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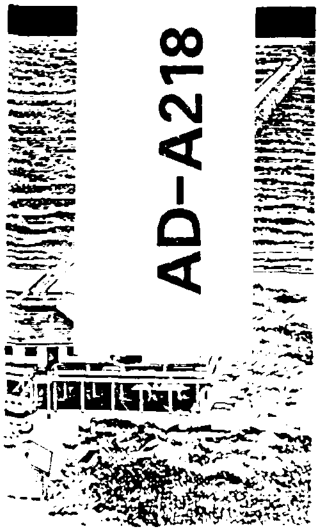

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ECONOMIC EVALUATION OF PROPOSED HELICOPTER LIDAR BATHYMETER SYSTEM

by

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Final Report

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This report presents an economic evaluation of the likely performance of a Helicopter Lidar Bathymeter System (HLBS), which is being developed through an international agreement between the United States and Canada. Optech, Inc., is developing the HLBS system, and the US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, is directing the overall development program.

The HLBS is being designed to operate out of a medium-sized commercial helicopter (such as a Bell 212) at approximately 200-m altitude. The system will generate a laser scan width of about 100-m wide and fly at speeds ranging from a few knots to 75 knots. Because of this significant increase in coverage rate, the system has potential to provide cost savings to the US Army Corps of Engineers. The report provides details and results of the economic feasibility analysis.

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EXECUTIVE SUMMARY

Introduction

The following pages present an evaluation of the likely economic performance of the Helicopter Lidar Bathymeter System (HLBS) under development for the U.S. Army Corps of Engineers (USACE) by Optech, Incorporated of Ontario, Canada. The HLBS employs a laser measuring device (Lidar), ground positioning systems, and data acquisition and processing systems to conduct hydrographic surveys with a degree of accuracy suitable for Class II and Class III USACE surveys. The system will operate on a Bell B-212 helicopter chartered from a commercial operator. The Coastal Engineering Research Center (CERC), which has the responsibility for directing and overseeing this project for the USACE, has received a conceptual design report from Optech and now faces a decision of whether to contract for the development of the operational prototype. The analysis reported herein relies on the Optech document for information on the performance of this system. A separate assessment of the technical merits of HLBS under CERC direction parallels this effort.

According to the Office of the Chief of Engineers, USACE contracts for or performs in-house over $30 million worth of Class II and Class III surveys during a typical year. However, a survey of Corps field offices shows that only a small proportion of these may have potential for HLBS use. The ultimate benefit of HLBS to the Corps depends on the annual volume of current survey projects which can be conducted using HLBS and the level of cost savings achieved.

This economic analysis assumes that the Corps will invest $5.55 million in the Optech system over the next three fiscal years and that two years will pass before the HLBS will be ready to conduct operational missions. (The HLBS will survey a number of projects during the formal test program but savings from these have not been included in this economic analysis.)

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The analysis seeks to answer the question: "Would USACE receive a positive return from contracting surveys to the private firms owning an HLBS?" This is referred to as the Contractor-owned/Contractor-operated scenario (Co/Co). The analysis addresses six variations of this basic scenario including one that asks: "Would USACE receive a positive economic return contracting with private firms to operate the government-owned operational prototype HLBS?" This is referred to as the government-owned/contractor-operated scenario (Go/Co).

If the economic analysis shows that USACE lost money under all of these scenarios, then one would question the economic worth of HLBS to the Corps. If, however, the program lost money under some scenarios and not others, then other factors would have to be weighed in order to reach a decision. If all scenarios show a positive return, then the system is more likely to provide the Corps with a long-term economic benefit.

Principal Findings

The economic analysis of HLBS includes the following findings:

- *A Contractor-owned/Contractor-operated HLBS should allow the Corps to provide Class II and Class III hydrographic surveys at a lower cost than today.*
- *The Government-owned/Contractor-operated operational prototype HLBS will provide a positive return on the Corps' investment.*
- *The economic analysis is most sensitive to annual mission hours and acquisition cost. In particular, acquisition costs are most important when annual mission hours are low.*
- *The potential savings from HLBS are greatest when a number of projects and missions are conducted together. This minimizes the influence of mobilization/demobilization on total costs.*

Economic Evaluation of the HLBS

The Net Present Value Technique

The accepted technique for evaluating the worth of investments which last longer than a single year is a net present value (NPV) or discounted cash flow analysis. In cases such as HLBS, the government will expend funds over a period of years to develop the system while achieving operational savings during later years. Similarly, a commercial operator would buy the system with an initial payment and then use it for a number of years, receiving some positive cash flow on account of its use. In cases such as these, one should recognize that the investment and operating savings occur in different time periods. Money has a time value: a dollar today is worth more than a dollar in the future, since it could earn interest. The NPV technique considers the time value of money.

The NPV technique brings all cash flows back to the present using a discount rate which reflects the potential alternative uses for the money. By bringing all cash outlays and cash savings back to the same point in time, one can determine whether an investment is worthwhile or whether it is the better of several investments. In the context of HLBS, cash outlays refer to the expenses incurred to buy and operate HLBS, while cash savings refer to money not spent to conduct conventional surveys. An NPV greater than zero means that USACE would save money by investing in HLBS technology.

A key parameter in the NPV analysis is the discount rate chosen to reflect the opportunity cost of the money invested. The Office of Management and Budget (OMB) prescribes a discount rate of ten percent in the evaluation of government projects.

<u>Annualized Costs</u>

When private sector firms invest in assets, they too must earn a return on their investment. However, such firms cannot borrow at rates as low as the government, must pay taxes on their profits, and have to consider the riskiness of their investment—or the chance that the investment will not work out as planned. The HLBS would constitute a very large investment for those firms and they take the chance that project work may not be forthcoming in sufficient volumes to support this investment. Recall that energy exploration in the U.S. has substantially fallen in the last few years. Companies that had invested in equipment to perform support work have had to sell off the equipment at a loss or perhaps gone out of business. To keep an investment in the HLBS analogous to an investment of similar risk, this analysis uses a 25-percent discount rate to amortize the commercial operators' purchase of the HLBS and associated equipment. The amortization rate converts a large initial investment into a stream of annual payments.

Estimating Prices for a Contractor-Owned HLBS

The following describes how the analysis estimates the price commercial firms would charge for HLBS services. These prices incorporate both the cost of performing the HLBS surveys and the normal profits earned from this work assuming that competitive conditions prevail in the market for contract hydrographic surveys. As shown below, these costs consist of helicopter charges, salaries and overhead for the contract laser and ground crew, the per diem allowances, the ground transportation for setting up ground stations, post processing, and HLBS maintenance. On top of this, the amortized cost of the investment is allocated across the different missions, assuming an annual contract of 150 mission hours. The amortization rate of 25 percent includes a normal profit. The cost savings to the Corps result from differences in the expected conventional survey costs and the estimated contractor price for the same mission. They represent the net annual benefits to Corps from HLBS operation. Using the OMB-prescribed discount rate of ten percent, this stream of benefits has been discounted to the present year, revealing the "Net Present Value in 1989 to USACE" shown in the tables.

Missions Evaluated

The economic analysis estimates the savings which would accrue from using HLBS to perform six specific survey missions selected in consultation with CERC. They include the following:

- Cape Cod Canal along with two small projects in the immediate area;

- o Delmarva Peninsula in Virginia—approximately 70 miles of the inland waterway;
- o Florida Intracoastal Waterway—approximately 140 miles of waterway along the west coast of Florida along with Tampa Harbor and several other projects;
- o A total of 37 harbors and inlets along the Maine Coast;
- o New Jersey Intracoastal Waterway—110 miles of waterway along coastal New Jersey;
- o Miami/Hollywood Area—a condition survey of ten miles of beachfront in Miami, four Florida harbors, and the harbor in San Juan, Puerto Rico.

Scenarios Evaluated

The base-case scenario of the economic analysis treats all six of these missions as having been conducted independently of one another. This means that each mission bears separate mobilization/demobilization costs for the HLBS and helicopter. The analysis also considers, however, pairing the six missions into three groups (division-wide scenario) and then treating all six missions as a single unit (Corps-wide scenario). The analysis also considers different ownership scenarios and the use of various types of positioning systems. These scenarios include:

1. Contractor-owned/Contractor-operated (Co/Co): Separate projects with UHF Trisponder.
2. Co/Co: Division-wide with UHF Trisponder.
3. Co/Co: Corps-wide with UHF Trisponder.
4. Co/Co: Separate projects with two-dimensional GPS.
5. Co/Co: Separate projects with three-dimensional GPS.
6. Government-owned/Contractor-operated (Go/Co): separate projects with UHF Trisponder.

Critical Assumptions

Because of the unproven nature of HLBS technology, a number of assumptions had to be made about relevant technical and economic parameters. The most important of these are as follows:

- The HLBS would require a Corps investment of $5.55 million which includes all software, data processing equipment and initial provisions of spare parts. The system would operate for seven years and would have no value at the end of this period.

- Annual system maintenance costs per year would be five percent of the HLBS commercial acquisition costs of $2.75 million or $137,500 per year.

- In the Co/Co scenarios, the HLBS would operate for 150 hours per year to complete Corps surveys. This equates to about $2.8 million worth of existing Corps surveys using conventional techniques.

- The Go/Co scenario assumes an increasing level of contracted missions rising from $900,000 in 1991 to $8.6 million in 1995 and thereafter.

- A B-212 helicopter would be chartered for $3,000 per day and $660 per flight hour. This price includes two pilots and a mechanic.

- The helicopter lessor will take two days to install and remove the HLBS and it will take two days and sixteen flight hours to travel to and from the mission area.

- The helicopter operates at a speed of 20 knots and an altitude of 200 meters when gathering data. This geometry produces a swath width of approximately 350 feet having a spot spacing of less than five meters along the line of flight. A swath width of 300 feet was used in the analysis of the missions to allow for a margin of error. The helicopter flies at 100 knots when not gathering data (deadhead).

- The helicopter must land at an airport supplying Jet-A fuel within a two-and-one-half hour flight time, while conducting surveys.

- The HLBS survey crew consists of four persons. This provides two people to operate the HLBS in the helicopter and two persons responsible for the placement of ground positioning systems and tide gauges.

- Each hour of data gathered will require two people working five hours each to prepare the survey products. (In the case of 3-D GPS ground stations, a six-to-one ratio would apply.)

- An additional 15 percent of mission and post processing costs were used to accommodate for potential inefficiencies.

Co/Co: Separate Missions with UHF Trisponder

This section examines one mission, the Florida Intracoastal Waterway, in detail and then presents the findings of the other missions.

The Florida Intracoastal Waterway Mission

Table 1 shows the projects included in the analysis of the Florida Intracoastal Waterway mission. This mission consists of a number of small projects along the west coast of Florida, a 140 mile segment of the Intracoastal Waterway, and a major project at Tampa Harbor. The expected conventional costs for this scenario are approximately $175,500 per year. Table 1 also shows the survey days, additional ground days and flight times for the mission. The helicopter flies deadhead when it is not collecting data.

Table 2 shows the basic assumptions used for the HLBS analysis. These include a commercial HLBS price of $2.75 million along with a UHF ground positioning system and tide gauges which cost $200,000. This table also includes other relevant parameters. Table 3 shows the derivation of the annual HLBS operating costs of $58,731 for this mission. Most of these costs result from the daily and hourly use charges for the helicopter. Figure 1 shows the areas surveyed in Tampa Bay on Day 3 of the mission.

All Missions

Table 4 shows the six missions considered in the study along with their expected conventional survey costs, the HLBS operating costs per mission, number of survey hours and HLBS days required, and the contractor price for performing each mission. This scenario assumes separate mobilization and demobilization for each mission. The price per mission is based on estimated HLBS operating costs and a 25 percent return on investment to the contractor based on 150 productive mission hours per year. Table 5 shows how the net present value is calculated based on a commercial HLBS costing $2.75 million and annual maintenance costs of five percent of this acquisition costs. The net annual benefit used in calculating the net present value arise from the $208,944 difference between the total expected conventional cost and the total price per mission. This figure has been raised to reflect a benefit level equivalent to 150 hours of HLBS survey work. In this scenario, the net present value to the Corps is approximately $3,185,207.

Table 1. Project Description of FL-IWW Mission

	Conventional			HLBS					
				Nautical Miles					
PROJECTS	Cost ($000)	Survey Freq	Expected Cost	Survey	Deadhead	Survey Days	Extra Grnd Days	Survey (Hours)	Deadhead (Hours)
Alafia River	3.0	1.00	$3,000	3.566	2.962			0.18	0.03
Anclote River	15.0	1.00	$15,000	7.241	1.975			0.36	0.02
Casey Pass	3.0	1.00	$3,000	0.434	0.408			0.02	0.00
Charlotte Harbor	4.5	1.00	$4,500	7.000	2.660			0.35	0.03
Clearwater Pass	2.5	1.00	$2,500	3.000	2.301			0.15	0.02
Hillsborough River	9.0	0.50	$4,500	2.414	24.375			0.12	0.24
IWW- CR to AR	30.0	1.00	$30,000	139.680	260.650	1.25	0.5	6.98	2.61
Johns Pass	7.5	1.00	$7,500	1.759	1.539			0.09	0.02
Longboat Pass	5.0	1.00	$5,000	1.646	1.317			0.08	0.01
New Pass	4.5	1.00	$4,500	3.493	2.997			0.17	0.03
Ozona	3.0	0.50	$1,500	1.136	1.136			0.06	0.01
Pass-A-Grille Pass	3.0	0.50	$1,500	2.567	1.990			0.13	0.02
St. Petersburg Harbor	3.0	1.00	$3,000	5.728	6.616	0.25		0.29	0.07
Tampa Harbor	90.0	1.00	$90,000	117.250	43.460	1		5.86	0.43
Totals	**$183**		$175,500	296.9	354.4	3.0	0.5	14.8	3.5

Table 2. Basic Assumptions

Co/Co Scenario

Positioning System (UHF); Separate Projects

LIFETIME COSTS		MISSION COSTS	
Commercial System Price	$2,750,000	Helicopter Lease Cost (Fixed)	$3,000
Positioning System (UHF)	$200,000	Helicopter Lease Cost ($/Flt.Hr)	$660
Equipment Time Horizon (Years)	7	Helicopter Set Up Time (Days)	2.00
		Helicopter Ferry Time Days (RT)	2.00
ANNUAL FACTORS		Helicopter Ferry Flight Hours (RT)	16.00
		Helicopter Crew	3
System Maintenance (% of Price)	5.00%		
Annual Mission Hours	150	Travel & Per Diem (Per Prsn/Day)	$70
		Number of Technical Laser Crew	2
LASER CREW PRICES PER DAY		Number of Ground Crew	2
		Number of Post Processing Crew	2
Party Chief	$325	Per Diem Cost Per Ground Vehicle	$50
Electronic Technician	$300		
Assistant Surveyor	$275	OPERATIONAL CHARACTERISTICS	
DISCOUNTING FACTORS		Survey Speed (Knots)	20
		Deadhead Speed (Knots)	100
OMB Discount Rate	10.0%	Altitude (Meters)	200
Private Discount Rate	25.0%	Swath Width (Feet)	300
Contractor-Owned/Contractor-Operated		Coverage Rate (Sq N Miles/Hr)	0.99
Amortization Factor	0.3163	Processing/Survey Hours Ratio	5
		Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3. Operating Costs per Mission

Co/Co Scenario;Separate Projects

Positioning System (UHF)

Mission: FL-IWW — OPERATING COSTS PER MISSION

HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	3		$9,000
Helicopter Mission Flight Hours	18.4		$12,137
Travel & Per Diem (Per Prsn/Day)	$70		$1,470
Total Helicopter Costs			$45,167
LASER CREW COSTS			
Number of Mission Days--Laser Crew	3		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$1,875
Travel & Per Diem (Per Prsn/Day)	$70		$420
Total Laser Crew Cost			$2,295
OTHER COSTS			
Number of Mission Days--Ground Crew	3.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$1,925
Travel & Per Diem (Per Prsn/Day)	$70		$490
Ground Transportation	$50		$350
Number of Survey Hours	14.85		
Post Processing (Technician $/Hr)	$38		$5,567
Efficiency Factor	15.0%		$2,937
(% Helicopter Flight, Laser Crew			
Total Other Costs			$11,269
TOTAL OPERATING COSTS PER MISSION			**$58,731**

Table 4. Summary of Costs and Prices

Co/Co Scenario Separate Projects

With UHF Trisponder Ground Positioning System

	Expected	HLBS					
Missions	Conventional Cost	Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Mission Price
Cape Cod	109,500	31,411	2.0	5	12,630	15,778	61,932
DelMarVa	69,765	34,733	3.5	5	5,779	10,000	68,482
FL-IWW	175,500	58,731	14.8	7	3,194	4,006	115,799
Hollywood	151,700	73,059	8.0	9	2,529	9,278	144,050
Maine	111,010	49,025	4.1	7	4,388	12,043	96,661
New Jersey	150,000	36,318	6.1	5	5,470	6,044	71,607
Total	**$767,475**	**$283,276**	**38.6**	**38**	**$5,665**	**$9,525**	**$558,531**

Table 5. Net Present Value to USACE

Co/Co Scenario

Positioning System (UHF); Separate Projects

Net Annual Benefit	$208,944	Amortization Factor	31.63%
Amortized First Costs	$933,208	Annual Mission Hours	150
Annual Costs	$1,070,708	Discount Rate	10.00%

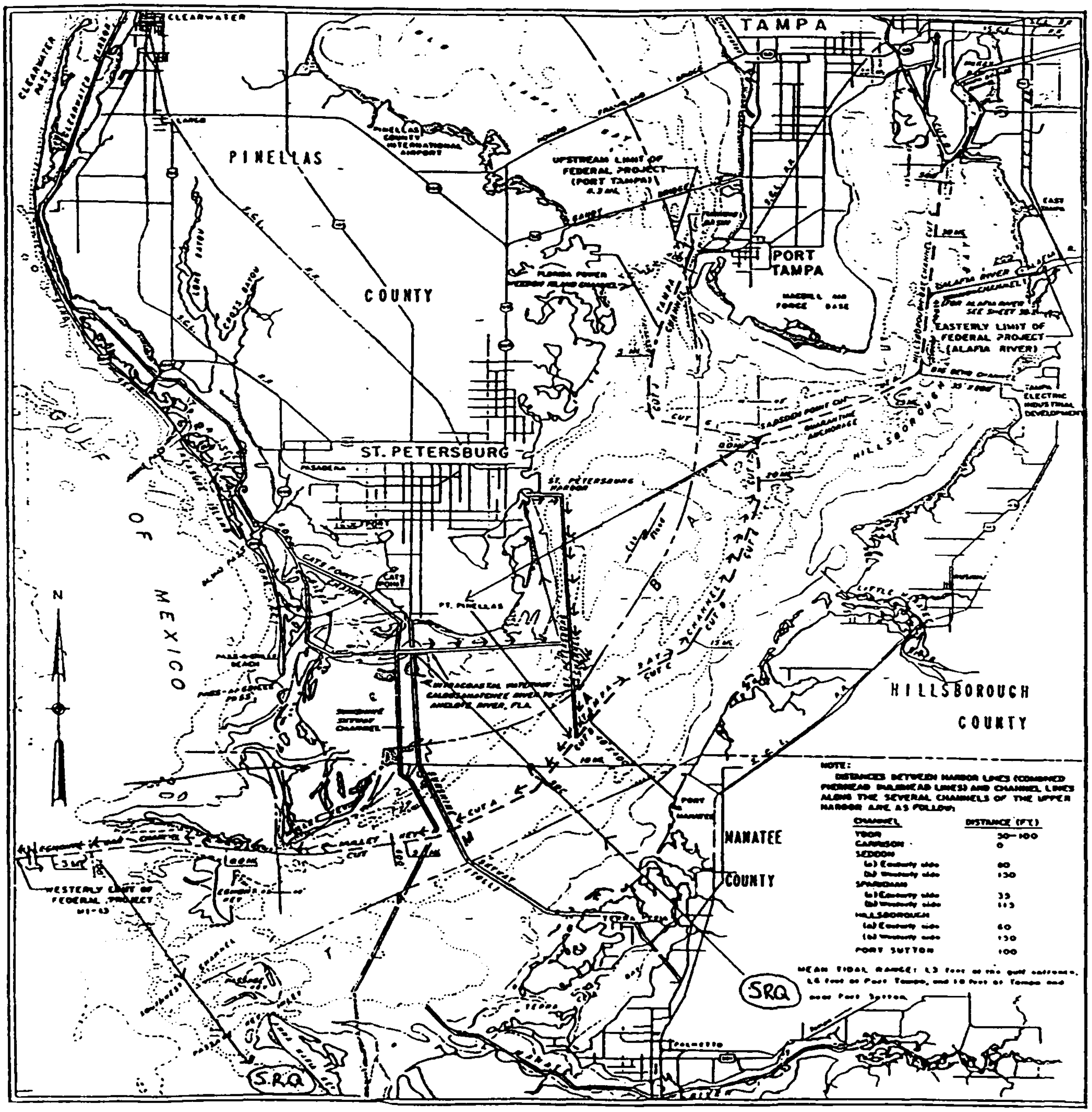
Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			812,768	812,768	812,768	812,768	812,768	812,768	812,768
Costs			---	---	---	---	---	---	---
Net Benefits			812,768	812,768	812,768	812,768	812,768	812,768	812,768
Discounted Net Benefits			602,113	544,814	492,968	446,056	403,608	365,200	330,447

Net Present Value in 1989 To USACE: ***$3,185,207***

Figure 1

TAMPA BAY

Day 3



Other Scenarios

The analysis also examined the benefits to the Corp from various levels of mission aggregation, alternative ground positioning systems and from the government prototype HLBS.

Mission Aggregation

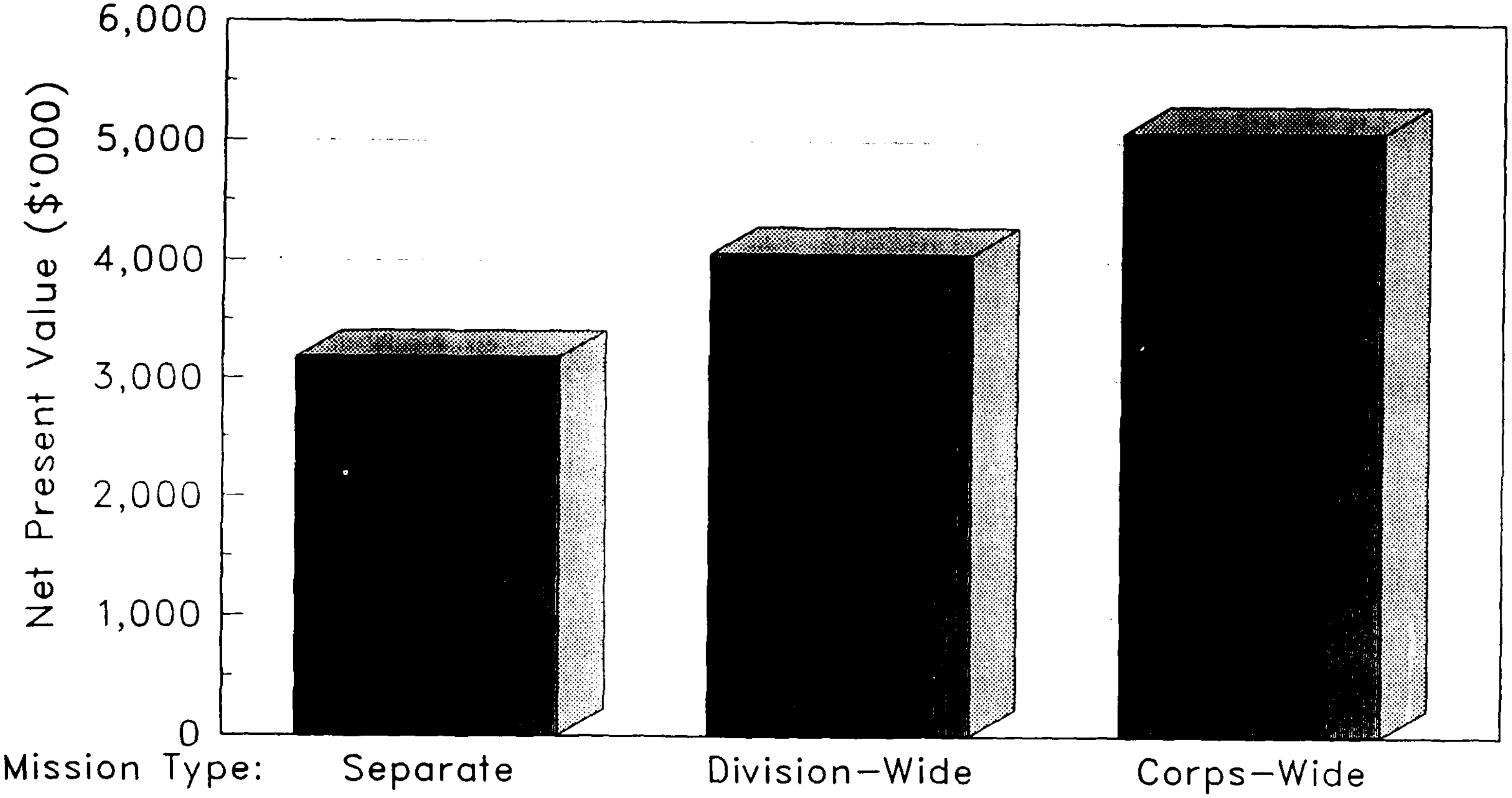
Figure 2 compares the net present values in 1989 of various HLBS mission scenarios based on varying levels of aggregation. For example, it shows that a Contractor-owned/Contractor-operated system conducting the six separate missions would produce a net present value of savings of approximately $3,185,207 for the Corps. These results are based on 150 hours of HLBS use per year and a system cost of $2.75 million. The net present value increases substantially as the six individual missions are grouped at the division-level and then again at the Corps level. These gains occur because fewer mobilizations/demobilizations occur when missions are aggregated.

Alternative Ground Positioning Systems

Figure 3 shows changes in the NPV for a Contractor-owned/Contractor-operated HLBS conducting the six separate missions using various ground positioning systems: UHF Trisponder, two-dimensional GPS or three-dimensional GPS. It can be seen that the economic analysis results are relatively insensitive to the choice of positioning system. This occurs because the UHF Trisponder has a low per unit cost. Even with a dozen automatic tide gauges, the equipment acquisition for this method would cost only $200,000 at 1989 price levels. The real savings might occur with the three-dimensional GPS system, which does not need separate tide gauges. This would greatly reduce the effort required to survey the Maine mission. Nevertheless, because the three-dimensional GPS system requires more post-processing time, the gains from the tide gauge advantage are all but negated.

Figure 2

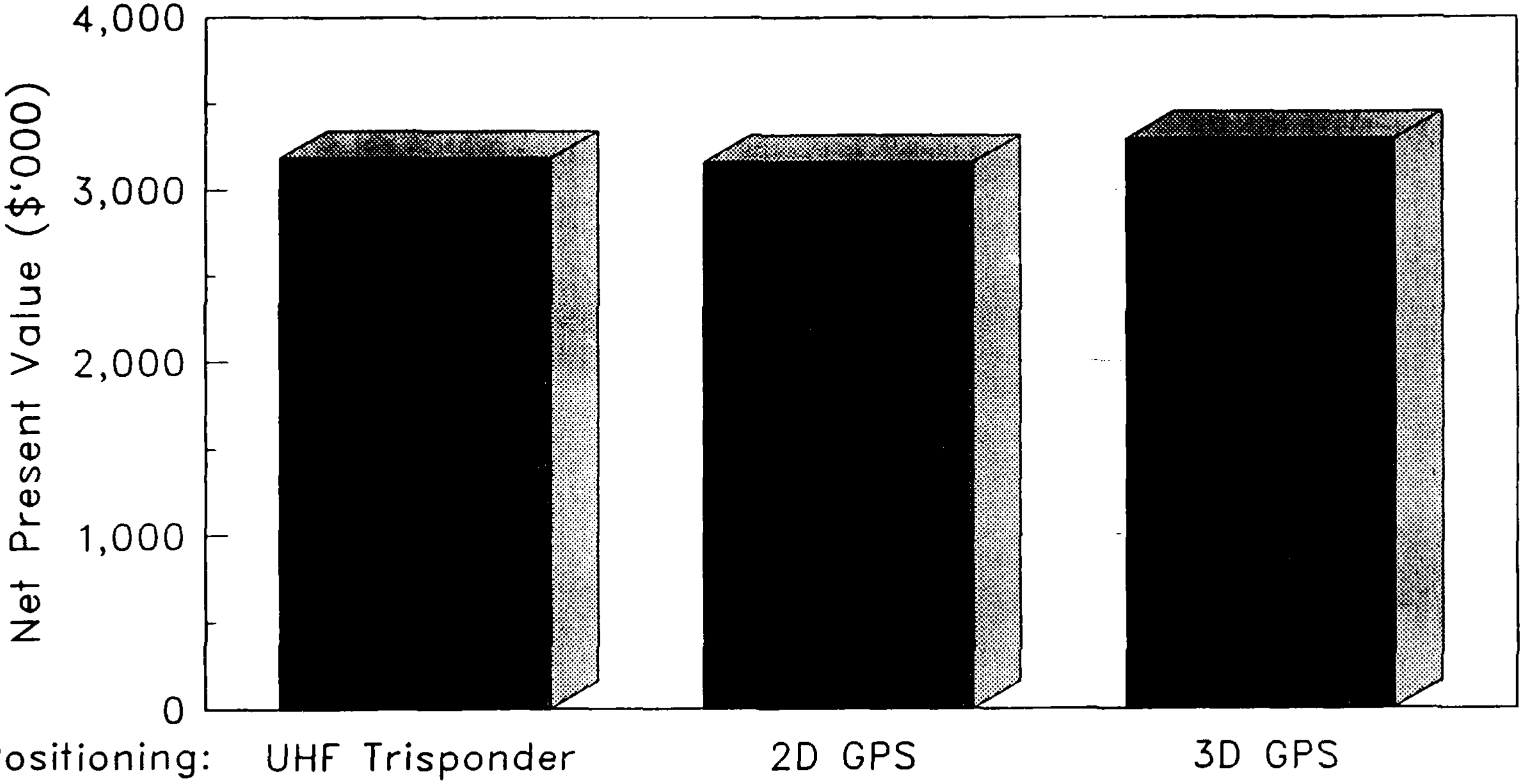
Comparison of HLBS Scenarios by Level of Mission Aggreagation



Note: All scenarios Contractor–Owned/Contractor Operated with UHF positioning.

Figure 3

Comparison of HLBS Scenarios by Type of Ground Positioning System



Note: All scenarios Contractor–Owned/Contractor Operated as separate missions.

Government-Owned/Contractor-Operated HLBS

Table 6 shows the economic analysis results for the government-owned/contractor-operated (Go/Co) scenario. It shows the missions included, the expected conventional survey costs and the HLBS operating costs. The net operating benefit is the difference between the cost of conducting the survey with conventional means and the cost of the survey using HLBS. Table 7 shows the net present value to the Corps of the Go/Co scenario. This is based on a recovery of all Corps costs for the development program and assumes seven years of operation thereafter conducting Corps survey missions under operation by a private contractor. The net annual benefit has been increased to account for increasing numbers of HLBS missions USACE will put under contract. (The Co/Co scenario, conversely, assumes a fixed contract equivalent to 150 mission hours.) The net present value to the Corps from this scenario is $6,650,869.

Sensitivity Analysis

This section shows how the economic analysis results change under different assumptions regarding methods of operation and costs. The sensitivity analysis uses the Co/Co: Separate Projects with UHF Trisponder scenario. Figure 4 shows how the net present value changes using a helicopter lease cost of $3,000 per day and various levels of HLBS acquisition costs and annual mission hours. At 150 hours of use per year, the Co/Co HLBS breaks even at an acquisition cost of $5 million. One reason for the importance of increased utilization can be seen in Figure 5 which shows the allocation of amortized acquisition and maintenance costs per hour at various levels of annual mission hours. For example, these costs fall in half from $10,707 per hour at 100 hours of use to $5,192 at 200 hours of use. As the number of mission hours increase, the annual cost per mission hour decrease.

Table 6. Summary of Costs and Prices

Go/Co Scenario Separate Projects

With UHF Trisponder Ground Positioning System

Missions	Expected Conventional Cost	HLBS Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Net Benefit
Cape Cod	109,500	31,411	2.0	5	12,630	15,778	78,089
DelMarVa	69,765	34,733	3.5	5	5,779	10,000	35,032
FL-IWW	175,500	58,731	14.8	7	3,194	4,006	116,769
Hollywood	151,700	73,059	8.0	9	2,529	9,278	78,641
Maine	111,010	49,025	4.1	7	4,388	12,043	61,985
New Jersey	150,000	36,318	6.1	5	5,470	6,044	113,682
Total	$767,475	$283,276	38.6	38	$5,665	$9,525	$484,199

Table 7. Net Present Value to USACE

Go/Co Scenario

Positioning System (UHF); Separate Projects

Net Annual Benefit	$484,199	Amortization Factor	20.54%
Amortized First Costs	$605,946	Annual Mission Hours	150
Annual Costs	$743,446	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			567,808	1,167,162	1,766,515	3,596,120	5,425,725	5,425,725	5,425,725
Costs	550,000	2,500,000	2,637,500	137,500	137,500	137,500	137,500	137,500	137,500
Net Benefits	(550,000)	(2,500,000)	(2,069,692)	1,029,662	1,629,015	3,458,620	5,288,225	5,288,225	5,288,225
Discounted Net Benefits	(497,661)	(2,046,827)	(1,533,265)	690,203	988,048	1,898,131	2,626,055	2,376,153	2,150,032

Net Present Value in 1989 To USACE: ***$6,650,869***

Figure 4

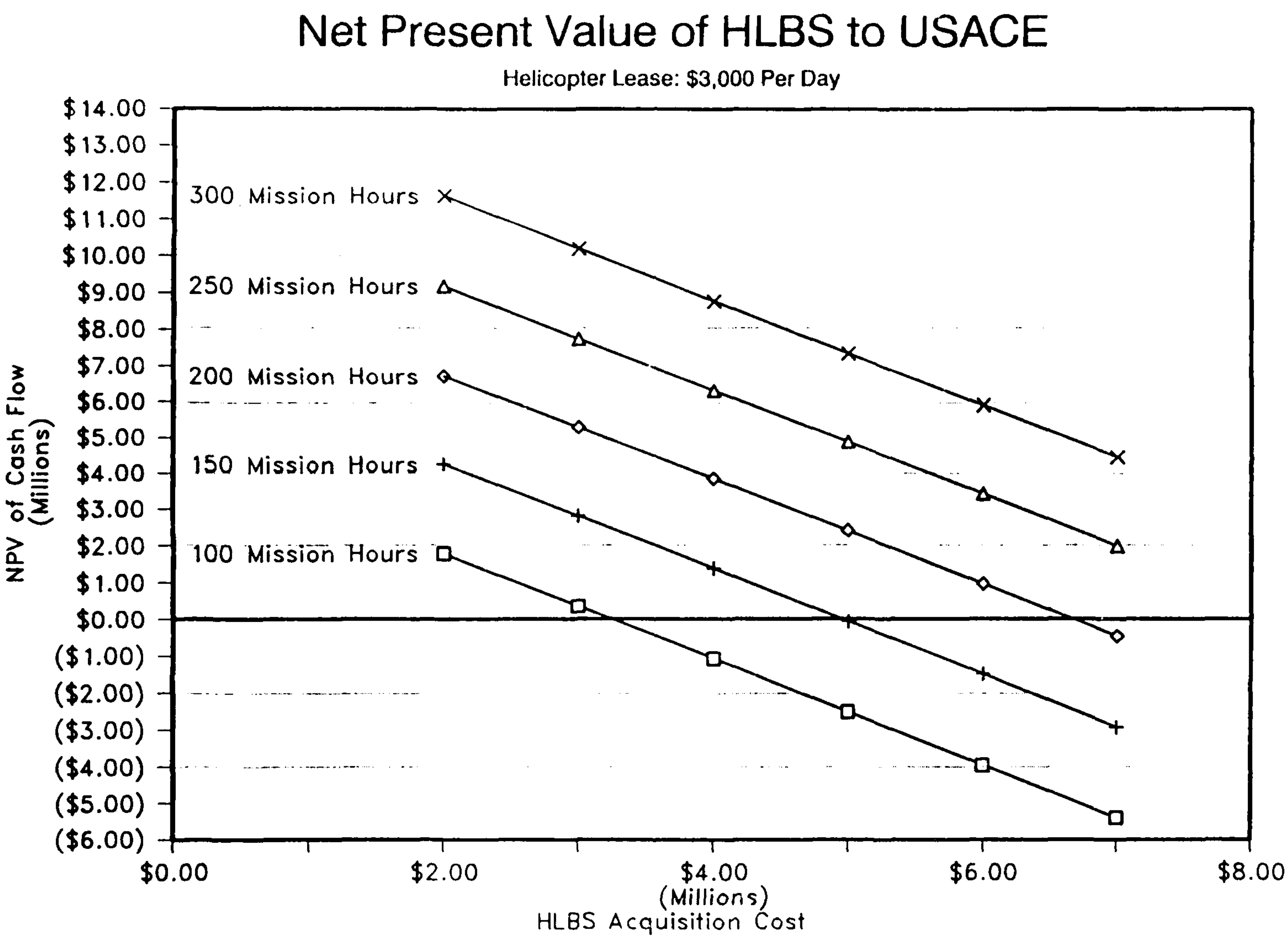
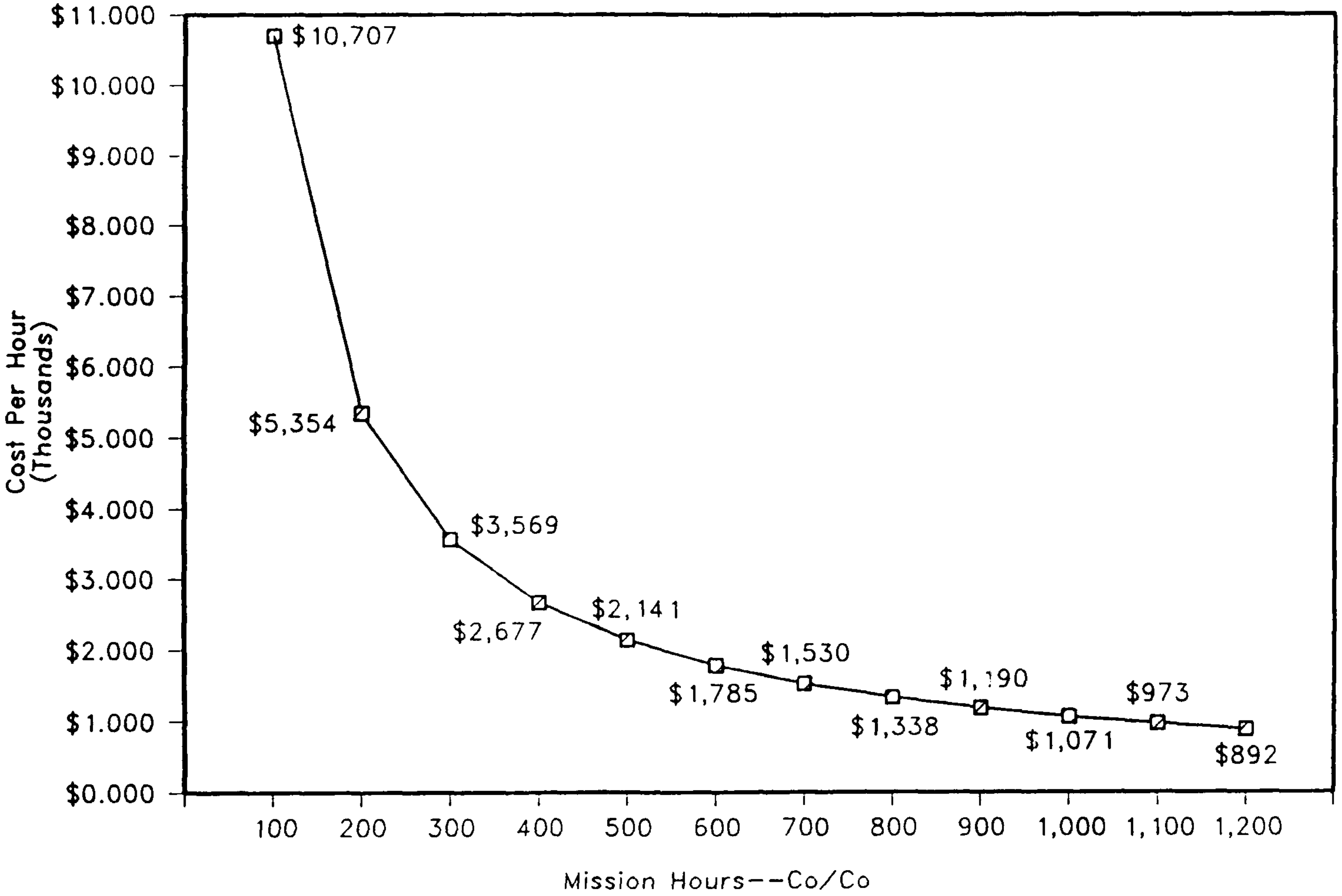

Net Present Value of HLBS to USACE
Helicopter Lease: $3,000 Per Day
300 Mission Hours
250 Mission Hours
200 Mission Hours
150 Mission Hours
100 Mission Hours
$14.00
$13.00
$12.00
$11.00
$10.00
$9.00
$8.00
$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00
$0.00
($1.00)
($2.00)
($3.00)
($4.00)
($5.00)
($6.00)
NPV of Cash Flow
(Millions)
$0.00
$2.00
$4.00
$6.00
$8.00
(Millions)
HLBS Acquisition Cost

Figure 5

Annual Costs Per Mission Hour

For Acquistion and Maintenance Costs



The World Market for HLBS Technology

The commercial viability of HLBS will depend ultimately on the following two factors:

- o The cost savings produced by HLBS in comparison to conventional surveys; and
- o The size of the market for which HLBS can produce acceptable survey results.

This study shows the likely cost savings that can be achieved by the Corps if it used HLBS for specific survey missions. HLBS has a broad potential application. For example, many near-shore areas and inland waterways from coastal Maine to Florida appear to be suitable for HLBS surveys during certain times of the year. Similar results are projected for the Gulf of Mexico from Key West to Galveston. Areas of the Great Lakes, Alaska and the Pacific Coast also appear to be surveyable with HLBS. In all these areas, the relevant market includes not only Corps surveys, but also work by federal, state and local government agencies as well as by the private sector.

There are many other areas of the world which ultimately may provide a market for HLBS. Prior studies have identified areas of the Caribbean, the Arctic and the coastal waters of Southeast Asia and Australia as having a high potential for HLBS. Surveys in these areas are currently conducted by the U.S. and foreign governments and the private sector.

PREFACE

The economic feasibility of a Helicopter Lidar Bathymeter System was investigated as part of a Headquarters, US Army Corps of Engineers, program to develop and assess the conceptual design and use of such a system to conduct hydrographic surveys of federally maintained navigation projects. The economic analysis was conducted by Gellman Research Associates, Inc., through a contract with Evans-Hamilton, Inc., (Contract No. DACW-39-88-D-0059) and was monitored by the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC).

The report was written by Messrs. Richard Golaszewski, David Barol, Joseph Phillips, William Zyskowski, and Edward Maillett of Gellman Research Associates, Inc. Point of contact and contract monitoring was provided by Mr. Douglas Evans of Evans-Hamilton Inc. Contract supervision and monitoring were conducted by Messrs. Sam Corson, Thomas Denes, and Jeff Lillycrop, CERC, WES. The study was conducted under the general supervision of Ms. Joan Pope, Chief, Coastal Structures and Evaluation Branch; Mr. Thomas Richardson, Chief, Engineering Development Division; and Dr. James R. Houston and Mr. Charles C. Calhoun, Chief and Assistant Chief of CERC, respectively.

COL Larry B. Fulton, EN, was Commander and Director of WES. Technical Director was Dr. Robert W. Whalin.

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CONVERSION FACTORS, NON-SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
fathoms	1.8288	metres
feet	0.3048	metres
inches	2.54	centimetres
knots (international)	0.5144444	metres per second
miles (US nautical)	1.852	kilometres
miles (US statute)	1.609347	kilometres
pounds (mass)	0.4535924	kilograms
square miles	2.589998	square kilometres

Chapter 1

INTRODUCTION

This report has been prepared for the U.S. Army Corps of Engineers Coastal Engineering Research Center (CERC) by Gellman Research Associates, Incorporated (GRA) under subcontract to Evans-Hamilton, Incorporated. It presents preliminary results of an economic evaluation of a proposed Helicopter Lidar Bathymeter System (HLBS) which is under development for CERC by Optech, Incorporated of Toronto, Canada. The technical details of the HLBS are reported in a document prepared by Optech, Inc., which describes the system.[1] This system is designed to produce hydrographic survey data with a level of precision suitable for Class 2 and Class 3 hydrographic surveys currently performed using a variety of conventional survey techniques for the Corps of Engineers. Such surveys are performed on either an in-house or a contract basis for Corps district and division offices nationwide.

1.1 Purpose of the Study

This study should determine whether the HLBS will offer decreased costs or increased productivity for current survey missions. This economic feasibility study of the HLBS will provide CERC with information necessary to determine whether continuation of the research project with Optech provides sufficient economic benefits. CERC has received findings from other studies assessing the technical merits of HLBS. This economic analysis assumes that the HLBS can produce data at a level of accuracy suitable for Class 2 and Class 3 survey missions. In addition, it is assumes that the laser system will be designed and operated to cause no environmental problems even when

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[1]Optech, Incorporated, Helicopter Lidar Bathymeter System Conceptual Design Report, prepared for U.S. Army Waterways Experiment Station under Contract No. DACW 39-88-C-0038, December 1988.

operated over populated areas. All assumptions regarding the technical performance of HLBS are as stated in the December, 1988, Optech report. In cases where the Optech document does not provide necessary information, this report notes the explicit assumptions used regarding such issues.

1.2 Scope of the Review

The general approach to the economic analysis seeks to provide information on the following question:

- What potential savings could the Corps achieve on current missions were the HLBS available from commercial firms for contract survey work?

The study considers whether application of HLBS technology in commercial production would provide sufficient savings to warrant private sector investment in these systems. Information on this question provides the Corps of Engineers with insights as to whether commercial firms would acquire such equipment for contract survey missions. By estimating the prices contract firms would charge to conduct HLBS surveys, the analysis estimates the cost savings to USACE.

The analysis also considers the dollar benefit over a seven year period which will accrue to USACE from contractor operation of the prototype HLBS for Corps survey missions.

The HLBS currently under development by Optech for CERC can be considered a technology demonstration program. At present, there is only one Airborne Lidar Bathymetry System in operation in North America: the "Larsen 500" system operated by the Canadian Government in a DC-3 fixed-wing aircraft. Preliminary analyses by the Corps of Engineers indicate significant potential savings from the operation of HLBS. However, the unproven nature of this technology requires a demonstration of the technical and economic feasibility of an HLBS in actual survey missions prior to its commercialization. (The Canadian Government is also contributing funds to this development program.)

The Corps of Engineers has provided information on the potential for HLBS application, frequency of surveys, location and cost for conventional survey missions currently conducted by the Corps. This study estimates costs for performing the same missions using the HLBS. For the Contractor-owned/Contractor-Operated (Co/Co) scenario, the study estimates the price of conducting surveys using HLBS. This is based on recovering all capital and operating costs and a return on the commercial firm's investment in the HLBS. The benefit to the Corps in this scenario is the present value of the difference between the cost of these surveys currently and the likely price that would be charged by the commercial survey firm. In the case of the prototype HLBS, the study assumes that it is a government-owned system operated under contract by a commercial survey firm (Go/Co) using a chartered helicopter as an equipment platform. The benefit to the Corps in this scenario is the present value of the difference in cost between conventional survey methods and HLBS costs including the CERC funding provided for the HLBS prototype. This question is answered by considering the aggregate annual value of Corps of Engineers survey missions and the potential cost savings from use of HLBS.

This report includes several sensitivity analyses conducted to investigate how mission aggregation as well as alternative ground positioning systems affect HLBS economics and the applicability of fixed-wing aircraft to perform airborne laser bathymetry missions. In addition, the sensitivity analysis considers the changes in cost based on the effect of different helicopter leasing periods on mission costs, the effect of different HLBS annual utilization levels on mission costs, and other parameters.

1.3 Organization of the Report

Chapter 2 contains a discussion of the approach and methodology used in the economic analysis of HLBS and the development of conventional survey cost data. It also describes the cost model developed for use in the study. Chapter 3 contains an analysis of the economics of using HLBS to perform actual Corps survey missions in relation to the cost of conventional technology for each of the six scenarios. Chapter 4 examines the sensitivity of the baseline economic results to changes in key assumptions. Chapter 5 discusses other issues relevant to the Corps decisions regarding HLBS technology such as the potential size of the worldwide market.

Appendices A through F contain discussions on the individual survey missions.

Chapter 2

ECONOMIC ANALYSIS APPROACH

This chapter describes the assumptions and methodology used to conduct the economic evaluation of the Helicopter Lidar Bathymeter System (HLBS). It discusses the sources of data on conventional survey cost (conventional survey as used in this report means those conducted or contracted by Corps field offices today) by briefly explaining the key elements involved in conducting these surveys. The second section discusses the development of the theoretical costs of using HLBS for survey missions. The final section discusses the structure of the cost model used in the economic analysis.

2.1 Conventional Survey Cost

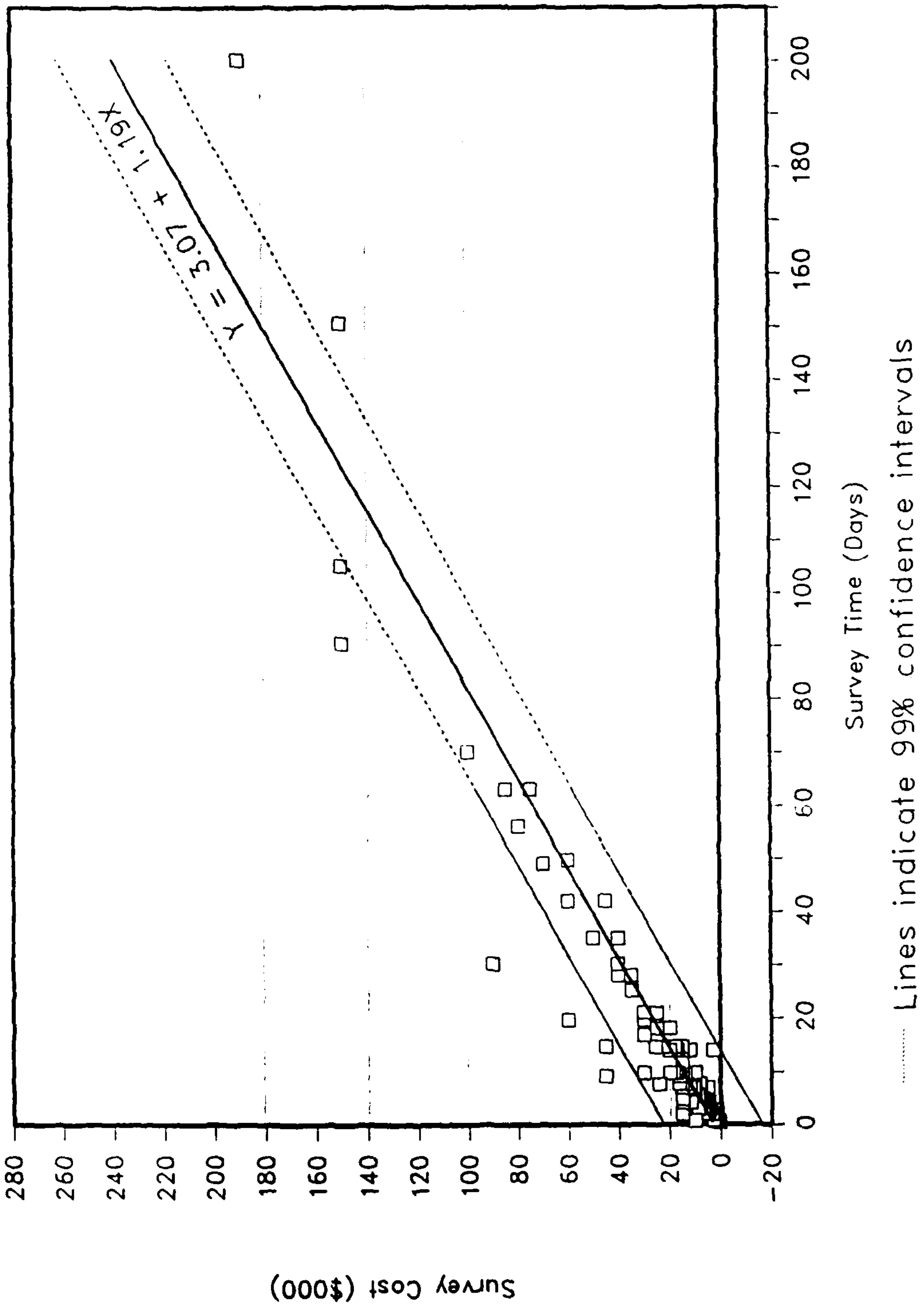
In August, the Corps of Engineers administered a survey of its field offices which conduct hydrographic surveys. The cover letter described the HLBS and suggested parameters which would guide whether a project could potentially be surveyed using the Lidar system. This poll of the field offices requested a list of current projects with a recommendation as to whether the project would be HLBS compatible. In addition, the survey requested both the current and preferred survey and dredge frequencies, water clarity (secchi) depths, the cost of conventional surveys, the time to conduct such surveys and the existence of seasonal limitations.

2.1.1 Review of Corps' Cost Data

From those field offices that responded to the Corps survey, GRA created a data base of nearly 400 Army Corps projects (see Chapter 1). By comparing cost as a function of time-to-conduct the survey (see Figure 2.1), GRA determined which survey responses were beyond the norm. For example, all of the New York District cost data were lower than what would otherwise have been expected and, consequently,

Figure 2.1

Cost of Existing Survey Techniques



results from this district have not been included in this analysis. Upon investigation, the study team found that some other districts also had not provided usable answers and thus their data were deleted from the database.

When reviewing the costs, GRA annualized the conventional cost data as shown in Table 2.1 by taking the survey frequency in years, finding the reciprocal (frequencies of every ten years become .1; every two years become .5; one year or less become 1.0), and then multiplying this number by the cost per survey to find the expected annual cost of surveying each project using the conventional means. *These values were later compared with the HLBS costs to provide measures of the annual survey dollars that were affected by one HLBS survey mission per year.*[1]

Table 2.1

THE DERIVATION OF
ANNUALIZED SURVEY COSTS

Survey Site	Frequency	Cost per Survey	Factor	Annualized Cost
A	Every five years	$20,000	0.2	$4,000
B	Once a year	$100,000	1.0	$100,000
C	Three times per year	$15,000	1.0	$15,000
D	Every ten years	$150,000	0.1	$15,000

2.1.2 Conventional Survey Missions

A hydrographic survey crew generally consists of four people. One individual handles the positioning system and tide gauge. The other three operate the boat and survey equipment. Operating according to a pre-established plan, they take soundings along survey lines perpendicular or parallel to the navigation channel. The interval

[1]This is why those conventional missions surveyed more than once a year were treated as a once-per-year survey.

between soundings and spacing of adjacent survey lines depends on the type of survey. Reference to established survey control points provides the means for establishing horizontal and vertical positions. The crew uses the sounding coordinates to prepare survey worksheets which contain the location and depth of soundings. Today much of the process employs automated equipment.

The survey team requires several specialized pieces of equipment such as a fully automated acquisition and plotting systems, dual frequency echosounder, a three-range X or Z band positioning system, and a vessel. The vessel's size will vary depending on the type of water. In addition, the study team would require personal computers and related software and hardware, some form of ground transportation and, perhaps, automatic tide gauges.

The survey team sets up electronic positioning system stations on the shore which, through triangulation, identify the exact position of the survey vessel. For inland waterways such as rivers and canals, a positioning method by range and azimuth has become the method of choice because, although the range is usually limited, the accuracies are higher. The ranging portion is usually more precise in these applications than that of an X or Z band frequency and regularly gives accuracy within one meter.

Prior to beginning a hydrographic survey, the survey team must set up its ground positioning systems on a Geodesic benchmark or USACE survey control point. By law, these benchmarks must be made available to surveyors. The only problem, which exists for new crews especially, is to gain permission from the landowner to cross the land and to be able to locate the benchmarks. This process may require considerable research prior to the surveying.

All hydrographic surveys require the collection of tidal or water level data to reduce the soundings to mean low tide depths. If an automatic gauge is used, the tide readings may be obtained after the data collection; otherwise, an observer will take manual tide readings during the survey and radio those readings to the survey vessel.

2.2 HLBS Technical Performance and Cost Assumptions

The Army Corps defines three survey classes: Class 1, Class 2 and Class 3, according to purpose and desired accuracy. Class 1 surveys, such as payment surveys which are performed both before and after dredging to measure quantities of fill moved for the determination of the proper payment, require the highest level of accuracy in both positioning and depth measurement so that payments will be consistent with the actual dredging performed. In general, a Class 1 survey requires X and Y (longitude and latitude) positioning accuracy within 1.5 meters, Class 2 require 2.7 meters and Class 3 requires 4.7 meters. The Z (depth) accuracy requirement for Class 1 survey is .5 feet*; Class 2 survey is .8 feet; and Class 3 is 1.4 feet.[2]

The analysis assumes that the data reported in the field office survey reflect all costs of conventional surveys.

2.2.1 HLBS Costs

The operational prototype HLBS will cost $5.5 million for the Army Corps to acquire. This amount includes software development, the purchase of a computer for post processing, a stock of spare parts, and the on board master unit for the ground positioning system. This price also includes training of the first laser crew on system operation. Although several years from production, *the estimated cost of a commercial HLBS unit is $2.75 million. The estimated annual maintenance costs are five percent of the commercial acquisition costs, or $137,500 per year. The operational prototype HLBS will enter operational use two years after the decision to enter development and will have a life of seven years with no salvage value.*

2.2.2 Helicopter Costs

Optech identified a number of candidate helicopter platforms for the HLBS in its December 1988 report. These include the two Bell Helicopter models, the B-205A, the

* A table of factors for converting Non-SI units of measurement to SI(metric) units is found on page 28.

[2] Engineering and Designs: Surveying and Mapping, Department of the Army Corps of Engineers, Office of the Chief Engineer, EM1110-1.

B-212, and the Sikorsky S-76. Of the three candidate helicopters, the B-212 was selected as the most cost-efficient helicopter capable of providing the electric power necessary to operate the HLBS. Besides mounting antennae and installing a power source for the HLBS and pilot guidance system, the helicopter would require no other modifications to transport and operate the system. Based on discussions with Optech and a review of its December report GRA assumes that the HLBS will be mounted to the seat attachment points in the cabin area of the B-212.

GRA conducted inquiries with approximately fifteen B-212 operators identified in the World Aviation Directory (1987) to elicit hourly charter costs and other charter terms for Bell 212 helicopters. *GRA analyzed the data for the U.S. operators to derive the average cost, used in this study, of $3,000 per day (short-term, $1,600 per day long-term) and $660 per flight hour.* This includes the use of the aircraft, a flight crew of two pilots and a crew chief/mechanic to perform normal maintenance. In addition to these charges, all crews involved in field work incur meal and lodging costs of $70.00 per-person-day.

The survey of helicopter operators also provided other useful information regarding the use of the HLBS. In addition to lower daily rental costs, the longer the time period contracted for (greater than 21 days), the more likely the operator would forego the cost of mounting the antennae, the pilot guidance system and the power supply for the HLBS. These potential cost savings, however, have not been factored into the analysis.

In the operational scenarios evaluated in this report, GRA assumes that four helicopter days, along with sixteen flight hours, will be used to mount the equipment, position the aircraft in the general survey area and return it back to base upon completion of the missions.

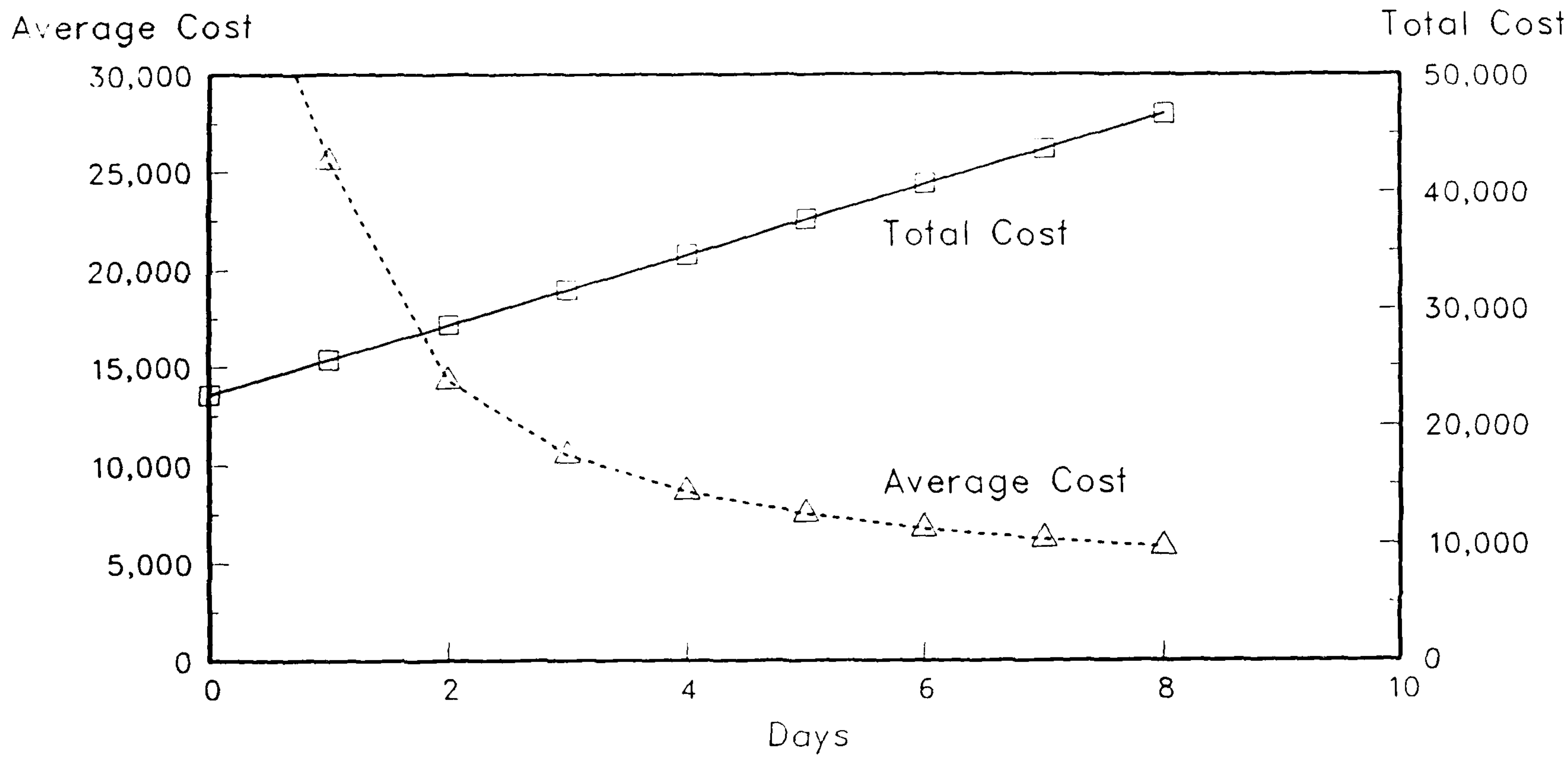
The greater number of missions the helicopter flies during a specific charter period, the smaller the effect these fixed costs will have on unit operating costs. If the mission lasted one day, then the four days of installation/access time and sixteen hours of flight time would be allocated to that single day's mission. If instead, the mission lasted five days, then each mission day would bear only one-fifth of these costs. To put this into perspective, Figure 2.2 shows the effect of the staging costs for the helicopter on the average price per day. The left vertical axis represents the average cost for renting the helicopter per day, while the right vertical axis represents the total cost of renting the helicopter. The total cost function is linear, with a fixed cost of $22,560 and a variable cost of $3,000 per day. The average cost function shows the average cost of renting the helicopter per day decreases as the number of days increases, eventually approaching a limit of $3,000. The average cost function continues to decrease, but at a decreasing rate, as the number of helicopter days increases.

For safety reasons, GRA has assumed a two-pilot operation for the Bell 212 because of the nature of the mission being flown. One of the two pilots would fly precise tracks focusing on the pilot guidance system while in the data acquisition mode. The second pilot would scan the area to watch out for other aircraft and to monitor the critical flight instruments. The cost reduction from two to one pilot operation is not significant enough to warrant foregoing this precaution.

GRA's preliminary research uncovered helicopters available in Pennsylvania, Texas, Louisiana, Oregon, California and Alaska. This search tracked only those charter companies listing Bell 212s in their fleets as shown in the <u>World Aviation Directory</u>. However, even from this limited sample of operators, it is apparent that on most occasions the Bell 212 can be obtained, albeit perhaps at some distance away from the mission site. In addition, many of the operators indicated that they had contracts which ran through the summer to fly fire-fighting missions for the U.S. Forest Service or others.

Figure ...

Total and Average Helicopter Costs over Time



Thus, it appears that the period October through April or May would be the months of the year when the Bell 212 was most likely available for lease to conduct HLBS survey missions.

The B-212 helicopter operates on jet aviation fuel. Because of the relatively low speed and altitude of the helicopter during data acquisition, *GRA assumes an upper limit of two-and-one-half hours between refueling stops.* Moreover, the helicopter must land at an airport which supplies jet aviation fuel.[3] After refueling, the helicopter then returns to where it left off to continue the mission.

<u>2.2.3 Laser Penetration</u>

The maximum depth likely for HLBS operation will be 50 meters in clear water. Minimum depth will range from 1 to 1.5 meters in clear water.[4] However, typical mission depth will be approximately twice the secchi depth[5] and is limited by water clarity, turbidity and bottom conditions. In addition, the HLBS will not operate well under conditions characterized by high winds and waves, fog and precipitation, or high levels of ambient light[6] (e.g., mid-day without clouds).

The analysis assumes that HLBS will be able to estimate data within the error tolerances stated for Class 2 and Class 3 surveys.

<u>2.2.4 Swath Width</u>

This analysis assumes that the helicopter, flying at 200 meters above the water at 20 knots, can survey a swath 352 feet wide with five-meter dot spacing. This will enable the helicopter to survey most of the intracoastal waterway in one pass. Harbors and

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[3]Information on fuel availability obtained from Aircraft Owners and Pilots Association, <u>AOPA Airports USA 1987</u>.

[4]Optech Report, pps. 173 and 175.

[5]Secchi is a device to measure water clarity. Secchi depth is the average point at which a disk becomes invisible in the water.

[6]<u>Ibid.</u>, pps. 173 and 174.

beach fronts may require multiple passes. The analysis assumes that the laser crew will structure its projects using 300-foot swaths which will allow an overlap to account for slight deviations in course. Note, that while aerial photography normally prescribes a twenty percent overlap, the relatively slow speed of the helicopter, its ability to circle back and resurvey missed data, and the flight guidance provided by the flight track monitor should greatly reduce the need for this large of an overlap allowance.

2.2.5 Mission Speed

For the purpose of this analysis, the helicopter speed has been assumed to be 20 knots (nautical miles per hour) while in the survey mode and 100 knots while flying other flight segments (deadhead). No allowance for turnaround or readjustment has been made in the mileage measurements even though, in actual operation, a helicopter will not be able to stop instantaneously or make angled turns and accurately stay on course. In reality, the helicopter will need to fly a loop to turn and then hover at the beginning of a given survey track to regain its equilibrium. Hence, the cost estimates have included a mission efficiency factor of 15 percent to accommodate just such exigencies.

2.2.6 Survey Crew Costs

The private contractor will employ a crew of four people. The following prices include the overhead and fee charged by the contractor:

Position	Per Day
Party Chief	$325
Equipment Technician	$300
Assistant Surveyor	$275
Assistant Surveyor	$275

These positions require knowledge of both hydrography and computers, and as such, are expensive. The crew will work twelve hour days, of which no more than eight will be spent surveying. In addition, two trained electronic technicians will review the data as part of the post processing. *Each hour of data gathered will require two technicians working five hours each to prepare the survey products (six hours in the case of 3-D GPS).*

It has further been estimated that the *crew travel and per diem cost per person day is $70.* The crew would include two people assigned to setting up the ground stations and the tide gauges. *Ground transportation for this activity has been estimated at $50 per vehicle or a total of $100 per day.*

2.2.7 Ground Positioning Systems

The hydrographic surveys analyzed in this report are designed to meet Army Corps of Engineers Class II and Class III survey accuracy requirements. Extremely accurate methods must therefore be employed to position the readings to known locations. Traditionally, this exact positioning has required, by means of triangulation, the use of at least two ground stations which broadcast a microwave frequency to the survey vehicle from known USACE benchmarks.

Microwave transmitters have historically been used for ground station transmitters. While appropriate for water-based surveying, the microwave-based system comes less practical when dealing with helicopters which move at a much faster rate of speed. Unobstructed line of sight must be maintained at all times between the microwave ground station and the helicopter. This is difficult to accomplish efficiently with a helicopter moving at 20 knots. Fortunately, better solutions are available.

Recent technological developments have provided at least two alternative technologies to enable efficient and accurate ground positioning. The first of these is the UHF Trisponder. This device enables accurate positioning within at least a 50 mile radius, and is less affected by line of sight obstructions such as trees and buildings. The available power is at least two to three times that provided by equivalent microwave transmitters. The principal benefit of this device over microwave is its ability to be located far enough from the actual site of the surveying so that the trisponder device can be used efficiently by more than one harbor or by a lengthy stretch of intracoastal waterway. All transmitters used for triangulation must be positioned so that at any time the helicopter can receive signals from two adjacent trisponders within an angle of between 30 and 150 degrees. This constraint would enforce use of a separate microwave device for each mile of survey in some congested areas, but is less of a problem for the more powerful UHF technology.

The UHF Trisponder is currently available from Del Norte Technology of Euless, Texas. The Del Norte UHF Trisponder has already been employed by the Corps in Savannah, Galveston and other projects. UHF Trisponders have been efficiently mounted on existing television or radio towers, or on the roofs of high rise buildings, since the only major obstacle which might interrupt the trisponder are intervening buildings.Significant advantages could be employed by using UHF Trisponders with helicopters since they would not have to be mounted on a tower to obtain approximate direct line of sight. The Del Norte Trisponder weighs 25 pounds and requires a 24 volt DC power source such as two automobile batteries connected in series. The entire device can be made portable with a 30 inch antenna.

The study assumes that UHF Trisponders will cost in the neighborhood of $16,000 each. A total of five are needed for the survey.

A second ground positioning technology is the Two-Dimensional Global Positioning System (2-D GPS). A single GPS unit can accurately control the location of the helicopter within one hundred miles and does not require triangulation. The GPS ground station is the same unit as that which fits into the helicopter; the only difference is that it must also send signals as well as receive them. Most GPS receivers cost between $50,000 and $60,000 although some have sold for as low as $32,000. The study assumes that the HLBS would require two 2-D GPS units costing $50,000 each.

At the forefront of technology are Three-Dimensional Ground Positioning Stations (3-D GPS). When available, these devices, at approximately the same cost as the two-dimensional design, will have the additional advantage of obviating the need for separate tide gauges. They will require, however, additional post-processing time. *This analysis assumes the use of two 3-D GPS ground stations at a cost of $50,000 each, no accompanying tide gauges, but a corresponding six-to-one post-processing hours to survey hours ratio.*

The ground crew consists of two people responsible for setting up the ground stations. The set up for GPS is practically instantaneous, with the machine needing approximately two minutes to lock onto the satellite. Geometry details are not important with GPS, only that the station has been sited on a known mark. The ground station then receives the signal from the satellite and sends the helicopter an adjustment factor determined by the difference between the known location and the location suggested by the satellite's signal. The unit in the helicopter, which also receives the satellite signal, then makes the required adjustment.

This analysis assumes that benchmarks are in close proximity to the ground station locations suggested in the Appendices.

The same people responsible for setting up the ground stations would also be responsible for setting up the automatic tide gauges. *Twelve automatic tide gauges are required for the scenarios put forth in this report, representing an approximate cost of $120,000. The study further assumes that the tide gauges will work and that the laser crew can leave both the tide gauges and the various ground stations unattended without their malfunctioning or being stolen.*

Each mission accounts for the need to set up these ground stations. In some cases, such as the Maine harbors, these ground stations and tide gauges become the limiting factor, as the rocky terrain and vast tide fluctuations require the ground crew to gauge the tide fluctuations at every project site. In Maine, even with two ground personnel, the helicopter will have to wait for the crew to move from one area to the next. Moreover, some projects in Maine are not easily reached by car and thus have either been dropped from the project list or have imposed time constraints on the HLBS mission. Other missions, to varying degrees, would suffer from similar constraints.

2.2.8 Processing of HLBS Data

The HLBS records the data from the laser and the positioning units on a magnetic computer tape. At the end of the day, this tape would be express mailed to a central processing facility where the data would be synthesized to produce the soundings at mean low water levels. *This study assumes that for every one hour of surveying, there will be five hours of post-processing involving a minicomputer and two technicians. (For the case of 3-D GPS units, six hours would be required.* The study assumes that the purchase of the minicomputers is included in the HLBS costs while the fully-allocated cost of the post-processing personnel is $38 per survey hour.

2.3 The HLBS Cost Model

GRA has developed a computer model for calculating the cost of the six HLBS missions, the net benefits from using HLBS to survey the projects included in these missions, and the net present value of these benefits over an appropriate period, given the parameters defined under each of the six scenarios. This section discusses the formulae used to determine the net present value of the investment. It then discusses the parameters, both fixed and variable, used in creating these cost formulae, illustrating with flow charts the various outputs from the computer model.

2.3.1 The Net Present Value Technique

The accepted technique for evaluating the worth of investments which last longer than a single year is a net present value (NPV) or discounted cash flow analysis. In cases such as HLBS, the government will expend funds over a period of years to develop the system while achieving operational savings during later years. Similarly, a commercial operator would buy the system with an initial payment and then use it for a number of years, receiving some positive cash flow on account of its use. In cases such as these, one should recognize that the investment and operating savings occur in different time periods. Money has a time value: a dollar today is worth more than a dollar in the future, since it could earn interest. The NPV technique considers this time value of money.

The NPV technique brings all cash flows back to the present using a discount rate which reflects the potential alternative uses for the money. By bringing all cash outlays and cash savings back to the same time, one can determine whether an investment is worthwhile or whether it is the better of several investments. In the context of HLBS, cash outlays refer to the expenses incurred to buy and operate HLBS, while cash savings refer to money the USACE does not spend to conduct surveys using conventional means. An NPV greater than zero means that USACE would save money by investing in HLBS technology.

A key parameter in the NPV analysis is the discount rate chosen to reflect the opportunity cost of the money invested. The Office of Management and Budget (OMB) prescribes a discount rate of ten percent in the evaluation of government projects.

2.3.2 Annualized Costs

When private sector firms invest in assets, they too must earn a return on their investment. However, such firms cannot borrow at rates as low as the government, must pay taxes on their profits, and have to consider the riskiness of their investment--or the chance that the investment will not work out as planned. The HLBS would constitute a very large investment for these firms which take the chance that project work may not be forthcoming. Recall that energy exploration in the U.S. has substantially fallen in the last few years. Companies that had invested in equipment to perform support work have had to sell the equipment at a loss or perhaps gone out of business. To keep an investment in the HLBS analogous to an investment of similar risk, this analysis uses a 25-percent discount rate to amortize the commercial operators' purchase of the HLBS and associated equipment. The amortization rate converts a large initial investment into a stream of annual payments.

2.3.3 Estimating Prices for a Contractor-Owned HLBS

The following section describes how the cost model estimates the price commercial firms would charge for HLBS services. These prices incorporate both the cost of performing the HLBS surveys and the normal profits earned from this work assuming that competitive conditions prevail in the market for contract hydrographic surveys. As shown below, these costs consist of helicopter charges, salaries and overhead for the contract laser and ground crew, the per diem allowances, the ground transportation for setting up ground stations, post processing, and HLBS maintenance. On top of this, the cost model adds the amortized cost of the investment allocated across the different missions, assuming an annual contract of 150 mission hours. The amortization rate of 25 percent incorporates a normal profit for the contractor.

2.3.4 Cost Formulae

The contractors will charge a price for conducting a survey mission. These prices include the mission operating costs, then the annualized investment for the HLBS system, ground stations and the annual maintenance cost (Figure 2.3), which is estimated at five percent of the initial laser price.

The cost model finds the net present value of the investment in HLBS by discounting the annual difference between benefits and costs. The figure, the net annual benefits, consist of the difference between the expected conventional cost and the cost to USACE of HLBS surveys–most often the price the contractor changes. The net annual benefit consists of the difference between the expected conventional costs of each scenario and the associated HLBS cost per mission (Figure 2.4). The operating cost per mission is the sum of the helicopter cost (Figure 2.5), laser crew cost (Figure 2.6), ground crew cost, post-processing cost and a factor for mission efficiency (Figure 2.7). The helicopter cost is the sum of the daily helicopter lease, the charge per flight hour and the air crew travel and per diem charge. The laser crew cost is the sum of the laser crew wages, per diem and travel. Post-processing costs are included in "Other Costs."

Figure 2.3

Annual Costs

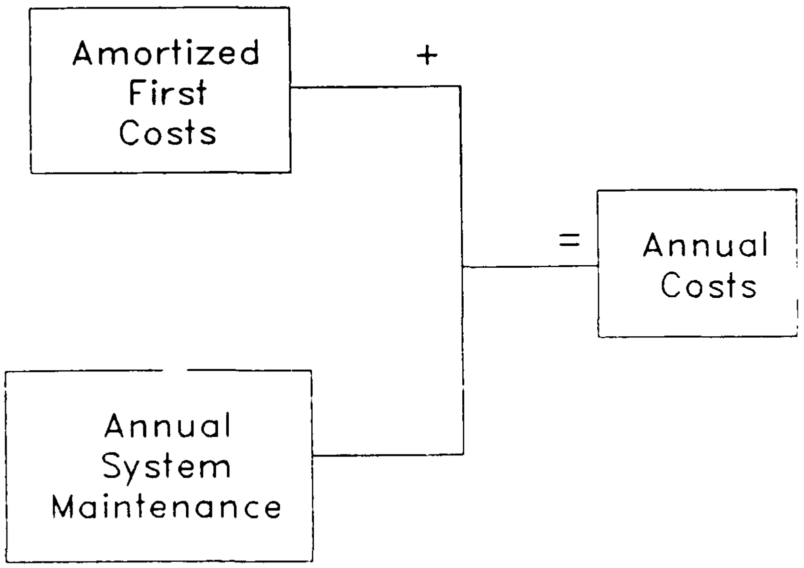


Figure 2.4

Operating Costs per Mission

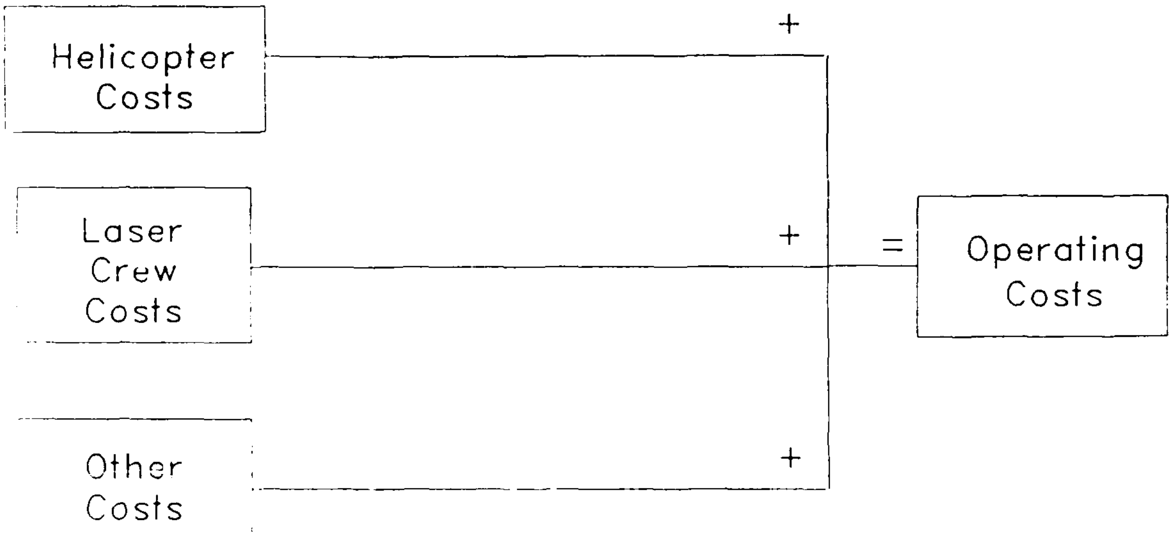


Figure 2.5

Helicopter Costs

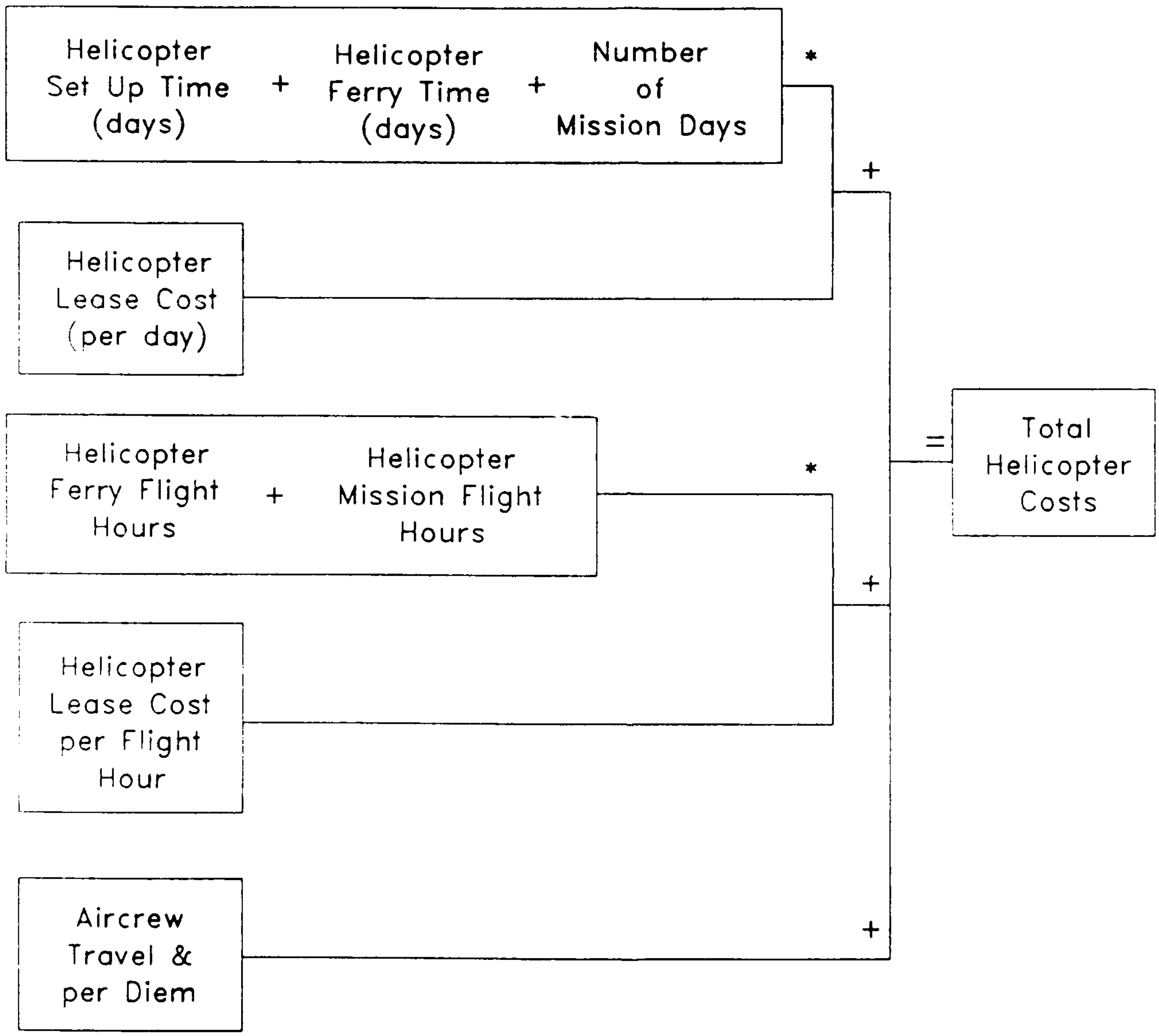


Figure 2.6

Laser Crew Costs

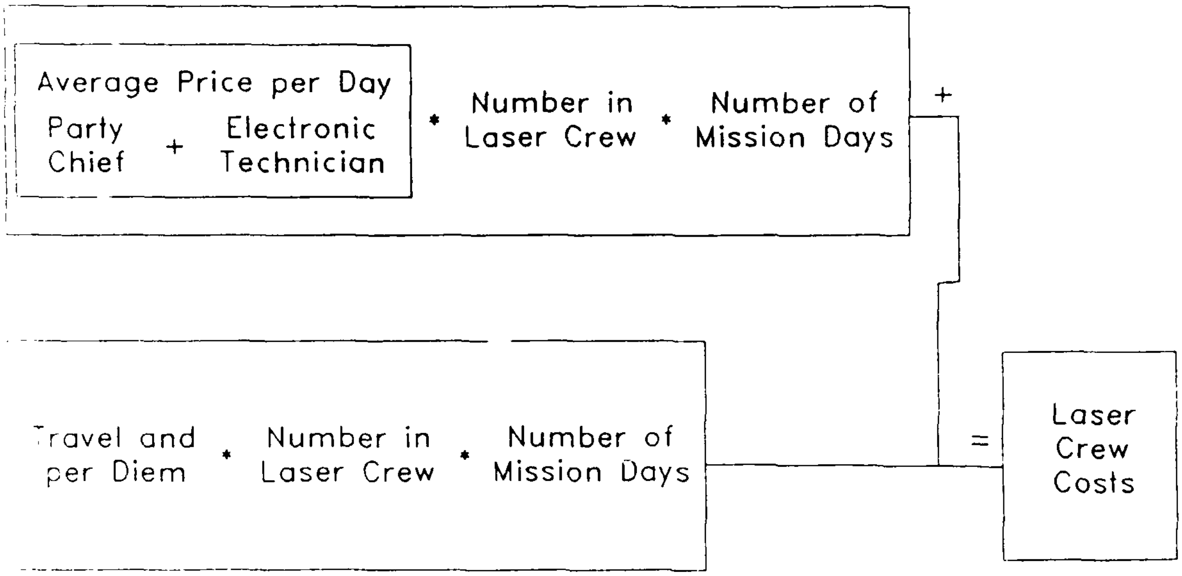


Figure 2.7
Other Costs

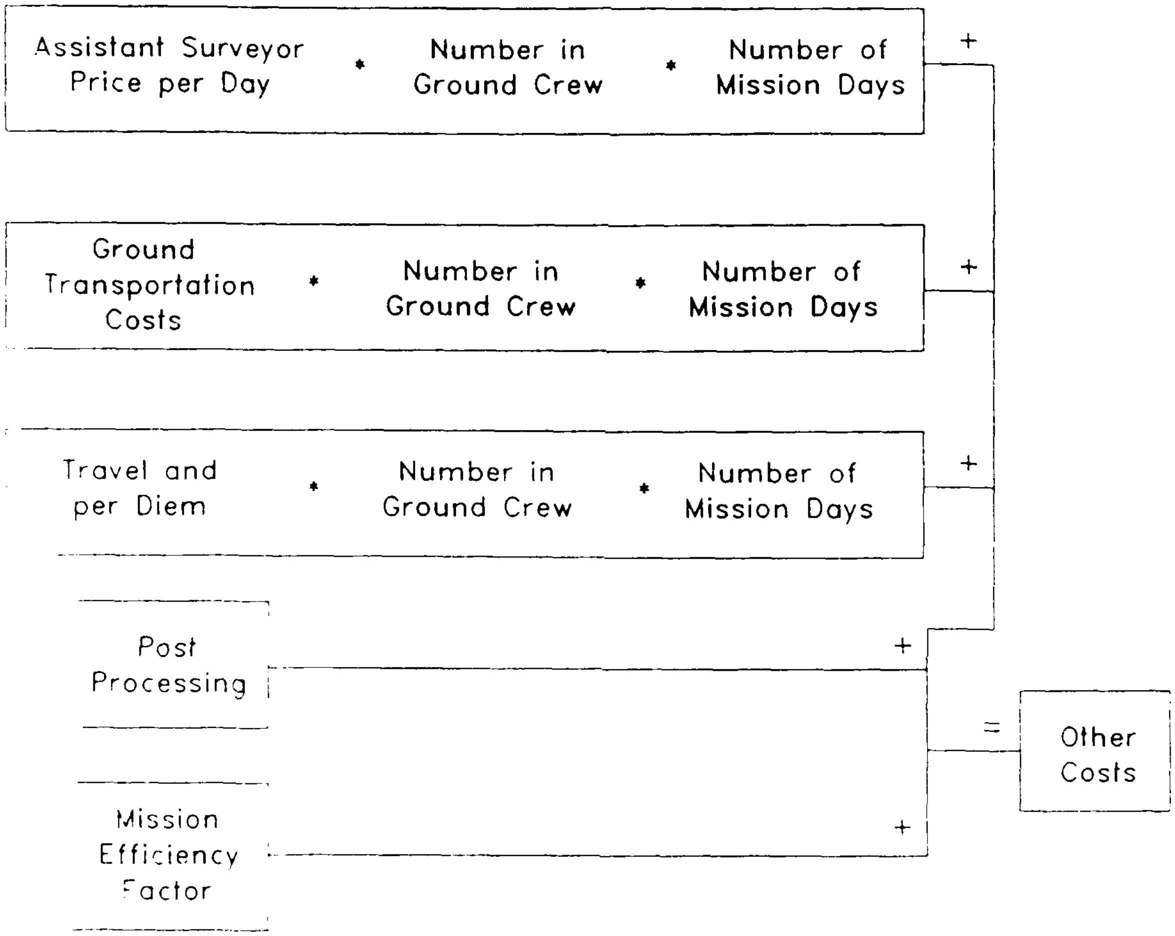
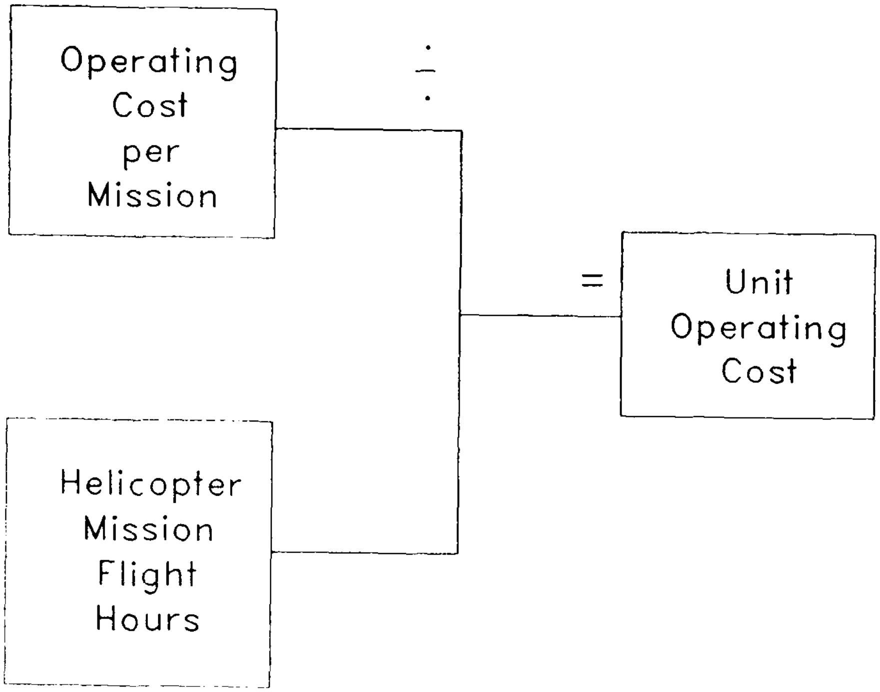


Figure 2.8 shows the unit operating costs. This is the operating cost per mission divided by the product of the number of survey hours times the coverage rate. The coverage rate consists of the potential number of square nautical miles surveyed per survey hour. It is found by multiplying the survey speed by the swath width and then dividing by the number of feet per square nautical mile. Since the cost to measure a 70-foot wide channel is the same as the cost to measure a 300-foot wide channel by HLBS, the measure of costs per square nautical mile may be misleading (same cost for 4.3 times as much area). A more appropriate measure may be cost per linear channel nautical mile, which takes account of the multiple passes made by either conventional or HLBS surveys which are required in wide areas of harbors. Unit costs based on area generally will yield results favorable to HLBS due to its wider swath.

Figure 2.8

Unit Operating Cost

(per hour)



Chapter 3

HLBS BENEFIT-COST ANALYSIS RESULTS

3.1 Introduction

This chapter reports the results of the benefit-cost analysis of the Helicopter Lidar Bathymeter System (HLBS). The Coastal Engineering Research Center (CERC) technical monitor selected candidate projects for inclusion in the economic analysis. The study team then created the specific survey missions which represented a cross-section of these projects. The analysis investigates six scenarios each consisting of six specific survey missions reported as HLBS-surveyable from field office responses.

The current survey costs for the projects within each mission were compared with the estimated HLBS price to determine the operating-cost savings potentially available from use of the system. The costs of purchasing the HLBS and the necessary ground positioning units and tide gauges, along with the annual cost of maintenance, were treated as fixed costs and recovered as part of this price. The remaining net benefits were then used to perform a discounted cash flow analysis.

3.1.1 Selection of Missions

The Corps of Engineers conducted a survey of field offices to identify existing survey projects which might have the potential for application of HLBS technology. For each project, the field office reported the survey frequency, the cost of the survey, and the time required to perform the survey. Also included with the survey responses were maps of each project. CERC specified that the analysis include the following types of projects:

- Inland waterway sections;
- A series of small harbors;
- A large harbor;
- A number of coastal inlets.

From these, six HLBS survey missions were developed for detailed analysis.

In the analysis of each mission, the study team selected specific projects that could be logically grouped into missions. The team then created hypothetical flight plans as required by the helicopter tracking system. They reviewed survey maps to determine the number of HLBS swaths to be flown, the time necessary to acquire the survey data as well as additional flight time needed for initial positioning, returning to the airport to refuel and moving from one site to another within survey areas. The team created the following survey missions:

- Cape Cod Canal–Approximately 35 miles of the Canal channel along with two small projects in the immediate area;
- Delmarva Peninsula–Approximately 70 miles of the inland waterway which contains a number of projects consisting of bays, inlets and channels along the waterway;
- Florida Inland Waterway–Approximately 140 miles of inland waterway on the west coast of Florida along with Tampa Harbor and a number of other related projects;
- Small Harbors in Maine–A series of 37 harbors located along the Maine coastline;
- Hollywood Florida Area–A condition survey of ten miles of beach front in Miami along with four Florida harbors, and the harbor in San Juan, Puerto Rico;
- New Jersey Inland Waterway–Almost 113 miles of waterway along coastal New Jersey.

3.1.2 Scenarios Evaluated

Each mission was evaluated under the following six scenarios:

1. Contractor-owned/Contractor-operated (Co/Co): Separate projects with UHF Trisponder. The economic analysis treats all six missions as being conducted independently of one another for the purpose of this scenario. This means that each mission bore separate mobilization and demobilization costs for the HLBS and helicopter. This scenario assumed the purchase and use of five UHF Trisponders for horizontal positioning and twelve automatic tide gauges for vertical positioning.

2. Co/Co: Division-wide with UHF Trisponder. This scenario is identical to #1 above except that the missions have been combined at the division-level for mobilization/demobilization.

3. Co/Co: Corps-wide with UHF Trisponder. This scenario is identical to #1 above except that the missions have been combined at the Corps-wide level for mobilization/demobilization.

4. Co/Co: Separate projects with two-dimensional GPS. This scenario is identical to #1 above except the laser crew would use a two-dimensional global positioning system (2-D GPS) instead of UHF Trisponders for horizontal positioning.

5. Co/Co: Separate projects with three-dimensional GPS. This scenario is identical to #1 above except that the contractor would use a three-dimensional global positioning system (3-D GPS) instead of UHF Trisponders. In addition, separate tide gauges would not be needed with the 3-D GPS for horizontal and vertical positioning.

6. Government-owned/Contractor-operated (Go/Co): separate projects with UHF Trisponder. This scenario is identical to #1 above except the HLBS would be owned by the government and operated by private contractors. In this scenario, the government pays the development cost for the operational prototype.

3.1.3 Critical Assumptions

Because of the unproven nature of HLBS technology, a number of assumptions had to be made about relevant technical and economic parameters. The most important of these are as follows:

- The HLBS would require a Corps investment of $5.55 million which includes all software, data processing equipment and initial provisions of spare parts.
- The system would operate for seven years and would have no value at the end of this period.
- Annual system maintenance costs would be five percent of the HLBS commercial acquisition costs of $2.75 million
- In the Co/Co scenarios, the HLBS would operate for 150 hours per year to complete Corps surveys. This equates to about $2.8 million worth of existing surveys using conventional techniques.
- The Go/Co scenario assumes an increasing level of contracted missions rising from $900,000 in 1991 to $8.6 million in 1995 and thereafter.
- Each hour of data gathered will require ten hours of processing (two people working five hours each) to prepare the survey products.
- A B-212 helicopter would be chartered for $3,000 per day and $660 per flight hour. This price includes two pilots and a mechanic.

- The helicopter lessor will take two days to install and remove the HLBS and it will take two days and sixteen flight hours to travel to and from the mission area.

- The helicopter operates at a speed of 20 knots and an altitude of 200 meters when gathering data. This geometry produces a swath width of approximately 350 feet with a spot spacing of less than five meters along the line of flight. A swath width of 300 feet was used in the analysis of the missions to allow a margin of error. The helicopter flies at 100 knots when not gathering data (deadhead).

- The HLBS survey crew consists of four persons (not including the helicopter crew). This provides two people to operate the HLBS in the helicopter and two persons responsible for the placement of ground positioning systems and tide gauges.

- An additional 15 percent of mission and post processing costs were used to accommodate for potential inefficiencies.

3.1.4 Description of Sections to Follow

The remainder of Chapter 3 outlines the six separate scenarios as they relate to the six missions, with particular emphasis on the Florida Intracoastal Waterway mission. Section 3.2 describes one mission (FL-IWW) in detail to show how the analysis of HLBS was approached. Section 3.3 shows the base case scenario benefit-cost results along with HLBS costs for operating one mission (FL-IWW). Section 3.4 shows the benefit-cost results for the other five scenarios. Section 3.5 compares the benefit-cost results among the five Co/Co scenarios.

3.2 Operational Mission: FL-IWW

This section highlights the background data for the FL-IWW mission. The following sections then show the results for all missions under each scenario evaluated in the study.

3.2.1 FL-IWW Projects

As shown in Table 3.1, the FL-IWW mission is composed, not only of the intracoastal waterway, but also of thirteen other projects along its path. Included in this mission is the particularly large survey of Tampa Harbor, which has a linear survey distance only twenty miles shorter than that of the IWW section in this mission.

Table 3.1 Project Description of FL–IWW Mission

	Conventional			HLBS					
	Cost	Survey	Expected	Nautical Miles		Survey	Extra	Survey	Deadhead
PROJECTS	($000)	Freq	Cost	Survey	Deadhead	Days	Grnd Days	(Hours)	(Hours)
Alafia River	3.0	1.00	$3,000	3.566	2.962			0.18	0.03
Anclote River	15.0	1.00	$15,000	7.241	1.975			0.36	0.02
Casey Pass	3.0	1.00	$3,000	0.434	0.408			0.02	0.00
Charlotte Harbor	4.5	1.00	$4,500	7.000	2.660			0.35	0.03
Clearwater Pass	2.5	1.00	$2,500	3.000	2.301			0.15	0.02
Hillsborough River	9.0	0.50	$4,500	2.414	24.375			0.12	0.24
IWW- CR to AR	30.0	1.00	$30,000	139.680	260.650	1.25	0.5	6.98	2.61
Johns Pass	7.5	1.00	$7,500	1.759	1.539			0.09	0.02
Longboat Pass	5.0	1.00	$5,000	1.646	1.317			0.08	0.01
New Pass	4.5	1.00	$4,500	3.493	2.997			0.17	0.03
Ozona	3.0	0.50	$1,500	1.136	1.136			0.06	0.01
Pass-A-Grille Pass	3.0	0.50	$1,500	2.567	1.990			0.13	0.02
St. Petersburg Harbor	3.0	1.00	$3,000	5.728	6.616	0.25		0.29	0.07
Tampa Harbor	90.0	1.00	$90,000	117.250	43.460	1		5.86	0.43
Totals	$183		$175,500	296.9	354.4	3.0	0.5	14.8	3.5

Table 3.1 outlines the conventional survey costs for each project as well as their annualized expected conventional costs. The table shows the nautical miles flown in both survey and deadhead modes, and the corresponding helicopter flight time in both survey and deadhead modes. The helicopter takes three days to fly a total of 18.3 hours due to the daily maximum flight time limit of eight hours per crew.

The ground crew will need three-and-one-half days to perform their duties. They require a half-day in advance of the helicopter's arrival to set up the ground stations for the first day's surveying. After that they are able to move the stations in advance of the helicopter, completing the job at the end of the third day (with 3-D GPS, the analysis assumes that the ground crew does not require the one-half day prior to the arrival of the helicopter.)

3.2.2 Trip Length

For each flying day, the helicopter is allotted eight total hours of flight time. For refueling purposes, the analysis assumes that the helicopter must land for fuel after a maximum of two-and-one-half hours in the air. Consequently, each survey day is divided into survey trips. In the case of the Florida Intracoastal Waterway project, the helicopter will fly a total of ten trips; four trips on each of the first two days and two trips on the last day of the mission. For more specific information on flight routes and times, refer to Appendix C.

3.3 Results of the Base Case Scenario: Co/Co: Separate Mission with UHF Trisponder

This section first describes the Contractor-owned/Contractor-operated (Co/Co) scenario with separate missions and UHF positioning systems. It shows the costs of conventional surveys and compares these to HLBS operating costs. Next it shows the calculation of the net benefit to the Corps of employing HLBS on these missions which includes recovery of fixed costs as well as an assumed profit margin for the contractor.

The following section shows how the base-case results change under different scenarios of mission grouping, positioning system used, and HLBS ownership.

The derivation of the net present value to the Corps due to a Contractor-owned/Contractor-operated HLBS treats each mission separately and uses the UHF Trisponders and automatic tide gauges for ground positioning. Table 3.2 shows the basic assumptions employed in this scenario. Note that the price for the commercial HLBS is $2.75 million: this remains constant for all scenarios. This scenario uses five Del Norte UHF Trisponders and twelve automatic tide gauges for a combined price of $200,000. Other pertinent assumptions within this scenario include: the Contractor-owned/Contractor-operated amortization factor of .3163, two days for the helicopter set up; two days of ferry time and sixteen flight hours to ferry the helicopter to its location.

3.3.1 Mission Description

This section discusses each of the missions and identifies the cost savings attributable to use of HLBS in comparison to conventional survey methods. Each of these discussions assumes the HLBS to be Contractor-owned/Contractor-operated with UHF Trisponders as the ground positioning system and separate helicopter leases for each mission. It then presents an evaluation of the overall savings available to the Corps from employing HLBS to conduct these surveys. Table 3.3 shows the key parameters for each of the missions including expected conventional survey costs, HLBS operating costs and HLBS mission prices.

Cape Cod Canal–This mission includes 34.6 miles of the Cape Cod Canal along with surveys of Onset Bay and Wareham Harbor in Massachusetts. These surveys currently cost $135,000 in the aggregate. However, because the Onset Bay and Wareham Harbor surveys are done infrequently, the annualized survey cost is $109,500. These surveys would require approximately 2.0 hours of HLBS data gathering. It is expected that this mission would incur operating costs of approximately $31,000 using HLBS. This includes the standard allowance of two days for installation and removal of

Table 3.2 Basic Assumptions

Co/Co Scenario

Positioning System (UHF); Separate Projects

LIFETIME COSTS		**MISSION COSTS**	
Commercial System Price	$2,750,000	Helicopter Lease Cost (Fixed)	$3,000
Positioning System (UHF)	$200,000	Helicopter Lease Cost ($/Flt.Hr)	$660
Equipment Time Horizon (Years)	7	Helicopter Set Up Time (Days)	2.00
		Helicopter Ferry Time Days (RT)	2.00
ANNUAL FACTORS		Helicopter Ferry Flight Hours (RT)	16.00
		Helicopter Crew	3
System Maintenance (% of Price)	5.00%		
Annual Mission Hours	150	Travel & Per Diem (Per Prsn/Day)	$70
		Number of Technical Laser Crew	2
LASER CREW PRICES PER DAY		Number of Ground Crew	2
		Number of Post Processing Crew	2
Party Chief	$325	Per Diem Cost Per Ground Vehicle	$50
Electronic Technician	$300		
Assistant Surveyor	$275	**OPERATIONAL CHARACTERISTICS**	
DISCOUNTING FACTORS		Survey Speed (Knots)	20
		Deadhead Speed (Knots)	100
OMB Discount Rate	10.0%	Altitude (Meters)	200
Private Discount Rate	25.0%	Swath Width (Feet)	300
Contractor-Owned/Contractor-Operated		Coverage Rate (Sq N Miles/Hr)	0.99
Amortization Factor	0.3163	Processing/Survey Hours Ratio	5
		Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.3 Summary of Costs and Prices

Co/Co Scenario Separate Projects

With UHF Trisponder Ground Positioning System

Missions	Expected Conventional Cost	HLBS Operating Costs	HLBS Survey Hours	HLBS Mission Days	HLBS Unit Cost Per Hour	HLBS Unit Cost Per Sq Mile	HLBS Mission Price
Cape Cod	109,500	31,411	2.0	5	12,630	15,778	61,932
DelMarVa	69,765	34,733	3.5	5	5,779	10,000	68,482
FL-IWW	175,500	58,731	14.8	7	3,194	4,006	115,799
Hollywood	151,700	73,059	8.0	9	2,529	9,278	144,050
Maine	111,010	49,025	4.1	7	4,388	12,043	96,661
New Jersey	150,000	36,318	6.1	5	5,470	6,044	71,607
Total	$767,475	$283,276	38.6	38	$5,665	$9,525	$558,531

the HLBS as well as two days of ferry time and 16 flight hours to access the Cape Cod survey site. Including all access time, the helicopter would be chartered for a total of five days to complete the mission. Appendix A contains a complete description of this mission.

Delmarva Peninsula–This mission consists of the Virginia portion of the inland waterway from the Chesapeake Bay to the Maryland State line within the Delmarva Peninsula. Using current survey techniques, these projects cost almost $155,000 to survey; on an annual basis, they represent approximately $70,000 worth of work per year. The present surveying does not include the entire waterway, but rather small sections along the waterway. The HLBS would survey the entire waterway in Virginia.

Using the HLBS, these surveys would require 3.5 hours of data gathering time along with another 0.4 hours of flight in and around the area. The total HLBS operating costs for these missions would be approximately $35,000. Appendix B provides further details of this mission.

Florida West Coast Intracoastal Waterway–This mission consists of just over 138 miles of inland waterway along the west coast of Florida. It includes another major project, a survey of Tampa Harbor. In addition to these major activities, 12 other smaller projects are included. This mission is used as the example in the detailed scenario analyses in Section 3.3.3. A complete description of this mission appears in Appendix C.

Hollywood Florida Harbors–This mission consists of a condition survey of ten miles of beachfront in Miami along with four harbors in the same area. In addition, the helicopter would be ferried to Puerto Rico to conduct a survey of San Juan Harbor. Currently, these projects cost the Corps just over $150,000 per year and are conducted annually. These same missions could be conducted using HLBS for just over $73,000 in operating costs. This assumes that the helicopter is brought into the Miami area and then conducts the Miami area and San Juan surveys before returning it to the helicopter charter company. The helicopter would be used for a total of nine days to conduct these missions. Appendix D contains a more complete description of this mission.

A Series of Harbors in Maine–This mission includes 37 harbors along the coast of Maine. Each project is quite small, but the annualized cost to the Corps is almost $111,000. In this mission, there is significant movement and setup for ground positioning systems resulting in the addition of an extra day of ground crew time in the analysis.

To appreciate the speed at which the HLBS gathers data, it only requires 4 1 hours to collect the data for the 37 harbors. An additional 5.6 hours of flight time is involved in repositioning the helicopter within the survey area. The operating costs of this mission is $49,025 using HLBS. The helicopter would spend three days in the survey area in addition to the four days of equipment installation and access to the survey site. Appendix E contains a more complete description of this mission.

New Jersey Intracoastal Waterway–This mission is conducted yearly by the Corps at a cost of $150,000. It consists of a survey of approximately 113 miles of the intracoastal waterway in New Jersey. This mission could be conducted using HLBS for $71,807 in operating costs. This includes one day of helicopter operation for the survey and four days to place the helicopter into position and condition for use. A more complete description of this survey mission appears in Appendix E.

3.3.2 Net Benefits to the Corps

Table 3.3 presents the summary of the costs and prices related to this scenario. Total conventional survey costs for all missions are $767,475 while total HLBS operating costs are $283,276. The six separate missions would take approximately 38 days to complete. Of these, 24 days would be spent in helicopter mobilization/demobilization. This analysis estimates that private contractors would charge a price of $558,531 for performing the six missions.

Table 3.4 shows the net present value for this scenario and how it was calculated. The difference between the expected conventional cost and the contractor mission price, both found in Table 3.3, yield the net annual benefit of $208,944. The annual Corps benefits of $812,768 are the result of multiplying the net annual benefit by the ratio of annual mission hours (150) to survey hours (38.6). In this scenario, the net present value to the Corps is $3,185,207, which represent the sum of each year's discounted net benefits.[1]

Table 3.5 shows the amortized first costs and annual costs for calculating the HLBS price in this scenario. First costs consist of the price of the HLBS and the positioning system. Using an amortization factor of .3163 based on private ownership, amortized first costs amount to $933,208. This amount, added to the system maintenance costs of $137,500 per year (five percent of the total HLBS price), yields the total annual cost for the HLBS of $1,070,708. These are allocated over the annual mission hours and have been incorporated into the HLBS price shown in Table 3.3.

3.3.3 The Florida Intracoastal Waterway Mission

Table 3.6 shows the derivation of the annual HLBS operating costs of $58,731 for the FL-IWW mission. This amount consists of $45,167 in helicopter costs, $2,295 in laser crew costs and $11,269 in other costs. The total helicopter costs result from the daily and hourly use charges for the helicopter. Note that half of these costs come from the mobilization and demobilization of the helicopter. Laser crew costs represent the total crew costs for operating the HLBS as well as for travel and per diem costs. Other costs result largely from ground crew costs ($1,925), post processing costs ($5,567) and the efficiency factor ($2,937).

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[1]The discounted net benefit is that year's net benefit multiplied by a continuous discount factor derived using the OMB-prescribed 10% discount rate.

Table 3.4 Net Present Value to USACE

Co/Co Scenario

Positioning System (UHF); Separate Projects

Net Annual Benefit	$208,944	Amortization Factor	31.63%
Amortized First Costs	$933,208	Annual Mission Hours	150
Annual Costs	$1,070,708	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			812,768	812,768	812,768	812,768	812,768	812,768	812,768
Costs			---	---	---	---	---	---	---
Net Benefits			812,768	812,768	812,768	812,768	812,768	812,768	812,768
Discounted Net Benefits			602,113	544,814	492,968	446,056	403,608	365,200	330,447

Net Present Value in 1989 To USACE: $3,185,207

Table 3.5 Amortized First Costs and Annual Costs

Co/Co Scenario;Separate Projects
Positioning System (UHF)

AMORTIZED FIRST COSTS	Totals
Commercial System Price	2,750,000
Positioning System (UHF)	200,000
Sum of First Costs	2,950,000
Amortization Factor	0.3163
Amortized First Costs	$933,208

ANNUAL COSTS	Totals
Amortized First Costs	$933,208
System Maintenance (% of Price)	$137,500
Total Annual Costs	$1,070,708

Table 3.6 Operating Costs per Mission

Co/Co Scenario;Separate Projects
Positioning System (UHF)
Mission: FL-IWW

OPERATING COSTS PER MISSION			
HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	3		$9,000
Helicopter Mission Flight Hours	18.4		$12,137
Travel & Per Diem (Per Prsn/Day)	$70		$1,470
Total Helicopter Costs			$45,167
LASER CREW COSTS			
Number of Mission Days--Laser Crew	3		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$1,875
Travel & Per Diem (Per Prsn/Day)	$70		$420
Total Laser Crew Cost			$2,295
OTHER COSTS			
Number of Mission Days--Ground Crew	3.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$1,925
Travel & Per Diem (Per Prsn/Day)	$70		$490
Ground Transportation	$50		$350
Number of Survey Hours	14.85		
Post Processing (Technician $/Hr)	$38		$5,567
Efficiency Factor	15.0%		$2,937
(% Helicopter Flight, Laser Crew			
Total Other Costs			$11,269
TOTAL OPERATING COSTS PER MISSION			$58,731

Table 3.7 shows the unit operating costs for the scenario. Unit operating costs amount to $3,194 per hour. This is based on the operating cost of $58,731 per mission divided by 18.4, the number of hours the helicopter uses to fly the mission. Table 3.7 also shows unit operating cost per square nautical mile ($4,006) and unit operating cost per square kilometer ($2,163).

3.4 Results of Different Scenarios

This section shows how the HLBS benefit-cost results change across different scenarios depending on the level of mission aggregation or the type of positioning system used. It also contains the benefit-cost results for the operational prototype HLBS under evaluation by CERC.

3.4.1 Co/Co: Division-Wide Missions with UHF Trisponder

This scenario ties the two Florida missions together, the two New England missions together, and the New Jersey and Delmarva missions together. Table 3.8 shows the basic assumptions used for this scenario, presented in terms of each mission. This scenario assumes the helicopter will be rented to survey the HLBS projects within a Corps division, so the helicopter set up time would take a total of two days, the ferry time would take two-and one-half days, and the ferry flight time would take twenty hours. This scenario adds four flight hours and one-half day to the ferrying costs to account for movement within the division. These lower per mission figures represented in the table arise because the helicopter would be used for two missions within each division and thus, the more efficient use of the helicopter lowers the cost of mobilization/demobilization.

Table 3.9 shows the costs and prices for each mission in this scenario. Total HLBS operating costs for all missions falls to $225,811. These missions would now take 28 days. The total contractor price for performing these missions would fall to $501,066.

Table 3.7 Unit Operating Costs

Co/Co Scenario;Separate Projects

Positioning System (UHF) Mission: FL-IWW

UNIT OPERATING COST (per hour)		
Operating Costs per Mission		$58,731
Helicopter Mission Flight Hours		18.4
Unit Operating Cost ($/Hrs)		**$3,194**
UNIT OPERATING COST (per Square Nautical Mile)		
Operating Costs per Mission		$58,731
Number of Survey Hours	14.85	
Coverage Rate (Sq N Miles/Hr)	0.99	
Square Nautical Miles		14.7
Unit Operating Cost ($/S.N.M.)		**$4,006**
UNIT OPERATING COST (per Square Kilometer)		
Operating Costs per Mission		$58,731
Square Kilometers		27.15
Unit Operating Cost ($/Sq Km)		**$2,163**

Table 3.8 Basic Assumptions

Co/Co Scenario

Positioning System (UHF); Division-Wide

LIFETIME COSTS		MISSION COSTS	
Commercial System Price	$2,750,000	Helicopter Lease Cost (Fixed)	$3,000
Positioning System (UHF)	$200,000	Helicopter Lease Cost ($/Flt.Hr)	$660
Equipment Time Horizon (Years)	7	Helicopter Set Up Time (Days)	1.00
		Helicopter Ferry Time Days (RT)	1.25
ANNUAL FACTORS		Helicopter Ferry Flight Hours (RT)	10.00
		Helicopter Crew	3
System Maintenance (% of Price)	5.00%		
Annual Mission Hours	150	Travel & Per Diem (Per Prsn/Day)	$70
		Number of Technical Laser Crew	2
LASER CREW PRICES PER DAY		Number of Ground Crew	2
		Number of Post Processing Crew	2
Party Chief	$325	Per Diem Cost Per Ground Vehicle	$50
Electronic Technician	$300		
Assistant Surveyor	$275	OPERATIONAL CHARACTERISTICS	
DISCOUNTING FACTORS		Survey Speed (Knots)	20
		Deadhead Speed (Knots)	100
OMB Discount Rate	10.0%	Altitude (Meters)	200
Private Discount Rate	25.0%	Swath Width (Feet)	300
Contractor-Cwned/Contractor-Operated		Coverage Rate (Sq N Miles/Hr)	0.99
Amortization Factor	0.3163	Processing/Survey Hours Ratio	5
		Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.9 Summary of Costs and Prices

Co/Co Scenario Division-Wide

With UHF Trisponder Ground Positioning System

	Expected	HLBS					
Missions	Conventional Cost	Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Mission Price
Cape Cod	109,500	21,833	2.0	3.25	8,779	10,967	48,447
DelMarVa	69,765	25,155	3.5	3.25	4,185	7,242	55,818
FL-IWW	175,500	49,154	14.8	5.25	2,673	3,353	109,070
Hollywood	151,700	63,482	8.0	7.25	2,197	8,062	140,864
Maine	111,010	39,447	4.1	5.25	3,531	9,690	87,531
New Jersey	150,000	26,740	6.1	3.25	4,027	4,450	59,335
Total	$767,475	$225,811	38.6	28	$4,232	$7,294	$501,066

Helicopter costs are less expensive in this scenario due to the lower set up time and ferry time caused by the Division-wide scenario of grouping the missions.

Table 3.10 shows a net annual benefit for the scenario of $266,409. At 150 hours of use, the annual savings would be $1,036,300. In this scenario, the net present value to the Corps rises to $4,061,222.

3.4.2 Co/Co: Corps-Wide Missions with UHF Trisponder

Table 3.11 shows the basic assumptions used for the scenario of a Contractor-owned/Contractor-operated Corps-wide missions using a UHF Trisponder. This scenario assumes the helicopter will be chartered to survey all six missions as a group. The table shows the average set up and ferry time for each mission. The total for all six missions would be two days for set up, four and one-half days for ferrying and thirty-six flight hours. An additional half-day and four hours flight time have been factored for positioning the helicopter between each of the missions. Also note that this scenario assumes the long-term daily lease rate of $1,600 per day.

Table 3.12 shows the costs and prices considered in this scenario. Total expected conventional survey cost for the scenario remains $767,475. Total HLBS operating costs for all missions falls to $158,765. The survey now takes only 20 days. The total contractor price required for performing all missions would fall to $434,020. Helicopter costs are less expensive in this scenario due to the even lower set up time and ferry time due to the Corps-wide grouping of the missions. Laser crew and other costs remain the same.

Table 3.10 Net Present Value to USACE

Co/Co Scenario

Positioning System (UHF); Division-Wide

Net Annual Benefit	$266,409	Amortization Factor	31.63%
Amortized First Costs	$933,208	Annual Mission Hours	150
Annual Costs	$1,070,708	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			1,036,300	1,036,300	1,036,300	1,036,300	1,036,300	1,036,300	1,036,300
Costs			---	---	---	---	---	---	---
Net Benefits			1,036,300	1,036,300	1,036,300	1,036,300	1,036,300	1,036,300	1,036,300
Discounted Net Benefits			767,710	694,652	628,548	568,733	514,611	465,639	421,328

Net Present Value in 1989 To USACE: ***$4,061,222***

Table 3.11 Basic Assumptions

Co/Co Scenario

Positioning System (UHF); Corps-Wide

LIFETIME COSTS	
Commercial System Price	$2,750,000
Positioning System (UHF)	$200,000
Equipment Time Horizon (Years)	7
ANNUAL FACTORS	
System Maintenance (% of Price)	5.00%
Annual Mission Hours	150
LASER CREW PRICES PER DAY	
Party Chief	$325
Electronic Technician	$300
Assistant Surveyor	$275
DISCOUNTING FACTORS	
OMB Discount Rate	10.0%
Private Discount Rate	25.0%
Contractor-Owned/Contractor-Operated Amortization Factor	0.3163

MISSION COSTS	
Helicopter Lease Cost (Fixed)	$1,600
Helicopter Lease Cost ($/Flt.Hr)	$660
Helicopter Set Up Time (Days)	0.33
Helicopter Ferry Time Days (RT)	0.75
Helicopter Ferry Flight Hours (RT)	6.00
Helicopter Crew	3
Travel & Per Diem (Per Prsn/Day)	$70
Number of Technical Laser Crew	2
Number of Ground Crew	2
Number of Post Processing Crew	2
Per Diem Cost Per Ground Vehicle	$50
OPERATIONAL CHARACTERISTICS	
Survey Speed (Knots)	20
Deadhead Speed (Knots)	100
Altitude (Meters)	200
Swath Width (Feet)	300
Coverage Rate (Sq N Miles/Hr)	0.99
Processing/Survey Hours Ratio	5
Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.12 Summary of Costs and Prices

Co/Co Scenario Corps-Wide

With UHF Trisponder Ground Positioning System

Missions	Expected Conventional Cost	HLBS Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Mission Price
Cape Cod	109,500	12,526	2.0	2.08	5,036	6,292	34,241
DelMarVa	69,765	15,847	3.5	2.08	2,637	4,562	43,323
FL-IWW	175,500	37,046	14.8	4.08	2,015	2,527	101,273
Hollywood	151,700	48,574	8.0	6.08	1,681	6,169	132,789
Maine	111,010	27,339	4.1	4.08	2,447	6,716	74,738
New Jersey	150,000	17,432	6.1	2.08	2,625	2,901	47,655
Total	$767,475	$158,765	38.6	20	$2,740	$4,861	$434,020

Table 3.13 shows the net present value based on this scenario. The benefits used in calculating the net present value arise from the $333,455 difference between the total expected conventional cost and the total price per mission. At 150 hours of use, the net present value to the Corps rises to $5,083,245.

3.4.3 Co/Co: Separate Missions with 2-D GPS

Table 3.14 shows the basic assumptions used for the HLBS analysis. This section examines the scenario composed of a Contractor-owned/Contractor-operated HLBS consisting of separate missions using 2-D GPS. The major change in this scenario is the use of a 2-D ground positioning system costing $220,000, which includes the cost of twelve tide gauges.

Table 3.15 shows the costs and prices used in this scenario. Total HLBS operating costs for all missions remain the same at $283,276. The total contractor price for performing all missions would increase, however, to $560,157, as a result of the slightly higher price of acquiring a 2-D GPS positioning system over a UHF system.

Table 3.16 shows the NPV to the Corps of this scenario. The benefits used in calculating the net present value arise from the $207,317 savings in total mission costs. At a level of 150 hours of annual use, the net present value to the Corps is $3,160,413.

3.4.4 Co/Co: Separate Missions with 3-D GPS

Table 3.17 shows the basic assumptions used for the analysis of the scenario composed of a Contractor-owned/Contractor-operated HLBS with separate missions using a 3-D GPS. The major change in this scenario is the use of a 3-D ground positioning system at a cost of $100,000, which eliminates the need for tide gauges. In addition, the ratio of post-processing to survey hours has increased to six-to-one (two people at six hours each). This allows for the additional time needed to process the additional data on tide levels from the 3-D system.

Table 3.18 shows the costs and prices considered in this scenario. Total HLBS operating costs rise to $284,232. Conversely, the total contractor price for performing all

Table 3.13 Net Present Value to USACE

Co/Co Scenario

Positioning System (UHF); Corps-Wide

Net Annual Benefit	$333,455	Amortization Factor	31.63%
Amortized First Costs	$933,208	Annual Mission Hours	150
Annual Costs	$1,070,708	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			1,297,102	1,297,102	1,297,102	1,297,102	1,297,102	1,297,102	1,297,102
Costs			---	---	---	---	---	---	---
Net Benefits			1,297,102	1,297,102	1,297,102	1,297,102	1,297,102	1,297,102	1,297,102
Discounted Net Benefits			960,916	869,473	786,732	711,864	644,122	582,825	527,362

Net Present Value in 1989 To USACE: ***$5,083,295***

Table 3.14 Basic Assumptions

Co/Co Scenario

Positioning System (2-D GPS); Separate Projects

LIFETIME COSTS		MISSION COSTS	
Commercial System Price	$2,750,000	Helicopter Lease Cost (Fixed)	$3,000
Positioning System (2-D GPS)	$220,000	Helicopter Lease Cost ($/Flt.Hr)	$660
Equipment Time Horizon (Years)	7	Helicopter Set Up Time (Days)	2.00
		Helicopter Ferry Time Days (RT)	2.00
ANNUAL FACTORS		Helicopter Ferry Flight Hours (RT)	16.00
		Helicopter Crew	3
System Maintenance (% of Price)	5.00%		
Annual Mission Hours	150	Travel & Per Diem (Per Prsn/Day)	$70
		Number of Technical Laser Crew	2
LASER CREW PRICES PER DAY		Number of Ground Crew	2
		Number of Post Processing Crew	2
Party Chief	$325	Per Diem Cost Per Ground Vehicle	$50
Electronic Technician	$300		
Assistant Surveyor	$275	OPERATIONAL CHARACTERISTICS	
DISCOUNTING FACTORS		Survey Speed (Knots)	20
		Deadhead Speed (Knots)	100
OMB Discount Rate	10.0%	Altitude (Meters)	200
Private Discount Rate	25.0%	Swath Width (Feet)	300
Contractor-Owned/Contractor-Operated		Coverage Rate (Sq N Miles/Hr)	0.99
Amortization Factor	0.3163	Processing/Survey Hours Ratio	5
		Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.15 Summary of Costs and Prices

Co/Co Scenario Separate Projects

With 2-D GPS Ground Positioning System

	Expected	HLBS					
Missions	Conventional Cost	Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Mission Price
Cape Cod	109,500	31,411	2.0	5	12,630	15,778	62,112
DelMarVa	69,765	34,733	3.5	5	5,779	10,000	68,681
FL-IWW	175,500	58,731	14.8	7	3,194	4,006	116,136
Hollywood	151,700	73,059	8.0	9	2,529	9,278	144,470
Maine	111,010	49,025	4.1	7	4,388	12,043	96,942
New Jersey	150,000	36,318	6.1	5	5,470	6,044	71,815
Total	**$767,475**	**$283,276**	**38.6**	**38**	**$5,665**	**$9,525**	**$560,157**

Table 3.16 Net Present Value to USACE

Co/Co Scenario

Positioning System (2-D GPS); Separate Projects

Net Annual Benefit	$207,317	Amortization Factor	31.63%
Amortized First Costs	$939,535	Annual Mission Hours	150
Annual Costs	$1,077,035	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			806,441	806,441	806,441	806,441	806,441	806,441	806,441
Costs			---	---	---	---	---	---	---
Net Benefits			806,441	806,441	806,441	806,441	806,441	806,441	806,441
Discounted Net Benefits			597,426	540,573	489,131	442,584	400,467	362,357	327,874

Net Present Value in 1989 To USACE: ***$3,160,413***

Table 3.17 Basic Assumptions

Co/Co Scenario

Positioning System (3-D GPS); Separate Projects

LIFETIME COSTS	
Commercial System Price	$2,750,000
Positioning System (3-D GPS)	$100,000
Equipment Time Horizon (Years)	7
ANNUAL FACTORS	
System Maintenance (% of Price)	5.00%
Annual Mission Hours	150
LASER CREW PRICES PER DAY	
Party Chief	$325
Electronic Technician	$300
Assistant Surveyor	$275
DISCOUNTING FACTORS	
OMB Discount Rate	10.0%
Private Discount Rate	25.0%
Contractor-Owned/Contractor-Operated Amortization Factor	0.3163

MISSION COSTS	
Helicopter Lease Cost (Fixed)	$3,000
Helicopter Lease Cost ($/Flt.Hr)	$660
Helicopter Set Up Time (Days)	2.00
Helicopter Ferry Time Days (RT)	2.00
Helicopter Ferry Flight Hours (RT)	16.00
Helicopter Crew	3
Travel & Per Diem (Per Prsn/Day)	$70
Number of Technical Laser Crew	2
Number of Ground Crew	2
Number of Post Processing Crew	2
Per Diem Cost Per Ground Vehicle	$50
OPERATIONAL CHARACTERISTICS	
Survey Speed (Knots)	20
Deadhead Speed (Knots)	100
Altitude (Meters)	200
Swath Width (Feet)	300
Coverage Rate (Sq N Miles/Hr)	0.99
Processing/Survey Hours Ratio	6
Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.18 Summary of Costs and Prices

Co/Co Scenario Separate Projects

With 3-D GPS Ground Positioning System

Missions	Expected Conventional Cost	HLBS Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Mission Price
Cape Cod	109,500	31,190	2.0	5	12,541	15,667	60,502
DelMarVa	69,765	34,641	3.5	5	5,763	9,973	67,197
FL-IWW	175,500	59,617	14.8	7	3,242	4,067	115,644
Hollywood	151,700	73,747	8.0	9	2,553	9,365	143,055
Maine	111,010	48,590	4.1	7	4,349	11,936	94,255
New Jersey	150,000	36,448	6.1	5	5,489	6,065	70,701
Total	$767,475	$284,232	38.6	38	$5,656	$9,512	$551,354

missions would fall to $551,354 due to helicopter capital costs. The total helicopter costs and the laser crew costs have remained the same but other costs have risen as a result of higher post-processing costs and efficiency costs. Ground crew costs have fallen, but not enough to offset the other operating cost increases.

Table 3.19 shows the net present value for this scenario rises to $3,294,608. This has resulted from a net annual benefit of $840,683 for 150 hours of HLBS use

3.3.6 Go/Co: Separate Missions with UHF Trisponder

Table 3.20 shows the basic assumptions used for the HLBS analysis of the scenario composed of a Government-owned/Contractor-operated HLBS with separate missions using a UHF Trisponder. The HLBS used would be the operational prototype developed with funding provided by USACE and the Canadian Government. These include the annual maintenance costs of $137,500 along with a UHF ground positioning system at a cost of $200,000. Table 3.21 shows the costs and prices for this scenario. The difference between this and the base case scenario lies with the net annual benefit, which the Government would derive for leasing the HLBS to a private contractors. This figure, shown in the last column of Table 3.21 consists of the difference between expected conventional costs and HLBS operating costs.

Table 3.22 shows how the net present value is calculated based on the USACE share of development costs over a three year period, 1989 to 1991. The benefits used in calculating the net present value arise from the $484,199 net annual benefit. This figure has been extrapolated by an annual dollar value of USACE contracts that rise from $900,000 in 1991 to $8.6 million in 1995 and beyond. In this scenario, the net present value to the Corps is $6,650,869.

Table 3.23 shows the amortized first costs and annual costs for the HLBS in this scenario. Using an amortization factor of .2054, based on Government ownership, amortized first costs amount to $605,946. This amount, added to system maintenance costs of $137,500 per year, yields a total annual cost for the HLBS in this scenario of

Table 3.19 Net Present Value to USACE

Co/Co Scenario

Positioning System (3-D GPS); Separate Projects

Net Annual Benefit	$216,120	Amortization Factor	31.63%
Amortized First Costs	$901,574	Annual Mission Hours	150
Annual Costs	$1,039,074	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			840,683	840,683	840,683	840,683	840,683	840,683	840,683
Costs			---	---	---	---	---	---	---
Net Benefits			840,683	840,683	840,683	840,683	840,683	840,683	840,683
Discounted Net Benefits			622,793	563,527	509,900	461 377	417,471	377,743	341,796

Net Present Value in 1989 To USACE: ***$3,294,608***

Table 3.20 Basic Assumptions

Go/Co Scenario

Positioning System (UHF); Separate Projects

LIFETIME COSTS		MISSION COSTS	
Commercial System Price	$2,750,000	Helicopter Lease Cost (Fixed)	$3,000
Positioning System (UHF)	$200,000	Helicopter Lease Cost ($/Flt.Hr)	$660
Equipment Time Horizon (Years)	7	Helicopter Set Up Time (Days)	2.00
		Helicopter Ferry Time Days (RT)	2.00
ANNUAL FACTORS		Helicopter Ferry Flight Hours (RT)	16.00
		Helicopter Crew	3
System Maintenance (% of Price)	5.00%		
Annual Mission Hours	150	Travel & Per Diem (Per Prsn/Day)	$70
		Number of Technical Laser Crew	2
LASER CREW PRICES PER DAY		Number of Ground Crew	2
		Number of Post Processing Crew	2
Party Chief	$325	Per Diem Cost Per Ground Vehicle	$50
Electronic Technician	$300		
Assistant Surveyor	$275	OPERATIONAL CHARACTERISTICS	
DISCOUNTING FACTORS		Survey Speed (Knots)	20
		Deadhead Speed (Knots)	100
OMB Discount Rate	10.0%	Altitude (Meters)	200
Private Discount Rate	25.0%	Swath Width (Feet)	300
Government-Owned/Contractor-Operated		Coverage Rate (Sq N Miles/Hr)	0.99
Amortization Factor	0.2054	Processing/Survey Hours Ratio	5
		Efficiency Factor (% Helicopter Flight, Laser Crew & Post Processing Costs)	15.0%

Table 3.21 Summary of Costs and Prices

Go/Co Scenario Separate Projects

With UHF Trisponder Ground Positioning System

Missions	Expected Conventional Cost	HLBS Operating Costs	Survey Hours	Mission Days	Unit Cost Per Hour	Unit Cost Per Sq Mile	Net Benefit
Cape Cod	109,500	31,411	2.0	5	12,630	15,778	78,089
DelMarVa	69,765	34,733	3.5	5	5,779	10,000	35,032
FL-IWW	175,500	58,731	14.8	7	3,194	4,006	116,769
Hollywood	151,700	73,059	8.0	9	2,529	9,278	78,641
Maine	111,010	49,025	4.1	7	4,388	12,043	61,985
New Jersey	150,000	36,318	6.1	5	5,470	6,044	113,682
Total	$767,475	$283,276	38.6	38	$5,665	$9,525	$484,199

Table 3.22 Net Present Value to USACE

Go/Co Scenario

Positioning System (UHF); Separate Projects

Net Annual Benefit	$484,199	Amortization Factor	20.54%
Amortized First Costs	$605,946	Annual Mission Hours	150
Annual Costs	$743,446	Discount Rate	10.00%

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
Benefits			567,808	1,167,162	1,766,515	3,596,120	5,425,725	5,425,725	5,425,725
Costs	550,000	2,500,000	2,637,500	137,500	137,500	137,500	137,500	137,500	137,500
Net Benefits	(550,000)	(2,500,000)	(2,069,692)	1,029,662	1,629,015	3,458,620	5,288,225	5,288,225	5,288,225
Discounted Net Benefits	(497,661)	(2,046,827)	(1,533,265)	690,203	988,048	1,898,131	2,626,055	2,376,153	2,150,032

Net Present Value in 1989 To USACE: ***$6,650,869***

Table 3.23 Amortized First Costs and Annual Costs

Go/Co Scenario;Separate Projects
Positioning System (UHF)

AMORTIZED FIRST COSTS	Totals
Commercial System Price	2,750,000
Positioning System (UHF)	200,000
Sum of First Costs	2,950,000
Amortization Factor	0.2054
Amortized First Costs	**$605,946**

ANNUAL COSTS	Totals
Amortized First Costs	$605,946
System Maintenance (% of Price)	$137,500
Total Annual Costs	$743,446

$743,446. Although not used to determine NPV, this table is indicative of the difference in capital costs facing private companies versus those facing the Government.

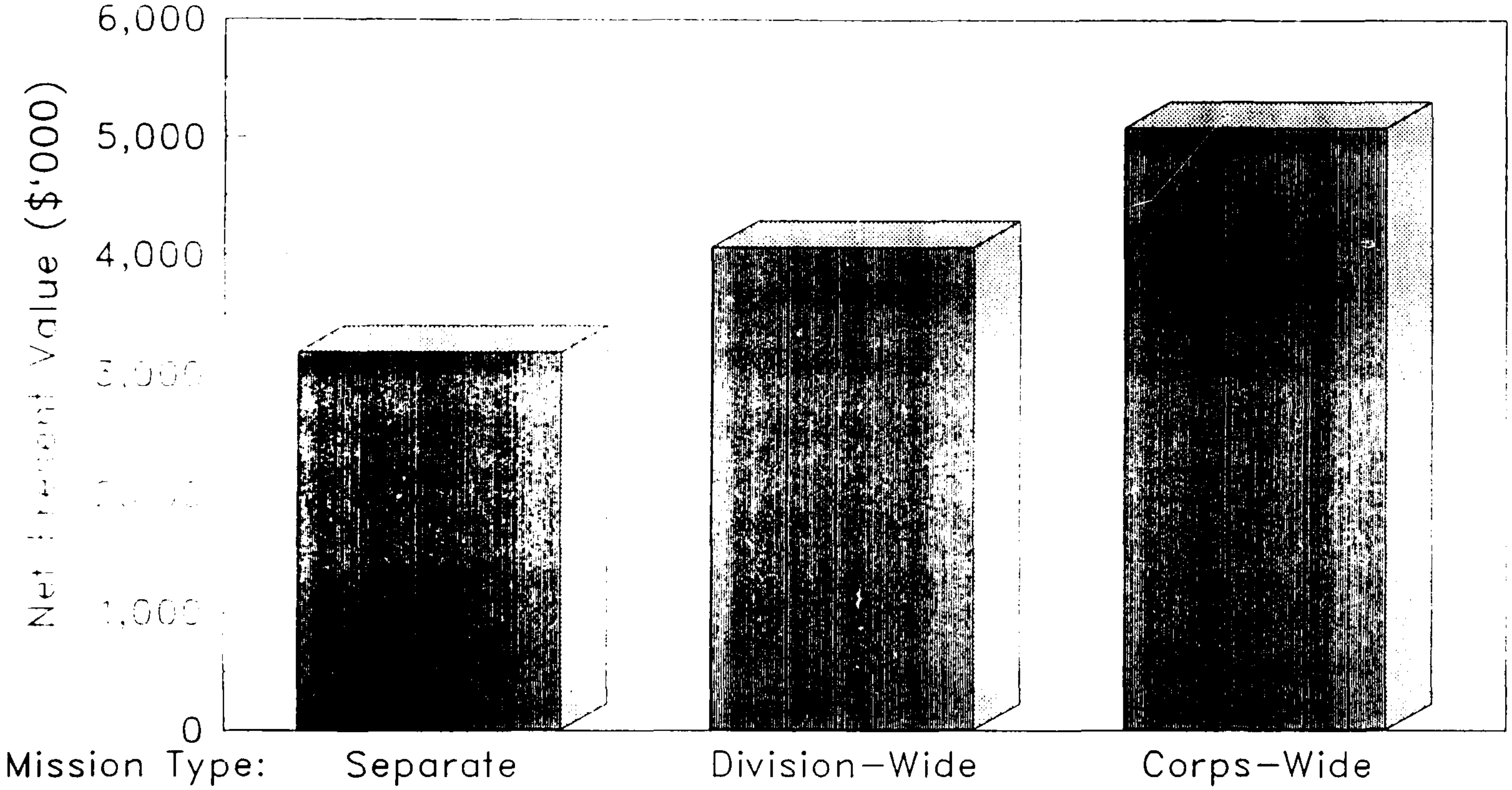
3.5 Comparison of Co/Co Scenarios

Figure 3.1 compares the net present values in 1989 to the USACE of HLBS mission scenarios based on varying levels of mission aggregation, but all using UHF positioning. For example, it shows that a Contractor-owned/Contractor-operated system conducting the six separate missions would produce a net present value of savings worth approximately $3,185,207 for the Corps. These results are based on 150 hours of HLBS use per year and a system cost of $2.75 million. The net present value increases substantially as the six individual missions are grouped at the division-level and then again at the Corps level. These gains are achieved because fewer days of mobilization/demobilization occur when missions are aggregated.

Figure 3.2 shows changes in the NPV for a Contractor-owned/Contractor-operated HLBS conducting the six separate missions using the different ground positioning systems: UHF Trisponder, two-dimensional GPS or three-dimensional GPS. The economic analysis results are relatively insensitive to the choice of positioning system. The UHF and 2-D positioning systems differ in cost by only $20,000. The 3-D positioning system, although costing $100,000 less than the UHF system and $120,000 less than the 2-D system, has a higher post-processing cost, which largely offsets savings in ground positioning system acquisition.

Figure 3.1

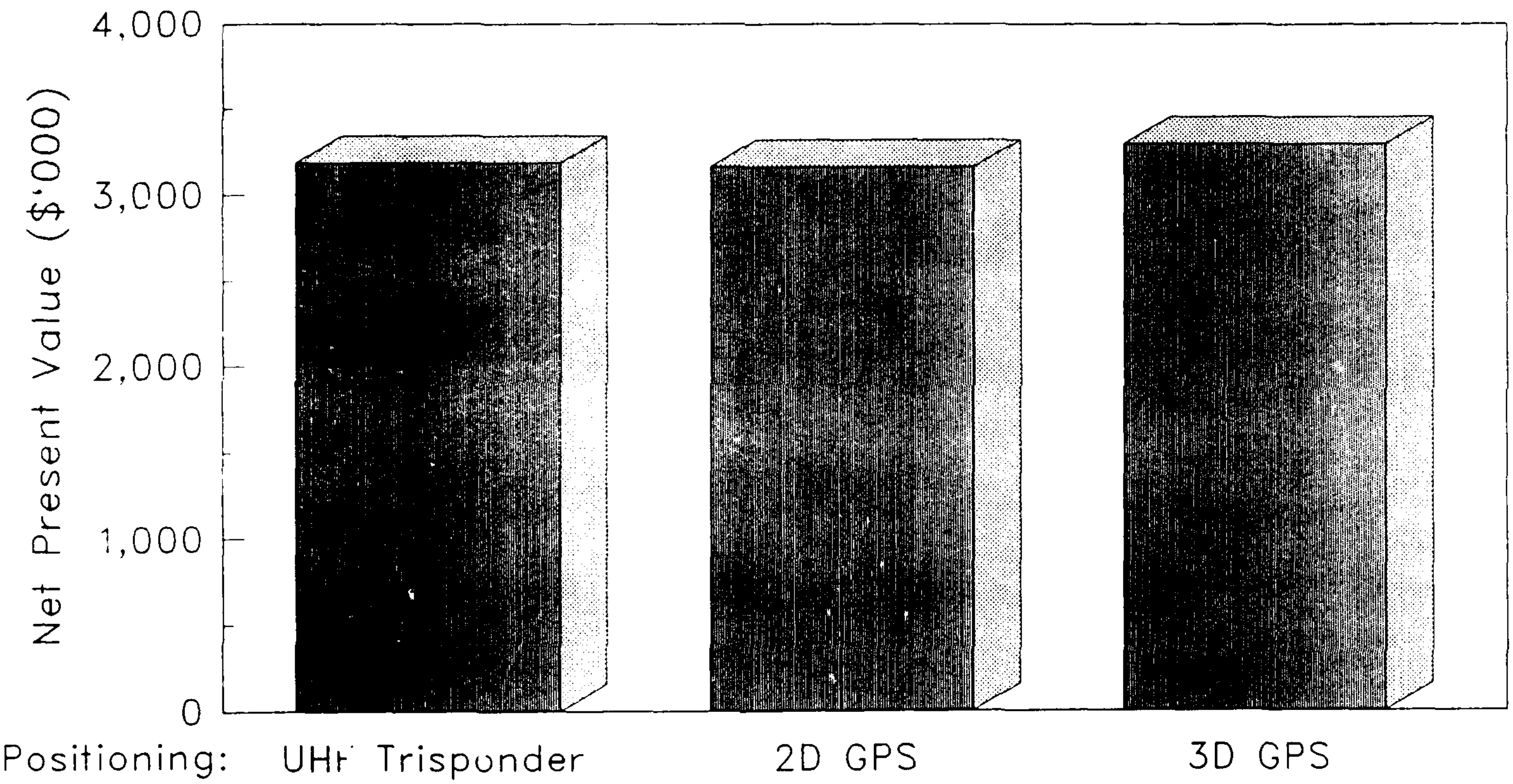
Comparison of HLBS Scenarios by Level of Mission Aggreagation



Note: All scenarios Contractor-Owned/Contractor Operated with UHF positioning.

Figure 3.2

Comparison of HLBS Scenarios by Type of Ground Positioning System



Note: All scenarios Contractor-Owned/Contractor Operated as separate missions.

Chapter 4

SENSITIVITY ANALYSIS

This section shows how the results of the economic analysis change under different assumptions regarding costs, methods of operation and HLBS utilization. It shows that the three most important factors affecting the net present value of the HLBS investment are mission hours, acquisition cost and helicopter lease costs. Less important factors in terms of impact on system economics are mission efficiency, discount rates, and helicopter hourly costs. All the sensitivity analysis in this section are based on the Co/Co: separate projects with UHF positioning scenario.

4.1 Cost Savings to Corps

Figure 4.1 shows the percentage of the expected conventional costs saved given increasing levels of annual mission hours. This graph demonstrates the significant gains to be made especially in levels under 300 hours. Increasing utilization from 100 hours to 150 results in a 17.9 percent net savings whereas increasing utilization from 600 hours to 650, although still beneficial, only saves 0.7 percent of expected costs.

4.2 Mission Hours, Acquisition Cost and Helicopter Lease

Figure 4.2 shows how the net present value changes using a helicopter lease cost of $3,000 per day and various levels of HLBS acquisition cost and annual mission hours. At 150 hours of use per year, the Co/Co breaks even at an acquisition cost of approximately $5 million. At 100 mission hours the break-even cost is $3.2 million. At 100 mission hours, an acquisition cost of less than $3.2 million would yield a positive net present value. The break-even HLBS system cost at 200 mission hours is $6.7 million; at 250 mission hours it is $8.4 million; and at 300 mission hours it is $10.1 million. At the acquisition cost of $2.75 million and 150 hours of use in the analysis, the net present value of survey cost savings to the Corps is $3.2 million.

Figure 4.1

Annual Cost Savings to Corps from HLBS

Co/Co: Separarte Projects with UHF Positioning

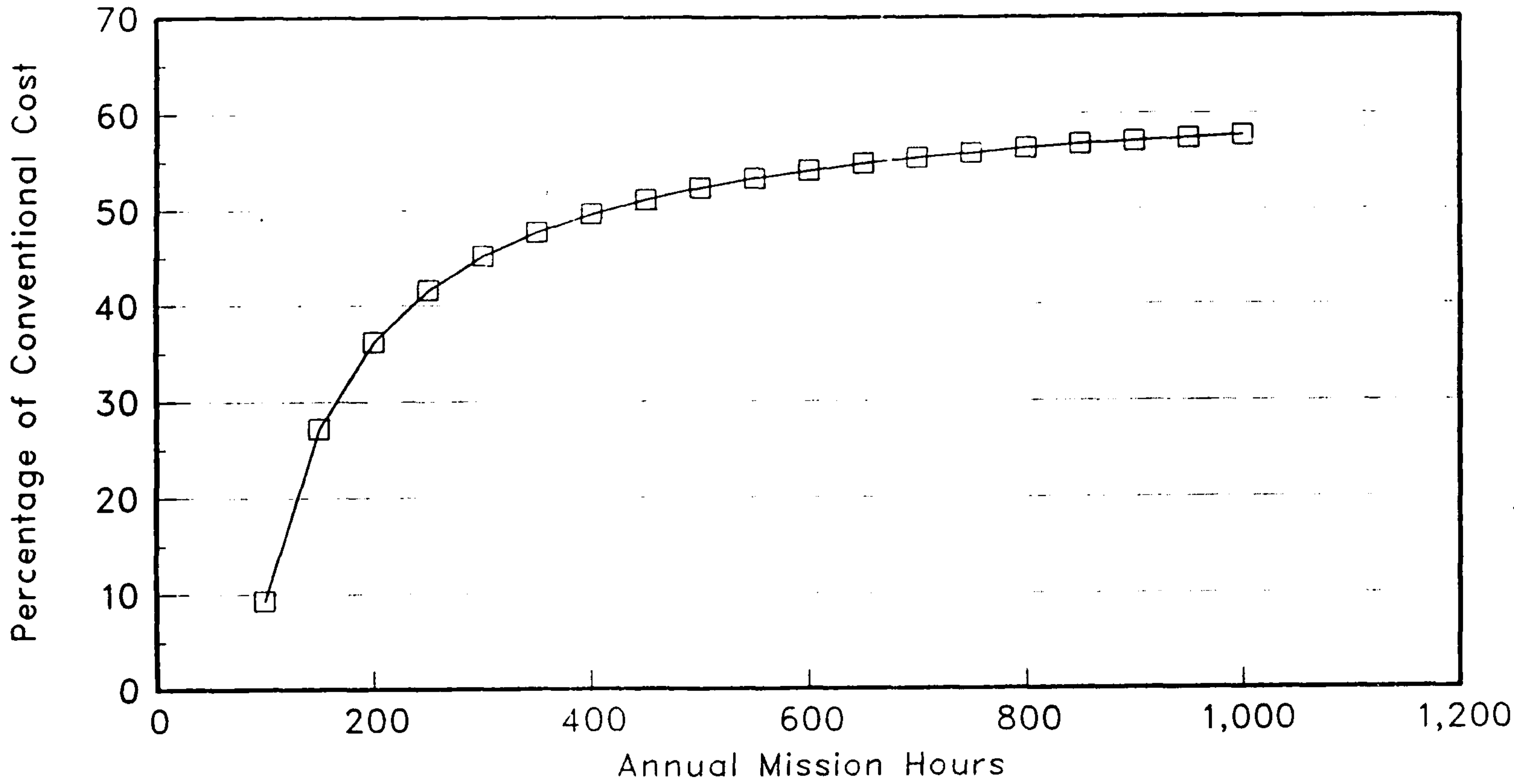


Figure 4.2

Net Present Value of HLBS to USACE

Helicopter Lease: $3,000 Per Day

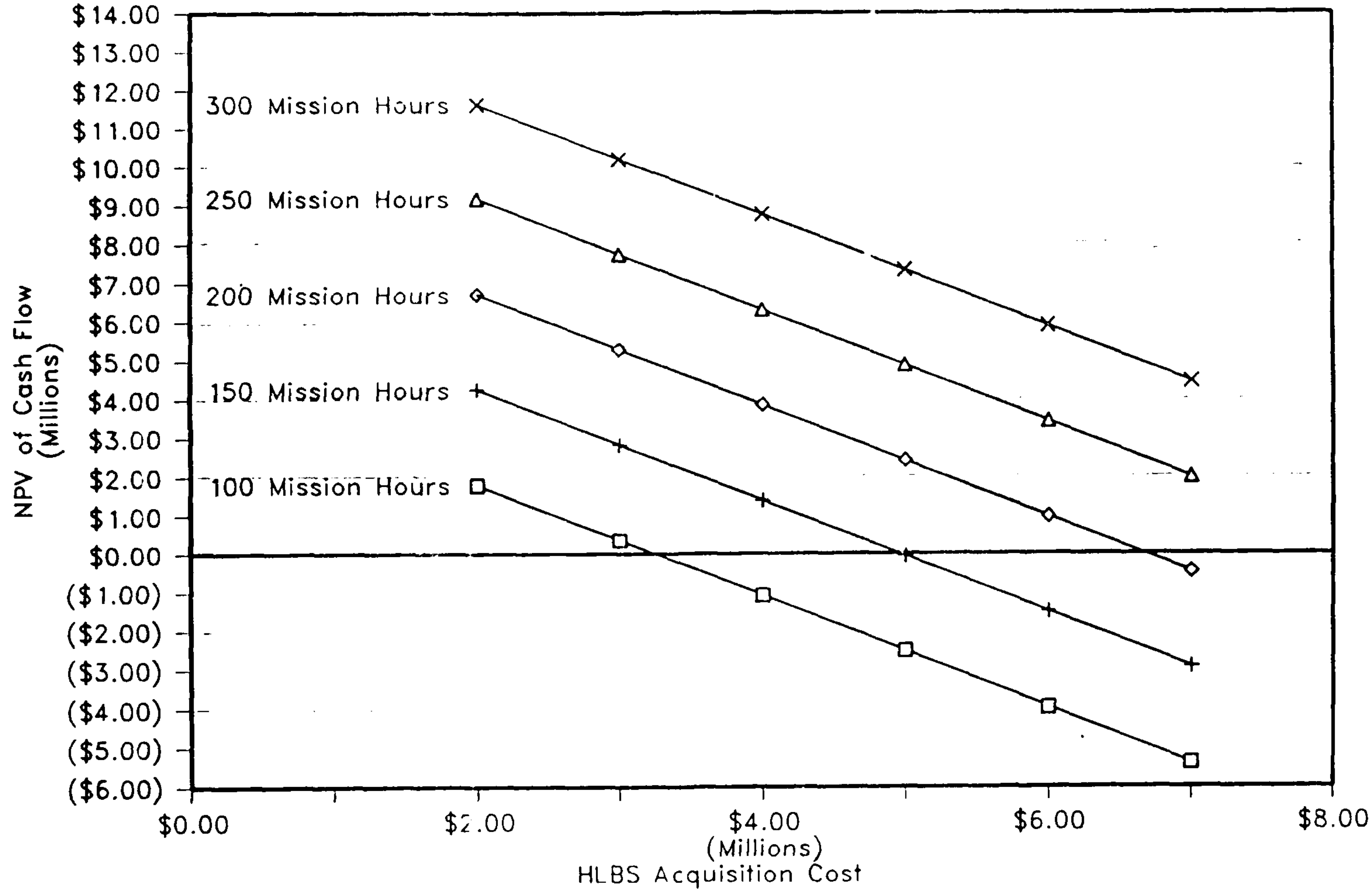


Figure 4.3 shows the sensitivity to mission levels for helicopter lease costs of $1,600 per day. This lower cost would be typical of lengthier helicopter lease periods. At 100 annual mission hours, the break-even acquisition cost would be $3.6 million; at 150 mission hours it would be $5.5 million; at 200 mission hours it would be $7.4 million; at 250 mission hours it would be $9.3 million; and at 300 mission hours it would be $11.2 million.

4.3 Costs and Utilization

The results in the earlier figures reveal that NPV is sensitive to both mission hours and acquisition costs. The reason acquisition costs exert such a pull is that the HLBS has a high ratio of fixed costs to total costs. Figure 4.4 shows the allocation of amortized acquisition costs and maintenance costs per hour at various levels of annual mission hours. As the number of mission hours increase, the annual cost per mission hour decreases. For example, these costs fall in half from $10,707 per hour at 100 hours of use to $5,354 per hour at 200 hours of use.

4.4 Efficiency

One of the operational characteristics built into the analysis was an efficiency factor. This adds an additional cost premium to accommodate for lost time due to the helicopter resetting itself after making a turn or a loop, having to backtrack to resurvey a missed area, and other such contingencies. This factor adds a percentage of the helicopter charter, laser crew and post processing costs back into the operating cost per mission. As such, the sensitivity analysis conducted on the efficiency factor raises operating costs and can be viewed as a means of testing sensitivity on a wide range of other operating cost components such as costs of the labor, per diem, ground transportation, number of crew and so forth. Figure 4.5 shows the net present value of the system at various levels of efficiency for both the separate projects and Corps-wide

Figure 4.3

Net Present Value of HLBS to USACE

Helicopter Lease: $1,600 Per Day

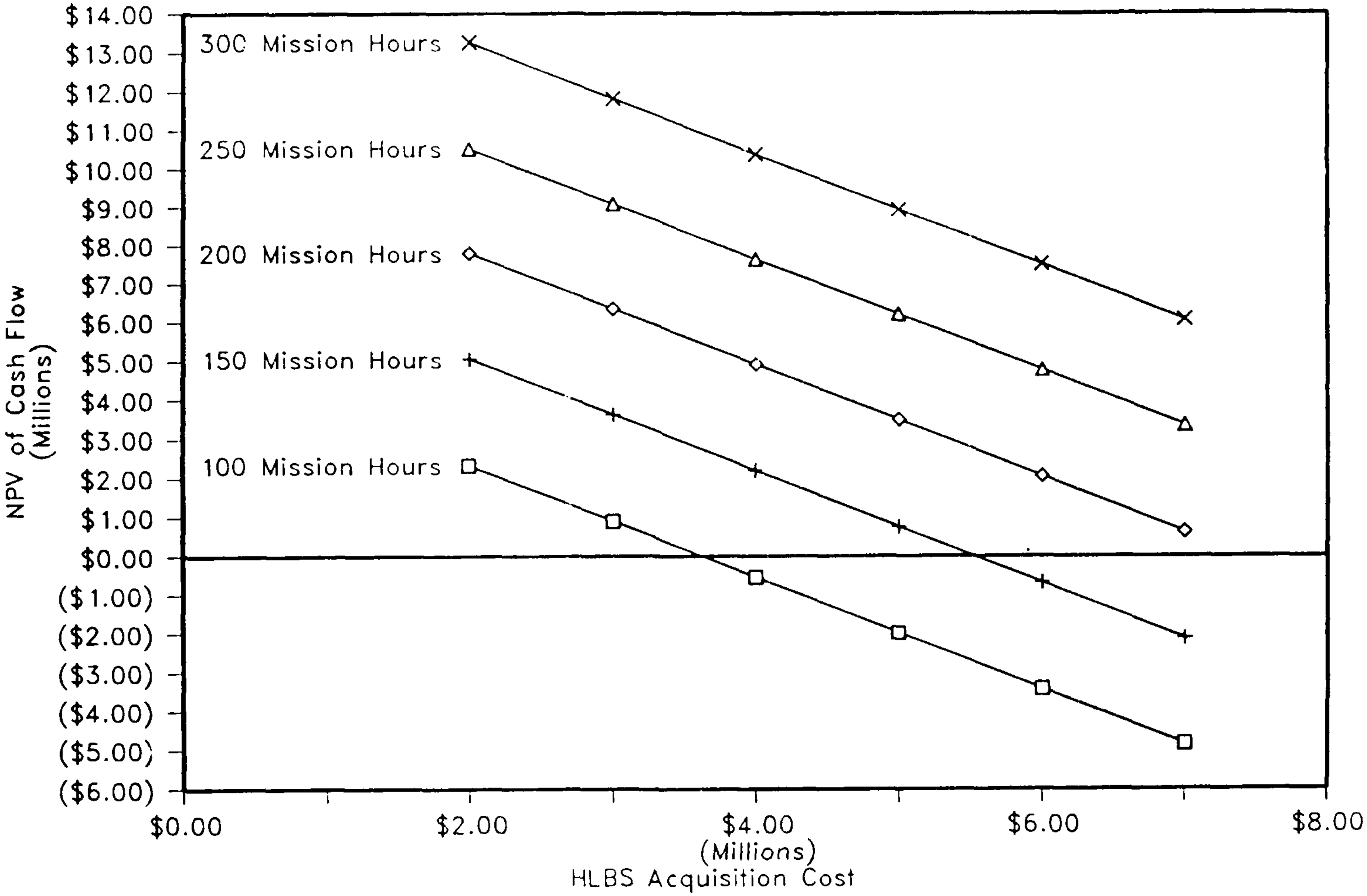
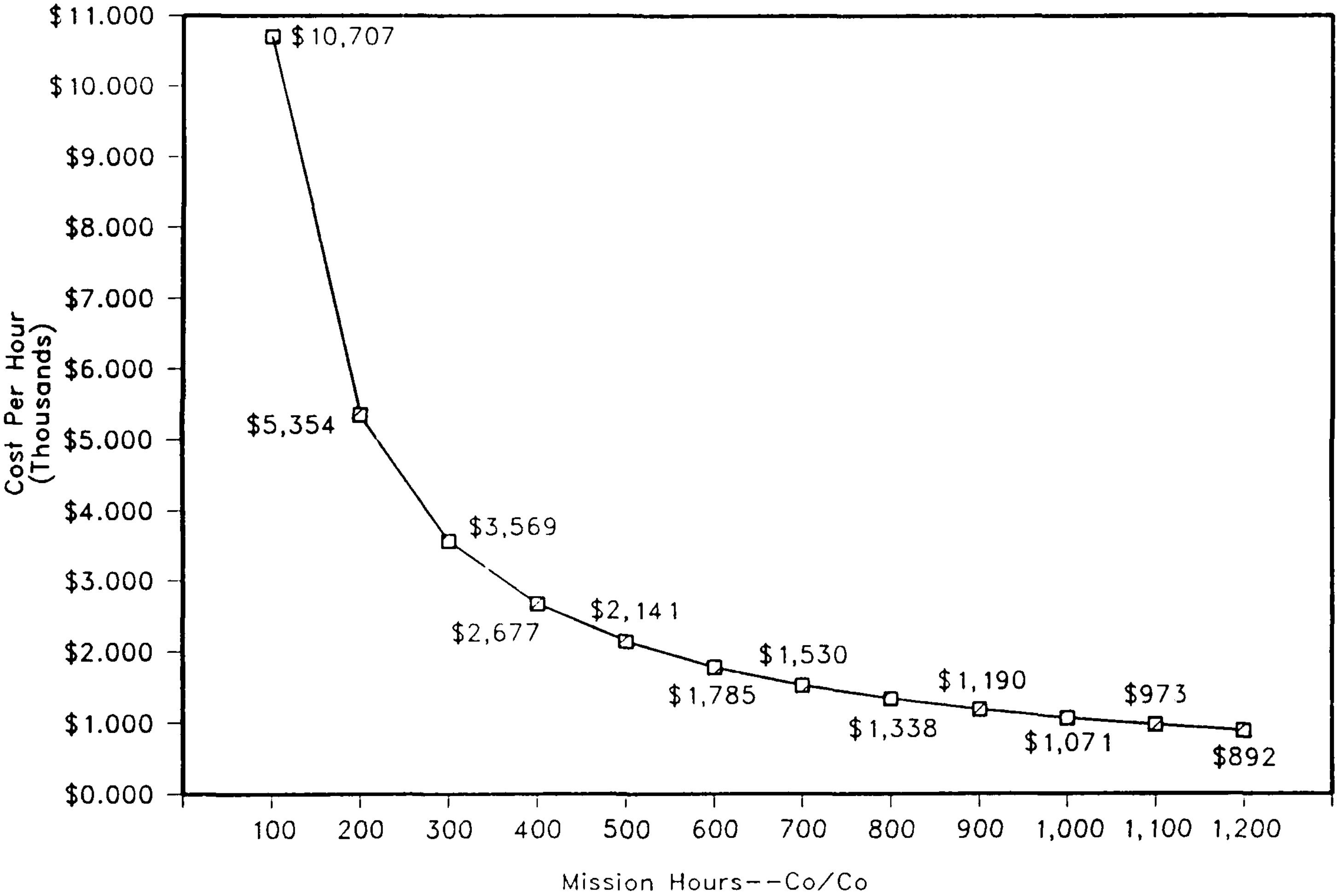


Figure 4.4

Annual Costs Per Mission Hour

For Acquistion and Maintenance Costs



scenarios. At a zero percent efficiency factor for the separate projects scenario, the net present value is over $3.3 million. This net present value descends in a straight line as the efficiency rises. At 60 percent added cost for efficiency, the net present value of the system falls to $2.7 million. At an additional 150 percent efficiency factor, the net present value falls to $1.7 million. At this rate it would require an efficiency factor of 306 percent to reach zero, the break-even point. This insensitivity to increases in operating costs is characteristic of a product or process with high fixed costs such as the acquisition cost and the mobilization/demobilization costs.

Under a Corps-wide scenario, the net present value is higher for each efficiency factor due to the lower average cost of mobilization and demobilization, otherwise the same low rate of decline applies.

4.5 Other Factors

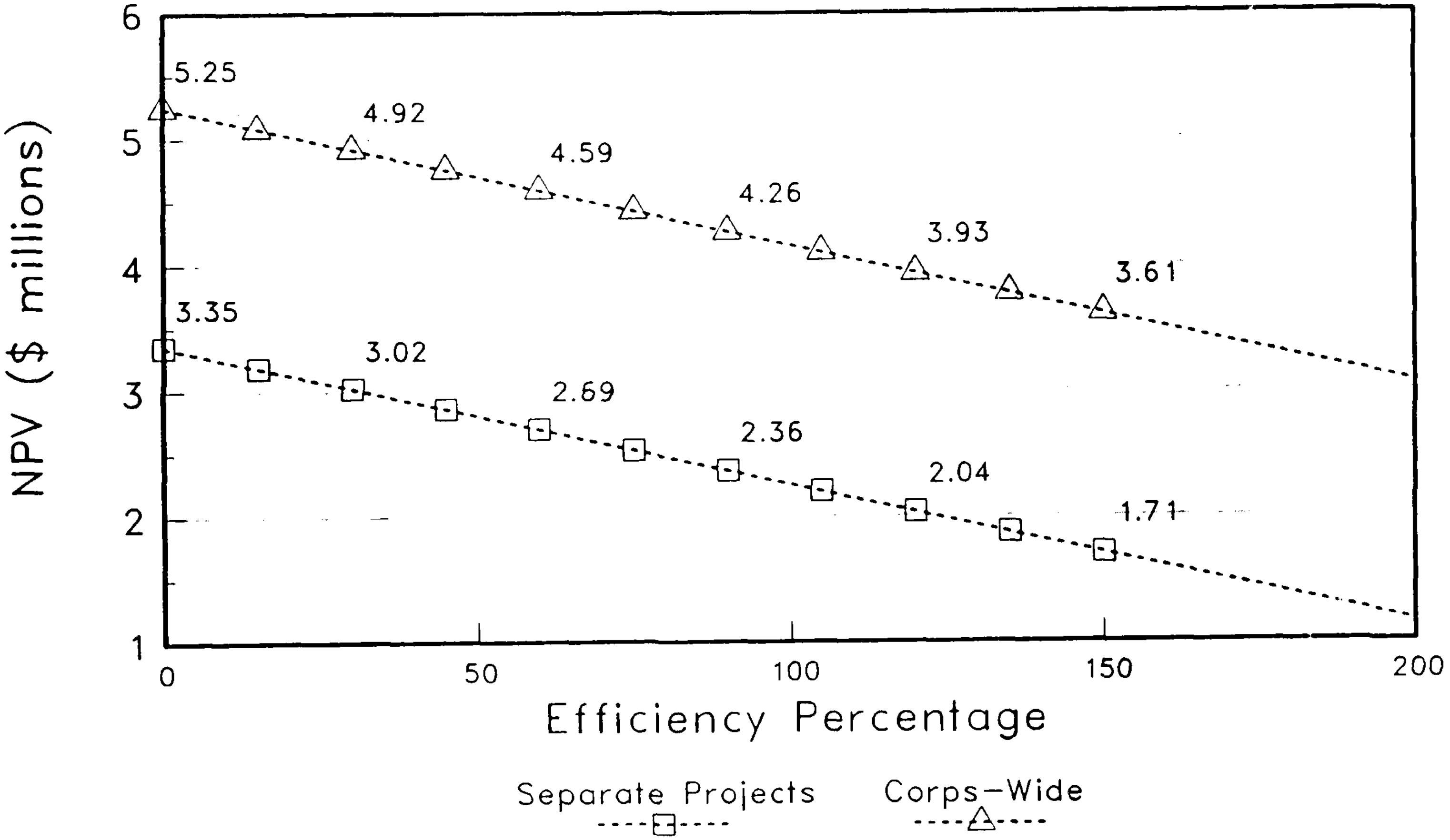
Sensitivity analyses could be performed for every single assumption made in the study. As mentioned in the previous paragraph, however, most of the parameters can be considered incorporated under the efficiency factor sensitivity. This section looks at two more factors worthy of consideration: one which would fall under the efficiency factor, but is worth viewing in the open, and another which was not covered.

4.5.1 Discount Rates

In financial analysis, the internal rate of return (IRR) is the discount rate at which the net present value of an investment turns to zero. This is a useful piece of information in conducting any analysis to make sure that the advocates for the investment have not selected a discount rate that was just low enough to prove their point correct. In many investments, the difference between an eight percent discount rate and a ten percent discount rate makes all the difference between accepting or rejecting a given project. There is no IRR for the Co/Co scenario because it does not consider a cost to the USACE, but rather only a series of benefits. Presumably, the Corps would choose

Figure 4.5

Net Present Value vs Efficiency Factor



Separate Projects; Y = 3,349,339 - 10,942X
Corps-Wide; Y = 5,247,429 - 10,942X

not to contract out projects if they became more expensive than its in-house capabilities. The private contractor, who must purchase the HLBS, bears the initial cost in this scenario. Increasing the OMB rate of return from ten percent to 25% and the private discount rate from 25 to 50 percent, however, will reduce the net present value of the HLBS to the Corps to $316,321. These rates are high enough to show that the choice of rates were not held low enough to successfully advocate for the HLBS.

4.5.2 Hourly Helicopter Costs

The daily lease cost has been subject to some sensitivity testing already, switching from $1,600 to $3,000 depending on the scenario. The hourly helicopter cost, however, has been held constant throughout the analysis at $660. Increasing this hourly cost by $1,000 would have a significant, but not critical effect on the analysis by reducing the net present value to $431,667. The reason for this steep decline is that while there are only 38.6 survey hours included in the analysis, each mission requires an additional 16 flight hours for mobilization and demobilization. But shifting from the separate project scenario to the Corps-wide scenario which has only one sixteen-hour mobilization and demobilization, with an additional four hours of flight time between missions, the net present value is restored to a lofty $3,244,413.

The conclusion that can be reached from this and from many of the other sensitivity analyses is that whereas, for the sake of conducting an economic analysis, many assumptions have been given a single value which time may prove did not predict their exact value in the marketplace three years hence, even great changes in many of these factors will not upset the conclusion of the analyses. Moreover, USACE has the capacity to offset declines in this NPV with institutional or management adjustments such as altering the way it contracts for its survey projects.

Chapter 5

COMMERCIALIZATION OF HLBS TECHNOLOGY

This chapter ties together a number of issues which will affect the commercialization of HLBS technology. It first discusses the U.S. and world markets for hydrographic surveys and points out some areas which may have promise for application of the HLBS. This chapter also explores the value of the improved survey data quality available with HLBS. The chapter next describes some problems which would have to be resolved to operate the HLBS in a fixed-wing aircraft. It concludes with a discussion of two issues: changes in how USACE contracts surveys and the need to refine the economic analysis of HLBS after the operational prototype system has been tested.

5.1 Market for HLBS

While its technical performance will ultimately determine the level of demand for HLBS, there is a degree of uncertainty surrounding this because only one such system has been successfully employed. (This is the Larsen 500 system being flown on behalf of the Canadian Government in a DC-3 aircraft by Terra Surveys.) Until constraints such as the specific depths of operation and other conditions can be tested, the size of the market for HLBS surveys is difficult to estimate. The world contains many coastal areas which are either unsurveyed or for which no recent surveys are available. With these in mind, it is useful to enumerate the potential uses for airborne lidar bathymeter systems.

The commercial and military hydrographic survey markets are relevant HLBS opportunities as well as other potential applications of this technology such as antisubmarine warfare or mine clearance. However, the analysis below concentrates on the hydrographic survey market. An Optech research report notes that less than 20 percent of the world's coastal waters have had recent hydrographic surveys.[1] Table 5.1 shows

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[1]Optech, Incorporated "Market Potential for a Helicopter-Borne Scanning Lidar System," undated, page 2.

those countries of the world which regularly attend International Hydrographic Organization meetings and have active survey programs. An asterisk denotes those countries which have existing or planned procurements of airborne survey systems.

5.1.1 U.S. Market

The Corps of Engineers represents one market of interest for commercial hydrographic surveys. Table 5.2 shows the estimated hydrographic survey budget of the Corps of Engineers by field office in FY 1983. Discussions with the Chief of Survey for the Corps indicate that the hydrographic survey budget is not broken out separately but that FY 1983 provides a representative baseline spending level for this activity at the Corps. Table 5.2 also shows whether and how these offices responded to the Corps of Engineers information request regarding HLBS potential for survey missions.

To ascertain the likely level of annual hydrographic survey missions which could be performed using HLBS, a more detailed investigation of the survey data was undertaken. In this case, district offices were asked whether HLBS potentially could be employed to conduct surveys of the specific project sites listed. These data, along with historic cost of survey and survey frequency (number of times performed per year) were used to estimate an annual dollar value of HLBS surveys as reported by the Corps offices. Table 5.3 contains the results of this analysis. The table shows that the volume of work which was reported as potentially surveyable with HLBS technology total slightly more than $2.8 million per year. As shown above in Table 5.2, some offices did not respond to the survey while others indicated no HLBS potential for survey missions within their office. These two groups accounted for almost 40 percent of the survey responses.

There is some question as to the ultimate level of survey missions that could be performed with HLBS. For example, the Seattle, Washington, office indicated no HLBS potential while the Portland, Oregon, office which operates in similar waters with respect to clarity, turbidity and depth, indicated several potential HLBS missions. Thus, there may be reasons to believe that the estimates in Table 5.3 above are conserva-

Table 5.1

COUNTRIES WHICH MAY BENEFIT FROM HLBS

Argentina	West Germany	Philippines
Australia*	Greece	Portugal
Belgium	Guatemala	Singapore
Brazil	Iceland	Spain
Canada*	India	Sri Lanka
Chile	Indonesia	Sweden*
People's Republic of China	Italy*	Trinidad/Tobago
Cuba	Japan	Turkey
Denmark*	Korea	USSR
Dominican Republic	Malaysia	United Kingdom
Ecuador*	Netherlands*	United States*+
Egypt	New Zealand	Venezuela
Fiji	Norway*	Yugoslavia
France*	Peru	

*Have plans to procure airborne hydrographic system.

+U.S. Government: National Oceanographic Survey, Defense Mapping Agency, U.S. Navy Oceanographic Office, Corps of Engineers.

Source: Optech, Inc. telecon 1/13/89.

Table 5.2

FIELD OFFICE RESPONSE TO HLBS SURVEY AND BUDGET AFFECTED

FOA	Office	Type	1983 Budget ($Millions)	Survey Response: Some Potential	No Potential	No Response
LMK	Vicksburg, MS	DIST	$1.7		X	
LMM	Memphis, TN	DIST	0.7		X	
LMN	New Orleans, LA	DIST	3.8		X	
LMS	St. Louis, MO	DIST	0.4			X
MRO	Missouri River	DIV	0.1			X
MRK	Kansas City, MO	DIST	0.1		X	
MRO	Omaha, NB	DIST	0.2			X
NAB	Baltimore, MD	DIST	0.6		X	
NAN	New York, NY	DIST	0.5	X		
NAO	Norfold, VA	DIST	0.9	X		
NAP	Philadelphia, PA	DIST	0.9	X		
NCB	Buffalo, NY	DIST	0.4			X
NCC	Chicago, IL	DIST	NIL			X
NCE	Detroit, MI	DIST	7.4	X		
NCR	Rock Island, IL	DIST	0.5	X		
NED	New England	DIV	2.1	X		
NPA	Anchorage, AK	DIST	1.8	X		
NPP	Portland, OR	DIST	1.2	X		
NPS	Seattle, WA	DIST	0.3		X	
NPW	Walla Walla, WA	DIST	0.2			X
ORH	Huntington, WV	DIST	0.3			X
ORL	Louisville, KY	DIST	0.2			X
ORN	Nashville, TN	DIST	NIL			X
ORP	Pittsburgh, PA	DIST	0.1			X
POD	Pacific Ocean	DIV	0.3	X		
SAC	Charleston, SC	DIST	NIL			X
SAJ	Jacksonville, FL	DIST	2.3	X		
SAM	Mobile, AL	DIST	2.5			X
SAS	Savannah, GA	DIST	0.2			X
SAW	Wilmington, NC	DIST	0.6	X		
SPK	Sacramento, CA	DIST	0.2			X
SPL	Los Angeles, CA	DIST	0.3			X
SPN	San Francisco, CA	DIST	0.4			X
SWA	Albuquerque, NM	DIST	NIL			X
SWF	Fort Worth, TX	DIST	NIL			X
SWG	Galveston, TX	DIST	1.5	X		
SWL	Little Rock, AR	DIST	0.4		X	
SWT	Tulsa, OK	DIST	0.1			X
Total and Amount ($Millions) By Response Category			$32.1	$20.0 (62.3%)	$6.6 20.6%)	$5.5 (17.1%)

*Excludes dredge payment surveys

Sources: Budget data from: CERC, "Helicopter-Mounted Lidar Bathymetic System, Field Working Group Presentation," July 13, 1988, p. 10. Survey responses tabulated by GRA.

Table 5.3

REPORTED ANNUAL VALUE OF HLBS SURVEYS FOR SELECTED CORPS OF ENGINEERS OFFICES ($000 - 1988)

Office	Amount
Anchorage, AK District	$ 45.3
Wilmington, NC District	96.1
Detroit, MI District	760.8
Galveston, TX District	82.4
Jacksonville, FL District	735.8
Rock Island, IL District	30.0
New England Division	372.0
Norfolk, VA District	211.8
Philadelphia, PA District	255.6
Pacific Ocean Division	35.0
St. Paul, MN District	210.0
Total	$2,834.6*

*Total does not add due to rounding.

Source: Analysis of Corps survey results. (Does not include New York City District because of discrepancies in data.)

tive. If, however, the Corps of Engineers can achieve a positive return on its investment by applying HLBS to about $2.8 million a year of conventional surveys, extrapolation of these conclusions to a larger HLBS potential would yield proportionally greater savings.

There is some information about the U.S. survey market not covered in the Corps requirements. A number of government agencies conduct hydrographic surveys using in-house personnel and equipment. The propensity of such organizations to acquire HLBS technology is unknown, yet some of these entities have investigated airborne lidar bathymeter systems in the past (e.g., the U.S. Navy HALS System). According to Nield[2], the Defense Mapping Agency (DMA) has a fundamental survey backlog amounting to about 200 ship-years of work. The coastal survey operation is down to one 400-foot ship and her four 36-foot launches.

According to Enabnit[3], the nautical charting plan of the National Ocean Survey (NOS) identifies the need for additional survey data to eliminate or resolve the chart deficiencies. The NOS survey requirements have been organized into scheduled and unscheduled surveys based on the priority of the survey. Unscheduled surveys are those for which documented, acknowledged requirements exists, but for those that NOS does not have adequate vessels and resources. The author gives a table of examples of required surveys that are beyond the capacity of NOS which are classified as unscheduled. (See Table 5.4)

According to Enabnit, it has been estimated that the list of unscheduled surveys contains three times as much work as the list of scheduled surveys. There are 100,000 square nautical miles of critical hydrography that have been identified for surveying during the current decade. The average survey rate of 6,000 square nautical miles per

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[2]Van K. Nield, "Airborne Laser Hydrography in the United States," presented at the Laser Hydrography Symposium Defense Research Center, Adelaide, Australia, September 30-October 3, 1980, pp. 3.

[3]David B. Enabnit, "Airborne Laser Hydrography," NOAA Technical Memorandum OTES 4, Rockville, MD, May 1982, pp. 12-15.

Table 5.4

EXAMPLES OF UNSCHEDULED SURVEYS

Maine coast, inshore areas (areas from Isle of Shoals to Canadian border, including harbor surveys of Bangor and Bath)

Albemarle Sound and tributaries (including harbor survey of Elizabeth City, NC)

Delaware Bay (inshore) (DE, NJ)

Hudson River (NY Harbor to north of Troy, NY; Lake Champlain; and Lake George)

Boque Inlet (NC)

Florida Intracoastal Waterway (Jacksonville to Miami)

Southwest coast of Florida and Florida Bay

South coast of Long Island (including the bays) and New Jersey coast out to 11-fathom curve

Lake Michigan (Wilmette to Waukeegan, IL)

New York State Barge Canal (Troy to Tonawanda, NY) (including Seneca, Cayuga, and Oneida Lakes)

Raritan Bay and River (NJ)

Rappahannock River (VA)

St. Lawrence River (Lake Ontario to Cornwell, ON)

Gardiners Bay and Peconic Bay (NY)

Vermilion Bay, White Lake, and Grand Lake (LA) Sabine Lake (TX)

Oshkosh to New London (including Lakes Butte des Morts, Poyqan, Winneconne, and Partridge and the Upper Fox and Wolfe Rivers) (WI)

New River to, and including, Jacksonville (NC)

Source: David B. Enabnit, "Airborne Laser Hydrography," NOAA Technical Memorandum UTOS, Rockville, MD, May 1982, pp. 13.

year will leave 40,000 square nautical miles unsurveyed by 1990. The author then looks at the future workload and notes the following:

- o In the last ten years, there has been a 55 percent increase in U.S. water borne commerce;
- o In the last ten years, energy exploration and production in U.S. coastal waters has almost doubled;
- o More than 100,000 people are employed off-shore;
- o More than 114 million people, 53 percent of the U.S. population, live in a coastal zone;
- o Almost 55 percent of the total U.S. industrial base is in a coastal zone;
- o New off-shore oil and gas tracts should cost more than $7 billion and port and harbor construction exceeds $1 billion annually.

These activities make use of NOS marine charts and their growth indicates growth in the hydrographic surveying requirement.

The author then goes on to list the following anticipated changes in user requirements that will increase the required amount of surveying:

- o The Congressional mandate for fishing obstruction charts must be met;
- o The use of deep draft vessels, particularly super tankers, will increase;
- o Recreational boating in fresh water, rivers and lakes will increase;
- o Competition for the use of off-shore resources will intensify along with the demand for conserving these resources and protecting the environment.
- o Bureau of Land Management and the United States Geological Survey (USGS) needs for managing and evaluating off-shore oil and gas resources must be met;
- o Demands for up-to-date NOS bathymetric maps and Topographic-Bathymetric maps being produced in cooperation with the USGS will increase;
- o The Defense Mapping Agency's plans for surveys outside of the U.S. waters will increase.

According to Norden and Litts[4], in the Western Gulf, limited areas are candidates for laser bathymetry. The southern half of Laguna Madre, Texas, is surveyable by

[4]Maxim F. Van Norden and Steven E. Litts, "The Transparency of Selected U.S. Coastal Waters with Applications to Laser Bathymetry," Naval Postgraduate School, Monterey, CA, Master's Thesis, September 1979, pp. 47-48.

laser bathymetry from November through February. The area from Matagorda Bay to Sabine Pass off Texas is surveyable all year up to depths of 10 to 20 fathoms. West of the Mississippi Delta, and possibly to the Sabine Pass, a strip from outside local estuaries and bays to the 10-fm depth contour is available to laser bathymetry from March to October.

According to the authors, the Eastern Gulf Coast area is the area best-suited to laser bathymetry. Off Florida from Panama City to the Panama Keys, an area of 30,000 square nautical miles bordered by the 30-fm depth contour may be surveyed by laser bathymetry during June through September, and a reduced area bordered by the 20-fm depth contour all year. From Panama City to the Eastern Mississippi Delta, an area of 8,800 square nautical miles bordered by the 20-fm depth contour is surveyable from October to December.

According to Enabnit, Williams, and Skove[5], in their study concerning the surveyability of ten U.S. sites, they conclude that the results of their study indicate that there is a large amount of area surveyable by laser. Table 5.5 shows the locations, estimated maximum area surveyable, estimated maximum depths reached, the optimal seasons for surveying and the confidence in the estimates that they obtained.

5.1.2 Non-U.S. Market

A recent United Nations report has assessed the state of hydrographic surveying worldwide.[6] While it does not specifically speak to laser hydrography, such as that produced by HLBS, the sheer magnitude of worldwide survey needs points to a large

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[5] David B. Enabnit, Jerome Williams, and Frederick A. Skove, "An Estimate of the Area Surveyable with an Airborne Laser Hydrography System at Ten U.S. Sites," NOAA Technical Report OTES 5, Rockville, MD, 1981, p. 15.

[6] United Nations Economic and Social Council, Review of the Latest Technology in Cartographic Data Acquisition, Manipulation, Storage and Presentation, With Special Emphasis on Potential Applications in Developing Countries: Hydrographic Surveying and National Charting, Fourth U.N. Regional Cartographic Conference for the Americas, January 23-27, 1989.

Table 5.5

ESTIMATES OF THE MAXIMUM AMOUNT OF AREA SURVEYABLE BY LASER AT TEN U.S. SITES

Location	Estimated Max. Area Surveyable	Estimated Max. Depth Reached	Optimum Season	Confidence In Estimates
Chesapeake Bay (Northern Half)	1,460 KM^2	9-10 Meters	Autumn	Low
Chesapeake Bay (Southern Half)	2,850 KM^2	9-11 Meters	Autumn	Medium
James River (Lower End)	161 KM^2	3-4 Meters	Summer	Low
Tampa Bay	785 KM^2	10-11 Meters	_____	Medium
Nantucket Sound	2,970 KM^2	18 Meters	_____	Medium
Gulf of Mexico (One Section North of Tampa Bay)	6,500 KM^2	21-30 Meters	_____	Low
Lake Erie	24,160 KM^2	18 Meters	Summer	Low
Lake Ontario	7,125 KM^2	8-11 Meters	Winter	Low
Lake Huron	35,670 KM^2	35 Meters	Summer	Low
New York Harbor	280 KM^2	7 Meters	Summer	Low

Source: David B. Enabnit, Jerome Williams, and Frederick A. Skove, "An Estimate of the Area Surveyable with an Airborne Laser Hydrography System of Ten U.S. Sites," NOAA Technical Report OTES 5, Rockville, MD, 1981, p. 15.

potential market for HLBS-type equipment. The principal findings of this study include the following:

- o About one-half of the world's maritime states have no hydrographic capability.
- o Of the almost 100 million square kilometers studied, only 31 percent is considered to be adequately surveyed.
- o The main needs are in developing coastal states where the lack of adequate surveys and nautical charts retards maritime commerce, fishing and resource exploitation and hence economic development.[7]
- o The largest needs (in terms of percent of total area requiring surveys) are in Africa and Australia.

The fact that many areas of the world are unsurveyed or require resurveying may result from a lack of available resources to dedicate for hydrographic surveying. HLBS technology, because of the large potential increases in survey productivity, offers the opportunity to meet survey needs in coastal areas and in certain inland water bodies.

A prior study has explored the potential of laser bathymeter surveys in Southeast Asia. According to Murdock[8], there are narrow strips along parts of the coastline of Southeastern Asia and Indonesia where laser bathymetry systems may offer advantages of speed, economy and accessibility in surveying. According to the author, due to the scarcity of data and the small scale of the charts, the exact dimensions of these strips cannot be ascertained. Also, the limits of surveyable areas vary over time. Though the author does not give a quantifiable amount of surveyable areas, he does consider a number of areas at different times, and implies that depending on the season, the possibility of laser surveying may exist. (See Table 5.6).

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[7] Ibid. p. 39.

[8] John H. Murdock, "The Transparency of Southeast Asian and Indonesian Waters," Naval Postgraduate School, Monterey, CA, Master's Dissertation, March 1980, pp. 72.

Table 5.6

POSSIBLE SURVEYABLE AREAS

IN SOUTHEAST ASIAN AND INDONESIAN WATERS

Jakarta Approaches, Apr-Jun

Jakarta Approaches, Jul-Sep

Jakarta Approaches, Oct-Dec

Java Sea, Jan-Mar

Java Sea, Apr-Jun

Java Sea, Jul-Sep

Java Sea, Oct-Dec

Java Sea, entire year

Makassar Strait, Flores Sea and Bali Sea, entire year

Malacca Strait, Dec-Apr

Bangkok Approaches, Apr-Oct

Bangkok Approaches, Nov-Dec

Gulf of Thailand, entire year

South China Sea (Southern Section), entire year

South China Sea (Northern Section), Apr-Nov

South China Sea (Northern Section), Dec-Mar

East China Sea, entire year

Source: John H. Murdock, "The Transparency of Southeast Asian and Indonesian Waters," Naval Postgraduate School, Monterey, CA, Master's Dissertation, March 1980, pp. 134-151.

5.2 HLBS Production Costs in Commercial Quantities

The ultimate number of HLBS systems produced will likely define the unit cost of each system. That is, the cost of the operational prototype HLBS as produced for the Corps of Engineers is likely to be higher than if HLBS was produced in modest quantities for the commercial market. Costs embedded in the Corps system such as software development and operational testing would not apply to commercial versions. The analysis does not assume any recoupment of development costs by the Corps of Engineers for later systems which have reached the market as a result of its development efforts.

Optech has developed an order-of-magnitude estimate which indicate that if twenty-five systems were produced, the unit cost would fall to approximately $2.75 million. While some uncertainty surrounds this estimate, the sensitivity analysis indicates that there be a margin between the expected cost in commercial quantities versus the cost of the proof-of-concept HLBS to allow for price increases, yet not invalidate the results of the benefit-cost analysis. A key consideration in the cost of commercial HLBS systems will be the technical and economic performance of the system. The estimate above is for a system equivalent to the Corps of Engineers operational prototype.

5.3 Fixed-Wing Platform for Airborne Lidar Bathymeter Systems

The Canadian Government uses an airborne lidar bathymeter system flying in a DC-3 aircraft, but this system has several differences from the HLBS. This system, known as the Larsen 500, operates with a laser pulse speed of 25 pulses per second or 1/8th the rate of the HLBS laser. Moreover, the DC-3 has a mission speed of up to 100 knots, approximately five times the speed contemplated for HLBS missions in the base case making comparison between the technical performance of the Larsen 500 and the HLBS inappropriate.

Mounting an HLBS 200 hertz laser in a fixed-wing platform would reduce data density by a factor of four. This is based on using an aircraft such as the DeHavilland Twin-Otter (DHC-6) which operates at speeds of about 80 knots.[9] The data density of this system could be increased by flying it at lower altitudes than the helicopter or increasing the laser repetition or firing rate. Flying additional paths or flying with the laser head in the profile or fixed position could also increase data density. However, for any given altitude and laser repetition rate, the helicopter will gather more dense data because it is possible to fly it at much slower speeds. One can infer then that a fixed-wing platform would not be suitable for Corps missions unless the data density requirements were relaxed. (The mission analysis contained in this report uses a helicopter speed of 20 knots and an altitude of 200 meters to produce spot spacing of about five meters in the regions of no overlap and lesser distances in the regions of overlap.[10])

The absolute level of helicopter operating costs are high relative to a fixed wing aircraft platform. The specific cost advantage of the airplane would partially offset the inefficiency of the increased turning radius needed to reacquire tracks where multiple tracks are required to complete a mission. A fixed-wing platform would be most appropriate for surveys which have long tracks and do not require dense data.

5.4 Value of Improved Survey Data Quality

The high speed at which the HLBS acquires useful data indicates that its survey results will contain many times more soundings per area of coverage than conventional methods. The study attributes no separable value to the additional density of data gathered over conventional surveys. In addition, the high production rate of the HLBS means that additional survey area can be covered within a fixed budget. Many organi-

[9]Telephone interview Boeing-Canada Aircraft, 1/18/89.

[10]Extrapolated from data on page 62 in the Optech report.

zations which have large backlogs for surveys may find HLBS attractive because they can survey many more sites in a given time without increases to current budget outlays for conventional surveys.

The increase in data density also may enable certain users to acquire information with HLBS that would not be cost-effective using conventional survey methods. For example, the effects of waves on beach erosion could be investigated using HLBS to provide a series of profiles of near-shore bottom conditions.

5.5 Contracting Issues

The Corps of Engineers is not the only U.S. agency that conducts hydrographic surveys. The Defense Mapping Agency, the U.S. Naval Oceanographic Office and the National Ocean Survey of the National Oceanic and Atmospheric Administration also have potential HLBS needs. Many states and private companies also conduct or contract for hydrographic surveys as part of coastal zone management programs and resource extraction processes. Thus, there are a large number of organizations which conduct surveys and which are candidate acquirers or users of HLBS technology. The key determinants of whether such entities will acquire airborne laser systems will be the actual performance of the Optech system developed for the Corps of Engineers and the amount of surveying that a single user can aggregate into missions suitable for such a system.

The likely markets for HLBS systems include government organizations and commercial survey firms. For the former group, the dollar-value of survey work currently performed or contemplated will play a key role in their acquisition decision for HLBS. For the private sector, return on investment is the typical criterion used in capital investment decisionmaking. In the case of HLBS, commercial survey firms would require certainty of sufficient dollar volume of revenue per year to cover variable operating costs as well as to contribute to the fixed costs of the system. This may mean, for example, that organizations such as the Corps of Engineers may have to aggregate those missions which are suitable for HLBS into sizable procurements so that a private-sector firm would be willing to invest in such equipment were it able to win a contract. This may require the Corps of Engineers to rethink the level of aggregation at which it procures hydrographic surveys. Presently, such contracts are let on a job or multi-job basis by each district office within the Corps. Until HLBS obtains widespread commercial use in other market areas, there is a need to provide a commercial operator with a procurement contract large enough to warrant an investment.

Each of the six individual scenarios evaluated in this study represents a significant change from current practice in the number of individual projects conducted as part of a single package. This type of aggregation is necessary to achieve savings from HLBS. In the sensitivity analysis, additional cost savings are shown when scenarios are grouped at the District Office and Corps-wide levels. The key factor for this cost reduction is that mobilization/demobilization occurs less frequently.

5.6 Future Economic Analyses

A number of important parameters in the economic evaluation have been developed using assumptions about HLBS performance. If the Corps moves forward with the Optech operational prototype, valuable experience with actual operation of the HLBS will result. Parameters such as data density requirements, optimum mission altitudes and speeds, the ratio of HLBS post-processing time to flight time, system maintenance requirements and the characteristics of areas amenable to survey with HLBS can then be specified with more certainty. At that point in time, it would be useful to revisit the economic analysis. The first step in this process would be to conduct an in-depth survey of Corps field offices, using operational test results on system performance, to identify those current survey projects (and costs of them) which have a high potential for HLBS use. With information on this and other key parameters, better insights into the likely economic, operational and other HLBS benefits can be developed for Corps of Engineers hydrographic survey missions.

Appendix A

CAPE COD CANAL

Cape Cod Canal in Massachusetts is a 32-foot deep channel stretching 20 miles from Cape Cod Bay into Buzzard's Bay (Figure A-1). Along the canal are two small projects called Wareham River and Onset Bay. The Army Corps of Engineers owns both the canal and the access to the canal on both sides. Along the canal are frequent benchmarks accessible from a service road. The GPS location for this project will be at the State Pier shown on Figure A-1. UHF trisponders will be located at Falmouth Cliffs and Sandwich Harbor. Surveying of the canal can be accomplished in one day. Set up and take down of UHF trisponders for this project should be accomplished within one quarter day each.

Scenario Analysis

A helicopter will be flown to Plymouth Airport, located 13.5 miles from the Cape Cod breakwater, which will serve as the starting point for the Lidar survey. The helicopter will fly from the airport to the breakwater and begin surveying along a southerly course over the canal. It will divert into the East Boat basin (Figure A-2) surveying the basin with two 300-foot passes. The helicopter will then return to the canal and continue surveying until Onset Bay (Figure A-3). It will survey Onset Bay with three passes. It will then proceed directly to Wareham Harbor (Figure A-4) which it will survey in one pass. It will then return to where it left the canal to survey the remainder of the Cape Cod Canal. This return, not involving surveying, will be at the speed of 100 knots. The helicopter will then proceed to survey the rest of the channel. This channel consists of two parts, the Hog Island channel with a 500-foot canal width and the Cleveland Ledge channel with a 700-foot canal width. The helicopter will fly to the end of the Cleveland Ledge channel and make three passes to survey the entire canal width. This will leave the helicopter at the southernmost end of the channel from where it will fly at 100 knots back to the southern end of the Hog Island channel.

Figure A-1

CORPS OF ENGINEERS

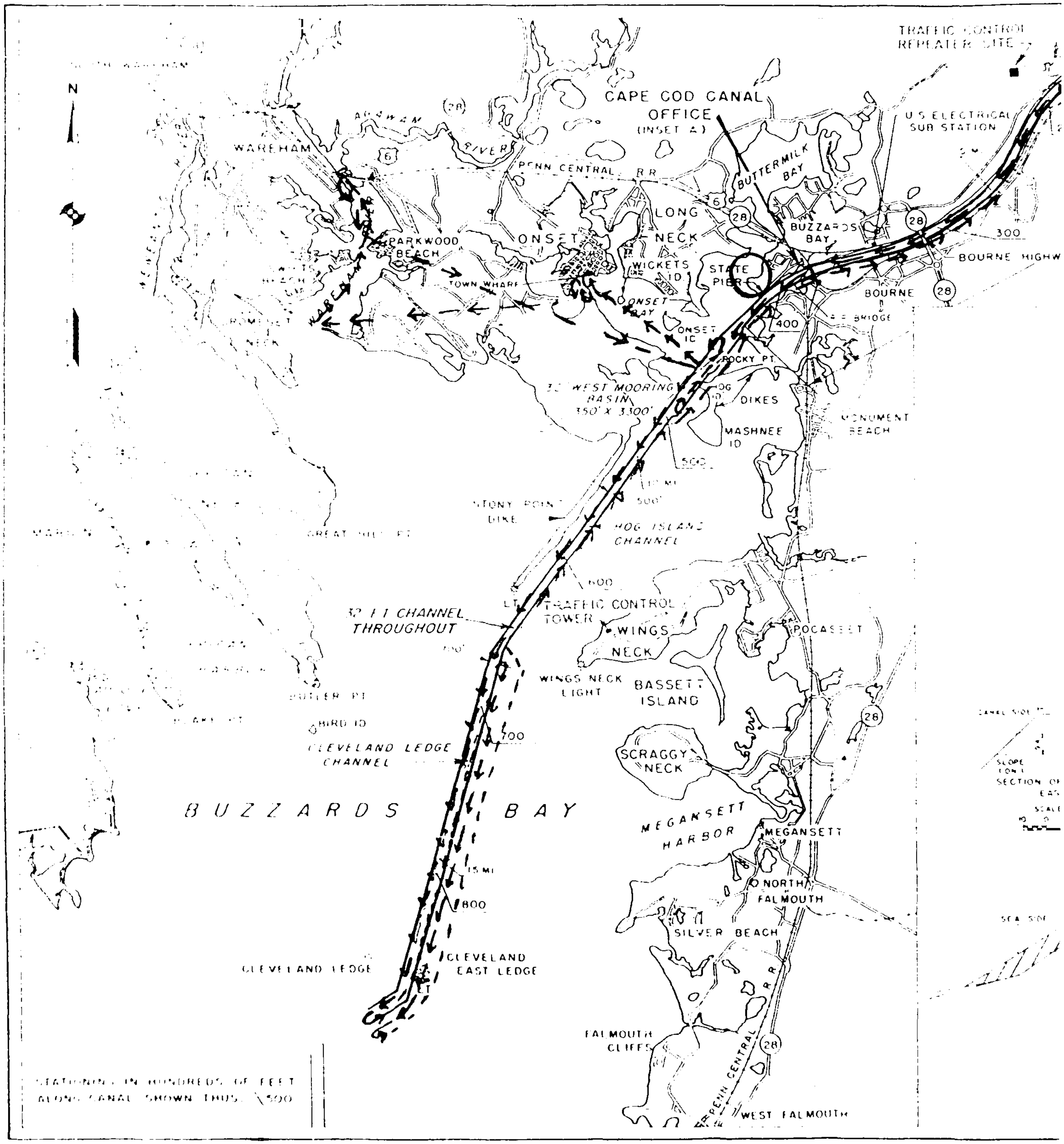
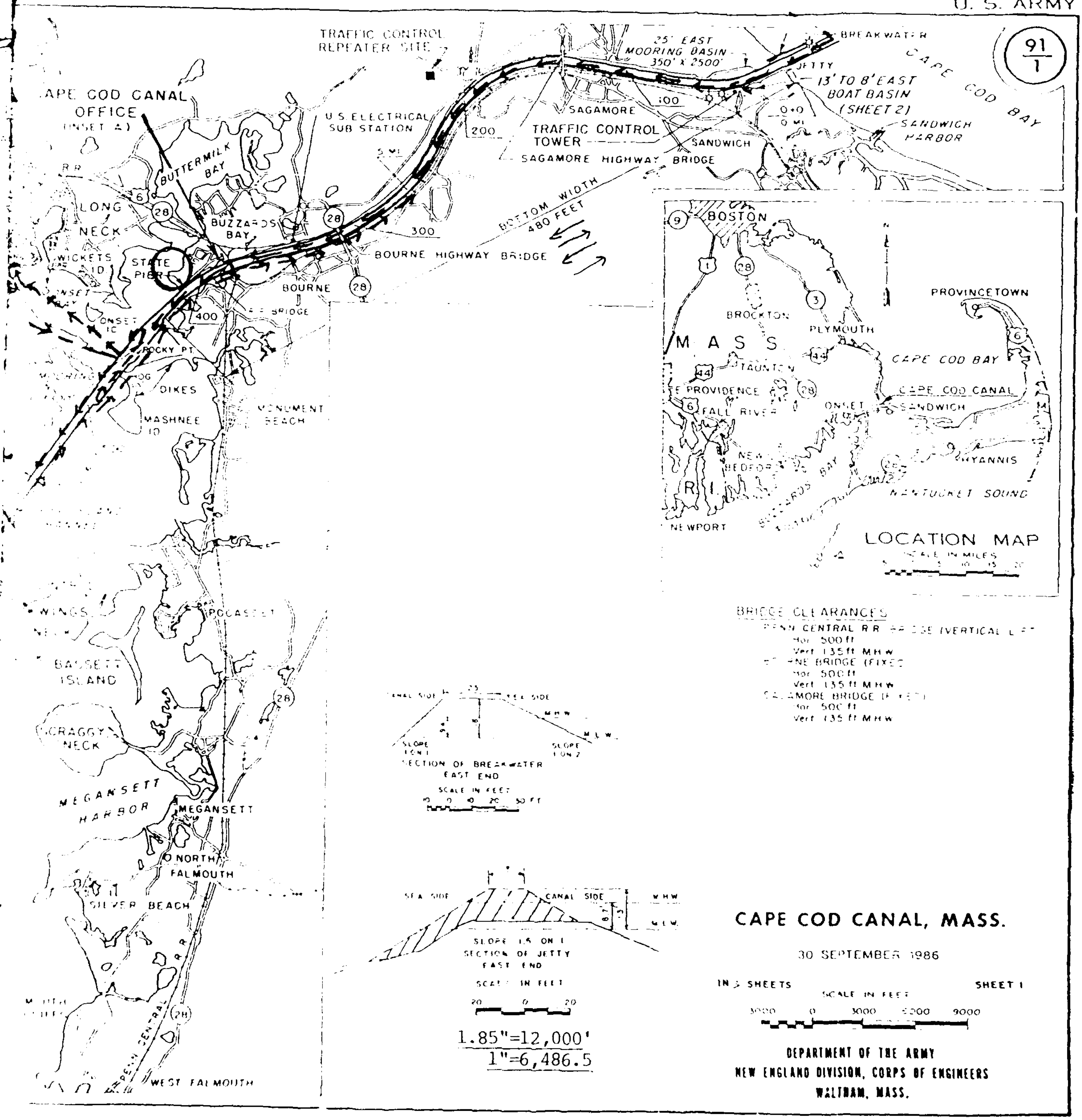


Figure A-1



1.85"=12,000'
1"=6,486.5

Figure A-2

CORPS OF ENGINEERS

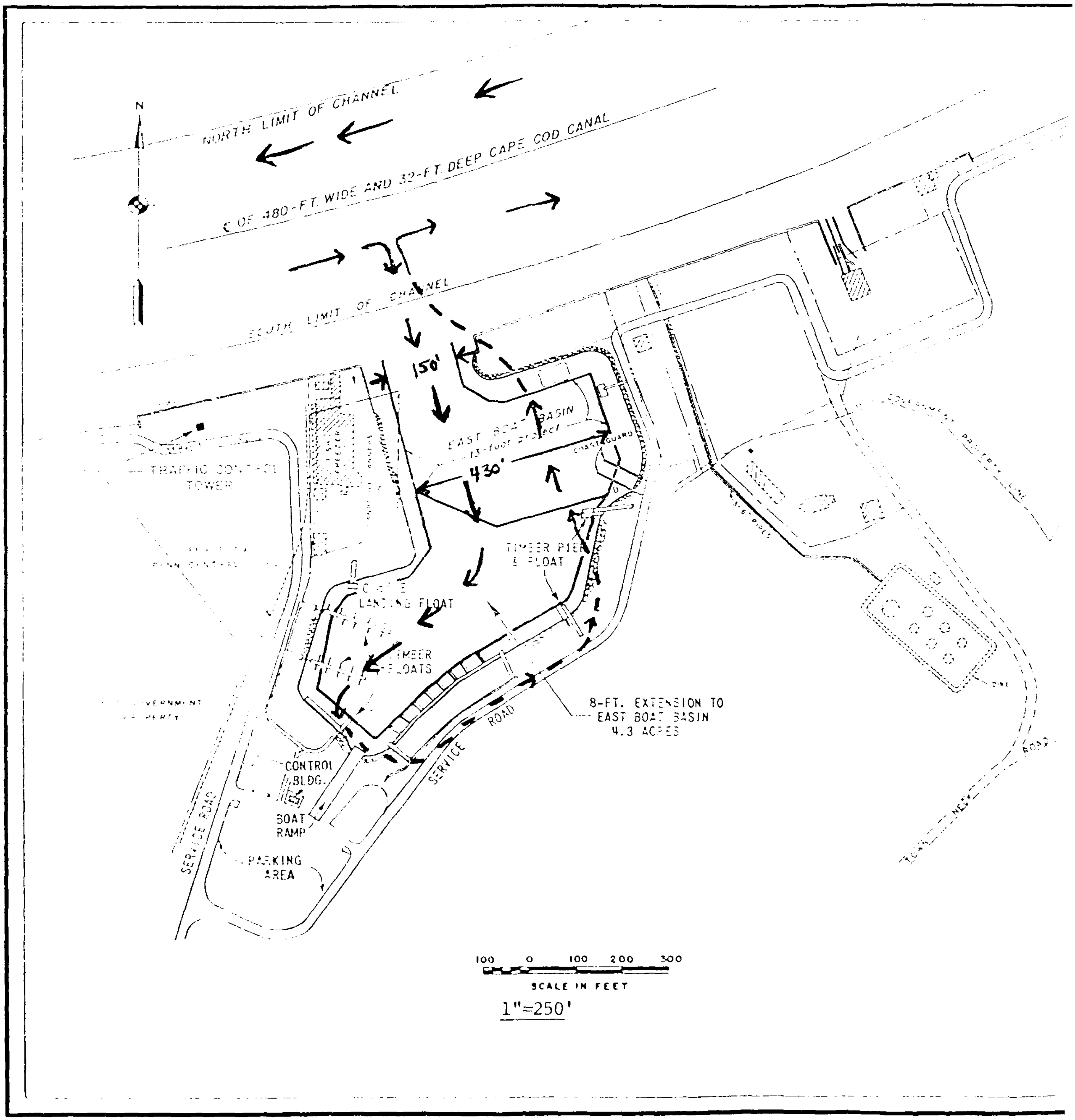
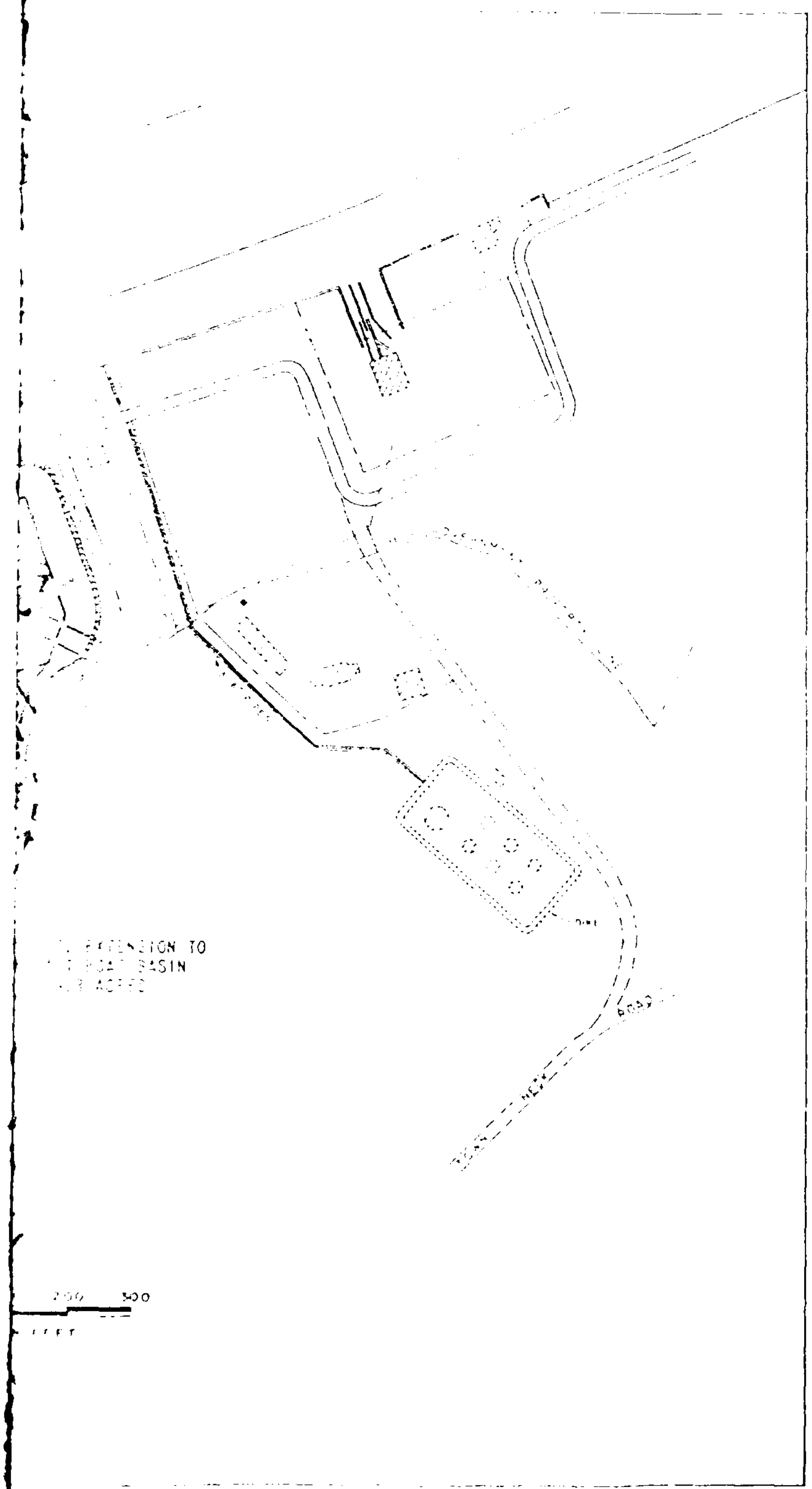
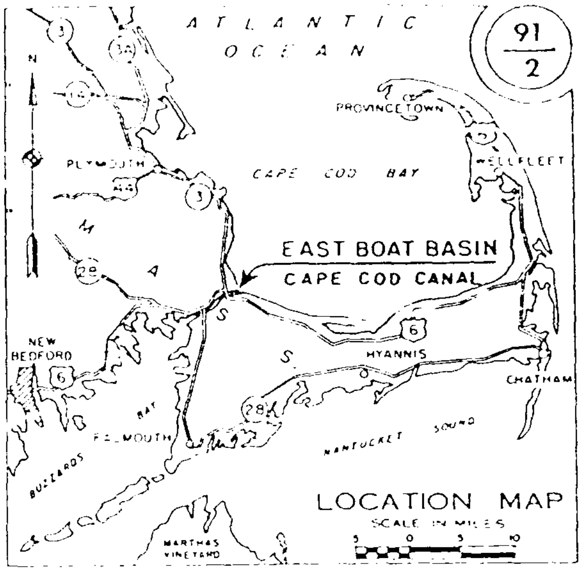


Figure A-2

U. S. ARMY





EAST BOAT BASIN

CAPE COD CANAL, MASS.

30 SEPTEMBER 1986

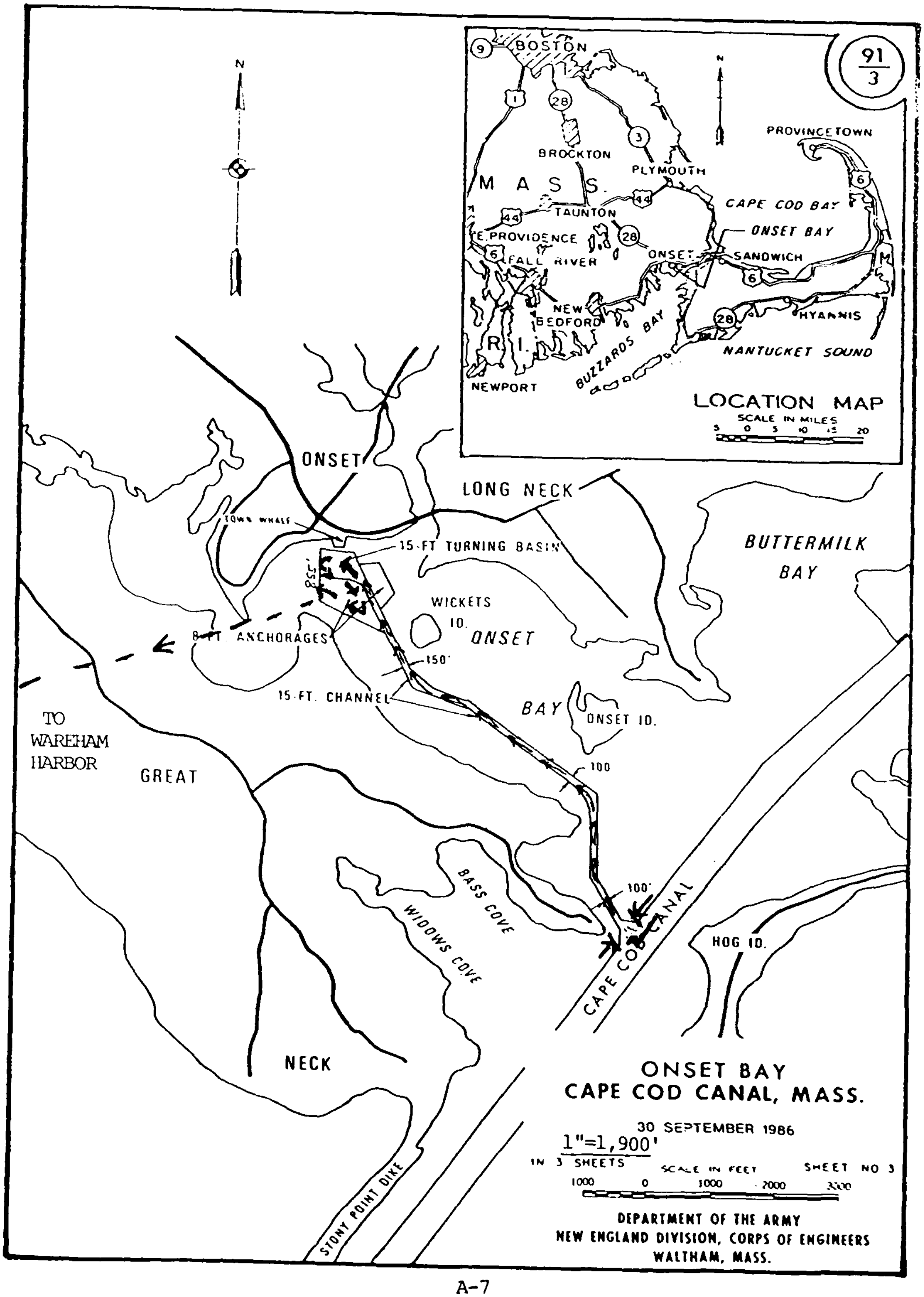
IN 3 SHEETS SHEET 2

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

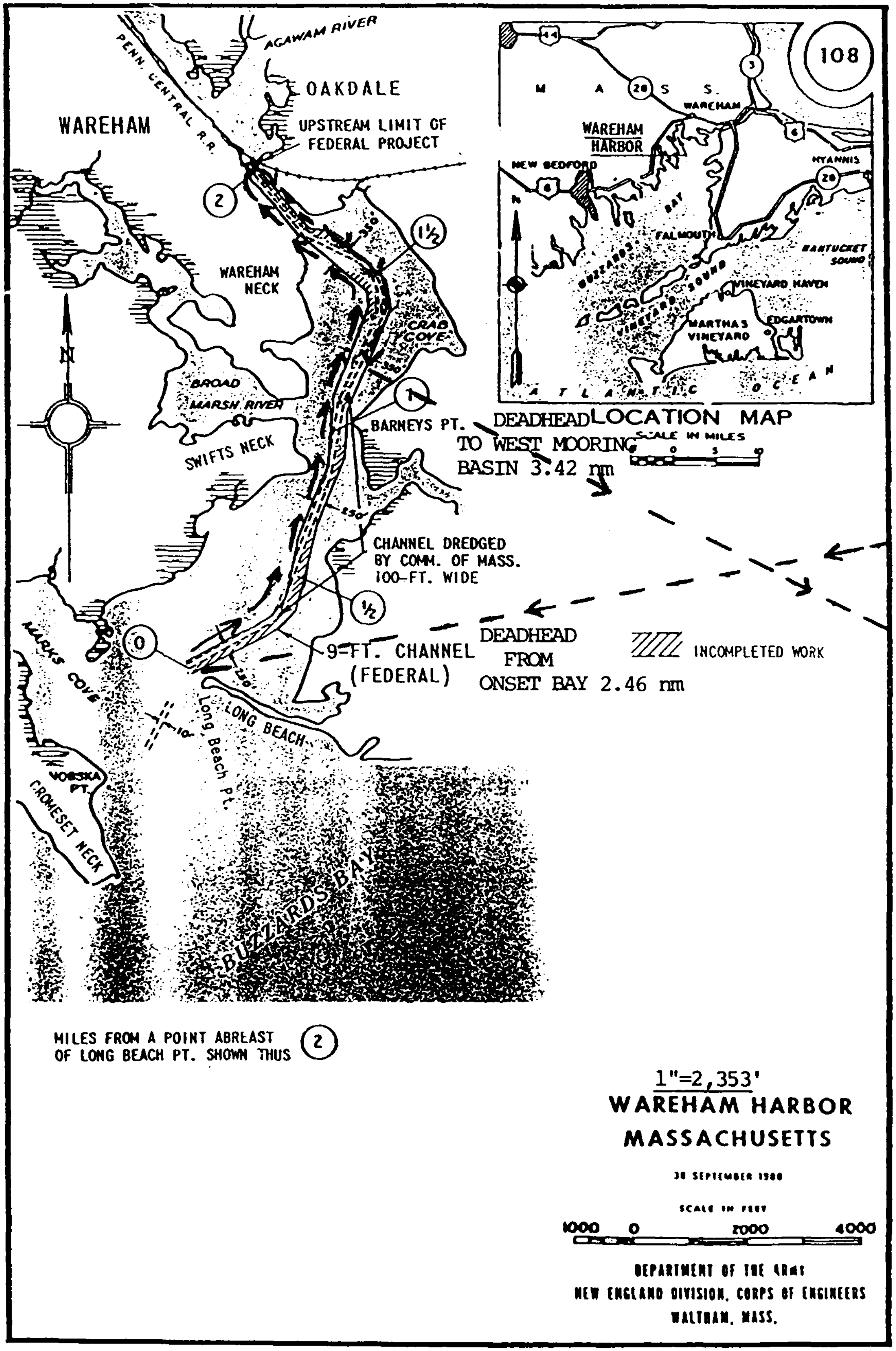
WALTHAM, MASS.

Figure A-3



N
BOSTON
BROCKTON
PLYMOUTH
MASS.
TAUNTON
E. PROVIDENCE
FALL RIVER
NEW BEDFORD
R.I.
NEWPORT
BUZZARDS BAY
ONSET
ONSET BAY
SANDWICH
CAPE COD BAY
PROVINCETOWN
HYANNIS
NANTUCKET SOUND
LOCATION MAP
SCALE IN MILES
5 0 5 10 15 20
91
3
ONSET
LONG NECK
TOWN WHARF
15-FT TURNING BASIN
BUTTERMILK
BAY
WICKETS
ID.
ONSET
8-FT. ANCHORAGES
150'
15-FT. CHANNEL
BAY
ONSET ID.
100
TO
WAREHAM
HARBOR
GREAT
BASS COVE
WIDOWS COVE
100'
CAPE COD CANAL
HOG ID.
NECK
STONY POINT DIKE
ONSET BAY
CAPE COD CANAL, MASS.
30 SEPTEMBER 1986
1"=1,900'
IN 3 SHEETS
SCALE IN FEET
SHEET NO 3
1000 0 1000 2000 3000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure A-4



AGAWAM RIVER
PENN. CENTRAL R.R.
OAKDALE
WAREHAM
UPSTREAM LIMIT OF FEDERAL PROJECT
WAREHAM NECK
CRAB COVE
BROAD MARSH RIVER
SWIFTS NECK
BARNEYS PT.
DEADHEAD TO WEST MOORING BASIN 3.42 nm
CHANNEL DREDGED BY COMM. OF MASS. 100-FT. WIDE
9-FT. CHANNEL (FEDERAL)
DEADHEAD FROM ONSET BAY 2.46 nm
INCOMPLETED WORK
MARKS COVE
LONG BEACH
Long Beach Pt.
NOBSKA PT.
CROMESET NECK
BUZZARDS BAY
108
M A S S.
WAREHAM
WAREHAM HARBOR
NEW BEDFORD
HYANNIS
FALMOUTH
NANTUCKET SOUND
VINEYARD HAVEN
EDGARTOWN
MARTHAS VINEYARD
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
MILES FROM A POINT ABREAST OF LONG BEACH PT. SHOWN THUS
1"=2,353'
WAREHAM HARBOR
MASSACHUSETTS
SCALE IN FEET
1000 0 2000 4000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

The Hog Island channel will require an additional pass. This will leave the helicopter at the northern end of that channel where it will survey the West Marine Basin in one more pass resulting in a total of three 300-foot passes for the 830 foot canal width at that point. It will then deadhead to the north end of the West Marine Basin. The helicopter will survey until the breakwater. At this point, the crew will break off its surveying activity and return to the Plymouth Airport.

Survey time was estimated using the calculations shown on Table A-1. The total survey time for the helicopter is 2.016 hours while the total time in deadhead and access deadhead will be 0.471 hours, for a total of 2.487 hours, which is within the 2.5 hour flight time requirement.

Mission Costs

The total survey nautical miles for this mission are 40.3, taking the helicopter 2.02 hours, while the deadhead nautical miles are 47.1, taking the helicopter 0.47 hours. The expected conventional cost for this scenario is $109,500 (Table A-2). The HLBS would be used for five days. This includes four days of ferry and set up and one day of surveying as shown in Table A-3. The total cost per mission is $31,411 which consists of helicopter cost of $28,251, laser crew cost of $765; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $12,630 as shown in Table A-4. Table A-4 also shows operating costs per square nautical mile of $15,778.

Table A-1

Deadhead from Plymouth Airport		13.5 nautical miles
Cape Cod Canal		
East Boat Basin	Survey:	0.49 nautical miles
Cape Cod Canal		
Breakwater to Onset	Survey:	14.95 nautical miles
32' West Mooring Basin	Survey: Deadhead:	1.63 nautical miles 0.54 nautical miles
Hog Island Channel	Survey:	6.46 nautical miles
Cleveland Ledge Channel	Survey: Deadhead:	11.05 nautical miles 3.68 nautical miles
Onset Bay	Survey: Deadhead:	1.56 nautical miles 2.46 nautical miles
Wareham Harbor	Survey: Deadhead:	4.18 nautical miles 3.42 nautical miles

Deadhead return to Plymouth Airport	13.5 NM	0.135 Hrs.
Shortstop Deadhead Allowance	10.0 NM	0.100 Hrs.
Total Deadhead	47.1 NM	0.471 Hrs.
Total Survey	40.32 NM	2.016 Hrs.
Total	87.42 NM	2.487 Hrs.

Table A-2

Project Description of Cape Cod Mission

PROJECTS	Conventional Cost ($000)	Conventional Survey Freq	Conventional Expected Cost	HLBS Nautical Miles Survey	HLBS Nautical Miles Deadhead	HLBS Survey Days	HLBS Extra Grnd Days	HLBS Survey (Hours)	HLBS Deadhead (Hours)
Cape Cod Canal	100.0	1.00	$100,000	40.320	47.100	0.5	0.5	2.02	0.47
Onset Bay	20.0	0.10	$2,000						
Wareham Harbor	15.0	0.50	$7,500						
Totals	$135		$109,500	40.3	47.1	1.0	0.5	2.0	0.5

Table A-3

Cape Cod	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	**Assumptions**		**Mission Totals**
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	1		$3,000
Helicopter Mission Flight Hours	2.5		$1,641
Travel & Per Diem (Per Prsn/Day)	$70		$1,050
Total Helicopter Costs			$28,251
LASER CREW COSTS			
Number of Mission Days--Laser Crew	1		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$625
Travel & Per Diem (Per Prsn/Day)	$70		$140
Total Laser Crew Cost			$765
OTHER COSTS			
Number of Mission Days--Ground Crew	1.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$825
Travel & Per Diem (Per Prsn/Day)	$70		$210
Ground Transportation	$50		$150
Number of Survey Hours	2.02		
Post Processing (Technician $/Hr)	$38		$756
Efficiency Factor	15.0%		$453
(% Helicopter Flight, Laser Crew			
Total Other Costs			$2,394
TOTAL OPERATING COSTS PER MISSION			$31,411

Table A-4

Cape Cod

UNIT OPERATING COST (per hour)

Operating Costs per Mission	$31,411
Helicopter Mission Flight Hours	2.5
Unit Operating Cost ($/Hrs)	$12,630

UNIT OPERATING COST (per Square Nautical Mile)

Operating Costs per Mission		$31,411
Number of Survey Hours	2.02	
Coverage Rate (Sq N Miles/Hr)	0.99	2.0
Unit Operating Cost ($/S.N.M.)		$15,778

SQUARE AREA SURVEYED

Nautical Miles	1.99
Kilometers	3.69

Appendix B

DELAWARE BAY-CHESAPEAKE BAY WATERWAY

The Chesapeake Bay waterway is a portion of the intracoastal waterway running along the Atlantic Coast through the States of Delaware, Maryland and Virginia, ending at Kiptopeke, Virginia on the Eastern Shore (Figures B-1, B-2, B-3). Access to the Canal is available at various points along the route by means of U.S. Route 13 and various public roads which reach the Canal from that road. Surveying of the Canal can be accomplished in one day.

Scenario Analysis

A helicopter will be flown to Ocean City Airport in Maryland. This will serve as the starting point for the Lidar survey, 23.6 nautical miles from the beginning of the Virginia portion of the waterway. The helicopter will fly from the airport to the Virginia State line and begin surveying a southerly course along the waterway, proceeding at 20 knots. A single GPS station located in the village of Painter, where U.S. Route 13 crosses VA Route 182 can control survey coordination for the entire waterway. The survey coordinates can alternatively be controlled from five UHF stations, the first of which will be located at the Maryland-Virginia border along U.S. Route 13. The second UHF station will be located at Nelsonia Village (where VA Route 679 crosses U.S. 13). The third UHF station will be located in the town of Keller, Virginia, a point where VA Route 180 crosses U.S. 13. The fourth UHF station is located along U.S. Route 13, near the village of Eastville, VA. The final UHF station will be located on Fisherman Island south of Kiptopeke, Virginia.

Logistics for placement of ground stations require that one ground station vehicle carry two UHF trisponders and place one at Nelsonia and proceed with the other one to the MD-VA border and wait until the helicopter has passed beyond its range and then return to collect the UHF unit at Nelsonia. This vehicle can return to base when the

Figure B-1

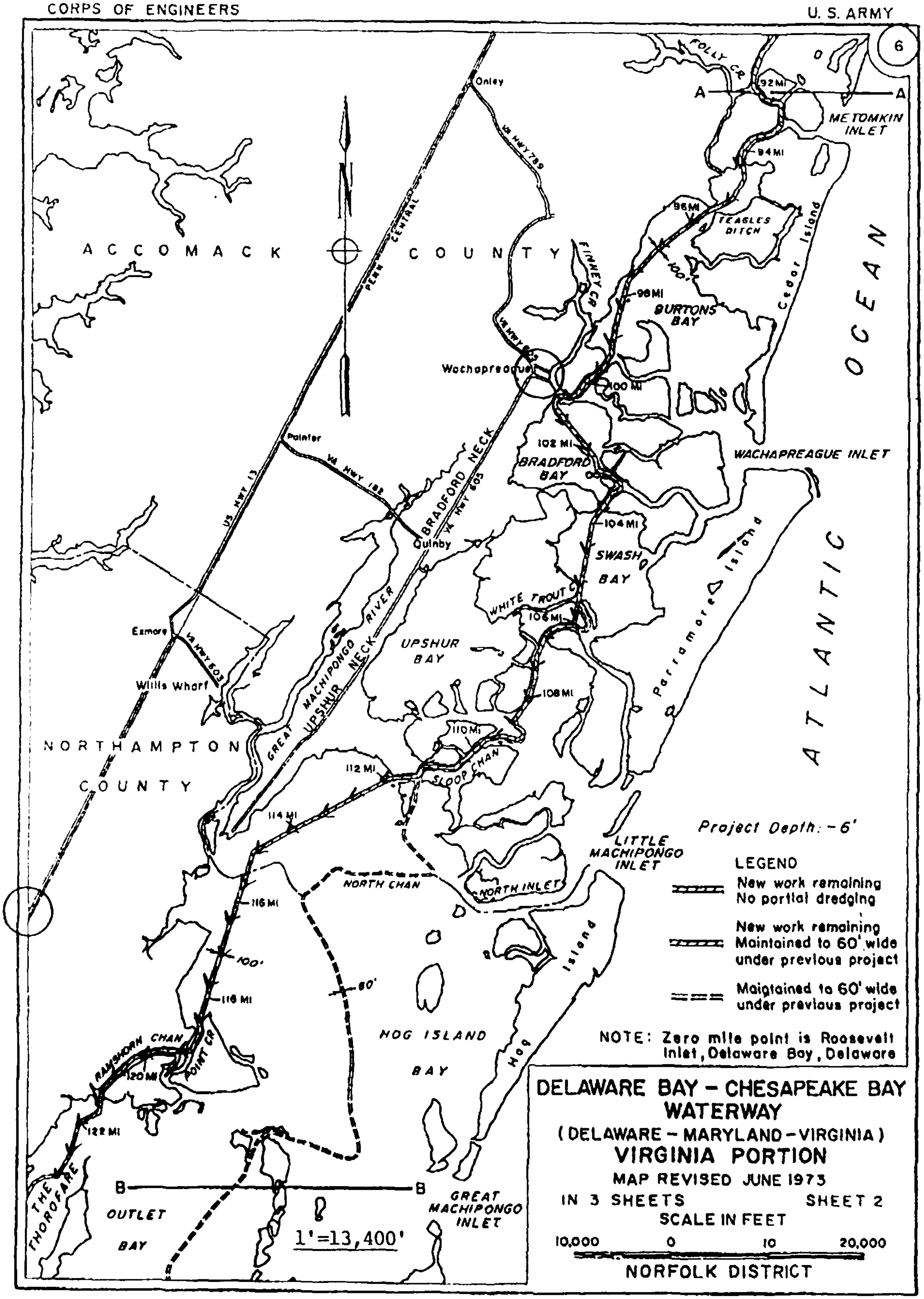

CORPS OF ENGINEERS
U. S. ARMY
6
ACCOMACK COUNTY
NORTHAMPTON COUNTY
ATLANTIC OCEAN
METOMKIN INLET
TEAGLES DITCH
BURTONS BAY
WACHAPREAGUE INLET
BRADFORD BAY
SWASH BAY
UPSHUR BAY
HOG ISLAND BAY
OUTLET BAY
GREAT MACHIPONGO INLET
LITTLE MACHIPONGO INLET
Project Depth: -6'
LEGEND
New work remaining No partial dredging
New work remaining Maintained to 60' wide under previous project
Maintained to 60' wide under previous project
NOTE: Zero mile point is Roosevelt Inlet, Delaware Bay, Delaware
DELAWARE BAY - CHESAPEAKE BAY WATERWAY
(DELAWARE - MARYLAND - VIRGINIA)
VIRGINIA PORTION
MAP REVISED JUNE 1973
IN 3 SHEETS
SHEET 2
SCALE IN FEET
10,000 0 10 20,000
NORFOLK DISTRICT
1'=13,400'

Figure B-2

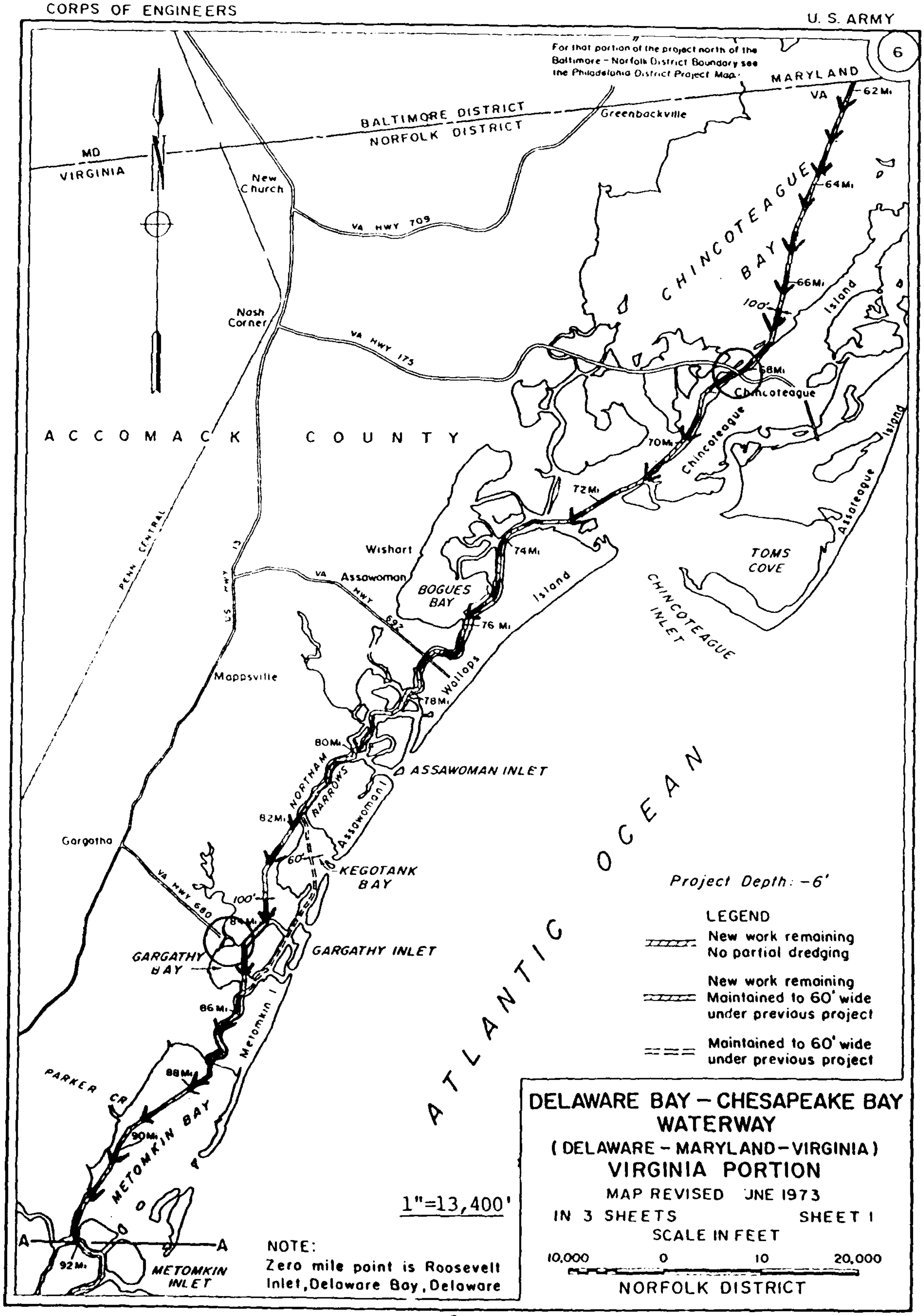
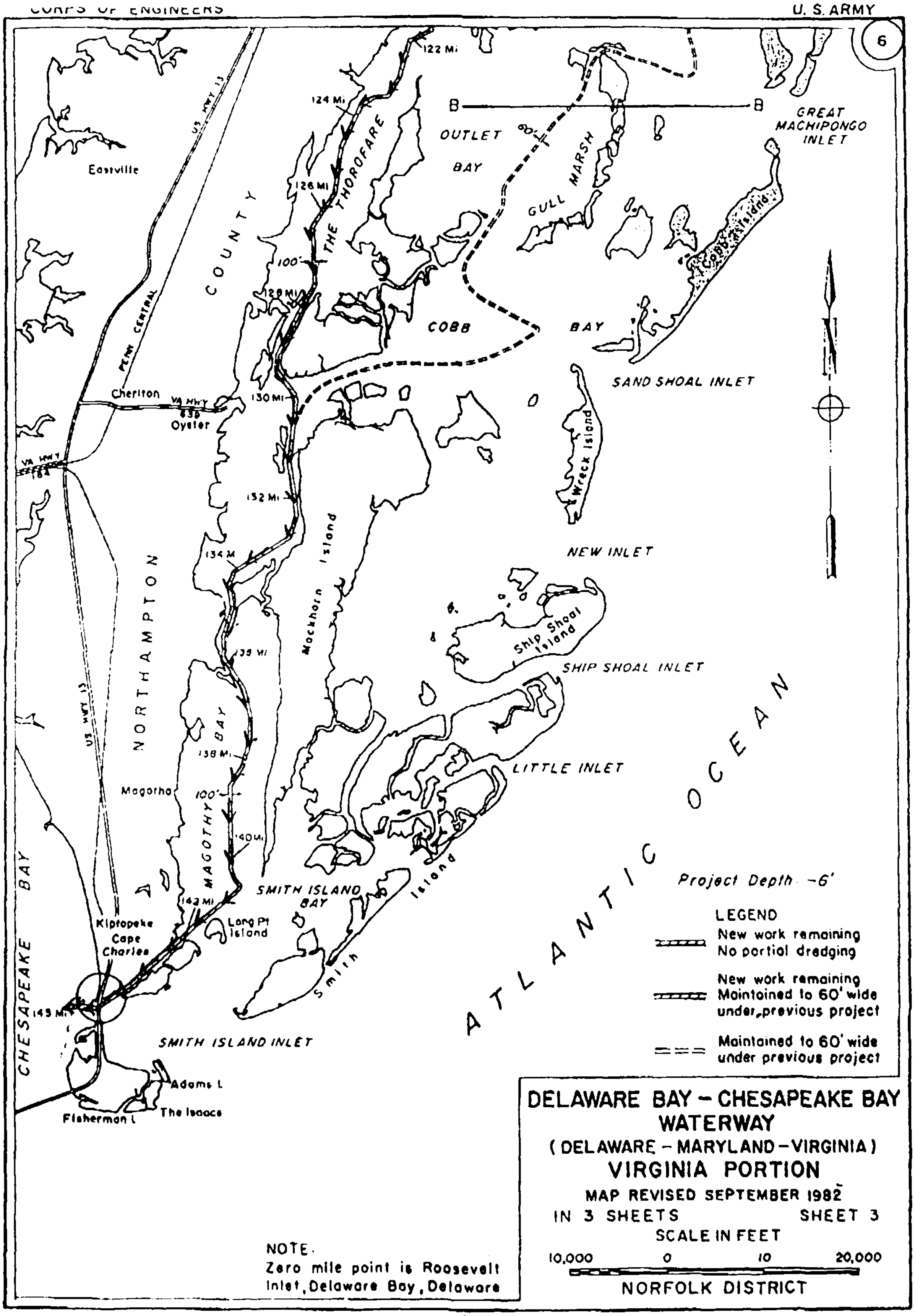

CORPS OF ENGINEERS
U. S. ARMY
For that portion of the project north of the Baltimore – Norfolk District Boundary see the Philadelphia District Project Map.
6
MARYLAND
VA
62 Mi
BALTIMORE DISTRICT
NORFOLK DISTRICT
Greenbackville
MD
VIRGINIA
New Church
VA HWY 709
64 Mi
CHINCOTEAGUE BAY
66 Mi
100'
Island
Nash Corner
VA HWY 175
68 Mi
Chincoteague
70 Mi
Chincoteague
Island
72 Mi
ACCOMACK COUNTY
Assateague
PENN CENTRAL
US HWY 13
Wishart
VA Assawoman
HWY 692
74 Mi
BOGUES BAY
Island
TOMS COVE
CHINCOTEAGUE INLET
76 Mi
Wallops
Mappsville
78 Mi
80 Mi
NORTHAM
NARROWS
Assawoman I
ASSAWOMAN INLET
82 Mi
Gargatha
VA HWY 680
60'
KEGOTANK BAY
100'
84 Mi
ATLANTIC OCEAN
Project Depth: –6'
LEGEND
New work remaining
No partial dredging
New work remaining
Maintained to 60' wide under previous project
Maintained to 60' wide under previous project
GARGATHY BAY
GARGATHY INLET
86 Mi
Metomkin I
PARKER CR
88 Mi
90 Mi
METOMKIN BAY
1"=13,400'
A
A
92 Mi
METOMKIN INLET
NOTE:
Zero mile point is Roosevelt Inlet, Delaware Bay, Delaware
DELAWARE BAY – CHESAPEAKE BAY WATERWAY
(DELAWARE – MARYLAND – VIRGINIA)
VIRGINIA PORTION
MAP REVISED JUNE 1973
IN 3 SHEETS
SHEET 1
SCALE IN FEET
10,000
0
10
20,000
NORFOLK DISTRICT

Figure B-3



CORPS OF ENGINEERS
U. S. ARMY
6
122 Mi
124 Mi
126 Mi
128 Mi
130 Mi
132 Mi
134 Mi
136 Mi
138 Mi
140 Mi
142 Mi
145 Mi
THE THOROFARE
OUTLET BAY
GULL MARSH
GREAT MACHIPONGO INLET
Cobb Island
COBB BAY
SAND SHOAL INLET
Wreck Island
NEW INLET
Ship Shoal Island
SHIP SHOAL INLET
LITTLE INLET
Mockhorn Island
MAGOTHY BAY
SMITH ISLAND BAY
Smith Island
SMITH ISLAND INLET
ATLANTIC OCEAN
CHESAPEAKE BAY
NORTHAMPTON COUNTY
Eastville
Cheriton
Oyster
Magotha
Kiptopeke
Cape Charles
Long Pt Island
Adams I.
The Isaacs
Fisherman I.
US HWY 13
PENN CENTRAL
VA HWY 639
VA HWY 184
100'
Project Depth -6'
LEGEND
New work remaining
No partial dredging
New work remaining
Maintained to 60' wide under previous project
Maintained to 60' wide under previous project
DELAWARE BAY – CHESAPEAKE BAY WATERWAY
(DELAWARE – MARYLAND – VIRGINIA)
VIRGINIA PORTION
MAP REVISED SEPTEMBER 1982
IN 3 SHEETS
SHEET 3
SCALE IN FEET
10,000 0 10 20,000
NORFOLK DISTRICT
NOTE.
Zero mile point is Roosevelt Inlet, Delaware Bay, Delaware

helicopter has passed out of range of Nelsonia. The other ground vehicle will be responsible for placement and collection of the other three UHF stations. Set up of ground stations will require one-half day prior to the beginning of the helicopter survey, and an additional one-half day after the end.

The entire waterway can be surveyed in a single pass since at no point is it wider than 100 feet. When the survey is completed at Kiptopeke, the helicopter will proceed at 100 knots to the Norfolk, VA Airport, a distance of 19.2 nautical miles. The total survey distance is 70.36 nautical miles which will require 3.52 hours to complete. When the helicopter reaches Metomkin Inlet (Figure B-2), it will return to Ocean City Airport for refueling: a round trip deadhead of 112 nautical miles requiring 1.12 hours plus refueling time. The helicopter will continue surveying until it reaches Great Machiopongo Inlet when it will deadhead to Norfolk Airport for refueling. This is a round trip deadhead of 94.5 nautical miles requiring 0.95 hours plus refueling time. The helicopter will then continue surveying to the end of the waterway of Kiptopeke. Other survey opportunities exist along the waterway, such as Chincoteague Bay, but these were not included due to the lack of alternative airports with jet fuel availability. The calculations are summarized in Table B-1.

Mission Costs

The following tables show the total survey nautical miles for this mission are 70.4, taking the helicopter 3.52 hours, while the deadhead nautical miles are 249.30, taking the helicopter 2.49 hours. The expected conventional cost for this scenario is $69,765 (Table B-2). The HLBS would be used for five days. This includes four days of ferry and set up and one day of surveying as shown in Table B-3. The total cost per mission is $34,733, which consists of helicopter cost of $30,577, laser crew cost of $765; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $5,779 as shown in Table B-4. Table B-4 also shows operating costs per square nautical mile of $10,000.

Table B-1

Virginia Portion

Delaware Bay - Chesapeake Bay Waterway

Figure B-1	25.80 NM	
Figure B-2	26.91 NM	
Figure B-3	17.64 NM	
	70.36 NM	
Deadhead Deadhead from Ocean City, MD to VA State Line:	23.6 NM	0.236 Hrs.
Refueling deadhead to Ocean City, MD from Metomkin Inlet	112 NM	1.12 Hrs.
Refueling deadhead to Norfolk Airport from Great Machiopongo Inlet	94.5 NM	0.945 Hrs.
Deadhead from Kiptopeke to Norfolk, VA	19.2 NM	0.192 Hrs.
Total Deadhead:	249.3 NM	2.493 Hrs.
Total Survey:	70.35 NM	3.518 Hrs.
Total:	319.65 NM	6.011 Hrs.

GPS Station: Painter, VA

UHF Stations

1. MD-VA Border on U.S. Route 13
2. Nelsonia, VA
3. Keller, VA
4. Eastville, VA
5. Fisherman Island, VA

Table B-2

Project Description of DelMarVa Mission

	Conventional			HLBS					
	Cost	Survey	Expected	---Nautical	Miles---	Survey	Extra	Survey	Deadhead
PROJECTS	($000)	Freq	Cost	Survey	Deadhead	Days	Grnd Days	(Hours)	(Hours)
Ches Bay to Mag Bay	8.5	0.50	$4,250	70.350	249.300	1	0.5	3.52	2.49
Cedar Island Bay, Bougues Bay	10.2	0.17	$1,700						
Echichy Marsh, Gargathy Inlet	8.5	1.00	$8,500						
Fishmn's Inlt,Gull Mrsh,Grgthy Cr	20.4	0.50	$10,200						
Hog Neck Creek, Hog Creek	6.8	0.20	$1,360						
Kegotank Bay	6.8	0.14	$971						
Lewis Crk,Bradfrd Bay,Burtns Bay	22.1	0.50	$11,050						
Metompkin Bay, North Channel	23.8	0.50	$11,900						
Northam Narrows,Swash Bay Channel	20.4	0.33	$6,800						
Sloop Channel, Upper Mag Bay	23.8	0.50	$11,900						
White Trout Creek	3.4	0.33	$1,133						
Totals	$155		$69,765	70.4	249.3	1.0	0.5	3.5	2.5

Table B-3

DelMarVa	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	1		$3,000
Helicopter Mission Flight Hours	6.0		$3,967
Travel & Per Diem (Per Prsn/Day)	$70		$1,050
Total Helicopter Costs			$30,577
LASER CREW COSTS			
Number of Mission Days--Laser Crew	1		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$625
Travel & Per Diem (Per Prsn/Day)	$70		$140
Total Laser Crew Cost			$765
OTHER COSTS			
Number of Mission Days--Ground Crew	1.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$825
Travel & Per Diem (Per Prsn/Day)	$70		$210
Ground Transportation	$50		$150
Number of Survey Hours	3.52		
Post Processing (Technician $/Hr)	$38		$1,319
Efficiency Factor	15.0%		$887
(% Helicopter Flight, Laser Crew			
Total Other Costs			$3,391
TOTAL OPERATING COSTS PER MISSION			$34,733

Table B-4

DelMarVa

UNIT OPERATING COST (per hour)		
Operating Costs per Mission		$34,733
Helicopter Mission Flight Hours		6.0
Unit Operating Cost ($/Hrs)		$5,779

UNIT OPERATING COST (per Square Nautical Mile)		
Operating Costs per Mission		$34,733
Number of Survey Hours	3.52	
Coverage Rate (Sq N Miles/Hr)	0.99	3.5
Unit Operating Cost ($/S.N.M.)		$10,000

SQUARE AREA SURVEYED	
Nautical Miles	3.47
Kilometers	6.43

Appendix C

FLORIDA INTERCOASTAL WATERWAY

The Florida Intercoastal Waterway (FL-IWW) from the Anclote River to the Caloosahatchee River is 160 miles long with a 100-foot wide channel. The channel is nine feet deep. The light and turbidity conditions make it a prime candidate for the laser bathymeter system. The helicopter and crew will be stationed at the Sarasota-Bradenton Airport (SRQ).

The survey will be conducted over three days. During the first day (Table C-1), the helicopter will survey the FL-IWW and several connecting waterways from the Caloosahatchee River to Johns Pass. On the second day, it will survey the FL-IWW from Johns Pass to the Anclote River, the Hillsborough River, and the northern section of Tampa Bay. On the third and final day, it will finish surveying Tampa Harbor, including the St. Petersburg Harbor and a small remaining portion of the FL-IWW.

The helicopter will fly a maximum of four, two and one-half hour trips each day, with a refueling stop between trips. Total flight time for each trip and refueling airport are as follows:

	Trip One	Trip Two	Trip Three	Trip Four
Day One	2.1 hrs.	1.8 hrs.	2.4 hrs.	1.4 hrs.
Day Two	1.8 hrs.	2.2 hrs.	1.9 hrs.	2.1 hrs.
Day Three	1.5 hrs.	1.2 hrs.	—	—

Refueling Airports

Day One: Rotunda Airport, Venice Municipal Airport, Albert Whitted Airport

Day Two: Clearwater Executive Airport, Peter O'Knight Municipal Airport

Day Three: Albert Whitted Airport

DAY ONE

Scenario Analysis

On Day One, the helicopter will survey the FL-IWW (Figure C-1) and several connecting waterways from the Caloosahatchee River to Johns Pass.

The helicopter will fly south from Sarasota-Bradenton Airport, to the southern point of the IWW at the Caloosahatchee River. This is a distance of 66 nautical miles which the helicopter will fly at the deadhead speed of 100 knots. Here, the helicopter will begin the survey. The helicopter will fly north along the FL-IWW until it reaches Charlotte Harbor, a distance of 26.9 nautical miles. The helicopter will leave the FL-IWW to refuel at Rotunda Airport. After refueling, the helicopter will deadhead back to the FL-IWW and survey seven nautical miles of Charlotte Harbor (Figure C-2). Next, the helicopter will survey 25 nautical miles of the IWW from Charlotte Harbor to Caseys Pass. The helicopter crew will detour the IWW to survey .43 nautical miles of Caseys Pass (Figure C-3) before refueling at Venice Municipal Airport.

After refueling, the helicopter will depart from Venice Municipal Airport and return to Caseys Pass. Here, the helicopter will resume surveying the FL-IWW from Caseys Pass to New Pass. This section of the FL-IWW is approximately 16.9 nautical miles. Upon arriving at New Pass, the flight team will detour from the FL-IWW to survey 3.5 nautical miles of New Pass (Figure C-4). The helicopter will deadhead back to the FL-IWW and continue to survey the FL-IWW from New Pass to Longboat Pass, a distance of 11.25 nautical miles. Next, the helicopter will survey the 1.646 nautical miles of Longboat Pass (Figure C-5). The helicopter will continue north along the FL-IWW surveying from Longboat Pass to Tampa Harbor, a distance of 10.62 nautical miles. The helicopter will then depart the IWW for a third refueling at Albert Whitted Airport.

After the third refueling, the helicopter will fly back to the IWW at Tampa Harbor and proceed to survey the next 8.75 nautical miles of the IWW up to Pass-A-Grille Pass. The helicopter will detour from the IWW to Survey Pass-A-Grille's 2.5

nautical miles (Figure C-6) and then continue surveying the next 6.2 nautical miles of the IWW to Johns Pass. After surveying 1.5 nautical miles of Johns Pass (Figure C-7), the helicopter crew will have completed its fourth trip of the day and will return to base headquarters at SRQ total flight time for Day One is 7.7 flying hours.

Table C-1

DAY ONE

Trip One

		NM	Hrs.
1.	Deadhead SRQ to Southern Point IWW	66.0	.66
2.	Survey IWW to Charlotte Harbor	26.90	1.345
3.	Deadhead IWW Charlotte Harbor to Rotunda Airport	9.50	.095

Trip Two

1.	Deadhead Rotunda Airport to IWW Charlotte Harbor, FL	9.5	.095
2.	Survey to Boca Grande Pass	.50	.025
3.	Boca Grande Pass 3 passes 2.16 NM long	6.5	.325
4.	Deadhead back to IWW	2.66	.0266
5.	Survey IWW Charlotte Harbor to Caseys Pass, FL (Venice Inlet)	25.0	1.25
6.	Channel 1 pass	.434	.02
7.	Deadhead back to IWW	.408	.00408
8.	Deadhead to Venice Municipal Airport	5.0	.050

Trip Three

1.	Deadhead Venice Municipal airport to IWW	5.0	.050
2.	Survey IWW Caseys Pass to IWW New Pass, FL	16.87	.844
3.	1st Channel into City Pier	.529	.0265
4.	Deadhead back to IWW	.397	.00397
5.	2nd Channel into Payne Terminal	.794	.040

Table C-1 (Continued)

		NM	Hrs.
6.	Deadhead back to IWW	.480	.00480
7.	3rd Channel out towards Gulf	2.170	.11
8.	Deadhead back to IWW	2.120	.02120
9.	Survey IWW New Pass to Longboat Pass, FL	11.25	.563
10.	Channel 1 pass	1.646	.08
11.	Deadhead back to IWW	1.317	.01317
12.	Survey IWW Longboat Pass to IWW Tampa Harbor	10.62	.531
13.	Deadhead from IWW @ Tampa Harbor to Albert Whitted Airport	8.75	.088

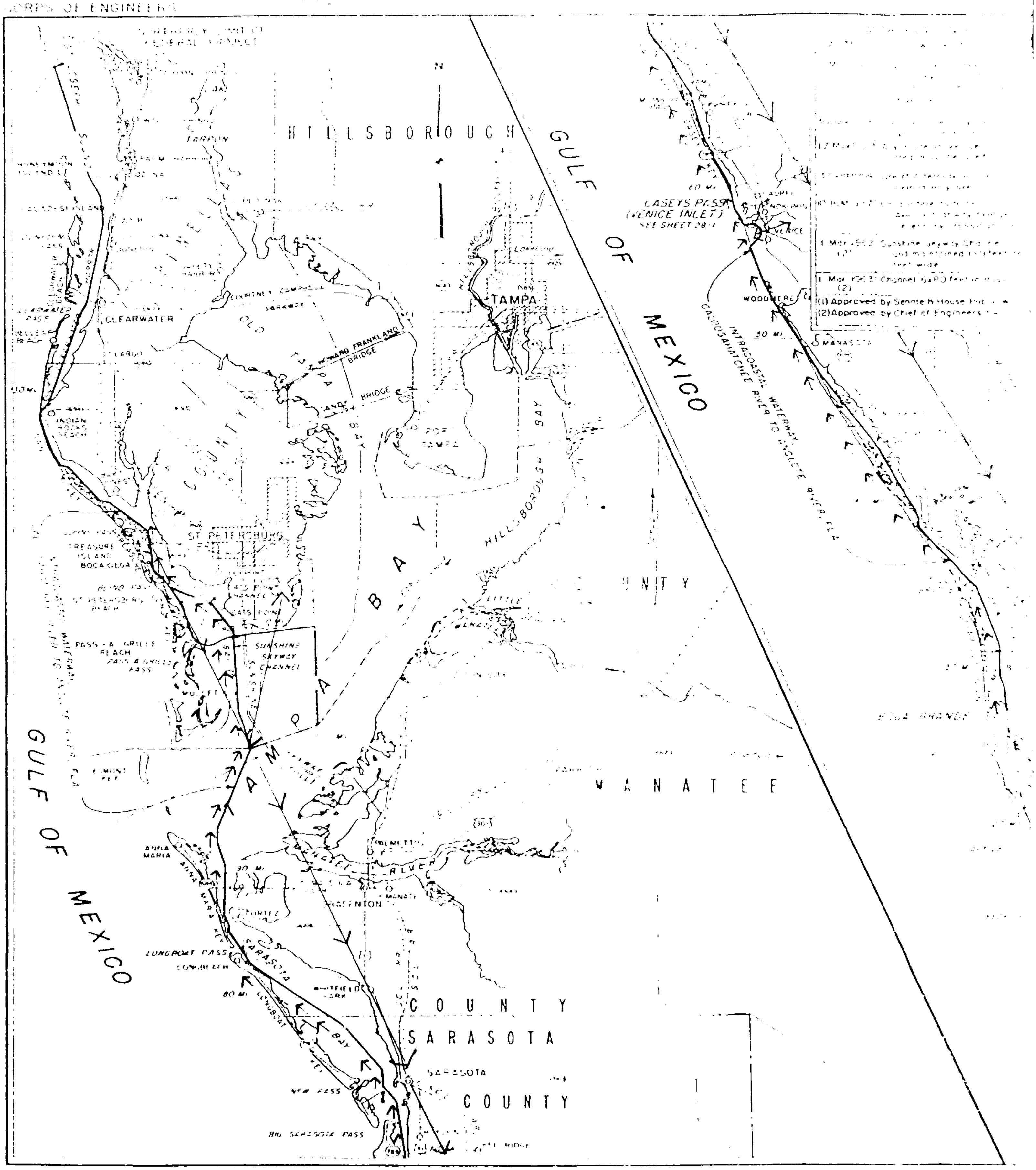
Trip Four

1.	Deadhead from Albert Whitted Airport to IWW @ Tampa Harbor	8.75	.0875
2.	Survey IWW from Tampa Harbor to Pass-A-Grille Pass, FL	8.75	.438
3.	Channel 1 pass	2.567	.13
4.	Deadhead back to IWW	1.99	.0199
5.	Survey IWW Pass-A-Grille to Johns Pass, FL	6.25	.312
6.	Channel 1 pass	1.759	.09
7.	Deadhead back to IWW	1.539	.01539
8.	Deadhead from Johns Pass to SRQ	33.12	.3312

Table C-1 (Continued)

	NM	Hrs.
Day One		
Trip One		
Total Survey	26.90	1.345
Total Deadhead	75.50	.755
Total	102.40	2.10
Trip Two		
Total Survey	32.434	1.620
Total Deadhead	17.568	.176
Total	50.002	1.796
Trip Three		
Total Survey	43.879	2.195
Total Deadhead	18.064	0.181
Total	61.943	2.376
Trip Four		
Total Survey	19.326	6.970
Total Deadhead	45.399	6.454
Total	64.725	1.424
Day One		
Total Survey	122.539	6.130
Total Deadhead	156.531	1.566
Total	279.07	7.696

CORPS OF ENGINEERS

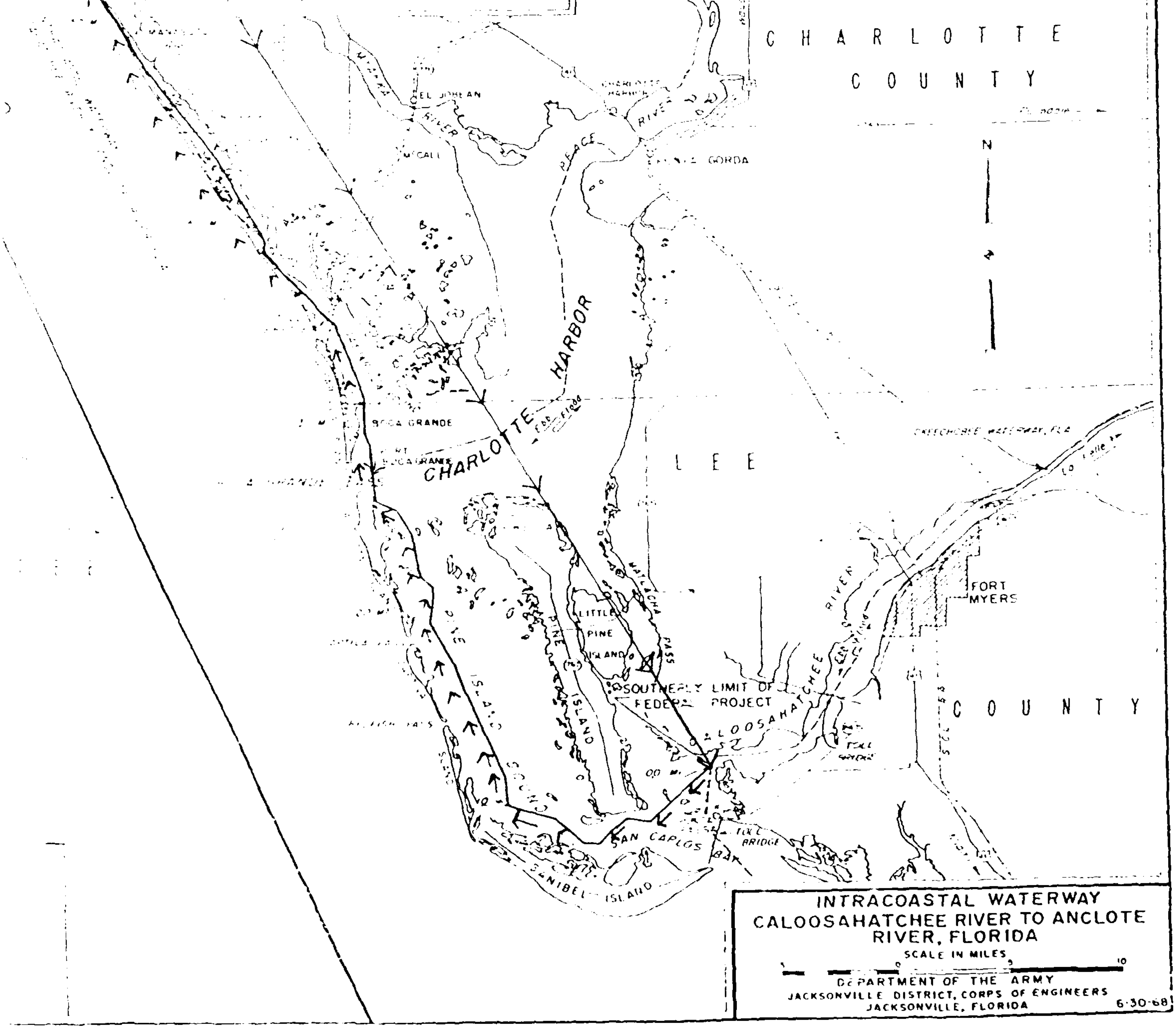


[illegible]	Specified in act
(2) May [illegible]	Specified in act
[illegible] Venice [illegible]	Specified in act
[illegible] May [illegible] to Venice Avenue highway Bridge and any other [illegible] See Route C-1	[illegible]
1 Mar 1960 Sunshine Skyway Channel to be improved (2) and maintained to 9 feet deep and 100 feet wide	—
1 Mar 1963 Channel 6x80 feet in Boca Ciega Bay (2)	—

(1) Approved by Senate & House Public Works Committees on these dates
(2) Approved by Chief of Engineers for accomplishment under Sec 107

[illegible] channel [illegible] from [illegible] River to Anclote River, deepening existing [illegible] feet [illegible] Casey [illegible] (Venice Inlet) [illegible] feet, maintenance of bulkheads, revetments, and two jetties built at Caseys Pass under a previous project, [illegible] improvement and maintenance of existing Sunshine Skyway barrow [illegible] to 9 by 100 feet. Waterway will include existing improved channels in Pine Island Sound from Punta Rassa to Charlotte Harbor, in the entrance to Roberts Bay at [illegible] Pass, in [illegible] Sarasota Bay and Sarasota Bay from Nokomis to [illegible] Bay, and in Boca Ciega Bay from Tampa Bay to Clearwater Harbor, a channel 6x80 feet along the south eastern side of Boca Ciega Bay and across Cats Point Shoal. Length of project waterway is about 150 miles.

MEAN TIDAL RANGE 1.7 feet at Punta Rassa, 1 foot at Port Boca Grande, 1.4 feet at Anna Maria, and 2 feet at entrance to Anclote River.



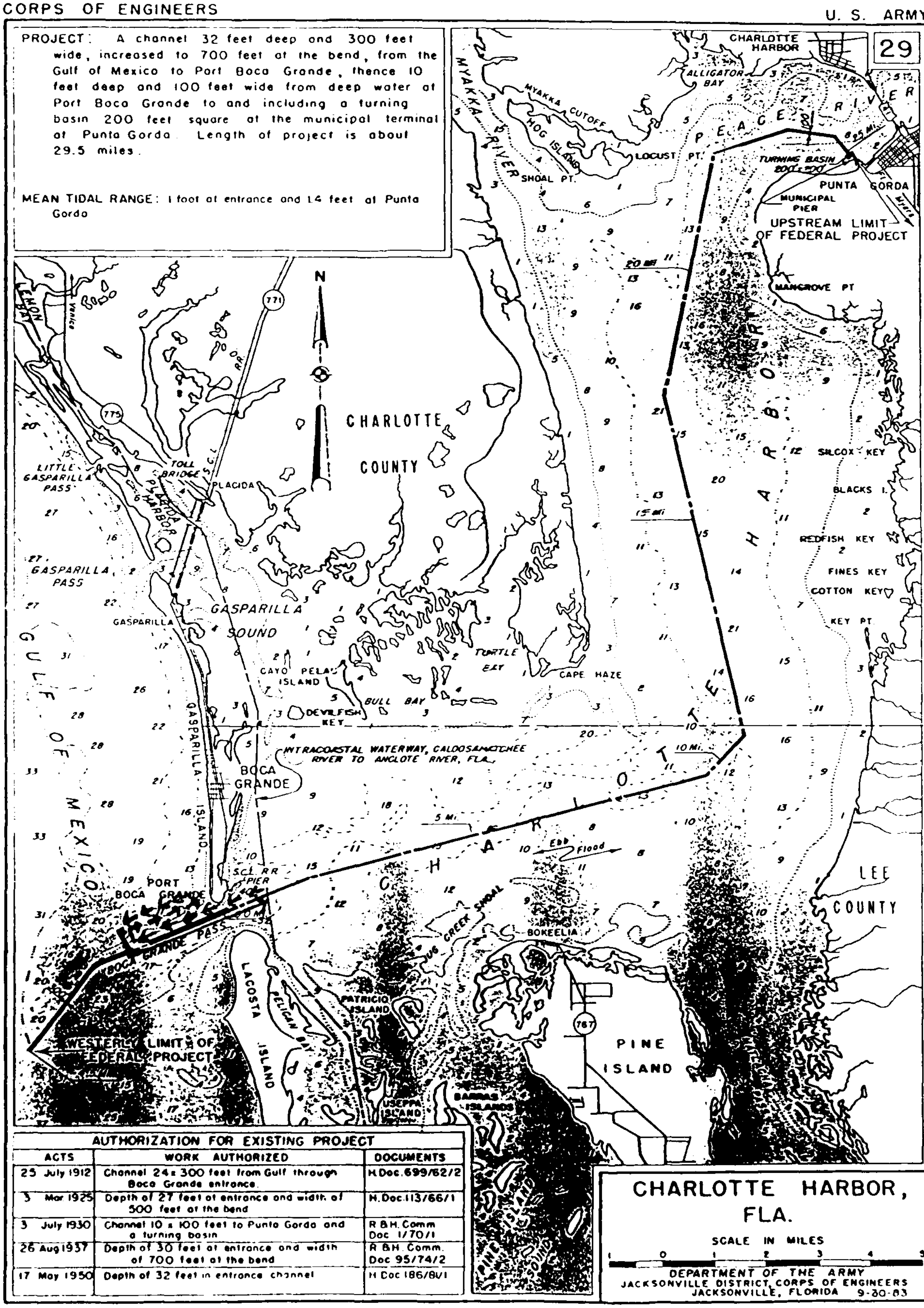
INTRACOASTAL WATERWAY
CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLORIDA

SCALE IN MILES

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

6-30-68

Figure C-2



AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
25 July 1912	Channel 24 x 300 feet from Gulf through Boca Grande entrance.	H.Doc.699/62/2
3 Mar 1925	Depth of 27 feet at entrance and width of 500 feet at the bend	H.Doc.113/66/1
3 July 1930	Channel 10 x 100 feet to Punta Gorda and a turning basin	R & H. Comm Doc 1/70/1
26 Aug 1937	Depth of 30 feet at entrance and width of 700 feet at the bend	R & H. Comm. Doc 95/74/2
17 May 1950	Depth of 32 feet in entrance channel	H Doc 186/81/1

Figure C-3

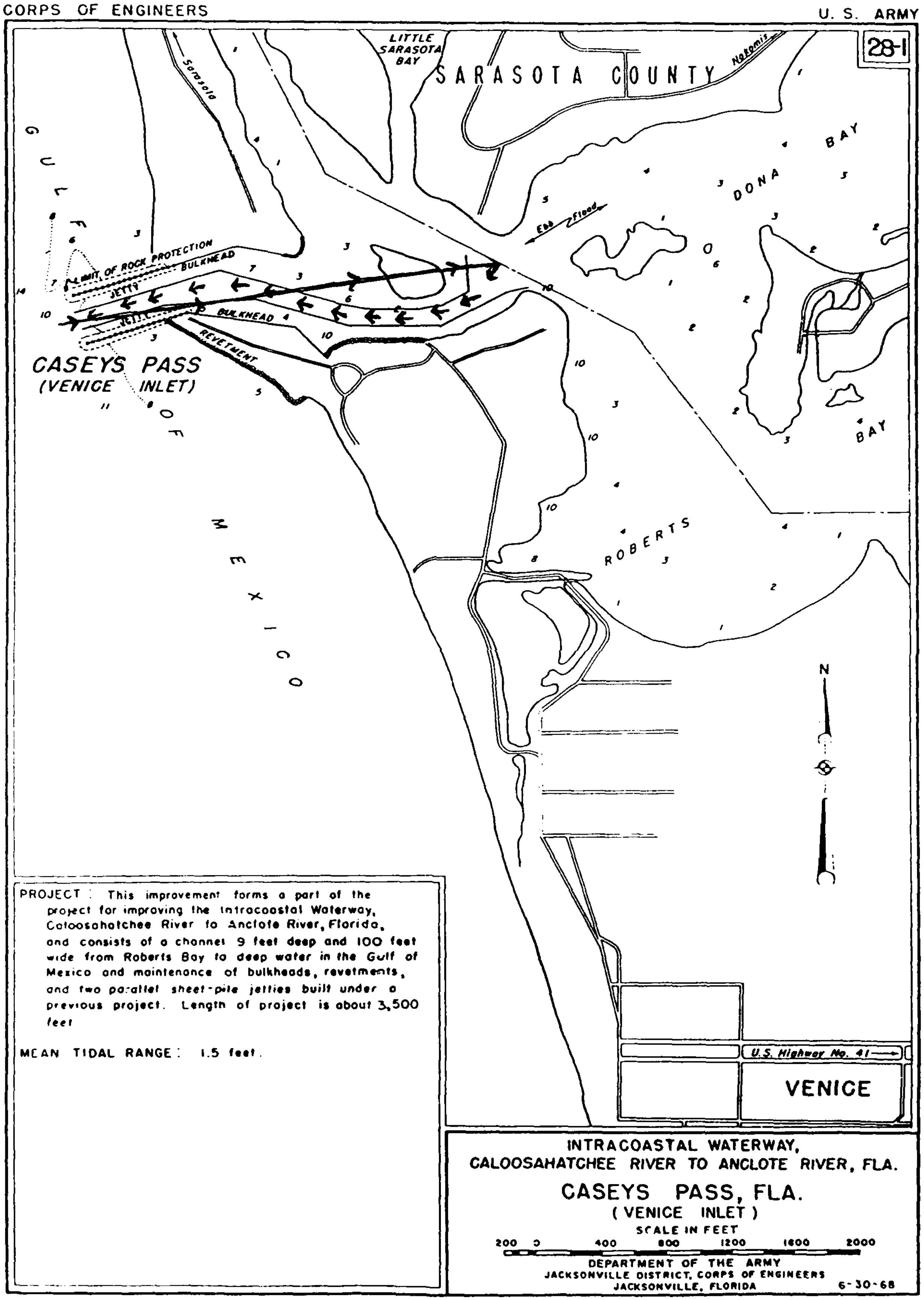
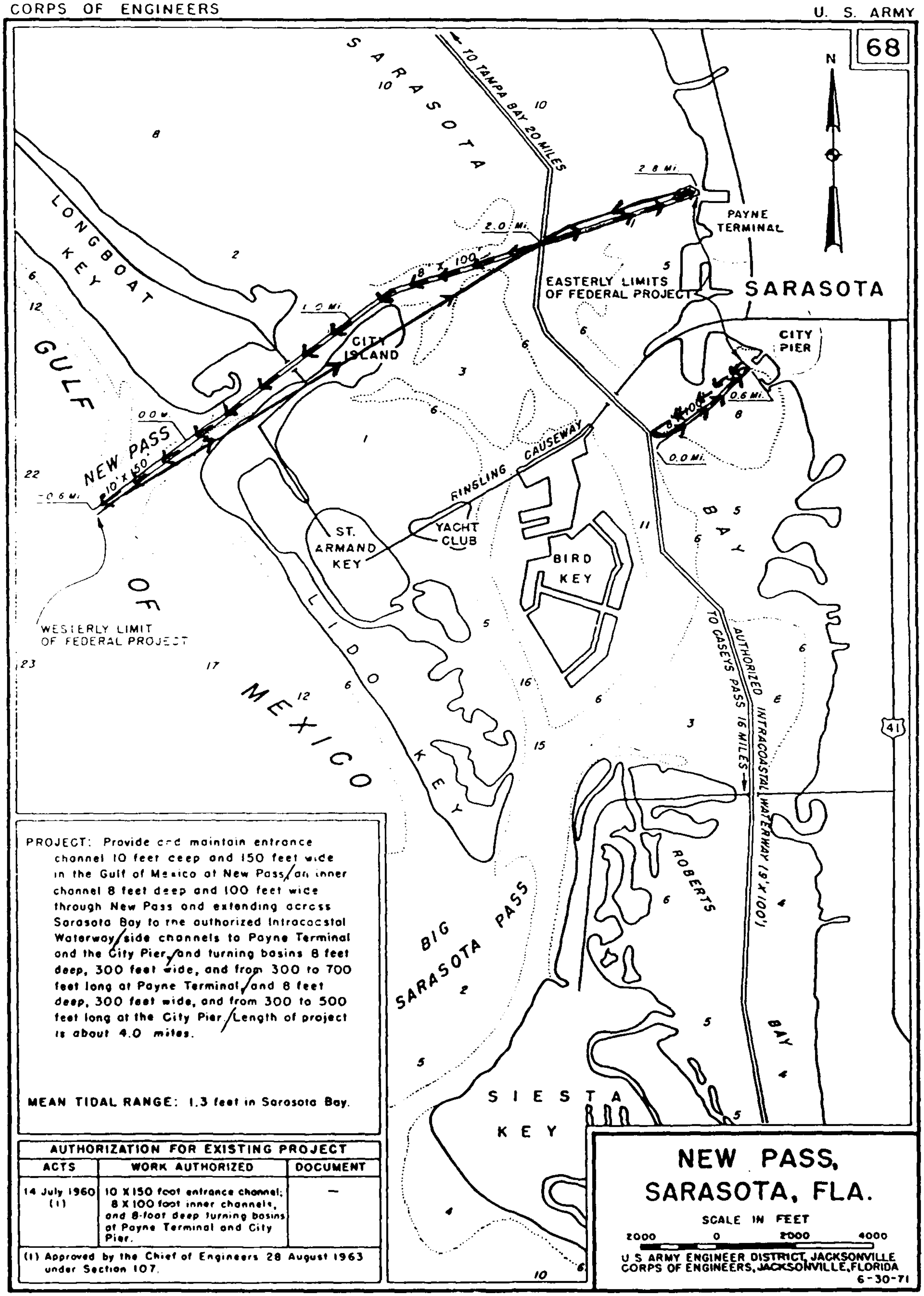
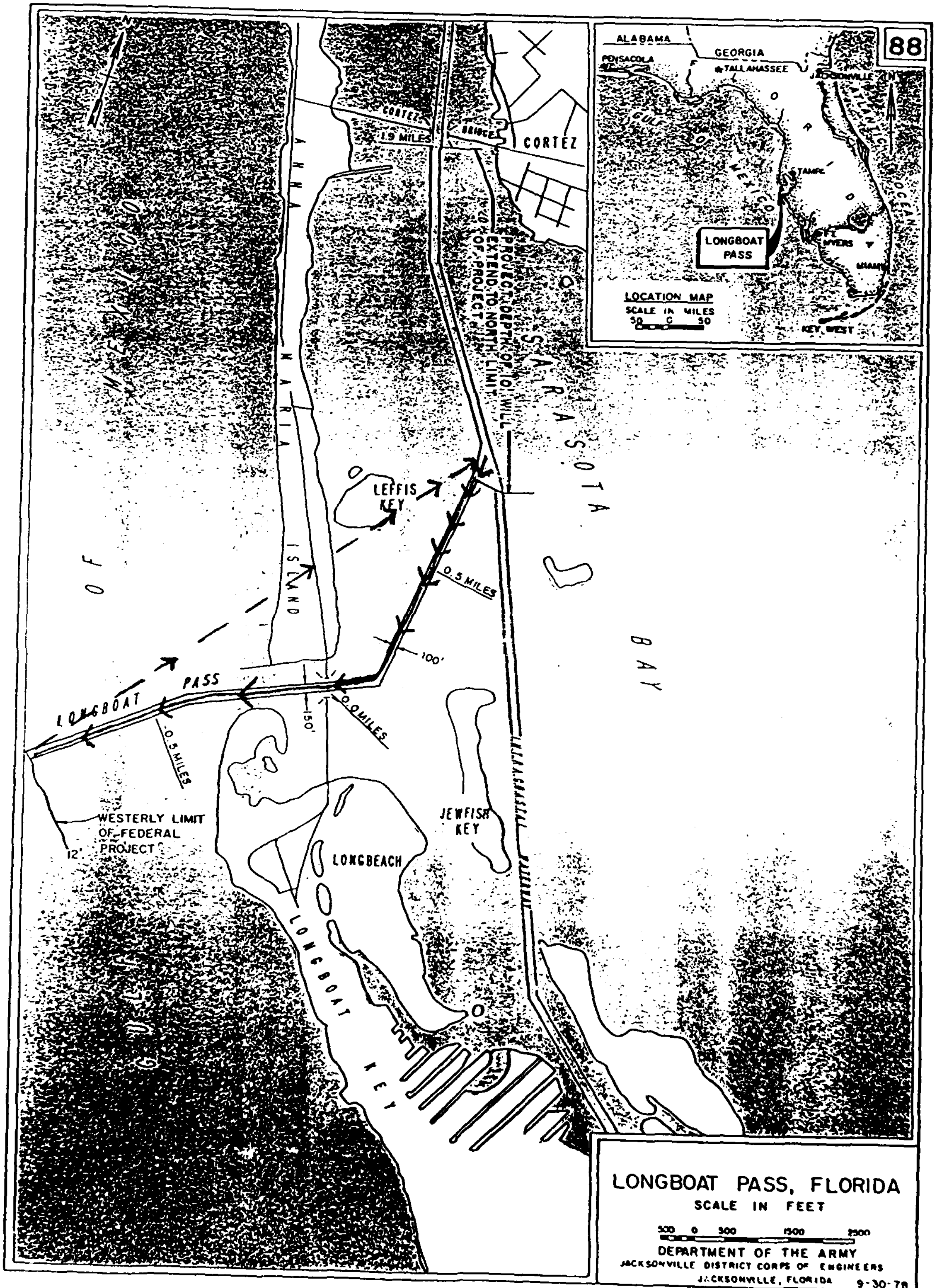

CORPS OF ENGINEERS
U. S. ARMY
28-1
LITTLE SARASOTA BAY
SARASOTA COUNTY
Nokomis
Sarasota
GULF OF MEXICO
DONA BAY
ROBERTS BAY
Ebb Flood
LIMIT OF ROCK PROTECTION
BULKHEAD
JETTY
JETTY
BULKHEAD
REVETMENT
CASEYS PASS
(VENICE INLET)
N
U.S. Highway No. 41
VENICE
PROJECT: This improvement forms a part of the project for improving the Intracoastal Waterway, Caloosahatchee River to Anclote River, Florida, and consists of a channel 9 feet deep and 100 feet wide from Roberts Bay to deep water in the Gulf of Mexico and maintenance of bulkheads, revetments, and two parallel sheet-pile jetties built under a previous project. Length of project is about 3,500 feet.
MEAN TIDAL RANGE: 1.5 feet.
INTRACOASTAL WATERWAY,
CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLA.
CASEYS PASS, FLA.
(VENICE INLET)
SCALE IN FEET
200 0 400 800 1200 1600 2000
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
6-30-68

Figure C-4



CORPS OF ENGINEERS
U. S. ARMY
68
N
TO TAMPA BAY 20 MILES
SARASOTA
LONGBOAT KEY
GULF OF MEXICO
NEW PASS
10' X 150'
8' X 100'
2.8 Mi.
2.0 Mi.
1.0 Mi.
0.0 Mi.
-0.6 Mi.
0.6 Mi.
PAYNE TERMINAL
EASTERLY LIMITS OF FEDERAL PROJECT
SARASOTA
CITY PIER
CITY ISLAND
RINGLING CAUSEWAY
ST. ARMAND KEY
YACHT CLUB
BIRD KEY
WESTERLY LIMIT OF FEDERAL PROJECT
LIDO KEY
BAY
TO CASEYS PASS 16 MILES
AUTHORIZED INTRACOASTAL WATERWAY (9' X 100')
41
ROBERTS BAY
BIG SARASOTA PASS
SIESTA KEY
PROJECT: Provide and maintain entrance channel 10 feet deep and 150 feet wide in the Gulf of Mexico at New Pass/an inner channel 8 feet deep and 100 feet wide through New Pass and extending across Sarasota Bay to the authorized Intracoastal Waterway/side channels to Payne Terminal and the City Pier/and turning basins 8 feet deep, 300 feet wide, and from 300 to 700 feet long at Payne Terminal/and 8 feet deep, 300 feet wide, and from 300 to 500 feet long at the City Pier/Length of project is about 4.0 miles.
MEAN TIDAL RANGE: 1.3 feet in Sarasota Bay.
AUTHORIZATION FOR EXISTING PROJECT
ACTS | WORK AUTHORIZED | DOCUMENT
14 July 1960 (1) | 10 X 150 foot entrance channel; 8 X 100 foot inner channels, and 8-foot deep turning basins at Payne Terminal and City Pier. | –
(1) Approved by the Chief of Engineers 28 August 1963 under Section 107.
NEW PASS, SARASOTA, FLA.
SCALE IN FEET
2000 0 2000 4000
U S ARMY ENGINEER DISTRICT, JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
6-30-71

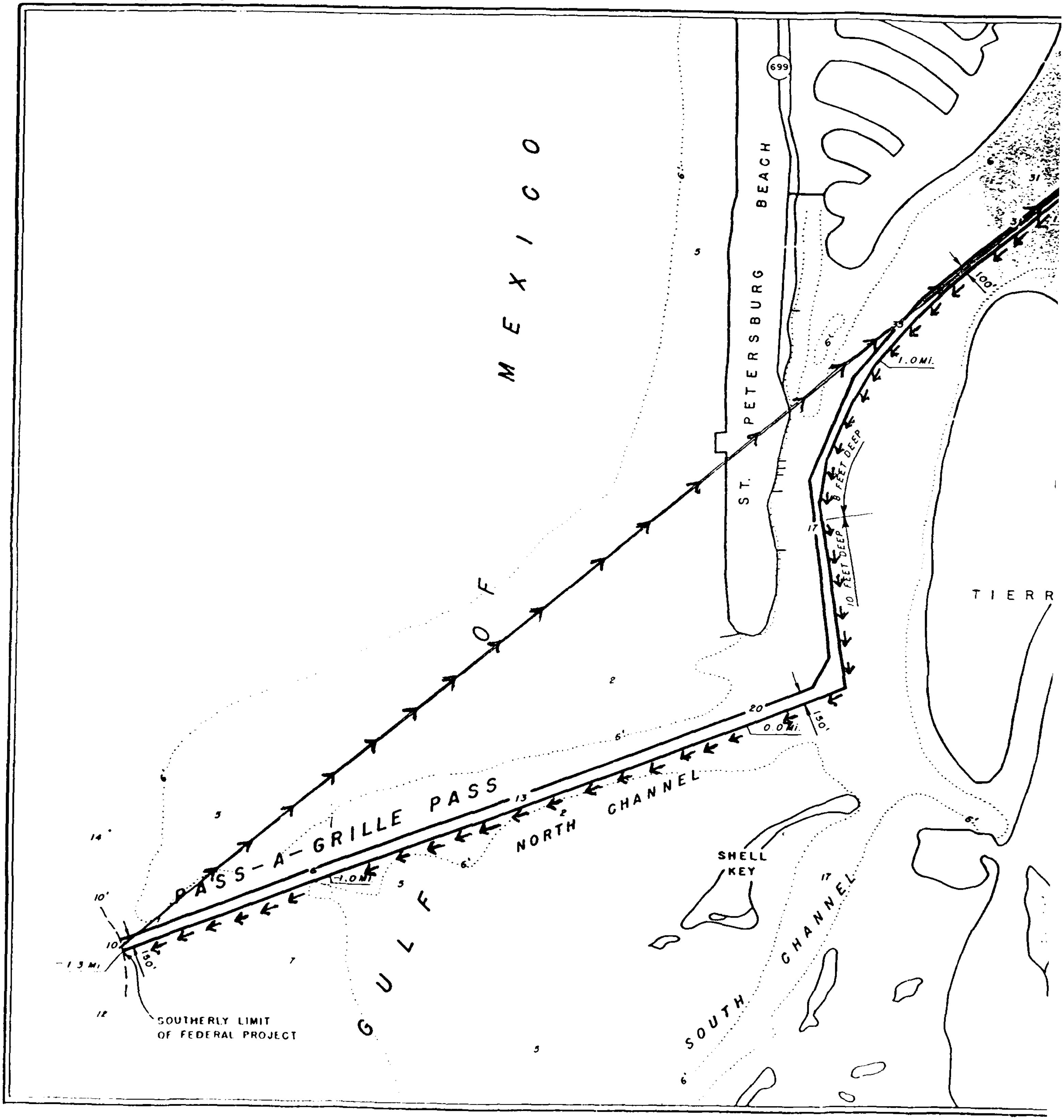
Figure C-5



88
ALABAMA
GEORGIA
PENSACOLA
TALLAHASSEE
JACKSONVILLE
TAMPA
FT. MYERS
MIAMI
KEY WEST
LONGBOAT PASS
LOCATION MAP
SCALE IN MILES
CORTEZ
CORTEZ BRIDGE
1.9 MILES
ANNA MARIA ISLAND
PROJECT DEPTH OF 10' WILL EXTEND TO NORTH LIMIT OF PROJECT
SARASOTA BAY
LEFFIS KEY
0.5 MILES
100'
LONGBOAT PASS
0.0 MILES
150'
-0.5 MILES
WESTERLY LIMIT OF FEDERAL PROJECT
12'
JEWFISH KEY
LONGBEACH
LONGBOAT KEY
LONGBOAT PASS, FLORIDA
SCALE IN FEET
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
9-30-78

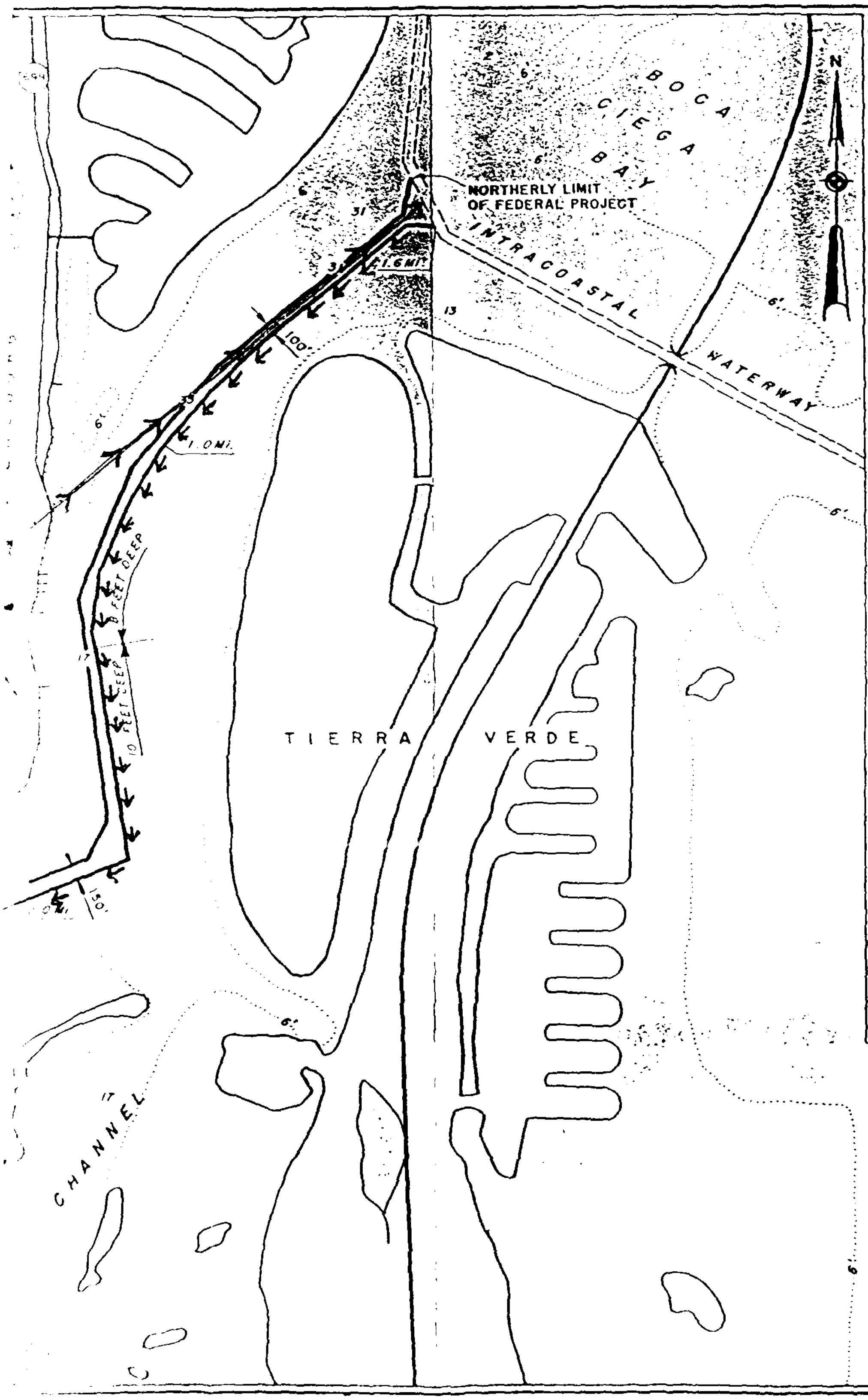
Figure C-6

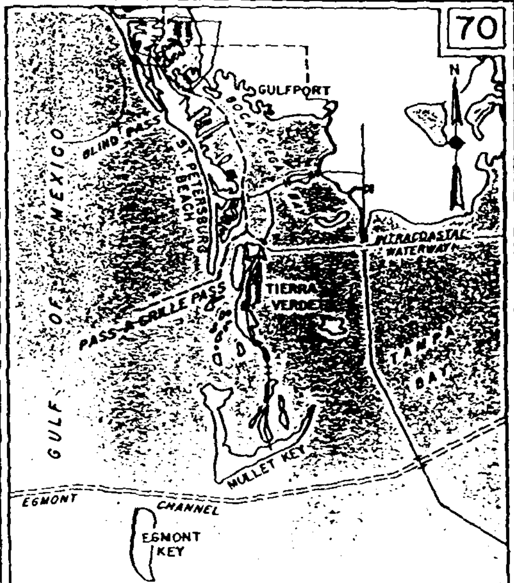
CORPS OF ENGINEERS



U. S. ARMY

70





VICINITY MAP

SCALE IN MILES

PROJECT Provide and maintain an entrance channel at Pass-a-Grille Pass 10 feet deep by 150 feet wide across the gulf bar, thence 8 feet deep by 100 feet wide to the Intracoastal Waterway. Length of project is about 2.9 miles.

MEAN TIDAL RANGE About 1.5 feet.

AUTHORIZATION FOR EXISTING PROJECT

ACT	WORK AUTHORIZED	DOCUMENT
14 July 1960 (1)	Entrance channel at Pass-a-Grille Pass 10 X 150 feet across the gulf bar and 8 X 100 feet to the Intracoastal waterway	—

(1) Approved by the Chief of Engineers 17 July 1964 under Section 107.

PASS-A-GRILLE PASS, PINELLAS COUNTY, FLA.

SCALE IN FEET

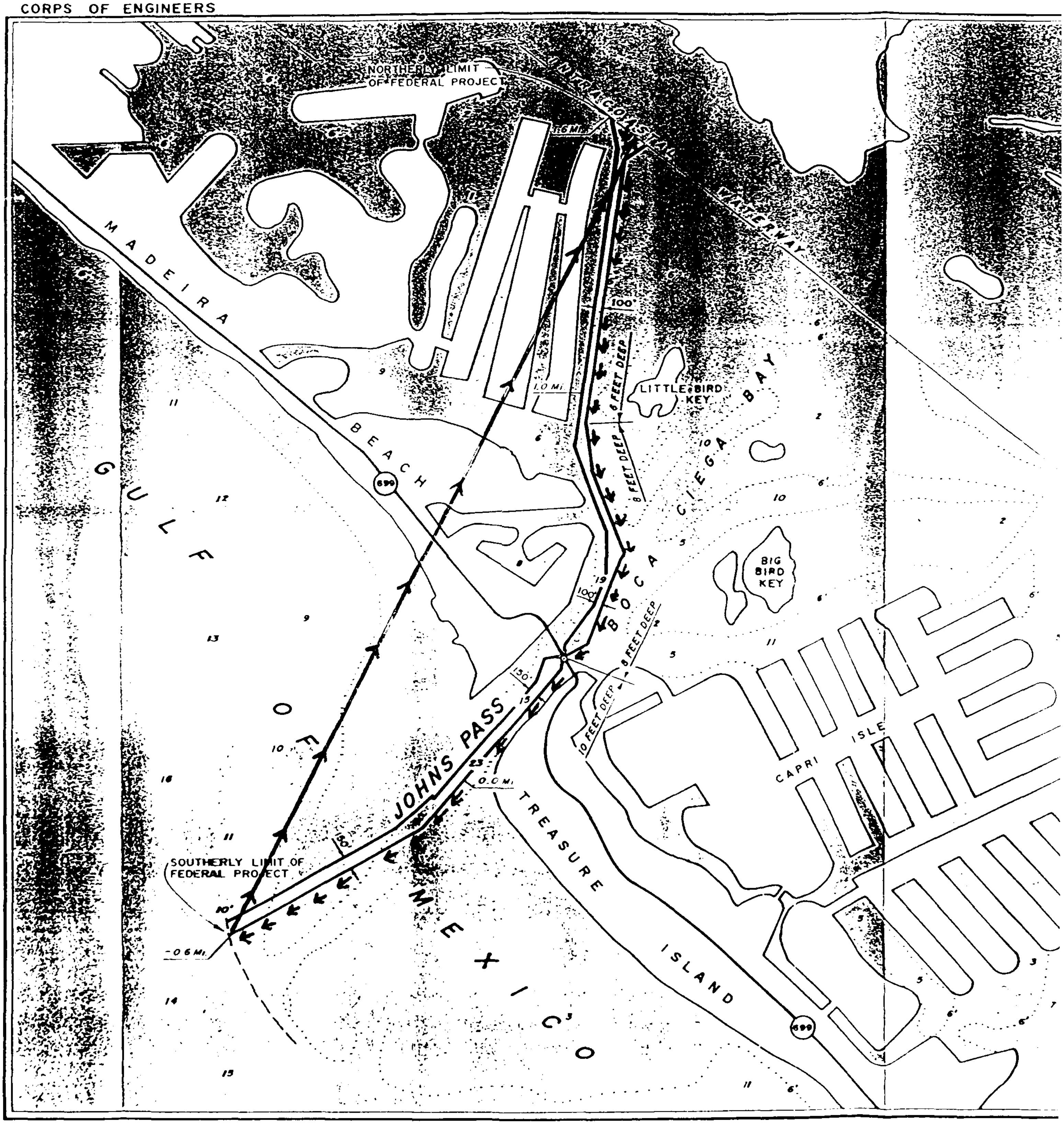
500 0 500 1000 1500

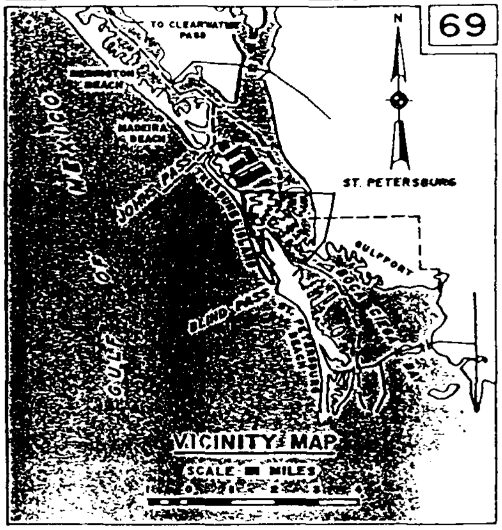
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

6-30-86

Figure C-7

CORPS OF ENGINEERS





PROJECT: Provide and maintain an entrance channel at Johns Pass 10 feet deep by 150 feet wide across the gulf bar, thence 8 feet deep by 100 feet wide into the pass, thence 6 feet deep by 100 feet wide to the Intracoastal Waterway. Length of project is about 2.2 miles.

MEAN TIDAL RANGE About 1.5 feet.

AUTHORIZATION FOR EXISTING PROJECT

ACT	WORK AUTHORIZED	DOCUMENT
14 July 1960 (1)	Entrance channel at Johns Pass 10 X 150 feet across the gulf bar, 8 X 100 feet into the pass, and 6 X 100 feet to the Intracoastal Waterway.	

(1) Approved by the Chief of Engineers 2 December 1964 under Section 107.

JOHNS PASS, PINELLAS COUNTY, FLA.

SCALE IN FEET

500 0 500 1000 1500

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

6-30-68

DAY TWO

Scenario Analysis

On Day Two, the helicopter's survey will cover the FL-IWW from Johns Pass to the Anclote River (Figure C-8). From the Anclote River, the helicopter will survey the Hillsborough River and then proceed to survey the northern section of Tampa Bay (Table C-2).

The helicopter will leave SRQ and deadhead to yesterday's ending point on the FL-IWW at John's Pass. Here the helicopter will begin to survey the next 15.6 nautical miles of the FL-IWW from John's Pass to Clearwater Pass (Figure C-8). The helicopter will survey the three nautical miles of Clearwater Pass (Figure C-9) and then head back to the FL-IWW to continue surveying north to Ozona (Figure C-10), a distance of 7.5 nautical miles. Again, the helicopter will detour to survey the one nautical mile of Ozona (Figure C-10).At the completion of the Ozona survey, the helicopter will deadhead over to the Clearwater Executive Airport for refueling.

After refueling, the helicopter will fly back to Ozona. It will survey the IWW up to the Anclote River, a distance of 5.6 nautical miles. The helicopter will next survey the Anclote River (Figure C-11). Once the helicopter arrives at the tip of the Anclote River, it will deadhead to the Hillsborough River, a distance of 24.3 nautical miles from the Anclote River. The helicopter will survey the Hillsborough River (Figure C-12), beginning 2.4 nautical miles from the mouth of the river, and surveying its way downstream. At the mouth of the Hillsborough River, the helicopter will begin to survey the northeastern section of Tampa Harbor (Figure C-13), including the Alafia River (Figure C-14). When the helicopter arrives at the Big Bend Channel in Tampa Harbor, it will head to the Peter O'Knight Airport for refueling.

After refueling, the helicopter will continue surveying the Tampa Harbor. The third segment of the survey will cover the upper portion of Tampa Harbor, from Big Bend Channel to the Tampa Channel turning Basin and back around to Hillsborough Bay Channel cut. The helicopter will return to Peter O'Knight Airport for refueling after surveying the Hillsborough Bay Channel cut.

After refueling, the helicopter has one more survey trip to make before heading home to base headquarters at SRQ. The helicopter will survey the Tampa Channel from Gadsden Point to Egmont Bar, a survey distance of 35 nautical miles. Total flight time for day two is eight flying hours.

Table C-2

DAY TWO

Trip One

		NM	Hrs.
1.	Deadhead from SRQ to Johns Pass	33.12	.331
2.	Survey IWW Johns Pass to IWW Clearwater Pass	15.625	.781
3.	1st Channel 1 pass to westerly edge	1.81	.09
4.	Deadhead to 2nd Channel	1.11	.0111
5.	2nd Channel 1 pass to northerly edge	1.19	.06
6.	Deadhead back to IWW	1.19	.0119
7.	Survey IWW Clearwater Pass to IWW Ozona, FL	7.50	.375
8.	Channel 1 pass	1.136	.06
9.	Deadhead back to IWW	1.136	.01136
10.	Deadhead from Ozona to Clearwater Executive Airport	6.25	.0625

Trip Two

1.	Deadhead from Clearwater Executive to Ozona	6.25	.062
2.	Survey IWW Ozona to IWW Anclote River, FL	5.625	.281
3.	Channel, West of IWW 1 pass	2.304 NM	.12
4.	Deadhead back to IWW	1.975 NM	.02
5.	Channel, East of IWW	4.937 NM	.25

Table C-2 (Continued)

		NM	Hrs.
Hillsborough River			
6.	Deadhead Access from Anclote River	24.375	.24
7.	Channel 1 pass	2.414	.12
8.	Survey Tampa Channel (Hillsborough River to Port Sutton Channel)	8.88	.444
9.	Deadhead Y Bar Channel, Garrison Channel and Port Sutton Channel	2.64	.026
10.	Survey Hillsborough Channel to Alafia River	4.29	.214
Alafia River, FL			
11.	Channel	3.566	.18
	Deadhead back to Tampa Harbor	2.962	.03
12.	Survey Hillsborough Channel (Alafia River to Big Bend Channel)	2.31	.115
13.	Deadhead to Peter O'Knight Airport	6.60	.066
Trip Three			
1.	Deadhead from Peter O'Knight Airport to Big Bend Channel	6.60	.066
2.	Survey Big Bend Channel	3.63	.181
3.	Deadhead Big Bend Channel	3.63	.036
4.	Survey Tampa Channel (Big Bend Channel to Tampa Channel turning Basin, around back up Hillsborough Bay Channel cut)	32.67	1.63
5.	Deadhead to Peter O'Knight Airport	1	.01

Table C-2 (Continued)

Trip Four

		NM	Hrs.
Tampa Harbor			
1.	Deadhead tip Peter O'Knight Airport to Gadsden Point cut	10.24	.102
2.	Survey Channel (Gadsden Point cut to Port Manatee Channel)	10.56	.528
3.	Survey Port Manatee Channel	6.94	.347
4.	Survey Channel (Port Manatee to Egmont Bar Channel)	17.82	.891
5.	Deadhead Egmont Bar Channel to SRQ	22.5	.23

Day Two:

Trip One

	NM	Hrs.
Total Survey	27.261	1.366
Total Deadhead	42.800	.428
Total	70.067	1.794

Trip Two

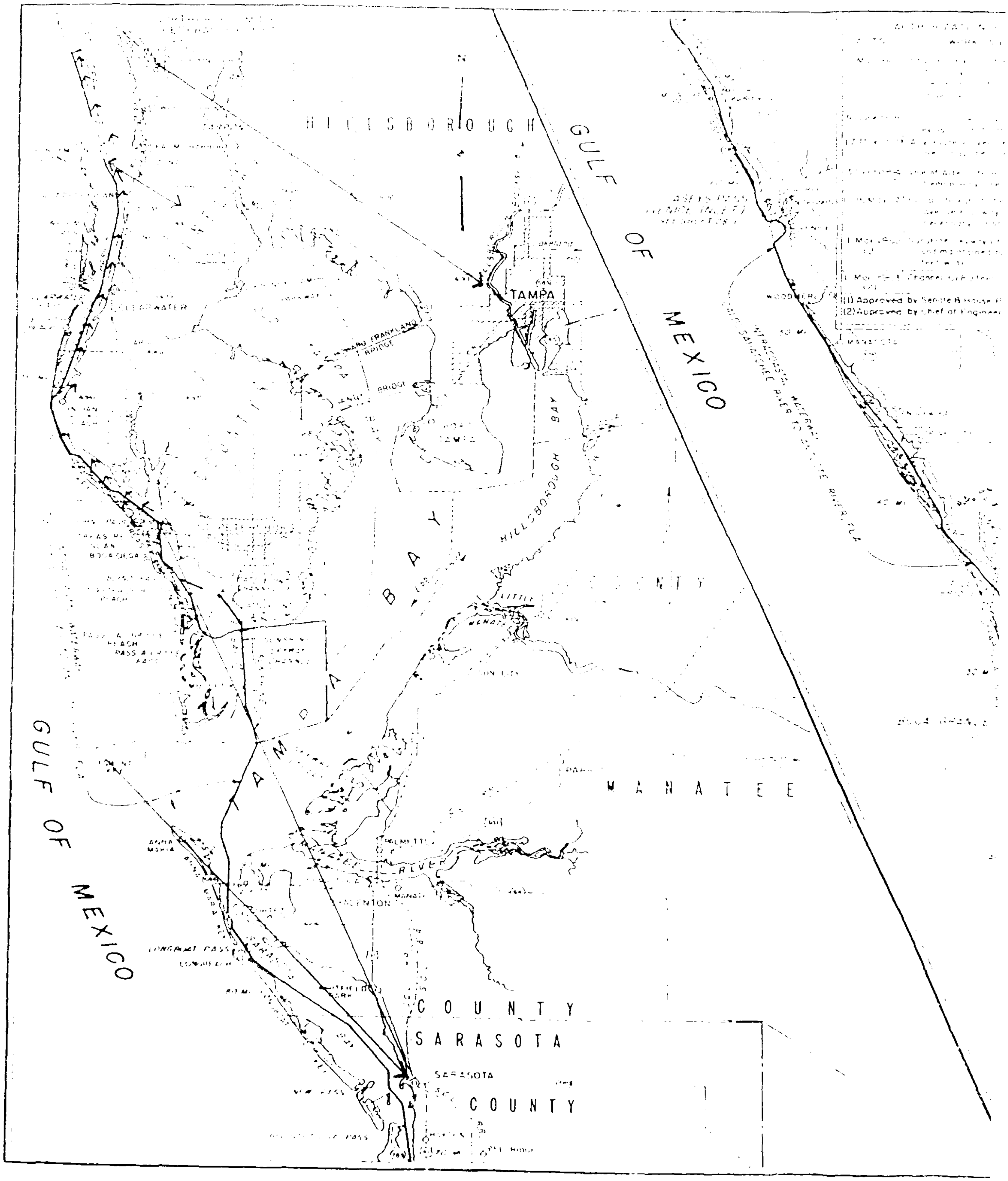
	NM	Hrs.
Total Survey	34.326	1.724
Total Deadhead	44.802	.444
Total	79.128	2.168

Trip Three

	NM	Hrs.
Total Survey	36.3	1.811
Total Deadhead	11.23	.112
Total	47.53	1.923

Table C-2 (Continued)

	NM	Hrs.
Trip Four		
Total Survey	35.32	1.766
Total Deadhead	32.74	.332
Total	68.06	2.098
Day Two		
Total Survey	133.207	6.667
Total Deadhead	131.578	1.316
Total	264.785	7.983



CORPS OF ENGINEERS
HILLSBOROUGH
GULF OF MEXICO
TAMPA
CLEARWATER
GANDY BRIDGE
HILLSBOROUGH BAY
TAMPA BAY
MANATEE
COUNTY
SARASOTA
COUNTY
SARASOTA
ANNA MARIA
PALMETTO
(1) Approved by Senate & House
(2) Approved by Chief of Engineers

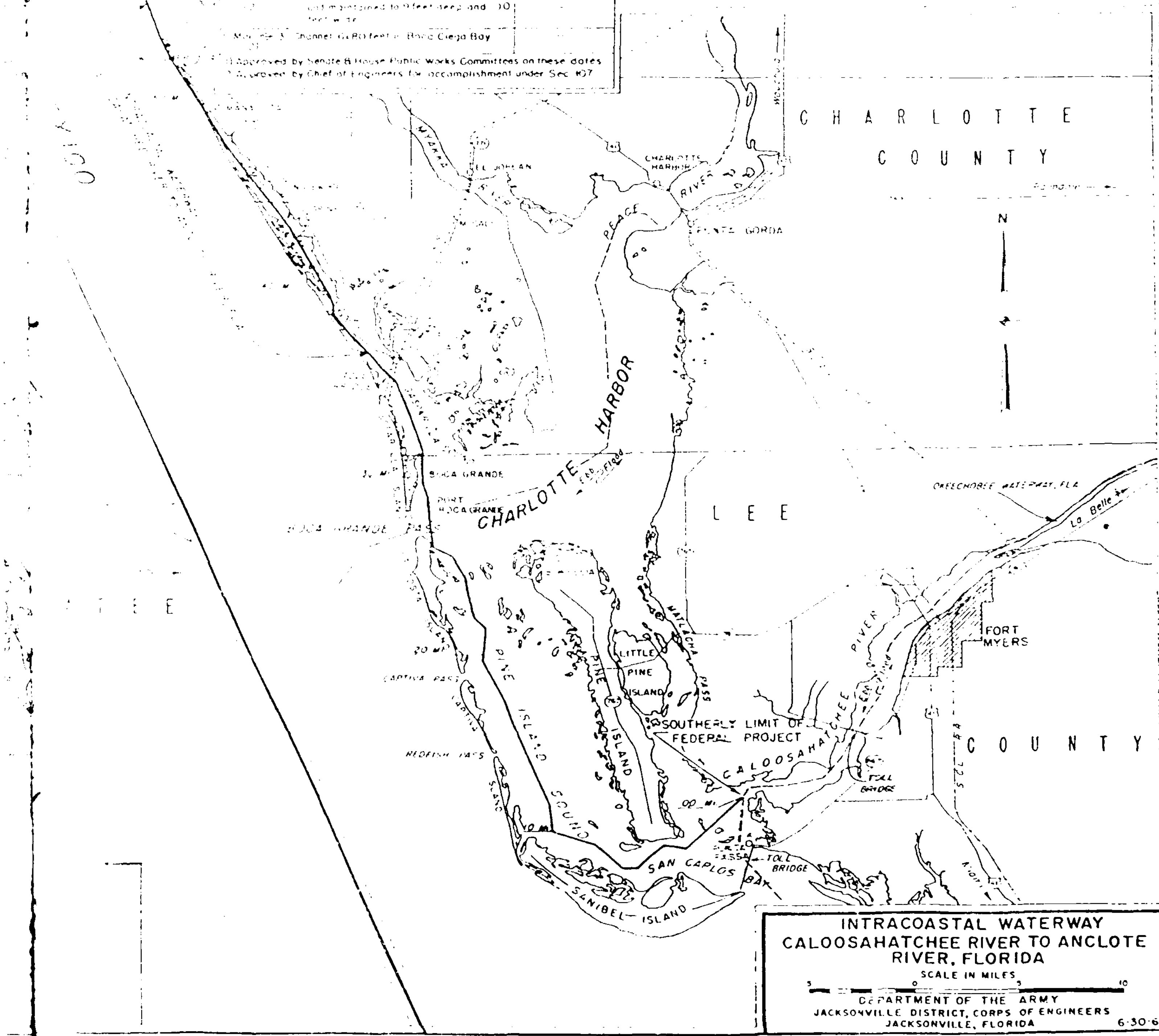
AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
[illegible]	[illegible] feet, deepening [illegible] of Caseys Pass to [illegible] feet, and construction of a highway bridge [illegible]	[illegible]
[illegible]	[illegible] may be modified at [illegible] of the [illegible] States	Specified in act
[illegible]	[illegible] Bay Route [illegible] Venice [illegible] Bay [illegible] be used	Specified in act
[illegible]	[illegible] use of [illegible] Route [illegible] Venice [illegible] Lemon Bay area	Specified in act
[illegible]	[illegible] costs of Venice Avenue highway bridge and any other necessary crossings [illegible] Route C-1	[illegible]
[illegible]	[illegible] Sunshine Skyway Channel to be improved and maintained to 9 feet deep and 100 feet wide	
[illegible]	Channel 6 x 80 feet in Boca Ciega Bay	

(1) Approved by Senate & House Public Works Committees on these dates
(2) Approved by Chief of Engineers for accomplishment under Sec 107

PROJECT A channel [illegible] x 100 feet from Caloosahatchee River to Anclote River; deepening existing 100 foot wide entrance channel at Caseys Pass (Venice Inlet) to [illegible] feet, maintenance of bulkheads, revetments, and two jetties built at Caseys Pass under a previous project, and improvement and maintenance of existing Sunshine Skyway borrow channel to 9 by 100 feet. Waterway will include existing improved channels in Pine Island Sound from Punta Rassa to Charlotte Harbor, in the entrance to Roberts Bay at Caseys Pass, in Little Sarasota Bay and Sarasota Bay from Nokomis to Tampa Bay, and in Boca Ciega Bay from Tampa Bay to Clearwater Harbor, a channel 6 x 80 feet along the south eastern side of Boca Ciega Bay and across Cats Point Shoal. Length of project waterway is about 160 miles.

MEAN TIDAL RANGE 1.7 feet at Punta Rassa, 1 foot at Port Boca Grande, 1.4 feet at Anna Maria, and 2 feet at entrance to Anclote River



INTRACOASTAL WATERWAY
CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLORIDA

SCALE IN MILES
5 0 5 10

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
6-30-68

Figure C-9

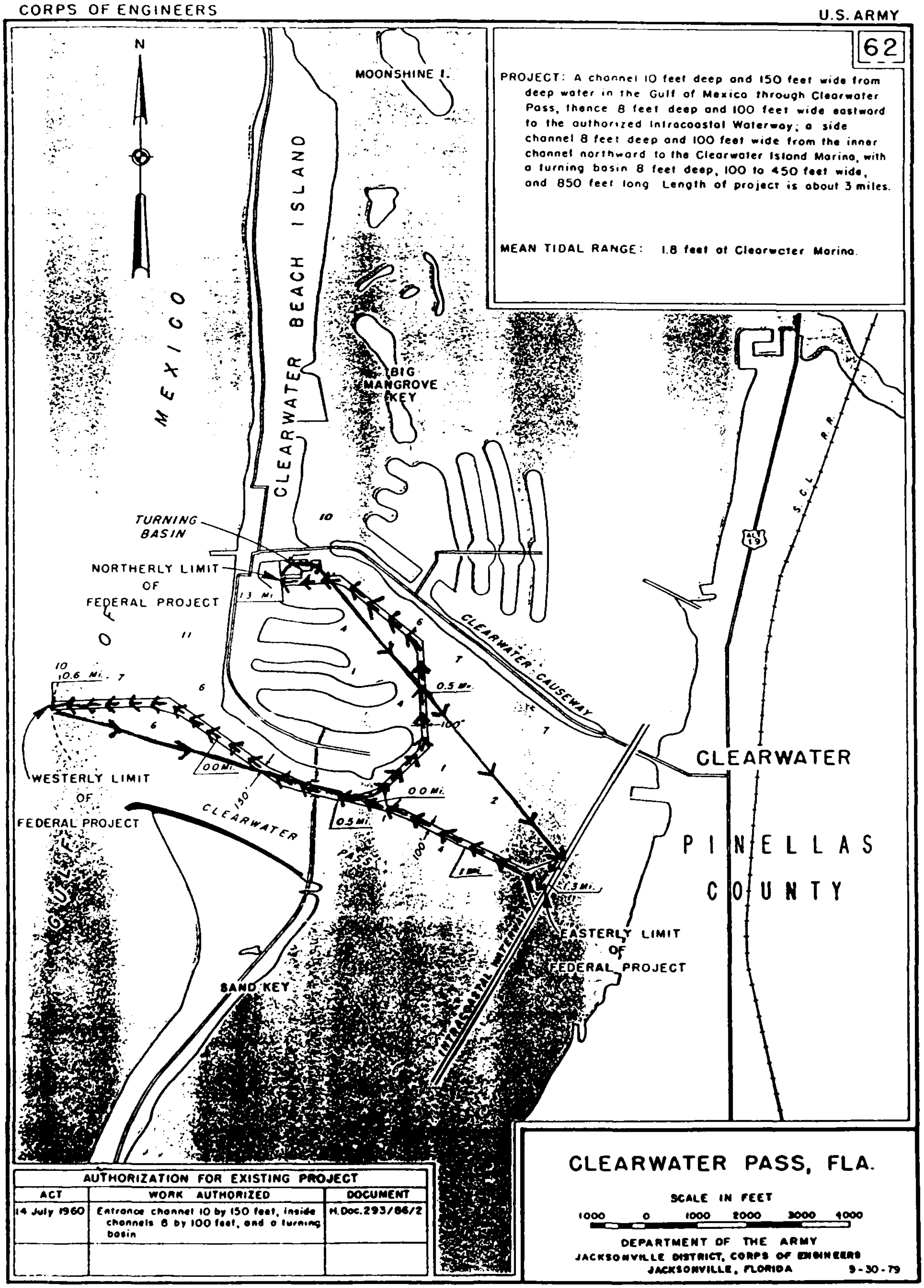
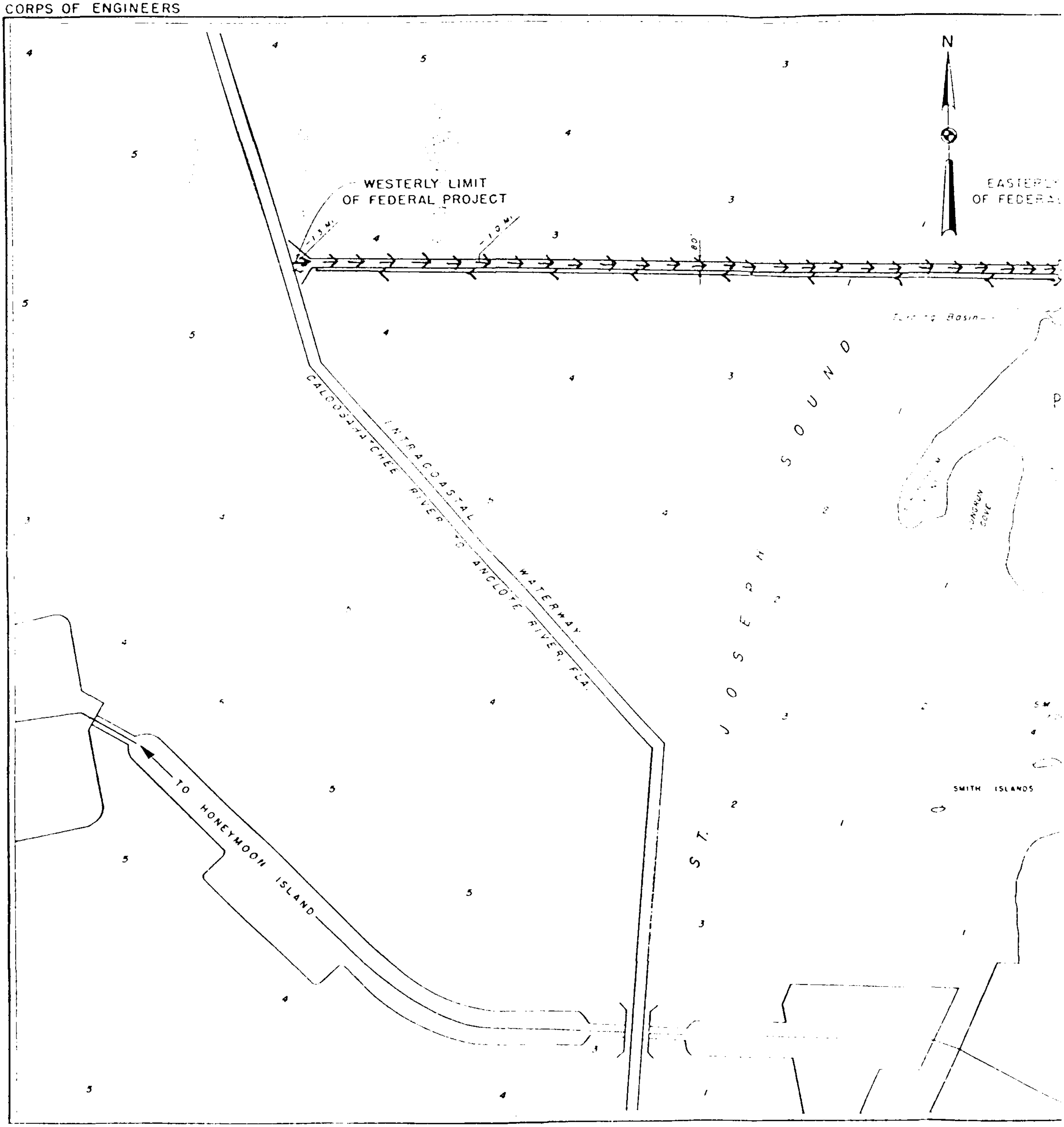

CORPS OF ENGINEERS
U.S. ARMY
62
PROJECT: A channel 10 feet deep and 150 feet wide from deep water in the Gulf of Mexico through Clearwater Pass, thence 8 feet deep and 100 feet wide eastward to the authorized Intracoastal Waterway; a side channel 8 feet deep and 100 feet wide from the inner channel northward to the Clearwater Island Marina, with a turning basin 8 feet deep, 100 to 450 feet wide, and 850 feet long. Length of project is about 3 miles.
MEAN TIDAL RANGE: 1.8 feet at Clearwater Marina.
N
MOONSHINE I.
CLEARWATER BEACH ISLAND
GULF OF MEXICO
BIG MANGROVE KEY
TURNING BASIN
NORTHERLY LIMIT OF FEDERAL PROJECT
1.3 Mi.
CLEARWATER CAUSEWAY
0.5 Mi.
10.6 Mi.
0.0 Mi.
WESTERLY LIMIT OF FEDERAL PROJECT
CLEARWATER PASS
0.5 Mi.
1 Mi.
1.3 Mi.
EASTERLY LIMIT OF FEDERAL PROJECT
SAND KEY
INTRACOASTAL WATERWAY
CLEARWATER
PINELLAS COUNTY
S.C.L. R.R.
ALT 19
AUTHORIZATION FOR EXISTING PROJECT
ACT | WORK AUTHORIZED | DOCUMENT
14 July 1960 | Entrance channel 10 by 150 feet, inside channels 8 by 100 feet, and a turning basin | H.Doc.293/86/2
CLEARWATER PASS, FLA.
SCALE IN FEET
1000 0 1000 2000 3000 4000
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
9-30-79

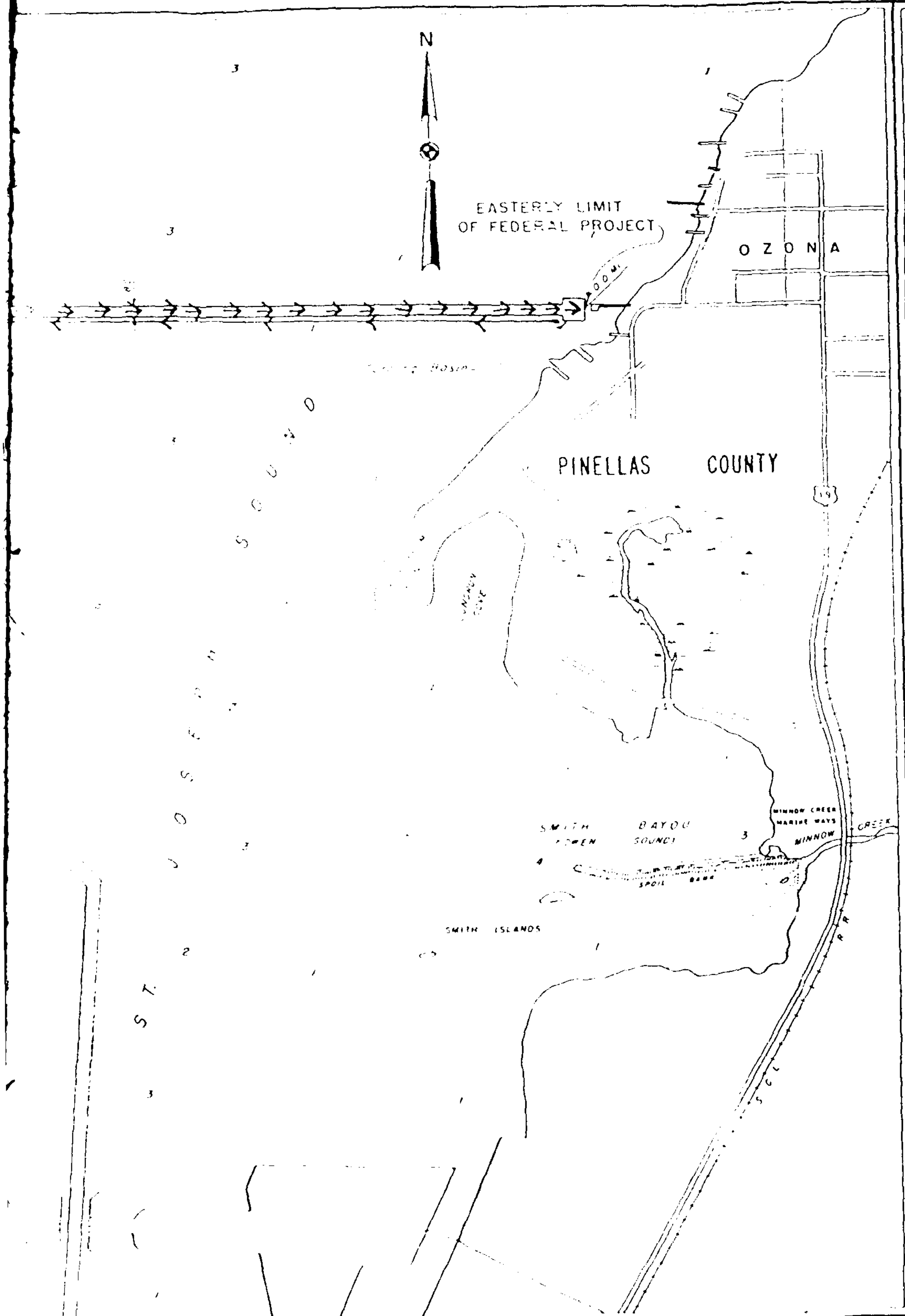
Figure C-10

CORPS OF ENGINEERS



U.S. ARMY

34



PROJECT: A channel 6 feet deep and 80 feet wide from the Intracoastal Waterway, Caloosahatchee River to Anclote River, to the head of the Ozona Fish Co pier, with a turning basin 6 feet deep and 150 feet square at the latter location. The length of the improvement is about 1.3 miles.

MEAN TIDAL RANGE: 1.8 feet at Ozona.

AUTHORIZATION FOR EXISTING PROJECT

ACT	WORK AUTHORIZED	DOCUMENT
17 May 1950	Channel 6'X80' and turning basin 6'X150'X150'	H DOC 326/81/1

OZONA, FLA.
CHANNEL AND TURNING BASIN

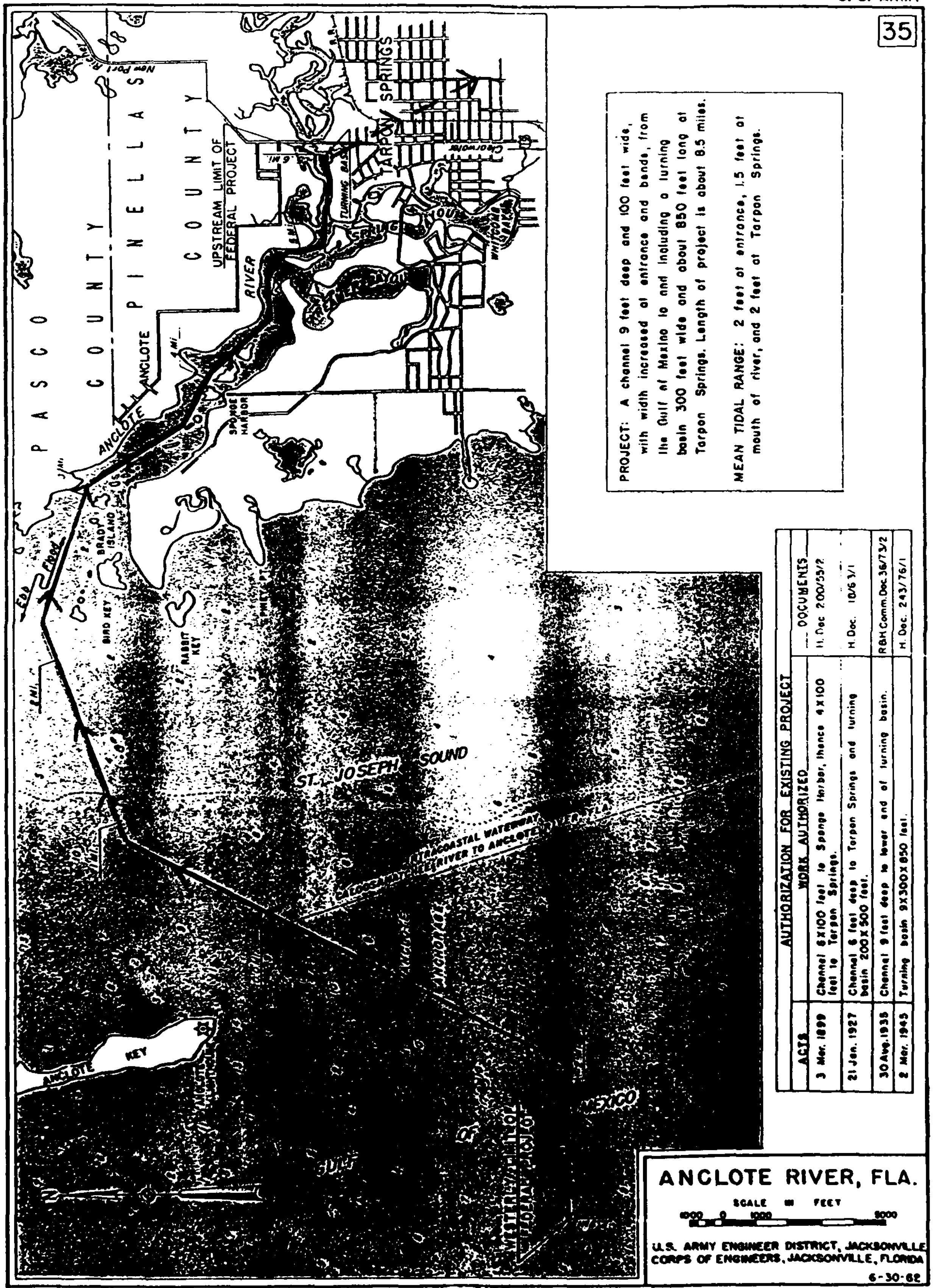
SCALE IN FEET

500 0 500 1000 1500

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

5-30-67

Figure C-11



AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
3 Mar. 1899	Channel 6X100 feet to Sponge Harbor, thence 4X100 feet to Tarpon Springs.	H. Doc. 200/55/2
21 Jan. 1927	Channel 6 feet deep to Tarpon Springs and turning basin 200X500 feet.	H. Doc. 18/63/1
30 Aug. 1935	Channel 9 feet deep to lower end of turning basin.	R&H Comm. Doc. 36/73/2
2 Mar. 1945	Turning basin 9X300X850 feet.	H. Doc. 243/76/1

Figure C-12

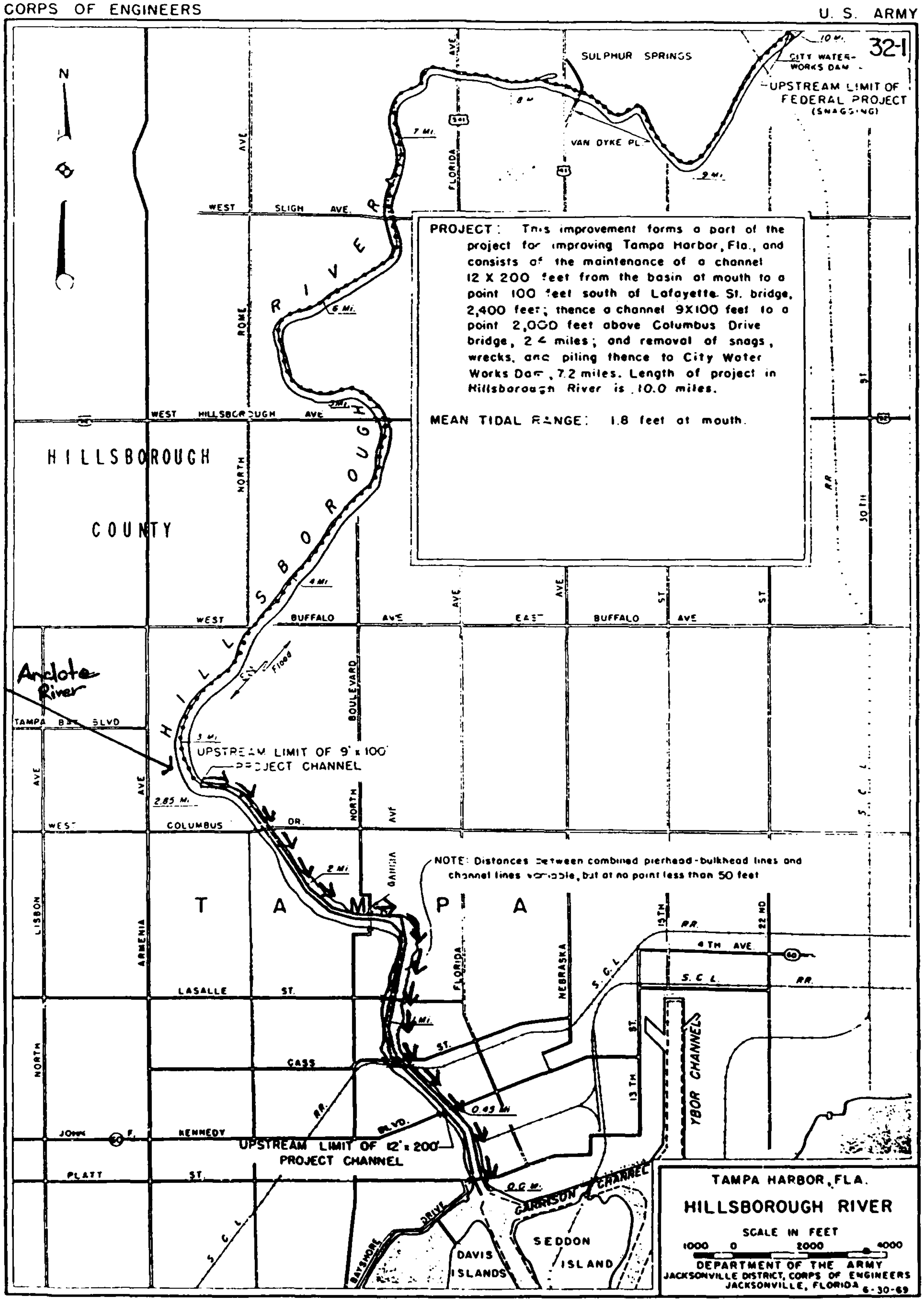
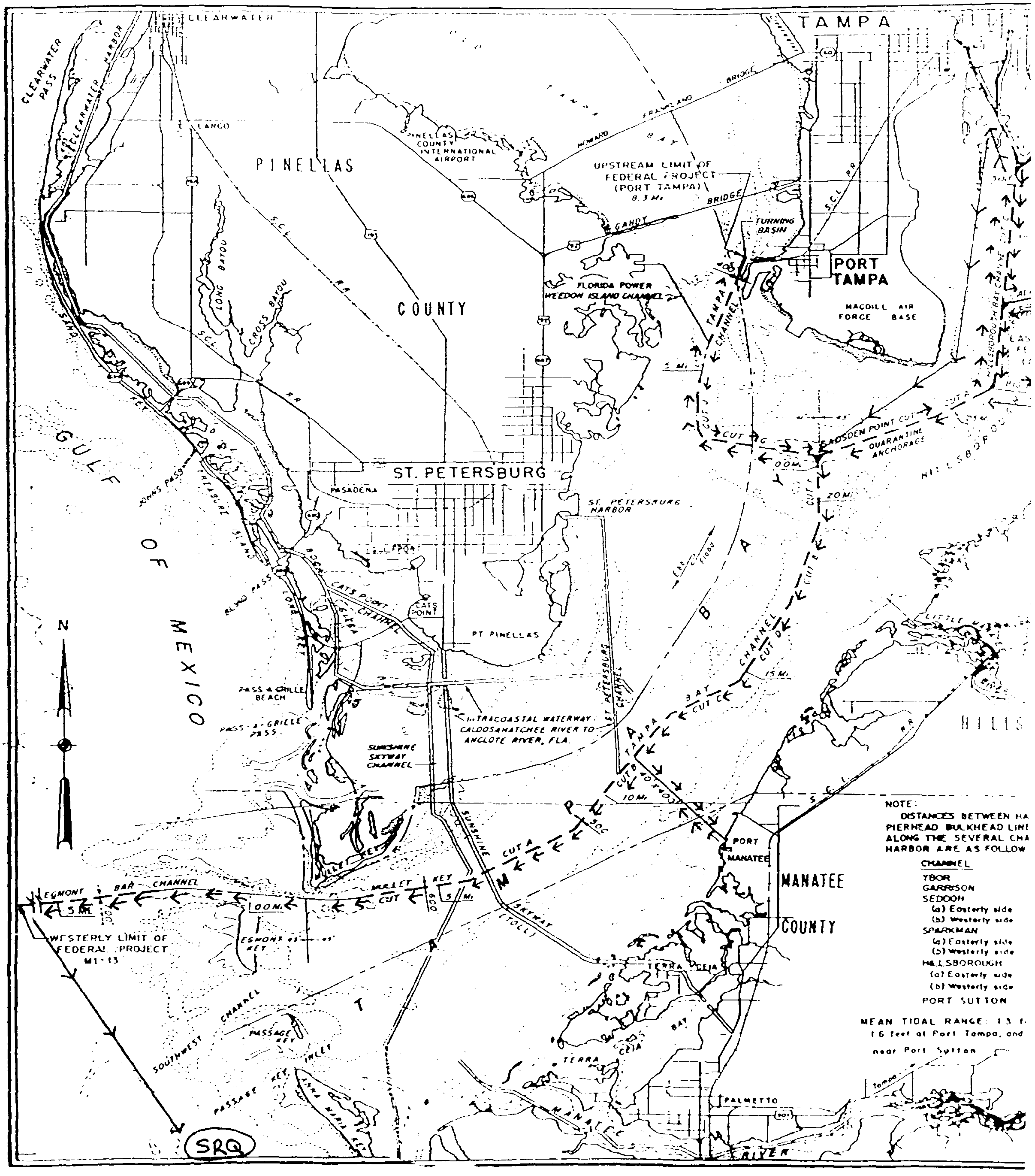
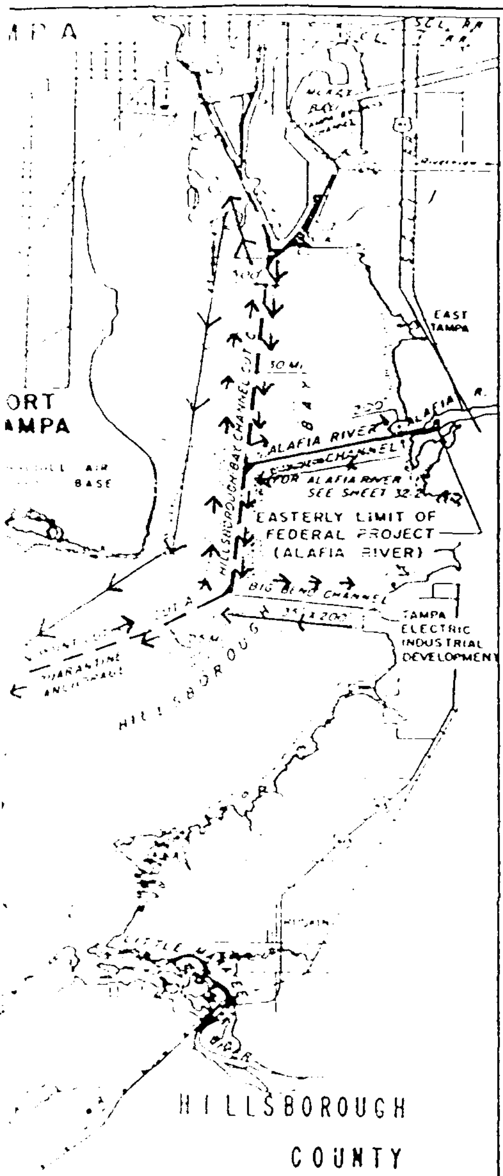
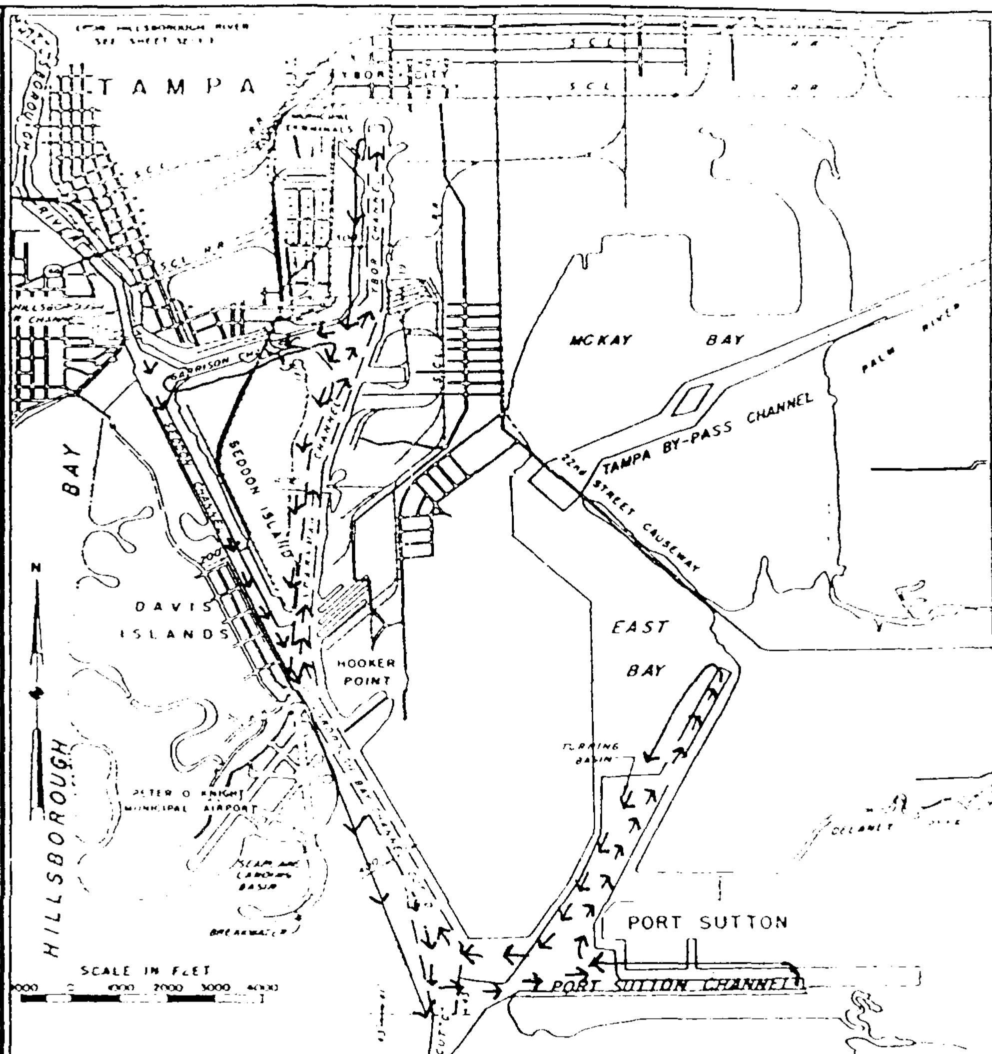

CORPS OF ENGINEERS
U. S. ARMY
32-1
SULPHUR SPRINGS
CITY WATER-WORKS DAM
UPSTREAM LIMIT OF FEDERAL PROJECT (SNAGGING)
VAN DYKE PL.
WEST SLIGH AVE.
PROJECT: This improvement forms a part of the project for improving Tampa Harbor, Fla., and consists of the maintenance of a channel 12 X 200 feet from the basin at mouth to a point 100 feet south of Lafayette St. bridge, 2,400 feet; thence a channel 9X100 feet to a point 2,000 feet above Columbus Drive bridge, 2.4 miles; and removal of snags, wrecks, and piling thence to City Water Works Dam, 7.2 miles. Length of project in Hillsborough River is 10.0 miles.
MEAN TIDAL RANGE: 1.8 feet at mouth.
HILLSBOROUGH RIVER
HILLSBOROUGH COUNTY
WEST HILLSBOROUGH AVE.
WEST BUFFALO AVE.
EAST BUFFALO AVE.
Anclote River
TAMPA BAY BLVD
UPSTREAM LIMIT OF 9' x 100' PROJECT CHANNEL
WEST COLUMBUS DR.
NOTE: Distances between combined pierhead-bulkhead lines and channel lines variable, but at no point less than 50 feet
T A M P A
4 TH AVE.
LASALLE ST.
CASS
JOHN F. KENNEDY BLVD.
UPSTREAM LIMIT OF 12' x 200' PROJECT CHANNEL
PLATT ST.
YBOR CHANNEL
GARRISON CHANNEL
DAVIS ISLANDS
SEDDON ISLAND
BAYSHORE DRIVE
TAMPA HARBOR, FLA.
HILLSBOROUGH RIVER
SCALE IN FEET
1000 0 2000 4000
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA 6-30-69

Figure C-13



TAMPA
PORT TAMPA
MACDILL AIR FORCE BASE
PINELLAS COUNTY
ST. PETERSBURG
GULF OF MEXICO
MANATEE COUNTY
CLEARWATER
CLEARWATER PASS
LARGO
PINELLAS COUNTY INTERNATIONAL AIRPORT
UPSTREAM LIMIT OF FEDERAL PROJECT (PORT TAMPA) 8.3 Mi.
GANDY BRIDGE
HOWARD FRANKLAND BRIDGE
TURNING BASIN
FLORIDA POWER WEEDON ISLAND CHANNEL
LONG BAYOU
CROSS BAYOU
JOHNS PASS
PASADENA
ST. PETERSBURG HARBOR
BLIND PASS
CATS POINT CHANNEL
CATS POINT
PT PINELLAS
PASS-A-GRILLE BEACH
PASS-A-GRILLE PASS
INTRACOASTAL WATERWAY CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLA.
SUNSHINE SKYWAY CHANNEL
SUNSHINE SKYWAY (TOLL)
ST. PETERSBURG CHANNEL
TAMPA BAY
TAMPA CHANNEL
EGMONT BAR CHANNEL
MULLET KEY
MULLET KEY CUT
WESTERLY LIMIT OF FEDERAL PROJECT M1-13
EGMONT KEY
SOUTHWEST CHANNEL
PASSAGE KEY
PASSAGE KEY INLET
ANNA MARIA KEY
TERRA CEIA
TERRA CEIA BAY
PALMETTO
MANATEE RIVER
PORT MANATEE
GADSDEN POINT CUT
QUARANTINE ANCHORAGE
HILLSBOROUGH BAY
HILLSBOROUGH BAY CHANNEL
CUT A
CUT B
CUT C
CUT D
CUT E
CUT F
CUT G
CUT J
5 Mi.
10 Mi.
15 Mi.
20 Mi.
SRQ
NOTE:
DISTANCES BETWEEN HA
PIERHEAD BULKHEAD LINE
ALONG THE SEVERAL CHA
HARBOR ARE AS FOLLOW
CHANNEL
YBOR
GARRISON
SEDDON
(a) Easterly side
(b) Westerly side
SPARKMAN
(a) Easterly side
(b) Westerly side
HILLSBOROUGH
(a) Easterly side
(b) Westerly side
PORT SUTTON
MEAN TIDAL RANGE: 1.3 f
1.6 feet at Port Tampa, and
near Port Sutton
N





AUTHORIZATION FOR EXISTING PROJECT		
ACT	WORK AUTHORIZED	DOCUMENTS
	TAMPA HARBOR (CONTINUED)	
31 DEC 1970	42 feet deep, 2,000 feet long, and 900 feet wide; Port Sutton entrance channel 44 X 400 feet; Port Sutton turning basin 44 feet deep with turning diameter of 1,200 feet; enlargement of turning basin at the entrance of Ybor Channel and deepening to 42 feet; East Bay entrance channel 44 X 400 and 500 feet about 2,000 feet North from Port Sutton turning basin; East Bay turning basin 44 feet deep with a 1,200 foot turning diameter; East Bay approach channel 44 X 300 feet about 2,500 feet North from the East Bay turning basin; and maintenance of Port Sutton terminal channel to 44 X 200 feet for a distance of 4,000 feet. Bottom 1 foot of all project segments in "inactive" ategory.	H. DOC. 91-401/91/2

NOTE.

DISTANCES BETWEEN HARBOR LINES (COMBINED PIERHEAD BULKHEAD LINES) AND CHANNEL LINES ALONG THE SEVERAL CHANNELS OF THE UPPER HARBOR ARE AS FOLLOW:

CHANNEL	DISTANCE (FT)
YBOR	50-100
GARRISON	0
SEDDON	
(a) Easterly side	80
(b) Westerly side	150
SPARKMAN	
(a) Easterly side	35
(b) Westerly side	115
HILLSBOROUGH	
(a) Easterly side	60
(b) Westerly side	150
PORT SUTTON	100

MEAN TIDAL RANGE 1.3 feet at the gulf entrance, 1.6 feet at Port Tampa, and 1.8 feet at Tampa and near Port Sutton

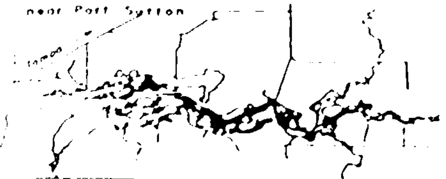
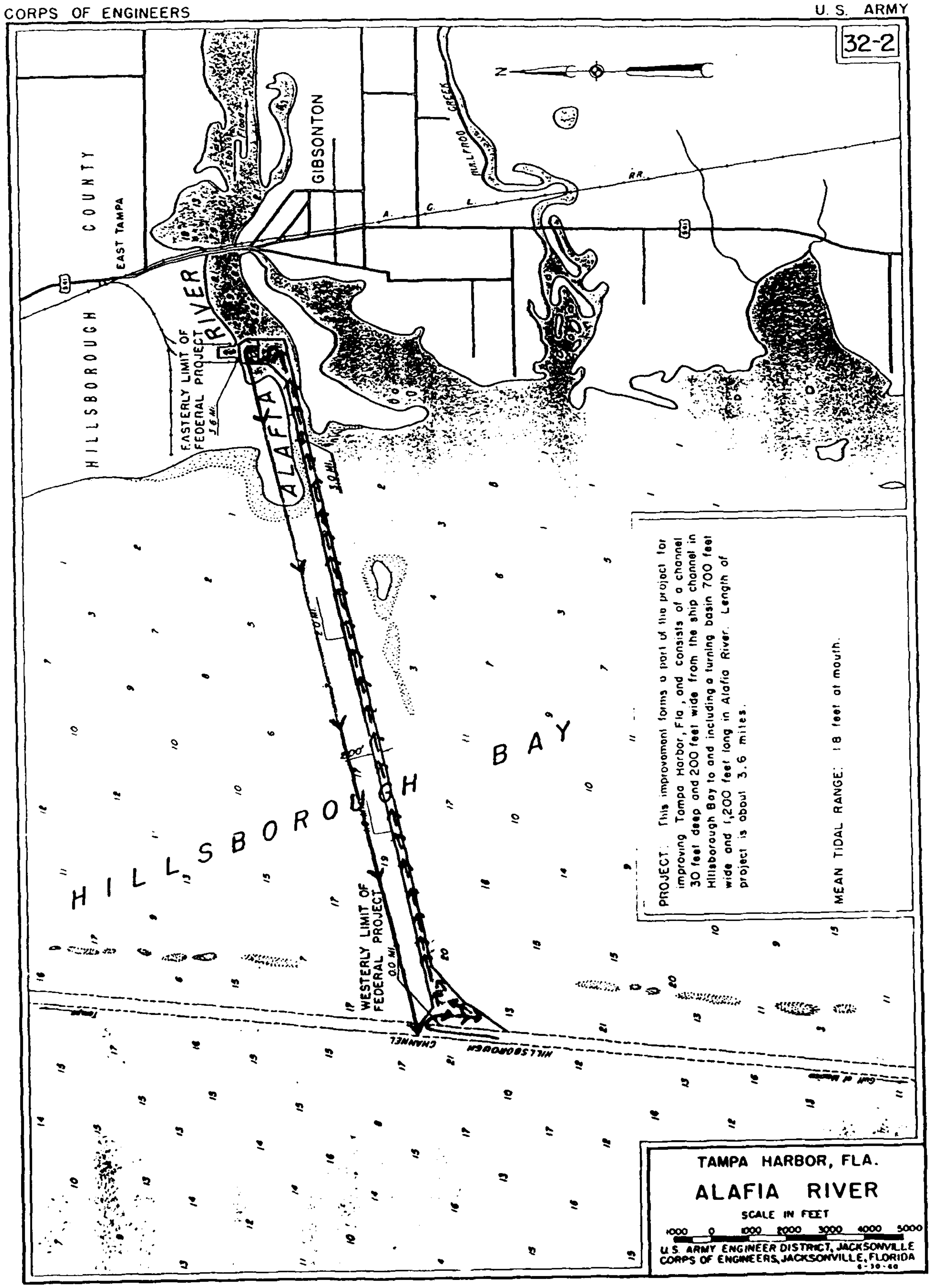


Figure C-14


CORPS OF ENGINEERS
U. S. ARMY
32-2
GIBSONTON
HILLSBOROUGH COUNTY
EAST TAMPA
BULLFROG CREEK
A. C. L. RR.
ALAFIA RIVER
EASTERLY LIMIT OF FEDERAL PROJECT
3.6 MI.
3.0 MI.
2.0 MI.
HILLSBOROUGH BAY
WESTERLY LIMIT OF FEDERAL PROJECT
0.0 MI.
HILLSBOROUGH CHANNEL
PROJECT: This improvement forms a part of the project for improving Tampa Harbor, Fla., and consists of a channel 30 feet deep and 200 feet wide from the ship channel in Hillsborough Bay to and including a turning basin 700 feet wide and 1,200 feet long in Alafia River. Length of project is about 3.6 miles.
MEAN TIDAL RANGE: 1.8 feet at mouth.
TAMPA HARBOR, FLA.
ALAFIA RIVER
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

DAY THREE

Scenario Analysis

On the third and final day, the helicopter will finish surveying Tampa Harbor (Table C-3, Figure C-15), including the St. Petersburg Harbor (Figure C-16) and the remaining portion of the FL-IWW (Figure C-17).

The helicopter will deadhead from SRQ to the west end of the IWW near Pass-A-Grille Pass. The helicopter will survey the portion of the FL-IWW which connects the St. Petersburg Channel to the main, north-south route of the FL-IWW. The total survey distance is about five nautical miles. From the FL-IWW, the helicopter will deadhead north to survey three nautical miles of St. Petersburg Harbor. Next, the helicopter will survey St. Petersburg Channel, approximately 2.4 nautical miles. After surveying the St. Petersburg Channel, the helicopter will survey the Tampa Bay Channel, from the St. Petersburg Channel north to Gadsden Point, a distance of 10.5 nautical miles. When the helicopter reaches Gadsden Point, it will then deadhead back to the Albert Whitted Airport for refueling.

After refueling, the helicopter will finish surveying the portion of Tampa Harbor which lies south of St. Petersburg Channel. The survey will cover the Tampa Channel Cut from St. Petersburg to Egmont Bar, a survey distance of twenty nautical miles. After finishing up the survey at Egmont Bar, the helicopter will depart to SRQ for the completion of the FL-IWW survey.

Table C-3

DAY THREE

Trip One

		NM	Hrs.
1.	SRQ Airport to West End IWW	24.40	.244
2.	Survey West portion IWW to St. Petersburg Channel	5.28	.264
St. Petersburg, FL			
3.	Deadhead Access from IWW	3.95	.04
4.	Harbor 2 passes @ 1,000′	.329	.02
5.	Port of St. Petersburg 4 passes @ 1,200′	.790	.04
6.	Deadhead 1,200′	.197	.01
7.	Remaining Harbor 1 pass @ 13,500′	2.222	.11
8.	Deadhead to St. Petersburg Channel	1.975	.02
9.	St. Petersburg Channel 1 pass	2.387	.12
10.	Deadhead @ 3,000′	.494	.005
Tampa Harbor			
11.	Survey Tampa Bay Channel from St. Petersburg Channel to Gadsden Point	10.56	.528
12.	Deadhead to Albert Whitted Airport	9.57	.096

Table C-3 (Continued)

Trip Two

		NM	Hrs.
1.	Deadhead Albert Whitted Airport to Tampa Harbor @ St. Petersburg Channel	3.18	.03
2.	Survey Tampa Harbor from St. Petersburg to Egmont Bar and back to eastern edge of Egmont Bar	19.59	.97
3.	Deadhead to SRQ from Egmont Bar	22.50	.225

Day Three

Trip One

	NM	Hrs.
Total Survey	21.568	1.082
Total Deadhead	40.586	.406
Total	62.154	1.489

Trip Two

	NM	Hrs.
Total Survey	19.59	.97
Total Deadhead	25.68	.26
Total	45.27	1.23

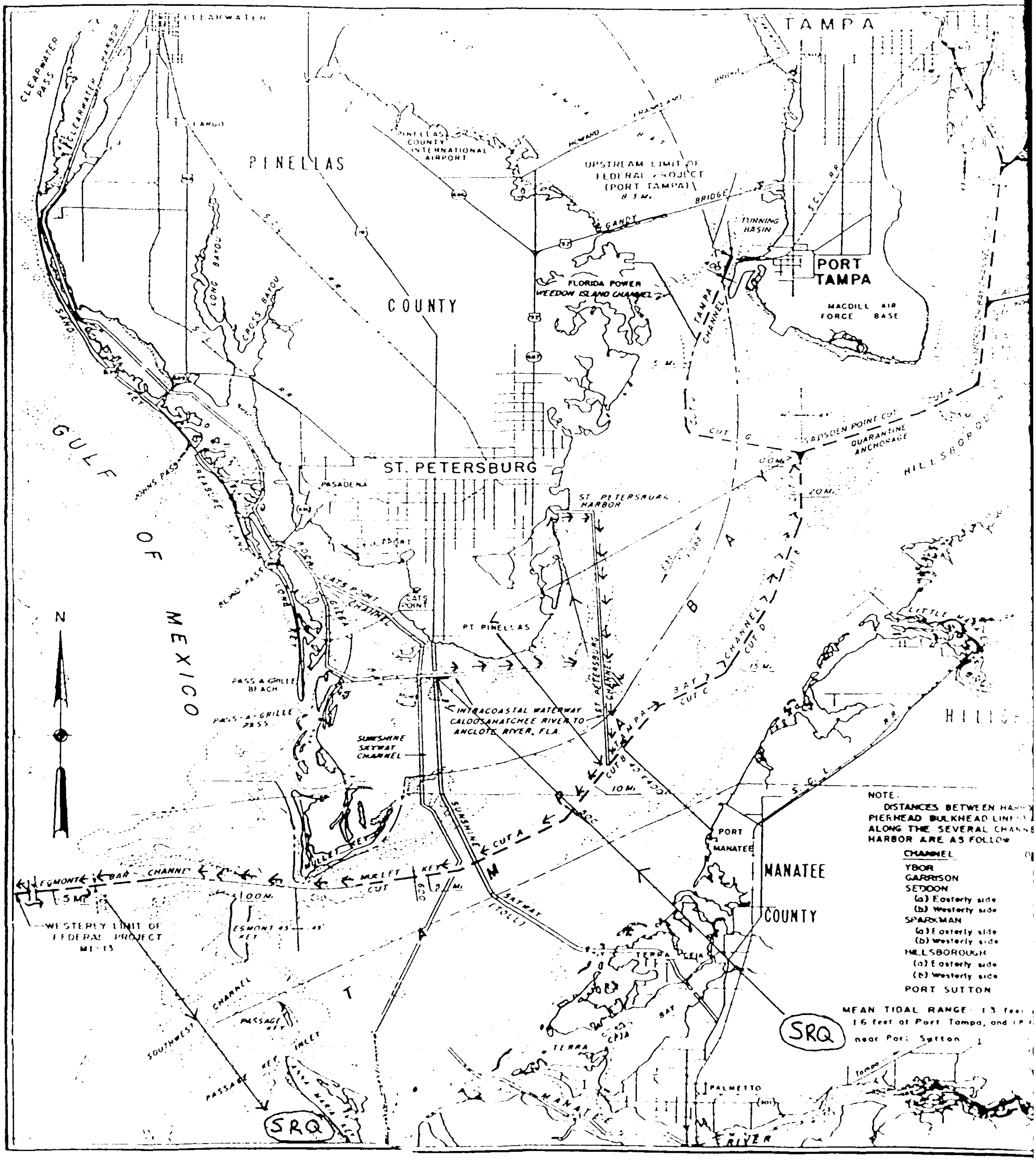
Day Three

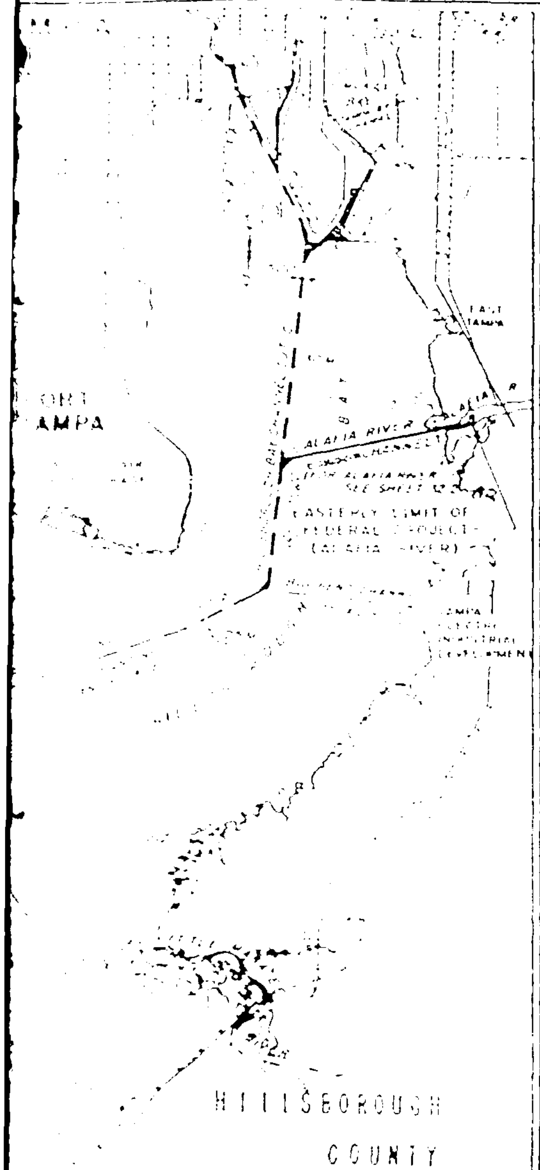
	NM	Hrs.
Total Survey	41.158	2.052
Total Deadhead	66.266	.667
Total	107.724	2.719

Total FL-IWW

	NM	Hrs.
Total Survey	296.9	14.8
Total Deadhead	354.4	3.5

Figure C-15


CLEARWATER
TAMPA
CLEARWATER PASS
PINELLAS
COUNTY
PINELLAS COUNTY INTERNATIONAL AIRPORT
UPSTREAM LIMIT OF FEDERAL PROJECT (PORT TAMPA)
GANDY BRIDGE
TURNING BASIN
PORT TAMPA
MACDILL AIR FORCE BASE
FLORIDA POWER WEEDON ISLAND CHANNEL
TAMPA CHANNEL
LONG BAYOU
CROSS BAYOU
GULF OF MEXICO
JOHNS PASS
ST. PETERSBURG
PASADENA
ST PETERSBURG HARBOR
GADSDEN POINT CUT
QUARANTINE ANCHORAGE
CUT G
CUT A
HILLSBOROUGH
BLIND PASS
CATS POINT CHANNEL
CATS POINT
PT PINELLAS
PASS-A-GRILLE BEACH
PASS-A-GRILLE PASS
INTRACOASTAL WATERWAY CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLA.
SUNSHINE SKYWAY CHANNEL
CHANNEL CUT D
CUT C
CUT B
CUT A
ST PETERSBURG CHANNEL
10 MI
N
EGMONT
BAR CHANNEL
MULLET KEY CUT
MULLET KEY
SUNSHINE SKYWAY (TOLL)
WESTERLY LIMIT OF FEDERAL PROJECT
ESMONT KEY
SOUTHWEST CHANNEL
PASSAGE KEY
PASSAGE KEY INLET
ANNA MARIA KEY
SRQ
TERRA CEIA
TERRA CEIA BAY
MANATEE RIVER
PALMETTO
PORT MANATEE
MANATEE
COUNTY
SRQ
NOTE:
DISTANCES BETWEEN HA... PIERHEAD BULKHEAD LIN... ALONG THE SEVERAL CHANN... HARBOR ARE AS FOLLOW
CHANNEL
YBOR
GARRISON
SEDDON
(a) Easterly side
(b) Westerly side
SPARKMAN
(a) Easterly side
(b) Westerly side
HILLSBOROUGH
(a) Easterly side
(b) Westerly side
PORT SUTTON
MEAN TIDAL RANGE: 1.3 feet ... 1.6 feet at Port Tampa, and ... near Port Sutton

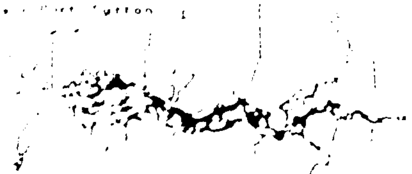


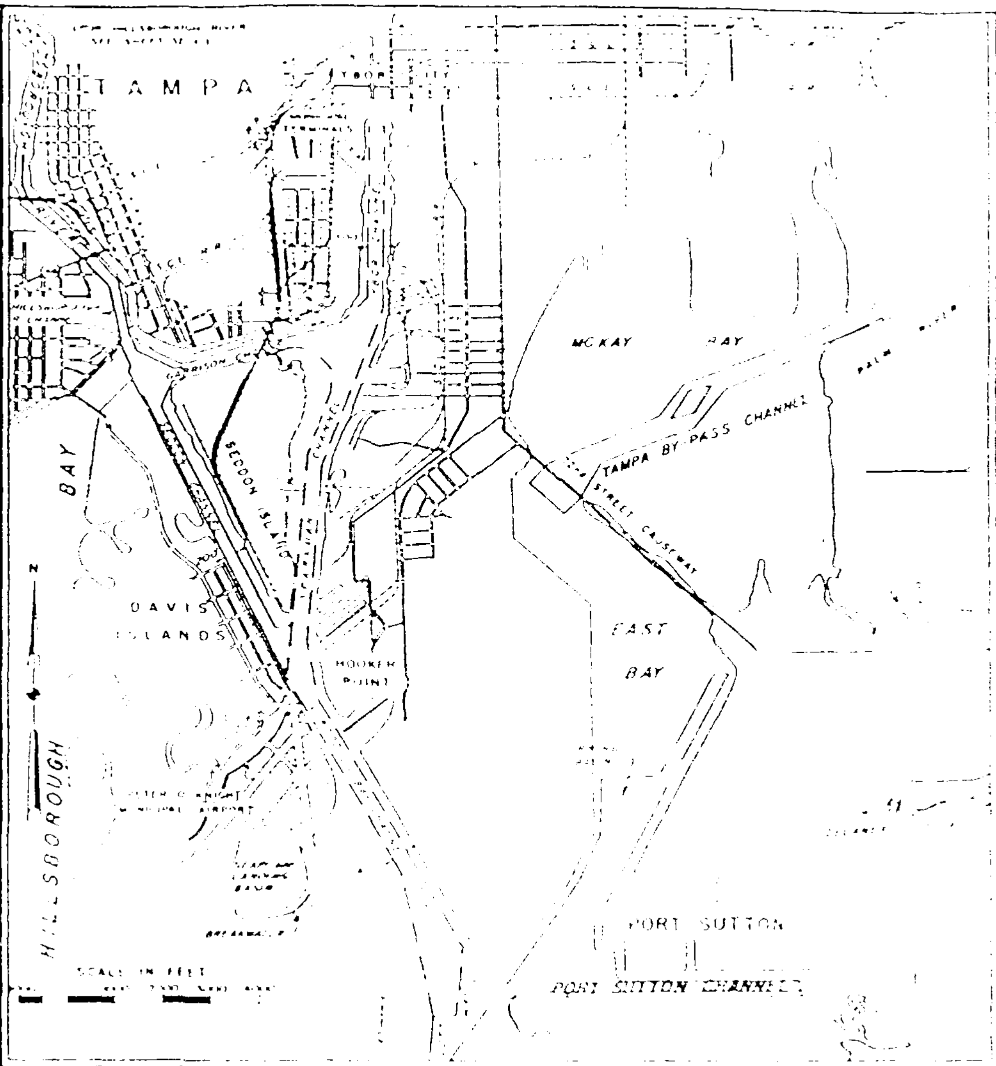
NOTE

DISTANCES BETWEEN HARBOR LINES (COMBINED PIERHEAD BULKHEAD LINES) AND CHANNEL LINES ALONG THE SEVERAL CHANNELS OF THE UPPER HARBOR ARE AS FOLLOW

CHANNEL	DISTANCE (FT)
YBOR	[illegible] 100
GARRISON	[illegible]
SEDDON	
(a) Easterly side	[illegible]
(b) Westerly side	[illegible]
SPARKMAN	
(a) Easterly side	[illegible]
(b) Westerly side	[illegible]
HILLSBOROUGH	
(a) Easterly side	[illegible]
(b) Westerly side	[illegible]
PORT SUTTON	[illegible]

MEAN TIDAL RANGE 1.3 feet at the gulf entrance, [illegible] feet at Port Tampa, and 1.8 feet at Tampa and Port Sutton

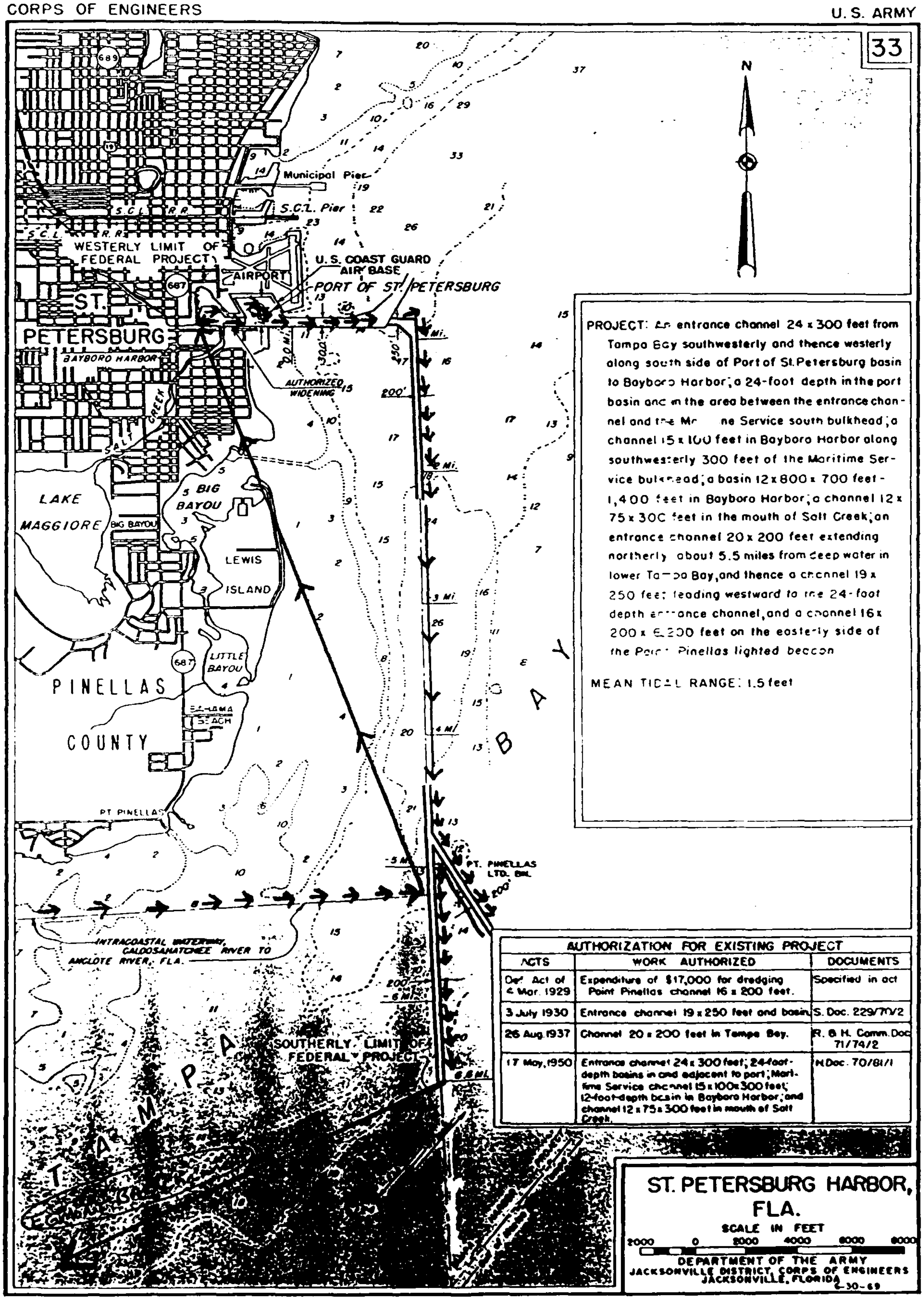




AUTHORIZATION FOR EXISTING PROJECT

ACT	WORK AUTHORIZED	DOCUMENTS
	TAMPA HARBOR (CONTINUED)	
31 DEC 1970	42 feet deep, 2,000 feet long, and 900 feet wide, Port Sutton entrance channel 44 X 400 feet; Port Sutton turning basin 44 feet deep with turning diameter of 1,200 feet; enlargement of turning basin at the entrance of Ybor Channel and deepening to 42 feet, East Bay entrance channel 44 X 400 and 500 feet about 2,000 feet North from Port Sutton turning basin, East Bay turning basin 44 feet deep with a 1,200 foot turning diameter, East Bay approach channel 44 x 300 feet about 2,500 feet North from the East Bay turning basin, and maintenance of Port Sutton terminal channel to 44 X 200 feet for a distance of 4,000 feet. Bottom , foot of all project segments in "inactive" category	H DOC 91 406 91-2

<u>Figure C-16</u>



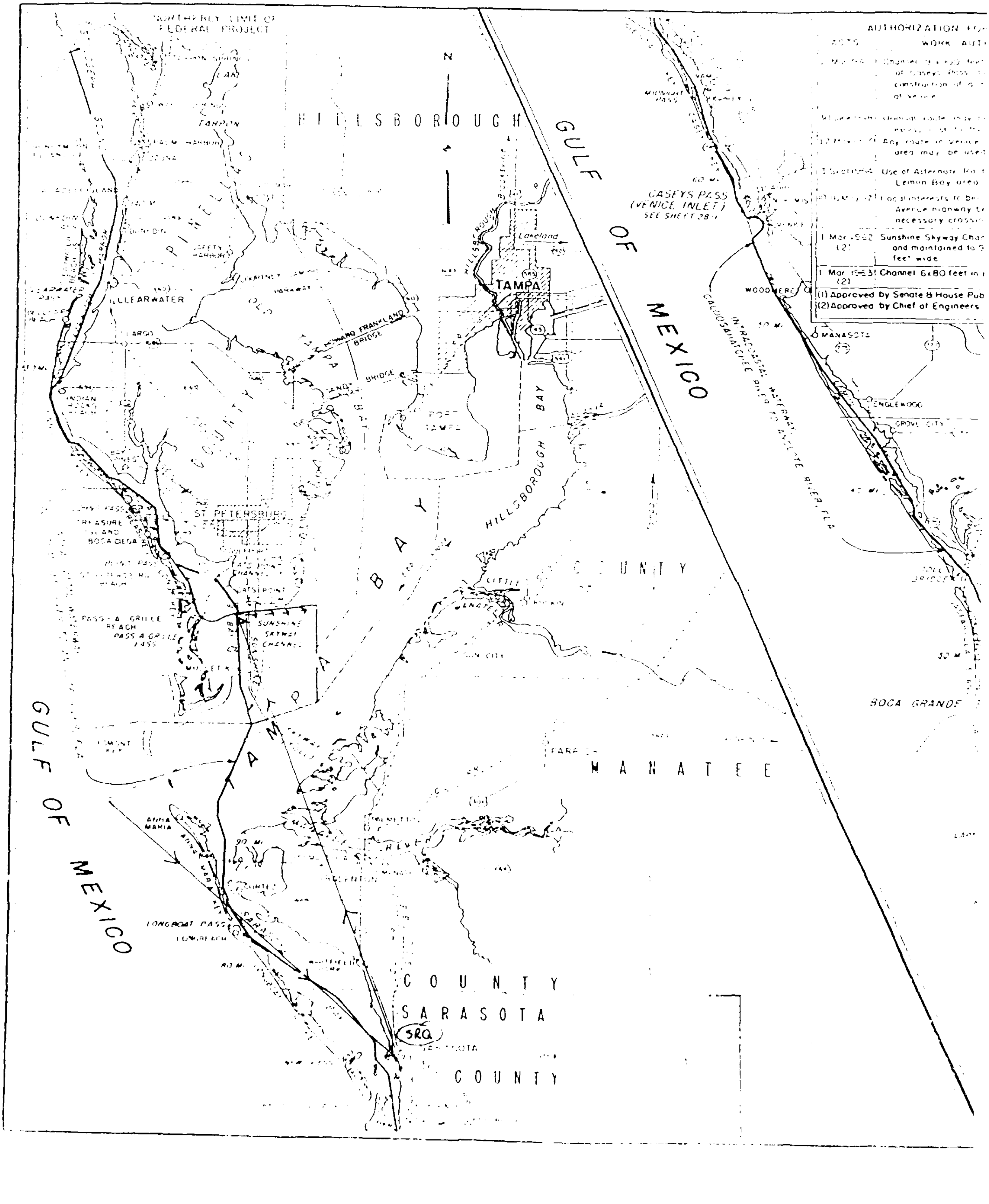
PROJECT: An entrance channel 24 x 300 feet from Tampa Bay southwesterly and thence westerly along south side of Port of St. Petersburg basin to Bayboro Harbor; a 24-foot depth in the port basin and in the area between the entrance channel and the Maritime Service south bulkhead; a channel 15 x 100 feet in Bayboro Harbor along southwesterly 300 feet of the Maritime Service bulkhead; a basin 12 x 800 x 700 feet - 1,400 feet in Bayboro Harbor; a channel 12 x 75 x 300 feet in the mouth of Salt Creek; an entrance channel 20 x 200 feet extending northerly about 5.5 miles from deep water in lower Tampa Bay, and thence a channel 19 x 250 feet leading westward to the 24-foot depth entrance channel, and a channel 16 x 200 x 6,200 feet on the easterly side of the Point Pinellas lighted beacon

MEAN TIDAL RANGE: 1.5 feet

AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
Def. Act of 4 Mar. 1929	Expenditure of $17,000 for dredging Point Pinellas channel 16 x 200 feet.	Specified in act
3 July 1930	Entrance channel 19 x 250 feet and basin	S. Doc. 229/70/2
26 Aug. 1937	Channel 20 x 200 feet in Tampa Bay.	R. & H. Comm. Doc 71/74/2
17 May, 1950	Entrance channel 24 x 300 feet; 24-foot-depth basins in and adjacent to port; Maritime Service channel 15 x 100 x 300 feet; 12-foot-depth basin in Bayboro Harbor; and channel 12 x 75 x 300 feet in mouth of Salt Creek.	H. Doc. 70/81/1

Figure C-17


NORTHERLY LIMIT OF FEDERAL PROJECT
TARPON
HILLSBOROUGH
N
GULF OF MEXICO
CASEYS PASS (VENICE INLET) SEE SHEET 28-1
AUTHORIZATION
1 Mar 1962 (2) Sunshine Skyway Channel and maintained to
1 Mar 1963 Channel 6x80 feet in
(1) Approved by Senate & House Pub
(2) Approved by Chief of Engineers
Lakeland
TAMPA
CLEARWATER
LARGO
PINELLAS COUNTY
HOWARD FRANKLAND BRIDGE
PORT TAMPA
BAY
HILLSBOROUGH BAY
ST PETERSBURG
TREASURE ISLAND AND BOCA CIEGA
PASS-A-GRILLE BEACH
SUNSHINE SKYWAY CHANNEL
COUNTY
TAMPA BAY
INTRACOASTAL WATERWAY CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLA
MANASOTA
ENGLEWOOD
GROVE CITY
BOCA GRANDE
MANATEE
ANNA MARIA
LONGBOAT PASS
COUNTY
SARASOTA
SRQ
COUNTY

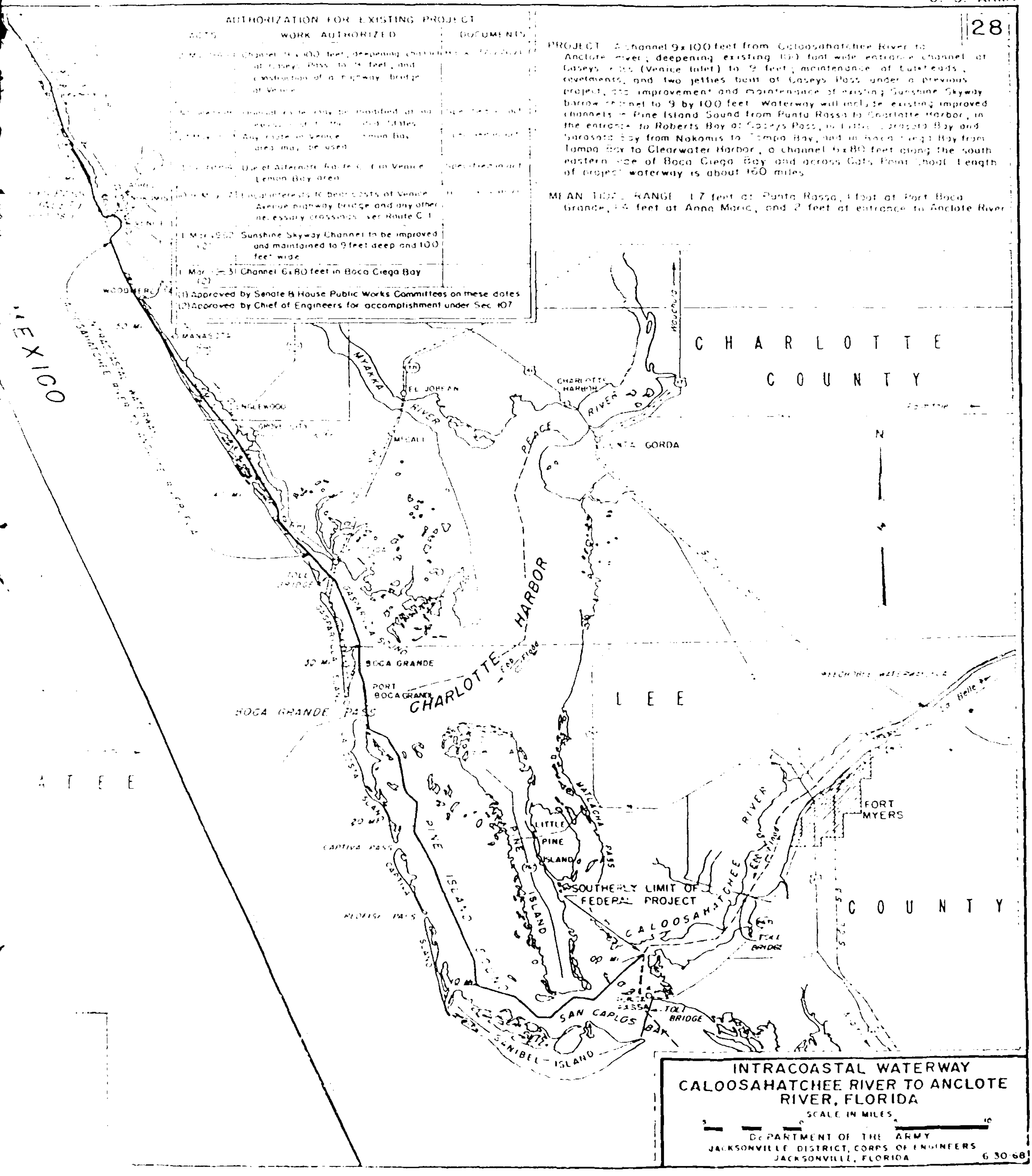
AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
[illegible]	Channel 9 x 100 feet, deepening channel at Caseys Pass to 9 feet, and construction of a highway bridge at Venice	[illegible]
[illegible]	[illegible] may be modified at no expense [illegible] United States	[illegible]
[illegible]	Any route in Venice [illegible] Lemon Bay area may be used	[illegible]
[illegible]	Use of Alternate Route C 1 in Venice Lemon Bay area	[illegible]
[illegible]	Local interests to bear costs of Venice Avenue highway bridge and any other necessary crossings over Route C 1	[illegible]
1 Mar 1962 (2)	Sunshine Skyway Channel to be improved and maintained to 9 feet deep and 100 feet wide	
1 Mar [illegible] 31 (2)	Channel 6 x 80 feet in Boca Ciega Bay	

(1) Approved by Senate & House Public Works Committees on these dates
(2) Approved by Chief of Engineers for accomplishment under Sec 107

PROJECT A channel 9 x 100 feet from Caloosahatchee River to Anclote River; deepening existing [illegible] foot wide entrance channel at Caseys Pass (Venice Inlet) to 9 feet; maintenance of bulkheads, revetments, and two jetties built at Caseys Pass under a previous project, and improvement and maintenance of existing Sunshine Skyway barrow channel to 9 by 100 feet. Waterway will include existing improved channels in Pine Island Sound from Punta Rassa to Charlotte Harbor, in the entrance to Roberts Bay at Caseys Pass, in Little Sarasota Bay and Sarasota Bay from Nokomis to Tampa Bay, and in Boca Ciega Bay from Tampa Bay to Clearwater Harbor, a channel 6 x 80 feet along the south eastern side of Boca Ciega Bay and across Cats Point Shoal. Length of project waterway is about 150 miles.

MEAN TIDAL RANGE 1.7 feet at Punta Rassa, 1 foot at Port Boca Grande, 1.4 feet at Anna Maria, and 2 feet at entrance to Anclote River



INTRACOASTAL WATERWAY
CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLORIDA

SCALE IN MILES

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

6 30 68

Ground Stations

This analysis assumes there will be five UHF ground stations along with one ground crew (see Figure C-18). Before Day One, the ground crew will need to layout the UHF stations along the following predetermined route.

The first UHF station will be located on Florida Route 41, approximately six- and-one-half nautical miles south of Punta Gorda. The second UHF station will also be located along Route 41, 20 nautical miles north of the first UHF station. The third ground station will be located at the SRQ base. The fourth ground station will be set up at Sun City, and the fifth ground station will be set up at the intersections of Route 693 and 686 in Pinellas County. As the helicopter moves north along the IWW, the ground crew can retrieve the first three ground stations. The first ground station will have to be moved to Peter O'Knight Municipal Airport before the start of Day Two.

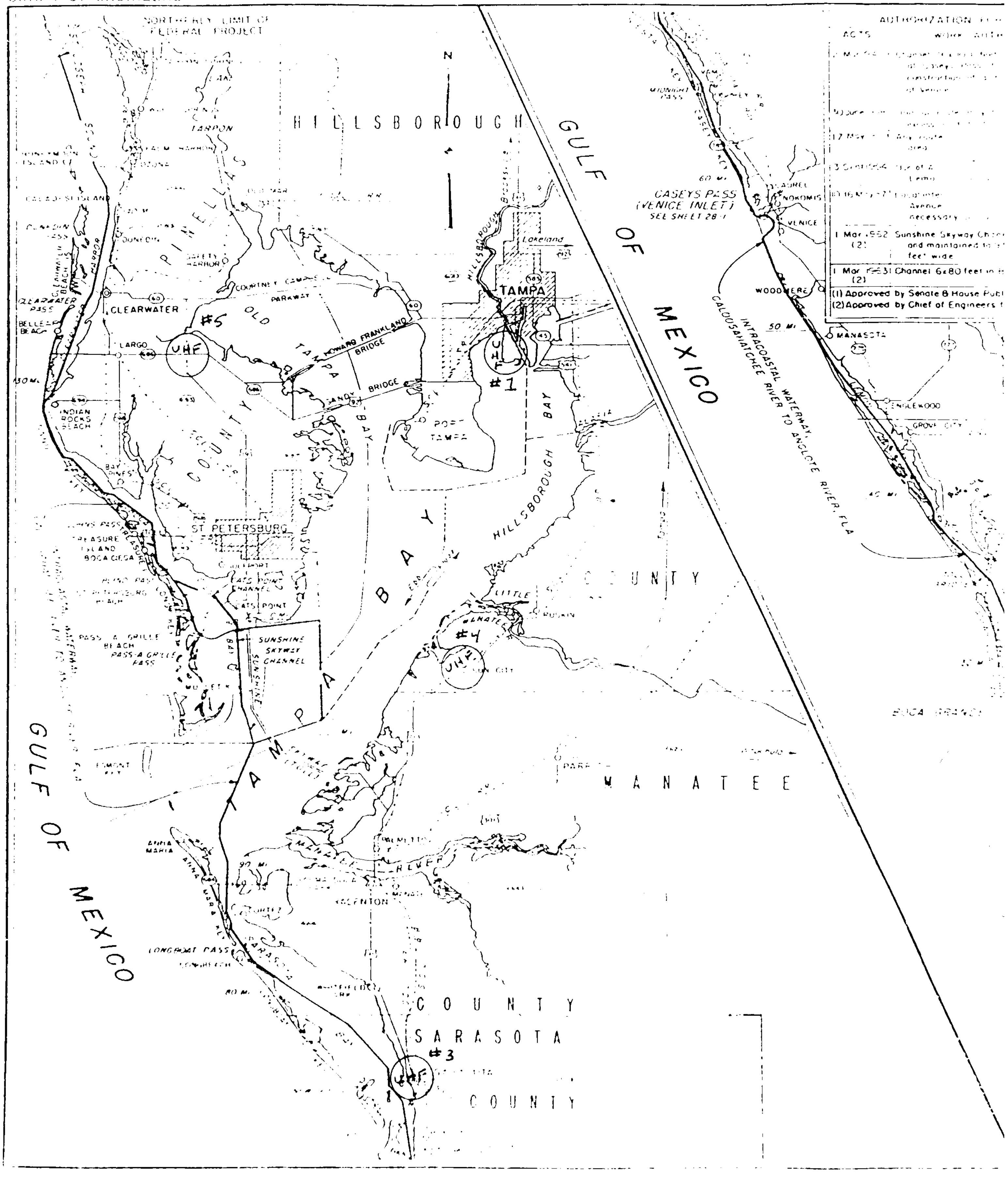
The ground crew will not be needed during Day Two since the three active ground stations, 1, 4 and 5 will remain in their place throughout the day and night. When the helicopter is finished surveying on the morning of the third day, the ground crew will then retrieve stations 1, 4 and 5.

Mission Costs

The total survey nautical miles for this mission are 296.9, taking the helicopter 14.8 hours, while the deadhead nautical miles are 354.4, taking the helicopter 3.5 hours. The expected conventional cost for this scenario is $175,500 (see Table C-4). The HLBS would be used for seven days. This includes four days of ferry and set up and three days of surveying as shown in Table C-5. The total cost per mission is $58,731, which consists of helicopter cost of $45,167, laser crew of $2,295; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $3,194 as shown in Table C-6. Table C-6 also shows operating costs per square nautical mile of $4,006, as well as operating costs per sqare kilometer of $2,163.

Figure C-18

CORPS OF ENGINEERS



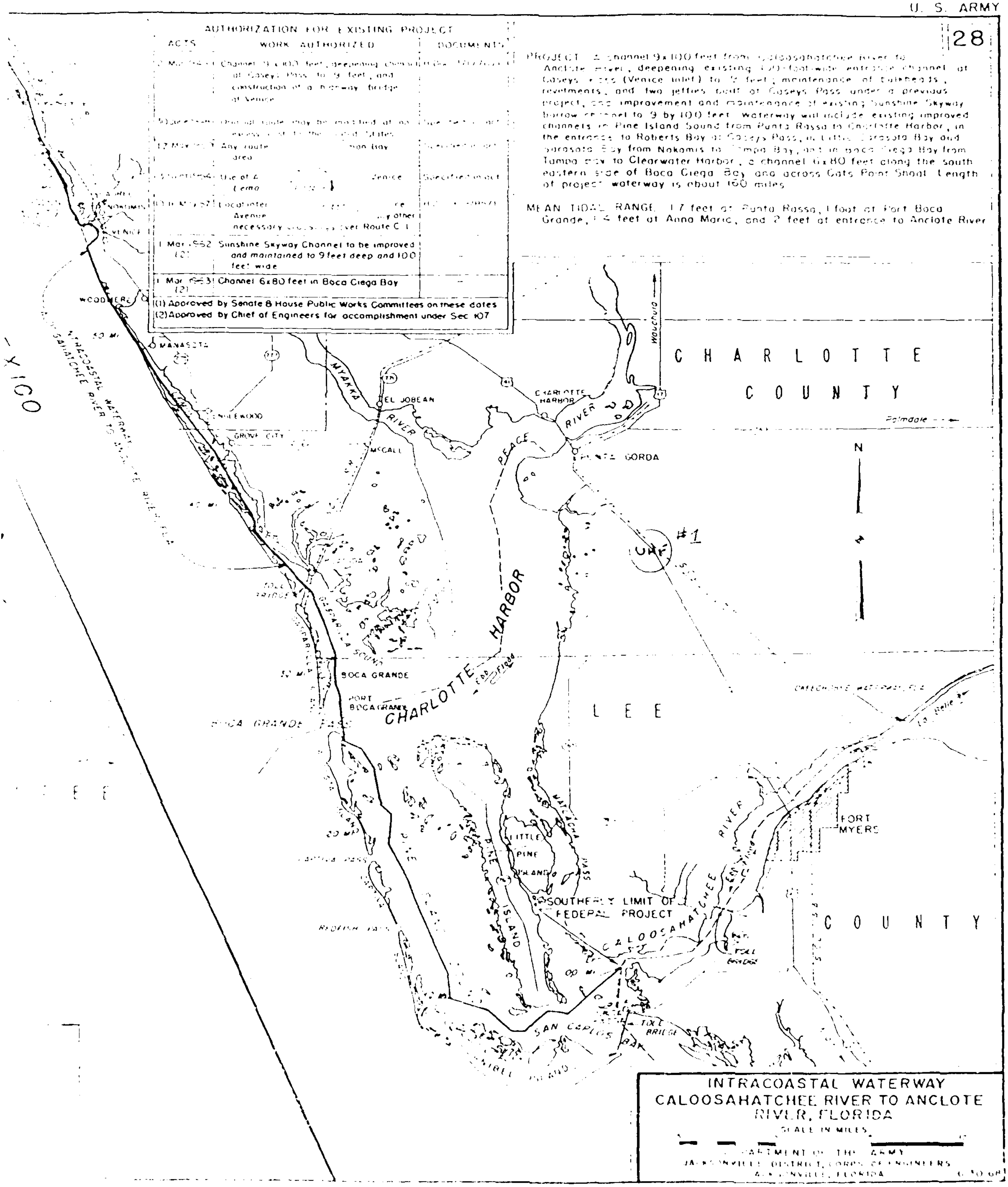
AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
2 Mar 1945	Channel 9 x 100 feet, deepening channel of Caseys Pass to 9 feet, and construction of a highway bridge at Venice	[illegible]
[illegible]	[illegible] route may be modified at no excess cost to the United States	[illegible]
17 May [illegible]	Any route [illegible] Bay area	[illegible]
[illegible]	Use of [illegible] Venice [illegible]	Specified in act
[illegible] May 57	Location [illegible] Avenue [illegible] other necessary crossings over Route C [illegible]	[illegible]
1 Mar 1962 (2)	Sunshine Skyway Channel to be improved and maintained to 9 feet deep and 100 feet wide	--
1 Mar 1963 (2)	Channel 6x80 feet in Boca Ciega Bay	--

(1) Approved by Senate & House Public Works Committees on these dates
(2) Approved by Chief of Engineers for accomplishment under Sec 107

PROJECT A channel 9x100 feet from Caloosahatchee River to Anclote River, deepening existing 100-foot-wide entrance channel at Caseys Pass (Venice Inlet) to 9 feet; maintenance of bulkheads, revetments, and two jetties built at Caseys Pass under a previous project, and improvement and maintenance of existing Sunshine Skyway borrow channel to 9 by 100 feet. Waterway will include existing improved channels in Pine Island Sound from Punta Rassa to Charlotte Harbor, in the entrance to Roberts Bay at Caseys Pass, in Little Sarasota Bay and Sarasota Bay from Nokomis to Tampa Bay, and in Boca Ciega Bay from Tampa Bay to Clearwater Harbor, a channel 6x80 feet along the south eastern side of Boca Ciega Bay and across Cats Point Shoal. Length of project waterway is about 160 miles.

MEAN TIDAL RANGE 1.7 feet at Punta Rassa, 1 foot at Port Boca Grande, 1.4 feet at Anna Maria, and 2 feet at entrance to Anclote River



INTRACOASTAL WATERWAY
CALOOSAHATCHEE RIVER TO ANCLOTE RIVER, FLORIDA

SCALE IN MILES

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

Table C-4

Project Description of FL-IWW Mission

PROJECTS	Conventional Cost ($000)	Conventional Survey Freq	Conventional Expected Cost	HLBS Nautical Miles Survey	HLBS Nautical Miles Deadhead	HLBS Survey Days	HLBS Extra Grnd Days	HLBS Survey (Hours)	HLBS Deadhead (Hours)
Alafia River	3.0	1.00	$3,000	3.566	2.962			0.18	0.03
Anclote River	15.0	1.00	$15,000	7.241	1.975			0.36	0.02
Casey Pass	3.0	1.00	$3,000	0.434	0.408			0.02	0.00
Charlotte Harbor	4.5	1.00	$4,500	7.000	2.660			0.35	0.03
Clearwater Pass	2.5	1.00	$2,500	3.000	2.301			0.15	0.02
Hillsborough River	9.0	0.50	$4,500	2.414	24.375			0.12	0.24
IWW- CR to AR	30.0	1.00	$30,000	139.680	260.650	1.25	0.5	6.98	2.61
Johns Pass	7.5	1.00	$7,500	1.759	1.539			0.09	0.02
Longboat Pass	5.0	1.00	$5,000	1.646	1.317			0.08	0.01
New Pass	4.5	1.00	$4,500	3.493	2.997			0.17	0.03
Ozona	3.0	0.50	$1,500	1.136	1.136			0.06	0.01
Pass-A-Grille Pass	3.0	0.50	$1,500	2.567	1.990			0.13	0.02
St. Petersburg Harbor	3.0	1.00	$3,000	5.728	6.616	0.25		0.29	0.07
Tampa Harbor	90.0	1.00	$90,000	117.250	43.460	1		5.86	0.43
Totals	$183		$175,500	296.9	354.4	3.0	0.5	14.8	3.5

Table C-5

FL-1WW	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	3		$9,000
Helicopter Mission Flight Hours	18.4		$12,137
Travel & Per Diem (Per Prsn/Day)	$70		$1,470
Total Helicopter Costs			$45,167
LASER CREW COSTS			
Number of Mission Days--Laser Crew	3		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$1,875
Travel & Per Diem (Per Prsn/Day)	$70		$420
Total Laser Crew Cost			$2,295
OTHER COSTS			
Number of Mission Days--Ground Crew	3.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$1,925
Travel & Per Diem (Per Prsn/Day)	$70		$490
Ground Transportation	$50		$350
Number of Survey Hours	14.85		
Post Processing (Technician $/Hr)	$38		$5,567
Efficiency Factor	15.0%		$2,937
(% Helicopter Flight, Laser Crew			
Total Other Costs			$11,269
TOTAL OPERATING COSTS PER MISSION			$58,731

Table C-6

FL-IWW

UNIT OPERATING COST (per hour)

Operating Costs per Mission	$58,731
Helicopter Mission Flight Hours	18.4
Unit Operating Cost ($/Hrs)	$3,194

UNIT OPERATING COST (per Square Nautical Mile)

Operating Costs per Mission		$58,731
Number of Survey Hours	14.85	
Coverage Rate (Sq N Miles/Hr)	0.99	14.7
Unit Operating Cost ($/S.N.M.)		$4,006

SQUARE AREA SURVEYED

Nautical Miles	14.66
Kilometers	27.15

Appendix D

PROJECTS BASED AT HOLLYWOOD AIRPORT, NORTH PERRY FLORIDA

There are six projects based at Hollywood Airport. Four of these projects are relatively small and as such can probably be completed in one-half day. These include Lake Worth, Port Everglades, Bakers Haulover Inlet and Miami Harbor. Miami Beach, the fifth project, will take a day and entail three trips with two refueling stops at the Hollywood Airport. San Juan, the sixth project, will take three and one-half days. It will take one and one-half days to fly from Hollywood Airport to San Juan. Then it will take one-half day to survey. Finally, it will take one and one-half days to return to Hollywood Airport.

If UHF trisponders are used, ground crew logistics would be as follows. The first ground vehicle will place UHF trisponders at Palm Beach and Greenacres City. The other vehicle will place units at Ft. Lauderdale and Hollywood and carry the fifth unit to North Miami Beach. These five UHF units will cover surveys of Lake Worth, Port Everglades and Baker's Haulover Inlet. As soon as the helicopter has left Lake Worth, the first vehicle will collect UHF units from Palm Beach and Greenacres City and proceed to deposit one at Key Biscayne to cover the Miami Beach near shore survey, and Miami Harbor. When these surveys are completed, the vehicles will collect their units and return to base. Set-up and disassembly of the UHF trisponders will require one-half day each.

In the case of San Juan, ground crew logistics require only that one ground vehicle proceed to Army Terminal and the other to Isla San Juan and both remain there until the survey is finished.

SCENARIO ANALYSIS

Lake Worth, Florida

The Lake Worth project is located in Palm Beach Harbor, Florida. Access from Hollywood Airport to the Lake Worth Inlet (Figure D-1) is 42.8 nautical miles which will require 0.428 hours at 100 knots. The helicopter pilot will begin the survey at the point of the harbor closest to the North Revetment. The survey of the east end of Lake Worth Inlet will require two passes of length 4,100 feet or 1.35 nautical miles. The west end of Lake Worth Inlet will require one pass of 2,300 feet or 0.38 nautical miles. The survey of the turning basin and area adjacent to the Port of Palm Beach would require five passes for an average width of 1,650 feet. This is a distance of 1.36 nautical miles. At the completion of this survey, the helicopter will be located at the east end of Lake Worth Inlet and will proceed to Port Everglades. The total survey is 3.09 nautical miles which will require 0.155 hours. The total deadhead is 42.8 nautical miles or .428 hours for a total of .583 hours. The GPS for this project is located at Hollywood Airport. UHF trisponders for this project should be located on television or radio towers (or on the roof of a high-rise building) in the cities of Palm Beach and Greenacres City. The calculations are summarized in Table D-1.

Figure D-1

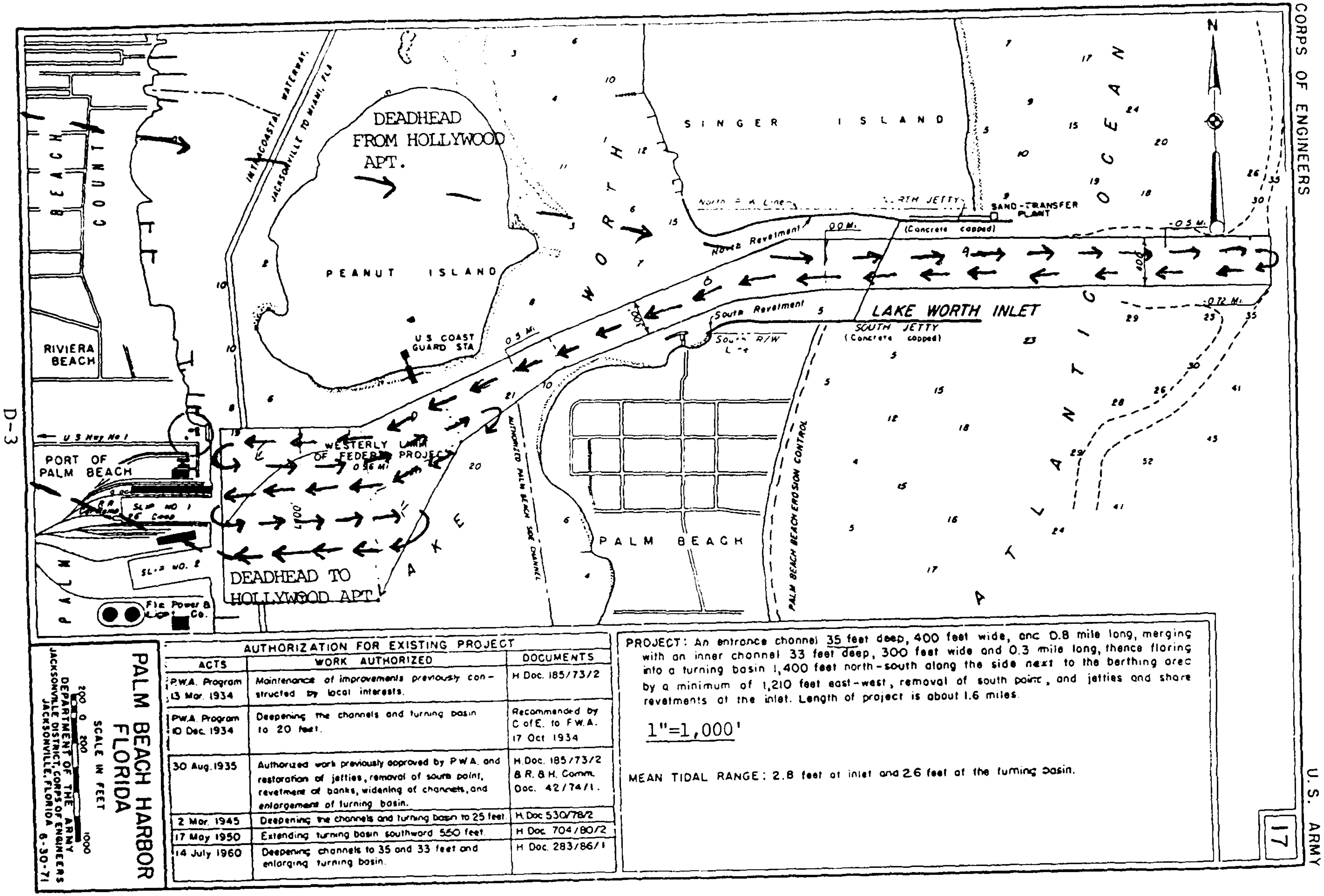

CORPS OF ENGINEERS
U.S. ARMY
17
N
ATLANTIC OCEAN
SINGER ISLAND
PEANUT ISLAND
LAKE WORTH INLET
LAKE WORTH
PALM BEACH
RIVIERA BEACH
PORT OF PALM BEACH
PALM BEACH COUNTY
DEADHEAD FROM HOLLYWOOD APT.
DEADHEAD TO HOLLYWOOD APT.
SAND-TRANSFER PLANT
(Concrete capped)
SOUTH JETTY
(Concrete capped)
North Revetment
South Revetment
U S COAST GUARD STA
WESTERLY LIMIT OF FEDERAL PROJECT
INTRACOASTAL WATERWAY, JACKSONVILLE TO MIAMI, FLA
AUTHORIZED PALM BEACH SIDE CHANNEL
PALM BEACH BEACH EROSION CONTROL
U S Hwy No 1
SLIP NO. 2
Fla. Power & Light Co.
AUTHORIZATION FOR EXISTING PROJECT
ACTS | WORK AUTHORIZED | DOCUMENTS
P.W.A. Program 13 Mar. 1934 | Maintenance of improvements previously constructed by local interests. | H. Doc. 185/73/2
P.W.A. Program 10 Dec. 1934 | Deepening the channels and turning basin to 20 feet. | Recommended by C of E. to F.W.A. 17 Oct 1934
30 Aug. 1935 | Authorized work previously approved by P.W.A. and restoration of jetties, removal of south point, revetment of banks, widening of channels, and enlargement of turning basin. | H. Doc. 185/73/2 & R. & H. Comm. Doc. 42/74/1.
2 Mar. 1945 | Deepening the channels and turning basin to 25 feet. | H. Doc 530/78/2
17 May 1950 | Extending turning basin southward 550 feet. | H. Doc. 704/80/2
14 July 1960 | Deepening channels to 35 and 33 feet and enlarging turning basin. | H. Doc. 283/86/1
PROJECT: An entrance channel 35 feet deep, 400 feet wide, and 0.8 mile long, merging with an inner channel 33 feet deep, 300 feet wide and 0.3 mile long, thence flaring into a turning basin 1,400 feet north-south along the side next to the berthing area by a minimum of 1,210 feet east-west, removal of south point, and jetties and shore revetments at the inlet. Length of project is about 1.6 miles.
1"=1,000'
MEAN TIDAL RANGE: 2.8 feet at inlet and 2.6 feet at the turning basin.
PALM BEACH HARBOR FLORIDA
SCALE IN FEET
200 0 200 1000
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
6-30-71

Table D-1

Lake Worth - Palm Beach Harbor

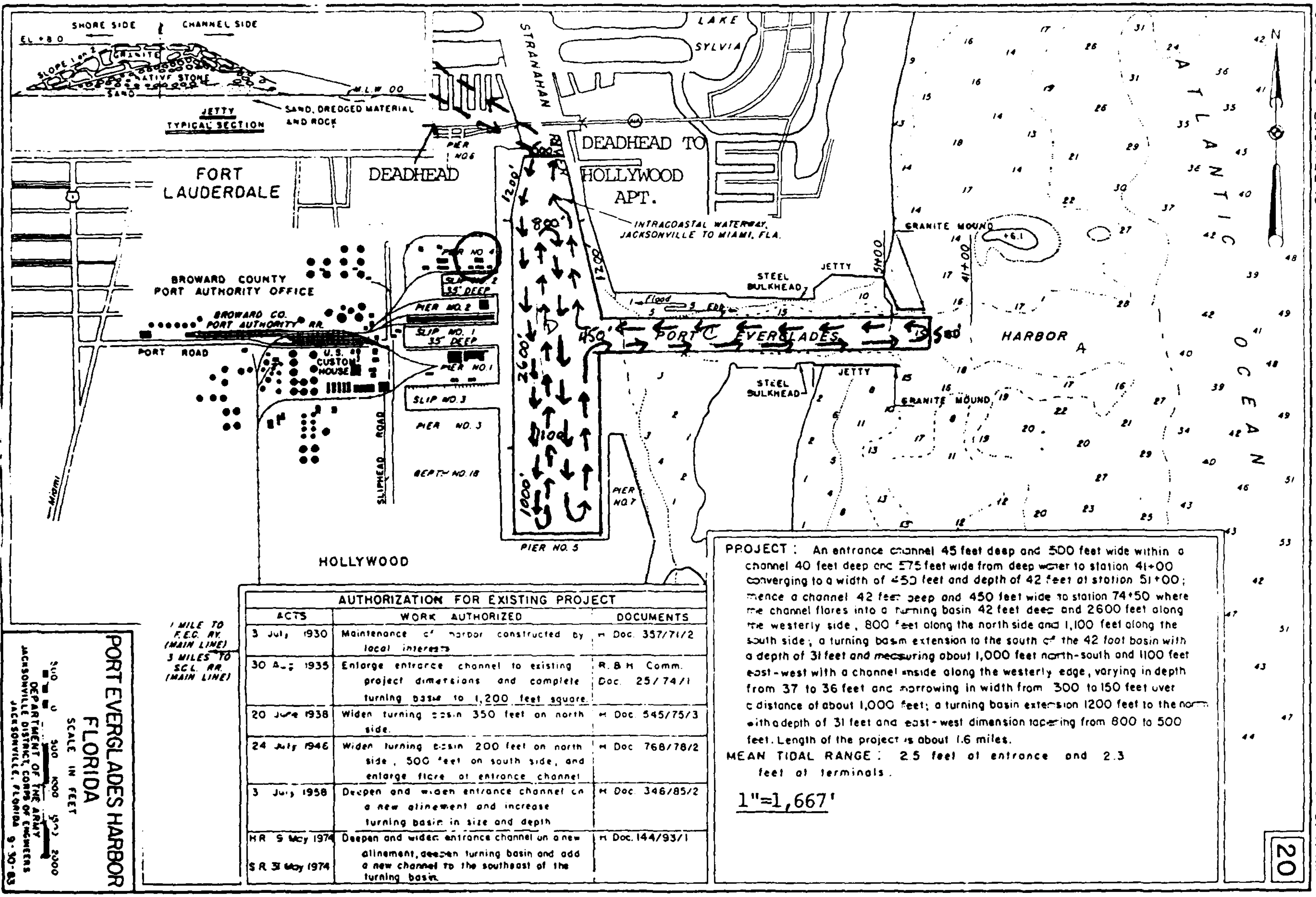
Deadhead from Hollywood Airport to Lake Worth Inlet =	42.8	NM
Lake Worth Inlet East End 2 passes @ 4100' =	1.35	NM
Lake Worth Inlet West End 1 pass @ 2300' =	0.38	NM
Turning Basin 5 passes @ avg. width 1650' =	1.36	NM

Total Survey =	3.09 NM	.155 Hr.
Total Deadhead =	42.8 NM	.428 Hr.
Total	45.17 NM	.583 Hr.

Port Everglades, Florida

Port Everglades, Florida, is the port facility adjacent to Fort Lauderdale, Florida. The helicopter will proceed from Lake Worth to the Stranahan River entrance to the harbor (Figure D-2). The deadhead to this point is 29.9 nautical miles. The helicopter will then proceed to the lower turning basin which requires four passes of length 4,000 feet or 2.63 nautical miles. The entrance channel will require two passes of 4,500 feet or 1.48 nautical miles. The northernmost part of the turning basin requires two passes of length 800 feet or 0.263 nautical miles. After completion of the turning basin the helicopter will proceed to Bakers Haulover Inlet. The total survey is 4.373 nautical miles which takes 0.219 hours. The total deadhead is 29.9 nautical miles or 0.299 hours for a total of 0.518 hours. The GPS for this project is at Hollywood Airport. The UHF stations for this project should be located on television or radio towers (or on the roof of high-rise buildings) in the cities of Ft. Lauderdale and Hollywood. The calculations are summarized in Table D-2.

Figure D-2



AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
3 July 1930	Maintenance of harbor constructed by local interests	H Doc. 357/71/2
30 Aug 1935	Enlarge entrance channel to existing project dimensions and complete turning basin to 1,200 feet square	R. & H. Comm. Doc. 25/74/1
20 June 1938	Widen turning basin 350 feet on north side.	H Doc. 545/75/3
24 July 1946	Widen turning basin 200 feet on north side, 500 feet on south side, and enlarge flare of entrance channel	H Doc. 768/78/2
3 July 1958	Deepen and widen entrance channel on a new alinement and increase turning basin in size and depth	H Doc. 346/85/2
HR 9 May 1974 SR 31 May 1974	Deepen and widen entrance channel on a new alinement, deepen turning basin and add a new channel to the southeast of the turning basin	H Doc. 144/93/1

PROJECT: An entrance channel 45 feet deep and 500 feet wide within a channel 40 feet deep and 575 feet wide from deep water to station 41+00 converging to a width of 450 feet and depth of 42 feet at station 51+00; thence a channel 42 feet deep and 450 feet wide to station 74+50 where the channel flares into a turning basin 42 feet deep and 2600 feet along the westerly side, 800 feet along the north side and 1,100 feet along the south side; a turning basin extension to the south of the 42 foot basin with a depth of 31 feet and measuring about 1,000 feet north-south and 1100 feet east-west with a channel inside along the westerly edge, varying in depth from 37 to 36 feet and narrowing in width from 300 to 150 feet over a distance of about 1,000 feet; a turning basin extension 1200 feet to the north with a depth of 31 feet and east-west dimension tapering from 800 to 500 feet. Length of the project is about 1.6 miles.

MEAN TIDAL RANGE: 2.5 feet at entrance and 2.3 feet at terminals.

1"=1,667'

Table D-2

Port Everglades, FL

Deadhead Lake Worth to Port Everglades =		29.9	NM
Lower Turning Basin 4 passes 4,000' long =		2.63	NM
Channel 2 passes 4,500' long =		1.48	NM
Upper Turning Basin 2 passes 800' long =		0.263	NM
Total Deadhead =	29.9 NM =	0.299	Hrs.
Total Survey =	4.373 NM =	0.219	Hrs.
Total	34.273 NM	0.518	Hrs.

Bakers Haulover Inlet, Florida

Bakers Haulover Inlet is near the town of Bal Harbor, Florida, along the intracoastal waterway. The helicopter will survey this channel starting at the west entrance which is 6.95 nautical miles from Bakers Haulover Inlet. The west entrance will require one pass of 667 feet or 0.110 nautical miles. The north entrance to the channel will be surveyed in one pass for 0.296 nautical miles. The marina basin will require an additional pass of 0.285 nautical miles. The area of the channel south of the marina will require one pass of 0.593 nautical miles. The total survey is 1.284 nautical miles which will take 0.064 hours. Total deadhead is 6.95 nautical miles or 0.070 hours. The total survey time including deadhead is 0.131 hours. The GPS for this project is at Hollywood Airport. (Figure D-3). The UHF stations for this survey should be located on television or radio towers (or on the roof of high-rise buildings) in the cities of Hollywood and North Miami Beach. The calculations are summarized in Table D-3.

Figure D-3

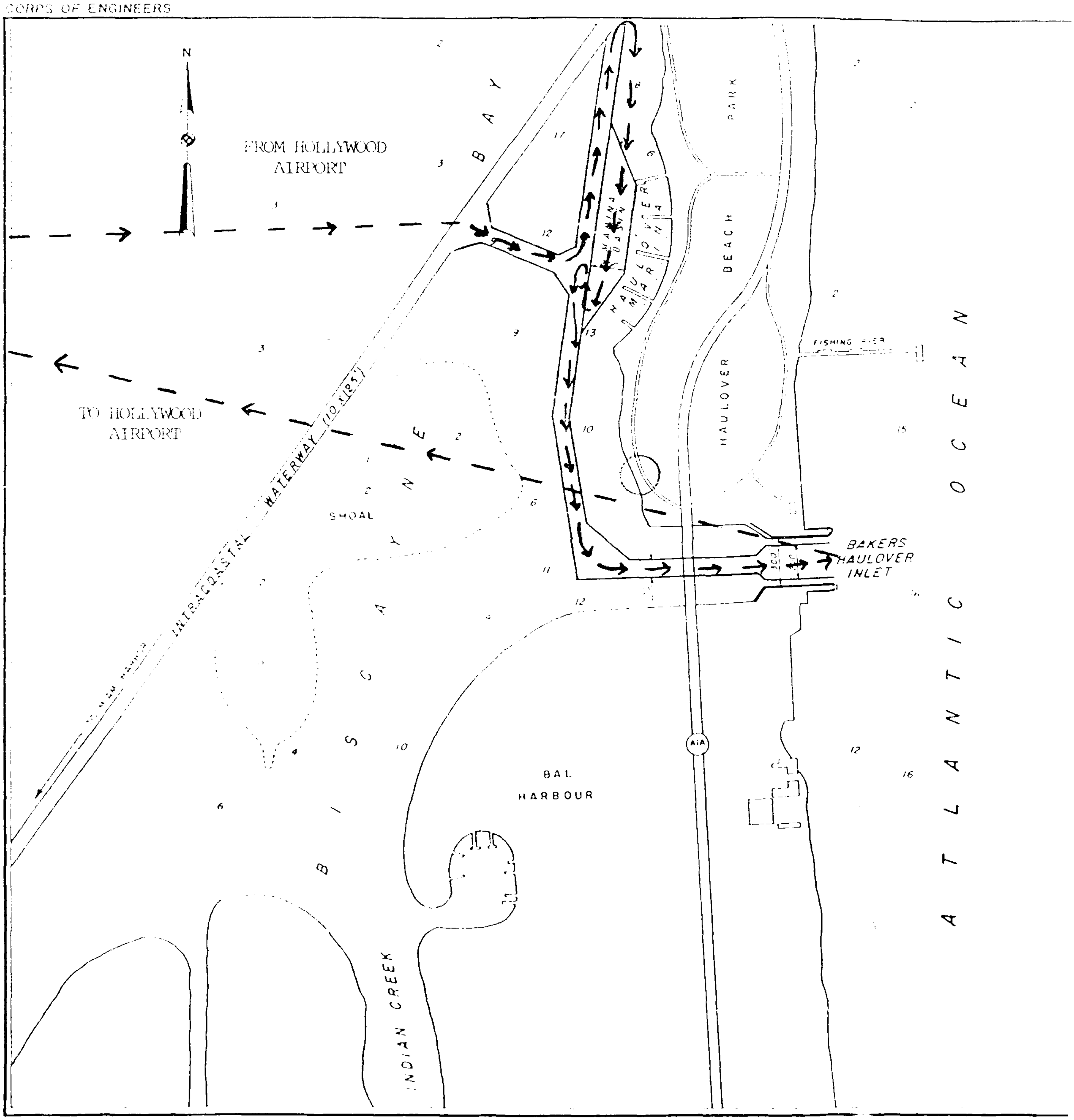
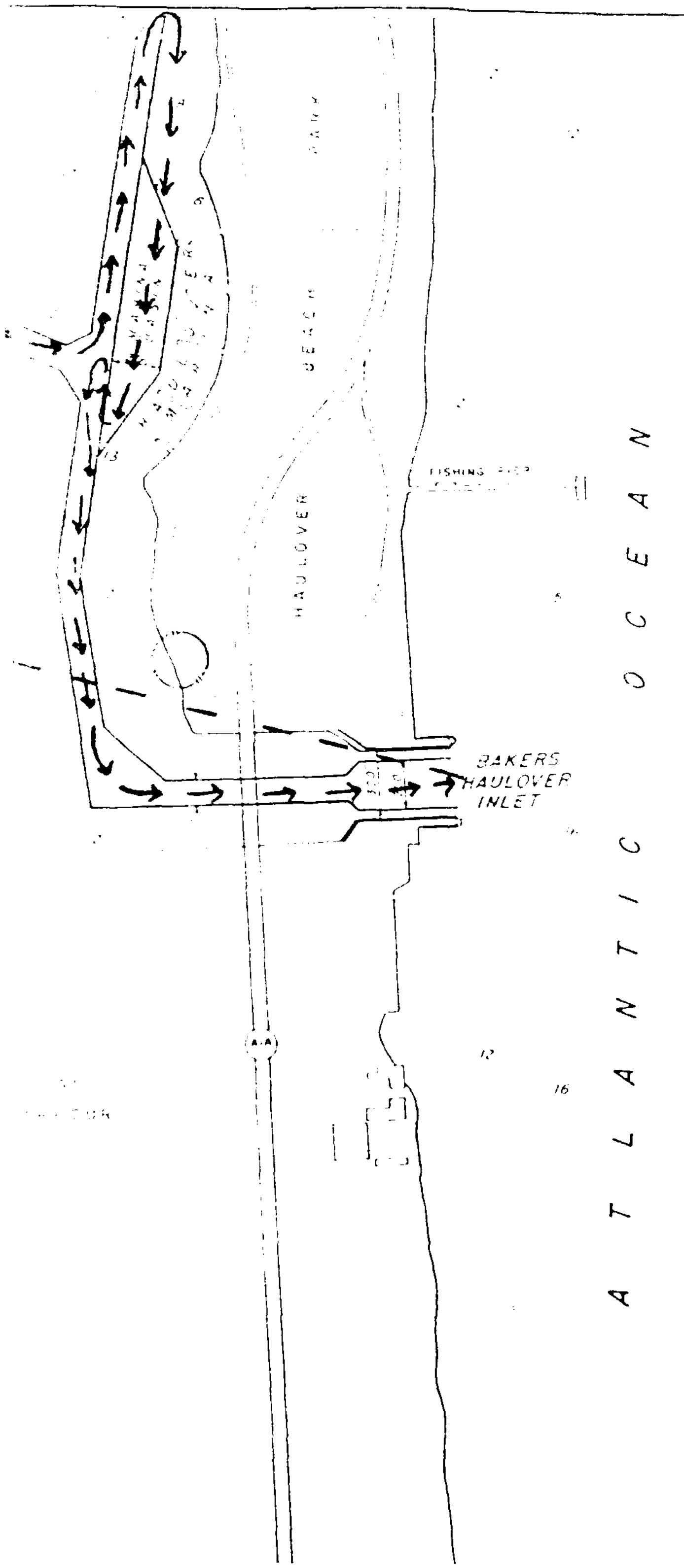

CORPS OF ENGINEERS
N
FROM HOLLYWOOD AIRPORT
TO HOLLYWOOD AIRPORT
BAY
BISCAYNE
SHOAL
INTRACOASTAL WATERWAY (10 X 125)
MARINA BASIN
HAULOVER MARINA
PARK
BEACH
HAULOVER
FISHING PIER
BAKERS HAULOVER INLET
ATLANTIC OCEAN
BAL HARBOUR
INDIAN CREEK
A1A

Figure D-3

U. S. ARMY

58



PROJECT: Reconstruction of existing jetties, protection of inlet shores seaward of existing 300-foot section, provision of a channel 11 feet deep and 200 feet wide in the ocean entrance, thence 8 feet deep and 100 feet wide to the Intracoastal Waterway, and a marina basin 8 feet deep and 200 feet wide. Length of project is 1.02 miles.

MEAN TIDAL RANGE: 2.5 feet near the inlet in the ocean and 2 feet in Biscayne Bay.

AUTHORIZATION FOR EXISTING PROJECT

ACT	WORK AUTHORIZED	DOCUMENT
14 July 1960	Channel 11 x 200 feet in ocean entrance, thence 8 x 100 feet to Intracoastal Waterway, marina basin 8 x 200 feet, reconstruction of jetties and protection of inlet shores	H. Doc. 189/86, 1

1"=667'

BAKERS HAULOVER INLET, FLORIDA

SCALE IN FEET

200 0 200 400 600 800 1000

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
6-30-71

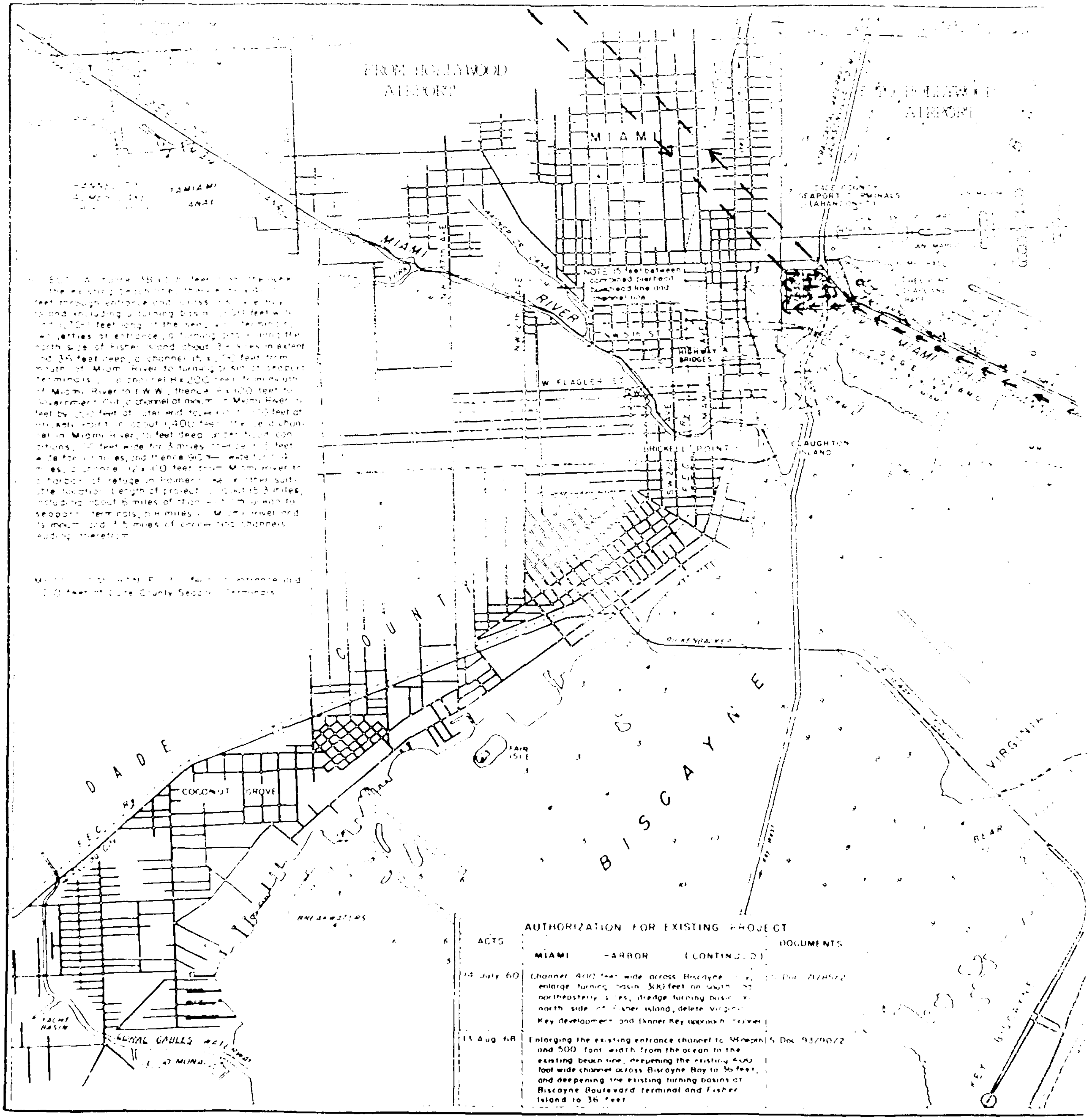
Table D-3

Bakers Haulover Inlet

Deadhead Port Everglade to Bakers Haulover Inlet =			6.95 NM	
West Entrance 667' 1 Pass =			.110 NM	
North Entrance	1,400'	1 Pass =	.296 NM	
Marina Basin	1,700'	1 Pass =	.285 NM	
South of Marina	3,600'	1 Pass =	.593 NM	
Survey			1.284 NM	0.064 Hr.
Total Deadhead			6.95 NM	0.070 Hr.
Overall Total			8.234 NM	.131 Hr.

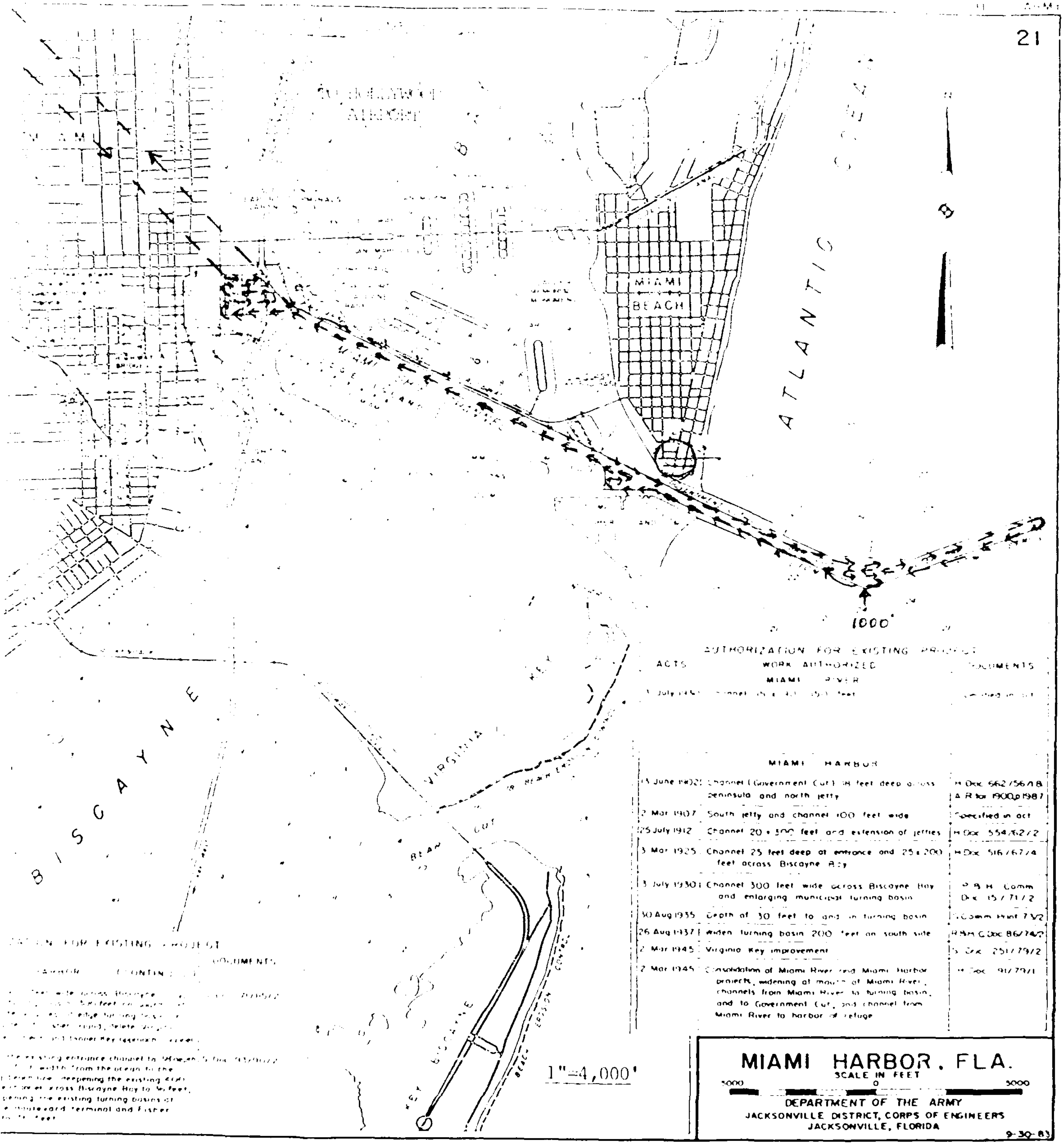
Miami Harbor, Miami Beach, Florida

Miami Harbor consists of the Miami ship channel and turning basin which passes through Miami Beach on its way to the Port of Miami, Florida. Deadhead access to the turning basin (Figure D-4) is 7.23 nautical miles from Bakers Haulover Inlet. The Outer Bar Cut requires two passes for a total of 4,500 feet or 1.48 nautical miles. The Bar Cut turn will require four passes of 1,500 feet length or 0.99 nautical miles. The Bar Cut itself requires two passes of 2,500 feet or 0.82 nautical miles. The pilot then surveys Government Cut in two passes for a length of 4,000 feet or 1.32 nautical miles. There is a turning basin at Fisher Island between the existing FEC channel and the Miami ship channel which requires four passes for a distance of 1,000 feet or 0.66 nautical miles. The helicopter then proceeds to the area adjacent to the Causeway which is 12,500 feet long or 4.11 nautical miles and requires two passes. The seaport area requires six passes or 1.97 nautical miles. At this point the pilot returns to Hollywood Airport, a distance of 14.9 nautical miles. The total survey is 11.35 nautical miles and will require 0.568 hours. Total deadhead is 22.13 nautical miles and requires 0.221 hours for a total of 0.789 hours. The GPS for this project is Hollywood Airport. The UHF stations for this project should be located on television or radio towers (or on the roof of high-rise buildings) in the cities of North Miami Beach and Key Biscayne. The calculations are summarized in Table D-4.



AUTHORIZATION FOR EXISTING PROJECT

ACTS	MIAMI HARBOR (CONTINUED)	DOCUMENTS
14 July 60	Channel 400 feet wide across Biscayne ..., enlarge turning basin 300 feet on south ... northeasterly sides, dredge turning basin ... north side of Fisher Island, delete Virginia Key development and Dinner Key approach channel.	[illegible] Doc. 21/86/2
13 Aug 68	Enlarging the existing entrance channel to 38 depth and 500 foot width from the ocean to the existing beach line, deepening the existing 400 foot wide channel across Biscayne Bay to 36 feet, and deepening the existing turning basins at Biscayne Boulevard terminal and Fisher Island to 36 feet.	S Doc. 93/90/2



AUTHORIZATION FOR EXISTING PROJECT

ACTS	WORK AUTHORIZED	DOCUMENTS
	MIAMI HARBOR	
13 June 1902	Channel (Government Cut) 18 feet deep across peninsula and north jetty	H Doc 662/56/1 & A R for 1900,p1987
2 Mar 1907	South jetty and channel 100 feet wide	Specified in act
25 July 1912	Channel 20 x 300 feet and extension of jetties	H Doc 554/62/2
3 Mar 1925	Channel 25 feet deep at entrance and 25 x 200 feet across Biscayne Bay	H Doc 516/67/4
3 July 1930	Channel 300 feet wide across Biscayne Bay and enlarging municipal turning basin	R & H Comm Doc 15/71/2
30 Aug 1935	Depth of 30 feet to and in turning basin	R Comm Print 73/2
26 Aug 1937	Widen turning basin 200 feet on south side	R&H C Doc 86/74/2
2 Mar 1945	Virginia Key improvement	S Doc 251/79/2
2 Mar 1945	Consolidation of Miami River and Miami Harbor projects, widening of mouth of Miami River, channels from Miami River to turning basin, and to Government Cut, and channel from Miami River to harbor of refuge	H Doc 91/79/1

MIAMI HARBOR, FLA.

SCALE IN FEET

5000 0 5000

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

9-30-83

Table D-4

Deadhead Bakers Haulover Inlet to Miami Harbor =		7.23 NM	
Outer Bar Cut			
4,500' 2 passes	=	1.48	NM
Bar Cut Turn			
1,500' 4 passes	=	0.99	NM
Bar Cut			
2,500' 2 passes	=	0.82	NM
Government Cut			
4,000' 2 passes	=	1.32	NM
Fisher Island (take 1/2 of longest side for traverse)			
1,000' 4 passes	=	0.66	NM
Causeway			
12,500' 2 passes	=	4.11	NM
Seaport			
2,000' 6 passes	=	1.97	NM
Deadhead return from Seaport		14.9	

Total Survey =	11.35 NM	=	0.568	Hrs.
Total Deadhead	22.13 NM	=	0.221	
Total	33.48		0.789	Hrs.

Miami Beach Near Shore Survey

This survey consists of monitoring a ten nautical mile by 3,000 foot area of ocean front. This area is currently monitored using conventional techniques which take soundings in lines perpendicular to the beach with 1,000-foot spacing. Conventional cost per line is $1,200. The ten mile beachfront requires 61 lines for a cost of $73,200.

The helicopter will fly a 300-foot swath 10 miles long and then turn around and survey the next swath farther out to sea. By so doing, the helicopter will collect soundings for the entire five square nautical mile area rather than lines at 1,000 foot spacings.

The helicopter, based at the Hollywood Airport, will fly eight nautical miles and then 150 feet to the northernmost point of the survey area. It will then fly four passes, first south then north, and finally conclude at the northern end of the survey course. The four passes of ten nautical miles each will take the helicopter two hours. At this time it will fly 8.27 miles back to the airport to refuel.

In its second trip, the helicopter will fly again to the northernmost point of the survey area and fly .32 nautical miles to the top of the fifth pass. It will again fly south and north four times, winding up at the northeastern corner of the survey area. It will then fly 8.47 nautical miles back to the airport to refuel. On its third trip, the helicopter will fly to the northernmost point of the survey and fly the remaining two passes to finish the survey. It will then return to the airport.

In total, the helicopter will spend 5.505 hours in flight of which five hours will be spent surveying. The GPS for this project is located at Hollywood Airport. The UHF stations for this project are located in North Miami Beach and Key Biscayne. The calculations are summarized in Table D-5.

Table D-5

MIAMI BEACH NEAR SHORE SURVEY

Trip One:

Airport to Survey	8.02 NM	.080	Hrs.
Six Passes	40 NM	2.000	Hrs.
Survey to Airport	8.27 NM	.083	Hrs.
Total		2.163	Hrs.

Trip Two:

Airport to Survey	8.32 NM	.083	Hrs.
Five Passes	40 NM	2.0	Hrs.
Survey to Airport	8.57 NM	.086	Hrs.
Total	57 NM	2.169	Hrs.

Trip Three

Airport to Survey	8.62 NM	.086	Hrs.
Two Passes	20 NM	1.0	Hrs.
Survey to Airport	8.72 NM	.087	Hrs.
Total		1.173	Hrs.

	Miles	Time
Total Survey	100 NM	5 Hrs.
Total Deadhead	50.52NM	0.505 Hrs.
Total	150.52 NM	5.505 Hrs.

San Juan, Puerto Rico

San Juan poses an extra challenge compared to other scenarios, since it lies far away from other Army Corps projects. For purpose of this scenario, it was assumed that San Juan would be surveyed with the same helicopter used for the Miami-Hollywood surveys. Thus, the costs embodied in this scenario do not include the set-up costs nor the costs of ferrying the helicopter from the helicopter's home base. It does include, however, the cost of ferrying the helicopter between Miami and San Juan.

Using the four-hour flight time restriction, the helicopter would need to make stops in San Salvador, Bahamas (330 NM), Puerto Plata, Dominican Republic (348 NM), and finally San Juan (295 NM). This would require nine hours and 44 minutes of flight, which would require approximately one-and-one-half days, factoring for time required for fueling stops. Thus, the helicopter would fly to Puerto Plata on day one. It would fly to San Juan and survey the harbor on day two, and then fly to San Salvador on day three, and return to Miami the morning of day four.

Surveying San Juan

San Juan Harbor has a series of large ship channels to be surveyed using the Lidar technology. (Figure D-5). The project should easily be completed within a single four-hour period of time. The helicopter will be based at San Juan Airport which is approximately five nautical miles from the Army Terminal Harbor section of San Juan Harbor. The GPS station for this project would be located at San Juan Airport. UHF trisponders for this project would be located at Carolina and Bayamon on television or radio towers (or on a high-rise building).

The helicopter will begin its survey at the Army Terminal and will proceed to survey Puerto Nuevo in two passes of 5000 feet length or 1.65 nautical miles (Figure D-5). The helicopter then surveys the Graving Dock South area in ten passes of 3000 feet

Figure D-5

CORPS OF ENGINEERS

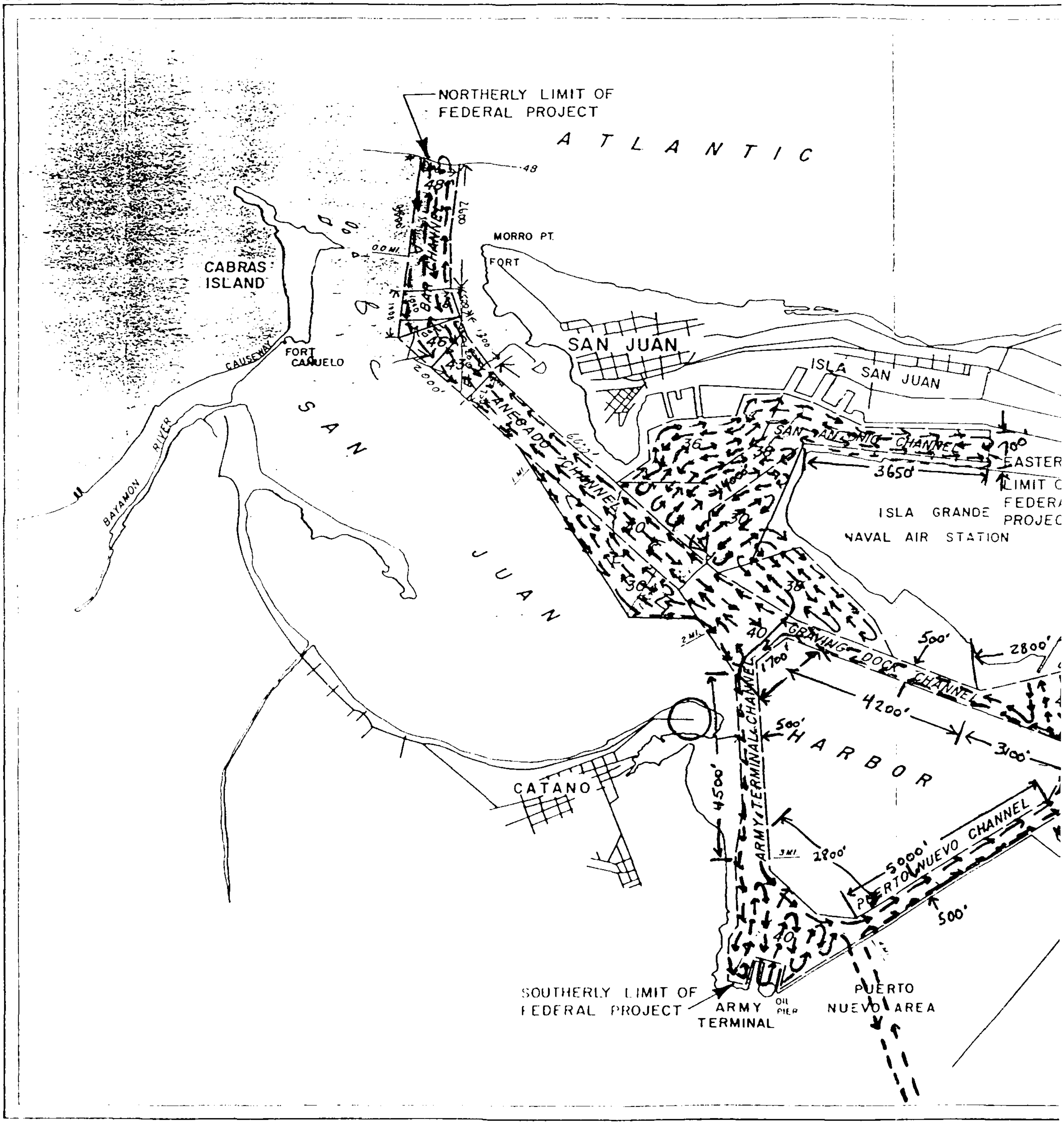
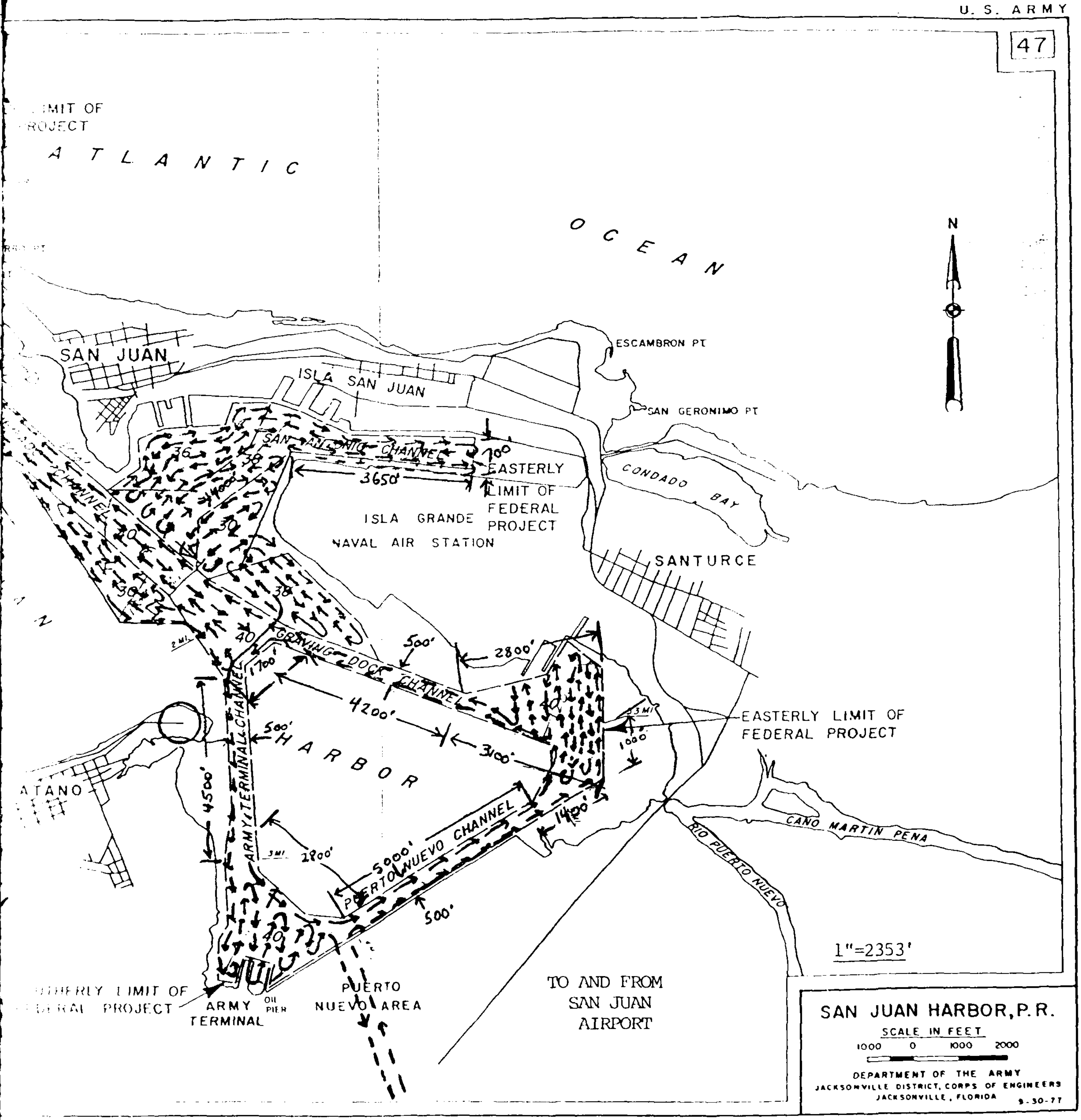


Figure D-5


U. S. ARMY
47
ATLANTIC
OCEAN
N
SAN JUAN
ISLA SAN JUAN
ESCAMBRON PT
SAN GERONIMO PT
SAN ANTONIO CHANNEL
700
3650'
EASTERLY LIMIT OF FEDERAL PROJECT
CONDADO BAY
ISLA GRANDE NAVAL AIR STATION
SANTURCE
GRAVING DOCK CHANNEL
500'
2800'
1700'
4200'
3100'
1000'
EASTERLY LIMIT OF FEDERAL PROJECT
HARBOR
4500'
ARMY TERMINAL CHANNEL
500'
2800'
5000'
PUERTO NUEVO CHANNEL
1400'
500'
CANO MARTIN PENA
RIO PUERTO NUEVO
ATANO
ARMY TERMINAL
OIL PIER
PUERTO NUEVO AREA
TO AND FROM SAN JUAN AIRPORT
1"=2353'
SAN JUAN HARBOR, P.R.
SCALE IN FEET
1000 0 1000 2000
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
9-30-77

or 4.94 nautical miles. The pilot will then survey the Graving Dock Channel in two passes of 4,200 feet or 1.38 nautical miles, by again first circling the harbor before the second pass.

The helicopter then surveys its first pass over Army Terminal Channel and then finishes Puerto Nuevo Channel and Graving Dock Channel. The helicopter will then proceed to Isla Grande West and survey in five passes of 3,800 feet or 3.13 nautical miles. The helicopter will survey San Antonio Channel West in 14 passes of 3,500 feet or 8.06 nautical miles. The pilot will then survey San Antonio Channel in three passes of 5,400 feet or 2.67 nautical miles. The helicopter will then deadhead to San Antonio Channel West, a distance of 3,700 feet or 0.609 nautical miles. The helicopter will then survey Anegato and Bar Channels in four passes of 13,000 feet or 8.56 nautical miles. The helicopter will then survey Anegato Channel West in four passes at 4,500 feet or 2.96 nautical miles and then proceed to Army Terminal Channel which it will survey in two passes at 4,500 feet or 1.48 nautical miles (Figure D-5).

Army Terminal Harbor will require ten passes of 2,400 feet in length or 3.95 nautical miles. At this point the survey will be completed and the helicopter will deadhead from Army Terminal channel to San Juan Airport. The GPS for this project will be located at San Juan Airport. The UHF trisponders for this project will be located at Army Terminal and on Isla San Juan. Total survey distance is 39.39 nautical miles which will require 1.971 hours. Total deadhead for this project is 10.61 nautical miles to require 0.106 hours. Total survey time is 2.077 hours. The calculations are summarized on Table D-6.

Table D-6

San Juan, PR

Army Terminal 10 passes 2,400′ =	3.95	NM
Puerto Nuevo Channel 2 passes 5,000′ =	1.65	NM
Graving Dock 10 passes 3,000′ =	4.94	NM
Graving Dock Channel 2 passes 4,200′ =	1.38	NM
Isla Grande West 5 passes 3,800′ =	3.13	NM
San Antonio Channel West 14 passes 3,500′ =	8.06	NM
San Antonio Channel 3 passes 5,400′ =	2.67	NM
Deadhead to San Antonio Channel West 3,700′ =	0.609	NM
Anegado and Bar Channel 4 passes @ 13,000′ =	8.56	NM
Anegado Channel West 4 passes @ 4,500′ =	2.96	NM
Army Terminal Channel 2 passes @ 4,500′ =	1.48	NM

Deadhead to Airport from Army Terminal Harbor: 5
Deadhead from Airport to Army Terminal Channel: 5

Total Survey: 39.39 NM	=	1.971	Hr.
Survey Deadhead: 10.61 NM	=	0.106	Hr.
Total:		2.077	Hr.

Survey Deadhead	10.61 NM	0.106 Hr.
Access Deadhead	1946 NM	19.46 Hr.
Total Deadhead	1956.61 NM	19.566 Hr.

MISSION COSTS

The total survey nautical miles for this mission are 159.5, taking the helicopter 7.97 hours, while the deadhead nautical miles are 2,091.5, taking the helicopter 20.91 hours. The expected conventional cost for this scenario is $151,700 (Table D-7). The HLBS would be used for nine days. This includes four days of ferry and set up and five days of surveying as shown in Table D-8. The total cost per mission is $73,059, which consists of helicopter cost of $58,517, laser crew cost of $3,825; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $2,529 as shown in Table D-9. Table D-9 also shows operating costs per square nautical mile of $9,278.

Table D-7

Project Description of Hollywood Mission

	Conventional			HLBS					
	Cost	Survey	Expected	---Nautical	Miles---	Survey	Extra	Survey	Deadhead
PROJECTS	($000)	Freq	Cost	Survey	Deadhead	Days	Grnd Days	(Hours)	(Hours)
Bakers Haulover	6.0	1.00	$6,000	1.284	6.95	0.5		0.06	0.07
Miami Beach	73.2	1.00	$73,200	100	33.08	1		5.00	0.33
Miami Harbor	15.0	1.00	$15,000	11.350	22.130			0.57	0.22
Palm Beach/Lake Worth	8.0	1.00	$8,000	3.09	42.8			0.15	0.43
Port Everglades	4.5	1.00	$4,500	4.373	29.900			0.22	0.30
San Juan Harbor	45.0	1.00	$45,000	39.390	1956.610	3.5		1.97	19.57
Totals	$152		$151,700	159.5	2091.5	5.0	0.0	8.0	20.9

Table D-8

Hollywood	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	**Assumptions**		**Mission Totals**
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	5		$15,000
Helicopter Mission Flight Hours	28.9		$19,067
Travel & Per Diem (Per Prsn/Day)	$70		$1,890
Total Helicopter Costs			$58,517
LASER CREW COSTS			
Number of Mission Days--Laser Crew	5		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$3,125
Travel & Per Diem (Per Prsn/Day)	$70		$700
Total Laser Crew Cost			$3,825
OTHER COSTS			
Number of Mission Days--Ground Crew	5		
Ground Crew (Nmbr & Avg Price)	2	$275	$2,750
Travel & Per Diem (Per Prsn/Day)	$70		$700
Ground Transportation	$50		$500
Number of Survey Hours	7.97		
Post Processing (Technician $/Hr)	$38		$2,990
Efficiency Factor	15.0%		$3,777
(% Helicopter Flight, Laser Crew			
Total Other Costs			$10,718
TOTAL OPERATING COSTS PER MISSION			$73,059

Table D-9

Hollywood

UNIT OPERATING COST (per hour)

Operating Costs per Mission		$73,059
Helicopter Mission Flight Hours		28.9
Unit Operating Cost ($/Hrs)		$2,529

UNIT OPERATING COST (per Square Nautical Mile)

Operating Costs per Mission		$73,059
Number of Survey Hours	7.97	
Coverage Rate (Sq N Miles/Hr)	0.99	7.9
Unit Operating Cost ($/S.N.M.)		$9,278

SQUARE AREA SURVEYED

Nautical Miles	7.87
Kilometers	14.58

Appendix E

MAINE HARBORS

This section deals with the hydrographic survey of 37 harbors along the coast of Maine. The survey is divided into six survey trips requiring a maximum of seven UHF stations. It is estimated that the six trips can be completed in six days. Since each of the harbors in Maine must have a tide gauge present when the helicopter takes its readings, the logistics required to move UHF stations and tide gauges prohibit more than two survey trips per day. Due to the mountainous terrain of parts of coastal Maine, UHF stations will be sited on the highest available local ground. The six trips have been grouped not by their relative sizes, but rather on proximity of 25 miles or less to two suitable sites for UHF stations. Hence, the trips vary in duration from less than one hour to over four hours each (including any stops for refueling).

TRIP ONE

This first survey of Maine harbors will cover five harbors with the helicopter based at Bar Harbor Airport. The harbors to be surveyed include: Bucks Harbor, Machias River, Eastport Harbor, Lubec Channel, and St. Croix River (Figures E-1 through E-5). The survey of these harbors will require three ground stations located at Machias, Lubec, and Calais, respectively.

Scenario Analysis

The helicopter will leave Bar Harbor Airport and fly deadhead to Bucks Harbor, a distance of 43.3 nautical miles which will require 0.433 hours. The survey at Bucks Harbor (Figure E-1) requires two passes of total length 2,400 feet or 0.39 nautical miles taking 0.02 hours.

The helicopter will deadhead from Bucks Harbor to Machias River (Figure E-2), a distance of 5.48 nautical miles requiring 0.055 hours. The survey is a straight line along the Machias River for a distance of 13,600 feet or 2.24 nautical miles requiring 0.112 hours.

The helicopter will deadhead to Eastport Harbor, a distance of 22.94 nautical miles requiring 0.229 hours. The survey at Eastport Harbor (Figure E-3) requires one pass in a straight line of length 681 feet or 0.112 nautical miles requiring 0.006 hours.

The helicopter will deadhead from Eastport Harbor to Lubec Channel, a distance of 2.89 nautical miles requiring 0.029 hours. The survey of Lubec Channel (Figure E-4) requires two passes of total length 26,200 feet or 4.31 nautical miles requiring 0.216 hours.

The helicopter will deadhead from Lubec Channel to the St. Croix River at Calais, a distance of 37.5 nautical miles, requiring 0.375 hours. The survey of the St. Croix River (Figure E-5) at this point requires a single pass of 18,975, feet or 3.12 nautical miles, requiring 0.156 hours.

The GPS for these surveys is located at Machias. UHF stations for this survey would be located at Pembroke and Northfield, ME. A total of five automatic tide gauges are required for these surveys.

The helicopter then returns to Bar Harbor Airport, a distance of 63.5 nautical miles requiring 0.635 hours. Because there are a number of very short surveys, a two minute allowance has been made for the helicopter to get up to cruising speed and decelerate to surveying speed for each harbor which is less than ten nautical miles from the previous harbor that was surveyed. This adds a deadhead allowance of 0.067 hours (Table E-1).

Deadhead travel time for this series of five harbor surveys is 1.823 hours. Along with survey time of 0.509 hours, this trip requires 2.332 hours.

Logistics for Trip One require a tide gauge reading at each harbor at the time that it is being surveyed. The five harbors will require three automatic tide gauges to be placed before the survey begins. The two ground vehicles can be used to man the remaining two harbors until the survey is complete when they can be used to retrieve the other tide gauges.

Figure E-1

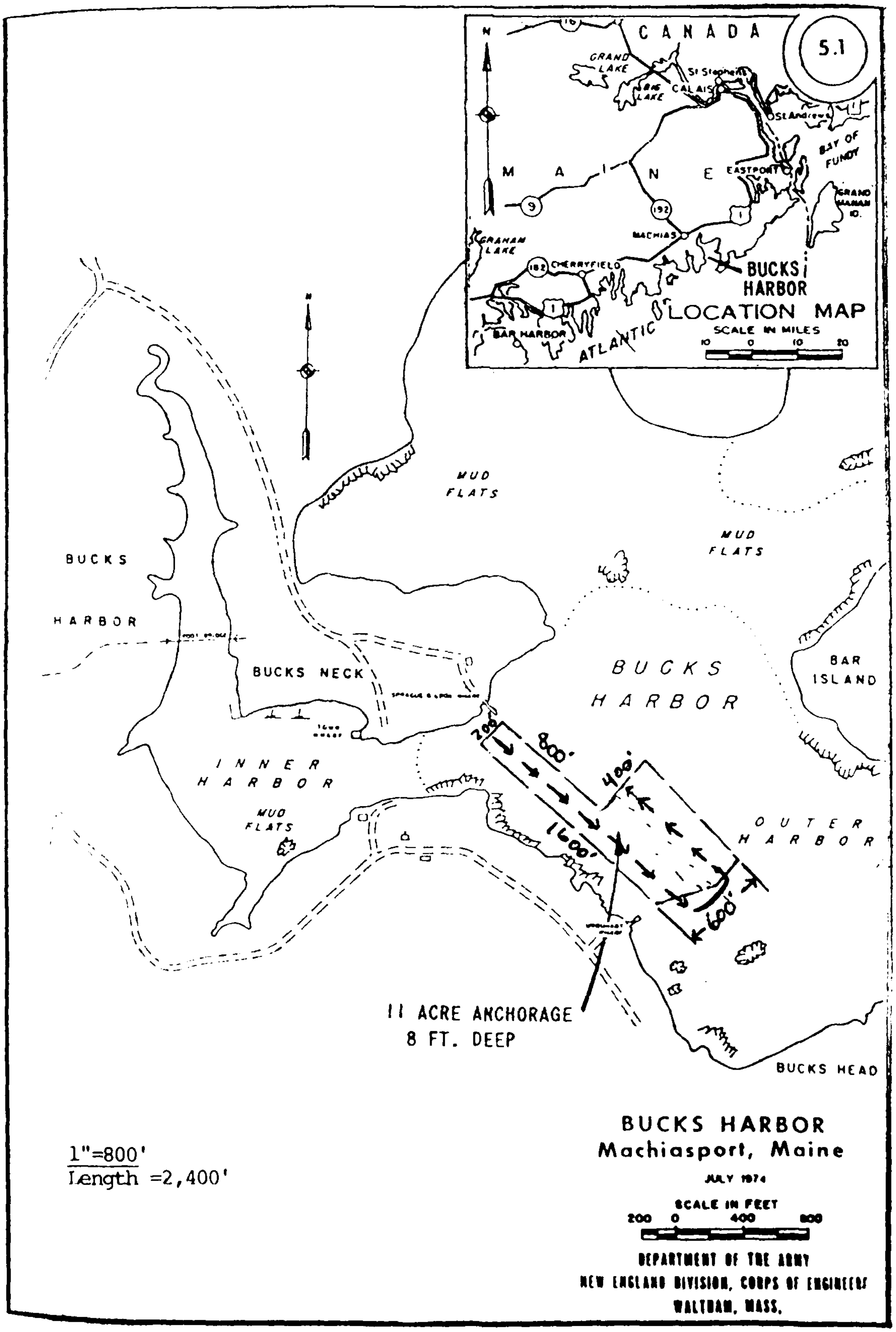

CANADA
5.1
GRAND LAKE
BIG LAKE
St Stephen
CALAIS
St Andrews
BAY OF FUNDY
MAINE
EASTPORT
GRAND MANAN ID.
MACHIAS
GRAHAM LAKE
CHERRYFIELD
BUCKS HARBOR
LOCATION MAP
SCALE IN MILES
10 0 10 20
BAR HARBOR
ATLANTIC
MUD FLATS
MUD FLATS
BUCKS HARBOR
BUCKS NECK
BUCKS HARBOR
BAR ISLAND
INNER HARBOR
MUD FLATS
OUTER HARBOR
200'
800'
400'
1600'
600'
11 ACRE ANCHORAGE
8 FT. DEEP
BUCKS HEAD
1"=800'
Length =2,400'
BUCKS HARBOR
Machiasport, Maine
JULY 1974
SCALE IN FEET
200 0 400 800
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-2

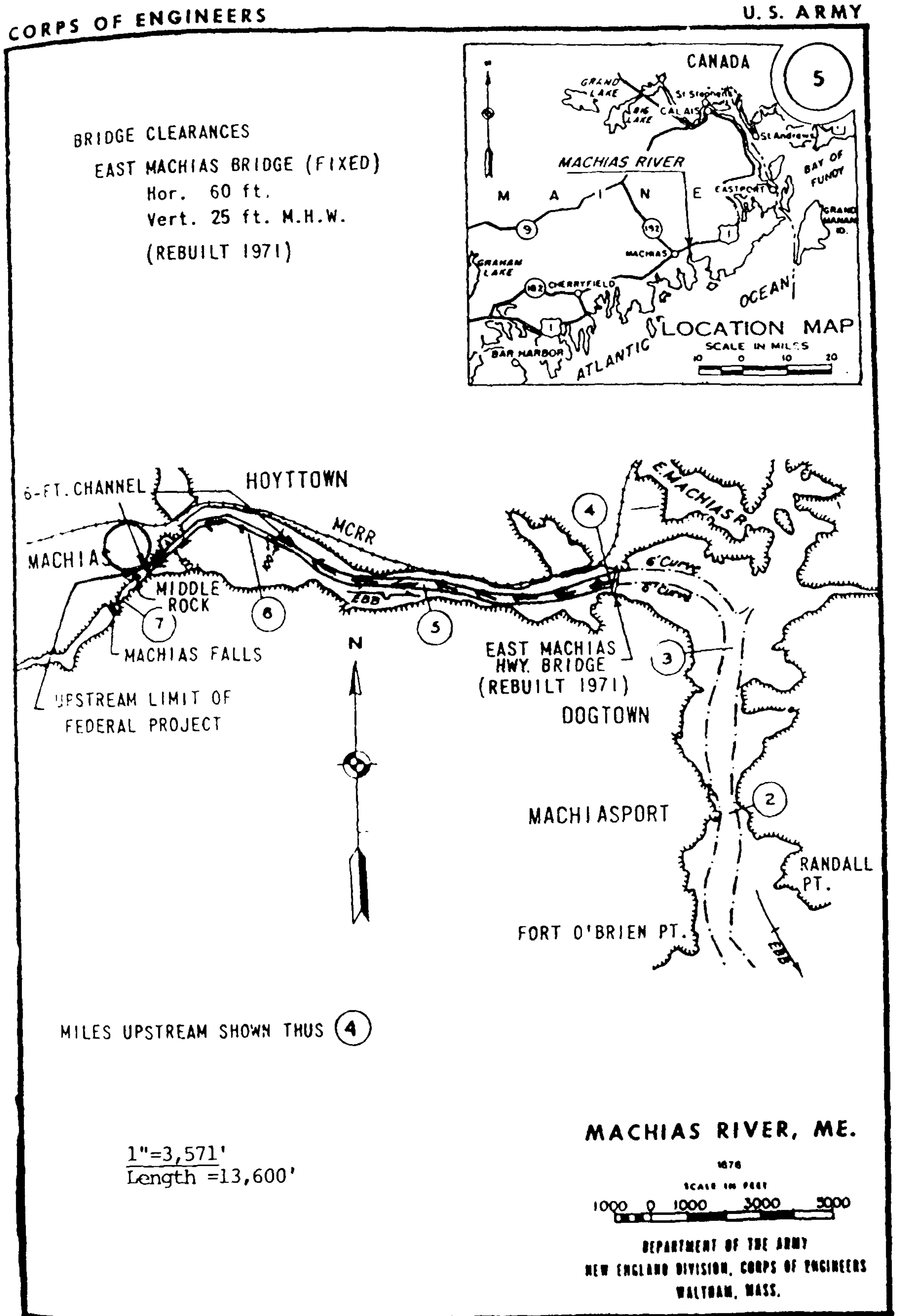

CORPS OF ENGINEERS
U. S. ARMY
BRIDGE CLEARANCES
EAST MACHIAS BRIDGE (FIXED)
Hor. 60 ft.
Vert. 25 ft. M.H.W.
(REBUILT 1971)
CANADA
5
GRAND LAKE
BIG LAKE
CALAIS
St Stephens
St Andrews
MACHIAS RIVER
BAY OF FUNDY
M A I N E
EASTPORT
GRAND MANAN ID.
9
192
1
MACHIAS
GRAHAM LAKE
182
CHERRYFIELD
BAR HARBOR
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
10 0 10 20
6-FT. CHANNEL
HOYTTOWN
MCRR
E. MACHIAS R.
MACHIAS
MIDDLE ROCK
7
6
5
4
3
2
EBB
6' Curve
8' Curve
MACHIAS FALLS
N
EAST MACHIAS HWY. BRIDGE (REBUILT 1971)
UPSTREAM LIMIT OF FEDERAL PROJECT
DOGTOWN
MACHIASPORT
RANDALL PT.
FORT O'BRIEN PT.
EBB
MILES UPSTREAM SHOWN THUS 4
1"=3,571'
Length =13,600'
MACHIAS RIVER, ME.
SCALE IN FEET
1000 0 1000 3000 5000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-3

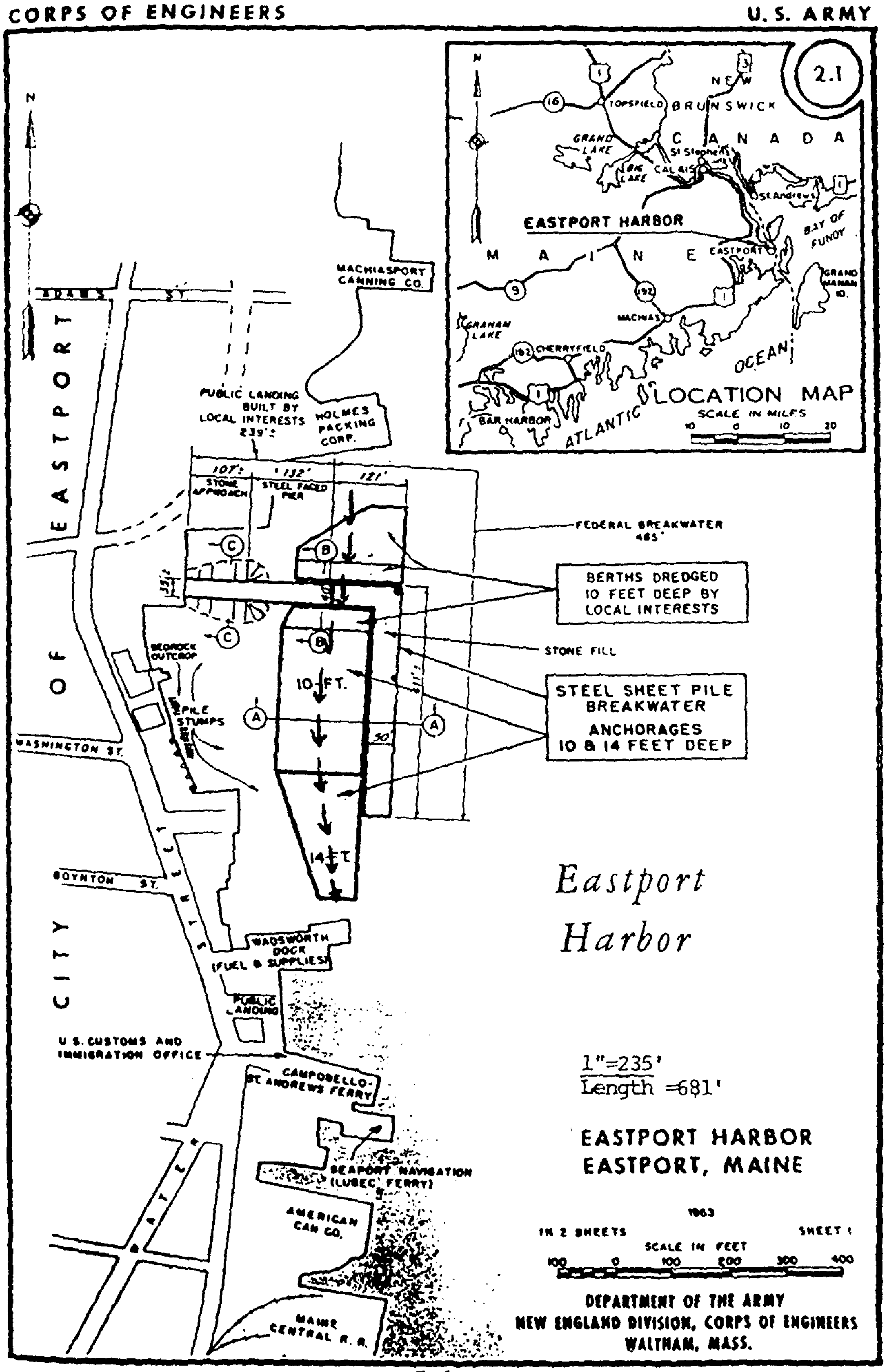

CORPS OF ENGINEERS
U.S. ARMY
2.1
EASTPORT HARBOR
LOCATION MAP
ATLANTIC OCEAN
BAY OF FUNDY
NEW BRUNSWICK
CANADA
MAINE
MACHIASPORT CANNING CO.
PUBLIC LANDING BUILT BY LOCAL INTERESTS 239'±
HOLMES PACKING CORP.
STONE APPROACH
STEEL FACED PIER
FEDERAL BREAKWATER 485'
BERTHS DREDGED 10 FEET DEEP BY LOCAL INTERESTS
STONE FILL
STEEL SHEET PILE BREAKWATER
ANCHORAGES 10 & 14 FEET DEEP
BEDROCK OUTCROP
PILE STUMPS
10 FT.
14 FT.
WASHINGTON ST.
BOYNTON ST.
CITY OF EASTPORT
WATER STREET
WADSWORTH DOCK (FUEL & SUPPLIES)
PUBLIC LANDING
U.S. CUSTOMS AND IMMIGRATION OFFICE
CAMPOBELLO-ST. ANDREWS FERRY
SEAPORT NAVIGATION (LUBEC FERRY)
AMERICAN CAN CO.
MAINE CENTRAL R.R.
Eastport Harbor
1"=235'
Length =681'
EASTPORT HARBOR
EASTPORT, MAINE
1963
IN 2 SHEETS
SHEET 1
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-4

CORPS OF ENGINEERS

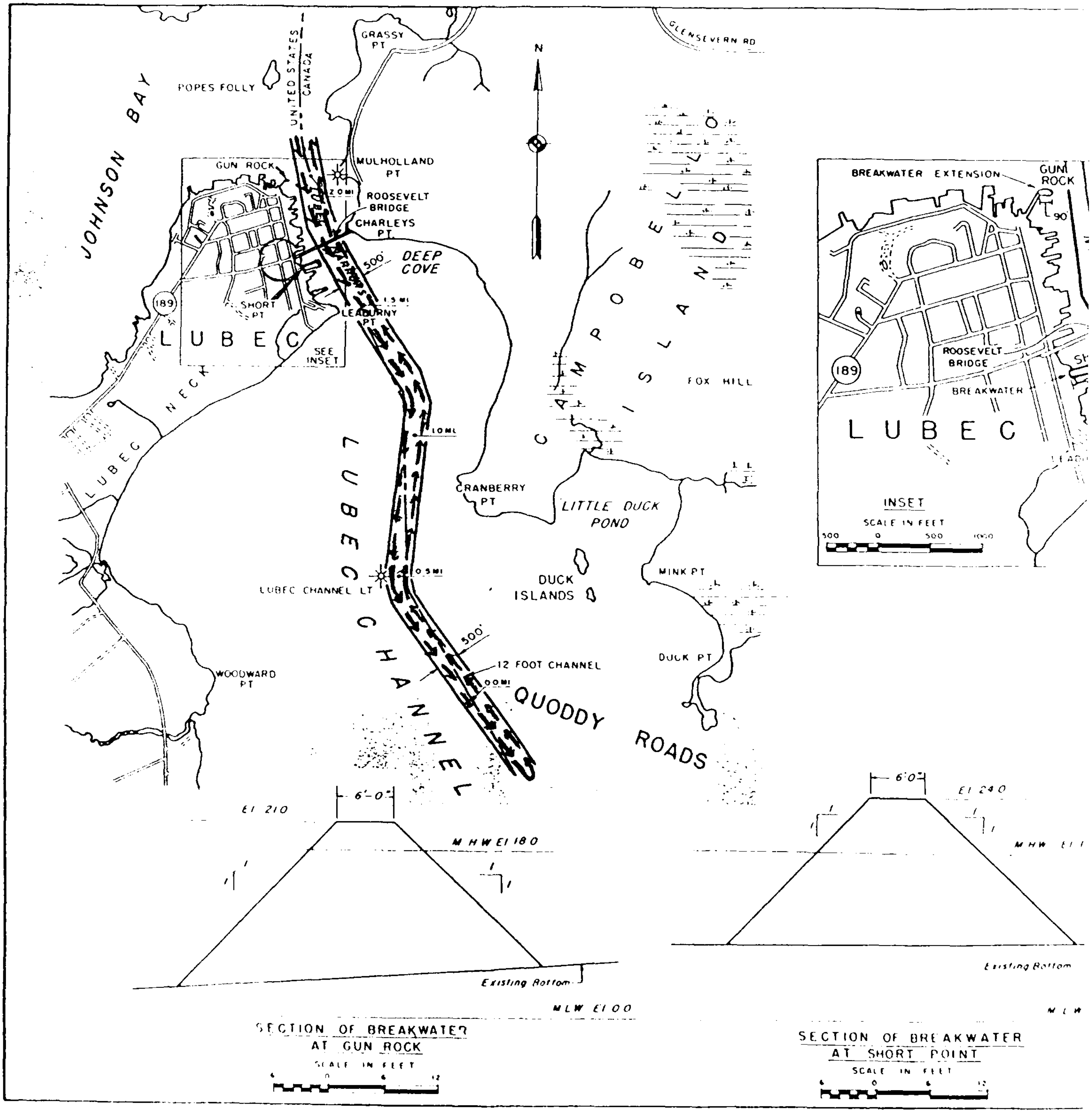


Figure E-4

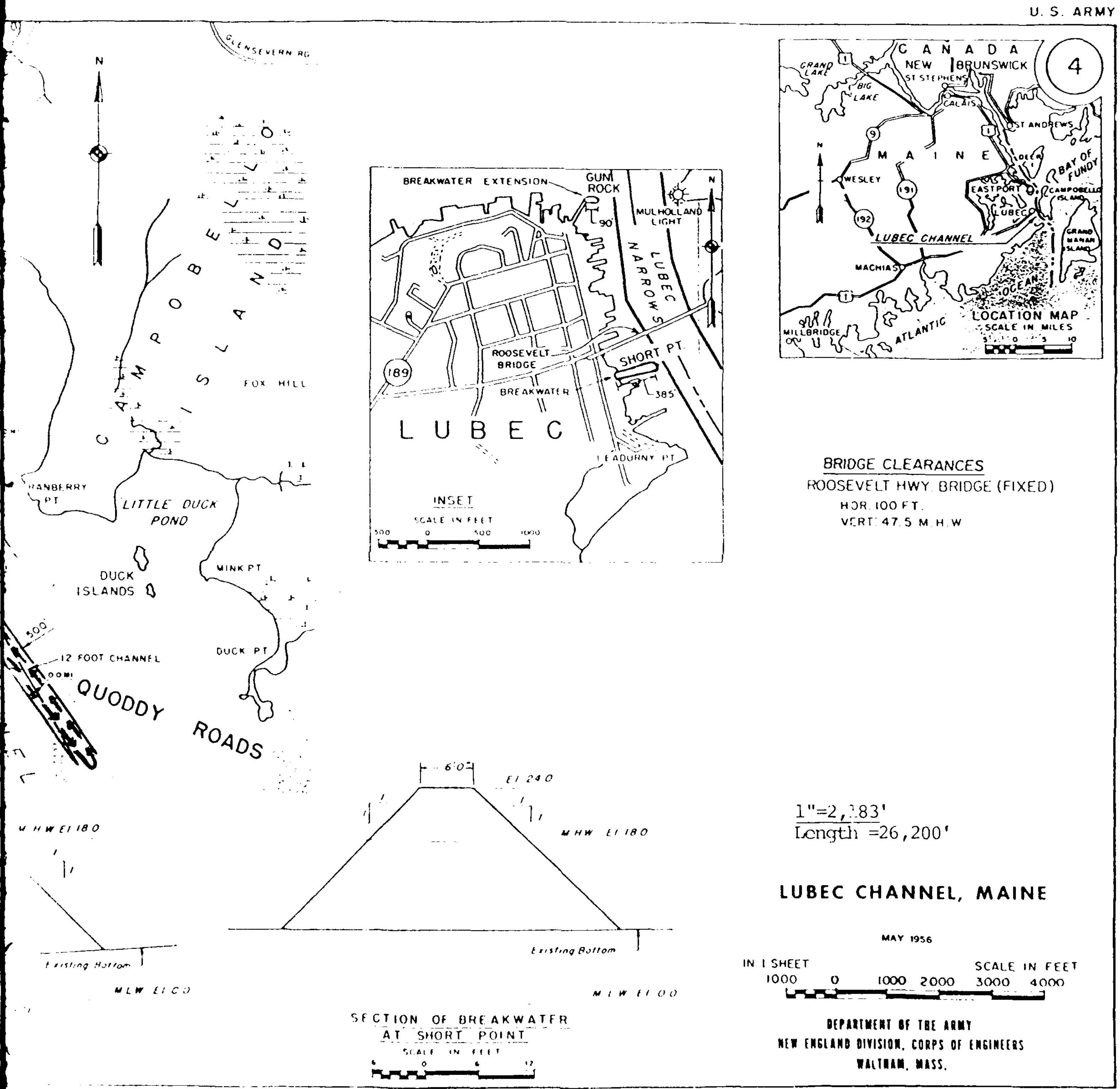
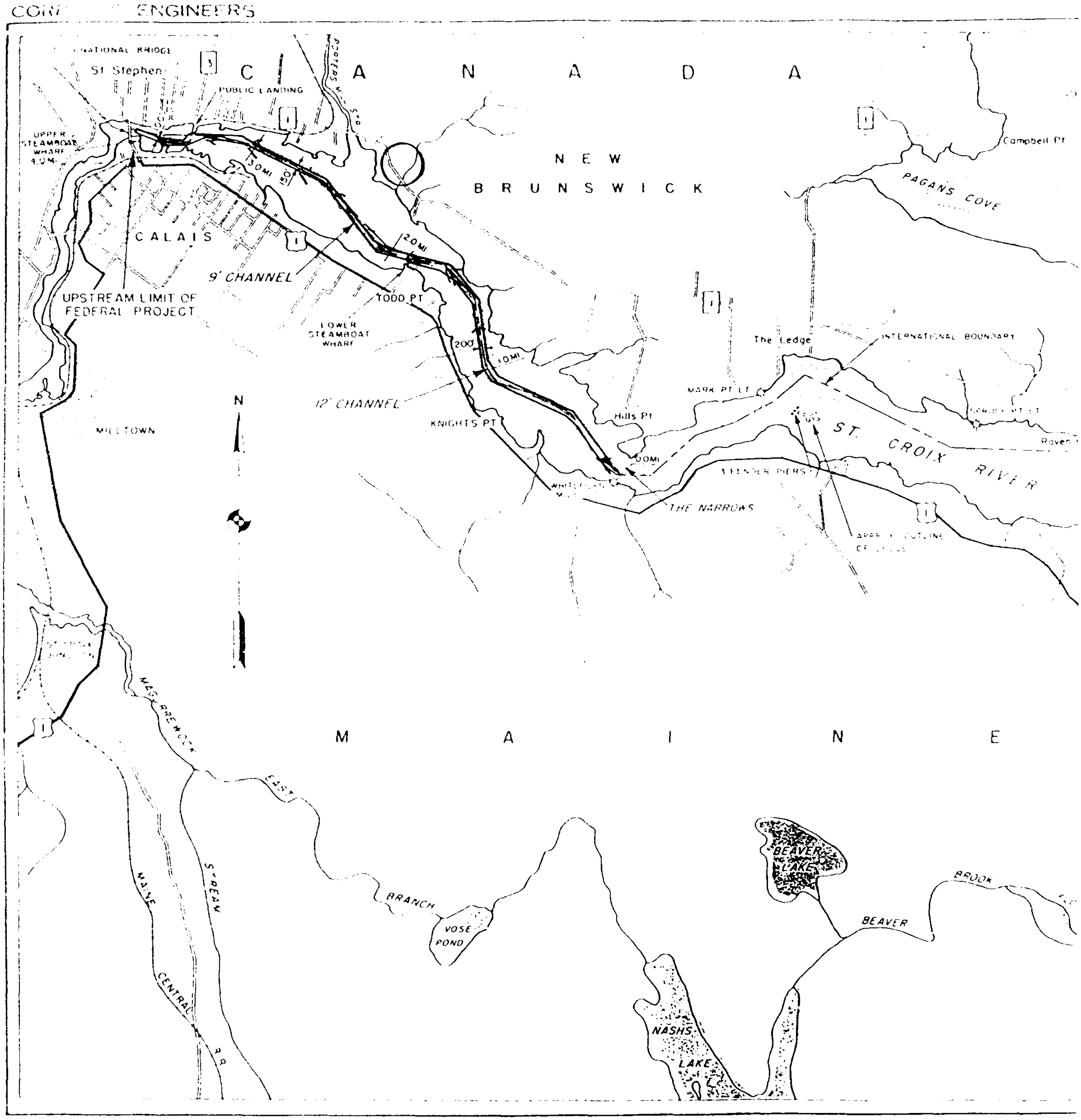

U. S. ARMY
CAMPOBELLO ISLAND
FOX HILL
LITTLE DUCK POND
DUCK ISLANDS
MINK PT
DUCK PT
12 FOOT CHANNEL
QUODDY ROADS
BREAKWATER EXTENSION
GUN ROCK
MULHOLLAND LIGHT
LUBEC NARROWS
ROOSEVELT BRIDGE
SHORT PT.
BREAKWATER
LUBEC
INSET
SCALE IN FEET
CANADA
NEW BRUNSWICK
MAINE
LUBEC CHANNEL
BAY OF FUNDY
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
BRIDGE CLEARANCES
ROOSEVELT HWY BRIDGE (FIXED)
HOR. 100 FT.
VERT. 47.5 M.H.W.
6'0"
El 24.0
MHW El 18.0
Existing Bottom
MLW El 0.0
SECTION OF BREAKWATER AT SHORT POINT
SCALE IN FEET
1"=2,183'
Length =26,200'
LUBEC CHANNEL, MAINE
MAY 1956
IN 1 SHEET
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-5



CORPS OF ENGINEERS
NATIONAL BRIDGE
St Stephen
C A N A D A
PUBLIC LANDING
UPPER STEAMBOAT WHARF 4.0 MI
NEW BRUNSWICK
Campbell Pt
PAGANS COVE
CALAIS
3.0 MI
150
2.0 MI
9' CHANNEL
UPSTREAM LIMIT OF FEDERAL PROJECT
TODD PT
LOWER STEAMBOAT WHARF
200
1.0 MI
The Ledge
INTERNATIONAL BOUNDARY
12' CHANNEL
MILLTOWN
N
KNIGHTS PT
Hills Pt
0.0 MI
ST. CROIX RIVER
THE NARROWS
M A I N E
EAST BRANCH
VOSE POND
BEAVER LAKE
BEAVER BROOK
NASHS LAKE
MAINE CENTRAL R.R.
STREAM

Figure E-5

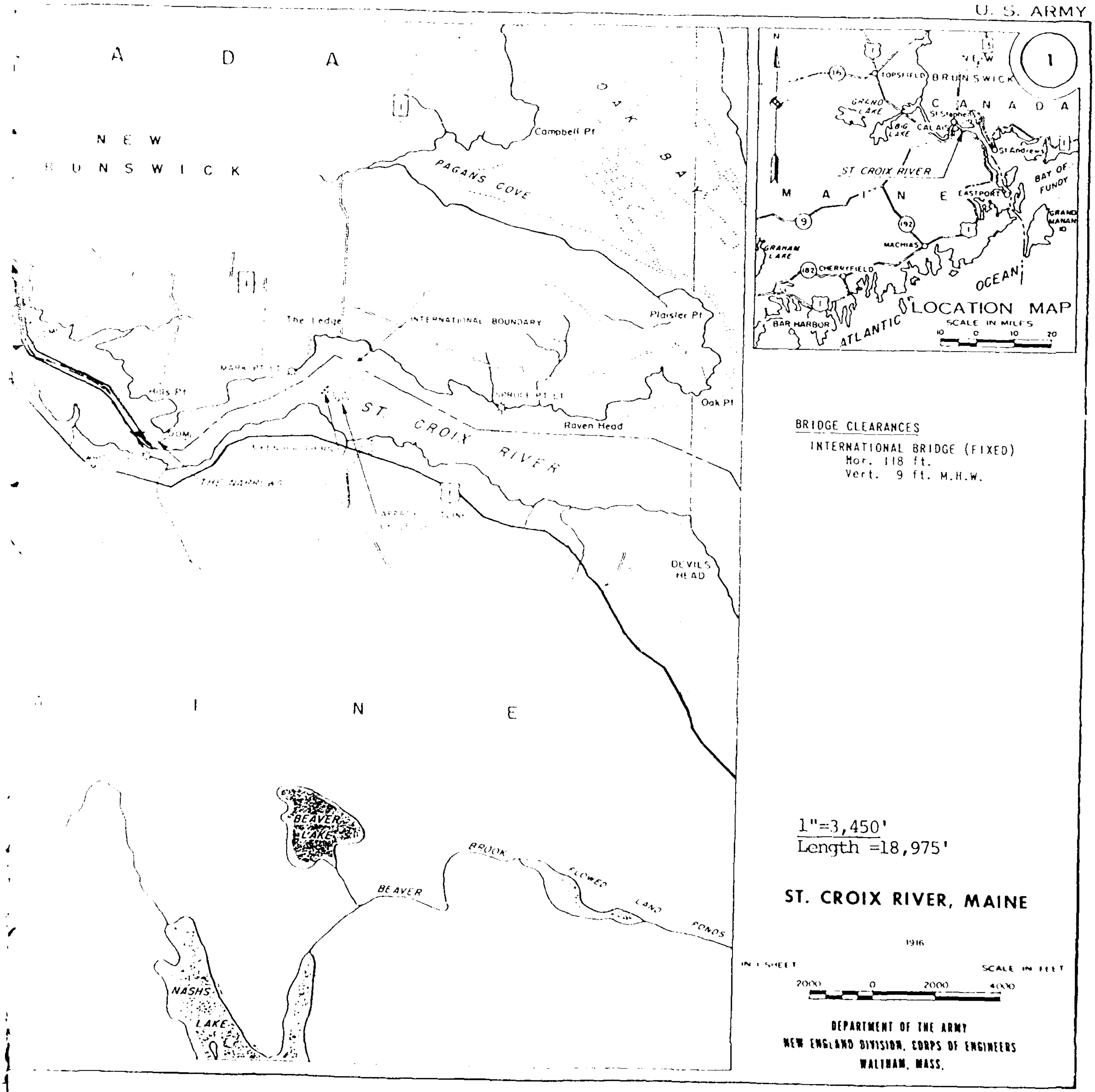

U. S. ARMY
A D A
N E W
UNSWICK
OAK BAY
Campbell Pt
PAGANS COVE
The Ledge
INTERNATIONAL BOUNDARY
Plaisler Pt
Hills Pt
ST CROIX RIVER
Raven Head
Oak Pt
DEVILS HEAD
I N E
BEAVER LAKE
BEAVER
BROOK
FLOWED LAND PONDS
NASHS LAKE
1
NEW BRUNSWICK
CANADA
TOPSFIELD
GRAND LAKE
BIG LAKE
St Stephen
CALAIS
St Andrews
ST CROIX RIVER
BAY OF FUNDY
MAINE
EASTPORT
GRAND MANAN
MACHIAS
GRAHAM LAKE
CHERRYFIELD
OCEAN
ATLANTIC
BAR HARBOR
LOCATION MAP
SCALE IN MILES
10 0 10 20
BRIDGE CLEARANCES
INTERNATIONAL BRIDGE (FIXED)
Hor. 118 ft.
Vert. 9 ft. M.H.W.
1"=3,450'
Length =18,975'
ST. CROIX RIVER, MAINE
1916
SCALE IN FEET
2000 0 2000 4000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-1

MAINE HARBOR SURVEY TRIP ONE (BAR HARBOR AIRPORT)

Bucks Harbor	(Figure E-1)
Machias River	(Figure E-2)
Eastport Harbor	(Figure E-3)
Lubec Channel	(Figure E-4)
St. Croix River	(Figure E-5)

Bucks Harbor			
Deadhead from base at Bar Harbor		43.3 NM	0.433 Hr.
Survey:	2,400′	0.39 NM	0.02 Hr.
Machias River			
Deadhead from Bucks Harbor		5.48 NM	0.055 Hr.
Survey:	13,600′	2.24 NM	0.112 Hr.
Eastport Harbor			
Deadhead from Machias River		22.94 NM	0.229 Hr.
Survey:	681′	0.112 NM	0.006 Hr.
Lubec Channel			
Deadhead from Eastport Harbor		2.89 NM	0.029 Hr.
Survey:	26,200′	4.31 NM	0.216 Hr.
St. Croix River			
Deadhead from Lubec Channel		37.5 NM	0.375 Hr.
Survey:	18,975′	3.12 NM	0.156 Hr.
Deadhead to base at Bar Harbor		63.5 NM	0.635 Hr.
Short trip deadhead allowance		6.7 NM	0.067 Hr.
Total deadhead		182.3 NM	1.823 Hr.
Total survey		10.17 NM	0.509 Hr.
Total		192.47 NM	2.332 Hr.

TRIP TWO

This is a series of six harbors to be surveyed from a helicopter based at Bar Harbor Airport. These harbors include Jonesport Harbor, Pig Island Gut, Beals Harbor, Corea Harbor, Bunker Harbor (Gouldsboro) and Winter Harbor. (Figures E-6 through E-11).

The GPS station for these surveys will be located at West Gouldsboro, Me. UHF stations for this project will be located at Columbia Falls and West Gouldsboro, ME. A total of four automatic tide gauges will be required for these surveys, plus the two manned ground vehicles.

Because there are numerous stops along this survey route this analysis allows for helicopter acceleration and deceleration when the distance from one harbor to the next is less than ten nautical miles. This allowance consists of two minutes per harbor for a total of 0.30 hours.

Scenario Analysis

The helicopter will fly from Bar Harbor Airport to Jonesport Harbor (Figure E-6), a distance of 33.2 nautical miles which will require 0.332 hours. The survey of Jonesport Harbor will require three passes of total length 3,990 feet, or 0.657 nautical miles, requiring 0.033 hours.

The helicopter will proceed from Jonesport to Pig Island Gut (Figure E-7) which is a channel between Pig Island and Great Wass Island, a distance of 0.72 nautical miles requiring 0.007 hours. The helicopter flies a single pass along this narrow channel of 6,400 feet or 1.053 nautical miles in length. This takes 0.053 hours.

The helicopter will proceed from Pig Island Gut to Beals Harbor (Figure E-8), a distance of 0.72 nautical miles requiring 0.007 hours. The survey of Beals Harbor can be accomplished in four passes of total length 3,000 feet or 0.494 nautical miles requiring 0.025 hours.

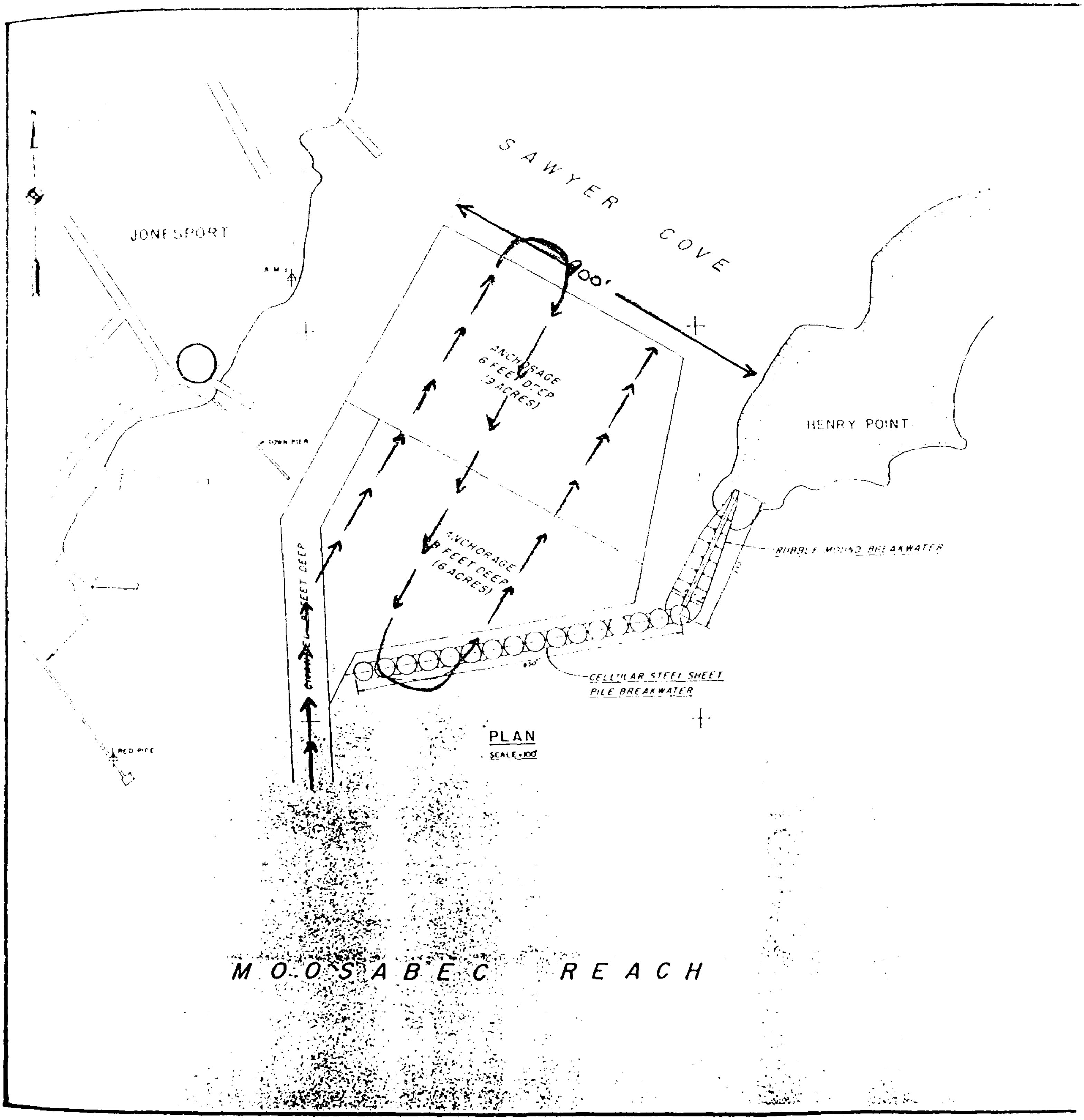
The helicopter will proceed directly from Beals Harbor to Corea Harbor (Figure E-9), a distance of 17.03 nautical miles requiring 0.17 hours. The survey of Corea Harbor requires a total survey length of 2,926 feet or 0.481 nautical miles taking 0.024 hours.

The helicopter will proceed from Corea Harbor to Bunker Harbor (Figure E-10), a distance of 5.34 nautical miles requiring 0.053 hours. The survey of Bunker Harbor can be accomplished in a single pass of length 806 feet or 0.133 nautical miles requiring 0.006 hours.

The helicopter will proceed from Bunker Harbor to Winter Harbor (Figure E-11), a distance of 5.8 nautical miles requiring 0.058 hours. The survey of Winter Harbor will require two passes of total length 2,000 feet or 0.329 nautical miles requiring 0.016 hours.

The helicopter will then return to Bar Harbor Airport (5.05 NM). Total deadhead miles for this survey is 75.36 NM requiring 0.754 hours. Total survey distance is 2.818 NM requiring 0.141 hours. The total time to complete this survey is 0.895 hours (Table E-2).

Figure



SAWYER COVE
JONESPORT
HENRY POINT
ANCHORAGE 6 FEET DEEP (3 ACRES)
ANCHORAGE 8 FEET DEEP (6 ACRES)
RUBBLE MOUND BREAKWATER
CELLULAR STEEL SHEET PILE BREAKWATER
TOWN PIER
RED PIPE
PLAN
SCALE 1"=100'
MOOSABEC REACH

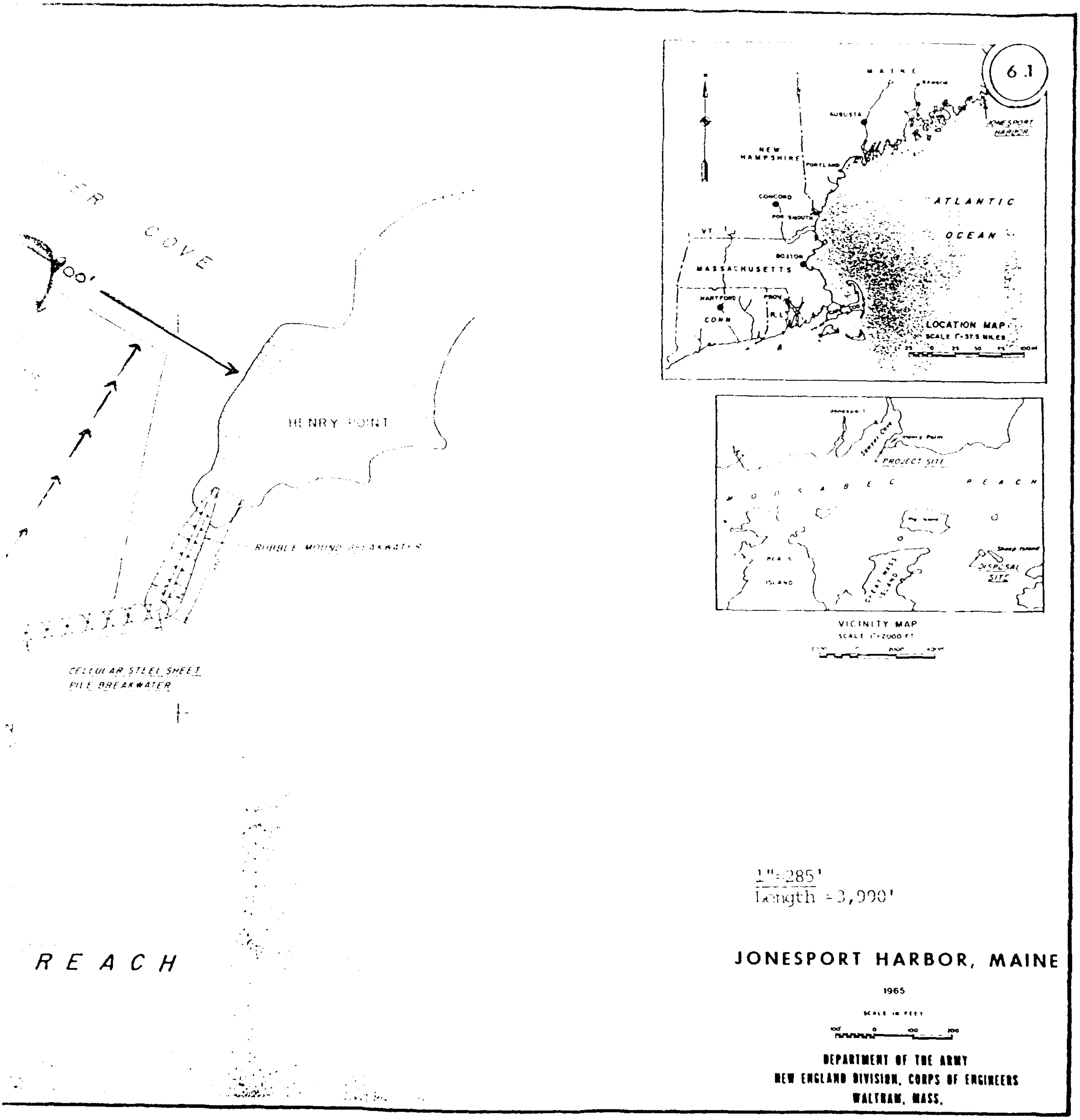

6.1
MAINE
AUGUSTA
JONESPORT HARBOR
NEW HAMPSHIRE
PORTLAND
CONCORD
PORTSMOUTH
VT.
ATLANTIC
OCEAN
BOSTON
MASSACHUSETTS
HARTFORD
PROV.
CONN
R.I.
LOCATION MAP
Jonesport
Henry Point
PROJECT SITE
PEACH
Sheep Island
DISPOSAL SITE
GREAT WASS ISLAND
ISLAND
VICINITY MAP
COVE
HENRY POINT
RUBBLE MOUND BREAKWATER
CELLULAR STEEL SHEET PILE BREAKWATER
REACH
1"=285'
Length =3,990'
JONESPORT HARBOR, MAINE
1965
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-7

CORPS OF ENGINEERS

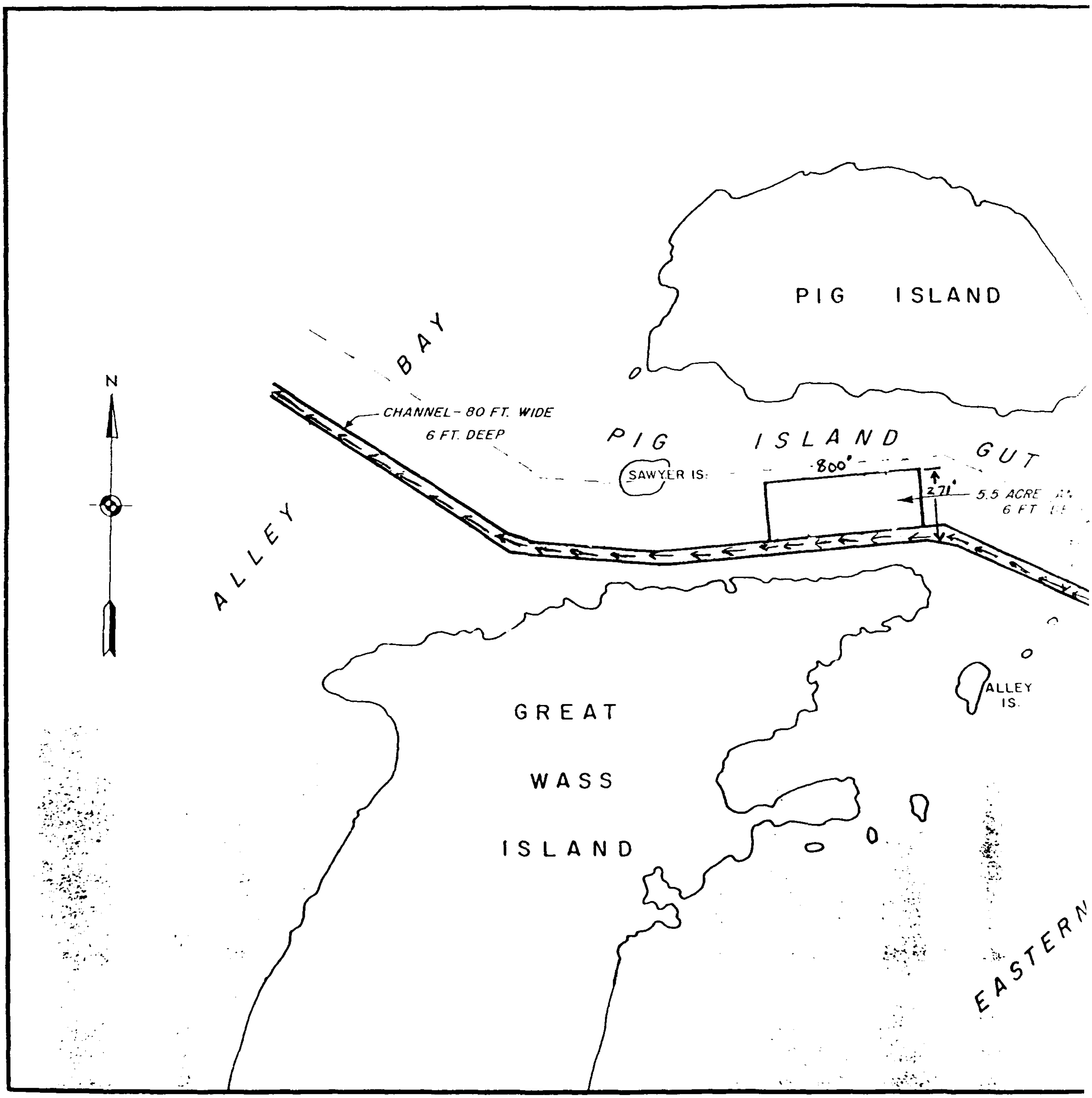
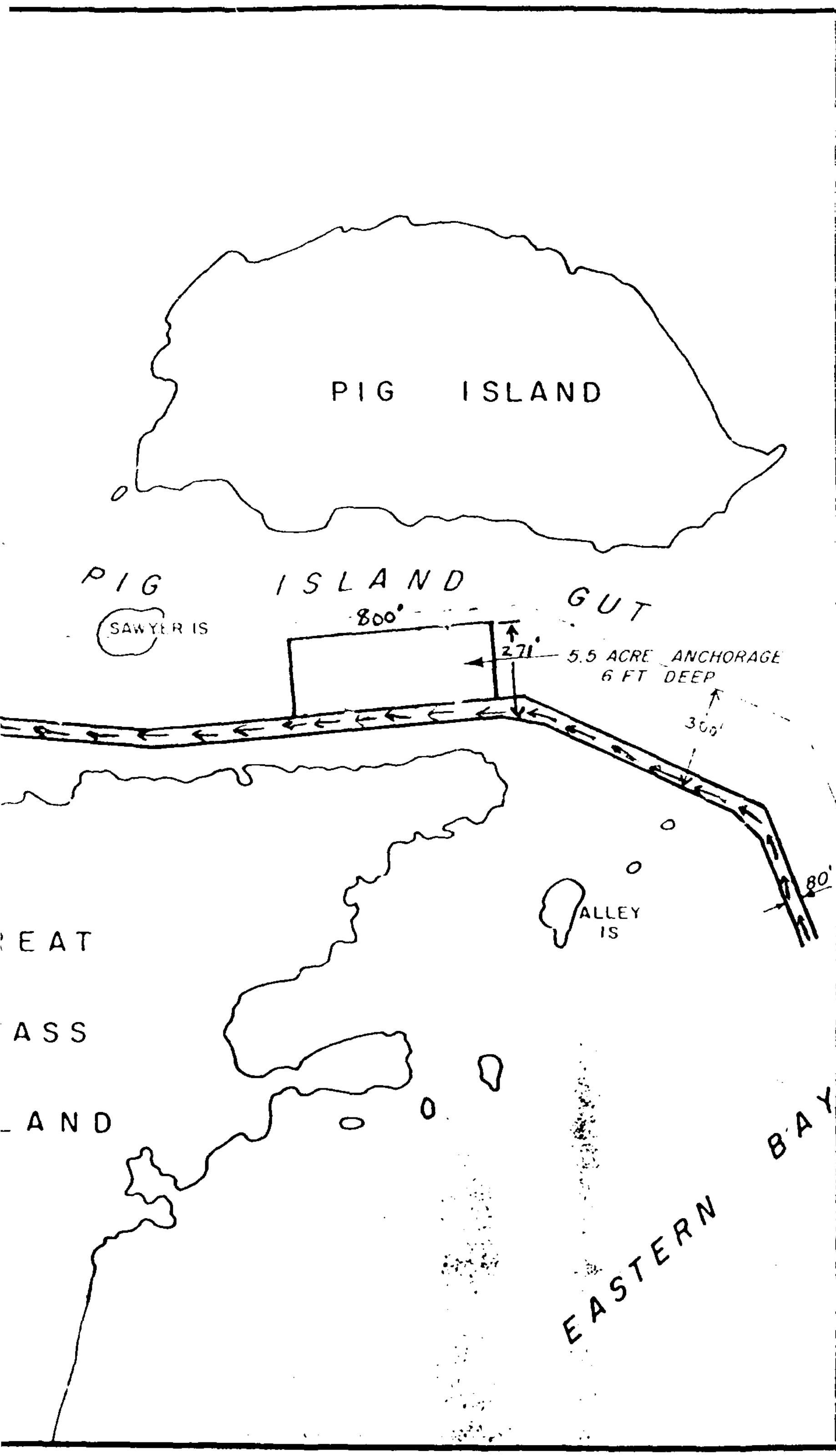
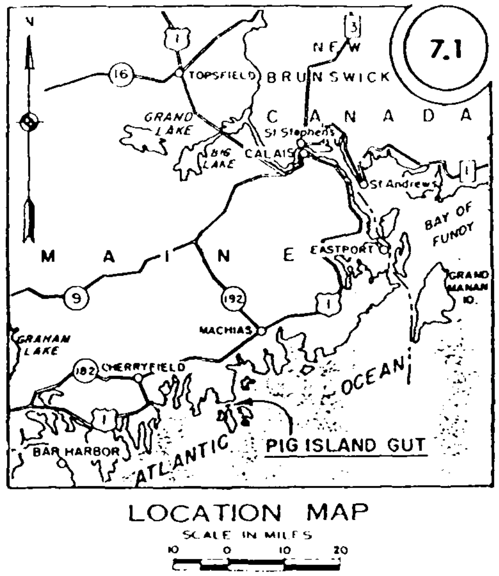
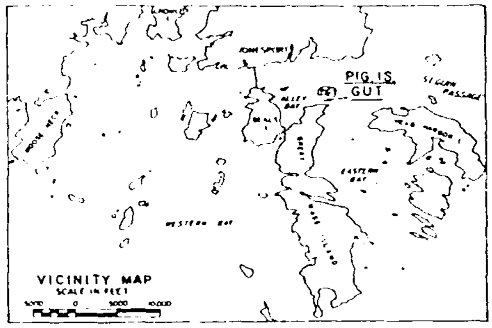


Figure E-7

U. S. ARMY







1"=571'
Length =6,400'

PIG ISLAND GUT
BEALS, MAINE

OCTOBER 1965

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-8

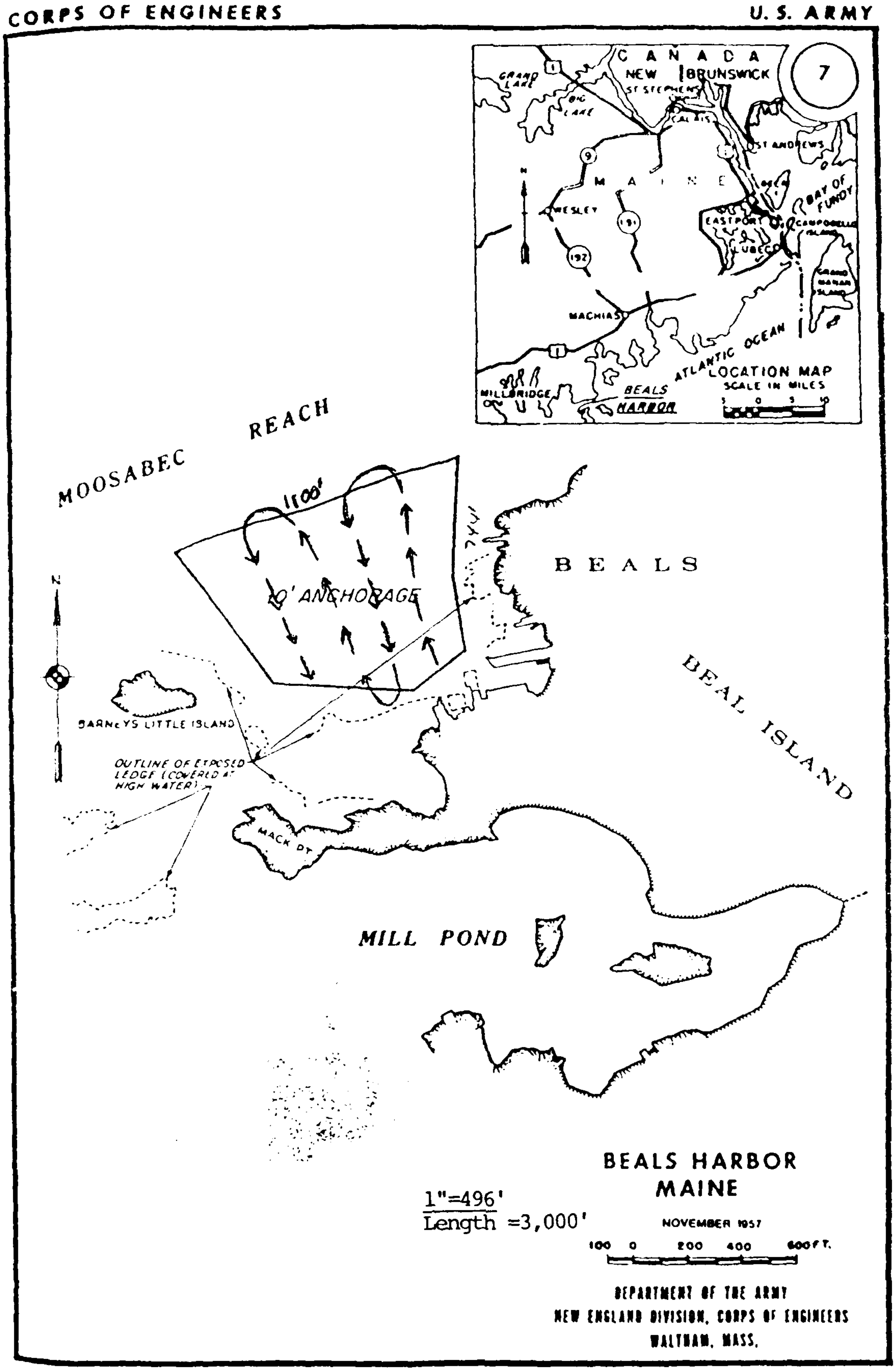

CORPS OF ENGINEERS
U. S. ARMY
CANADA
NEW BRUNSWICK
7
MAINE
BAY OF FUNDY
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
BEALS HARBOR
MOOSABEC REACH
1100'
10' ANCHORAGE
BEALS
BEAL ISLAND
BARNEYS LITTLE ISLAND
OUTLINE OF EXPOSED LEDGE (COVERED AT HIGH WATER)
MACK PT
MILL POND
BEALS HARBOR
MAINE
1"=496'
Length =3,000'
NOVEMBER 1957
100 0 200 400 600 FT.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-9

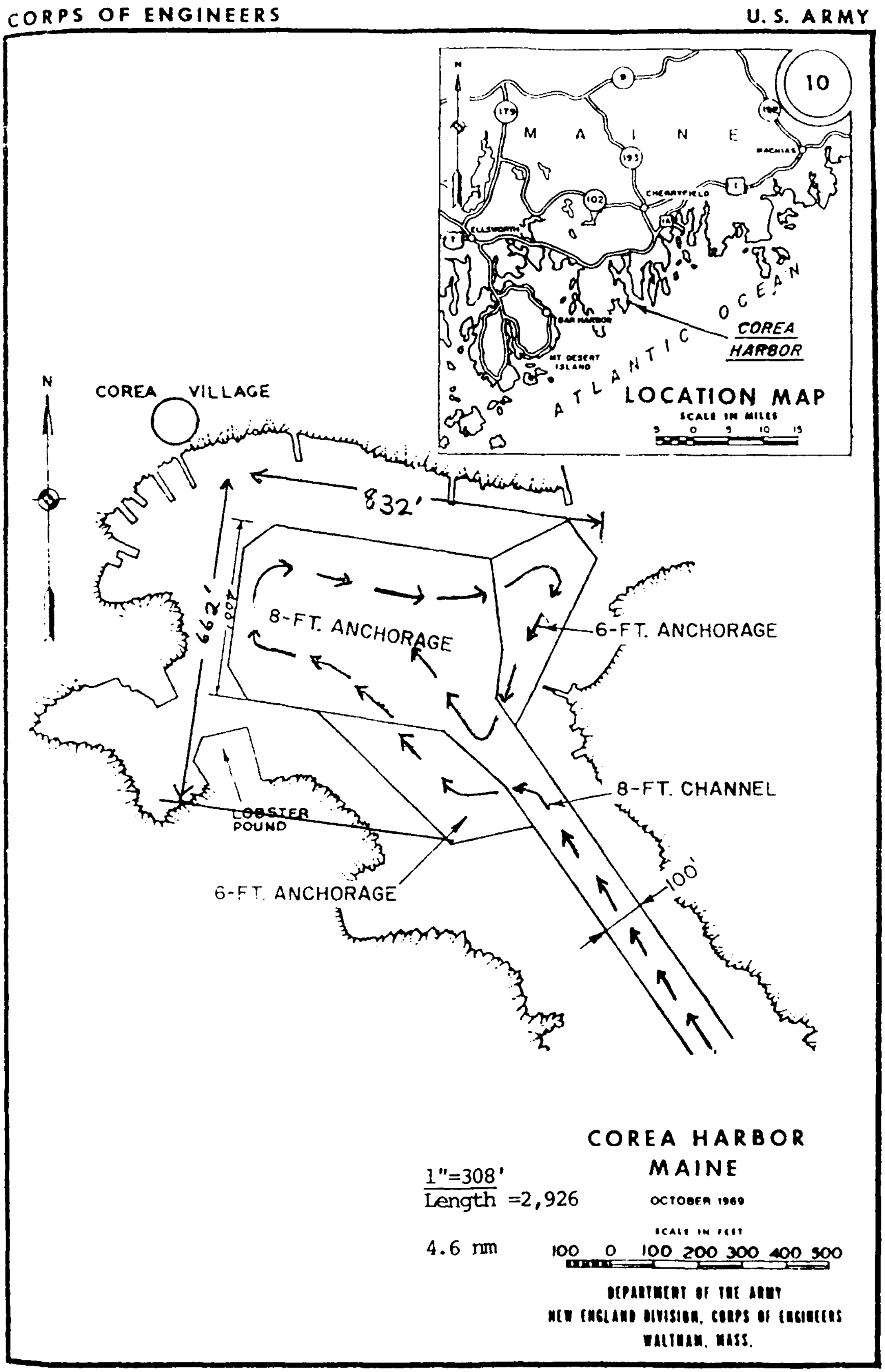

CORPS OF ENGINEERS
U.S. ARMY
10
MAINE
CHERRYFIELD
ELLSWORTH
BAR HARBOR
MT. DESERT ISLAND
ATLANTIC OCEAN
COREA HARBOR
LOCATION MAP
SCALE IN MILES
5 0 5 10 15
N
COREA VILLAGE
832'
662'
400'
8-FT. ANCHORAGE
6-FT. ANCHORAGE
8-FT. CHANNEL
LOBSTER POUND
6-FT. ANCHORAGE
100'
COREA HARBOR
MAINE
OCTOBER 1969
1"=308'
Length =2,926
4.6 nm
SCALE IN FEET
100 0 100 200 300 400 500
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-10

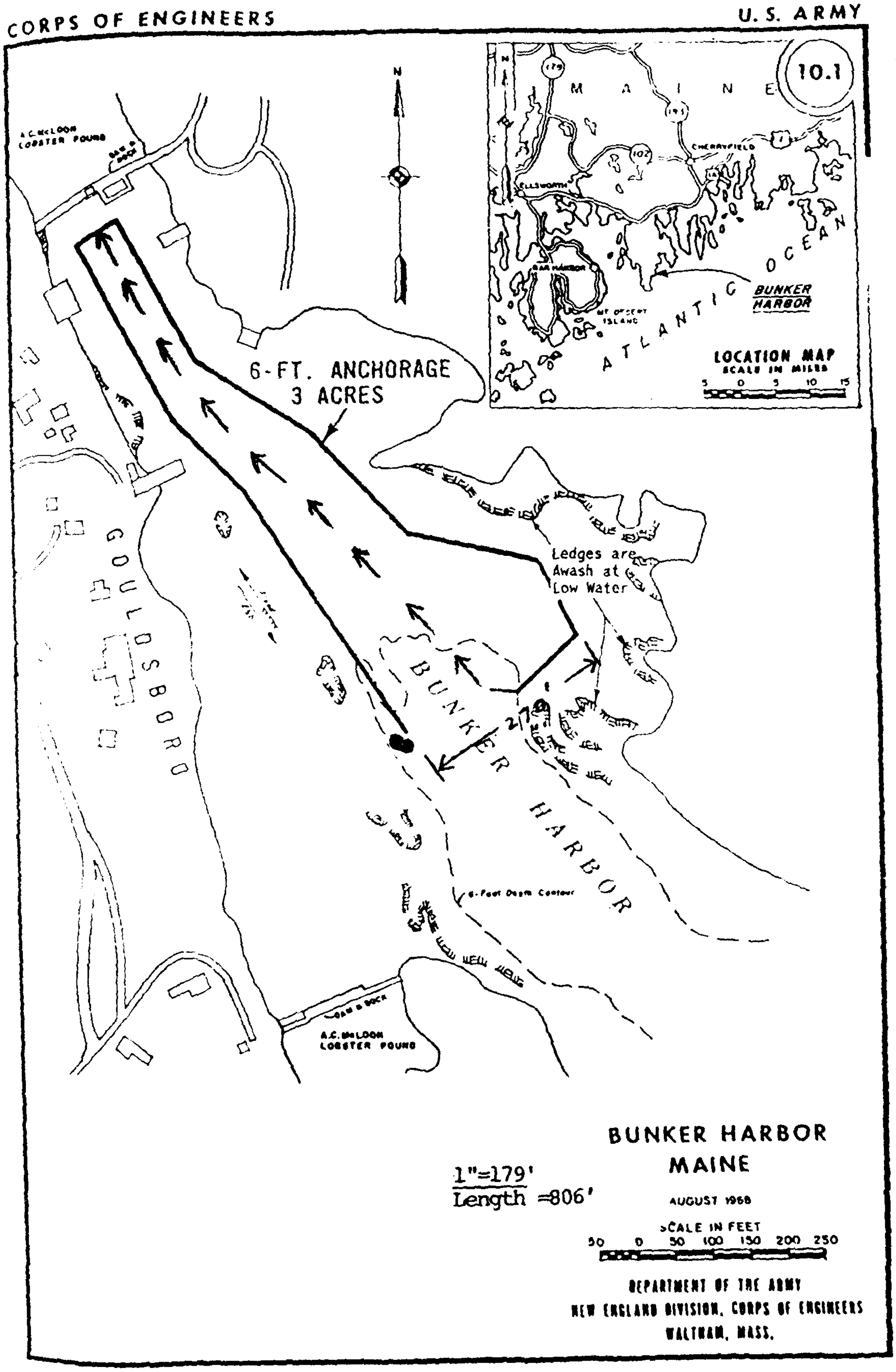

CORPS OF ENGINEERS
U. S. ARMY
10.1
N
M A I N E
ATLANTIC OCEAN
BUNKER HARBOR
LOCATION MAP
SCALE IN MILES
5 0 5 10 15
6-FT. ANCHORAGE
3 ACRES
Ledges are
Awash at
Low Water
GOULDSBORO
BUNKER HARBOR
270'
6-Foot Depth Contour
A.C. McLOON
LOBSTER POUND
BUNKER HARBOR
MAINE
AUGUST 1968
SCALE IN FEET
50 0 50 100 150 200 250
1"=179'
Length =806'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-11

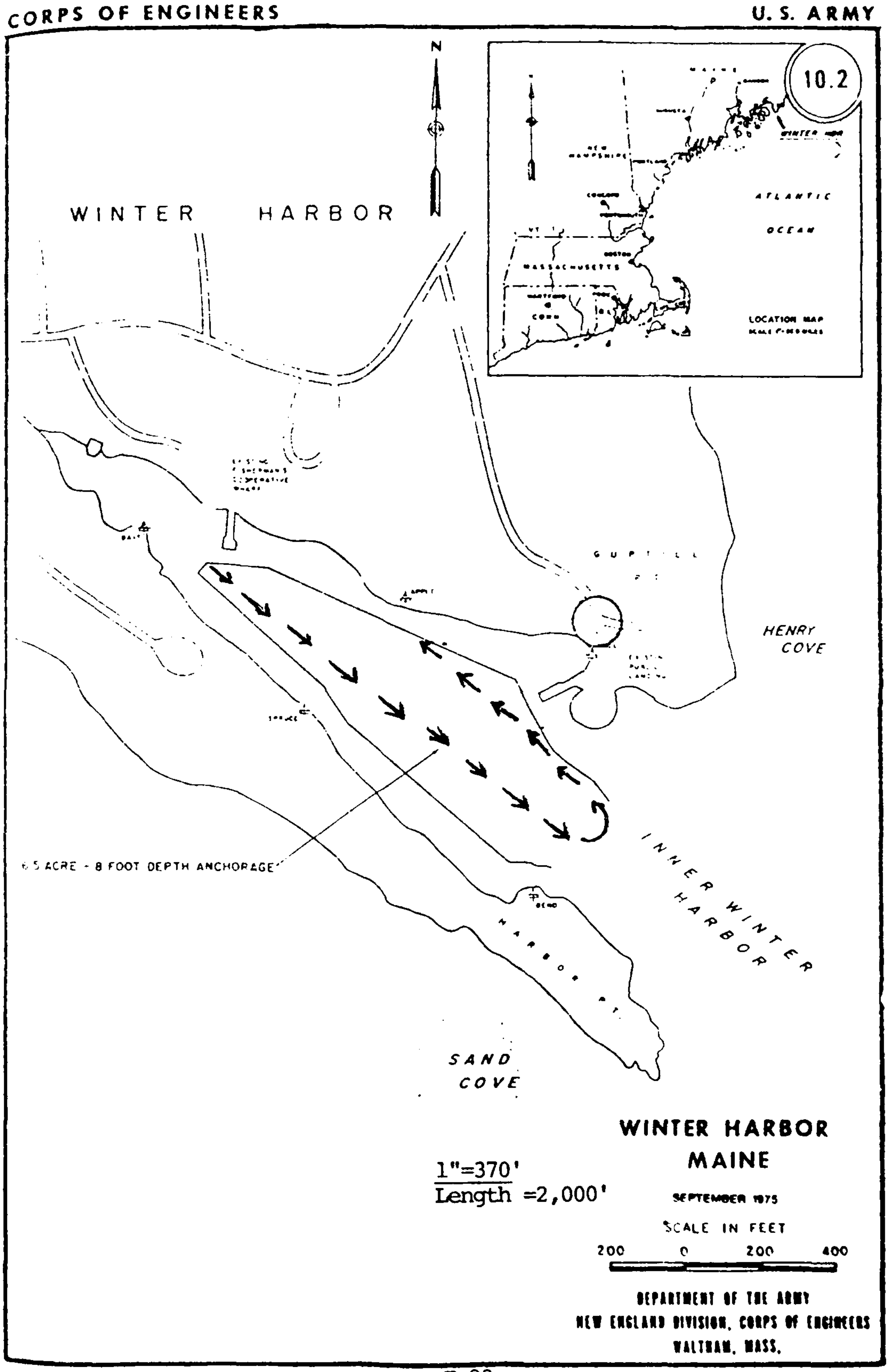

CORPS OF ENGINEERS
U.S. ARMY
10.2
WINTER HARBOR
ATLANTIC
OCEAN
LOCATION MAP
HENRY
COVE
6.5 ACRE - 8 FOOT DEPTH ANCHORAGE
INNER WINTER
HARBOR
SAND
COVE
WINTER HARBOR
MAINE
1"=370'
Length =2,000'
SEPTEMBER 1975
SCALE IN FEET
200
0
200
400
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-2

MAINE HARBOR SURVEY TRIP TWO (BAR HARBOR AIRPORT)

Jonesport Harbor	(Figure E-6)
Pig Island Gut	(Figure E-7)
Beals Harbor	(Figure E-8)
Corea Harbor	(Figure E-9)
Bunker Harbor (Gouldsboro)	(Figure E-10)
Winter Harbor	(Figure E-11)

Jonesport Harbor			
Deadhead from Base at Bar Harbor		33.2 NM	0.332 Hr.
Survey:	3,990′	0.657 NM	0.033 Hr.
Pig Island Gut			
Deadhead from Jonesport		0.72 NM	0.007 Hr.
Survey:	6,400′	1.053 NM	0.053 Hr.
Beals Harbor			
Deadhead from Pig Island Gut		0.72 NM	0.007 Hr.
Survey:	3,000′	0.494 NM	0.025 Hr.
Corea Harbor			
Deadhead from Beals Harbor		17.03 NM	0.170 Hr.
Survey:	2,926′	0.481 NM	0.024 Hr.
Bunker Harbor			
Deadhead from Corea Harbor		5.34 NM	0.053 Hr.
Survey:	806′	0.133 NM	0.006 Hr.
Winter Harbor			
Deadhead from Bunker Harbor		5.8 NM	0.058 Hr.
Survey:	2,000′	0.329 NM	0.016 Hr.
Deadhead return to Bar Harbor Airport		5.05 NM	0.051 Hr.
Short stop deadhead allowance		13.3 NM	0.133 Hr.
Total deadhead		75.36 NM	0.754 Hr.
Total survey		2.818 NM	0.141 Hr.
Total		78.178 NM	0.895 Hr.

TRIP THREE

This is a series of seven harbors to be surveyed from a helicopter based at Bar Harbor Airport. These harbors include Bar Harbor, Northeast Harbor, Bass Harbor, Frenchboro Harbor (Long Island), Isle Au Haut, Deer Island Thoroughfare (Stonington) and Union River (Ellsworth) (Figures E-12 through E-18).

The GPS station for these surveys will be located at Bass Harbor, ME. UHF stations will be located at Cadillac Mountain, Schoodic Point and Sargentville, ME. A total of five automatic tide gauges will be required for these surveys, plus the two manned ground vehicles.

Because there are numerous stops along this survey route this analysis allows for helicopter acceleration and deceleration when the distance from one harbor to the next is less than ten nautical miles. This allowance consists of two minutes per harbor for a total of 0.30 hours.

Scenario Analysis

The helicopter will fly from Bar Harbor Airport to Bar Harbor (Figure E-12), a distance of 7.94 nautical miles requiring .079 hours. The survey of Bar Harbor will require a single pass of 2,510 feet or 0.413 nautical miles requiring 0.021 hours.

The helicopter will proceed from Bar Harbor to Northeast Harbor (Figure E-13), a distance of 6.49 nautical miles requiring 0.065 hours. The survey of Northeast Harbor requires seven passes of total length 11,500 feet or 1.89 nautical miles requiring 0.095 hours.

The helicopter will then fly from Northeast Harbor to Bass Harbor (Figure E-14), a distance of 4.04 nautical miles requiring 0.04 hours. The survey of Bass Harbor requires a total survey length of 4,742 feet or 0.78 nautical miles requiring 0.039 hours.

The helicopter will then proceed from Bass Harbor to Frenchboro Harbor off Long Island (Figure E-15), a distance of 7.50 nautical miles requiring 0.075 hours. The survey of Frenchboro Harbor can be accomplished in two passes of total length 2,183 feet, or 0.359 nautical miles, requiring 0.018 hours.

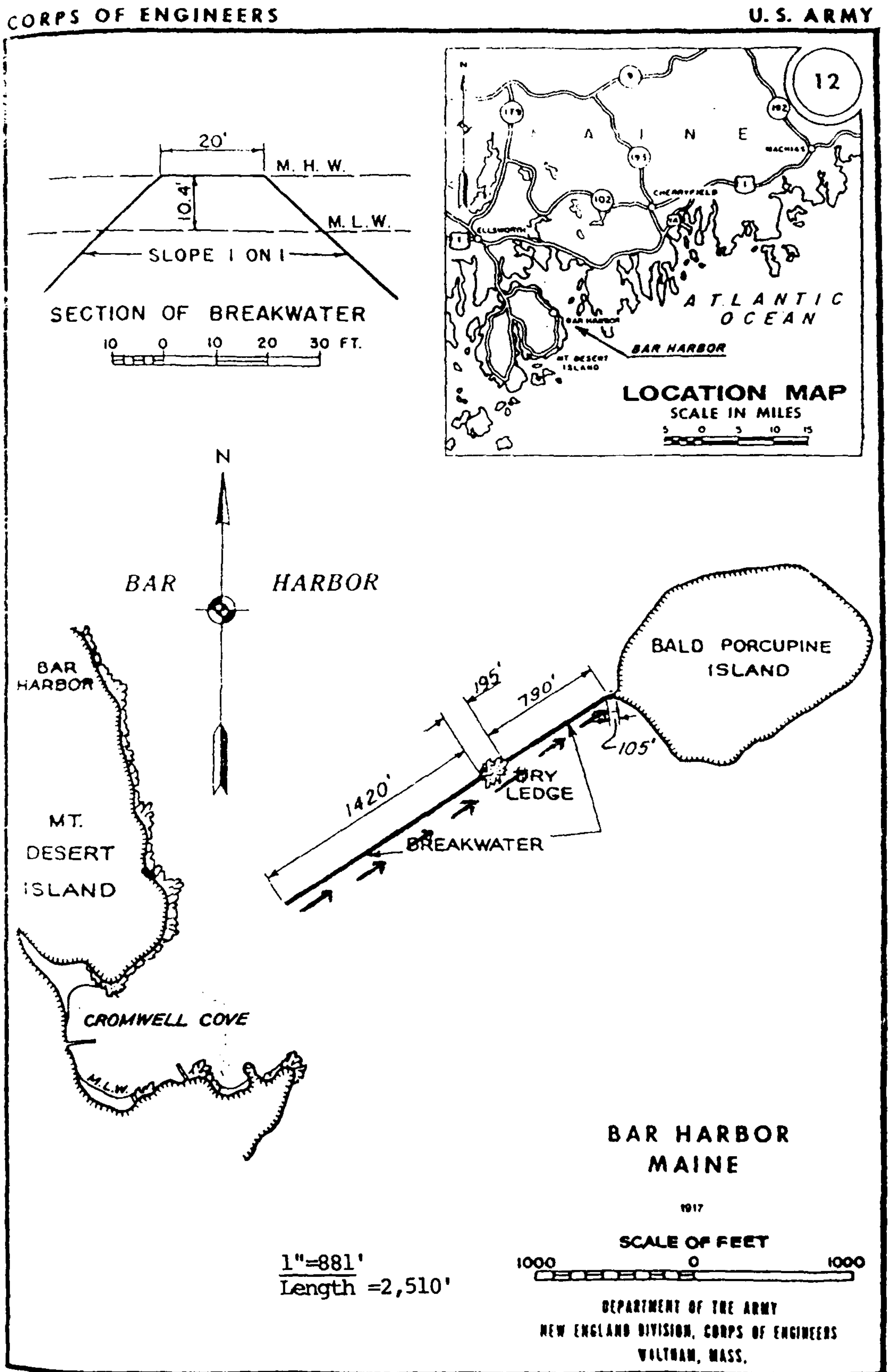
The helicopter will then fly from Frenchboro Harbor to Isle Au Haut, a distance of 11.98 nautical miles requiring 0.12 hours. The survey of Isle Au Haut Thoroughfare (Figure E-16) requires a single pass length of 1,685 feet or 0.277 nautical miles requiring 0.014 hours.

The helicopter will proceed from Isle Au Haut to Deer Island Thoroughfare (Stonington, Figure E-17), a distance of 6.93 nautical miles requiring 0.0693 hours. The survey will require a single pass of 1,250 feet or 0.206 nautical miles requiring 0.01 hours.

The helicopter will proceed from Deer Island Thoroughfare to Union River (Ellsworth, Figure E-18), a distance of 25.3 nautical miles requiring 0.253 hours. The total survey can be accomplished in a single pass of 21,780 feet or 3.58 nautical miles requiring 0.179 hours.

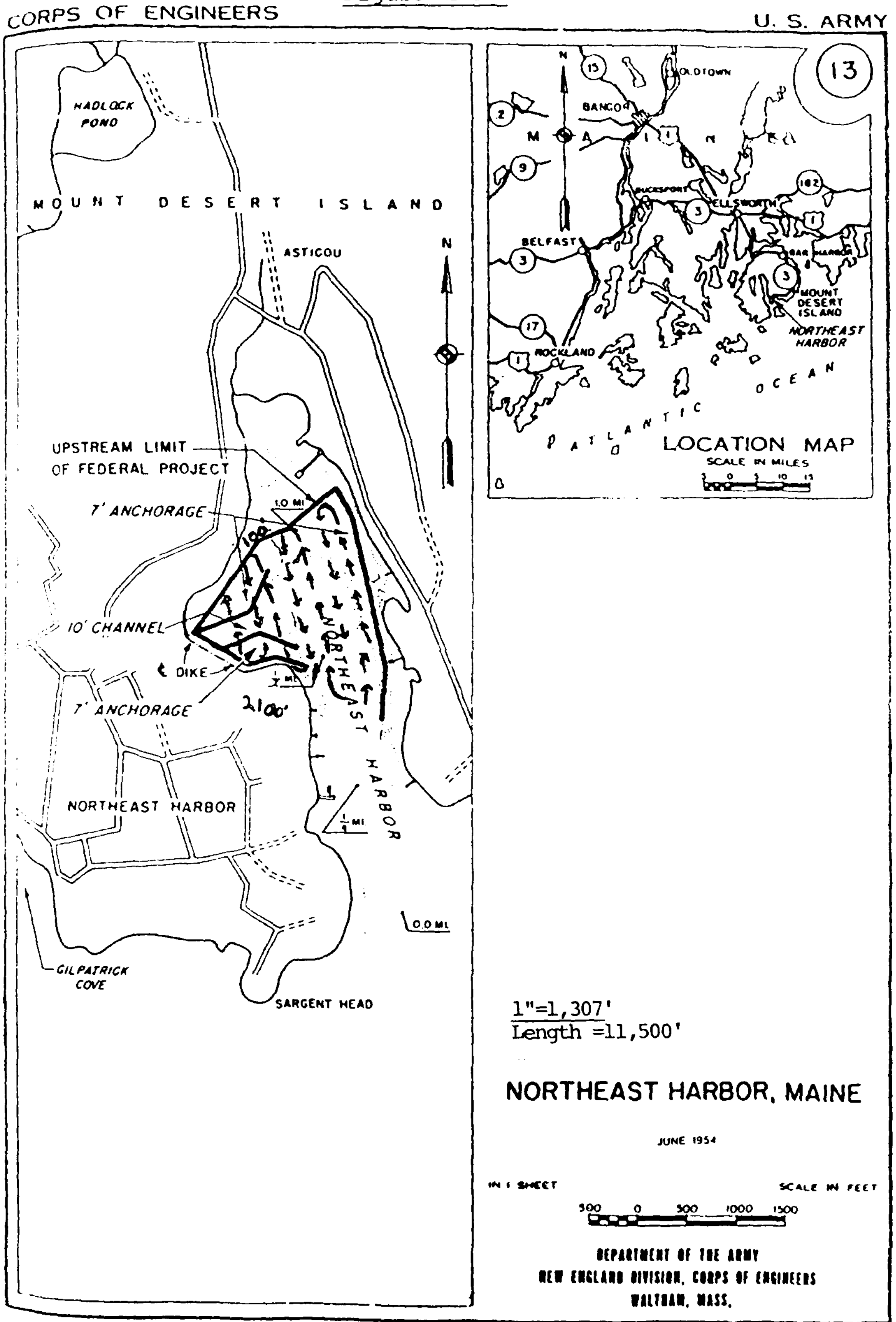
The helicopter will then return to Bar Harbor Airport, a distance of 5.78 nautical miles requiring 0.058 hours. Deadhead for this trip is 0.893 hours; survey time is 0.375 hours for a total time to survey of 1.268 hours (Table E-3).

Figure E-12



CORPS OF ENGINEERS
U.S. ARMY
20'
M. H. W.
10.4'
M. L. W.
SLOPE 1 ON 1
SECTION OF BREAKWATER
10 0 10 20 30 FT.
12
MAINE
ATLANTIC OCEAN
BAR HARBOR
LOCATION MAP
SCALE IN MILES
N
BAR HARBOR
BAR HARBOR
MT. DESERT ISLAND
BALD PORCUPINE ISLAND
195'
790'
1420'
105'
DRY LEDGE
BREAKWATER
CROMWELL COVE
M.L.W.
BAR HARBOR MAINE
1917
SCALE OF FEET
1000 0 1000
1"=881'
Length =2,510'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-13



1"=1,307'
Length =11,500'

NORTHEAST HARBOR, MAINE

JUNE 1954

IN 1 SHEET

SCALE IN FEET

500 0 500 1000 1500

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-14

CORPS OF ENGINEERS

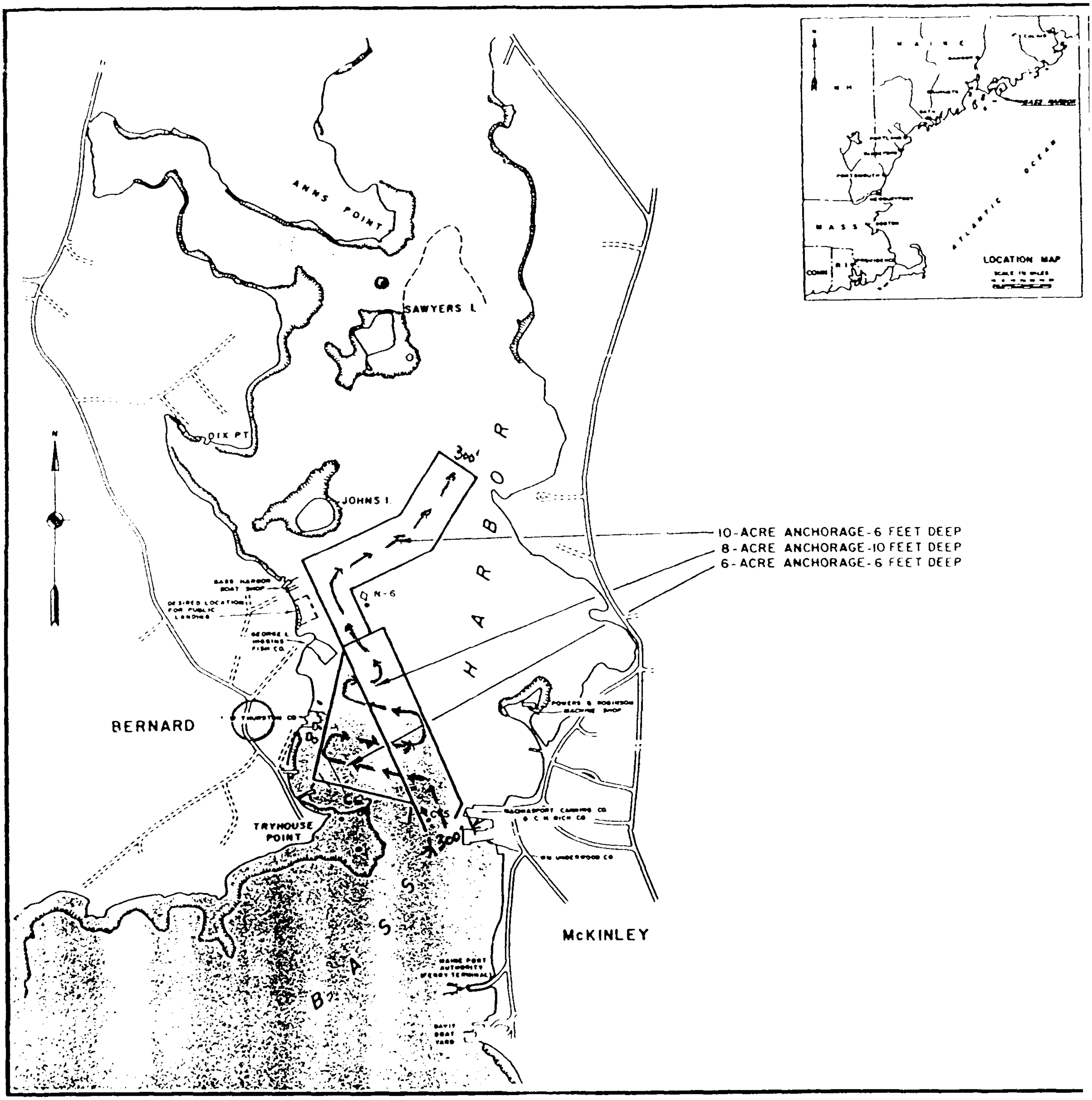


Figure E-14

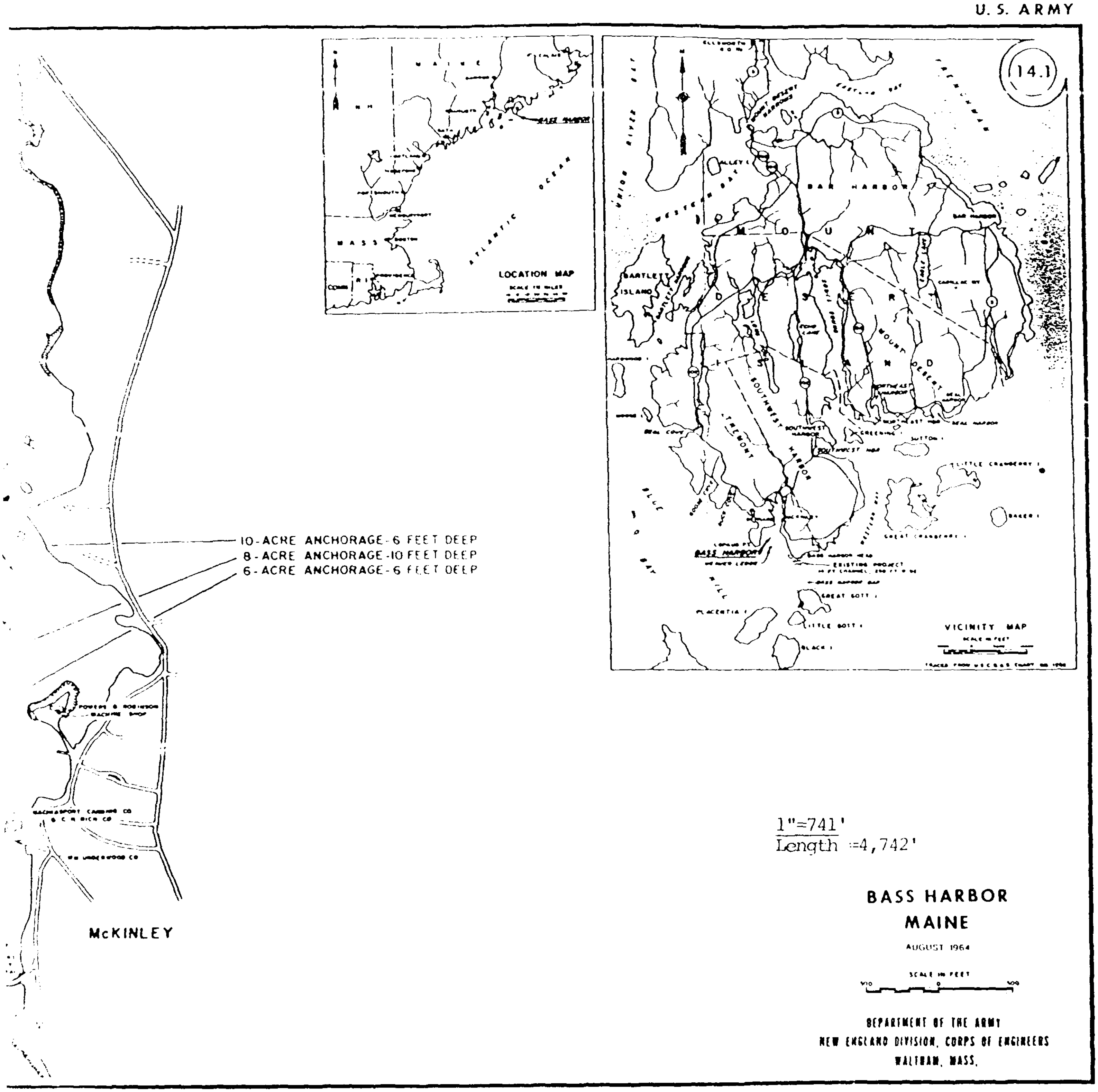

U. S. ARMY
14.1
LOCATION MAP
ATLANTIC OCEAN
MAINE
N. H.
MASS
CONN
R. I.
BASS HARBOR
VICINITY MAP
BAR HARBOR
MOUNT DESERT
BARTLETT ISLAND
WESTERN BAY
SOUTHWEST HARBOR
TREMONT
SEAL COVE
NORTHEAST HBR
SEAL HARBOR
LITTLE CRANBERRY I.
GREAT CRANBERRY I.
BAKER I.
BASS HARBOR HEAD
EXISTING PROJECT
BASS HARBOR BAR
GREAT GOTT I.
LITTLE GOTT I.
PLACENTIA I.
BLACK I.
BLUE HILL BAY
10-ACRE ANCHORAGE-6 FEET DEEP
8-ACRE ANCHORAGE-10 FEET DEEP
6-ACRE ANCHORAGE-6 FEET DEEP
POWERS & ROBINSON MACHINE SHOP
McKINLEY
1"=741'
Length =4,742'
BASS HARBOR
MAINE
AUGUST 1964
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-15

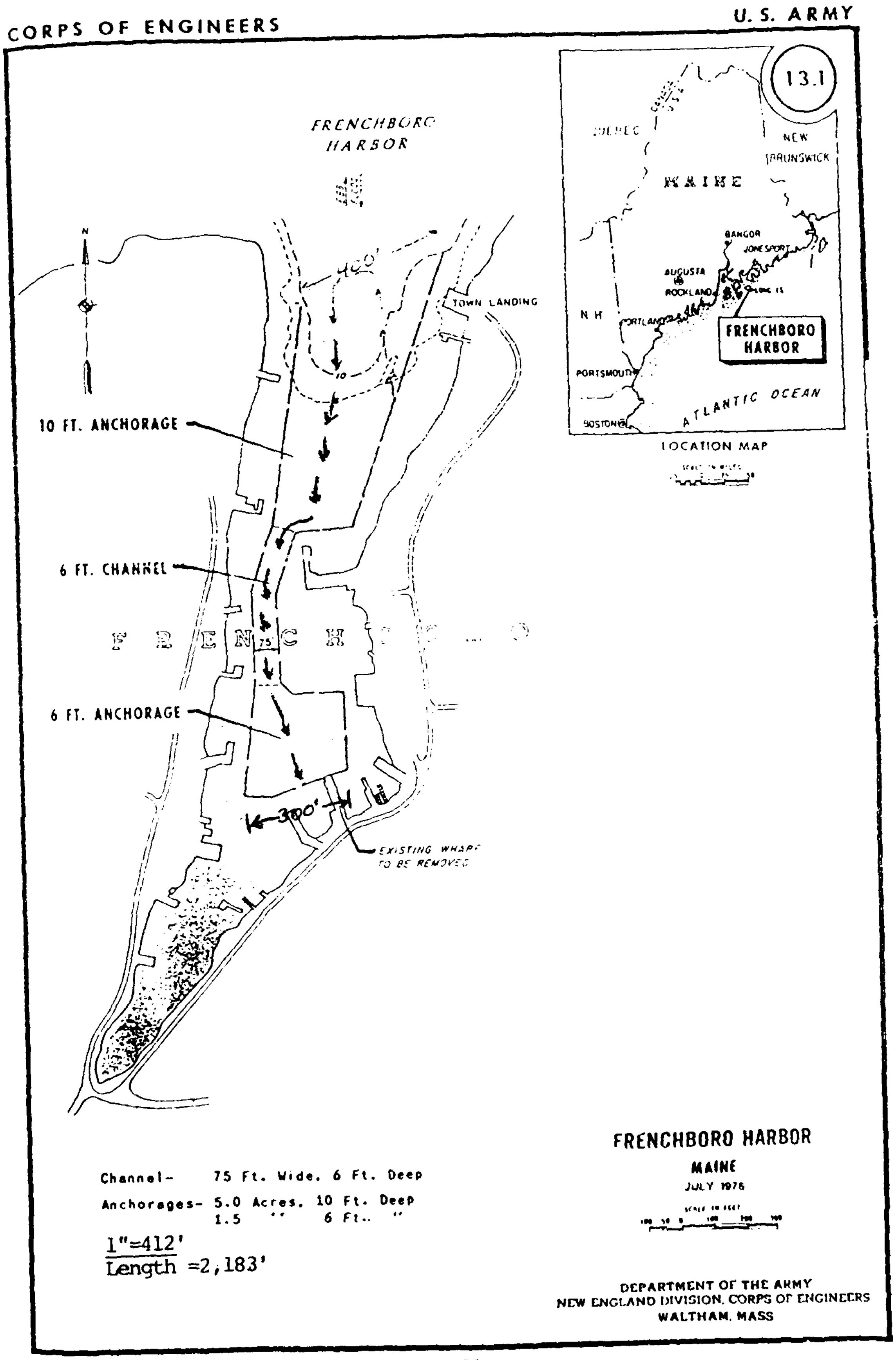

CORPS OF ENGINEERS
U. S. ARMY
FRENCHBORO HARBOR
400'
TOWN LANDING
10 FT. ANCHORAGE
6 FT. CHANNEL
6 FT. ANCHORAGE
75'
300'
EXISTING WHARF TO BE REMOVED
13.1
NEW BRUNSWICK
MAINE
BANGOR
JONESPORT
AUGUSTA
ROCKLAND
N H
PORTLAND
PORTSMOUTH
BOSTON
ATLANTIC OCEAN
FRENCHBORO HARBOR
LOCATION MAP
FRENCHBORO HARBOR
MAINE
JULY 1976
Channel- 75 Ft. Wide, 6 Ft. Deep
Anchorages- 5.0 Acres, 10 Ft. Deep
1.5 " 6 Ft. "
1"=412'
Length =2,183'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

Figure E-16

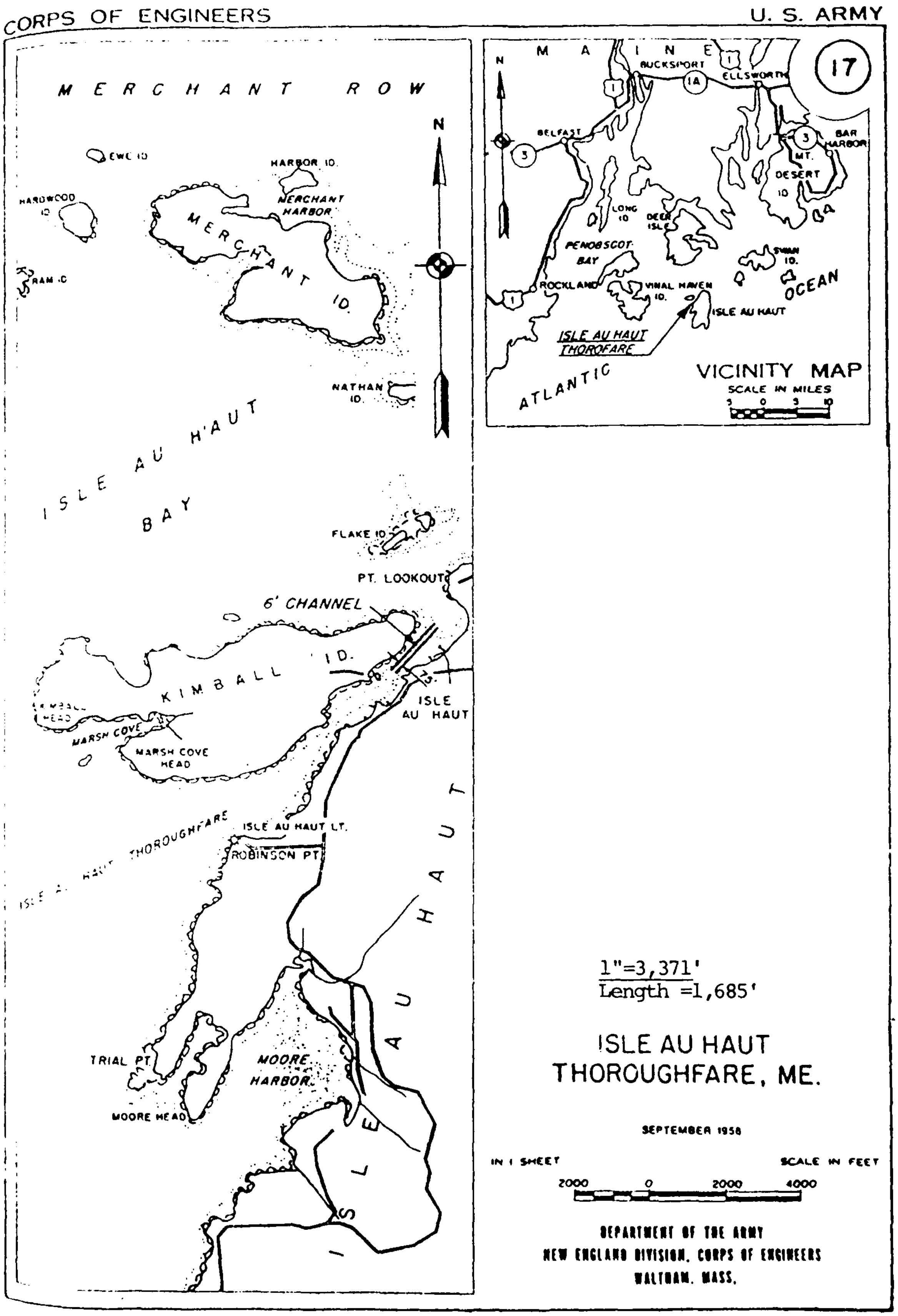

CORPS OF ENGINEERS
U. S. ARMY
MERCHANT ROW
N
EWE ID.
HARBOR ID.
HARDWOOD ID.
MERCHANT HARBOR
MERCHANT ID.
RAM ID.
NATHAN ID.
ISLE AU HAUT BAY
FLAKE ID.
PT. LOOKOUT
6' CHANNEL
KIMBALL ID.
KIMBALL HEAD
MARSH COVE
MARSH COVE HEAD
ISLE AU HAUT
ISLE AU HAUT THOROUGHFARE
ISLE AU HAUT LT.
ROBINSON PT.
TRIAL PT.
MOORE HARBOR
MOORE HEAD
ISLE AU HAUT
MAINE
BUCKSPORT
ELLSWORTH
17
BELFAST
BAR HARBOR
MT. DESERT ID.
LONG ID.
DEER ISLE
PENOBSCOT BAY
SWAN ID.
ROCKLAND
VINAL HAVEN ID.
OCEAN
ISLE AU HAUT
ISLE AU HAUT THOROFARE
ATLANTIC
VICINITY MAP
SCALE IN MILES
1"=3,371'
Length =1,685'
ISLE AU HAUT THOROUGHFARE, ME.
SEPTEMBER 1958
IN 1 SHEET
SCALE IN FEET
2000 0 2000 4000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-17

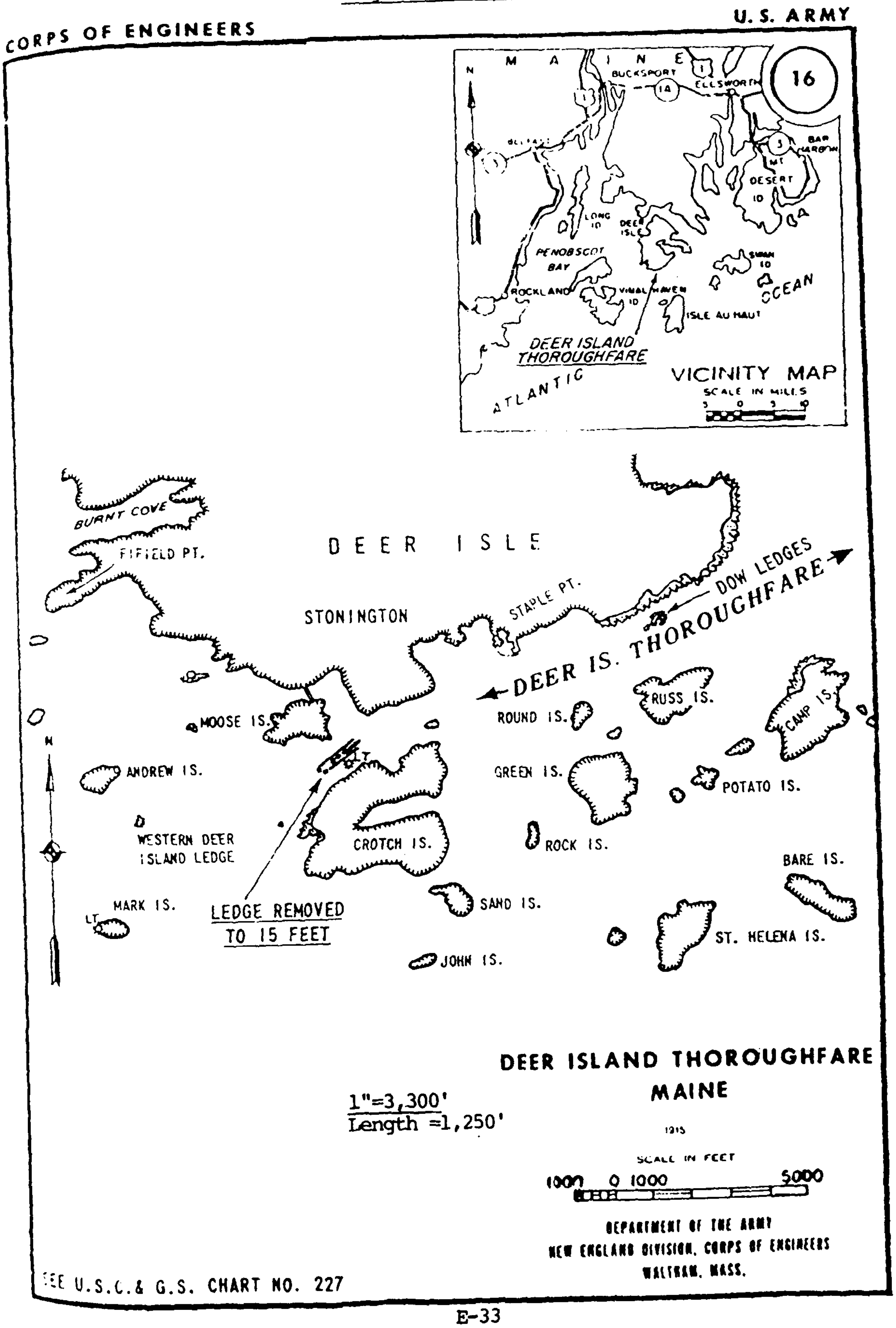

CORPS OF ENGINEERS
U. S. ARMY
M A I N E
BUCKSPORT
ELLSWORTH
16
BAR HARBOR
MT DESERT ID
LONG ID
DEER ISLE
PENOBSCOT BAY
SWAN ID
ROCKLAND
VINALHAVEN ID
OCEAN
ISLE AU HAUT
DEER ISLAND THOROUGHFARE
ATLANTIC
VICINITY MAP
SCALE IN MILES
BURNT COVE
FIFIELD PT.
DEER ISLE
STONINGTON
STAPLE PT.
DOW LEDGES
DEER IS. THOROUGHFARE
MOOSE IS.
ROUND IS.
RUSS IS.
CAMP IS.
ANDREW IS.
GREEN IS.
POTATO IS.
WESTERN DEER ISLAND LEDGE
CROTCH IS.
ROCK IS.
BARE IS.
MARK IS.
LT
LEDGE REMOVED TO 15 FEET
SAND IS.
ST. HELENA IS.
JOHN IS.
DEER ISLAND THOROUGHFARE
MAINE
1"=3,300'
Length =1,250'
SCALE IN FEET
1000 0 1000 5000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
SEE U.S.C.& G.S. CHART NO. 227

Figure E-18

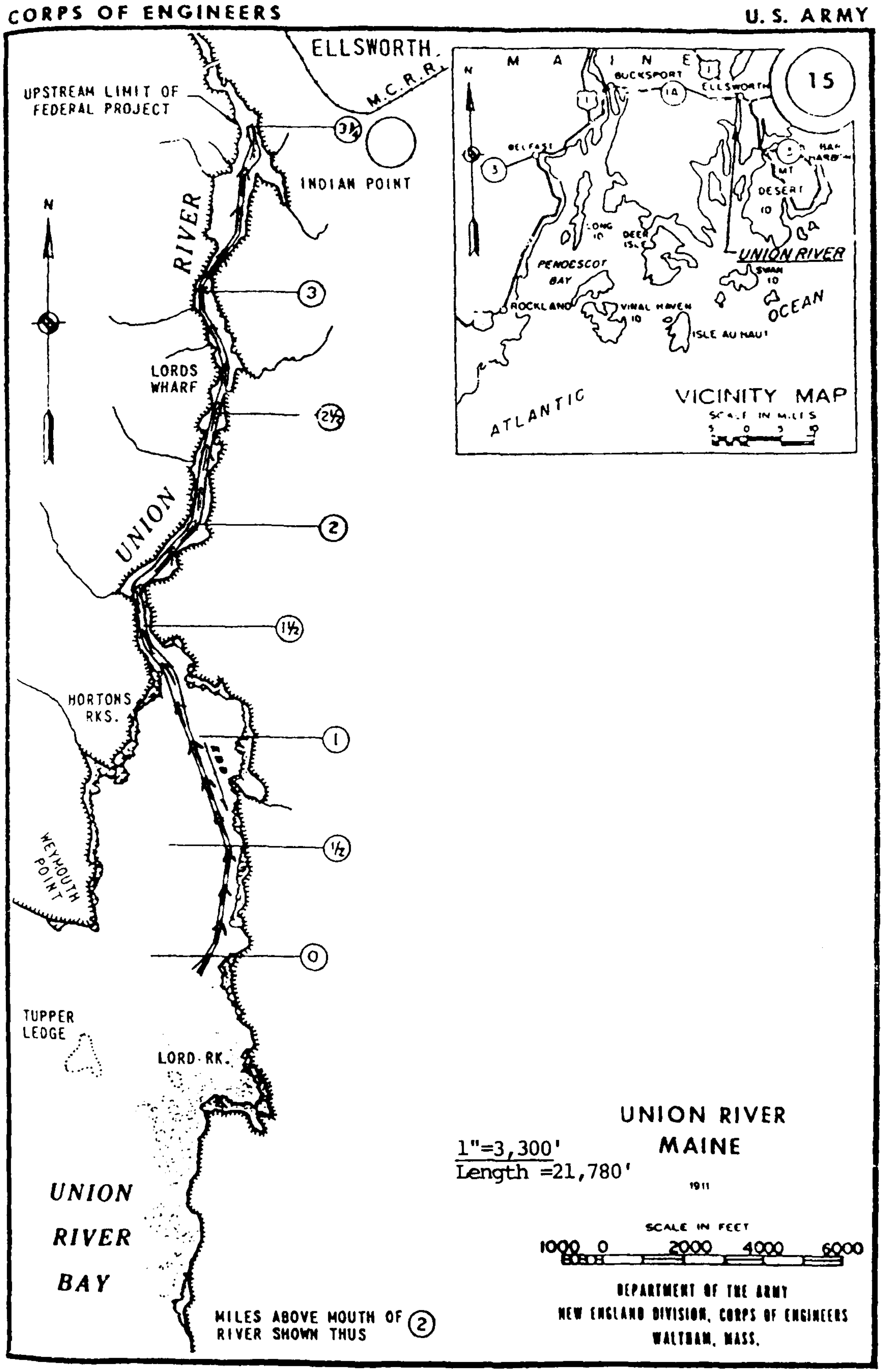

CORPS OF ENGINEERS
U.S. ARMY
ELLSWORTH
M.C.R.R.
UPSTREAM LIMIT OF FEDERAL PROJECT
INDIAN POINT
RIVER
LORDS WHARF
UNION
HORTONS RKS.
WEYMOUTH POINT
TUPPER LEDGE
LORD RK.
UNION RIVER BAY
MILES ABOVE MOUTH OF RIVER SHOWN THUS
MAINE
BUCKSPORT
ELLSWORTH
BELFAST
MT DESERT
UNION RIVER
PENOBSCOT BAY
ROCKLAND
VINAL HAVEN
ISLE AU HAUT
OCEAN
ATLANTIC
VICINITY MAP
15
UNION RIVER
MAINE
1"=3,300'
Length =21,780'
1911
SCALE IN FEET
1000 0 2000 4000 6000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-3

MAINE HARBOR SURVEY TRIP THREE (BAR HARBOR AIRPORT)

Bar Harbor	(Figure E-12)
Northeast Harbor	(Figure E-13)
Bass Harbor	(Figure E-14)
Frenchboro Harbor (Long Island)	(Figure E-15)
Isle Au Haut	(Figure E-16)
Deer Island Thoroughfare (Stonington)	(Figure E-17)
Union River (Ellsworth)	(Figure E-18)

Bar Harbor			
Deadhead from Bar Harbor Airport		7.94 NM	.079 Hr.
Survey:	2,510'	0.413 NM	0.021 Hr.
Northeast Harbor			
Deadhead from Bar Harbor		6.49 NM	0.065 Hr.
Survey:	11,500'	1.89 NM	0.095 Hr.
Bass Harbor			
Deadhead from Northeast Harbor		4.04 NM	0.04 Hr.
Survey:	4,742'	0.78 NM	0.039 Hr.
Frenchboro Harbor			
Deadhead from Bass Harbor		7.50 NM	0.075 Hr.
Survey:	2,183'	0.359 NM	0.018 Hr.
Isle au Haut			
Deadhead from Frenchboro Harbor		11.98 NM	0.12 Hr.
Survey:	1,685'	0.277 NM	0.014 Hr.
Deer Island Thoroughfare			
Deadhead from Isle Au Haut		6.93 NM	0.069 Hr.
Survey:	1,250'	0.206 NM	0.010 Hr.
Union River			
Deadhead from Deer Island Thoroughfare		25.3 NM	0.253 Hr.
Survey:	21,780'	3.58 NM	0.179 Hr.
Deadhead return to Bar Harbor Airport		5.78 NM	0.058 Hr.
Short stop deadhead allowance		13.33 NM	0.133 Hr.
Total deadhead		89.29 NM	0.893 Hr.
Total survey		7.51 NM	0.375 Hr.
Total		96.80 NM	1.268 Hr.

TRIP FOUR

This is a series of seven harbors surveyed from a helicopter base at Rockland Airport. The harbors to be surveyed are: Stockton Harbor, Searsport Harbor, Belfast Harbor, Camden Harbor, Carvers Harbor (Vinalhaven), Owls Head Harbor, and George River (Thomaston). (Figures E-19 to E-25). The GPS station for these surveys is located in Rockland. UHF stations will be located at Seargentville and Rockport, ME. A total of seven automatic tide gauges will be required for these surveys.

Scenario Analysis

The helicopter will proceed from Rockland Airport to Stockton Harbor (Figure E-19), a distance of 27.13 nautical miles requiring 0.271 hours. The survey of Stockton Harbor can be accomplished in a single pass of length 4,200 feet or 0.69 nautical miles requiring 0.035 hours.

The helicopter will fly from Stockton to Searsport Harbor (Figure E-20), a distance of 6.06 nautical miles, requiring 0.061 hours. The survey of Searsport Harbor can be accomplished in six passes of total length 18,161 feet or 2.99 nautical miles requiring 0.149 hours.

The helicopter will proceed from Searsport to Belfast Harbor (Figure E-21), a distance of 4.33 nautical miles requiring 0.043 hours. The survey of Belfast Harbor will require six passes of total length 5,614 feet or 0.92 nautical miles requiring 0.046 hours.

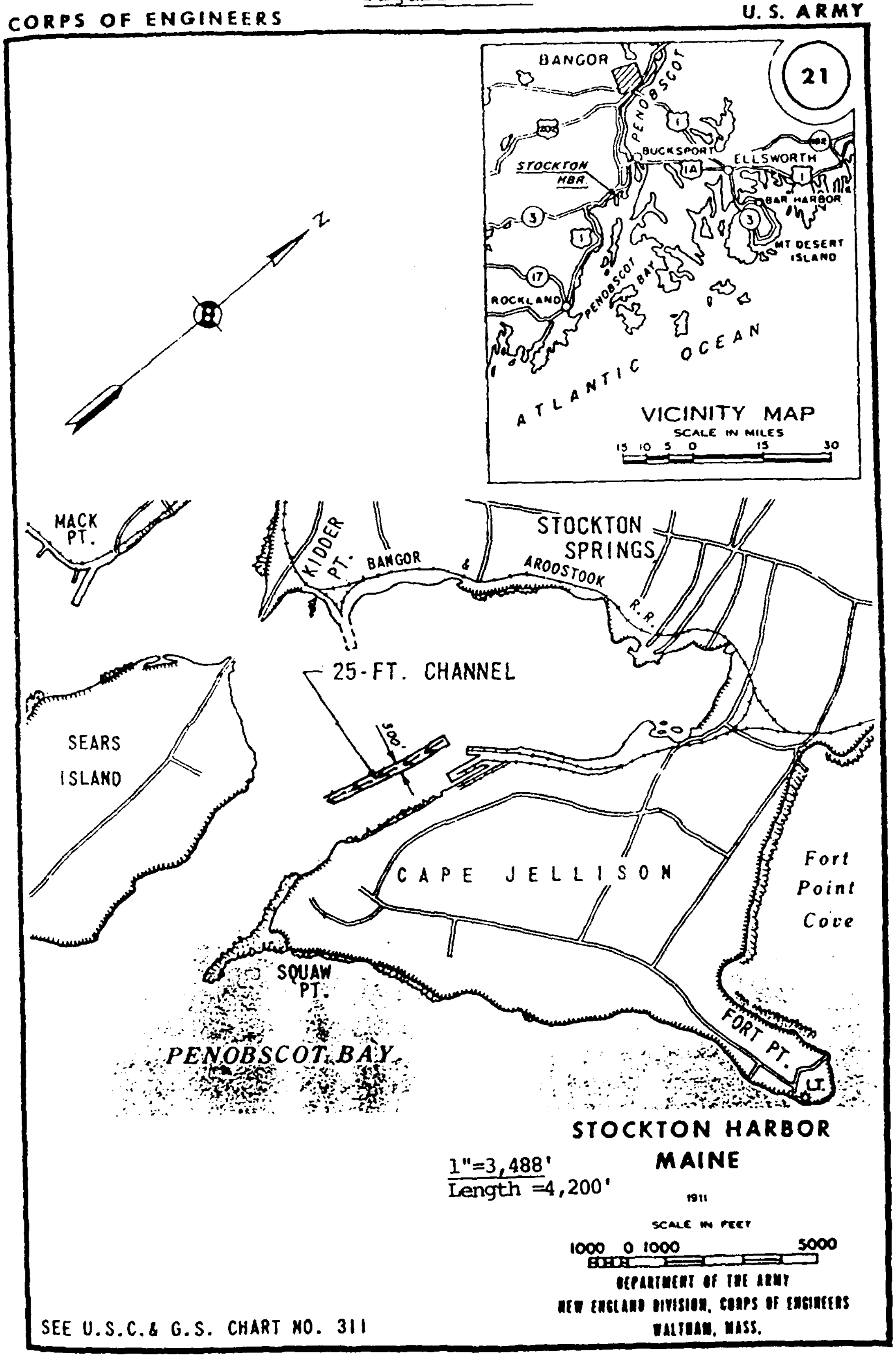
The helicopter will proceed from Belfast to Camden Harbor (Figure E-23), a distance of 12.3 nautical miles requiring 0.123 hours. The survey of Camden Harbor can be accomplished in three passes of total length 7,802 feet or 1.28 nautical miles requiring 0.064 hours.

The helicopter will proceed from Camden to Carvers Harbor, on Vinalhaven Island (Figure E-23), a distance of 14.43 nautical miles requiring 0.144 hours. The survey will require seven passes of total length 10,234 feet or 1.68 nautical miles requiring 0.084 hours.

The helicopter will fly from Carvers Harbor to Owls Head Harbor (Figure E-24), a distance of 10.25 nautical miles requiring 0.103 hours. The survey of Owls Head Harbor requires two passes of total length 1,523 feet or 0.25 nautical miles requiring 0.013 hours. The helicopter will fly from Owls Head Harbor to George's River (Thomaston) (Figure E-25), a distance of 5.48 nautical miles requiring 0.055 hours. The survey of George's River can be accomplished in a single pass of total length 4,617 feet or 0.76 nautical miles requiring 0.038 hours.

Since there are a number of short stops in this survey group, allowance has been made for acceleration and deceleration of two minutes for each harbor which is less than ten nautical miles from the preceding harbor. This amounts to an additional deadhead of 0.10 hours. The helicopter will return from George's River to Rockland Airport, a distance of 3.32 nautical miles requiring 0.033 hours. Total deadhead required for this survey collection is 0.933 hours. Total surveying time for this collection is 0.429 hours for a total time of 1.362 hours (Table E-4).

Figure E-19



1"=3,488'
Length =4,200'

Figure E-20

CORPS OF ENGINEERS

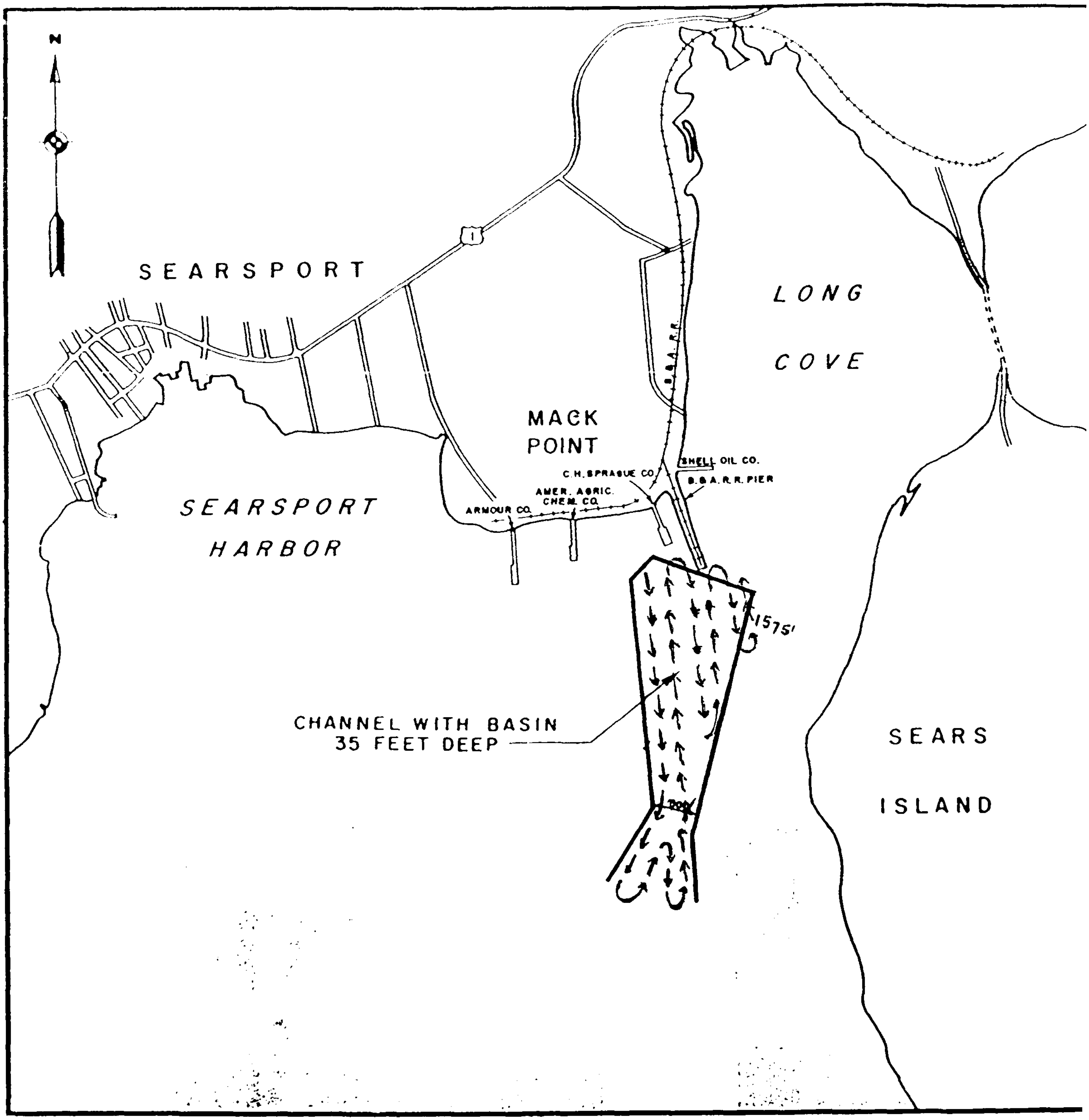


Figure E-20

U.S. ARMY

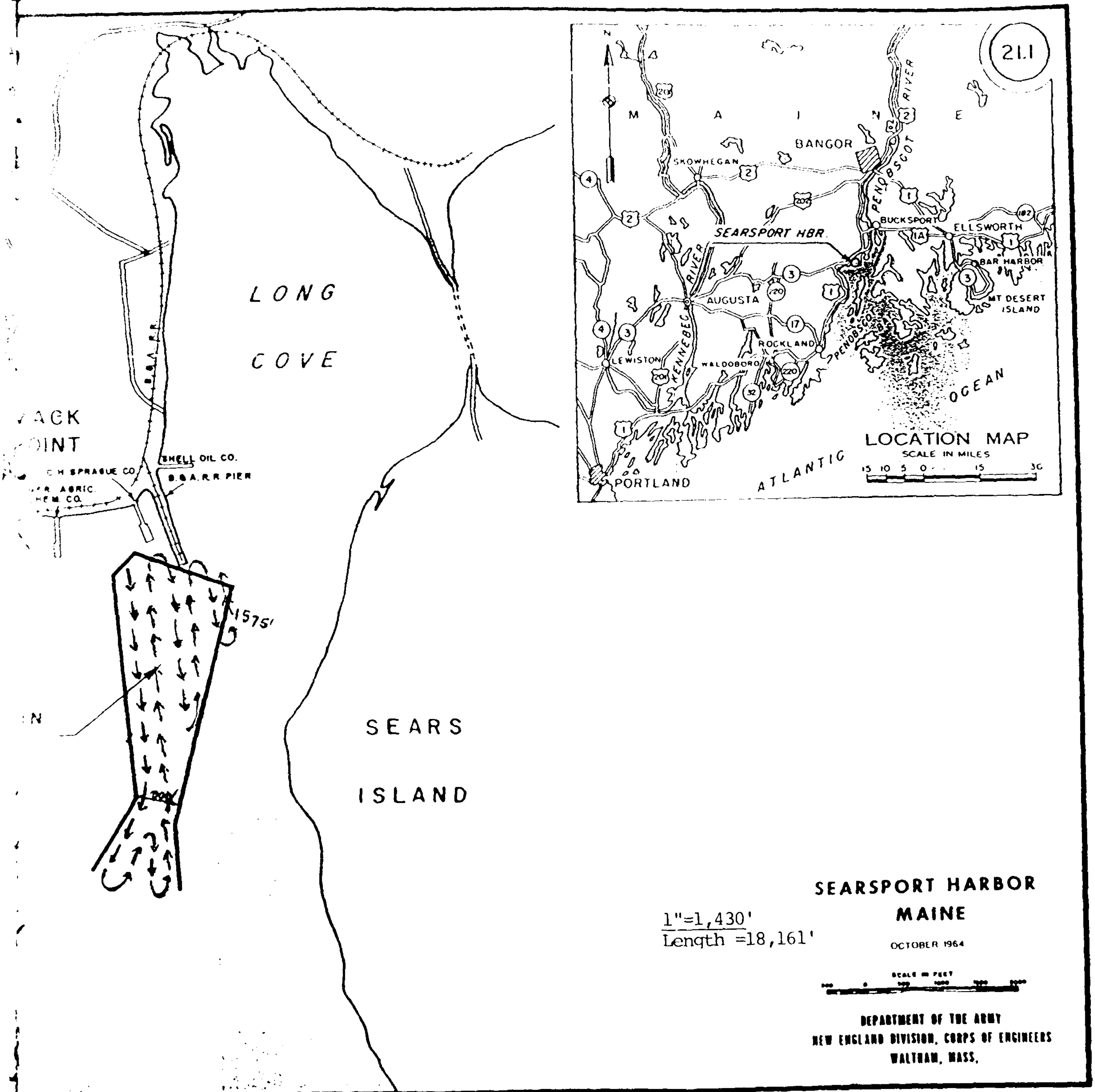


Figure E-21

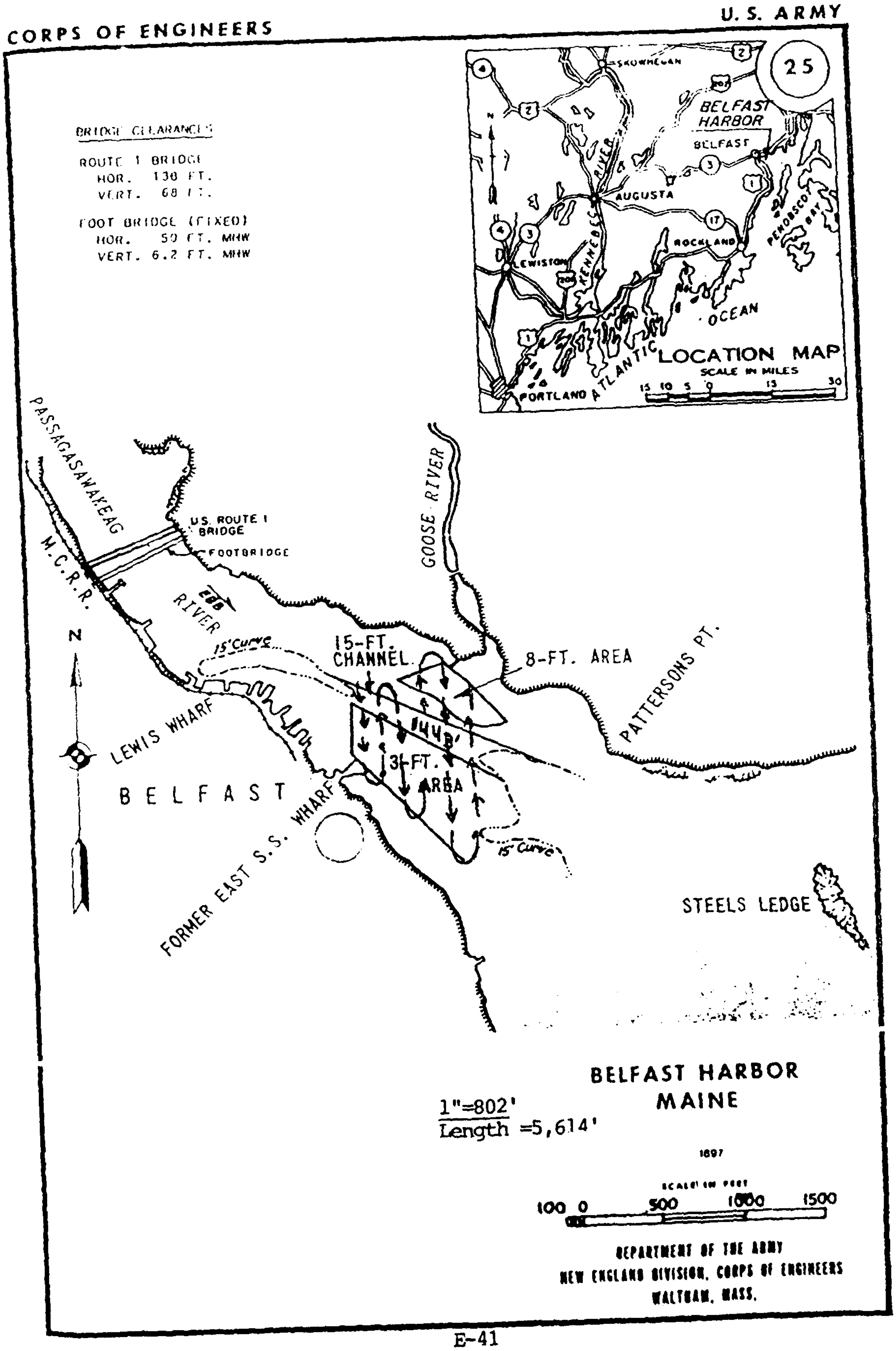

U.S. ARMY
CORPS OF ENGINEERS
BRIDGE CLEARANCES
ROUTE 1 BRIDGE
HOR. 138 FT.
VERT. 68 FT.
FOOT BRIDGE (FIXED)
HOR. 50 FT. MHW
VERT. 6.2 FT. MHW
25
BELFAST HARBOR
SKOWHEGAN
BELFAST
AUGUSTA
KENNEBEC RIVER
LEWISTON
ROCKLAND
PENOBSCOT BAY
OCEAN
ATLANTIC
PORTLAND
LOCATION MAP
SCALE IN MILES
15 10 5 0 15 30
PASSAGASAWAKEAG
M.C.R.R.
U.S. ROUTE 1 BRIDGE
FOOTBRIDGE
RIVER
EBB
GOOSE RIVER
15' Curve
15-FT. CHANNEL
8-FT. AREA
PATTERSONS PT.
LEWIS WHARF
BELFAST
3-FT. AREA
FORMER EAST S.S. WHARF
STEELS LEDGE
N
BELFAST HARBOR
MAINE
1"=802'
Length =5,614'
1897
SCALE IN FEET
100 0 500 1000 1500
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-22

CORPS OF ENGINEERS U.S. ARMY

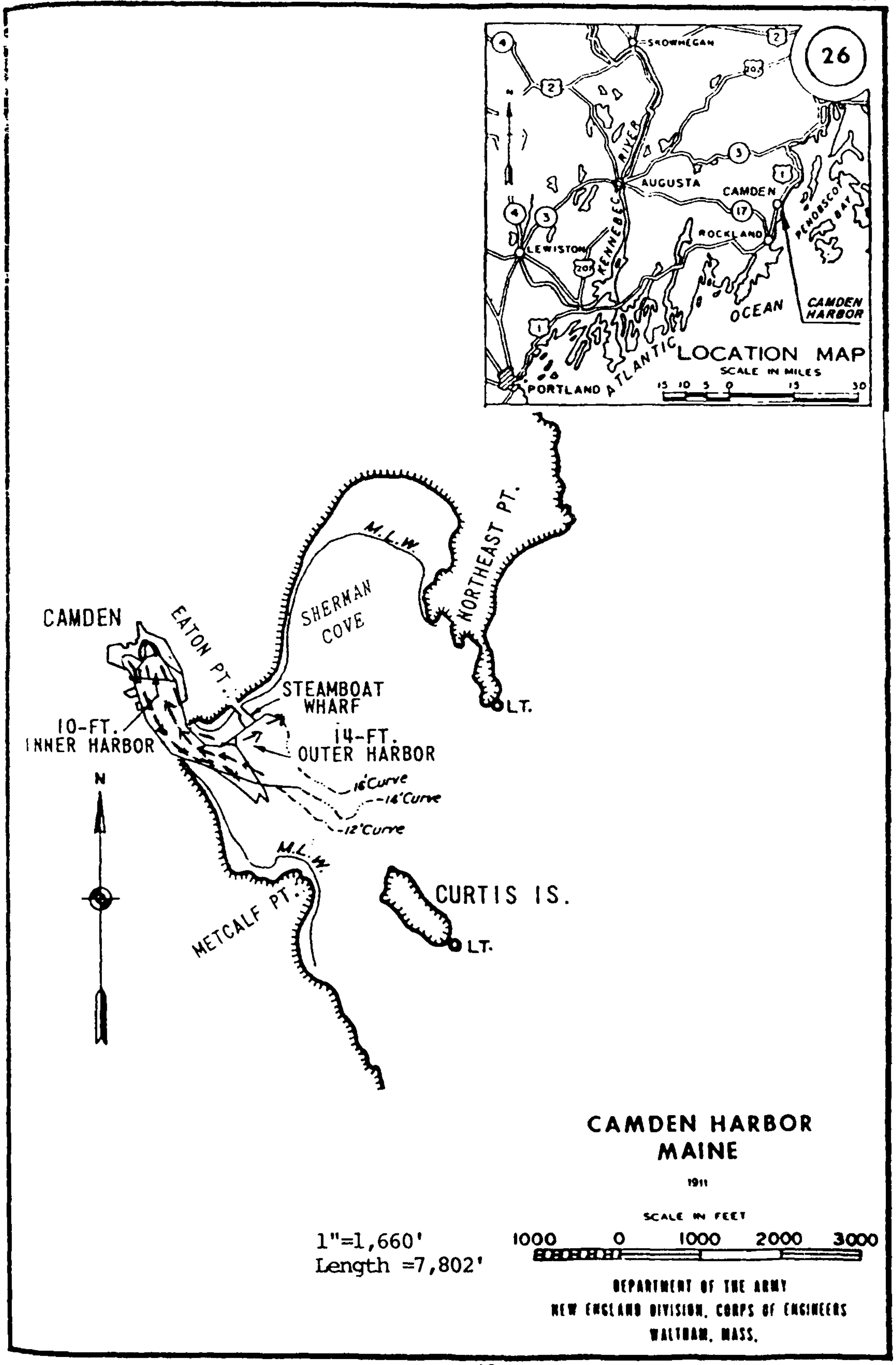


Figure E-23

CORPS OF ENGINEERS

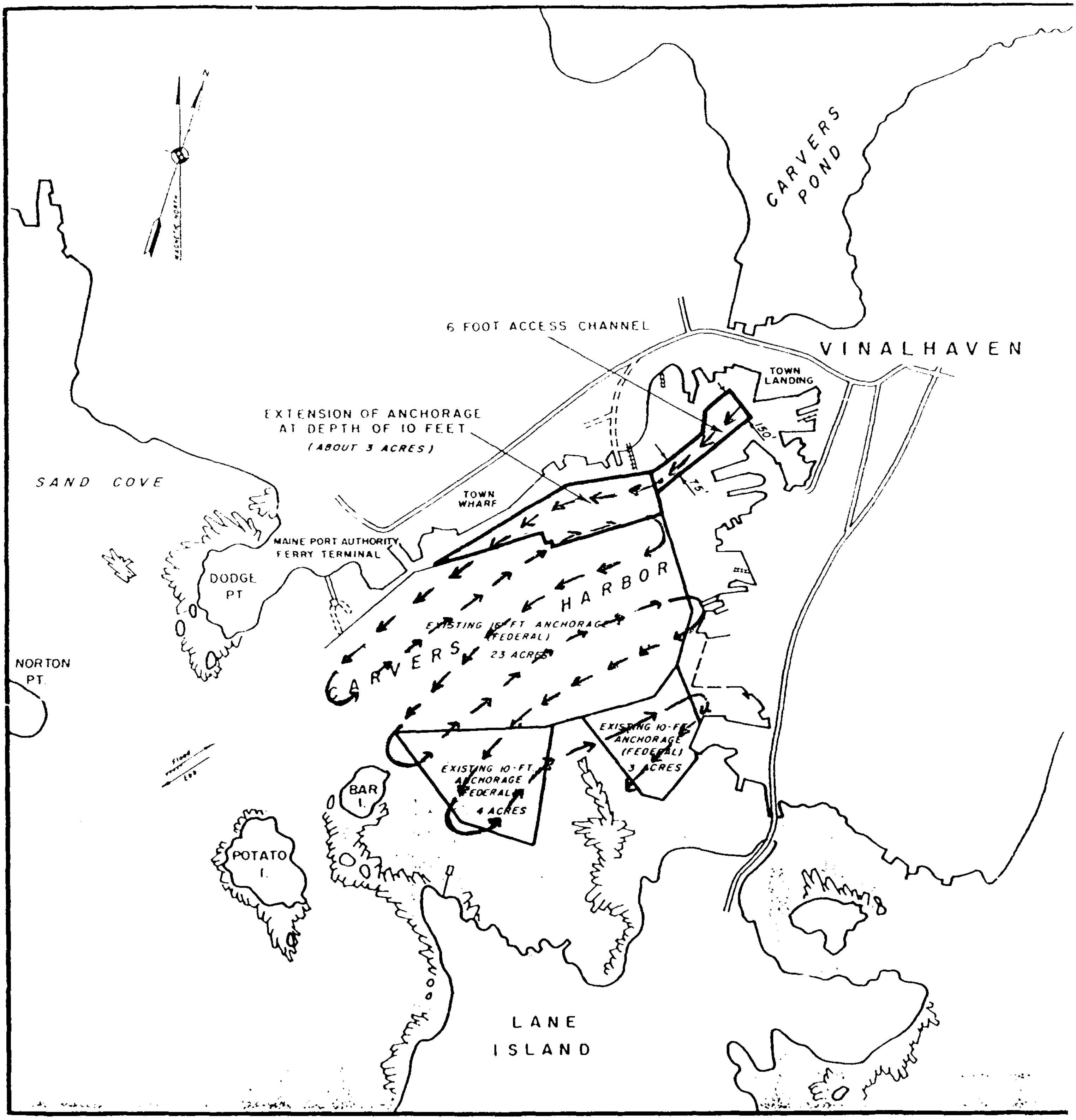
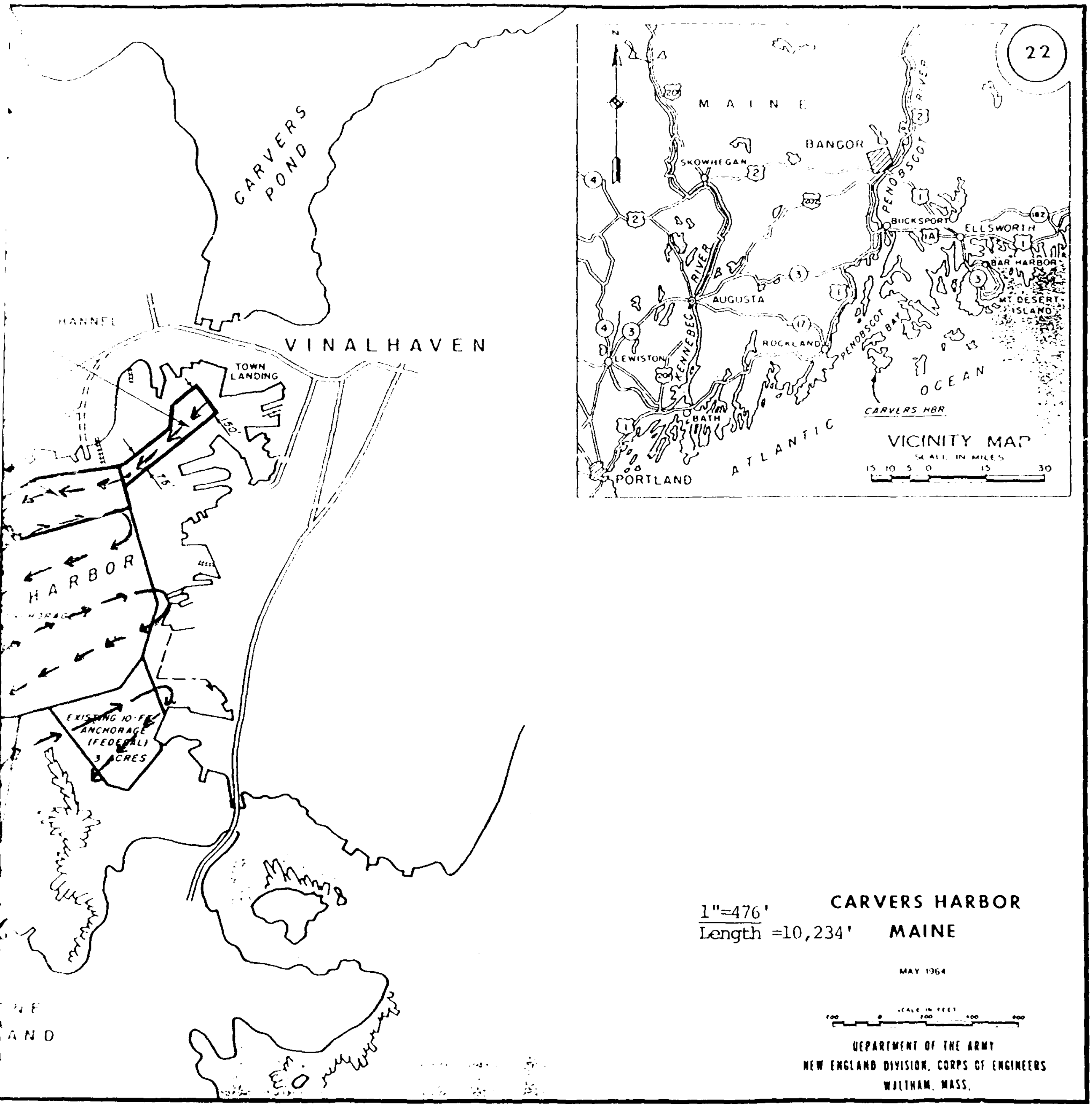


Figure E-23

U. S. ARMY



1"=476'
Length =10,234'

CARVERS HARBOR
MAINE

MAY 1964

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-24

CORPS OF ENGINEERS U.S. ARMY

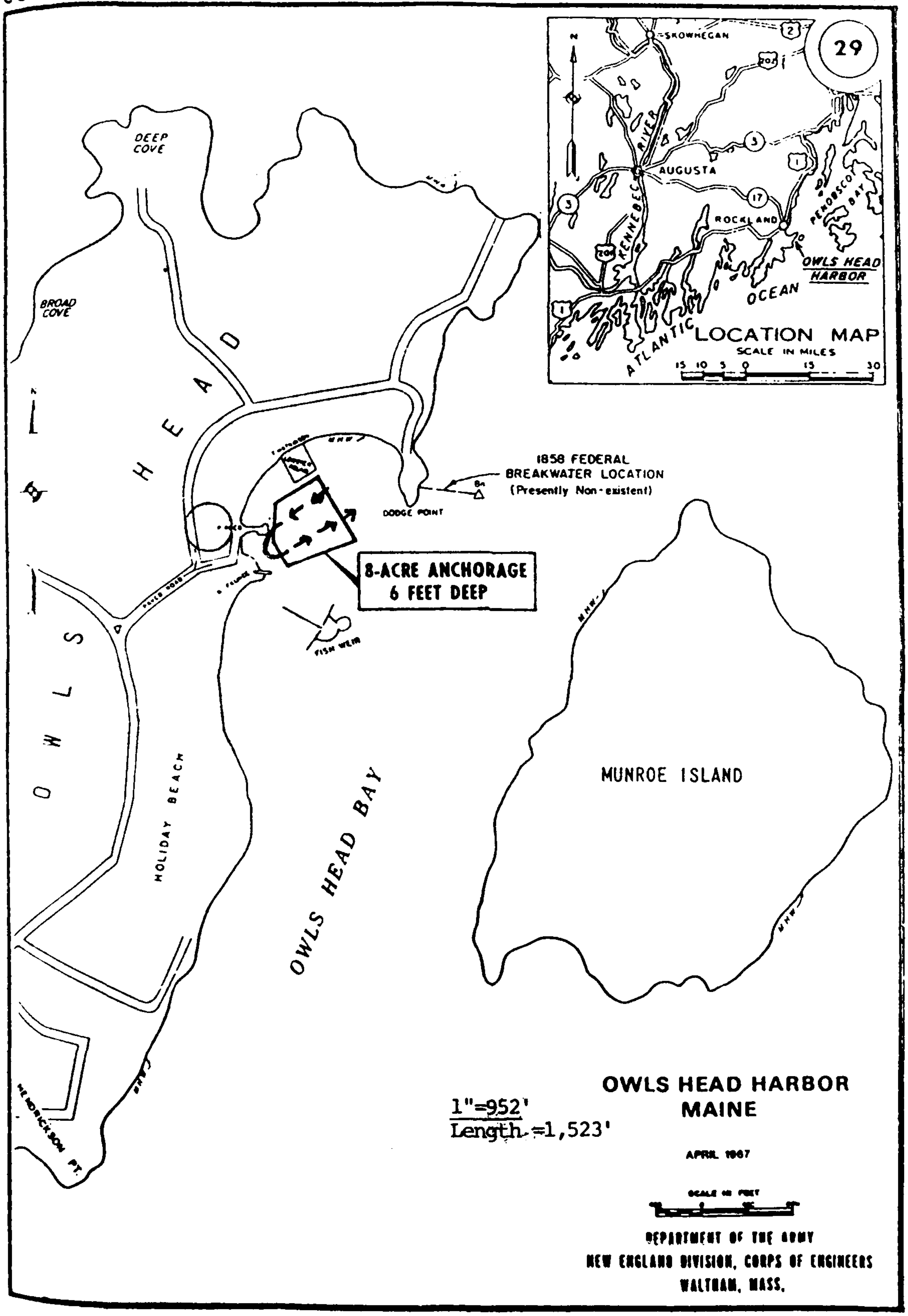


Figure E-25

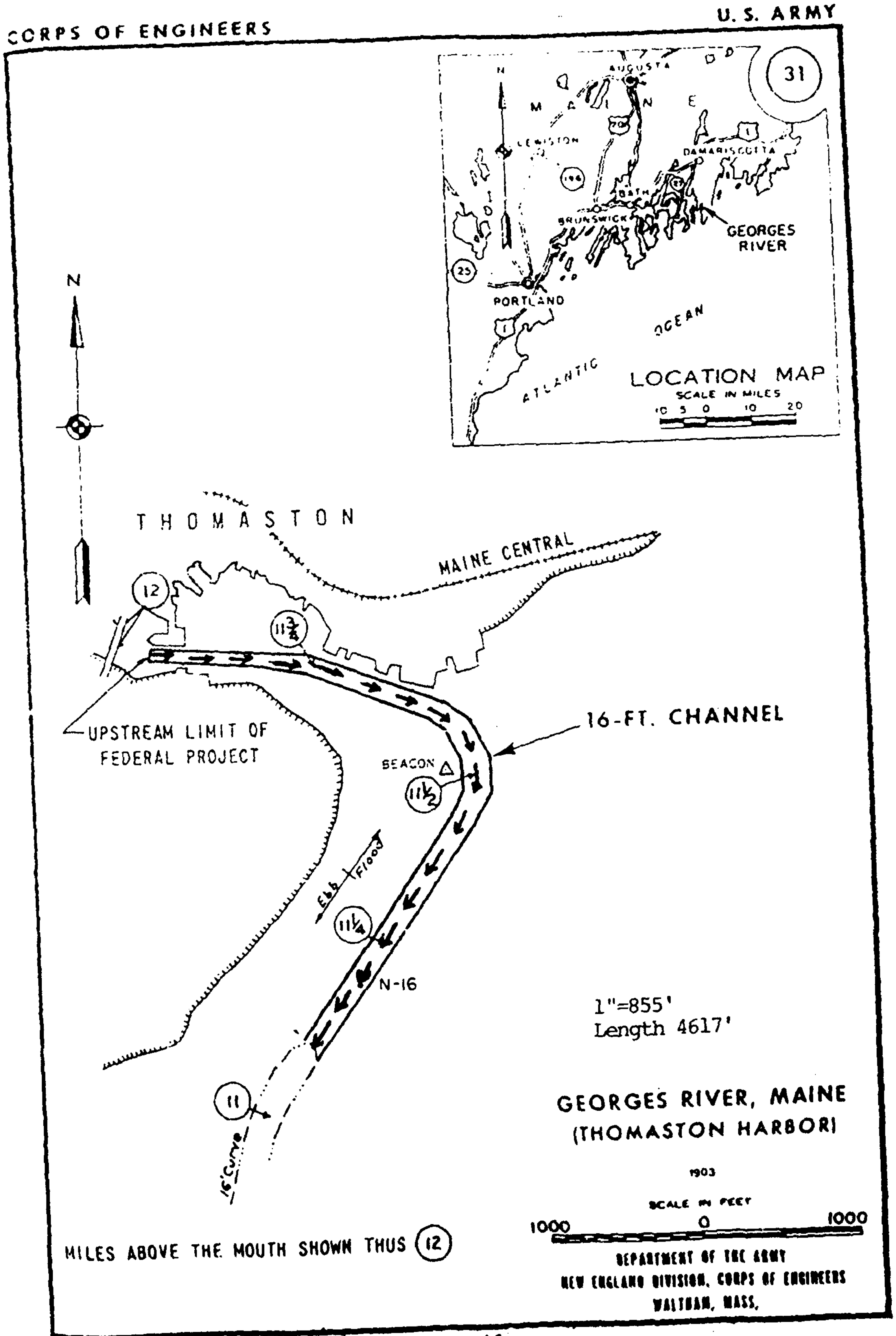

CORPS OF ENGINEERS
U. S. ARMY
31
AUGUSTA
MAINE
LEWISTON
DAMARISCOTTA
BATH
BRUNSWICK
GEORGES RIVER
PORTLAND
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
10 5 0 10 20
N
THOMASTON
MAINE CENTRAL
12
11 3/4
UPSTREAM LIMIT OF FEDERAL PROJECT
16-FT. CHANNEL
BEACON
11 1/2
Ebb
Flood
11 1/4
N-16
11
16' Curve
1"=855'
Length 4617'
GEORGES RIVER, MAINE
(THOMASTON HARBOR)
1903
SCALE IN FEET
1000 0 1000
MILES ABOVE THE MOUTH SHOWN THUS 12
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-4

MAINE HARBOR SURVEY TRIP FOUR (ROCKLAND AIRPORT)

Stockton Harbor	(Figure E-19)
Searsport Harbor	(Figure E-20)
Belfast Harbor	(Figure E-21)
Camden Harbor	(Figure E-22)
Carver's Harbor (Vinalhaven)	(Figure E-23)
Owls Head Harbor	(Figure E-24)
George's River (Thomaston)	(Figure E-25)

Stockton Harbor			
Deadhead from Rockland Airport		27.13 NM	0.271 Hr.
Survey:	4,200'	0.69 NM	0.035 Hr.
Searsport Harbor			
Deadhead from Stockton		6.06 NM	0.061 Hr.
Survey:	18,161'	2.99 NM	0.149 Hr.
Belfast Harbor			
Deadhead from Searsport		4.33 NM	0.043 Hr.
Survey:	5,614'	0.92 NM	0.046 Hr.
Camden Harbor			
Deadhead from Belfast		12.3 NM	0.123 Hr.
Survey:	7,802'	1.28 NM	0.064 Hr.
Carver's Harbor (Vinalhaven)			
Deadhead from Camden		14.43 NM	0.144 Hr.
Survey:	10,234'	1.68 NM	0.084 Hr.
Owls Head Harbor			
Deadhead from Carver's Harbor		10.25 NM	0.103 Hr.
Survey:	1,523'	0.25 NM	0.013 Hr.
George's River			
Deadhead from Owls Head		5.48 NM	0.055 Hr.
Survey:	4,617'	0.76 NM	0.038 Hr.
Deadhead return to Rockland Airport		3.32 NM	0.033 Hr.
Short stop deadhead allowance		10.0 NM	0.100 Hr.
Total deadhead		93.3 NM	0.933 Hr.
Total survey		8.57 NM	0.429 Hr.
Total		101.87 NM	1.362 Hr.

TRIP FIVE

This is a series of seven harbors surveyed from a helicopter base at Rockland Airport. The harbors to be surveyed are: New Harbor (Bristol), East Boothbay Harbor, Boothbay Harbor and Hendricks Harbor (Southport), Kennebec River, Cathance River (Bath), and Harraseeket River (Freeport) (Figures E-26 through E-32). The GPS station for these surveys will be located in Richmond, ME. UHF stations will be located at Pemaquid and Damariscotta, ME. A total of five automatic tide gauges plus the two manned vehicles will be required for these surveys.

Scenario Analysis

The helicopter will proceed from Rockland Airport to New Harbor (Figure E-26), a distance of 20.5 nautical miles requiring 0.205 hours. The total survey length of this harbor is 3,422 feet or 0.563 nautical miles requiring 0.028 hours. Because the harbor is divided into two pieces there is an internal deadhead of 700 feet or 0.115 nautical miles requiring 0.006 hours. The ground station for this survey is Boothbay. The helicopter will fly from New Harbor to East Boothbay Harbor (Figure E-27), a distance of 4.62 nautical miles requiring 0.046 hours. The survey of East Boothbay Harbor can be accomplished in a single pass of 1,000 feet or 0.165 nautical miles requiring 0.008 hours.

The helicopter will fly from East Boothbay to Boothbay Harbor (Figure E-28), a distance of 1.44 nautical miles requiring 0.014 hours. The survey of Boothbay Harbor is flown in two passes of total length 2,448 feet or 0.402 nautical miles requiring 0.02 hours.

The helicopter will fly from Boothbay Harbor to Hendricks Harbor (Figure E-24), a distance of 2.89 nautical miles requiring 0.023 hours. The survey of Hendricks Harbor can be accomplished in a single pass of length 300 feet or 0.049 nautical miles requiring 0.002 hours.

The helicopter will proceed from that point to the beginning of the Kennebec River in the town of Augusta (Figure E-30), a distance of 30.0 nautical miles requiring 0.30 hours. Survey of the Kennebec River will proceed south for a distance of 45.07 nautical miles requiring 2.254 hours. The survey can be accomplished in a single pass with the exception of both channels around Swan Island requiring a complete circuit of that island and deadhead from the north end of the island to the south. This results in an internal deadhead at Swan Island of 3.75 nautical miles or 0.038 hours. Ground stations for this survey are required at two points, Maine Route 24 at milepost 31 and Maine Route 209 opposite Lee Island at milepost 7. At the point where the Kennebec River reaches Merrymeeting Bay, approximately 3 miles north of the city of Bath, the helicopter will deviate to survey the Cathance River directly adjacent to the Kennebec River (Figure E-31). This results in a survey length of 14,832 feet or 2.44 nautical miles for a survey time of 0.122 hours. An internal deadhead is required at this point to return from the Cathance River to the Kennebec River which is a distance of 2.16 nautical miles or 0.022 hours.

The helicopter will pause to refuel when it reaches the town of Bath, ME along the Kennebec River. It will fly deadhead roundtrip to Augusta Airport for this purpose, for a total distance of 50.5 miles requiring 0.505 hours plus refueling time.

The helicopter will proceed from the mouth of the Kennebec River to the Harraseeket River (Figure E-32), distance of 15.15 nautical miles requiring 0.152 hours. The Harraseeket River may be surveyed in a single pass of length 4,121 feet or 0.678 nautical miles requiring 0.034 hours.

Because there are numerous stops in this survey, a two minute acceleration/deceleration allowance has been made for each harbor which is less than 10 nautical miles from the preceding harbor. This results in an additional short stop deadhead allowance of 0.133 hours. At this point the helicopter will deadhead to the base at Portland Airport, a distance of 34.63 nautical miles requiring 0.346 hours. Total deadhead for this survey is 1.791 hours, total survey time is 2.468 hours for a total time of 4.259 hours (Table E-5).

Figure E-26

CORPS OF ENGINEERS

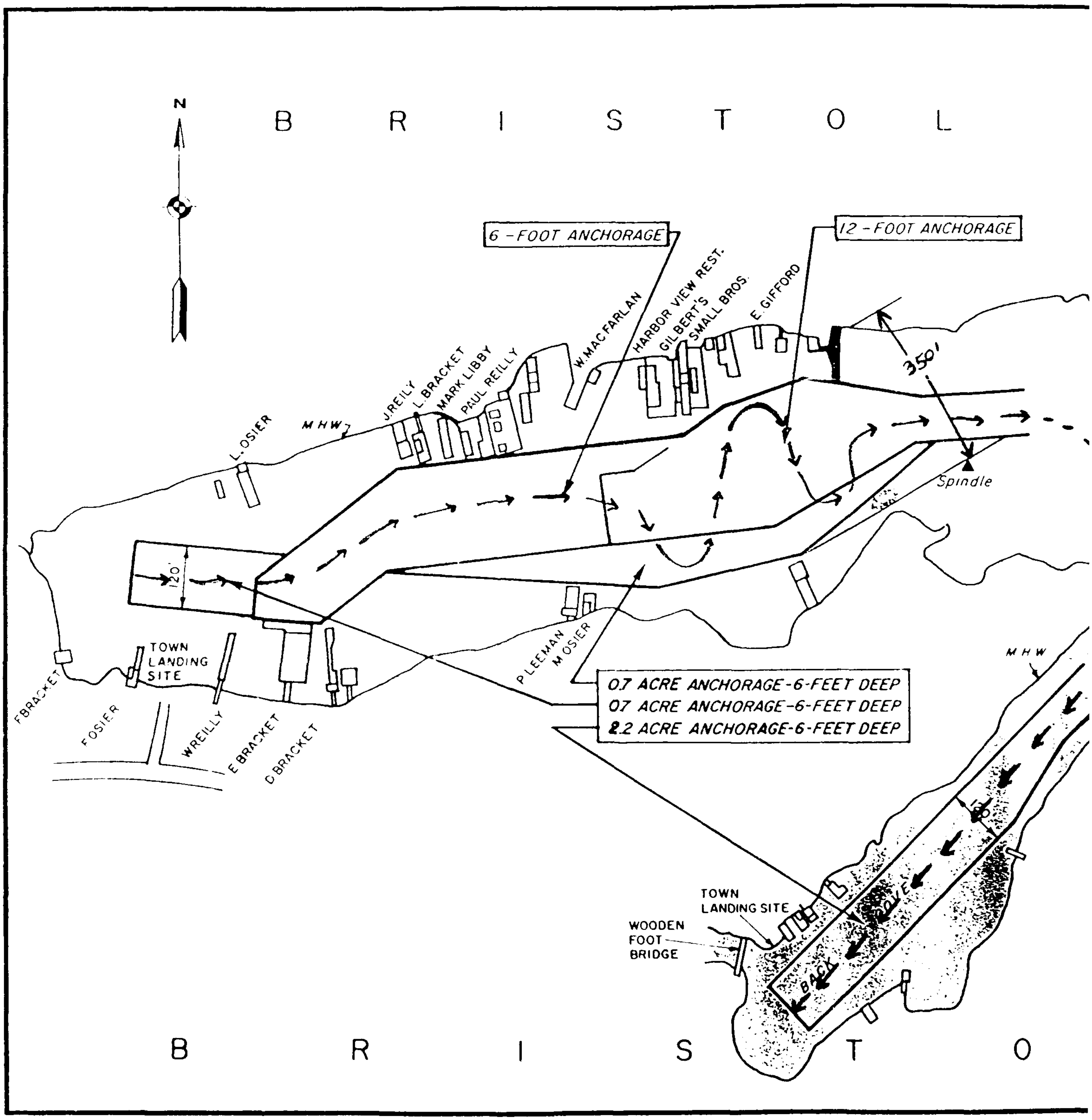


Figure E-26

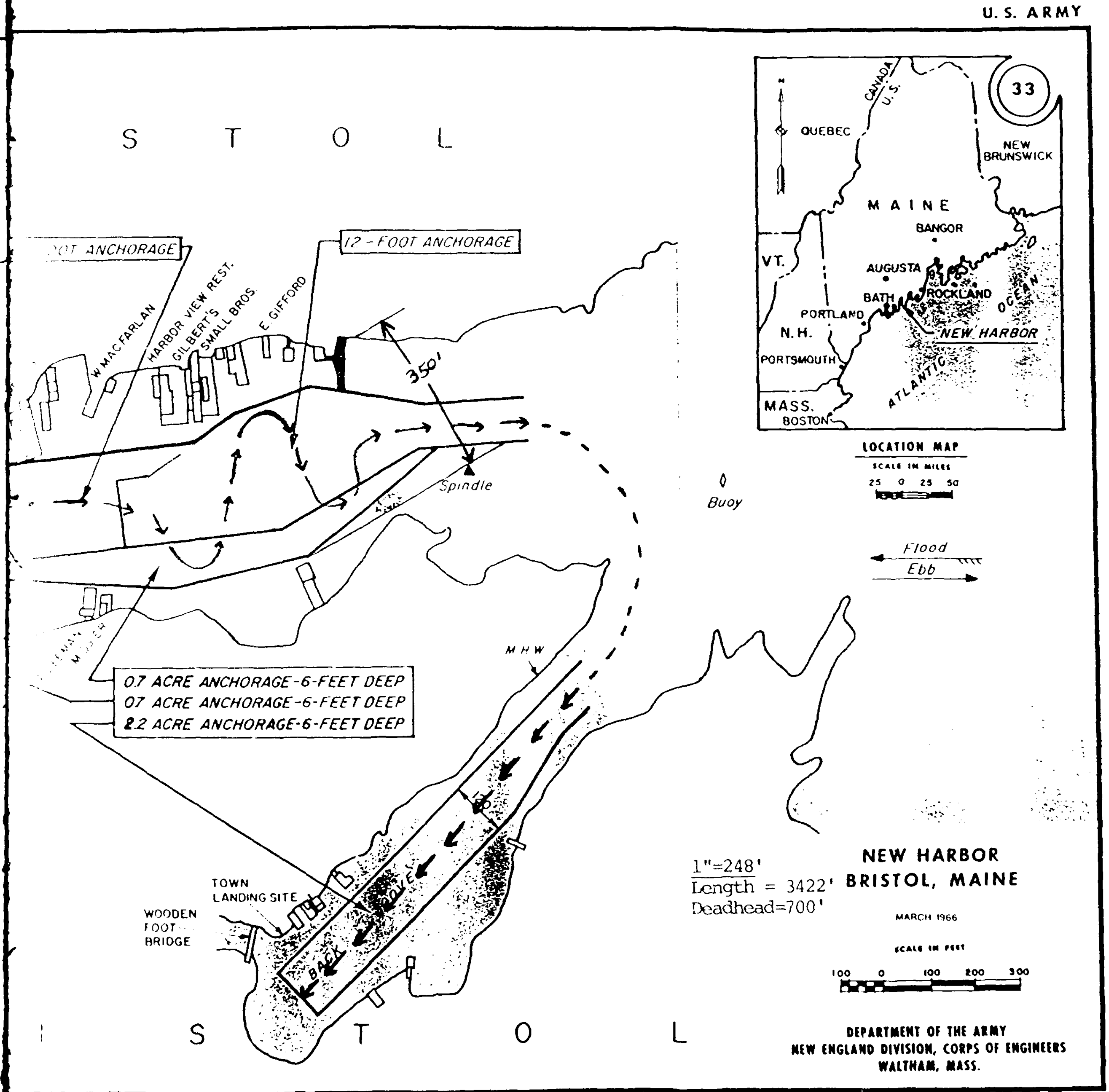

U.S. ARMY
S T O L
S T O L
OOT ANCHORAGE
12 - FOOT ANCHORAGE
W. MACFARLAN
HARBOR VIEW REST.
GILBERT'S
SMALL BROS
E. GIFFORD
350'
Spindle
Buoy
Flood
Ebb
M H W
0.7 ACRE ANCHORAGE - 6 - FEET DEEP
07 ACRE ANCHORAGE - 6 - FEET DEEP
2.2 ACRE ANCHORAGE - 6 - FEET DEEP
TOWN LANDING SITE
WOODEN FOOT BRIDGE
BACK COVE
1"=248'
Length = 3422'
Deadhead=700'
NEW HARBOR
BRISTOL, MAINE
MARCH 1966
SCALE IN FEET
100 0 100 200 300
33
QUEBEC
CANADA
U.S.
NEW BRUNSWICK
MAINE
BANGOR
VT.
AUGUSTA
BATH
ROCKLAND
OCEAN
PORTLAND
N.H.
NEW HARBOR
PORTSMOUTH
ATLANTIC
MASS.
BOSTON
LOCATION MAP
SCALE IN MILES
25 0 25 50
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-27

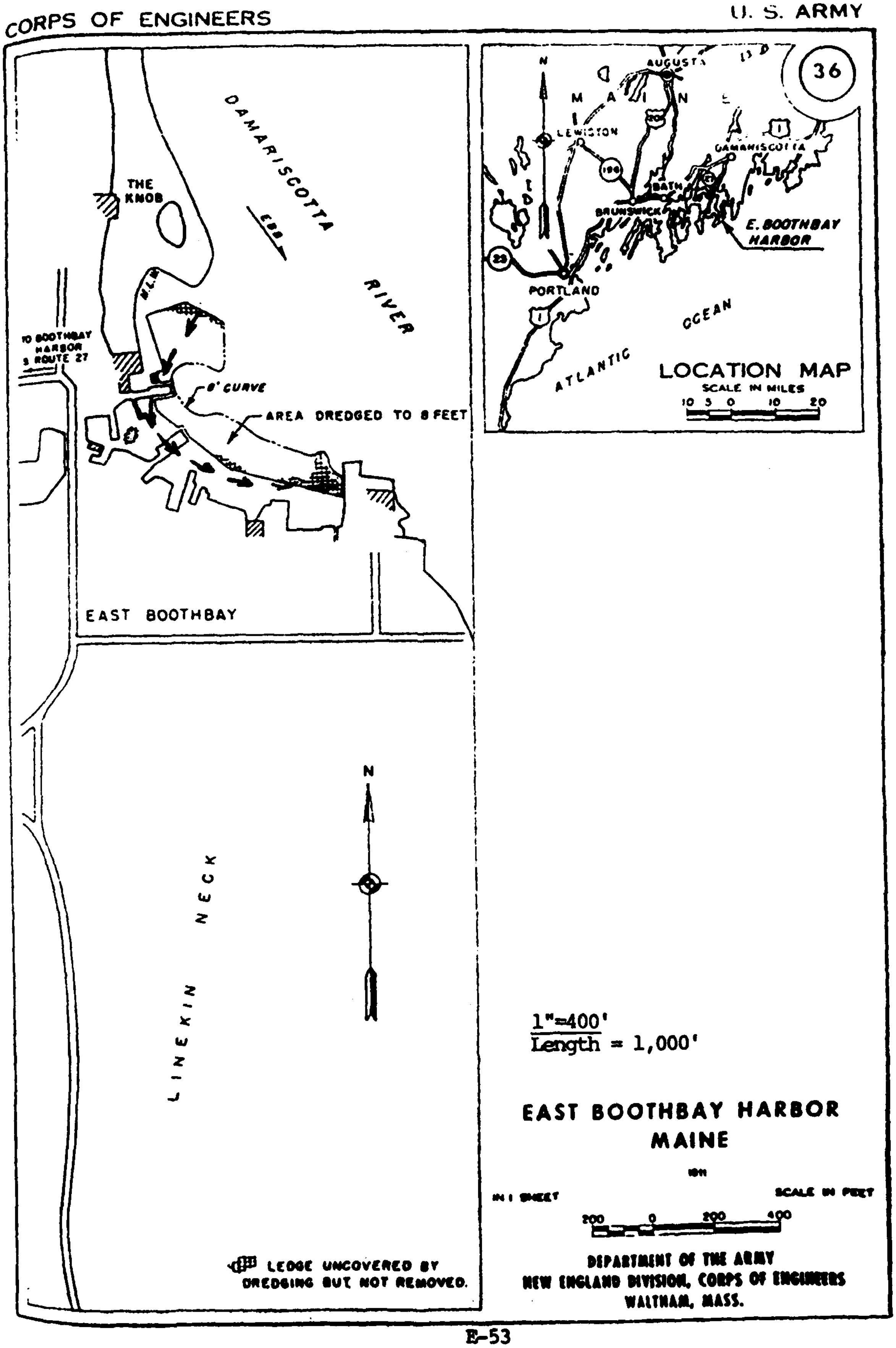

CORPS OF ENGINEERS
U. S. ARMY
THE KNOB
DAMARISCOTTA RIVER
EBB
TO BOOTHBAY HARBOR & ROUTE 27
8' CURVE
AREA DREDGED TO 8 FEET
EAST BOOTHBAY
LINEKIN NECK
N
LEDGE UNCOVERED BY DREDGING BUT NOT REMOVED.
36
AUGUSTA
MAINE
LEWISTON
DAMARISCOTTA
BATH
BRUNSWICK
E. BOOTHBAY HARBOR
PORTLAND
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
10 5 0 10 20
1"=400'
Length = 1,000'
EAST BOOTHBAY HARBOR
MAINE
SCALE IN FEET
200 0 200 400
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-28

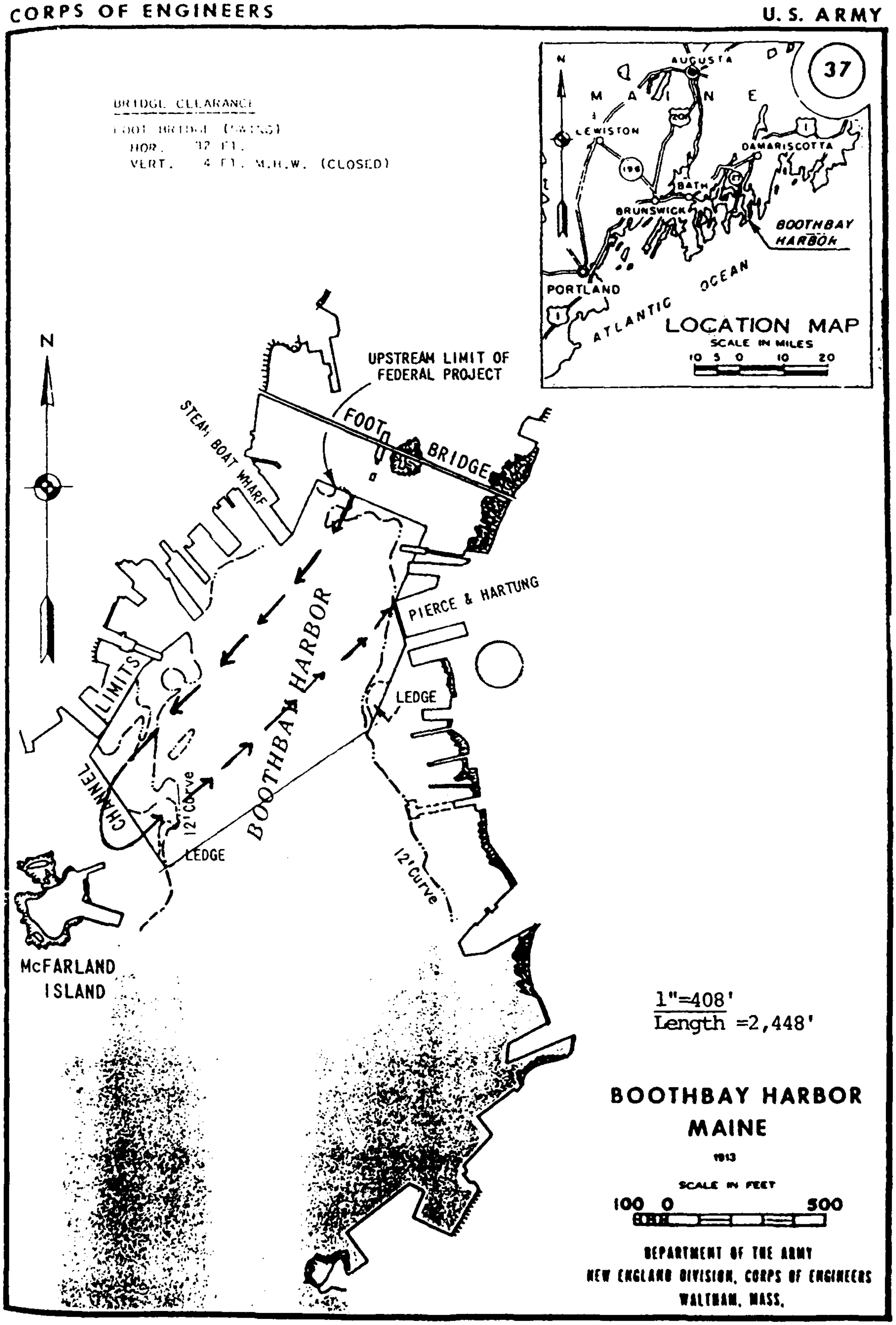

CORPS OF ENGINEERS
U.S. ARMY
BRIDGE CLEARANCE
FOOT BRIDGE
VERT. 4 FT. M.H.W. (CLOSED)
37
AUGUSTA
MAINE
LEWISTON
DAMARISCOTTA
BATH
BRUNSWICK
BOOTHBAY HARBOR
PORTLAND
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
10 5 0 10 20
N
UPSTREAM LIMIT OF FEDERAL PROJECT
FOOT BRIDGE
STEAM BOAT WHARF
PIERCE & HARTUNG
LIMITS
BOOTHBAY HARBOR
LEDGE
CHANNEL
12' Curve
LEDGE
12' Curve
McFARLAND ISLAND
1"=408'
Length =2,448'
BOOTHBAY HARBOR
MAINE
1913
SCALE IN FEET
100 0 500
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-29

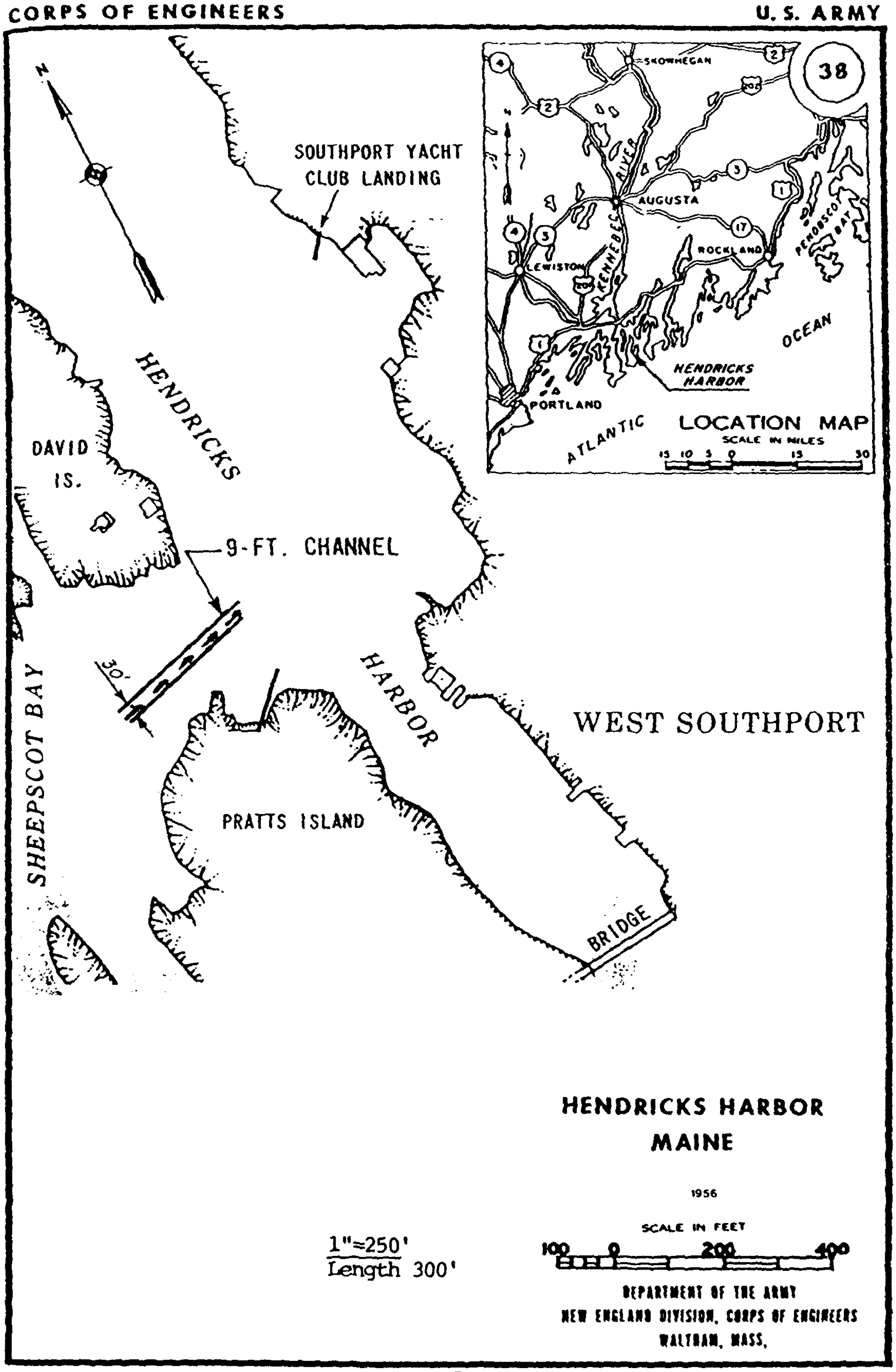

CORPS OF ENGINEERS
U.S. ARMY
N
SOUTHPORT YACHT CLUB LANDING
38
SKOWHEGAN
AUGUSTA
KENNEBEC RIVER
LEWISTON
ROCKLAND
PENOBSCOT BAY
OCEAN
HENDRICKS HARBOR
PORTLAND
ATLANTIC
LOCATION MAP
SCALE IN MILES
15 10 5 0 15 30
HENDRICKS
DAVID IS.
9-FT. CHANNEL
30'
HARBOR
WEST SOUTHPORT
SHEEPSCOT BAY
PRATTS ISLAND
BRIDGE
HENDRICKS HARBOR
MAINE
1956
SCALE IN FEET
100 0 200 400
1"=250'
Length 300'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-30

CORPS OF ENGINEERS

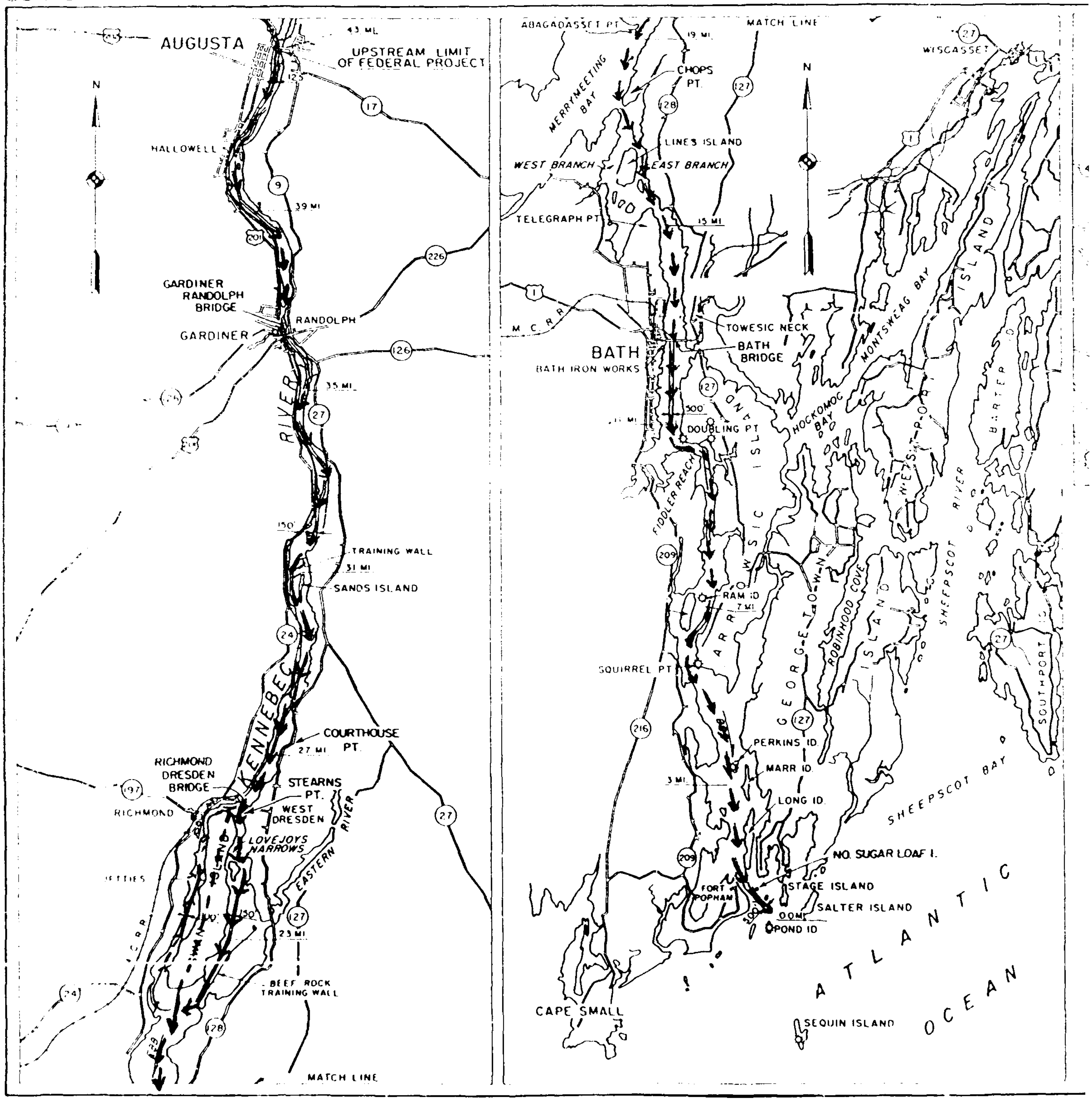


Figure E-30

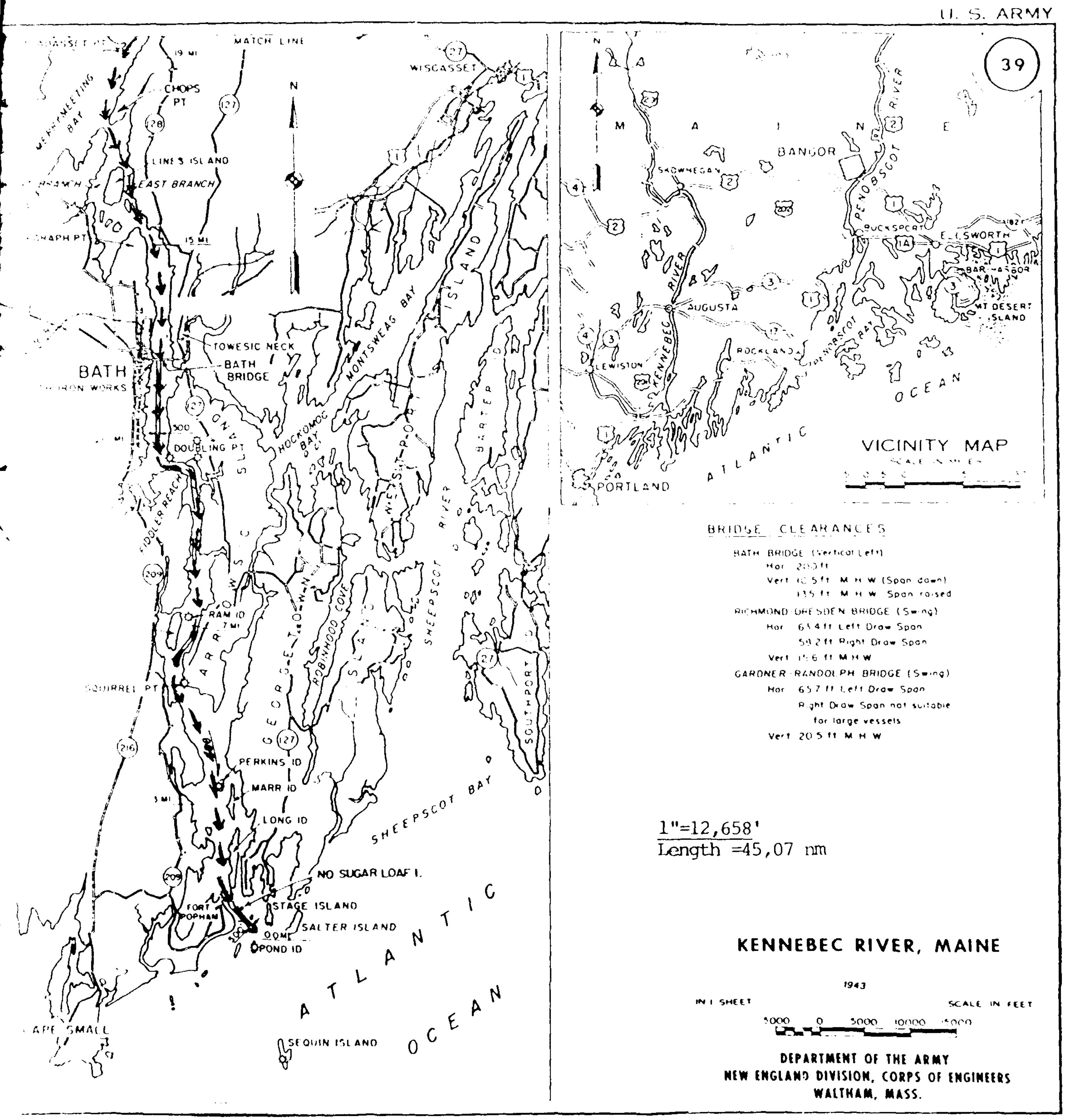

U. S. ARMY
39
MATCH LINE
WISCASSET
CHOPS PT
LINES ISLAND
EAST BRANCH
MERRYMEETING BAY
15 MI
TOWESIC NECK
BATH
BATH BRIDGE
IRON WORKS
DOUBLING PT
FIDDLER REACH
HOCKOMOCK BAY
MONTSWEAG BAY
ISLAND
ARROWSIC
GEORGETOWN
ROBINHOOD COVE
SHEEPSCOT RIVER
SOUTHPORT
RAM ID
SQUIRREL PT
PERKINS ID
MARR ID
LONG ID
SHEEPSCOT BAY
NO SUGAR LOAF I.
STAGE ISLAND
FORT POPHAM
SALTER ISLAND
POND ID
ATLANTIC OCEAN
CAPE SMALL
SEQUIN ISLAND
MAINE
BANGOR
SKOWHEGAN
PENOBSCOT RIVER
BUCKSPORT
ELLSWORTH
BAR HARBOR
MT DESERT ISLAND
KENNEBEC RIVER
AUGUSTA
LEWISTON
ROCKLAND
PENOBSCOT BAY
PORTLAND
ATLANTIC OCEAN
VICINITY MAP
BRIDGE CLEARANCES
BATH BRIDGE (Vertical Left)
Hor 200 ft
Vert M H W (Span down)
ft M H W Span raised
RICHMOND DRESDEN BRIDGE (Swing)
Left Draw Span
Right Draw Span
Vert M H W
GARDNER RANDOLPH BRIDGE (Swing)
Hor Left Draw Span
Right Draw Span not suitable
for large vessels
Vert 20.5 ft M H W
1"=12,658'
Length =45,07 nm
KENNEBEC RIVER, MAINE
1943
IN 1 SHEET
SCALE IN FEET
5000 0 5000 10000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-31

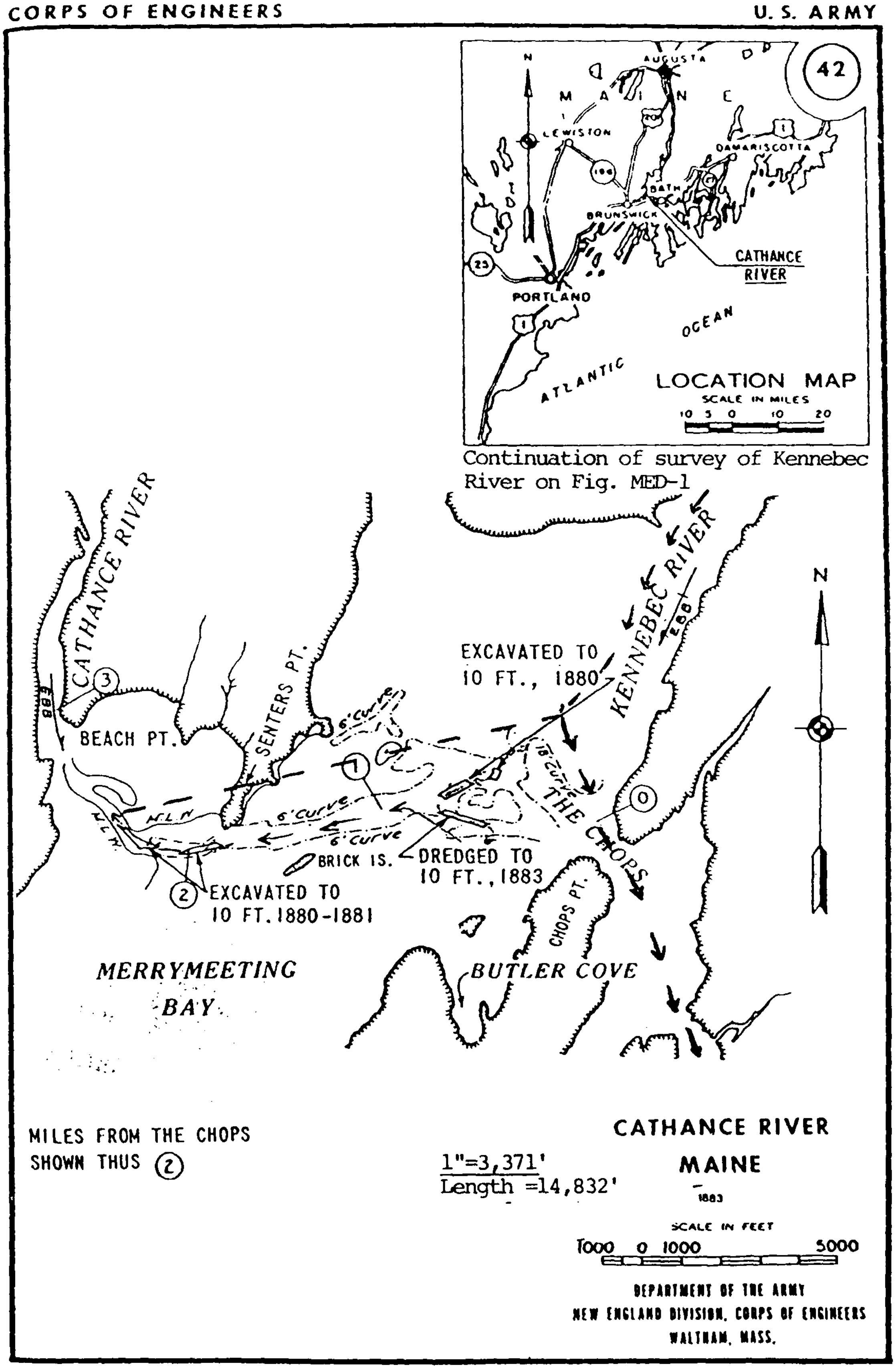

CORPS OF ENGINEERS
U. S. ARMY
42
AUGUSTA
MAINE
LEWISTON
DAMARISCOTTA
BATH
BRUNSWICK
CATHANCE RIVER
PORTLAND
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
10 5 0 10 20
Continuation of survey of Kennebec River on Fig. MED-1
CATHANCE RIVER
KENNEBEC RIVER
EBB
EXCAVATED TO 10 FT., 1880
SENTERS PT.
BEACH PT.
6' CURVE
18' CURVE
THE CHOPS
BRICK IS.
DREDGED TO 10 FT., 1883
EXCAVATED TO 10 FT. 1880-1881
CHOPS PT.
MERRYMEETING BAY
BUTLER COVE
N
MILES FROM THE CHOPS SHOWN THUS 2
1"=3,371'
Length =14,832'
CATHANCE RIVER
MAINE
1883
SCALE IN FEET
1000 0 1000 5000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-32

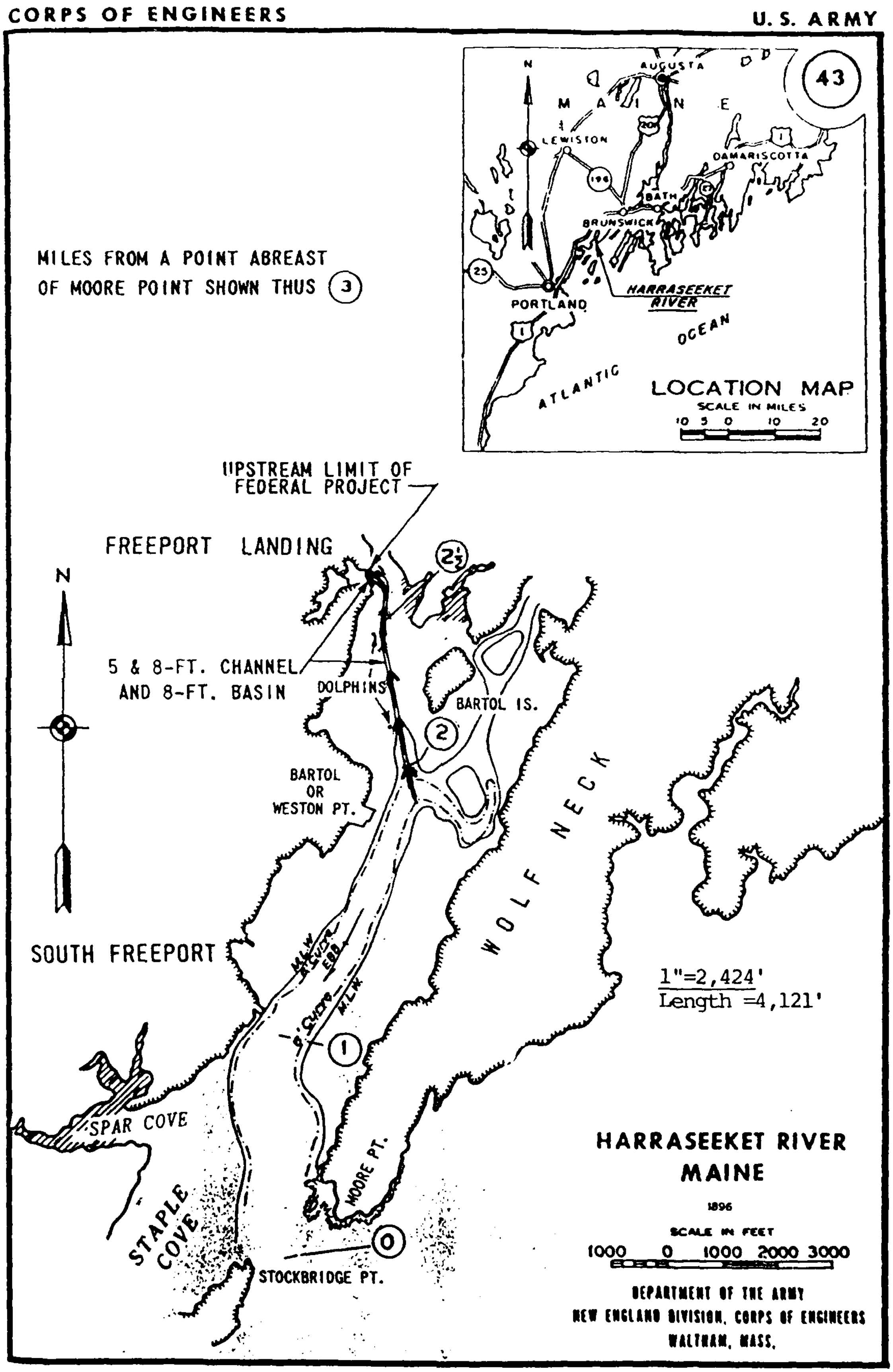

CORPS OF ENGINEERS
U. S. ARMY
MILES FROM A POINT ABREAST
OF MOORE POINT SHOWN THUS 3
AUGUSTA
MAINE
LEWISTON
DAMARISCOTTA
BATH
BRUNSWICK
PORTLAND
HARRASEEKET RIVER
ATLANTIC OCEAN
43
LOCATION MAP
SCALE IN MILES
10 5 0 10 20
UPSTREAM LIMIT OF
FEDERAL PROJECT
FREEPORT LANDING
5 & 8-FT. CHANNEL
AND 8-FT. BASIN
DOLPHINS
BARTOL IS.
BARTOL
OR
WESTON PT.
WOLF NECK
SOUTH FREEPORT
1"=2,424'
Length =4,121'
SPAR COVE
STAPLE COVE
MOORE PT.
STOCKBRIDGE PT.
HARRASEEKET RIVER
MAINE
1896
SCALE IN FEET
1000 0 1000 2000 3000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-5

MAINE HARBOR SURVEY TRIP FIVE (ROCKLAND AIRPORT)

New Harbor (Bristol)	(Figure E-26)
East Boothbay Harbor	(Figure E-27)
Boothbay Harbor	(Figure E-28)
Hendricks Harbor (Southport)	(Figure E-29)
Kennebec River	(Figure E-30)
Cathance River (Bath)	(Figure E-31)
Harraseeket River (Freeport)	(Figure E-32)

New Harbor			
Deadhead from Rockland Airport		20.5 NM	0.205 Hr.
Survey:	3,422′	0.563 NM	0.028 Hr.
Internal deadhead:	700′	0.115 NM	0.006 Hr.
East Boothbay Harbor			
Deadhead from New Harbor		4.62 NM	0.046 Hr.
Survey:	1,000′	0.165 NM	0.008 Hr.
Boothbay Harbor			
Deadhead from East Boothbay		1.44 NM	0.014 Hr.
Survey:	2,448′	0.402 NM	0.02 Hr.
Hendricks Harbor			
Deadhead from Boothbay Harbor		2.89 NM	0.023 Hr.
Survey:	300′	0.049 NM	0.002 Hr.
Kennebec River			
Deadhead from Hendricks Harbor		30 NM	0.30 Hr.
Survey:	237,970′	45.07 NM	2.254 Hr.
Internal deadhead at Swan Island 22,784′		3.75 NM	0.038 Hr.
Refuel at Augusta Airport when survey reaches Bath, ME roundtrip deadhead to Augusta:		50.5 NM	0.505 Hr.
Cathance River			
Surveyed in middle of Kennebeck survey above			
Survey:	14,832′	2.44 NM	0.122 Hr.
Internal deadhead:	13,147′	2.16 NM	0.22 Hr.

Table E-5 (Continued)

Harraseeket River

Deadhead from mouth of Kennebec River		15.15 NM	0.152 Hr.
Survey:	4,121'	0.678 NM	0.034 Hr.

Deadhead to base at Portland	34.63 NM	0.346 Hr.
Short stop deadhead allowance	13.33 NM	0.133 Hr.
Total deadhead	179.09 NM	1.791 Hr.
Total survey	49.37 NM	2.468 Hr.
Total	228.46 NM	4.259 Hr.

TRIP SIX

This is a series of five harbors to be surveyed from a helicopter based at Portland Airport. The harbors to be surveyed are: Scarborough River, Cape Porpoise (Kennebunkport), Kennebunk River, Josias River (Ogunquit) and York Harbor. (Figures E-33 through E-37.)

Scenario Analysis

The helicopter will begin at Portland Airport and proceed from that point to the Scarborough River (Figure E-33), a distance of 4.33 nautical miles requiring 0.043 hours. The survey of the Scarborough River can be accomplished in two passes of total length 7,910 feet or 1.30 nautical miles requiring 0.065 hours.

The helicopter will deadhead from Scarborough River to Cape Porpoise (Kennebunkport Beach, Figure E-34), a distance of 16.59 nautical miles requiring 0.166 hours. The survey of Cape Porpoise can be accomplished in a single pass of length 4,718 feet or 0.776 nautical miles requiring 0.039 hours.

The helicopter will deadhead from Cape Porpoise to the Kennebunk River (Figure E-35), a distance of 2.89 nautical miles requiring 0.029 hours. The survey of the Kennebunk River can be accomplished in a single pass of length 6,000 feet or 0.987 nautical miles requiring 0.049 hours.

The helicopter will proceed from the Kennebunk River to Josias River (Figure E-36), a distance of 6.49 nautical miles requiring 0.065 hours. The survey of the Josias River can be accomplished in a single pass of length 1,571 feet or 0.259 nautical miles requiring 0.013 hours.

The helicopter will proceed from Josias River to York Harbor (Figure E-37), a distance of 7.50 nautical miles requiring 0.075 hours. The survey of York Harbor will require a survey of 4,147 feet or 0.683 nautical miles requiring 0.034 hours.

Because there are numerous stops in this survey, a two minute acceleration/deceleration allowance has been made for each harbor which is less than 10 nautical miles from the preceding harbor. This results in an additional short stop deadhead allowance of 0.133 hours. At this point the helicopter will deadhead to the base at Portland Airport, a distance of 34.63 nautical miles requiring 0.346 hours. Total deadhead for this survey is 0.857 hours, total survey time is 0.201 hours for a total time of 1.058 hours (Table E-6).

Figure E-33

CORPS OF ENGINEERS

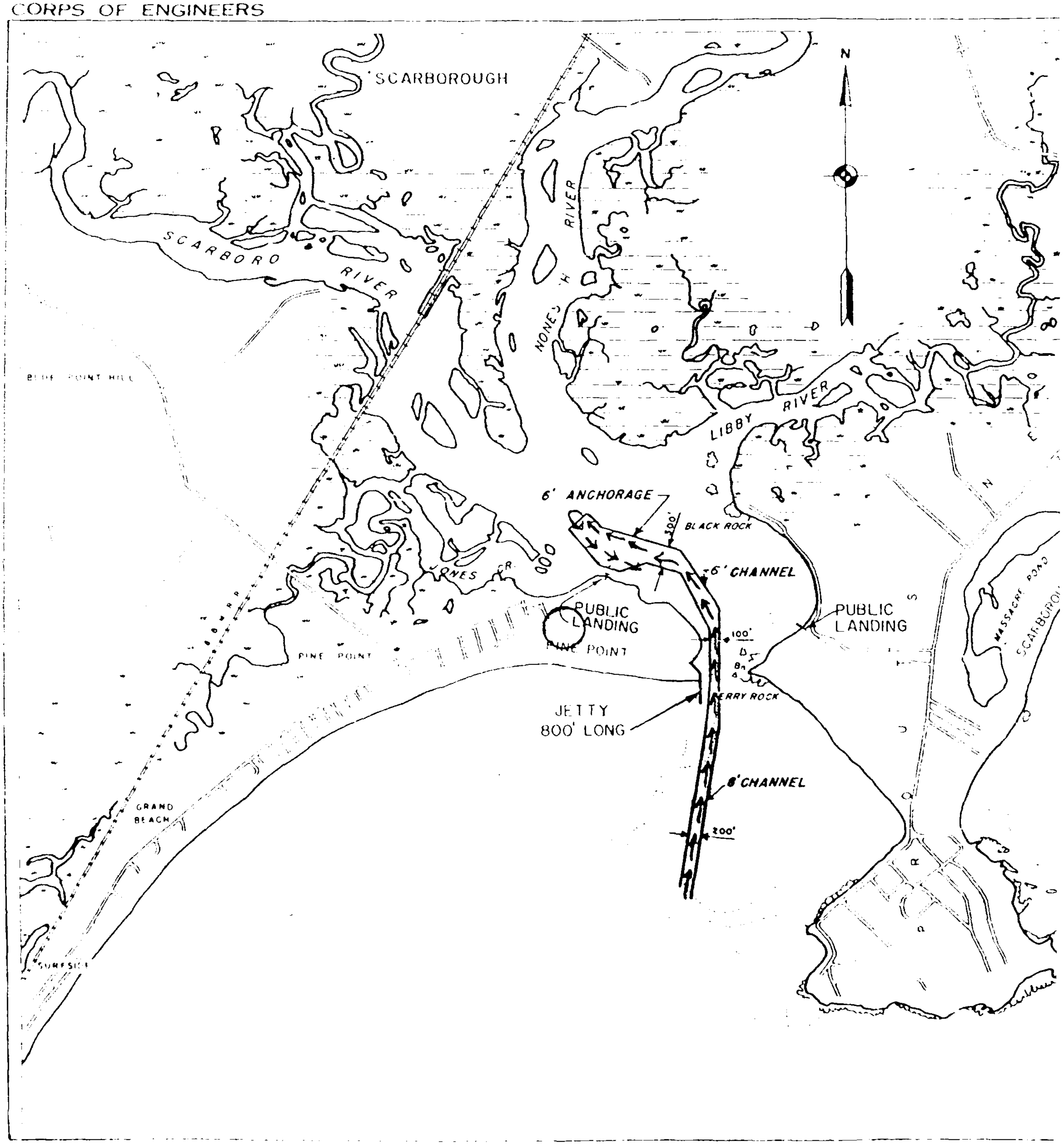


Figure E-33

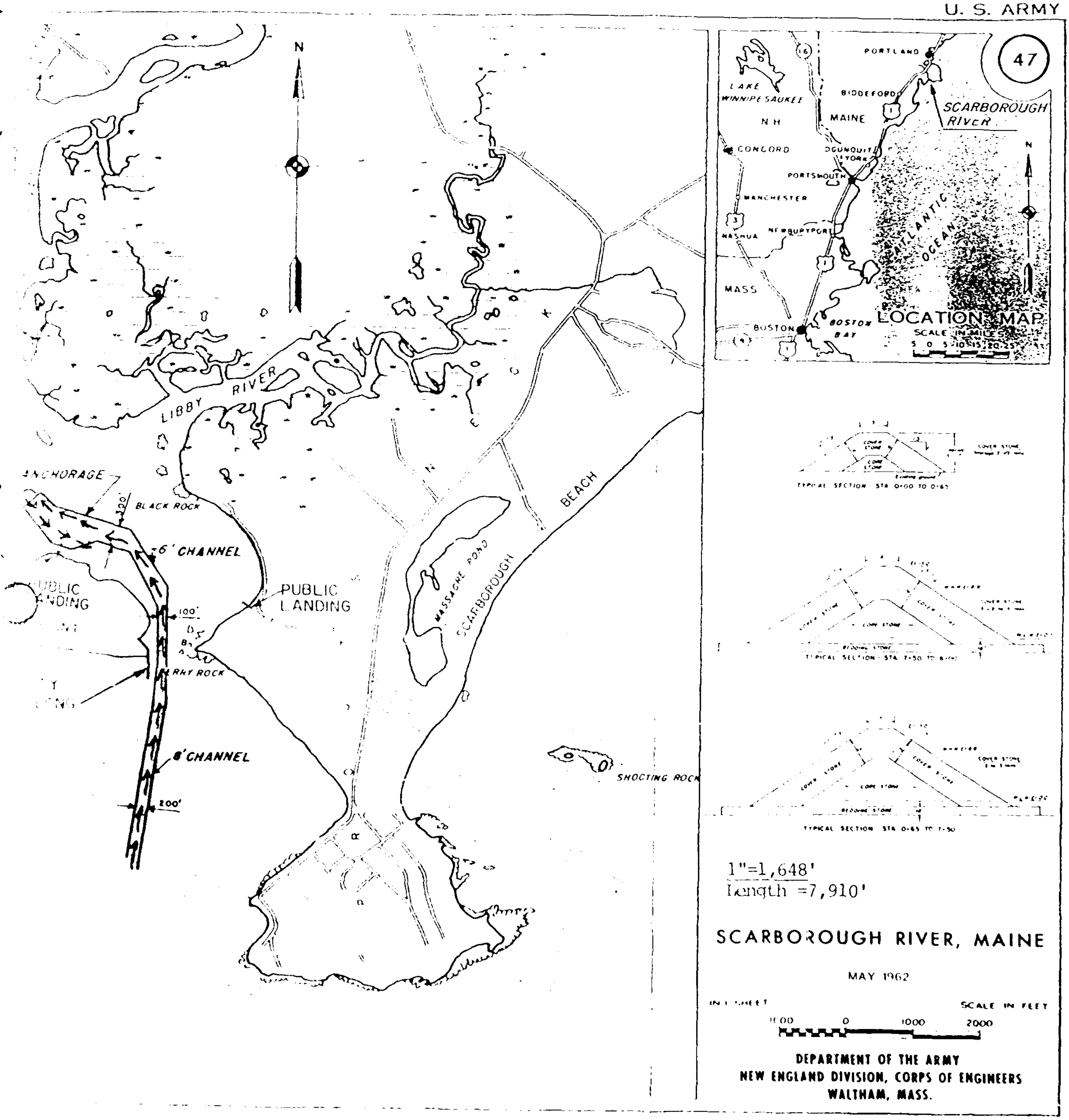

U. S. ARMY
47
SCARBOROUGH RIVER
LOCATION MAP
ATLANTIC OCEAN
PORTLAND
BIDDEFORD
MAINE
N H
MASS
CONCORD
MANCHESTER
NASHUA
PORTSMOUTH
NEWBURYPORT
BOSTON
BOSTON BAY
LAKE WINNIPESAUKEE
LIBBY RIVER
ANCHORAGE
BLACK ROCK
6' CHANNEL
8' CHANNEL
PUBLIC LANDING
SCARBOROUGH BEACH
MASSACRE POND
SHOOTING ROCK
100'
200'
TYPICAL SECTION STA 0+00 TO 0+65
TYPICAL SECTION STA 0+65 TO 7+50
COVER STONE
CORE STONE
1"=1,648'
Length =7,910'
SCARBOROUGH RIVER, MAINE
MAY 1962
SCALE IN FEET
1000
0
1000
2000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-34

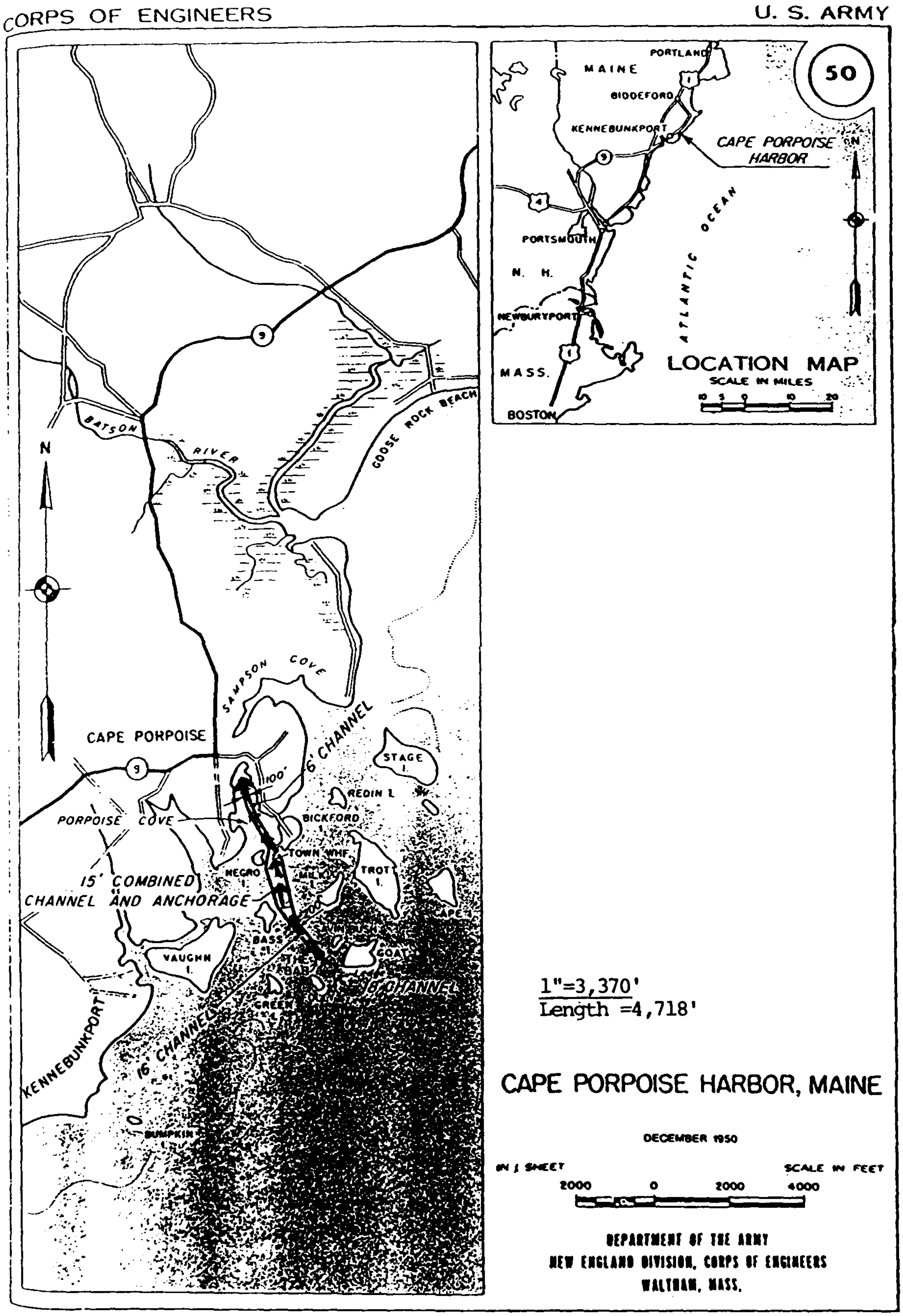

CORPS OF ENGINEERS
U. S. ARMY
50
MAINE
PORTLAND
BIDDEFORD
KENNEBUNKPORT
CAPE PORPOISE HARBOR
PORTSMOUTH
N. H.
NEWBURYPORT
MASS.
BOSTON
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
BATSON RIVER
GOOSE ROCK BEACH
SAMPSON COVE
6' CHANNEL
100'
CAPE PORPOISE
STAGE I.
REDIN I.
BICKFORD I.
PORPOISE COVE
TOWN WHF.
NEGRO I.
TROT I.
15' COMBINED CHANNEL AND ANCHORAGE
BASS I.
GOAT
VAUGHN I.
THE BAR
GREEN
8' CHANNEL
16' CHANNEL
KENNEBUNKPORT
BUMPKIN
1"=3,370'
Length =4,718'
CAPE PORPOISE HARBOR, MAINE
DECEMBER 1950
SCALE IN FEET
2000
0
2000
4000
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-35

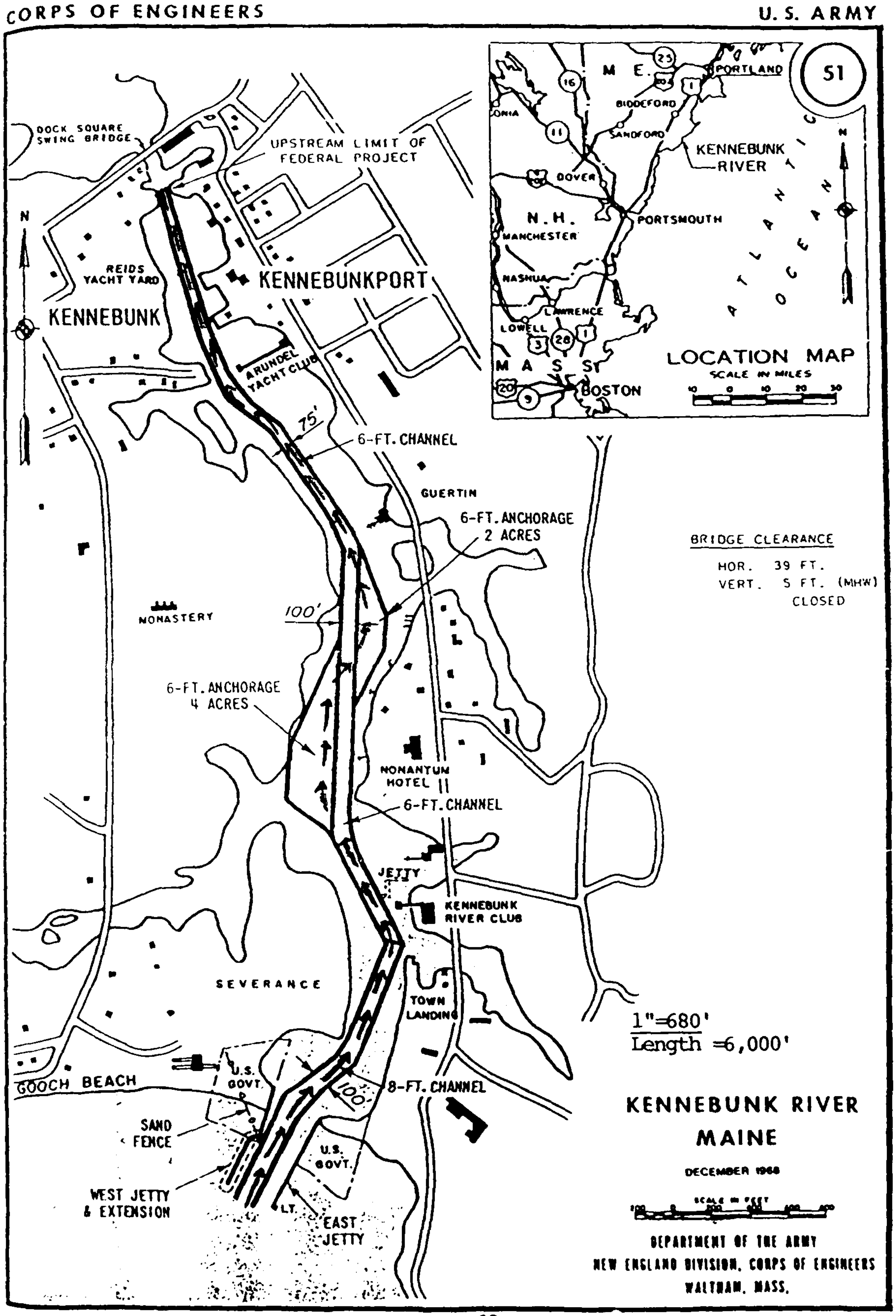

CORPS OF ENGINEERS
U. S. ARMY
DOCK SQUARE SWING BRIDGE
UPSTREAM LIMIT OF FEDERAL PROJECT
REIDS YACHT YARD
KENNEBUNKPORT
KENNEBUNK
ARUNDEL YACHT CLUB
75'
6-FT. CHANNEL
GUERTIN
6-FT. ANCHORAGE 2 ACRES
MONASTERY
100'
6-FT. ANCHORAGE 4 ACRES
NONANTUM HOTEL
6-FT. CHANNEL
JETTY
KENNEBUNK RIVER CLUB
SEVERANCE
TOWN LANDING
GOOCH BEACH
U.S. GOVT.
SAND FENCE
100'
8-FT. CHANNEL
U.S. GOVT.
WEST JETTY & EXTENSION
LT.
EAST JETTY
M E.
PORTLAND
51
BIDDEFORD
SANFORD
KENNEBUNK RIVER
DOVER
N.H.
PORTSMOUTH
MANCHESTER
NASHUA
LAWRENCE
LOWELL
M A S S
BOSTON
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
BRIDGE CLEARANCE
HOR. 39 FT.
VERT. 5 FT. (MHW)
CLOSED
1"=680'
Length =6,000'
KENNEBUNK RIVER
MAINE
DECEMBER 1968
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-30

CORPS OF ENGINEERS

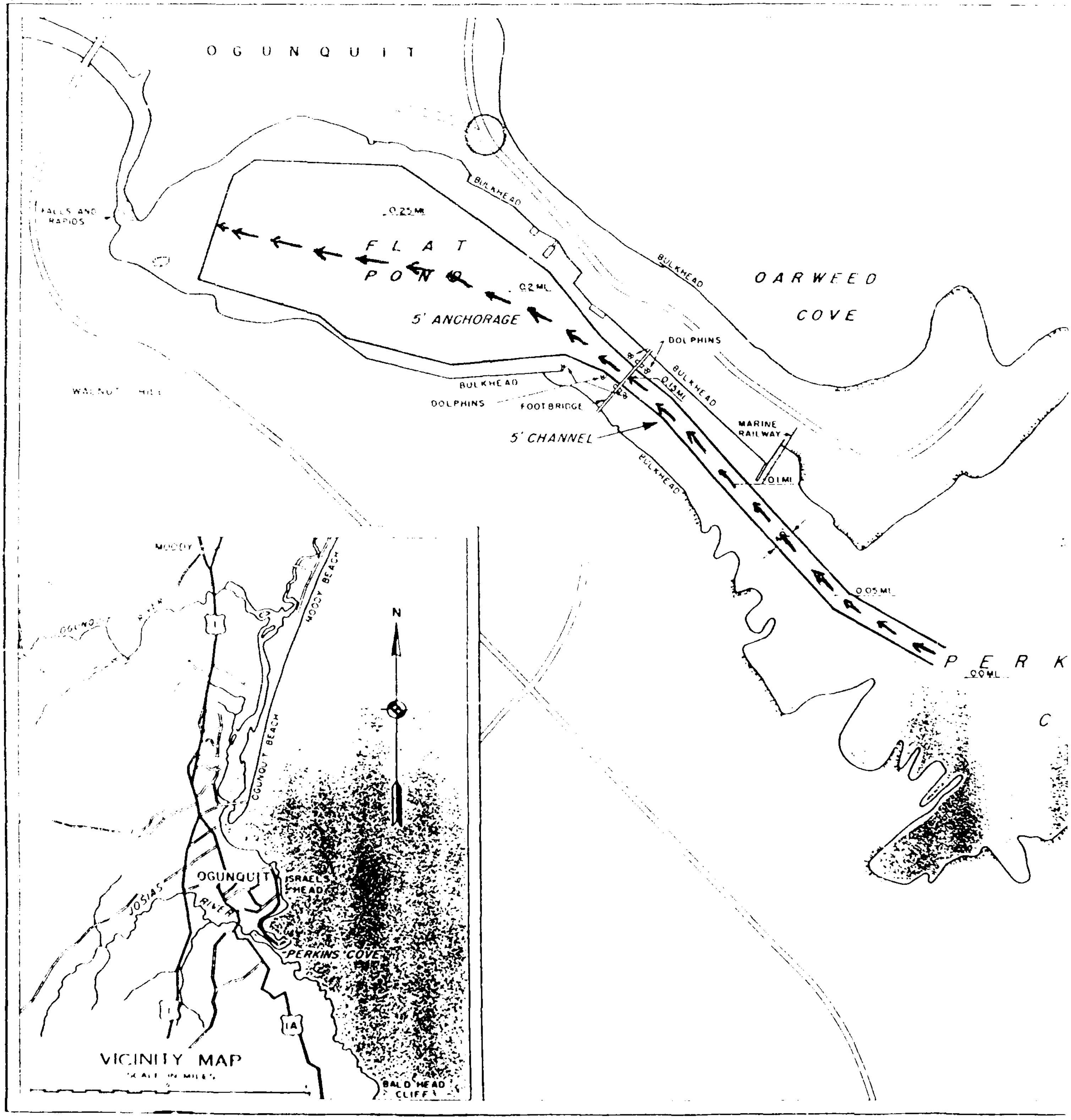
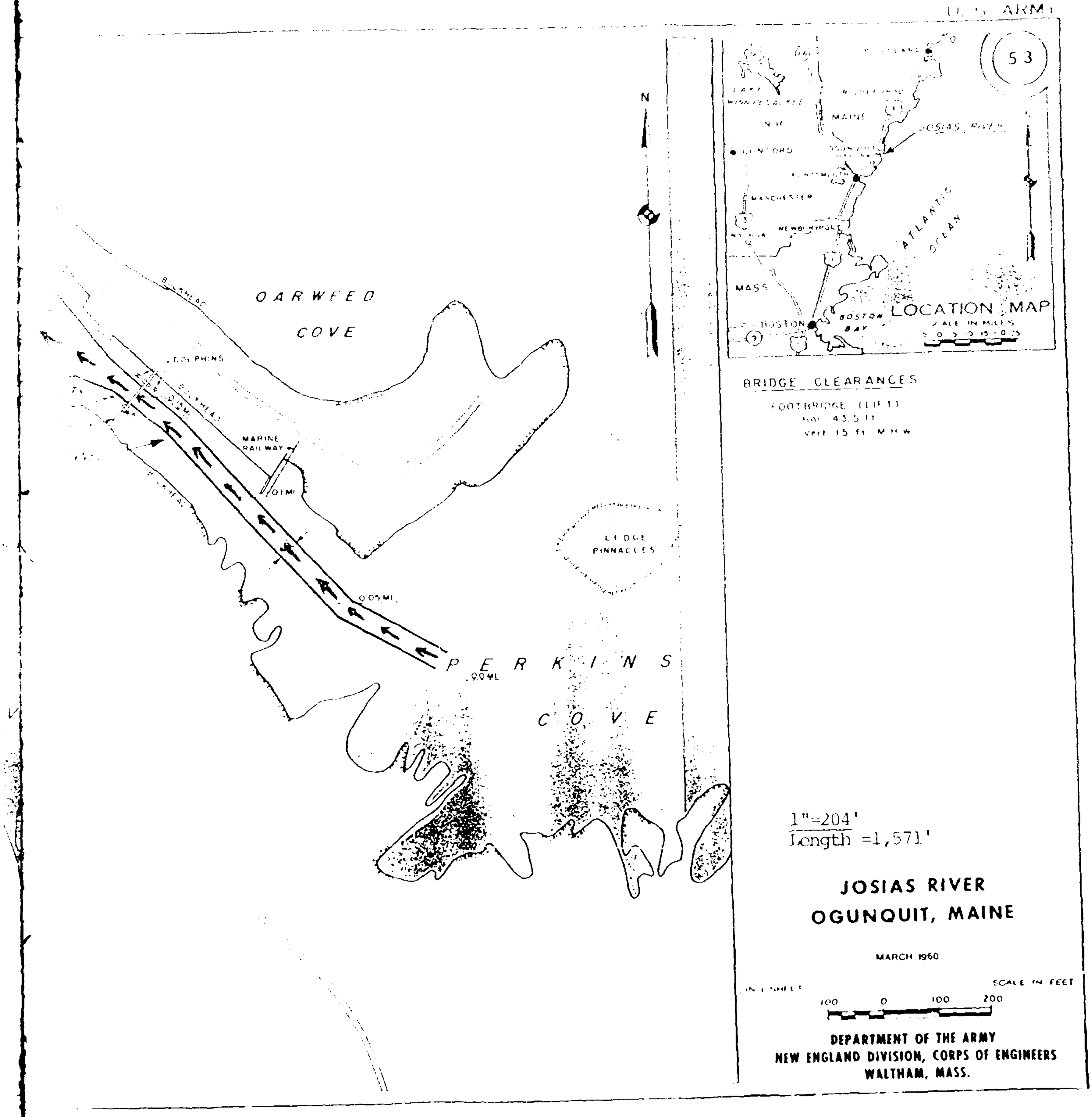
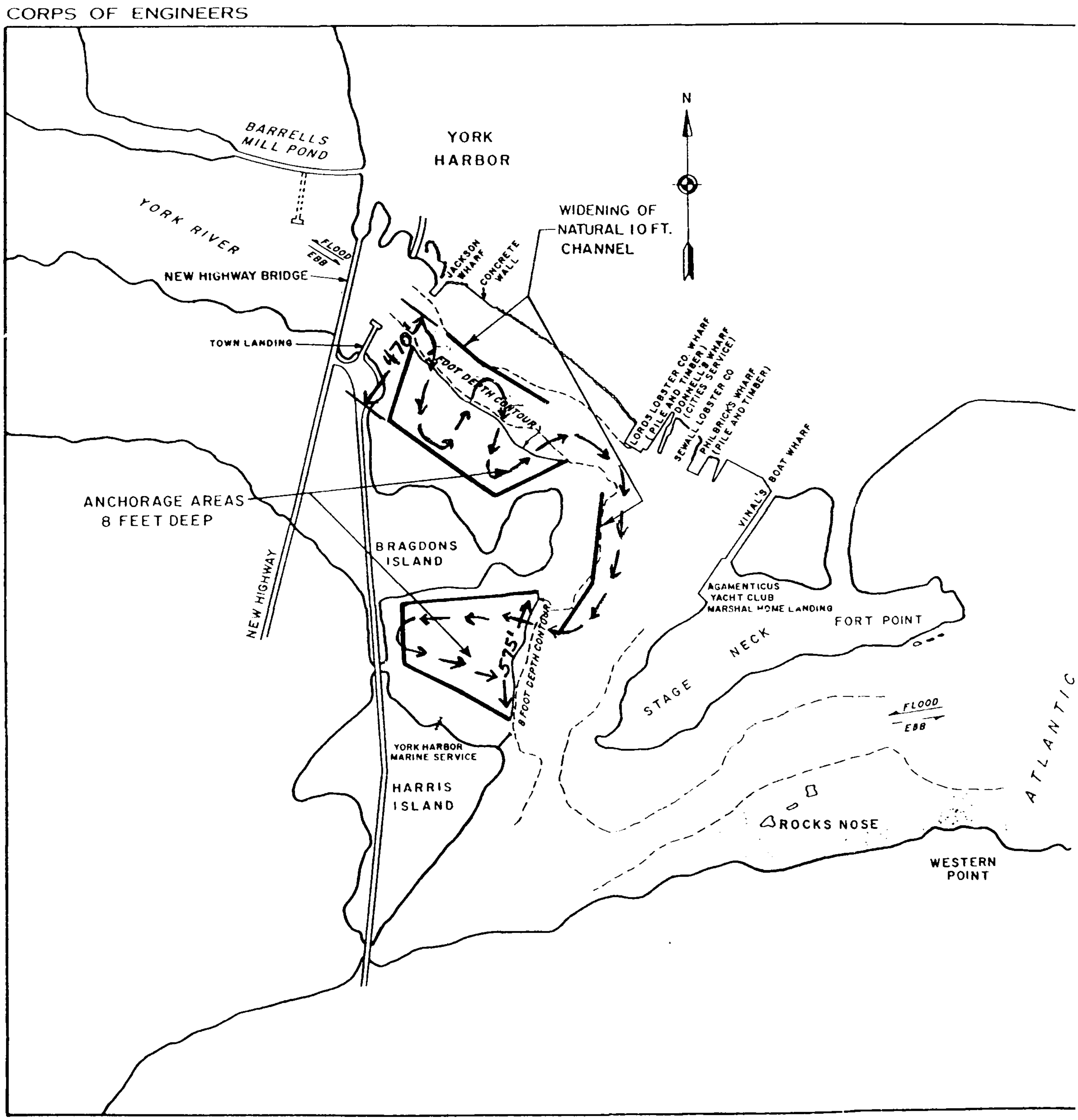


Figure E-36



U.S. ARMY
53
N
OARWEED
COVE
DOLPHINS
BULKHEAD
MARINE
RAILWAY
0.1 MI
LEDGE
PINNACLES
0.05 MI
PERKINS
COVE
0.0 MI
MAINE
N.H.
MASS
JOSIAS RIVER
MANCHESTER
NEWBURYPORT
BOSTON
BOSTON BAY
ATLANTIC OCEAN
LOCATION MAP
SCALE IN MILES
BRIDGE CLEARANCES
FOOTBRIDGE (LIFT)
Hor. 43.5 ft
Vert. 15 ft. M.H.W.
1"=204'
Length =1,571'
JOSIAS RIVER
OGUNQUIT, MAINE
MARCH 1960
SCALE IN FEET
100
0
100
200
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Figure E-37



CORPS OF ENGINEERS
BARRELLS MILL POND
YORK HARBOR
N
YORK RIVER
FLOOD
EBB
WIDENING OF NATURAL 10 FT. CHANNEL
NEW HIGHWAY BRIDGE
JACKSON WHARF
CONCRETE WALL
TOWN LANDING
470'
8 FOOT DEPTH CONTOUR
LORDS LOBSTER CO. WHARF (PILE AND TIMBER)
DONNELL'S WHARF (CITIES SERVICE)
SEWALL LOBSTER CO.
PHILBRICK'S WHARF (PILE AND TIMBER)
VINAL'S BOAT WHARF
ANCHORAGE AREAS 8 FEET DEEP
BRAGDONS ISLAND
NEW HIGHWAY
AGAMENTICUS YACHT CLUB
MARSHAL HOME LANDING
FORT POINT
STAGE NECK
575'
8 FOOT DEPTH CONTOUR
FLOOD
EBB
ATLANTIC
YORK HARBOR MARINE SERVICE
HARRIS ISLAND
ROCKS NOSE
WESTERN POINT

Figure E-37

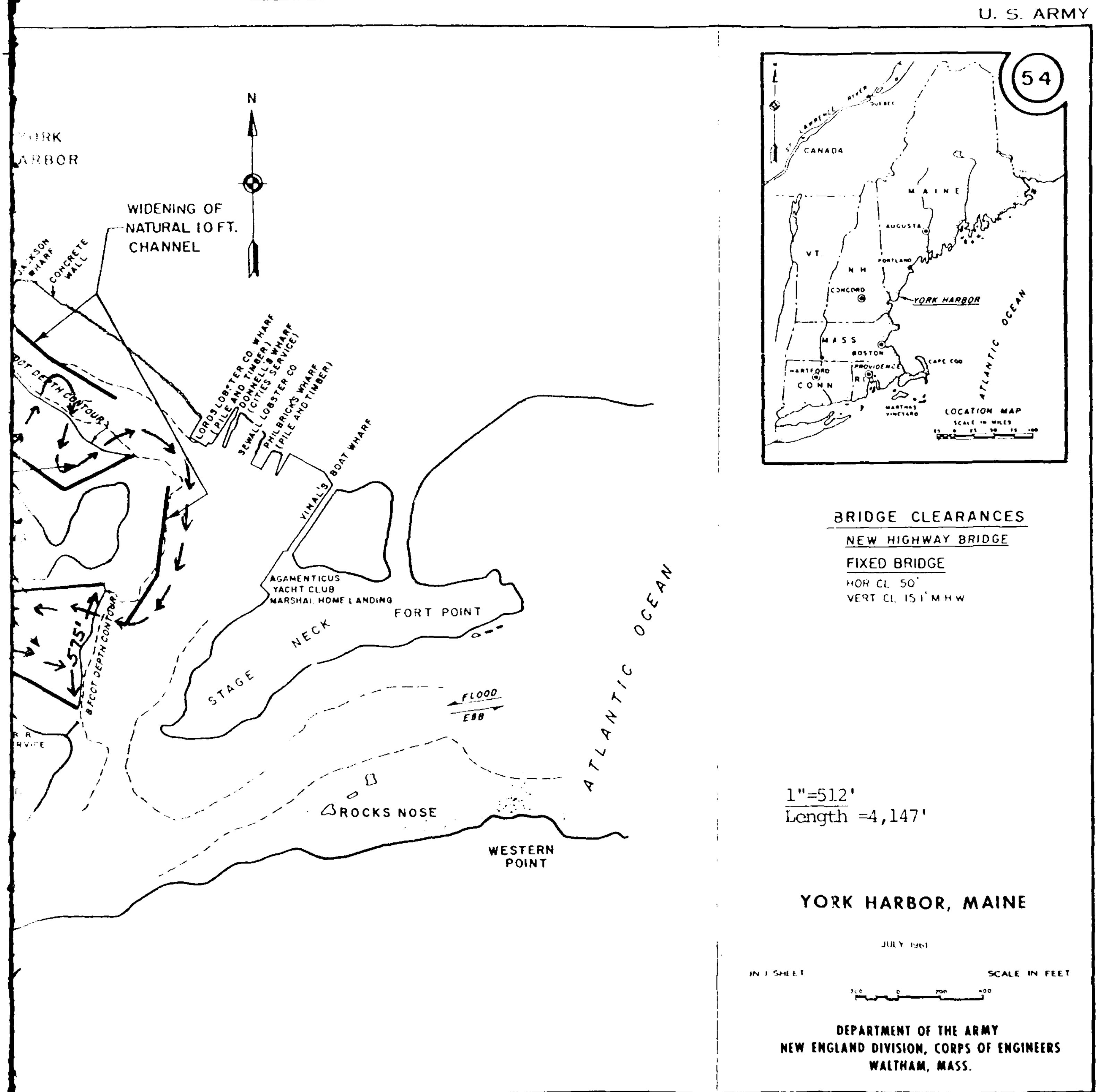

U. S. ARMY
N
YORK HARBOR
WIDENING OF NATURAL 10 FT. CHANNEL
JACKSON WHARF
CONCRETE WALL
LORDS LOBSTER CO. WHARF (PILE AND TIMBER)
DONNELL'S WHARF (CITIES SERVICE)
SEWALL LOBSTER CO.
PHILBRICK'S WHARF (PILE AND TIMBER)
VINAL'S BOAT WHARF
AGAMENTICUS YACHT CLUB
MARSHAL HOME LANDING
FORT POINT
STAGE NECK
575'
FLOOD
EBB
ATLANTIC OCEAN
ROCKS NOSE
WESTERN POINT
54
CANADA
MAINE
AUGUSTA
PORTLAND
VT.
N.H.
CONCORD
YORK HARBOR
MASS
BOSTON
HARTFORD
PROVIDENCE
CONN
R.I.
CAPE COD
ATLANTIC OCEAN
LOCATION MAP
BRIDGE CLEARANCES
NEW HIGHWAY BRIDGE
FIXED BRIDGE
HOR CL 50'
VERT CL 15.1' M.H.W.
1"=512'
Length =4,147'
YORK HARBOR, MAINE
JULY 1961
IN 1 SHEET
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

Table E-6

MAINE HARBOR SURVEY TRIP SIX (PORTLAND AIRPORT)

Scarborough River	(Figure E-33)
Cape Porpoise (Kennebunkport)	(Figure E-34)
Kennebunk River	(Figure E-35)
Josias River (Ogunquit)	(Figure E-36)
York Harbor	(Figure E-37)

Scarborough River			
Deadhead from Portland Airport1		4.33 NM	0.043 Hr.
Survey:	7,910′	1.30 NM	0.065 Hr.
Cape Porpoise			
Deadhead from Scarborough River		16.59 NM	0.166 Hr.
Survey:	4,718′	0.776 NM	0.039 Hr.
Kennebunk River			
Deadhead from Cape Porpoise		2.89 NM	0.029 Hr.
Survey:	6,000′	0.987 NM	0.049 Hr.
Josias River			
Deadhead from Kennebunk River		6.49 NM	0.065 Hr.
Survey:	1,571′	0.259 NM	0.013 Hr.
York Harbor			
Deadhead from Josias River		7.50 NM	0.075 Hr.
Survey:	4,147′	0.683 NM	0.034 Hr.
Deadhead to base at Portland		34.63 NM	0.346 Hr.
Short stop deadhead allowance		13.3 NM	0.133 Hr.
Total deadhead		85.73 NM	0.857 Hr.
Total survey		4.01 NM	0.201 Hr.
Total		89.74 NM	1.058 Hr.

Mission Costs

The total survey nautical miles for this mission are 82.5, taking the helicopter 4.12 hours, while the deadhead nautical miles are 705.1, taking the helicopter 7.05 hours. The expected conventional cost for this scenario is $111,010 (Table E-7). The HLBS would be used for seven days. This includes four days of ferry and set up and three days of surveying as shown in Table E-8. The total cost per mission is $49,025, which consists of helicopter cost of $40,404, laser crew cost of $2,295; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $4,338 as shown in Table E-9. Table E-9 also shows operating costs per square nautical mile of $12,403.

Table E-7

Project Description of Maine Mission

PROJECTS	Conventional: Cost ($000)	Conventional: Survey Freq	Conventional: Expected Cost	HLBS: Nautical Miles Survey	HLBS: Nautical Miles Deadhead	HLBS: Survey Days	HLBS: Extra Grnd Days	HLBS: Survey (Hours)	HLBS: Deadhead (Hours)
A--Bucks Hbr, Machias River	20.3	1.00	$20,270	10.172	182.3	0.5	0.5	0.51	1.82
A--Eastport, Lubec, St Croix									
B--Corea, Bunker, Winter	13.9	1.00	$13,930	2.818	75.360	0.5		0.14	0.75
B--Jnsprt, Pig Isle Gut, Beals									
C--Bar,Deer Isle,Union,Frenchboro	18.1	1.00	$18,050	7.510	89.290	0.5		0.38	0.89
C--Isle Au Haut,Northeast,Bass									
D--Carvrs,OwlsHead,Georgs,Stocktn	22.8	1.00	$22,830	8.570	93.300	0.5		0.43	0.93
D--Searsport,Belfast,Camden									
E--Cathance,Harraseeket,Kennebec	12.18	1.00	$12,180	49.37	179.09	0.5		2.47	1.79
E--New, East Boothbay, Hendricks									
F--Kennebunk, Josias, York	23.8	1.00	$23,750	4.01	85.73	0.5		0.20	0.86
F--Scarborough, Cape Porp							0.5		
Totals	$111		$111,010	82.5	705.1	3.0	1.0	4.1	7.1

Table E-8

Maine	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	3		$9,000
Helicopter Mission Flight Hours	11.2		$7,374
Travel & Per Diem (Per Prsn/Day)	$70		$1,470
Total Helicopter Costs			$40,404
LASER CREW COSTS			
Number of Mission Days--Laser Crew	3		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$1,875
Travel & Per Diem (Per Prsn/Day)	$70		$420
Total Laser Crew Cost			$2,295
OTHER COSTS			
Number of Mission Days--Ground Crew	4		
Ground Crew (Nmbr & Avg Price)	2	$275	$2,200
Travel & Per Diem (Per Prsn/Day)	$70		$560
Ground Transportation	$50		$400
Number of Survey Hours	4.12		
Post Processing (Technician $/Hr)	$38		$1,546
Efficiency Factor	15.0%		$1,619
(% Helicopter Flight, Laser Crew			
Total Other Costs			$6,325
TOTAL OPERATING COSTS PER MISSION			$49,025

Table E-9

Maine

UNIT OPERATING COST (per hour)

Operating Costs per Mission	$49,025
Helicopter Mission Flight Hours	11.2
Unit Operating Cost ($/Hrs)	$4,388

UNIT OPERATING COST (per Square Nautical Mile)

Operating Costs per Mission		$49,025
Number of Survey Hours	4.12	
Coverage Rate (Sq N Miles/Hr)	0.99	4.1
Unit Operating Cost ($/S.N.M.)		$12,043

SQUARE AREA SURVEYED

Nautical Miles	4.07
Kilometers	7.54

Appendix F

NEW JERSEY INTRACOASTAL WATERWAY

The survey of the New Jersey Intracoastal Waterway will begin where the Delaware Bay meets the Cape May Canal and will proceed along the Intracoastal Waterway for 122 nautical miles north to Atlantic Highlands.

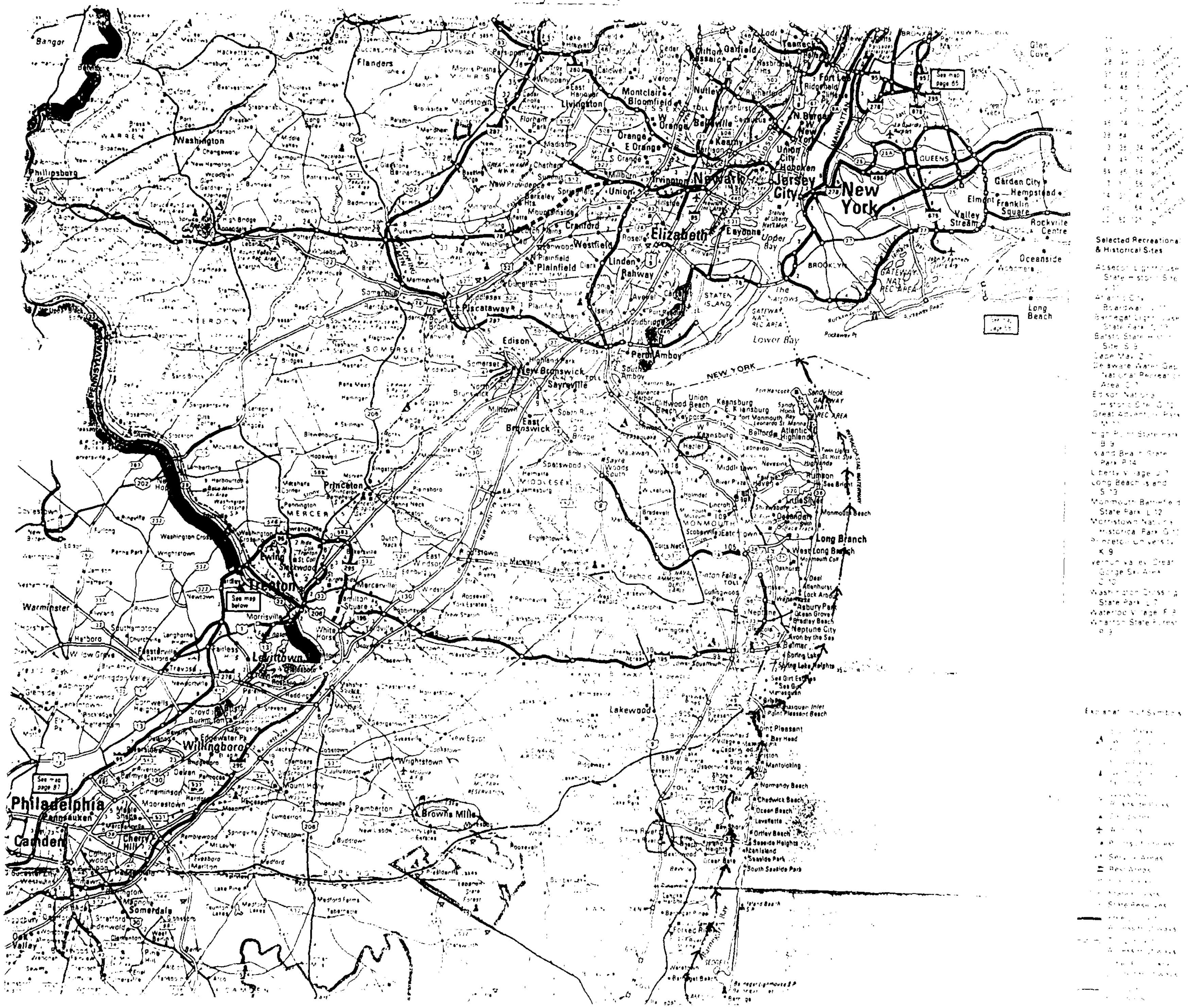
Scenario Analysis

The surveying will take one day, the set-up will take one-half day, and the take down will take one-half day. There will be five UHF trisponders stationed at Fortescue, Egg Harbor City, Browns Mills, Hazlet and CGAS (Coast Guard Air Station) Brooklyn Heliport. The GPS Station will be located at Browns Mills. The UHF trisponders will be set up one-half day before surveying. One team will set up the trisponders at Fortescue and Egg Harbor City; the other team will set up the trisponders at Browns Mills, Hazlet and the CGAS Brooklyn Heliport (Figure F-1).

The helicopter will make three trips, and have refuelings at the Atlantic City Airport in Bakersfield and the Toms River Airport in Toms River.

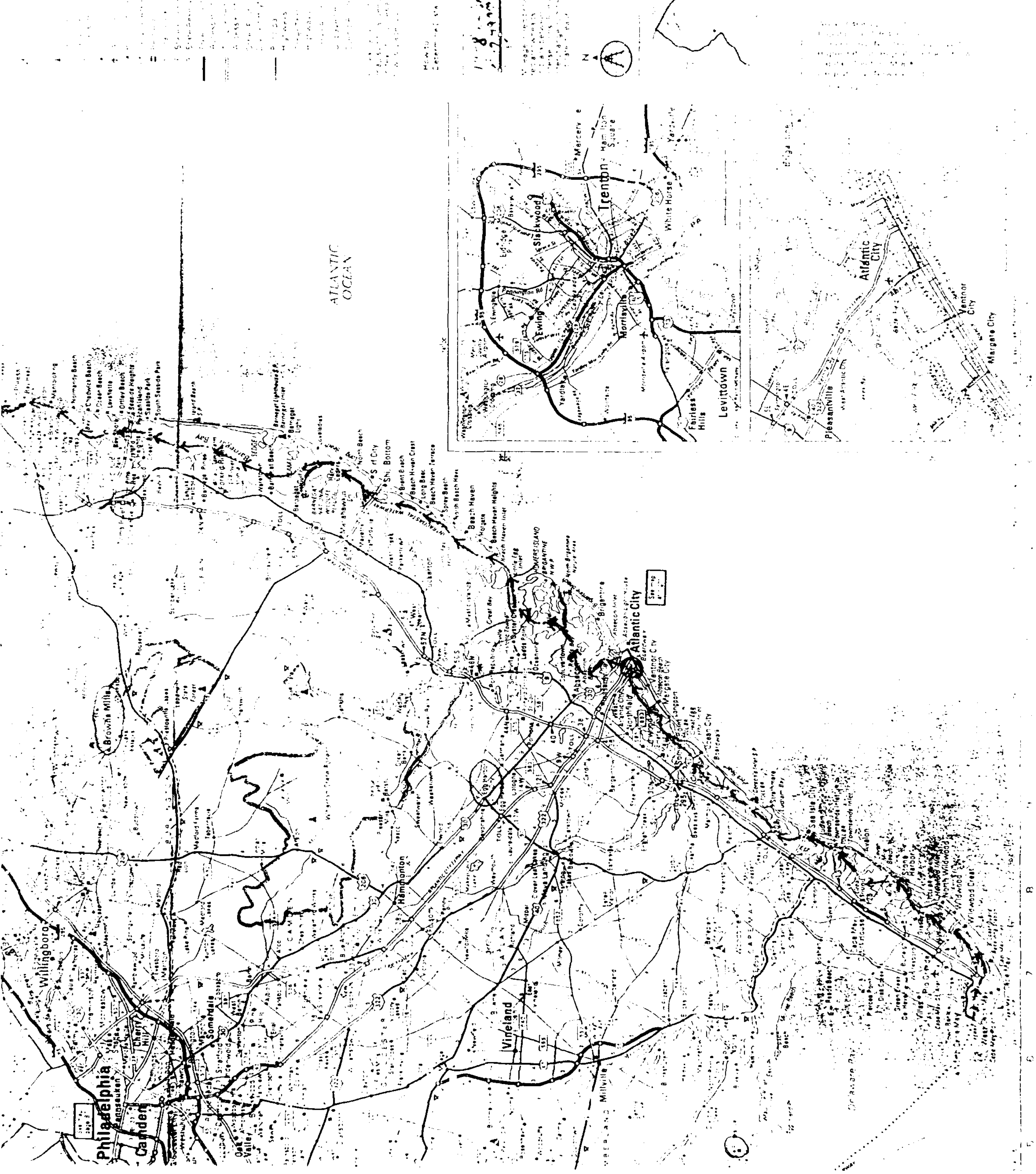
On Trip One the helicopter will fly deadhead at 100 knots from the Atlantic City Airport at Bakers Field to the beginning of the New Jersey Intracoastal Waterway at the Delaware Bay. This is approximately 37.45 nautical miles and will take .375 hours. At this point, the helicopter will begin surveying at 20 knots. It will follow the Intracoastal Waterway from the beginning of the Cape May Canal to the Cape May Inlet. It will then survey up the Jersey coast along the Intracoastal Waterway until it reaches Atlantic City Airport at Bakersfield. This is approximately 37.45 nautical miles and will take 1.837 hours. The helicopter will then refuel at the Atlantic City Airport in Bakersfield. The total survey miles for Trip One are 37.45 nautical miles. The total hours for Trip One are 2.248 hours.

Figure F-1



New York
Jersey City
Newark
Elizabeth
Philadelphia
Camden
Trenton
Princeton
New Brunswick
Long Branch
Lakewood
Levittown
Willingboro
Browns Mills
Washington
Flanders
Bangor
Phillipsburg
Edison
Perth Amboy
Plainfield
Westfield
Livingston
Montclair
Bloomfield
Garden City
Hempstead
Valley Stream
Oceanside
Long Beach
Lower Bay
Upper Bay
Brooklyn
Queens
Manhattan
Warminster
Selected Recreational & Historical Sites
Explanation of Symbols

New Jersey



ATLANTIC OCEAN
Philadelphia
Camden
Willingboro
Somerdale
Vineland
Millville
Hammonton
Atlantic City
Ventnor City
Margate City
Brigantine
Beach Haven
Browns Mills
Trenton
Levittown
Morrisville
Ewing
Fairless Hills
White Horse
Pleasantville

On Trip Two the helicopter will continue surveying the New Jersey Intracoastal Waterway from the Atlantic City Airport at Bakersfield along the Jersey Coast to Seaside Heights. This is approximately 44.94 nautical miles and will take 2.247 hours. The helicopter will then fly deadhead at 100 knots to Toms River Airport to refuel. This is approximately 5.24 nautical miles and will take .052 hours. Total survey miles for Trip Two are 44.94 nautical miles. Total hours for Trip Two are 2.299 hours.

On Trip Three the helicopter will fly deadhead at 100 knots from Toms River Airport to Seaside Heights. This is approximately 5.24 nautical miles and will take .052 hours. The helicopter will then continue surveying from Seaside Heights, the New Jersey Intracoastal Waterway up into the beginning of the New York Intracoastal Waterway. This is approximatley 39.32 nautical miles and will take 1.966 hours. The helicopter will then fly deadhead at 100 knots from the beginning of the New York Intracoastal Waterway to the CGAS Brooklyn Heliport. This is approximately 7.49 nautical miles and will take .075 hours. Total survey miles for Trip Three are 1.966 miles. Total hours for Trip Three are 2.093 hours (*Table F-1*).

When the UHF trisponders are no longer needed, the first team will take down the trisponders at Fortescue and Egg Harbor City. The second team will take down the trisponders at Browns Mills and Hazlet. The fifth trisponder will be picked up by the helicopter at the CGAS Brooklyn Heliport.

Mission Costs

The total survey nautical miles for this mission are 121.7, taking the helicopter 6.09 hours, while the deadhead nautical miles are 55.4, taking the helicopter .55 hours. The expected conventional cost for this scenario is $150,000 (Table F-2). The HLBS would be used for five days. This includes four days of ferry and set up and one day of surveying as shown in Table F-3. The total cost per mission is $36,138, which consists of helicopter cost of $30,992, laser crew cost of $765; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $5,470 as shown in Table F-4. Table F-4 also shows operating costs per square nautical mile of $6,004.

mission is $36,138, which consists of helicopter cost of $30,992, laser crew cost of $765; and other costs as shown in the table. The operating cost per hour for this scenario has been calculated to be $5,470 as shown in Table F-4. Table F-4 also shows operating costs per square nautical mile of $6,004.

Table F-1

HELICOPTER FLIGHT

	Hours	Total Hrs. Between Refueling	NM	Total Survey Miles
Trip One				
1) Deadhead 100 Knots				
From: Atlantic City Airport/ Bakers Field To: Beginning of NJ at Delaware Bay	.375	.375	37.45	0
2) Surveying 20 Knots				
From: Beginning of NJ at Delaware Bay To: Atlantic City	1.873	2.248	37.45	37.45
3) Deadhead 100 Knots				
From: Atlantic City To: Atlantic City Airport/ Bakers Field, Refuel	0	2.248	0	37.45
Trip Two				
1) Surveying 20 Knots				
From: Atlantic City Airport/ Bakers Field To: Seaside Heights	2.247	2.247	44.94	44.94
2) Deadhead 100 Knots				
From: Seaside Heights To: Toms River Airport, Refuel	.052	2.299	5.24	44.94

Table F-1 (Continued)

HELICOPTER FLIGHT

	Hours	Total Hrs. Between Refueling	NM	Total Survey Miles
Trip 3				
1) Deadhead 100 Knots				
From: Toms River Airport To: Seaside Heights	.052	.052	5.24	0
2) Surveying 20 Knots				
From: Seaside Heights To: NY	1.966	2.018	39.32	39.32
3) Deadhead 100 Knots				
From: NY To: CGAS Brooklyn Heliport	.075	2.093	7.49	39.32

Table F-2

Project Description of New Jersey Mission

	Conventional			HLBS					
	Cost	Survey	Expected	Nautical Miles		Survey	Extra	Survey	Deadhead
PROJECTS	($000)	Freq	Cost	Survey	Deadhead	Days	Grnd Days	(Hours)	(Hours)
NJ-IWW	150.0	1.00	$150,000	121.710	55.420	1	0.5	6.09	0.55
Totals	$150		$150,000	121.7	55.4	1.0	0.5	6.1	0.6

Table F-3

New Jersey	OPERATING COSTS PER MISSION		
HELICOPTER COSTS	Assumptions		Mission Totals
Helicopter Lease Cost (Fixed)	$3,000		
Helicopter Lease Cost ($/Flt.Hr)	$660		
Helicopter Ferry & Set Up (Days)	4		$12,000
Helicopter Ferry Flight Hours (RT)	16.00		$10,560
Number of Mission Days--Hlcptr Crew	1		$3,000
Helicopter Mission Flight Hours	6.6		$4,382
Travel & Per Diem (Per Prsn/Day)	$70		$1,050
Total Helicopter Costs			$30,992
LASER CREW COSTS			
Number of Mission Days--Laser Crew	1		
Tech Laser Crew (Nmbr & Avg Price)	2	$312.5	$625
Travel & Per Diem (Per Prsn/Day)	$70		$140
Total Laser Crew Cost			$765
OTHER COSTS			
Number of Mission Days--Ground Crew	1.5		
Ground Crew (Nmbr & Avg Price)	2	$275	$825
Travel & Per Diem (Per Prsn/Day)	$70		$210
Ground Transportation	$50		$150
Number of Survey Hours	6.09		
Post Processing (Technician $/Hr)	$38		$2,282
Efficiency Factor	15.0%		$1,093
(% Helicopter Flight, Laser Crew			
Total Other Costs			$4,560
TOTAL OPERATING COSTS PER MISSION			$36,318

Table F-4

New Jersey

UNIT OPERATING COST (per hour)

Operating Costs per Mission	\$36,318
Helicopter Mission Flight Hours	6.6
Unit Operating Cost (\$/Hrs)	\$5,470

UNIT OPERATING COST (per Square Nautical Mile)

Operating Costs per Mission		\$36,318
Number of Survey Hours	6.09	
Coverage Rate (Sq N Miles/Hr)	0.99	6.0
Unit Operating Cost (\$/S.N.M.)		\$6,044

SQUARE AREA SURVEYED

Nautical Miles	6.01
Kilometers	11.13