Shadow Lawn
Mobile Home Park
Redevelopment Plan

Prepared for:

The Borough of Highlands
Monmouth County, New Jersey

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Prepared By:

Christopher N Dochney, PP, AICP
License No. 06225

Maryann Bucci-Carter, PP, AICP
License No. 04905

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Greg Baxter – Board Attorney

Kim Gonzales – Borough Administrator
Brian J. Chabarek – Borough Attorney

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INTRODUCTION

Redevelopment is the process of rebuilding a previously developed area that has fallen into a state of disrepair and has become detrimental to the general welfare of the community. This can involve the acquisition and demolition of existing structures and facilities if needed to make way for new improvements. Redevelopment planning is the process of determining how the redevelopment of particular properties can best improve a community, and to use local government powers to encourage development and growth where it otherwise would be unlikely to happen.

New Jersey laws allow for a municipality to utilize redevelopment as a tool to stimulate economic development and improve conditions on properties that meet certain statutory criteria that qualify them as being '*in need of redevelopment.'* Redevelopment as a planning instrument offers a number of potential benefits to the Borough. Through redevelopment, the Borough is allowed more flexibility to negotiate with, and offer financial incentives such as long-term tax abatements to potential developers, than is otherwise available through standard land development procedures. Under redevelopment the Borough can take a more proactive approach to improving targeted areas. This can be used as a means to stimulate development where it might not occur through market forces and private capital alone.

In December of 2016, the Mayor and Council of the Borough directed the Land Use Board, in Resolution 16-228, to undertake an investigation of the area of Block 105.107, Lot 1.1, the Shadow Lawn Mobile Home Park on Ocean Boulevard, to determine if it met the statutory criteria as found in N.J.S.A. 40A:12A-5 to be designated as an Area in Need of Redevelopment. The Land Use Board after conducting the required investigation and holding a public hearing, recommended that the area met the statutory criteria. The Mayor and Council accepted this recommendation in Resolution 18-069, that the area was found to meet the necessary statutory criteria, and the site was designated as an Area in Need of Redevelopment in March of 2018.

This Plan provides a detailed guide for the revitalization of this property. It shall serve as the formal planning and zoning regulatory document to establish permitted land uses, building and dimensional standards, and design standards for all development within the Area.

STATUTORY REQUIREMENTS

This Plan and the provisions herein have been prepared pursuant to Section 7 of the Local Redevelopment and Housing Law (LRHL) (N.J.S.A. 40A:12A-7), which provides that "no redevelopment project shall be undertaken or carried out except in accordance with a redevelopment plan adopted by ordinance of the municipal governing body, upon its finding that the specifically delineated project area is located in an area in need of redevelopment…according to criteria set forth in section 5…as appropriate." Pursuant to the requirements of the LRHL, this Redevelopment Plan includes an outline for the planning, development, redevelopment, or rehabilitation of the redevelopment area sufficient to indicate:

1. Its relationship to definite local objectives as to appropriate land uses, density of population and improved traffic and public transportation, public utilities, recreational and community facilities, and other public improvements.

2. Proposed land uses and building requirements in the redevelopment area.

3. Adequate provision for the temporary and permanent relocation, as necessary, of residents in the redevelopment area, including an estimate of the extent to which decent, safe and sanitary dwelling units affordable to displaced residents will be available to them in the existing local housing market.

4. An identification of any property within the redevelopment area proposed to be acquired in accordance with redevelopment plan;

5. Any significant relationship of the redevelopment plan to:

   (a) The Master Plans of contiguous municipalities;
   (b) The Master Plan of the County in which the municipality is located, and;
   (c) The State Development and Redevelopment Plan (the "SDRP") adopted pursuant to the "State Planning Act," P.L. 1985, c.398 (C.52:18A-196 et al.).

6. As of the date of the adoption of the resolution finding the area to be in need of redevelopment, an inventory of all housing units affordable to low and moderate income households, as defined pursuant to section 4 of P.L.1985,c.222 (C.52:27D-304), that are to be removed as a result of implementation of the redevelopment plan, whether as a result of subsidies or market conditions, listed by affordability level, number of bedrooms, and tenure.

7. A plan for the provision, through new construction or substantial rehabilitation of one comparable, affordable replacement housing unit for each affordable housing unit that has been occupied at any time within the last 18 months, that is subject to affordability controls and that is identified as to be removed as a result of implementation of the redevelopment plan. Displaced residents of housing units provided under any State or federal housing subsidy program, or pursuant to the "Fair Housing Act,", P.L.185,c.222 (C.52:27D-301 et

al.), provided they are deemed to be eligible, shall have first priority for those replacement units provided under the plan; provided that any such replacement unit shall not be credited against a prospective municipal obligation under the "Fair Housing Act,", P.L.185,c.222 (C.52:27D-301 et al.), if the housing unit which is removed had previously been credited toward satisfying the municipal fair share obligation. To the extent reasonably feasible, replacement housing shall be provided within or in close proximity to the redevelopment area. A municipality shall report annually to the Department of Community Affairs on the progress in implementing the plan for the provision of comparable, affordable replacement housing required pursuant to this section.

The LRHL provides that "a redevelopment plan may include the provision of affordable housing in accordance with the "Fair Housing Act," P.L. 1985, c.222 (C.52:27D-301 et al.) and the housing element of the municipal master plan." Finally, the Plan is required to describe its relationship to pertinent municipal development regulations, and must note whether the provisions of the Plan supersede applicable provisions of the development regulations of the municipality or constitute an overlay zoning district.

DESCRIPTION OF REDEVELOPMENT AREA

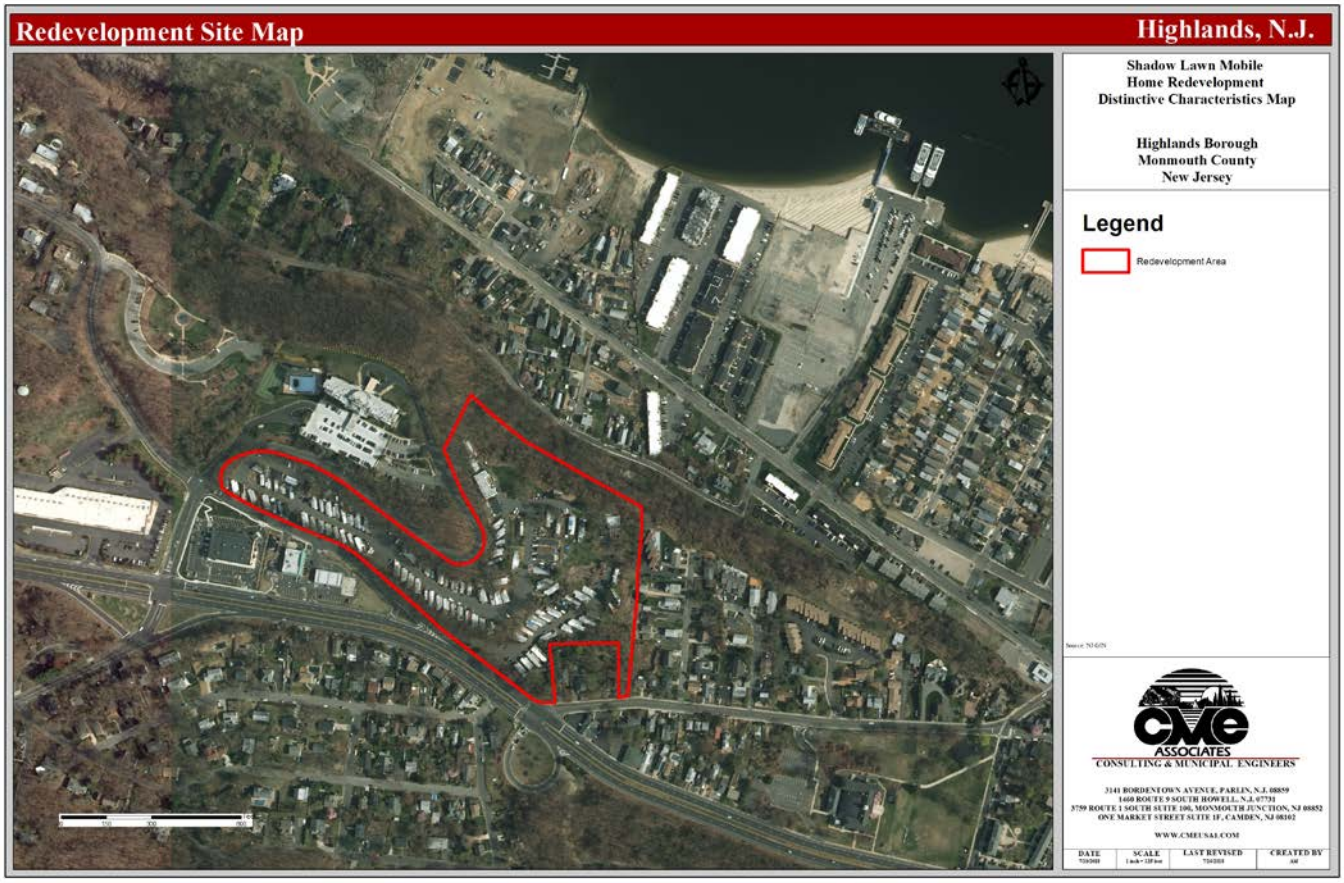
The Area governed by this Redevelopment Plan includes the following tax parcels:

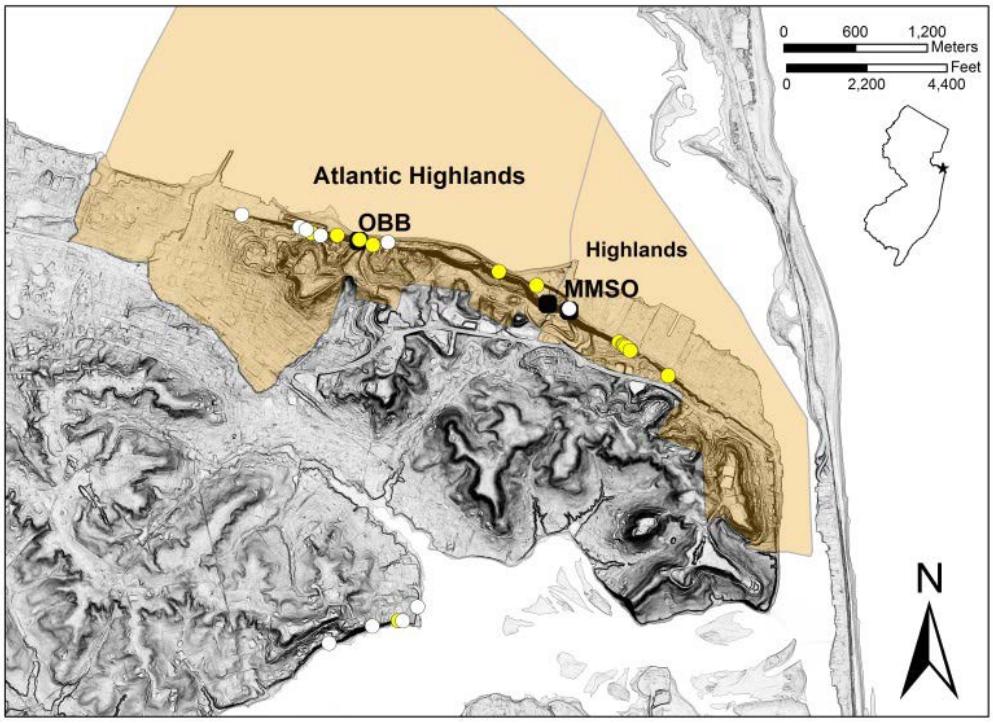
- Block 105.107, Lot 1.1

The Redevelopment Area Boundary map on the following page illustrates the extents of the lands governed by this Redevelopment Plan. The area is located on Ocean Boulevard, just north of Route 36 in the western end of the Borough on top of the hill overlooking Sandy Hook Bay. The 13.1 acre site is currently developed with the Shadow Lawn Mobile Home Park, which consists of approximately 100 mobile home dwellings, and a small apartment building, organized around a single street named Laurel Drive. One narrow driveway provides access to the site from Ocean Boulevard, while an exit only driveway provides access to Route 36 on the eastern end of the site.

Geographically located on Sandy Hook Bay, most of the Borough of Highlands sits just above sea level. However this site sits near the top of a steep cliff which rises 120 feet above sea level. Immediately to the north and west of the area is the Eastpointe Condominium tower, a 16 story residential building, which contains approximately 165 dwelling units and associated parking. Further west along Ocean Boulevard is the Mt. Mitchill Scenic Overlook Park which provides views of the Raritan and Sandy Hook Bays, and to New York City to the north. Just to the south of the area is a CVS pharmacy and a Quick Check gas station and convenience store on Route 36. To the east of the area and down the hill are residential neighborhoods made up primarily of detached single-family homes.

Slopes within the Atlantic Highlands region of Monmouth County are susceptible to rainfall induced shallow landslides, and are being actively monitored by the United States Geological Survey (USGS) for slope movement, rainfall, soil moisture, and other hazardous conditions that could destabilize the slopes. The Redevelopment Area, being located at the top of the coastal bluff overlooking Sandy Hook Bay, is made up of slump block and is susceptible to these types of landslides. The topography of this ridgeline creates slopes in excess of 20 percent over much of the property. There have also been a number of landslides recorded along the bluffs in the region which have resulted in significant property damage.





Location of historic landslides in the Atlantic Highlands Region (from NJGWS database)

RELATIONSHIP TO LOCAL OBJECTIVES

This Plan provides standards to facilitate the redevelopment of the site known as the Shadow Lawn Mobile Home Park, into a mixed use area that provides a multitude of residential and commercial opportunities for the community. The objectives of the Redevelopment Plan are as follows:

1. Encourage new development activity and economic opportunity for the Borough.

2. Stimulate the redevelopment of underutilized land in a manner that will complement and capitalize on the unique topography and geographic location of the area.

3. Provide for flexibility and creativity with respect to design of buildings and improvements within the Redevelopment Area while ensuring that the aesthetics of redevelopment projects are of a high standard.

4. Redevelop the property in a manner that will minimize the hazards posed by the threat of landslides on the bluff, and protect critical environmental resources.

5. Develop new housing options to attract new residents to the Borough of Highlands which will help to support businesses in the area.

6. Provide new opportunities for affordable housing for area residents.

7. Allow for new commercial development to serve the needs of the community.

8. Provide for the redevelopment of the Area in a manner consistent with the Borough's Master Plan Land Use Plan Element.

The Redevelopment Plan objectives articulated above are consistent with and seek to advance the goals of the Borough's Master Plan Reexamination Report, and the State Development and Redevelopment Plan, as discussed herein.

LAND USE PLAN

Relationship to the Borough's Zoning and Land Development Regulations

In order to implement the Plan consistent with the objectives herein, the Redevelopment Area shall be developed in accordance with the standards detailed in this Redevelopment Plan. Except where otherwise noted, this Plan shall supersede the underlying zoning regulations including use, bulk, and design standards of the Borough's Land Use Ordinance as they relate to the area governed by this Redevelopment Plan. The definition of terms found in the Borough's Land Use Ordinance shall apply unless otherwise noted herein.

All development within the Redevelopment Area must be approved by the Land Use Board of the Borough of Highlands, and shall be submitted following the normal subdivision and site plan submission and review procedures as found in N.J.S.A. 40:55D-1 et seq, and those within the Borough's Land Use Ordinance.

Land Use and Building Requirements

Compliance with the following standards shall be treated as zoning requirements. Any deviation from these standards that would result in a "d" variance as per N.J.S.A. 40:55D-70.d of the municipal land use law, shall be addressed as an amendment to the Plan. The Land Use Board shall not have the authority to allow deviations from these standards which would result in a "d" variance.

The Land Use Board shall have the authority to grant any deviations from these standards which would result in a "c" variance, as per N.J.S.A. 40:55D-70.c, to the same extent that they may grant relief from such standards under normal subdivision and site plan review processes.

Land Use Regulations

The intent and purpose of these land use regulations are to allow for a flexible redevelopment of the site with a potential range of residential uses, from single-family detached dwellings to mid-rise multi-family dwellings, and also to permit appropriate complementary commercial uses that could take advantage of the scenic views offered by the location at the top of the bluff.

Definitions

Critical Slope Area – Any topographic slope of fifteen percent (15%) or greater.

All other definitions used within the Borough's Land Use Ordinance shall apply.

Permitted Principal Uses

The following uses are permitted as principal uses within the Redevelopment Area:

Residential Uses:

- Single-family detached dwellings
- Two-family dwellings
- Townhouses
- Multi-family dwellings

Public Uses:

- Municipal facilities and essential services
- Public parks and recreation spaces

Commercial Uses

- Retail sales and services
- Restaurants, bars, taverns, and other eating establishments
- Professional, administrative, and business offices

Other Uses:

- Any other use which is substantially similar in nature to the uses listed as permitted principal uses.
- Mixed-use buildings consisting of any combination of the above listed permitted uses

Conditionally Permitted Uses

The following uses are permitted as conditional uses, with the required conditions for approval noted below:

- Hotel
    a. Minimum Lot Area shall be 5 acres.
    b. Each unit for rental shall have a minimum gross floor area of 350 square feet.
    c. An off-street drop off area shall be provided for guests checking in and out.
    d. A restaurant, tavern, or bar shall be permitted as an accessory use to a hotel, subject to additional parking being provided at the ratio according to the parking requirements listed in this Plan.
- Bed and Breakfast
    a. Minimum Lot Area shall be 10,000 square feet.
    b. With the exception of minimum lot area, all standards for a single or two family dwelling shall be met.
    c. An off-street drop off area shall be provided for guests checking in and out.
    d. The service of food shall be limited to guests of the establishment only.

Prohibited Uses

- Industrial Uses
- Take Out Restaurants
- Gas stations/Automobile Service Stations
- Automobile Repair Garages
- Automobile sales
- Drive-thru facilities

Permitted Accessory Uses

- Off-street surface parking lots;
- Structured parking garages;
- Signs;
- Utility buildings which are incidental to residential uses;
- Residential clubhouses or common recreation areas;
- Any other use or structure that is deemed by the Land Use Board to be customary, incidental, and accessory to the principal uses or structures permitted herein.

Area, Yard, and Building Requirements

Except where otherwise noted, the following area requirements shall apply to all development within the Redevelopment Area:

Single-family or two-family dwellings:

- Minimum Lot Area – 5,000 square feet per dwelling
- Minimum Front Yard Setback – 20 feet
- Minimum Side Yard Setback – 8 feet
- Minimum Rear Yard Setback – 30 feet
- Maximum Building Height – 2.5 stories or 35 feet
- Maximum Building Coverage – 30 percent

Townhouses:

- Minimum Lot Area – 2,000 square feet per dwelling
- Max number of units per structure – 5 dwellings
- Minimum Front Yard Setback – 12 feet
- Minimum Side Yard Setback – 15 feet
- Minimum Rear Yard Setback – 30 feet
- Maximum Building Height – 3 stories or 40 feet
- Maximum Building Coverage – 50 percent

Multi-family dwellings, or mixed-use buildings which contain residential uses:

- Minimum Front Yard Setback – 25 feet
- Minimum Side Yard Setback – 25 feet
- Minimum Rear Yard Setback – 50 feet
- Maximum Building Height – 10 stories or 125 feet
- Maximum Building Coverage – 50 percent

All other permitted uses:

- Minimum Front Yard Setback – 25 feet
- Minimum Side Yard Setback – 25 feet
- Minimum Rear Yard Setback – 60 feet
- Maximum Building Height – 3 stories or 40 feet
- Maximum Building Coverage – 35 percent

Overall Density Requirements:

- The maximum permitted residential density over the entire Redevelopment Area shall not exceed 30 dwelling units per gross acre.
- For the purposes of calculating residential density, if any hotel or bed and breakfast is proposed within the Redevelopment Area, each guest room shall be considered a residential dwelling unit.

Multi-family Residential Minimum Unit Floor Area Requirements:

- Studio apartment – 400 square feet
- One bedroom apartment – 550 square feet
- Two bedroom apartment – 700 square feet
- Three bedroom apartment – 900 square feet

Accessory Structure Requirements

- No accessory structures shall be permitted within the required front yard area.
- The minimum required rear and side yard setbacks for an accessory structure shall be one-half that of the principal structure.
- The maximum permitted height of any accessory structure shall be 15 feet.

Additional Requirements

- Commercial uses shall be permitted only as a part of a planned mixed-use development which includes residential uses.

- Commercial uses shall be limited to occupying no greater than 25 percent of the Redevelopment Area. This shall include any structures and associated parking, circulation, or accessory uses and facilities with any non-residential use.
- The maximum total floor area of all commercial uses within the Redevelopment Area shall not exceed 25,000 square feet.
- The permitted impervious coverage anywhere within the Redevelopment Area shall be subject to the review and approval of the Land Use Board Engineer, and/or any qualified professional retained by the Land Use Board or the Borough to review any redevelopment applications for this Area.
- All impervious coverage shall be the minimum necessary to effectuate the goals of this Redevelopment Plan, and shall be designed with the intent to minimize detrimental impacts to the stability of the slopes within the site.
- More than one permitted principal use or structure may be permitted on a single lot. In such an instance the minimum separation between buildings shall be as follows:
    a. For buildings of 1-3 stories in height: 25 feet
    b. For buildings of 4-6 stories in height: 50 feet
    c. For buildings of 7 stories in height or greater: 75 feet
- Where more than one principal use is proposed on a site, the bulk standards for each use shall apply separately.
- A landscaped buffer of at least 50 feet in width shall be provided for any development which will abut a residential property or residentially zoned property.
- A landscaped buffer of 50 feet in width shall be provided along the frontage of Ocean Drive.

Off-Street Parking Requirements

Off-street parking shall be provided on site for each use at the following ratios:

Use	Parking Requirement
Single-family dwellings	2 spaces / dwelling
Two-family dwellings	2 spaces / dwelling
Townhouses	2 spaces / dwelling
Multi-family dwellings	1.7 spaces / dwelling unit
Municipal Facilities	1 space / employee on maximum shift
Professional, Administrative, Business Offices	1 space / 300 square feet gross floor area
Public Parks and Recreation	At the discretion of the Land Use Board
Retail Sales and Services	1 space / 250 square feet of gross floor area
Restaurants, Bars, Taverns, Eating Establishments	1 space / 3 seats
Hotel	1.2 spaces / sleeping room
Bed and Breakfast	1 space / guest room + 2
Any other use	At the discretion of the Land Use Board

Where any required parking calculation results in a fraction of a parking space, the required amount of off-street parking shall be rounded up to the nearest whole number of parking spaces.

Critical Slope Areas

Given the nature of the slump block of the ridgeline and bluffs of the Redevelopment Area, special consideration shall be given to protection of the slopes in any grading, soil disturbance, and stormwater management plans. Any application for development or redevelopment within the Redevelopment Area shall include a geotechnical report and feasibility study prepared by a qualified professional engineer that has demonstrated experience in analysis of slump block areas and landslide prone areas from prior projects. The report shall contain at minimum the following information:

- A review of relevant previous professional studies and reports regarding slump blocks and landslides within the Area, including:
    - Slump Blocks in the Atlantic Highlands of New Jersey, by James P. Minard (1974)
    - Report of Atlantic Highlands-Highlands, Environmental Impact Statement, by Converse Ward Davis Dixon, (1978), provided in Appendix D.
    - USGS Landslide Monitoring in the Atlantic Highlands Area, New Jersey (active)
- An analysis of the soil conditions within the Redevelopment Area, and their suitability to support any proposed development.
- An analysis of the potential impacts of construction activity on the stability of the soils and the slopes.
- A detailed plan to protect and stabilize the slopes prior to, during, and after construction of any development project.
- An analysis of the impacts of stormwater on the stability of the soils and slopes on site.
- A detailed plan to minimize any potential impacts of stormwater on the stability of soils and slopes on the site.
- The geotechnical report and related plans shall be subject to the review and approval of the Board Engineer, and/or any other qualified geotechnical professional retained by the Borough or the Land Use Board for the purposes of reviewing any redevelopment applications within the Redevelopment Area.
- It shall be the developer's obligation to bear the cost of any Geotechnical Engineering expert retained by the Land Use Board, via application escrow.

Critical slope areas shall have the following protections:

- Except as otherwise noted herein, all development shall conform to the standards of the Borough's Steep Slopes and Slump Blocks Ordinance, found in §21-84B of the Zoning Ordinance.
- A redeveloper shall demonstrate that the disturbance of any critical slope area is necessary for the proposed development of the site.

- A redeveloper shall demonstrate that non-critical areas have been utilized to the maximum extent reasonably practicable, and that disturbance of critical slope areas has been minimized.
- Appropriate revegetation and landscaping of any disturbed critical slope areas shall be provided to help to adequately stabilize the slope in accordance with best practices for soil conservation and stormwater management techniques.
- No drainage shall be permitted to flow overland down critical slope areas, and all drainage shall be designed to minimize any impacts to existing down gradient facilities.

Design Standards

The following standards are intended to provide guidance in regards to the aesthetics of buildings, landscaping, and other site amenities and design features in order to encourage a high standard of development.

Any deviation from the following Design Standards of this Redevelopment Plan shall be treated as a design waiver. The Land Use Board shall have the authority to grant design waivers as an exception to these standards if it finds that the proposed conditions are satisfactory, and will generally advance the purposes of this Redevelopment Plan, without any substantial detriment to the public welfare or the intent of this Plan.

Redevelopment of the Area shall comply with the following design standards:

General Design Standards

- The design of buildings and landscaping within the Redevelopment Area shall be considerate of the site's prominent location as a potentially highly visible gateway into the Borough of Highlands. Attention should be given to the aesthetics of the building and site design as it would be visible from Route 36, within the site itself, and from the rest of the Bough at the bottom of the cliffs, or from Sandy Hook. All buildings and landscaping shall be designed to be attractive from each of these points of view.
- Buildings shall be designed using a color palette that complements the architectural context of the surrounding area.
- The visual impact of any parking facilities, or other accessory structures or uses shall be minimized to the greatest extent feasible.
- Blank, or featureless walls shall be avoided.

Architectural Design Standards

- Primary exterior building materials shall be wood, brick, stone, stucco, metal, glass, or other similarly durable and attractive materials.
- Exterior building walls shall be consistent in their quality and finish on all elevations visible from a public right-of-way.
- Buildings which have a horizontal width of greater than 100 feet shall be designed so as to visually separate the proportions into vertical segments.
- No building shall have a wall with an uninterrupted length of more than 60 feet without including a change in the vertical plane of the facade. This may be achieved through any one or combination of the following:
    - Pilasters, bay windows, building step-backs, and other façade recesses or projections.
    - The step-back or projection shall be a minimum of 18 inches from the primary building façade.

    - The changes in the building façade plane shall occur over at least two stories of a building which is 3 stories in height or greater. For buildings less than 3 stories in height, the change may occur on only a single story.
- If exterior shutters are used, they shall be sized and mounted to fit their window opening, whether or not they are actually operable.

Landscaping and Fence Design Standards

- Sidewalks of at least 5 feet in width shall be provided along the frontage of all streets within and adjacent to the Redevelopment Area.
- Sidewalks of at least 5 feet in width shall be provided to provide access between any proposed Redevelopment Project and the public right-of-way.
- Where the foundation of a building is exposed, it shall be screened by plant materials.
- Shade trees shall be required along the frontage of any public right-of-way, or any private access road within the Redevelopment area.
- Shade trees shall be located within 10 feet of the curb, and spaced no greater than 40 feet apart.
- Shade trees shall be a deciduous species which is native to the Monmouth County region.
- Shade trees shall have a minimum caliper of 2.5 inches at the time of planting.
- No chain link fences shall be permitted.
- Barbed wire, razor wire, or other such materials are prohibited on any fence within the Redevelopment Area.
- Fences in a front yard area shall have a maximum height of 4 feet.
- Fences in a side or rear yard area shall have a maximum height of 6 feet.
- Retaining walls shall be constructed of a material which will complement the design of buildings and landscaping on the site.
- Where a buffer is required, it shall be made up of a mixture of dense evergreen planting materials of sufficient quantity and shape to effectively visually screen the Redevelopment Area from adjacent land uses.

Parking and Circulation Design Standards

- Loading and service areas shall be located to the side or rear of a building, and shall be screened from public view.
- Parking lots or structured parking garages shall be located interior to the site, and shall be screened from public view.
- Parking lots shall be surrounded by any combination of a garden wall, fence, or landscaping of a minimum height of 3 feet.
- Structured parking garages shall be designed to be visually integrated with the building(s) they are intended to serve. The architectural style, materials, and massing should complement the building(s).

- Circulation design shall be provided in accordance with the standards of the Borough's Land Use Ordinance.

Lighting Standards

- The maximum height of any freestanding light shall be 15 feet, or the height of the principal structure on the property, whichever is lesser.
- All lighting shall include shields and shall be directed towards the site.
- All lighting shall be provided in accordance with the standards of the Borough's Land Use Ordinance.

Mechanical Equipment and Utilities Standards

- All mechanical equipment shall be located internally within a building, or to the side or rear of a principal building and shall be screened from public view.
- Where feasible, utilities shall be located underground.
- Utility meters shall be located internally within a building, or to the side or rear of a principal building, and shall be screened from public view.
- Trash and recycling storage facilities shall be located within each principal building.
- Permanent outside storage of trash or recyclable materials shall be prohibited.

Signage Standards

- All signage shall be in accordance with the Borough's Land Use Ordinance.

RELATIONSHIPS TO OTHER PLANS

Borough of Highlands Plans

Pursuant to the LRHL, "all provisions of the Redevelopment Plan shall be either substantially consistent with the municipal master plan or designed to effectuate the master plan." (N.J.S.A. 40A:12A-7d).

Borough of Highlands Master Plan Reexamination Report (2016)

The Borough's Master Plan was adopted in 2004. The Borough adopted its most recent reexamination report of the Master Plan in December of 2016. The following goals and objectives of the Master Plan have a relationship to this Redevelopment Plan:

- To meet the needs of the Borough with the creation of mixed use development of exceptional design quality, a waterfront destination for activity and relaxation.
- A redeveloped community offering homes, employment, services, civic spaces, and leisure in a quality environment which will form part of the established communities of the Bayshore Region.
- To protect the existing natural resource base through sensitive design, energy efficiency, sustainable waste management, and to minimize the impact on the local environment.
- Strive to increase the percentage of owner-occupied housing in the Borough.
- Require that infill development be compatible with the neighborhood and conform to the setbacks of existing buildings on the block.
- Create attractive gateways at the principal entrances to the Borough through upgraded land uses, streetscape improvements, and signage.
- Encourage redevelopment in areas that need rehabilitation or improvement.
- Capitalize on the economic resources represented by Sandy Hook, Route 36, the Twin Lights, the New York Ferry, and the physical attractiveness of the area.
- Encourage neighborhoods to improve their aesthetic appeal and identity.

The Master Plan Reexamination included a specific discussion for Shadow Lawn Mobile Home Park:

- This is one of the few tracts of land left for development in the Borough. The Borough's 2016 Housing Element references this site as a potential location to include affordable housing in a development. It is a recommendation of this report to create a new mixed use zoning district consisting of this lot to encourage the redevelopment of the site, taking into consideration its proximity to Route 36 and multi-family zone districts, and its location of top of the hill.

- The Shadow Lawn Mobile Home Park should be rezoned to a mixed use district which would permit multi-family housing at a density of 30 units per acre, as well as restaurants, retail space, and office uses.
- The Land Use Plan Map, identifies the lands within this Redevelopment Area as being proposed for mixed use development.

In addition to general land use goals and recommendations, the Plan noted issues with regard to the stability of the slopes on which the site is located. The Plan recommends that the Borough review and update their steep slope protection ordinances, and work with the US Geological Survey to mitigate any issues of erosion and slumping of cliffs.

This Plan is intended to carry out the recommendations of the Master Plan Reexamination Report by creating new use, dimension, and design regulations specific to the Shadow Lawn Mobile Home Park.

Highlands Borough Housing Element and Fair Share Plan (2016)

The Borough's Housing Element and Fair Share Plan (HEFSP) indicates that based on a preliminary report issued by the Superior Court's appointed Regional Master, Richard Reading, that the Borough must provide 55 affordable housing units to meet its Round 3 (1999-2025) affordable housing fair share obligation. However, the Superior Court, Monmouth County Vicenage, has yet to make a legal determination as to the Borough's fair share obligation for the Prior Round (1987-1999) or the Borough's Round Three obligation. The Plan specifically notes that this site has the potential to be rezoned and developed with a mixed use development. The Plan notes show that if the site were to be developed with multi-family housing, with an affordable housing set aside of 15% of units for rentals, or 20% of units for for-sale, the site could produce approximately 16-25 units of affordable housing for the Borough. The HEFSP included the potential for 16 units on the site through inclusionary development to address this need as part of the mechanisms identified to bring the Borough into compliance with fair share housing requirements.

This Redevelopment includes an affordable housing requirement, and will implement the recommendations of the Housing Element and Fair Share Plan to help the Borough reach its fair share affordable housing goals.

Monmouth County Plans

Monmouth County Master Plan (2016)

The Monmouth County Master Plan includes the following goals and objectives which are relevant to this Plan:

- Promote beneficial development and redevelopment that continues to support Monmouth County as a highly desirable place to live, work, play, and stay.

- Encourage the redevelopment and revitalization of highway commercial corridors that incorporate multi-purpose uses, higher design standards, are located outside Special Flood Hazard Areas, and improve circulation both on and off-site.

The Plan also identifies Highlands Borough as a priority growth reinvestment area, which is an area that the County wishes to highly encourage intense development, redevelopment, revitalization, and hazard mitigation investments.

This Plan will further the goals of the County Master Plan.

Bayshore Region Strategic Plan (2006)

The Monmouth County Planning Board adopted the Bayshore Region Strategic Plan in September of 2006. This document provides an assessment of existing conditions and makes recommendations for land use and economic development for all of the communities which lie along the Raritan and Sandy Hook Bays in the northern end of the County. The plan identifies the area on Route 36 near the site as a strategic gateway into Highlands Borough, and recommends creating a center of activity around the intersection of Route 36 and Linden Avenue.

This Plan will contribute to the development of this site as an attractive gateway into the Borough, and help to transform the area into a center for activity along Route 36.

State Plans

State Development and Redevelopment Plan (2001)

The State Plan Policy Map and State Development and Redevelopment Plan (SDRP) classify the Redevelopment Area as being within the Metropolitan Planning Area (PA-1). The Metropolitan Planning Area is made up of existing urban centers and post-war suburbs that have strong ties to a major metropolitan center. The intention of the State Plan is that the majority of future growth and redevelopment be directed to lands within Planning Areas 1 and 2. These areas have the available infrastructure to support compact growth and development, and by directing growth to these areas, the character of existing communities can best be protected.

The goals, objectives, and provisions of this Redevelopment Plan are intended to guide the revitalization of the Redevelopment Area in a manner consistent with the State Plan policies established for the Metropolitan Planning Area in which the Redevelopment Area is located. These goals are advanced by redeveloping lands in an area with existing infrastructure capacity.

Draft State Strategic Plan (2011) – not officially adopted

The State Strategic Plan was developed in 2011 as an update to the State Development and Redevelopment Plan, however it has not as of yet been officially adopted. The goals of this Draft Plan included:

- Enhance opportunities for attraction and growth of industries of statewide and regional importance.
- Guide and inform regional planning so that each region of the State can experience appropriate growth according to the desires and assets of that region.
- Ensure that strategies for growth include preservation of our State's critical natural, agricultural, scenic, recreation, and historic resources, recognizing the role they play in sustaining and improving the quality of life for New Jersey residents and attracting economic growth.
- The State Strategic Plan lists all areas that located within the Metropolitan Planning Area (PA-1) of the State Development and Redevelopment Plan, as being within "priority growth investment areas" where public and private investment to support development and redevelopment should be encouraged and supported.

Other Plans

Master Plans of Contiguous Municipalities

The Redevelopment Area is located in the western end of the Borough, and is adjacent to the Borough of Atlantic Highlands, and the Township of Middletown.

The Borough of Atlantic Highlands most recently adopted a Master Plan in May of 2006, and last revised the Plan in August of 2007. The Plan notes that future land uses for the areas adjacent to Highlands Borough are currently zoned for and used as single-family residences, and no changes are proposed for this land use pattern.

Middletown Township sits directly across Route 36 from the Redevelopment Area. The areas of Middletown adjacent to Route 36 are currently developed with low-density single family dwellings. The Township adopted a Master Plan Reexamination Report in August of 2014. The future land use map of the Plan identifies these areas to remain as single family dwellings, and further west of the Area multi-family dwellings are proposed.

This Plan proposes a mix of residential and commercial uses which will complement the surrounding the residential communities both within Highlands Borough and the adjacent municipalities.

ADMINISTRATIVE AND PROCEDURAL REQUIREMENTS

Acquisition and Relocation

The Area governed by this Redevelopment Plan is a Non-Condemnation Redevelopment Area. The use of eminent domain for the acquisition of property is not authorized by this Plan. Provisions for the acquisition of property will not be required. However, the Redevelopment Area contains residential uses, as there are approximately 100 mobile home units on the site. It is estimated that approximately 50 units are occupied at the present time. Provisions for providing relocation assistance for any current residents of the mobile home community will be necessary.

The Borough and/or the redeveloper will provide relocation assistance to all residents pursuant to applicable State and Federal laws as necessary.

Any approval for development which would result in the retirement of the mobile home park or the removal of any residents of the mobile home park shall condition such an approval that the applicant or redeveloper provide proof, to the satisfaction of the Land Use Board, that adequate private residential facilities and circumstances exist for the relocation of those residents consistent with the requirements of N.J.S.A. 46:8C-21. Although N.J.S.A. 46:8C-21 is invoked by an application for one (1) or more variance(s), the requirements of N.J.S.A. 46:8C-21 shall apply to the aforementioned circumstances regardless of whether or not the application requires one (1) or more variance(s). For purposes of this chapter, "adequate private residential facilities and circumstances" shall share the definition of "comparable housing or park site" as provided in N.J.S.A. 2A:18-61.7(a). A redeveloper must provide proof of compliance with this paragraph to the Land Use Board prior to obtaining final approval. This Section is not severable from the other provisions of the chapter and the zoning modifications herein are conditioned upon the above relocation provision.

Inventory and Replacement of Affordable Housing

The Redevelopment Area governed by this Redevelopment Plan contains no housing units previously identified as affordable to low and moderate income households, as defined pursuant to section 4 of P.L.1985, c.222 (C.52:27D-304). No deed restricted affordable units for which the Borough is eligible to receive affordable housing credits pursuant to the Fair Housing Act and its implementing regulations, including Uniform Housing Affordability Controls, N.J.A.C. 5:80-26.1 et. Seq., will be removed as a result of implementation of this Redevelopment Plan. For that reason, the Borough is not required to plan for the provision of new or substantially rehabilitated affordable housing as a result of the implementation of this Redevelopment Plan.

This Redevelopment Plan however does require that affordable housing units as defined in Section 4 of P.L.1985, c.222 (C.52:27D-304), be included within any residential development to assist in meeting the Borough's fair share affordable housing obligations.

Amending the Redevelopment Plan

Upon compliance with the requirements of applicable law, the Borough Mayor and Council may amend, revise, or modify this Redevelopment Plan in general or for specific properties within the Redevelopment Area as circumstances may make such changes necessary and appropriate. The review and approval of any proposed amendments shall be undertaken in accordance with the procedures set forth in the LRHL. Any proposed changes in the Land Use Plan, including changes to permitted uses, building height, building setbacks, parking requirements, or other bulk standards, shall require notice and public hearings in a manner similar to the adoption of the original Plan.

Redevelopment Powers

The Borough may use any and all redevelopment powers granted to it pursuant to the LRHL to effectuate this Plan, except that the use of eminent domain shall be prohibited. The Borough may enter into agreements with a designated redeveloper(s) in connection with the construction of any aspect of the Redevelopment Plan, including off-site improvements.

Conveyance of Land

The Borough may sell, lease, or otherwise convey to a redeveloper for redevelopment, subject to restrictions, controls and requirements of the Redevelopment Plan, all or any of the properties designated in need of redevelopment within the Redevelopment Area of this Plan that it owns or may acquire via means other than eminent domain. The Borough may also use its redevelopment powers pursuant to the LRHL to enter into other agreements with a designated redeveloper or redevelopers in connection with the implementation of the Redevelopment Plan.

Duration of the Plan

The Redevelopment Plan, as it may be amended from time to time, shall be in full force and effect upon its adoption by ordinance by the Borough of Highlands Mayor and Council, and shall be in effect until the Mayor and Council shall by ordinance adopt new regulations to supersede those found in this Redevelopment Plan.

REDEVELOPER OBLIGATIONS

Redevelopment under the terms of this Redevelopment Plan shall only be undertaken pursuant to a redevelopment agreement entered into between the Borough, acting as the Redevelopment Agency, and a designated redeveloper. The following restrictions and controls on redevelopment shall apply notwithstanding the provisions of any zoning or development ordinance or other regulations now or hereafter in force:

- The redeveloper will be obligated to carry out the specified improvements in accordance with this Redevelopment Plan.
- The redeveloper, its successors or assignees, shall develop the Redevelopment Area in accordance with the uses and building requirements specified in the Redevelopment Plan.
- Until the required improvements are completed and a certificate of completion is issued, the redeveloper covenants provided for in N.J.S.A. 40A:12A-9 and imposed in any redevelopment agreement, lease, deed or other instruments shall remain in full force and effect.
- The redevelopment agreement(s) shall contain provisions to assure the timely construction of the redevelopment project, the qualifications, financial capability and financial guarantees of the redeveloper(s) and any other provisions necessary to assure the successful completion of the project.
- The redevelopment agreement(s) shall provide provisions requiring that sufficient funds be deposited in escrow to allow the Borough and/or the Borough Land Use Board to hire their own independent geotechnical engineering expert to review the geotechnical report and the proposed plans of the redeveloper(s).
- The redevelopment agreement(s) shall provide provisions for the appropriate relocation assistance in compliance with all applicable Federal or State laws for any residents removed as a result of any redevelopment project(s).

AFFORDABLE HOUSING REQUIREMENTS

The redeveloper shall provide for an affordable housing component to the project so as to contribute towards the Borough's constitutional fair share obligation through any lawful mechanism recognized by the Fair Housing Act and the Council on Affordable Housing's implementing regulations as agreed upon by the Borough. Compliance with this requirement shall be included in any redevelopment agreement(s) entered into by the Borough and the designated redeveloper(s).

Any redevelopment project(s) within the Redevelopment Area shall include affordable residential units in compliance with the Borough's Housing Element and Fair Share Plan, and any ordinances adopted to implement the Housing Element and Fair Share Plan.

LAND USE BOARD REVIEW PROCESS

Pursuant to N.J.S.A. 40A:12A-13, all applications for development of sites governed by this Redevelopment Plan shall be submitted to the Borough Land Use Board for review and approval. The following provisions shall govern review of any proposed redevelopment projects for the redevelopment area:

- No building or zoning permit shall be issued by the construction or zoning official for any work resulting in a change of intensity of development or change of use for any properties or buildings within the area of the Redevelopment Plan without prior review and approval of the work by the Land Use Board, or the Borough Mayor and Council if necessary.
- Regular maintenance and minor repair shall not require Land Use Board review and approval.
- As part of site plan approval, the Land Use Board may require the redeveloper to furnish performance guarantees pursuant to N.J.S.A. 40:55D-53 and as required in the Borough's Land Use Ordinance. The performance guarantees shall be in favor of the Borough of Highlands, and the Borough Engineer shall determine the amount of any performance guarantees.
- Any subdivision of lots or parcels of land within the Redevelopment Area shall be in compliance with the Redevelopment Plan and reviewed by the Land Use Board pursuant to the Local Redevelopment and Housing Law and N.J.S.A. 40:55D-1 et seq.
- Once a property has been redeveloped in accordance with the Redevelopment Plan, it may not be converted to any use not expressly permitted in this Redevelopment Plan. No non-conforming use, building, or structure may be expanded or made more non-conforming in nature after adoption of this Redevelopment Plan. A use or structure not conforming to the requirements of this Redevelopment Plan may not be reconstructed in the event of its destruction. The Land Use Board shall determine the issue of whether the non-conforming use or building structure has been "destroyed."
- The regulations and controls of this Redevelopment Plan shall be implemented, where applicable, by appropriate covenants, or other provisions and through agreements between the redeveloper and Borough pursuant to N.J.S.A. 40A:12A-8 and 40A:12A-9.
- The extent of the redeveloper's responsibility for any installation or upgrade of infrastructure related to the development of the Redevelopment Area, or contribution thereto, shall, whether on-site or off-site, be subject to a redevelopment agreement with the Borough of Highlands, as the municipal redevelopment agency.
- A redeveloper shall be required to pay all applicable escrow fees and other required charges in accordance with applicable provisions of the Borough Ordinance and State law. Additionally, a redeveloper shall be required to pay their proportional share of the cost of any studies, plans, reports, or analyses prepared by the Borough or its designated redevelopment entity as part of this Redevelopment Plan. Any such payments required to reimburse the Borough shall be specified in the redevelopment agreement.

The above provisions are all subject to approval by ordinance and/or resolution according to law. If a court of competent jurisdiction finds any word, phrase, clause, section, or provision of this Redevelopment Plan to be invalid, illegal, or unconstitutional, the word, phrase, clause, section, or provision shall be deemed severable, and the remainder of the Redevelopment Plan and implementing ordinances shall remain in full force and effect.

AMENDMENT TO ZONING MAP AND DEVELOPMENT REGULATIONS

The Borough's Zoning Map is hereby amended to reference this Redevelopment Plan as a zoning district encompassing the Redevelopment Area as illustrated in the Redevelopment Area Map. Additionally, the listing of zoning districts in the Borough of Highlands Land Use Ordinance is hereby amended to include a reference to this Redevelopment Plan constituting such substitute zoning districts.

Where specifically provided for herein, the development standards set forth in this Redevelopment Plan shall supersede the Land Use Ordinance of the Borough of Highlands. In all other instances, the Borough Land Use Ordinance shall remain in full force and effect.

APPENDICES

Appendix A:

Resolution of the Governing Body designating the Area in Need of Redevelopment

BOROUGH OF HIGHLANDS
COUNTY OF MONMOUTH

RESOLUTION 18-069

RESOLUTION ACCEPTING RECOMMENDATION OF BOROUGH OF HIGHLANDS MUNICIPAL LAND USE BOARD AND DESIGNATING BLOCK 105.107, LOT 1.1, COMMONLY REFERRED TO AS THE SHADOW LAWN MOBILE HOME PARK SITE, AS AN AREA IN NEED OF REDEVELOPMENT PURSUANT TO THE NEW JERSEY LOCAL REDEVELOPMENT AND HOUSING LAW, N.J.S.A. 40A:12A-1 ET. SEQ.

WHEREAS, by way of Resolution 16-228, lawfully adopted on December 7, 2016, the governing body directed and authorized the Borough of Highlands Land Use Board (the "Board") to conduct a preliminary investigation to determine whether Block 105.107, Lot 1.1 (the "Study Area"), commonly referred to as the Shadow Lawn Mobile Home Park Site, qualifies as an "area in need of redevelopment" pursuant to the Local Redevelopment and Housing Law, N.J.S.A. 40A:12-1, et. seq.; and

WHEREAS, by way of Resolution 16-228, the governing body resolved that this redevelopment area determination shall authorize the municipality to use all of those powers provided by the New Jersey Legislature for use in a redevelopment area, other than the use of eminent domain ("Non-Condemnation Redevelopment Area"); and

WHEREAS, as part of its preliminary investigation, the Board caused Heyer, Gruel & Associates, Licensed Professional Planners to prepare an Area in Need of Redevelopment Investigation Report (the "Investigation Report") for the Board for its consideration in determining whether the Study Area should be designated a Non-Condemnation Redevelopment Area; and

WHEREAS, the Investigation Report prepared by Heyer, Gruel & Associates, dated November 2017, determined that the Study Area met the statutory criteria in accordance with the Local Redevelopment and Housing Law, to be designated as "an area in need of redevelopment", which is attached hereto and made a part hereof as Exhibit A; and

WHEREAS, the area recommended for determination as "an area in need of redevelopment" is specifically described in the Investigation Report and the boundaries of same are shown on the maps and exhibits included within the said Investigation Report, which is attached hereto and made a part hereof as Exhibit A; and

WHEREAS, the Borough of Highlands Land Use Board, pursuant to all notices required by law, conducted a public hearing on January 31, 2018 to determine whether the Study Area meets the statutory criteria of an area in need of redevelopment and considered any public comments and objections thereto; and

WHEREAS, as a result of the hearing, the Board made recommendations to the Mayor and Council of the Borough of Highlands that the Study Area as described in the Investigation Report, which is annexed hereto as Exhibit A, be designated as a Non-Condemnation Area in Need of Redevelopment pursuant to N.J.S.A. 40A:12A-5, which recommendations were memorialized in a Resolution of the Borough of Highlands Land Use Board duly adopted on February 14, 2018; and

WHEREAS, the Mayor and Borough Council reviewed the aforesaid Resolution of the Borough of Highlands Land Use Board, as well as the Investigation Report dated November 2017, which is annexed hereto as Exhibit A; and

NOW THEREFORE BE IT RESOLVED, that the Mayor and Council of the Borough of Highlands accepts the Board's recommendations set forth in the Borough of Highlands Municipal Land Use Board Resolution dated February 14, 2018, and that it hereby adopts the recitals and findings of the Borough of Highlands Land Use Board and the Investigation Report attached hereto as Exhibit A, as if fully set forth herein, and therefore determines and declares that the area of investigation, as contained in the Investigation Report of Block 105.107, Lot 1.1, be and is hereby determined to be a Non-Condemnation Area in Need of Redevelopment, pursuant to the Local Redevelopment and Housing Law, N.J.S.A. 40A:12A-1 et. seq.

BE IT FURTHER RESOLVED, that the designation of Block 105.107, Lot 1.1 as a Non-Condemnation Area in Need of Redevelopment shall not authorize the Borough to exercise the power of eminent domain to acquire any property in the study area.

BE IT FURTHER RESOLVED, that the Borough hereby reserves all other authority and powers granted to it in the Local Redevelopment Law.

BE IT FURTHER RESOLVED, that the Local Redevelopment and Housing Law, N.J.S.A. 40A:12A-1 et. seq. provides for procedures to establish a Redevelopment Plan for the municipality, and the Mayor and Council of the Borough of Highlands have determined that it will embark upon the preparation of such a Redevelopment Plan.

BE IT FURTHER RESOLVED, that pursuant to N.J.S.A. 40A:12-6(b)(5)(c), the Borough Clerk is hereby authorized and directed to transmit a certified copy of this Resolution to the Commissioner of the Department of Community Affairs for review.

BE IT FURTHER RESOLVED, that pursuant to N.J.S.A. 40A:12A-6(b)(5)(d), the Borough Clerk is hereby authorized and directed to transmit a certified copy of this Resolution upon all record owners of the properties located within the delineated area of the Investigation Report as those names are listed within the official Tax Assessor's records within ten (10) days of the adoption hereof.

BE IT FURTHER RESOLVED, that pursuant to N.J.S.A. 40A:12A-6(b)(5)(d), the Borough Clerk is hereby authorized and directed to transmit a certified copy of this Resolution upon each person, if any, who filed a written objection and stated in such submission an address to which notice of this determination may be sent.

BE IT FURTHER RESOLVED, that a certified copy of this Resolution and underlying documents shall be available for public inspection during regular business hours at the office of the Borough Clerk.

MOTION to approve R-18-069:

	INTROUCED	SECONDED	AYE	NAY	ABSTAIN	ABSENT
BRASWELL			X			
BROULLON	X		X			
D'ARRIGO			X			
RYAN			X			
O'NEIL		X	X			

I, Bonnie Brookes, Municipal Clerk of the Borough of Highlands, in the County of Monmouth, State of New Jersey, hereby certify this to be a true copy of the action of the Governing Body, at its Council Meeting, held March 21st 2018. WITNESS my hand this 22nd day of March 2018.

Bonnie Brookes, RMC
Municipal Clerk

Appendix B:

Resolution of the Governing Body acting on the Redevelopment Plan (to be added upon adoption)

Appendix C:

Converse Ward Davis Dixon Report, (1978)

PRELIMINARY DRAFT REPORT OF
ATLANTIC HIGHLANDS-HIGHLANDS
PIGGYBACK ENVIRONMENTAL
IMPACT STATEMENT
GEOLOGY, HYDROGEOLOGY,
GEOTECHNICS

For

ECOL SCIENCES, INC.

By

CONVERSE WARD DAVIS DIXON, INC.

27 September 1978

Project No. C7807-12

ConverseWardDavisDixon
Geotechnical Consultants

27 September 1978

Ecol Sciences, Inc.
P. O. Box 245
20 Union Street
Rockaway, New Jersey 07866

Attention: Mr. Peter R. Spinney

Preliminary Draft Report: Atlantic Highlands-Highlands Piggyback Environmental Impact Statement
Geology, Hydrogeology, Geotechnics
(C7807-12)

Gentlemen:

This preliminary draft report covers our portion of the Atlantic Highlands-Highlands Piggyback Environmental Impact Statement, pertaining to geology, hydrogeology, and geotechnics. This work was authorized by you in a letter dated 18 July 1978.

Thank you for the opportunity of working with you on this project. Please call us if we may be of further assistance.

Respectfully submitted,

CONVERSE WARD DAVIS DIXON, INC.

Stuart R. Remz
Project Geologist

Gary S. Salzman, P.E.
Principal Engineer

JMD:GSS:SRR/jrs

Converse Ward Davis Dixon, Inc.
91 Roseland Avenue
Post Office Box 91
Caldwell, New Jersey 07006

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PROJECT DESCRIPTION

The overall project consists of performing a piggyback Environmental Impact Statement for the various alternatives to raise the quality of sewage effluent from the Atlantic Highlands-Highlands area to at least secondary treatment level.

The portion of the EIS to be completed by Converse Ward Davis Dixon, Inc. (CWDD) includes the referenced items of work outlined in the "Draft Outline for Atlantic Highlands-Highlands EIS, Attachment C", provided to us by Ecol Sciences, Inc.

In general, our work was confined to specific geologic, hydrogeologic, and geotechnical aspects of Section II (Description of the Existing Environment Within the Project Area); Section III (Environmental Constraints to Growth); Section VI (Impacts Associated with Feasible Alternatives); and Section VII (Adverse Environmental Impacts which Cannot Be Avoided Should the Feasible Alternatives Be Implemented and Steps Taken to Minimize Harm to the Environment).

Sections II and III are presented in this Preliminary Draft Report. On 6 September, we were instructed by Mr. Peter R. Spinney of Ecol Sciences at a joint meeting with Betz, Converse, Murdoch, Inc., to postpone work on Sections VI and VII until preliminary alternative schemes have been finalized. This would include the evaluation of the alternative options discussed at the referenced meeting.

PURPOSE AND SCOPE OF STUDY

The purpose of the general study was to evaluate the natural environment in terms of the alternative schemes to upgrade sewage from the study area to at least secondary treatment level. The portions of the study specifically assigned to CWDD, and presented in part in this Preliminary Draft Report, deal with the geologic, hydrogeologic, and geotechnical aspects of the natural environment.

SCOPE

The following services were performed:

1. Data Collection - We collected and reviewed existing data from our files, professional journals and publications, government publications, and previous consultant reports which were provided to us. All data sources are listed either in the References or Additional Data Sources sections of our report.
2. We obtained and interpreted stereo pairs of aerial photographs dated 1974 at a scale of 1" = 1000', and dated 1977 at a scale of 1" = 800'.
3. We visited the study area and performed a geologic reconnaissance.
4. We analyzed, interpreted, correlated, and evaluated all data obtained and produced this preliminary draft report containing our findings.

SECTION II. B. 1. a. PHYSIOGRAPHY

SECTION II. B. 1. a. PHYSIOGRAPHY

Monmouth County, in its entirety, lies in the Atlantic Coastal Plain physiographic province. The Atlantic Coastal Plain also includes the southeastern portions of Mercer and Middlesex Counties, as well as the entire counties of Ocean, Burlington, Camden, Gloucester, Salem, Cumberland, Atlantic, and Cape May. Regionally, the Atlantic Coastal Plain stretches as far south as Georgia.

In New Jersey, along the Trenton-New Brunswick line (northwestern limit of the Coastal Plain), the surface elevation is less than 100 feet above sea level. Southwest of Trenton, the elevation gradually decreases, following the Delaware River to sea level near the southern extremity of the state. At the northern limit of the Coastal Plain area, near Raritan and Sandy Hook Bays, the surface elevation is nearly 400 feet above sea level. From this high point, the surface slopes to sea level at the Atlantic coastline and to an elevation of approximately 100 feet along the northwestern boundary of the province. The higher areas to the north have been dissected to a subdued, hilly topography; farther south, the ground surface, due to its near sea level elevation, is mostly flat or with just gentle relief.

The physiography of the study area is unlike that of any other coastal area within the state. Bluffs, rising up to a maximum height of more than 200 feet, stretch along almost the entire bay shore, and dominate the region. This is the only location in the New Jersey Coastal Plain in which hills, higher than 200 feet, border on the ocean. The area has been dissected by streams, and presents a "rugged" appearance which is caused by the sandy, permeable nature of the sediments, and the semi-resistant layers of cemented sand locally present. The permeability of the unconsolidated material allows (to a large degree) water to pass through the sediments instead of eroding the surface; the semi-resistant layers of cemented sand resist erosion by water, and create the steep slopes.

SECTION II. B. 1. b. STRATIGRAPHY

SECTION II. B. 1. b. STRATIGRAPHY

The exposed stratigraphy of the project area has been the subject of many dissertations. The nomenclature and characteristics of the deposits are therefore well documented and extensively researched.

Introduction

The study area is underlain by a series of marine and beach-complex strata, which are tilted, or dip, gently to the southeast at a rate of about 10 to 40 feet per mile. The uppermost strata have been subjected to normal stream erosion, so that the surface appears hilly.

The upper layers have been defined as Pleistocene (ice age), recent in age, and consist of beach sands, alluvium, and tidal marsh deposits. Beneath this veneer are the coastal plain sediments. These strata are represented, in descending age, by: the Cohansey sand (youngest), thought to be of Miocene and Pliocene age; the Vincentown formation and the Hornerstown sand, of Paleocene age; and the Tinton sand, Red Bank sand, Navesink formation, and the Mount Laurel sand (oldest), all of upper Cretaceous age.

Sediments of upper Cretaceous age continue downward. However, they are not exposed in the study area. They are: the Wenonah formation, the Marshalltown formation, the Woodbury clay, the Merchantville formation, and the Magothy formation. Beneath the Cretaceous sediments is the Wissahickon formation, a pre-Cambrian metamorphic basement complex extending to great depths.

Geologic History

In late pre-Cambrian time (about 600 million years ago), the oldest known rocks in Monmouth County were deposited as sands and muds in a large coastal trough complex or geosyncline. The sediments were deposited over a sufficient time span to allow thousands of feet of material to accumulate in the slowly sinking trough. As more and more material was deposited, the mass of overlying sediments caused sufficient heat and pressure buildups to indurate, or lithify, the unconsolidated sands and muds into sandstones and shales. Subsequent intrusion of subterranean lava (called magma), and metamorphism altered the sandstones and shales to the gneisses and schists of the Wissahickon formation.

After uplift, the Wissahickon formation was eroded to a nearly flat plane. During early Cretaceous time (about 120 million years ago) the Appalachian Mountains were uplifted to the west. Eastward flowing streams then deposited sand, clay, and gravel on top of the Wissahickon formation during late Cretaceous time.

Whenever an erosional surface is encountered between two lithologic (rock) units, it is indicative of a change in physical conditions (e.g. deposition changing to non-deposition, etc.) and temporal gaps may occur in the stratigraphic sequence. These temporal gaps are generally termed unconformities, and exist world-wide. The late (upper) Cretaceous deposits lie unconformably on the Wissahickon formation.

After partial erosion of the upper Cretaceous deposits, the ocean began a series of advances and withdrawals across Monmouth County, and sand or clay was deposited during the many oceanic retreats and advances. Cretaceous deposition ended in Monmouth County by a complete withdrawal of the sea.

An interval of erosion ensued, and the landward edges of the Cretaceous deposits were eroded away. The next oceanic advance occurred over 60 million years ago during the Tertiary period. Alternating erosion and deposition continued throughout this time, and sands, clays, and gravels were deposited, unconformably, on the Cretaceous materials.

The deposits formed during the most recent million years and those now forming belong to the Quaternary system, which began with the advance of continental glaciers. Sand and gravel were deposited by meltwaters from receding glaciers. Deposits formed since the disappearance of the last glacier belong to the Recent Series.

Study Area Stratigraphy

The exposed stratigraphic units of the study area consist of a succession of 7 formations of late Cretaceous and Tertiary ages, which have a maximum thickness of about 300 feet. In addition, thin bands of alluvial and tidal-flat material are present along drainage courses and waterways, and a thick mass of beach sand constitutes Sandy Hook (the offshore barrier bar) and the flat beach areas at Waterwitch and Highlands (Pleistocene and Recent age).

The following stratigraphic descriptions have been adapted from Minard (1974).

Mount Laurel Sand

The oldest unit cropping out in the Atlantic Highlands is the Mount Laurel Sand. It crops out along the base of the bluffs adjacent to the bay, where nearly the entire thickness (25 feet) is exposed. The lower two-thirds of the formation is mostly thin-bedded very fine to medium-grained glauconitic (glauconite is a potentially unstable mineral, composed largely of iron, aluminum, and silica) quartz sand containing thin layers of clay and silt, which constitute about 40 percent of this part of the formation. The formation is greenish gray to dark greenish gray; much lignite and mica are present. The upper third of the formation is thick-bedded coarse-grained to pebbly sand containing about 31 percent clay and silt. Glauconite may constitute nearly half the formation in the upper few feet, and fossils and fossil fragments are common there.

Navesink Formation

The Navesink Formation overlies the Mount Laurel Sand; it is a massive to thick-bedded, clayey, glauconite sand about 25 feet thick. Clay and silt constitute about 26 to 30 percent of the formation. The rest consists almost entirely of fine- to coarse-grained glauconite sand. The formation is largely dusky green to greenish black and olive black. A small amount of quartz sand is present as a trace of fine grains throughout, but is especially plentiful, as are fossil remains, in the base and near the middle. The formation underlies the lower and middle slopes of hills along Sandy Hook Bay.

Red Bank Sand

Overlying the Navesink Formation is the Red Bank Sand which is divided into two members, the lower Sandy Hook Member and the upper Shrewsbury Member (Minard, 1969, p. 16). The Sandy Hook member is a compact dark-gray massive-bedded silty, clayey feldspathic (feldspars are a common group of rock forming minerals composed largely of calcium, potassium, sodium and silica) quartz sand about 15 to 30 feet thick. The sand is fine to very fine and contains abundant mica, carbonaceous matter, and pyrite; glauconite is abundant in the basal few feet. Fossils are abundant, and concretionary (spherical, hollow balls) masses of siderite (an iron carbonate mineral) are present locally. Clay-silt content ranges from about 27-36 percent. The unit underlies middle slopes along Sandy Hook Bay and lower slopes along the Navesink River.

The Shrewsbury is a massive-bedded silty and clayey, fine to medium feldspathic quartz sand about 90 to 105 feet thick. Many coarse grains and some very coarse grains are present, especially in the upper half of the member. Much of the member consists of fairly loose sand, except locally where crusted or cemented by iron oxide. Clay-silt content ranges from about 10-18 percent. The unit underlies middle to upper slopes along Sandy Hook Bay and along the Navesink River.

Tinton Sand

The Tinton Sand overlies the Red Bank Sand and is the uppermost unit of Cretaceous age in the area. It is massive-bedded, clayey, medium to very coarse feldspathic quartz-glauconite sand to glauconitic quartz sand. It is stained, crusted, and cemented by iron oxide and is mostly shades of brown. The sand is poorly sorted (well graded); grain size ranges from clay and silt to very coarse sand. Granules are locally abundant, and some pebbles are present in the upper few feet. Glauconite also is more abundant in the upper part. Clay-silt content is about 32 percent. The unit underlies steep middle to upper slopes of the highest hills.

Hornerstown Sand

Unconformably above the Tinton is the Hornerstown Sand, the lowermost unit of Tertiary age. Typically it is dusky green and grayish olive massive-bedded poorly sorted clayey glauconite sand. Locally the upper few feet is oxidized to dusky red and may contain thin layers of ironstone. Several percent quartz sand is present throughout, and as much as 30 percent occurs in the basal two feet. Grain size ranges from clay to coarse sand; clay constitutes one-third to one-half the formation locally. The formation underlies middle to upper slopes of the highest hills. It is well exposed at Waterwitch on Sandy Hook Bay, along the north side of the Navesink River, and near the top of several other bluffs at various localities.

Vincentown Formation

The Vincentown Formation is thick to massive-bedded medium glauconitic quartz sand. Typically it is light greenish to yellowish gray, but locally it is moderate red and brown and is cemented by iron oxide. Glauconite content is nearly half the sand fraction in the basal few feet. Grain size ranges from clay to coarse sand, but generally more than half the unit is medium sand. Much of the sand is clean and loose, but in some outcrops, as much as 25 percent clay

and silt are present. The formation does not appear to be fossiliferous in the Atlantic Highlands area, but it is very fossiliferous elsewhere (Minard, 1969, p. 24). It underlies steep middle and upper slopes in the hills.

Cohansey Sand

The Cohansey Sand is composed chiefly of clean, somewhat pebbly, medium to coarse quartz sand; however, much fine and very coarse sand and granules also are present. The distinctive characteristic of the sand is the well-formed cross stratification (the arrangement of layers at one or more angles to the dip of the formation). The sand typically is yellowish gray and grayish to pale yellowish orange, except where stained grayish red to moderate brown by iron oxide.

The basal contact is distinct and unconformable. In most outcrops it overlies the massive glauconitic sand of the Vincentown. Locally, the basal contact is irregular and cuts down through the Hornerstown to the Tinton (Minard, 1969, p. 28). Locally, basal beds are micaceous fine sand and silt and resemble the Kirkwood Formation. The Cohansey underlies the upper slopes and caps the highest hills in the area.

Beach and Dune Sand

Beach and dune sand comprise all of Sandy Hook spit, the offshore bar and the south shore of Sandy Hook Bay. The beach sand consists primarily of quartz eroded and transported from proximal formations. Minor concentrations (less than 5%) of reworked glauconite impart a gray-green hue to some of the beach sand. Grain sizes range from small pebbles to clay; however, the sand is largely medium to coarse, fairly clean and loose, and perpetually shifting. Shore accumulations of the beach sand are generally less than 10 feet thick.

The dune sand on Sandy Hook is primarily medium-grained and better sorted than the beach sand. The dunes on Sandy Hook are partially stabilized and fairly well vegetated.

Recent Alluvium

Recent alluvium, derived from proximal formations, is found in and along present stream courses and at the base of some steep slopes. These deposits are composed chiefly of sand and gravel, with minor amounts of silt, clay, and peat.

The deposits have a very limited areal extent and average 5 to 10 feet in thickness, although local accumulations of 20 feet have been noted.

Tidal-Marsh Deposits

Tidal-marsh sediments consist largely of organic-rich, water-saturated muds containing minor amounts of sand, deposited in swampy areas near the mouths of streams. These sediments have a very limited areal extent and are quite thin.

SECTION II. B. 1. c. GEOLOGIC CONDITIONS

SECTION II. B. 1. c. GEOLOGIC CONDITIONS

The study area lies in the Atlantic Coastal Plain geologic province. The surficial and underlying sediments all have a marine or beach origin, with the exception of limited recent alluvial deposits and glacial deposits. The upper sediments are of Tertiary age, and the lower sediments are of upper Cretaceous age (see Sec. II. B. 1. b.).

Structure

The Tertiary geologic units strike about N.60-70°E. and dip gently southeast. The Cretaceous units strike about N.50-60°E. and dip southeast at about 40 feet per mile. There are some local anomalies, at least in the Tertiary units, but this may be due to displacement from slumps. In general, the structure of the Atlantic Coastal Plain is monoclinal; all beds dip in the same direction. There are no reported faults (except for slump scarps) or other structural features in the area.

Unstable Areas

The geologically unstable areas are confined to the slump block locations outlined on Drawing 2. It should be noted that the locations plotted on Drawing 2 are the actual blocks which have failed; the stability of adjoining areas may also be questionable due to the successive failures which may occur. A description of each slump block appears in Section II. B. 1. d. and failure mechanisms are discussed in Section II. B. 1. e. An idealized cross section is drawn through slump block A and appears as Drawing 3.

SECTION II. B. 1. d. DESCRIPTION OF SLUMP BLOCKS

SECTION II. B. 1. d. DESCRIPTION OF SLUMP BLOCKS

A slump, as defined in the Glossary of Geology and Related Sciences, is "the downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as several subsidiary units, usually with a backward rotation on a more or less horizontal axis parallel to the cliff or slope from which it descends". A slump block is the mass that has slumped.

During a routine geologic mapping of the Sandy Hook quadrangle completed in 1969, Minard (1969) noted two ancient slump blocks in the study area, and one ancient slump block along the Navesink River, south of the study area. The 1969 publication is the first detailed technical report of these slump blocks. When the most recent episode of apparent slumping was reported by local residents (1972-1974), Minard returned to the area and found seven additional ancient slump blocks, with renewed movement in the B block complex. The descriptions which follow are adapted from Minard's work and augmented by interpretation of air photos and field observations. Movement has occurred as both complete block failures and as partial block failures.

In general, slumping produces several geomorphic features and events indicative of the particular type of movement of these blocks. The erosional and rotational features observed suggest strongly that the mode of movement is of the Toreva block type, defined as a "landslide consisting essentially of a single large mass of unjostled material which, during descent, has undergone a backward rotation toward the parent cliff about a horizontal axis, which roughly parallels it." (Reiche, 1937) This type of landslide is prevalent in the southwestern United States, especially near Toreva, Arizona, where the phenomenon was originally studied. As is customary, the process bears the name of the type locality, hence Toreva-block.

The features and events peculiar to Toreva-block movement are:

1) Downward movement of a mass of rock or earth.

2) A rotational movement of the block, normal (perpendicular) to the scarp face of detachment.

3) Inward tilting of the upper surface of the block and an upward drag of the beds in contact with the scarp face down along which the block slides.

4) An elongate depression on the scarp side of the surface of the block resulting from the tilt and drag.

5) A concave scarp from which the inner convex surface of the block detaches, and a convex bulge at the outer base, or toe of the block.

Toreva blocks characteristically fail as a single episode. The secondary slumping observed in the study area is not characteristic of the classical Toreva failure.

The secondary slumping noted in the study area, shears the primary block about in half. It results in farther downward displacement, and additional rotation and tilting of beds in the outer block. Successive episodes of slumping on the same block are possible in unconsolidated materials.

Ancient Slump Blocks

In his original investigation, Minard (1969) theorized that the slumping was caused primarily by wave erosion at the toe of slope. Therefore, Minard reasoned that slumping probably occurred before the formation of Sandy Hook and the barrier bar, which currently shelter the bluffs. Radiocarbon dating of plant material obtained from 90 feet below sea level beneath Sandy Hook suggests strongly that the spit did not extend as far north 10,000 years ago as it currently does. Therefore, Minard initially concluded the blocks probably date from about that time or earlier. In his second investigation, Minard (1975) discovered that Sandy Hook and the barrier bar had been breached periodically throughout its existence; hence the slumping may be much younger than originally thought. In fact, the most recent reported episode of slumping (1972-1974) occurred while Sandy Hook was a promontory, proving that direct wave erosion of the toe of slope is not necessarily an a priori factor for slumping, and hence, dating the slumps by the presence or absence of Sandy Hook and the barrier bar may not be valid.

In terms of geologic time, the slumping must have been fairly recent, due to the movement of Tertiary material by slumping. In addition, several episodes of slumping have been reported within the last 200 years. However, the actual time when the ancient slumps first occurred is unknown.

Block A - Block A is located along the shore of Sandy Hook Bay, slightly west of Waterwitch (see Drawing 2). The block measures about 450 feet wide (north-south) and about 1,400 feet long (east-west). At least two separate episodes of

slumping have occurred within this block prior to 1972. The original slump transported the entire block. The failure zone was located in the basal member of the Red Bank sand (Sandy Hook member) and the Navesink formation. The secondary slumping affected only a portion of the block. The failure zone was located primarily in the upper member of the Red Bank sand (Shrewsbury member). Based on stratigraphic correlation with intact bluff sediments, the maximum downward displacement resulting from slumping is estimated at about 85 feet. There is an inward tilt of the upper block surface, indicating a backward rotation of the beds during failure, indicative of classical Toreva slump block movement. Other morphologic traits characteristic of slump block failure which are present include a convex inner face abutting the concave scarp (the actual slippage surface), a prominent bulge at the slope toe, and a conspicuous sag or depression on the inner upper surface. The secondary slump line occurs about at the middle of the block.

Block B - Slump block B is located in Atlantic Highlands, about 2,000 feet west of the Highlands municipal border. Originally mapped as a single slump episode prior to 1972 (Minard, 1969), the block has been re-evaluated and is presently considered to represent four episodes of failure. Blocks B-1 (the primary block) and B-2 (the initial secondary slump) failed prior to 1972; Blocks B-3 and B-4 are new secondary failures which formed subsequent to the summer of 1972. The overall length of the entire block is about 3,000 feet. The width varies, being about 400 feet at its maximum. The wider, eastern part of the block exhibits the classic convex scarp fitting into the concave scarp of detachment. The upper surface is depressed near the inner part, parallel to the long axis, similar to block A. Some boulder size blocks of ironstone are present, and tilted scarpward due to rotation during failure. Block B-2 forms a ramplike feature from west to east reflecting the vertical displacement along an ancient secondary failure line.

Although remnants from a past slumping episode, Blocks B-1 and B-2 contributed during the 1972-1974 slumping episode. Block B-1 is the least active; however, cracks in the road pavement adjacent to B-1 and in a rock wall at the west end of the inner rupture zone appeared in 1972, strongly suggestive of renewed activity. Block B-2 was noticeably reactivated in 1972. Damage to private homes, largely due to vertical displacement of as much as 1 foot, occurred. Fissures, cracked walls, and cracked concrete works occurring from 1972 to 1974, all indicate that Block B-2 has been reactivated.

During the 1972-1974 slumping episode, Blocks B-3 and B-4 appeared, slightly west of the ancient B blocks. The new generation of slumps (all secondary and part of the B-block complex) have irregular, unstable, and jumbled surfaces (not indicative of Toreva blocks). Several fissures were reported to have opened below the main upper scarp, further subdividing the main blocks into smaller ones (it is very probable that there are more than four independent block movements within the B block), resulting in severe tilting of trees and the stretching of vines. The most recent movement appears to have been on the lower blocks; however, some of the upper blocks have slid under and wedged beneath the lower blocks.

Blocks B-3 and B-4 may have initiated movement as a base failure. Material at the toe of bluffs may have moved towards the bay, causing a decrease in the support of the bluffs. The bluffs may have then failed sequentially, before the uppermost block (B-3) began the slumping, which has produced a 13-16 foot scarp.

Block C - Slump block C lies outside the study area, and will not be considered.

Block D - Slump block D is the easternmost slump shown on Drawing 2. It measures approximately 1500 feet long and 600 feet wide. Block D exhibits some of the classical Toreva-block characteristics: a convex inner bulge fitting into a concave scarp, and the surface of the block noticeably inclined inward, indicating the backward rotation suggestive of Toreva blocks.

Block E - Slump block E is located just west of slump block D, and topographically above slump block F. It is a small block which has been modified considerably by man. The only geomorphic feature visible is a concave scarp which may be indicative of Toreva-block slumping.

Block F - Slump block F is located on the west side of slump block D. The block itself has been eroded away, leaving only the typical scarp.

Block G - Slump block G lies just west of slump block A-1 in Atlantic Highlands. Block G appears to be small with minor downward displacement.

Block H - Slump block H lies just west of block G and just east of block B-1. It is also small with minor downward displacement, and shows a typical convex inner outline fitted into the concave scarp behind it.

Block I - Slump block I is about 150 feet wide and 750 feet long. It lies at the west end of the bluffs, near Atlantic Highlands Yacht Harbor. Block I also shows the convex-concave profile typical of Toreva-blocks.

Block J - During our air photo interpretation segment of this investigation, another possible slump block was discovered, mapped, and designated as Slump Block J. Slump block J is located just south of the slump block B complex (B-1 - B-4), and measures about 2700 feet long and 1100 feet wide. Typical features viswble through air photo analysis include a backward tilt of the block due to rotation, and the remnants of a convex inner surface nestled into the concave scarp along the slippage surface. There is a slight bulge along the eastern portion of the toe.

The block appears to have undergone intense erosion, especially in the upper scarp areas, thus suggesting that the block is ancient and not currently active. However, the B block complex may be the successive failures of Block J. Block B was active in 1972-1974; however, there was no reported movement of Block J.

Measured Shear Zone

In preparing this report, no new subsurface data were obtained; we were limited to a review of available reports prepared previously by others.

A report prepared for Ford, Bacon & Davis, Inc. by Dames & Moore, and dated 25 March 1975, disclosed the results of 4 borings performed between Stations 43+50 and 51+50 on the right-of-way for the proposed force main. (See Drawing 2 for location.) After sampling, slope indicator casing was installed and periodic readings obtained of horizontal subsurface movements.

After an initial series of measurements in late September and October of 1974 which disclosed virtually no movement, measurements were suspended until 20 March 1975. At that time, a northward "displacement" of the upper soils of up to 2.6 inches was found to have occurred in the interim. The displacements were charted as occurring in a zone between 22½ and 37½ feet below the ground surface, with the actual displacement zone in each hole occurring over a limited reach of 10 feet or less. No record of subsequent measurements is provided.

The Dames & Moore report also disclosed that other inclinometers had been installed previously by Woodward-Moorhouse

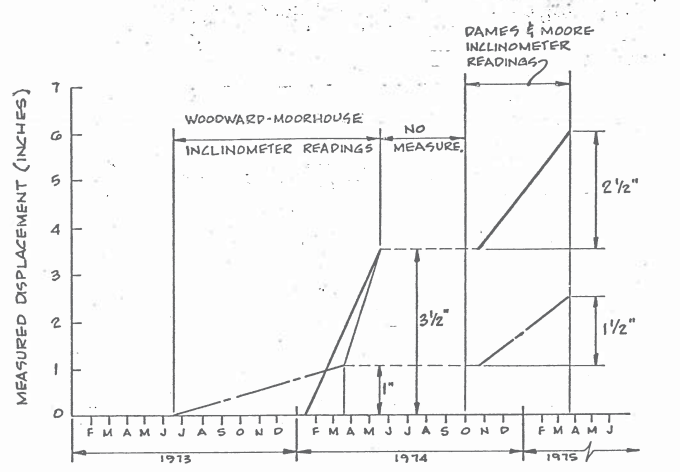
Associates. Two installed close to the Dames & Moore inclinometers had also revealed movements: in one, 1 inch between June 1973 and March 1974, with blockage of the casing occurring in April of that year at a location where the later Dames & Moore work measured about 1½ inches; in the other, 3½ inches between January and May of 1974, blockage in October 1974, compared with a subsequent 2½ inches in the nearby Dames & Moore inclinometer. The frequency of measurement in the Woodward-Moorhouse inclinometers is not indicated; thus, the time span over which the movements occurred cannot be determined.

The depth of the displacement zones in the Woodward-Moorhouse tests are comparable with the later Dames & Moore work. The inclinometer readings are pictorially portrayed on Figure 1 (next page).

The boring advanced for the Dames & Moore inclinometer SI-4 (which showed the smallest movement, less than ½ inch) encountered an artesian condition commencing at 28-foot depth (approximately the mid-depth of the zone where movement was measured) and continuing flow for the duration of the measurement period.

Dames & Moore reports that no apparent weakness of the soil was discovered in any of the samples obtained. However, two of the five piston samples attempted in what later developed to be the zone of movement of B-3, were reported to have been lost in sampling; i.e. no recovery made. What seems significant about this is that the material was weak enough to permit piston sampling; no piston samples were attempted elsewhere. The material obtained by piston sampling may have been softened by dilatence (due to the shearing action). It seems possible also that one or the other of the lost piston samples could have contained the active shear zone in this region.

Dames & Moore further concludes from their results that "it is evident that the movement is occurring as shear over a zone several feet thick . . ." In SI-3, the 2½+ inches of movement is measured as occurring over about a 7-foot thick zone. However, had this movement occurred in a much thinner zone, say one foot thick, the casing could either break or be seriously deformed, precluding measurement. Alternately, the relative stiffness of the casing would have been forced to the edge of the loose hole drilled (6-inch diameter vs. 3-inch diameter casing) and possibly forced slightly into the side walls of the hole; thus, the stiffness of the casing would tend to smooth out the possible abrupt movements, making the record to appear as if the movement had



NOTE: THE DATA THAT THIS FIGURE IS BASED UPON WAS SECURED BY WOODWARD - MOORHOUSE, AND DAMES & MOORE, FROM INCLINOMETER READINGS.

FOR LOCATION OF STUDY, SEE DRAWING No.2

MEASURED SHEAR ZONE MOVEMENT

ATLANTIC HIGHLANDS-HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

Project No. C7807-12

Figure No. 1

ConverseWardDavisDixon Geotechnical Consultants

FORM NO. D88/78 Approved for publication 9-27-78 by [illegible]

occurred over a greater thickness. As further movement occurred, eventually either the casing would become deformed, as apparently occurred in October of 1974 to the Woodward-Moorhouse inclinometer near SI-3, or break, as may be the case with the other Woodward-Moorhouse inclinometer in April of 1974.

On the basis of the available data, it seems certain that a shear zone has developed in the area discussed in the Dames & Moore report. Significant, ongoing movements (6 inches or more in the vicinity of SI-3 over a 15-month period) have been recorded. The artesian condition reported in SI-4 exists within the apparent shear zone, indicating that excessive pore pressures may be present. There are reports of springs emergent on the slope above the right-of-way (Dames & Moore, page 5); this emergence can be restricted and/or blocked during the winter months by heavy ground freezing, causing an increase in pore pressure within the slope, and a net reduction in the shear strength of the soil in the slope.

The extent of the area that is affected cannot be defined on the basis of the available information. Movement is seen occurring in 3 borings over a length (east-west) of 400+ feet. The depth and shape of the shear zone and thus the areal extent, cannot be defined on the basis of the available information. There is no reason to believe that this movement has totally ceased. It seems possible that the movement has continued to occur through to the present.

SECTION II. B. 1. e.

PROBABLE FACTORS INVOLVED IN SLUMP BLOCK MOVEMENT

SECTION II. B. 1. e. PROBABLE FACTORS INVOLVED IN SLUMP BLOCK MOVEMENT

The slump block phenomenon within New Jersey is peculiar to only the Atlantic Highlands region. The presence of high bluffs composed of unconsolidated, permeable material containing abundant but localized concentrations of glauconite and calcareous fossil remains, combined with a high groundwater table and intermittent erosion at the toe of the bluffs, make the bluffs susceptible to isolated episodes of slumping. The most recent episode of major slumping lasted about 2 years (1972-1974) (Minard, 1974).

It should be noted that the reported slumping phenomenon appears intermittent; periods of activity may be separated by tens of years (or more) of quiescence, only to be followed by renewed slumping.

Given the set of existing conditions, the probable factors which may contribute to slump block movement are: 1. wave erosion, 2, high groundwater table, 3. slope mass and gravity forces, 4. construction activity and local slope overloading, and 5. geochemical weathering.

1. Wave Erosion - The southern portion of Sandy Hook Spit has been shown to be ephemeral (Cook, 1868; Barber and Howe, 1844). Sandy Hook spit was breached by the Atlantic Ocean in at least two separate episodes in the last 200 years. The first breaching occurred in 1778 and lasted until about 1800. The second episode occurred in 1830. The openings in the spit are reported to have been as wide as 3 miles. Therefore, it appears as if high energy direct wave erosion has attacked the bluffs at least twice in the last 200 years. Evidence of severe erosion and associated slumping has been documented by Cook (1868) and Barber and Howe (1844).

2. High Groundwater Table - The effect of high groundwater on internal pore water pressure is well documented. Jones (1973) summarizes the effects: "The modes of action of the rain are raising the piezometric surface in the slope forming material, seepage toward the slope, removal (dissolution) of soluble binders in joints, subsurface erosion, rearrangement of grains, chemical weathering, and displacement of air in voids and joints. The modes of action combine (with construction activity) to produce changes in the stress of the slope forming material, thus causing damage to intergranular bonds, rearrangement of grains, opening of new joints and closing of old ones, an increase in pore water pressure, and elimination of surface tension. When some

of the various elements of the processes combine to increase shearing stresses and/or to decrease cohesion and frictional resistance to a sufficient degree, a slide (slump) is activated."

3. Slope Mass and Gravity - In light of all other factors, slope mass and gravity forces play subtle roles in slump block failure. An increase in slope mass, such as new construction or an increase in soil moisture due to rainfall, may, in combination with other factors, induce slumping. Gravity forces exert a constant downward force on the slopes and in combination with other factors (e.g. lowered shear strength) may also induce movement.

4. Construction Activity and Local Slope Overloading - "The modes of action of construction operations are high frequency vibrations and an acceleration of creep by undermining and locally overloading the slope" (Jones, 1973). It has been speculated that driving of piles for a new concrete bridge near a slump area, weakened the slope area (perhaps by partial liquefaction of the soil), and after subsequent heavy rains, slumping was initiated. An excavation of an outfall line along the toe of the slope may have been a contributing factor by reducing or stabilizing force at the toe of slope.

5. Geochemical Weathering - The interaction of several geochemical elements present in the lithology provide a positive environment for slumping. As noted in the lithologic descriptions, the upper part of the Mount Laurel, the entire Navesink, and the basal part of the Red Bank (Sandy Hook member) formations all have several common characteristics: 1) stratigraphic position; they underlie the lower parts of the bluffs in the slump areas; 2) they are largely firm and compact-appearing in place - they are relatively unweathered; 3) in part they all contain abundant glauconite and calcareous fossil remains.

Recent research (Benson, 1946; Proix-Noe, 1946; Drouhin, et al, 1948) has indicated that the presence of glauconite and calcareous material, in combination with other factors (permeable layers, high groundwater, etc.), are associated with landslides (slumping) on a world-wide scale.

In general, glauconite is a hydrated iron alumino-silicate with a dioctahedral illite structure. There is frequent replacement of Al^{+3} by Fe^{+3}, Fe^{++}, and Mg^{++} resulting in net charge deficiency. This type of atomic structure allows considerable base exchange. Often Ca^{++} and Na^{++}, as well as K^{+} are the interlayer cations.

According to Hedding (1932) glauconite forms in a shallow sea in agitated waters which are not highly oxygenated, and during times of decreased deposition of detritus. The lack of oxygen in association with bacterial action (always associated with authigenic - formed in situ - glauconite formation) creates a reducing environment for the formation of glauconite.

When exposed to an oxidizing environment, the glauconite changes form from a suspension or gel to a solid, due to the introduction of electrolytes which cause flocculation (clumping). As infiltrating rainfall migrates through the calcareous zones, it becomes basic (pH greater than 7); and glauconite is unstable in the presence of basic waters. When the now basic infiltrating waters contact the glauconitic beds, the glauconite changes phase from a flocculated solid to a colloidal suspension or gel. Continuous infiltration by water progressively washes away the glauconitic gel, thus reducing the cohesion of the soil. When sufficient glauconite has been removed and replaced by water, the soil has the consistency of a viscous liquid. In this condition, the shear strength of the glauconitic beds is very greatly diminished and slump failure can be initiated. Other mechanisms, such as a saturated groundwater condition, erosion at the toe of slope, the overloading of slopes, or vibrations (see above) likely contribute to inducement of slumping, but it is the instability of the soil containing glauconite, under the conditions present in the study area, that is the most probable mechanism of slump failure.

SECTION II. B. 1. f.

DESCRIPTION OF THE INTERRELATIONSHIPS OF THE GEOLOGIC CHARACTERISTICS OF THE REGION, AND THEIR IMPORTANCE TO THE SERVICE AREA

SECTION II. B. 1. f. DESCRIPTION OF THE INTERRELATIONSHIPS OF THE GEOLOGIC CHARACTERISTICS OF THE REGION, AND THEIR IMPORTANCE TO THE SERVICE AREA

The Atlantic Highlands-Highlands region is rich in geologic resources, which provide support for the area's economy and general health. The geology of the Atlantic Coastal Plain physiographic province provides for a seasonal tourist trade, including beach and marina facilities. In addition, the granular nature of the sediments, as well as their areal extent and accessibility, provide an excellent setting for sand quarry operations. The sandy nature of the deposits also provides for good septic field operations and for an excellent water supply.

Negative aspects of the geologic characteristics of the study region include the slump block problem and a complex groundwater relationship with the main body of Atlantic Coastal Plain aquifers.

Beaches and Marina Facilities

The ephemeral nature of Sandy Hook (see Sec. II. B. 1. e.) has provided excellent present-day conditions for beach creation and stabilization, and marina facilities. During the time Sandy Hook spit was breached by the Atlantic Ocean, high energy wave action cut into and eroded the bluffs and created the sandy beaches along the bay shore. Under present conditions, the spit shelters the bay and beaches, eliminating the need for massive and costly beach erosion protection works required by other Coastal Plain shore regions.

Similarly, the bay protection provided by Sandy Hook spit allows for a quiet water condition conducive to marina facilities, which are located along the bay shore.

The protected beach-marina-shore combination, and the proximity of the study area to the population centers of the New York, New Jersey, and eastern Pennsylvania metropolitan areas, provide the necessary physiographic, geologic, and demographic constituents for a vigorous resort economy.

Sand Quarry Operations

Although no sand quarries are currently operating within the political boundaries of the study area, several old quarry works abut the south municipal border. The wide general expanse of the surficial sandy material, as well

as the hilly terrain, suggest that sand quarrying, under strict municipal control, could conceivably augment the study area's economy.

Water Supply and Septic Field

The Tertiary and Cretaceous aquifers underlying the study area provide an excellent, high yield, good quality, potable water supply. The deep aquifers, the Englishtown Sand and the Magothy and Raritan formations, are amongst the most heavily used in the state.

The sandy nature of the surficial soils provides sufficient permeability and filtering capacity for efficient leaching of septic effluent. The consistency of groundwater quality in the study area indicates biochemical wastes have not escaped septic treatment and have not contaminated groundwaters. Published groundwater quality analyses (Jablonski, 1968) indicate no fecal colliform contamination in near surface groundwaters.

SECTION II. B. 1. g.

EVALUATION OF EFFECTS OF INCREASED GROUNDWATER USES

AND SLOPE STABILITY

SECTION II. B. 1. g. EVALUATION OF EFFECTS OF INCREASED GROUNDWATER USES AND SLOPE STABILITY

Introduction

Slope failures have been historically associated world-wide with high groundwater levels (Cedergren 1968). The saturated groundwater condition lowers slope stability and contributes to failures in the following ways:

1. By reducing or eliminating the cohesive strength of the soil. The apparent cohesive strength of a non-saturated granular soil is caused by interstitial water in tension - a force which tends to hold grains together. In the saturated condition, interstitial waters are taken out of the tension condition, thus eliminating apparent cohesion forces.

2. By producing neutral pore water pressures, which reduce effective stresses, thereby lowering shear strength. The effect of the buoyant condition on a granular medium is to reduce the vertical downward acting intergranular force, which is proportional to the restraint to lateral movement.

3. By producing horizontally inclined seepage forces which increase the overturning moments and the possibility of failure. Groundwater seepage, or movement, can create a nearly horizontal force which contributes significantly to the torque (overturning moment) involved in slope failure.

4. By allowing further introduction of water to the failure planes after small initial movements open a fissure.

5. By supplying fluid that fills soil pores during earthquakes or severe shocks, leading to liquefaction failures. During earthquakes or other shocks (e.g. blasting), certain granular materials at certain densities collapse, causing excess pressures on the pore water fluid. It can occur to the point where individual grains are momentarily separated from each other. This can cause the sand to temporarily have the consistency of a viscous liquid (quicksand) and thus respond quickly to failure forces.

Slope Stability and Increased Groundwater Uses in the Study Area

Under normal saturated groundwater conditions, increased groundwater usage (pumpage) would tend to lower the groundwater level, thereby making the steep bluffs more stable by reducing the nearly horizontal seepage forces, and by reducing pore waters to a state of tension, thus increasing apparent cohesion.

The study area, however, does not reflect normal saturated groundwater conditions. There is a hydrostatic head (pressure) in downdip areas (see Section II. B. 3. c. 2) which retards the transmission of groundwater from the study area (recharge zones) down to the main body of the aquifer. Therefore, most of the recharge generated in the study area is lost as base flow in nearby streams.

Moderately increased pumping, therefore, may only draw off the groundwater currently lost to stream flow and not lower the groundwater table. Based on the estimate of 0.55 mgd/mi^2 recharge lost to stream flow (Jablonski, 1968), it appears that pumping in the study area would have to increase by more than 1.1 mgd to lower the groundwater table significantly. Allowing an average water consumption rate of 50 gallons per day per person, the population of the study area would have to increase by about 22,000 people in order to increase pumping to the point of appreciably lowering the groundwater table.

Additionally, water uses such as lawn watering, car washing, etc. return water to the ground as recharge, which would further inhibit groundwater table lowering.

Within the parameters presented, it seems unlikely that increased groundwater usage will affect the bluff slope stability to any great degree.

SECTION II. B. 2

SOILS AS THEY RELATE TO GEOLOGIC INSTABILITY

SECTION II. B. 2 SOILS AS THEY RELATE TO GEOLOGIC INSTABILITY

As previously stated (see Sec. II. B. 1. c.), the areas of geologic instability within the study area are confined to the slump block zone and the shore areas. As indicated on the soils map, the slump block zone is composed of soil designate M-23 (silty coarse to fine Sand with occasional clay layers) and the shore areas are composed of soil designate MB-13 (medium Sand). The soil characteristics have a direct bearing on the geologic instability.

Slump Block Zone - The near surface soils in the slump block zone are compact and firm, and generally considered stable and not prone to sliding. The soils in question belong to the upper part of the Mount Laurel, the entire Navesink, and basal part of the Red Bank (Sandy Hook member) formations. Common characteristics of these soils include topographic location (they underlie the lower parts of the bluffs), they are firm and compact in place, they are unweathered, and they all contain significant concentrations of glauconite and calcareous fossil remains. In addition, the soils are sufficiently permeable to allow for significant infiltration of rainfall.

Under a more usual set of conditions (e.g. the absence of glauconite and water seepage) slope stability would be a function of the angle of internal friction (ranging up to approximately 40°). If wave erosion then undercut the toe of the bluffs, and was the only factor involved in slumping, then when the angle of repose approached critical values due to wave erosion, the slopes would fail and establish a new equilibrium.

Wave erosion at the toe of the bluffs, however, is not the only factor involved in slumping. The presence of glauconitic beds in combination with overlying calcareous fossils, generally permeable soils, and wave erosion at the toe of slope, produces Toreva type block movement. (See Section II. B. 1. e. 5.)

Shore Areas

Under present conditions, Sandy Hook protects the shore areas from massive erosion by ocean currents and waves. The shore areas will remain stable as long as Sandy Hook is not breached by the Atlantic Ocean.

Sandy Hook, however, has been shown to be ephemeral, being breached at least two times in the recent past. Should Sandy Hook again be breached by the ocean, high energy wave erosion would attack and erode the shore areas, and ocean currents would redistribute the eroded material. Loose beach sand areas would be among the first soils to be affected, with the more consolidated shore areas eroding more slowly.

A secondary effect of the breaching of Sandy Hook would be the eroding of the toe of known slump blocks, possibly reactivating movement, and initiating new slumps.

SECTION II. B. 3. GROUNDWATER RESOURCES

SECTION II. B. 3. GROUNDWATER RESOURCES

The strata underlying Monmouth County contain several viable aquifers, some of which are hydrologically connected, such that there is vertical leakage, or transference of water amongst aquifers.

The most heavily used aquifers in Monmouth County are the Raritan and Magothy formations, and the Englishtown formation. Combined, these aquifers contribute about three-fourths of the groundwater used in Monmouth County.

In the study area, however, these aquifers are well below the surface and will not be affected by any near surface construction, dewatering, excavation, or other man-made disturbance. Therefore, for the purposes of this study, aquifers below the Mount Laurel sand will not be considered.

a) Groundwater Quality

Mount Laurel Sand - The Mount Laurel sand and the Wenonah formation, although distinct and separate geologic units, are hydrologically connectedand will therefore be considered as a single aquifer. Water quality in this aquifer is generally good, having moderate hardness and low dissolved mineral content. Six analyses (Jablonski, 1968) of dissolved solids indicated a range of 112 to 145 ppm (parts per million). The hardness ranged from 56 to 110 ppm in 8 samples tested. The pH ranged from 6.5 to 8.1 in seven samples tested, and the iron content was less than 0.3 ppm in 8 of 9 samples tested. As of 1964, there was no indication of high chloride contents - an indication of the absence of salt water intrusion; however, the aquifer may be in connection with salt water in Sandy Hook Bay or in the Atlantic Ocean (see Section VI. C. 5. a. 3., entitled Saltwater Intrusion).

Navesink formation - Except for the lower sandy fossiliferous zone, the Navesink formation, in conjunction with the basal clay member of the overlying Red Bank sand, forms a confining layer, or aquiclude, between the Mount Laurel sand and the overlying formations. It has been reported that domestic tapping of the lower sandy zone of the Navesink formation has encountered waters of excellent quality.

Red Bank sand - The Sandy Hook member (see Section II. B. 1. a.) of the Red Bank sand, in combination with the upper portions of the Navesink formation, forms an aquiclude. The Shrewsbury member does serve as a minor aquifer, with water

quality described as acidic, and requiring iron removal treatment. There has been no indication of high chloride content, indicative of the absence of saltwater intrusion; however, the aquifer may be tied hydrologically to the Navesink River, the Shrewsbury River (both estuaries), Sandy Hook Bay, and the Atlantic Ocean (see Section VI. C. 5. a. 3., entitled Saltwater Intrusion).

Tinton sand - The Tinton sand is hydrologically tied to the Shrewsbury member of the Red Bank sand and exhibits the same water quality characteristics.

Hornerstown sand - Due to its clayey nature, the Hornerstown sand serves as an aquiclude. There are no reported wells tapping the Hornerstown sand.

Vincentown formation - The Vincentown sand serves as a very minor aquifer, contributing negligible amounts of groundwater to Monmouth County. General water quality has been reported to be excellent; however, locally the water may have a low pH and excessive iron concentrations.

Cohansey sand - The Cohansey sand is not considered a viable aquifer due to limited thickness and areal extent.

SECTION II. B. 3. b. 1

GROUNDWATER QUANTITY - SAFE SUSTAINED YIELD

SECTION II. B. 3. b. GROUNDWATER QUANTITY

Introduction

The quantity of groundwater available in any particular basin is dependent upon the annual available recharge from the outcrop areas or other sources (well injection of waste waters, irrigation seepage, aquifer leakage, etc.), the aquifer storage capacity, and the coefficient of transmissibility (the ease of which water is transmitted through the aquifer).

In an attempt to simplify a complex relationship, the term "safe sustained yield" has been created to place an upper limit on the withdrawals any particular aquifer can tolerate without suffering adverse effects. These adverse effects may include such common items as simply lowering of the water table (lowering of the water table is a natural response to pumping which, in itself, may not be damaging to the aquifer), or they might include such devastating effects as lowering the water table sufficiently to cause saltwater intrusion, or a change in the physical conditions of the aquifer, such that it is no longer suitable to store water in sufficient quantities to be economically useable.

The ambiguity of the term safe sustained yield (safe yield) has been underscored by Thomas (1951),

> "Safe yield is an Alice-in-Wonderland term which means whatever its user chooses."

The first use of the term safe yield occurred in 1920 by Oscar E. Meinzer (noted hydrologist), and was defined, by Meinzer, in 1923 as:

> "The rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is harmful to the aquifer itself, or to the quality of the water, or is no longer economically feasible."

Meinzer's definition has been accepted (in essence) as the basis for the standard definition in the Glossary of Geology and Related Sciences, American Geologic Institute (1957).

Hydrogeology

To estimate the safe sustained yields of the aquifer-complex beneath the study area, it is necessary to examine and understand the active groundwater system beneath the study area.

Observed water levels in the Wenonah-Mount Laurel and Vincentown formations indicate that vertical leakage, from stratigraphically adjacent aquifers, supplies much of the recharge in downdip areas. This is also the case with the deeper, more heavily used aquifers (Englishtown and Magothy formations). Therefore, much of the recharge entering the outcrop zones in the study area is lost as base flow in effluent streams due to the hydrostatic head created downdip.

Since safe sustained yield is some function of recharge modified by other aquifer characteristics, it follows that the safe sustained yields in down-dip pumping areas (where vertical leakage contributes heavily to recharge) will be affected negligibly by outcrop area recharge. The discussion and estimation of safe sustained yields will therefore be limited to the portion of the aquifers within the study area, where significant outcrop zones occur, and where surface recharge is the determining factor in estimating safe sustained yield for the study area.

Safe Sustained Yield

Due to the hydrologic transparency of the aquifers in the study area, they will be considered as a single unit. Safe sustained yield, as used in this report, is an evaluation of the rate at which groundwater can be withdrawn from the near surface aquifers without adversely affecting the aquifer itself, the quality of the water, the economic feasibility of pumping, or drawing from groundwater storage.

To estimate the safe sustained yield of the near surface aquifers within the study area, it is first necessary to estimate the average annual recharge of the study area, assuming the entire area is a recharge zone, and no other recharge occurs outside the study area.

To determine the annual recharge from precipitation, the following relationship is considered:

$$R = P - (E_T + CP) \quad A - Q_S A$$

where R = annual recharge from precipitation

P = average annual precipitation = 44.67 in./yr. (Jablonski, 1968)

E_T = weighted evapotranspiration extrapolated from work done in southeastern Middlesex County = 27.7 in./yr.

C = runoff factor extrapolated from work done in southeastern Middlesex County = .05

A = area of the study area = 1.98 $mi.^2$

Q_S = base stream flow = 0.55 million gallons per day (mgd) per square mile (Jablonski, 1968)

On the basis of the above equation (with appropriate units conversion), the amount of recharge available within the study area is about 300,000 gallons per day. A conservative estimate of safe sustained yield would be about 75% of the computed annual recharge, thereby providing for the maintenance of aquifer storage for use during extreme drought conditions. Therefore, a conservative estimate for the safe sustained yield of the aquifers within the study area is .75 x 300,000 gallons per day = 225,000 gallons per day. This estimate should not be taken literally - it is an order of magnitude, under a specified set of conditions that were tailored to the study area due to the lack of any definitive studies on safe sustained yield in the study area. Additionally, as noted earlier, the term safe sustained yield is somewhat ambiguous; therefore, the results obtained in this study should not be compared with any other estimates, unless all assumptions made in this report match the conditions of comparable data.

Also, most of the groundwater supplies of the study area are obtained from the deeper aquifers (Englishtown Sand, Raritan and Magothy Formations). The safe yields of these deeper aquifers very greatly exceed the safe yields of the near surface, local aquifers.

SECTION II. B. 3. b. 3.

EFFECT OF WITHDRAWALS ON SLOPE STABILITY

SECTION II. B. 3. b. 3. EFFECT OF WITHDRAWALS ON SLOPE STABILITY

As previously discussed (Sec. II. B. 1. g.), it appears unlikely that increased groundwater pumpage for consumption in the study area will provide greater stability in the bluff area. However, assuming it would be feasible to design a well system with the associated engineering works capable of permanently lowering the water table in the study area, greater bluff stability would still be questionable.

One of the prime mechanisms of slump block failure is the successive dissolution and washing away of glauconite from both the Tertiary and Cretaceous beds (see Sec. II. B. 1. c.). This is accomplished primarily by downward percolating recharge, which first comes in contact with calcareous fossil remains, thus becoming alkaline. The alkaline waters then attack the flocculated glauconite, which is reduced to a colloidal suspension and washed away.

If the groundwater table were permanently lowered and groundwater gradients were increased due to pumpage, the upper beds would be essentially "dry" (100% of the interstitial water cannot be withdrawn by pumping). As a response, surface recharge may increase in both quantity and downward velocity, due to the "perched" dry condition, become alkaline by contact with fossil remains, and attack and erode the glauconitic constituents in greater quantities. This could result in both an increase in slope instability, due to the faster rate of glauconite destruction, and an increase in slope stability by dewatering. Definitive quantitative judgments as to net slope stability increase or decrease due to dewatering and its ramifications are not possible unless an exhaustive aqueous geochemical study is performed; however, a cursory review of available data suggests that the destruction of glauconite may have more significance than the effect of groundwater withdrawals concerning the stability of these bluffs, especially in light of the predicted increases in surface recharge, assuming a lowered groundwater table.

SECTION II. B. 3. c. 2.

EFFECTS OF DEVELOPMENT ON TOTAL RECHARGE

SECTION II. B. 3. c. 2. EFFECTS OF DEVELOPMENT ON TOTAL RECHARGE

Introduction

Development of open land invariably reduces the recharge capacity of the land, simply by covering a permeable medium (the natural ground) with a less permeable medium (concrete, asphalt, etc.). By developing open land without runoff controls, thereby reducing infiltration, all incident rainfall becomes high velocity runoff, increasing peak stream flow, compounding flood situations, and increasing surface water erosion potential. It should be noted that development with properly designed and maintained runoff and pollution control facilities will have a virtually insignificant impact on groundwater recharge.

The rainfall lost as uncontrolled runoff due to development generally leaves the watershed quickly as stream flow and may be classified as a permanently lost resource. The manifestations of lost groundwater recharge attributed to development oftentimes result in the lowering of the piezometric surface due to lost infiltration and increased pumping (increases in water supply demand generally accompany increases in development; new development invariably increases the water consuming population).

To determine the effects of development on the total recharge of the groundwater system, the sources and ultimate disposition of the recharge must be investigated.

Sources of Recharge

A large portion of the study area serves as a recharge zone, utilizing rainfall as a source. Vertical leakage amongst aquifers in downdip areas also provides recharge to the groundwater system. It has been shown that the vertical leakage in the downdip areas has also created a hydrostatic head, or pressure, which retards the transmission of recharge entering the outcrop areas, to the main body of the aquifers, to the extent that most of the recharge entering the outcrop areas surfaces in nearby streams; very little of this surface recharge ever becomes a water resource.

Effects of Development in the Study Area on Total Recharge

The study area is 1.98 square miles. Assuming the entire study area serves as a surface recharge zone for the combined groundwater systems, a very large portion of the total surface

recharge zone lies outside the boundaries of the study area. In addition, as stated above, a large percentage of the surface recharge generated in the study area is released as stream flow and is lost.

Due to the relatively small area of recharge zone represented by the study area, and considering that most of the recharge entering the groundwater system from the study area is lost to surface streams, it therefore seems likely that development in the study area will not significantly affect the total recharge of the groundwater system.

Development may, however, cause a reduction of the effluent groundwater maintaining base flow in nearby streams, which, in turn, may influence the water quality of those streams.

SECTION II. B. 6. a. ENVIRONMENTALLY SENSITIVE AREAS - GEOLOGICALLY

SECTION II. B. 6. ENVIRONMENTALLY SENSITIVE AREAS

a) Geologically unstable areas - Geologic instability within the study area is confined to the slump blocks noted on Drawing 2, and all shore areas adjacent to Sandy Hook Bay.

Slump Blocks - The nature of slump block movement is such that active periods may be separated by long intervals of dormancy. As might be expected, the literature documenting slump failures in the Atlantic Highlands-Highlands region is sparse and vague. Cook (1868) discussed shoreline and beach erosion due to the breaching of Sandy Hook, in conjunction with apparent slump activity:

> "At Long Branch, which is hard upland, the wear (from wave erosion) is very serious. The spot where the first boarding house was located thirty years since . . . is now all worn away, and the shoreline west of it. The wear is irregular; last year it was from 12 feet to 20 feet. Along the shores of Sandy Hook and Raritan Bay the wear is equally as rapid. At the Highlands enormous slides have been the result of wear."

Cook does not provide temporal data; however, Minard (1974) suggests that Cook's writings imply recency. Minard places Cook's observations east and southeast of referenced slump block A.

A second reference to slumping was recorded by Barber and Howe (1844):

> "In the spring of 1782 a slide of earth happened at Greenland bank, the highest point of the Highlands, situated two miles north of Beacon Hill. The noise was heard for a distance of several miles. On the ridge of mountains, commonly called Navesink hills, in Monmouth co., East Jersey, a considerable quantity of land, some say 40 acres, gave way, in April last, and sunk directly down a considerable depth . . . The tops of trees, that sunk with the soil, and which were mostly of considerable bulk, are now nearly level with edges of the remaining ground. Round this again the earth opens, in one continuous fissure, a foot or more in breadth, for a considerable distance; and, as is conjectured, from its present appearance, will shortly go down also - the foundation being perhaps but a loose quicksand."

Minard interprets Greenland bank as the highest point in the highlands and suggests that the reported slide is slump

block A, or in the near vicinity. Minard further suggests that other than current slumping, slump block A is the most youthful-appearing major block.

Other than Cook (1868), Barber and Howe (1844), and Minard (1969, 1974), no mention of slumping in the study area was found in the literature search. If it is assumed that no other slumping has occurred in the study area other than what is reported in the literature, then three distinct episodes of failure can be catalogued. The first episode occurred in 1782 (perhaps slump block A). The second episode may have occurred in the years prior to 1868; and the third episode in 1972-1974. It is interesting to note that the 1782 slump episode coincides with one of the breachings of Sandy Hook, "Sandy Hook . . . changed its character from a promontory to an island in 1778, by an opening forced by sea . . .". (Barber & Howe, 1844) Several breachings of Sandy Hook have occurred in the recent past. From the descriptions offered by Cook (see above), it appears as if Sandy Hook was again breached by the ocean. If this is the case, then the first and second episodes of slumping can be attributed, at least in part, to wave erosion at the toe of the bluffs. The third episode of slumping occurred while Sandy Hook was a promontory; therefore, wave erosion cannot be associated with the third slumping episode. It seems likely that increased population, with associated increased water usage (including septic use) may be responsible for the contemporary slumping. Virtually all public water supplies in the study area draw water from the deeper aquifers. Water uses (e.g. lawn watering, car washing, and septic effluent) may have, in effect, transported water from the deeper aquifers and recharged it to the upper aquifers. The increased recharge, therefore, would have intensified the geochemical weathering processes (see Section II. B. 1. e.) and, at least in part, may have activated the recent slumping episode. In addition, the installation of the Bayshore Outfall line, which predated the recent reported slumping occurrence by one year, may have contributed vibratory disturbances and removal of a portion of the toe of slope in sufficient quantities to accelerate slumping.

In any case, there is documented evidence that a portion of the toe of slope has undergone significant movement as late as 1975 (See Section II. B. 1. d.), indicating that wave erosion at the toe of slope is not, at least at the present time, a prerequisite for slump block movement.

Shore Areas - Presently, Sandy Hook shelters the bay and the bay shore from massive wave erosion. Should Sandy Hook become breached by the Atlantic Ocean as has happened in the recent past, the shore and beach areas would be subject to high energy wave erosion. Presumably, the conditions of equilibrium which exist now, would be upset and a new equilibrium would be established. The probable effects of the breaching of Sandy Hook would be the successive westward erosion of beaches, the subsequent undercutting of the bluffs (which has been shown to be associated with prior episodes of slumping), the establishment of new bay currents which would modify the bay floor (and possibly initiate slumping by removing sand from the toe of the bluffs), and the creation of a new sand bar, probably north of the study area.

The large scale shore erosion caused by a breach in Sandy Hook spit would not be as intense as the current erosion of beach areas in the barrier bar communities of southern New Jersey. The difference in erosion magnitude is due primarily to the angle of incidence of wave attack. In barrier bar locations, the wave attack strikes normal (perpendicular) to the shore, allowing the full component force of the waves to erode beach deposits. In the study area, the wave attack would strike obliquely at the shoreline, thus allowing some part of the component force of the waves to erode the beach. However, it should be noted, the erosion of the beaches and shore areas is tantamount to removing mass from the toe of slope of the slump blocks, and thus, erosion due to the breaching of Sandy Hook spit may foster renewed slump block activity.

SECTION II. B. 6. c.

ENVIRONMENTALLY SENSITIVE AREAS

STEEP SLOPES

SECTION II. B. 6. c. ENVIRONMENTALLY SENSITIVE AREAS - STEEP SLOPES

Steep slopes (generally considered greater than 15% grades) are sensitive areas due to sheet and gully erosion from rapidly flowing runoff. Based on air photo interpretation and field reconnaissance, the only example of severe slope erosion within the study area occurs directly northeast of the Eastpointe Condominium, on the concave scarp of slump block A-1. Many erosion rills are present on the slopes, just east of slump block A-1.

Another sensitive aspect of steep slopes is the possibility of conventional slope failures. The northern slopes of the bluffs approximate 80% grades in the most severe cases (based on USGS Quadrangle map). This corresponds to an existing slope angle of about 38.5°, which approaches a critical value for these materials. The steep slope angle suggests that conventional slope failures should have occurred in the past; however, no conventional slope failure evidence has been reported. Possible explanations for the stability of the slopes, in terms of conventional slope failures (not slump blocks) are the vegetative cover on the slopes, and the cohesion of the soil.

The vegetative cover provides protection. The dense growth visible on hillside slows the flow of runoff, reduces the resultant erosion, and prevents loosening of the sand. The vegetative root systems also consume water, such that near surface interstitial water is held in tension; thus providing some amount of apparent cohesive strength to the near surface soils.

SECTION II. B. 6. d.

ENVIRONMENTALLY SENSITIVE AREAS - SOILS

SECTION II. B. 6. d. ENVIRONMENTALLY SENSITIVE AREAS - SOILS

From a foundation feasibility point of view, sensitive soils within the study area include designates AR and MTM as noted on Drawing 5, entitled Soils Map.

AR - recent alluvium - These soils represent recent deposition by streams. They are variable in composition and depth, but generally consist of sand, silt, and organic materials. The organic materials have very low strength parameters and will respond to loading by consolidating, or settling over a number of years. Structures founded on these soils, without prior pretreatment of the soils, may suffer severe damage due to foundation settlement.

AR/MTM - shallow deposits of recent alluvium (AR) overlying deposits of marine tidal marsh. The fractional symbol is indicative of a strata change within the upper 10 feet of soil. The numerator designates the surficial layer, and the denominator designates the lower stratum. In the AR/MTM designation, the AR represents recent alluvium as described above. The MTM represents marine tidal marsh deposits consisting largely of organic material of a marine origin. These organic deposits are more extensive than AR organics, although they approximate the same strength characteristics and present the same type of foundation problems as many AR soils.

Other environmentally sensitive soils within the study area include soils on steep slopes, which are subject to rill or gully erosion. Soils situated on the north bluff slopes are mapped as M-23; they are stratified deposits of marine and continental origin. The soils are composed of silty coarse to fine sand with occasional clay layers. Interpretation of stereo pairs of aerial photos indicates that along the north slopes of the bluffs, rills and small gullies have begun to dissect the escarpments created by slump block movement.

This condition is especially evident on the slopes in the vicinity of Eastpointe Condominium, where rapid runoff from paved parking areas may have contributed to slope erosion in the form of rills, gullies, and in one instance, sheet erosion at the top of the slope.

If rill and gully erosion of the steep slopes is left unchecked, the slopes will steepen, especially in the mid-slope region, and increase the probability of conventional landslides at the top of the slopes.

SECTION II. B. 6. h.

ENVIRONMENTALLY SENSITIVE AREAS - AQUIFER RECHARGE AREAS

SECTION II. B. 6. h. ENVIRONMENTALLY SENSITIVE AREAS - AQUIFER RECHARGE AREAS

Aquifer outcrop areas are mapped on Drawing 6. The nature of the study area is such that surface recharge impinging on aquiclide outcrops will run off and at least partially infiltrate aquifer outcrops; thus, with the exception of the beach areas, and possibly the bluff escarpment faces, the entire study area contributes some recharge to the groundwater system.

Without retention/detention/artificial recharge facilities, urbanization of groundwater recharge areas would ordinarily adversely affect both the quantity and quality of recharge, especially in water table aquifers. By covering naturally permeable material with virtually impermeable materials (concrete, asphalt, etc.), the infiltrative capacity of the soils directly affected is nullified. If the runoff generated from developed areas is fed into storm sewers, then that quantity of runoff, which would normally become recharge, is lost and the overall quantity of recharge generated in the area is reduced.

Similarly, development in aquifer recharge areas generally degrades recharge quality. Recent research has suggested that runoff from multiple dwelling unit type developments contains increased bacteriological contaminants, as well as increased levels of heavy metals and hydrocarbons from automobile bodies, fluid leakage, emissions, and tires.

Since most of the recharge generated within the study area is lost as base stream flow (see Sec. II. B. 3. b. 1.), the effect of development on regional groundwater parameters will be somewhat buffered. Most of the recharge originating from developed areas will, in all likelihood, be lost as base stream flow due to the topographic position of the most developable land (the flats located on top of and to the south of the bluffs) within the study area. It should not be assumed, however, that all recharge from developed land will be lost as stream flow; some of this recharge may reach the main body of the aquifer system and thus, introduce contaminants into the groundwater reservoir.

Aquifer outcrop areas, therefore, are considered environmentally sensitive areas, but not significantly sensitive in light of the groundwater regimen. The aquifer outcrop condition exists in most of northern Monmouth County and southern Middlesex County. In addition, there are pollution control methods available to mitigate the environmental effects of urbanization of recharge areas. These methods include various means of collection, treatment, and recharge of urban runoff.

SECTION III ENVIRONMENTAL CONSTRAINTS TO GROWTH

A - AREAS WHERE NO GROWTH SHOULD OCCUR

B - AREAS WHERE LIMITED GROWTH SHOULD OCCUR

SECTION II. A. ENVIRONMENTAL CONSTRAINTS TO GROWTH - AREAS WHERE NO GROWTH SHOULD OCCUR

1. Geologically unstable areas - Areas where no growth should occur due to geologic instability are restricted to the line of known slump blocks, including the toe of slope and the areas south of the slump blocks as mapped on Drawing 7. Within this zone, there is virtually no "safe" location for either existing or new facilities. No growth should occur in these areas for two reasons:

A) development construction may provide the impetus for renewed movement due to vibration, excavation, dewatering, and the local overloading of slopes.

B) when the slump blocks again become active, damage to new growth in the slump block zone will contribute significantly to the overall damage totals.

2. Steep slopes - Areas where no growth should occur due to excessively steep slopes are mapped on Drawing 7, and are restricted to slump block escarpments where slopes attain better than 30^{o} inclines. Urbanization of these areas would prove impractical in terms of construction and conventional slope stability. Also, damage could occur with renewed slump block activity.

SECTION III. B. AREAS WHERE LIMITED GROWTH SHOULD OCCUR

1. Geologically unstable areas - Areas where growth should be limited due to geologic instability are mapped on Drawing 7, and are restricted to the shore areas composed largely of beach sand. While these areas are not presently unstable, there is a good probability that they will become unstable at some future date, due to the ephemeral nature of Sandy Hook spit. Historical evidence indicates that Sandy Hook has been breached two or three times in the last 200 years. Should Sandy Hook be breached by the Atlantic Ocean again, the shore areas would be subjected to large scale, high energy wave erosion, which would severely modify the unprotected shore areas.

2. Steep slopes - Areas where growth should be limited due to steep slopes have been mapped on Drawing 7, and are limited to areas where slopes exceed 10^{o} (15% grades). Construction in these areas should be limited to single unit dwellings, which will not require massive earth cuts and fills, nor generate significant amounts of man-made impervious cover, which, in turn, generates higher runoff quantities and velocities, thus accelerating slope erosion. There should be no development when these slopes are part of slump blocks.

REFERENCES

Barber, J. W. and Howe, H., 1844, Historical collection of the State of New Jersey, S. Tuttle, New York.

Cedergren, Harry R., 1968, Seepage, Drainage, and Flow Nets, John Wiley & Sons, Inc., New York, pp. 299-345.

Cook, G. H., 1868, Geology of New Jersey: Newark, N.J., New Jersey Geol. Sur.

_____ 1885, Annual report of the State Geologist for the year 1885, New Jersey Geol. Sur., Trenton.

Drouhin, G., et al, Slide and subsidence of the hills of St. Raphael - Telemy, Proc. Sec. Int. Conf. on Soil Mech. and Foundation Eng., Rotterdam.

Jablonski, Leo A., 1968, Groundwater Resources of Monmouth County, New Jersey, Special Report No. 23, State of New Jersey, Department of Conservation and Economic Development, Division of Water Policy and Supply, Trenton.

Jones, F. O., 1973, Landslides of Rio de Janeiro and the Sierra das Araras escarpment, Brazil, U.S. Geol. Sur. Prof. Paper 697, Washington, D.C.

Mann, John F., Jr., 1963, Factors affecting the safe yield of groundwater basins, ASCE, Trans., pp. 180-190.

Meinzer, Oscar E., 1920, Quantitative methods of estimating groundwater supplies, Geol. Soc. Amer. Bull., V. 31, p. 329.

Minard, James P., et al., 1961, Redefinition of the Mount Laurel sand (upper Cretaceous) in New Jersey, U.S. Geol. Sur. Prof. Paper 424-C, pp. C-64-67, Washington, D.C.

Minard, James P., 1974, Slump blocks in the Atlantic Highlands of New Jersey, U.S. Geol. Sur. Prof. Paper 898, Washington, D.C.

_____ 1969, Geology of the Sandy Hook Quadrangle in Monmouth County, New Jersey, U.S. Geol. Sur. Bull. 1276, Washington, D.C.

Olsson, Richard K., 1963, Latest Cretaceous and earliest Tertiary stratigraphy of New Jersey Coastal Plain, A.A.P.G. Bull., V. 47, No. 4, pp. 643-665.

Owens, James P. and Minard, James P., 1960, Some characteristics of glauconite from the coastal plain formations of New Jersey, U.S. Geol. Sur. Prof. Paper 400-B, pp. B-430-B-432, Washington, D.C.

Reiche, Parry, 1937, The Toreva-block - a distinctive landslide type, J. Geol., V. XLV, pp. 538-548.

Rogers, Franklin C., 1950, Engineering Soil Survey of New Jersey, Report No. 1, Rutgers University, Engineering Research Bulletin No. 15, College of Engineering, New Brunswick, N.J. (Physiography)

Seaber, Paul R., 1962, Cation hydrochemical facies of groundwater in the Englishtown formation of New Jersey, U.S. Geol. Sur. Prof. Paper 450-B, pp. B-124-126, Washington, D.C.

Strahler, Arthur N., 1940, Landslides of the Vermillion and Echo Cliffs, northern Arizona, J. Geomorph., V. III, No. 3,

ADDITIONAL DATA SOURCES

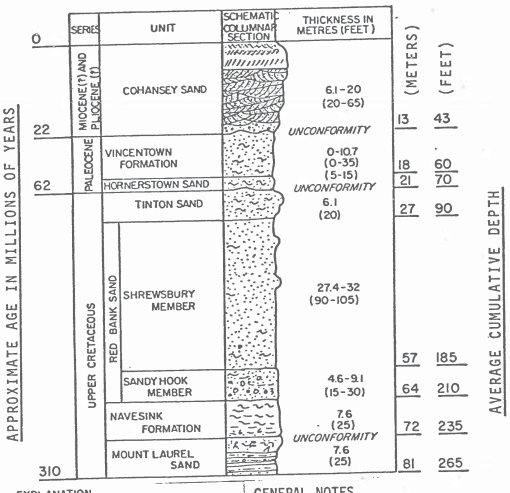
Dames and Moore, Report, Slope Stability Study - Phase II, Proposed Force Main, Atlantic Highlands, Monmouth County, New Jersey, Atlantic Highlands-Highlands Regional Sewerage Authority.

Fellows, Read and Weber, Inc., 1975, General Electric Credit Corporation versus Atlantic Highlands-Highlands Regional Sewerage Authority, Eastpointe Condominium, Engineers Report.

Hamil, Martha M., 1975, Landsliding and Slope Stability in the Atlantic Highlands of New Jersey, report prepared at the request of Fellows, Read and Weber, Inc. on behalf of G.E. Credit Corporation.

REVISED NOV. 9, 1978

ADAPTED FROM "SLUMP BLOCKS IN THE ATLANTIC HIGHLANDS OF N.J.", GEOLOGICAL SURVEY PAPER 898, BY MINARD, 1974.



GENERAL NOTES

THESE DRAWINGS (NOS. 1 THROUGH 10) ARE PART OF CONVERSE WARD DAVIS DIXON REPORT NO. C7807-12, AND SHOULD BE READ TOGETHER WITH THE REPORT FOR COMPLETE EVALUATION.

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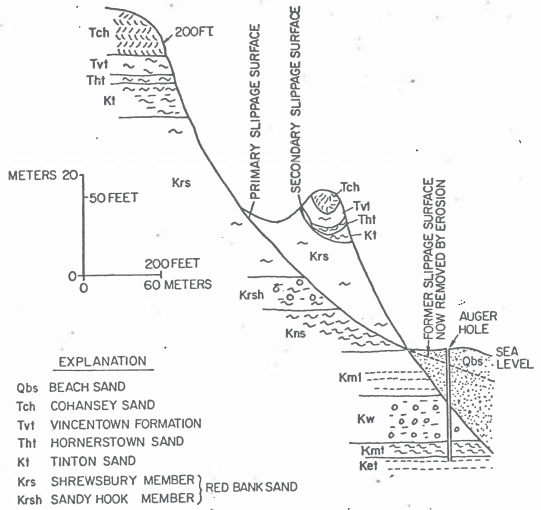
9-27-78 DATE

GEOLOGIC COLUMN

ATLANTIC HIGHLANDS-HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC

ConverseWardDavisDixon Geotechnical Consultants

Scale	Project No.
NONE	C7807-12
Prepared by: HB	Date: 9-17-78
Checked by: SRR	Drawing No. 1
Approved by: GSS	



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IDEALIZED CROSS SECTION THROUGH SLUMP BLOCK A

ATLANTIC HIGHLANDS-HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

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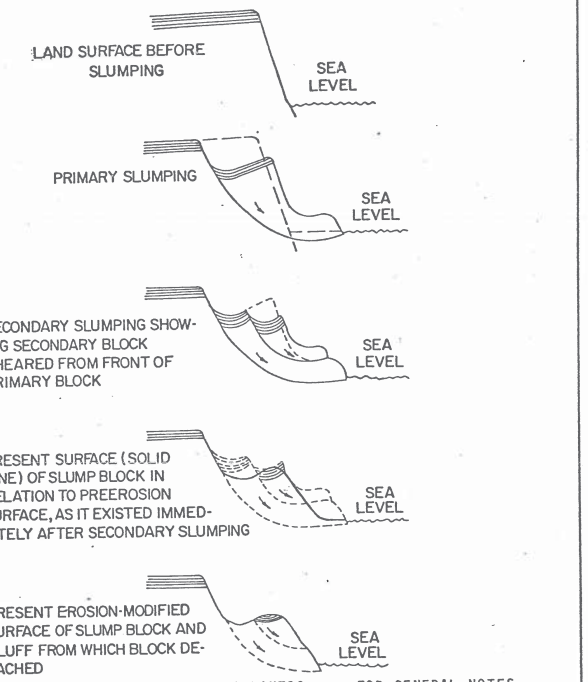
AS SHOWN	C7807-12
Prepared by: HB	Date: 9-17-78
Checked by: SRR	Drawing No. 3
Approved by: GSS	



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SCHEMATIC SLUMP BLOCK HISTORY

ATLANTIC HIGHLANDS-HIGHLANDS
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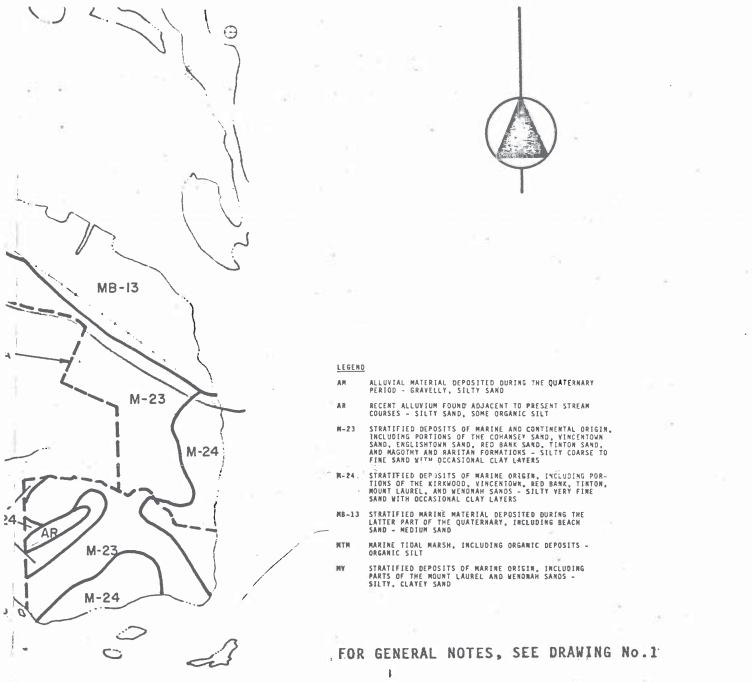

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SOILS MAP

ATLANTIC HIGHLANDS - HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

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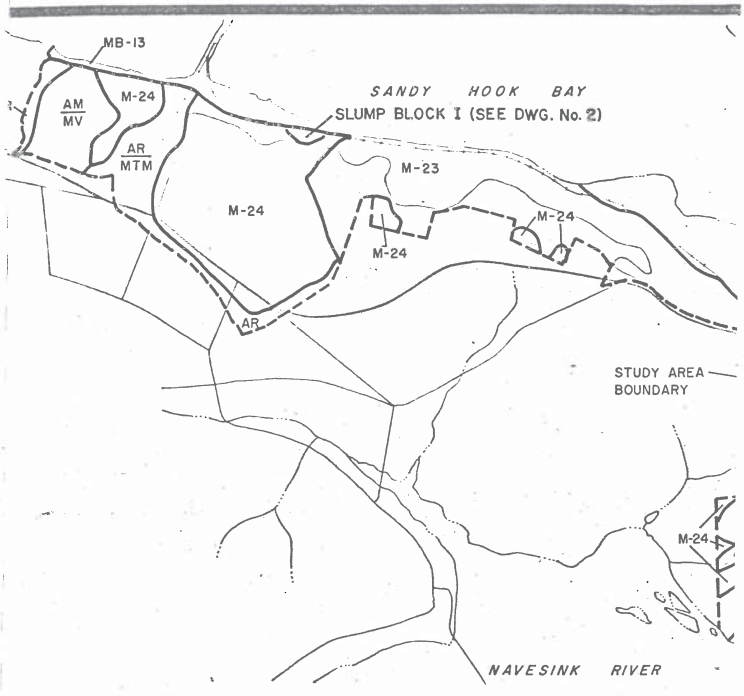
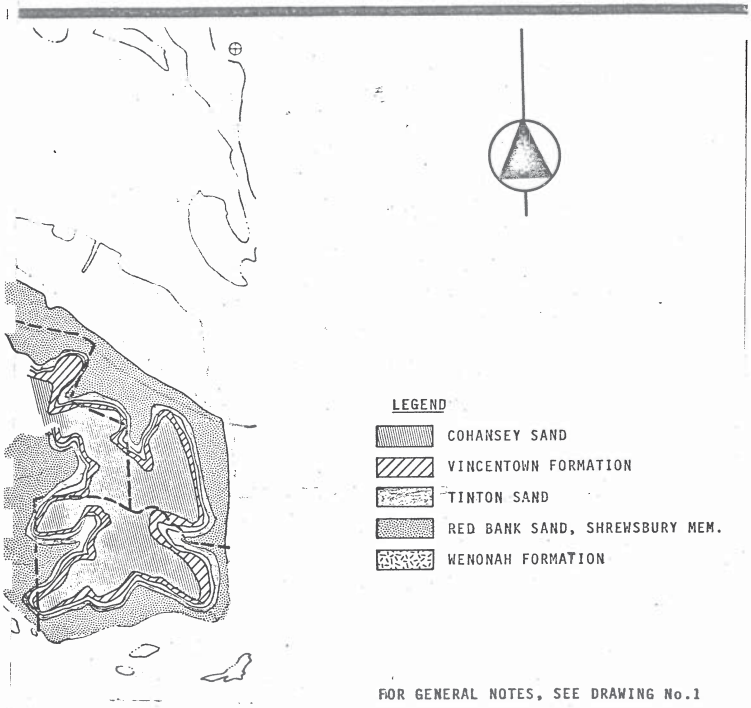
Scale: 1:24000 | Project No.: C7807-12
Date: 9-10-78 | Drawing No.: 5
Prepared by: JAP
Checked by: SRR
Approved by: GSS



ADAPTED FROM "THE ENGINEERING SOIL SURVEY OF N.J.", REPORT No.19 MONMOUTH COUNTY, RUTGERS UNIVERSITY 1955 AND MODIFIED BY INTERPRETATION OF STEREO PAIRS OF AERIAL PHOTOS.



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AQUIFER OUTCROP ZONES

ATLANTIC HIGHLANDS - HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

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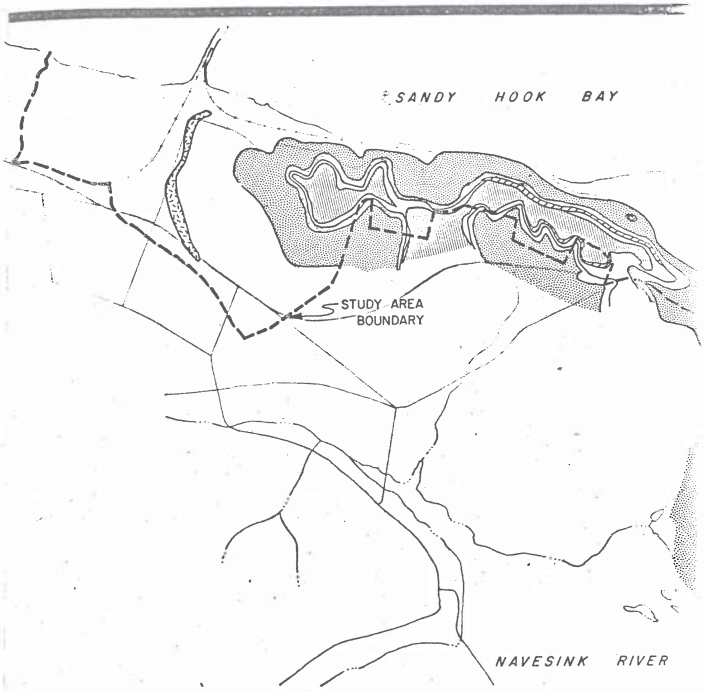
Scale: 1:24000 | Project No.: C7807-12
Date: 9-12-78 | Drawing No.: 6
Prepared by: JAP
Checked by: SRR
Approved by: GSS



DAPTED FROM "GEOLOGICAL MAP AND SECTION
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MINARD, 1969), AND MODIFIED BY INTER-
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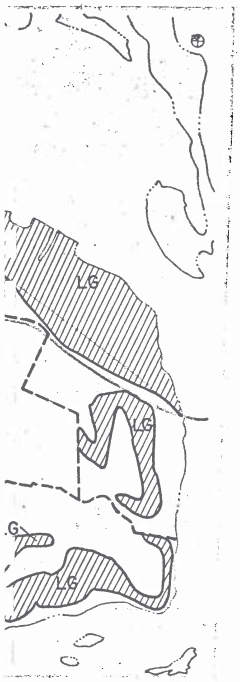
HOTOS.



LEGEND

LG — LIMITED GROWTH (STEEP SLOPES AND SHORE AREAS)

NG — NO GROWTH (VERY STEEP SLOPES AND SLUMP BLOCK AREAS)

FOR GENERAL NOTES, SEE DRAWING No.1

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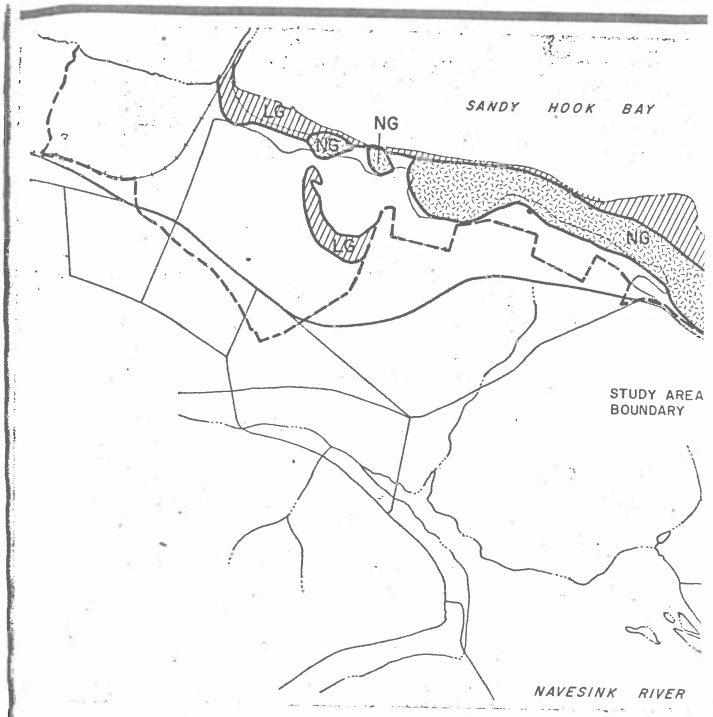
ENVIRONMENTAL CONSTRAINTS MAP

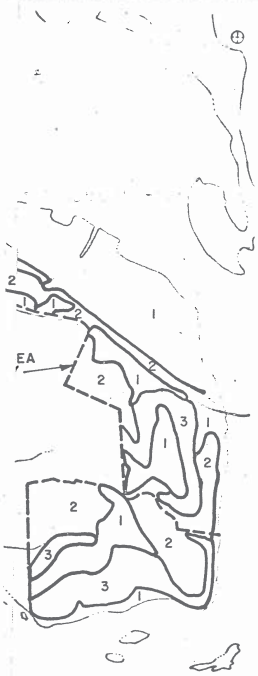
ATLANTIC HIGHLANDS - HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

Scale 1"=2000'
Date 9-15-78
Prepared by JAP
Checked by SRR
Approved by GSS

Project No. C7807-12
Drawing No. 7

ConverseWardDavisDixon Geotechnical Consultants





LEGEND

1 = 0-5%

2 = 5-15%

3 = 15-30%

4 = >30%

NOTE: NO GROWTH SHOULD OCCUR IN AREAS DESIGNATED AS 4. GROWTH SHOULD BE LIMITED IN AREAS DESIGNATED AS 3.

FOR GENERAL NOTES, SEE DRAWING No.1

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9-27-78 — DATE

SLOPE MAP

ATLANTIC HIGHLANDS - HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

Scale 1:24000
Date 9-11-78
Prepared by JAP
Checked by SRR
Approved by GSS

Project No. C7807-12
Drawing No. 8

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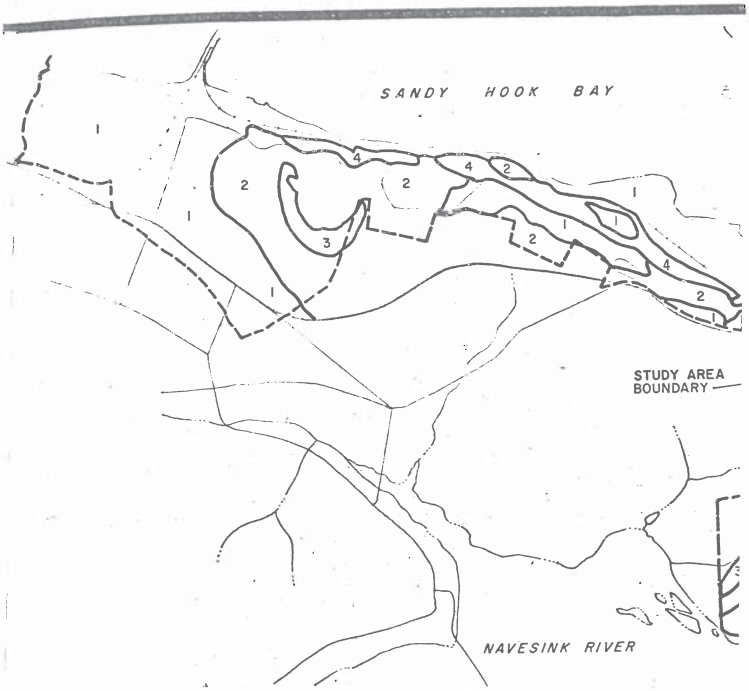

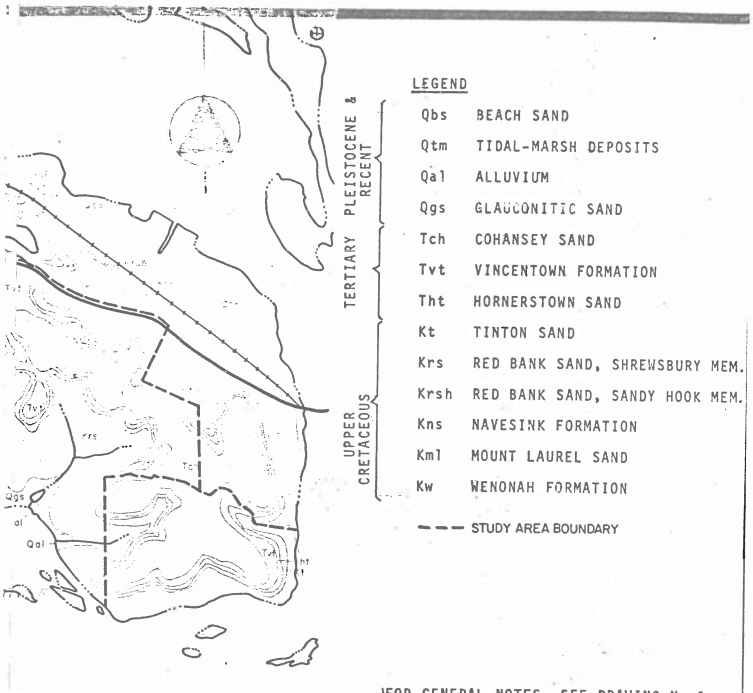

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9-27-78 DATE

GEOLOGY MAP

ATLANTIC HIGHLANDS - HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

Scale 1:24000 | Project No. C7807-12
Date 9-1-78 | Drawing No. 9
Prepared by JAP
Checked by SRR
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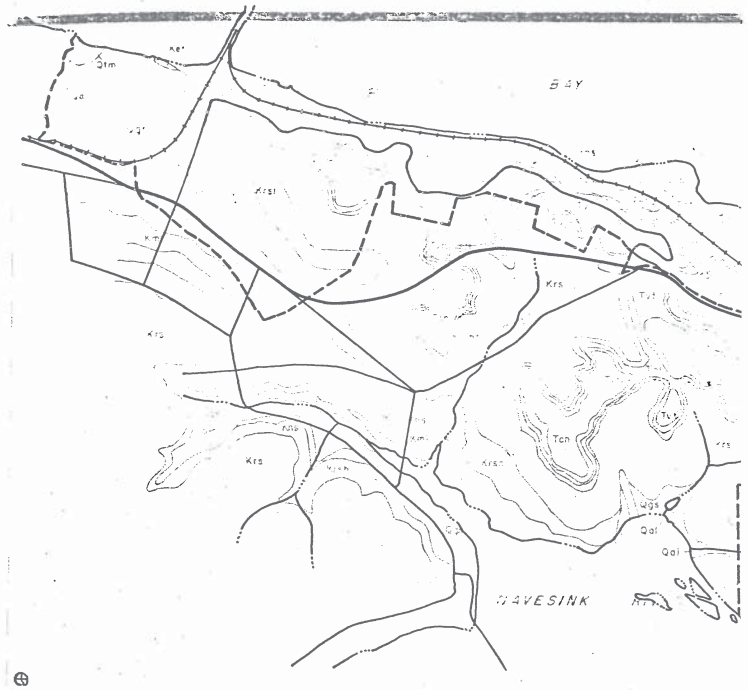

GEOLOGIC INFORMATIOM WAS OBTAINED FROM A MAP ENTITLED "GEOLOGIC MAP AND SECTION OF THE SANDY HOOK QUADRANGLE, MONMOUTH COUNTY, NEW JERSEY" BULLETIN 1276, PLATE 1. (FROM MINARD, 1969).

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MAP SOURCE: BASE MAP WAS ADAPTED FROM U.S. DEPT. OF COMMERCE NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION, NATIONAL OCEAN SURVEY, 72nd EDITION, AUG. 1978, No. 12327.

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11-15-78 DATE

OCEAN SOUNDINGS MAP (SOUNDINGS IN FEET)

ATLANTIC HIGHLANDS-HIGHLANDS
NEW JERSEY
FOR ECOL SCIENCES, INC.

Scale 1:40,000 | Project No. C7807-12
Prepared by JAP | Date 11-15-78
Checked by SRR | Drawing No. 10
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