DEPARTMENT OF NATURAL RESOURCES'
DIVISION OF GEOLOGY AND EARTH RESOURCES

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# COASTAL PROCESSES OF THE WHATCOM COUNTY MAINLAND

by

Thomas A. Terich
Dept. of Geography & Regional Planning
Western Washington State College

Prepared in cooperation with the
U.S. Geological Survey

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Numerous natural erosional and depositional processes operate upon shorelines to create a diversity of coastal landforms. Waves are among the most important causes of this diversity as they remove, build, and shape beaches and sea cliffs.

It is at this interface of water and land that man concentrates much of his activities. Many industries select waterfront locations for the import and export of waterborne commodities. Some commercial interests require shoreline or waterfront locations to accommodate their activities. Finally, increasing development pressures are placed upon coastlines for residential and recreational uses. Thus, man's impacts are intense and varied.

Concern for the future wise use of our shorelines has risen at the national level in the form of the Coastal Zone Management Program and within Washington State as the Shoreline Management Act. The purpose of these complementary federal and state programs is to provide a foundation of study and understanding of shorelines so intelligent decisions can be made for their use. It is in this spirit that this study of Whatcom County's mainland shoreline has been prepared.

The shoreline of Whatcom County has been divided in this report into several segments. These segments may be viewed as individual compartments that represent internal units of form and process. Natural or manmade events within shoreline segments have identifiable effects. Therefore, it is important to recognize these stretches of shoreline as individual management units, much like the neighborhood is the fundamental planning unit within many cities. This report discusses the natural and man induced changes occurring within each shoreline segment and gives suggestions for future management considerations.

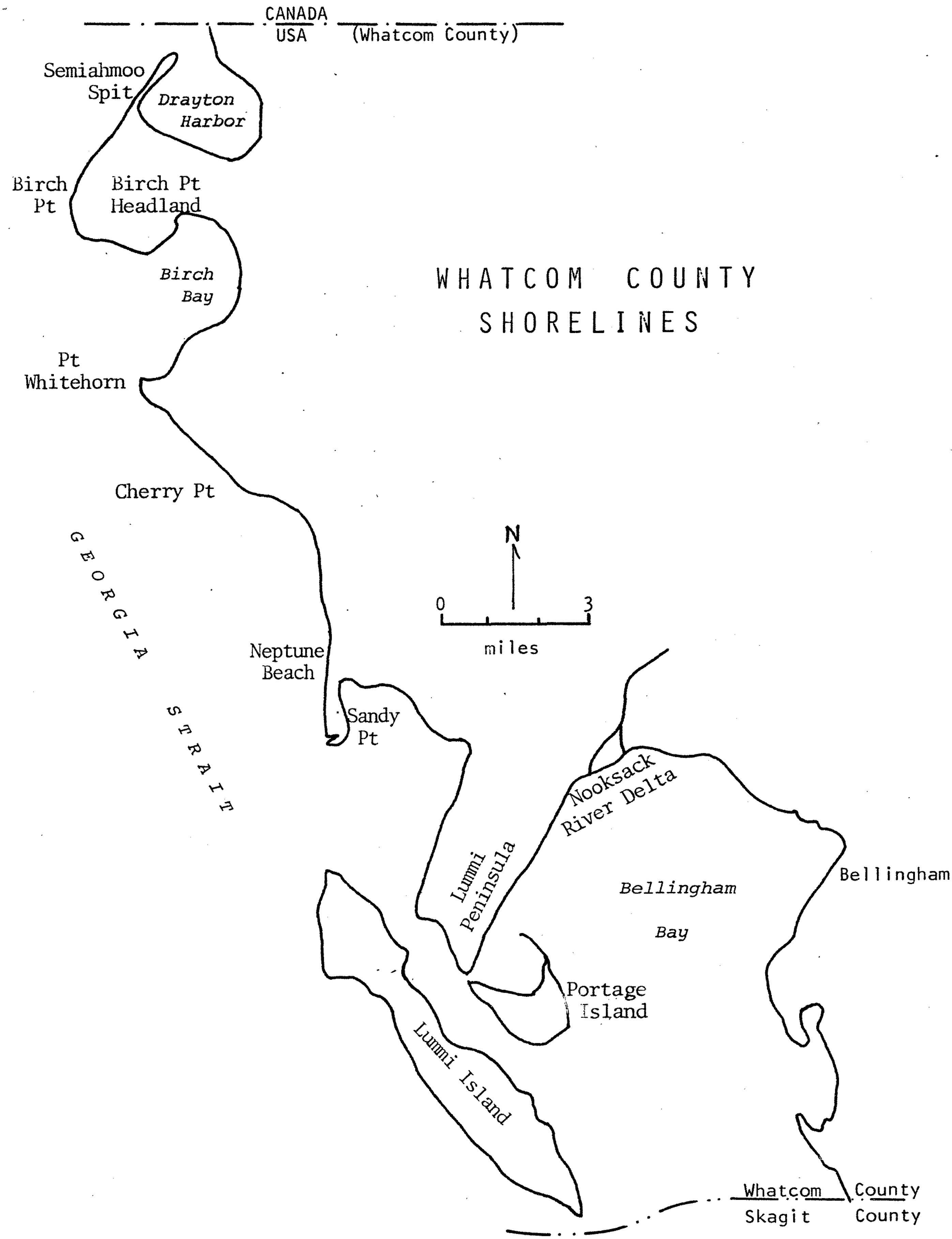

CANADA
USA
(Whatcom County)
Semiahmoo Spit
Drayton Harbor
Birch Pt
Birch Pt Headland
Birch Bay
WHATCOM COUNTY SHORELINES
Pt Whitehorn
Cherry Pt
GEORGIA STRAIT
N
0
3
miles
Neptune Beach
Sandy Pt
Nooksack River Delta
Lummi Peninsula
Bellingham Bay
Bellingham
Portage Island
Lummi Island
Whatcom County
Skagit County

FIGURE 1

## SEMIAHMOO SPIT

At the northern most reach of Whatcom County's shoreline is a spit approximately 2000 meters long trending northeasterly from the north side of Birch Point (fig.2). The spit separates Drayton Harbor from Semiahmoo Bay and provides some protection for small boats and shoreline developments within the bay.

The northeasterly growth of Semiahmoo Spit indicates that sediment eroded from Birch Point has been transported by littoral drift northward, leading to the growth of the spit. Archeological evidence indicated the spit has developed across Drayton Harbor over the last 4000 to 5000 years (Grabert & Schwartz, 1972).

Semiahmoo Spit is a low depositional feature rising approximately two meters above mean high water. Its low undulating sandy surface is covered with beach and grass scattered trees. It is only thirty to forty meters wide along its southern connection with Birch Point. High storm waves frequently overtop this area limiting access to the spit. Toward the northeastern end, the spit gently broadens to nearly three hundred meters, and appears to be quite stable. Comparison of aerial photos and maps for decades past show little change of the shoreline.

The spit's northwest facing beach is approximately ten meters wide and has a slope of ten to fifteen per cent. The highest part of the berm is composed primarily of sand and shell fragments which grade downslope to gravels and cobbles on the foreshore, a gradation common to most beaches. The finer sediments are usually found high on the backshore where they are washed by storm waves or blown by winds. Coarser sediments prevail on the foreshore where waves are more frequent and their energy

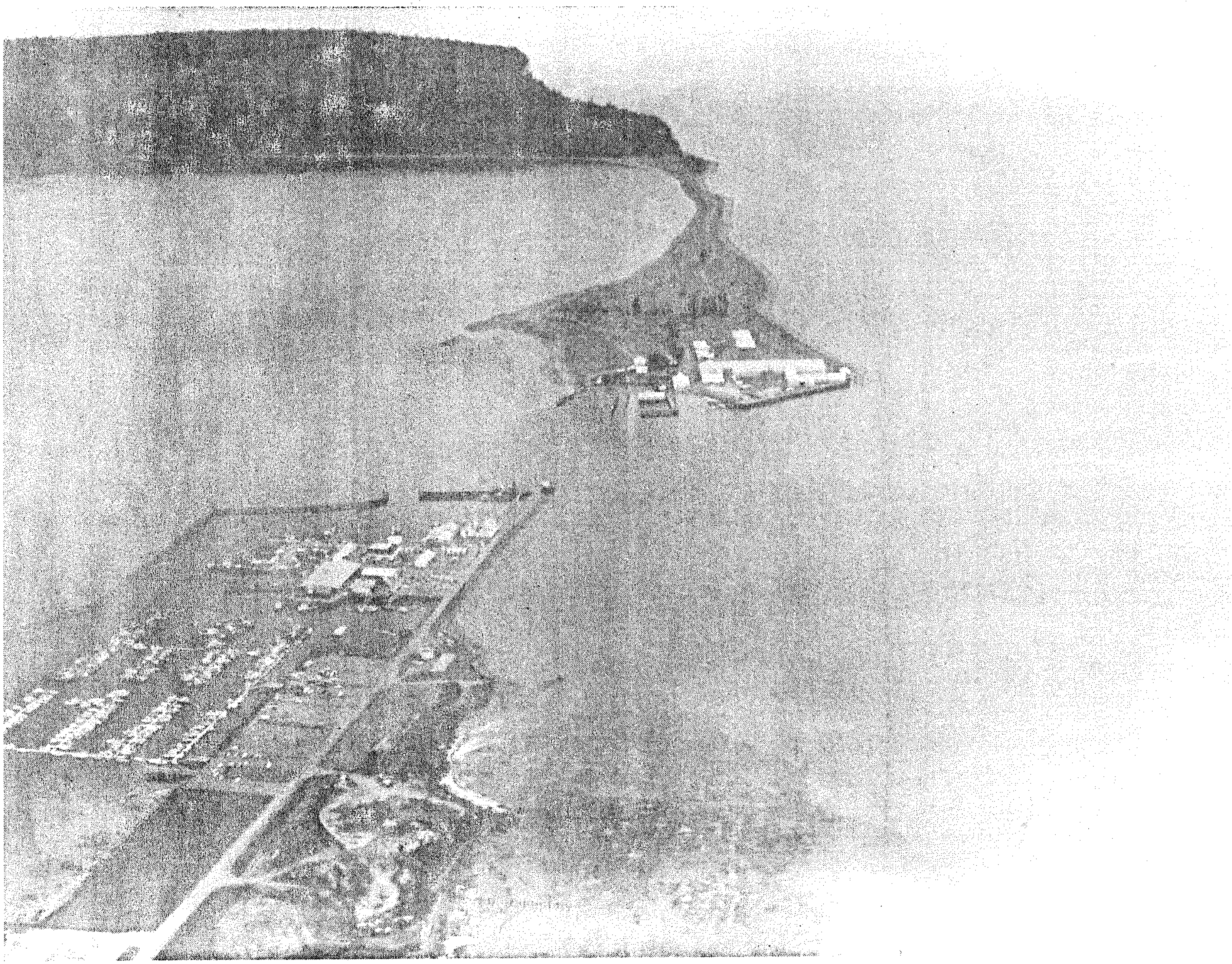


Figure 2

is more intense. Farther offshore, where water depths increase and wave action weakens, the sediments tend to be finer grained.

The west shore of Semiahmoo Spit has open water exposure to the west and southwest. It is from the latter direction that most storm winds and waves arrive. Southwesterly storm waves one to one and one-half meters high (four to five feet) account for much of the erosion and transport of sediments from Birch Point to Semiahmoo Spit.

Semiahmoo Spit appears to be a relative stable shoreline feature. It derives its stability from the continued flow of eroded sediments from Birch Point. Nonetheless, it is susceptible to natural or man-made actions that could cause it to undergo sudden, drastic changes.

Human use tolerance zones have been established for large spits with dune-trough cross-sectional zones. Semiahmoo Spit does not have such distinctive zones; however, certain specific development controls should be followed. They can be summarized:

1) The beach and low sandy swells and swales behind the beach should be kept free of any development.
2) Foot trails across the swells and swales to the beach should be kept to a minimum to preserve beach grass growth and reduce wind erosion.
3) All motorized vehicles should remain on designated roadways.
4) No structures should be placed along the narrow southern end of the spit. The beach should be "nourished" with additional sediment to help protect the access road.
5) The northern and northeastern areas of the spit are the most tolerant of development. The planned unit development approach, utilizing an overall design concept, should be required for any development.

6) Land oriented recreation activities, especially those requiring campgrounds or large paved areas should be avoided.

7) There is a potential for recreational development on the spit, but its location and intensity should be governed strictly by the constraints necessary to maintain the physical stability of Semiahmoo Spit.

## BIRCH POINT

Semiahmoo Spit is essentially an appendage of Birch Point, which is a large headland lying between Drayton Harbor to the north and Birch Bay to the south. The headland reaches maximum elevations of approximately 80 meters on the northeastern side near Drayton Harbor. From that point, the topography gently lowers westerly and southwesterly to the 25 and 30 meter high sea cliffs that rim the headland.

Easterbrook (1973) shows Birch Point to be composed primarily of Bellingham glaciomarine drift with a veneer of sand and gravel. This material, when wet, has low strength and is prone to slumping or flow, particularly along the sea cliffs. Many of the slope failures resemble amphitheater-like notches in the sea cliffs. Glacial debris and uprooted vegetation from the slope failures litter the backshore.

The beach surrounding the headland is 10 to 15 meters wide with a slope ranging from 10 to 15 percent. It is composed primarily of gravels and cobbles, most of which were eroded from the sea cliff. A few very large boulders are scattered on the beach, presumed to also have originated from the erosion of the sea cliffs.

Birch Point has long open water exposures to the west, southwest and south. Northwesterly exposure is limited across Semiahmoo Bay. Winds up to 30 knots from the south and southwest could generate waves up to 2 meters (6 feet) high. During the summer, these waves are lower, corresponding to a weakening of the prevailing southerly wind velocities. Westerly winds up to 20 knots may build waves up to 1 1/2 meters (5 feet) high to attack Birch Point's western shore.

A few homes have been constructed on the backshore, at the base of the sea cliffs north of Birch Point. In most cases, the beach fronting the structures is only 10 meters wide, requiring seawalls or bulkheads for protection from wave attack. A few residents have constructed small concrete groins, or laid boulders transverse to the beach in an effort to trap the northward moving sediment and build up the beach fronting their property (Fig. 3).

Here is a clear case where homes have been constructed too close to the shoreline. Home owners have been forced to install erosion defense structures. While protecting their own properties, they may be aggravating the erosion of nearby or distant properties. Bulkheads and seawalls armor the backshore reducing the amount of sediment available to the beach. Groins and similar structures installed transverse to the beach restrict the prevailing northward movement of beach sediment which ultimately feeds Semiahmoo Spit.

The following land management concerns should be observed at Birch Point:

1) The sea cliffs around Birch Point are moderately unstable and subject to failure. Developments should be set back from the cliff edge.***
2) Vegetation clearing and land disturbance should be kept to a minimum to preserve natural hydrological conditions.

*** The set back distance will have to be determined upon closer study.

Figure 3

3) Beach level home sites should be discouraged.

4) The impacts of protective bulkheads, rip rap and similar structures should be recognized and discouraged.

5) Structures or materials (boulders) placed transverse to the beach should not be permitted.

## BIRCH BAY

Birch Bay is a very interesting place of study for both the coastal geomorphologist and anthropologist. Larsen (1971) studied the relationship between former stands of sea level and early Indian settlements around Birch Bay. The curvilinear shape of Birch Bay's shoreline resembles similar shorelines around the world that are shaped by the refraction or bending of waves to the lee of a nearby headland (Fig. 4 ).

Northwesterly waves travel down Georgia Strait and are refracted around Birch Point into Birch Bay (Fig. 5 ). Waves sweep counter-clockwise around Birch Bay transporting beach sediment in the same direction. Evidence of this sediment movement is shown by Terrell Creek which approaches within 100 meters of flowing into the south end of Birch Bay but is offset nearly 3 km to the north before emptying into the bay. Moreover, many property owners on the bay's southwestern shoreline have constructed small groins in an effort to retard the longshore sediment transport and build up the beach fronting their properties. In all cases, sediment build-up occurs on the south side of the groins, indicating a south to north (counter clockwise) direction of wave energy transmission and resultant longshore sediment transport.

On the north side of the bay, the northward drifting sediment converges with southeastward drifting sediments driven into the bay by wave

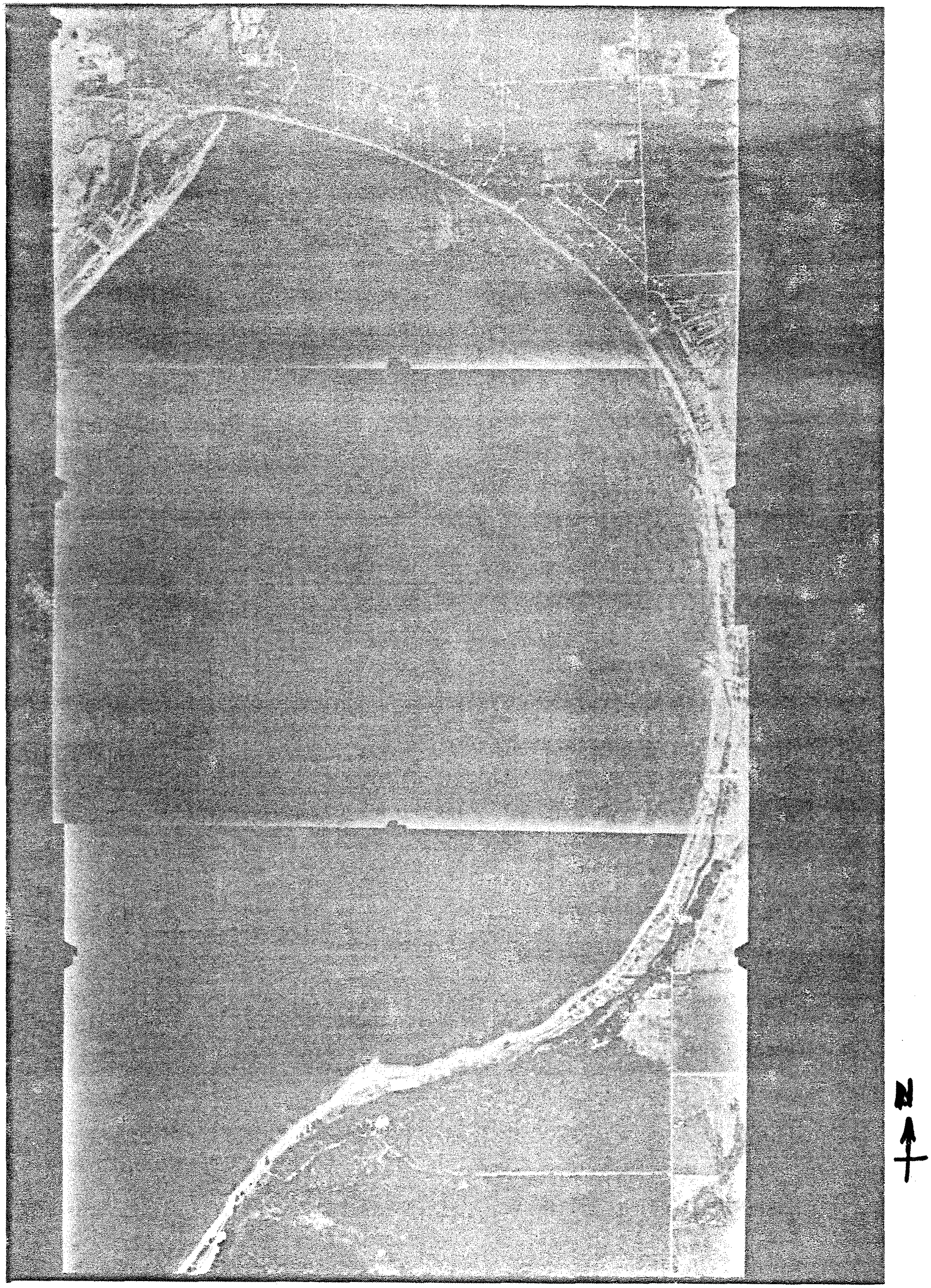



Figure 4

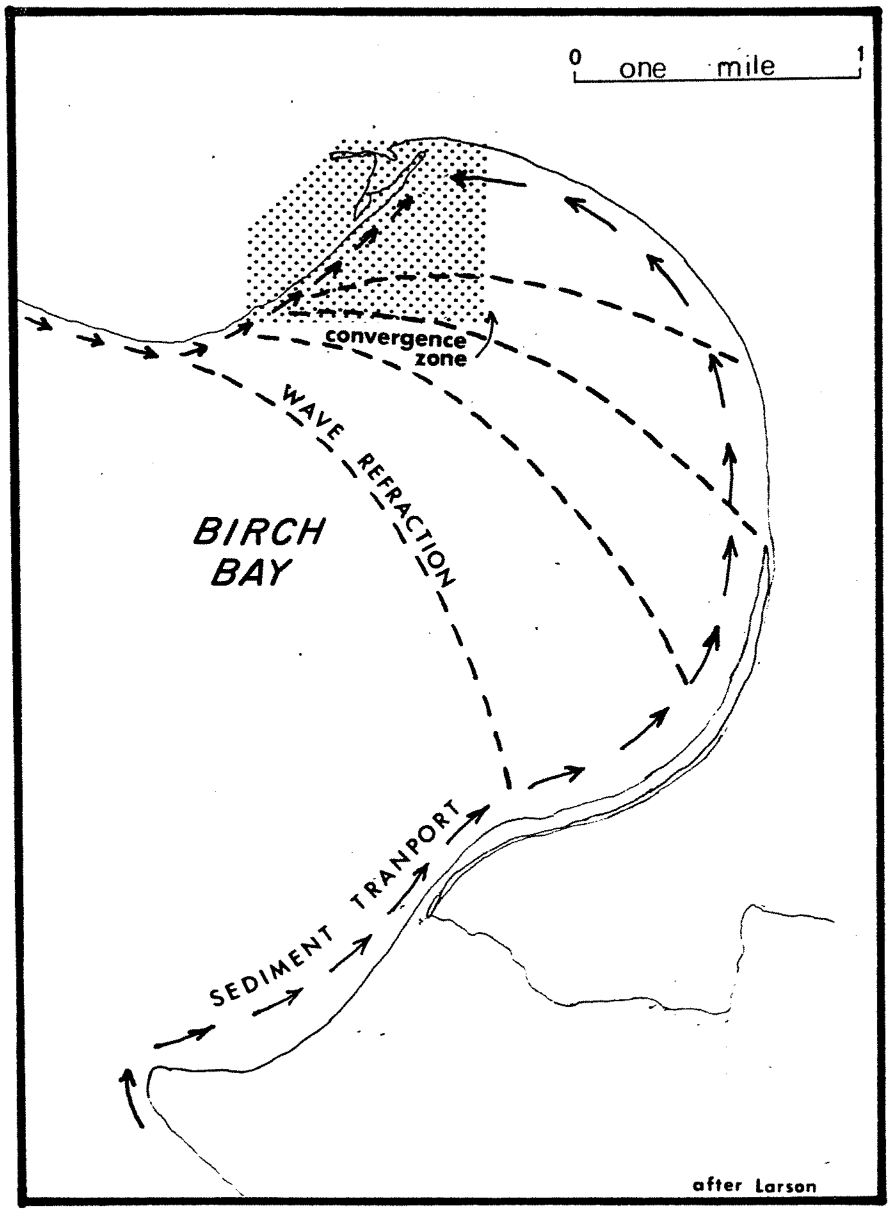


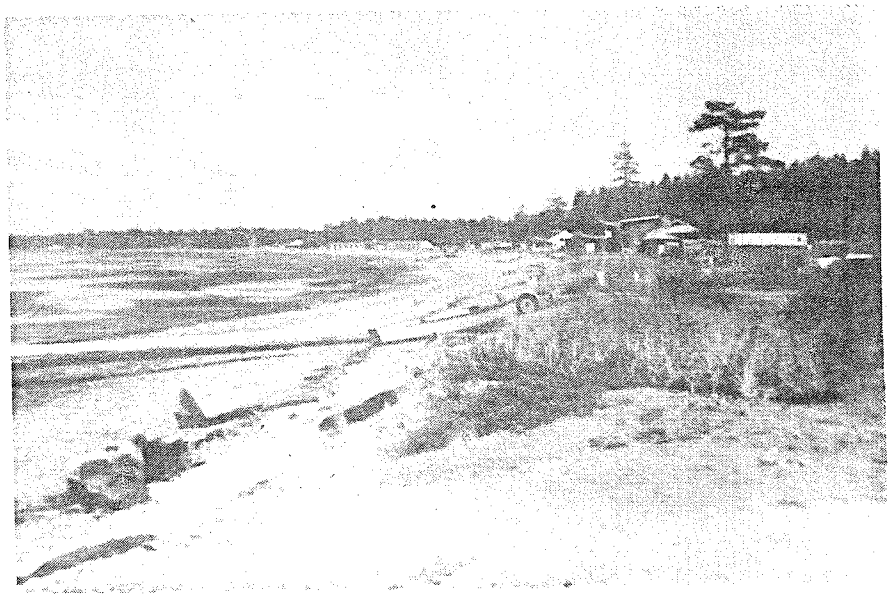

Figure 5. Wave refraction and sediment transport at Birch Bay.

refraction around Birch Point. This process has led to the formation of at least twelve coalesced eastward trending spits on the north side of the bay (Larsen 1971). The coalesced spits have advanced the shoreline 500 to 700 meters into Birch Bay. Their low hummocky surface is about 3 meters above sea level and is now being subdivided for a recreational housing development.

As waves refact around Birch Bay's shoreline, their energy declines. This reduction of energy is reflected in the physical character of the beach. First, the beach sediment becomes progressively finer from south to north and the beach slope declines. This can be attributed to the fact that waves sort and redistribute beach sediment so that the finer is ultimately deposited at locations of relatively low turbulence. Similarly, the beach flattens in areas of lower wave energy.

Birch Bay is a very popular recreational site in Whatcom County. Thousands of visitors may be found enjoying the bay during summer holidays. The recreational attraction of Birch Bay has led to the construction of many bayfront homes over the past twenty-five to thirty years. Bayfront property and homes sell for premium prices, and such homes line the eastern shore. Many of the homes have been constructed very close to the shoreline to take full advantage of the bayfront location. The short construction setback has limited the amount of beach "buffer" each home has from high waves and natural beach erosion. This has forced most of the residents to build bulkheads and groins to protect their properties. The proliferation of bulkheads and groins on the shoreline is shown by the contrasting photos taken of the same beach in 1957 and 1964 (Fig. 6 ).

Property owners downdrift of groins experience rapid loss of their beach and have been forced to also construct groins lest the waves threaten



Birch Bay shore in 1957 (note tree in upper right)

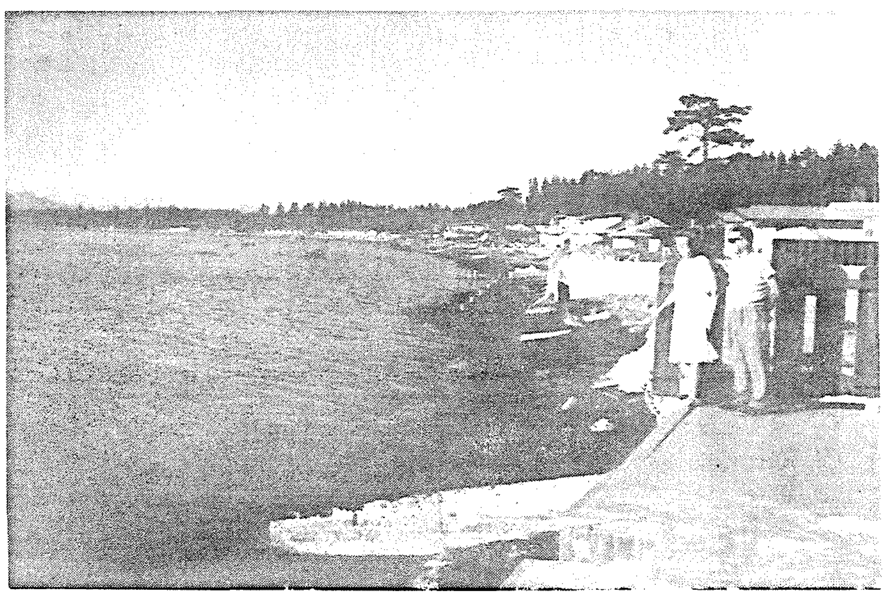


Figure 6. Birch Bay shore in 1957 (above) and 1964 (below). Note tree in upper right of both photos.

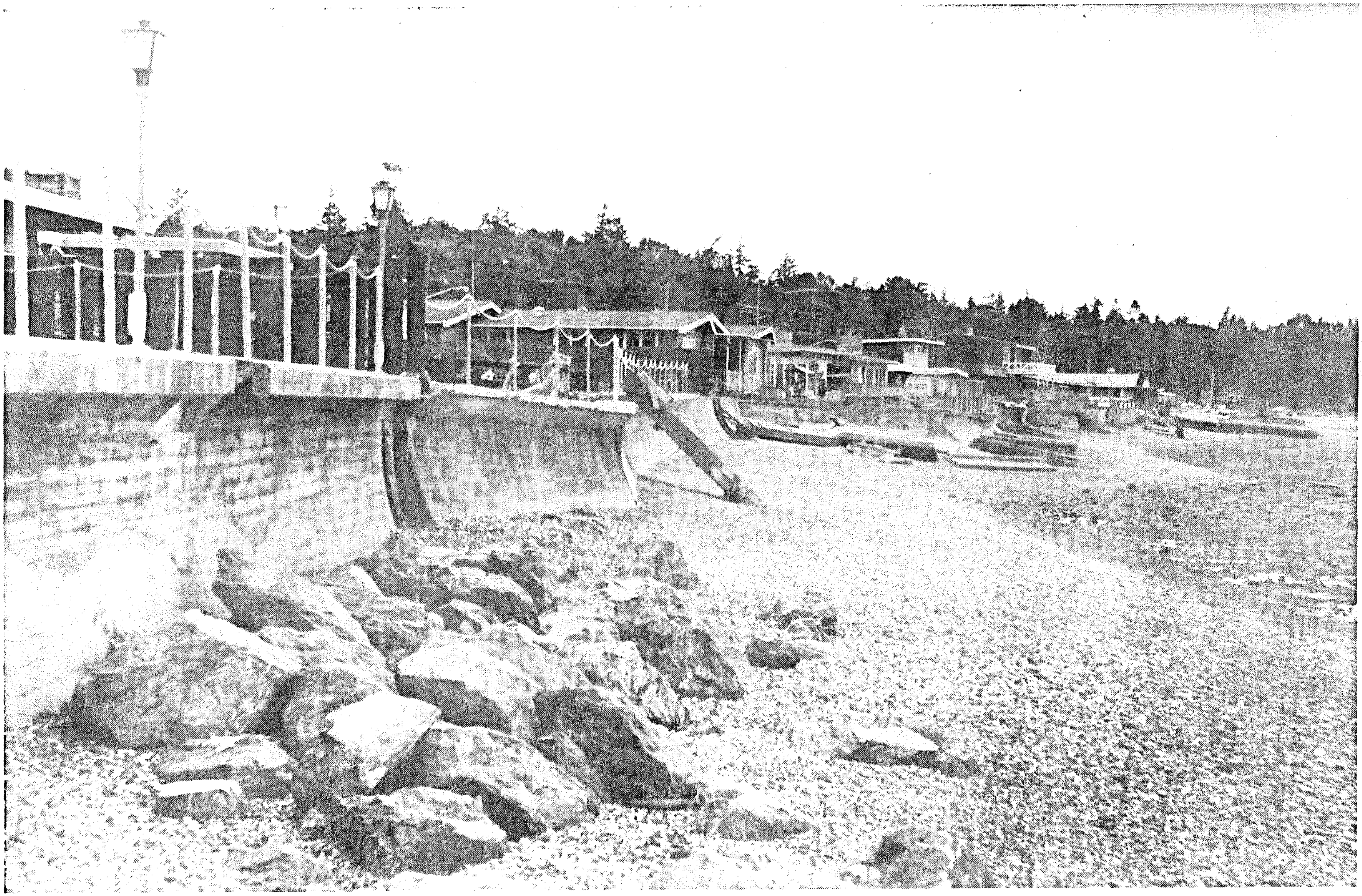


Figure 7

their homes. Thus, the beachfront property owners around Birch Bay's eastern shore are in competition for beach sediment. This competition has led to ill feelings and legal action for property damage claims by few of the homeowners against their neighbors (Fig. 7 ).

Property owners at Birch Bay must recognize that their independent action against erosion affects neighboring properties. The fight against erosion would probably be more successful if all property owners acted collectively. Several actions can be taken to reduce continuing erosion and halt the competition among the residents for beach sediment:

1) Remove all groins or similar installations that directly restrict the longshore drift of beach sediment.
2) Discourage the use of rip rap unless absolutely required against an immediate erosion hazard.
3) Require a greater construction setback for new housing.
4) Replenish the beach "Buffer" with large volumes of sediment of similar grain size.

## SANDY POINT

Sandy Point is a south trending spit approximately 2500 meters long. Like Semiahmoo Spit and the coalesced spits within Birch Bay, it too is of recent geological origin.

Sandy Point is about three to four meters above mean sea level. Its low undulating sandy surface has been significantly modified by channel dredging and home construction. A 1947 aerial photo shows that prior to development, it was devoid of trees and used for agriculture and grazing (Fig. 8 ). Over the last twenty years, Sandy Point has become a popular housing development. Many homes have been constructed along its western

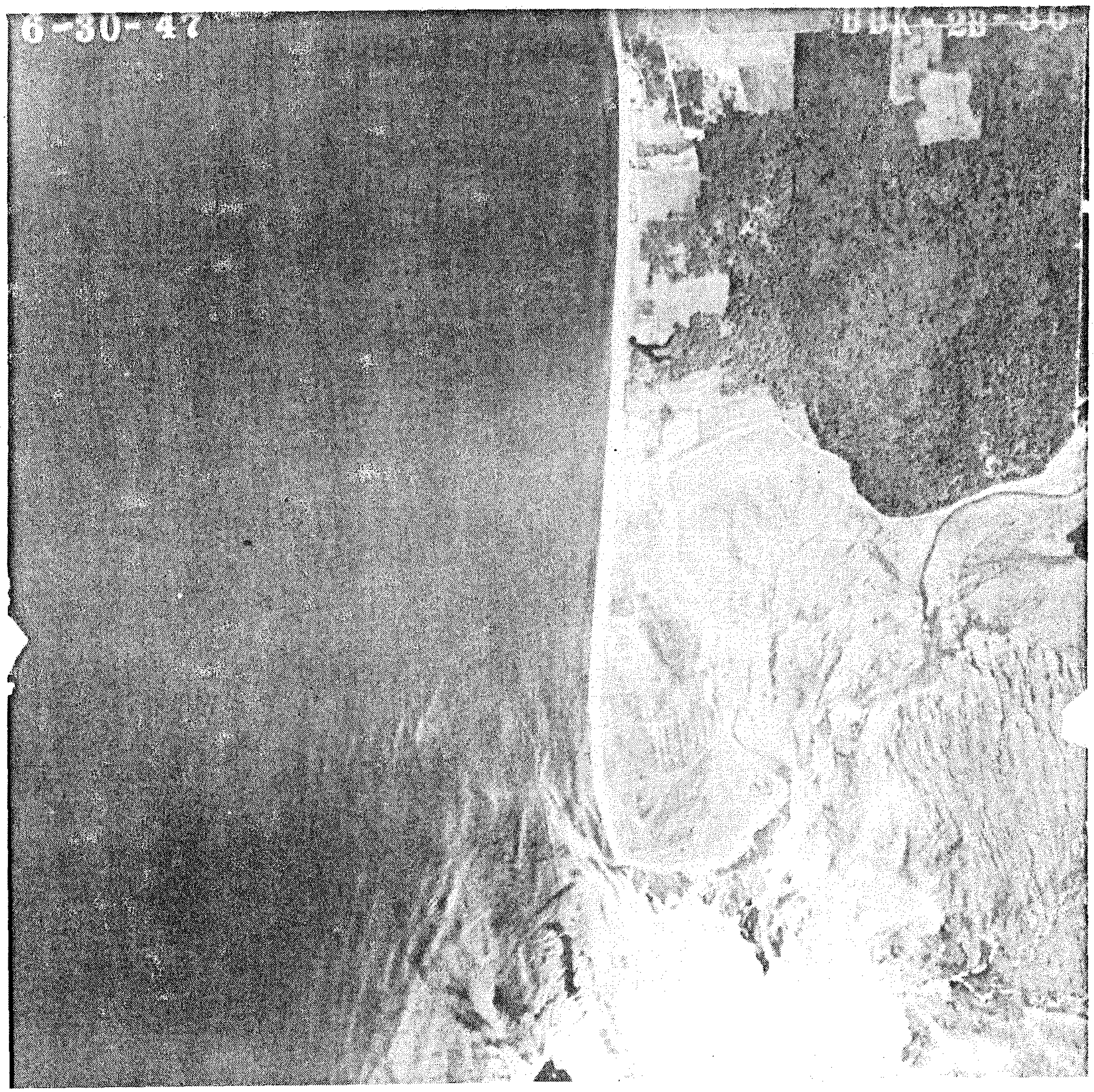



Figure 8

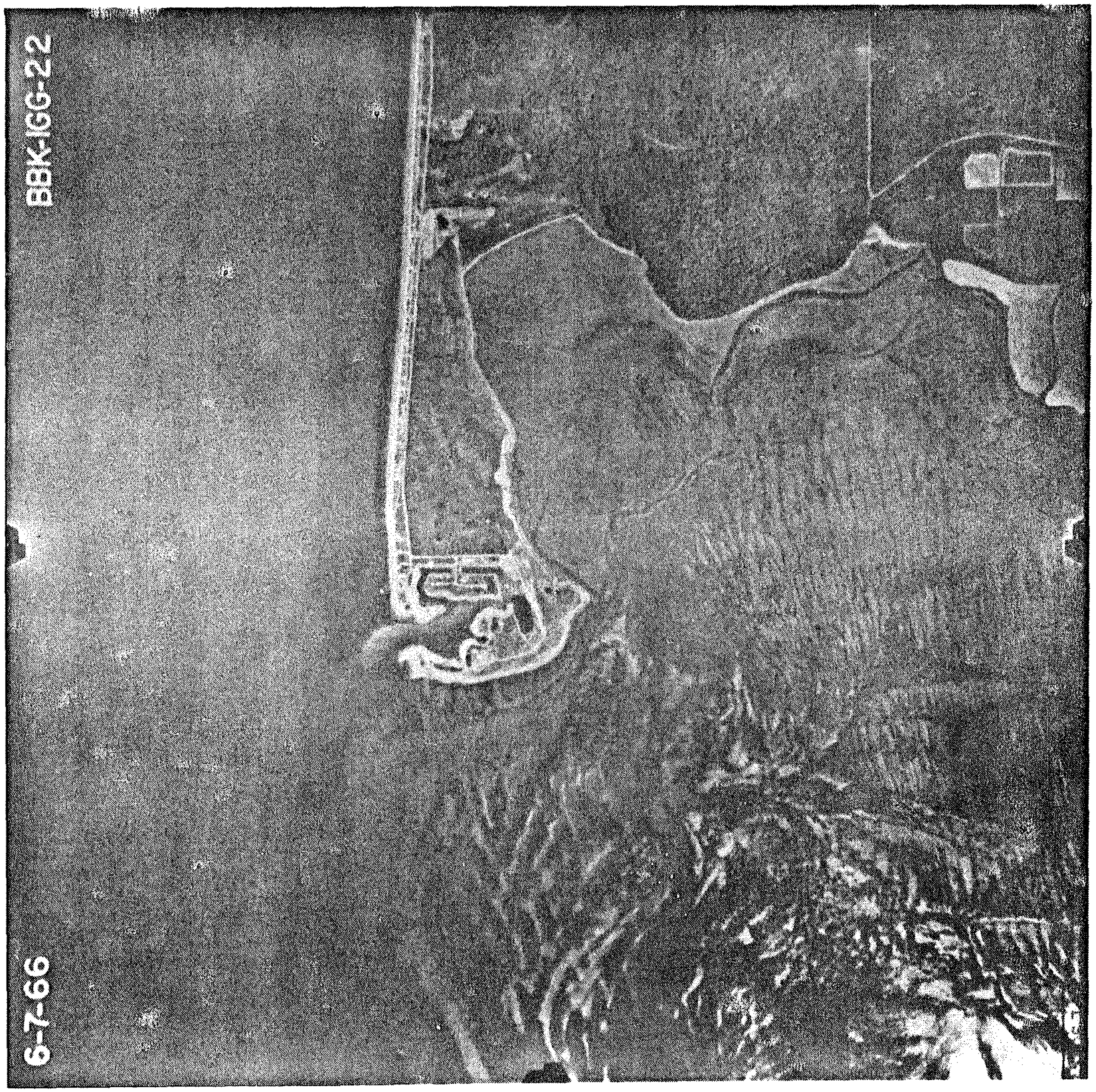



Figure 9

Figure 10

shoreline. Lately, additional homes have been built in the interior, adjacent to channels that have been dredged to provide additional waterfront properties (Fig. 9 ). Unfortunately, the channel dredging is creating sediment erosion and deposition problems. The channel entrance has interrupted the longshore sediment transport along the southwestern shore. Much of the southward moving sediment is driven into the channel by wave and tidal action resulting in two immediate problems. First, the sediment supply to the distal end of the spit has been significantly reduced causing erosion of the beach. The owners of two large homes there have been forced to install concrete bulkheads and groins to help preserve the remaining beach (Fig. 10 ). Secondly, the inflow of sediment into the channel is causing shoaling within the mouth. Dredging of the sediment is necessary to keep the channel open to navigation.

The homeowners along the west beach have experienced high storm waves. In April 1975, strong northwesterly winds created high waves that eroded the beach. Several beachfront homes sustained water damage and a few structural damage from waves and drift logs thrown by the waves. Many homeowners have built bulkheads to protect their properties. In some cases a continuous wooden bulkhead crosses property lines, creating a collective line of defense.

A few planning and management guidelines may help to preserve the beach at Sandy Point and reduce the hazard of wave attack to beachfront homeowners:

1) Future beachfront homes should be built several meters behind the highest berm on the beach.
2) Sandy Point homeowners should be particularly alert to any shoreline development plans in the Cherry Point-Neptune Beach area that could

interrupt the sediment supply to the spit.

3) No groins should be allowed on the west beach.

4) Sediment dredged from the channel could help restore the beach at the far south end of the spit.

## CHERRY POINT

The Cherry Point shoreline is a cliffed shoreline nearly 10 km in length from Point Whitehorn to Neptune Beach (Fig. 1). Although it appears relatively uniform along its entire length, a close inspection reveals some differences. To facilitate a clear presentation of these differences, the shoreline will be divided into two sections; Point Whitehorn to Cherry Point and Cherry Point to Neptune Beach.

### Point Whitehorn to Cherry Point

The shoreline from Point Whitehorn south to Cherry Point is fairly linear with a northwesterly-southeasterly orientation. Bluffs 30 to 40 meters high rise steeply from the beach. The bluffs are composed of Vashon Till and Deming sand overlain by glaciomarine draft (Easterbrook, 1973). Vashon Till is a compact impermeable deposit of pebbles in a matrix of clay, silt and sand. Deming sand consists of stratified sand, clay, and gravel (Easterbrook, 1973).

Numerous debris flows and slump failures are found along the shore bluffs. Although there is some evidence of wave cutting at the base of the bluffs, this does not appear to be a chief cause of erosion. The debris flows and slumps appear to result from groundwater stauration increasing internal pressures within the glacial strata reducing their cohesiveness. Ampitheater-like notches are found on the upper four to six meters of the cliffs similar to those found in the cliffs at Birch

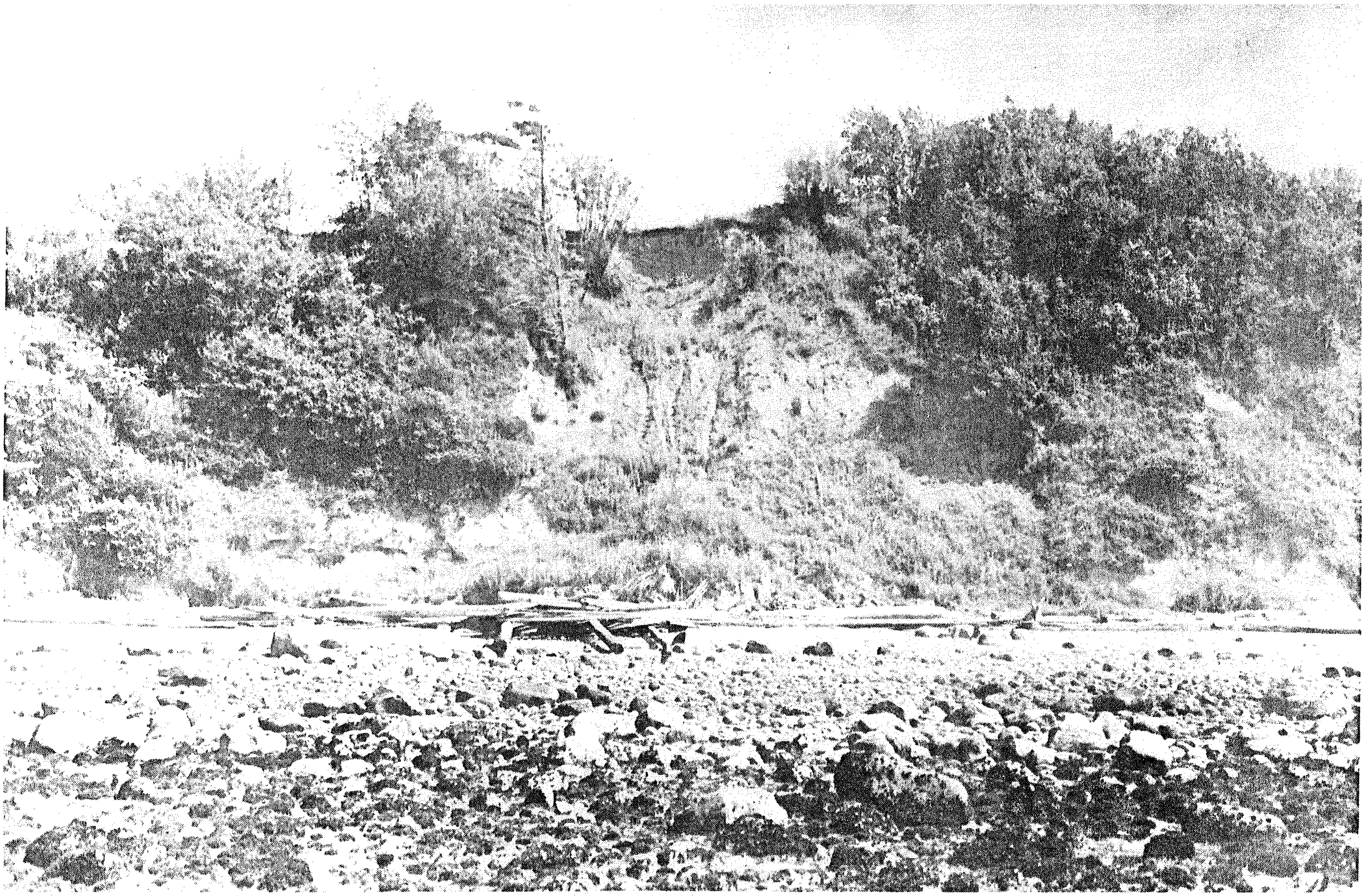


Figure 11

Point. These are caused when saturated glaciomarine drift dislodges and slumps down the face of the underlying impermeable till onto the beach below (Fig. 11). Small gullies are also carved into the face of the sea cliffs by small intermittently flowing streams draining the cultivated fields on the top of the bluffs. During the long wet winter season, these streams are very active sites of localized sea cliff erosion.

Eroded sediments from the sea cliffs are deposited upon the beach as slumps or small alluvial fans. Waves remove and redeposit the sediments elsewhere along the beach. The beach from Point Whitehorn to Cherry Point varies in width and slope and dependent upon wave conditions and the physical characteristics of the beach sediment. During the time of the survey, the beach width ranged from 20 to 30 meters with a slope of five to ten percent. Large logs, some in excess of 20 meters long, littered the backshore at the base of the bluffs.

Wave action sorts and deposits eroded beach sediments into zones. The berm is composed predominately of gravel thrown highest on the beach by waves. Downslope, approximately at the mid-tide level of the foreshore, wave action removes smaller sized materials leaving cobbles behind. On the low tide level of the foreshore, patches of cobbles are interspersed with sand and gravel.

Southerly winds and waves prevail along the Cherry Point shoreline; however, wind driven waves seldom achieve heights above 1.5m (5 feet) as Lummi Island and Orcas Island approximately 15 km. to the south, restrict the fetch. Northwest of Cherry Point is a fetch in excess of 100 km. into Georgia Strait. A northwesterly wind of 20 knots with a duration greater than 2 hours can generate waves 2 meters (6 feet) high. Such waves occur infrequently; however, waves of 2.1 and 2.4 meters (7 to 8 ft.) high have been measured within the Strait of Georgia.

The prevailing flow of littoral sediments along the Cherry Point shoreline is not clearly understood at this time, however, Sandy Point, a spit that has developed to the south of Cherry Point cliffs, indicates a net south sediment transport. It has grown contrary to prevailing southerly winds and waves that become progressively fetch limited and less effective movers of beach sediment. This suggests that south from Cherry Point, northwesterly waves, although less frequent, become the prime movers of beach sediment leading to a net south sediment drift. Over the long term, this has formed Sandy Point.

These conditions change from Cherry Point to Point Whitehorn. The fetch increases and the northwest-southeast shoreline exposure increases the angle of wave attack. This evidence suggests that north from Cherry Point the net sediment movement is northwesterly. Seasonal monitoring of beach sediment will have to be conducted to completely determine the net and seasonal flow of beach sediment along the Cherry Point shoreline.

Cherry Point to Neptune Beach

The shoreline from Cherry Point south to Neptune Beach displays some differences in physical processes and characteristics when compared to the shoreline north of Cherry Point. First and foremost, the net longshore sediment transport is southerly. Excellent evidence is given by Sandy Point. Furthermore, the beaches are composed of finer grained sediment. Whereas the beaches to the north of Cherry Point were predominately cobble, the beaches to the south of Cherry Point have a greater abundance of sand and gravel. Finally, the heavily vegetated sea cliffs south of Cherry Point appear more stable, although a few gullies and slump failures are present.

One very large active erosion site is located about 200 meters north of the Mobil pier (Fig. 12). Large uprooted trees and debris indicate

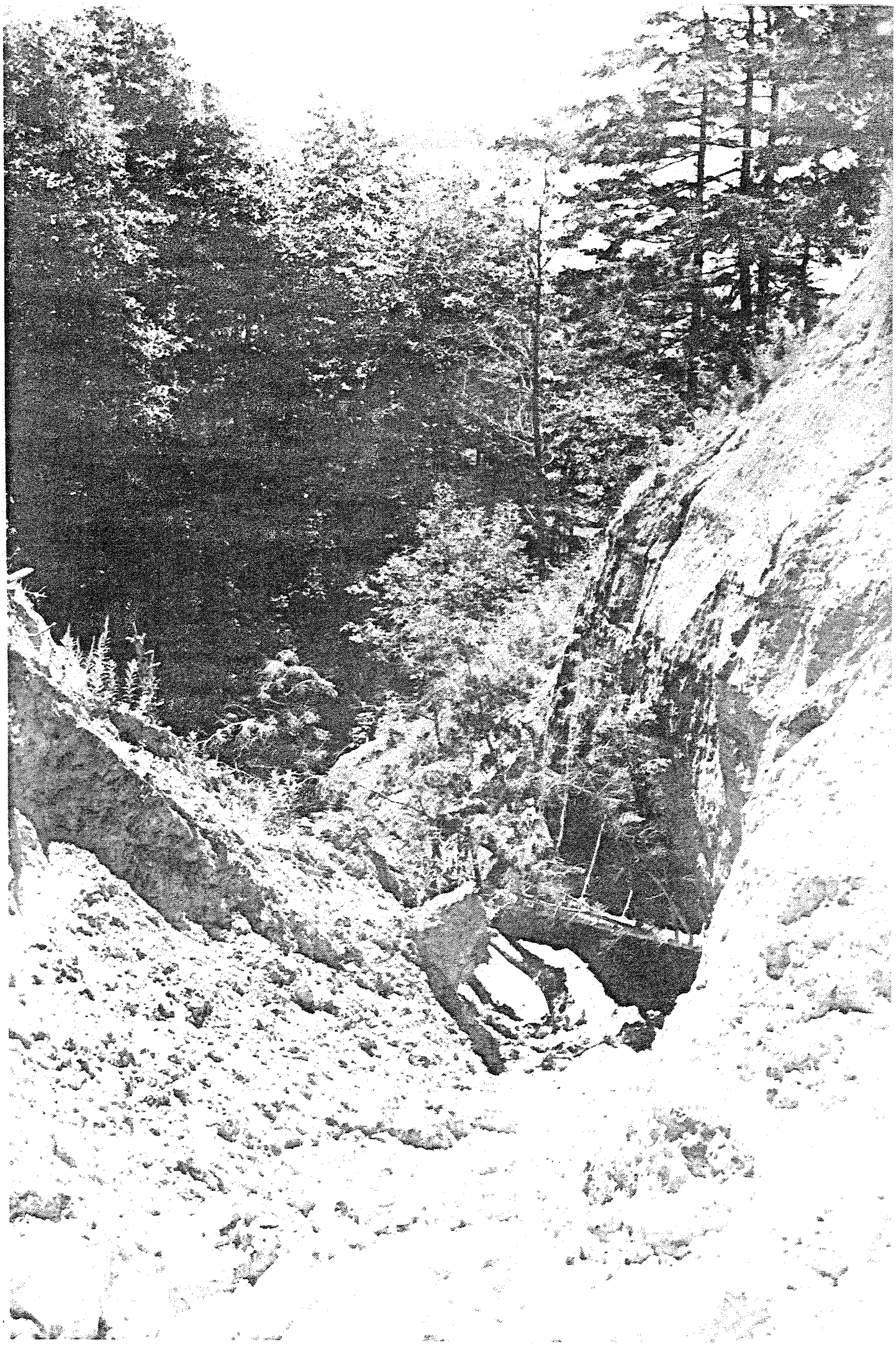


Figure 12

Figure 13

very rapid erosion is occuring. The headwall of the site is semicircular in plan and shows no sign of having been cut by water flowing down the face of the cliff. The indications are that erosion is the result of groundwater action similar to those slope failures along the sea cliffs north of Cherry Point and at Birch Point.

The beach to the south of Cherry Point has a greater abundance of sands and gravels that may reflect the receipt of lower wave energy as fetch is limited. Furthermore, the berm at the base of the sea cliffs has intermittent growths of coastal dune grass (Elymus Mollix Complex). The dune grass is evidence of stability indicating waves seldom erode the berm or sea cliffs (Fig. 13).

The Cherry Point shoreline is largely undeveloped, save two oil refineries (Mobil and ARCO) and one aluminum smelter (INTALCO). The physical impact to the beach of each industry is minimal despite the large shipping piers each has constructed across the shoreline. Future development of the area appears likely as the site offers nearshore deep water for shipping. A few shoreline planning policies should be followed:

1) The sea cliffs are moderately unstable and are subject to failure, all buildings should be constructed at least 150 feet back from the cliff edge.
2) Vegetation clearing and land disturbance should be kept to a minimum to preserve the natural hydrological conditions.
3) No beach level structure sites allowed.
4) Any structures (piers, etc.) installed along the shoreline should be designed to allow the free flow of beach sediment.

## THE BELLINGHAM BAY SHORELINE

Bellingham Bay is a south facing semicircular shaped bay with approxi-

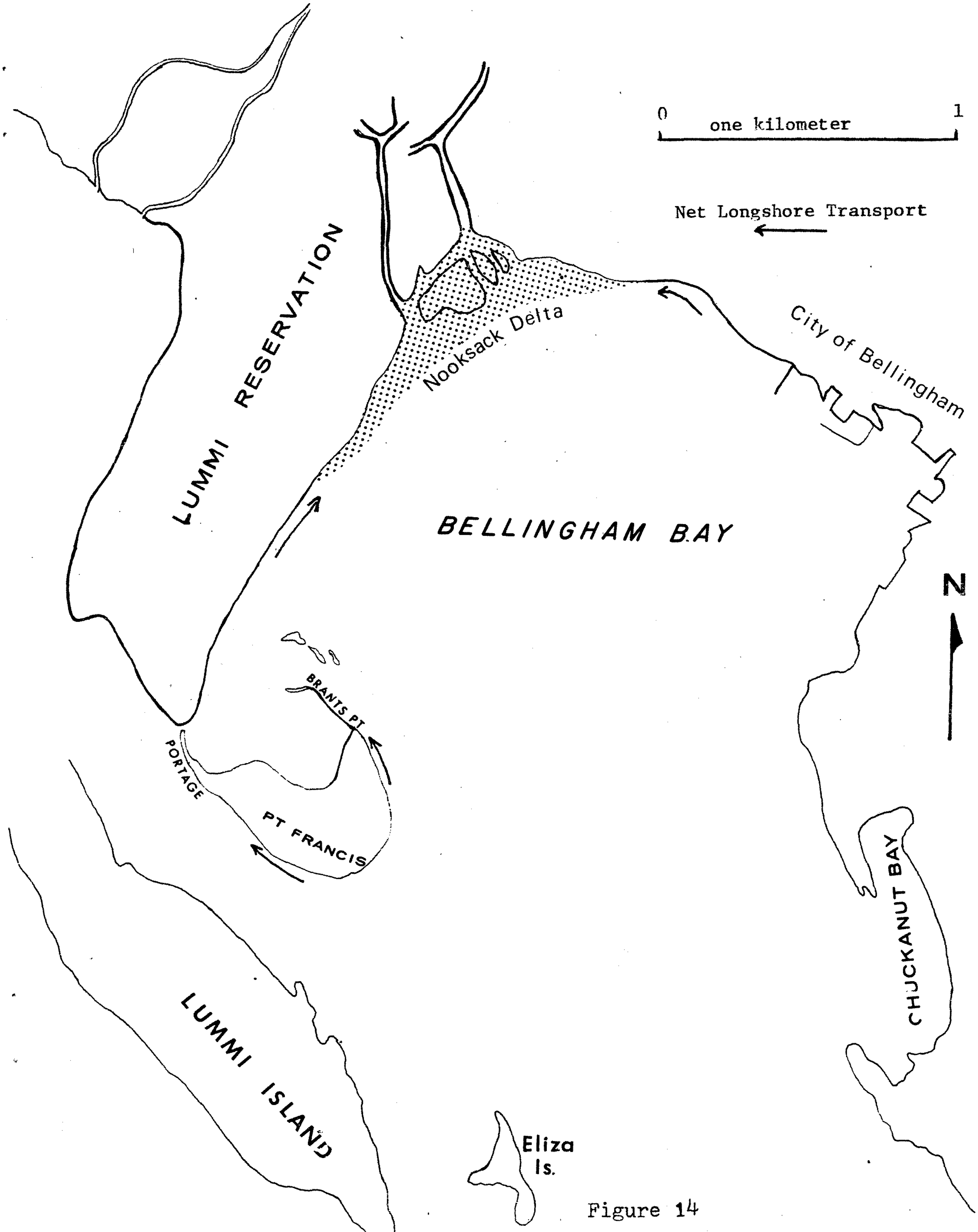

0
one kilometer
1
Net Longshore Transport
LUMMI RESERVATION
Nooksack Delta
City of Bellingham
BELLINGHAM BAY
N
BRANTS PT
PORTAGE
PT FRANCIS
CHUCKANUT BAY
LUMMI ISLAND
Eliza
Is.

Figure 14

mately 20 km. of shoreline (Fig. 14). The Nooksack River enters the bay from the north dividing the bay's shoreline into two distinctive east and west sections. The shoreline to the east of the delta has been significantly modified over the past decades by landfills, piers, and breakwaters for numerous port oriented industrial and commercial establishments associated with the port and City of Bellingham. Furthermore, the shoreline southeasterly from the port is comprised of the Chuckanut Formation, a massive sandstone, which creates a different interface between land and water from that found elsewhere along the county's shoreline. The shoreline to the west of Nooksack delta has narrow beaches rimmed with low bluffs composed of glacial material. A similar shoreline is found on the small island off the tip of the reservation known as Point Francis or Portage Island. The shoreline and tidelands of the reservation and the tidelands of the island are under the jurisdiction of the Lummi Indian Tribe and remain largely undeveloped.

Southerly winds and waves prevail within Bellingham Bay. During the winter, waves up to 1.2 meters (4.0 ft.) are often generated within the bay by southerly winds 30 to 40 knots in velocity. In the summer, prevailing southerly wave buildup is smaller as winds are weaker. Southerly and southeasterly waves strike with greatest intensity along the south facing shoreline of the Lummi Reservation. The waves, often armed with drift logs, rapidly erode the bluffs. Occassionally, northeasterly winds create waves up to 0.5 meters (1.5 ft.) that break along piers and wharves on the east side of the bay; however, these waves are largely insignificant.

Point Francis or Portage Island, on the southwest side of the bay, was studied by Vonheeder (1972). He found the south facing shoreline of the island to be eroding from southerly wave attack. Unfortunately, he was unable to determine with confidence an average recession rate for the sea cliffs. However, it is clear that the sediment eroded from the cliffs is transported northward around the eastern and western flanks of the island where it is deposited in the form of two "horn-like" features, Brant Point on the east and The Portage on the west. The Portage provides an overland connection between the island and Lummi mainland during low tidal periods. The west side of the island has a flat beach plain approximately 500 meters long with a low undulating surface two to three meters above mean sea level. The south face of the beach is overtopped by storm waves. As a result, low areas are filled with brackish water and halophytic salt marsh vegetation.

North and northeasterly of Point Francis are the shore bluffs of the Lummi Reservation. These bluffs are exposed to southerly wave attack as are those on the south shore of Point Francis. Waves, armed with drift debris from the Nooksack River actively erode and oversteepen the bluffs (Fig. 15 ). Recently fallen trees on the beach and trees soon to fall from the bluff, as it retreats undermining roots, are positive indicators of the rapid and continual erosion.

Closer inspection of the bluffs reveal that wave attack is not the only cause of bluff erosion. Many slumps and debris falls along the 6 km. long shore bluffs have a dense growth of Equisetum. This plant, more commonly known as horsetail, thrives on highly saturated soils. They indicate that the bluffs are saturated during the wet season, which is another factor leading to instability and slope failure. During the summer dry season, the plant dies due to a reduction of soil moisture. Large dessication cracks form as the bluff face dries and the soil contracts.

The Lummi Indian Tribe is very concerned about the bluff erosion and the threat it poses to Lummi Shore Drive, the main road that is parallel

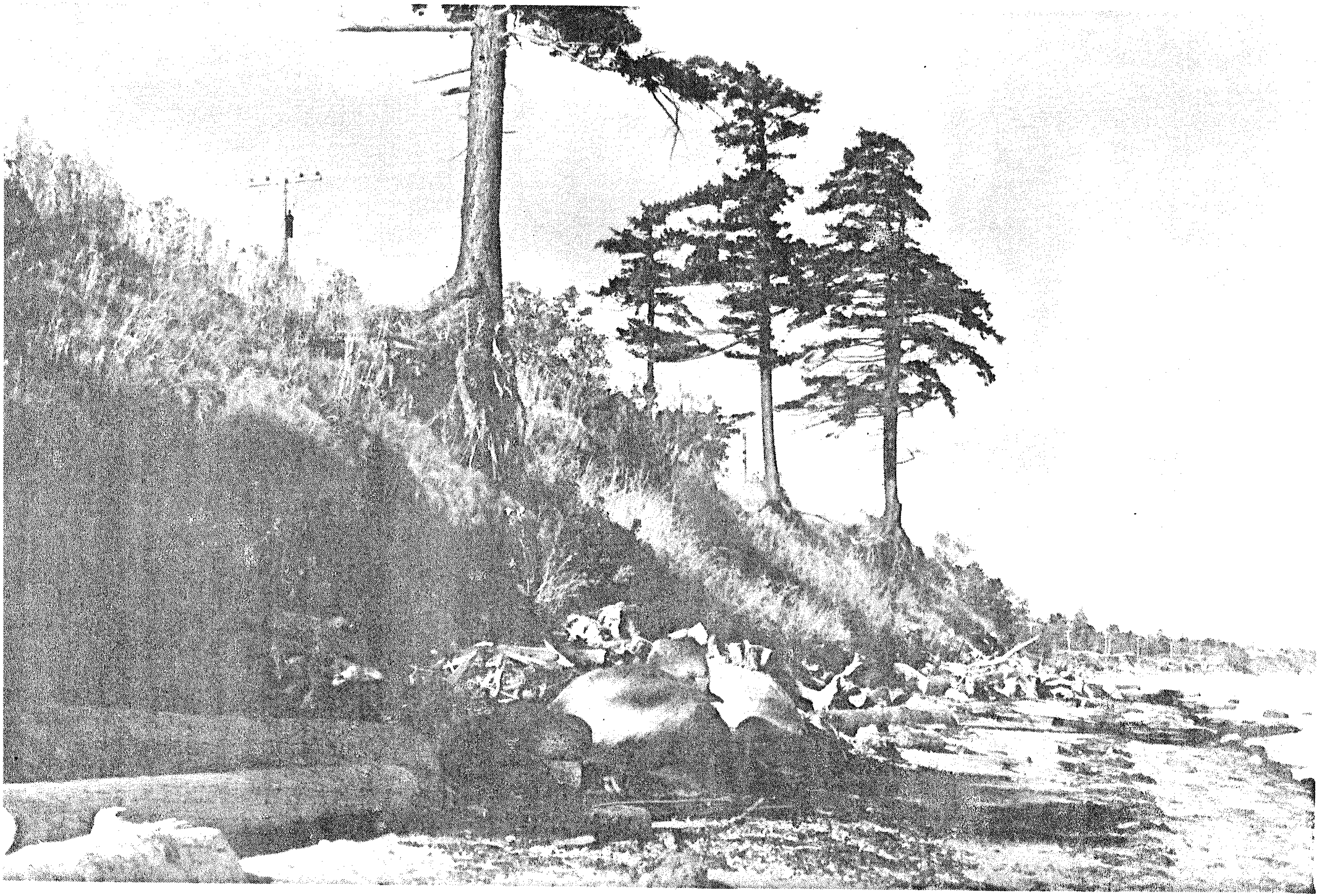


Figure 15

to and near the edge of the bluffs. They have placed rip rap in rapid erosion area where the road veers close to the beach.

The beach at the base of the shore bluffs is 8 to 10 meters wide and composed chiefly of sand and gravel with patches of cobbles. The base of the bluffs is littered with logs and debris from the Nooksack River. Wave cut notches are plainly visible at the base of the bluffs where wave erosion is carried northeasterly by longshore transport towards the Nooksack delta.

Nooksack Delta

The Nooksack River has flowed between Lummi Bay, north of the Lummi Peninsula, and Bellingham Bay in the recent past (Easterbrook, 1973). At the turn of the century, the course of the river changed so that the main flow went into Bellingham Bay where it remains today (fig 16). Sternberg (1967) has estimated the river to deposit 690,000 cubic meters of sediment into Bellingham Bay annually. Prevailing southerly waves have stunted the forward growth of the delta into the bay forcing the sediment to be deposited laterally along the eastern and northwestern margins of the bay. The lateral movement of the sediment is causing much shoaling and the development of large tidal flats near the delta. The shoaling on the east side of the bay is a problem for port expansion and shipping.

The shoreline to the east of the delta has become sheltered from wave attack by the deposition of tidal flats which are part of the delta. Bluffs up to 30 meters high border the beach, lowering toward the Nooksack delta. They are heavily vegetated save in a few places where small slumps have occurred scaring the bluff face. Wave erosion of these bluffs does not appear to be significant; however, the Burlington-Northern Railroad has dumped large amounts of rip rap over one place along the bluff in an apparent effort to retard erosion and protect the rail line above.

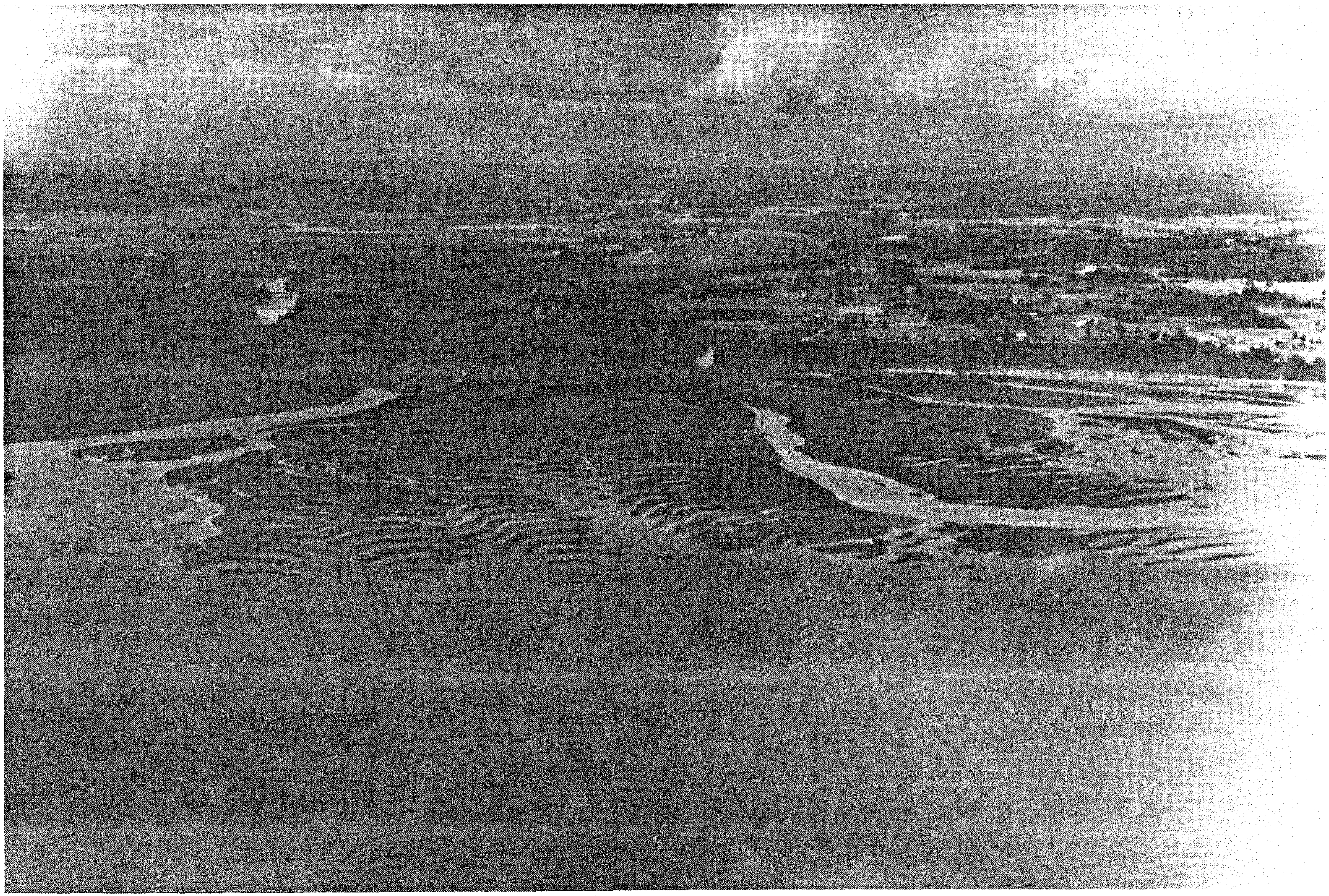


Figure 16

The nearly level beach varies in width from 15 to 30 meters. The beaches near the delta are composed primarily of sand derived from the Nooksack River. The beaches farther to the east are composed chiefly of gravels and cobbles. There are two reasons for the rapid change in beach sediment size. First, the beaches farther away from the delta receive less river sand. Second, the net longshore sediment transport is westerly, towards the delta. Thus, the net longshore currents sweep any fine grain sediment from the eastern-most beaches towards the delta leaving the coarser sediment behind. Furthermore, air photo inspection of the delta reveals a small spit approximately 150 meters long projecting westerly into the delta from the adjacent beach providing further proof of the westerly longshore sediment transport. Thus, the delta appears to be a net deposition zone for beach and fluvial sediments.

Whatcom County's southern most shoreline south from the Port of Bellingham for a distance of approximately 8 km. is composed of the Chuckanut Formation. The Chuckanut Formation is a series of late Cretaceous and early Tertiary arkoses, conglomerates, and siltstones folded into a series of north-south tranding anticlines (structural arches) and synclines (structural troughs) (Mustoe, 1971).

The Chuckanut Formation creates a visually pleasing shoreline; however, it is nearly devoid of sandy beaches save in a few isolated pockets (Fig. 17). Most of the shoreline consists of massive sandstone cliffs, large fallen boulders, and small islets projecting from the water just offshore. Stunted shrubs and gnarled trees cling to small rocky crevesses adding to the unique beauty of the shoreline.

Of particular interest to artists and researchers are unusual weathering forms displayed upon the rocks within the shore zone. Mustoe (1971)

Figure 17. Chuckanut shoreline
(photo no prepared)

studied the shoreline weathering characteristics of the Chuckanut Formation in order to explain some of the curious patterns that resemble cavities (Fig. 18). Mustoe refers to these features as aveoli and attributes their formation to biochemical weathering of the rock surfaces. Additional beauty is shown by the drapery-like blankets of rock that overhang more actively eroding parts of the sandstone.

Wave cut notches in the Chuckanut Formation are plainly visible in many places. Few are so deeply cut as to cause extensive collapsing of the upper rock. Immediately below the wave cut notch is usually found a small nearly flat step or platform several centimeters up to a few meters in width. They are the result of wave erosion on hard surfaces. The surface has numerous irregularities where tide pools form.

Many homes have been constructed on the sea cliffs and promontories of the Chuckanut Formation. The spectacular scenery afforded many of these residences place a high premium upon their value. The greatest hazard to continued development lies with construction in marginal areas that are prone to landslides, rockfalls and planar slides. Developers should take care not to <u>undercut</u> the toe support of bluffs and hillsides; reduce <u>overloading</u> of bluffs and hillsides with structures and landfills; prevent <u>saturation</u> of bluff materials by septic drain fields; and reduce <u>vibrations</u> that may trigger failures from blasting, and the excessive operation of heavy machinery.

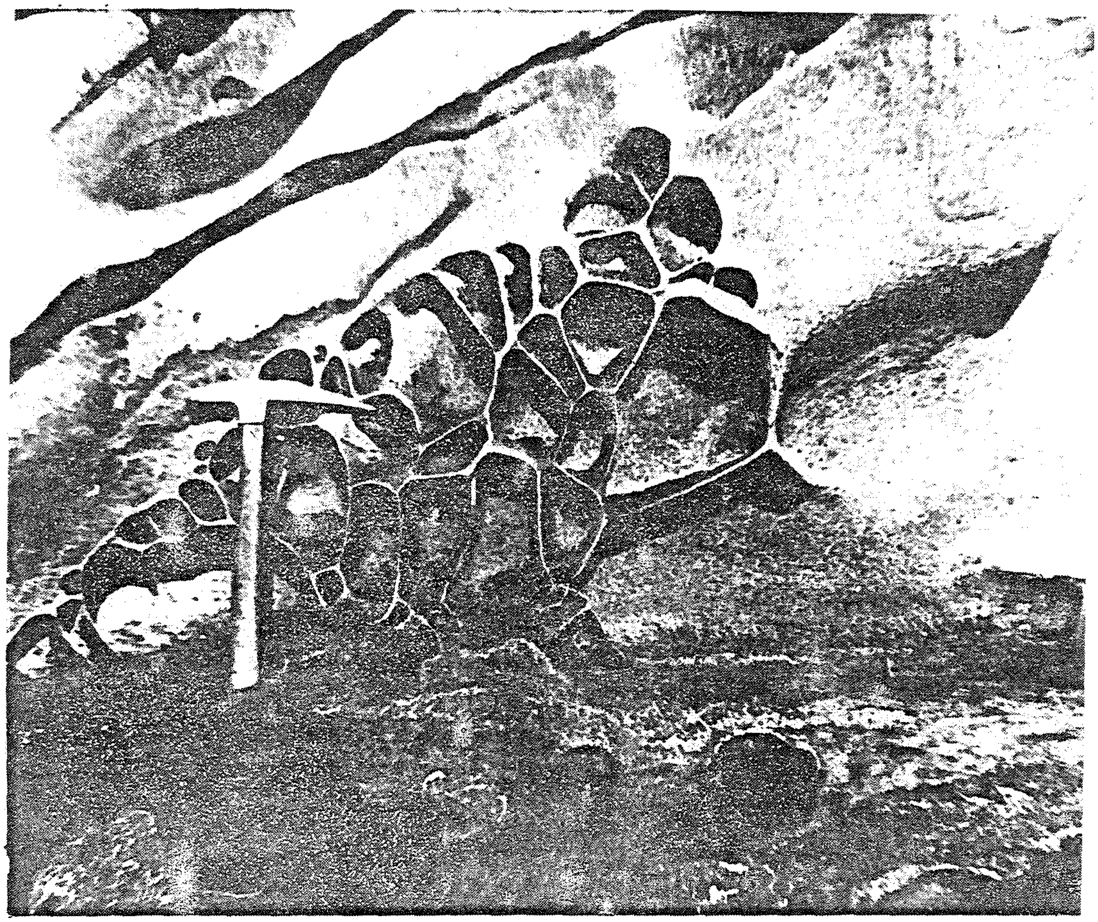


Figure 18 Alveoli weathering on Chuckanut Formation
(Mustoe 1971)

## SUMMARY

The shoreline of Whatcom County is physically varied, consisting of high bluffs of glacial drift, low sandy beaches, deltas, and hard rock cliffs. Each is subject to similar geological processes, yet each responds differently enhancing the natural diversity of the shoreline.

Rapid "cause-effect" relationships exist within and sometimes between shoreline segments. It is therefore important to have some knowledge of the physical characteristics and processes operating within and between them to access the impacts of natural or manmade changes. It is hoped this report begins to identify some of the natural and man induced changes occurring to the Whatcom County shoreline and provides a foundation for future study and understanding.

## REFERENCES


Easterbrook, Donald (1973) Environmental Geology of Western Whatcom County, Washington. U.S. Geological Survey Report.

Larsen, C.E. (1972). An Investigation into The Relationship of Change in Relative Sea Level to Social Change in the Prehistory of Birch Bay, Washington. Unpublished M.S. thesis, Department of Anthropology, Western Washington State College.

Mustoe, G. (1971). Biochemical Origin of Coastal Weathering Features in The Chuckanut Formation of Northwest Washington. Unpublished M.S. thesis, Department of Geology, Western Washington State College.

Schwartz, M.L. and Grabert, G. (1973). "Coastal Processes and Prehistory of Maritime Cultures", in Coastal Geomorphology, D. Coates (ed.).

Sternberg, R. (1967). "Recent Sediments in Bellingham Bay, Washington." Northwest Science. Vol. 44, No. 2.

Vonheeder, E.R. (1972). Origin and Development of Coastal Landforms at Point Francis, Washington. Unpublished M.S. thesis, Department of Geology, Western Washington State College.