1-1-1964

Greater Boston Geomorphology

Nichols, Robert L.

TRIP A - Saturday

GREATER BOSTON GEOMORPHOLOGY

Robert L. Nichols, Tufts University*

Foster Street Stop, Brighton, Newton Quadrangle, Massachusetts; 0.3 mile north of Chestnut Hill Reservoir.

To be seen:

(1) outcrop of Roxbury conglomerate
(2) glacial grooving and striations
(3) dominant orientation of striations and grooves is N.27° - 35° W
(4) curved striations and striations to N.65° W. caused by local deflection of ice flow by rock obstructions

Discussion:

(1) the N.10°-35° W. striations of the Boston area produced by late Wisconsin, post-drumlin glaciation
(2) nature of deflection of ice flow by small rock obstruction

Parker Hill Drumlin Stop, Boston, seen from Boylston St., Brookline Village.

To be seen:

(1) shape and orientation of drumlin (Fig. 1)
(2) drumlin till
(3) oxidation of till
(4) position of bedrock high

Discussion:

(1) significance of depth of oxidation
(2) age of drumlin
(3) effect of later ice having different flow direction on drumlin shape

Boston Government Center Stop, (the foundation excavation for the new City Hall if this is still open; otherwise some other excavation in the area).

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* The co-leader of this field trip, C.A. Kaye, has been prevented, by pressures of other commitments, from sharing the authorship of this guide.

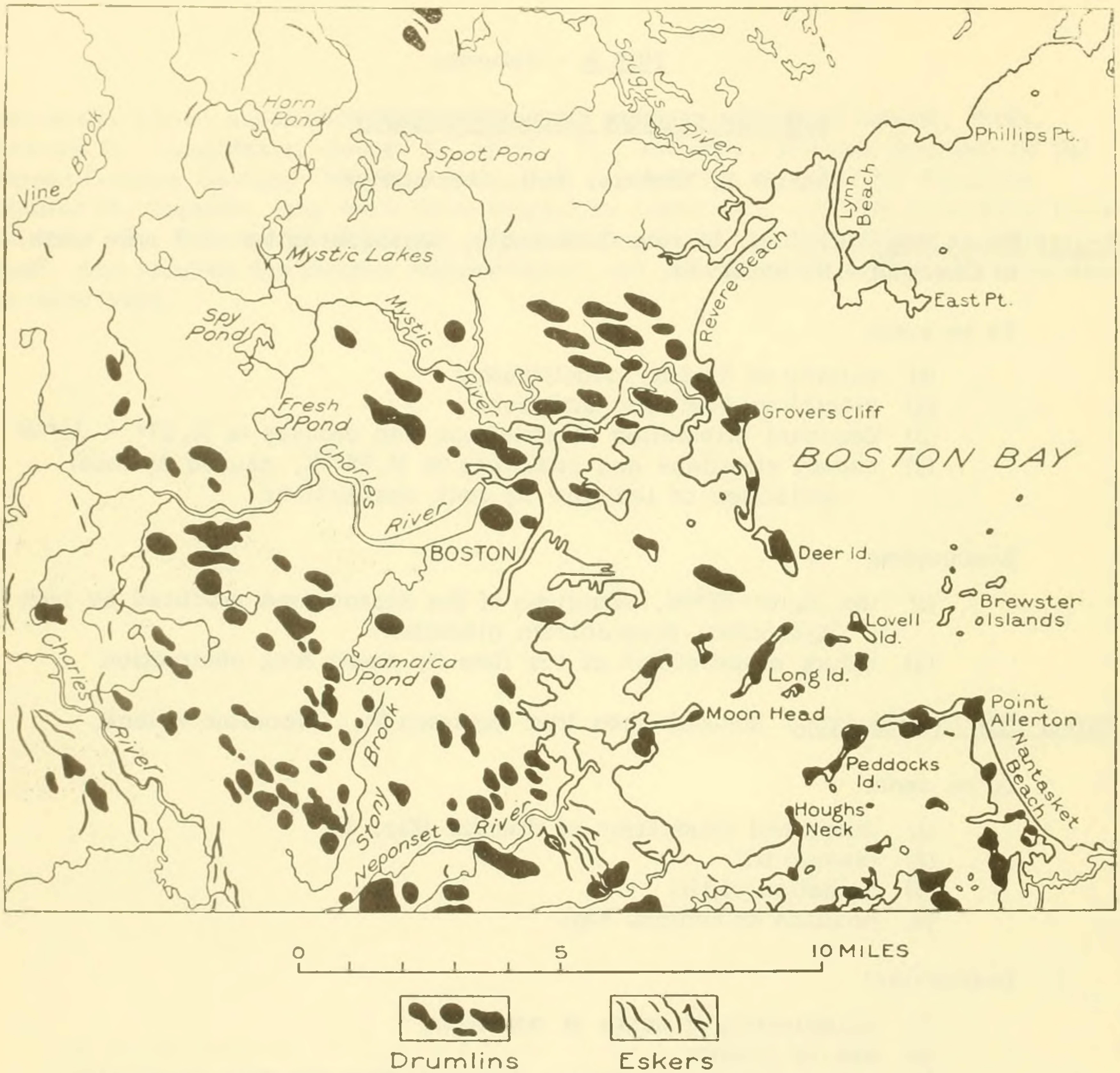


Figure 1. Distribution of drumlins and eskers in the Boston area (Fig. 5 from LaForge, Laurence, 1932, Geology of the Boston Area, Massachusetts: Geological Survey Bull. 839).

To be seen:

(1) stratigraphic sequence (Fig. 2)
  d. sandy clay and clay
  c. clay
  b. oxidized gravel
  a. very compact clay
(2) folding and faulting
(3) unconformity above Clay c. (above)

Discussion:

(1) age and correlation of deposits (Table 1)
(2) depositional environment
(3) nature of deforming forces
(4) sea-level fluctuations

Snake Island Stop, Winthrop, Massachusetts, Hull Quad., Massachusetts (Figs. 3, 4, 5).

The following geological features can be seen:

(1) boulder pavement
(2) marine cliff
(3) till
(4) off shore peat
(5) beach
(6) marsh

Discussion:

(1) lost islands
(2) simple flying bar
(3) sub-aerial and submarine flying bars
(4) winged drumlin
(5) winged flying bar

Shirley Gut Stop, Boston, Massachusetts, Hull Quad., Massachusetts (Figs. 3, 6, 7).

Discussion:

(1) Point Shirley, Deer Island
(2) Colonial and recent history
(3) closing of Shirley Gut
(4) hydraulic and longshore currents
(5) growth of spits

Nixes Mate Stop, Boston, Massachusetts, Hull Quad., Massachusetts (Fig. 3).

Figure 2. North-south geologic cross section, lower Boston Common, at site of underground garage (Fig. 34.1 from Kaye, C.A., 1961, Pleistocene stratigraphy of Boston, Mass.: U.S. Geological Survey Prof. P. 424-B, p. 73-76).

Deposit	Description	Remarks	Depth of oxidation [1]	Direction of ice flow	Relative sea level [2]
Drift IV	Boston basin: mostly outwash. Uplands: till and outwash.		In outwash generally less than 4 ft, in till 1½ ft.	S.10°-35°E	Lower than −30 ft.
Oxidation of Clay III					Lower than −35 ft.
Clay III	Marine clay. More than 180 ft thick under lowlands. Precompressed to depths of 70 ft.	Possibly deposited when ice front was not far from Boston.	3 ft under Drift IV, 10 ft elsewhere.		Found to altitude +25 ft in Boston. Contains fairly deep water fauna suggesting sea level above +50 ft.
Oxidation of Drift III					Lower than − 20 ft.
Drift III	The drumlin till.	Very compact in drumlins; less compact as ground moraine.	Maximum 65 ft in drumlins; where less, oxidized zone probably eroded by Late Wisconsin ice.	S. 60°–80° E.	Possibly above +50 ft.
Clay II	Probably marine.	Probably source of shells in Drift III. May have been deposited during advance of Iowan ice.	None where recognized. May have been eroded.		Possibly about +50 ft.
Oxidation of Drift II					−45 ft (?)
Drift II	Mostly gravelly outwash; some associated till.	Folded in places.	65 ft or more in sand and gravel. Some pebbles decomposed.	Unknown.	Below −75 ft.
Clay I	Probably marine.	Recognized only in borings.	None noted; possibly eroded.		−45 ft or above.
Drift I	Very compact till.	Recognized with certainty only in deep borings.	None noted.	Unknown.	(?)

[1] Oxidized zone of all units but Drift IV was subject to erosion by later ice.
[2] Altitudes refer to present mean sea level.

Table 1. Pleistocene deposits of Boston, Mass. (Table 1 from Kaye, C.A., 1961, Pleistocene stratigraphy of Boston, Mass.: U.S. Geol. Survey Prof. P. 424-B, p. 73-76).

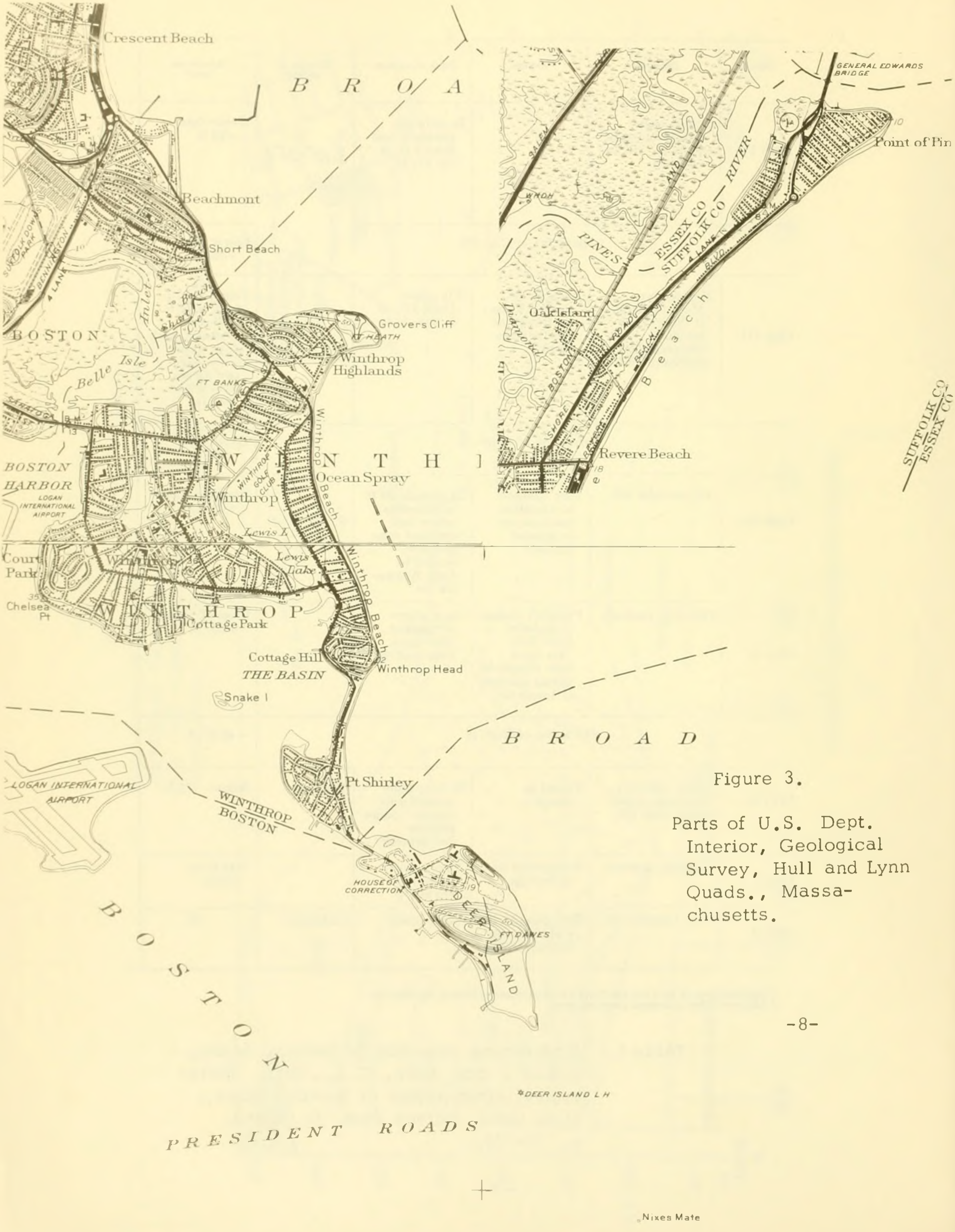


Figure 3.

Parts of U.S. Dept. Interior, Geological Survey, Hull and Lynn Quads., Massachusetts.

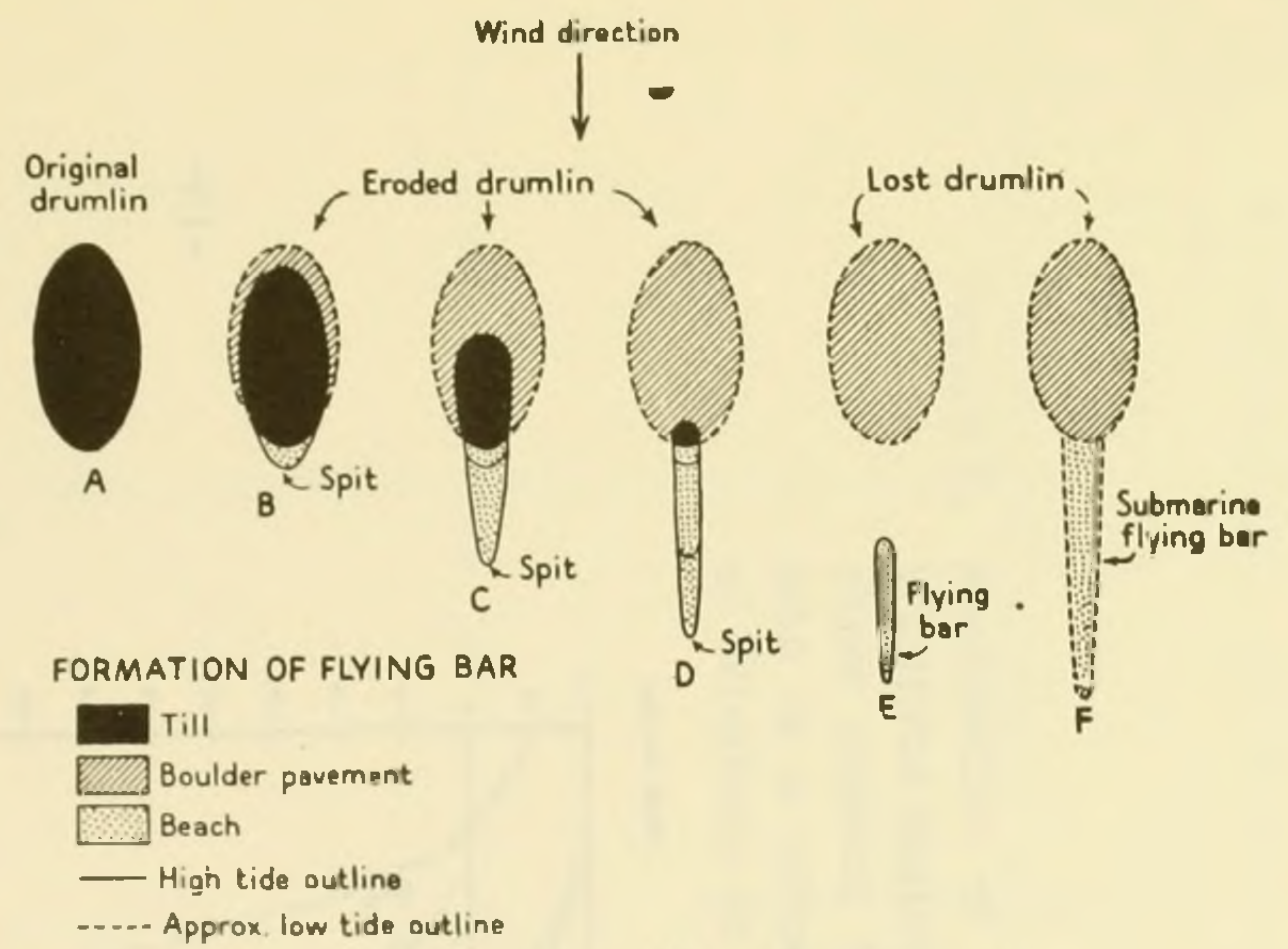


Figure 1. Formation of a simple flying bar.

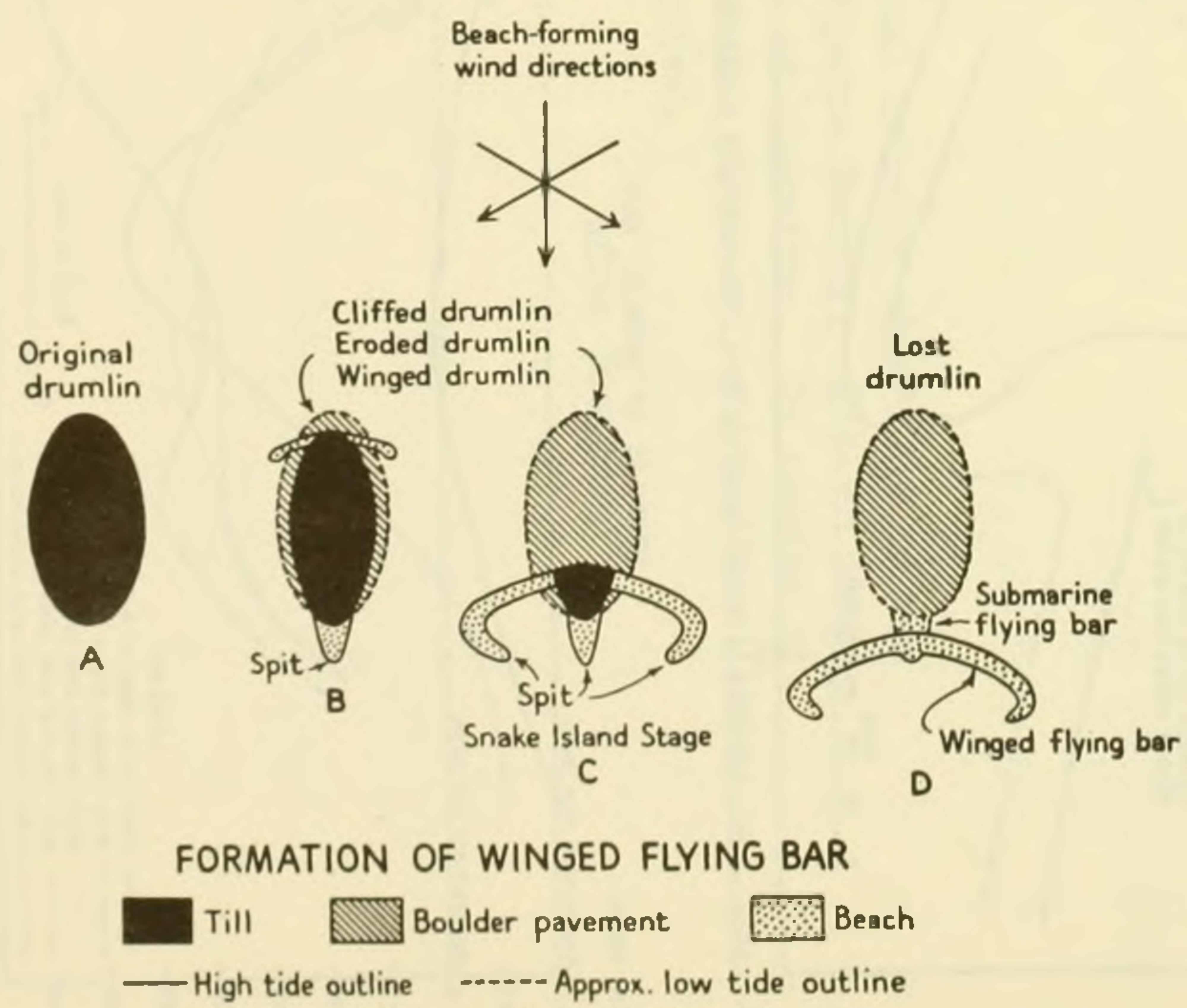


Figure 4. Formation of a winged flying bar.

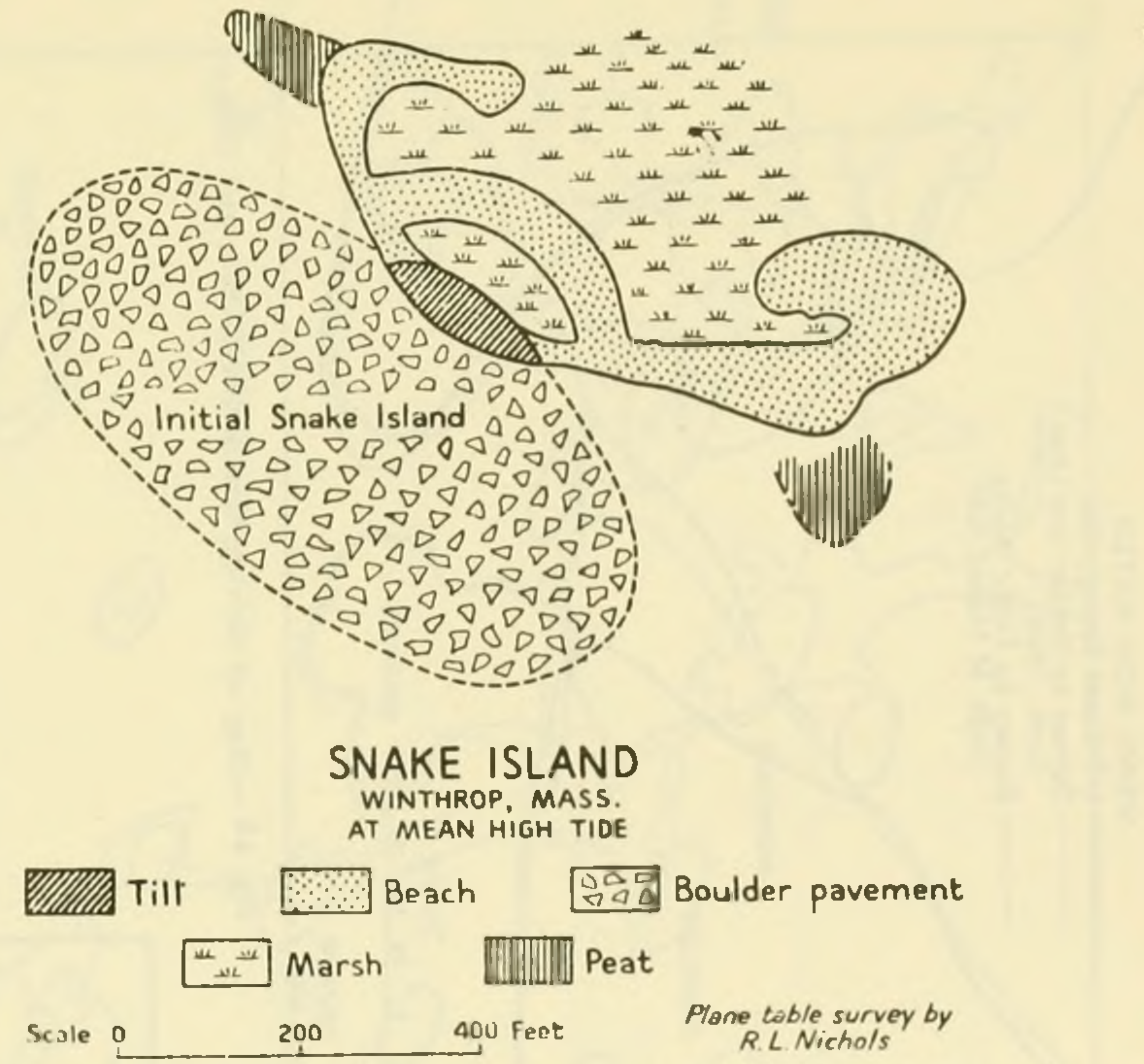


Figure 5. Snake Island, Winthrop, Mass., in Boston Harbor. A potential winged flying bar.

after R. L. Nichols

Hull, Mass.
Quad., U. S. G. S.

A sand bar formerly attached to an island becomes a flying bar when the island is destroyed. Snake Island in Boston Harbor is an excellent example of a potential flying bar.

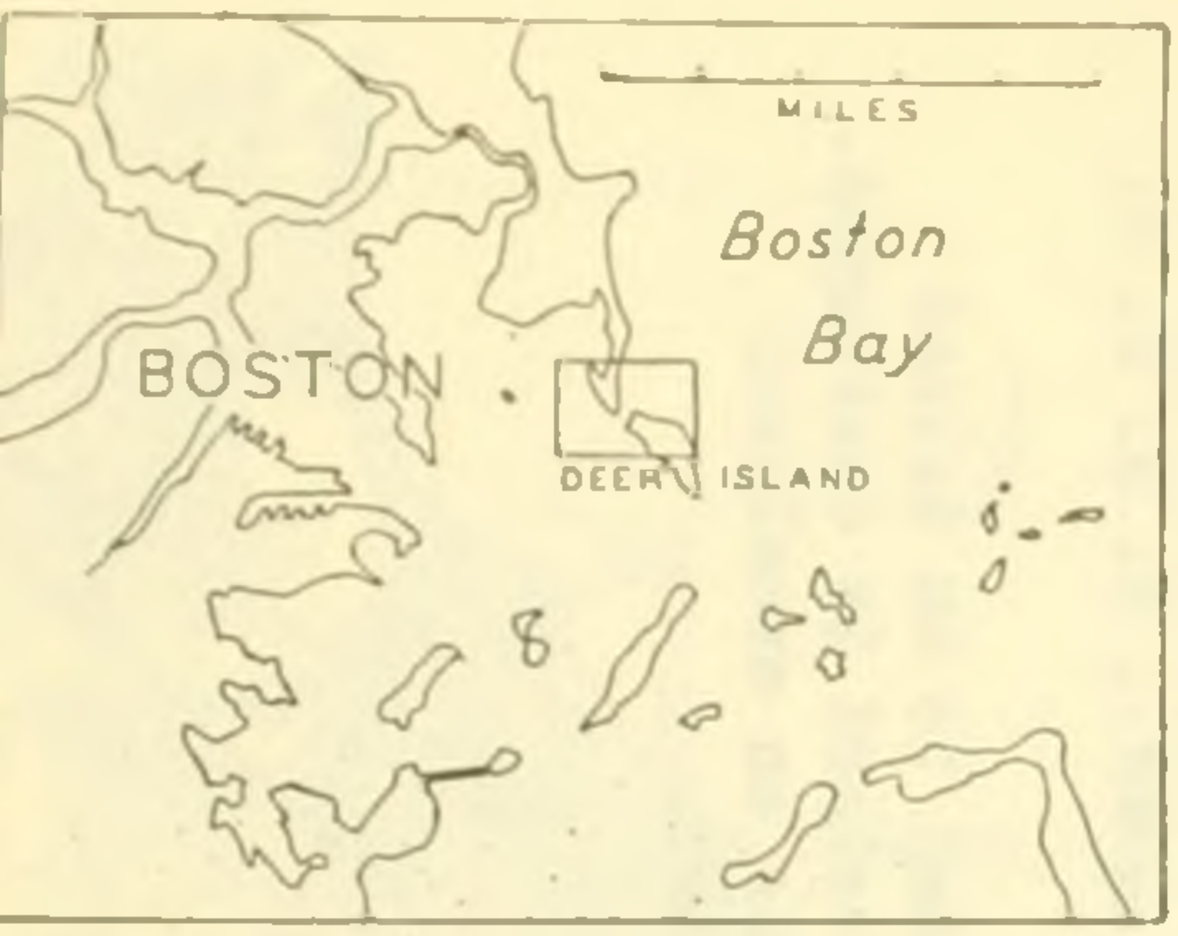


Fig. 6a.—Index map of Boston Harbor, Massachusetts. Area considered in text outlined

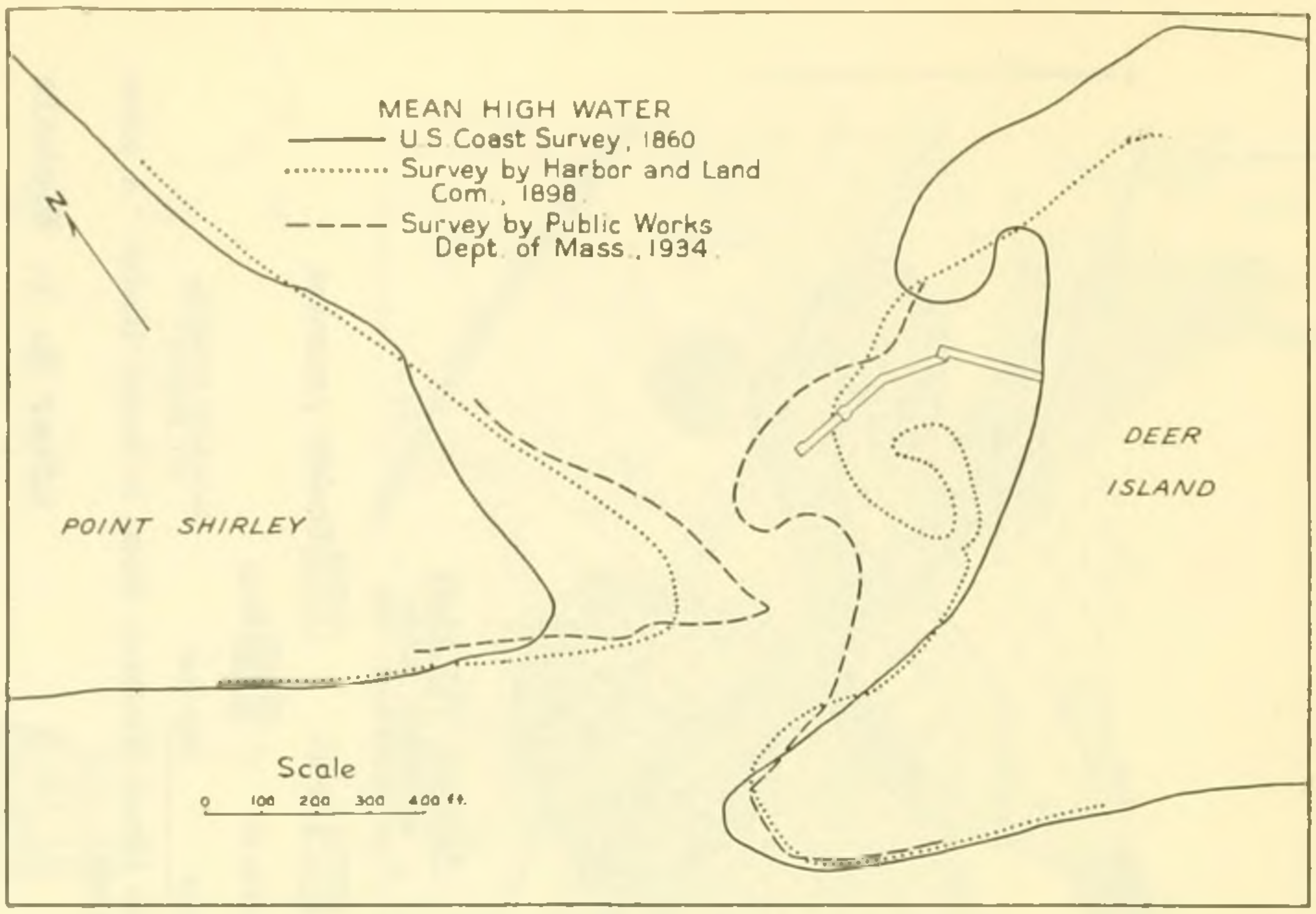
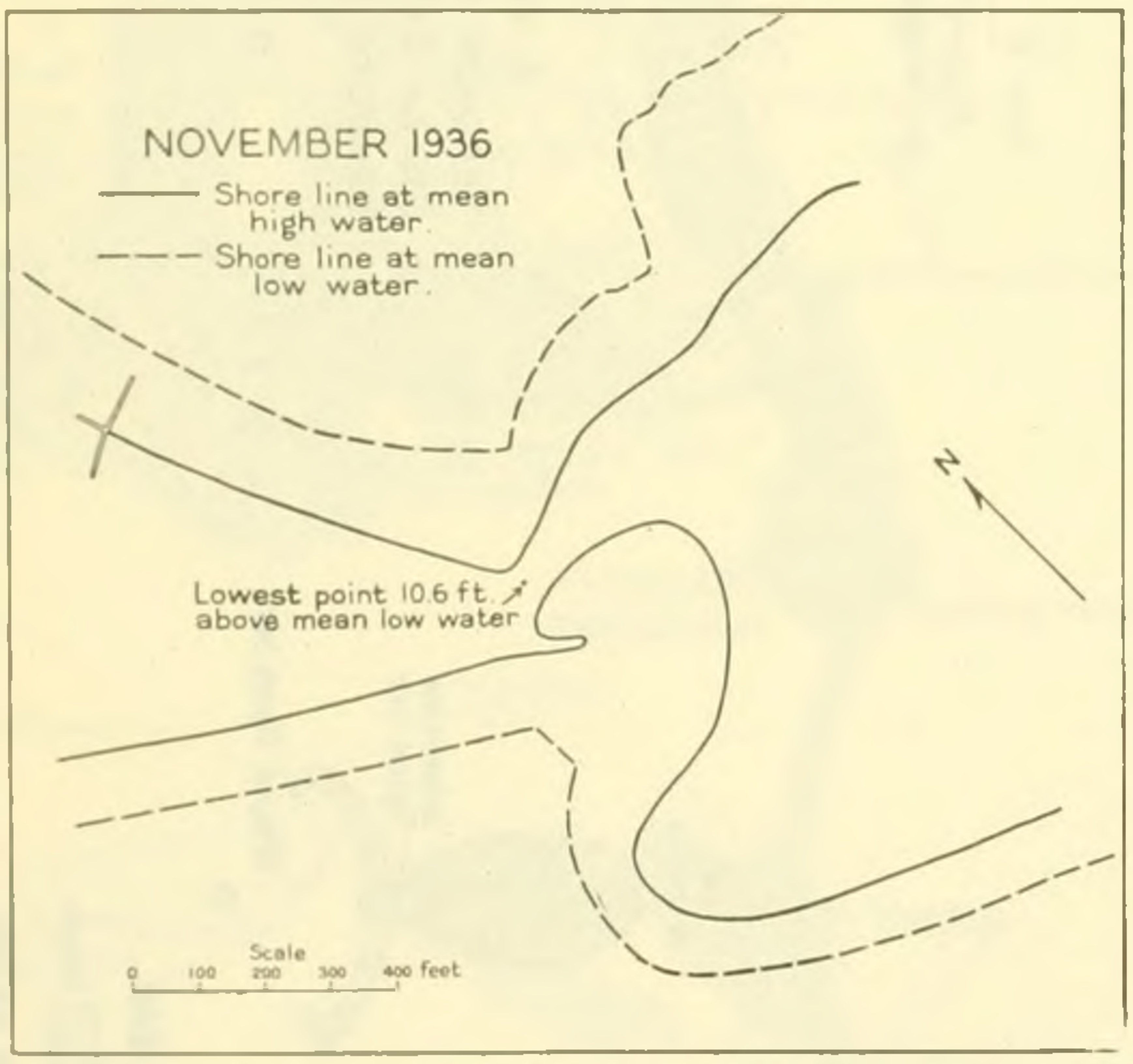


Fig. 6b—Map of Shirley Gut in 1860, 1898, and 1934



6c.—Map of Shirley Gut in 1936. Map by R. L. Nichols and Louis Riseman

Figure 6. Diagrams showing the closing of Shirley Gut.

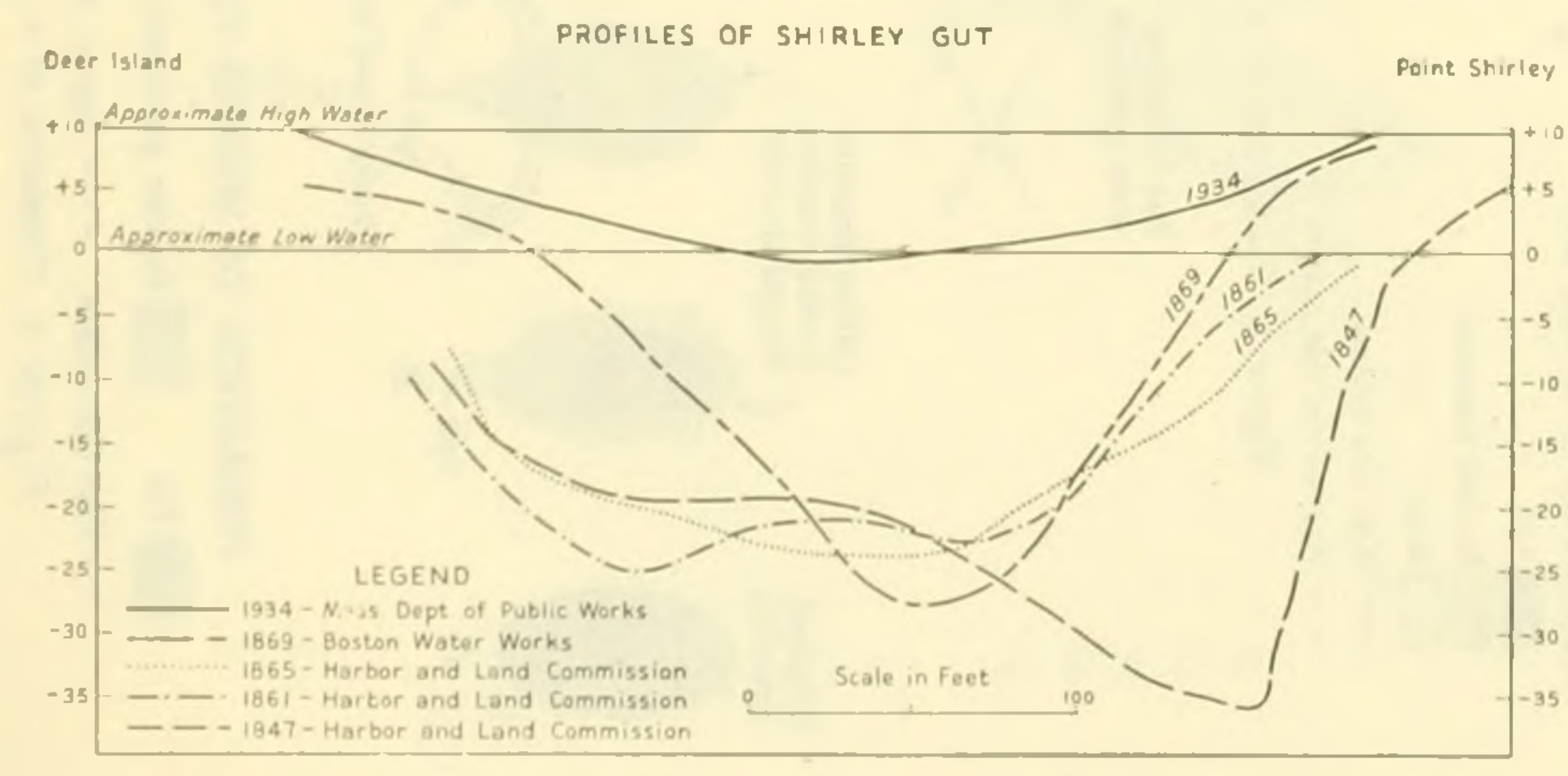


Fig. 6d.—Transverse profiles of Shirley Gut

after Nichols

drumlins
eroded drumlins
boulder pavements
tied islands
tombolos
marine cliffs
lost islands
lost drumlins
spits
beaches
off-shore fine-grained marine deposits
shoals
wave-cut platforms

Figure 7. Restoration of initial drumlin shoreline of the Winthrop region, Boston Harbor. Broken lines show present form of shoreline. In center of map is a glacial delta plain on which the village of Winthrop is located.

after Johnson

Discussion:

(1) story of island
(2) evidence of lost islands
historic evidence
shoals
low-tide boulder-pavement islands
boulder pavements
volume of beaches
alignment of beaches
height and orientation of marine cliffs
(3) localities

Shirley Gut Drumlin Stop, Winthrop, Massachusetts, Hull Quad., Massachusetts (Fig. 3,8).

The following geologic features are present:

(1) fossil marine cliff
(2) prograded beach
(3) till
(4) eolian sand
(5) beach-buried boulder pavement
(6) wave-cut platform
(7) polygenetic topography

Discussion:

(1) Why the change from a retrograding to a prograding coastline?

Short Beach Stop, Winthrop, Massachusetts, Lynn Quad., Massachusetts (Figs. 3,9).

The following features can be seen:

(1) Beachmont drumlin; coalescing drumlins (Winthrop Highlands)
(2) boulder pavements
(3) peat and marsh in back of beach
(4) peat on beach face
elevation
characteristics
significance
(5) retrograding beach

Winthrop Head Drumlin Stop, Winthrop, Massachusetts, Hull Quad., Massachusetts (Figs. 3, 10)

The following features can be seen:

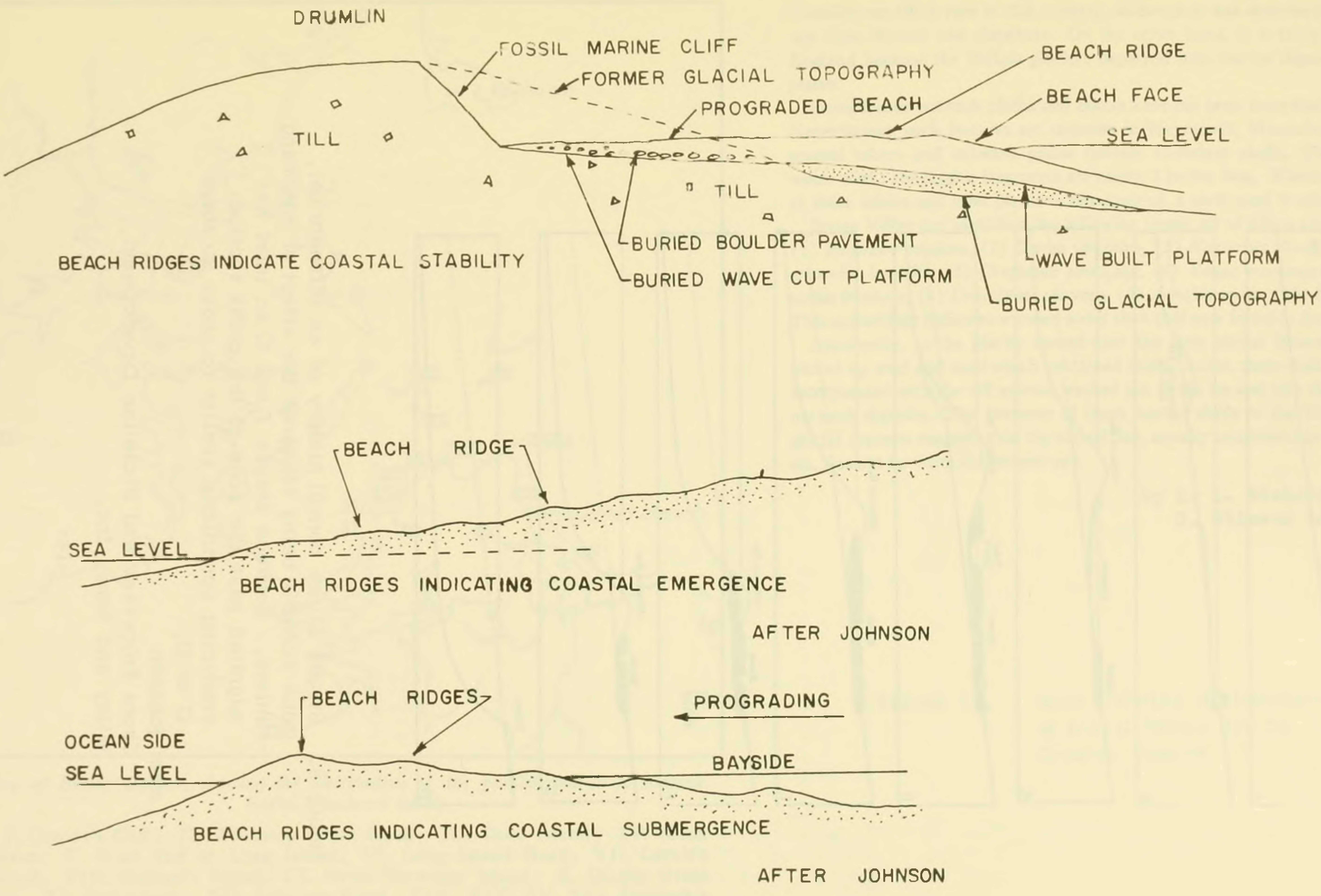


Figure 8. Beach ridges on emerging, submerging, and stable coastlines.

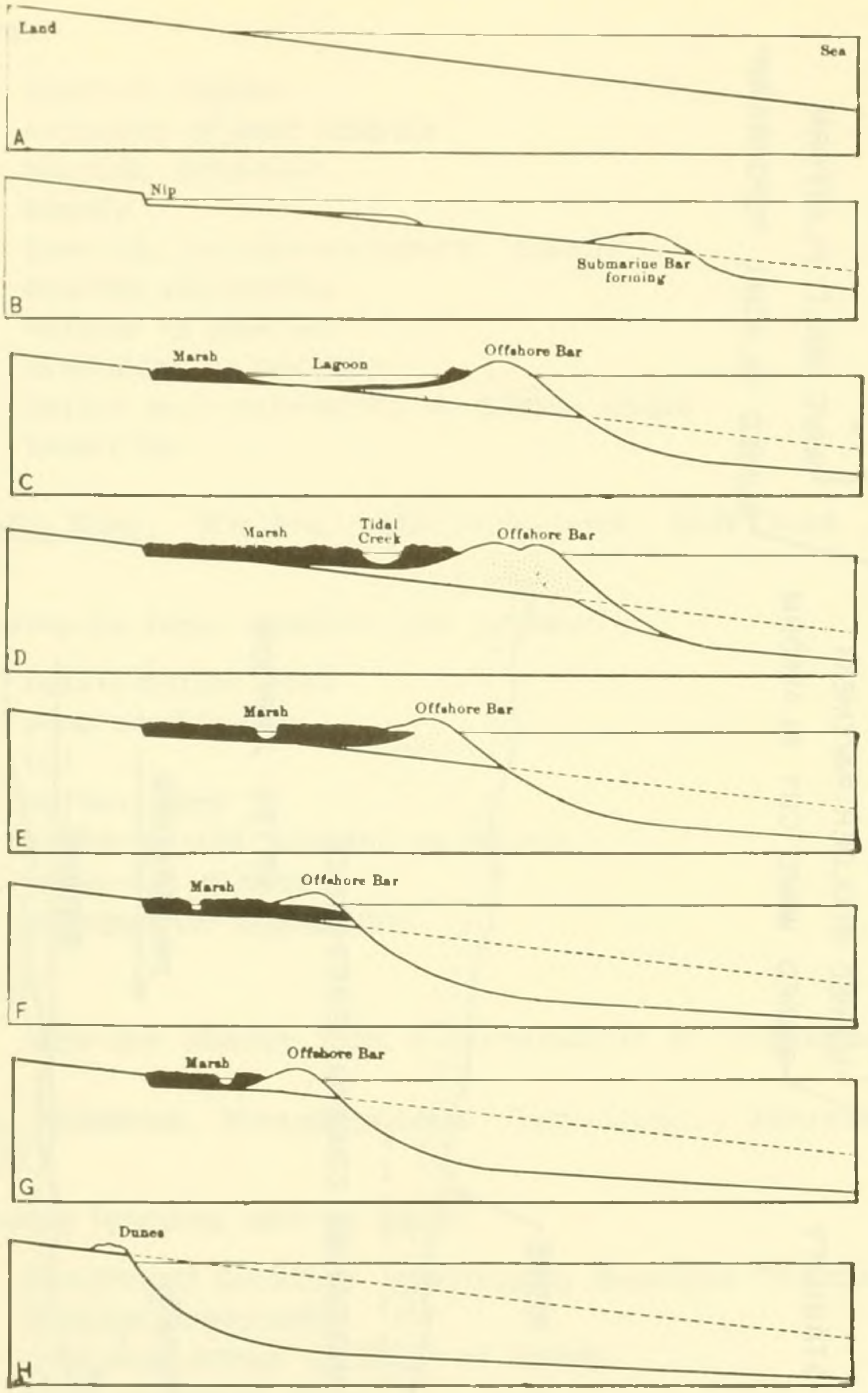
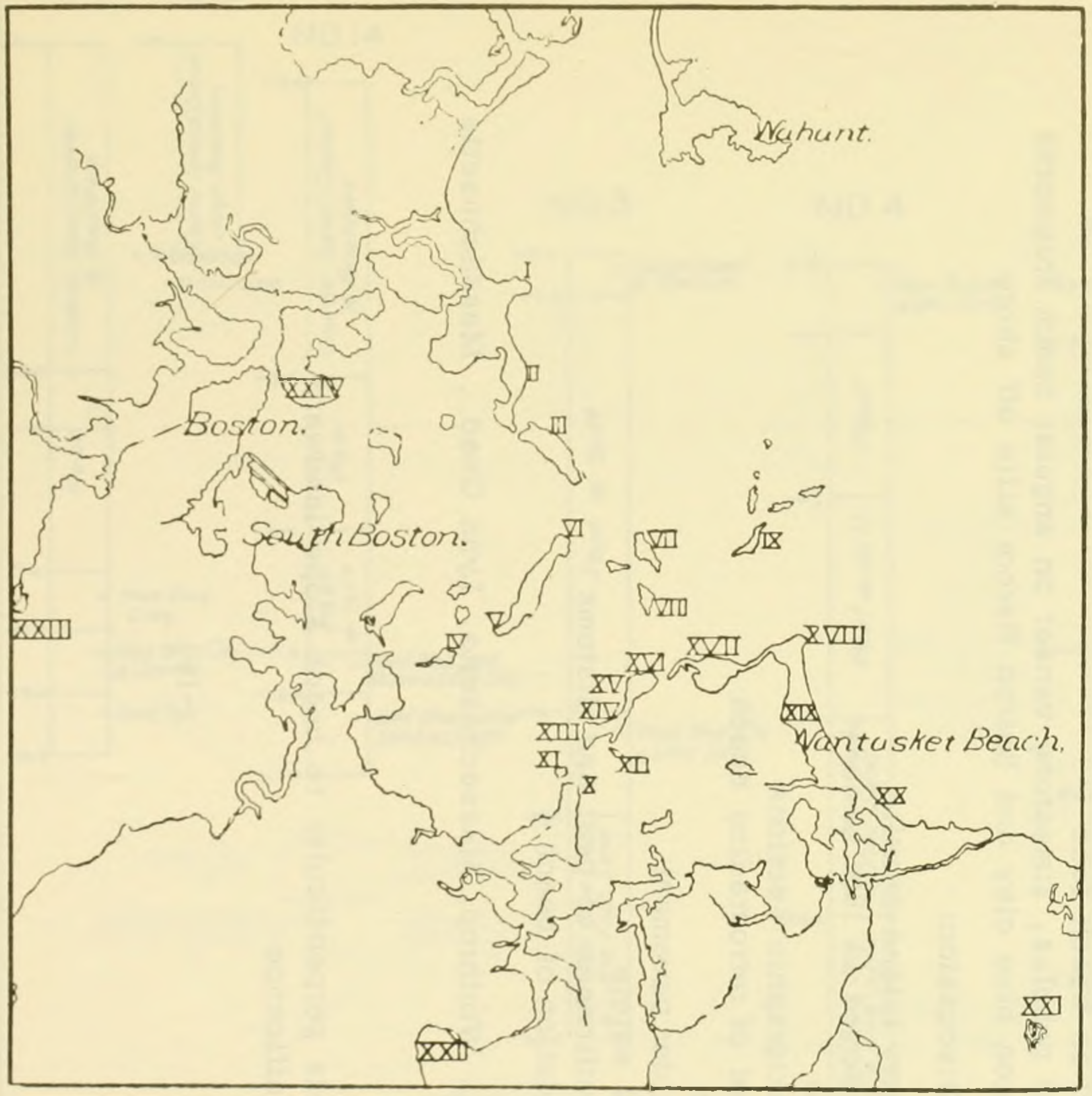


Figure 9. Stages in the normal history of an offshore bar, due account being taken of the effect of migrating inlets. Between stages F and G an inlet has migrated past the zone of the cross section, producing conditions similar to those in stage C or D.

after Johnson
Shore Processes and Shoreline Development, Wiley and Sons, Inc.



Map of Boston Harbor, showing the distribution of the fossiliferous drift sections. Scale, 1 inch = 4 miles.

I, Grover's Cliff; II, Winthrop Great Head; III, Deer Island; IV, Moon Island; V, West End of Long Island; VI, Long Island Head; VII, Lovell's Island; VIII, George's Island; IX, Great Brewster Island; X, Quincy Great Hill; XI, Nut Island; XII, Princess Head; XIII, XIV, XV, XVI, Peddock's Island; XVII, Telegraph Hill, Hull; XVIII, Point Allerton, Hull; XIX, Strawberry Hill, Hull; XX, Sagamore Head, Hull; XXI, well on James' Hill, Cohasset; XXII, well in Braintree; XXIII, well in Jamaica Plain; XXIV, well in East Boston.

after Crosby and Ballard

Fossiliferous till is rare in this country, although it was described many years ago from Boston and elsewhere. On the other hand, it is fairly common in England because the British glaciers deployed into marine deposits in many places.

Fossiliferous outwash plains and eskers have not been described in America. Nevertheless, such features are common in Weymouth, Massachusetts, where several eskers and outwash plains contain abundant shells. The shells are water worn; the largest fragments are nearly 3 inches long. Where the material of these eskers and sand plains is fine-grained, a shell sand is often found.

James Miller has identified the following forms, all of which are now living: (1) *Eupleura caudata*, (2) *Ostrea virginica*, (3) *Nassarius obsoleta*, (4) *Venericardia borealis*, (5) *Crepidula fornicata*, (6) *Venus mercenaria*, (7) *Nassarius trivittata*, (8) *Urosalpinx cinereus*, (9) *Anachis avara*, (10) *Polinices* sp?. This assemblage indicates warmer water than that now found in Boston Harbor.

Apparently, as the glacier moved over the inter-glacial Boston Harbor, it picked up mud and sand which contained shells. Later, these shells were either incorporated with the till or were washed out of the ice and into the eskers and outwash deposits. The presence of these marine shells in the till and fluvioglacial deposits suggests that the strand line, usually considered as pre-Wisconsin, was not far from the present one.

by R. L. Nichols
G. Stimson Lord

Figure 10. Map showing distribution of fossiliferous till in Greater Boston.

(1) eroded drumlin
(2) boulder pavement
(3) beach ridge
(4) cliff profile
(5) yellow and gray till
(6) fossiliferous gray till

Subjects for Discussion:

(1) rate of recession of marine cliff
(2) duration of coastal stability from boulder pavement
(3) restoration of drumlin
(4) distribution of fossiliferous till
(5) distribution of fossiliferous outwash
(6) age and climatic significance of shells

Roughans Point Stop, Revere, Massachusetts, Lynn Quad., Massachusetts (Figs. 3, 11, 12, 13).

The following features can be seen:

(1) cuspate beach
(2) Cherry Island boulder pavement
(3) peat and marsh in back of beach
(4) distribution of marine cliffs on Beachmont drumlin
(5) peat on beach face
(6) peat pebbles, limestone veneer on angular beach fragments
(7) Boston blue clay and Boston Harbor silts off shore

Subjects for Discussion:

(1) Cherry Island drumlin
destroyed in 18th century
size
(2) stratigraphic sections
(3) proof of retrograding beach
peat
boulder pavement
real estate
(4) significance of peat and diatoms
(5) evolution of beach

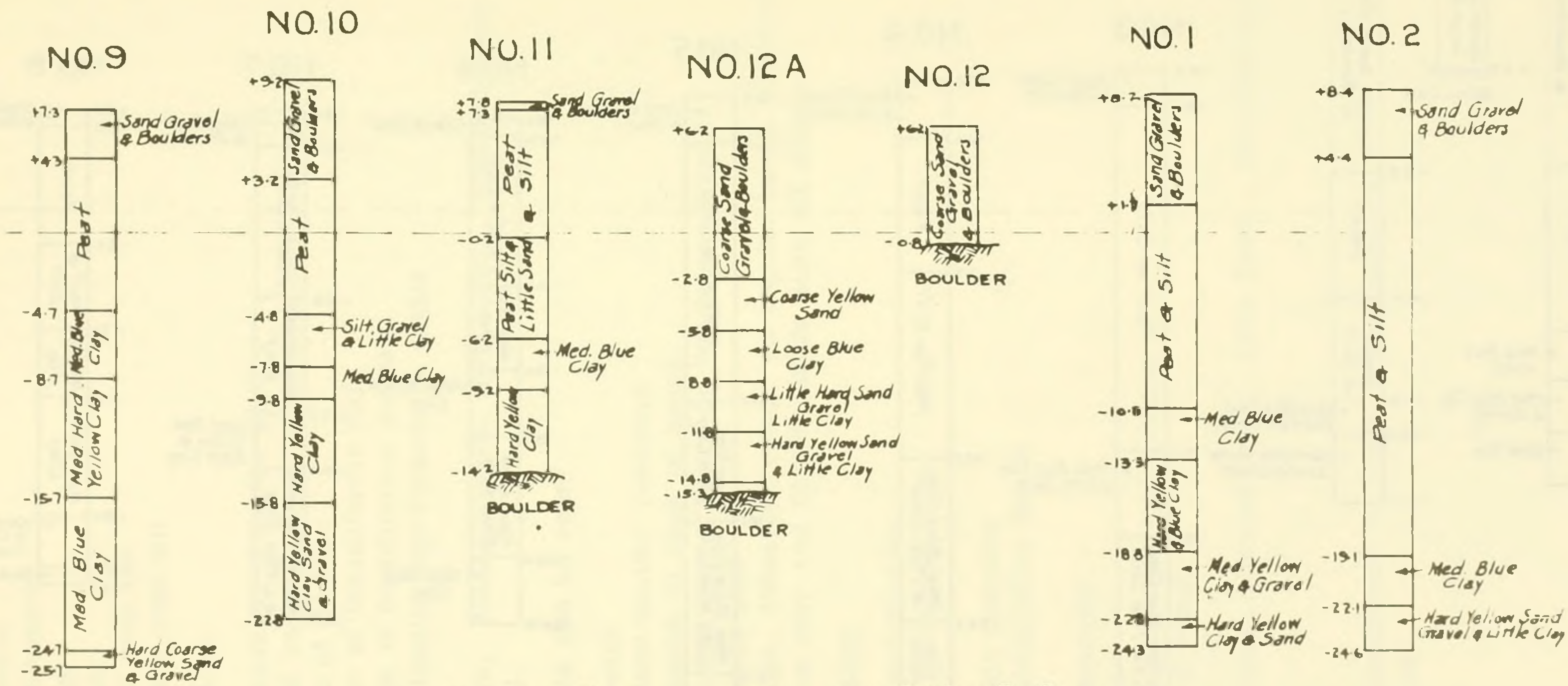
Winthrop Beach Stop, Winthrop, Massachusetts, Lynn Quad., Massachusetts (Figs. 3, 14).

Discussion:

(1) roads perpendicular to beach slope landward
significance

Roughans Point, Beachmont, Lynn Quad., U. S. G. S.
Borings made to see what kind of foundation there was for a sea wall.

Figure 11. Columnar sections, Roughans Point, Revere, Massachusetts.

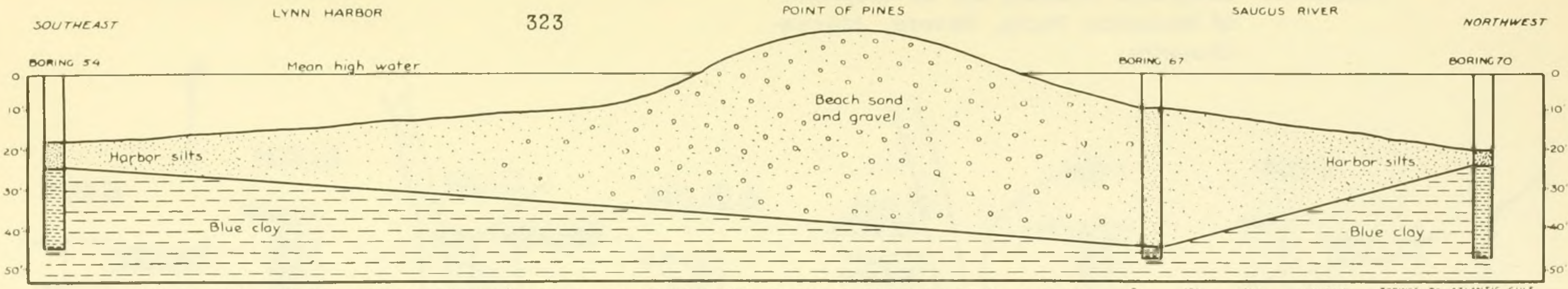


Roughans Point, Beachmont, Lynn Quad., U. S. G. S.
Borings made to see what kind of foundation there
was for a sea wall.

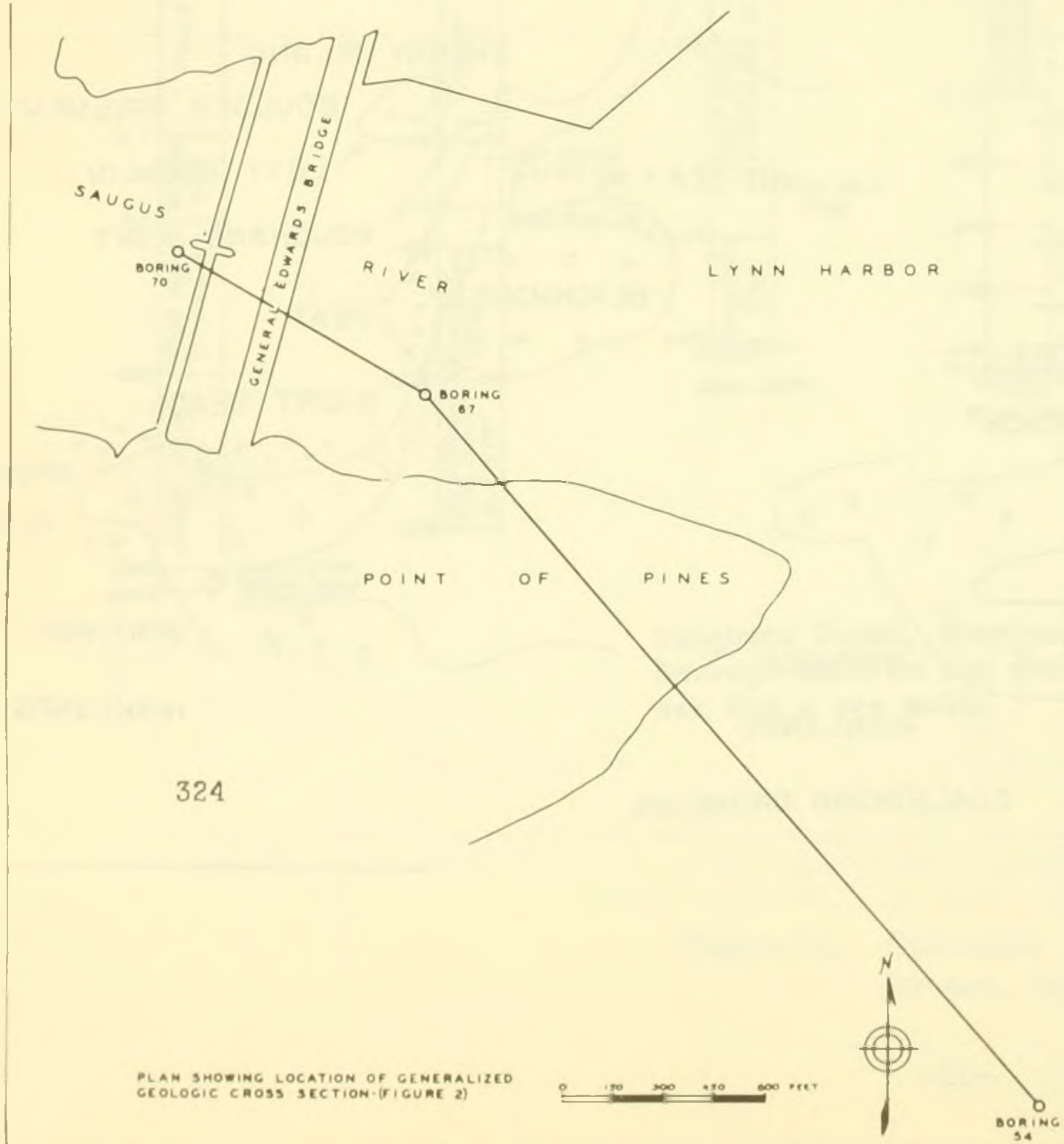
Figure 12. Columnar sections, Roughans Point, Revere, Massachusetts.

Figure 13. Diagrams showing the development of Roughans Point, Revere, Massachusetts.

cuspate beach	lost drumlin
drumlins	offshore peat
coalescing drumlins	tombolo
boulder pavements	marsh deposits
marine cliffs	retrograded beach
lost island	



GENERALIZED GEOLOGIC CROSS SECTION THROUGH POINT OF PINES, SHOWING POSITION OF BLUE CLAY.



PLAN SHOWING LOCATION OF GENERALIZED GEOLOGIC CROSS SECTION-(FIGURE 2)

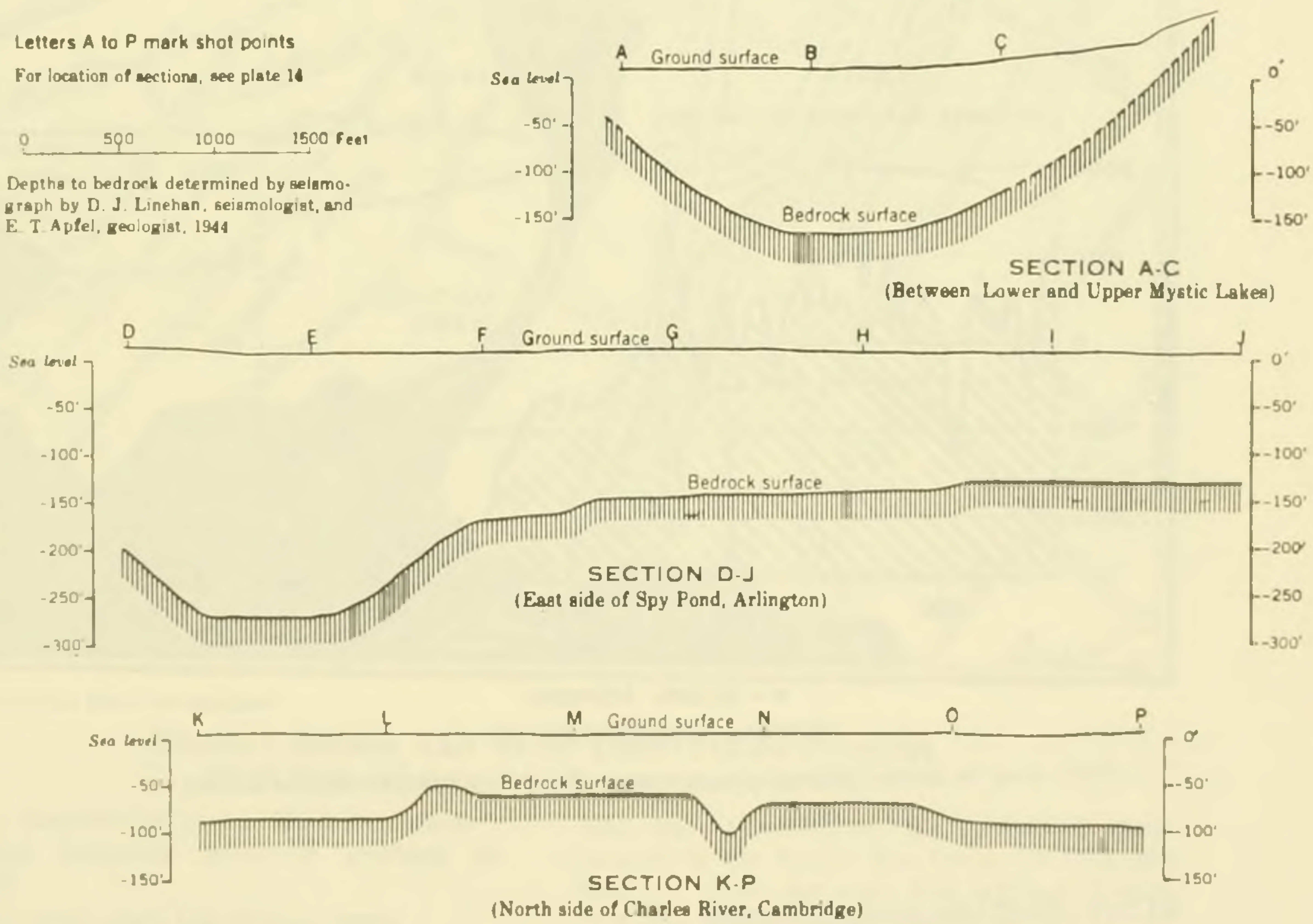
Fig. 14 valley cut in Boston Blue Clay by Saugus River during low stand of sea

section not transverse to valley

(2) proof of post-glacial low stand of sea level
beach ridges
archaeological evidence
submerged weathering profiles
submerged fresh water peat
drowned forests
submerged sub-aerial valleys cut in Boston Blue
oyster line
marine peat

(3) breakwater (1934)
prograding shoreline

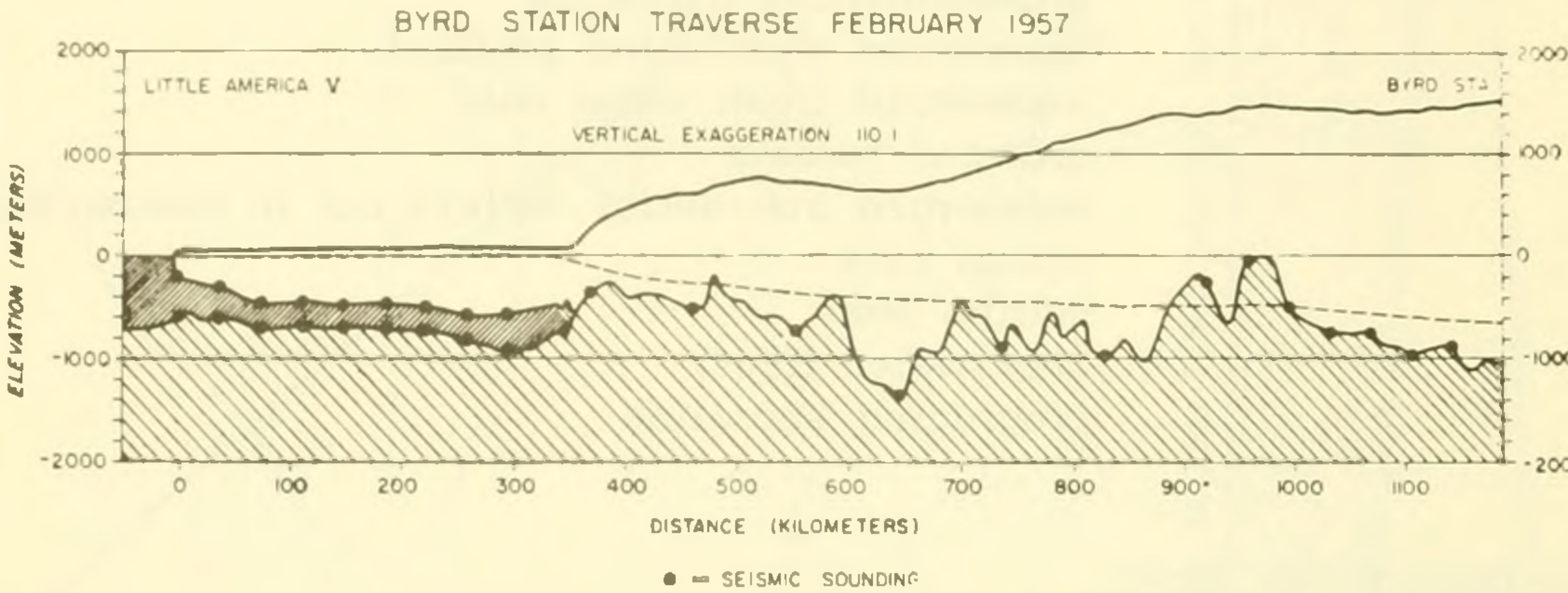
Pre-Glacial Sea Level



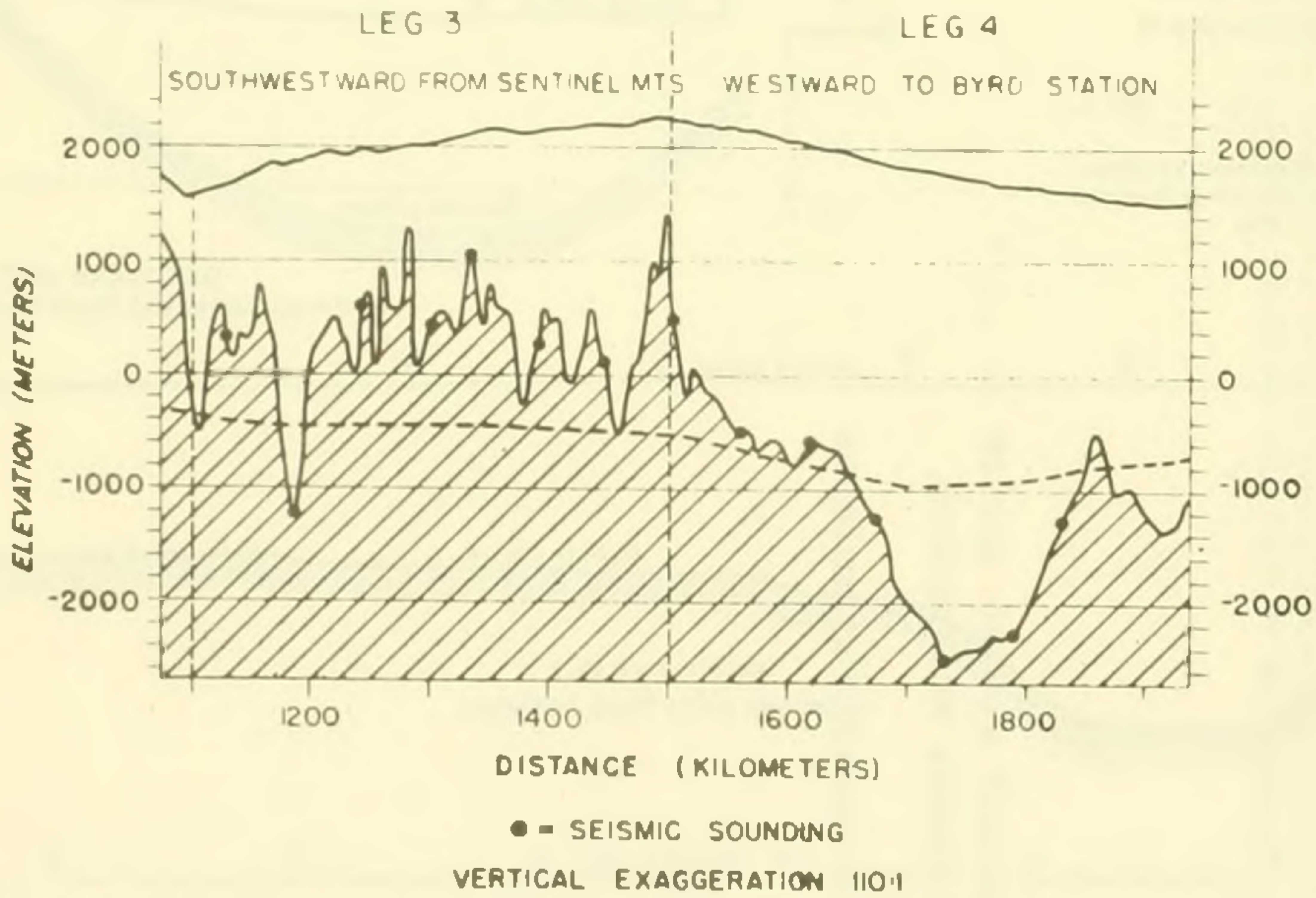
after Chute

Figure 15. The buried bedrock valleys that underlie the Mystic Lakes and the Charles River.

Glacial Sea Level



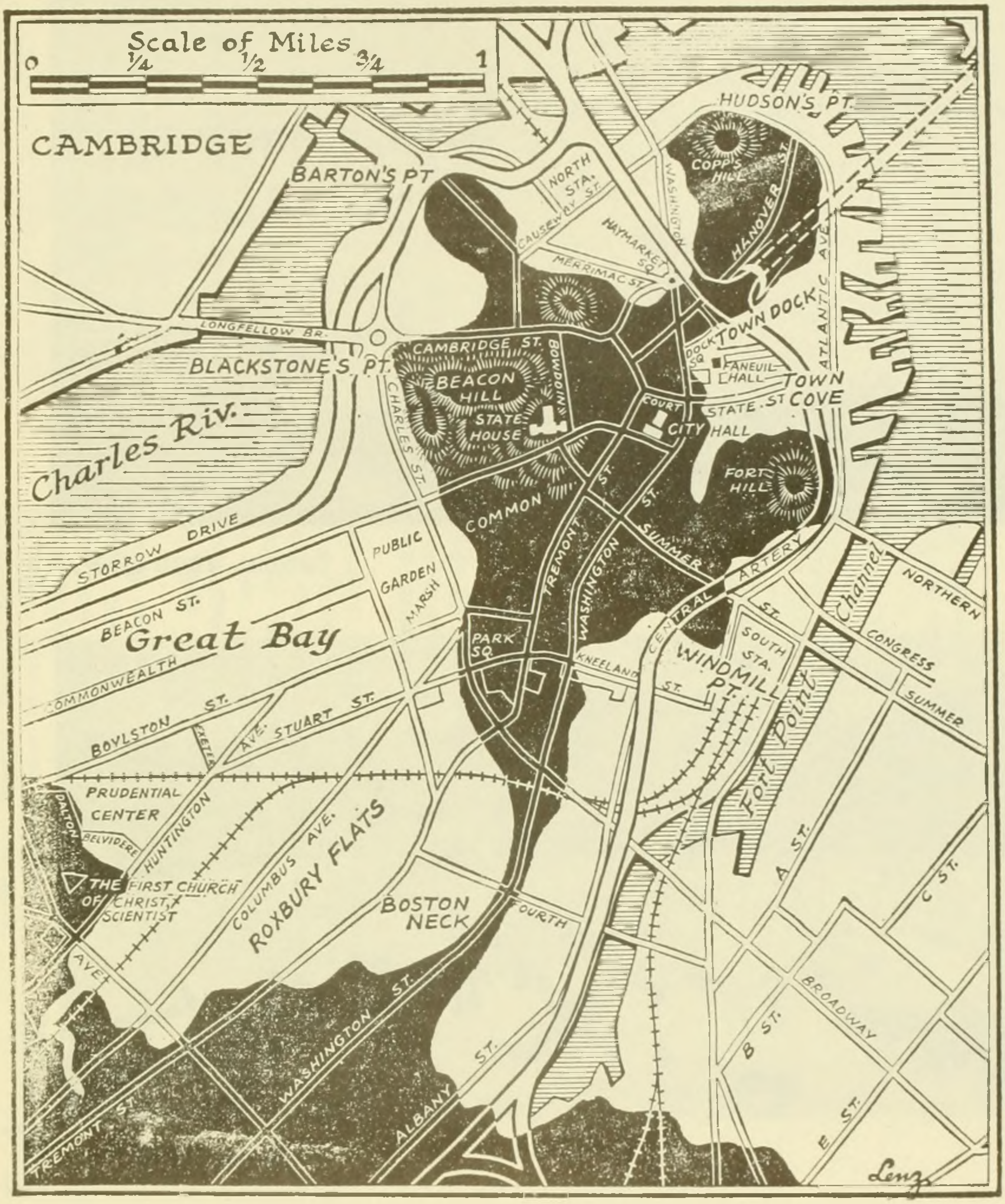
Profile from Little America V to Byrd Station. Dashed line represents adjusted sea-level



Profile along the Sentinel Mountains traverse route. Dashed line represents adjusted sea-level

after Bentley and Ostenso

Figure 16. Glacial and post-glacial sea levels in Antarctica.



By Russell Lenz, Chief Cartographer

Figure 17.

Boston: Before and After Land Fill-In Projects

Ralph Waldo Emerson's poem recalls Boston of 1773

Kenneth D. Swan, Missoula, Mont.

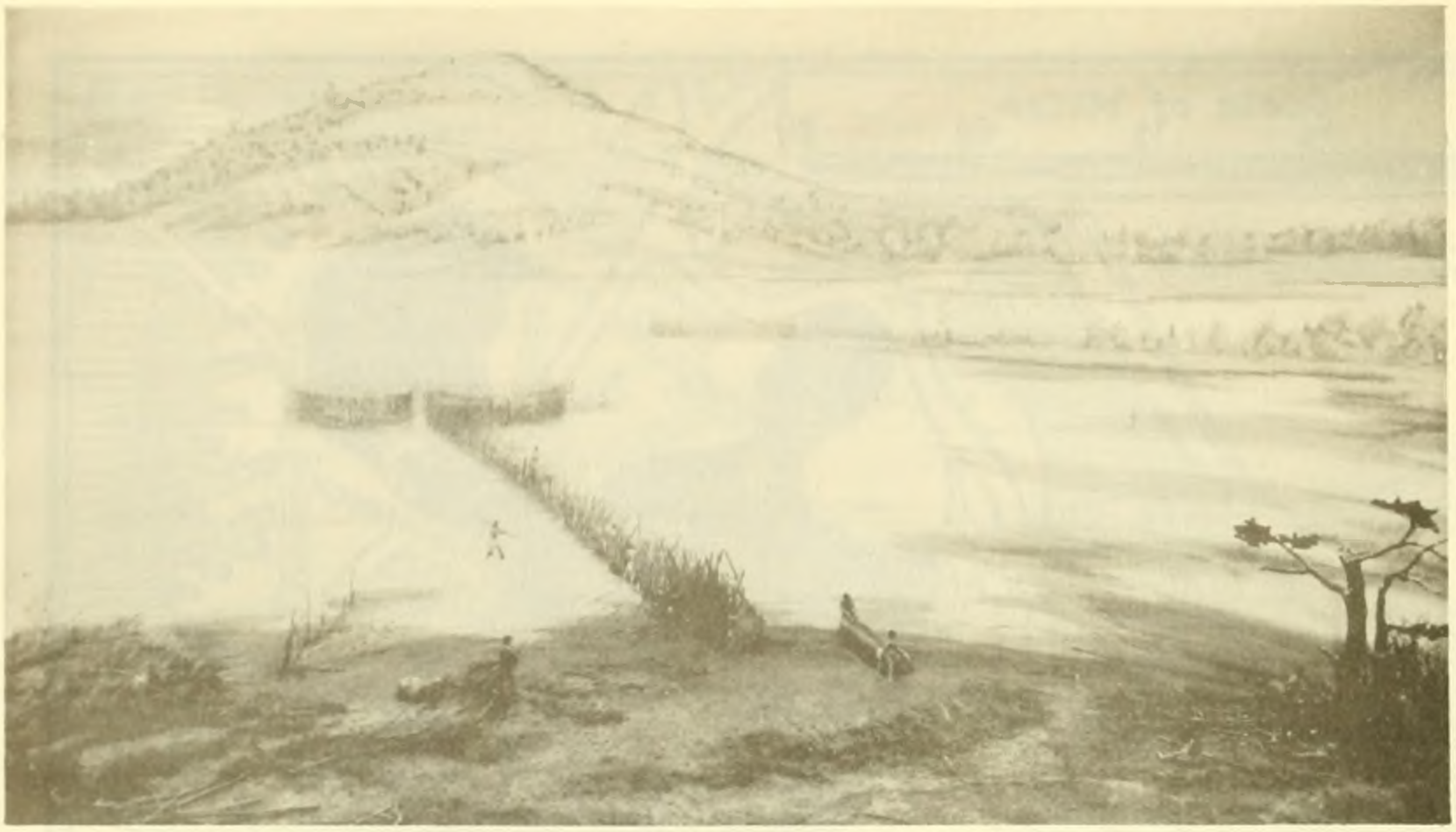
Q. The following poem is credited to Emerson:

> The rocky nook and hilltops three
> Looked eastward from the farms,
> And twice each day the flowing sea,
> Took Boston in its arms.

There is no question as to the references to the hilltops three, the farms, or the almost complete encirclement of Boston by salt water at high tide, but where and what was "the rocky nook?"

A. These are the opening lines of Emerson's poem "Boston," which was read in Faneuil Hall Dec. 16, 1873, on the centennial anniversary of the Boston Tea Party. In 1773, the year of which the poet was writing, Boston was still a pear-shaped peninsula jutting out into the bay, connected to the mainland by only a narrow strip of land. It seems logical to assume that this peninsula is the "rocky nook" Emerson mentioned, as one definition of "nook," now obsolete, is "a projecting piece of land." As the city grew in population and importance, land was reclaimed from the tidal overflow of the Charles River. This was done by filling in the Bay area with land taken from the "hilltops three." Beacon Hill is the only one now remaining.

Figure 18



about 4000 B. P.

about 1858

1863

Figure 19.

The Boylston Street Fishweir

by Frederick Johnson
Curator
Robert S. Peabody Foundation

THIS DIORAMA is an impression of the way the Back Bay region of Boston may have looked one early spring morning about 4,000 years ago. Indians are gathering brush to repair a fishweir in preparation for the spring run of fish. Salmon, alewives, and other migratory fish will swim along the shore at high tide, follow the brush fence, and be trapped in the heart-shaped enclosure beyond. It is low tide and one dugout canoe is being pushed off the mud to go out to the weir. Other weirs may be seen in the background.

The view across Back Bay is east toward what is now Boston Common, with Beacon Hill prominent in the background and Breed's and Bunker Hills across the Charles River in the distance. The present Charles Street would run just below the trees or about forty feet above the shore line of the Beacon Hill depicted in this diorama. The smoke rising from the Common is from Indian campsites which we believe must have been located here.

Proof of the existence of these weirs along the shores of the ancient Back Bay was discovered in 1939 when the foundations for the New England Life home office building were dug, unearthing 65,000 stakes, all of which had been sharpened by stone axes. These excavations penetrated some eighteen feet of gravel dumped to fill in the Back Bay during the 1850's and 1860's as shown in the next diorama. Beneath this fill was a twelve-foot layer of mud, which had accumulated as the level of the ocean rose over the centuries. Stakes from other weirs have been uncovered while digging several foundations in the area between Boylston and Stuart Streets.

The fact that the fishweir stakes were buried in mud and that the mud included remains of plants, shellfish, and even pollen and other miscroscopic organisms was evidence that the stakes had been in place for a long time. It also confirmed the fact that sea level had risen some twelve feet during this time.

Evidence secured by scientists during this excavation was the basis of an extended research project under the auspices of the R. S. Peabody Foundation, Phillips Academy, Andover, Massachusetts, the findings of which were published in two books. The date 2500 B. C. established in this research was confirmed by radiocarbon analysis of the wooden stakes from the weir.

In these early days, a wide tidal stream ran under what is now Clarendon Street toward the ancient Charles River. In the vicinity of Beacon Street, this stream divided to flow around a long, narrow island which extended from Arlington Street to Dartmouth Street. This island partially restricted the rise and fall of the tide so that the early Back Bay was a great, shallow pond bordered by sedge meadows. There were probably islands in this pond about which the currents flowed, providing extensive spawning grounds for fish.

In addition to the fish population, Back Bay was an excellent habitat for ducks, geese, and other kinds of birds as well as deer and small game. This plentiful supply of food made it a fine place for the Indians to build their villages.

We have no way of describing these Indians in detail, but we do know that about 2500 B.C. they were living all over New England by hunting, fishing, and gathering berries and nuts. In spite of the fact that they had not learned to cultivate corn or even to make clay pottery, they were comfortable and well-fed — as the man dozing against the tree will testify!

courtesy New England Mutual Life Insurance Co.

igure 20.

The Filling-in of Back Bay

by Walter Muir Whitehill
Director and Librarian
Boston Athenaeum

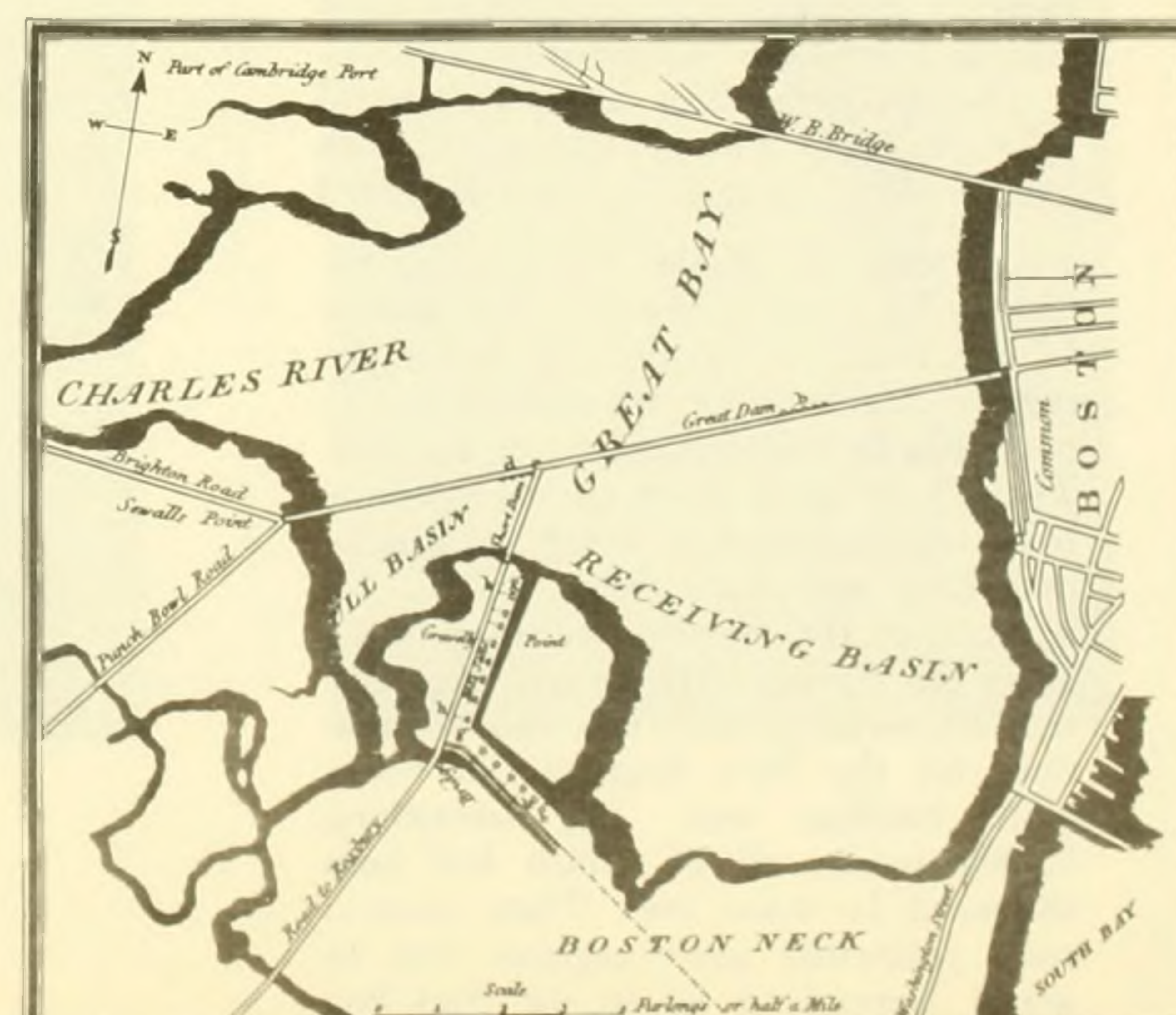
THIS DIORAMA shows the method by which the Back Bay was changed from water into land. Until the nineteenth century this name was applied to the great reaches of mud flats and salt marshes. These were covered by the water at high tide. They extended from the Charles River to the narrow neck of land that connected the peninsula upon which Boston was built with the Roxbury mainland. For it must be remembered that Boston, which now appears to be built upon a solid segment of Massachusetts coast, was originally on a hilly peninsula, almost completely surrounded by water. From the end of the eighteenth century the hills were gradually leveled or reduced in height, one by one, to fill in the coves and produce more land for an expanding town. But the greatest change in the shape of Boston began soon after the war of 1812 when Uriah Cotting undertook to dam the waters of the Back Bay to obtain tidal power for a series of mills.

A milldam, fifty feet wide and a mile and a half long, carrying a toll road, which ran along the line of Beacon Street from Charles Street to Sewell's Point (now Kenmore Square), enclosing about six hundred acres of the Back Bay, was completed in 1821. A cross dam running out from Gravelly Point in Roxbury on a line roughly corresponding to the present Massachusetts Avenue, subdivided this area into a westerly full basin and an easterly receiving basin. At high tide, water was admitted to the full basin by filling sluices just west of the cross dam; it then passed through sluices below the mill sites on Gravelly Point into the easterly receiving basin, from which it drained back into the Charles River by emptying sluices in the main dam at about the present level of Exeter Street. But before this scheme was fully developed, railway lines from Providence and Worcester which were built through the Back Bay basins seriously jeopardized Uriah Cotting's vision of industrial water power. These rights of way hampered the flowing of water, and eventually turned the Back Bay into a stinking nuisance. Thus during the eighteen fifties plans were developed for filling the entire Back Bay and creating new land.

The Legislature in May of 1857 authorized Commissioners on the Back Bay to fill in the area and sell the lands thus created. The plan adopted envisioned four new streets — Marlborough Street, Commonwealth Avenue, Newbury and Boylston Streets — parallel to the milldam, intersected at regular intervals by cross streets, alphabetically named from Arlington to Hereford. In July, 1858, the Commissioners contracted with a Vermonter, Norman Carmine Munson, to do the work. Munson and his partner, George Goss, made full use of the latest technological developments. Gravel was dug by steam shovel in Needham, nine miles away, and brought by gravel trains of thirty-five cars each that ran day and night over railway tracks into the Back Bay.

The diorama shows the scene soon after work began, looking from the site of this building toward the Public Garden, Common, and Beacon Hill. Two gravel trains have reached the end of temporary spurs leading from the Boston and Providence line; are dumping their loads and are about to return to the Needham pits for more. Workmen are leveling the fill, while engineers consult plans, and forward-looking visitors contemplate the site of a future house. Before long the inexorable gravel trains, arriving every forty-five minutes, will have filled the mud flats that still appear in the diorama, and the construction of buildings along Arlington Street will begin.

Two dams divided the Back Bay basin in 1821, thereby opening a toll road along the line of the present Beacon St. and mill sites on Gravelly Point.



Map reprinted from "Boston, A Topographical History," by Walter Muir Whitehill, Harvard University Press, reproduced with permission.

courtesy New England Mutual Life Insurance Co.

Figure 21.

The Boston Society of Natural History

by Walter Muir Whitehill

A LITTLE OVER five years have passed since the period represented by the preceding diorama. There we were standing on the site of this building looking towards Beacon Hill. Here, in 1863, we are instead in the now-filled Boylston Street looking west towards this site.

The tone of the Back Bay was early set by the number and character of the churches and institutions that flocked there. Almost on the wheels of the gravel cars came the Unitarians of the Federal Street Church, over which William Ellery Channing had presided from 1803 to 1842. This congregation began to build in 1859, at the corner of Arlington and Boylston Streets, the present Arlington Street Church.

The Legislature in the winter of 1860-1861 voted to the Boston Society of Natural History, organized in 1830, a grant of land on Berkeley Street extending from Boylston to Newbury. Upon this site the Society soon built a three-story brick museum, designed by William G. Preston, which is the most conspicuous feature of this diorama. Since the metamorphosis of the Society into the Museum of Science, now located in Science Park on the Charles River Basin, this handsome building has been converted into a store for Bonwit Teller's.

The remainder of the block was granted by the Legislature to the Massachusetts Institute of Technology, which had been incorporated by an act of 10 April 1861, and whose first building was authorized in 1863. That building, designed by Preston, in singularly felicitous relation to its neighbor, was named in honor of William Barton Rogers, the founder of the Institute. The diorama shows only the foundations of the Rogers Building, which was some seven decades later demolished to make way for the New England Mutual Life Insurance Company building.

The majority of the earlier Back Bay houses were built by individual owners, according to their own plans. Only in Newbury Street and the upper reaches of Marlborough was there extensive speculative construction for resale. While not by any means identical in design, or even in height, the houses in the new streets had a certain grandiose unity of feeling that set a tone for the new region. For several decades Back Bay streets had a prairie-like quality that is evident in this diorama. Handsome and sophisticated buildings loom up out of a plain of dusty gravel that would, with the passage of years, be steadily reduced by new construction. But in 1864 the great open spaces predominated.

In this diorama, houses on Commonwealth Avenue are built from Arlington to Berkeley Streets. On the water side of Beacon Street they extend above Clarendon, but filling is still going on, for below Dartmouth Street a gravel train is arriving with its load. The future site of Copley Square still remains to be filled.

Back Bay Stop, Boston, Massachusetts,
Boston South Quad., Massachusetts
(Figs. 17, 18, 19, 20, 21)

Discussion:

(1) Boylston Street fish weir, sea level lower than today, (about 4000 B.P.)
(2) Milldam, cross dam, full basin, receiving basin (about 1821)
(3) Filling-in of Back Bay, Needham, Mass. sand and gravel (1859)
(4) First buildings (about 1863)

MAPS

U.S. Dept. Interior, Geological Survey, Boston South Quad., Massachusetts

U.S. Dept. Interior, Geological Survey, Hull Quad., Massachusetts

U.S. Dept. Interior, Geological Survey, Lynn Quad., Massachusetts

U.S. Dept. Interior, Geological Survey, Newton Quad., Massachusetts

TRIP A - Saturday

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NORTHEASTERN MASSACHUSETTS GEOMORPHOLOGY- Sunday, Trip A

Robert L. Nichols, Tufts University

Patch Beach Stop, Beverly, Massachusetts, Marblehead North Quad., Massachusetts (Fig. 1).

Features to be seen:

(1) uplifted marine clay
(2) marine cliff
(3) retrograding baymouth beach
(4) valley cut in clay
(5) magnetiferous and pyritic sands
(6) man-made fill

Discussion:

(1) Colonial trail
(2) city land grab
(3) magnitude of marine erosion since Colonial time
(4) reason for location of valley

Rafe's Chasm Stop, Normans Woe, Magnolia, Massachusetts, Gloucester Quad., Massachusetts (Fig. 2).

Magnificent examples of marine chasms eroded along trap dikes and shear planes (you have never seen any as good).

Geologic features to be seen:

(1) dike chasms
(2) shear plane chasms
(3) wave-cut bench
(4) wave-washed surfaces
(5) boulder beach
(6) single, compound, and composite dikes, screens
(7) phenocrysts and inclusions in dikes
(8) Quincy Granite

Discussion:

(1) glacial erosion along dikes
(2) positions of sea level
(3) origin of bedrock cliffs

Topsfield Road Stop, Ipswich, Massachusetts (1.8 miles from Ipswich Post Office going southwest along Topsfield Rd.).

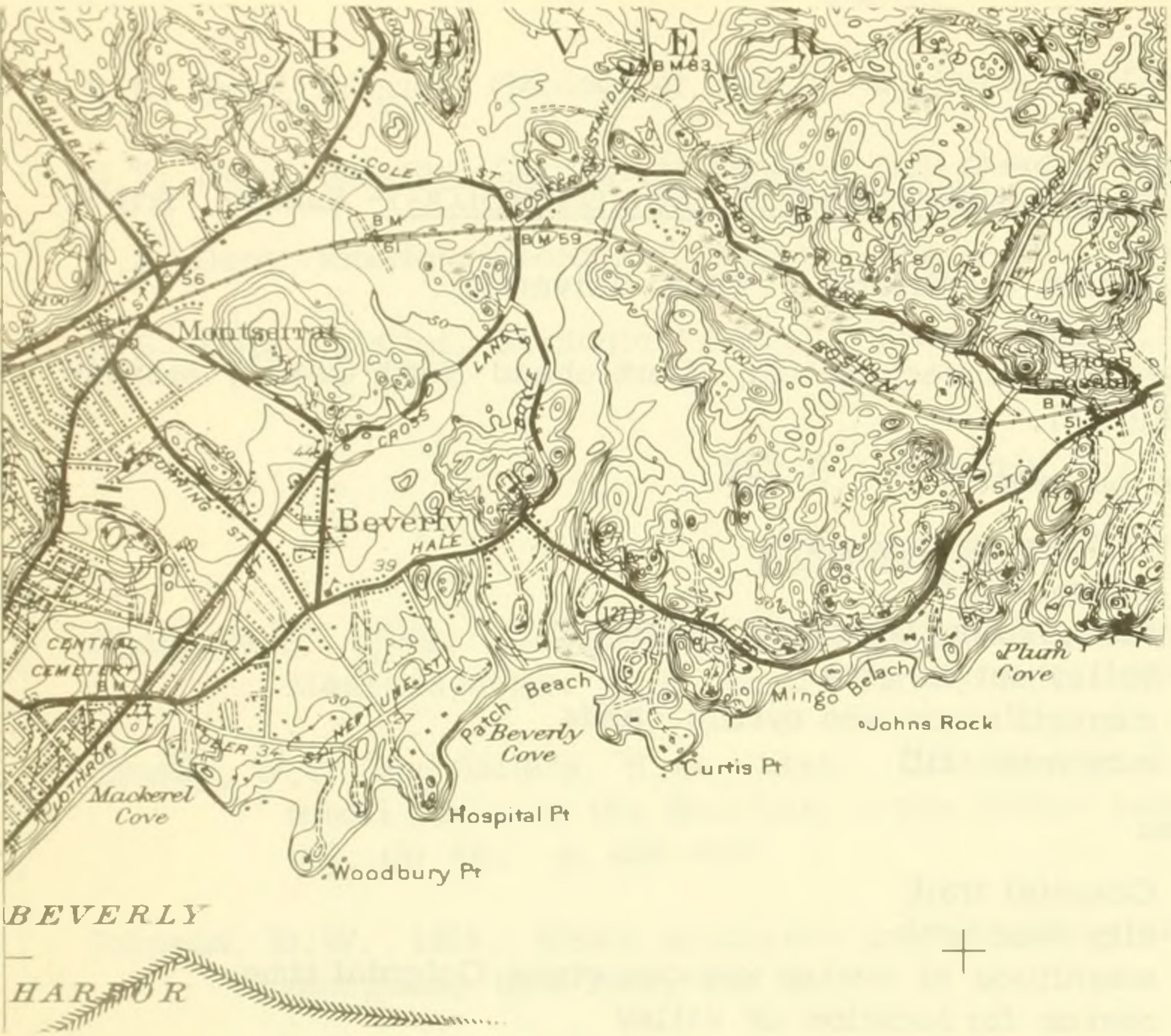
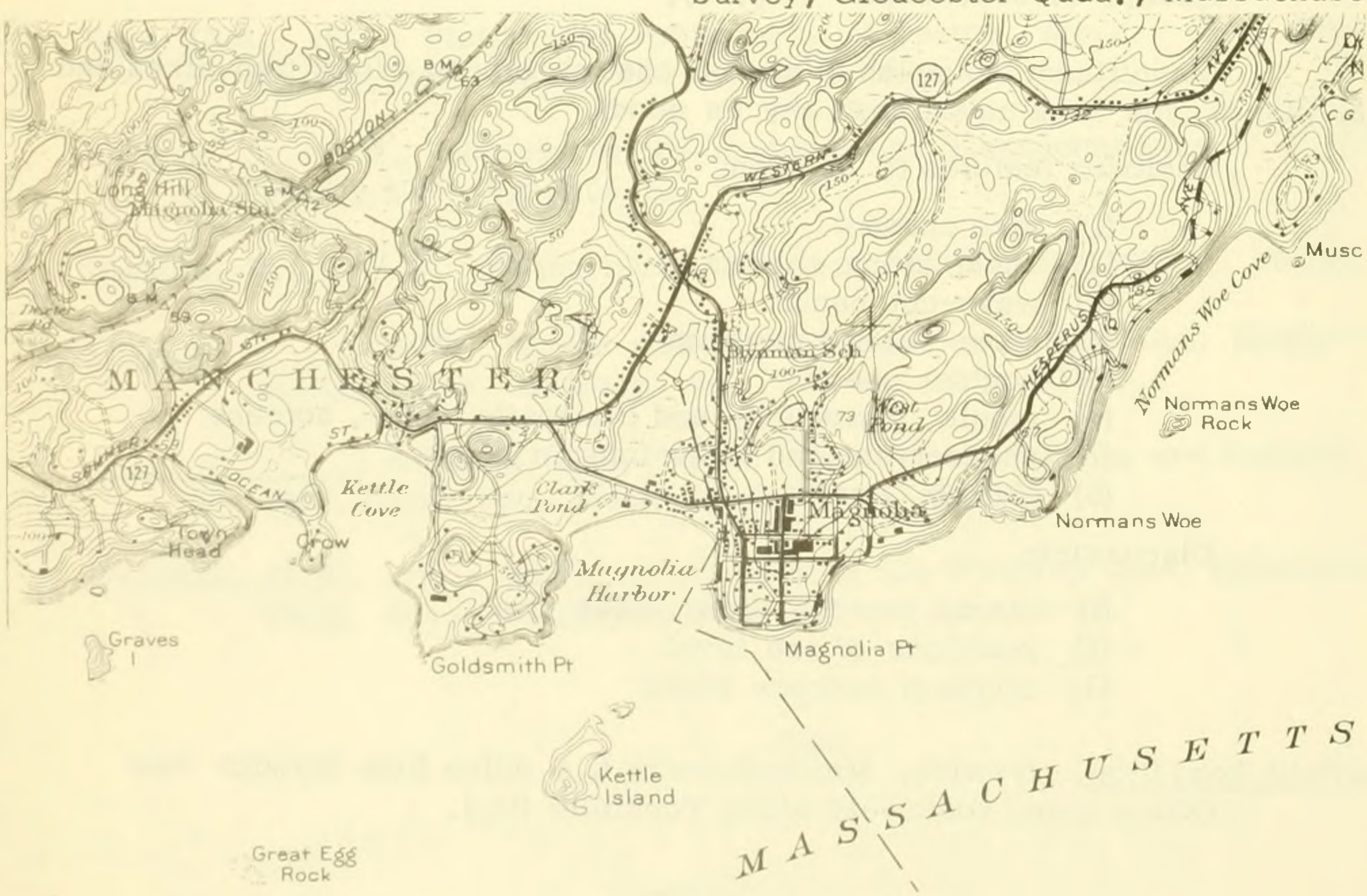
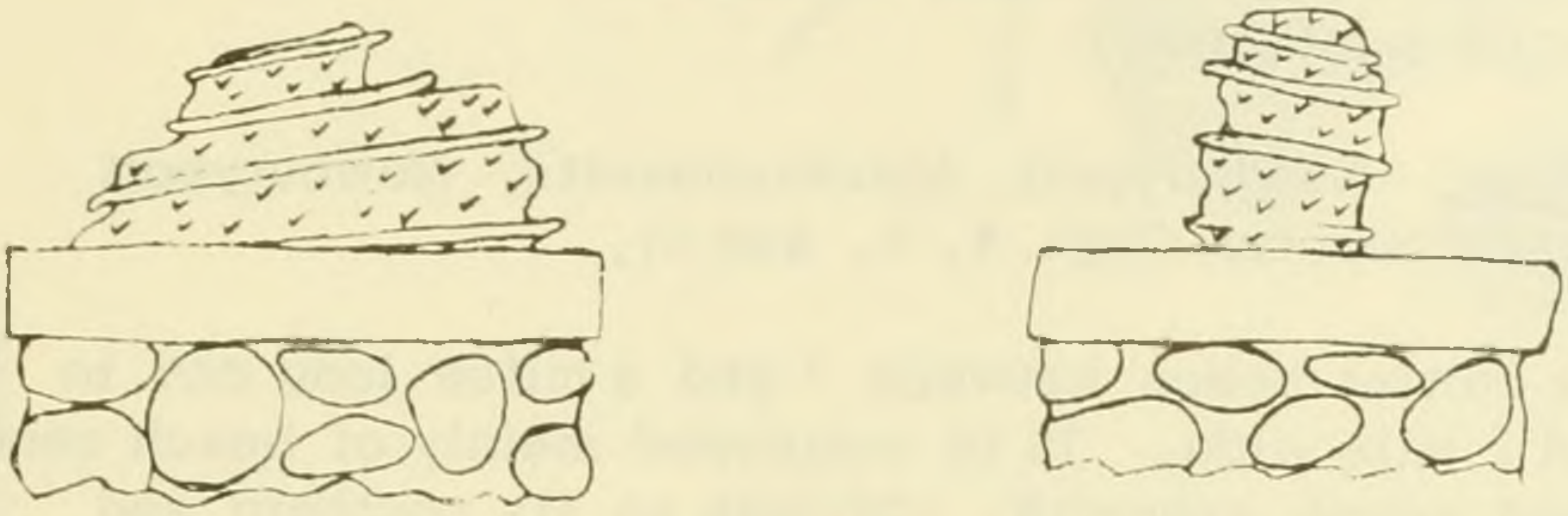


Figure 1. Part of U.S. Dept. Interior, Geological Survey, Marblehead North Quadrangle, Massachusetts.

Figure 2. Part of U.S. Dept. Interior, Geological Survey, Gloucester Quad., Massachusetts.





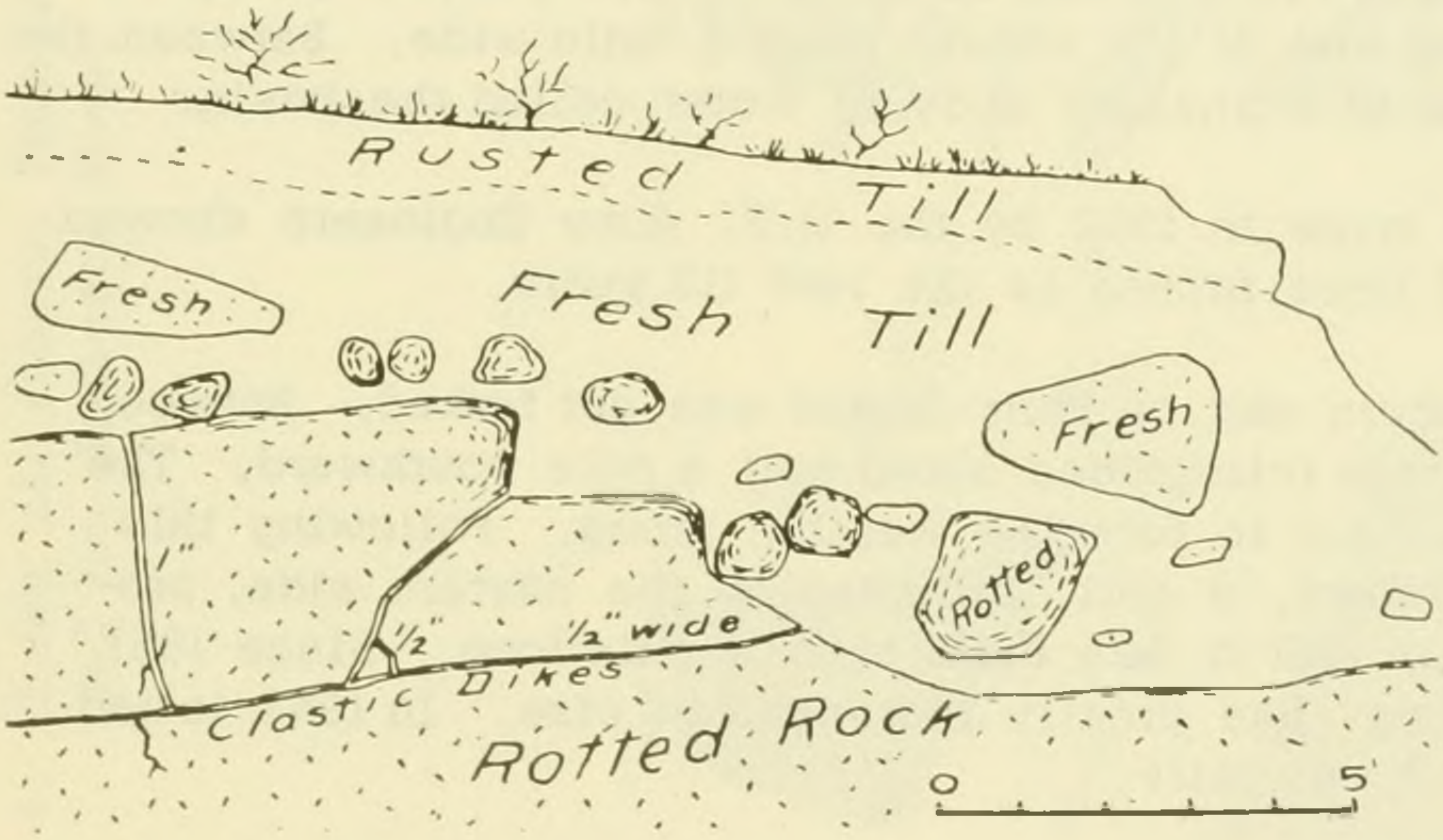


Figure 3. a. Oddly shaped boulders, Topsfield Road, Ipswich, Massachusetts
b. Pre-glacial weathering.

Discussion:

(1) significance of oddly shaped boulders
(2) pre-glacial weathering

North End of Plum Island Stop, Newburyport, Massachusetts, Newburyport East Quad., Massachusetts (Figs. 4, 5, and 6).

Plum Island is a barrier beach between 7 and 8 miles long and in most places between $\frac{1}{2}$ and 1 mile wide. It is composed mainly of beach sands and gravels, dune sand, and marsh deposits, although on its southern end there are small areas of till, outwash, and marine clay. Salisbury beach, which is north of Plum Island, is also a barrier beach about $4\frac{1}{2}$ miles long composed of beach sands and gravels, dune sand, and marsh deposits. The Merrimack River reaches the ocean between Plum Island and Salisbury beach.

The northern end of Plum Island is forked. The eastern prong is approximately $1\frac{1}{4}$ miles long and at its widest point $\frac{1}{2}$ mile wide. Between the eastern and western prongs is a shallow body of water called the Basin.

A study of maps made in 1942 by the U.S. Army Engineers showed that the eastern prong had been formed in the last 113 years.

In 1827 the northern end of Plum Island was not forked. Between 1827 and 1851 the eastern side retrograded about half a mile southward. The western side was modified later to form the western prong. Following this period of retrograding southward, a spit, attached to the eastern side, prograded northward so that by 1851 it was more than a mile long. Since 1851 this spit, the eastern prong, has greatly increased in size. In 1942 it had an area of approximately .3 sq. mile.

North Ridge Stop, Ipswich, Massachusetts, Ipswich Quad., Massachusetts.

Dune-Veneered Spit West of Steep Hill Stop, Ipswich, Massachusetts, Ipswich Quad., Massachusetts (Fig. 7).

Castle Neck Stop, Ipswich, Massachusetts, Ipswich Quad., Massachusetts (Fig. 7).

Geologic features which can be seen are:

(1) dune-veneered drumlin
(2) dune-veneered fossil marine cliff
(3) dune-veneered tombolo and spit
(4) second-story boulder pavement
(5) periglacial ventifacts
(6) cross-bedding, blowouts, eolian depressions, garnetiferous sand, etc.

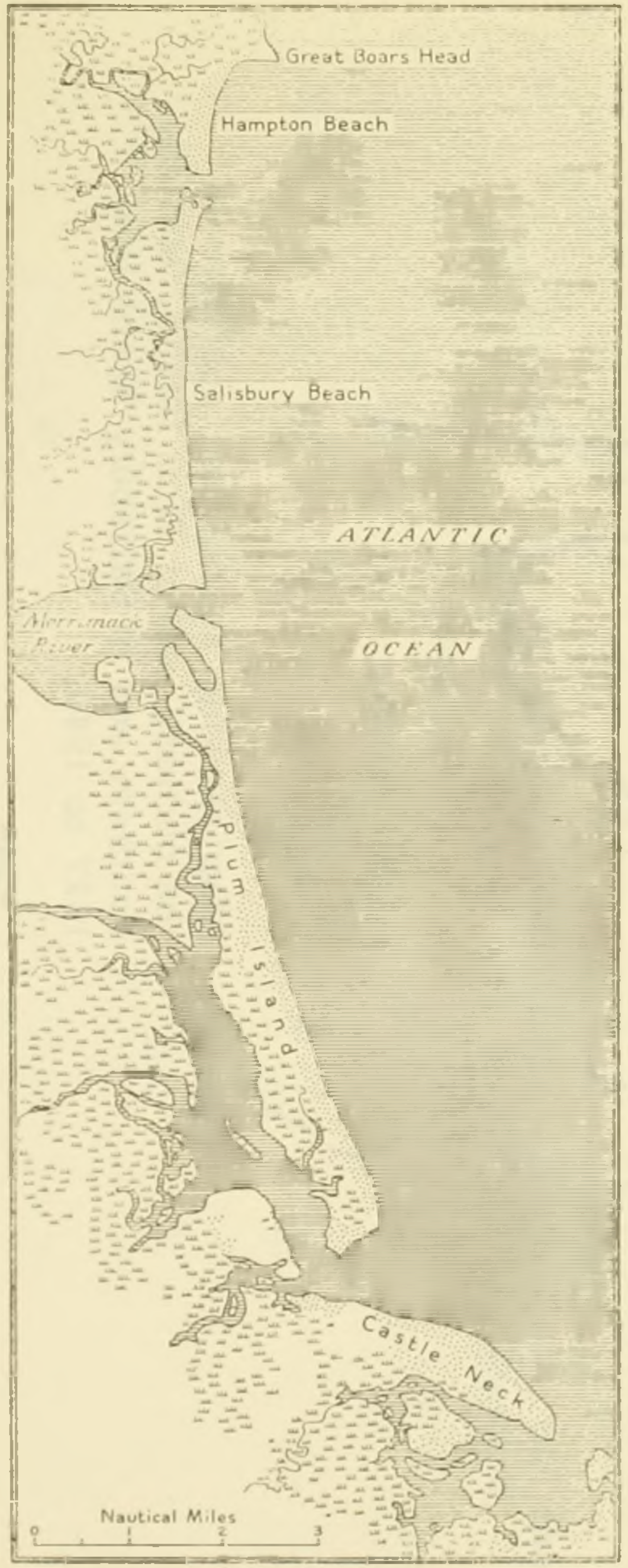


Figure 4. Index map showing Plum Island, Salisbury Beach, and the Merrimack River.

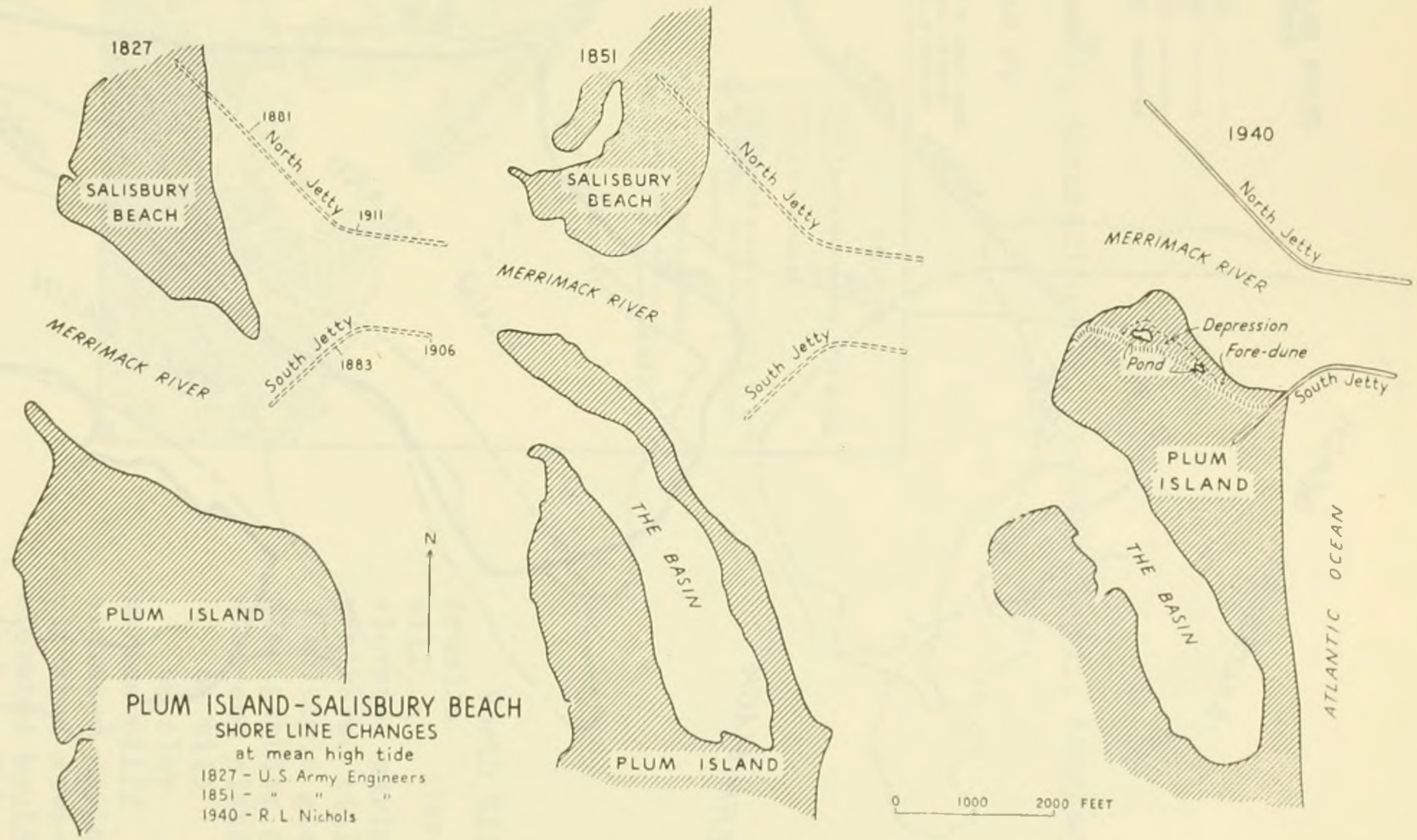


Figure 5. The positions of the north end of Plum Island in 1827, 1851, and 1940.

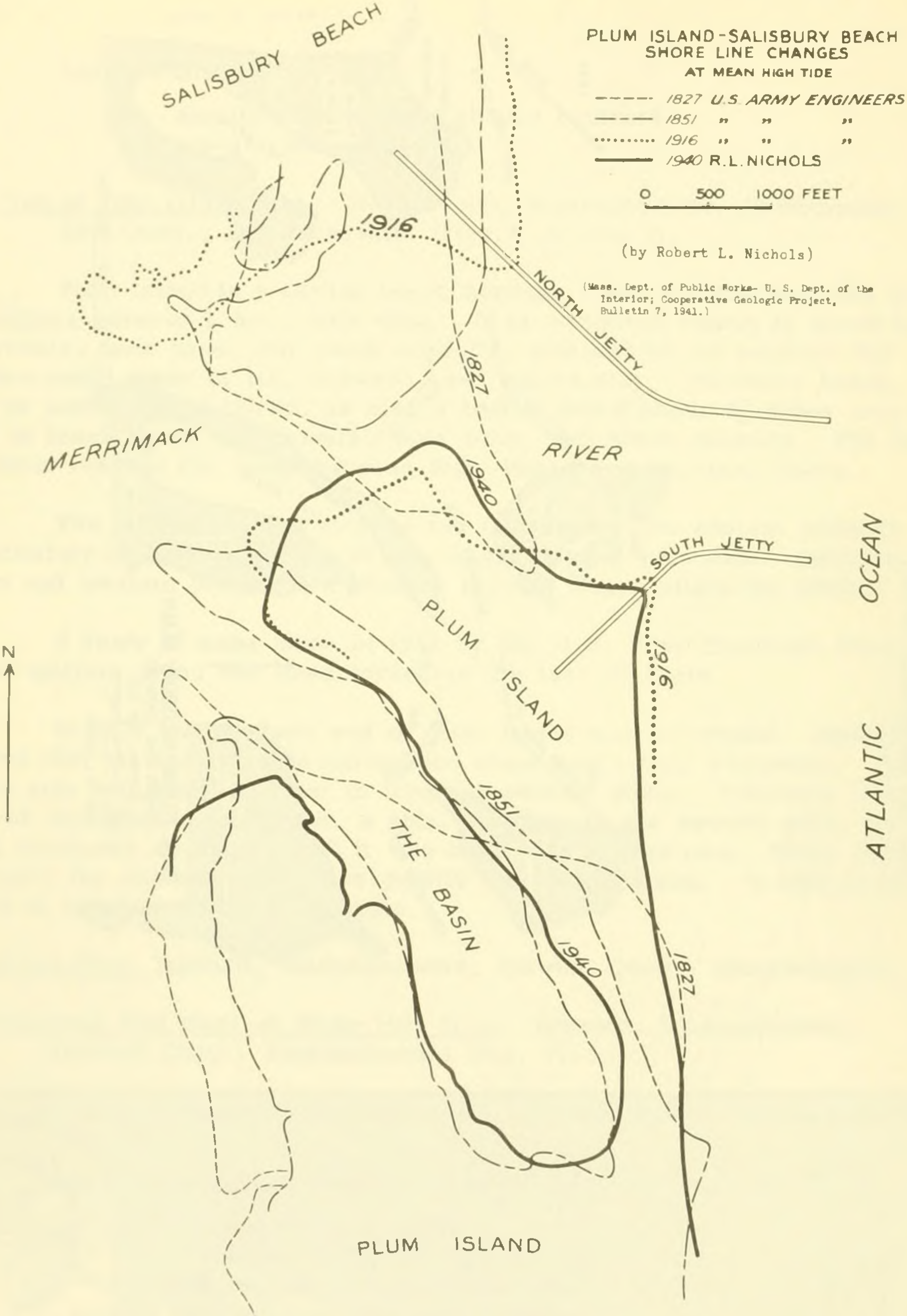
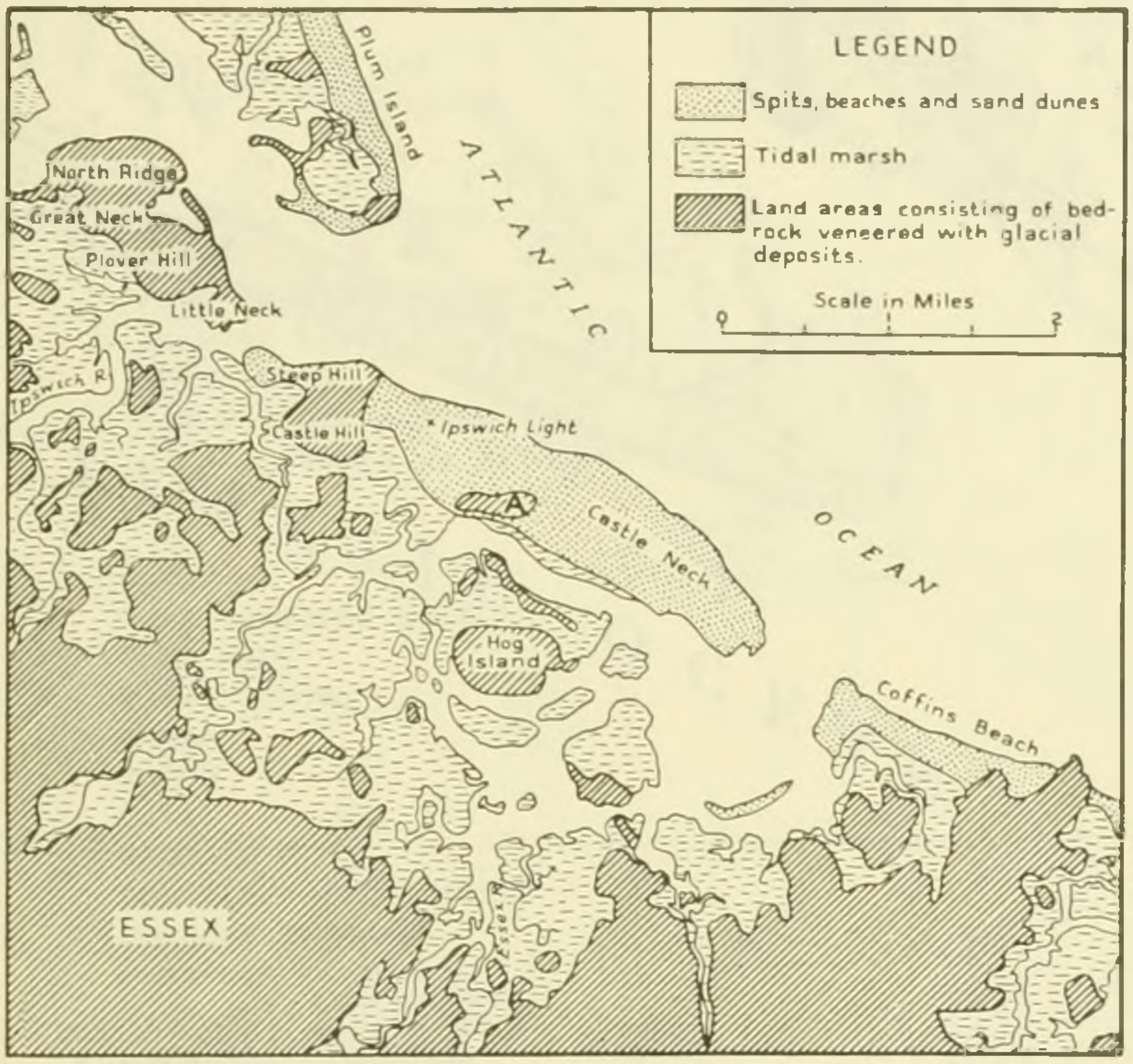


Figure 6. Map showing successive positions of the northern end of Plum Island, and the southern end of Salisbury Beach from 1827 to 1940.

North Ridge Stop, Ipswich, Massachusetts, Ipswich Quad., Massachusetts.



North Ridge

drumlin

till clay-till contact

elevated marine clay

weathered till below clay

multiple glaciation?

clay pebbles on beach

wave-cut platform

on till

on clay

marine cliff

elevated marine cliff?

elevated wave-cut platform?

elevated boulder pavement?

patches of loess in road cuts

few feet thick

weathered loess

Figure 7. A map showing North Ridge, Castle Neck, and the dune-veneered spit west of Steep Hill, Ipswich, Massachusetts.

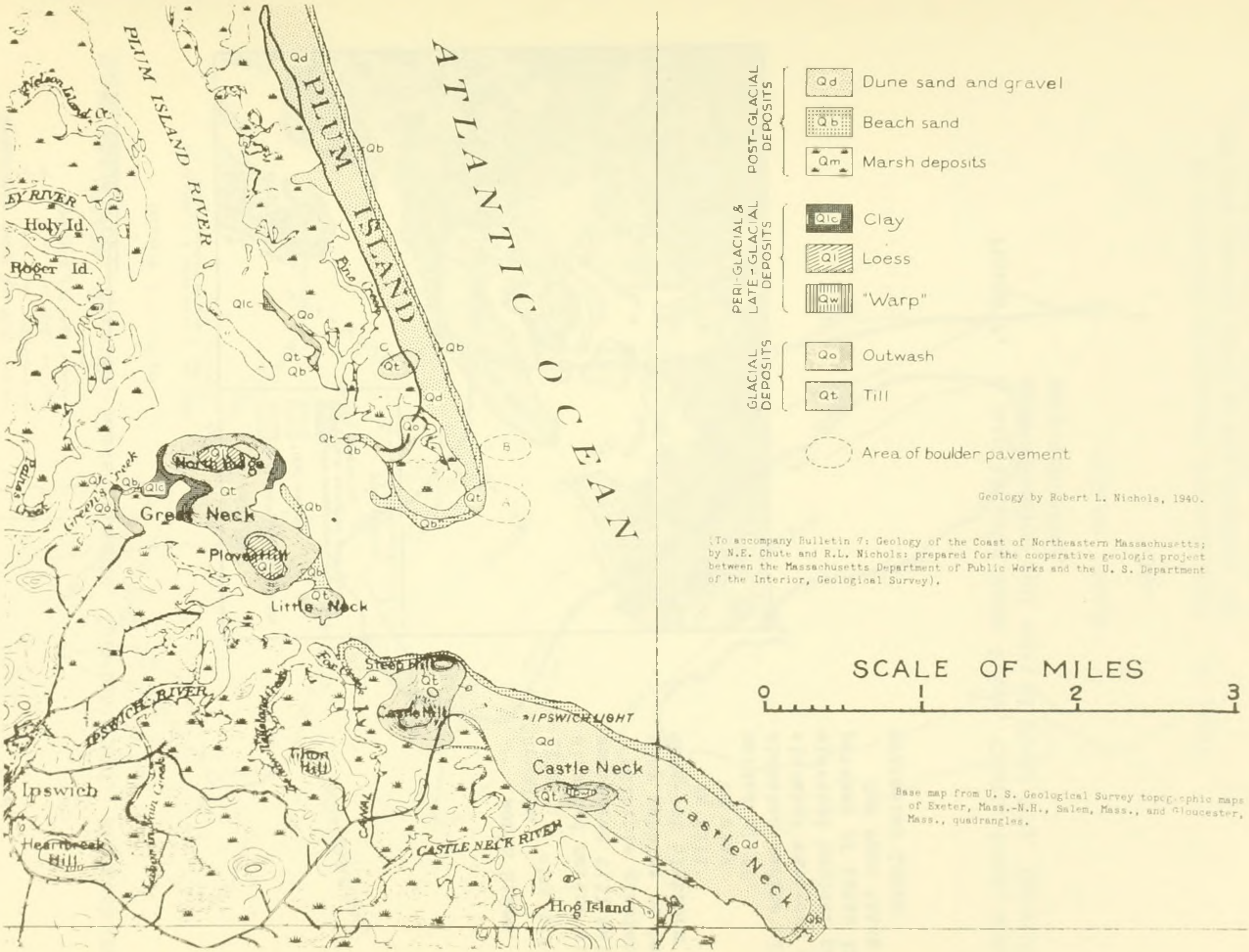
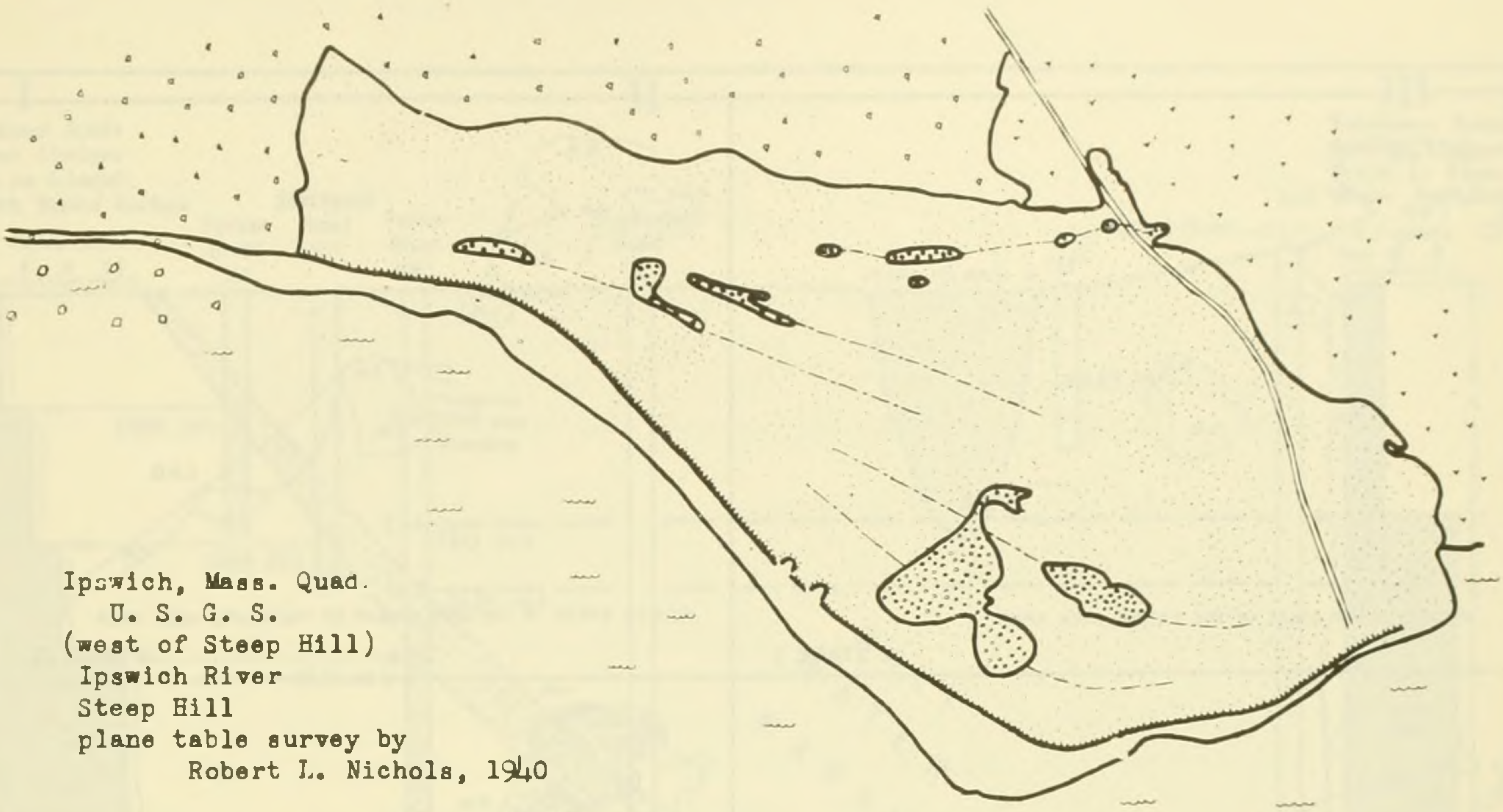


Figure 8. Geologic map of the south end of Plum Island, the Great Neck area, and the Castle Neck area, Ipswich Quad., Massachusetts.



Ipswich, Mass. Quad.
U. S. G. S.
(west of Steep Hill)
Ipswich River
Steep Hill
plane table survey by
Robert L. Nichols, 1940

spit
dune veneered spit
dune sand
beach gravel
water
marsh
till
drumlin
inactive marine cliff
boulder pavement
wave-cut platform
blow outs
parabolic dunes
dune veneered till
dune veneered drumlin
dune buried soil on drumlin
beach veneered boulder pavement
ripple marks
eolian cross bedding
sand slides
grass rings
sand domes
beach ridges
dune migration
dune buried trees
ripple mark migration
yardangs
garnetiferous sand
boundary of drumlin and beach
boundary of drumlin and dunes
boundary of dunes and beach

spit I
spit II
spit III
land
ocean
wave cut platform
beach deposits
retrograding cliff
retrograding beach
fulcrum I
fulcrum II
fulcrum III
shifting fulcrum
initial shoreline
marine cliff I, II, III.

garnet history
bedrock → till → beach → dunes

Figure 9. Dune-veneered spit immediately west of Steep Hill, Ipswich.

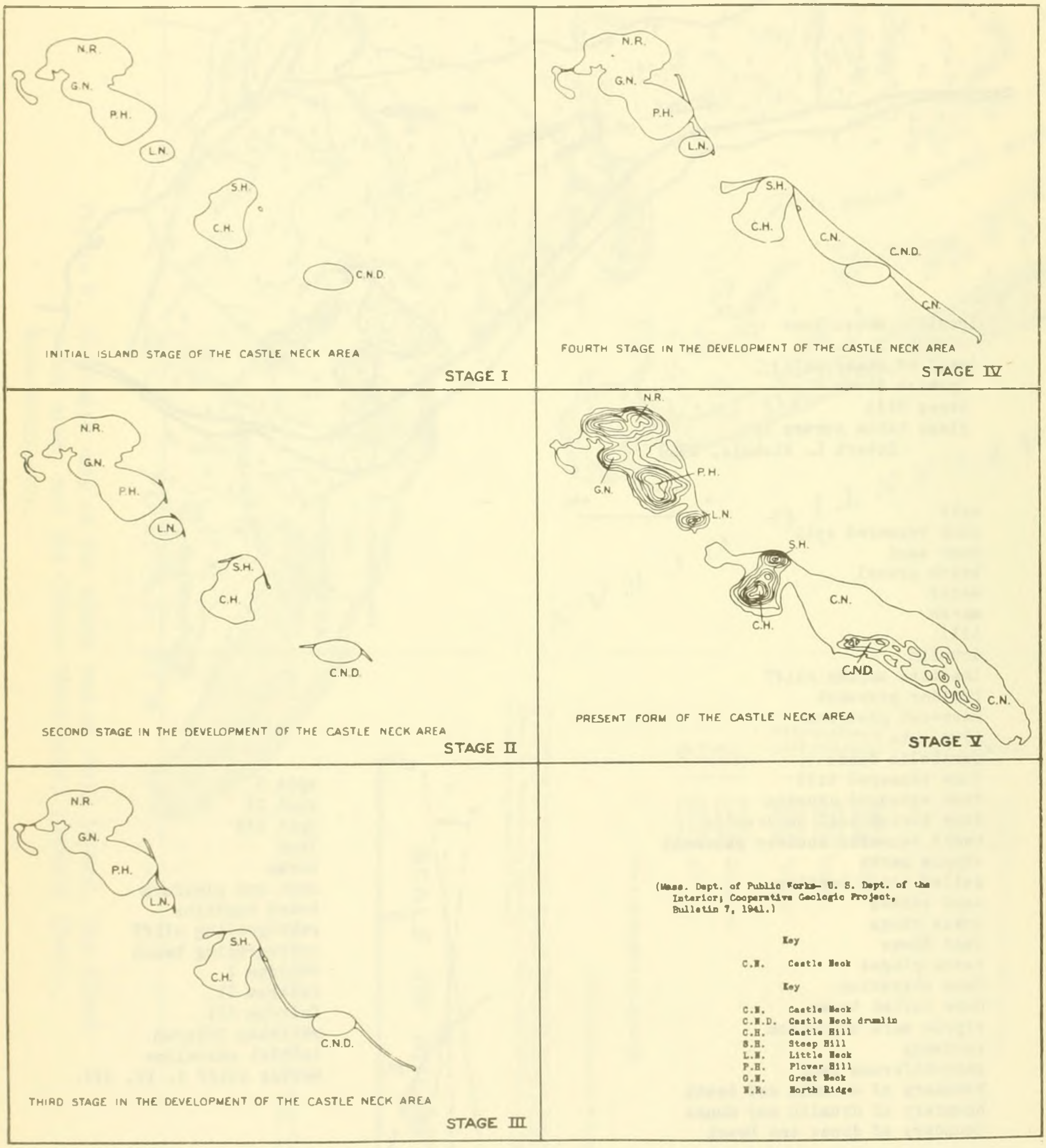
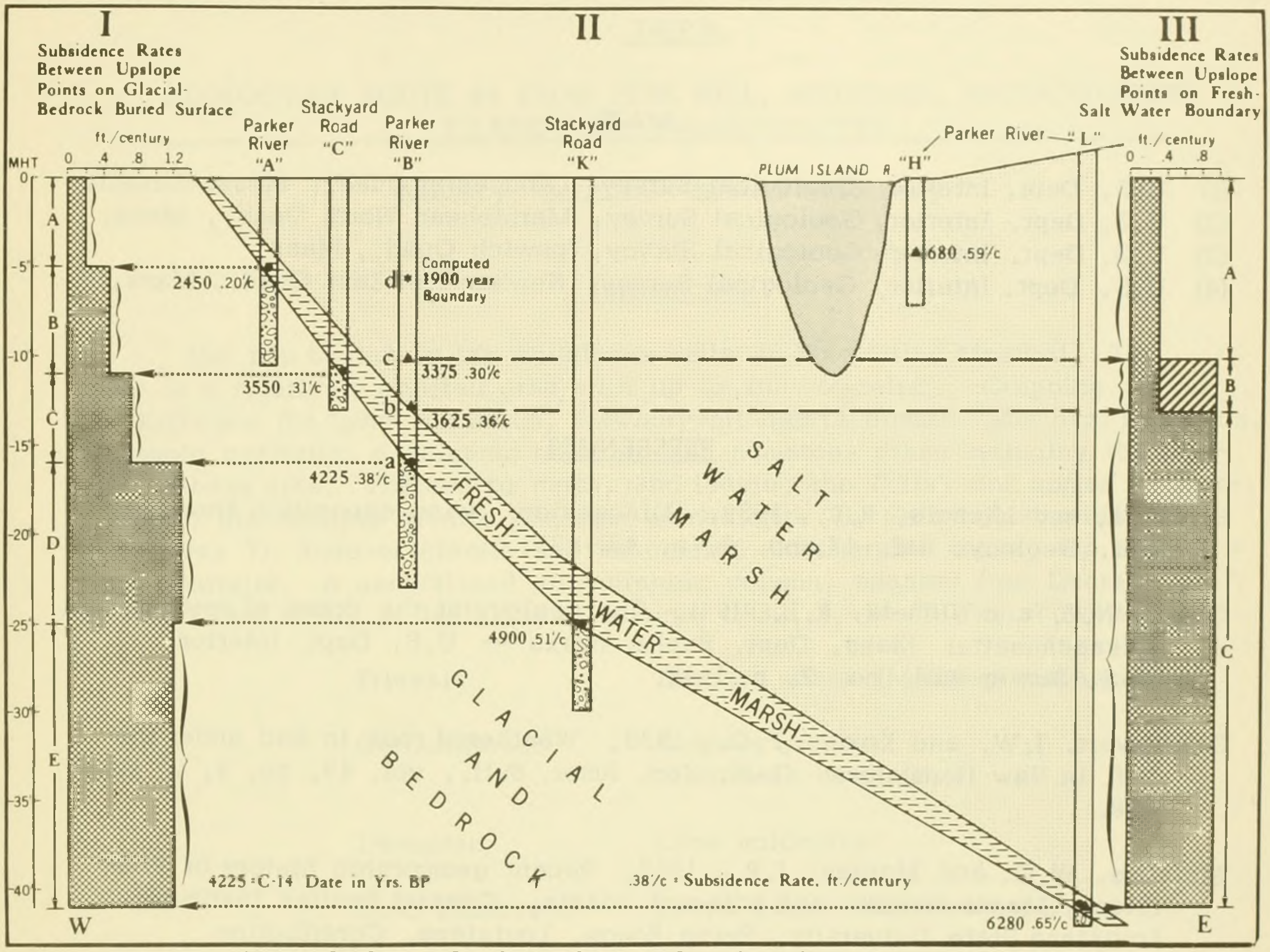


Figure 10. Diagram showing 5 stages in the evolution of Castle Neck and neighboring beaches.



Cross-section of Plum Island marsh correlated with radiocarbon dated peat. I. Indicates subsidence rates calculated on fresh marsh peat between upslope points. II. Shows marsh development rates calculated from position of dated peat to the surface. III. Portrays subsidence rates between the upslope fresh-salt water boundary.

after McIntire and Morgan

Figure 11. Cross-section of Plum Island marsh correlated with radiocarbon dated peat.

(7) grain size of beach and eolian sand (Plum Island, Castle Neck, etc.)

MAPS

(1) U.S. Dept. Interior, Geological Survey, Gloucester Quad., Massachusetts
(2) U.S. Dept. Interior, Geological Survey, Marblehead North Quad., Mass.
(3) U.S. Dept. Interior, Geological Survey, Ipswich Quad., Mass.
(4) U.S. Dept. Interior, Geological Survey, Newburyport East Quad., Mass.

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