Division of Science, Technology and Mineral Resources  
Robert G. Doyle, Director

PENOBSCOT BAY PHYSICAL RESOURCES REPORT

(Preliminary)

by

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Department of Economic Development
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FOREWORD

The concept of development through conservation and enlightened land use policies require that the State provide for the generation and interpretation of basic resource data which will assign values, resolve conflicts of interest, set standards, monitor and measure changes over time.

The continental boundary is a dynamic zone of high energy and the locus of very rapid geological change. Earth materials are moved and distributed in complex erosion-transportation-deposition systems that respond quickly to man's modifications of the coastal zone. It is also the zone of interplay between marine and terrestrial air masses. It is therefore, a zone of continuing engineering problems.*
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(All plates and photographs are in pocket in back cover of report.)
INTRODUCTION

This is the first of a series of reports on the physical environment of the major estuaries of the State. In this series we will describe the physical setting of each estuary, commenting on the potential for industrial or scientific facility location, as well as defining the limits of alteration of the natural assets which must be preserved. Presented here are such data as configuration and composition of the ocean bottom, surface and bedrock geology of the coastal areas, atmospheric data, availability and quality of water and construction materials, and configuration of the land surface relief. Large scale charts showing the physical features are included in the report, as well as data tables for detailed information of six locations chosen as potential development. There is particular detail given to the Penobscot Bay estuary as an ideal location for a major shipbuilding facility. Emphasis is placed, generally, on presenting data for industrial activity employing large numbers of skilled labor without spoiling or polluting the environment. One
section of each report deals with water quality, the fisheries areas and present pollution levels.

LOCATION AND DESCRIPTION OF THE ESTUARY

The area covered by this report includes all of Penobscot Bay exclusive of the Vinal Islands and Long Island with its northern limit the Verona Island. The area includes portions of Knox, Waldo and Hancock Counties (Figure 1). The Bay embraces approximately 300 square miles with a linear shoreline of 150 miles and is located mid-way along the Maine coast between Kittery and Eastport.

Penobscot Bay is one of the larger irregularities along the Maine coast. These irregularities result from post-glacial submergence of the land which occurred approximately 10,000 years ago. Penobscot Bay, like many other estuaries along the coast, is a fjord-like physical feature. It displays the narrow, glacially scoured deep channel with a seaward shelf and a relatively regular nearshore bottom.

Marine Data

There are seven well developed harbors in the Bay: Thomaston, Rockland, Rockport, Belfast, Searsport, Penobscot, Castine and Deer Isle Harbor. Of these, only Thomaston and possibly Belfast lack the minimum 30 to 40
feet of water necessary for major development. Rockland and Searsport are presently used as commercial and industrial ports for oil, grains, paper and chemical facilities.

The average water depth for the inner Bay is 80 feet rising to 35 feet in the harbors. Mean tidal range is 4 to 12 feet, and the Bay currents average 2.5 knots, except in the upper Bay island channels where currents move at four to seven knots.

Land Features

In this report a ten mile wide strip of land from shore is included as the land area described. The geography and topography is an irregular pattern. Steep, 50° inclined, sea cliffs averaging thirty feet above sea level are common. Bedrock or unconsolidated glacial outwash form the sea cliffs. Where unconsolidated materials are exposed to marine erosion, active undercutting and degrading occur.

Relief

There is an irregular surface cover composed of glacially deposited gravels and cobbles, a lower layer of marine clay, and occasional "hardpan" glacial till beds. Ten percent of the surface has exposed bedrock terrain. The relief is highly irregular, averaging 80 to 120 feet, except for the two high ranges on the northwest side of the
bay: the Camden Hills where Mt. Megunticook stands at 1,385 feet elevation; and the Belfast Hills which reach 600 feet.

Drainage

The ten mile land strip is generally well drained; local irregularities in a normal coastal drainage pattern occur inland behind the coastal hill ranges of Knox County and the Belmont Area west of Belfast. A series of minor rivers and streams drain the area. Of these, the Passagassawakeag River at Belfast, the Union and Megunticook Rivers draining the Camden Hills, and the Bagaduce River which controls the Castine-Cape Rosier Basins on the east side of the Estuary. Several large lakes lie within the area of study; Megunticook and Knight lakes on the west shore of the Bay are the largest.

Culture

Rockland, Rockport-Camden, Belfast and Castine are the principal centers of business and population. Census figures indicate a population of 35,000 for the Bay area. It is served by two major highways, Routes U.S. 1 and Maine Route 3. Rockland, Belfast and Searsport are served by branch lines of the Maine Central and Bangor-Aroostook Railroads. Rockland is served by the Northeast Airlines scheduled air service at the Rockland Municipal Airport. A series of small air strips are scattered throughout the region.
Geology

The area is underlain by rock units of lower Paleozoic age. The sedimentary rocks are highly metamorphosed into complex schists and gneisses. Intense folding and shearing has deformed the rocks into vertical bands with an axial trend of north 25° east for all the layered rocks.

Granite bodies occur on the north and east sides of Penobscot Bay. Most of the area above Verona Island, and all of Southern Hancock County are underlain by granite rock of various types; although gray, binary granite is the most common.

Both the metamorphic and granite rocks are described as crystalline basement for engineering requirements discussions. They are tough, competent and grossly massive. Artesian water supplies from the deep fracture system are usually adequate for general purpose supplies, but supplemental sources from surface water bodies and the gravel zones are often necessary for industrial purposes.

WEATHER DATA

Historical weather data for each of the individual harbors is poor with the exceptions of Rockland, Belfast and Castine. Data for Rockland Harbor is the most complete of all the harbors in the Bay. This is partially due to
the fact that the U. S. Coast Guard maintains offices and mooring facilities there, and hence serves as a major compiler of weather data. Of these particular data, perhaps the most useful is that on fog. In addition to its Rockland facilities, the Coast Guard maintains several light-stations within and surrounding the Bay. Two of these light-stations, Fort Point, east of Searsport, and Owls Head, south of Rockland, were the principal sources of fog data in this study. Data compiled from records of the Fort Point Station for the period from 1950-1963 indicates that fog horn operation averaged 847 hours per year. Data compiled from records of the Owls Head Station indicated a yearly average of 888 hours of fog horn operation for the same period. In terms of 24-hour days, these hours of operation would convert to 35 and 37 days respectively. However, discussions with numerous private sources around the Bay indicated that their coastal communities were effected by fog 20-25% of the time. For the purposes of this report, and within the limits of information available, we feel justified in projecting the number of days of at least 6 hours of fog conditions to be approximately 70 days per year. The probability of fog days was greatest during the period from May to September. The Coast Guard fog horn operations records for these two stations--Owls Head and
HOURS OF FOG HORN OPERATION
PENOBSCOT BAY 1968 - 1969

SOURCE: U.S. COAST GUARD
Fort Point—during the period July 1, 1968, to June 30, 1970, are presented in figure 2 and in the table below:

Average Fog Horn Operation (hourly)

Fort Point - Total 1079

<table>
<thead>
<tr>
<th>Month</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
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Owls Head - Total 1832

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<th>Sept</th>
<th>Oct</th>
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There were 753 more fog horn operation hours (FHOH) at Owls Head during the period than at Fort Point. The inner bay location of Fort Point, near Searsport, 25 miles up the Bay from Owls Head is an indication of the greater fog cover time on the open coast relative to inland areas. There is the equivalent of one 24 hour per day month more fog on the open coast. Of equal interest is the fact that the months of June to October are the time of greatest FHOH. In figure 3 there is a plot of wind direction speed and FHOH. Note that the time of greatest FHOH compares with the highest southwest and easterly winds. The northwest high pressure system winds hold the moist air masses off the coast in the winter and early spring. (Figures 2 & 3)

The Penobscot Bay region is typical of the climatologi-
COMPARISON OF FOG HORN OPERATION TIME TO WIND VELOCITY AND STRENGTH, PENOBSCOT BAY 1957 - 1969

SOURCE: U.S. WEATHER BUREAU AND E.S.S.A. DATA
cal environment found along the Maine coastline. The coastal region shares many of the same climatic conditions found throughout the State. These include: (1) changeable-ness of the weather, (2) large ranges of temperature, both diurnal and annual; and, (3) great differences between the same seasons in different years. Recent history tells us that both summers and winters have been fairly moderate in nature. Near shore and shoreline areas are more adversely effected by winter rather than summer storm fronts. The cool ocean has a tempering effect on summer thunderstorms but it contributes to the effects of winter "Northeasters".

Although coastal regions may receive in excess of 70" of snow annually, they may also receive upwards of 4" of rain during some winter months. Coastal regions are more seriously effected by ice storms and glazing conditions than inland areas. Temperatures for the Bay region have mean maximums of 78°-82° in the summer while winter temperatures average 32°-34° with average minimum readings of 10°. The probability of sub-zero temperatures in this region is approximately 5% and the average annual temperature is in the upper 40's, all in Fahrenheit.

Because the eight harbors under study are somewhat evenly distributed around the Bay, climatological data for any given harbor will be indicative of the conditions to be found in the other harbors. Prevailing winds for the Bay are generally southwesterly in the summer, and north-northwesterly in the winter. (Figure 4)
MAXIMUM WIND VELOCITY REPORTINGS
ROCKLAND COAST GUARD STATION, 1954-1959
TEN MOST FREQUENT WIND DIRECTIONS

ROMAN NUMERALS INDICATE ORDER OF WIND/DAY
PERCENTAGE FROM EACH DIRECTION

PATTERN INDICATES MAXIMUM VELOCITIES REPORTED
<table>
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<th>Station Name/Number</th>
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<td>3304</td>
<td>3304</td>
<td>1954-1959</td>
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| Total               | 5671           | 10,714        | 1933             | 936                  |

**Notes:**
- Less than 0.05 percent.
- February 1958 missing, February 1960 substituted.

U.S. Comm. ESSA, Env. Data Serv., Asheville, N.C.
BATHYMETRY AND APPROACHES TO PENOBSCOT BAY

Penobscot Bay represents the largest indentation on Maine's irregular coastline. In plan view this indentation is triangular in shape, the base leg of which stretches east-west from Tenants Harbor to Isle Au Haut for a distance of 30 miles, and the apex located just above Searsport where the Penobscot River empties into Penobscot Bay. A series of small and large islands divide the Bay into two parts, East Penobscot Bay and West Penobscot Bay. The western shore of Penobscot Bay reveals numerous coastal irregularities which mark the harbor towns of Searsport, Rockland, Rockport, Camden and Belfast. The upper half of the eastern shore of the Bay is even more irregular with Castine, Harborside, and Cape Rosier forming the major harbors. The lower half of the eastern shore of the Bay is characterized by numerous islands the most prominent being Deer Isle and Isle Au Haut. The Bay proper is occupied by numerous islands which include the major islands of Vinalhaven, North Haven and Islesboro (Long Island).

Penobscot Bay occupies the lower channel of the pre-glacial Penobscot River which flowed out onto the continental Shelf at a time when sealevel was considerably lower than exists today. The old stream channel in what is now West Penobscot Bay is believed to be structurally
controlled by a large magnitude fault which extends up the Bay to Isleboro where it bifurcates and extends northward along both sides of the island. These stream channels were scoured and deepened by lobes of ice which extended down the ancestral river valley during Wisconsin time (or the last glaciation). Deglaciation and a rise in sealevel drowned the ancestral valley to form the Penobscot Bay or estuary.

Because submergence effected a land surface which has been modified by glacial activity, the Maine coast is classified as a fjord type of coastline. Fjords are overdeepened glacial troughs that reach the coast below sealevel; so they become long arms of the sea stretching inland between rocky walls.

In plan view, fjords have a characteristic rectilinear pattern which is determined by belts of structural weakness. The latter may be relatively weak sediments or schists enclosed by massive crystalline rocks, or they are fractured belts with closely spaced joints or faults. The distribution of fjords is conditioned by (1) appropriate tectonic structures in regions near the sea; (2) pre-existing valleys which followed these structures; and, (3) heavy glaciation by seaward-moving ice of sufficient thickness and surface slopes that the
main valleys were overdeepened up to or beyond the coast.

The bathymetric map of Penobscot Bay (Plate I) was contoured on depth values designated on the United States Coast and Geodetic Survey Chart No. 1203. In West Penobscot Bay, two deep channels of at least 180 feet of water extend southward along both sides of Long Island and coalesce into one restricted main channel immediately south of the island. As indicated on the map, deep water is in close proximity to most land areas. The channel in West Penobscot Bay continues to Junken Ledge where the waterway abruptly widens into relatively shallower waters marked by numerous shoals and islands. This phenomenon suggests a typical fjord profile where a shallow bedrock threshold or sill occurs at the seaward approaches to landward deep water channels. This terminal rock barrier which occurs near the seaward entrance is usually submerged at a shallow depth. The bathymetric map reveals that there are several channels which breach the sill and allow access to West and East Penobscot Bays. The first of these channels is Two Bush Channel which trends northeast-southwest and extends up the west side of the Bay. A second trends northward past Bantam Ledge and between Foster Ledges and Large Green Island. A third approach extends northward between
Matinicus Island and Wooden Ball Island and thence west-northwest to the main channel. A fourth access to West Penobscot Bay is gained via an east-west route north of Three Fathom Ledge and Matinicus Island or northward into East Penobscot Bay west of Isle Au Haut.
BOTTOM SEDIMENTS AND GEOLOGIC HISTORY

The composition of bottom sediments in the Bay is poorly known. There are only a few sources of information available, a recent publication from 1963-65 cruises by research projects from Woods Hole, and scattered comments in the marine logs which the staff were able to review. Personal communication with Dr. D. A. Dean, of the Darling Center, has provided some information regarding the upper Bay east of Verona Island. Also, a master's thesis on the bottom sedimentation and benthonic life in the Searsport Harbor area provides some bottom sampling data and is included in this study, (Shorey, 1969).

The bedrock sub-basement on the sea floor of the Bay is of the same geologic rock type and topography as found on land. The metamorphosed sediment and granite bodies were eroded by action of the glacial ice into long, north-south trending ridges and valleys formed by alternating bands or resistant and softer rocks. The resulting topography was filled to a smooth plain by valley filling from outwash of landward glacial debris (sand, gravel, cobbles) and the deposition, at least to the Junken Ledge area in the southern part of Penobscot Bay, of a thick layer of blue-gray marine clay (the Presumscot formation
Bloom, 1960). This clay layer represents a time period when the ice had melted but the coast had not recovered from the downwarping effect of the ice weight.

From the available data it appears that the southern lip of the Bay and the immediate fore area to the north and of the Vinal Isles is underlain by gravel banks, sand plain patches and bare rock nubbles. Moving northward, there is a wide area of bottom material composed of greenish silty clay and minor sand. Further up the estuary the bottom becomes more clayey and the color changes to brown or dark gray. Within shallow closed harbors, there are considerable accumulations of anaerobic mud which is sulfide rich and highly contaminated with woodchips and organic compounds.

Both Dean's description of Verona and the Searsport Harbor study indicate the contaminated nature of the bottom. They are summarized here as follows:

There is still insufficient data available on the bottom types and distribution of sediments to make a definitive presentation. However, most inner bays have an upper layer of silty, black-greenish black muck intermixed with wood chips and scattered small cobbles. The composition does not indicate an anaerobic nor particularly sulfide-rich, environment,
although much of the bottom is not hospitable to an active biota. Several areas are presently under study and a planned addition to this report will include ocean bottom composition and sedimentation(?) data.

**CURRENT SYSTEMS AND QUANTATIVE WATER DATA**

There are two major scoured channels in the Bay representing Venturi current systems. Between Jellison Point and West Penobscot is a strong current, reaching bottom and developing a scour floor. The second clean bottom area is off Northport on the west side of the Bay. There is presently very little current data available for Penobscot Bay although the second year of a two year ESSA research project in the Bay will retrieve considerable current information.

During 1969 scientists with this ESSA project made a series of observations of temperature and salinity throughout the central part of Penobscot Bay. These observations indicate that there is a remarkable homogenation of water below the five meter mark, in terms of both temperature and salinity. The salinity patterns do show a unique seasonal variation. Figure 6 shows the distribution of salinity readings taken in the first (April) and
SALINITY RECORDING
LEFT NUMBER: AUGUST READING
RIGHT NUMBER: OCTOBER READING

BUCKSPORT
VERONA ISLAND

Belfast
sixth (October) runs of the 1969 ESSA survey. The effects of summer thermal radiation and decreased summer rainfalls seem not to affect the salinity values immediately. The possibility of a thermal--gravity layering--and consequent non-mixing with the lower layers may cause the sharp drop in the October salinity readings. A thin, freshwater, lightweight wedge appears to build up during the summer months, then to be dissipated by storm action, wind shift and T/solubility reactions in the winter months.

At 15 meters downward, however, both T & S are remarkably constant. At 10-25 meters, all readings for temperature vary between 27.5° C and 29.0° C with 85% of all T readings between 27.8° C and 28.6° C. Salinity values from samples at 10-35 meters mostly lie between 29.9% and 31.8%.

It is apparent from this ESSA work, and other reportings that the upper few meter bands of the estuary water column are the reaction sections. This has important consequences for planning man-produced contribution elements to the effluent. Only 10% of the volume of water in the estuary seems to be involved in physio-chemical reaction system. This requires limitation to which the water budget will accept.
SHORE AREA DESCRIPTION

This section describes in general terms the surficial deposits, bedrock geology and freshwater resources data for the area surrounding the Bay, to a distance of 10 to 15 miles from shore.

Surficial Materials Description. The surface materials, exclusive of bedrock exposures, found around the shore of Penobscot Bay are the result of glacial activity. They consist of three major types which have been, to some extent, reworked by post-glacial forces. These types of material are: (1) unconsolidated, unsorted debris--from silt to boulder size, (2) ice contact deposits--eskers, moraines, kame fields, outwash plains, and (3) marine clay (the Presumscot formation), refer to Plate III.

The debris materials are generally found inland of the strand line a mile or two. Composed of a great variety of materials and sizes, they represent partly reworked trash material left in situ by the melting of the ice sheet. Because of their unsorted nature and random distribution, debris materials do not make good building materials or foundation sites. The debris is of varying thickness, but as reworked gravels, often occurring as the surface layer in valley fillings.
Ice contact deposits are of lesser extent than the debris materials but of far greater importance. Eskers, kame fields and outwash plains are excellent groundwater sources and make the best gravel bank prospects. The ice contact deposits around the Bay occur along the west shore between Rockland and Bucksport, usually back from the shore a short distance. A good description of ice contact deposits is available by either Bloom or Borns in their more recent works (see Bibliography).

The marine clay layer is the most widespread surficial material in the Bay area. It occurs all along the Maine coast extending inland as much as 40 miles. Bloom has described the material and named it the Presumscot formation of post-Wisconsin Ice age. It was formed after melting of the last (Wisconsin) ice sheet when the ocean covered large areas of the coast and upriver lowlands. The material is not a true chemical-mineralogical clay; rather, it is a dark blue-gray to dull brown 'rock flour'. It is very similar in physical characteristics to present day tidal flats.

The marine clay covers a large area of the upper Bay from Belfast northward. Between Rockland and Camden there are also thick deposits of marine clay, especially in the lowlands behind the shore foreland. In the steep cliff area of the region, it is mostly devoid of clay, or any
surficial materials.

There are several localities along the coast where streams have cut through the pervasive clay and exposed a hardpan till material. This is very resistant, forming the valley floor of steep 'vee' shaped stream troughs. North of Castine along the east side of the Bay, and in the area east of Belfast, there are several examples of hardpan exposure. Such exposures are significant only in that they give evidence of the excellent foundation layer lying above the bedrock.

A recent upsurge of interest in surficial materials has prompted proposals of a series of studies on the Pleistocene and Holocene deposits in Maine. It is expected that a clearer picture of our present surface will be available in a year or two.

**Bedrock Geology of the Area.** The bedrock of the Penobscot Bay area consists of a complicated series of highly metamorphosed rocks of lower Paleozoic age differing in both structural pattern and rock type on the east and west side of the Bay. The rocks on the west side of the Bay between Belfast and Rockland compose a series of quartzites, schists and phyllites which form a resistant buttress all along the west shore. This buttress sequence is best displayed between Rockland and Rockport where the
deep waters north of Clam Cove result from the carving out of a nearshore channel by a less resistant bed or by a fault or fracture sequence very near to the present shore. The buttress unit is the quartzitic member of the Penobscot formation; see right side, Photograph 9.

The Penobscot formation covers most of the nearshore area between Belfast and Clam Cove north of Rockland. The Penobscot formation, of still questionable age, is represented near the Bay by a series of thick bands of quartzite and black sulfide-rich schist or phyllite and occasional layers of meta-volcanic rock. The variety of rock representing the formation has caused erosional differences and accounts for the great variety of terrain to be found along the coast. North of Rockland there are no granite bodies in the west shore area until the Bucksport-Verona Island channel is reached. Here, there is a complex series of granites, highly altered thermal aureole rocks and green phyllites which have caused a confused spectrum of topography. This accounts for the wiggling of the channel in the Verona-Bucksport area and the sharp break in terrain north of Frankfort up the river a few miles. There are very large granite bodies between Bucksport and Frankfort. These granite bodies were quarried for dimension stone up until a few years ago when the last one closed. Plate II shows the location of such units.
Along the east shore of Penobscot Bay there is a completely different rock section with the exception of those rocks in Orland township a few miles south of Bucksport. These rocks are a much softer and less resistant equivalent of the Penobscot formation rocks on the west shore. From the town of West Penobscot south to the Cape Rosier-Deer Isle Peninsula area, the geology is extremely complicated with a series of Silurian and Devonian meta-volcanic rocks. These rocks are highly faulted and further altered by hydrothermal solutions. There are numerous sulfide deposits in the area which further develop a complicated erosional pattern. The rocks in general are much less resistant than those on the west shore as evidenced by the lower relief and lower elevation of the general area. (Photo 7)

Faulting is particularly complex, especially in the Castine Peninsula area. This has resulted in a series of small blocky hills and torturous right-angle valleys in the area except along the immediate coast where the marine clay has smoothed out the irregularities sufficient to make a level strand area. This subsequent leveling has also developed a series of marsh and tidal flat areas which cover at least 20% of the area. This same marsh system does not occur to as great an extent on the west shore primarily because of a difference in
underlying rock type. There are a few granite bodies just south of Orland township but these do not contribute significantly to the development of the terrain. Several fjord-like embayments; two of them in Cape Rosier and several in the Castine area, result from sudden changes in the resistance of the rock type and the development of an open-fracture system. The rocks in the east side of the Bay trend north-south as opposed to the slightly northeast direction for the strike of the rocks on the west side of the Bay. These two strike attitudes cause the slightly asymmetrical 'vee' shape of Penobscot Bay.

In summary, the rocks of the area are generally resistant to erosion, develop good foundation material and also offer opportunities for quarrying for construction. The east side of the Bay is of lower elevation and of less relief than the west side of the Bay primarily because of a difference in erosional characteristics. The water is deeper on the west side of the Bay for reasons of changing resistant qualities of bands of the Penobscot formation or by faulting which follows the present shore.

**Freshwater Resources and Supplies.** The availability of freshwater is not a serious consideration to
most of Penobscot Bay's shoreline development areas.
Thomaston is located on the St. George River, which is
a potential source. Rockland and Rockport, while not
located on rivers, obtain their public water supplies,
as does Thomaston, from Mirror Lake and Chickawaukie
Pond. The total storage capacity of these two lakes is
approximately three billion gallons. Belfast, located
at the mouth of the Little River, gets its water supply
both from this River and two wells. Total capacity
of this combined system is not known, but average daily
consumption is averaging about 2.5 million gallons.
Searsport uses Halfmoon Pond as its water supply.
Total storage capacity of this Pond is unknown but it
can yield approximately one to one and one half million
gallons per day. The levels of present use require
only 50% of this potential; Castine, although located
on the Bagaduce River, derives its total water supply
from wells. This community has municipal storage
facilities amounting to 2.5 million gallons, but
apparent use amounts to only 80,000 gallons per day.

The quality of all sources of public water supplies
is good but generally receives some treatment by the
consuming municipalities. Most of the lakes and ponds
have a small summer population which causes minor pollu-
tion. However, cottage owners frequently use the lake water for drinking purposes. All the sources of water noted above, with the exception of springs and wells, are not very seriously affected by farming or industrial activity. However, shoreline soil types and bottom sediments may have quite an effect on water color and quality. Because of the variety of bottom sediment types and colors, large variations in water coloration and quality are not uncommon. Suspended sediments, caused primarily by the action of stream inflow and shoreline runoff, shade the water color but do not alter it harmfully for direct consumption. Clear water is often difficult to find, especially in areas where original and reworked silt-mixed marine clay deposits occur.
LOCALITY DESCRIPTIONS

Rockland Area Sites. There are two sites under consideration in the Rockland area. The first site, and the more attractive one, is in the south end of Rockland harbor in what is called Back Cove. The second site is a deep water location north of the Rockland area known as Clam Cove. This latter site is much more difficult to develop and there are summer vacation home communities in the area.

Back Cove. Back Cove is an estuary with very shallow water one half mile out into the harbor. It has relatively flat, well drained land behind it which would be usable for installation. In addition, the tidal area can be sealed off, giving a 1700 acre flat site in the flats area. The harbor is presently 25 feet to 40 feet in front of the clam flats area but with dredging this can hopefully be deepened to approximately 50 feet. Near the breakwater area there is 50 feet of water. This deep water stands as the roadstead and major acreage for deep draft ships which occasionally come into the harbor.

The approaches are excellent both from the east in the main Penobscot Bay channel and from the southwest to Two Bush Channel. Rockland harbor was, and still is, used
to some extent as the harbor area for a Navy trial course in lower Penobscot Bay. Sections of the Atlantic fleet have used the harbor on occasion from 1925 to date.

Depending on the type of facility involved, this location can be actively considered. It would be an easy one to flood and sufficient water does stand offshore still protected by the breakwater.

**Clam Cove.** This site has the advantage of having been considered as the location for a major cement industry. It is presently owned by Martin Marietta which has a cement plant in Thomaston, four miles to the west. It would be necessary to knock down quartzite ridge and build a breakwater with the removed material. Approximately 60 feet of water would thus be available in a restricted but well protected location.

There is a 300 acre clam flat area which is dry at low tide. This would be the only area where an installation could be built in the Clam Cove area. The land around the cove lies steeply on all sides.

We do not specifically recommend Clam Cove but, (1) because it is in single ownership and has a railroad right-of-way clearance to it, and (2) because it does represent protected deep water; we offer it for consideration.
For both sites there is generally a thick layer of mud and flats which is dredgable to perhaps 20 feet below its present level. The city of Rockland is a traditional shipbuilding port. Mine sweepers were built there during World War II. Many support facilities, including machine tool shops and foundaries, are located in the city. It is an active oil depot and has a large number of ship chandlers operated in town. There is a Coast Guard Station located in the middle of the harbor, and also a coal wharf which unloads a considerable tonnage of coal each week to supply local industry.

Belfast Harbor. This is one of the oldest operational harbors in the Bay. It has been the traditional ferry and tug base for the last century. The harbor is excellent with an average inner cove water depth of 15 feet. It is well protected from all storm directions and is on a clear deep roadstead.

Rail and road transportation is good--Belfast is only 40 miles from the Augusta turnpike. Electric power, fresh water and support facilities, as well as an excellent labor market, put Belfast high on the recommended locality list.

The topography of the land surrounding Belfast Harbor has made development somewhat difficult. There is a very
narrow strand area platform around the harbor. The steep cliffs close the harbor on the south, west and north sides leaving only a small flat, low area on the east shore. Future developments at Belfast will require particular land use and industrial classification so that the closed-in wall areas will not be a disadvantage.

Searsport-Jellison Point. This is the northern-most harbor area in the Bay. It is well protected from storms and wind except for moderate exposure from Southerlies, which are rare in the winter storm season. There are two undeveloped deep water harbor possibilities in the area, Sears Island east shore and the southeast shore of Cape Jellison. There is flat land between the Island and Cape Jellison but water depths are quite shallow. West of Sears Island, the existing W. R. Grace and J. P. fuel pipeline terminals crowd the available shore front space. Steep cliffs and very shallow water almost preclude consideration of the west shore of Searsport.

The seaward approaches to either area are excellent. Fifty to seventy thousand D.W.T. cargo and fuel ships make an easy passage up the northern Penobscot roadstead from the channel.

A dredged channel of 35 feet serves Searsport and Sears Island; and a natural, 75 foot channel lies close
to the south shore of Cape Jellison. A dredged turning basin with 800 feet turning radius has been made off Searsport Harbor. At Cape Jellison, the Bay channel narrows to 1.3 miles but water depths of 50 to 75 feet allow maximum use of the width.

The area is served by the Searsport spur of the Bangor and Aroostook Railroad providing daily service into the Bangor junction yards, from which rail passage north, east and south is excellent. Highway contact is over Route 1 to the south and Route 1A-207 to the north. Jetport air service at Bangor is 42 miles distance.

Detailed descriptions of these two harbors follow.

**Sears Island.** This locality is located one quarter mile offshore and just to the east of the W. R. Grace Co. terminal. A half-tide bar connects it to the mainland, and bridge access would not be difficult. The island, owned by the B.A.R. (in fee) consists of 950 acres of gently rolling timber and brush land. The topography and relief are gentle; and land rises from low sea cliffs to an altitude of 180 feet on the east side of the island. The land slope is steeper on the east side with a 7% grade from the back of the island ridge.

The island is mantled with a thin layer of post-glacial rubble material, gravel cobbles, silts and sand.
Some clay is noted below the coarse rubble. Bedrock is present along the shore, mostly on the east side. The rock consists of highly folded and cleaved quartzites and slates (or schists). Bedding is thick to massive; and the rocks are highly competent.

This bedrock is present in visible ledges at the tidal zone, but gives way to a silty sand, brown clay and sand to seaward (note sample 11-104 of plate 2).

The island is uninhabited and does not support an economic marine resource. The island is held by B.A.R. as a future development potential. With a moderate land sculpturing program a 380 acre level site could be established on the east shore, offering 4,000 feet of shore frontage on 20-60 feet of water in a protected, accessible harbor.

Cape Jellison. This harbor area has several very important assets. First, it has a 75 foot deep shore channel on its southeast side. It is in a protected fjord-like location with only the strongest September and April storms to reach it. The land surface behind the shore is level, undeveloped and easily moldable. There is an old railroad right-of-way connecting it (now as a dirt road) with the B.A.R. track system. It offers a two mile long straight shoreline along the Bay.
The Cape is as strategically located to rail and water transport as Searsport and has the extra advantages of easy access and a larger acreage for development. There are over 1,400 acres of usable land on the Cape. Equally important, the land behind the Cape is undeveloped and could be used for a new town, using as a nucleus the bypassed village of Stockton Springs. This town overlooks Penobscot Bay and would make an ideal town site. Parenthetically, the local people would generally welcome a shipbuilding industry in the area. Perhaps even providing pressure to sell on some reluctant local owners.

East Bay Shore Sites

**Castine-Cape Rosier.** The east side of upper Penobscot Bay mirrors, to some degree, the fjord character of Cape Jellison. Although the principal topographic expression on the west--Bay facing--shore of the Castine Peninsula is in steep shear cliffs dropping from heights of 50 to 200 feet into the sea, parts of both the Peninsula shore and on Cape Rosier are low and of slight topographic relief. Two such areas are considered here--West Penobscot Plains, and Orrs Cove on Cape Rosier.

**West Penobscot.** This area consists of 600 acres of flat marsh and meadow land drained by Clements Brook. There is a narrow 500 foot wide tidal shelf along the shore,
with 45 to 55 feet of water in the Bay channel. It lies directly across the narrowed upper Bay from Cape Jellison, separated by only 1.3 miles of water.

Plates V and VI in the supplementary folder show the location of various industrial and developmental parameters for the Penobscot Bay area. These include: electric power, industrial sites, transportation routes and cultural data. Plate 7 is an index map showing the location of the eleven photographs of potential development sites inside the Bay. A more complete report on the industrial potential of the Bay has been prepared by the Development Division of the Department of Economic Development.
REFERENCES


Data Files, Department of Economic Development, Economic and Power Distribution Information, Augusta, Maine, April, 1970.


*Flawn, P. T., Goals for Texas in the Coastal Zone and the Sea, Governor's Conference, Houston, Texas, September, 1970, as a general source.
#3 SEARS ISLAND - EAST SHORE LOOKING SOUTHWEST
#4 SQUAW POINT - CAPE JELLISON & STOCKTON HARBOR
#7 WEST PENOBSCOT SHORE - CASTINE PENINSULA