

82-40-017

John S. Truhan Consulting Engineers, Inc.

*A Professional Corporation*

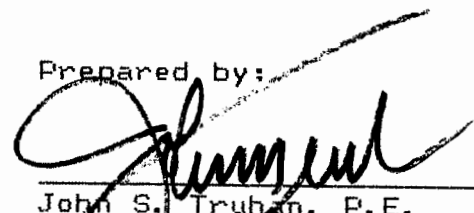
John S. Truhan, PE, PP  
Allen N. Chace, PE, LS  
Dennis J. Galvin, PE  
Joseph Malison, ASLA

1443 Lakewood Road  
Wall, New Jersey

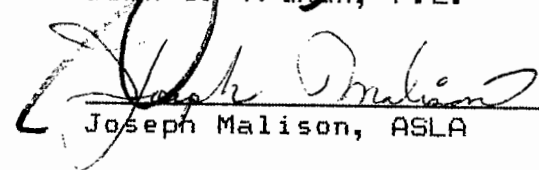
Mailing Address: P.O. Box K  
Manasquan, New Jersey 08736

PHASE I  
NATURAL RESOURCE INVENTORY  
PREPARED FOR  
BOROUGH OF HIGHLANDS  
MONMOUTH COUNTY, NEW JERSEY  
APRIL 23, 1992

Prepared by:



John S. Truhan, P.E.



Joseph Malison, ASLA

## TABLE OF CONTENTS

	<u>PAGE NO.</u>
I. Preface.....	1
II. Project Introduction and Scope.....	2
III. Geology.....	3
IV. Slump Blocks.....	18
V. Soils.....	24
VI. Water Resources.....	40
VII. Natural and Waterfront Features.....	47
VIII. Summary and Recommendations.....	53

## REFERENCES

### LIST OF EXHIBITS

I. Physiographic Provinces of New Jersey.....	4
II. Geologic Map of New Jersey.....	5
III. Shoreline Changes Sandy Hook 1685-1961.....	9
IV. Geologic Map.....	11
V. Slump Block Map.....	20
VI. Slump Block Cross Section.....	21
VII. Detail of Slump Block.....	22
VIII. Areas of New Jersey with Acid-Producing Deposits.....	36
IX. Major Landforms of Monmouth County.....	49
X. Mount Mitchell.....	50
XI. Highlands Bluffs.....	51
XII. Natural Resource Inventory Outline.....	55

### LIST OF FIGURES

I. Diagrammatic Geologic Cross Section of New Jersey.....	6
II. Soil Texture Triangle.....	26
III. Typical Soil Profile.....	28

### LIST OF TABLES

I. General Geologic Column.....	12
II. Geologic and Hydrogeologic Units in the Coastal Plain of New Jersey.....	13
III. Building Site Development/Construction Materials/Sanitary Facilities.....	33
IV. Water Management/Soil and Water Features/ Wildlife Habitat.....	34
V. Recreational Development.....	35
VI. Slope Classes in Monmouth County Soils.....	38
VII. Plant Affinity for Wetland Conditions.....	42

TABLE OF CONTENTS  
(CONTINUED)

PAGE NO.

LIST OF PHOTOGRAPHS

I.	Oblique Aerial Photograph of Slump Blocks A and B.....	19
II.	An Area Along the Eastern Edge of the Tinton-Phalanx-Urban Land General Soil Map Unit.....	29
III.	An Exposure of Iron-Cemented Sandstone in an Area of Phalanx Loamy Sand, 0 - 10 Percent Slopes.....	30

I. PREFACE

The completion of all phases of the Natural Resource Inventory will become a planning tool that can be used by the Borough of Highlands to ensure that environmental criteria is utilized when reviewing property that is proposed for alteration. It is imperative that wise decisions are made early on in this review and decision making process, so future development (or no development, if so warranted) can proceed in a logical manner protecting the health, safety, and general welfare of the public.

Foreknowledge of natural resource constraints and goals will enable the Environmental Commission and Planning Board members to make value judgments on alternatives. Potential problems are addressed and specific concerns worthy of emphasis such as historical preservation, steep slopes, vistas, slump blocks, waterfront access, etc., are carefully managed or preserved.

The citizens of Highlands and the surrounding region settled this area because of its high quality natural resources. The following is a description of Highlands which was written in 1922 that was excerpted from the "History of Monmouth County":

"The Highlands on the Shrewsbury River is at the present day one of the most beautiful locations in the world. Situated twenty-six (26) miles from New York City, by which it is connected by land and water routes, it has a normal population of about eighteen hundred, increased during the summer season to nearly twenty thousand, largely residents of the metropolises of New York and New Jersey, attracted by the boating, fishing, surf and still water bathing. Trolleys connect the Borough with all parts of the County and State, while in the summer seasons boats ply every hour and a half between New York and the Highlands, and the railroad furnishes ninety-two trains daily. There are stores that cater to every want, good markets and fresh products from farms nearby, municipal filtered artesian water, electric and gas light, with churches of all leading

denominations, scenic effects and wealth, making an ideal all-year residential town, with beautiful shaded streets and concrete sidewalks."

While some of Highland's options have been foreclosed, there still remains other areas that need to be addressed and goals need to be established.

The Natural Resource Inventory must be incorporated into the Borough's Master Plan and associated zoning and land use ordinances and include environmental quantity protection standards such as regulations to prevent the destruction of the breathtaking vistas, slope protection, etc., then the Borough of Highlands, which was considered "one of the most beautiful locations in the world", will continue to exist for future generations.

## II. PROJECT INTRODUCTION AND SCOPE:

While it is not possible to address all the material required for a complete Natural Resource Inventory under the scope of the 1991 N.J.D.E.P.E. Matching Environmental Grant Program, the following geological analysis is the first step toward this total inventory goal.

In formulating the methodology for this phase, certain important geological aspects are generally discussed and environmental factor maps were prepared. These geological maps and text will describe potential concerns as they relate to slump blocks, steep slopes, soil limitations, wetlands, and soil erosion.

This data base is based upon presently available literature and recent engineering and planning studies performed by this office in conjunction with the preparation of the Borough's Land Use Master Plan and Waterfront Development Concept. Through the years as being

Borough Engineer, we have discovered and/or are aware of areas of potential concern that were addressed during the preparation of this first overview phase of the Natural Resource Inventory.

The intent of this Natural Resource Inventory for the Borough of Highlands is to provide an introductory information data base that relates and applies local conditions and circumstances to the specific environmental factor. The first phase of the Borough's total Natural Resource Inventory will only address various geological conditions while offering a general understanding of the natural resource.

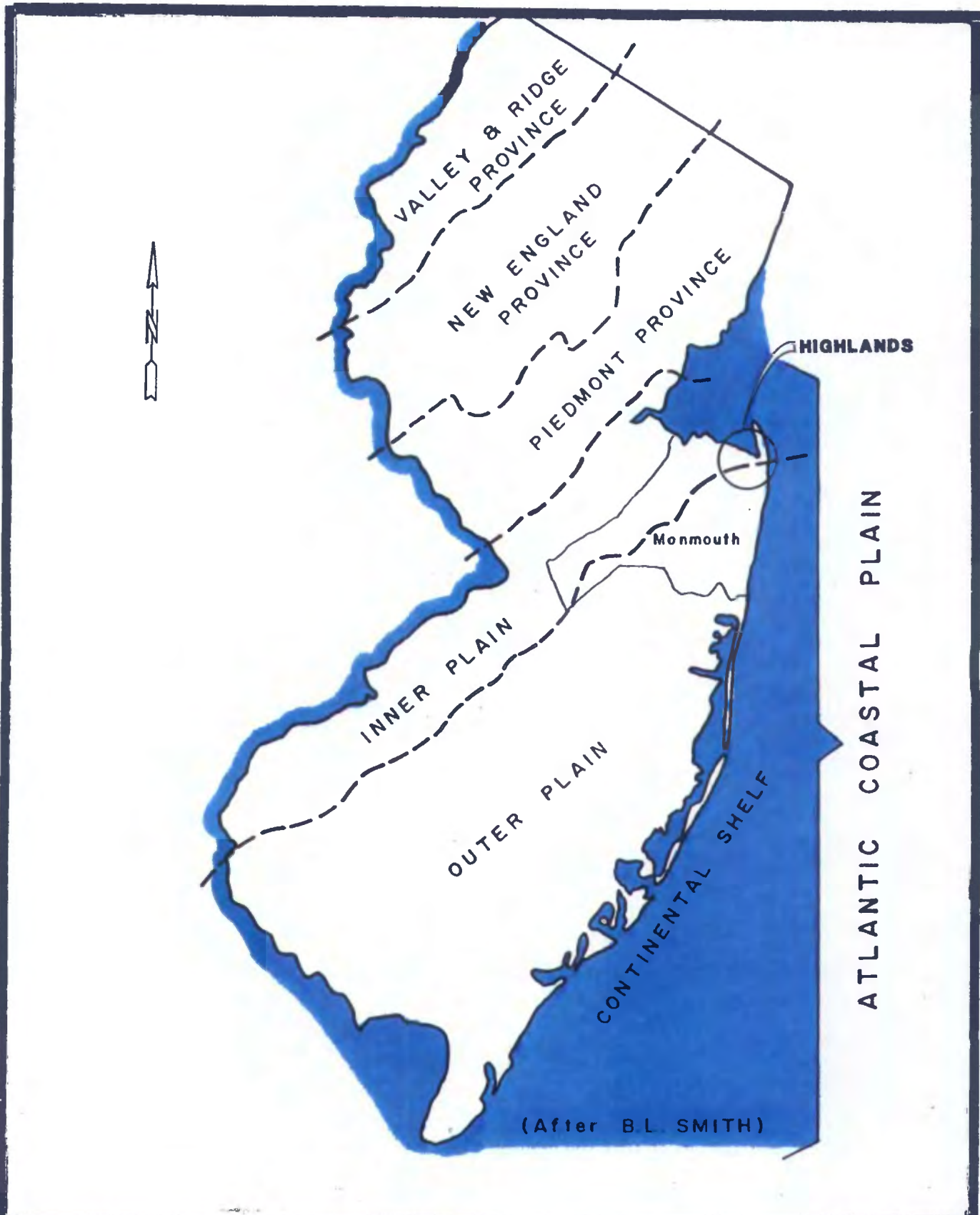
### III. GEOLOGY:

#### A. General Physiography and History:

New Jersey contains four (4) unique and diverse regions known as Physiographic Provinces. These areas (reference is made to Exhibits I and II) are comprised of distinctive landforms and rock formations that drastically influence topography, soil formation, drainage, hydrology, erosion, and plant cover.

Southeast of a line approximately running between Trenton and Carteret is the Atlantic Coastal Plain Province of which Highlands is a part of. This coastal province is further divided into the inner and outer segments, and Highlands is situated on the inner coastal plain.

The topography of the inner coastal plain generally is flat to very gently undulating and overlap the rocks of the Piedmont Province. This area is formed on unconsolidated and semi-consolidated marine and alluvial (water deposited) sediments which are mainly sand, greensand, marl, and clay with variable amounts of gravel in some areas. They have been deposited alternately during sea level



(After B. L. SMITH)

SCALE: 1" = 20± MILES  
 0 10 20


SOURCE: "Natural Features Study for Monmouth County" prepared by the Monmouth County Environmental Council, dated April 1975.

**PHYSIOGRAPHIC PROVINCES OF NEW JERSEY**

**EXHIBIT # I**

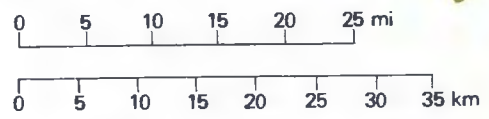
**John S. Truhan Consulting Engineers, Inc.**  
*A Professional Corporation*

- SEDIMENTARY ROCKS**
- CENOZOIC**
- Holocene: *beach and estuarine deposits*
  - Tertiary: *sand, greensand marl, clay*
- MESOZOIC**
- Cretaceous: *sand, clay, greensand marl*
  - Jurassic: *siltstone, shale, sandstone, conglomerate*
  - Triassic: *siltstone, shale, sandstone, conglomerate*
- PALEOZOIC**
- Devonian: *conglomerate, sandstone, shale, limestone*
  - Silurian: *conglomerate, sandstone, shale, limestone*
  - Ordovician: *shale, limestone*
  - Cambrian: *limestone, sandstone*

- IGNEOUS AND METAMORPHIC ROCKS**
- MESOZOIC**
- Jurassic: *basalt*
  - Jurassic: *diabase*
- PRECAMBRIAN**
- marble*
  - gneiss, granite*
-  Limit of late Wisconsinan glaciation



Scale 1:1,000,000



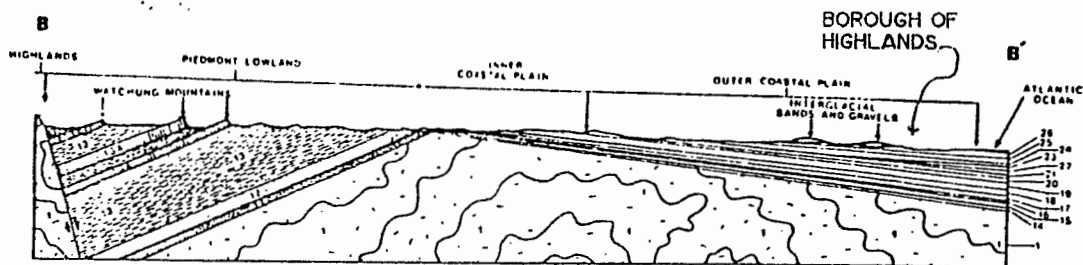
**EXHIBIT II  
GEOLOGIC MAP OF NEW JERSEY**

Department of Environmental Protection  
Geological Survey

1984

fluctuations which covered most of the State. These sediments, which range in age from the present time to 135 million years ago (cretaceous geological era), dip toward the coast and extend beneath the Atlantic Ocean (reference is made to Figure I), and the outer coastal plain to the edge of the Continental shelf. They range in thickness from 0 feet along the Piedmont Province to 4500 feet near Atlantic City to more than 40,000 feet approximately fifty (50) miles off-shore near the Baltimore Canyon Trough.

### Diagrammatic Geologic Cross Section of New Jersey

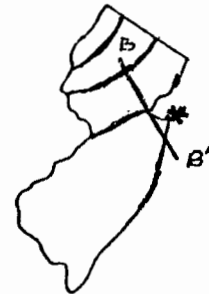


DIAGRAMMATIC GEOLOGIC CROSS SECTION OF NEW JERSEY

J. J. THRELKEL & P. E. WOLFE

**KEY:**

- |      |  |                   |
|------|--|-------------------|
|      |  | <b>Tertiary</b>   |
| 26   | Cohansey sand                          |                   |
| 25   | Kirkwood sand                          |                   |
| 24   | Manasquan-Shark River glauconite marls |                   |
| 23   | Hornerstown-Vincentown marls and sands |                   |
|      |  | <b>Cretaceous</b> |
| 22   | Red Bank-Tinton sands                  |                   |
| 21   | Navesink glauconite marls              |                   |
| 20   | Wenonah-Mt. Laurel sands               |                   |
| 19   | Marshalltown glauconite marls          |                   |
| 18   | Englishtown sand                       |                   |
| 17   | Woodbury clays                         |                   |
| 16   | Merchantville clays                    |                   |
| 15   | Magothy lignitic sands and clays       |                   |
| » 14 | Potomac Group-Raritan Formation        |                   |



Source: Peter Wolfe, The Geology and Landscapes of New Jersey, 1977.

Figure I

The physiography of Highlands is vastly different than any other region of the coastal communities. The most dramatic feature is the bluffs, or the abrupt rise from sea level to over 200 feet. All the other Atlantic Coast communities are characterized by sandy beaches and adjacent lowlands and wetlands and relatively few areas of the entire Monmouth County are above 100 feet in elevation.

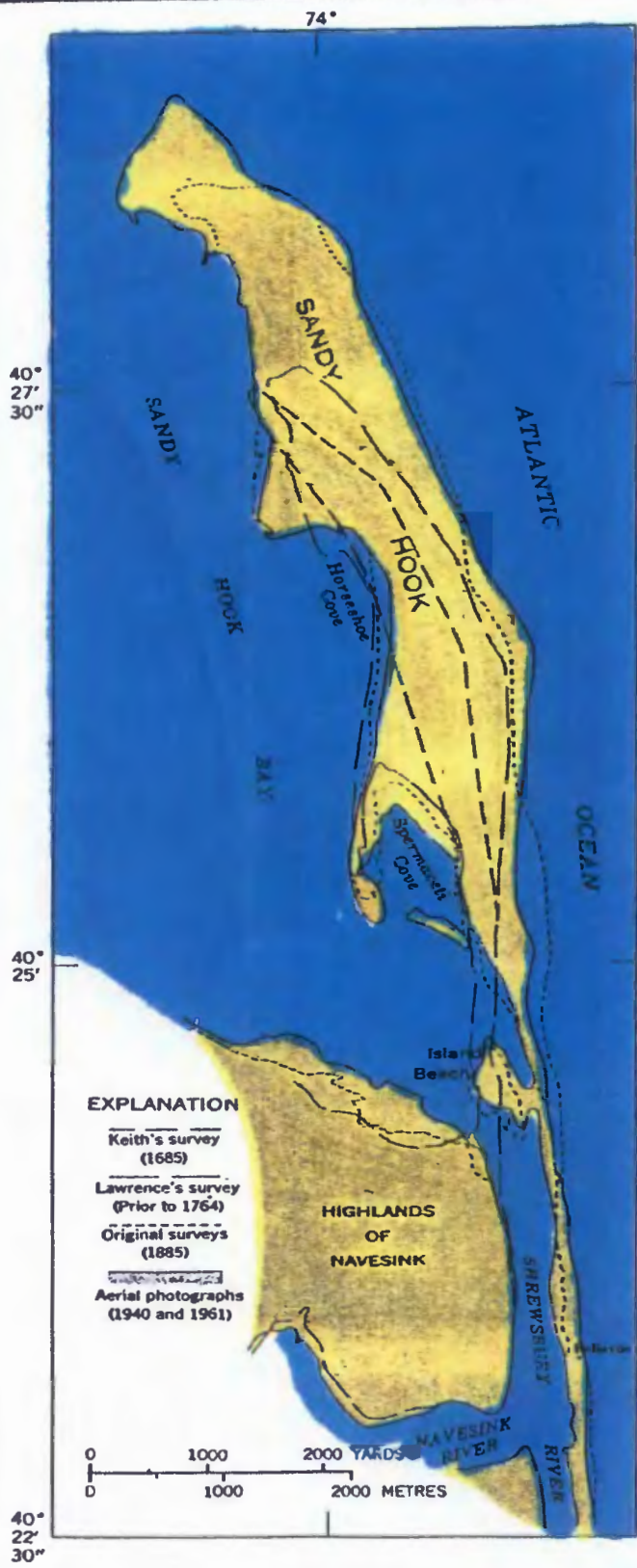
There are other areas in the Coastal Plain Province that are erosion resistant, iron-cemented sediments similar to Mount Mitchell in Highlands, such as Telegraph Hill, Mount Holly, Arney Mount, etc., and are called Cuesta Ridge Peaks (Mount Mitchell is discussed in further detail in Section VII). These ridge peaks extend in a southwest direction across Monmouth County from Mount Mitchell and form the drainage divide between the Delaware River and the Atlantic Ocean. The Borough of Highlands sits east of this line and water drains directly into the Atlantic.

Highlands present coastal waterfront configuration had been greatly affected by the last glacier (the late Wisconsin Advance) which melted back from its maximum extent approximately 20,000 years ago (reference is made to Exhibit II). This rapid post-glacial melting and rise in sea level slowed approximately 6,000 years ago flooding the deepened valleys and previously established shorelines. To the east of the mainland, barrier islands started to form which are continuing to be reshaped by erosion and deposition of beach sand caused by ocean currents and waves.

The mouth of the Navesink River has now been completely blocked by this sand bar or litoral drift and water is now rerouted past Highlands in a northerly direction into the Sandy Hook Bay. At

various times, ocean storms breached this bar and caused an inlet near the present Route 36/Highlands Bridge, but was finally filled in over one hundred years ago. The following is a brief history of the progressive changes of the Highlands shoreline and of Sandy Hook spit, as reported by G. H. Cook in his geological study of New Jersey dated 1885 (Page 77):

"From a point about one and one-third miles (2.1 km) north of Highlands to about one mile (1.6 km) south of it, near Bellevue, on the N.J.S.R.R., the beach has been washed away and remade again and again since the settlement of the country, and doubtless previously by Shrewsbury inlets, once important to navigators. The dates of the inlets, which have been handed down mainly by tradition, are as follows \* \* \* \* Previous to 1778 Sandy Hook was connected to The Highlands of Navesink by a narrow isthmus or bar [Lawrence's survey, fig. 4] and the Navesink or North Shrewsbury River was open to the ocean on the east, there being no beach for about three miles (4.8 km) north of the present Seabright (fig. 2). In 1777-8 a passage was broken through the isthmus, and the tidal currents flowing through this channel allowed the waves to build up gradually a bar or sand reef which closed the eastern passage [through the present bar near Bellevue, Exhibit III] or old Shrewsbury inlet in 1810. From this time on the outer beach continued and the Navesink River flowed through its present outlet [north and northwest, Exhibit III] until 1830 or 1831, when a breach was made in the sand reef and the second Shrewsbury inlet was formed. Shortly after a bar formed across the present mouth of the river and connected Sandy Hook with the mainland, just north of Highlands, by way of Island Beach (Exhibit III). About 1835 the residents of the vicinity undertook to open a channel through the bar, and after much labor cut a ditch through it, which was gradually widened and deepened the tides until it became navigable. The second inlet opened in 1830 or 1831, and closed about 1840. The third opened in 1837 or 1838, and for a time there were two navigable inlets - the second or more southerly being most used. The east inlet closed in the latter part of 1848. Within the past 35 years the sea has made occasional breaches in the strip of beach under discussion [the offshore bar that presently (1974) connects Sandy Hook with the mainland in the vicinity of Long Branch adjacent to the south of the map area (Exhibit III), but the efforts of the property owners, and especially of the railroad company, since the building of the road, have prevented them from attaining any magnitude."



**SHORELINE CHANGES  
SANDY HOOK 1685 - 1961**

**EXHIBIT #III**

**John S. Truhan Consulting Engineers, Inc.**  
A Professional Corporation

SOURCE: "Slump Blocks in the Atlantic Highlands of New Jersey", prepared by James P. Minard and published by the U.S. Department of the Interior as Geological Survey Professional Paper 898, dated 1974.

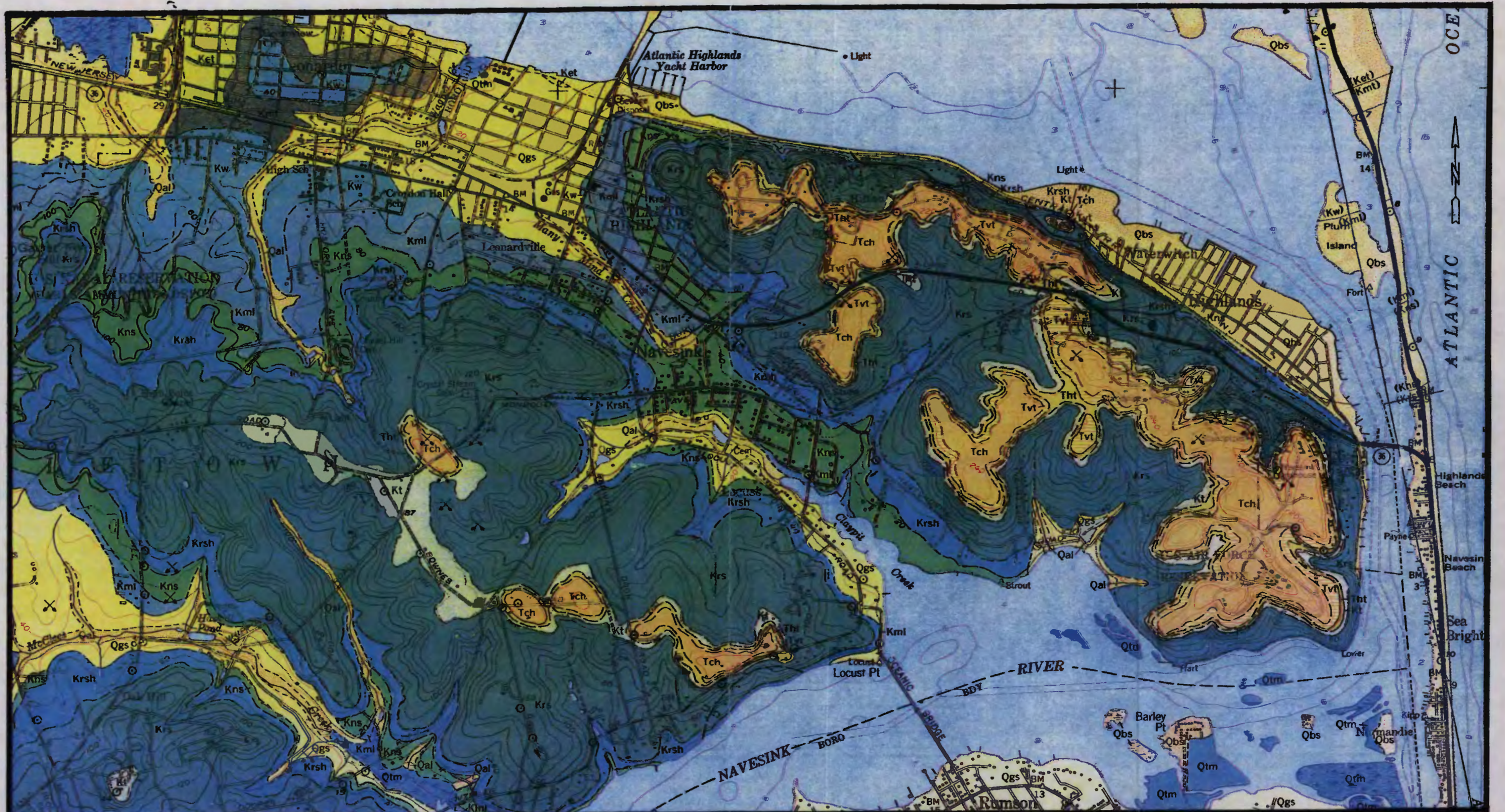
This Coastal Region Drift process has formed the Sandy Hook Spit, which extends some additional five (5) miles further north from Highlands. Sandy Hook, which protects the Borough from the ocean, has lengthened appreciably during the last 100 years increasing in length by more than one (1) mile. However, the majority of Sandy Hook's development probably was at the expense of soil erosion from the Highlands Bluffs and its associated slump blocks (reference is made to Section IV), and other unstable parts of the shoreline along the north side of the Navesink River.

B. Stratigraphy:

Stratigraphy is the geological study of the origin and sequence of the composition and distribution of the underlying sediment layers. Analysis of surficial geology (underground formations) is important for planning purposes in areas where aquifers (ground water) need to be accurately located for public water supplies, home locations on soil formation outcrops that may slump, pollution infiltration and migration to the groundwater, acidic soils, etc.

The area of Highlands not only contains the thickest and most complete stratigraphic cross-section on the N.J. Coastal Plain, it also is very well-exposed and can be easily viewed from downtown looking south along the bluffs.

The exposed stratigraphic layers or out-crops in the Borough consist of eight (8) geological formations (reference is made to Exhibit IV). Tables I and II reveal the approximate time period or age when these layers were laid down by the advances and retreats of the sea. The deposited layers were then subsequently eroded away



Tidal-marsh deposits	Oleocoanite sand	Howestown Sand	Navesink Formation	Marshalltown Formation	Contact Long dashed where approx. locality limited; short dashed where indefinite; detail where concealed
Alluvium	Cohansey Sand	Tinton Sand	Mount Laurel Sand	Englishtown Formation	Fault bounding slump block Dashed where approximately horizontal; U, upthrown side; D, downthrown side
Beach sand	Vicostown Formation	Red Bank Sand Ft. Stevens Member Sandy Hook Member	Wenonah Formation		

SCALE: 1" = 2000'

0 1000 2000

SOURCE: "Geologic Map and Section of the Sandy Hook Quadrangle, Monmouth County, New Jersey", U.S. Department of the Interior Geological Survey, 1969, Bulletin 1276 Plate I.

**GEOLOGIC MAP**

**EXHIBIT # IV**

**John S. Truhan Consulting Engineers, Inc.**  
A Professional Corporation

TABLE I

# GENERAL GEOLOGIC COLUMN

## MONMOUTH COUNTY

(NOT TO SCALE)

DURATION IN MILLIONS OF YEARS

CENOZOIC 65 M.Y.	QUATERNARY 2.5 M.Y.	RECENT DEPOSIT	
		CAPE MAY, BRIDGETON AND PENSAUKEN FORMATIONS	
	TERTIARY 62.5 M.Y.	PLEISTOCENE 2.5 M.Y.	COHANSEY SAND
		MIOCENE 19 M.Y.	KIRKWOOD FORMATION
		EOCENE 16 M.Y.	MANASQUAN FORMATION SHARK RIVER MARL
		PALEOGENE 11 M.Y.	VINCENTOWN FORMATION
			HORNERSTOWN FORMATION
			RED BANK AND TINTON SANDS
			NAVESINK FORMATION
		MEZOZOIC 160 M.Y.	CRETACEOUS 71 M.Y.
MARSHALLTOWN FORMATION			
ENGLISHTOWN FORMATION			
WOODBURY CLAY MECHANTVILLE FORMATION			
MAGOTHY FORMATION			
RARITAN FORMATION			
WISSAHICKON FORMATION			
PALEOZOIC 345 M.Y.	CAMBRIAN 70 M.Y.	WISSAHICKON FORMATION	

Not found  
in Borough of  
Highlands

Not exposed at  
surface in the  
Borough of  
Highlands

Not exposed  
at surface in  
Monmouth County

Geologic and hydrogeologic units in the Coastal Plain of New Jersey

SYSTEM	SERIES	GEOLOGIC UNIT	LITHOLOGY	HYDROGEOLOGIC UNIT	HYDROLOGIC CHARACTERISTICS		
Quaternary	Holocene	Alluvial deposits	Sand, silt, and black mud.	Undifferentiated	Surficial material, commonly hydraulically connected to underlying aquifers. Locally some units may act as confining units. Thicker sands are capable of yielding large quantities of water.		
		Beach sand and gravel	Sand, quartz, light-colored, medium-to coarse-grained, pebbly.				
	Pleistocene	Cape May Formation					
Tertiary	Miocene	Pensauken Formation	Sand, quartz, light-colored, heterogeneous clayey, pebbly.	Kirkwood-Cohansey aquifer system	A major aquifer system. Ground water occurs generally under water-table conditions. In Cape May County the Cohansey Sand is under artesian conditions.		
		Bridgeton Formation					
		Beecon Hill Gravel	Gravel, quartz, light colored, sandy.				
		Cohansey Sand	Sand, quartz, light colored, medium to coarse-grained, pebbly; local clay beds.				
	Oligocene	Kirkwood Formation	Sand, quartz, gray and tan, very fine-to medium-grained, micaceous, and dark-colored diatomaceous clay.	Confining unit	Thick diatomaceous clay bed occurs along coast and for a short distance inland. A thin water-bearing sand is present in the middle of this unit.		
				Rio Grande water bearing zone			
				Confining unit			
	Eocene	Atlantic City 800-foot sand	Sand, quartz, gray and tan, very fine-to medium-grained, micaceous, and dark-colored diatomaceous clay.	Atlantic City 800-foot sand	A major aquifer along the coast.		
	Oligocene	Piney Point Formation	Sand, quartz and glauconite, fine-to coarse-grained.	unit	Piney Point aquifer	Yields moderate quantities of water.	
	Eocene	Shark River Formation	Sand, quartz and glauconite, fine-to coarse-grained.	unit	Piney Point aquifer	Yields moderate quantities of water.	
Paleocene	Manasquan Formation	Clay, silty and sandy, glauconitic, green, gray and brown, fine-grained quartz sand.	confining	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.		
Paleocene	Vincentown Formation	Sand, quartz, gray and green, fine-to coarse-grained, glauconitic, and brown clayey, very fossiliferous, glauconite and quartz calcarenite.	confining	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.		
Paleocene	Hornerstown Sand	Sand, clayey, glauconitic, dark green, fine to coarse-grained.	confining	Vincentown aquifer	Yields small to moderate quantities of water in and near its outcrop area.		
Cretaceous	Upper Cretaceous	Tinton Sand	Sand, quartz, and glauconite, brown and gray, fine to coarse grained, clayey, micaceous.	Composite	Red Bank sand		
		Red Bank Sand					
		Wavesink Formation	Sand, clayey, silty, glauconitic, green and black, medium-to coarse-grained.				Poorly permeable sediments.
		Mount Laurel Sand	Sand, quartz, brown and gray, fine-to coarse-grained, slightly glauconitic.			Wenonah-Mount Laurel aquifer	A major aquifer.
		Wenonah Formation	Sand, very fine-to fine-grained, gray and brown, silty, slightly glauconitic.			Marshalltown-Wenonah confining unit	A leaky confining unit.
		Marshalltown Formation	Clay, silty, dark greenish gray, glauconitic quartz sand.				
		Englishtown Formation	Sand, quartz, tan and gray, fine-to medium-grained; local clay beds.			Englishtown aquifer system	A major aquifer. Two sand units in Monmouth and Ocean Counties.
		Woodbury Clay	Clay, gray and black, micaceous silt.			Merchantville-Woodbury confining unit	A major confining unit. Locally the Merchantville Formation may contain a thin water-bearing sand.
		Merchantville Formation	Clay, glauconitic, micaceous, gray and black; locally very fine-grained quartz and glauconitic sand.				
		Megothy Formation	Sand, quartz, light-gray, fine-to coarse-grained. Local beds of dark-gray lignitic clay.			Potomac-Raritan-Megothy aquifer system	Upper aquifer
	Raritan Formation	Sand, quartz, light-gray, fine-to coarse-grained, pebbly, arkosic, red, white, and variegated clay.	Middle aquifer				
	Lower Cretaceous	Pittsford Group	Alternating clay, silt, sand, and gravel.	Confining unit			
Lower aquifer							
Pre-Cretaceous	Bedrock	Precambrian and Lower Paleozoic crystalline rocks, metamorphic schist and gneiss; locally Triassic sandstone, shale and Jurassic basalt.	Bedrock confining unit	No wells obtain water from these consolidated rocks, except along Fall Line.			

Modified from Zapecza, 1984, table 1

and/or separated into various sands, clays and gravels on top of the old cretaceous rocks.

One of most important formations is the Raritan/Magothy in that it provides approximately 75% of all the water for not only the residents of Highlands, but also Monmouth County. This formation which does not out-crop in this area of the County, is covered by the following formations and only comes to the surface in the East Brunswick/South Amboy area, which is the dividing line between the Coastal Plain and Piedmont Province.

The Borough's main water supply is in this important formation and its associated aquifer (Old Bridge). Highlands wells are at depth of 600 - 779 feet, which is the upper portion of the Raritan/Magothy Formation system.

The eight (8) geological areas exposed are described in general as follows. The description will start with the oldest formation or succession and finish with the youngest sediment. The alluvial or beach sand unit and slump blocks in the steep bluffs along Sandy Hook Bay will also be discussed in this section.

1. Navesink Formation (Kns):

This very narrow band found only adjacent and running parallel to the former railroad tracks consist of semi-consolidated green sandy marl (reference is made to Exhibit IV and Map I). The best exposure are the bluffs where the entire 25± foot thick formation can be seen. Since the Navesink is of marine origin many fossils can be found in some of the outcrops at the base of this formation. This poor permeable sediment (clays and silts) often will be the source of

springs and wetlands caused by water from the overlaying sands flowing downward until it hits this restrictive layer and exits at its outcrop.

2. Red Bank Formation (Krsh, Krs):

This sand layer found also in a thin band above the aforementioned layer actually consists of two (2) members, an upper and lower. The lower member (Sandy Hook Member) is composed of medium to fine grain mycoses sand typically a dark gray and brownish-black in color. It ranges in thickness from about 15 to 30 feet and the contact with the Navesink formation is very distinct.

Both microfossils and megafossils are abundant in this member in some of the outcrops. Soil developed on this member is generally a clay sand which usually is not very well drained.

The upper member of the Red Bank is the Shrewsbury Sand. This sand ranges in color from yellowish gray and grayish orange pink to a moderate reddish brown and can contain ledges and masses of ironoxide-cemented sand particles.

The entire Red Bank formation is excellently exposed from the mouth of the Navesink River west to Atlantic Highlands Yacht Harbor. The entire 120 foot thick sediment layer is nearly continuously exposed in the bluff along Bay View Street at the Waterwitch area about 300 feet southeast of an existing slump block. In addition, this same area also reveals the other four (4) overlying formations that are exposed in the top portion of the bluff. The Navesink Formation and the lower Red Bank contact (Sandy Hook member) can also be seen about 800 feet southeast of this bluff exposure in a road bank cut. The majority of the higher elevations of the Borough

are comprised of this sediment. It is also this loose-bedded sand that contributes to the slumping or landslides of the Borough.

This formation at only time yielded small quantities of water in and near its outcrop area for local residents prior to public water.

3. Tinton Sand (Kt):

The Tinton Formation is the youngest of the Cretaceous formations (60 - 70 million years old) and can only be found in Monmouth County where it attains a maximum thickness of 25 feet. Furthermore, the Tinton, like the Red Bank is only exposed in the Highlands region. This formation consists of 60 - 80 percent glauconite which gives it a light olive gray to grayish green color and the soil that develops from this parent material on the few level upland areas of the town is a clayey sandy soil which allows for poor permeability.

4. Hornerstown Sand (Tht):

This territory marine origin sediment is also a dusky green to grayish-olive clayey glauconite sand and is found along narrow steep outcrops near the steep bluff at Waterwitch and in the area of the twin tower lighthouse. It ranges in thickness from about 5 to 14 feet, has poor permeability, and very little topsoil is developed on it because of its steepness.

5. Vincentown Formation (Tut):

The Vincentown is marine in origin approximately 50 - 60 million years old and the sandy material ranges in thickness from 0 to 35 feet thick in the Highlands area. It is typically light greenish to yellowish gray and locally it is oxidized to a mottled moderate red

and olive brown. This formation is considered to be the most fossiliferous in the coastal plain of New Jersey and contains abundant animal remains, however, based upon geological studies this appears is not the case in the Highlands area.

Due to its narrow steep outcrop characteristic (found only along a thin area on top of the bluffs), very little topsoil has developed on it.

6. Cohansey Sand (Tch):

The Cohansey generally, as a rule, will cap previously eroded formation remnants; however, because of this erosion process, the major Kirkwood Formation usually underlying the Cohansey was not mapped in Highlands. The Kirkwood Formation is generally 60 - 100 feet thick in Monmouth County and 600 feet thick in Atlantic and Cape May counties and is considered a major aquifer.

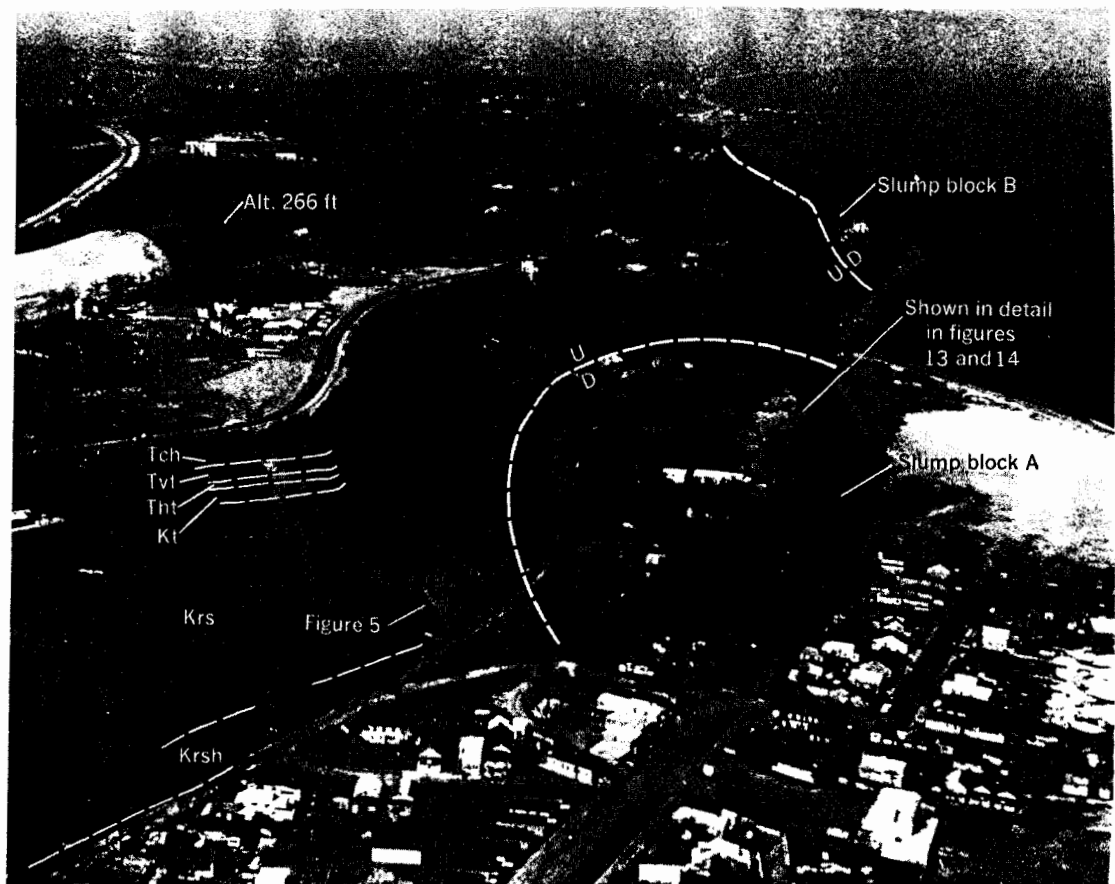
The Cohansey sand which ranges in thickness from 2 - 65 feet is sometimes called the water table aquifer and is located on the highest portions of the Borough; such as the upper part of the bluff at Waterwitch. The formation contains many gravel layers that usually are cemented together by iron oxide water erosion resistant ledges, which probably is the main reason why the high hills and considerable relief exist in Highlands. Much of this rock is in uniform layers and has been quarried to be used for construction of buildings and retaining walls. The topsoil developed from the Cohansey is generally very sandy and locally contains a high level of ironstone fragments. No fossils are found in the formation.

7. Beach Sand (Obs):

Beach sand, which is the youngest sediment, is located under downtown Highlands. These deposits along the south shore of Sandy Hook Bay are comprised principally of quartz sand from the aforementioned underlying formations. The grain sizes range from clay to small pebbles. The sand portions are generally clean and loose therefore shifting or eroding if not protected. These sandy flats are similar to a point bar and have helped in protecting the Highland's bluffs from slumping into the Bay when the Sandy Hook barrier sand bar was breached by the Ocean. It is also thought by Geologist James P. Minard that downtown Highlands is comprised of material from slump block failures along the north and west side of the Navesink River.

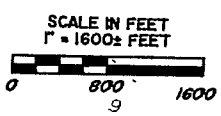
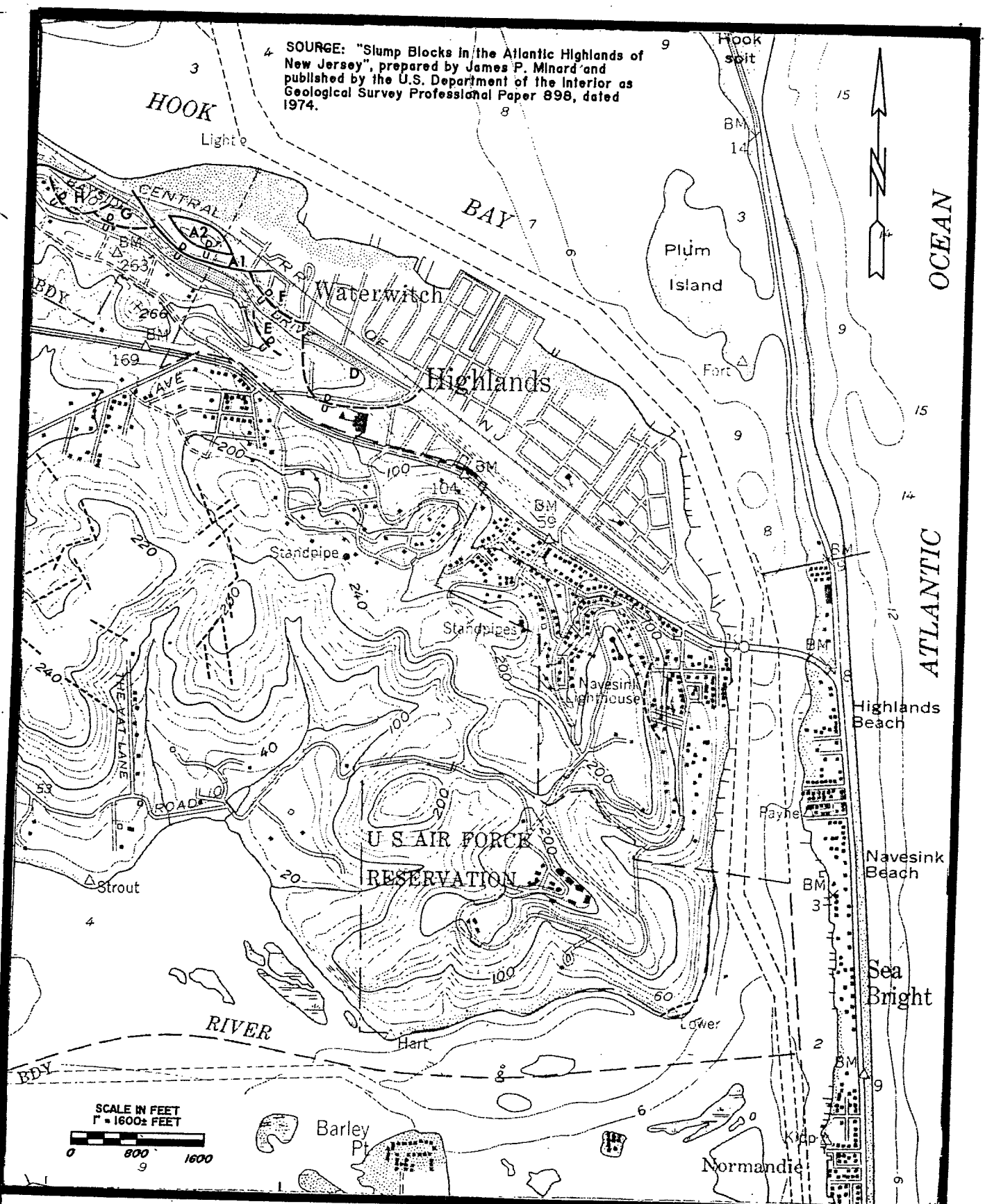
IV. SLUMP BLOCKS:

There are several slump blocks in the bluffs of Highlands which are of concern (reference is made to Exhibits V, VI, and VII, Photograph A, and Maps II and III).



Photograph I - Oblique aerial photograph (looking west) of slump blocks A and B. The concave scarp behind block A (outlined by road on top) and the outward bulges at the bases of both slump blocks can be seen. The units at the top of the bluff, on the left, are exposed in the cutbank in block A, where they have been displaced 85 feet vertically downward of letter symbols.

4 SOURCE: "Slump Blocks in the Atlantic Highlands of New Jersey", prepared by James P. Minard and published by the U.S. Department of the Interior as Geological Survey Professional Paper 898, dated 1974.

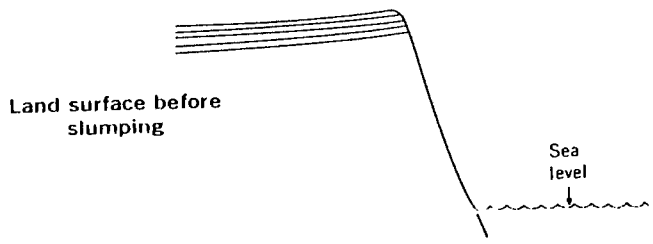


- |         |                                    |
|---------|------------------------------------|
| —       | Lineament                          |
| ---     | Joint or possible zone of weakness |
| - - - - | Uprthrown side of slump block      |
| - - - - | Downthrown side of slump block     |

# SLUMP BLOCK MAP

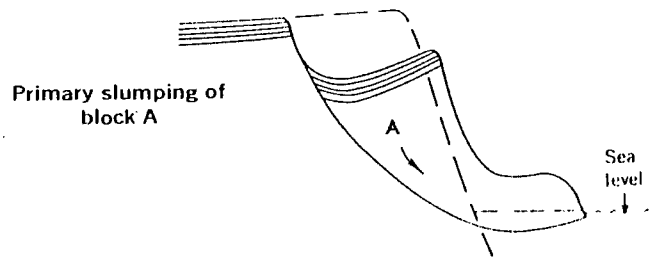
EXHIBIT # V

John S. Truhan Consulting Engineers, Inc.  
A Professional Corporation



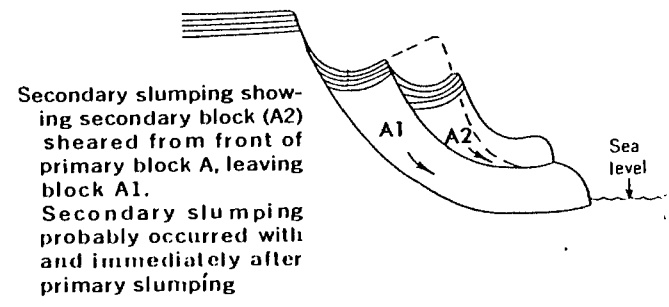
Land surface before slumping

Sea level



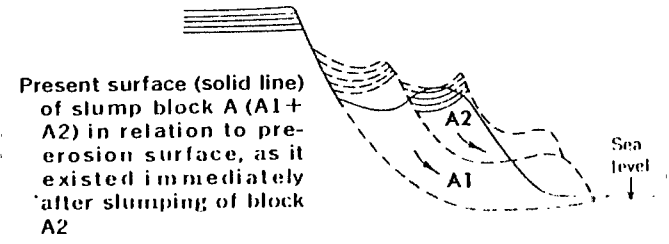
Primary slumping of block A

Sea level



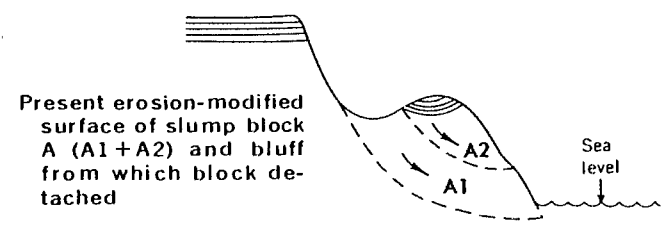
Secondary slumping showing secondary block (A2) sheared from front of primary block A, leaving block A1. Secondary slumping probably occurred with and immediately after primary slumping

Sea level



Present surface (solid line) of slump block A (A1+A2) in relation to pre-erosion surface, as it existed immediately after slumping of block A2

Sea level



Present erosion-modified surface of slump block A (A1+A2) and bluff from which block detached

Sea level

Diagrammatic cross sections through the bluff at the location of slump block A, showing progressive steps in the history of the slumping.

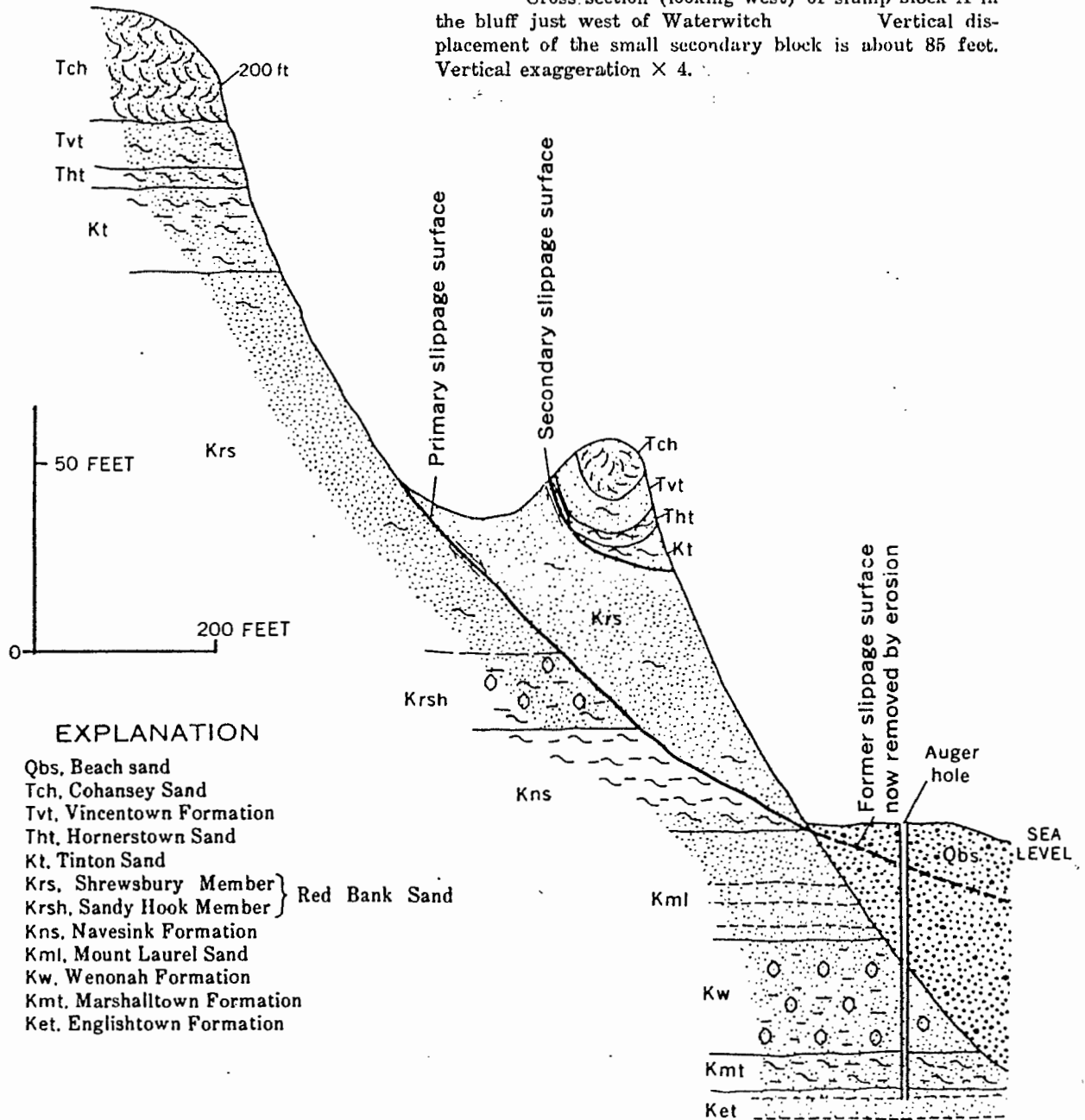
# SLUMP BLOCK CROSS SECTION

EXHIBIT #VI

John S. Truhan Consulting Engineers, Inc.  
A Professional Corporation

SOURCE: "Slump Blocks in the Atlantic Highlands of New Jersey", prepared by James P. Minard and published by the U.S. Department of the Interior as Geological Survey Professional Paper 898, dated 1974.

Cross section (looking west) of slump block A in the bluff just west of Waterwitch Vertical displacement of the small secondary block is about 85 feet. Vertical exaggeration  $\times 4$ .



**EXPLANATION**

- Qbs, Beach sand
- Tch, Cohansey Sand
- Tvt, Vincentown Formation
- Tht, Hornerstown Sand
- Kt, Tinton Sand
- Krs, Shrewsbury Member } Red Bank Sand
- Krsh, Sandy Hook Member }
- Kns, Navesink Formation
- Kml, Mount Laurel Sand
- Kw, Wenonah Formation
- Kmt, Marshalltown Formation
- Ket, Englishtown Formation

**DETAIL OF SLUMP BLOCK**

**EXHIBIT #VII**

**John S. Truhan Consulting Engineers, Inc.**  
A Professional Corporation

SOURCE: "Slump Blocks in the Atlantic Highlands of New Jersey", prepared by James P. Minard and published by the U.S. Department of the Interior as Geological Survey Professional Paper 898, dated 1974.

The entire bluff along the Sandy Hook Bay and the Navesink River, which is comprised of unconsolidated sands, has a history of slumping and landslides.

The major mechanism that causes these slides has been water erosion or the wave cutting forces of the shoreline at the base of these steep bluffs.

Historical records show that at various times in history, the Sandy Hook was either connected to the main land (prior to 1778) at Highlands or the Sandy Hook was an island (reference is made to Exhibit III), and the Navesink and the Shrewsbury River were open to the Ocean.

When the Sandy Hook was an island and/or breached by ocean storms, the Highlands downtown point bar (remnants remain undeveloped at Waterwitch) was eroded away by ocean waves and tidal currents, possibly enough to expose the base of the bluffs to active erosion and slumping. Exhibit III reveals the former shorelines of downtown Highlands approximately 400 LF toward the south or at the base of the bluffs.

Several technical geological studies have been performed for this area describing the processes leading to slumps. They explain other major factors or mechanisms for movement such as the weight on top of the blocks (roads, homes, etc.) removal of material at the toe, and excess water moving over the surface causing erosion or moving through the geological formations. Heavy rains tend to saturate the soils thereby increasing the weight on the slump block. Heavy rains also infiltrate these sandy high permeable geological formations raise the water table above the lower less permeable formations to a

possibly critical height that causes a slump. These less permeable zones are also the location of seeps or springs and are discussed under the wetlands section of this report.

Like many locations which have natural beauty, the bluffs have been threatened by human activity. This particularly attractive location which offers spectacular views of Sandy Hook Bay and the New York City skyline has been disturbed and developed with homes. The damaging aspect done prior to the current knowledge of the slumping potential has caused some concerns. There is an increased amount of danger to structures at the top of the bluffs and at its base.

Careful planning must be required and all development should be prohibited in this erosion hazard area unless absolutely necessary. Before any construction is started in these areas, an engineering analysis and testing should be performed.

The prevention or redirection of surface drainage water and its natural infiltration points should be analyzed, which can contribute to the aforementioned mechanisms.

These precautionary recommendations along with setback requirements from these areas should be adopted. Vegetation preservation which helps stabilize the bluffs and reduce the rate of erosion (as described in the subsequent section) should also be implemented.

#### V. SOILS:

##### A. Introduction:

The study of soils is a very complex science and the task that was undertaken by the United States Department of Agriculture (USDA) which formed the Soil Conservation Service (SCS) in order to

map where different soil types occur was enormous. The finding of SCS and the information presented in the County's soil survey is a very important source of valuable data that is used in all types of land planning. This information is used by: farmers and foresters to evaluate the productivity of the soil for maximum food and fiber yields; engineers, planners, community officials, and developers to evaluate potential construction sites; and environmentalists and conservationists to protect and enhance sensitive areas such as wetlands, recreation areas, wildlife areas, and pollution prone areas.

Soils contain numerous properties and can vary over short distances that will effect their use. Some soils are subject to flooding and high water tables (wetlands) limiting underground basement construction and septic tank absorption fields while others may be too steep or unstable to support roads and dwellings causing irreparable damage.

There are thirty-two (32) different soil series in Monmouth County and a total of eighty-five (85) types or subseries as mapped by Monmouth County Soil Conservation Service. However, in the Borough of Highlands, only two (2) soil series exist.

For the purpose of the following sections, information will be presented in a concise manner and briefly touch upon the composition of the general characteristics of all soils.

The two (2) soil types in Highlands and how their characteristics effect the residents will subsequently follow in the text.

B. Soil Properties:

The combined effects of water, plant life, erosion, climate, etc., on the underlying geological formations through chemical and physical weathering has created a valuable natural resource a loose surface that is called soil. Soils are primarily classified by the size of particles (gravel to sand to silt to clay) and are generally a mixture of these various particle sizes. Figure II shows a graphic triangle representation of how soils are described as they relate to particle percentages or texture.

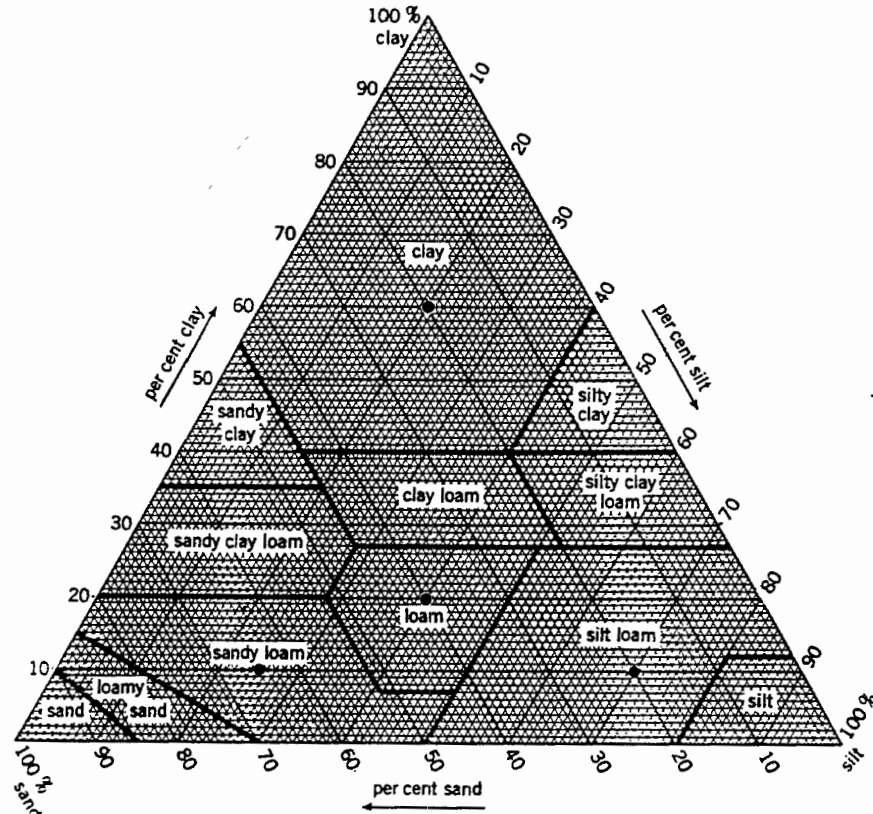


Figure II - Soil Texture Triangle

The knowledge of soil particle size and texture is important because it determines water intake rates which will affect the soil erosion potential and its usefulness in the Borough of Highlands especially on the steep slopes (see Soil Erosion, Section V-G).

Soils also vary in structure which is how these particles arrange themselves into an aggregate soil structure also influences the ability of water to flow through or penetrate and how fast water will erode away the soil. These factors will be referred to later in the text.

Color, another soil property is influenced by its parent geological formation and the different chemical weathering and water reaction processes that occur. Poorly drained or wetland soils tend to be subdued in color (gray, white) due to an incomplete oxidation process. Upland soils or drier soils generally are brighter such as yellowish browns or reddish browns. If a soil shows mottling, such as patches of bright and gray colors it is generally caused by fluctuating water table resulting in soil saturation at certain times of the year.

#### C. Soil Development:

The study of profiles is very important because they are used to differentiate and classify soils for their usefulness in either agriculture or land development. As a soil develops from the underlying formations, it produces distinct layers or horizons. Each soil type develops differently due to the effects of water, drainage, climate, vegetations, and its relationship to slope, etc., and each layer is different in depth or profile. Each soil profile is also different in texture, color, and particle displacement and can

generally be broken down into four (4) major horizons as shown on a typical profile, Figure III.

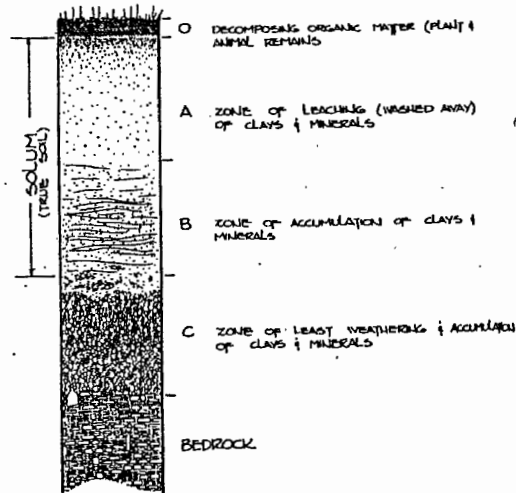


Figure III - Typical Soil Profile

The surface layer or "O" horizon is where undisturbed soil exists and where vegetation debris accumulates and over time become thicker and thicker.

The layer directly under the surface is the "A" horizon which contains most of the organic matter and is also called the zone of maximum leaching by water. The loss of water, minerals, and nutrients occurs here and passes downward to the next level (B level).

Sandy textured soils generally in a rainy environment are lighter in color than the horizon above and below it. Also, clay particles passed through the "A" horizon and accumulate in the "B" horizon which generally is a dense heavier layer because it contains more fine clay particles and usually is yellow or brown in color. The "A" and "B" horizons are called the "solium".

The "C" horizon is the layer where the true soil is formed and consists of partially weathered and broken down rock or parent material.

D. Soil Types Located in the Borough of Highlands:

The aforementioned characteristics form the two (2) soil series. A brief analysis of the soil series, along with selected soil properties is provided in Section E and shown in Tables III through V, which follow.

The Monmouth County Soil Survey indicated that the Borough is comprised of the Phalanx and Udorthents series, and the Phalanx is further divided into two (2) subseries (reference is made to Map III).

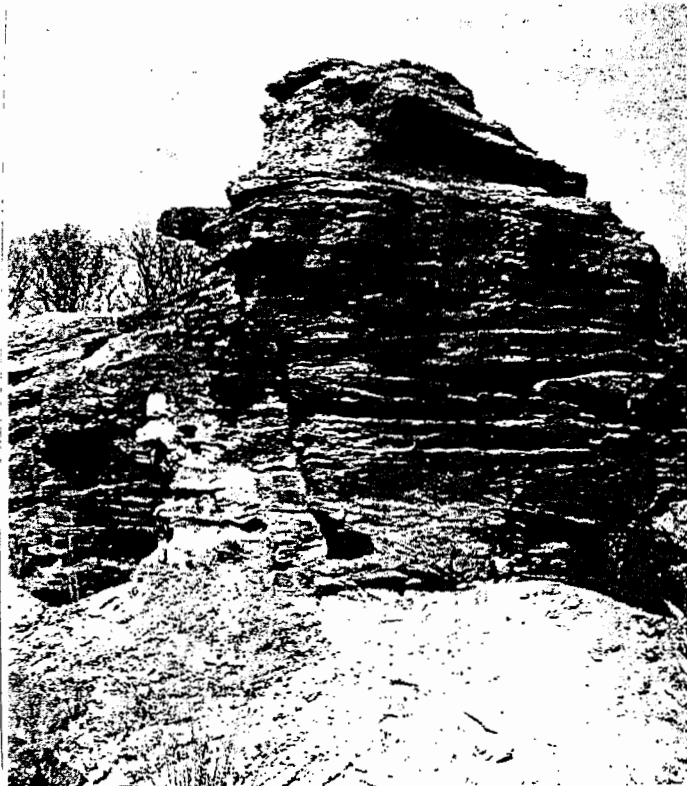
1. Phalanx Loamy Sand (PhB, 0-10 percent slopes):

This is a nearly level to moderately sloping soil found in the southeastern portion of the municipality particularly around the Henry Hudson Regional School and the Twin Lights Historical Museum (reference is made to Photograph II). It comprises only a small portion of the Borough and the entire soil unit only makes up less than 0.4% of all the soils found in Monmouth County.



Photograph II - An area along the eastern edge of the Tinton-Phalanx-Urban land general soil map unit.

This well-drained soil is most likely formed from the acid loamy sediments of the Cohansey formation as previously discussed due to its iron cemented sandstone nature. The iron cemented layer is usually at a depth of 20 to 40 inches. This layer may be only 1/8 inch to several feet in thickness (reference is made to Photograph III).



Photograph III - An exposure of iron-cemented sandstone in an area of Phalanx loamy sand, 0 to 10 percent slopes.

A typical soil profile for the surface layer ("O" horizon) is a dark brown loamy textured sand two (2) inches thick which is extremely acid. The subsurface layer ("A" horizon) contains brown loamy sand particles 2 to 7 inches thick containing up to 14 percent ironstones. The subsoil "B" horizon is a strong brown and yellowish red loamy sand up to 3 inches thick which is very strongly acid. This blocky structure layer also contains a few distinct clay bridges that impeded water movement. The substratum ("C" horizon)

extends to a depth of 60 inches or more and contains hard structured (indurated) layers of iron cemented sandstones.

Due to this type of cemented pan structure, the soil is very restricted to plant roots. The common native species includes, but is not limited to, Chestnut Oak, Black Oak, White Oak, Virginia Pine, and Pitch Pine.

The seasonal high water table is greater than six (6) feet, the permeability of water is moderate to moderately rapid and surface run-off is slow to medium.

The main limitations of this soil series according to the SCS Survey are sites for dwellings and other community developments which is due to its cemented pan, cut banks caving potential and its slopes.

1. Phalanx Loamy Sand (PhD, 10 to 25 percent slope):

This soil is similar in description as described above with the exception of its steep slopes and severe water erosion potential. All of the areas above or south of Shore Drive are mapped as this type. It comprises approximately 1.0% of all the soils encountered in Monmouth County.

2. Udorthents - Urban Land Complex (Ud 0 - 3 percent slopes):

This soil is mapped in the areas lying north of Shore Drive or the downtown portion of the Borough and consist of nearly level and gently sloping soils. These soils have been altered by development during the excavation or filling process of the land.

Since these soils have been altered in some way and differ from place to place a typical soil profile can not be determined. Generally, in filled areas of the Borough, this soil type

is comprised of a loamy material more than 20" in depth which was deposited over flood plains, tidal marshes, over very poorly drained soils, or beach sand. Some of this fill soil may also contain materials such as concrete, brick, asphalt, etc. Prior to the construction of roads, parking lots and dwellings, on-site investigation and evaluation will be required on a site by site bases in order to determine the limitations to further development.

E. Soil Limitation Management Tables:

The following tables (III through V) reflect the degree and kind of development limitations the aforementioned soils have. Estimates were made by the SCS for their behavioral characteristics which then can be used to evaluate potential uses.

F. Acid Soils:

Acid soil is found in many areas of New Jersey (reference is made to Exhibit VII), and can be considered very serious if exposure to oxygen happens. Upon exposure with the air, certain geological formations or deposits that contain iron sulfide minerals (pyrite) produce sulfuric acid which can become toxic, killing aquatic life or land vegetation. Construction activities generally expose these areas at depths from 4 - 16 feet, and in a few instances may be encountered near the surface.

The following geologic formations in the Coastal Plain physiographic province in New Jersey sometimes contain substantial acid-producing deposits:

- Raritan Formation
- Magothy Formation
- Merchantville Formation
- Woodbury Clay
- Englishtown Sand
- Marshalltown Formation

TABLE III  
--BUILDING SITE DEVELOPMENT--

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
PhD----- Phalanx	Severe: cemented pan, cutbanks cave.	Moderate: slope, cemented pan.	Severe: cemented pan.	Severe: slope.	Moderate: cemented pan, slope.	Severe: thin layer.
PhE----- Phalanx	Severe: cemented pan, cutbanks cave.	Moderate: cemented pan.	Severe: cemented pan.	Moderate: slope, cemented pan.	Moderate: cemented pan.	Severe: thin layer.
UD*: Udorthents.						
Urban land-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable.

--CONSTRUCTION MATERIALS--

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
PhB, PhD----- Phalanx	Good-----	Probable-----	Probable-----	Poor: area reclaim, small stones.
UD*: Udorthents.				
Urban land-----	Variable-----	Variable-----	Variable-----	Variable.

--SANITARY FACILITIES--

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
PhB----- Phalanx	Severe: cemented pan.	Severe: seepage, cemented pan.	Severe: seepage.	Severe: cemented pan, seepage.	Poor: area reclaim, small stones.
PhD----- Phalanx	Severe: cemented pan.	Severe: seepage, cemented pan, slope.	Severe: seepage.	Severe: cemented pan, seepage.	Poor: area reclaim, small stones.
UD*: Udorthents.					
Urban land-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable.

TABLE IV

-WATER MANAGEMENT--

Soil name and map symbol	Limitations for--		Features affecting--			
	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grass waterwa
PhB----- Phalanx	Severe: seepage, piping.	Severe: no water.	Deep to water	Droughty, fast intake, cemented pan.	Large stones, cemented pan.	Large sto droughty
PhD----- Phalanx	Severe: seepage, piping.	Severe: no water.	Deep to water	Droughty, fast intake, cemented pan.	Slope, large stones, cemented pan.	Large sto slope, droughty
UD*: Udorthents.						
Urban land-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable.

-SOIL AND WATER FEATURES-

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corros	
		Frequency	Duration	Months	Depth Ft	Kind	Months		Uncoated steel	Concr
PhB, PhD----- Phalanx	B	None-----	---	---	>6.0	---	---	Low-----	Low-----	Moder
UD*: Udorthents.										
Urban land-----	-	None-----	---	---	>2.0	---	---	---	---	--

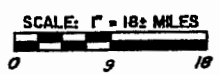
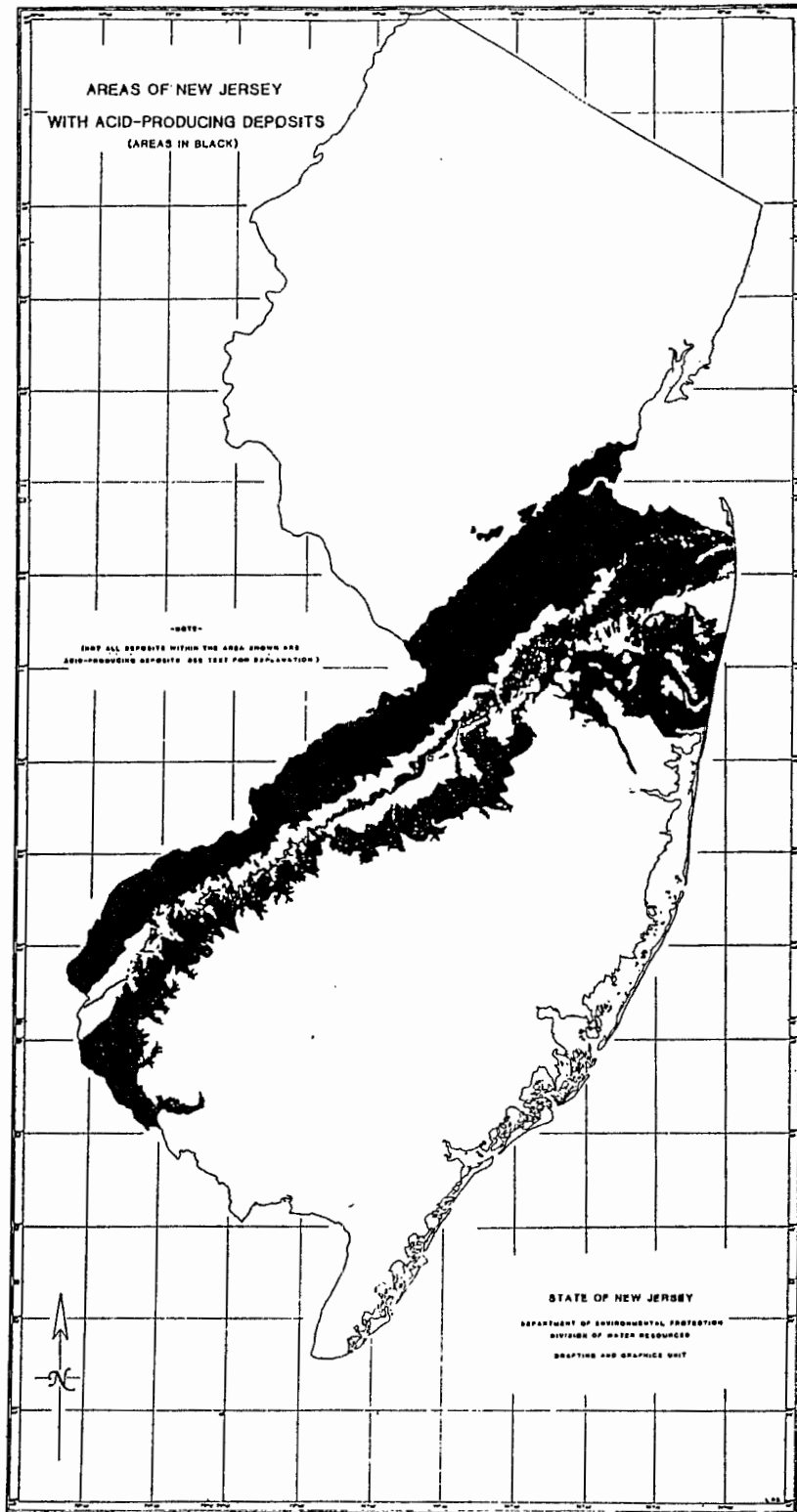
--WILDLIFE HABITAT--

Soil name and map symbol	Potential for habitat elements							Potential as habitat for		
	Grain and seed crops	Grasses and legumes	Wild herba-ceous plants	Hardwood trees	Conif-erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetlan wildlife
PhB----- Phalanx	Poor	Fair	Good	Fair	Fair	Poor	Very poor.	Fair	Fair	Very poor.
PhD----- Phalanx	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
UA. Udorthents										
UD*: Udorthents.										
Urban land-----	---	---	---	---	---	---	---	---	---	---

TABLE V

--RECREATIONAL DEVELOPMENT--

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
PhB----- Phalanx	Severe: cemented pan.	Severe: cemented pan.	Severe: cemented pan.	Slight-----	Severe: thin layer.
PhD----- Phalanx	Severe: cemented pan.	Severe: cemented pan.	Severe: slope, cemented pan.	Slight-----	Severe: thin layer.
UD*: Udorthents.					
Urban land-----	Variable-----	Variable-----	Variable-----	Variable-----	Variable.



SOURCE: "Technical Manual for Stream Encroachment", prepared by Stream Encroachment Section, N.J. Department of Environmental Protection, Division of Coastal Resources, revised July, 1988.

**AREAS OF NEW JERSEY  
WITH ACID-PRODUCING DEPOSITS**

**EXHIBIT #VIII**  
**John S. Truhan Consulting Engineers, Inc.**  
*A Professional Corporation*

Navesink Formation  
Red Bank Sand  
Kirkwood Formation

The main factor to minimizing or preventing potential problems is to minimize the time during which acid-producing deposit areas are exposed to the air and the prompt burial of the deposit under one (1) foot of soil.

Not all deposits within these formations are acid producing which will require further on-site testing prior to major foundation constructions. Simple chemical tests should be performed in the field during preconstruction investigations and during construction in the areas of the municipality where the aforementioned geological formations come to the surface. The NJDEPE and the current standards of SCS have set forth a guideline that should be followed. Highlands should incorporate them in their Land Use Regulations to safeguard against this potential problem.

G. Topography and Erosion Potential:

Map II presents the topographic contours of the Borough of Highlands. The closer the contour lines, the steeper the slopes.

A factor often related to development potential and use is slope. If an area is flat, water will tend to collect after a rain and cause flooding problems and if the slopes are too steep, erosion potential exists and development restrictions exist.

As indicated on the map, steeply sloping areas tend to be concentrated primarily in the southern part of the Borough and the flatter (0-3% slopes) areas are associated with the downtown areas.

The southern steep areas that have been developed generally have slopes of 15 - 25 percent or less. These areas are also intermixed with some slopes of 30 - 35 percent which so far have not been developed.

Highlands also contains an area known as the bluffs which has slopes that range from 75 percent to over 100 percent.

Table VI indicates the slope classes as generally found in Monmouth County and their associated erosion potential.

TABLE VI

SLOPE CLASSES IN MONMOUTH COUNTY SOILS

A *0-2%	Nearly flat slopes, little or no danger or erosion.
B 2-5%	Slopes moderately subject to erosion under clean cultivation.
C 5-10%	Under tillage, slopes greatly subject to erosion but controllable with suitable practices.
D 10-15%	Slopes extremely subject to erosion under cultivation.
E 15-25%	Slopes extremely subject to erosion under cultivation and not controllable under such use. Sod cover will protect soil.
F 25% +	Soils best protected by being kept in woodland.

\*A one percent slope = a drop of 1 foot in 100 feet of horizontal distance.

Soil erosion may be defined as the wearing away or loss of soil and usually the "A" horizon which is the most productive layer. This action is caused by either wind or water and the degree of severity is determined by the site's exposure to wind and water influences, lack of vegetative cover, the climate, the soil texture and character, and the length and degree of the slope.

Water is the most common soil eroding agent which erodes by the impact of raindrops on bare soil. As water runs off from saturated soils, it carries loose soil particles with it. As erosion continues in the Borough of Highlands, the fine textured areas in the surface wash away faster leaving behind the iron cemented sediments as previously discussed. Due to the Borough's steep slopes, these slopes must be kept from eroding by careful maintenance and management of hillside vegetation and if development or construction is going to happen, proper review and design must be followed. If erosion occurs in the slump block areas, the potential for landslides drastically increases.

Highlands also contains a natural water's edge (floodplain of Sandy Hook Bay) and is also subject to erosion (reference is made to Section VI-C).

Dense plant material can be used to control and prevent water caused soil erosion in three separate ways and are usually more effective and attractive than other paving solutions. First, the leaves and branches of a plant interrupt and break the force of the raindrops; second, the roots form a fibrous mat within the soil holding it in place; and, third, the dead leaves, etc., form a dense organic mulch on the soil increasing its water rate absorption.

Precautionary measures must be taken by the Environmental Commission and Planning Board to determine that any building, construction, or the removal or destruction of trees, shrubs, etc., does not have a detrimental impact on the soils and, in particular, the slump block areas.

A Land Use Ordinance should be drafted that will require a slope permit review process prior to any land disturbance that will impose certain conditions in critical slope areas.

VI. WATER RESOURCES:

A. Wetlands Definition:

Currently within the State of New Jersey, two (2) regulatory agencies have jurisdiction over work in the valuable wetland/water areas. These are the U.S. Army Corps of Engineers (USCE) and the New Jersey Department of Environmental Protection and Energy (NJDEPE), Bureau of Freshwater Wetlands (BFW). The USCE regulates the filling of wetland/water areas under the authority of Section 404 of the Clean Water Act. The BFW regulates all activities in wetland/water areas and buffers under the authority of the New Jersey Freshwater Wetlands Protection Act.

The responsible agencies employ the "three parameter methodology" in determining whether a site contains uplands or wetlands with the BFW being the lead agency.

Wetlands regulated by the BFW are defined as follows: "Freshwater wetlands or wetlands means an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation; provided, however, that the Department in designating a wetlands shall use the three-parameter approach (that is hydrology, soils, and vegetation) enumerated in the January 10, 1989 'Federal Manual for Identifying and Delineating Jurisdiction of Wetlands' (developed by

the United States Environmental Protection Agency (USEPA) and any subsequent amendments thereto".

Pursuant to this definition, wetlands are identified as areas that exhibit all three (3) of the following parameters:

1. Wetland vegetation (Hydrophytes)
2. Hydric soils
3. Hydrology - the degree of flooding or soil saturation.

First, wetlands are sites that have hydrophyte species as their predominant plants. Hydrophytes are defined as any plants growing in water or on a substrate that is at least periodically deficient in oxygen (anaerobic) as a result of excessive water content. During the growing season, most plant roots must have access to free oxygen for respiration and growth; flooding at this time would have serious implications for growth and survival of most plants. In a wetland situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on them. Since many plants are not restricted to a single type of habitat, the U.S. Fish and Wildlife Service (U.S.F.W.S.) has developed a classification scheme that assigns species to habitat classes according to the following rules:

Table VII	
Plant Affinity for Wetland Conditions	
Classification	Percentage of Occurrence in Wetlands
Obligate (OBL)	> 95
Facultative Wet (FACW)	66-95
Facultative (FAC)	33-66
Facultative Upland (FACU)	1-33

Wetlands are identified as those areas that are dominated by obligate (OBL), facultative wet (FACW), and facultative (FAC+ and FAC) species.

A listing of these plants can be found in the National List of Plants Species That Occur In Wetlands, 1988, New Jersey, compiled by the United States Fish and Wildlife Service in cooperation with the United States Environmental Protection Agency and the United States Soil Conservation Service.

Second, sites must have as their predominant substrates, soils that exhibit hydric characteristics, as defined by the N.J. Department of Environmental Protection as follows:

"Hydric soil" means a soil that in its undrained condition is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. These soils may be on New Jersey's Official List of Hydric Soils developed by the United States Department of Agriculture Soil Conservation Service and the United States Fish and Wildlife Service National Wetlands Inventory, in "The

Wetlands of New Jersey", 1985, published by the United States Fish and Wildlife Service, or in the United States Environmental Protection Agency Wetlands Identification and Delineation Manual. Alluvial land, as mapped by soil surveys, may also be considered a hydric soil for the purposes of wetland classification. Also, wet phases of somewhat poorly drained soils not on New Jersey's Official List of Hydric Soils may also, on occasion, be associated with a wetland and shall be considered a hydric soil.

Hydric soils may be classified into two (2) broad groups: "organic" and "mineral". Organic soils (histosols) develop under conditions of nearly continuous saturation and/or inundation. All organic soils are hydric soils except folists, which are freely drained soils occurring on dry slopes where excess litter accumulates over bedrock. Organic soils are commonly known as peats or mucks. All other hydric soils are mineral soils. Mineral soils have a wide range of textures (sandy to clayey) and colors (red to gray). They are usually gray, mottled immediately below the surface horizon or they have thick, dark-colored surface layers overlying gray or mottled subsurface horizons. Mineral soils with low to moderate organic content which are saturated for substantial periods of the growing season, produce gleyed soils (blueish, greenish, or grayish colors immediately below the A-horizon or at ten [10] inches, whichever is shallower). Mineral soils that are not saturated as long, to produce gleyed soils, will either have bright mottles and a low matrix chroma or will lack mottles but have a low matrix chroma. Soils that have brightly colored mottles and a low matrix chroma are indicative of an active water table and fall into one of the following color features

immediately below the A-horizon (or at ten [10] inches, whichever is shallower):

- a. Matrix chroma of two (2) or less, and a value of four (4) or more in moistened mottled soils, have low or moderate organic content.
- b. Matrix chroma of one (1) or less in moistened unmottled soils having a value of four (4) or more.
- c. Matrix chroma of less than two (2) and a value of less than four (4), when organic matter content is high (but less than the percentage of organic matter associated with organic soils). (Reference is made to Department of the Army Corps of Engineers, Delineation Manual, Page 13, Y.87). Atypical situations can occur when there is significant coloration due to the nature of the parent material, such as the case of Triassic Brunswick in the Piedmont region. The strong red shale permeates the soils formed above it, masking the hydric conditions.

The United States Department of Agriculture, Soil Conservation Service has developed a county-based list of New Jersey's hydric soils (SCS File Code 390-11-13). This list is designed to supersede the "Official List of New Jersey Hydric Soils" published by the United States Fish and Wildlife Service in 1984. On the new county-based list, soil mapping units are classified as either being hydric or having hydric soil components as inclusions. Mapping units not listed are, through exclusion, non-hydric.

Third, wetland areas must also meet the criteria for wetland hydrology. The sites must have a seasonal high water table within twelve (12) inches of the soil surface and/or be seasonally saturated or inundated at least 12.5 percent of the growing season. Wetland indicator characteristics may also be used and they include drainage patterns, drift lines, watermarks, historic record and stream gauge data.

The resource value of the freshwater wetland will be determined by the NJDEPE along with an appropriate transitional zone (buffer) adjacent to the boundary line. Wetlands are critical habitats for many threatened and endangered plant and animal species and play many important roles including the maintenance of surface and ground water quality. The program established by the NJDEPE for transitional zones is deemed to be the minimum standard necessary to protect the long-term integrity of the wetlands. The three (3) classifications will be ordinary, intermediate, or exceptional in value. Exceptional value wetland will have habitats with threatened or endangered species and remain suitable for breeding, resting or feeding. Freshwater wetlands of ordinary value shall be isolated wetlands, drainage ditches, swales or detention facilities. Intermediate resource value areas shall be all wetlands not defined as exceptional or ordinary.

B. Wetlands Mapped in Highlands:

The Bureau of Freshwater Wetlands delineated and mapped the Borough in 1986, using infra-red aerial photography, as having two (2) ecological types of wetlands (reference is made to Map VI, entitled "Wetlands and Flood Hazard Zone").

The largest area is associated with the Sandy Hook Bay and the Shrewsbury River. This delineation line (the upper wetlands boundary, UWB) was transformed to the present wetlands map to show the areas that were regulated under the Wetlands Act of 1970. The coastal wetlands system is an environmentally valuable land area which acts as a transitional zone absorbing waves and storm surges. Even though the majority of these areas have been developed with water dependent

usages (bulkheading, marinas, etc.), there are still natural edges that are remaining and all these land areas (developed and undeveloped beach areas) are regulated by N.J.D.E.P.E. and should only be developed following careful Planning Board review.

The second type of wetlands system is a Palustrine Broad-Leaved Saturated Forest which is associated with the bluffs. This forested area, which is the most widespread wetland system, is a small ditch or channel at the base of the steep slopes. This wetland complex of seepage areas or springs follows the clay layers of the underlying geological formations, in particular the Navesink.

A detailed study of the vegetation, soils, and hydrology of this area will be required by the New Jersey Freshwater Regulatory Agency if any development or alteration is proposed.

C. Floodplains:

According to the Flood Insurance Rate Map (H-01, Borough of Highlands, New Jersey, Community Panel Number 345297A, July 1, 1974, and revised June 30, 1976), the downtown area is mapped as a Zone A6 having a 100 year flood elevation at 10 feet mean sea level (reference is made to Map VI, entitled "Wetlands and Flood Hazard Zone). The 500 year flood line runs adjacent to the 100 year flood line along a thin band, and was not shown on the map due to its slight offset.

The 100 year flood line approximately follows Shore Drive and flood waters have the potential of reaching an elevation of 10 feet.

The majority of the downtown area which is only at elevations ranging from 5 to 7 feet, will be subjected to considerable amounts of flooding and property damage in the event of a major

coastal storm. This line, as depicted on the map, should not be thought to be the exact location. Because there are fringe properties that are located south of Shore Drive at a slightly lower elevation that may also have the potential of being flooded.

Since 1968, the Natural Flood Insurance Program (NFIP) has provided federally backed flood insurance that encourages residents and municipal officials to enact and enforce floodplain management regulations. The objective of these regulations is to ensure that any proposed development will not contribute to a public safety hazard and if homes are existing in these flood hazard areas, they should meet the floodproofing requirements of the NFIP.

As of 1990, there were approximately 554 residents with flood insurance. According to NJFP, there have been 215 claims filed since January 1, 1978 of which \$377,155 in damage restoration was paid out. The NFIP has recently adopted a community rating system program which encourages municipalities to adopt additional management programs in order to reduce flood related problems, reduce insurance rates, and assist in providing advise and information. The NJDEPE Division of Coastal Resources Flood Plain Management Section should be contacted for further information on these program benefits.

## VII. NATURAL AND WATERFRONT FEATURES:

### A. Scenic Resources:

The value of a scenic resource is important in design considerations and must be included in the planning and zoning process. Pertinent questions should also be asked on aesthetics and if the proposed development will compete with or block the view of a scenic resource. If Highlands sets high aesthetic goals, it will

attract and encourage developers to use and improve the natural environment in a way that is not detrimental to the current and future residents and tourists.

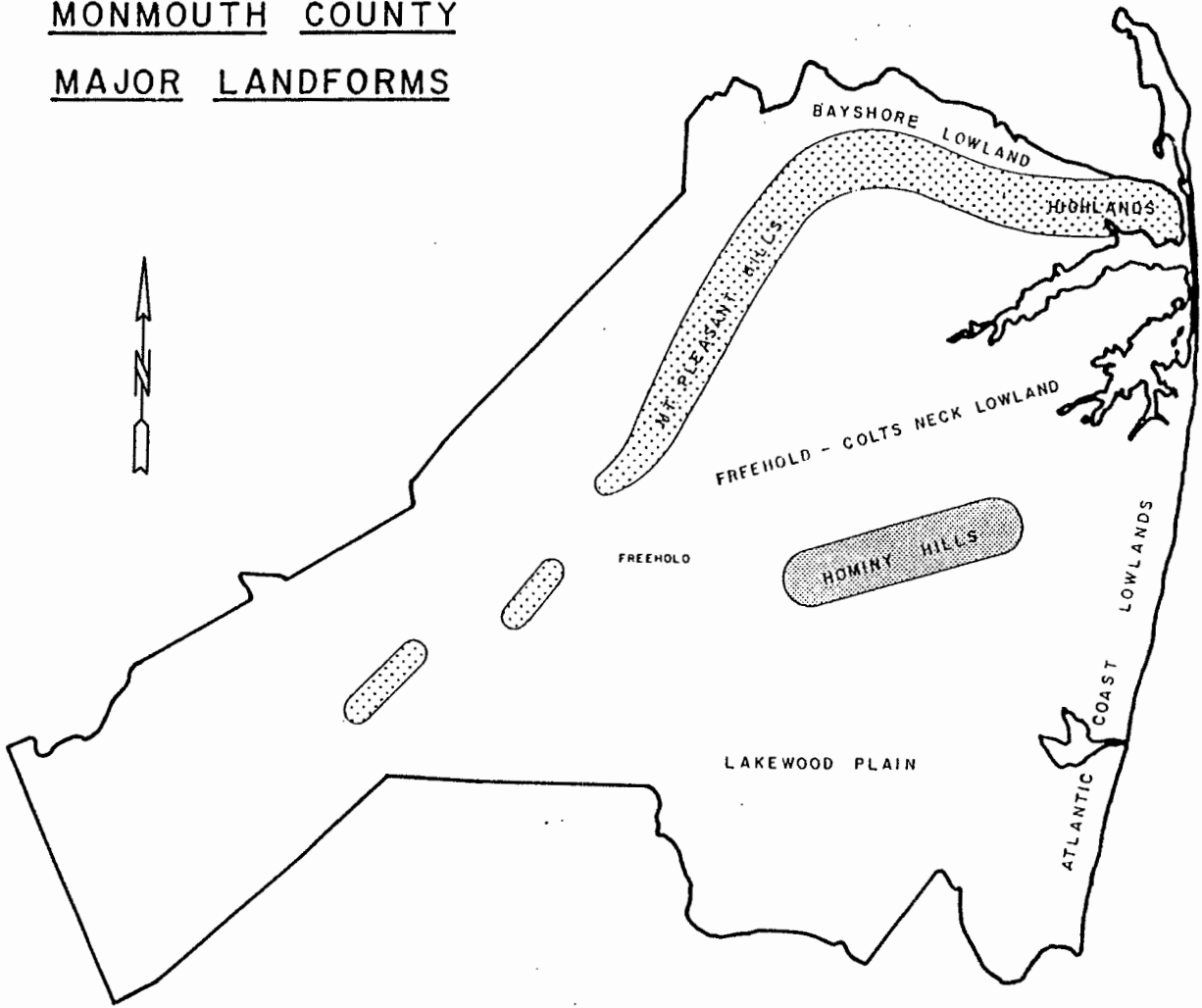
All scenic values generally involve unique locations and large areas. Some of the unique areas in the Highlands are as follows:

1. Landforms - As previously discussed, a range of hills or a miniature mountain range, which originates at Highlands and extends into Burlington County, divides the State. These geological oddities are formed on the sand deposits which are capped with ironstone and are called Cuesta Ridge Peaks. They are generally steep on one side and gently sloping on the other. Mount Mitchell in the Borough of Highlands is one of these areas and is located on a ridge by the name of Mount Pleasant Hills which extends into the Town of Imlaystown (reference is made to Exhibits IX and X and Map V, entitled "Waterfront and Recreational Resources").

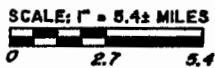
Mount Mitchell, at an elevation of 266 feet and one of the highest points in Monmouth County, offers excellent focal point vistas toward New York City, Sandy Hook Bay, the Verrazano-Narrows Bridge, Sandy Hook Historic Lighthouse, and Gateway National Recreation Area. Several parking pull-offs along the way up the mountain are provided, and if possible, should be improved with signage and information plaques.

2. Highlands Bluffs - Early settlers, as stated in the introduction of this report, came to Highlands because of its natural beauty of which are the precipitous bluffs (reference is made to Exhibit XI).

MONMOUTH COUNTY  
MAJOR LANDFORMS



PREPARED BY THE MONMOUTH COUNTY PLANNING BOARD 12/74



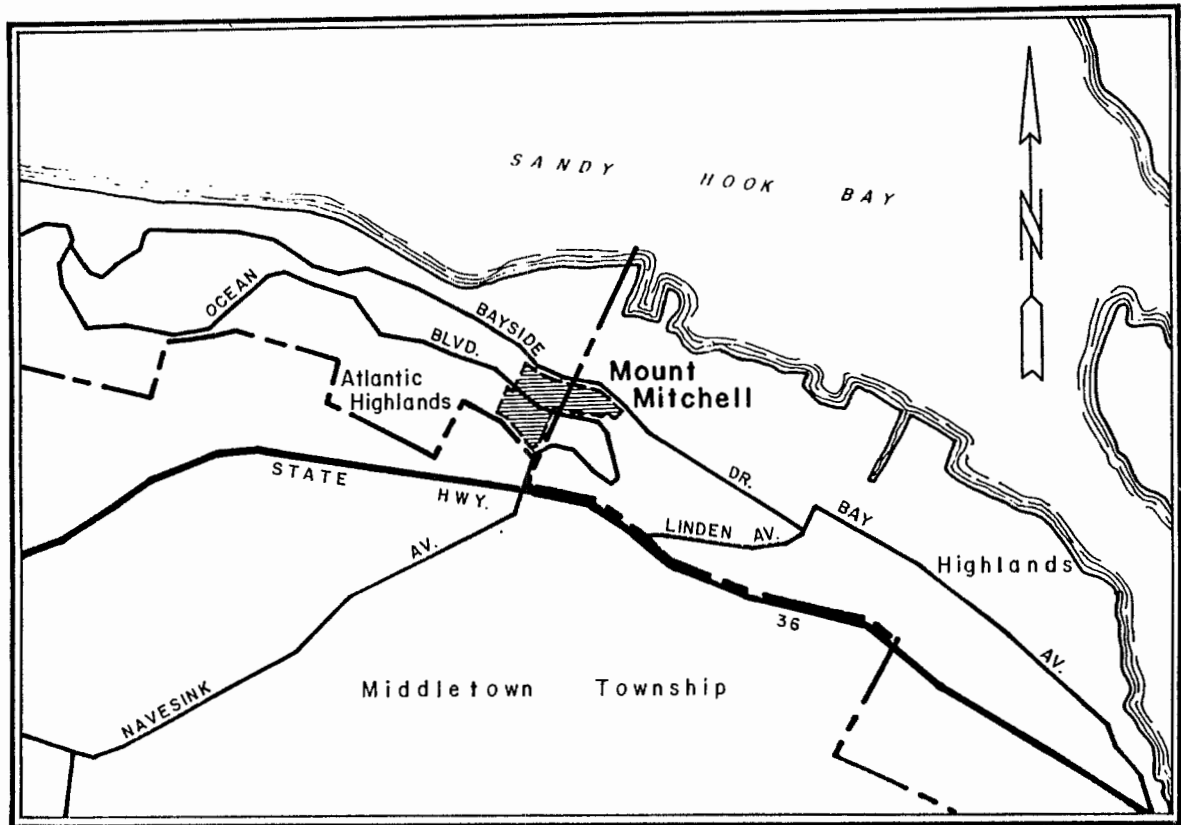
SOURCE: "Natural Features Study for Monmouth County" prepared by the Monmouth County Environmental Council, dated April 1975.

**MAJOR LANDFORMS  
OF MONMOUTH COUNTY**

**EXHIBIT # IX**

**John S. Truhan Consulting Engineers, Inc.**  
*A Professional Corporation*

# MOUNT MITCHELL



## LOCATION

Mt. Mitchell is located on Ocean Blvd. in Atlantic Highlands, in the far northeastern section of Monmouth County.

## DESCRIPTION

Mt. Mitchell Scenic Overlook is one of a kind in Monmouth. With an elevation of 266 feet it is one of the highest points in the County and provides an excellent view of the surrounding areas. On a clear day the New York skyline, the Verrazano-Narrows Bridge, Ft. Hancock and the Sandy Hook and Raritan Bays are all easily discernable, as are some points south along the shore. There are several stops along the route with different views of the areas, as well as a park located at Mt. Mitchell's peak.

SCALE IN FEET  
1" = 2000'



SOURCE: "Monmouth County Unique Areas Study", prepared by the Monmouth County Environmental Council, dated December 1978

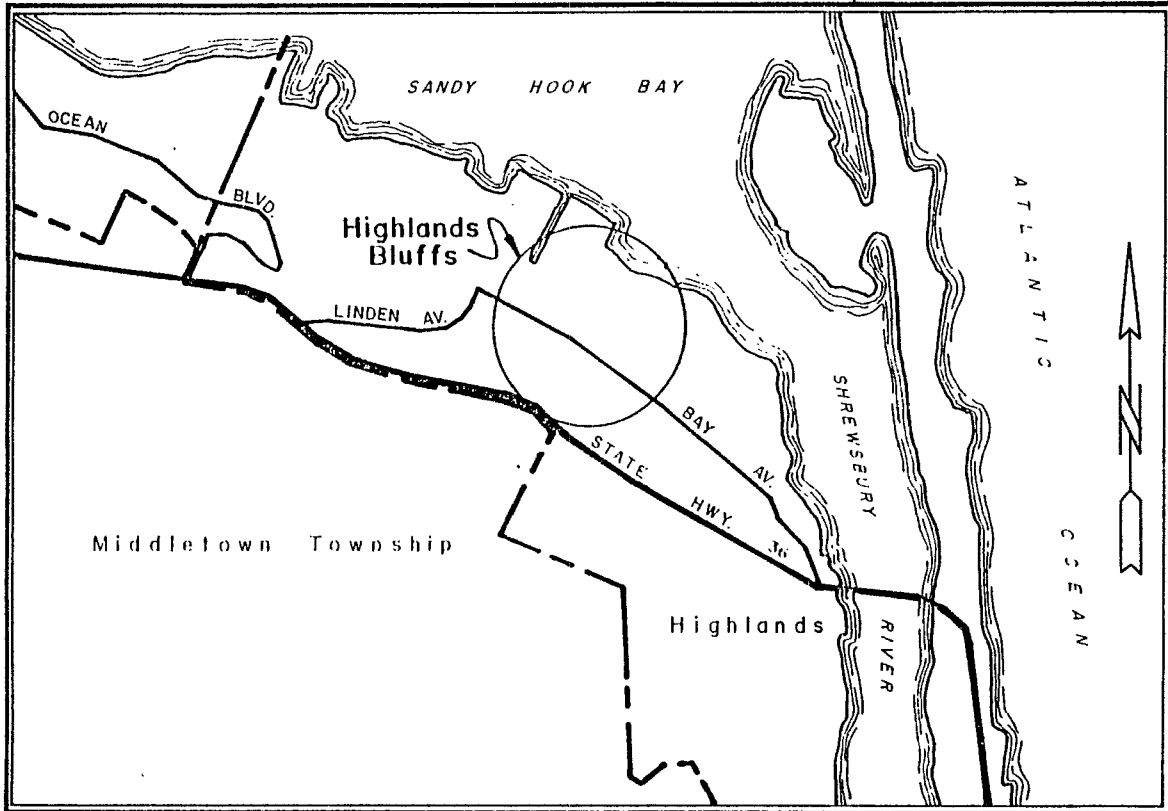
## **MOUNT MITCHELL**

**EXHIBIT # X**

**John S. Truhan Consulting Engineers, Inc.**

*A Professional Corporation*

# HIGHLANDS BLUFFS



## LOCATION

The highlands bluffs or hills (sometimes known as the Highlands of the Navesink) are located along the Sandy Hook Bay and Navesink River in the Boroughs of Highlands and Atlantic Highlands and Middletown Township. The portion of the highlands outlined in the discussion lies within the Borough of Highlands.

## DESIGNATION

Geologic/Paleontologic/Historic



SOURCE: "Monmouth County Unique Areas Study", prepared by the Monmouth County Environmental Council, dated December 1978.

## HIGHLANDS BLUFFS

EXHIBIT # XI

John S. Truhan Consulting Engineers, Inc.  
A Professional Corporation

The Highlands Bluffs are the only area in the entire Coastal Plain Province of New Jersey that is higher than 200 feet. They also offer an excellent cross-sectional view of the geological layers that contain numerous marine fossil specimens dating back 100 million years. Several reports have been prepared by an active group of amateur collectors for these formations, particularly the Navesink Formation. Some of these ammonite collections have been donated to the Smithsonian Institution. The largest collection was made by Mr. Harold Menbryk of Harrison, New Jersey. Other specimens from these bluffs are stored in the National Museum of Natural History in Washington, D.C., and the U.S. Geological Survey's Mosaic Invertebrate Fossil Collection at the Federal Center in Denver, Colorado.

The historical bluffs are subjected to slumping, as much as 40 acres at one time, and have greatly contributed to the formation and size of the Sandy Hook Spit or barrier sand bar.

3. Waterfront - Highlands has several recreational waterfront access areas open to the public (reference is made to Map V). These areas no longer exist in a natural habitat state due to the associated demand for intense waterfront development. Nevertheless, they should be maintained and should be improved upon. Map V lists each one of these areas and offers a brief description of the proposed design ideas that can be incorporated into each site. The Borough should encourage a personal commitment of the local residents in preserving and protecting the Sandy Hook Bay waterfront for not only themselves and the tourist industry, but also for the future generations to come.

VIII. SUMMARY AND RECOMMENDATIONS:

The first part of this Natural Resource Inventory has briefly discussed the dynamic processes that shaped the coastal plain of New Jersey and which continues to do so. Highlands is characterized by its steep rising bluffs out of the Atlantic Ocean to a point 266 feet above sea level at Mount Mitchell. The interaction of water, land, climate, and various life forms through a variety of never ending cycles has changed Highlands. Erosion, weathering, and the deposition of sand, silt and clay takes place very slowly. Other dynamic forces (glaciers, uplifting, etc.) evolve over millions of years, but man can speed up this alteration process and sometimes to the detriment of the natural environmental resources. One of the most damaging aspects of development is the removal of vegetation to build houses, condominiums, hotels, shopping centers, and even roads. Since the soils of Highlands are formed on unconsolidated marine sediments, it is susceptible to erosion and landslides, particularly the bluffs. Sediments can then accumulate in navigational channels and effect shipping and boating or along the waterfront effecting marine life and recreation.

Local town planners should be concerned with this geological formation and restrict detrimental human development not because of its potential erosion hazards but also to protect its beauty. Highlands allows for breathtaking views and picturesque vistas across Sandy Hook Bay because of its ruggedness in topography which should be considered in the development review process.

Ordinances to protect the health, safety, and welfare of the residents and property within the Borough of Highlands should be reviewed and updated if warranted in order to reduce potential hazards. A slope permit regulating any work or disturbance should be implemented and setback limits should be established in the slump block area. Development restrictions and the preservation of the bluffs and vistas should also be considered in the design process.

The waterfront map presented only briefly touches on some of the potential recreation resources that can be designed for the Sandy Hook Bay and Shrewsbury River and should be expanded upon and incorporated in the Municipal Master Plan.

The attached outline offers further sections of a complete Natural Resource Inventory that will need to be incorporated with this report such as water resources and historical heritage. The value of cultural and historical resources and their preservation into the land use process are also of value to a community as the depth of bedrock or the kind of soil drainage or geological slumping that exists in a given area. Eventually, the final section of a Natural Resource Inventory will address specific project recommendations and revisions of the Land Use Ordinance and Master Plan incorporating the goals and objectives of the Environmental Commission for the coming years.

John S. Truhan Consulting Engineers, Inc.  
*A Professional Corporation*

BOROUGH OF HIGHLANDS  
NATURAL RESOURCE INVENTORY OUTLINE  
ENVIRONMENTALLY SENSITIVE MASTER PLAN

- I. Preface
- II. Geology
  - A. Soil Formation
    - 1. SCS Soil Mapping for Area
    - 2. Soil Classification Listing
    - 3. Bedrock
    - 4. Soil Development History
    - 5. Slopes
    - 6. Soil Erosion Potential
    - 7. Wetlands
- III. Hydrology
  - A. Climate - Regional and General
  - B. Groundwater Hydrology - Aquifer Characteristics
  - C. Surface Hydrology - Floodplains, Springs and Streams
  - D. Water Quality
    - 1. Shrewsbury River
    - 2. Sandy Hook Bay
  - E. Stormwater Management
    - 1. Community Development
    - 2. Erosion Control Management
    - 3. Groundwater Recharge
    - 4. Potential Pollution Problems
- IV. Ecology
  - A. Existing Vegetation
  - B. Wildlife

V. Natural Resource Utilization and Man's Impact on the Environment

A. History

1. Brief Description of Development of Highlands
2. Historical Sites
3. Fishing and Boating Industry

B. Scenic Resources

1. Parks and Recreation
2. Waterfront Development Plan
3. Bayshore Development Plan
4. Twin Lights
5. Public and Quasi Public Uses

C. Housing and Commercial Development

1. Demography
2. Transportation Systems
3. Land Use Master Plan
4. Towncenter

VI. Natural Resources Inventory Implementation

A. Environmental Data Base for Planning Methodology

1. Professional Staffs
2. Environmental Impact Ordinance
3. Public Participation
4. Site Plan Reviews

B. Interpretation of Potential Limitations and Conservation Methods

1. Foundation Limitation
2. Run-off and Stormwater Management
3. Slopes
4. Floodplain
5. Historical Sites

## REFERENCES

- Judson, Deffeys, Hargraves, "Physical Geology", Prentice-Hall, Inc., 1976
- Donahue, Miller, Shickluna, "Soils", Prentice-Hall, Inc., 1977
- Berger, Kermit C., "Introductory Soils", University of Wisconsin, Macmillan Company, NY, 1978
- Geological Survey Professional Paper 898, "Slump Blocks in Atlantic Highlands of New Jersey", James P. Minard, 1974
- Geological Survey Professional Paper 845, "Ammonities from the Navesink Formation at Atlantic Highlands, New Jersey", William A. Cobban, 1974
- Geological Survey Bulletin 1276, "Geology of the Sandy Hook Quadrangle in Monmouth County, New Jersey", James P. Minard, 1969
- Monmouth County Environmental Council, "Monmouth County Unique Areas Study", 1978
- Monmouth County Environmental Council, "Natural Features Study for Monmouth County", April 1975
- NJDEP Division of Coastal Resources, "Rules on Coastal Resources and Development", NJAC 7:7E-1.1 et seq, 1986
- United States Department of Agriculture Soil Conservation Service, "Soil Survey of Monmouth County, New Jersey", 1989
- John S. Truhan Consulting Engineers, Inc., "Borough of Highlands Master Plan", 1990
- Department of Housing and Urban Development, "Federal Insurance Administration Flood Hazard Boundary Map H-01, Community Parcel No. 345297A", 1976