NEW JERSEY TURNPIKE AUTHORITY

ENGINEERING STUDIES AND ESTIMATES

NEW JERSEY TURNPIKE

North Section

AMMANN & WHITNEY
EDWARDS AND KELCEY
FREDERIC R. HARRIS, INC.
O. J. PORTER & CO.

Associated

September 1949

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September 14, 1949.

Mr. Paul L. Troast, Chairman,
New Jersey Turnpike Authority,
State Capitol,
Trenton, New Jersey.

Dear Sir:

In accordance with our agreement with the New Jersey Turnpike Authority dated May 7, 1949, the report entitled "Engineering Studies and Estimates, New Jersey Turnpike, North Section" is submitted herewith.

Under this agreement we were to undertake a preliminary engineering study and report for the Turnpike from Main Street in Bonhamtown, New Jersey, to the vicinity of the George Washington Bridge.

We have completed the preliminary engineering and traffic studies required to determine the physical feasibility of this facility. We have established the most advantageous locations and traffic capacities of roadways and interchanges in terms of physical conditions and indicated initial and probable future traffic. We have laid out the selected line and interchanges; prepared right-of-way maps; conducted the subsurface investigations and foundation explorations required for location and preliminary design; prepared preliminary designs of roadways and structures; determined requirements for operation and maintenance including toll-taking facilities. We have estimated capital costs of the completed project, including costs of right-of-way, construction and accessory facilities and equipment. We have estimated the annual cost of operation and maintenance. Estimates have been made of the time required for final design, preparation of contract drawings and specifications; for letting contracts; and for completing construction by the most advantageous stages so that the Turnpike may be placed in partial operation as sections are completed. An estimate has been made of the probable date when the northern portion of the Turnpike can be placed in operation.

The report presents our findings, conclusions and recommendations supported by pertinent data and information developed by the study.

Throughout the study we received full cooperation, support and valuable assistance from the New Jersey Turnpike Authority, the New Jersey State Highway Department, the Port of New York Authority, railroads and public utilities and other consultants engaged by the Authority. We wish to acknowledge that earlier studies by various agencies have anticipated some of our recommendations. Our objective has been to integrate such studies with our own to the extent that they serve the present objectives and purposes of the Turnpike Authority.

Respectfully submitted,

O. H. Ammann

AMMANN & WHITNEY

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SYNOPSIS

Our investigation clearly indicates the urgent public need for the New Jersey Turnpike. Presently and prospectively there is a very large volume of motor vehicular traffic moving through and within the State of New Jersey. This present and prospective traffic cannot be adequately accommodated on the existing or contemplated highway system of the State.

The New Jersey Turnpike will provide a much needed highway artery for through movements. It is designed to permit the free, orderly, and speedy flow of a large number of vehicles. By means of grade separations and other features of modern highway design, movements will be unhampered by traffic lights, cross traffic and other types of bottlenecks. The Turnpike is designed as a toll highway for all types of motor vehicles; passenger cars, buses and trucks.

The standards, upon which the preliminary design of the northern portion of the Turnpike is based, are adapted to the characteristics of this type of traffic and will provide the finest highway so far built. They include such outstanding features as 12 foot traffic lanes, 10 foot shoulders for disabled vehicles, a minimum design speed of 60 miles per hour, with corresponding minimum sight distance, maximum grade of 3%, separation of opposing lanes of traffic by a 20 foot center strip, guard rails on fills of 10 feet and over, pavement to withstand the heaviest loaded trucks, a minimum radius of curvature for horizontal curves of 3,000 feet, and acceleration and deceleration lanes 1,200 feet long at all turn out points.

For the northern 30.1 miles of the Turnpike from Bonhamtown to Route 6 we recommend the alignment shown on Plate 3. Our studies show that this is the shortest and most economical line that can be built with due regard for topography and existing structures. The region traversed by the northern portion of the Turnpike is generally highly developed industrially and commercially. The recommended line will cause the least disturbance to the communities through which it passes.

Our traffic studies indicate the need for seven interchanges in the northern portion of the Turnpike as shown on Plate 3. Interchanges are provided for connection through the existing highway system with the Holland and Lincoln Tunnels and the George Washington Bridge.

Our traffic studies also show that the heaviest travelled section will be between Routes 35 and 3. In this section we recommend a six-lane highway with construction of the bridges overpassing it to span a future eight-lane dual-dual highway. Elsewhere we recommend a four-lane highway for initial construction with similar provision for future expansion to a six-lane highway.

In the northern portion of the Turnpike there are two outstanding features; the high level crossing of the Passaic and Hackensack rivers and the provision of a firm foundation for the highway through the deep, soft, marsh of the New Jersey Meadows. However, neither presents any insurmountable engineering or construction problem.

For the bridges crossing the Passaic and Hackensack, the preliminary design selected is riveted plate girders continuous over several spans up to 375 feet in length and vertical clearance for navigation of 110 feet. The deck structure is to be supported by slender piers of steel or reinforced concrete. The foundations for the piers are simple stepped concrete footings supported by steel H piles driven to bed rock.

Vertical sand drains are provided for the rapid stabilization of the fills through the bad ground of the Meadows. By this means fills up to 40 feet in height can be safely carried across these marshes. The amount of fill to be placed is approximately 14 million cubic yards, the greater part of which must be brought in from points distant from the line of the Turnpike.

Provisions are made for the facilities and services auxiliary to the Turnpike, including traffic aids and safety devices, toll collection, administration and maintenance buildings and equipment, police, and communications. We recommend that the facilities for concessions, such as restaurants, gasoline stations and snack bars, be constructed by the Authority and provision has been made for them in our estimates of cost.

The need for the Turnpike is so urgent that its construction should be completed and the Turnpike opened to traffic at the earliest possible date. A short construction period will also minimize interest and other charges. An engineering and construction program calling for the completion of the entire Turnpike by November 1951 meets these circumstances. In our opinion this schedule is stringent but feasible if construction plans are started promptly.

Our estimate of cost for the construction of the northern portion of the Turnpike is $95,300,000. This includes all construction, equipment and real estate costs. It does not include any allowance for contingencies for which we recommend $14,673,000, or 16.5% of the construction cost exclusive of real estate. In accordance with the instructions of the Chief Engineer of the Authority the above figures do not include legal and administrative expenses during construction, engineering, interest during construction, insurance, bond discount and expenses already incurred by the State Highway Department.

Our estimate of the annual cost of operation of the northern portion of the Turnpike is $1,130,000 for the first year and $1,260,000 in the tenth year. Both of these amounts include $98,600 for general administrative cost which is applicable to the portion of the Turnpike from Deepwater to Bonhamtown.

Engineering Studies and Estimates
New Jersey Turnpike
North Section

The New Jersey Turnpike is planned to cross the State in a north-east direction in a relatively straight line from Deepwater, the New Jersey terminus of the Delaware Memorial Bridge now under construction across the Delaware River, to the vicinity of the George Washington Bridge. Plate 1 shows the proposed route in relationship to other main highways in the United States. This relationship is shown to larger scale for New Jersey and adjacent states in Plate 2.

The Turnpike will connect southern and western states with the New York metropolitan area and points north in New York State and northeast in New England. Starting at Deepwater, the Turnpike will roughly parallel the Delaware River, pass close to the Philadelphia-Camden and Trenton areas, thence traverse the industrial areas of Elizabeth and Newark, and then connect with roads leading to the Holland and Lincoln Tunnels and the George Washington Bridge. Access throughout will be provided to centers of population and industry.

This report covers the northern 30 miles of the Turnpike from Main Street in Bonhamtown to a connection with New Jersey Route 6, over which traffic may move to the George Washington Bridge without stop lights. The map, Plate 3, shows the recommended line and interchanges in relation to the principal cities in New Jersey from Deepwater to Route 6. The northern portion of the Turnpike with which this report is concerned is shown in red. The recommended line is the shortest that can be built with due consideration given to existing structures, industrial and residential developments, topography and economy of construction and operation.

ALIGNMENT

Bonhamtown is about 5 miles east of New Brunswick, about 2 miles from Metuchen, and less than a mile from New Jersey Route 25, which the Turnpike will roughly parallel in this vicinity. Toward the north from Bonhamtown, the Turnpike will cross New Jersey Route 4 Parkway now under construction and heavily travelled New Jersey Route 35. It will skirt Woodbridge and then pass through Sewaren and Port Reading, paralleling the Central Railroad of New Jersey on the west side of the tracks through Linden and Elizabeth. At Elizabeth it will pass over the main line tracks of the

Central Railroad of New Jersey and continue northward between the Newark Airport and the Newark Branch of the Central Railroad of New Jersey.

North of the Airport, the Turnpike will cross the Central Railroad of New Jersey and the Greenville Branch of the Pennsylvania Railroad and pass under the Lehigh Valley freight line, thence proceeding to a crossing over the Passaic River slightly west of the electric power plant of the Public Service Corporation. After crossing the Passaic River, it will swing to a more northeasterly direction and cross the Hackensack River north of the Pennsylvania Railroad main line and skirt the south side of Laurel Hill. Thence the Turnpike will follow practically a straight line through the Meadows at the foot of the Secaucus upland with an interchange at New Jersey Route 3, which connects directly with the Lincoln Tunnel. From Route 3 to Route 6 the Turnpike will be mostly in undeveloped meadow land. It will pass over the freight distribution yards of the Susquehanna and Western Railroad and the New York Central West Shore Railroad and cross Overpeck Creek before reaching the interchange with Route 6.

Advantage is taken of the engineering and construction work already done by the New Jersey State Highway Department for the previously proposed Route 100 from Route 4 Parkway to Morse's Creek. A study of this portion of the project showed that the location adopted by the Highway Department could not be bettered.

Through Elizabeth no better location could be found than the one, previously selected by the Highway Department, which parallels the railroad and requires the taking of several blocks of houses. The location on the east side of Newark Airport is acceptable to the Port of New York Authority and provides the best alignment.

The crossings of the Passaic and Hackensack Rivers are control points and critical in any selection of routes. The location of these crossings is influenced by a variety of factors, principally the Pulaski Skyway on the south and Laurel Hill on the north. The Skyway presents a major obstacle to be either hurdled or underpassed. Laurel Hill offers a natural abutment for the high viaduct over the Hackensack River. In passing Laurel Hill on the south side, there is no interference with existing buildings. Moreover, advantage is taken of the rock formation to lessen the length of high structure.

Several alternate routes for the crossing of the Passaic and Hackensack Rivers were studied, but in each case the physical obstacles would require a considerably greater expense than for the route adopted. A route to the west of the adopted line, using the west slope of Laurel Hill as an abutment for the Hackensack River bridge, would provide more space for an interchange with proposed New Jersey Routes 10 and 101. However, it would be inconveniently situated for connection with the Holland Tunnel, or with the proposed new tunnel under the Hudson River at 14th Street, Manhattan. It would be obstructed by the county institutions on the west side of Laurel Hill and would traverse the freight yards of the Delaware, Lackawanna and Western and the Erie Railroads at their widest points.

A route to the east of the adopted line, crossing the Passaic River north of the Skyway, and thence northeast across the Hackensack and the marshes was considered. It would parallel Tonnelle Avenue on the better ground just west of this highway. It would relieve congestion on Tonnelle Avenue and afford a closer access to the tunnels under the Hudson River. However, such a line would not be suited for interchange with proposed New Jersey Routes 10 and 101. It would require grades in excess of 4% on the Passaic River approach if it underpasses the Pulaski Skyway, or else the prohibitive expense of a structure over the Skyway.

A route to the southeast of the adopted line, crossing the two rivers south of the Skyway, and thence north along the east side of the Meadows, would be confronted by major industrial developments and highway interferences that could be relocated only at extreme cost. It would also limit industrial expansion on the Hackensack River in the Marion Point area.

Through Secaucus the selected line has the benefit of being approximately straight and requires the least taking of existing structures. It is located near the west edge of the meadow land to preserve the upland for other uses and to avoid the expense of stabilization necessary in the deep soft marsh to the east.

From Route 3 to Route 6 several alternate lines were studied. A high level route through Fairview and Ridgefield was abandoned because it would require the relocation of nearly a hundred homes, very expensive deep rock cuts and fills, and the relocation, regrading or closing of many streets and highways. This high level route would be over a mile longer and cost over $6,400,000 more than the recommended line without increasing revenue.

The recommended line north of Route 3 will take few buildings and interfere very little with industrial development. Any route through this area must cross the Meadows and extensive railroad trackage. The structures required for the recommended line are the least costly of any studied and the route is the shortest which is feasible.

DESIGN STANDARDS

The design standards encompassed by this report conform to modern practice for the highest type of through highways. They will insure that the Turnpike will be the finest highway ever constructed. Such high functional standards are essential to minimize depreciation and obsolescence thus preserving capital value and providing revenue for a long period of years. These standards will afford the greatest public service by encouraging maximum patronage, and maximum adaptability to modern driver and vehicle requirements. They will also provide maximum inherent safety and reduce operation and maintenance costs.

Standards for alignment and grade of modern highways are based on design speeds. The design speed of the New Jersey Turnpike from Bonhamtown to Wood Avenue in Linden is 70 miles per hour and from Wood Avenue to Route 6 is 60 miles per hour. The design speed is lower north of Wood Avenue because of more frequent interchanges in the populous and highly industrial metropolitan area and an anticipated heavier traffic load. Sight distance on a highway is the distance at which a 4-inch object on the pavement, such as something dropped from a truck, is first visible to a driver with eye level four and a half feet above the pavement. The minimum sight distance for 70 miles per hour is the length of roadway required to stop a vehicle moving at that speed after a normal driver sees the object and before he reaches it. The resulting minimum sight distance of 600 feet determines the minimum radii of both horizontal and vertical curves. For 60 miles per hour the minimum sight distance is 475 feet.

Based upon the maximum design speed and minimum sight distance, the minimum radius of horizontal curvature is 3,000 feet. Radii of curvature of 10,000 feet or more are used where feasible. Where possible, the minimum length of curve including transition is set at 600 feet. The distance between reverse curves is kept to a minimum of 1,000 feet in rural areas and 800 feet in urban areas. Between curves in the same direction a tangent of 2,500 feet or more is used. Where this is not feasible the tangent is replaced by a flat curve. Exit ramps from the Turnpike spiral down to a minimum radius of 125 feet. Superelevation varies from 3% for a 3,000-foot radius to 1% for a radius of 10,000 feet. No superelevation is provided when the radius exceeds 10,000 feet.

Vertical curves generally have a minimum length of 600 feet or more. In some cases where this is impractical a minimum of 400 feet is used.

Generally grades are kept to 2% and the maximum grade of 3% is only used where the flatter grade is impractical or uneconomical. The maximum grades on ramps are 5.5% on upgrades and 5% on downgrades.

Acceleration and deceleration lanes, each 1,200 feet in length and adjacent to the travelled roadway, are provided for traffic entering and leaving the Turnpike at each interchange and at all other turn out points, such as gas stations and restaurants. These lanes will permit vehicles to speed up and blend into the main traffic flow and slow down as they leave the main roadway with safety and least interference to the through flow of traffic on the Turnpike.

The table below summarizes the standards on which the preliminary design of the northern portion of the Turnpike is based.

Design speed	
North of Wood Avenue	60 miles per hour
South of Wood Avenue	70 miles per hour
Minimum sight distance	
North of Wood Avenue	475 feet
South of Wood Avenue	600 feet
Minimum length of vertical curves	600 feet
Minimum radius of horizontal curves	3,000 feet
Minimum distance between horizontal curves*	2,500 feet
Minimum distance between reverse curves	
In rural areas	1,000 feet
In urban areas	800 feet
Minimum radius on ramps	125 feet
Maximum grade	3%
Maximum grade on ramps	
Up	5.5%
Down	5%
Minimum grade	0.5%
In meadows	0.0%
Maximum superelevation for 3,000-foot curves	3%
Traffic lane width	12 feet
Left shoulder width	5 feet
Right shoulder width	10 feet
Acceleration and deceleration lane	
Length	1,200 feet
Width	12 feet
Center strip, edge to edge of pavement	
South of Route 35	26 feet
North of Route 35	20 feet
Passaic and Hackensack bridges	6 feet

* Except at one point south of the Passaic River.

Minimum vertical clearance	15 feet
Normal width of right-of-way	250 feet
Guard rails on fills 10 feet and over	
Fill slopes	
Over 10 feet in height	1 on 2
Less than 10 feet in height	1 on 4
Loading on highway bridges	H20 - S16
Distance between curb and railing on Pasaic and Hackensack bridges	3 feet
Horizontal clearance from right edge of pavement to structures	12 feet

TRAFFIC

Other consultants conducted traffic surveys and studies to determine prospective income from the operation of the New Jersey Turnpike. For the purposes of the preliminary engineering study of the northern portion of the Turnpike, existing traffic data were used to estimate: (1) the volumes of traffic which will probably be attracted to the Turnpike along various sections, when it is opened late in 1951 and at the end of the following ten-year period in 1962; (2) the most useful functional alignment for the Turnpike, consistent with physical conditions and costs; (3) the location of economically warranted interchanges between the Turnpike and the local road system; (4) capacities required and the number of lanes and other traffic accommodation needed along various sections of the Turnpike and on interchange ramps; (5) the most advantageous locations, numbers and capacities of gas stations, restaurants and other public services required along the route.

The primary source of information for these preliminary traffic determinations was the Newark Metropolitan Area Origin and Destination Survey conducted by the New Jersey State Highway Department in cooperation with the Public Roads Administration in 1945. Since computations based on this origin and destination survey were found to check closely with the actual traffic counts which are made periodically by the State Highway Department, these basic data are considered reliable for the purposes of the preliminary traffic analysis.

This traffic analysis established potential traffic volumes from areas tributary to each section of the proposed turnpike in 1945. Volumes and characteristics of traffic that may be expected to use the Turnpike, when it is opened and by the end of the following ten-year period, were estimated by applying expansion factors developed from gasoline consumption in the State of New Jersey, from traffic counts on New Jersey Route 25, growth of truck registrations, and from Hudson River crossing counts for a period of years by the Port of New York Authority.

Taking all tangible factors into consideration, those portions of the total potential traffic from areas tributary to the Turnpike and which would have good reason to patronize the Turnpike, were assigned to it. The total peak hour traffic demands for which roadway and interchange capacity must be provided were derived from the resulting figures. The same data were used to estimate other functional requirements including gas stations and restaurants for the Turnpike.

In accordance with generally accepted practice, the number of lanes provided on roadways and on interchange ramps should accommodate peak hour traffic loads without congestion. The number of lanes required to accommodate expected traffic on the Turnpike and on the access ramps were computed on the basis of standards of highway capacity for New Jersey developed by the New Jersey State Highway Department.

From traffic studies it is considered that a six-lane highway with three lanes in each direction may ultimately be required from Bonhamtown to Route 35, and from Route 3 to Route 6, and an eight-lane dual-dual highway from Route 35 to Route 3. For the initial construction, a four-lane highway is recommended from Bonhamtown to Route 35 and from Route 3 to Route 6 with construction of the bridges overpassing it to span a future six-lane highway when the traffic load proves the need for more capacity. From Route 35 to Route 3 the initial construction is recommended as six lanes with a similar provision for expansion to eight lanes dual-dual. Ample right-of-way is provided for such expansion.

INTERCHANGES

Toll interchanges between the Turnpike and local roadways are located along the route at points which will provide maximum public convenience and service consistent with physical conditions and with capital and operating costs. Selection of these locations was governed by the existence of adequate local access roadways connecting with major feeder highways and with concentrations of population and industry in adjacent tributary areas. Interchanges in the northern portion of the Turnpike are located at seven points: Route 4 Parkway connecting to Route 25 and interior points; Route 35, connecting to seashore and upland points and to Route 25; Elizabeth, connecting to Goethals Bridge and inland points; Port Street-Newark Airport, connecting to Routes 25 and 29; Raymond Boulevard at Route 25 and Pulaski Skyway in

Newark; Route 3, connecting to the Lincoln Tunnel and upland points; Route 6, connecting to George Washington Bridge and upland points.

All interchanges are adapted to facilitate free and uninterrupted flow of vehicles and to eliminate cross and other interfering movements of traffic. Except for the interchange at Route 4 Parkway, the double J type of interchange is used throughout to reduce the number of structures. This treatment also permits routing all traffic through a single toll plaza at each interchange for economy in toll collection.

Preliminary engineering estimates of traffic assigned to each of these interchanges determined ramp capacities and characteristics, toll taking facilities, and the numbers of toll collection personnel required.

SUBSURFACE CONDITIONS

Geologically the northern portion of New Jersey varies from mountains of exposed older formations to tidal marshes. The Piedmont slopes immediately above the marshy borders are coated with scattered remnants of glacial moraines and glacial outwash. Some basaltic extrusions and small but important trap rock intrusions rise above the glacial hummocks and coastal flatlands.

The marshlands in the northern portion of the State are unique in composition, depth and geographical location. Varved post-glacial deposits of very soft clay, silt and fine sand extend to more than 150 feet in depth in some portions of the Hackensack Meadows. The locus of greater depths defines an approximate north to south channel which may have been the ancient course of the Hudson River or some glacial stream.

The upper layers of the varved deposit at one time constituted the ground surface, when it was subjected to periods of drying which resulted in the formation of a crust. As the softer central layers compressed under the weight of the overburden, the surface subsided but retained its firmness so that it is now a submerged crust beneath the more recent meadow mat above it. Evidence of this sinking process is seen in the numerous dead cypress islands throughout the Meadow.

From Bonhamtown to the Rahway River the proposed New Jersey Turnpike traverses the low rolling hills of glacial capping which have been cut by sluggish meandering semi-tidal streams. From the Rahway River to the Passaic River the location in general skirts or crosses a comparatively shallow marsh. From the Passaic River to the northerly terminus at Route 6 the deep marsh offers the only location which is not heavily industrialized and built up. Geological factors were important controls in selecting the design and alignment through the Hackensack Meadows. The line of the Turnpike is located wherever possible to avoid the deepest portion of this marsh and heavy fills are held to a minimum.

The preliminary foundation study started with the collection of existing boring logs, pile records, geological publications and other data pertaining to the vicinity of the various alternate locations which were studied for the Turnpike. The New Jersey Highway Department furnished much information which had been secured over a period of years, some with respect to the planning of Route 100. In studying the geology of the area, Bulletin 50 published by the New Jersey Department of Conservation and Development proved invaluable. This agency was also helpful in supplying maps, coordinate data and other information. The Port of New York Authority, state and municipal agencies, various railroads and power companies and other private corporations, extended their cooperation in the assembly of existing foundation information.

Because the feasibility and cost of constructing the Turnpike over the major rivers and the soft meadow lands is controlled to a great extent by the foundation conditions, an extensive test boring program was necessary to supplement existing data and obtain reliable preliminary information. A total of 152 test borings aggregating 7,155 lineal feet were made. Many of these borings extended to bed rock; some to depths of 150 feet. Samples for laboratory analysis and testing were recovered from approximately 25% of the total footage bored, averaging one sample in every 5 feet or at each change in type of material. These samples were tested for classification, general soil properties, compression characteristics and strength.

Approximately half of the borings were located at sites of proposed structures to determine pile lengths or type of footing. In the Meadows such borings also furnished fill foundation data. A great number of borings were made at considerable distances from structure sites in order to estimate the amount of settlement and the strength characteristics of the soil beneath embankments.

An extensive additional boring and laboratory test program will be necessary in connection with the final design to determine the length of piling required for structures and to guide the detail requirements for stabilizing the roadway over the marshy ground.

In conjunction with the borings an intensive laboratory testing program was completed, utilizing approximately fifty per cent of the 2,500 samples, and visually checking the field classification of the others. Previous laboratory tests of samples in connection with recent construction in the Meadows confirmed the estimate of the performance of the soils represented by the Turnpike samples.

Subsurface materials in the section, Bonhamtown to Route 4, consist almost entirely of glacial till. The underlying older sediments are at such depth as to have no effect on the Turnpike construction. The lack of marshy ground and the visible appearance of the glacial till in this area made it unnecessary to conduct an extensive boring program. The few borings in this section were made at the locations of proposed structures. During the next design stage some investigation of subgrade and anti-frost properties of the soil will be necessary.

The section, Route 4 to the Rahway River, also consists almost entirely of glacial sands, gravels, and clays with one marsh area of moderate depth near the Woodbridge River crossing. The graded roadbed constructed by the Highway Department was stabilized by the excavation and backfill method. Turnpike construction will require the stabilization of the approach to the Woodbridge Avenue bridge over the Turnpike.

The subsurface material in the section, Rahway River to Morse's Creek, consists principally of marsh ranging up to about 18 feet in depth. Under New Jersey State Highway contracts the compressible material has been treated either by excavation and replacement or by the installation of vertical sand drains under an embankment surmounted by an overload. The removal of overload and the construction of bridges and pavement are included in the proposed Turnpike work.

The portion of the Turnpike from Morse's Creek to Bayway Avenue passes through the Esso Standard Oil Refinery where the New Jersey State Highway Department completed subsurface investigation and preliminary plans. The marshy ground at this location extends to 20 feet in depth.

The subsurface material at Bayway Avenue, the Goethals Bridge, the Elizabeth River, and the Elizabeth interchange consists of filled ground and shallow marsh with thicknesses to 16 feet and with bed rock at depths ranging from 15 to 30 feet.

Through the City of Elizabeth to immediately north of the Central Railroad of New Jersey at Elizabethport, the subsurface material consists principally of glacial sands, gravels, and clays.

The relatively firm silts and sands beneath the marsh in the section, Elizabethport to Port Street, occur at depths of from 3 to 25 feet. The overlying compressible material is a very soft peat and organic silty clay. This material will require treatment to avoid the serious and continuing settlement which has been occurring at the Newark Airport during the last seven years.

Considerable filled ground over a generally shallow marsh of less than six feet in depth exists between Port Street and Raymond Boulevard. The shallow marsh has been rendered less compressible by the filling and dumping. In the central portion of this section the Turnpike traverses a small island of firm sandy ground in the vicinity of Wilson Avenue.

The foundation materials from Raymond Boulevard to Route 3 present difficult problems of construction and are of major importance in selecting the alignment and the design of foundations for structures and heavy embankments. The stratification of the subsurface soils at the Passaic and Hackensack River crossings are shown on Plates 9, 10 and 11. From Raymond Boulevard to the Passaic River the soft marsh and sandy sediments range from 40 to 65 feet in depth. The overburden materials here, however, contain a greater proportion of fine sand than found at other parts of the deep meadow.

The depth of compressible material increases from about 60 feet at the Passaic River to approximately 100 feet at Belleville Turnpike becoming shallower, about 70 feet in depth, at the Hackensack River. The foundations for the embankment between the two bridges will require stabilization and piling will be required to support the two major structures over the rivers.

Between the Passaic and Hackensack Rivers the meadow consists of two layers of compressible soil, a very soft peat and organic clay at the surface, and a soft varved silt and clay formation separated from the peat by 2 to 15 feet of firmed clay, silt and fine sand. This submerged crust will support, without displacement, the low roadway fills required between the bridge approaches. However, stabilization of the upper marsh mat and very soft clay will be required. Stabilization of the soft clay and silt below the crust will be necessary under the heavy fill approaches to the structures which range up to 40 feet in height.

Immediately north of the Hackensack River the intrusive trap rock which comprises Laurel Hill furnishes positive support for the Hackensack River Bridge approach and for the Turnpike roadway. Subsurface investigation from Laurel Hill to County Road revealed very shallow meadow or none at all. From County Road the depth of compressible materials increases to approximately 40 feet and then diminishes to nothing at Secaucus Road where the Turnpike crosses a short spur of hilly ground. From Secaucus Road to Route 3 the depth of meadow increases rapidly from west to east but is relatively shallow under the location selected for the Turnpike. At Route 3 the depth of meadow rapidly increases to its maximum as shown on Plate 11. The connection from the Route 3 interchange to the Lincoln Tunnel crosses a very deep section of the meadow ranging up to 170 feet in depth. The location of this interchange has been selected to avoid heavy fills and structures over this very deep marshy area.

A great number of borings were made in the section, Route 3 to Route 6, which crosses the marsh for the entire distance in an attempt to find a location which would avoid as much of the deep meadow as possible. Stabilization of the marsh will be required for the entire length. The roadway fills are held to the minimum required to clear high tides without longitudinal grades in the flats and with ample cross slopes and outlets to provide good drainage. Heavy fills, requiring deep stabilization, will be necessary at the approaches to the structures in this section.

EARTHWORK

The bulk of excavation of earth and glacial fill occur from Bonhamtown to Route 4. Small amounts of such excavation will occur at Wilson Avenue and Secaucus Road. The specifications for roadway excavation should follow the New Jersey State Highway standard specifications, with special clauses to fit particular conditions.

Construction of the Turnpike at Laurel Hill will require over 200,000 cubic yards of rock excavation, of which the major portion will be in through cut. A portion of this construction will involve side hill excavation in hard trap rock.

The large number of grade separations, stream crossings, and Railroad separations will require approach fills with embankments 40 feet above the existing surface. A height of 60 feet is planned at Laurel Hill adjacent to the rock cut where the fundation material is relatively firm.

It is not practical to balance excavation against embankment quantities, with the exception of a portion of the roadway between Bonhamtown and Route 4. Even there, such balance is calculated for a three-foot embankment below finished profile grade to provide for the placement of selected subgrade and subbase material to support adequately the pavement to carry heavy truck loads.

The bulk of the embankment material for the Turnpike must be obtained from upland borrow pits or dredged from channels in the New York area.

Hydraulic fill may be brought in by ocean-going hopper dredges, or by means of scows. Borrow pit material may be transported by railroad or truck.

STABILIZATION

The soft soils underlying a major portion of the Turnpike from the Rahway River to Route 6 will require special treatment to avoid displacement and settlement. Complete stabilization is recommended to prevent movement at bridges as well as to eliminate lateral displacements and mud waves. The fill immediately adjacent to bridges will be stabilized for the ultimate width of the Turnpike to safeguard the structures against movement when additional lanes are provided.

In some cases the Turnpike can be economically stabilized by the removal of unsuitable foundation soil, replacing it with clean sand. In the case of the deep marshes, however, this is uneconomical. This treatment for low fills in the Hackensack Meadow between Route 3 and Route 6 would cost approximately $700,000 per mile more than the vertical sand drain method as shown on Plate 12, which is planned for the stabilization of the majority of the embankments. The sand drain treatment has been used with success on three recently constructed New Jersey Highway projects, one of which is immediately adjacent to the proposed Turnpike at Route 3.

The embankment through the deep meadow will undoubtedly undergo some settlement. Vertical sand drains for fills less than 10 feet high are proposed to extend only through the upper meadow mat. The settlement which occurs because of slow compression of the underlying soft varved silts and clays may require more than the average amount of maintenance. Stabilizing the deeper layers under shallow fills would be uneconomical.

At approaches to structures and under fills above 10 feet in height the vertical sand drains have been extended through the soft center and into the firmer clay, silt and fine sand comprising the lower part of the compressible material. This stabilizing treatment renders embankments adjacent to bridges economical for heights up to 40 feet.

PAVEMENT

Carefully controlled high quality materials are recommended for use to a depth of about 36 inches below the surface of the pavement on all fills and in clay cuts to provide a good foundation for the pavement. The lower, or subbase course, should consist of clean, pervious sand or sand and gravel with very low capillarity to forestall frost action. The next course of the material should consist of very well graded angular sand and gravel or of crushed rock with a uniform gradation to permit the highest bearing value obtainable with this type material.

The subbase material is extended across the full width of the road bed to the outer slopes for good drainage. A crown at the center and a transverse slope of 2 per cent in each direction is planned. The depth below the surface of the pavement at the inside edge should be 24 to 36 inches depending on the character of the underlying soil.

A heavy duty pavement on an adequate subbase and a firm subgrade is recommended. It should receive further careful consideration in the final design stage, particularly because axle loads permitted in New Jersey are exceptionally heavy.

DRAINAGE

Study of an adequate drainage plan indicated need for varied treatments.

Through low-lying meadowland, where the Turnpike is level and at low elevation, water will drain across the pavement both ways to flat right and left side slopes and thence to the meadow. At most locations, water will flow to appropriately spaced inlets and thence in transverse pipes through the embankment to longitudinal ditches.

Where the Turnpike is on embankment adjacent to bridges over streams, railroads, or other highways, water will be disposed of in frequent drop inlets and carried either directly or through conduits and side ditches to nearby natural drainage channels.

The bridges over the Passaic and Hackensack Rivers are designed to be self-draining by means of continuous open steel curbs. Other long viaducts and river crossings are drained by means of scuppers in the roadways adjacent to curbs. The use of scuppers is not contemplated for short bridges where the ordinary roadway drainage is sufficient.

BRIDGE STRUCTURES AND FOUNDATIONS

The northern portion of the New Jersey Turnpike requires the construction of eighty-two bridges and viaducts. Of these, six bridges carry the Turnpike over navigable streams, namely, the Rahway River, Elizabeth

River, Passaic River, Hackensack River, Bellman's Creek and Overpeck Creek. Other bridges carry the Turnpike over railroads, streets and other highways, over minor rivers and miscellaneous structures. Additional structures carry local highways, streets or railroads over the Turnpike, or over roads, railroads and streams. These structures eliminate all grade crossings.

Permits for the crossings over navigable streams must be obtained from the Department of the Army. Permits have already been granted to the New Jersey State Highway Department for bridges crossing the Rahway and Elizabeth Rivers, with vertical clearances of 35 and 20 feet respectively and horizontal clearances of 70 and 60 feet respectively. Bellman's Creek is a minor stream with negligible water traffic and the vertical and horizontal clearances of 10 feet and 70 feet provided should be ample. Vertical and horizontal clearances at Overpeck Creek will be adequate to meet navigation requirements and to provide necessary water way capacity.

The principal problem of bridge permits confronting the Turnpike Authority pertains to the crossings of the Passaic and Hackensack Rivers. A study of the available statistics of the traffic on these rivers, coupled with informal conferences with shipping and navigation interests, indicates that a vertical clearance of 110 feet at both rivers would be ample for existing and future navigation.

For the Passaic River crossing the proposed clearances are shown on Plate 15. They provide for a clear width of 350 feet between fenders normal to the channel, a minimum vertical clearance above mean high water of 101 feet at the fender lines, 110 feet for a width of 277 feet and 113 feet at mid-span.

For the Hackensack River crossing the proposed clear width between fenders is 250 feet normal to the channel. The minimum vertical clearance above mean high water is 103 feet at the fender line, 110 feet for a width of 190 feet normal to the channel and 112 feet at mid-span.

Alternate studies made for low level lift bridges, instead of high level fixed spans over these two rivers, indicated that the former would be considerably more expensive in construction and operation and would constitute an undesirable obstruction to the uninterrupted flow of traffic on the Turnpike.

For all bridge structures over the Turnpike a minimum vertical clearance of 15 feet above the center line of the pavement is provided following the standard recently adopted by the Pennsylvania Turnpike Commission.

The horizontal clearance from the edge of the pavement to the faces of center piers is at least 8′-3″ and that from the edge of the pavement to abutments or side piers is 12 feet.

Structures passing over the Turnpike are designed with a single central support between the abutments. Since future expansion in the width of the Turnpike is anticipated, the designed spans are long enough to accommodate the additional lanes. A special problem is presented in passing the Turnpike under the Goethals bridge approach in Elizabeth. The available width between the piers supporting this bridge is limited. Only two lanes of the Turnpike can be passed under one span. Consequently, the third lane of the Turnpike in each direction will be separated from the other two lanes and passed under an adjacent span. This splaying out of the six lanes of the Turnpike also necessitates the placing of intermediate piers to support bridges of the Baltimore & Ohio Railroad and the relocated Bayway over the Turnpike at this location.

The center strip and roadway shoulders of the Turnpike are generally carried under the overhead crossings without narrowing. The abutments of several of these crossings are designed with vertical faces parallel to the Turnpike. However, where the underlying soil is of poor supporting quality, open side spans are provided with sloped embankments at both sides of the highway. This will increase the visibility and the feeling of openness in passing along the Turnpike.

For streets passing under the Turnpike the plans provide a width considered ample for future requirements of each locality.

In the design of all bridges the aim is economy commensurate with good appearance. It is believed that this purpose is best attained by simplicity in form and structural arrangement, by clear expression of function, uniformity in type of structures and avoidance of unnecessary architectural embellishments. Piers and abutments are designed with plain concrete surfaces with simple architectural lines. All forms of trusses and conspicuous bracing are avoided whenever possible. Likewise it is considered desirable to avoid extension of major carrying girders, trusses or arches above and alongside the roadway of the Turnpike to provide a clear, unobstructed view from the deck, especially on the high bridges and their long viaduct approaches.

The design of all structures which are to carry streets and highways was based upon the Standard Specifications for Highway Bridges, Fifth Edition (1949), adopted by the American Association of State Highway Officials, and upon the H20 - S16 — 44 loading specified therein. Bridges which are to carry railroads are designed in accordance with the specifications of the American Railway Engineering Association (1949).

In general, short spans for both over- and underpasses are bridged with structures of composite structural steel and reinforced concrete. This design permits extensive use of rolled beam sections. Riveted plate girders below the deck are used in a few cases of exceptionally long spans. Piers are of concrete frame construction. The concrete abutments are of gravity or semi-gravity type and retaining walls are of reinforced cantilever design. Bridges that carry railroads on concrete decks have membrane waterproofing covered with asphalt block to protect the deck slab.

The only portions of the bridge structures which extend above the roadway deck are the curbs, parapets and railings which are designed to provide the required safety. The railings are not over 3′-6″ high above the roadway surface and will not obstruct the view from passing cars.

For the major bridges over the Passaic and Hackensack Rivers, whose spans range up to 375 feet, riveted plate girders continuous over several spans are selected to carry the roadway. For economy consistent with functional design the depth of the girders is increased slightly at the supporting piers. This type and form lends the structure a light, graceful and most inconspicuous appearance as seen in the landscape. The deck structure is to be supported by slender piers of steel or reinforced concrete.

Foundations for the piers supporting the major bridges are designed in accordance with the Specifications of the American Association of State Highway Officials for highway bridges. Soil and rock profiles were obtained from available information on existing nearby structures and from a series of new borings. Inasmuch as no continuous and satisfactory soil stratum was encountered, the major structures are supported on foundations consisting of stepped concrete footings and steel H piles driven to bed rock. The rock is in most cases the red sandy shale which underlies much of the northeastern part of New Jersey, rather friable when exposed, but possessing considerable load bearing capacity when confined beneath deep overburden.

For the piers in open water at river crossings granite facing is provided in the tidal range. Fenders are also provided as protection against contact with vessels or the abrasive effects of ice.

UTILITIES

Construction of the Turnpike will require rearrangement and protection of numerous public and private utilities on public highways and private right-of-ways wherever interferences will occur. Negotiation with the owners of electric, water, gas, oil and sewer lines is one of the earliest tasks confronting the Authority, if building of the Turnpike is to proceed in an orderly manner. The estimated expenditures for construction required to clear utility interferences are included in the cost summary.

The costs for relocating and protecting utilities are estimated on the basis of all work required to clear these interferences along the route of the Turnpike in accordance with standards established by the State Highway Department for parkways and freeways. In general this implies removal of all utilities located within the right-of-way of the Turnpike with the exception of direct crossings required for their operation. Power lines over the Turnpike are limited to those carrying 26 KV or higher, with no poles or towers on the right-of-way. All other utility crossings are carried underground with terminal manholes or control valves located outside of the right-of-way, with the exception that existing overhead power and communication lines passing under the high viaducts in the vicinity of the Passaic and Hackensack Rivers are not put underground. Any existing crossing of substandard construction under the Turnpike, is either reinforced or replaced to comply with standards of the New Jersey State Highway Department.

Power and light services to interchange toll booths, maintenance and administration buildings, bridges and to concession locations are provided by underground primary or secondary services through the right-of-way. These are connected to electric utility lines where they are available in the immediate vicinity. For service to loads at locations along the Turnpike remote from a public street or highway, provision is made for installation of buried primary cable alongside the roadway or within the right-of-way. Step down transformers are located in the vicinity of the load. Cable is installed in conduit when on viaducts or under paving.

Water, gas and sanitary services will be required at certain of the concession locations, toll booths, administration and maintenance buildings, and are provided for in the cost estimates. Provision is made for extension of water lines from the nearest municipal mains to these locations. Gas service is provided for the administration, maintenance and restaurant buildings, but not to toll booth locations, where the necessary hot water heating can be accomplished more economically by other means. Sanitary connections are made wherever possible to existing sewers in the vicinity of each building. In certain cases, where minor buildings are located in outlying areas, it will be more economical and satisfactory to provide septic tanks.

TRAFFIC AIDS AND SAFETY DEVICES

In the preliminary design, provision is made for substantial guard rails to be installed along the outside shoulder line on all fills with an elevation of 10 feet or more above the adjacent terrain. These guard rails are of such strength and design as to deflect vehicles which might overwise overrun the shoulder. At all other locations the slopes are gradual and the overall drop so slight that a guard rail is not considered necessary.

Painted lines are provided to mark the division between traffic lanes on the main roadway. They are also provided to guide movements into and through interchanges. For this purpose glass bead impregnated paint is recommended to insure maximum visibility, particularly during hours of darkness.

In the preliminary design of the Turnpike, provision is made for reflectors mounted on three-foot posts to be installed along the outer side of the roadway, in each direction, to delineate at night the course of the roadway ahead. Similar installations on the Pennsylvania Turnpike, in Michigan, and elsewhere provide a luminous guide line that can be seen a half mile ahead under normal headlights on clear nights and sufficient distance in bad weather or fog to permit safe driving at reasonable speeds. These installations also serve as a guide to snow removal crews in plowing out to, but not beyond, the edge of the road in heavy weather when the snow cover often conceals the pavement.

A suitable type of galvanized cattle fence is provided along both sides of the Turnpike right-of-way. This fence will define the right-of-way and keep pedestrians and animals off the Turnpike where they would introduce serious hazards to high speed traffic.

Adequate provisions are made for signs along the entire route of the Turnpike. The design standards of the Turnpike are such that warning signs of danger ahead will not be required, except for secondary cautions. The primary need for signs will be for directions and information to drivers. All signs should be reflectorized or electrically illuminated as required. Signs with large, legible copy should be used to give directions to drivers. These should include direction signs placed along the Turnpike well in advance of and directly at the approaches to interchanges. They should also include signs appropriately placed at major junction points on adjacent highways to direct traffic to the Turnpike. Copy size on all signs and the method of illumination should be such as to attract attention and be legible far enough away so that approaching motorists will have enough time to adjust their speed and to make decisions well ahead of arrival at the point where action is required.

Based on the experience of other turnpikes and freeways, it is concluded that general lighting of the entire Turnpike is unnecessary. In the preliminary designs no lighting is provided along the main roadway of the Turnpike, except at interchange and concession locations, since delineation of the edges of the roadway can be clearly accomplished by the use of reflectors.

Toll plazas are provided with highway lighting to give about .5 foot-candle average intensity. Lighting is of the multiple type, and is energized from the same secondary source supplying the toll booths. Wiring between poles is by means of cable buried in the ground, except where it passes under the pavement where conduit is used. Series lighting is extended along the roadways approaching the toll plazas in four cases where the feeder roads are lighted. This will avoid short, dark stretches on the access roads which bring traffic to the Turnpike.

Beneath bridges carrying the Turnpike over streets or highways with pedestrian sidewalks, lighting is required at sixteen locations. In addition, provision is made for lighted direction signs at the beginning of deceleration lanes at five of the interchanges, and for some increased lighting of ramps carrying relocated streets or highways over the Turnpike.

Lights as aids to marine and air navigation are provided for bridges.

CONCESSIONS

Roadside services, which are essential to the convenience and comfort of the patrons en route, are provided at various points along the northern portion of the Turnpike. These facilities include gas stations, restaurants, snack bars, and wayside pay station telephones. Such concessions are revenue producers and will attract traffic to the Turnpike as well. Ample land for each of these facilities and for future expansion is provided in the estimates. Expected volumes of traffic require duplicate accommodations for traffic moving in each direction. Thus, a restaurant on each side of the Turnpike just north of New Jersey Route 35 will serve the needs of patrons in both directions better than a single restaurant on one side only.

The layout and architectural treatment of these concession areas and buildings will make them a considerable asset to the attractive appearance of the Turnpike. The fact that all turns will be right-hand turns means that traffic approaching each roadside concession will always come from the same direction. This affords a unique opportunity for arranging buildings, signs and access roads so as to present the oncoming motorist with a most favorable aspect, and to provide him with a smoothly functional route for approach, parking, transacting business, and departure from the facility. All structures are architecturally modern, but not "futuristic", pleasing in proportions, and without undue ornament. They accent the horizontal lines in keeping with a high speed highway. A liberal use of glass provides pleasant vistas and the feeling of spaciousness from within.

Gasoline service areas with necessary structures and paving are included in the estimates of cost for the northern portion of the Turnpike. These service station areas are located just south of Route 3 in Secaucus, in North Elizabeth and just north of Route 35. Each of the three gasoline service areas has a gas station on both sides of the Turnpike. Thus, three stations, averaging 10 miles apart on each side of the Turnpike, are provided in the northern portion.

The most feasible location along the route of the northern portion of the Turnpike for major restaurant facilities is just north of Route 35 in Woodbridge Township. The site selected includes sufficient acreage for two restaurants, one on each side of the road with adequate parking. A single large restaurant, seating up to 700 or more patrons, would introduce troublesome operational and parking problems. It is also planned that counter restaurant or snack bar service be available at each of the six gasoline station sites.

Pay station telephone booths, with turn outs for vehicles, on Route 25 near the Newark Airport have been popular. In addition to telephone service at gas stations and restaurants, telephone pay stations have been included in plans for the Turnpike at intervals of about 3½ miles, on each side along the route.

Based on the experience of the Pennsylvania and Maine Turnpikes, it is concluded that the New Jersey Turnpike Authority should contract with private garages along roads adjacent to the Turnpike to perform other than minor services required by Turnpike patrons. Such service should be given at prescribed rates such as schedules of designated service garage charges to members of the American Automobile Association. Each gasoline station along the Turnpike should be required to maintain a pick-up truck to perform minor services, on call, to users of the Turnpike who require gasoline and such attention as tire changes. During peak traffic periods, these service trucks may cruise crowded sections of the Turnpike. The system of communication used on the Turnpike should be connected to such service contractors who will be called by Turnpike radio or telephone as needed.

ADMINISTRATION

The success of the New Jersey Turnpike will reflect the competency, skill and good judgment of its administration, its management and its staff.

As in any other large business unusual as well as changing conditions will require prompt and accurate decisions, planning and adjustments if maximum patronage is to be encouraged and if operating and maintenance costs are to be kept to a minimum.

Three commissioners of the New Jersey Turnpike Authority are authorized by law. Serving under them will be an executive director, secretary-treasurer, personnel and public relations directors, superintendent of tolls, a superintendent of maintenance and superintendent of police and their subordinates.

Adequate provision has been made in estimates of costs for the employment of aggressively able men for these important key positions.

OPERATION AND MAINTENANCE

An administrative building for the Turnpike Authority and its immediate staff with adequate office space, equipment and furnishings is planned in the southwest quadrant formed by the intersection of the Turnpike and Route 35.

A toll plaza is an integral part of each traffic interchange between the Turnpike and adjacent feeder roadways. The size of plaza and the number of collectors and toll booths required were estimated on the basis of anticipated peak hour traffic flow through the interchanges and a rate of toll collection of 300 vehicles per hour for each toll collection lane. For short periods the rate of toll collection per toll taker may be as high as 400 per hour.

The method of toll collection and accounting used on the Pennsylvania and Maine Turnpikes was developed expressly for turnpike use. This system is adapted to handle many points of access and egress, different trip distances and varying toll scales for a given trip depending on the classification of the vehicle. The system has worked well on the Pennsylvania and Maine Turnpikes. No better methods appear to have been developed. It is proposed that the New Jersey Turnpike adopt the same system. If connections are made in the future to toll turnpikes in adjacent states, full advantage can be taken of opportunities to interchange traffic from one turnpike to another with least confusion.

The system is based on the issuance of a ticket to each driver entering the Turnpike. Appropriate punchings record the point of entrance, vehicle classification and other data. At the point of departure the driver surrenders his ticket, pays the required toll and is given a receipt stub. All cards received by each toll collector are turned in to headquarters with his report at the end of his tour of duty. His report is checked with an automatic treadle recorder count. After final punching of data, the collection tickets are used for accounting and statistical purposes. Special machines scan the data on these punched tickets very rapidly and produce, in a few hours, complete accounting and statistical records which would involve much more time and cost if done by hand.

A treadle, which functions when subjected to the rolling action of vehicle wheels, is provided in each toll collection lane. The treadle actuates an electric printing recorder to count the passage of vehicles in terms of numbers of axles. The recorder, which is contained in a locked cabinet located in a locked room, may be opened only by proper officials. This automatic recorder provides a constant check with the collection reports of each toll taker during his tour of duty.

A specially trained force of traffic officers will be maintained exclusively for the Turnpike. These officers will patrol the Turnpike in cars that can be clearly identified. Their function will be to expedite traffic flow, assist patrons, handle emergencies and control drivers whose actions might otherwise endanger themselves or other traffic. Headquarters for traffic officers will be in the administration building at the Route 35 interchange. For the northern portion of the Turnpike, the number of men on duty will vary from 4 during periods of light traffic up to 15 during heavy peak loads. This force is deemed adequate to provide necessary service and to maintain order. All traffic police cars will be equipped with two-way radio for inter-communication with headquarters, with other fixed points on the Turnpike, with other official Turnpike vehicles and with local and state police.

The effectiveness of administrative and maintenance operations of the Turnpike will be greatly facilitated by an adequate system of inter-communication. Such a system will permit integrated and effective action not only during emergencies but under normal circumstances and is essential. Subscriber telephone service will be provided at the administration and maintenance headquarters, at toll interchanges, at restaurants and gas stations. Pay station booths will be installed at other points along the Turnpike. A system of two-way radio will also be installed to provide communication between all fixed administrative and operating points on the Turnpike, between these fixed points and police, administrative and operating vehicles and maintenance crews and between other necessary official vehicles. Each system, the telephone service and the radio, will supplement and provide an emergency standby for the other.

No aspect of toll road operation is more important than efficient and economical repair and maintenance. Continuing and thorough maintenance will insure greatest success of the Turnpike by attracting maximum patronage. A high standard of maintenance is most economical in the end because capital investments are preserved and ultimate structural and other replacements are postponed.

Preventative maintenance anticipates and prevents deterioration; routine or sustaining maintenance insures a smoothly operating facility; and emergency maintenance, which includes prompt and complete snow removal, is necessary if the Turnpike is to operate as an efficient highway transportation facility.

Major categories of maintenance are those for travelled ways, shoulders, bridges and other structures; traffic aids and safety devices; snow removal and ice control; and trees, shrubbery and plantings.

A maintenance superintendent, a superintendent of equipment and their assistants and a secretary will be housed in the Administration Building. Equipment required for standby purposes and for general turnpike maintenance will be kept in one or more of the divisional maintenance buildings, one of which will be located on the north side of Route 35.

It is felt that major overhaul and repair of maintenance equipment which would otherwise require a machine shop and other expensive facilities, can be best handled by contract.

Satisfactory maintenance of the Turnpike will require the establishment of properly staffed and equipped maintenance divisions, each division covering two or more sections of from 10 to 15 miles in length. A divisional maintenance point will be established in the southeast quadrant of the Route 35 interchange area, with two crews of men and necessary equipment to maintain the Turnpike for approximately 10 miles to the south and 10 miles to the north. A second divisional maintenance building will be provided near the Port Street interchange in Newark. From this point, two maintenance crews, one to each section, will maintain the Turnpike from Port Street to Route 6, and from Port Street to Linden. Equipment at divisional maintenance points will consist of light and heavy trucks; snow plow and snow removal units and attachments; pick-up trucks and cars; and necessary hand tools and bulk materials. Personnel required will be a foreman for each maintenance section with a crew of permanent employees whose constant duty will be the maintenance of their section in fully serviceable condition at all times. It is recommended that extra equipment and forces required to meet abnormal or emergency conditions be provided on a part-time or contract basis.

CONSTRUCTION PROCEDURE

A tentative engineering and construction program for the Turnpike contemplates the completion of plans and specifications for grading, drainage and foundations for major bridges, by December 15, 1949. It schedules the completion of construction and the opening of the Turnpike to traffic by November 15, 1951. This is a stringent program but one which we believe is feasible if construction plans are started promptly.

While it would be feasible to construct the Turnpike and open it to traffic by successive sections, we recommend that if possible the portion north of Route 35 be completed and opened to traffic as a unit. If necessary the opening of the section from Route 3 to Route 6 might be deferred.

For completion by November 1, 1951, full advantage must be taken of the resources of the construction industry. The work should be broken down into a number of contracts for advertising and award to bring these resources into play and to secure the widest possible competition. In the portion north of Bonhamtown the following contract divisions and dates for awarding contracts are suggested:

1. Demolition of structures on the right-of-way during January, 1950.

2. Clearing, fill, stabilization, grading, drainage and pipe culverts during January and February, 1950.

   (a) Bonhamtown to Route 35 including interchange, service and administration area.

   (b) Morse's Creek to South City Limits of Elizabeth.

   (c) South City limits of Elizabeth to viaduct over Central Railroad of New Jersey at north edge of Elizabethport.

   (d) Elizabethport to north end of Port Street interchange.

   (e) North end of Port Street interchange to Passaic River Bridge.

   (f) Passaic River Bridge to Hackensack Bridge.

   (g) North end of Hackensack Bridge to Secaucus Road.

   (h) Route 3 Interchange.

   (i) Route 3 to Route 6.

Because of the quantities of fill and the time required for stabilizing the marshy ground top priority should be applied successively to (b) (f) (h) and (i).

3. Foundations for Passaic and Hackensack Bridges during January 1950.

4. Superstructures for Passaic and Hackensack Bridges during March, 1950.

5. Other bridges, approximately eight contracts successively from March to June 1950.

6. Pavement, three contracts of about ten miles each, successively during the spring of 1951. The minor amount of grading remaining between Route 35 and Morse's Creek could be included in one of these contracts.

7. Guard rails, fencing, lighting, toll booths, signs, pavement marking, gasoline stations and snack bars, one contract for each type of facility for the entire Turnpike.

8. Separate contracts for administration and maintenance buildings and restaurants.

ESTIMATES OF COST

In preparing the estimates of cost, every effort was made to be as realistic as possible. The preliminary designs were carried to the point where quantities could be determined with reasonable accuracy. The principal unit prices used, were adopted after comparison with prices for similar work on recently awarded construction and after discussion with contractors and manufacturers. Neither the quantities nor unit prices contain contingency features.

As instructed we have not included in the estimates any expenses for engineering, interest during construction, insurance, bond discount, administrative and legal services during construction and the cost of the work already undertaken by the State Highway Department in connection with Route 100. It is understood that the general consultants to the Authority will add these items in assembling their estimates. The estimates in this report do cover all construction costs including sub-surface explorations, equipment for toll collection, maintenance, administration and real estate. These estimates include costs for the administration building which are applicable to the entire turnpike. We have also estimated the annual cost of operation and maintenance.

The estimates of cost are given in the following tables:

ESTIMATE OF COST OF CONSTRUCTION, EQUIPMENT AND REAL ESTATE

Item	*Quantity*	*Unit*	*Unit Cost*	*Total*
Removal of Structures		Lump Sum		$ 255,000
Utilities — Maintenance and Restoration thereof		Lump Sum		2,221,000
Grading and Stabilization				
Clearing and Grubbing	760	Acres	300.00	228,000
Unclassified Roadway Excavation	883,000	Cu. Yd.	.60	530,000
Rock Excavation	225,000	Cu. Yd.	5.00	1,125,000
Muck Excavation	161,000	Cu. Yd.	1.25	202,000
Borrow (in Place)	10,560,000	Cu. Yd.	Variable	17,138,000
Overload Removal	2,044,000	Cu. Yd.	.50	1,022,000
Sand Blanket	2,197,000	Cu. Yd.	2.80	6,152,000
Vertical Sand Drains	3,288,000	Lin. Ft.	.90	2,960,000
Excavation and Grading Gasoline Stations	283,000	Sq. Yds.	3.50	996,000
Total — Grading and Stabilization				$30,353,000
Drainage				
Culverts		Lump Sum		229,400
Catch Basins and Drains		Lump Sum		558,600
Total — Drainage				$ 788,000
Pavement				
Turnpike including Interchanges, Acceleration and Deceleration Lanes, and Intersecting Roads	1,094,000	Sq. Yds.	5.00	5,468,000
Pavement at Gasoline facilities including Acceleration and Deceleration Lanes and Access Roads	187,200	Sq. Yds.	5.00	936,000
Sub-base	504,000	Cu. Yds.	1.50	757,000
Total — Pavement				7,161,000
Shoulders				
Turnpike including Interchanges and Intersecting Cross Roads	575,000	Sq. Yds.	1.00	575,000
Curbing				
Concrete at Interchanges	34,000	Lin. Ft.	2.00	68,000
Sod	288,000	Lin. Ft.	.20	58,000
Total — Curbing				$ 126,000

Item	*Quantity*	*Unit*	*Unit Cost*	*Total*
Bridges				
Passaic River		Lump Sum		$10,649,000
Hackensack River		Lump Sum		8,020,000
Turnpike over Streams		Lump Sum		3,290,200
Roads over Turnpike		Lump Sum		4,288,000
Turnpike over Roads		Lump Sum		5,117,000
Railroads over Turnpike including Track changes		Lump Sum		2,233,000
Turnpike over Railroads		Lump Sum		2,510,600
Turnpike over Road and Railroad		Lump Sum		4,591,100
Other Bridges				1,749,100
Total — Bridges				$42,448,000
Buildings				
Administration	1	Lump Sum		450,000
Maintenance	2	Lump Sum		362,000
Restaurants & Snack Bars	6	Lump Sum		1,044,000
Filling Stations	6	Lump Sum		600,000
Toll Plaza Structures		Lump Sum		309,000
Total — Buildings				2,765,000
Utility Services				
Power and Light		Lump Sum		273,500
Gas, Water and Sewer		Lump Sum		157,500
Telephone		Lump Sum		34,000
Total — Utility Services				$ 465,000
Traffic Aids and Safety Devices				
Reflector Delineation		Lump Sum		17,800
Signs		Lump Sum		195,500
Pavement Marking		Lump Sum		15,700
Guard Rail	201,750	Lin. Ft.	2.00	403,500
Right of Way Fencing	214,800	Lin. Ft.	.30	64,500
Total — Traffic Aids				$ 697,000
Top Soil, Fertilizer and Seeding		Lump Sum		$ 697,000
Subsurface Explorations		Lump Sum		$ 360,000
TOTAL COST CONSTRUCTION				$88,911,000

Item	Quantity	Unit	Unit Cost	Total
Equipment				
Maintenance, Snow Removal, De-icing, etc.				544,500
Shop				12,500
Administration and Office				25,500
Toll Collection				170,900
Police				35,600
Radio				105,000
Total — Equipment				$ 894,000
Real Estate Takings				$ 4,995,000
Appraisals, Administration and Legal Expense				500,000
TOTAL COST OF CONSTRUCTION, EQUIPMENT AND REAL ESTATE FOR THE NORTH PORTION				$95,300,000

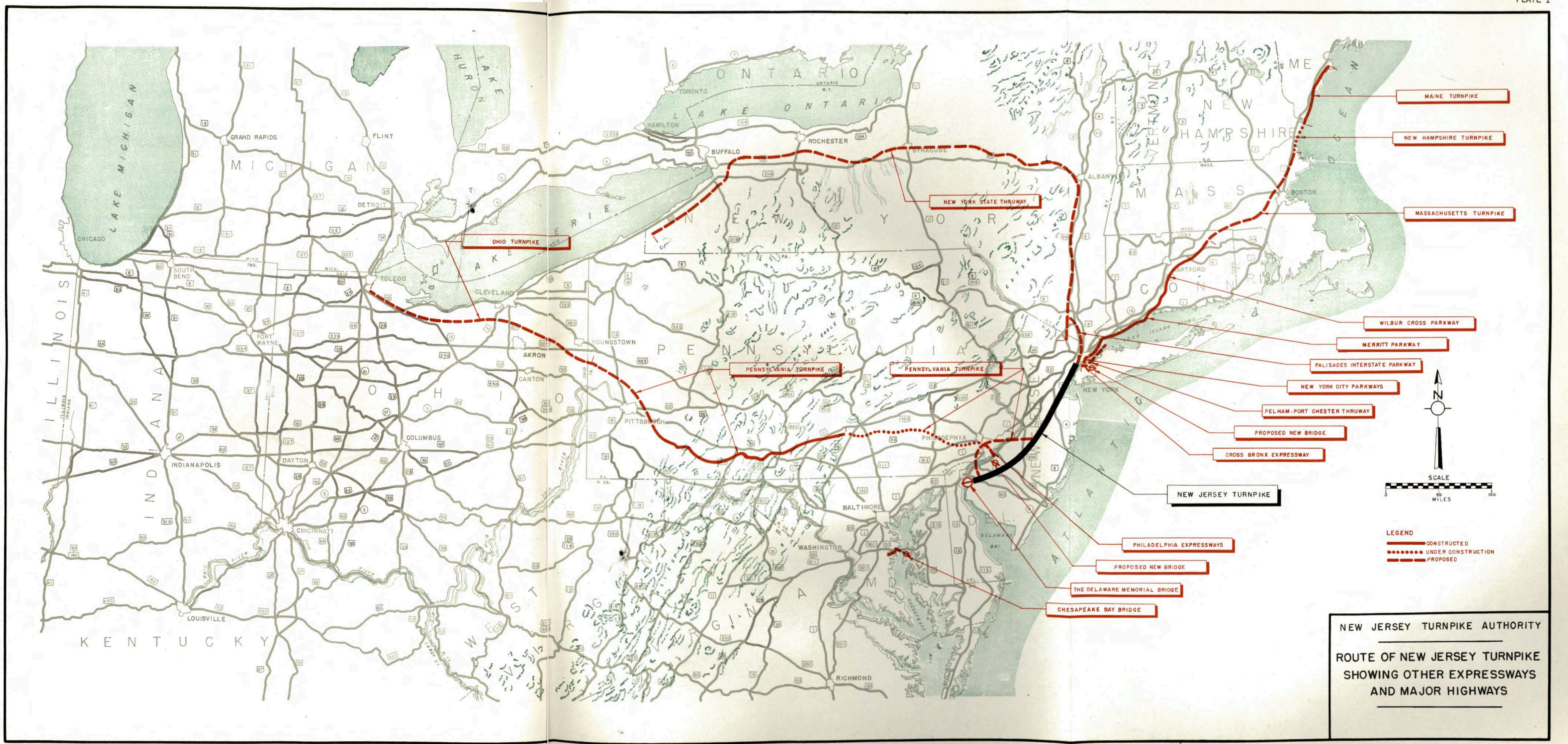
ESTIMATE OF COST OF OPERATION AND MAINTENANCE

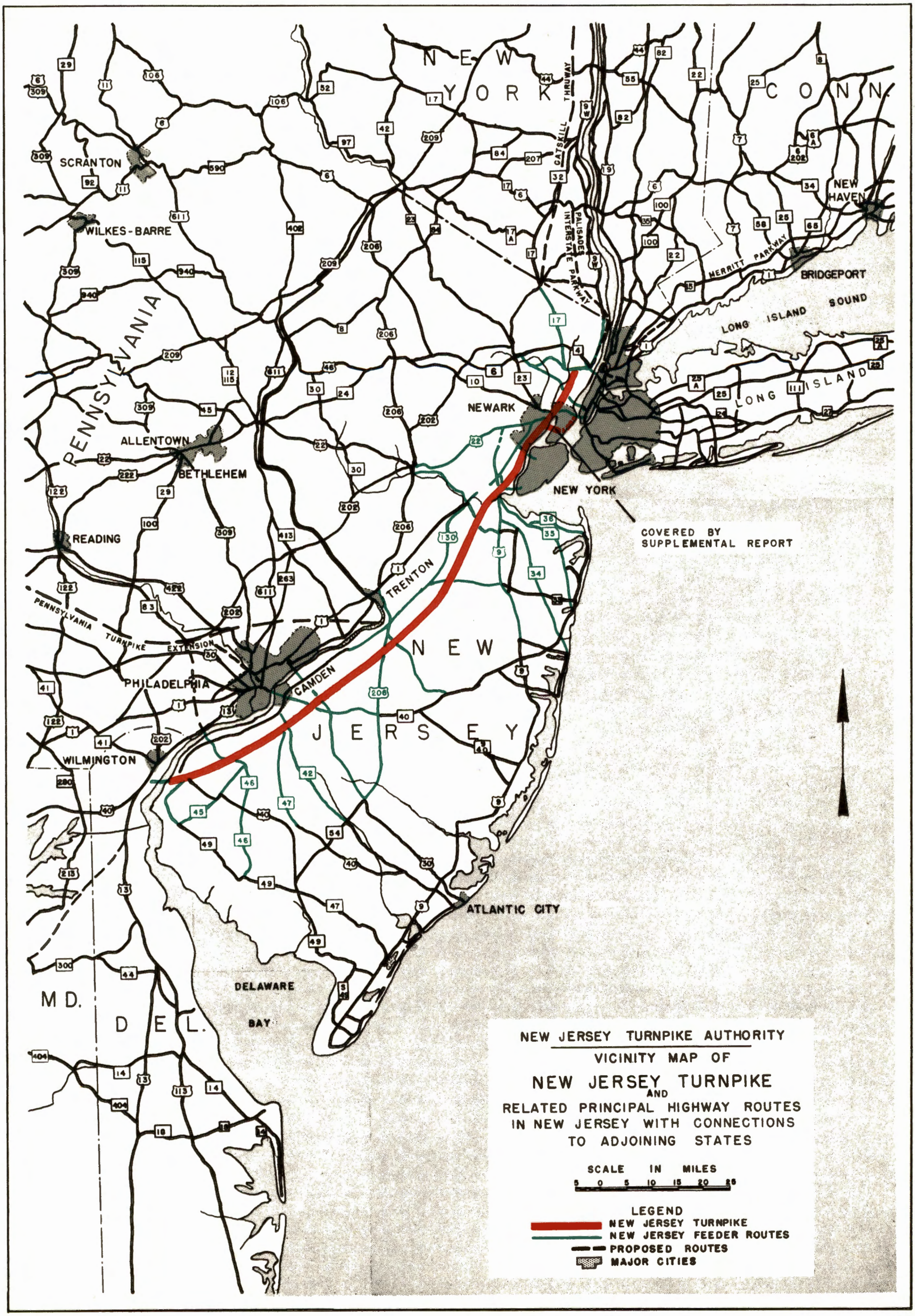
	First Year			*Tenth Year*		
	North	*South*	*Total*	*North*	*South*	*Total*
Executive and Administrative Staff	117,500	98,600	216,100	120,300	98,600	218,900
Toll Collection	514,900		514,900	577,600		577,600
Maintenance and Repair	240,900		240,900	303,800		303,800
Police	159,500		159,500	159,500		159,500
	1,032,800	98,600	1,131,400	1,161,200	98,600	1,259,800

NOTE: North refers to costs for northern section from Bonhamtown to Route 6. South refers to costs applicable to the Turnpike south of Bonhamtown.

The above estimates do not include any contingencies. A reasonable allowance for contingencies to cover variations in quantities and unit prices and to meet unforeseen conditions is, of course, essential in an estimate of this type. The contingencies which we recommend for the northern portion of the Turnpike are $14,673,000, or 16.5% of the construction cost, not including real estate or equipment.

PLATES


MAINE TURNPIKE
NEW HAMPSHIRE TURNPIKE
MASSACHUSETTS TURNPIKE
NEW YORK STATE THRUWAY
OHIO TURNPIKE
PENNSYLVANIA TURNPIKE
PENNSYLVANIA TURNPIKE
WILBUR CROSS PARKWAY
MERRITT PARKWAY
PALISADES INTERSTATE PARKWAY
NEW YORK CITY PARKWAYS
PELHAM-PORT CHESTER THRUWAY
PROPOSED NEW BRIDGE
CROSS BRONX EXPRESSWAY
NEW JERSEY TURNPIKE
PHILADELPHIA EXPRESSWAYS
PROPOSED NEW BRIDGE
THE DELAWARE MEMORIAL BRIDGE
CHESAPEAKE BAY BRIDGE
SCALE
MILES
0
50
100
LEGEND
CONSTRUCTED
UNDER CONSTRUCTION
PROPOSED
N
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ONTARIO
MICHIGAN
ILLINOIS
INDIANA
OHIO
KENTUCKY
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMPSHIRE
MASS
CONN
MD
DEL
ATLANTIC OCEAN
ME
CHICAGO
GRAND RAPIDS
FLINT
DETROIT
TOLEDO
CLEVELAND
SOUTH BEND
FORT WAYNE
AKRON
CANTON
YOUNGSTOWN
PITTSBURGH
COLUMBUS
DAYTON
INDIANAPOLIS
CINCINNATI
LOUISVILLE
TORONTO
HAMILTON
BUFFALO
ROCHESTER
SYRACUSE
ALBANY
BOSTON
HARTFORD
NEW YORK
PHILADELPHIA
BALTIMORE
WASHINGTON
RICHMOND
DELAWARE BAY
NEW JERSEY TURNPIKE AUTHORITY
ROUTE OF NEW JERSEY TURNPIKE
SHOWING OTHER EXPRESSWAYS
AND MAJOR HIGHWAYS


NEW YORK
CONN.
PENNSYLVANIA
NEW JERSEY
MD.
DEL.
SCRANTON
WILKES-BARRE
ALLENTOWN
BETHLEHEM
READING
PHILADELPHIA
WILMINGTON
CAMDEN
TRENTON
NEWARK
NEW YORK
NEW HAVEN
BRIDGEPORT
ATLANTIC CITY
LONG ISLAND SOUND
LONG ISLAND
DELAWARE BAY
CATSKILL THRUWAY
PALISADES INTERSTATE PARKWAY
MERRITT PARKWAY
PENNSYLVANIA TURNPIKE EXTENSION
COVERED BY SUPPLEMENTAL REPORT
NEW JERSEY TURNPIKE AUTHORITY
VICINITY MAP OF
NEW JERSEY TURNPIKE
AND
RELATED PRINCIPAL HIGHWAY ROUTES IN NEW JERSEY WITH CONNECTIONS TO ADJOINING STATES
SCALE IN MILES
5 0 5 10 15 20 25
LEGEND
NEW JERSEY TURNPIKE
NEW JERSEY FEEDER ROUTES
PROPOSED ROUTES
MAJOR CITIES


NEW JERSEY TURNPIKE AUTHORITY
ROUTE MAP OF
NEW JERSEY TURNPIKE
SHOWING LOCATIONS OF TOLL INTERCHANGES IN RELATION TO MAJOR CITIES
SCALE IN MILES
1 0 1 2 3 4 5
LEGEND
NEW JERSEY TURNPIKE NORTHERN SECTION
NEW JERSEY TURNPIKE SOUTHERN SECTION
MAJOR CITIES
DELAWARE MEMORIAL BRIDGE
DEEPWATER INTERCHANGE
SWEDESBORO INTERCHANGE
SOUTH CAMDEN INTERCHANGE
NORTH CAMDEN INTERCHANGE
MT. HOLLY INTERCHANGE
BORDENTOWN INTERCHANGE
HIGHTSTOWN INTERCHANGE
NEW BRUNSWICK INTERCHANGE
N.J. RT. 4 PKWY. INTERCHANGE
N.J. RT. 35 INTERCHANGE
ELIZABETH INTERCHANGE
PORT ST. INTERCHANGE
RAYMOND BLVD. INTERCHANGE
N.J. RT. 6 INTERCHANGE
N.J. RT. 3 INTERCHANGE
HUDSON CO. BLVD. INTERCHANGE
AVENUE E INTERCHANGE
COMMUNIPAW AVE. INTERCHANGE
COVERED BY SUPPLEMENTAL REPORT
WILMINGTON
NEW CASTLE
DELAWARE RIVER
PENNSVILLE
PENNS GROVE
SALEM
CHESTER
HAVERFORD
ARDMORE
ABINGTON
PHILADELPHIA
CAMDEN
GLOUCESTER
BURLINGTON
BRISTOL
MORRISVILLE
TRENTON
BORDENTOWN
YARDVILLE
MT. HOLLY
FORT DIX
HIGHTSTOWN
PRINCETON
FREEHOLD
MILLTOWN
SOUTH RIVER
SOMERVILLE
NEW BRUNSWICK
PLAINFIELD
WESTFIELD
SUMMIT
UNION
LINDEN
WOODBRIDGE
CARTERET
BAYONNE
ORANGE
BLOOMFIELD
NUTLEY
PATERSON
RUTHERFORD
HACKENSACK
RIDGEFIELD PARK
NORTH BERGEN
HUDSON RIVER
UPPER NEW YORK BAY
LOWER NEW YORK BAY
RARITAN BAY
SANDY HOOK BAY
RED BANK
P.R.R.
READING
C.R.R. N.J.
L.V.R.R.
ERIE

PLATE 4

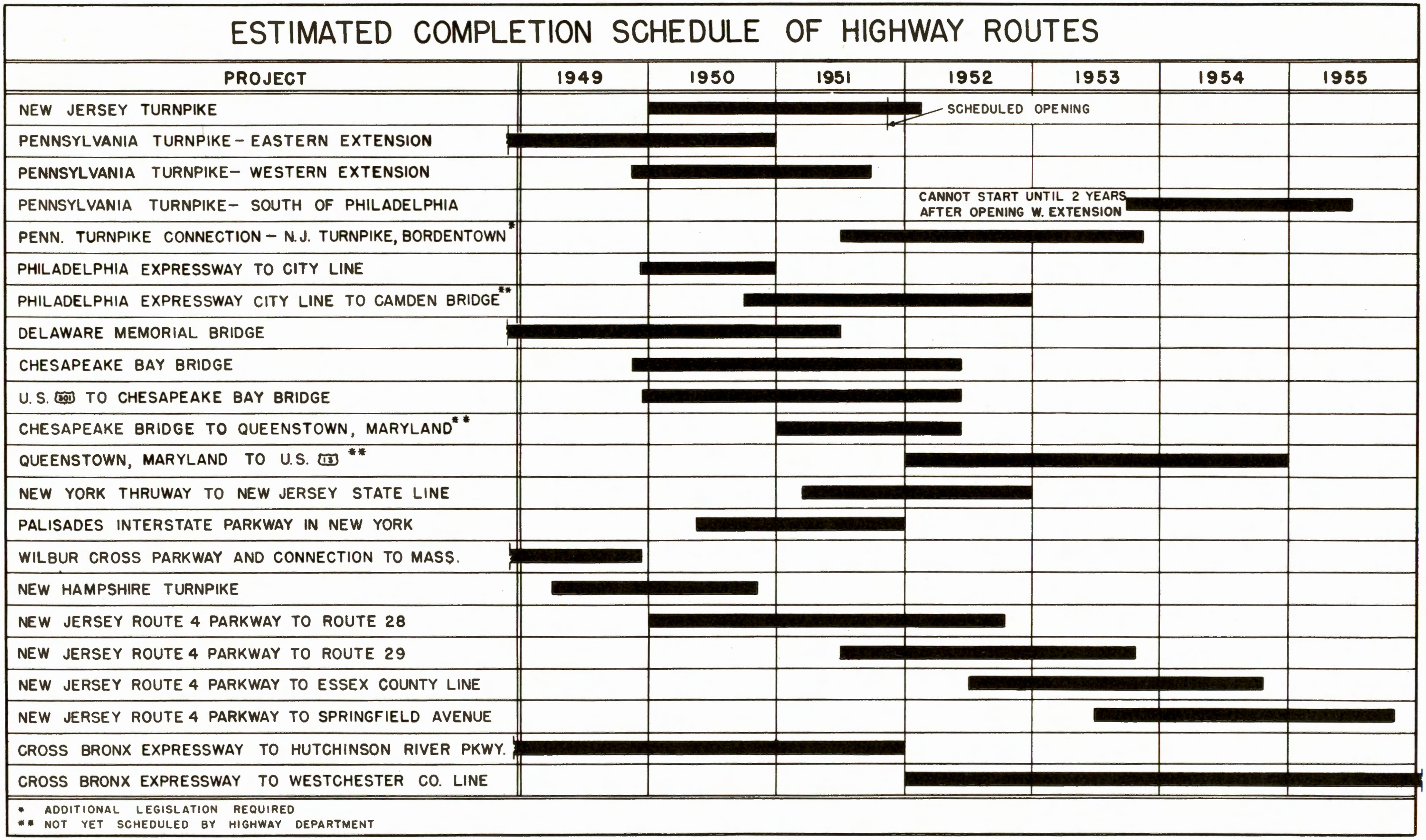
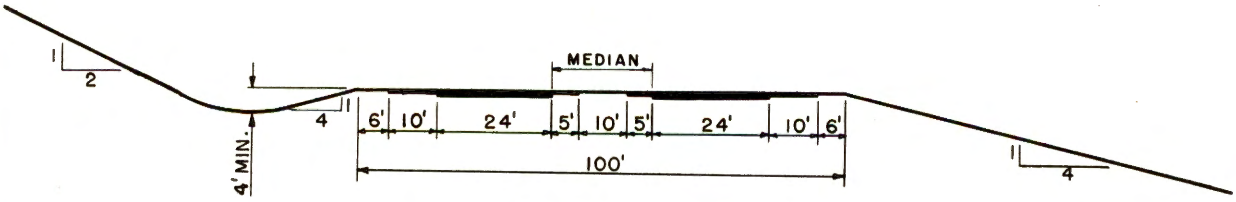

ESTIMATED COMPLETION SCHEDULE OF HIGHWAY ROUTES
PROJECT
1949
1950
1951
1952
1953
1954
1955
NEW JERSEY TURNPIKE
SCHEDULED OPENING
PENNSYLVANIA TURNPIKE - EASTERN EXTENSION
PENNSYLVANIA TURNPIKE - WESTERN EXTENSION
PENNSYLVANIA TURNPIKE - SOUTH OF PHILADELPHIA
CANNOT START UNTIL 2 YEARS AFTER OPENING W. EXTENSION
PENN. TURNPIKE CONNECTION - N.J. TURNPIKE, BORDENTOWN*
PHILADELPHIA EXPRESSWAY TO CITY LINE
PHILADELPHIA EXPRESSWAY CITY LINE TO CAMDEN BRIDGE**
DELAWARE MEMORIAL BRIDGE
CHESAPEAKE BAY BRIDGE
U. S. 301 TO CHESAPEAKE BAY BRIDGE
CHESAPEAKE BRIDGE TO QUEENSTOWN, MARYLAND**
QUEENSTOWN, MARYLAND TO U.S. 13 **
NEW YORK THRUWAY TO NEW JERSEY STATE LINE
PALISADES INTERSTATE PARKWAY IN NEW YORK
WILBUR CROSS PARKWAY AND CONNECTION TO MASS.
NEW HAMPSHIRE TURNPIKE
NEW JERSEY ROUTE 4 PARKWAY TO ROUTE 28
NEW JERSEY ROUTE 4 PARKWAY TO ROUTE 29
NEW JERSEY ROUTE 4 PARKWAY TO ESSEX COUNTY LINE
NEW JERSEY ROUTE 4 PARKWAY TO SPRINGFIELD AVENUE
CROSS BRONX EXPRESSWAY TO HUTCHINSON RIVER PKWY.
CROSS BRONX EXPRESSWAY TO WESTCHESTER CO. LINE
* ADDITIONAL LEGISLATION REQUIRED
** NOT YET SCHEDULED BY HIGHWAY DEPARTMENT

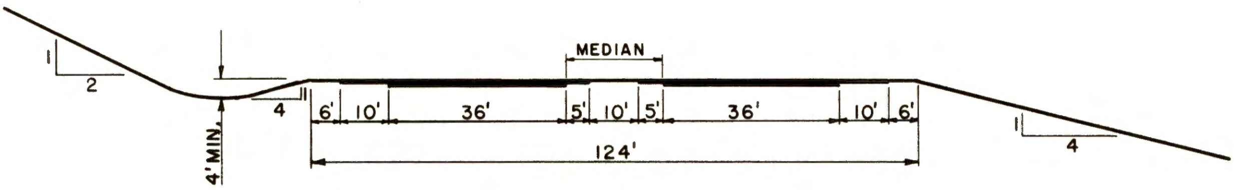
PLATE 5

TYPICAL BRIDGE CARRYING LOCAL TRAFFIC OVER TURNPIKE



NOTE:
SOUTH OF ROUTE 35 THE MEDIAN STRIP WILL BE
26 FEET WIDE

TYPICAL SECTION FOR 4 LANES



NOTE:
SLOPES FOR HIGH FILLS ARE 2:1

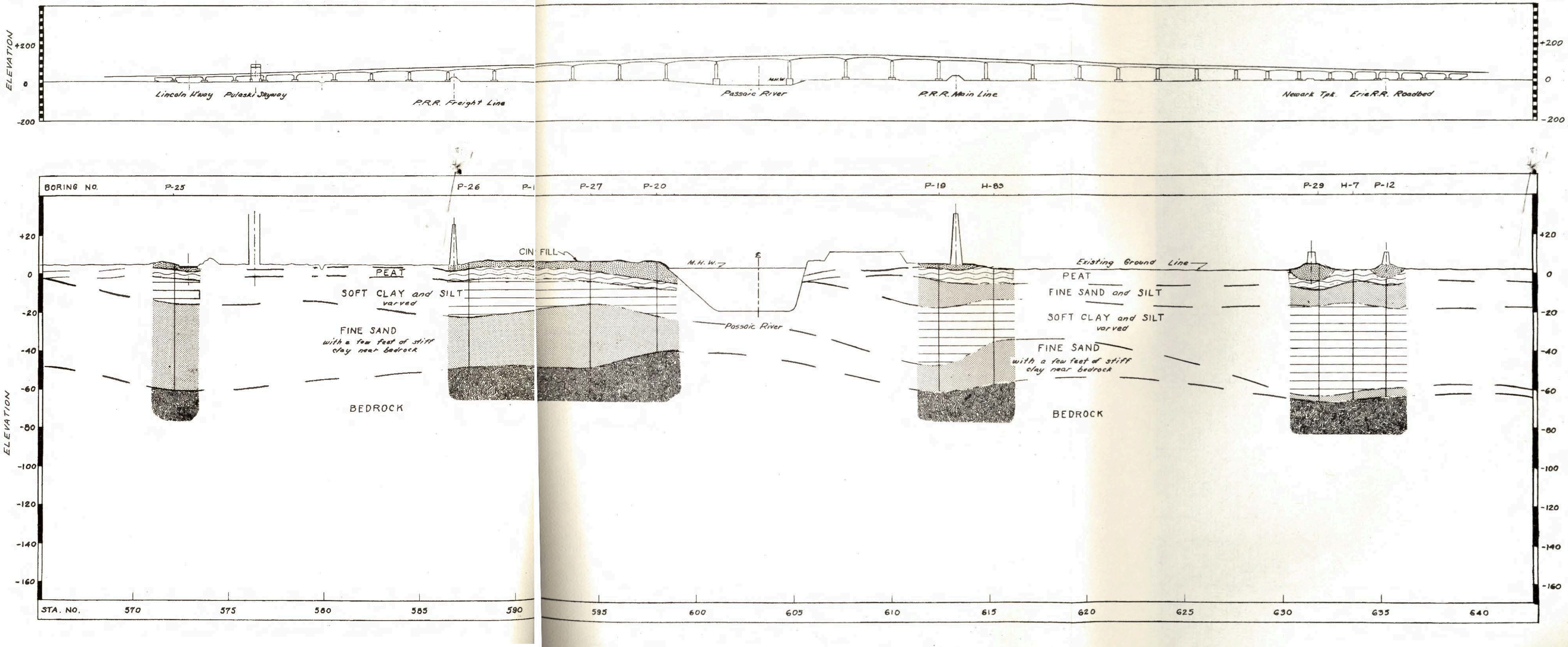
TYPICAL SECTION FOR 6 LANES

CROSS SECTIONS OF 4 AND 6 LANE PORTIONS OF THE TURNPIKE

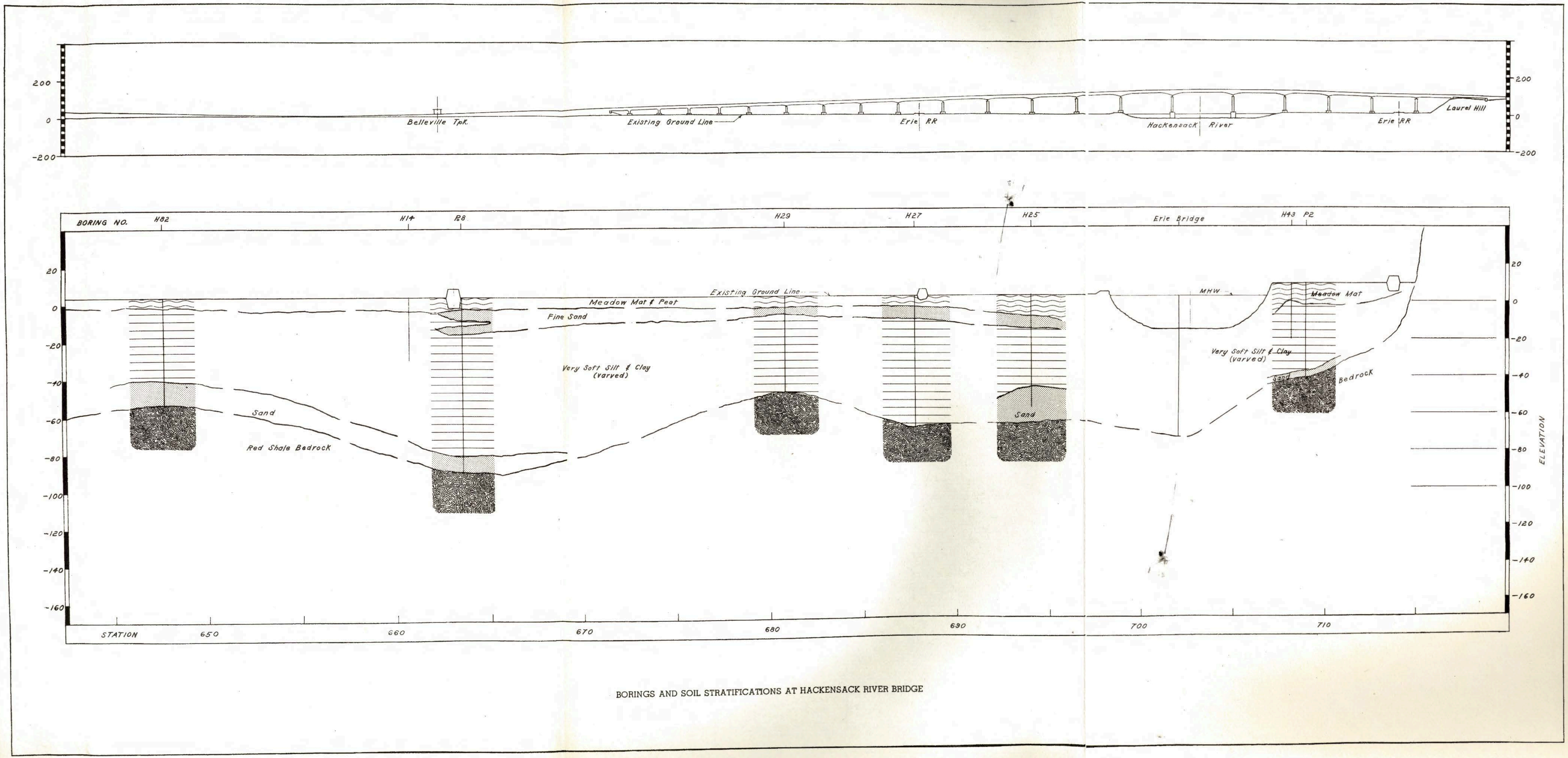
TOLL INTERCHANGE AT ROUTE 35

PLATE 7

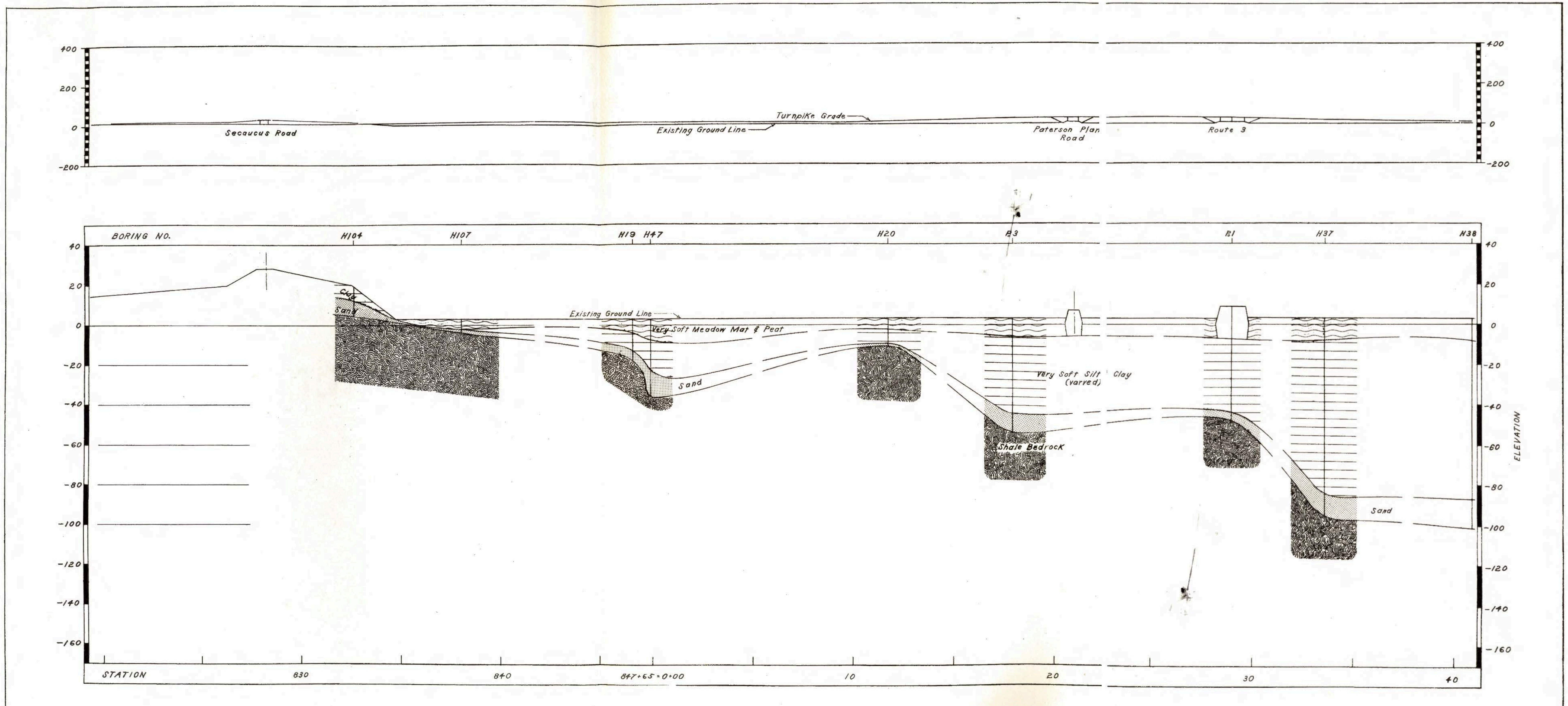
TOLL COLLECTION BOOTHS



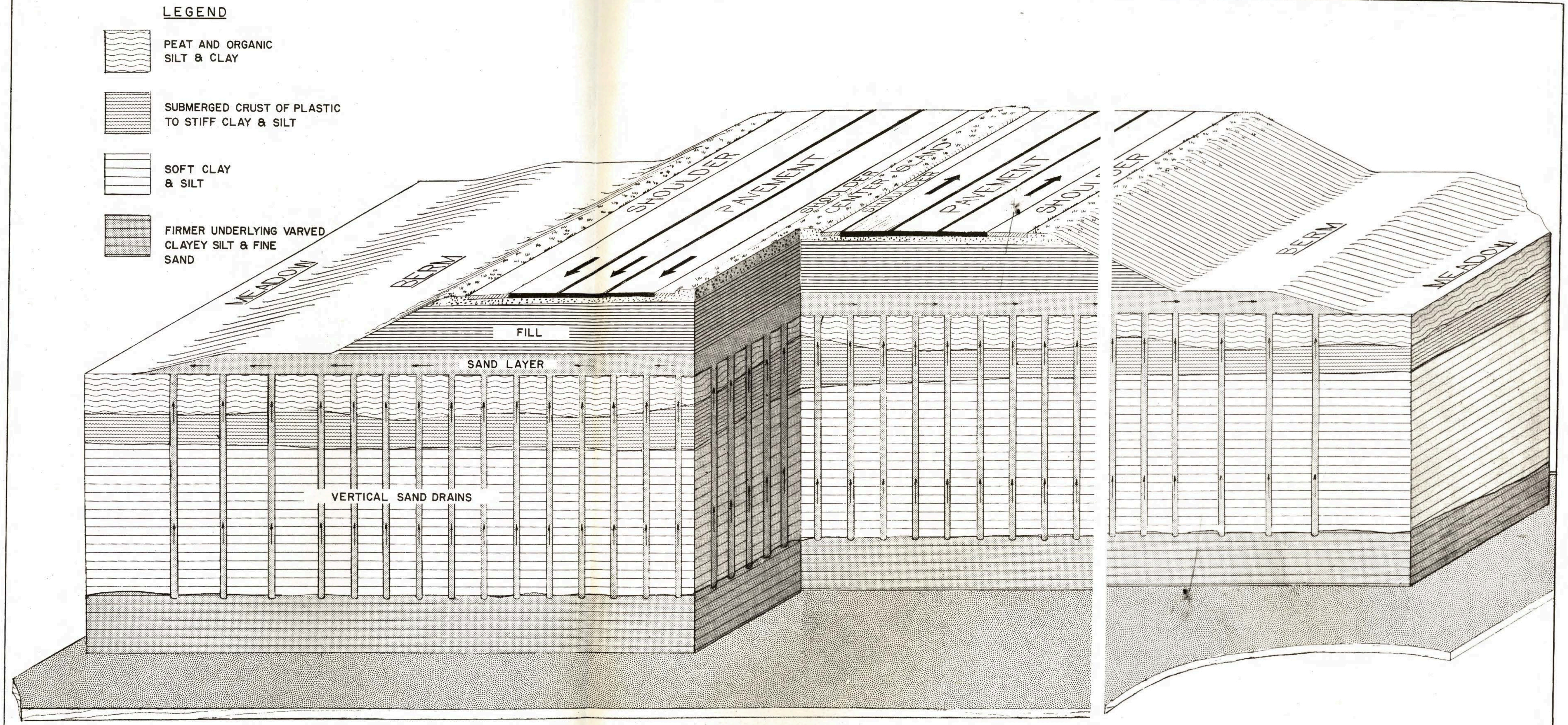
BORINGS AND SOIL STRATIFICATION AT PASSAIC RIVER BRIDGE



BORINGS AND SOIL STRATIFICATIONS AT HACKENSACK RIVER BRIDGE

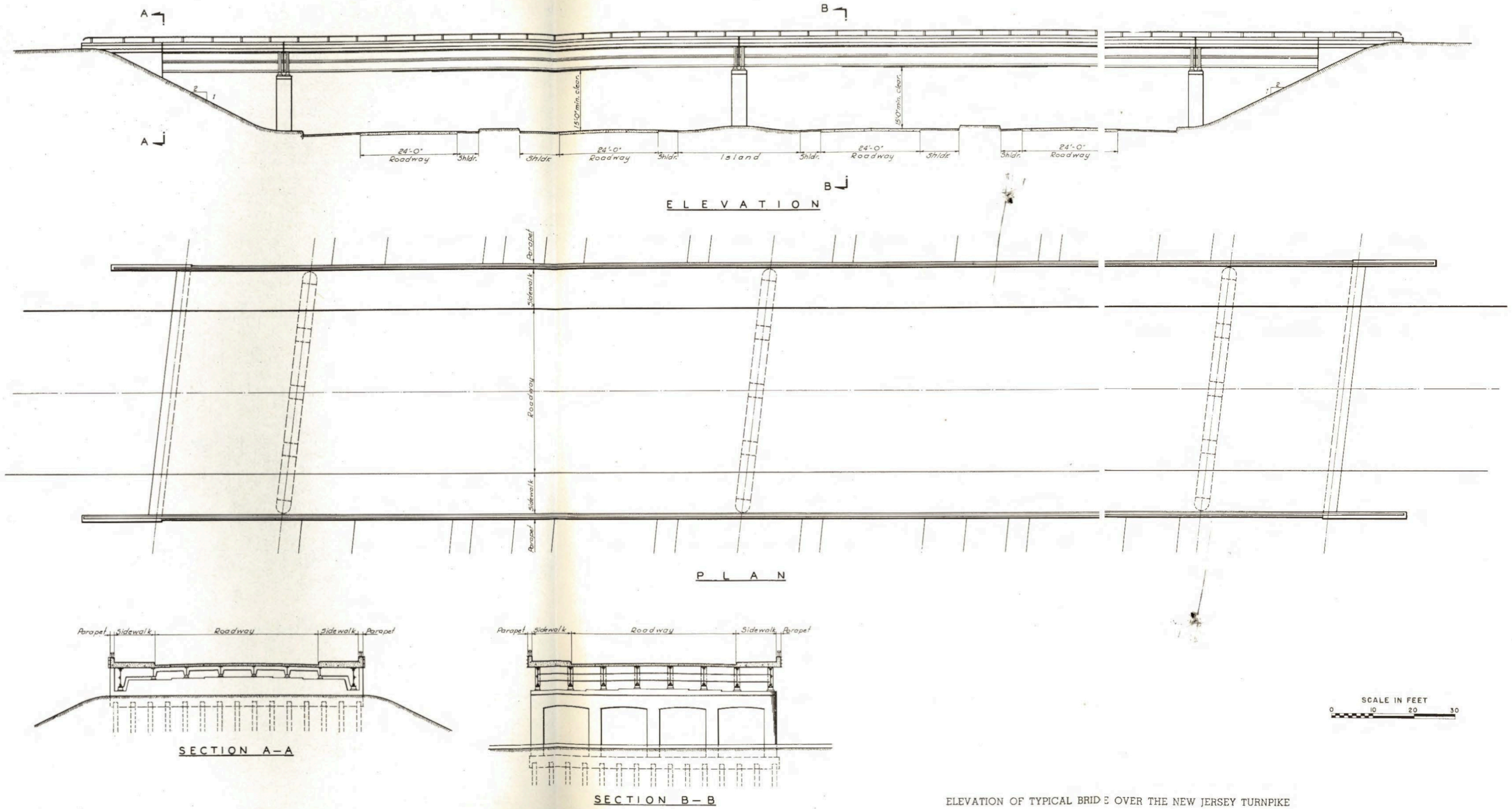


BORINGS AND SOIL STRATIFICATIONS AT SECAUCUS

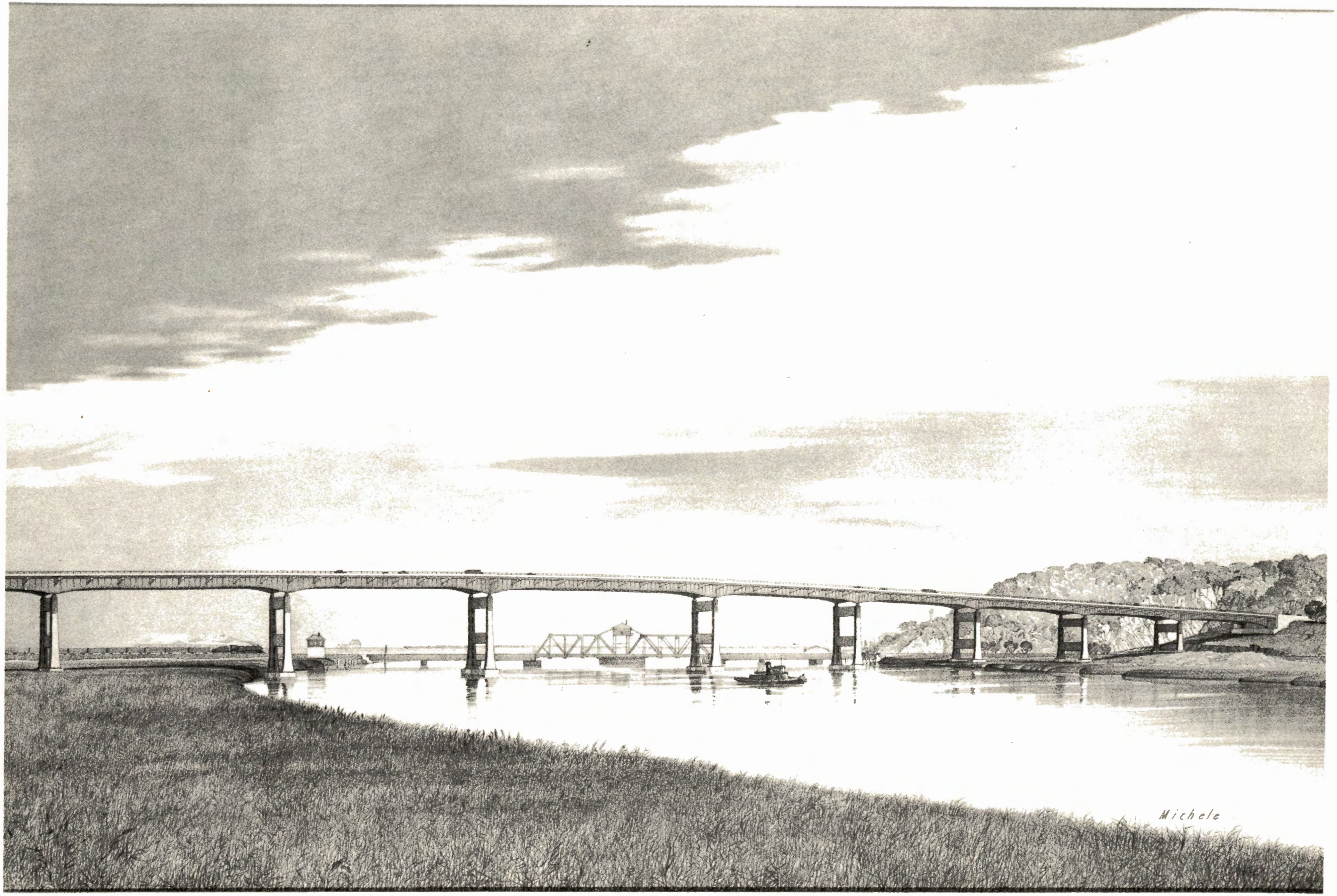


NOTE: ARROWS SHOW DIRECTION OF FLOW OF WATER TO AND FROM VERTICAL SAND DRAINS DURING FILLING AND OVERLOADING PERIOD.

CUTAWAY SECTION OF VERTICAL SAND DRAIN ABILIZATION BENEATH HEAVY FILLS



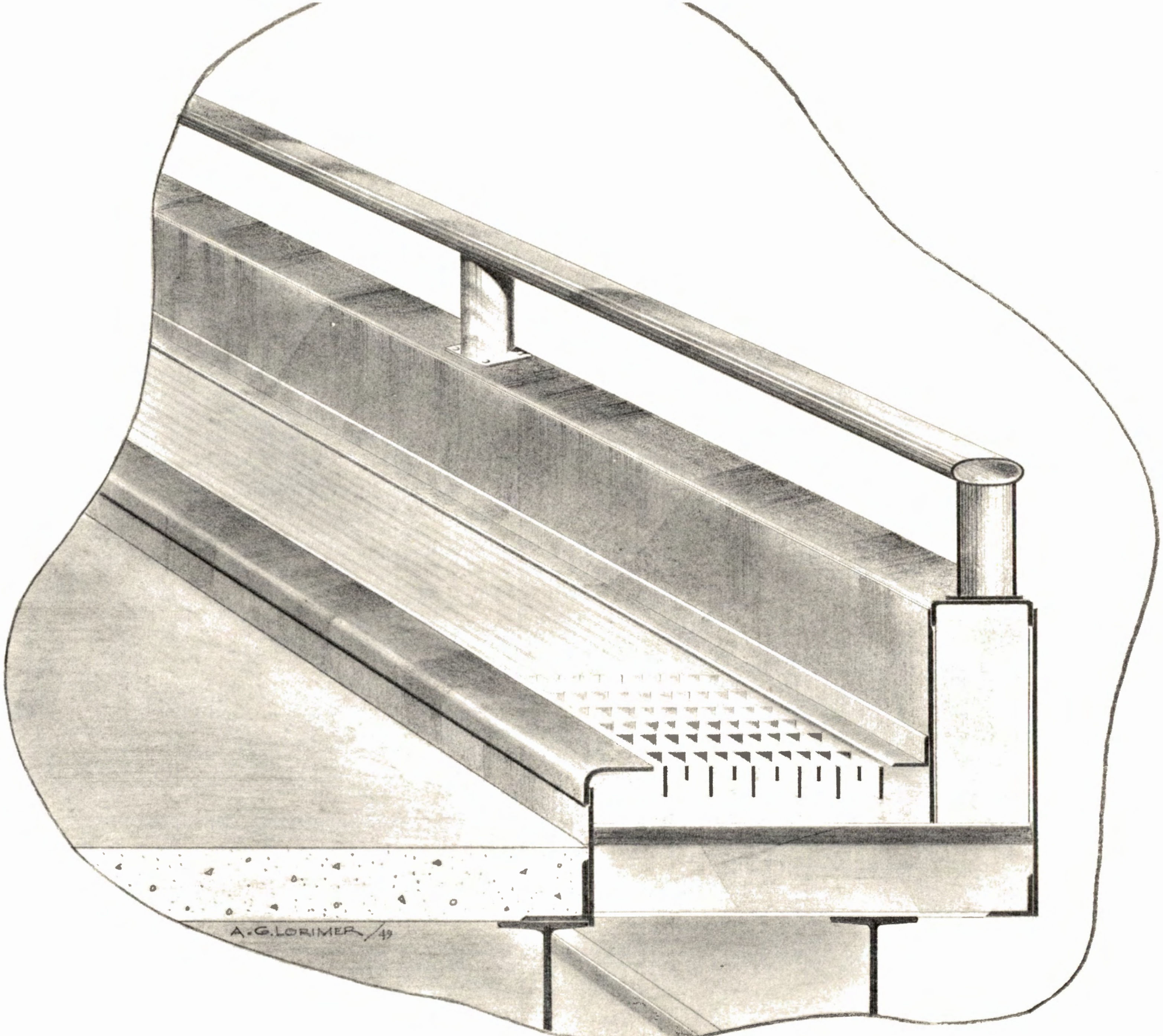
ELEVATION OF TYPICAL BRIDGE OVER THE NEW JERSEY TURNPIKE



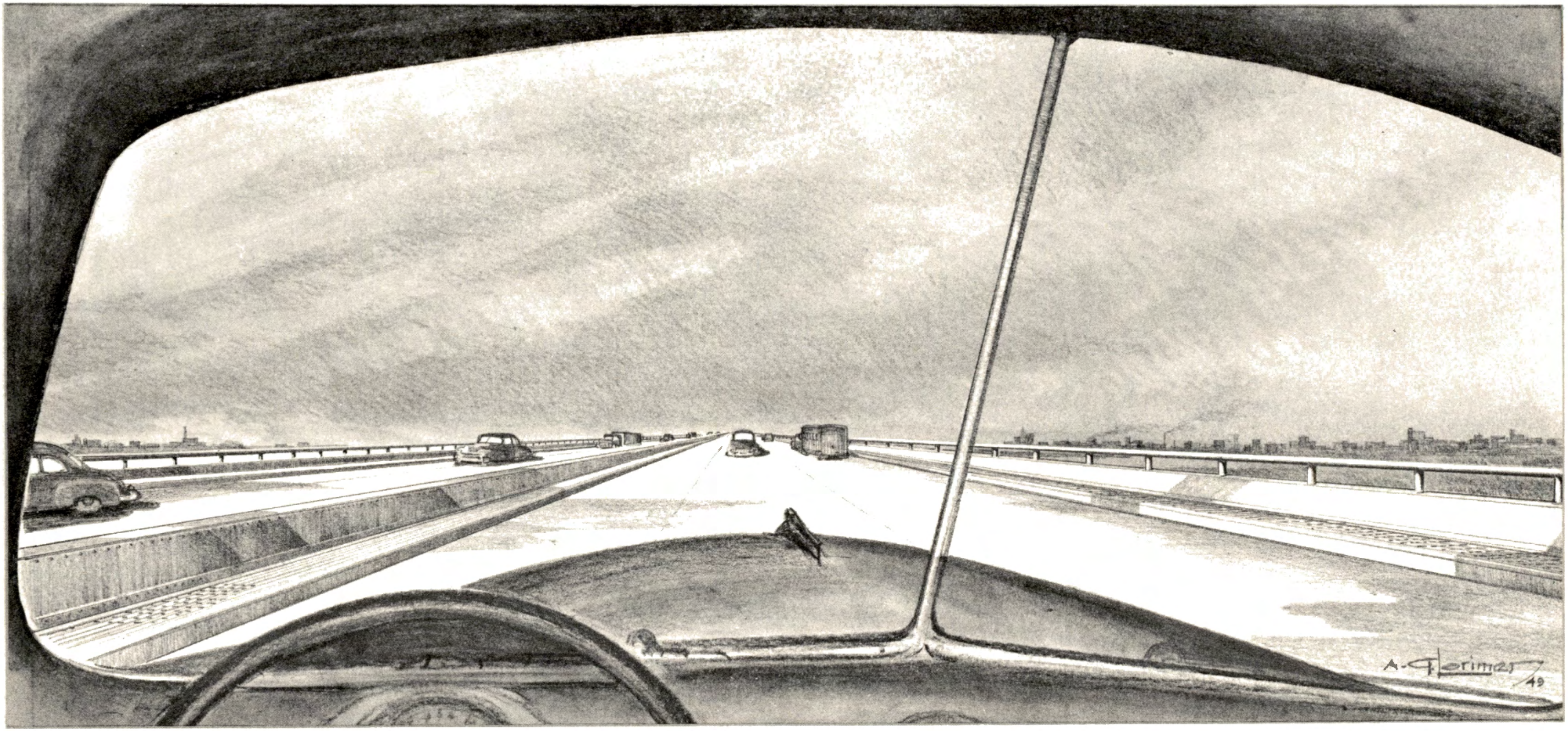
BRIDGE OVER HACKENSACK RIVER

PLATE 14

ELEVATION OF BRIDGE OVER PASSAIC RIVER

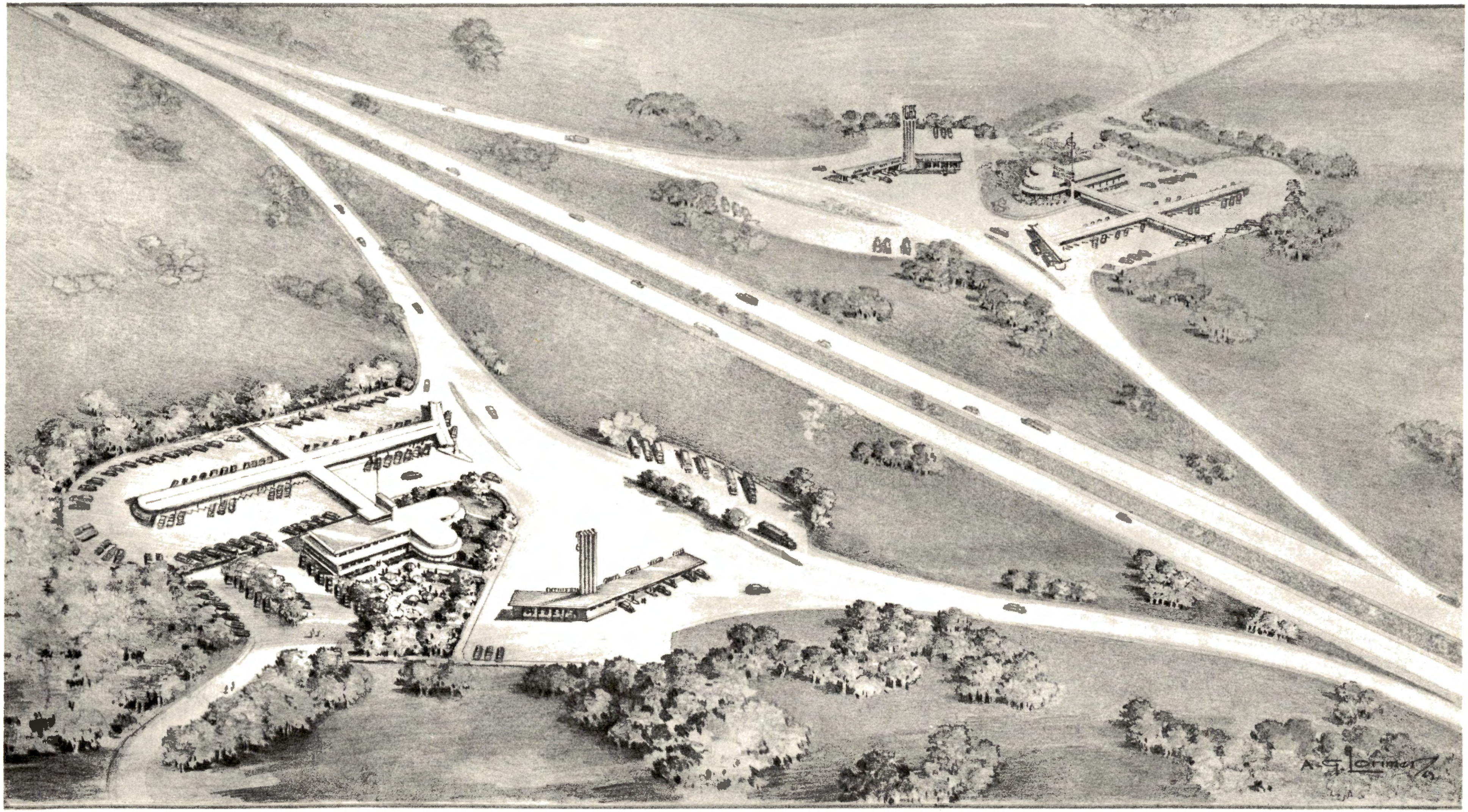


RAILING AND PARAPET FOR MAJOR BRIDGES



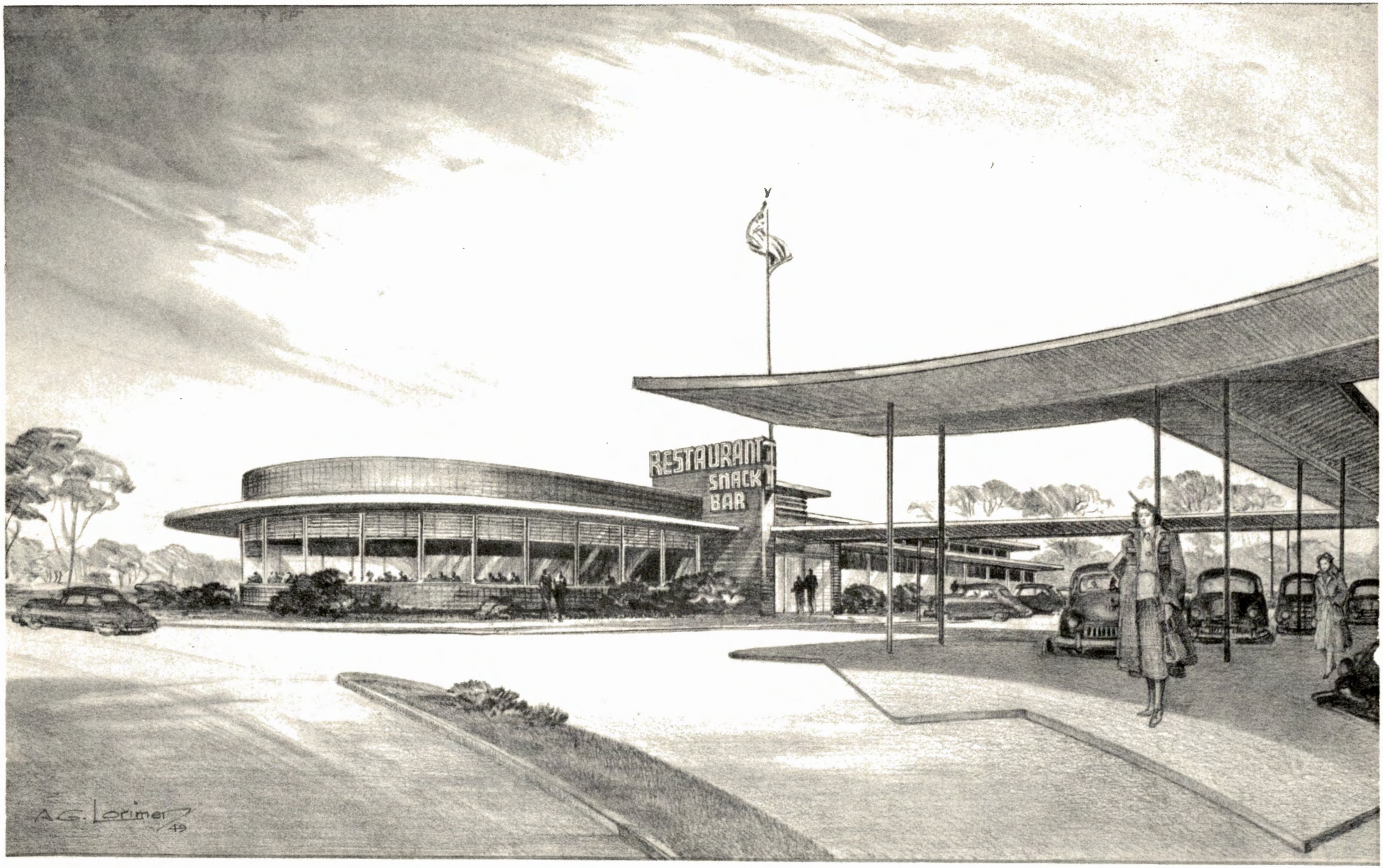
DRIVERS—EYE VIEW OF ROADWAY ON MAJOR BRIDGE

PLATE 17



AERIAL PERSPECTIVE OF RESTAURANT AND GAS STATION

PLATE 18



PERSPECTIVE OF RESTAURANT NEAR ROUTE 35

PLATE 19

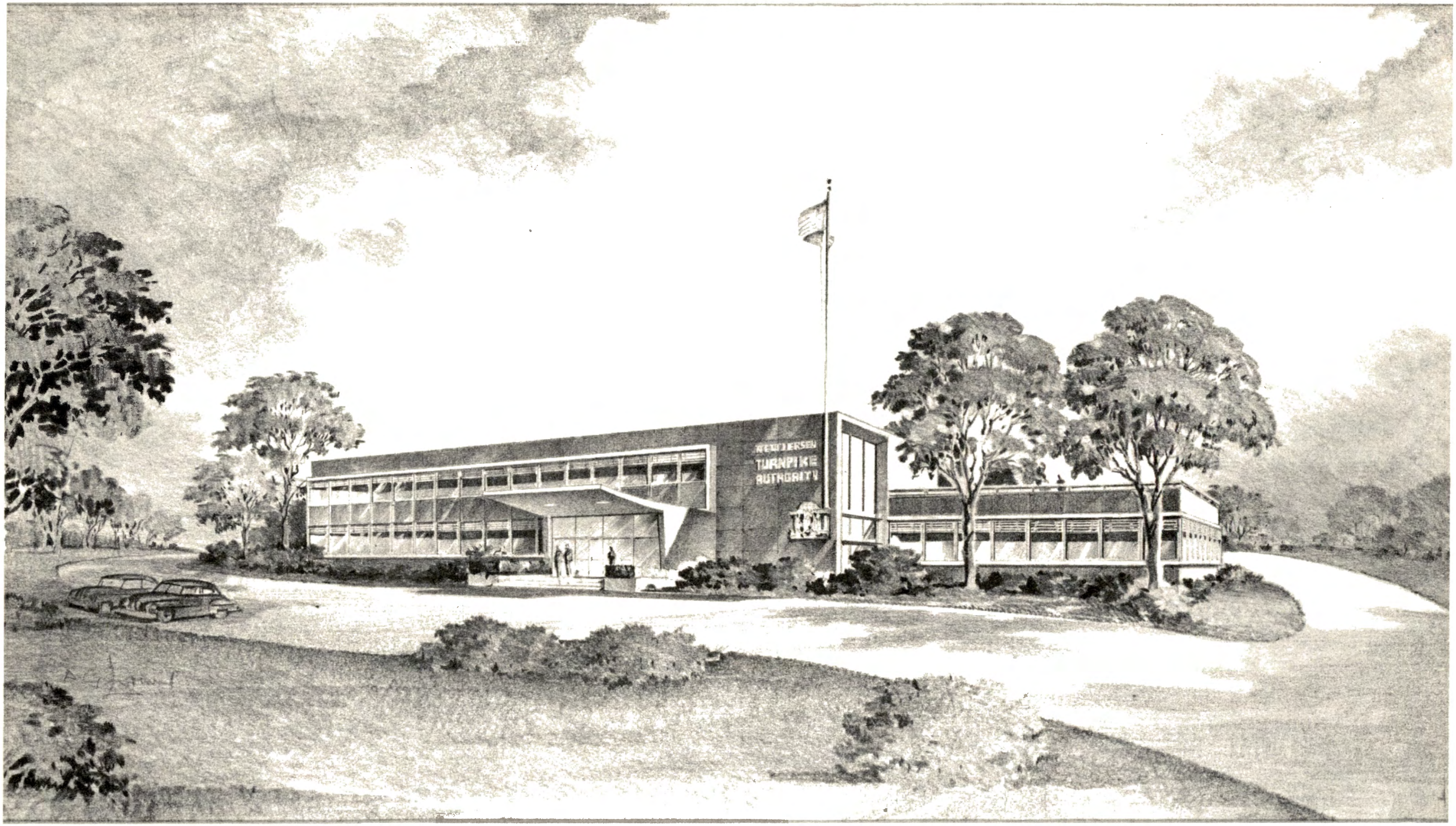


PLATE 20

ADMINISTRATION BUILDING AT ROUTE 35

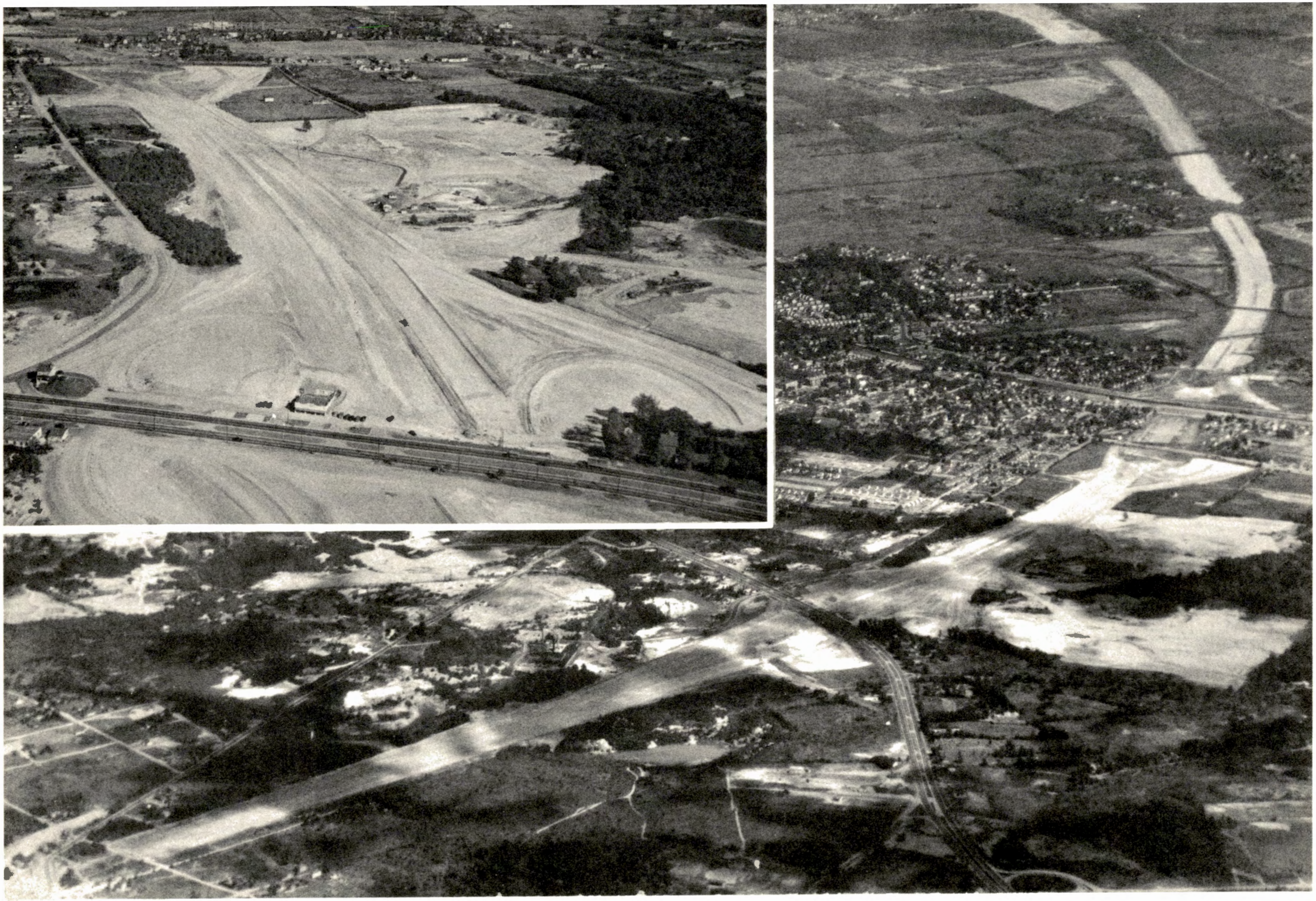
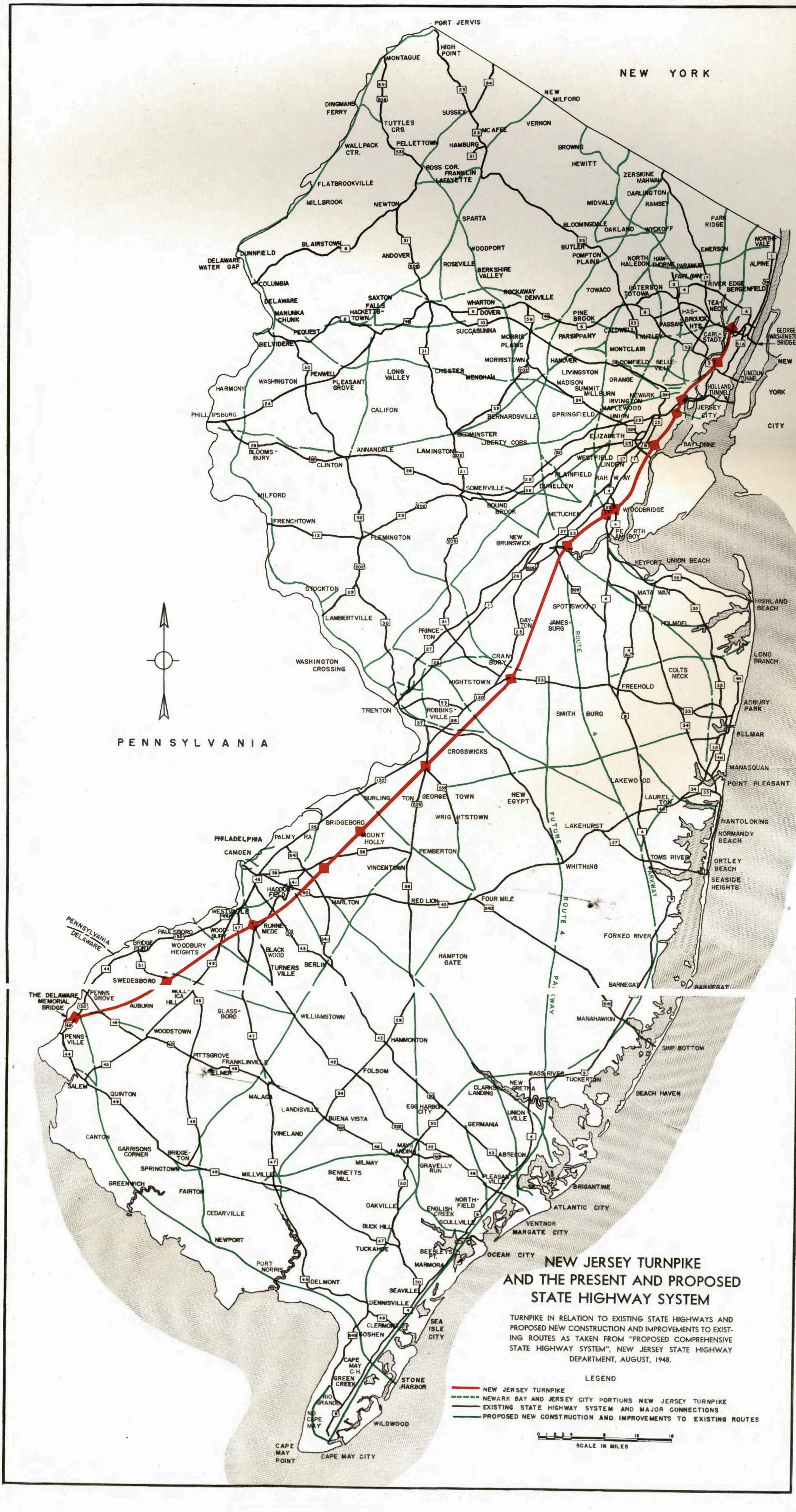


PLATE 21

AIR PHOTO OF 6.55 MILE SECTION OF TURNPIKE
Graded by New Jersey Highway Department from Route 4 Parkway to Morse's Creek.
Inset shows graded portion of Route 35 interchange in more detail.



NEW JERSEY TURNPIKE AND THE PRESENT AND PROPOSED STATE HIGHWAY SYSTEM

TURNPIKE IN RELATION TO EXISTING STATE HIGHWAYS AND PROPOSED NEW CONSTRUCTION AND IMPROVEMENTS TO EXISTING ROUTES AS TAKEN FROM "PROPOSED COMPREHENSIVE STATE HIGHWAY SYSTEM", NEW JERSEY STATE HIGHWAY DEPARTMENT, AUGUST, 1948.

PLATE 22