4.11 Soils and Geology

A. INTRODUCTION

Soils and geologic resources in the project area have been inventoried and evaluated relative to their physical characteristics and geotechnical capability to accommodate Build Alternative tunnels, structures, embankments and other project elements. For analysis purposes, an area extending approximately 200 to 250 feet from both sides of each affected rail line has been considered, although a more general geographic area has also been applied when discussing distribution and characteristics of major soil and rock units.

This section also describes future conditions with the No Build Alternative and potential long-term impacts of the Build Alternative. Potential impacts have been evaluated with respect to geologic structure and faults, seismicity, slope stability, and unique geologic features, based on available soils and geologic data.

B. EXISTING CONDITIONS

NEW JERSEY

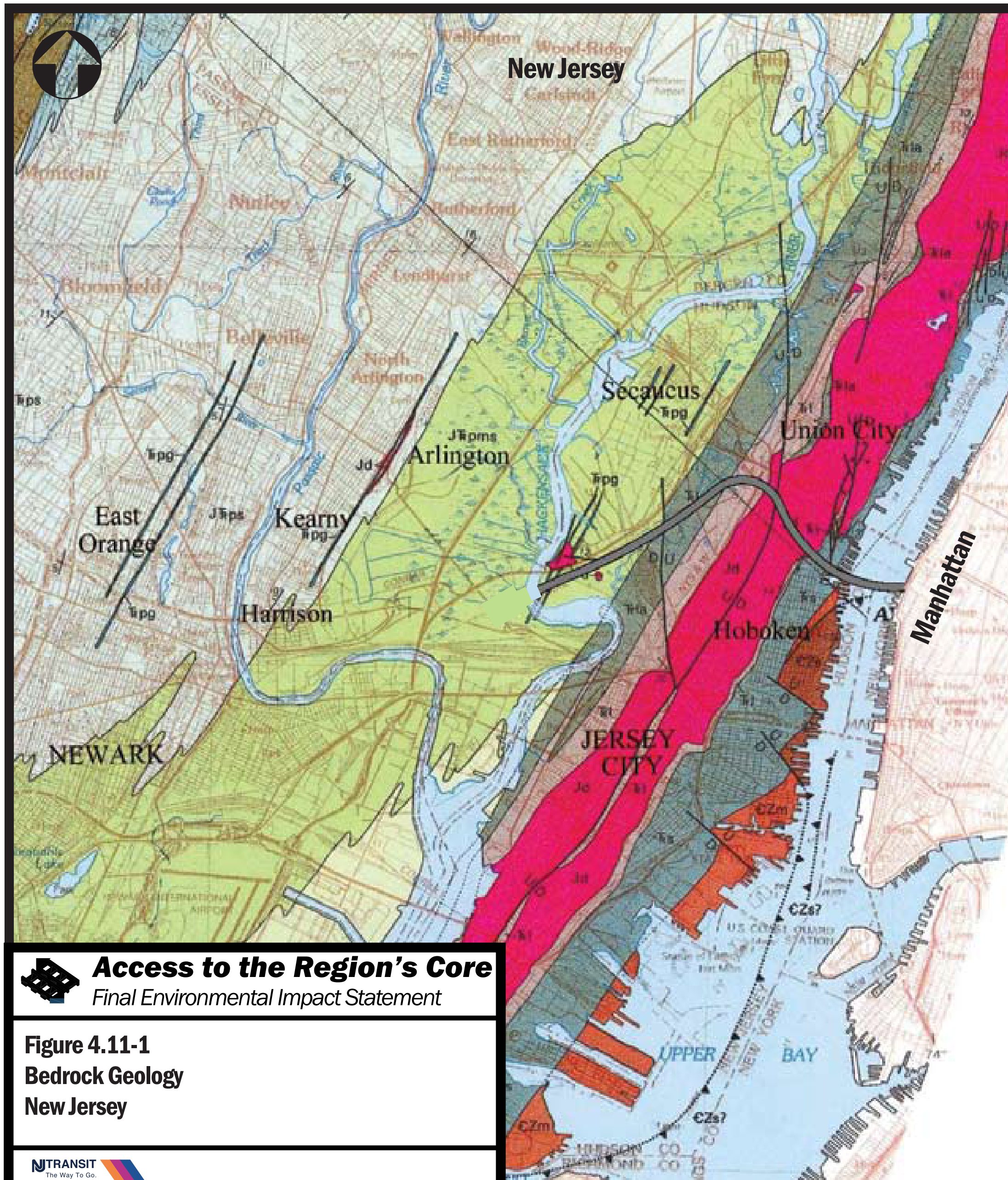
GEOLOGY

The New Jersey portion of the project area is located within the Piedmont physiographic province, a broad lowland interrupted by long, northeast-trending ridges and uplands. The most prominent physiographic feature in the eastern part of the province is the Palisades, a striking north-south topographic ridge near the Hudson River that rises above the surrounding lowlands of the Meadowlands.

As shown on the bedrock geologic map (see **Figure 4.11-1**), most of the project area is underlain by rocks of the Newark Basin, a northeast-trending Late Triassic-Early Jurassic rift basin filled with a thick sequence of sedimentary rocks and intrusive and extrusive igneous rocks (Drake et al., 1996). The topography of the bedrock surface shows two narrow, deep, glacially scoured troughs, one on either side of the NJ Meadowlands. Along the eastern margin of the Newark Basin, Triassic sedimentary rocks overlie the older metamorphic rocks of the Manhattan Prong.

Metamorphic rocks in the project area occur only along the Hudson River waterfront in Hoboken and Jersey City. Serpentinite is exposed along the Hudson River waterfront at Castle Point in Hoboken and is believed to extend south into Jersey City. The serpentinite is rich in naturally occurring asbestiform minerals.

Sedimentary rocks in the project area are stratigraphically within the Newark Group and include the Stockton, Lockatong, and Passaic Formations. The Stockton Formation is an arkosic sandstone forming the basal beds of the Newark Basin. It is mapped in a narrow band along the Hudson River. The Lockatong Formation consists of siltstones and argillite, and in the project area, also includes a unit of arkosic sandstone. It is mapped on either side of the Palisades ridge. The Passaic Formation is predominantly sandy mudstone and siltstone. It is the rock unit underlying the Hackensack and lower Passaic River basins.



Legend

Contact - Dotted where concealed. Queried where uncertain

Faults - Dotted where concealed. Queried where uncertain

Normal Fault - U, upthrown side; D, downthrown side

Reverse Fault - U, upthrown side; D, downthrown side

Fault - Movement sense not known

Inclined thrust fault - Teeth on upper plate

ARC Build Alternative

Diabase and granophyre (Early Jurassic)

Passaic Formation (Lower Jurassic and Upper Triassic)

Passaic Formation, sandy mudstone

Passaic Formation, sandstone

Passaic Formation, graybeds

Lockatong Formation (Upper Triassic)

Lockatong Formation, arkosic sandstone

Stockton Formation (Upper Triassic)

Manhattan Shist (Cambrian)

Serpentinite (Cambrian)

Not to Scale

Source: Drake, Avery Ala, Jr., Richard A. Volkert, Donald H. Monteverde, Gregory C. Herman, Hugh F. Houghton, Ronald A. Parker, and Richard Dalton, 1996. ***Bedrock Geologic Map of Northern New Jersey***, U.S. Geological Survey, Miscellaneous Investigations Series, Map I 2540-A.

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Figure 4.11-1
Bedrock Geology
New Jersey

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The igneous rock unit in the project area is the Palisades diabase. It is the dense, resistant rock that underlies the topographically prominent Palisades ridge along the Hudson River, as well as Laurel Hill and Little Snake Hill near the Hackensack River. The Lockatong Formation was locally thermally metamorphosed where intruded by the Palisades diabase sill.

Several faults have been mapped, most of which are steeply dipping and strike north of northeast (Drake et al., 1996; Baskerville, 1994). A major fault with a mapped trace length of about 14 miles, predominantly within the diabase and parallel to its contact with the sedimentary rocks on either side, extends from near the Kill Van Kull north to near Bellmans Creek. Kings Bluff, the section of the Palisades ridge in Weehawken immediately east of the Lincoln Tunnel approach helix, is a diabase fault block, bounded by north-striking faults about two miles long. A 2.5-mile-long mapped fault in North Bergen parallels the Kings Bluff fault. In Hoboken, the serpentinite is believed to be in thrust fault contact with the Manhattan Schist along a 1.5-mile-long, northeast-striking fault trace that extends beneath the Hudson River. Two additional faults, each striking northwest and less than one-mile-long, are mapped within the metamorphic and sedimentary rocks in the project area near the Hoboken-Jersey City waterfront. In Secaucus, two faults, each less than one-mile-long, have been mapped at Laurel Hill and nearby in Jersey City. A north-striking fault about four-miles-long has been mapped near the Croxton rail yard.

The NEC is located in a moderately active seismic area subject to strong shaking from infrequent earthquakes. According to the U.S. Geologic Survey National Seismic Hazard Map of New Jersey, the New Jersey portion of the project area is susceptible to a peak acceleration of 0.2g with a two percent probability of exceedance in 50 years (USGS, 2004a). Most of the project area is relatively flat and low lying, with no potentially unstable slopes sensitive to disturbance. The strength and near-vertical columnar jointing of the Palisades have allowed development of steep natural slope faces, but both natural and cut faces in the diabase are susceptible to rock falls.

SOILS

Thickness of surficial materials in the project area ranges from less than a few feet, in areas of rock outcrops at the Palisades and Laurel Hill, to greater than 150 feet at a glacially eroded bedrock trough in the vicinity of North Bergen. As shown on **Figure 4.11-2**, surficial materials consist of deposits of glacial, eolian, alluvial, and marsh/estuarine origin (Stone, Stanford, and Witte, 2002). Weathered bedrock is present beneath the surficial deposits in some portions of the project area.

The Rahway till is the surficial unit directly overlying bedrock. Its mapped exposures are in the vicinity of Secaucus and along the Palisades. It is a nonstratified, compact deposit generally less than 30 feet thick. Overlying the till are deposits of glacial Lake Hackensack and Lake Bayonne, which are in turn overlain by post-glacial tidal marsh, estuarine, and terrace deposits. A large percentage of soils in the project area have been altered by excavation or filling for residential, commercial or industrial purposes. Earth and manmade materials that have been placed as fill include gravel, sand, silt, clay, trash, cinders, ash, and construction debris. Along the Hudson River shoreline in Hoboken, large land areas were reclaimed by filling tidal marsh and other low-lying areas with a variety of materials, including shotrock from tunnel construction, construction debris, clean granular fill, cinders, ash, and garbage.

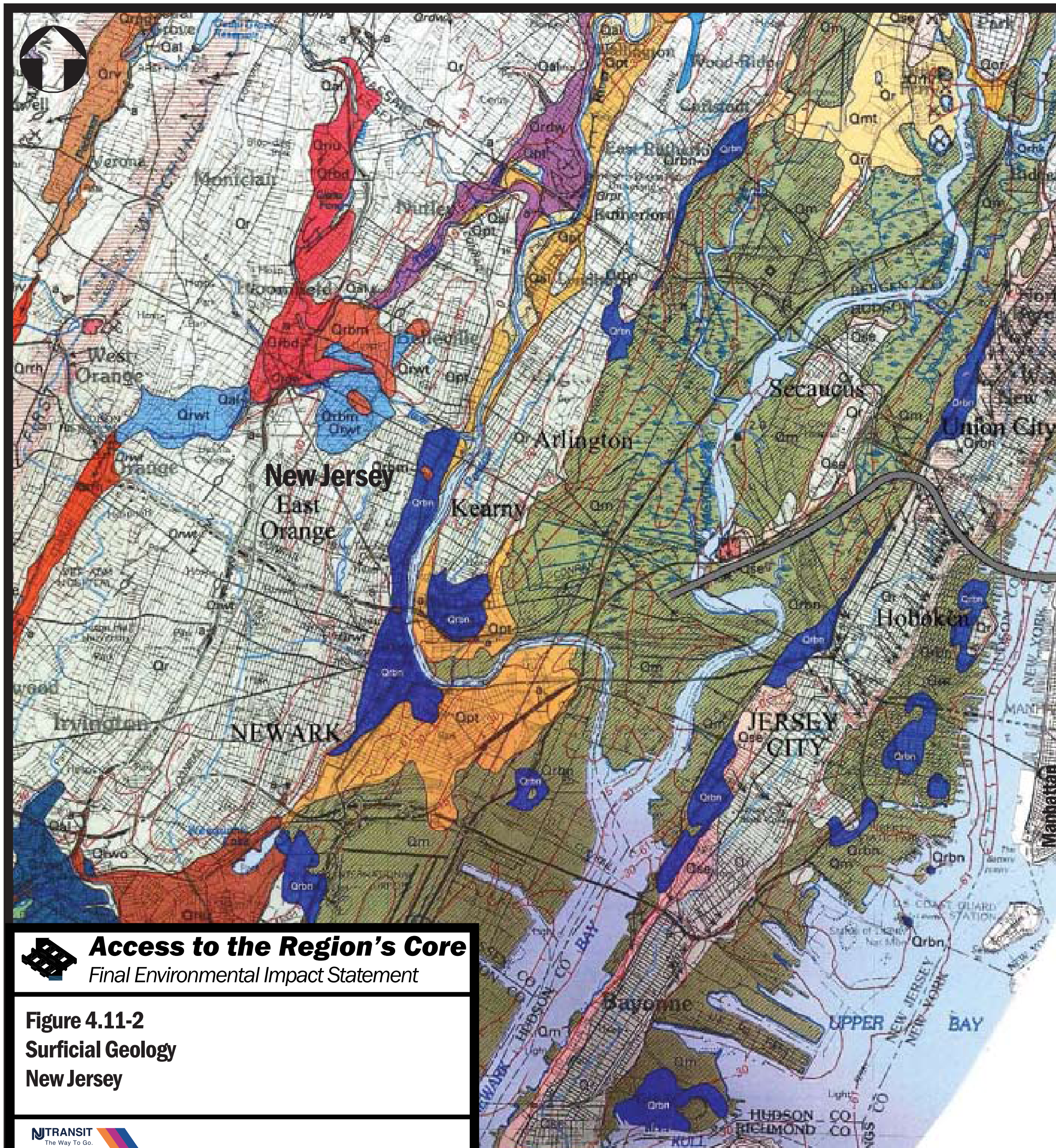

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Figure 4.11-2
Surficial Geology
New Jersey

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Legend

Contact - Accurately located, except approximately located where surface is poorly exposed or where boundary between units is gradational.

Glacial Striations and Grooves - Scratches and grooves on bedrock that ice-flow direction, observation at tip of arrow.

30 Bedrock Surface contours (selected) - Show Altitude, in meters, relative to sea level, of the surface of bedrock or coastal plain sediments. Hachured contours represent depressions in the bedrock surface.

ARC Build Alternative

- Artificial Fill
- Qm Tidal Marsh & Estuarine Deposits
- Qmt Moonachie Terrace Deposits
- Qpt Passaic Terrace Deposits
- Qse Eolian Deposits
- Qrbd Brookdale Terrace Deposits
- Qrwt Glacial Lake Watsessing Deposits
- Qrbn Glacial Lake Bayonne Deposits
- Qrdw Delawanna Deposits
- Qrbm Bloomfield Deposits
- Qrv Verona Deposits
- Qrez Elizabeth Deposits
- Qr Rahway Till

Not to Scale

Source: Stone, Byron D., Scott D. Stanford, and Ron W. Witte, 2002. Surficial Geologic Map Northern New Jersey, U.S. Geological Survey, Miscellaneous Investigations Series, Map I-2540-C.

HUDSON RIVER

GEOLOGY

The Hudson River portion of the project area is located between the Piedmont physiographic province on the west and the Manhattan Prong of the New England Upland physiographic province on the east. The Hudson River estuary system has a channel morphology that reflects the three navigational channels maintained by USACE: a central channel 45 feet deep from Upper New York Harbor to West 59th Street; a New York channel 40 feet deep through the length of the project area; and a New Jersey channel along the Weehawken-Edgewater waterfront 40 feet deep south of Weehawken and 30 feet deep north of Weehawken.

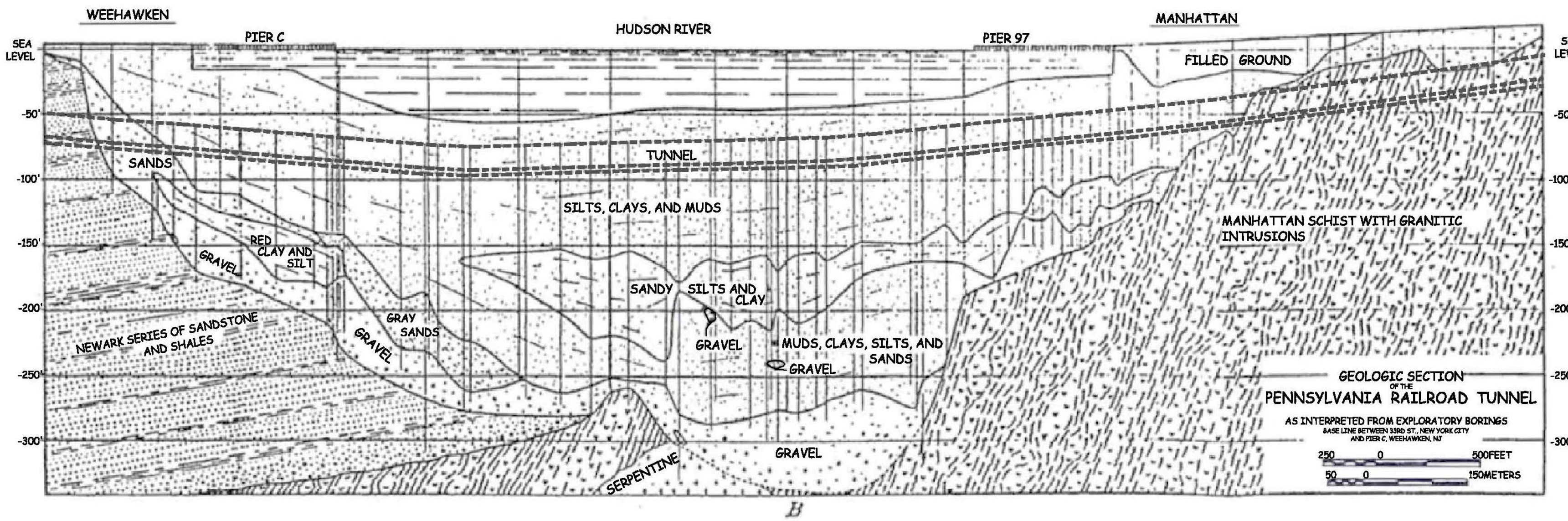
The topography of bedrock surface underlying the Hudson River shows a narrow, deep, glacially scoured trough that extends to more than 300 feet below sea level (Coch and Weiss, 1989; Stanford, 1993; 1996). The elevation of the bottom of the bedrock trough generally rises downstream toward Upper New York Harbor. Depth to rock is about 150 feet below mean low water at the New York bulkhead line at West 28th Street in Manhattan, and about 60 feet below mean low water at the New Jersey bulkhead line in Hoboken. Based on exploratory borings drilled in 1904 for the Pennsylvania Railroad Tunnel, the maximum depth of the bedrock trough along the existing Pennsylvania Railroad Tunnel alignment is at a point about 1,500 feet west of the Manhattan bulkhead line (see **Figure 4.11-3**).

The eastern part of the Hudson River channel is underlain by metamorphic rocks of the Manhattan Prong, primarily schist. Serpentinite is present about mid-channel. Schist is present west of mid-channel near the southern limit of the project area and extends south to the Hoboken-Jersey City waterfront. The western part of the Hudson River channel is underlain by northwest-dipping sedimentary rocks of the Stockton Formation of the Newark Group, which overlie the much older metamorphic rocks of the Manhattan Prong.

Similar to adjacent areas in New York and New Jersey, the Hudson River portion of the project area is located in a moderately active seismic area subject to strong shaking from infrequent earthquakes. According to the U.S. Geologic Survey National Seismic Hazard Map of New York, this portion of the project area is susceptible to a peak acceleration of 0.2g, with a two percent probability of exceedance in 50 years (USGS, 2004a; 2004b).

SOILS

Based on borings drilled for the Pennsylvania Railroad for construction of the existing North River Tunnels (circa 1906), the maximum thickness of surficial materials overlying bedrock of the Hudson River in the project area is about 300 feet, with a complex stratigraphy of glacial, fluvial, lacustrine, and estuarine deposits (see **Figure 4.11-3**). The uppermost surficial material in the Hudson River through much of the project area is a thick sequence of post-glacial estuarine deposits of gray, organic silty clay and clayey silt with traces of fine sand and shells (Coch and Weiss, 1989; Stanford, 1993; 1996; Stanford and Harper, 1991).



Source: Sanborn, James F., 1950. "Engineering Geology in the Design and Construction of Tunnels," in *Application of Geology to Engineering Practice (Berkey Volume)*, Sidney Paige, Chairman, Geological Society of America, New York, pp. 45-81.

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Figure 4.11-3

Cross Section of the Hudson Valley at the Pennsylvania Railroad Tunnel (Circa 1906)

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NEW YORK

GEOLOGY

The New York portion of the project area is located within the Manhattan Prong of the New England Upland physiographic province. As shown on **Figure 4.11-4**, most of the area is underlain by schist of the Hartland Formation. A granitic intrusion has been mapped between Ninth and Twelfth Avenues between West 31st Street and West 40th Street. Serpentinite has been reported between Tenth and Eleventh Avenues at the northern part of the project area, and at scattered locations as far south as West 26th Street. The serpentinite is believed to contain naturally occurring asbestiform minerals, which if disturbed, could pose potential inhalation hazards during construction. Measures to protect workers, as well as to minimize any environmental hazardous associated with spoils removal are further described in Section 5.12.

The project area is located in a moderately active seismic zone subject to strong shaking from infrequent earthquakes. According to the U.S. Geologic Survey National Seismic Hazard Map of New York, the project area is susceptible to a peak acceleration of 0.2g, with a two percent probability of exceedance in 50 years (USGS, 2004b).

SOILS

Thickness of surficial materials is variable, but is generally less than 50 feet, except for filled areas adjacent to the Hudson River where the rock surface drops off steeply (Baskerville, 1994). Most of the surface soils have been altered by excavation, filling, or paving for residential, commercial, or industrial purposes.

Historical records indicate that areas along the Hudson River extend beyond the original mid-19th Century shoreline. Filled for urban development, these areas are typically former bays or tidal marshes with organic deposits beneath the fill. The entire length of the Hudson River waterfront in the project area is reclaimed, except for a section from about West 44th Street to West 52nd Street. The original western Manhattan shoreline extended inland as far as Tenth Avenue at West 24th Street.

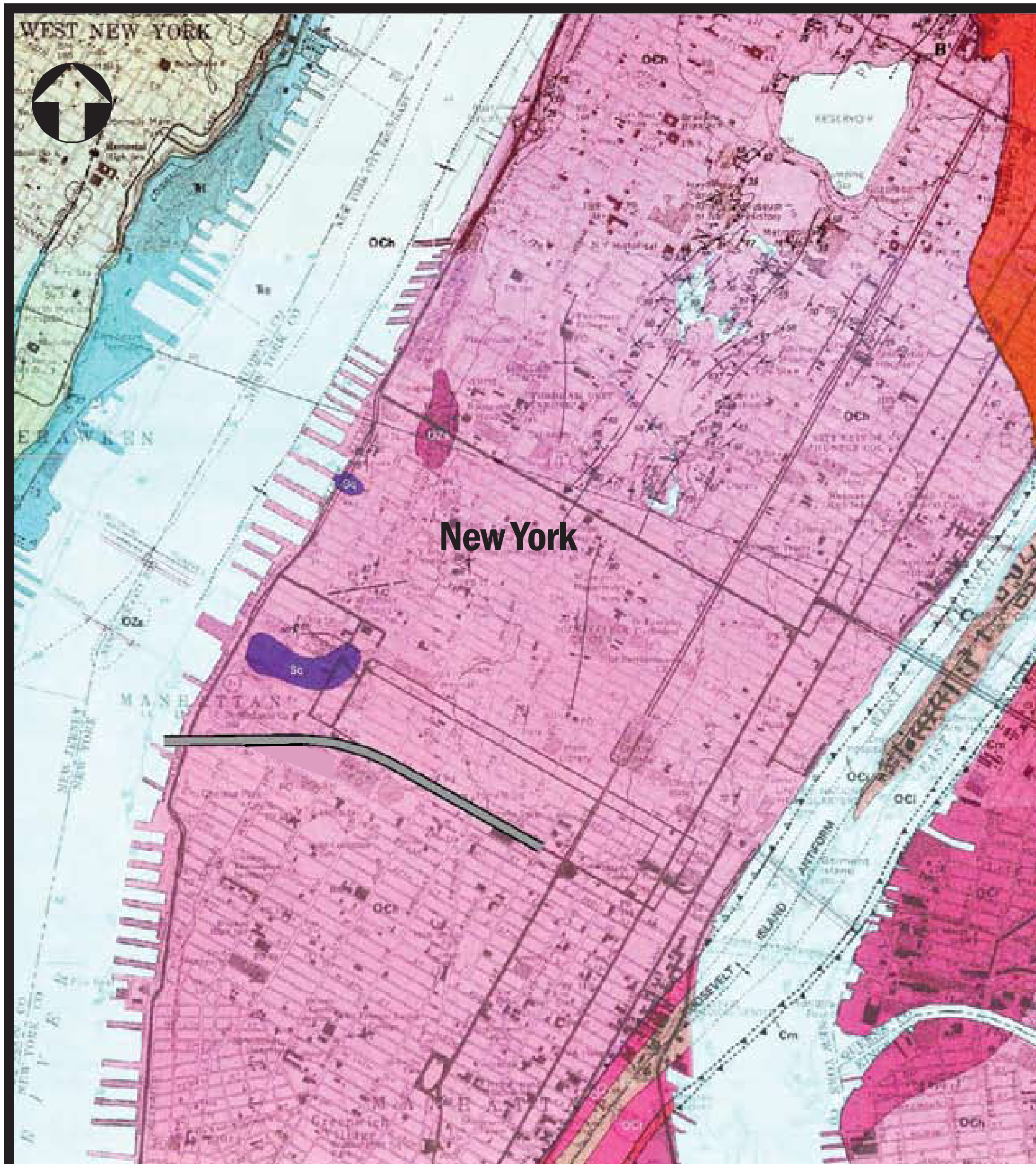
C. FUTURE NO BUILD CONDITIONS

NEW JERSEY

Maintenance and development activities for existing and proposed facilities, such as site excavation, site clearing, and landscaping, within and surrounding the project area would be expected to continue, and would create changes in the built environment, but would not adversely impact soils and geologic conditions within which the Build Alternative would be constructed. Normal geologic processes, such as erosion and sedimentation, would also continue. No specific impacts with respect to soils or geology would be anticipated.

HUDSON RIVER

Maintenance activities, such as dredging within the Hudson River, would be expected to continue, but would not adversely impact soils and geologic conditions within which the Build Alternative would be constructed. Normal geologic processes, such as erosion and sedimentation, would also continue. No specific impacts with respect to soils or geology would be anticipated.



Legend

- Contact
- Fault
- Thrust Fault
- Overturned Thurst Fault
- Thrust Fault Coincident in Map View
- Antiform
- Synform
- Uncertain Axial Trace
- ARC Build Alternative

Sg	Granite and Pegmatite (Silurian)
OCr	Ravenswood Granodiorite (Middle Ordovician to Middle Cambrian)
OCh	Hartland Formation (Middle Ordovician to Lower Cambrian)
OCi	Inwood Marble (Lower Ordovician to Lower Cambrian)
OZs	Serpentinite (Lower Ordovician to Upper Proterozoic)
Cm	Manhattan Schist (Lower Cambrian)
Yfb	Fordham Gneiss, Member B (Middle Proterozoic)

Not to Scale

Sources:

Baskerville, Charles A., 1992. Bedrock and Engineering Geologic Maps of Bronx County and Parts of New York and Queens Counties, New York, U.S. Geological Survey Miscellaneous Investigations Series Map I-2003.

Baskerville, Charles A., 1994. Bedrock and Engineering Geologic Maps of New York County and Parts Kings and Queen Counties, New York, and Parts of Bergen and Hudson Counties, New York, U.S. Geological Survey, Miscellaneous Investigations SeriesNot Map I-2306.

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Figure 4.11-4
Bedrock Geology
New York

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NEW YORK

Maintenance and development activities for existing and proposed facilities, such as site excavation, site clearing, and landscaping, within and surrounding the project area would be expected to continue and would create changes in the built environment, but would not adversely impact soils and geologic conditions within which the Build Alternative would be constructed. Normal geologic processes, such as erosion and sedimentation, would also continue. No specific impacts with respect to soils or geology would be anticipated.

D. LONG-TERM IMPACTS OF THE BUILD ALTERNATIVE

NEW JERSEY

Soil and rock affected by the Build Alternative would be excavated and disturbed during construction. Once the Build Alternative is operational, no further potential long-term impacts to the underlying bedrock geology or soils would be expected as a result of either the proposed Build Alternative track improvements or new tunnels beneath the Palisades and Hoboken. No long-term changes would be expected to geologic structures or faults, to bedrock, soils, or geologic stability, to seismicity, or to the rock and soil units surrounding excavations.

HUDSON RIVER

Soil and rock affected by the Build Alternative would be excavated and disturbed during construction. Once the Build Alternative is operational, no further potential long-term impacts to soils and geology would be anticipated due to the Build Alternative tunnels. No long-term changes would be expected to geologic structures or faults, to bedrock, soils, or geologic stability, to seismicity, or to the rock and soil units surrounding excavations.

NEW YORK

Soil and rock affected by the Build Alternative would be excavated and disturbed during construction. Once the Build Alternative is operational, no further potential long-term impacts to soils and geology would be anticipated due to the Build Alternative tunnels and station structures. No long-term changes would be expected to geologic structures or faults, to bedrock, soils, or geologic stability, to seismicity, or to the rock and soil units surrounding excavations.

E. MITIGATION

No long-term adverse impacts to soils and geology would occur with the Build Alternative; therefore, no mitigation will be required.