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GEOMORPHOLOGY AND VEGETATION
OF
THEODORE ROOSEVELT ISLAND

by

Lindsey Kay Thomas, Jr.
Research Park Naturalist
Conservation, Interpretation, and Use



National Park Service Division of Natural History Sciences	THRO-63
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Scientific Report No. 2
November 19, 1963

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National Park Service
National Capital Region
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1963
Washington, D. C.

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ABSTRACT

The geology of Theodore Roosevelt Island and Little Island was revised using boring data and a map showing the rock outcrops. The island appears to have begun as a remnant of schist (Piedmont rock) that was resistant to the erosive power of the Potomac River and through alluvial accretions (Coastal Plain sediments) it has increased in size.

A series of maps of the island dating as far back as 1670 shows the physical growth of the island as well as the origin of Columbia Island from Theodore Roosevelt Island accretions and the origin of Little Island from Columbia Island.

Maps covering a period of more than 160 years show hydrarch succession that advances from water to marsh to deciduous swamp. Maps covering a period of about 20 years show a water to deciduous swamp succession without the intermediate marsh stage. Secondary succession from cleared land or fields to deciduous forest on the upland is demonstrated from the maps and historical descriptions.

Xerarch successions starting with bare rock and ending with deciduous forest and deciduous swamp as well as a change from swamp to forest are suggested to explain the existence of some of the habitats.

Several hypotheses are presented to explain these geomorphologic and vegetative changes.

The present deciduous forest is shown from historical data to be largely planted and the hemlock grove completely planted in 1935 and 1936. The other habitats are largely the result of natural processes. As a result of both natural and artificial influences there are eleven habitats on the island. They are the intertidal, open water, marsh, deciduous swamp, wet thicket, deciduous forest, hemlock grove, field, thicket, bare rock, and intermittent spring or seep habitats. Most of these habitats are shown on a vegetative cover and successional map.

INTRODUCTION

Description

Theodore Roosevelt Island is located in Washington, D. C. in the Potomac River between the Francis Scott Key and Arlington Memorial Bridges (see Figure 26). Immediately south is Little Island (unnamed in the Figures), and further south is Columbia Island. Upstream just west of Key Bridge are the Three Sisters Islands (see Figure 21). Theodore Roosevelt Island straddles two geographic provinces, the Piedmont and the Coastal Plain. The soils of the island are sandy loams, loams, and silt loams (Table 3).

The island is almost 0.7 of a mile long and 0.3 of a mile wide at its widest place (Figure 26). In 1909 (District of Columbia Surveyor's Office) this island contained 88.18 acres. In 1932 (U. S. Congress *Senate*) it had increased to about 91 acres.

The island contains two topographic high areas near the center. The higher is 44 feet in elevation (Figure 26). The land slopes to the water from these prominences abruptly on the east and west and gradually on the north. On the south the land drops off sharply to a shoulder that covers most of the south end of the island. The east part of the island is a flat alluvial plain and Little Island is an extension of this plain. In the northwest part of the island a spring or seep flows intermittently toward the west. There are two inlets full at high tide and almost empty at low tide. The smaller one is located at the northwest corner of the island and the larger one extends down the south-east part of the island (Figure 1).

Schist outcrops in several places on the island. Most of these outcrops are at the north end of the island at low elevations. There are, however, a few outcrops at the southern end near the water. Figure 24 shows the more important outcrops. Formerly this rock was known as granite-gneiss (Carr, 1950), but a re-examination shows it to be a micaceous schist (Coulter, 1963; Masters, 1962).

The upland is covered largely by deciduous forest and the lowland for the most part by deciduous swamp and marsh (Figure 27).

Theodore Roosevelt Island, Little Island, Columbia Island, and the Three Sisters Islands are the property of the U. S. Government and are administered by the National Park Service through its National Capital Regional Office.

History

The island has had a variety of names and owners of which only a few will be mentioned. One of its earliest names was Anacostien (Figure 2), but during the time it was owned by the Mason family it

was generally called Mason's Island. The first owner to do much with the island was John Mason. The island has been in agricultural use at least as early as 1792 (Figure 4), at which time John Mason probably started to build the house on its high prominence at the south end (Figures 8, 11, 14, 24; Duhamel, 1935, p. 137). He raised sheep, cotton, and maize on the island (Warden, 1816, pp. 141-144, 150, 151).

When the island passed into the hands of other owners it was generally called Analostin or Analostan Island. Figures 12 and 15 (1864 and 1905) show an orchard at the north end of the island. In the late 1880's the Columbia Athletic Association constructed a running track which included part of area D of Figure 24.

In 1932 the Roosevelt Memorial Association gave the island to the federal government as a memorial to Theodore Roosevelt (U. S. Congress, 1932). At this time it was known as Roosevelt Island. So there would be no confusion for which Roosevelt the island was a memorial, the name was later changed to Theodore Roosevelt Island (U. S. Congress, 1933). The Theodore Roosevelt Memorial Association hired Olmsted Brothers, Landscape Architects, to draw up a plan for the island as a memorial. At that time the plan was to recreate a climax forest on the island (Olmsted and Pope, 1934). In accordance with the plan buildings and other physical evidences of man's occupation of the island were removed and 25 to 33 thousand trees and shrubs were planted between 1935 and 1937 (Olmsted Brothers, 1935c, 1936a; Arthur, 1936; Olmsted, 1936a, 1943) by the National Park Service. In preparation for this planting brush and some trees, particularly box-elders, were removed. Some topographic changes were also a part of the memorial plan for the island. The most noticeable change was the steepening of the south end of the island into a distinct shoulder (compare Figures 1 and 24; Olmsted Brothers, 1945).

In December of 1959 construction started on the Theodore Roosevelt Bridge which will cross the southern tip of the island, and in the summer of 1963 an area north of the two topographic prominences (approximately D in Figure 24) was cleared for the Monument to Theodore Roosevelt.

Purpose

Although Theodore Roosevelt Island is one of the most popular areas in the District of Columbia for observing nature, little is actually known of its natural history. The present study was undertaken to determine the geomorphology of the island and the development of vegetative types or habitats found on the island.

METHODS AND RESULTS

This report is based on both field work and a study of the literature. Field work was carried on in 1962 and 1963. The references cited in this report should serve as a useful starting point for any further investigation of the area.

Geologic map

The first geologic map of the area was in 1901 (Darton and Keith). This map as well as later geologic maps (Darton, 1950; Carr, 1950) together with a map by the Public Buildings and Public Parks (Figure 24), drill hole data from the Theodore Roosevelt Bridge, Monument, and proposed overlook, and on the ground field investigations were the basis of Figure 1. The spring was discovered on one of the field trips to the island. Later a map (Olmsted Brothers, 1935d) was found in the National Capital Region map files showing the spring. With the use of this map and field knowledge the spring or seep was placed on the Figure 1 map. The soil samples (Figure 1) were taken under different vegetative types and at different elevations on the island. These were tested by the author and the results given in Table 3.

Map series

In choosing the maps of Theodore Roosevelt Island to be included in this report, only the ones showing significant changes or differences were selected (Figures 2 through 16 and 18 through 26). In preparing the maps for the figures, the title, author, orientation arrow, and scale were included when available. The maps, except for Figure 1, are arranged in chronological order.

The island in 1792 and 1911

Figure 17 shows the changes that have taken place in the shore lines between 1792 and 1911. This is a revision made by lining up the western shore of the island for both years rather than the eastern shore as shown on the original map (National Capital Region, 19__).

Vegetation map

The Habitat and Successional Map (Figure 27) was modified from the maps of 1955 (Figure 1) and 1932 (Figure 24) and by field work in 1962 and 1963. A study of the literature showed which open areas had been planted by the National Park Service between 1935 and 1937; these were eliminated from the successional pattern. The boundaries of the

hemlock grove and area C (Figure 27) were plotted from pace traverses and by observation. Because of the many plantings of trees and shrubs on the island by the National Park Service in 1935 and 1936, no attempt was made to determine the boundary between swamp and forest on the basis of differences in species composition. The boundary was rather arbitrarily placed at the 12 foot contour (M.L.W. datum). The swamp, then, receives most of the floods (Table 2) and is in general tidal, and generally more moist than the forest (Table 3), while the forest receives none but the highest floods and is drier.

Species lists

The species and types of species listed in Table 1 are limited to those that are most numerous or conspicuous. Herbs, shrubs, and trees are included. No counts or measurements were made and no attempt was made to get complete coverage. The arrangement in the lists is alphabetical. Other species in this study are mentioned in the body of the discussion.

Flood levels

At the foot of Wisconsin Avenue at the Potomac River is a U. S. Weather Bureau tide gage which is opposite the north end of Theodore Roosevelt Island. The data shown in Table 2 comes from the Weather Bureau records of this tide gage as well as the earliest records in this vicinity made before the gage was built. Mean low water is zero on the gage.

Soil analysis

The moisture percentage was calculated by the formula

$$P_w = \frac{\text{Wt. of wet soil} - \text{wt. of dry soil}}{\text{wt. of dry soil}} \times 100$$

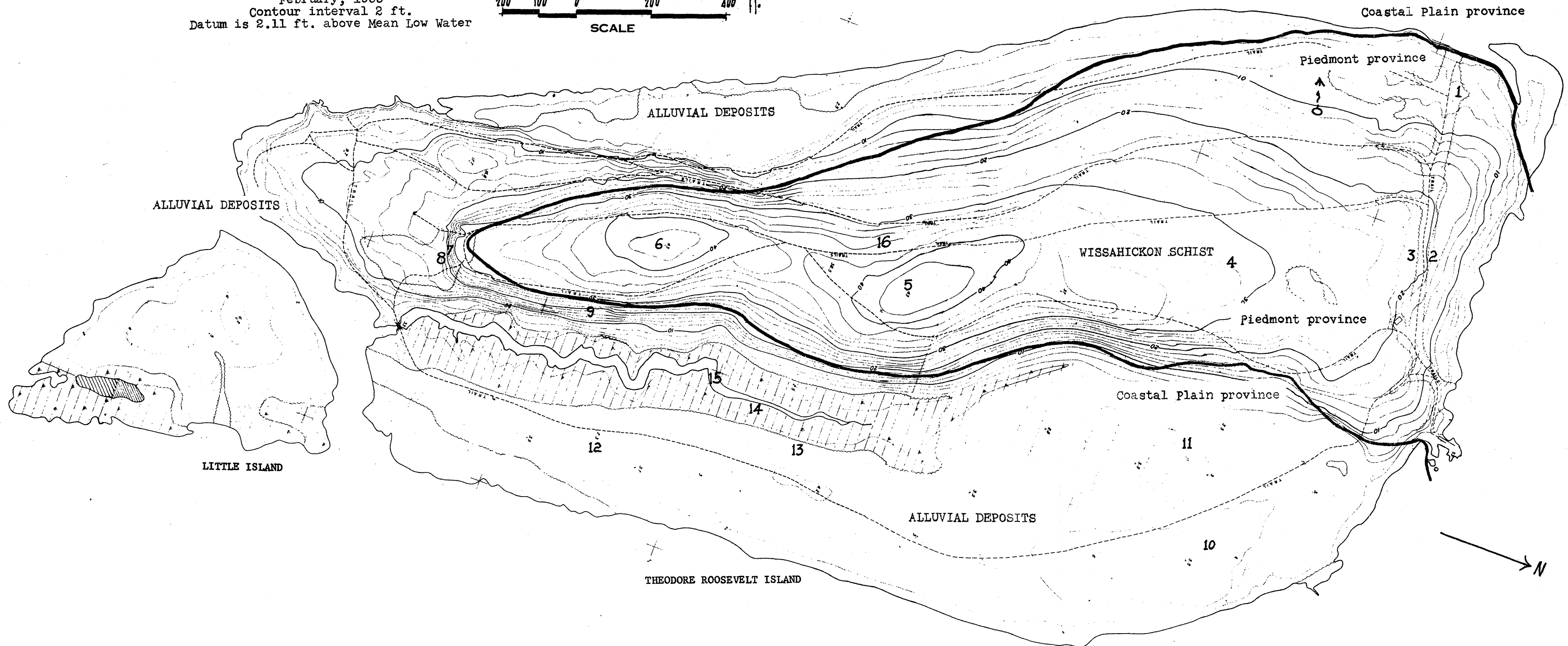
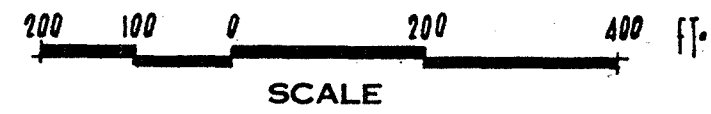
Approximately 100 grams of soil was obtained for each sample and weighed for wet soil. These were dried in an oven overnight at 110° C., and the dry weight obtained.

The colorimetric method of determining soil pH was used. The scale of the LaMotte soil test kit which was used limited the determinations to full pH values.

The mechanical analysis of the seventeen soil samples was done by visual approximation and volume. For each sample a graduate cylinder was filled with soil to the 25 cc. mark. Sufficient water was added to settle the soil and enough more soil added to bring it to the 25 cc. mark again. One cubic centimeter of ammonium hydroxide solution was added and then the cylinder was filled with water to the 100 cc. mark. With the top of the cylinder covered it was shaken for ten minutes. The ammonia and the shaking deflocculate the soil. The soil was then allowed to settle and

readings taken after 25 seconds, 1 1/3 hours, and overnight. These readings were taken to represent volumes of sand, silt, and clay respectively. On this basis the volume percentages of these three size classes were calculated. The textural class as determined by mechanical analysis is determined by the weight percentage of each class. The textural classes in Table 3, however, have been determined by volume percentage. The textural classification which has been used in the U. S. Department of Agriculture (Lutz and Chandler, 1946, pp. 230 and 231) was used in the textural class determinations except that the percentages used were volume rather than weight percentages.

DISTRICT OF COLUMBIA
DEPARTMENT OF HIGHWAYS
February, 1955
Contour interval 2 ft.
Datum is 2.11 ft. above Mean Low Water





VIRGINIA AND MARYLAND

*As it is Planted and
Inhabited this present
Year 1670 Surveyed and
Exactly Drawne by the
Only Labour & Endeavour
of*
Augustin Herrman
Bohemienfis

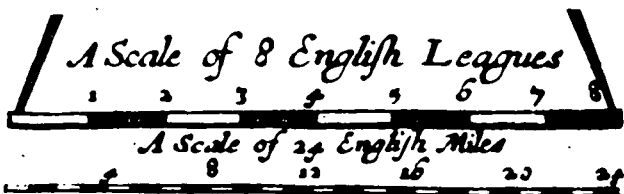
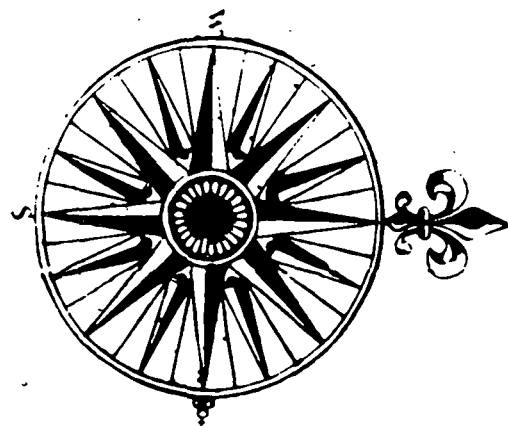


Figure 2. Theodore Roosevelt Island (Anacostien Ile) in 1670.

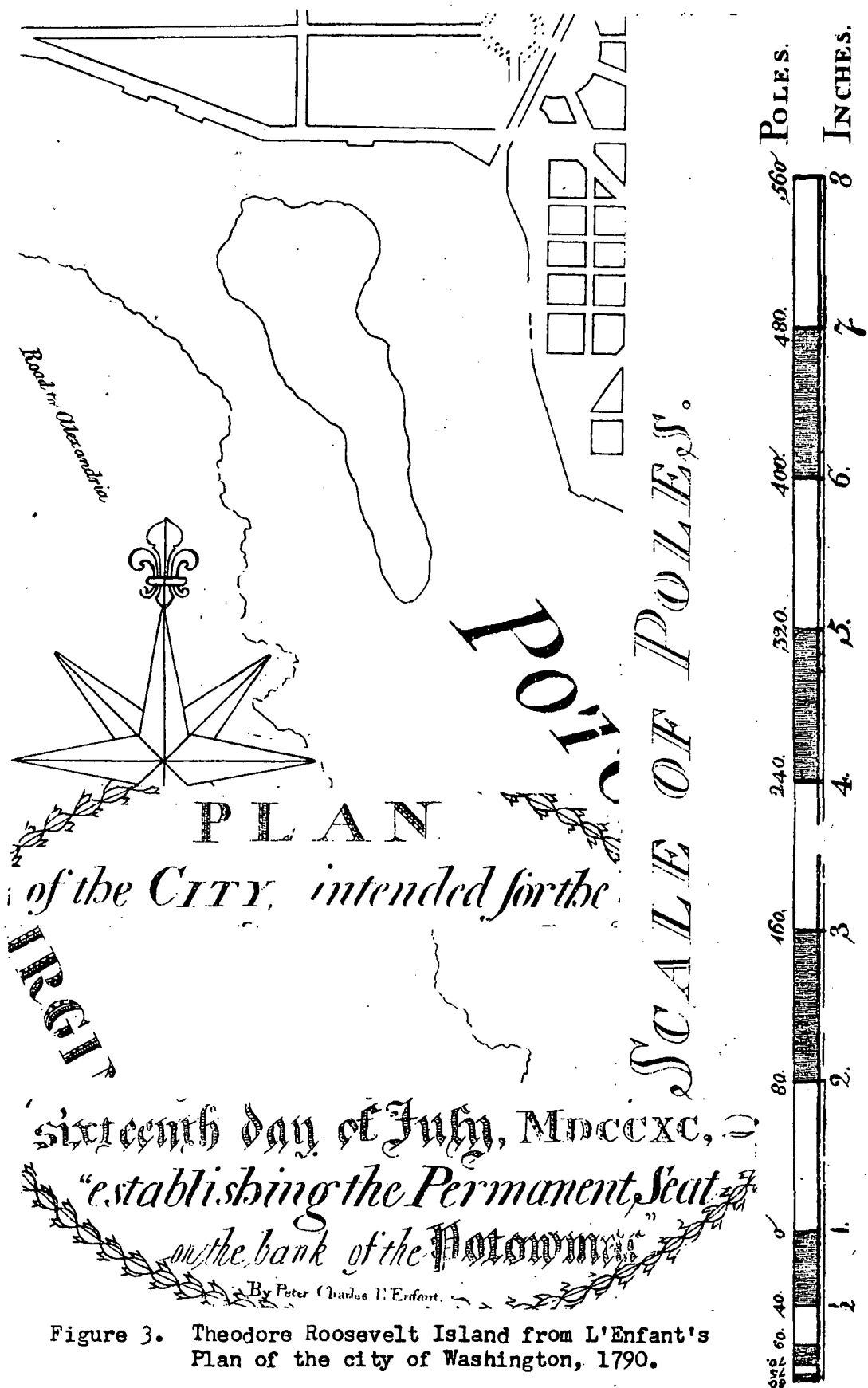
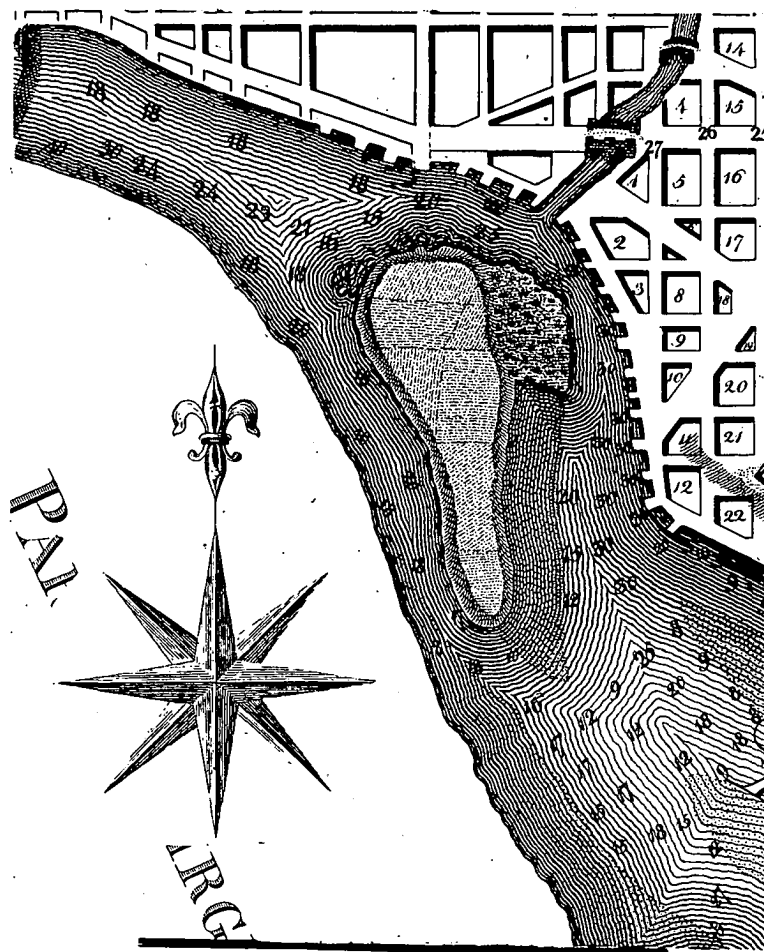


Figure 3. Theodore Roosevelt Island from L'Enfant's Plan of the city of Washington, 1790.



Engraved by Thackara & Vallance Philad.^a 1792.

IN order to execute this plan,

Mr. ELLICOTT drew a true Meridional

PLAN

*of the CITY of
Washington
in the Territory of Columbia,*

SCALE OF Poles.

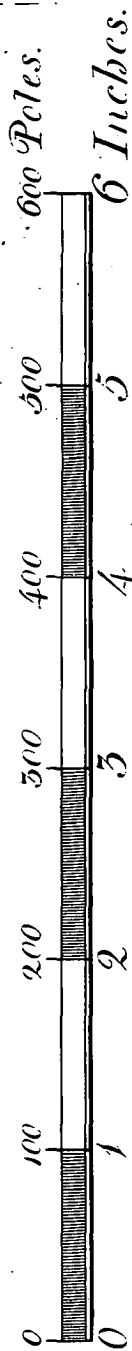


Figure 4. Theodore Roosevelt Island from Ellicott's Plan of the city of Washington, 1792.

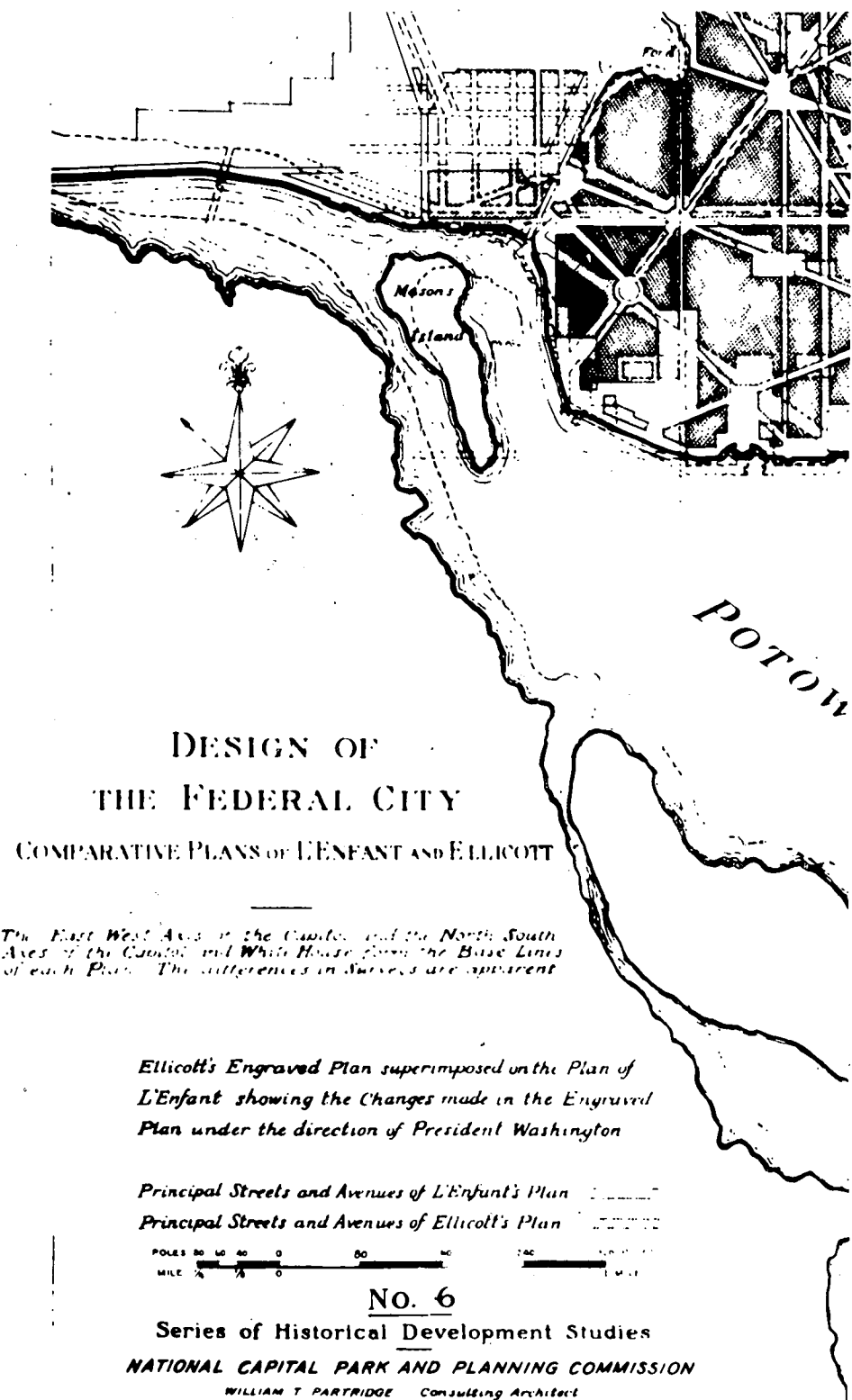


Figure 5. Theodore Roosevelt Island (Mason's Island) showing L'Enfant's and Ellicott's plans superimposed.

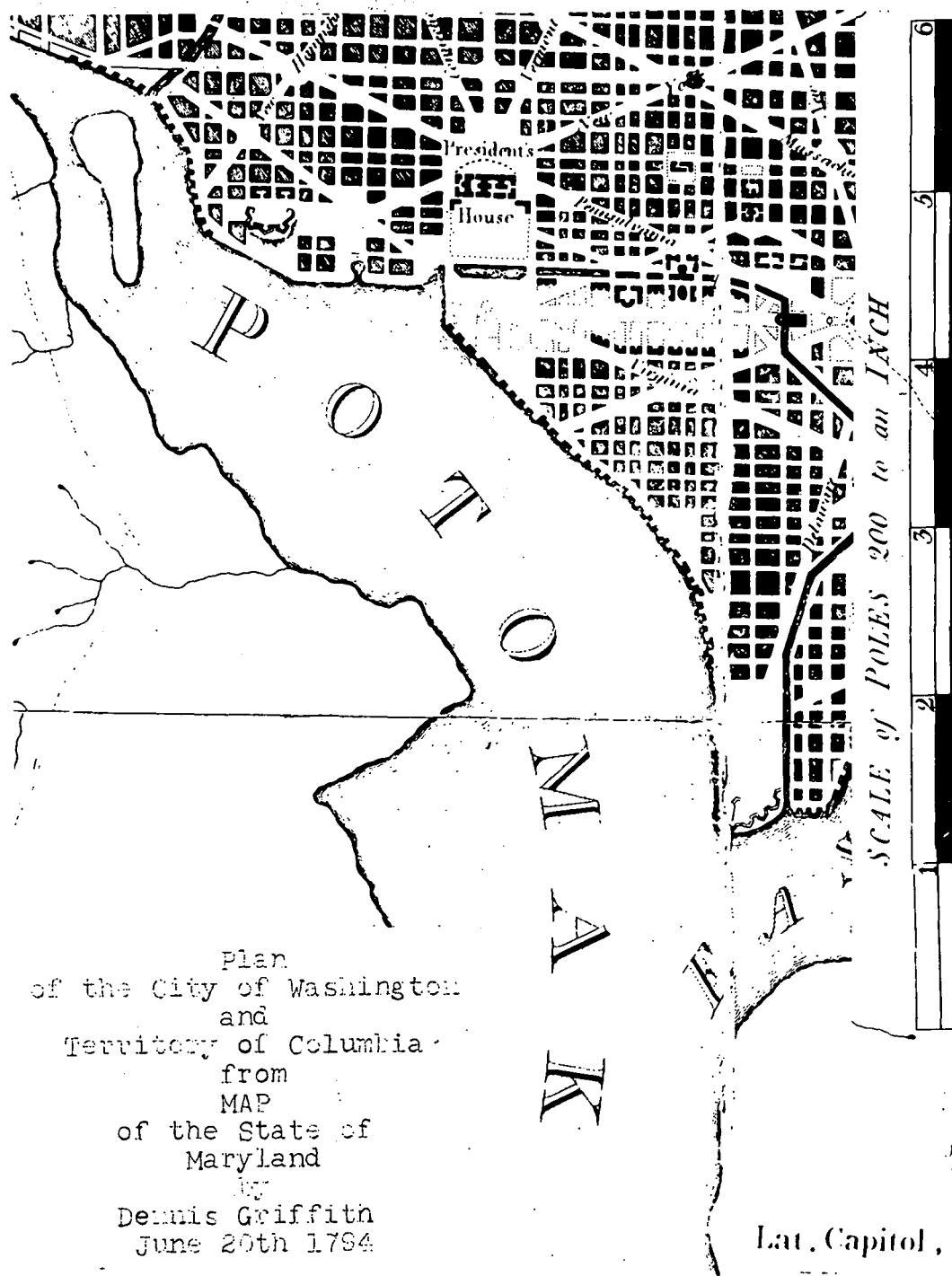


Figure 6. Theodore Roosevelt Island from Plan on Map of Maryland, 1794.

THE DERMOTT OR TIN CASE
MAP OF THE
CITY OF WASHINGTON
1797-8

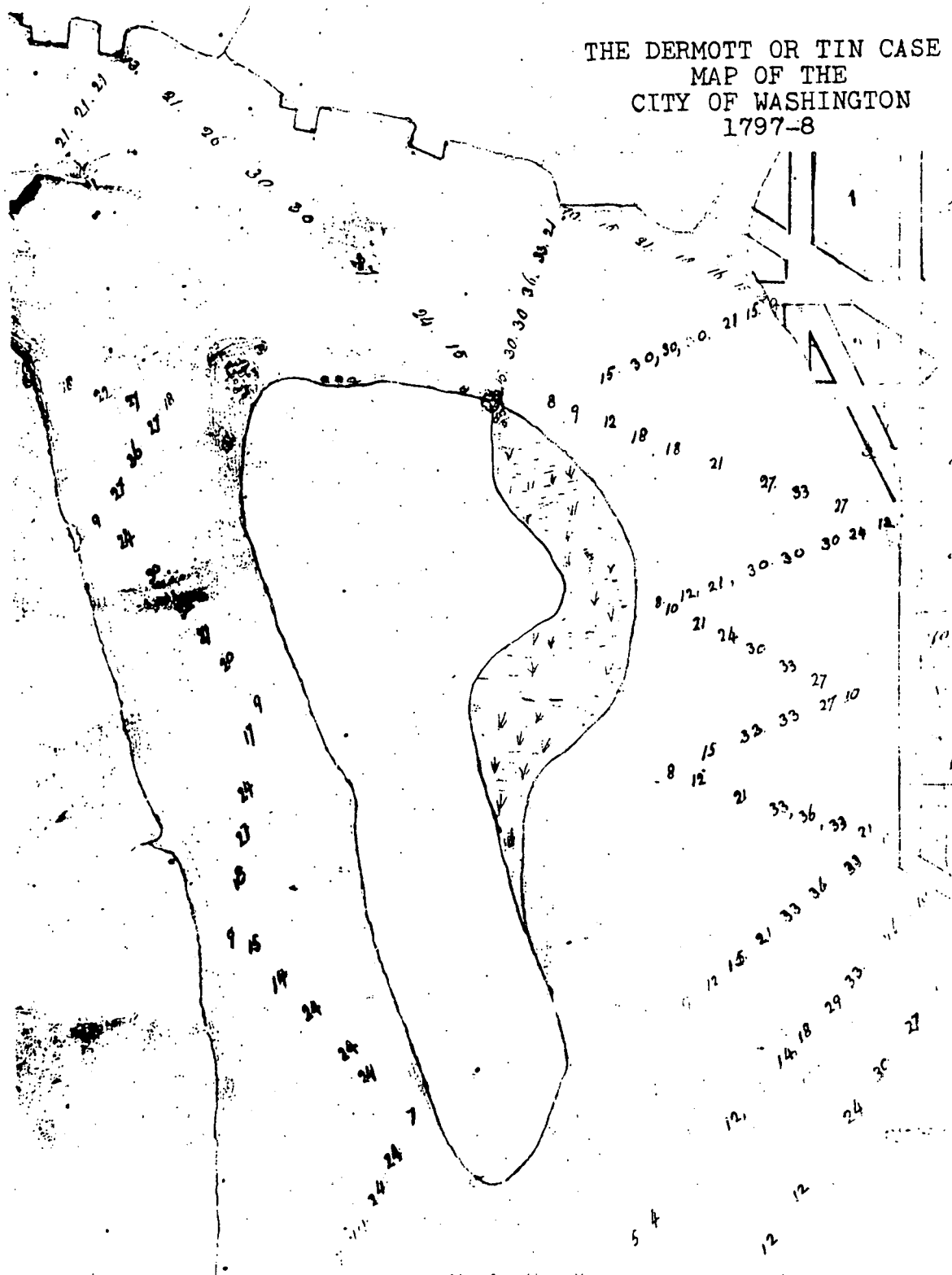


Figure 7. Theodore Roosevelt Island, 1797-8.

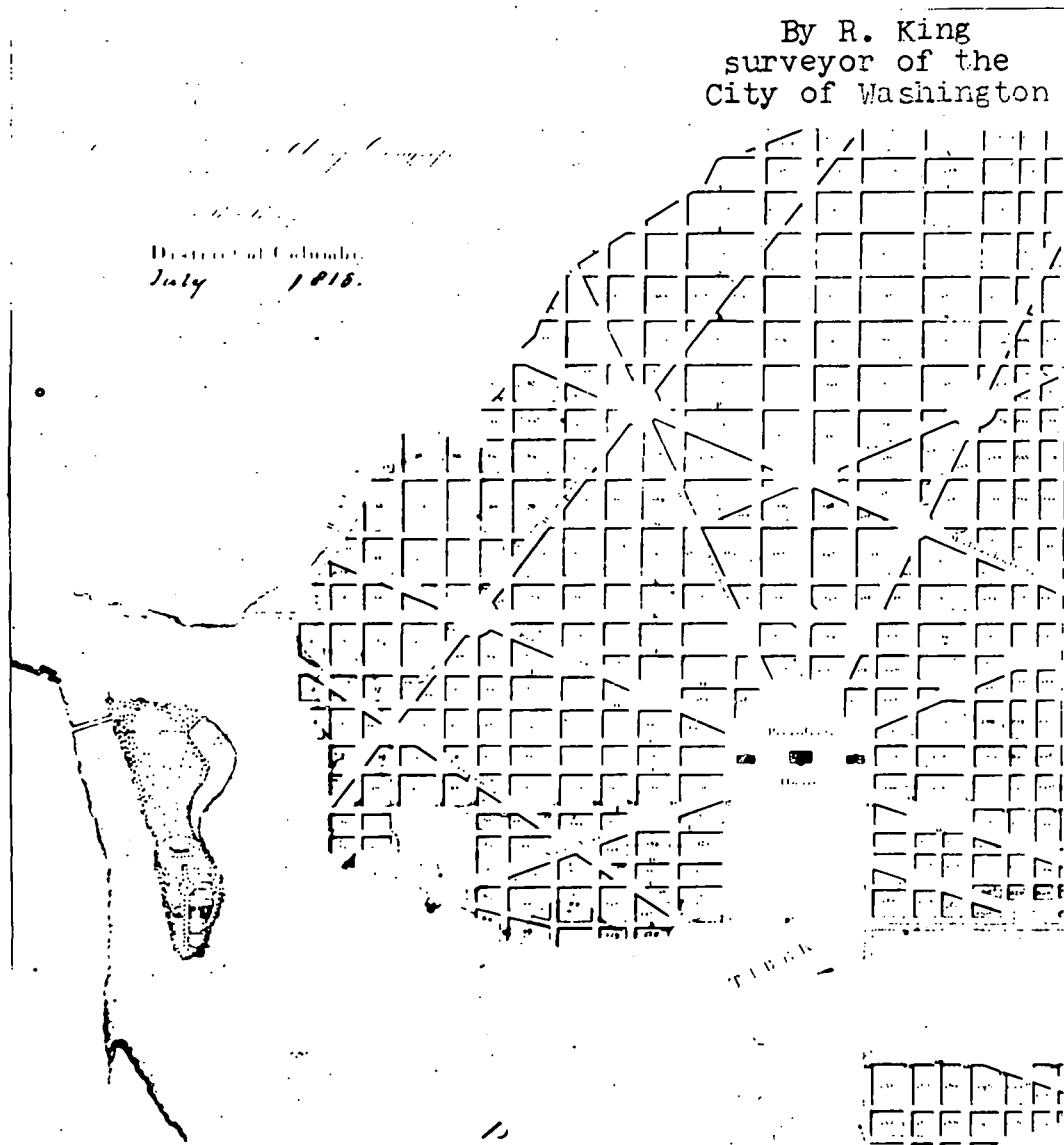


Figure 8. Theodore Roosevelt Island, 1818.

1849
 HEAD of NAVIGATION
 of the
 POTOMAC RIVER
 Surveyed and Drawn
 under the direction of
 Capt. Campbell Graham Top. Engrs.
 by
 S. T. Abert.

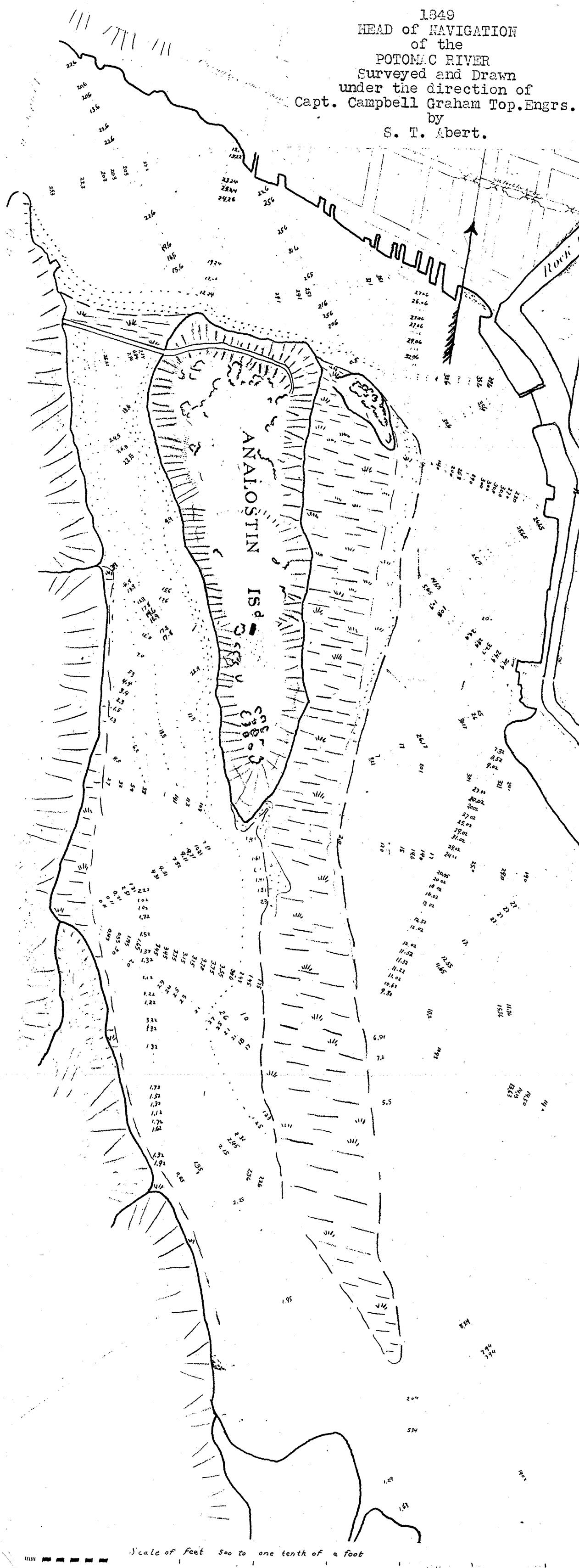


Figure 10. Theodore Roosevelt Island (Analostin Island) in 1849.

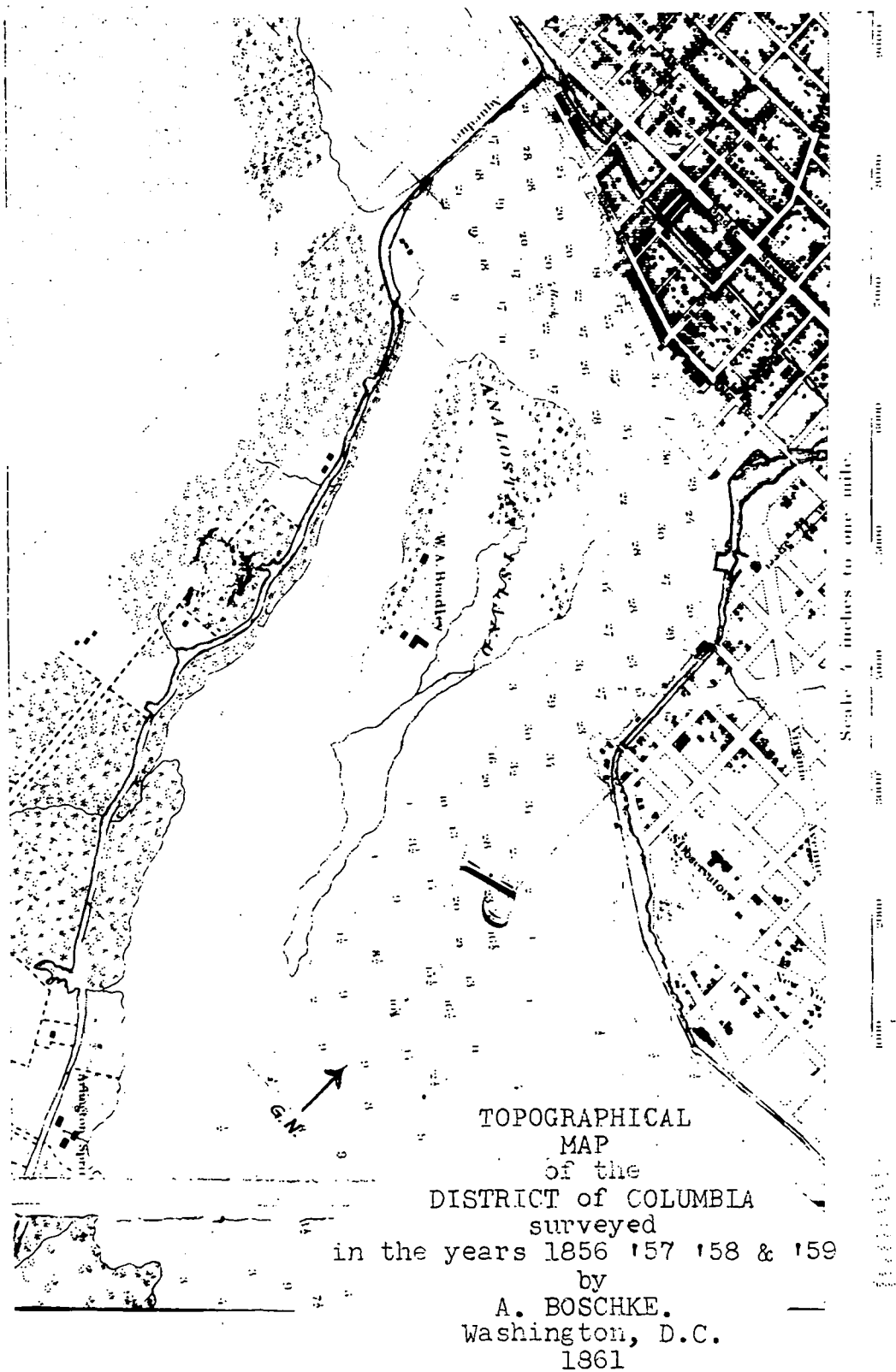


Figure 11. Theodore Roosevelt Island, 1856, '57, '58, and '59.



POTOMAC RIVER

GEORGETOWN

From a Trigonometrical Survey

under the direction of A.D. BACHE Superintendent of the

SURVEY OF THE COAST OF THE UNITED STATES

Scale 40000

1864

Statute Miles

Nautical Miles

Figure 12. Theodore Roosevelt Island, 1864.

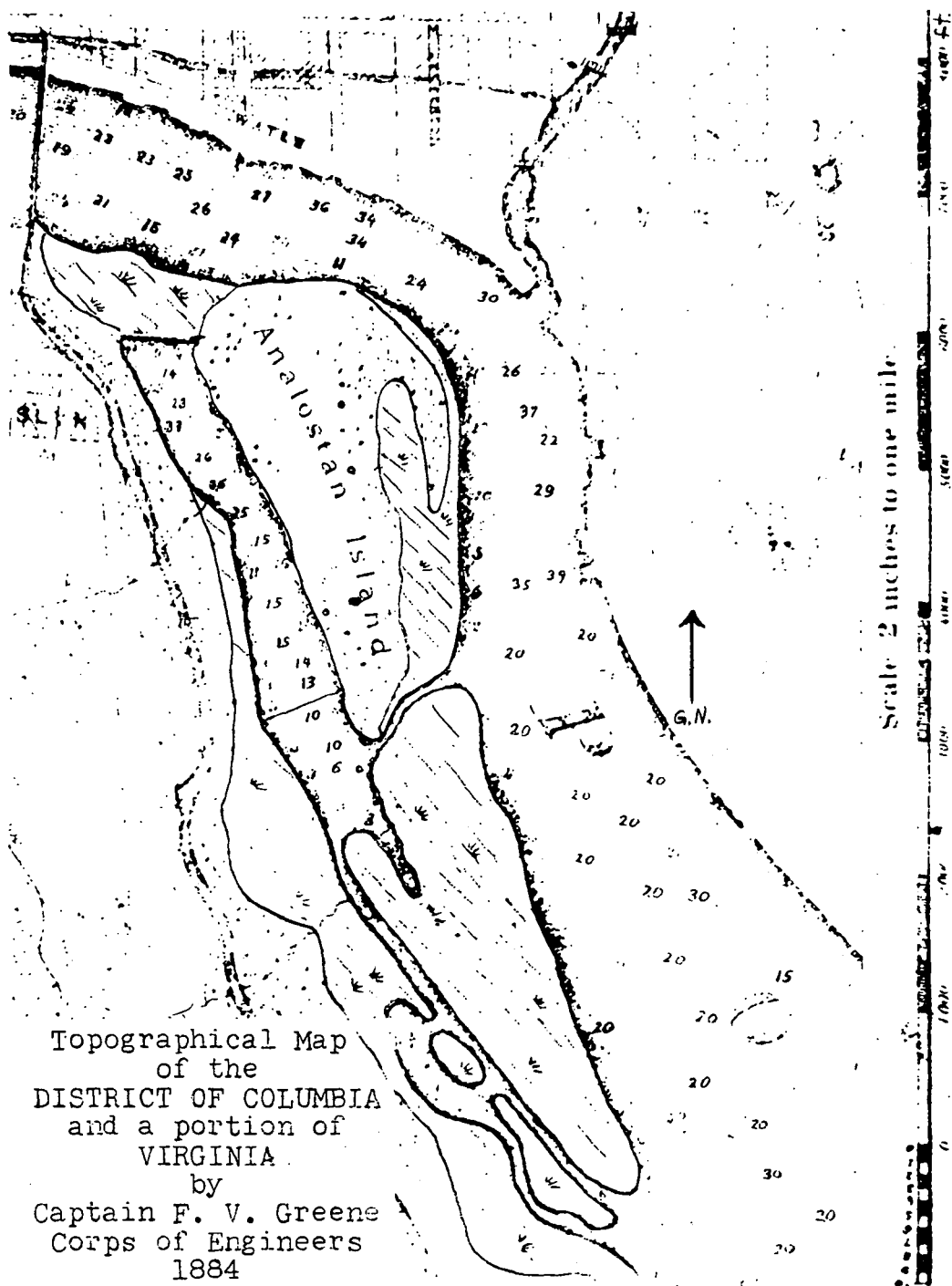


Figure 13. Theodore Roosevelt Island, 1884.

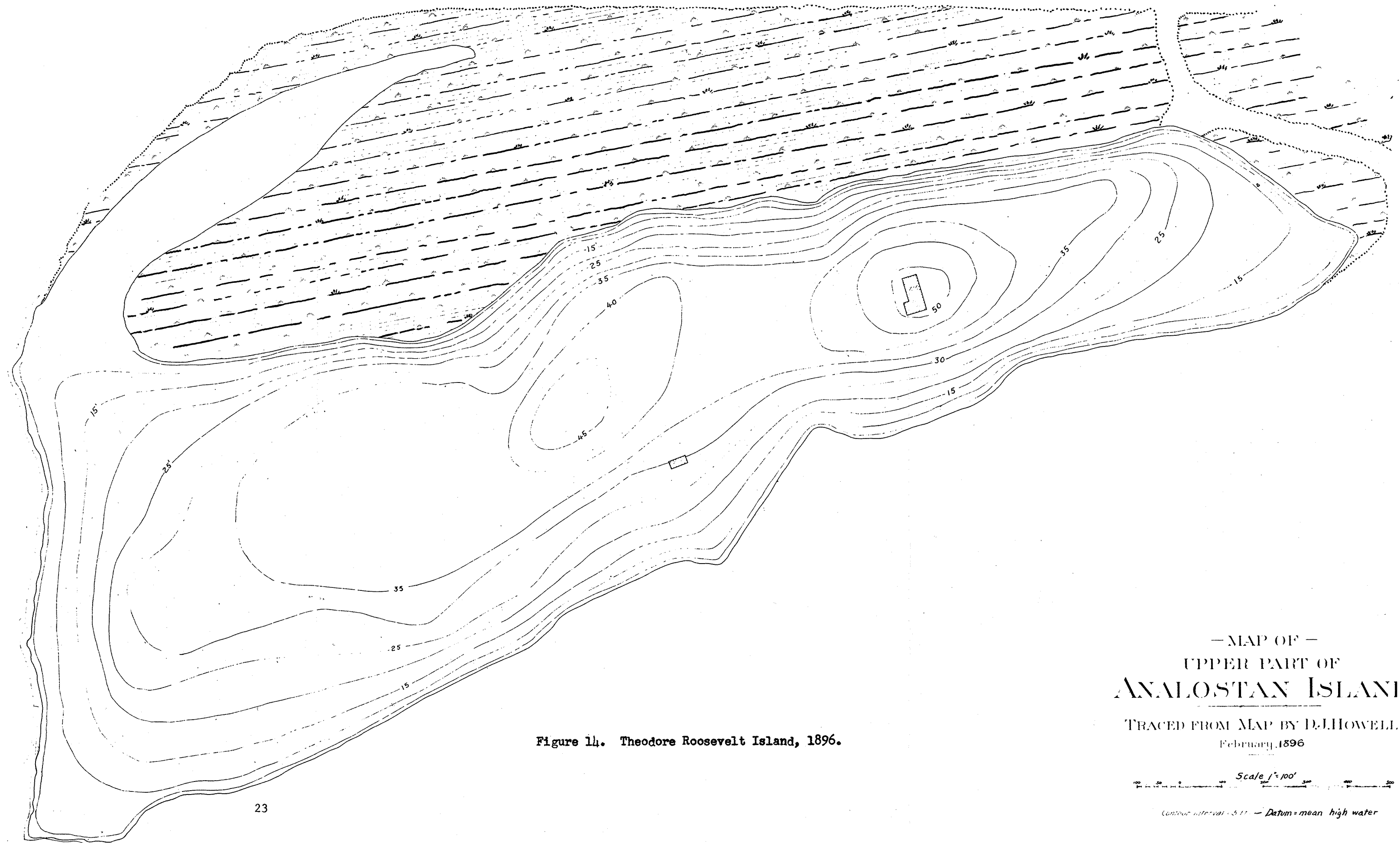
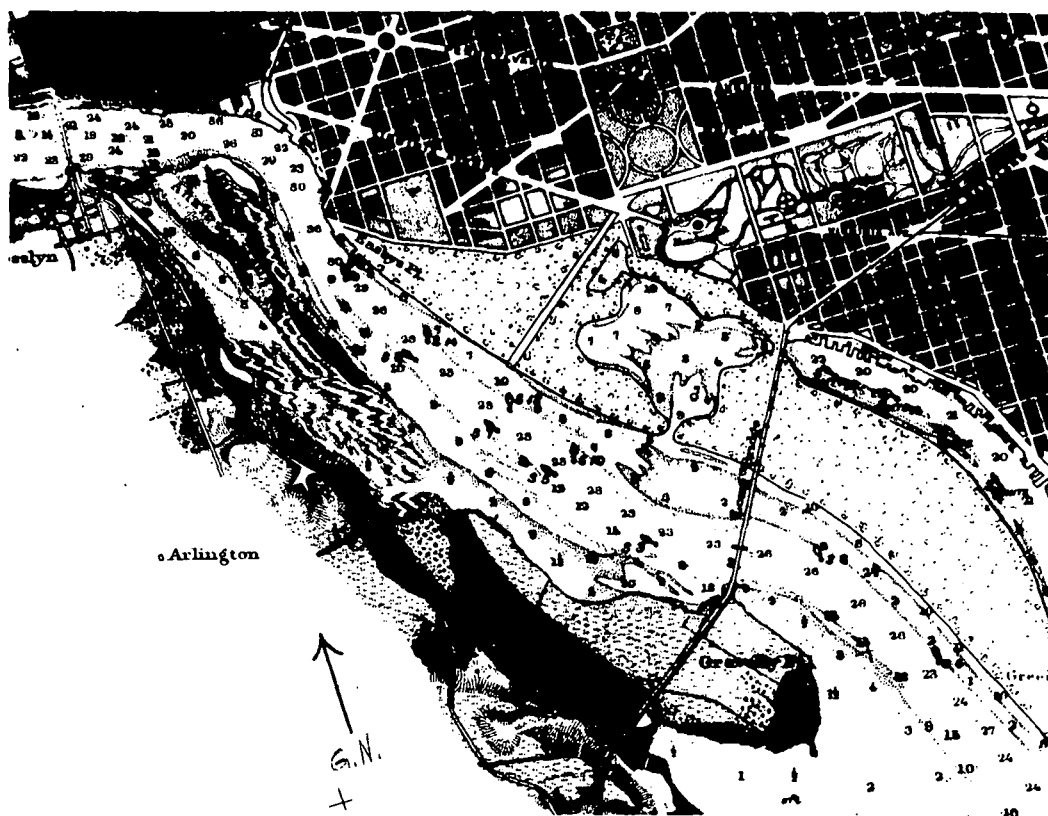


Figure 14. Theodore Roosevelt Island, 1896.



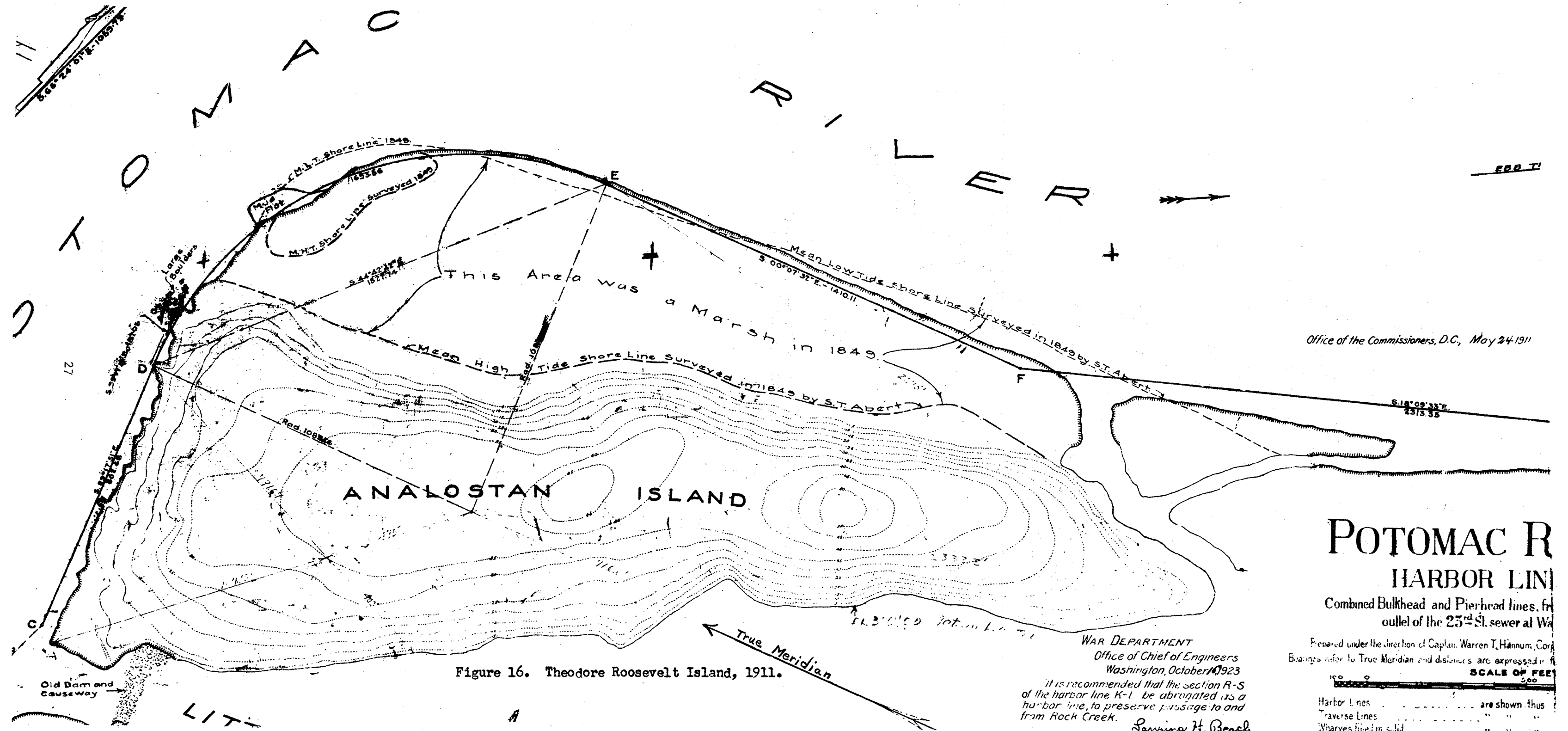


Figure 16. Theodore Roosevelt Island, 1911.

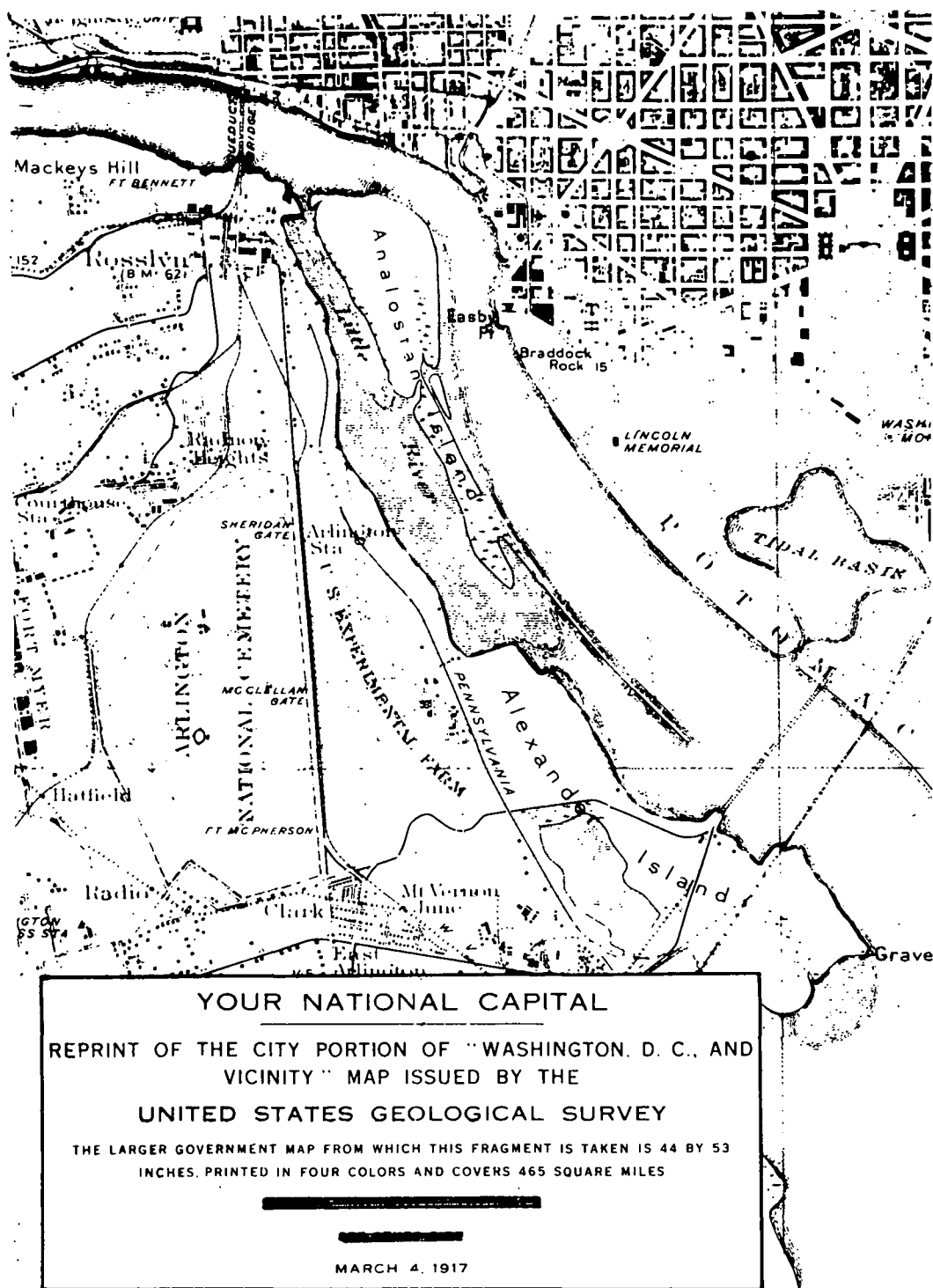


Figure 18. Theodore Roosevelt Island, 1917.

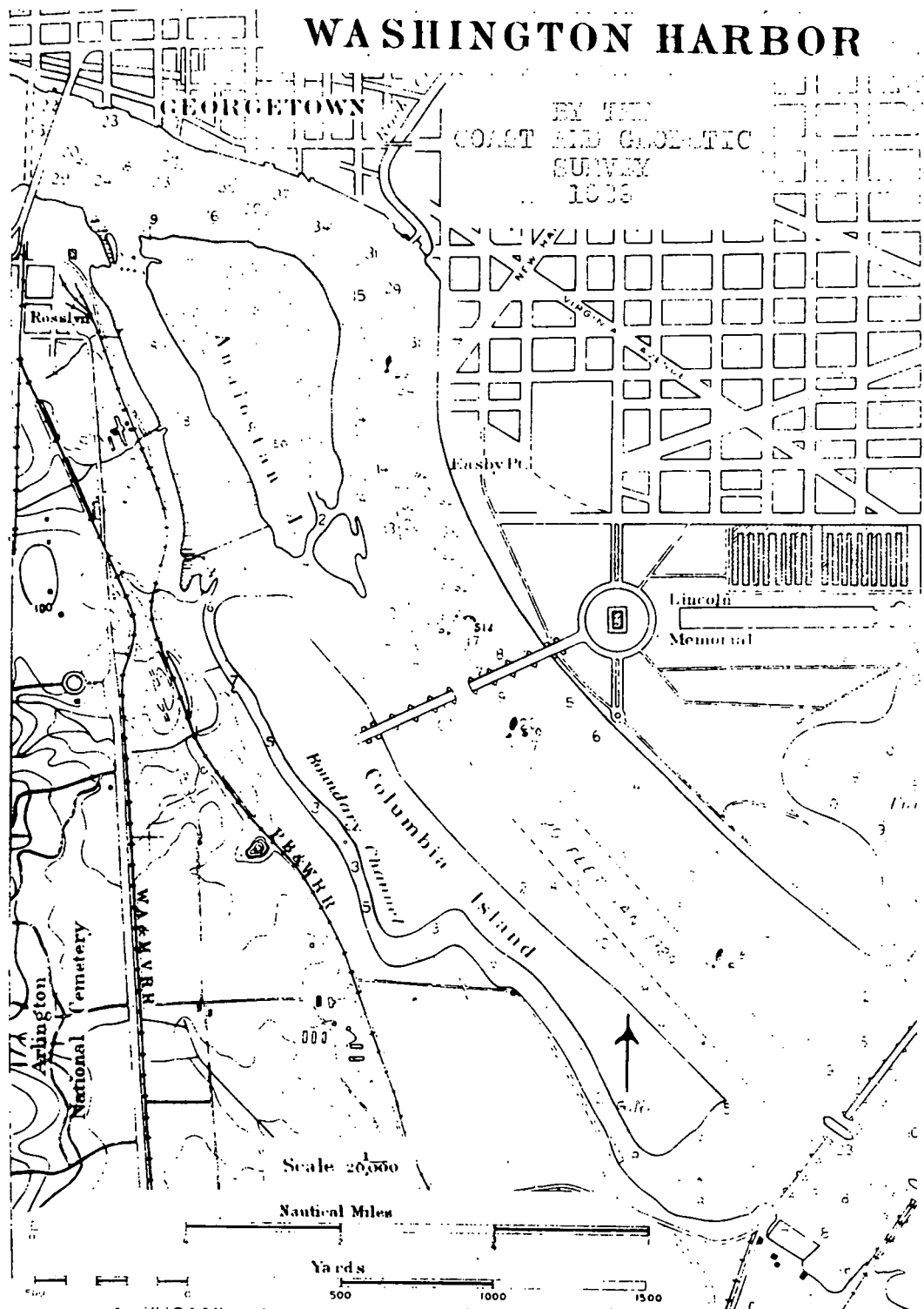
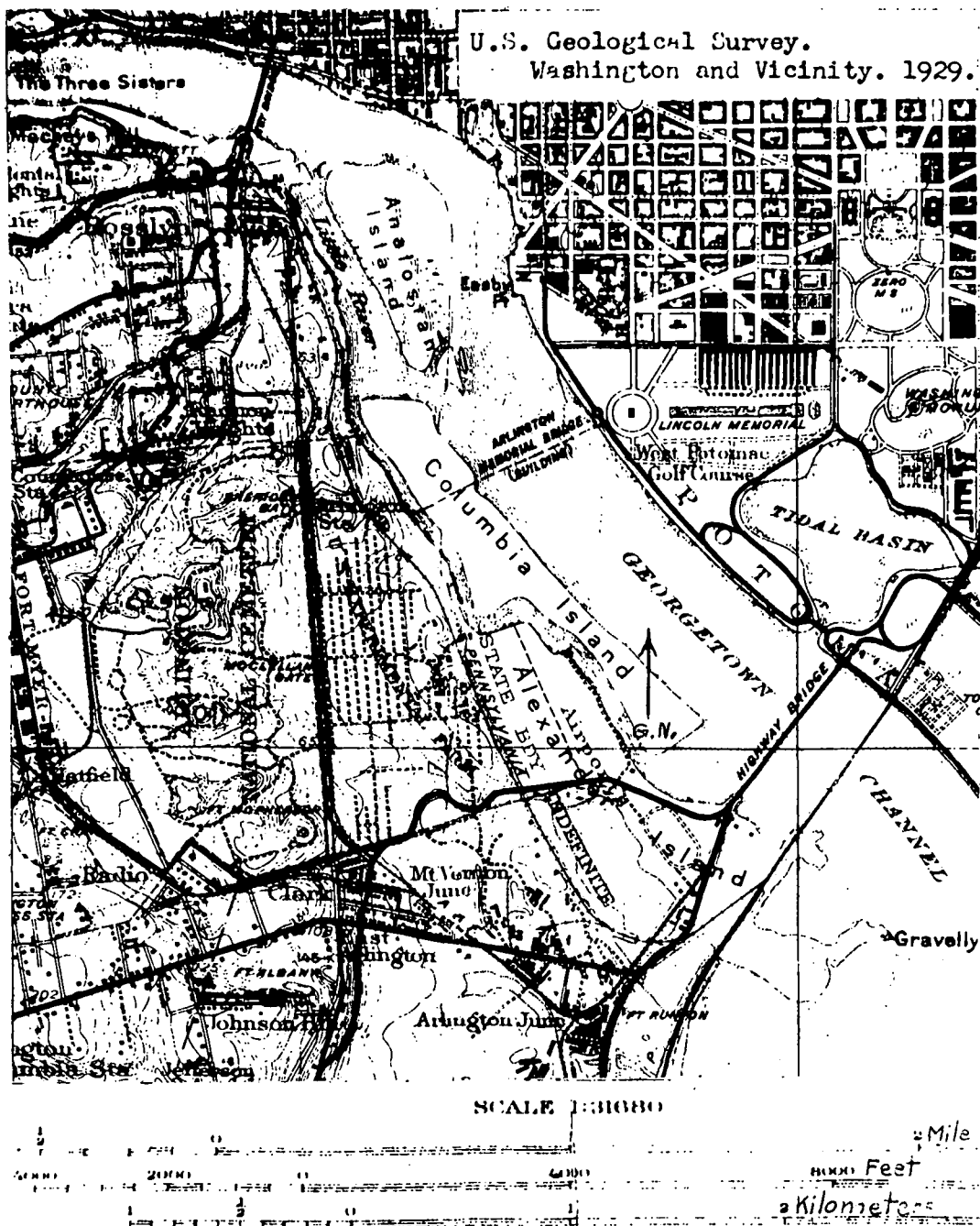


Figure 20. Theodore Roosevelt Island,
Coast and Geodetic Survey, 1929.



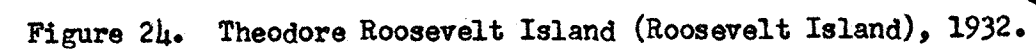
Contour interval 10 feet. Datum is mean sea level.

Figure 21. Theodore Roosevelt Island,
U. S. Geological Survey, 1929.



Figure 22. Man-made land along Virginia shore near Theodore Roosevelt Island, 1863 to 1931.

L I T T L E R I V E R



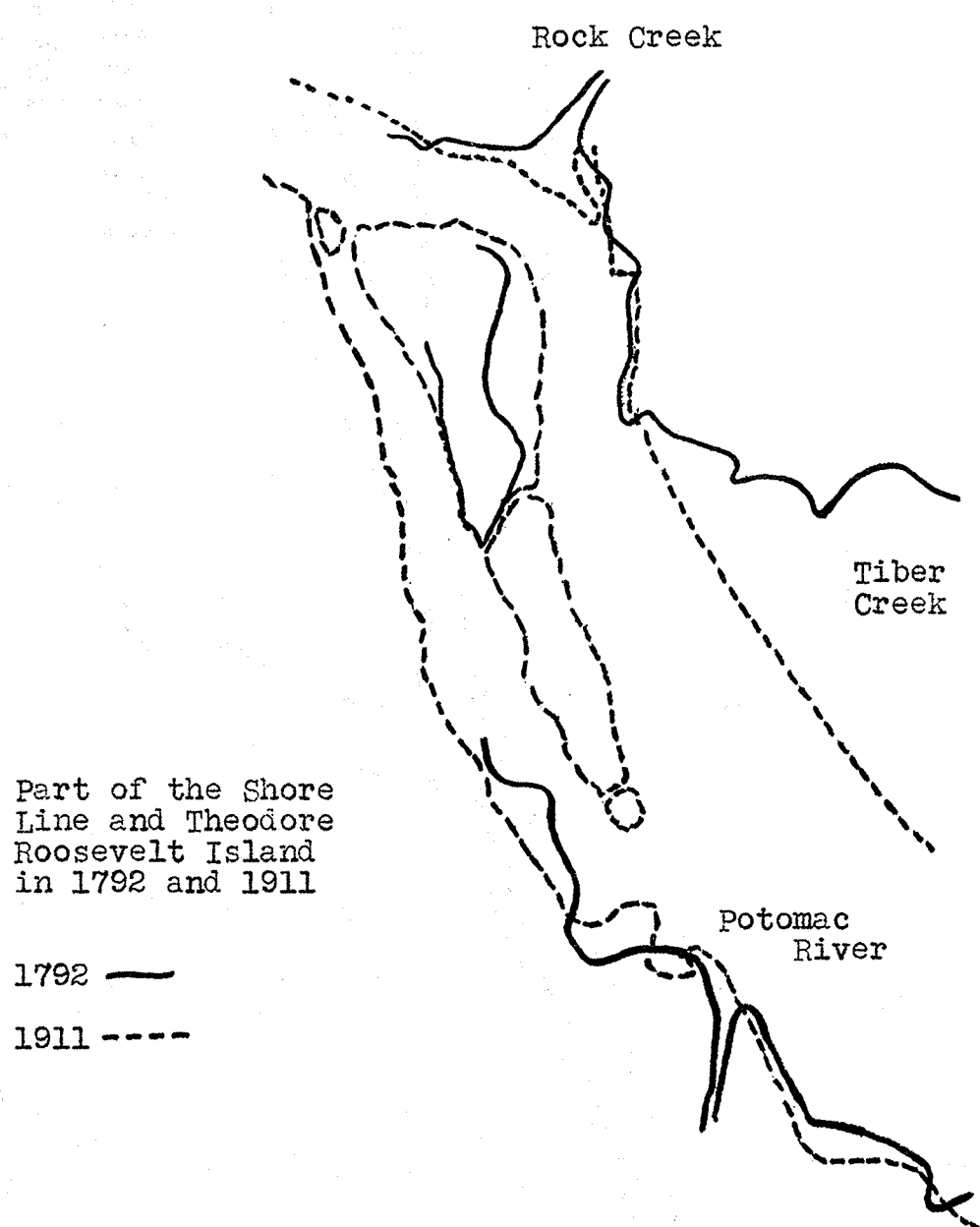


Figure 17. The shore lines of Theodore Roosevelt Island in 1792 and 1911.

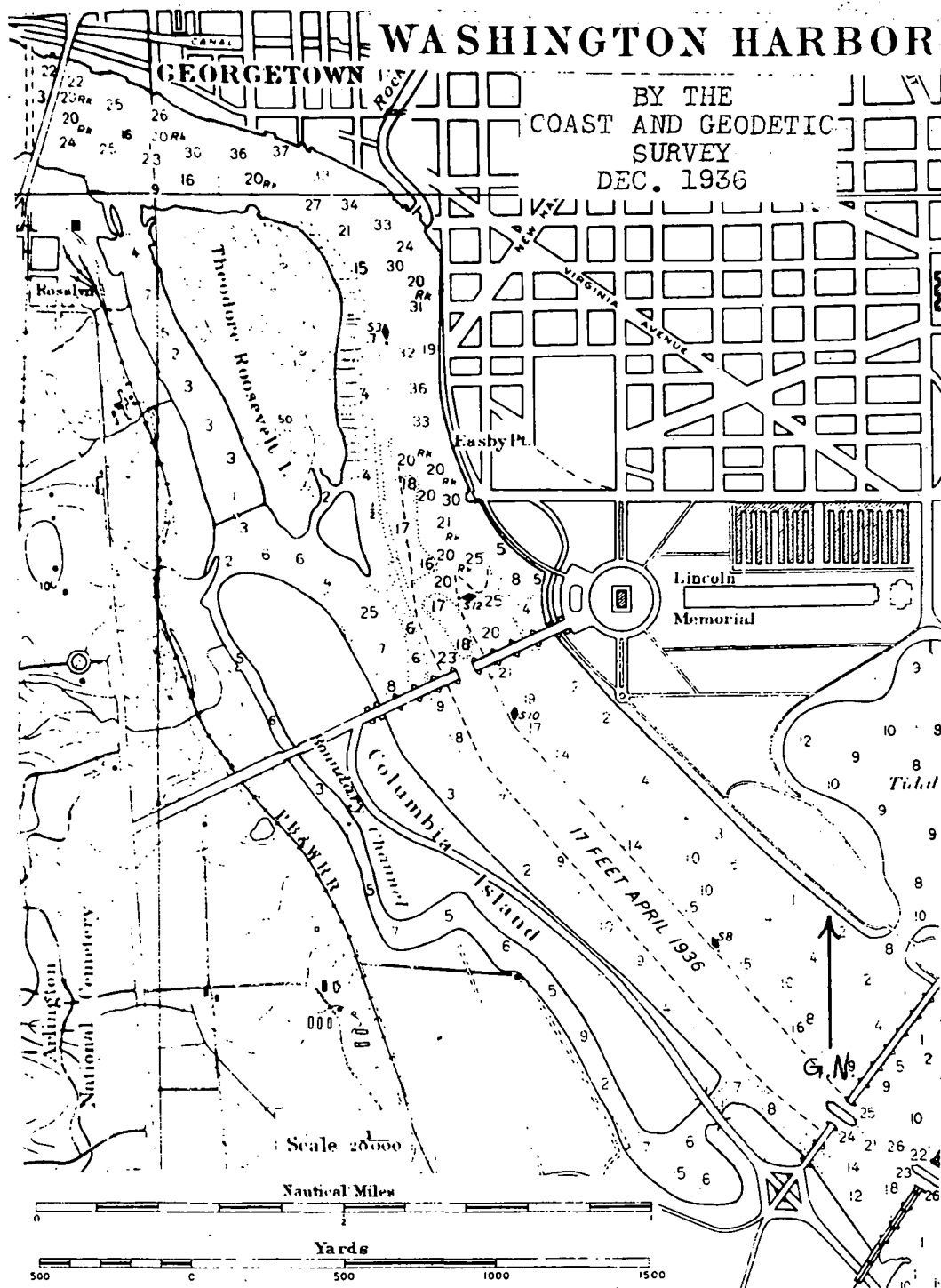


Figure 25. Theodore Roosevelt Island, 1936.

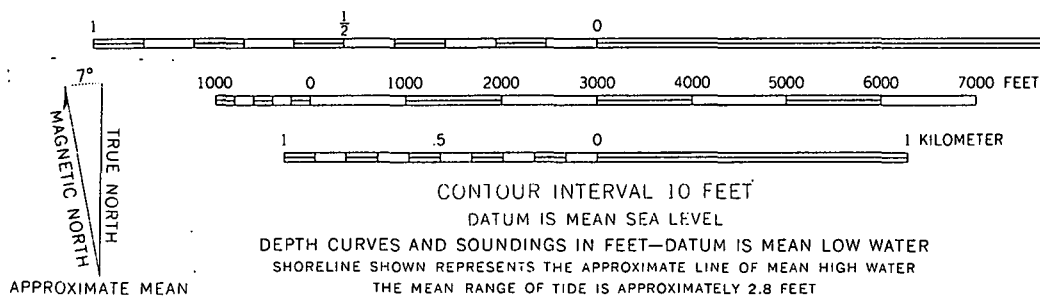


Figure 26. Theodore Roosevelt Island, 1956.

DISTRICT OF COLUMBIA
DEPARTMENT OF HIGHWAYS
February, 1955
Contour interval 2 ft.
Datum is 2.11 ft. above Mean Low Water

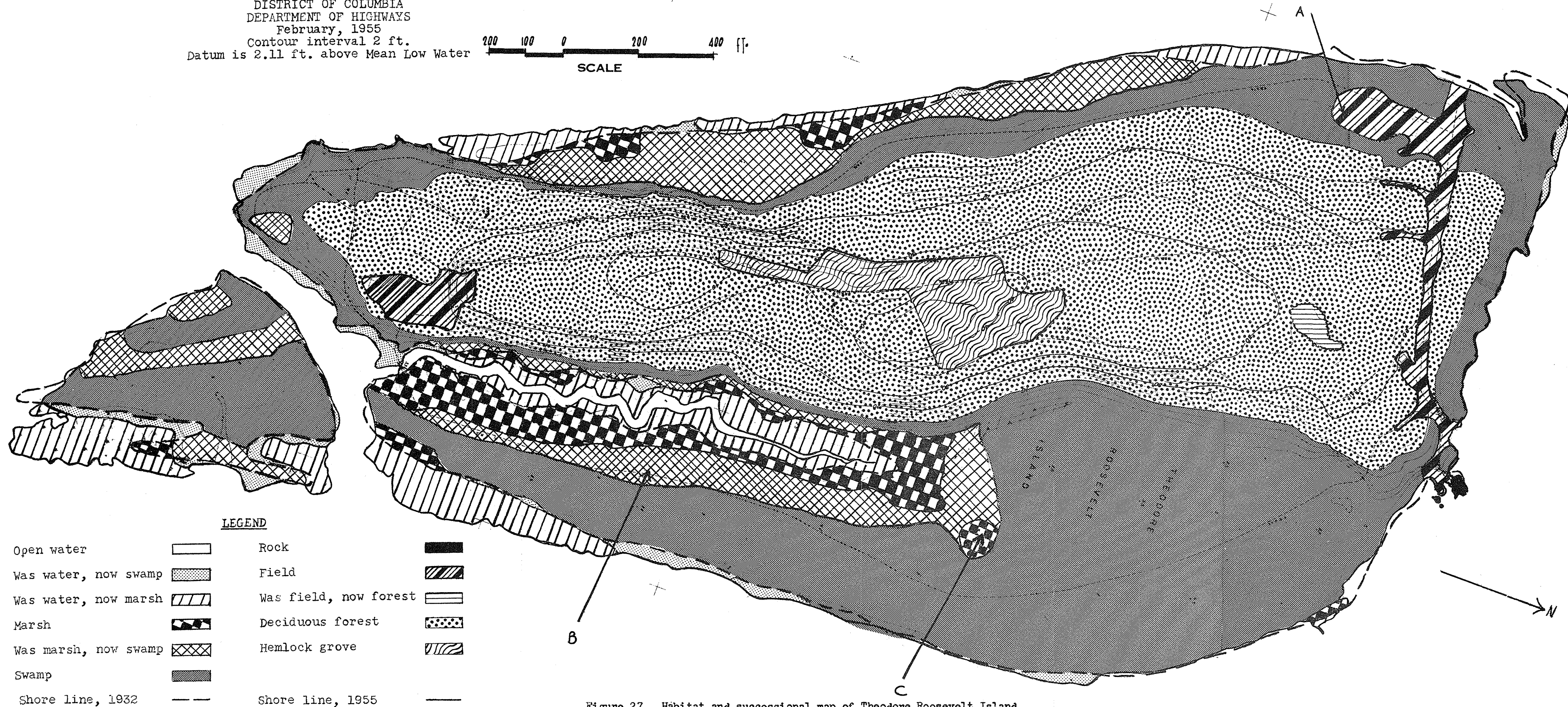


Figure 27. Habitat and successional map of Theodore Roosevelt Island.

Theodore Roosevelt Island
(data obtained 10/63)

Acer saccharinum L.
 Alnus serrulata (Ait.) Willd.
 Aster pilosus Willd.
 Cornus amomum Mill.
 Gramineae
 Lichens
 Musci
 Physocarpus opulifolius (L.) Maxim.
 Platanus occidentalis L.
 Rhus radicans L.
 Rosa palustris Marsh.
 Ulmus americana L.

Three Sisters Islands
(data obtained 10/63)

Acer saccharinum L.
 Achillea millefolium L.
 Alnus serrulata (Ait.) Willd.
 Campsis radicans (L.) Seem.
 Cornus amomum Mill.
 Gramineae
 Lichens
 Musci
 Parthenocissus quinquefolia (L.)
 Planch.
 Platanus occidentalis L.
 Quercus bicolor Willd.
 Rhus radicans L.
 Robinia pseudo-acacia L.
 Rosa micrantha Sm.
 Ulmus americana L.
 Viburnum prunifolium L.

Table 1. Sample of Vegetation on the rocks of Three Sisters Islands
 and the boat landing of Theodore Roosevelt Island.

<u>Date</u>	<u>Crest stage in feet</u>	<u>Place</u>
May-June 1889	19.5	Aqueduct Bridge
Feb.-Mar. 1902	12.0	" "
March 1924	8.0	Key Bridge
May 1924	12.1	" "
April 1929	8.1	" "
May 1932	7.6	" "
August 1933	11.1	" "
March 1936	17.3	Wisconsin Ave. *
April 1937	14.3	" "
October 1937	7.8	" "
October 1942	17.7	" "
October 1954	8.9	" "
August 1955	8.8	" "

*Datum on this gage is zero at Mean Low Water.

Table 2. Potomac River Floods above 7 feet from U. S. Weather Bureau
 Records (Washington, D. C.)

Habitat	Station**	% Moisture	pH	Volume Percentage			Textural Class##
				sand	silt	clay	
Field	1	14.7	5	52	34	14	sandy loam
Field	7	14.9	5	71*	20*	9*	sandy loam
Field	8	14.9	5	59	28	13	sandy loam
Thicket	2	17.6	4	54	34	11	sandy loam
Thicket	3	16.3	5	43	46	11	loam
Forest	4	23.4	5	27	58	15	silt loam
Forest#	5	17.6	5	45	43	12	loam
Forest	6	19.0	7	38*	56*	7*	silt loam
Forest	9	18.4	5	55	34	11	sandy loam
Hemlock	16	19.0	4	52*	29*	19*	sandy loam
Rock Creek Park (Forest)###	--	22.0	5	55*	35*	10*	sandy loam
Swamp (dry)	10	22.0	6	44*	54*	3*	silt loam
Swamp (moist)	11	42.8	7	30	64	6	silt loam
Swamp (inundated)	12	42.8	6	45	48	7	loam
Wet thicket	13	49.2	5	44*	48*	7*	loam
Marsh	14	88.7	5	65	28	7	sandy loam
Open water (bottom sample at high tide)	15	143.9	5	56*	40*	4*	sandy loam

** Station numbers refer to numbers in Figure 1.

* Average of two readings from same sample.

Sample not taken from under hemlocks.

Based on Volume percentage.

Sample taken in northeastern Rock Creek Park near the base of an old American chestnut (*Castanea dentata* (Marsh.) Borkh.) about 100 feet above the Rock Creek and on the southeast side of this stream.

Table 3. Soil Statistics of Theodore Roosevelt Island

DISCUSSION

Geology

Theodore Roosevelt Island began as a rock jutting out of the middle of or toward the Georgetown side of the Potomac River channel (Figures 2, 3, 4, 5, 6). Brooke surveyed the Potomac River in 1737. He shows the island a little closer to the Virginia shore than to the District shore, although the north point of the island is shown equally distant from both shores.

The island is made up of rocks typical of the Piedmont province surrounded by alluvium which is considered to be in the Coastal Plain province (Figure 1). The Piedmont rocks are those of the Wissahickon Formation, a micaceous schist (Coulter, 1963) which form the core of the island. The top of the schist is extremely irregular. This is illustrated by Warden's account (1816, p. 136) of the digging of a well. He relates that a mass of trees was discovered at the depth of fifteen feet. After the workman cut through them and removed several of large dimensions, he came to "huge ones with their tops upwards." Martin (183_, p. 494) mentions that agatized wood was found in the digging of a well on the island.

These well digging incidents when correlated with the geologic map (Figure 1) indicate that somewhere within the Piedmont and on high ground is a significant alluvial deposit. One possibility is that the surface Piedmont does not extend as far south as shown. However, borings taken for the Theodore Roosevelt Monument site (Raymond, 1962) show that the area north of the two peaks is schist. Another possibility is that there may be a subsurface depression in the schist between the two summits (Figure 1) which later filled with alluvium.

The remnant of schist that resisted erosion by the Potomac River formed a nucleus around which the Coastal Plain sediments, the alluvial sand and gravel, were deposited. With each uplift of the land or lowering of the sea level, the alluvial beds were deposited at different elevations on the downstream end of the island, thus producing a series of steps or terraces (Nussear, 1946; Carr, 1950; Masters, 1962; Figure 1).

Xerarch successions

Shortly after the exposure of the core of schist, lichens, mosses, grasses, deciduous trees and deciduous shrubs probably started growing and the situation was similar to that which can be seen at the present boat landing (rock, Figure 27) or the Three Sisters Islands (Table 1). The plants on the higher elevations of this schist may have differed from those growing lower by including the evergreen Pinus virginiana Mill. This pine is found growing on the rocks well above the Potomac River at Great Falls. It is imagined that the first plants were probably the lichens and mosses and that as soil accumulated in the rock crevices from their breakdown of

the rock and their organic remains that the herbaceous plants started to invade the island. Floods aided the soil build up at least on the lower elevations (Table 2) by dropping rock particles and organic debris that had washed down from upstream. In this way the soil at the lower elevations would have developed faster than the soil at the higher elevations on the island, and therefore the succession of vegetative types would have proceeded faster.

When sufficient soil had accumulated, woody plants, shrubs, and trees invaded the rocky part of the island. At the same time, of course, animals also aided in the soil development for every stage of plant succession would have attracted new animals to the island and animal cadavers and excrement would have helped to enrich the soil. Even in the early stages of xerarch succession there were probably nematodes associated with the soil supporting the mosses (Hickman, 1955, p. 217).

Finally, the vegetation on the island probably appeared as a deciduous forest on the higher elevations and a deciduous swamp near the water. Warden's report (1816, pp. 138-141, 147) which was probably recorded about nineteen years after the Masons started living on the island (Warden, 1816, p. 137; Duhamel, 1935, p. 137) lists only deciduous wild plants. Figure 24 which shows a sample of the trees on the island in 1932 indicates a deciduous forest. The trees on this map must include both those that had come in naturally and those that had been planted by previous owners (Roosevelt Memorial Association, 1931). In 1934 (Arnold) the vegetation consisted of a dense and luxuriant growth of mixed hardwoods. In addition the rock based part of other nearby islands of the Potomac River as well as the uplands away from the river in the general region of Theodore Roosevelt Island have been observed by the author to be covered primarily by deciduous forests. All these evidences support the concept of a deciduous forest as the vegetative cover of the higher elevations and a deciduous swamp near the water on the rock based part of the island before its disturbance by man.

Older lotic hydrarch succession

If the deposition of Coastal Plain sediments at the south end of this rock island were fairly rapid to produce a bar as occurs at the Three Sisters Islands, then the typical lentic hydrarch succession with its cat-tails probably did not occur or was of limited extent. The plants which are found on the bars of the Three Sisters Islands are Cyperus erythrorhizos Muhl., Polygonum punctatum Ell., Echinochloa crusgalli (L.) Beauv., and Cornus amomum Mill. These same plants probably occurred on the bar at the south end of the island with the exception of Echinochloa crusgalli which is not native to the New World. Echinochloa walteri (Pursh) Heller which is native to the Washington, D. C. area and is also found in wet places may have occurred on the bar of Theodore Roosevelt Island.

The present bar on the east side of the island is dominated by deciduous swamp (Figure 27). On this older bar or river terrace a deciduous swamp probably followed this herbaceous vegetation and when the land uplifted or the river level lowered the drier land gave way to a deciduous forest, or perhaps the gradual buildup of the swamp floor resulted in forest before the river level or land changed. In any case the end result appears to have been a deciduous forest (Warden, 1816, pp. 138-141, 147; Figure 24; Roosevelt Memorial Association, 1931; Arnold, 1934).

As the land was uplifted, or the sea lowered, the river must also have cut deeper into its channel. This would have lowered the water level and exposed new land surfaces to be invaded by vegetation. Some of the new land surfaces were mud, sand, or gravel from river deposition and deposition from island runoff. These same bar plants probably became pioneers on this new land next to the water. If the change in river level was rapid then fairly dry alluvium would be exposed and the succession of plant communities may have been similar to the common concept of secondary succession--bare ground to herbs to the woody shrubs and trees--which ends in a deciduous forest. In places where schist was exposed xerarch succession would have begun.

Even after the exposure of new land by the change in the river level a new bar would have started forming at the south end of the island. The increased tillage of the land of the upper Potomac drainage by 1811 (Custis, 1811) resulted in more erosion products that helped to accelerate the growth of a bar forming at that time.

River channel changes

The east side of Theodore Roosevelt Island is a relatively new addition to the island. In former times very little alluvial material collected on the east side, otherwise the present alluvial lowland would have formed long ago. Periodic floods probably washed away whatever had accumulated. The balance between deposition and erosion must have been delicate because greater than usual deposition would have occurred due to the influence of the tide in slowing the river current.

The island is located at a bend in the river (Figures 3, 4, and 5). Sediment would have been deposited on the inside of the bend (Gilluly, 1959, pp. 203-206) making the Little River shallower than the Georgetown channel. George Washington Parke Custis, quoted by Jackson (1878, p. 71) said that before 1784 the east and west channels around the island were both open and ships sailed up the east channel to Georgetown.

The situation may have been as follows. Alluvium was deposited in the west channel (inside part of the bend) making the river shallower at this point. Floods periodically flushed both channels out as happened in 1784 and 1852, and probably in 1870 and 1877 (Jackson, 1878, pp. 71, 74, 75). With these flushings the west channel became the main river channel.

With the Little River as the main channel the reduced flow of water in the east channel hastened deposition on the east side of the island (which is the inside bank of the east channel). At the same time, however, the west channel began to fill in and as the water depth became shallower more water passed through the east channel and deposition slowed down. When the extreme floods and ice floes came both channels would have been scoured to some extent, but the west channel acting as a chute cutoff, a short cut, would have received the brunt of the flushing and become the main channel again. Thus the east and west channels tend to alternate as the main river channels.

Younger lotic hydrarch succession

The small lowland, or most of it, on the northeast side of Ellicott's map or plan (Figure 4) in 1792 probably developed since the flood of 1784 which flushed out the river channel. Note that both channels are deep at this time. The Dermott map (Figure 7) which shows many more soundings shows that in 1798 both channels were about equally deep.

The vegetation on this bar was probably the same that was found on the former bar at the south end of the island and hence the same that is found on the bars of the Three Sisters Islands. The bars of the Three Sisters Islands are submerged at high tide and appear to be dominated by grass, Echinochloa crusgalli. Either this grass or E. walteri could have been growing on Roosevelt Island in 1792. The alluvial meadow that Martin (183_, p. 494) mentioned was rapidly forming on the north side of the island probably was dominated by one or both of these two grasses.

In 1810 a causeway was built from the island to the Virginia shore (Green, 1962, p. 35). With the damming of the Little River, the whole brunt of river deposition was thrown on the east channel. The sediment which normally would have been deposited in both channels was now being put down in one channel with the result that the small alluvial accumulation of 1792 (Figure 4) expanded rapidly (Figures 8, 9, and 10). A bar also formed behind the causeway (Figure 10). The piers of the aqueduct (Figure 9) and later the Key Bridge (Figures 19, 20, 21) would have caused deposition by creating a frictional drag on the current.

As the bar grew higher, shrubs such as Cornus amomum (a conspicuous shrub on a bar of the Three Sisters Islands) would probably have started growing, and later trees arrived. Besides the process that builds up bars (and spits), the process that builds natural levees was and still is operating. Along the entire bar or spit on the east side of the island is a natural levee. As would be expected, then, trees and shrubs would start growing first on the higher ground of the levee. This seems to be confirmed by Robert King's map of 1803 (Duhamel, 1935, facing p. 145) which is substantially the same as Figure 8. On these maps trees are shown on the outside of the marsh land next the river. Figure 10 (in 1849) shows definitely a small island of trees at the northeast corner of the island which is surrounded by marsh on three sides and water on the fourth. Fifteen years

later (Figure 12) this island of trees is connected to the rock based island by a bar that is definitely higher than the marsh and alluvial meadow. This connecting bar continued to grow especially in width (Figures 13 through 15, 24, 26, 27). The alluvial meadow of Martin in 183_ was by 1849 (Figure 10) being transformed into a swamp. The map symbols indicate both in Figures 8 and 10 deciduous trees. Figure 11 shows symbols for evergreen trees. It is possible that a few Pinus virginiana Mill. occurred in the lowlands of the island, but probably not as shown in this Figure. Two of these pines are growing at the north end of the island north of the present causeway trail (Figure 1), but not on the bar. Subsequent maps (Figures 13, 15, 19, 20, 24, and 25) do not show evergreens. Examination of Little Island, the most recent part of the bar or spit (field check and Figure 24) gives no evidence of evergreen trees as part of the successional pattern.

Lentic hydrarch succession

As the bar on the east side of the island extended itself into a spit, marsh vegetation developed in the slower protected waters (Figures 4, 7 through 10). As water was being changed into marsh, the older parts of the marsh next to the spit were being converted into swamp (Figures 11, 13, 16, 18 through 21). In other words the marsh was adding to the spit accumulations and adding trees and shrubs by lentic hydrarch succession to the woody plants already there on the bar by lotic hydrarch succession.

Other marsh areas have developed in the slack water depressions of the shore (Figures 18 through 21, and 24). Warden (1816, p. 147) mentioned reeds in a marsh of the island. The reeds in the midst of which the muskrats built their houses (ibid.) were probably the cattails (Typha latifolia L. and T. angustifolia L.) which abound in the present marshes.

Changed stream pattern

When the flood of 1852 came it washed out the west channel just as the flood of 1784 had done (Jackson, 1878, pp. 71 through 73), but the accumulations in the east channel and at the south end of the island were too great to be removed to any great extent (Figures 10, 11, and 12). If anything noticeable was done to the eastern accumulations by this flood, it was to make the incipient inlet on that side (Figures 9 and 10) more pronounced (Figure 11). This was probably done by a combination of deposition on the spit where the trees offered more resistance to the current and gouging out the marsh with its less resistant herbaceous vegetation.

The total effect of the situation now was that the deposition rate had exceeded the erosive power of the stream. The spit continued to grow (Figures 13 through 16).

Changed position in river

As was mentioned previously (see Geology, this paper), this island apparently started somewhere near the middle of the river. As the main channel alternated between the east and west sides of the island (River channel changes, this paper), the island would be located to one side or the other of the middle. This explains why Little River is shown wider than the Georgetown channel in Figures 3, 4, and 6. The flood of 1784 had opened up this channel as the main channel (Jackson, 1878, p. 71).

By 1797-8 (Figure 7) the west channel had apparently already begun to fill in (River channel changes, this paper) to become narrower. The causeway was built later (Green, 1962, p. 35) and this prevented upstream alluvium from being deposited in Little River. After every flood that washed out the causeway (1852, 1870, and 1877; Jackson, 1878, pp. 73, 75), the river would have deposited detritus in this west channel. Little River has progressively become shallower and narrower not only from river alluvium but also the conversion of water to land by the marshes on both shores of the channel (Figures 4, 7, 9, 10, 12, 13, 15, 19, 20, 25, and 26).

The diminution of Little River was hastened by artificial fill on the Virginia side. Between 1863 and 1931 six acres of fill were placed at the north end of Little River (Figure 22). Figure 23 shows that almost two-thirds of Little River at the north end of the island was filled in. A permit was given in 1954 (Gartside) to place 6,000 cu. yd. of earth and broken concrete for the proposed access road to the causeway (compare Figures 25 and 26). A map and contract (National Capital Parks, 1954; and 1954-1956) shows the fill area between the Virginia shore and a small island, (Figures 20, 24, 25) in the Little River channel. This explains the disappearance of this island (Figures 25 and 26).

When the present causeway was built in 1954-5 (Zywicki, 1955; Thompson, 1955), it was constructed low so that it was under water at high tide. Alluvium is now dropped everyday by the stream as it is slowed down by the incoming tide. A bar can now be seen on the upstream side of the causeway at low tide (field observations from 1958 to 1963).

Origin of Columbia Island

In 1818 (Figure 8) the island was still largely the rock based land (note New Hampshire Avenue extended comes almost to the tip of the island). By 1838 (Figure 9) the accumulations at the south end of the island more than doubled the length of the island. By 1884 (Figure 13) this southern extension of the island was rather well defined and covered with marsh. This extension was considered as a part of the island (Figures 14, 17, 18).

These southern accumulations are in the same place as the present Columbia Island (compare Figures 18 and 19). Hydraulic fill (Bartel, 1963) plus the severance of this land (see Origin of Little Island) from the higher

land northward created a Columbia Island solid enough to support a bridge and roadway (Figures 20, 21, and 25).

Origin of Little Island

At least by 1864 (Figure 12) a small channel started to develop between the rock based land and its southern alluvial extension. By 1884 (Figure 13) this channel was fairly well defined. It appears to be a natural development. Soon after Columbia Island was built from the south part of Roosevelt Island (Analogostan Island), Little Island was cut off the north end of Columbia Island (Figures 19 and 20) apparently by dredging. Carstens (1963) says that this shallow (8 to 9 foot) channel between Little Island and Columbia Island was a proposed dredging area which would explain its sudden appearance between 1928 (U.S. Coast and Geodetic Survey, 1928; substantially the same as Figure 19) and 1929 (Figure 20).

Vegetational changes by man

While the physical aspects of the island have been changed by the influence of man, the vegetation has also changed under the same influence. Warden's description (1816, pp. 138-141, 147) of the wild plants on the island must have been from remnants of vegetation left comparatively undisturbed, for the island, except the alluvial land, was under cultivation and in pasture land (Warden, 1816, pp. 141-144, 150, and 151; Duhamel, 1935, map facing p. 145; Figure 8). From 1842 to 1932 the island had several owners (Duhamel, 1935, pp. 144, 145; Congress, ^{sensu} 1932). During this time the vegetation of the higher land was periodically disturbed by the various uses to which it was put (Roosevelt Memorial Association, 1931; Duhamel, 1935, pp. 144, 145). The running track of the Columbia Athletic Association (Club) of the late 1880's was located in the vicinity of D (Figure 24; Duhamel, 1935, p. 145; Olmsted Brothers, 1935d.)

A succession (secondary) of plant communities on the higher land starting with cultivated and pasture fields (Warden, 1816, pp. 141-144, 150, 151; Duhamel, 1935, map facing p. 145; Figures 4, 8) and ending in hardwood forest (Figures 9 through 13, 15, 19, 20, and 24; Arnold, 1934) had occurred by 1934.

The next large disturbance of the vegetation, however, was the extensive planting operation in 1935-6 (Olmsted, 1943; Arthur, 1936). Olmsted (1934) recommended the removal of fallen deadwood, standing dead trees, and dead and living weedy growth consisting mainly of brambles, grasses, Japanese honeysuckle, poison ivy, and sumac. Reports by Fahey (1934), Jeffers (1934), Olmsted and Pope (1934), and Arthur (1936) showed that the weeding work including removal of Japanese honeysuckle and deadwood, brush, and weedy trees (undesirable and overabundant trees) was done on the island. The latter included boxelders up to 4 and 5 inches in diameter. In the fall of 1935 there were 25,000 young trees and shrubs

planted, and in the spring of 1936 additional shrubs and ground plants were set out (Arthur, 1936). Finnan (1936a; 1936b) mentioned that 10 or 15 acres of lawn had been planted.

The flood of March, 1936 did damage to the plantings. Fahey (1936) said that the whole northern end and the lower portions of the east and west sides had been completely scoured of top soil leaving the roots of all the trees remaining exposed to the air. Olmsted Brothers (1936b) said that perhaps some scattered remnants of the plantings at the north end were spared by this flood.

In a letter to C. Marshall Finnan (Superintendent, National Capital Parks) from Olmsted Brothers (1935b) it was mentioned that honeysuckle did not occur on the small island, but a dense stand of small boxelders should be removed. Finnan (1935) directed that the boxelders should be removed as recommended. The removal of the boxelders apparently opened up the lowland forest on Little Island to allow invasion by the Japanese honeysuckle, because Little Island at this time is heavily covered with this exotic vine.

The cleared areas C and D in Figure 24 were planted with trees (Olmsted, 1935d; Olmsted Brothers, 1935c). In area D many of the small trees were removed and part of the area prepared for lawn (Olmsted, 1937; Olmsted Brothers, 1937, and 1943). Now area D has reverted to forest.

Area E (Figure 24) has partly grown up to forest and partly grown up to a thicket. This area (E) is on the south and east side of the present orientation station at the north end of the island. In 1935 (Olmsted, 1935a, 1935b) Mr. Olmsted proposed toilet facilities and shelter in this clearing in connection with a picnic area. These facilities were never built. The area was not planted in the 1935-6 planting operation (Olmsted, 1935c, p. 4; 1935d). The grading plan (Olmsted Brothers, 1937) for the picnic area which includes this area shows quite a few trees already in the area. Olmsted (1936b) in referring to a list "Plant Materials Required to Complete Planting Roosevelt Island" said that the general plan calls for a considerable amount of additional planting other than that on the list, especially at the southern end of the island. The records do not indicate whether planting was done in this cleared area or not. For these reasons the successional background of this area was not included in Figure 27, but appears only as deciduous forest.

Area F (Figure 24) according to Olmsted Brothers (1935c, 1943) was a comparatively high area due to filling. A field check was made of this area. The fill is apparently natural. Olmsted apparently was merely stating that the marsh next to the swamp in this area was slightly higher than the marsh southward. He suggested that the area be planted with ash and baldcypress. The area apparently was planted with white ash, Fraxinus americana L., and common baldcypress, Taxodium distichum (L.) Richard (Olmsted, 1936a; Olmsted Brothers, 1935c, 1936a, and 1936b). This area is shown in Figure 27 as swamp.

Olmsted (1934) said there had been occasional brush fires on the island in the past. Both he and Pope said (Olmsted and Pope, 1934, p. 2) of the field at the south end of the island (Figure 27) that fire had denuded the area of good trees. Jeffers (1934) said that this area was already open. However, this statement must have been somewhat relative because the map of 1932 (Figure 24) does not show this as a cleared area. Another map made in 1932 (Office of Public Buildings and Public Parks) shows all the clearings of Figure 24 as grassland or meadow, but does not show this as a cleared area. Although an open area, it must have been cleared further in order to be treated mainly in open turf and other low growth as recommended by Olmsted and Pope (1934).

Recent succession and present habitats

As a result of the natural and artificial influences on the island there are eleven habitats which can be recognized by their physical or vegetational characteristics. Seven of these habitats are listed in the legend of Figure 27.

The intermittent spring or seep is shown in Figure 1 instead of Figure 27. The spring or seep appears to have been hollowed out by man.

The intertidal habitat which surrounds both Theodore Roosevelt and Little Islands between the low and high tide levels is not shown in Figure 27. The mean range of the tide is 2.8 feet and the spring range is 3.2 feet (Coast and Geodetic Survey, 1963). This habitat is composed primarily of sand and mud, and in some places Wissahickon schist is exposed at low tide.

Closely related to the intertidal habitat is the open water (Figure 27). Even at low tide all the water does not drain from the inlet at the south end of the island, or the small inlet at the northwest corner of the island (field checks made in 1962 and 1963).

The marsh is a wet area (Table 3) dominated by herbaceous vegetation. Part of the marsh area in 1955 was open water in 1932 (Figure 27). Alluvial deposits from the river and cumulose deposits from the adjacent vegetation would account for this change in habitat. The marshes are in areas protected from the river current, so cumulose deposits would assume greater importance as the protection increased.

There is no sharp dividing line between swamp and forest. Both habitats are dominated by trees and shrubs, but the swamps are generally more moist than forests, but not as wet as marshes (Table 3). There may be a difference in species composition, but no studies were made to confirm this. Much of the higher part of the island was planted with trees and shrubs whereas a large part of the lower ground was left comparatively untouched (Olmsted Brothers, 1935c, 1936a; Olmsted, 1935d, 1936a). For this study the 12 foot contour (M.L.W. datum) was used as the dividing line between the habitats, thus the swamp receives most of the floods (Table 2).

2

Some of the areas that were swamp in 1955 were marsh in 1932, while other swamp areas were water (Figure 27). The build up of the soil and lowering of the soil moisture (Table 3) would be mostly by cumuloose deposits in the change from marsh to swamp, but in the change from water (or intertidal area) to swamp the alluvial deposits must be more important. At the north end of the island where the deciduous swamp is found on the Piedmont, the soil would be largely residual. As the weathering of the schist in this area progressed deeper into the rock, water probably would have filled the pores so that a swamp would develop from the bare rock instead of the deciduous forest.

In some of these "was water, now swamp" areas there may have been a marsh stage before the swamp developed; other areas are so small they may be due to discrepancies in mapping. Most of these "was water, now swamp" areas probably had no intermediate stage of successional development either because the river current would be too swift for the establishment of a marsh, or the water and intertidal area was too shaded by shore trees for marsh development.

Areas A and B on the map in Figure 24 are shown as cleared. Another map (Office of Public Buildings and Public Parks) completed in 1932 shows both these areas with grass or field (not marsh) symbols, yet these areas must certainly have been marsh rather than field. A field check of these areas in October of 1963 shows that they are noticeably lower than the rest of the swamp on Little Island. An examination of Figures 16, 18, and 19 shows that area A was water at least as recently as 1922. In all probability these two areas were dominated by Phalaris arundinaceae L., a grass that is found throughout the marsh around the inlet at the south end of the main island and that dominates the small isolated marsh (C) shown in Figure 27.

Between the swamps and the adjacent marshes is a wet thicket. This zone contains many trees and shrubs, but is open enough to allow many marsh plants to grow under the canopy. The soil is drier than in a marsh, but wetter than a swamp (Table 3). A good place to see this type is at B in Figure 27.

Except for the hemlock grove, the forest on the island is deciduous. Like the swamp it is dominated by trees and shrubs, but it is on the higher ground above the swamp. The small area at the north end of the island "was field, now forest" (Figure 27) was a clearing in 1955, but at the time of this study (1963) is dominated by deciduous trees and shrubs.

The soil under the deciduous forest is largely residual (Raymond Concrete Pile Co., 1962; Figure 1), except along its borders and at the southern end where it occurs on the Coastal Plain (Figures 1 and 27). Some of the alluvial soil material is undoubtedly deposited on parts of the residual soil during high floods (Table 2).

The hemlock grove is an artificial habitat. The hemlocks were planted in the 1935-1936 planting season (Olmsted Brothers, 1935c; Olmsted, 1935d,

1936a, 1943). A search has been made on the island for several years and although cones are produced by these trees, no seedling hemlocks have been found. It would appear that they are so far removed from their natural environment that they cannot reproduce themselves.

The hemlock grove is on quite high ground and probably seldom if ever receives any transported soil materials. It is certain that it has not since the grove was planted (Table 2). The residual soil under the grove has a moisture content similar to the deciduous forest surrounding it (Table 3). As might be expected under coniferous trees, the soil is acid (Lutz and Chandler, 1946, p. 368; Table 3).

The fields are areas dominated by herbaceous vegetation. Grass is often a conspicuous part of the vegetative cover, but in the summer and fall these areas may appear to be dominated by wild flowers. They are the driest of the habitats listed in Table 3. The field at the south end of the island is on alluvial soil, while at the north end the field grows on the Piedmont. Like the forest at the north end of the island, the field probably receives some alluvium during floods (Table 3).

Between the deciduous forests and adjacent fields there is generally a thicket zone made conspicuous by shrubs and small trees, but open enough to contain many herbaceous plants. The soil moisture content is about the same as for the forest (Table 3). The southern part of the north field at A in Figure 27 is actually more like a young thicket. Here the area is dominated by tall herbs and brambles (Rubus).

Rocks outcrop in various places on the island. These are generally well shaded and influenced by the surrounding vegetation. The largest and most conspicuous place is the somewhat detached area at the boat landing (Figure 27). This rock habitat is characterized by having a rather large bare rock surface, small amount of soil, and plants growing mostly in the crevices. With no protective soil and vegetative covering, the area undergoes extremes of temperature and moisture. Table 1 shows a few of the plants that grow under these conditions.

The shore lines of 1932 and 1955 are shown in Figure 27. In some places new land has been added as previously explained, but in other places especially at the north end, land appears to have disappeared. This may be due to discrepancies in mapping, but it may also be due to an actual loss of land by erosion. Fahey (1936) said that the flood of March 1936 completely scoured the north end of the island of topsoil and removed many of the plantings (Fahey, 1936; Olmsted Brothers, 1936b). Some of this soil erosion was of course due to the soil disturbance by the many plantings, yet it may be possible that the floods of 1936, 1937, and 1942 and many minor floods (Table 2) could be responsible for removing some of these areas.

There is no large variation in the soil pH on the island (Table 3). According to Olmsted Brothers (1935a) numerous tests of the soil pH were

taken on the island and they showed a general tendency toward alkalinity with a few spots as low as pH 5. Table 3 shows the soil of the island to be slightly acid. The discrepancy may be due to different methods of determining the pH, although the record does not indicate how the former tests were conducted. It must also be remembered that soil pH in a forest is not constant, but varies throughout the year (Lutz and Chandler, 1946, p. 366).

Future habitats

There are two spits on the island. One is on the east side and the other one is starting at the northwest corner. The spit at the northwest corner is growing to form a bar across the mouth of the inlet. Even now the water does not completely empty from this inlet at low tide (field checks made in 1962 and 1963).

Another bar was growing at the south end of the east spit until the dredging for the Theodore Roosevelt Memorial Bridge piers took place between Theodore Roosevelt Island and Little Island. (Construction on this bridge started December 15, 1959.) The author observed in the summers of 1958 and 1959 that as this bar built up it would completely close off this tidal inlet. Even with this bar dredged out this incipient lagoon is not completely emptied at low tide (field checks made in 1962 and 1963).

When the bars across the mouths of these inlets are complete there will be two small ponds on the island.

SUMMARY AND CONCLUSIONS

Geology

A significant revision of the geology of Theodore Roosevelt Island was made using boring data, a map of the rock outcrops, and revised nomenclature of the formations.

The island apparently began as a remnant of resistant schist (Piedmont rock) in the Potomac River and through alluvial accretions a significant part of the island today is composed of Coastal Plain alluvium, both the older higher river deposits and the lower more recent alluvial flood plain. The island has grown more rapidly within the past 200 years than it has in previous years. This is attributed partly to increased erosion and deposition from man's disturbance of the watershed and partly from the building of a causeway which changed the stream flow pattern. A change in the position of the island in the river by artificial fill as well as the natural fill from the influence of the causeway emphasized this changed flow pattern. Build up of the eastern flood plain was prevented before this time of rapid growth by an alternation between the east and west channels around the island as the main stream with periodic flushings of both channels by floods and floes.

Columbia Island was shown to have originated from the more recent southern accretions of Theodore Roosevelt Island and at one time was considered a part of this island. Little Island was shown to be the cut off northeast corner of Columbia Island.

Vegetation

Maps covering a period of more than 160 years show hydrarch successions that start with water, progress to herbaceous marsh, and end with deciduous swamp. Maps covering a period of more than twenty years show a hydrarch succession from water to deciduous swamp without the intermediate marsh stage.

Secondary succession of habitats on the upland from open areas to forested areas of deciduous trees and shrubs is shown on maps covering a period of over 160 years. Historical descriptions supplement the data from the maps.

A xerarch succession on the schist is suggested on the basis of plants growing at the present time on essentially bare rock and the final covering of the Piedmont part of the island. The succession suggested for the lower part of the rock near the water is from bare rock to lichen-moss community to herbs to deciduous swamp, and on the higher elevations of rock (except in water holding depressions) pines and deciduous trees would follow the herb dominated stage with the pines eventually disappearing and leaving a dominant deciduous forest.

A hydrarch succession on the higher river deposits at the south end of Roosevelt Island is suggested progressing from deciduous swamp to deciduous forest.

Historical information shows that the present deciduous forest was largely planted and the hemlock grove completely planted in 1935 and 1936, while the other habitats are largely the result of natural forces.

Information from field trips correlated with that from history brings forth strong evidence that disturbance of the natural habitat has allowed the exotic Japanese honeysuckle to invade and heavily infest Little Island.

There are eleven habitats on this island as a result of both natural and artificial influences. They are the intermittent spring, intertidal, open water, marsh, deciduous swamp, wet thicket, deciduous forest, hemlock grove, field, thicket, bare rock habitats. As a result of natural processes another habitat consisting of two small ponds will be added to these eleven in the future. One of these ponds will be in the northwest part of the island and the other will be in the southeast part.

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