

Conditions at the causeway are often judged by operators as too rough. If offshore and attempting to use the causeway, operators will "jog at sea" until sea conditions are smooth enough to use harbor facilities without undue risk of damage. If they are already at the causeway and conditions worsen, barges or tugs will untie and wait at sea until conditions improve.

A simulation of causeway operations by oceangoing equipment (excludes lighters and fishing vessels) indicated 55 vessel days of delay annually. Providing the proposed improvements can eliminate all delays associated with sea conditions at the causeway, benefits would include reduced waiting time for oceangoing line haul equipment. Time is evaluated at $582 per hour or $14,000 per day, which includes

tug, fuel, crew salary and benefits, hull and machinery insurance, maintenance, dock fees, barge, P&I, dock standby crew, loader, truck, and lift. Waiting time for dock crews includes three machine operators and a crane or loader, truck/trailer, and forklift. The opportunity cost of tying up dock labor is $450 per person per day, or $1,350 per day for the crew.

The cost of lost time at destination harbors was estimated based on a leisure time loss at $3 per hour and one person delayed for each destination. There are actually a number of persons waiting for delivery, but we have assumed one person could be assigned responsibility to wait for the cargo and provide security when it is delivered and set on the beach at each of 10 village destinations. Daily lost time at the villages is therefore $3 x 24 x 10 = $2,160. Total value of reduced delay is based on the cost of line haul equipment, so the higher range benefit is ($14,000 + $1,300 + $2,160) x 55 = **$960,300**. An estimate for the lower range is arrived at by a 25-percent adjustment to accommodate variations in unit costs that were held constant during the evaluation. $960,000 x 0.75 = **$720,300**.

11.5 Cruise Ship Benefits

The simulator that was used to analyze delay problems included a cruise ship in the fleet. Delay benefits were categorized as commercial transportation savings for all users of the causeway during the delay analysis. To the extent the cruise ship requires time at the causeway, improvement of causeway conditions would provide a benefit. The benefit from delay reduction is not completely explained by the vessel contributing to dock congestion, as all vessels arriving immediately behind it are delayed by the fact they cannot dock. Cruise ships have the shortest causeway use times, and because they keep a tight schedule, they have little tolerance for delay. If they are unable to call at Nome without delay, they will either lighter passengers or stand offshore.

The delay analysis was not run under conditions with and without the cruise ship in the fleet to identify benefits specifically associated with it. The hospitality industry, specifically cruise ships, is an expected strong potential growth industry for Nome. The future fleet, however, did not include increased numbers of ships, so no benefits are claimed for future increases.

11.6 Summary of Benefits for Improving the Causeway

Benefits for improving the causeway are listed by category in table B-17.

Median annual benefits representing a potential level of accomplishment are **$1,285,600**. Benefits for other levels of improvement are presented in the discussion of project maximization.

TABLE B-17.—*Benefits for improving the causeway ($000)*

Benefit category	**Lower range**	**Higher range**
Travel Cost Saving	$149.0	$327.4
Deadloss Reduction	88.4	122.4
Leisure Time	72.5	95.0
Lighter	18.0	18.0
Commercial Shippers	720.3	960.3
TOTAL	**$1048.2**	**$1523.1**

12. INCREMENTAL BENEFITS FOR ADDING A CELL TO THE CAUSEWAY

With all of the previously evaluated improvements in place, there would still be a residual delay problem. The problem would be most noticeable in the fall, when crabbers would need to wait because there is not adequate terminal space to accommodate all of the vessels immediately upon arrival. Vessel delays have been estimated at 108 to 162 hours.

The impact of an additional mooring cell on reduced waiting times was estimated by simulating arrivals with the presence of two cells and with three. Arrival scenarios developed in the analysis of causeway improvements demonstrated the following results:

- The first simulation, based on random arrivals of 13 vessels during each of eight 6-hour periods, demonstrated repeatedly that half or more of the vessels would arrive during the first 6 hours, and the balance during the next 12 to 18 hours. This resulted in fleet waiting time of about 426 hours with two cells and 174 hours with three cells, a reduction of 59 percent.

- A second simulation was based on the assumption that vessel arrivals would be random, but that the fleet would be self-directed to minimize waiting. It was stipulated that half the vessels would arrive randomly in the first 24 hours and half in the second 24 hours. Total waiting time was 144 hours under this scenario with two cells and 60 hours with three cells, a reduction of 58 percent.

Results of the se scenarios were used as a basis for estimating reductions in waiting time that would be expected with the addition of a cell. An additional cell is anticipated to reduce dockside congestion by 58.5 percent, or 63-95 hours annually.

The value of the delay reduction is estimated using vessel operating and crew time unit savings previously estimated. An additional cell would result in incremental benefits ranging from (63 h x $140) + (63 h x $15 x 4 crew) = **$12,600** to (95 h x $219) + (95h x $15 x 4 crew) = **$26,500**.

The addition of a cell should also be considered as an alternative to protection of the causeway. If a cell is added near the shore, it provides a moorage that is incidentally protected by the jetty.

The benefits for each cell were prorated based on the first cell to be improved being the least costly. This would be the inner cell. Of the total causeway problems assessed in this report, the inner cell explains 43 percent. Therefore, one cell would earn 43 percent of the benefits earned by two. One cell could be protected either by a

lesser extension or by building a new cell behind a shorter jetty. This is probably an understatement of the benefit, but it is inconsequential in terms of leading to any serious error in plan formulation. So the benefit for improved use of one cell would be **$552,800**, for two cells **$1,285,600**, and for three cells **$ 1,305,100**. The incremental benefits for a third cell were too small to warrant further investigation ($19,500). Significant dredging would be associated with the near-shore location, in addition to the cost of the cell itself. The cost of the additional cell was estimated to exceed benefits several times over.

13. PROJECT MAXIMIZATION

13.1 Incremental Evaluation

The benefit evaluation develops benefits for three separate increments after performing an analysis to support major rehabilitation as the most likely without-project condition. The increments are as follows:

- **Improvement of Conditions at the Entrance.** This consists of increasing the 2.4-m authorized entrance depth to 3 m and expanding the channel dimensions to accommodate the present-day fleet. In addition to revised channel dimensions and alignment, the improvement includes a 910-m jetty to provide calmer waters at the entrance.

- **Improvement of Conditions at the Causeway.** The existing causeway would be modified by attachment of a 71.6-m spur breakwater at the seaward end. The existing causeway breach would be enlarged as part of a sand-bypassing plan, which would include a sediment trap.

- **Addition of a Moorage Cell.** This increment was evaluated but was not economically justified.

13.2 NED Project Depth

In addition to the separable increments aspect of the benefit evaluation, there is also the question of NED project depth. The concern with optimization of depth is that adequate project dimensions are provided to accommodate the fleet in a way that maximizes overall net economic returns. If a project is scaled deeper than it needs to be, more construction and maintenance costs are incurred than benefits produced, and net benefits will not be at their maximum. If a project is not scaled deep enough, some net benefits that could otherwise be earned will not be realized. An added concern is that risk associated with loss of life may not be adequately addressed.

In many cases, harbor development projects involve creating deeper harbors to accommodate deeper vessels that offer lower unit shipping costs. The lower shipping costs often make up a major share of the project benefits. The issue of project depth in most cases is also a major cost concern. With the improvements proposed for the Nome harbor no major shifts are expected in fleet makeup, and economy-of-scale benefits are not a major issue.

13.3 Evaluation Procedure

The benefit evaluation developed a lower and higher range of benefits where variations in development scenarios revealed outcome differences that could be large

enough to impact decision making. From the high and low range, median values were selected and used in formulation and justification. The median value of the potential benefits was used to anchor the upper end of two benefit curves: one for various depths of the entrance and jetty, and one for various depths of the causeway. For purposes of the incremental justification, a project-in-service date of 2000 has been assumed.

13.4 Present Operating Practice

Present vessel operating practices at Nome vary from time to time as the channel shoals, as wave activity varies, and as navigation conditions change at ports serviced from Nome. Operators attempt to maintain about 0.6m (2 feet) of water under vessel keels under quiescent wave conditions, and an additional allowance for wave activity at both the causeway docks and the inner harbor. The shallow depth at the inner harbor seldom allows the attainment of both these conditions, and at times neither condition is met. Shoaling at the entrance and the present draft of the fleet require that many vessels stand offshore and await favorable wave conditions. The alternative to waiting offshore is to enter and sustain damages. It is critical that harbors serviced by Nome be supplied when navigation conditions at those harbors are favorable for resupply; thus vessels are often loaded light, and high-damage-potential crossings are frequently made from the inner harbor. The purpose of the improvements is the reduction of delays, damages, and light loading. Present practice at the causeway docks is to have 2 feet of under-keel clearance and an adequate allowance for wave activity. The allowance for wave activity is about two-thirds of the wave height. Vessels do not now approach the docks when wave heights at sea exceed about 1 m (3 feet).

13.5 Inner Harbor Entrance Depth Evaluation

Regarding depth evaluation, there is no practical option for any of the users to wait on tides as a tradeoff against construction of a deeper channel, as the difference between MLLW and MHHW is only 0.49m. In construction of the benefit curve, options for evaluation of the NED project depth range from the 2.4-m authorized depth of the existing project to the depth needed by the fishing fleet and the lighter fleet to solve problems related to damage and delay. The majority of damage and delay problems are solved at a channel depth of 3 m, which would accommodate present users about 95 percent of the time.

Beyond a project depth of 3 m, incremental benefits would be earned during times when water is blown out of the harbor, but these occasions are relatively infrequent, and the increment constitutes only about 3 percent of the benefit evaluation. Project depth would have to be increased by an added 2 m to provide adequate depth during all blowdown events. At this scale of project (about 5 m) the entrance would be useable about 97 percent of the time, with interruptions remaining due to residual wave conditions not impacted by the jetty.

The procedure to determine NED depth involved generation of a benefit curve based on actual shipping practices. Data in support of practices was gathered from project users. There is a large variation in practices among users, with two prevailing points of view but no consensus. The two points of view reflect differing opinions and perceptions of channel depth uncertainty, differences in cargo carried, and differences in destinations served. They also reflect outlooks characteristic of different parts of the navigation season when conditions might be drastically different. It was not possible to identify an operating practice that fit all operators through an entire season. Therefore, a benefit curve was calculated based on a mean of the two generalized operating practices.

Vessels may be loaded to less than their 2.3-m design draft for the following reasons:

- Lack of a full load for destination ports
- Shoaling of the channel, which makes normal loading impossible
- Cargo bulk that fills the vessel without drafting it to its design marks
- Compensation for vessel behavior in sea conditions
- Desire to minimize damages and maximize vessel control

For these operators, vessels capable of drafting 2.3 m would frequently load to 1.7 m. They would do this in order to clear the channel bottom, hoping for a channel depth of at least 2.3 m. With a channel depth of 2.3 m and a draft of 1.7 m, contact with the bottom is still a definite possibility in rough conditions.

According to conversations with users of the inner harbor at Nome, even with these explanations for light loading, some operators load their vessels to the design draft or at least intend to load them to the design draft at every opportunity. Given a deeper project, they would use maximum vessel draft. With a fully loaded vessel, these users also stated a desire to minimize damages and provide channel bottom clearance for vessel behavior in sea conditions. They also stated a concern with the shoaling problem at Nome and often plan on an additional allowance for the uncertainty of the channel depth at any given time. Factors that influence these operators' vessel loading include the following:

- Cargo density allows a full load, to the extent channel depth is available.
- A full load is traded off against prospects of damage.
- If the vessel has a full load at 2.3 m, it probably will not be able to use a 2.3-m channel because the vessel will move about in waves and swell. Vessels fully loaded to 2.3 m ordinarily need to allow some clearance for behavior of the vessel. Allowance is needed for the boat to move up and down in the water and also for bottom suction. In the past, some vessels loaded to 2.3 m had to be beached at Nome

because they could not get into the harbor. Also, a vessel drafting 2.3 m can be expected to incur some damage practically any time of year.

- These operators claim that opportunities to load full will sometimes be reduced to partial loads to accommodate unknown channel depth. Channel depth varies between 2.4 m and 1 m during the season and would continue to vary as much after major rehabilitation. As the season progresses, operators increase allowances.

- For these operators, referred to as the maximum load group, the following general operating practices prevailed. Operators with vessels capable of drafting 2.3 m would desire to load to 2.3 m. In a with-project condition they would be expected to do this while still allowing about 0.6m under-keel clearance, plus an allowance for uncertainty of the channel depth at Nome. So these operators would be hoping for a channel of 3.5 m, which would generally include tide, wind setup, river flow, a newly authorized project, and new dredging. In the without-project condition this loading scenario is not practical due to potential damages, so most operators follow the light-loading practice.

These described practices were used as the basis for developing a single incremental depth v. incremental benefit curve reflecting a median of the two practices, shown as figure B-2. The benefit curve is based on estimating benefits using the entire fleet. The optimization at 3 m is a result of a slight inflection in the cost curve at 3 m. The benefit curve is essentially a straight line between 2.9 m and 4.9 m.

13.6 Incremental Cost of Entrance Improvement

All project work needed to construct and maintain the entrance channel to a depth of 3 m and all costs of the jetty are required for improvement of the entrance. Features not included in the cost of improving the entrance are the causeway stub breakwater, dock approach, sediment trap, and selected relocations. The total cost of the NED project less these items, associated interest, and preconstruction engineering and design (PED) leave an annual cost of $1,863,000. Scaling of the NED plan required estimating the cost of projects providing greater and lesser depths. Incremental costs at various depths were determined by using the unit cost of the NED plan without the causeway work included, and varying the quantities to reflect different depths. A project with 0.6 m less depth would save $14,500 annually, and a project with 0.6m greater depth would add $29,000 annually over the cost of the NED plan. Net benefits of projects with the entrance channel at various depths are shown in table B-18.

TABLE B-18.—*Entrance optimization ($000)*

	Entrance channel depth			
	2.4 m	**2.9 m**	**3.0 m**	**3.6 m**
Benefit	0	$2,322.0	$2,325.0	$2,351.0
Cost	$1,848.0	1,860.0	1,863.0	1,893.0
Net benefits	0	$462.0	$520.0	$458.0

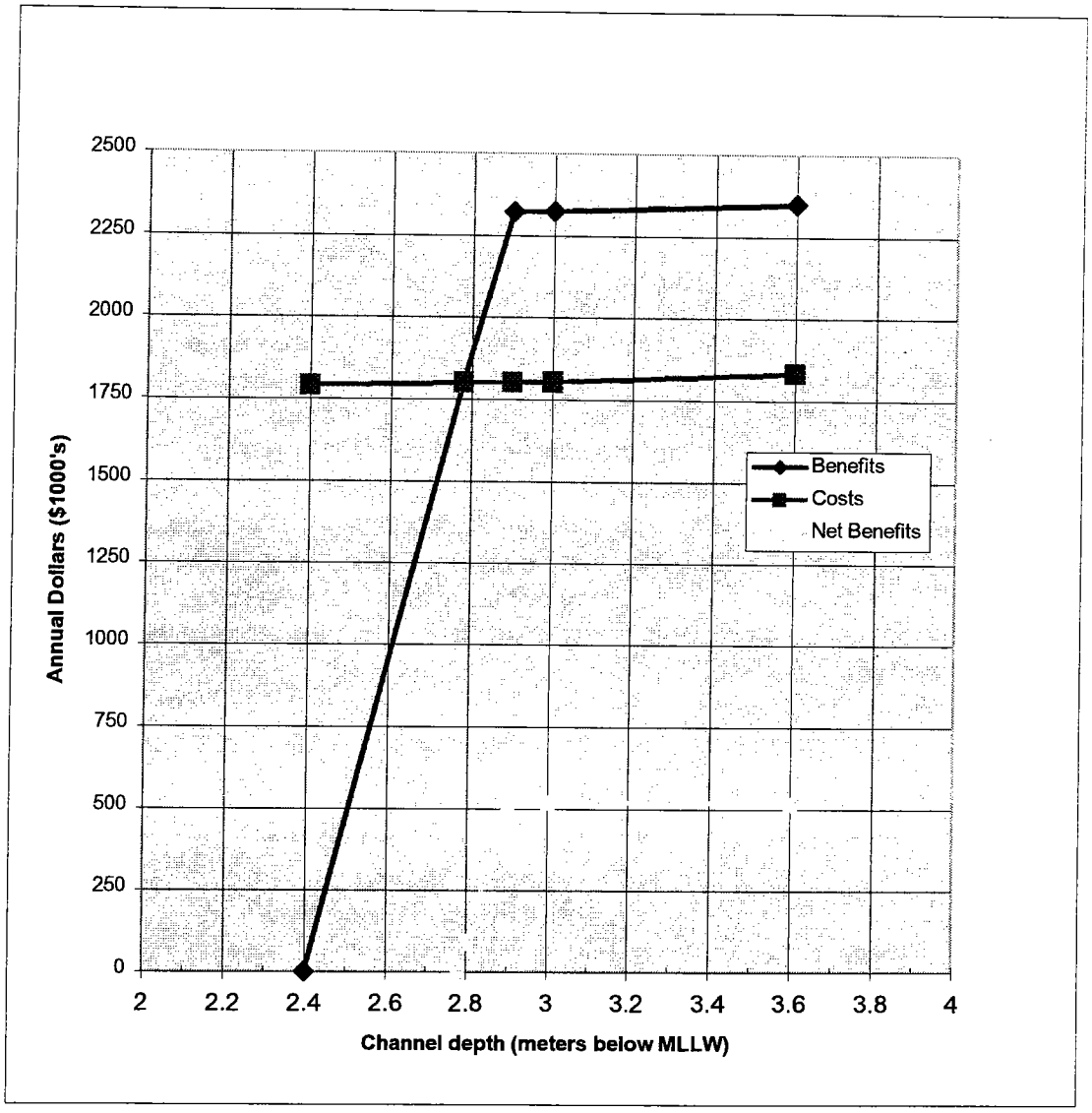

FIGURE B-2.—Entrance optimization.

13.7 Causeway Depth Evaluation

The causeway is occasionally used by the lighter fleet. Protection of the causeway would minimize damages to vessels tying up during rough conditions. Benefits associated with damage reduction are $18,000 annually, and would be earned even if depth at the causeway were not increased, so they are not included in the incremental depth evaluation.

The fishing fleet that represents new users of the causeway will draft to 3.4 m. Without allowance of adequate depth for these new users, the fleet would not be induced to use the project, and benefits identified as $427,300 annually would not be

realized. These are benefits for transportation cost savings, reduced deadloss, and time saved.

In addition to the new causeway users in the fishing fleet are the oceangoing tugs and barges, which draft to 5.49 m. The oceangoing equipment would be less impacted by delays with a deeper project. Benefits associated with elimination of delays are $840,000 annually.

The causeway fleet loads to maximum draft whenever possible. The cargo trips are very long, so vessels are used to maximum capacity. Depth at the causeway is reliable and predictable, but vessels must still adopt standard practice of allowing for vertical excursion induced by sea conditions, and for effects of bottom suction during the approach. In this analysis, standard allowances of 0.6 m have been included. They are based on data gathered during preparation of channel design and are summarized in appendix A of this report. The area adjacent to the causeway does not shoal, as does the entrance to the inner harbor. Operators do not need to allow for the uncertainty of whether the expected depth will be there. For that reason, users agree that vessels are loaded to the maximum at every opportunity, and only one scenario is necessary to account for operating practice.

Benefits, costs, and net benefits of a causeway at various depths are enumerated in table B-19 and shown in figure B-3.

TABLE B-19.—*Causeway optimization*

	Depth of water at causeway				
	4.7 m	**6.0 m**	**6.7 m**	**7.3 m**	**8.6 m**
Benefit	$427,000	$1,000,000	$1,285,600	$1,298,000	$1,324,100
Cost	367,000	494,000	520,000	547,000	642,000
Net benefits	$60,000	$506,000	$765,000	$751,000	$682,000

13.8 Incremental Cost of Causeway Improvement

These features are associated with improvement of the causeway: stub breakwater at a cost of $1,416,000; dock approach at a cost of $853,000; sediment trap at a cost of $1,272,000; bridge construction and relocations at a cost of $1,795,100, including PED and indirect costs; plus adjustments for interest during construction and amortization, yielding an annual cost of $520,000. For purposes of scaling, unit costs were adjusted to reflect the incremental cost of various depths. A project at 0.6 m less depth than the NED plan would save $28,300 annually, while a project 0.6 m deeper would add $29,000 annually.

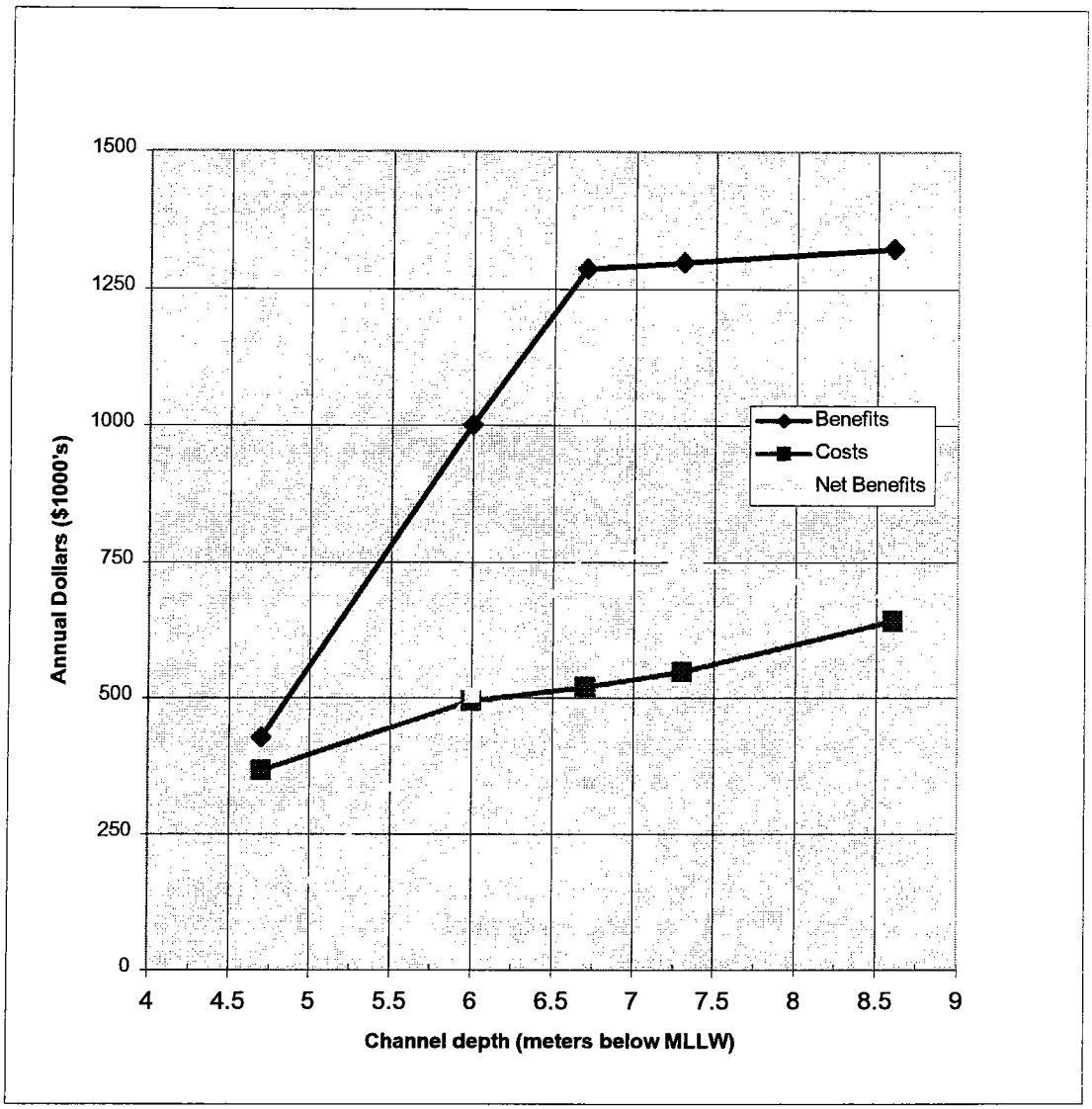

FIGURE B-3.—Causeway channel optimization.

The plan that meets all planning objectives and provides maximum net benefits consists of an inner harbor at –3 m, an improved entrance using an extended jetty, and a –3-m entrance channel. The jetty and relocated entrance reduce project operation and maintenance cost, save the cost of major rehabilitation, and also provide the plan having the lower overall cost. Modifications to the causeway and deepening of the channel alleviate congestion, damage, and delay problems experienced by oceangoing commercial shippers and fishing boats. The annual benefit of the selected plan is $3,607,500, its annual cost is $2,372,000, and the benefit-to-cost ratio is 1.5 to 1.

The incremental justification of the NED plan for Nome Harbor is seen in table B-20.

TABLE B-20.—*NED plan incremental justification, Nome Harbor*

Project increment	Annual incremental benefit	Annual incremental costs	Net benefits
Improvement to jetty and entrance	$2,321,900	$1,863,000	$459,000
Protection of the causeway	1,285,600	520,000	766,000
TOTAL	**$3,607,500**	**$2,383,000**	**$1,225,000**

13.9 Comparison of the NED Plan With Other Alternatives

During the course of the planning study fourteen specifically identifiable plans developed and were evaluated in various degrees of detail. Plans showing major environmental problems, incompatibility with planning objectives, or incompatibility with existing infrastructure were investigated only until it became obvious the plans would not work. This allowed reconnaissance level investigation of all plans, and de-emphasis of Plans A through F early in the process. Plans H through N received constant attention through the remainder of the study with the NED Plan evolving in the form of Plan L. A summary comparison of all plans is shown in the following table.

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TABLE B-21.—*Comparison of alternatives for Nome harbor and facilities*

Plan	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
Depth (m)														
Outer	-4.3	-4.3	-4.3	-2.4	-3.7	-4.3	-2.4	-3.7	-3.7	-6.7	-6.7	-6.7	-6.7	-2.4
Inner	-3.1	-3.1	-3.1	-2.4	-2.4	-3.1	-2.4	-3.1	-3.1	-3.1	-3.1	-3.1	-3.1	-2.4
Construct. cost (millions of $)	10	13	4	8.6	12	7	0.5	22	13	18.5	14.5	18.2	22	0
O&M cost/yr ($000)	300	300	200	200	200	200	200	200	200	200	200	440	440	200
Evaluation (1=best, 10=worst)	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
O&M	10	10	10	10	8	10	10	1	1	1	1	3	3	10
Wave protection	10	8	10	10	8	10	10	5	5	5	3	1	1	10
Alignment	10	2	10	10	1	7	1	1	1	1	1	1	1	10
Width	5	1	10	10	1	5	1	1	1		1	1	1	10
Safety	9	2	10	10	8	8	9	5	5	4	2	1	1	10
Contaminants														
Petroleum	5	8	5	5	8	5	1	3	3	5	4	3	3	1
Arsenic	10	1	10	5	5	10	4	7	5	4	4	4	4	1
Fish pass near shore	3	7	7	5	10	3	5	8	4	5	5	1	1	1
Accommodate increased use														
Harbor	10	5	10	10	10	10	10	1	1	1	1	1	1	10+
Causeway	10	10	10	10	10	10	9	10	9	4	4	1	1	10
Circulation	2	2	10	10	10	10	10	10	10	2	2	2	2	1
Shoreline impacts	10	10	10	10	10	10	10	10	10	10	10	3	3	10

Notes: Evaluation was by team consensus. The conclusion that plan L was more responsive to planning objectives without unconscionable increases in cost or in environmental impacts made weighting of variables unnecessary.

Definitions of plans:

A: New channel next to existing, with spending beach.
B: New channel off causeway with breakwater.
C: Harbor outside riverbed in Nome Spit.
D: Major rehabilitation of existing project.
E: Channel through spit with breakwater/revetment.
F: Channel through spit.
G: Additional causeway cell only.
H: Channel through spit with new breakwaters extending past depth of closure.
I: Channel through spit with single breakwater extending past depth of closure.
J: Plan I, but with –22' depth at the causeway.
K: Plan J, but with causeway extension.
L: Plan K, but with a sand bypass added.
M: Plan L, but with the breakwater designed to a crest height of +17'.
N: No action.

14. LOCAL IMPACTS AND OTHER SOCIAL EFFECTS

14.1 Purpose

The study described in this appendix has three objectives: (1) to evaluate alternative solutions to navigation-related problems; (2) to determine the best solution in terms of the National Economic Development point of view; (3) to assess economic and social impacts on the local scene. This portion of the report zeros in on local human impacts as they relate to construction of the project and its long-term effects.

14.2 Impact Analysis Compared to Benefit/Cost Analysis

This aspect of the report is an impact analysis, not a benefit/cost analysis. The main difference between the impacts reported in this section and those preceding is that by concentrating on the local scene and on financial transactions, many impacts that are not identified from the national perspective are surfaced. These otherwise invisible impacts should be expected to become major concerns to local inhabitants. Some impacts evident in the community-level analysis disappear when viewed from the national perspective because countervailing activities in another part of the Nation may offset the potential project impacts.

The nature of a regional or local impact analysis is to identify but not include countereffects outside the selected impact area in order to provide a more complete accounting of local changes that can be associated with the proposed project. An impact analysis examines the economic changes that occur from some external impact to an economy or from the contribution of an industry to an economy. The charge here is to evaluate the impacts of the NED-scale harbor improvement on the Nome community. In that regard, there is a major difference between local impact analysis and benefit/cost analysis.

Suppose (hypothetically) that navigation problems were ignored, and the existing project was allowed to deteriorate, eventually collapsing and closing off all use of the inner harbor. The local fishing fleet would be displaced to an alternative harbor, taking fishing jobs with them. In addition, local food processors, industry suppliers, and related service industries would experience a decline in sales and subsequent reduction in employment at Nome, causing potentially catastrophic economic effects on the local scene. But if the fishermen were as productive (same output at the same cost) operating from the alternative port, there would be no net cost to the Nation as a whole. If fishermen were more profitable at the alternative port, there would be a net gain to the Nation.

What benefit/cost analysis may show (as opposed to an impact study) is that what is good or bad for a local community may not have the same qualities for the Nation as a whole. An impact study can provide some important insights for policymakers that are not seen in a benefit/cost analysis. It can demonstrate the severity of suffering to a

region from an external economic shock. It can demonstrate the contribution of a particular industry to the local economy. It can demonstrate to policymakers the internal linkages of the local economy. It can bring noneconomic factors into view such as culture, social structure, values, and history. It can include subjective evaluations and local accounting frameworks that have no place in the NED or benefit/cost model.

14.3 Transportation Impacts

Studies relating to transportation are difficult by their very nature. The economic benefits and costs are diffused across many industries and in many cases across broad regions, or even globally. Transportation has sometimes subtle but important effects on industry competitiveness. Cause-and-effect relationships are usually identifiable at the level of the primary user, but beyond that, uncertainties of inter-industry activities, rescheduling practices, use of alternative modes, restructuring of rates, contract arrangements, cost abstraction, market strategy, etc., are often so complex as to obscure secondary effects.

In this impact analysis, transportation costs are viewed as a source of cost increases or decreases that account for changes in the structure of the economic base and related local service industries. Only two scenarios are evaluated, and they represent the two extreme cases: (1) abandonment of local navigation works, which has major negative relocation impacts on the local fishing fleet and negative delay impacts on commercial shippers; and (2) full development of the NED plan, which has positive impacts on all users.

14.4 Evaluation Procedure

In this impact study, transportation savings that occur at Nome are regarded as regional exports. As such, changes in transportation savings have the effect of local demand shift caused by external factors. This point of view is supported by the fact that transportation savings bring dollars into the community in the form of returns to local labor and capital, to the extent savings to shippers are passed on. So even if commercial shipping equipment is owned and operated by out-of-region residents, the presumption is that savings to shippers will result in price competition among shippers, which passes savings on to be enjoyed by Nome residents. Savings therefore represent an improvement in industry earnings or in value added at the community level. The savings represent a final demand shift.

Ordinarily, dollar leakage from the local impact area would be accounted for by excluding savings in benefit categories where factors of production are generally not local in nature. These returns do not belong in the accounting of local job impacts. In this case, however, a theoretical willingness-to-pay test has been applied to all benefit categories. In that sense, the direct beneficiary would be willing to pay an amount up to the limit of the benefit to enjoy increased efficiency gains made possible by the project. Therefore, any leakage from the local impact area is theoretically reclaimable

through a fee system that would properly recognize risks and returns. On this basis, recognizing the prospect of generating a high-side estimate, leakage is ignored in the accounting of job impacts.

Two benefit categories have been discounted 100 percent in this analysis: (1) subsistence, and (2) lost leisure time. The reason for excluding them is that neither represents a direct cash transaction inside or outside the impact area. Both meet the test of willingness to pay, but it is difficult if not impossible to demonstrate a specific link between changes in either category and employment opportunities.

Three other potential benefit categories investigated in the NED study but not included in project benefits were also excluded from the local impact analysis: (1) prevention of vessel sinkings, (2) prevention of cargo damage, and (3) increased harvest of unexploited resources. An unusually wide band of uncertainty surrounds these three areas. They were excluded because point estimates could not be reasonably established, and the data was insufficient to identify a reasonable range with acceptable confidence.

In export-based industries, increased earnings can be translated to increased employment opportunities, and they in turn can be used to explain increased employment in the non-basic sector. For simplicity, this evaluation counts only direct effects.

There being no practical means of accounting for possible structural changes at the local level, new employment and earnings are distributed among various local industries proportionately to their role in the local economy as presented earlier in this report. Direct financial effects (net local transportation and fishing sector cost increases or decreases) are translated into jobs, using average earnings per employee in the census area as presented in census data. This simplified approach allows an estimation of direct primary employment effects without specifically accounting for specific industry productivity per employee, or inter-industry input/output relationships required to trace secondary or indirect impacts. As such, the estimation of employment impacts may be considered to be an overstatement of primary effects and understatement of secondary effects in a long-run equilibrium situation.

Also at issue is the extent to which economic gains are absorbed into the economy without recognizing ongoing changes in factors of production. An extreme example of this would be a workplace technological innovation such as computers, which increase industry earnings through increased output per employee, while not necessarily increasing employment on a 1:1 ratio. This simplified impact analysis holds output per employee as a constant, and does not introduce structural changes that certainly would take place over time. Therefore, job losses and gains are in equivalent terms, using average earnings per employee as a basis for estimating equivalent jobs. After total equivalent jobs are estimated, employment is allocated among local opportunities based on the existing economic framework of the Nome

census district, knowledge of local development plans, and the assumption that the government sector will not increase.

14.5 Major Rehabilitation

Given the deteriorated condition of the sheet-pile structure and related channel and harbor maintenance problems, catastrophic failure of the existing project is a likely outcome if no remedial action is taken. Loss of service of the project would introduce a major economic shock to Nome and satellite villages, which depend on the harbor as a lifeline linking them to the outside world. Immediate direct impacts would result in the losses summarized in table B-22.

TABLE B-22.—*Job loss impact from shutdown of inner harbor and entrance*

Impact category	Local financial loss ($000)	Equivalent local job loss
Shipping delay cost	$321.0	12
Dock delay cost	68.8	2
Travel cost savings	111.0	4
Crab harvest travel saved	105.0	4
Crab deadloss	338.1	13
Halibut harvest	442.0	16
Salmon harvest	635.0	24
TOTAL	**$2020.90**	**75**

14.6 Impacts of the NED Plan

Impacts of the NED plan are identified by comparing its effects against present-day conditions (with the existing harbor). Implicit in this approach is the assumption that, as a minimum, there will be major rehabilitation of the existing project to preserve service now being provided. This assumption is justified on the grounds that the existing harbor is essential to the economy of the region and has been illustrated as a worthy project from the NED point of view as well. Employment impacts of the NED plan on the Nome area are itemized in table B-23.

Gains in economic efficiency are the engine that speeds up the local economy. Insertion of greater purchasing power would bolster all sectors of the economy. Major changes in the distribution of employment among the various local opportunities are anticipated to continue the distribution of employment in the census district. One exception is that the presently robust government sector is not anticipated to expand with an increase in local economic activity. To the contrary, it might be expected to remain stable or even shrink if agency activity related to economic hardship is alleviated. Table B-24 summarizes the distribution of job impacts expected from the NED harbor plan.

TABLE B-23.—*Employment impacts of the NED plan*

Impact category	Local financial gain ($000)	Equivalent local job gain
Travel cost saving	238.2	9
Deadloss reduction	105.4	4
Lighter fleet	18.0	-
Commercial shipping	840.2	31
Damage prevention	1,273.5	47
Light loading	15.5	-
Reduced long-term delay	97.0	4
TOTAL	**$2,587.8**	**95**

TABLE B-24.—*Distribution of job impacts*

Industry	Job loss from shutdown	Job gain from NED plan
Fishing	4	5
Mining	4	5
Construction	2	3
Manufacturing	1	2
Transportation	8	10
Wholesale trade	1	1
Retail trade	14	17
Services	37	47
Finance, insurance	6	8
	75	**95**

14.7 Short-Term Construction Impacts

Lacking detailed local labor and materials cost estimates of all plans considered, potential local economic impacts were estimated by using $15 million (represents an estimated 60 to 80 percent of construction expenditures) as an estimate of project expenditures going to local suppliers, using early planning cost estimates. This is substantially higher than similar harbor projects because the quarry is local, and both equipment and experienced skilled labor are available.

Construction expenditures will be incurred over about two construction seasons. The greatest impact on the community will be traffic associated with use of the quarry haul road and other streets necessary to deliver construction material to the jetty and causeway.

There will be some influx of workers, primarily engineering staff and representatives of various government agencies. Seasonal surges through Nome are a part of the fabric of the community and basically are expected, planned for, and generally of

minimal impact. Both water and air traffic are expected to increase, but not to the extent of requiring rescheduling of equipment or addition of new equipment.

14.8 Other Social Effects

In the long run, modification of the harbor is anticipated to expand local employment opportunities, and increased earnings will provide resources to enhance the tax base. Since a stable, growing economy is more likely to provide an incentive for families to settle in Nome compared to communities with fewer opportunities, some of the more footloose part of the population will become rooted at or near Nome. Increased stability of the population is anticipated to help expand Nome's already strong sense of place and encourage the feeling of community well being and pride that is basic to successful social mobility programs.

The standard of living at Nome compares unfavorably with other urban areas of the United States. Lack of economic growth, coupled with high living costs associated with the remote, isolated location, are challenges that need to be overcome if the standard of living is to make needed gains in the near future. An improved local transportation system and its spinoff effects will help provide ingredients necessary for local incomes to outpace increases in living cost.

The Nome population is made up of about 50 percent Alaska Natives. Within the Bering Straits School District, the percentage of students who are Alaska Natives is 94 percent. Indications are that the non-Native population are adults and are probably more likely to be in the non-poverty sector of the population. Overall, for the school district, the U.S. census estimates more than 31 percent of the population lives below the poverty level, compared to about 10 percent for the State as a whole. Employment opportunities and lower transportation costs would help reduce some of the barriers to a disadvantaged population.

15. SENSITIVITY OF NED PLAN TO SELECTED VARIABLES

15.1 Sensitive Variables

To the extent possible, sensitive variables have been identified during the economic evaluation, and applied as higher and lower values to generate a range of benefits for the different categories of economic effects evaluated. Where there appeared to be recent fluctuations in values that could be explained, and where a reliable value or unit price could be estimated, a single value was used. The project justification and maximization depend on median values.

The range of values accommodates some of the uncertainty in the data and provides the analyst with a measure of differences that can result from variations in assumptions. The higher range is neither more nor less likely than the lower, as the ranges were an attempt to blanket the range of reasonable estimates. The main variables and the general nature of their impacts are summarized below:

- Delay cost for oceangoing crab vessels, $7,450-$7,980 per day. Both were used, and a range of benefits was demonstrated.

- Norton Sound red king crab harvest, 136,000-227,000 kg per year. The higher estimate was used based on support from ADF&G.

- Halibut harvest, $50 million-$100 million annually. The higher value was used, and overall benefits are higher by 4 percent.

- Halibut bycatch value, $2.20-$4.40 per kg. Value choice did not affect the benefit calculation.

- Crab prices, $4.40-$9.90 per kg. $8.80 was used as reflective of long-run future expectations resulting from dynamic market forces. Use of higher crab prices tends to work its way through the evaluation by leading to somewhat higher benefits in some categories. About 7 percent of total benefits are sensitive to changes in crab prices.

- The benefit evaluation used Nome-based commercial fishing fleets of 65, 50, and 45 vessels. The equilibrium fleet based on income is 50 boats. Sponsor concurs.

- Income threshold for entering commercial fishing at Nome--$19,000, $24,600, and $27,000. Equilibrium fleet is consistent with $24,650.

- Opportunity cost of time, $3.00-$15.00 per hour. $3.00 was used for the local fleet, and $15.00 for oceangoing crews. Differences are supportable by alternate earning possibilities.

- Delay cost for oceangoing commercial hauling equipment is $14,000 per day. Operating cost is supported by interviews, owners' data, and comparison with other recent navigation reports. In the final analysis, the cost of oceangoing hauling equipment is related to 20 percent of higher-range project benefits. Lower-range benefits include a 75-percent adjustment for uncertainties in data and to accommodate one commercial shipper who set the lower range of daily cost at $12,000.

- Dock standby crew, $1,350 per day. This value is based on local wages actually paid, including employee benefits, according to shippers.

- Delay cost for lighters, $6,300 per day. The value was narrowed from a range of figures supportable by industry interviews and cost data.

- Airfreight, $0.66-$1.76 per kg. The range of values is based on operational cost for various loads and destinations. The report used a narrower range based on the cost of serving six selected villages with maximum expected loads. Benefits are not impacted by a choice of airfreight costs.

- Vessels in the size range 17.7-30.7 m cost $537,000 to $747,000 annually to operate. The range was used to determine a range of benefits, as the final results were expected to be sensitive to variations. Costs are well documented.

- Vessels in the size range 30.7-39.9 m cost $702,000-$1,099,000 annually to operate. The range was used to determine a range of benefits, as the final results were expected to be sensitive to variations. Operating cost is well documented.

- Crab deadloss was estimated to be reduced by 10 percent due to project-induced efficiency. Use of a straight-line function indicated variations in estimates of time saved would not significantly impact estimates of mortality. Crab deadloss information is based on casual interviews with operators, not scientific research. The uncertainties in data were tempered by use of a conservative estimate.

- Vessels in the Nome day fleet were valued at $220,000-$300,000 each, based on manufacturer information. A range of vessel values was used to generate a median benefit value. Use of higher-range values increases benefits by 4 percent, and lower-range values decrease benefits by 4 percent.

- Manufacturer's estimate of vessel cosmetic repairs, $10,000-$40,000 per boat annually. Ranges were taken into account and are reflected in a range of benefits.

- Subsistence harvest, $6.60-$11.00 per kg. A value of $8.80/kg was used.

- Biomass surveys indicate an unexploited Norton Sound biomass of 223,000 tons of potentially commercial species. Significant commercial harvest of new target species is a definite possibility for a Nome-based fleet. Time requirements for development of markets and development of harvest practices put possible economic gains into a long-term future scenario. Benefits were not estimated.

- Late-season delivery, leading to long-term delay to wait out the winter, was a major concern with shippers and residents who did not want to be forced into shipment by air. It was not possible for shippers to determine how much cargo would be impacted by improvements. Certainly the proposed harbor improvements would result in less stranding of cargo at Nome, but little data is available to support an estimate. The number of variables at play suggests identifying one factor, such as a harbor improvement, as being entirely responsible for solving the problem of stranded cargo would be difficult to support. The local shipping operators and city officials support the idea that stranding of cargo is a continual problem, but they recognize some residual stranding would occur even with every problem solved at Nome. Significant problems with equipment, management at other ports, weather, etc., would still remain. We have assumed 10 percent of one shipment per year would be project-related. About 2 percent of total benefits are involved.

- Damage reduction to cargo was a recurring theme during discussions with shippers. There was a consensus that reduced number of days at sea would reduce the possibility that cargo damage would occur, but shippers were not comfortable in estimating damages or damages prevented. Benefits were not estimated.

- Benefits that could be earned from prevention of vessel sinkings were estimated but not claimed. With a history of 30 serious events per year in the Bering Sea-Norton Sound area, annual cost of serious incidents is $537,000. Of the 30 serious events, each year three vessels are lost, at an average replacement value of $260,000. The economic consequences of vessel losses and related events amount to $1,317,000 annually. The issue of vessels sunk is separate from the issue of vessel damage. This report documents benefits associated with prevention of damages other than vessels sunk, and includes them in the project formulation and justification. Every effort was made to isolate the issue of total loss from events causing less than total loss, but some overlap is probably inevitable.

Though the intention was to develop benefits in both categories and include them both, concern with duplication is the reason for not including vessel loss separately in benefits used for plan formulation and justification.

- Operation and maintenance cost--Benefits for saving of annual dredging cost were based on recent years when only channel dredging was conducted. The years selected are among the lowest 6 dredging years on record since 1964. Price level adjustments were made using national data. Regarding O&M cost of the recommended plan, the cost estimate includes annual maintenance, plus major maintenance at 10-year intervals. This maintenance program addresses uncertainty in the estimate of infill rates by including costs adequate to maintain the project under a worst-case scenario.

15.2 Range Of Benefits Generated

As some inputs to the benefit evaluation were ranges rather than specific numbers, the output was also produced as a range. Table B-25 demonstrates the range of benefits produced in each sensitive category.

The results display a 32-percent difference in the overall total. Under the high and the low ranges, all of the proposed improvements appear to be economically justified. Numerous other variations in inputs could be tested; however, those listed in this section and others discussed in the text and woven into the methodology are hopefully inclusive of the major uncertainties. Median values were used in plan formulation and justification.

TABLE B-25.—*Display of range of benefits generated ($000)*

Category	Lower range	Higher range
Basic project replacement		
Shipping delay cost	$321	$321
Dock delay cost	68.8	68.8
Leisure time (villages)	110.2	110.2
Travel cost savings	93.0	129.0
Crab harvest travel saved	90.0	120.0
Leisure time (crew)	51.6	51.6
Crab deadloss	225.4	450.8
Subsistence	207.9	346.5
Halibut fishery	442	442
Salmon fishery	385	885
SUBTOTAL	**$1,994.9**	**$2,924.9**
Entrance improvement		
Fishing fleet damage, anchoring out	$248.7	$260.7
Fishing fleet damage, project-related	672.7	897.0
Lost time	59.4	118.8
Tug and barge damage	208.0	260.0
Light loading	15.5	15.5
Long-term delay	70.0	124.0
O&M cost savings	202.8	512.8
SUBTOTAL	**$1,477.1**	**$2,188.8**
Improved causeway use		
Travel cost savings	$149.0	$327.4
Deadloss reduction	88.4	122.4
Leisure time	72.5	95.0
Lighter moorage	18.0	18.0
Commercial shippers	720.3	960.3
SUBTOTAL	**$1,048.2**	**$1,523.1**
Added causeway cell	12.6	26.5
TOTAL	**$4,532.8**	**$6,663.3**

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Joy Baker
NOME HARBORMASTER
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Scott Pederson
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Dick Campbell
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Leonard Campbell
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Ed Glotfelty
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Bruce Kovarik
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APPENDIX C
GEOTECHNICAL ANALYSIS

Includes internal appendixes:

A – Site Investigation Field Notes

B – Soil Boring Logs

C - Survey Notes

D – Geotechnical Reports

E – Chemical Quality Assurance Report

F – Detection Limits for Volatile and Semi-Volatile Analyses

FINAL REPORT

NOME HARBOR SITE INVESTIGATION REPORT

Prepared for

THE CITY OF NOME
U.S. ARMY CORPS OF ENGINEERS
ALASKA DISTRICT

January 28, 1997

Woodward-Clyde

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TABLE OF CONTENTS

Section 1 **Introduction** **1-1**

Section 2 **Methods** **2-1**

2.1 Surface and Subsurface Soil Sampling 2-1
2.2 Sediment Sampling 2-1

Section 3 **Data** **3-1**

3.1 Surface and Subsurface Soil Samples 3-1
3.2 Sediment Samples 3-2

Section 4 **Analysis** **4-1**

4.1 Chemical Results 4-1
4.2 Geotechnical Results 4-2

Section 5 **Conclusions and Recommendations** **5-1**

5.1 Conclusions 5-1
5.2 Recommendations 5-1

References

List of Tables

Table 3-1 Summary of Samples Collected and Analyses Performed 3-4
Table 3-2 Summary of Analytical Results for Semivolatile Organic Compounds 3-5
Table 3-3 Summary of Analytical Results for Bis(2-ethylhexyl)phthalate 3-6
Talbe 3-4 Summary of Analytical Results for Metals 3-7
Table 3-5 Summary of Miscellaneous Sampling Results 3-8

List of Figures

Figure 1-1 State and Vicinity Map 1-2
Figure 3-1 Sediment and Soil Sampling Locations 3-9

List of Appendices

Appendix A Site Investigation Field Notes
Appendix B Soil Boring Logs
Appendix C Survey Notes
Appendix D Geotechnical Reports
Appendix E Chemical Quality Assurance Report
Appendix F Detection Limits for Volatile and Semi-Volatile Organic Analyses
Appendix G Chemical Reports

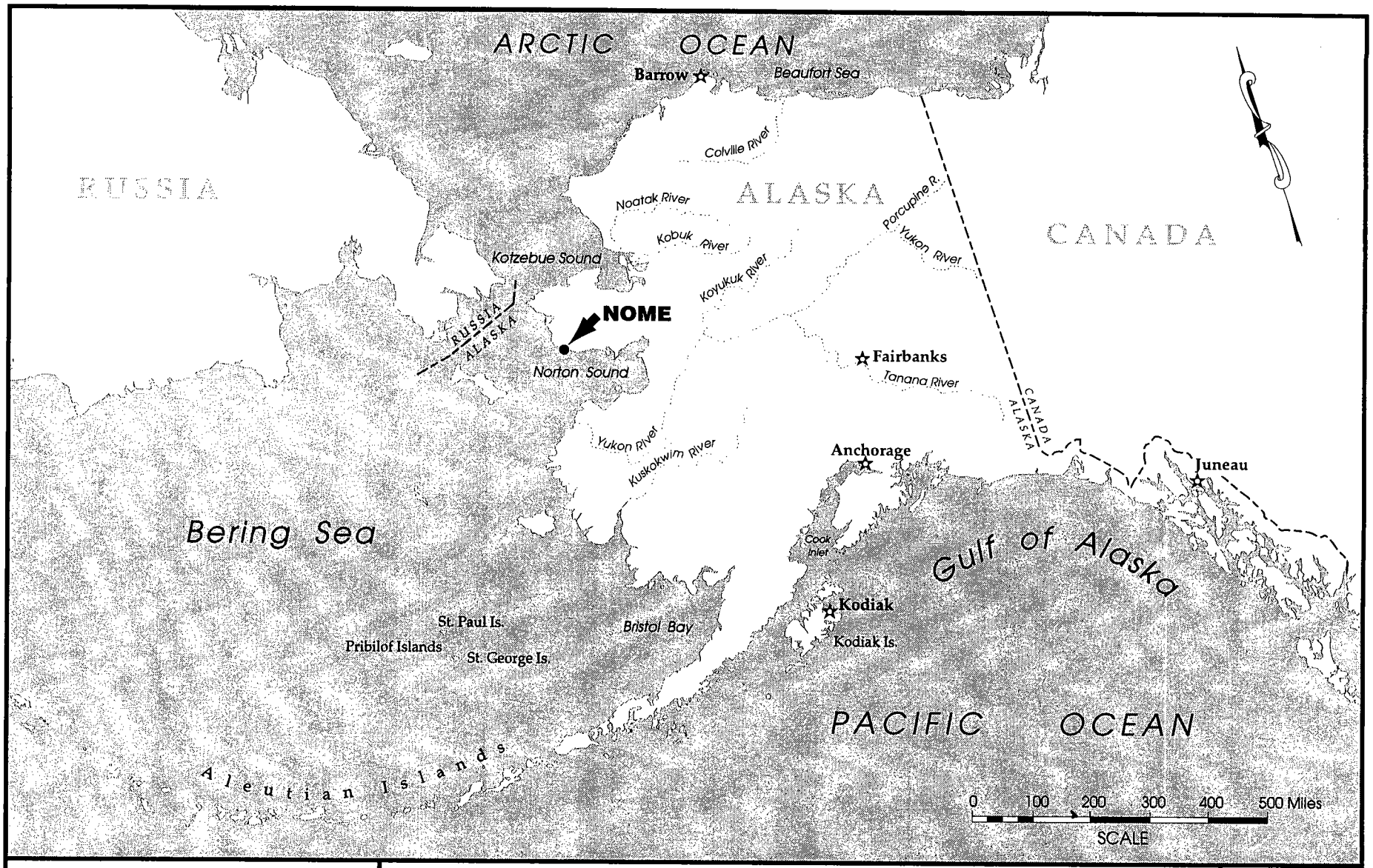
Woodward-Clyde was contracted by the City of Nome to complete a geotechnical/chemical site investigation for the Nome Harbor Improvements Project. Figure 1-1 shows the project location. The City of Nome provided a scope of work which included sampling sediments in and around the harbor, collecting two surface soil samples, and drilling and sampling four soil borings. The scope of work was dated June 23, 1997, and was prepared by the U.S. Army Corps of Engineers, Alaska District.

Field work was conducted during two separate trips., 1997. Subsurface soil samples, two sediment samples, and two surface soil samples were collected during the first trip to Nome (December 8, 1997 to December 12). The remaining four sediment samples were collected on December 22, 1997. The second trip was necessary because ice conditions did not allow safe access to the off-shore sampling locations.

The project was managed by Woodward-Clyde's Anchorage, Alaska office. Drilling services were provided by Discovery Drilling of Anchorage. Soil boring locations were surveyed by George Krier, professional land surveyor. Chemical analyses were conducted by MultiChem Analytical Services of Renton, Washington. Alaska Testlab, located in Anchorage, performed the geotechnical analyses.

This report describes the work conducted during the site investigation, summarizes field and analytical data, discusses analytical results, and provides recommendations based upon data acquired during the investigation. Field notes are provided as Appendix A. Logs for the four soil borings are included as Appendix B. Survey notes for the four soil borings are provided in Appendix C. Geotechnical reports are included as Appendix D. The Chemical Quality Assurance Report is provided in Appendix E. Laboratory detection limits for the volatile and semi-volatile organic analyses conducted are sumarized in Appendix F.

Several copies of the report include an Appendix G, which contains copies of the laboratory reports. Three of the reports with Appendix F were delivered to the USACE Alaska District, and two were delivered to the City of Nome.



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NOME HARBOR SITE INVESTIGATION — NOME, ALASKA

LOCATION MAP
NOME, ALASKA

PROJECT NUMBER 976057NA
FILE NAME FIG1-1.AI
FIGURE 1-1

2.1 SURFACE AND SUBSURFACE SOIL SAMPLING

Two surface soil samples were collected from the sand spit located between the Snake River and Norton Sound. Soil was collected from a depth of 0 to 15 centimeters (cm) using decontaminated stainless steel spoons. The soil from each surface sample location was homogenized in a stainless steel bowl before collecting samples for analysis, except for soil analyzed for volatile organic compounds.

Soil borings were advanced using a hollow-stem auger drilling rig. The drill rig was a skid-mounted, gas-powered, CME-45C. Split-spoon samples were collected by driving 61-cm long, 7.62-cm diameter split-spoons with a 152-kilogram (Kg) hammer. The soil was visually inspected and logged in the field logbook. The soil was field screened for volatile hydrocarbons with a photoionization detector (PID). Headspace analysis results were recorded in the field log book and are also reported on the soil boring logs.

Drilling and sampling was conducted according to the Nome Harbor Site Investigation Work Plan (Woodward-Clyde, December 1997), except for backfilling the completed soil borings. The work plan stated that soil boring be backfilled with soil cuttings and 20 cm of bentonite. No bentonite was placed in the soil borings because there was no evidence of contamination based on field measurements.

Subsurface soil samples were collected at the depths indicated in the work plan, except for the deepest sample at each soil boring. The work plan stated that a sample would be collected at 10 meters (m) below ground surface (bgs) from each boring. The deepest samples collected were from 6.7 m bgs, because heaving sands were encountered. The heaving sands filled the augers when the center rod was removed and the augers were below the water table. Heaving sands were encountered in each of the soil borings drilled and prevented collection of subsurface soil samples deeper than 6.7 m bgs.

2.2 SEDIMENT SAMPLING

Sediment samples were collected from the Snake River and Norton Sound. A Ponar sediment sampler was used to collect five of the six sediment samples. The samples were collected through holes cut in the ice. The sediment samples were collected according to the work plan, except for SED-8. Sediment sample SED-8 was collected using a shovel instead of the Ponar. A representative sample could not be collected using the Ponar at that location because the gravel-sized sediments held the Ponar open, causing the finer sediments to drop out the bottom of the sampler.

Table 3-1 shows which analyses were performed for all of the samples collected. The following two sections describe the analytical results. Lists of analytes for Environmental Protection Agency (EPA) Methods 8270b and 8260a are included in Appendix E. These lists, which are included to document which analytes were analyzed for, also provide the laboratory detection limits and State of Washington, Department of Ecology, Sediment Management Standards for comparison. State of Washington standards are included because similar standards have not been established by the State of Alaska. Figure 3-1 shows all samples locations and sample identifiers.

3.1 SUBSURFACE SOIL SAMPLES

No volatile organic compounds (VOCs) were detected in the soil samples collected from any of the soil borings (AP-1000 through AP-1003), except for methylene chloride in two soil samples. Several semi-volatile organic compounds (SVOCs) were detected in soil samples from AP-1000 and AP-1001. Table 3-2 presents a list of SVOC detections from the soil boring samples. The majority of SVOC analytes detected were polycyclic aromatic hydrocarbons (PAHs). These compounds are often associated with fuel products. A laboratory contaminant (bis (2-ethylhexyl) phthalate) was detected in all of the soil samples collected from the soil borings (Table 3-3).

Soil samples collected from the soil borings were analyzed for nine metals (Table 3-4). Cadmium, selenium, and silver were not detected in any of the samples collected from soil borings AP-1000 through AP-1003. Mercury was detected in only three subsurface soil samples, 1.52 - 2.13 m bgs in AP-1001, 0 - 0.61m bgs in AP-1002 and 1.52 - 2.13 m bgs in AP-1003.

Arsenic was detected in the 19 soil samples at concentrations of 21 to 260 milligrams per kilogram (mg/Kg). The highest arsenic concentration was in the sample collected from soil boring AP-1003 at a depth of 6.10 - 6.71 m bgs. Barium was detected in the 19 soil samples at concentrations of 8 to 47 mg/Kg. The highest barium concentration was detected in the sample collected from soil boring AP-1001 at a depth of 1.52 - 2.13 m bgs.

Chromium was detected in the 19 soil samples at concentrations of 6.5 to 18 mg/Kg. The highest chromium concentration was detected in the sample collected from soil boring AP-1000 at a depth of 3.05 - 3.66 m bgs. Copper was detected in the 19 soil samples at concentrations of 5.8 to 14 mg/Kg. The highest copper concentration was detected in the samples collected from soil borings AP-1000 and AP-1003 at depths of 3.05 - 3.66 m bgs and 4.57 - 5.18 m bgs, respectively.

Lead was detected in the 19 soil samples at concentrations of 3 to 52 mg/Kg. The highest lead concentration was detected in the sample collected from soil boring AP-1001 at a depth of 1.52 - 2.13 m bgs.

Several other analyses were also performed on the subsurface soil samples (Table 3-5). Ammonia-nitrogen, nitrate-nitrite as nitrogen, sulfate and sulfide analyses were not performed on sediment samples collected above water. Total organic carbon percentages ranged from 0.23 to

1.7 in the subsurface soil samples. Nitrate/Nitrite as nitrogen was detected in six of the eight subsurface soil samples collected; the detections ranged from 0.27 to 1.3 mg/Kg. Sulfate ($S0_4$) was detected in all eight of the subsurface soil samples collected; the detections ranged from 10 to 130 mg/Kg. Sulfide was not detected above detection limits (0.62 to 0.8). Percent moisture content results ranged from 3.0 to 22.

Grain-size analyses (sieve and hydrometer) and Atterburg test limits were conducted on all subsurface soil samples. The geotechnical reports are include in Appendix D. All of the subsurface soil samples were classified as non-plastic and were characterized as sand with either silt or gravel.

3.2 SURFACE SOIL AND SEDIMENT SAMPLES

Chemical analyses were performed only on SED-1 through SED-7. SED-8 was collected up river and only analyzed for geotechnical analyses. No VOCs were detected in any of the sediment or surface soil samples analyzed (SED-1 through SED-7). No SVOCs were detected in any of the sediment samples (SED-1 through SED-4, and SED-7). SVOCs were detected in surface soil sample SED-6 (Table 3-2). The majority of SVOC analytes detected in SED-6 are polycyclic aromatic hydrocarbons (PAHs). A laboratory contaminant (bis (2-ethylhexyl) phthalate) was detected in each of the sediment and surface soil samples collected (Table 3-3).

Sediment and surface soil samples (SED-1 through SED-7) were also analyzed for nine metals; laboratory results are summarized in Table 3-4. Concentrations of cadmium, selenium, and silver were not detected above laboratory reporting limits. The other metals analyzed were arsenic, barium, chromium, copper, lead, and mercury. Sediment sample SED-7 contained the highest concentration of each of these metals except for lead. Arsenic was detected in the seven sediment samples at concentrations of 5.1 to 210 mg/Kg. The highest arsenic concentration was detected in sediment sample SED-7, and the lowest arsenic concentration was detected in sediment sample SED-2.

Barium was detected in all sediment and surface soil samples analyzed at concentrations of 5.6 to 45 mg/Kg. The highest barium concentration was in sediment sample SED-7, and the lowest barium concentration was in sediment sample SED-2. Chromium was detected in all sediment samples analyzed at concentrations of 4.7 to 22 mg/Kg. The highest chromium concentration was detected in sediment sample SED-7, and the lowest chromium concentration was detected in sediment sample SED-1.

Copper was detected in all sediment and surface soil samples analyzed at concentrations of 2.3 to 23 mg/Kg. The highest copper concentration was detected in sediment sample SED-7, and the lowest copper concentration was in sediment sample SED-2. Lead was detected in five of the seven sediment samples at concentrations of 2.1 to 25 mg/Kg. Lead was not detected in sediment samples SED-2 and SED-3. The highest lead concentration was in surface soil sample SED-6. Mercury was detected at a concentration of 0.20 mg/Kg in sediment collected sample

SED-7. Mercury was not detected above laboratory reporting limits in the other six sediment samples.

Several other analyses were also performed on the sediment samples (Table 3-5). Ammonia-nitrogen, nitrate-nitrite as nitrogen, sulfate and sulfide analyses were not performed on surface soil samples. Total organic carbon percentages ranged from 0.14 to 1.2. Ammonia nitrogen (NH_3) was detected in one of the five sediment samples analyzed (SED-7). Nitrate/Nitrite as nitrogen (NO_2-NO_5) was detected in four of the five sediment samples collected. The detections ranged from 0.72 to 3.7 mg/Kg. Sulfate ($S0_4$) was detected in all five of the sediment samples collected. The detections ranged from 250 to 460 mg/Kg. Sulfide (S_2) was detected in one (SED-7) of the five sediment samples analyzed (510 mg/Kg).

Grain-size analyses (sieve and hydrometer) and Atterburg test limits were conducted on all sediment and surface soil samples. The geotechnical reports are included in Appendix D. All of the sediment and surface soil samples were classified as non-plastic and were classified as poorly graded sand (SP) by the testing laboratory. Percent moisture content results ranged from 4.1 to 50.

TABLE 3-1
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED
NOME HARBOR SITE INVESTIGATION, ALASKA

Laboratory:			Multichem Analytical Services								Alaska Test Lab	
			VOCs	SVOCs	TOC	Metals	Ammonia-Nitrogen	Nitrate-Nitrite as Nitrogen	Sulfate	Sulfide	Grain-size	Atterburg
Sample Location	Sample Depth (m)	Sample ID	8260A	8270B	9060	7000 Series	350.3M	353.3M	9035	9030	ASTM D-422	ASTM D-2216
SED-1	0-0.015	97NH-024SD	X	X	X	X	X	X	X	X	X	X
SED-2	0-0.015	97NH-025SD	X	X	X	X	X	X	X	X	X	X
SED-3	0-0.015	97NH-026SD	X	X	X	X	X	X	X	X	X	X
SED-4	0-0.015	97NH-027SD	X	X	X	X	X	X	X	X	X	X
SED-5	0-0.015	97NH-001SD	X	X	X	X					X	X
SED-6	0-0.015	97NH-002SD	X	X	X	X					X	X
SED-7	0-0.015	97NH-007SD	X	X	X	X	X	X	X	X	X	X
SED-8	0-0.015	97NH-008SD									X	X
AP-1000	0-0.61	97NH-003SB	X	X	X	X					X	X
AP-1000	1.52-2.13	97NH-004SB	X	X	X	X					X	X
AP-1000	3.05-3.66	97NH-005SB	X	X	X	X	X	X	X	X	X	X
AP-1000	4.57-5.18	97NH-006SB	X	X	X	X	X	X	X	X	X	X
AP-1001	0-0.61	97NH-009SB	X	X	X	X					X	X
AP-1001	1.52-2.13	97NH-010SB	X	X	X	X					X	X
AP-1001	3.05-3.66	97NH-011SB	X	X	X	X					X	X
AP-1001	4.57-5.18	97NH-012SB	X	X	X	X	X	X	X	X	X	X
AP-1001	5.49-6.10	97NH-013SB	X	X	X	X	X	X	X	X	X	X
AP-1002	0-0.61	97NH-014SB	X	X	X	X					X	X
AP-1002	1.52-2.13	97NH-015SB	X	X	X	X					X	X
AP-1002	3.05-3.66	97NH-016SB	X	X	X	X					X	X
AP-1002	4.57-5.18	97NH-017SB	X	X	X	X	X	X	X	X	X	X
AP-1002	6.10-6.71	97NH-018SB	X	X	X	X	X	X	X	X	X	X
AP-1003	0-0.61	97NH-019SB	X	X	X	X					X	X
AP-1003	1.52-2.13	97NH-020SB	X	X	X	X					X	X
AP-1003	3.05-3.66	97NH-021SB	X	X	X	X					X	X
AP-1003	4.57-5.18	97NH-022SB	X	X	X	X	X	X	X	X	X	X
AP-1003	6.10-6.71	97NH-023SB	X	X	X	X	X	X	X	X	X	X

TABLE 3-2
SUMMARY OF ANALYTICAL RESULTS FOR SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs)
NOME HARBOR SITE INVESTIGATION, ALASKA(a)

Sample Location	SED-6	AP-1000	AP-1000	AP-1000	AP-1001	Sediment Management Standards(b)		EPA RBC(e)		PSDDA Level(h)
Sample Depth (m)	Surface	1.52-2.13	3.05-3.66	4.57-5.18	1.52-2.13					
Sample Date (1997)	8-Dec	9-Dec	9-Dec	9-Dec	11-Dec					
Sample ID	97NH-002SD	97NH-004SB	97NH-005SB	97NH-006SB	97NH-010SB	SQS(c)	CSL(d)	Industrial	Residential	
Benzoic Acid (mg/Kg)	0.012	ND (0.85)	ND (1.1)	ND (0.99)	ND (0.89)	650	650	1000000(f)	310000(f)	0.400
2-Methylnaphthalene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.009 J(0.18)	38	64	--	--	--
Acenaphthylene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.018 J(0.18)	66	66	--	--	0.210
Phenanthrene (mg/Kg)	0.026 J (1.1)	ND (0.17)	ND (0.21)	ND (0.20)	0.18	100	480	--	--	0.320
Anthracene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.052 J(0.18)	220	1200	610000(f)	23000(f)	0.130
Di-n-butylphthalate (mg/Kg)	ND (0.22)	0.25	ND (0.21)	ND (0.20)	0.022 J(0.18)	220	1700	--	--	1.400
Fluoranthene (mg/Kg)	0.031 J(0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.66	160	1200	82000(f)	3100(f)	0.630
Pyrene (mg/Kg)	0.027 J(0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.61 J(0.18)	1000	1400	61000(f)	2300(f)	0.430
Benzo(a)anthracene (mg/Kg)	0.014 J(0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.41	110	270	7.8	0.88	0.450
Chrysene (mg/Kg)	0.016 J(0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.42	110	460	780	88	0.670
Benzo(total b and k)fluoranthene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.50	230	450	7.8-78(g)	0.88-8.8(g)	0.800
Benzo(a)pyrene (mg/Kg)	0.014 J(0.22)	ND (0.17)	0.11 J(0.21)	0.027 J(0.20)	0.36	99	210	0.78	0.088	0.680
Indeno(1,2,3-CD)pyrene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.19	34	88	7.8	0.88	0.069
Dibenzo(a,h)anthracene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.10 J(0.18)	12	33	0.78	0.088	0.120
Benzo(g,h,i)perylene (mg/Kg)	ND (0.22)	ND (0.17)	ND (0.21)	ND (0.20)	0.20	31	78	--	--	0.540

Notes:

- ND Analyte Not Detected (Reporting Limit in Parentheses)
- J Estimated Value
- (a) Results for Bis (2-Ethylhexl) Phthalate are listed in Table 2
- (b) State of Washington Department of Ecology Sediment Management Standards
- (c) Marine Sediment Quality Standards
- (d) Marine Sediment Cleanup Screening Levels
- (e) EPA 1997, EPA Region III Risk-Based ConcentrationTable, based on direct human soil ingestion
- (f) Based on non-carcinogenic value
- (g) Lower value is for Benzo(b)fluoranthene, and higher value is for Benzo(k)fluoranthene while analytical value provides total for Benzo(b and k)fluoranthene
- (h) Screening Levels, Puget Sound Dredged Disposal Analysis, April 1997

TABLE 3-3
SUMMARY OF ANALYTICAL RESULTS FOR BIS (2-ETHYLHEXYL) PHTHALATE NOME HARBOR SITE INVESTIGATION, ALASKA

Sample Date 1997	Sample ID	Sample Location	Sample Depth (m)	Bis (2-Ethylhexyl) Phthalate (mg/Kg)
22-Dec	97NH-024SD	SED-1	0-0.015	0.019*
22-Dec	97NH-025SD	SED-2	0-0.015	0.024*
22-Dec	97NH-026SD	SED-3	0-0.015	0.060*
22-Dec	97NH-027SD	SED-4	0-0.015	0.027*
8-Dec	97NH-001SD	SED-5	0-0.015	0.025**
8-Dec	97NH-002SD	SED-6	0-0.015	0.065**
10-Dec	97NH-007SB	SED-7	0-0.015	0.071**
9-Dec	97NH-003SB	AP-1000	0-0.61	0.052**
9-Dec	97NH-004SB	AP-1000	1.52-2.13	0.059**
9-Dec	97NH-005SB	AP-1000	3.05-3.66	0.025**
9-Dec	97NH-006SB	AP-1000	4.57-5.18	ND (0.20)**
11-Dec	97NH-009SB	AP-1001	0-0.61	0.010***
11-Dec	97NH-010SB	AP-1001	1.52-2.13	0.020***
11-Dec	97NH-011SB	AP-1001	3.05-3.66	0.030***
11-Dec	97NH-012SB	AP-1001	4.57-5.18	0.037***
11-Dec	97NH-013SB	AP-1001	5.49-6.10	0.015***
11-Dec	97NH-014SB	AP-1002	0-0.61	0.11***
11-Dec	97NH-015SB	AP-1002	1.52-2.13	0.010***
11-Dec	97NH-016SB	AP-1002	3.05-3.66	0.019***
11-Dec	97NH-017SB	AP-1002	4.57-5.18	0.025***
11-Dec	97NH-018SB	AP-1002	6.10-6.71	0.043***
11-Dec	97NH-019SB	AP-1003	0-0.61	0.029***
11-Dec	97NH-020SB	AP-1003	1.52-2.13	0.059***
11-Dec	97NH-021SB	AP-1003	3.05-3.66	0.017***
11-Dec	97NH-022SB	AP-1003	4.57-5.18	0.014***
11-Dec	97NH-023SB	AP-1003	6.10-6.71	0.43***

NOTES:

ND Analyte not detected (reporting limit in parentheses)
* 0.019 mg/Kg Bis (2-Ethylhexyl) Phthalate detected in laboratory blank
** 0.032 mg/Kg Bis (2-Ethylhexyl) Phthalate detected in laboratory blank
*** 0.015 mg/Kg Bis (2-Ethylhexyl) Phthalate detected in laboratory blank

TABLE 3-4
SUMMARY OF ANALYTICAL RESULTS FOR METALS NOME HARBOR SITE INVESTIGATION, ALASKA

Reference Values				Arsenic (mg/Kg)	Barium (mg/Kg)	Cadmium (mg/Kg)	Chromium (mg/Kg)	Copper (mg/Kg)	Lead (mg/Kg)	Mercury (mg/Kg)	Selenium (mg/Kg)	Silver (mg/Kg)
Mean in Alaska Soil(a)				6.7	595	--	50(d)	24	12	--	--	--
EPA Industrial Soil RBC(b)				610	140000	1000	10000(e)	82000	--	610	10000	10000
EPA Residential Soil RBC(b)				23	5500	39	390(e)	3100	--	23	390	390
Marine Sediment Quality Standard(c)				57	--	5.1	260	390	450	0.41	--	6.1
Marine Sediment Cleanup Screening Level(c)				93	--	6.7	270	390	530	0.59	--	6.1
Sample Date (1997)	**Sample ID**	**Sample Location**	**Sample Depth (m)**	**Arsenic (mg/Kg)**	**Barium (mg/Kg)**	**Cadmium (mg/Kg)**	**Chromium(d) (mg/Kg)**	**Copper (mg/Kg)**	**Lead (mg/Kg)**	**Mercury (mg/Kg)**	**Selenium (mg/Kg)**	**Silver (mg/Kg)**
22-Dec	97NH-024SD	SED-1	0-0.015	14	11	ND (0.33)	4.7	3.0	2.1	ND (0.11)	ND (0.34)	ND (0.67)
22-Dec	97NH-025SD	SED-2	0-0.015	5.1	5.6	ND (0.32)	4.9	2.3	ND (1.9)	ND (0.13)	ND (0.32)	ND (0.64)
22-Dec	97NH-026SD	SED-3	0-0.015	6.5	8.0	ND (0.37)	5.7	2.6	ND (2.2)	ND (0.14)	ND (0.36)	ND (0.73)
22-Dec	97NH-027SD	SED-4	0-0.015	11	6.6	ND (0.39)	5.2	2.4	2.7	ND (0.15)	ND (0.37)	ND (0.77)
8-Dec	97NH-001SD	SED-5	0-0.015	26	7.4	ND (0.51)	8.4	5.2	5.1	ND (0.11)	ND (0.26)	ND (0.51)
8-Dec	97NH-002SD	SED-6	0-0.015	35	21	ND (0.62)	13	11	25	ND (0.13)	ND (0.33)	ND (0.62)
10-Dec	97NH-007SD	SED-7	0-0.015	210	45	ND (2.7)	22	23	12	0.20	ND (0.49)	ND (1.1)
9-Dec	97NH-003SB	AP-1000	0-0.61	29	8.3	ND (1.2)	10	12	6.1	ND (0.11)	ND (0.26)	ND (0.50)
9-Dec	97NH-004SB	AP-1000	1.52-2.13	32	13	ND (0.49)	8.4	6.3	3.1	ND (0.10)	ND (0.26)	ND (0.49)
9-Dec	97NH-005SB	AP-1000	3.05-3.66	43	28	ND (0.62)	18	14	6.6	ND (0.12)	ND (0.33)	ND (0.62)
9-Dec	97NH-006SB	AP-1000	4.57-5.18	98	17	ND (1.5)	13	8.9	5.1	ND (0.11)	ND (0.29)	ND (0.61)
11-Dec	97NH-009SB	AP-1001	0-0.61	35	8.3	ND (0.27)	6.5	10	5.7	ND (0.11)	ND (0.52)	ND (0.53)
11-Dec	97NH-010SB	AP-1001	1.52-2.13	21	47	ND (0.28)	8.7	11	52	1.7	ND (0.26)	ND (0.55)
11-Dec	97NH-011SB	AP-1001	3.05-3.66	29	12	ND (0.25)	8.4	6.8	4.2	ND (0.094)	ND (0.26)	ND (0.51)
11-Dec	97NH-012SB	AP-1001	4.57-5.18	26	11	ND (0.31)	8.6	7.1	3.4	ND (0.12)	ND (0.29)	ND (0.61)
11-Dec	97NH-013SB	AP-1001	5.49-6.10	93	15	ND (0.62)	13	10	5.2	ND (0.11)	ND (0.30)	ND (0.62)
11-Dec	97NH-014SB	AP-1002	0-0.61	33	12	ND (0.27)	8.6	7.5	7.1	0.27	ND (0.27)	ND (0.54)
11-Dec	97NH-015SB	AP-1002	1.52-2.13	23	9.6	ND (0.26)	9.3	6.1	3.1	ND (0.10)	ND (0.25)	ND (0.51)
11-Dec	97NH-016SB	AP-1002	3.05-3.66	26	8.0	ND (0.26)	7.7	5.8	3.0	ND (0.11)	ND (0.25)	ND (0.51)
11-Dec	97NH-017SB	AP-1002	4.57-5.18	47	15	ND (0.29)	4.7	6.7	4.3	ND (0.11)	ND (0.30)	ND (0.59)
11-Dec	97NH-018SB	AP-1002	6.10-6.71	110	24	ND (0.59)	16	11	6.6	ND (0.12)	ND (0.30)	ND (0.59)
11-Dec	97NH-019SB	AP-1003	0-0.61	31	33	ND (0.26)	12	8.1	18	ND (0.099)	ND (0.25)	ND (0.53)
11-Dec	97NH-020SB	AP-1003	1.52-2.13	40	13	ND (0.26)	6.8	9.9	11	0.61	ND (0.26)	ND (0.51)
11-Dec	97NH-021SB	AP-1003	3.05-3.66	22	20	ND (0.25)	7.3	11	4.1	ND (0.097)	ND (0.25)	ND (0.51)
11-Dec	97NH-022SB	AP-1003	4.57-5.18	35	8.6	ND (0.55)	9.4	14	6.2	ND (0.11)	ND (0.27)	ND (0.55)
11-Dec	97NH-023SB	AP-1003	6.10-6.71	260	25	ND (0.56)	11	7.3	4.4	ND (0.11)	ND (0.29)	ND (0.56)

NOTES:

-- Value not established
(a) Arbogast, et al., 1987, Geometric mean for Alaska soils and surficial materials
(b) EPA 1997, EPA Region III Risk-Based Concentration (RBC) Table, based on direct human soil ingestion. Metals RBCs are based on non-carcinogenic values.
(c) State of Washington Department of Ecology Sediment Management Standards
(d) Value is for total chromium
(e) Value is for chromium IV
ND Analyte not detected (reporting limit in parentheses)

TABLE 3-5
SUMMARY OF MISCELLANEOUS SAMPLING RESULTS
NOME HARBOR SITE INVESTIGATION, ALASKA

Sample Date (1997)	Sample ID	Sample Location	Sample Depth (m)	Total Organic Carbon (% carbon)	Ammonia Nitrogen (mg/Kg)	Nitrate/Nitrite as Nitrogen (mg/Kg)	Sulfate (mg/Kg)	Sulfide (mg/Kg)	Percent Moisture	Frost Classification*
22-Dec	97NH-024SD	SED-1	0-0.015	0.14	ND (0.26)	0.74	280	ND (0.7)	21.0	NFS
22-Dec	97NH-025SD	SED-2	0-0.015	0.15	ND (0.26)	0.72	460	ND (0.84)	21.0	NFS
22-Dec	97NH-026SD	SED-3	0-0.015	0.15	ND (0.25)	3.7	410	ND (0.76)	30.0	NFS
22-Dec	97NH-027SD	SED-4	0-0.015	0.14	ND (0.27)	0.77	250	ND (0.78)	30.0	NFS
8-Dec	97NH-001SD	SED-5	0-0.015	0.24	--	--	--	--	4.1	NFS
8-Dec	97NH-002SD	SED-6	0-0.015	0.88	--	--	--	--	23.0	PFS-F2
10-Dec	97NH-007SD	SED-7	0-0.015	1.2	14	ND (0.25)	400	510	50.0	PFS-S2
10-Dec	97NH-008SD	SED-8	0-0.015	--	--	--	--	--	--	NFS
9-Dec	97NH-003SB	AP-1000	0-0.61	0.24	--	--	--	--	4.1	NFS
9-Dec	97NH-004SB	AP-1000	1.52-2.13	0.31	--	--	--	--	2.5	PFS-S2
9-Dec	97NH-005SB	AP-1000	3.05-3.66	0.62	0.33	0.53	30	ND (0.8)	22.0	F2
9-Dec	97NH-006SB	AP-1000	4.57-5.18	0.35	0.27	ND (0.25)	10	ND (0.7)	16.0	PFS-F2
11-Dec	97NH-009SB	AP-1001	0-0.61	0.28	--	--	--	--	3.3	PFS-S2
11-Dec	97NH-010SB	AP-1001	1.52-2.13	1.7	--	--	--	--	6.7	PFS-F2
11-Dec	97NH-011SB	AP-1001	3.05-3.66	0.30	--	--	--	--	3.1	NFS
11-Dec	97NH-012SB	AP-1001	4.57-5.18	0.39	ND (0.23)	0.96	22	ND (0.64)	16.0	NFS
11-Dec	97NH-013SB	AP-1001	5.49-6.10	0.34	ND (0.24)	1.3	22	ND (0.65)	16.0	PFS-S2
11-Dec	97NH-014SB	AP-1002	0-0.61	0.31	--	--	--	--	5.4	PFS-S2
11-Dec	97NH-015SB	AP-1002	1.52-2.13	0.27	--	--	--	--	4.4	NFS
11-Dec	97NH-016SB	AP-1002	3.05-3.66	0.27	--	--	--	--	3.2	NFS
11-Dec	97NH-017SB	AP-1002	4.57-5.18	0.23	ND (0.22)	0.48	58	ND (0.62)	13.0	NFS
11-Dec	97NH-018SB	AP-1002	6.10-6.71	0.40	0.32	0.31	130	ND (0.73)	17.0	PFS-S2
11-Dec	97NH-019SB	AP-1003	0-0.61	0.37	--	--	--	--	3.0	PFS-S2
11-Dec	97NH-020SB	AP-1003	1.52-2.13	0.28	--	--	--	--	3.4	PFS-F2
11-Dec	97NH-021SB	AP-1003	3.05-3.66	0.30	--	--	--	--	2.5	NFS
11-Dec	97NH-022SB	AP-1003	4.57-5.18	0.29	ND (0.21)	0.27	130	ND (0.76)	12.0	NFS
11-Dec	97NH-023SB	AP-1003	6.10-6.71	0.38	0.48	ND (0.25)	120	ND (0.7)	14.0	PFS-S2

NOTES:

-- Not Analyzed

ND Analyte not detected (reporting limit in parentheses)

* The system used for frost classification is documented at the beginning of Appendix C

4.1 CHEMICAL RESULTS

There are no regulations that specify the maximum concentration of potentially hazardous compounds in dredged soils in Alaska. Reference values from several sources are included in this report for comparison. Three standards from the State of Washington are included: Marine Sediment Quality Standards (SQS), Marine Sediment Cleanup Screening Levels (CSL), and the Puget Sound Dredged Disposal Analysis (PSDDA) screening levels. EPA Risk Based Concentrations (RBCs) for both residential and industrial settings and the mean concentration of metals in Alaska soils are also included. The EPA RBC are not regulations, but are provided as screening levels. Each of the reference values are included in Tables 3-2 and 3-4.

VOCs are not considered a concern based on analytical data for the surface soil, subsurface soil, and sediment samples collected during this investigation. Methylene chloride was the only VOC detected, and its presence is most likely the result of laboratory contamination.

Several SVOCs were detected in the subsurface soil samples and one of the sediment samples. Two SVOCs, benzo(a)pyrene (0.36 mg/Kg) and dibenzo(a,h)anthracene (0.1 J mg/Kg), were detected in AP-1001 (1.5-2.1 m) above EPA residential RBCs. Although the SMS and PSDDA regulations do not apply in Alaska, they are presented as a reference to compare to sampling results.

Two surface soil samples were collected in 1990 from a location just west of AP-1000 (James M. Montgomery Consulting Engineers, Inc., 1990a). Elevated concentrations of VOCs, including benzene (0.007 mg/Kg), tetrachloroethene (0.030 mg/Kg), toluene (0.037 mg/Kg), and xylene (0.922 mg/Kg) were detected in one sample. Elevated concentrations of SVOCs were also detected. The SVOCs detected in the 1990 sample were nearly the same types as the analytes detected in AP-1001 and SED-6. The highest concentrations of SVOCs detected in the 1990 samples were roughly 30 times greater than the highest concentrations SVOCs detected in the samples collected in 1997.

The concentration of metals detected in sediment, surface soil and subsurface soil samples were compared to the mean concentration of metals in Alaskan soils (Arbogast, et al., 1987), EPA industrial and residential RBCs, SQS, and CSL. These standards are included as reference values, and are not enforceable regulatory standards. Three metals (arsenic, lead and mercury) exceeded one or more of the reference values.

Arsenic was detected above the SQS (57 mg/Kg) in four subsurface soil samples and one sediment sample, and above the CSL (93 mg/Kg) in three subsurface soil samples and one sediment sample. The concentration of arsenic detected in nearly all the subsurface soil samples exceeded the EPA residential RBC for arsenic (23 mg/Kg). Arsenic was detected above the EPA residential RBC in both of the surface soil samples and one sediment sample collected from the Snake River. The concentration of arsenic detected in all of the samples collected, except for two off-shore sediment samples, exceeded the mean concentration of arsenic in Alaska soils.

Although the concentration of arsenic is elevated above the mean concentration of arsenic in Alaska soils, the concentrations are not significantly elevated above the concentrations detected in soil and sediment samples from other sampling sites in Nome. Sediment samples were collected as part of a U.S. Army Corps of Engineers (USACE) investigation of a petroleum contaminated defense site at the Nome Airport (James M. Montgomery Consulting Engineers, Inc., 1990b). Two sediment samples were collected from Center Creek, which runs through the airport and into the Snake River, approximately 1.5 miles upstream of Nome Harbor. One sample was collected from Center Creek, upstream of the airport and defense site being investigated by the USACE. The second sample was collected from Center Creek, downstream and closer to several areas impacted by petroleum releases. The concentrations of arsenic detected were 100 mg/Kg and 40 mg/Kg, respectively.

The concentration of lead was detected above the mean concentration of lead in Alaska soils, in two subsurface soil samples (AP-1001, 1.52 - 2.13, and AP-1003, 1.52 - 2.13) and one surface soil sample (SED-6). Lead concentrations were detected below the SQS (450 mg/Kg) and CSL (530 mg/Kg). There are no EPA RBCs for lead.

Mercury was detected above the SQS (0.41 mg/Kg) and CSL (0.59 mg/Kg) in soil from borings AP-1001 (1.7 mg/Kg) and AP-1003 (0.61mg/Kg) at a depths of 1.52 - 2.13 m. The concentrations of mercury detected at the site did not exceed EPA RBCs.

The concentrations of metals detected in surface soil samples collected from the spit (James M. Montgomery Consulting Engineers, Inc., 1990a), were similar to the concentrations found during this investigation, except for lead and selenium. Lead was detected at 250 mg/Kg in one sample collected in 1990, but the highest concentration detected in 1997 was only 52 mg/Kg. Selenium was detected at 0.95 to 1.2 mg/Kg in the 1990 samples (including the background sample) and was not detected in the 1997 samples.

Several other chemical analyses were conducted on the sediment and soil samples. These analyses included total organic carbon (TOC), Ammonia-Nitrogen, Nitrate/Nitrite as Nitrogen, sulfate, and sulfide. Generally, the concentrations of these analytes are higher in the off-shore sediment samples than the subsurface soil samples.

4.2 GEOTECHNICAL RESULTS

Grain-size descriptions of the subsurface soil samples, tend to be more coarse grained than the off-shore sediment samples. Although the soil testing laboratory described all the samples as sand with or without silt and gravel, the field descriptions of the samples indicated greater variability. The subsurface soil samples were generally described as predominantly medium sand, while the off-shore sediment samples were described as fine sand. While there was some variability in the descriptions of the subsurface soil samples, the four off-shore sediment samples were nearly identical (fine sand).

Based on the blow counts and the visual identification, the subsurface soil samples are characterized as loose. Another indication of the looseness of the soils, is that heaving sands

were encountered in each of the borings drilled. The heaving sands prevented sampling more than 3 m below the water table.

Once the channel has been cut, the maximum angle that soils could be stable is equal to the angle of internal friction of the soil. If the slopes are cut at a higher angle, then the soils will fail roughly to the angle on internal friction. The angle of internal friction for soil in the spit is approximately 30° (USACE 1984). The slightest disturbance to soils left at this angle would reduce the angle even further. A table in the Soil and Water Conservation Engineering (Schwab, et al, 1966) manual, recommends a side slope no steeper than 3:1 (18°) for deep channels in loose sandy soils.

5.1 CONCLUSIONS

There does not appear to be a basis of concern for VOCs or SVOCs in the subsurface soils and sediments. Two subsurface soil samples had SVOCs detected above EPA residential RBCs; these detections are only slightly above the RBCs. The mixing that will occur while dredging and moving the soils to a new location, should reduce the concentrations of the detected SVOCs below RBCs.

The concentrations of arsenic and mercury were detected above the SQS and CSL in several samples; therefore, these soil may be unsuitable for ocean disposal based on Washington State standards. The concentration of arsenic was detected above the mean concentration of arsenic in Alaska soils and EPA residential RBCs in most samples. The elevated levels of arsenic are most likely the result of naturally high background levels of arsenic in Nome soils. Mercury was not detected above EPA RBCs.

Although the Washington State standards and PSDDA regulations do not apply in Alaska, they are presented as a reference to compare to sampling results. The EPA RBC are not regulations, but are also provided as screening levels.

Soil grain-size analyses and visual descriptions, indicate that the soils in the area of the proposed channel are loose sands.

5.2 RECOMMENDATIONS

Soils excavated from the proposed channel could be disposed in the Nome Ocean Dredged Material Disposal Sites, provided that regulatory agencies accept the elevated arsenic and mercury concentrations. The City of Nome plans to maximize land disposal of dredged material.

The loose sandy soils at the site would allow a variety of excavation methods to be used. This includes backhoes on barges or pipeline dredges. A pipeline dredge is currently being used to dredge the existing channel and should be considered for dredging the new channel. Standard earth-moving equipment could be used to remove soils above the water table and may decrease the time required to dredge the new channel. Dredging can also occur during the winter from an ice platform. The City of Nome has successfully dredged the existing harbor through the ice in the past.

A stable channel side slope should be no steeper than 3:1 (18°). All preliminary designs that have been reviewed, show armor rock defining the boundary of the channel. It is suggested that this protection to the side slopes of the channel remain in the design, since the loose sandy soils at the site will not likely remain in place after construction.

Abogast, et al., 1987.

James M. Montgomery Consulting Engineers, Inc., 1990a, *Chemical Contamination Report Nome - Nome Spit Site*, prepared for the U.S. Army Corps of Engineers, Defense Environmental Restoration Program, Nome Area - Seward Peninsula Project (Contract No. DACA85-85-C0039).

James M. Montgomery Consulting Engineers, Inc., 1990b, *Chemical Contamination Report Nome - Airport Site*, prepared for the U.S. Army Corps of Engineers, Defense Environmental Restoration Program, Nome Area - Seward Peninsula Project (Contract No. DACA85-85-C0039).

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Appendix A to the Geotechnical Analysis

SITE INVESTIGATION FIELD NOTES

MEASUREMENT CONVERSIONS

INCH CM

IF YOU KNOW	MULTIPLY BY	TO FIND
LENGTH		
inches	2.540	centimeters
feet	30.480	centimeters
yards	0.914	meters
miles	1.609	kilometers
millimeters	0.039	inches
centimeters	0.393	inches
meters	3.280	feet
meters	1.093	yards
kilometers	0.621	miles
WEIGHT		
ounces	28.350	grams
pounds	0.453	kilograms
grams	0.035	ounces
kilograms	2.204	pounds
VOLUME		
fluid ounces	29.573	milliliters
pints	0.473	liters
quarts	0.946	liters
gallons (U.S.)	3.785	liters
milliliters	0.033	fluid ounces
liters	1.056	quarts
liters	0.264	gallons (U.S.)

TEMPERATURE

°C = (°F - 32) x .555
°F = (°C x 1.8) + 32

Inches	Decimals of foot	Milli-meters
1/16	.0052	1.5875
1/8	.0104	3.1750
3/16	.0156	4.7625
1/4	.0208	6.3500
5/16	.0260	7.9350
3/8	.0313	9.5250
1/2	.0417	12.700
5/8	.0521	15.875
3/4	.0625	19.050
7/8	.0729	22.225
1"	.0833	25.400
2"	.1667	50.800
3"	.2500	76.200
4"	.3333	101.60
5"	.4167	127.00
6"	.5000	152.40
7"	.5833	177.80
8"	.6667	203.20
9"	.7500	228.60
10"	.8333	254.00
11"	.9167	279.40
1 foot	1.0000	304.80

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CONTENTS

PAGE	REFERENCE	DATE

12/8/97 Nome Harbor ①

840 Call George Krier. No answer.

910 Pick up supplies from Air ~~Cargo~~ sk Cargo Express.

927 Call office, talk to Gary

950 Check in at Stampede

1015 Talk to Gilbert. He lives near drilling site.

1030 NAC - Drillers equipment is still there (i.e., not pickal up yet).

1055 Stop by Randy Romenesko's office. Not in, left message.

1108 Call Kyle Brown. The plane that Eric and Jeff were on had mechanical problems and had to return to Anchorage.

Scott Kuhl 12/8/97

② Nome Harbor 12/8/97

1130 Stop by Randy's office
Talk to Randy about plans for the day and possibility of getting sediment samples in the Bering Sea.

1200 Lunch

100 Go to apartment to prepare sample kits.

145 Go to AC store for DI water and ziplock bags.

200 Arrive at site. Walk to each boring location

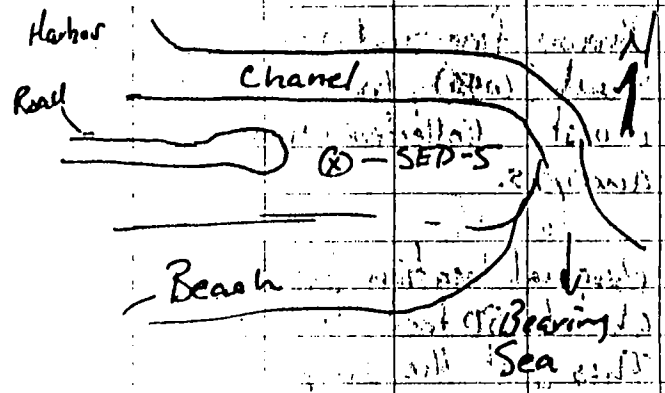
205 Talk to Randy, he is showing the SB-2 location to utility people. May have to move SB-2, because of utility easment along the road.

215 Use GPS to locate SED-5.

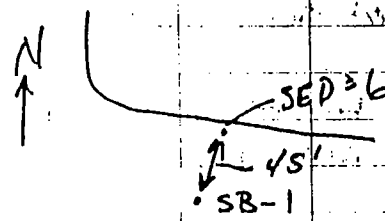
Scott Kahell 12/8/97

Nome Harbor 12/8/97 ③

245 Collect SED-5
Brown med sand (60%), fine sand (40%), and trace coarse sand and gravel, moist.



315 Collect SED-6



330 Found frozen soil at SED-6.
Leave to get hammer.

Scott Kahell 12/8/97

④ Nome Harbor 12/8/97

335 Meet drillers on the way back to the apartment. They have hammer I can borrow.

415 Finish collecting SED-6.

Brown fine sand (80%), medium sand (20%), trace coarse sand, moist. Collected volume for all analyses.

Original location for Sed-6 was about 80 feet north of SB-1. This put the sample in the river. The sample location was moved back to the river bank and collected from frozen soils.

430 Get new hammer handle for the grisk drillers hammer I borrowed.

500 Return to apartment, pack more sample kits.

Scott Kalell 12/8/97

Nome Harbor 12/8/97 ⑤

600 Finish preparing for tomorrow.

Scott Kalell 12/8/97

(6) Nome Harbor 12/9/97

800 Start preparing to sample

915 Drill rig arrives by fork lift

920 Pick up PID from AK Air.

935 Drill rig in place, trying to start. Weather: cloudy, light wind, 5-10°F, dark. Sun rise is at about 1130am.

1025 Drill rig still not started. Batt is ok, but spark plugs are not getting spark.

1045 Go to get lunch while drillers go to get parts.

1140 Return to site.

1145 Drill rig starts. Drillers had to replace solinoid.
Preparing drill rig for drilling.

SB-01 was surveyed in at 8.6 ft. above MLLS.

Scott Kalal 12/9/97

Nome Harbor 12/9/97 (7)

0 — 8.6 surface

$\square^{5}_{7}$

8.6 — 0.0

$\square^{10}_{12}$

$\square^{15}_{17}$

23 — 15' Below MLLS

0-2 Collected at 1210 pm
Brown medium sand (50%), coarse sand (30%), fine sand (15%), fine gravel (5%), dry. HNO: 0.5, No odor.

1241
5-7 Blows: 7-66-5 Weather: Cloudy, light wind.
Rec: 100% (24") Odor: None
Hm: 3.5

Brown coarse sand (50%) with medium and fine sand (50%) trace fine gravel, dry.

Scott Kalal 12/9/97

Nome Harbor 12/9/97

1300 Depth 10-12 Blows: 4-3-7-8
Rec: 100% Odor: None
Hnu: 3.0

Brown with some black sand grains. Top is medium sand with some fine sand that grades into a fine sand at the bottom of the spoon, wet.

1310 Depth 15-17 Blows: 4-6-6-7
Rec: 100% Odor: None
Hnu: 1.0

Top 8" is a dark ~~grey~~ SK gray fine sand, wet. 8 to 20 inches is a medium sand (50%) with fine sand (10%) and coarse sand (40%), wet. Bottom 4" is a black fine sand, wet.

1330 Rig quits, will not restart. Drillers leave to get starter switch.

Scott Kahl 12/9/97

Nome Harbor 12/9/97

1400 Drillers return with new starter switch.
Drill rig is a skid mounted CME 75C. Gas powered. 4¼" augers, 5' in length. 340 lb hammers.

1425 Rig still will not start.

1440 Leave site to get GPS. Meet Randy on the way to the Apartment. Give Randy a run down on drilling.

1450 Call Gary, brief him on progress so far.

1600 Return to site. Drillers start working on rig. I try to get GPS fix. Batteries may be low.

1630 Mark location for SED-7.

1700 Drillers leave for the day.

Scott Kahl 12/9/97

(10) Nome Harbor 12/9/97

Drill Rig is still not working. Augers are at 20', and the rods have sandled in.

The drillers are going to call back to their office and talk to their mechanic.

Sample #s:

97NH-001SD SED-5, 8260, 8270 Metals, TOC, Sieve + Hydrometer analysis, Atterburg

97NH-002SD SED-6, 8260, 8270, Atterburg, Metals, TOC, sieve and Hydrometer analysis.

97NH-003SB 0-2 SB-1 8260, 8270, Metals, TOC Grain size, ~~Hydro~~ Hydro, Frost class, atterburg.

97NH-004SB SB-1 & SR 5-7, 8260, 8270 Metals, TOC, Grain size, Frost class., atterburg.

Scott Kahll 12/9/97

Nome Harbor 12/9/97 (11)a

97NH-005SB 10-12 SB-1 8260, 8270, metals, TOC, grain size, frost class., atterburg, Nitrate-Nitrogen, Ammonia nitrogen, Sulfate, Sulfite.

97NH-006SB 15-17 SB-1 Same Analyses as above.

(SK)

Scott Kahll 12/9/97

Nome Harbor 12/10/97

800 Finish labelling samples collected so far.

900 Leave Apartment. Met drillers on my way out. They were working on the drill rig this morning but could not get it started.

930 Go to Alaska CAB garage to find Randy. Randy is going to help me cut holes in the ice. Called Randy at home, he will be at the site around 12 noon.

1000 Go to drillers apartment. New part should be in this afternoon.

1045 Go to site to locate SED-8 Used GPS to find the sample location.

1125 Randy arrives. He needs to go and get an ~~track~~ ax.

Scott Kuhl 12/10/97

Nome Harbor 12/10/97

SED-7 will be 97NH-007SD. This sample will be collected at the location noted in the workplan.

SED-8 will be 97NH-008SD. This sample will also be collected at the location noted in the workplan.

97NH-007SD - SED-7 8260, 8270, RCRA 8 Metals, TOC, SO_4, NH_3, NO_2-NO_3, S_2, Grain Size, Atterburg

97NH-008SD SED-8 Grain Size, ~~RCRA 8 metals~~ SK, Atterburg

1228 Collect Sample SED-7. Water was 4.5 feet deep.

Dark brown medium sand, with trace organics.

2 SK Photos of digging hole.

Scott Kuhl 12/10/97

(13) Nome Harbor 12/10/97

1245 Start digging hole at SED-8.
Photo #4 - Looking SE at hole and ~~poles~~ power poles east of site.
Photo #5 - Looking NE to another set of power poles.
Photo #6 - Looking NW at SED-8 and road. Airport in the distance.

1340 Collect SED-8. Sediment was very coarse and the clam shell sample would only bring up on rock at a time. Since the sediment was just below the ice and the ice was about 2' thick. I was able to use a shovel to bring up the sample.

1400 Return to apartment, call Gary, and check messages.

Scott Kahl 12/10/97

Nome Harbor 12/10/97 (14)

1430 Gtask Go to find Randy. Randy not in office.

SED-8 Description
Dark brown sandy gravel
50% gravel, 30% coarse sand, 20% medium sand.

1630 Stop by Randy's office again. He is in a city council meeting. Go to dinner.

SK

Scott Kahl 12/10/97

(15) Nome Harbor 12/11/97

The Drillers picked up the electronic ignition control ~~unit~~ this morning. The drill ran for a few minutes when the drillers started to smell burning wires(!).

Discovery is sending a mechanic up today, to try to fix the drill.

940 Arrive on site the drillers are going to move the drill rig to a garage.

1030 Stop by Randy's office. Gave Randy a briefing on what has happened so far:
- Rig still not running
- River seal samples collected.
- Samples collected so far were sent last night.

1055 Call Gary.

Scott Kuhl 12/11/97

Nome Harbor SK 12/11/97 (16)

1445 Mechanic from Discovery gets drill running.

1500 Arrive at Drill site. SB-1 will not be drilled or sampled further. Setting drill on SB-2.

Starting elevation of SB-2 is 14'. SB-2 was moved several feet NW since it was in a utility easement.

Photo #7 - Start drilling SB-2. Sled dogs in the background.

1510 Start drilling SB-2

1515 SB-2 0-2
Hue: 6.0
Light grayish brown coarse sand (40%) with medium sand (30%), fine gravel (20%) and fine sand (10%); dry.

Scott Kuhl 12/11/97

(17)

Nome Harbor 12/11/97

1530 SB-2 5-7'
Blows: 4-2-3-4 Odor: None
Rec: 100%
Hnu: 10.0
Dsc: Grayish brown medium sand (60%), coarse sand (20%) fine gravel (10%), and fine sand (10%), trace organics, dry.

Photos 8,9,10 - Dogs.

1600 SB-2
Blows: 3.3.3.4 Depth 10-12
Rec: 20" Odor: None
Hnu: 7.0

Brown medium sand (60%), coarse sand (30%) and fine sand (10%), moist.

1609 SB-2
Blows: 6.6.7.6 Depth: 15-17
Rec: 20" Odor: None
Hnu: 10

Scott Kadell 12/11/97

Nome Harbor 12/11/97 (18)

Brown coarse sand (50%), medium sand (30%), fine gravel (10%), fine sand (10%) wet.

1625 Augers at 20'. Sand has heaved 2-3 feet into the augers.

1630 SB-2 ~~20-22~~ 15-20
Blows: 6.7.8.7 Odor: None
Rec: 20"
Hnu: 16

Dark brown fine sand (60%) and medium sand (40%), wet

Sample is from soil that heaved into the augers. So sample came from adjacent to augers at 20'. Without adding water to the augers, if we risk sanding the rods and augers in the ground if we continue.

Scott Kadell 12/11/97

(19) Nome Harbor 12/11/97

Photos 11, 12 - Removing auger from SB-2.

1700 Setting up on SB-3.

1710 SB-3 0-2
B. ~~Grayish brown~~ Dark Brown SK medium sand (~~40~~ 60% SK), fine sand (~~40~~ 40% SK) and coarse sand (~~30~~ 0%); ~~dry~~ moist SK
No odor. Hnu: 2.0

Starting Elevation of SB-3 was 13.9'.

Photos 13, 14 - Drilling at SB-3.

1722 SB-3 5-7
Blows: 13-14-7-11 Odor: None
Rec: 20"
Hnu: ~~4.5~~ SK 0.0
Dark brown med sand (70%), fine sand (20%), coarse sand (10%), dry

Scott Kahill 12/11/97

Nome Harbor 12/11/97 (20)

1733 SB-3 10-12
Blows: 3-5-4-5 Odor: None
Rec: 23"
Hnu: ~~3.5~~ SK 0.0

Dark brown medium sand (40%) coarse sand (~~30~~ 40%), fine sand (20% 4 SK), fine gravel (10%), moist.

1745 SB-3 15-17
Blows: 6-13-7-6 Odor: None
Rec: 20"
Hnu: ~~1.5~~ SK 2.0

Dark brown coarse sand (40%), medium sand (30%), fine gravel (20%) fine sand (10%), wet.

1752 SB-3 20-22
Blows: 6-8-10-10 Odor: None
Rec: 18"
Hnu: 0.0
Dark brown ~~coarse sand (50%)~~ SK fine gravel (~~30~~ 60% SK), medium sand (~~40~~ 40% SK), wet.

Scott Kahill 12/11/97

Nome Harbor 12/11/97

1800 Start ~~filling~~ pulling augers from SB-3. Sands started to heave from 15' to 20'.

1820 Start setting up on SB-4. Original elevation for SB-4 is 14.8.

1840 Start drilling at SB-4.

1846 SB-4 0-2
Dark brown medium sand (60%) coarse sand (30%), fine sand (10%), moist. Hnu: Odor:

1855 SB-4 5-7
Blows: 14-8-8-9 Odor: None
Rec: 19"
Hnu: 4.5

Dark brown med. (70%), fine sand (20%), coarse sand (10%), dry

Photo #15 - Drilling at SB-4

Scott Kahill 12/11/97

Nome Harbor 12/11/97

1900 SB-4 10-12
Blows: 4-5-5.5 Odor: None
Rec: 20"
Hnu: 3.5
Dark brown medium sand (40%), coarse sand (30%), fine sand (20%), fine gravel (10%), moist.

1915 SB-4 15-17
Blows: 4-4-5-8 Odor: None
Rec: 19"
Hnu: 1.5
Dark brown coarse sand (40%) medium sand (30%), fine gravel (20%) fine gravel (10%), wet.

1925 SB-4 20-22
Blows: 8-12-13-15 Odor: None
Rec: 18"
Hnu 0.0
Dark brown, coarse sand (50%), fine gravel (30%), medium sand (20%), wet.

1930 Start pulling augers from hole. Sands had started to heave.

Scott Kahill 12/11/97

(23) Nome, Harbor 12/11/97

2000 Leave site for the day

97NH-009SB SB-2 0-2 1515
8260, 8270, Metals, TOC
Grain size, Atterburg

97NH-010SB SB-2 5-7 1530
Same as above

97NH-011SB SB-2 10-12 1600
Same as above

97NH-012SB SB-2 15-17 1609
8260, 8270, Metals, TOC
Grain Size, Atterburg,
NO_2-NO_3, NH_3, S_2, SO_4

97NH-013SB SB-2 20-22 1630
Same as above.

97NH-014SB SB-3 0-2 1710
8260, 8270, Metals, TOC,
Grain Size, Atterburg.

Scott Kalat 12/11/97

Nome Harbor 12/11/97 (24)

97NH-015SB SB-3 5-7 1722
8260, 8270, Metals, TOC,
Grain Size, Atterburg

97NH-016SB SB-3 10-12 1733
Same as above

97NH-017SB SB-3 15-17 1745
8260, 8270, Metals, TOC,
Grain Size, Atterburg,
NO_2-NO_3, NH_3, S_2, SO_4

97NH-018SB SB-3 20-22 1752
Same as above.

97NH-019SB SB-4 0-2 1846
8260, 8270, Metals, TOC
Grain Size, Atterburg,
~~NO_2-NO_3, NH_3, S_2, SO_4~~ SK

97NH-020SB SB-4 5-7 1855
Same as above

Scott Kalat 12/11/97

(25) Nome Harbor, 12/11/97

97NH-021SB SB-3 10-12 1900
8260, 8270, Metals, TOC,
Grain Size, Atterburg,
~~NO_2-NO_3, NH_3, S_2, SO_4~~ sk

97NH-022SB SB-4 15-17 1915
~~820 sk~~ 8260, 8270, Metals, TOC,
Grain Size, Atterburg,
NO_2-NO_3, NH_3, S_2, SO_4

97NH-023SB SB-4 20-22 1925
Same as above.

Scott Kahell 12/11/97

Nome Harbor, 12/22/97 (26)

630 Leave Anchorage
800 Arrive in Nome
900 Go to Randy Romeneska's office, pick up bottles and sediment sampler
930 Breakfast. Program sampling locations into GPS.
1015 Stop by Randy R.'s office. Called Randy C., not in. Called Gary Busse, updated him on progress so far.
1030 Randy C. is not at the Alaska Cab garage.

1145 Found Randy C. at Hanson grocery store. We will meet at the causeway in one hour.

~~Sampling at four sediment~~ sk

Samples (sediment) will be collected from four locations

Scott Kahell 12/22/97

(27) Nome Harbor 12/22/97

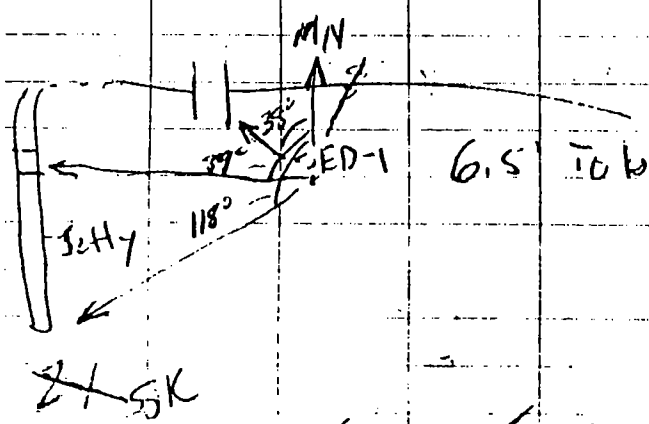
97NH-024SD SED-1
8260, 8270, Metals, TOC,
Grain size, Atterberg,
NO_2-NO_3, NH_3, SO_4, S_2

97NH-025SD SED-2
Same as above

97NH-026SD SED-3
Same as above

97NH-027SD SED-4
Same as above.

1400 Arrive at SED-1



6.5' to bottom

SK

Scott Kuhl 12/22/97

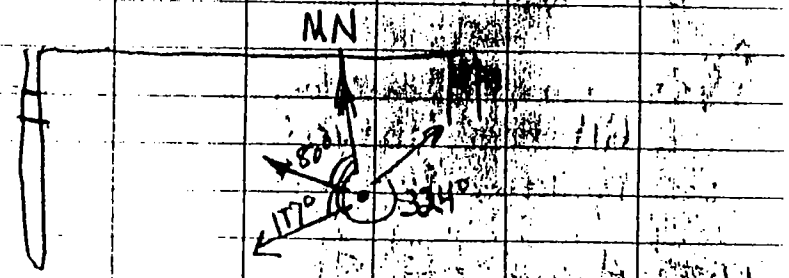
Nome Harbor 12/22/97 (28)

1445 Collect SED-1

Grayish brown fine sand (90%) with little silt (10%); wet. No odor

SK

1505 Arrive at SED-2

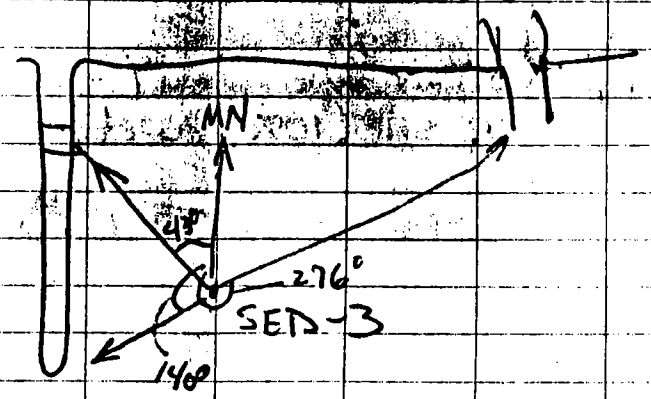


1548 Finish sampling SED-2

1616 Arrive at SED-6

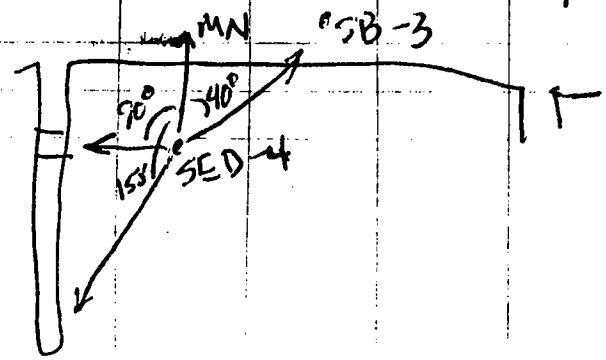
SK

Scott Kuhl 12/22/97



1855 Finish Sampling SED-3
All bags labelled SED-4
by accident.

1715 Arrive at SED-4

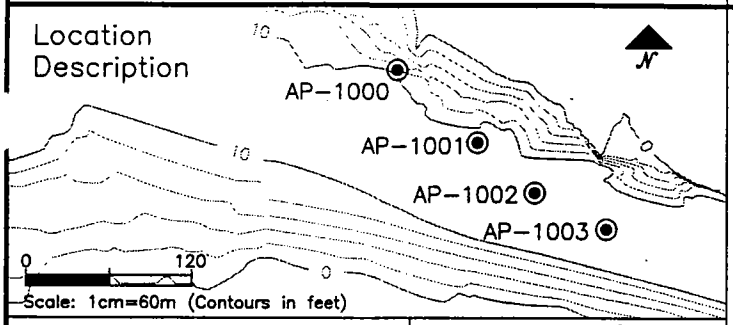


Appendix B to the Geotechnical Analysis

SOIL BORING LOGS

Project: Nome Harbor Site Investigation	Field Hole No. SB-1	Permanent Hole No. AP-1000

Location Description



☒ Test Boring ☐ Test Pit ☐ Monitoring Well

Logged By: Scott Kendall
Driller: Discovery Drilling Rig: CME-45C
Drill Method: 11.43-cm Hollow Stem Auger
Sample Method: Split Spoon
Hammer Wt: 152 Kg Drop: Standard
Start Date: 12/9/97 Time: 1205
Complete Date: 12/9/97 Time: 1330
Weather: Cloudy, light wind, −15.0°C to −12.2°C Instrumentation:

Coordinate System: State Plane
Datum: Alaska Zone 8 50008 NAD 27
Northing (m) 1,169,877.36
Easting (m) 179,961.27

Elevation Datum ☐ MSL ☒ Other

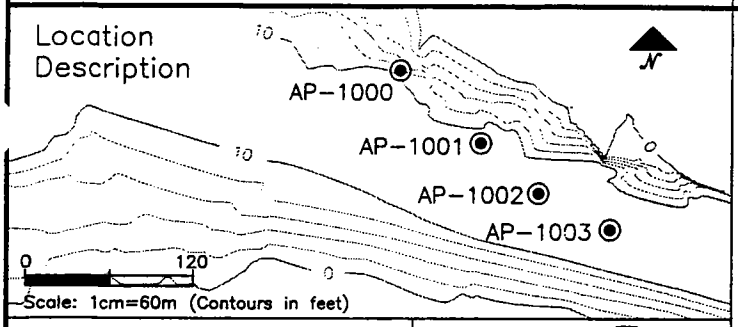
Top of Hole Elevation (m)	Depth Drilled (m)	Total Depth (m)	Depth to Groundwater (m)
2.59 MLLW	4.57	5.18	2.13 to 3.05

Depth (m)	Sample I.D.	Sample Interval	USCS Symbol	Classification	Max. Size (cm)	Description and Remarks	Graphic Log	Blows/15.24cm	OVA Reading (ppm)	Water Screen Interval
	97NH-003SB		SW	SAND		Brown, medium- (50%) to coarse-grained (30%) with little fine-grained sand (15%) and trace fine gravel (5%)			0.5	
1										
	97NH-004SB		SW	SAND		Brown, coarse-grained (50%) with medium- and fine-grained sand (50%), trace fine gravel, dry, medium dense, recovery 61.0cm		7 6 6 5	3.5	
2										
3	97NH-005SB		SP	SAND		Mostly brown with some black, medium-grained with some fine-grained sand grading to fine-grained sand at 3.66m, wet, medium dense, recovery 61.0cm		4 3 7 8	3.0	
4										
5	97NH-006SB		SP SW SP	SAND		Dark gray, fine-grained, wet to 4.78m Medium- (50%) to coarse-grained (40%) sand with little fine-grained sand (10%), wet, medium dense to 5.12m Fine-grained, wet, medium dense to 5.18m, recovery 61.0cm		4 6 6 7	1.0	
6						Bottom of boring at 5.18m Boring backfilled with drill cuttings				
7										
8										

Project No:		Page No:	Hole No.
976057NA	Woodward-Clyde Engineering & sciences applied to the earth & its environment	1 of 1	AP-1000

Project: Nome Harbor Site Investigation	Field Hole No. SB-2	Permanent Hole No. AP-1001

Location Description



☒ Test Boring ☐ Test Pit ☐ Monitoring Well

Logged By: Scott Kendall
Driller: Discovery Drilling Rig: CME-45C
Drill Method: 11.43-cm Hollow Stem Auger
Sample Method: Split Spoon
Hammer Wt: 152 Kg Drop: Standard
Start Date: 12/11/97 Time: 1510
Complete Date: 12/11/97 Time: 1650
Weather: Partly cloudy, light wind, −15.0°C to −20.6°C Instrumentation:

Coordinate System: State Plane
Datum: Alaska Zone 8 50008 NAD 27
Northing (m) 1,169,821.12
Easting (m) 180,025.94

Elevation Datum ☐ MSL ☒ Other

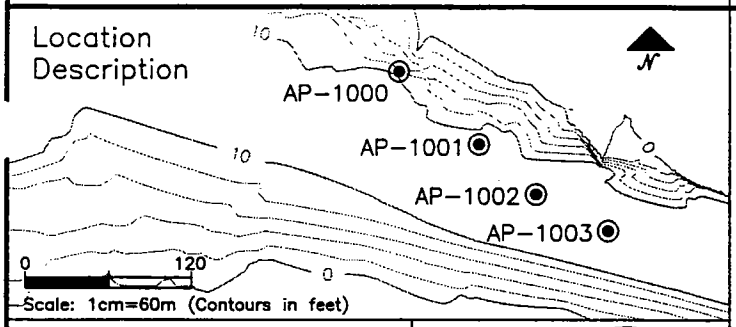
Top of Hole Elevation (m)	Depth Drilled (m)	Total Depth (m)	Depth to Groundwater (m)
4.02 MLLW	5.49	6.10	3.66 to 4.57

Depth (m)	Sample I.D.	Sample Interval	USCS Symbol	Classification	Max. Size (cm)	Description and Remarks	Graphic Log	Blows/ 15.24cm	OVA Reading (ppm)	Water Screen Interval
	97NH-009SB	☒	SW	SAND with gravel		Light grayish brown, coarse- (40%) to medium-grained (30%) with fine gravel (20%) and little fine-grained sand (10%), dry			6.0	
1										
2	97NH-010SB	☒	SP	SAND		Dark grayish brown, medium-grained (60%) with coarse-grained sand (20%), little fine gravel (10%), and little fine-grained sand, trace organics, dry, loose, recovery 61.0cm		4 2 3 4	10.0	
3	97NH-011SB	☒	SP	SAND		Brown, medium-grained (60%) with coarse-grained sand (30%) and little fine-grained sand (10%), moist, loose, recovery 50.8cm		3 3 3 4	7.0	
4										▽
5	97NH-012SB	☒	SW	SAND		Brown, coarse- (50%) to medium-grained (30%), little fine gravel (10%) and fine-grained sand (10%), wet, medium dense, recovery 50.8cm		6 6 7 6	10	
6	97NH-013SB	☒	SP	SAND		Dark brown, fine- (60%) to medium-grained (40%), wet, medium dense, recovery 50.8cm, heaving sand		6 7 8 7	16	
7						Bottom of boring at 6.10m Boring backfilled with drill cuttings				
8										

Project No:		Page No:	Hole No.
976057NA	Woodward-Clyde Engineering & sciences applied to the earth & its environment	1 of 1	AP-1001

Project: Nome Harbor Site Investigation	Field Hole No. SB-3	Permanent Hole No. AP-1002

Location Description



☒ Test Boring ☐ Test Pit ☐ Monitoring Well

Logged By: Scott Kendall
Driller: Discovery Drilling Rig: CME-45C
Drill Method: 11.43-cm Hollow Stem Auger
Sample Method: Split Spoon
Hammer Wt: 152 Kg Drop: Standard
Start Date: 12/11/97 Time: 1700
Complete Date: 12/11/97 Time: 1810
Weather: Partly cloudy, light wind, -15.0°C to -20.6°C Instrumentation:

Coordinate System: State Plane
Datum: Alaska Zone 8 50008 NAD 27
Northing (m) 1,169,780.28
Easting (m) 180,055.45

Elevation Datum ☐ MSL ☒ Other

Top of Hole Elevation (m): 4.21 MLLW

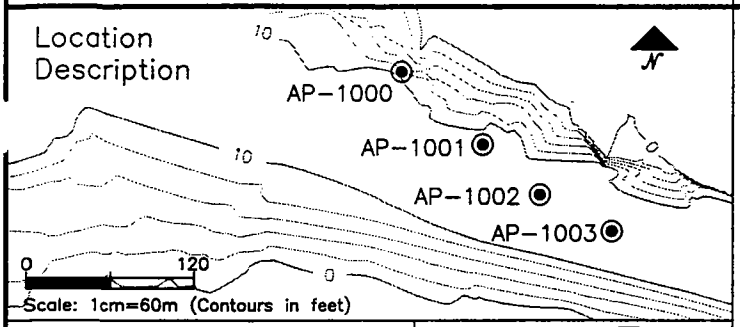
Depth Drilled (m): 6.10 | Total Depth (m): 6.71 | Depth to Groundwater (m): 3.66 to 4.57

Depth (m)	Sample I.D.	Sample Interval	USCS Symbol	Classification	Max. Size (cm)	Description and Remarks	Graphic Log	Blows/15.24cm	OVA Reading (ppm)	Water Screen Interval
	97NH-014SB	X	SP	SAND		Dark brown, medium-grained (60%) with coarse-grained sand (30%) and little fine-grained sand (10%), moist			2.0	
1										
	97NH-015SB	X	SP	SAND		Dark brown, medium-grained (70%) with fine-grained sand (20%), and little coarse-grained sand, dry, medium dense, recovery 50.8cm		13 14 7 17	0.0	
2										
3	97NH-016SB	X	SW	SAND		Dark brown, medium- (40%) to coarse-grained (40%), little fine-grained sand (10%) and fine gravel (10%), moist, loose, recovery 58.4cm		3 5 4 5	0.0	
4										▽
	97NH-017SB	X	SW	SAND with gravel		Dark brown, coarse- (40%) to medium-grained (30%), with fine gravel (20%) and little fine-grained sand, wet, medium dense, recovery 50.8cm, heaving sand		6 13 7 6	2.0	
5										
6	97NH-018SB	X	GP	SANDY GRAVEL		Dark brown, fine gravel (60%) with medium-grained sand, wet, medium dense, recovery 45.7cm		6 8 10 10	0.0	
7						Bottom of boring at 6.71m Boring backfilled with drill cuttings				
8										

Project No: 976057NA	Woodward-Clyde Engineering & sciences applied to the earth & its environment	Page No: 1 of 1	Hole No. AP-1002

Project: Nome Harbor Site Investigation	Field Hole No. SB-4	Permanent Hole No. AP-1003

Location Description



☒ Test Boring ☐ Test Pit ☐ Monitoring Well

Logged By: Scott Kendall
Driller: Discovery Drilling Rig: CME-45C
Drill Method: 11.43-cm Hollow Stem Auger
Sample Method: Split Spoon
Hammer Wt: 152 Kg Drop: Standard
Start Date: 12/11/97 Time: 1820
Complete Date: 12/11/97 Time: 1940
Weather: Partly cloudy, light wind, -15.0°C to -20.6°C Instrumentation:

Coordinate System: State Plane
Datum: Alaska Zone 8 50008 NAD 27
Northing (m) 1,169,754.25
Easting (m) 180,119.55

Elevation Datum ☐ MSL ☒ Other

Top of Hole Elevation (m)	Depth Drilled (m)	Total Depth (m)	Depth to Groundwater (m)
4.54 MLLW	6.10	6.71	3.66 to 4.57

Depth (m)	Sample I.D.	Sample Interval	USCS Symbol	Classification	Max. Size (cm)	Description and Remarks	Graphic Log	Blows/ 15.24cm	OVA Reading (ppm)	Water Screen Interval
	97NH-019SB	X	SP	SAND		Dark brown, medium-grained (60%) with coarse-grained sand (30%) and little fine-grained sand (10%), moist				
1										
2	97NH-020SB	X	SP	SAND		Dark brown, medium-grained (70%) with fine-grained sand (20%) and little coarse-grained sand (10%), dry, medium dense, recovery 48.3cm		14 8 8 9	4.5	
3	97NH-021SB	X	SW	SAND		Dark brown, medium- (40%) to coarse-grained (30%), with fine-grained sand (20%) and little fine gravel (10%), moist, loose, recovery 50.8cm		4 5 5 5	3.5	
4										▽
5	97NH-022SB	X	SW	SAND		Dark brown, coarse- (40%) to medium-grained (30%), with fine-grained sand (20%) and little fine gravel, wet, loose to medium dense, recovery 48.3cm		4 4 5 8	1.5	
6	97NH-023SB	X	SW	GRAVELLY SAND		Dark brown, coarse-grained sand (50%) with fine gravel (30%) and medium-grained sand (20%), wet, medium dense, recovery 45.7cm, heaving sand		8 12 13 15	0.0	
7						Bottom of boring at 6.71m Boring backfilled with drill cuttings				
8										

Project No:		Page No:	Hole No.
976057NA	Woodward-Clyde Engineering & sciences applied to the earth & its environment	1 of 1	AP-1003

Appendix C to the Geotechnical Analysis

SURVEY NOTES

GEORGE KRIER
PROFESSIONAL LAND SURVEYOR
P.O. BOX 1058
NOME, ALASKA 99762
1 (907) 443-5358

24 December 1997

Woodward-Clyde
Attn: Scott Kendall
3501 Denali Street, Suite 101
Anchorage, Alaska 99503

Scott:

The ground level xyz coordinates of the lath used to mark SB-1 through 4 are:

	Northing	Easting	Elev.
SB-1	3,838,180.3	590,424.1	8.5
SB-2	3,837,995.8	590,636.3	13.2
SB-3	3,837,861.8	590,773.1	13.8
SB-4	3,837,776.4	590,943.4	14.9

Copies of the notes will be sent along with the final billing.

George Krier

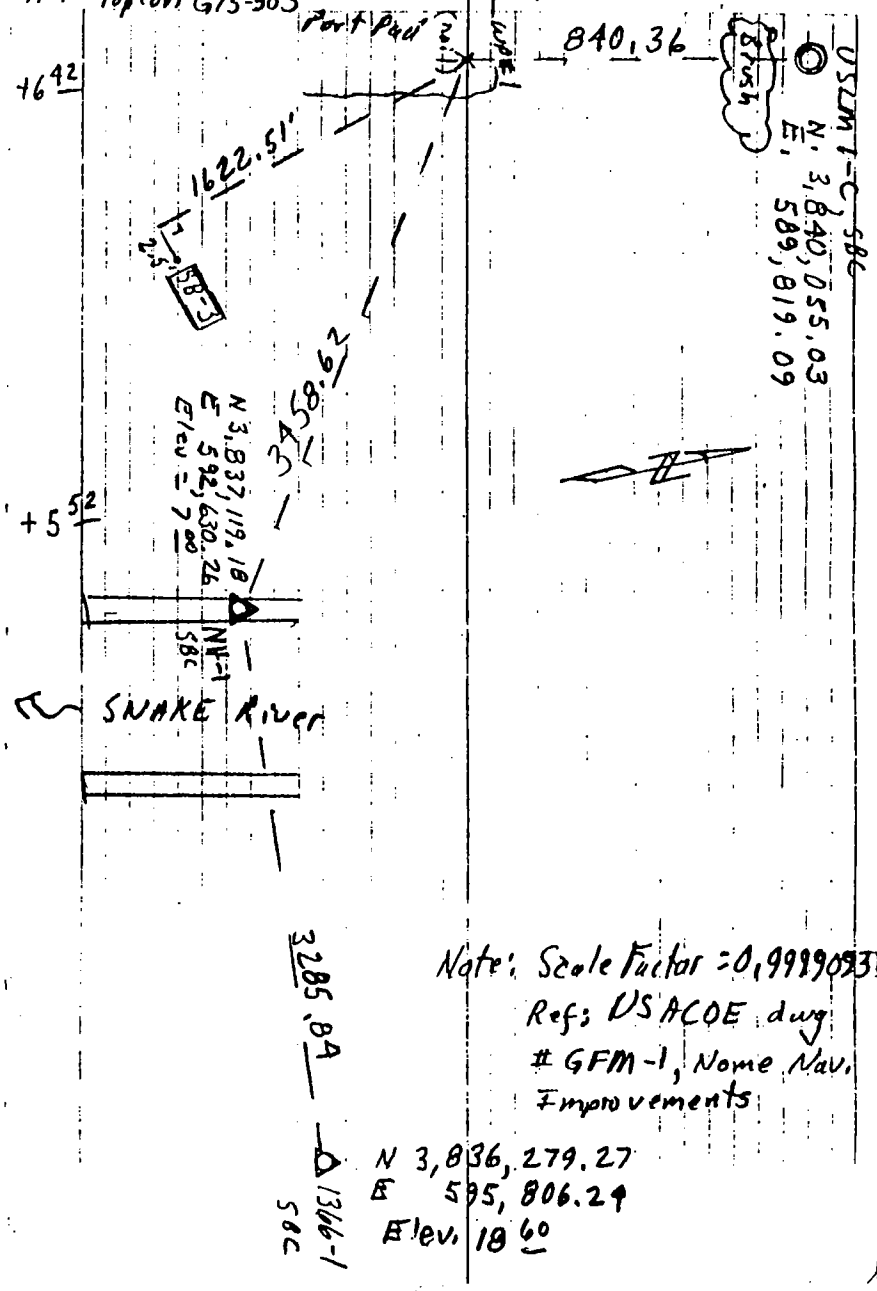
SB-1 thru 3 Final Lath Locations, Requested
by Scott Kendall 22 Dec 97

23 Dec 97
-5°F, 29.3 Hg
Top Con GTS-303

TM G. Krier
φ John Ahmasuk

51

⊼@	FS	∡RT	Dist	Vert Δ	Rod Height	⊼+
NH-1	1366-1	0-00	3285.84	+9.64	4.81	+6.42
			3285.84	+10.40		
	SB-4 Lath	① 186-28-10	1810.54	+8.33	6.92	
		② 12-56-40	1810.54	+8.43		
	WP#1	① 202-31-05	3458.62	+39.44	5.43	
		② 45-02-30	3458.62	+39.44		
WP#1	NH-1	0-00	3458.61	-40.96	4.81	+5.52
			3458.62	-41.02		
	USLM 1-C	228-27-50	840.36	(3 sections)		
	2 Offset to SB-3 Lath	① 19-22-30	1622.52	-33.66	5.34	
		② 38-45-00	1622.50	-33.66		
	SB-2 Lath	① 20-54-20	1435.88	-34.33	5.34	
		② 41-48-40	1435.88	-34.27		
	SB-1 Lath	① 24-59-10	1170.20	-38.94	5.34	
		② 49-58-15	1170.19	-38.98		



Note: Scale Factor = 0.99990931
Ref: USACOE dwg
GFM-1, Nome Nav. Improvements

Appendix D to the Geotechnical Analysis

GEOTECHNICAL REPORTS

NOTE

Sample locations were identified in the field as follows: "97NH-" followed by a three digit consecutive number beginning with 001, followed by "SD" or "SB." In the following geotechnical reports, Alaska Testlab identifies sample locations substituting a "5D" or "5B" for the "SD" or "SB."

FROST DESIGN SOIL CLASSIFICATION[1]

Frost[2] Group		Kind of Soil	Percentage Finer than 0.02 mm by Weight	Typical Soil Types Under Unified Soil Classification System
NFS[3]		(a) Gravels Crushed stone Crushed rock	0 to 1.5	GW, GP
		(b) Sands	0 to 3	SW, SP
PFS[4]	(MOA NFS)	(a) Gravels Crushed stone Crushed rock	1.5 to 3	GW, GP
	(MOA F2)	(b) Sands	3 to 10	SW, SP
S1	(MOA F1)	Gravelly soils	3 to 6	GW, GP, GW-GM, GP-GM
S2	(MOA F2)	Sandy soils	3 to 6	SW, SP, SW-SM, SP-SM
F1		Gravelly soils	6 to 10	GM, GW-GM, GP-GM
F2		(a) Gravelly soils (b) Sands	10 to 20 6 to 15	GM, GW-GM, GP-GM SW, SW-SM, SP-SM
F3		(a) Gravelly soils (b) Sands, except very fine silty sands (c) Clays, PI>12	Over 20 Over 15 -	GM, GC SM, SC CL, CH
F4		(a) All silts (b) Very fine silty sands (c) Clays, PI>12 (d) Varved clays and other fine-grained, banded sediments	- Over 15 - -	ML, MH SM CL, CL-ML CL and ML CL, ML and SM; CL, CH and ML; CL, CH, ML and SH

---

1 Berg, Richard and Thadeus Johnson, "Revised Procedure for Pavement Design Under Seasonal Frost Conditions," Special Report 83-27, U.S. Army Corps of Engineers, Cold Research and Engineering Laboratory, September 1983.

2 C.O.E. Frost groups directly correspond to the Municipality of Anchorage soil frost classification groups, except as noted.

3 Non Frost Susceptible.

4 Possibly frost-susceptible, but requires laboratory test to determine frost design soil classification.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM DESIGNATION: D2487
Based on the Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50% retained on #200 sieve	Gravels More than 50% of coarse fraction retained on #4 sieve	Clean Gravels Less than 50% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes #4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty Sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey Sand[G,H,I]
Fine-Grained Soils 50% or more passes the #200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3-in. (75mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
[D] Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = \frac{D_{60}}{D_{10}}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg Limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

ALASKA TESTLAB
A Division of DOWL, Incorporated
4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

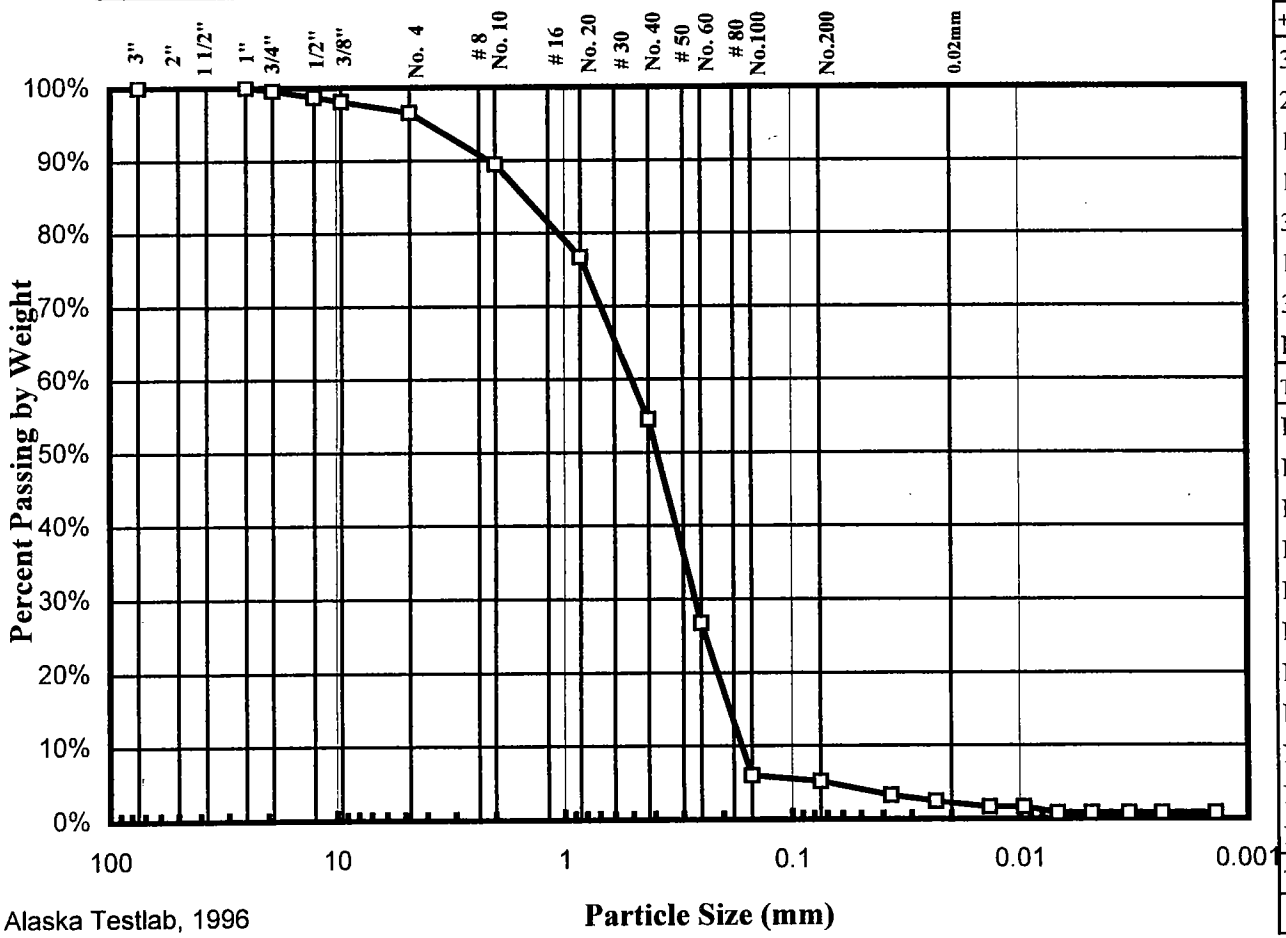
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0015D
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2693
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Silt , SP-SM
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	100%	
1/2"	99%	
3/8"	98%	
No. 4	97%	
Total Wt. of Coarse Fraction = 3501.2g		
No. 8		
No. 10	89%	
No. 16		
No. 20	77%	
No. 30		
No. 40	55%	
No. 50		
No. 60	27%	
No. 80		
No. 100	6%	
No. 200	5.2%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.2%	

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David L. Andersen, P.E., Assistant Manager

ALASKA TESTLAB
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(907) 562-2000 FAX (907) 563-3953

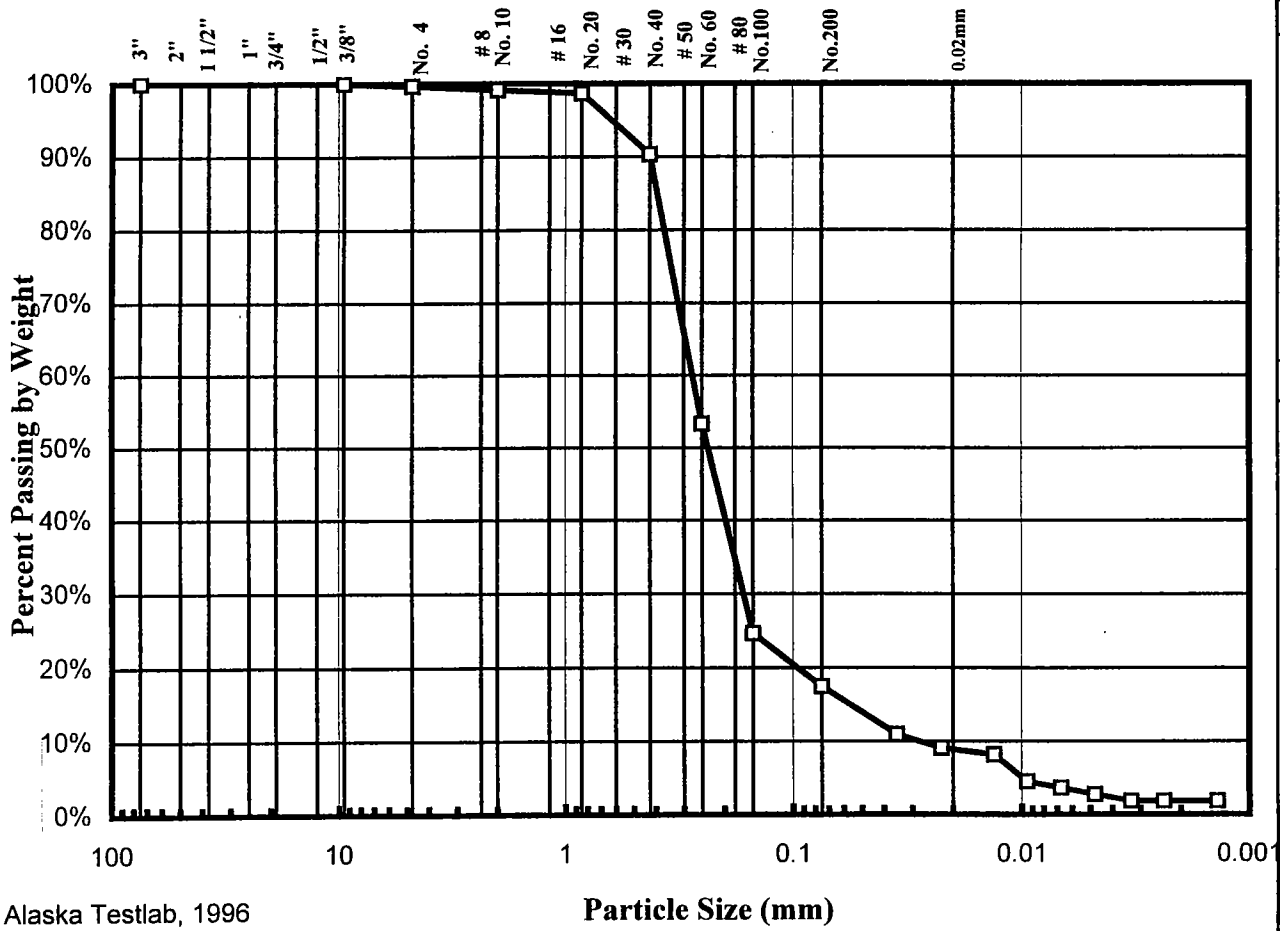
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0025D
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2694
Received: December 16, 1997

Engineering Classification: Silty SAND , SM
Frost Classification: PFS-F2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"	100%	
No. 4	100%	
Total Wt. of Coarse Fraction = 1145.2g		
No. 8		
No. 10	99%	
No. 16		
No. 20	99%	
No. 30		
No. 40	90%	
No. 50		
No. 60	53%	
No. 80		
No. 100	25%	
No. 200	17%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	8.9%	

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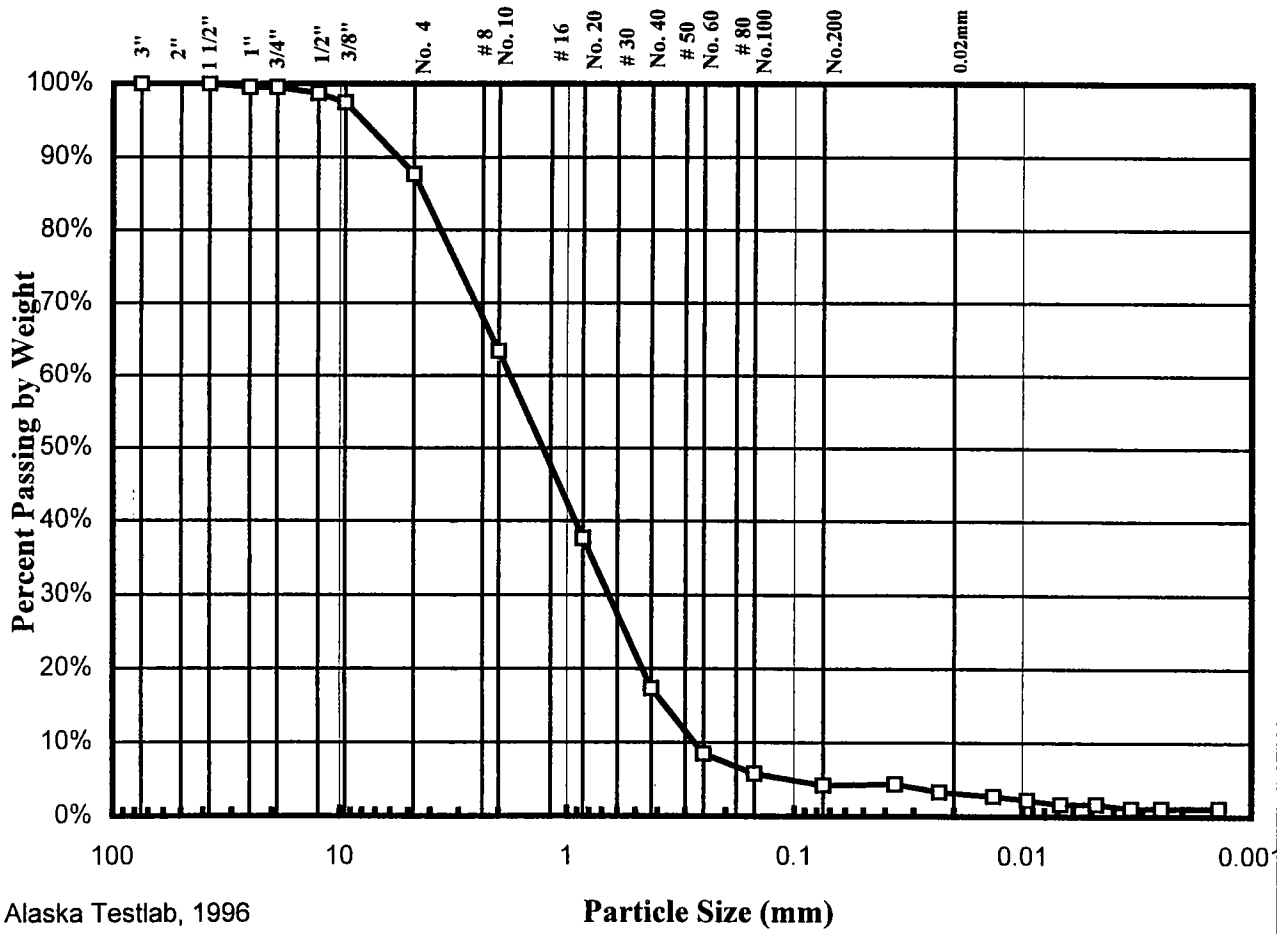
(907) 562-2000 FAX (907) 563-3953

Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0035B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2695
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	100%	
3/4"	100%	
1/2"	99%	
3/8"	97%	
No. 4	88%	
Total Wt. of Coarse Fraction = 2891.6g		
No. 8		
No. 10	63%	
No. 16		
No. 20	38%	
No. 30		
No. 40	17%	
No. 50		
No. 60	8%	
No. 80		
No. 100	6%	
No. 200	4.2%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	3.2%	

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Client: Woodward-Clyde Federal Services

Project: Nome Harbor Proj. No. 976057NA

Location: 97NH-0045B

Submitted by Client

PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

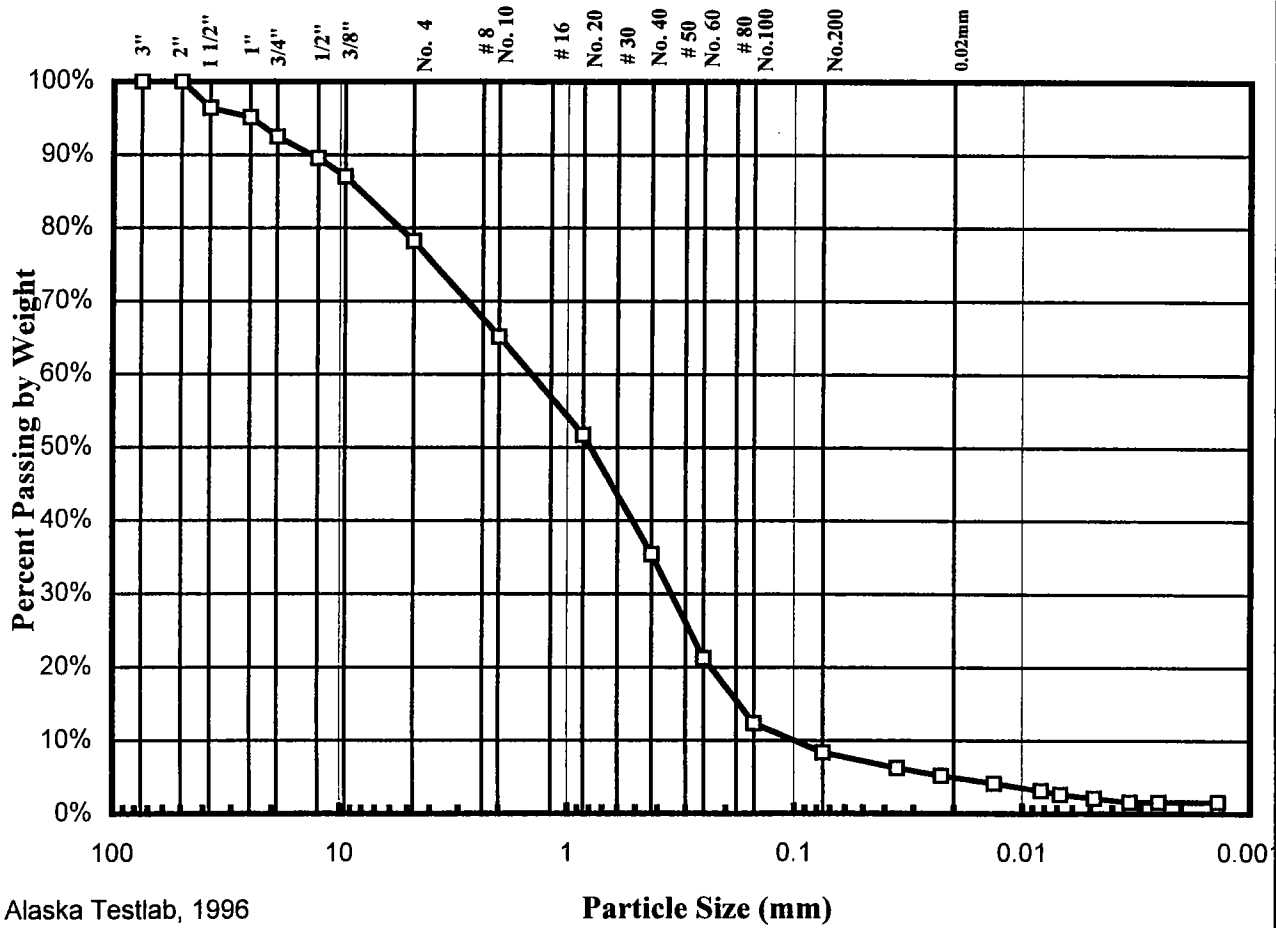
W.O. A27659

Lab No. 2696

Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Silt and Gravel, SP-SM

Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"	100%	
1 1/2"	96%	
1"	95%	
3/4"	92%	
1/2"	90%	
3/8"	87%	
No. 4	78%	
Total Wt. of Coarse Fraction = 2019.3g		
No. 8		
No. 10	65%	
No. 16		
No. 20	52%	
No. 30		
No. 40	35%	
No. 50		
No. 60	21%	
No. 80		
No. 100	12%	
No. 200	8.4%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	4.9%	

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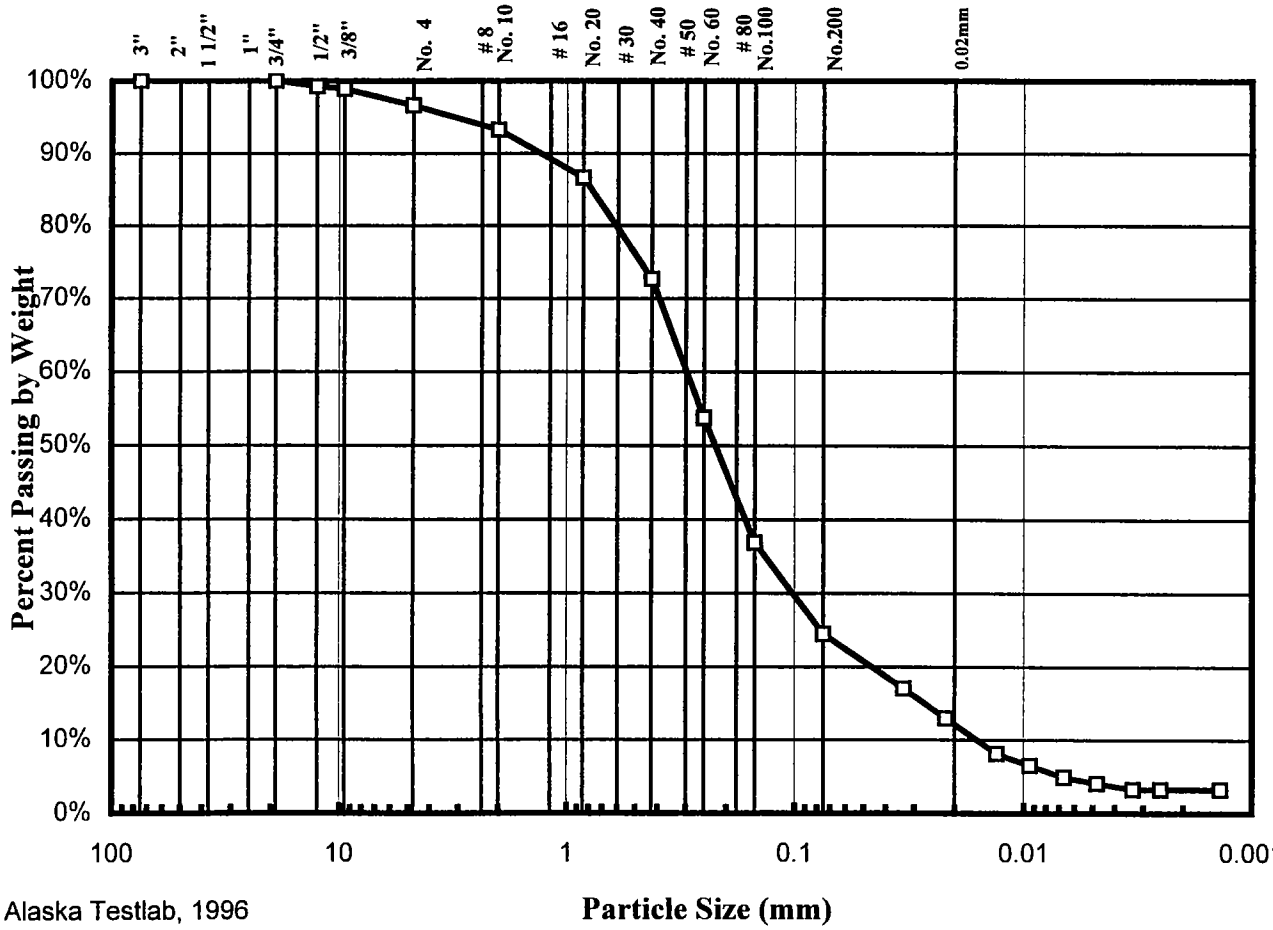
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NB-0055B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2697
Received: December 16, 1997

Engineering Classification: Silty SAND , SM
Frost Classification: F2



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	99%	
No. 4	97%	
Total Wt. of Coarse Fraction = 2009.4g		
No. 8		
No. 10	93%	
No. 16		
No. 20	87%	
No. 30		
No. 40	73%	
No. 50		
No. 60	54%	
No. 80		
No. 100	37%	
No. 200	24%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	12.1%	

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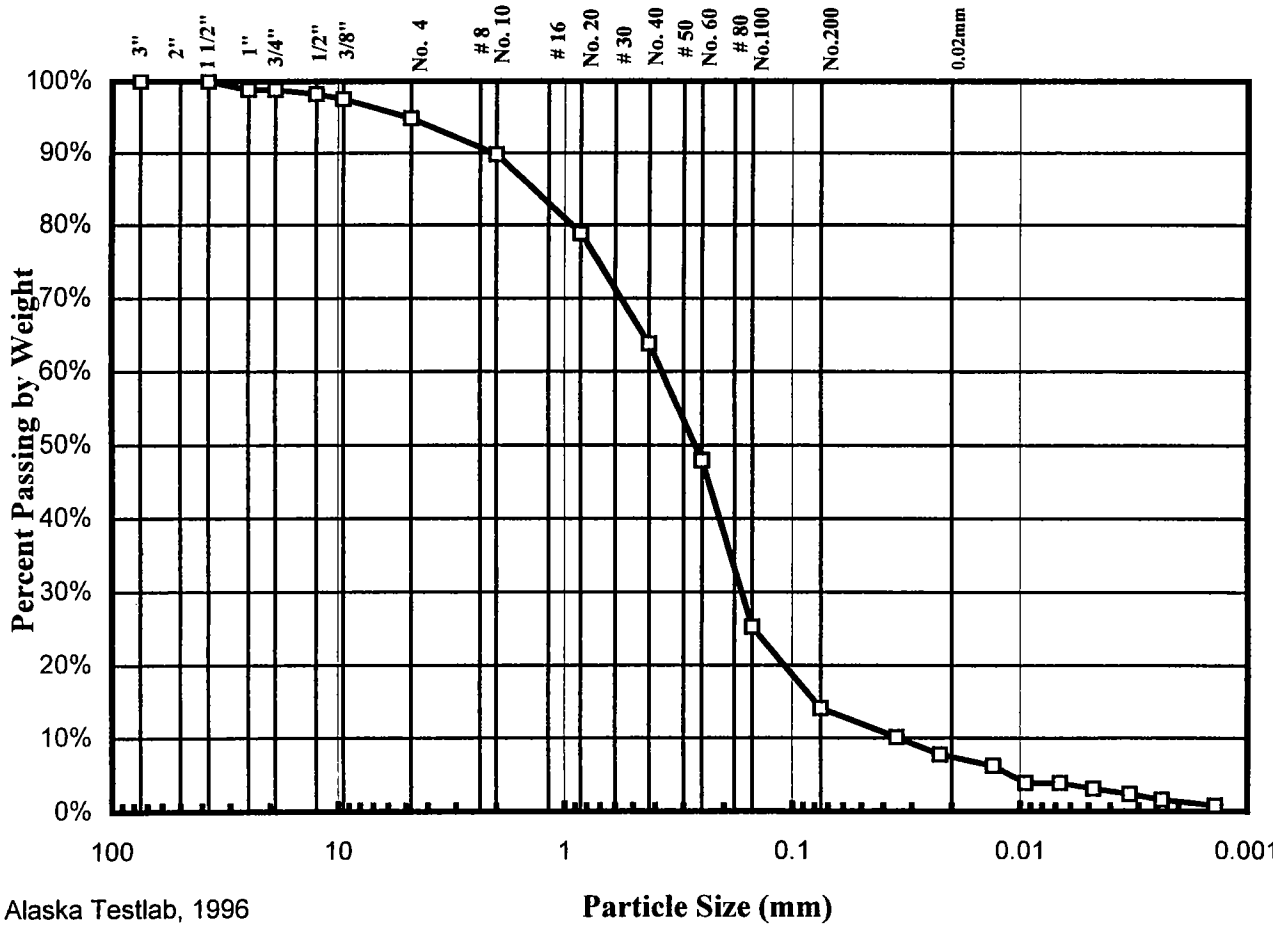
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0065B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2698
Received: December 16, 1997

Engineering Classification: Silty SAND , SM
Frost Classification: PFS-F2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	99%	
3/4"	99%	
1/2"	98%	
3/8"	98%	
No. 4	95%	
Total Wt. of Coarse Fraction = 1955g		
No. 8		
No. 10	90%	
No. 16		
No. 20	79%	
No. 30		
No. 40	64%	
No. 50		
No. 60	48%	
No. 80		
No. 100	25%	
No. 200	14%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	7.4%	

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David L. Andersen, P.E., Assistant Manager

ALASKA TESTLAB
A Division of DOWL, Incorporated
4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

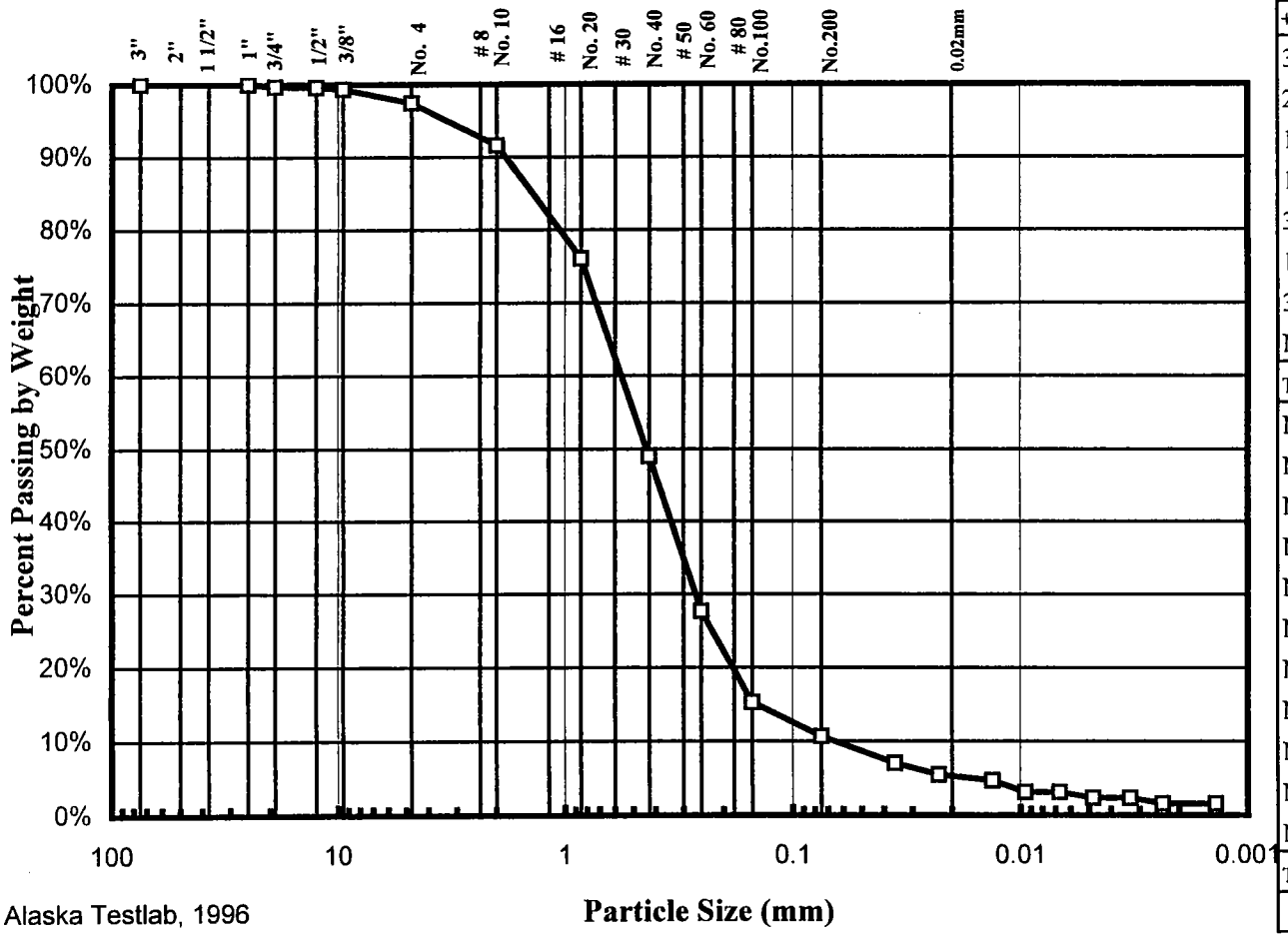
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0075D
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2699
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	100%	
1/2"	100%	
3/8"	99%	
No. 4	97%	
Total Wt. of Coarse Fraction = 2582.9g		
No. 8		
No. 10	92%	
No. 16		
No. 20	76%	
No. 30		
No. 40	49%	
No. 50		
No. 60	28%	
No. 80		
No. 100	15%	
No. 200	11%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	5.3%	

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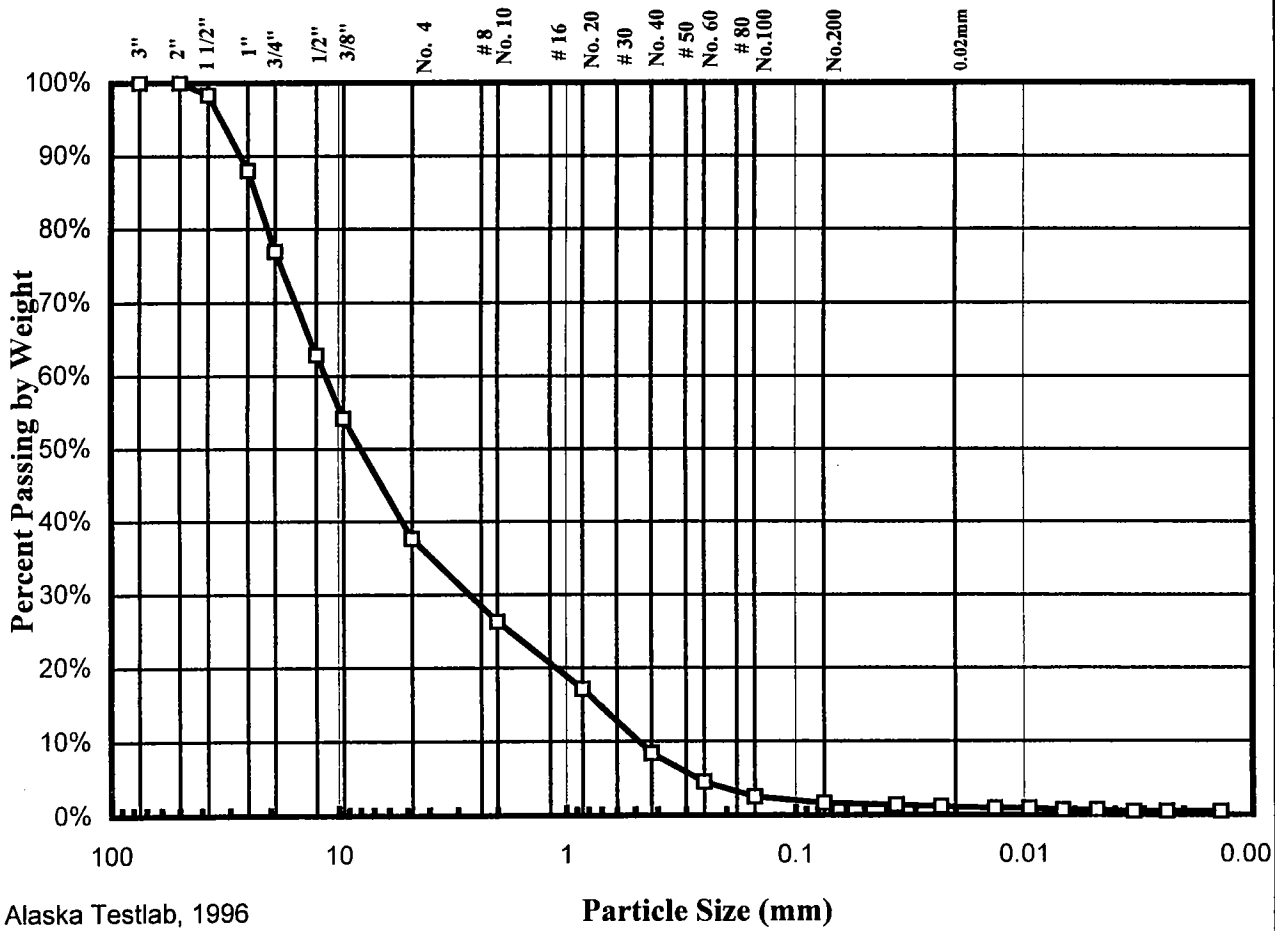
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0085D
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2700
Received: December 16, 1997

Engineering Classification: Well Graded GRAVEL with Sand, GW
Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"	100%	
1 1/2"	98%	
1"	88%	
3/4"	77%	
1/2"	63%	
3/8"	54%	
No. 4	38%	
Total Wt. of Coarse Fraction = 5574.7g		
No. 8		
No. 10	26%	
No. 16		
No. 20	17%	
No. 30		
No. 40	8%	
No. 50		
No. 60	5%	
No. 80		
No. 100	3%	
No. 200	1.7%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	1.1%	

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(907) 562-2000 FAX (907) 563-3953

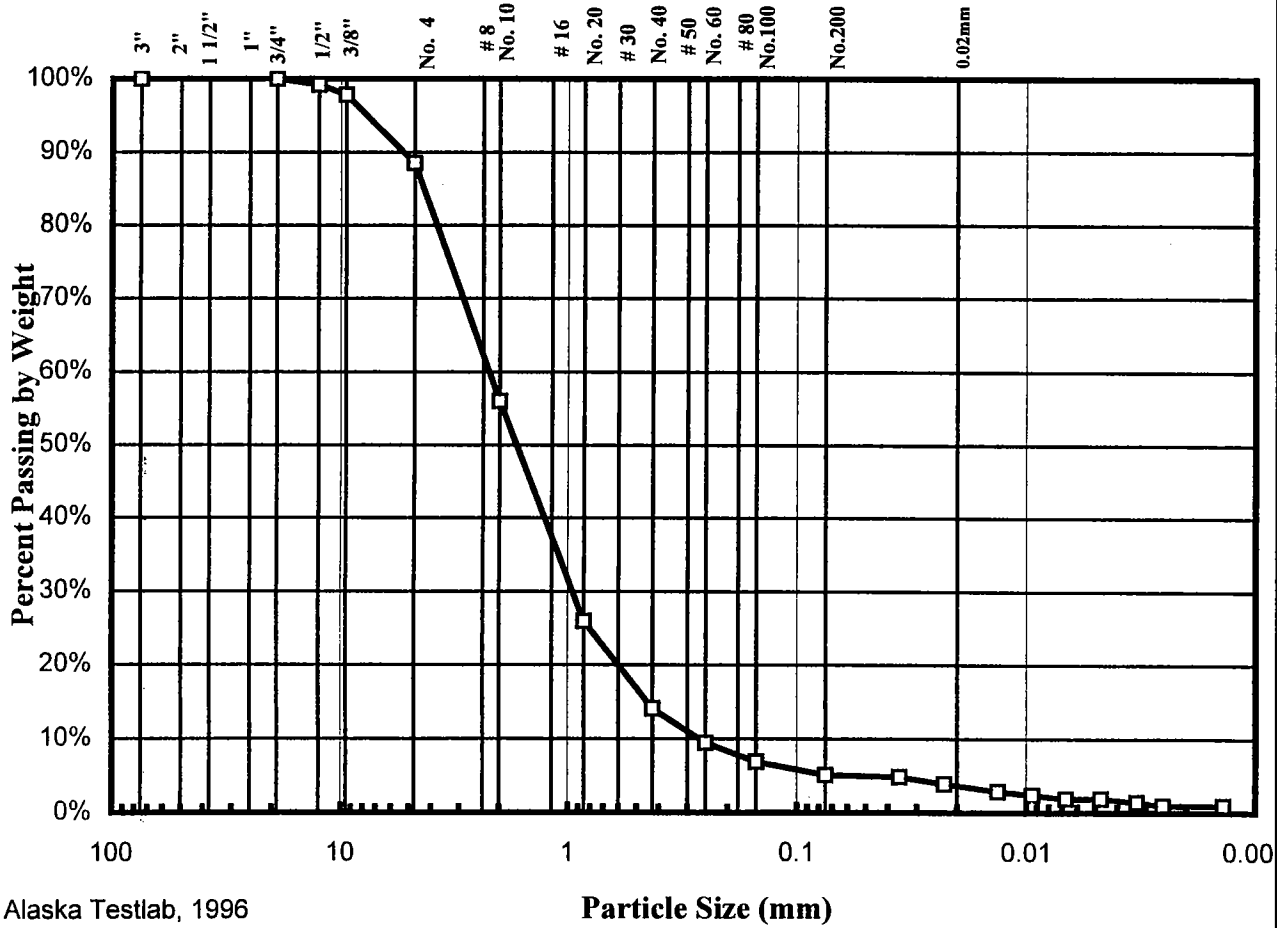
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0095B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2701
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	98%	
No. 4	89%	
Total Wt. of Coarse Fraction = 1999.7g		
No. 8		
No. 10	56%	
No. 16		
No. 20	26%	
No. 30		
No. 40	14%	
No. 50		
No. 60	9%	
No. 80		
No. 100	7%	
No. 200	5.1%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	3.6%	

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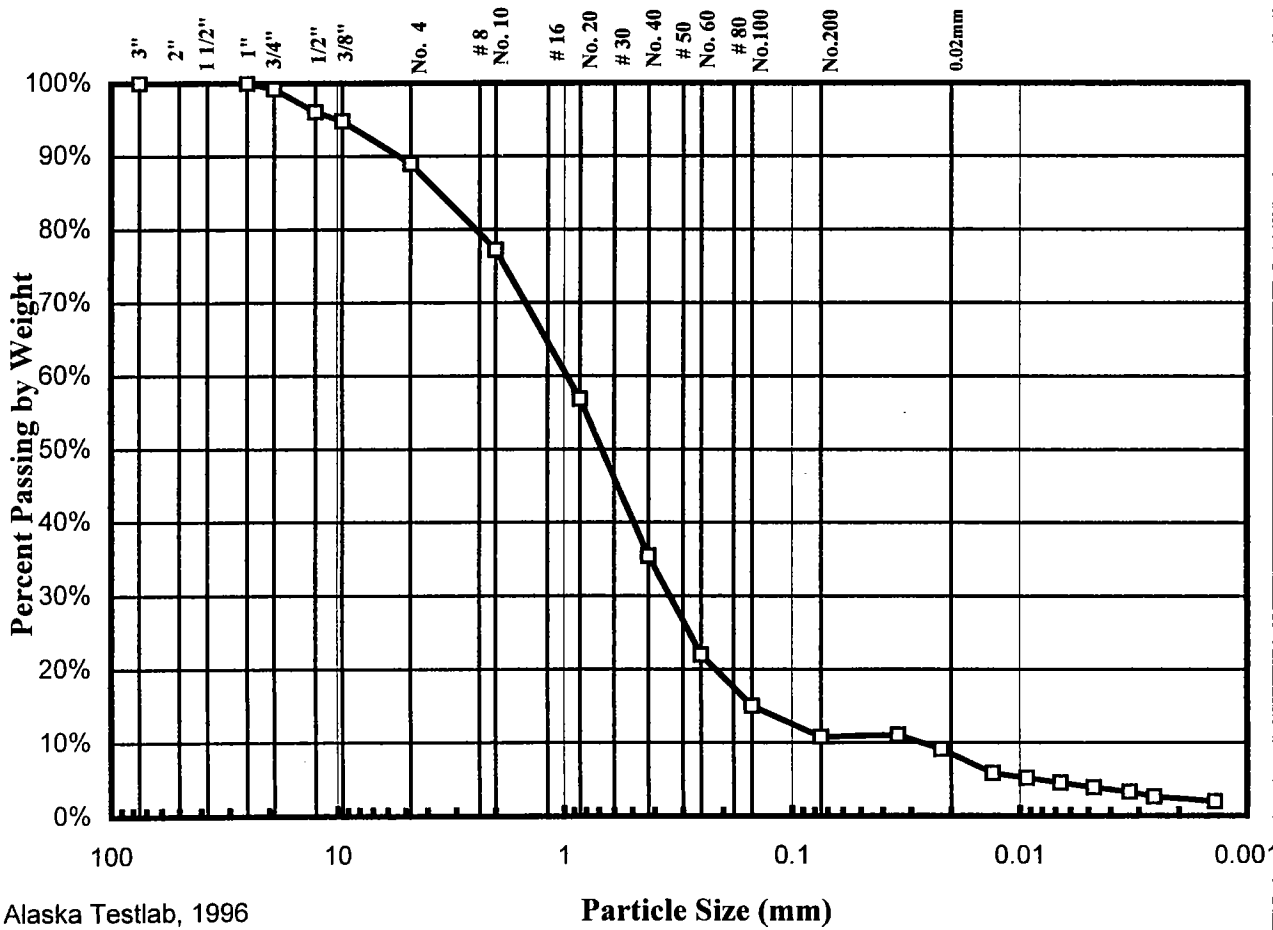
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0105B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2702
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-F2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	99%	
1/2"	96%	
3/8"	95%	
No. 4	89%	
Total Wt. of Coarse Fraction = 1650.5g		
No. 8		
No. 10	77%	
No. 16		
No. 20	57%	
No. 30		
No. 40	35%	
No. 50		
No. 60	22%	
No. 80		
No. 100	15%	
No. 200	11%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	8.5%	

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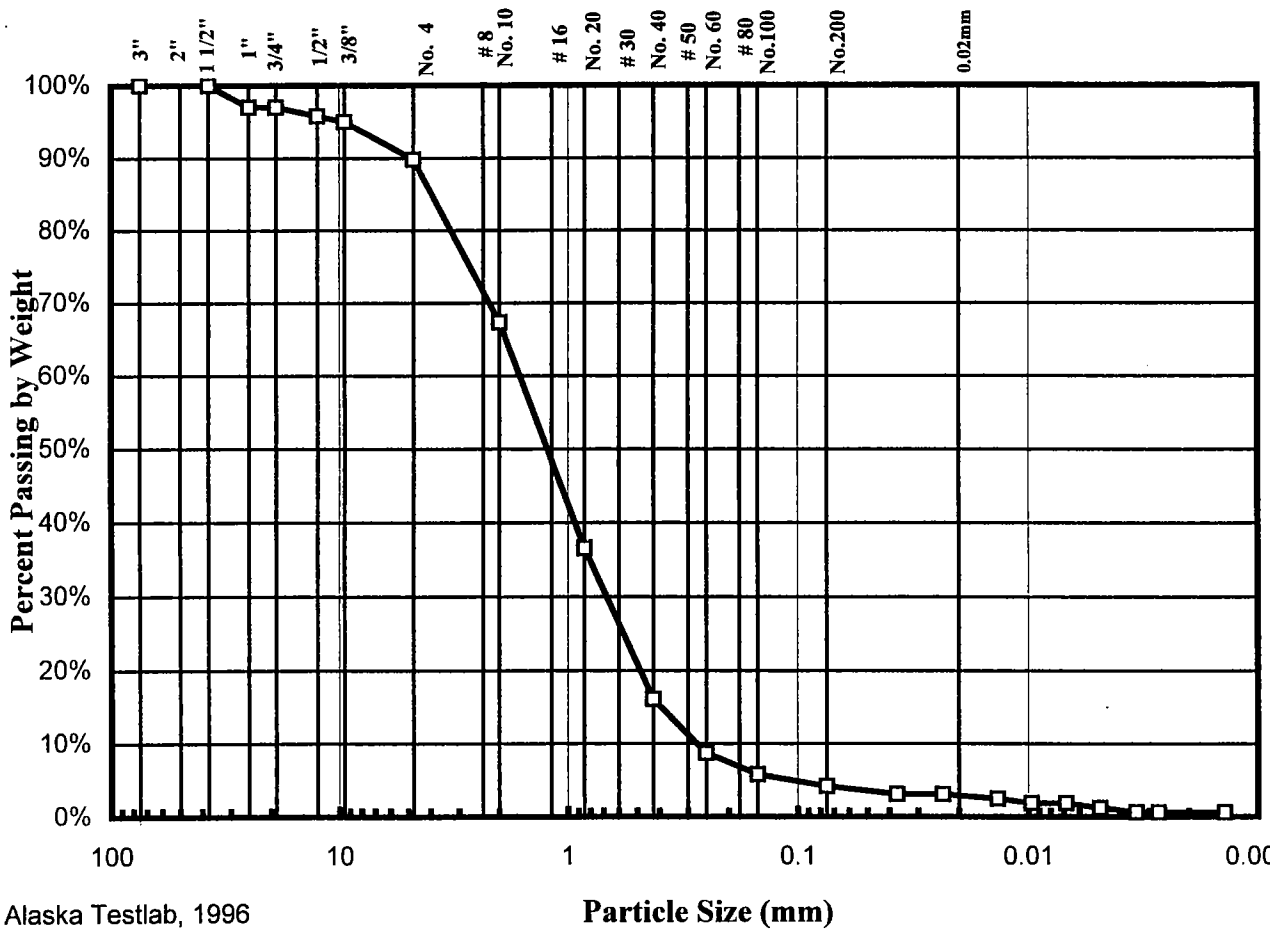
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0115B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2703
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	97%	
3/4"	97%	
1/2"	96%	
3/8"	95%	
No. 4	90%	
Total Wt. of Coarse Fraction = 1665.4g		
No. 8		
No. 10	67%	
No. 16		
No. 20	37%	
No. 30		
No. 40	16%	
No. 50		
No. 60	9%	
No. 80		
No. 100	6%	
No. 200	4.2%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.9%	

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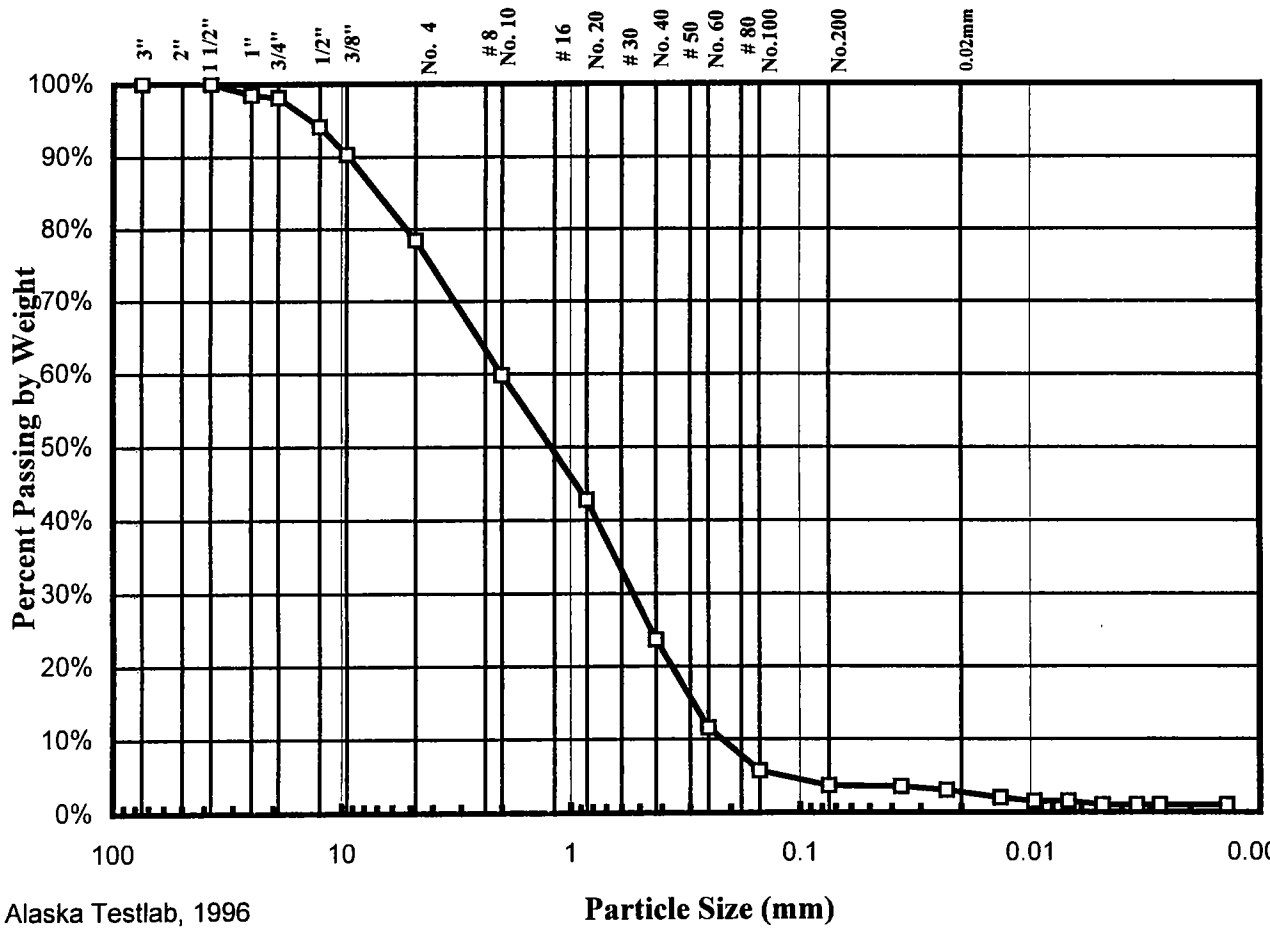
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0125B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2704
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Gravel, SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	99%	
3/4"	98%	
1/2"	94%	
3/8"	90%	
No. 4	78%	
Total Wt. of Coarse Fraction = 1766.3g		
No. 8		
No. 10	60%	
No. 16		
No. 20	43%	
No. 30		
No. 40	24%	
No. 50		
No. 60	12%	
No. 80		
No. 100	6%	
No. 200	3.7%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.7%	

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Client: Woodward-Clyde Federal Services

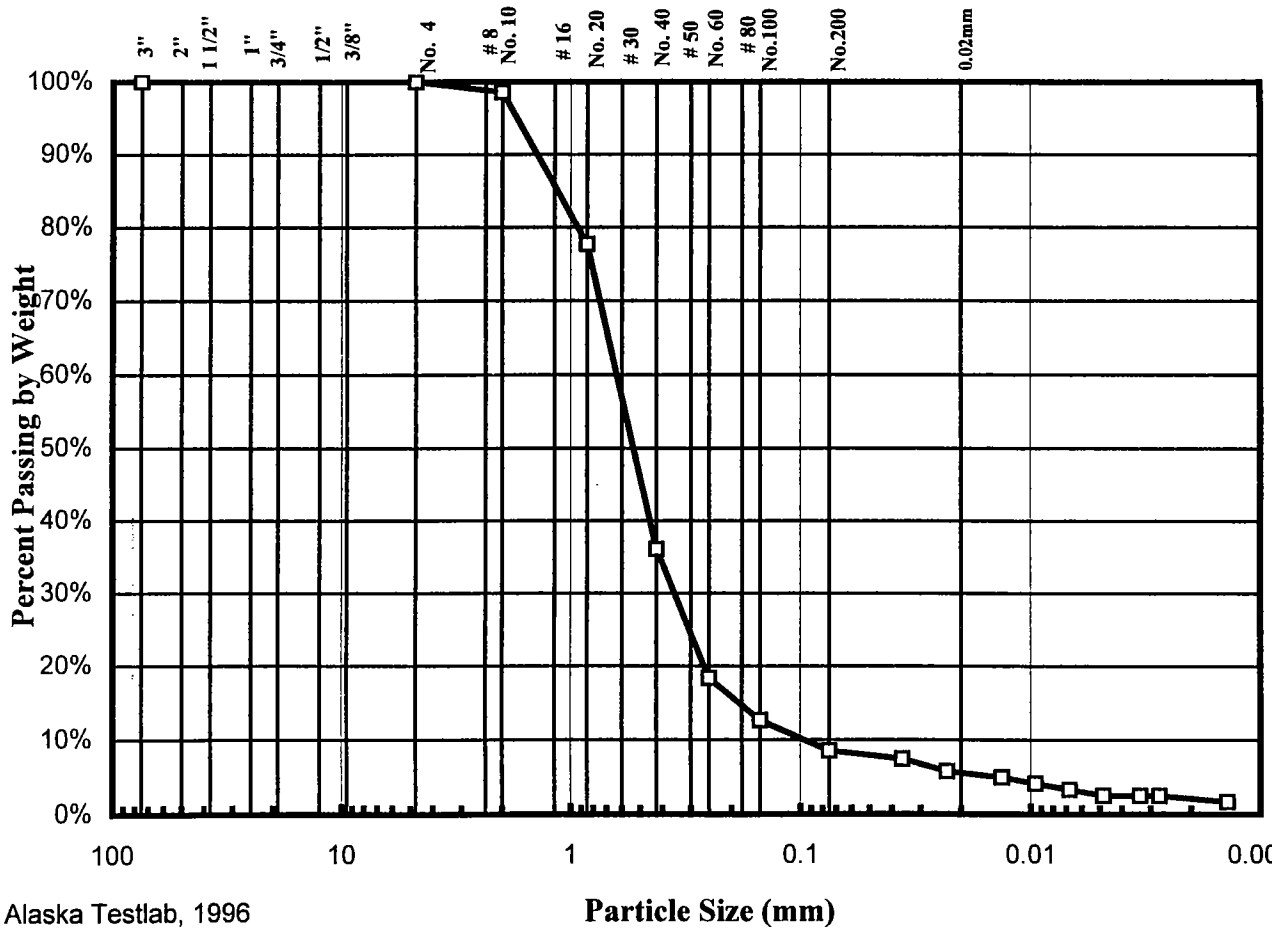
Project: Nome Harbor Proj. No. 976057NA

Location: 97NH-0135B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2705
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4	100%	
Total Wt. of Coarse Fraction = 1077.5g		
No. 8		
No. 10	99%	
No. 16		
No. 20	78%	
No. 30		
No. 40	36%	
No. 50		
No. 60	18%	
No. 80		
No. 100	13%	
No. 200	8.5%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	5.6%	

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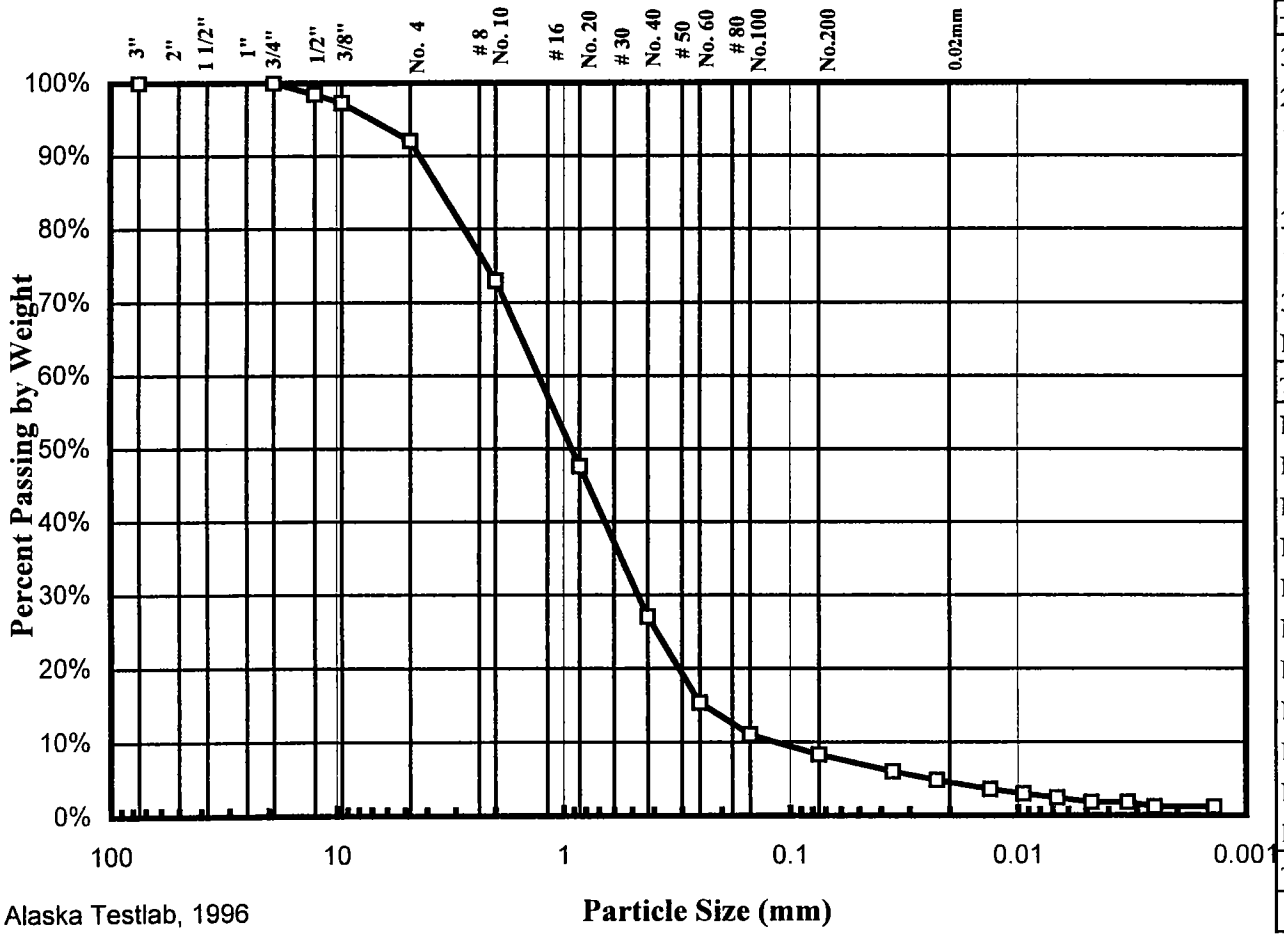
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0145B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2706
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	98%	
3/8"	97%	
No. 4	92%	
Total Wt. of Coarse Fraction = 1917.5g		
No. 8		
No. 10	73%	
No. 16		
No. 20	48%	
No. 30		
No. 40	27%	
No. 50		
No. 60	15%	
No. 80		
No. 100	11%	
No. 200	8.3%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	4.5%	

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(907) 562-2000 FAX (907) 563-3953

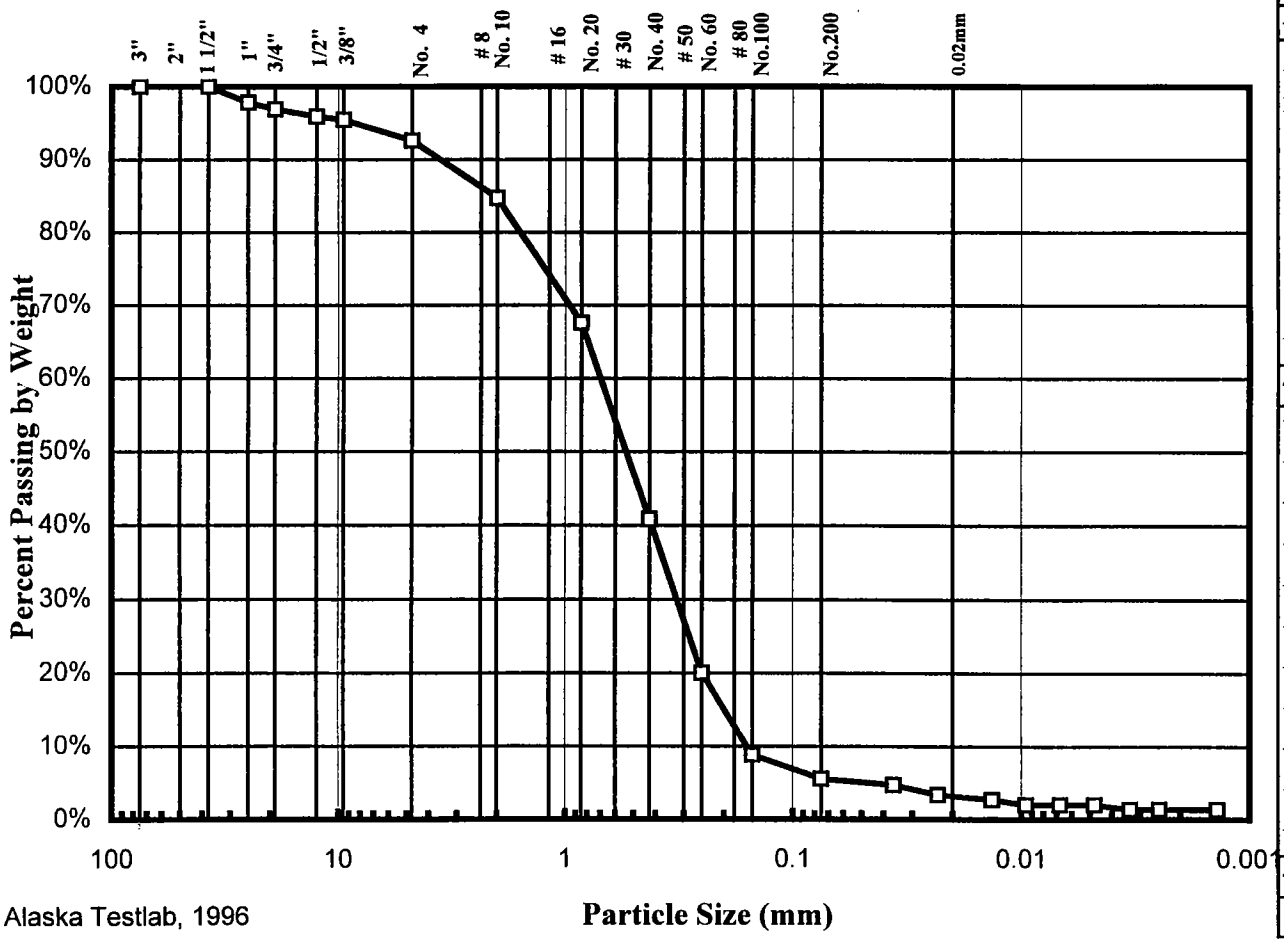
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0155B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2707
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Silt , SP-SM
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	98%	
3/4"	97%	
1/2"	96%	
3/8"	95%	
No. 4	93%	
Total Wt. of Coarse Fraction = 1513.6g		
No. 8		
No. 10	85%	
No. 16		
No. 20	68%	
No. 30		
No. 40	41%	
No. 50		
No. 60	20%	
No. 80		
No. 100	9%	
No. 200	5.5%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	3.2%	

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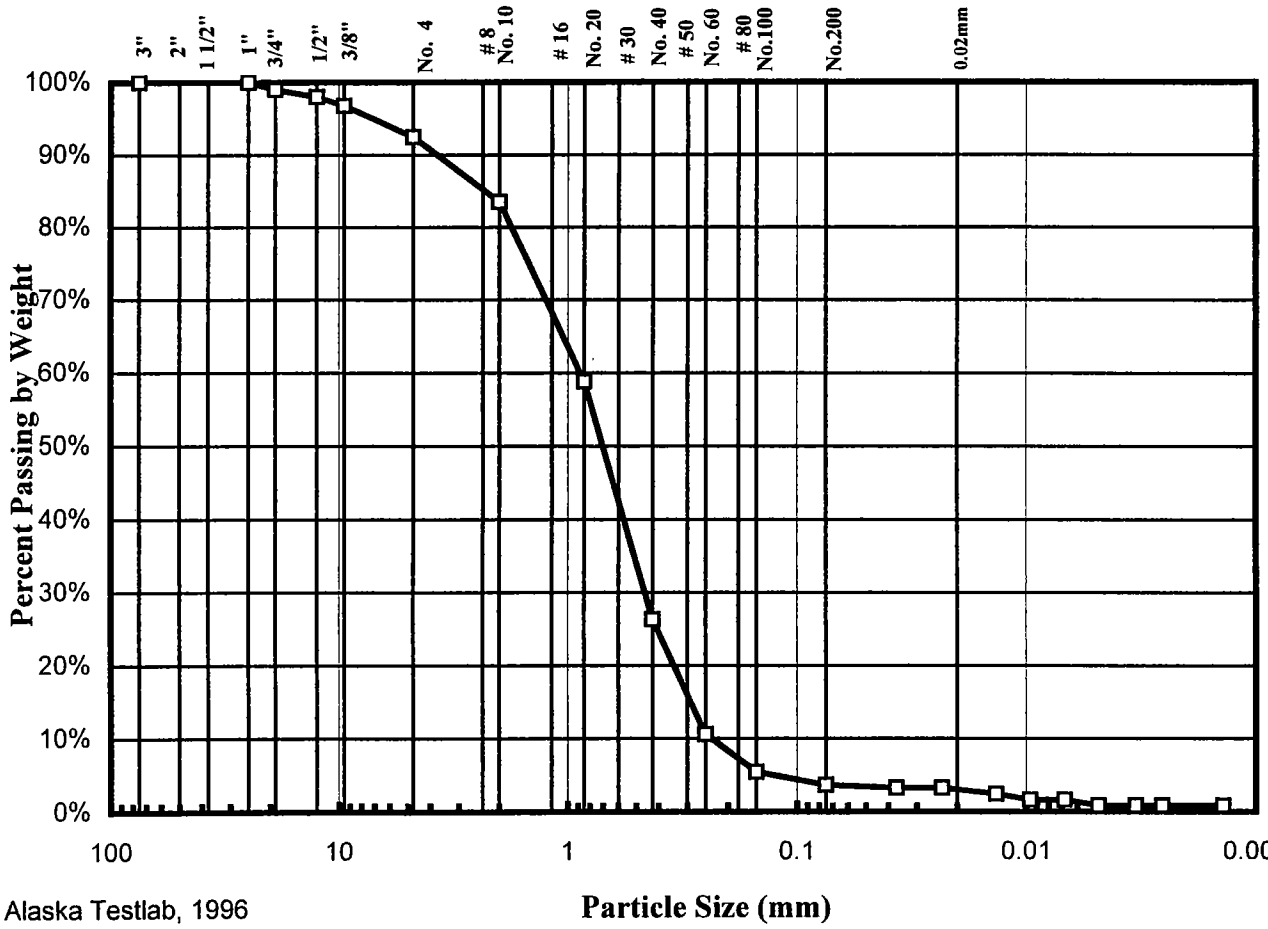
4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0165B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2708
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"	100%	
3/4"	99%	
1/2"	98%	
3/8"	97%	
No. 4	92%	
Total Wt. of Coarse Fraction = 2037.6g		
No. 8		
No. 10	84%	
No. 16		
No. 20	59%	
No. 30		
No. 40	26%	
No. 50		
No. 60	11%	
No. 80		
No. 100	5%	
No. 200	3.7%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	3.0%	

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(907) 562-2000 FAX (907) 563-3953

Client: Woodward-Clyde Federal Services

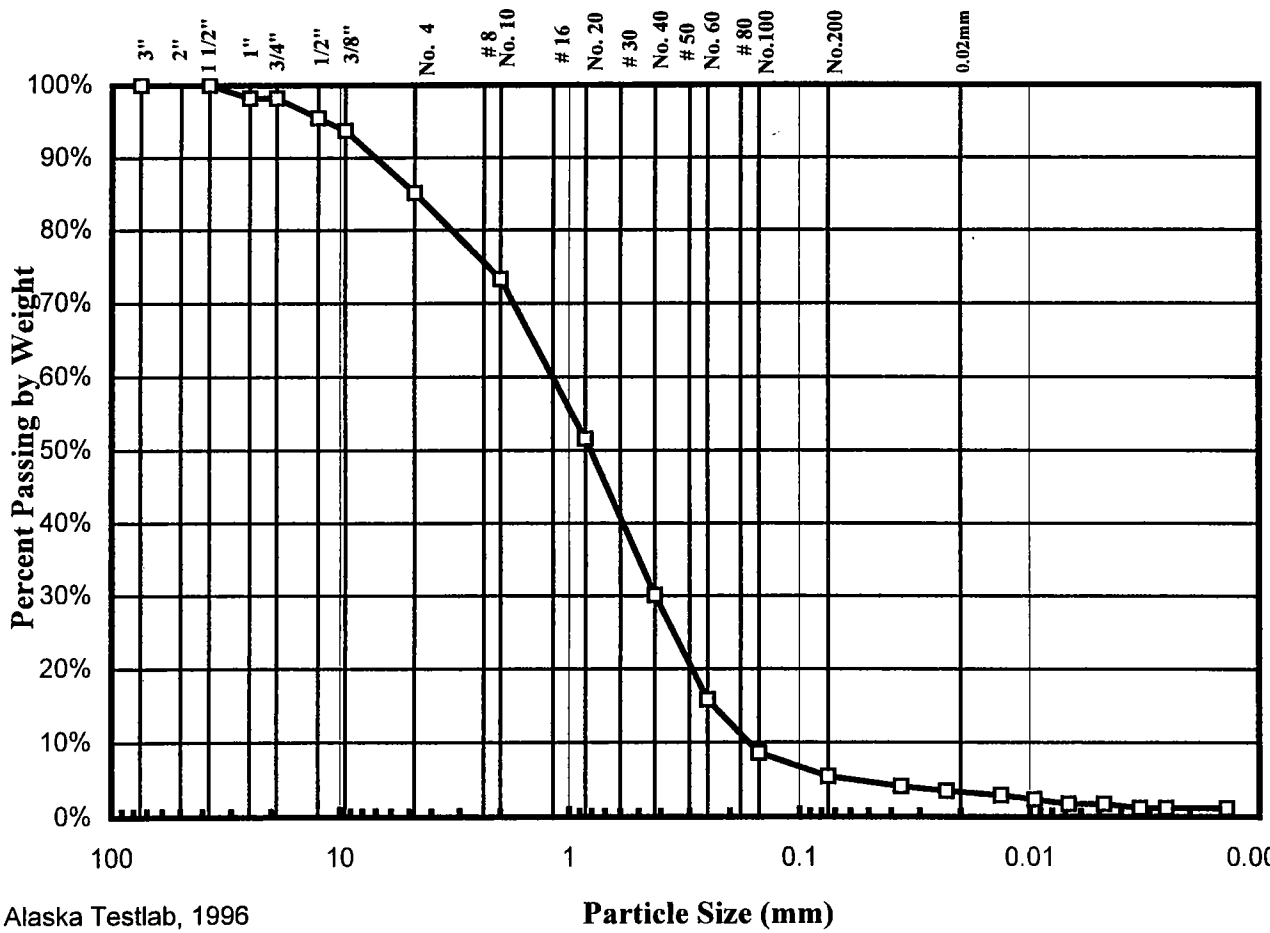
Project: Nome Harbor Proj. No. 976057NA

Location: 97NH-0175B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2709
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Silt and Gravel, SP-SM
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	98%	
3/4"	98%	
1/2"	95%	
3/8"	94%	
No. 4	85%	
Total Wt. of Coarse Fraction = 2187.5g		
No. 8		
No. 10	73%	
No. 16		
No. 20	52%	
No. 30		
No. 40	30%	
No. 50		
No. 60	16%	
No. 80		
No. 100	9%	
No. 200	5.4%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	3.3%	

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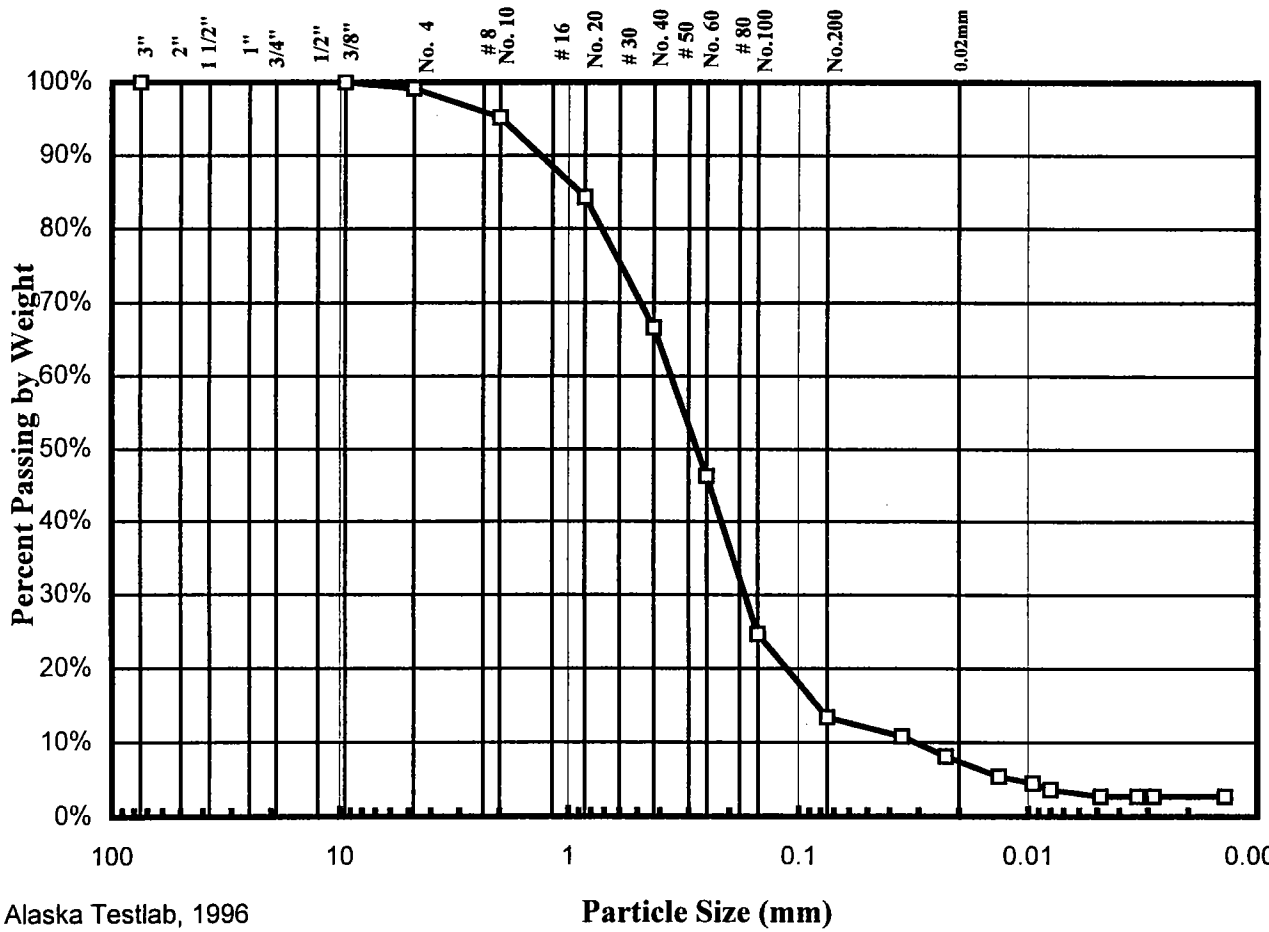
(907) 562-2000 FAX (907) 563-3953

Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0185B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2710
Received: December 16, 1997

Engineering Classification: Silty SAND , SM
Frost Classification: PFS-F2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"	100%	
No. 4	99%	
Total Wt. of Coarse Fraction = 2531.4g		
No. 8		
No. 10	95%	
No. 16		
No. 20	84%	
No. 30		
No. 40	67%	
No. 50		
No. 60	46%	
No. 80		
No. 100	25%	
No. 200	13%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	7.4%	

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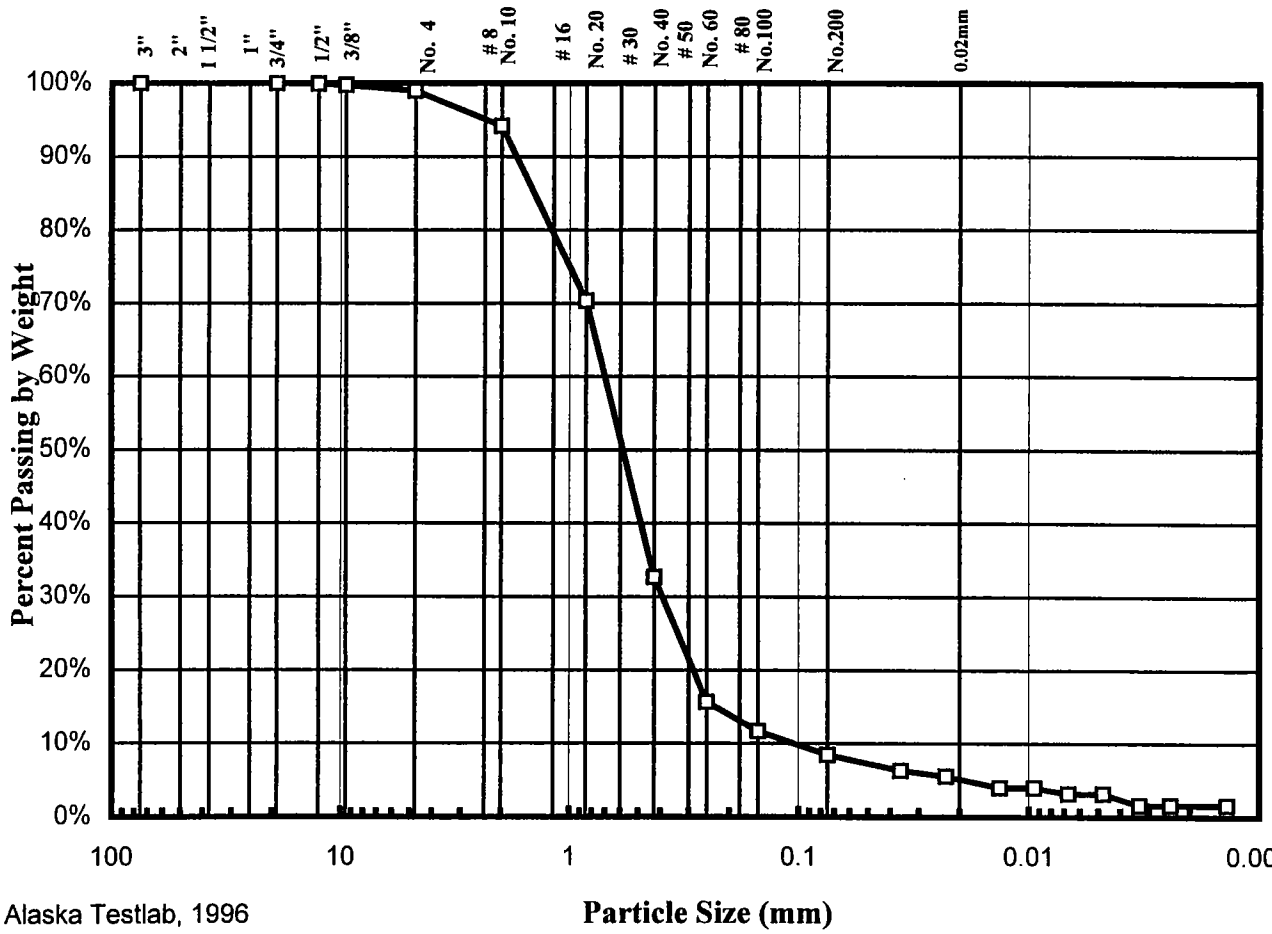
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0195B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2711
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	100%	
3/8"	100%	
No. 4	99%	
Total Wt. of Coarse Fraction = 2243g		
No. 8		
No. 10	94%	
No. 16		
No. 20	70%	
No. 30		
No. 40	33%	
No. 50		
No. 60	16%	
No. 80		
No. 100	12%	
No. 200	8.4%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	5.1%	

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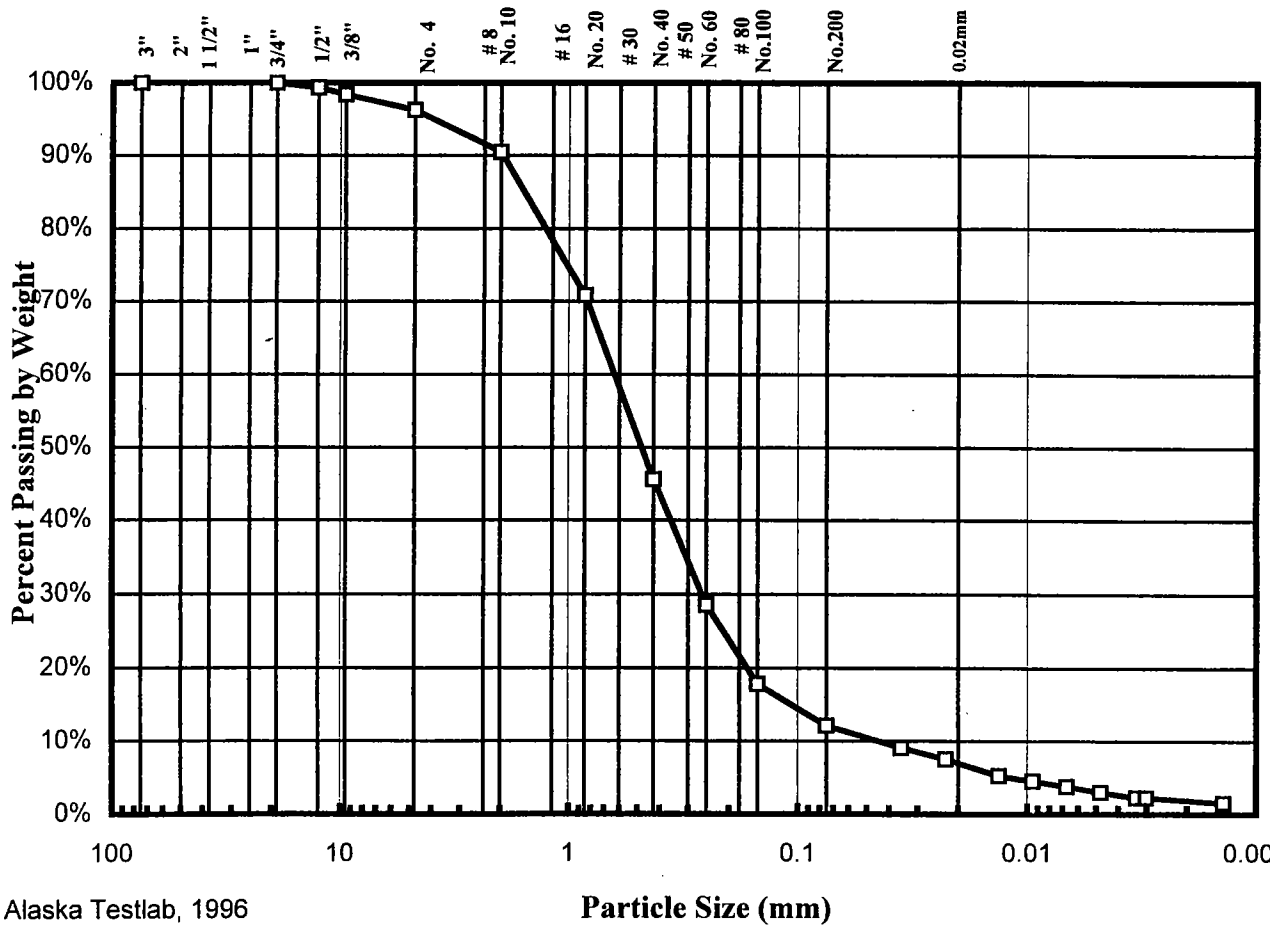
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0205B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2712
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-F2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	98%	
No. 4	96%	
Total Wt. of Coarse Fraction = 1453.3g		
No. 8		
No. 10	90%	
No. 16		
No. 20	71%	
No. 30		
No. 40	46%	
No. 50		
No. 60	29%	
No. 80		
No. 100	18%	
No. 200	12%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	7.0%	

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(907) 562-2000 FAX (907) 563-3953

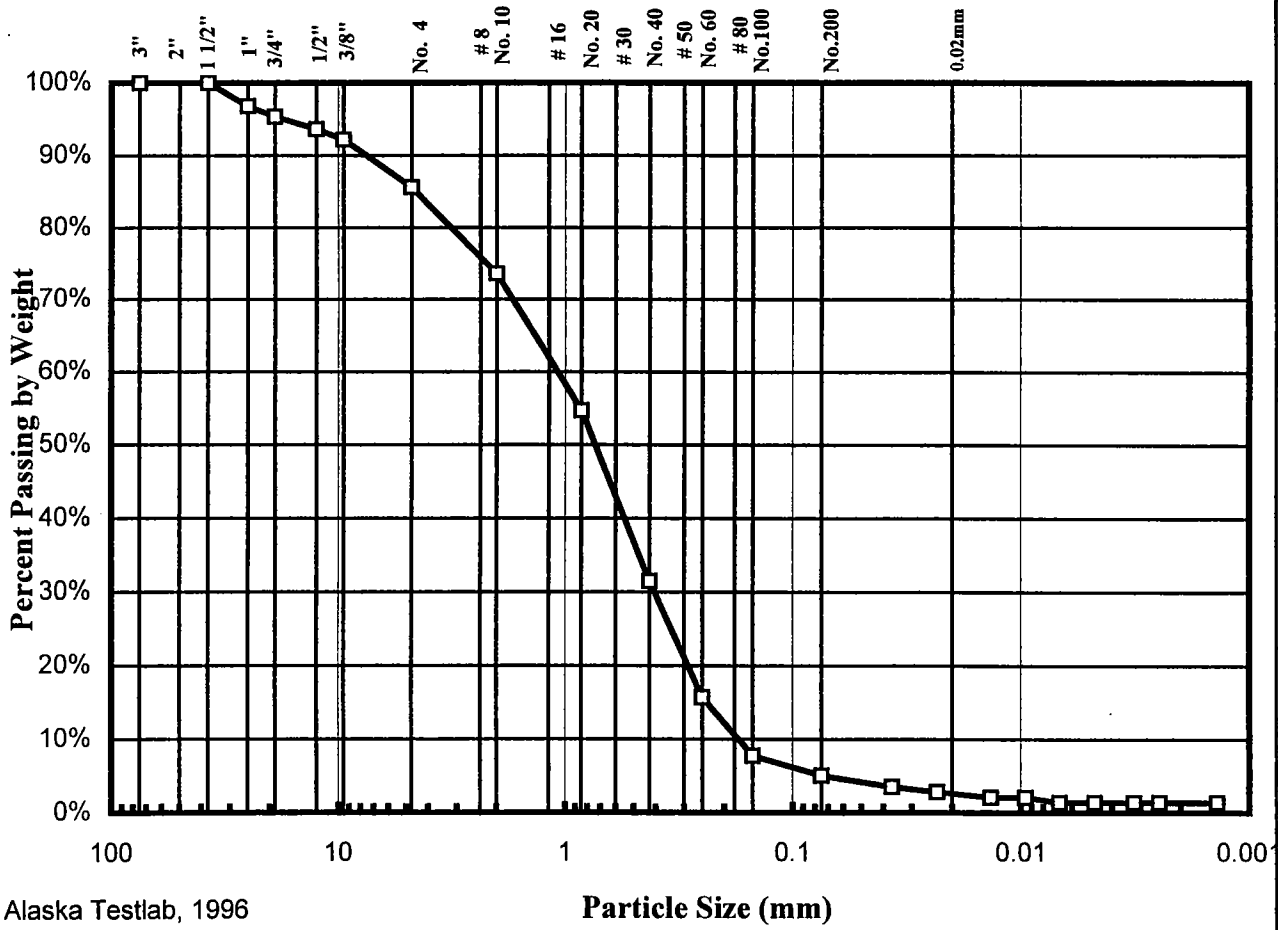
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0215B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2713
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND with Silt , SP-SM
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	97%	
3/4"	95%	
1/2"	94%	
3/8"	92%	
No. 4	86%	
Total Wt. of Coarse Fraction = 1893.8g		
No. 8		
No. 10	74%	
No. 16		
No. 20	55%	
No. 30		
No. 40	31%	
No. 50		
No. 60	16%	
No. 80		
No. 100	8%	
No. 200	5.1%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.6%	

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ALASKA TESTLAB
A Division of DOWL, Incorporated
4040 B Street Anchorage, Alaska 99503
(907) 562-2000 FAX (907) 563-3953

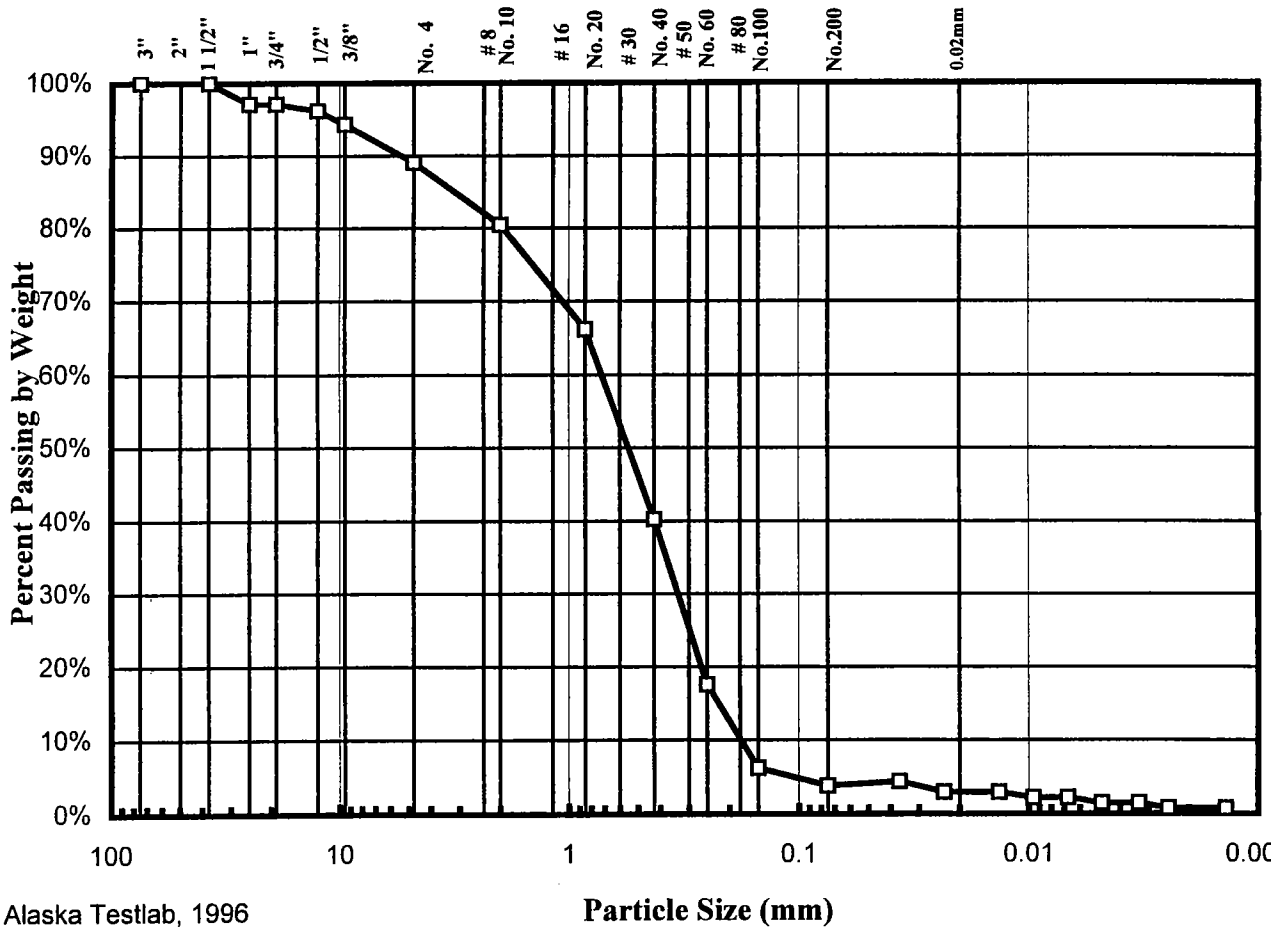
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA

PARTICLE-SIZE DISTRIBUTION

Location: 97NH-0225B
Submitted by Client
PI = Non Plastic

W.O. A27659
Lab No. 2714
Received: December 16, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	97%	
3/4"	97%	
1/2"	96%	
3/8"	94%	
No. 4	89%	
Total Wt. of Coarse Fraction = 1913.2g		
No. 8		
No. 10	80%	
No. 16		
No. 20	66%	
No. 30		
No. 40	40%	
No. 50		
No. 60	18%	
No. 80		
No. 100	6%	
No. 200	3.8%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.9%	

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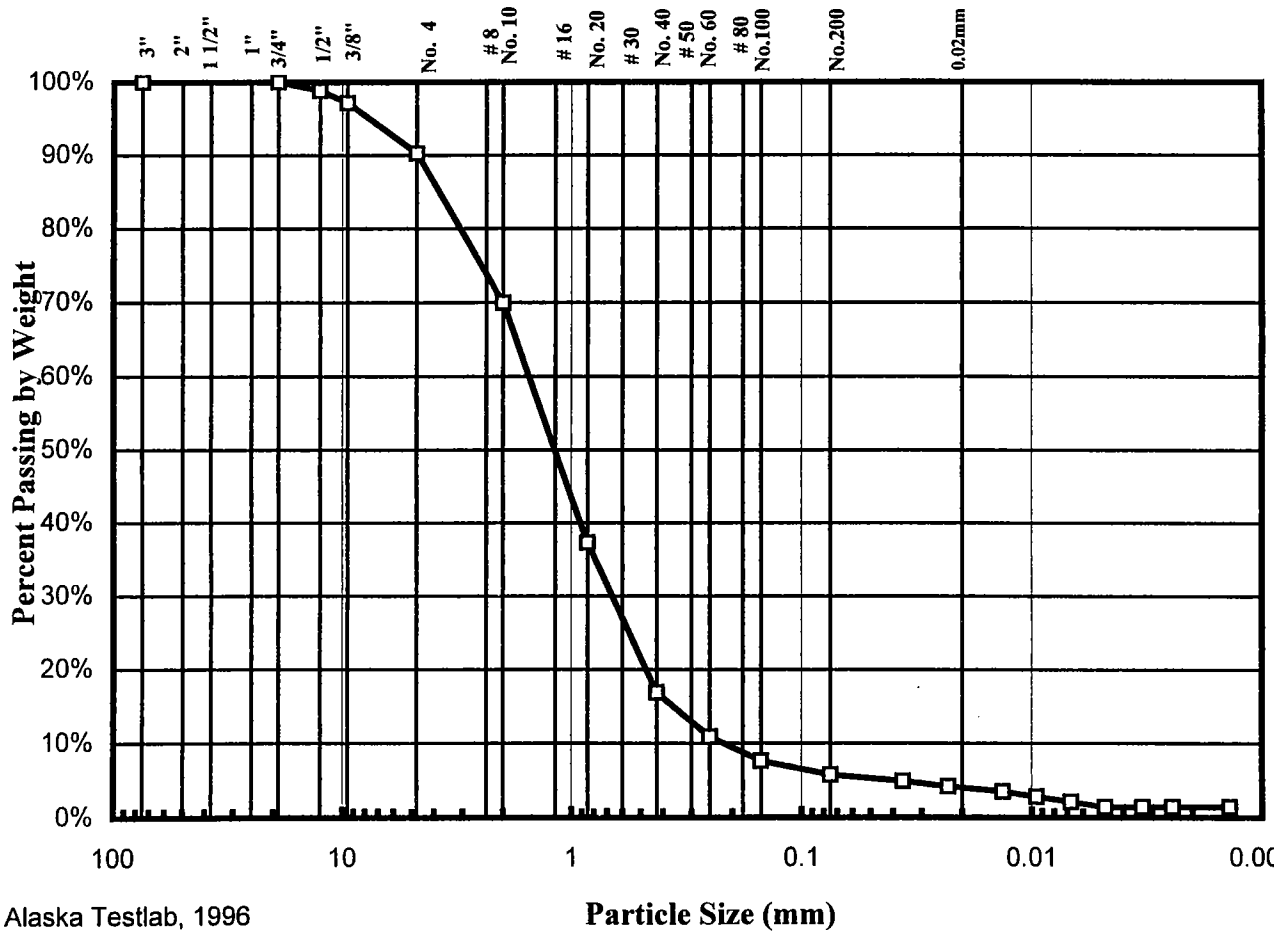
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0235B
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2715
Received: December 16, 1997

Engineering Classification: Well Graded SAND with Silt , SW-SM
Frost Classification: PFS-S2 (MOA F2)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	97%	
No. 4	90%	
Total Wt. of Coarse Fraction = 1521.9g		
No. 8		
No. 10	70%	
No. 16		
No. 20	37%	
No. 30		
No. 40	17%	
No. 50		
No. 60	11%	
No. 80		
No. 100	8%	
No. 200	5.7%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	4.0%	

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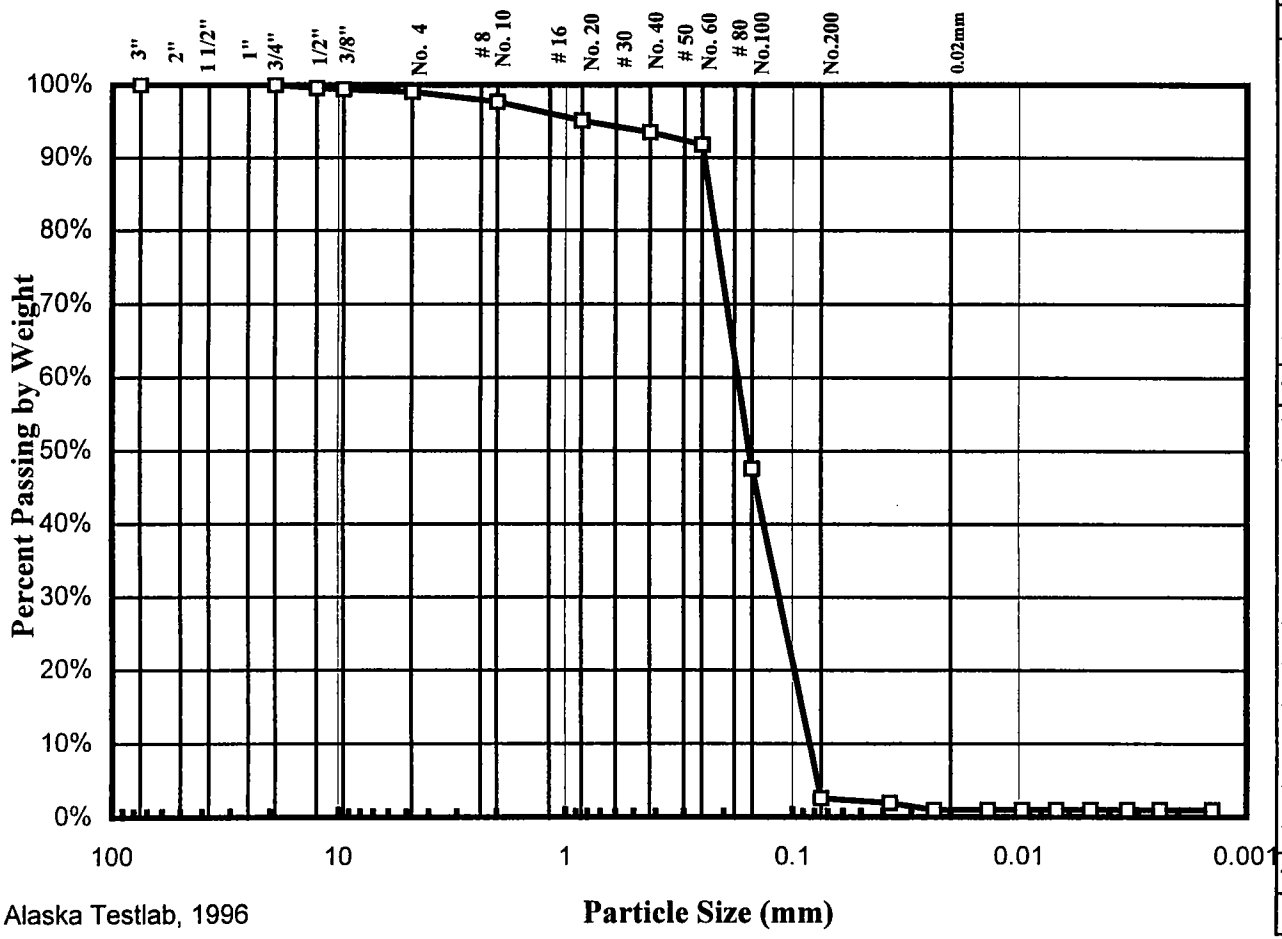
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0245D
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2723
Received: December 23, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	100%	
3/8"	99%	
No. 4	99%	
Total Wt. of Coarse Fraction = 1866.7g		
No. 8		
No. 10	98%	
No. 16		
No. 20	95%	
No. 30		
No. 40	93%	
No. 50		
No. 60	92%	
No. 80		
No. 100	48%	
No. 200	2.6%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	1.0%	

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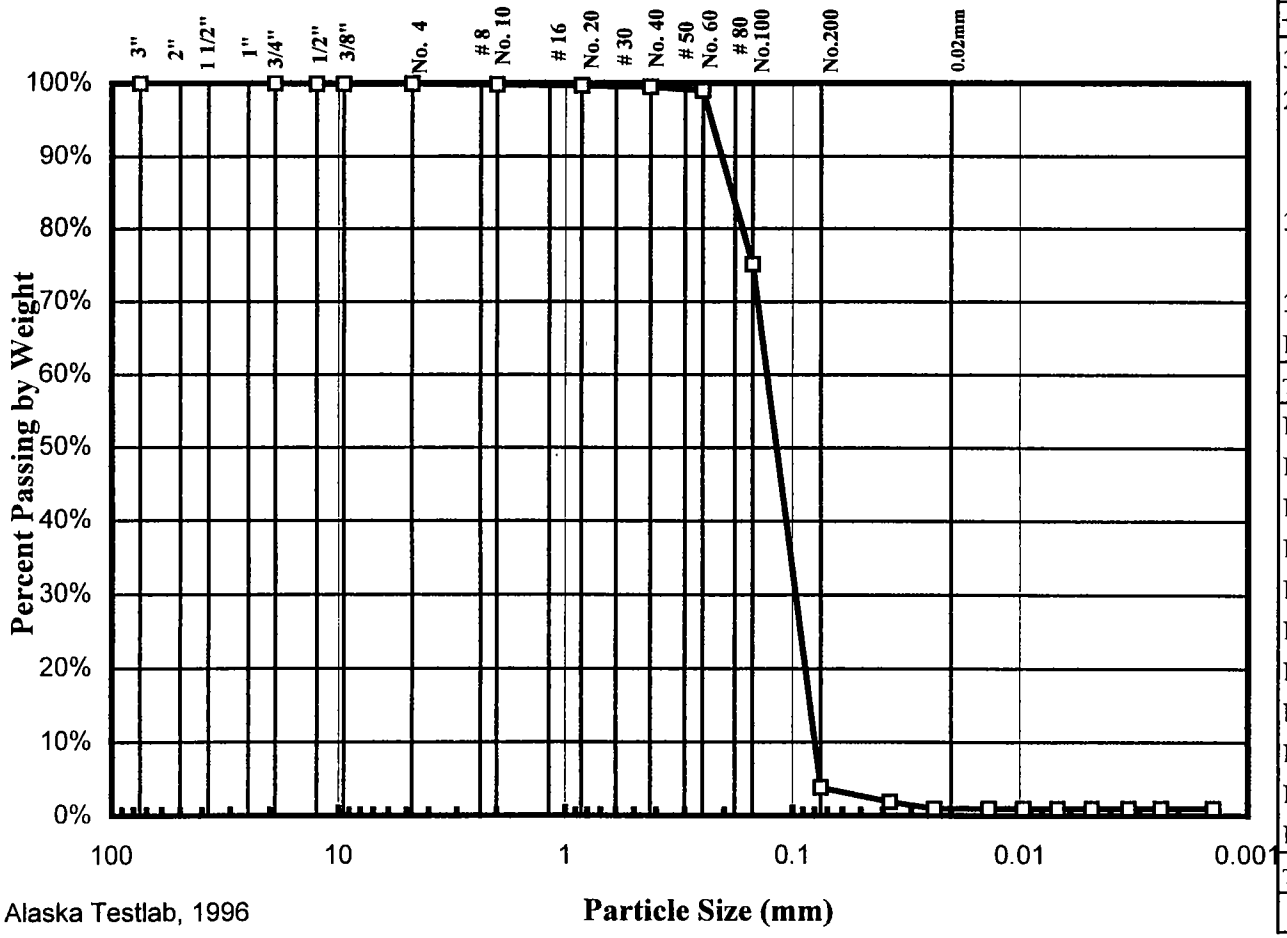
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0255D
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2724
Received: December 23, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	100%	
3/8"	100%	
No. 4	100%	
Total Wt. of Coarse Fraction = 2319.9g		
No. 8		
No. 10	100%	
No. 16		
No. 20	100%	
No. 30		
No. 40	99%	
No. 50		
No. 60	99%	
No. 80		
No. 100	75%	
No. 200	3.9%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	0.9%	

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Client: Woodward-Clyde Federal Services

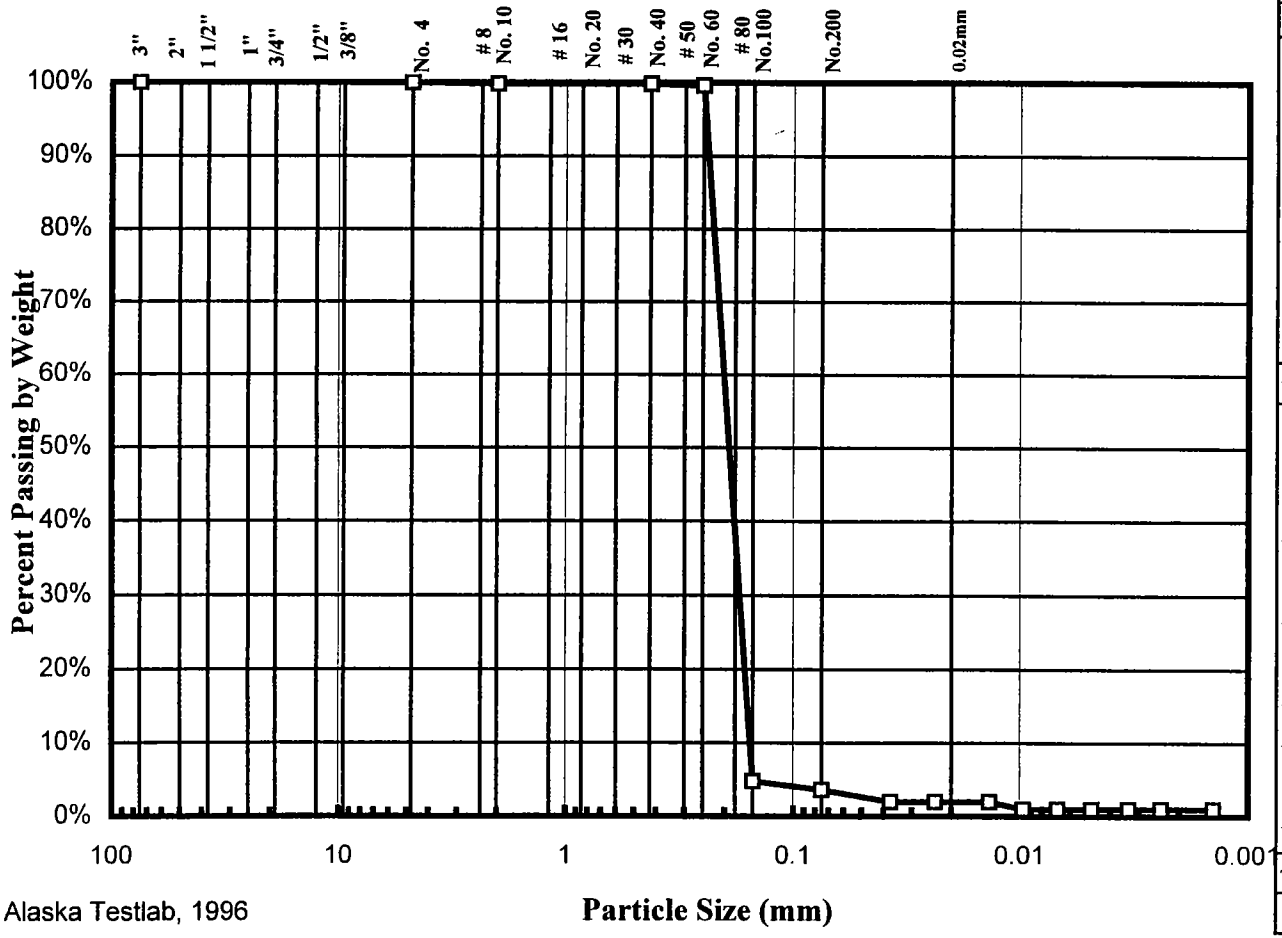
Project: Nome Harbor Proj. No. 976057NA

Location: 97NH-0265D
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2725
Received: December 23, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4	100%	
Total Wt. of Coarse Fraction = 1899.9g		
No. 8		
No. 10	100%	
No. 16		
No. 20		
No. 30		
No. 40	100%	
No. 50		
No. 60	100%	
No. 80		
No. 100	5%	
No. 200	3.6%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	2.0%	

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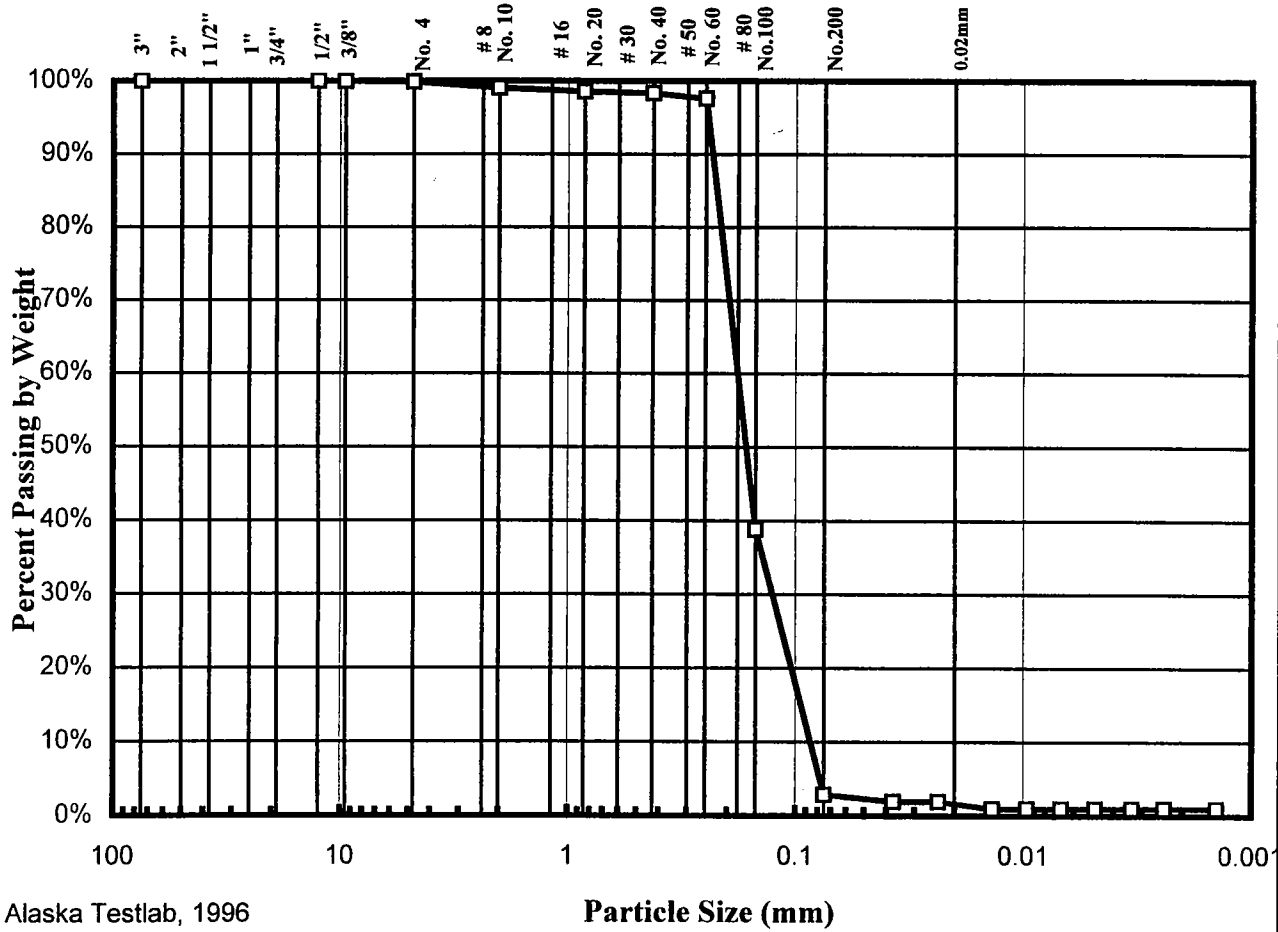
Client: Woodward-Clyde Federal Services
Project: Nome Harbor Proj. No. 976057NA
Location: 97NH-0275D
Submitted by Client
PI = Non Plastic

PARTICLE-SIZE DISTRIBUTION

W.O. A27659
Lab No. 2726
Received: December 23, 1997

Engineering Classification: Poorly Graded SAND , SP
Frost Classification: NFS (MOA)



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"	100%	
3/8"	100%	
No. 4	100%	
Total Wt. of Coarse Fraction = 2160.2g		
No. 8		
No. 10	99%	
No. 16		
No. 20	99%	
No. 30		
No. 40	98%	
No. 50		
No. 60	98%	
No. 80		
No. 100	39%	
No. 200	2.9%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	1.6%	

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Appendix E to the Geotechnical Analysis

CHEMICAL QUALITY ASSURANCE REPORT

CHEMICAL QUALITY ASSURANCE REPORT
NOME HARBOR SITE INVESTIGATION, ALASKA

Summary

The data reviewed are acceptable for use based on a majority of acceptable quality control data. The data may be used to assess analyte concentrations with the stated qualifications.

Introduction

This section presents a quality control (QC) review of data generated from collection and analysis of samples from the December 1997 Nome Harbor Site Investigation. Twenty-seven primary samples were submitted to MultiChem Analytical Services, Inc. in Renton, Washington for analysis. This review includes evaluation of the following:

- Chain of custody and holding times
- Laboratory report and reporting of required analyses
- Laboratory blanks
- Laboratory duplicates
- Matrix spike/matrix spike duplicates (MS/MSD)
- Surrogate recoveries (where applicable)
- Reporting limits

The samples were analyzed for one or more of the following chemicals or chemical groups:

- Volatile Organic Compounds (SW846 8260)
- Semivolatile Organic Compounds (SW846 8270)
- RCRA Metals (SW846 6010/7000)
- Conventionals (ammonia, nitrate + nitrite as nitrogen, sulfide, sulfate, total organic carbon (TOC) and total solids)

Sample Case

The following laboratory data groups were included in this review: 712025, 712029, and 712053. Qualified data are summarized below.

Field ID	Laboratory ID	Analyte	Qualifier
97NH-001SD	712025-1	bis(2-ethylhexyl)phthalate	0.17 U
97NH-002SD	712025-2	bis(2-ethylhexyl)phthalate	0.22 U
97NH-003SB	712025-3	bis(2-ethylhexyl)phthalate	0.17 U
97NH-004SB	712025-4	bis(2-ethylhexyl)phthalate	0.17 U
97NH-005SB	712025-5	bis(2-ethylhexyl)phthalate	0.21 U
97NH-006SB	712025-6	bis(2-ethylhexyl)phthalate	0.67 U
97NH-007SD	712025-7	none	
97NH-008SD	712025-8	none	
97NH-009SB	712029-1	bis(2-ethylhexyl)phthalate	0.17 U
97NH-010SB	712029-2	bis(2-ethylhexyl)phthalate	0.18 U
97NH-011SB	712029-3	bis(2-ethylhexyl)phthalate	0.17 U
97NH-012SB	712029-4	bis(2-ethylhexyl)phthalate	0.20 U
97NH-013SB	712029-5	bis(2-ethylhexyl)phthalate	0.20 U
97NH-014SB	712029-6	bis(2-ethylhexyl)phthalate	0.18 U
97NH-015SB	712029-7	bis(2-ethylhexyl)phthalate	0.17 U
97NH-016SB	712029-8	bis(2-ethylhexyl)phthalate	0.17 U
97NH-017SB	712029-9	bis(2-ethylhexyl)phthalate	0.19 U
97NH-018SB	712029-10	bis(2-ethylhexyl)phthalate	0.20 U
97NH-019SB	712029-11	bis(2-ethylhexyl)phthalate	0.17 U
97NH-020SB	712029-12	bis(2-ethylhexyl)phthalate	0.17 U
97NH-021SB	712029-13	bis(2-ethylhexyl)phthalate	0.17 U
97NH-022SB	712029-14	bis(2-ethylhexyl)phthalate	0.19 U
97NH-023SB	712029-15	bis(2-ethylhexyl)phthalate	0.19 U
97NH-024SD	712053-1	bis(2-ethylhexyl)phthalate	0.21 U
		sulfide	J
97NH-025SD	712053-2	bis(2-ethylhexyl)phthalate	0.21 U
97NH-026SD	712053-3	bis(2-ethylhexyl)phthalate	0.24 U
97NH-027SD	712053-4	bis(2-ethylhexyl)phthalate	0.24 U

Laboratory Report and Reporting of Required Analyses

The laboratory reported all requested analyses and the associated QC results were included, as requested. The project scope of work stated that Woodward-Clyde would provide industry-accepted evaluation of data quality.

Chain of Custody and Holding Times

Samples were maintained under chain of custody until arrival at the laboratory. Samples were preserved and cooled.

The following samples were analyzed outside of the holding time specified in the QAPP. No data were qualified due to these results.

Sample ID	Analyte	Recommended Holding Time	Actual Holding Time	Qualifier
012SB	total solids	7	8	none
013SB	total solids	7	8	none
017SB	total solids	7	8	none
018SB	total solids	7	8	none
022SB	total solids	7	8	none
023SB	total solids	7	8	none

Method Blanks

Method blanks were used to determine if samples were contaminated through laboratory procedures or equipment. The QC frequency requirement of one laboratory blank per analytical batch was met. The laboratory method blanks were free of contamination with the following exceptions.

Type of Blank	Batch	Date	Analyte	Result
method blank	712025	24 Dec 97	bis(2-ethylhexyl)phthalate	0.032 J
method blank	712029	30 Dec 97	bis(2-ethylhexyl)phthalate	0.015 J
method blank	712053	6 Jan 98	bis(2-ethylhexyl)phthalate	0.019 J

Qualified data are summarized in the Sample Case section (page E-2). No field or trip blanks were submitted with the samples.

Laboratory Duplicates

The laboratory duplicate relative percent difference (RPD) was within specified control limits with the following exception. The batch 712025 arsenic laboratory duplicate RPD was high (51%). No data were qualified. The laboratory analyzed matrix spike/matrix spike duplicates for VOCs and WTPH-Gasoline. No data were qualified due to these results.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

Matrix spike analyses were used to assess matrix effects with respect to the analytical data. The QC frequency requirement of one MS per analytical batch was met. The MS/MSD and BS percent recoveries and relative percent differences (RPD) were within the control limits with the following exceptions.

- The batch 712025 semivolatile blank spike percent recovery was slightly below the control limits (39%). The MS percent recoveries were within the control limits, therefore, no data were qualified.
- The batch 712025 and 712029 arsenic MS percent recovery was not calculated due to high analyte concentration. The BS percent recoveries were within the control limits, therefore, no data were qualified.
- The batch 712029 phenol MS RPD was slightly above the control limits. No data were qualified.
- The batch 712053 sulfate MS percent recovery was outside the control limits due to high analyte concentration. The BS percent recoveries were within the control limits, therefore, no data were qualified.
- The batch 712053 sulfide MS percent recovery was low (55.6%). Sample 024SD is qualified as estimated (J) sulfide.

Surrogate Recoveries

Surrogate compounds were used in the analysis of organic compounds to monitor analyte extraction efficiency/method accuracy on a per sample basis. No data were qualified due to surrogate percent recoveries.

Reporting Limits

To ensure that the level of sensitivity required for project goals was met, reporting limits were reviewed. The reporting limits generally meet industry standards.

Appendix F to the Geotechnical Analysis

DETECTION LIMITS FOR VOLATILE AND SEMI-VOLATILE ANALYSES

VOLATILE ORGANIC COMPOUNDS (METHOD 8260A)
ANALYTES AND DETECTION LIMITS

Analytes	Dection Limits (mg/Kg)	Analytes	Dection Limits (mg/Kg)
dichlorodifluromethane	0.002-0.004	chlorodibromomethane	0.002-0.004
chloromethane	0.005-0.010	tetrachloroethene	0.002-0.004
vinyl chloride	0.002-0.004	1,1,1,2-tetrachloroethane	0.002-0.004
bromomethane	0.005-0.010	chlorobenzene	0.002-0.004
chloroethane	0.002-0.004	ethylbenzene	0.002-0.004
trichlorofluoromethane	0.002-0.004	bromoform	0.002-0.004
1,1-dichloroethene	0.002-0.004	styrene	0.002-0.004
methylene chloride	0.010-0.020	total xylenes	0.002-0.004
trans-1,2-dichloroethene	0.002-0.004	1,1,2,2-tetrachloroethane	0.002-0.004
1,1-dichloroethane	0.002-0.004	1,2,3-trichloropropane	0.002-0.004
chloroform	0.002-0.004	isopropylbenzene	0.002-0.004
cis-1,2-dichloroethene	0.002-0.004	bromobenzene	0.002-0.004
bromochloromethane	0.002-0.004	n-propylbenzene	0.002-0.004
2,2-dichloropropane	0.002-0.004	2-chlorotoluene	0.002-0.004
1,1,1-trichloroethane	0.002-0.004	4-chlorotoluene	0.002-0.004
1,2-dichloroethane	0.002-0.004	1,3,5-trimethylbenzene	0.002-0.004
1,1-dichloropropene	0.002-0.004	tert-butylbenzene	0.002-0.004
carbon tetrachloride	0.002-0.004	1,2,4-trimethylbenzene	0.002-0.004
benzene	0.002-0.004	sec-butylbenzene	0.005-0.010
dibromomethane	0.002-0.004	1,3-dichlorobenzene	0.002-0.004
1,2-dichloropropane	0.002-0.004	1,4-dichlorobenzene	0.002-0.004
trichloroethene	0.002-0.004	p-isopropyltoluene	0.002-0.004
bromodichloromethane	0.002-0.004	1,2-dichlorobenzene	0.002-0.004
cis-1,3-dichloropropene	0.002-0.004	n-butylbenzene	0.002-0.004
trans-1,3-dichloropropene	0.002-0.004	1,2-dibromo-3-chloropropane	0.005-0.010
1,1,2-trichloroethane	0.002-0.004	1,2,4-trichlorobenzene	0.005-0.010
toluene	0.002-0.004	naphthalene	0.005-0.010
1,2-dibromoethane (EDB)	0.002-0.004	hexachlorobutadiene	0.005-0.010
1,3-dichloropropane	0.002-0.004	1,2,3-trichlorobenzene	0.005-0.010

SEMIVOLATILE ORGANIC COMPOUNDS (METHOD 8270B)
ANALYTES, DETECTION LIMITS, AND MARINE SEDIMENT STANDARDS

Analytes	Laboratory Dection Limits (mg/Kg)	Sediment Management Standards* SQS (mg/Kg)	CSL (mg/Kg)	Analytes	Laboratory Dection Limits (mg/Kg)	Sediment Management Standards* SQS (mg/Kg)	CSL (mg/Kg)
n-nitrosodimethylamine	0.17-0.33	--	--	3-nitroaniline	0.83-1.7	--	--
phenol	0.17-0.33	420	1200	acenaphthene	0.17-0.33	16	57
aniline	0.17-0.33	--	--	2,4-dinitrophenol	0.83-1.7	--	--
bis(2-chloroethyl)ether	0.17-0.33	--	--	4-nitrophenol	0.83-1.7	--	--
2-chlorophenol	0.17-0.33	--	--	dibenzofuran	0.17-0.33	15	58
1,3-dichlorobenzene	0.17-0.33	--	--	2,4-dinitrotoluene	0.17-0.33	--	--
1,4-dichlorobenzene	0.17-0.33	3.1	9	2,6-dinitrotoluene	0.17-0.33	--	--
benzyl alcohol	0.17-0.33	57	73	diethylphthalate	0.17-0.33	61	110
1,2-dichlorobenzene	0.17-0.33	2.3	2.3	4-chlorophenyl-phenylether	0.17-0.33	--	--
2-methylphenol	0.17-0.33	63	63	fluorene	0.17-0.33	23	79
2,2'-oxybis(1-chloropropane)	0.17-0.33	--	--	4-nitroaniline	0.83-1.7	--	--
3/4-methylphenol	0.17-0.33	--	--	4,6-dinitro-2-methylphenol	0.83-1.7	--	--
n-nitroso-di-n-propylamine	0.17-0.33	--	--	n-nitrosodiphenylamine	0.17-0.33	11	11
hexachloroethane	0.17-0.33	--	--	4-bromophenyl-phenylether	0.17-0.33	--	--
nitrobenzene	0.17-0.33	--	--	hexachlorobenzene	0.17-0.33	0.38	2.3
isophorone	0.17-0.33	--	--	pentachlorophenol	0.83-1.7	360	690
2-nitrophenol	0.17-0.33	--	--	phenanthrene	0.17-0.33	100	480
2,4-dimethylphenol	0.17-0.33	29	29	anthracene	0.17-0.33	220	1200
benzoic acid	0.83-1.7	650	650	di-n-butylphthalate	0.17-0.33	220	1700
bis(2-chloroethoxy)methane	0.17-0.33	--	--	fluroanthene	0.17-0.33	160	1200
2,4-dichlorophenol	0.17-0.33	--	--	benzidine	1.7-6.7	--	--
1,2,4-trichlorobenzene	0.17-0.33	0.81	1.8	pyrene	0.17-0.67	1000	1400
naphthalene	0.17-0.33	99	170	butylbenzylphthalate	0.17-0.67	4.9	64
4-chloroaniline	0.17-0.33	--	--	3,3'-dichlorobenzidine	0.33-1.3	--	--
hexachlorobutadiene	0.17-0.33	3.9	6.2	benzo(a)anthracene	0.17-0.67	110	270
4-chloro-3-methylphenol	0.17-0.33	--	--	bis(2-ethylhexyl)phthalate	0.010	47	4500
2-methylnaphthalene	0.17-0.33	38	64	chrysene	0.17-0.67	110	460
hexachlorocyclopentadiene	0.17-0.33	--	--	di-n-octylphthalate	0.17-0.33	58	78
2,4,6-trichlorophenol	0.17-0.33	--	--	benzo(b)fluoranthene	0.17-0.33	230**	450**
2,4,5-trichlorophenol	0.83-1.7	--	--	benzo(k)fluoranthene	0.17-0.33	230**	450**
2-chloronaphthalene	0.17-0.33	--	--	benzo(a)pyrene	0.17-0.33	99	210
2-nitroaniline	0.83-1.7	--	--	indeno(1,2,3-cd)pyrene	0.17-0.33	34	88
dimethylphthalate	0.17-0.33	53	53	dibenzo(a,h)anthracene	0.17-0.33	12	33
acenaphthylene	0.17-0.33	66	66	benzo(g,h,i)perylene	0.17-0.33	31	78

* State of Washington, Department of Ecology, Sediment Management Standards: Marine Sediment Quality Standards (SQS), and Marine Sediment Cleanup Screening Levels (CSL). Dashes indicate that a standard has not been established.

** SQS and CSL values are for total benzo(b)fluoranthene plus benzo(k)fluoranthene

APPENDIX D
COST ESTIMATE

**** TOTAL PROJECT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY REPORT, DATED: JUNE 98

PROJECT: SMALL BOAT HARBOR
LOCATION: NOME, ALASKA

DISTRICT: ALASKA
P.O.C.: Valarie H. Smith

ACCOUNT NUMBER	FEATURE DESCRIPTION	CURRENT MCACES ESTIMATE PREPARED: FEB 12 98 EFFECTIVE PRICING LEVEL: OCT. 97 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZ./BUDGET YEAR: 1 OCT 99 EFFECT. PRICING LEVEL: 1 OCT 98 COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE..... SPENT THRU FY 95 ($K)	COST ($K)	CNTG ($K)	FULL ($K)
09	CHANNELS AND CANALS	145	15	10%	160	145	15	160		149	15	164
10-1	MOB AND DEMOB	525	53	10%	578	525	53	578		539	54	593
10	BREAKWATER AND SEAWALLS	10,101	1,515	15%	11,616	10,101	1,515	11,616		10,374	1,556	11,930
12	NAVIGATION PORTS & HARBOR	6,777	1,017	15%	7,794	6,777	1,017	7,794		6,959	1,044	8,003
32	REMOVAL OF CONTAMINATED MATER	731	256	35%	987	731	256	987		751	263	1,014
	TOTAL CONSTRUCTION COSTS =====	18,279	2,855	16%	21,134	18,279	2,856	21,135		18,772	2,932	21,704
01---	LANDS AND DAMAGES	940	141	15%	1,081	940	141	1,081		965	145	1,110
02	RELOCATIONS	120	24	20%	144	120	24	144		123	25	148
30---	PLANNING, ENGINEERING & DESIGN	486	48	10%	534	486	49	535		499	50	549
31---	CONSTRUCTION MANAGEMENT	1,080	0	0%	1,080	1,080		1,080		1,109		1,109
	TOTAL PROJECT COSTS ==========>	20,905	3,068	15%	23,973	20,905	3,070	23,975		21,468	3,152	24,620

THIS TPCS REFLECTS A PROJECT COST CHANGE OF $

TOTAL FEDERAL COSTS ==========> [redacted]

TOTAL NON-FEDERAL COSTS ==========>

THE MAXIMUM PROJECT COST IS =======> $

DISTRICT APPROVED: DISTRICT APPROVED DATE: _____

CHIEF, COST ENGINEERING, Frank Antolin

CHIEF, REAL ESTATE, Dennis Klein

CHIEF, PLANNING, Kenneth Hitch

CHIEF, ENGINEERING, Kenneth Hitch (acting)

CHIEF, OPERATIONS, Allen Churchill

CHIEF, CONSTRUCTION, Michael B. Rogers

PROJECT MANAGER, William S. Appleton

DDE (PM), Claude Vining

DIVISION APPROVED:

_____ CHIEF, COST ENGINEERING

_____ DIRECTOR, REAL ESTATE

_____ CHIEF, PROGRAMS MANAGEMENT

_____ DIRECTOR OF PPMD

DIVISION APPROVED DATE: _____

**** TOTAL CONTRACT COST SUMMARY ****

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY REPORT, DATED: JUNE 98

PROJECT: SMALL BOAT HARBOR
LOCATION: NOME, ALASKA

DISTRICT: ALASKA
P.O.C.: Valarie H. Smith

		CURRENT MCACES ESTIMATE PREPARED: FEB 12 98 EFFECTIVE PRICING LEVEL: OCT. 97				AUTHORIZ./BUDGET YEAR: 1 OCT 99 EFFECT. PRICING LEVEL: 1 OCT 98				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
09	CHANNELS AND CANALS	145	15	10%	160		145	15	160	1 QTR 99	2.7%	149	15	164
10-1	MOB AND DEMOB	525	53	10%	578		525	53	578	1 QTR 99	2.7%	539	54	593
10	BREAKWATER AND SEAWALLS	10,101	1,515	15%	11,616		10,101	1,515	11,616	1 QTR 99	2.7%	10,374	1,556	11,930
12	NAVIGATION PORTS & HARBOR	6,537	981	15%	7,518		6,537	981	7,518	1 QTR 99	2.7%	6,713	1,007	7,720
32	REMOVAL OF CONTAMINATED MATER	731	256	35%	987		731	256	987		2.7%	751	263	1,014
	TOTAL CONSTRUCTION COSTS =====	18,039	2,819	16%	20,858		18,039	2,820	20,859			18,526	2,895	21,421
P-01---	LANDS AND DAMAGES	940	141	15%	1,081		940	141	1,081	1 QTR 99	2.7%	965	145	1,110
P-02	RELOCATIONS	120	24	20%	144		120	24	144		2.7%	123	25	148
P-30---	PLANNING, ENGINEERING & DESIGN									1 QTR 99				
0.4%	Project Management	70	7	10%	77		70	7	77		2.7%	72	7	79
0.3%	Planning & Environmental Compliance	50	5	10%	55		50	5	55		2.7%	51	5	56
1.7%	Engineering & Design (includes EDC)	300	30	10%	330		300	30	330		2.7%	308	31	339
0.2%	Engineering Tech Review & VE	35	4	10%	39		35	4	39		2.7%	36	4	40
0.1%	Contracting & Reprographics	25	3	10%	28		25	3	28		2.7%	26	3	29
P-31---	CONSTRUCTION MANAGEMENT	1,080	0	0%	1,080		1,080		1,080	1 QTR 99	2.7%	1,109		1,109
	TOTAL COSTS ==========>	20,659	3,032	15%	23,691		20,659	3,034	23,693			21,216	3,115	24,331

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE FEASIBILITY REPORT, DATED: JUNE 98

PROJECT: SMALL BOAT HARBOR
LOCATION: NOME, ALASKA

DISTRICT: ALASKA
P.O.C.: Valarie H. Smith

		CURRENT MCACES ESTIMATE PREPARED: FEB 12 98 EFFECTIVE PRICING LEVEL: OCT. 97				AUTHORIZ./BUDGET YEAR: 1 OCT 99 EFFECT. PRICING LEVEL: 1 OCT 98				.....FULLY FUNDED ESTIMATE.....				
ACCOUNT NUMBER	FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FEATURE MID PT	OMB (%)	COST ($K)	CNTG ($K)	FULL ($K)
12.2.1	Navigation ports & Harbor	240	36	15%	276		240	36	276	1 QTR 99	2.7%	246	37	283
12.2.2	Navigation ports & Harbor			10%										
12.2.3	Navigation ports & Harbor			10%										
12.04 --	Navigation ports & Harbor			10%										
	TOTAL CONSTRUCTION COSTS =====	240	36	15%	276		240	36	276		2.7%	246	37	283
30---	PLANNING, ENGINEERING & DESIGN													
0.4%	Project Management	1		10%	1		1		1	1 QTR 99	2.7%	1		1
0.3%	Planning & Environmental Compliance	1		10%	1		1		1	1 QTR 99	2.7%	1		1
1.7%	Engineering & Design	4		10%	4		4		4	1 QTR 99	2.7%	4		4
0.2%	Engineering Tech Review & VE			10%										
0.1%	Contracting & Reprographics			10%										
				10%										
31---	CONSTRUCTION MANAGEMENT									1 QTR 99	2.7%			
	TOTAL COSTS ==========>	246	36	15%	282		246	36	282			252	37	289

Nome Harbor Main Design
Nome, Alaska

Y:/MCACES/SBH/FEASIBIL/ALTE-M

Designed By: CENPA-EN-CW-HH
Estimated By: CENPA-EN-CE

Prepared By: Valarie H. Smith/M. Zimmermann
907-753-5672

Preparation Date: 06/23/98
Effective Date of Pricing: 06/23/98
Est Construction Time: 720 Days

Sales Tax: 0.00%

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Release 5.30A

Project Discription:
Construct a

Bases Of Design: Fesibility Report, dated Feb. 1998

Construction Schedule:
Overtime; This cost est. has the crew working 2-10 shift days and a six day week.

Acquisition Plan: This will be a single awarded contract to construct @
a. 3,000 LF breakwater with a crest elevation of +14 Feet MLLW.
b. 230 LF stub breakwater off the existing causeway with a cress elevation of +14 Feet MLLW.
c. Dredge a new entrance channel to the Nome Harbor.
d. Dredge to -22 FT MLLW at the dock appoach channel.
e. Dredge a sediment sump at the breach of the existing causeway.
f. Fill existing navigation channel with dredged material.
g. Demolish and leave in place the existing concrete jetties.

Sub contracting Plan: N/A

Project Construction:
Site access; The project site can either be accessed by land based or marine floating equip.

Borrow areas; It is assumed that the Cape Nome Quarry will be the source for the breakwater rock material.

Construction Methodology; IT IS ASSUMED, that the proposed project will be constructed in spring thru fall months.
The Prime Contractor will mobilize from Seattle area.
The constructing of the breakwater and dredging with floating marine equipment.
The rock material, loaded on barges at Cape Nome Quarry and barged to the breakwaters stations for placing.
The dredged material is scheduled for upland disposal at a predetermined area.
Perform final cleanup, prepare equipment, camp and etc. for demob and demob.

Unusual Conditions (Soil, Water, Weather)
(reserved for latter input)

Unique Technuques of Construction; N/A

Equipment/Labor Availability & Distance Traveled;
Equip. The Nome area has large earth moving equipment and skilled and unskilled labor which the Prime contractor may use for the breakwater and dredging, but if the equip. and labor will be available at time construction is uncertain.

Environmental Concerns; Contaminated soils have been discovered in the proposed project construction area. This is currently under study as

to what impact and corrective actions to take.

Contingencies by Feature or Sub Feature

02 Reloactions; 20% The sewer line and causeway breach are still in the early in the design stages and not enough information at this time.

09 Jetties; 10% These are two small concrete structures that will be demolished in place and covered with armor stone.

10 Breakwater; 15% The existing causeway at Nome was constructed in 1985 and it has been field tested with a high performance rating. The new proposed breakwaters has been engineered and designed based on the same design. The new breakwater lengths, rock size and quantities have established. A model study has been made and a lot work has already gone into this project.

12 Navigiation; 15% Geotech has performed soil bore logs and has been determined the dredging material. The channel depth has been determined and it is doubtful if the material quantities will change. As with the breakwater a lot of thought has already gone into the channel design and model study. The project location and channel has established.

32 Hazardous and Toxic Waste; 30% Even though soil bore logs have performed, at this time material quantites and handling, disposal and testing procedures have not set.

Effective dates for labor, equipment and material pricing

Labor and equip 1997 MCACES Anchorage, Davis Bacon adjusted rate 1997. Equip. EP 1110-1-8 Volume 9, August 1995

SUMMARY REPORTS

SUMMARY PAGE

PROJECT INDIRECT SUMMARY - Contract....1
PROJECT INDIRECT SUMMARY - Sub Feat....2
PROJECT DIRECT SUMMARY - Contract....5
PROJECT DIRECT SUMMARY - Sub Feat....6
LABOR COST TO PRIME SUMMARY....9

DETAILED ESTIMATE

DETAIL PAGE

1. Prime Contractor....1
02. Relocations
03. Utilities, Sewer Line....6
09. Channels and Canals
01. Breakup Jetties....7
02. ARMOR ROCK PLACEMENT....8
10. Breakwaters and Seawalls
1. Mob, Demob & Preparatory Work....10
2. Breakwater-MAIN....11
3. Breakwater-STUB....17
04. Navigation Foundation....23
05. Hydrographic Survey....24
12. Navigation Ports & Harbors
5. Ent. Channel....25
6. Dock Approch....32
8. Sediment Trap....37
9. Hydrographic surveys....40
04. Bridge construction (Breach)....41
32. Removal of Contaminated Material
01. Mob, Demob & Preparatory Work....42
03. Institutional Actions....43
08. Containment for Wastes....44

BACKUP REPORTS

BACKUP PAGE

CREW BACKUP - Contract....1
LABOR BACKUP - Contract....2
EQUIPMENT BACKUP - Contract....3

* * * END TABLE OF CONTENTS * * *

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate

TIME 11:57:35

** CONTRACTOR SETTINGS **

		AMOUNT	PCT	PCT S	RISK	DIFF	SIZE	PERIOD	INVEST	ASSIST	SUBCON
AA Prime Contractor											
Prime Contractor's Field Overhead	C										
Prime's Home Office Expense	P		6.46								
Prime Contractor's Profit	P		7.00								
Prime Contractor's Bond	P		0.87								

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate
** PROJECT INDIRECT SUMMARY - Contract **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
02 Relocations		120,000	0	0	0	0	120,000	
09 Channels and Canals		114,389	11,325	8,121	9,368	1,246	144,449	
10 Breakwaters and Seawalls		8,415,158	833,124	597,439	689,200	91,654	10,626,574	
12 Navigation Ports & Harbors		5,366,872	531,335	381,024	439,546	58,453	6,777,230	
32 Removal of Contaminated Material		578,991	57,322	41,106	47,419	6,306	731,144	
TOTAL Nome Harbor Main Design		14,595,409	1,433,105	1,027,690	1,185,534	157,659	18,399,398	

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate
** PROJECT INDIRECT SUMMARY - Sub Feat **

TIME 11:57:35

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
02 Relocations								
02_03 Utilities, Sewer Line		120,000	0	0	0	0	120,000	
TOTAL Relocations		120,000	0	0	0	0	120,000	
09 Channels and Canals								
09_01 Breakup Jetties		33,000	3,267	2,343	2,703	359	41,672	
TOTAL Breakup Jetties		33,000	3,267	2,343	2,703	359	41,672	
09_02 ARMOR ROCK PLACEMENT								
09_02. 1 ARMOR ROCK PLACEMENT	160.00 EA	81,389	8,058	5,778	6,666	886	102,777	642.36
TOTAL ARMOR ROCK PLACEMENT	1924.00 BCY	81,389	8,058	5,778	6,666	886	102,777	53.42
TOTAL Channels and Canals		114,389	11,325	8,121	9,368	1,246	144,449	
10 Breakwaters and Seawalls								
10_ 1 Mob, Demob & Preparatory Work		415,660	41,151	29,510	34,043	4,527	524,891	
TOTAL Mob, Demob & Preparatory Work		415,660	41,151	29,510	34,043	4,527	524,891	
10_ 2 Breakwater-MAIN								
10_ 2. 2 Core Rock Placement	65200 BCY	2,393,073	236,921	169,898	195,992	26,064	3,021,948	46.35
10_ 2. 3 Secondary Rock Placement	23100 BCY	907,988	89,893	64,463	74,364	9,889	1,146,597	49.64
10_ 2.01 ARMOR ROCK PLACEMENT	79400 BCY	3,535,334	350,008	250,993	289,543	38,505	4,464,383	56.23
TOTAL Breakwater-MAIN		6,836,395	676,822	485,354	559,900	74,459	8,632,929	
10_ 3 Breakwater-STUB								
10_ 3. 1 ARMOR ROCK PLACEMENT	16100 BCY	731,518	72,422	51,935	59,911	7,967	923,753	57.38
10_ 3.02 Secondary Rock Placement	4022.00 BCY	157,289	15,572	11,167	12,882	1,713	198,623	49.38
10_ 3.03 Core Rock Placement	6304.00 BCY	230,296	22,800	16,350	18,861	2,508	290,815	46.13
TOTAL Breakwater-STUB		1,119,103	110,794	79,451	91,654	12,189	1,413,192	
10_04 Navigation Foundation	2.00 EA	8,000	792	568	655	87	10,102	5051.16
10_05 Hydrographic Survey	3.00 EA	36,000	3,564	2,556	2,948	392	45,460	15153

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
TOTAL Breakwaters and Seawalls		8,415,158	833,124	597,439	689,200	91,654	10,626,574	
12 Navigation Ports & Harbors								
12_ 5 Ent. Channel								
12_ 5.01 Ent. Channel -22 Ft to -12 FT	112400 BCY	903,612	89,460	64,152	74,006	9,842	1,141,072	10.15
12_ 5.02 Ent. Channel -12 Ft to -10 FT	179200 BCY	1,385,929	137,211	98,395	113,507	15,095	1,750,136	9.77
TOTAL Ent. Channel	291600 BCY	2,289,541	226,671	162,547	187,513	24,937	2,891,208	9.91
12_ 6 Dock Approch								
12_ 6.01 Dock Approach (Federal)	57750 BCY	507,006	50,195	35,995	41,524	5,522	640,242	11.09
12_ 6.02 Dock Approach (Non-Federal)	26000 BCY	190,329	18,843	13,512	15,588	2,073	240,345	9.24
TOTAL Dock Approch	83750 BCY	697,334	69,038	49,508	57,112	7,595	880,587	10.51
12_ 8 Sediment Trap								
12_ 8.01 MECHANICAL DREDGING	178000 LCY	430,838	42,654	30,588	35,286	4,692	544,057	3.06
12_ 8.02 Upland Disposal	178000 LCY	574,459	56,873	40,784	47,048	6,257	725,421	4.08
TOTAL Sediment Trap	140800 BCY	1,005,297	99,527	71,372	82,334	10,949	1,269,478	9.02
12_ 9 Hydrographic surveys	2.00 EA	24,000	2,376	1,704	1,966	261	30,307	15153
12_04 Bridge construction (Breach)								
12_04.07 Bridges, Superstructure and Deck		1,350,700	133,723	95,894	110,622	14,711	1,705,650	
TOTAL Bridge construction (Breach)		1,350,700	133,723	95,894	110,622	14,711	1,705,650	
TOTAL Navigation Ports & Harbors		5,366,872	531,335	381,024	439,546	58,453	6,777,230	
32 Removal of Contaminated Material								
32_01 Mob, Demob & Preparatory Work		15,000	1,485	1,065	1,228	163	18,942	
TOTAL Mob, Demob & Preparatory Work		15,000	1,485	1,065	1,228	163	18,942	
32_03 Institutional Actions								
32_03.03 Monitor/Sample/Test & Analysis		25,000	2,475	1,775	2,047	272	31,570	
TOTAL Institutional Actions		25,000	2,475	1,775	2,047	272	31,570	

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate
** PROJECT INDIRECT SUMMARY - Sub Feat **

TIME 11:57:35

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
32_08 Containment for Wastes								
32_08.03 Haul and stock pile containment	21000 BCY	341,527	33,812	24,247	27,971	3,720	431,277	20.54
32_08.04 Haul to channel	21000 BCY	197,464	19,549	14,019	16,172	2,151	249,355	11.87
TOTAL Containment for Wastes		538,991	53,362	38,266	44,143	5,870	680,632	
TOTAL Removal of Contaminated Material		578,991	57,322	41,106	47,419	6,306	731,144	
TOTAL Nome Harbor Main Design		14,595,409	1,433,105	1,027,690	1,185,534	157,659	18,399,398	

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
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** PROJECT DIRECT SUMMARY - Contract **

TIME 11:57:35

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
02 Relocations		0	0	120,000	0	120,000	
09 Channels and Canals		1,052	1,617	78,720	33,000	114,389	
10 Breakwaters and Seawalls		154,969	568,844	7,655,344	36,000	8,415,158	
12 Navigation Ports & Harbors		1854726	2,137,446	102,000	1,272,700	5,366,872	
32 Removal of Contaminated Material		289,527	152,748	96,716	40,000	578,991	
TOTAL Nome Harbor Main Design		2300273	2,860,656	8,052,780	1,381,700	14,595,409	
Prime Contractor's Field Overhead						1,433,105	
SUBTOTAL						16,028,514	
Prime's Home Office Expense						1,027,690	
SUBTOTAL						17,056,204	
Prime Contractor's Profit						1,185,534	
SUBTOTAL						18,241,739	
Prime Contractor's Bond						157,659	
TOTAL INCL INDIRECTS						18,399,398	

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate
** PROJECT DIRECT SUMMARY - Sub Feat **

TIME 11:57:35

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
02 Relocations							
02_03 Utilities, Sewer Line		0	0	120,000	0	120,000	
TOTAL Relocations		0	0	120,000	0	120,000	
09 Channels and Canals							
09_01 Breakup Jetties		0	0	0	33,000	33,000	
TOTAL Breakup Jetties		0	0	0	33,000	33,000	
09_02 ARMOR ROCK PLACEMENT							
09_02. 1 ARMOR ROCK PLACEMENT	160.00 EA	1,052	1,617	78,720	0	81,389	508.68
TOTAL ARMOR ROCK PLACEMENT	1924.00 BCY	1,052	1,617	78,720	0	81,389	42.30
TOTAL Channels and Canals		1,052	1,617	78,720	33,000	114,389	
10 Breakwaters and Seawalls							
10_ 1 Mob, Demob & Preparatory Work		27,620	373,040	15,000	0	415,660	
TOTAL Mob, Demob & Preparatory Work		27,620	373,040	15,000	0	415,660	
10_ 2 Breakwater-MAIN							
10_ 2. 2 Core Rock Placement	65200 BCY	38,885	59,788	2,294,400	0	2,393,073	36.70
10_ 2. 3 Secondary Rock Placement	23100 BCY	17,492	26,895	863,600	0	907,988	39.31
10_ 2.01 ARMOR ROCK PLACEMENT	79400 BCY	45,688	70,246	3,419,400	0	3,535,334	44.53
TOTAL Breakwater-MAIN		102,065	156,929	6,577,400	0	6,836,395	
10_ 3 Breakwater-STUB							
10_ 3. 1 ARMOR ROCK PLACEMENT	16100 BCY	18,512	28,462	684,544	0	731,518	45.44
10_ 3.02 Secondary Rock Placement	4022.00 BCY	3,030	4,659	149,600	0	157,289	39.11
10_ 3.03 Core Rock Placement	6304.00 BCY	3,742	5,754	220,800	0	230,296	36.53
TOTAL Breakwater-STUB		25,284	38,875	1,054,944	0	1,119,103	
10_04 Navigation Foundation	2.00 EA	0	0	8,000	0	8,000	4000.00
10_05 Hydrographic Survey	3.00 EA	0	0	0	36,000	36,000	12000

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
TOTAL Breakwaters and Seawalls			154,969	568,844	7,655,344	36,000	8,415,158	
12 Navigation Ports & Harbors								
12_ 5 Ent. Channel								
12_ 5.01 Ent. Channel -22 Ft to -12 FT	112400	BCY	420,745	482,868	0	0	903,612	8.04
12_ 5.02 Ent. Channel -12 Ft to -10 FT	179200	BCY	644,634	741,294	0	0	1,385,929	7.73
TOTAL Ent. Channel	291600	BCY	1065379	1,224,162	0	0	2,289,541	7.85
12_ 6 Dock Approch								
12_ 6.01 Dock Approach (Federal)	57750	BCY	234,341	272,664	0	0	507,006	8.78
12_ 6.02 Dock Approach (Non-Federal)	26000	BCY	88,350	101,979	0	0	190,329	7.32
TOTAL Dock Approch	83750	BCY	322,691	374,643	0	0	697,334	8.33
12_ 8 Sediment Trap								
12_ 8.01 MECHANICAL DREDGING	178000	LCY	206,849	223,989	0	0	430,838	2.42
12_ 8.02 Upland Disposal	178000	LCY	259,806	314,653	0	0	574,459	3.23
TOTAL Sediment Trap	140800	BCY	466,655	538,641	0	0	1,005,297	7.14
12_ 9 Hydrographic surveys	2.00	EA	0	0	0	24,000	24,000	12000
12_04 Bridge construction (Breach)								
12_04.07 Bridges, Superstructure and Deck			0	0	102,000	1,248,700	1,350,700	
TOTAL Bridge construction (Breach)			0	0	102,000	1,248,700	1,350,700	
TOTAL Navigation Ports & Harbors			1854726	2,137,446	102,000	1,272,700	5,366,872	
32 Removal of Contaminated Material								
32_01 Mob, Demob & Preparatory Work			0	0	0	15,000	15,000	
TOTAL Mob, Demob & Preparatory Work			0	0	0	15,000	15,000	
32_03 Institutional Actions								
32_03.03 Monitor/Sample/Test & Analysis			0	0	0	25,000	25,000	
TOTAL Institutional Actions			0	0	0	25,000	25,000	

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
32_08 Containment for Wastes								
32_08.03 Haul and stock pile containment	21000	BCY	188,843	79,605	73,080	0	341,527	16.26
32_08.04 Haul to channel	21000	BCY	100,684	73,144	23,636	0	197,464	9.40
TOTAL Containment for Wastes			289,527	152,748	96,716	0	538,991	
TOTAL Removal of Contaminated Material			289,527	152,748	96,716	40,000	578,991	
TOTAL Nome Harbor Main Design			2300273	2,860,656	8,052,780	1,381,700	14,595,409	
Prime Contractor's Field Overhead							1,433,105	
SUBTOTAL							16,028,514	
Prime's Home Office Expense							1,027,690	
SUBTOTAL							17,056,204	
Prime Contractor's Profit							1,185,534	
SUBTOTAL							18,241,739	
Prime Contractor's Bond							157,659	
TOTAL INCL INDIRECTS							18,399,398	

Thu 25 Jun 1998
Eff. Date 06/23/98

U.S. Army Corps of Engineers
PROJECT ALTE-M: Nome Harbor Main Design - Nome, Alaska
Current Working Estimate
** LABOR COST TO PRIME SUMMARY **

TIME 11:57:35

SRC LABOR ID	DESCRIPTION	TYPE	HOURS	*** DATABASE *** RATE	TOTAL	*** TO PRIME *** RATE	TOTAL
MIL B-EQOPRCRN	Equip. Operators, Group 1	Laborer	1680.00	45.56	76534.75	45.56	76534.75
MIL B-EQOPRMED	Equip. Operators, Group 2	Foreman	3106.39	45.18	140334.62	52.26	162340.60
		Laborer	50.40	44.68	2251.68	44.68	2251.68
MIL B-LABORER	Laborers, Group 3	Foreman	893.62	40.31	36020.27	40.31	36020.27
		Laborer	4015.21	39.81	159838.97	40.31	161849.53
MIL B-SKILLWKR	Skilled Workers	Foreman	43.24	37.38	1616.43	37.38	1616.43
		Laborer	345.95	36.88	12758.49	36.88	12758.49
MIL B-TRKDVRHV	Truck Driver, Group 1	Laborer	11275.56	44.10	497259.13	50.81	572933.80
CIV X-DECK-ENG	Marine Deck Engineer	Laborer	3099.79	44.95	139334.75	51.74	160390.27
CIV X-DECKHAND	Marine Deck Hand	Laborer	4000.13	39.41	157642.60	45.70	182794.60
MIL X-EQOPRHVY	Outside Equip. Operators, Heavy	Laborer	5706.18	43.96	250869.77	51.07	291419.22
MIL X-EQOPRMED	Outside Equip. Operators, Medium	Laborer	2606.39	36.64	95497.64	42.30	110240.72
MIL X-EQOPROIL	Outside Equip. Oilers	Laborer	5706.18	33.16	189219.67	38.13	217567.33
CIV X-SURVEYOR	Hydrographic Surveyor	Laborer	5074.98	39.41	200009.98	45.81	232474.47
MEL X-TUG-CAPT	Tug Boat Captain	Laborer	900.34	49.47	44540.78	57.16	51462.07
		Total	48504.34				2272654.24

APPENDIX E
REAL ESTATE REQUIREMENTS

APPENDIX E
REAL ESTATE REQUIREMENTS

NOME NAVIGATION IMPROVEMENTS

REAL ESTATE PLAN

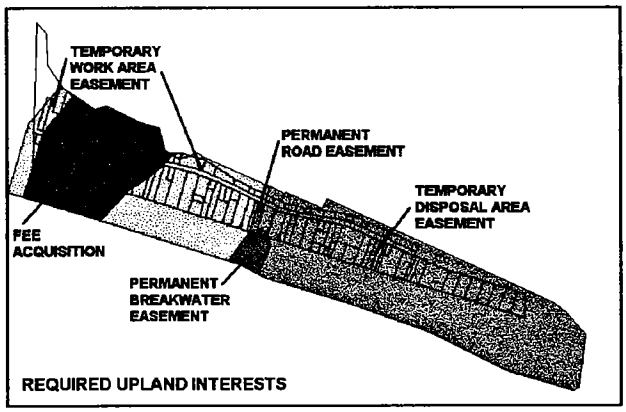
Project

Nome Navigational Improvement Project, located in Nome, Alaska. The latest approved Reconnaissance Report is dated December 1996. The local sponsor is the city of Nome.

Project Summary

The project is located at the mouth of the Snake River at the western end of Nome. It involves cutting a new channel through the Nome Spit and closing the old channel at the mouth of the river. There will be extensive dredging in the existing river channel and into Norton Sound. An armor rock jetty (breakwater) will extend into Norton Sound east of the new entrance channel. It will tie into upland beach on the south shore of the spit. An area 100 feet east of the new channel and between the new channel and the breakwater will be used for temporary staging and work area. A disposal area will comprise the remainder of the spit east of the breakwater. The old entrance channel also will serve as a disposal area, and upon project completion will be filled to grade with adjoining uplands. Additional sponsor portions of the project (non-federal) will involve minor dredging of areas next to the existing causeway. The lands involved in the project are owned by the city of Nome and various private landowners. Land uses are mixed, but trend toward marine commercial and industrial uses.

Real Property Interests Required for General Navigational Features of the Project



Public access is currently available to the project site. The sponsor will provide all lands necessary for the Federal portion of the project. These will involve all uplands required for the new entrance channel, breakwater and disposal areas. The land requirements are: (1) fee simple interest for the channel, (2) a temporary (2-year) work area

easement, (3) a temporary (2-year) easement for a disposal area, (4) a permanent easement for the breakwater, and (5) a permanent easement for access to the breakwater. No interest is required for lands below mean high water, as these areas are subject to the Federal right of navigational servitude. An existing sewer main will need to be relocated to a greater depth to pass under the new channel, but will stay within its existing right-of-way. The severed road will need to be relocated to re-establish access to the spit. Five Public Law (P.L.) 91-646 relocations (relocation of persons) are anticipated.

Current Ownership

General title information is based solely on city assessment records; an official title search has not been performed. It is anticipated that the ownership status will change before project award. There is a mixture of private and city-owned property within the project limits. There are about 121 separate lots. Of these, the sponsor currently owns 23 lots; 98 lots are owned by 16 different private owners. The attitude of the landowners towards the project is generally positive. The surface and subsurface estates are owned separately on the unplatted lands. The city owns the surface; the regional Native corporation owns the subsurface. There are no known federally owned lands within the project area. All other project areas lie below the mean high water line and are subject to the Federal right of navigational servitude. The city sponsor owns all tidelands affected by the project.

Improvements

There are five marginal cabin residences on lots 12, 13, 14, 17, and 18, Block Two. The cabins have no utility services. Water is carried in, sewage is carried out, there is no electricity, and heat is from wood stoves. These cabins are owned by the city, subject to a life estate interest held by the current occupants. These interests will need to be acquired and the occupants relocated in accordance with P.L. 91-646. The availability of replacement housing is limited; there is an anticipated need for last resort housing benefits.

Mineral Activity

There is no known mineral activity occurring above mean high water, and no acquisitions of mineral interest are anticipated. However, it is not uncommon in Nome for a title search to reveal the existence of old mining claims that cloud title and can complicate the real estate acquisition process.

Relocation of Roads and Utilities

There is a sewer main line that lies within the platted roadway. The line will be relocated to a greater depth within the existing right-of-way in order to run under the new channel. No new rights-of way acquisitions are anticipated. There are no other known utility relocations. The new channel will sever the Gold Street (a platted but

undeveloped road). Physical access will be restored by filling the existing channel. The sponsor will provide legal access across the filled channel to ensure access to the properties on the spit. Real estate costs associated with these relocations are relatively small and are included with administrative expenses. An attorney's opinion of compensability has not been completed.

Local Sponsor's Acquisition Experience and Title Search

The sponsor was provided with a real estate information packet during the reconnaissance phase. The city's experience and ability to acquire real estate has been evaluated and rated as moderately capable. The city has the legal authority to condemn lands for public purposes; however, it is anticipated it will require contractor support to complete acquisitions and relocations in a manner complying with P.L. 91-646.

The city has indicated that land acquisition on the spit is not believed to be a problem. Contact has been made with landowners, and a preliminary title search has been carried out.

Hazardous and Toxic Wastes

The current plan indicates that any contaminated soils will be encapsulated within the filled channel disposal area in a manner satisfactory to current regulations. It is not anticipated that the presence of any of these materials will adversely affect acquisition.

Schedule

Due to the number of separate parcels, ownerships, and P.L. 91-646 relocations, at least 6-8 months from the date of the Project Cooperation Agreement approval should be allocated to give the sponsor time to provide the needed real estate. The local sponsor concurs with this general schedule.

Summary

The following tables summarize the required real estate interests for the Nome Harbor project and the baseline real estate cost estimate. (The same tables are in the main report as tables 11 and 12.)

TABLE E-1.—*Summary of required real estate interests*

Feature	Acres	Owner	Interest
Areas Above Mean High Water:			
Channel	4.5	City/private	Fee (Estate #1)
Breakwater tie-in	0.4	City/private	Permanent Easement (Estate #9)
Breakwater access road	0.1	Private	Permanent Easement (Estate #11)
Work and staging area	5.1	City/private	Temporary Easement (Estate #15)
Disposal area	11.3	City/private	Temporary Easement (Estate #15)
Areas Below Mean High Water:			
Channel, breakwaters, disposal area	N/A	City	Navigational servitude

TABLE E-2.—*Baseline real estate cost estimate*

Item	Cost
Payments for real estate	$715,000
P.L. 91-646 relocations	125,000
Administrative costs	100,000
Total real estate costs	**$940,000**

Assessment of Non-Federal Sponsor's
Real Estate Acquisition Capability

Sponsor: *CITY OF NOME* Project: *Navigation Improvement Project*

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? *YES*

b. Does the sponsor have the power of eminent domain for this project? *YES, per city attorney (Brooks Chandlar)*

c. Does the sponsor have "quick-take" authority for this project? *YES, per atty.*

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? *NO*

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? *NO.*

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? *YES.*

b. If the answer to II.a. is yes, has a reasonable plan been developed to provide such training? *NO, City will contract for real estate services. The city was provided a partner packet during the Recon phase.*

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? No. *The City does not have in-house staff with real estate acquisition experience. However, the City plans to contract with a private real estate services firm. The District Real Estate staff, as always, will assist as much as possible.*

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? *Yes with contract help.*

e. Can the sponsor obtain contractor support, if required, in a timely fashion? *Yes, with the support of the District Real Estate Division.*

f. Will the sponsor likely request USACE assistance in acquiring real estate? *No.*

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? *Yes.*

b. Has the sponsor approved the project/real estate schedule/milestones? *Specific dates for the project schedule have not been finalized, although the schedule is expected to allow 6 t0 8 months to complete real estate acquisition and certification. The 6 – 8 month timeframe has been discussed with the city manager and he concurs with it based on his knowledge of project plans to date.*

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? *YES. The city has been involved with other projects including the Nome seawall and causeway, harbor dredging.*

b. With regard to this project, the sponsor is anticipated to be: highly capable/ fully capable/ ***moderately capable/*** marginally capable/ insufficiently capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? *YES. The undersigned had a telephone conversation with the City Manager to review the questions and discuss the issues and responses.*

b. Does the sponsor concur with this assessment? *YES. He was not asked his opinion on the final assessment rating, however, from his indications of the lack of staff knowledge and training, I believe he would concur.*

Source:
Mike Yanez
City of Nome
Telephone: (907) 433-NOME

Prepared by:

Name: Douglas B. Trosper
Title: Appraiser

Reviewed/approved by:

Dennis E. Klein
Chief, Real Estate Division

APPENDIX F
CORRESPONDENCE

CITY OF NOME

P.O. BOX 281 - NOME, ALASKA 99762
TELEPHONE (907) 443-5242

December 17, 1996

Colonel Peter A. Topp
District Engineer
U.S. Army Engineer district, Alaska
P.O. Box 898
Anchorage, Alaska 99506-0898

Dear Colonel Topp,

This letter expresses the intent of the city of Nome, Alaska, to cooperate with the Federal Government in initiating a feasibility study for the Nome Navigation Improvements. We understand that the City of Nome would be required to pay the non-Federal share of the costs of the feasibility study as specified by Section 101 of the Water Resources Development Act of 1986 (Public Law 99-662). We further understand that the non-Federal share of these features, based on the above law, is currently estimated to be $540,000.00.

We have reviewed a proposed draft Project Study Plan. The City of Nome is the organization empowered by law to provide the non-Federal cooperation required for the Nome Harbor. We hereby inform you that it is our intent to enter into a Feasibility Cost Sharing Agreement (FCSA) if a feasibility study is approved by the Corps' Headquarters office.

We also understand that if the feasibility study indicates federal interest and construction is authorized and funded by Congress, the City of Nome would be required to do the following:

a. Contribute in cash the local share of the project planning and construction cost;

b. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction, operation, and maintenance of the project, including suitable disposal areas for dredged material, with any necessary retaining dikes, bulkheads, and embankments or the cost thereof,

c. Accomplish in a timely manner, without cost to the United States;, all alterations and relocations of the buildings, streets, utilities, storm drains, pipelines, power lines, and other structures and improvements required for construction, operation, or maintenance of the project;

d. Hold and save the United States free from damages due to the construction and maintenance of the project, except damages due to the fault or negligence of the U.S. or its contractors;

e. Assume responsibility for construction and installation of all non-Federal project features;

f. Maintain and operate all the non-Federal works after completion in accordance with regulations prescribed by the Secretary of the Army;

g. Provide and maintain berthing areas, floats, piers, slips, and similar marina and mooring facilities as needed for the transient and local vessels, as well as needed public use shore facilities open and available to all on equal terms;

h. Assume financial responsibility for the cleanup of hazardous materials located on project lands and covered under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) without cost-sharing credit; and

I. Be responsible for operating, maintaining, repairing, replacing and rehabilitating the project in a manner so that liability will not arise under CERCLA.

The City of Nome has the ability to obtain the non-Federal portion of the project funds. This will be a combination of local and state funds. The City Council will authorize expenditures from the Port enterprise fund and the State Department of Transportation will also propose partial funding for this feasibility study in the Governor's budget which will be considered by the Legislature in its upcoming session which begins in January.

The Port of Nome was the Corps' first project in Alaska and has helped Nome become what it is today. The Port currently serves as the only regional port in Northwest Alaska and is growing due to this transhipment activity, along with expansion of the fisheries in the Community Development Quota program, and increased marine related tourism activity. The proposed improvements to the Port will increase water borne commerce in the Bering Strait region, reduce navigation safety hazards inherent in the current jetty configuration, and also reduce sedimentation sources which should lower the Corp's maintenance expenditures for Nome.

I want to thank you for your commitment to the Port of Nome and for the dedication and professionalism of your staff, particularly Sofia Troutman and Carl Stormer, in preparing the Reconnaisance Study and the Project Study Plan. We understand that if this letter of intent is acceptable, you as district Engineer will recommend that funds for the Federal share of the feasibility study be procured. We understand that this letter is a statement of intent, not a binding contract.

Sincerely,

John Handeland, Mayor
City of Nome

EN-CW

STATE OF ALASKA

TONY KNOWLES, GOVERNOR

3132 CHANNEL DRIVE
JUNEAU, ALASKA 99801-7898

TEXT: (907) 465-3652
FAX: (907) 586-8365
PHONE: (907) 465-3900

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

OFFICE OF THE COMMISSIONER

May 26, 1998

Sheldon L. Jahn, Colonel
District Engineer, Corps of Engineers
U.S. Army Engineer District, Alaska
PO Box 898
Anchorage, Alaska 99506-0898

Dear Colonel ~~Jahn~~: Sheldon,

The Department has reviewed the draft Navigation Improvements Study for the Port of Nome. The Nome project, in response to the significant demand for improvements to make the port more productive and safer for marine operations represents an important improvement to transportation in Alaska.

The State and City have made a considerable investment in the existing causeway, barge facility and small craft harbor. The proposed project will protect and enhance the utility of these major port facilities. Of note is the City's willingness to fund substantial project development costs. This will greatly enhance the community's position for receiving additional support for the non-federal cost of the project.

The community has been successful in obtaining all funds needed to bring the project to the current threshold. While direct financial participation by the State is subject to appropriations, the Department supports this project and the community's effort in securing funding through that process.

Sincerely,

Joseph L. Perkins, P.E.
Commissioner

cc: John Handeland, Mayor, City of Nome

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CITY OF NOME

P.O. BOX 281 - NOME, ALASKA 99762
TELEPHONE (907) 443-5242

June 24, 1998

COLONEL SHELDON L. JAHN
Commander and District Engineer
U.S. Army Corps of Engineers
P.O. Box 898
Anchorage, Alaska 99506-0898

SUBJECT: CITY OF NOME SUPPORT AND MATCHING CONTRIBUTION FOR THE PORT OF NOME NAVIGATIONAL IMPROVEMENTS PROJECT

Dear Colonel Jahn:

On behalf of the City of Nome, Alaska, I wish to state our strong support for the proposed Port of Nome Navigational Improvements Project ("Project") as studied and modeled by the U.S. Army Corps of Engineers with the support of the City as a partner in the feasibility study. We agree with and support the findings in the feasibility study.

We understand that the preliminary "fully-funded" estimate for the Project is $24,878,000. We further understand the City of Nome will be required to contribute $4,039,000 as our part of the up-front Project cost share; while the remaining cost share portion, amounting to $1,010,000, can be financed over a 30-year period. This amount ($5,049,000) represents approximately 20% of the total fully funded project cost and includes: 100% of local costs, 20% of the general navigation features cost, 35% of the costs of dredging in excess of 20-feet, 25% of the planning engineering and design costs, and 100% of LERRDS. The local cost share amount represents 100% of local costs, 20% of the General Navigation Features, 25% of the cost of dredging in excess of 20-ft., 25% of the Planning Engineering and Design Cost and 100% of LERRDS.

The City has conducted several work sessions and town meetings in discussing this project as well as other community projects for inclusion in our capital plan and legislative priorities. The Port Project has been identified by City Council resolution as one of Nome's top priorities and we have actively promoted this project to our federal and state legislative representatives and state administrative officials.

We believe in the benefits of the Project. One hundred years of Nome's history are filled with tales of maritime losses caused by Bering Sea storms and difficulties accessing Nome's port/harbor facilities for safe harbor sheltering and commerce. Hundreds of thousands of dollars have been lost over the years and lives placed at risk due to vessels awaiting out storms for days

at a time awaiting oceanic conditions to subside to safe levels for mooring. The Port Project will save lives and dollars and cause Nome to become a more attractive community to the maritime industries.

Our support and belief in the Project has also been shared by the Alaska Industrial Development & Export Authority (AIDEA) whose Board unanimously approved a loan to the City in an amount up to $30,000,000 for this project. Anticipating this loan will enable the Project construction to be initiated as early as 1999, this loan will be repaid by the Corps' and City's contributions. State legislation has been passed which authorizes this loan by AIDEA.

The City intends to meet the matching funds requirement through the following measures:

1) With the passage of legislation authorizing the AIDEA loan, the City will utilize an appropriate amount of these loan funds to match its 20%. The City will work with AIDEA in the development of repayment terms for these funds.

2) The City is actively seeking grant support from the State of Alaska through the DOT/PF's program of Corps-projects matching funds. Through these efforts, we hope to acquire at least 50% of our match. (Refer to the May 26, 1998 letter of support from State DOT/PF Commissioner Joseph L. Perkins, P.E. indicating his interest in and support of the Project.)

3) The City intends to seek available sources of revenue such as revenue bonds (if needed) for the repayment of the AIDEA loan dollars attributable to the City's matching portion. The debt service on these bonds will be met through several revenue-generating methods including, but not limited to, port tariff rate adjustments, increased port and harbor use, port land leases on existing properties and to-be-developed properties, prospective increased revenues from the newly-constructed small boat harbor.

We are impressed by the scope of the Project design and the work of the professionals who have contributed to the Project's study, design and administration. We are committed to participate in the Project. Furthermore, we are appreciative of the cooperation of the Corps of Engineers and its personnel and look forward to promoting this partnership of federal, state and local governments.

Sincerely
CITY OF NOME, ALASKA

JOHN K. HANDELAND
Mayor