COASTAL WETLANDS BUFFER DELINEATION

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EXECUTIVE SUMMARY

The New Jersey Coastal Management Program requires that development in the coastal zone incorporate a buffer to protect environmentally sensitive areas such as wetlands. Development adjacent to wetlands can negatively affect these systems through increased runoff, sedimentation and the introduction of a variety of pollutants. Administration of this policy has not been uniform because no guidelines have been written for the definition of adequate buffers in varying development situations.

The objectives of the present investigation were a) to measure the levels of direct human disturbance occurring in a variety of wetland/development systems in order to assess the effectiveness of existing buffers in limiting the level of wetland disturbance, b) to describe changes in wetland plant communities attributable to physical disturbance, and c) to develop management guidelines for the implementation of buffers in the protection of coastal wetlands in developing areas.

Over 250 wetlands occurring adjacent to developed areas and separated from the development by some form of vegetated buffer (as well as developed areas with no buffer and wetlands in undeveloped areas) were evaluated for study. In all, 100 study sites were selected in three wetland types (salt marsh, tidal freshwater marsh, and hardwood swamp) in four development situations of increasing land use intensity: agricultural/recreational, single family/low density residential, high density residential, and commercial/industrial.

Buffer width, slope and plant species composition were measured at each site. An index of direct human disturbance (DHD) was developed from measurements of physical wetland disturbance which allowed comparison of relative numeric representations of wetland degradation in a variety of different situations. An array of observable human impacts, ranging from eroded areas, filling, and oil spills to dumping of debris and the destruction of vegetation were recorded and used to calculate the index. The wetland plant communities were sampled in detail at each site using line transect methods. From measurements of the relative cover of over 200 plant species several indices of community diversity, richness and evenness were calculated. Levels of disturbance were compared between similar wetlands protected by buffers of different widths in different land use situations, while community indices were compared between disturbed and undisturbed wetlands of similar type. The data were analyzed using an array of correlations, regressions, analyses of variance and cluster analysis.

In all cases, disturbance levels in wetlands adjacent to high density residential and commercial/industrial land uses tended to be higher than in lower intensity land use situations. The composition and width of the buffer had varying influence on

the reduction of the level of disturbance. In many cases the primary causes of disturbance in wetlands were the original development activities which took place next to the wetland and were unrelated to current human use of the upland.

Disturbance in salt marshes took the form of filling and excavation as well as the dumping of refuse including construction materials, solvent containers, and treated wood products. In general, the primary disturbance in sampled salt marshes had taken place during the original development activities. Existing buffers, which tended to be narrow bands of successional vegetation, had grown up after the primary disturbances had taken place, or had been been breached during development, so that they had little impact on mitigating the degredation of the salt marsh. Physical disturbance of the wetland by current residents of the adjacent development was minimal. While statistical analysis showed little relationship between disturbance levels and measured buffer parameters, salt marshes appeared to benefit from the presence of some form of buffer.

Highest levels of wetland disturbance were measured in tidal freshwater marshes. Located almost exclusively in areas of high human population density, these wetlands also showed the greatest evidence of disturbance by current residents of the adjacent development. Disturbance took the form of filling, the destruction of vegetation along the marsh border and the dumping of refuse in the marsh. Because these wetlands occurred in stream channels and were bordered by steep wooded slopes, effective buffers tended to be in place during the initial development. However, narrow buffers at high intensity land use sites have allowed the filling of tidal freshwater marsh area and the destruction of much of the plant community at the marsh edge.

Strongest relationships between buffer width and DHD were found at hardwood swamp sites. Hardwood swamps tended to show evidence of disturbance attributable to the original construction activity: felled and uprooted trees, slash piles mixed with discarded construction materials and abandoned containers of solvents, cleaners and wood treatments. No particular current land use type was associated with higher levels of disturbance in adjacent hardwood swamp wetlands, indicating that high disturbance levels may be due to previous land uses. Many of the studied swamps were associated with stream corridors which were a source of attraction for current residents, with the result that paths and trails to the water had often been cut through the wetland.

Direct human disturbance may cause changes in the species composition of impacted wetland plant communities. Upland and cosmopolitan species invaded spoil piles left in salt marshes after the original construction in the adjacent upland. Disturbed riverine tidal freshwater marshes tended to be more mixed and undisturbed marshes tended to be monotypic stands of perennials. Trampling in hardwood swamps seems to select against certain sensitive plant species. However, due to high between-site variability in all wetland types, such changes must be assessed on a site-by-site basis considering the natural variability inherent in wetland systems.

Certain minimum buffer widths were found to be effective in limiting the level of direct human disturbance in wetlands of different types under different land use regimes. Such buffers, effective against abuse of the wetlands by current residents of the adjacent developments, can have no impact on the disturbances that are due to original construction activities. Buffers, in order to be effective at minimizing human disturbance in wetland systems to the greatest extent possible, must be defined in place and enforced prior to and during development of adjacent areas. Wetlands contiguous with certain special lands (eg. endangered species habitat) require particular consideration.

A rationale for the use of buffers in wetland protection, a specific definition of a wetlands buffer, and a series of guidelines for the implementation of such buffers in the management of wetland systems in New Jersey's coastal zone are presented as part of this report for the consideration of the Division of Coastal Resources.

1.0 INTRODUCTION

1.1 INTENT OF STUDY

The New Jersey Coastal Management Program is reviewed every two years to identify areas of the program in need of significant improvement. It was noted in the evaluation conducted in 1984 that the New Jersey Coastal Management Program incorporates a special areas policy on buffers which states that adjacent developments must allow a buffer to protect sensitive areas such as wetlands. However, administration of this policy, according to the Environmental Advisory Committee, had not been uniform because no guidelines have been established to define a proper buffer for varying adjacent developments. As a result of this evaluation the National Oceanic and Atmospheric Administration indicated it would support a request by the Division of Coastal Resources to fund an appropriate research study to more adequately define its buffer policy. To this end the Division has funded the following study to produce a method or model for determining suitable wetland buffer distances to various types of development in the defined Coastal Zone.

1.2 BACKGROUND

Many wetlands managers believe that the most effective means of mitigating the loss of coastal wetlands is minimization of any adverse impacts of development from the outset. Development adjacent to wetlands can negatively affect wetland systems through increased runoff (Harris and Marshall 1963, Conner, et al. 1981), sedimentation (Darnell 1976) and the introduction of chemical and thermal pollutants (Ehrenfeld 1983, Scott et al. 1985).

Recently, controversy has arisen over the need for buffer zones between wetlands and developed upland areas. Criteria are needed for the establishment of buffer zones for the protection of specific wetland functions. A buffer acts as a barrier which lessens the impacts of adjacent areas upon one another. Specifically, buffer zones have been considered to be strips of vegetation located between developed upland and low-lying wetlands used to protect environmentally sensitive areas (Clark et al. 1980).

In New Jersey, all land within 300 ft of Division of Coastal Resources (NJDEP) defined wetlands "and within the drainage area of those wetlands comprises an area within which the need for a wetlands buffer shall be determined" (NJDEP 1986). This 300 ft buffer can be reduced only if the proposed development can be shown to cause minimum adverse impacts to adjacent wetlands (NJDEP 1986). Ten of the 15 east coast states require the implementation of some kind of buffer under different circumstances. Yet, there has been only one set of detailed guidelines proposed for the actual definition and setting of buffer zones: a model proposed by Roman and Good (1983) which suggests a methodology for the determination of buffer widths in the New Jersey Pinelands.

1.3 OBJECTIVES

We propose several hypotheses that may be used in assessing the effectiveness of an upland buffer, operationally defined as all vegetation which existed at the time of investigation between the delineated wetland boundary and the farthest extent of adjacent development, in protecting wetlands from the adverse impacts of development:

1. Ineffective buffers allow increased direct human disturbance within the wetland.

2. Increased human disturbance in turn causes changes in the species composition of wetland plant communities.

3. For any given wetland/development situation there exists a minimum buffer width such that buffers narrower than that minimum are ineffective in protecting the wetland.

The main objectives of this investigation were:

1. To measure the levels of disturbance occurring in a variety of wetland/development systems in order to assess the effectiveness of existing buffers;

2. To describe changes in wetland plant community composition attributable to disturbance generated by adjacent land use practices; and,

3. To develop management guidelines for the establishment of buffer zones adequate to minimize the impacts of human disturbance on coastal wetlands in certain development situations.

1.4 LITERATURE REVIEW

Buffers in Timber Harvesting

Research into timber harvesting methods along forest streams has shown that the loss of vegetation adjacent to these waterways can have serious deleterious effects on the aquatic biota at the point of disturbance as well as downstream through sedimentation and thermal pollution (Lantz 1971, Broderson 1973, Moring 1975, Newbold 1977). Clearcut logging has been shown to increase stream temperatures from 6 F to 28 F, reducing concentrations of available dissolved oxygen and resulting in direct fish mortality, reduced growth rates and long-term changes in the species composition of impacted streams (Brazier and Brown 1973). Uncut zones flanking streams create shade, block the flow of debris and stabilize the stream bank (Brazier and Brown 1973, Froehlich 1973). Vegetation increases hydraulic resistance to surface flow, lowering flow velocity and promoting infiltration (O'Meara, et al. 1976). Root systems maintain soil structure, preventing sediment loading and resultant reduction in dissolved oxygen (Broderson 1973; Steinblums, et al. 1981).

Several authors have modelled the stream protection abilities of undisturbed vegetation (Lantz 1971; Steinblums, et al. 1981). Brazier and Brown (1973) identified several factors which determined the effectiveness of buffer strips, including: their ability to intercept solar radiation, canopy height, stream discharge and stream width. The authors reported that, for the "small" streams they examined (stream widths were not reported), maximum shading ability of stream-side buffers was achieved within 80 ft (24.4 m). Ninety percent of the maximum was reached within 55 ft (16.8 m). They concluded that specifying 100 to 200 ft buffer strips arbitrarily without site-specific examination was needlessly costly in the amount of merchantable timber left on the stump, but assessed buffer effectiveness only in terms of maintaining stream temperatures.

While recommending no specific buffer widths, Moring (1975) stated that the most significant feature of buffers was their function as "policemen" against logging near stream banks; suggesting that, in the abscence of buffers, damage to forest streams was more likely to occur. Newbold (1977) reported that 30 m (98.4 ft) buffer strips were required to protect benthic fauna from the effects of logging near northern California streams. Reductions in the species diversity of the macroinvertebrate communities of streams with buffers less than 30 m were not significantly different from unprotected streams. Effective buffer width needs to be assessed on a site-specific basis and is a function of the stream values being protected (Lantz 1971).

Agricultural Buffers

In agriculture, buffer effectiveness varies with slope, local climate, soil and water table characteristics, as well as the nature of the farm operation (eg. time of harvest, total acreage under cultivation, type of crop, tillage practice and types and amounts of biocides and fertilizers applied) (Clark et al. 1980). Nutrient loading from managed watersheds can contribute large amounts of nutrients to the receiving waters of estuaries and adjacent wetlands. Cook and Campbell (1939) showed that differing types of vegetation provided varying levels of erosion protection and resistance to overland flow. Recent work has shown that riparian forests act as nutrient sinks and are able to remove and assimilate excess nutrients in farmland runoff (Yates and Sheridan 1983; Lowrance, et al. 1984). Wooded riparian areas on the coastal plain of Maryland were capable of removing excess nutrient loads in agricultural runoff--as much as 80% of excess phosphorous and 89% of excess nitrogen (Hall, et al. 1986). Most of the total changes in nutrient concentrations occurred within the first 19 m (62.3 ft) of riparian forest and particulates leaving the riparian buffer zone were more organic in nature and had a greater exchange capacity than particulates leaving cropland (Peterjohn and Correll 1984). Similar results have been reported in North Carolina where researchers reported 80% reductions in nitrogen concentrations in agricultural runoff passing through a forested buffer (Hall, et al. 1986). In Georgia, reductions in observed nitrate, nitrite, and orthophosphate phosphorous, levels in runoff between upland cropped areas and watershed outlets exceeded reductions attributable solely to dilution; with some 97% of the nitrogen and approximately 37% of excess phosphorous being retained by woody alluvial vegetation (Yates and Sheridan 1983).

Functions and Values of Wetlands

Wetland functions and values are often stated in terms of broad generalities, though data to support these conclusions may be more difficult to obtain than expected. Generalities often accepted about wetlands include:

1. Wetlands provide a natural area for the control of storm water or flood tides.

2. Stormwater flow through wetlands slows runoff thereby increasing filtration and maintaining downstream water quality.

3. Wetlands are highly productive systems which support terrestrial, estuarine and oceanic food webs.

4. Wetlands have some direct human value, often may difficult to quantify, that is educational, recreational or aesthetic.

Wetlands function in the control of storm water. Riparian forests and estuarine wetlands by their magnitude may provide a temporary storage area for stormwater and potentially alleviate downstream damage. Neiring (1973) calculated that a 6 inch rise in water over a ten acre wetland will place more than 1,500,000 gallons of water in storage. Bertulli (1981) concluded that the presence of adjacent swamp forest lowered stream storm flow from a 100 year storm event from 155 cubic meters/sec to 83 cubic meters/sec. In a computer model of three watersheds Ogawa and Male (1983) simulated the effect on peak river flow of various amounts of encroachment into riverine wetlands. A 25% encroachment produced increases in peak flow in 28% of their simulations, 50% encroachment increased peak flow in >60% of their simulations. A 75% encroachment produced peak flow increases in 90% of the simulations. Finally, 100% encroachment into riverine wetlands produced peak flow increases in all simulations and and as great as 200% increases in 38% of their simulations. The presence of forest or wetland adjacent to rivers ensures that water flows into areas where plants are well adapted to periodic flooding (Harms et al. 1980). Mitsch et al. (1977) states that flooding of the Cache River in Illinois imports high levels of nutrients into an adjacent riparian forest.

Water flow through a wetland slows the water thereby increasing filtration and maintaining downstream water quality. Murdoch and Capobiancho (1979) found the upstream portion of the Cootes Paradise marsh effectively filtered water from an upstream wastewater treatment plant. Approximately 80% of the total phosphate was removed from the water passing through this area before entering the main portion of the marsh. The major emergent plant in this area, *Glyceria grandis* was shown to have the highest tissue concentrations (among the three areas sampled) of nitrogen and phosphorus. *Glycera grandis* also contained 4.95

ppm lead, 15.5 ppm zinc and 2.67 ppm chromium (Pooled mean from 3 sample sites, collected in April and July). DeLaune and Patrick (1979) found that Georgia Gulf coast marshes along the Mississippi river accumulated 1.35 cm/yr of sediment. They concluded that those marshes were a sink for nitrogen. When streamside and inland samples were compared accumulations of 210 kg/ha/yr v. 134 kg/ha/yr nitrogen, 16.5 kg/ha/yr v. 7.5 kg/ha/yr phosphorus and 3930 kg/ha/yr v. 2370 kg/ha/yr carbon were recorded. Van Raalte et al. (1974) found the addition of nitrogen in the form of sewage sludge to a salt marsh altered the nitrogen cycle. The study suggests that blue-green algae which fix atmospheric nitrogen shifted to the more readily availably nitrogen in the sludge. Valiela et al. (1973, 1975) and Sullivan and Diaber (1974) both report increases in productivity of Spartina alterniflora with the addition of nitrogen from sludge and fertilizer, respectively. DeLaune et al. (1981) studied heavy metal uptake in Louisiana salt marsh plants and concluded that these plants accumulated heavy metals from natural sources in a relatively pristine area. Gallagher and Kibby (1980) found Carex lyngbyei, Salicornia virginica, Juncus balticus and Potentilla pacifica accumulated chromium, copper, iron, manganese, strontium, lead and zinc from contaminated soil. Concentrations of heavy metals were higher in dead plants than in live plants.

Coastal wetlands are highly productive ecological systems which are physically linked to adjacent wetlands, estuaries and the nearshore ocean through the tidal exchange of materials and biologically linked by the migration of organisms (Thayer, et al. 1978). Hopkinson and Hoffman (1984) state that of the five systems they studied (marsh, estuarine water, nearshore zone, estuarine plume and midshelf) only the marsh was autotrophic, fixing 2.6 times more carbon than was consumed in respiration and sedimentation. Teal (1962) reports that 45% of salt marsh primary production is exported to the estuary. De la Cruz (1978) summarizes imports and exports of several salt marshes.

The dependence of food chains on wetlands is well documented. Walker in Wharton et al. (1982) reported >25 species of fish use flooded riparian forests to forage for terrestrial insects. Dickson and Noble (1978) studied the vertical distribution of birds in a hardwood swamp. A total of 26 species were found distributed throughout the canopy. Best et al. (1978) found a total of 21 species of birds in a floodplain forest in Iowa. Northern waterthrushes, Seiurus novaboracensis, commonly forage on exposed mudflats adjacent to riparian forests and defend territories which extend into the forest during their spring and fall migrations. Wood ducks (Aix sponsa) showed marked preference for buttonbush (Cephalanthus occidentalis) swamps on the edges of open water in southern Illinois--the swamps providing important brood-rearing habitat and flooded woodlands providing important sources of mast (Parr, et al. 1979). The diversity and abundance of aquatic invertebrates in the wetland community, as well as their availability, is a primary consideration in area management for wood ducks (Drobney and Frederickson 1979).

Research on organisms dependent on the productivity of salt marshes often focuses on those species of commercial importance such as fish, shellfish, waterfowl and furbearers. Commercially important shellfish include clams *Mercenaria mercenaria* and *Mya arenaria*, mussels *Mytilus edulis*, oysters *Crassostrea virginica* and crabs *Callinectes sapidus*. Several species of fish spawn or spend some part of their life cycle in the salt marsh and in adjacent tidal creeks (Weinstien 1979 Shenker and Dean 1979). Checklists of indigenous have been compiled by several authors for estuaries along the Atlantic coast. Shenker and Dean (1979) found a total of 22 species of larval and juvenile fish in salt marsh creeks in South Carolina, Bozeman and Dean (1980) found 16 species in this same area. In Delaware, Derickson and Price (1973) found 46 species. Chenowith (1973) identified larvae of 17 species in estuaries near Boothbay, Maine. Oviatt and Nixon (1973) found 99 species in Narragansett Bay, Rhode Island. Merriner et al. (1976) and Castagna and Richards (1970) found 41 species in the Piankatank River and 70 species on the Eastern Shore of Virginia, respectively. In many of these samples include commercially valuable species including herring, alewife and shad (*Alosa* sp. and *Clupea* sp.), anchovies (*Anchoa* sp.), American eel (*Anguilla rostrata*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*) and winter flounder (*Pseudopleuronectes americanus*). These areas also provide food in the form of small fish and invertebrates. Dickerson and Price (1973) state 89% of their catch was comprised of 5 species important as food for commercial species. Markle and Grant (1976) report that 44% of the gut contents of juvenile *M. saxatilis* was small fish including gobies (*Gobiosoma boscii*) and silversides (*Menidia* sp.). In addition these and other species (*Fundulus* sp. and *Gambusia affinis*) feed also on salt marsh detritus (Kneib 1978) or on detritivores such as mosquito larvae and polychaets (Talbot et al. 1978).

The salt marsh is also an important feeding and nesting ground for waterfowl, wading birds and raptors. *Spartina* sp. marshes along the St. Lawrence River, Quebec maintain a large population of breeding black ducks, *Anas rubripes* during spring and summer. Four other species of waterfowl, eight species of waterbirds, six passerines and two raptors feed on the marsh. Migrating birds which also frequent the marsh include four other species of waterfowl and 20 species of shorebirds. Custer and Osborn (1978) discussed factors important to the feeding behavior of snowy egrets (*Egretta thula*), great egrets (*Casmerodius albus*) and Louisiana herons (*Hydranassa tricolor*) in salt marshes near Beaufort, North Carolina. Willard (1977) notes that 11 species of herons are supported by coastal marshes from Long Island, south. Spinner in Custer and Osborn (1969) correlates the number of wading birds per state with the total acreage within that state. Reed and Moisan (1971) Note that marsh hawks (*Circus cyaneus*) and merlin (*Falco columbarius*) hunt on *Spartina* sp. marsh. Ospreys (*Pandion haliaetus*) often nest in or near marshes and have been observed foraging on the marsh when inclement weather prohibits fishing (Wiley and Lohrer 1973).

Ecotonal areas adjacent to wetlands are important as nesting habitat for some marsh birds (Hawkins and Leck 1977) and nesting success for those birds may be greater within the ecotone than in the marsh (Meanley and Webb 1963). Black ducks nest under low bushes in the ecotone (Tiner 1985) and very often within upland areas, sometimes hundreds of yards from the wetland (Stotts and Davis 1960).

Wetlands are also important to several species of mammals. Meadow voles (Microtus pennsylvanicus) forage on the salt marsh grasses Spartina patens and Distichlis spicata (Howell 1984). Meadow voles and rice rats (Oryzomys palustris) sometimes build their nests in or near muskrat (Ondatra zibetheca) huts (Harris 1953). Rodents trapped on the Barnegat National Wildlife Refuge, New Jersey include meadow voles, muskrats, and meadow jumping voles (Zapus hudsonius) (Bosenberg 1977). Shure (1970) found meadow voles, house mice and masked shrews (Sorex cinereus) in the salt marsh along Island Beach State Park, New Jersey.

New Jersey's Coastal Wetlands

The most easily recognized of the three major wetland types in New Jersey's coastal zone are the vast expanses of salt marsh which border back bays and coves, spreading from the bay side of barrier islands inland (Carlson and Fowler 1980). Dissected by meandering creeks, channels and guts, the salt marsh extends up tidal rivers until the prevailing salinity regime begins to favor freshwater species. A distinct zonation of the marsh vegetation develops in response to the period and duration of tidal flooding. The low marsh, subject to at least daily inundation, is dominated by generally monotypic stands of Spartina alterniflora (salt marsh cord grass). As more sediment builds up, raising the level of the marsh above mean high tide, the vegetation is flooded less often and may be exposed for much longer periods. In these high marsh situations, Spartina patens (salt hay) tends to be the dominant species. However, the high marsh is typically divided into subzones, due to differences in depth and period of flooding, which may form a mosaic of vegetation types (Good 1965). Species diversity increases as several species become abundant, including Distichlis spicata (spike grass), Juncus gerardii (black grass), Iva frutescens (marsh-elder) and the glassworts (Salicornia spp.). Spartina patens and Distichlis spicata often form nearly monotypic stands, with Distichlis spicata prevalent in the less well-drained areas. Spartina alterniflora and Iva frutescens border tidal creeks and man-made ditches in the high marsh. The upland edge of the salt marsh is often bordered by Phragmites australis (common reed), Panicum virgatum (switch grass) and Iva frutescens, as well as Baccharis halimifolia (groundsel-tree), Juniperus virginiana (red cedar), Myrica pensylvanica (northern bayberry), Toxicodendron radicans (poison ivy), Solidago sempervirens (seaside goldenrod) and a host of grasses and rushes (Tiner 1985).

Tidal freshwater marshes are the scarcest wetland type in New Jersey's coastal zone. The majority of the state's riverine tidal marshes occur in the Delaware River and its tributaries. Exhibiting a vegetational zonation due to elevation and the frequency of flooding much like the salt marsh, the low marsh is dominated by non-persistent emergents, including Zinzania aquatica (wild rice), Nuphar advena (spatterdock), Polygonum punctatum (water smartweed), Sagittaria latifolia (broadleaf arrowhead), and Bidens laevis (bur marigold). Spatterdock, wild rice and Peltandra virginica (arrow-arum) often form extensive pure and mixed stands. In association with species such as Impatiens capensis (jewelweed), Polygonum arifolium (halberd-leaved tearthumb), Amaranthus cannabinus (water hemp), and Pontederia cordata (pickerelweed), these dominant plants form as many as 18 major tidal freshwater wetland communities in the Hamilton Marshes near Trenton (Whigham and Simpson 1975). High marsh communities form behind natural levees which separate the higher elevations from the river channel. In general, the high marsh is colonized by persistent emergents and plant diversity is greater than in the adjacent riverine community. The plant associations are more mixed and include Typha latifolia (narrow-leaved cattail), bur marigold, water smartweed, halberd-leaved tearthumb, wild rice (sometimes in pure stands), broadleaf arrowhead, water hemp, and Sparganium americanum (burreed) (McCormick and Ashbaugh 1972, Ferren 1975).

Palustrine forested wetland, "hardwood swamps", are the most abundant and widespread wetland type in New Jersey, but because they lack the dramatic expanse of the salt marsh or the distinctive vegetation of the freshwater marsh, they are the most easily overlooked. They are mainly found in the floodplains of rivers and perennial streams, although they may form in upland depressions and along the borders of coastal marshes. Wetland communities are very complex and extremely diverse, varying widely in response to local conditions (Tiner 1985). Acer rubrum (red maple) is the dominant species in the majority of wetland types in southern New Jersey, with Nyssa sylvatica (black gum) and Liquidambar styraciflua (sweet gum) co-dominant or locally dominant. The shrub layer is generally a dense association of such species as Clethra alnifolia (sweet pepperbush), Vaccinium corymbosum (common highbush blueberry), Rhododendron viscosum (swamp azalea), Leucothoe racemosa (swamp sweetbells), and Viburnum dentatum (southern arrowwood). In wetter areas, where the understory is more open, species including Symplocarpus foetidus (common skunk cabbage), Osmunda cinnamomea (cinnamon fern), Osmunda regalis (royal fern), Polygonum sagittatum (arrow-leaved tearthumb) and Carex stricta (tussock sedge) may become established. Diversity in the species composition of hardwood swamps is the rule.

Disturbance to Wetlands Systems

Human activity affects practically every class of habitat, every species, and every type of natural process in the Nation's wetlands (Darnell 1978). Urbanization in a watershed has the effect of producing flood hydrographs of much shorter duration and with higher peaks. For example, a population density increase from 100 to 13,000 persons per square mile creates a 10 fold increase in the peak rate of surface runoff, while related time parameters decrease to approximately one-tenth of values for rural areas (Brater and Sherrill 1975).

The impacts of human activity are often unforeseen. Pulses of thermal effluents from an upstream nuclear reactor caused progressive deterioration of the canopy of a cypress-tupelo wetland (due to direct bole mortality and premature leaf senescence) in Georgia (Scott et al. 1985).

Working in the New Jersey Pine Barrens, Ehrenfeld (1983) showed that wooded wetlands adjacent to developed areas tended to lose herbaceous species characteristic of the pinelands and "suffered" a decline in the frequency of characteristic shrubs. Apparently, the addition of nutrients to the traditionally nutrient-poor ground and surface water originating from developed areas favored the establishment of a group of cosmopolitan and exotic herbaceous species from surrounding areas at the expense of native flora.

Draining has dramatic and possibly irreversible detrimental impacts on wetland vegetation, but even short-term alteration in the flooding cycle caused by development should be expected to impact wetland plant associations (McLeese and Whiteside 1977, Thibodeau and Nickerson 1985). Changes in flooding frequency of riparian bottomland forest resulted in changes in arthropod communities and seasonal abundances with implications for wildlife species dependent on these food sources (Uetz, et al. 1979). Changes in vegetation composition and structure directly affects the density and diversity of aquatic invertebrates (Voigts 1976), and can be expected to directly affect wetland use by insect-feeding birds (Orians 1966, Voigts 1973).

The degree of water quality degradation through nutrient loading was found to be directly correlated with the level of agricultural development in a Florida watershed (Terry and Tanner 1984): Vegetation in wetlands adjacent to these developed areas tended to accumulate elevated concentrations of various nutrients. Agricultural land uses in an Ontario watershed resulted in disturbed stream flow patterns, heavier sediment and nutrient loads and higher stream temperatures, reduced species diversity and altered composition of stream insect communities (Dance and Hynes 1980).

The primary effects of clearing and paving of upland areas are the disturbances in the quality, volume and rate of flow of freshwater discharges into estuarine systems--including coastal wetlands (Clark 1977). The total volume of stormwater developed areas deliver to adjacent wetlands may be increased because of reduced evapotranspiration and percolation. Alterations in flood patterns can adversely affect duck nesting or prevent nesting in disturbed wetland areas (Miller and Collins 1954). Vegetated areas in the watershed also regularize storm flow and dampen violent surges. Wetland plants are very sensitive to changes in water level (Bourn and Cottam 1950, Harris and Marshall 1963) and aquatic animals are adapted to particular ranges of stream flow velocity (Fraser 1972).

Paving of areas adjacent to wetlands alters runoff patterns and the resultant surge flows carry higher concentrations of contaminated sediments and other pollutants (Clark 1977) including salts and hydrocarbons from roadways (Darnell, et al. 1976). Suspended solids increase water temperatures, reduce available oxygen in aquatic systems and can clog filtration structures of benthic animals, over-taxing metabolism and reducing productivity (Loosanoff and Tommers 1948; Darnell, et al. 1976).

Wetlands Legislation

Federal protection of coastal wetlands has been a result of the sweeping environmental legislation of the 1970's and the growing recognition of the important functions and values of wetlands systems. In 1972 Congress passed the Federal Water Pollution Control Act (FWPCA) prohibiting the discharge of pollutants into navigable waters. Section 404 of the act requires that a permit be acquired from the Corps of Engineers for any discharge of dredged or fill material into the waters of the United States. The tendency has been towards a broad definition of the requirements of the act to include lakes, rivers and wetlands (Richardson 1981). Recognizing the need for more specific protection of the nation's coastal areas, in 1972 Congress ratified the Coastal Zone Management Act (CZMA) which required the states to promulgate their own coastal zone management strategies and regulations.

With the passage of this federal legislation, the stage was set for the assumption of responsibility for the protection of the coastal zone, including coastal wetlands, by the states. As a result, almost all 30 coastal states (including the Great Lakes states) have established programs that directly or indirectly regulate the use of their coastal wetlands. Often, permit regulations require that development be set back a certain minimum distance from the wetland border through the establishment of a buffer zone (Table 1).

In 1970, New Jersey enacted the Wetlands Act (N.J.S.A. 13:9A-1 et. seq.) "to provide for an orderly development consistent with the ecology of wetlands," (Carlson and Fowler 1980). In response to CZMA mandates, New Jersey passed the Coastal Area Facility Review Act (CAFRA) in 1973 which requires an inventory of all environmental resources and current land uses in the coastal zone. Together, these statutes require that builders of certain facilities constructed in the coastal zone of New Jersey apply for and receive a permit issued by the commissioner of the New Jersey Department of Environmental Protection.

Table 1. State wetland policies regulating development in coastal wetlands.

Location	Wetland Policy	Reference
	States Not Requiring a Buffer Setback	
Delaware	Permit required for development within delineated wetlands.	DNREC regulations (1984)
Florida	Permit required for development within delineated wetlands.	Wetlands Protection Act of 1984
Georgia	Permit required for development within delineated wetlands; best management practices required.	Coastal Marshlands Protection Act (1970)
Louisiana	Permit required for development in coastal areas below 5 ft above mean high water.	Coastal Resources Management Act (1978)
Maine	Permit required to alter or develop coastal wetlands; buffer required for extractive activities.	Maine DEP (1983) Site Location of Development (MRSA Title 38)
Virginia	Permit required for development within delineated wetlands provided that there will be no adverse impacts from development.	Va. Marine Resources Commission 1982
	States Requiring a Buffer Setback	
California	100 ft minimum buffer required between development and the landward edge of wetland/riparian vegetation.	Ca. Coastal Commission (1981)
Connecticut	Development within coastal zone (defined as 100 yr flood tide mark or a 1000 ft linear setback from inland boundary of tidal wetland--whichever is farther inland) by permit; Setback of 50-200 ft for septic systems.	CT Coastal Management Act CT Inland Wetlands and Watercourses Act (1972)
Maryland	1000 ft critical area defined around Chesapeake Bay within which local governments are responsible for enforcement of best management practices.	MD General Assembly (1984)
Massachusetts	100 ft zone adjacent to wetland in which development activity is subject to permit.	Wetlands Protection Act (M.G.L. c. 131, s. 40)
New Hampshire	75 ft buffer required adjacent to coastal wetlands	NH Code of Administrative Rules
New Jersey	300 ft buffer within which development must have no adverse impacts on wetland or wetland ecotone	NJDEP 1986
New York	Development within 100 ft of a freshwater wetland by permit only.	Freshwater Wetlands Act (1980)
N. Carolina	75 ft buffer required landward of mean high water along estuarine shorelines; visible siltation confined to upper 25 % of the buffer.	NC Administrative Codes (1985)
Rhode Island	Development within 200 ft inland from the border of coastal wetlands by permit only; 50 ft setback required adjacent to freshwater wetlands.	Olsen and Seavey (1983), Klein (1980)

2.0 METHODS

2.1 STUDY SITE SELECTION

Wetland/buffer study sites were located throughout the New Jersey Coastal Zone. Possible study sites were identified by personnel of the Division of Coastal Resources (NJDEP), Bureaus of Planning and Project Review and Coastal Enforcement and Field Services. Additional sites were located by New Jersey Agricultural Experiment Station (NJAES) personnel by examining U.S. Fish and Wildlife Service National Wetlands Inventory maps and Soil Conservation Service county soil survey maps. Some 250 possible sites were cataloged.

Three wetland types were selected for study, on the basis of their prevalence in the coastal zone: salt marsh (E2EM), tidal freshwater marsh (primarily limited to riverine emergent tidal marsh--R1EM), and palustrine hardwood swamps (PFO1) (designations follow Cowardin, et al. 1979). Four land use categories were established to assess the relative levels of human impact on wetland systems from varying degrees of development:

1. Agricultural and recreational land uses (designated AG/REC);

2. Low-density residential land uses (representing single-family housing where < 30% of the developed area is in paving and structures) designated RES-L;

3. High-density residential land uses (multi-unit structures, condominiums and apartment complexes, as well as residential areas where there is > 30% impervious cover) designated RES-H; and,

4. Industrial and commercial land uses (designated IND/COMM).

Each of the possible study sites was assessed in the field by NJAES personnel using these criteria. In all, 100 study sites were found to be suitable for use. Forty-two salt marsh sites (Table 1), 25 tidal freshwater marsh sites (Table 2), and 32 hardwood swamp sites (Table 3) were sampled in 10 New Jersey Counties (Figure 1).

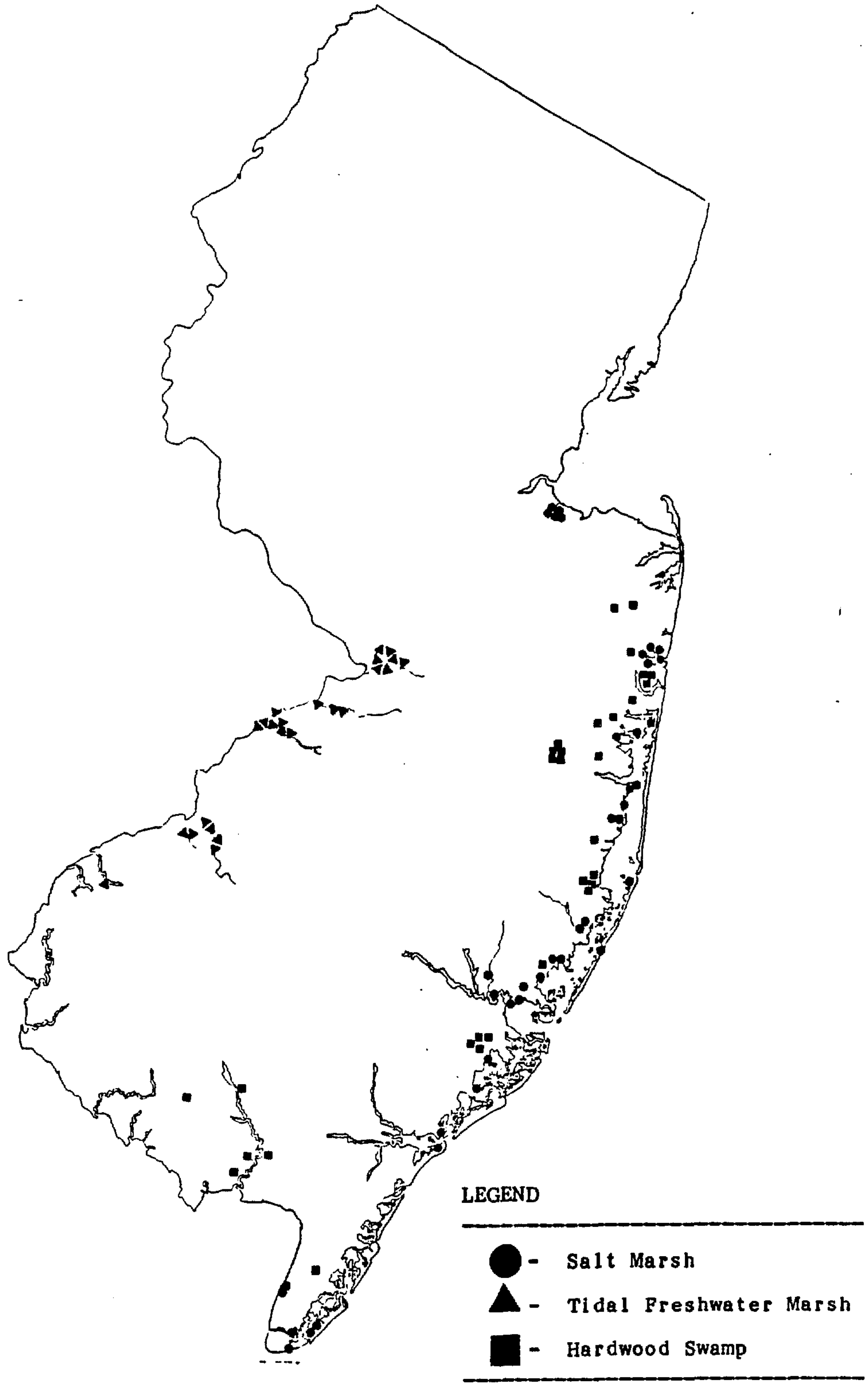


Figure 1. Location of wetland/buffer study sites within the New Jersey coastal zone.

Table 2. Salt marsh wetland/buffer study sites sampled by NJAES personnel from 30 May to 16 October 1986.

Site Number	Location	Land Use	Buffer Width (ft)	Wetland Size (acres)	Buffer Slope (deg)
058	Shelter Cove Condominium, 6 th St. and Delaware Ave., Beach Haven, Ocean Co.	RES-H	0	4	0
068	Glimmer Glass Island, Brielle Rd., Manasquan, Monmouth Co.	RES-L	50	2	<5
077	Dock Rd., Cheesequake State Park, Middlesex Co.	REC	300	44	15
079	Sand Pit Point, Cheesequake State Park, Middlesex Co.	REC	300	47	25
080	Hooks Lake, Cheesequake State Park, Middlesex Co.	REC	50	61	0
081	Farry Point, Cheesequake State Park, Middlesex Co.	REC	70	101	0
082	Arrowsmith Point, Cheesequake State Park, Middlesex Co.	REC	150	101	15
092	Mushquash Cove, Nathan Pl., Neptune, Monmouth Co.	REC	50	5	5
096	Hillside Rd., Neptune, Monmouth Co.	RES-L	40	9	5
097	Marconi Rd., Neptune, Monmouth Co.	RES-L	60	2	10
098	Manasquan Golf Course, Brielle, Monmouth Co.	RES-L	40	1	10
108	Tranquility Park, Between Rt. 109 and Cape May Canal, Lower Twp., Cape May Co.	RES-L	120	17	<5
110	End of Somers Town Lane, Galloway Twp., Atlantic Co.	RES-L	0	101	<5
121	Dock Rd./Brook St., Parkertown, Ocean Co.	REC	0	11	<5
125	Radio Rd.,/Holden St., Mystic Island, Ocean Co.	RES-L	110	101	<5
131	Adams Ave., New Gretna, Burlington Co.	RES-L	5	26	<5
134	Amasa Rd., New Gretna, Burlington Co.	REC-L	20	15	<5
139	Ocean Gate Yacht Basin, Bayview Ave., Ocean Gate, Ocean Co.	COMM	15	101	5

Table 2. Continued

142	Bayview Ave., Ocean Gate, Ocean Co.	REC	25	71	<5
143	Butler Ave., Holly Park, Ocean Co.	RES-H	0	1	<5
146	Rocknacks Yacht Basin, Bay Way, Lanoka Harbor, Ocean Co.	REC	15	10	5
167	Rt. 30 east, behind Old Gas Station, near Atlantic City, Atlantic Co.	COMM	150	40	<5
238	Sea Pirate Light, Rt. 9, West Creek, Ocean Co.	REC	300	101	<5
239	Szathmary Supply, Bay Ave., Manahawkin, Ocean Co.	IND	50	6	5
240	Gale Rd., Brick Twp., Ocean Co.	RES-L	40	94	<5
242	Neptune Ave., Neptune, Monmouth Co.	RES-L	300	14	5
243	Seaview Condos, Sea Spray Ct., Shark River Island, Monmouth Co.	RES-H	10	32	25
245	Mandalay Rd., Mantoloking Pt., Ocean Co.	RES-L	300	66	<5
247	Victoria Point, Bar Harbor, Ocean Co.	RES-L	0	30	<5
248	The Meadows, Lafayette St., Cape May Co.	RES-H	100	101	5
249	Pelican Bay, North Station Ave., Wildwood Crest, Cape May Co.	RES-H	0	10	0
250	Capeshore Lab, King Crab Landing, Cape May Co.	REC	130	27	<5
251	Capeshore Lab II, King Crab Landing, Cape May Co.	REC	20	27	<5
252	Toledo Ave., Wildwood Crest, Cape May Co.	RES-H	40	101	0
253	Tennesee Ave., Ocean City, Cape May Co.	RES-H	0	28	0
255	No. 53, Sea Meadow Dr., Parkertown, Ocean Co.	RES-L	100	101	<5
256	Bay Harbor Blvd., Brick Twp., Ocean Co.	RES-L	70	59	<5
257	Rocknacks II, Bay Way, Lanoka Harbor, Ocean Co.	REC	20	10	<5
259	Pirate Cove Motel, South Side of Longport Blvd., Egg Harbor Twp., Atlantic Co.	RES-H	30	9	<5
262	Alabama/Ocean Blvd., Mystic Island, Ocean Co.	RES-L	150	2	<5
292	Cook Ave, NY & Longbranch RR, Laurence Harbor, Middlesex Co.	RES-H	250	101	15
299	Holly Lake Park, Tuckerton, Ocean Co.	RES-H	180	3	5

Table 3. Fresh water tidal marsh wetland/buffer study sites sampled by NJAES personnel from 30 May to 16 October 1986.

Site Number	Location	Land Use	Buffer Width (ft)	Wetland Size (acres)	Buffer Slope (deg)
224	Henry St., Riverside, Burlington Co.	RES-H	30	101	10
226	Burlington Park, Rt. 660, Burlington Twp. Burlington Co.	REC	100	28	24
227	Burlington Park II, Rt. 660, Burlington Twp., Burlington Co.	REC	75	28	20
258	Curtin Marina, end of Rt. 566, Burlington Twp., Burlington Co.	IND	15	2	25
260	Pureland Industrial Complex, End of Heron Drive., Gloucester Co.	IND	225	39	<5
265	Soden Dr., Yardville, Mercer Co.	RES-L	42	23	21
266	Highland Ave., Yardville, Mercer Co.	RES-L	258	16	20
267	Soden Dr. II, Yardville, Mercer Co.	RES-L	55	16	18
268	Grover Ave., Bordentown, Burlington Co.	RES-L	196	33	16
269	40 Edgewood Rd. West, Bordentown, Burlington Co.	RES-L	163	18	30
270	Bradlees, Rt. 206 South, Bordentown, Burlington Co.	COMM	207	18	32
271	Ridge/Station Ave, Glendora, Camden Co.	RES-H	70	62	31
272	Hillcrest Apartments, On Hilltop Dr., Bordentown, Burlington Co.	RES-H	200	96	31
273	400 Front St., Runnemede, Camden Co.	RES-H	75	62	<5
274	Hilltop Dr., Bordentown, Burlington Co.	AGRIC	301	101	23
275	Creek Rd., Behind Timber Cove Apartments, Bellmawr, Camden Co.	RES-H	85	25	<5

Table 3. Continued

276	Reliance Co/Municipal Garage at Karr Dr. Bellmawr, Camden Co.	IND	50	25	<5
281	544 Oakside Pl., Woodbury, Gloucester Co.	RES-H	150	18	<5
282	Briar Hill Lane, Woodbury, Gloucester Co.	RES-L	150	13	<5
284	Polk St., Riverside, Burlington Co.	RES-L	41	22	<5
285	Harris/Washington St., Riverside, Burlington Co.	RES-H	100	64	<5
286	Rockland Dr., Willingboro, Burlington Co.	RES-H	300	38	9
287	Larchmont/2nd St., Beverly, Burlington Co.	RES-H	300	81	<5
289	Hecker/Harris St., Riverside, Burlington Co.	RES-H	40	64	<5
290	Pulaski/River Dr., Riverside, Burlington Co.	RES-H	30	71	17
291	628 River Dr., Riverside, Burlington Co.	RES-H	21	71	11

AGRIC=agricultural, COMM=commercial, IND=industrial, REC=recreational, RES-H=high density residential, RES-L=low density residential.

Table 4. Hardwood swamp wetland/buffer study sites sampled by NJAES personnel from 30 May to 16 October 1986.

Site Number	Location	Land Use	Buffer Width (ft)	Wetland Size (acres)	Buffer Slope (deg)
054	Ricci Bros., Dragston/Rt. 553, Downe Twp., Cumberland Co.	AGRIC	95	63	0
063	Smithvlle Phase 1A, Rt. 9, near Moss Mill Rd., Galloway Twp., Atlantic Co.	RES-L	45	7	<5
111	Club at Galloway, West side of Wrangleboro Rd., Galloway Twp., Atlantic Co.	RES-H	200	39	<5
112	Pinnacle, East side of Wrangleboro Rd., Galloway Twp., Atlantic Co.	RES-H	301	38	<5
113	Toms River Intermediate School, Hooper Ave., Toms River, Ocean Co.	REC	70	32	<5
190	Convalesent Center, Magnolia Dr., Middle Twp., Cape May Courthouse, Cape May Co.	RES-H	0	11	0
207	Kettle Creek, Rt. 70, North Lakewood, Ocean Co.	IND	150	5	<5
220	224 Timberlake Dr., Stafford Twp., Ocean Co.	RES-L	0	101	0
222	Caldors, Rt. 549, Brick Twp., Ocean Co.	COMM	30	9	20
231	Torrey Pine, Holiday City I, Ocean Co.	RES-H	100	42	10
232	Torrey Pine, Holiday City II, Ocean Co.	RES-H	230	42	10
233	Troumaka St., Holiday City III, Ocean Co.	RES-H	0	42	10
234	Lagos Ct., Holiday City IV, Ocean Co.	RES-H	200	77	10
235	Lagos Ct., Holiday City V, Ocean Co.	RES-H	175	77	10
244	Brook St./Rt. 9, Parkertown, Ocean Co.	RES-L	95	5	<5
246	Lakeside Dr. S., near Deer Head Lake, Forked River, Ocean Co.	RES-L	90	52	<5
254	Smith Dr., Brick Twp., Ocean Co.	RES-L	70	22	0
261	The Club at Mattix Forge, Great Creek Rd., Galloway Twp., Atlantic Co.	RES-H	250	34	<5
263	Crossroads/Four Seasons, Ridgeway St., Barnegat, Ocean Co.	RES-H	0	11	0
264	Barnegat Swamp, Cedar St., Barnegat, Ocean Co.	RES-H	301	11	<5

Table 4. Continued

277	Mulford St., Millville, Cumberland Co.	RES-H	45	13	18
278	Warren Ave., Port Norris, Cumberland Co.	RES-L	300	22	0
279	Maurice River Twp. School, Port Norris-Mauricetown Rd. (Rt. 548), Cumberland Co.	REC	301	34	<5
280	Delsea Fire House, Rt. 47, Maurice R. Twp., Cumberland Co.	REC	0	4	0
283	Pine Dr., Wayside, Monmouth Co.	RES-H	100	101	5
288	Branch Rd., Oakhurst, Monmouth Co.	RES-H	0	30	0
293	Cottonwood Dr., Old Mill, Monmouth Co.	RES-H	40	21	16
294	Allenwood/Woodfield, Wall Twp., Monmouth Co.	RES-L	75	15	<5
295	Butternut Rd., (St. Catherine's), Old Mill, Monmouth Co.	RES-H	0	23	0
296	Water/Birdsall St., Barnegat, Ocean Co.	RES-L	0	6	0
297	Baseball Field, Water St., Barnegat, Ocean Co.	REC	0	14	0
298	Spruce Dr., Old Mill, Monmouth Co.	RES-H	60	21	14

AGRIC=agricultural, COMM=commercial, IND=industrial, REC=recreational, RES-H=high density residential, RES-L=low density residential.

2.2 WETLAND DELINEATION

Wetland boundaries were delineated in the field using the U.S. Army Corps of Engineers multi-parameter approach (Environmental Lab 1987). Ecotonal plant associations were first identified using the U.S. Fish and Wildlife Service regional plant list to classify species as wetland (USFWS designations FACW or OBL) or upland species (FACU or UPL) (Reed 1986). Soil cores were then taken to determine at what point the seasonal high water table occurred 12 in below the ground surface (Environmental Lab 1987).

Buffer zones were defined operationally in the field as all existing vegetation which occurred between the delineated wetland boundary and the farthest limit of adjacent development. The limit of development was generally defined as the beginning of paved surfaces, maintained lawns, or fencing. In some cases, the corridor of vegetation (often late old-field or early successional forest situations) between developed area and wetland had become established after construction and there was, in effect, no buffer present during construction.

2.3 MEASUREMENT OF HUMAN DISTURBANCE

Direct human disturbance of the vegetation in the study sites was measured in several ways. Disturbance and vegetation variables were sampled using line transect methods (Cox 1972, Roman, et al. 1985). One transect of 30 m was placed in the wetland parallel to the direction of the ecotone and divided into a series of contiguous intervals. Three 50 m transects (where width of the buffer permited) were run perpendicular from the first transect into the ecotone and upland. Where 50 m was inadequate to obtain a representative sample of the vegetation in all three zones (i.e. wetland, ecotone and upland), perpendicular transects were extended to as much as 100 m from the parallel.

The number and widths of all paths, trails and other areas of degraded vegetation (eg. bare ground areas, eroded areas) which were crossed by the vegetation transects were recorded. Also recorded were such things as slash piles, discarded construction materials (eg. broken concrete, open and discarded containers of paint, solvents and roofing substances), felled trees and cut stumps, discarded appliances and automobile or machine parts. All forms of refuse or disturbance intercepted by the transect lines (as well as the length of the transect intercepted and the width, on either side of the transect line, of the area disturbed) was described and recorded. Only debris and disturbance which could be identified as having an upland origin (as opposed to disturbance due to tidal action, eg. flotsam washed onto a marsh) was considered in the analysis.

Human degradation of study sites was also measured by counting individual pieces of debris not intercepted by sampling transects. All debris seen within 1.0 m on either side of the transects was counted and described. In addition, two 30 m transects parallel to the wetland/upland ecotone, one in the ecotone itself and the other placed in the adjacent upland, were walked to count debris as previously described. Such things as tires, grass clippings, empty cleaning agent containers, as well as discarded bottles, plastic and cans seen from these transects were recorded.

The slope and aspect of vegetation transects were recorded. Notes of the approximate age of the development, the presence of exotic species, current land use and the estimated size of the wetland were recorded in the field. Size estimates were later compared to U.S. Geological Survey topographic maps and U.S. Fish and Wildlife Service National Wetlands Inventory maps for verification.

2.4 CALCULATION OF DISTURBANCE INDEX (DHD)

The index of direct human disturbance (DHD) was calculated using a modified formula from the ecological literature for the calculation of vegetation importance values (see Cox 1972). The number of pieces of debris recorded in the wetland portion of the sampling transects was summed to obtain a total count (N) and divided by the total area searched (A) to obtain an estimate of litter density (litter/square meter):

Equation 1. $L=N/A$

Where transect intercepts were recorded (eg. an area of disturbed soil, siltation, etc. intercepted by the transect line), they were summed and a disturbance dominance index (D) (after Cox 1972) was calculated:

Equation 2. $D=\sum I/l$ where D=disturbance dominance

I=intercept length occupied by disturbance

l=total transect length sampled

Finally, a frequency of occurrence was calculated for disturbance intercepts:

Equation 3. $F=\sum f/l$ where F=disturbance frequency

f=number of disturbance intercepts

l=total transect length

The final disturbance index is a simple sum of the individual indices multiplied by 100 for clarity:

Equation 4. $$DHD=(L+D+F)x100$$

DHD was made an additive index to reflect the increasing degree of degradation a wetland suffers as several types of direct human disturbance (litter, trampling, siltation, etc.) are compounded. Intuitively, a wetland with high debris density and many instances of trampling (high disturbance dominance) would be more degraded than would a similar site with high debris density but no other human disturbance.

2.5 VEGETATION SAMPLING

At alternate meter intervals along each transect, percent cover of all herbaceous species within a square meter quadrat was estimated (Braun-Blanquet 1932, Daubenmire 1959). All non-herbaceous plants intercepted by the transect (either physically touching the transect or by underlying or overlying the transect line) were recorded to species. For each intercepted woody species, an intercept length was recorded as that portion of the transect line (a 30 m or 50 m nylon tape) intercepted by the plant or by a perpendicular projection of the plant's foliage to the transect line (Figure 2). The width, representing the maximum width of the plant (or clump of plants where individual canopies were indistinguishable) perpendicular to the transect line was also recorded. Canopy species were recorded as percent cover over the transect line. Canopy coverage was measured as a vertical projection of the overhead canopy to the transect line. The height of all shrubs intersected was estimated to the nearest 0.5 meters.

2.6 VEGETATION ANALYSIS

From measurements made of vegetation in the field, a series of descriptive statistics were calculated for each species in each canopy (i.e. overstory, shrub layer and herbaceous layer) and in each community type (i.e. upland, ecotone and wetland) (Brower and Zar 1984). Relative frequency of a woody species was expressed as a proportion of the total number of individuals of that species encountered to the total number of individuals of all species encountered. The relative frequency of herbaceous species was expressed as the number of sampling plots in which the species occurred over the total number of sampling plots. Relative dominance for woody species was expressed as the sum of the intercept lengths for a given species divided by the total transect length sampled. Relative density for shrub species was calculated as the total area occupied by the species (the sum of all length x width measurements recorded for the species) divided by the total area sampled (taken to be the transect length multiplied by 2 m, which was the area searched for herbaceous species). For herbaceous species, relative cover was calculated as the total area covered by the species divided by the total area occupied by all species. The final importance value was a simple additive function of all descriptive statistics:

Equation 5. $\text{IMPORTANCE} = \text{RFRE} + \text{RDOM} + \text{RDEN}$

for woody species, or

Equation 6. $\text{IMPORTANCE} = \text{RFRE} + \text{RCOV}$

for herbaceous species.

Where RFRE = relative frequency
RDOM = relative dominance
RDEN = relative density
RCOV = relative cover

The assumption being made in the course of the vegetation analysis was that direct human disturbance has adverse impacts on the species composition of the affected wetlands, either by favoring the establishment of disturbance resistant invading species or by altering the habitat of more sensitive wetland species causing their disappearance or reduction in importance) (Shisler 1973, Ehrenfeld 1983, Thibodeau and Nickerson 1985). In all, 103 tidal freshwater marsh, 121 hardwood swamp, and 82 salt marsh herbaceous species were recorded. In an effort to reduce the number of variables (i.e. the number of species) to manageable levels, we calculated several community indices expressive of community relationships within the herbaceous layer. In all cases we assumed that the herbaceous community would be the first in which changes in community structure would appear. Diversity in the herbaceous layer of sampled wetlands was measured using the index developed by Shannon and Weaver (1949):

Equation 7. $H = -[(n/N) \ln (n/N)]$

where H = community diversity

n = total sample plots in which species occured

N = total plots sampled

Because community diversity is a function of both species richness and species evenness (i.e. the relative distribution of species in the community), these effects were separated using a simple sum of the number of different species present (richness) and the index of evenness developed by Shannon and Weaver (1949):

Equation 8. $e = H/\ln S$

where e = community evenness

H = community diversity

S = total number of species present

Richness is an expression of the number of species present, while evenness is a measure of how the individual plants are distributed among the different species. Relatively low values of evenness, therefore, suggest that the majority of individual plants in a stand belong to one or only a few species. Thus, a monotypic stand would have an evenness value of 0.

2.7 STATISTICAL ANALYSIS

2.7.1 DISTURBANCE

Disturbance indices were calculated for all sites and compared with the physical variables (eg. buffer width, slope, etc.) recorded for each site. An analysis of variance (ANOVA) was run to explore the interactions between physical variables (eg. buffer width, slope, etc.) recorded at each site and levels of disturbance. Subsequently, relationships between DHD and individual variables were examined using Spearmans rank correlation coefficient (range from 1.0 to -1.0) (Hollander and Wolf 1973) and multiple regression (Zar 1974). Significance was assessed at the $p<0.05$ level. Finally, a minimum effective buffer width was determined using multiple comparisons between established buffer width categories through the Kruskal-Wallis and Wilcoxon rank sum procedures (Hollander and Wolfe 1973). Kruskal-Wallis can be roughly equated to a non-parametric analysis of variance, which seemed desirable because various aspects of the data set, notably the very small sample sizes, seemed to fail the assumptions of normality required of traditional statistical procedures. All analyses were conducted using the Statistical Analysis System (SAS 1985) on the IBM AS9000.

2.7.2 VEGETATION

Indices of direct human disturbance were calculated from disturbance variables for each study site in each of three zones: wetland, ecotone and upland (ecotone and upland together comprising the buffer zone). Herbaceous vegetation community indices were calculated for the wetland zone at each study site. To detect relationships between human disturbance and community composition, correlation analyses were done between indices of human disturbance, buffer width and composition (expressed as shrub density in the buffer) and the herbaceous community descriptive indices.

Where correlation analysis suggested relationships between disturbance and community composition, cluster analysis on a matrix formed from the relative cover values for all herbaceous species recorded at each study site was run using an average linkage algorithm (Pielou 1984). Study site clusters formed in the anlysis were then examined for changes in herbaceous community structure due to direct human disturbance. The analysis should produce clusters of sites having similar species composition. If, as hypothesized, disturbance of the types measured here (eg. debris, trampling) does alter species composition, highly disturbed sites should cluster together apart from pristine or relatively undisturbed sites.

3.0 RESULTS AND DISCUSSION

3.1 ANALYSIS OF VARIANCE

Levels of direct human disturbance (DHD) were calculated for the wetlands sampled at all study sites (Tables 5, 6, and 7). Results of the ANOVA are presented in Table 8. The analysis suggested a significant model effect (R-square=0.514). The main model factors (land use and wetland type) produced significant differences, while principal interaction terms were not significant.

Duncans multiple range test was used to separate out components of the significant model terms (Table 8). Commercial and industrial land uses produced the highest levels of disturbance in adjacent wetlands (average DHD=59.16) and agricultural/recreational uses the lowest (average DHD=13.64). The highest levels of disturbance were recorded in tidal freshwater marshes (average DHD=54.05). Disturbance at these sites was significantly higher than that recorded at either salt marsh or hardwood swamp study sites (average DHD of 28.34 and 25.07, respectively) (Table 9).

Apparently, land use type accounted for much of the variance in the model suggesting that the type of development adjacent to wetlands has a significant effect on the level of direct human disturbance recorded in nearby wetland areas. Industrial/commercial land uses and agricultural/recreational land use types form the two extremes of land use intensity and human activity. Higher levels of human impact would be expected in areas of high human density, and this seems to be reflected in the results of the multiple comparisons test (Table 8). Residential land use impacts were not significantly different between high density and low density development. We suggest that residential impacts are, for the most part, similar in form at different resident densities (given common demographic factors such as average age of residents, etc.) and that only the level of that disturbance tends to change with human density. The lack of a signficant differences between the measured levels of DHD at the two residential land use types was probably due to a high variance in the recorded amounts of disturbance. That is, some higher density developments (for example, the Holiday City sites in Tables 4 and 7) had very low levels of disturbance recorded in adjacent wetlands. We feel this to be a reflection of differences in the demographics of the residents: Holiday City, for example, is a primarily retirement community and residents are less likely to trespass on wetlands than are young children, the primary sources of disturbance at most of the tidal freshwater marsh study sites (Table 6).

Table 5. Disturbance indices calculated from upland originated disturbance measured in the wetland at salt marsh wetland/buffer study sites.

SITE	DISTURBANCE FREQUENCY	DISTURBANCE DOMINANCE	LITTER DENSITY	DHD
58	0.00	0.00	0.00	0.00
68	0.06	0.88	0.00	93.75
77	0.00	0.00	0.00	0.00
79	0.02	0.07	0.00	9.15
80	0.01	0.02	0.07	10.57
81	0.01	0.06	0.11	17.71
82	0.00	0.00	0.00	0.00
92	0.05	0.14	0.12	31.37
96	0.00	0.00	0.18	18.29
97	0.00	0.00	0.01	1.16
99	0.00	0.00	0.00	0.00
108	0.02	0.02	0.00	4.22
110	0.10	0.10	0.10	30.00
121	0.00	0.00	0.04	4.17
125	0.00	0.00	0.00	0.00
131	0.02	0.02	0.02	5.26
134	0.02	0.01	0.85	88.33
139	0.22	0.63	0.09	94.20
142	0.05	0.03	0.04	12.00
143	0.17	0.14	1.02	133.48
146	0.00	0.00	0.01	1.39
167	0.05	1.14	0.00	119.30
238	0.00	0.00	0.41	40.67
239	0.00	0.00	0.05	4.92
240	0.00	0.00	0.03	3.33
242	0.00	0.00	0.12	11.54
243	0.01	0.07	0.04	11.84
245	0.01	0.02	0.90	92.78
247	0.06	0.12	0.09	26.60
248	0.05	0.03	0.04	12.28
249	0.02	0.07	0.06	14.39
250	0.03	0.02	0.04	7.85
251	0.02	0.19	0.01	22.27
252	0.10	0.46	0.35	91.25
253	0.16	0.24	0.44	84.44
255	0.01	0.00	0.01	2.12
256	0.00	0.00	0.01	0.88
257	0.00	0.00	0.00	0.00
259	0.05	0.50	0.10	65.25
262	0.00	0.00	0.11	11.11
292	0.00	0.00	0.00	0.00
299	0.00	0.00	0.13	12.50

Table 6. Disturbance indices calculated from upland originated disturbance measured in the wetland at tidal freshwater marsh wetland/buffer study sites.

SITE	DISTURBANCE FREQUENCY	DISTURBANCE DOMINANCE	LITTER DENSITY	DHD
224	0.00	0.00	0.17	17.05
226	0.00	0.00	0.02	1.79
227	0.00	0.00	0.01	0.78
258	0.06	0.28	0.06	39.43
260	0.00	0.00	0.00	0.00
265	0.05	0.15	0.20	40.35
266	0.01	0.23	0.01	25.66
267	0.00	0.00	0.00	0.00
268	0.00	0.00	0.04	3.51
269	0.02	0.07	0.07	16.22
270	0.00	0.00	0.10	10.00
271	0.04	0.45	0.11	60.21
272	0.00	0.00	0.01	0.81
273	0.12	1.33	0.41	185.76
274	0.00	0.00	0.01	0.96
275	0.03	0.05	1.27	134.50
276	0.07	0.23	1.59	189.10
281	0.00	0.00	0.10	10.00
282	0.00	0.00	0.17	17.11
284	0.05	0.45	0.27	76.72
285	0.06	0.55	0.67	127.41
286	0.00	0.00	0.00	0.00
287	0.04	0.40	0.90	134.13
289	0.02	0.02	2.78	281.36
290	0.05	0.05	0.22	32.44
291	0.00	0.00	0.00	0.00

Table 7. Disturbance indices calculated from upland originated disturbance measured in the wetland at hardwood swamp wetland/ buffer study sites.

SITE	DISTURBANCE FREQUENCY	DISTURBANCE DOMINANCE	LITTER DENSITY	DHD
54	0.00	0.00	0.00	0.00
63	0.00	0.00	0.00	0.00
111	0.07	0.22	0.03	31.23
112	0.02	0.01	0.00	3.04
113	0.00	0.00	0.09	8.70
190	0.01	0.04	0.02	6.67
207	0.00	0.00	0.07	6.80
220	0.06	0.06	0.08	20.31
222	0.13	0.12	0.43	68.67
231	0.00	0.00	0.11	11.11
232	0.00	0.00	0.04	4.35
233	0.02	0.02	0.05	8.36
234	0.00	0.00	0.04	4.35
235	0.00	0.00	0.00	0.00
244	0.02	0.07	0.03	11.96
246	0.00	0.00	0.11	10.53
254	0.02	0.02	0.27	31.37
261	0.00	0.00	0.02	2.31
263	0.04	0.06	0.69	78.60
264	0.00	0.00	0.00	0.00
277	0.02	0.00	0.76	78.22
278	0.00	0.00	0.00	0.00
279	0.00	0.00	0.00	0.00
280	0.05	0.12	0.19	35.63
283	0.00	0.00	0.04	3.57
288	0.09	0.20	0.02	30.25
293	0.13	0.57	0.62	131.58
294	0.00	0.00	0.00	0.00
295	0.10	0.31	0.35	75.24
296	0.02	0.02	0.14	19.05
297	0.11	0.39	0.32	81.39
298	0.03	0.05	0.31	38.82

Table 8. Analysis of variance (ANOVA) of measured levels of disturbance (DHD): three wetland types and four levels of land use intensity and their interaction terms (** indicates signifianct F value). Results of Duncan's multiple range test (DMRT) on the wetland type and land use means follow (means in the same column followed by the same letter are not significantly different (N=100, df=degrees of freedom, alpha level=0.05).

Source	df	F	PR>F
Use	1	4.30	<0.01 **
Type	2	2.45	0.09
Type X Use	6	0.96	0.46
Width(Type)	14	1.40	0.18
Use X Width(Type)	19	0.79	0.71

Source Means (DMRT)

Land Use			Wetland Type		
IND/COMM	59.16	a	Tidal Fresh Marsh	54.05	a
RES-H	49.15	a b	Salt Marsh	28.34	b
RES-L	21.36	c b	Hardwood Swamp	25.07	b
AG/REC	13.64	c			

3.2 BUFFER VARIABLE RELATIONSHIPS

After the ANOVA suggested a model effect, correlation and regression analyses were conducted on individual wetland types to explore relationships between the recorded levels of disturbance and physical variables used in the model.

3.2.1 SALT MARSHES

A correlation matrix for the buffer physical variables and the disturbance indices calculated at each study site were computed for each wetland type (Table 10). The correlation analysis on salt marsh wetland/buffer study sites produced no significant relationships between the level of disturbance in the wetland and any of the variables of interest. However, a scatter plot of DHD against buffer width (Figure 3) suggests a steeply declining relationship. Subsequent simple linear regression indicates that there is a significant inverse linear relationship between buffer width and the level of direct human disturbance

Table 9. Mean disturbance levels measured at 100 study sites in 3 wetland types and at 4 land use categories. (Number in parentheses represents observations in the wetland/land use category).

Land Use	Salt Marsh	Tidal Fresh Marsh	Hardwood Swamp	Total
			Wetland Type	
REC/AG	12.09 (13)	1.17 (3)	25.14 (5)	13.64 (21)
RES-L	24.34 (16)	25.65 (7)	11.65 (8)	21.36 (31)
RES-H	42.54 (10)	81.97 (12)	29.87 (17)	49.15 (39)
IND/COMM	72.81 (3)	59.63 (4)	37.73 (2)	59.16 (9)
TOTAL	28.34 (42)	54.05 (26)	25.07 (32)	33.98 (100)

REC/AG -Recreational or agricultural
RES-L - Low density residential
RES-H - High density residential
IND/COMM - Indusrial or Commercial

(i.e. as buffer width declines, the level of disturbance increases) (Table 11). These results should be interpreted with caution and with an eye toward the nature of buffers sampled adjacent to salt marshes.

Buffer zones were defined operationally in the field as all existing vegetation which occurred between the delineated wetland boundary and the farthest limit of adjacent development. The limit of development was generally defined as the beginning of paved surfaces, maintained lawns or fencing. In some cases the corridor of existing vegetation (often late oldfield or early successional forest in the case of salt marsh sites) between developed areas and the wetland had become established after construction activities had ceased (often because those activities had destroyed any buffering vegetation) so that there was, in effect, no buffer in place during construction. These types of situations were most prevalent in salt marsh study sites.

Table 10. Correlation matrix of buffer variables and the index of direct human disturbance (DHD) recorded in the wetland at salt marsh wetland/buffer study sites. Matrix includes Spearman's rank correlation coefficients and the probability of significance (N=42, alpha level = 0.05).

	Width	Use	Slope	Density	DHD
Width	1.0000 0.000				
Use	-0.1727 0.274	1.0000 0.000			
Slope	0.3357 0.029	0.3357 0.029	1.0000 0.000		
DHD	0.0626 0.697	0.2944 0.062	0.0271 0.867	-0.1206 0.447	1.0000 0.000

The primary source of disturbance recorded in salt marsh study sites were remnants of the original construction activity which occurred in the adjacent upland. In general, disturbance attributable to current residents is negligible:

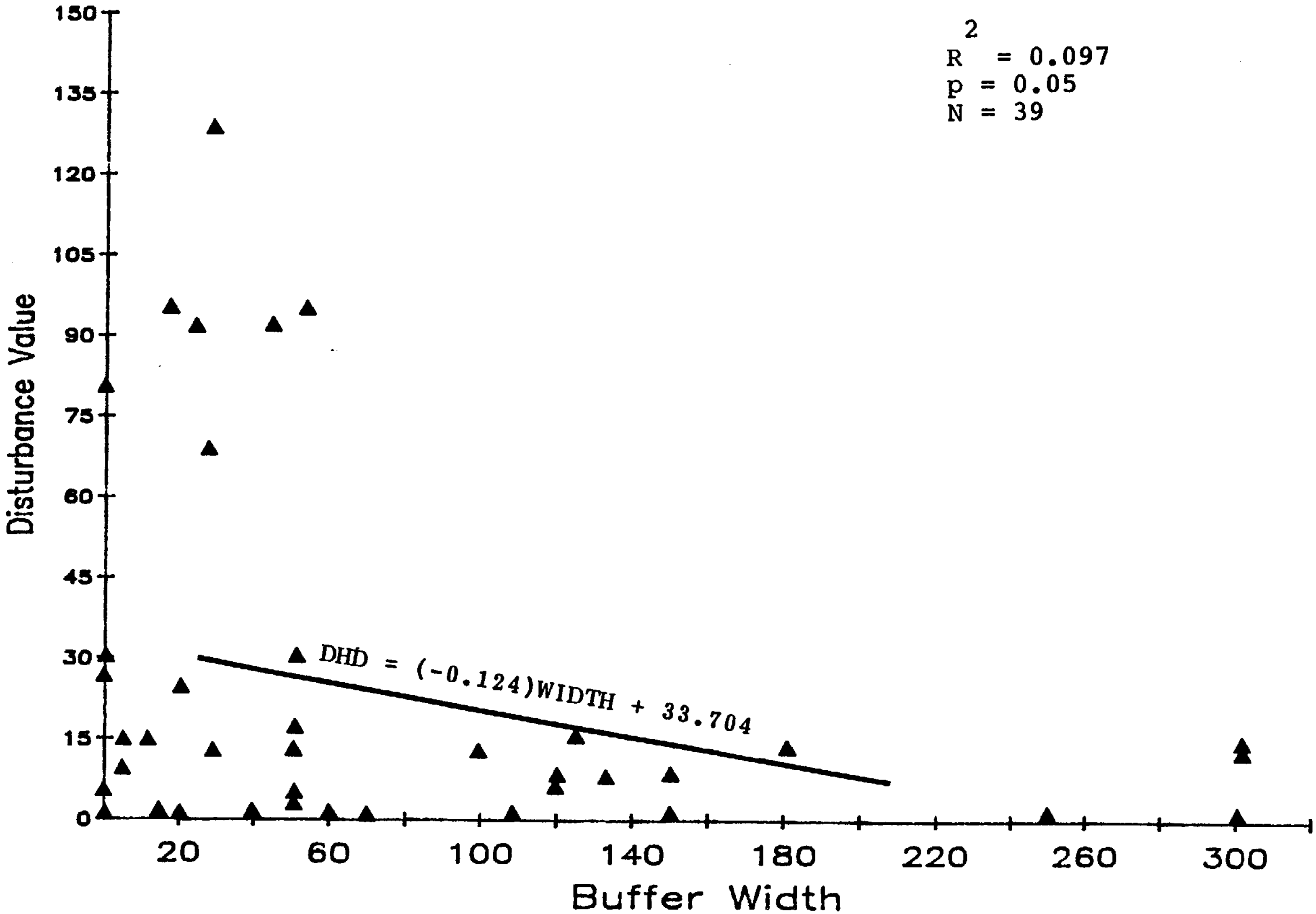
At site 259 (Pirate Cove Motel, Egg Harbor Township) a high density residential land use occurs adjacent to a *Spartina alterniflora* dominated low marsh. The buffer is actually a 30 ft strip of dead or dying *Juniperus virginiana*, *Rosa multiflora*, *Phytolacca americana* and *Phragmites australis* which has grown up on the disturbed soil that resulted from construction. The

Table 11. Results of simple linear regressions on the level of disturbance (DHD) measured at three different wetland types. DHD was the dependent variable, while land use, buffer width and buffer slope were independent variables. (N = the number of observations, RSQ = coefficient of determination, F = the F value of the model).

	Wetland Type								
	Salt Marsh			Tidal Fresh Marsh			Hardwood Swamp		
Variable	N	RSQ	F	N	RSQ	F	N	RSQ	F
USE	39	0.15	6.76	24	0.09	2.49	32	0.02	0.72
WIDTH	39	0.09	3.97**	25	0.16	4.45**	32	0.25	9.96**
SLOPE	39	0.06	2.44	25	0.23	6.75**	32	0.08	2.65

** $p < 0.05$

Figure 3. Scatter plot of disturbance vs. buffer width at salt marsh study sites.



wetland/upland ecotone has formed on fill (broken cinder blocks, conduit and other construction materials mixed with sand) which had been bulldozed into the marsh and which extends in a band out into the marsh a distance of approximately 45 ft. Iva frutescens, Baccharis halmifolia and Phragmites australis have become established on the raised surface of the marsh. At Ocean Gate Yacht Basin (site 139) a 15 ft buffer of Prunus serotina, Myrica pensylvanica and Rosa multiflora has grown up adjacent to the boatyard abutting the Spartina patens/Distichlis spicata marsh. However, Phragmites australis, Iva frutescens and Rosa multiflora have become established in the marsh on a band of fill material (primarily discarded construction materials) which extends out into the marsh some 30 ft. Large numbers of discarded creosote soaked pilings have been stacked in the marsh with the result that vegetation under and around them has been killed. A Spartina alterniflora low marsh adjacent to high density residential development at Wildwood Crest (site 252) is strewn with discarded insulation, fence posts and footings, clapboards, paint and solvent containers. The ecotonal buffer between the development and the marsh is an artificial association of Rhus coppalina, Iva frutescens and Phragmites australis which has developed on fill placed into the marsh. Maintained lawns adjacent to the marsh were also established on fill.

Development at high density sites (i.e. land uses 3 and 4) has occurred at the expense of the wetland/upland ecotone. Upland buffers at these sites have been destroyed during construction and disturbance of the types measured here has taken place in the marsh during this initial development activity. Piles of abandoned construction materials overgrown with weeds and vines were a common sight, as were fingers of fill material creeping beyond the wetland border. In most cases, currently existing buffers have grown up after development and therefore after the primary disturbance to the wetland has taken place. These buffers, as illustrated in the above examples, would have no influence on levels of DHD in the wetland.

While correlation analysis produced no significant positive relationship between land use intensity and the level of direct human disturbance, our field observations suggest that such a relationship does exist and would be signficant given a larger sample size. Calculated levels of disturbance at salt marsh sites shows a steadily increasing rate as the level of development in the adjacent upland increases (Table 9). Low density sites (land use types 1 and 2) tended to have higher levels of direct human disturbance directly attributable to current land use. At low density sites that exhibited high levels of DHD (eg. Amasa Landing in New Gretna, site 134, and Farry Point in Cheesequake State Park, site 81), disturbance primarily took the form of human paths, trails (with associated litter) and cut down or trampled vegetation. Uncontrolled access to the marsh resulted in the destruction of vegetation.

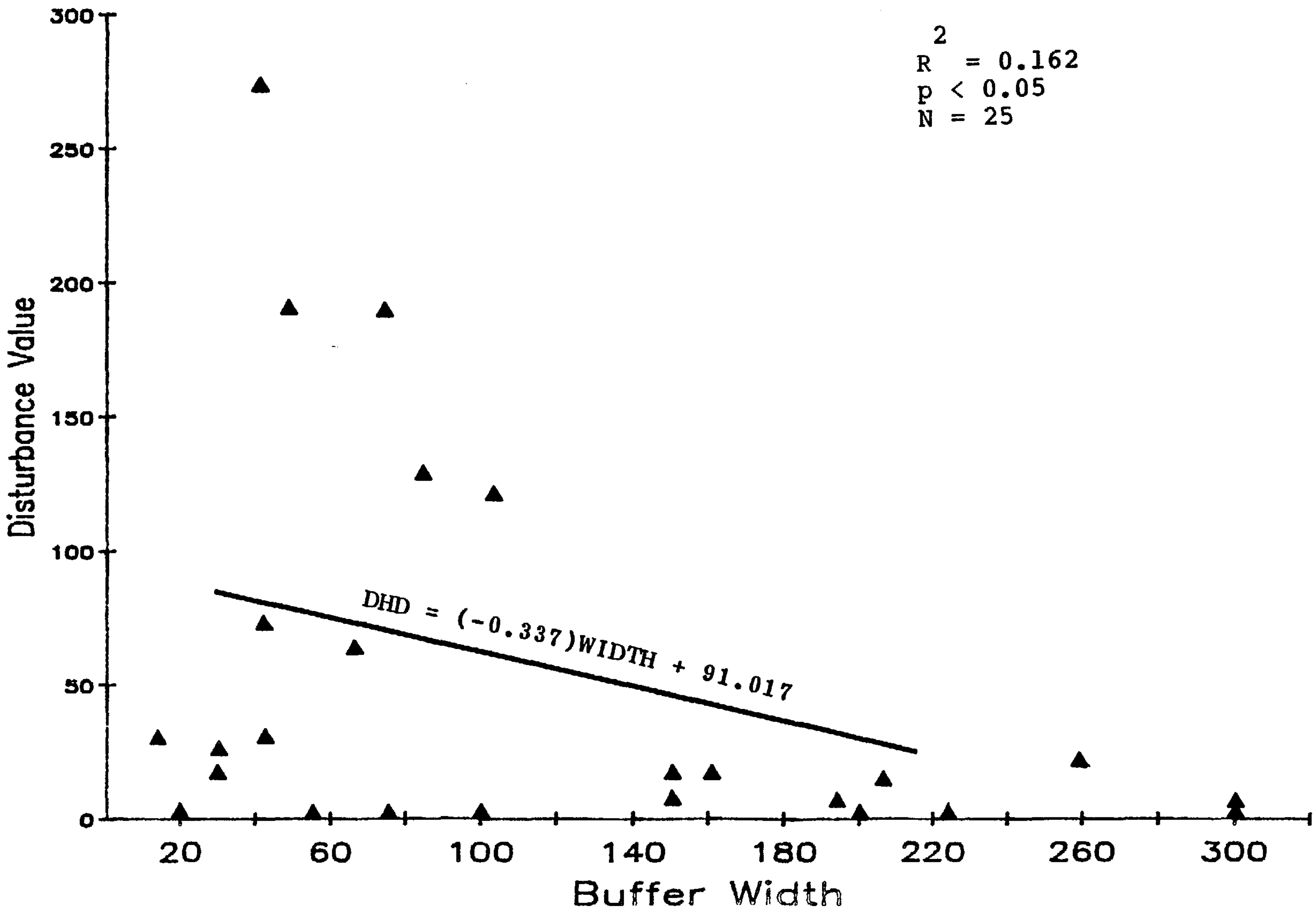
3.2.2 TIDAL FRESHWATER MARSHES

The correlation analysis of the freshwater marsh study sites indicated significant negative correlations with buffer slope and buffer shrub density suggesting that wetlands bordered by buffers that are steeply sloped and have dense shrub layers were subject to lower levels of direct human disturbance attributable to the adjacent land use (Table 12). Correlation suggested that there was a similar inverse relationship between buffer width and DHD. Subsequent regression analysis of buffer width on DHD (Table 11) produced a significant inverse linear relationship, demonstrated by a scatter plot of DHD against buffer width (Figure 4).

Table 12. Correlation matrix of buffer variables and the index of direct human disturbance (DHD) recorded in the wetland at tidal freshwater marsh wetland/buffer study sites. Matrix includes Spearman's rank correlation coefficients and probability of significance (N=26, alpha level=0.05).

	Width	Use	Slope	Density	DHD
Width	1.0000 0.000				
Use	-0.1612 0.432	1.0000 0.000			
Slope	0.0676 0.743	-0.2088 0.306	1.0000 0.000		
DHD	-0.3278 0.102	0.2926 0.147	-0.4587 0.018	-0.3304 0.099	1.0000 0.000

Figure 4. Scatter plot of disturbance vs. buffer width at freshwater marsh study sites.



Tidal freshwater marshes were generally the most disturbed of the three wetland types studied (average DHD=54.05). These wetlands were found almost exclusively in densely populated areas, particularly in the Delaware River and its tributaries, and were found by Simpson, et al. (1983) to be more vulnerable to adverse human impacts, including nutrient enrichment from sewage treatment facilities and non-point-source runoff from parking lots, as a result of this proximity. Dredge spoil deposition, highway construction and other human activity have seriously impacted the vegetation of tidal freshwater marshes along the Delaware River (Ferren and Schuyler 1980).

The highest levels of direct human disturbance calculated at tidal freshwater marsh study sites occurred adjacent to high density residential land uses (Table 9). Disturbance took the form of trash thrown into the marsh or destruction of vegetation. For example, at Hecker Street, Riverside (site 289) a very high level of disturbance (DHD=281.36) was due to residents piling a large variety of debris into the marsh. Tires, broken cinder blocks and other construction materials, open and discarded containers of cleaning solvents and litter formed the majority of the disturbance recorded in a Polygonum arifolium/Peltandra virginica marsh on the Rancocas River. In addition, marsh vegetation had been cut down along the marsh edge and wide areas had been excavated. This stretch of marsh, effectively screened from the street by a steep slope overgrown with dense Polygonum cuspidatum (Japanese Knotweed), was apparently a tacitly recognized community dump of long standing.

At Front Street, Runnemede (site 273), a Zinzania aquatica/Peltandra virginica marsh growing along the north branch of Otter Brook had been considerably disturbed (DHD=185.76). A wide area of fill extended into the marsh made up of discarded plastic sheeting, building materials (notably asphalt and tar) and concrete slabs. A rip-rap berm had been erected on the fill below the resident's property. The currently existing buffer was a 70 ft band of Phytolacca americana and Rosa multiflora. Similarly, the Zinzania aquatica marsh adjacent to an apartment complex on Station Avenue, Glendora (site 271) was being used as a dump for discarded construction material. The existing buffer, a narrow fring of Acer rubrum/Liquidambar styraciflua forest, had been breeched at several points and broken cinder block, brick and gravel was dumped down slope into the marsh. Large areas of the marsh were devoid of vegetation, with the exception of Solidago spp. growing among the debris. Tires had been scattered throughout the marsh, resulting in the destruction of considerable amounts of vegetation. The Sagittaria latifolia/Nuphar advena marsh along Big Timber Creek adjacent to site 276 (Reliance Co., Bellmawr) was also used as a convenient place to dump debris. A chain link fence, built partly on fill, separated the marsh from a storage yard. The slash removed from clearing the area around the fence was tossed into the marsh. Phragmites australis and Typha latifolia have become established on the elevated marsh adjacent to the fence. Machine parts, solvent containers and spilled lubricants were recorded in the marsh.

In general, the majority of observed direct human disturbance at tidal freshwater marsh sites was due to current residents dumping refuse into the marsh and children tearing up vegetation on the marsh border. Filling was common. Many residents apparently believed that the water front was theirs for whatever purpose. Along the Rancocas River in Riverside the naturally forested buffer had been replaced by a row of planted Acer saccharinum and maintained grass. One resident admitted to cutting down the tall marsh vegetation which grew along the banks of the river to get a better view of water skiers using the water. Destruction of marsh vegetation was restricted to the upper edge of the marsh, probably due to the impassability of the marsh soils. Because these wetlands occurred in stream channels with steep adjacent slopes, development directly along the wetland border was not practical. Consequently, many buffering zones of natural vegetation remained intact along the wetland borders, in contrast to the salt marsh sites.

3.2.3 HARDWOOD SWAMPS

The correlation analyses of hardwood swamp sites showed no significant relationships between disturbance and land use intensity, but did show a significant ($p<0.01$) inverse relationship with buffer width, suggesting that disturbance in hardwood swamps decreased with increasing buffer width (Table 13). Subsequent regression analysis (Table 11) demonstrated a significant inverse linear relationship between buffer width and the level of disturbance, as expressed in the scatter plot of width against DHD (Figure 5).

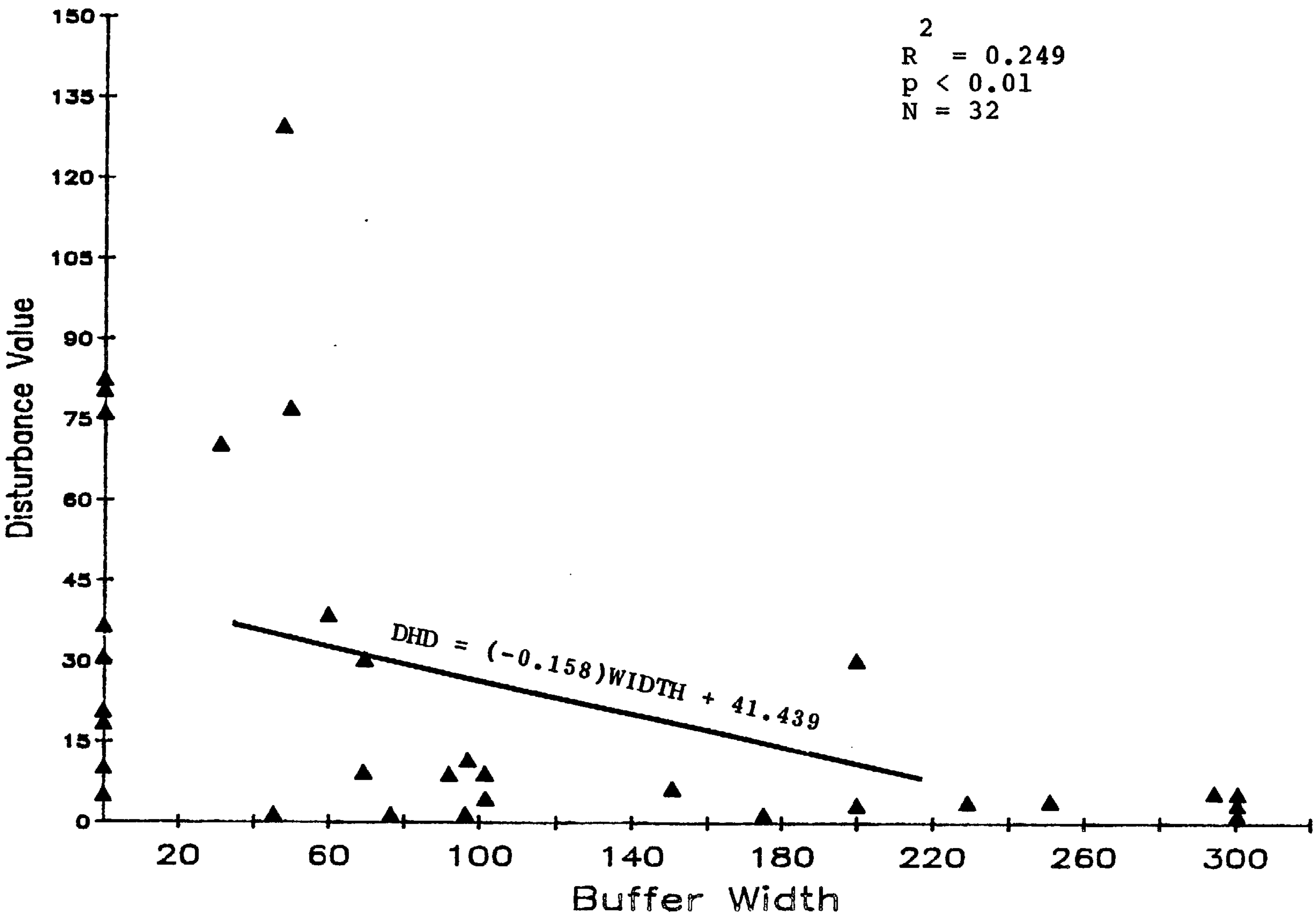
Levels of direct human disturbance at hardwood swamp study sites were relatively low (average DHD=25.07). In contrast with salt marsh and tidal freshwater marsh sites, no one land use type demonstrated a higher average level of disturbance (Table 9). The primary disturbance observed in hardwood swamps was the result of current residents pushing their property lines beyond what was their legal boundary. The gradual slopes and transitions between upland and wetland at these sites facilitated boundary transgression. Major disturbances seldom occurred far beyond the wetland ecotone, but where they did they were remnants of the original construction and included slash piles and felled trees. Disturbance by present residents included paths cut through the swamp (many swamps were associated with streams and paths generally provided access to them) and grass clippings, cut tree limbs, etc. deposited beyond backyard boundaries.

Table 13. Correlation matrix of buffer variables and the index of direct human disturbance (DHD) recorded in the wetland at hardwood swamp wetland/buffer study sites. Matrix includes Spearman's rank correlation coefficients and probability of significance (N=32, alpha level=0.05).

	Width	Use	Slope	Density	DHD
Width	1.0000 0.000				
Use	0.1037 0.572	1.0000 0.000			
Slope	0.3199 0.074	0.5043 0.003	1.0000 0.000		
DHD	-0.5739 0.002	-0.1221 0.553	-0.1108 0.589	-0.2797 0.121	1.0000 0.000

At the Caldors Shopping Center in Brick Township (site 222), a *Acer rubrum* floodplain forest associated with Cedar Bridge Branch was located adjacent to the mall parking lot. The steep slope leading from the lot to the creek was densely littered with trash, packaging materials, broken asphalt, and discarded industrial cleaning agents. Shopping carts were found in the creek and thrown into the forest. Areas of burned and trampled vegetation were found throughout the site and there were several well-trampled paths leading to the creek. Similarly, steep slopes behind Millford Street, Millville (site 277) were covered with several years of refuse. Open paint cans and containers of solvents and pesticides had been tossed into the wetland at the base of the slope. Grass clippings and discarded tree branches, trash, appliances and tires littered the slope and cut stumps, broken branches and uprooted seedlings were found along vegetation transects. The area adjacent to the baseball field on Water Street, Barnegat (site 297) was cleared by bulldozing the area and pushing the waste material into the nearby swamp. Surviving trees in the swamp had been uprooted, broken or cut down, apparently by adolescents using the field. Broken concrete

Figure 5. Scatter plot of disturbance vs. buffer width at hardwood swamp study sites.



and slash were piled in the wetland. The swamp along Hannabrand Brook in Old Mill (site 293) had been the dumping area for used automotive oil filters, discarded oil, tires, building sand and appliances. Gullies have been eroded into the slopes above the swamp and up to 18 inches (in some places) of silt covered the soil surface within the wetland.

3.3 MINIMUM BUFFER WIDTH DETERMINATION

In order to determine minimum effective buffer widths, we compared the level of disturbance recorded in wetlands bordered by existing buffers of varying widths. To facilitate multiple comparisons, study sites were assigned to one of four buffer width categories:

1. WIDTH $\leq$ 50 ft.
2. 50 ft > WIDTH $\leq$ 100 ft
3. 100 ft > WIDTH $\leq$ 150 ft
4. WIDTH > 150 ft.

Mean disturbance calculated at each width category for each wetland type was statistically compared using the Kruskal-Wallis procedure (Table 14).

Table 14. Results of the Kruskal-Wallis test of the levels of disturbance (mean DHD) measured at three wetland types in four buffer width categories (H = the chi-square approximation test statistic, N = number of observations comprising the mean, ** = significance at alphal level=0.05).

	Wetland Type					
	Salt Marsh		Fresh Marsh		Hardwood Swamp	
Buffer Width Category	N	DHD	N	DHD	N	DHD
1	18	38.05	8	84.55	13	48.77
2	9	19.48	7	72.92	7	14.48
3	8	20.44			3	7.16
4	7	23.81	11	19.85	9	5.03
H	4.64		4.22		12.44**	

3.3.1 SALT MARSHES

The Kruskal-Wallis multiple comparisons detected no significant differences in mean disturbance levels calculated for the four buffer width categories at salt marsh study sites. However, mean disturbance at sites with existing buffers greater than 50 ft was only half of mean DHD recorded at sites with narrower buffers. A larger sample size may prove this difference significant. A regression model of buffer width on the level of human disturbance suggested a significant relationship (Figure 3). These results appear to be a function of the fact that existing buffers, upon which multiple comparisons were made, have no direct impact on the levels of disturbance as measured in salt marsh study sites. This is because the buffer has become established only after the major disturbances to the marsh have already been registered, or because the buffer was breached during original development activity which impacted the marsh.

3.3.2 TIDAL FRESHWATER MARSHES

While the multiple comparisons did not detect a significant difference in mean disturbance levels between buffer width categories, the large disparity between mean DHD values suggested that a difference was being obscured by small sample sizes used in the comparisons. Therefore, pair-wise comparisons between categories were computed using Wilcoxon's rank sum test, which detected a significant difference in mean DHD between sites with buffers less than 50 ft and sites with buffers greater than 150 ft (Table 15). The hypothesis that wider buffers reduced the level of disturbance in the adjacent wetland was also supported by the fact that mean DHD increased more than 3 fold between categories 2 (50 to 100 ft) and 4 (greater than 150 ft).

Table 15. Pairwise Wilcoxon's rank sum tests between mean disturbance levels measured at tidal freshwater marsh sites with different buffer widths (N = number of sites, SE = standard error; CV = coefficient of variation; P > Z = the probability that the calculated test statistic is greater than the expected value at alpha level=0.05, ** = significant difference).

Buffer Width Category	N	$\bar{X}$	SE	CV	P > Z
1	8	84.55	34.88	116.68	0.80
2	7	72.92	28.96	105.10	
1	8	84.55	34.88	116.68	0.05**
4	11	19.85	11.71	195.61	
2	7	72.92	28.96	105.10	0.13
4	11	19.85	11.71	195.61	

3.3.3 HARDWOOD SWAMPS

The Kruskal-Wallis test detected a significant difference between mean disturbance recorded in wetlands protected by buffers of varying widths. Subsequent pair-wise comparisons between buffer width categories showed a significantly lower level of disturbance recorded at sites with buffer widths greater than 150 ft than at sites with buffer widths less than 50 ft (Table 16). There was a large, though not significant, drop in mean DHD between 50 and 100 ft (mean DHD more than tripled between the second and first buffer width categories). There was also no significant difference in the level of DHD between category 2 and 3, although DHD was halved between these two categories.

Table 16. Pairwise Wilcoxon's rank sum tests between mean disturbance levels measured at hardwood swamp sites within different buffer width categories. (N = number of sites; SE = standard error; CV = coefficient of variation; P > Z = the probability that the calculated test statistic is greater than the expected value at alpha level=0.05, ** = significant result).

Buffer Width Category	N	$\bar{X}$	SE	CV	P ≥ Z
1	13	48.76	10.97	81.09	0.01**
2	7	14.48	5.67	103.68	
1	13	48.76	10.97	81.09	<0.01**
3	3	7.16	2.18	52.85	
1	13	48.76	10.97	81.09	<0.01**
4	9	5.03	3.33	198.78	
2	7	14.48	5.67	103.68	0.44
3	3	7.16	2.18	52.85	
2	7	14.48	5.67	103.68	0.15
4	9	5.03	3.33	198.78	
3	3	7.16	2.18	52.85	0.73
4	9	5.03	3.33	198.78	

3.4 VEGETATION ANALYSIS

Descriptive indices were calculated for wetland herbaceous community at each study site (Tables 17, 18, and 19). Indices were then compared to calculated levels of direct human disturbance and several buffer parameters measured at each site.

3.4.1 SALT MARSHES

There were no signficant ($p<0.05$) relationships between any of the wetland herbaceous community indices and the level of disturbance recorded at salt marsh study sites (Table 20). However, because the correlation analysis did suggest some relationship between DHD and species evenness ($p<0.10$) (i.e. a trend toward a more even distribution of individuals among species at disturbed sites), a cluster analysis was performed on a matrix of relative cover values recorded for all species identified in the herbaceous wetland communities at salt marsh study sites. The result of the analysis, presented as a dendrogram (Figure 6), indicated that 2 relatively distinct subsets of study sites existed.

These clusters were best described by inspection of the species composition of the marshes within each subset (Table 21). The first cluster consisted of study sites at which *Spartina patens* was the dominant species in the marsh. *Juncus gerardii* and *Distichlis spicata* were co-dominant in the herbaceous community at these sites, which tended to be high marsh situations. The second cluster is composed of sites at which *Spartina alterniflora* dominated the marsh, with only sparse cover of *Juncus gerardii* and *Distichlis spicata*. These were generally low marsh situations subject to considerable flooding. Levels of human disturbance in the wetland were not significantly different between these 2 groups of marshes (Wilcoxon's rank sum test) and is is unlikely that these clusters are related to disturbance of the kinds recorded here, but merely reflect differences in species composition in response to varying environmental conditions.

Table 17. Community indices calculated from relative cover values for herbaceous species recorded in the wetland at salt marsh study sites (see text for index calculation).

Site Number and Location		Community Indices Diversity	Richness	Evenness
58	Shelter Cove, Beach Haven	0.00	1	0.00
68	Glimmer Glass Island	0.43	2	0.11
77	Dock Rd., Cheesequake	1.27	10	0.23
79	Sand Pit Pt., Cheesequake	0.51	11	0.12
80	Hooks Lake, Cheesequake	1.62	9	0.30
81	Farry Point, Cheesequake	1.70	16	0.31
82	Arrowsmith Pt., Cheesequake	1.48	10	0.30
92	Mushquash Cove, Neptune	2.20	22	0.39
96	Hillside Rd., Neptune	0.58	11	0.14
97	Marconi Rd., Neptune	1.24	11	0.28
99	Manasquan Golf Course	0.58	10	0.15
108	Tranquility Park	0.99	7	0.23
110	Reeds Bay Village	1.40	11	0.28
121	Dock Rd., Parkertown	0.79	7	0.15
125	Holden St., Mystic Island	1.25	12	0.24
131	Adams Ave., New Gretna	1.68	20	0.31
134	Amasa Rd., New Gretna	1.70	10	0.32
139	Ocean Gate Yacht Basin	2.11	14	0.38
142	Bayview Ave., Ocean Gate	1.59	11	0.31
143	Butler Ave., Holly Park	0.13	4	0.40
146	Rocknacks Yacht Basin	1.52	10	0.32
167	Rt. 30E, Atlantic City	0.33	7	0.70
238	Sea Pirate Light	1.67	16	0.28
239	Szathmary Co., Manahawkin	1.44	10	0.27
240	Gale Rd., Brick Twsp.	1.63	16	0.30
242	Neptune Ave., Neptune	1.75	20	0.33
243	Seaview Condos, Neptune	1.90	9	0.22
245	Mandalay Rd., Mantoloking	1.50	13	0.29
247	Victoria Point, Bar Harbor	1.43	12	0.27

Table 17. Continued

248	The Meadows, Cape May City	0.30	7	0.70
249	Pelican Bay, Wildwood Crest	1.89	18	0.34
250	Capeshore, King Crab Landing	1.53	11	0.29
251	Capeshore Lab II	0.96	6	0.22
252	Toledo Ave., Wildwood Crest	1.46	15	0.29
253	Tennessee Ave., Ocean City	0.54	6	0.12
255	Sea Meadow Dr., Parkertown	2.90	21	0.36
256	Bay Harbor Blvd., Brick Twsp.	0.92	12	0.20
257	Rocknacks II, Lanoka Harbor	1.36	15	0.26
259	Pirate Cove Motel	0.59	7	0.12
262	Ocean Blvd., Mystic Island	0.96	10	0.21
292	Cook Ave., Laurence Harbor	1.18	10	0.22
299	Holly Lake Park, Tuckerton	1.17	14	0.24

Table 18. Community indices calculated from relative cover values for herbaceous species recorded in the wetland at freshwater marsh study sites (see text for index calculation).

Site Number and Location		Community Indices		
		Diversity	Richness	Evenness
224	Henry St., Riverside	1.24	15	0.2
226	Burlington Park	2.00	20	0.35
258	Curtin Marina, Burlington	1.40	14	0.28
260	Pureland Industrial	1.30	12	0.19
265	Soden Dr., Yardville	1.96	25	0.36
266	Highland Ave., Yardville	2.23	28	0.39
267	Soden Dr. II, Yardville	1.93	17	0.33
268	Grover Ave., Bordentown	1.87	14	0.33
269	Edgewood Rd., Bordentown	2.15	28	0.35
270	Bradlees, Bordentown	2.35	25	0.42
271	Noname Apts., Glendora	2.27	20	0.50
272	Hillcrest Apts., Bordentown	2.58	36	0.43
273	400 Front St., Runnemede	1.97	17	0.42
274	Hilltop Dr., Bordentown	1.92	20	0.35
275	Timber Cove Apts., Bellmawr	2.16	21	0.42
276	Reliance Co., Bellmawr	2.19	26	0.40
281	544 Oakside Pl., Woodbury	1.78	23	0.34
282	Briar Hill Lane, Woodbury	1.29	24	0.27
284	Polk St., Wayside	2.35	23	0.40
285	Washington St., Riverside	2.23	21	0.39
286	Rockland Dr., Willingboro	2.27	22	0.40
287	Larchmont/2nd St., Beverly	2.52	34	0.42
289	Hecker/Harris St., Riverside	2.21	22	0.39
290	Pulaski/River Dr., Riverside	1.67	17	0.34
291	628 River Dr., Riverside	1.36	14	0.28

Table 19. Community indices calculated from relative cover values for herbaceous species recorded in the wetland at hardwood swamp study sites (see text for index calculation).

Site Number and Location		Community Indices: Diversity	Richness	Evenness
54	Ricci Bros., Downe Twsp.	1.20	10	0.30
63	Smithville, Galloway Twsp.	1.49	24	0.31
111	Club at Galloway	1.56	10	0.32
112	Pinnacle, Galloway Twsp.	1.22	9	0.29
113	Toms R. Intermediate School	1.84	22	0.40
190	CapeMay Convalescent Center	2.16	22	0.37
207	Kettle Creek, N. Lakewood	2.72	37	0.48
220	Colony Village	0.65	3	0.16
222	Caldors, Brick Twsp.	2.60	18	0.47
231	Holiday City I	1.39	12	0.31
232	Holiday City II	1.33	9	0.36
233	Holiday City III	0.49	8	0.11
234	Holiday City IV	1.49	12	0.32
235	Holiday City V	1.13	8	0.30
244	Brook St., Parkertown	0.26	8	0.60
246	Pheasant Run, Forked R.	1.90	10	0.26
254	Smith Dr., Brick Twsp.	1.41	7	0.50
261	The Club at Mattix Forge	1.53	9	0.35
263	Crossroads, Barnegat	0.63	3	0.14
264	Barnegat Swamp, Barnegat	1.15	8	0.26
277	Mulford St., Millville	2.29	21	0.48
278	Warren Ave., Port Norris	0.35	5	0.90
279	Maurice R. Twsp. School	2.90	16	0.5
280	Delsea Fire House	1.64	12	0.42
283	Pine Dr., Wayside	0.88	9	0.26
288	Branch Rd., Oakhurst	0.95	6	0.24
293	Cottonwood Dr., Old Mill	0.69	3	0.24
294	Allenwood, Wall Twsp.	1.49	20	0.33
295	Butternut Rd., Old Mill	0.80	3	0.20
296	Birdsall St., Barnegat	1.49	6	0.34
297	Water St., Barnegat	1.34	18	0.26
298	Spruce Dr., Old Mill	1.13	8	0.30

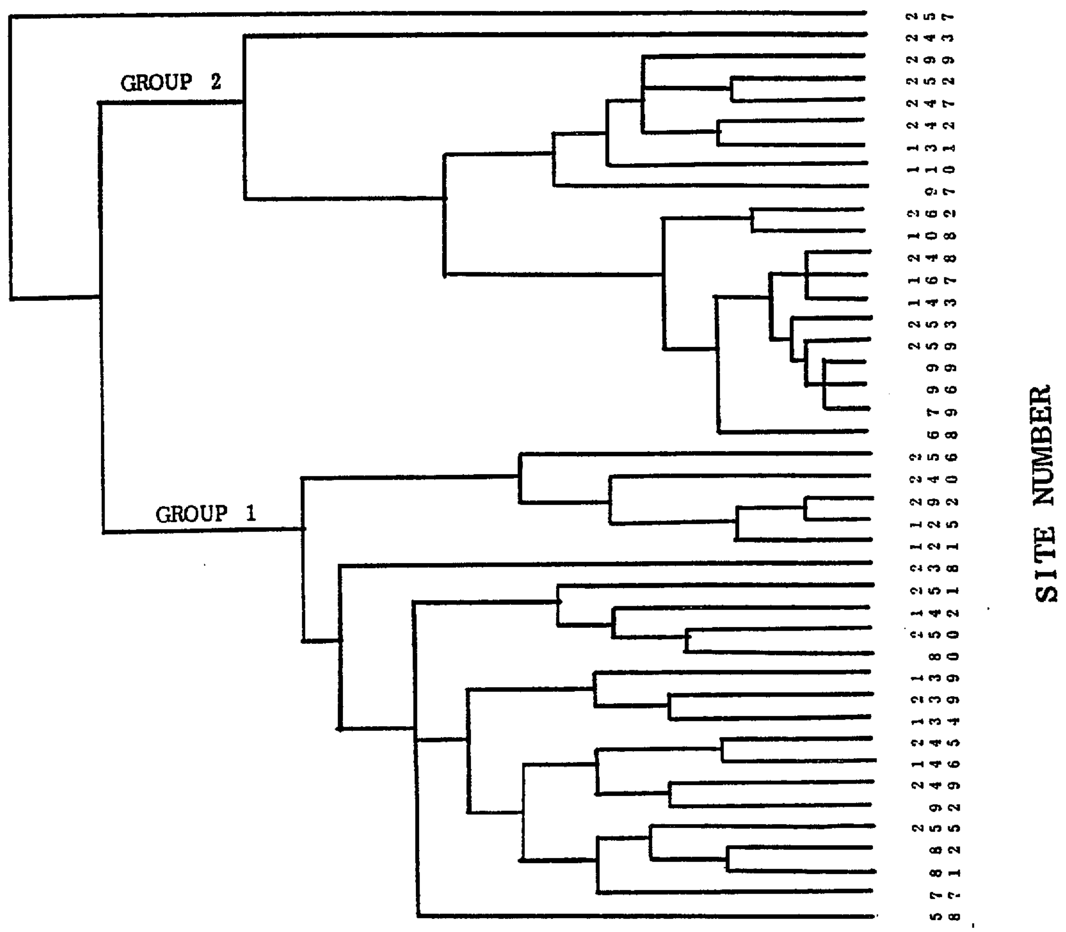


Figure 6. Dendrogram representing average linkage cluster analysis of the herbaceous communities at salt marsh study sites.

Table 20. Correlation matrix relating wetland zone herbaceous layer community indices, human disturbance, buffer width and buffer shrub density measured at salt marsh study sites. Matrix includes Spearman's rank correlation coefficients and the probability of significance (N=42, alpha level=0.05).

	Diversity H	Richness N	Evenness E
Total Disturbance	0.0227 0.8867	-0.0497 0.7547	0.2648 0.0901
Buffer Width	-0.0890 0.9552	0.2095 0.1830	0.0698 0.6606
Buffer Shrub Density	-0.0876 0.5812	-0.0652 0.6812	-0.0142 0.9291

Table 21. Average relative cover values of major plant species (and mean disturbance, DHD) calculated for subsets of salt marsh study sites suggested by cluster analysis (Figure 6).

Species	Group 1	Group 2
Distichlis spicata	25.87	3.02
Juncus gerardii	9.03	1.34
Spartina alterniflora	11.91	72.11
Spartina patens	23.26	8.28
DHD	19.44	30.73

To examine the effects of direct human disturbance on the 2 subsets of salt marsh study sites separated by cluster analysis, species composition at disturbed *Spartina patens*-dominated marshes (Group 1 in Table 21) was compared to the composition of similar, undisturbed (i.e. DHD=0) marshes (Table 22). Wilcoxon's rank sum test was used to compare community indices and relative cover values of individual species calculated for disturbed and undisturbed sites (Table 23).

Table 22. Species composition, expressed as average relative cover, of the wetland herbaceous communities at undisturbed (DHD=0) and disturbed salt marshes in the first cluster group (only species with an average relative cover >1.0 are reported; N=number of study sites; community indices are average values).

Species	Undisturbed (N=4)	Disturbed (N=16)
Spartina patens	47.49	30.34
Phragmites australis	18.05	10.30
Spartina alterniflora	14.81	8.19
Distichlis spicata	13.85	23.86
Salicornia spp.	1.37	0.09
Atriplex patula	0.64	0.15
Panicum spp.	0.11	1.87
Solidago sempervirens		3.59
Limonium nashii		0.19
Species Richness	10.00	12.44
Species Evenness	0.25	0.28
Species Diversity	1.29	1.47
DHD	0.00	25.52

The community indices (diversity, species richness, and species evenness) were not significantly different between disturbed and undisturbed study sites. The relative cover values of dominant plant species (here broadly defined as a species whose average relative cover value exceeded 1.0) did not differ between disturbed and undisturbed marshes. Disturbed marshes, however, tended to have a large number of minor (relative cover <1.0) species present (Table 23). Consequently, a matrix of cover values of all minor species recorded in the wetland communities of disturbed high marsh study sites was created and correlated with the level of disturbance (DHD) (Table 24). No species displayed a significant relationship with the disturbance index.

Table 23. Pair-wise Wilcoxon's rank sum tests comparing the mean relative cover values (MEAN) of dominant herbaceous species recorded in the wetlands at disturbed (D) and undisturbed (U) salt marshes in the first cluster group (N=number of sites; SE=standard error; CV=coefficient of variation; P>Z=probability that the calculated test statistic is greater than the expected value at alpha=0.05) (see Table 39 for species names).

Species	Type	N	Mean	SE	CV	P≥Z
20	U	4	0.65	0.52	183.93	0.41
	D	16	0.15	0.07	209.64	
57	U	4	13.85	4.49	89.79	0.32
	D	16	23.86	4.68	78.52	
98	U	4	0.27	0.26	213.49	0.16
	D	16	8.95	2.91	129.92	
131	U	4	0.11	0.10	199.69	0.19
	D	16	1.63	1.12	275.56	
133	U	4	18.04	8.56	116.92	0.22
	D	16	10.30	2.31	89.54	
159	U	4	1.37	0.57	105.84	<0.01
	D	16	0.09	0.05	203.66	
189	U	4	14.81	5.25	67.48	0.25
	D	16	8.19	2.49	121.42	
191	U	4	47.51	7.14	64.67	0.15
	D	16	30.34	5.34	70.37	

Table 24. Matrix of average relative cover values measured for minor ($\bar{X}$<1.0) species recorded in the herbaceous communities of disturbed salt marshes in the first cluster group and Spearman's rank correlation coefficient from the comparison of relative cover and the level of disturbance (note: correlations were calculated based on relative cover values at 42 study sites) (alpha level=0.05) (see Table 39 for species names).

	SITE NUMBER															
Species	256	146	255	240	121	239	250	80	142	249	251	92	134	245	139	r
3			1.56									6.89				-0.0119
7							3.96									-0.0854
20			0.19					0.61		1.11	0.29			0.09		0.1472
44			0.21				0.04									-0.1463
45	1.73		1.41							7.81				1.76		-0.1191
63	0.93															-0.1145
64															0.74	0.2746
89									0.51							-0.1046
94		0.22		0.73					0.04			4.47			0.42	0.0025
95				0.23												0.0126
100													2.25			0.2501
106			1.29							1.52		0.29				0.2273
114				0.20												-0.1134
126				0.68												-0.1390
127				0.45								0.29				-0.1317
130										3.45						-0.0690
146												0.09				-0.0869
152	3.46			0.05								0.18				-0.1165
166	10.85		0.05											1.68		-0.0791
167													0.07	0.47		0.3037**
169		7.73	0.73	0.02	0.10					0.08		6.34	0.07	3.83		-0.1176
183				2.18		0.03				1.77					0.26	-0.0700
193												0.06				0.0126
195			0.15													-0.1093
199			0.02						0.14							0.1216
205			0.49													-0.1399
DHD	0.88	1.39	2.12	3.33	4.17	4.92	7.85	10.57	12.00	14.39	22.27	31.37	88.33	92.78	94.20	

Table 25. Species composition, expressed as average relative cover, of the wetland herbaceous communities at disturbed salt marshes in the second cluster group with community compostion of site 99 presented for comparison (only species with an average relative cover >1.0 are reported; N=number of sites; community indices are averages).

Species	Site 99	Disturbed (N=17)
Spartina alterniflora	88.25	67.59
Phragmites australis	3.22	10.30
Spartina patens	3.17	8.41
Distichlis spicata	0.29	3.08
Salicornia spp.		2.98
Juncus gerardii		1.62
Solidago sempervirens	2.09	
Atriplex patula	0.93	
Species richness	10.00	10.10
Species evenness	0.15	0.20
Species diversity	0.58	0.96
DHD	0.00	32.54

Similar analyses were attempted on the second subset of salt marsh study sites, primarily *Spartina alterniflora*-dominated low marshes, provided by the cluster analysis (Table 25). However, paucity of undisturbed low marsh study sites made statistical comparison with disturbed sites impossible. Site 99, the one undisturbed *Spartina alterniflora* marsh in our sample, was presented for qualitative comparisons. There does not appear to be any difference in the herbaceous community as a result of disturbance, although disturbed marsh communities tended to have a larger number of minor constituent species.

In general, the disturbed salt marsh herbaceous communities (in both low and high marsh situations) tended to contain a wide range of species not found in the undisturbed sites. Many of these species (eg. *Solidago sempervirens*, *Limonium carolinianum*) are commonly found in New Jersey's salt marshes, but were shown to occur prevalently on spoil piles resulting from mosquito ditching (Shisler 1973). The majority of these minor species, however, were typically upland or cosmopolitan plants (eg. *Pteridium aquilinum*, *Solidago graminifolia*, *Ipomoea* spp.) that have invaded the upper part of the marsh from the bordering upland. Spoil piles of discarded construction material, siltation, and filling which remain after the original development activities adjacent to these wetlands provided the habitats, removed from the tidal action and salinity regimes which determine the species composition of undisturbed salt marshes, that allowed the establishment of these opportunistic plants.

3.4.2 TIDAL FRESHWATER MARSHES

Community evenness at tidal freshwater marsh sites was significantly correlated with total disturbance, indicating that the distribution of individual plants was skewed toward a more even distribution of species in the community (Table 26). Species richness correlated significantly with buffer width. No other relationships were significant. Correlation analysis did suggest that the herbaceous communities at disturbed sites demonstrated a change in the distribution of individuals among constituent species.

A cluster analysis was then performed on a matrix of relative cover values recorded for all herbaceous species identified in the wetland at tidal freshwater marsh study sites. The results of the analysis, expressed as a dendrogram (Figure 7), suggested two fairly distinct subsets of study sites. Examination of the species composition of these marshes provided an explanation (Table 27).

Table 26. Correlation matrix relating wetland zone herbaceous layer community indices, human disturbance, buffer width and buffer shrub density at tidal freshwater marsh study sites. Matrix includes Spearman's rank correlation coefficients and the probability of significance (N=26, alpha level=0.05).

	Diversity H	Richness N	Evenness E
Total Disturbance	0.25159	0.30316	0.43010
	0.2150	0.1322	0.0283
Buffer Width	0.34018	0.39516	0.23633
	0.0891	0.0457	0.2451
Buffer Shrub Density	-0.01113	0.12530	-0.06091
	0.9570	0.5419	0.7676

Table 27. Average relative cover values of 13 major plant species (and mean disturbance, DHD) calculated for subsets of freshwater marsh study sites suggested by cluster analysis (Figure 7).

Species	Group 1 (N=6)	Group 2 (N=17)
Amaranthus cannabinus	0.26	1.13
Ambrosia trifida	1.15	3.74
Bidens laevis	0.95	8.11
Bidens spp.	0.01	2.44
Cuscuta grenovii	0.18	0.76
Impatiens capensis	4.99	17.50
Mikania scandens	1.32	0.56
Nuphar spp.	0.0	5.45
Peltandra virginica	10.31	8.89
Pilea pumila	2.28	2.06
Polygonum arifolium	3.49	13.84
Sagittaria latifolia	2.35	6.65
Zinzania aquatica	45.39	8.25
DHD	45.51	61.37

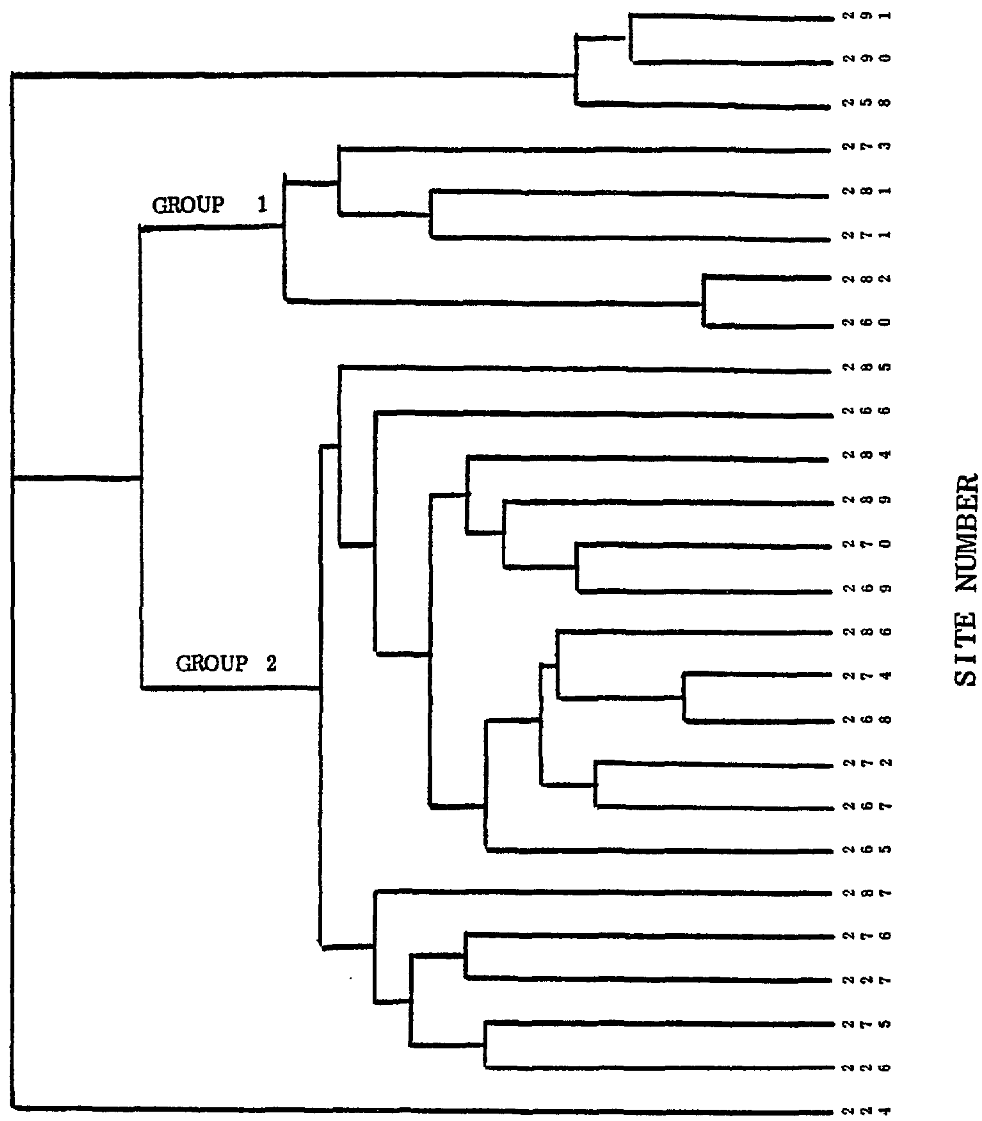


Figure 7. Dendrogram representing average linkage cluster analysis of the herbaceous communities at freshwater marsh study sites.

The first group of sites were located in Camden and Gloucester counties. *Zinzania aquatica* dominates the marsh community in this area (Good and Good 1974) and wild rice was the most widespread species in this group of study sites. The second group consists of study sites in Mercer and northern Burlington counties where wild rice communities are far less numerous (Whigham and Simpson 1975). This is reflected in the average cover value calculated for wild rice at the second group of sites. Levels of direct human disturbance were not significantly different between the 2 subsets of study sites (Wilcoxon's rank sum test) and these clusters were probably not a reflection of relative levels of disturbance in the two subsets of sites.

Table 28. Species composition, expressed as average relative cover, of the wetland herbaceous communities at undisturbed (DHD=0) and disturbed tidal freshwater marshes in the first cluster group (only species with an average relative cover >1.0 are reported; N=number of sites; community indices are averages).

Species	Undisturbed (N=2)	Disturbed (N=4)
Zinzania aquatica	33.34	40.67
Nuphar spp.	30.80	
Peltandra virginica	12.65	6.68
Pontederia cordata	8.06	
Sagittaria latifolia	3.15	2.18
Amaranthus cannabinus	3.01	0.19
Bidens laevis	2.96	0.97
Polygonum punctatum	2.03	1.59
Impatiens capensis	1.55	5.47
Pilea pumila	0.78	2.61
Polygonum arifolium	0.29	4.22
Phragmites australis		8.96
Sparganium spp.		1.89
Mikania scandens		1.65
Ambrosia trifida		1.44
Lythrum salicaria		1.11
Species richness	13.0	21.0
Species evenness	0.24	0.38
Species diversity	1.33	1.83
DHD	0.00	68.27

Table 29. Pair-wise Wilcoxon's rank sum tests comparing the mean relative cover values (MEAN) of dominant herbaceous species recorded in the wetlands at disturbed (D) and undisturbed (U) tidal freshwater marshes in the first cluster group (N=number of sites; SE=standard error; CV=coefficient of variation; P>Z= probability that the calculated test statistic is greater than the expected value at alpha=0.05) (see Table 39 for species names).

Species	Type	N	Mean	SE	CV	P>Z
4	U	2	1.01	0.36	51.36	0.85
	D	15	1.36	0.66	186.99	
26	U	2	13.22	1.29	13.86	0.41
	D	15	7.60	2.36	120.36	
92	U	2	21.89	9.31	60.15	0.56
	D	15	18.38	1.89	39.86	
122	U	2	5.66	8.00	141.42	0.88
	D	15	4.86	7.04	144.79	
132	U	2	2.39	1.95	115.38	0.39
	D	15	8.96	2.63	113.76	
143	U	2	0.28	0.24	121.22	0.38
	D	15	3.41	1.23	139.72	
157	U	2	4.21	2.31	77.59	0.63
	D	15	6.91	1.96	109.76	
214	U	2	6.51	2.11	45.84	0.95
	D	15	6.91	2.29	128.09	

To examine the effects of disturbance on the two different types of marshes defined by the cluster analysis, species composition at disturbed sites was compared to the composition of similar undisturbed (i.e. DHD=0) marshes (Table 28). Wilcoxon's rank sum test was used to compare relative cover values for each species, as well as the community indices, between disturbed and undisturbed study sites within each marsh type (Table 29).

Analysis of the first subset of sites, *Zinzania aquatica*-dominated marshes in southwestern New Jersey, produced no significant differences between disturbed and undisturbed sites as described by the relative cover values of individual species or by the indices of community composition. Disturbed sites tended to display higher species richness: 23 plant species were present in disturbed marshes with relative cover values greater than 1.0, as compared to only 13 species at the undisturbed sites. However, the majority of these species were plants typical of riverine marshes in the state (Good and Good 1975, Ferren 1976, Leck and Graveline 1979, Simpson, et al. 1983), and their appearance at the disturbed sites may be a function of the small sample sizes used here to describe a highly variable system. The 3 dominant species not typical of tidal freshwater marshes (*Lythrum salicaria*, *Mikania scandens*, and *Phragmites australis*), as well as all other herbaceous species recorded during sampling in the wetlands of these study sites, were combined into a matrix of relative cover values and correlated with DHD in an effort to detect species indicative of disturbance among the minor community members (Table 30). Correlation produced signficant relationships only with typical marsh species (*Apios americanus*, *Cicuta maculata*, and *Polygonum sagittatum*).

Analysis of the second subset of sites produced similar results (Tables 31 and 32). Differences in species composition between disturbed and undisturbed sites were not significant and suggested only the natural variability inherent in New Jersey's tidal freshwater marshes. The matrix of minor species (Table 33) indicated significant relationships between the level of disturbance in the wetland and the relative cover of 2 species not typically associated with freshwater marshes (*Eupatorium rugosum* and *Glechoma hederacea*). However, these species were recorded at only a few study sites (2 and 1, respectively) and occurred a very low densities (relative cover < 1.0). While their correlation with DHD suggests a relationship with disturbance, small sample size makes definite conclusions about their indicator status difficult. Because of the wide variability in species composition of the marshes surveyed, the presence of any species at only highly disturbed sites must be taken as only reflecting this variability and not as evidence of indicator status (for example, *Mikania scandens* in Table 28). Apparently disturbance of the kinds recorded have little short-term impacts on the herbaceous community. This may probably due to the great resiliency of marsh vegetation which is naturally adapted to wide fluctuations in habitat conditions and a diverse array of environmental stresses (Odum, et al. 1984).

Table 30. Matrix of average relative cover values measured for minor (average cover <1.0) species recorded in the herbaceous communities of tidal freshwater marshes in the first cluster group and Spearman's rank correlation coefficient from the comparison of relative cover and the level of disturbance (note: correlations calculated based on relative cover at 26 study sites) (alpha level=0.05).

	SITE NUMBER				
SPECIES	281	282	271	273	r
4			0.52	0.25	0.3255
8				1.97	0.4384**
28					-0.0755
29		0.45			0.1301
40			0.36	1.23	0.4846**
41	0.22	0.17		1.35	-0.0617
46	0.02	0.06		0.62	0.0173
69	0.36				-0.1526
103				0.62	0.3574*
112		0.17	0.94		-0.0285
125	0.44				-0.1827
144	0.24	0.56			0.4869**
168		0.33			-0.2785
179	1.38				-0.0614
DHD	10.00	17.11	60.21	185.76	

Table 31. Species composition (expressed as average relative cover of the wetland herbaceous communities at undisturbed (DHD=0) and disturbed tidal freshwater marshes in the second cluster group (only species with an average relative cover >1.0 are reported; N=number of study sites; community indices are average values).

Species	Undisturbed (N=2)	Disturbed (N=15)
Polygonum arifolium	25.22	13.68
Impatiens capensis	21.89	18.38
Bidens laevis	13.22	7.60
Ambrosia trifida	6.68	2.55
Zinzania aquatica	6.51	6.92
Nuphar spp.	5.66	4.86
Sagittaria latifolia	4.21	6.91
Scirpus robustus	2.87	1.56
Typha latifolia	2.76	1.79
Peltandra virginica	2.39	8.96
Pilea pumila	2.02	2.09
Cuscuta gronovii	1.63	
Amaranthus cannabinus	1.00	1.36
Bidens spp.		1.95
Heteranthera reniformis		1.37
Lythrum salicaria		1.06
Phragmites communis		1.54
Polygonum cuspidatum		1.35
Polygonum punctatum	0.28	3.42
Sparganium spp.		2.83
Typha angustifolia		1.95
Species Richness	19.50	24.10
Species Evenness	0.37	0.38
Species Diversity	2.10	2.20
DHD	0.00	69.55

Table 32. Pair-wise Wilcoxon's rank sum tests comparing the mean relative cover values (MEAN) of dominant herbaceous species recorded in the wetlands at disturbed (D) and undisturbed (U) tidal freshwater marshes in the second cluster group (N=number of sites; SE=standard error; CV=coefficient of variation; P>Z=probability that the calculated test statistic is greater than the expected value at alpha=0.05) (see Table 39 for species names).

Species	Type	N	Mean	SE	CV	P≥Z
6	U	2	0.83	0.83	141.42	0.79
	D	4	1.44	1.41	195.39	
26	U	2	2.96	2.07	98.89	0.25
	D	4	0.97	0.51	105.18	
92	U	2	1.55	1.51	137.77	0.29
	D	4	5.47	2.09	76.52	
132	U	2	12.65	12.19	136.28	0.58
	D	4	6.68	4.38	131.38	
139	U	2	0.28	0.28	141.42	0.21
	D	4	4.22	1.75	82.99	
157	U	2	3.14	0.11	4.72	0.62
	D	4	2.18	1.19	109.07	
214	U	2	33.34	31.78	134.80	0.77
	D	4	40.47	8.21	40.60	

Table 33. Matrix of average relative cover values measured for minor ($\bar{X}$<1.0) species recorded in the herbaceous communities for disturbed tidal freshwater marshes in the second cluster group and Spearman's rank correlation coefficient (values from -1.0 to 1.0) from the comparison of relative cover and the level of disturbance (note: correlations calculated based on relative cover values at 26 study sites) (alpha level=0.05) (see Table 39 for species names).

	Site Number															
Species	227	272	274	226	268	270	269	266	265	284	285	287	275	276	289	r
8	0.55	0.20					0.25						1.58	0.67		0.438**
14		0.32	1.64		0.16	0.73	2.28	0.49	1.39				0.07			-0.184
16			0.28													-0.141
25									0.93	0.03		0.04				-0.026
29		0.40	1.04					0.44				0.60	0.41	0.79		0.130
39		0.12							1.66		0.18					0.153
40		0.85						0.35	0.86		0.36				1.13	0.438**
41		2.22	0.96			0.26	0.16	0.14	0.43							-0.184
46		0.94	0.36	0.69	0.16	0.21	0.56	1.45	0.33	0.51	0.64	0.37	0.58	0.12	0.75	-0.144
76													0.55		0.59	0.590**
86															1.69	0.617**
89							1.66						3.51			0.395**
120		0.78	0.04		0.33	0.16	1.19	1.39			0.05			2.76	1.26	0.164
125		1.13	0.20				2.72	1.68					0.21	0.05		-0.183
126								1.55	0.07							-0.080
144		0.04							0.03	0.03		0.18		0.34	0.75	0.487**
146	1.32			0.29												-0.188
158												2.56				0.217
169								0.44		11.05		0.73				0.073
174	0.89	0.12		0.67		0.05		0.82								-0.241
182									1.66							-0.037
194	3.14			0.52		0.31										-0.182
196								0.29	0.33						0.21	0.199
198				1.04												-0.141
DHD	0.79	0.81	0.96	1.78	3.51	10.00	16.22	25.66	40.35	76.72	127.41	134.13	134.50	189.10	281.36	

3.4.3 HARDWOOD SWAMPS

Significant relationships were suggested by the correlation analysis between buffer width and species evenness in the wetland herbaceous community and between species richness and the level of disturbance (Table 34). This apparent decline in species richness with increasing level of disturbance prompted subsequent cluster analysis on a matrix of relative cover values for 121 herbaceous species recorded in the wetlands at hardwood swamp study sites. The results, presented as a dendrogram (Figure 8), offers no clear ordination of sites. This appears to be a reflection of the fact that the natural species composition of these sites were inherently dissimilar as a result of sampling in different physiographic subprovinces of the New Jersey coastal plain. We feel that attempting to ordinate forests of different species character confounded any clustering based on the effects of disturbance. Inadequate sample size prevented any meaningful ordination within physiographic type.

Table 34. Correlation matrix relating wetland zone herbaceous layer communtiy indices, human disturbance, buffer width and buffer shrub density at hardwood swamp study sites. Matrix includes Spearman's rank correlation coefficients and probability of significance (N=32, alpha level=0.05).

	Diversity H	Richness N	Evenness E
Total Disturbance	-0.06594 0.7199	-0.23963 0.1865	-0.19186 0.2928
Buffer Width	0.12589 0.4924	0.02115 0.9085	0.34682 0.0518
Buffer Shrub Density	0.27315 0.1304	0.25574 0.1577	0.20127 0.2693

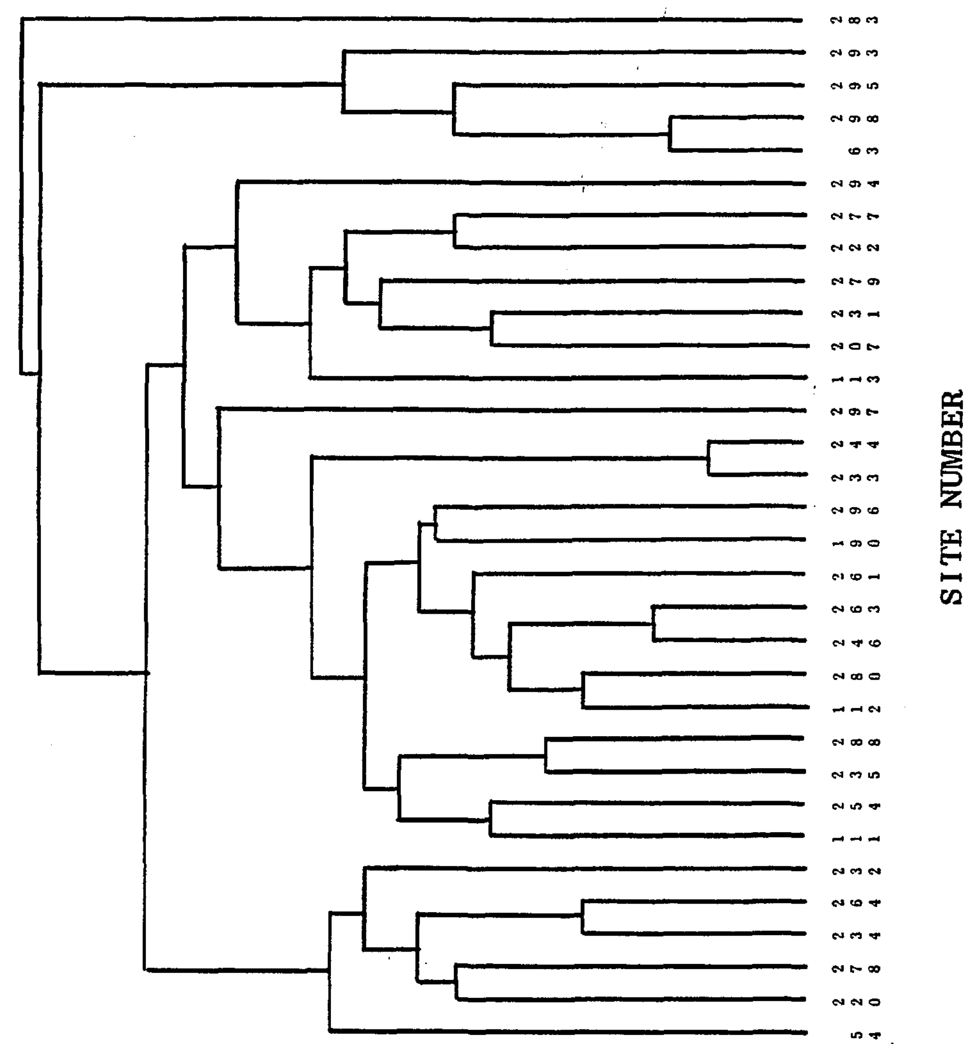


Figure 8. Dendrogram representing average linkage cluster analysis of the herbaceous communities at hardwood swamp study sites.

Table 35. Species composition, expressed as average relative cover, of the wetland herbaceous communities at undisturbed (DHD=0), disturbed and highly disturbed (DHD > 25.06) hardwood swamp study sites (only species with average relative cover >1.0 are reported here, N = number of study sites).

Species	Undisturbed (N=7)	Disturbed (N=24)	Highly Disturbed (N=10)
Woodwardia areolata	28.28	13.38	8.52
Osmunda cinnamomea	9.62	28.51	23.52
Impatients capensis	8.71	11.42	26.97
Carex spp.	8.40	2.33	0.04
Thelypteris palustris	6.25	0.78	1.85
Woodwardia virginica	6.13	1.41	2.69
Onoclea sensibilis	5.92	0.22	0.52
Lycopodium obscurum	4.83	0.23	0.55
Boebmeria cylindrica		3.66	1.24
Osmunda regalis		3.39	5.75
Symplocarpus foetidus		2.86	2.55
Pteridium aquilinum		2.75	2.55
Carex venusta			1.55
Species Richness	13.00	11.90	9.90
Species Evenness	0.41	0.34	0.33
Species Diversity	1.39	1.43	1.35
DHD	0	33.42	64.98

Table 36. Pair-wise Wilcoxon's rank sum tests comparing the mean relative cover values (MEAN) of dominant herbaceous species recorded in the wetlands at disturbed (D) and undisturbed (U) hardwood swamp study sites (N=number of sites; SE=standard error; CV=coefficient of variation; P>Z=probability that the calculated test statistic is greater than the expected value at alpha=0.05) (see Table 39 for species names).

Species	Type	N	Mean	SE	CV	P≥Z
35	U	7	8.40	6.02	189.72	0.21
	D	10	0.04	0.04	316.23	
92	U	7	8.71	8.38	254.64	0.24
	D	10	26.97	11.06	129.65	
110	U	7	4.83	4.83	264.58	0.41
	D	10	0.55	0.54	316.23	
125	U	7	5.92	4.38	196.11	0.26
	D	10	0.52	0.45	273.04	
126	U	7	9.62	6.15	169.11	0.22
	D	10	23.52	8.09	108.79	
199	U	7	6.25	4.74	196.11	0.40
	D	10	1.85	1.43	244.95	
210	U	7	28.28	13.55	126.77	0.20
	D	10	8.52	4.14	153.67	
211	U	7	6.13	3.55	153.24	0.43
	D	10	2.69	2.26	265.41	

Table 37. Average relative cover ($\bar{X}$), standard error of the mean (SE), and coefficient of variation (CV) for minor herbaceous species recorded at 24 disturbed hardwood swamp study sites. The last column, r, represents Spearman's rank correlation coefficient from the comparison of average cover with the level of disturbance (alpha level = 0.05).

Species	$\bar{x}$	SE	CV	r
Ambrosia artemisifolia	0.06	0.06	489.90	-0.1012
Apocynum spp.	0.06	0.06	489.90	0.2416
Arisaema spp.	0.54	0.54	489.90	-0.1129
Asclepias spp.	0.02	0.02	489.90	-0.1012
Aster radula	0.31	0.31	489.90	-0.1012
Aster spp	0.19	0.12	311.11	-0.0585
Bidens spp.	0.09	0.07	389.47	0.2320
Carex venusta	0.65	0.65	489.90	0.2416
Cicuta maculata	0.28	0.28	489.90	0.2946
Commelina communis	0.14	0.14	489.90	0.0387
Drosera filiformis	0.22	0.16	351.27	-0.1312
Drosera intermedia	0.04	0.03	419.20	-0.1053
Drosera rotundifolia	0.25	0.21	413.17	-0.1177
Eupatorium dubium	0.15	0.14	478.87	0.2524
Eupatorium pilosum	0.26	0.18	349.06	-0.1358
Eupatorium purpureum	0.18	0.12	340.01	0.2392
Hypericum virginicum	0.18	0.15	417.57	-0.1167
Lycopodium alopecuroides	0.19	0.14	357.57	-0.1285
Lycopodium obscurum	0.22	0.22	489.90	-0.1284
Lycopus virginicus	0.29	0.20	340.89	0.2059
Onoclea sensibilis	0.22	0.19	427.36	-0.1378
Panax quinquefolius	0.31	0.31	489.90	-0.1019
Panicum spp.	0.37	0.20	263.63	0.1268
Peltandra virginica	0.44	0.36	406.95	0.2636
Polygonum punctatum	0.12	0.12	489.90	-0.1191
Polygonum spp.	0.14	0.14	489.90	-0.1201
Smilax herbacea	0.11	0.08	341.42	0.0986

While inadequate sample sizes prohibited an analysis based on forest type, an attempt was made to assess the impacts of direct human disturbance on the herbaceous communities at hardwood swamp study sites. We compared the species composition at undisturbed sites (DHD=0) with that at disturbed sites and at "highly disturbed' sites, defined at those sites at which the value of DHD calculated for the wetland herbaceous community exceeded the mean level (DHD=25.06) for all swamp sites (Table 35). There were no significant differences in species richness, species evenness, or species diversity between disturbed and undisturbed communities. Certain species (eg. Woodwardia areolata and Onoclea sensibilis) demonstrated lower mean relative cover values at the disturbed sites, while others (eg. Osmunda cinnamomea and Impatiens capensis) appeared to increase at disturbed sites. Pairwise comparisons using Wilcoxon's rank sum test detected no significant differences in the relative cover of individual species between disturbed and undisturbed sites (Table 36).

Several species (eg. Boebmeria cylindrica and Pteridium aquilinum) occurred only at disturbed sites. A matrix of cover values of all minor (relative cover < 1.0) species recorded in the wetland communities of disturbed hardwood swamps was created and correlated with the level of disturbance (Table 37). No significant relationships were found between disturbance and any of the minor species recorded.

Hardwood swamps are very diverse and variable systems. Tiner (1985) recognizes at least 8 major types of palustrine forested wetland in northern New Jersey and as many at 8 different types in the southern part of the state. Acer rubrum (Red Maple) dominates the majority of hardwood swamp forests, but may be associated in the canopy with a wide range of species, including Liquidambar styraciflua (Sweet Gum), Nyssa sylvatica (Black Gum), Quercus palustris (Pin Oak), and Pinus rigida (Pitch Pine). Even more diverse are the herbaceous communities which develop below. Trampling is an important form of degredation in the disturbed swamps we examined, and species such as Woodwardia areolata (Netted Chain Fern) and Thelypteris palustris (Marsh Fern) which are sensitive to trampling tend to drop out of disturbed communities. However, the high between-site variability in the composition of the herbaceous communities at hardwood swamp study sites makes generalization difficult. Little is known about the resistance of individual species to the forms of direct disturbance measured here. At the same time, the importance of different species to the structure and functioning of the herbaceous community in hardwood swamp forests has only been guessed at. Until these relationships are better understood, the search for species indicative of disturbance will probably remain a difficult one.

4.0 CONCLUSIONS AND GUIDELINES

4.1 CONCLUSIONS

The following section is organized in two parts. The first is a summary of the major results of the disturbance analysis considered for individual wetland types. The second is a summary of general conclusions drawn from the vegetation analysis on all three wetlands of interest. A general discussion of the results follows.

I. Disturbance

1. Salt Marshes

a) Elucidation of relationships between the level of direct human disturbance (DHD) measured in the wetland and the physical characteristics of the adjacent buffer were partly confounded by the fact that, in many cases, existing buffers have become established after initial construction/development activity had taken place or that the buffer had been breached during development.

b) Current resident impacts, of the types measured here, appear to be minimal. The major forms of disturbance to the marsh were attributable to the initial construction.

c) Significant inverse linear relationships between buffer width and the level of DHD in the wetland suggest that disturbance in the wetland was reduced by removing development from the wetland border.

d) DHD measured in salt marshes adjacent to high intensity development, particularly industrial/commercial land uses, tended to be higher than at lower intensity sites.

e) Because most of the disturbance measured at salt marsh study sites pre-dated the establishment of many existing buffers, no particular buffer width afforded a significantly higher degree of protection to the marsh than any other.

2. Tidal Freshwater Marshes

a) Tidal freshwater marshes tended to have significantly higher levels of DHD in the wetland than any other wetland type.

b) Correlation analysis detected signficant relationships between the level of wetland disturbance and the composition of adjacent buffers. Steeply sloping buffers with dense shrub understories provided the greatest protection (lowest recorded DHD).

c) The major forms of disturbance recorded in tidal freshwater marshes were attributable to current residents of the adjacent development.

d) The width of the existing buffer was significantly related to the level of wetland disturbance: As buffer width increased, wetland disturbance decreased.

e) DHD recorded in wetlands adjacent to high density residential land uses was higher than at lower intensity development sites.

f) Wetland disturbance measured in marshes with existing buffers less than 50 ft. wide was significantly higher than disturbance levels in marshes where the buffer was between 50 and 100 ft. No significant reduction in disturbance occurred after 100 ft.

3. Hardwood Swamps

a) Correlation and regression analyses demonstrated a significant inverse relationship between wetland disturbance and buffer width.

b) The most prevalent forms of disturbance recorded in the wetland were the destruction of vegetation attributable to initial development activity and refuse dumping by current residents.

c) No particular level of land use or form of development resulted in a significantly higher level of disturbance in adjacent wetlands.

d) Wetland disturbance measured in hardwood swamps with existing buffers less than 50 ft wide was significantly higher than in swamps with buffers of 100 ft. No further signficant reduction in the level of wetland disturbance occurred after 100 ft.

II. Vegetation Analysis

1. Increasing levels of direct human disturbance were signficantly correlated with changes in the species composition (as expressed by community indices) in three wetland types of interest.

   a) Increased species evenness at disturbed salt marsh sites was attributable to the colonization of spoil piles and filled areas in the upper marsh by plant species from the adjacent upland. These disturbed areas, remnants of the initial development activities, provided habitats divorced from the tidal regimes of the marsh.

   b) Greater species evenness at tidal freshwater marsh sites reflected an increasing number of different species at disturbed sites as compared to monotypic stands of vegetation which were more prevalent at undisturbed sites.

   c) Declining species richness at disturbed hardwood swamp sites was due to an increase in minor species at these sites and the loss of certain species which were sensitive to the particular forms of disturbance (notably trampling) recorded here.

2. The very high between-site variability in the species composition of the herbaceous communities in all three wetland types obscured the results of comparisons between disturbed and undisturbed sites relative to the presence or absence of species.

3. No significant relationship was found between the presence/absence or relative abundance of any herbaceous species and the level of direct human disturbance.

In general, the composition of existing buffers (i.e. shrub density in the buffer, buffer slope, etc.) had varying effects on the levels of direct human disturbance recorded in adjacent wetlands. In particular, buffers at salt marsh study sites appeared to have very little impact on many of the forms of disturbance measured in the wetland community. Many of these buffers became established only after the development activities in the contiguous upland had been completed. Or, if the buffer was in place during construction, it had been breached or destroyed during development. Consequently, the filling, dumping and excavation, which have had the greatest adverse impacts on disturbed salt marshes, took place without the constraints of an effective buffer zone.

Significant inverse relationships between buffer width and disturbance in salt marshes appears to reflect a reduction in impacts by current residents near the wetland. Current resident impacts tended to be minimal and were discouraged to a great extent by vegetated buffers. Disturbance due to current residents tended to be higher at industrial and commercial land use sites, probably because a greater number of people using the area around the marsh increased the chance of impact, and because industrial activity produces more human refuse (eg. discarded construction materials, tires, machine parts) than was produced at residential sites. While comparisons between different buffer widths showed no particular buffer width to be signficantly better than another at protecting the marsh, disturbance at sites with narrow buffers (less than 50 ft) was double the level at marshes with wider buffers.

Tidal freshwater marshes tended to have the highest levels of recorded wetland disturbance. The majority of these study sites were located in areas of high human population density (particularly the Delaware River area) and were therefore more likely to suffer the impacts of human disturbance. Unlike the other wetland types, these were generally riverine systems and, as such, were narrowly defined. Development occurred on all sides of the wetland not along one border. Major forms of disturbance tended to be due to the current residents near the marsh, primarily because well-developed buffers were in place during construction. The level of wetland disturbance increased with the level of development and was significantly related to buffer width. Unlike residents near salt marshes, people living along the rivers which supported freshwater tidal marshes tended to consider the riverfront and the marsh as part of their property. Dumping of trash into the river channel, thus removing it from view, and the destruction of "offensive" vegetation was prevalent. Disturbance was greater at industrial/commercial land use sites. Dumping of particular concern for the health of the riverine wetland system included discarded lubricant, solvent and pesticide containers, in addition to machine parts and construction materials. Where well-developed buffers shielded the marsh from adjacent development, human disturbance rarely penetrated into the wetland. Buffers of 100 ft and greater provided significantly more protection, reflected in lower disturbance, to the adjacent wetlands than did buffers less than 50 ft. We feel that the comparatively high levels of disturbance recorded at tidal freshwater marsh study sites and their relative scarcity in the state argues for correspondingly greater protection for these wetland types.

Strongest relationships between DHD and buffer width were found in the analysis of hardwood swamp sites. Initial development impacts, in the form of trampled and cut vegetation, were prevalent in disturbed swamps, but current resident impacts (primarily discarding refuse, cutting unwanted vegetation) were most common. Because the majority of adverse impacts recorded in hardwood swamps were limited to the area immediately adjacent to current property boundaries, the level of disturbance at sites with buffers less than 50 ft was significantly greater than at sites with buffers of 100 ft or more.

Direct human disturbance may cause changes in the species composition of impacted wetlands. Upland and cosmopolitan plant species colonized spoil piles and filled areas in salt marshes which had been disturbed during initial development. Disturbed riverine tidal freshwater marshes tended to be more mixed and undisturbed marshes were more likely to be monotypes of perennial species. Trampling in hardwood swamps seems to select against certain sensitive plant species. However, due to high between-site variability in all wetland types, such changes must be assessed on a site-by-site basis considering the natural variation inherent in wetland systems. Our sampling was designed to detect overt changes in vegetation composition and took place on only one day. Further refinement in the description of wetland herbaceous communities which acknowledges the natural changes in that composition over the seasons is needed to detect the more subtle changes in wetland vegetation that may be caused by human disturbance.

4.2 BUFFER ZONE RATIONALE

The three chief types of construction-related human intrusions into wetland systems identified in the literature were:

1. The outright destruction of wetland habitats,

2. The sometimes enormous increase in the load of suspended solids carried in overland runoff, and

3. The alteration of these surface water levels, as well as stream flow patterns, resulting in flood hydrographs of shorter duration and higher intensity.

Buffer zones of intact, natural vegetation, maintained between development activities and adjacent wetlands can effectively control the severity of soil erosion and remove a variety of pollutants from stormwater runoff. Buffers preserve esthetic qualities by both screening buildings from natural areas and enhancing the appearance of developed areas. Buffer zones act as a two-way filter in that they lessen both human impacts on wetlands (e.g., filtering runoff and reducing pollutant and nutrient loads, reducing sedimentation, influencing biochemical degredation, and mediating thermal pollution) and wetland impacts on development by reducing flood damage and restricting the movement of biting flies which breed in wetlands (Shulze, et al. 1975).

4.3 BUFFER ZONE DEFINITION

New Jersey regulations define a buffer to be a transitional area of native vegetation that mitigates adverse impacts of development on adjacent wetlands (NJDEP 1986). By definition, then, buffer zones are generally ecotonal areas between upland and wetland.

An ecotone is a transitional area between two or more different ecological communities (Odum 1971). The ecotonal community itself commonly contains many of the plants and animals found in the overlapping communities in addition to organisms characteristic of and sometimes restricted to the ecotone (Odum 1971). Known as the "edge effect", the number of species is often greater in the ecotone than in adjacent communities (Odum 1971, Clark 1974). Ecotonal situations are valuable habitat for a variety of wildlife, providing food, cover, resting and nesting sites and migration corridors, facilitating local dispersal as well as regional movements (Smith 1980).

A buffer zone is an area contiguous to coastal wetlands that is retained in a natural and undisturbed condition. Because ecotones are valuable wildlife habitat and because the structural diversity and distribution of edge habitats can have critical impacts on wildlife use of these habitats, buffer zones include, but are not limited to, the wetland/upland ecotonal community. The ecotone may be roughly defined as the uppermost limit of native plant species designated as FACW or FACW- by the U.S. Fish and Wildlife Service wetlands plant inventory for New Jersey (Reed 1986). In view of their protective function in regard to adjacent wetlands, certain activities should be precluded in maintained buffers:

1) no fertilizer application except where necessary to establish vegetation in eroding areas or in order to restore native vegetation.

2) no pesticide application

3) no felling or other cutting of trees

4) no filling or excavation

5) no construction of permanent buildings or culverts.

However, in keeping with the Department of Environmental Protection's policy of encouraging public use of wetlands, activities which may be allowed include the cutting and maintenance (without the use of herbicides) of foot paths and rights of way using best management practices to control soil erosion, and the erection of boardwalks.

4.4 RECOMMENDED GUIDELINES

The following is a series of recommended policies for the implementation of buffer zones in the management of coastal wetlands. "Buffer zone" and "buffer" refer to the definition of buffer zones as stated in Section 4.3 above, except where otherwise specified.

1. Buffer zone widths should be set on a case-by-case basis considering different wetland types and land use intensities.

2. Buffers should be established in advance of development and enforced prior to and during development activities in order to:

   a) minimize adverse impacts of construction activities on the wetland, and

   b) preserve, in its natural condition critical, ecotonal habitat for wildlife.

3. Certain minimum buffer widths (Table 38) are effective in minimizing the levels of direct human disturbance to wetlands in specific situations:

Table 38. Recommended buffer widths (ft) for use in the management of three wetland types at different land use intensities in the New Jersey coastal zone.

	Salt Marsh	Tidal Freshwater Marsh	Hardwood Swamp
Low Intensity[a] (<30% impervious cover)	50	100	50
High Intensity (>30% impervious cover)	100	150	100

[a] Low Intensity - low density or single family housing, recreational and agricultural land uses

High Intensity - industrial/commercial or high density residential land use

4. Where development is proposed in or adjacent to any of the following land use designations, High Intensity buffer widths (Table 38) are recommended in all cases:

   a) areas within a Division of Coastal Resources defined Limited Growth Region (NJAC 7:7E-5.3);

   b) areas of high environmental sensitivity (NJAC 7:7E-5.4);

   c) areas designated as Critical Wildlife Habitat (NJAC 7:7-3.37); and,

   d) areas adjacent to state wildlife management areas, federal wildlife refuges, and private sanctuaries.

5. Where development is proposed within that area of the New Jersey coastal zone under the jurisdiction of the New Jersey Pinelands Commission (NJAC 7:7-3.42) and:

   a) within the Pinelands Protection Area use buffer zones as recommended in Table 38; or if

   b) within the New Jersey Pinelands Preservation area, use High Intensity buffer widths in all cases,

   as consistent with the intent, policies and objectives of the Pinelands Commission.

5.0 RESEARCH NEEDS

The assessment of environmental impacts is difficult due to the long time period over which environmental changes occur. The limited scope imposed on this study by time constraints allowed for the examination of only a small subset of the array of possible human impacts on wetland systems and their mitigation using buffer zones. To more fully understand the role of buffers in the protection of coastal wetlands, further research is required in several areas:

1. The impacts of human disturbance on the species composition of wetlands over time and the implications of these changes on the functioning of wetland systems.

2. The effects of sedimentation on wetland communities and the implications of soil type and structure on the effectiveness of buffers.

3. The movement of pollutants (point and non-point sources) across buffer zones and the uptake of pollutants by vegetation in the buffer and the wetland, as well as the alteration of pollutant discharges by the buffer vegetation prior to its passage into the adjacent wetland.

4. The impacts of urban run-off and stormwater outfalls on the functioning of wetland systems.

5. The use made of the wetland/upland ecotone by wetland dependent wildlife and the minimum buffer widths required to maintain wildlife use of wetlands in the presence of human disturbance.

REFERENCES

Adams, L.W., D.L. Leedy, and T.M. Franklin. 1982. Wildlife enhancement in urban stormwater control. In: Proc. Stormwater Detention Facilities (W. DeGroot, ed.), p. 385. Amer. Soc. Civil Eng.

Adamus, P.R. 1983. A Method for Wetland Functional Assessment: Vol. II. FHWA assessment method. U.S. Dept. Trans., Federal Highway Admin. Report No. FHWA-IP-82-24. Office of Research, Devel. and Tech. Washington, D.C.

Adamus, P.R. and L.T. Stockwell. 1983. A Method for Wetland Functional Assessment: Vol. I. Critical review and evaluation concepts. U.S. Dept. Trans., Federal Highway Admin. Report No. FHWA-IP-82-23. Office of Research, Devel. and Tech. Washington, D.C.

Allen, H.H. 1978. Role of wetland plants in erosion control of riparian shorelines. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 403-414. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Anderson, P.H., M.W. Lefor, and W.C. Kennard. 1978. Transition zones of forested inland wetlands in northeastern Connecticut. Report No. 29, Univ. Conn. Inst. Water Research. 92 pp.

Anderson, P.H., M.W. Lefor, and W.C. Kennard. 1980. Forested wetlands in eastern Connecticut: Their transition zones and delineation. Water Res. Bull. 16(2):248-255.

Barber, R.T., W.W. Kirby-Smith, and P.E. Parsley. 1978. Wetland alterations for agriculture. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 642-651. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Bardecki, M.J., ed. 1981. Proceedings of a Pre-Conference Session of the Ontario Wetlands Conference. Federation of Ontario Naturalists and the Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 191 pp.

Barfield, B.J., D.T.Y. Kao, and E.W. Tollner. 1975. Analysis of the sediment filtering action of grassed media. Res. Report No. 90, Univ. Kentucky, Water Resource Research Inst. Lexington, KY. 50 pp.

Barnard, W.D., C.K. Ansell, J. Harn, and D. Kevin. No date. The Use and Regulation of Wetlands in the United States. Off. of Technology Assessment, U.S. Congress. Washington, DC. 10 pp.

Barton, D.R., W.D. Taylor, and R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. N. Amer. J. Fish. Mgmt. 5:364-378.

Bates, G.H. 1935. The vegetation of footpaths, sidewalks, cart-tracks and gateways. J. Ecol. 23:470-487.

Bell, K.L. and L.C. Bliss. 1985. Alpine disturbance studies: Olympic National Park, USA. Biol. Conserv. 5(1):25-32.

Bertulli, J.A. 1981. Influence of a forested wetland on a southern Ontario watershed. In: Proceedings of the Ontario Wetlands Conference (A. Champagne, ed.), pp. 33-47. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Best, L.B., D.F. Stauffer and A.R. Geier. 1978. Evaluating the Effects of Habitat Alteration on Birds and Small Mammals Occupying Riparian Communties. In: Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. U.S. Department of Agriculture. General Technical Report WO-12.

Bogardus, R., J. Schmid, and J. Andrea. 1979. The Estuarine Study. WAPORA, Inc., Washington, D.C. Prepared for N.J. Dept. Environmental Protection, Div. Coastal Resources.

Bourn, W.S. and C. Cotton. 1950. Some Biological Effects of Ditching Tidewater Marshes. U.S. Fish and Wildlife Service, Resource Report 19. 30 pp.

Bozeman, E.L. and J.M. Dean. 1980. The Abundance of Esturine Larval and Juvenile Fish in a South Carolina Intertidal Creek. Estuaries 2(3):89-97.

Bosenberg, R. 1977. Wetlands Ecology: I-multi-marsh investigations. Project #W-53-R-5. Job # and title: I-H Rodent Populations. N.J. Department of Environmental Protection.

Brater, E.F. and J.D. Sherrill. 1975. Rainfall-runoff relations on Urban and Rural Areas. EPA-670/2-75-046. U.S. Environ. Protection Agency, National Environmental Resource Center, Cincinnati, OH. 97 pp.

Braun-Blanquet, J. 1932. Plant sociology. English translation. McGraw-Hill, New York, NY. 438 pp.

Brazier, J.R. and G.W. Brown. 1973. Buffer strips for stream temperature control. Res. Paper No. 15, Forest Research Lab. Oregon State Univ. 9 pp.

Broderson, J.M. 1973. Sizing buffer strips to maintain water quality. M.S. Thesis, Univ. of Washington. 84 pp.

Brower, J.E. and J.H. Zar. 1984. Field and Laboratory Methods for General Ecology, 2nd ed. Wm. C. Brown Co. Publishers, Iowa. 226 pp.

Brown, G.W. and J.T. Krygier. 1970. Effects of clear-cutting on stream temperature. Water Resources Research 6(4):1133-1139.

Bryan, T.A. 1981. The Rhode Island Fresh Water Wetlands Program. In: Selected Proc. of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 603-611. Freshwater Society, MN. 660 pp.

Burden, R.F. and P.F. Randerson. 1972. Quantitative studies of the effects of human trampling on vegetation as an aid to the management of semi-natural areas. J. Appl. Ecol. 9:439-457.

Burton, T.M. 1981. The effects of riverine marshes on water quality. In: Selected Proc. of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 139-151. Freshwater Society, MN. 660 pp.

Burton, T.M., R.R. Turner, and R.C. Harriss. 1977. Suspended and dissolved solids exports from three north Florida watersheds in contrasting land use. In: Watershed Research in Eastern North America (D.L. Correll, ed.), pp. 471-485. Watershed Research Workshop, Chesapeake Bay Center for Envl. Studies, Smithsonian Institute. Edgewater, MD. 924 pp.

Carlson, C. and J. Fowler. 1980. The Salt Marsh of Southern New Jersey. Center for Environ. Research, Stockton State College. Pomona, NJ. 50 pp.

Carter, V., M.S. Bedinger, R.P. Novitzki, and W.O. Wilen. 1978. Water resources and wetlands. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 344-376. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Champagne, A., ed. 1981. Proceedings of the Ontario Wetlands Conference. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Chance, C.J. 1978. Multipurpose development programs in riparian ecosystems: The Tennesee Valley Authority Experience. In: Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems (R.R. Johnson, and J.F. McCormick, eds.), pp. 299-303. General Tech. Report WO-12, Forest Service, USDA. Washington, D.C. 410 pp.

Chenoweth, S.B. 1973 Fish Larvae of the Estuaries and Coast of Central Maine. Fishery Bulletin 71(1):105-113.

Clark, J. 1974. Coastal Ecosystems: Ecological Considerations for Management of the Coastal Zone. The Conservation Foundation. Washington, D.C. 178 pp.

Clark, J., J.S. Banta, and J.A. Zinn. 1980. Coastal Environmental Management: Guidelines for Conservation of Resources and Protection Against Storms. The Conservation Foundation. Washington, D.C. 161 pp.

Clark, J.R. 1977. Coastal Ecosystem Management: A Technical Manual for the Conservation of Coastal Zone Resources. The Conservation Foundation, John Wiley & Sons. NYC, New York. 928 pp.

Clark, J.R., ed. 1985. Coastal Resources Management: Development Case Studies. Coastal Management Publ. No. 3. Research Planning Inst., Inc. Columbia, SC.

Clark, J.S. and W.A. Patterson, III. 1985. The development of a tidal marsh: Upland and oceanic influences. Ecol. Monog. 55(2):189-217.

Cole, D.N. 1978. Estimating the susceptibility of wildland vegetation to trailside alteration. J. Appl. Ecol. 15:281-286.

Conant, F., P. Rogers, M. Baumgardner, C. McKell, R. Dasmann, and P. Reining. 1983. Resource inventory and baseline study methods for developing countries. Publ. No. 83-3. Amer. Assoc. for the Advancement of Science. Washington, D.C. 539 pp.

Cook, H.L. and F.B. Campbell. 1939. Characteristics of some meadow strip vegetations. Agric. Eng. 20:345-348.

Correll, D.L., ed. 1977. Watershed Research in Eastern North America. Vols. I and II. Watershed Research Workshop, Chesapeake Bay Center for Environ. Studies, Smithsonian Institute. Edgewater, MD. 924 pp.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Fish & Wildlife Service Publ. No. FWS/OBS-79/31, U.S. Dept. of Interior. Washington, D.C. 103 pp.

Cox, G.W. 1972. Laboratory Manual of General Ecology, 2nd ed. Wm. C. Brown Co. Publs., Iowa. 195 pp.

Custer, T.W. and R.G. osborn. 1978. Feeding-site Description of Three Heron Species Near Beaufort, North Carolina. Wading Birds Research Report #7, National Audubon Society.

Custer, T.W. and R.G. Osborn. 1978. Feeding Habitat Use by Colonially-breeding Herons, Egrets, and Ibises in North Carolina. The Auk 95:733-743.

Dale, D. and T. Weaver. 1974. Trampling effects on vegetation of the trail corridors of north Rocky Mountain forests. J. Appl. Ecol. 11:767-772.

Dance, K.W. and H.B.N. Hymes. 1980. Some Effects of Agricultural Land Use on Stream Insect Communities. Env. Poll. Ser. A. 22:19-28.

Darnell, R.M. 1978. Impact of human modification on the dynamics of wetland systems. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 200-209. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Darnell, R.M., W.E. Pequegnat, B.M. Jones, F.J. Benson, and R.E. Debenbaugh. 1976. Impacts of construction activities in wetlands of the United States. EPA Publ. No. 600/3-76-045. U.S. Environmental Protection Agency, Corvallis, OR. 392 pp.

Daubenmire, R. 1959. A canopy coverage method of vegetation analysis. Northw. Sci. 33:43-64.

de la Cruz, A. A. 1978. Production and Transport of Detritus in Wetlands. Wetland Functions and Values: The State of Our Understanding, 162-174. Proceedings of the National Symposium on Wetlands. American Water Resources Association, Minneapolis Minnesota.

DeLaune, R.D. and W.H. Patrick, Jr. 1979. Rate of Sedimentation and its Role in Nutrient Cycling in a Louisiana Salt Marsh. Estuary and Wetland Proceedings:401-412.

DeLaune, R.D., C.N. Reddy and W.H. Patrick, Jr. 1981. Accumulation of Plant Nutrients and Heavey Metals Through Sedimentation Processes and Accretion in a Louisiana Salt Marsh. Estuaries 4(4):328-334.

Dept. of Environ. Quality Engineering (DEQE). No date. A Guide to the Coastal Wetlands Regulations of the Massachusetts Wetlands Protection Act (G.L. 131, s.40). Division of Wetlands, DEQE. Boston, MA. 158 pp.

Dept. of Water Resources and Env. Engineering. 1982. Vermont Streambank Conservation Manual. Agency of Environmental Conservation, Montpelier, VT. 60 pp.

Derickson, W.K. and K.S. Price. 1973. The Fishes of the Shore Zone Rehoboth and Indian River Bays, Delaware. Transactions of the American Fisheries Society 102(3):552-562.

Dickson, J.G. and R.E. Noble. 1978. Verticle Distribution of Birds in a Louisiana Bottomland Hardwood Forest. The Wilson Bulletin 90(1):19-30.

Dorney, R.S. 1954. Ecology of marsh raccoons. J. Wildl. Manage. 18(2):217-225.

Drobney, R.D. and L.H. Frederickson. 1979. Food Selection by Woodducks in Relation to Breeding Status. Journal of Wildlife Management 43:109-120.

Duebbert, H.F. and H.A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. J. Wildl. Manage. 38(2):257-265.

Duebbert, H.F. and J.T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. J. Wildl. Manage. 44(2):428-437.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Co. San Francisco, CA.

Ehrenfeld, J.G. 1983. The effects of changes in land-use swamps of the New Jersey Pine Barrens. Biol. Cons. 25:353-375.

Ehrenfeld, J.G. and J.P. Schneider. 1983. The sensitivity of cedar swamps to the effects of non-point source pollution associated with suburbanization in the New Jersey Pine Barrens. Center for Coast. & Envl. Studies, Div. Water Resources. Prepared for U.S. Dept. of Interior, Office of Water Policy. 42 pp.

Eilers, H.P., A. Taylor, and W. Sanville. 1983. Vegetative delineation of coastal salt marsh boundaries. Environ. Mgmt. 7(5):443-452.

Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Tech. Rept. Y-87-1. U.S. Army Engineer Waterways Exp. Sta., Vicksburg, MS.

Erman, D.C., J.D. Newbold, and K.B. Roby. 1977. Evaluation of streamside bufferstrips for protecting aquatic organisms. Contribution No. 165, Calif. Water Resources Center, Univ. California. Davis, CA. 48 pp.

Fenzl, R.N. and J.R. Davis. 1964. Hydraulic resistance relationships for subsurface flows in vegetated channels. Trans. Amer. Soc. Agric. Eng. 1964:46-51, 55.

Ferren, W.R., Jr. and A.E. Schuyler. 1980. Intertidal vascular plants of river systems near Philadelphia. Proc. Acad. Nat. Sci. of Phila. 132:86-120.

Ferren, W.R., Jr., R.E. Good, R. Walker and J. Arsenault. 1981. Vegetation and flora of Hog Island, a brackish wetland in the Mullica River, New Jersey. Bartonia. 48: 1-10.

Fisler, G.F. 1961. Behavior of salt-marsh *Microtus* during winter high tides. *J. Mammal.* 42(1):37-43.

Fraser, J.C. 1972. Regulated Discharge and the Stream Environment. pp. 263-285. *In*: R.T Oglesby, C.A. Carlson and J.A. McCann (eds.), River Ecology and Man. Academic Press, N.Y.

Freda, J. and P.J. Morin. 1985. Adult home range of the Pine Barrens tree frog (*Hyla andersoni*) and the physical, chemical, and ecological characteristics of its preferred breeding ponds. Center for Coastal and Environ. Studies, Div. Pinelands Research. 42 pp.

Fried, E. 1981. Wetlands protection laws. *In*: Selected Proc. of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 595-602. Freshwater Society, MN. 660 pp.

Friedman, R.M. and C.B. DeWitt. 1978. Wetlands as carbon and nutrient reservoirs: A spatial, historical and societal perspective. *In*: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 175-185. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Gallagher, J.L and H.V. Kibby. 1980. Marsh Plants as Vectors in Trace Metal Transport in Oregon Tidal Marshes. *American Journal of Botany* 67(7):1069-1074.

Garbisch, E.W., Jr. 1977. Marsh development for shore erosion control. Proc. of the Workshop on the Role of Vegetation in Stabilization of the Great Lakes Shoreline. Comm. Coastal Zone Mgmt., Great Lakes Basin Comm.

Goldshore, L.P. 1979. The N.J. Riparian Rights Handbook. State NJ, County and Municipal Government Study Commission., NJ-DEP. 152 pp.

Golet, F.C. 1973. Classification and evaluation of freshwater wetlands as wildlife habitat in the glaciated Northeast. *Trans. Northeast Fish and Wildlife Conf.* 30:257-279.

Golet, F.C. 1976. Freshwater wetlands as wildlife habitats. *In*: Proc.: Third Wetlands Conference, pp. 84-103. Report No. 26, Univ. Conn. Inst. Water Research.

Golet, F.C. 1981. Wetlands and wildlife. In: A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast (J.S. Larson, ed.), pp. 12-14. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA. 91 pp.

Good, R.E. 1965. Salt marsh vegetation of Cape May, New Jersey. Bull. N.J. Acad. Sci. 10:1-11.

Good, R.E., J.G. Ehrenfeld, and C.T. Roman. 1985. Evaluation of the variable buffer distance in protecting Pinelands wetlands and water quality from development impacts. A proposal submitted to The Jessie Smith Noyes Foundation by CCES, Rutgers Univ., New Brunswick, NJ. 20 pp.

Good, R.E. and N.F. Good. 1975. Vegetation and production of the Woodbury Creek-Hessian Run freshwater tidal marshes. Bartonia. 43: 38-45.

Good, R.E., D.F. Whigham, and R.L. Simpson, eds. 1978. Freshwater Wetlands: Ecological Processes and Management Potential. Academic Press, Inc. NYC, NY. 378 pp.

Goodwin, R.H. and W.A. Niering. 1975. Inland Wetlands of the United States. Library of Congress, U.S.A. 550 pp.

Greene, G.E. 1950. Land use and trout streams. J. Soil Water Cons. 5:125-126.

Greeson, P.E., J.R. Clark, and J.E. Clark, eds. 1979. Wetland Fuctions and Values: The State of Our Understanding. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Gucinski, H. 1978. A note on the relation of size to ecological value of some wetlands. Estuaries 1(3):151-156.

Gupta, T.R. and J.H. Foster. 1981. Economics of preserving inland wetlands for water supply. In: A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast (J.S. Larson, ed.), pp. 17-20. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA.

Haan, C.T. and R.W. DeVore, eds. 1975. National Symposium on Urban Hydrology and Sediment Control. Office of Research and Engineering Services, Publ. No. UKY-BU109. Univ. Kentucky. Lexington, KY. 314 pp.

Hall, T.N., C. Jones, P. Meckley, and L. Wrabel. 1986. A proposal to adopt forest buffers as an agricultural best management practice. U.S. Fish and Wildl. Serv., Annapolis, MD. 14 pp. (mimeo).

Hamilton, S.F. and J.E. Erickson. 1984. Estuarine Mitigation: The Oregon Process. State of Oregon, Div. of State Lands. 62 pp.

Hamilton, S.F. and M.E. Harbert. 1973. Oregon Estuaries. State of Oregon, Div. of State Lands.

Harms, W.R. et al. 1980. The Effects of Flooding on the Swamp Forest in Lake Ocklawaha, Florida. Ecology 61:1412-1421.

Harris, V.T. 1953. Ecological Relationships of Meadow Voles and Rice Rats in Tidal Marshes. Journal of Mammalogy 34(4): 479-487.

Harris, S.W. and W.H. Marshall. 1963. Ecology of Water Level Manipulations on a Northern Marsh. Ecology 44:331-343.

Haussman, R.F. and E.W. Pruett. 1978. Permanent logging roads for better woodlot management. U.S. Dept. of Agric., Forest Serv., Northeast Area. Broomall, PA.

Hawkins, P. and C.F. Leck. 1977. Breeding bird communities in a tidal freshwater marsh. Bull. N.J. Acad. Sci. 22: 12-17.

Heit, W.S. 1944. Food habits of red foxes of the Maryland marshes. J. Mammal. 25:55-58.

Hewlett, J.D. and J.C. Fortson. 1982. Stream temperature under an inadequate buffer strip in the southeast Piedmont. Water Resources Bull. 18(6):983-988.

Hoffman, E.J., G.L. Mills, J.S. Latimer, and J.G. Quill. 1984. Urban runoff as a source of polycyclic aromatic hydrocarbons to coastal waters. Environ. Sci. Tech. 18:580-587.

Hollander, M. and D.A. Wolfe. 1973. Nonparametric statistical methods. John Wiley and Sons, Inc., New York, NY. 503 pp.

Horwitz, E.L. 1978. Our Nation's Wetlands. An interagency task force report coordinated by the Council on Environ. Qual. Washington, DC. 70 pp.

Howell, P.T. 1984. Use of salt marshes by meadow voles. Estuaries 7(2):165-170.

Hummel, M. 1981. Wetland wildlife values. In: Proceedings of the Ontario Wetlands Conference (A. Champagne, ed.), pp. 27-32. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Ivanovici, A.M., ed. 1984. Inventory of Declared Marine and Estuarine Protected Areas in Australian Waters. Vol. 1. Australian National Parks & Wildlife Service, Publ. No. 12.

Jaworski, E. 1981. The economics of wetland protection. In: Proceedings of the Ontario Wetlands Conference (A. Champagne, ed.), pp. 58-62. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Johnson, R.R. and J.F. McCormick. 1978. Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. General Tech. Report WO-12, Forest Service, USDA. Washington, D.C. 410 pp.

Jones, J.C. and M.P. Lynch. 1978. Local and environmental management--can it work? A case study of the Virginia Wetlands Act. Coastal Zone Mgmt. J. 4:127-150.

Kadlec, R.H. and J.A. Kadlec. 1978. Wetlands and water quality. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 436-456. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Karr, J.R. and I.J. Schlosser. 1977. Impact of nearstream vegetation and stream morphology on water quality and stream biota. National Tech. Info. Service Publ. No. PB-272 652. Prepared for U.S. Envl. Protection Agency, Envl. Research Lab. Athens, GA. 90 pp.

Karr, J.R. and I.J. Schlosser. 1978. Water resources and the land-water interface. Science 201:229-234.

Kao, D.T.Y., B.J. Barfield, and A.E. Lyons, Jr. 1975. On-site sediment filtration using grass strips. In: National Symposium on Urban Hydrology and Sediment Control (C.T. Haan and R.W. DeVore, eds.), pp. 73-82. Office of Research and Engineering Services, Publ. No. UKY BU109. Univ. Kentucky. Lexington, KY. 314 pp.

Kibby, H.V. 1978. Effects of wetlands on water quality. In: Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems (R.R. Johnson, and J.F. McCormick, eds.), pp. 289-298. General Tech. Report WO-12, Forest Service, USDA. Washington, D.C. 410 pp.

Klein, S.B. 1980. Select state inland wetland protection laws: A review of state laws and their natural resource data requirements. Natural Resource Info. Systems Project, National Conference of State Legis. Denver, CO. 108 pp.

Kneib, R.T. 1978. Habitat, Diet, Reproduction and Growth of the Spotfin Killifish, *Fundulus luciae* from a North Carolina Salt Marsh. *Copeia* 1:164-168.

Kreutzwiser, R. 1981. Recreational values of lakeshore marshes. *In*: Proceedings of the Ontario Wetlands Conference (A. Champagne, ed.), pp. 48-57. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Kropp, R.H. 1982. Comprehensive stormwater management in New Jersey. *NJ Mosq. Control Assoc.* 69:42-48.

Lake, J. and J. Morrison. 1977. Environmental impact of land use on water quality. EPA-905/9-77-007-B. Prepared for U.S. EPA Great Lakes National Program Office. Chicago, IL.

Lantz, R.L. 1971. Guidelines for stream protection in logging operations. A report of the research division, Oregon State Game Commission. Portland, OR. 29 pp.

La Prade, D. Nov. 27, 1985. New Setbacks Opposed. *Outer Banks Current* 6(34):1,2.

Larson, J.S., ed. 1973. A guide to important characteristics and values of freshwater wetlands in the northeast. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA. 91 pp.

Larson, J.S. 1975. Evaluation models for public management of freshwater wetlands. *Trans. N. Amer. Wildl. Nat. Resource Conf.* 40:220-228.

Larson, J.S., ed. 1976. Models for evaluation of freshwater wetlands. Water Resources Research Center, Publ. No. 32. Univ. of Massachusetts, Amherst, MA.

Larson, J.S. 1981. Wetlands and floods. *In*: A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast (J.S. Larson, ed.), pp. 15-16. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA. 91 pp.

Lee, R. and D.E. Samuel. 1976. Some thermal and biological effects of forest cutting in West Virginia. *J. Environ. Qual.* 5(4):362-366.

Lewis, J.C. and E.W. Bunce, eds. 1980. Rehabilitation and creation of selected coastal habitats: Proceedings of a workshop. FWS/OBS-80/27. U.S. Fish & Wildlife Service, Biological Services Program. Washington, D.C. 162 pp.

Liddle, M.J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. Biol. Conserv. 7:17-36.

Linde, 1969. Techniques for Wetland Management. Research Rep. No. 45, Dept. of Natural Resources. Madison, WI.

Lonard, R.I., E.J. Clairain, R.T. Huffman, J.W. Hardy, L.D. Brown, P.E. Ballard, and J.W. Watts. 1981. Analysis of methodologies used for the assessment of wetlands values. Envl. Lab., U.S. Army Eng. Waterways Exp. Sta., Vicksburg, MS. Prepared for U.S. Water Resources Council. Washington, D.C. 79 pp.

Loosanoff, V.L. and F.D. Tommers. 1948. Effects of Suspended Slit and other Substances on Rate of Feeding of Oysters. Science 107:69-70.

Lugo, A.E. and M.M. Brinson. 1978. Calculations of the value of saltwater wetlands. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 120-130. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

McCormick, J. and T. Ashbaugh. 1972. Vegetation of a section of Oldmans Creek tidal marsh and related areas in Salem and Gloucester Counties, New Jersey. Bull. N.J. Acad. Sci. 17: 31-37.

McLeese, R.L. and E.P. Whiteside. 1977. Ecological Effects of Highway Construction Upon Michigan Woodlots and Wetlands: Soil Relationships. Journal of Environmental Quality 6:467-471.

Magoon, O.T., H. Converse, D. Miner, D. Clark, and L.T. Tobin, eds. 1985. Coastal Zone '85, Volumes 1 & 2. Amer. Soc. Civil Engineers. NYC, NY. 2672 pp.

Markley, M.L. 1979. Soil series of the Pine Barrens. In: Pine Barrens: Ecosystem and Landscape (R.T.T. Forman, ed.), pp. 81-93. Academic Press, NY. 601 pp.

Meanley, B. and J.S. Webb. 1963. Nesting ecology and reproductive rate of the red-winged blackbird in tidal marshes in the upper Chesapeake Bay region. Chesapeake Science. 4: 90-100.

Meeks, R.L. 1969. The Effect of Drawdown Date on Wetland Plant Succession. Journal of Wildlife Management 33:817-821.

Merriner, J.V., W.H. Kriete and G.C. Grant. 1976. Seasonality, Abundance and Diversity of Fishes in the Piankatank River, Virginia (1970-1971). Chesapeake Science 17(4):238-245.

Miller, A.W. and B.D. Collins. 1954. A Nesting Study of Ducks and Coots on Tule Lake and Lower Kalmath National Wildlife Refuges. California Fish and Game 40:17-37.

Mitsch, W.J., C.L. Dodge and J.R. Weimhoff. 1977. Forested Wetlands for Water Resource Management in Southern Illinois. University of Illinois at Urbana-Champaign, Water Resource Center, Research Report No. 132, NTIS No. PS 276 659.

Moring, J.R. 1975. The Alsea watershed study: Effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part III - Discussion and Recommendations. Fishery Res. Rep. No. 9, Oregon Dept. Fish & Wildlife. Corvallis, OR. 23 pp.

Motts, W.S. and R.W. Heeley. 1981. Wetlands and ground water. In: A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast (J.S. Larson, ed.), pp. 5-8. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA. 91 pp.

Mudroch, A. and J.A. Capobianco. 1979. Effects of Treated Effluent on a Natural Marsh. Journal Water Pollution Control Federation 51(9):2243-2256.

N.J. Dept. of Environ. Protection. 1982. Coastal Resource and Development Policies. N.J. DEP, Div. Coastal Resources, Bureau of Coastal Planning and Devel. Trenton, NJ. 196 pp.

N.J. Dept. of Environ. Protection, Off. of Environ. Analysis. 1979. Tidelands Index: Lands Subject to Investigation for Areas Now or Formerly Below Mean High Water. Natural Resource Council.

N.J. Dept. of Environ. Protection and U.S. Dept. of Commerce. 1978. New Jersey Coastal Management Program--Bay and Ocean Shore Segment. N.J. DEP, Div. Marine Services, Office of Coastal Zone Mgmt. (OCZM), Trenton, NJ and National Oceanic and Atmospheric Admin. (NOAA), OCZM, Washington, D.C. 466 pp.

Newbold, J.D. 1977. The use of benthic macroinvertebrates as indicators of logging impact on streams with an evaluation of buffer strip effectiveness. PhD dissertation, Univ. California, Berkeley. Berkeley, CA. 103 pp.

Newbold, J.D., D.C. Erman, and K.B. Roby. 1980. Effects of logging on macroinvertebrates in streams with and without buffer strips. Can. J. Fish. Aquatic Sci. 37:1076-1085.

Newling, C.J. and H.K. Smith. 1982. The Corps of Engineers Wetland Research Program. Wetlands 2:280-285.

Niering, W.A. 1973. The ecological role of inland wetlands. In: Proc.: Wetlands Conference, pp. 100-109. Report No. 21, Univ. Conn. Inst. Water Research.

Oberts, G.L. 1981. Impact of wetlands on watershed water quality. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 213-226. Freshwater Society, MN. 660 pp.

Odum, E.P. 1971. Fundamentals of ecology. W.B. Saunders Company, Philadelphia, PA. 574 pp.

Odum, H.T. 1978. Principles for interfacing wetlands with development. In: Environmental Quality Through Wetlands Utilization (M.A. Drew, ed.), pp. 29-56. Coord. Council on the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin. Tallahassee, FL.

Odum, W.E., M.L. Dunn, and T.J. Smith III. 1978. Habitat value of tidal fresh water wetlands. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 248-255. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Odum, W.E., T.J. Smith III, J.K. Hoover, and C.C. McIvor. 1984. The ecology of tidal freshwater marshes of the United States east coast: a community profile. U.S. Fish and Wildl. Serv. FWS/OBS-83/17. 177 pp.

Ogawa, H. and J.W. Male. 1983. The Flood Mitigation Potential of Inland Wetlands. Water Resources Research Center. Publication No. 13. University of Massachusetts at Amherst.

Olsen, S. and G.L. Seavey. 1983. The State of Rhode Island Coastal Resources Management Program. Coastal Resources Management Council, Providence, RI. 127 pp.

O'Meara, T., T. Chaney, and W. Klockner. 1976. Maryland Uplands Natural Areas Study, Field Notebook, Western Shore. Coastal Zone Management Program, Maryland Dept. Natural Resources. Annapolis, MD. 195 pp.

Oregon State Soil and Water Conservation Commission. 1978. Stream Corrider Management. A Report for the Dept. of Environmental Quality. Enterprise, OR. 59 pp.

Oviatt, C.A. and S.W. Nixon. 1973. The Demersal Fish of Narragansett Bay: An Analysis of Community Structure, Distribution and Abundance. Estuarine and Coastal Marine Science 1:361-378.

Palfrey, R. and E. Bradley. No date. Natural Buffer Areas Study. Tidewater Administration, Maryland Dept. Natural Resources. 31 pp.

Parr, D.E., M.D. Scott and D.D. Kennedy. 1979. Autumn Movements and Habitat Use by Woodducks in Southern Illinois. Journal of Wildlife Management 43:102-108.

Phillips, J.D. 1984. Transgression and vegetation change, Delaware Bay, New Jersey. Proc. Coastal Society

Porter, B.W. 1981. The wetland edge as a communtiy and its value to wildlife. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 15-25. Freshwater Society, MN. 660 pp.

Reed, A. and G. Moisan. 1971. The Spartina Tidal Marshes of the St. Lawrence Estuary and Their Importance to Aquatic Birds. Le Naturaliste Canadien 98:905-922.

Reed, D.M. 1981. Areawide wetland protection and management efforts in southeastern Wisconsin. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 519-528. Freshwater Society, MN. 660 pp.

Reed, P.B., Jr. 1986. Wetland plants of the state of New Jersey 1986. U.S. Fish and Wildl. Serv. WELUT-86/W12.30.

Reimold, R.J. and W.H. Queen, eds. 1974. Ecology of Halophytes. Academic Press, Inc. NYC, NY. 605 pp.

Reppert, R.T. 1981. Wetland values, concepts and methods for wetlands evaluation. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 385-393. Freshwater Society, MN. 660 pp.

Richards, C.E. and M. Castagna. 1970. Marine Fishes of Virginia's Eastern Shore (Inlet and Marsh, Seaside Waters). Chesapeake Science 11(4):235-248.

Richardson, B. 1981. Selected Proceedings of the Midwest Conference on Wetland Values and Management. Freshwater Society, MN. 660 pp.

Roman, C.T. and R.E. Good. 1983. Wetlands of the New Jersey Pinelands: Values, functions, impacts and a proposed buffer delineation model. N.J. Pinelands Comm. Publ. No. 82-4074. Div. of Pinelands Research, Center for Coastal & Environ. Studies.

Roman, C.T. and R.E. Good. 1985. Delineating wetland buffer protection areas: The New Jersey Pinelands model. Proc. National Wetlands Assessment Symposium. 22 pp.

Roman, C.T., R.A. Zampella, and A.Z. Jaworski. 1983. Vegetation, soils and water table relationships in wetland to upland transition zones of the New Jersey Pine Barrens. Bull. Ecol. Soc. Amer. 64:172-173.

Roman, C.T., R.A. Zampella, and A.Z. Jaworski. 1985. Wetland boundaries in the New Jersey Pinelands: Ecological relationships and delineation. Water Resources Bull. 21(6):1005-1012.

Sadler, R.R. 1970. Buffer strips: A possible application of decision theory. BLM Tech. Note, Filing Code 5000-6512. U.S. Dept. Interior. Portland, OR.

Salm, R.V. and J.R. Clark. 1984. Marine and Coastal Protected Areas: A Guide for Planners and Managers. International Union for Conservation of Nature and Natural Resources, Switzerland. ISBN 2-88032-805-5.

Sather, J.H. and R.D. Smith. 1984. An overview of major wetland functions. Publ. No. FWS/OBS-84/18, U.S. Fish & Wildlife Service, Biological Services Program. 68 pp.

Schitoskey, F.,Jr. and R.L. Linder. 1978. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 307-311. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Schultz, C.J. 1981. Regulating shoreland-wetlands in Wisconsin. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 587-593. Freshwater Society, MN. 660 pp.

Scott, M.L., R.R. Sharitz and L.C. Lee. 1985. Disturbance in a Cypress-tupelo Wetland: an Interaction Between Thermal Loading and Hydrology. Wetlands 5:53-68.

Shabman, L.A. and S.S. Batie. 1981. Basic economic concepts important for wetlands valuation. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 431-443. Freshwater Society, MN. 660 pp.

Shannon, C.E. and W. Weaver. 1949. The mathematical theory of communication. The University of Illinois Press, Urbana.

Shay, J. 1981. Wetland protection in the 80's. In: Proceedings of the Ontario Wetlands Conference (A. Champagne, ed.), pp. 19-25. Federation of Ontario Naturalists and Dept. of Applied Geography, Ryerson Polytechnical Inst. Toronto, Ontario. 193 pp.

Shenker, J.M. and J.M. Dean. 1979. The Utilization of an Intertidal Salt Marsh Creek by Larval and Juvenile Fishes: Abundance, Diversity and Temporal Variation. Estuaries 2(3): 154-163.

Shisler, J.K. 1973. Pioneer plants on spoil piles associated with mosquito ditching. Proc. 60th Ann. Mtg. New Jersey Mosq. Exterm. Assoc. 135-141.

Shisler, J.K. and D.C. Charette. 1984. Evaluation of artificial salt marshes in New Jersey. Publ. No. P-40502-01-84, New Jersey Agricultural Exp. Sta. New Brunswick, NJ. 160 pp.

Shulze, T.L., E.J. Hansens and J.R Trout. 1975. Some Environmental Factors Affecting the Daily and Seasonal Movements of the Salt Marsh Greenhead, *Tabanus nigrovittatus*. Environmental Entomology 4:965-971.

Shure, D.J. 1970. Ecological relationships of small mammals in a New Jersey barrier beach habitat. J. Mammal. 51(2):267-278.

Simpson, R.L., R.E. Good, M.A. Leck and D.F. Whigham. 1983. The ecology of freshwater tidal wetlands. Bioscience. 33:255-259.

Smardon, R.C. 1981. Visual-cultural values of wetlands. In: A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast (J.S. Larson, ed.), pp. 9-11. Water Resources Research Center, Publ. No. 31. Univ. of Massachusetts, Amherst, MA. 91 pp.

Smith, R.L. 1980. Ecology and Field Biology. Harper and Row, Publishers, Inc., New York, N.Y. 835 pp.

Snedaker, S.C. and C.D. Getter. 1985. Coastal Resources Management Guidelines. Coastal Management Publ. No. 2. Research Planning Inst., Inc. Columbia, SC.

Solomon, R.C., B.K. Colbert, W.J. Hansen, S.E. Richardson, L.W. Canter, and E.C. Vlachos. 1977. Water resources assessment methodology (WRAM)-- impact assessment and alternative evaluation. Tech. Report Y-77-1, Envl. Effects Lab., U.S. Army Eng. Waterways Exp. Sta. Vicksburg, MS. 150 pp.

Sorensen, J.C., S.T. McCreary, and M.J. Hershman. 1984. Institutional Arrangements for Management of Coastal Resources. Coastal Management Publ. No. 1. Research Planning Inst., Inc. Columbia, SC. 165 pp.

SAS Institute Inc. 1985. SAS user's guide: Statistics, Version 5 Edition. SAS Institute Inc., Cary, NC. 956 pp.

Stotts, V.D. and D.E. Davis. 1960. The black duck in the Chesapeake Bay of Maryland: breeding behavior and biology. Chesapeake Science. 1: 127-154.

Sullivan, M.J. and F.C. Daiber. 1974. Responce in Production of Cordgrass, Spartina alterenifolia, to Inorganic Nitrogen and Phosphorus Fertilizer. Chesapeake Science 15:121-123.

Swift, L.W. and S.E. Baker. 1973. Lower water temperatures within a streamside buffer strip. U.S. Dept. of Agric., Forest Serv. Res. Note SE-193. Southeast. For. Exp. Sta., Asheville, NC. 7 pp.

Swift, L.W., Jr. and J.B. Messer. 1971. Forest cuttings raise temperatures of small streams in the southern Appalachians. J. Soil Water Cons. 26:111-116.

Talbot, C.W., K.W. Able and J.K. Shisler. 1979. Salt Marsh Fishes of New Jersey. A Preliminary Survey. Bulletin of the N.J. Academy of Science 24:99.

Teal, J.M. 1962. Energy Flow in the Salt Marsh Ecosystem of Georgia. Ecology 43(4):614-624.

Tedrow, J.C.F. 1979. Development of Pine Barrens Soils. In: Pine Barrens: Ecosystem and Landscape (R.T.T. Forman, ed.), pp. 61-79. Academic Press, NY. 601 pp.

Thayer, G.W., et al. 1978. Habitat Values of Salt Marshes, Mangroves and Seagrasses for Aquatic Organisms. pp. 235-247, in: Greeson, P.E., J.R Clark and J.E Clark. Wetland Functions and Values: the State of Our Understanding. American Water Resource Association, Technical Publication Series No. TPS79-2 Minneapolis, Minnesota. 674 pp.

Thibodeau, F.R. and N.H. Nickerson. 1985. Changes in a wetland plant association induced by impoundment and draining. Biol. Cons. 33: 269-279.

Thurow, C., W. Toner, and D. Erley. 1975. Performance controls for sensitive lands: A practical guide for local administrators. U.S. Dept. of Commerce, National Tech. Info. Service Publ. No. PB-245 177. Prepared for, Wash. Environ. Research Center, Office of Research and Development. U.S. Environ. Protection Agency. Washington, D.C. 523 pp.

Tiner, R.W., Jr. 1985. Wetlands of New Jersey. U.S. Fish & Wildlife Service, National Wetlands Inventory. Newton Corner, MA. 117 pp.

Tollner, E.W., B.J. Barfield, and C.T. Haan. 1975. Vegetation as a sediment filter. In: National Symposium on Urban Hydrology and Sediment Control (C.T. Haan and R.W. DeVore, eds.), pp. 61-64. Office of Research and Engineering Services, Publ. No. UKY BU109. Univ. Kentucky, Lexington, KY. 314 pp.

Tollner, E.W., B.J. Barfield, C.T. Haan, and T.Y. Kao. 1976. Suspended sediment filtration capacity of simulated vegetation. Trans. Amer. Soc. Agric. Eng. 19:678-682.

Trimble, G.R., Jr. and R.S. Sartz. 1957. How far from a stream should a logging road be located? J. Forestry 55:339-341.

Valiela, I., J.M. Teal amd W. Sass. 1973. Nutrient Retention in Salt Marsh Plots Experimentally Fertilized with Sewage Sludge. Esturine and Coastal Marine Science 1:261-269.

Valiela, I., J.M. Teal and W. Sass. 1975. Production and Dynamics of Salt Marsh Vegetation and the Effects of Experimental Treatment with Sewage Sludge: Biomass, Production and Species Composition. Journal of Applied Ecology 12:973-982.

Van Roatle, C.D., I. Valiela, E.J. Carpenter and J.M. Teal. 1974. Inhibition og Nitrogen in Salt Marshes Measure and By Acetylene Reduction. Estuary and Coastal Marine Science 2:301-305.

Voigts, D.K. 1976. Aquatic Invertibrate Abundance in Relation to Changing Marsh Vegetation. American Midland Naturalist 95:313-322.

Uetz, G.W., K.L. Van Derlaan, G.F. Summers, P.A.K. Gibson and L.L. Getz. 1979. The Effects of Flooding on Floodplain Arthropod Distribution, Abundance and Community Structure. American Midland Naturalist 101: 286-299.

U.S. Army Corps of Engineers. 1980. A habitat evaluation system (HES) for water resources planning. Lower Miss. Valley Div. Vicksburg, MS. 89 pp.

U.S. Environmental Protection Agency. 1981. New England Wetlands: Plant Identification and Protective Laws. U.S. EPA, Region 1. JFK Federal Bldg. Boston, MA.

U.S. Environmental Protection Agency. 1984. Technical Report: Literature Review of Wetland Evaluation Methodologies. U.S. EPA, Region 5. Chicago, IL. 120 pp.

Walker, M. 1980. Utilization by Fishes of a Blackwater Creek Floodplain in North Carolina. M.S. Thesis. E. Carolina University.

Walker, R.A. 1973. Wetlands preservation and management on Chesapeake Bay: The role of science in natural resource policy. Coastal Zone Mgmt. J. 1(1):75-101.

Weinstein, M.P. 1979. Shallow Marsh Habitats as Primary Nurseries fot Fishes and Shellfish, Cape Fear River, North Carolina. Fishery Bulletin 77(2):339-357.

Weller, M.W. 1978. Wetland habitats. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 210-234. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Wiley, J.W. and F.E. Lohrer. 1973. Additional Records of Non-fish Prey Taken by Osprey. The Wilson Bulletin 85(4):468-470.

Willard, D.E. 1977. The Feeding Ecology and Behavior of Five Species of Herons in Southeastern New Jersey. The Condor 79:462-470.

Williams, J.D. and C.K. Dodd, Jr. 1978. Importance of wetlands to endangered and threatened species. In: Wetland Functions and Values: The State of Our Understanding (P.E. Greeson, J.R. Clark, and J.E. Clark, eds.), pp. 565-575. Amer. Water Resources Assoc., Tech. Publ. Series No. TPS79-2. Minneapolis, MN. 674 pp.

Wilson, L.G. 1967. Sediment removal from flood water by grass filtration. Trans. Amer. Soc. Agric. Eng. 10:35-37.

Wolverton, C.L. 1981. Michigan's state-level wetland protection program. In: Selected Proceedings of the Midwest Conference on Wetland Values and Management (B. Richardson, ed.), pp. 565-572. Freshwater Society, MN. 660 pp.

Wycoff, R.L. and R.D.G. Pyne. 1975. Urban water management and coastal wetland protection in Collier County, Florida. Water Resources Bull. 11(3):455-468.

Young, R.A. and C.K. Mutchler. 1969. Effect of slope shape on erosion and runoff. Trans. Amer. Soc. Agric. Eng. 12:231-239.

Zampella, R.A. and C.T. Roman. 1983. Wetlands protection in the New Jersey Pine Barrens. Wetlands 3:124-133.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ. 620 pp.

Zedler, J.B. 1982. The ecology of southern California coastal salt marshes: A community profile. FWS/OBS-81/54. U.S. Fish & Wildlife Service, Biological Services Program. Washington, D.C. 110 pp.

Zedler, J.B. 1984. Salt Marsh Restoration: A Guidebook for Southern California. California Sea Grant Report No. T-CSGCP-009. San Diego State Univ., San Diego, CA.

APPENDICES

Table 39. Species number, scientific name and common name of plant species encountered during sampling of wetland/buffer study sites.

1	Achillea millefolium	Yarrow
2	Alisma triviale	Water Plaintain
3	Althaea officinalis	Marsh Mallow
4	Amaramthus cannabinus	Water Hemp
5	Ambrosia artemisiifolia	Common Ragweed
6	Ambrosia trifida	Great Ragweed
7	Ammophila breviligulata	American Beach Grass
8	Apios americana	Ground Nut
9	Apocynum spp.	Dogbane
10	Arisaema spp.	Jack-in-the-pulpit
11	Artemisia vulgaris	Mugwort
12	Asclepias spp.	Milkweed
13	Aster praeltus	Willow Aster
14	Aster puniceus	Purple-stemmed Aster
15	Aster radula	Rough-leaved Aster
16	Aster spp.	Aster
17	Aster subulatus	Annual Salt Marsh Aster
18	Aster tenuifolius	Perrenial Salt Marsh Aster
19	Athyrium filix-femina	Lady Fern
20	Atriplex patula	Orache
21	Baptisia tintoria	Wild Indigo
22	Barbaria vulgaris	Wintercress
23	Bartonia virginica	Bartonia
24	Bidens aristosa	Tick Sunflower
25	Bidens frondosa	Beggar-tick
26	Bidens laevis	Bur-marigold
27	Bidens lutea	Beggar-tick
28	Bidens spp.	Beggar-tick
29	Boehmeria cylindrica	False Nettle
30	Botrychium dissectum	Cut-leaved Grape Fern
31	Cakile edentula	Sea Rocket
32	Caltha palustris	Marsh Marigold
33	Carex intumescens	Sedge
34	Carex lurida	Sedge
35	Carex spp.	Sedge
36	Carex venusta	Sedge
37	Centaurea spp.	Knapweed
38	Chenopodium album	Lamb's-quarters
39	Chelone glabra	Turtlehead
40	Cicuta maculata	Water Hemlock
41	Cinna arundinacae	Cinna
42	Circium arvense	Canada Thistle
43	Commelina communis	Asiatic Day Flower

Table 39. Continued.

44	*Convolvulus arvensis*	Field Bindweed
45	*Convolvulus sepium*	Hedge Bindweed
46	*Cuscuta gronovii*	Dodder
47	*Cyperus erythrorhizos*	Cyperus
48	*Cyperus flavescens*	Cyperus
49	*Cyperus spp.*	Cyperus
50	*Cypripedium acaule*	Pink Lady's Slipper
51	*Datura stramonium*	Jimsonweed
52	*Daucus carota*	Wild Carrot
53	*Decodon verticillatus*	Swamp Loosestrife
54	*Dennstaedtia punctilobula*	Hay-scented Fern
55	*Desmodium spp.*	Tick-trefoil
56	*Digitaria serotina*	Crabgrass
57	*Distichlis spicata*	Spike grass
58	*Drosera filiformis*	Thread-leaved Sundew
59	*Drosera intermedia*	Spatulate-leaved Sundew
60	*Drosera rotundifolia*	Round-leaved Sundew
61	*Drosera spp.*	Sundew
62	*Echinochola crusgalli*	Barnyard Grass
63	*Eleocharis parvula*	Eleocharis
64	*Eleocharis rostellata*	Eleocharis
65	*Eleocharis spp.*	Eleocharis
66	*Epilobium coloratum*	Purpleleaved Willow Herb
67	*Erechtites hieracifolia*	Fireweed
68	*Eriophorum virginicum*	Cottongrass
69	*Eupatorium dubium*	Joe-pye-weed
70	*Eupatorium hyssopifolium*	Hyssop-leaved Thorwort
71	*Eupatorium maculatum*	Spotted Joe-pye-weed
72	*Eupatorium perfoliatum*	Boneset
73	*Eupatorium pilosum*	Hairy Thoroughwort
74	*Eupatorium purpureum*	Sweet Joe-pye-weed
75	*Eupatorium rotundifolium*	Round-leaved Thorwort
76	*Eupatorium rugosum*	White Snakeroot
77	*Eupatorium serotinum*	Late Flowering Thorwort
78	*Eupatorium spp.*	Thoroughwort
79	*Fragaria spp.*	Strawberry
80	*Frageria virginiana*	Common Strawberry
81	*Galium spp.*	Bedstraw
82	*Galium triflorum*	Fragrant Bedstraw
83	*Geum canadense*	White Avens
84	*Geum spp.*	Avens
85	*Geum virginianum*	Rough Avens
86	*Glechoma hederacea*	Ground Ivy
87	*Helianthus spp.*	Sunflower
88	*Heteranthera reniformis*	Mud Plaintain

Table 39. Continued.

89	*Hibiscus palustris*	Swamp Rose Mallow
90	*Hypericum mutilum*	Dwarf St. Johnswort
91	*Hypericum virginicum*	Marsh St. Johnswort
92	*Impatiens capensis*	Jewelweed
93	*Ipomoea pandurata*	Wild Potato Vine
94	*Ipomoea spp.*	Morning Glory
95	*Iris tridentata*	Blue Flag
96	*Juncus dichotomus*	Juncus
97	*Juncus effusus*	Soft Rush
98	*Juncus gerardi*	Black Grass
99	*Juncus roemerianus*	Juncus
100	*Juncus spp.*	Juncus
101	*Kosteletzhya virginica*	Seashore Mallow
102	*Lactuca canadensis*	Wild Lettuce
103	*Leersia oryzoides*	Rice Cutgrass
104	*Lepidium virginicum*	Poor Man's Pepper
105	*Lilium superbum*	Turk's Cap Lily
106	*Limonium nashii*	Sea Lavender
107	*Linaria vulgaris*	Butter-and-eggs
108	*Lycopodium alopecuroides*	Foxtail Clubmoss
109	*Lycopodium complanatum*	Running Pine
110	*Lycopodium obscurum*	Tree Clubmoss
111	*Lycopus americanus*	Horehound
112	*Lycopus virginicus*	Bugleweed
113	*Lysimachia ciliata*	Fringed Loosestrife
114	*Lysimachia quadrifolia*	Whorled Loosestrife
115	*Lythrum lineare*	Narrowleaved Loosestrife
116	*Lythrum salicaria*	Purple Loosestrife
117	*Maianthemum canadense*	Canada May Flower
118	*Medeola virginiana*	Indian Cucumber Root
119	*Mentha piperita*	Peppermint
120	*Mikania scandens*	Climbing Hempweed
121	*Monotropa uniflora*	Indian-pipe
122	*Nuphar spp.*	Spatterdock
123	*Oenothera biennis*	Evening Primrose
124	*Oenothera spp.*	Primrose
125	*Onoclea sensibilis*	Sensitive Fern
126	*Osmunda cinnamomea*	Cinnamon Fern
127	*Osmunda regalis*	Royal Fern
128	*Oxalis spp.*	Wood Sorrel
129	*Panax quinquefolius*	Wild Ginsing
130	*Panicum polyanthes*	Panic Grass
131	*Panicum spp.*	Panic Grass
132	*Peltandra virginica*	Arrow Arum
133	*Phragmites communis*	Phragmites

Table 39. Continued.

134	*Phytolacca americana*	Pokeweed
135	*Podophyllum peltatum*	Mayapple
136	*Polygala lutea*	Yellow Milkwort
137	*Polygonatum biflorum*	Solomon's-seal
138	*Polygonella articulata*	Jointweed
139	*Polygonum arifolium*	Halberd-leaved Tearthumb
140	*Polygonum cespitosum*	Long Bristled Smartweed
141	*Polygonum cuspidatum*	Japanese Knotweed
142	*Polygonum pensylvanicum*	Pennsylvania Smartweed
143	*Polygonum punctatum*	Water Smartweed
144	*Polygonum sagittatum*	Arrow-leaved Tearthumb
145	*Polygonum scandens*	Climbing False Buckwheat
146	*Polygonum spp.*	Smartweed
147	*Pontederia cordata*	Pickerelweed
148	*Potentilla canadensis*	Dwarf Cinquefoil
149	*Potentilla spp.*	Cinquefoil
150	*Prenanthes altissima*	Tall White Lettuce
151	*Prenanthes trifoliata*	Gall-of-the-earth
152	*Pteridium aquilinum*	Bracken Fern
153	*Rhynchospora filifolia*	Horned Rush
154	*Rumex acetosella*	Sheep Sorrel
155	*Rumex crispus*	Curly Dock
156	*Sagittaria graminea*	Grass-leaved Arrowhead
157	*Sagittaria latifolia*	Broad-leaved Arrowhead
158	*Sagittaria rigida*	Sessile-fruit Arrowhead
159	*Salicornia spp.*	Glasswort
160	*Sanicula marilandica*	Black Snakeroot
161	*Sanicula spp.*	Snakeroot
162	*Sarracenia purpurea*	Pitcher-plant
163	*Saururus cernuus*	Lizard's Tail
164	*Scirpus americana*	Scirpus/Three-square
165	*Scirpus cyperinus*	Wool Grass
166	*Scirpus olneyii*	Scirpus/Three-square
167	*Scirpus paludosus*	Scirpus/Three-square
168	*Scirpus robustus*	Scirpus/Three-square
169	*Scirpus spp.*	Scirpus/Three-square
170	*Scutellaria lateriflora*	Mad Dog Skullcap
171	*Scutellaria spp.*	Skullcap
172	*Sencio aureus*	Golden Ragwort
173	*Sicyos angulatus*	Bur-cucumber
174	*Sium suave*	Water Parsnip
175	*Smilacina racemosa*	False Solomon's-seal
176	*Smilax herbacea*	Carrion Flower
177	*Solanum dulcamara*	Purple Nightshade/Bsweet
178	*Solanum nigrum*	Common Nightshade

Table 39. Continued.

179	Solanum spp.	Nightshade
180	Solidago altissima	Tall Goldenrod
181	Solidago canadensis	Canada Goldenrod
182	Solidago gigantea	Late Goldenrod
183	Solidago graminifolia	Lanced-leaved Goldenrod
184	Solidago nemoralis	Gray Goldenrod
185	Solidago odora	Sweet Goldenrod
186	Solidago sempervirens	Seaside Goldenrod
187	Solidago spp.	Goldenrod
188	Sparganium spp.	Bur-reed
189	Spartina alterniflora	Spartina
190	Spartina cynosuroides	Spartina
191	Spartina patens	Spartina
192	Stachys tenufolia	Smooth Hedge-nettle
193	Stellaria media	Common Chickweed
194	Symplocarpus foetidus	Skunk Cabbage
195	Thalictrum dioicum	Early Meadow-rue
196	Thalictrum polygamum	Tall Meadow-rue
197	Thalictrum spp.	Meadow-rue
198	Thelypteris noveboracensis	New York Fern
199	Thelypteris palustris	Marsh Fern
200	Thelypteris simulata	Massachusetts Fern
201	Thlaspi arvense	Field Pennycress
202	Tovara virginiana	Virginia Knotweed
203	Trientalis borealis	Starflower
204	Trifolium spp.	Clover
205	Typha angustifolia	Narrow-leaved Cattail
206	Typha latifolia	Broad-leaved Cattail
207	Urtica dioica	Stinging Nettle
208	Viola sororia	Wooly Blue Violet
209	Viola spp.	Violet
210	Woodwardia areolata	Netted Chain Fern
211	Woodwardia virginica	Virginia Chain Fern
212	Xanthium chinense	Beach Clot Bur
213	Xyris spp.	Yellow-eyed Grass
214	Zinzania aquatica	Wild Rice
215		Wild Yam Root
219	Pilea Pumila	Clearweed
221		Grasses
222	Taraxacum spp.	Dandelion
223	Plantago lanceolata	English Plantain
224		Fesque Grass
225	Anemone quinquefolia	Wood Anemone
360	Schizachyrium spp.	Little Blue Stem Grass
364		Old Field

Table 39. Continued.

365	*Polygonum coccineum*	Swamp Smartweed
366	*Polygonum hydropiperoides*	Mild Water-pepper
370	*Erigiron canadensis*	Horseweed
371	*Plantago major*	Common Plantain
375	*Chimaphila umbellata*	Pipsissewa
376	*Pluchea purpurascens*	Salt-marsh Fleabane
394	*Sisyrinchium spp.*	Blue-eyed Grass
226	*Acer negundo*	Box Elder
227	*Acer rubrum*	Red Maple
228	*Acer saccharinum*	Silver Maple
229	*Acer saccharum*	Sugar Maple
230	*Ailanthus altissima*	Tree-of-heaven
231	*Albizzia julibrissin*	Silk Tree
232	*Alnus rugosa*	Speckled Alder
233	*Amelanchier intermedia*	Shadbush
234	*Amelanchier spp.*	Shadbush
235	*Arctostaphylos uva-ursi*	Bearberry
236	*Baccharis halimifolia*	Groundsel Bush
237	*Betula nigar*	River Birch
238	*Betula populifolia*	Grey Birch
239	*Carpinus caroliniana*	Ironwood
240	*Carya cordiformis*	Butternut Hickory
241	*Carya glabra*	Pignut Hickory
242	*Carya ovata*	Shagbark Hickory
243	*Carya tomentosa*	Mockernut Hickory
244	*Castanea dentata*	American Chestnut
245	*Chephalanthus occidentalis*	Buttonbush
246	*Chamacyperis thyoides*	Atlantic White Cedar
247	*Chamaedaphne calyculata*	Leatherleaf
248	*Chimaphila maculata*	Spotted Wintergreen
249	*Clethra alnifolia*	Pepperbush
250	*Cornus amomum*	Silky Dogwood
251	*Cornus florida*	Flowering Dogwood
252	*Diospyros virginiana*	Persimmon
253	*Euonymus americanus*	American Strawberry Bush
254	*Fagus grandifolia*	American Beech
255	*Fraxinus pennsylvanica*	Green Ash
256	*Fraxinus spp.*	Ash
257	*Gaultheria procumbens*	Teaberry/Wintergreen
258	*Gaylussacia baccata*	Black Huckleberry
259	*Gaylussacia dumosa*	Dwarf Huckleberry
260	*Gaylussacia frondosa*	Dangleberry
261	*Hamamelis virginiana*	Witch Hazel
262	*Hedera helix*	English Ivy

Table 39. Continued.

263	Ilex glabra	Inkberry
264	Ilex opaca	American Holly
265	Ilex verticillata	Winterberry
266	Iva frutescens	Marsh Elder
267	Juglans nigra	Black Walnut
268	Juniperus virginiana	Eastern Red Cedar
269	Kalmia angustifolia	Sheep Laurel
270	Kalmia latifolia	Mountain Laurel
271	Leucothoe racemosa	Swamp Sweetbells
272	Liquidambar styraciflua	Sweetgum
273	Ligustrum vulgare	Common Privet
274	Lindera benzoin	Spicebush
275	Lireodendron tulipifera	Yellow Poplar
276	Lonicera japonica	Japanese Honeysuckle
277	Lonicera xylosteum	European Honeysuckle
278	Lyonia ligustrina	Maleberry
279	Lyonia mariana	Staggerbush
280	Magnolia virginiana	Sweetbay Magnolia
281	Mitchella repens	Partridge Berry
282	Morus alba	White Mulberry
283	Morus rubra	Red Mulberry
284	Morus spp.	Mulberry
285	Myrica pennsylvanica	Bayberry
286	Nyssa sylvatica	Black Gum
287	Parthenocissus quinquefolia	Virginia Creeper
288	Pinus rigida	Pitch Pine
289	Plantanus occidentalis	Sycamore
290	Populus deltoides	Cottonwood
291	Prunus avium	Sweet Cherry
292	Prunus serotina	Black Cherry
293	Pyrus arbutifolia	Red Chokeberry
294	Pyrus spp.	Chokeberry
295	Quercus alba	White Oak
296	Quercus bicolor	Swamp White Oak
297	Quercus coccinea	Scarlet Oak
298	Quercus falcata	Southern Red Oak
299	Quercus ilicifolia	Scrub Oak
300	Quercus marilandica	Black Jack Oak
301	Quercus muehlenbergii	Chinquapin Oak
302	Quercus palustrus	Pin Oak
303	Quercus phellos	Willow Oak
304	Quercus prinoides	Dwarf Chestnut Oak
305	Quercus prinus	Chestnut Oak
306	Quercus rubra	Red Oak
307	Quercus stellata	Post Oak

Table 39. Continued.

308	Quercus velutina	Black Oak
309	Rhododendron viscosum	Swamp Azalea
310	Rhus copallina	Winged Sumac
311	Rhus glabra	Smooth Sumac
312	Rhus radicans	Poison Ivy
313	Rhus typhina	Staghorn Sumac
314	Rhus vernix	Poison Sumac
315	Robinia pseudoacacia	Black Locust
316	Rosa multiflora	Multiflora Rose
317	Rosa spp.	Rose
318	Rubus allegheniensis	Blackberry
319	Rubus flagellaris	Prickly Dewberry
320	Rubus hispidus	Bristly Dewberry
321	Rubus ideaus	Red Raspberry
322	Rubus occidentalis	Black Raspberry
323	Rubus spp.	Raspberry/Dewberry/etc.
324	Salix fragilis	Crack Willow
325	Salix nigra	Black Willow
326	Salix sericea	Silky Willow
327	Salix spp.	Willow
328	Sambucus canadensis	Common Elderberry
329	Sambucus spp.	Elderberry
330	Sassafras albidum	Sassafras
331	Smilax glauca	Glaucous Greenbriar
332	Smilax rotundifolia	Common Greenbriar
333	Tilia americana	Basswood
334	Ulmus americana	American Elm
335	Vaccinium angustifolium	Late Lowbush Blueberry
336	Vaccinium atrococcum	Black Highbush Blueberry
337	Vaccinium corybosum	C. Highbush Blueberry
338	Vaccinium Macrocarpon	Large Leaf Blueberry
339	Vaccinium vacillans	Early Lowbush Blueberry
340	Viburnum cassinoides	Northern Wild Raisin
341	Viburnum dentatum	Southern Arrowwood
342	Vibrunum prunifolium	Smooth Blackhaw
343	Viburnum recognitum	Northern Arrowwood
344	Vitus labrusca	Fox Grape
345	Vitus spp.	Grape
346	Wisteria floribunda	Japanese Wisteria
347	Wisteria frutescens	American Wisteria
352	Wisteria spp.	Wisteria
353	Rhus spp.	Sumac
354	Rosa rugosa	
355	Campsis radicans	Trumpet Creeper
356	Smilax spp.	Greenbriar

Table 39. Continued

357	*Forsythia spp.*	Forsythia
358	*Lonicera spp.*	Honeysuckle
361	*Acer platanoides*	Norway Maple
363	*Paulonia tomentosa*	Princess Tree
369	*Alnus serrulata*	Smooth Alder
372	*Celtus occidentalis*	Hackberry
374	*Gaylussacia spp.*	Huckleberry
377	*Hudsonia tomentosa*	False Heather

APPENDIX II

Location of Wetland/Buffer Study Sites
(Refer to Tables 2, 3, and 4)

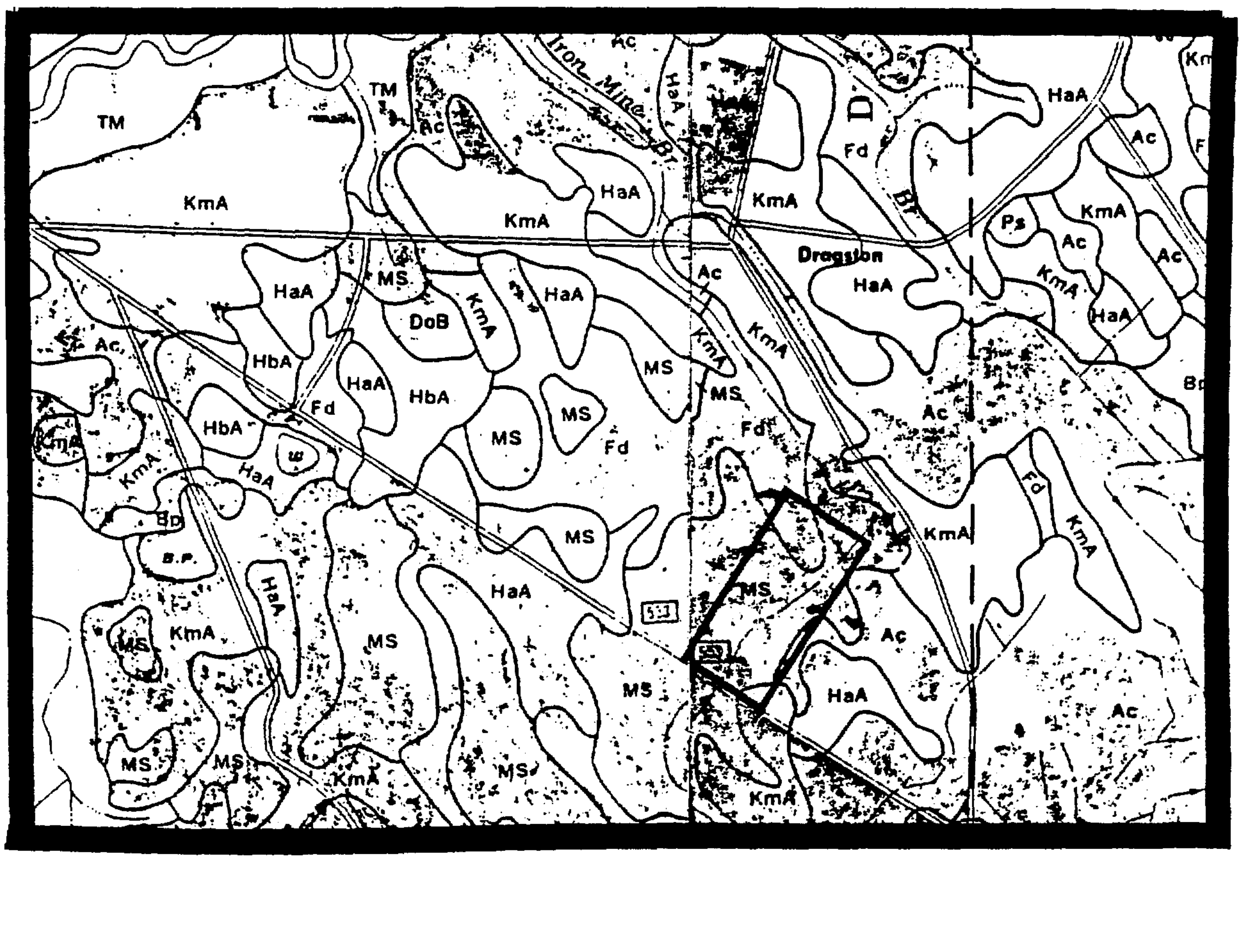
SITE 54 Ricci Bros., Downe Twp., Cumberland County.

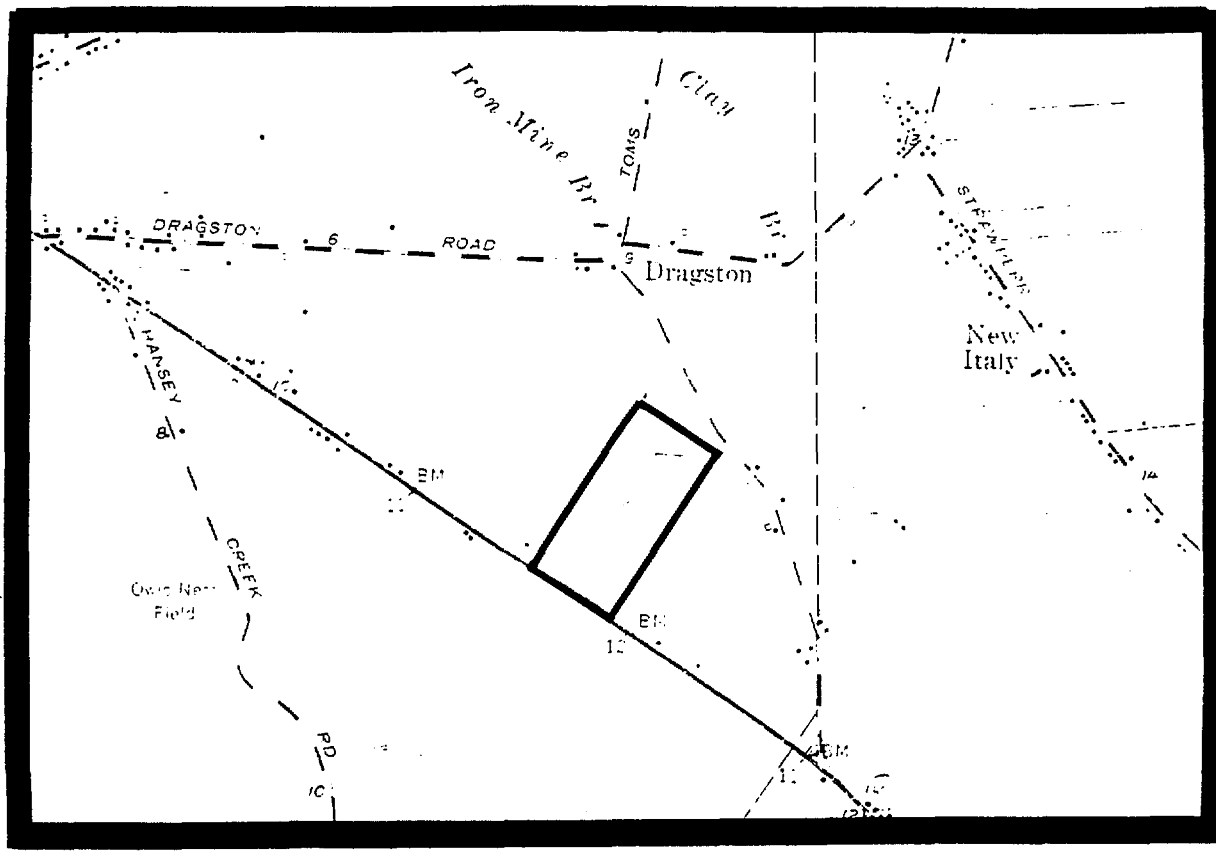
MAP A: Sheets # 36&37, Cumberland county soil survey (Scale 1:20,000)

MAP B: U.S.G.S. Dividing Creek, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Dividing Creek, N.J. Quadrangle (Scale 1:24,000)

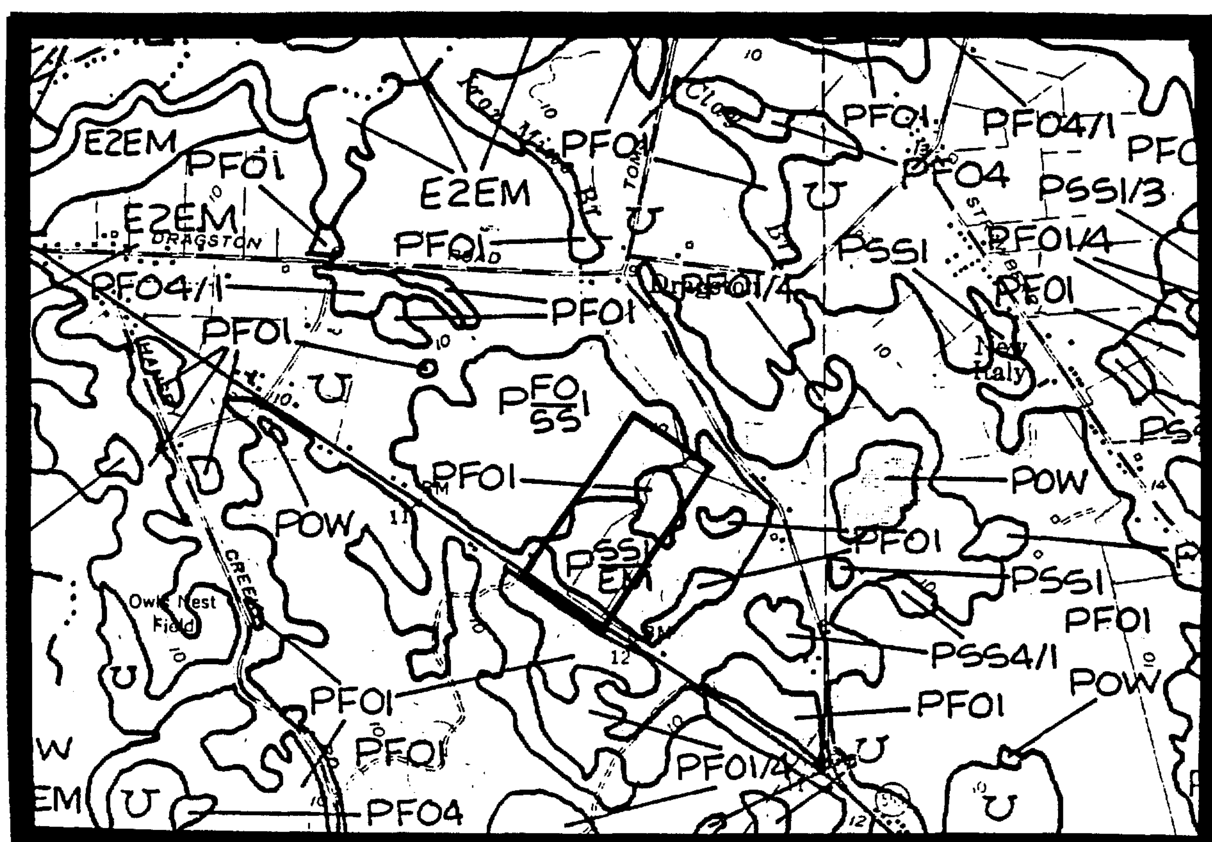
MAP A




Iron Mine Br
Clay
TOMS
DRAGSTON
ROAD
Dragston
New
Italy
HANSEY
CREEK
Owls Nest
Field
BM
PD

MAP B

MAP C


E2EM
PFO1
E2EM
DRAGSTON
PFO1
PFO4/1
PFO4
PSS1/3
PFO1/4
PSS1
PFO1/4
PFO4/1
PFO1
PFO1
PFO1
PFO
SS1
POW
PFO1
POW
PFO1
PSS1
EM
PSS1
PFO1
PSS4/1
Owls Nest
Field
PFO1
POW
PFO1
PFO1
PFO1/4
PFO4
New
Italy

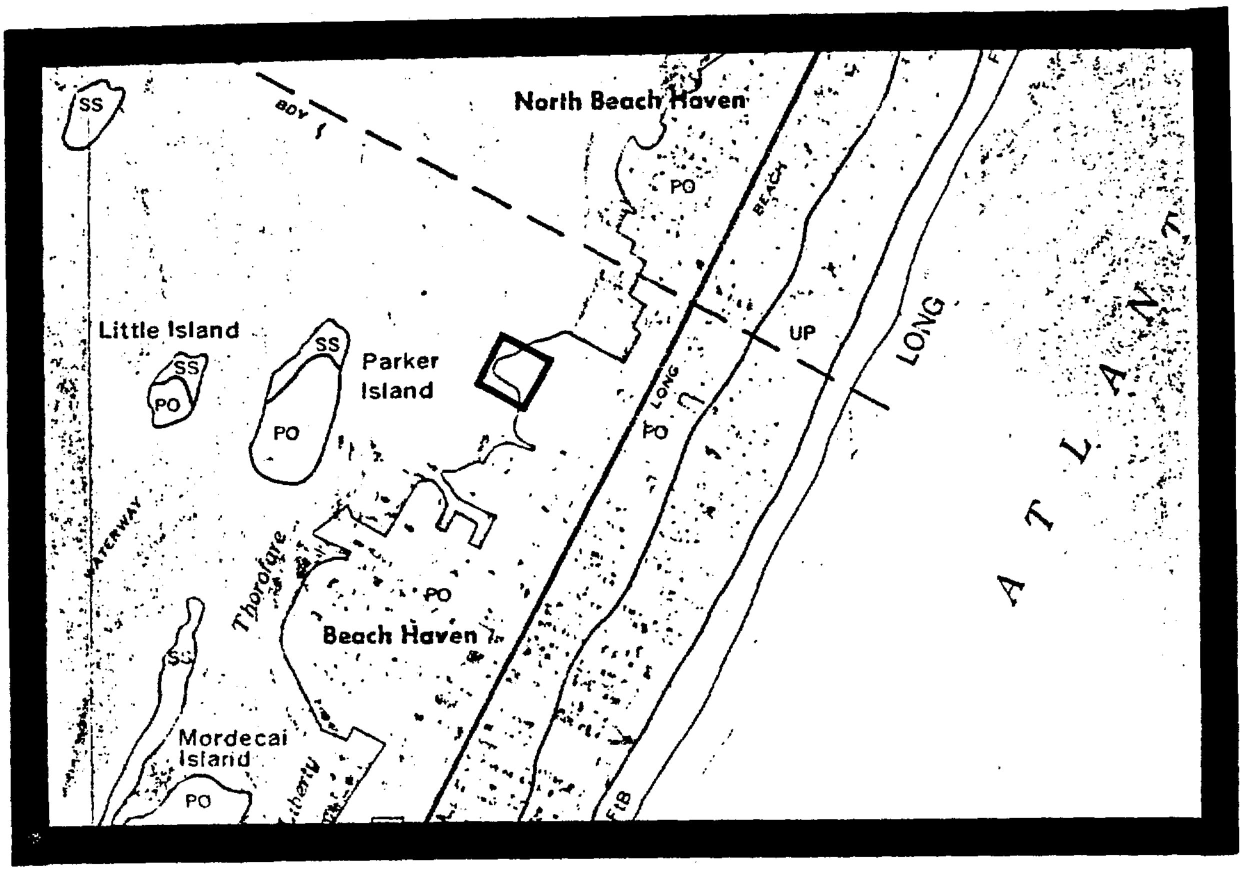
SITE 58 Shelter Cove, Beach Haven, Ocean County.

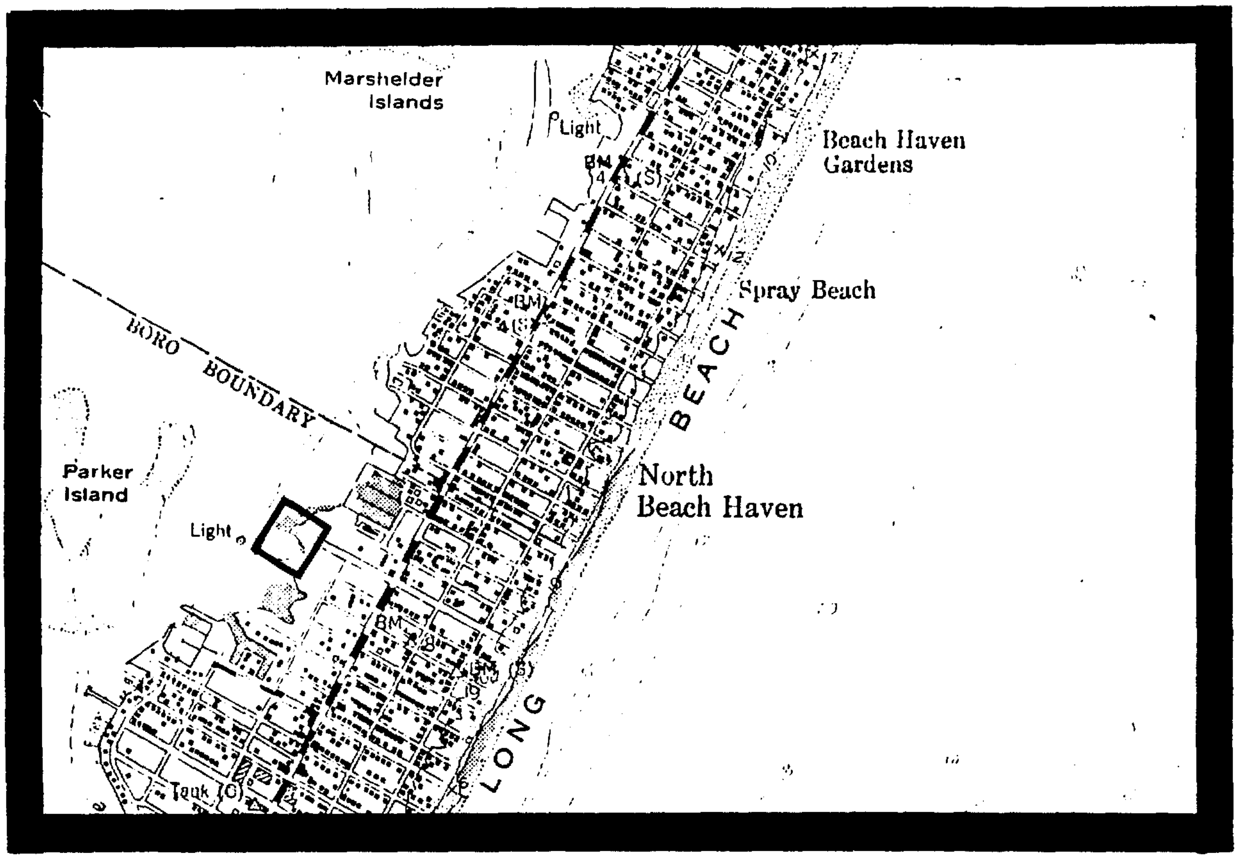
MAP A: Sheet # 60, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Beach Haven, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beach Haven, N.J. Quadrangle (Scale 1:24,000)

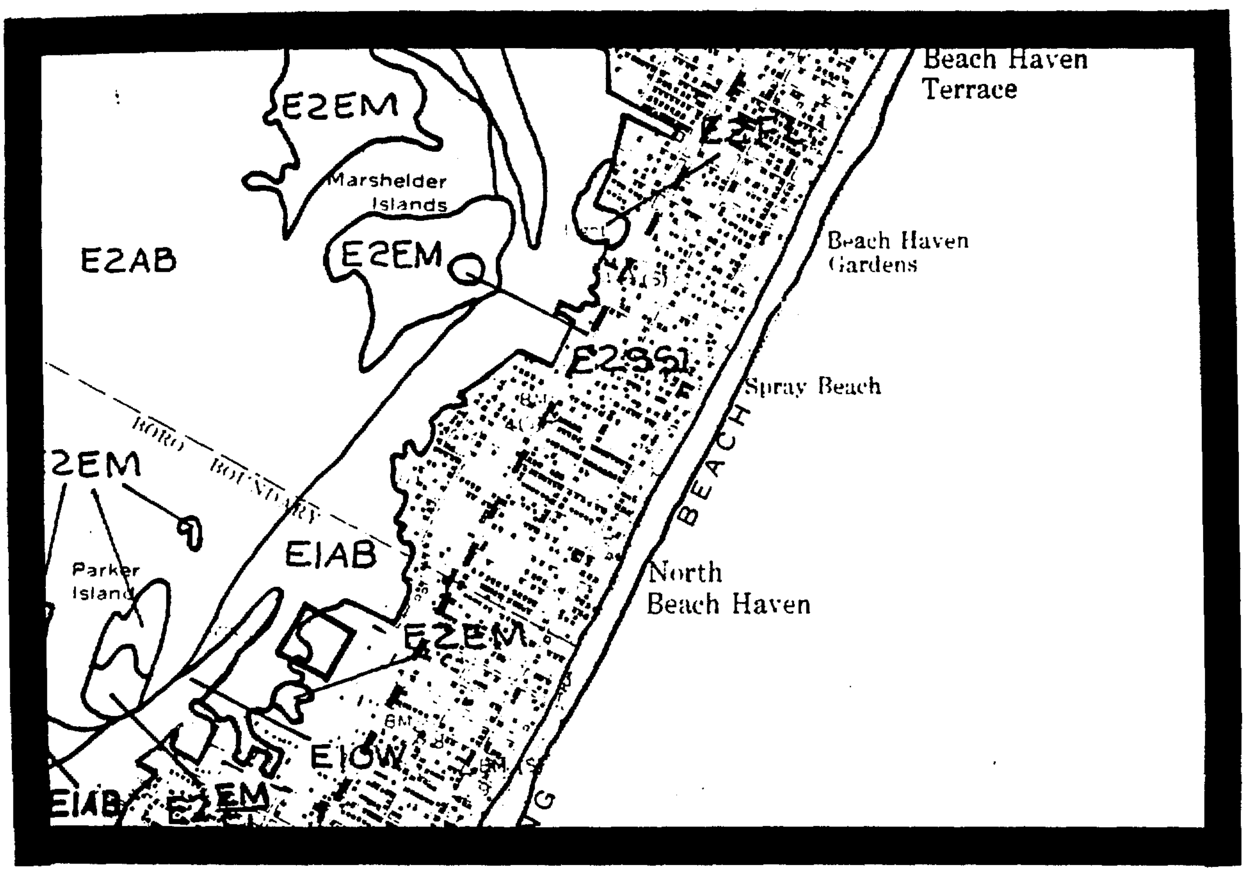
MAP A




Marshelder
Islands
Light
Beach Haven
Gardens
Spray Beach
BORO BOUNDARY
BEACH
Parker
Island
Light
North
Beach Haven
LONG
Tank (C)

MAP B

MAP C


E2EM
Beach Haven
Terrace
E2EL
Marshelder
Islands
E2AB
E2EM
Beach Haven
Gardens
E2SS1
Spray Beach
BORO BOUNDARY
BEACH
2EM
E1AB
Parker
Island
North
Beach Haven
E2EM
E1OW
E1AB
E2EM

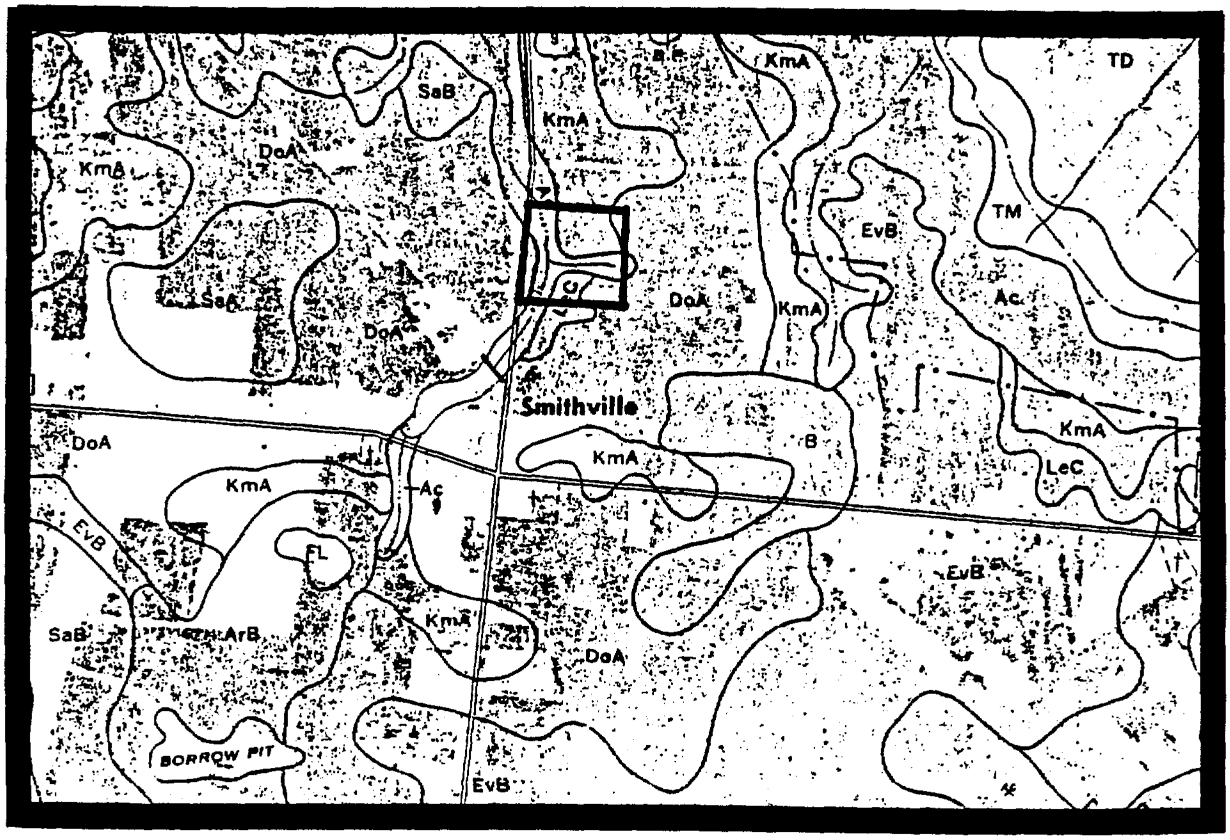
SITE 63 Smithville Phase 1A, Galloway Twp., Atlantic County.

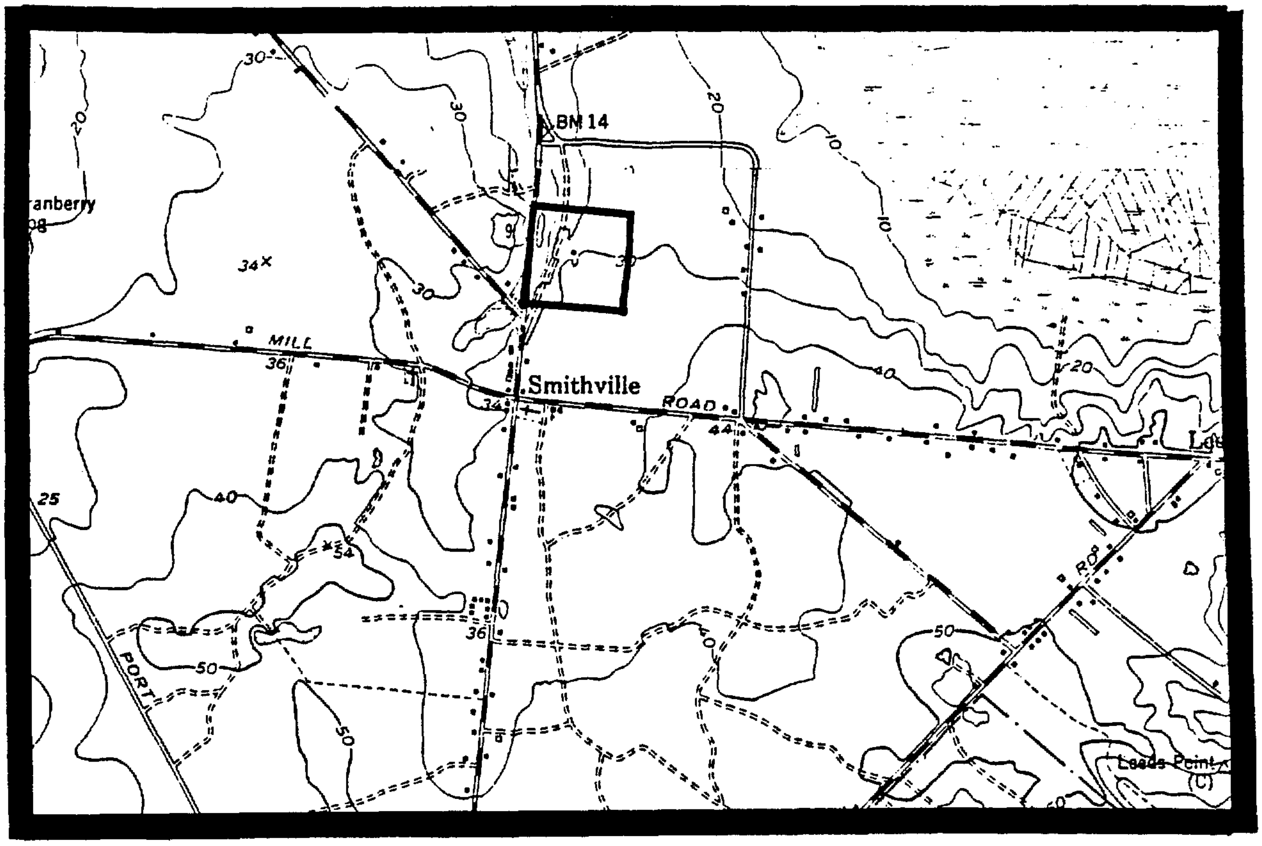
MAP A: Sheet # 27, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Oceanville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Oceanville, N.J. Quadrangle (Scale 1:24,000)

MAP A

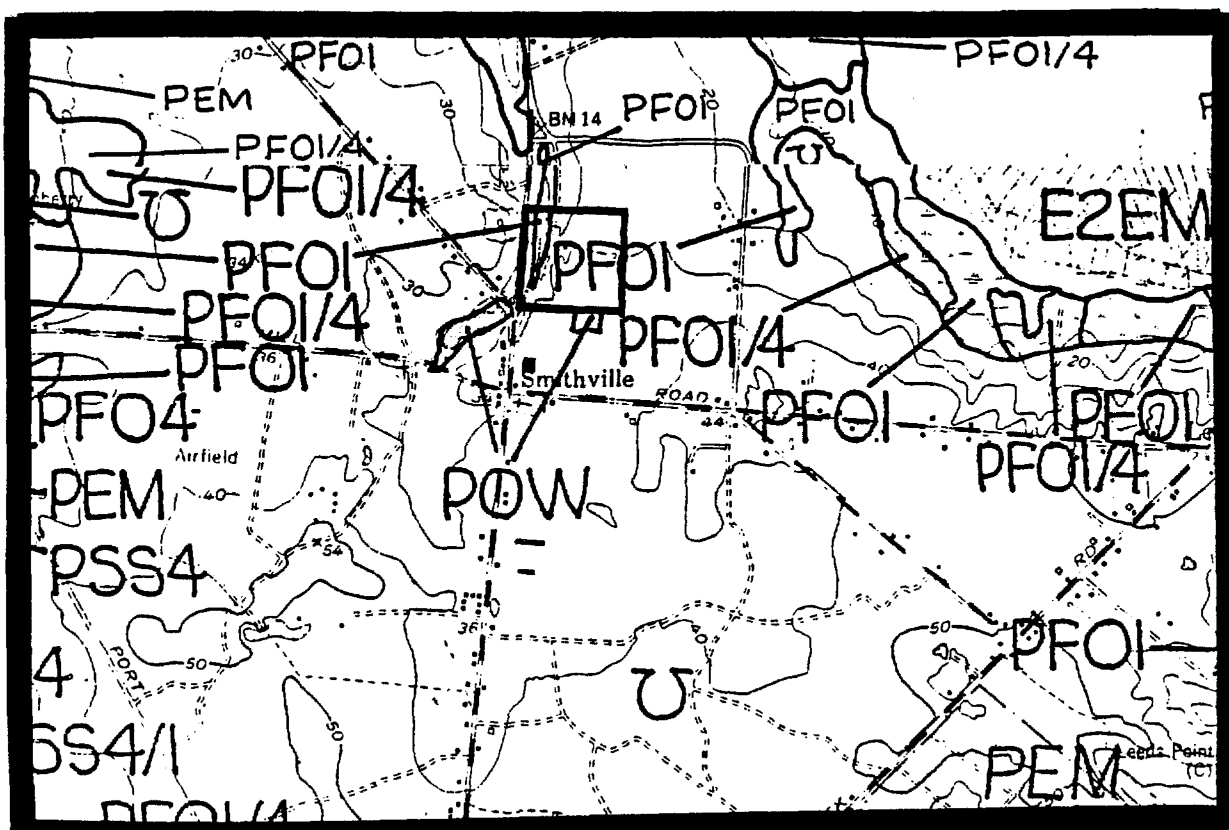




BM 14
Smithville
MILL
ROAD
PORT
Leeds Point

MAP B

MAP C



PEM
PFO1
PFO1/4
PFO4
PSS4
POW
E2EM
Smithville
Airfield
BM 14

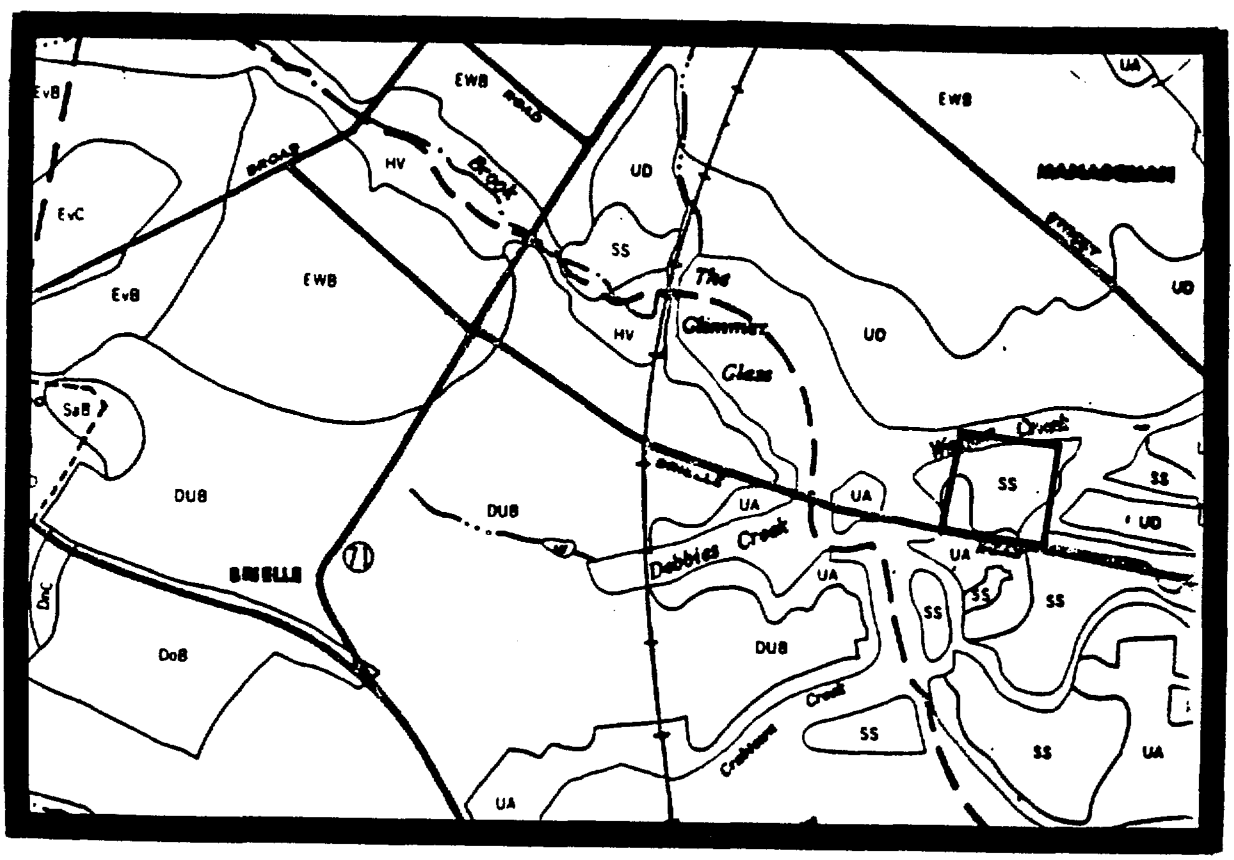
SITE 68 Glimmer Glass Island, Manasquan, Monmouth County.

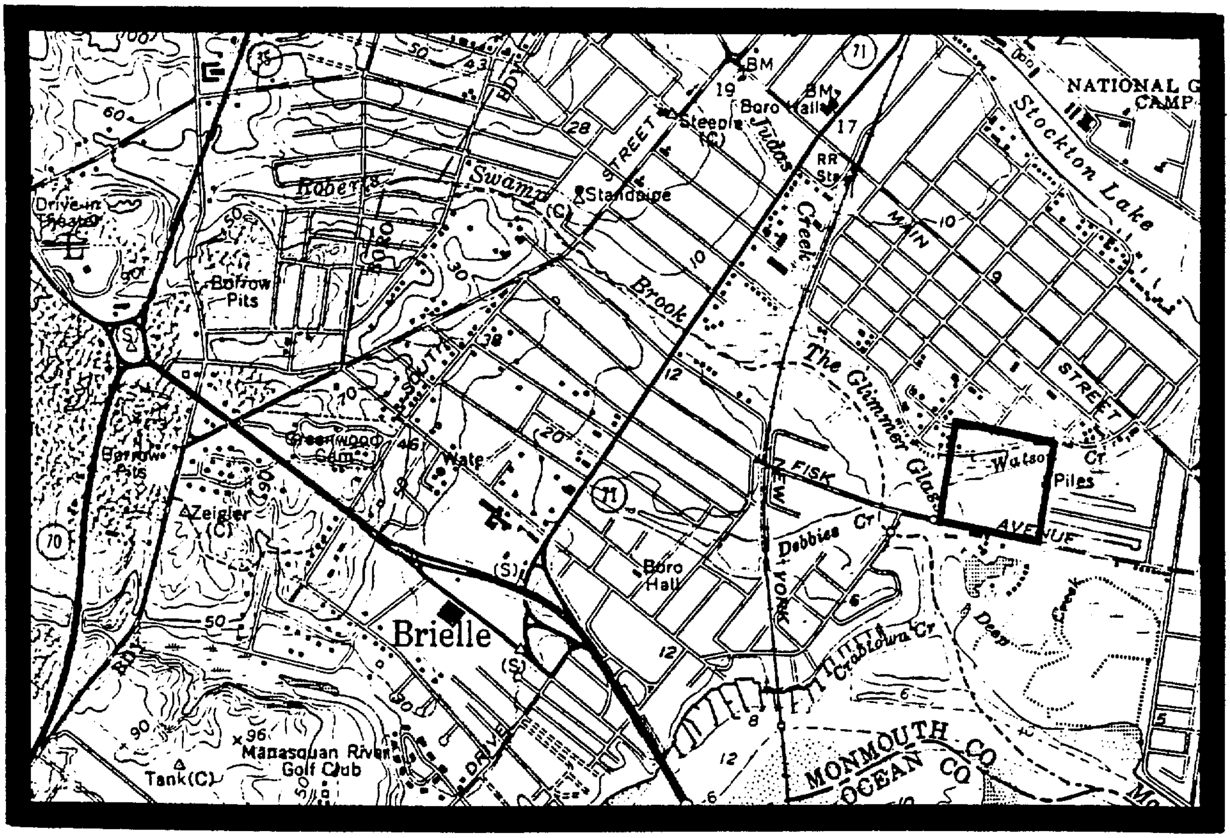
MAP A: Sheet # 58, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Point Pleasant, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Point Pleasant, N.J. Quadrangle (Scale 1:24,000)

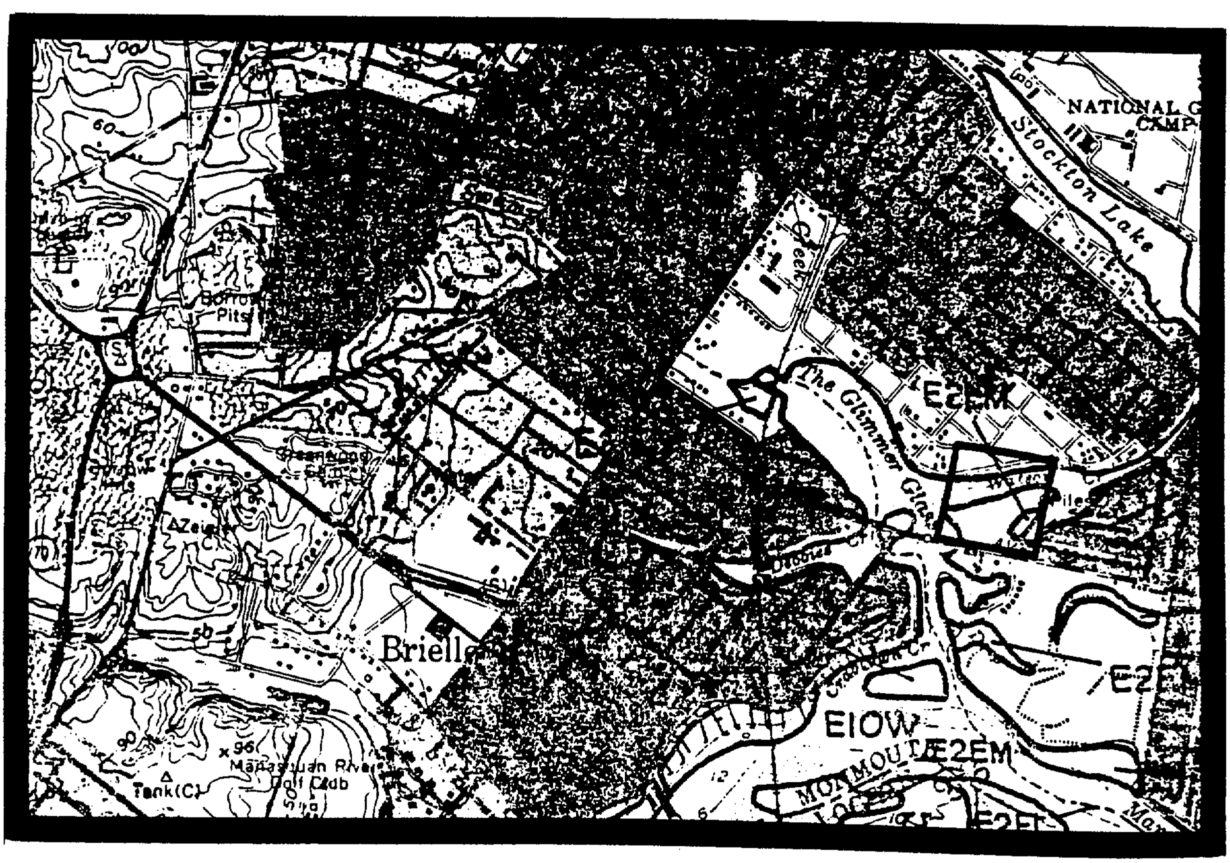
MAP A




NATIONAL G
CAMP
Stockton Lake
Boro Hall
Steeple (C)
Judas
Creek
RR Sta
MAIN
STREET
Standpipe
Swamp
Brook
The Glimmer Glass
Borrow Pits
Greenwood Cem
Water
Zeigler (C)
FISK
AVENUE
Piles
Debbies Cr
Boro Hall
Brielle
Crabtown Cr
Deep Creek
Manasquan River Golf Club
Tank(C)
MONMOUTH CO
OCEAN CO

MAP B

MAP C


NATIONAL G
CAMP
Stockton Lake
Creek
The Glimmer Glass
E2EM
Brielle
EIOW
E2EM
E2
Tank(C)
Manasquan River Golf Club

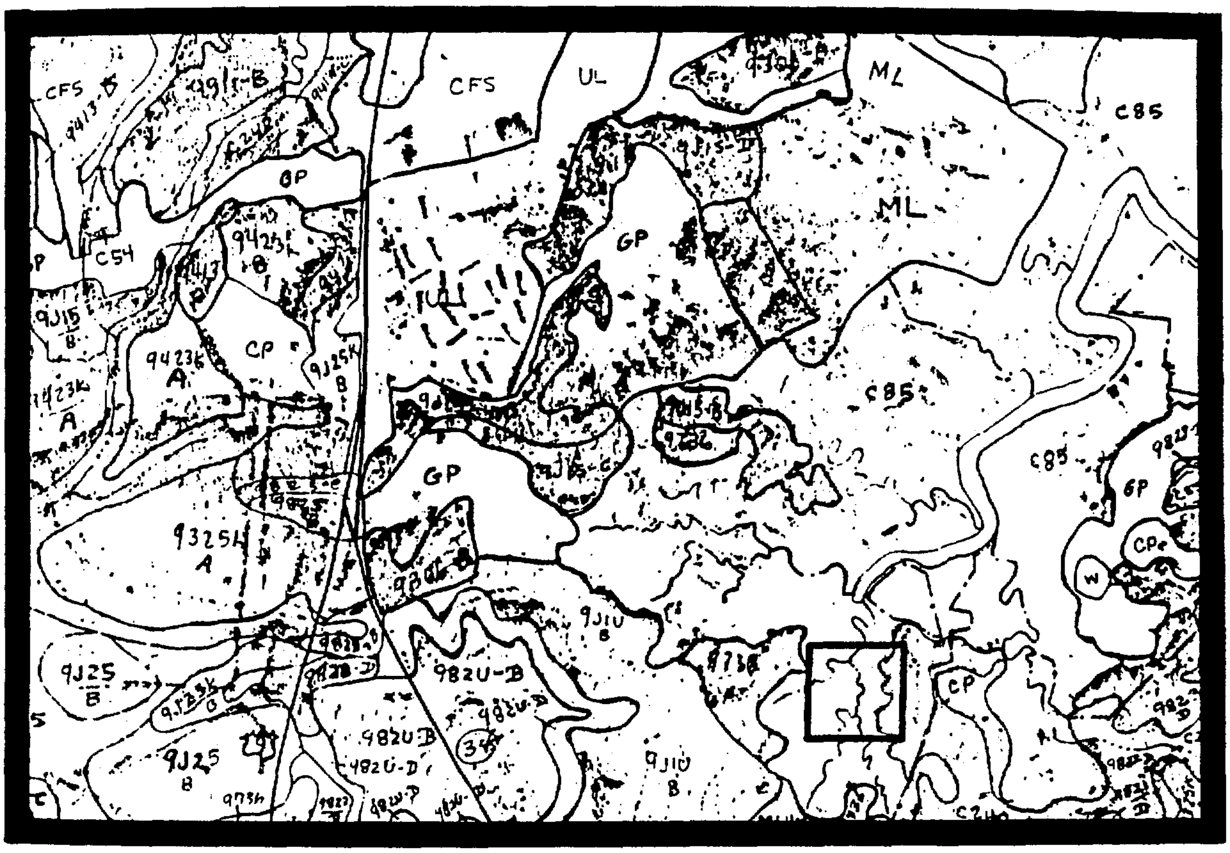
SITE 77 Dock Rd., Cheesequake State Park, Middlesex County.

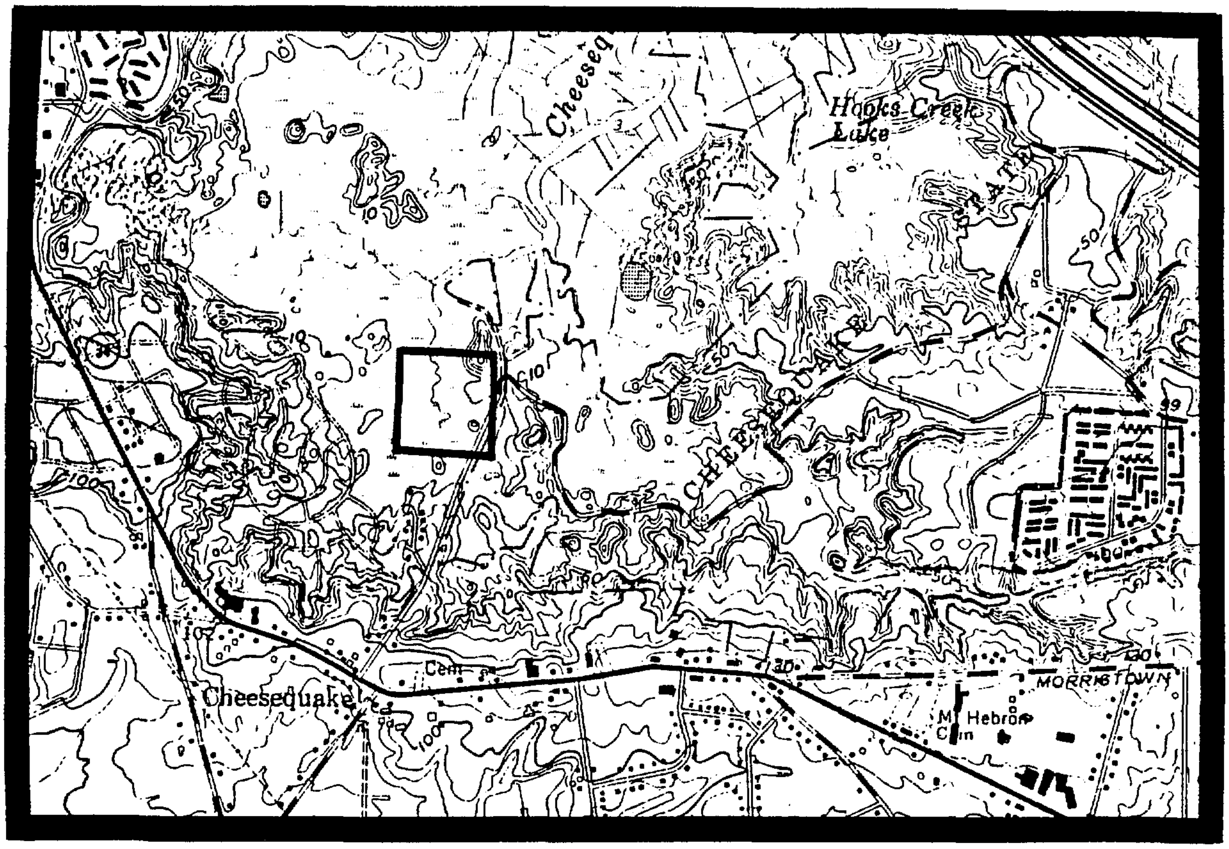
MAP A: Sheet # 15, Middlesex County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. South Amboy, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, South Amboy, N.J. Quadrangle (Scale 1:24,000)

MAP A




Cheeseq
Hooks Creek
Lake
Cheesequake
Cem
MORRISTOWN
Mt Hebron
Cem

MAP B

MAP C


E2EM
Hooks Creek
Lake
POW
POW
E1OW
PF01
PF04
Cheesequake
Cem
MORRISTOWN
Mt Hebron
Cem
POW

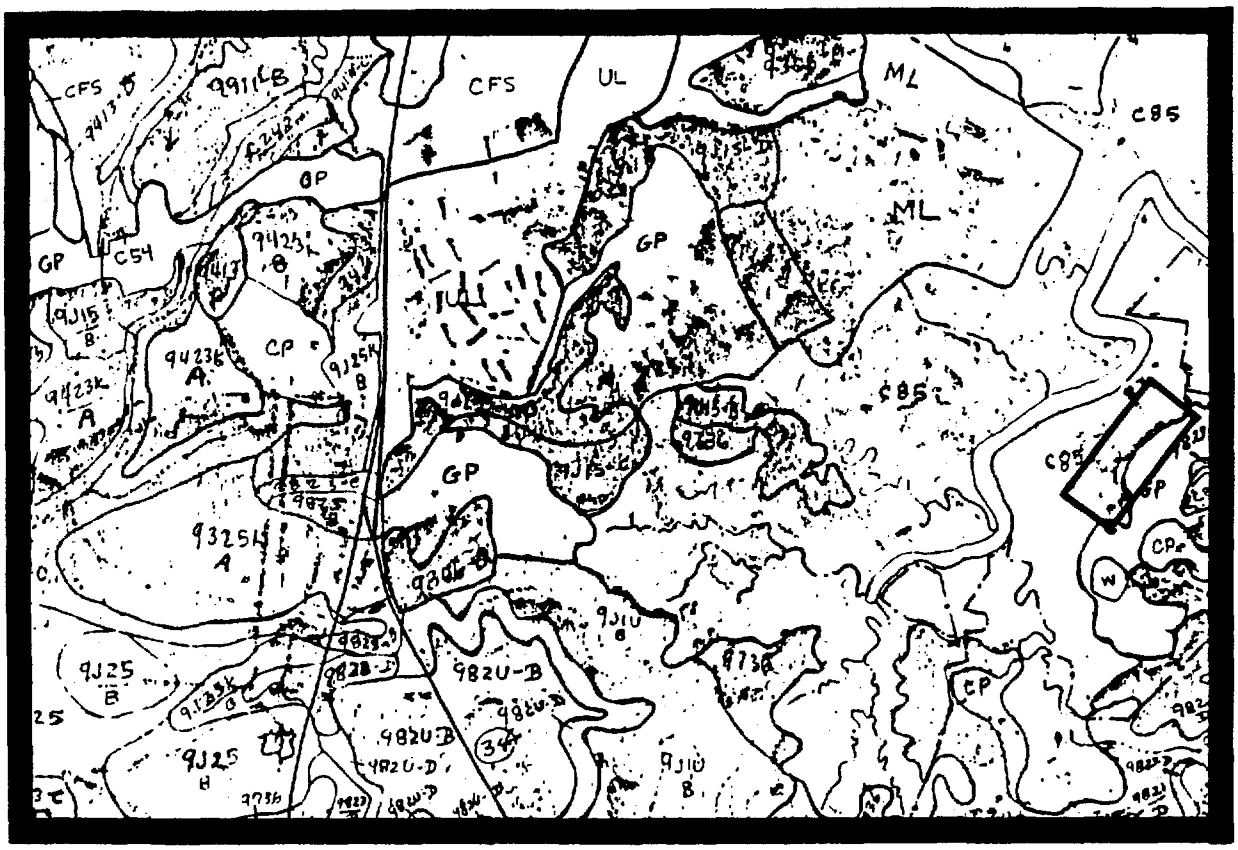
SITE 79. Sand Pit Point, Cheesequake State Park, Middlesex County.

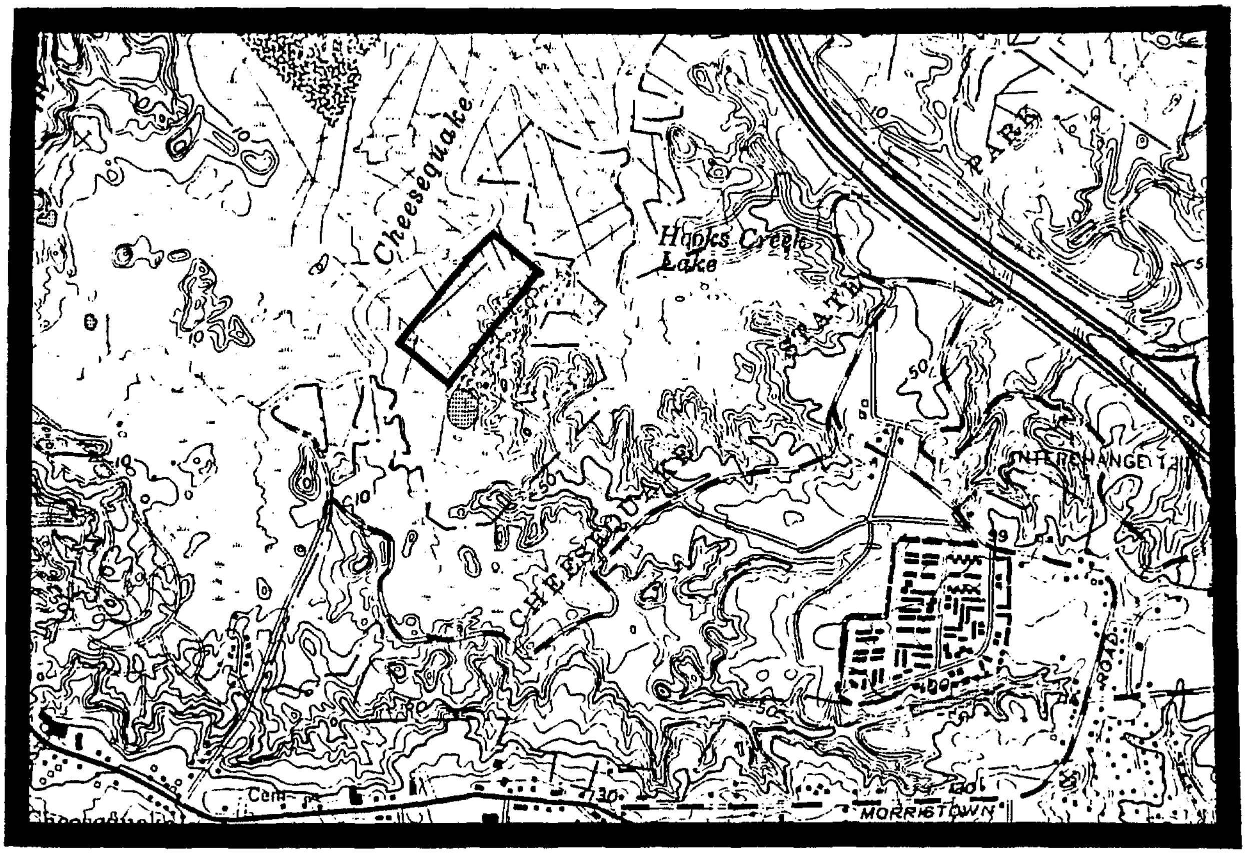
MAP A: Sheet # 15, Middlesex County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. South Amboy, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, South Amboy, N.J. Quadrangle (Scale 1:24,000)

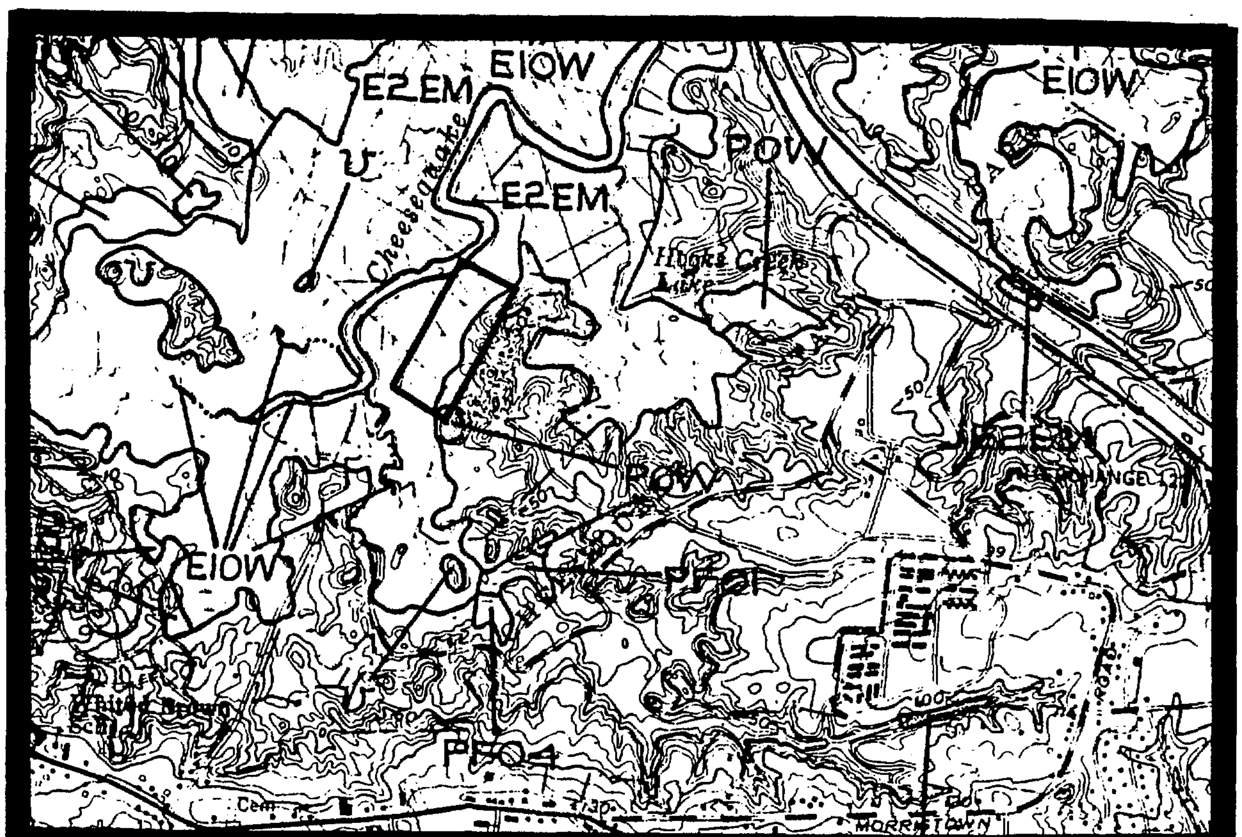
MAP A




Cheesequake
Hooks Creek Lake
PARK
STATE
CHEESEQUAKE
INTERCHANGE
ROAD
Cem
MORRISTOWN

MAP B

MAP C


E1OW
E2EM
E2EM
E1OW
POW
Cheesequake
Hooks Creek Lake
POW
E1OW
PFO1
PFO4
INTERCHANGE
ROAD
Cem
MORRISTOWN

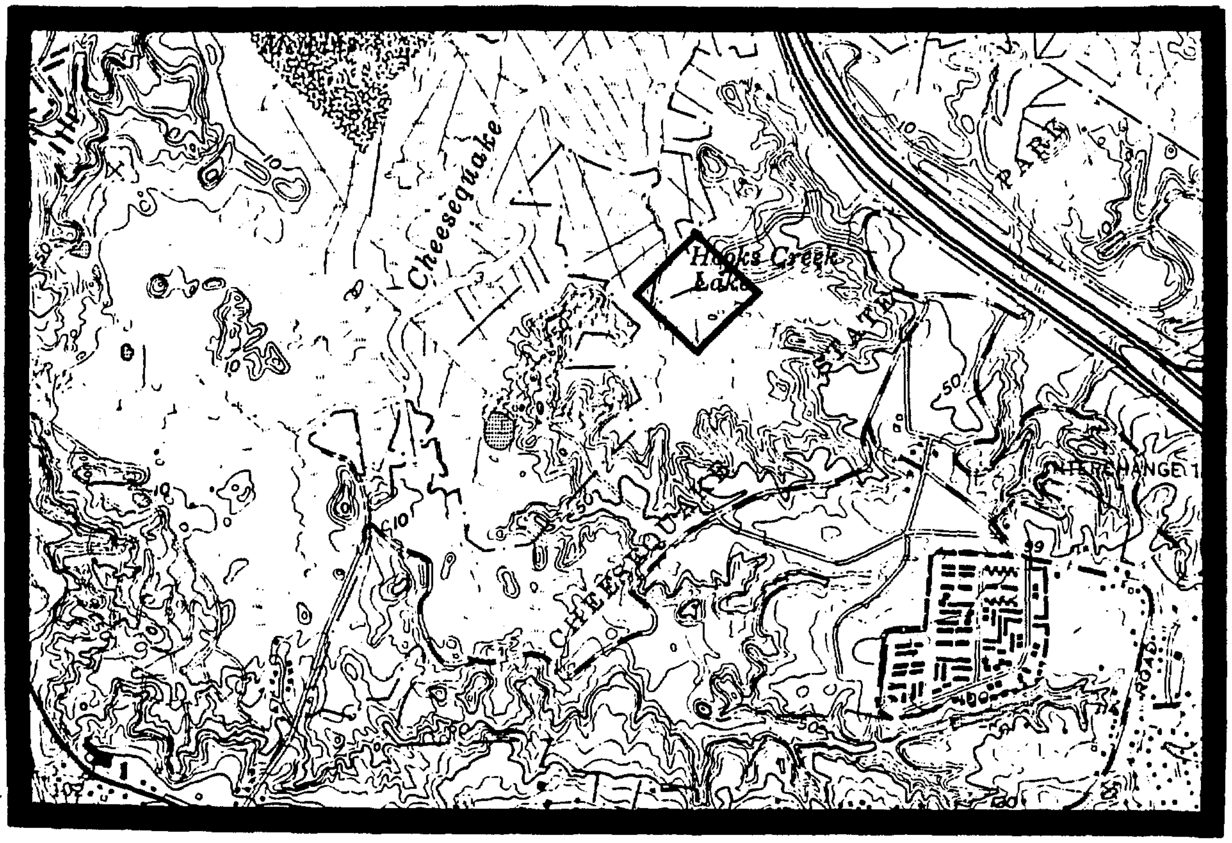
SITE 80 Hooks Lake, Cheesequake State Park, Middlesex County.

MAP A: Sheet # 16, Middlesex County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. South Amboy, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, South Amboy, N.J. Quadrangle (Scale 1:24,000)

MAP A


Cheesequake
Hooks Creek Lake
INTERCHANGE

MAP B

MAP C


Cheesequake
E2EM
E1OW
POW
E2EM
Hooks Creek Lake
E1OW
POW
INTERCHANGE
E1OW

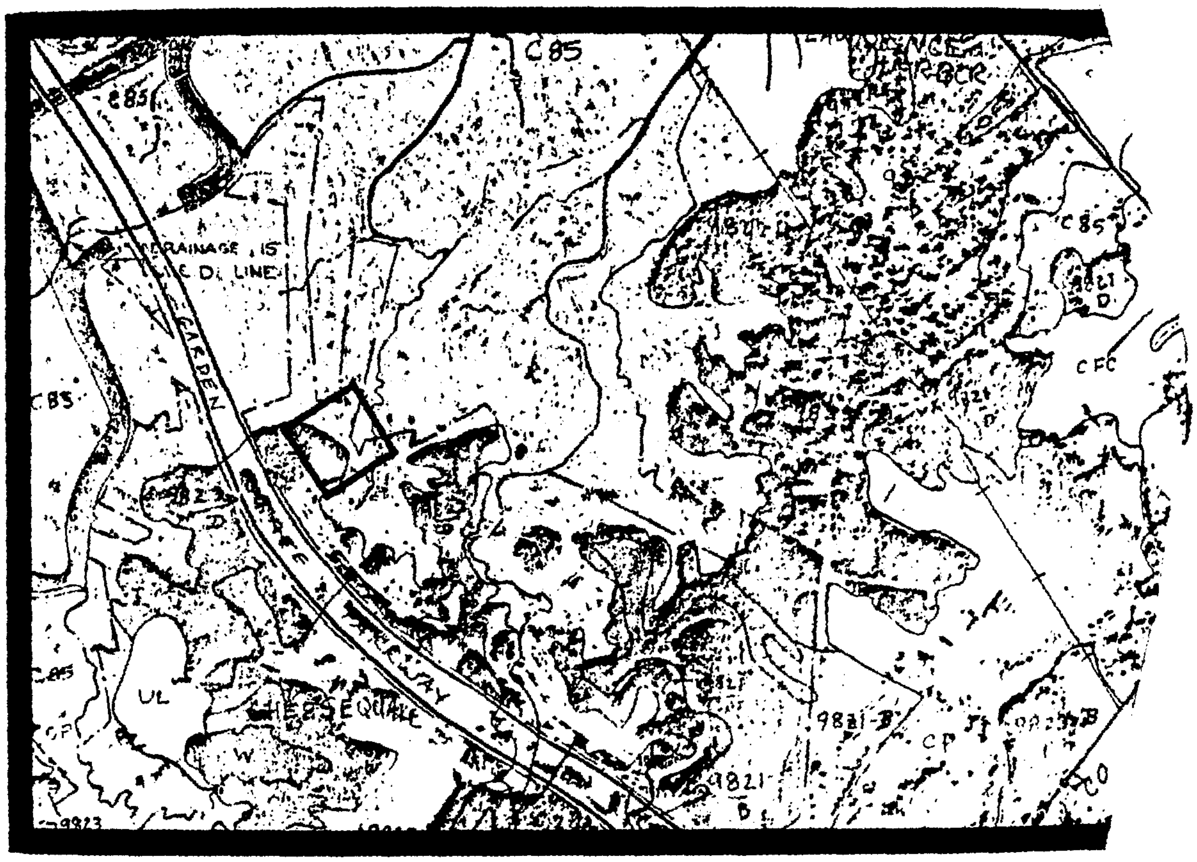
SITE 81 Farry Point, Cheesequake State
County.

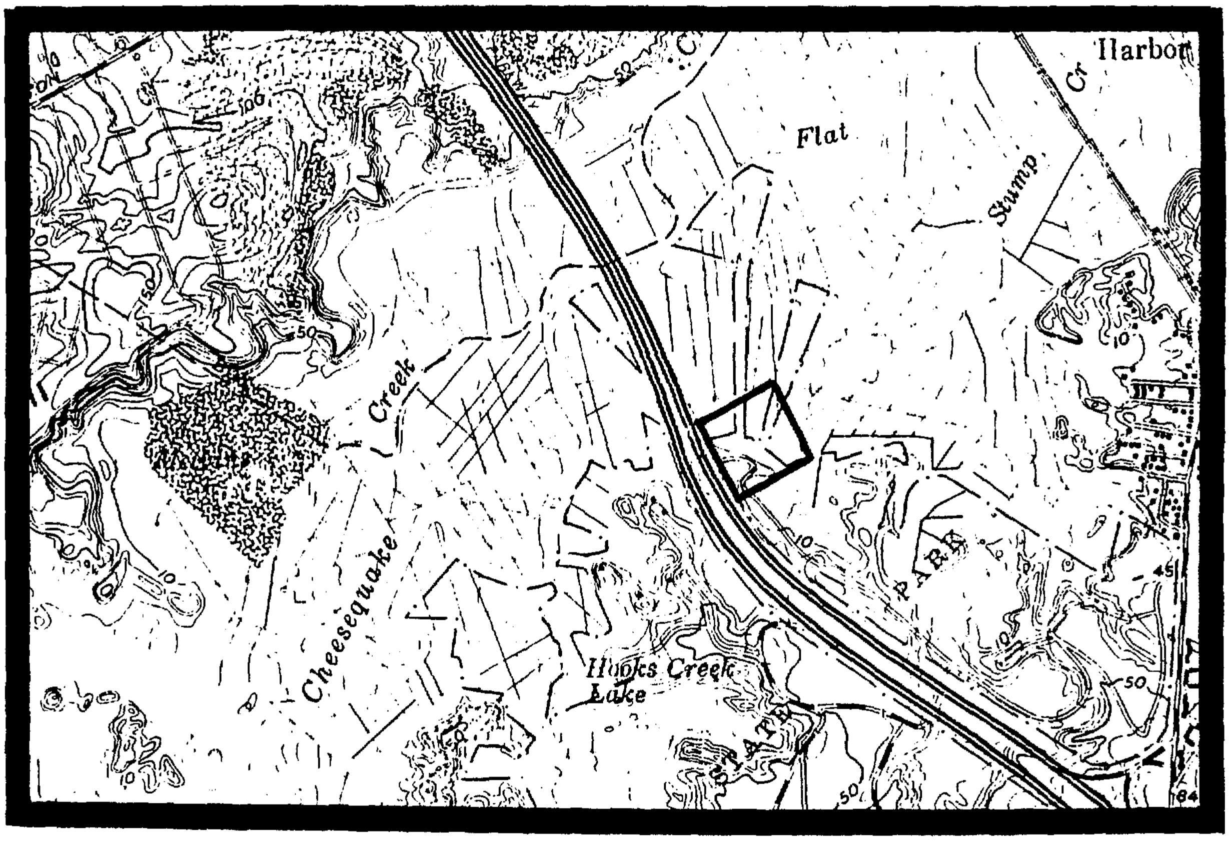
MAP A: Sheet # 16, Middlesex County Soil
(Scale 1:20,000)

MAP B: U.S.G.S. South Amboy, N.J. Topograpl
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventor
Amboy, N.J. Quadrangle (Scale 1:24

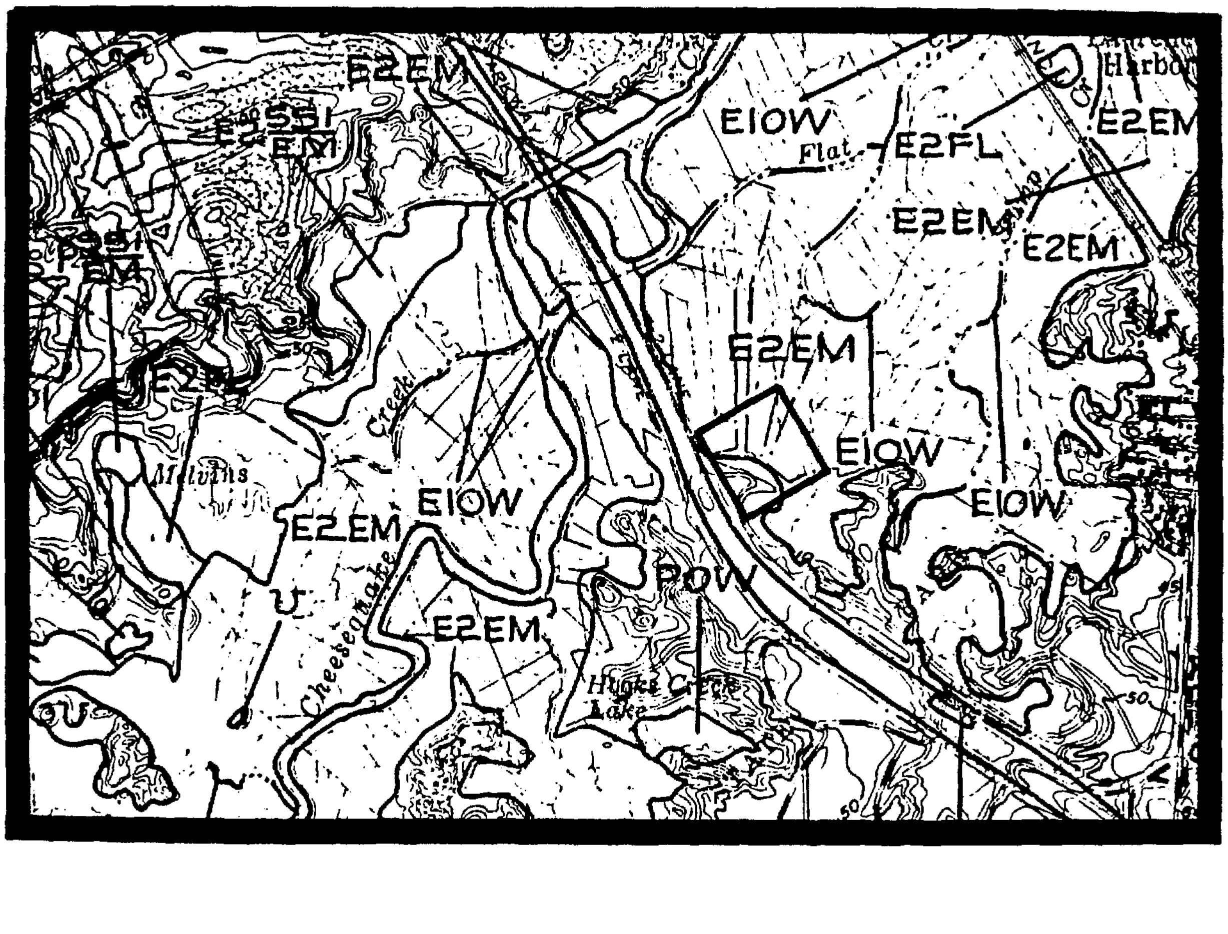
MAP A




Harbor
Flat
Stump
Creek
Cheesequake
Hooks Creek
Lake

MAP B

MAP C


Harbor
E2EM
E1OW
Flat
E2FL
E2EM
E2EM
E2EM
E1OW
Creek
Cheesequake
E1OW
E2EM
E2EM
E1OW
POW
Hooks Creek
Lake

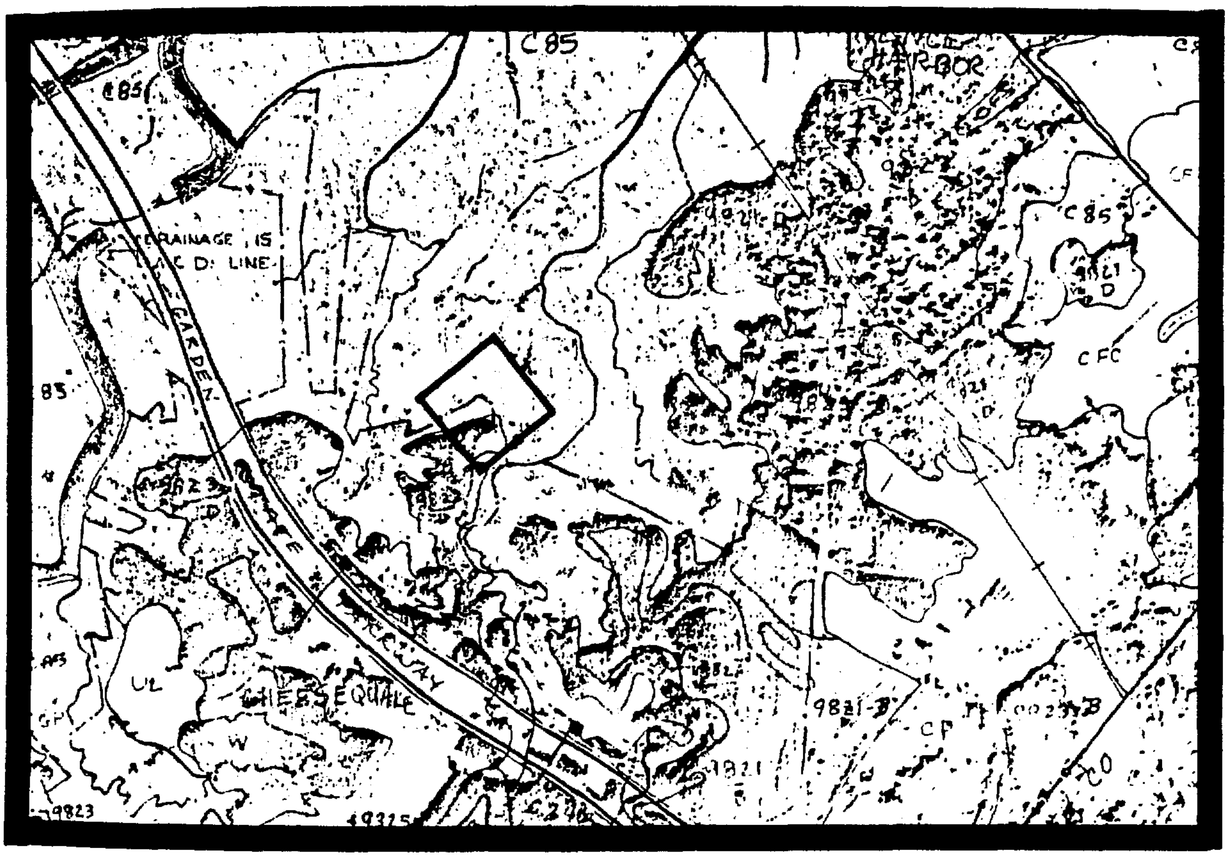
SITE 82 Arrowsmith Point, Cheesequake State Park, Middlesex County.

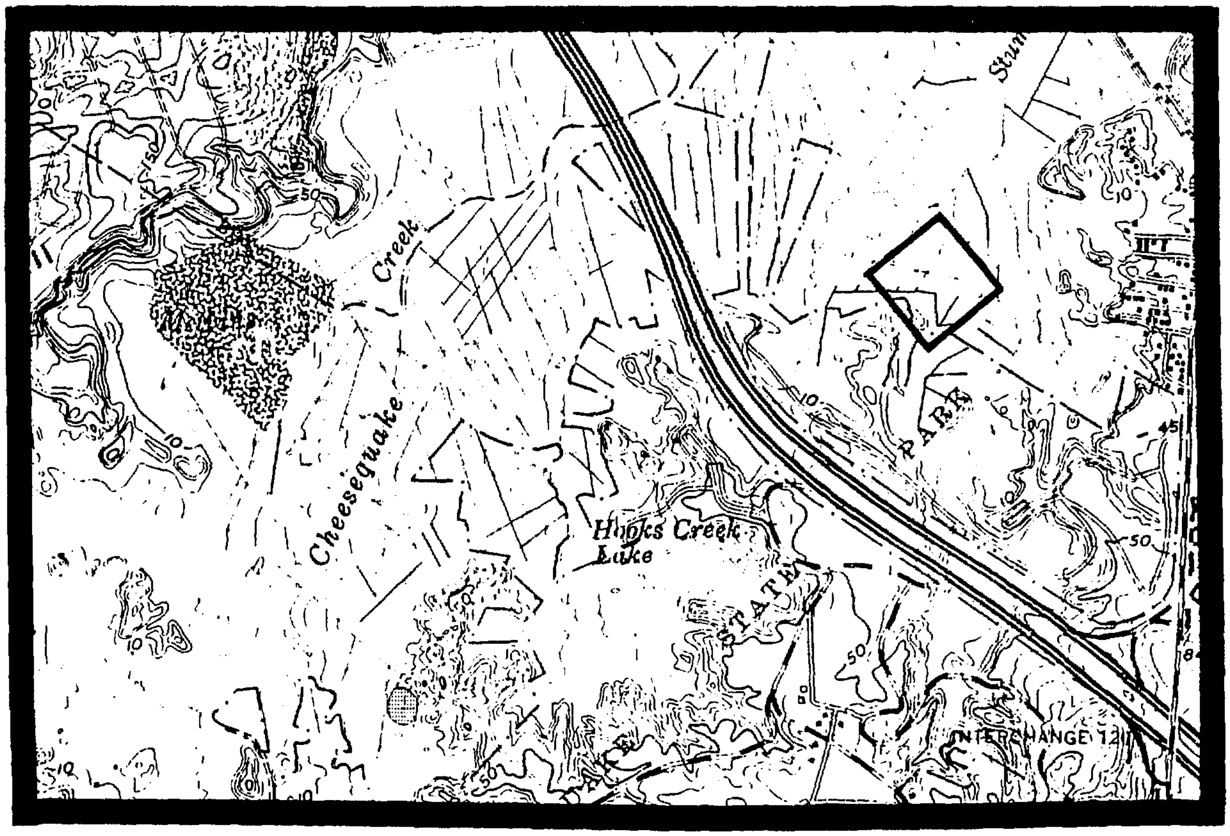
MAP A: Sheet # 16, Middlesex County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. South Amboy, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, South Amboy, N.J. Quadrangle (Scale 1:24,000)

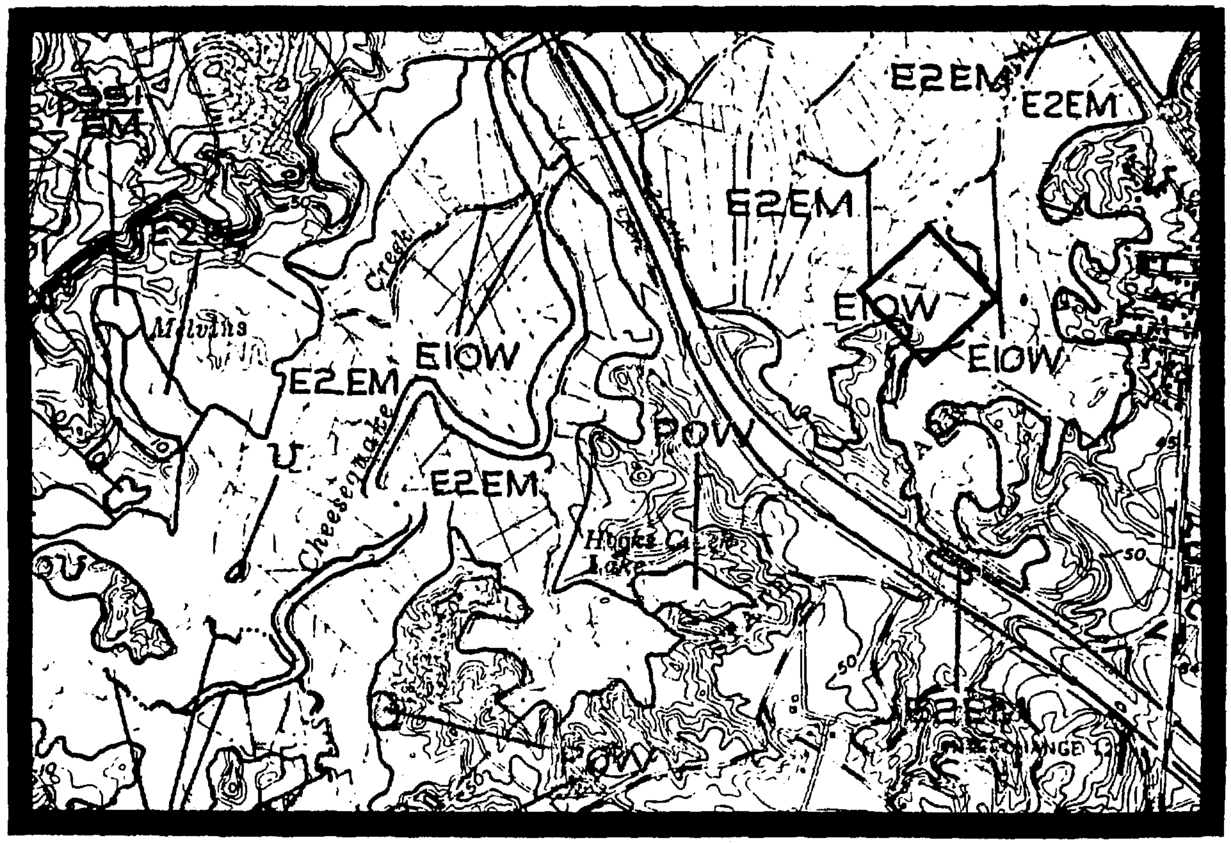
MAP A




Creek
Cheesequake
Hooks Creek
Lake
PARK
STATE
INTERCHANGE 120
50
10

MAP B

MAP C


E2EM
E2EM
E2EM
E1OW
E1OW
E1OW
E2EM
E2EM
POW
POW
Melvins
Creek
Cheesequake
50

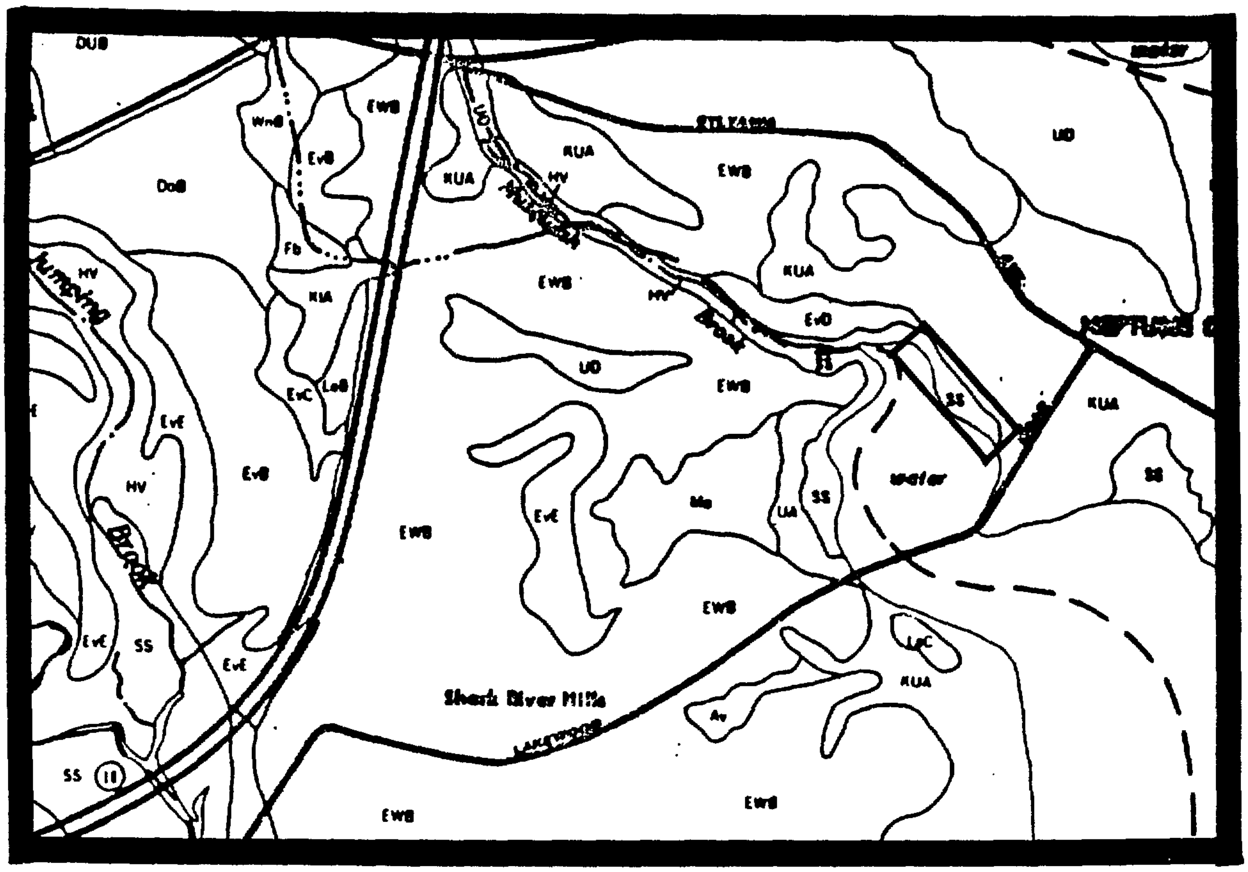
SITE 92 Mushquash Cove, Neptune, Monmouth County.

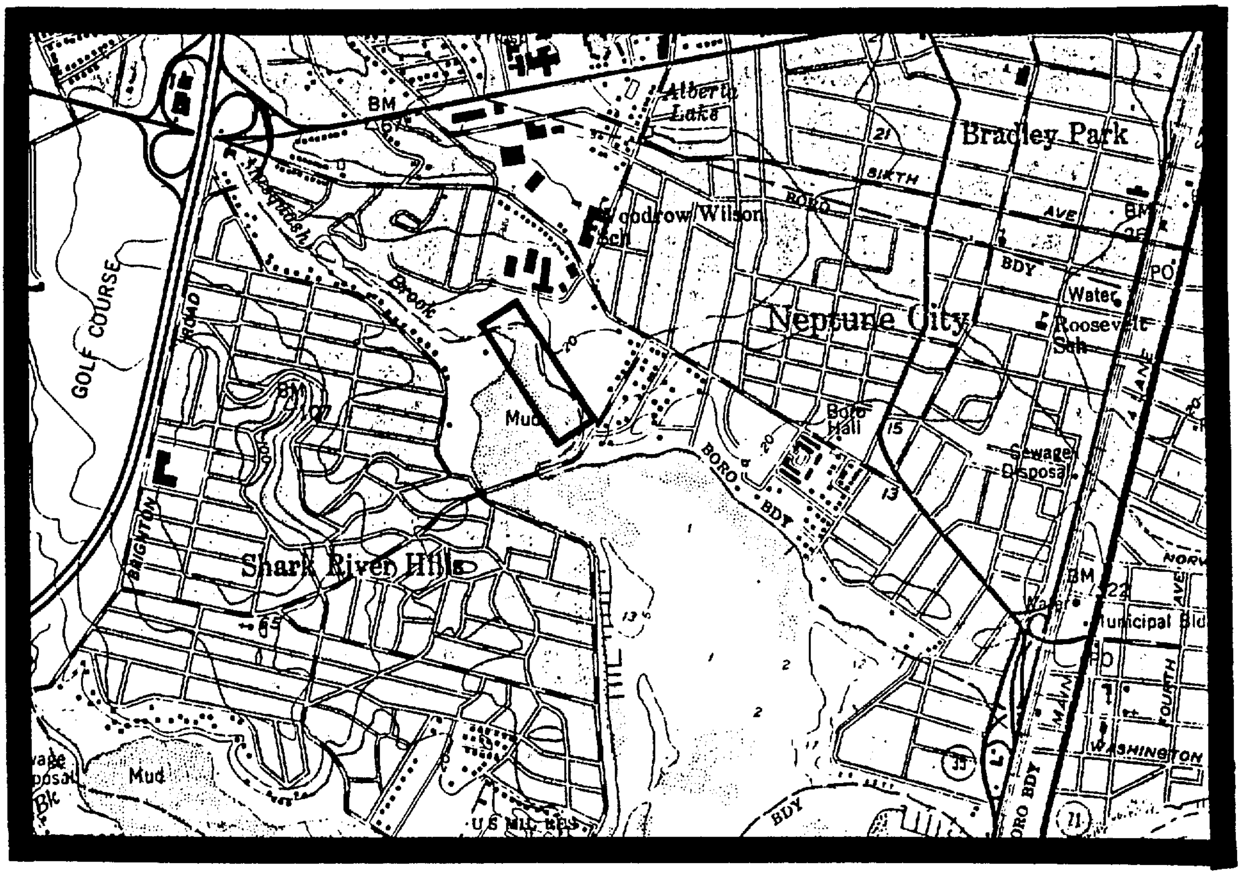
MAP A: Sheet # 45, Monmouth County Soil Survey
(Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury
Park, N.J. Quadrangle (Scale 1:24,000)

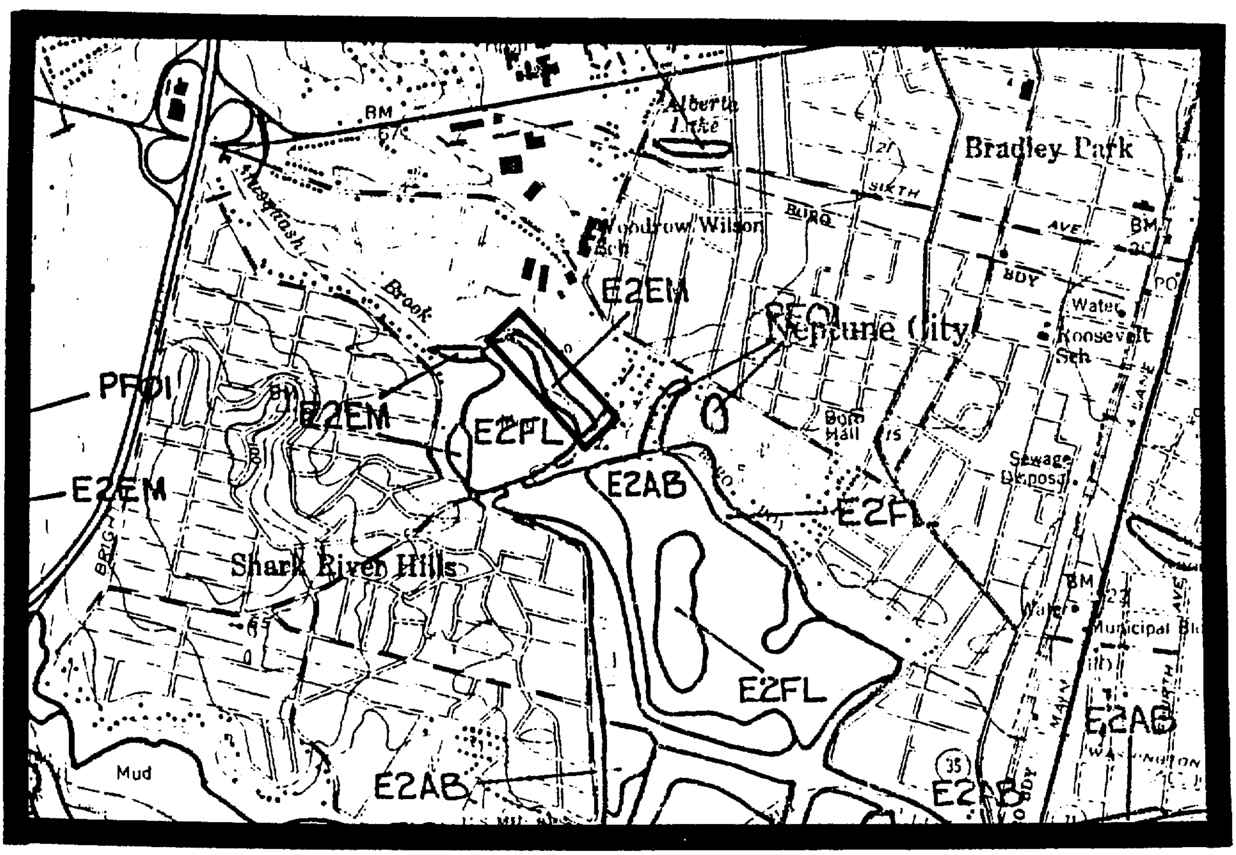
MAP A




Alberta Lake
Bradley Park
SIXTH AVE
BORO BDY
Woodrow Wilson Sch
Water
Neptune City
Roosevelt Sch
GOLF COURSE
BRIGHTON ROAD
Brook
Mud
Boro Hall
Sewage Disposal
Shark River Hills
Municipal Bld
FOURTH AVE
MAIN
WASHINGTON
Mud

MAP B

MAP C


Alberta Lake
Bradley Park
SIXTH AVE
Woodrow Wilson Sch
Brook
E2EM
Neptune City
Roosevelt Sch
PFOI
E2EM
E2FL
E2EM
E2AB
E2FL
Boro Hall
Sewage Disposal
Shark River Hills
E2FL
E2AB
Mud
E2AB
E2AB

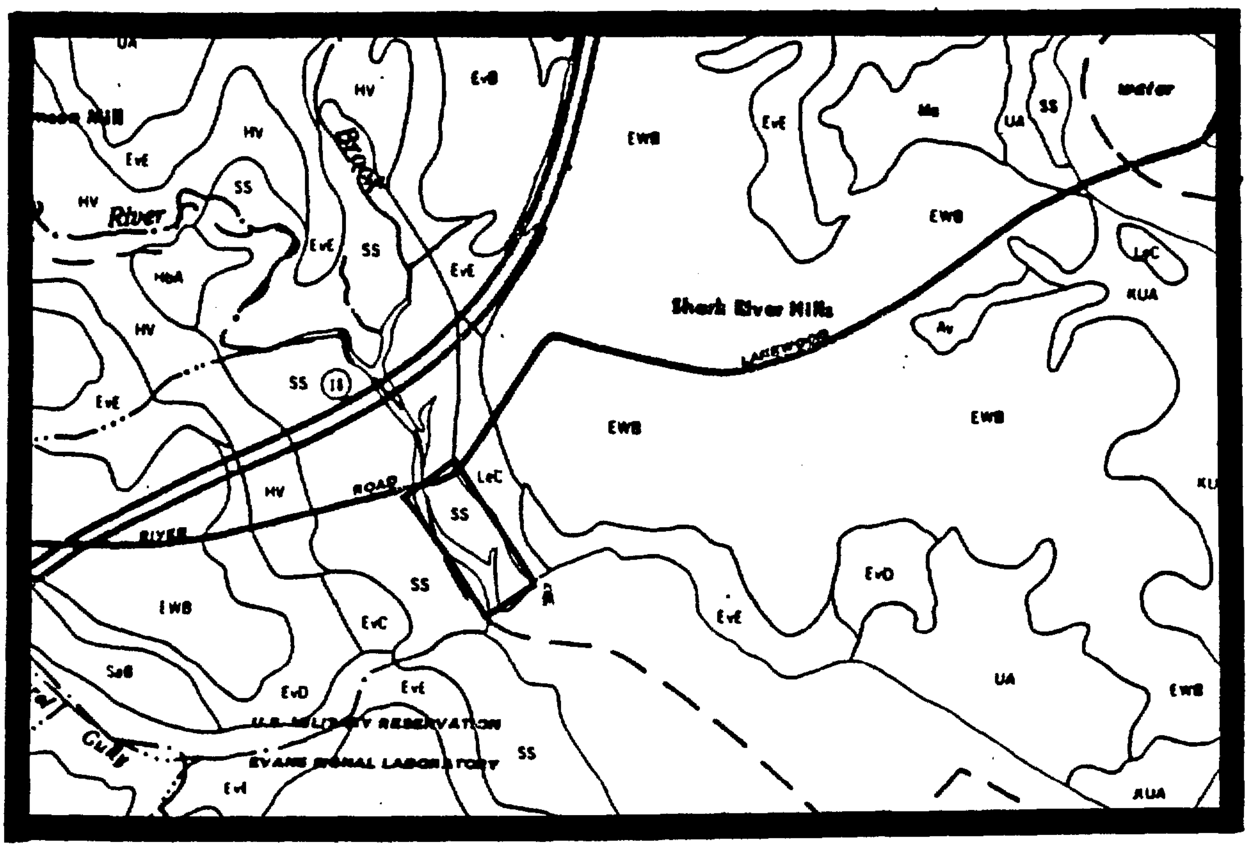
SITE 96 Hillside Rd., Neptune, Monmouth County.

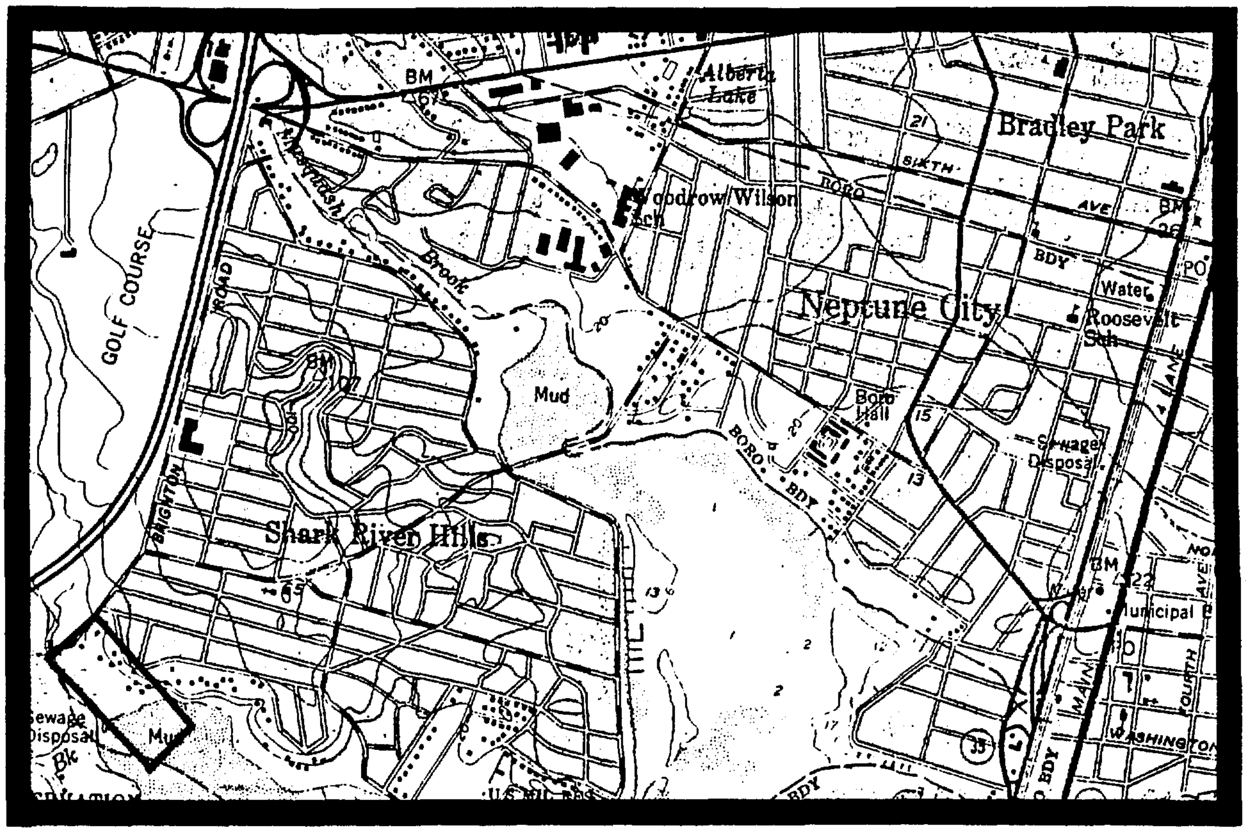
MAP A: Sheet # 45, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

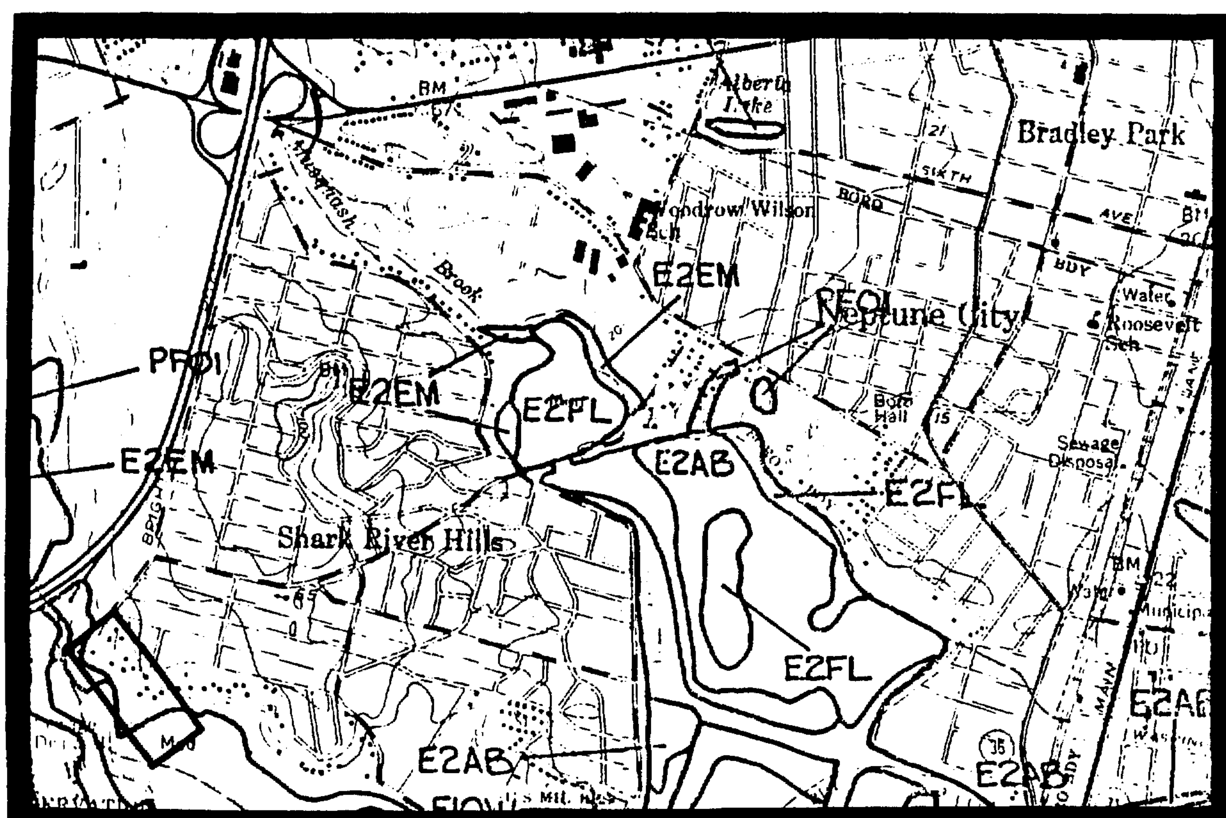
MAP A




Alberta Lake
BM 67
Bradley Park
SIXTH AVE
BORO BDY
Woodrow Wilson Sch
Brook
GOLF COURSE
BRIGHTON ROAD
Neptune City
Water
Roosevelt Sch
Mud
Boro Hall
Sewage Disposal
Shark River Hills
Municipal
MAIN
FOURTH
WASHINGTON
Sewage Disposal
Mud

MAP B

MAP C


Alberta Lake
BM 67
Bradley Park
SIXTH AVE
BORO BDY
Woodrow Wilson Sch
Brook
E2EM
PEOI
Neptune City
Water
Roosevelt Sch
PFOI
E2EM
E2FL
E2EM
E2AB
Boro Hall
E2FL
Sewage Disposal
Shark River Hills
E2FL
Municipal
E2AB
E2AB
E2AB

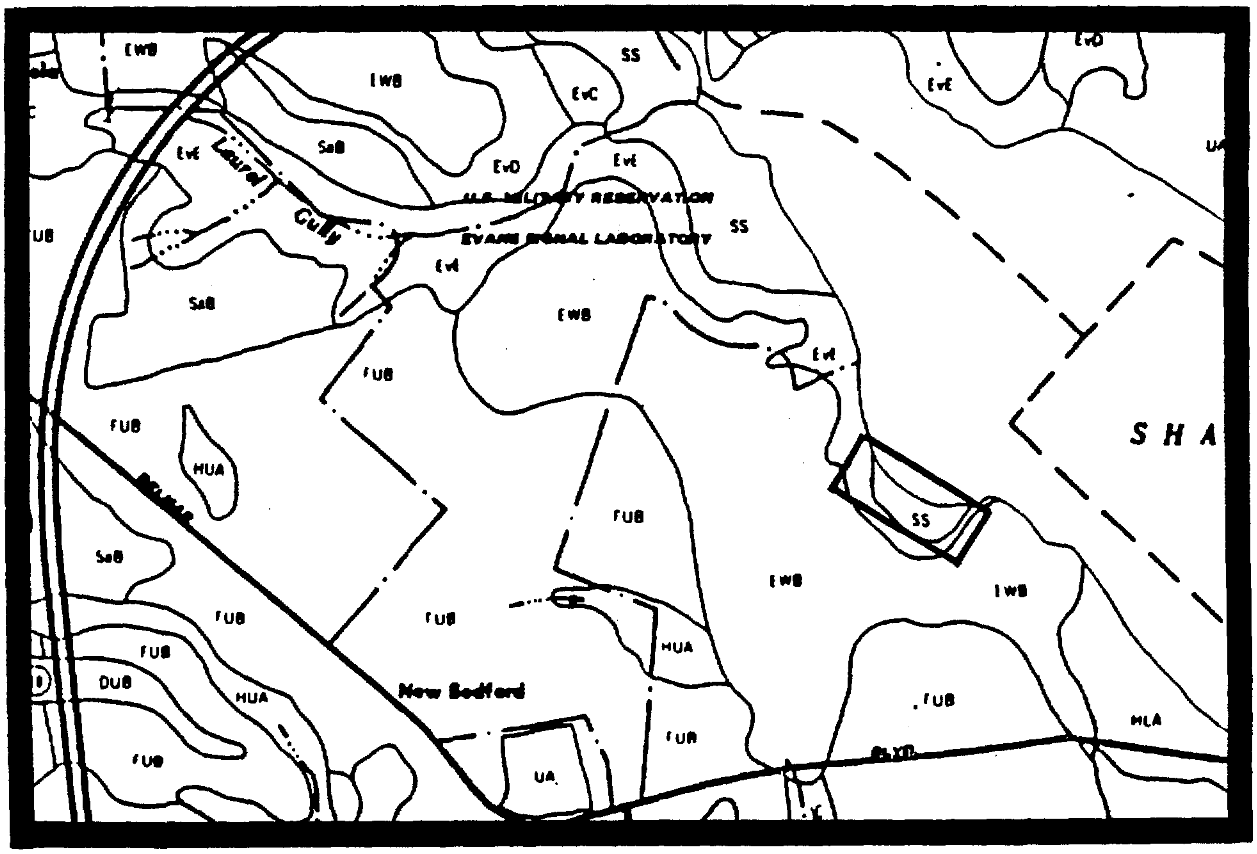
SITE 97 Marconi Rd., Neptune, Monmouth County.

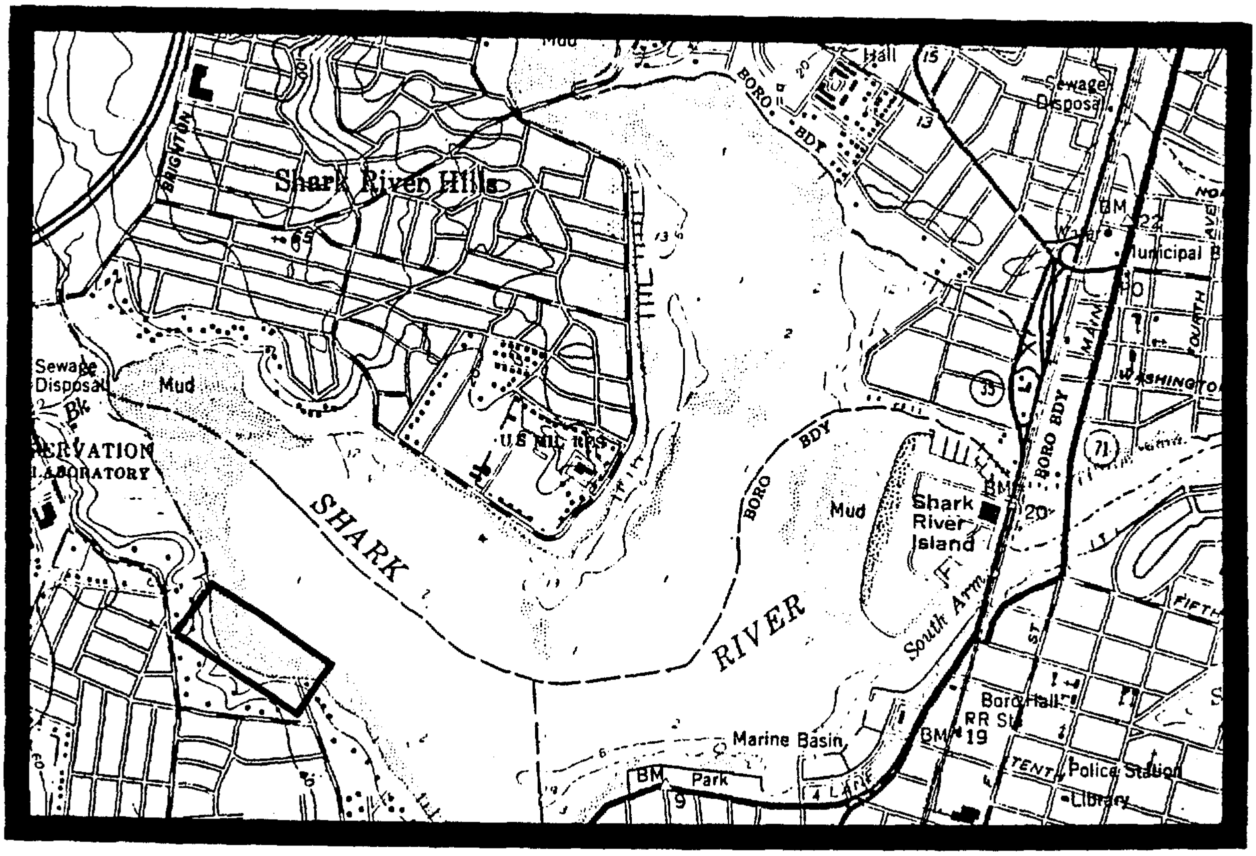
MAP A: Sheet # 45, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

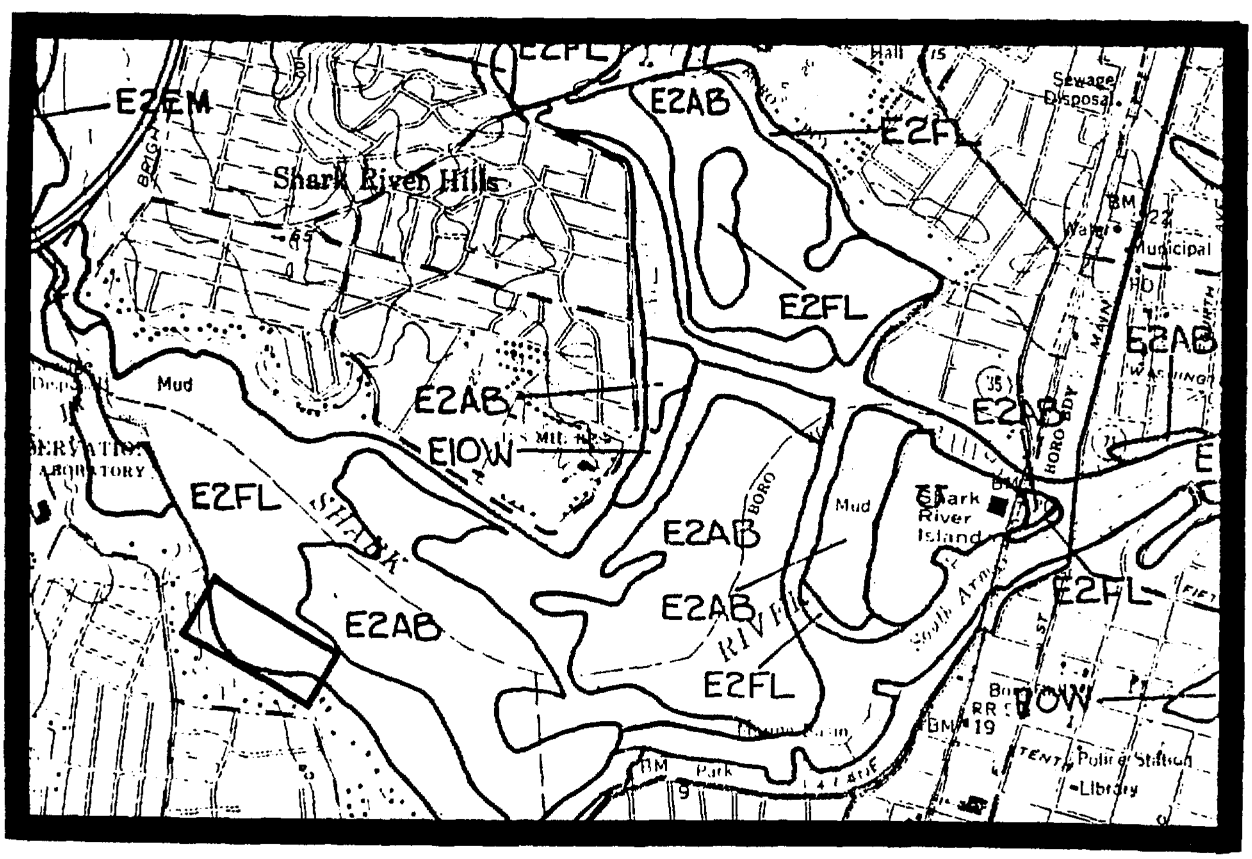
MAP A




Sewage Disposal
Shark River Hills
Mud
Sewage Disposal
Bk
SERVATION
LABORATORY
SHARK
RIVER
BORO BDY
Mud
Shark River Island
South Arm
Marine Basin
Park
Boro Hall
RR St
Police Station
Library
Municipal
Water
35
71

MAP B

MAP C


E2EM
E2AB
E2FL
Shark River Hills
E2FL
E2AB
E1OW
E2FL
E2AB
E2AB
E2AB
E2AB
E2FL
E2FL
E2AB
POW
Mud
Shark River Island
Sewage Disposal
Police Station
Library

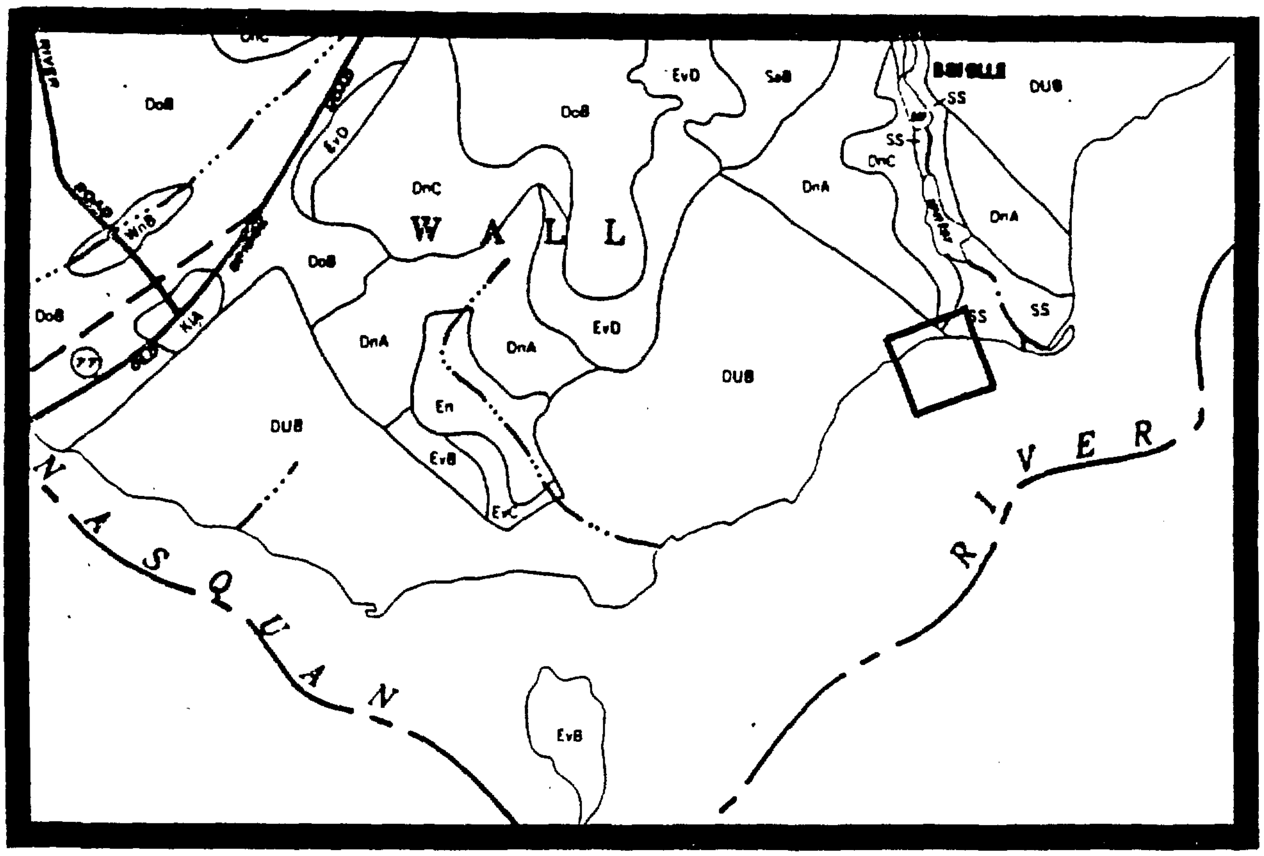
SITE 99 Manasquan Golf Course, Brielle, Monmouth County.

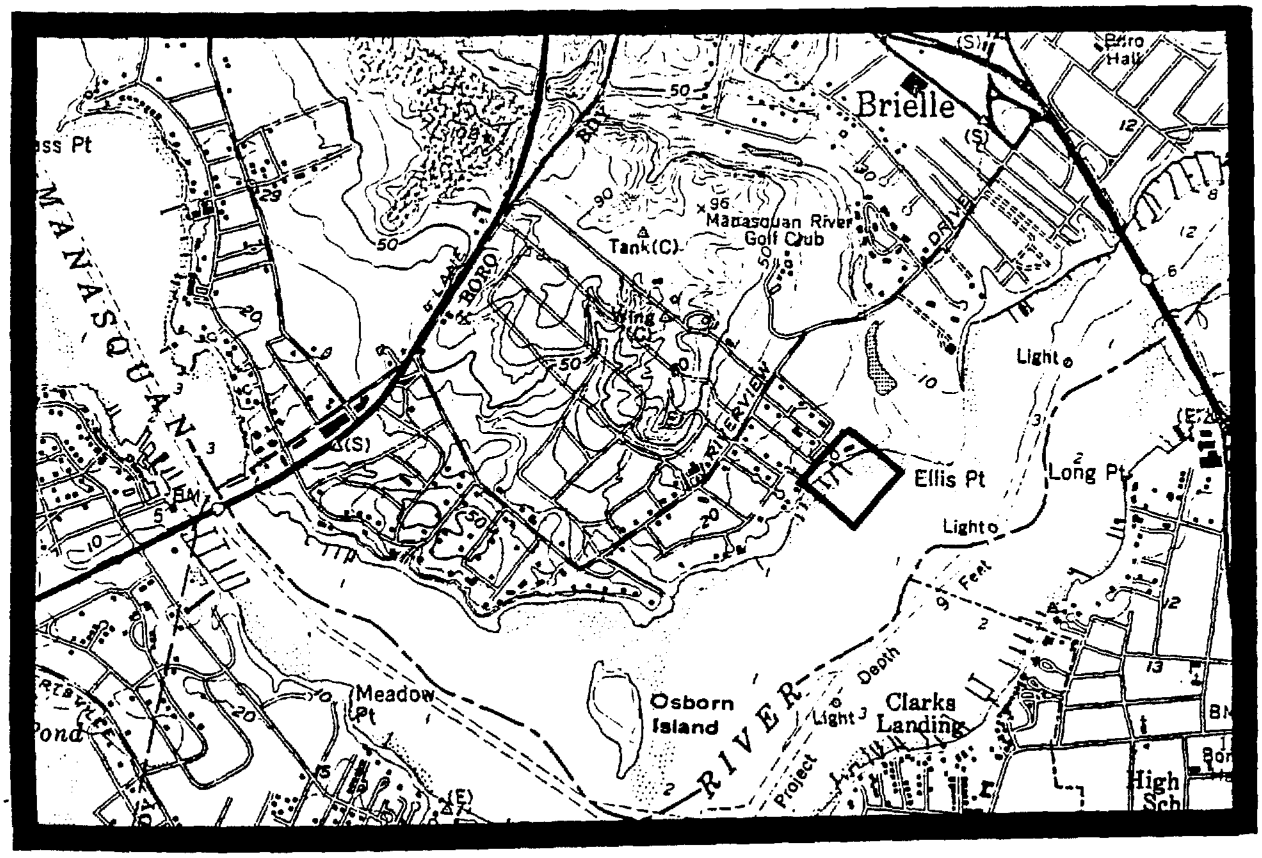
MAP A: Sheet # 61, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Point Pleasant, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Point Pleasant, N.J. Quadrangle (Scale 1:24,000)

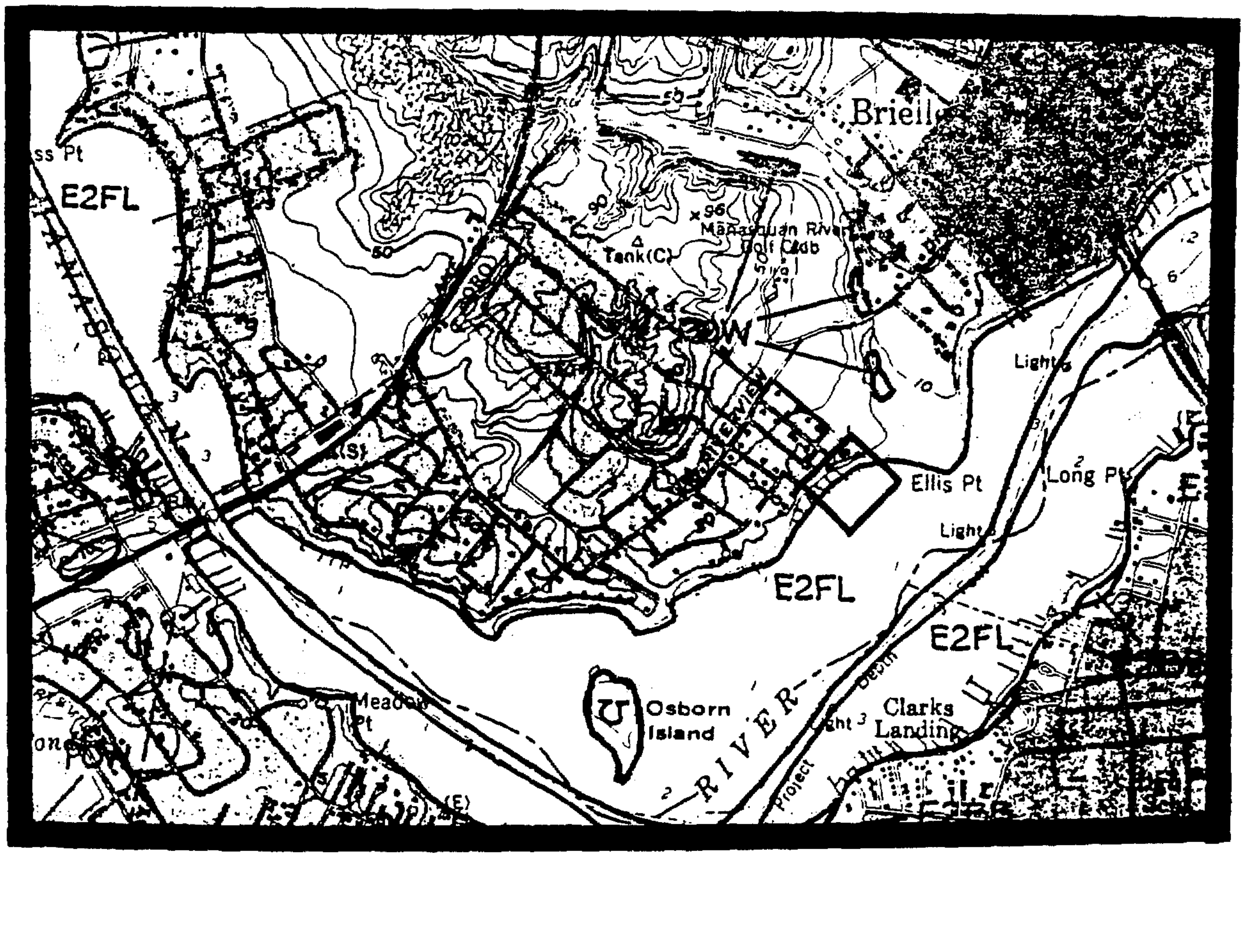
MAP A




Brielle
Boro Hall
Manasquan River
Golf Club
Tank(C)
MANASQUAN
RIVERVIEW
BORO
Ellis Pt
Long Pt
Light
9 Feet
Depth
Project
Osborn
Island
Clarks
Landing
RIVER
Meadow
Pt
High
Sch

MAP B

MAP C


Brielle
E2FL
Manasquan River
Golf Club
Tank(C)
Ellis Pt
Long Pt
Light
E2FL
E2FL
Osborn
Island
Clarks
Landing
RIVER
Meadow
Pt

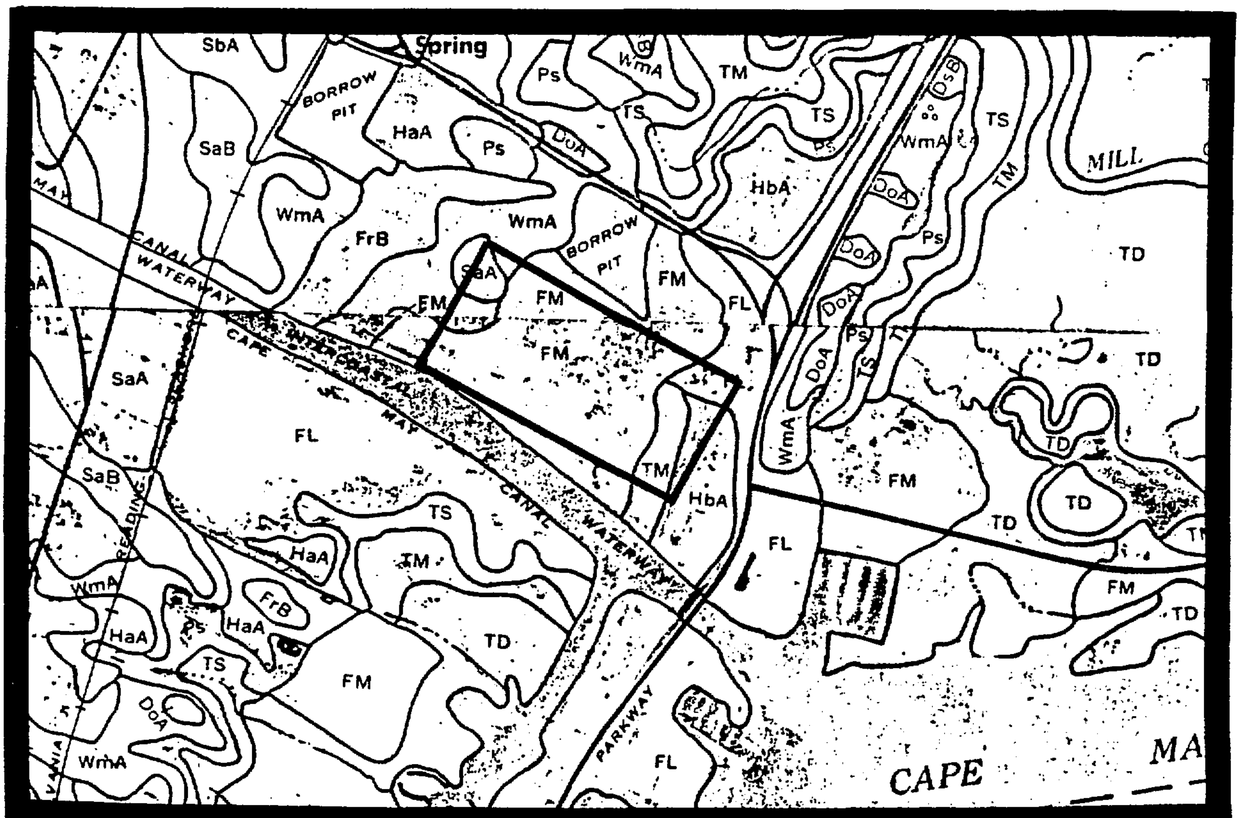
SITE 108 Tranquility Park, Lower Twp., Cape May County.

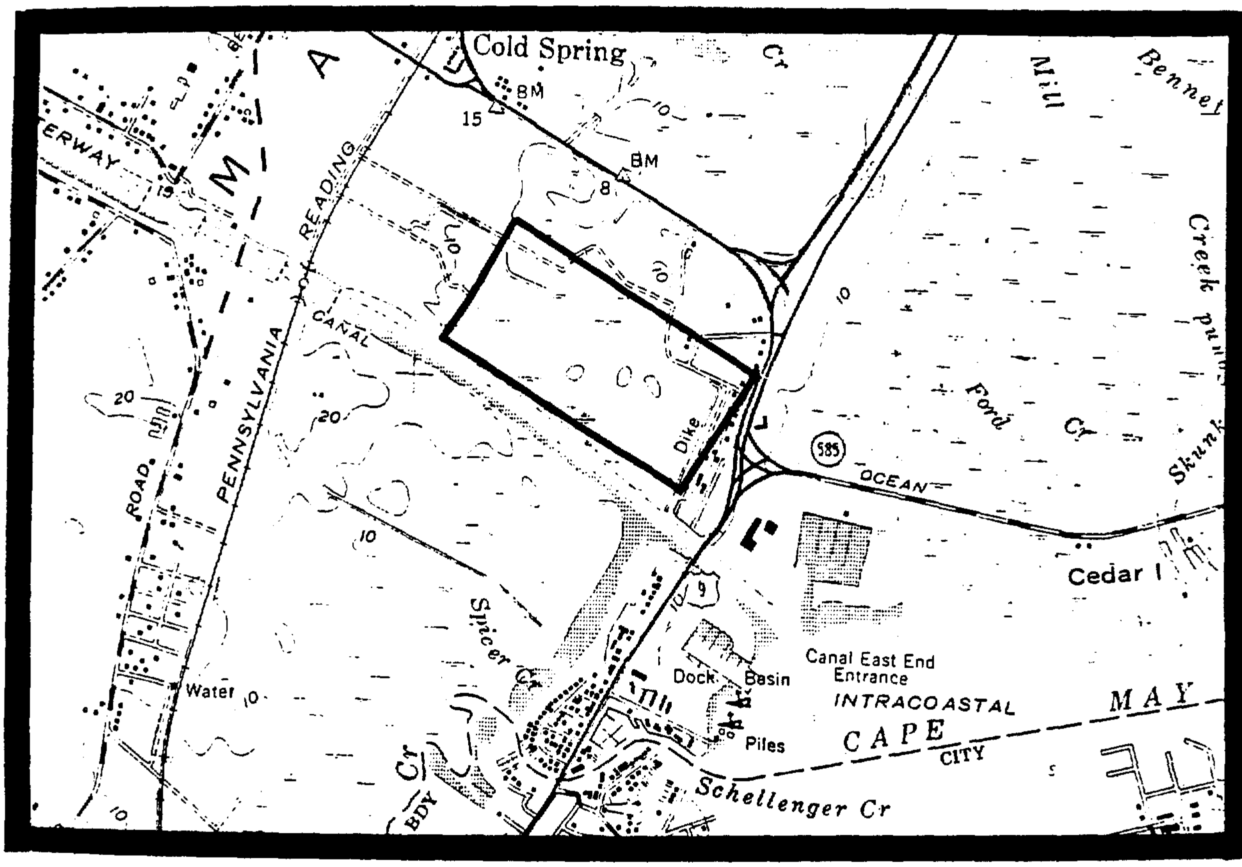
MAP A: Sheet # 29, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Cape May, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Cape May, Quadrangle (Scale 1:24,000)

MAP A

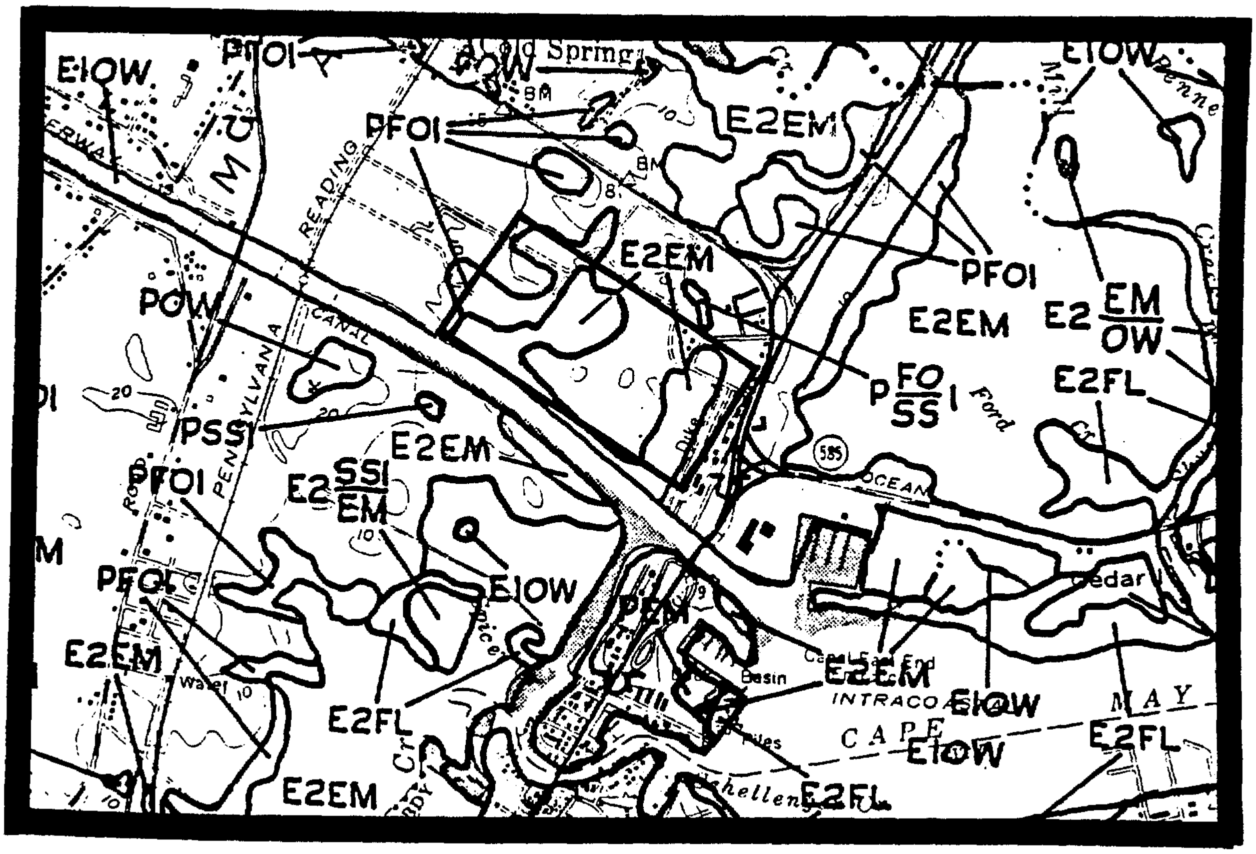




Cold Spring
BM
Mill
Bennet
Creek
Pond
Cr
Skunk
PENNSYLVANIA
READING
CANAL
ROAD
Dike
585
OCEAN
Cedar I
Spicer Cr
Canal East End
Entrance
Dock
Basin
INTRACOASTAL
MAY
CAPE
CITY
Piles
Water
Schellenger Cr
BDY

MAP B

MAP C



E1OW
PFO1
E2EM
POW
PSS1
E2 SSI/EM
PFO1
E2EM
E1OW
E2FL
PEM
PFO1
E2 EM/OW
P FO/SS 1
E2FL
E2EM
E1OW
E1OW
E2FL
E2FL
E2EM

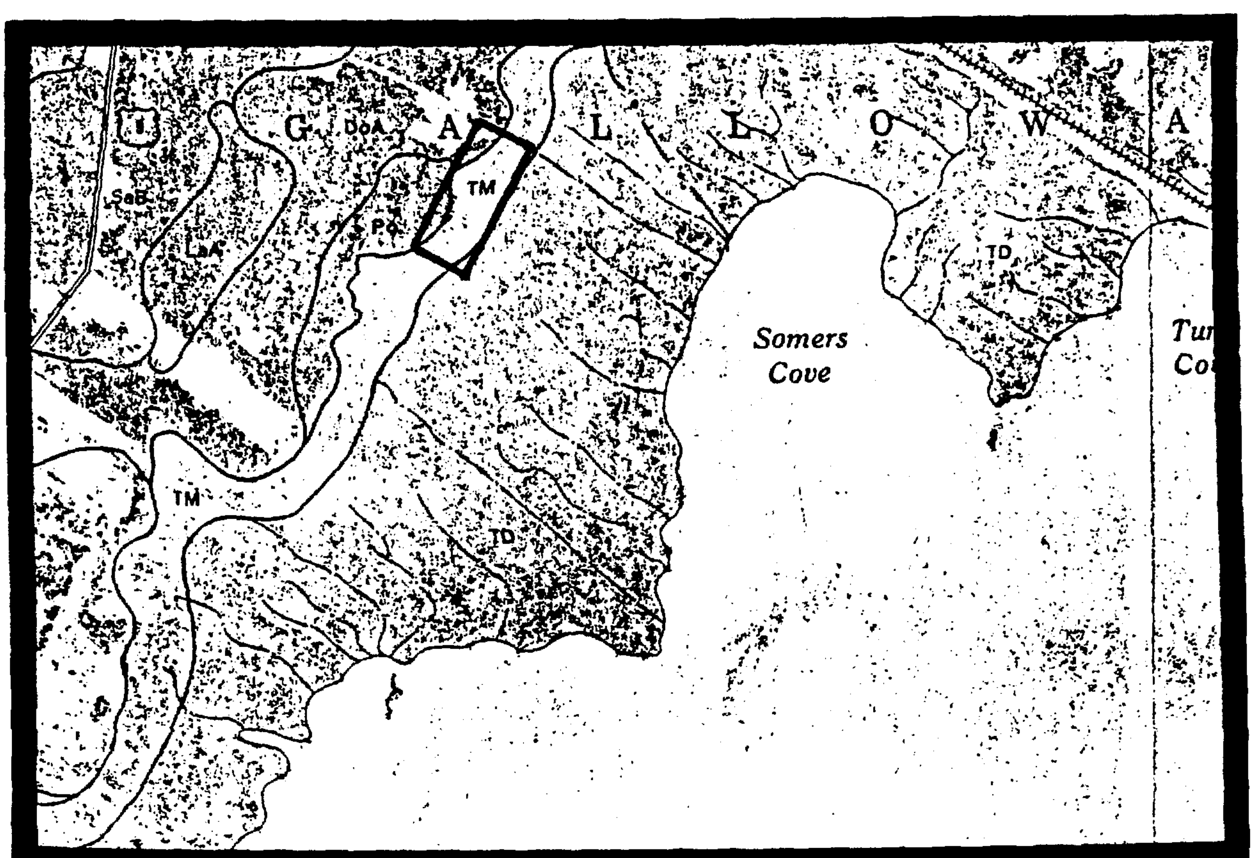
SITE 110 Reeds Bay Village, Galloway Twp., Atlantic County.

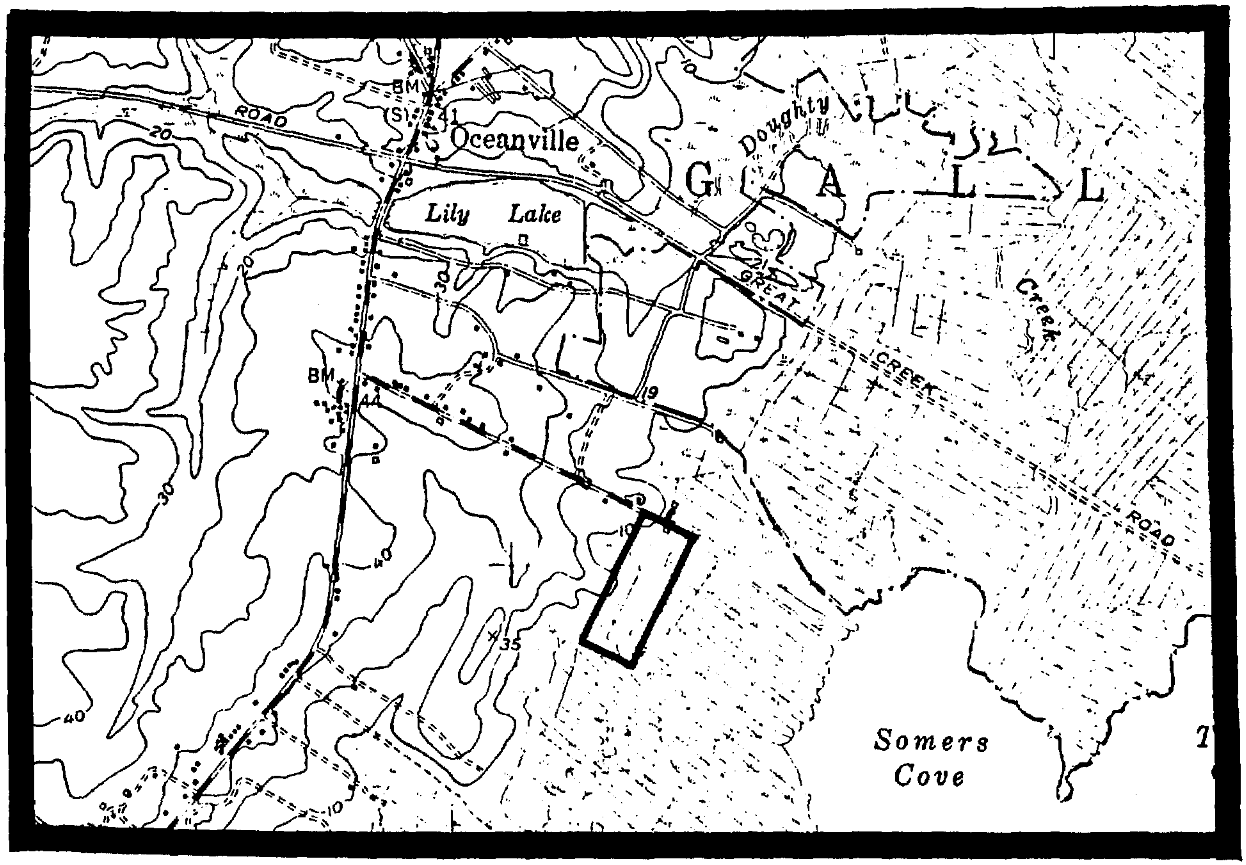
MAP A: Sheet # 34, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Oceanville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Oceanville, N.J. Quadrangle (Scale 1:24,000)

MAP A

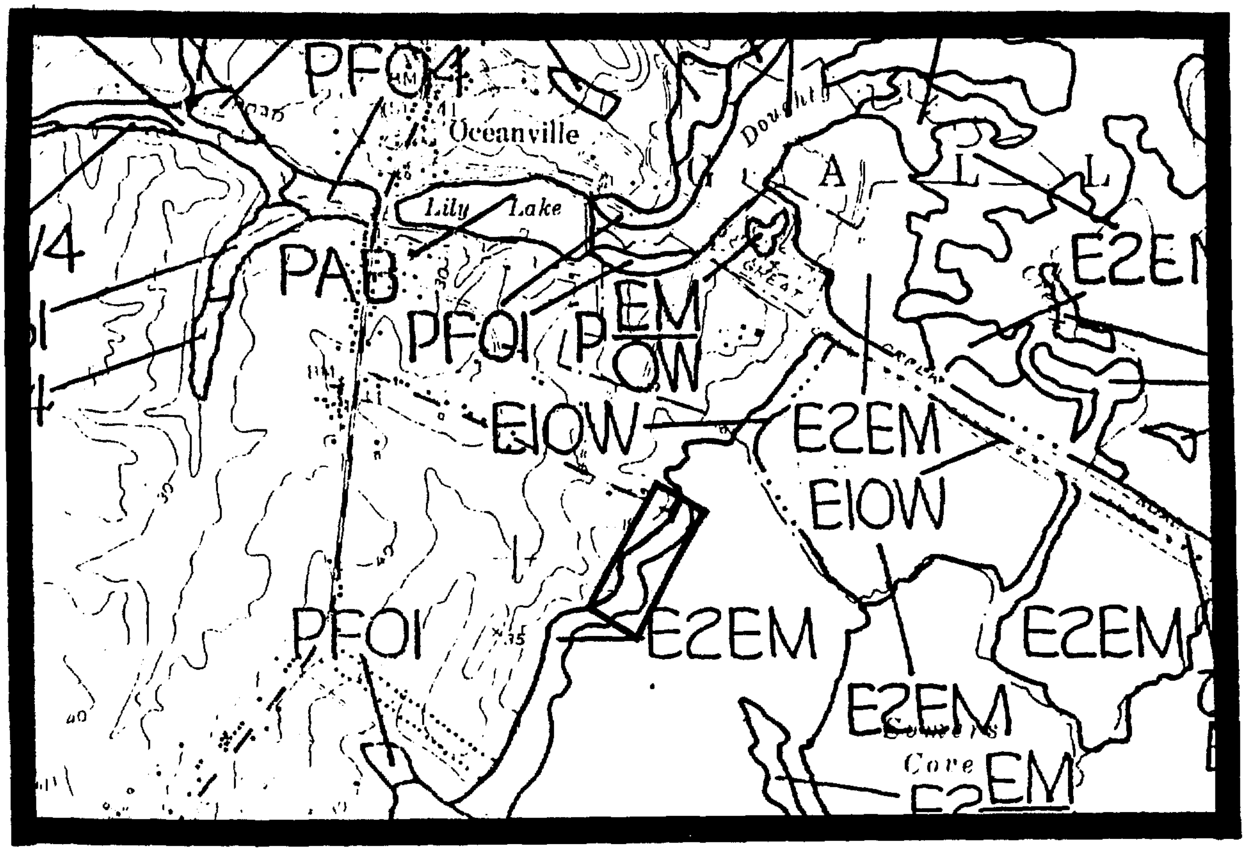




ROAD
Oceanville
Doughty
G A L L
Lily Lake
GREAT
Creek
CREEK
ROAD
Somers
Cove

MAP B

MAP C



PFO4
Oceanville
Lily Lake
PAB
PFOI
P EM/OW
EIOW
E2EM
EIOW
E2EM
PFOI
E2EM
E2EM
E2EM
EM

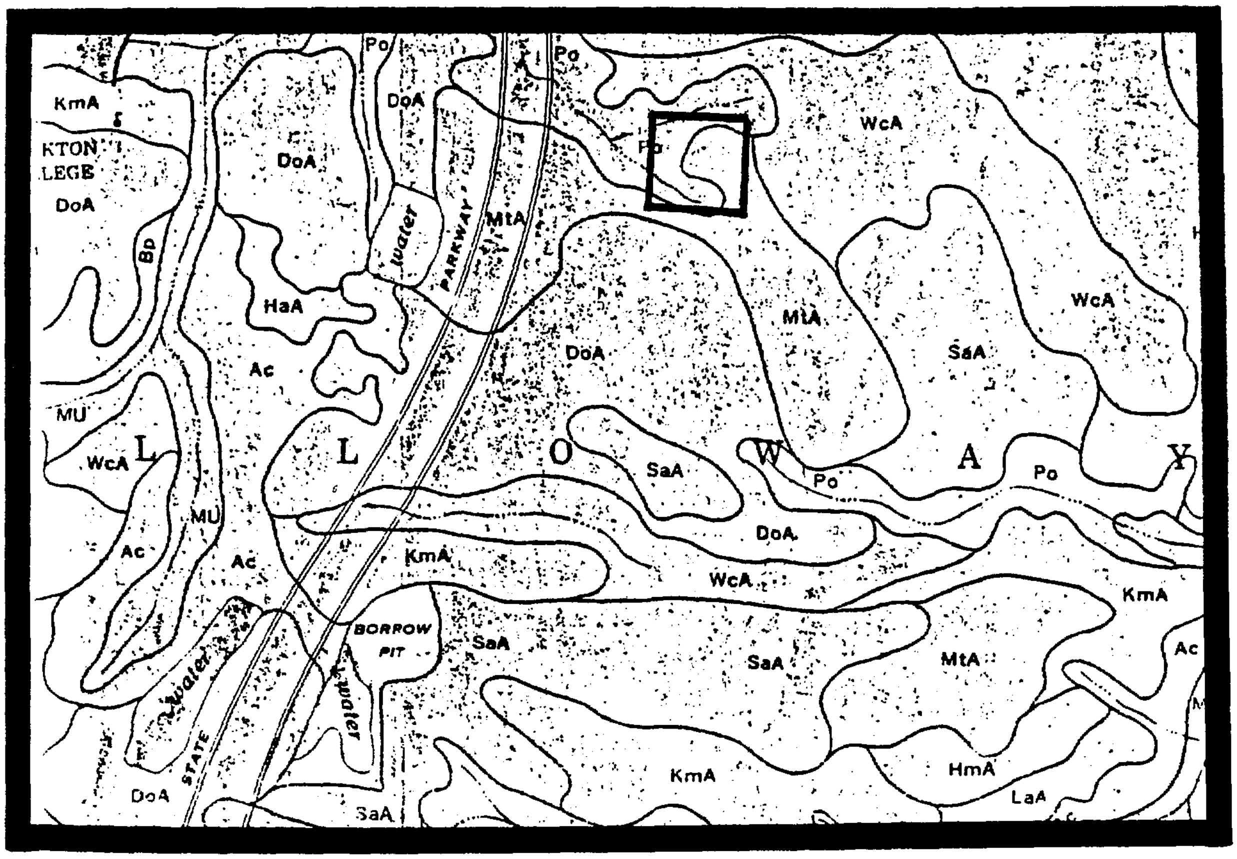
SITE 111 Club at Galloway, Galloway Twp., Atlantic County.

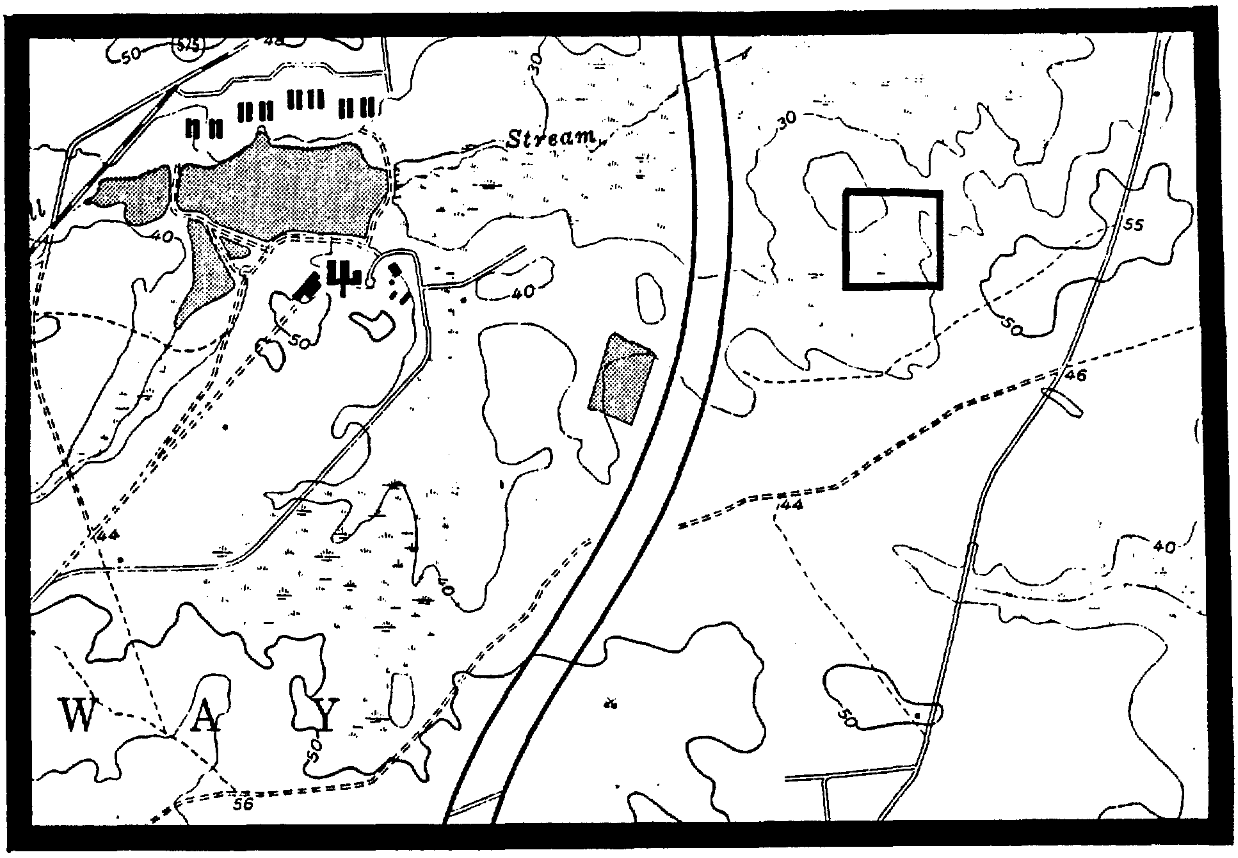
MAP A: Sheet # 26, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Pleasantville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Pleasantville, N.J. Quadrangle (Scale 1:24,000)

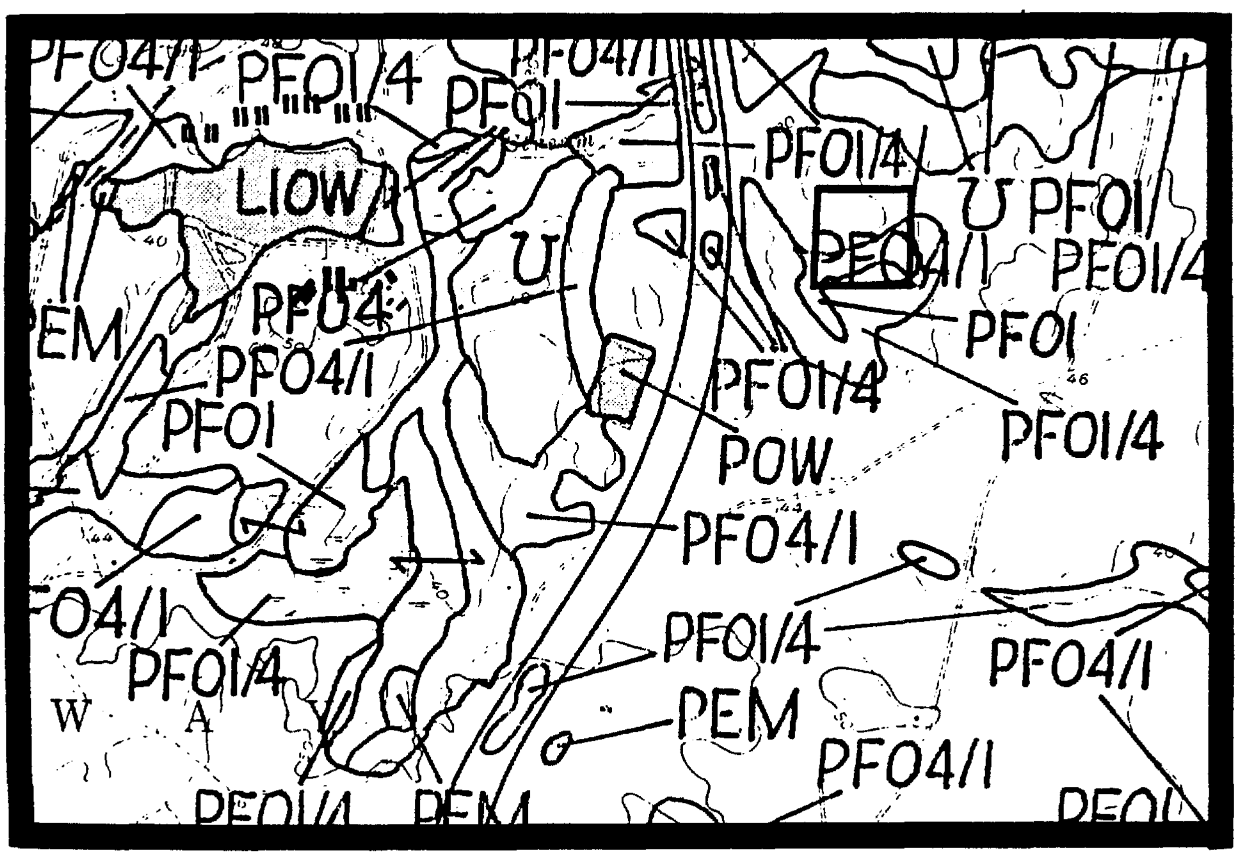
MAP A




Stream
W A Y

MAP B

MAP C


PF04/1
PF01/4
PF01
LIOW
U
PF04
PEM
PF04/1
PF01
Q
PF01/4
U PF01/
PE01/4
PF01
PF01/4
POW
PF01/4
PF04/1
PF04/1
PF01/4
PF01/4
PF04/1
PEM
PF04/1
W A

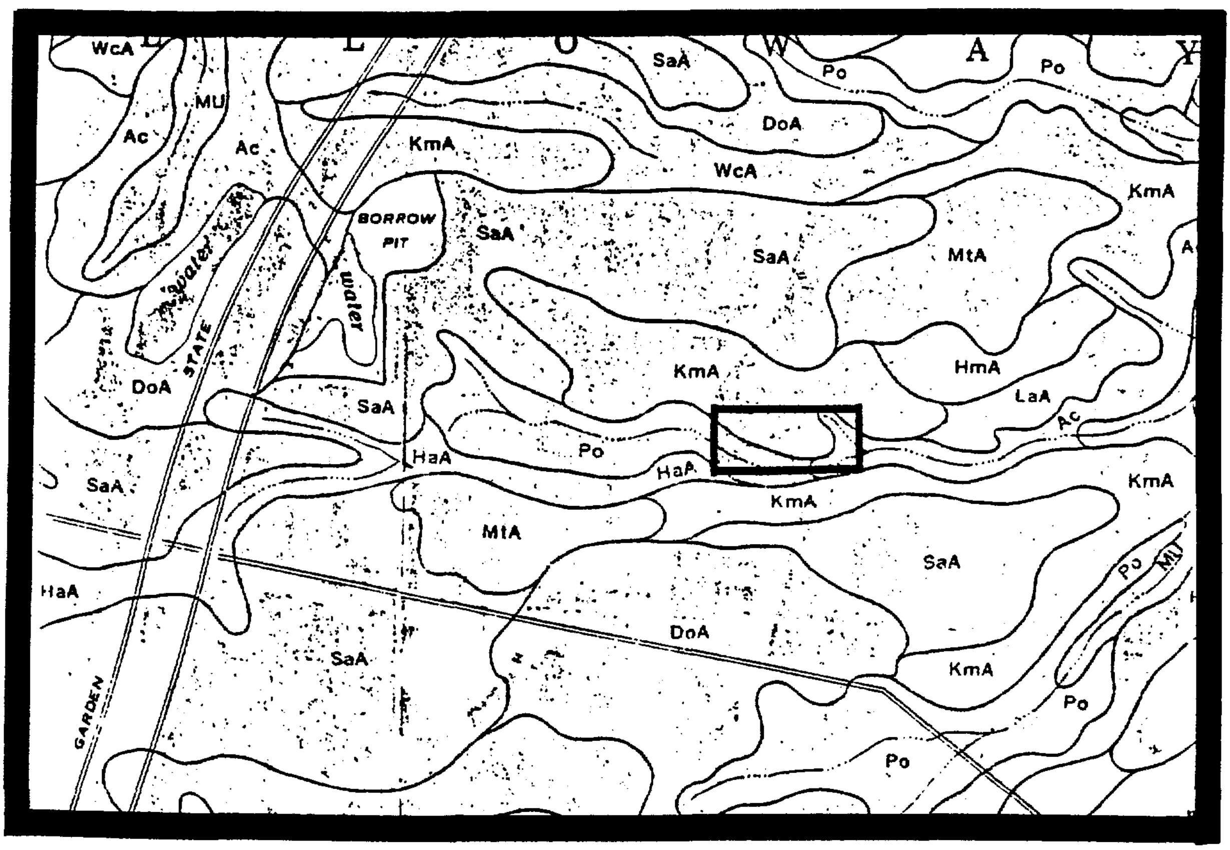
SITE 112 Pinnacle, Galloway Twp., Atlantic County.

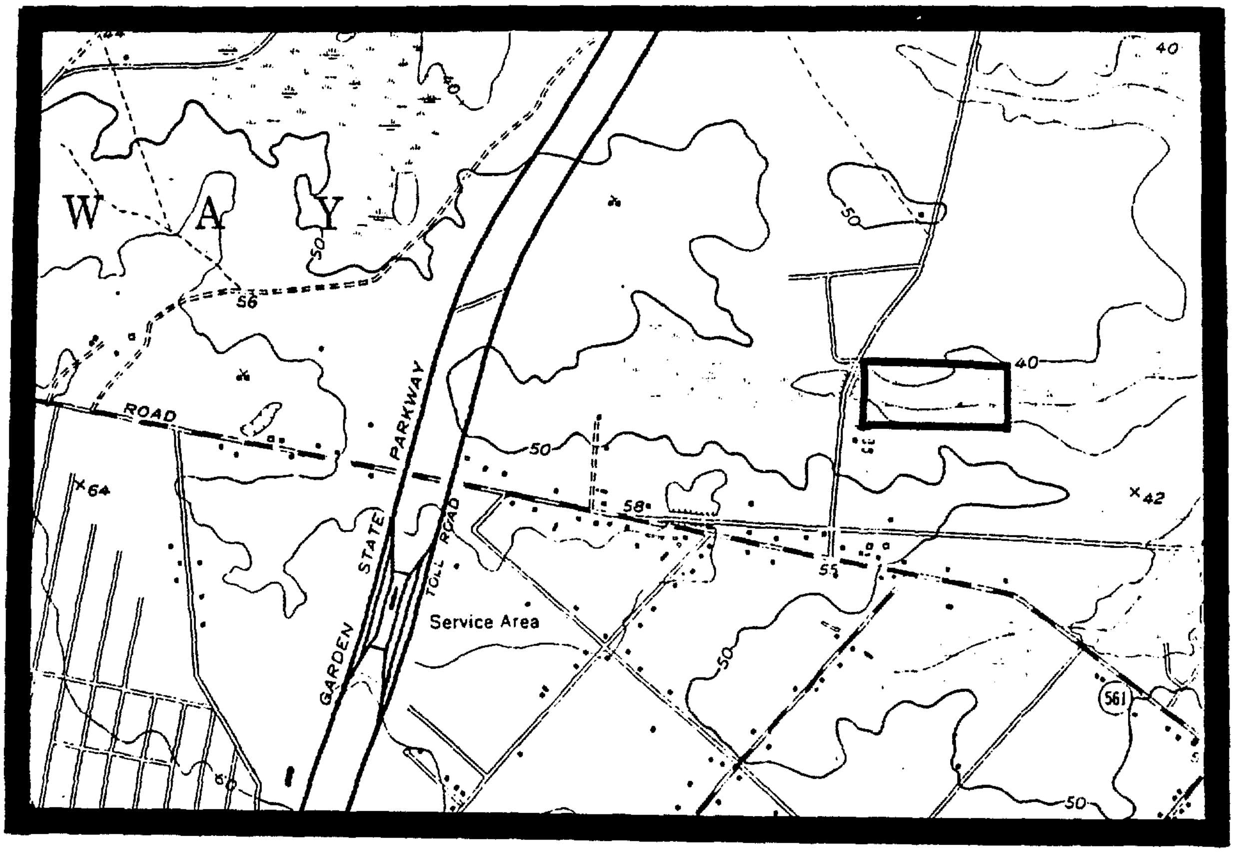
MAP A: Sheet # 26, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Pleasantville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Pleasantville, N.J. Quadrangle (Scale 1:24,000)

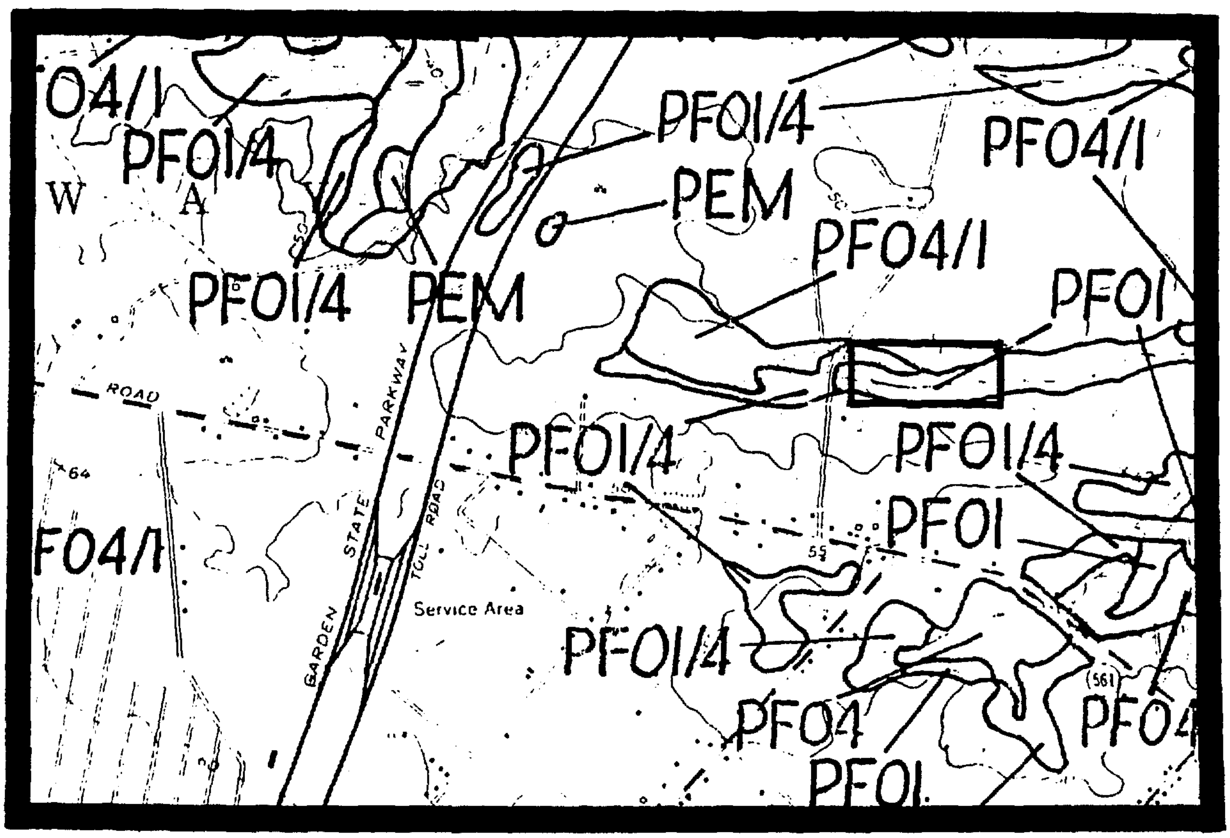
MAP A




W A Y
ROAD
GARDEN STATE PARKWAY
TOLL ROAD
Service Area
561

MAP B

MAP C


PF01/4
PF04/I
PEM
PF01/4
PEM
PF04/I
PF01
PF01/4
PF01/4
PF01
PF01/4
PF04
PF01
PF04
ROAD
GARDEN STATE PARKWAY
TOLL ROAD
Service Area

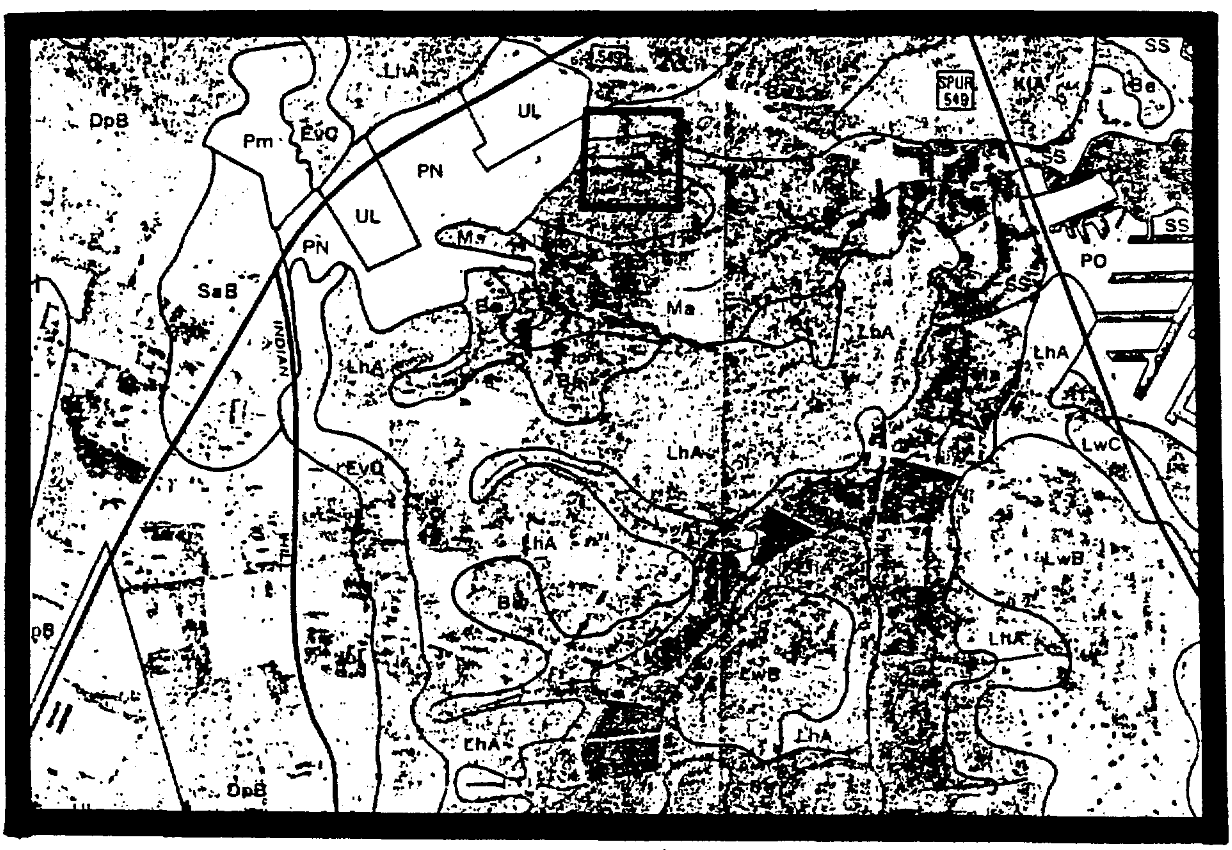
SITE 113 Toms River Intermediate School, Toms River, Ocean County.

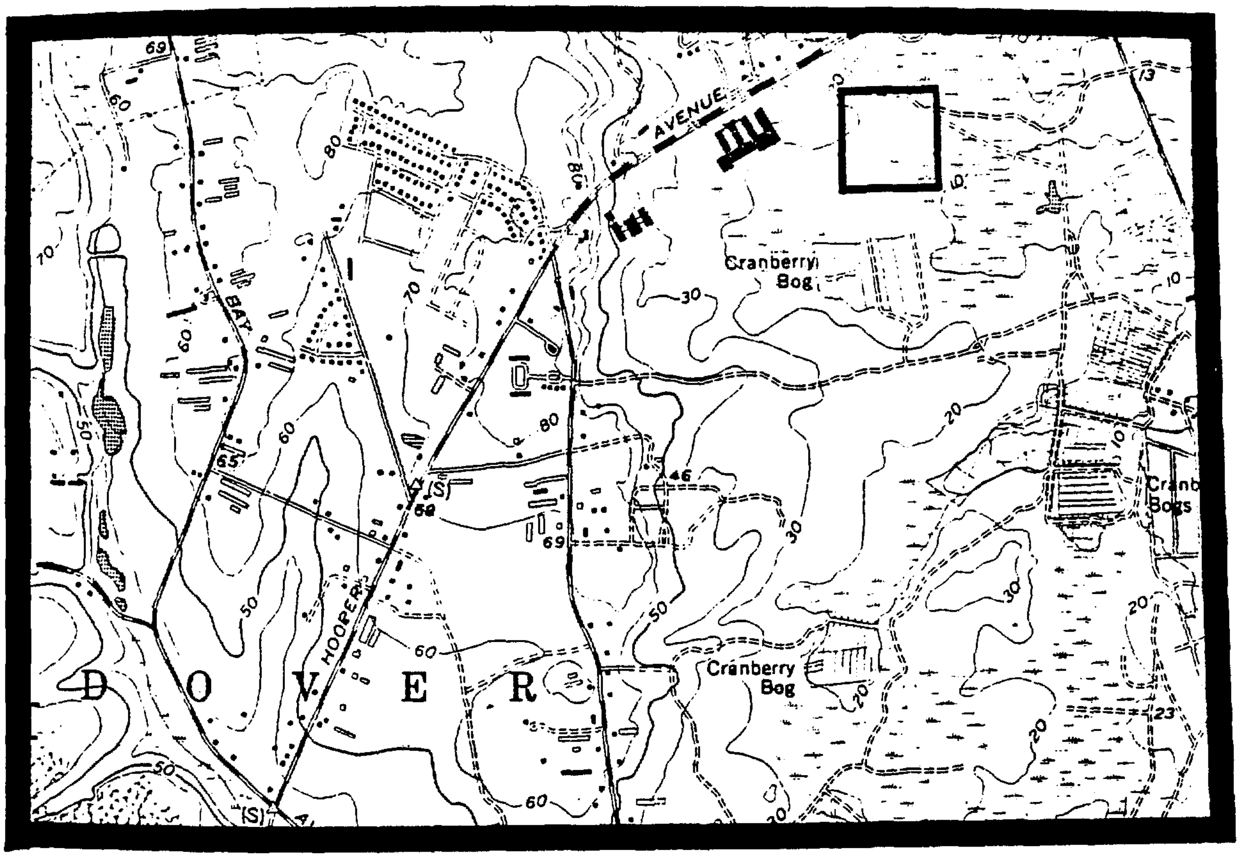
MAP A: Sheet # 26, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Toms River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Toms River, N.J. Quadrangle (Scale 1:24,000)

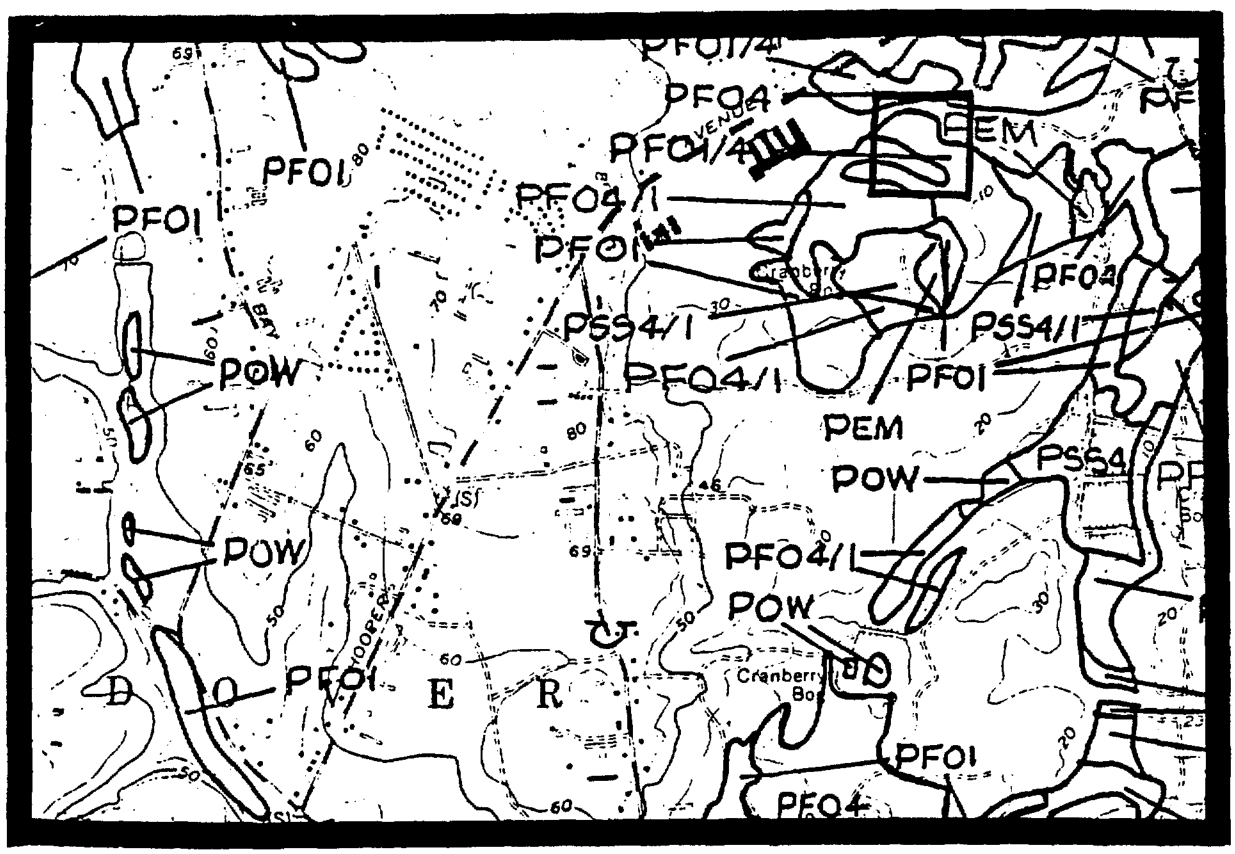
MAP A




AVENUE
Cranberry Bog
Cranberry Bog
BAY
HOOPER
D O V E R

MAP B

MAP C


PF01/4
PF04
PF01/4
PEM
PF01
PF01
PF04/1
PF01
PSS4/1
PF04
PSS4/1
POW
PF04/1
PF01
PEM
POW
PSS4
POW
PF04/1
POW
PF01
D O V E R
PF01
PF04

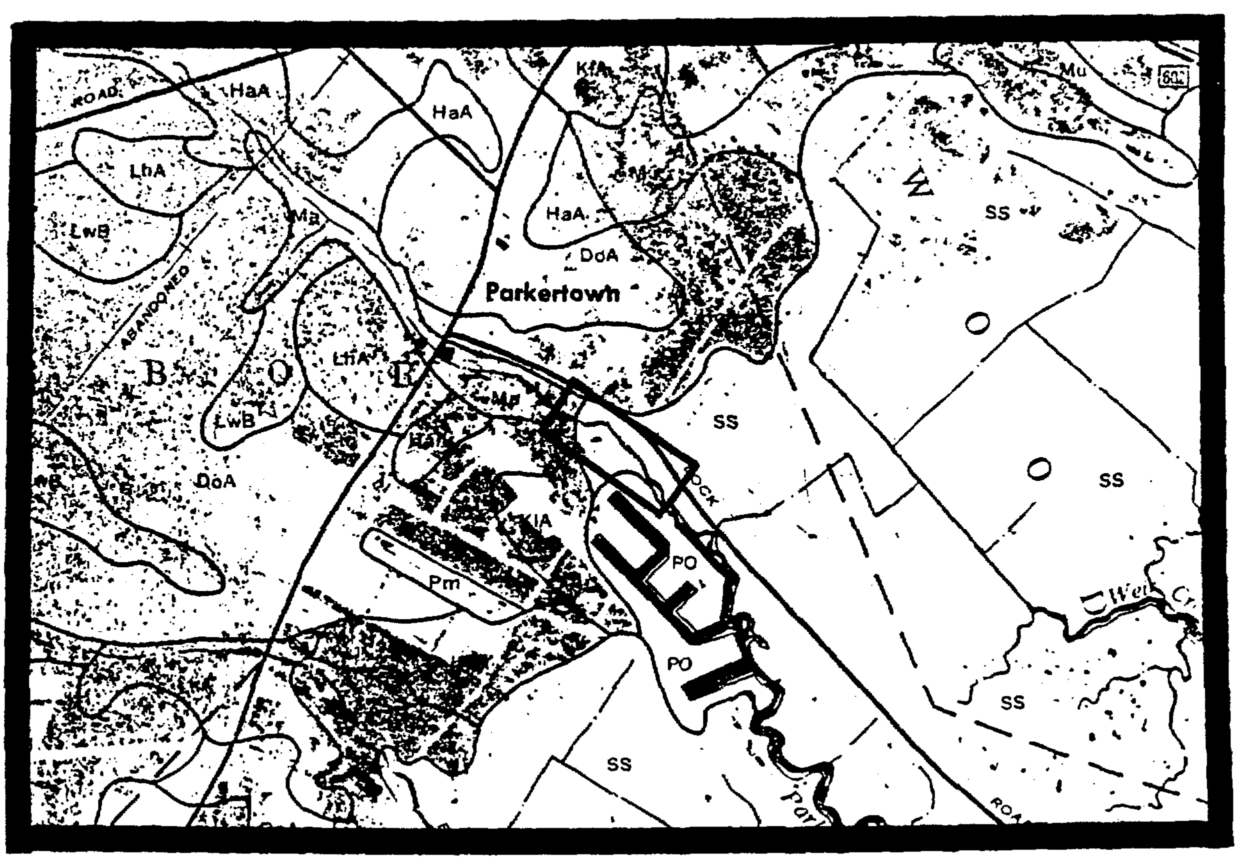
SITE 121 Dock Rd.,/Brook St., Parkertown, Ocean County.

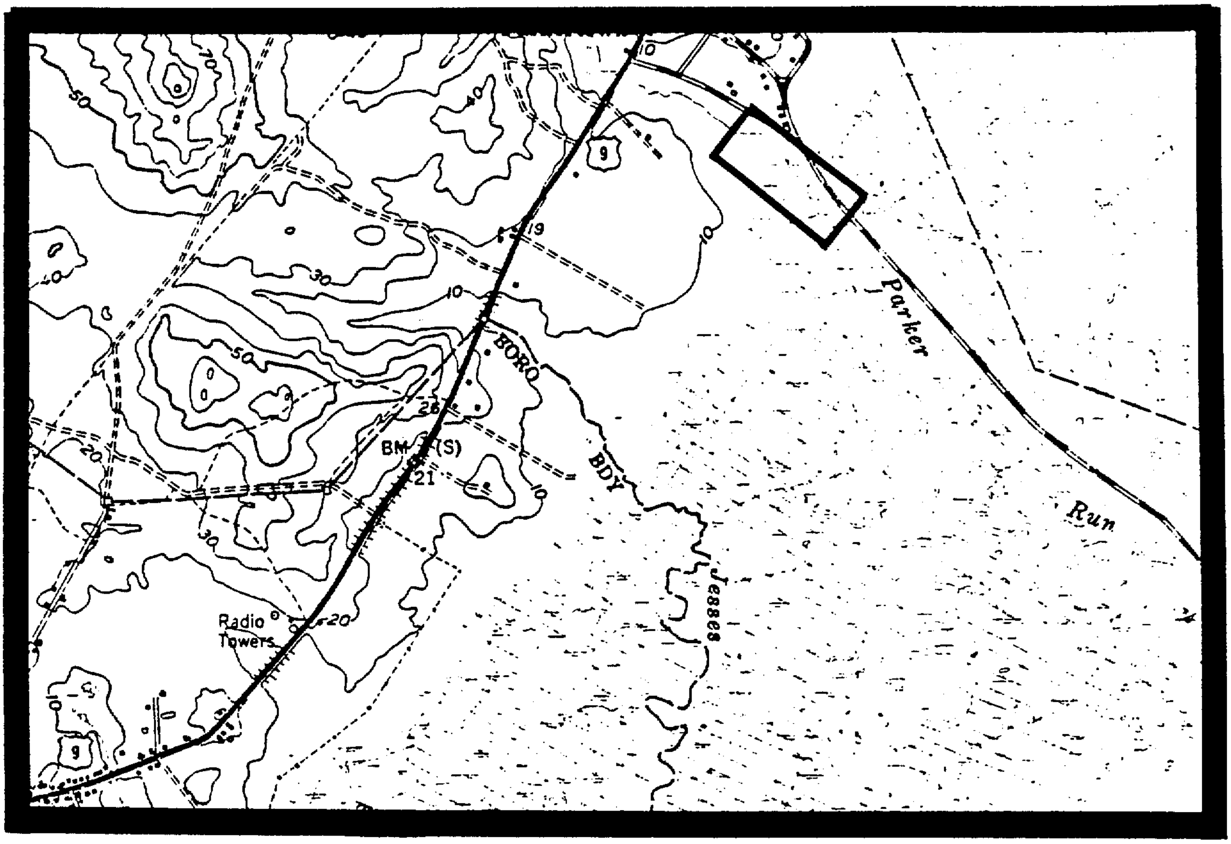
MAP A: Sheet # 56, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton,
N.J. Quadrangle (Scale 1:24,000)

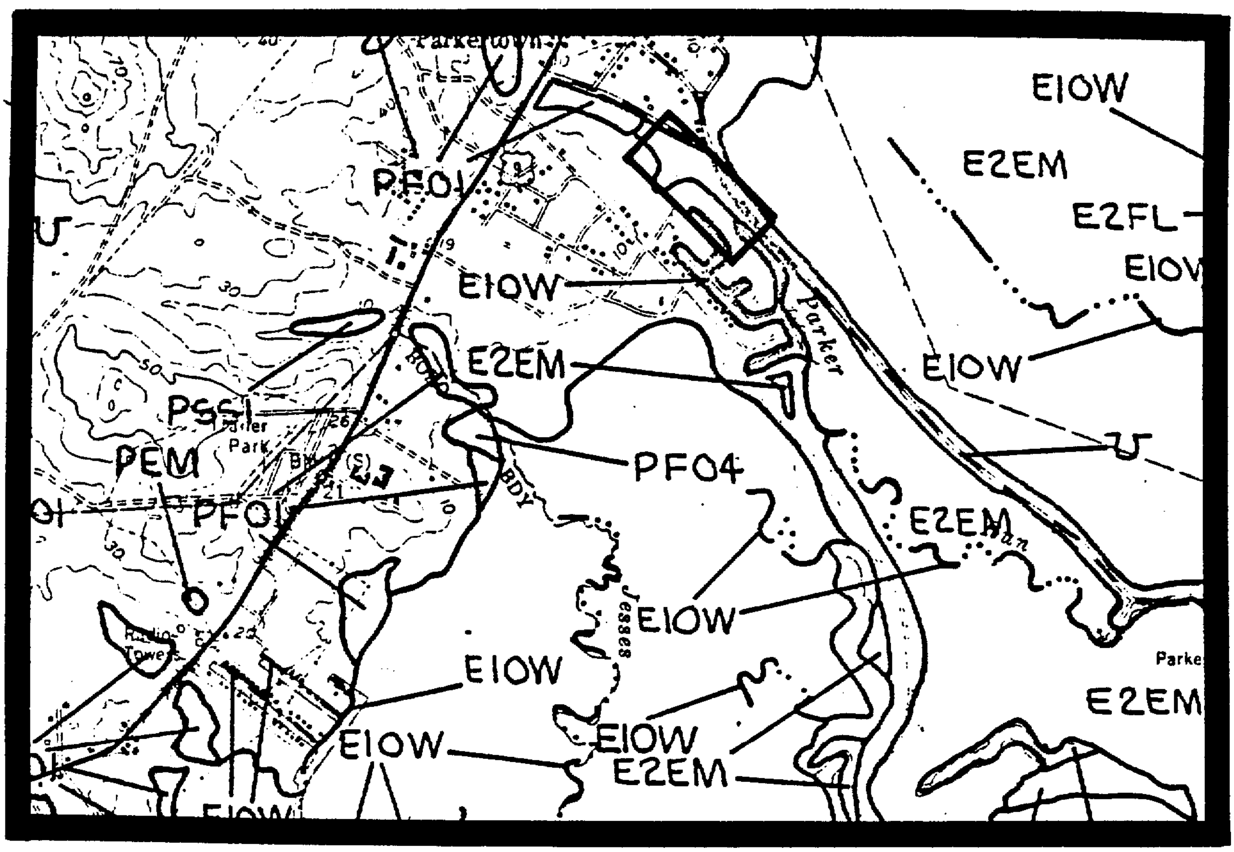
MAP A




Parker
Run
BORO
BDY
Jesses
Radio Towers

MAP B

MAP C


E1OW
E2EM
E2FL
PFO1
E2EM
PSS1
PEM
PFO1
PFO4
Parker
BORO
BDY
Jesses
E1OW
E1OW
E1OW
E1OW
E2EM
Radio Towers
Parker Park
E2EM

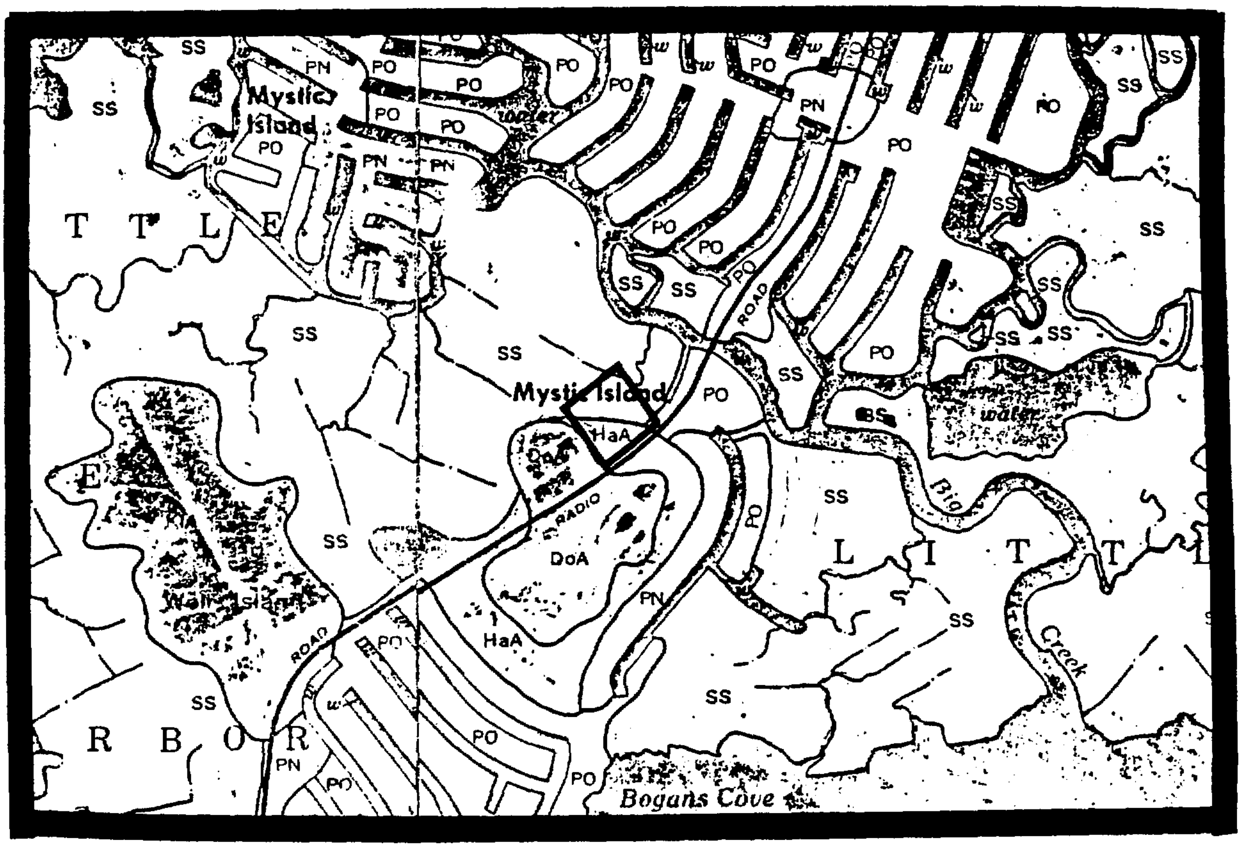
SITE 125   Radio Rd.,/Holden St., Mystic Island, Ocean County.

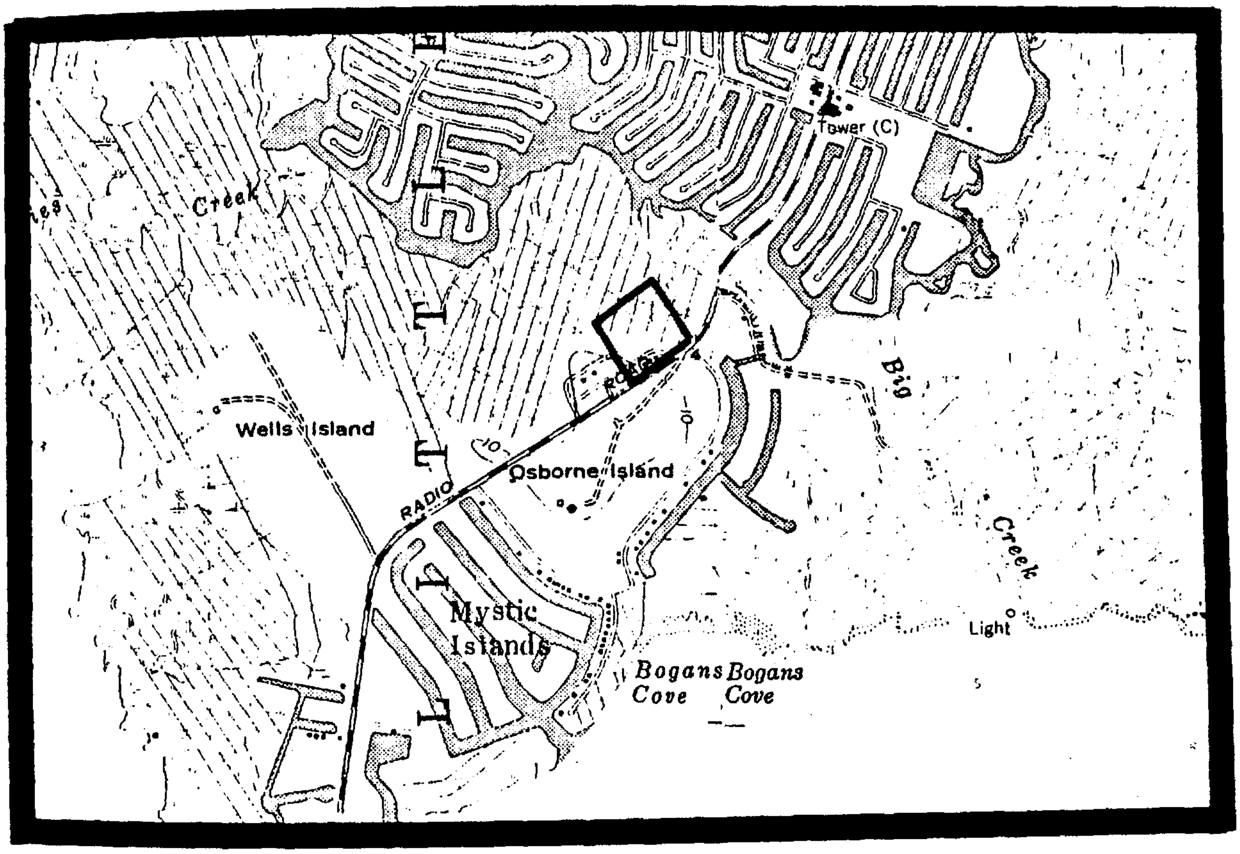
MAP A: Sheets # 61 & 62, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton & New Gretna, N.J. Topographic Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton & New Gretna, N.J. Quadrangles (Scale 1:24,000)

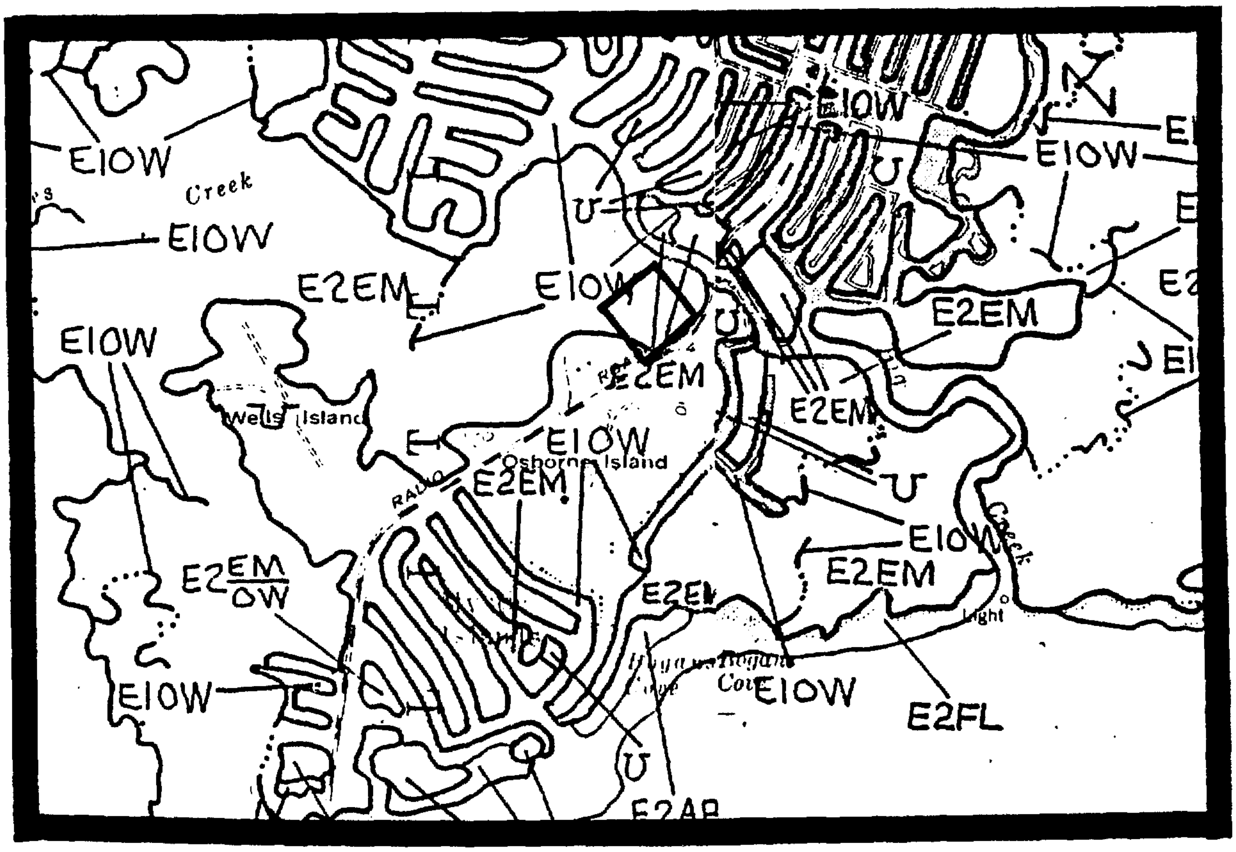
MAP A




Creek
Tower (C)
Big
Creek
Wells Island
Osborne Island
RADIO
Mystic
Islands
Bogans
Cove
Bogans
Cove
Light

MAP B

MAP C


E1OW
Creek
E1OW
E2EM
E1OW
E1OW
E2EM
E2EM
E2EM
Wells Island
E1OW
Osborne Island
RADIO
E2EM
E1OW
Creek
E2EM
E2EM/OW
Light
E1OW
E1OW
E2FL

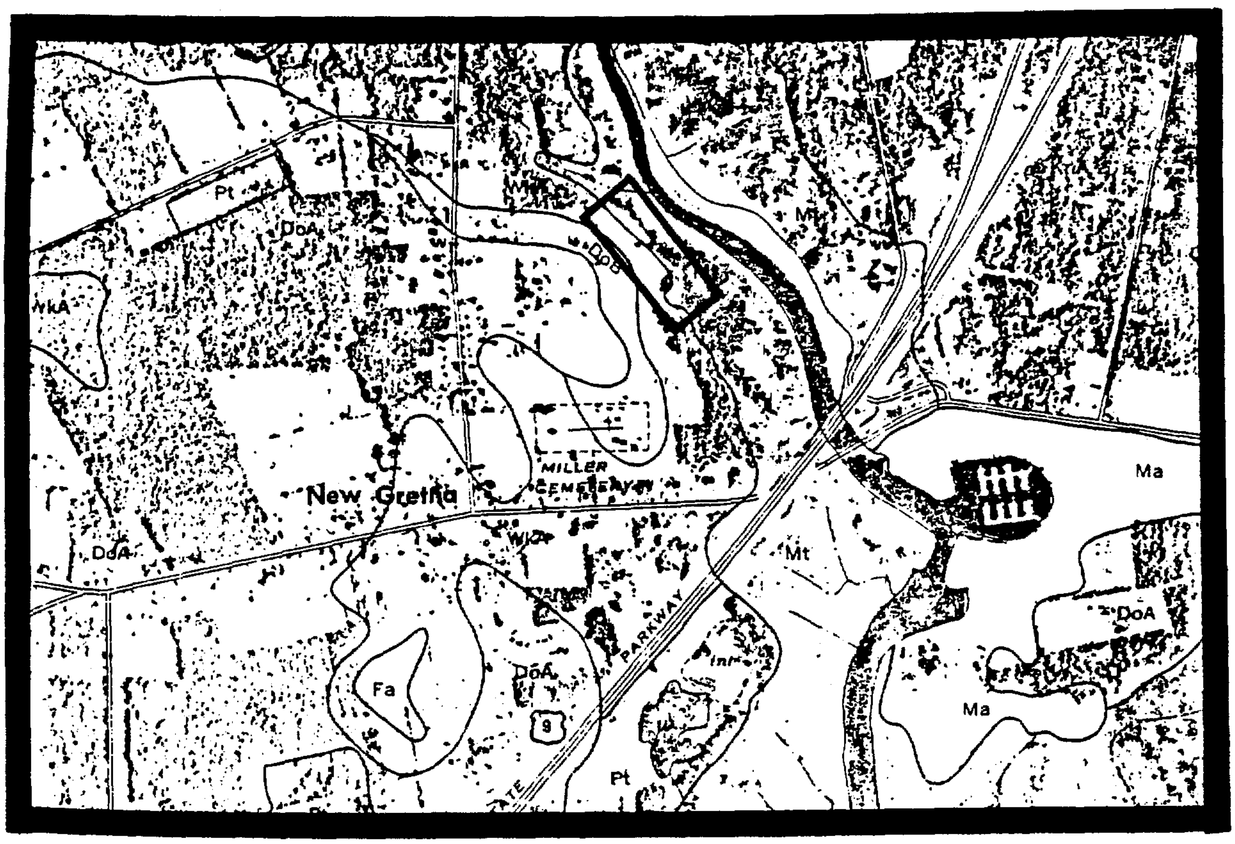
SITE 131 Adams Ave., New Gretna, Burlington County.

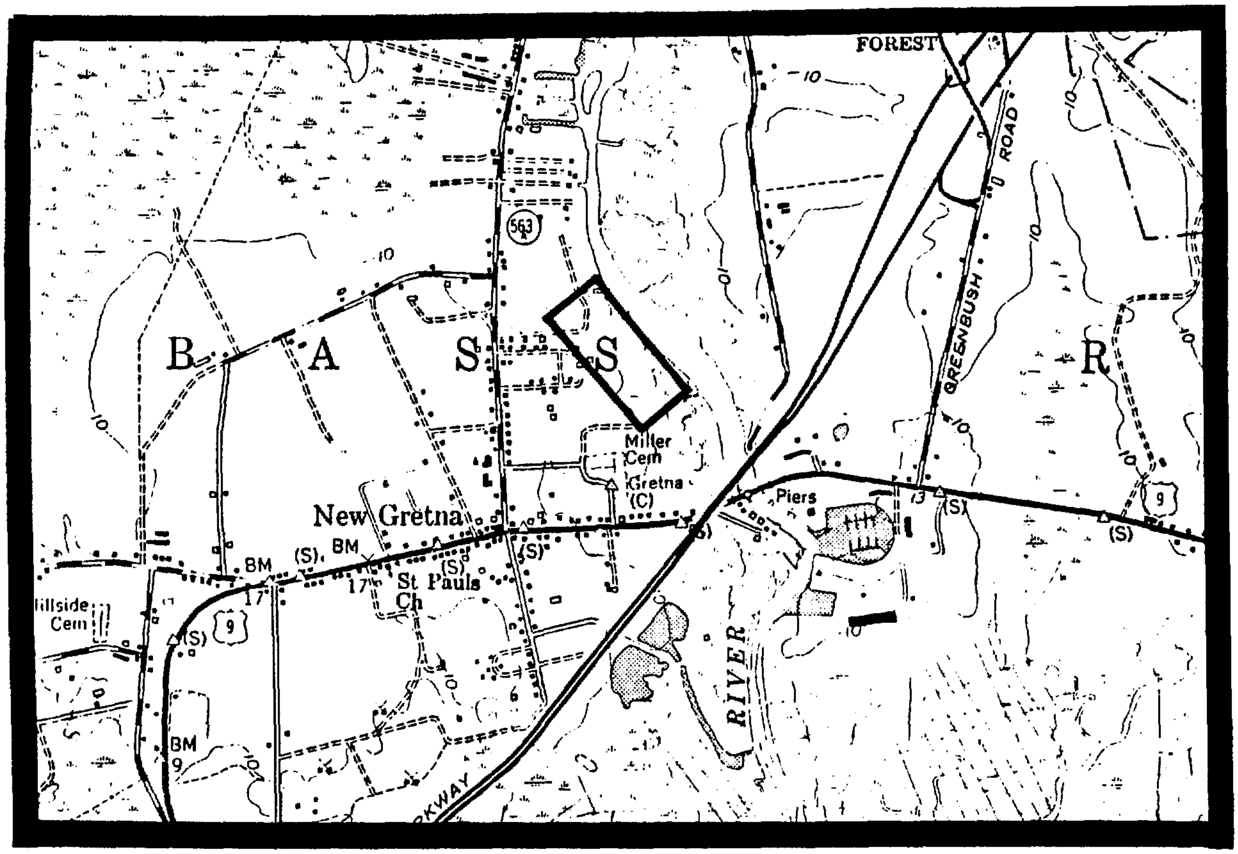
MAP A: Sheet # 100, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. New Gretna, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S National Wetlands Inventory, New Gretna, N.J. Quadrangle (Scale 1:24,000)

MAP A

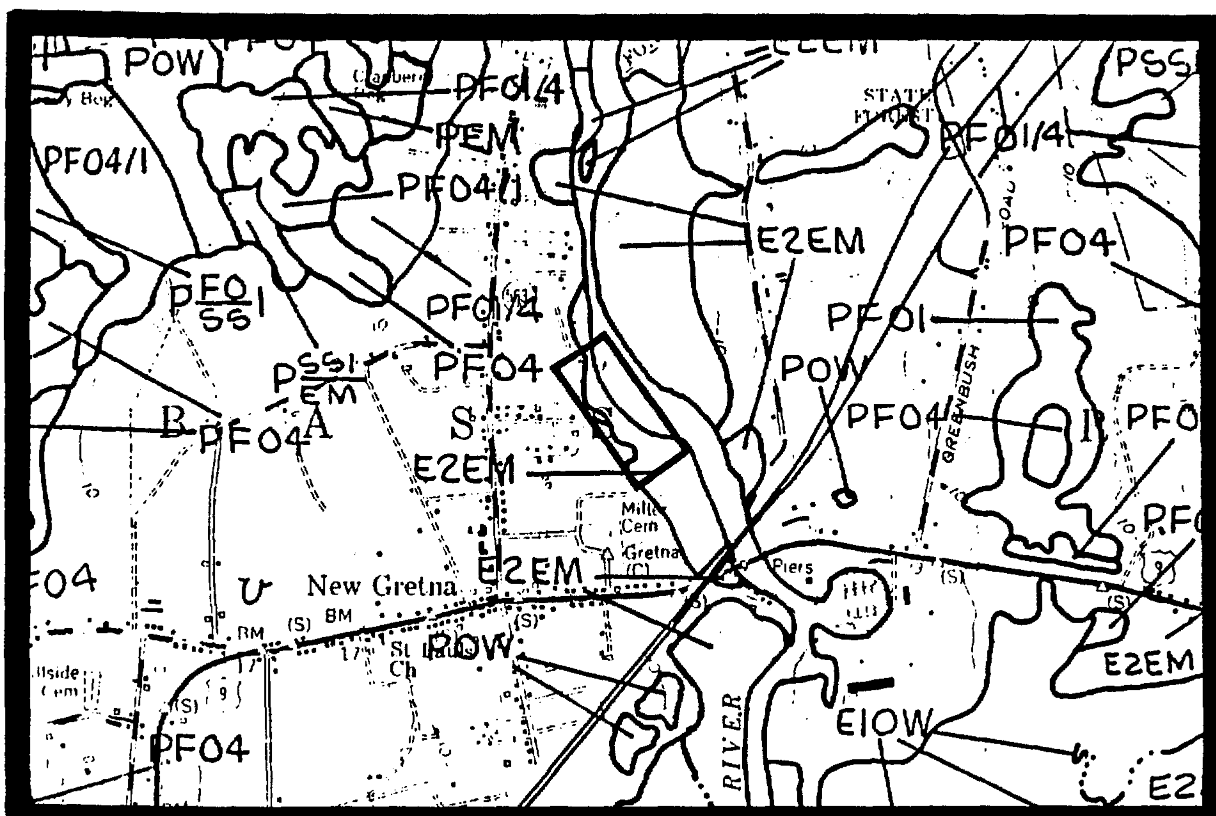




FOREST
GREENBUSH ROAD
B A S S R
Miller Cem
Gretna (C)
New Gretna
Piers
BM
St Pauls Ch
Hillside Cem
RIVER
PKWAY

MAP B

MAP C



POW
PF01/4
PEM
PF04/1
E2EM
PF04
PF01
PFO/SS1
PSS1/EM
B A S
POW
PF04
GREENBUSH
E2EM
New Gretna
E2EM
POW
E1OW
E2EM
RIVER

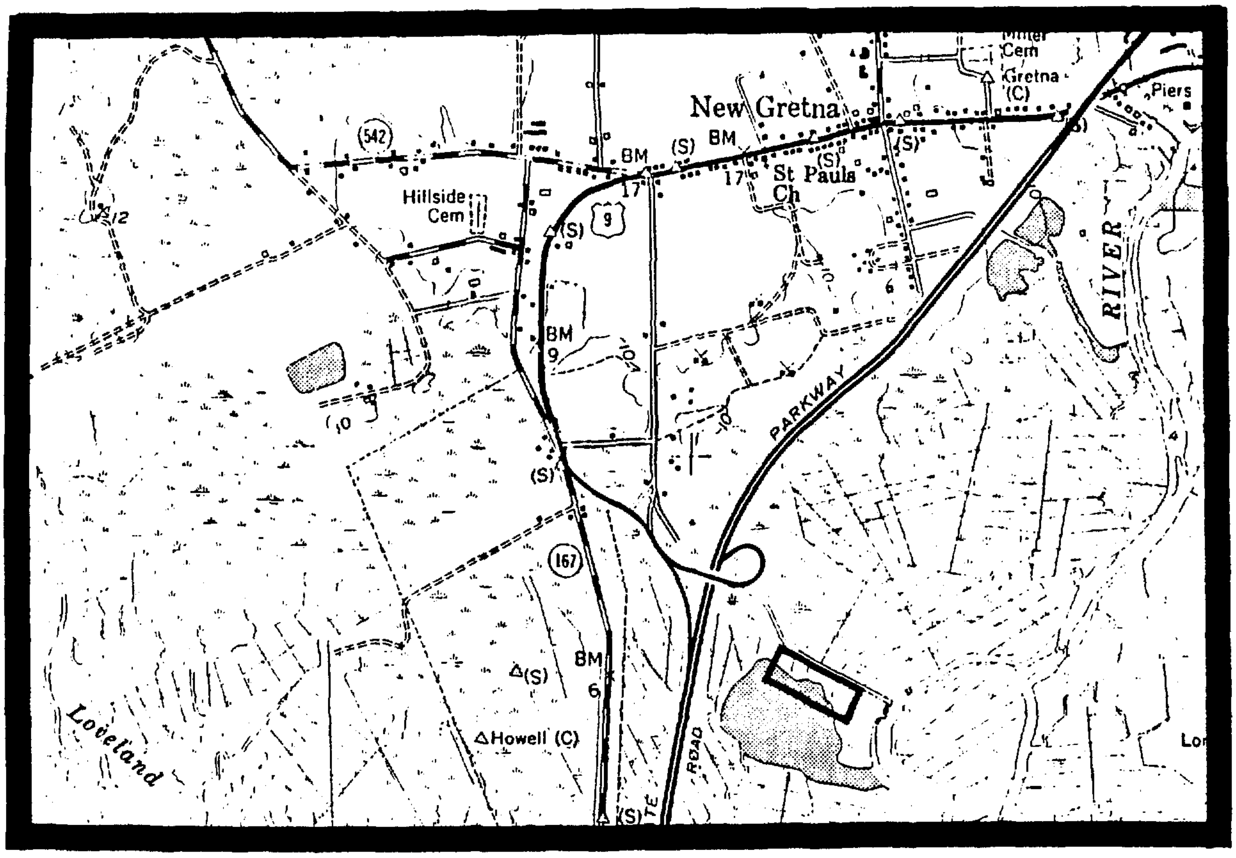
SITE 134 Amasa Rd., New Gretna, Burlington County.

MAP A: Sheet # 100, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. New Gretna, N.J. Topographic Quadrangle (Scale 1:24,000)

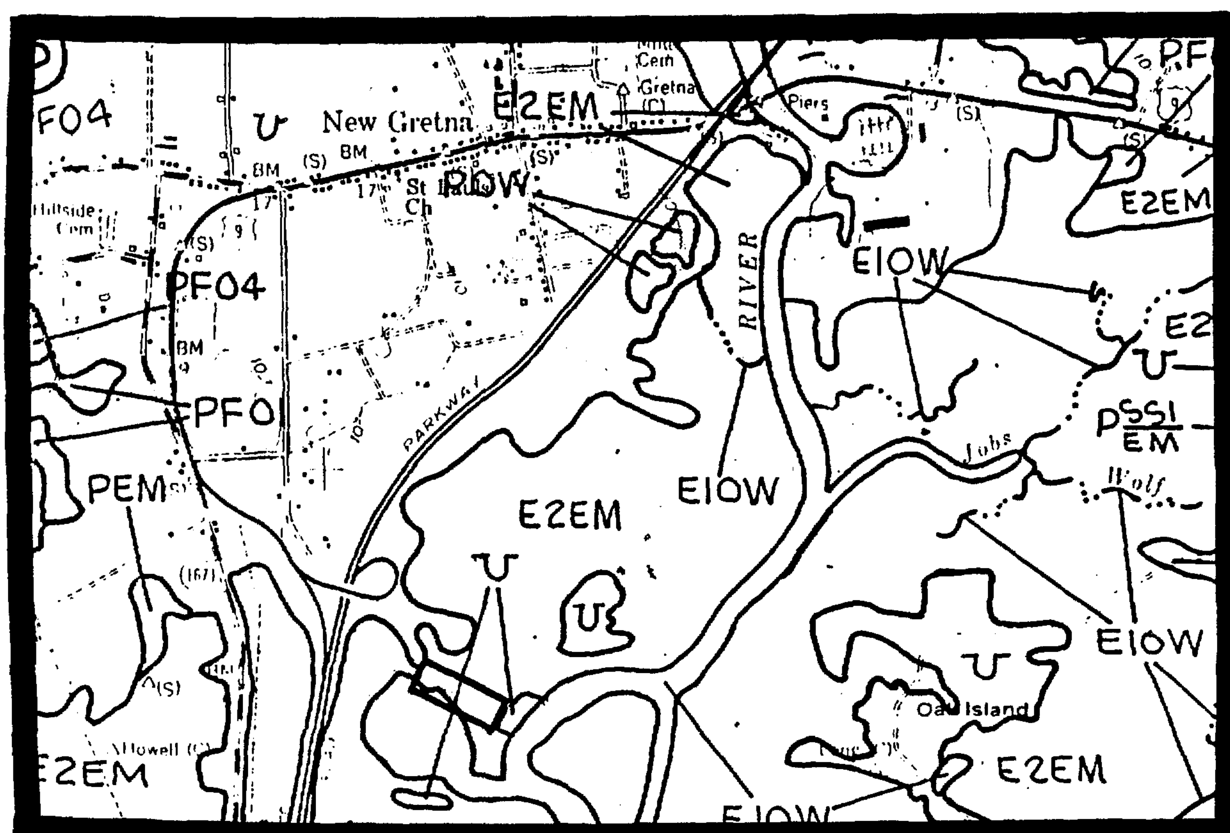
MAP C: U.S.F.W.S. National Wetlands Inventory, New Gretna, N.J. Quadrangle (Scale 1:24,000)

MAP A


New Gretna
Gretna (C)
Piers
Hillside Cem
St Pauls Ch
BM
PARKWAY
RIVER
Loveland
Howell (C)
ROAD

MAP B

MAP C


PF04
New Gretna
E2EM
ROW
St Pauls Ch
Gretna (C)
Piers
E1OW
RIVER
PARKWAY
PFO1
PEM
E2EM
U
P SS1/EM
Jobs
Wolf
Oak Island
E1OW
E2EM

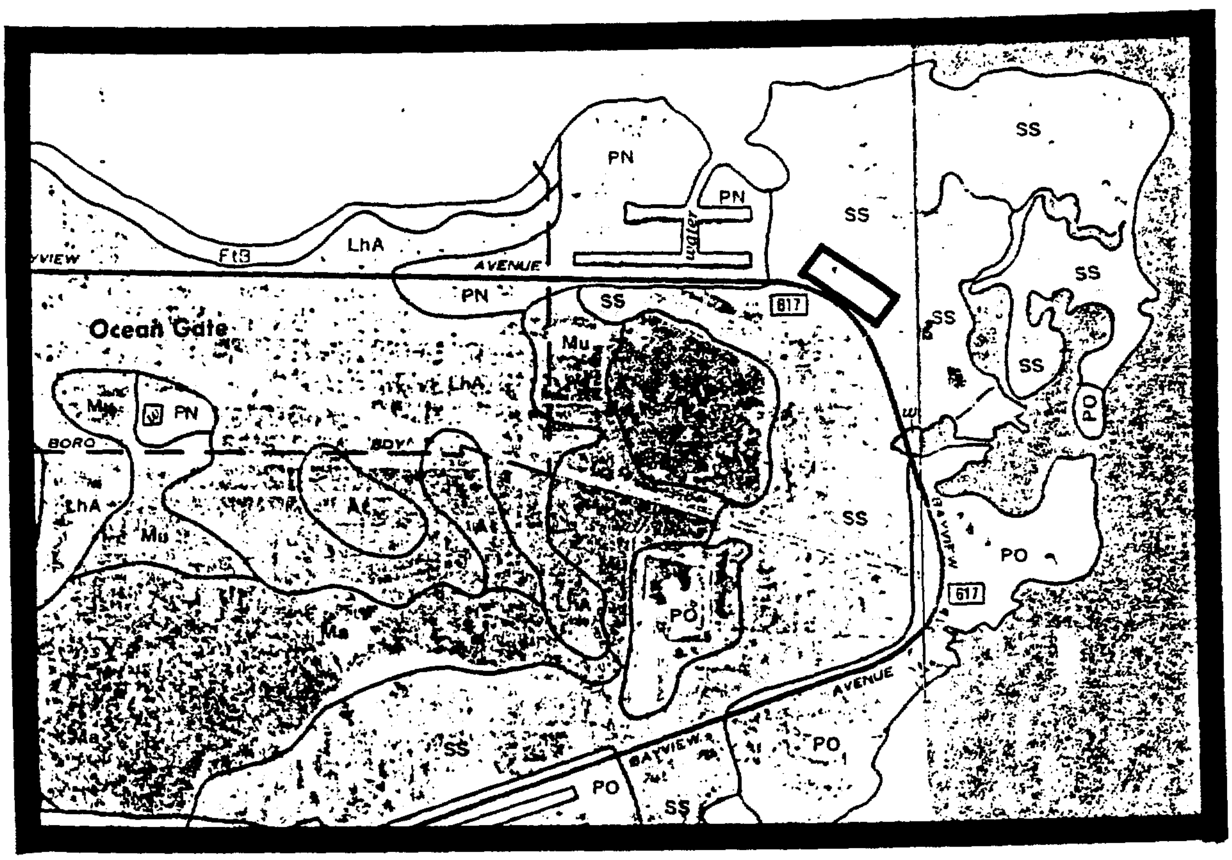
SITE 139 Ocean Gate Yacht Basin, Ocean Gate, Ocean County.

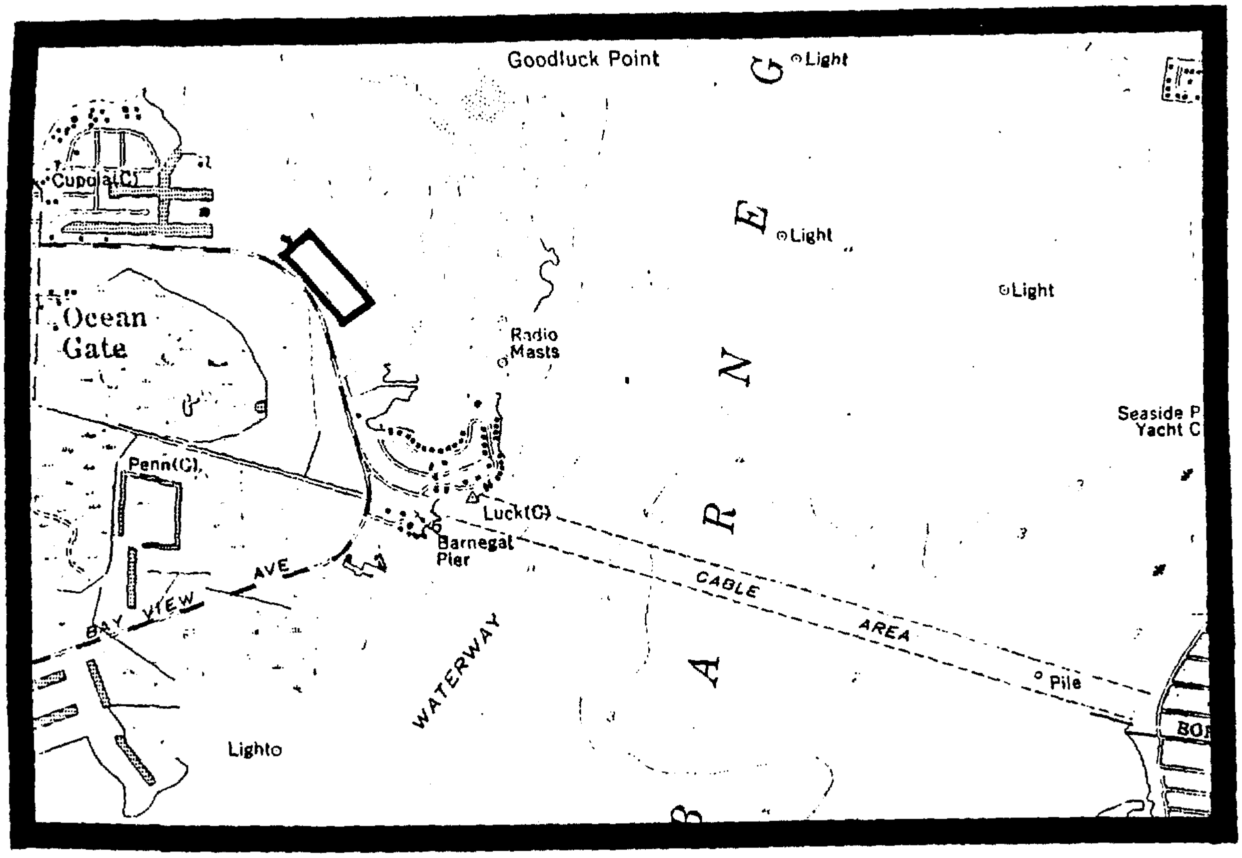
MAP A: Sheets # 31 & 32, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Toms River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Toms River, N.J. Quadrangle (Scale 1:24,000)

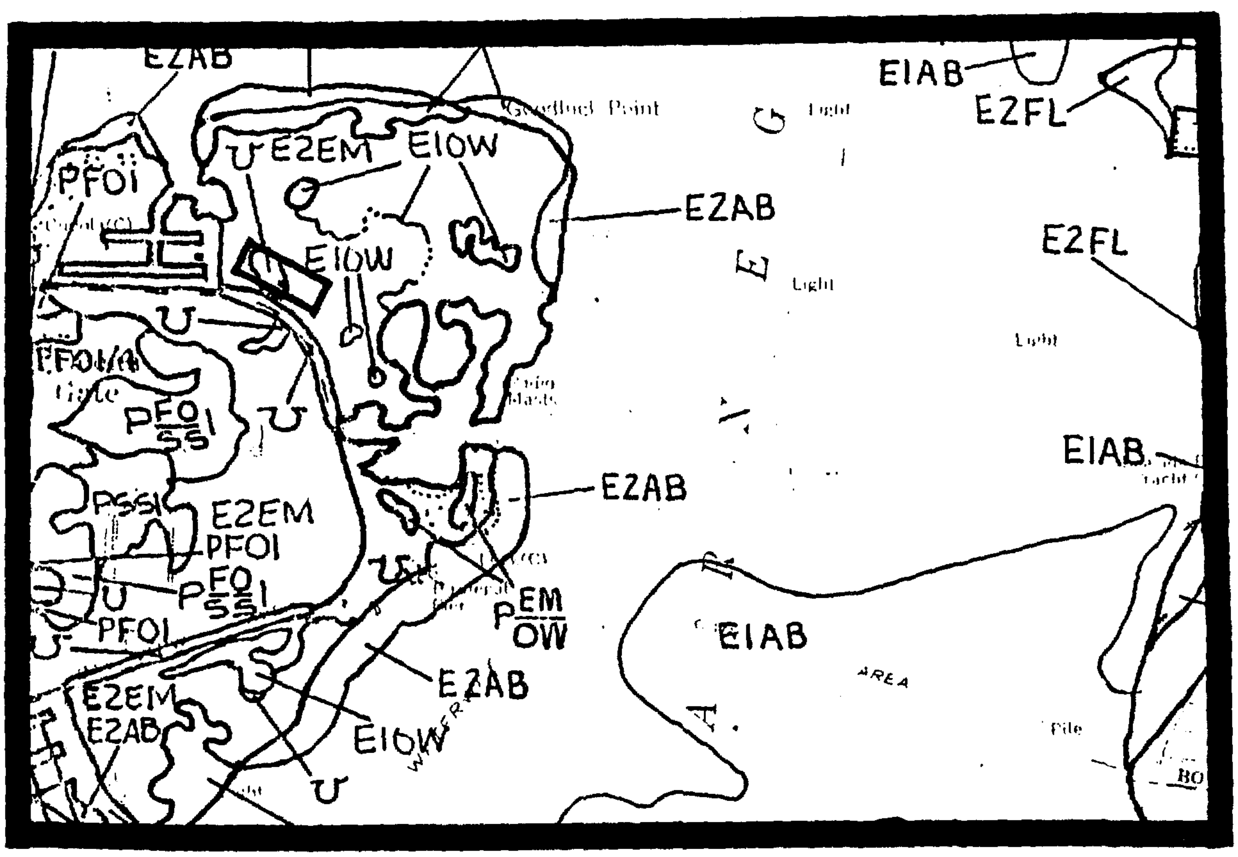
MAP A




Goodluck Point
Light
Cupola(C)
Light
Light
Ocean
Gate
Radio
Masts
Seaside P
Yacht C
Penn(C)
Luck(C)
Barnegat
Pier
AVE
BAY VIEW
CABLE
AREA
Pile
WATERWAY
Lighto

MAP B

MAP C


E2AB
E1AB
E2FL
PFO1
E2EM
E1OW
E2AB
E1OW
E2FL
PFO1/4
PFO/SS1
E1AB
PSS1
E2EM
PFO1
E2AB
PFO/SS1
PFO1
PEM/OW
E1AB
E2EM
E2AB
E2AB
E1OW

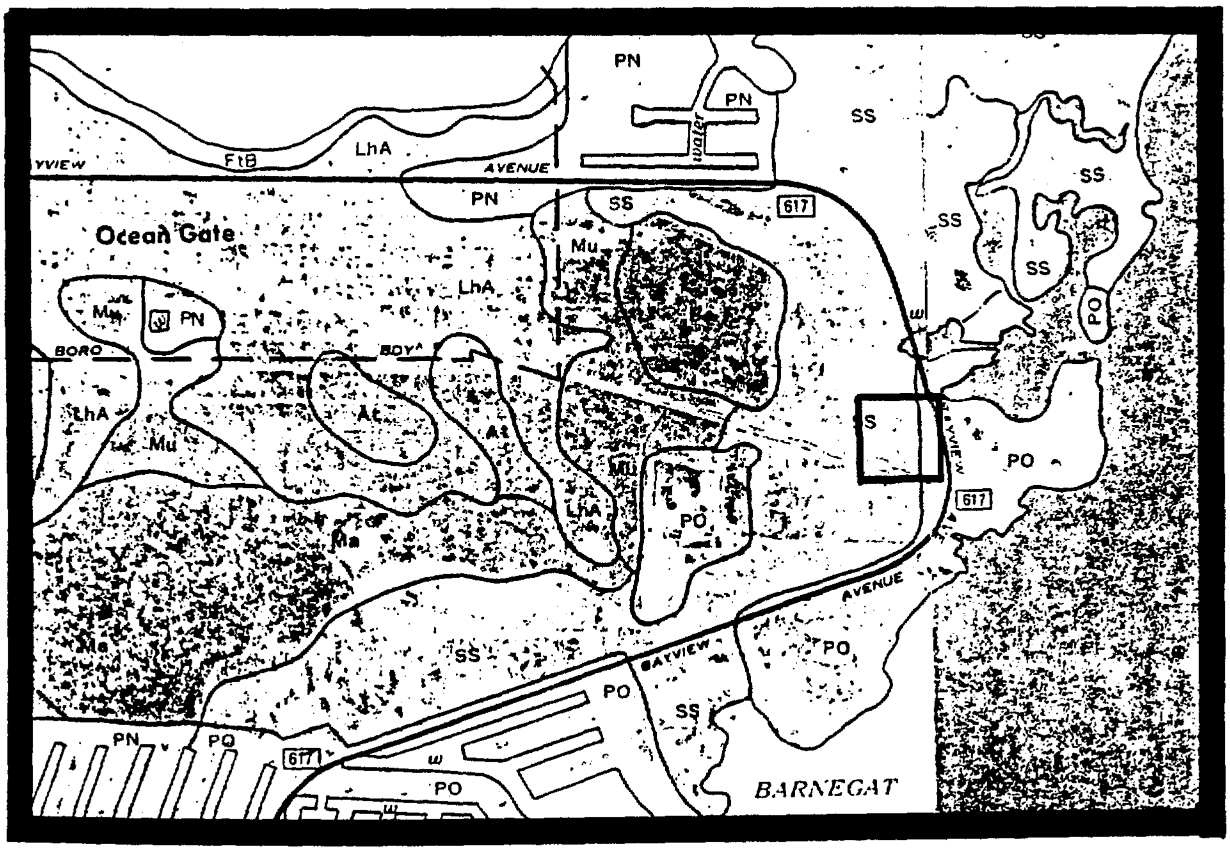
SITE 142 Bayview Ave., Ocean Gate, Ocean County.

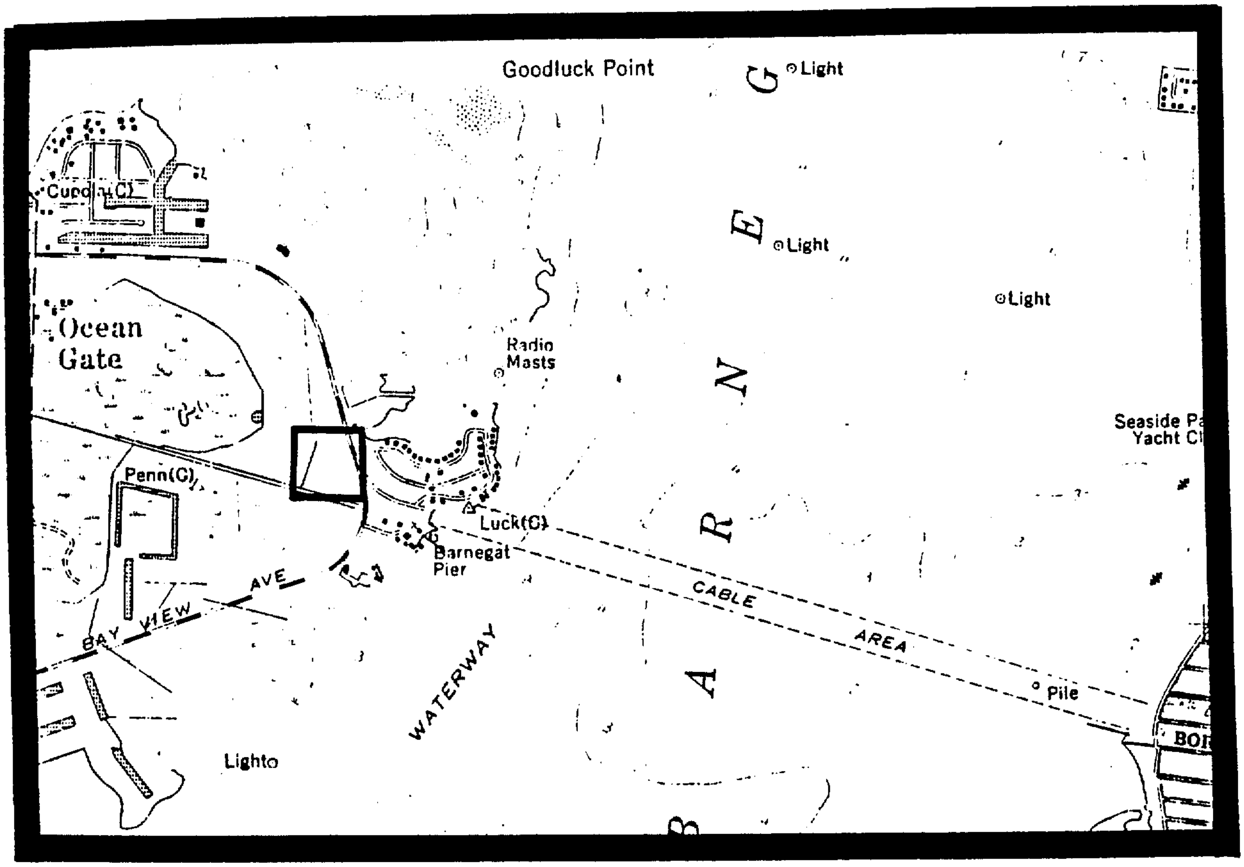
MAP A: Sheets # 31 & 32, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Toms River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Toms River, N.J. Quadrangle (Scale 1:24,000)

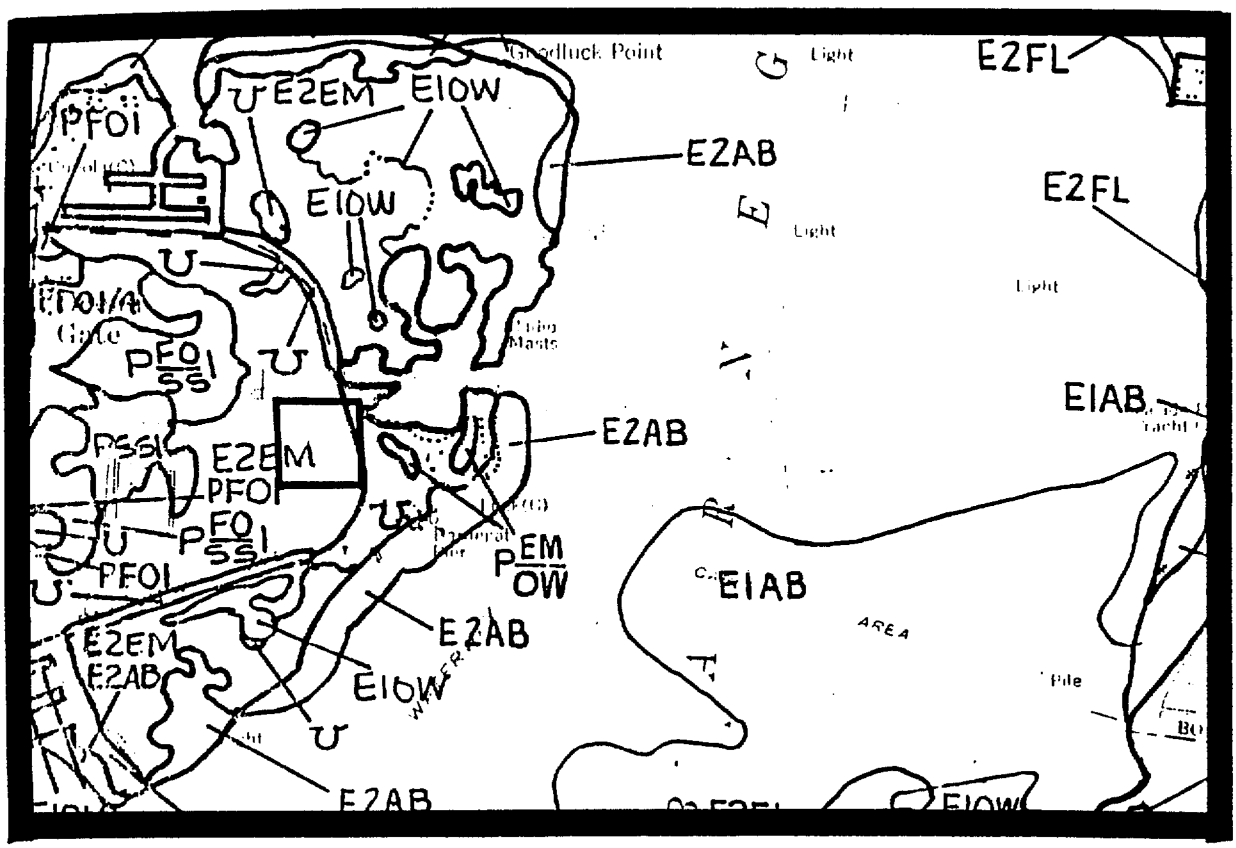
MAP A




Goodluck Point
Light
Light
Light
Cupola(C)
Ocean
Gate
Radio
Masts
Seaside P
Yacht Cl
Penn(C)
Luck(C)
Barnegat
Pier
AVE
BAY VIEW
CABLE
AREA
WATERWAY
Pile
Lighto

MAP B

MAP C


Goodluck Point
E2EM
E1OW
PFOI
E2AB
E1OW
E2FL
E2FL
PFO
SSI
E2AB
E1AB
PSSI
E2EM
PFOI
PFO
SSI
PFOI
P EM
OW
E1AB
E2EM
E2AB
E2AB
E1OW
E2AB

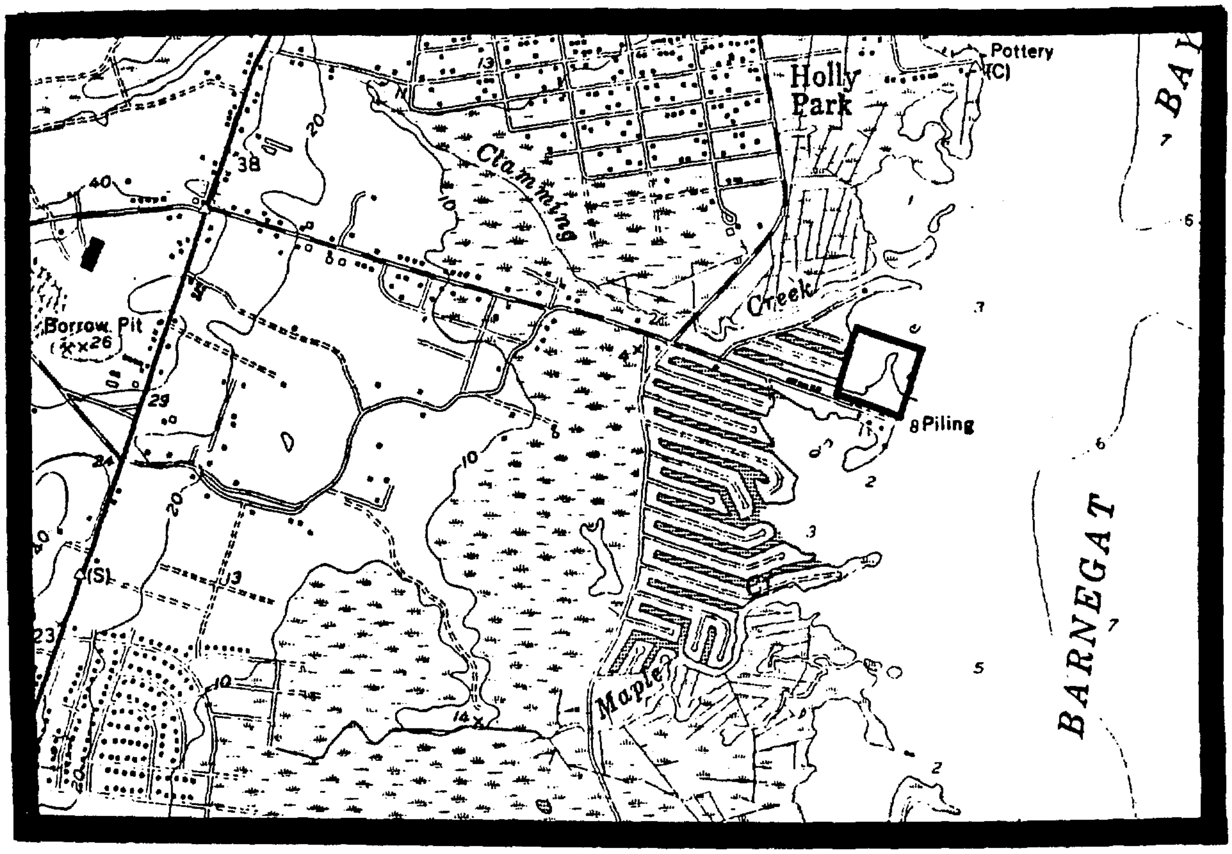
SITE 143 Butler Ave., Holly Park, Ocean County.

MAP A: Sheet # 36, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Toms River, N.J. Topographic Quadrangle (Scale 1:24,000)

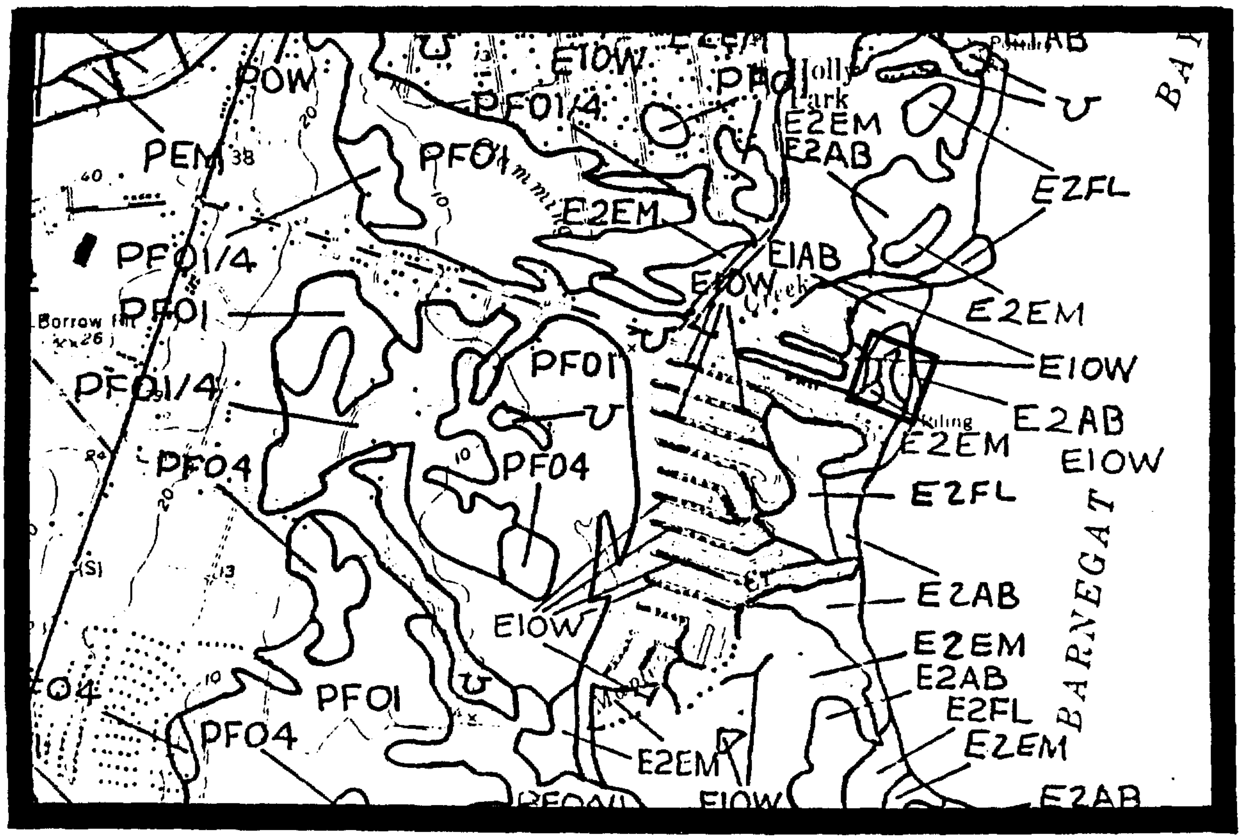
MAP C: U.S.F.W.S. National Wetlands Inventory, Toms River, N.J. Quadrangle (Scale 1:24,000)

MAP A


Pottery
(C)
Holly
Park
BAY
Clamming
Creek
Borrow Pit
8 Piling
Maple
BARNEGAT

MAP B

MAP C


E1OW
POW
PF01/4
PFO
PEM
PFO1
E2EM
E2AB
E2FL
E1AB
PF01/4
PF01
PF01/4
PF01
PF04
PF04
E2EM
E1OW
E2AB
E2EM
E1OW
E2FL
E1OW
E2AB
E2EM
E2AB
E2FL
E2EM
PF01
PF04
E2EM
E1OW
E2AB
BARNEGAT
BAY

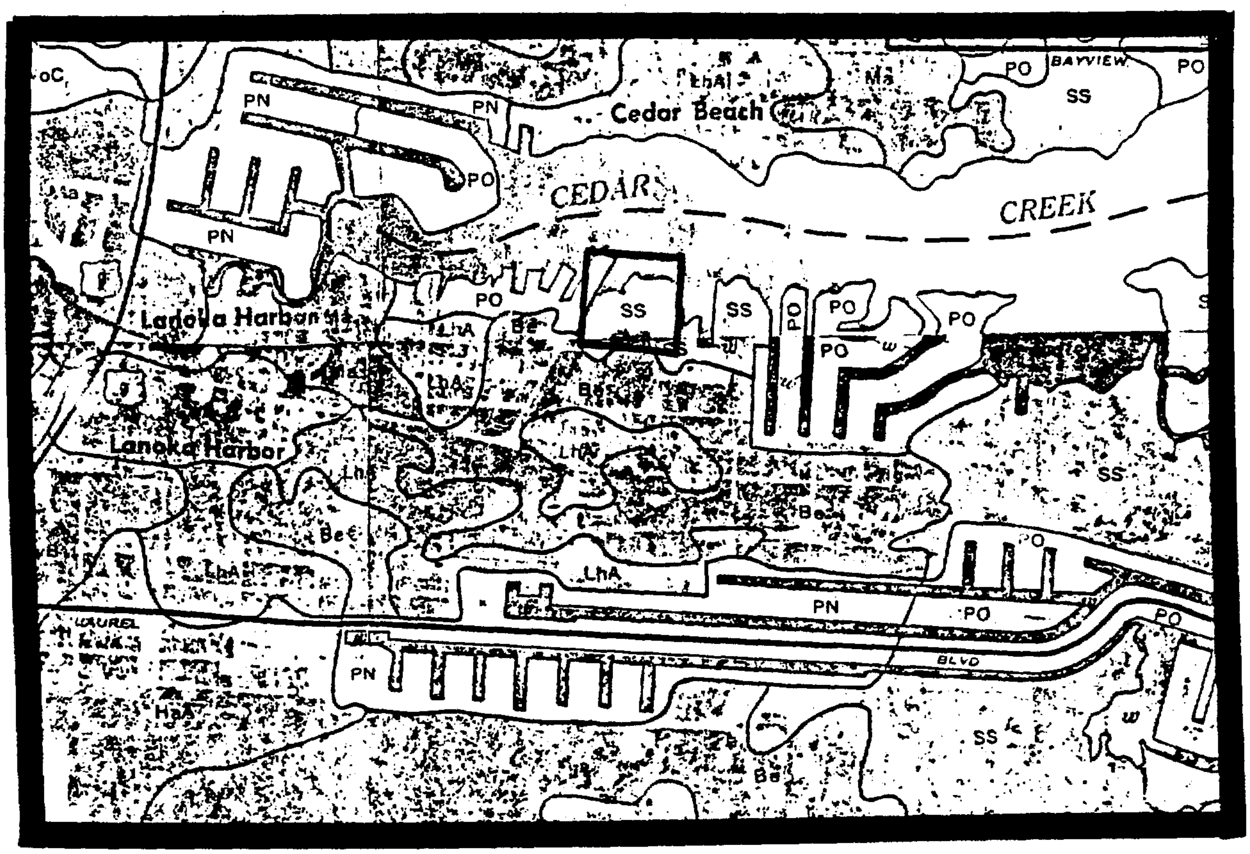
SITE 146 Rocknacks Yacht Basin, Lanoka Harbor, Ocean County.

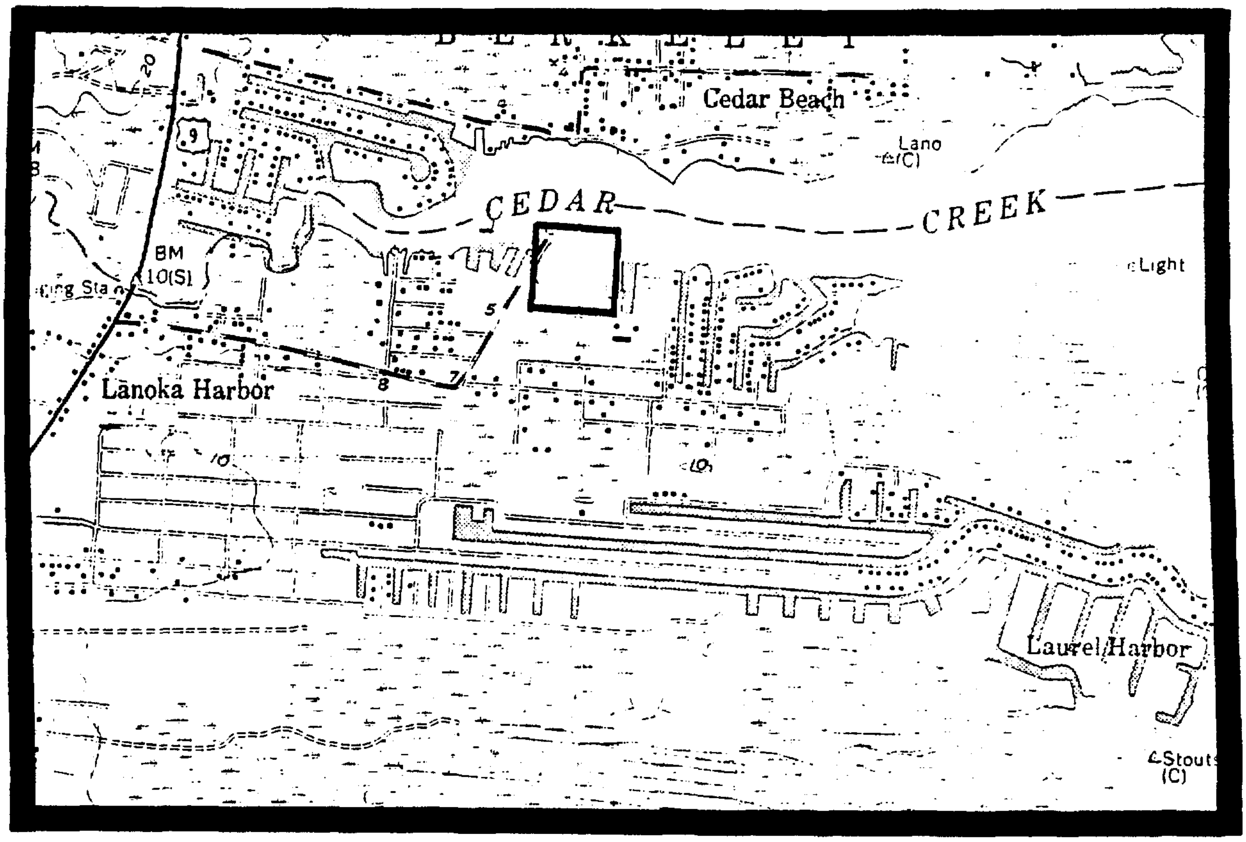
MAP A: Sheets # 36 & 40, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked River, N.J. Quadrangle (Scale 1:24,000)

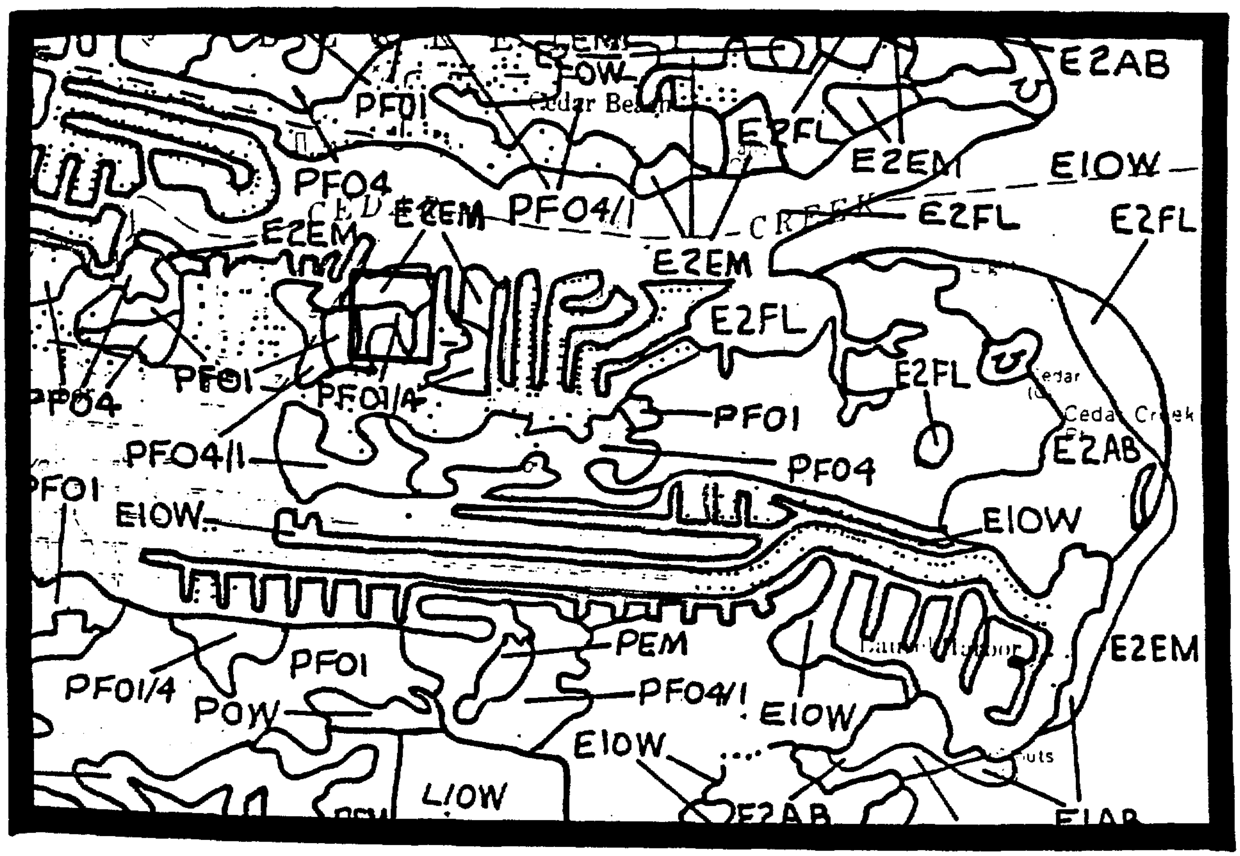
MAP A




Cedar Beach
CEDAR
CREEK
Lanoka Harbor
Laurel Harbor
BM
10(S)
Light
Stouts
(C)

MAP B

MAP C


E2AB
PF01
E2FL
E2EM
E1OW
PF04
E2EM
PF04/1
E2FL
E2FL
E2EM
E2EM
E2FL
PF01
PF04
PF01/4
PF01
E2FL
PF04/1
PF04
E2AB
PF01
E1OW
E1OW
PEM
E2EM
PF01
PF01/4
POW
PF04/1
E1OW
E1OW
L1OW

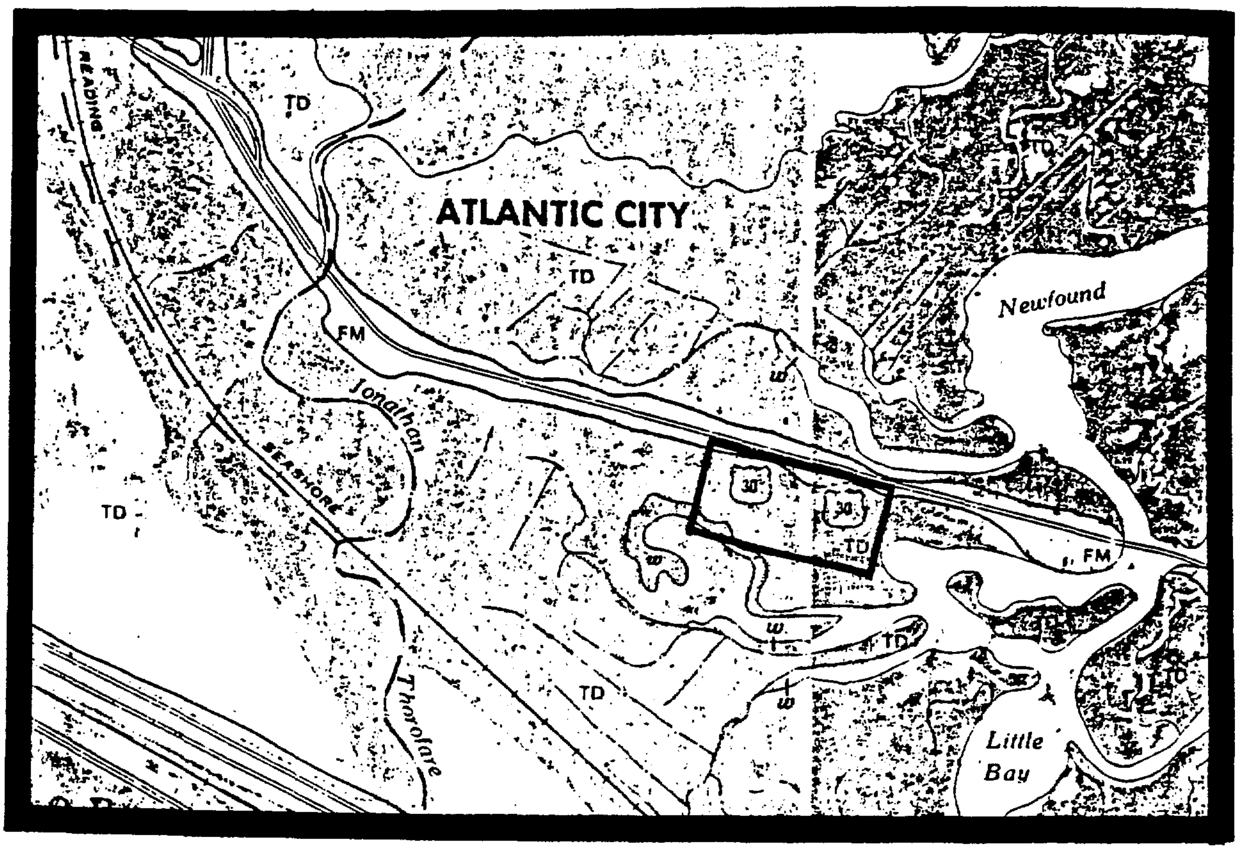
SITE 167 Old Gas Station, Rt. 30 east, near Atlantic City, Atlantic County.

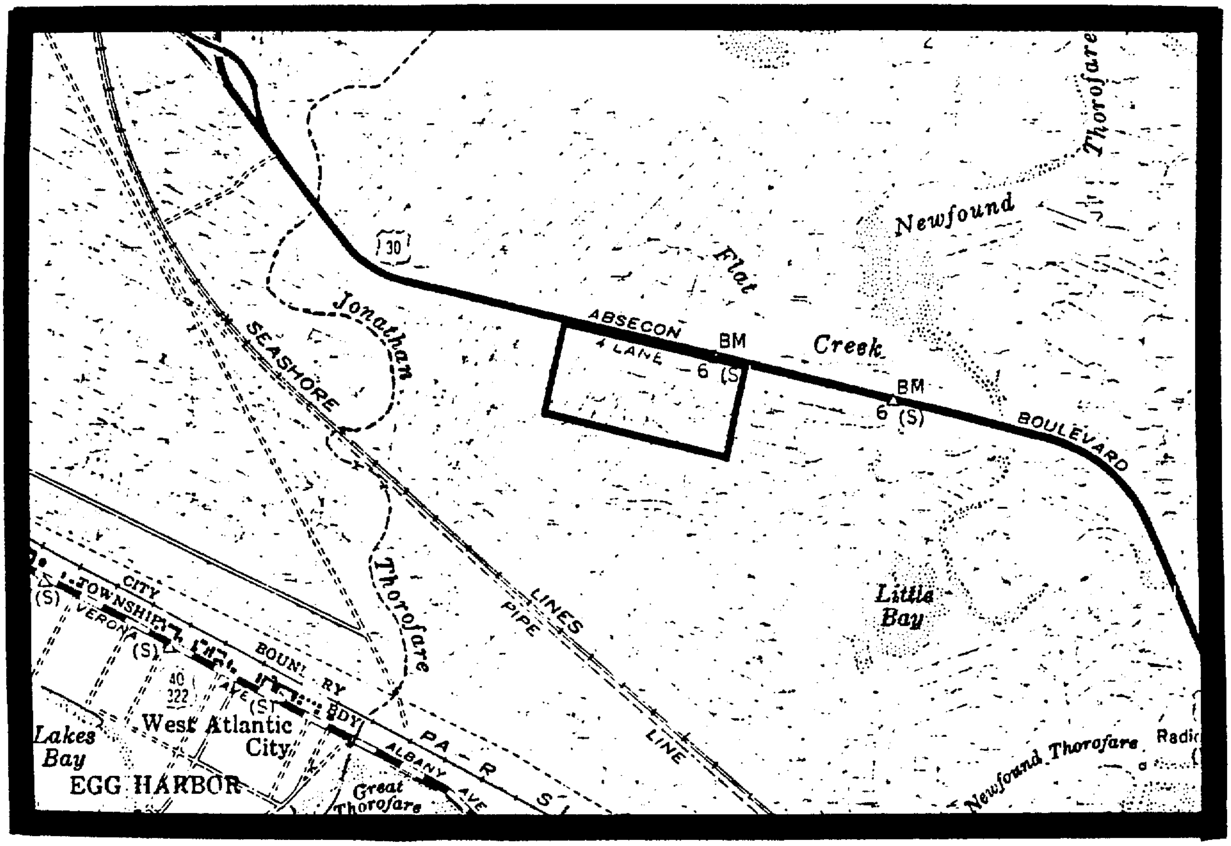
MAP A: Sheets # 40 & 41, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Oceanville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Oceanville, N.J. Quadrangle (Scale 1:24,000)

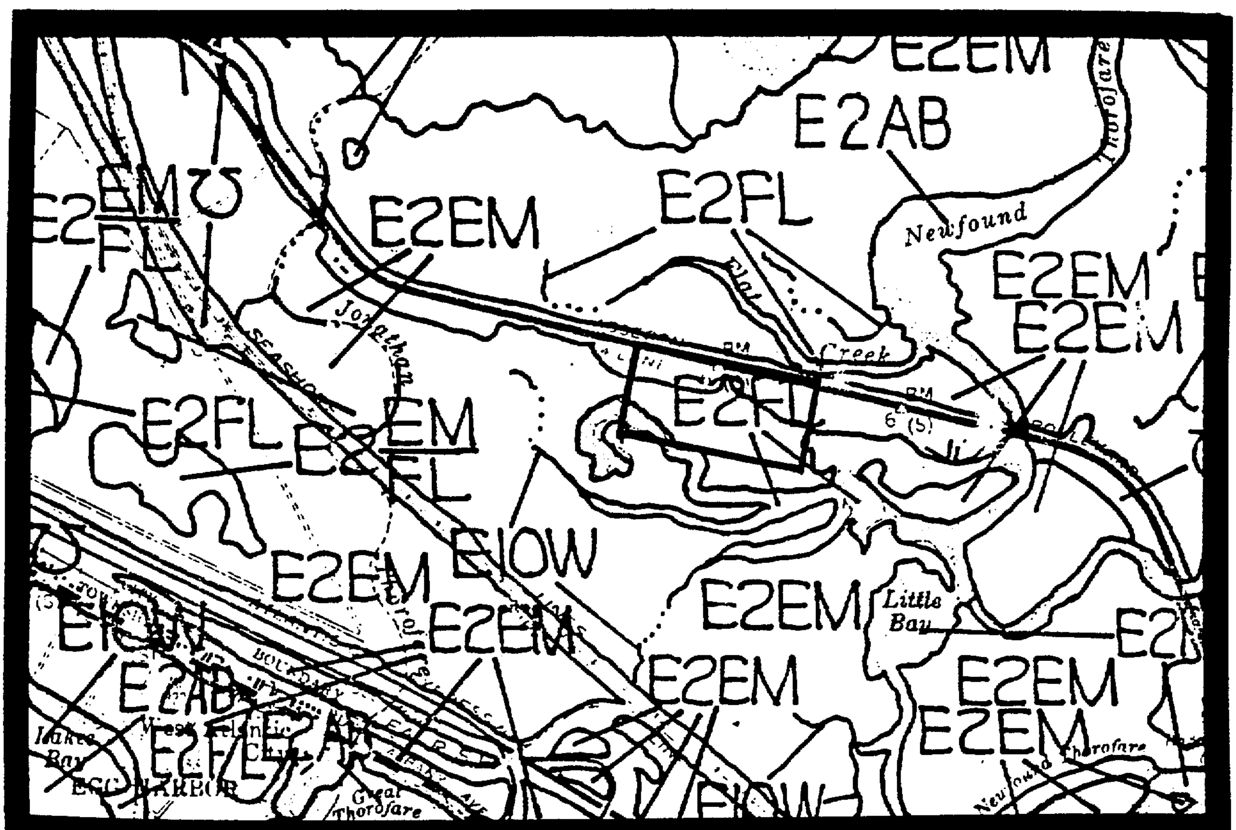
MAP A




Thorofare
Newfound
Flat
ABSECON
4 LANE
BM
6 (S)
Creek
BOULEVARD
30
Jonathan
SEASHORE
LINES
PIPE
LINE
Thorofare
Little
Bay
CITY
TOWNSHIP
VERONA
BOUN RY
BDY
ALBANY AVE
40
322
West Atlantic
City
Lakes
Bay
EGG HARBOR
Great
Thorofare
Newfound Thorofare
Radio

MAP B

MAP C


E2EM
E2AB
E2FL
E2EM
E2FL
E2EM
E2EM
E2FL
EM
E2FL
E1OW
E2EM
E2EM
E2EM
E1OW
E2AB
E2FL
E2AB
E2EM
E2EM
E2EM
Newfound
Flat
Creek
Jonathan
SEASHORE
Little
Bay
Lakes
Bay
EGG HARBOR
Great
Thorofare
Newfound Thorofare

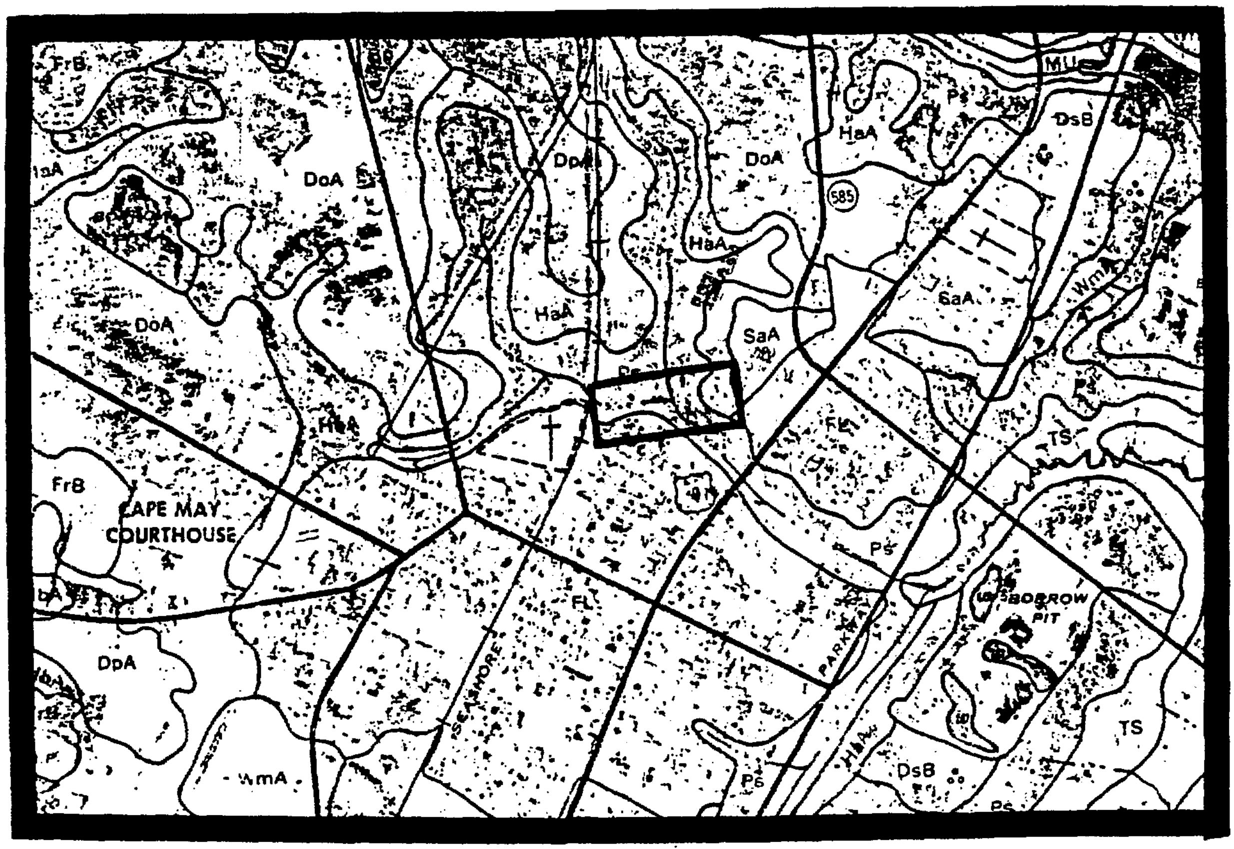
SITE 190 Convalesent Center, Cape May Courthouse, Cape May County.

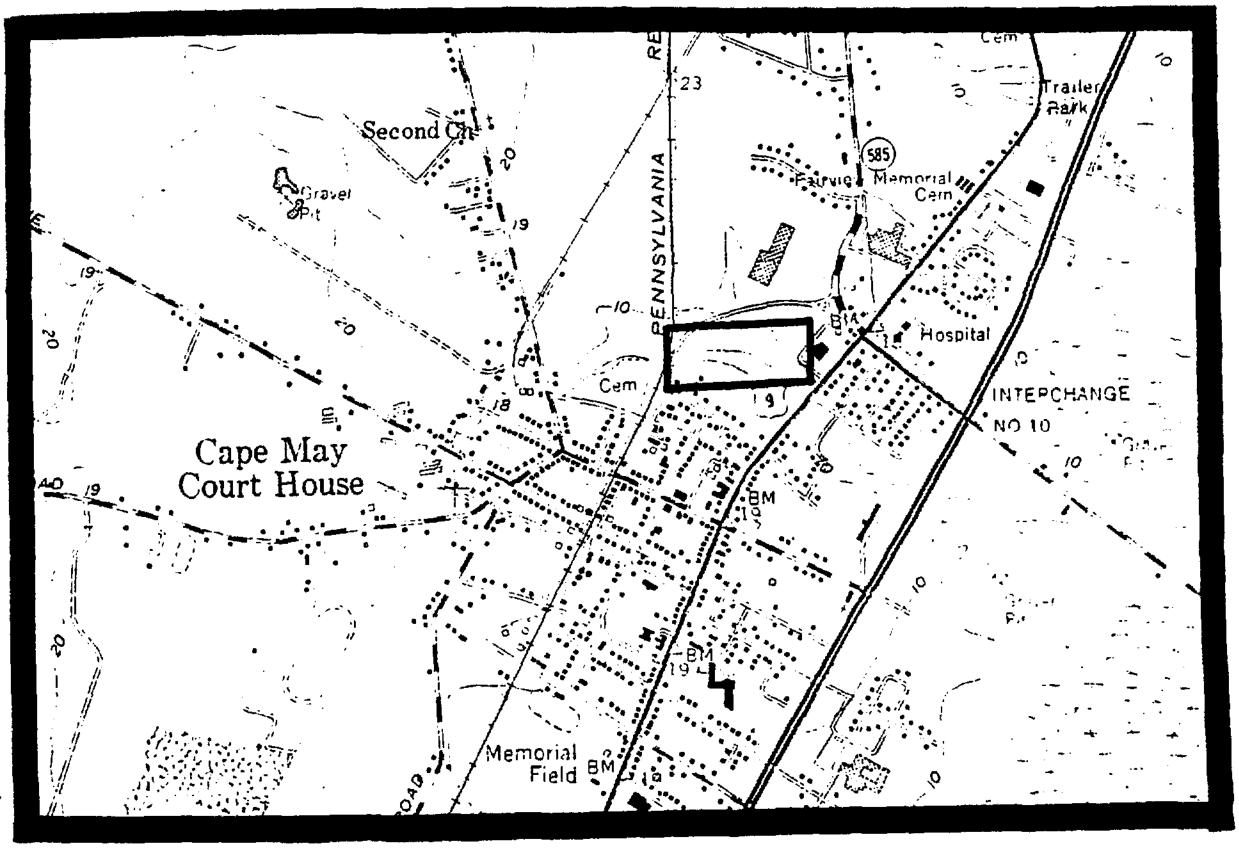
MAP A: Sheet # 21, Cape May Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Stone Harbor, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Stone Harbor, N.J. Quadrangle (Scale 1:24,000)

MAP A

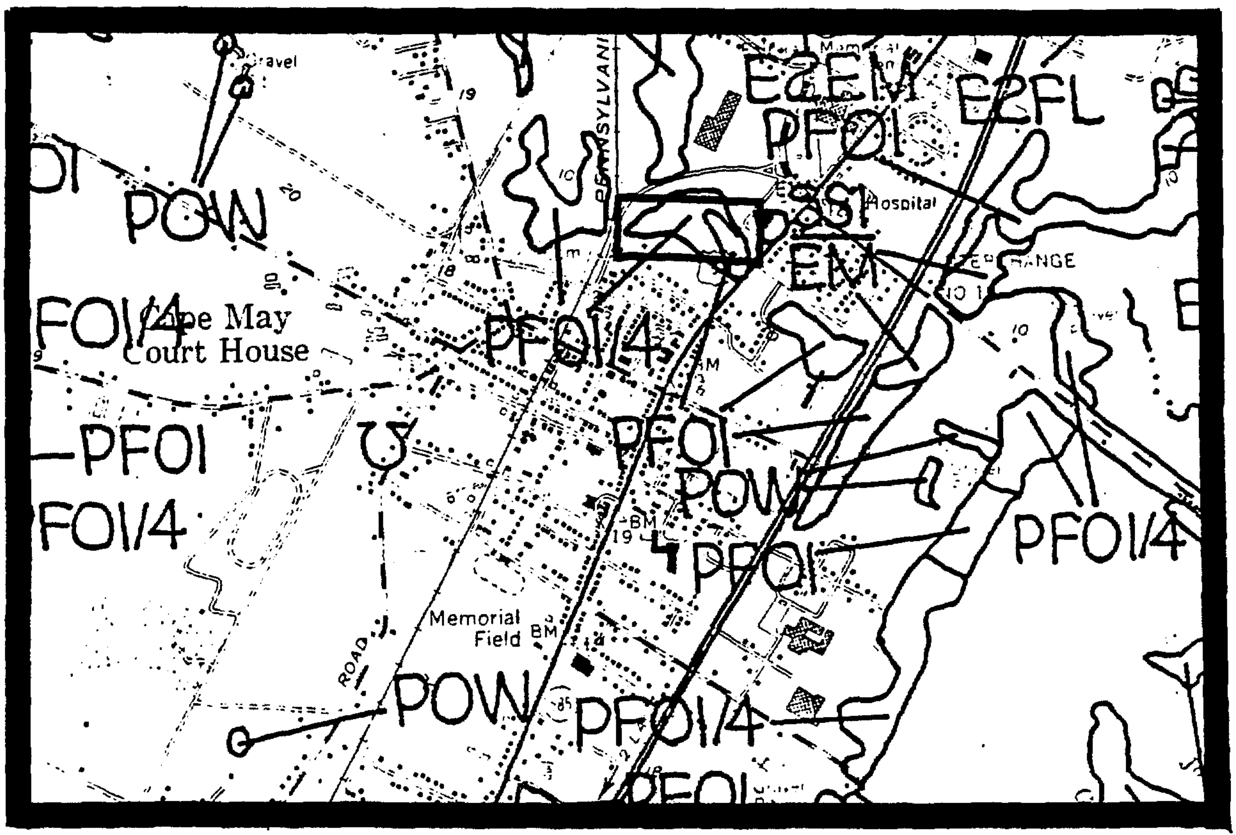




Second Ch
Gravel Pit
PENNSYLVANIA
Fairview Memorial Cem
Trailer Park
Hospital
INTERCHANGE NO 10
Cem
Cape May Court House
Memorial Field
585

MAP B

MAP C



POW
PFOI/4
PFOI
E2EM
E2FL
E2SS1
EM
Cape May Court House
Memorial Field
Hospital

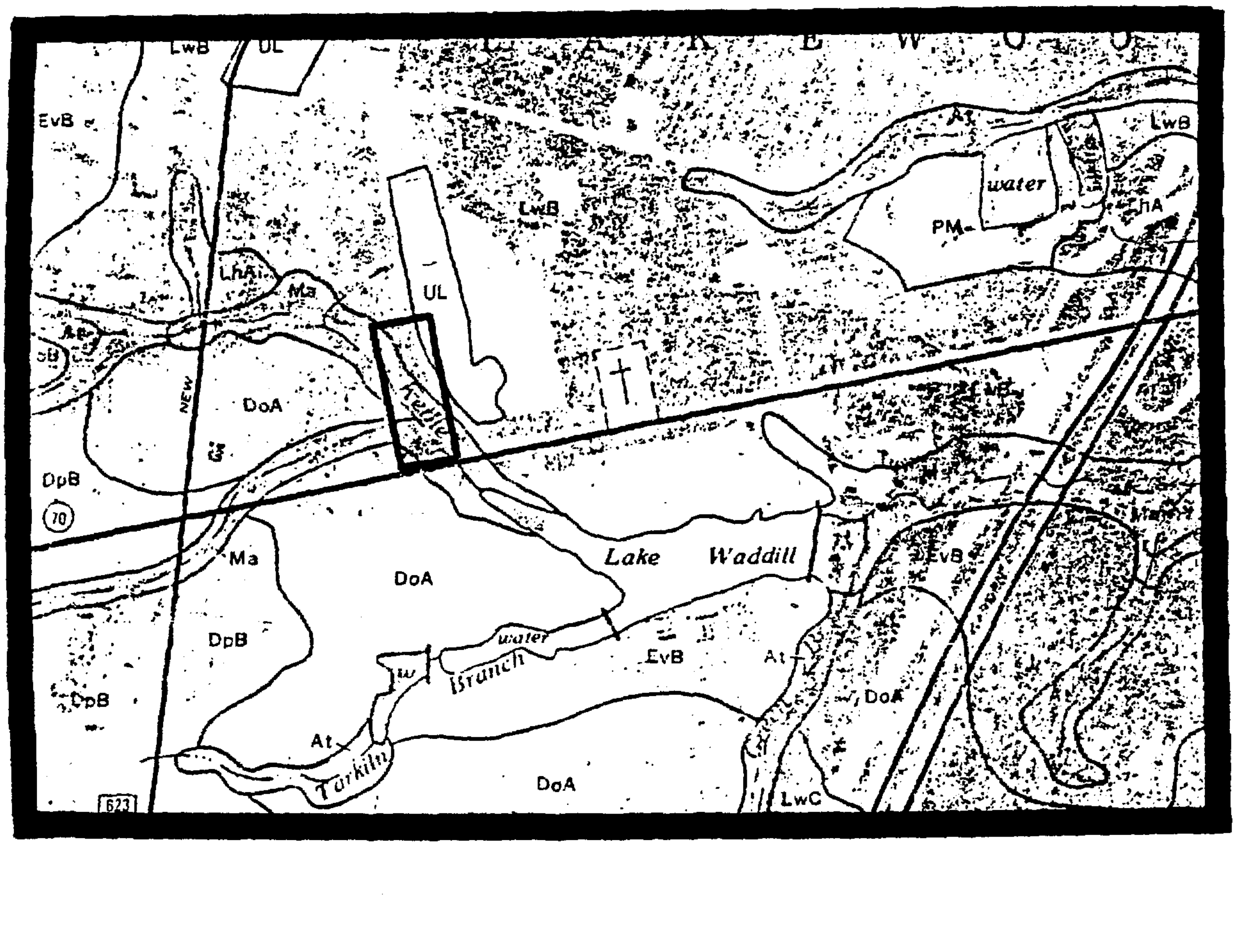
SITE 207 Kettle Creek, Rt. 70, North Lakewood, Ocean County.

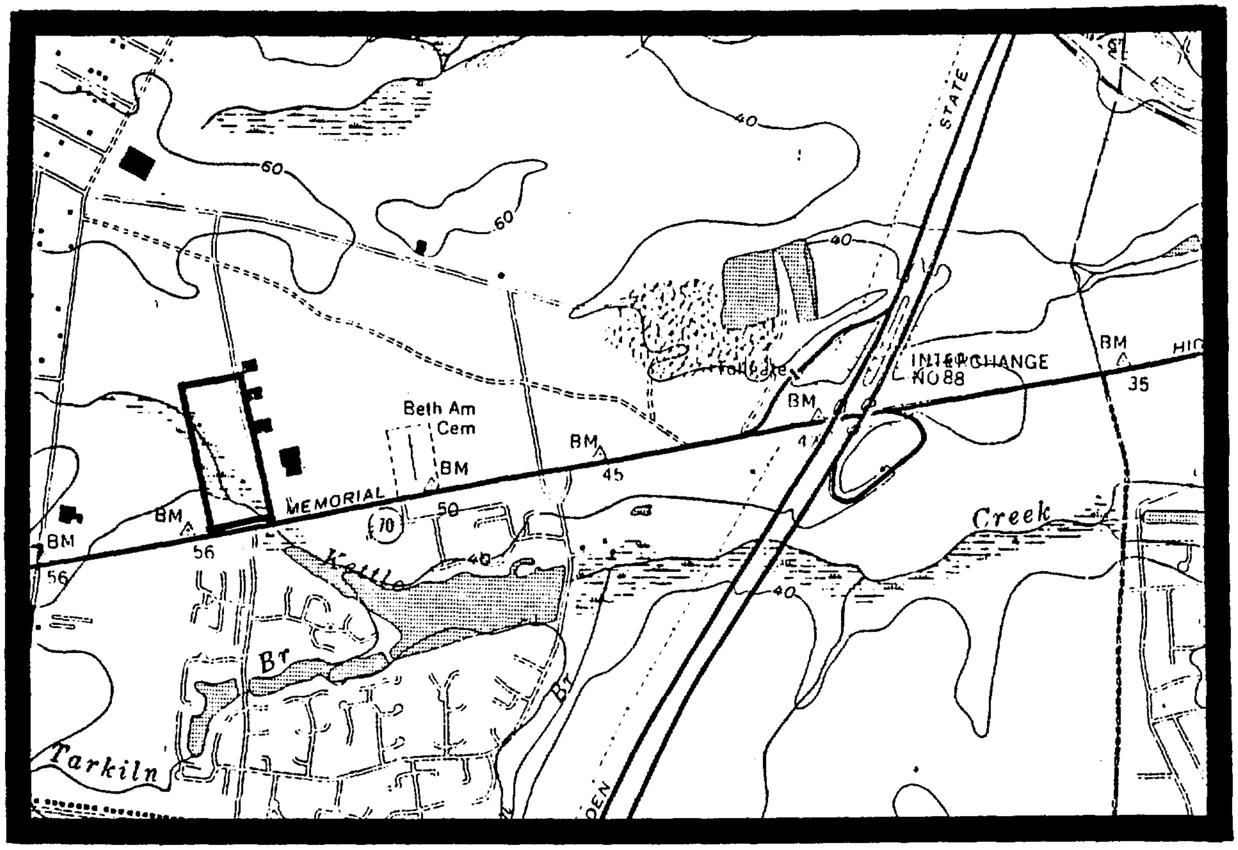
MAP A: Sheet # 14, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Lakewood, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Lakewood, N.J. Quadrangle (Scale 1:24,000)

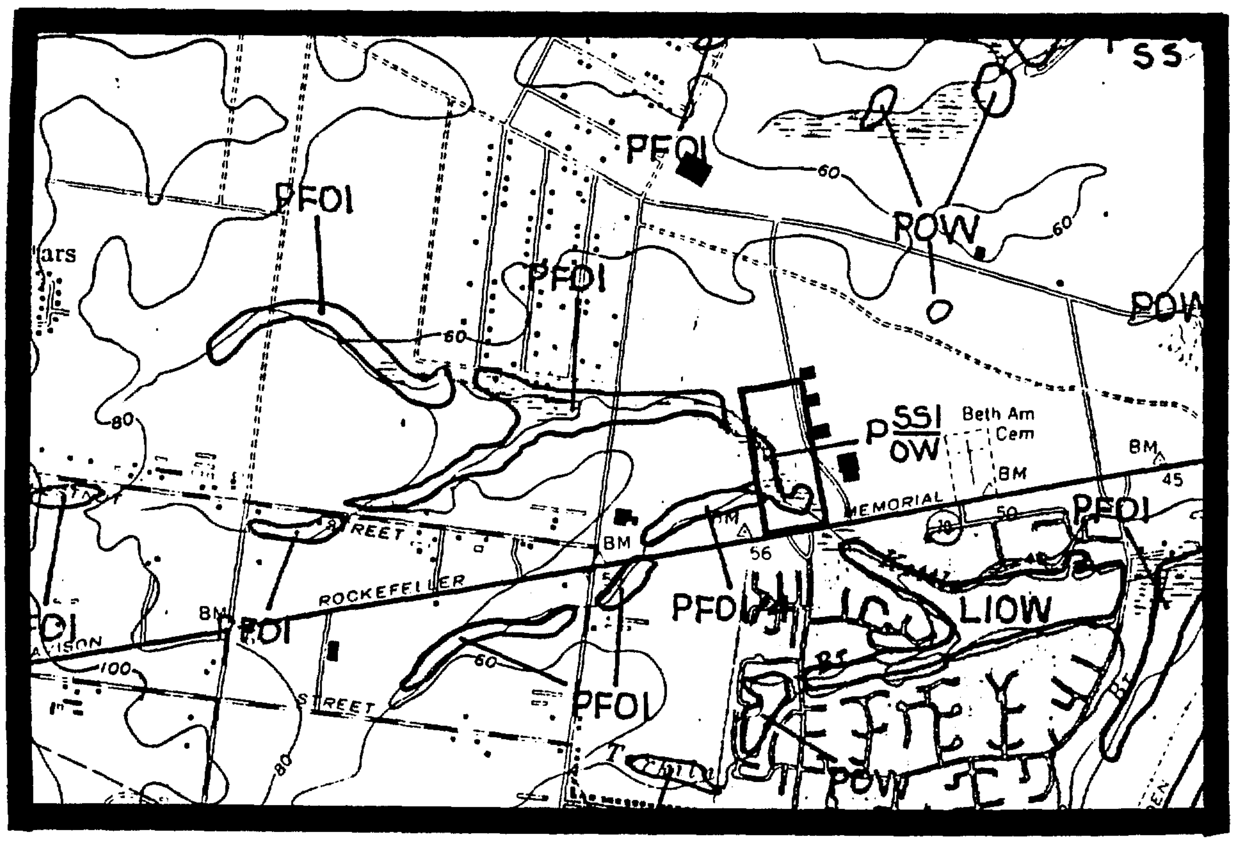
MAP A




STATE
60
40
Beth Am
Cem
BM
INTERCHANGE
NO 88
35
45
MEMORIAL
70
50
56
Creek
Kettle
Br
Tarkiln

MAP B

MAP C


PFOI
POW
60
80
100
PSSI/OW
Beth Am
Cem
BM
45
MEMORIAL
STREET
ROCKEFELLER
56
LIOW
Br

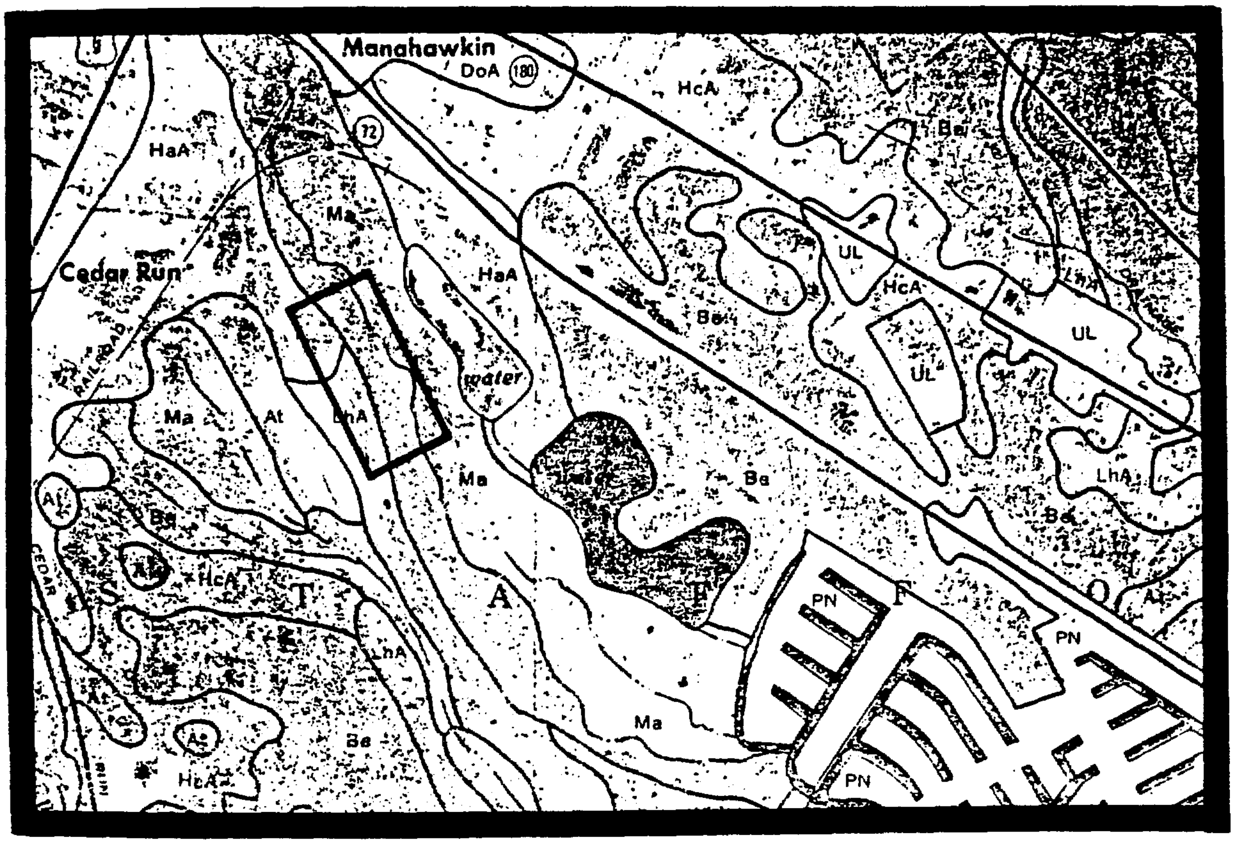
SITE 220   Colony Village, Stafford Twp., Ocean County.

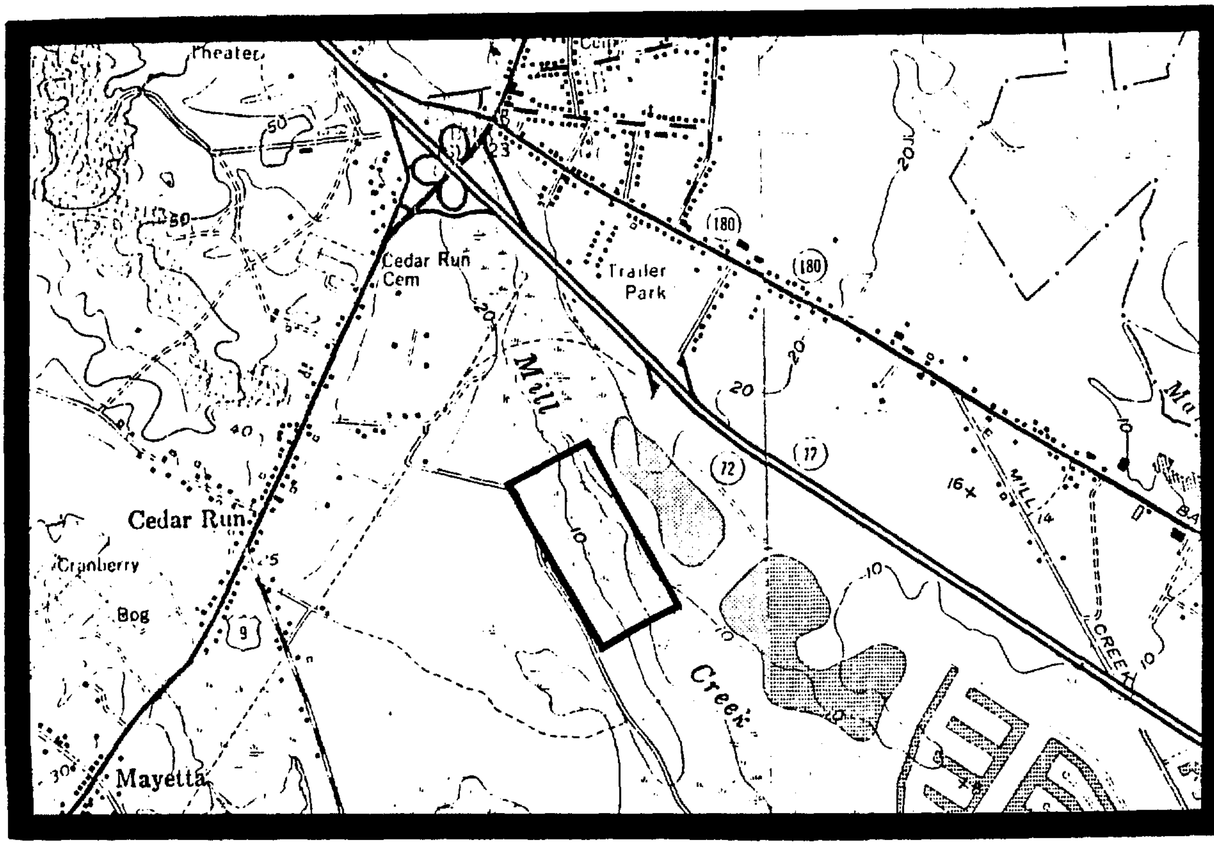
MAP A: Sheet # 54, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Ship Bottom & West Creek, N.J. Topographic
Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Ship
Bottom & West Creek, N.J. Quadrangles
(Scale 1:24,000)

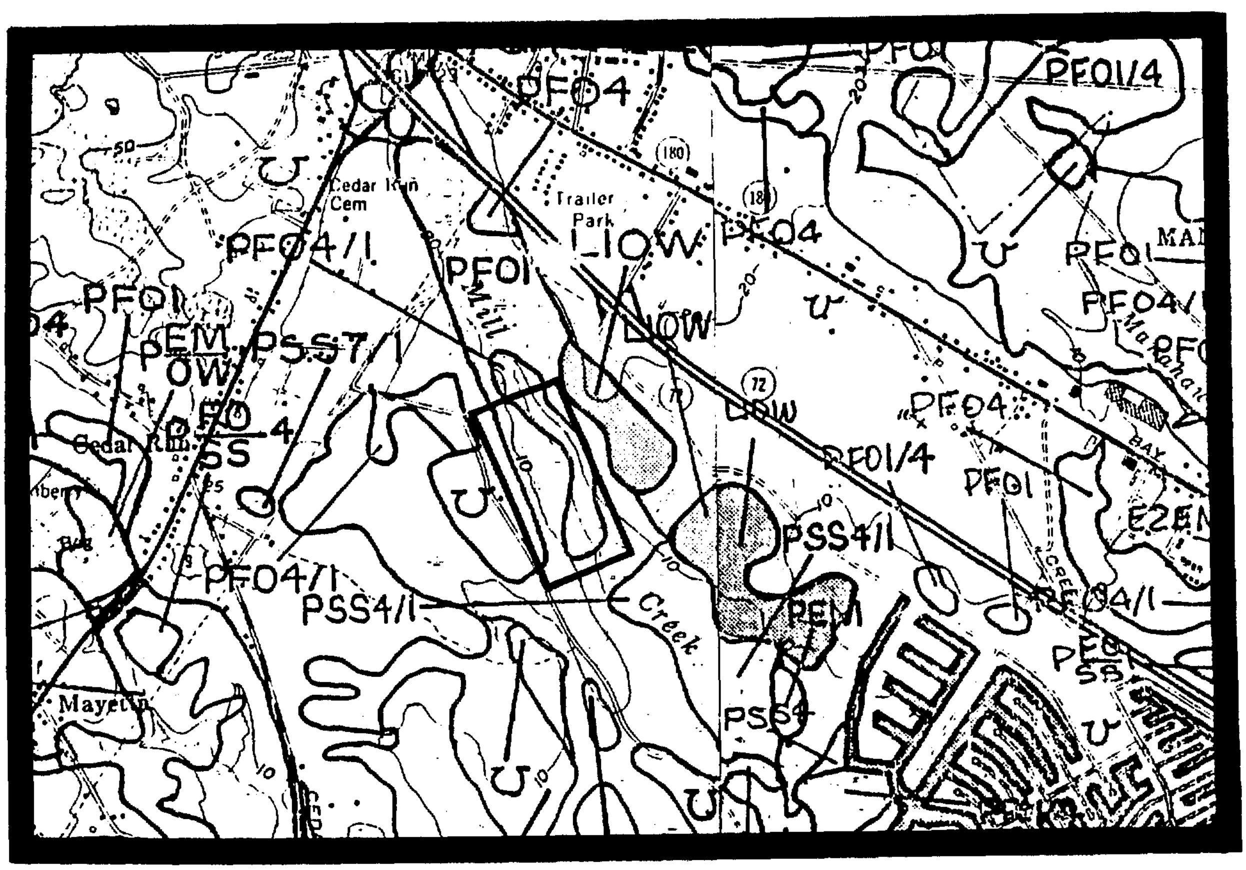
MAP A




Theater
50
Cedar Run Cem
Trailer Park
(180)
20
Mill
(72)
(17)
Cedar Run
Cranberry Bog
9
10
Creek
Mayetta
MILL
CREEK

MAP B

MAP C


PFO4
PFO1/4
Cedar Run Cem
Trailer Park
PFO4/1
PFO1
L1OW
PFO4
PFO1
PFO4/1
PEM
POW
PSS7/1
L1OW
PFO4
PFO1/4
PFO1
PSS4/1
PFO4/1
PSS4/1
PEM
Creek
Mill
Mayetta
E2EM

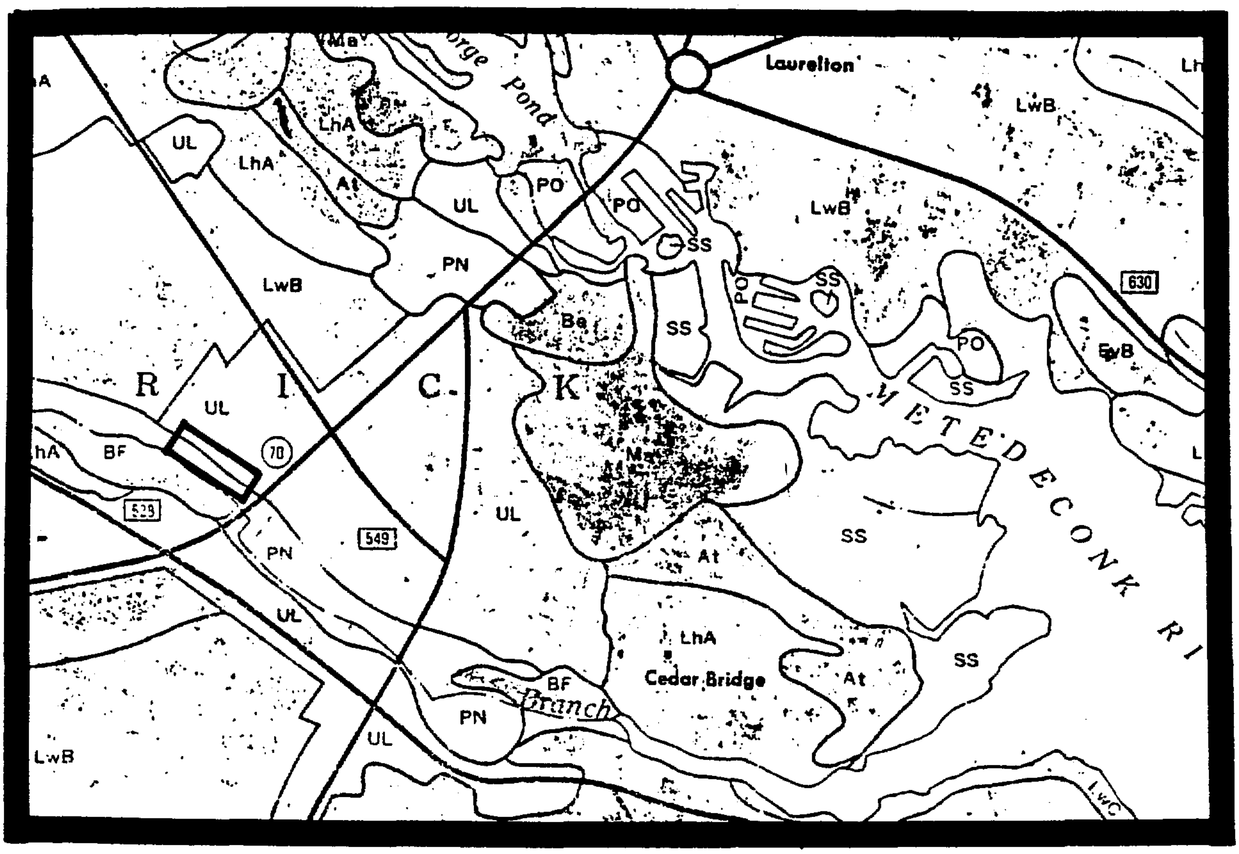
SITE 222 Caldors, Rt. 549, Brick Twp., Ocean County.

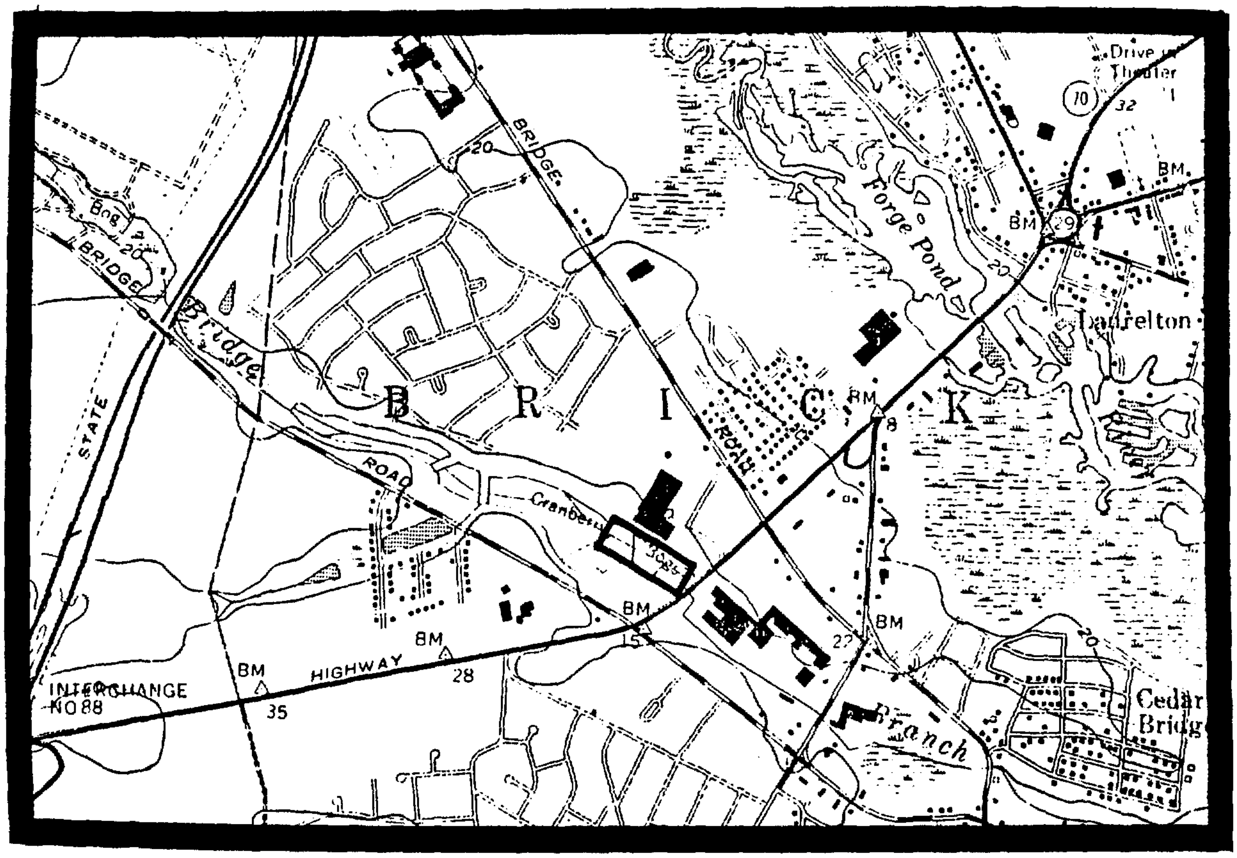
MAP A: Sheet # 14, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Lakewood, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Lakewood, N.J. Quadrangle (Scale 1:24,000)

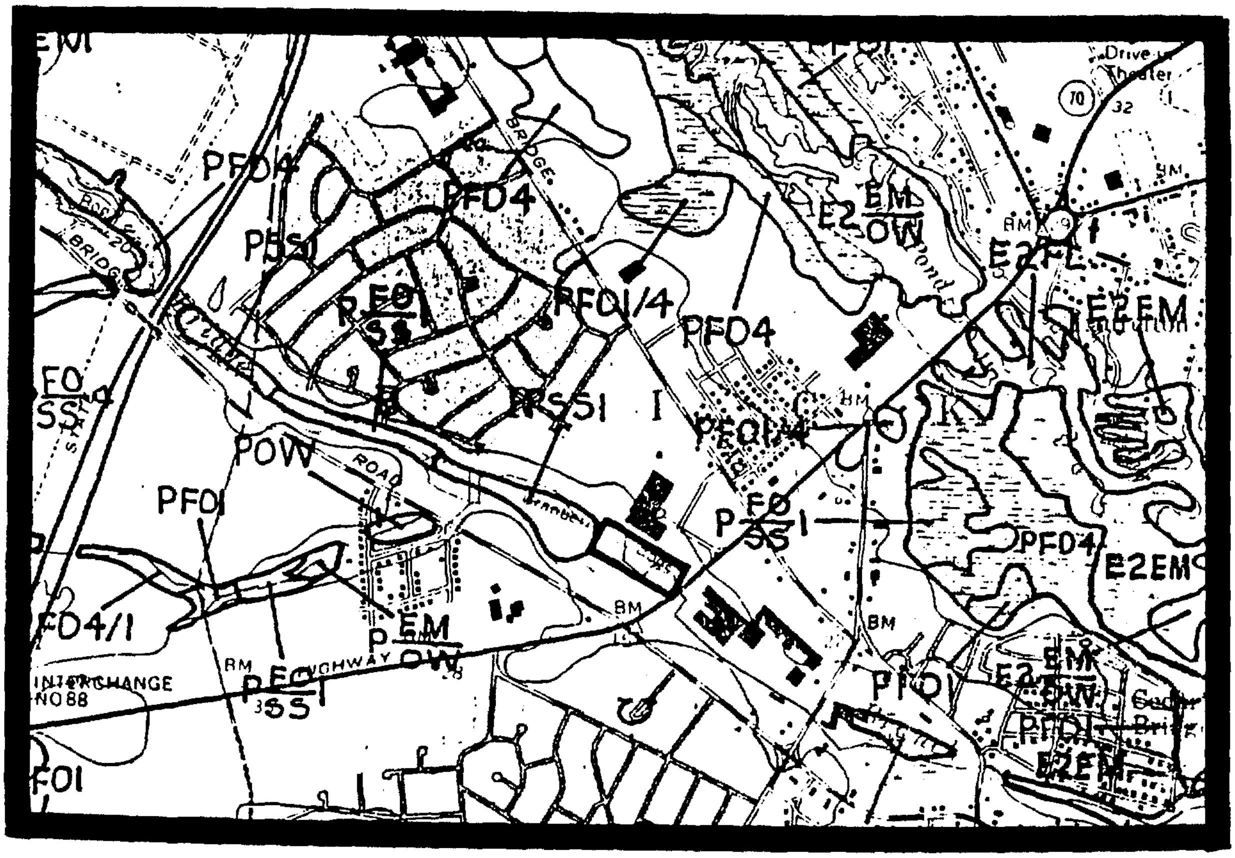
MAP A




Drive-in Theater
70
32
BM
29
Forge Pond
Laurelton
B R I C K
BM
Bog
BRIDGE
Bridge
ROAD
Cranberry
STATE
BRIDGE
BM
15
BM
27
BM
28
BM
35
HIGHWAY
INTERCHANGE NO 88
Branch
Cedar Bridge

MAP B

MAP C


Drive-in Theater
70
32
PFO4
PFO4
PSS1
PFO1/SS
PFO1/4
PFO4
E2 EM/OW
E2FL
E2EM
FO/SS
POW
PFO1
PSS1
PFO1/4
P FO/SS1
PFO4
E2EM
FO4/1
P EM/OW
BM
INTERCHANGE NO88
P FO/SS1
PFO1
E2 EM/OW
PFO1
E2EM
FO1

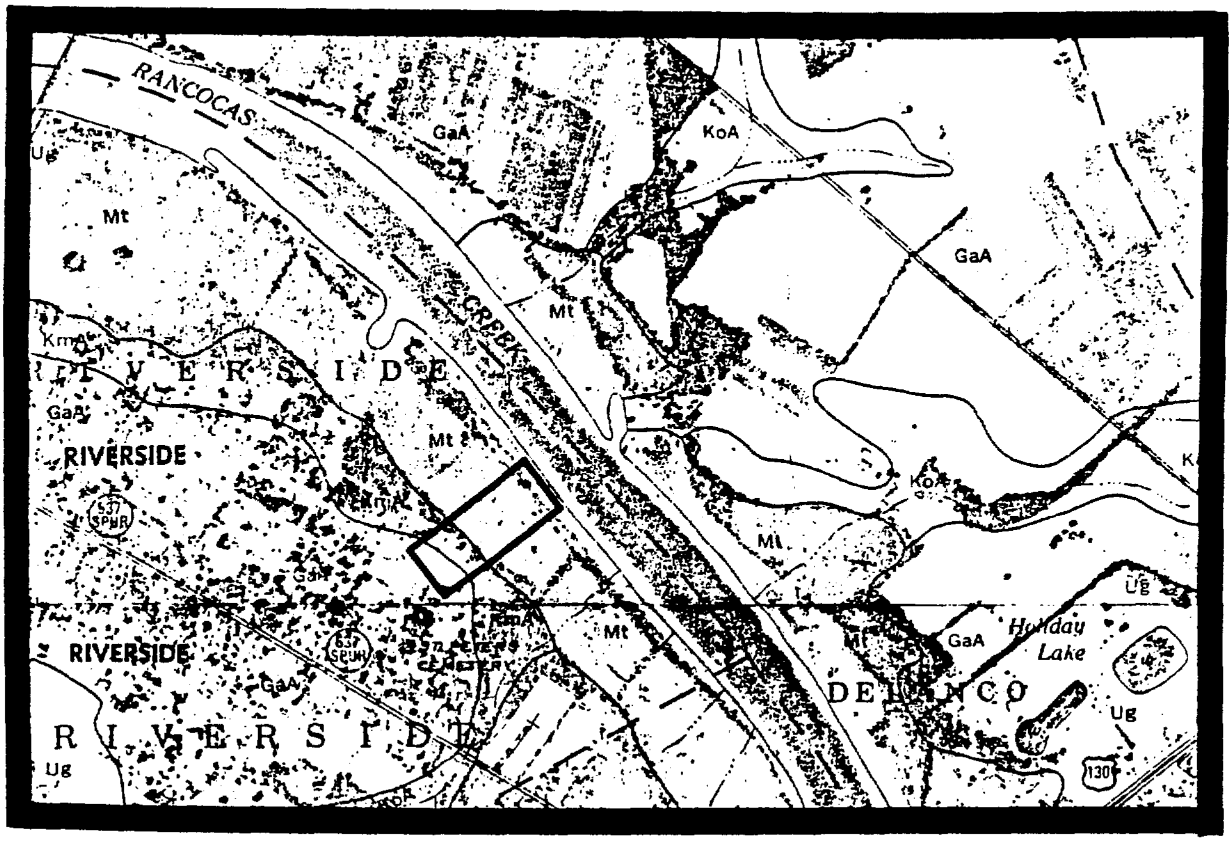
SITE 224 Henry St., Riverside, Burlington County.

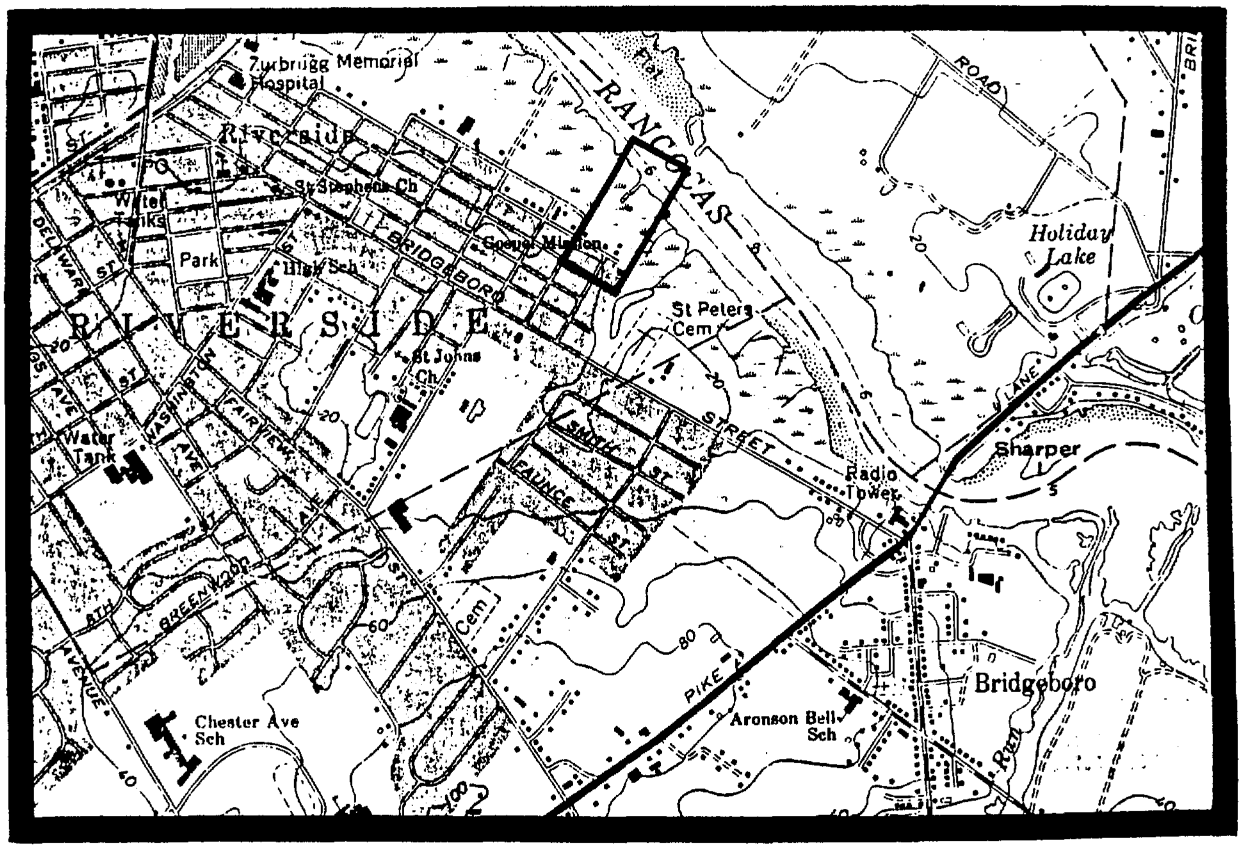
MAP A: Sheets # 13 & 25, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

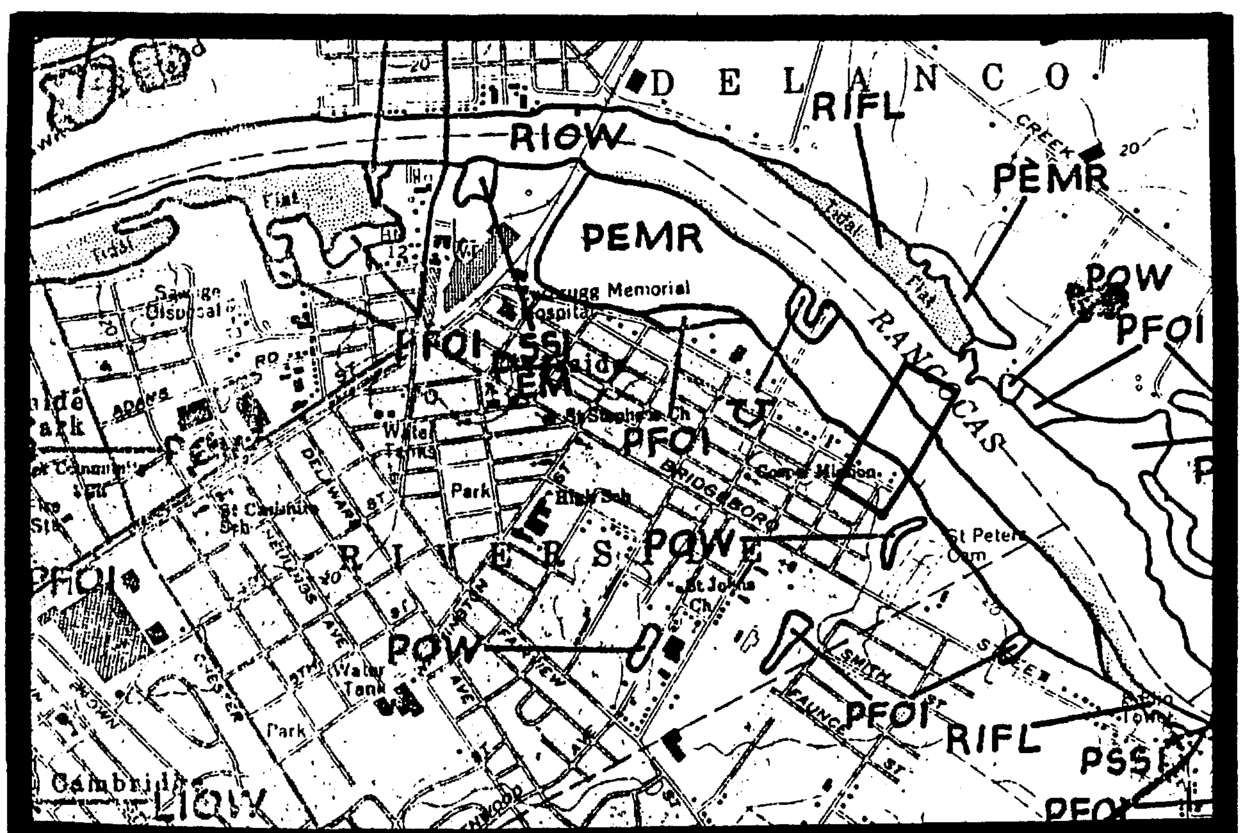
MAP A




Zurbrugg Memorial Hospital
Riverside
St Stephens Ch
Water Tanks
Park
High Sch
Gospel Mission
BRIDGEBORO
RIVERSIDE
RANCOCAS
ROAD
Holiday Lake
St Peters Cem
St Johns Ch
STREET
Water Tank
SMITH ST
FAUNCE ST
Radio Tower
Sharper
GREENWOOD
Cem
PIKE
Aronson Bell Sch
Bridgeboro
Chester Ave Sch

MAP B

MAP C


DELANCO
RIFL
RIOW
CREEK
PEMR
PEMR
Flat
Sewage Disposal
Zurbrugg Memorial Hospital
PFOI
SS
POW
PFOI
St Stephens Ch
PFOI
Water Tanks
Park
High Sch
Gospel Mission
BRIDGEBORO
RANCOCAS
POWE
St Peters Cem
St Johns Ch
PFOI
POW
Water Tank
SMITH
FAUNCE ST
PFOI
RIFL
PSS
Park
Cambridge

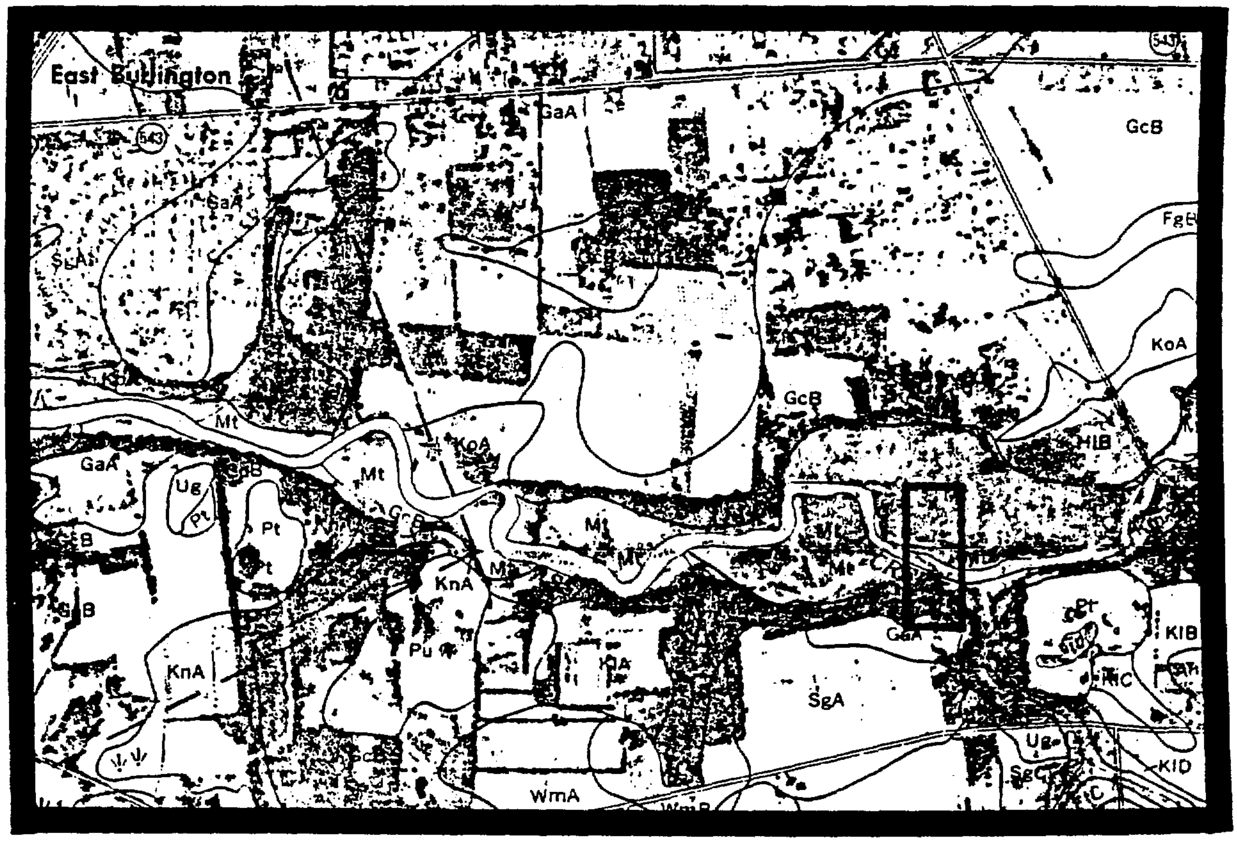
SITE 226 Burlington Park, Rt. 660, Burlington Twp., Burlington County.

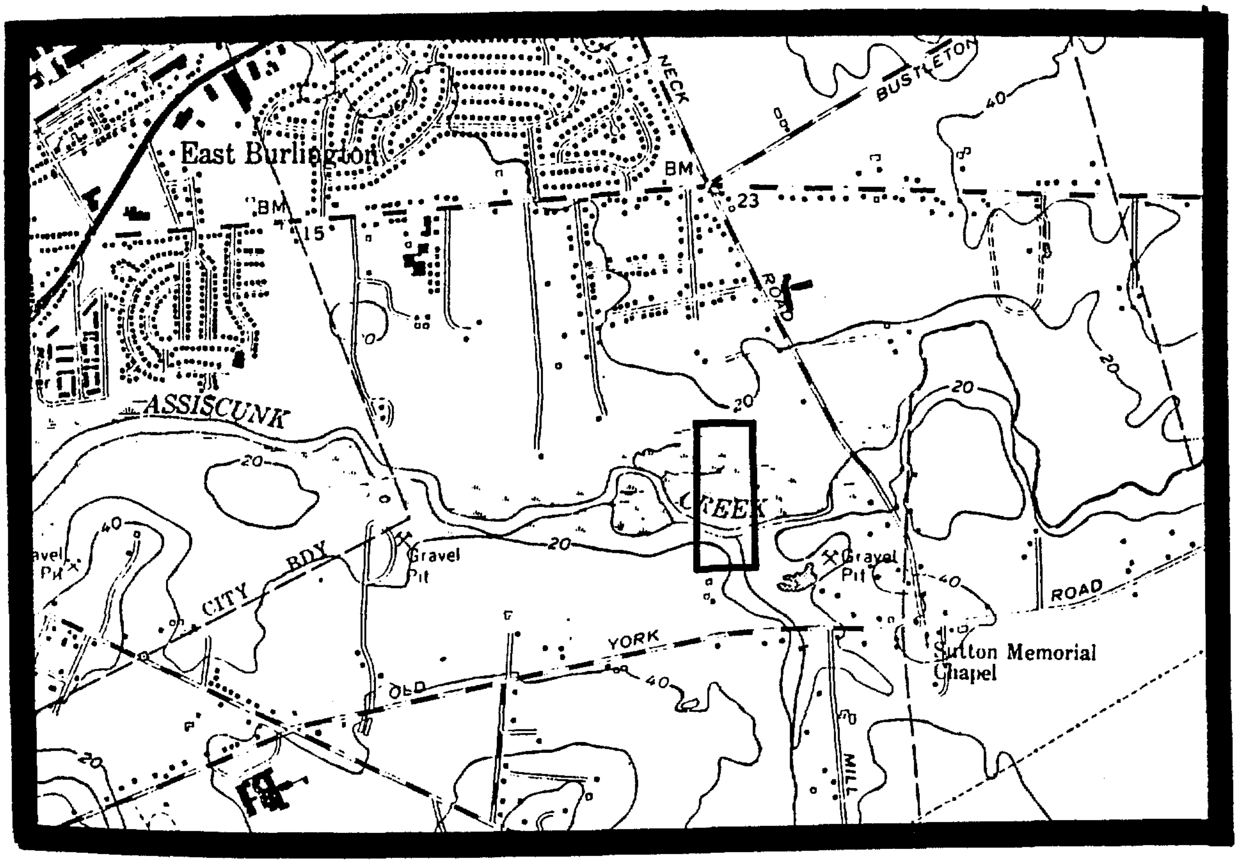
MAP A: Sheets # 7 & 14, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Bristol, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Bristol, N.J. Quadrangle (Scale 1:24,000)

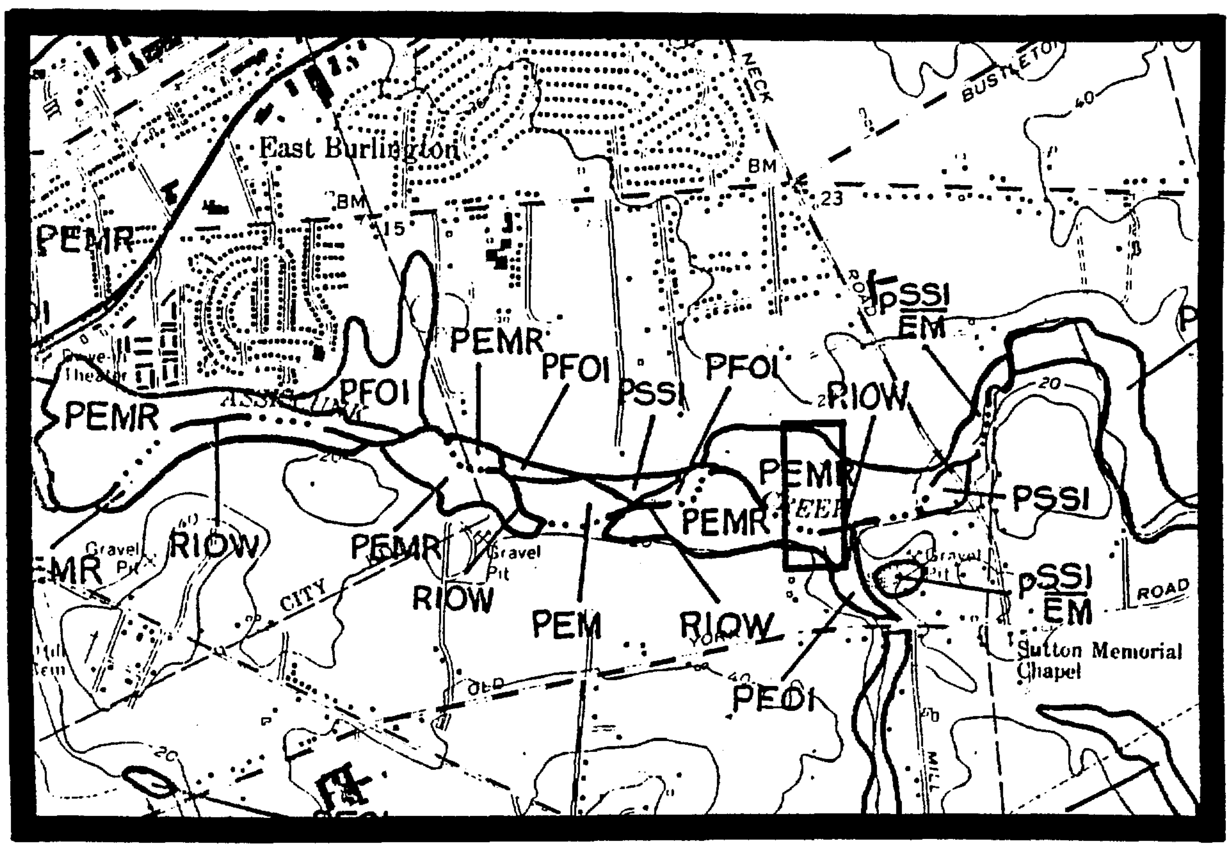
MAP A




East Burlington
BM
15
NECK
BUSTLETON
BM
23
ROAD
ASSISCUNK
CREEK
Gravel Pit
Gravel Pit
CITY
BDY
ROAD
YORK
OLD
Sutton Memorial Chapel
MILL

MAP B

MAP C


East Burlington
BM
15
NECK
BUSTLETON
BM
23
ROAD
PEMR
PSSI
EM
PEMR
PFOI
PSSI
PFOI
RIOW
PEMR
PFOI
PEMR
PEMR
PSSI
RIOW
PEMR
RIOW
PEM
RIOW
PSSI
EM
PEOI
CITY
Gravel Pit
Gravel Pit
ROAD
OLD
MILL
Sutton Memorial Chapel

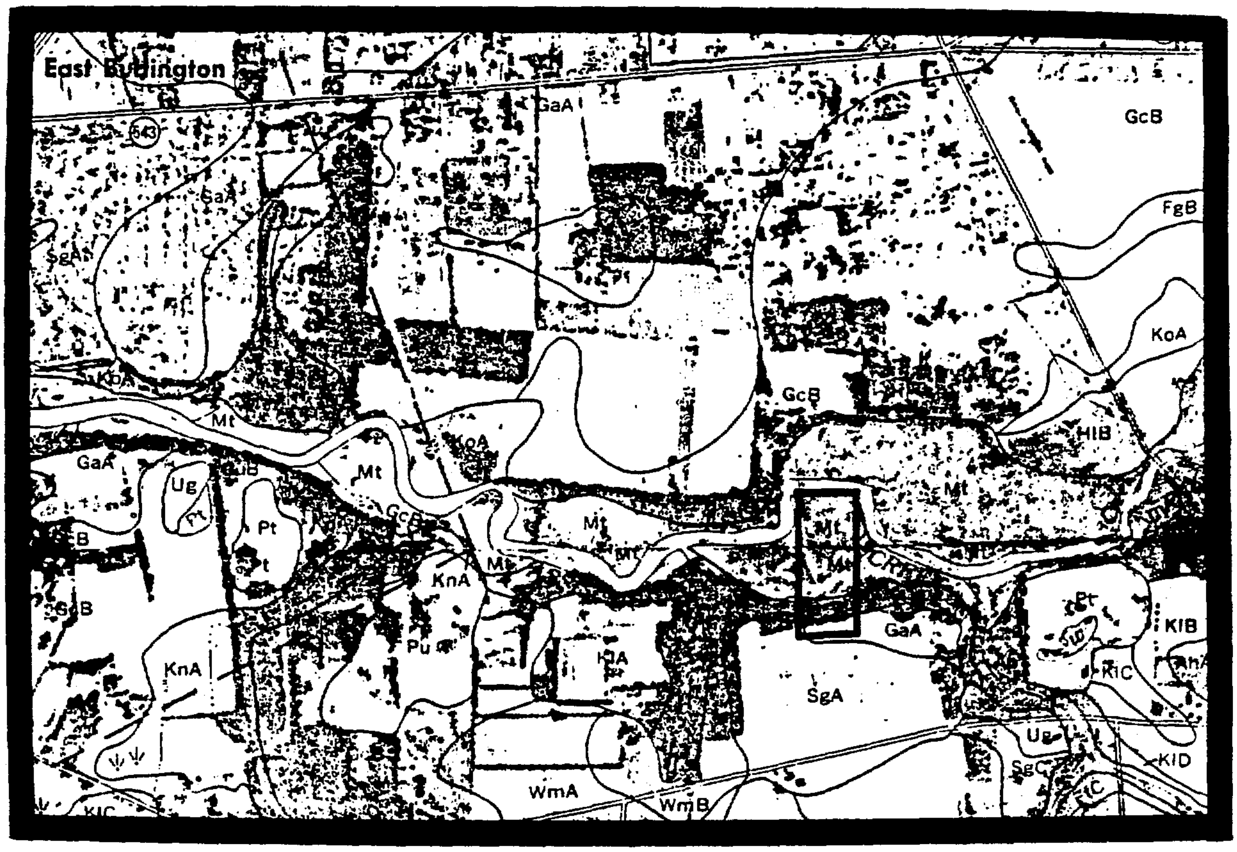
SITE 227 Burlington Park, Rt. 660, Burlington Twp., Burlington County.

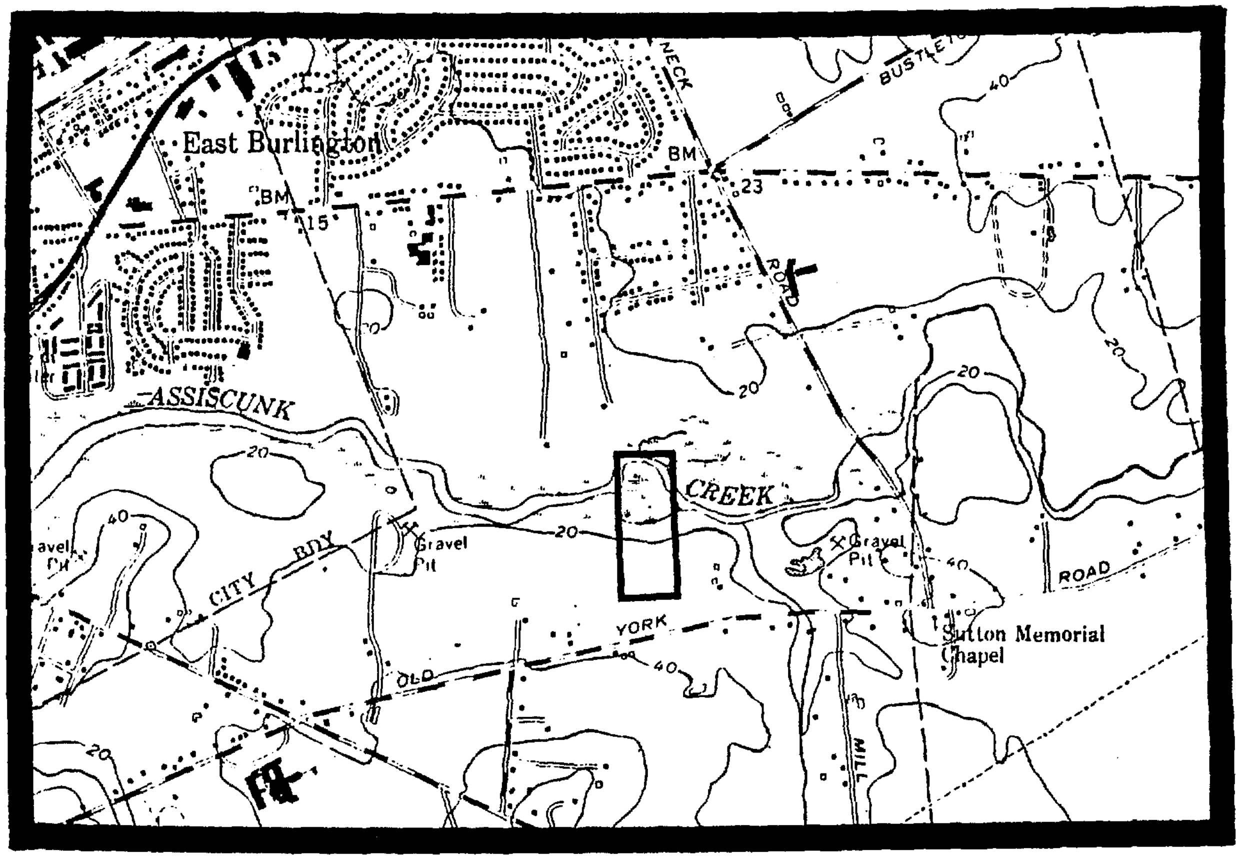
MAP A: Sheets # 7 & 14, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Bristol, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Bristol, N.J. Quadrangle (Scale 1:24,000)

MAP A

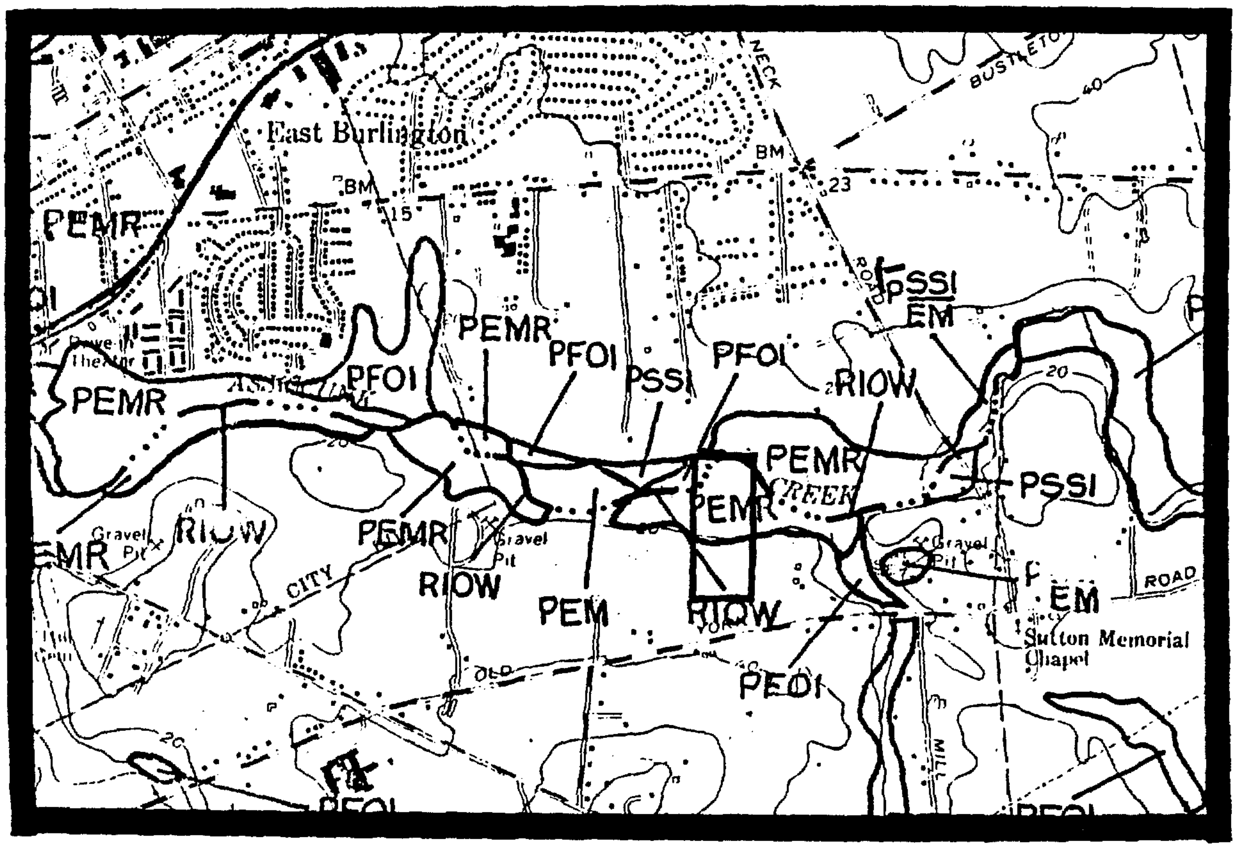




East Burlington
ASSISCUNK
CREEK
Gravel Pit
CITY BDY
YORK
OLD
ROAD
MILL
NECK
BUSTLETON
Sutton Memorial Chapel

MAP B

MAP C



East Burlington
PEMR
PFOI
PSSI
RIOW
PEM
PEOI
EM
CREEK
Gravel Pit
CITY
ROAD
MILL
NECK
Sutton Memorial Chapel

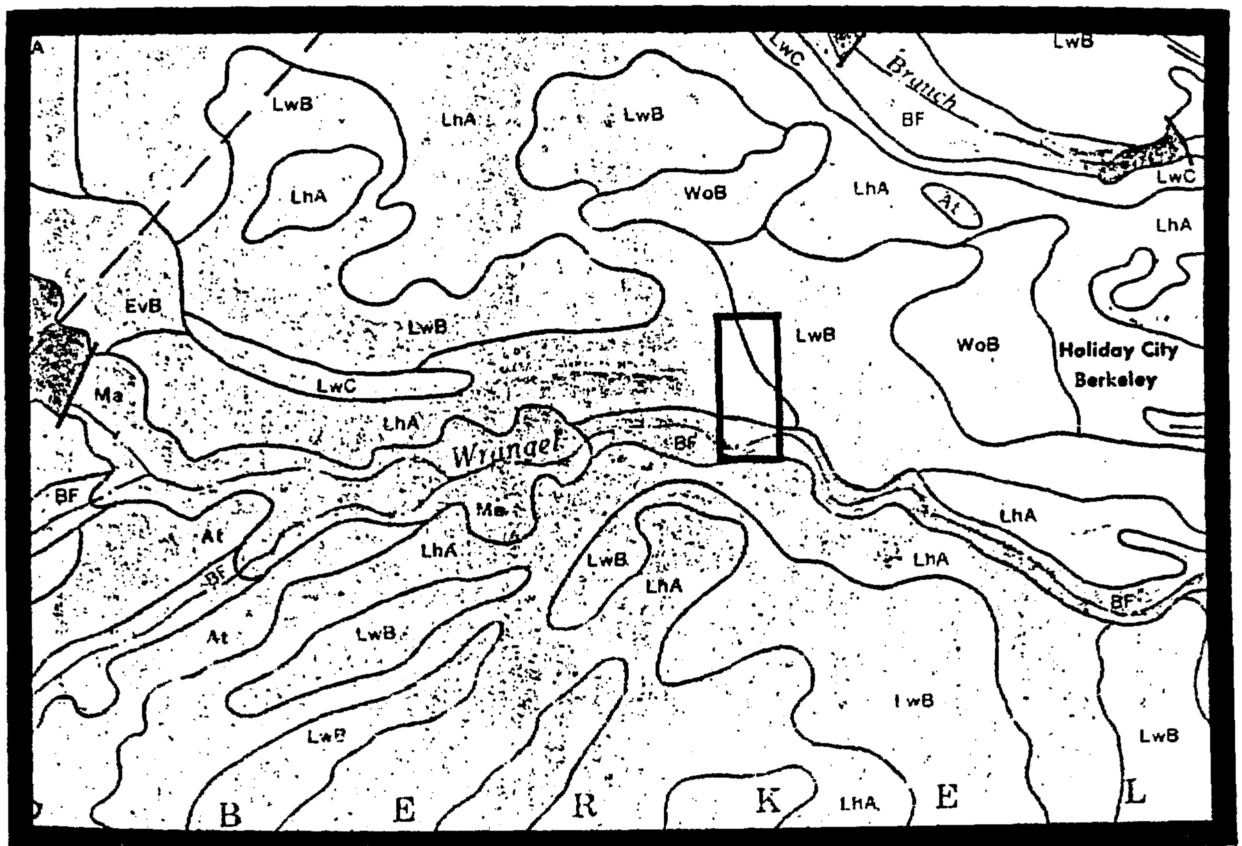
SITE 231 Torrey Pine, Holiday City I, Ocean County.

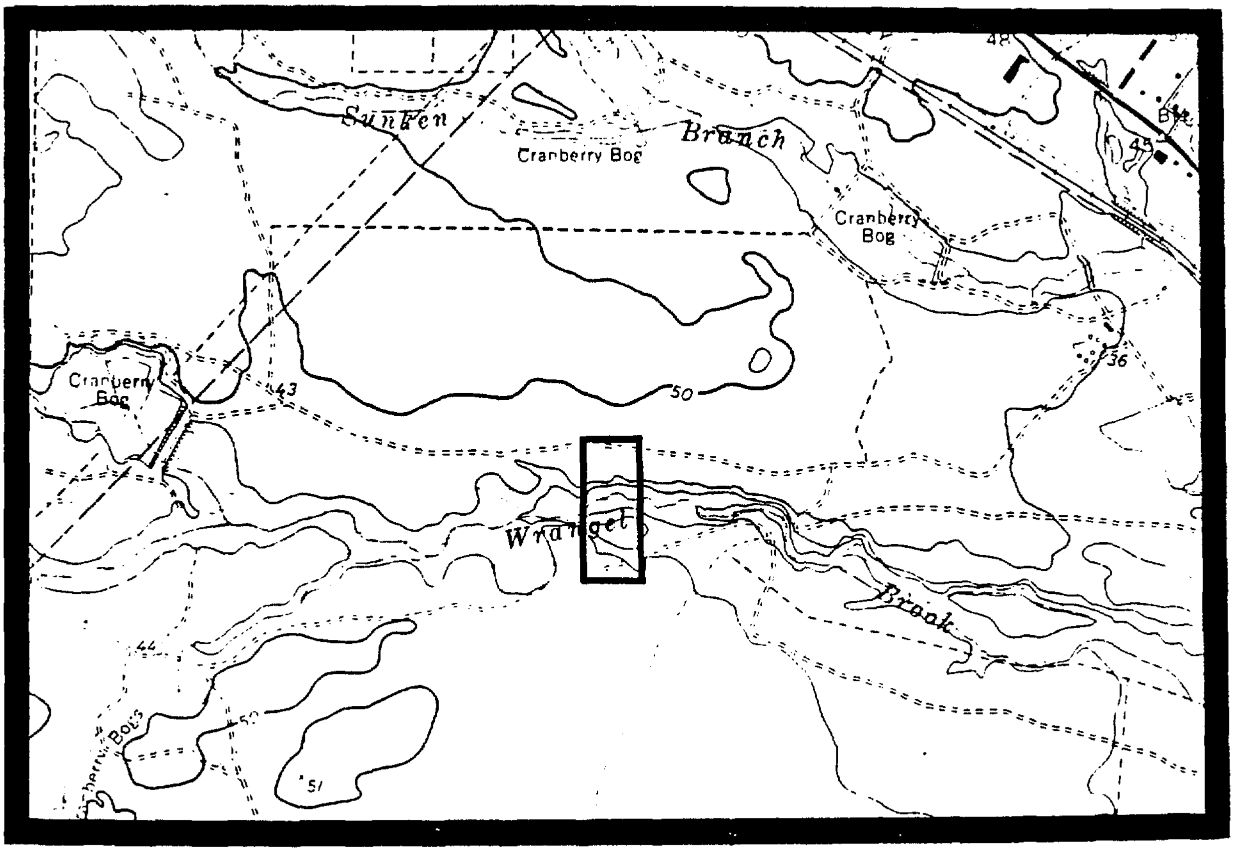
MAP A: Sheet # 25, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Keswick Grove, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keswick Grove, N.J. Quadrangle (Scale 1:24,000)

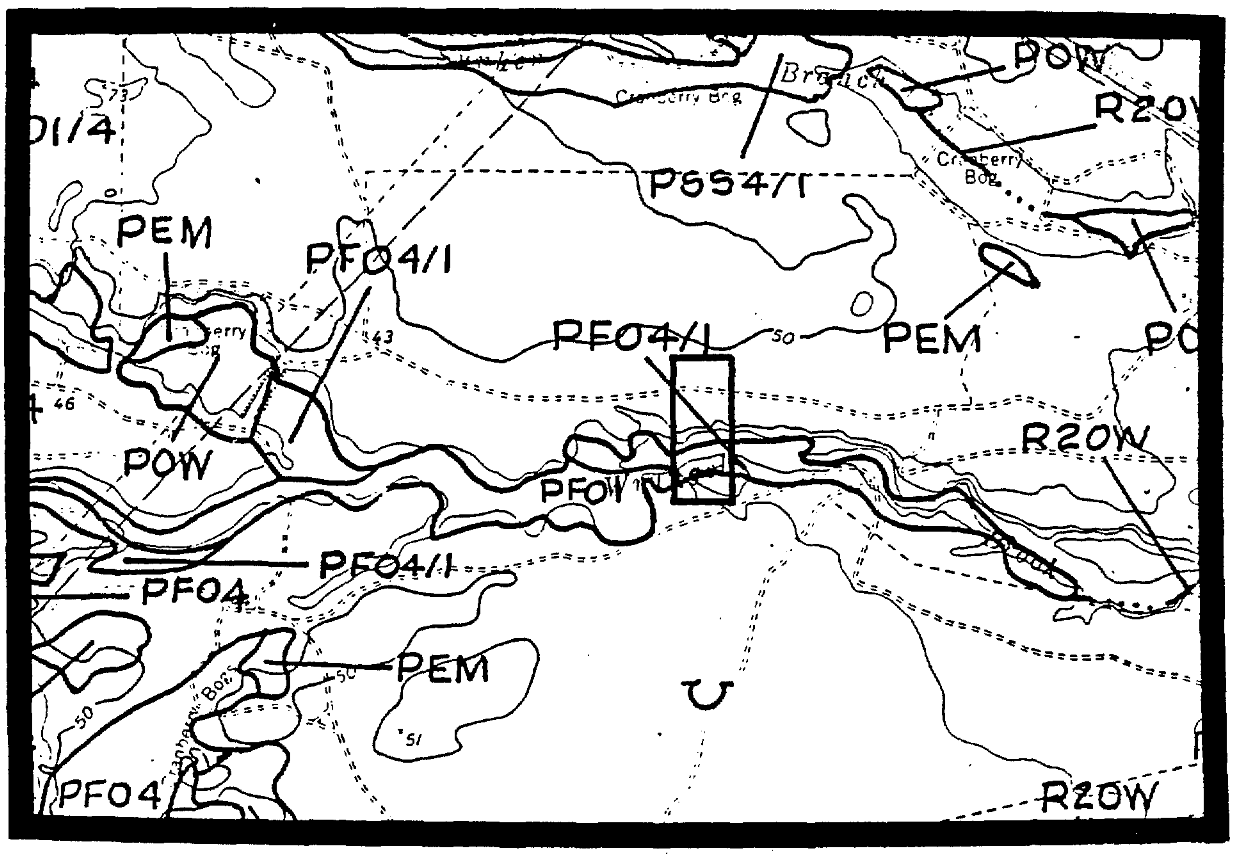
MAP A




Sunken
Branch
Cranberry Bog
Cranberry Bog
Cranberry Bog
Wrangel
Brook
43
50
44
36
48
51

MAP B

MAP C


POW
R2OW
PSS4/1
PEM
PFO4/1
PFO4/1
PEM
POW
PFO1
R2OW
PFO4/1
PFO4
PEM
PFO4
R2OW
Branch
Cranberry Bog
43
46
50
51

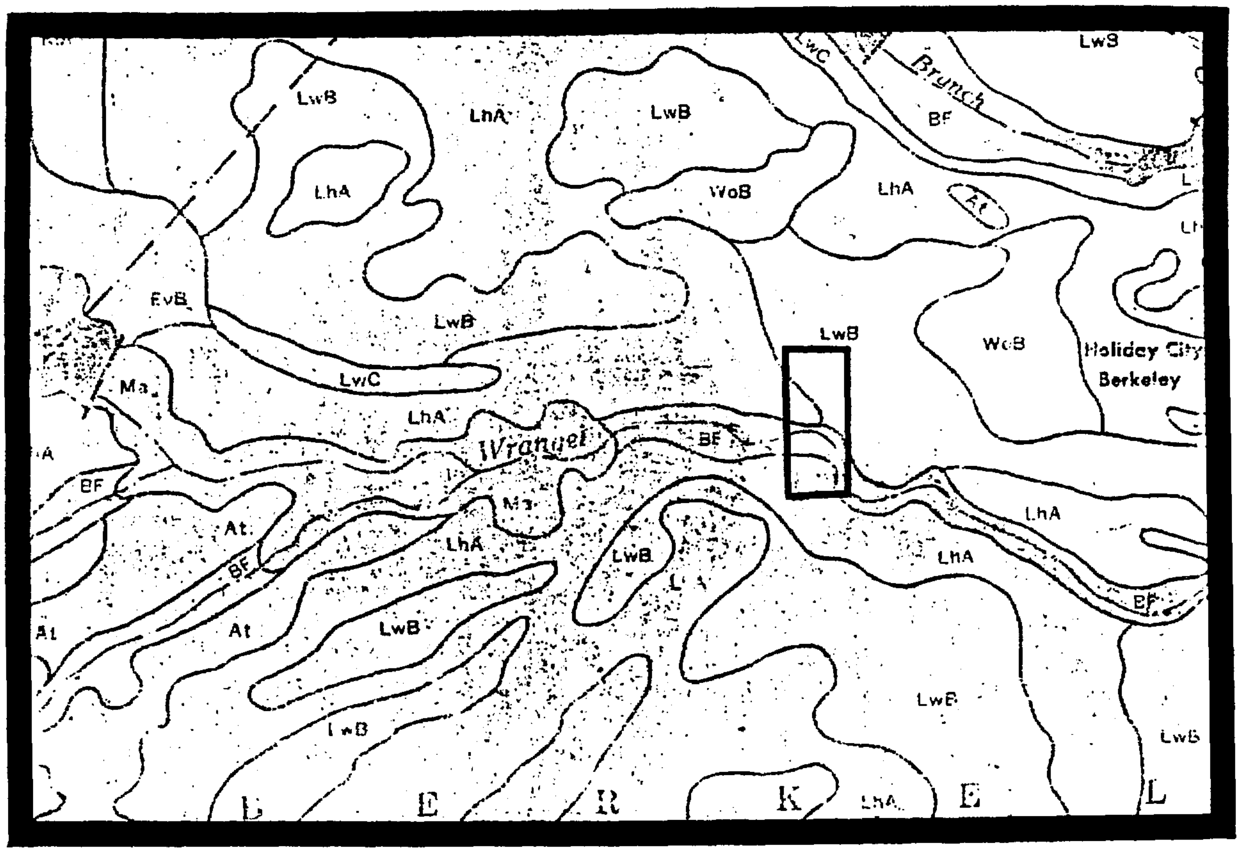
SITE 232 Torrey Pine, Holiday City II, Ocean County.

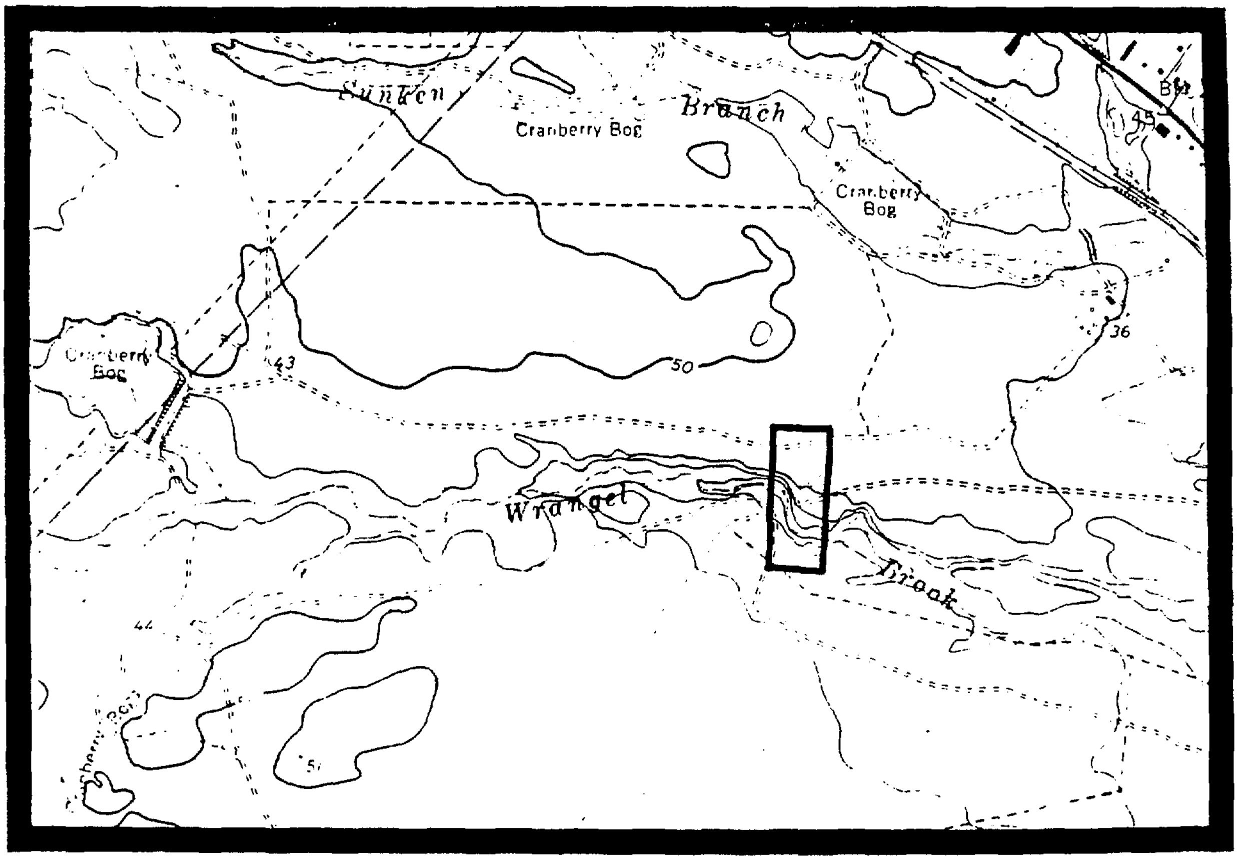
MAP A: Sheet # 25, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Keswick Grove, N.J. Topographic
Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keswick
Grove, N.J. Quadrangle (Scale 1:24,000)

MAP A

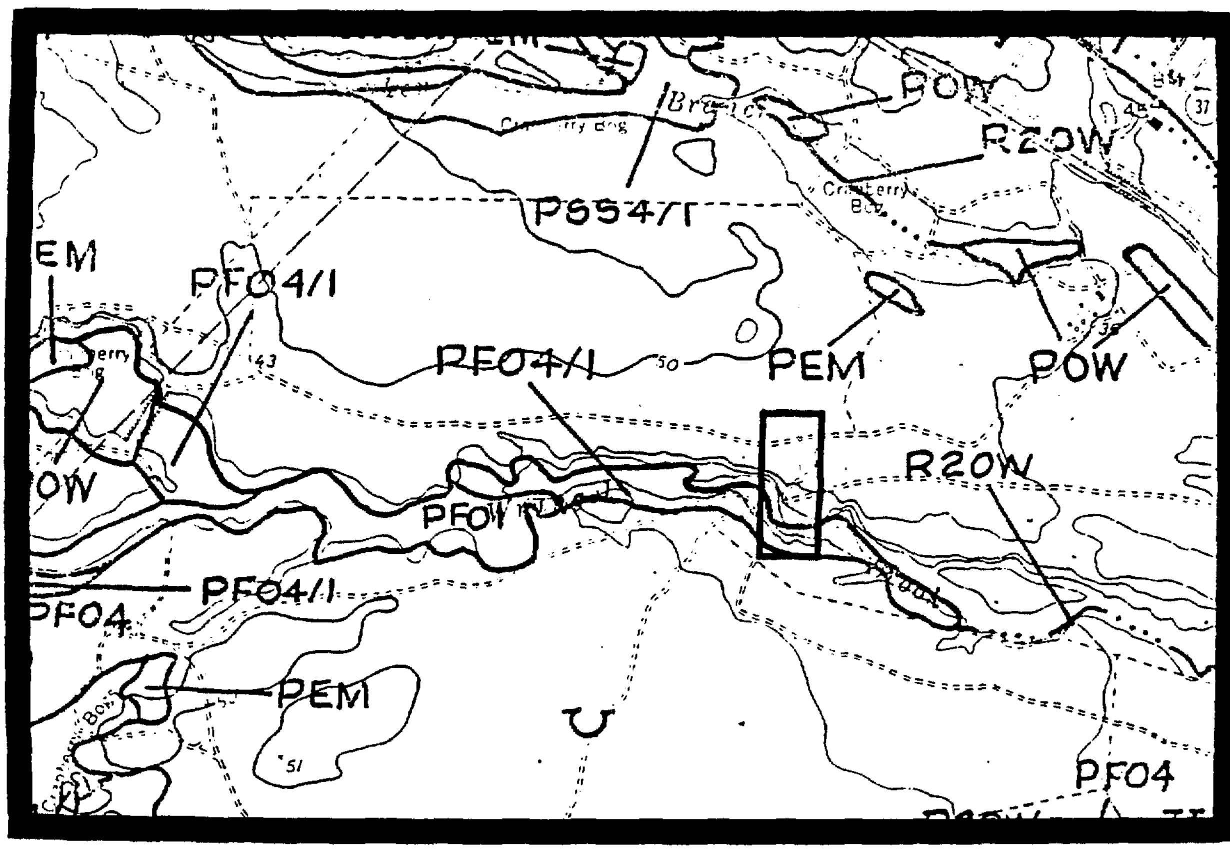




Sunken
Branch
Cranberry Bog
Cranberry Bog
Cranberry Bog
Wrangel
Brook
50
43
44
36
51

MAP B

MAP C



POW
R2OW
PSS4/1
EM
PFO4/1
PFO4/1
PEM
POW
OW
R2OW
PFO4/1
PFO4
PEM
PFO4

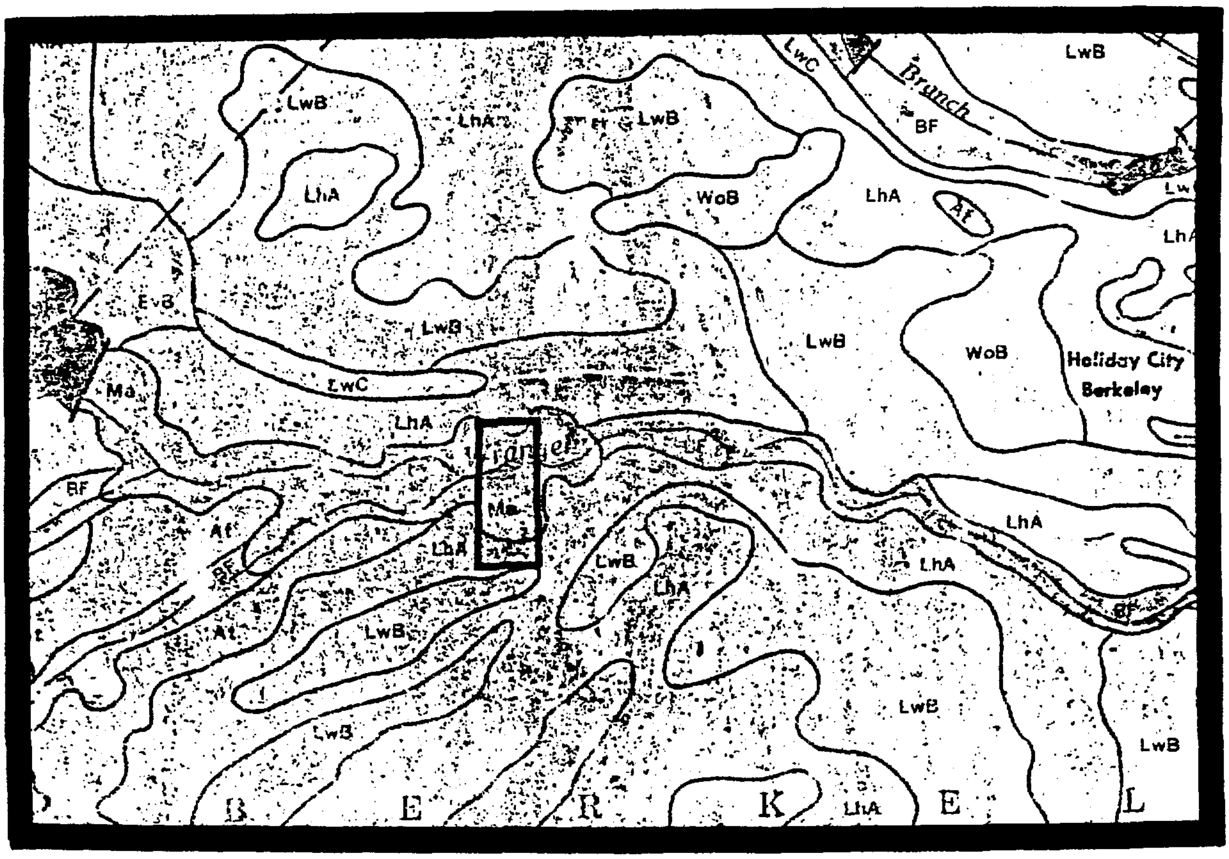
SITE 233 Troumaka St., Holiday City III, Ocean County.

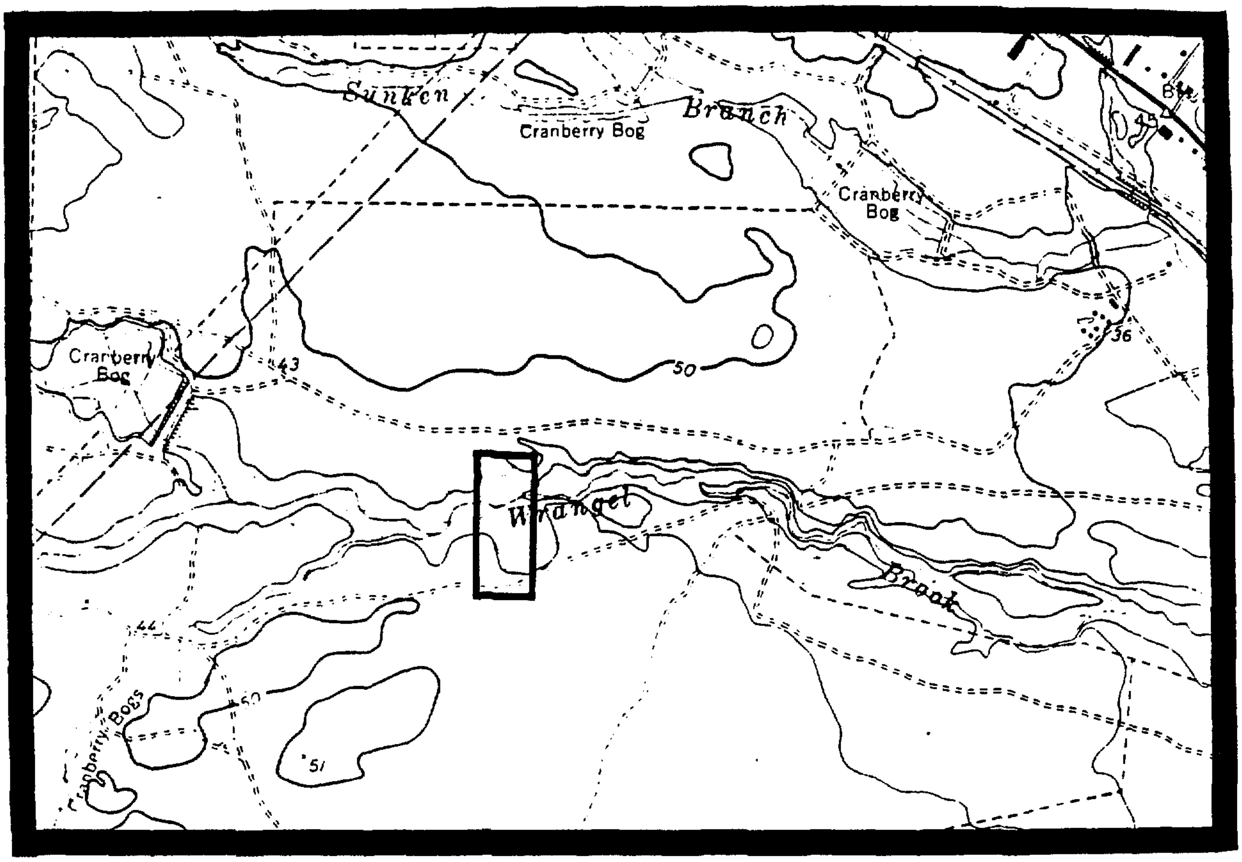
MAP A: Sheet # 25, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Keswick Grove, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keswick Grove, N.J. Quadrangle (Scale 1:24,000)

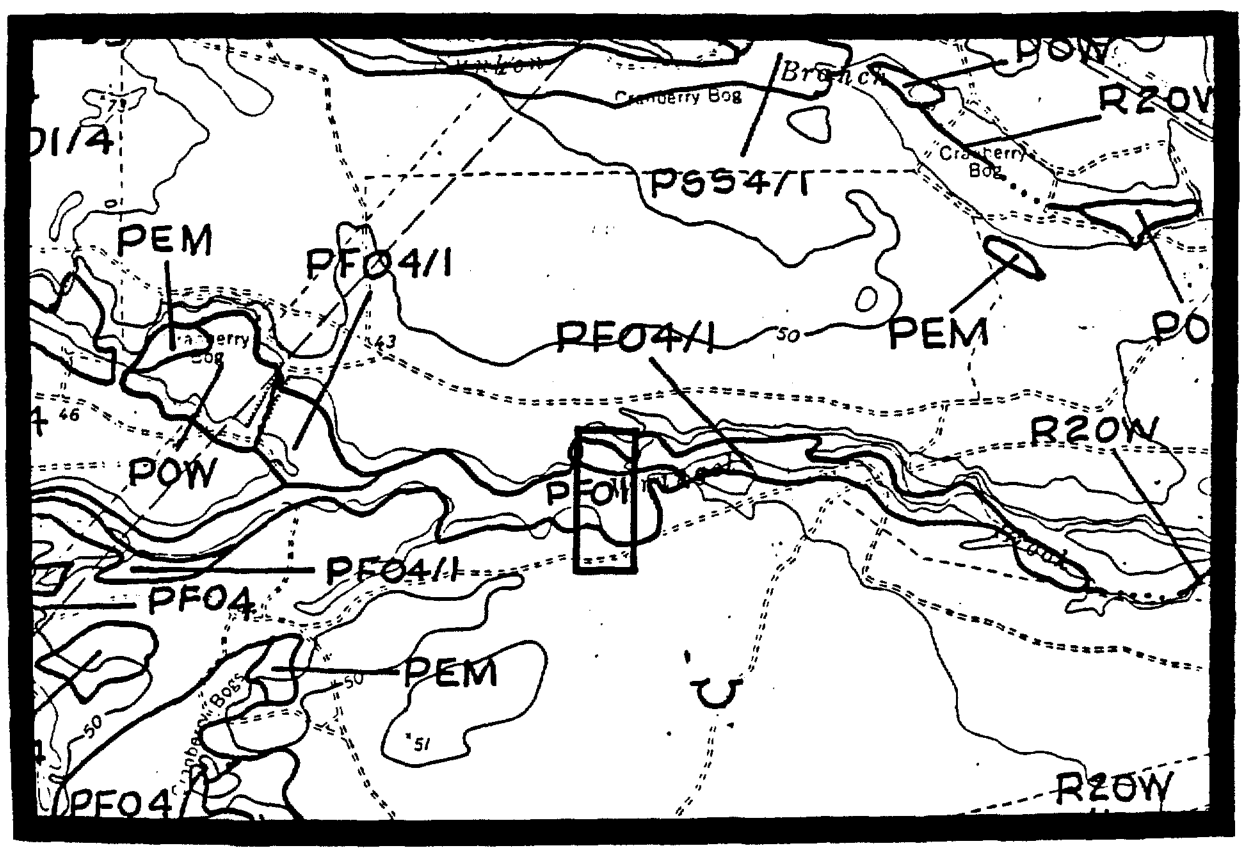
MAP A




Sunken
Branch
Cranberry Bog
Cranberry Bog
Cranberry Bog
43
50
36
Wrangel
Brook
44
60
51
Cranberry Bogs

MAP B

MAP C


Branch
Cranberry Bog
POW
R2OW
Cranberry Bog
PSS4/1
PEM
PFO4/1
PFO4/1
50
PEM
43
46
POW
R2OW
PFO1
PFO4/1
PFO4
PEM
50
51
Cranberry Bogs
PFO4
R2OW

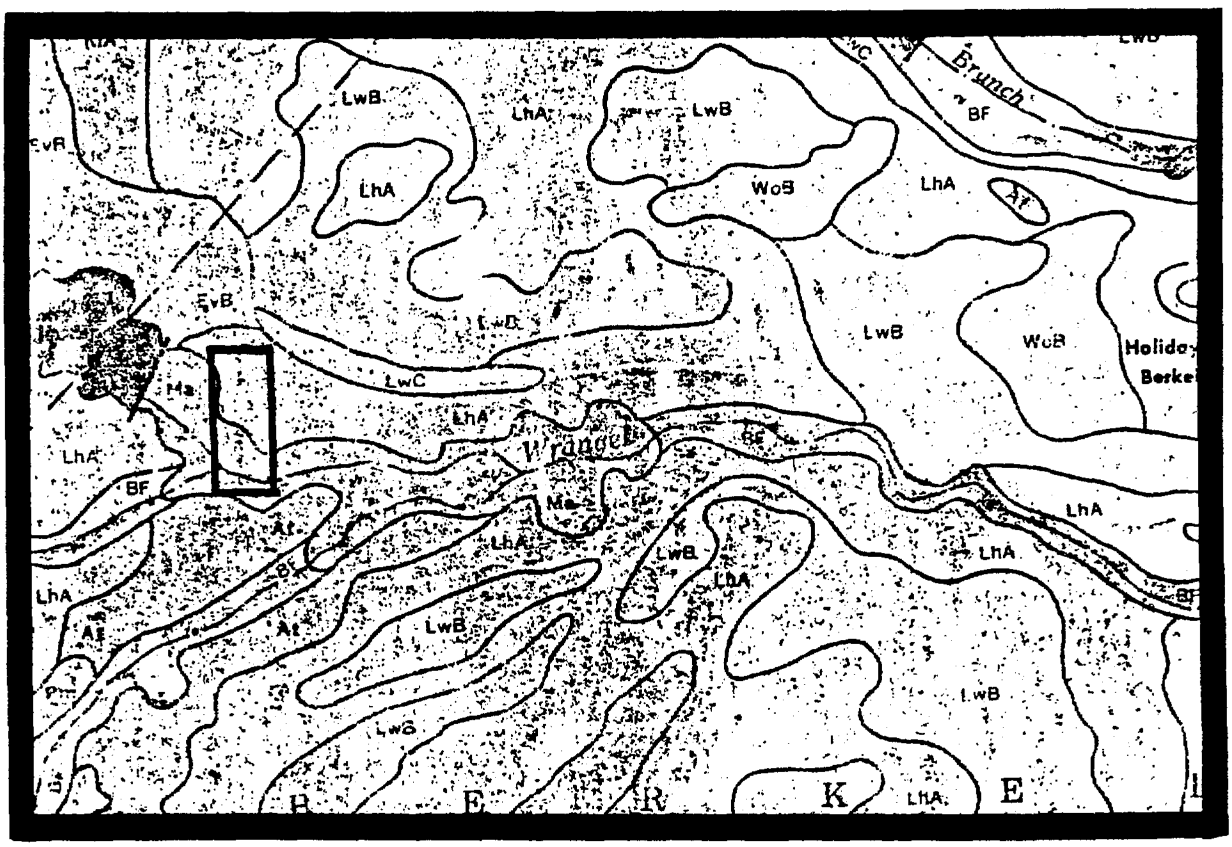
SITE 234 Lagos Ct., Holiday City IV, Ocean County.

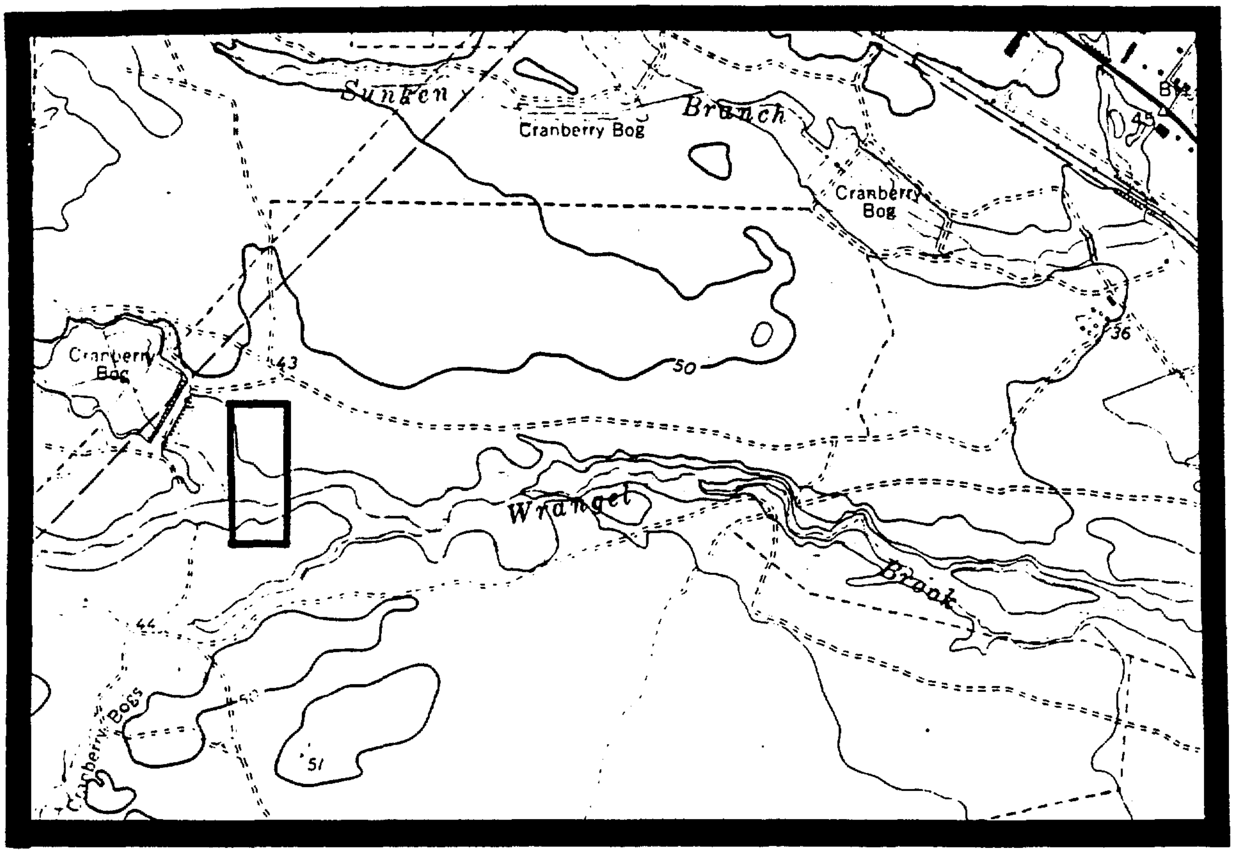
MAP A: Sheet # 25, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Keswick Grove, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keswick Grove, N.J. Quadrangle (Scale 1:24,000)

MAP A

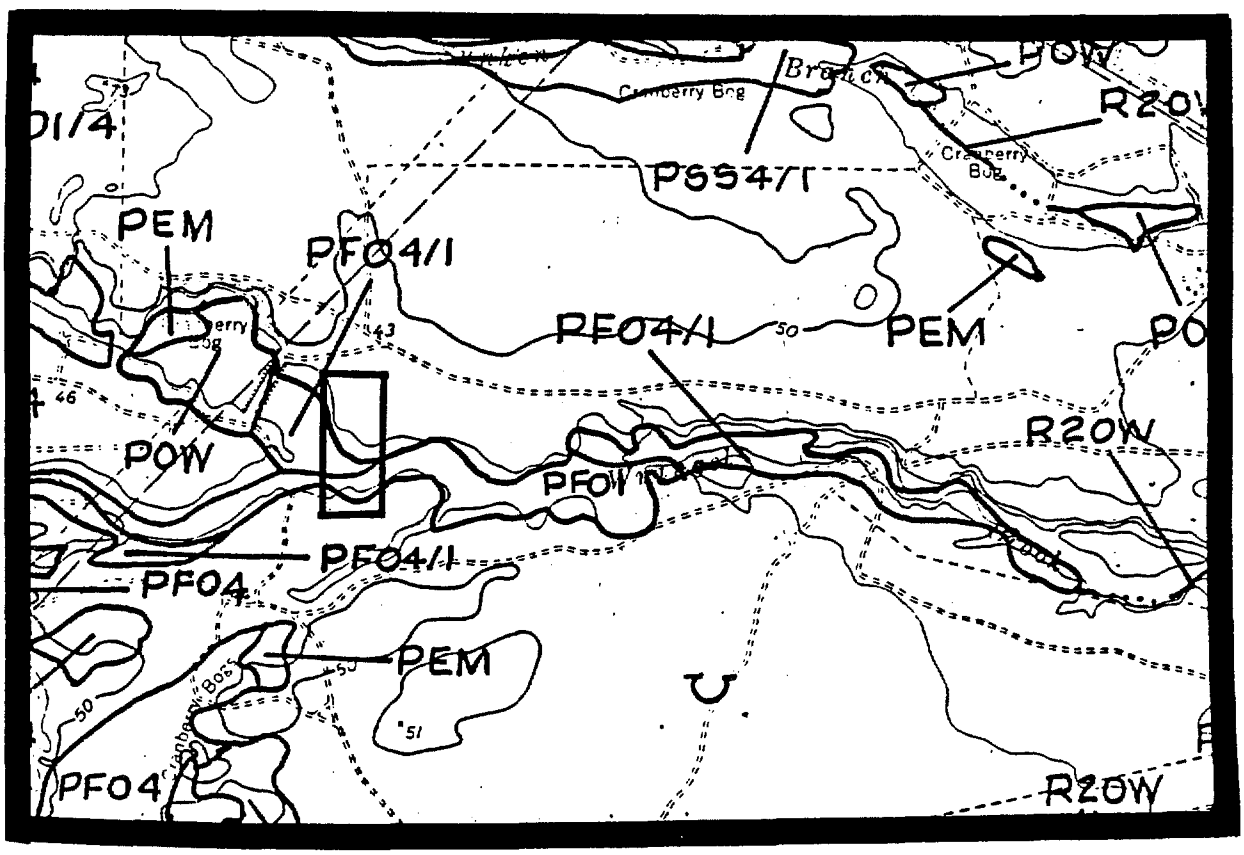




Sunken
Branch
Cranberry Bog
Cranberry Bog
Cranberry Bog
Wrangel
Brook
Cranberry Bogs
43
50
44
51
36

MAP B

MAP C



Branch
Cranberry Bog
POW
R2OW
PSS4/1
PEM
PFO4/1
PFO4/1
PEM
POW
R2OW
PFO4/1
PFO4
PEM
R2OW
PFO4
Cranberry Bogs
43
50
51
46

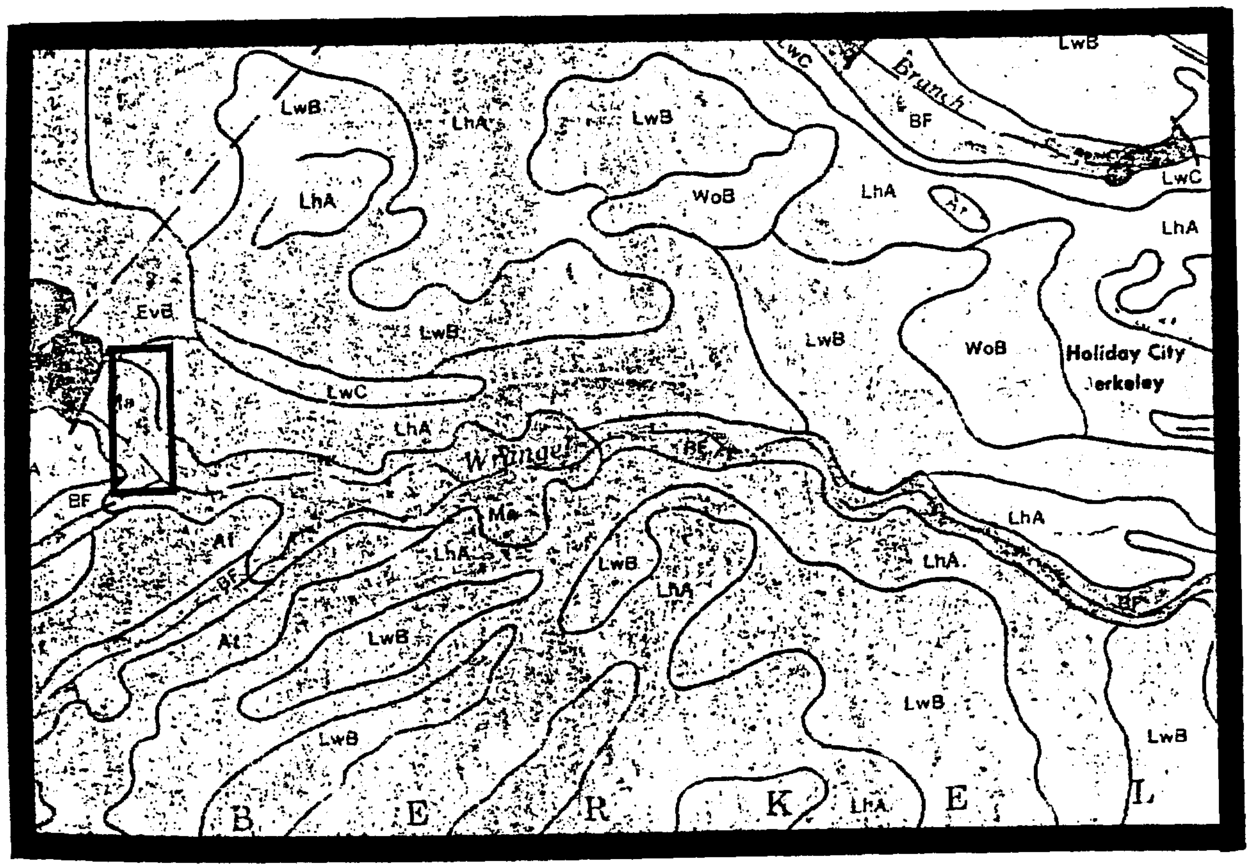
SITE 235 Lagos Ct., Holiday City V, Ocean County.

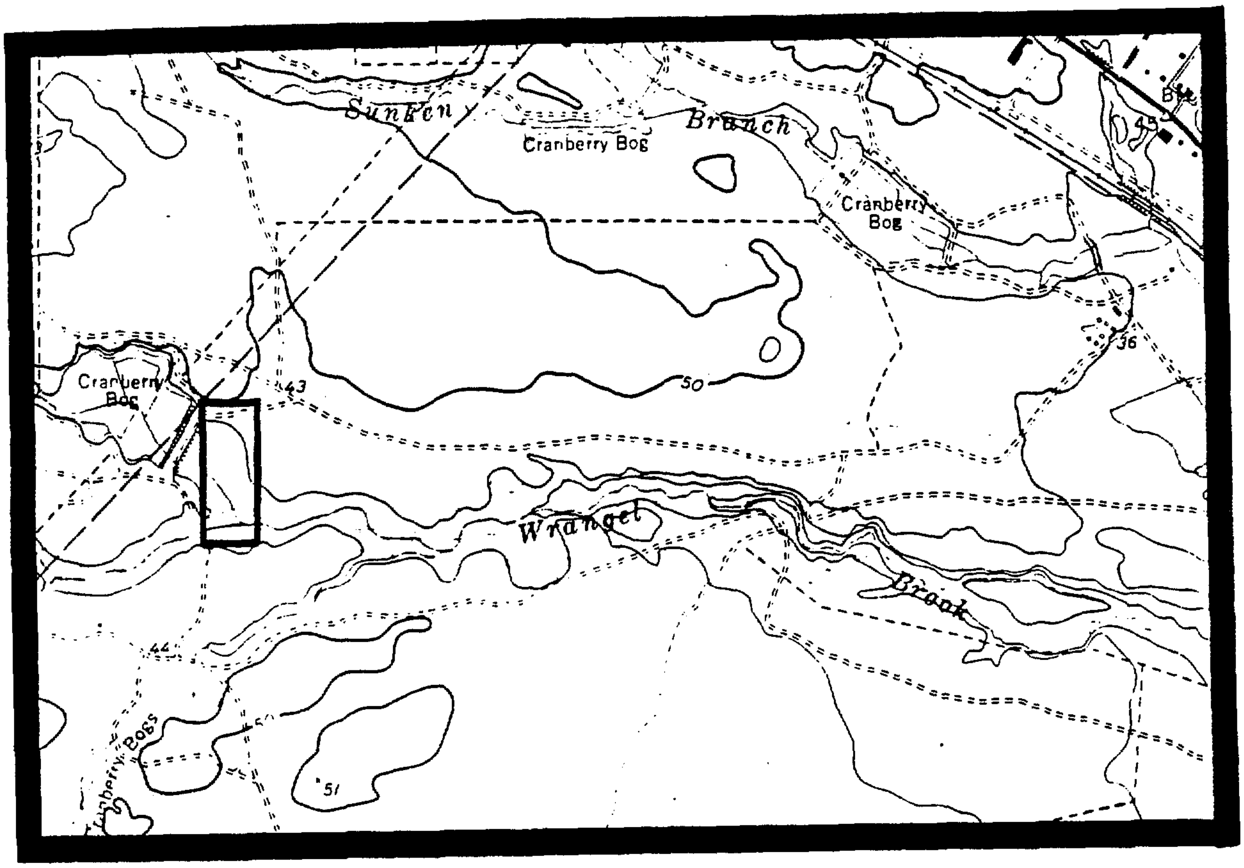
MAP A: Sheet # 25, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Keswick Grove, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keswick Grove, N.J. Quadrangle (Scale 1:24,000)

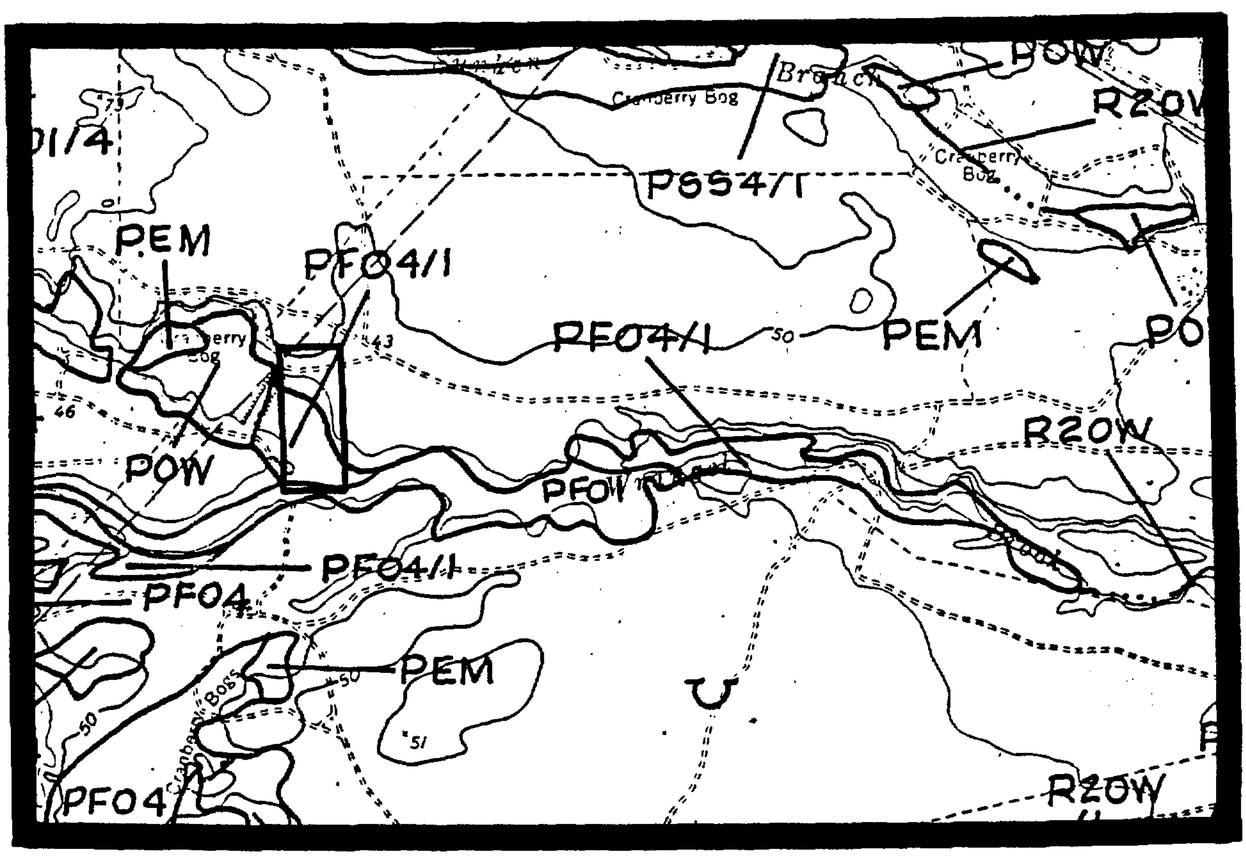
MAP A




Sunken
Branch
Cranberry Bog
Cranberry Bog
Cranberry Bog
Wrangel
Brook
Cranberry Bogs
43
50
44
51
36

MAP B

MAP C


POW
R2OW
PSS4/1
Cranberry Bog
PEM
PFO4/1
PFO4/1
PEM
POW
R2OW
PFOW
PFO4/1
PFO4
PEM
PFO4
R2OW
50
51
43
46

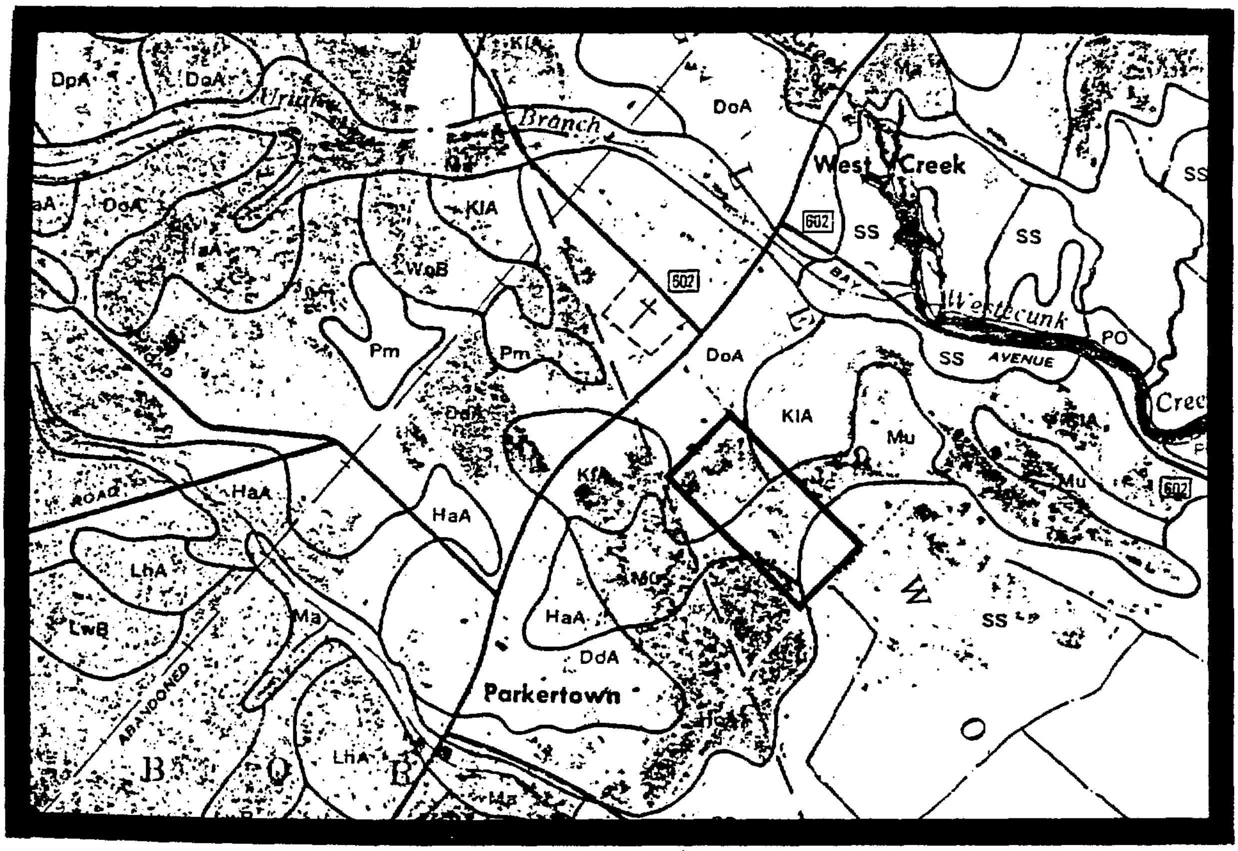
SITE 238 Sea Pirate Light, Rt. 9, West Creek, Ocean County.

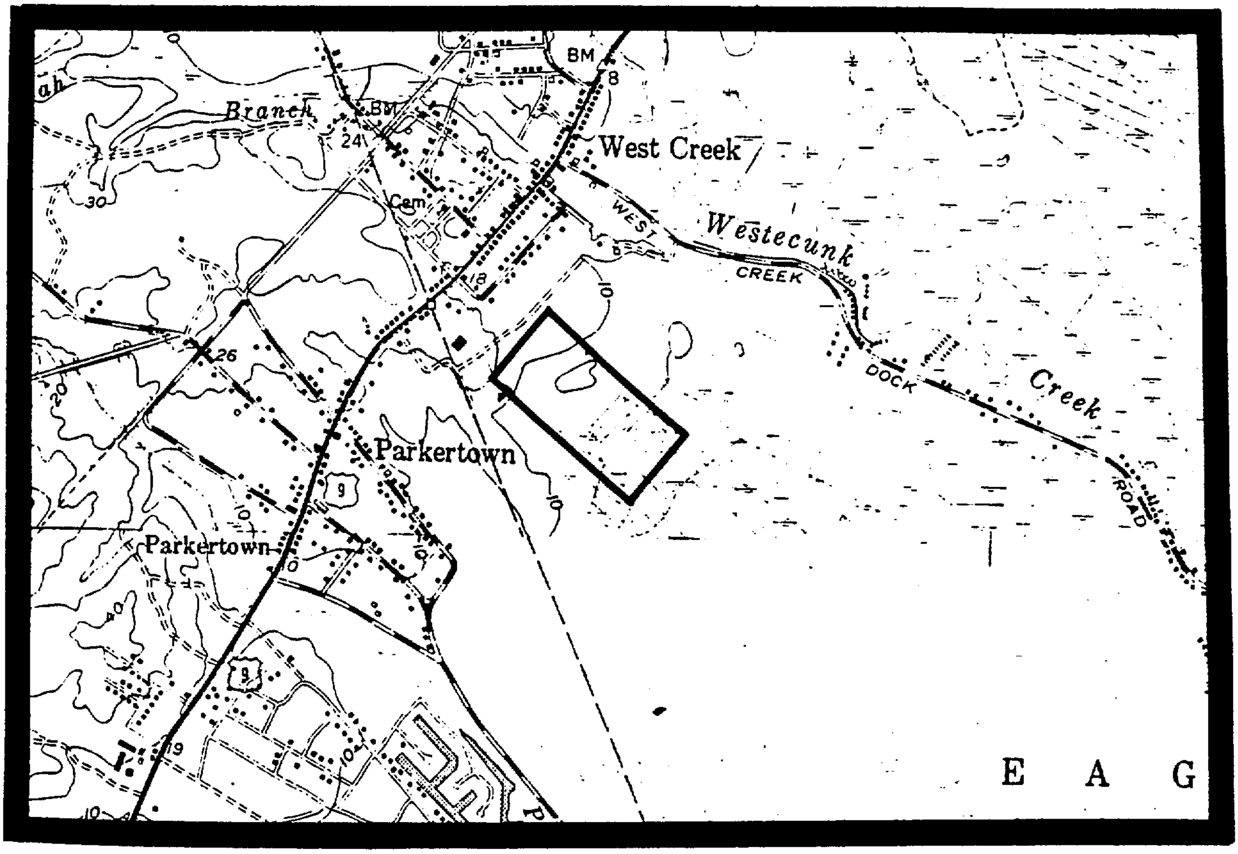
MAP A: Sheet # 56, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton & West Creek, N.J. Topographic Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton & West Creek, N.J. Quadrangles (Scale 1:24,000)

MAP A

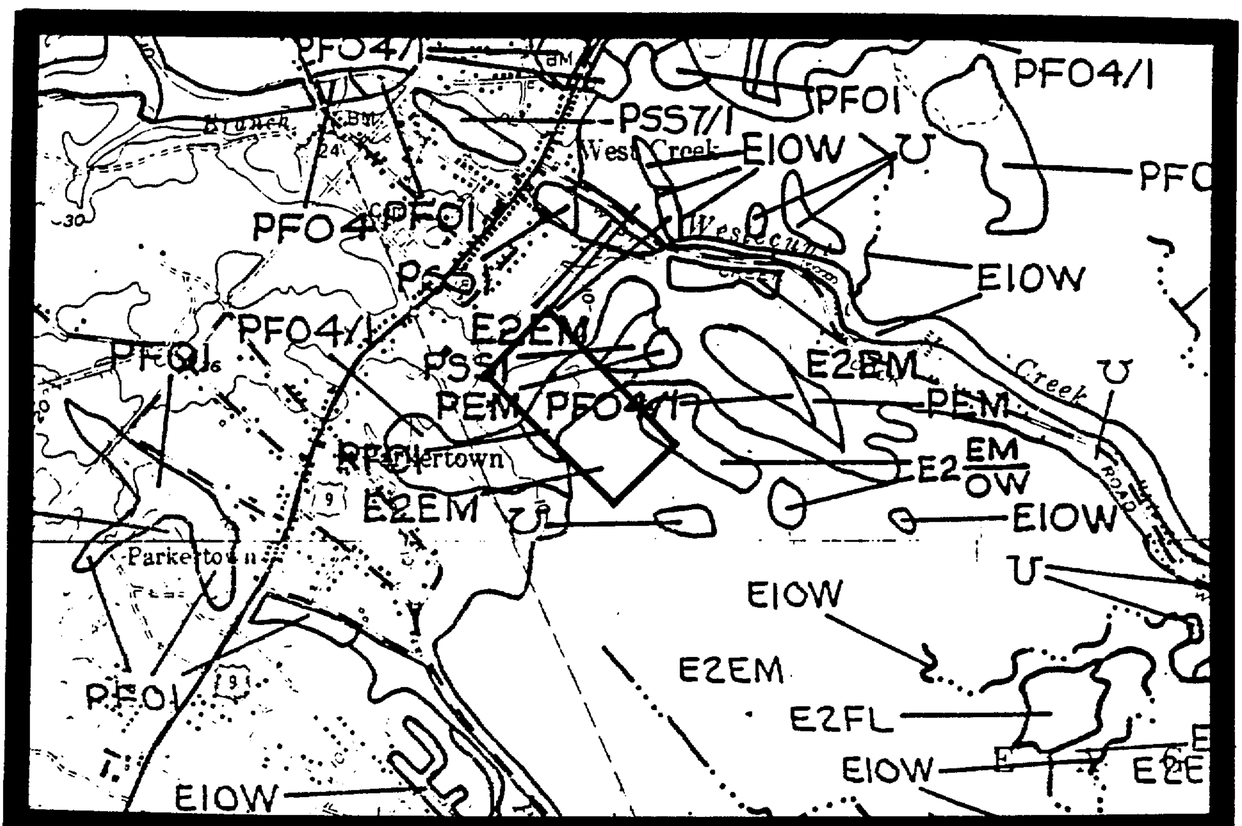




Branch
BM
24
West Creek
Cem
Westecunk
WEST
CREEK
DOCK
ROAD
Creek
Parkertown
Parkertown
9
E A G

MAP B

MAP C



PF04/1
PF01
PF04/1
PSS7/1
West Creek
E1OW
PF0
PF04
PF01
E1OW
PF04/1
E2EM
PF01
E2EM
PEM
PF04/1
PEM
Parkertown
E2 EM/OW
E2EM
E1OW
Parkertown
E1OW
E2EM
PF01
E2FL
E1OW
E1OW
Creek
ROAD

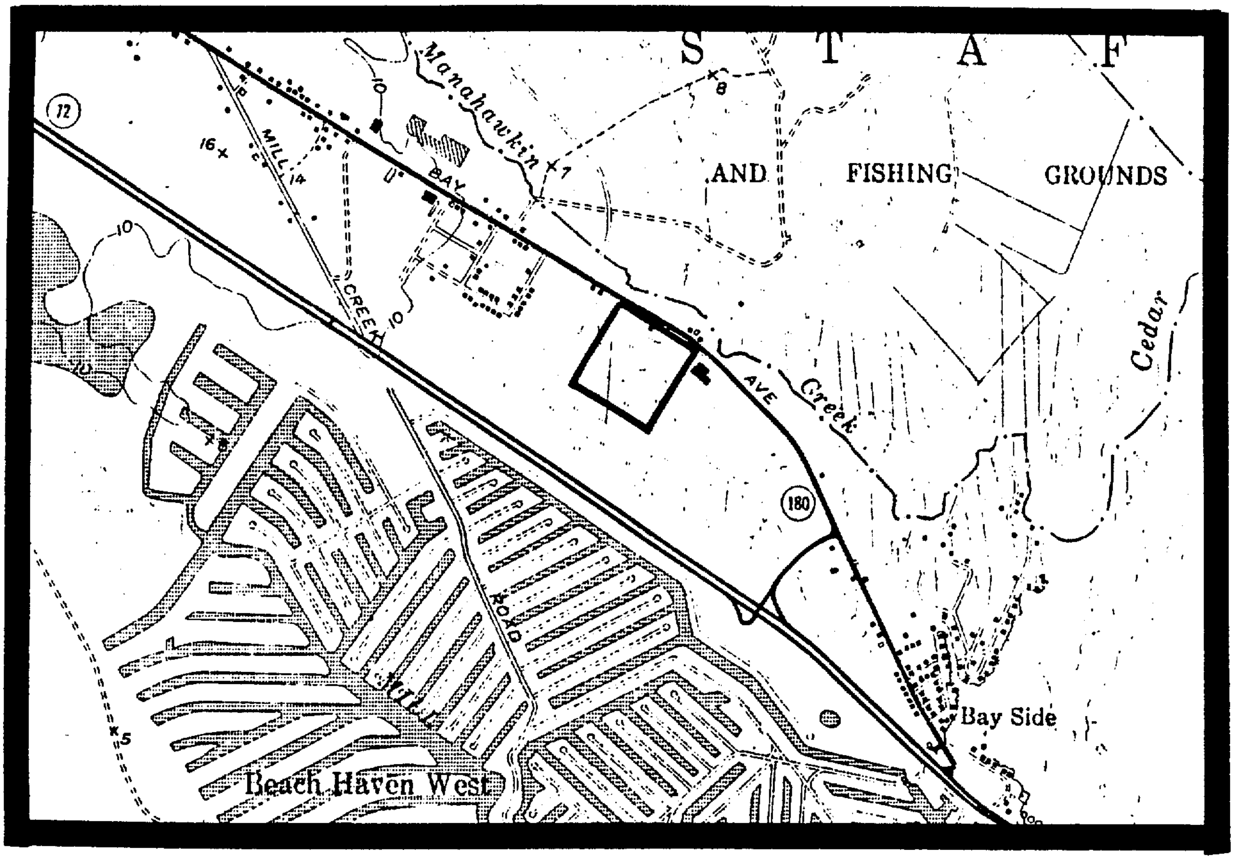
SITE 239 Szathmary Supply, Manahawkin, Ocean County.

MAP A: Sheet # 54, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Ship Bottom, N.J. Topographic Quadrangle (Scale 1:24,000)

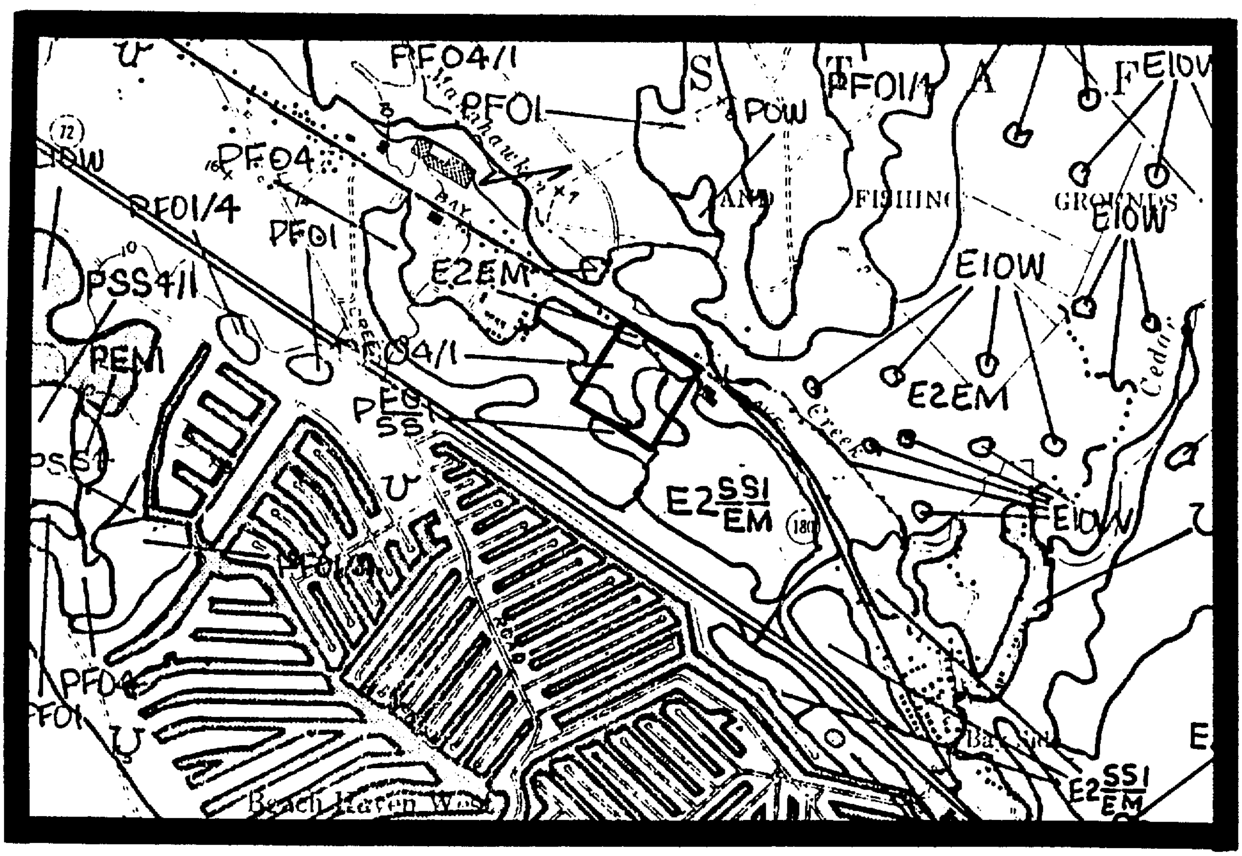
MAP C: U.S.F.W.S. National Wetlands Inventory, Ship Bottom, N.J. Quadrangle (Scale 1:24,000)

MAP A


S T A F
AND FISHING GROUNDS
Manahawkin
Cedar
Creek
BAY
MILL
CREEK
AVE
ROAD
Bay Side
Beach Haven West

MAP B

MAP C


PF04/1
PF01
PF01/1
POW
E1OW
PF04
PF01/4
PF01
E2EM
PSS4/1
PEM
PF04/1
E2EM
E2 SSI/EM
PF01/3
PF04
E2 SSI/EM
Beach Haven West

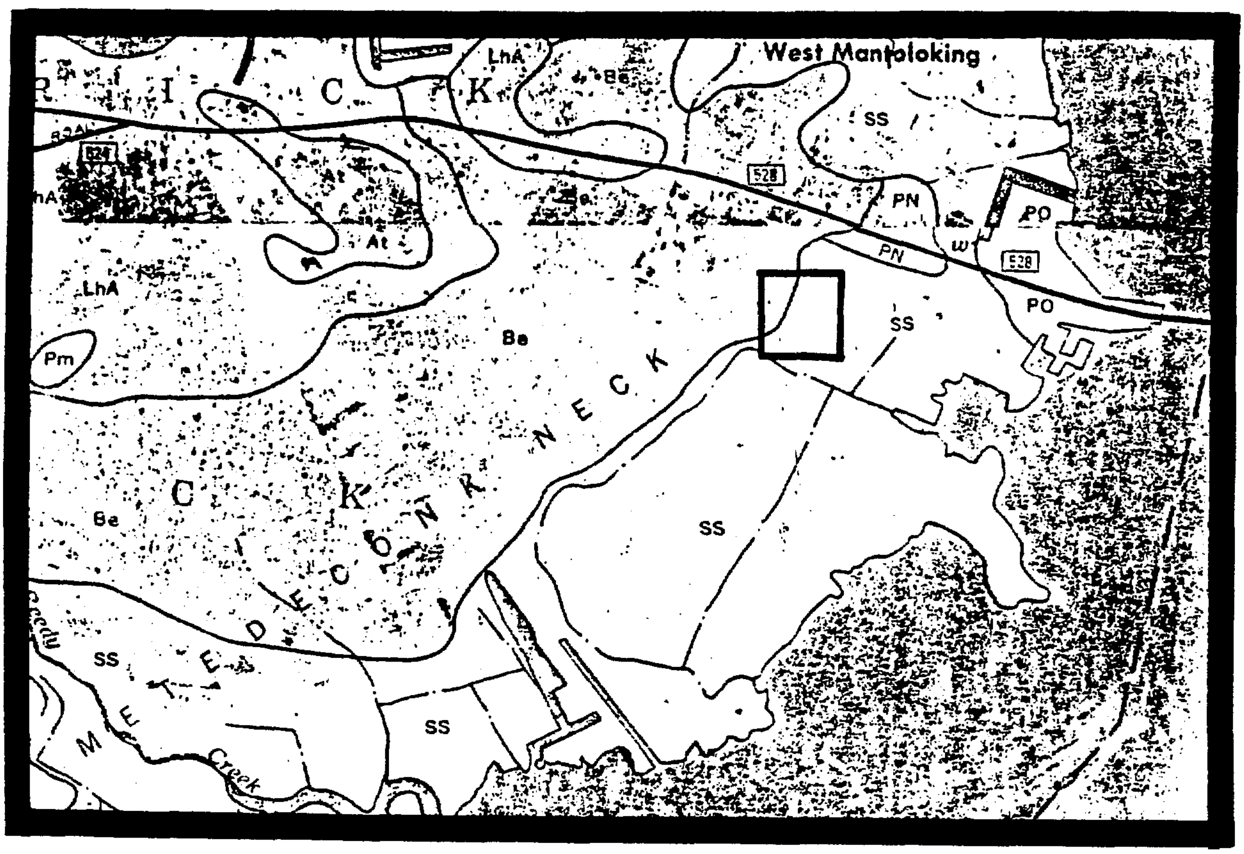
SITE 240 Gale Rd., Brick Twp., Ocean County.

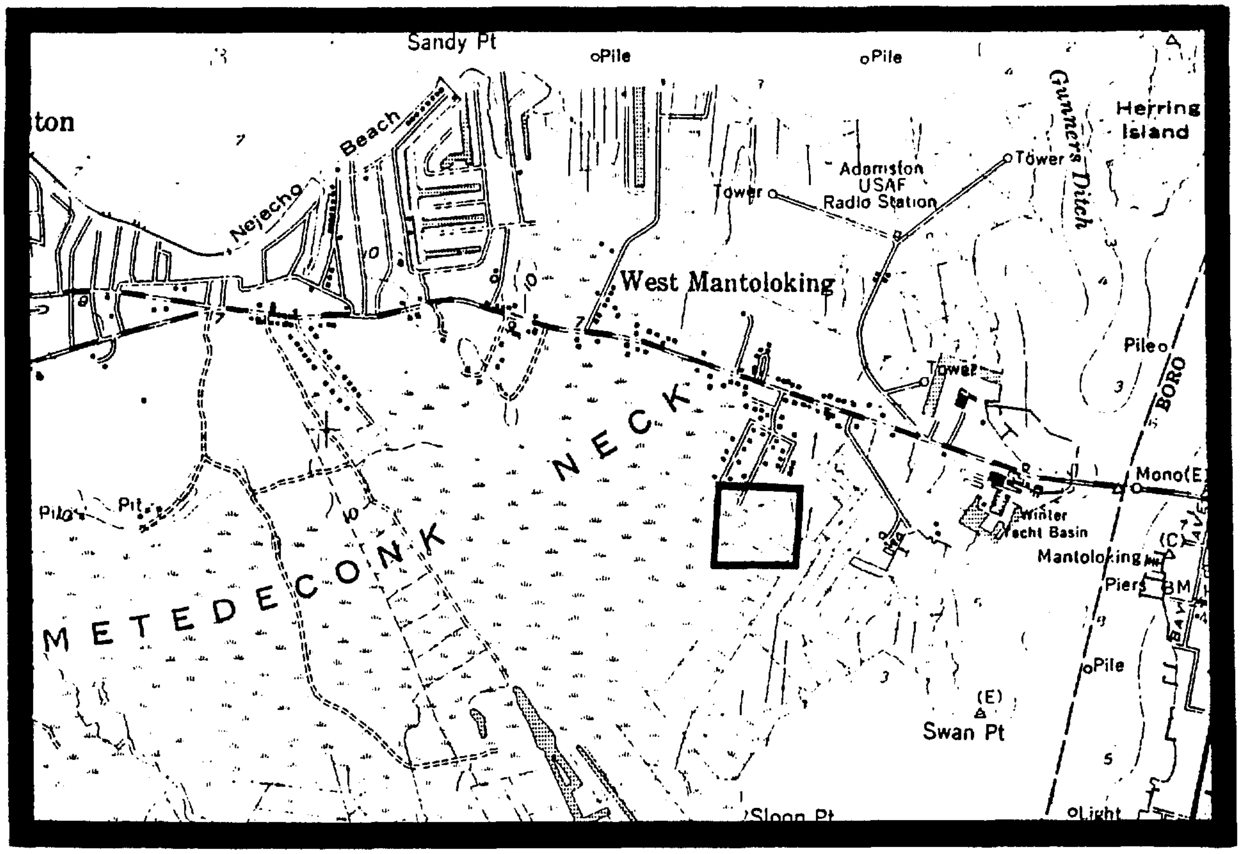
MAP A: Sheets # 15 & 21, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Point Pleasant, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Point Pleasant, N.J. Quadrangle (Scale 1:24,000)

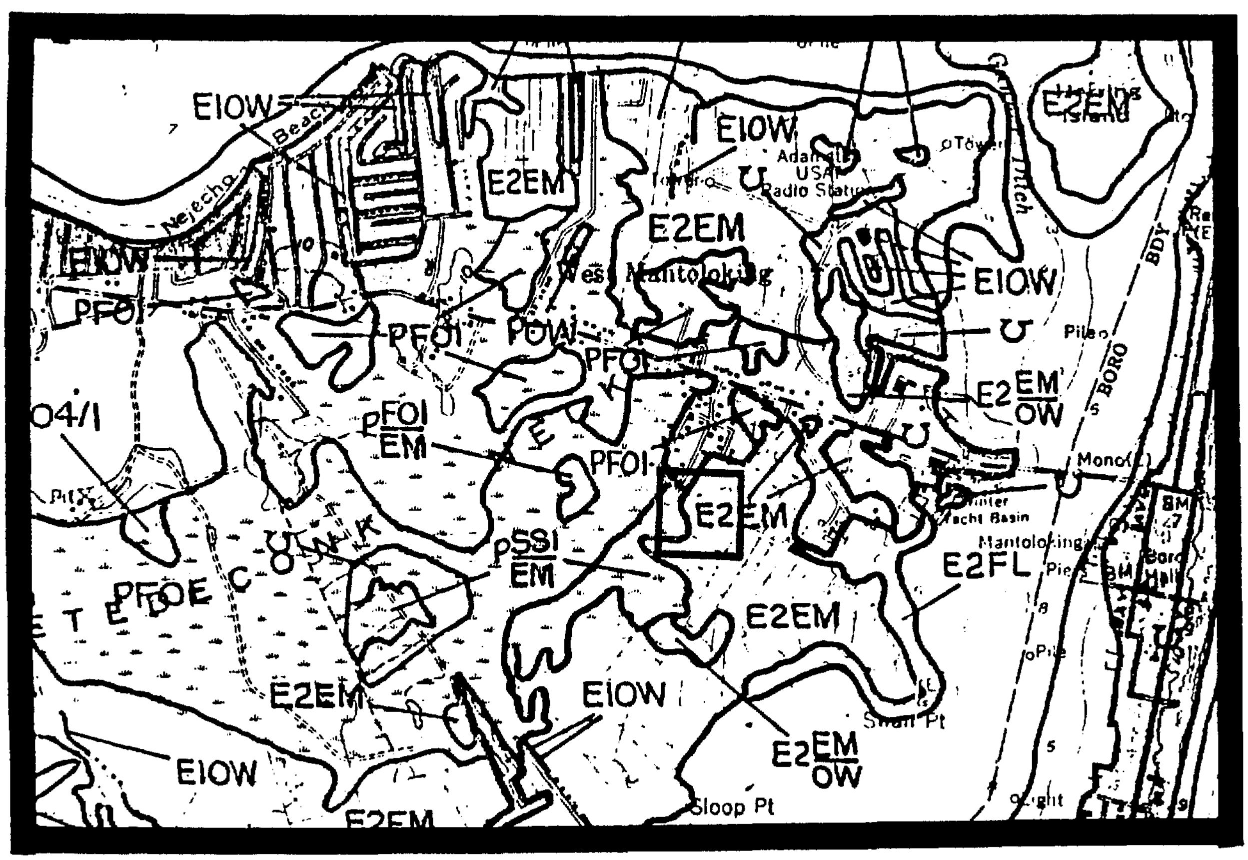
MAP A




Sandy Pt
Pile
Pile
Herring Island
Nejecho Beach
Adamston USAF Radio Station
Tower
Tower
Gunners Ditch
West Mantoloking
Pile
METEDECONK NECK
Mono(E)
Winter Yacht Basin
Mantoloking
Piers
BM
Pile
Swan Pt
Sloop Pt
Light
BORO

MAP B

MAP C


E1OW
E2EM
E1OW
E2EM
E2EM
E1OW
West Mantoloking
PFO1
PFO1
POW
PFO1
E1OW
E2 EM/OW
PFO1/EM
PFO1
E2EM
PSS1/EM
E2FL
E2EM
E2EM
E1OW
E2 EM/OW
E1OW
Sloop Pt
Swan Pt

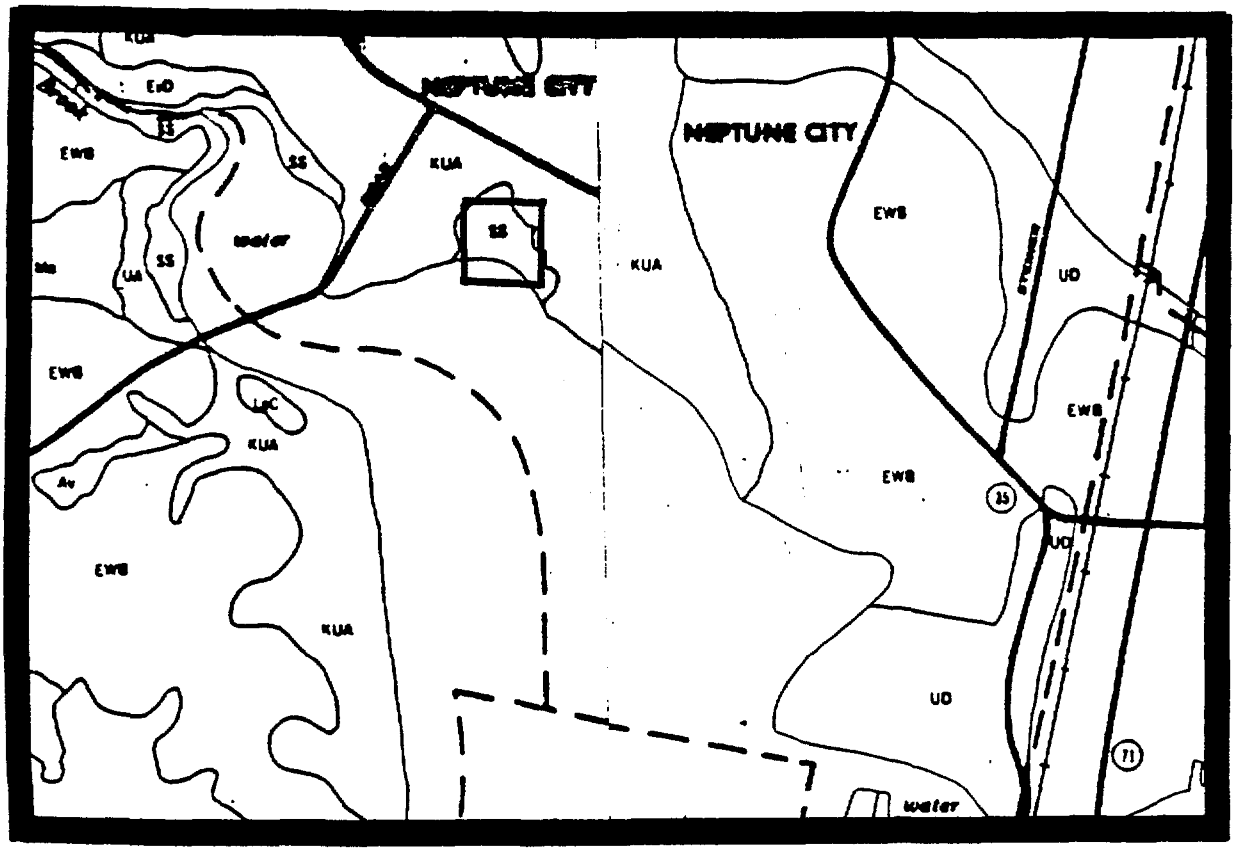
SITE 242 Neptune Ave., Neptune, Monmouth County.

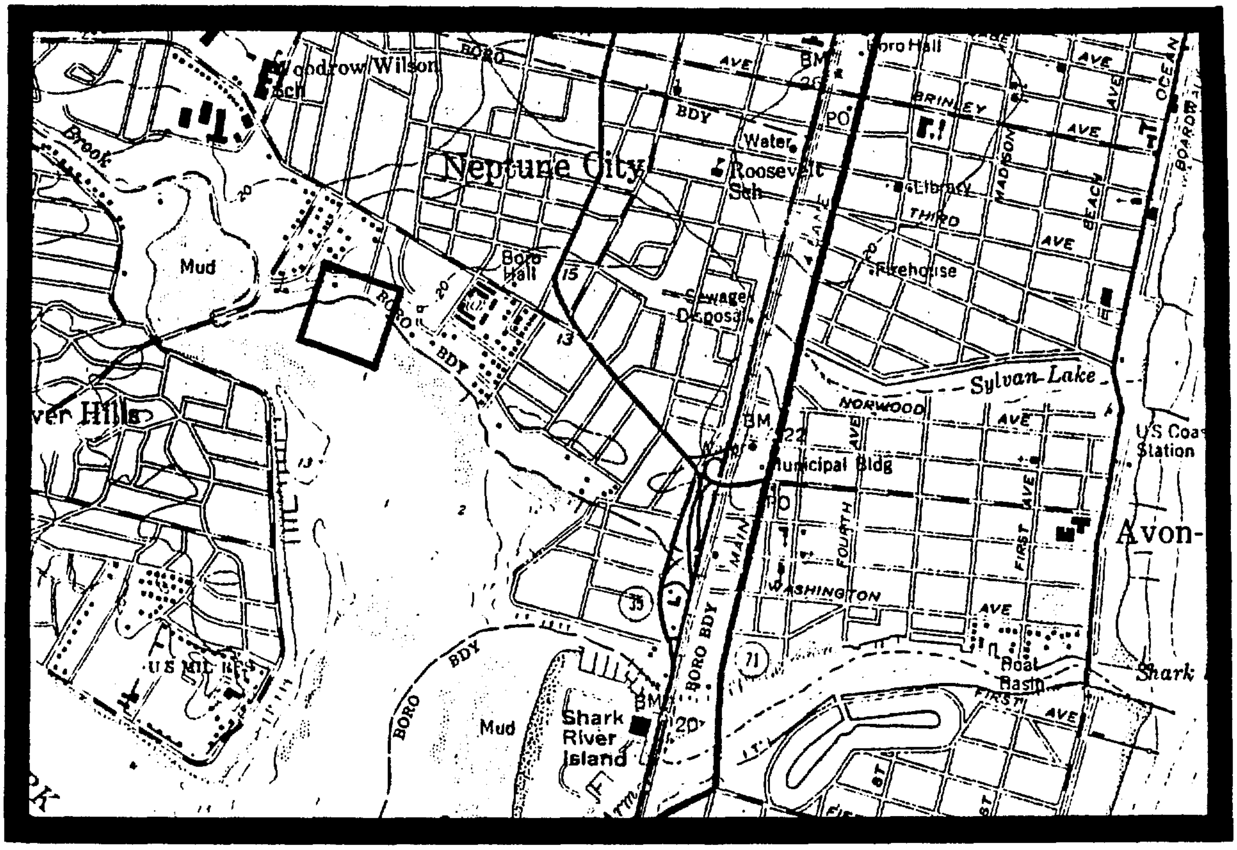
MAP A: Sheets # 38 & 45, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

MAP A

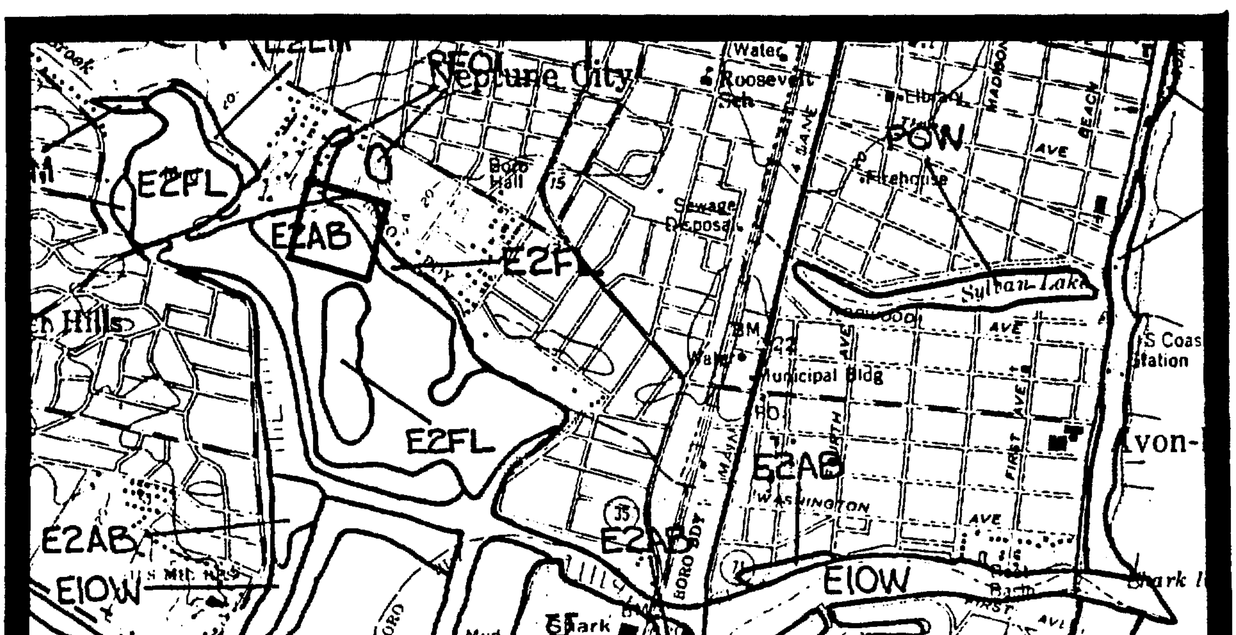




Woodrow Wilson Sch
BORO
BDY
Neptune City
Water
Roosevelt Sch
Boro Hall
BRINLEY
AVE
Library
THIRD
Firehouse
Sewage Disposal
Mud
Sylvan Lake
NORWOOD
Municipal Bldg
FOURTH
FIRST
WASHINGTON
MAIN
BORO BDY
MADISON
BEACH
OCEAN
Avon-
Boat Basin
Shark
Shark River Island
Mud

MAP B

MAP C



Neptune City
Water
Roosevelt Sch
Boro Hall
Sewage Disposal
Firehouse
POW
Sylvan Lake
E2FL
E2AB
E2F
E2FL
Municipal Bldg
Avon-
E2AB
E1OW
E1OW
E2AB
E2AB
E2FL
Mud
Shark River Island
South Arm
RIVER
Silver Lake

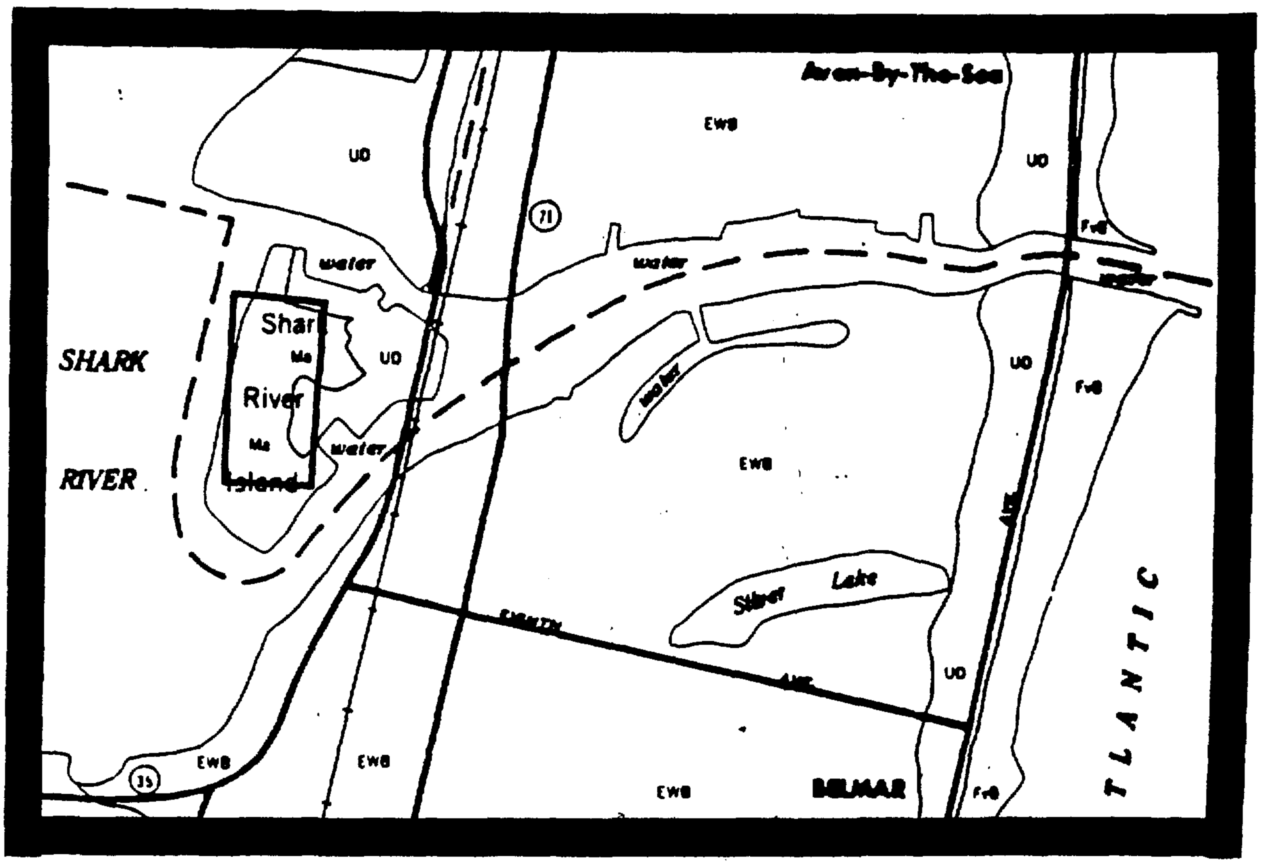
SITE 243 Seaview Condominiums, Neptune, Monmouth County.

MAP A: Sheet # 38, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

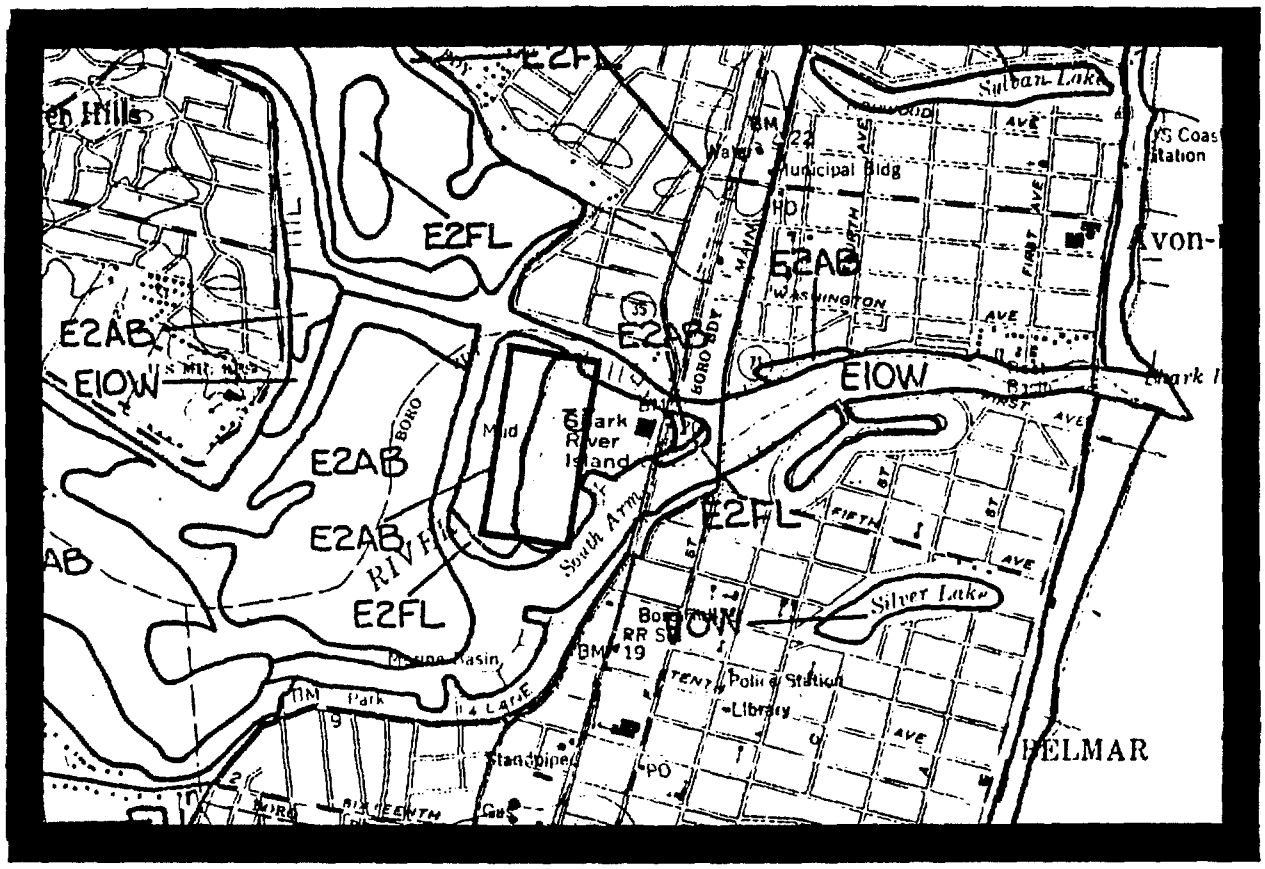
MAP A




Sylvan Lake
NORWOOD
AVE
US Coast Station
Municipal Bldg
Avon-
WASHINGTON
AVE
Boat Basin
Shark
FIRST
Mud
Shark River Island
BORO BDY
RIVER
South Arm
FIFTH
Silver Lake
Boro Hall
RR Sta
Marine Basin
Police Station
Library
Park
Standpipe
PO
BELMAR
SIXTEENTH

MAP B

MAP C


E2FL
Sylvan Lake
Municipal Bldg
E2FL
E2AB
Avon-
E2AB
E2AB
E1OW
E1OW
Shark
Shark River Island
E2AB
E2AB
E2FL
South Arm
E2FL
E1OW
Silver Lake
AB
Police Station
Library
Standpipe
PO
BELMAR

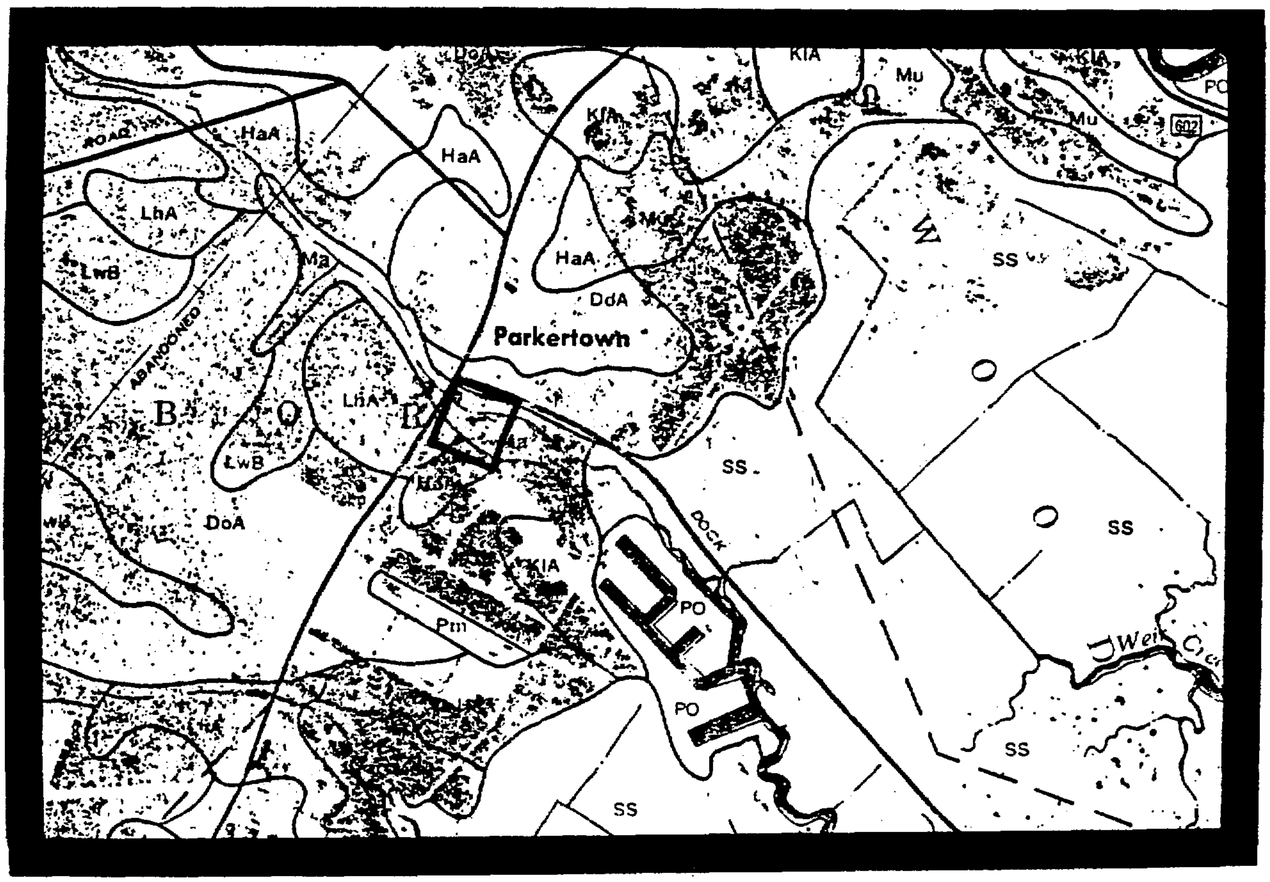
SITE 244 Brook St./Rt. 9, Parkertown, Ocean County.

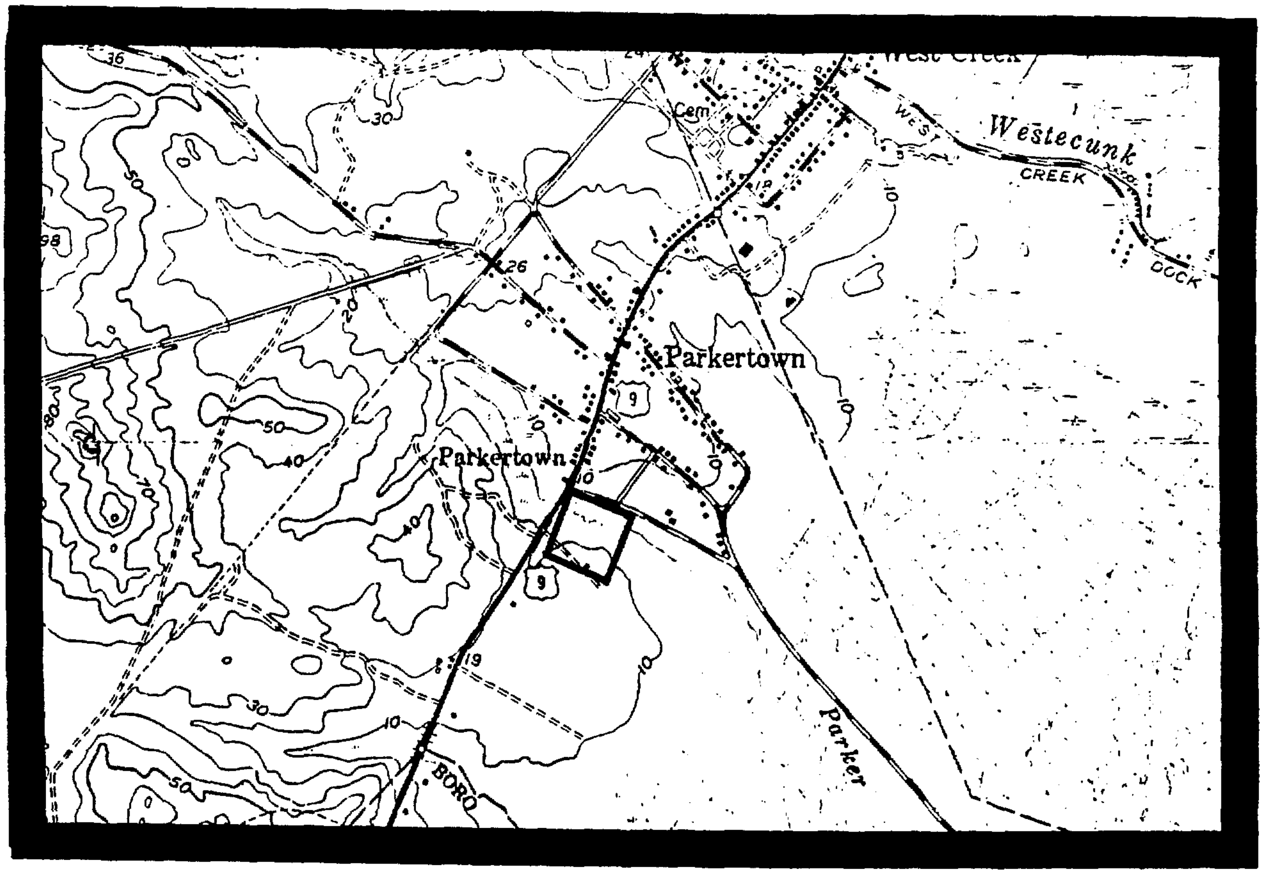
MAP A: Sheet # 56, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton & West Creek N.J. Topographic Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton & West Creek, N.J. Quadrangles (Scale 1:24,000)

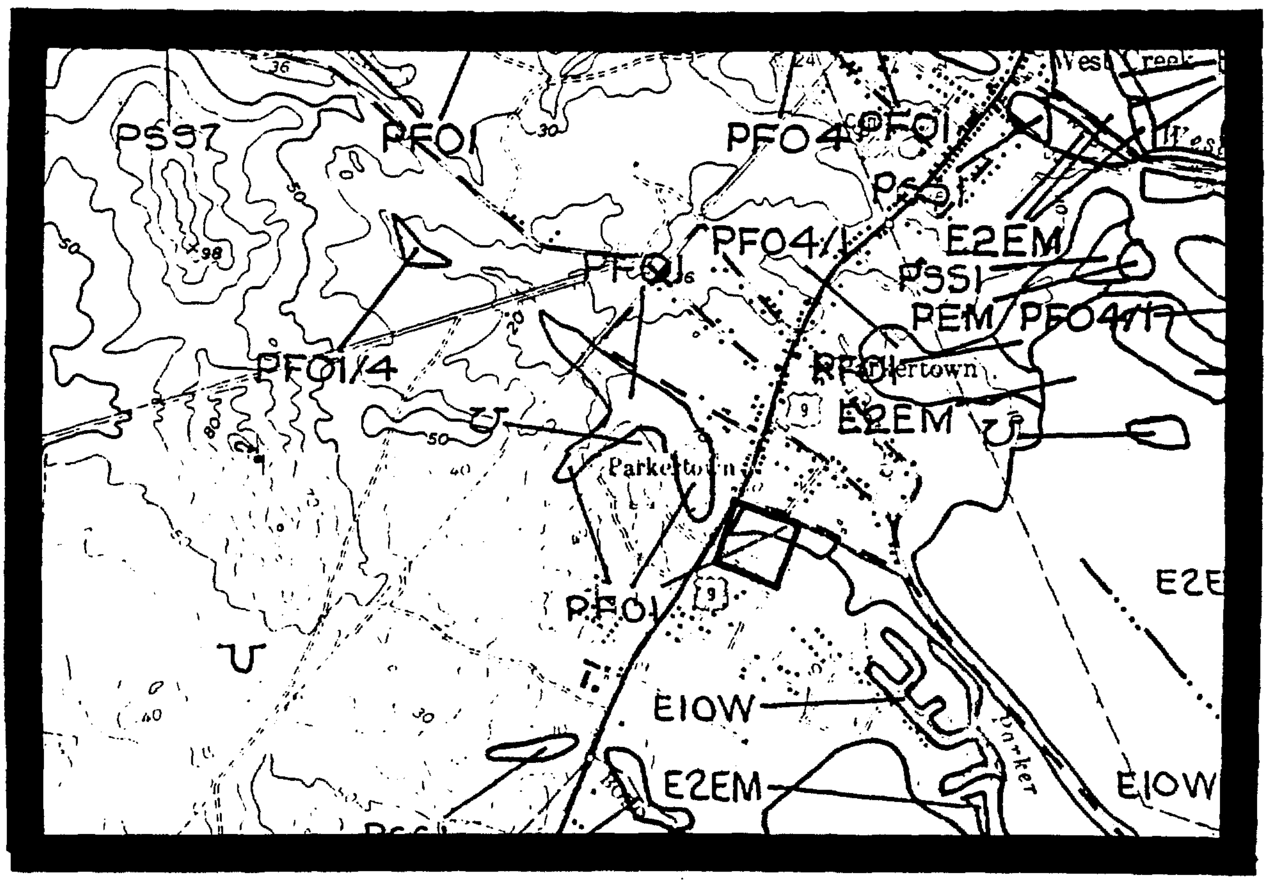
MAP A




West Creek
Westecunk
WEST
CREEK
DOCK
Cem
Parkertown
Parkertown
Parker
BORO
36
30
50
98
26
20
10
80
70
40
19
9

MAP B

MAP C


PSS7
PFO1
PFO4
PFO1
PFO4/1
E2EM
PSS1
PEM
PFO4/1
PFO1/4
PFO1
Parkertown
E2EM
Parkertown
PFO1
E1OW
E2EM
E1OW
E2E
Parker
36
30
50
98
80
40
9

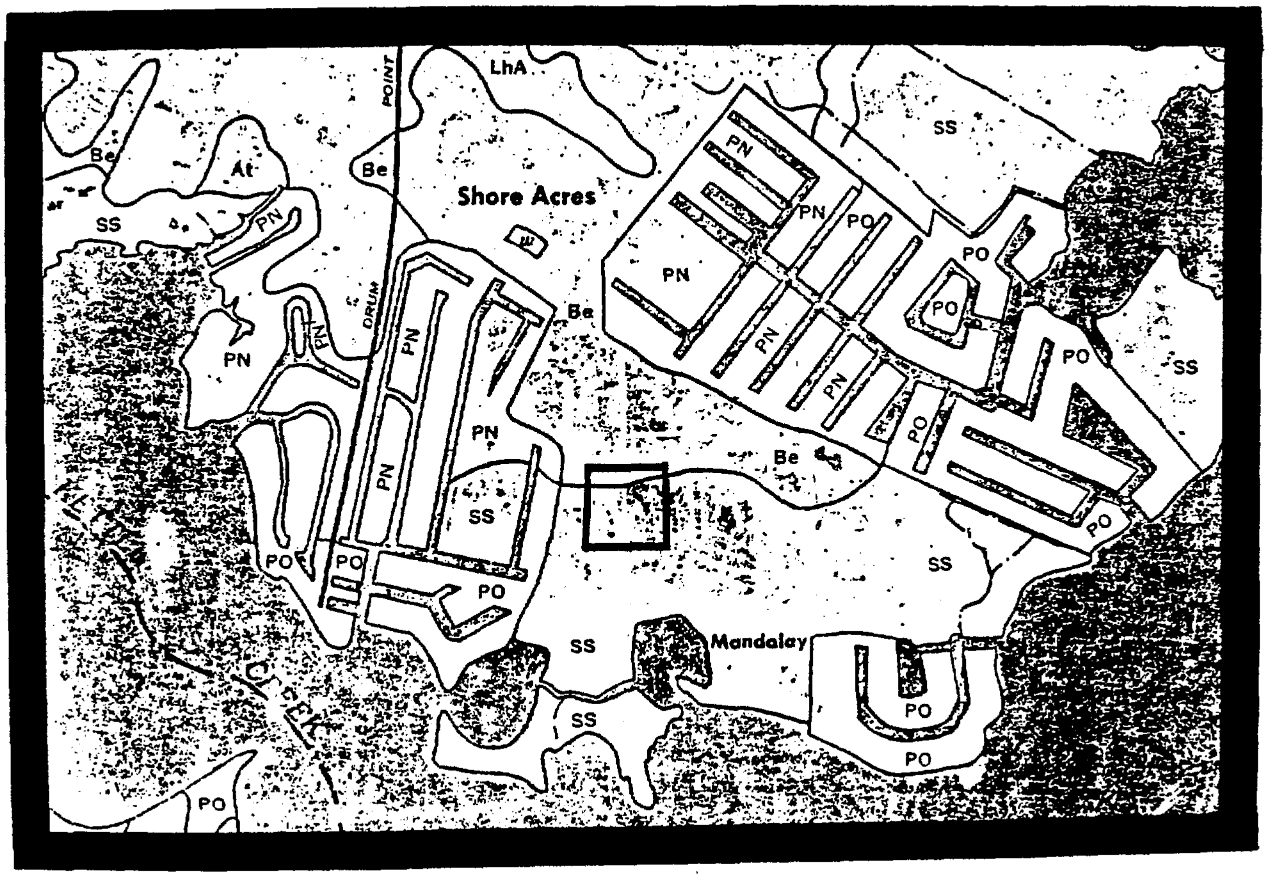
SITE 245 Mandalay Rd./Pinecrest Dr., Mantoloking Pt., Ocean County.

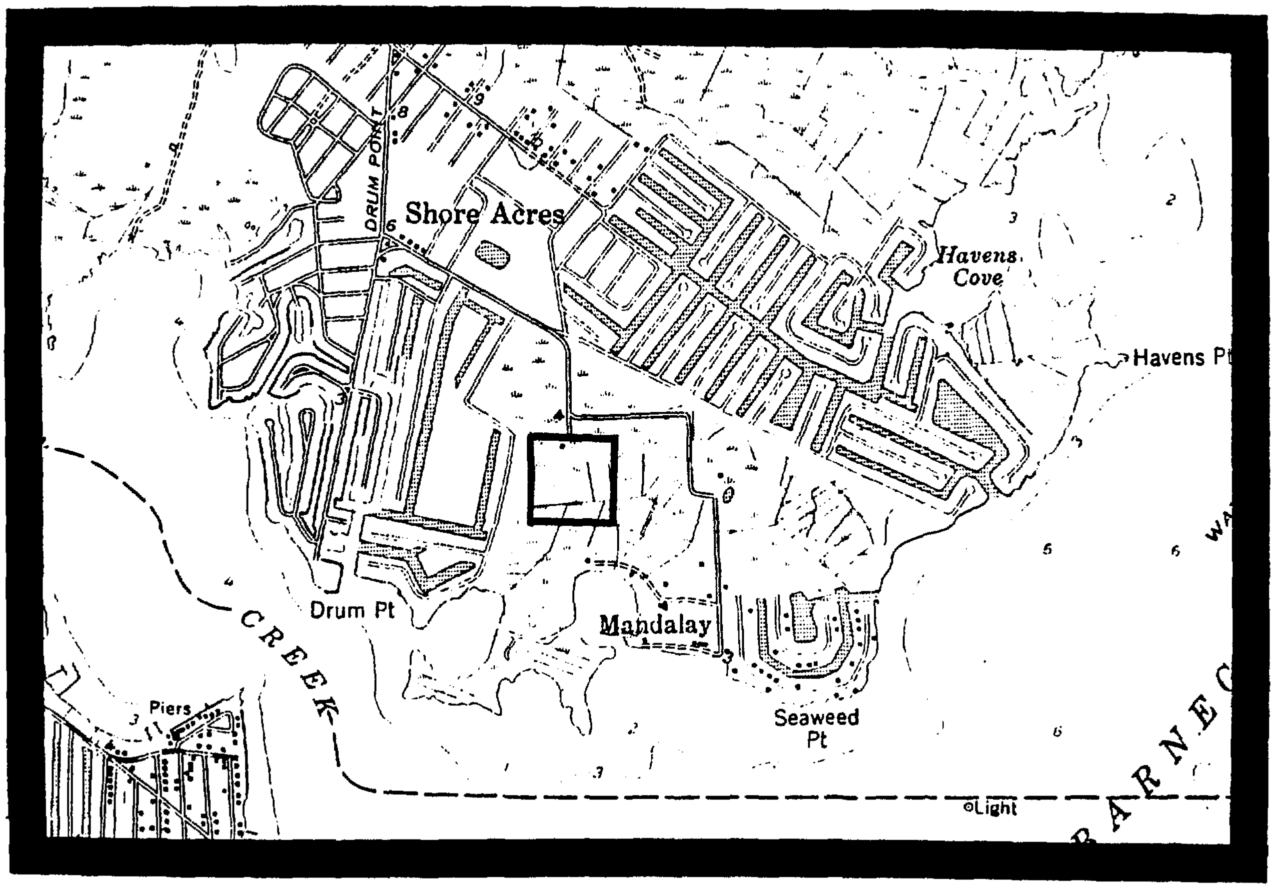
MAP A: Sheet # 21, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Point Pleasant N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Point Pleasant, N.J. Quadrangle (Scale 1:24,000)

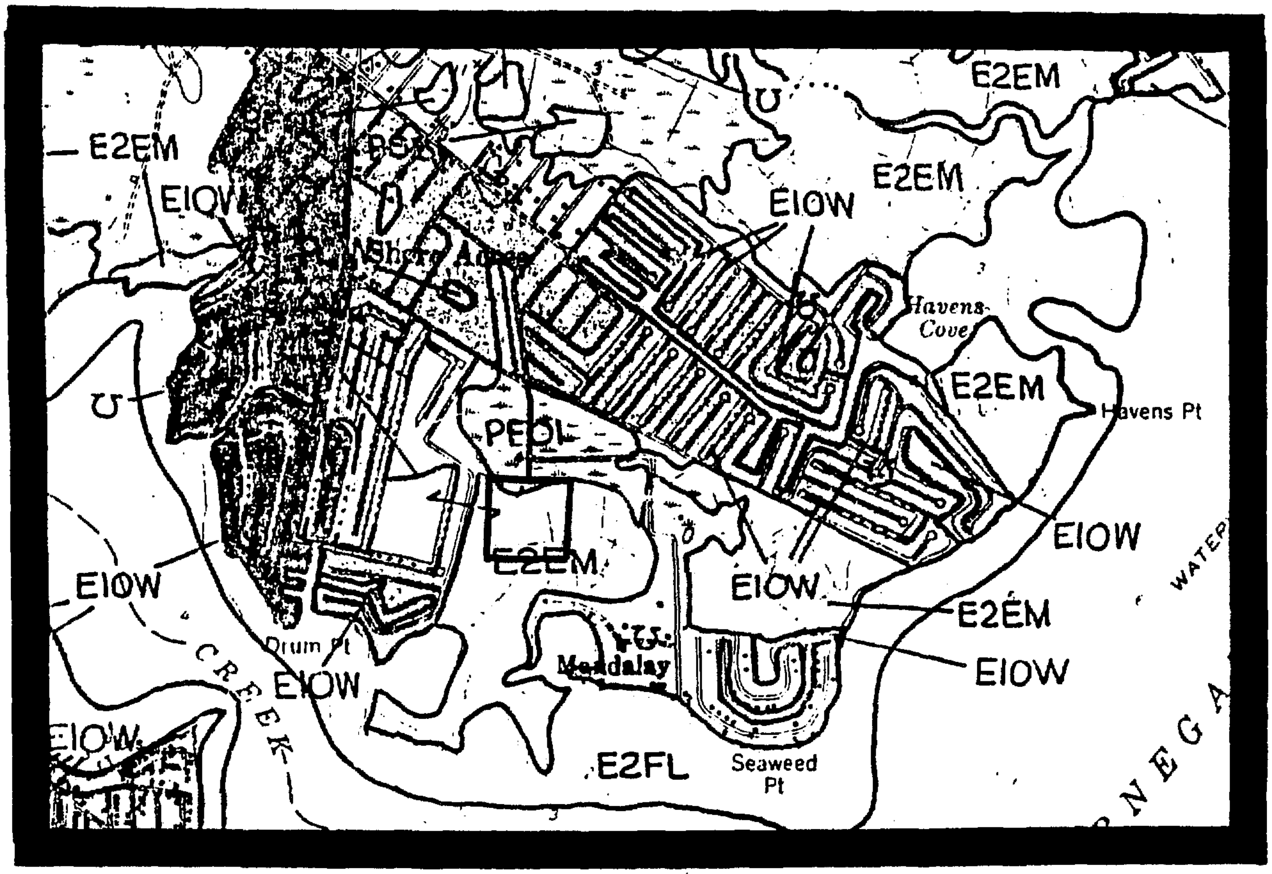
MAP A




Shore Acres
DRUM POINT
Havens Cove
Havens Pt
Drum Pt
Mandalay
CREEK
Piers
Seaweed Pt
Light
BARNEG

MAP B

MAP C


E2EM
E1OW
U
PEOL
Havens Cove
Havens Pt
E2FL
Seaweed Pt
Drum Pt
Mandalay
CREEK
WATER
NEGA

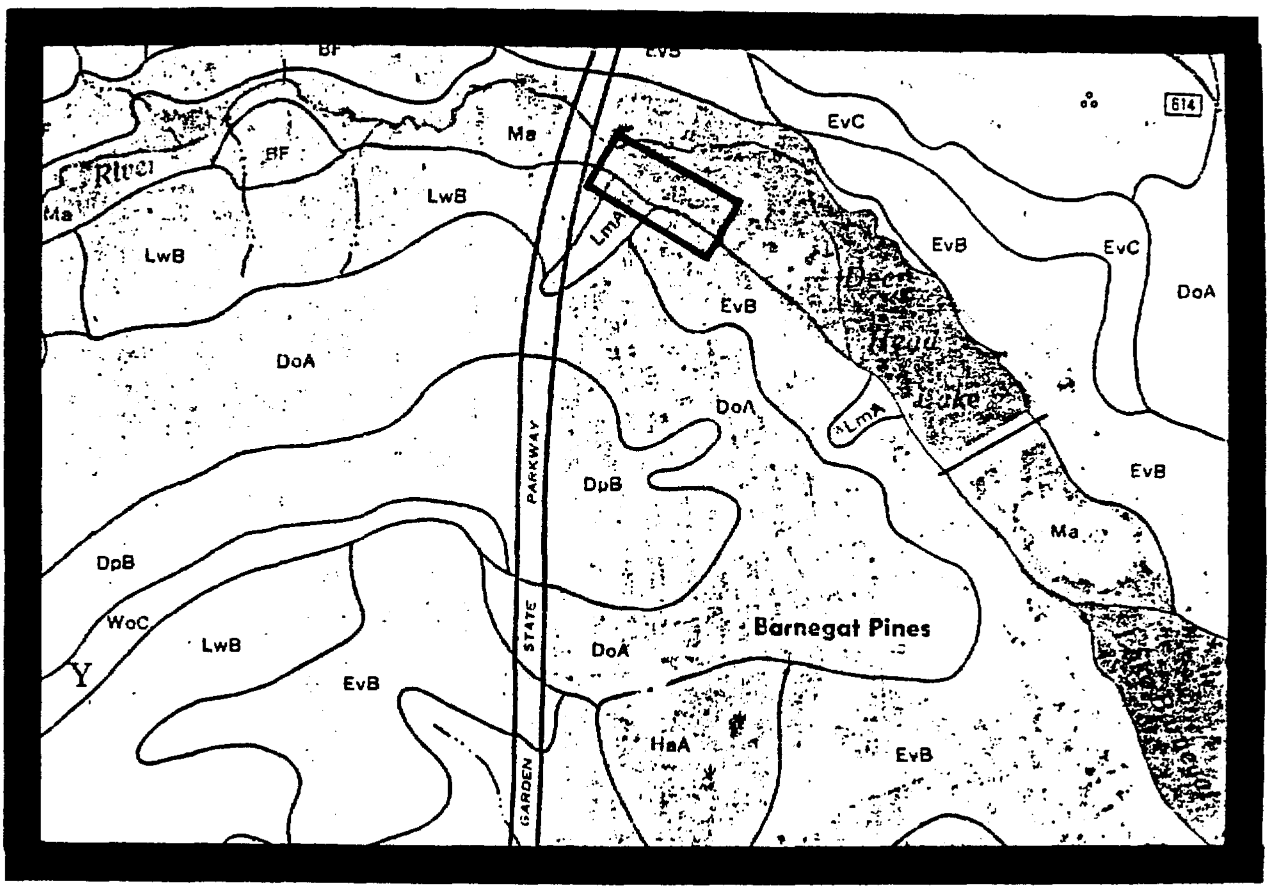
SITE 246 Pheasent Run, Forked River, Ocean County.

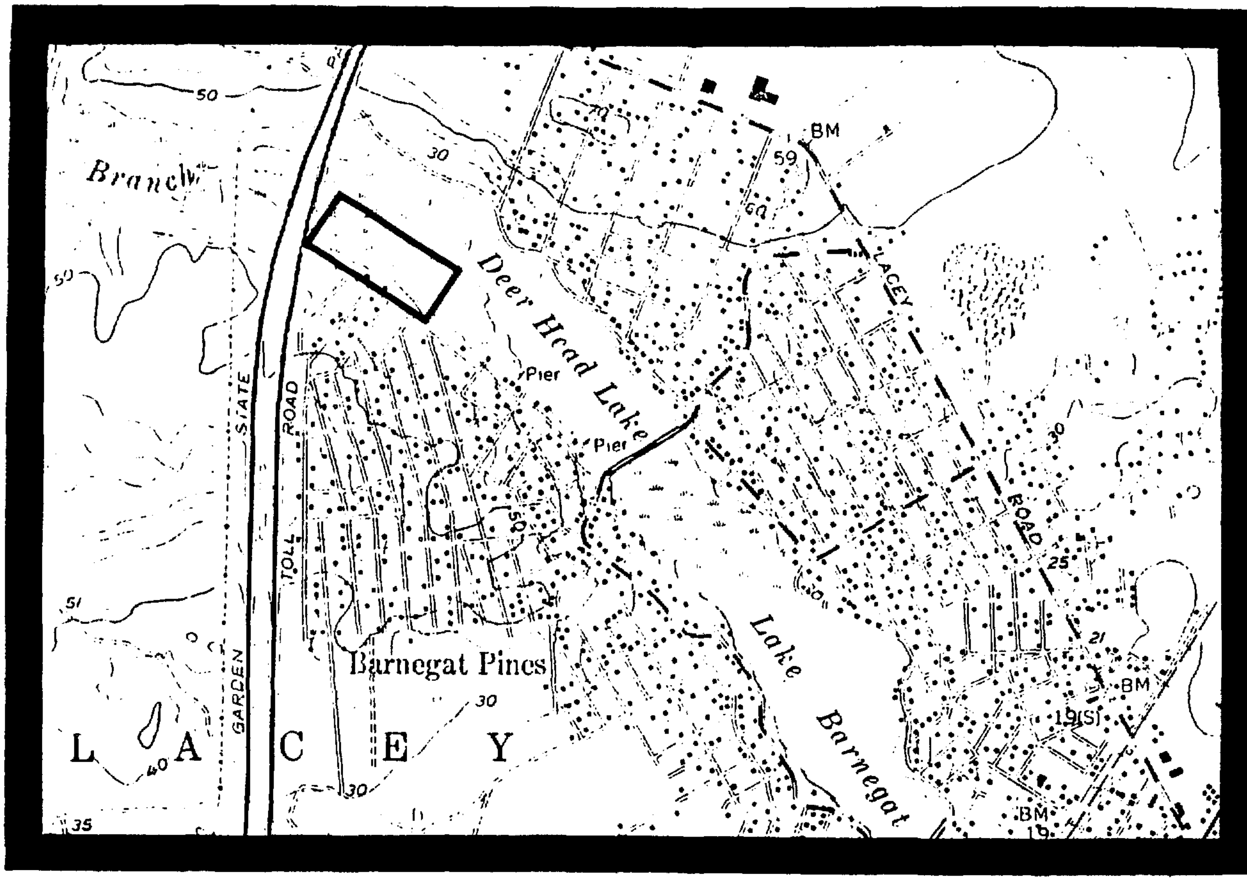
MAP A: Sheet # 39, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Forked River N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked
River, N.J. Quadrangle (Scale 1:24,000)

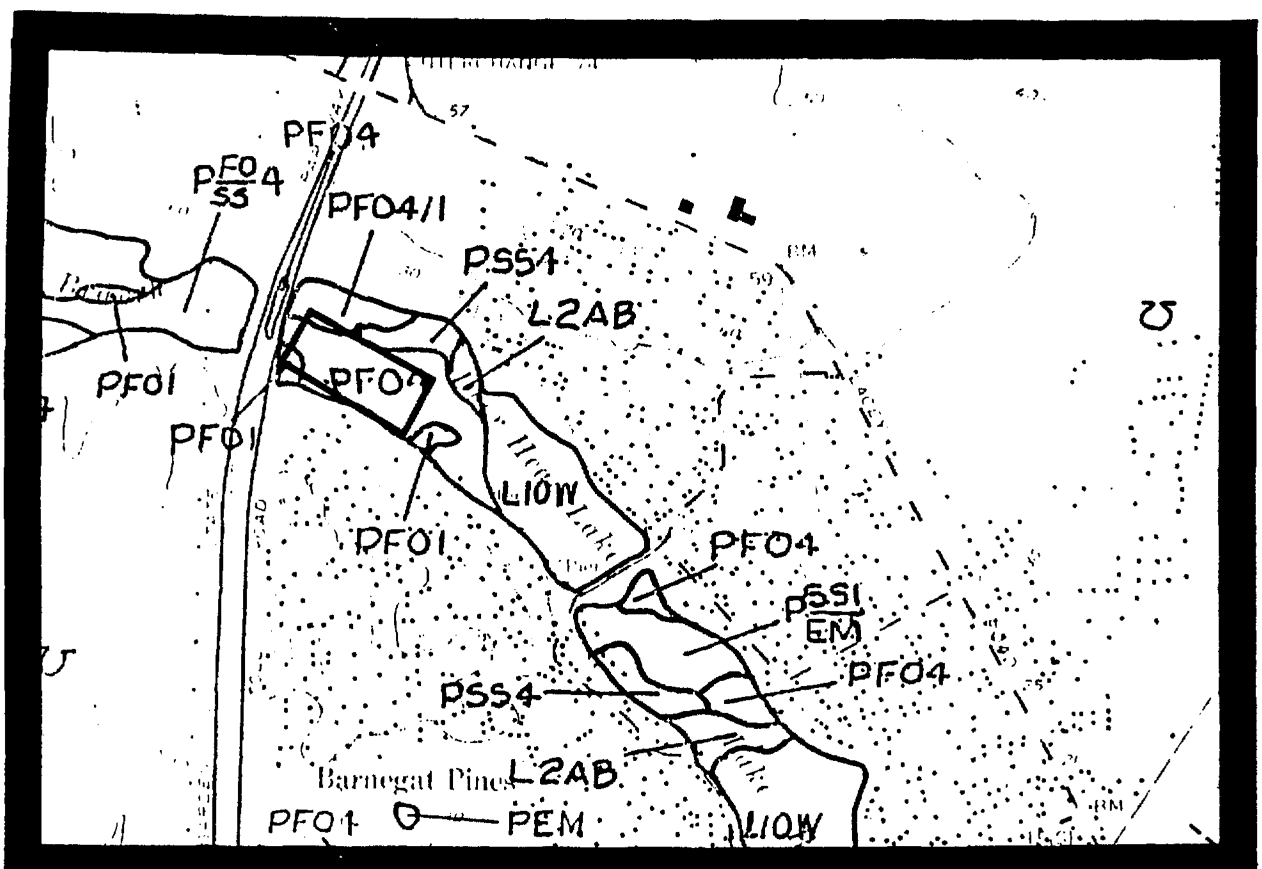
MAP A




Branch
Deer Head Lake
Pier
Pier
STATE
GARDEN
ROAD
TOLL
LACEY
ROAD
Barnegat Pines
L A C E Y
Lake Barnegat
BM
50
30
51
40
35
25
21
19(S)

MAP B

MAP C


PFO4
P FO/SS 4
PFO4/1
PSS4
L2AB
PFO1
PFO1
L1OW
PFO1
PFO4
P SS1/EM
PFO4
PSS4
L2AB
Barnegat Pines
PFO1
PEM
L1OW

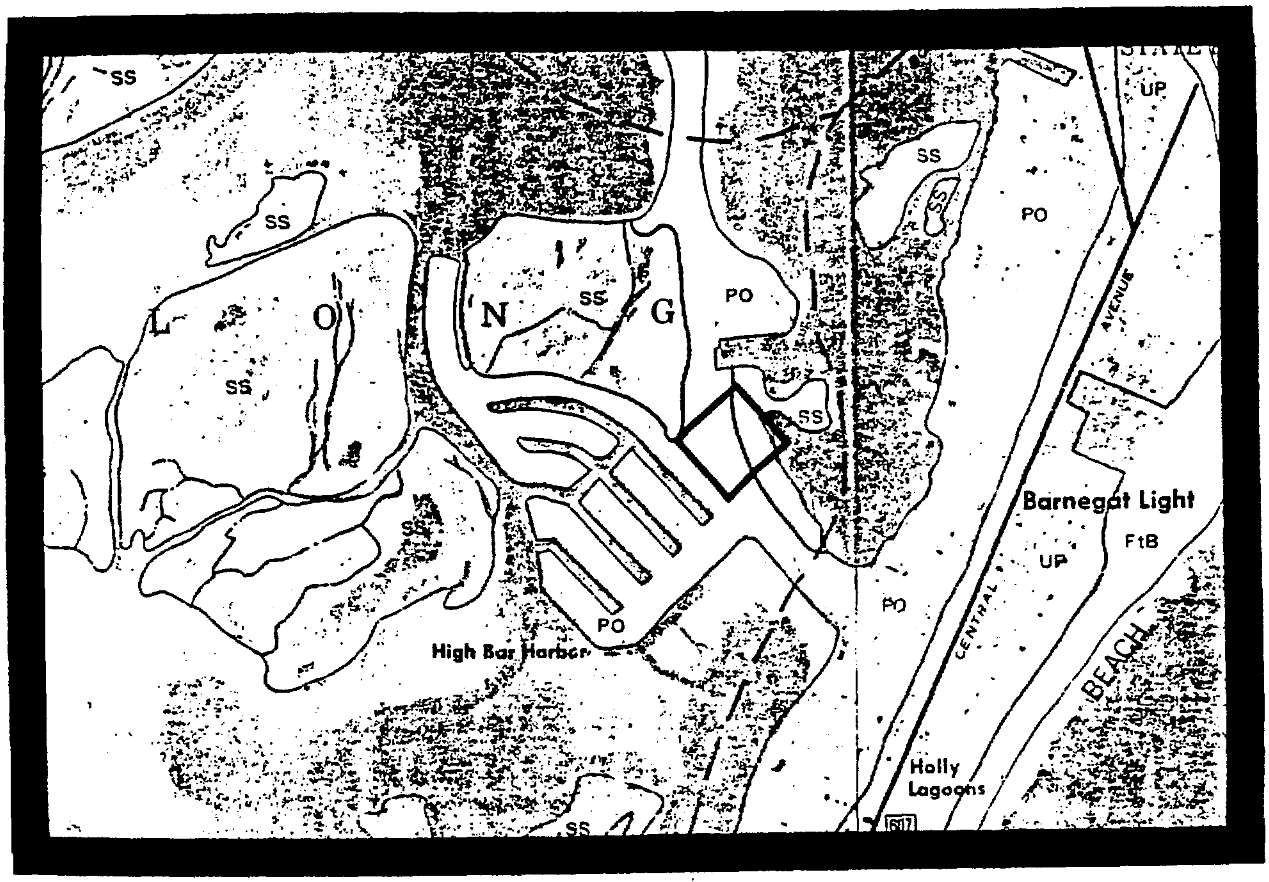
SITE 247 Victoria Point, Bar Harbor, Ocean County.

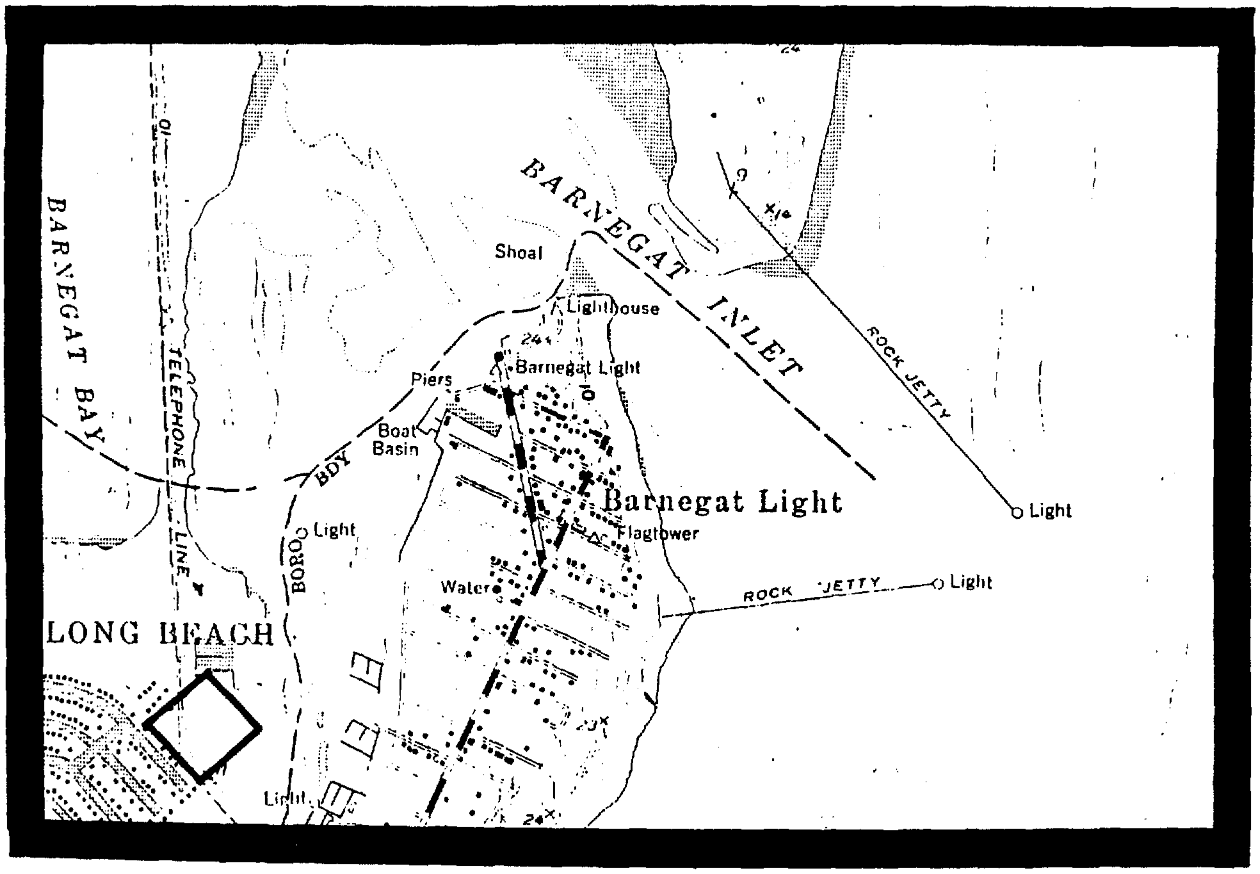
MAP A: Sheet# 48, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Barnegat Light N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Barnegat
Light, N.J. Quadrangle (Scale 1:24,000)

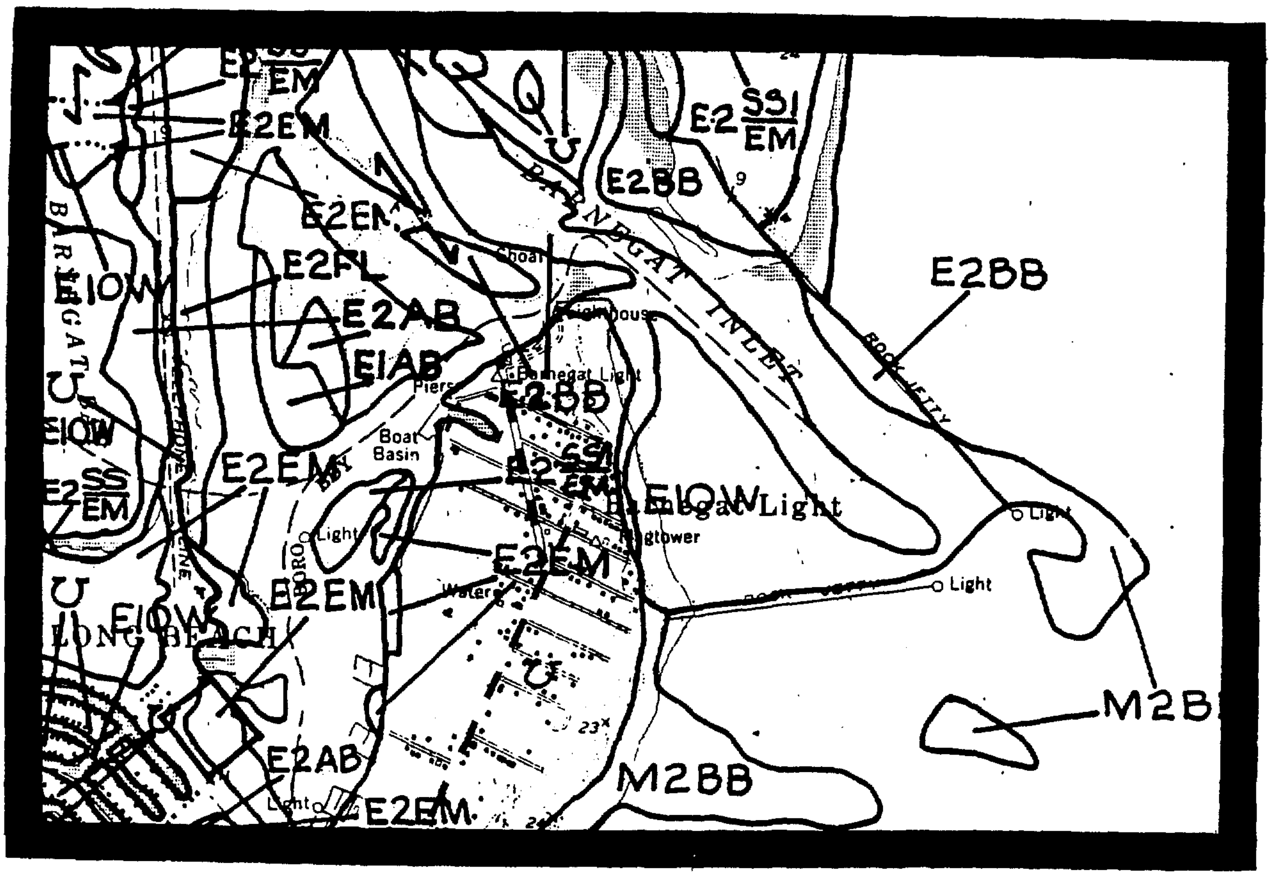
MAP A




BARNEGAT INLET
Shoal
Lighthouse
Barnegat Light
Piers
Boat Basin
BDY
BORO
Light
Barnegat Light
Flagtower
Water
ROCK JETTY
Light
ROCK JETTY
Light
BARNEGAT BAY
TELEPHONE LINE
LONG BEACH

MAP B

MAP C


E2EM
E2 SS1/EM
E2BB
E2EM
E2FL
E2AB
E1AB
E1OW
E2BB
E2BB
E1OW
E2EM
E2 SS/EM
E2 SS1/EM
E1OW
E2EM
E2EM
E1OW
E2AB
E2EM
M2BB
M2B
BARNEGAT INLET
Light
Light

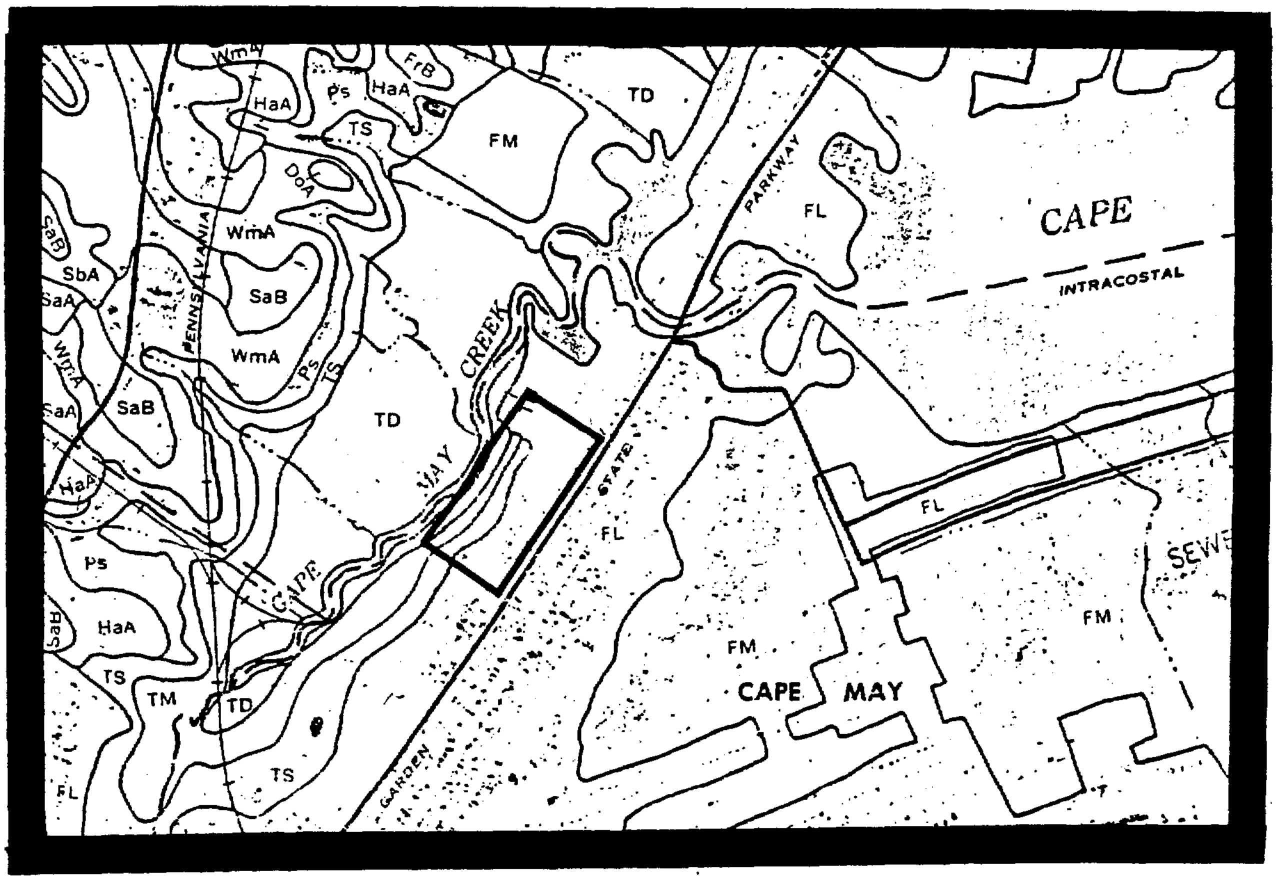
SITE 248 The Meadows, Cape May City, Cape May County.

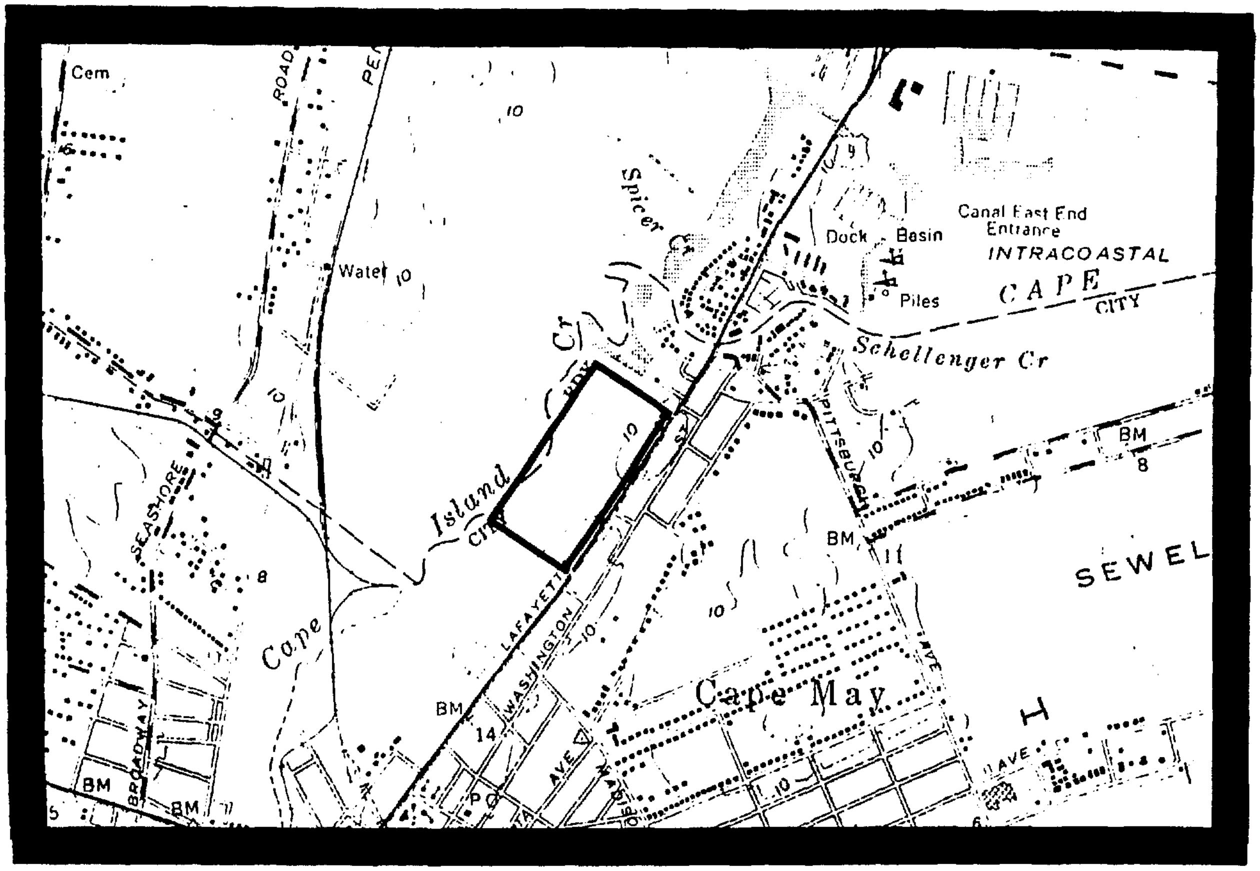
MAP A: Sheet # 29, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Cape May N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Cape May N.J. Quadrangle (Scale 1:24,000)

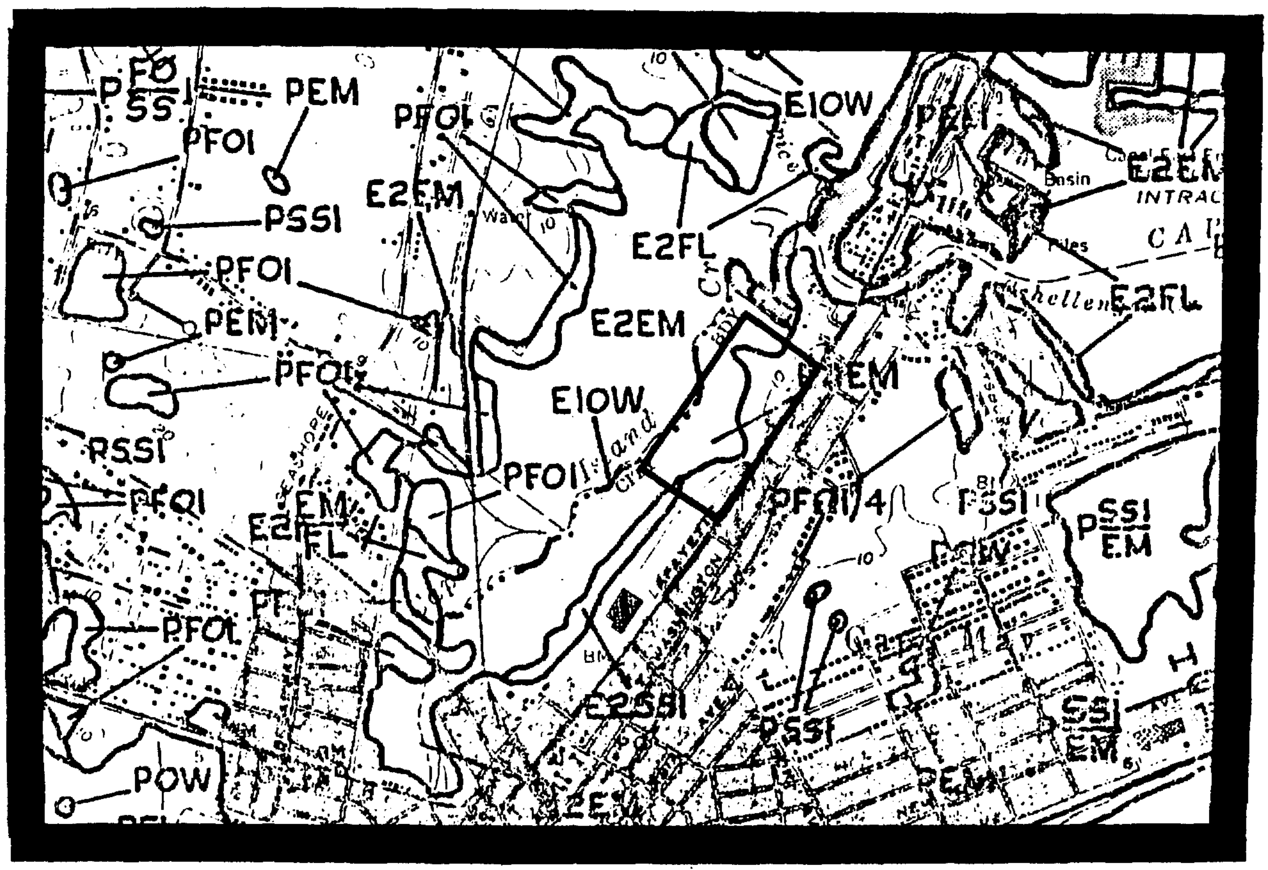
MAP A




Cem
ROAD
Water
Spicer Cr
Canal East End Entrance
Dock Basin
INTRACOASTAL
Piles
CAPE CITY
Schellenger Cr
Island Cr
SEASHORE
PITTSBURGH
BM
SEWEL
LAFAYETTE
WASHINGTON
Cape
Cape May
BROADWAY
AVE

MAP B

MAP C


PEM
PFO1
PSS1
E2EM
E1OW
E2FL
PFO1
PEM
E2FL
PSS1
PFO1
PSS1
PSS1
EM
SS1
EM
POW
E2SS1
Basin
Piles

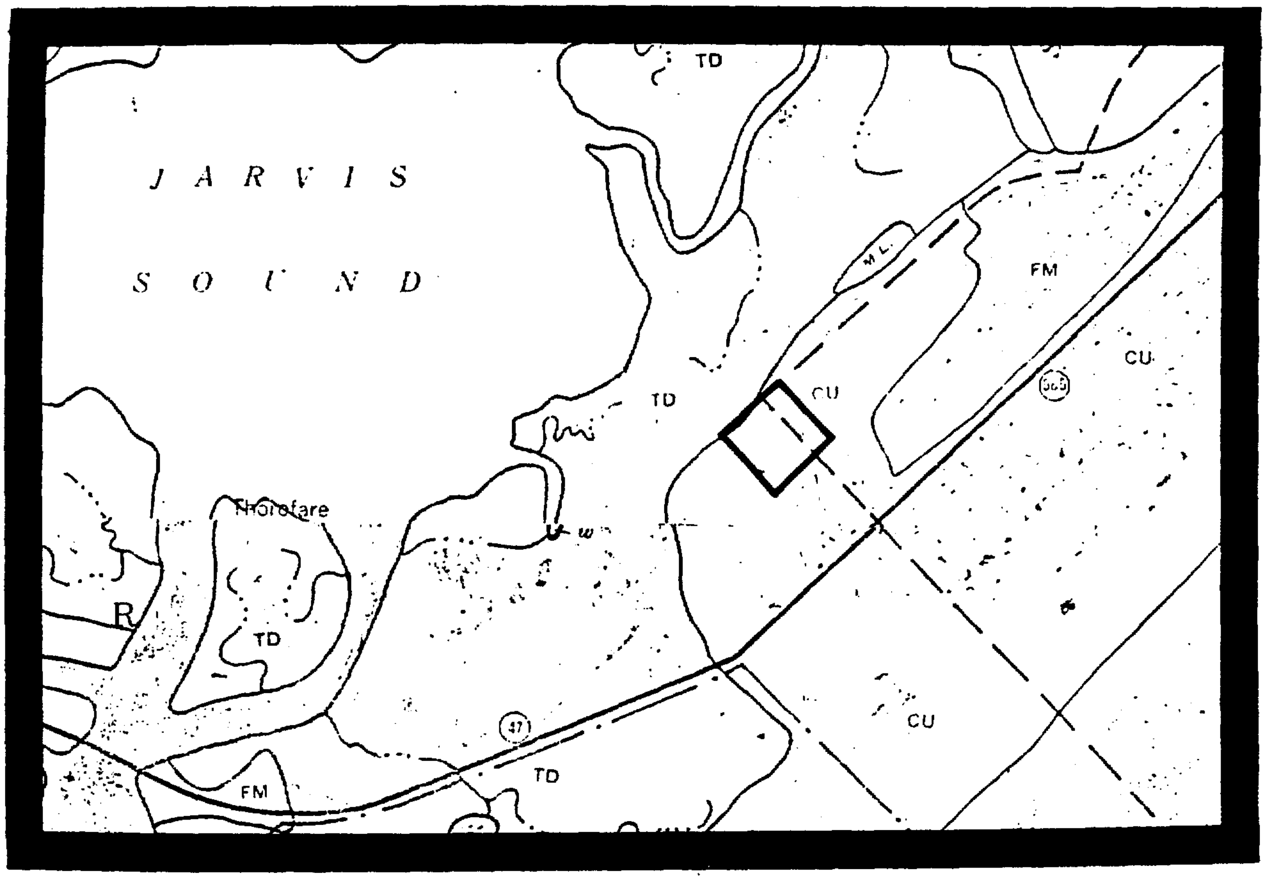
SITE 249 Pelican Bay, Wildwood Crest, Cape May County.

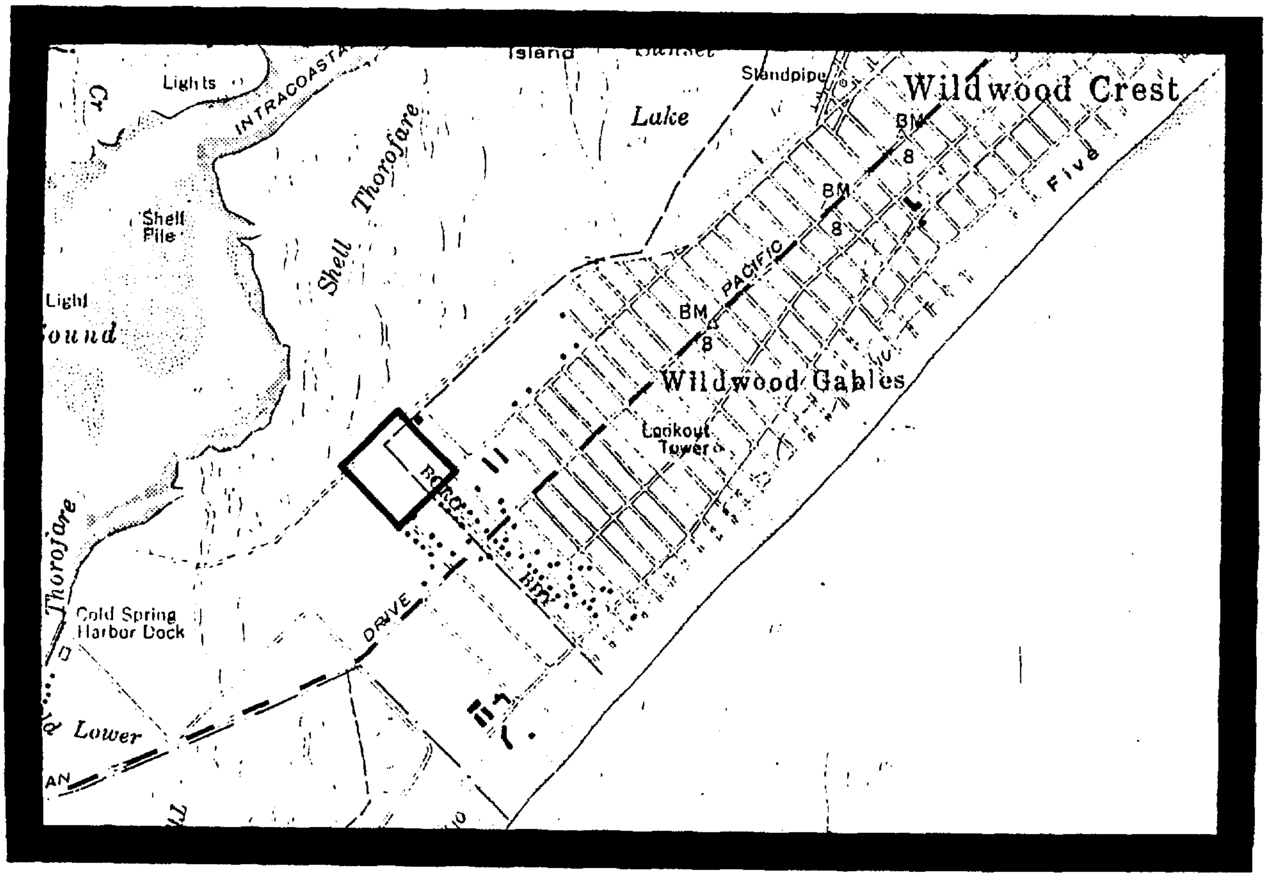
MAP A: Sheets # 26 & 29, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Wildwood, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Wildwood, N.J. Quadrangle (Scale 1:24,000)

MAP A

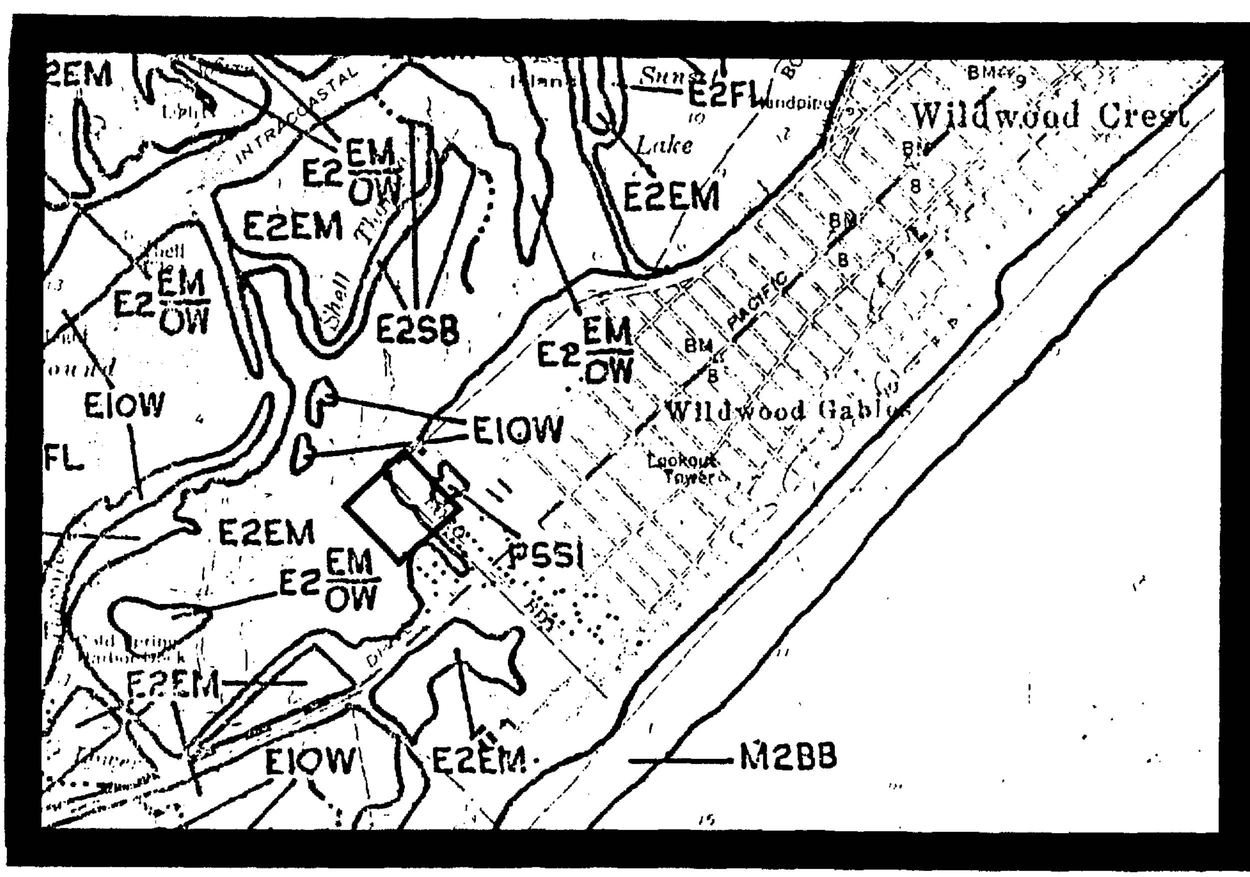




Lights
INTRACOASTAL
Island
Standpipe
Wildwood Crest
Lake
Shell Pile
Shell Thorofare
Light
ound
BM
8
PACIFIC
Five
Wildwood Gables
Lookout Tower
BORO
DRIVE
Cold Spring Harbor Dock
Thorofare
Lower

MAP B

MAP C



2EM
INTRACOASTAL
E2 EM/OW
E2FL
Lake
Wildwood Crest
E2EM
E2EM
E2 EM/OW
E2SB
E2 EM/OW
PACIFIC
E1OW
E1OW
Wildwood Gables
Lookout Tower
FL
E2EM
PSS1
E2 EM/OW
E2EM
E1OW
E2EM
M2BB

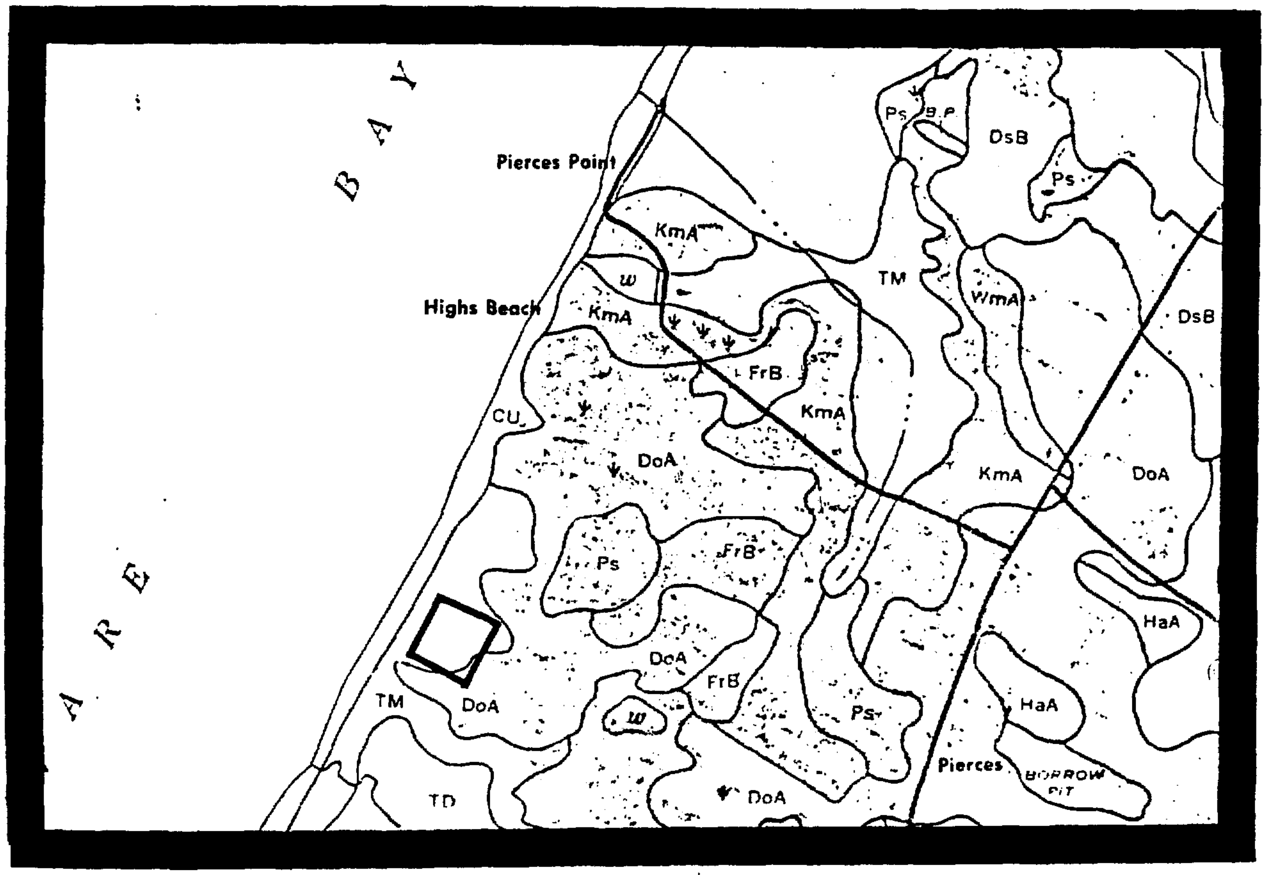
SITE 250 Capeshore Lab, King Crab Landing, Cape May County.

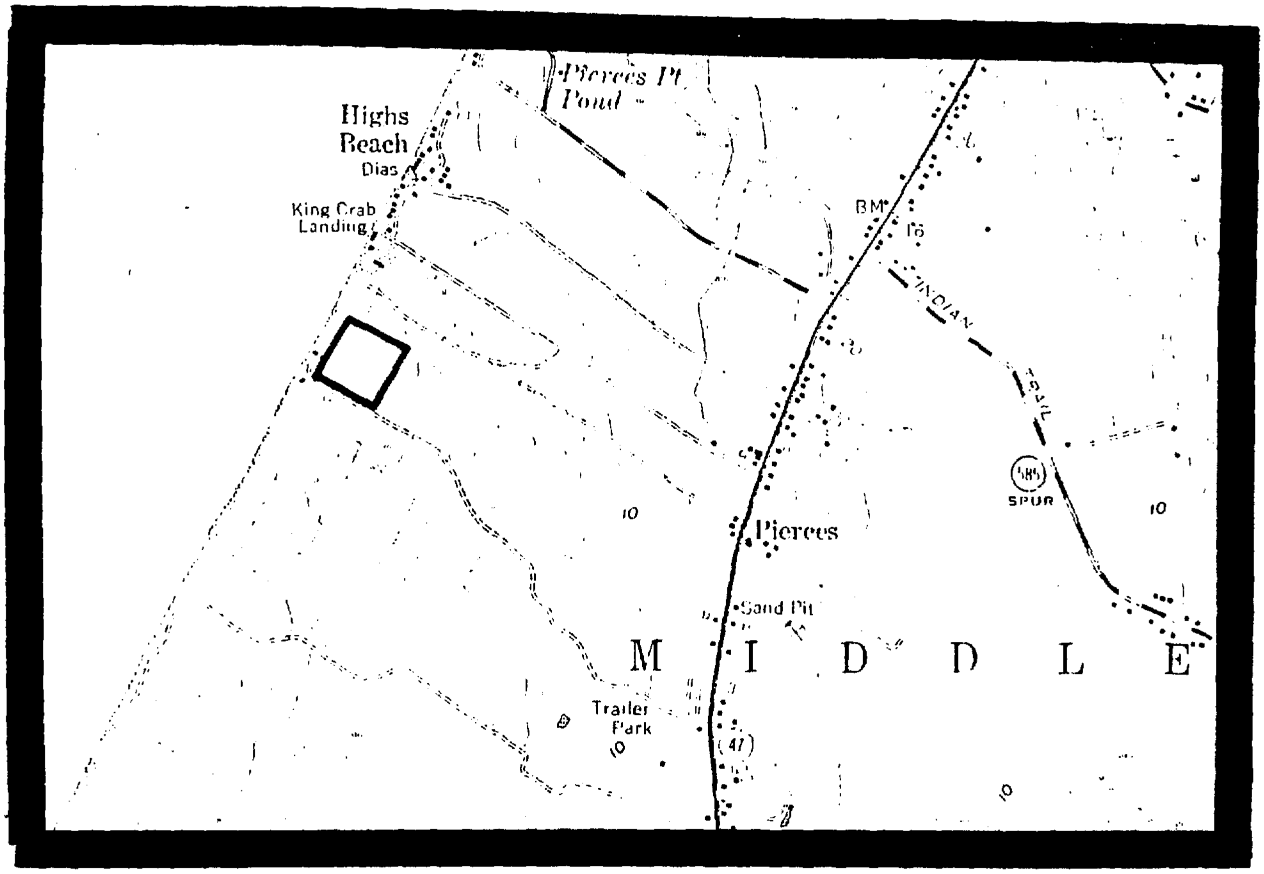
MAP A: Sheet # 20, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Rio Grande, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Rio Grande, N.J. Quadrangle (Scale 1:24,000)

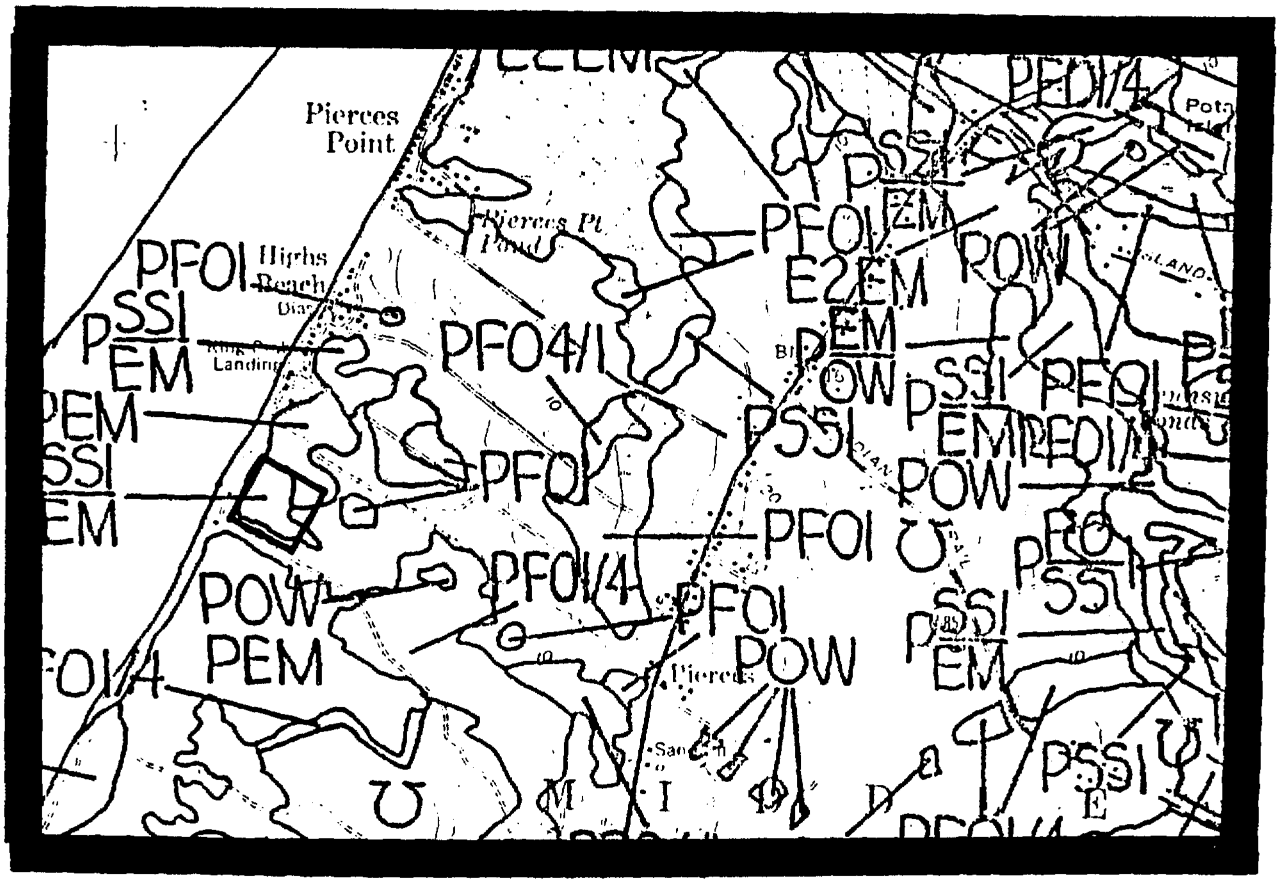
MAP A




Pierces Pt. Pond
Highs Beach
Dias
King Crab Landing
BM
INDIAN TRAIL
585 SPUR
Pierces
Sand Pit
M I D D L E
Trailer Park
47

MAP B

MAP C


Pierces Point
Pierces Pt. Pond
Highs Beach
PFOI
PSSI
PEM
PFO4/I
PFOI/4
E2EM
ROW
POW
PSSI
PEM
PFOI/4
PFOI
PSSI
POW
PEM

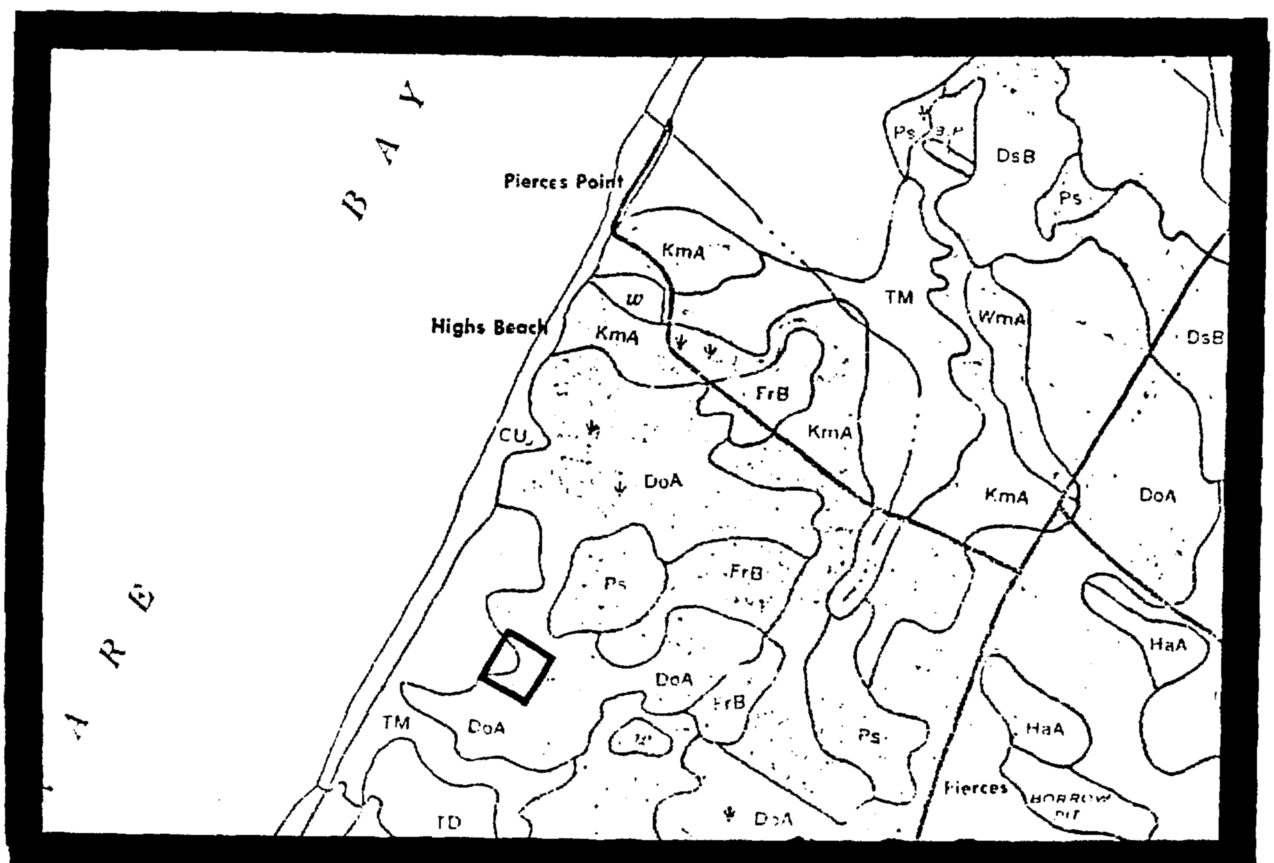
SITE 251 Capeshore Lab II, King Crab Landing, Cape May County.

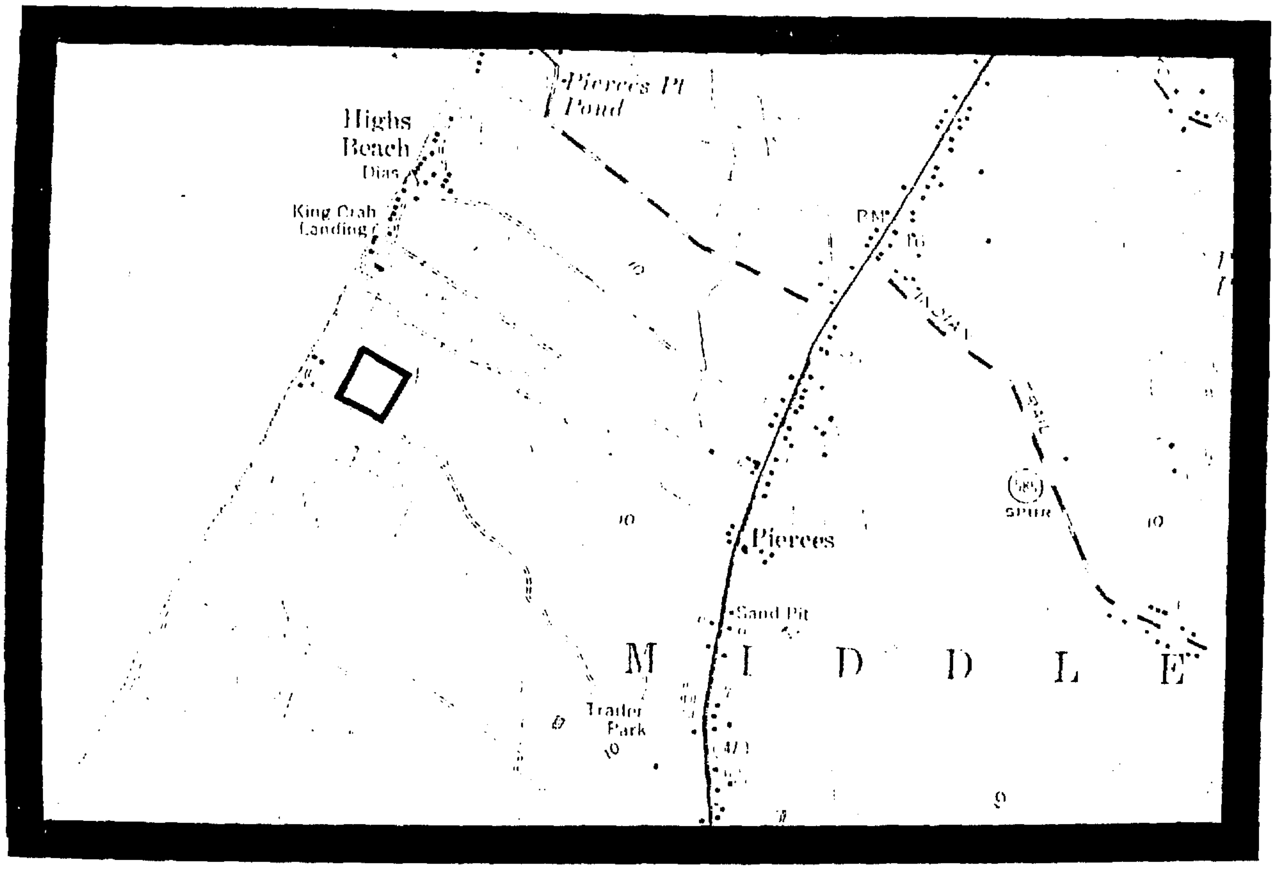
MAP A: Sheet # 20, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Rio Grande, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Rio Grande, N.J. Quadrangle (Scale 1:24,000)

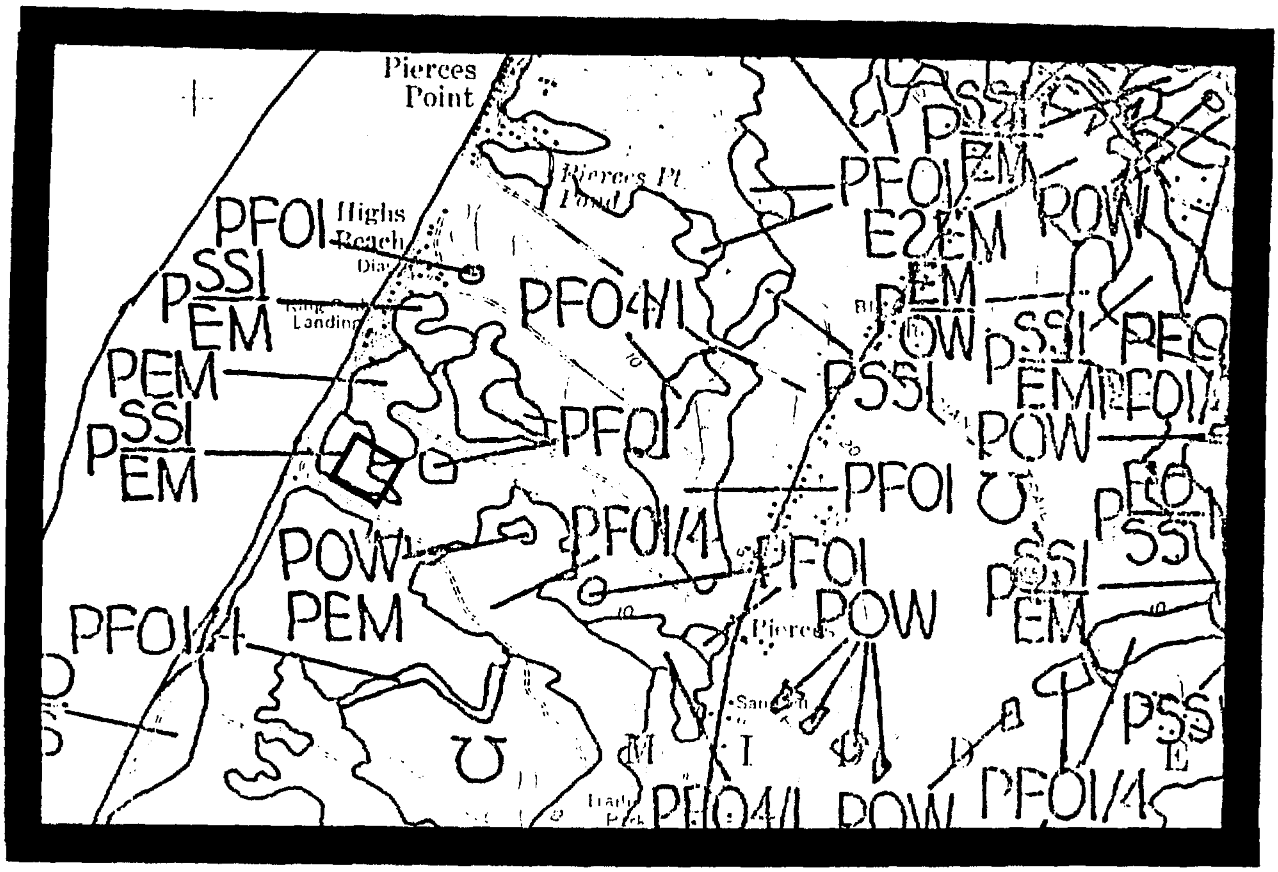
MAP A




Pierces Pt
Pond
Highs
Beach
Dias
King Crab
Landing
Pierces
Sand Pit
M I D D L E
Trailer
Park

MAP B

MAP C


Pierces
Point
Pierces Pt
Pond
Highs
Beach
PFOI
PSSI
EM
PEM
PFO4/I
PFOI
POW
PFOI/4
PSSI
PFO4/I
POW
PFOI/4

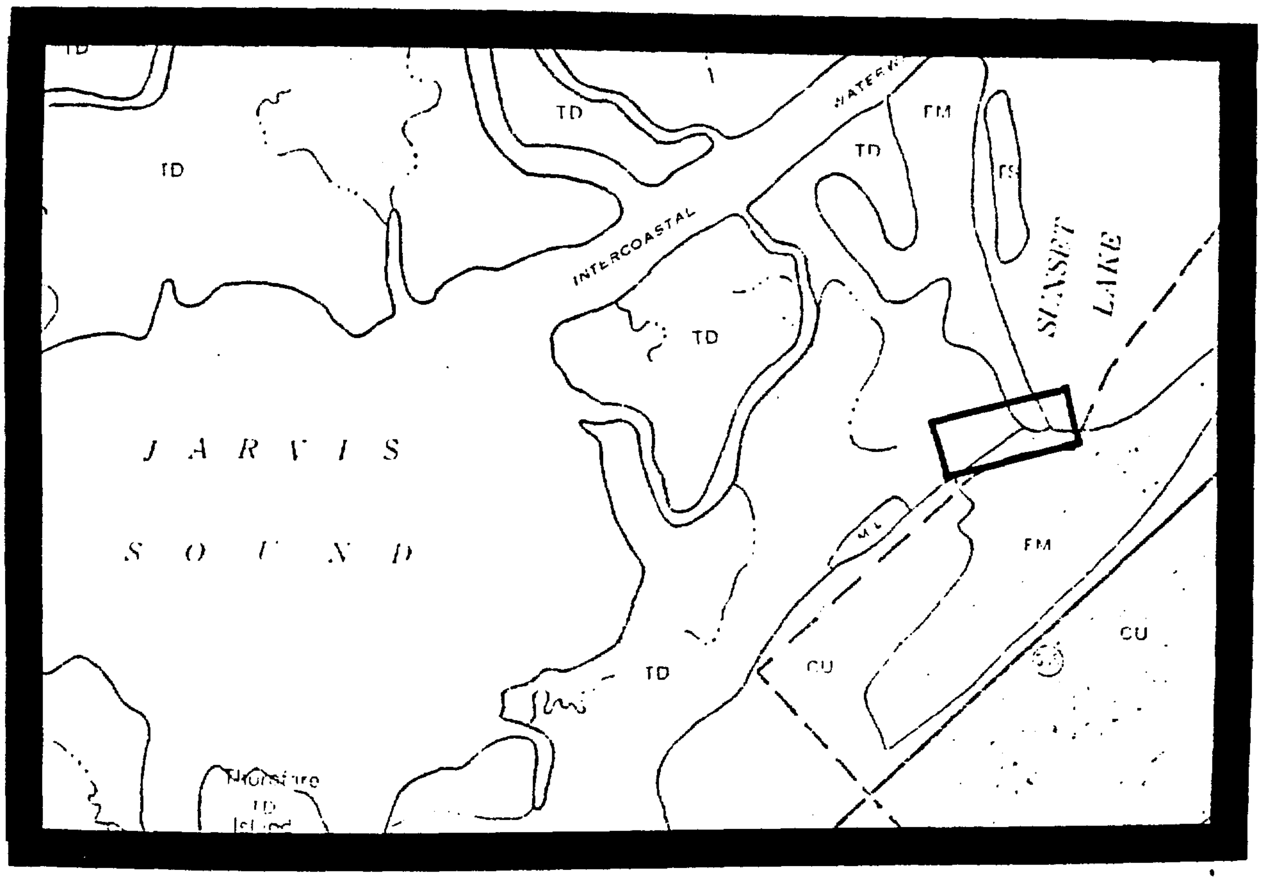
SITE 252 Toledo Ave., Wildwood Crest, Cape May County.

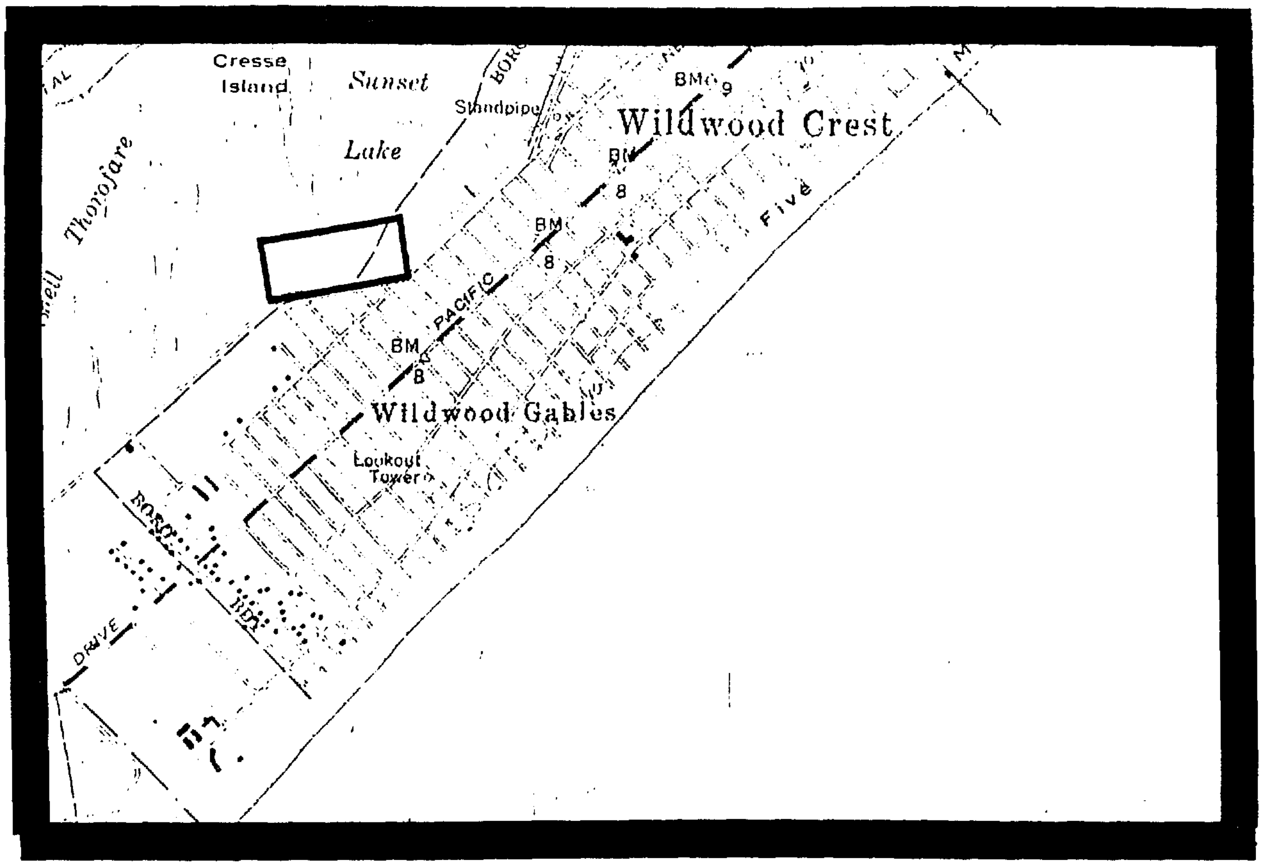
MAP A: Sheet # 26, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Wildwood, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Wildwood, N.J. Quadrangle (Scale 1:24,000)

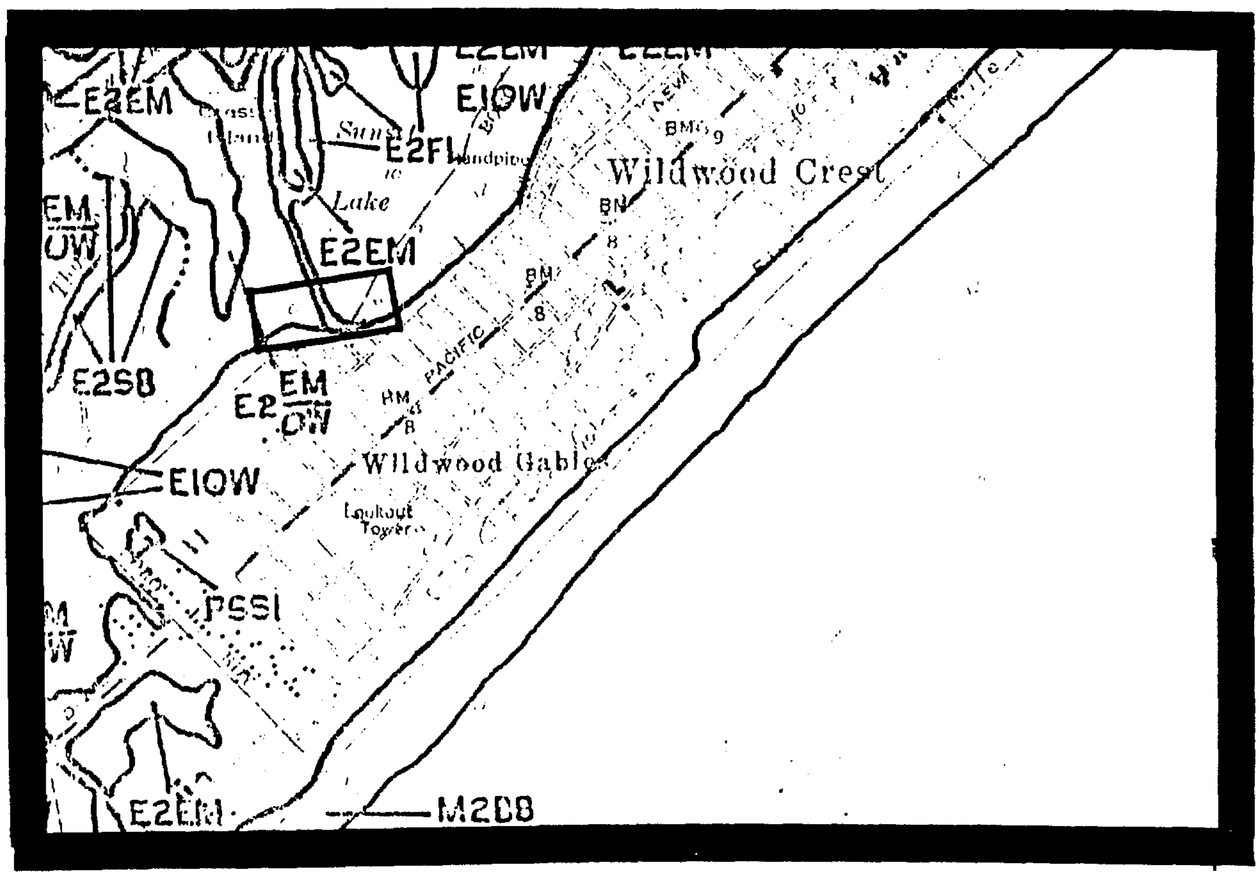
MAP A




Cresse Island
Sunset
Lake
Standpipe
BM 9
Wildwood Crest
BM 8
BM 8
Five
PACIFIC
BM 8
Wildwood Gables
Lookout Tower
DRIVE

MAP B

MAP C


E2EM
E1OW
E2FL
Wildwood Crest
EM
OW
E2EM
E2SB
E2 EM/OW
PACIFIC
Wildwood Gables
E1OW
Lookout Tower
PSS1
E2EM
M2OB

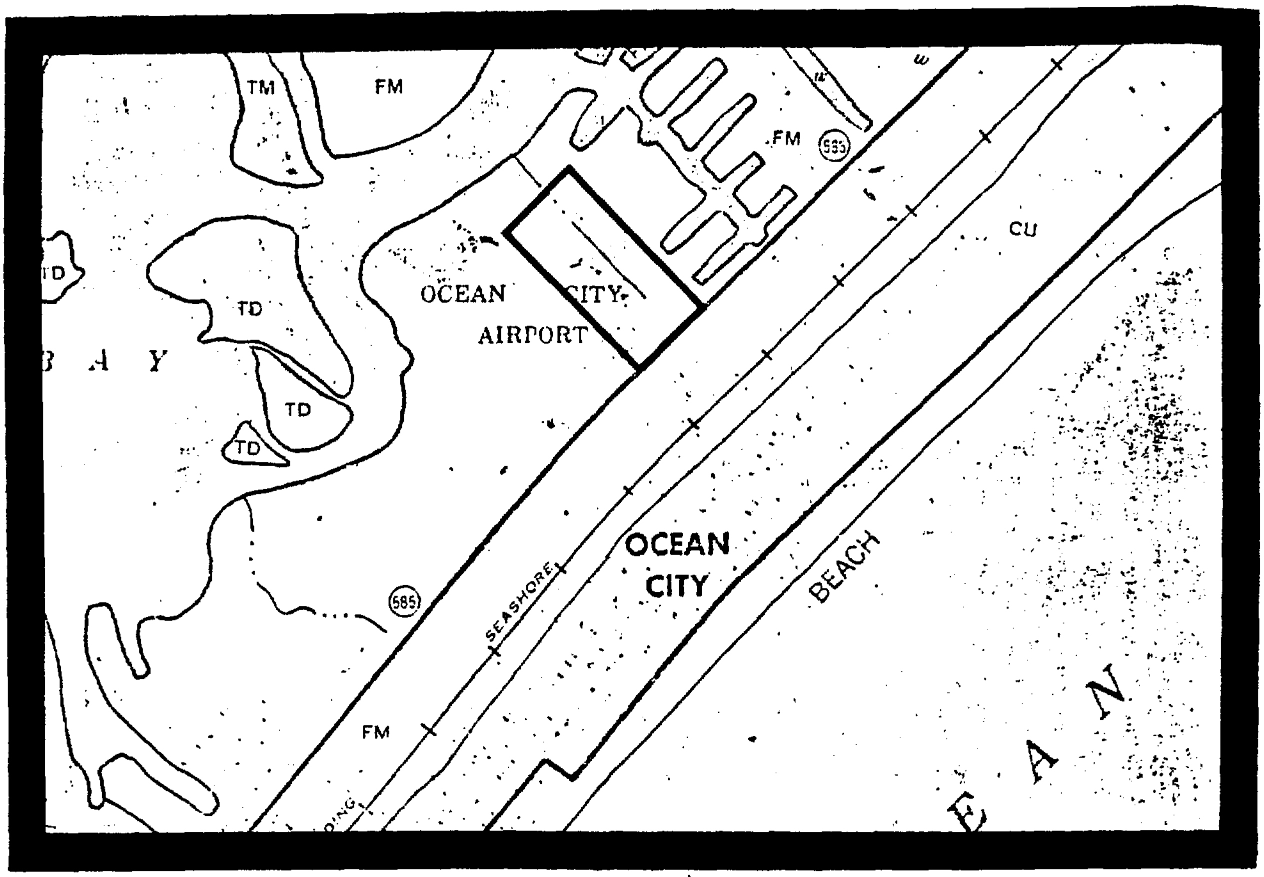
SITE 253 Tennesee Ave., Ocean City, Cape May County.

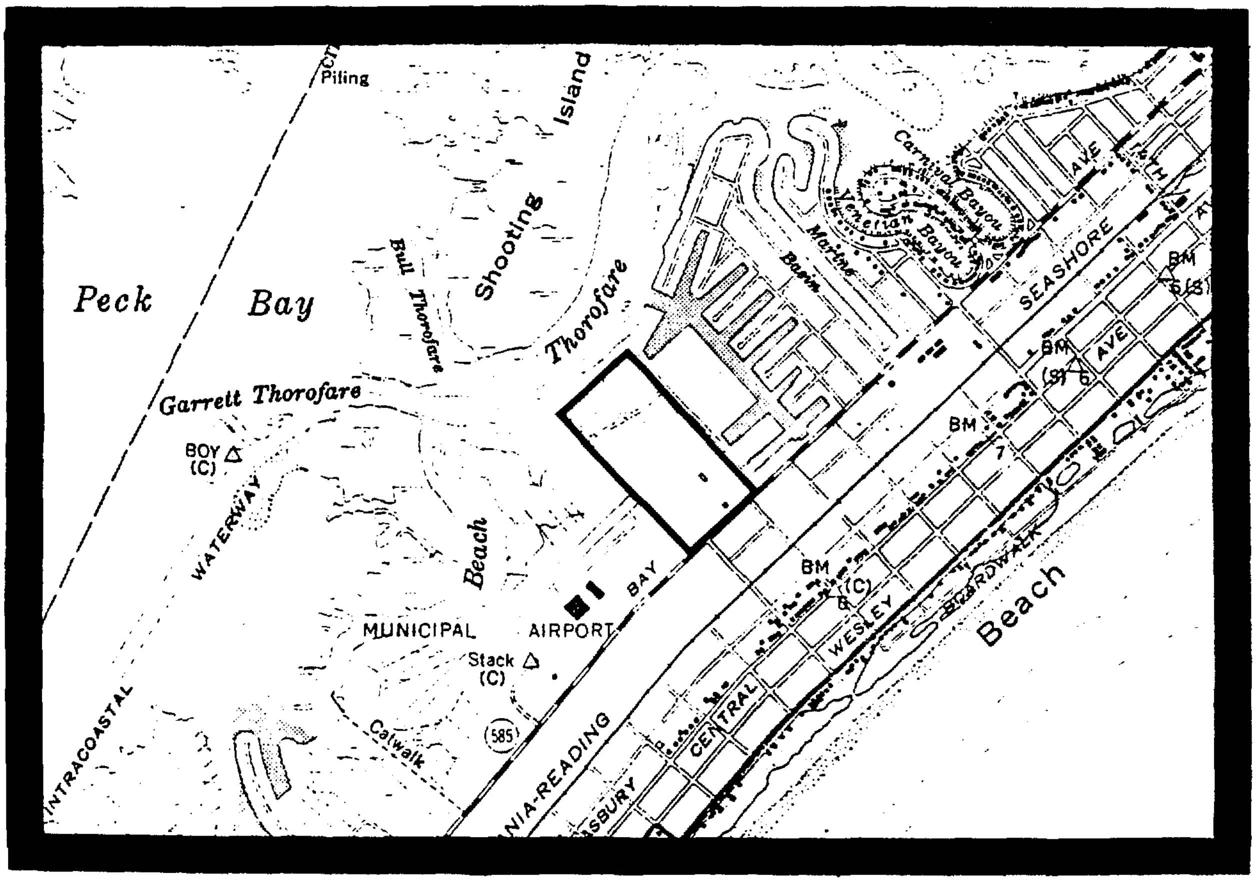
MAP A: Sheet # 9, Cape May County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Ocean City, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Ocean City, N.J. Quadrangle (Scale 1:24,000)

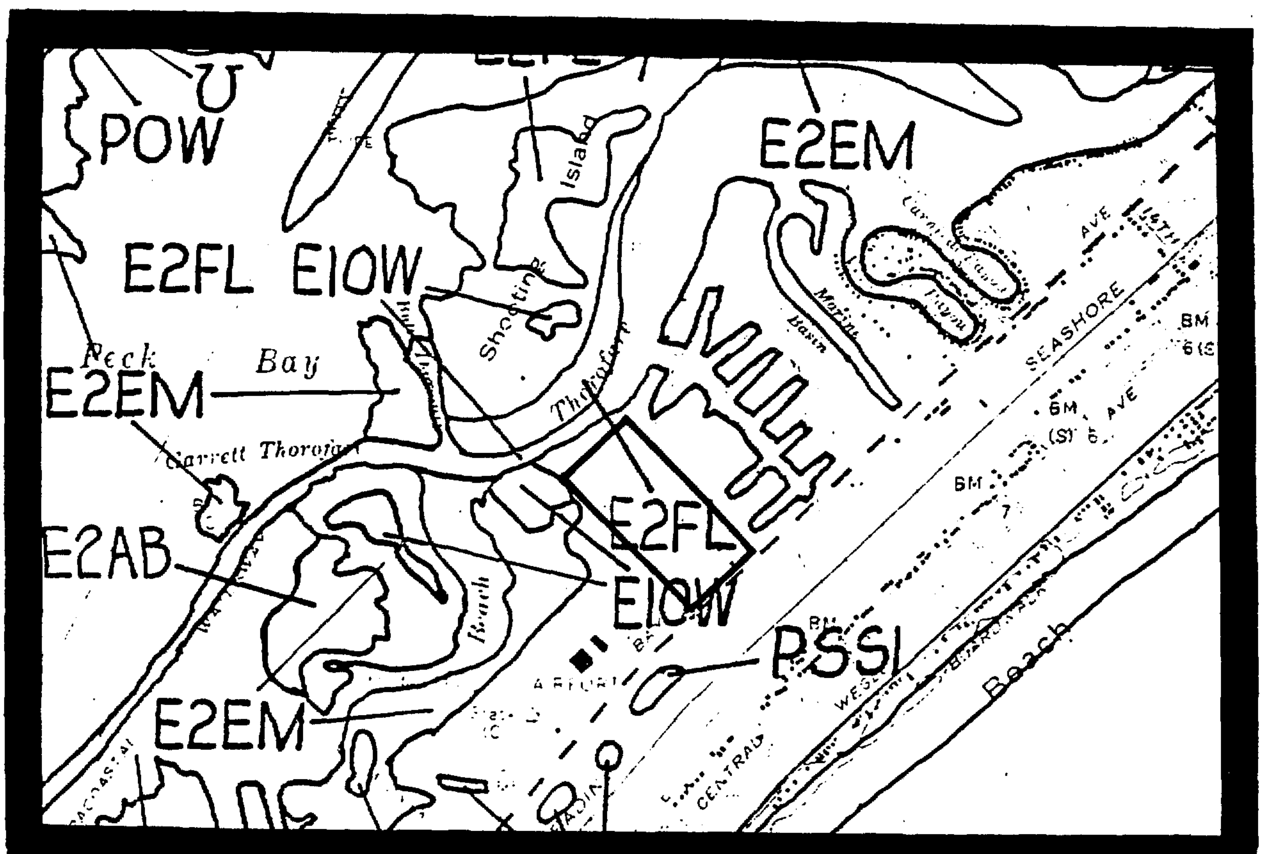
MAP A




Piling
Shooting Island
Peck Bay
Bull Thorofare
Thorofare
Carnival Bayou
Venetian Bayou
Marina Basin
SEASHORE AVE
Garrett Thorofare
BOY △ (C)
WATERWAY
Beach
MUNICIPAL AIRPORT
BAY
Stack △ (C)
Catwalk
585
INTRACOASTAL
NIA-READING
SBURY
CENTRAL
WESLEY
BOARDWALK
Beach
BM

MAP B

MAP C


POW
E2EM
E2FL
E1OW
Peck Bay
E2EM
E2AB
E2FL
E1OW
PSS1
E2EM
SEASHORE
Beach

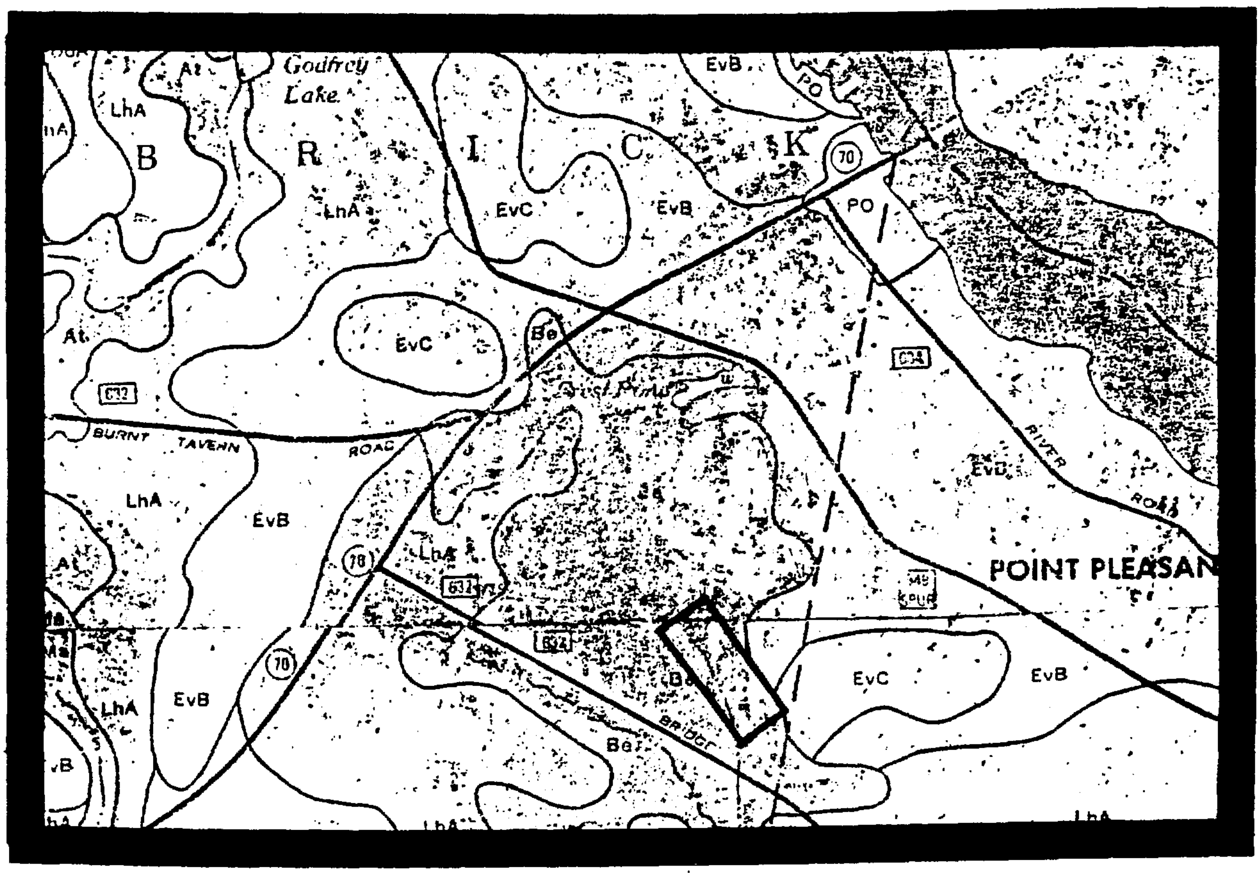
SITE 254 Smith Dr., Brick Twp., Ocean County.

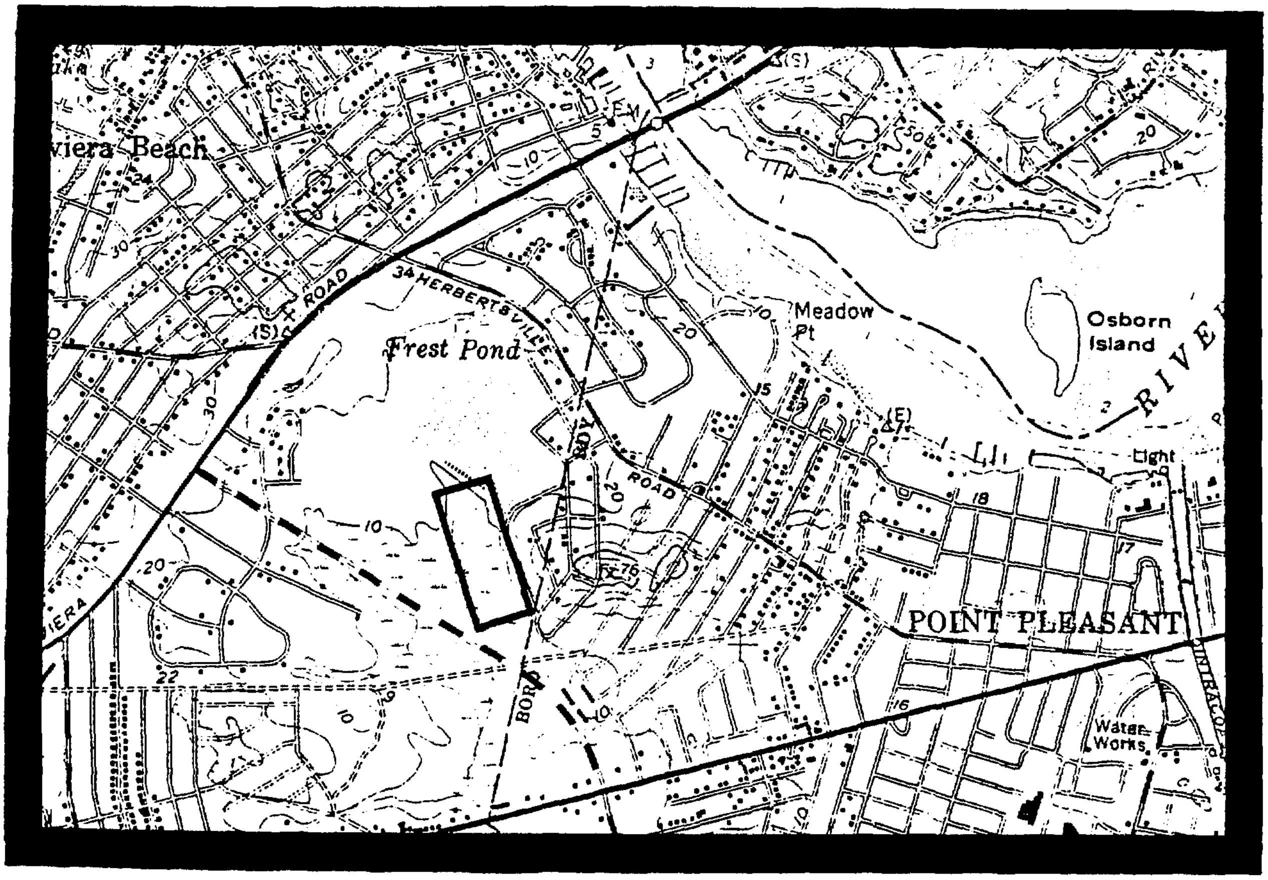
MAP A: Sheets # 9 & 15, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Point Pleasant, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Point Pleasant, N.J. Quadrangle (Scale 1:24,000)

MAP A

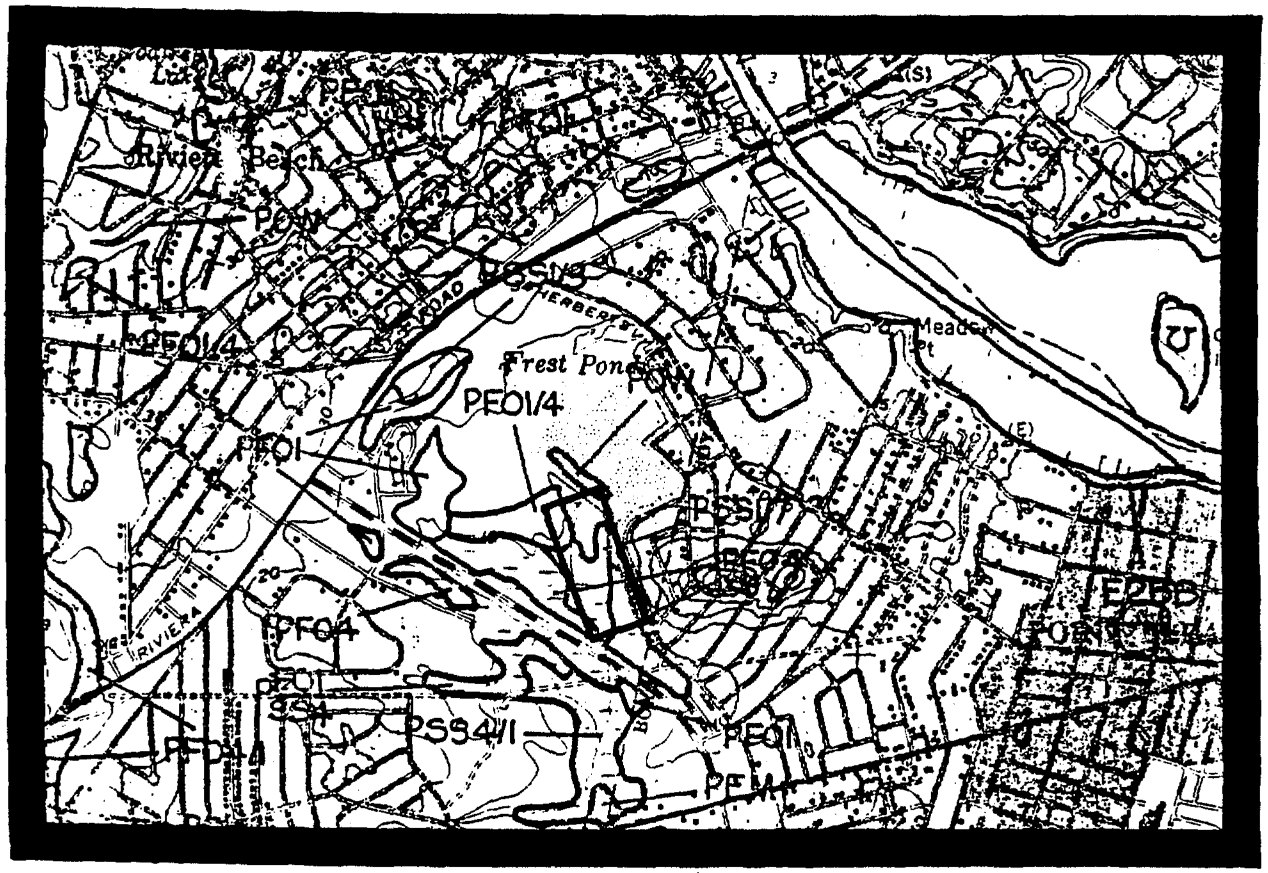




Riviera Beach
ROAD
HERBERTSVILLE
Frest Pond
Meadow Pt
Osborn Island
RIVER
ROAD
Light
POINT PLEASANT
BORO
Water Works

MAP B

MAP C



Riviera Beach
PEM
PSS1/3
HERBERTSVILLE
ROAD
PFO1/4
Frest Pond
PEM
PFO1/4
PFO1
Meadow Pt
PSS1/7
E2BP
PFO4
PSS4/1
PFO1
PFO1/4
PEM
RIVIERA

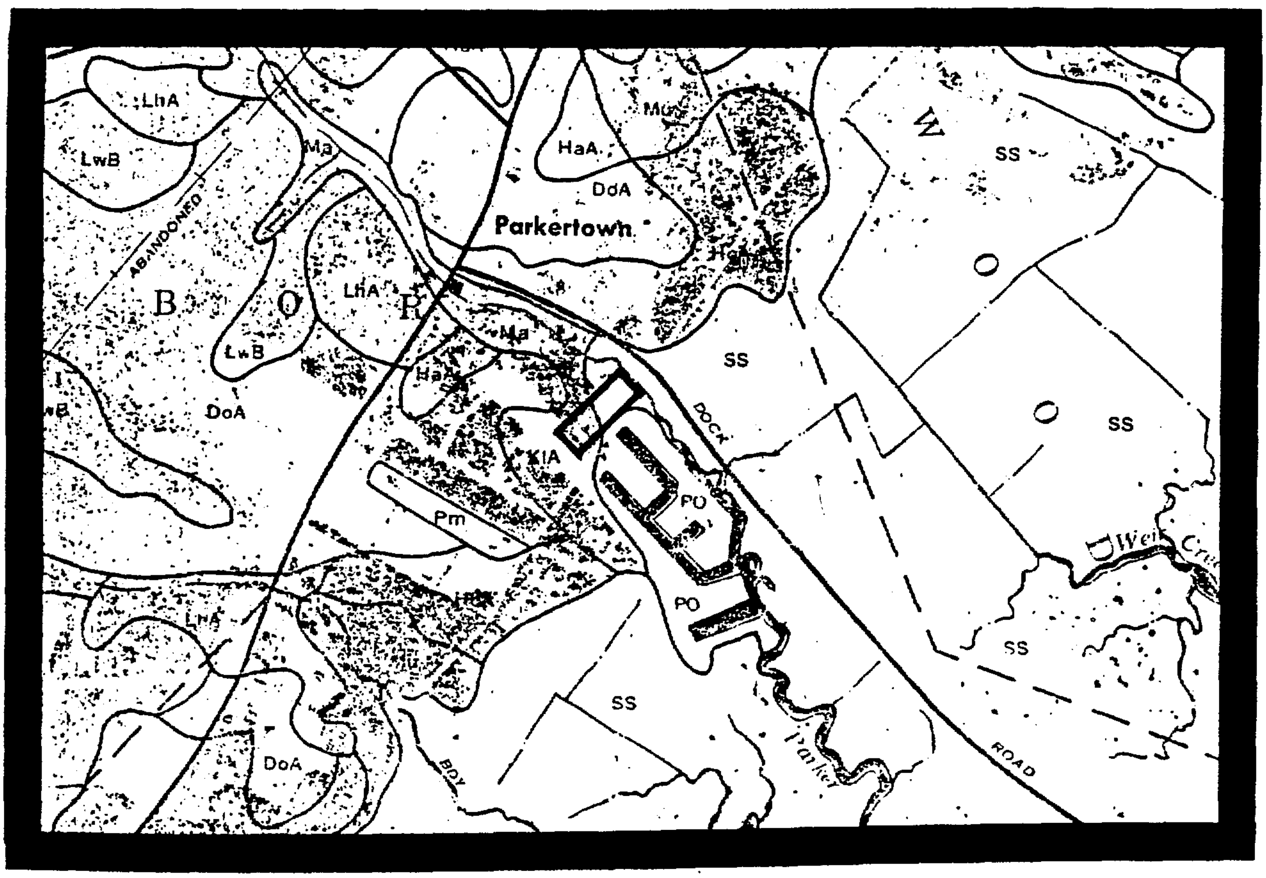
SITE 255 No. 53, Sea Meadow Dr., Parkertown, Ocean County.

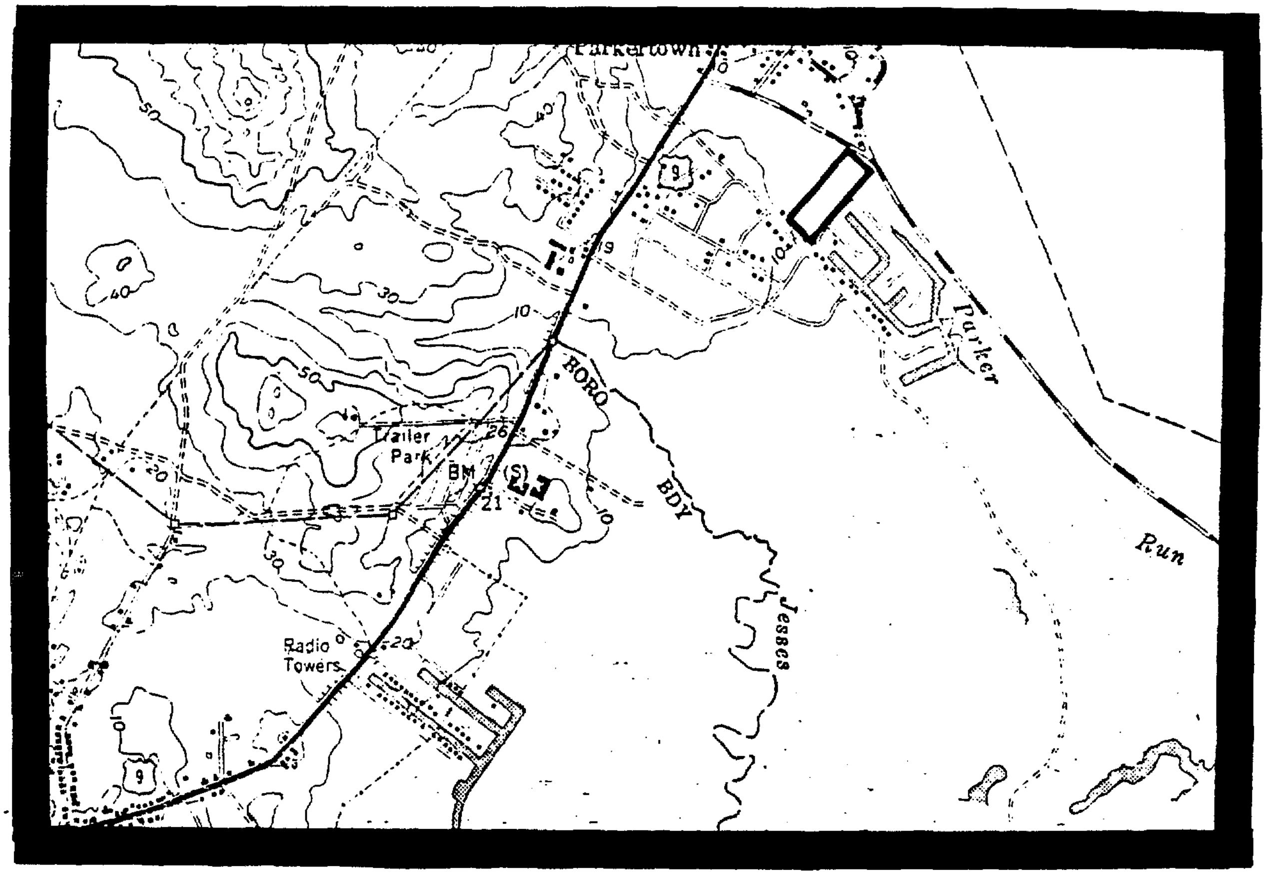
MAP A: Sheet # 56, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton, N.J. Quadrangle (Scale 1:24,000)

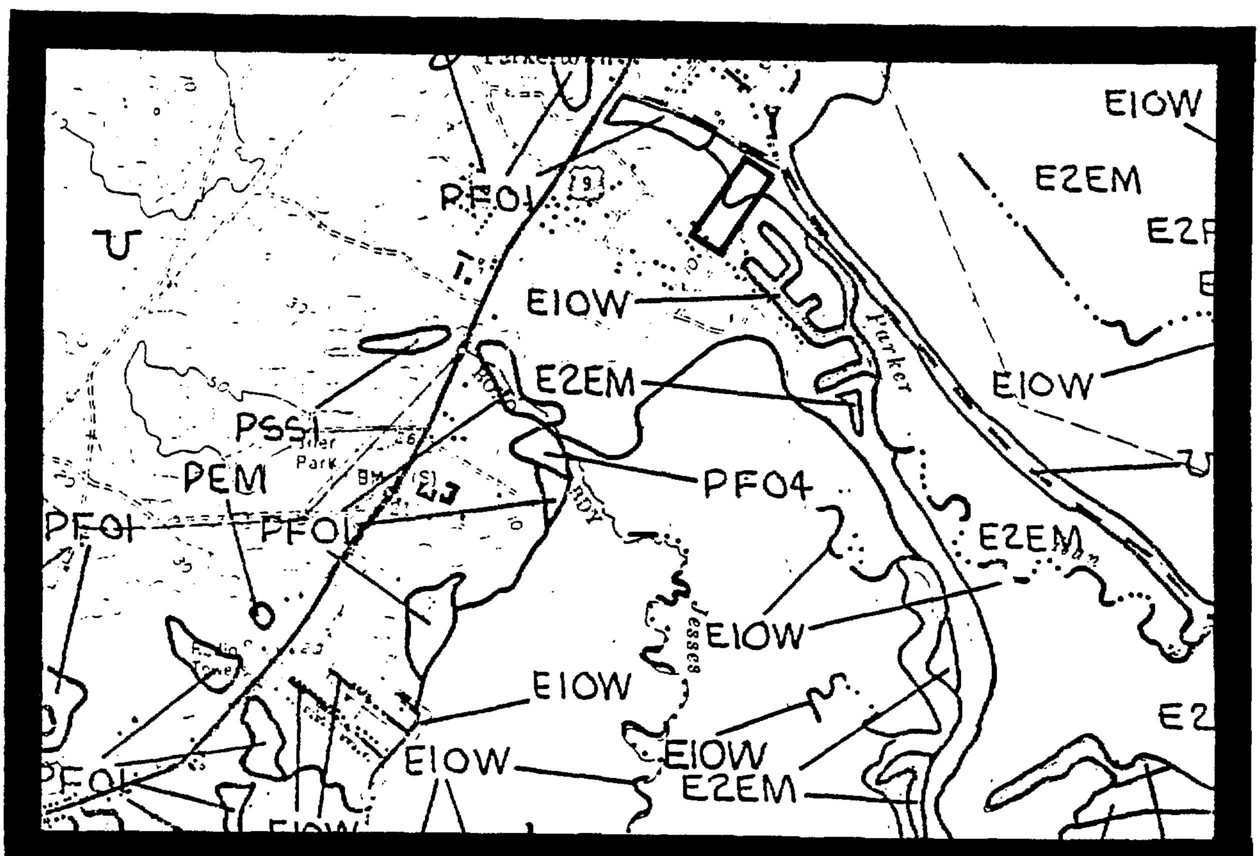
MAP A




Trailer
Park
BM
Radio
Towers
BORO
BDY
Jesses
Parker
Run

MAP B

MAP C


E1OW
E2EM
PFO1
E1OW
E2EM
PSS1
PEM
PFO4
PFO1
PFO1
E2EM
E1OW
E1OW
E1OW
E1OW
E2EM
PFO1
Parker
Jesses

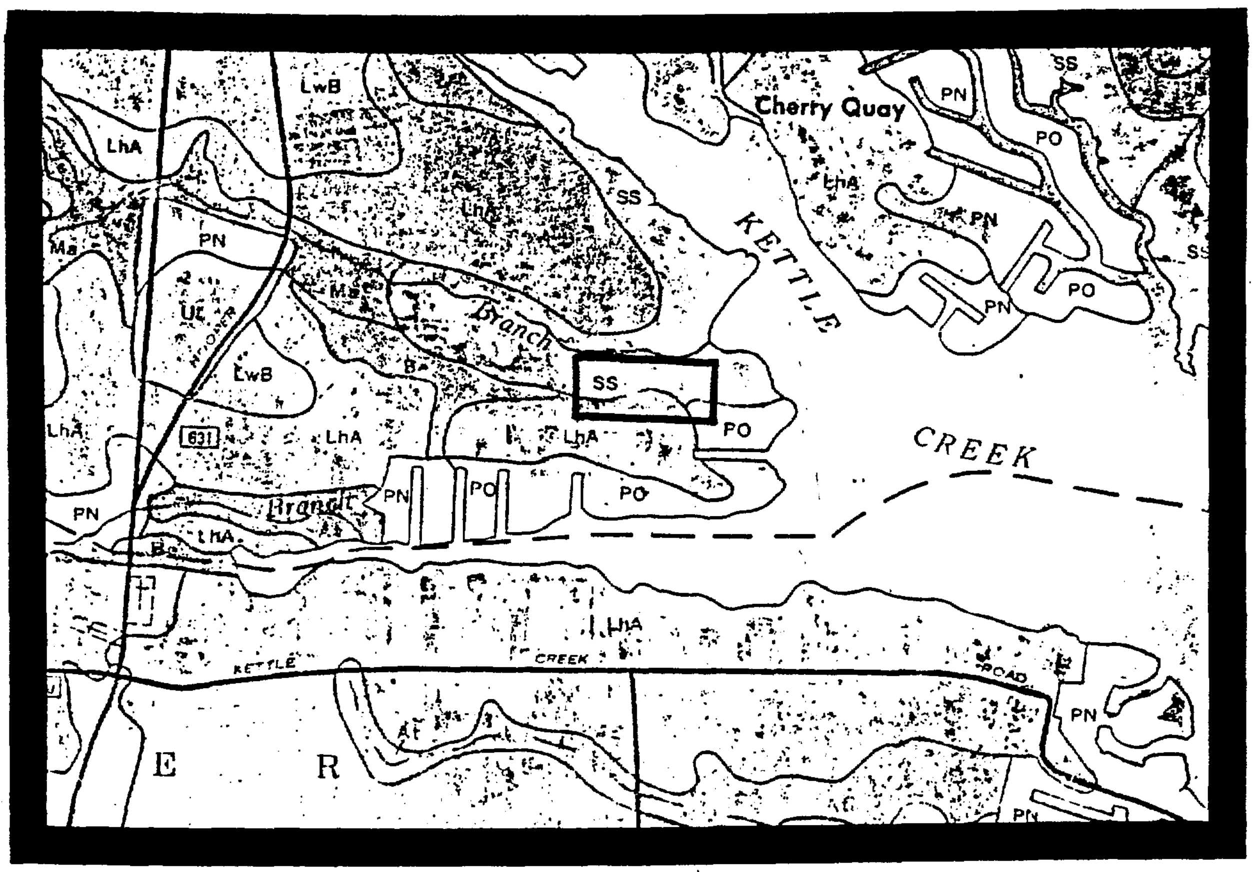
SITE 256   Bay Harbor Blvd., Brick Twp., Ocean County.

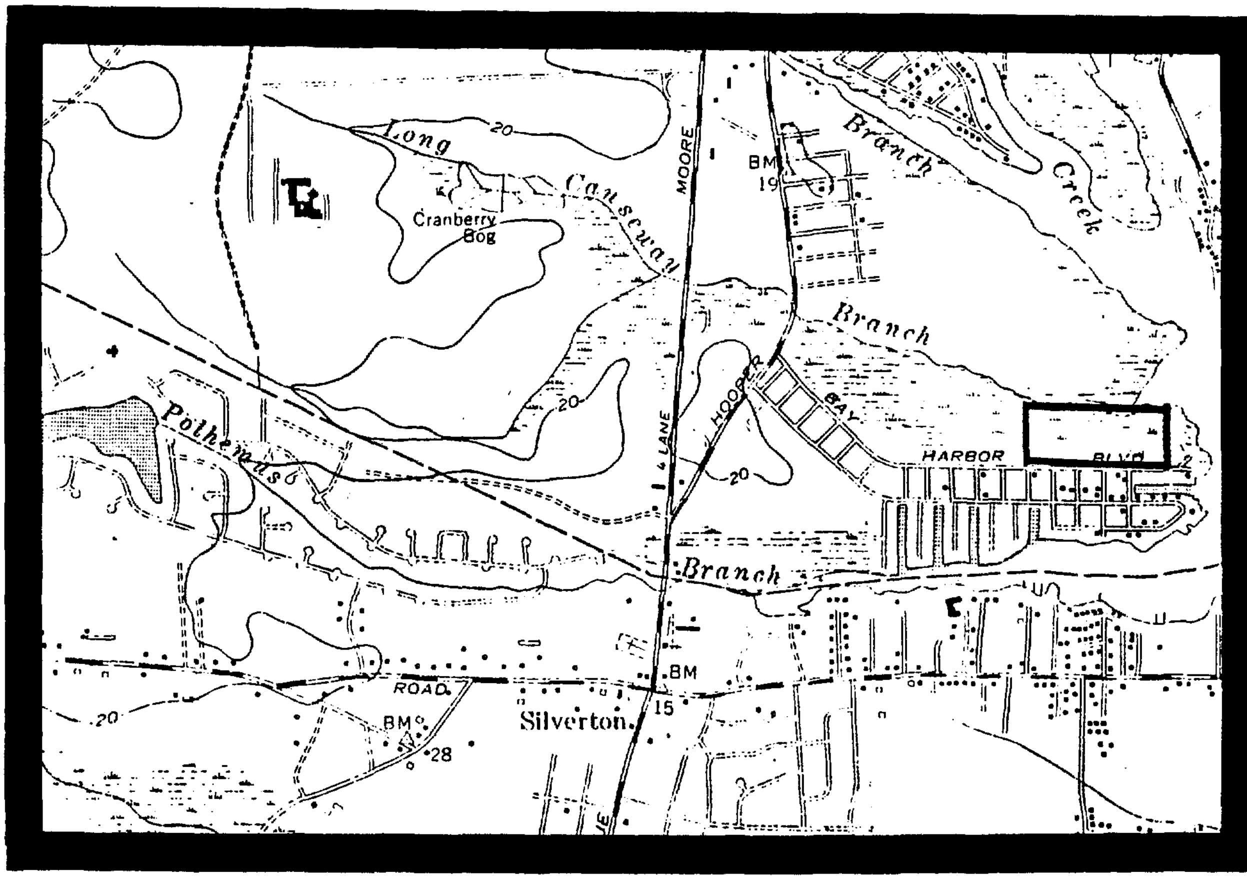
MAP A: Sheet # 20, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Lakewood, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Lakewood, N.J. Quadrangle (Scale 1:24,000)

MAP A

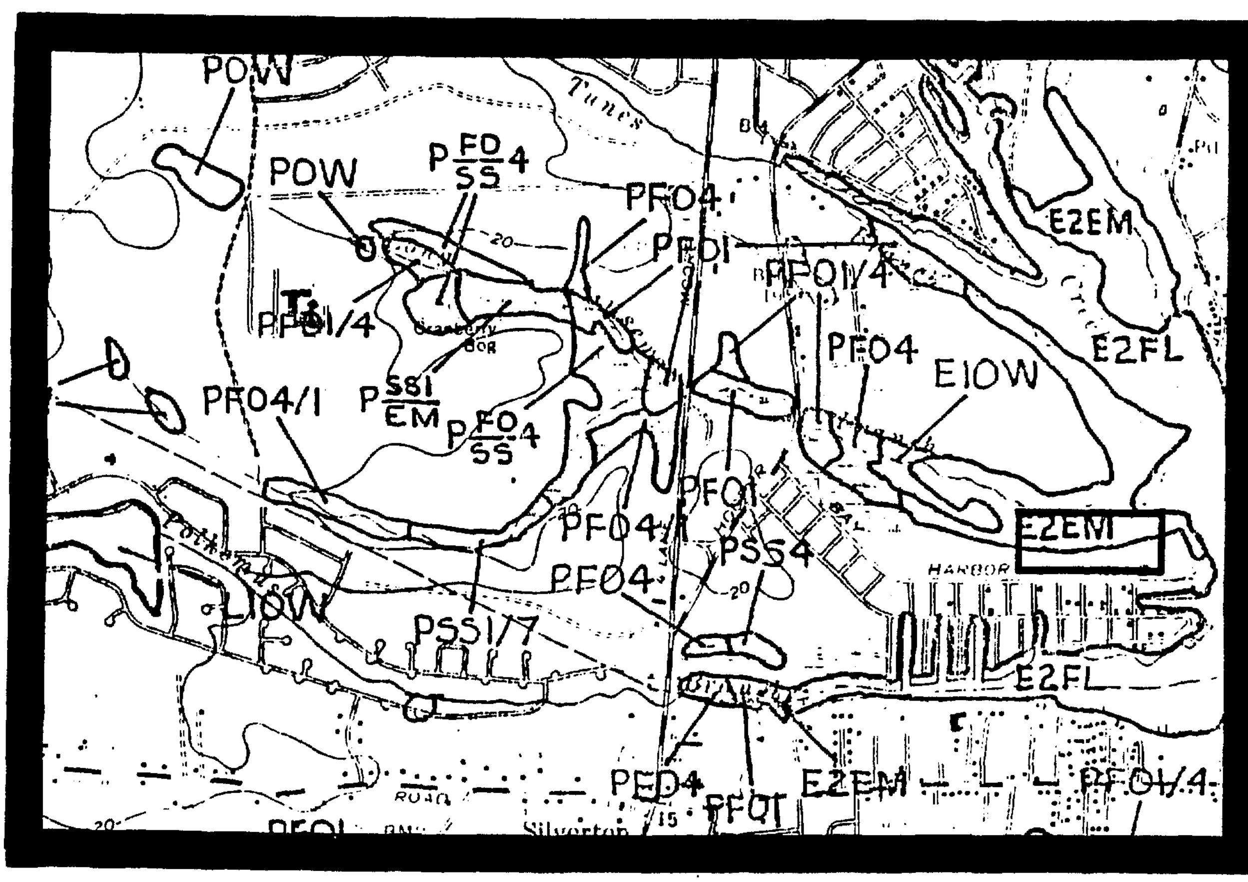




Long
Causeway
Cranberry Bog
MOORE
BM 19
Branch
Creek
Branch
Polhemus
HOOPER
BAY
HARBOR
BLVD
4 LANE
Branch
BM
ROAD
15
Silverton
BM
28
20

MAP B

MAP C



POW
POW
P FO/SS 4
PFO4
PFO1
PFO1/4
PFO1/4
E2EM
E2FL
PFO4
E1OW
PFO4/1
P SS1/EM
P FO/SS 4
PFO1
PFO4/1
PSS4
PFO4
L1OW
PSS1/7
E2EM
HARBOR
E2FL
PFO4
PFO1
E2EM
PFO1/4
PFO1
Silverton

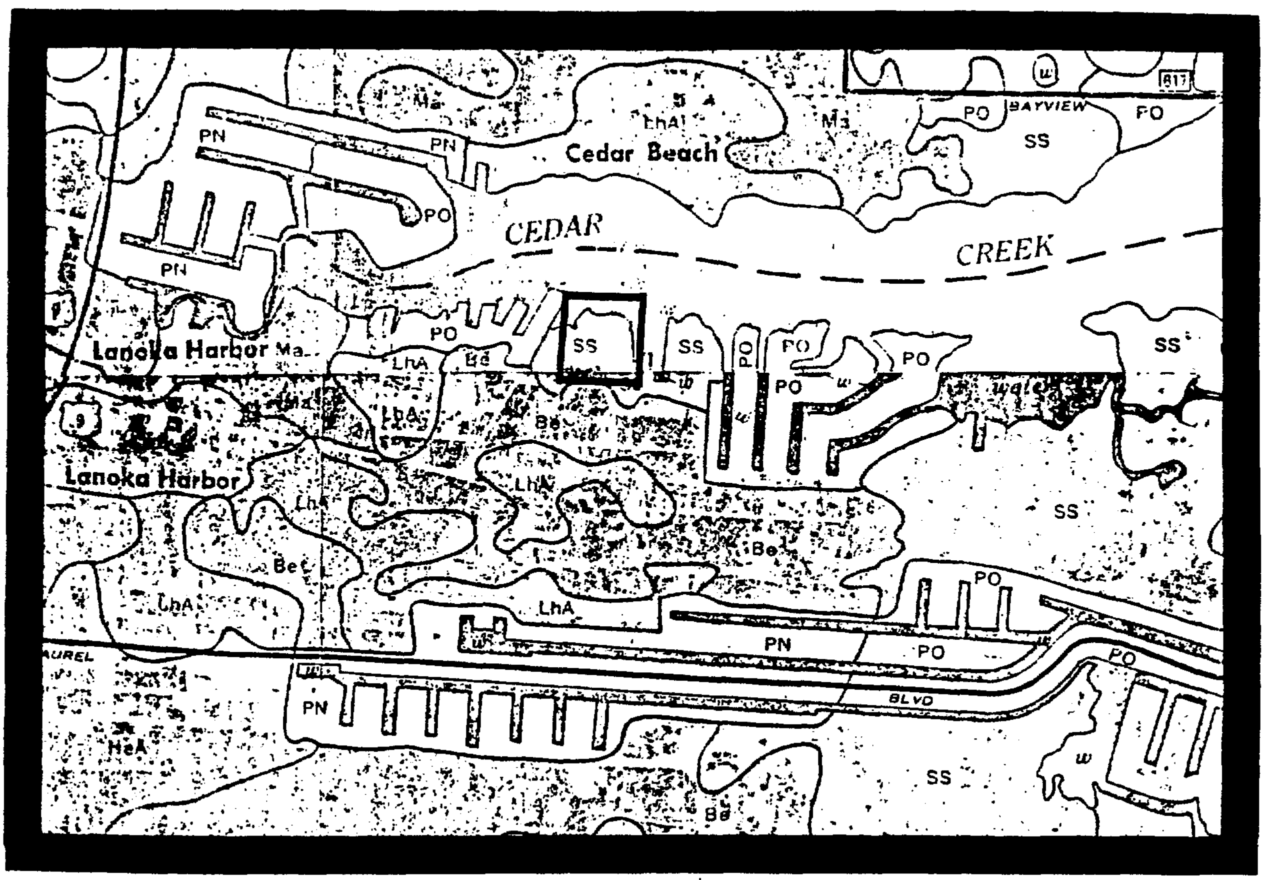
SITE 257 Rocknacks II, Lanoka Harbor, Ocean County.

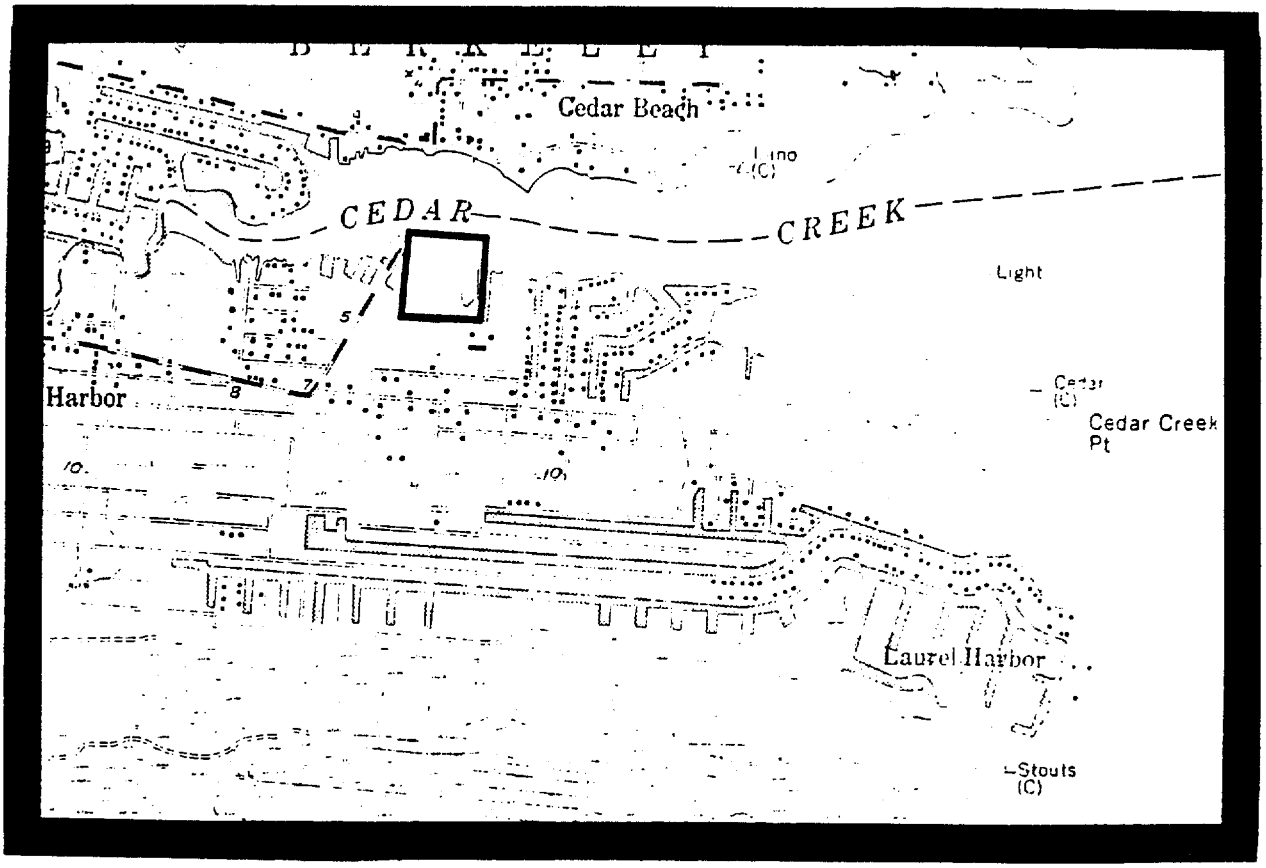
MAP A: Sheets # 36 & 40, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked
River, N.J. (Scale 1:24,000)

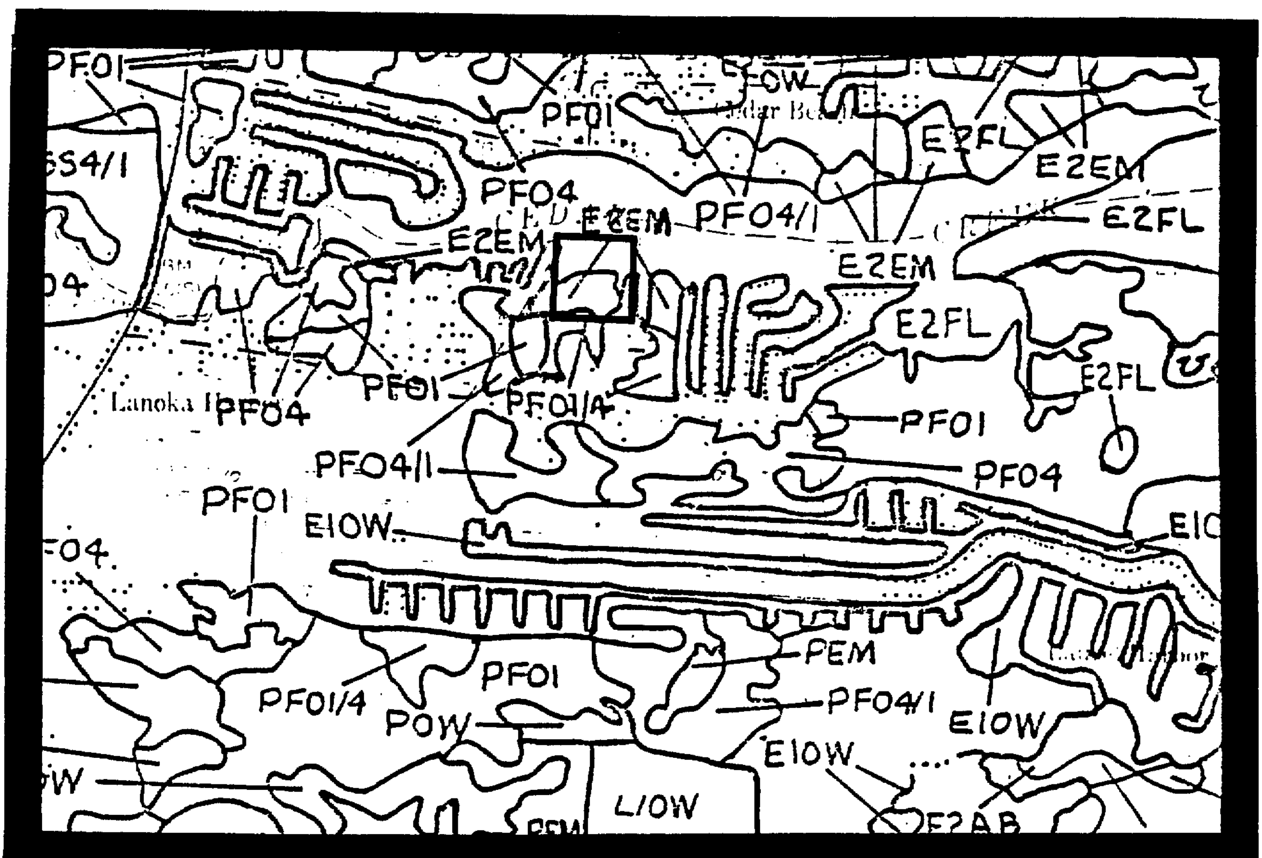
MAP A




Cedar Beach
CEDAR
CREEK
Light
Harbor
Cedar Creek Pt
Laurel Harbor
Stouts (C)

MAP B

MAP C


PF01
PF04
PF04/1
E2EM
E2FL
PF01/4
PF04/1
Lanoka
E1OW
PEM
POW
L1OW

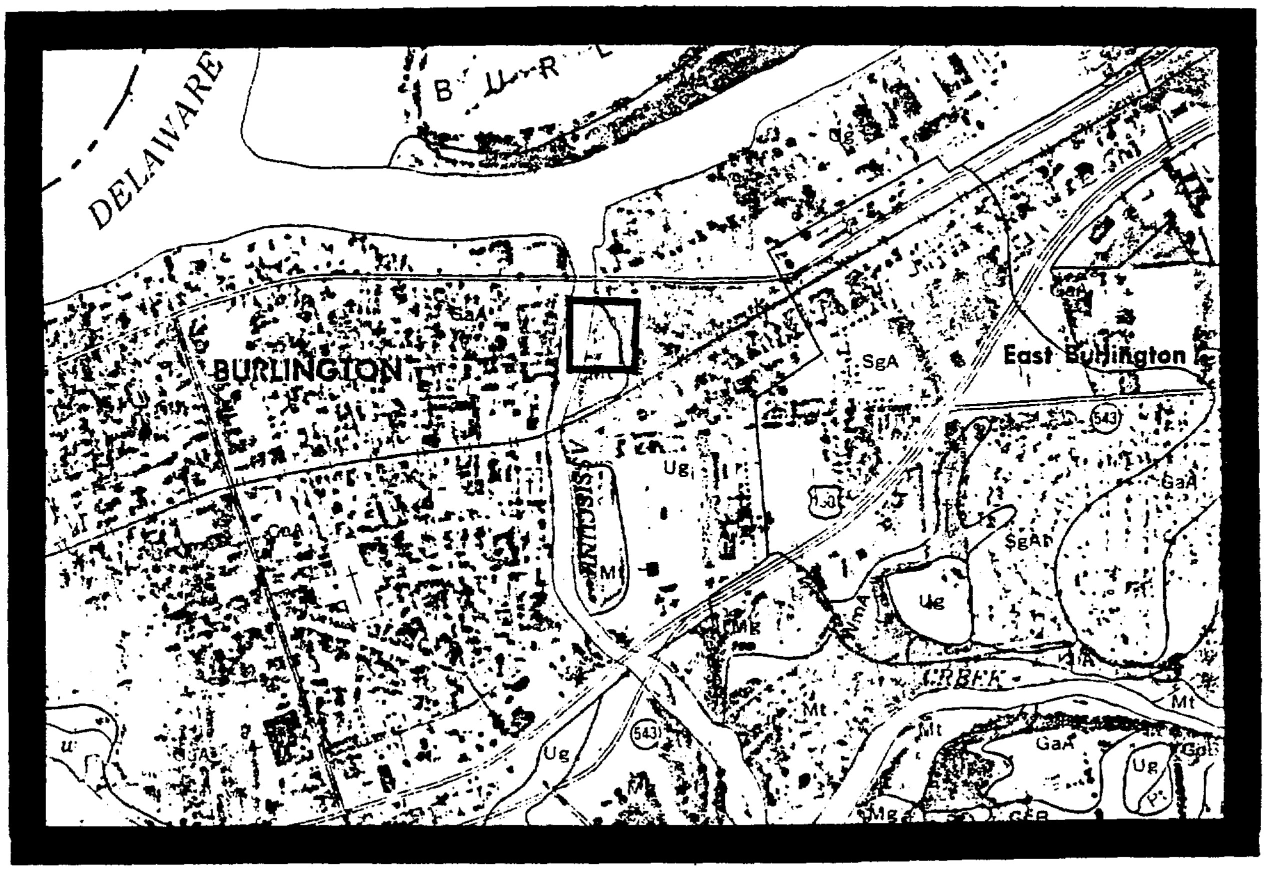
SITE 258 Curtin Marina, end of Rt. 566, Burlington Twp., Burlington County.

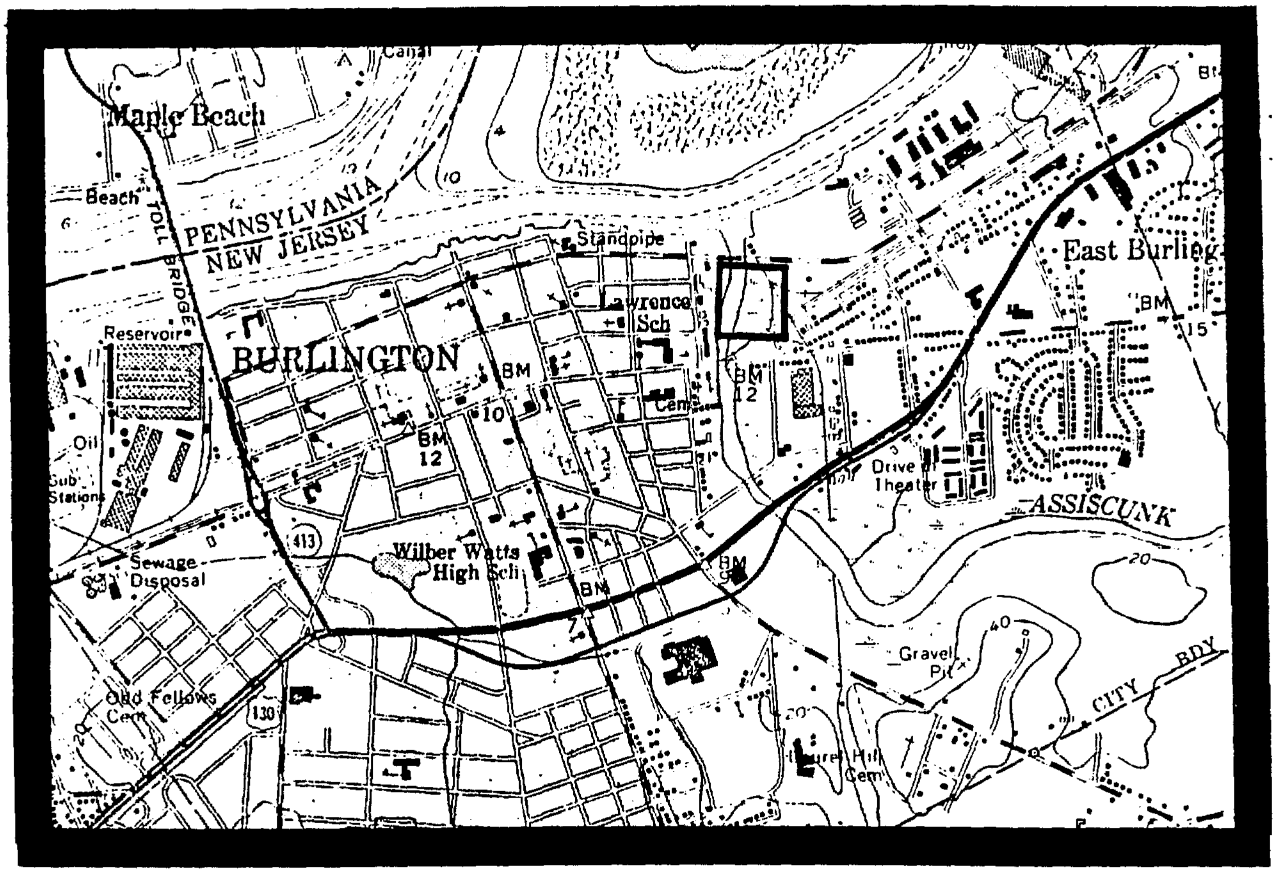
MAP A: Sheet # 7, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Bristol, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. Narional Wetlands Inventory, Bristol, N.J. Quadrangle (Scale 1:24,000)

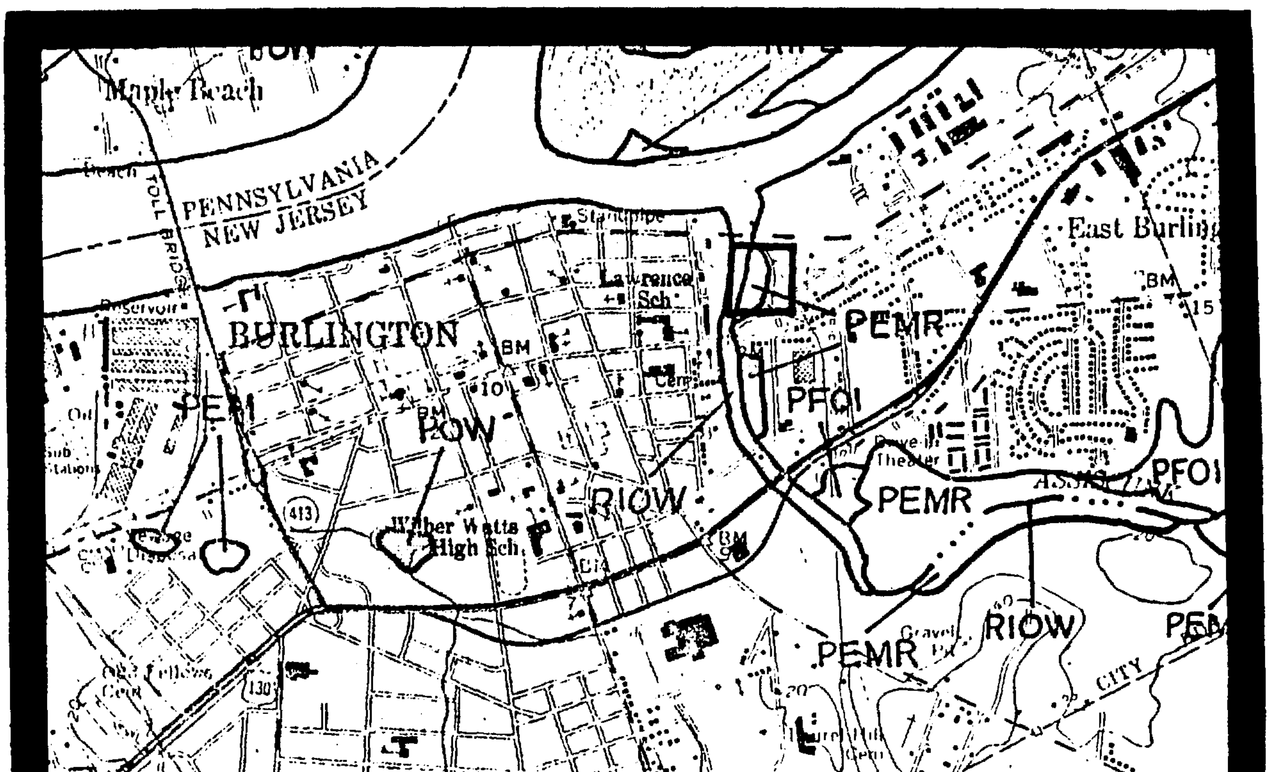
MAP A




Maple Beach
PENNSYLVANIA
NEW JERSEY
TOLL BRIDGE
Standpipe
Lawrence Sch
Reservoir
BURLINGTON
BM 12
Cem
Oil
Sub Station
Sewage Disposal
413
Wilber Watts High Sch
East Burling
Drive Theater
ASSISCUNK
Gravel Pit
CITY BDY
Odd Fellows Cem
130
Laurel Hill Cem

MAP B

MAP C


Maple Beach
PENNSYLVANIA
NEW JERSEY
Standpipe
Lawrence Sch
BURLINGTON
PEMR
PFOI
ROW
RIOW
PEMR
PFOI
413
Wilber Watts High Sch
East Burlin
PEMR
RIOW
130
CITY

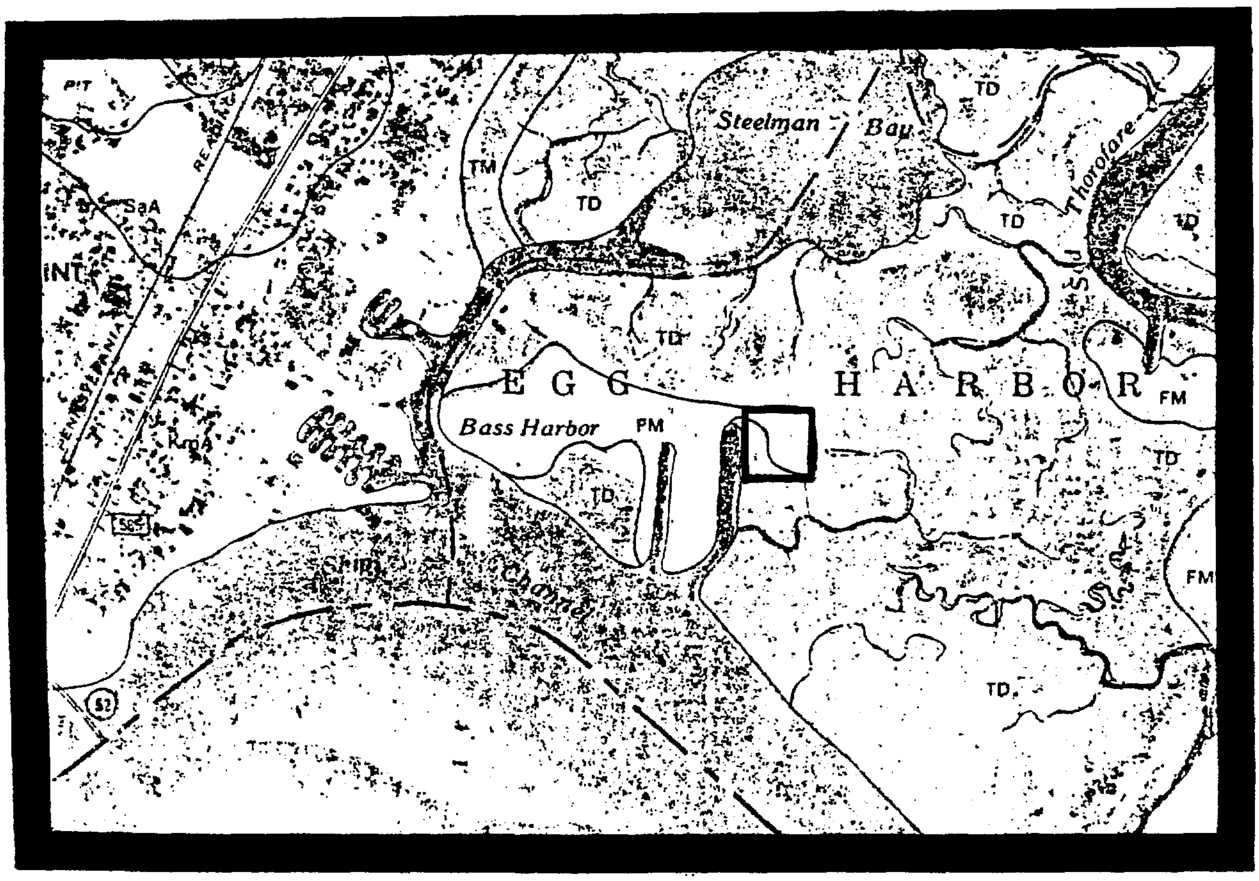
SITE 259 Pirate Cove Motel, Rt. 152, Egg Harbor Twp., Atlantic County.

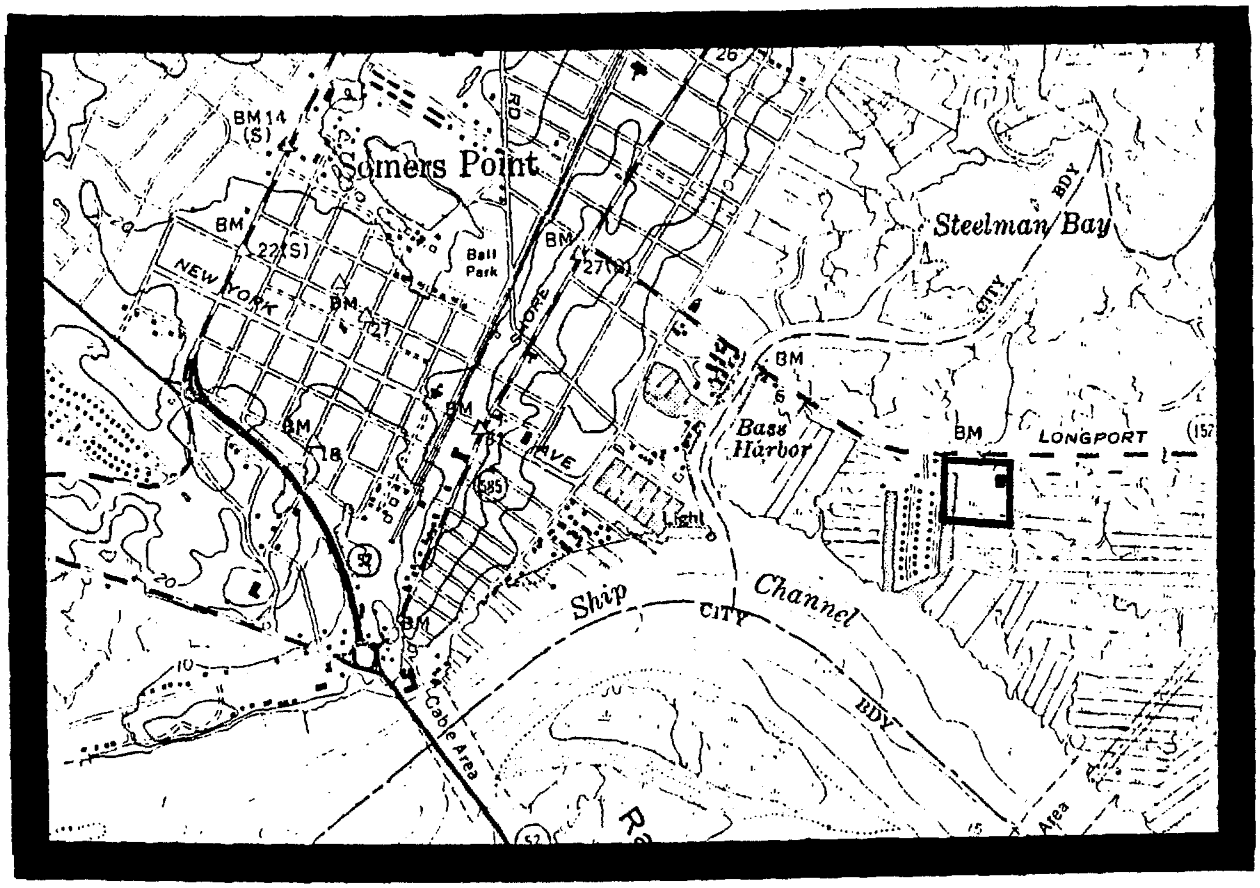
MAP A: Sheet # 50, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Ocean City, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Ocean City, N.J. Quadrangle (Scale 1:24,000)

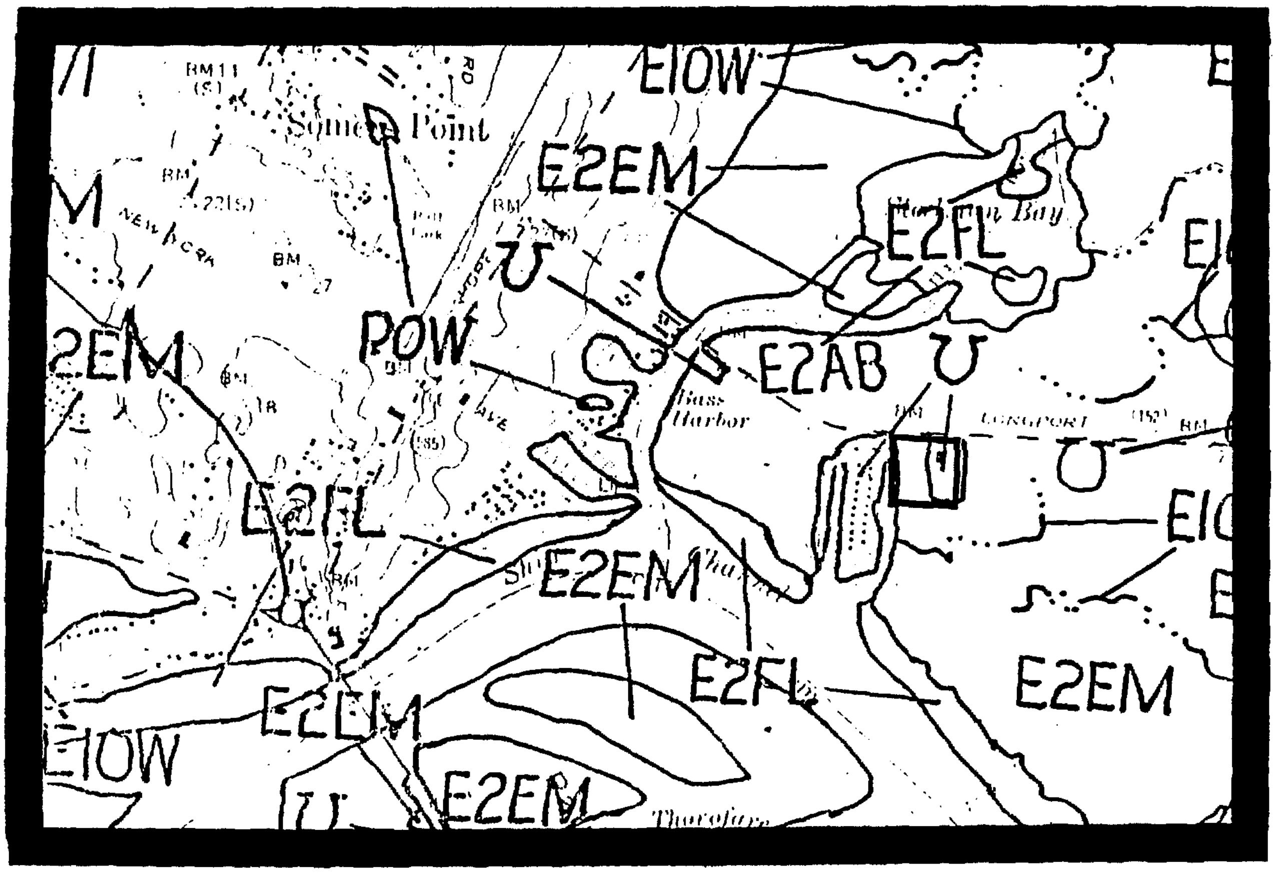
MAP A




Somers Point
Steelman Bay
NEW YORK
AVE
Ball Park
Bass Harbor
LONGPORT
Ship
Channel
CITY
BDY
Cable Area
Light

MAP B

MAP C


E1OW
E2EM
E2FL
POW
E2AB
E2EM
E2FL
E2EM
E2FL
E2EM
E1OW
E2EM
Somers Point
Bass Harbor
LONGPORT
Thorofare

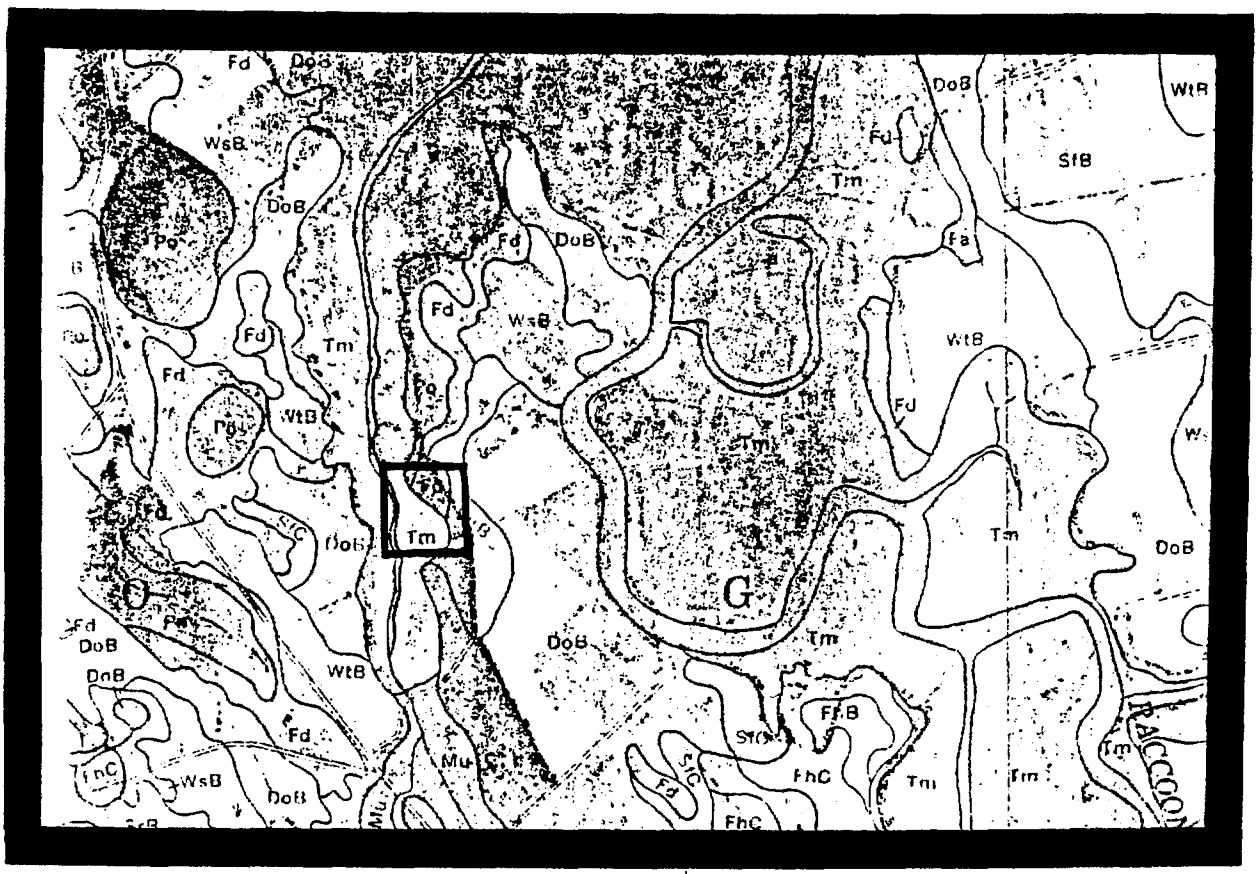
SITE 260 Pureland Industrial Complex, Gloucester County.

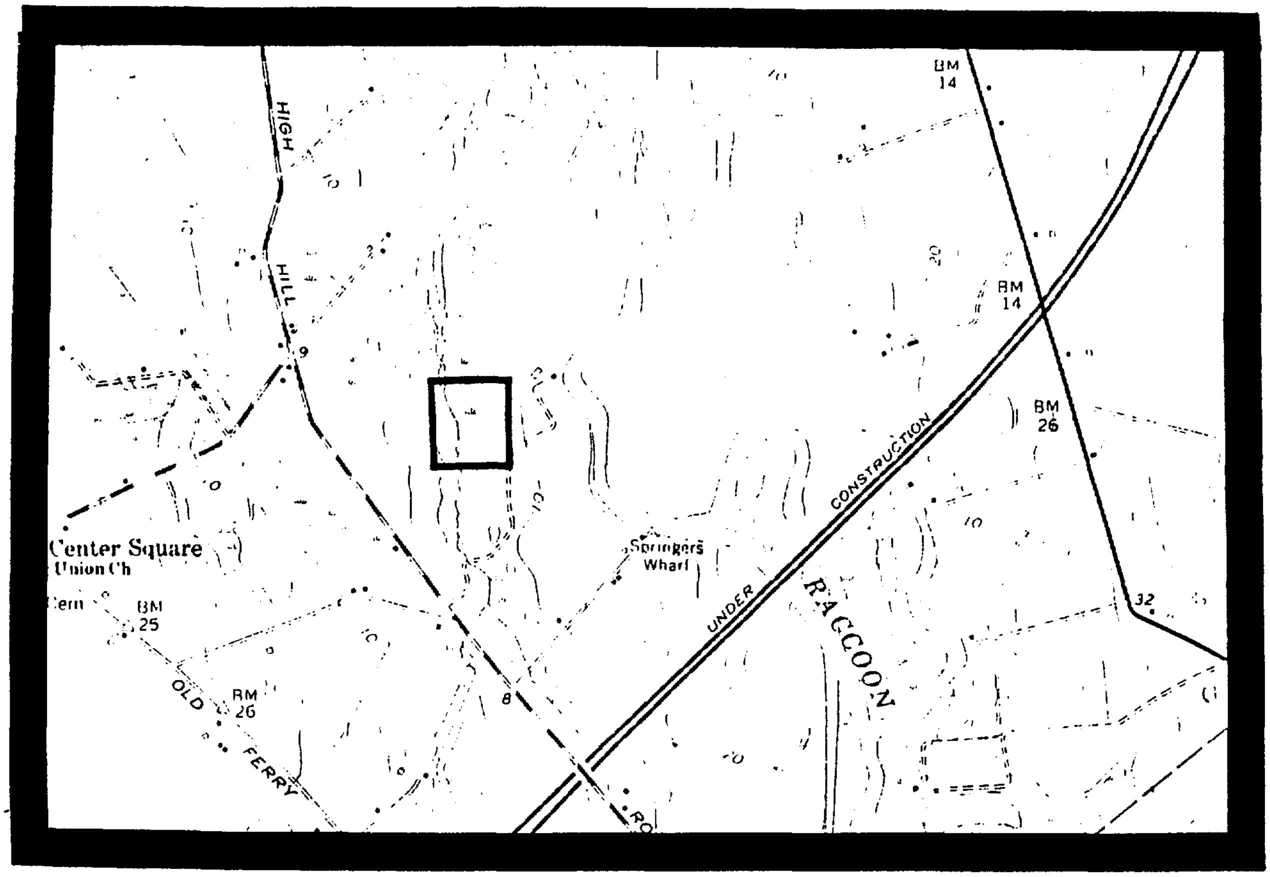
MAP A: Sheet # 12, Gloucester County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Bridgeport, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Bridgeport, N.J. Quadrangle (Scale 1:24,000)

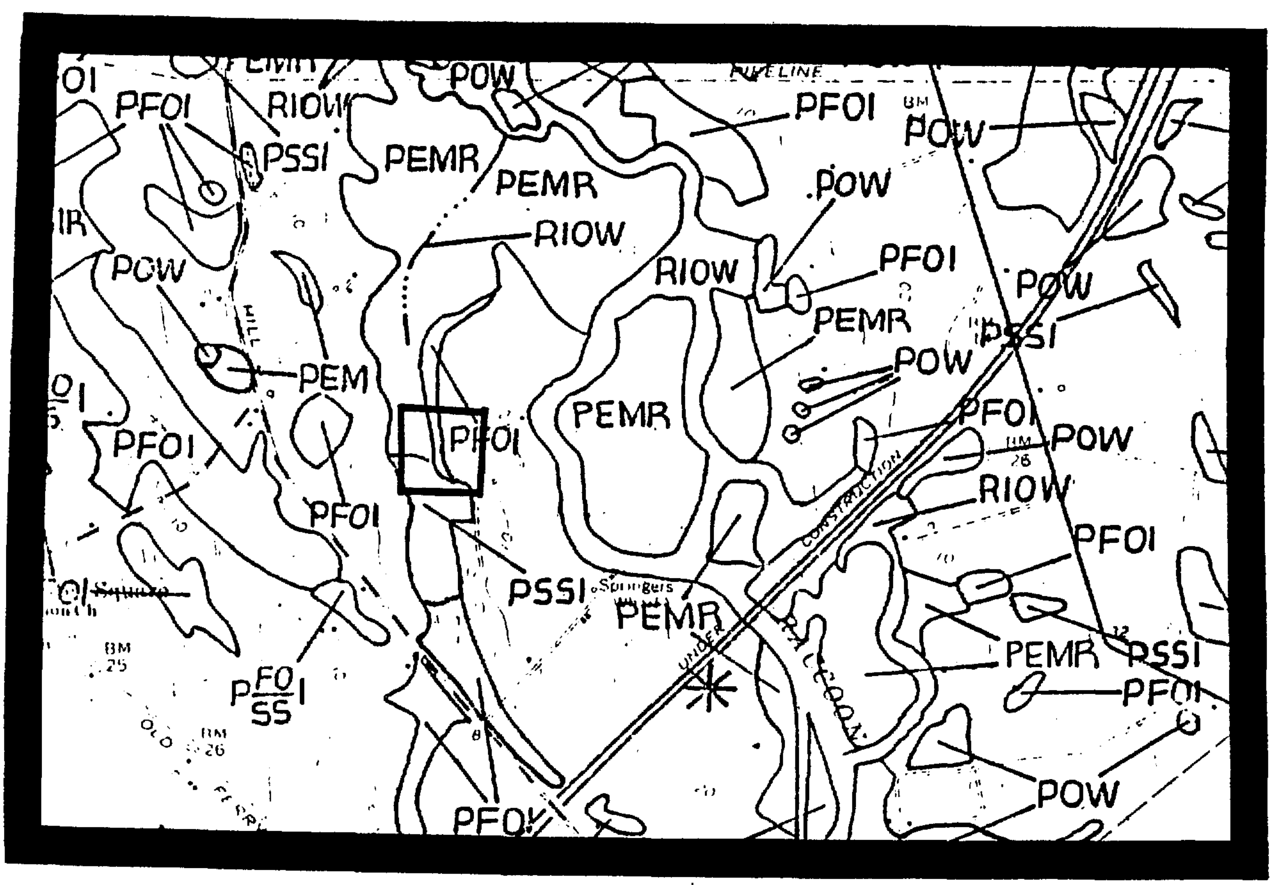
MAP A




HIGH HILL
Center Square
Union Ch
Cem
BM 25
BM 26
OLD FERRY RO
BM 14
BM 14
BM 26
Springers Wharf
UNDER CONSTRUCTION
RACCOON
32

MAP B

MAP C


PIPELINE
PFOI
RIOW
PSSI
PEMR
POW
PEMR
PFOI
POW
RIOW
RIOW
PFOI
POW
POW
PEMR
PSSI
PEM
POW
PFOI
PEMR
PFOI
PFOI
POW
PFOI
RIOW
PFOI
PSSI
PEMR
Springers
PFOI
P FO/SS I
PEMR
PSSI
PFOI
POW
PFOI
UNDER CONSTRUCTION
RACCOON

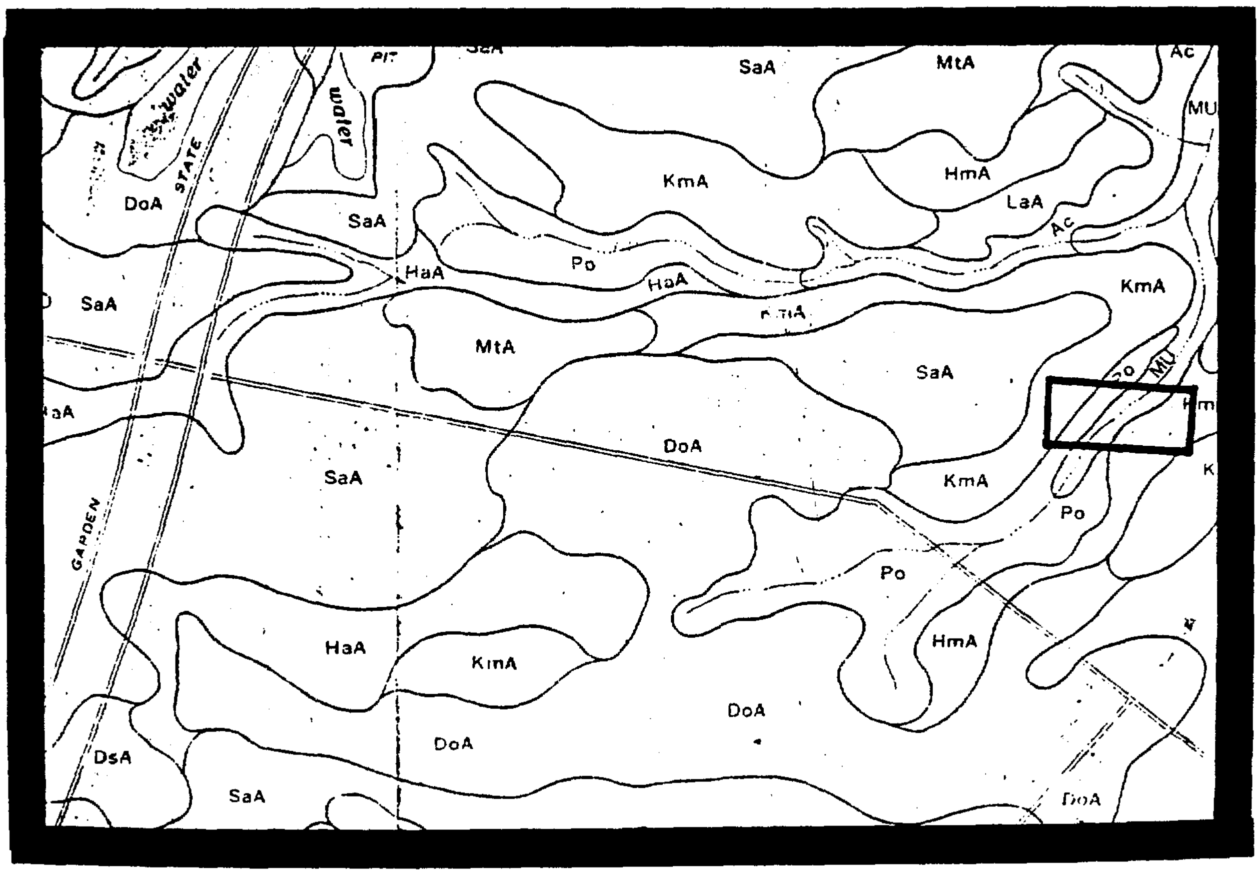
SITE 261 The Club at Mattix Forge, Galloway Twp., Atlantic County.

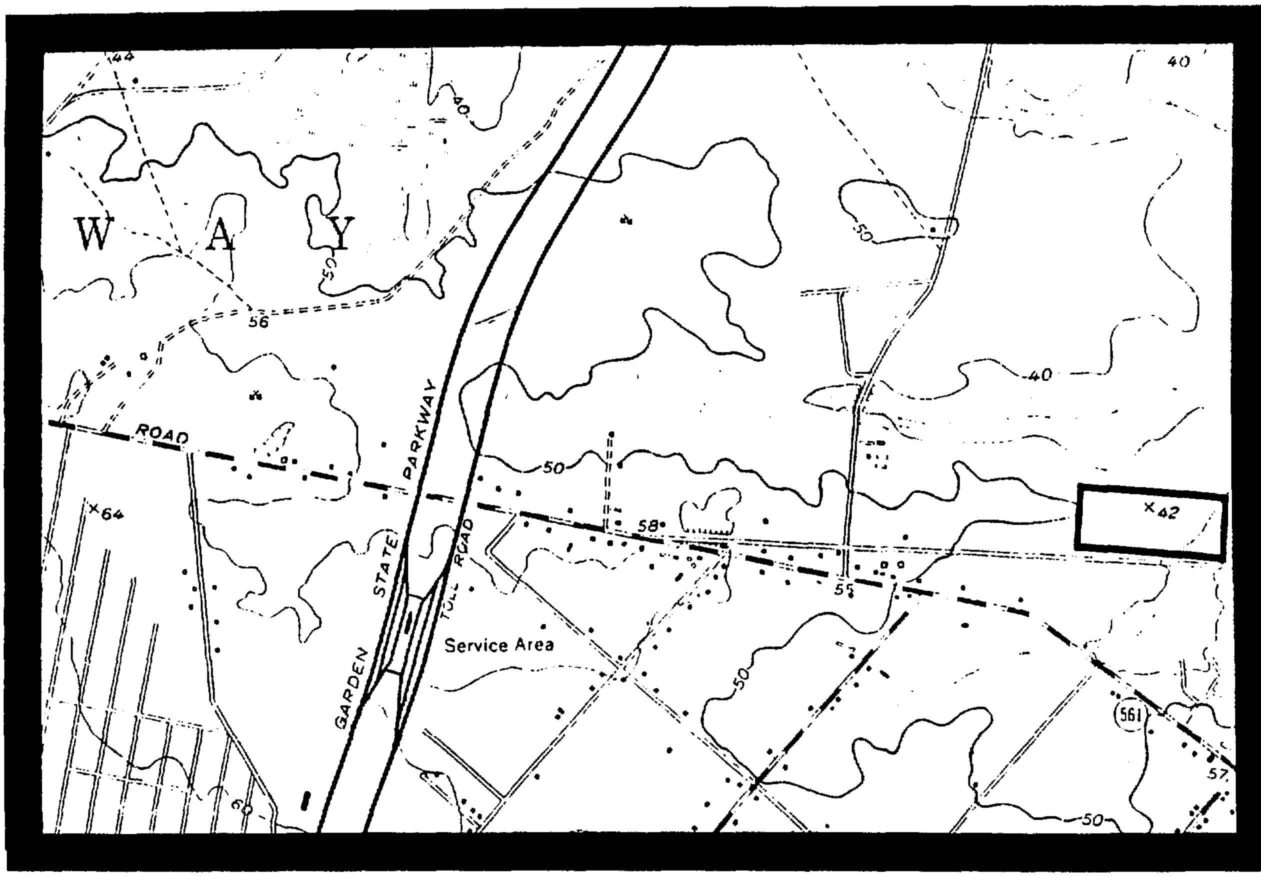
MAP A: Sheet # 26, Atlantic County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Pleasantville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Pleasantville, N.J. Quadrangle (Scale 1:24,000)

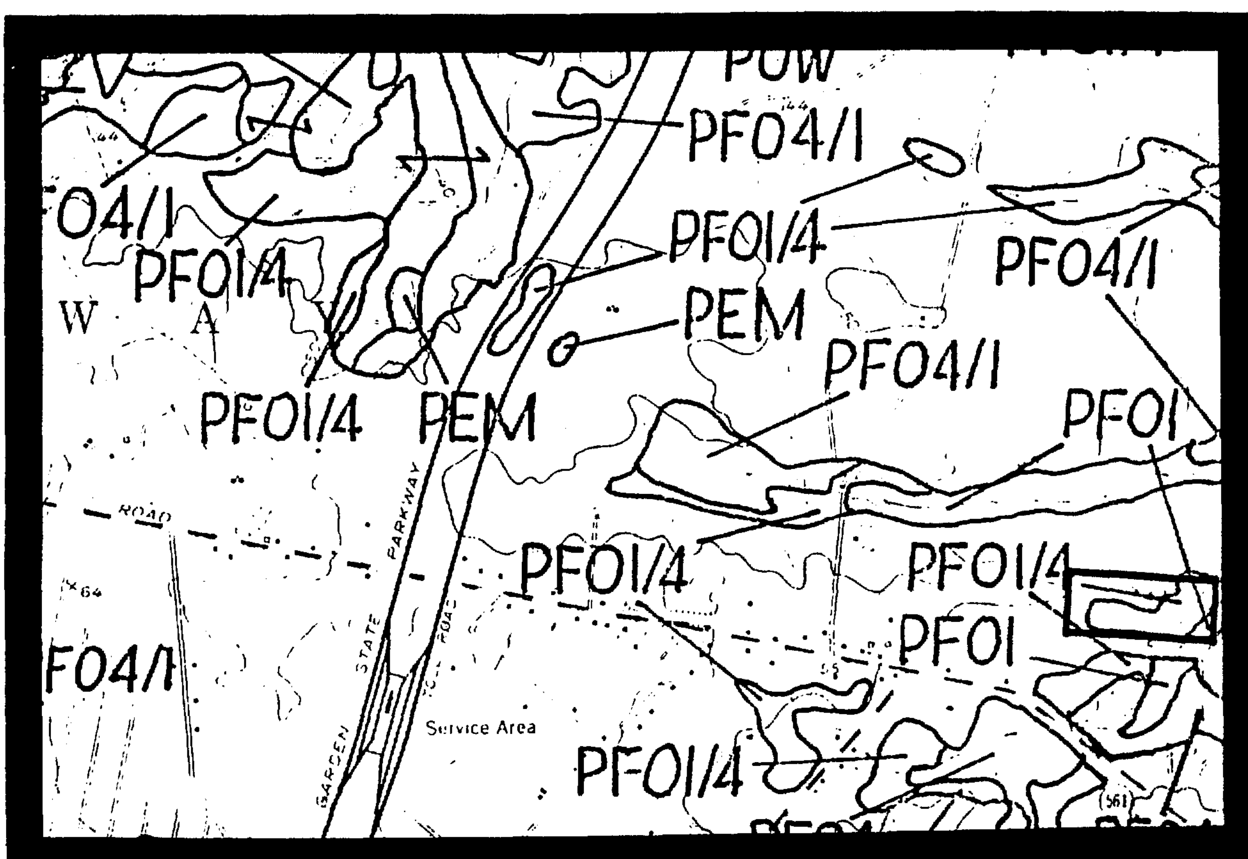
MAP A




W A Y
ROAD
PARKWAY
GARDEN STATE
TOLL ROAD
Service Area
561

MAP B

MAP C


PF04/1
PF01/4
PF04/1
PEM
PF04/1
PF01/4
PEM
PF01
PF01/4
PF01/4
PF01
F04/1
PF01/4
Service Area
PARKWAY
ROAD

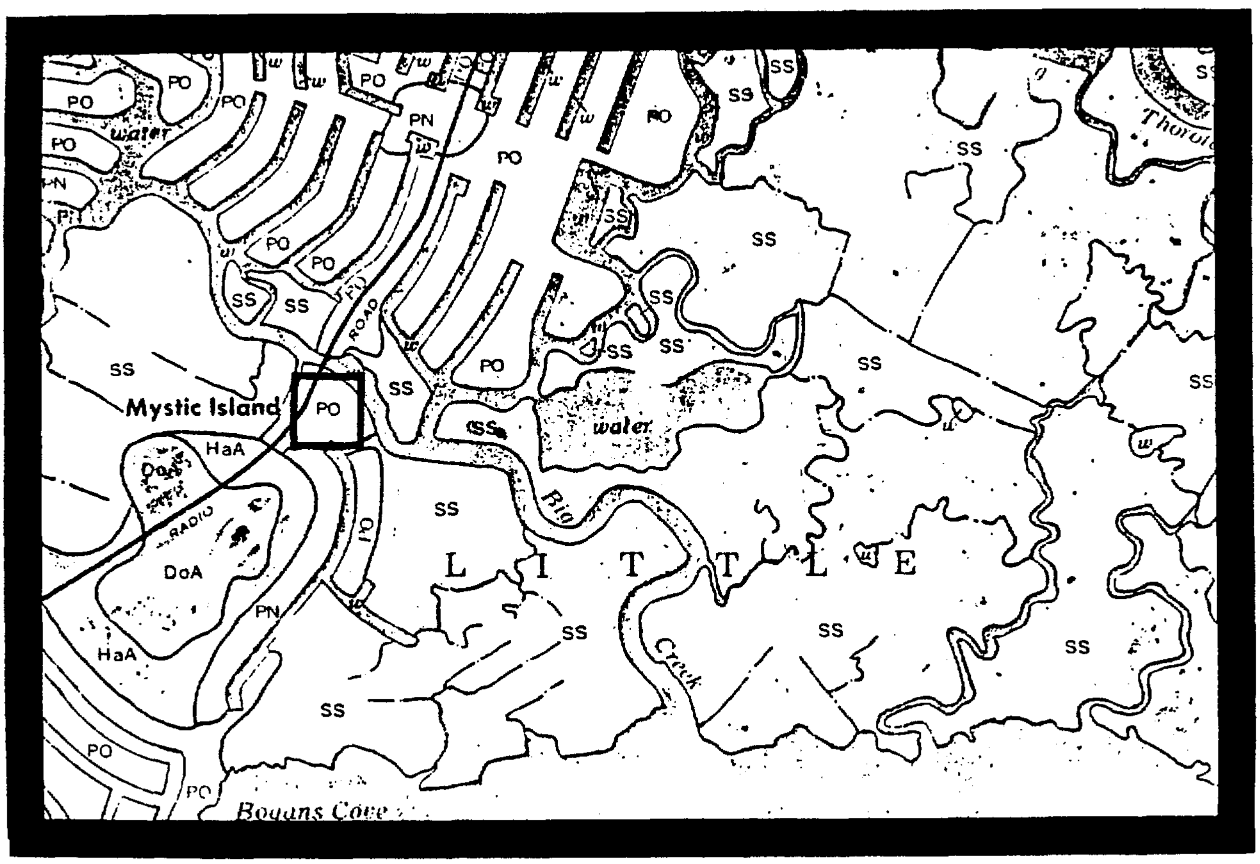
SITE 262 Alabama/Ocean Blvd., Mystic Island, Ocean County.

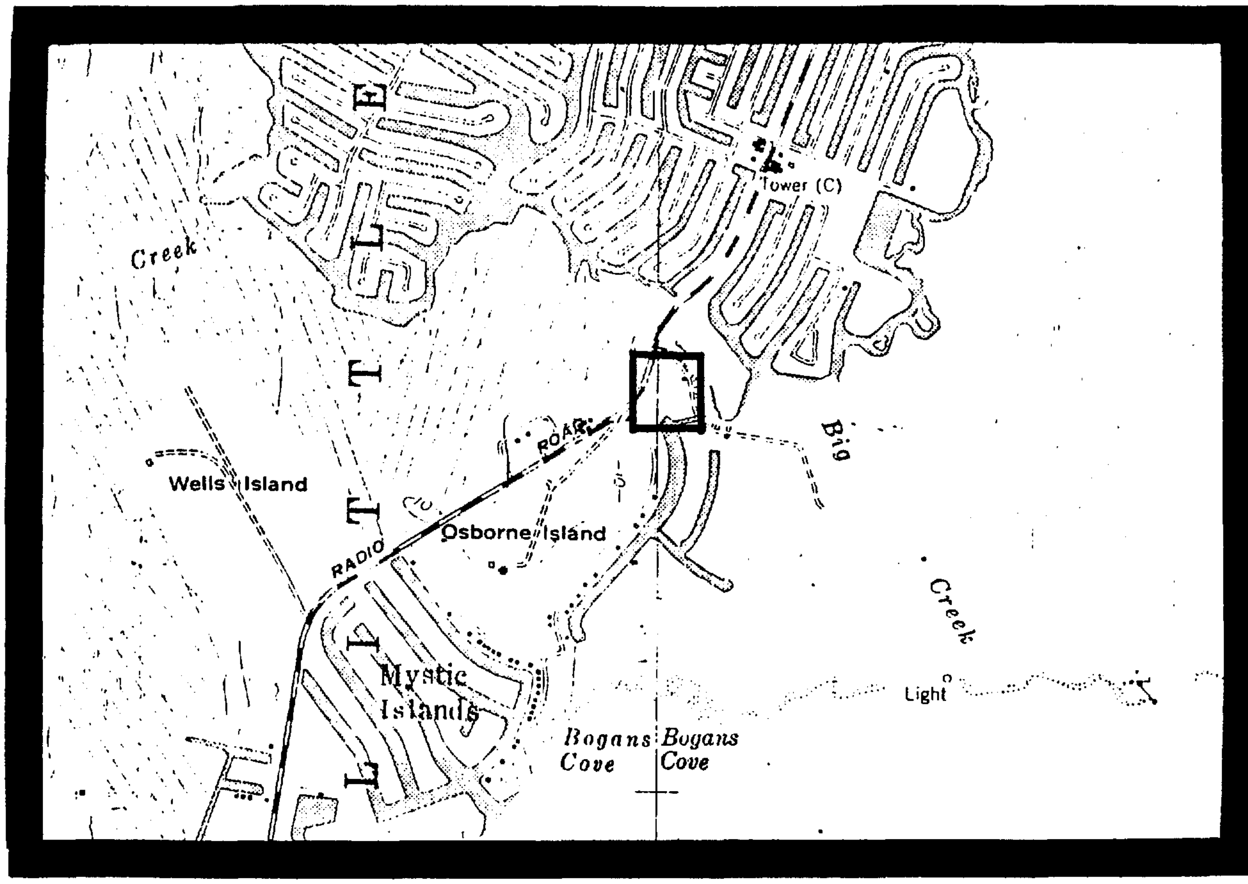
MAP A: Sheet # 62, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton & New Gretna, N.J. Topographic Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tuckerton & New Gretna, N.J. Quadrangles (Scale 1:24,000)

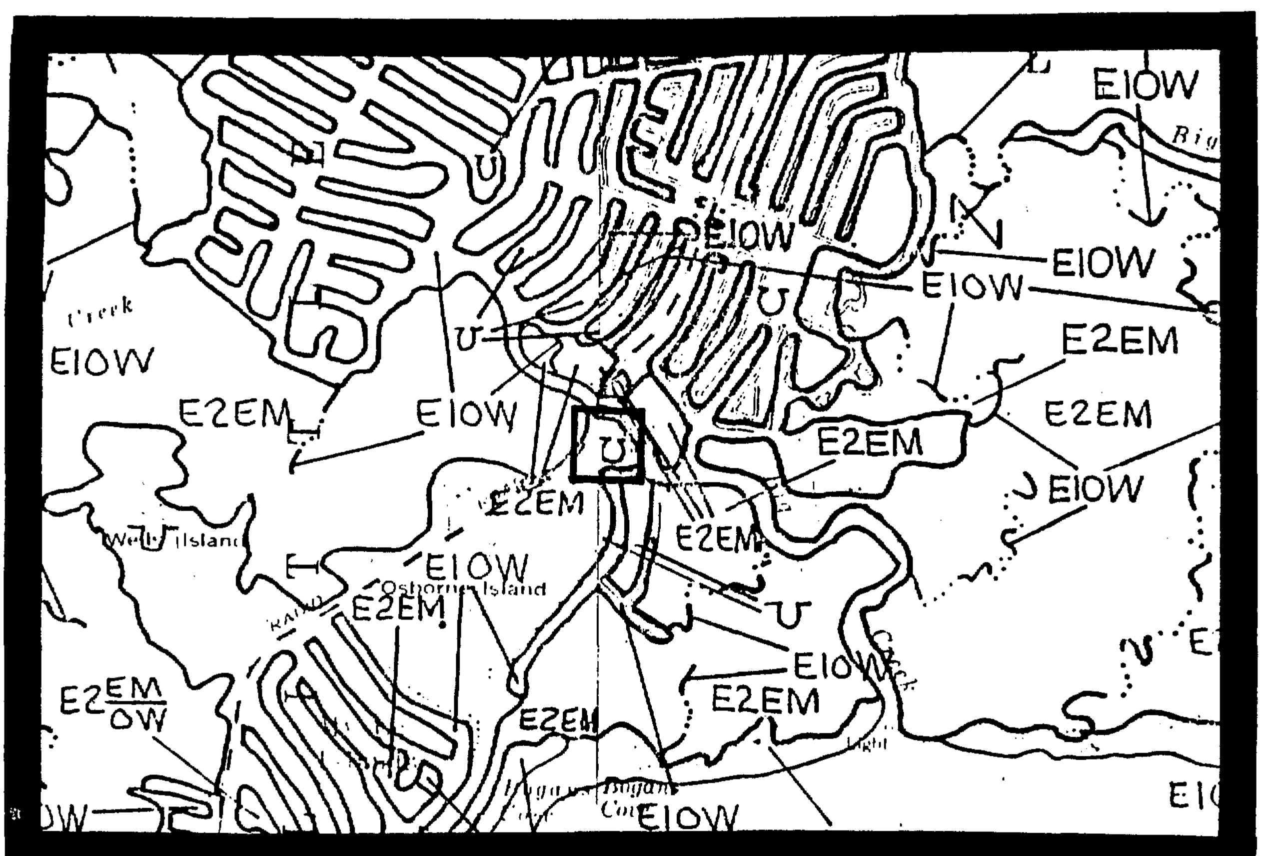
MAP A




Creek
Tower (C)
Big
ROAD
RADIO
Wells Island
Osborne Island
Creek
Mystic Islands
Light
Bogans Cove
Bogans Cove

MAP B

MAP C


E1OW
E1OW
E1OW
E1OW
Creek
E1OW
E2EM
E2EM
E1OW
E2EM
E2EM
E2EM
E1OW
E2EM
E2EM
Wells Island
E1OW
Osborne Island
E2EM
E2 EM/OW
E1OW
E2EM
E2EM
Light
E1OW

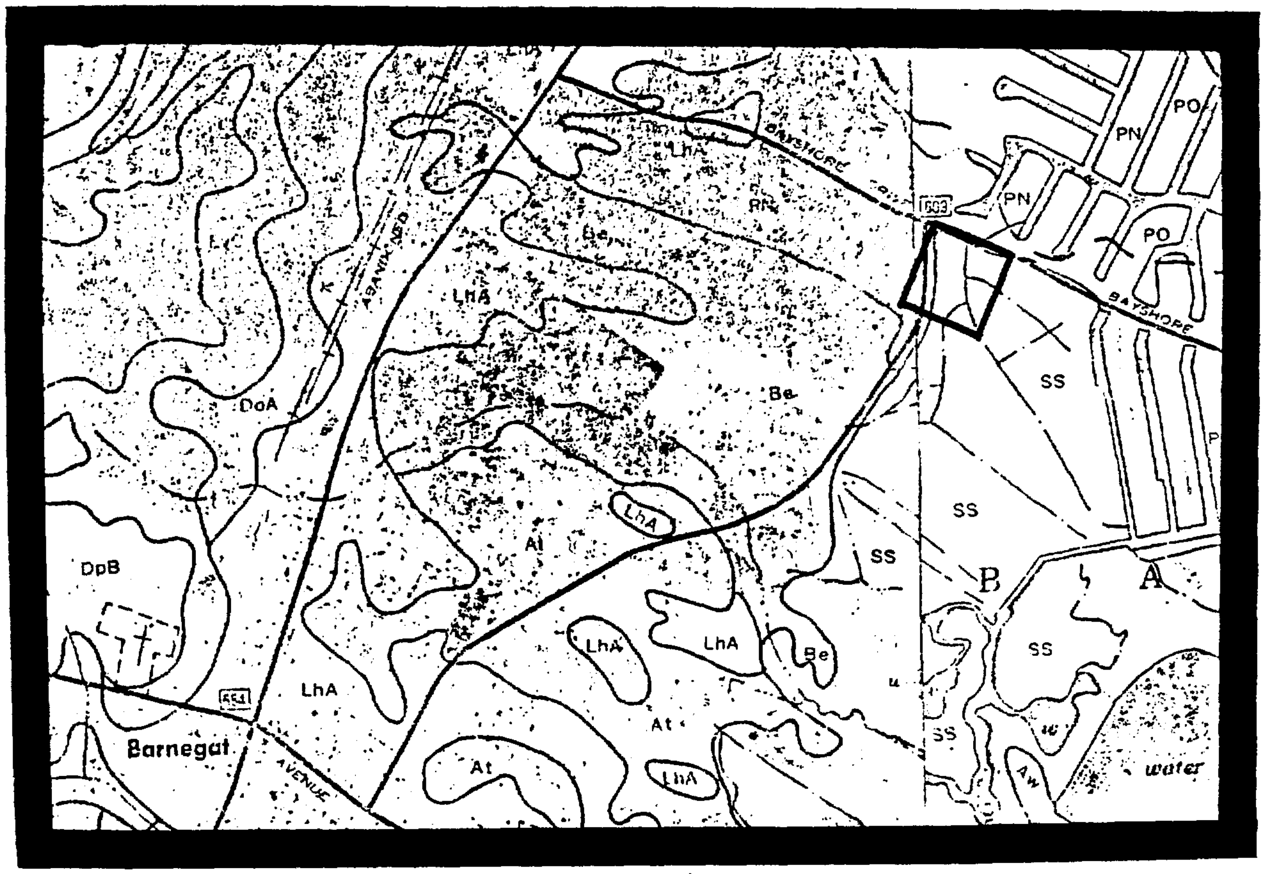
SITE 263 Crossroads/Four Seasons, Barnegat, Ocean County.

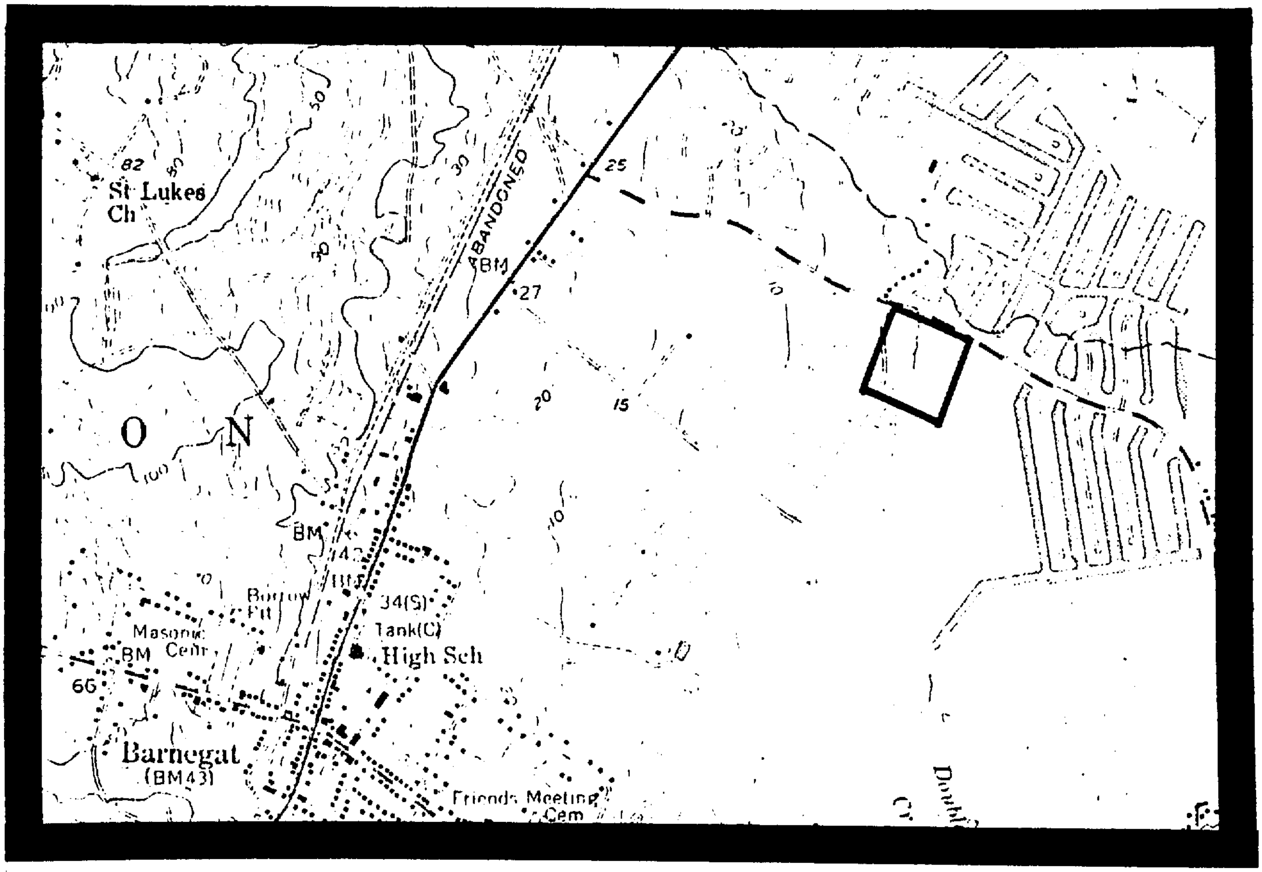
MAP A: Sheets # 47 & 48, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked River, N.J. Quadrangle (Scale 1:24,000)

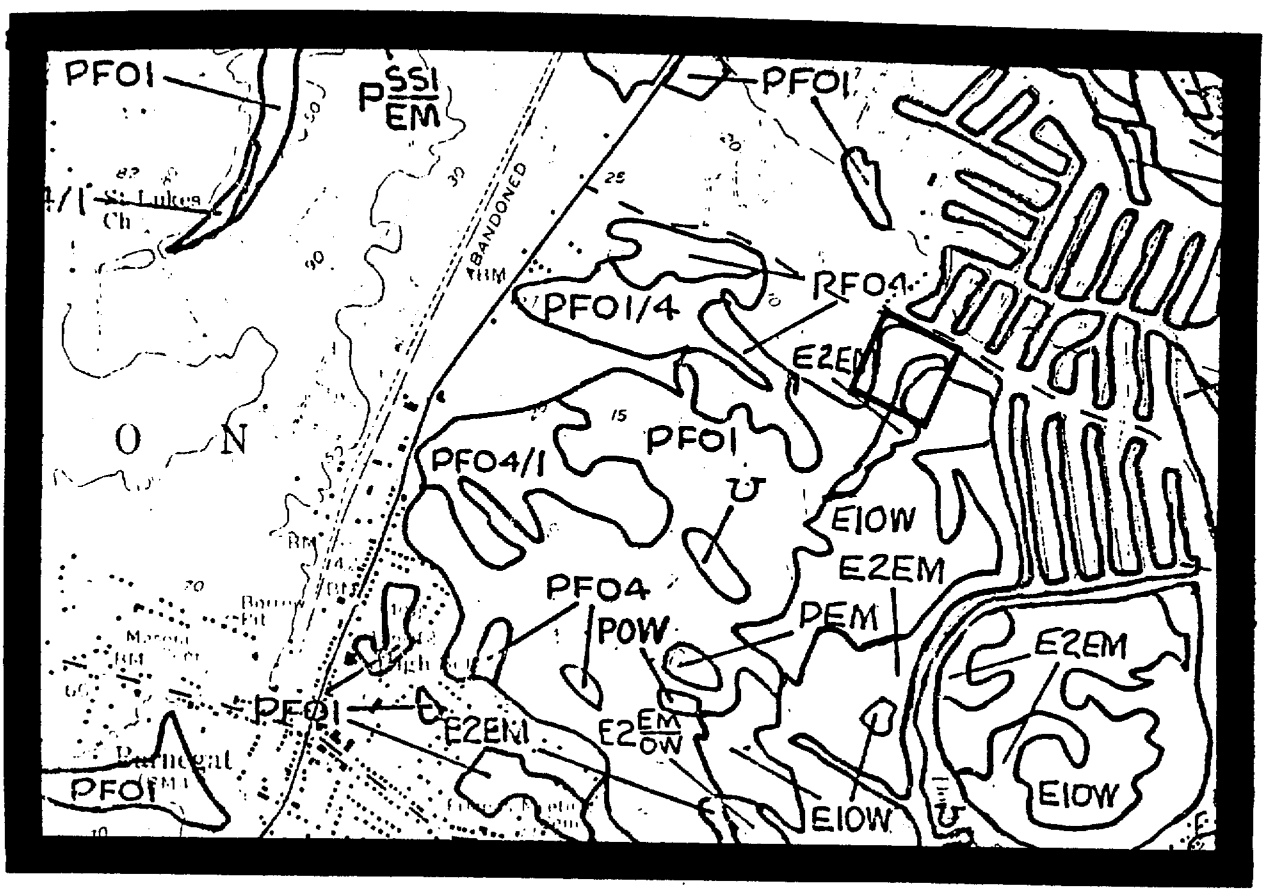
MAP A




St Lukes Ch
ABANDONED
BM
O
N
Borrow Pit
Masonic Cemy
34(S)
Tank(C)
High Sch
Barnegat
(BM43)
Friends Meeting Cem

MAP B

MAP C


PFO1
P SSI/EM
ABANDONED
PFO4
PFO1/4
E2EM
PFO1
PFO4/1
E1OW
E2EM
PFO4
POW
PEM
E2EM
PFO1
E2EM
E2 EM/OW
E1OW
E1OW
PFO1

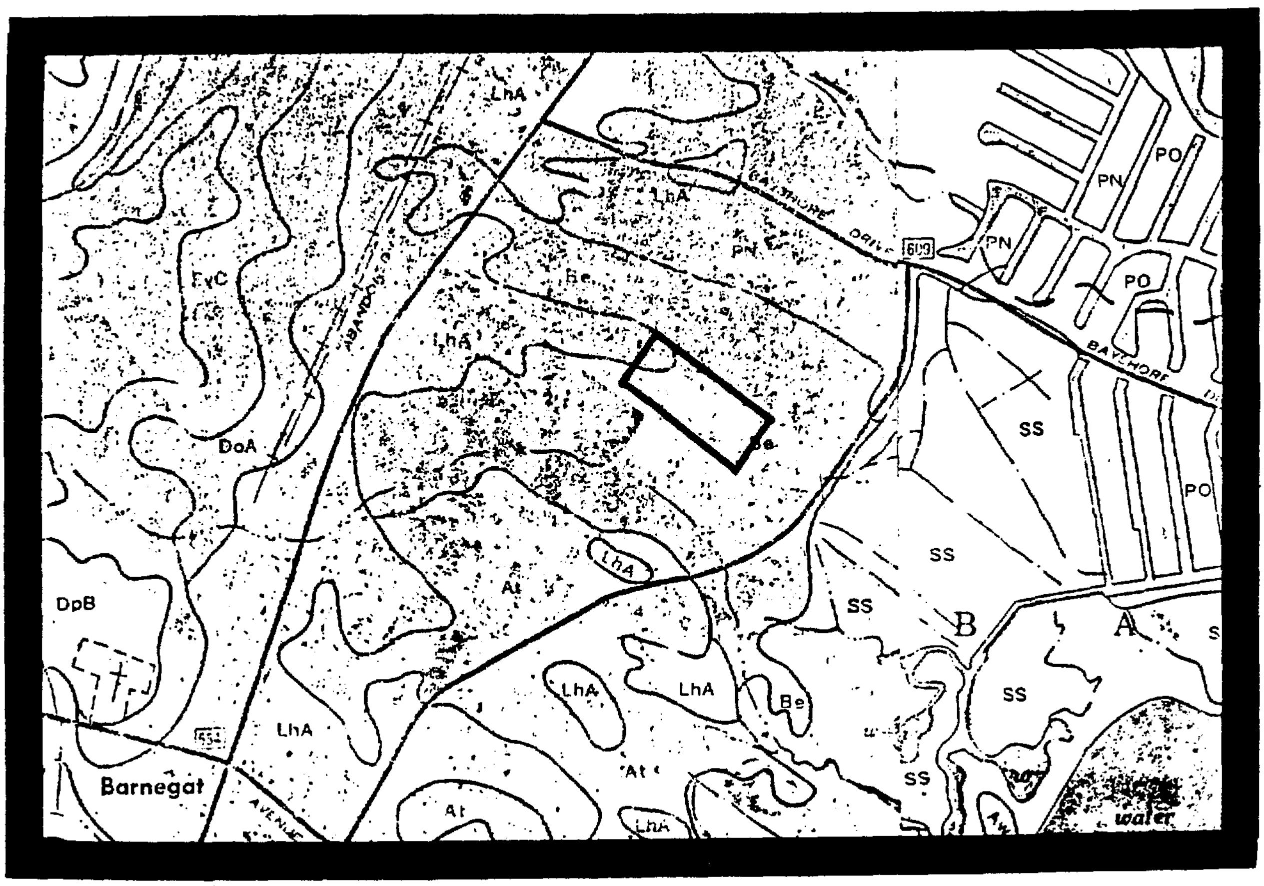
SITE 264 Barnegat Swamp, Barnegat, Ocean County.

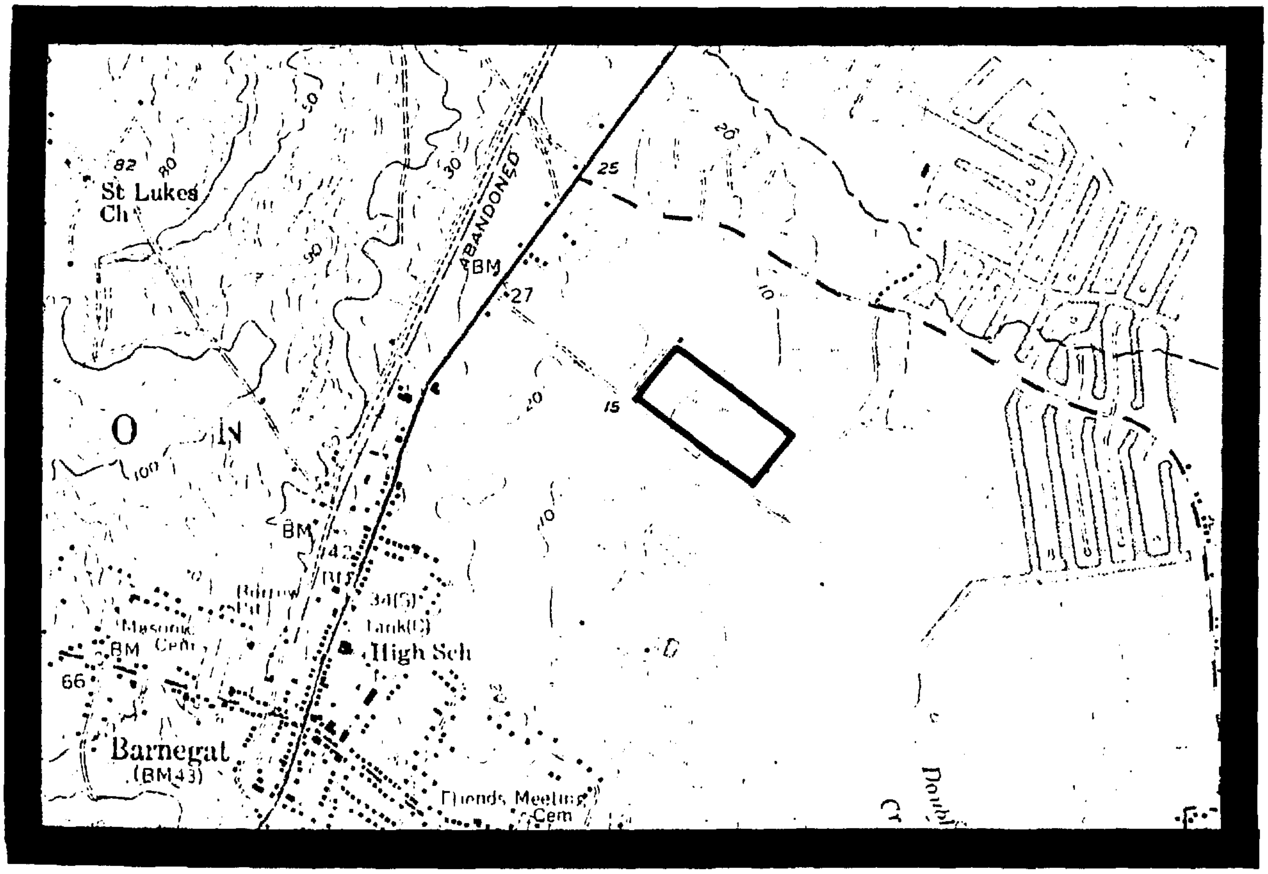
MAP A: Sheets # 47 & 48, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked River, N.J. Quadrangle (Scale 1:24,000)

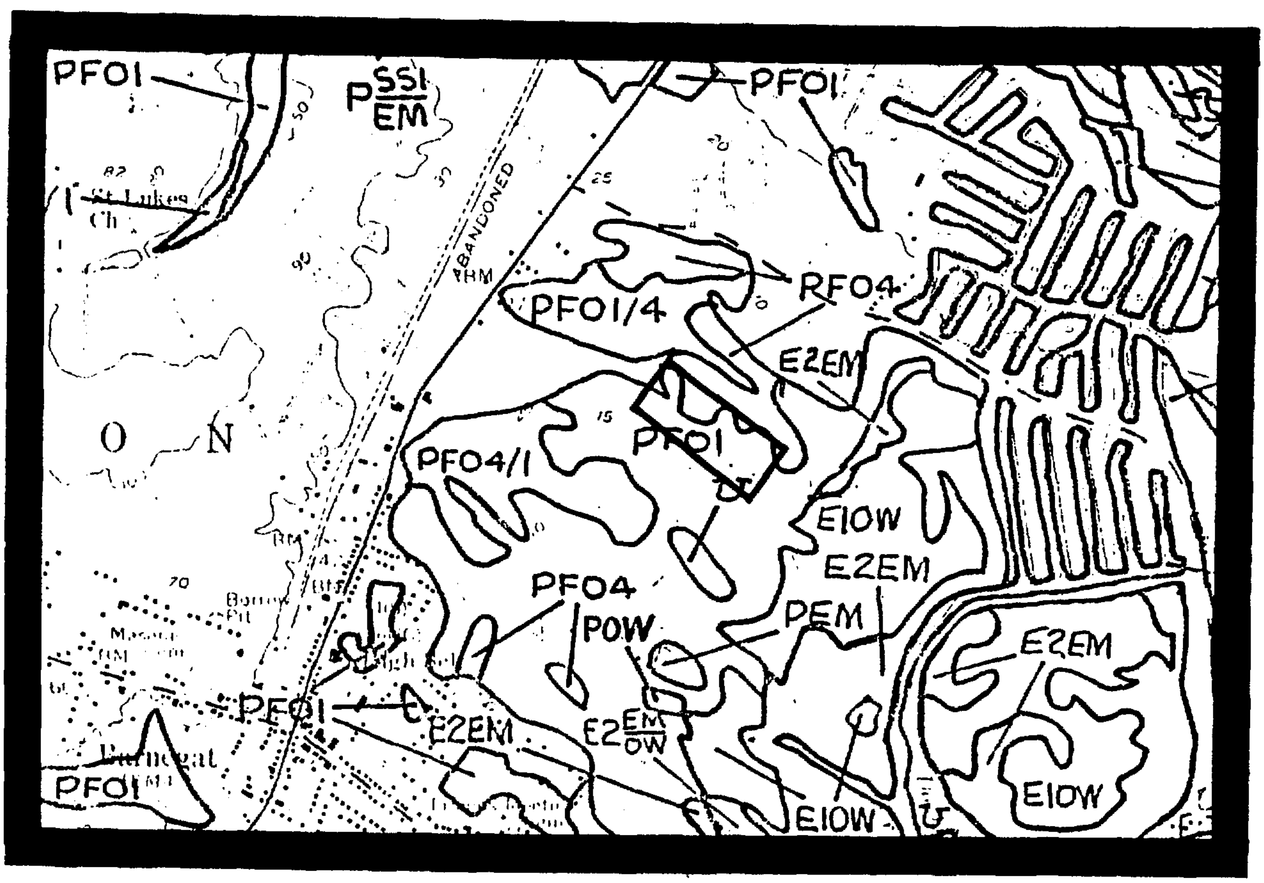
MAP A




St Lukes Ch
ABANDONED
High Sch
Barnegat
(BM43)
Friends Meeting Cem

MAP B

MAP C


PFO1
P SSI/EM
PFO1
RFO4
PFO1/4
E2EM
PFO4/1
PFO1
E1OW
E2EM
PFO4
POW
PEM
E2EM
PFO1
E2EM
E2 EM/OW
E1OW
E1OW
PFO1

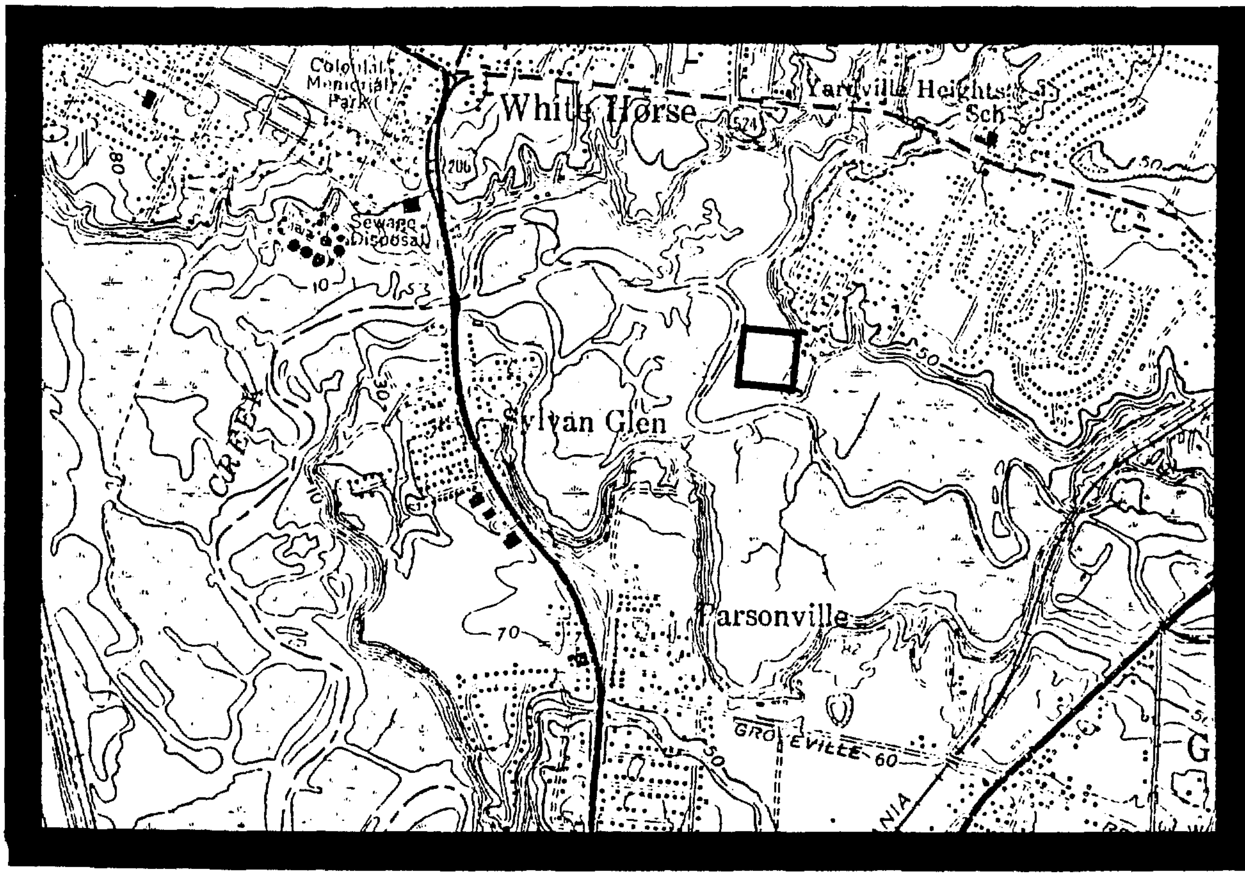
SITE 265 Soden Dr., Yardville, Mercer County.

MAP A: Sheets # 27 & 30, Mercer County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

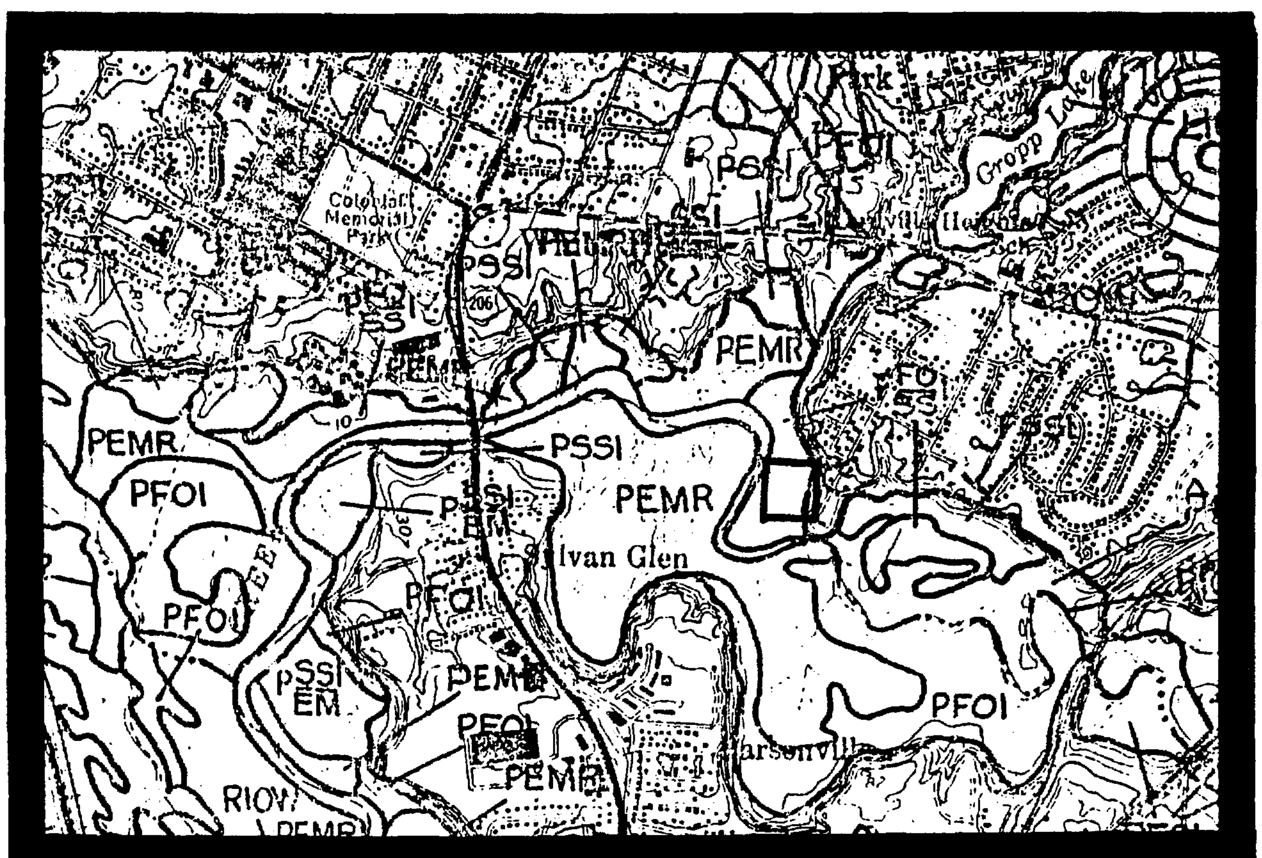
MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

MAP A


Colonial Memorial Park
White Horse
Yardville Heights Sch
Sewage Disposal
CREEK
Sylvan Glen
Parsonville
GROVEVILLE

MAP B

MAP C


Park
Gropp Lake
Colonial Memorial Park
PSSI
PFOI
PEMR
PSSI
PFOI
PSSI
PEMR
PEMR
PFOI
Sylvan Glen
PFOI
PSSI EM
PEMB
PFOI
PEMB
PFOI
RIOW
PEMR

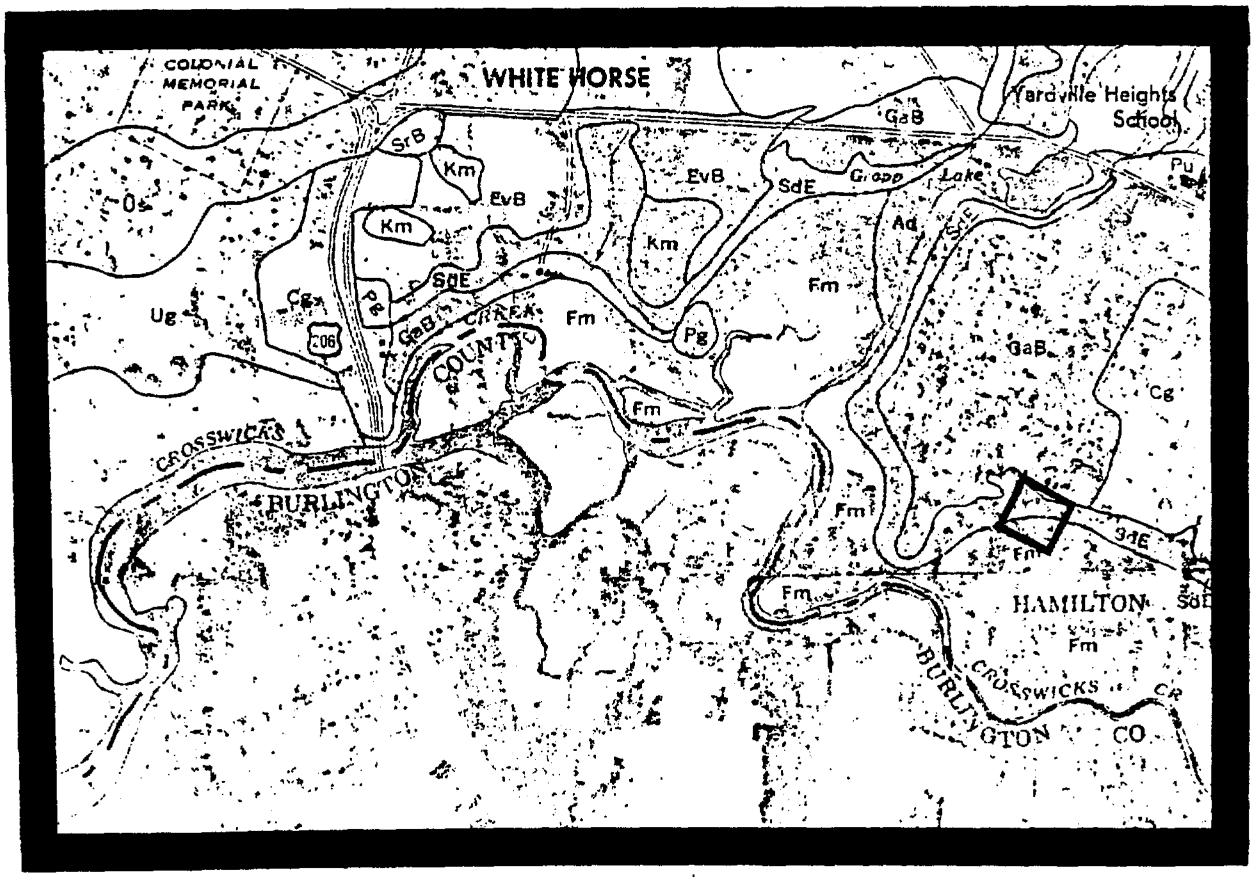
SITE 266 Highland Ave., Yardville, Mercer County.

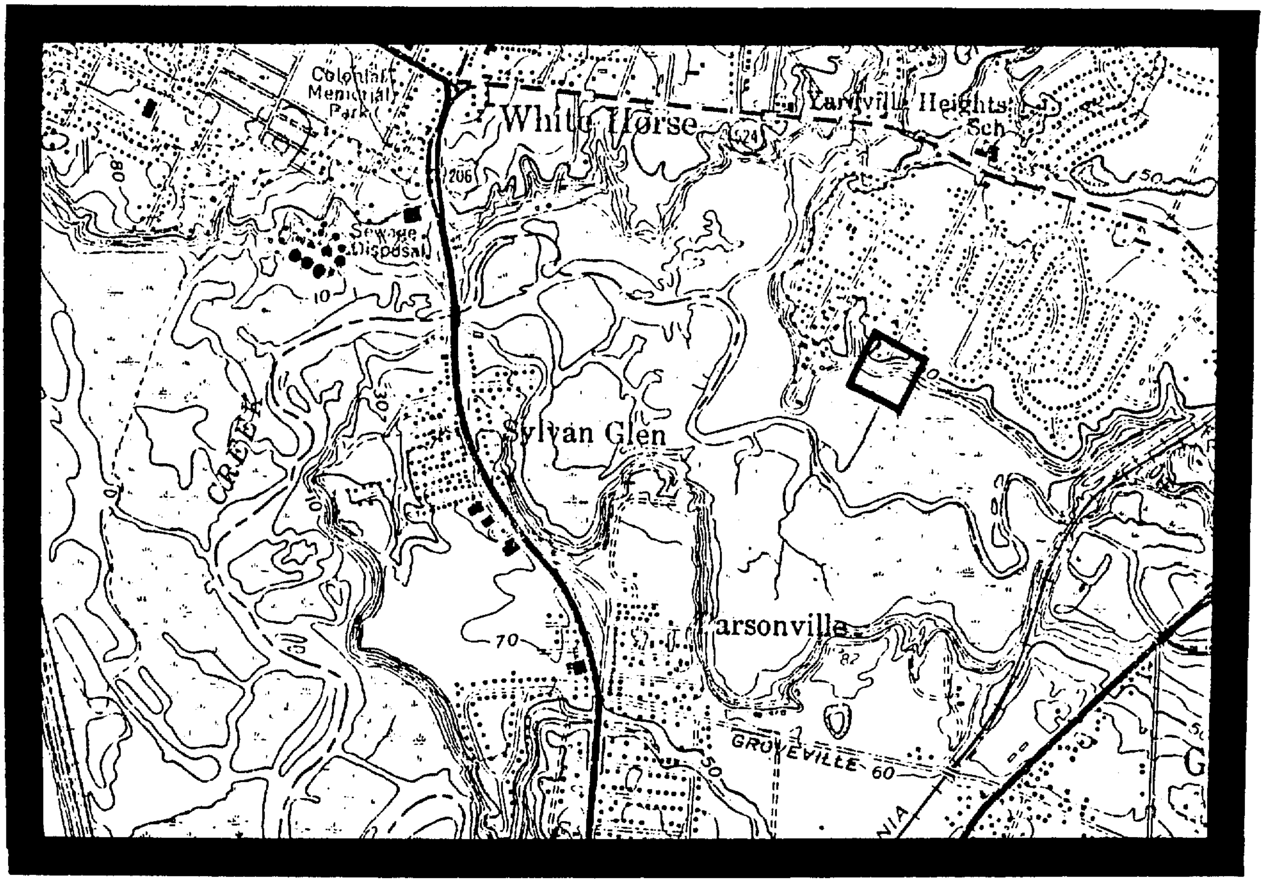
MAP A: Sheets # 27 & 30, Mercer County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

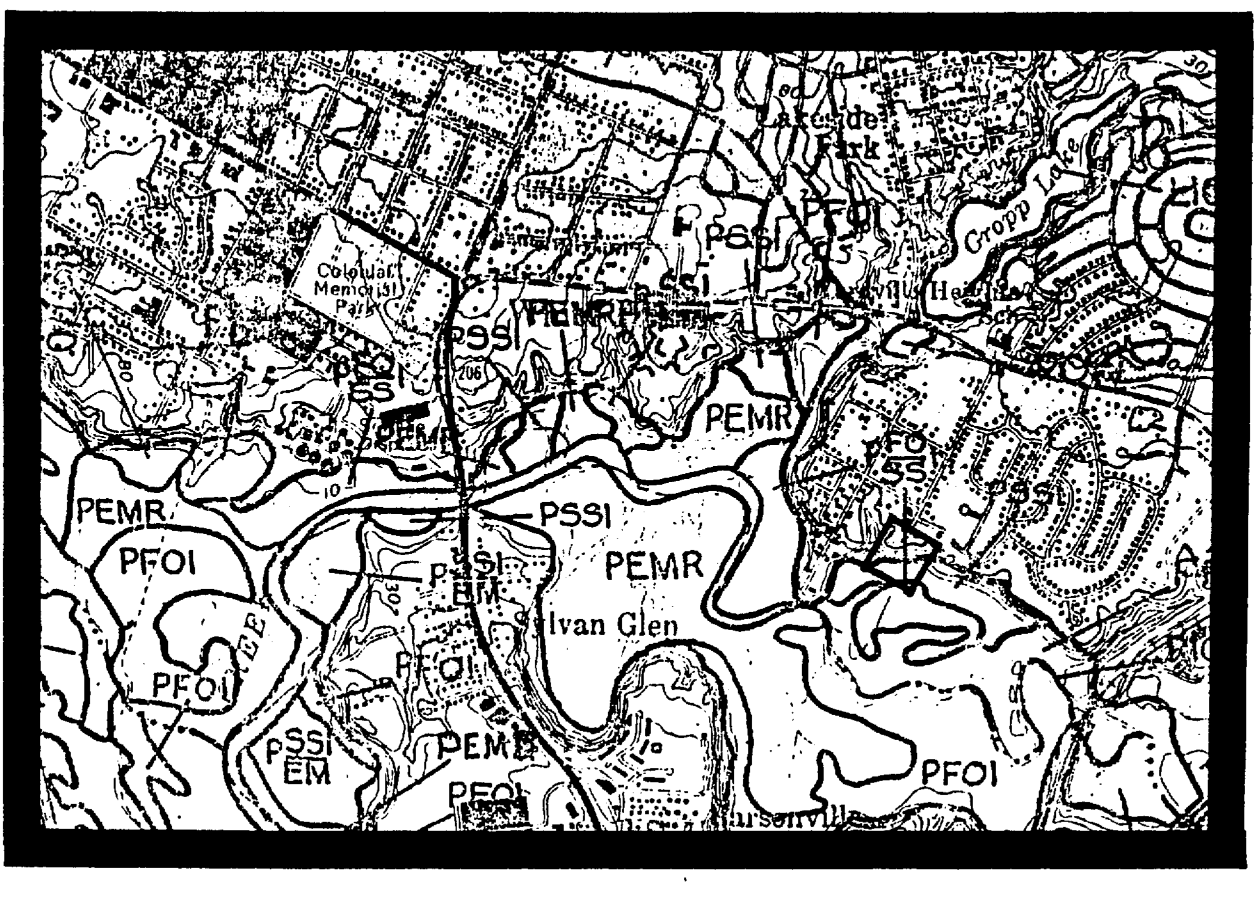
MAP A




White Horse
Sylvan Glen
Sewage Disposal
GROVEVILLE
206

MAP B

MAP C


Gropp Lake
PSSI
PFOI
PEMR
PEMR
PSSI
PEMR
PFOI
PSSI EM
PFOI
PFOI
PSSI EM
PFOI
Sylvan Glen
206

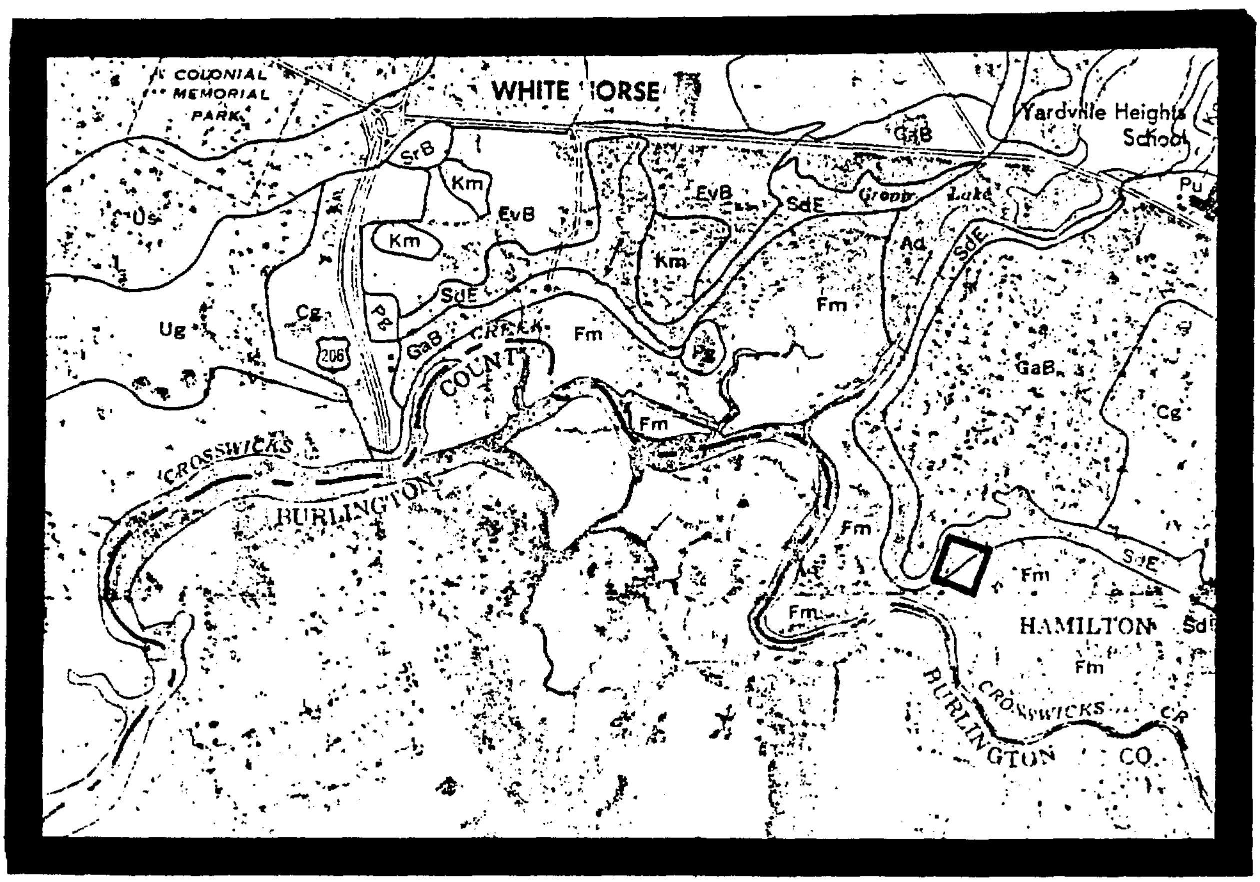
SITE 267 Soden Dr. II, Yardville, Mercer County.

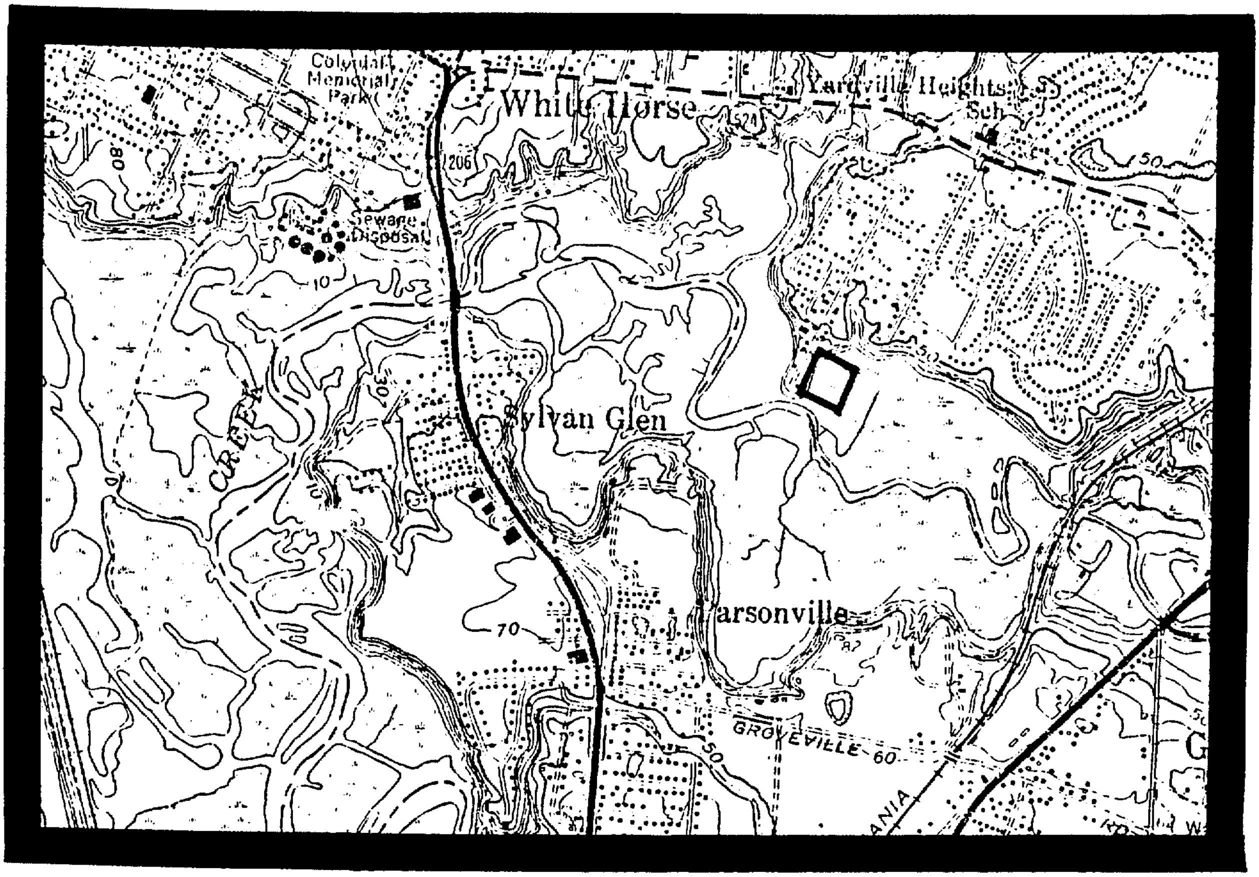
MAP A: Sheets # 27 & 30, Mercer County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

MAP A

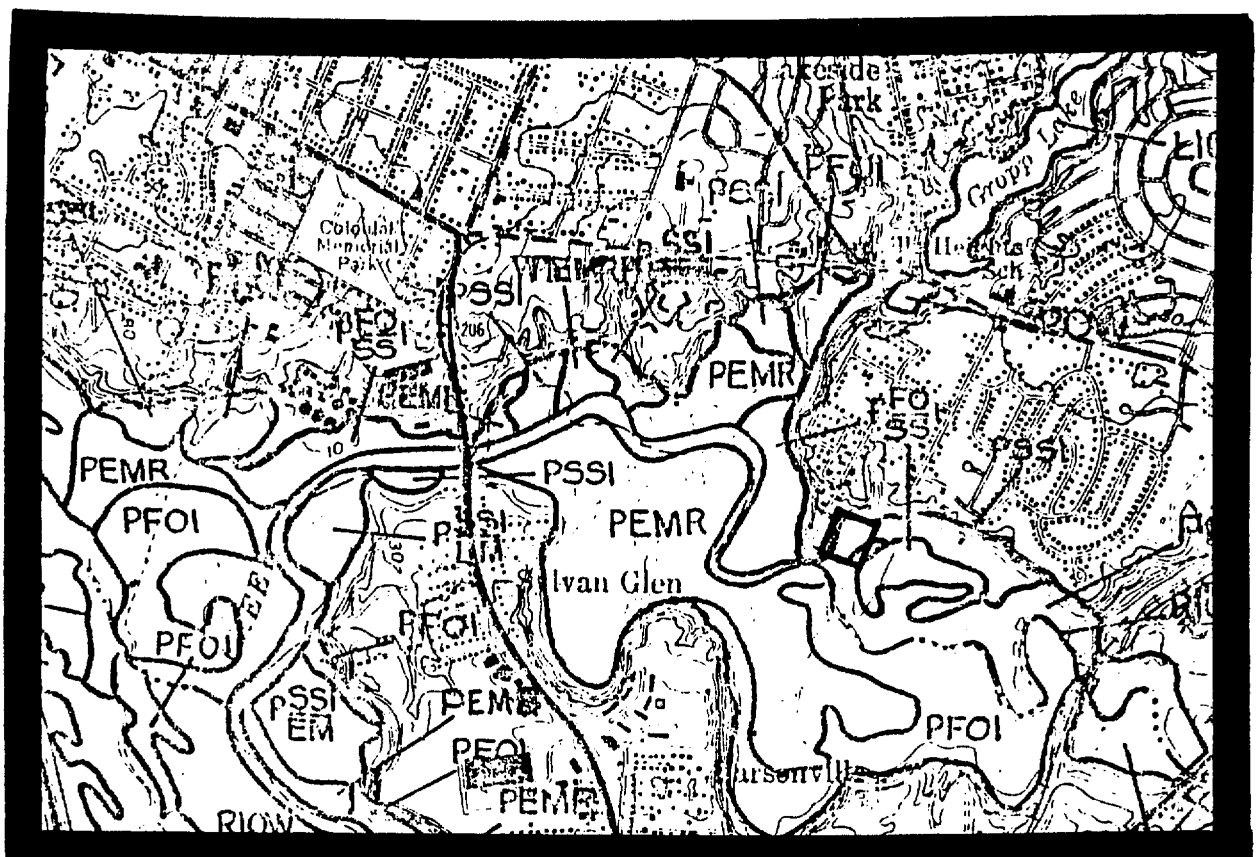




Colonial Memorial Park
White Horse
Yardville Heights
Sch
524
206
Sewage Disposal
Sylvan Glen
Parsonville
GROVEVILLE

MAP B

MAP C



Lakeside Park
Colonial Memorial Park
Gropp Lake
PFOI
PSSI
PEMR
PFOI
PSSI
PEMR
PSSI
PFOI
PSSI
PEMR
Sylvan Glen
PFOI
PFOI
PSSI
EM
PEMR
PFOI
PEMR
PFOI

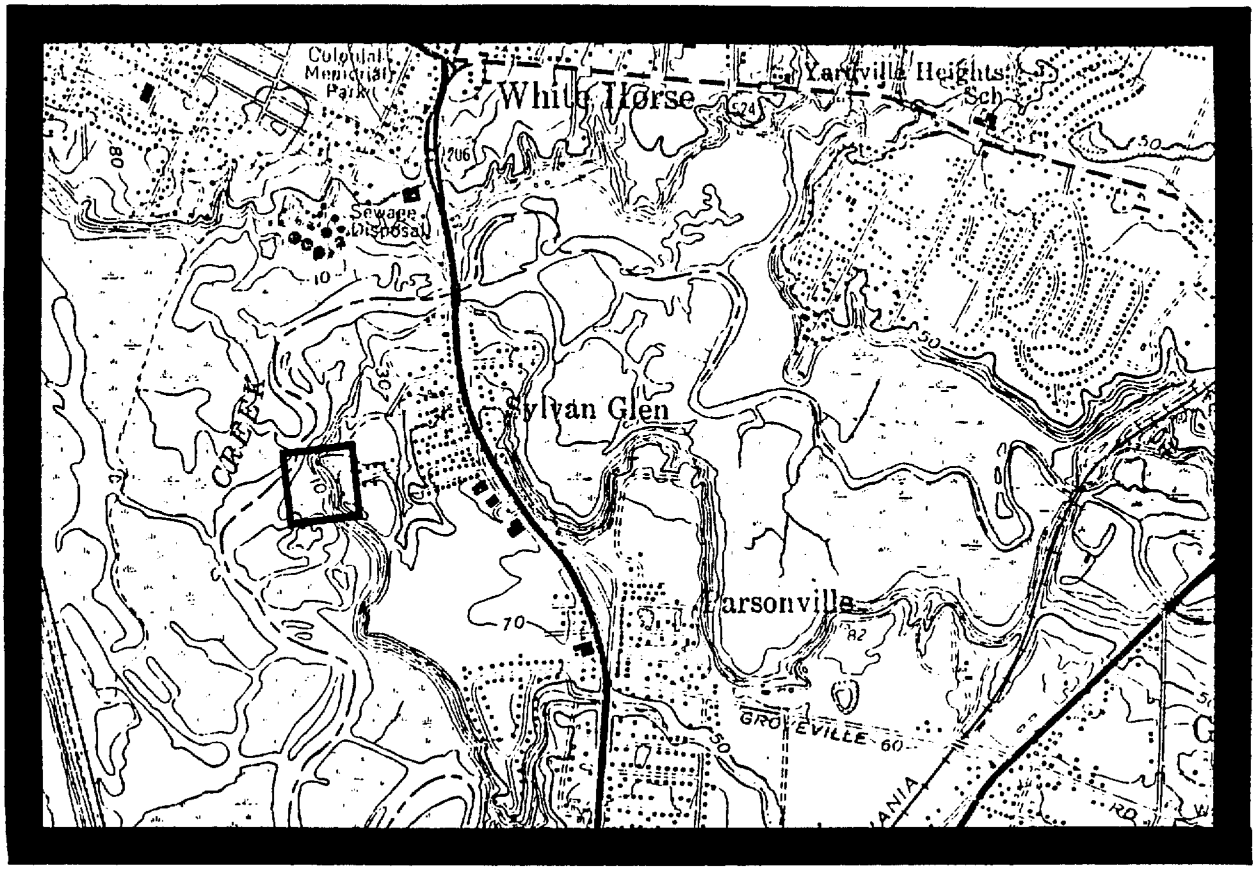
SITE 268 Grover Ave., Bordentown, Burlington County.

MAP A: Sheet # 1, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

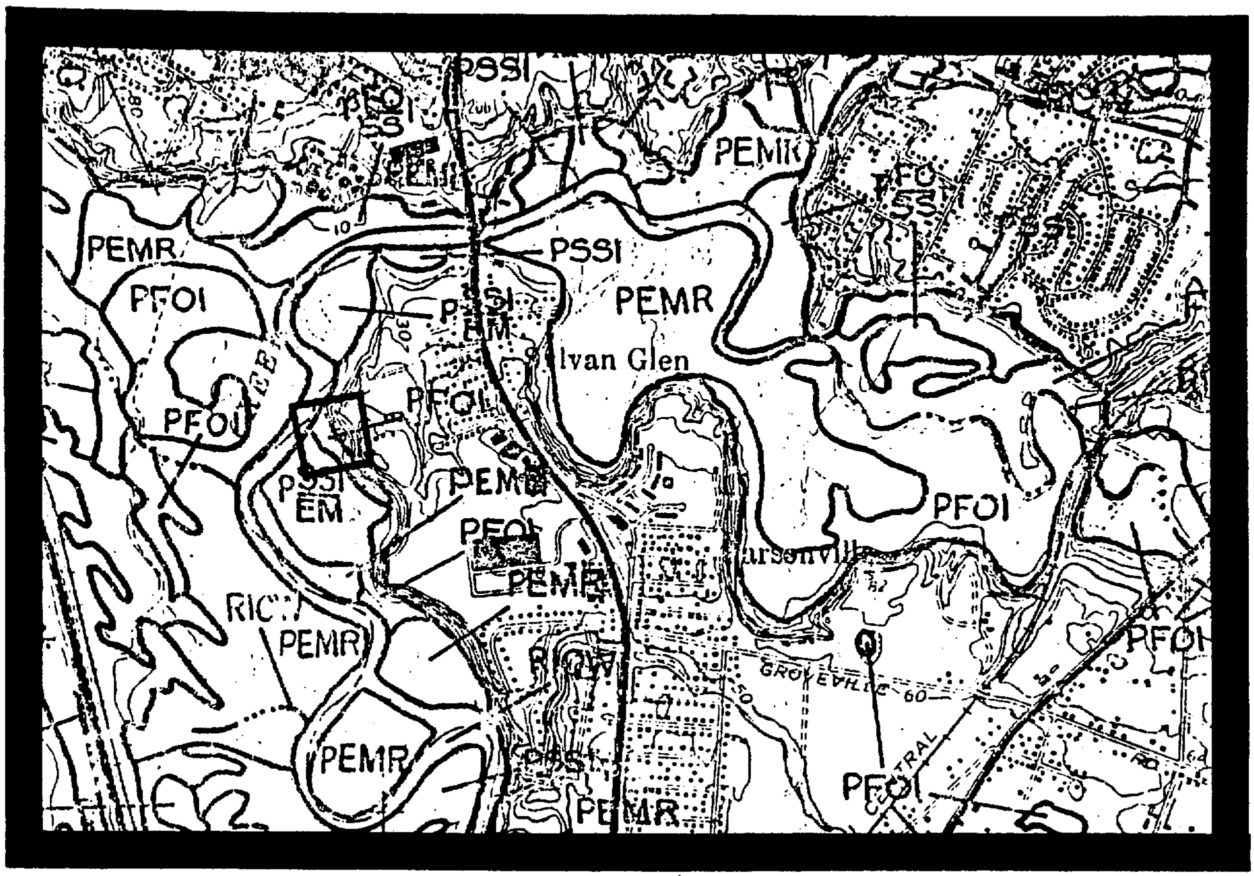
MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

MAP A


Colonial Memorial Park
White Horse
Yardville Heights
Sch
Sewage Disposal
Sylvan Glen
Parsonville
CREEK
GROVEVILLE

MAP B

MAP C


PSSI
PEMR
PFOI
PSSI
PEMR
Sylvan Glen
PFOI
PSSI EM
PEMR
PFOI
PEMR
PEMR
PEMR
PFOI
PFOI
PFOI
PEMR

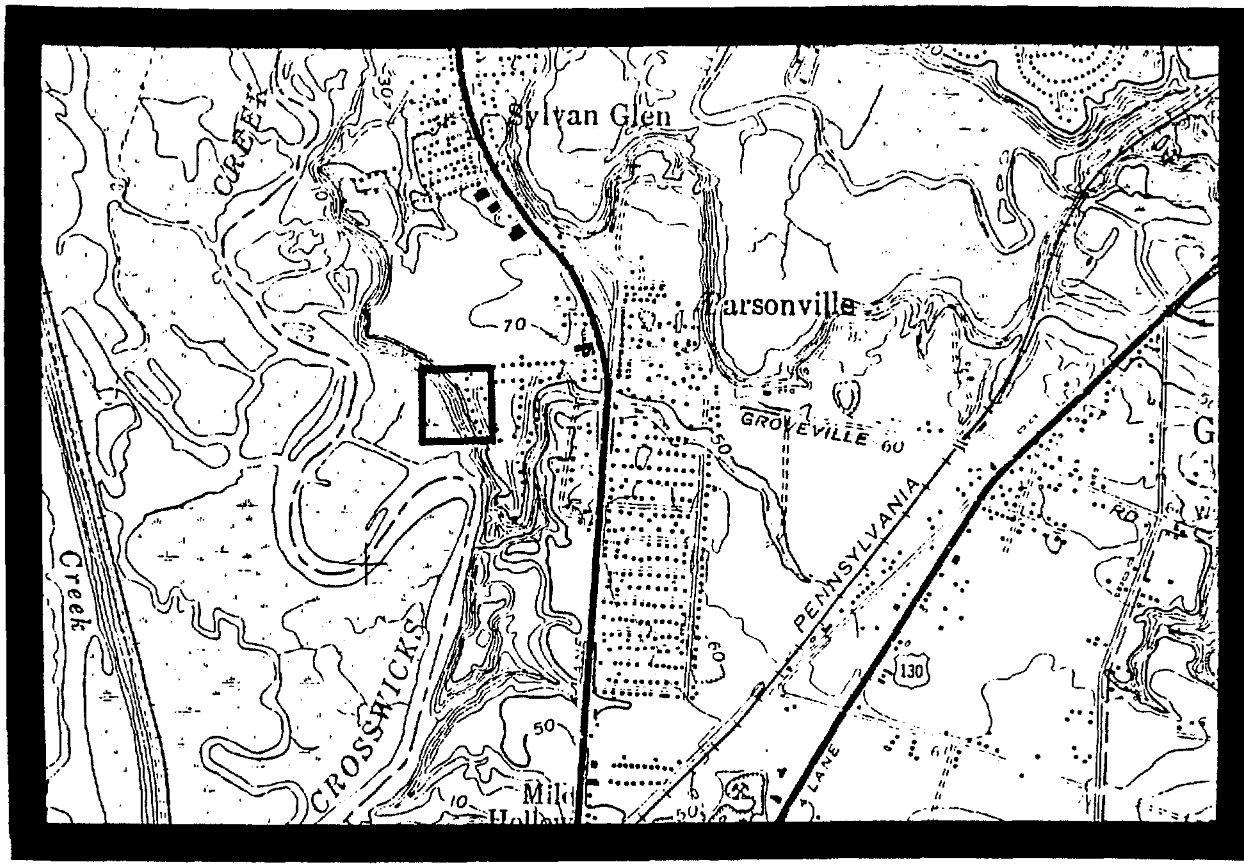
SITE 269 40 Edgewood Rd. West, Bordentown, Burlington County.

MAP A: Sheet # 1, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S.National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

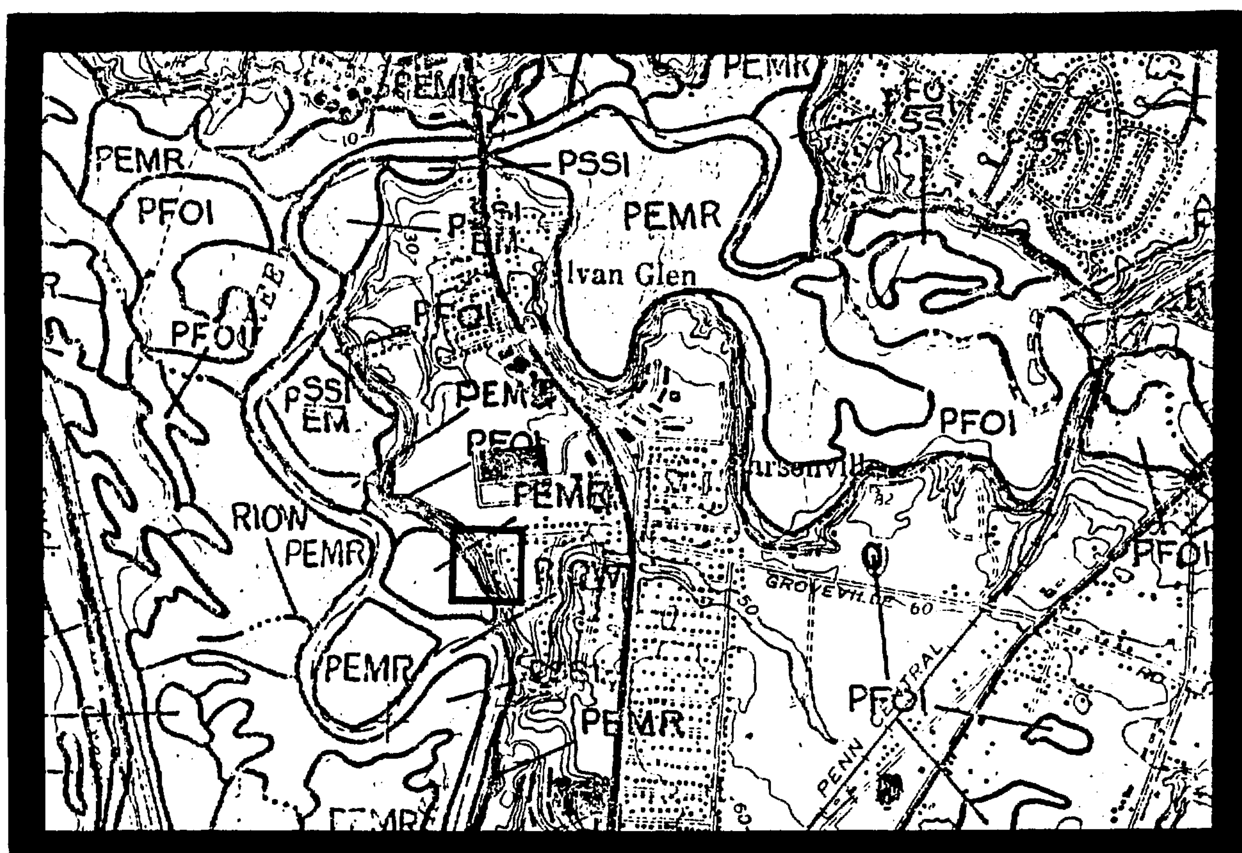
MAP A



Sylvan Glen
CREEK
70
GROVEVILLE 60
50
PENNSYLVANIA
130
Creek
CROSSWICKS
50
LANE

MAP B

MAP C



PEMR
PSSI
PFOI
PEMR
Sylvan Glen
PFOI
PSSI
EM
PEMR
PFOI
PFOI
PEMR
RIOW
PEMR
GROVEVILLE 60
PEMR
PFOI
PEMR
PENN

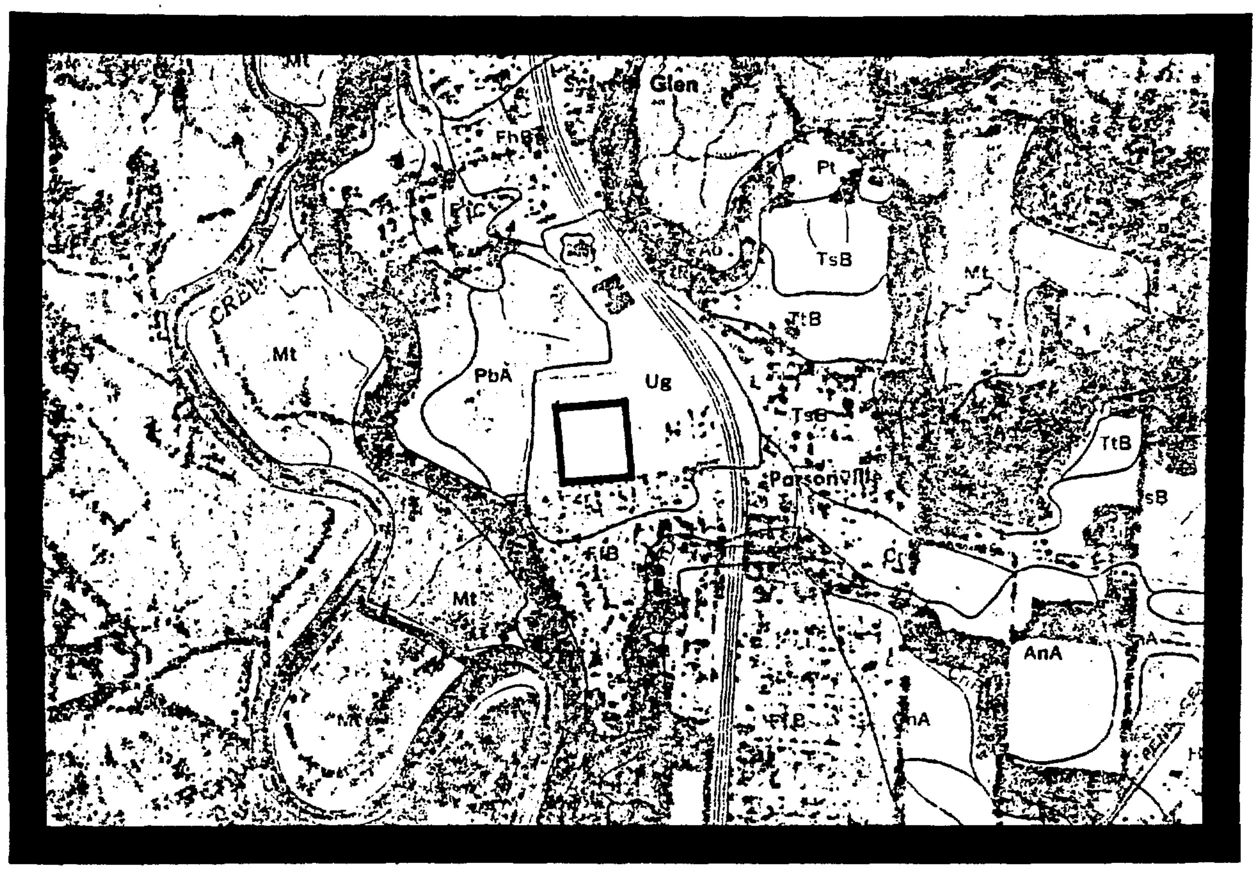
SITE 270 Bradlees, Rt. 206 South, Bordentown, Burlington County.

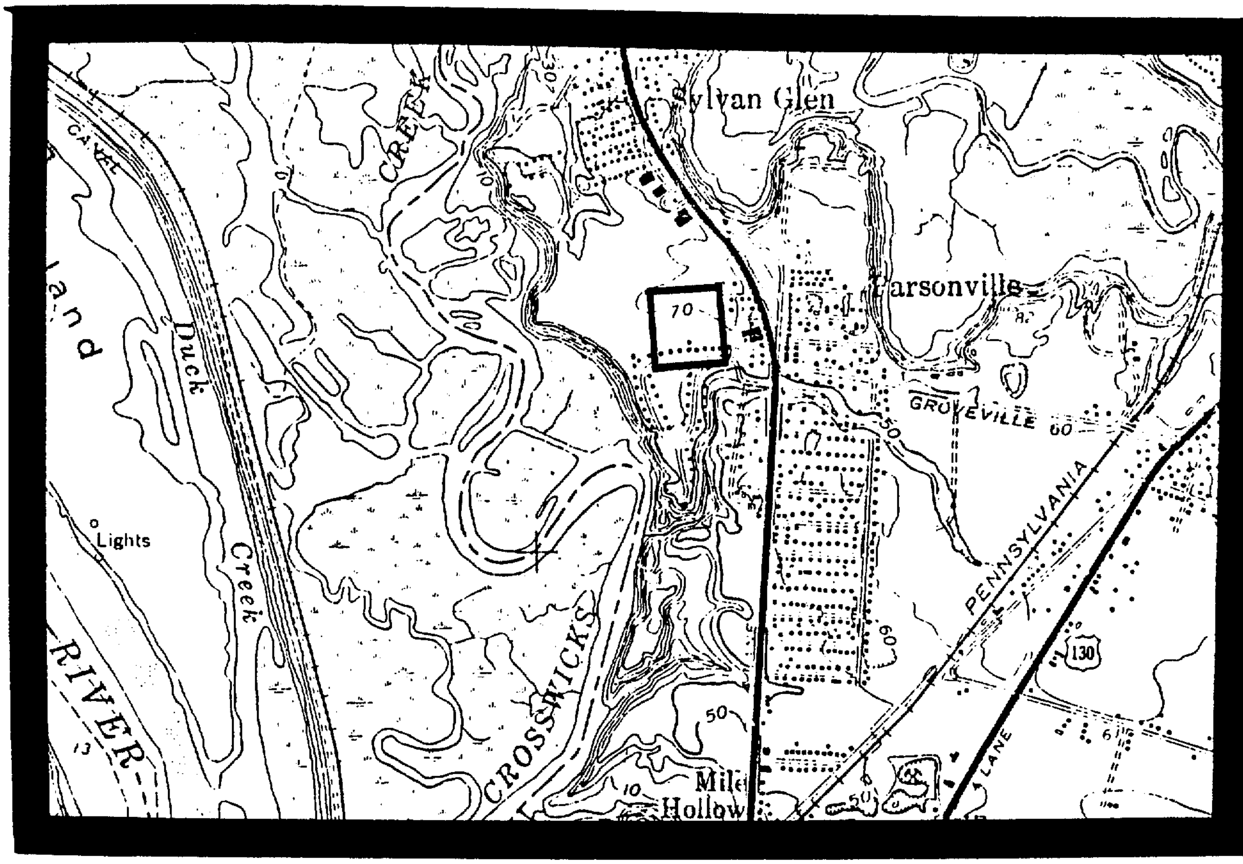
MAP A: Sheet # 1, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

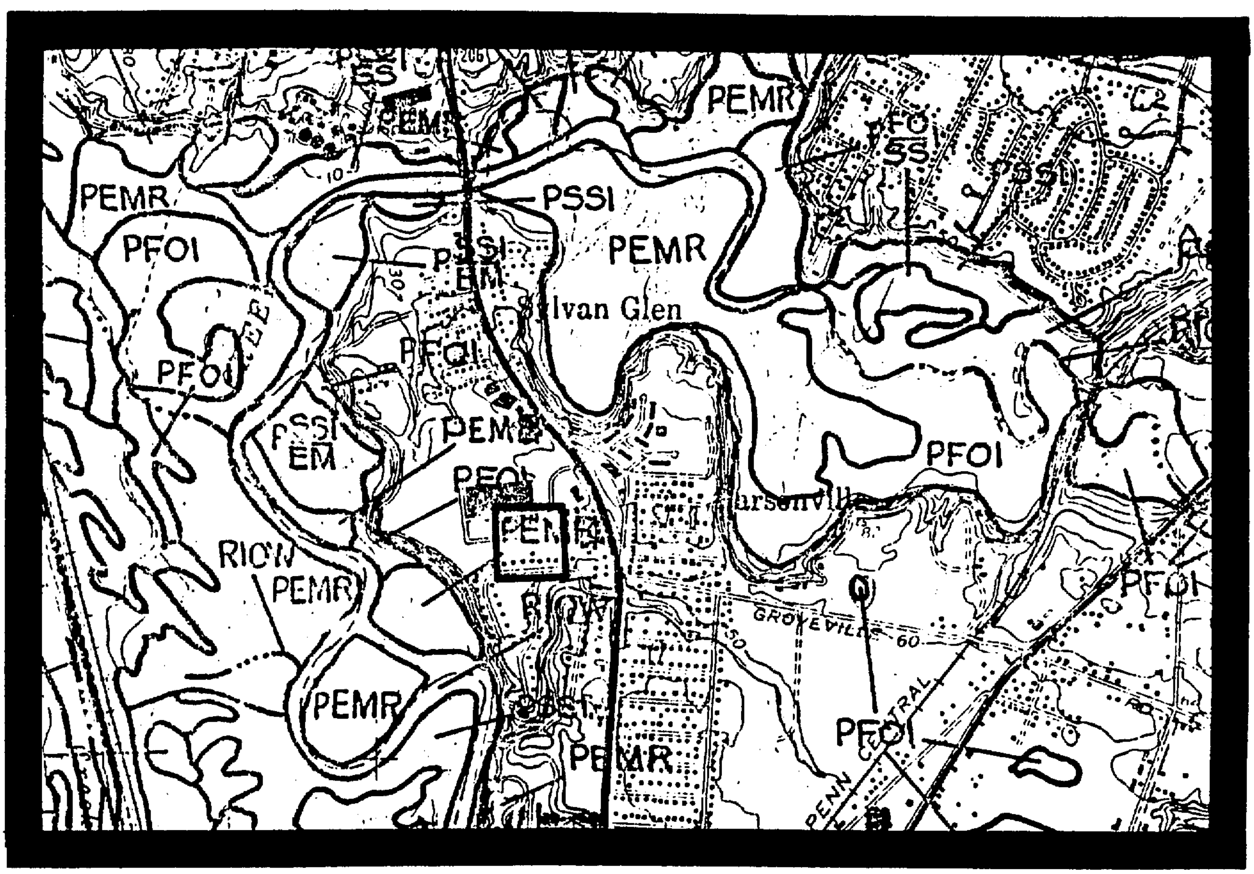
MAP A




Sylvan Glen
Parsonville
GROVEVILLE
PENNSYLVANIA
130
CROSSWICKS
Duck
Creek
CREEK
CANAL
Lights
RIVER
70
50
60
10
Mill
Hollow
LANE

MAP B

MAP C


PEMR
PSSI
PFOI
SS
PFO
EM
Sylvan Glen
RIOW
PENN CENTRAL
10
60

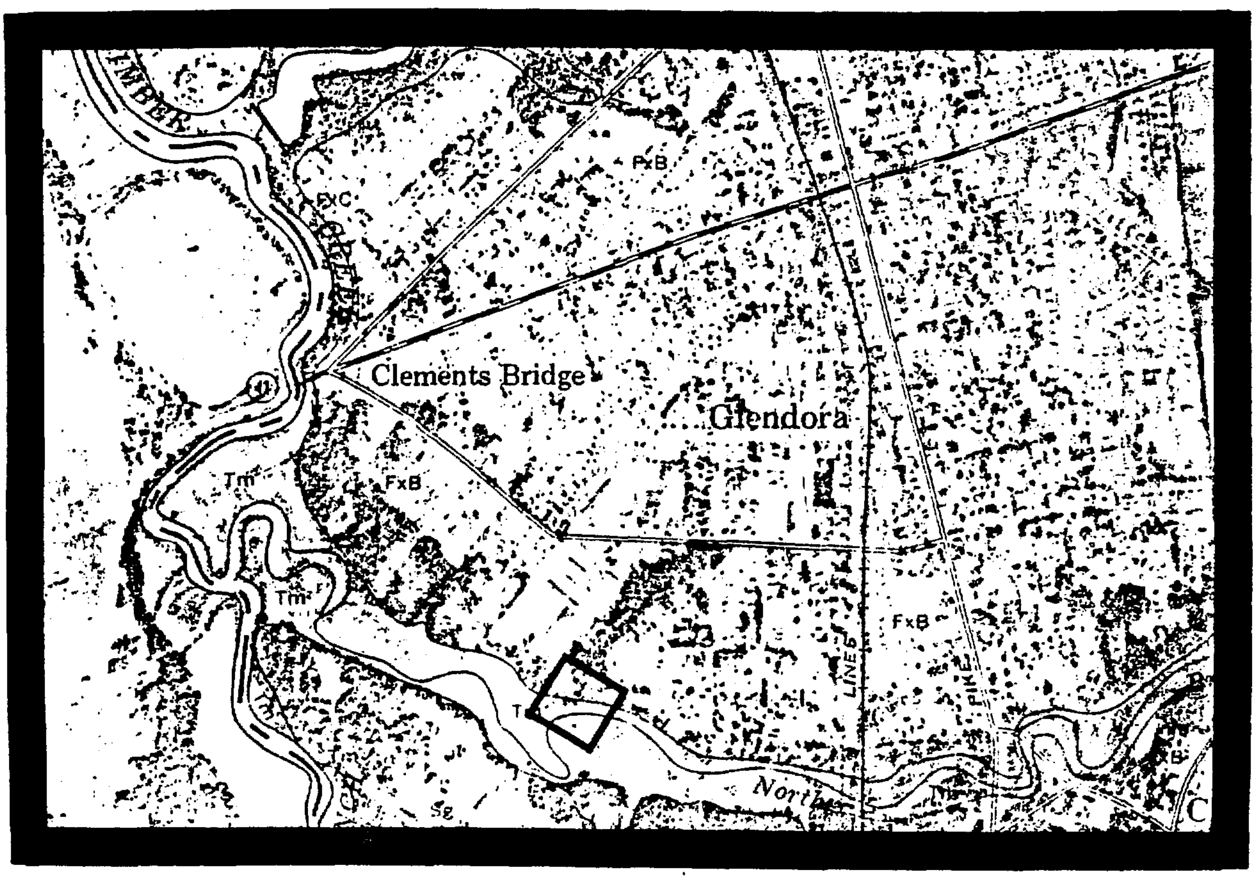
SITE 271 Ridge/Station Ave., Glendora, Camden County.

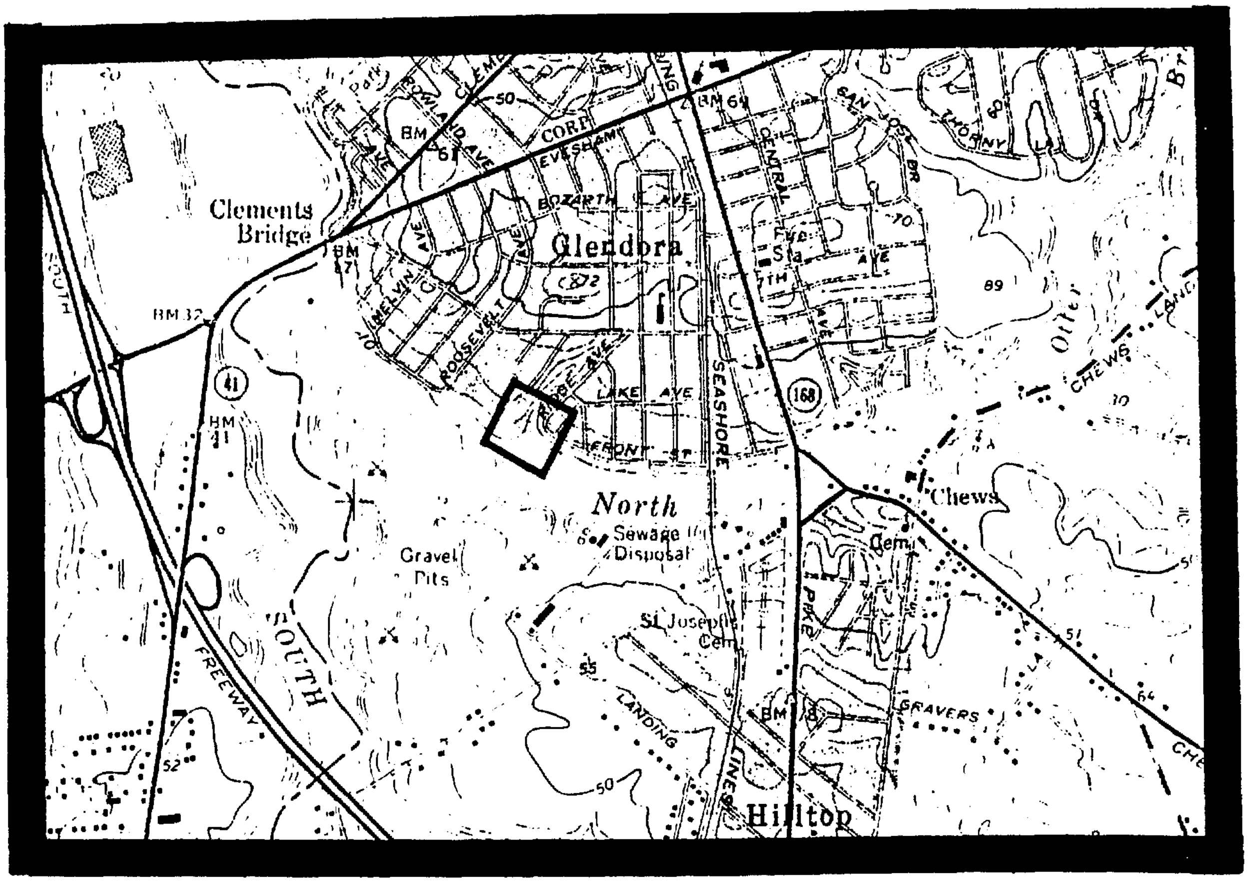
MAP A: Sheet # 11, Camden County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Runnemede, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Runnemede, N.J. Quadrangle (Scale 1:24,000)

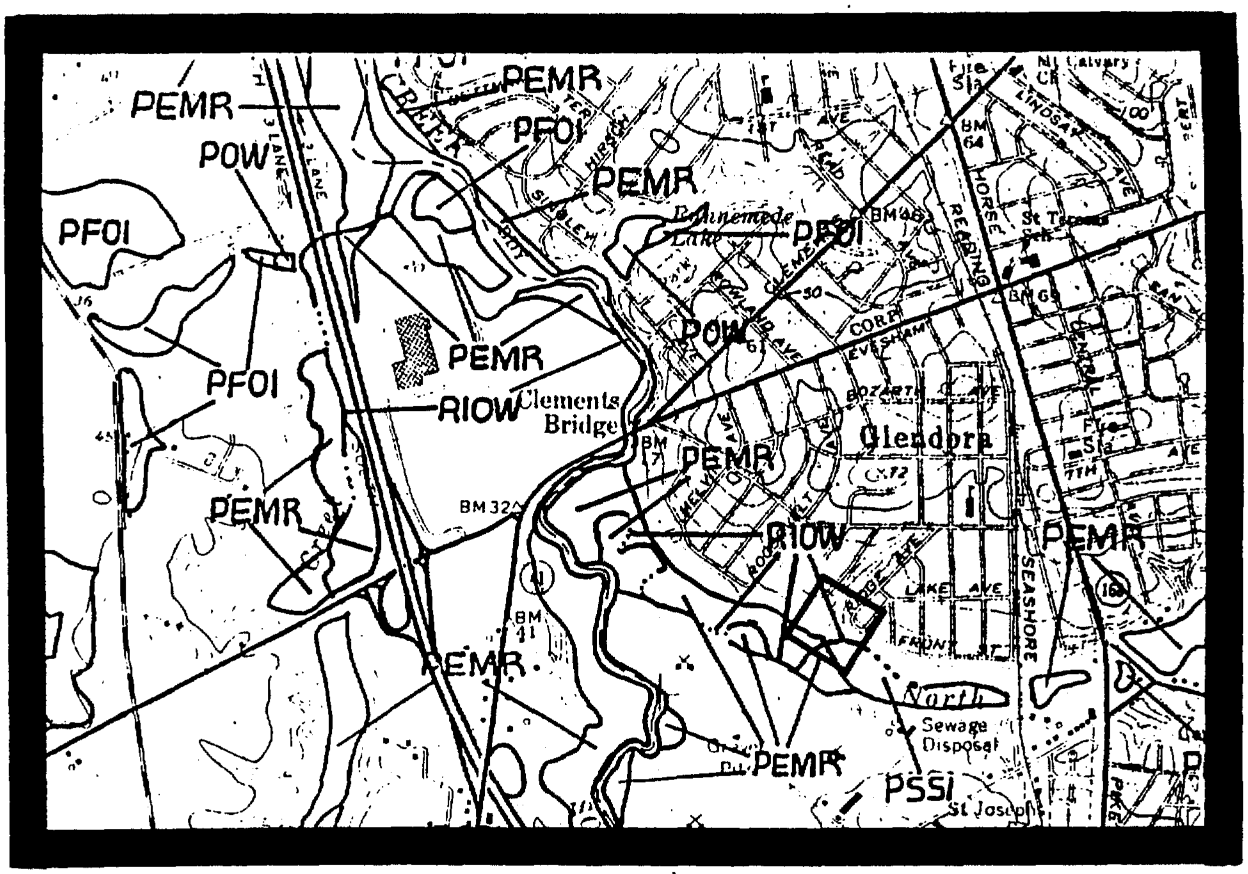
MAP A




Clements
Bridge
Glendora
EVESHAM
BOZARTH
ROOSEVELT
LAKE AVE
FRONT ST
SEASHORE
North
Sewage
Disposal
Gravel
Pits
SOUTH
FREEWAY
St Joseph
Cem
Chews
Cem
LANDING
GRAVERS
CHEWS
Hilltop
BM 32
BM 41
BM 17
BM 61
BM 69
BM 78

MAP B

MAP C


PEMR
PFOI
POW
PFOI
PEMR
PFOI
PEMR
RIOW
Clements
Bridge
Runnemede
Lake
PFOI
POW
PFOI
PEMR
PEMR
RIOW
PEMR
PEMR
PEMR
PSSI
Glendora
North
Sewage
Disposal
St Joseph
EVESHAM
BOZARTH
LAKE AVE
FRONT ST
SEASHORE
READING
HORSE
LINDSAY
BM 32
BM 41
BM 17
BM 46
BM 64
BM 69

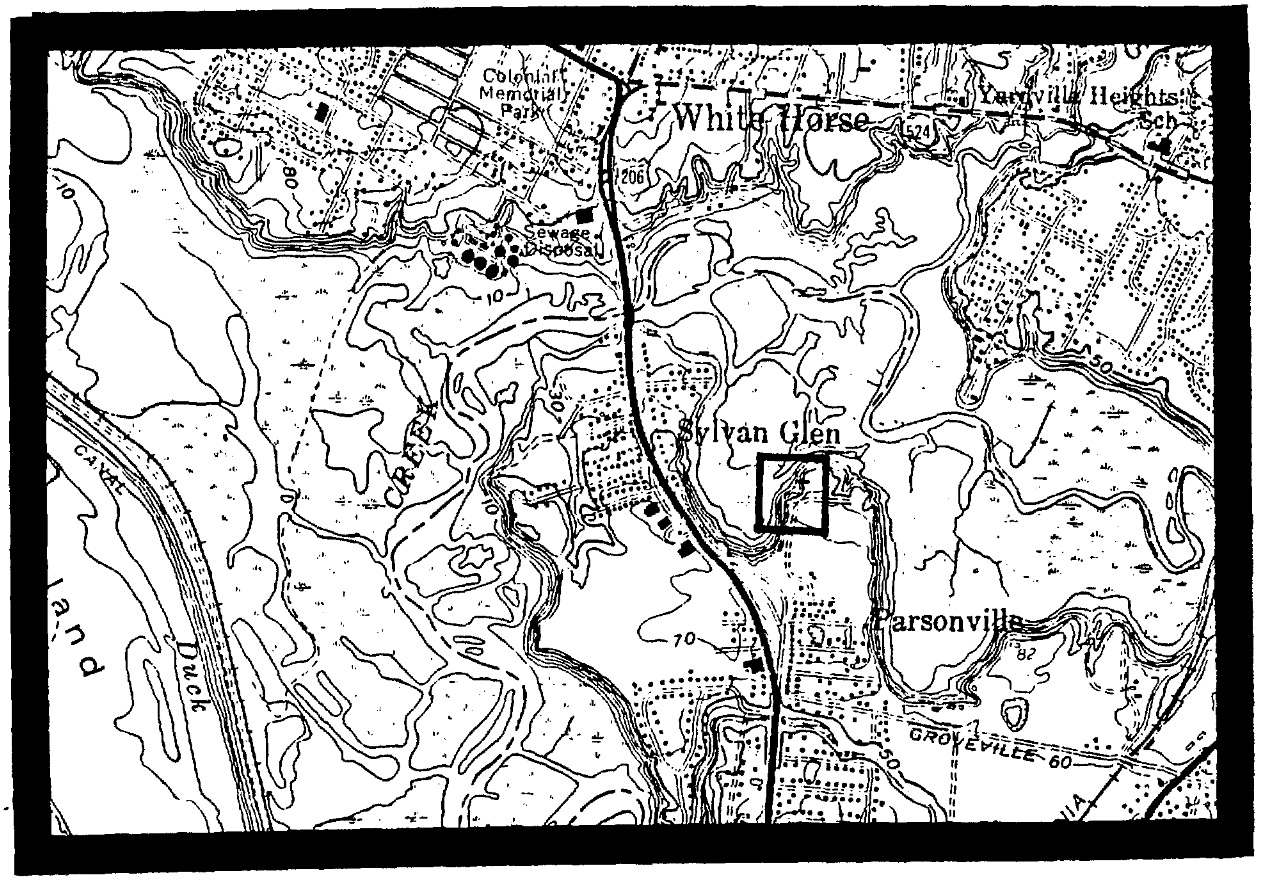
SITE 272 Hillcrest Apartments, Bordentown, Burlington County.

MAP A: Sheet # 1, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

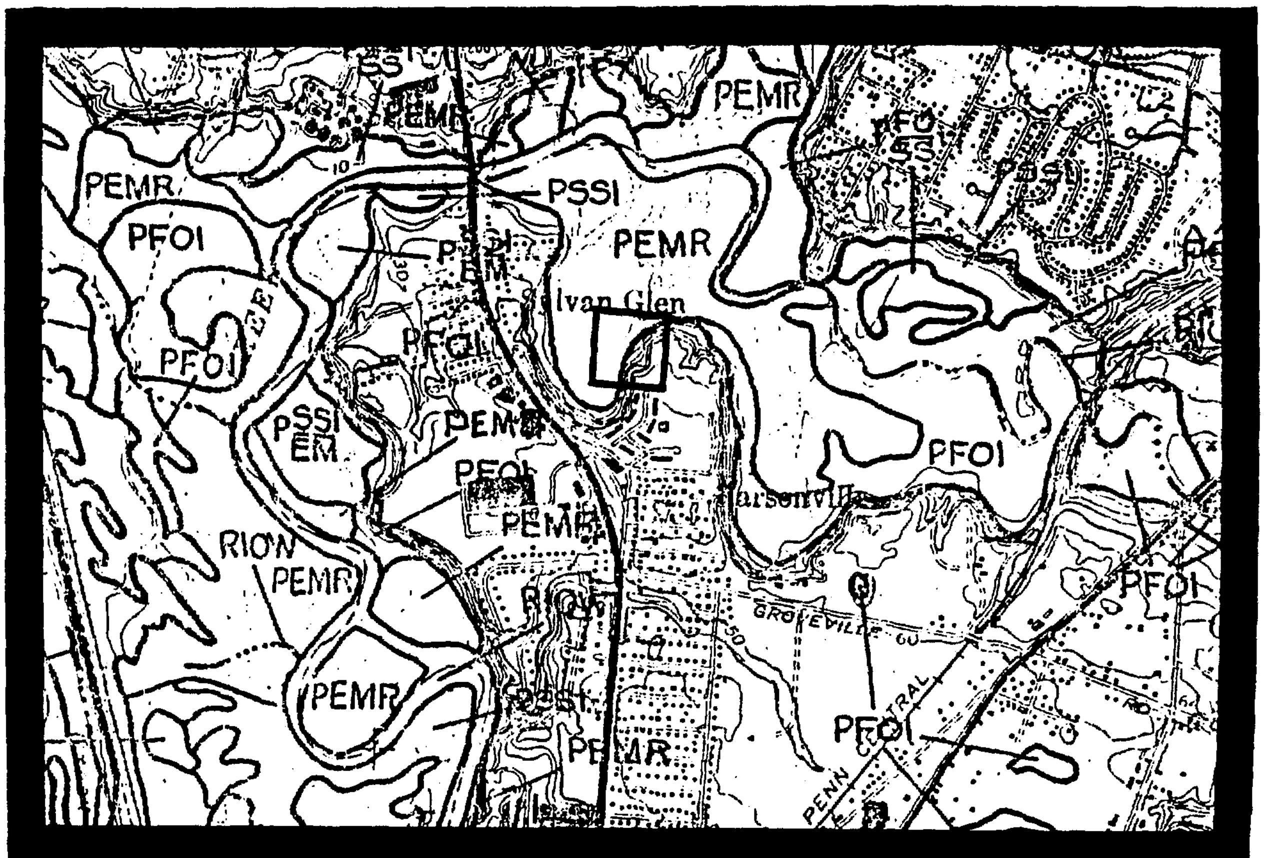
MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

MAP A


Colonial Memorial Park
White Horse
Yardville Heights
206
524
Sewage Disposal
CREEK
CANAL
Sylvan Glen
Parsonville
Duck
GROVEVILLE

MAP B

MAP C


PEMR
PSSI
PFOI
Sylvan Glen
PSSI EM
Parsonville
RION
GROVEVILLE
PENN CENTRAL

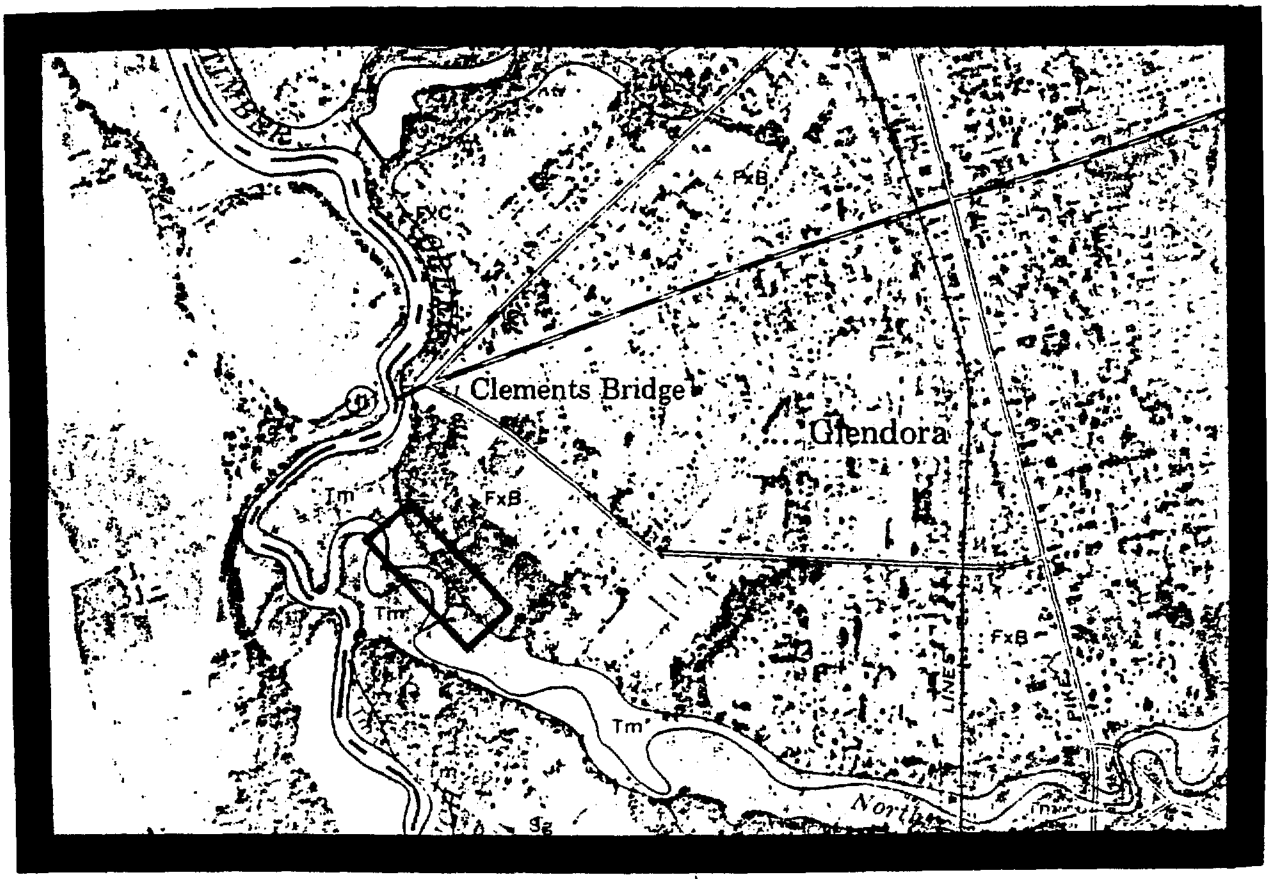
SITE 273 400 Front St., Runnemede, Camden County.

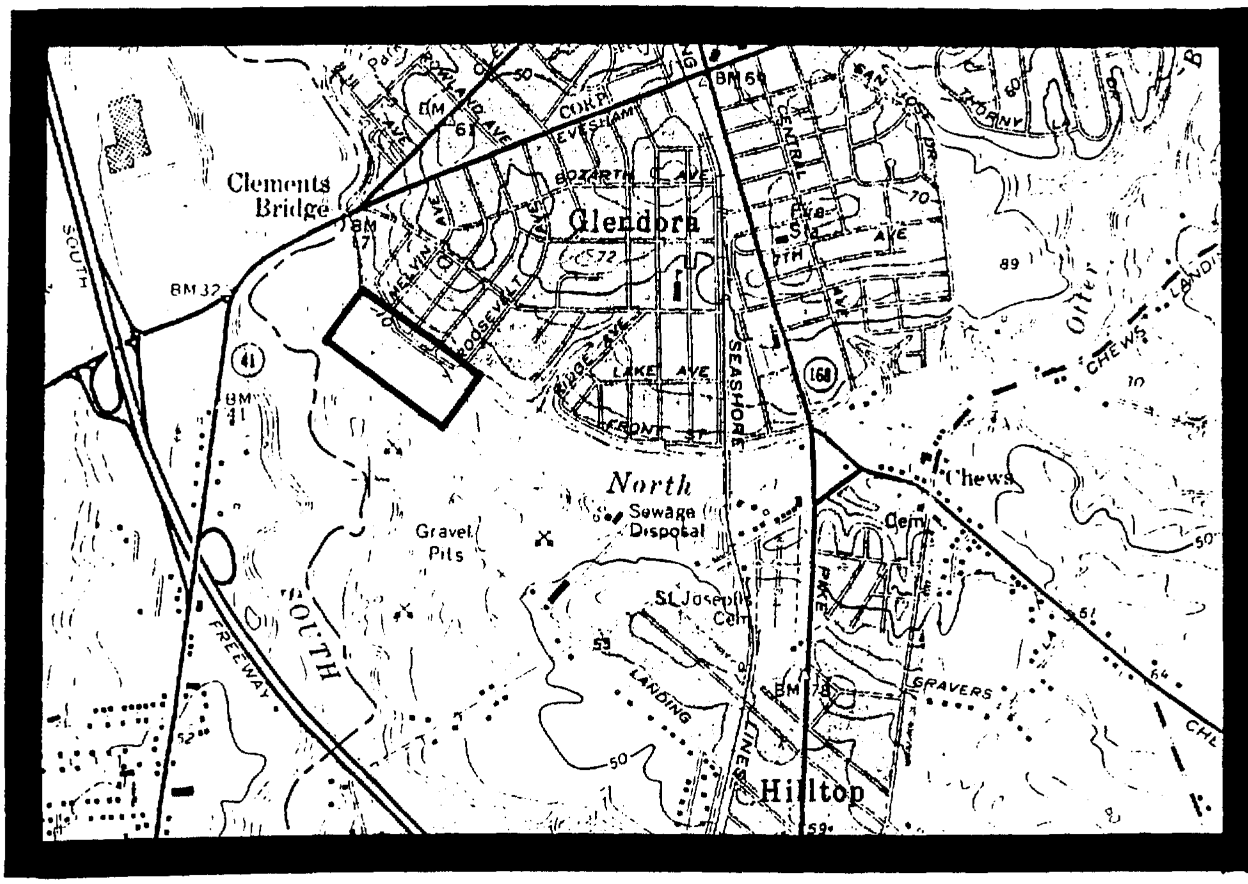
MAP A: Sheet # 11, Camden County Soil Survey
(Scale 1:15,840)

MAP B: U.S.G.S. Runnemede, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Runnemede,
N.J. Quadrangle (Scale 1:24,000)

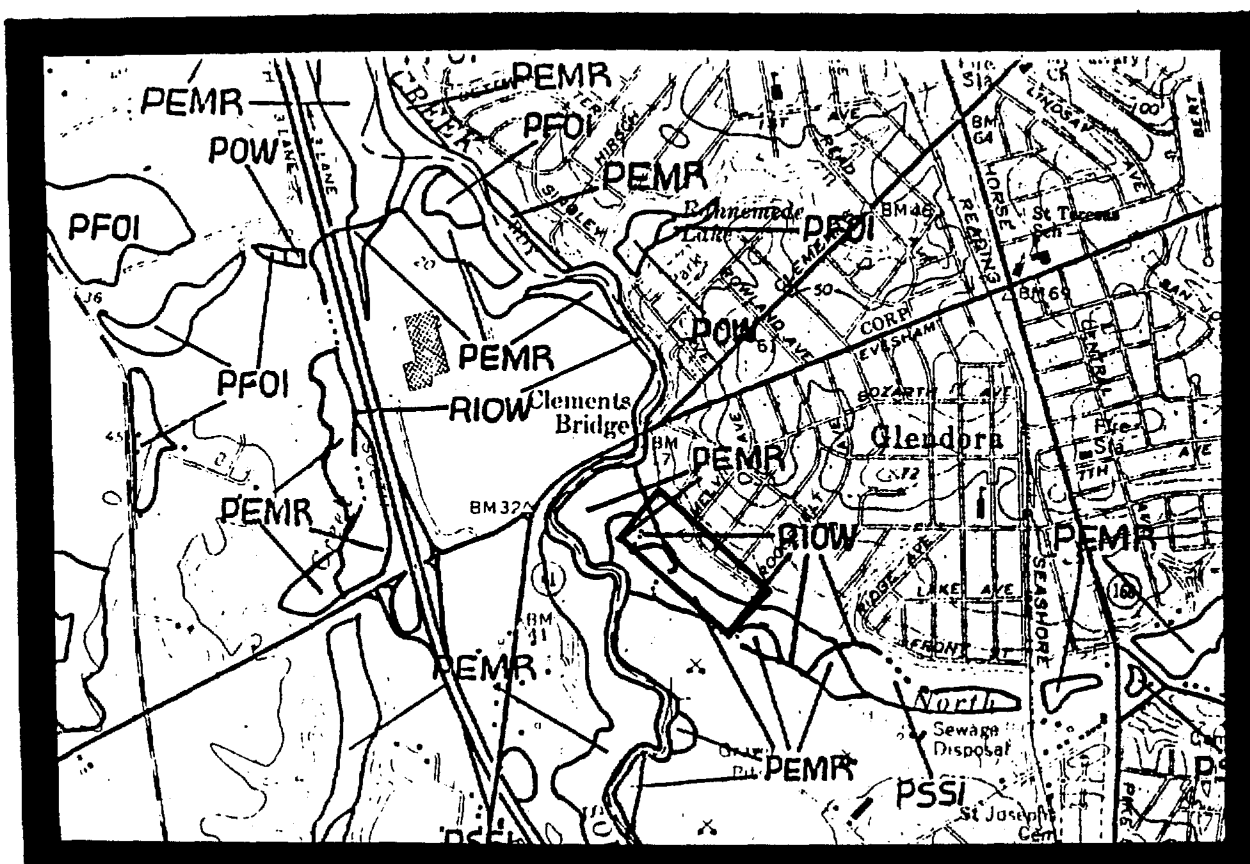
MAP A




Clements Bridge
Glendora
BOZARTH AVE
EVESHAM
LAKE AVE
FRONT ST
North
Sewage Disposal
Gravel Pits
St Joseph's Cem
Chews
Cem
SOUTH
FREEWAY
LANDING
GRAVERS
SEASHORE
LINES
Hilltop

MAP B

MAP C


PEMR
POW
PFOI
PFOI
PEMR
PFOI
PEMR
PFOI
POW
PEMR
RIOW
Clements Bridge
Glendora
PEMR
RIOW
PEMR
PEMR
PEMR
PSSI
North
Sewage Disposal
St Joseph Cem
St Teresa Sch
EVESHAM
SEASHORE
LAKE AVE
FRONT ST

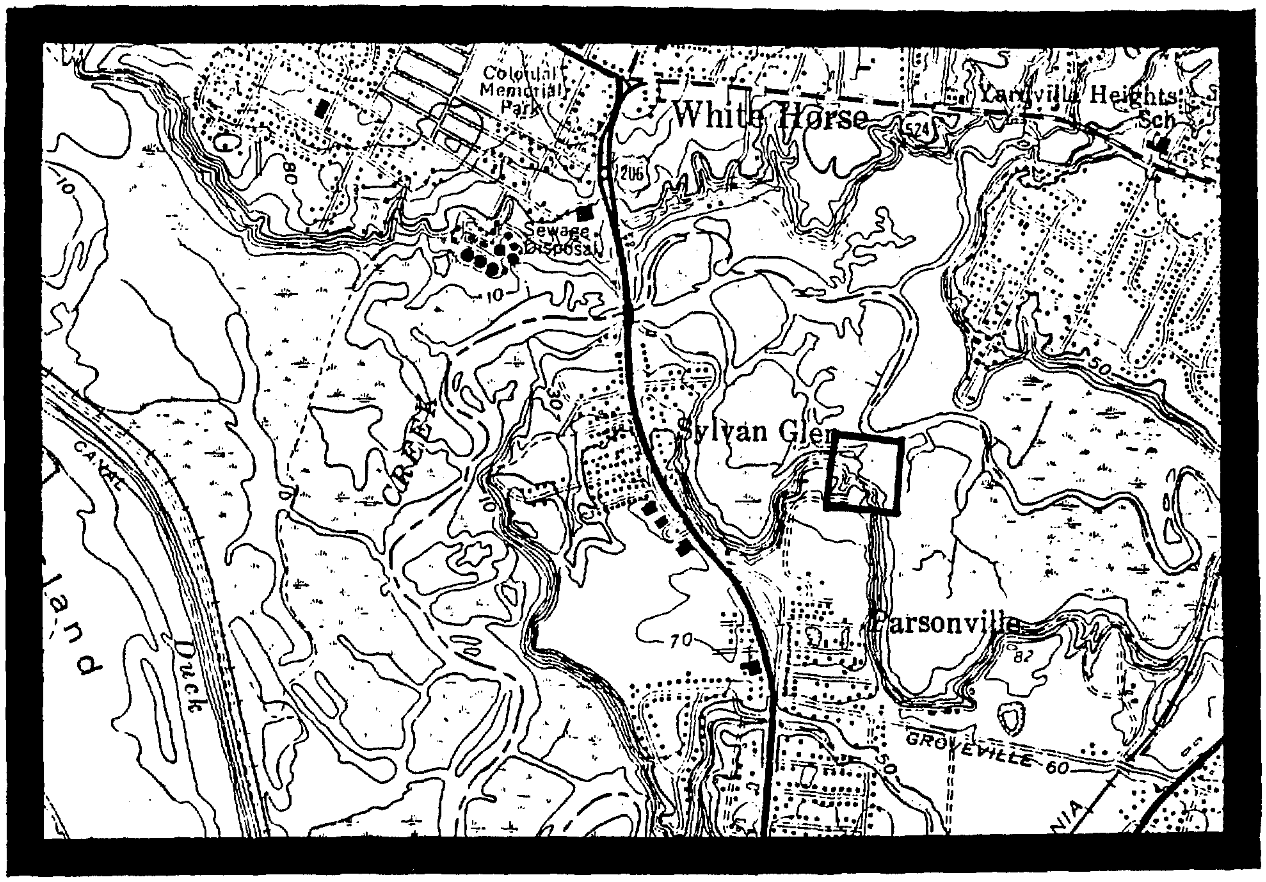
SITE 274 Hilltop Dr., Bordentown, Burlington County.

MAP A: Sheet # 1, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Trenton East, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Trenton East, N.J. Quadrangle (Scale 1:24,000)

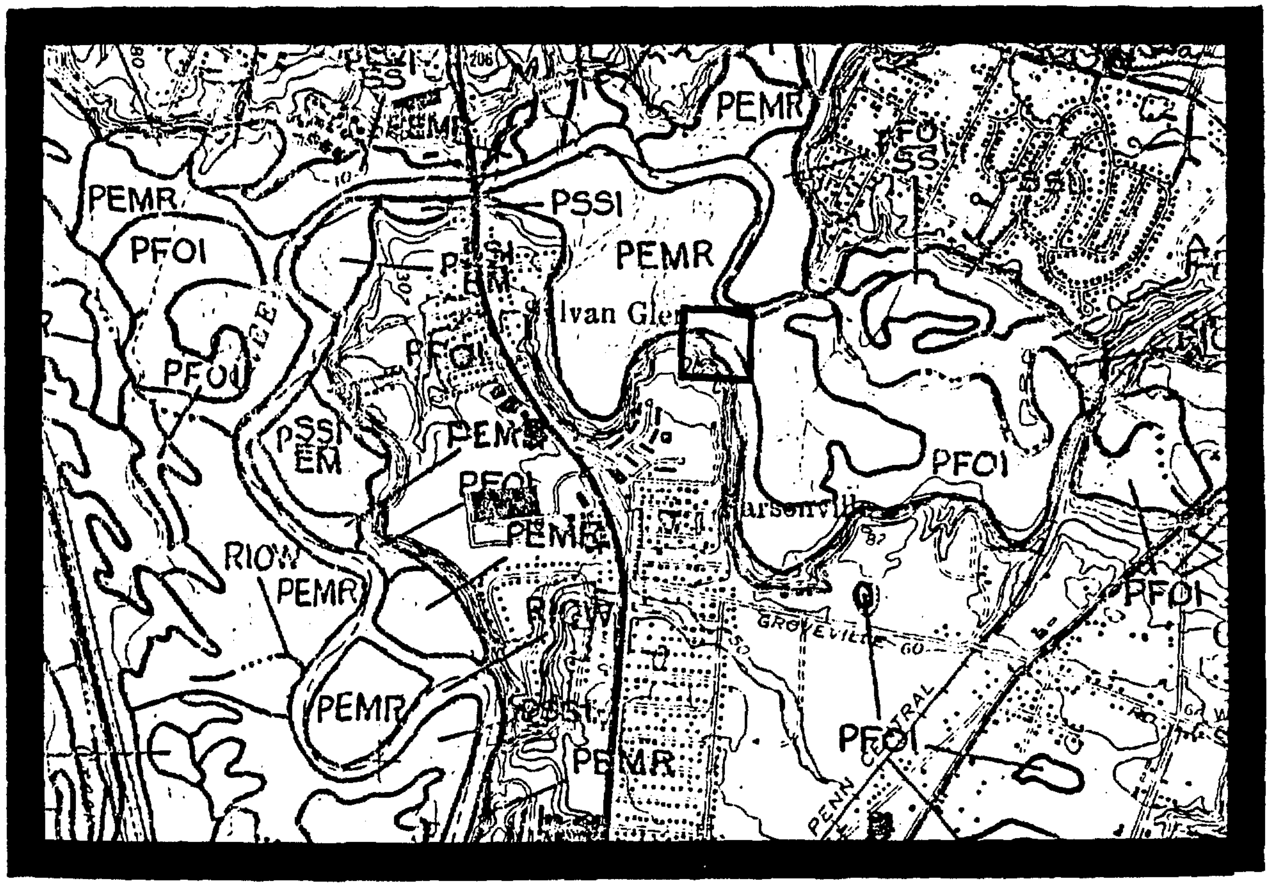
MAP A



Colonial Memorial Park
White Horse
Yardville Heights
Sch
Sewage Disposal
Sylvan Glen
Parsonville
Duck
CANAL
CREEK
GROVEVILLE

MAP B

MAP C



PEMR
PSSI
PFOI
PSSI EM
RIOW
PFO SS
Sylvan Glen
Parsonville
GROVEVILLE
PENN CENTRAL

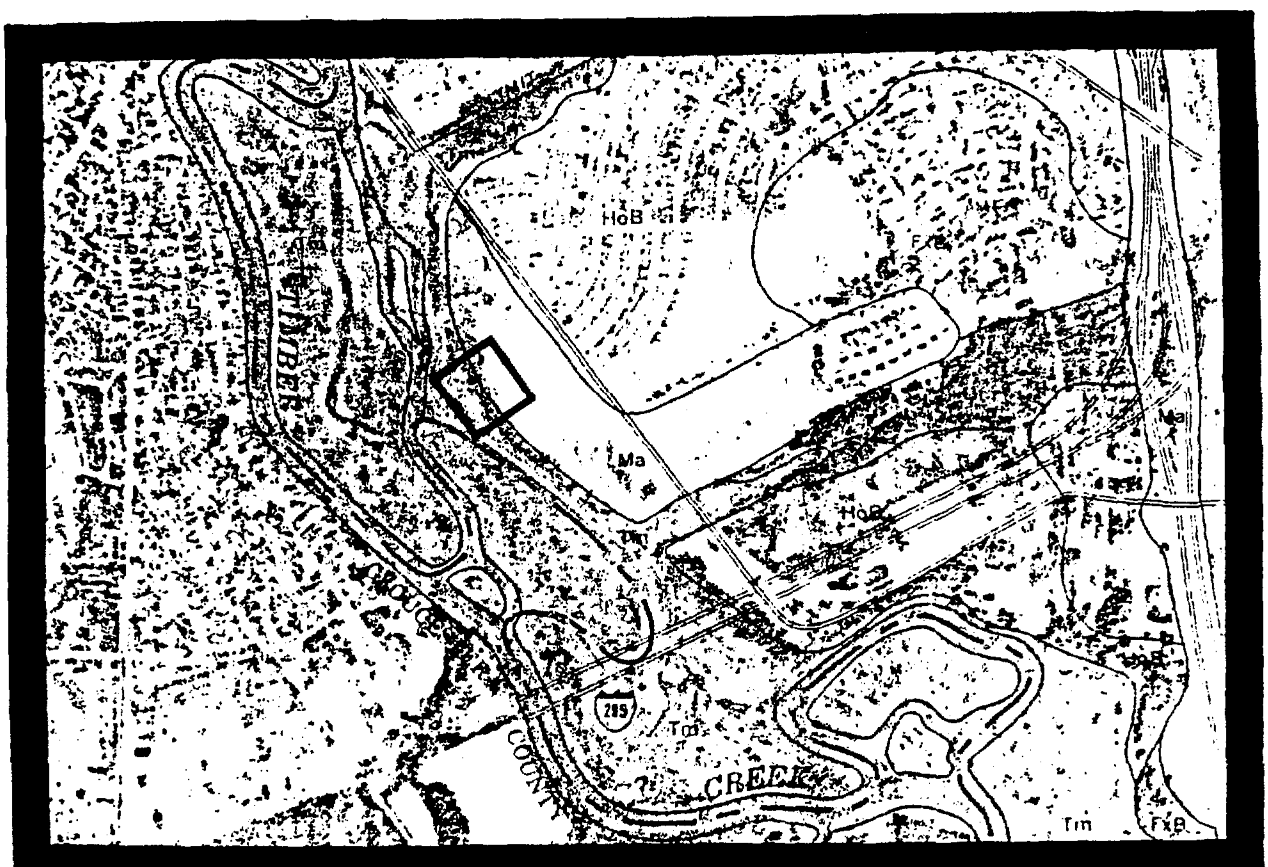
SITE 275 Timber Cove Apartments, Bellmawr, Camden County.

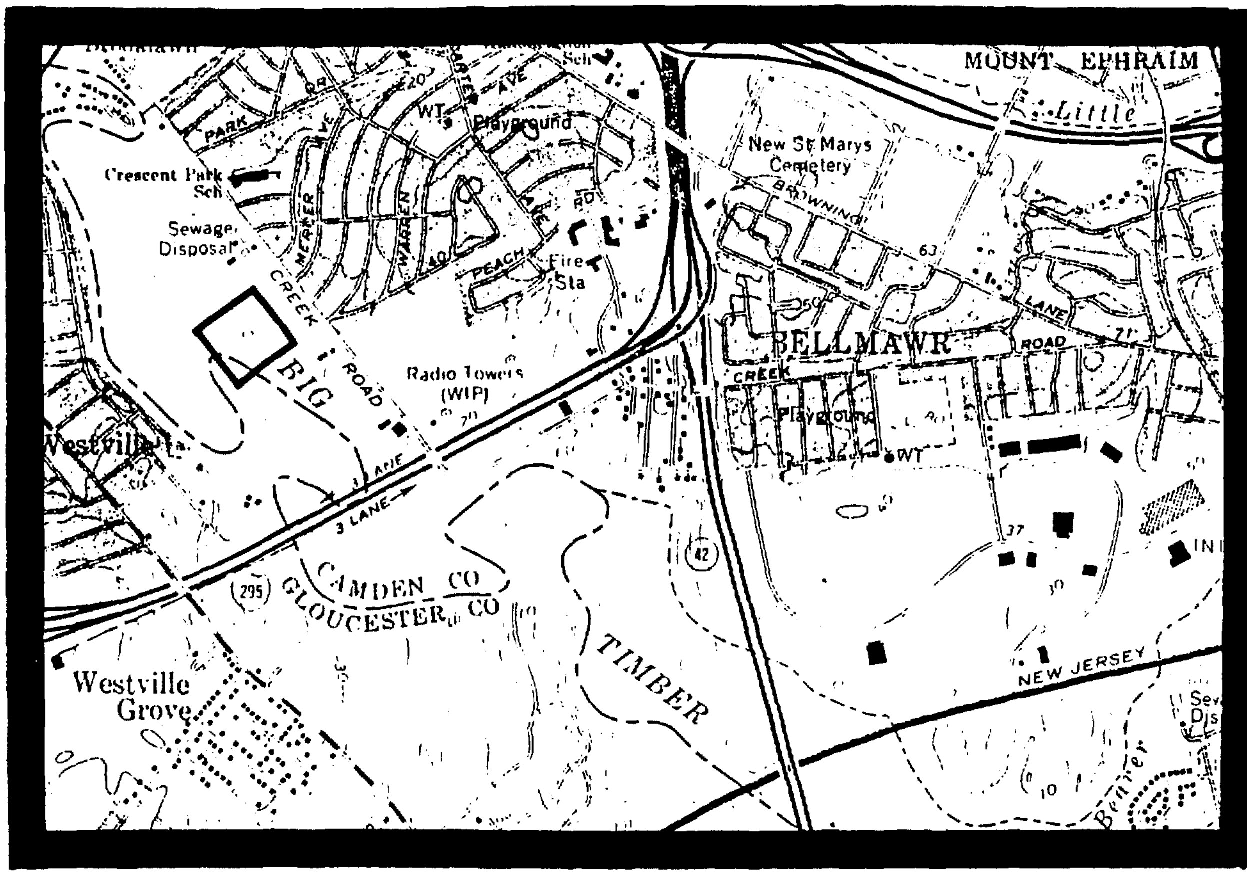
MAP A: Sheet # 8, Camden County Soil Survey
(Scale 1:15,840)

MAP B: U.S.G.S. Runnemede, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Runnemede, N.J. Quadrangle (Scale 1:24,000)

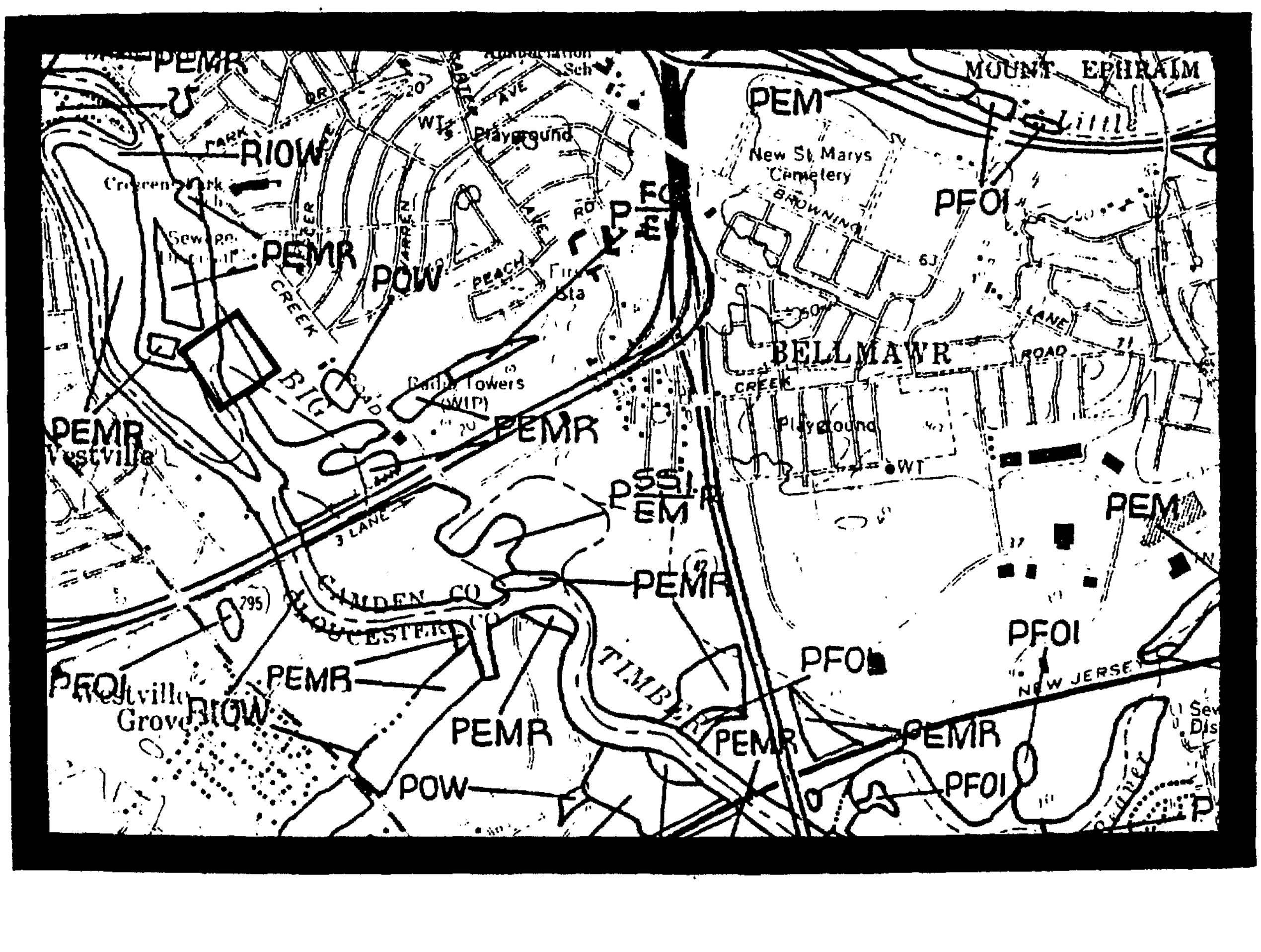
MAP A




MOUNT EPHRAIM
Little
New St Marys Cemetery
BROWNING
Crescent Park Sch
Sewage Disposal
Playground
Fire Sta
Radio Towers (WIP)
BIG CREEK ROAD
BELLMAWR
Westville
CAMDEN CO
GLOUCESTER CO
TIMBER
Westville Grove
NEW JERSEY
3 LANE
295
42

MAP B

MAP C


MOUNT EPHRAIM
PEM
PEMR
RIOW
PFOI
POW
New St Marys Cemetery
PEMR
BELLMAWR
CAMDEN CO
TIMBER
NEW JERSEY
Westville Grove

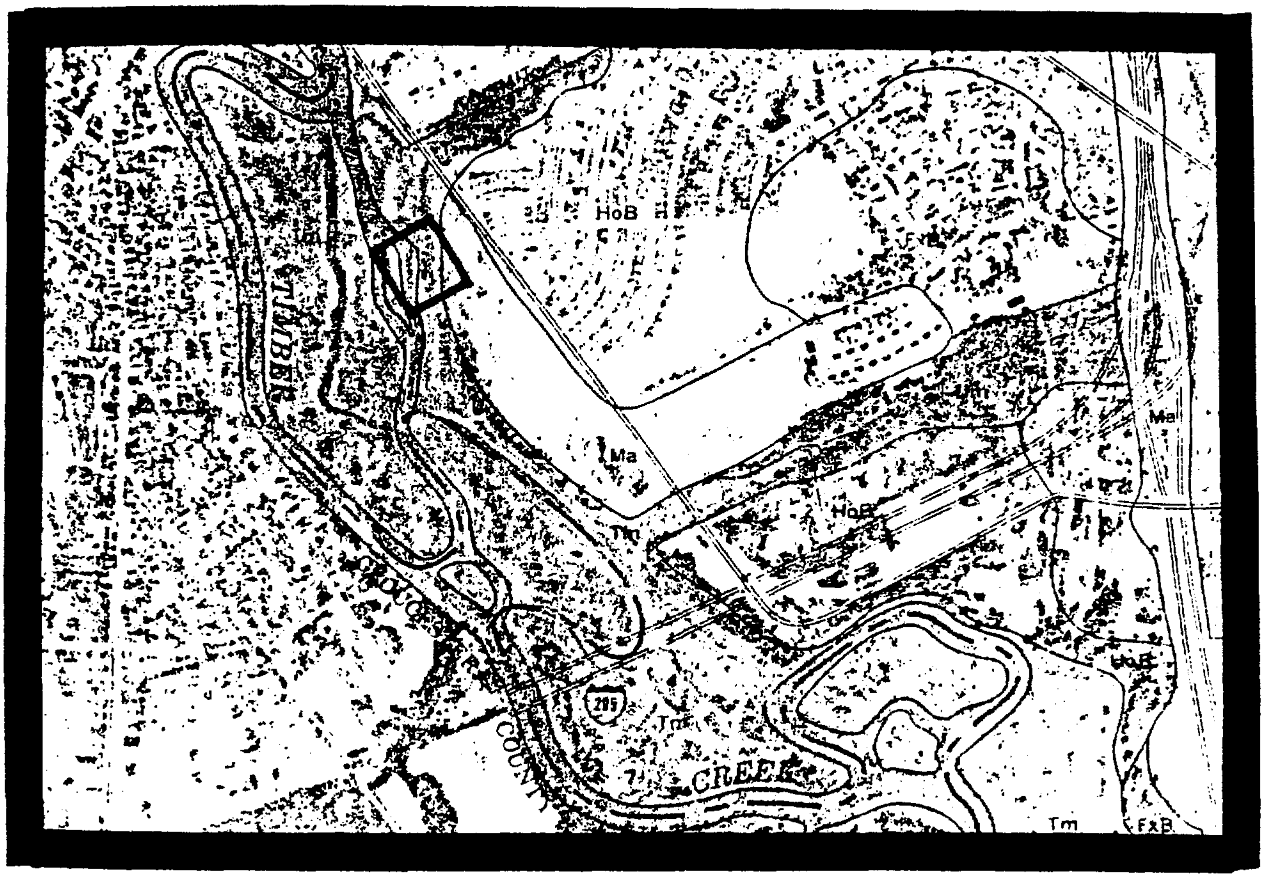
SITE 276 Reliance Co., Bellmawr, Camden County.

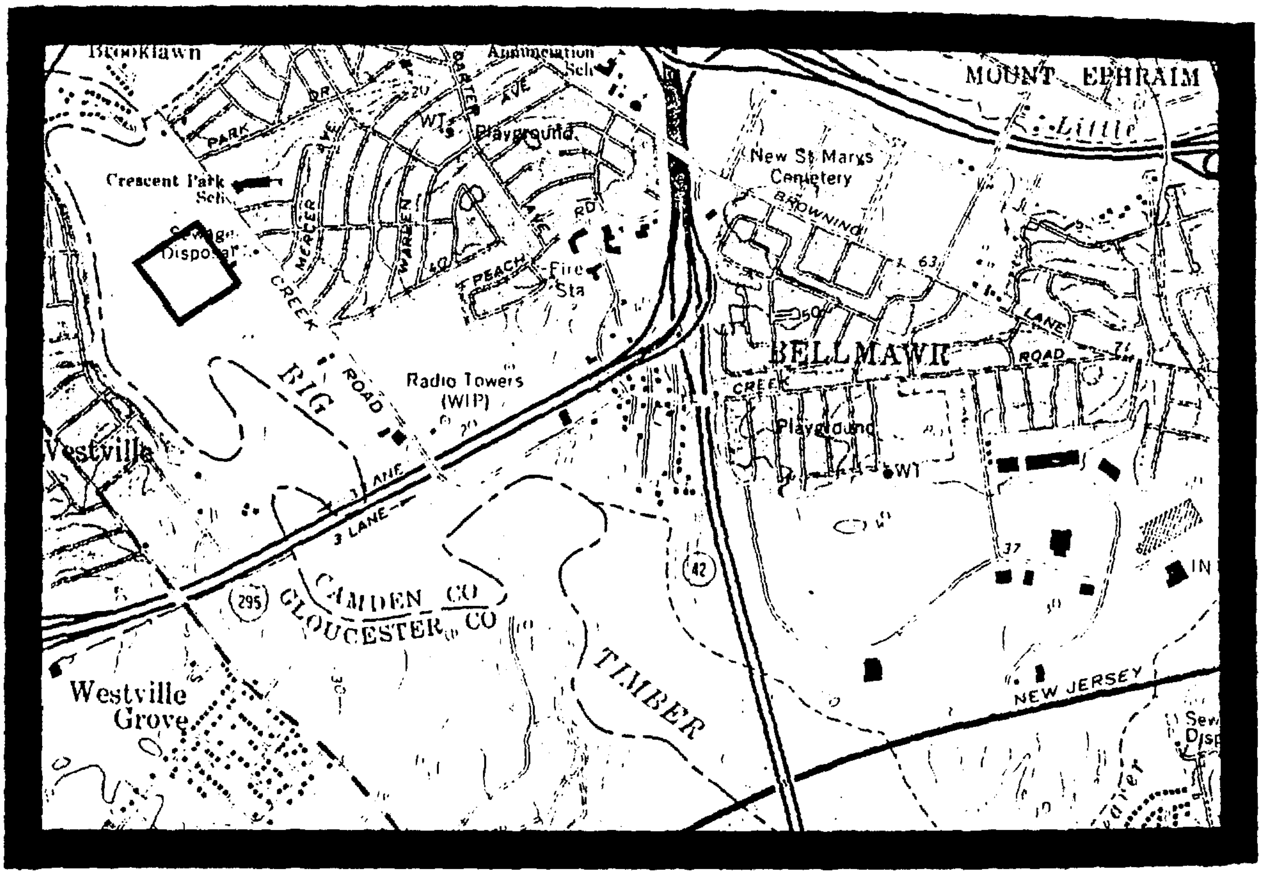
MAP A: Sheet # 8, Camden County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Runnemede, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Runnemede, N.J. Quadrangle (Sclae 1:24,000)

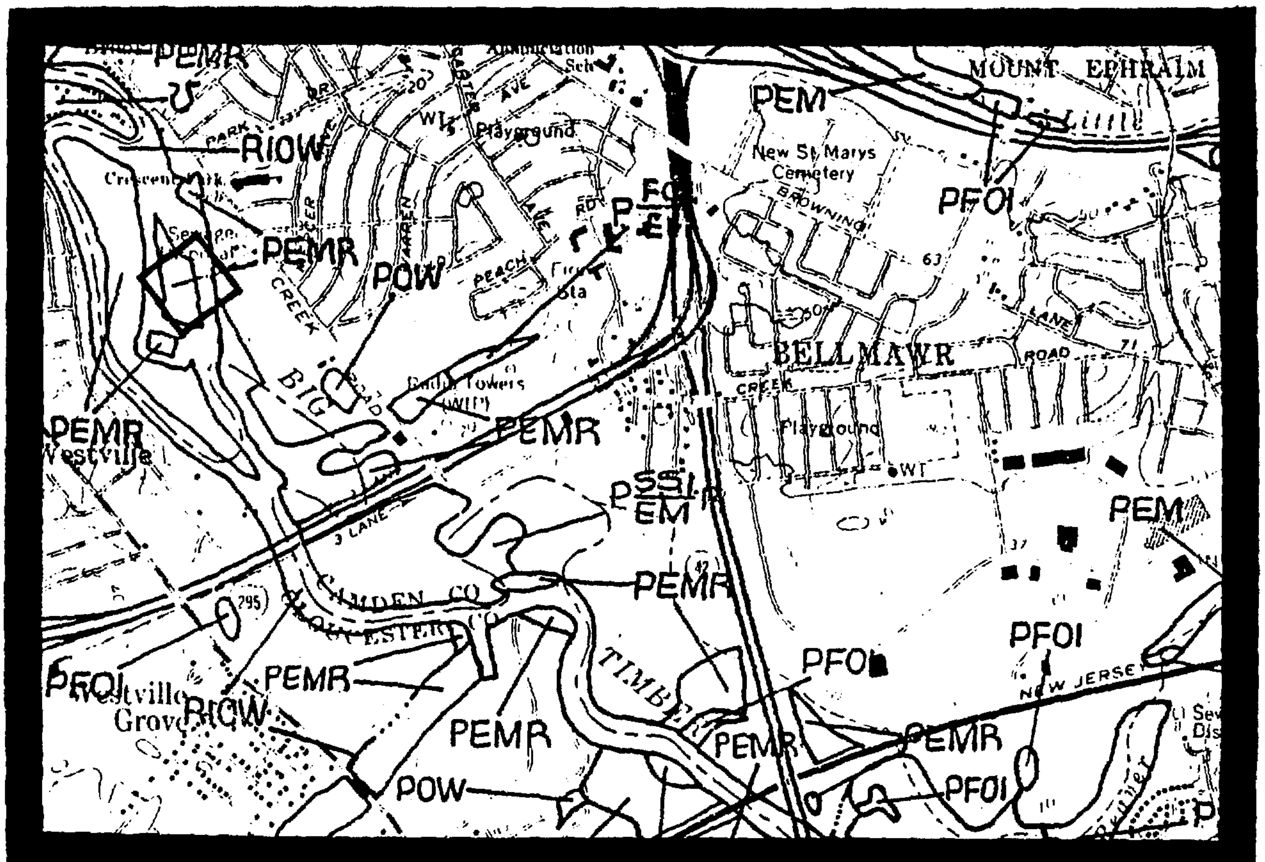
MAP A




Brooklawn
MOUNT EPHRAIM
Little
Crescent Park Sch
New St Marys Cemetery
Playground
BROWNING
MERCER
WARREN
PEACH
Fire Sta
BELLMAWR
ROAD
CREEK
BIG
ROAD
Radio Towers (WIP)
Westville
Playground
3 LANE
295
42
CAMDEN CO
GLOUCESTER CO
TIMBER
NEW JERSEY
Westville Grove

MAP B

MAP C


PEMR
MOUNT EPHRAIM
PEM
RIOW
New St Marys Cemetery
Playground
PFOI
PEMR
POW
BELLMAWR
PEMR
Westville
PSS1
EM
PEM
PEMR
CAMDEN CO
GLOUCESTER CO
PFOI
PFOI
PFOI
PEMR
RIOW
PEMR
TIMBER
PEMR
PEMR
POW
PFOI
NEW JERSEY

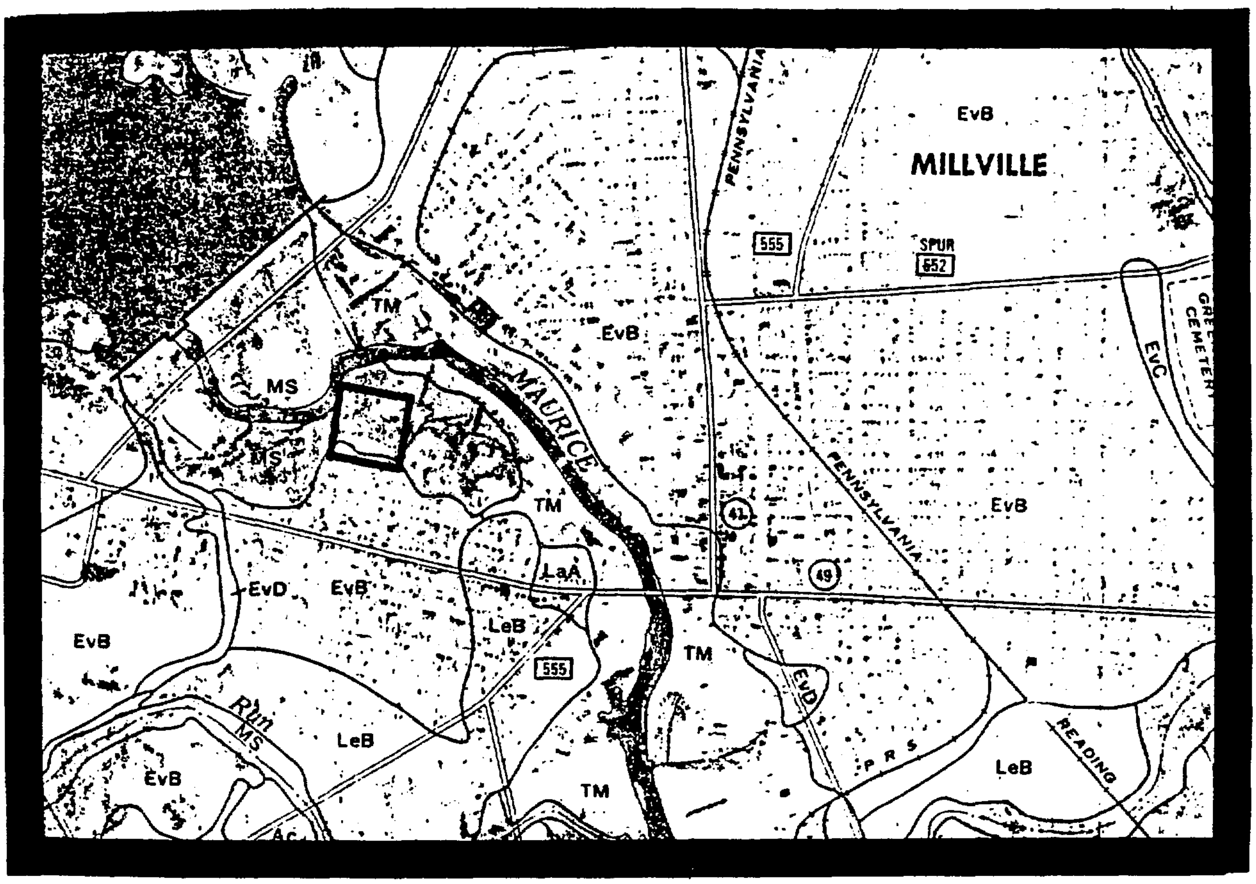
SITE 277 Mulford St., Millville, Cumberland County.

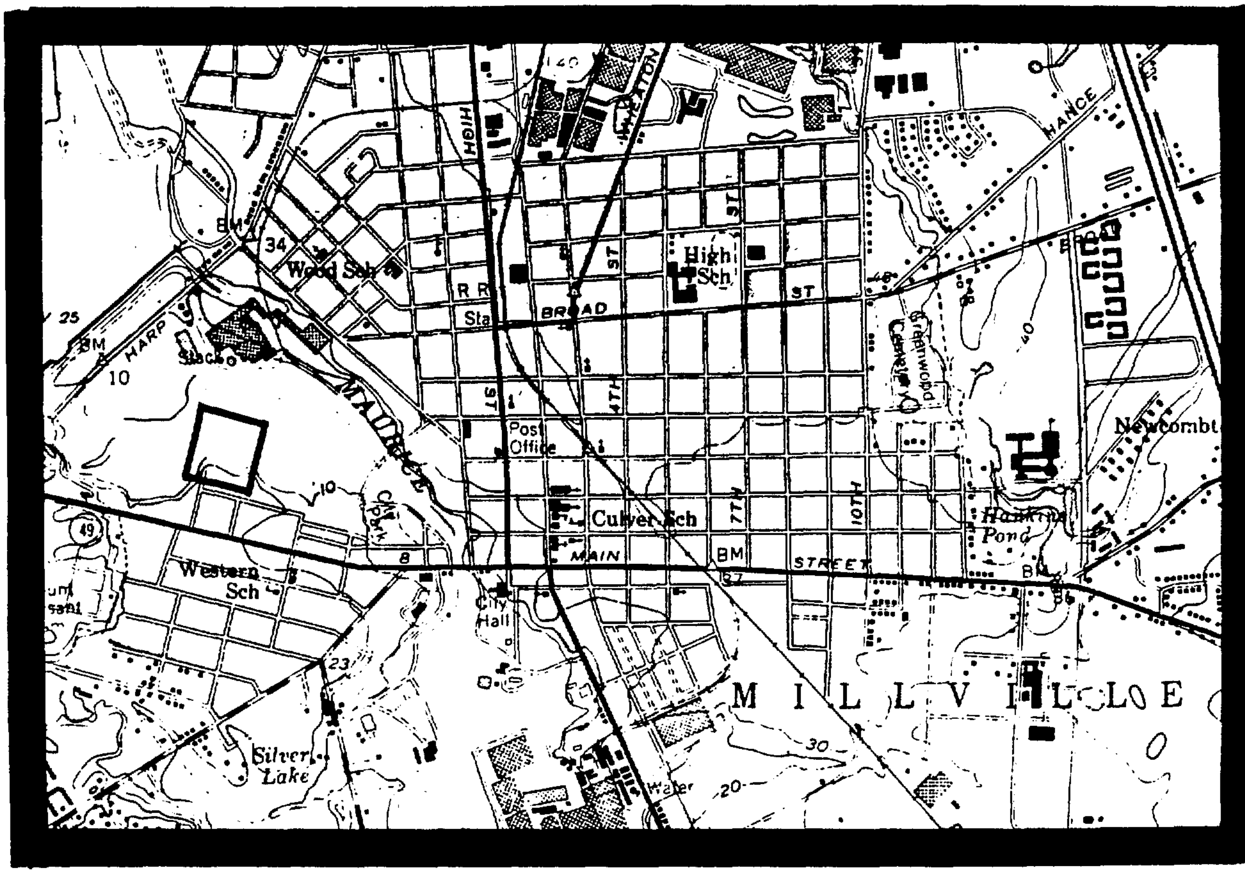
MAP A: Sheet # 19, Cumberland County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Millville, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Millville, N.J. Quadrangle (Scale 1:24.000)

MAP A

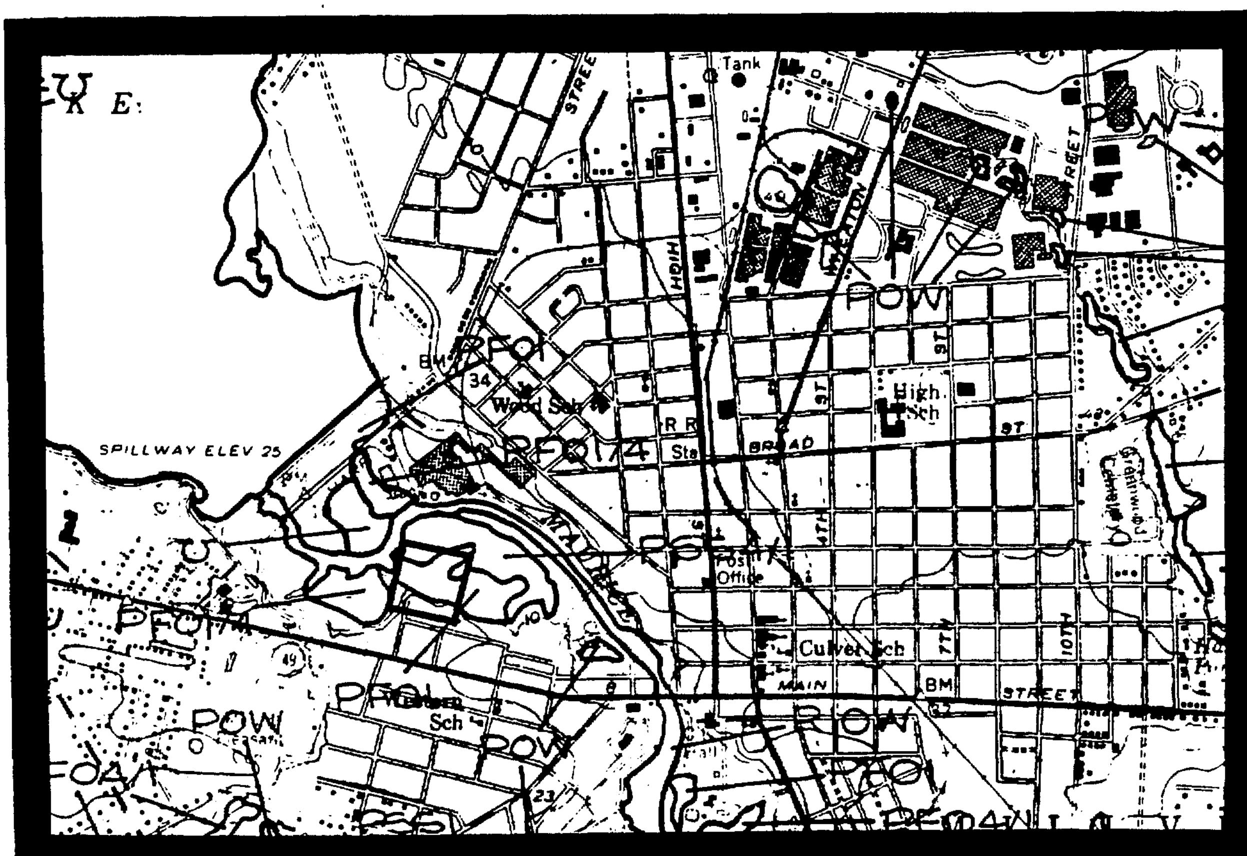




HIGH
WHARTON
HANCE
BM
34
Wood Sch
High Sch
R R
Sta
BROAD
ST
HARP
Slacko
10
MAURICE
Post Office
4TH
7TH
10TH
Newcomb
City Park
Culver Sch
Hawkins Pond
49
Western Sch
MAIN
BM
STREET
City Hall
23
M I L L V I L L E
Silver Lake
30
Water
20

MAP B

MAP C



Tank
STREET
HIGH
WHARTON
STREET
BM
34
Wood Sch
High Sch
R R
Sta
BROAD
ST
SPILLWAY ELEV 25
Post Office
4TH
7TH
10TH
Culver Sch
49
MAIN
BM
STREET
Western Sch
23
POW

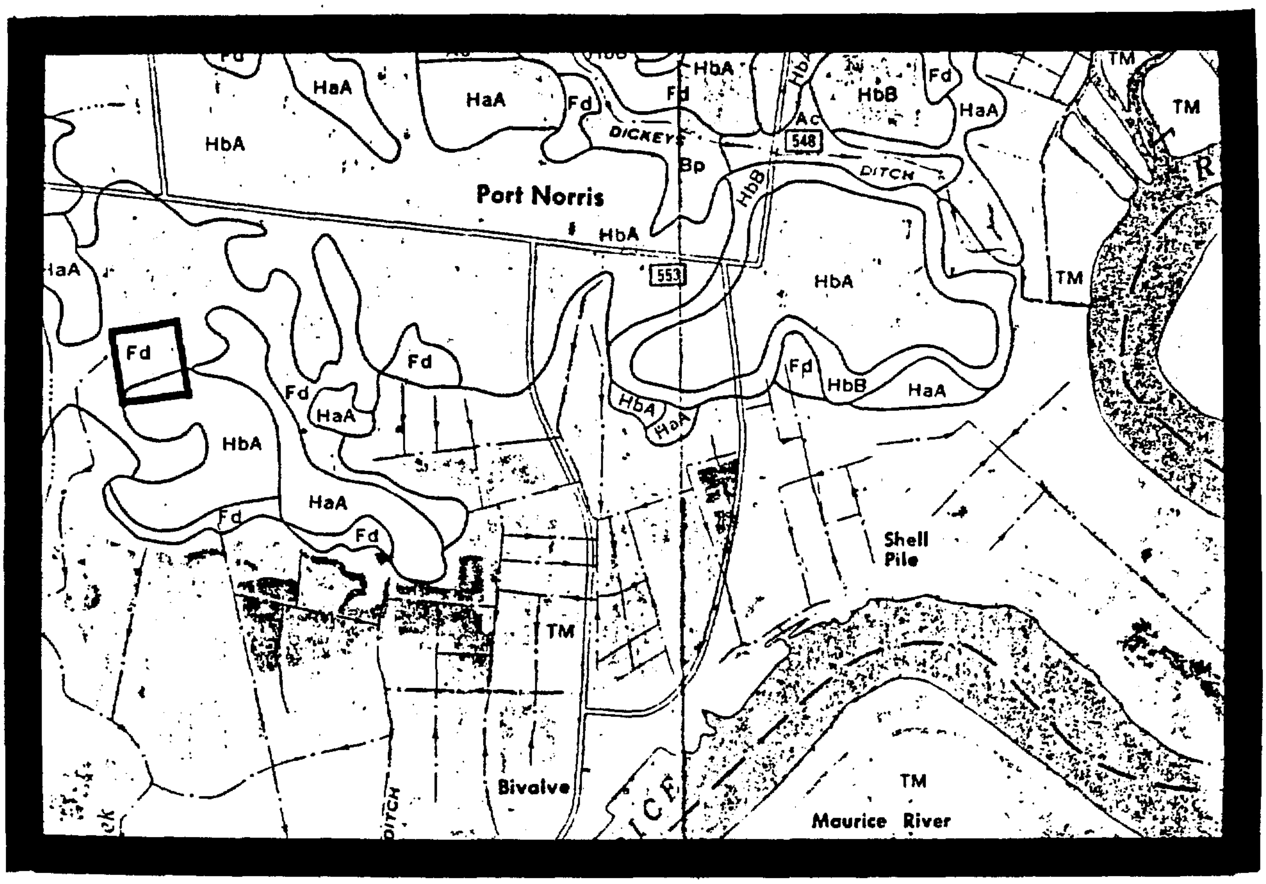
SITE 278   Warren Ave., Port Norris, Cumberland County.

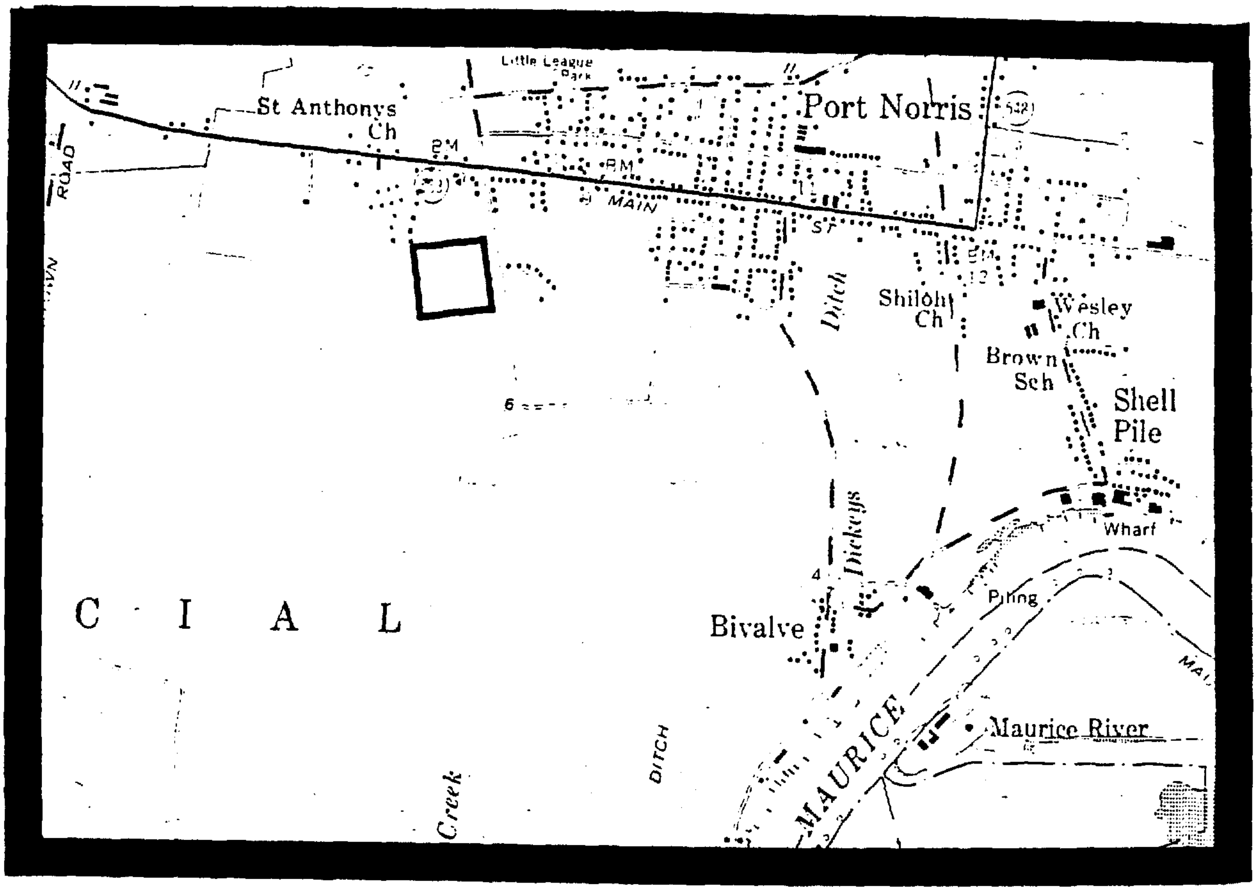
MAP A: Sheet # 40, Cumberland County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Port Norris, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Port Norris, N.J. Quadrangle (Scale 1:24,000)

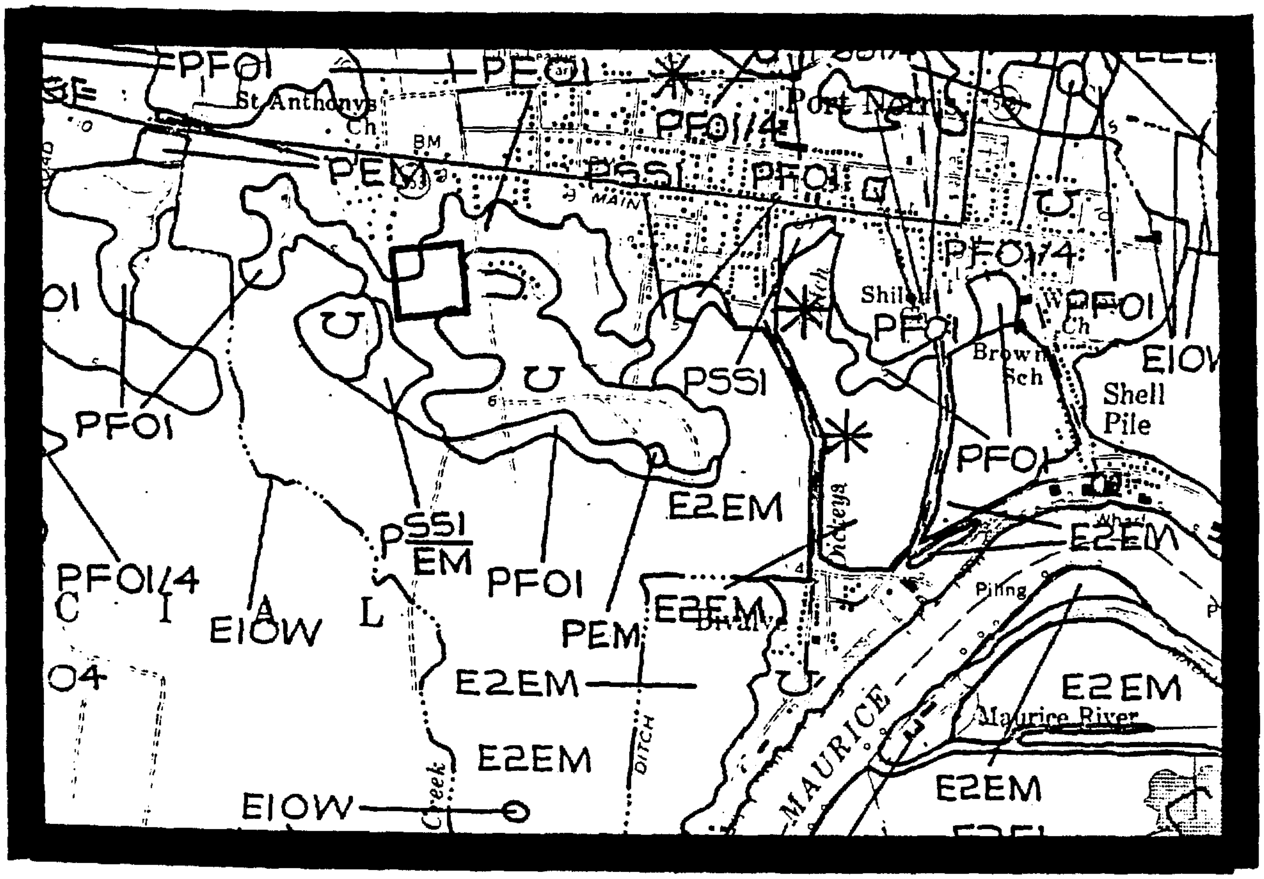
MAP A




St Anthonys Ch
Little League Park
Port Norris
MAIN ST
Ditch
Shiloh Ch
Wesley Ch
Brown Sch
Shell Pile
Wharf
Dickeys
Piling
Bivalve
C I A L
MAURICE
Maurice River
DITCH
Creek

MAP B

MAP C


PFO1
St Anthonys Ch
Port Norris
PFO1/4
PEM
PSS1
PFO1
MAIN
PFO1/4
PFO1
E1OW
Shell Pile
PFO1
PSS1
PSS1/EM
PFO1
E2EM
E2EM
PFO1/4
E1OW
PFO1
PEM
E2EM
Bivalve
E2EM
E2EM
Maurice River
MAURICE
E2EM
E1OW
E2EM
DITCH
Creek

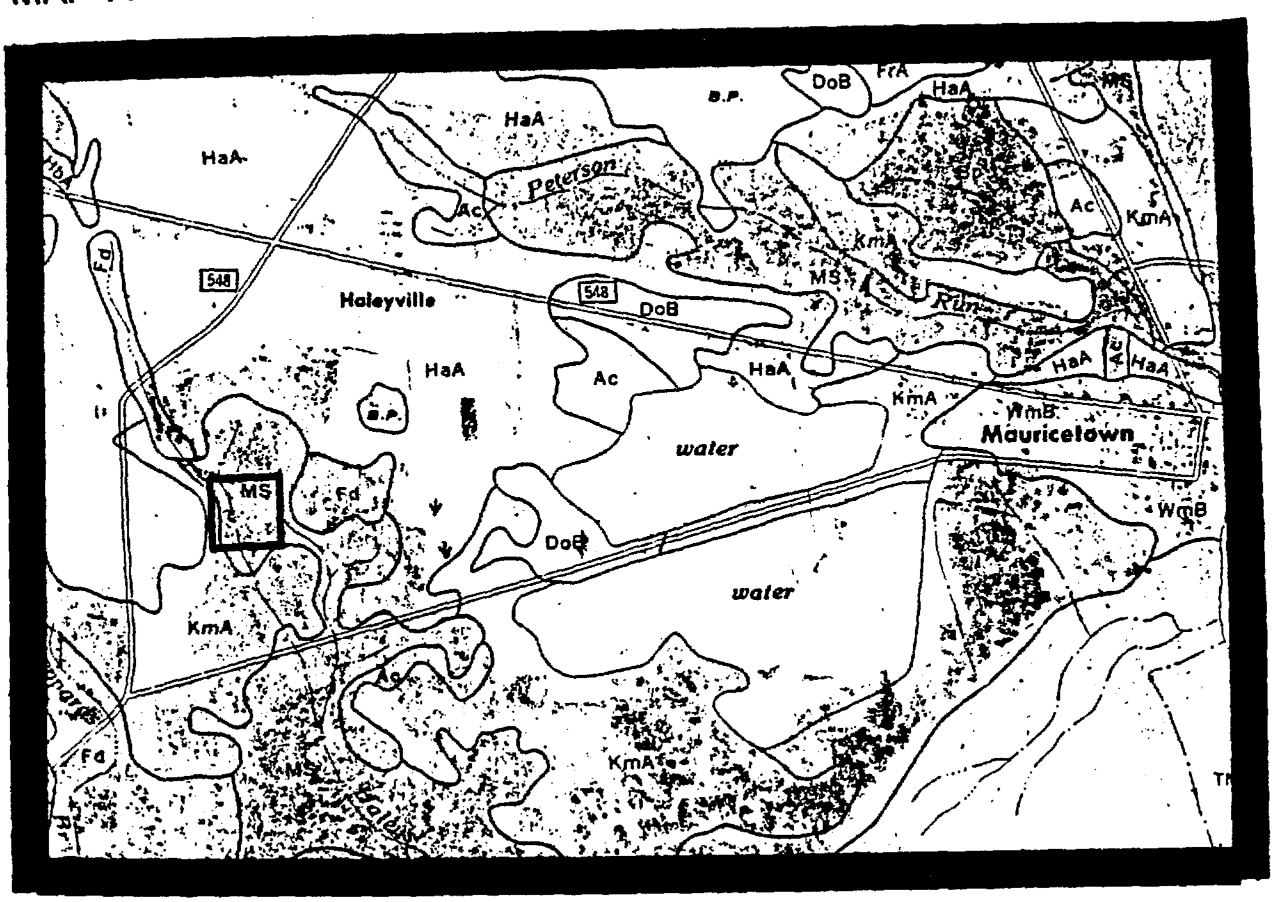
SITE 279 Maurice River Twp. School, Maurice River Twp., Cumberland County.

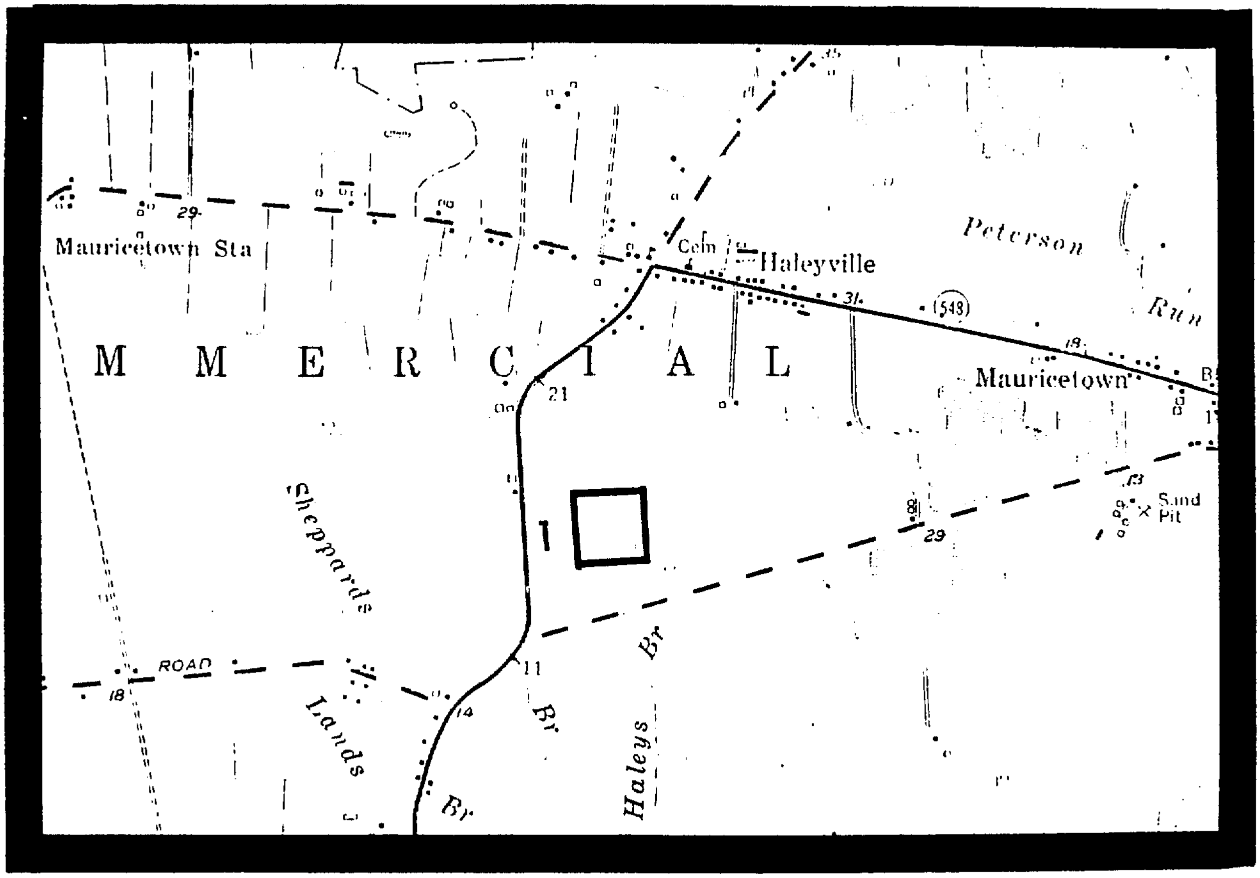
MAP A: Sheet # 37, Cumberland County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Dividing Creek, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory. Dividing Creek, N.J. Quadrangle (Scale 1:24,000)

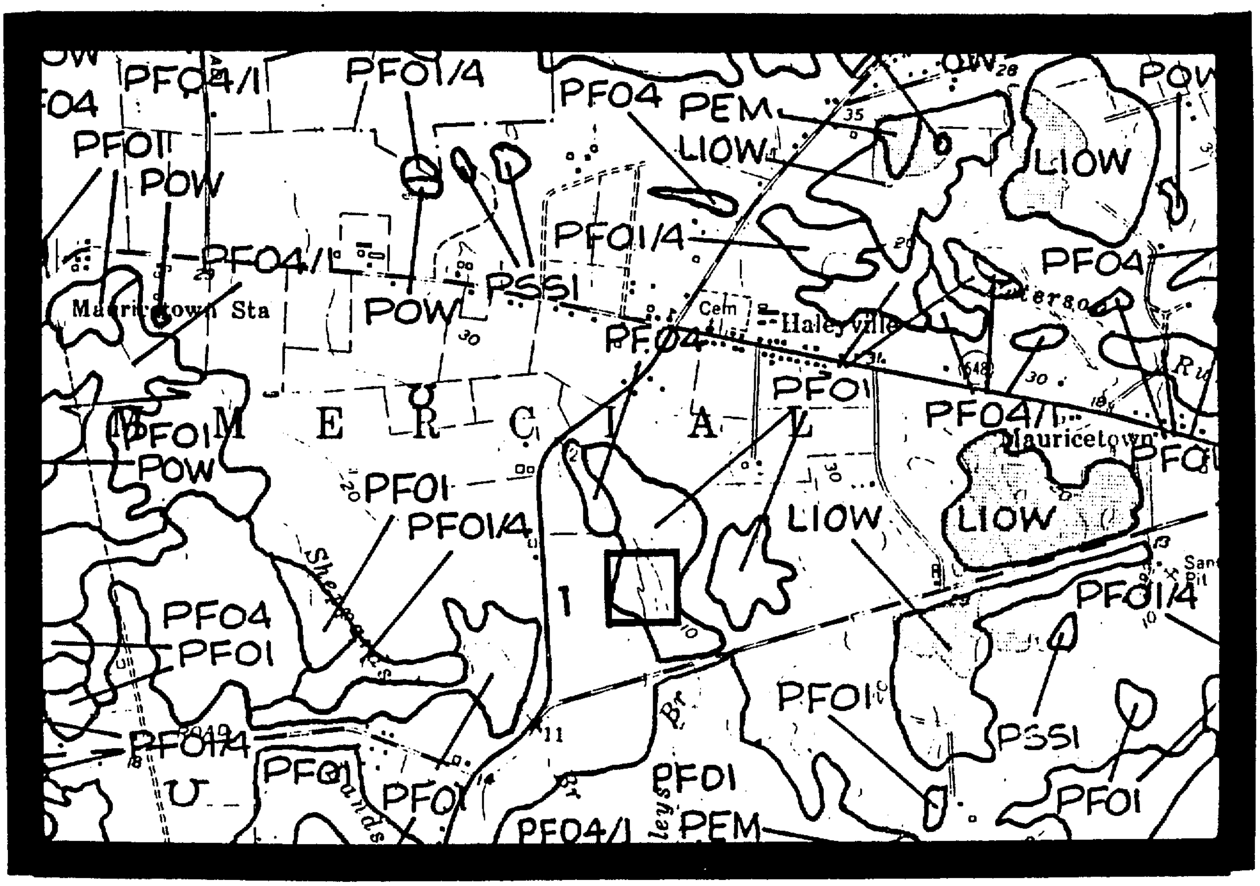
MAP A




Mauricetown Sta
Cem
Haleyville
Peterson
Run
548
Mauricetown
M M E R C I A L
Sheppards
ROAD
Lands
Br
Haleys
Br
Sand Pit
1

MAP B

MAP C


PFO4/1
PFO1/4
PFO4
PEM
L1OW
PFO1
POW
PSS1
Mauricetown Sta
Cem
Haleyville
Mauricetown
M E R C I A L
PFO4/1
PFO1
PFO1/4
PFO4
PFO1
PSS1
PFO1
PFO4/1
PEM
1

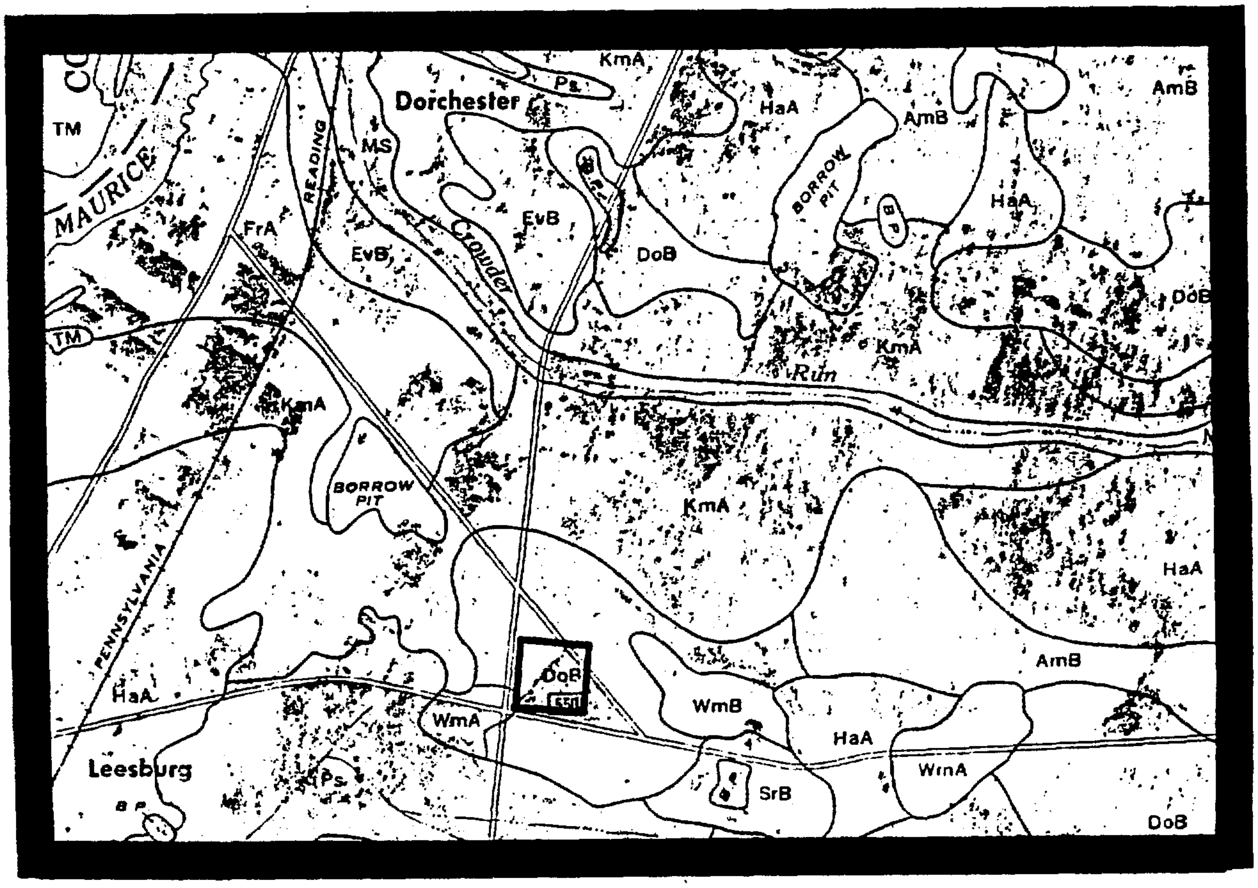
SITE 280 Delsea Fire House, Rt. 47, Maurice River Twp., Cumberland County.

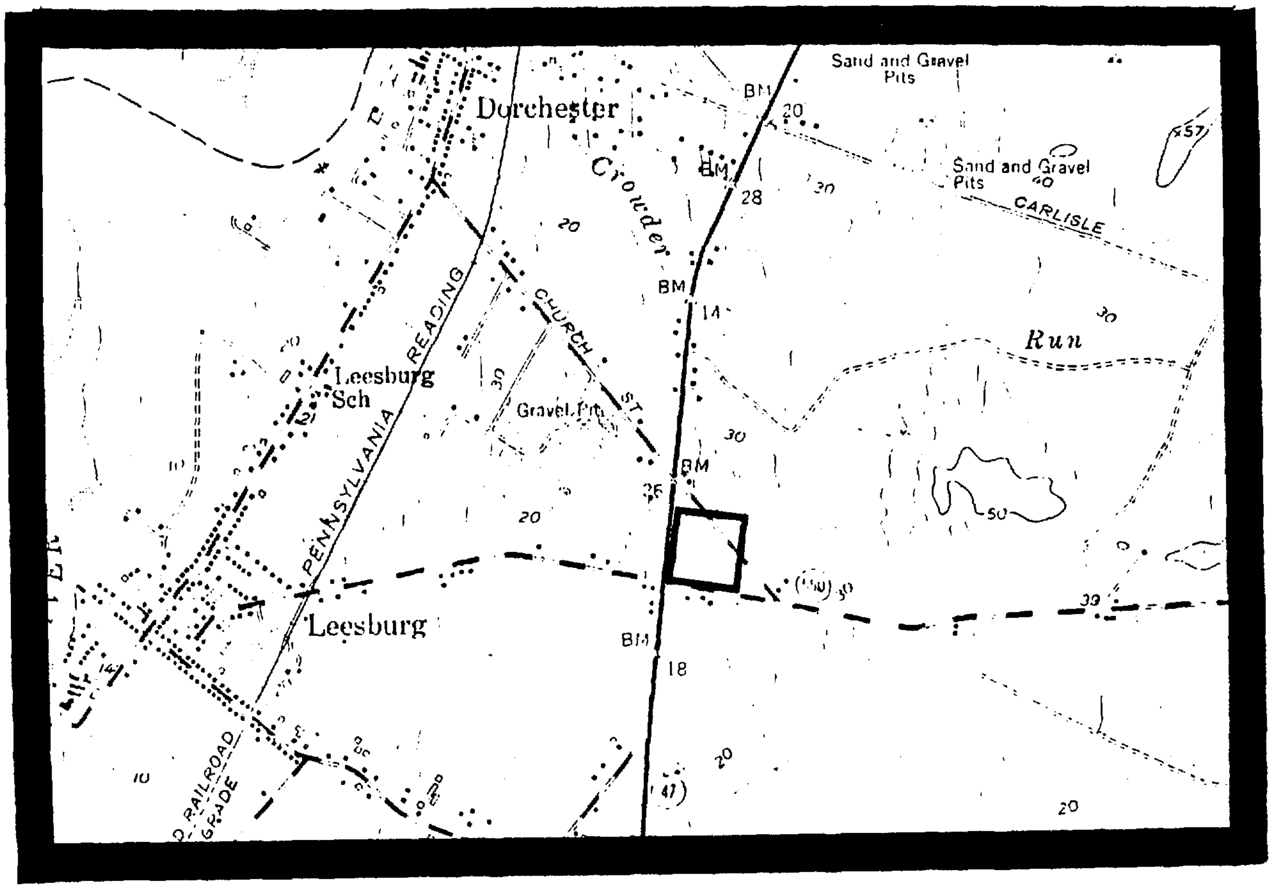
MAP A: Sheet # 38, Cumberland County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Port Elizabeth, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Port Elizabeth, N.J. Quadrangle (Scale 1:24,000)

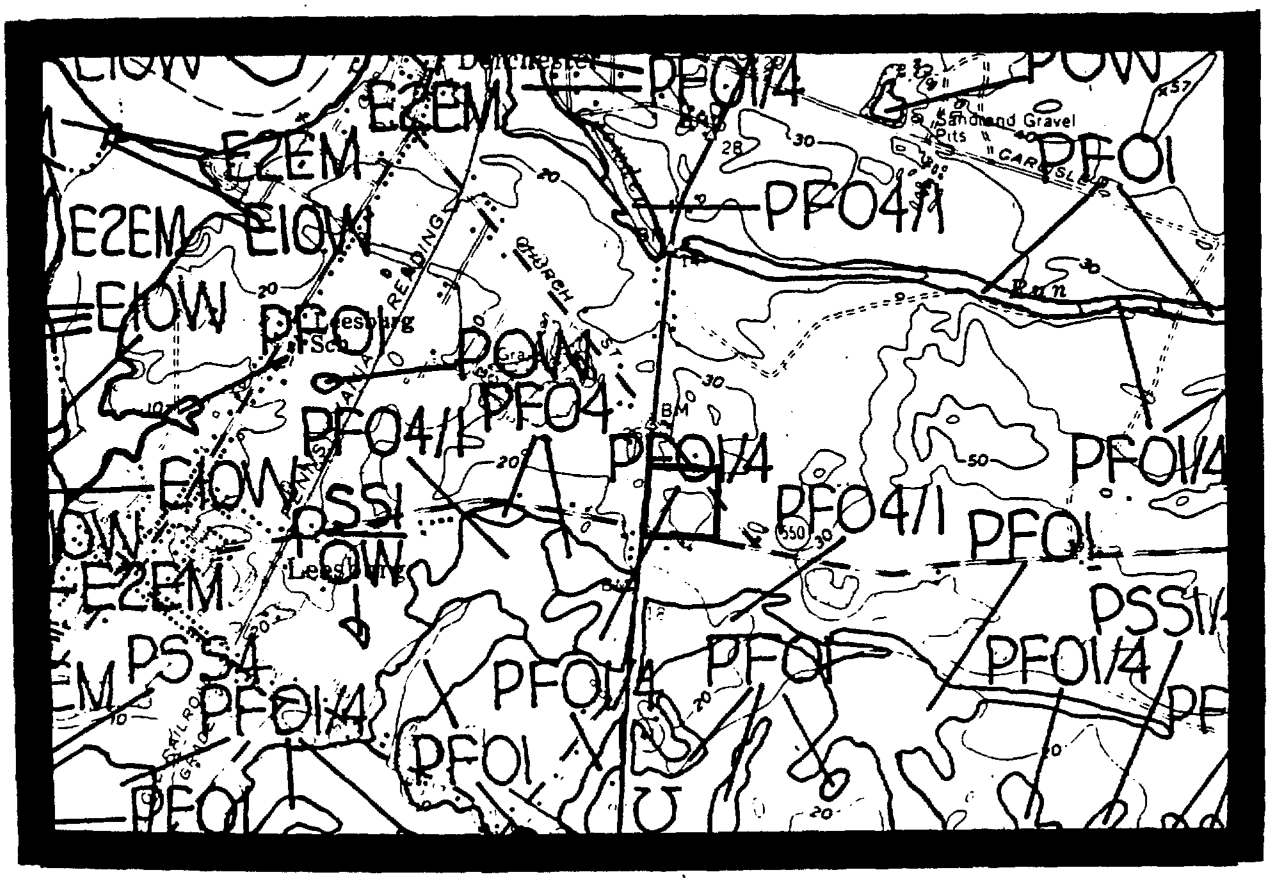
MAP A




Dorchester
Crowder
Sand and Gravel Pits
Sand and Gravel Pits
CARLISLE
Run
PENNSYLVANIA READING
CHURCH ST
Leesburg Sch
Gravel Pit
Leesburg
RAILROAD GRADE

MAP B

MAP C


E1OW
E2EM
PFO1/4
PFO4/1
POW
PFO1
PFO4
PSS1
PFOL
PSS1/4
PSS4
Leesburg Sch
Run
READING
Sand and Gravel Pits
CARLISLE

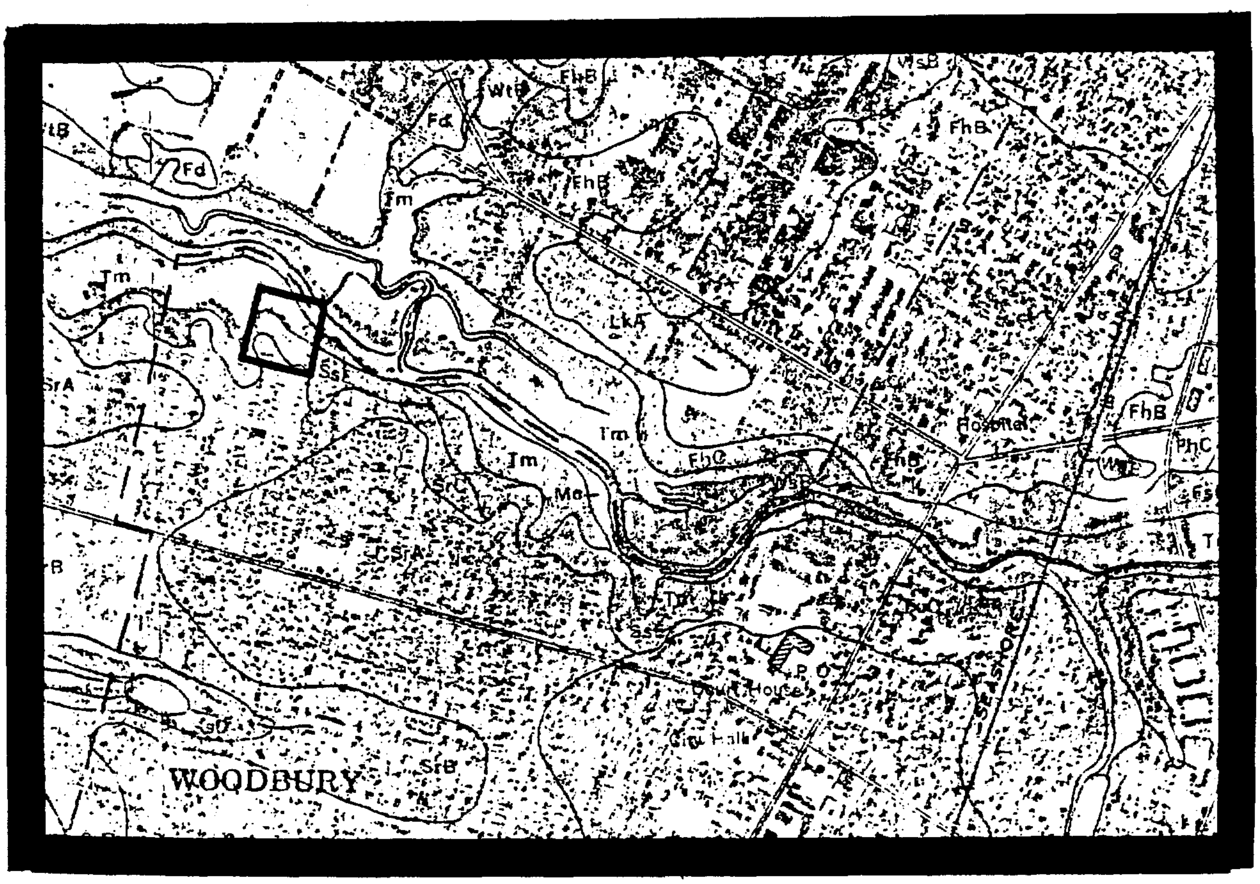
SITE 281 544 Oakside Pl., Woodbury, Gloucester County.

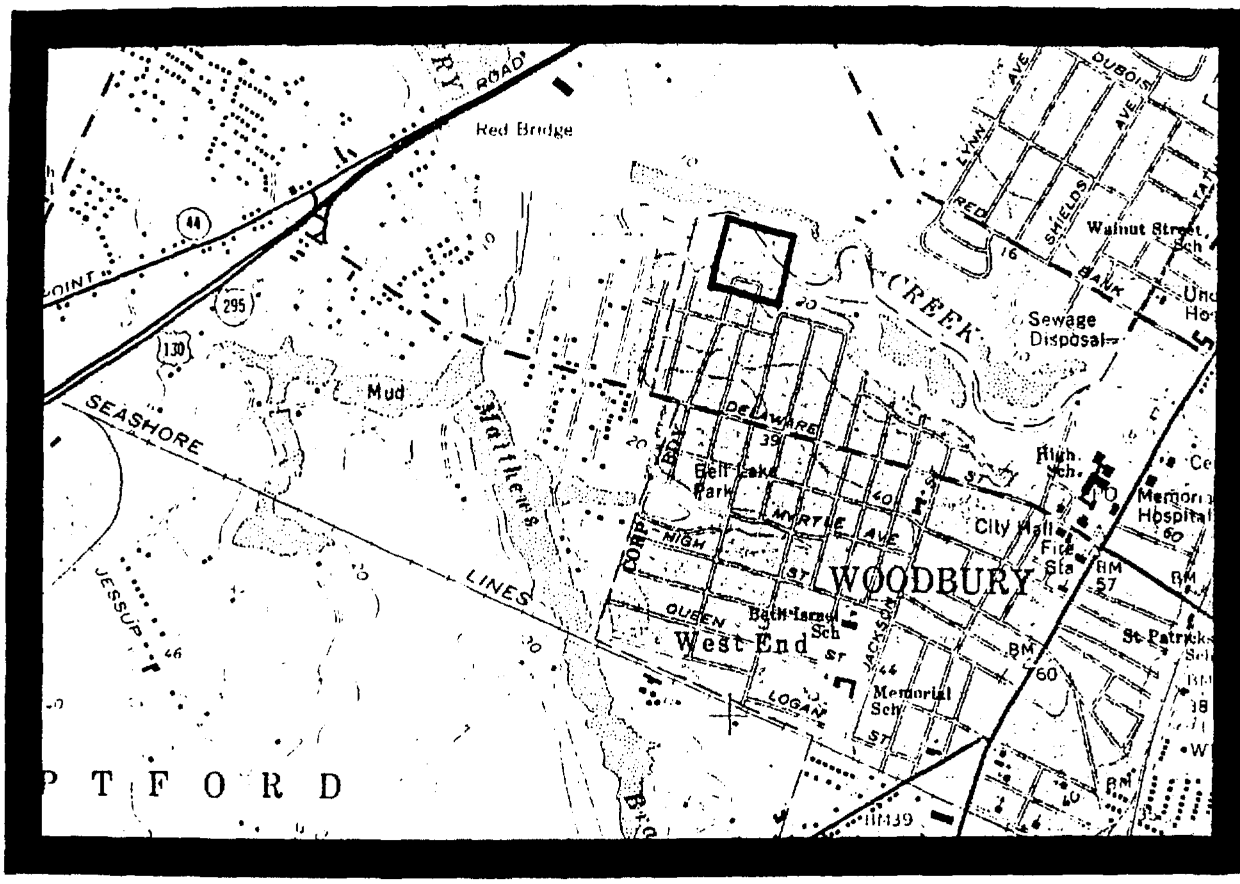
MAP A: Sheet # 4, Glocester County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Woodbury, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Woodbury, N.J. Quadrangle (Scale 1:24,000)

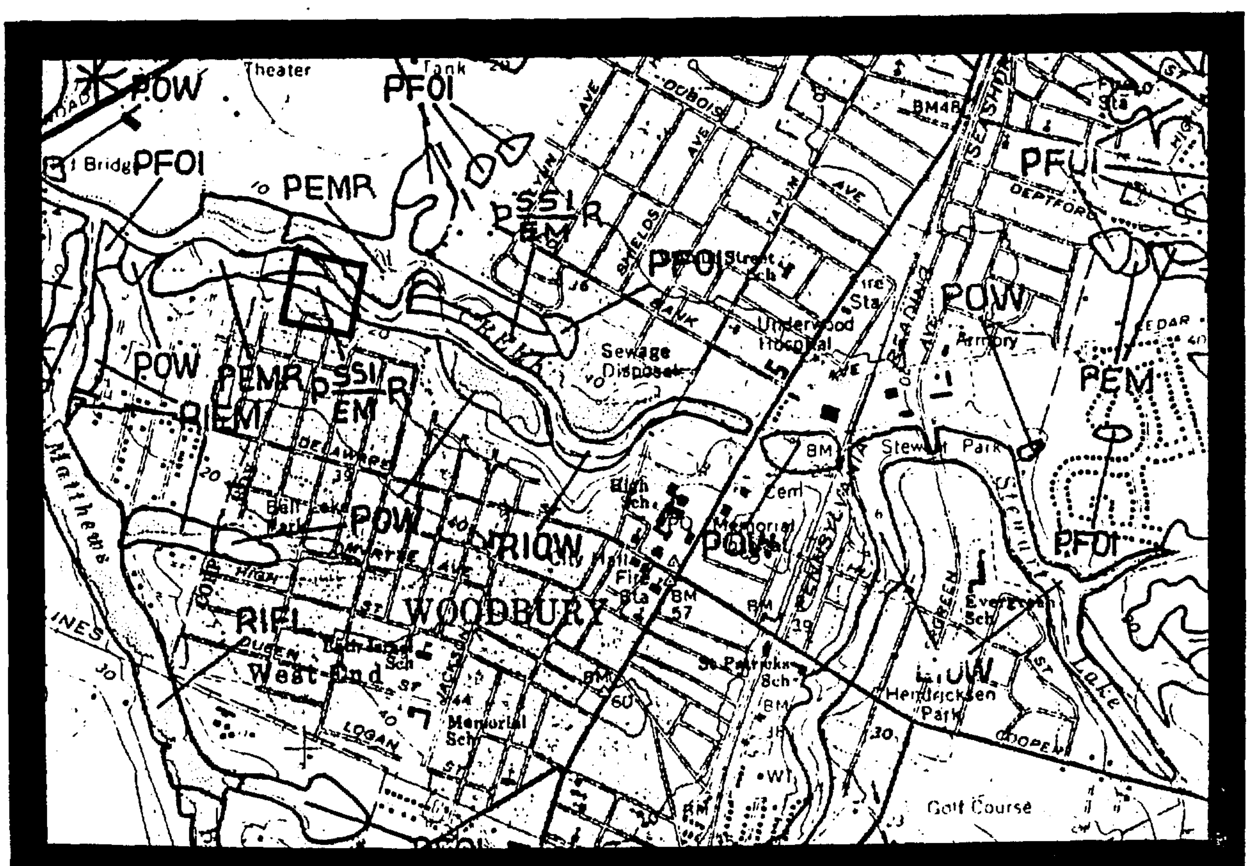
MAP A




Red Bridge
ROAD
SEASHORE
LINES
Mud
Matthews
CREEK
Sewage
Disposal
DELAWARE
Bell Lake
Park
MYRTLE AVE
HIGH
WOODBURY
West End
Memorial
Sch
LOGAN
City Hall
High
Sch
Memorial
Hospital
Walnut Street
Sch
JESSUP
P T F O R D

MAP B

MAP C


POW
PFOI
PEMR
PSS1R
PEM
Theater
Tank
Sewage
Disposal
Underwood
Hospital
Armory
DEPTFORD
Stewart Park
RIOW
RIFL
WOODBURY
West End
Memorial
Sch
Hendrickson
Park
Golf Course
Matthews
COOPER

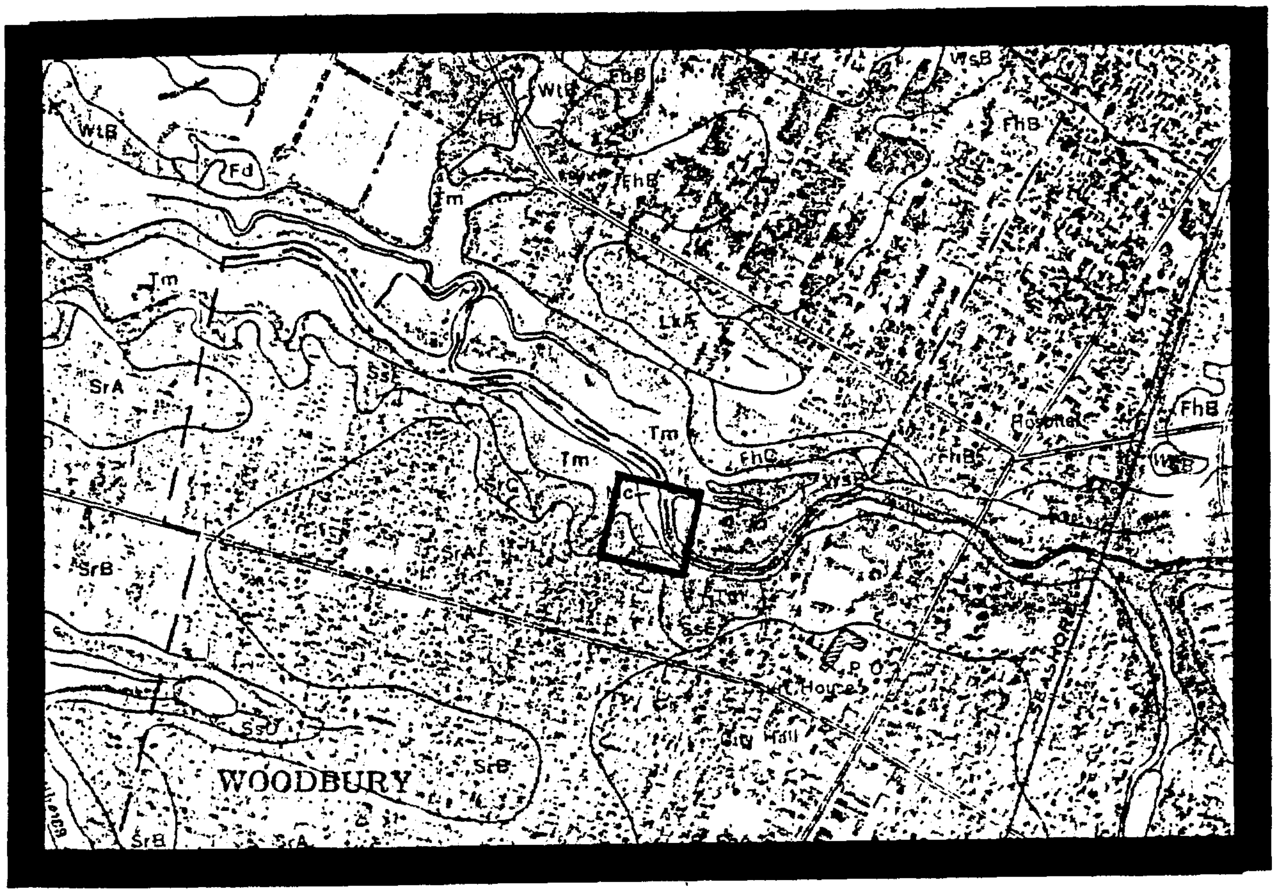
SITE 282 Briar Hill Lane, Woodbury, Gloucester County.

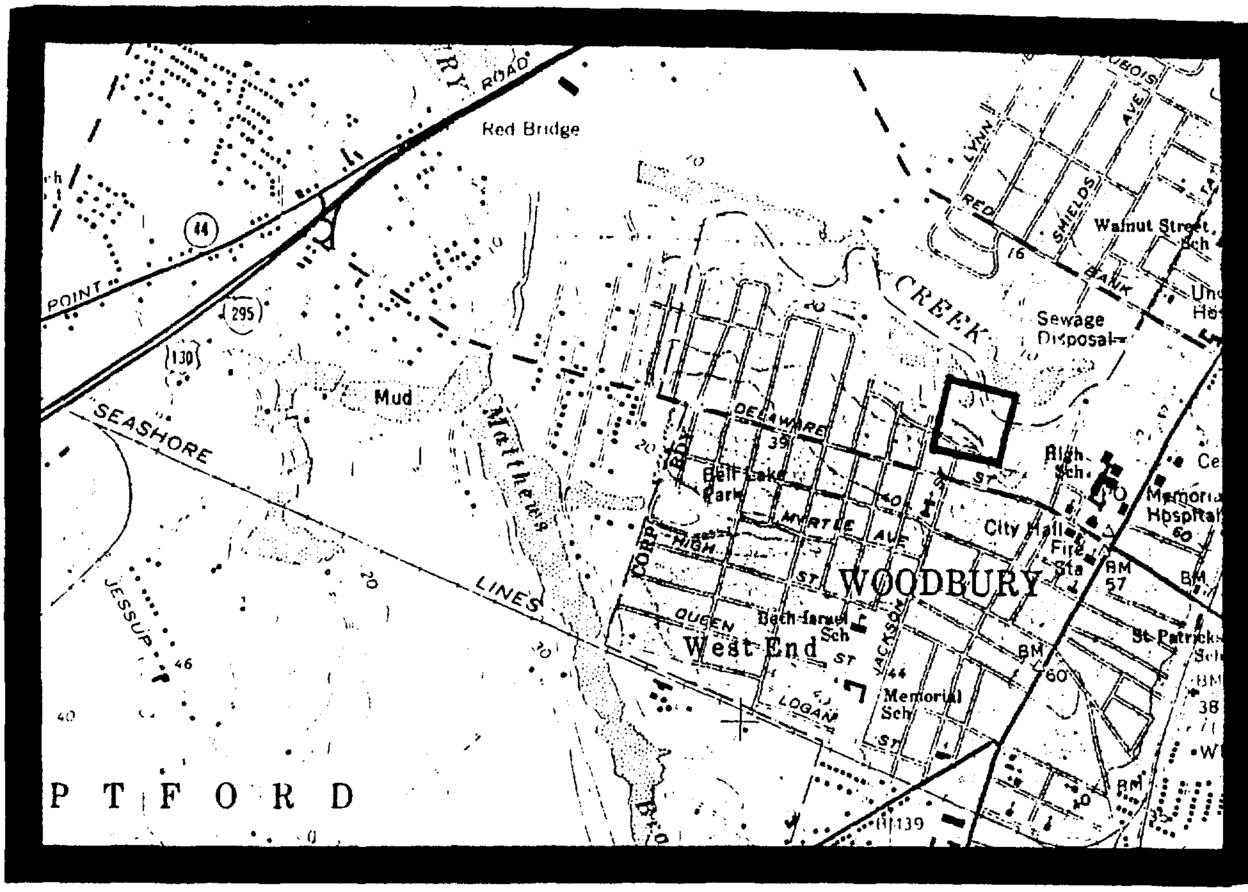
MAP A: Sheet # 4, Gloucester County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Woodbury, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Woodbury, N.J. Quadrangle (Scale 1:24,000)

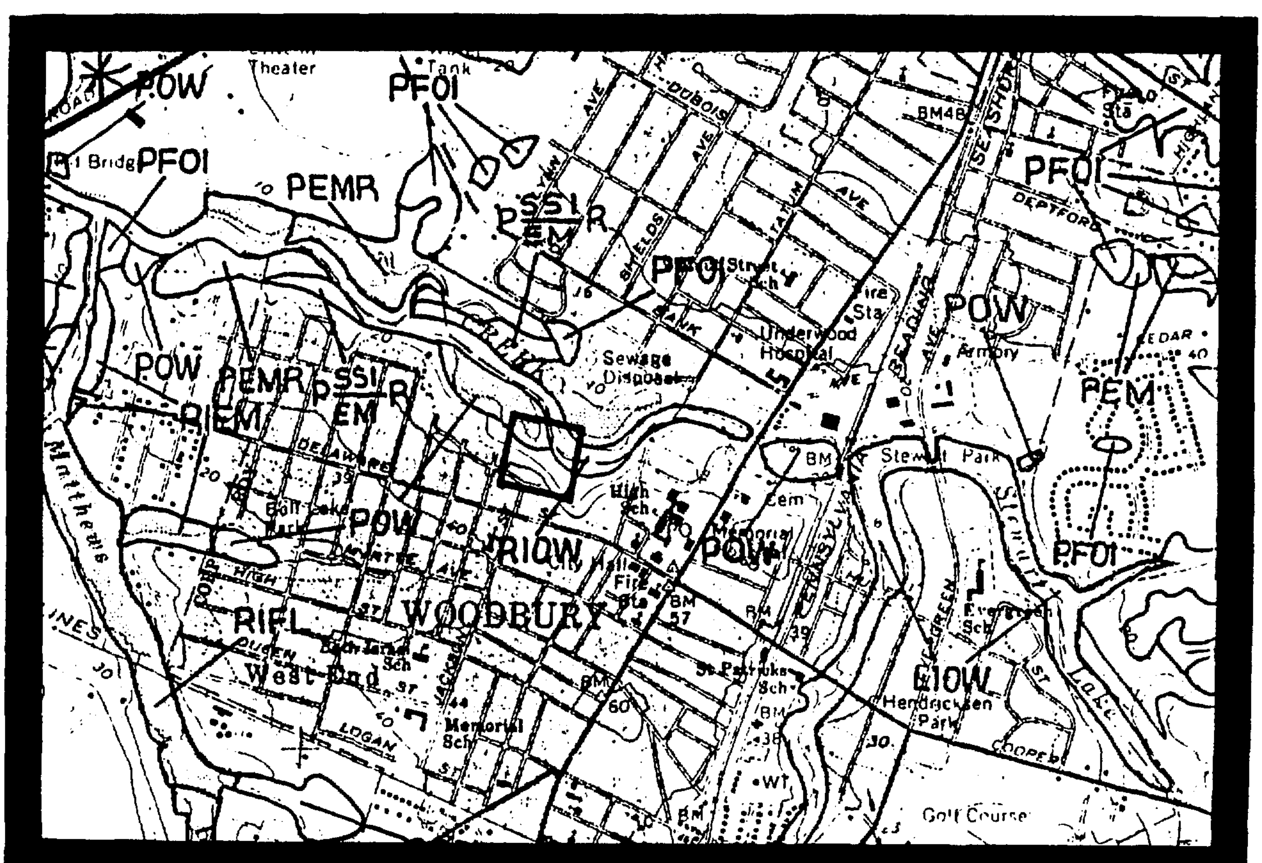
MAP A




Red Bridge
ROAD
POINT
SEASHORE
LINES
Mud
Matthews
CREEK
Sewage
Disposal
DELAWARE
Bell Lake
Park
MYRTLE
AVE
HIGH
City Hall
Fire
Sta
WOODBURY
QUEEN
West End
Beth Israel
Sch
LOGAN
Memorial
Sch
JACKSON
High
Sch
Memorial
Hospital
St Patricks
Walnut Street
Sch
SHIELDS
AVE
LYNN
RED
BANK
JESSUP
P T F O R D

MAP B

MAP C


POW
Theater
PFOI
Tank
PFOI
PEMR
PSS1
PEM
R
PFOI
POW
PEMR
PSS1
PEM
R
PIEM
POW
R1OW
POW
R1FL
WOODBURY
West End
Matthews
Sewage
Disposal
Underwood
Hospital
Fire
Sta
Armory
POW
PEM
PFOI
E1OW
Hendricksen
Park
Golf Course
Stewart Park
DEPTFORD
DUBOIS
SHIELDS
BANK
READING
AVE
SEASHORE
CEDAR
COOPER
Evergreen
Sch
St Patricks
Sch
Memorial
Sch
Beth Israel
Sch
QUEEN
LOGAN
DELAWARE
HIGH
Bell Lake
Park
City Hall
Cem

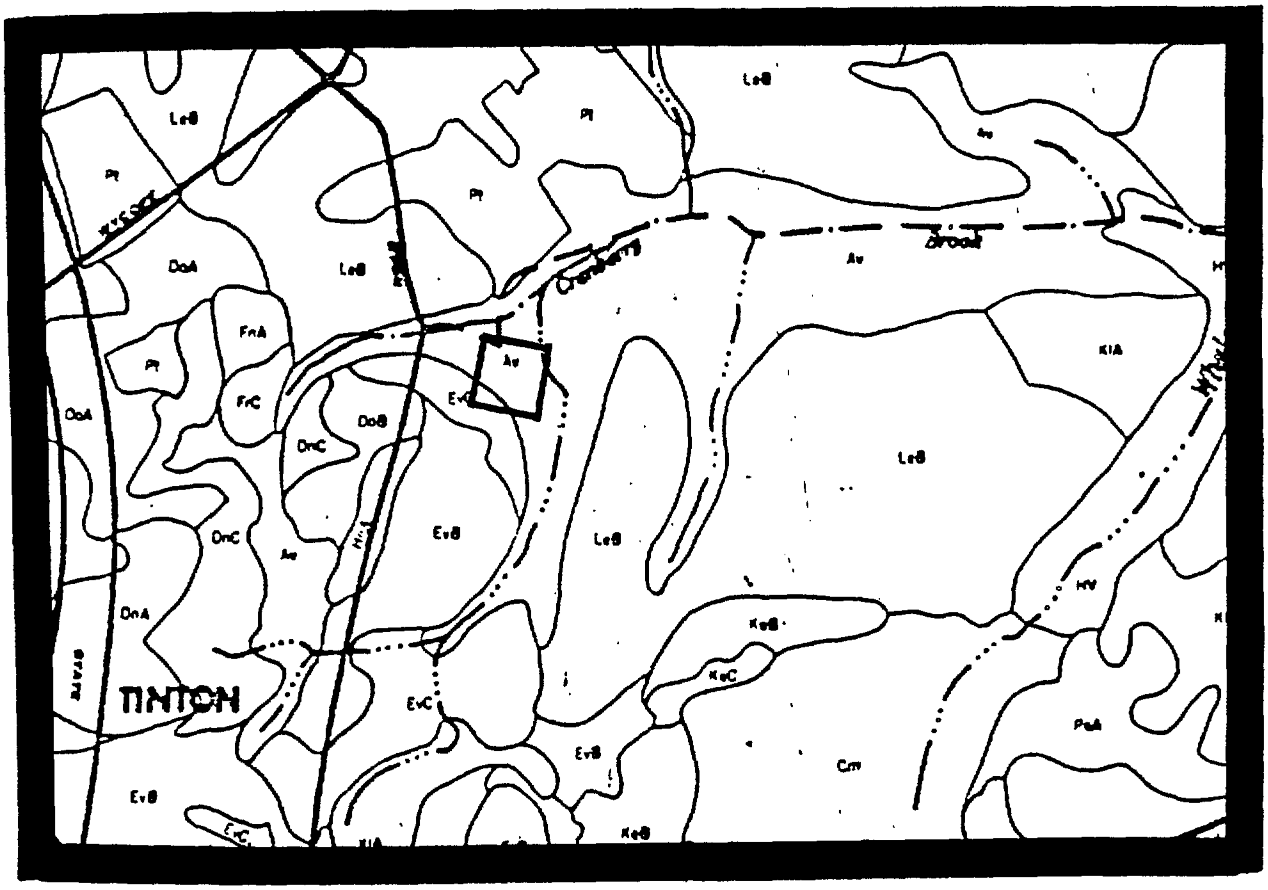
SITE 283 Pine Dr., Wayside, Monmouth County.

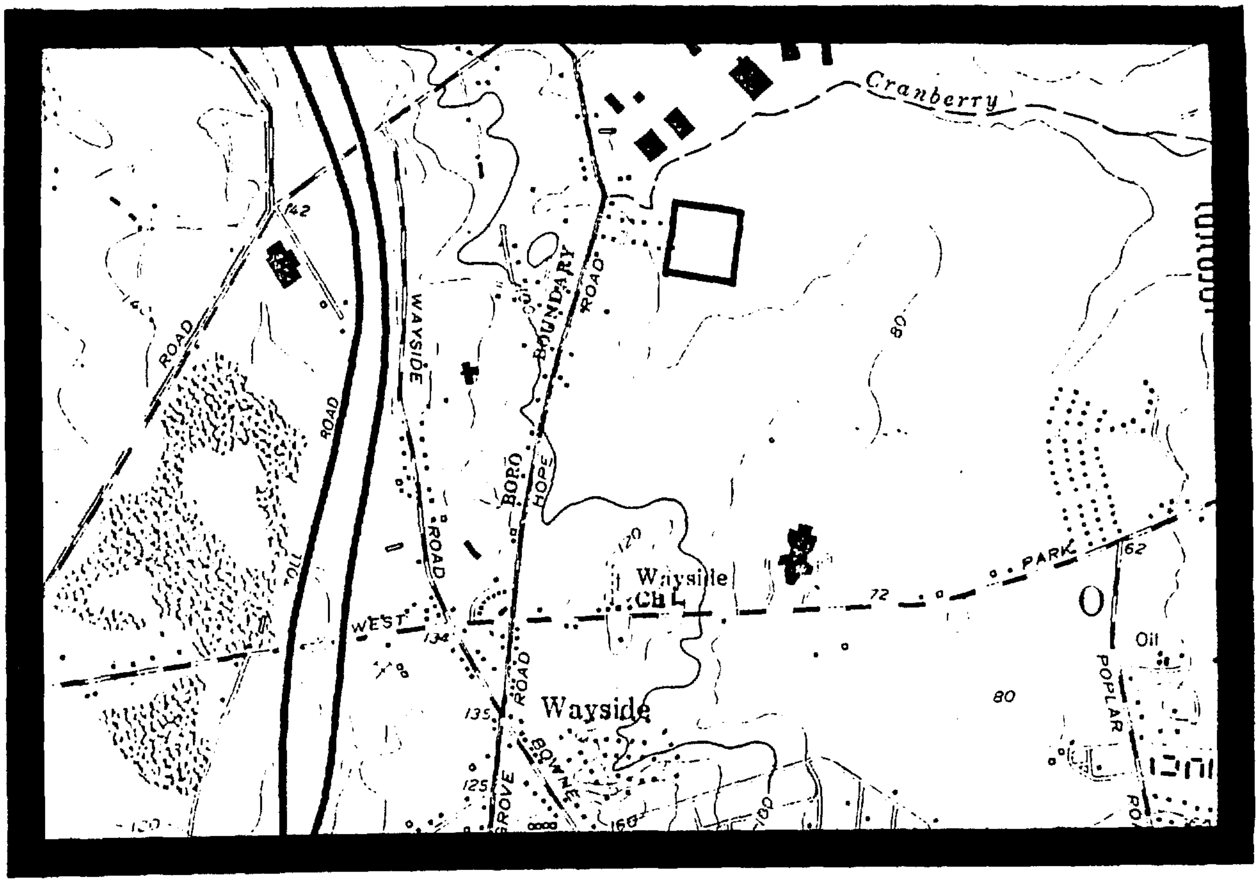
MAP A: Sheet # 29, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Long Branch, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Long Branch, N.J. Quadrangle (Scale 1:24,000)

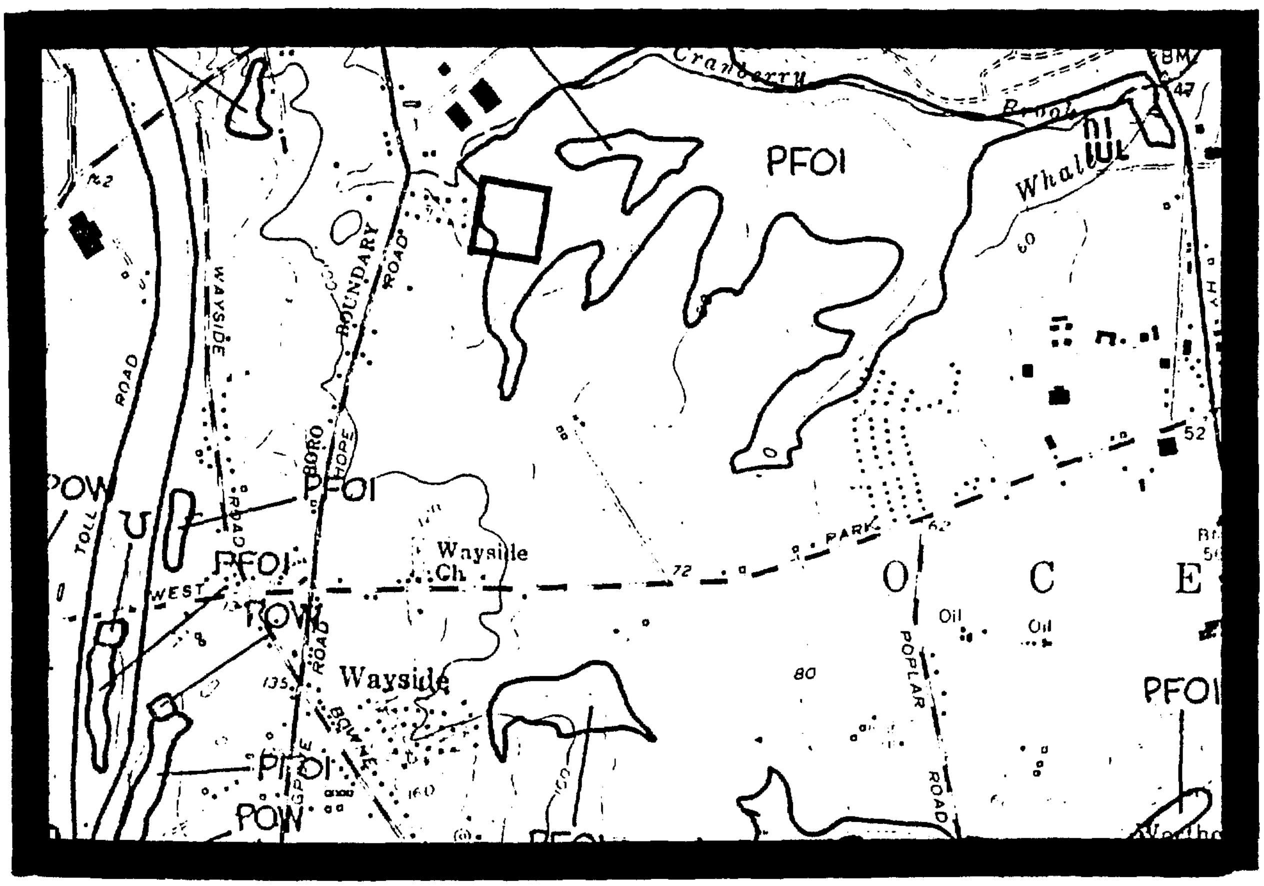
MAP A




Cranberry
142
ROAD
WAYSIDE
BOUNDARY
ROAD
ROAD
BORO
HOPE
ROAD
TOLL
WEST
134
Wayside
Ch
120
72
PARK
62
O
Oil
POPLAR
80
135
Wayside
ROAD
BOWNE
GROVE
125
160

MAP B

MAP C


Cranberry
Brook
BM
47
PFOI
Whale
60
142
WAYSIDE
BOUNDARY
ROAD
ROAD
BORO
HOPE
POW
U
PFOI
ROAD
TOLL
PFOI
WEST
POW
Wayside
Ch
72
PARK
62
O
C
E
Oil
Oil
52
135
Wayside
80
POPLAR
PFOI
BOWNE
160
PFOI
POW
ROAD

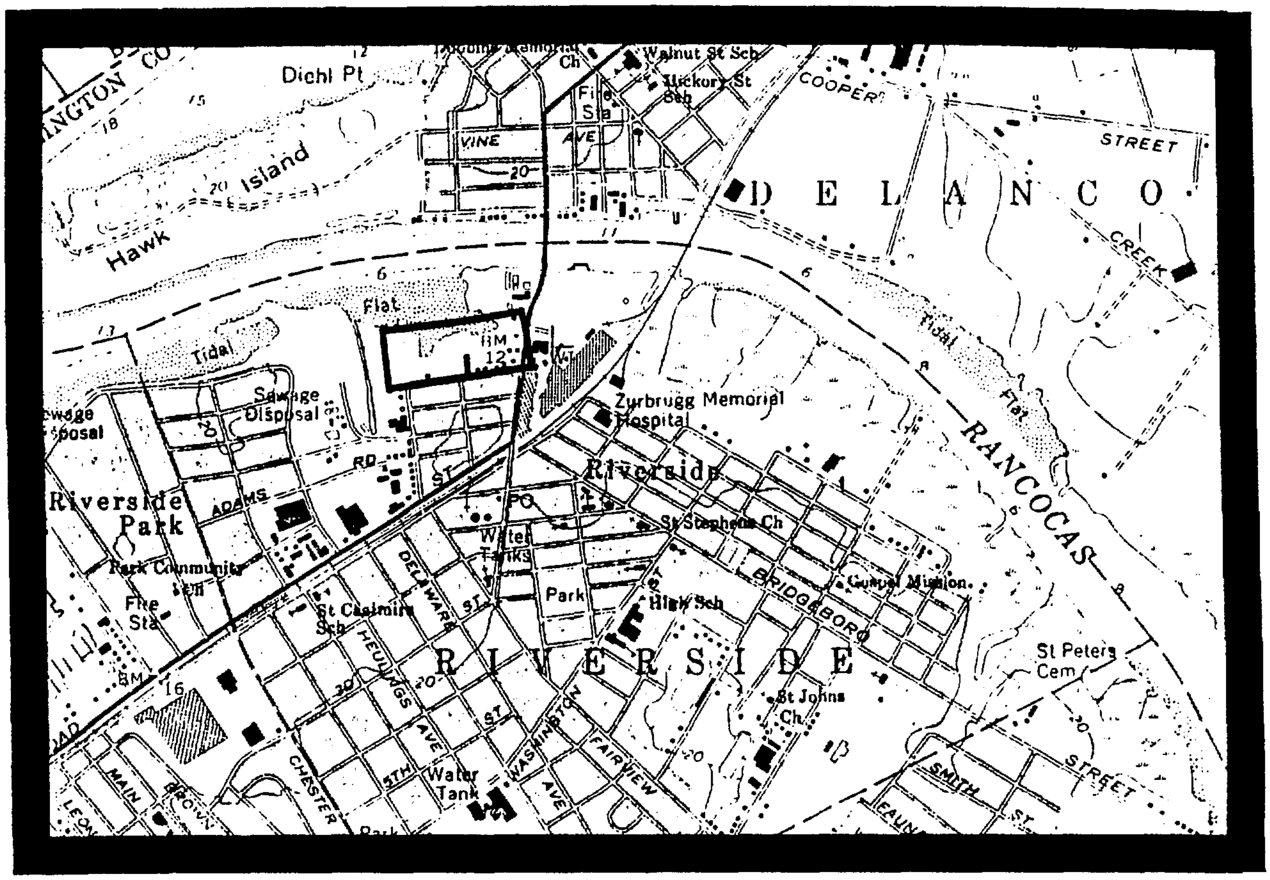
SITE 284 Polk St., Riverside, Burlington County.

MAP A: Sheet # 12, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

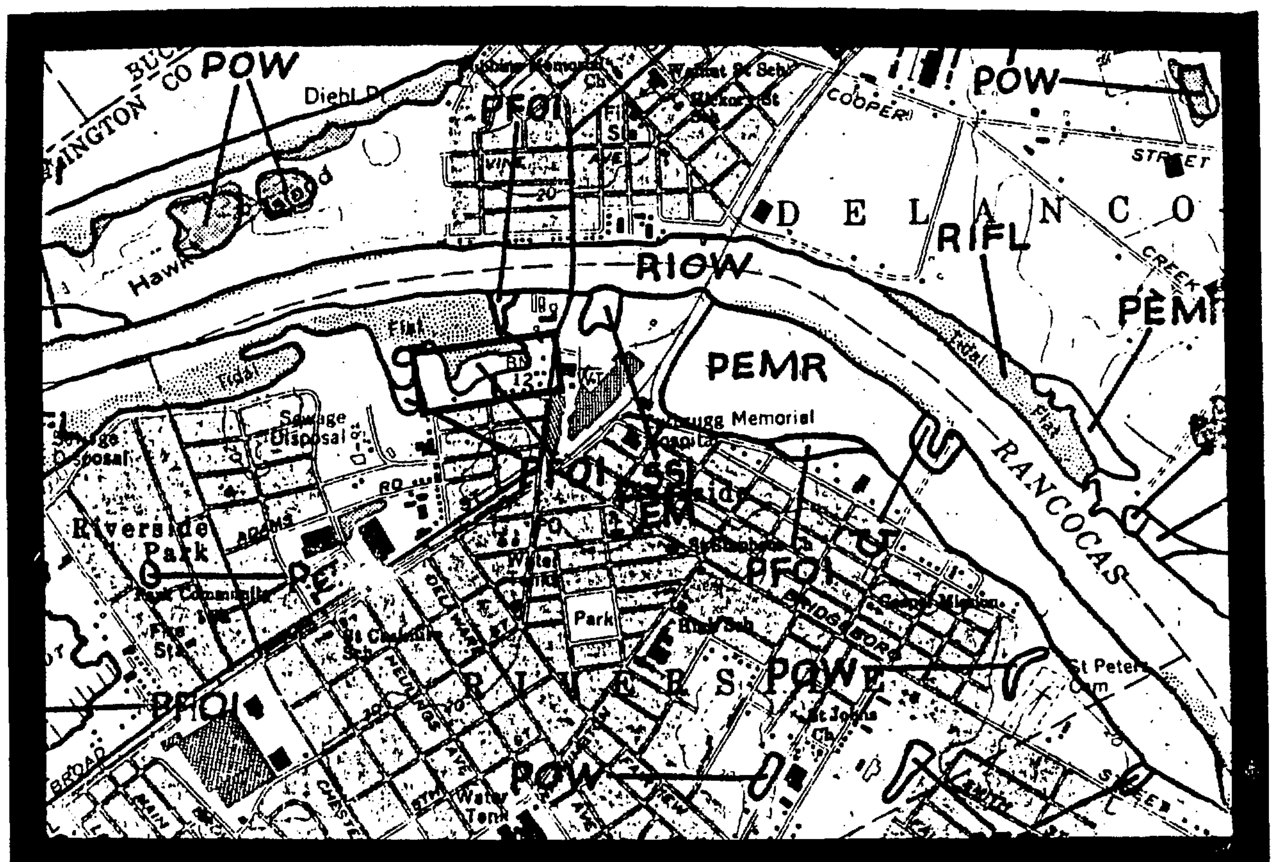
MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

MAP A


Diehl Pt
Hawk
Island
Walnut St Sch
Hickory St Sch
COOPER
STREET
D E L A N C O
CREEK
VINE
AVE
Tidal
Flat
RANCOCAS
BM 12
Zurbrugg Memorial Hospital
Sewage Disposal
Riverside Park
Park Community
Fire Sta
Riverside
PO
St Stephens Ch
Water Tanks
Park
High Sch
BRIDGEBORO
Gospel Mission
R I V E R S I D E
St Peters Cem
St Johns Ch.
St Casimirs Sch
DELAWARE
HEULINGS
AVE
WASHINGTON
FAIRVIEW
SMITH
STREET
Water Tank
CHESTER
MAIN
BROWN
ADAMS
RD
ST
BM 16

MAP B

MAP C


POW
Diehl Pt
PFOI
COOPER
STREET
D E L A N C O
RIFL
CREEK
PEM
Hawk
RIOW
Flat
Tidal
PEMR
RANCOCAS
Sewage Disposal
Riverside Park
PE
ADAMS
RD
Park
High Sch
POWE
St Peters Cem
St Johns Ch
POW
PFOI
Water Tank

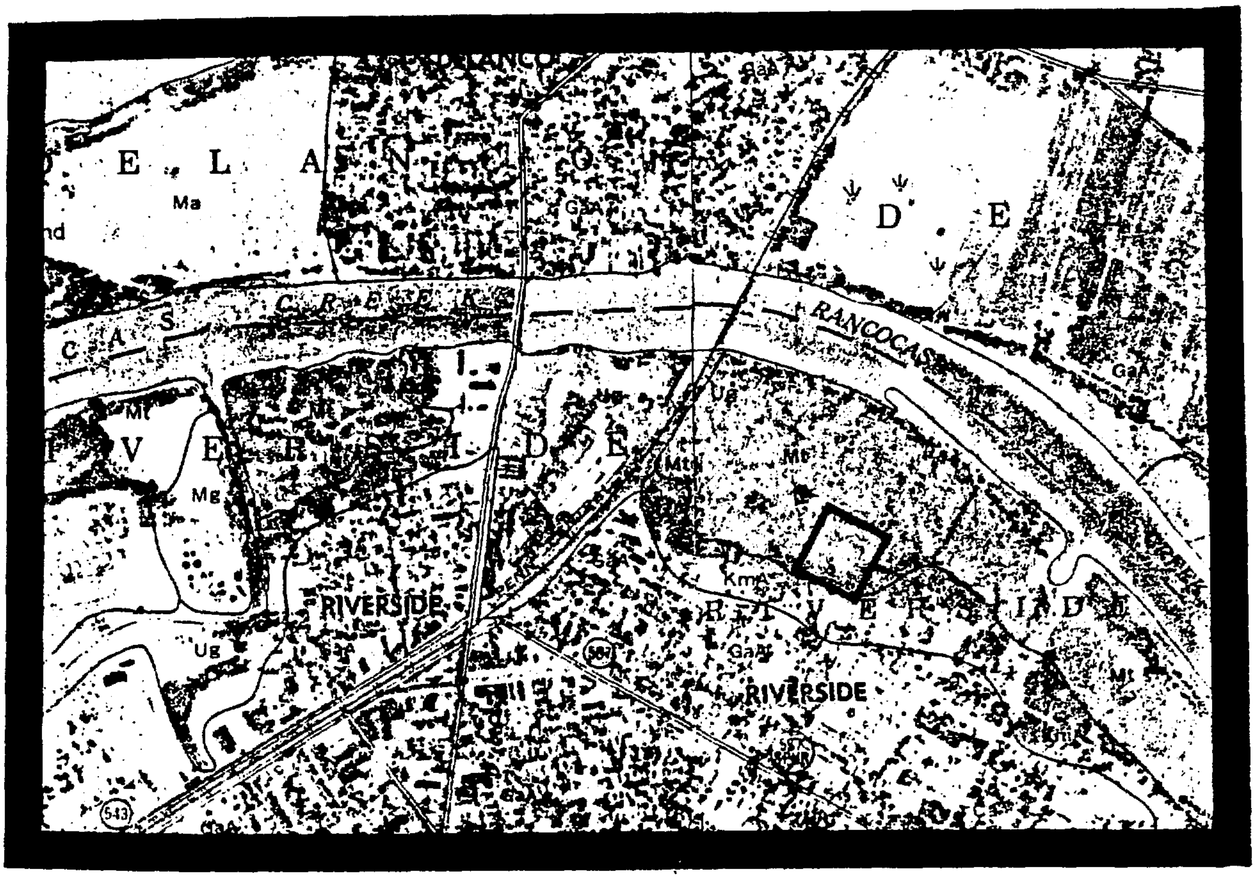
SITE 285 Harris/Washington St., Riverside, Burlington County.

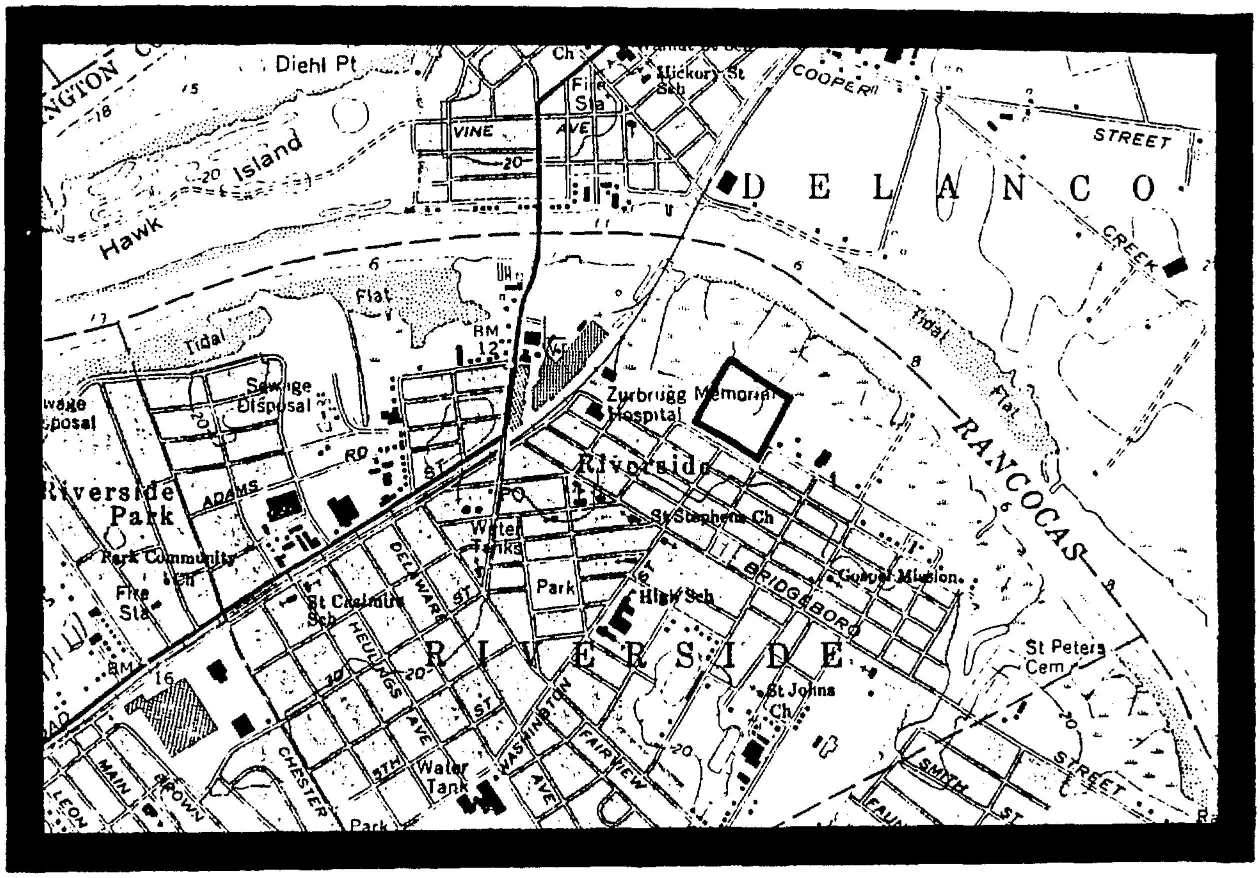
MAP A: Sheets # 12 & 13, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

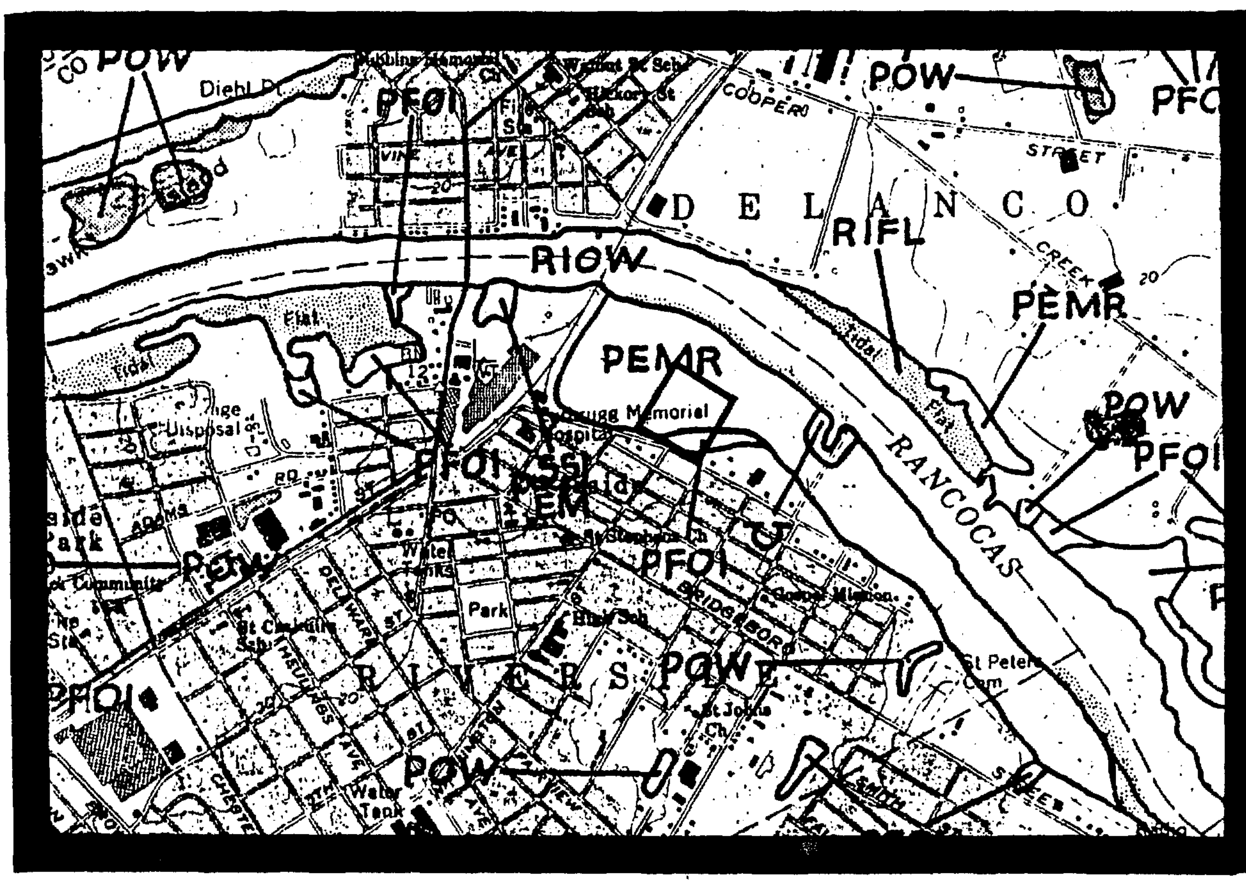
MAP A




Diehl Pt
Hawk Island
Flat
Tidal
DELANCO
COOPER
STREET
CREEK
RANCOCAS
Zurbrugg Memorial Hospital
Riverside
St Stephens Ch
Gospel Mission
Sewage Disposal
Riverside Park
Park Community
Fire Sta
St Casimirs Sch
Water Tanks
Park
High Sch
RIVERSIDE
St Peters Cem
St Johns Ch
Water Tank
VINE AVE
ADAMS
DELAWARE ST
HEULINGS AVE
WASHINGTON AVE
FAIRVIEW
CHESTER
BRIDGEBORO
SMITH
MAIN
BROWN
5TH

MAP B

MAP C


POW
PFOI
PFO
RIOW
RIFL
PEMR
PEM
SS
DELANCO
RANCOCAS
Diehl Pt
Flat
Tidal
Riverside
Zurbrugg Memorial Hospital
St Stephens Ch
Gospel Mission
Water Tanks
Park
High Sch
St Peters Cem
St Johns Ch
Water Tank
COOPER
STREET
CREEK
VINE AVE
ADAMS
BRIDGEBORO

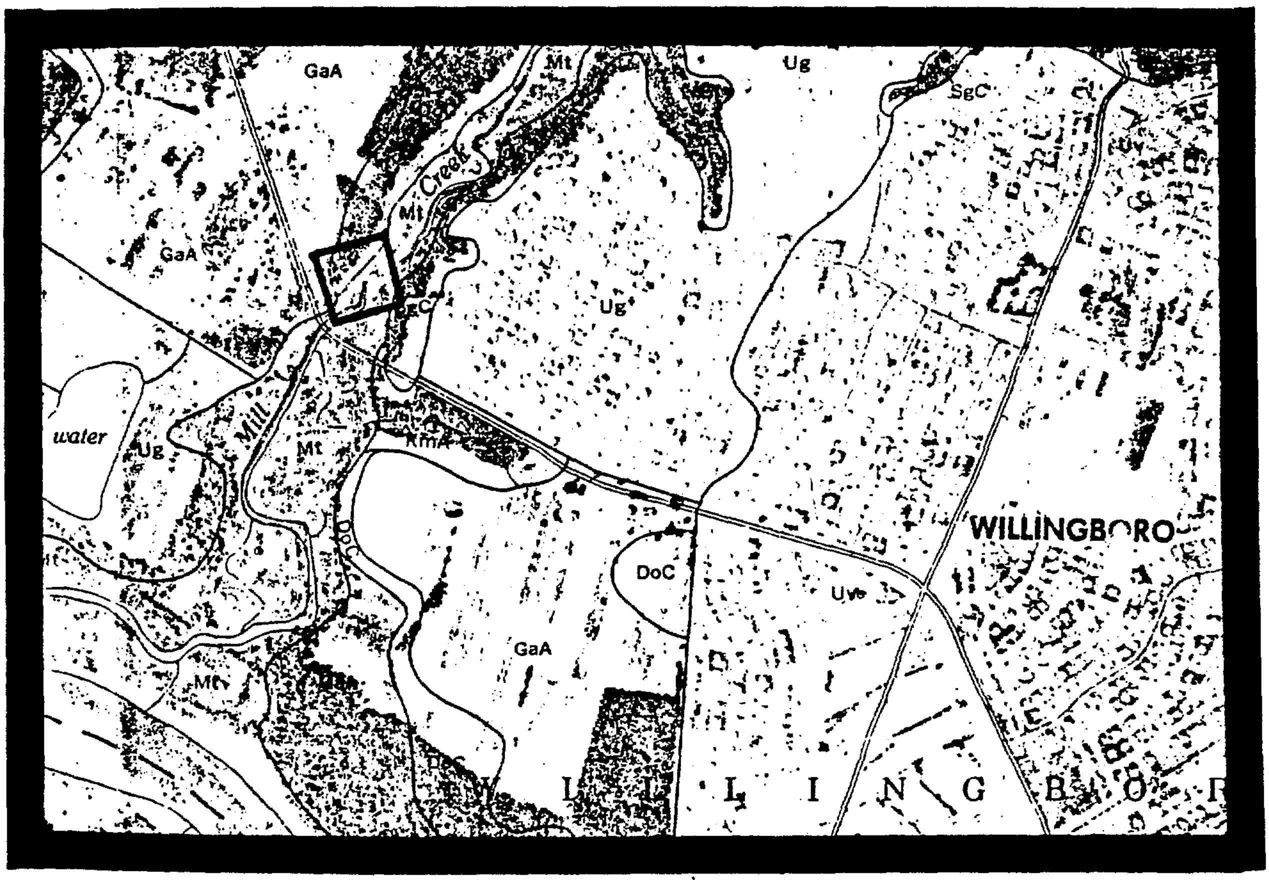
SITE 286 Rockland Dr., Willingboro, Burlington County.

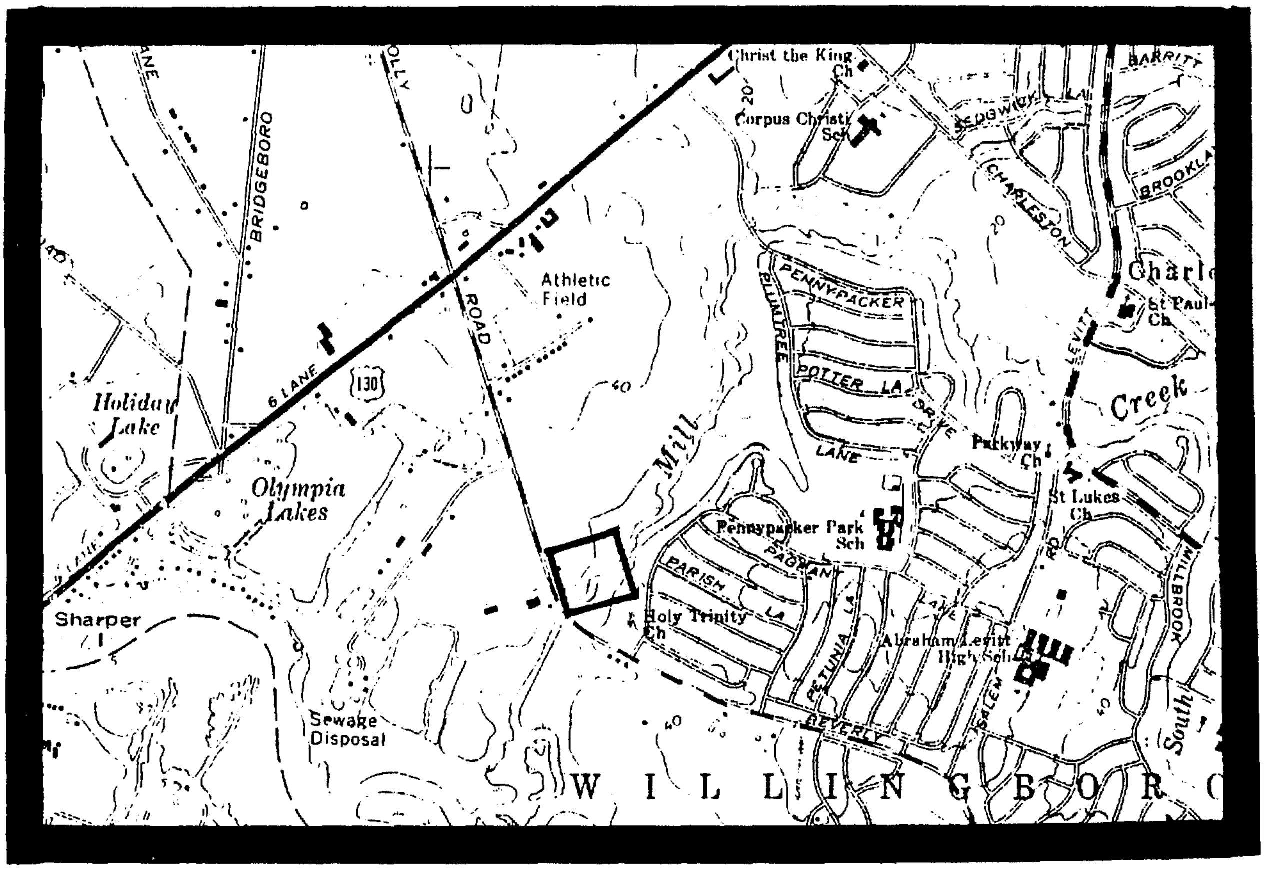
MAP A: Sheet # 21, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

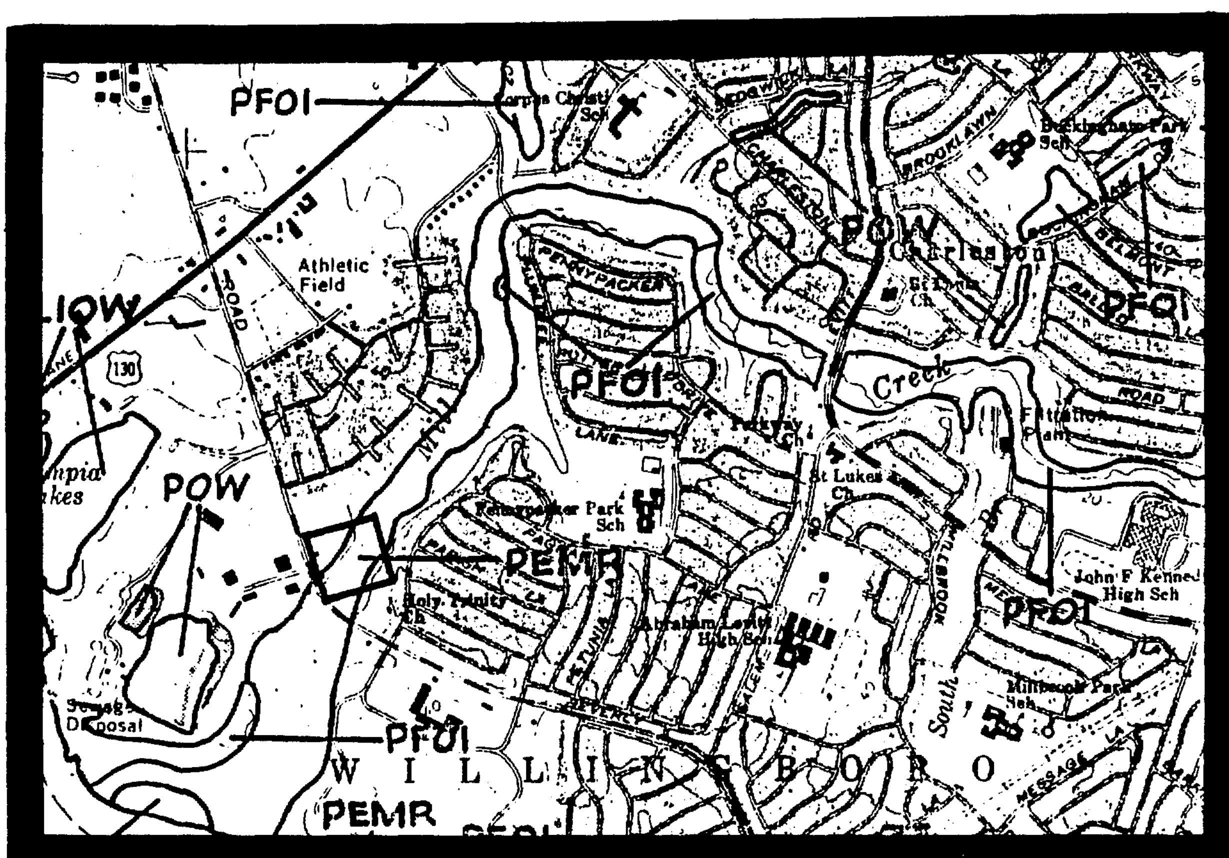
MAP A




Christ the King Ch
Corpus Christi Sch
BARRITT
SEDGWICK LA
CHARLESTON
BROOKLAWN
Charl
St Paul's Ch
BRIDGEBORO
ROAD
Athletic Field
6 LANE
130
Holiday Lake
Olympia Lakes
Sharper
Sewage Disposal
Mill
PENNYPACKER
PLUMTREE
POTTER LA
DRIVE
LANE
Parkway Ch
St Lukes Ch
Creek
LEVITT
Pennypacker Park Sch
PARISH LA
Holy Trinity Ch
Abraham Levitt High Sch
PETUNIA LA
SALEM
BEVERLY
MILLBROOK
South
W I L L I N G B O R O

MAP B

MAP C


PFO1
Corpus Christi Sch
SEDGWICK LA
CHARLESTON
BROOKLAWN
Buckingham Park Sch
POW
Charleston
Athletic Field
ROAD
130
PENNYPACKER
PFO1
Creek
Parkway Ch
LANE
St Lukes Ch
Pennypacker Park Sch
POW
PEMR
Holy Trinity Ch
PETUNIA LA
Abraham Levitt High Sch
MILLBROOK
SALEM
BEVERLY
John F Kennedy High Sch
PFO1
Millbrook Park Sch
South
MESSAGE LA
Sewage Disposal
PFO1
W I L L I N G B O R O
PEMR

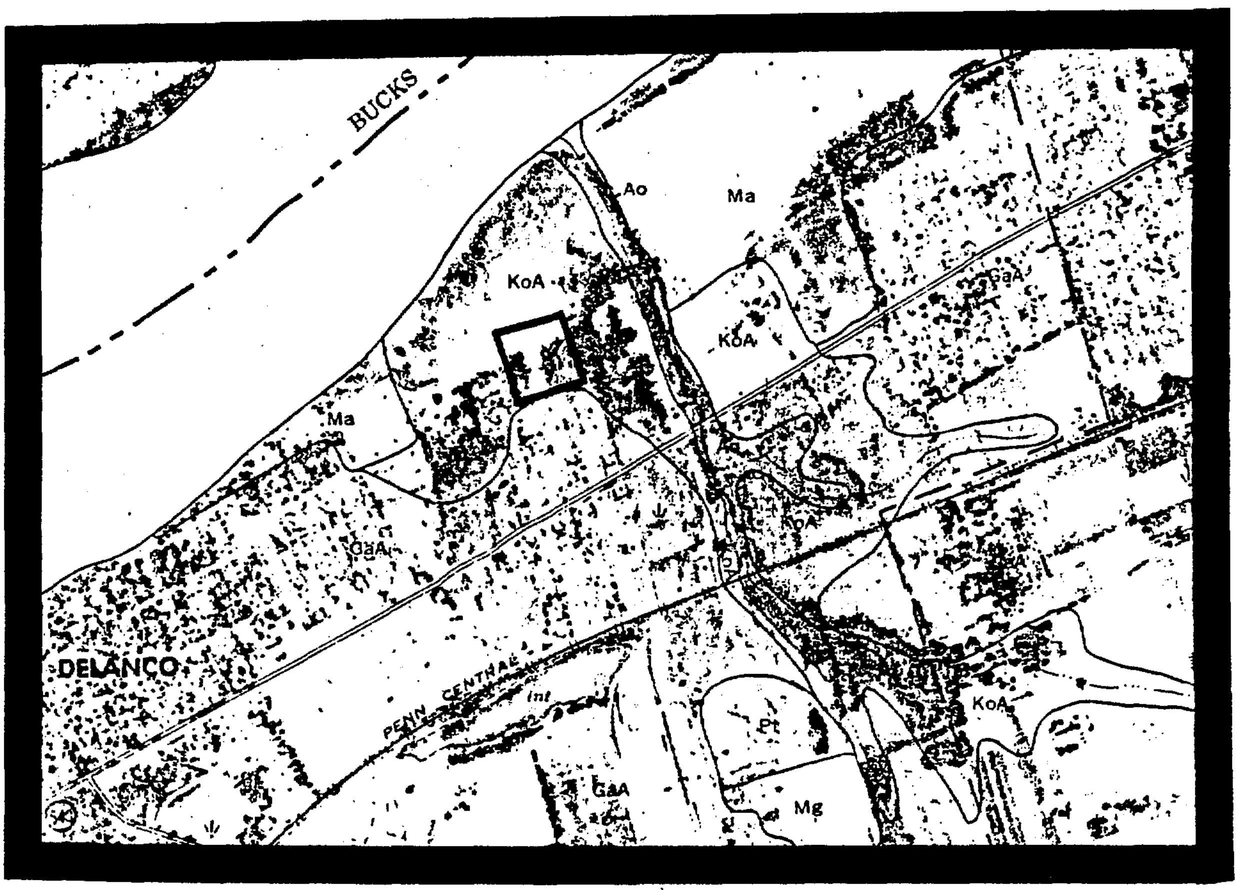
SITE 287 Larchmont/2nd St., Beverly, Burlington County.

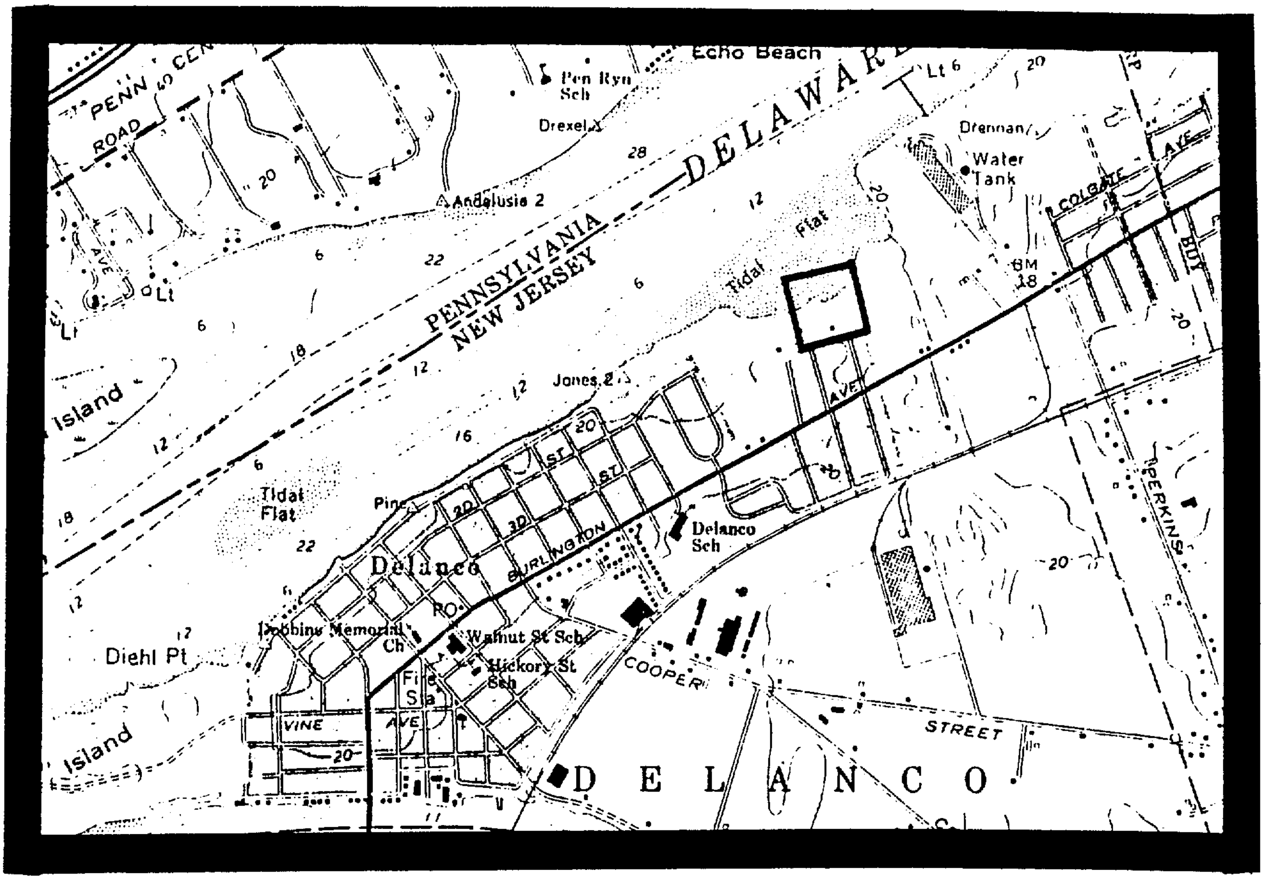
MAP A: Sheet # 13, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly N.J. Quadrangle (Scale 1:24,000)

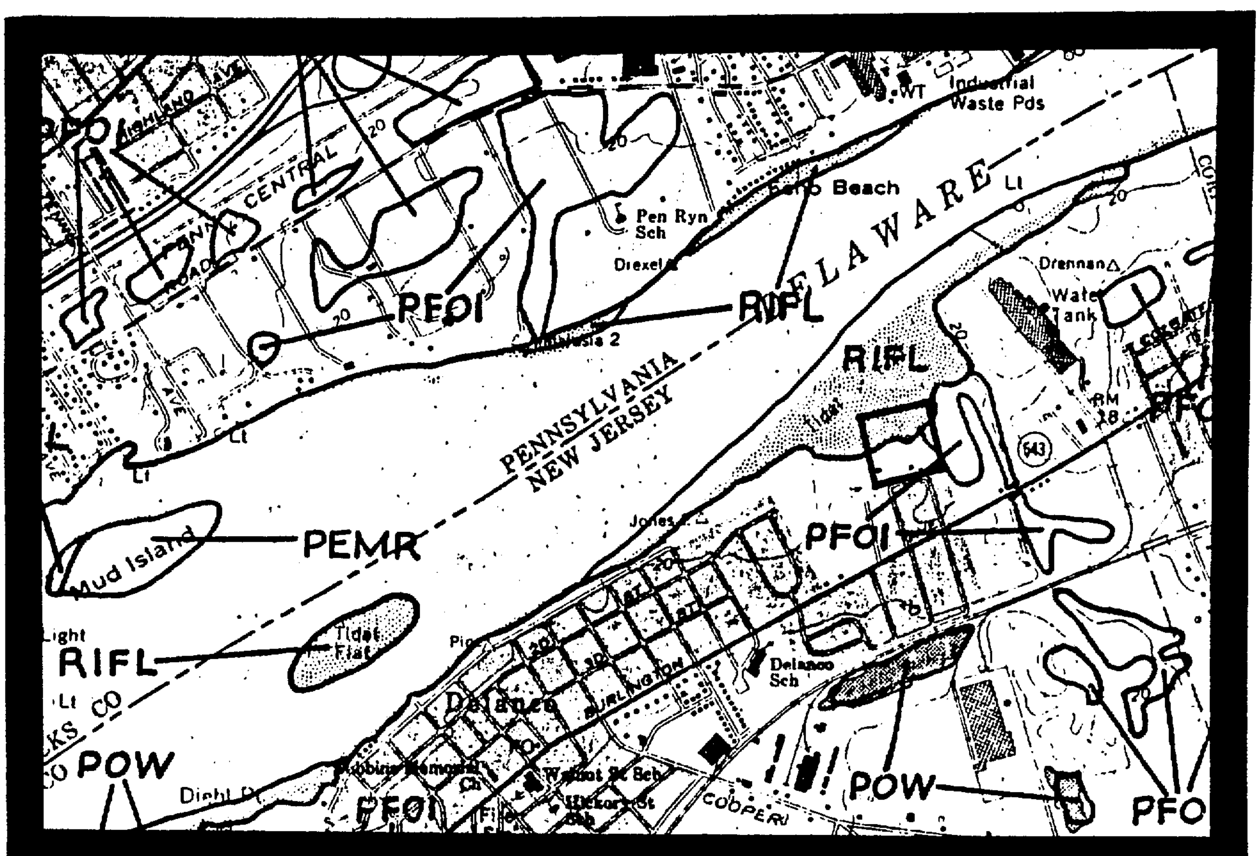
MAP A




Echo Beach
Pen Ryn Sch
Drexel
Andalusia 2
DELAWARE
Drennan
Water Tank
COLGATE
PENNSYLVANIA
NEW JERSEY
Tidal Flat
Island
Jones 2
Tidal Flat
Delanco
BURLINGTON
Delanco Sch
Dobbins Memorial Ch
Walnut St Sch
Hickory St Sch
Diehl Pt
Island
VINE AVE
COOPER
STREET
PERKINS
D E L A N C O

MAP B

MAP C


HIGHLAND AVE
CENTRAL
PENN
ROAD
Industrial Waste Pds
Echo Beach
DELAWARE
Pen Ryn Sch
Drexel
PFOI
RIFL
Drennan
Water Tank
RIFL
Tidal
PENNSYLVANIA
NEW JERSEY
Jones
PFOI
PEMR
Mud Island
RIFL
Tidal Flat
Delanco
BURLINGTON
Delanco Sch
POW
Dobbins Memorial Ch
Walnut St Sch
Hickory St Sch
Diehl Pt
PFOI
COOPER
POW
PFO

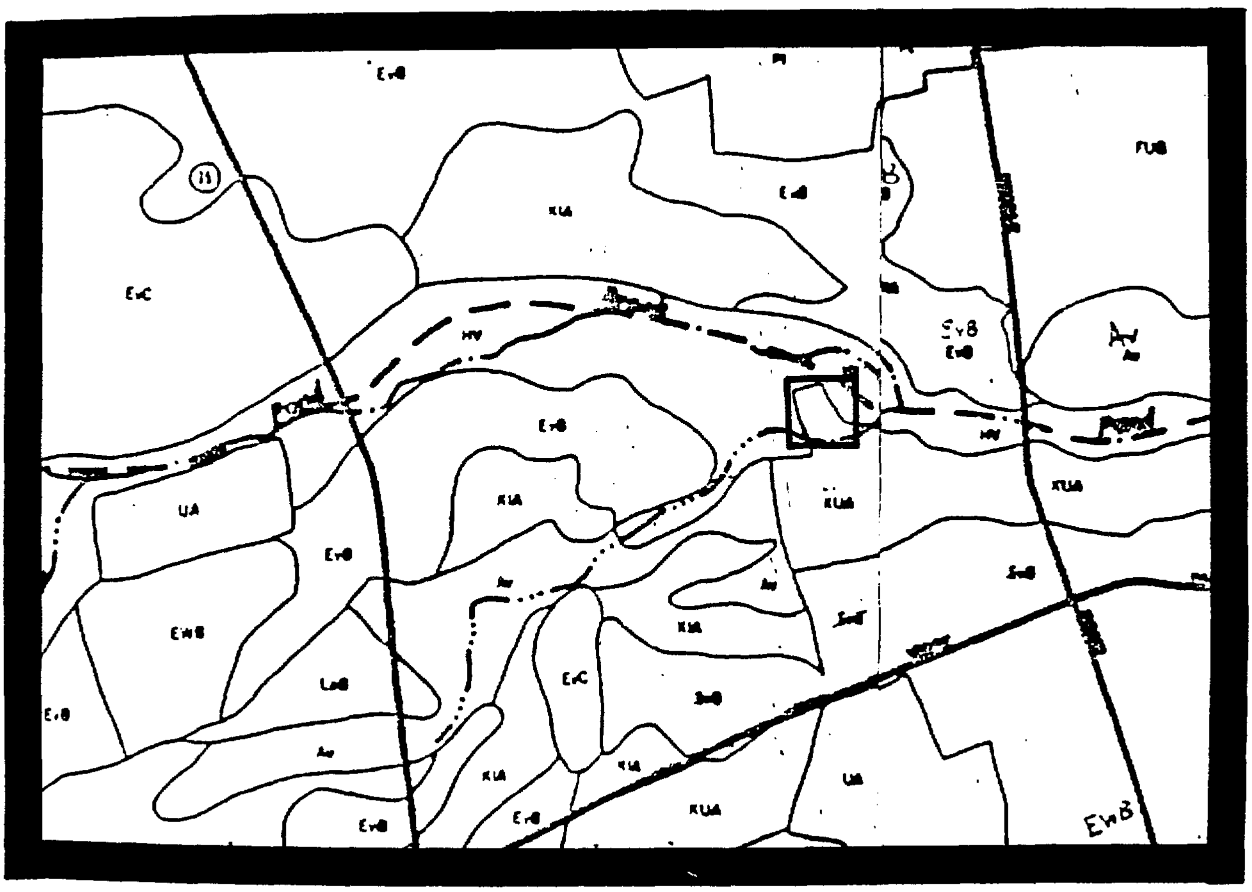
SITE 288 Branch Rd., Oakhurst, Monmouth County.

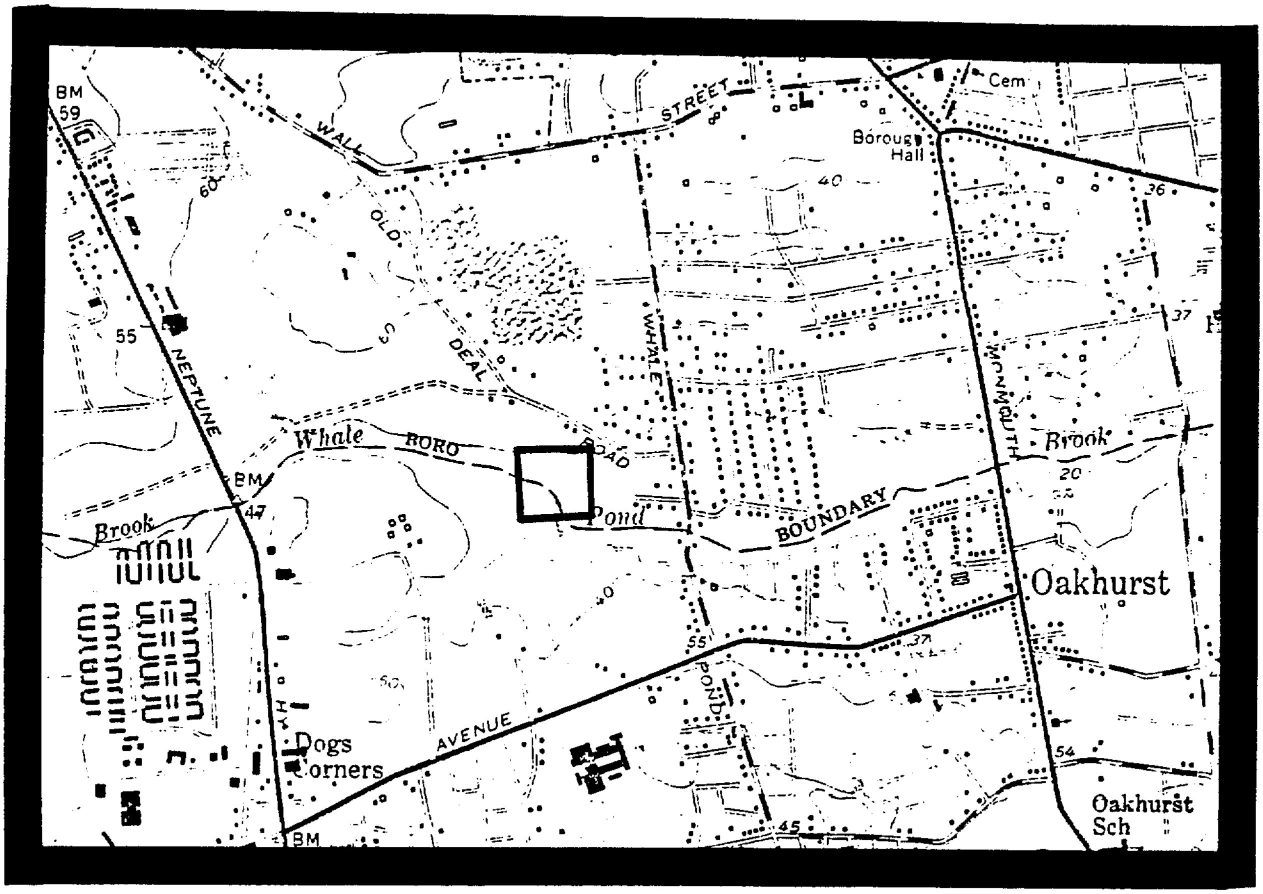
MAP A: Sheets # 29 & 30, Monmouth County Soil Survey
(Scale 1:15,840)

MAP B: U.S.G.S. Long Branch, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Long
Branch, N.J. Quadrangle (Scale 1:24,000)

MAP A

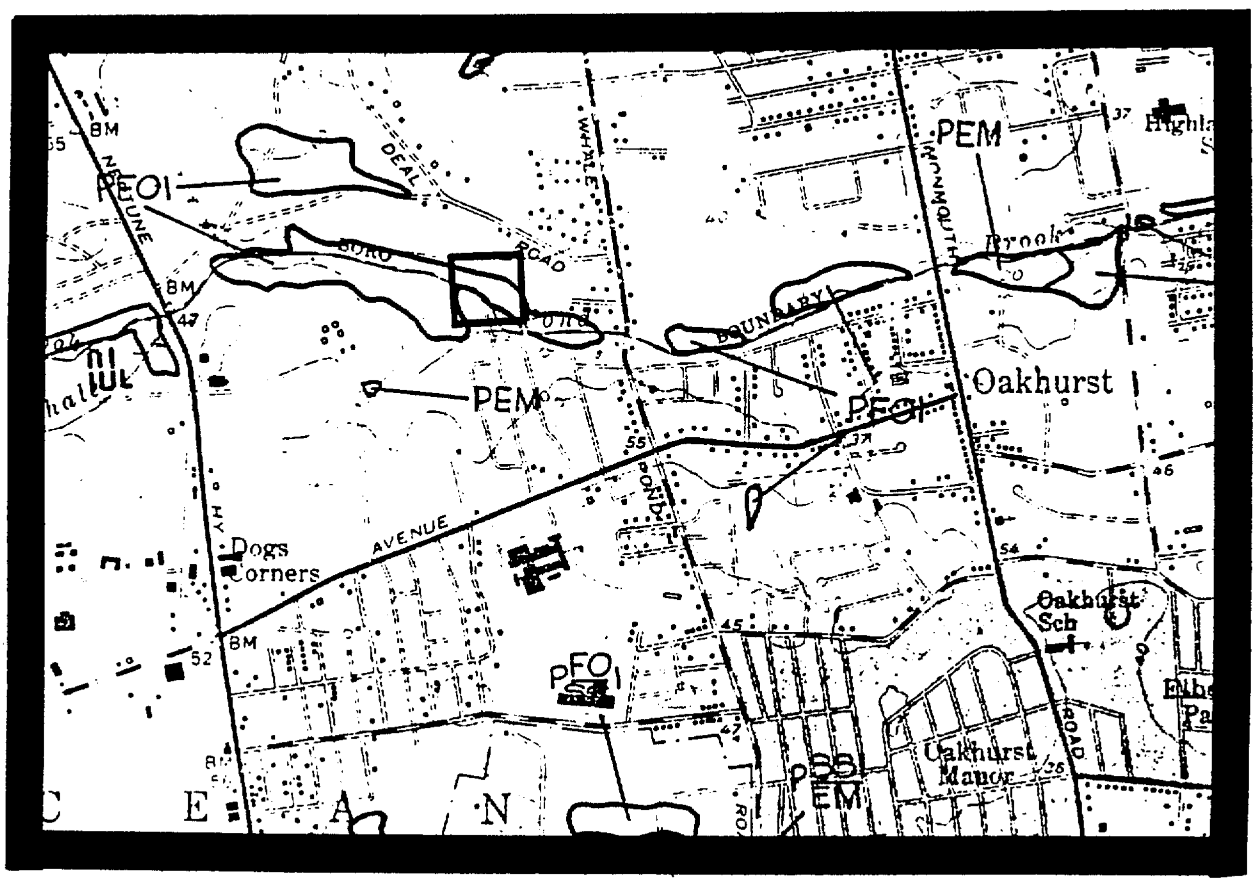




BM
59
WALK
STREET
Cem
Borough
Hall
OLD
DEAL
ROAD
WHALE
POND
NEPTUNE
HY
Whale
Pond
Brook
BORO
BOUNDARY
MONMOUTH
Brook
Oakhurst
AVENUE
Dogs
Corners
Oakhurst
Sch
BM

MAP B

MAP C



BM
NEPTUNE
PEO1
DEAL
ROAD
WHALE
MONMOUTH
PEM
Brook
BORO
BOUNDARY
Oakhurst
PEM
PEO1
POND
AVENUE
HY
Dogs
Corners
BM
PFO1
Oakhurst
Sch
Oakhurst
Manor
ROAD
PEM
E
A
N

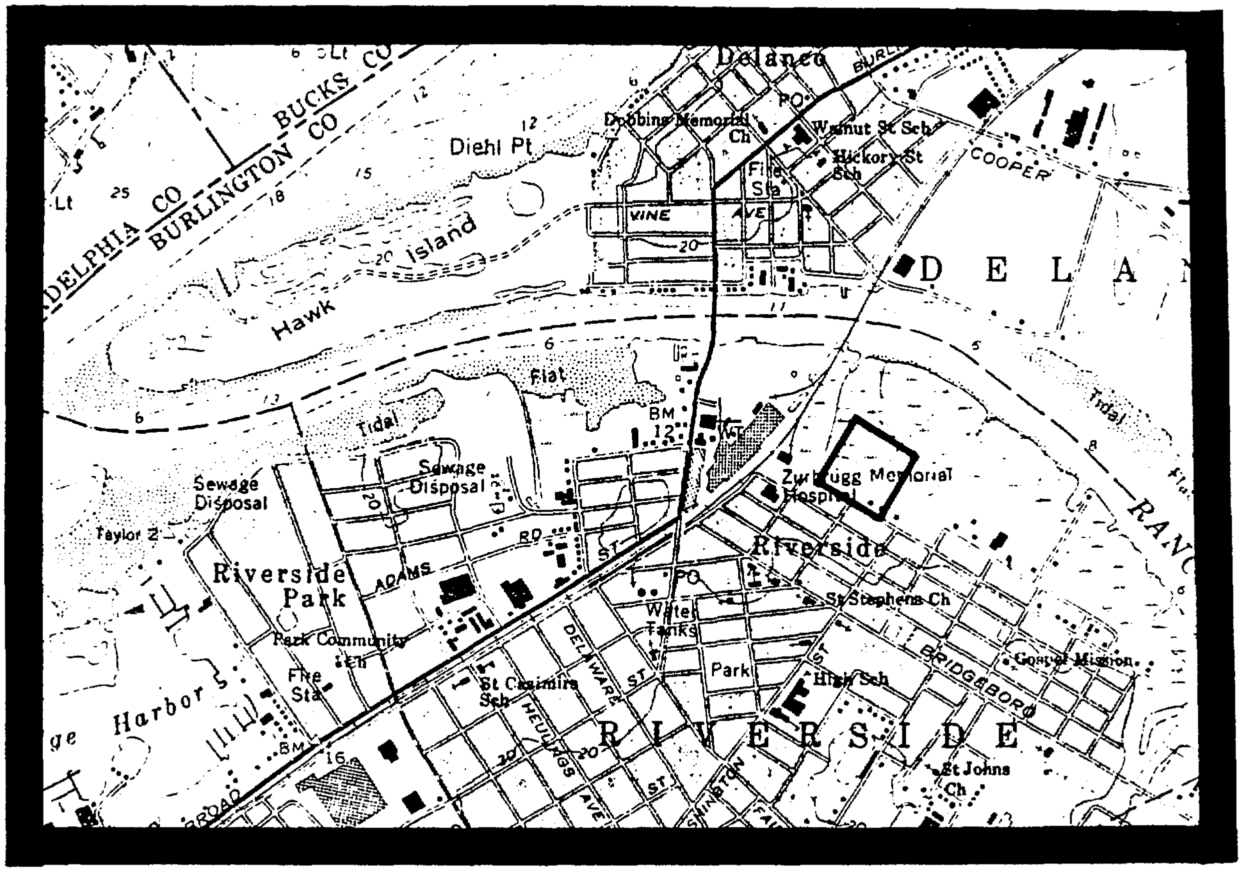
SITE 289 Hecker/Harris St., Riverside, Burlington County.

MAP A: Sheets # 12 & 13, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

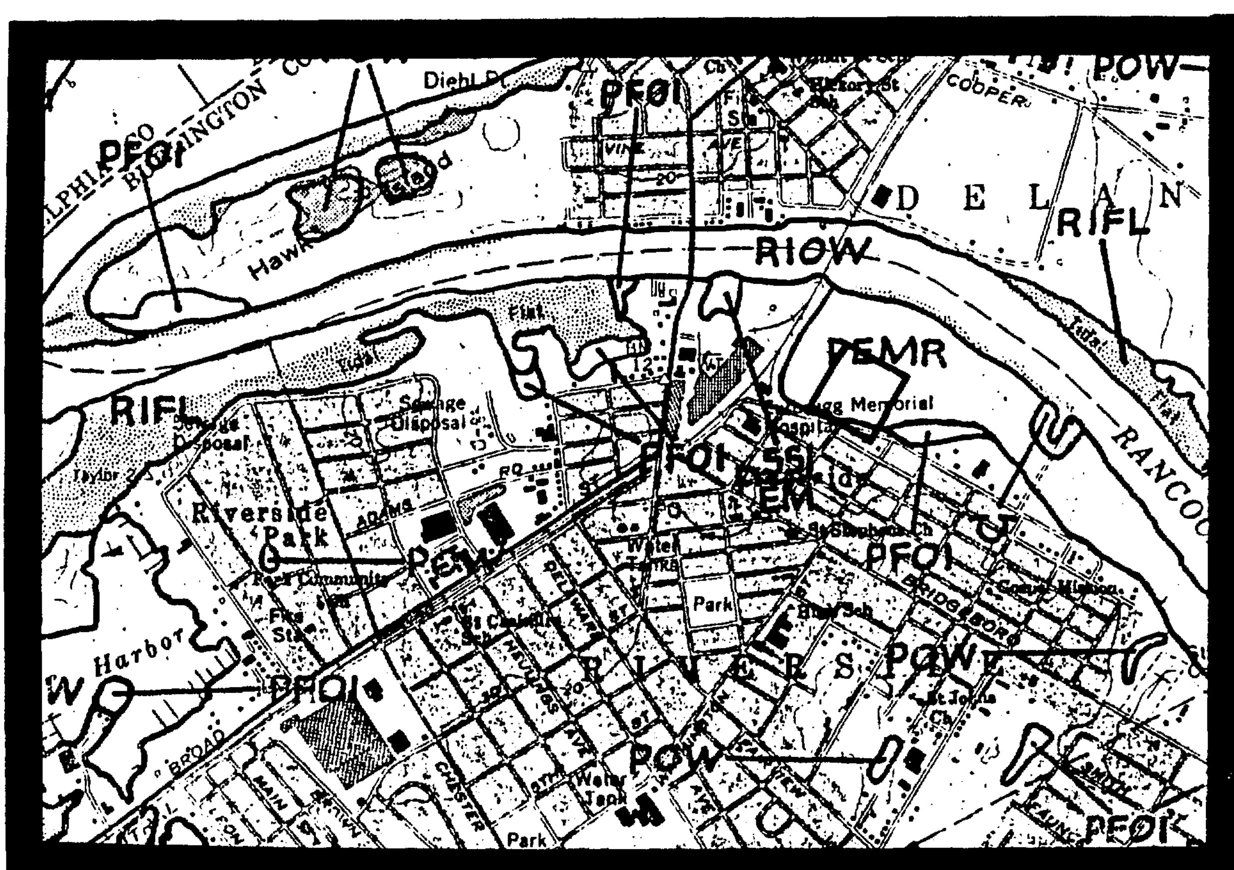
MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

MAP A


Delanco
BUCKS CO
BURLINGTON CO
Diehl Pt
Hawk
Island
Dobbins Memorial Ch
Walnut St Sch
Hickory St Sch
Fire Sta
VINE AVE
COOPER
D E L A
Flat
Tidal
Sewage Disposal
Taylor 2
Zurbrugg Memorial Hospital
Riverside
Riverside Park
ADAMS
RD
ST
PO
Water Tanks
St Stephens Ch
Park Community Ch
Fire Sta
St Casimirs Sch
DELAWARE ST
Park
High Sch
BRIDGEBORO
Gospel Mission
Harbor
HEULINGS AVE
R I V E R S I D E
St Johns Ch
BROAD
RANC

MAP B

MAP C


Diehl
BURLINGTON
PFO1
POW
PFOI
COOPER
Hickory St Sch
Fire Sta
VINE AVE
D E L A N
RIFL
Hawk
RIOW
Flat
Tidal
PEMR
Sewage Disposal
RIFL
Taylor
Memorial
Hospital
RANCO
PFOI
SS1
EM
Riverside Park
ADAMS
Water Tanks
St Stephens Ch
PEW
PFO1
Park Community Ch
Fire Sta
Park
Gospel Mission
BRIDGEBORO
Harbor
PFOI
POW
St Johns Ch
BROAD
MAIN
CHESTER
Water Tank
POW
Park
SMITH
PFOI

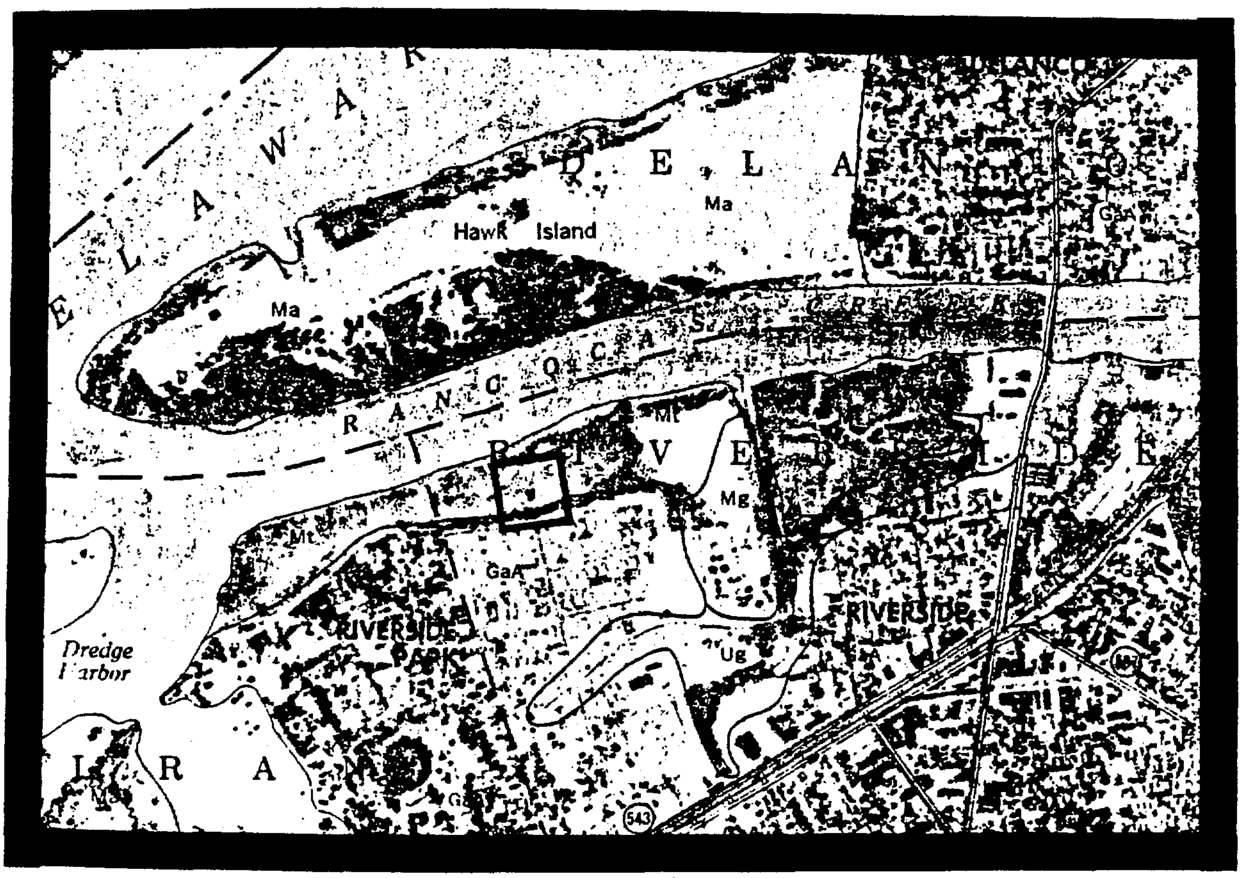
SITE 290 Pulaski/River Dr., Riverside, Burlington County.

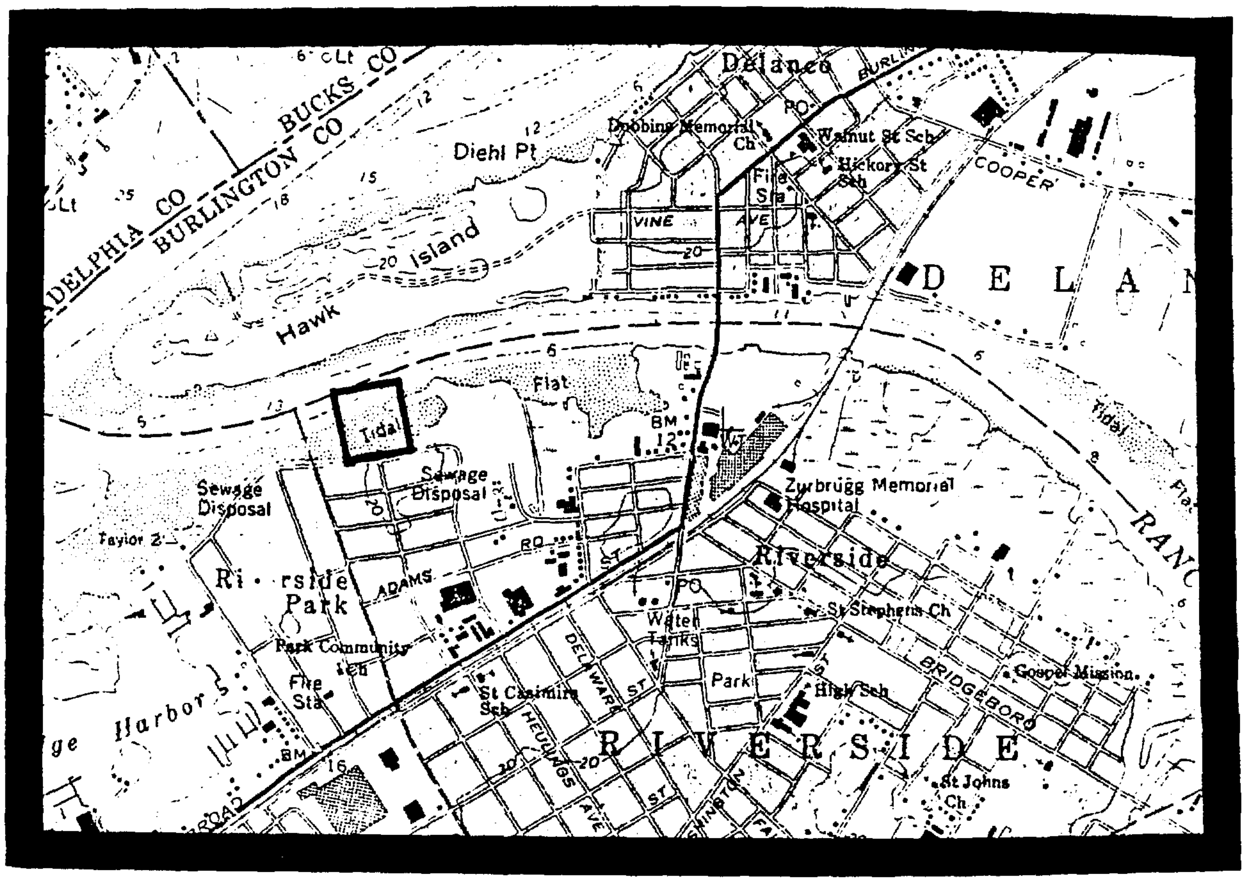
MAP A: Sheet # 12, Burlington County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly, N.J. Quadrangle (Scale 1:24,000)

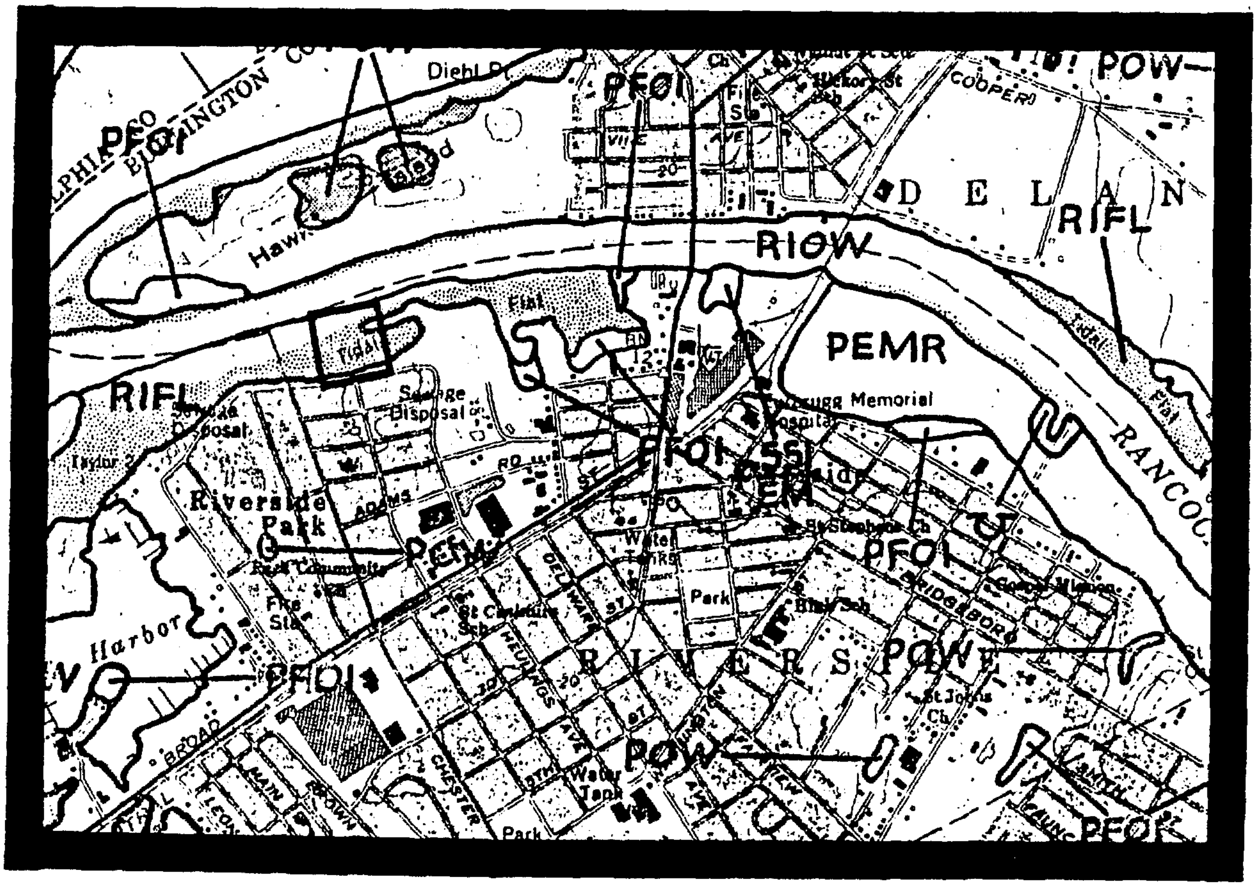
MAP A




BUCKS CO
BURLINGTON CO
Delanco
Diehl Pt
Dobbins Memorial Ch
Walnut St Sch
Hickory St Sch
COOPER
Fire Sta
VINE AVE
Hawk Island
D E L A N
Flat
Tidal
Sewage Disposal
Zurbrugg Memorial Hospital
Riverside
Riverside Park
ADAMS
PO
St Stephens Ch
Park Community Sch
Water Tanks
Park
High Sch
BRIDGEBORO
Gospel Mission
St Casimirs Sch
DELAWARE ST
HEULINGS AVE
R I V E R S I D E
St Johns Ch
Harbor
BROAD

MAP B

MAP C


PFO
RIFL
RIOW
PEMR
PFOI
PEM
POW
Diehl Pt
Hickory St Sch
COOPER
D E L A N
Flat
Tidal
Sewage Disposal
Riverside Park
ADAMS
Water Tanks
Park
High Sch
St Johns Ch
Harbor
BROAD
CHESTER

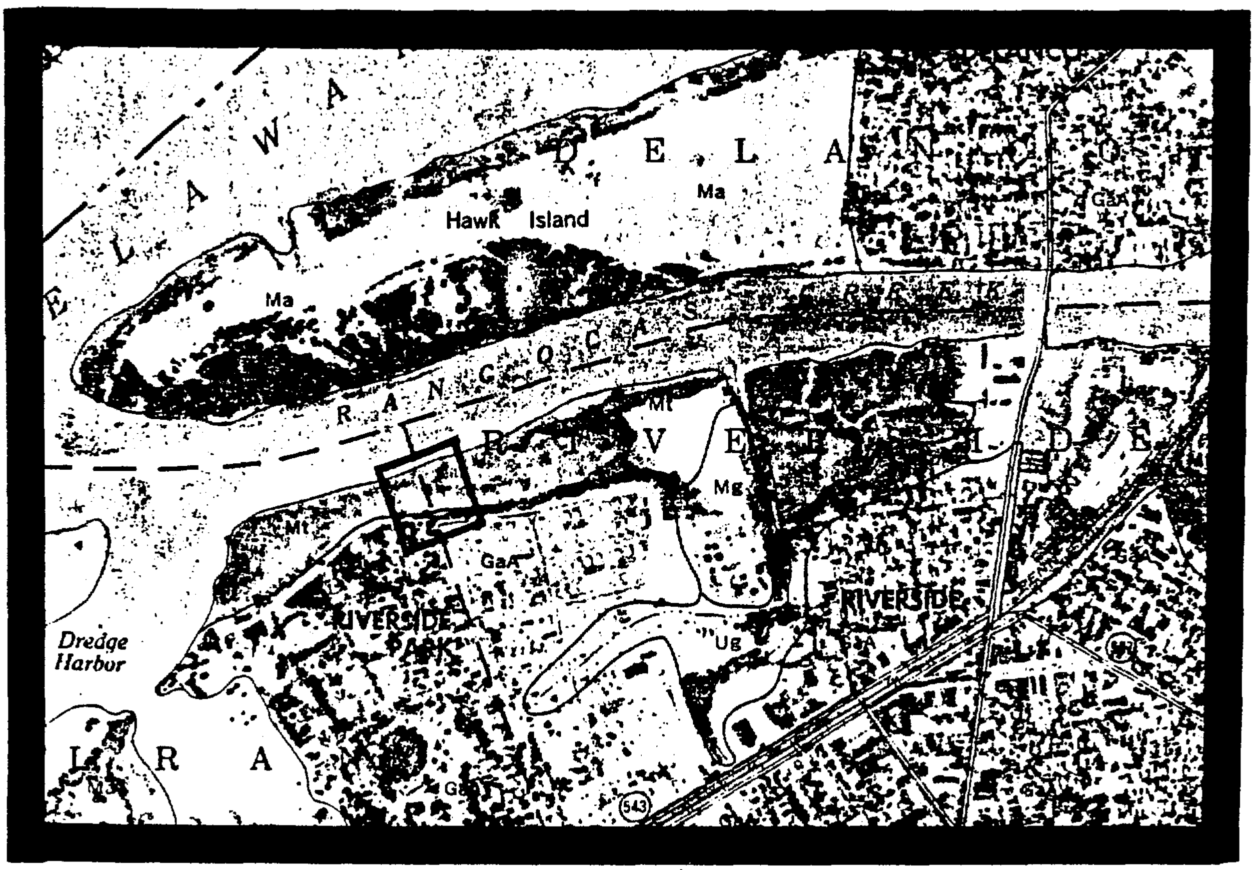
SITE 291   628 River Dr., Riverside, Burlington County.

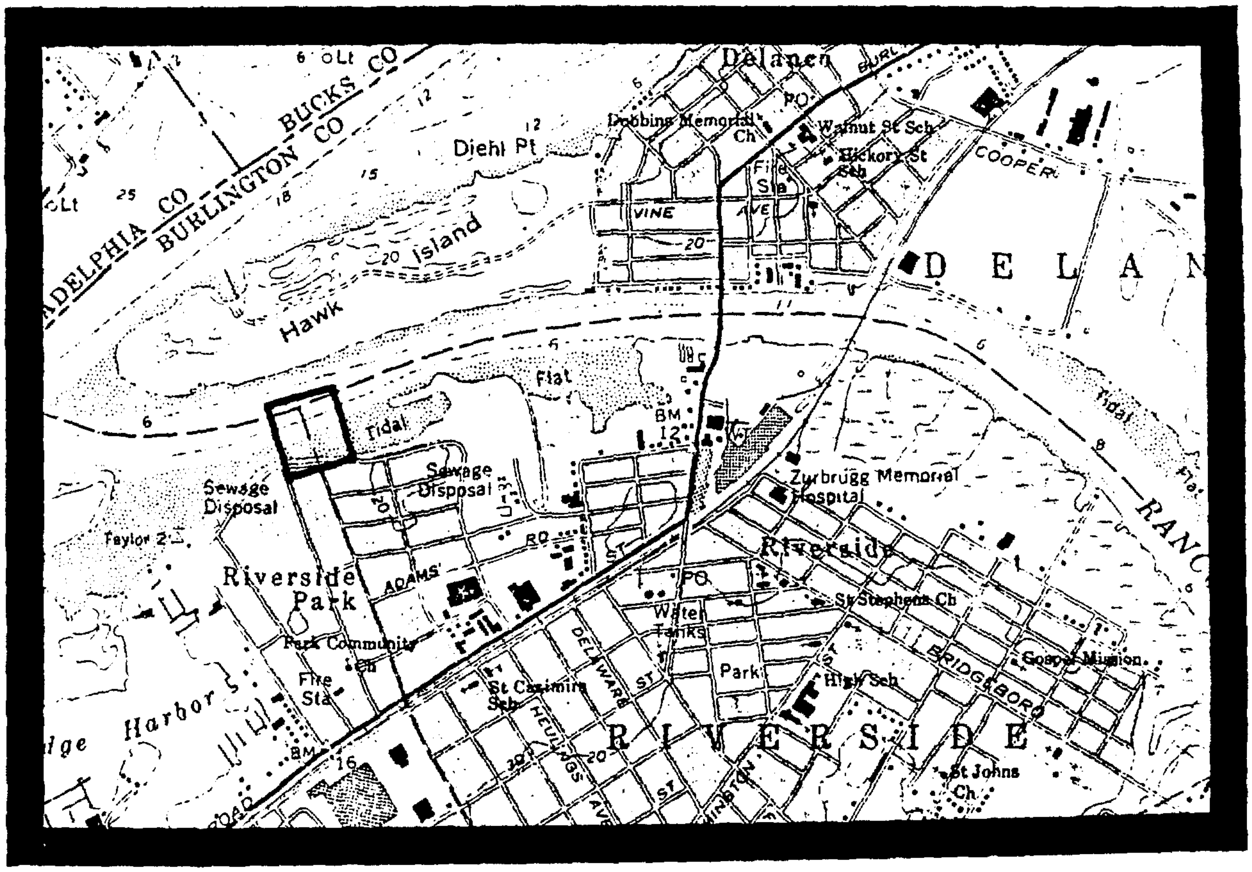
MAP A: Sheet # 12, Burlington County Soil Survey
(Scale 1:15,840)

MAP B: U.S.G.S. Beverly, N.J. Topographic Quarangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Beverly,
N.J. Quadrangle (Scale 1:24,000)

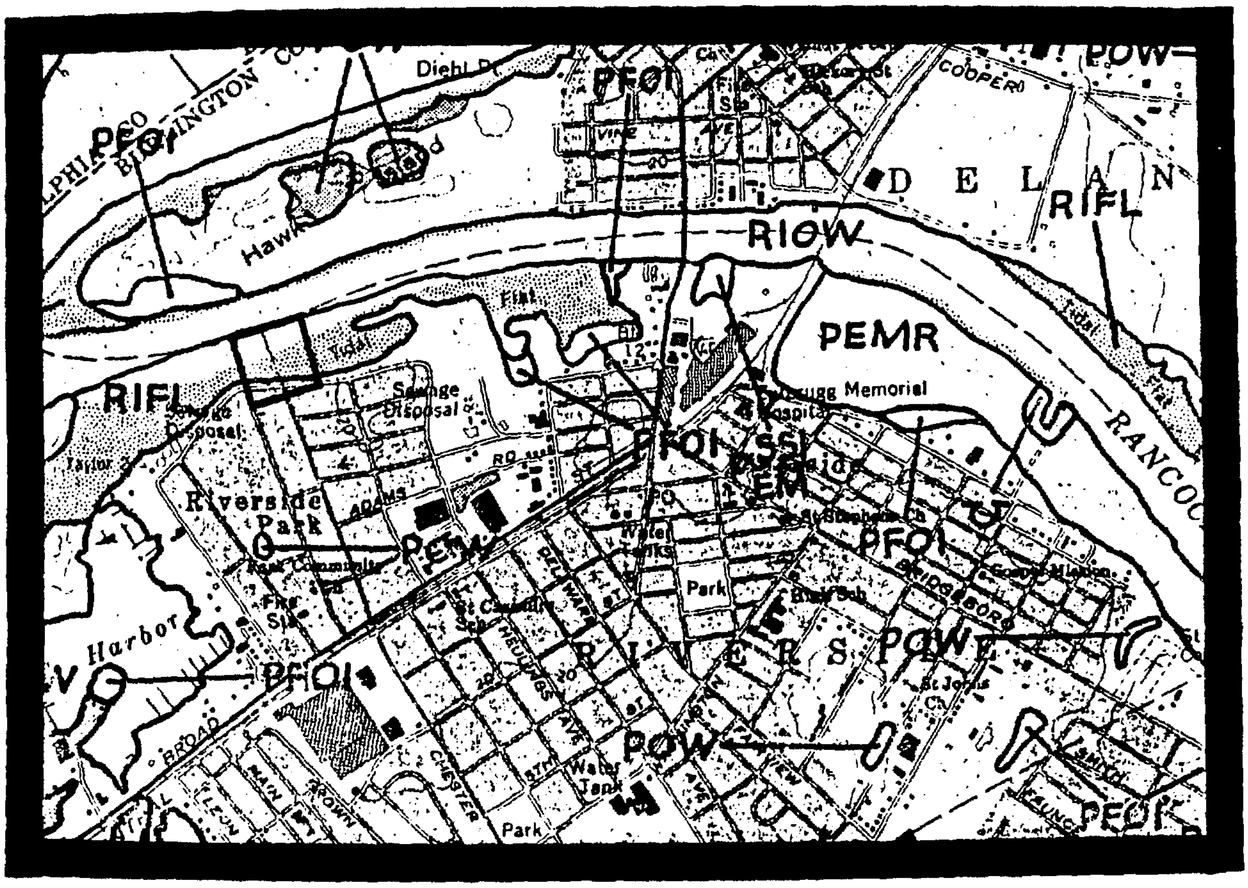
MAP A




Delanco
BUCKS CO
BURLINGTON CO
Diehl Pt
Dobbins Memorial Ch
Walnut St Sch
Hickory St Sch
COOPER
Fire Sta
VINE AVE
Island
Hawk
D E L A N
Flat
Tidal
Sewage Disposal
Zurbrugg Memorial Hospital
Riverside
PO
Riverside Park
ADAMS
Water Tanks
St Stephens Ch
Park Community Sch
Fire Sta
Park
High Sch
Gospel Mission
BRIDGEBORO
St Casimirs Sch
DELAWARE
HEULINGS AVE
R I V E R S I D E
St Johns Ch
Harbor
BROAD

MAP B

MAP C


Diehl Pt
PFOI
COOPER
POW
PFO
VINE AVE
D E L A N
RIFL
RIOW
Hawk
PEMR
Flat
Tidal
RIFL
Sewage Disposal
Zurbrugg Memorial Hospital
PFOI
SS
PEM
Riverside Park
PEM
PFO
Park
POWE
PFOI
Harbor
POW
BROAD
CHESTER
Water Tank
Park
PFOI
RANCOCAS

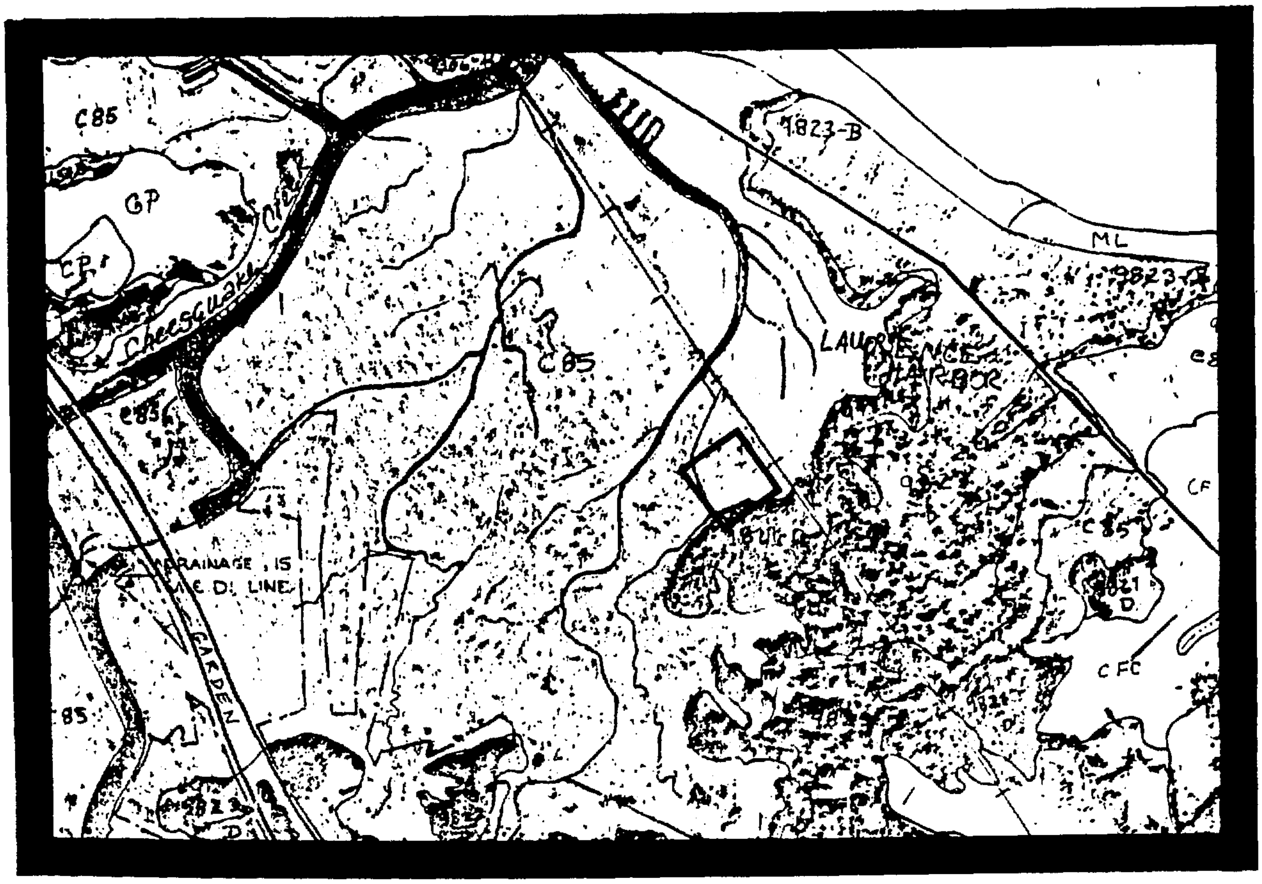
SITE 292 Cook Ave, NY & Longbranch RR, Laurence Harbor, Middlesex County.

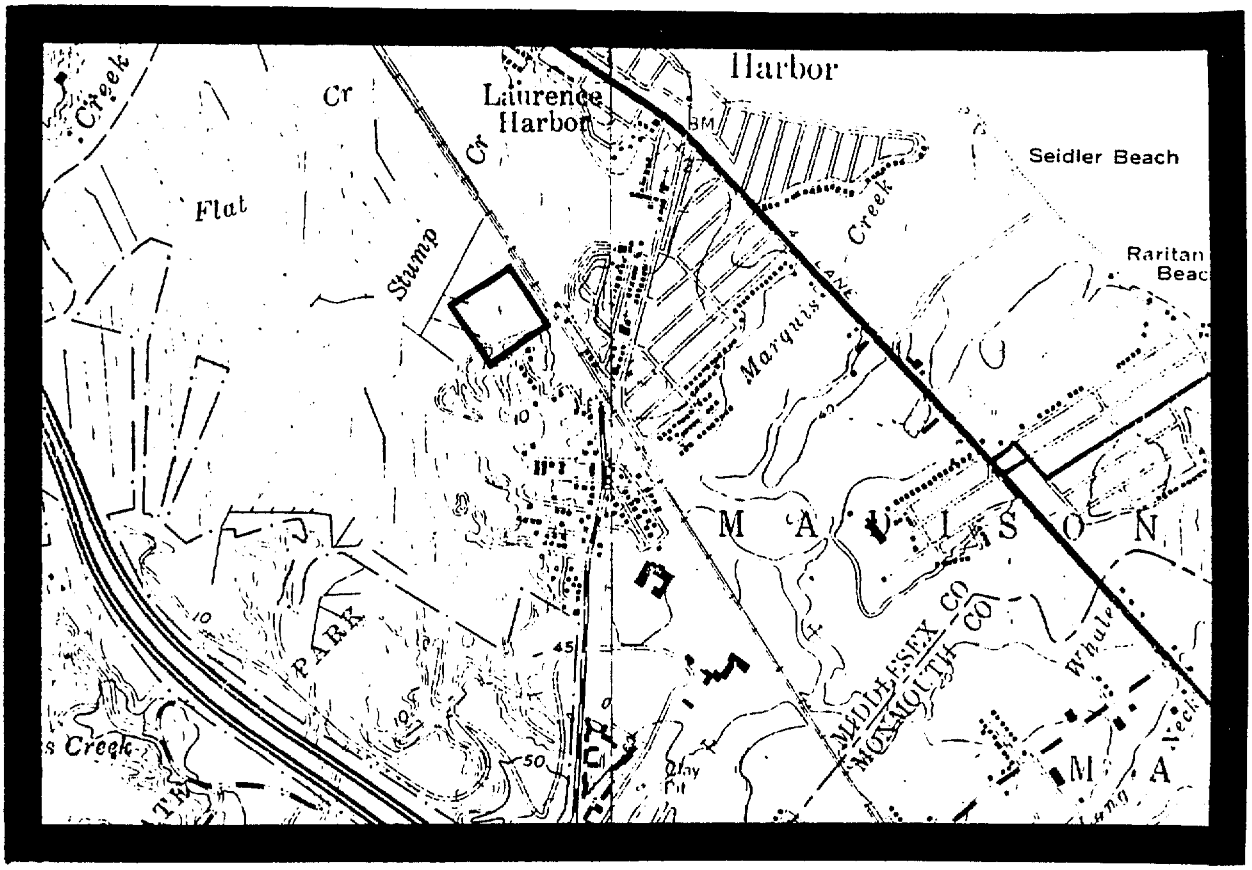
MAP A: Sheet # 16, Middlesex County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Keyport & South Amboy, N.J. Topographic Quadrangles (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Keyport & South Amboy, N.J. Quadrangles (Scale 1:24,000)

MAP A

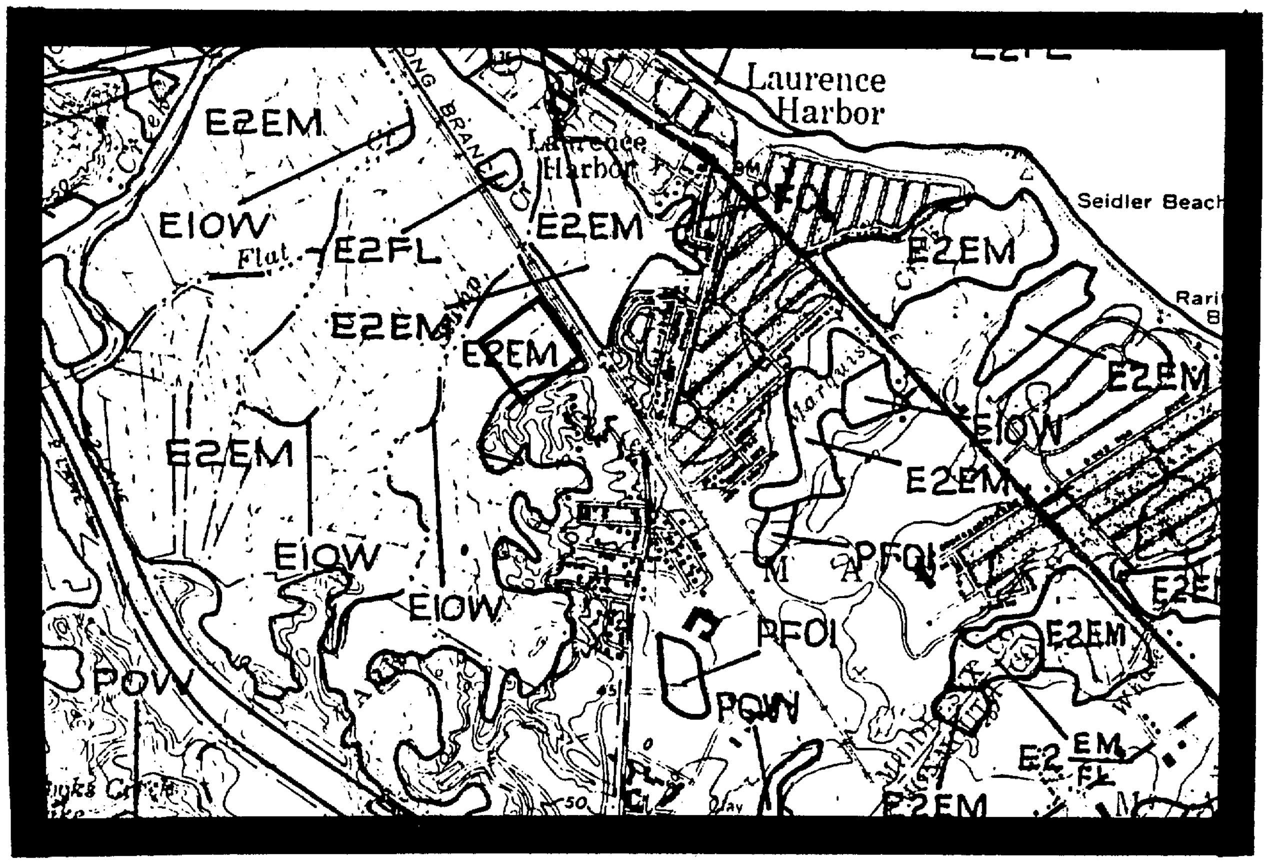




Harbor
Cr
Laurence Harbor
Seidler Beach
Flat
Stump
Cr
Creek
Marquis
PARK
MIDDLESEX CO
MONMOUTH CO
Whale

MAP B

MAP C



Laurence Harbor
Laurence Harbor
Seidler Beach
E2EM
E1OW
Flat
E2FL
E2EM
E2EM
E2EM
E2EM
E2EM
PFOl
E1OW
E2EM
E1OW
E1OW
PFOl
PFOl
E2EM
POW
POW
E2 EM/FL
E2EM

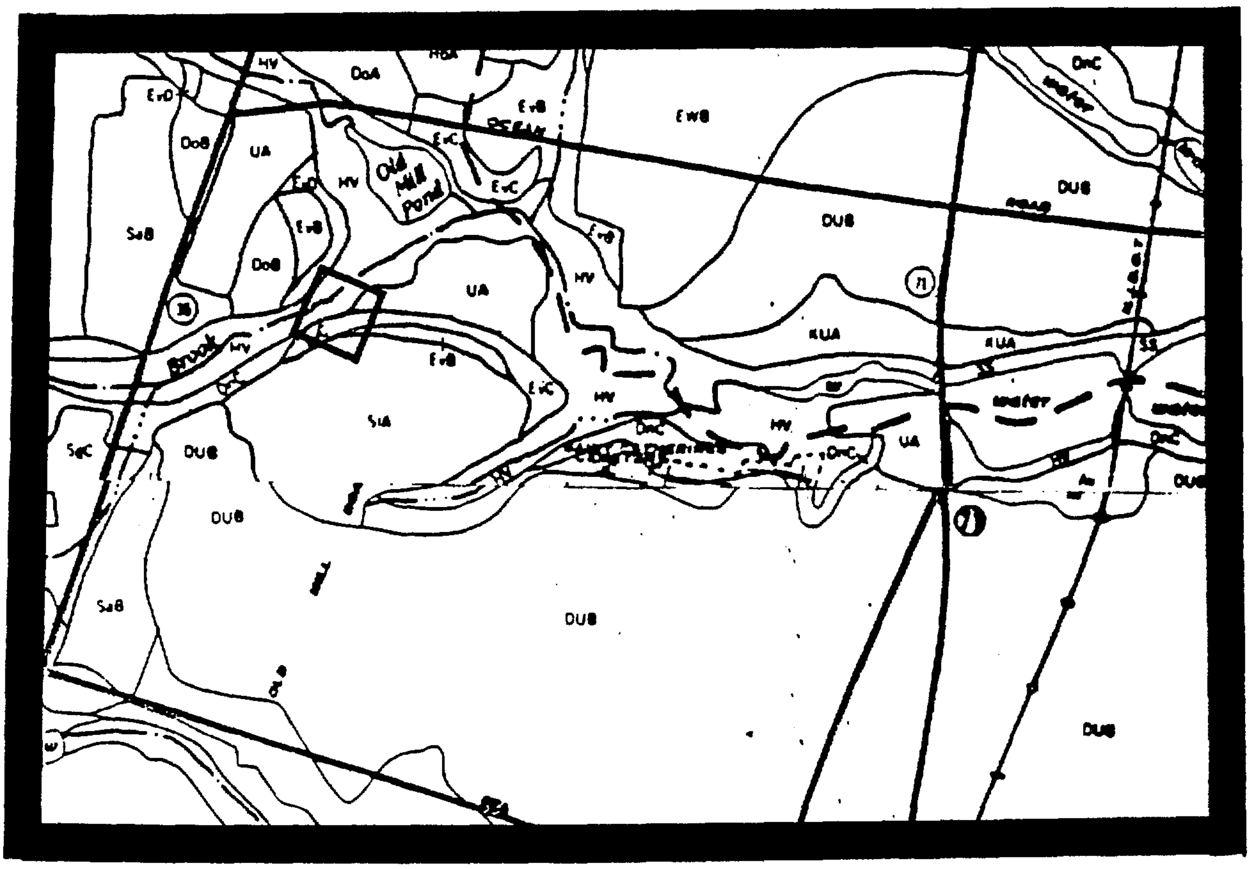
SITE 293 Cottonwood Dr., Old Mill, Monmouth County.

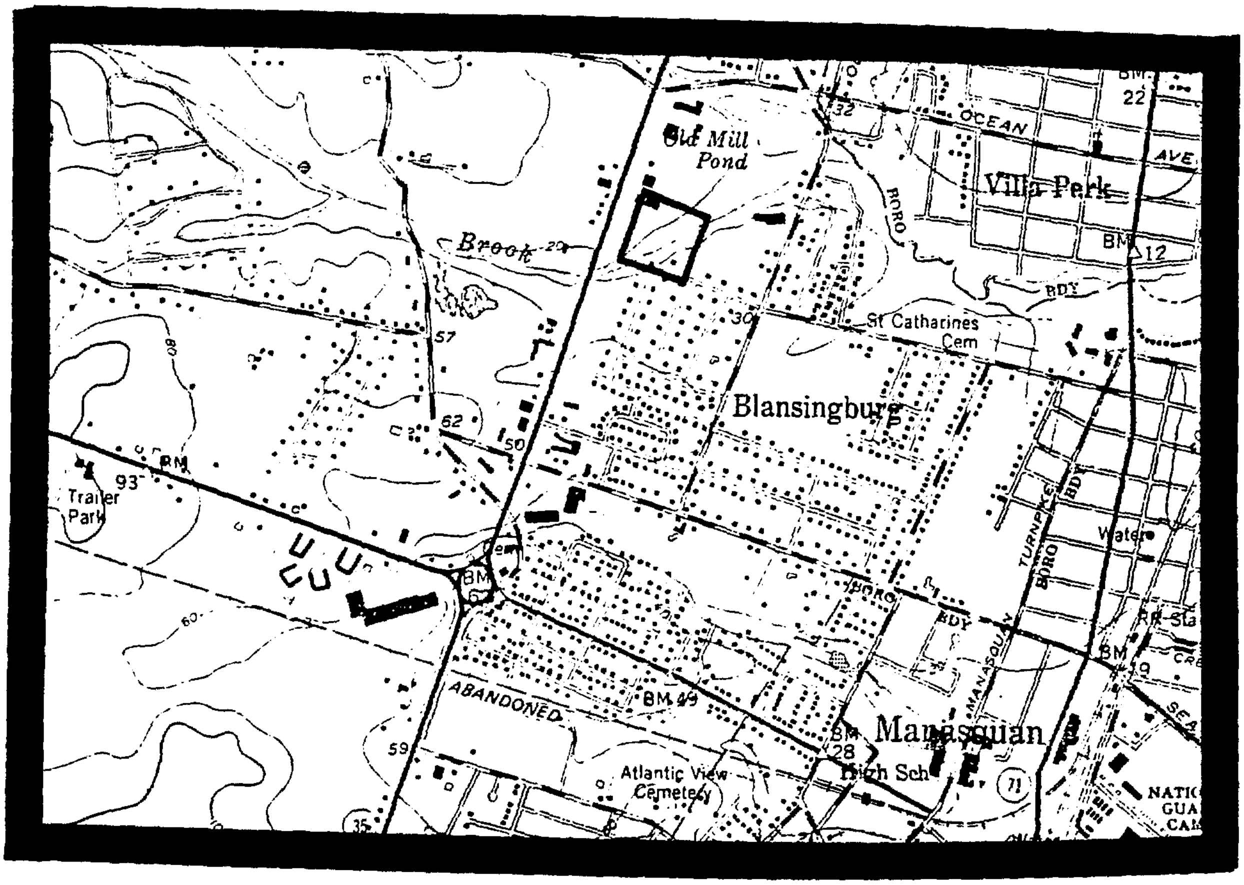
MAP A: Sheets # 53 & 58, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

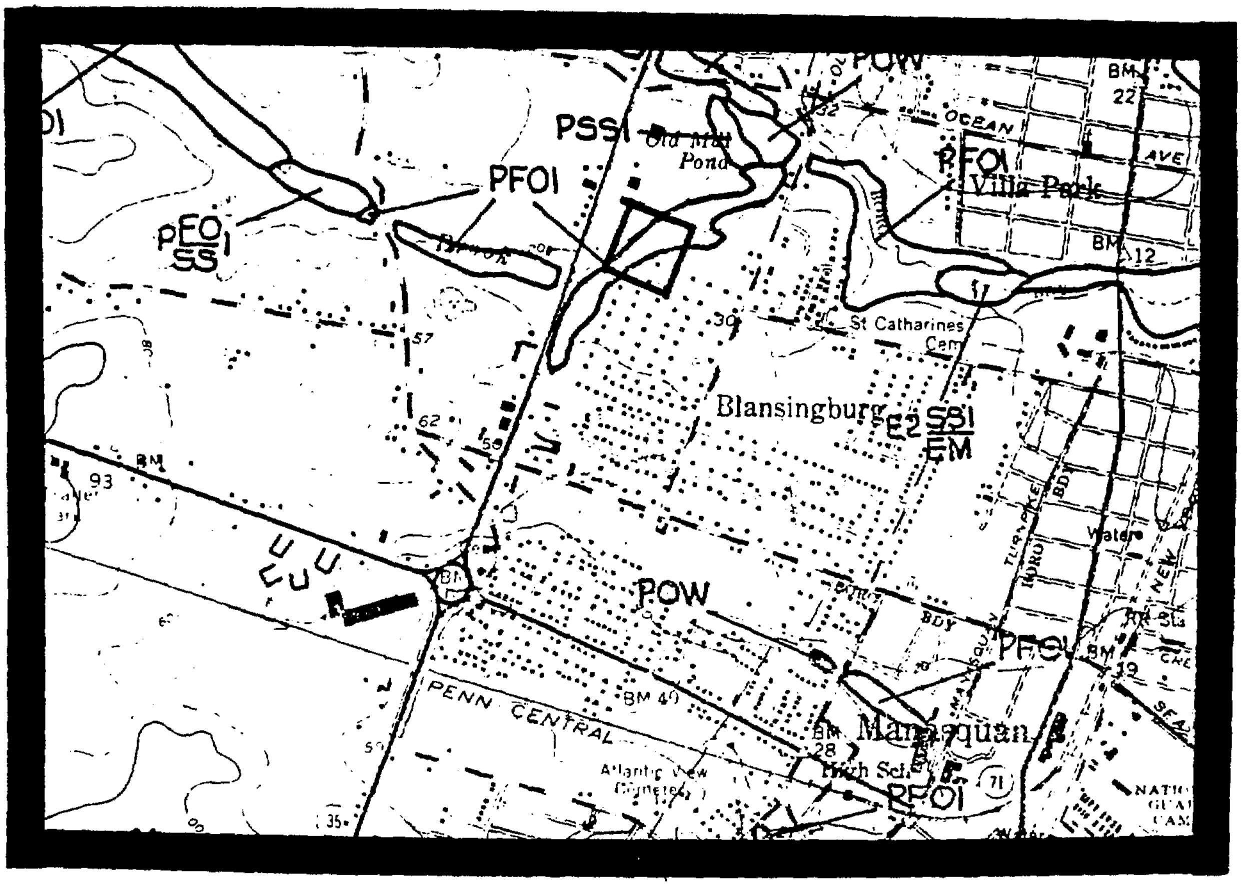
MAP A




Old Mill Pond
Villa Park
Brook
St Catharines Cem
Blansingburg
Trailer Park
ABANDONED
Atlantic View Cemetery
Manasquan
High Sch
OCEAN AVE

MAP B

MAP C


PSS
Old Mill Pond
PFOI
Villa Park
PFO/SS
St Catharines Cem
Blansingburg
E2 SSI/EM
POW
PFOI
PENN CENTRAL
Atlantic View Cemetery
Manasquan
High Sch
PFOI

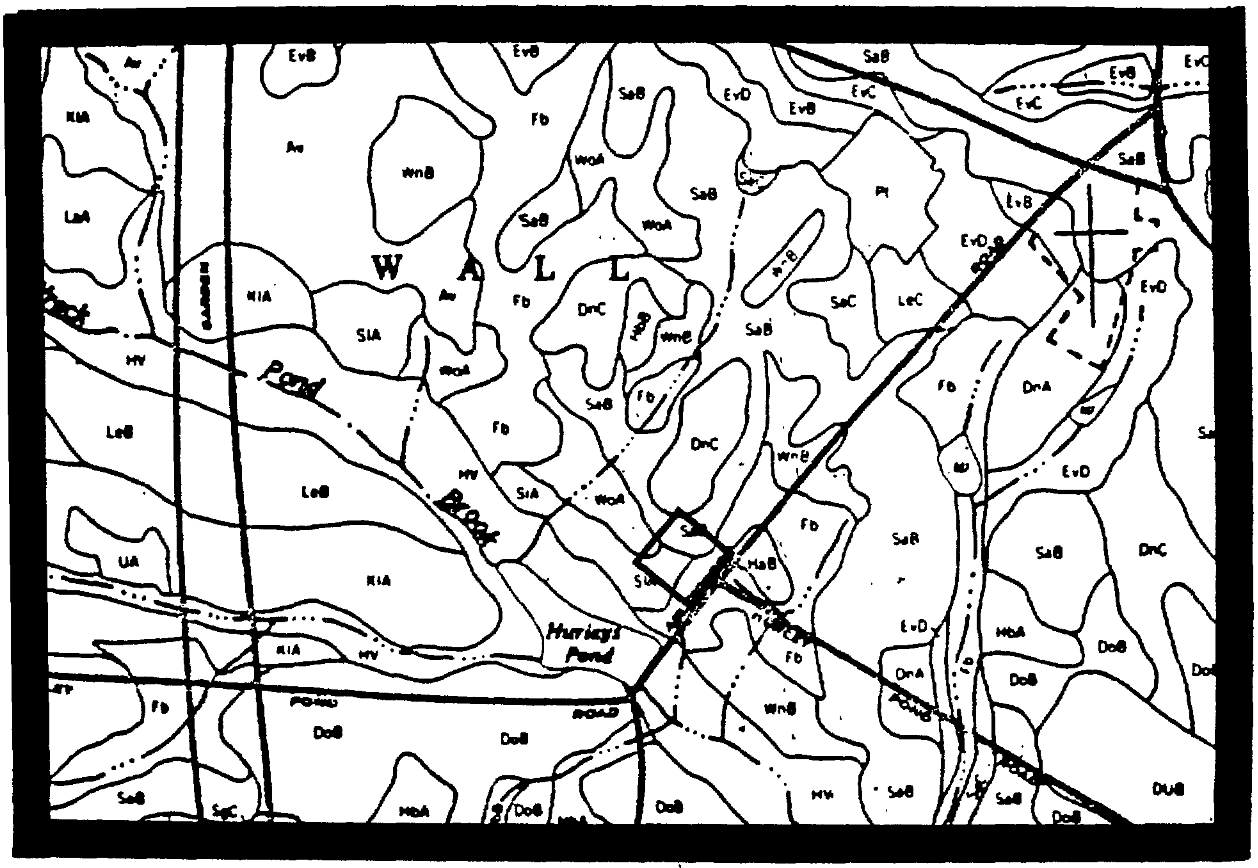
SITE 294 Allenwood/Woodfield, Wall Twp., Monmouth County.

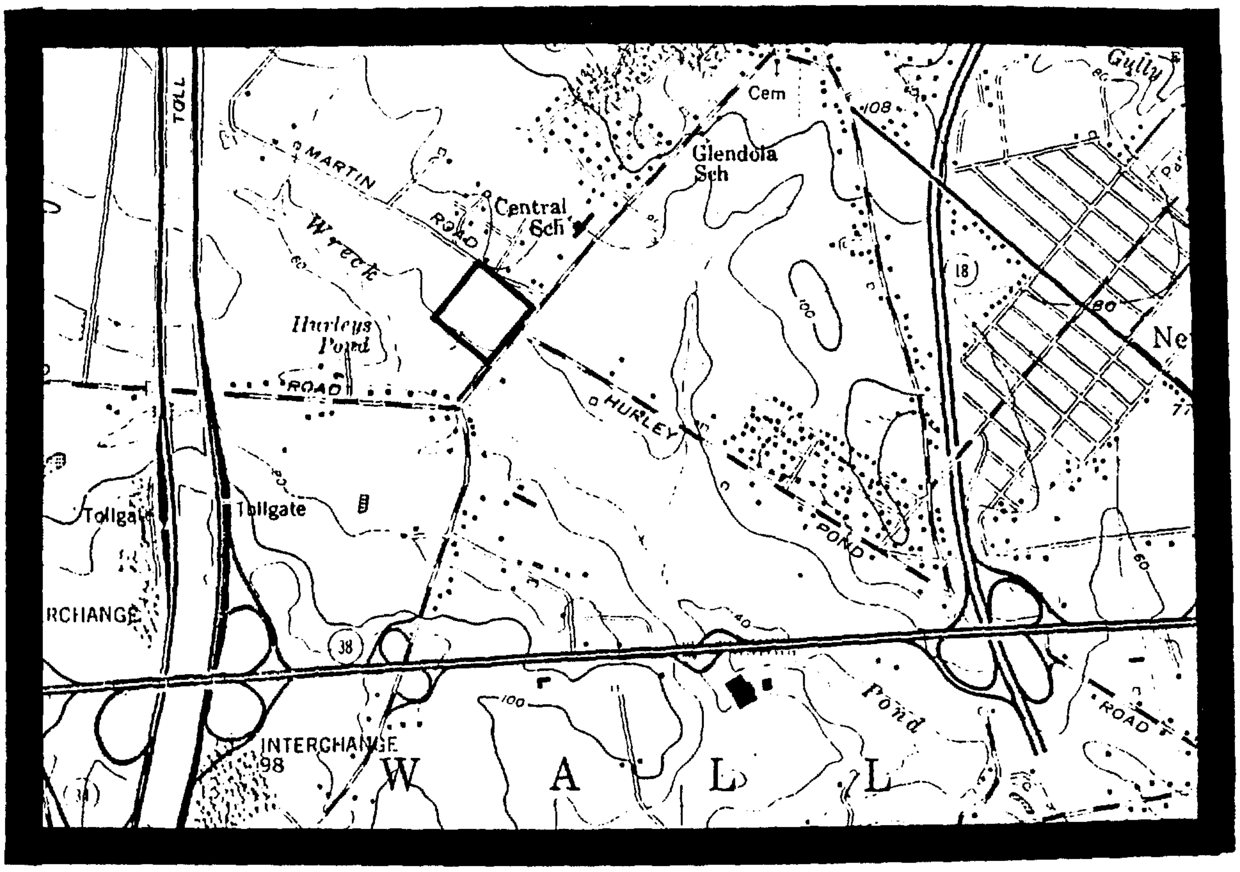
MAP A: Sheet # 45, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

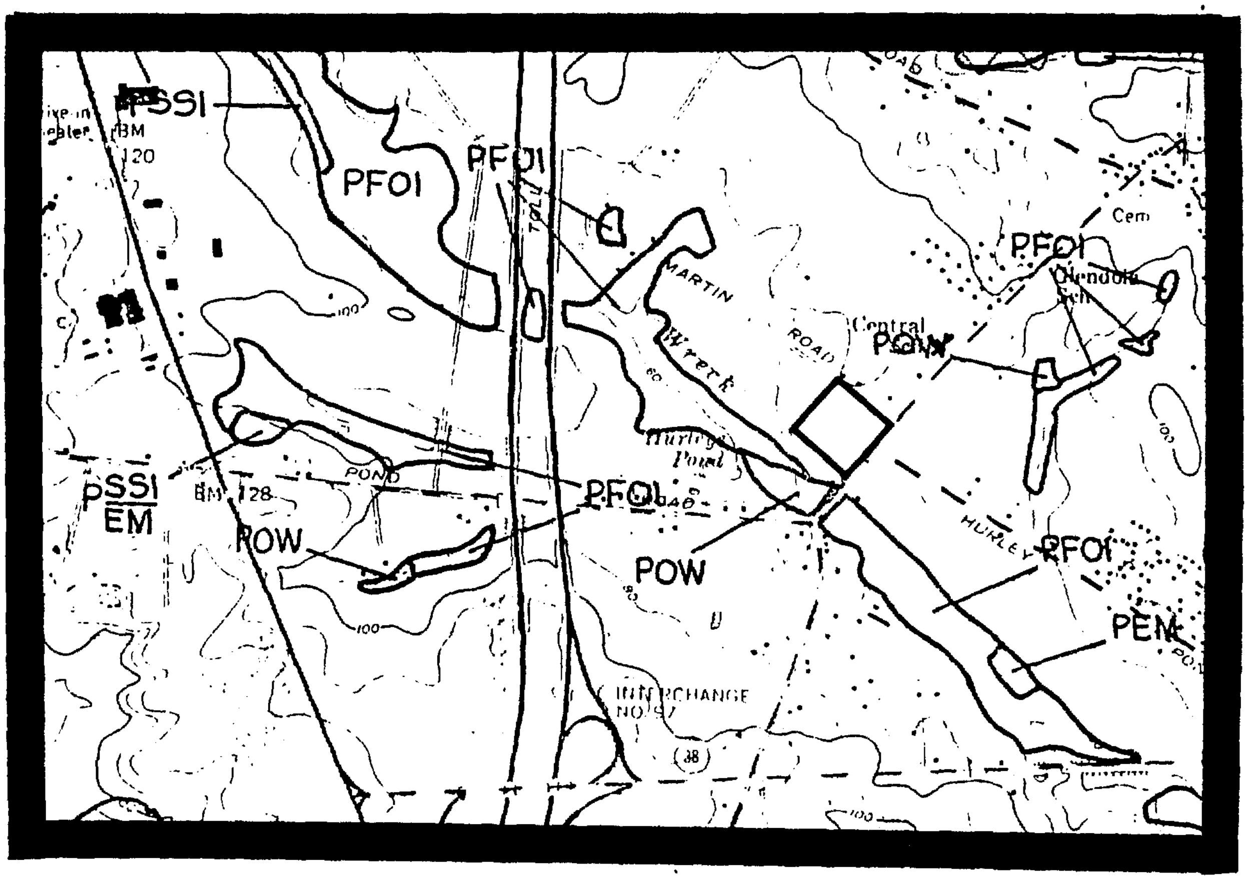
MAP A




TOLL
MARTIN ROAD
Central Sch
Glendola Sch
Cem
Wreck
Hurleys Pond
ROAD
HURLEY
POND
Tollgate
Tollgate
RCHANGE
INTERCHANGE
98
38
18
Pond
ROAD
Gully
Ne
W A L L

MAP B

MAP C


PSSI
PFOI
PFOI
TOLL
MARTIN
Wreck
ROAD
Central
POW
PFOI
Glendola Sch
Cem
Hurleys Pond
PSSI
EM
BM 128
POND
PFOI
POW
POW
HURLEY
PFOI
PEM
INTERCHANGE NO. 97
38

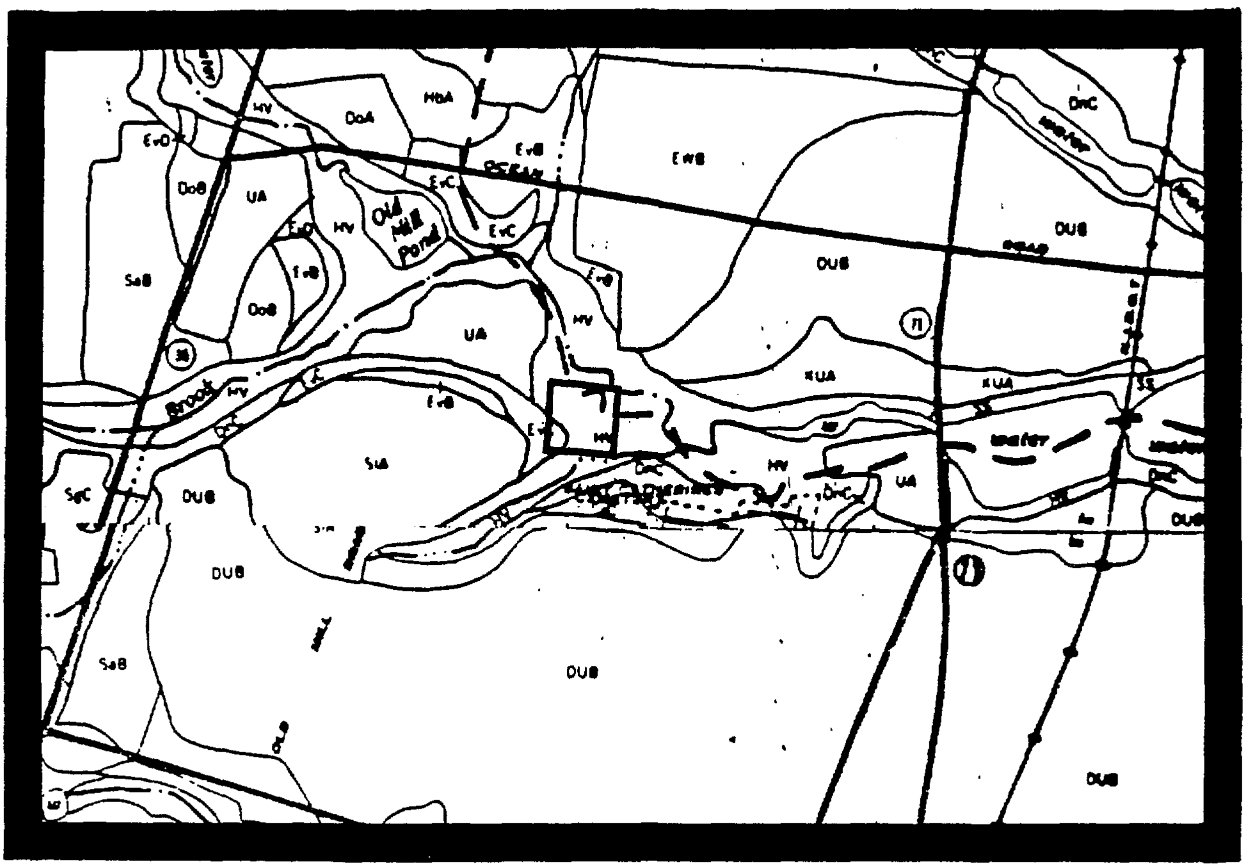
SITE 295 Butternut Rd., (St. Catherine's), Old Mill, Monmouth County.

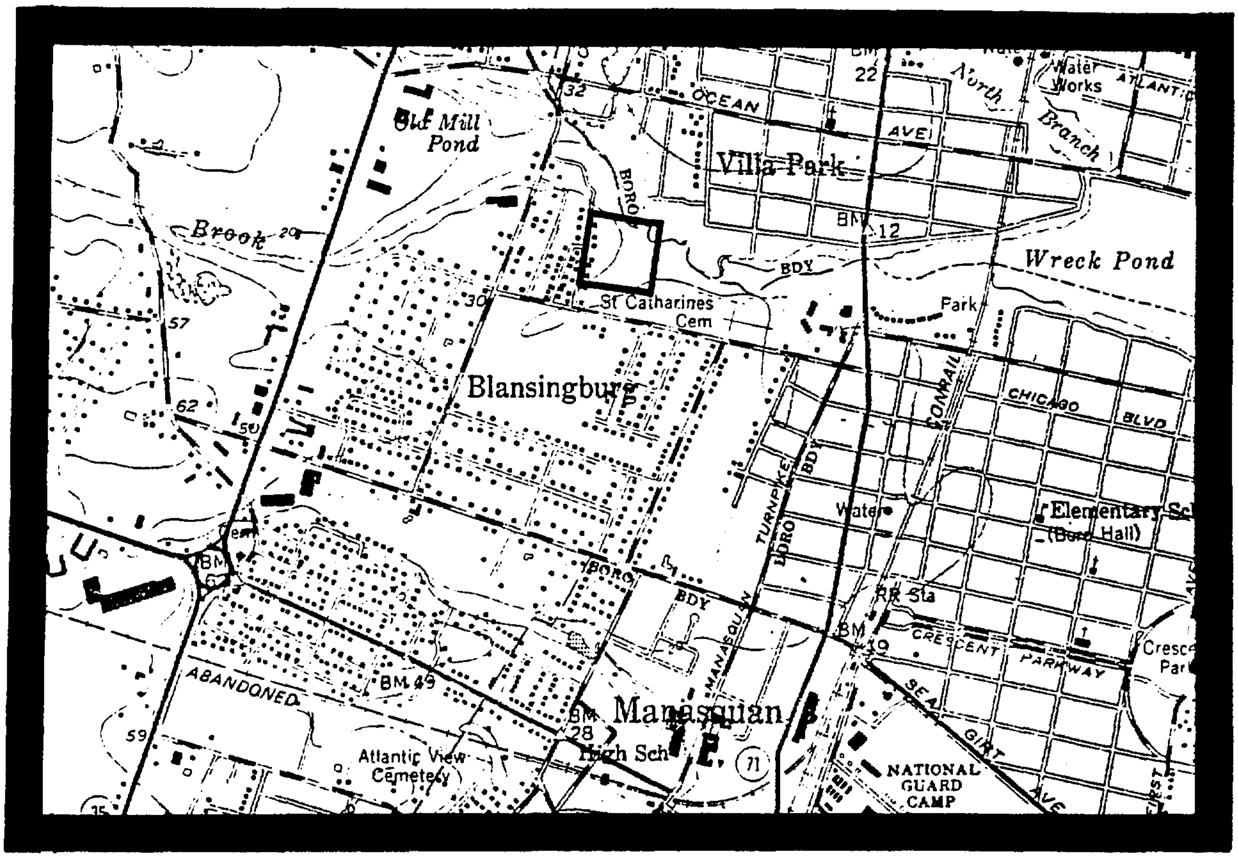
MAP A: Sheets # 53 & 58, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

MAP A




Old Mill Pond
Villa Park
Ocean Ave
North Branch
Water Works
Brook
Wreck Pond
BM 22
BM 12
BORO BDY
St Catharines Cem
Park
Blansingburg
Conrail
Chicago Blvd
Turnpike
Water
Elementary Sch (Boro Hall)
RR Sta
BM 19
Crescent Parkway
Crescent Park
Sea Girt Ave
Abandoned
BM 49
BM 28
Manasquan
High Sch
Atlantic View Cemetery
National Guard Camp

MAP B

MAP C


POW
PSSI
PFOI
Old Mill Pond
Villa Park
Ocean Ave
Water Works
BM 22
BM 12
E1OW
Wreck Pond
St Catharines Cem
Park
Blansingburg
E2SSI EM
E2EM
Chicago Blvd
Water
New
Elementary Sch (Boro Hall)
Penn Central
BM 49
BM 28
BM 19
Manasquan
High Sch
Atlantic View Cemetery
Crescent Parkway
Sea Girt Ave
National Guard Camp

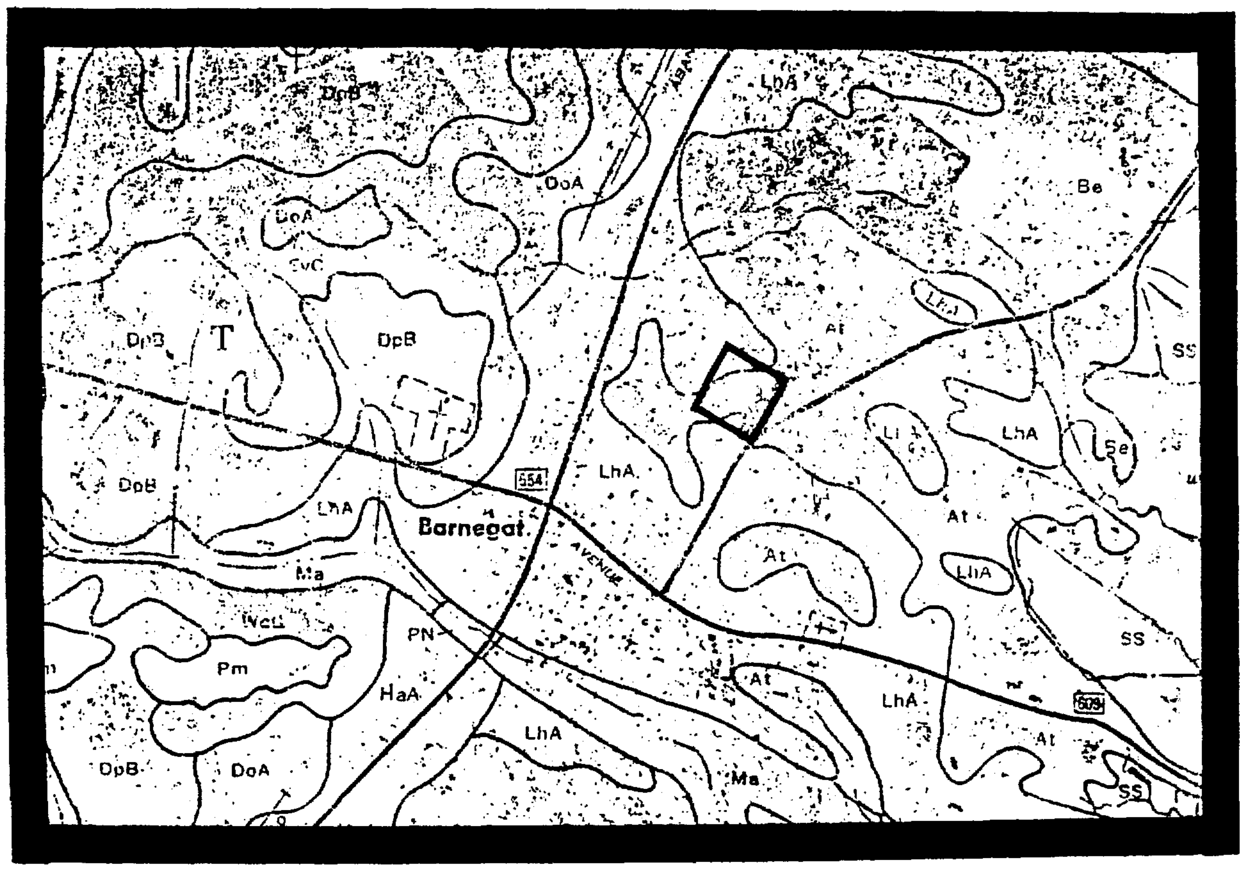
SITE 296 Water/Birdsall St., Barnegat, Ocean County.

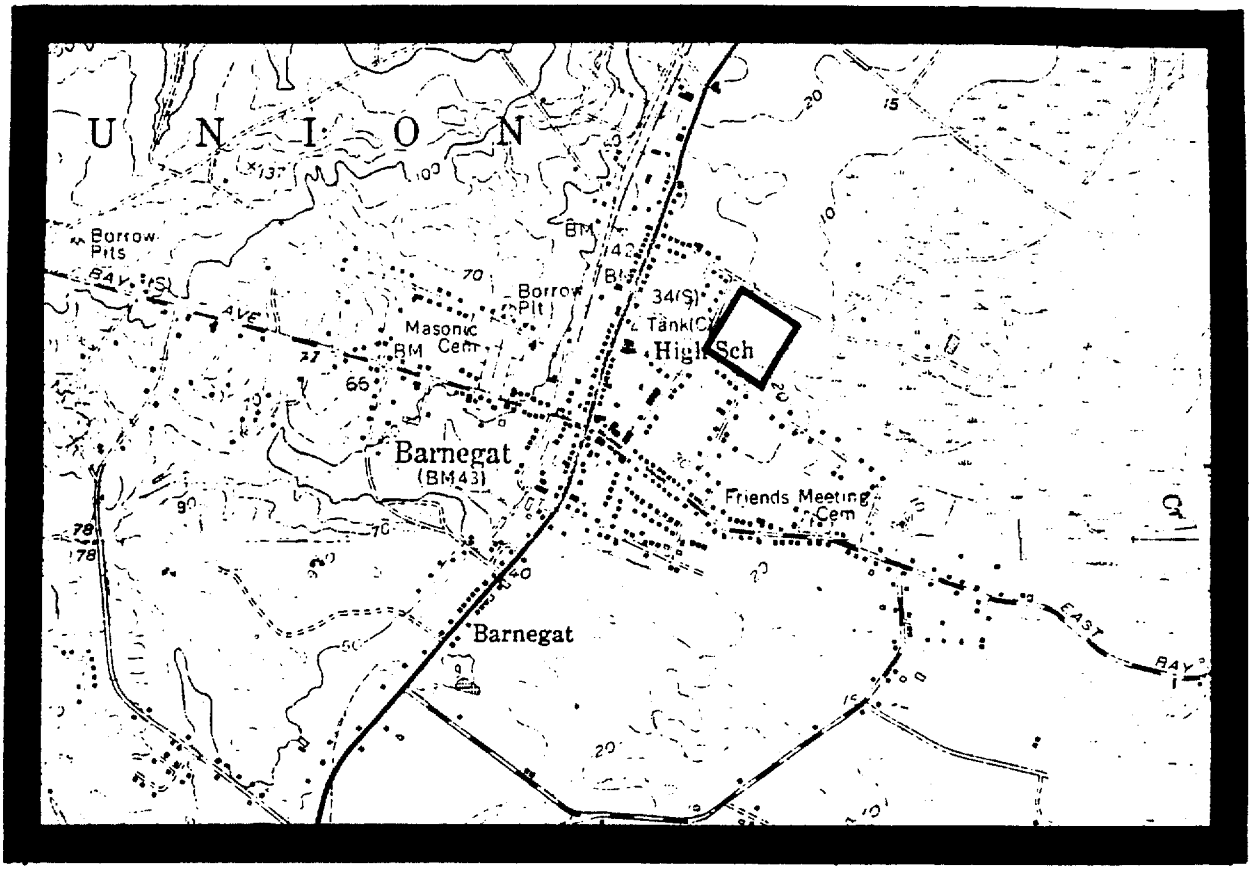
MAP A: Sheet # 47, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory. Forked River, N.J. Quadrangle (Scale 1:24,000)

MAP A

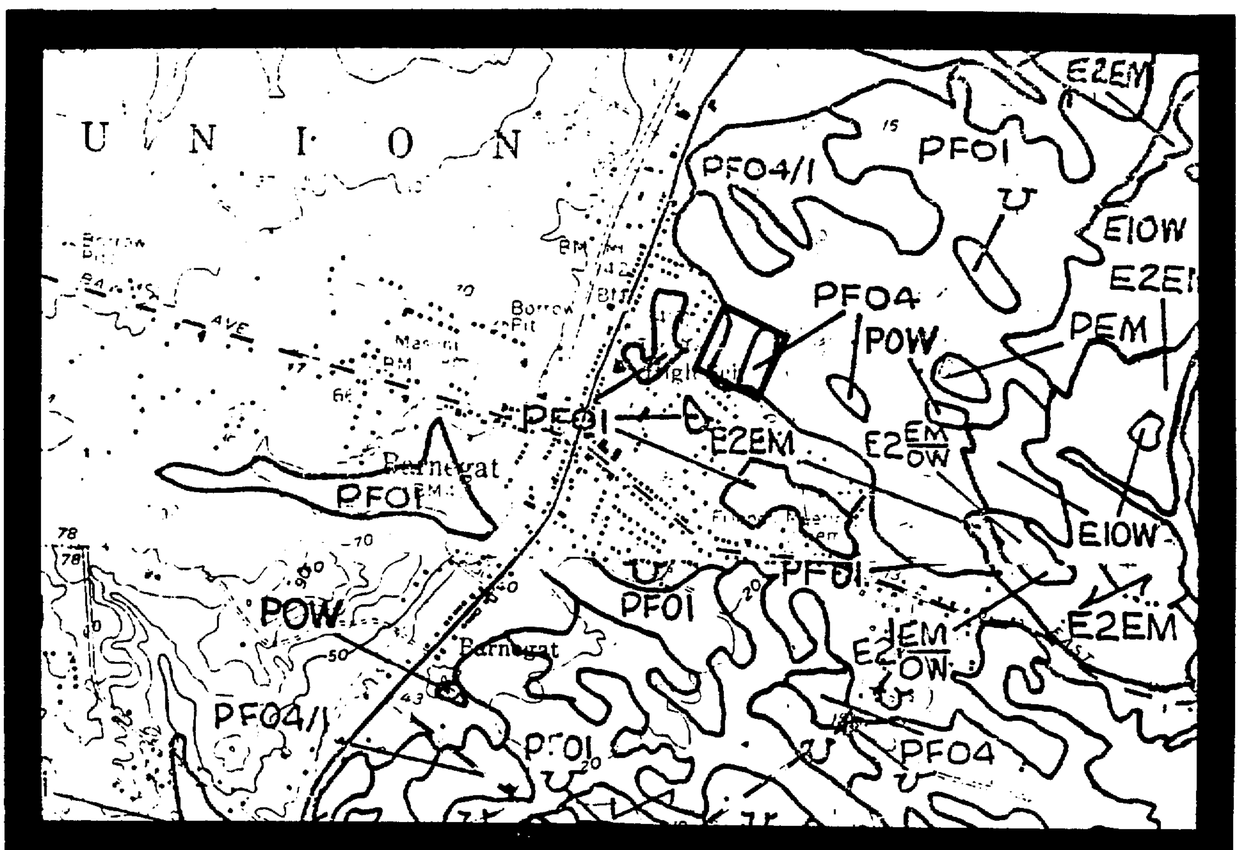




U N I O N
Borrow Pits
BAY
AVE
Borrow Pit
Masonic Cem
BM
34(S)
Tank
High Sch
Barnegat
(BM43)
Friends Meeting Cem
Barnegat
EAST
BAY

MAP B

MAP C



U N I O N
E2EM
PFO1
PFO4/1
E1OW
E2EM
PFO4
POW
PEM
PFO1
E2EM
$E2\frac{EM}{OW}$
PFO1
E1OW
PFO1
PFO1
E2EM
POW
$E2\frac{EM}{OW}$
PFO4/1
PFO1
PFO4

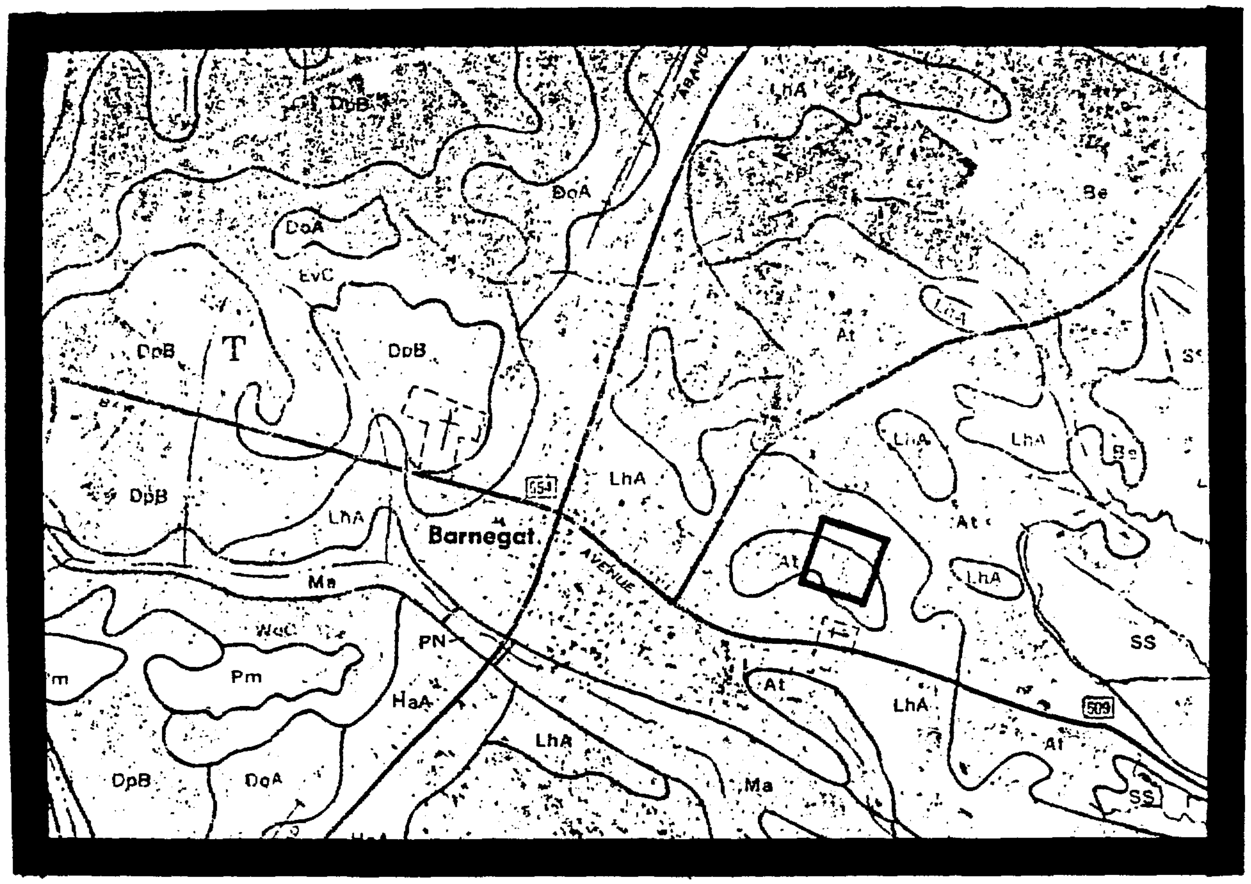
SITE 297 Baseball Field, Water St., Barnegat, Ocean County.

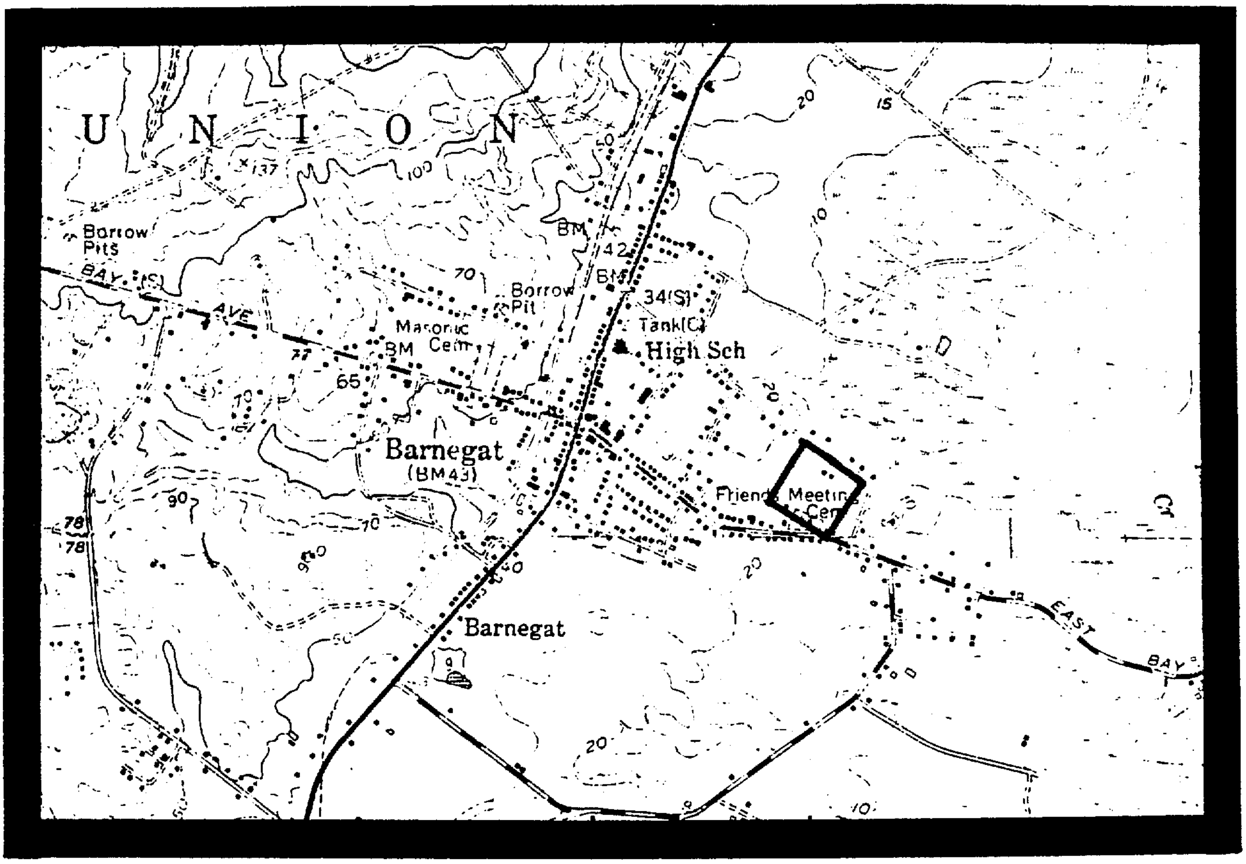
MAP A: Sheet # 47, Ocean County Soil Survey (Scale 1:20,000)

MAP B: U.S.G.S. Forked River, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Forked River, N.J. Quadrangle (Scale 1:24,000)

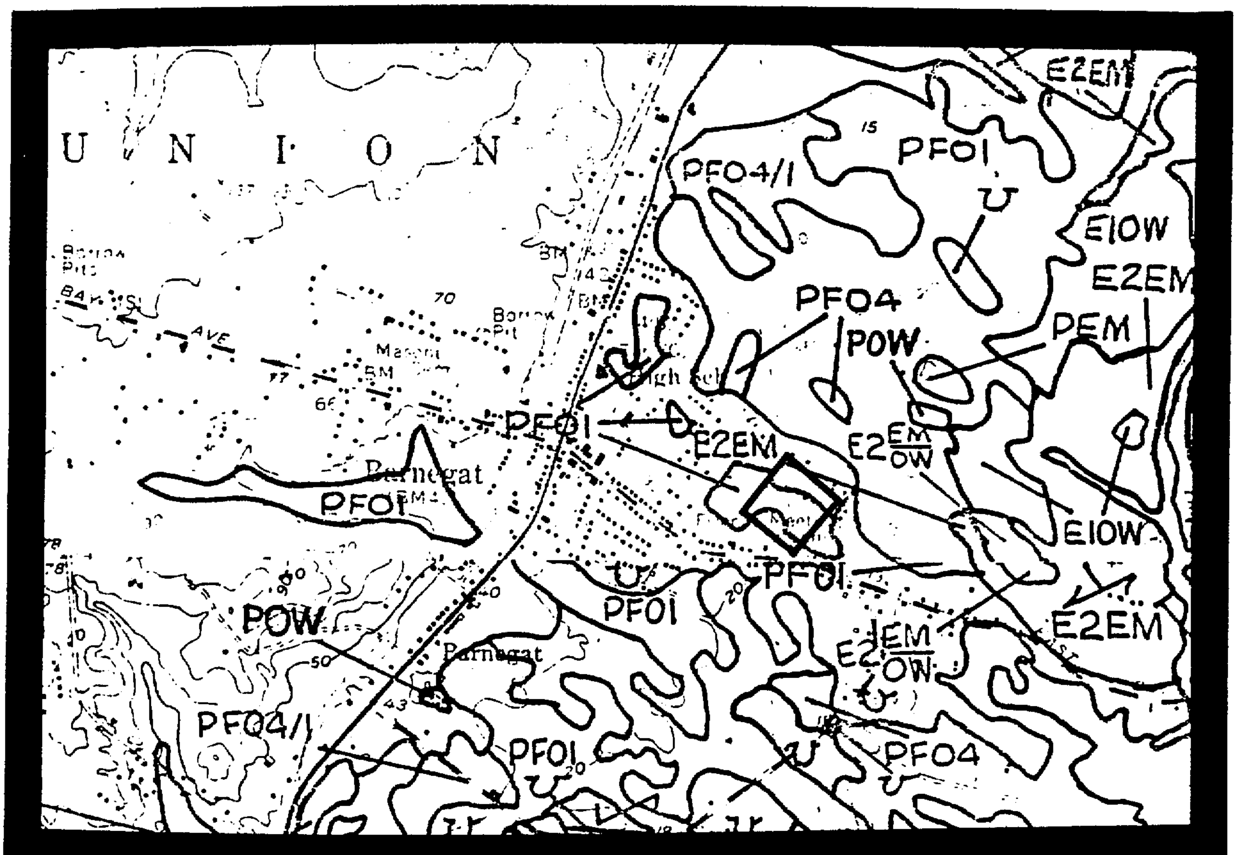
MAP A




U N I O N
Borrow Pits
BAY AVE
Borrow Pit
Masonic Cem
BM
High Sch
Tank(C)
Barnegat
(BM43)
Friends Meeting Cem
Barnegat
EAST BAY

MAP B

MAP C


U N I O N
E2EM
PFO4/1
PFO1
E1OW
E2EM
PFO4
POW
PEM
PFO1
E2EM
E2 EM/OW
PFO1
E1OW
PFO1
PFO1
E2EM
POW
E2 EM/OW
Barnegat
PFO4/1
PFO1
PFO4

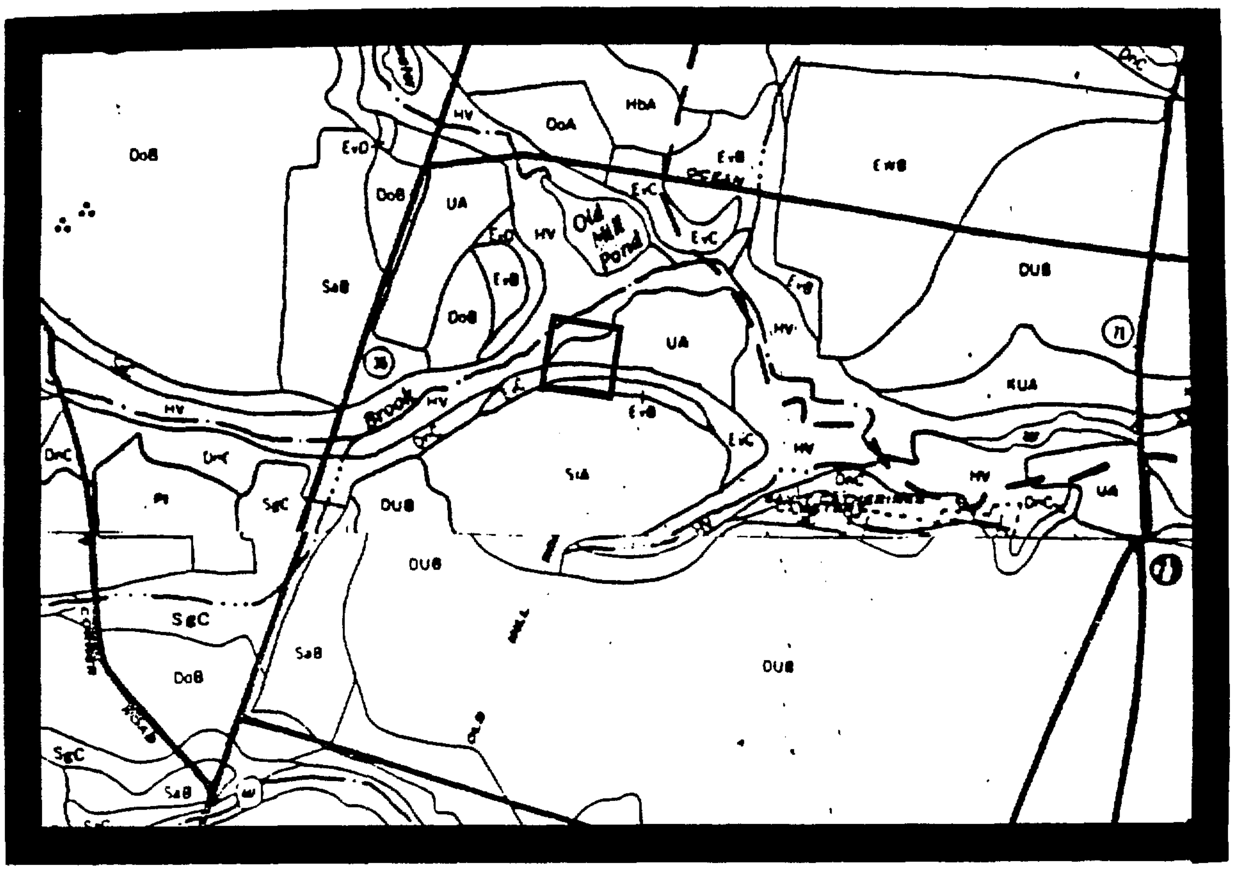
SITE 298 Spruce Dr., Old Mill, Monmouth County.

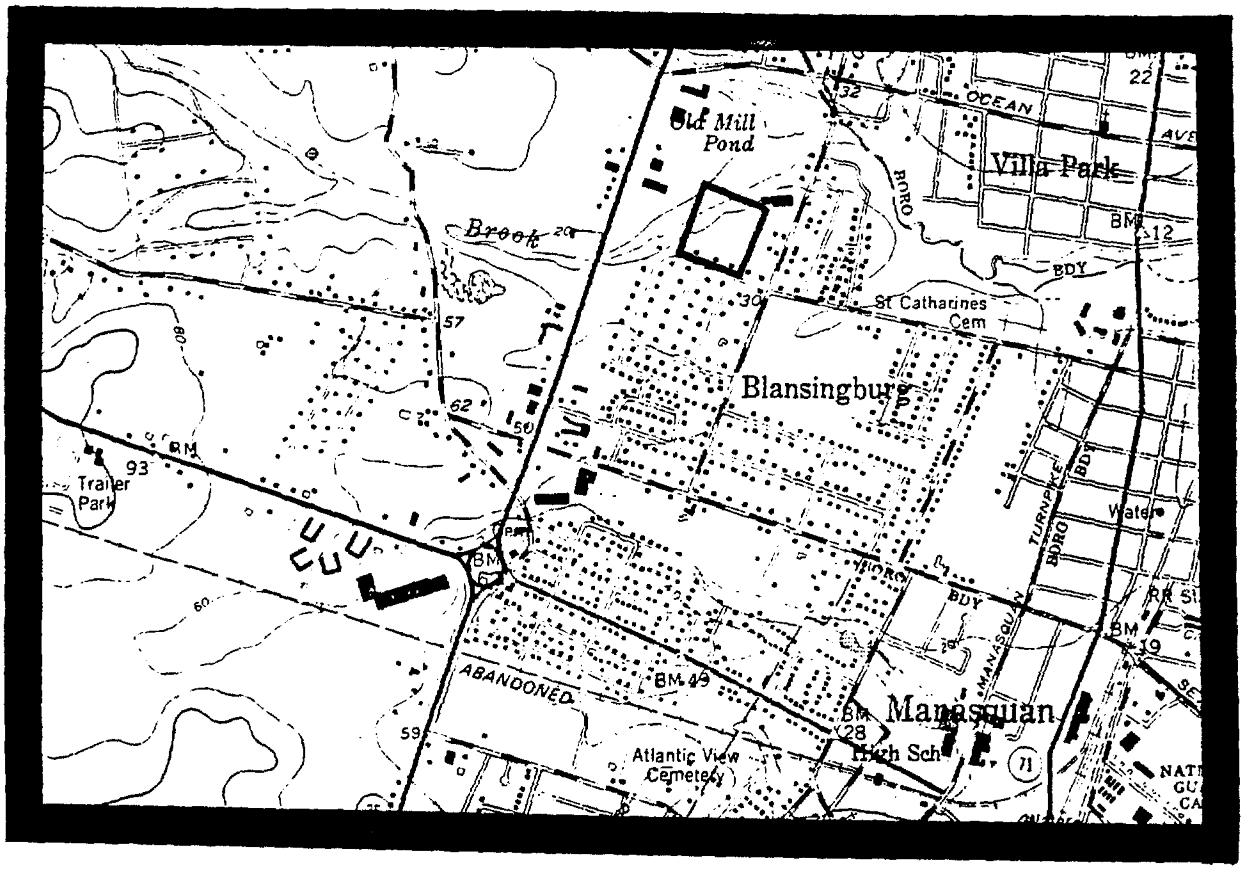
MAP A: Sheets # 53 & 58, Monmouth County Soil Survey (Scale 1:15,840)

MAP B: U.S.G.S. Asbury Park, N.J. Topographic Quadrangle (Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Asbury Park, N.J. Quadrangle (Scale 1:24,000)

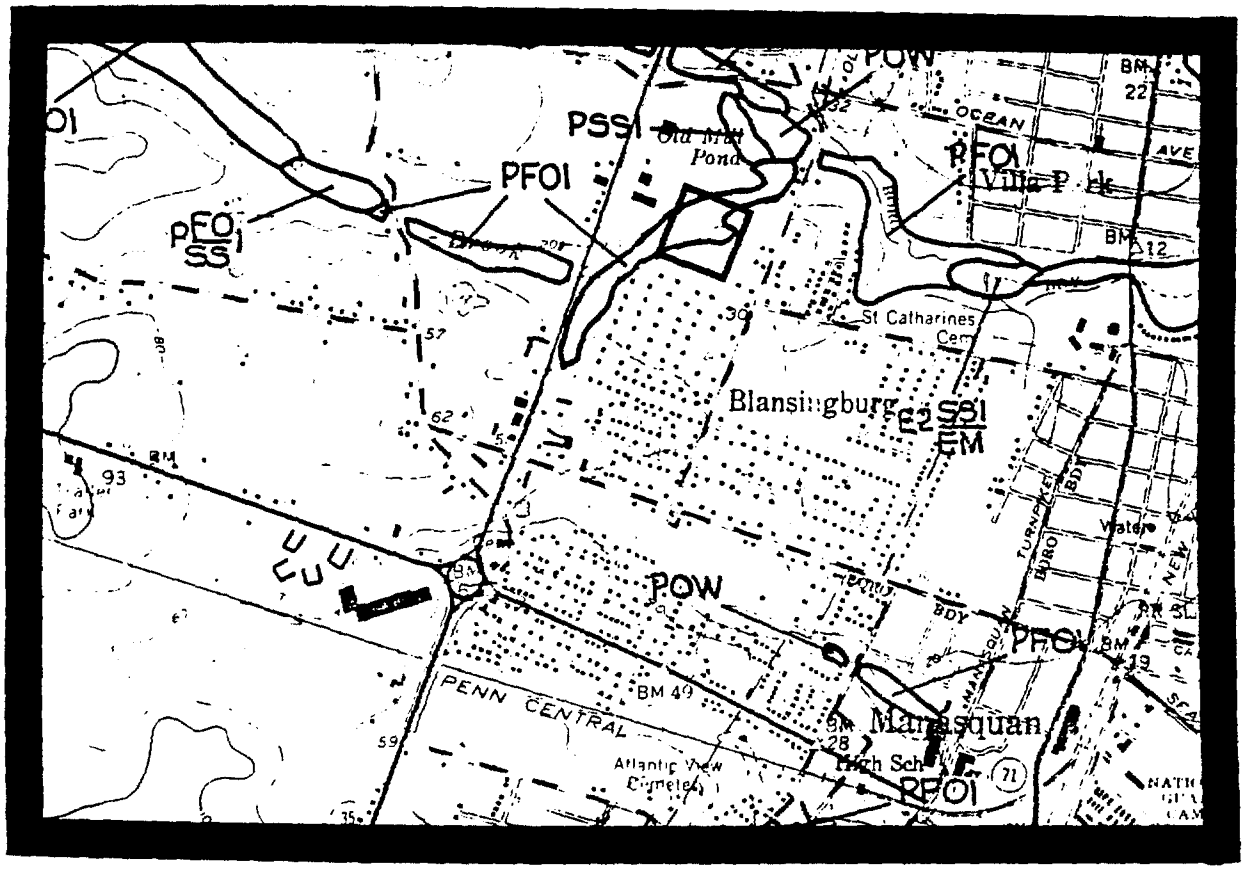
MAP A




Old Mill Pond
OCEAN AVE
Villa Park
BM 12
Brook
St Catharines Cem
Blansingburg
Trailer Park
93
Water
TURNPIKE
MANASQUAN
ABANDONED
BM 49
BM 28
Manasquan
High Sch
Atlantic View Cemetery
71

MAP B

MAP C


POW
PSS1
Old Mill Pond
PFO1
OCEAN AVE
PFO1
Villa P rk
PFO1/SS1
BM 12
St Catharines Cem
Blansingburg
E2 SS1/EM
Water
POW
PFO1
PENN CENTRAL
BM 49
Manasquan
High Sch
PFO1
Atlantic View Cemetery
71

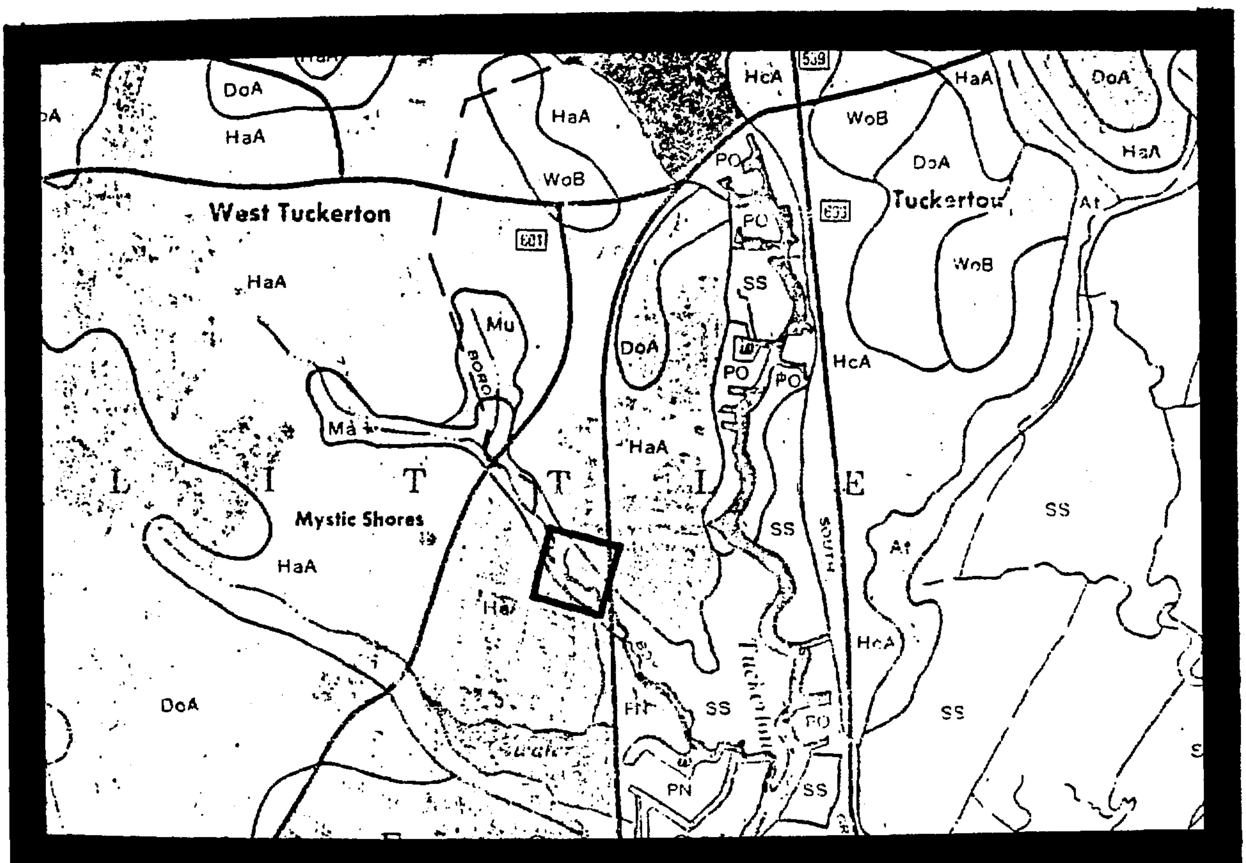
SITE 299 Holly Lake Park, Tuckerton, Ocean County.

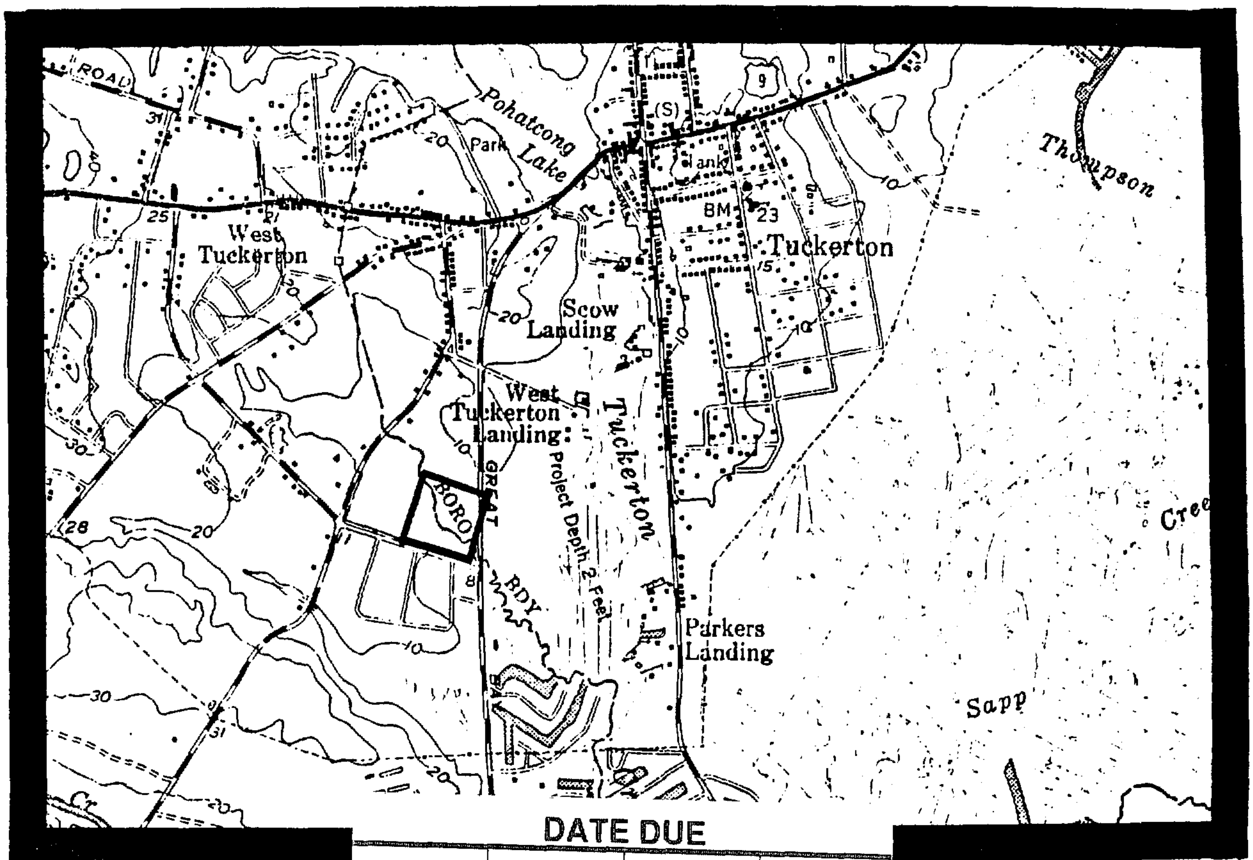
MAP A: Sheet # 59, Ocean County Soil Survey
(Scale 1:20,000)

MAP B: U.S.G.S. Tuckerton, N.J. Topographic Quadrangle
(Scale 1:24,000)

MAP C: U.S.F.W.S. National Wetlands Inventory, Tockerton,
N.J. Quadrangle (Scale 1:24,000)

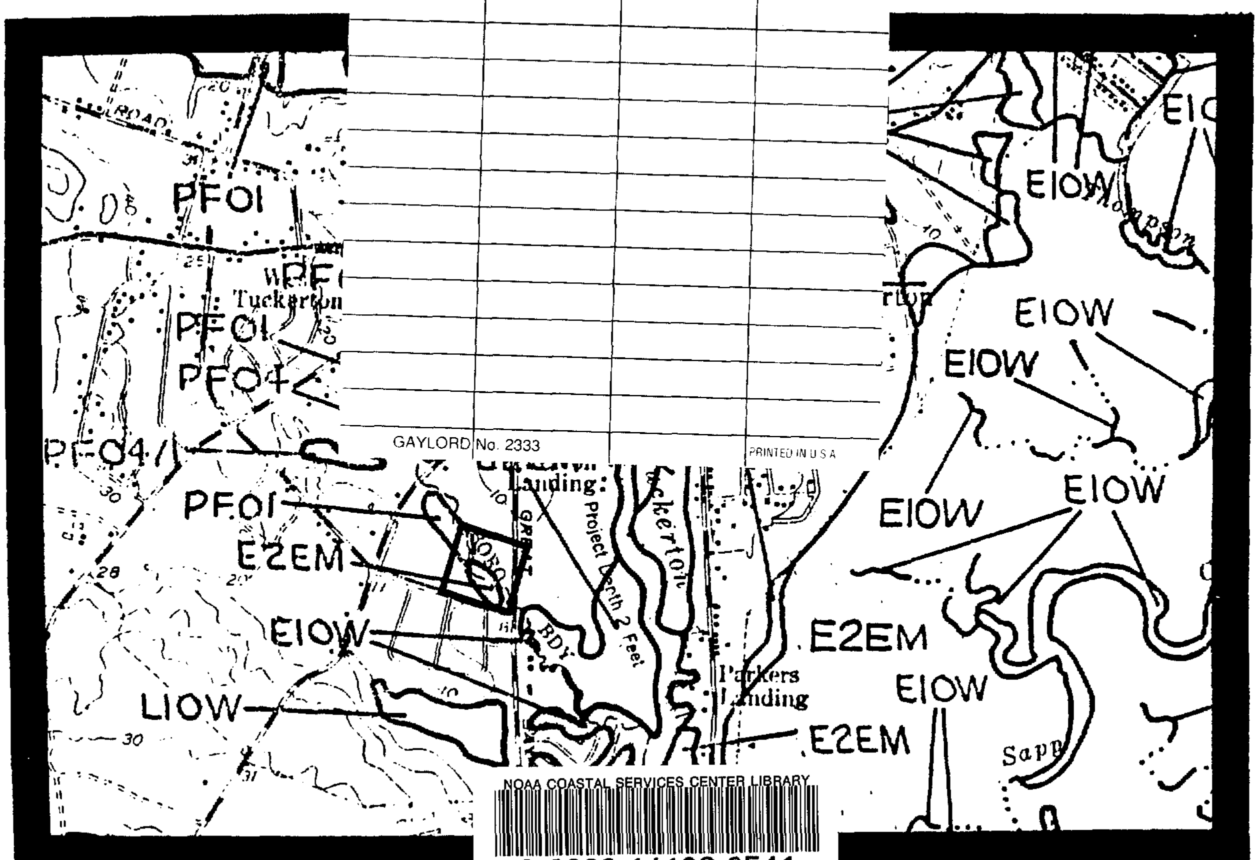
MAP A




ROAD
Pohatcong
Lake
Park
West
Tuckerton
Tuckerton
Scow
Landing
West
Tuckerton
Landing
Tuckerton
BORO
GREAT
BDY
Project Depth 2 Feet
Parkers
Landing
Thompson
Cree
Sapp

MAP B

MAP C


ROAD
PFO1
PFO1
PFO4/
PFO4/
PFO1
E2EM
E1OW
L1OW
BORO
Project Depth 2 Feet
Parkers
Landing
E1OW
E1OW
E1OW
E1OW
E1OW
E1OW
E2EM
E1OW
E2EM
Thompson
Sapp