Chapter 14: Soils and Geology

14.1 INTRODUCTION

The types of soils and geologic conditions, as well as the potential for seismic activity at a project site, need to be accounted for as part of the design for a proposed action. Potential construction considerations with respect to geologic structure and faults, seismicity, slope stability, and unique geologic features, are identified based on available soils and geologic data. This information informs the engineering design for structural foundations, and helps with estimates of the amount of materials to be excavated, and identification of any dewatering needs during construction. This chapter describes the analysis FRA conducted of the potential effects of the No Action Alternative and the Preferred Alternative on soils and geologic conditions, as well as the potential for seismic activity in the area, which the Project Sponsor would need to account for as part of the design of the Preferred Alternative. These analyses also describe potential impacts of the Preferred Alternative following construction. FRA has evaluated potential impacts with respect to geologic structure and faults, seismicity, slope stability, and unique geologic features, based on available soils and geologic data.

14.2 REGULATORY CONTEXT

There are no relevant Federal or state regulations or executive orders for evaluating impacts to geologic resources or soils. However, a geotechnical evaluation of geologic resources, including soil borings and collections to determine appropriate foundations for the Preferred Alternative is required. The design and construction of the Preferred Alternative would be in accordance with the following guidance document and local codes and regulations:

- New York City Building Code, 2014 edition
- NYCDOB Regulations
- ASCE 7–10, 2010 edition

14.3 ANALYSIS METHODOLOGY

The Study Area for this resource category is the Project Site. FRA analyzed existing reference information about the soils and geology at the Project Site to identify type of soil/geology present, analyzed support needed for the engineering design for the Tunnel Encasement and Platform structure foundations, estimated the amount of materials to be excavated from the site, and identified any dewatering needs during construction of the Preferred Alternative. Please see Analysis Methodology in Chapter 11 of **Appendix B**, for a complete description of the methodology used for the analysis of this resource category.

14.4 AFFECTED ENVIRONMENT

14.4.1 GEOLOGY

The Study Area is reclaimed land, formerly part of the Hudson River, which was purposefully filled to expand Manhattan Island's shoreline within the last 200 years. Urban fill is typically reworked sandy and granular geologic materials, generally containing various inclusions such as cinders, construction debris, or other refuse. The natural soils under the fill consist of alluvial sediment. The sediment of this area along the Hudson River is primarily soft clays and silts with varying amounts of fine sand. With depth, this alluvial sediment transitions to denser glacial soils, typically a mixture of clay and sand with occasional areas of gravel, cobbles and boulders. The bedrock at the site is characterized by metamorphic rock ranging from about elevation (el.) +20 feet beneath Eleventh Avenue to about el. -110 feet beneath Twelfth Avenue, with elevations being referenced to the National Geodetic Vertical Datum of 1929 (NGVD29) datum. See **Figure 14-1** for an excerpt of USGS Bedrock mapping, which indicates the bedrock contours and the demarcation of the man-made fill area. See **Appendix J1**, "Geotechnical Report-Platform," and **Appendix J2**, "Geotechnical Report-Terra Firma," for more detailed information regarding the characteristics of the geology of the Project Site.

14.4.2 SEISMIC ACTIVITY AND FAULTS

The Study Area is located on the western side of Manhattan Island. Based on **Figure 14-1**, the nearest fault line is about 1.5 miles to the east, with another fault line about 2 miles to the south. These represent older fault lines that are not tectonically active (such as those on the western coast of the United States, where seismic activity is more prevalent) (see **Appendix J3**, "Site-Specific Seismic Study.")

Available information from USGS does indicate that there is probabilistic chance that a future seismic event could be experienced in the Study Area. The USGS data is based on seismic activity around the United States, and takes into consideration the frequency and magnitude of such activity—those activities which usually result in an earthquake. While it is reasonable to expect that a future earthquake having a magnitude between 5.0 and 6.0 could occur, the data from USGS does not indicate when such a seismic event could occur, and if the actual magnitude would be higher or lower than the range currently expected.

14.4.3 SOIL

The Study Area comprises UrA, urban land, reclaimed substratum.[1] Urban land soils are areas covered by impervious materials such as asphalt. The soils that comprise these urban lands were material that were dumped in order to advance the shore line westwards into the Hudson. As shown on **Figure 14-2**, the Study Area is located outboard of the original western shoreline of Manhattan (which is assumed to date back to the time of colonization of Manhattan island in the 1600s). The soils are materials which may have been excavated from other nearby areas, but may also include debris as the shoreline was pushed westward into the Hudson River.

14.4.4 GROUNDWATER AND AQUIFERS

The groundwater in the Study Area is not part of an aquifer used for public potable water. New York City's system of upstate reservoirs provides drinking water to the city. Groundwater is discussed in Chapter 12, "Contaminated Materials."

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[1] https://websoilsurvey.sc.egov.usda.gov/

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GEOLOGIC UNITS COMBINED ACCORDING TO SIMILAR ENGINEERING CHARACTERISTICS

The major common attribute of engineering significance used in the grouping of these units is similarity of rock type, which should give rise to reasonably uniform strength characteristics for intact rock (rock without faults or other discontinuities). Intact-rock strength decreases with an increase in discontinuity frequency and in weathering (Farmer, 1983). Formal geologic-unit names are in parentheses.

g/smt/s	Gray sillimanite-muscovite-tourmaline schist (Manhattan Schist)
g/pqm/s	Gray plagioclase-quartz-muscovite schist (Walloomsac Formation)
w/cd/m	White calcite-dolomite marble (Inwood Marble and lenses in the Hartland Formation (O€hm), and coarse-grained siliceous dolomite (Yfm))
bw/gpb/g	Black and white garnet-plagioclase-biotite gneiss (Fordham Gneiss, member B)
g/qbp/s	Gray quartz-biotite-plagioclase schist (Fordham Gneiss, member C)
p/mbp/g	~~Pink muscovite-biotite-plagioclase gneiss (Fordham Gneiss, member A)~~
w/qmim/gr	White quartz-microcline-muscovite granite (Hartland Formation)
g/bmq/s	Gray biotite-muscovite-quartz schist (Hartland Formation)
g/gkmboq/s	Gray garnet-kyanite-muscovite-biotite-oligoclase-quartz schist (Hartland Formation)
g/spm/s	Gray sillimanite-plagioclase-muscovite schist (Hartland Formation)
w/gr	White granite
gn/sp	Green serpentinite
gb/am	Greenish-black amphibolite (in all units except marble and Walloomsac Formation)
am	Amphibolite (usually looks black in outcrops)
g/sgmi/g	Gray sillimanite-garnet-microcline gneiss (Ravenswood Granodiorite)
dg/pa/d	Dark-gray plagioclase-augite diabase (Palisade Diabase)
gnr/sh-ss	Greenish-red shale and sandstone (Passaic Formation)
g-b/sh	Gray and black shale (Lockatong Formation)
g-rb/ss	Gray and reddish-brown sandstone (Stockton Formation)

EXPLANATION OF MAP SYMBOLS

SUBSURFACE ENGINEERING STRUCTURES

City Water Tunnels No. 1, 2, and 3, and Richmond Water Tunnel

Old and New Croton Aqueducts—Where aqueduct is shown side-by-side with City Water Tunnel No. 3, water tunnel actually is directly beneath aqueduct

Subway, railroad, or auto tunnel—Where City Water Tunnel No. 1 directly underlies subway tunnel, only the former is shown

Consolidated Edison Co. gas tunnel

Sewer tunnel

FORMER DRAINAGE AND SHORELINE

Former drainage and shoreline—In blue. Shown only where different from present drainage and shoreline. Areas formerly under water shown by dot pattern. Where very small, former ponds are labelled "p". Straight line segments probably are furrows and ditches built to lower the water table

Former swamp or marsh—In blue. Dashed line defines where swamp or marsh adjoins higher ground. Very small occurrences are labelled "s"

GEOLOGY—SURFACE AND SUBSURFACE

Contact between geologic units—Dashed where approximately located; dotted where under water; queried where uncertain. Where shown solid under water, was located by test borings and tunnel data

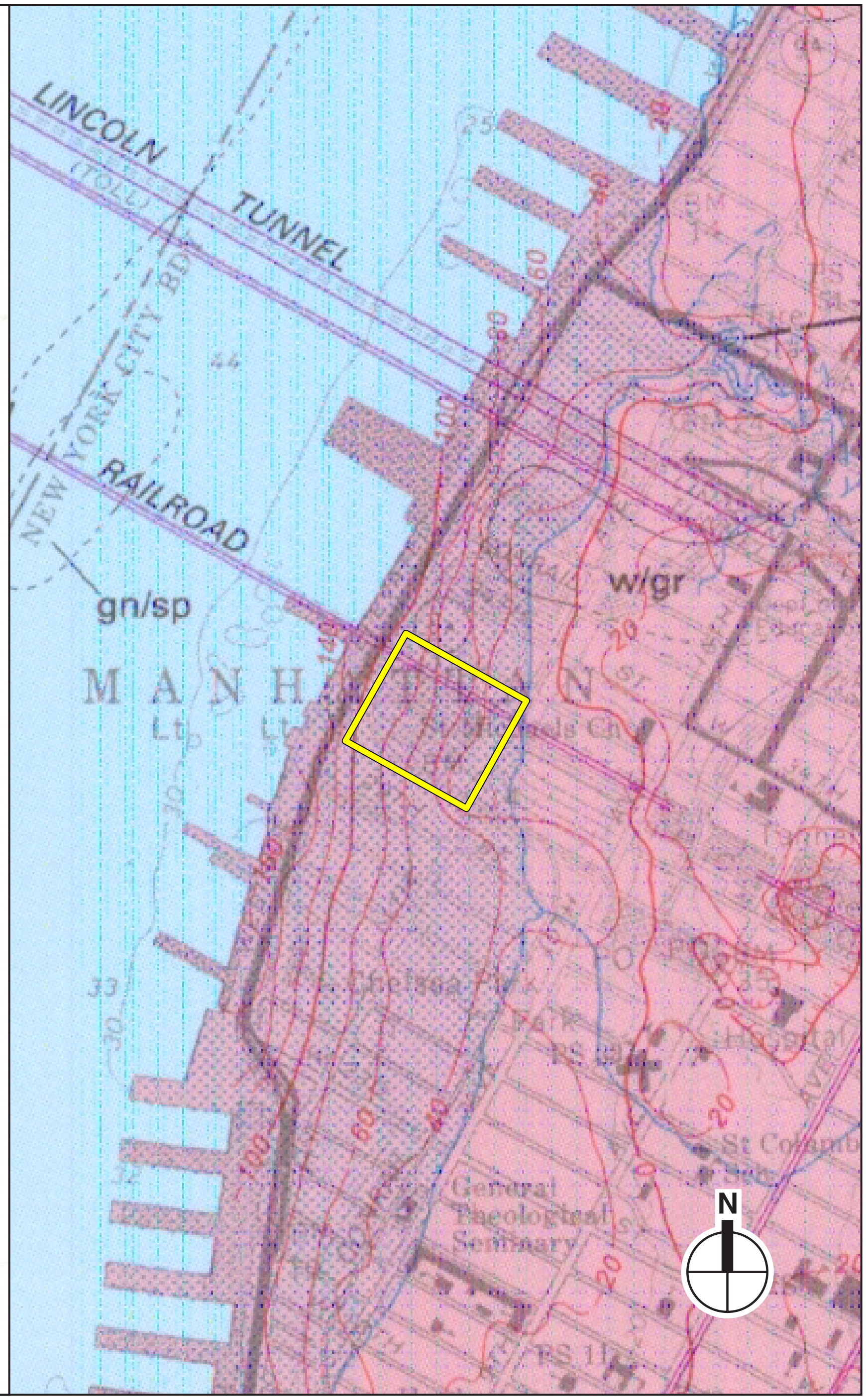
Fault—Paired arrows show relative movement; U, upthrown side; D, downthrown side. Dashed where approximately located; dotted where under water; queried where uncertain. Where seen in tunnel, arrow shows inclined dip, and short line normal to fault trace shows vertical dip

Thrust fault—Sawteeth on upper plate. Dashed where approximately located; dotted where under water. Where seen in tunnel is shown solid. Alternating solid and open sawteeth indicate thrust faults coincident in map view (near Roosevelt [Welfare] Island; see sheet 1)

Crush or shear zone encountered in underground workings—Shows dip where known

Contours on the bedrock surface—Based on same datum as topographic contours. Closed, hachured areas indicate depressions. Contour interval 20 ft, except 10 ft on Wards Island

Single outcrop or area of closely spaced outcrops



0 0.25 MILES

Project Site (Western Rail Yard)

Bedrock Map
Figure 14-1

3.10.21

Project Site (Western Rail Yard)

0 1,000 FEET

1865 Viele Map

WESTERN RAIL YARD INFRASTRUCTURE PROJECT

Figure 14-2

14.5 ENVIRONMENTAL CONSEQUENCES

14.5.1 NO ACTION ALTERNATIVE

No impacts affecting the soils and geology would occur under the No Action Alternative since no excavation or foundation construction would occur. As such, the Project Site would remain in use as an open rail yard, and the current LIRR operational facilities would remain on the terra firma portion of the Project Site.

14.5.2 OPERATIONAL IMPACTS OF THE PREFERRED ALTERNATIVE

The Preferred Alternative would require the support of excavation structures and foundation structures intended to function over the 100-year design life. The Project Sponsor would design these structures to transfer load of the Overbuild to the underlying bedrock.

The groundwater level is currently below the elevation of the existing rail yard. Since there would be no intent to change the elevation of the rail yard as part of the Preferred Alternative, FRA has determined that no impact to the groundwater would result from the Preferred Alternative. Impacts to groundwater are discussed in Chapter 12.

14.5.2.1 PLATFORM

The design of the 9.8-acre Platform spanning the Western Rail Yard would include deep foundations and a concrete slab to cover the active rail yard below, and reinforced building foundations to support the planned Overbuild. The Project Sponsor would drill approximately 400 caissons (i.e., watertight columns) into bedrock through the water table and soil to the rock that is as deep as 120 feet below the surface in certain locations. The design for the Platform’s support columns would thread them between the existing railroad tracks and associated infrastructure in the Western Rail Yard. Bedrock would support the caissons.

The caissons, located between the set of tracks, would form a grid pattern, with a greater number of caissons in the areas where the buildings of the Overbuild would be located above. Depending on the vertical and horizontal loads on the caissons, the distance between caissons would be between about 10 and 80 feet, and the diameter of the caissons would range from about 24 inches to 60 inches. Once constructed, the Platform would not have an impact on the underlying soils and bedrock since construction of the caissons would remove materials and replace them with concrete.

14.5.2.2 TUNNEL ENCASEMENT

The Tunnel Encasement in the Western Rail Yard would extend diagonally across the Project Site, and would be between approximately 50 and 65 feet wide and between approximately 27 and 38 feet high. See Chapter 3, “Alternatives,” for a more detailed description of the Tunnel Encasement.

Per the Project Sponsor’s design, secant pile walls would compose the Tunnel Encasement. Secant piles consist of a series of interlocking concrete cylinders that form support for the structure above and a waterproof basement wall.

Once in place, the casing would be adequate to support the adjacent soils and any structures placed above it.

The Tunnel Encasement would not have an impact on the underlying soils and bedrock, since the encasement would be fixed in place and designed to withstand the lateral loads of soil and bedrock, and would not result in any further changes to the soils or bedrock in the area.

14.5.3 CONSTRUCTION IMPACTS OF THE PREFERRED ALTERNATIVE

14.5.3.1 EXCAVATION AT TUNNEL ENCASEMENT

As stated previously, the Tunnel Encasement would require secant piles. Installing secant piles involves the construction of guide walls, which provide an accurate alignment for the drilling auger. A drilling rig then advances an initial series of cylindrical holes to the desired depth (the primary piles), spacing them slightly less than one pile diameter apart. A concrete pump is connected to the drilling apparatus, and fills the holes with slow-curing, or soft, concrete to form piles. The rig then drills a second series of holes for the secondary piles, which intersect each primary piles at two locations (the secant). The drilling equipment and concrete pump then fill the secondary piles with concrete, while a crane lowers the steel reinforcement into the secondary pile. After completion (and curing) of all concrete secant piles, hydraulic excavators can excavate the tunnel cavity to the desired depth or until bedrock is encountered.

Excavation for the proposed Tunnel Encasement would vary in depth from about 60 feet below existing ground surface near Eleventh Avenue to about 70 feet below existing ground surface at its maximum depth near Twelfth Avenue. Therefore, rock blasting would be necessary to excavate about 25,000 cubic yards of bedrock to create a trench for construction of the concrete casing.[2] Excavation would involve controlled rock blasting techniques, with special techniques such as channel drilling and rock splitting planned in some areas to reduce vibration on nearby facilities, buildings, tracks, and railroad systems and operations.

Bedrock excavation within the Tunnel Encasement would fragment the bedrock a combination of controlled blasting, chemical fracturing, or hoe ramming, removing the fractured rock by hydraulic excavator. Controlled blasting dislodges rock from the underlying parent material by the detonation of explosive charges placed in holes drilled into the bedrock under a prescribed regime that considers geologic factors and the number, depth, and spacing of explosive charges to maximize the fracturing effect of the blast while minimizing the strength of the charge and resultant vibration. The excavation of any dislodged rock would then occur, exposing the undisturbed bedrock. The Project Sponsor would repeat this process until it achieves the desired depth. See Section 14.6.3 in this chapter for a discussion of potential vibration impacts from construction activities and the methodology and procedures for measuring and minimizing vibration. Construction of the Tunnel Encasement would permanently remove about 25,000 cubic yards of bedrock,[3] and there would be no adverse environmental impacts.

The construction of the Tunnel Encasement would not have an impact on the underlying soils and bedrock, since the drilling and installation of secant piles is implemented to remove soil and bedrock materials in a contained and controlled manner. The secant piles are designed to withstand the lateral loads of soil and bedrock, to provide a stable excavation can be created for the Tunnel Encasement.

The Project Sponsor would truck excavated rock material to a crushing and recycling facility, beneficially reuse it off-site, or haul it to a permitted disposal facility.

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[2] Amtrak and FRA. November 2014. Finding of No Significant Impact, Supplemental Environmental Assessment for Construction of a Concrete Casing Extension in the Hudson Yards, New York, New York.

[3] Amtrak and FRA. November 2014. Finding of No Significant Impact, Supplemental Environmental Assessment for Construction of a Concrete Casing Extension in the Hudson Yards, New York, New York.

The Project Sponsor would handle excavated soil and bedrock either by stockpiling it on-site or loading it directly onto trucks and hauled off-site for reuse or disposal. The Project Sponsor would remove, transport, and dispose of the soil/rock at licensed disposal facilities in accordance with regulatory guidance and action levels established in federal, state, and municipal standards. The Project Sponsor would perform the excavation and material removals in coordination with NYCT, LIRR, the MTA, and Amtrak to limit interference with rail operations during removals. For bedrock removal, the Project Sponsor's contractor would obtain and adhere to the excavation, rock splitting and blasting permit from the NYCDOB and/or the New York City Fire Department (FDNY). The Project Sponsor would monitor vibrations during construction and develop action levels to evaluate the potential impacts of the contractor's means and methods for removal of rock and soil on adjacent facilities.

14.5.3.2 DEWATERING AT TUNNEL ENCASEMENT

A support of excavation system that utilizes secant piles typically requires minimal dewatering once the initial dewater of the excavation takes place, compared to support of excavation systems that traditionally use solider piles and lagging panels. Note that the secant piles would be used to support excavations in soil materials. As excavation to the bottom of the Tunnel Encasement continues into bedrock, the existing groundwater—which may flow through joints, cracks, or fractures in the bedrock mass that is not treated with secant piles—would require pumping and treatment in accordance with the dewatering plan.

14.5.3.3 EXCAVATION FOR CASSIONS

To install caissons, the Project Sponsor would drill 24- to 72-inch diameter holes vertically into the ground. As the drill advances holes, a metal casing would be advanced with the drill head to keep the drill hole open. When the drilling activity reaches bedrock, a drill head designed for drilling rock would replace the drill head designed for soil. The new drill head (for bedrock) would continue advancing the hole between about 8 and 40 feet into the bedrock, creating a rock socket; the exact depth of which would be dependent on the diameter and load-carrying capacity of the caisson. The drilling head and drilling equipment remove the soil and bedrock debris as the hole is being drilled. It is estimated that approximately 16,000 cubic yards of soil and 5,000 cubic yards of rock would be excavated as a result of caisson installation. Once the drill head has reached the bottom of the rock socket, a concrete pump would be connected to the drill rig, and concrete would be pumped into the cased hole and rock socket, as the steel beam reinforcement is lowered and centered within the casing and rock socket.

The metal caisson for each pile would extend approximately two feet above the surface of the yard. Bolts embedded in the concrete would extend above the top of the pile in order to attach base plates to the pile.

Construction of a caisson would require a minimum of four major pieces of equipment, including a foundation-drilling rig, cranes to install casing and reinforcement, a front-end loader to load soil and rock spoils onto trucks, a concrete pumper, and cranes to install base plates and structural steel atop the caisson foundation. Multiple caisson installation operations would likely occur simultaneously during each phase of platform construction. As such, eight or more pieces of heavy construction equipment may occupy the temporary work deck at one time. Work associated with drilling and installation of the caissons would occur from the temporary work deck at track level, or from rail-mounted equipment.

14.5.3.2 *DEWATERING AT CASSIONS*

Although the drilling for caissons would be deeper than the water table, dewatering would not be likely to occur during caisson construction. The Project Sponsor would employ a steel casing with a polymer or bentonite slurry to maintain and open holes during drilling until it could install concrete via tremie method[4] into the caisson. The Project Sponsor would collect and recycle displaced slurry between the successive installation of caissons.

14.5.3.4 TRUCK ROUTING

The Project Sponsor would employ dump trucks, tractor-trailer rigs, and other vehicles to remove demolition debris and excavation spoils from the Project Site and deliver construction material to the Project Site. Although the final destination of debris and spoils and the origin of trucks delivering materials would be at the discretion of the contractors selected, for purposes of environmental impact analyses, FRA has assigned reasonable worst-case assumptions regarding probable truck origin/destination according to the items being transported. Construction trucks making deliveries and carrying soils and debris from the Project Site would adhere to designated truck routes. The duration of trucking activities for the construction of the Preferred Alternative would occur over approximately five years, and the hourly number of trucks projected would be 15–20 trucks during the peak hour for the Platform and 8–10 trucks for the Tunnel Encasement during the peak hour. The movement of these trucks would not result in impacts to soils or geological formations in the Study Area from construction of the Preferred Alternative. The Project Sponsor would oversee:

- Trucking of demolition and excavation debris to destinations west of the Hudson River via the Lincoln Tunnel or the George Washington Bridge.
- Deliveries of concrete, likely from a batching plant in Brooklyn, New York, via the Brooklyn-Battery Tunnel and the West Side Highway.
- Deliveries of diesel and gasoline fuel for on-site equipment, likely from Queens, Brooklyn, or the Bronx, New York.

14.6 AVOIDANCE, MINIMIZATION, AND MITIGATION MEASURES

The Project Sponsor would undertake measures to avoid, minimize, and mitigate construction activities. These various control measures related to geology, soil and foundation construction are included in the following subsections. The Project Sponsor would develop the corresponding construction guidance documents in advance of construction commencement. The Project Sponsor would be responsible for the Project Sponsor's Contractor implementing the measures to avoid, minimize, and mitigate construction activities.

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[4] Tremie Method, is the most common and expeditious way to place large volumes of concrete to considerable thickness under water. Tremie refers to placement of concrete by gravity feed from a hopper through a vertical pipe extending above the surface to the underwater floor. As concrete flows from the bottom of the pipe, the gravity feed adds more to the hopper so that the tremie pipe is continuously charged with fresh mix. The major aim in underwater concreting is to place the mix in its final position with as little disturbance as possible. As concrete flows from the tremie pipe, it buries the end of the pipe in the mass. Gradually the mix flows out toward the edges to fill the concrete forms. As the concrete builds up, its bulk raises sufficiently to keep its delivery end buried. The concrete around the end of the pipe seals it from the water and prevents aggregate segregation and washing away of cement.

14.6.1 FUGITIVE DUST CONTROL PLAN

The Project Sponsor would develop a fugitive dust control plan as an element of the CEPP for the Preferred Alternative (see Chapter 22, "Mitigation Measures and Project Commitments"). These measures would include, at a minimum, the following provisions:

- Controlling fugitive dust through water spraying or use of a biodegradable dust suppressant solution;
- Maintaining large piles of soil, rock or sediment in a wet condition, coated with a dust suppressant and/or covered to prevent wind erosion and fugitive dust and covering longer-term stockpiles with weighted tarps.
- Performing concrete- and rock-grinding, drilling, and saw-cutting operations with a wet blade or using mist if the activity is generating significant dust. Such operations in an enclosed space would utilize vacuum collection or extraction fans.
- Stabilizing or wetting loose material during loading and unloading if the activity is generating dust plumes, and covering this material during transportation to and from the Project Site and Additional Housing Sites.

14.6.2 DEWATERING PLAN

The dewatering plan, which is included as an element of the CEPP for the Preferred Alternative, would require pumping of dewatering water into sedimentation tanks for removal of sediments prior to reuse on the sites or discharge into the City's sewer system or the Hudson River via the existing LIRR outfall that serves the rail yard. The Project Sponsor would periodically test water and particles in such tanks pH and contaminants. Depending on test results, the Project Sponsor would treat the water for contaminants prior to disposal, as per NYSDEC, or NYCDEP regulations, and depending on point of discharge (i.e., City sewers or stormwater conveyance pipe to the Hudson River). See Chapter 15, "Water and Natural Resources," for additional information on dewatering.

14.6.3 CONSTRUCTION NOISE AND VIBRATION

Construction practices that would be used to the extent feasible and practicable to reduce noise and vibration levels associated with construction of the Preferred Alternative are listed in Chapter 8, "Noise and Vibration."

14.6.4 LIRR/MTA COORDINATION

The Project Sponsor would conduct construction work in accordance with LIRR guidelines and design/construction criteria, which require persons engaged in pre-construction or construction activities located on or near the tracks, or with the potential of fouling a track in the Western Rail Yard to attend the LIRR Contractor Roadway Worker and Safety Training in accordance with provisions of 48 CFR Part 214 and LIRR Rules and Regulations. LIRR regulations also require that MTA and LIRR receive and approve plans—to result in a construction agreement entered into between MTA and LIRR and the Project Sponsor—for construction activities related to work at the Western Rail Yard.

14.6.5 UTILITY PROTECTION

The Project Sponsor has undertaken an inventory of underground utilities on the Project Site through a review of existing utility drawings and information, as well as performing geotechnical surveys. The Project Sponsor performed this work as part of the engineering and design of the Preferred Alternative. The Project Sponsor's Contractor would confirm location of underground utility lines to ensure avoidance by digging test pits at each caisson location. See Chapter 13, "Utilities and Energy," for additional information on utilities. The Project Sponsor's Contractor would likely conduct additional geotechnical surveys if necessary. The Project Sponsor or Contractor may conduct additional soil and groundwater testing to characterize more fully soil constituents for disposal purposes. ✷