Appendix H: Construction Impacts

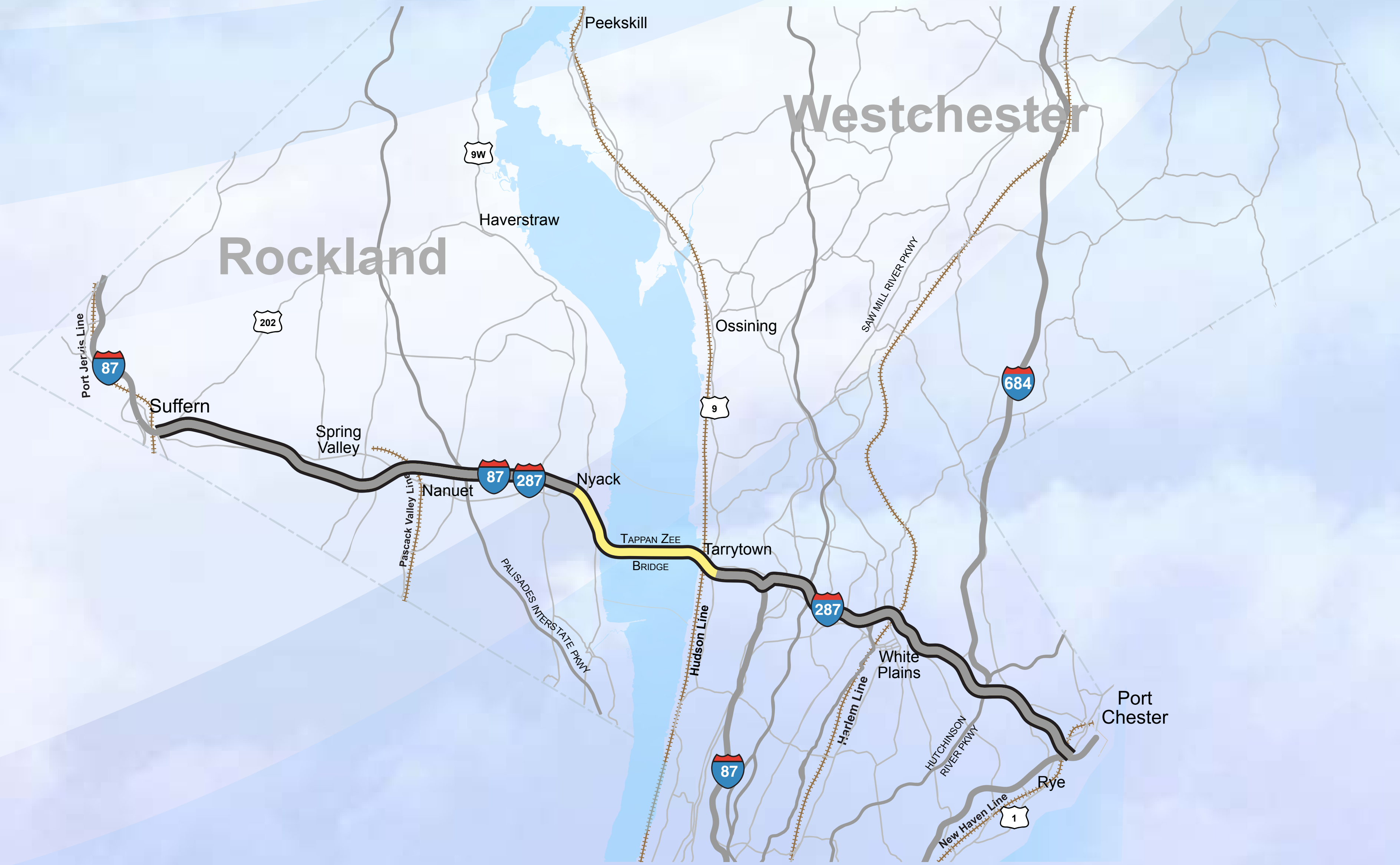
H-1 Construction of the Feasible Options for the Replacement Tappan Zee Bridge (TP6/7)—Final Draft

New York State Department of Transportation
New York State Thruway Authority

Tappan Zee Hudson River Crossing Project

Construction of the Feasible Alternatives for the Replacement Tappan Zee Bridge & Landings (TP6/7)

18 January 2012



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1 Introduction

1.1 Project Overview

The Federal Highway Administration (FHWA), acting as the federal lead agency, and the New York State Department of Transportation (NYSDOT) and the New York State Thruway Authority (NYSTA), acting as the co-sponsoring agencies, are preparing an environmental impact statement (EIS) to identify alternatives for the Tappan Zee Hudson River Crossing project and to analyze the potential environmental impacts of those alternatives.

The project study area consists of a linear corridor of approximately 4 miles of Interstate 287 extending from the South Broadway Bridge in Rockland County to Route 9 South Broadway in Westchester County, and includes the existing Tappan Zee Bridge (TZB).

Project History

The TZB opened to traffic in 1955 as part of the New York State Thruway extension between Suffern, New York and Yonkers, New York. Over the years, the bridge and its highway connections have been the subject of numerous studies and transportation improvements, however despite these improvements, congestion has grown steadily and the aging bridge structure has reached the point where major reconstruction is needed to sustain this vital link in the transportation system.

In April 2000, a Long Term Needs Assessment and Alternatives Analysis was completed by the New York State Governor's I-287 Task Force. The report concluded that while there was no single preferred solution for addressing the transportation needs in Tappan Zee Bridge/I-287 Corridor, both a short-term aggressive Transportation Demand Management (TDM) program and longer-term capital improvements were needed. All of the long-term alternatives evaluated by the Task Force called for replacement of the existing TZB because it was concluded that rehabilitation of the existing bridge would be highly disruptive, perhaps as costly, and not as beneficial in mobility enhancement or meaningful congestion relief as compared to a replacement bridge.

On November 28, 2000, the NYSTA and the Metropolitan Transportation Authority Metro-North Commuter Railroad (MNR) announced that an EIS would be undertaken to identify and evaluate alternatives to address the mobility needs of the I-287 Corridor, as well as the structural and safety needs of the TZB. On December 23, 2002, the FHWA and the Federal Transit Administration (FTA) published a Notice of Intent (NOI) to prepare an Alternatives Analysis (AA) and EIS for the Tappan Zee Bridge/I-287 Corridor in the Federal Register.

Over the years the FHWA, FTA, NYSDOT, NYSTA, and MNR have advanced design options including identification of alternatives for transit modes along the corridor and highway and bridge improvements, and have undertaken assessments of the affected environment, including detailed data collection. A number of reports were prepared and made public to document project advancement and provide opportunities for input from the interested public and agencies.

In 2011, while advancing financial analysis, it was determined that funding for the corridor project (bridge replacement, highway improvements, and new transit service) was not possible at this time. The financing of the crossing with provision for future transit, however, was considered affordable. Therefore, it was determined that the scope of the project should be limited, and efforts to replace the Hudson River crossing independent of the transit and highway elements should be advanced. On October 12, 2011, FHWA and FTA published an NOI to rescind the Tappan Zee Bridge/I-287 Corridor Project, thereby concluding the environmental review process for the combined study of bridge, highway, and transit elements.

On that same date, FHWA published a new NOI for the Tappan Zee Hudson River Crossing Project to examine alternatives for an improved Hudson River crossing between Rockland and Westchester Counties. As described in the NOI, the FHWA, NYSDOT and NYSTA are preparing an EIS to identify alternatives for an improved Hudson River crossing and to document the potential environmental consequences of these alternatives. Although the Tappan Zee Hudson River Crossing Project will undertake an independent environmental review, the study will rely on previous relevant documents prepared for the Tappan Zee Bridge/I-287 Corridor Project (as listed above).

Project Purpose and Need

The purpose and need for the Tappan Zee Hudson River Crossing Project builds on the problems and deficiencies in the corridor, and states the basis for identifying and selecting solutions to effectively and efficiently address those needs, while respecting the natural and human environment.

On October 12, 2011, a revised NOI for the project was published in the Federal Register (Vol. 73 No. 31) which stated:

"The purpose and need of the project is to maintain a vital link in the regional and national transportation network by providing an improved Hudson River crossing between Rockland and Westchester Counties, New York."

Based upon these project purposes and needs, the *Scoping Information Package* (SIP) (October 2011) identified three goals and objectives to address the deficiencies of the existing bridge. The project goals and objectives were developed to indicate how the project will address the purpose and need. Objectives are used to measure progress in the attainment of goals. Project alternatives developed to respond to the purpose and need are evaluated by how well they meet the goals by determining their likely performance against various objectives. All levels of evaluation conducted throughout the development of the EIS will be consistent with the purpose and need and the project's goals and objectives.

One of the key steps in preparation of the EIS is the development and refinement of the EIS alternatives. The process of assessing these alternatives is documented in the *Alternatives Evaluation Report for the Tappan Zee Hudson River Crossing (AER) (January 2012).*

The purpose of the AER is to identify reasonable alternatives for the Hudson River Crossing project to be evaluated in the draft environmental impact statement (DEIS). A total of 12 options under the four alternatives (No Build, Tunnel, Rehabilitation and Replacement Alternatives) were evaluated against the project goals and objectives. As detailed in the AER, scoping concluded with the selection of two Replacement Alternative options Short Span Option S3 and Long Span Option L4 for further evaluation in the DEIS (see Figure 1.3).

1.2 Purpose of Report

This report outlines the processes involved in the construction of Short Span and Long Span RTZB options, being the two Replacement Alternative options put forward for further evaluation in the DEIS. The details presented are intended to inform the overall environmental assessments and provide the basis for construction duration and cost estimate.

All plans and construction methods described in this report are conceptual only. The construction methods given in this report should not be considered definitive. They are likely methods developed on the basis of experience from equivalent project precedents. Plans and construction methods described in report are for the purpose of investigating and evaluating environmental impacts in the DEIS. It is important to note that each contractor will use construction means and methods that are most suitable and economical for his specific constraints and which could differ from what is presented in this report.

Further, it is noted that all staging areas are the responsibility of the contractor, and those described within this report are put forward as potential sites only. The contractor is responsible for the selection of potential staging areas required for the construction of the project, and would be required to obtain all of the necessary permits and approvals for each and any site.

1.3 Scope of Report

The limits of work described in this report encompasses the construction of the bridge over the Hudson River and the bridge landings on the Rockland and Westchester shores. For the purposes of this report, a study area has been generally defined as a 4-mile stretch of the Interstate 87/287(New York State Thruway) right-of-way generally between the South Broadway Bridge in Rockland County and Route 9 South Broadway in Westchester County.

It addresses the anticipated construction equipment, the means of delivery of equipment and material, the anticipated number of construction crews and their size and the means of demolition of the existing bridge. This report also includes a detailed estimate of the construction schedule.

1.4 Report Organization

This report is organized as follows:

- Chapter 2 presents features of the Short Span Option and the Long Span Option which are considered notable from a construction perspective.
- Chapter 3 discusses the high level construction sequence and schedule of the RTZB and its landings. Graphical representation of significant construction events and schedule summaries are included in this chapter.
- Chapter 4 addresses the construction preliminaries which are important first steps that must take place at the commencement of the bridge project. These include the selection and development of the potential staging areas as well as dredging of a channel along the alignment of the bridge to provide access for construction vessels. This chapter also addresses temporary platform (trestle) structures which may be used in the near shore shallow water zones.
- Chapter 5 presents substructure construction. This includes all bridge components below the tops of the piers including piles, pile caps columns and pylons.
- Chapter 6 presents superstructure construction, which includes all bridge components above the top of the piers. These components include the bridge deck, bearings and joints, roadway finishes, lighting, signage and the shared use path, etc.
- Chapter 7 provides the details of the Rockland and Westchester landings. It also includes the reconfiguration of the Toll Plaza and overall phasing plan for the traffic. Much of the details are covered in the drawings which are included in Appendix E.
- Chapter 8 presents the details of demolition of the existing TZB.
- Chapter 9 addresses specific inputs that may be used for a quantitative environmental analysis. Specifically, this chapter addresses pile hammer activities, construction crew requirements and concrete truck deliveries. The variation in these activities during the full duration of the project is also tracked.
- Appendix A shows the detailed construction sequence and schedule of individual bridge elements for both Short and Long Span Options. It also includes the global schedules for the two bridge options.

Short Span Option

Long Span Option

Figure 1.1 - Short Span and Long Span Options to be Evaluated in the DEIS

2 Replacement Bridge Options

While the overall focus of this paper is on the construction methods associated with these two options, this chapter will review their notable structural features of the Short and Long Span options. The features of the bridge landings on each shore are discussed in Chapter 7.

Bridge Types

Figure 1.1 shows the cross-section and arrangement for the Short Span Option and the Long Span Option. Figures 2.1 and 2.2 show the plan arrangements and elevations of the two bridge options. It is noted that the east and west approach structures over the Hudson River make up about 85 % of the total bridge length. The remainder consists of the Main Span.

Evaluation of possible Main Span bridge types identified a Cable-Stayed Option and an Arch Option as suitable forms for the RTZB Main Span. The requirements to construct these two options will be discussed herein.

Bridge Components

The following subsections present details of physical components of the RTZB options including details of general arrangements, superstructure and foundations. Common to both options are:

- Main Span Clearance
  - A desirable clearance of 139 feet above Mean High High Water (MHHW, Spring Neap Tide) over the shipping channel has been adopted as design criteria.
  - 600-foot wide shipping channel
  - Main Span has a length of approximately 1,200 feet and a minimum clearance between fenders of 1,000 feet, consistent with the Main Span of the existing bridge.
- Replacement Bridge is located to the north of the existing TZB.
- The choice of pile diameters is a function of the soil types under each foundation. For simplicity, pile groupings have been classified into seven foundation zones whose extents are shown in Figures 2.1 and 2.2. The pile diameters in each foundation zone are as follows:
  - Foundation zone 1 piles: 6-foot diameter
  - Foundation zone 2 piles: 4-foot diameter
  - Foundation zone 3 piles: 4-foot diameter
  - Foundation zone 4 piles: 8-foot diameter
  - Foundation zone 5 piles: 10-foot diameter, includes rock sockets
  - Foundation zone 6 piles: 6-foot diameter
  - Foundation zone 7 piles: 6-foot diameter

The number of piles per pile cap for each option differs but the pile type is constant across the two bridge types. Note that the pile zones mentioned above are distinct from substructure construction zones which are described in section 2.3.

2.1 Short Span Bridge Option

The Short Span Bridge Option is comprised of two independent superstructure decks supported on two column bents. Details include:

General arrangement (Figure 2.1)

- Bridge is comprised of approximately 63 Spans – 43 in the West Approach to the Main Spans and 16 in the East Approach.
- Approach spans are nominally 230 feet between piers measured along the centerline of the southern structure.
- On the approach structures, the substructure elements – piles, pile caps and columns - will be aligned symmetrically under the highway decks.
- The Main Span length is approximately 1200 feet. The Main Span structure will either be a cable-stayed bridge or an arch bridge. The construction of both structural types will be discussed in this technical paper.

Superstructure

- The deck in the approaches and the Main Span is a pre-stressed concrete box girder.
- For the Cable-Stayed Option, two double-leg pylons are to be used on each end of the Main Span. The maximum height of the pylons is 480 feet above MHHW (approx 400 feet above the roadway).
- For the Arch Option, four parallel arch ribs are required to suspend the two external highway decks. The maximum height of the arch ribs is 350 feet above MHHW (approx 200 feet above the roadway).

Substructure (Appendix D)

- On the approaches, the substructure is comprised of piles, pile caps and columns. On the Cable-Stayed Option, the substructure is comprised of piles, pile caps and pylons. On the Arch Option, it is comprised of piles and pile caps.
- The pile caps, columns and pylons will be made of cast-in-place reinforced concrete. For pile details, see subsection on Bridge Components, above.

2.2 Long Span Bridge Option

The Long Span Bridge Option is comprised of two independent superstructure decks supported on two independent column bents. The upper decks of the two bridges will carry highway traffic. Details include:

General arrangement (Figure 2.2)

- Bridge is comprised of approximately 36 Spans – 23 in the West Approach to the Main Span and 10 in the East Approach.
- Approach spans are nominally 430 feet between piers measured along the centerline of the southern structure.
- Each deck will be supported by an independent substructure comprised of columns, pile caps and piles.
- The Main Span length is approximately 1200 feet. The Main Span structure will either be a cable-stayed bridge or an arch bridge. The construction of both structural types will be discussed in this technical paper.

Superstructure

- The superstructure deck in the approaches and the Main Span will be a Long Span steel truss.
- For the Cable-Stayed Option, two double-leg pylons will be used on each end of the Main Span. The maximum height of the pylons is 480 feet above MHHW (approx 400 feet above the roadway).
- For the Arch Option, four parallel arch ribs are required to suspend the two external highway decks. The maximum height of the arch ribs is 350 feet above MHHW (approx 200 feet above the roadway).

Substructure (Appendix D)

- On the approaches, the substructure is comprised of piles, pile caps and columns. On the cable-stayed Main Span, the substructure is comprised of piles, pile caps and pylons. On the arch Main Span, it is comprised of piles and pile caps.
- The pile caps, columns and pylons will be made of cast-in-place reinforced concrete. For pile details, see subsection on Bridge Components, above.

2.3 Substructure Construction Zones

The substructure construction across the Hudson River is divided into three distinct substructure construction zones – A, B and C as shown in Figure 2.1 and 2.2.

The construction zones differ with respect to water depth and cofferdam type as described below.

Further considerations on water depths and their limitations on access by construction vessels, as well as dredging to enable access are discussed in Chapter 4.

Substructure Zone A

- Zone A1 is in the shallowest water depths (less than 7 feet) near the Rockland County shore. In this zone, the substructure components are constructed within cofferdams from temporary platforms with direct upland access from the landing.
- Zone A2 is similar to zone A1 with water depths less than 7 feet but is located near the Westchester County shore.

Substructure Zone B

- Zone B1 is in water depths ranging from 7-18 feet near the Rockland County shore. In this zone, the substructure components will also be constructed within typical cofferdams but access will be from barges and support vessels in the river.
- Zone B2 is similar to zone B1 with water depths ranging from 7-18 feet but is located near the Westchester County shore.

Substructure Zone C

- Zone C: is in water depths ranging from 18-45 feet around the area of the main river channel. In this zone, the substructure components will be constructed within hung cofferdams, and access will be from barges and support vessels in the river.

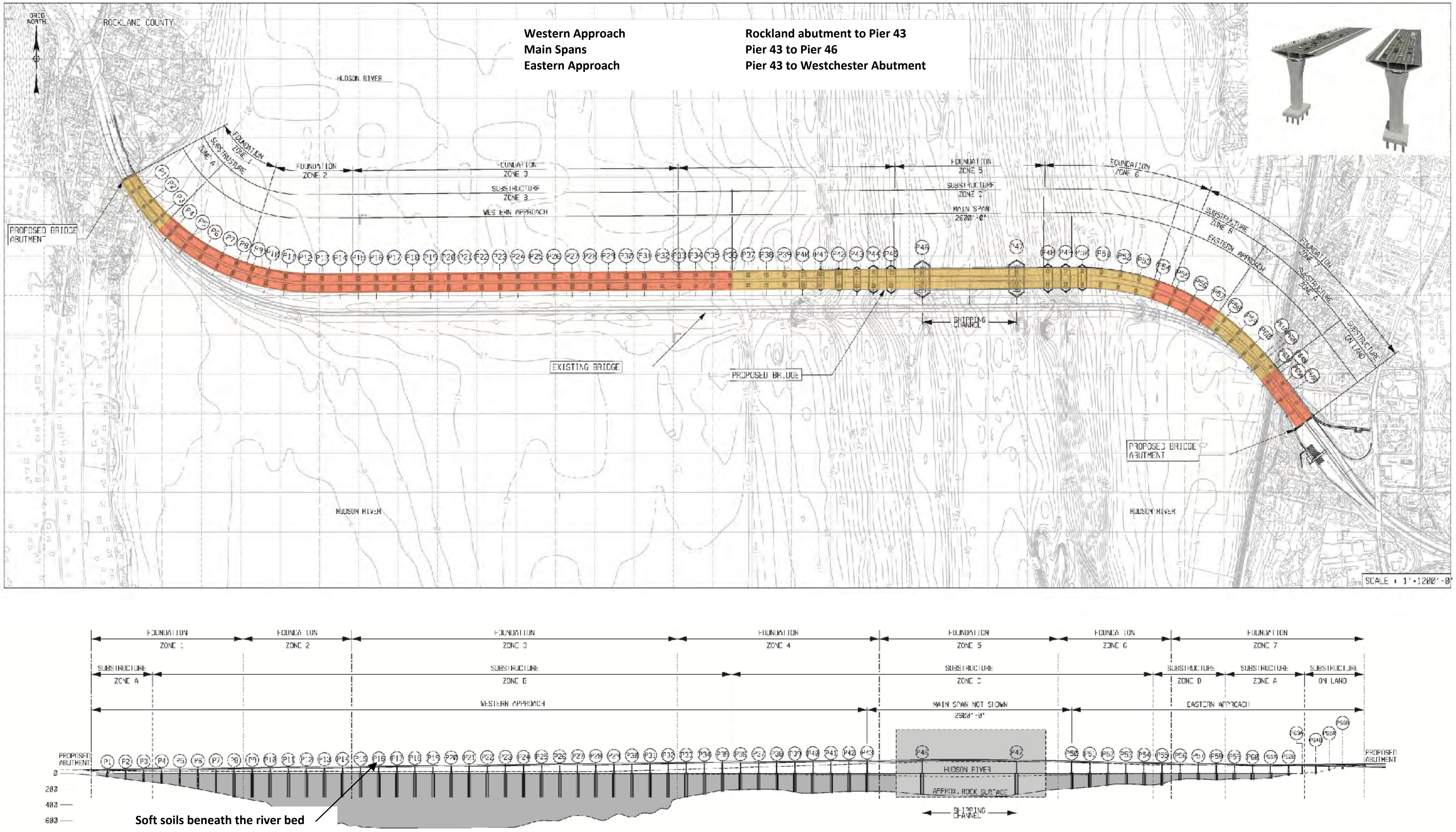


Figure 2.1 - Short Span Bridge Option – Indicative Plan and Elevation

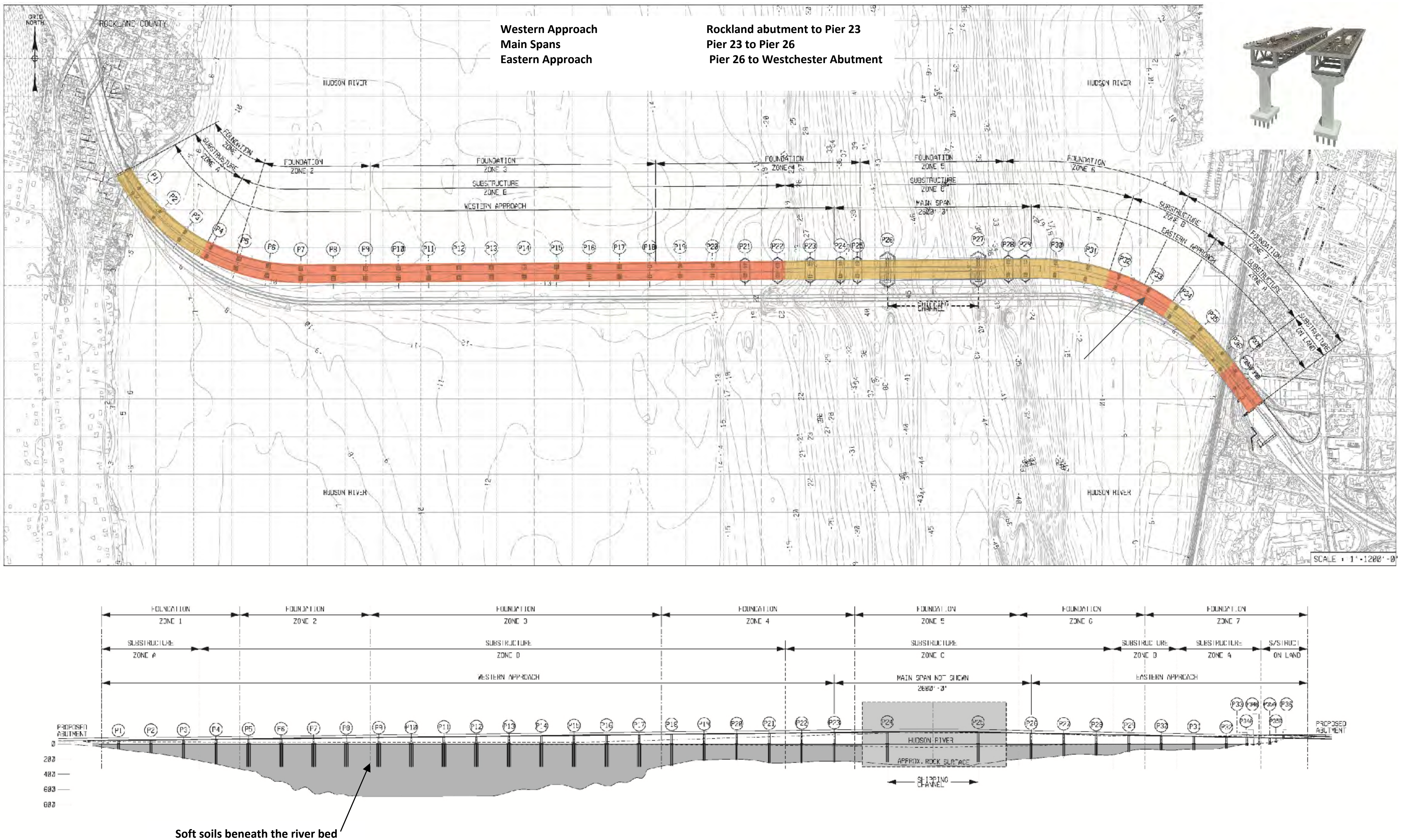


Figure 2.2 - Long Span Bridge Option – Indicative Plan and Elevation

3 Construction Sequence and Duration

The following approximate construction durations are anticipated for the two RTZB options:

- Short Span – 5½ years
- Long Span – 4½ years

The Long Span Option requires less time than the Short Span Option because it has fewer piles and fewer piers. The time for superstructure erection is also shorter by 8 months.

These durations are measured from the beginning of the in-river work, commencing with the pile driving for the Main Span foundations and concluding with the opening of the South RTZB structure to traffic.

Prior to the initiation of in-river work, approximately 1 year of preliminary work will be required at the landings and inland to facilitate access and establish staging and work areas. After completing the RTZB, demobilization and site restoration will be required. Table 3.1 identifies the construction elements that will be built during the Preliminary, and Construction phases.

It is anticipated that both north and south RTZB structures will be constructed simultaneously. That is, at a given pier, the south and then the north foundations will be constructed before moving to the next pier. For the Long Span Option, the south truss and then the north truss will be similarly placed before moving to the next span.

The construction of the RTZB comprises the following principal construction elements:

1. Landings – Roadway work
2. Bridge Staging Areas
3. Dredging – 3 Phases
4. Main Span – Piles, Pile Caps and Pylons, Superstructure and Deck
5. Approach Spans – Piles, Pile Caps and Pylons, Superstructure and Deck
6. Tie-ins – Piles, Pile Caps and Pylons, Superstructure and Deck
7. Demolition of Existing TZB

The tie-ins define a construction area comprising the connection of the bridge with the upland highway. It includes a portion of the bridge and a portion of the highway. Because the right of way is limited at both shores, the new RTZB bridge structures and approach roadways will overlap the existing TZB structure and roadway at both shores. The tie-in extents are defined by the points where the existing, temporary and final structures and roadways will overlap and are applied universally to the existing and the north and south replacement structures and approach roadways. On the Rockland shore, the tie-in extent is from immediately east of the South Broadway Bridge to Pier 7 of the Short Span Option or Pier 3 of the Long Span Option. On the Westchester side, the tie-ins run from Pier 51 of the Short Span Option or Pier 30 of the Short Span Option to immediately west of the South Broadway Bridge (Rt. 9).

In constructing the Main Span, the Approach Spans and their tie-ins, three major types of basic construction activities will repeatedly take place. These activities are: placing the pile foundations, constructing the pile caps and piers, and constructing the deck superstructure. The methods of placing piles and constructing pile caps and piers are similar for the Short and Long Span options. Their superstructure construction methods are very different. There are a significant number of activities involved in substructure (piles and piers), and superstructure construction. These are described in detail in Chapters 5 and 6.

Owing to the length of the bridge, significant overlap of activities will take place. A detailed global construction schedule demonstrating the overlapping nature of the activities is presented in Appendix A. Summaries are presented in Figure 3.9 and 3.10. A visual sequence of events captured at the beginning of each year of construction is shown in Figure 3.2 through Figure 3.7 for the Long Span Option.

For the RTZB, the sequence of construction is constrained by the existing development at both the Rockland and Westchester shores and the need to maintain at least seven lanes of traffic in operation at all times. There is not enough room to construct the north tie-in, the south tie-in and maintain the existing TZB transition. As a result of the limited ROW available at landings, a portion of which is used by the existing transition from the Thruway to the TZB, it is necessary to stage the north and south transitions of the RTZB to the Thruway, referred to as tie-ins, within the remaining available ROW. This will occur during the 3rd year of construction and is depicted in the three bars under *Landings – Roadway work*, in the Short Span and Long Span schedules of Figures 3.9 & 3.10.

While the majority of the north and south structures of the Short Span and Long Span options will be constructed simultaneously, assessment of the limited ROW at the landings identified that the northern most highway structure of either RTZB option must be constructed and tied into the Thruway first, and all traffic transferred thereto. Following this, the portion of the existing TZB that interferes with construction of the south tie-in is demolished. Once these portions of the TZB are removed, the Rockland and Westchester tie-in portions of the south structure can be constructed and the eastbound traffic can be transferred to the new south structure. The balance of the TZB will then be demolished.

Preliminary Phase	Build Phase
Year of Construction	
2013	2014 - 2017
Duration of Construction	
1 year	4 years
Project Components	
Bridge Staging Area	Main Span pylons – north and south
River Staging Area	Approach piers – north and south
Inland Staging Area	Superstructure – north and south
Relocate NYSTA facilities	RTZB Tie-ins and landings – North Structure
Dredge for both structures	Reconfigure Toll Plaza
	8 lane operation on north structure
	Demolish existing TZB tie-ins
	RTZB tie-ins and landings – South Structure
	Demolish balance of TZB
	Westchester Broadway Bridge
Main Span foundations – north and south	Main Span foundations – north and south
Approach foundations – north and south	Approach foundations – north and south

Table 3.1 - Phasing of Construction Elements

3.1 Construction Sequence

The following address the major construction activities for both the Short and Long Span Options.

1. Landing Construction (See Chapter 7 for further details)

To accommodate the staging of traffic on the existing TZB and the north and south structures, temporary roadways will be constructed to convey the traffic while maintaining the existing number of lanes and design speed. On the Westchester landings, a temporary Toll Plaza will be constructed.

2. Staging Areas (See Chapter 4 for further details)

Areas to support the RTZB construction will be developed prior to and after the initiation of in-river work. These include River, Inland and Bridge staging areas. River Staging Areas, north or south of the RTZB support storage, assembly and fabrication activities for the large superstructure elements. Inland Staging Areas are the principal support facilities for day-to-day construction of the RTZB and include concrete production, materials laydown, crew staging and administration. Bridge Staging Areas are temporary trestle-type platforms constructed at the Rockland and Westchester landings. They enable the transfer of concrete, materials and crews brought from Inland Staging Areas to the vessels that will take them to the in-river work sites. Activities to create the staging areas include site preparation, relocation of existing NYSTA and NYSP facilities, construction of access ways, temporary trestle platforms in the Hudson River and support facilities.

3. Dredging (See Chapter 4 for further details)

Dredging on the Hudson River is subject to controls from regulatory authorities. This report assumes that dredging will be limited to an annual three-month window, beginning on the 1st of August. Given the length of shallow water on the Rockland Approach, it is anticipated that two cycles of dredging occurring over two years will be required. A third dredging cycle will be required to provide access to demolish and remove the landing approaches of the existing TZB in order to construct the South Structure tie-ins.

4. Main Span

The in-river construction will start with driving the piles for the Main Span. The pile placement activity will be repeated to provide foundations for each of the pylons (towers) or arches of the Main Span. Once the pylons are above the deck level, construction of the Main Span superstructure can commence concurrent with completing the pylons. Construction of the arches is more complex than the cable stayed pylons and is described in Sections 6.4.The arches have to be completed before the superstructure can be added.

5. Approach Spans (See Chapters 5 and 6 for further details)

The Approach Spans will be constructed from the Main Span towards the shores. This work will initially begin in deeper water requiring no dredging. For both Short and Long Span options, the south and then north substructure will be constructed in sequence at each pier before moving to the next pier closer toward the shore. The substructure activities include sheet piling for temporary cofferdams, pile driving and construction of pile caps and pier columns.

The superstructure activity is different for the Short and Long Span options. For the Short Span Option, a gantry spanning several piers will be used to lift full width deck segments from barges below. These will be tied together using post-tensioning cables to form the decks. It is anticipated that the north superstructure will be completed first using two gantries proceeding from the Main Span towards the shores. The staging of the gantries to expeditiously construct both the south and north structures is detailed in the global schedule in Appendix A.

For the Long Span Option, the super structure is of parts – a truss section and a deck surface placed above. The truss sections are massive and will likely arrive by barge. At each span, the south section would be placed, then the north. Truss erection would be staged from the Main Span towards the shores. For each span, the truss would arrive in two parts. A smaller part that could be lifted by crane and placed atop the pier and secured into place, and the balance of the span that would use winches to be lifted from its barge between the piers where it will then be secured by bolting or welding to the smaller pier-top truss pieces. Once a span is complete, deck segments are lifted from barges, distributed upon the deck and secured to the trusses.

6. Tie-ins

As described previously, the tie-in elements connect the RTZB to the shore and are formally defined as the overlapping areas of road and structure between the existing TZB and the RTZB structures. The tie-ins are essentially a continuation of the approach structures, however they have to interface with the upland roadways which have been reconstructed, but modified to carry traffic in a temporary configuration. The tie-ins include the construction of the abutments, construction of temporary finger-piers from the Bridge Staging Areas to access and construct the foundations (it is impractical to dredge all the way to the shore), and staged demolition of parts of the existing TZB to enable completion of the north structure, then subsequently to enable construction of the entire south structure tie-in.

Construction of the tie-ins will occur in stages. With the completion of each stage, a portion of the TZB traffic will be transferred to the north structure of the RTZB. Initially this will be the westbound traffic, then the eastbound traffic, 4 lanes each way. With the existing TZB empty, its tie-in can be demolished and the south tie-in constructed in the space it once occupied. Once the south tie-in is completed the eastbound traffic will be transferred to the south structure and the north structure completed to its final configuration which includes the shared use path (SUP) and full shoulders.

Detours and Ramp Closures

The only anticipated extended ramp closure is the on-ramp from Broadway (Route 9) to the TZB in Westchester. This ramp will be closed approximately 12 months into the construction period and remain closed for approximately 48 months.

In addition, short closures may be required in Rockland across River Road and South Broadway (Route 9W) to facilitate local construction requirements. These closures may include weekend closures of roads, or closures for shorter periods (hour(s)) to allow for the movement of heavy machinery or for the delivery of materials. Closures on South Broadway would likely occur in the first 18 months. On River Road, closures could occur at any time during construction as all access to the Rockland Bridge Staging Area (RBSA) is across this road. River Road is likely to be signalized to allow for construction access.

Closures of Interchange 9 and 10, or other local ramps is not currently envisaged in the construction sequence, but may be required for short durations to allow for the movement of heavy vehicles.

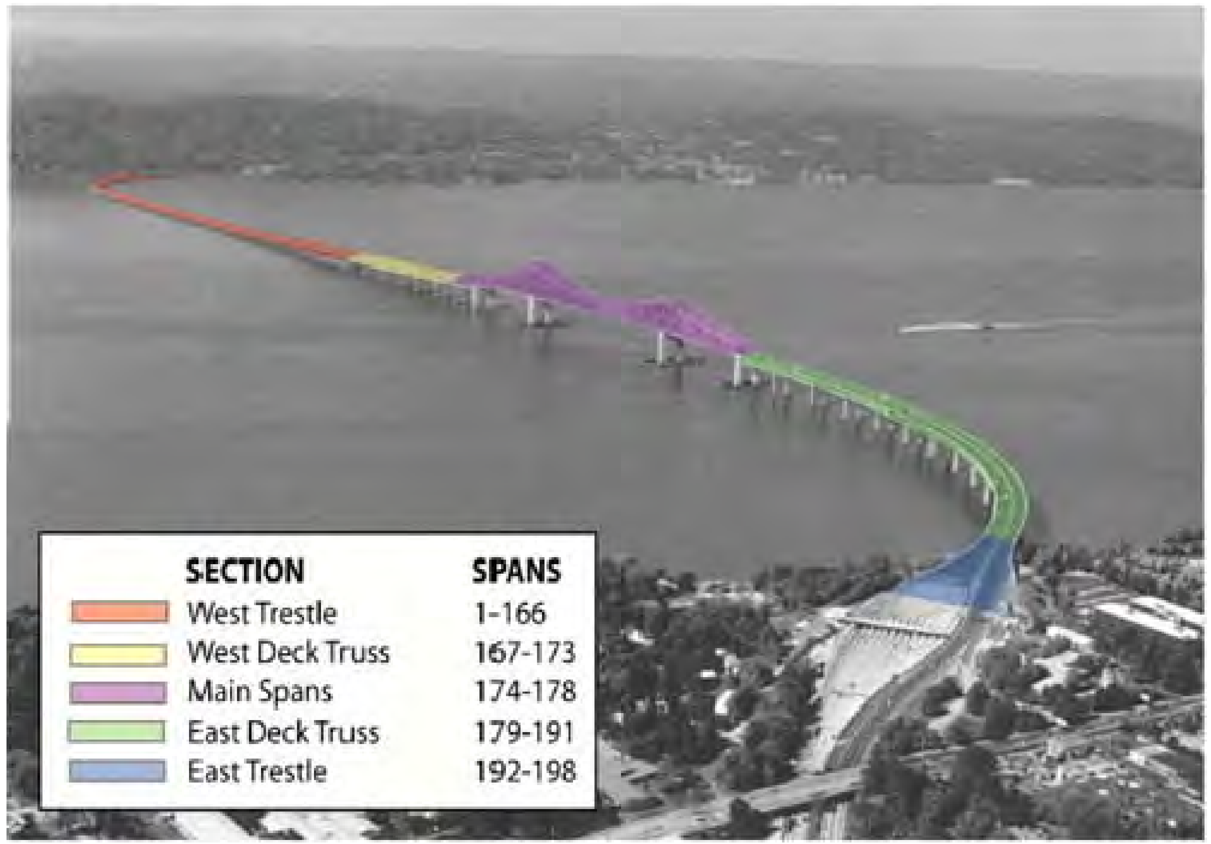


Figure 3.1 - Principal Structural Segments of the TZB

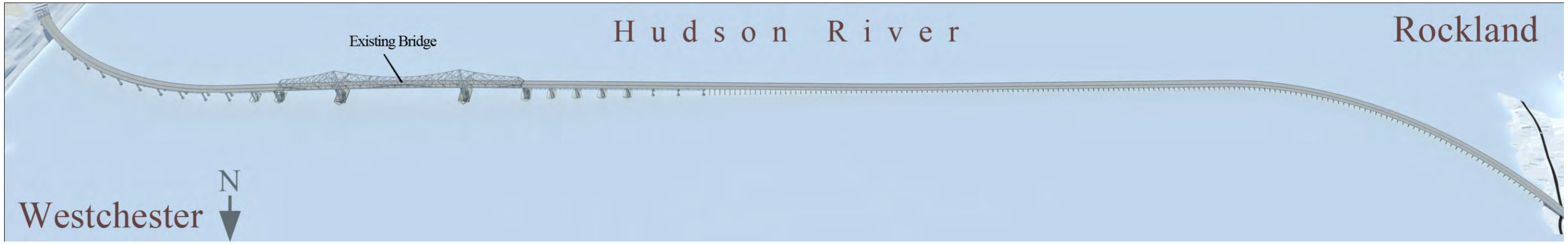


Figure 3.2 - Construction Sequence, Year 0

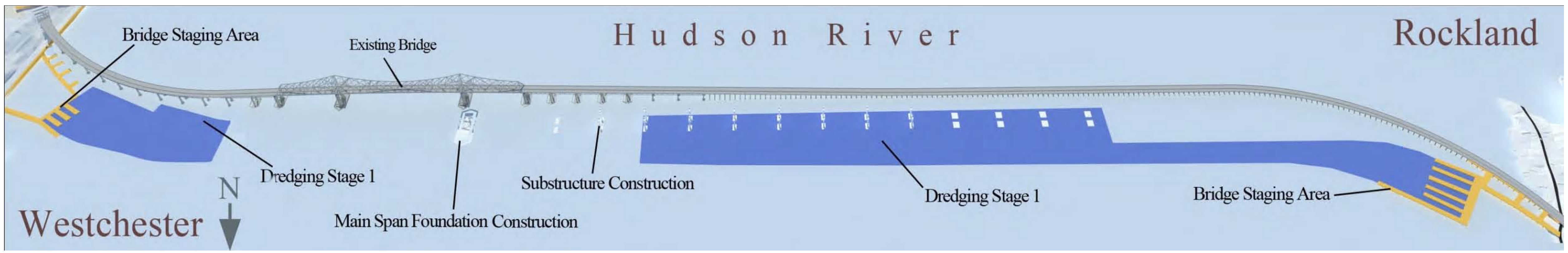


Figure 3.3 - Construction Sequence, Year 1

Activities Year 0-1:
- Site preparation
- Relocation of existing NYSTA facilities
- Dredging period 1 Hudson River dredging
- Construction of access ways, temporary trestle platforms
- Construction of support facilities
- Cofferdam construction
- Pile installation
- Pilecap construction
- Column construction

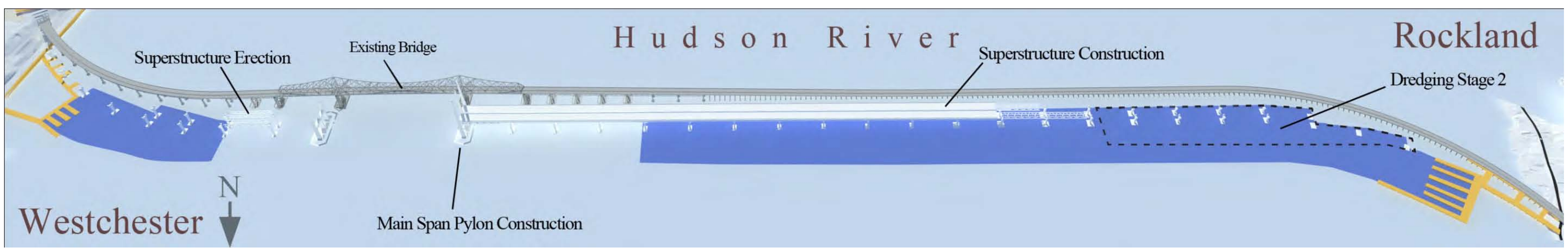


Figure 3.4 - Construction Sequence, Year 2

Activities Year 1-2:
- Dredging period 2 Hudson River dredging
- Continuing cofferdam construction
- Continuing piling installation
- Continuing pilecap construction
- Column construction
- Pylon or arch construction at main spans
- Deck erection primarily in approaches

(Long Span Option depicted, Short Span Option similar)

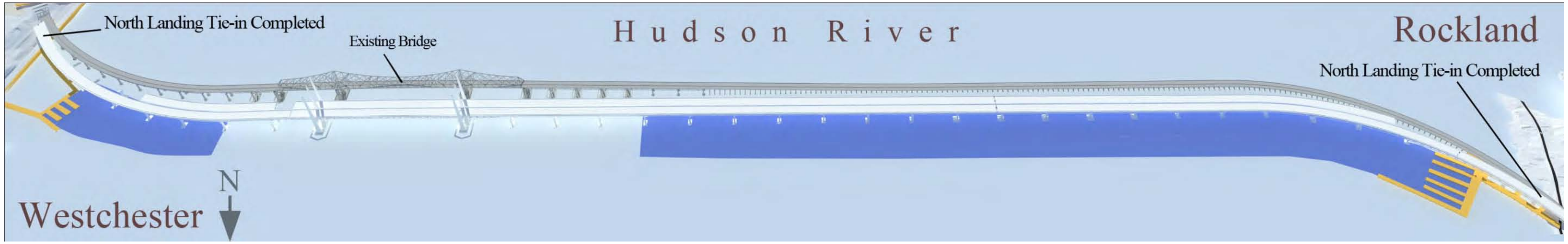


Figure 3.5 - Construction Sequence, Year 3

Activities Year 2-3:
- Continuing piling installation
- Continuing pilecap construction
- Continuing column construction
- Continuing pylon or arch construction at main spans
- North Structure deck erection completed through north tie-ins

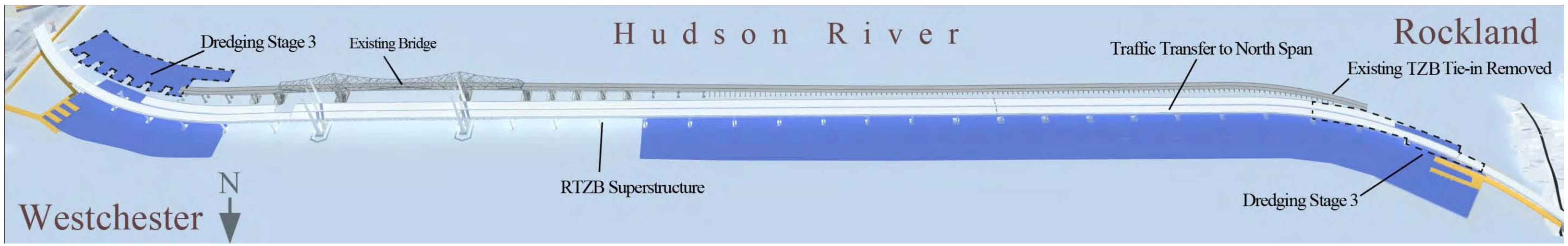


Figure 3.6 - Construction Sequence, Year 4

Activities Year 3-4:
- Transfer of traffic from traffic from existing TZB to north structure of RTZB
- Demolition of TZB tie-ins in near shore areas
- Dredging Period 3 dredging in near shore areas
- Cofferdam construction
- Piling installation
- Pilecap construction
- Column construction
- Deck erection through north tie-ins

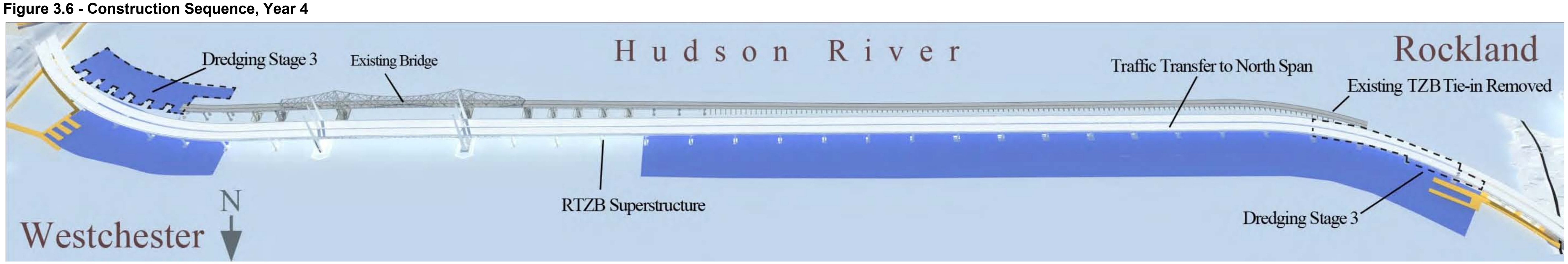


Figure 3.7 - Construction Sequence, Year 5

Activities Year 4-5:
- Deck erection through south tie-ins
- Completion of RTZB in near shore area
- Transfer of traffic to final configuration
- Demolition of the remainder of the existing TZB

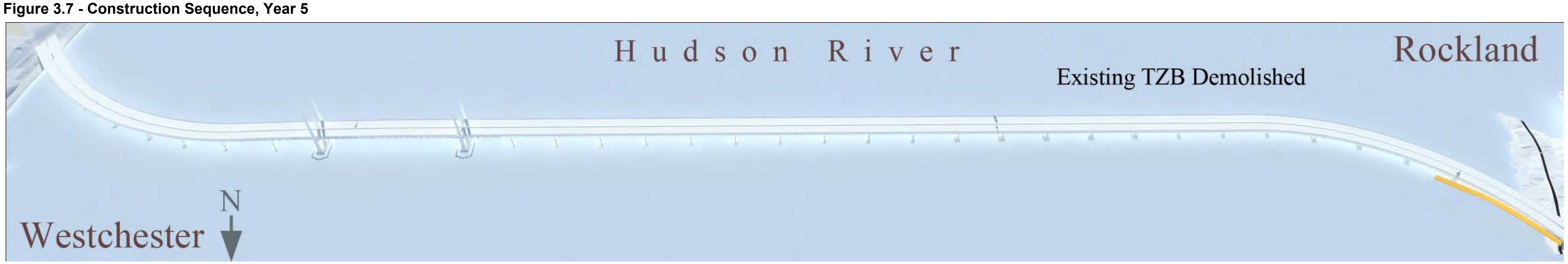


Figure 3.8 – Completed Replacement Tappan Zee Bridge

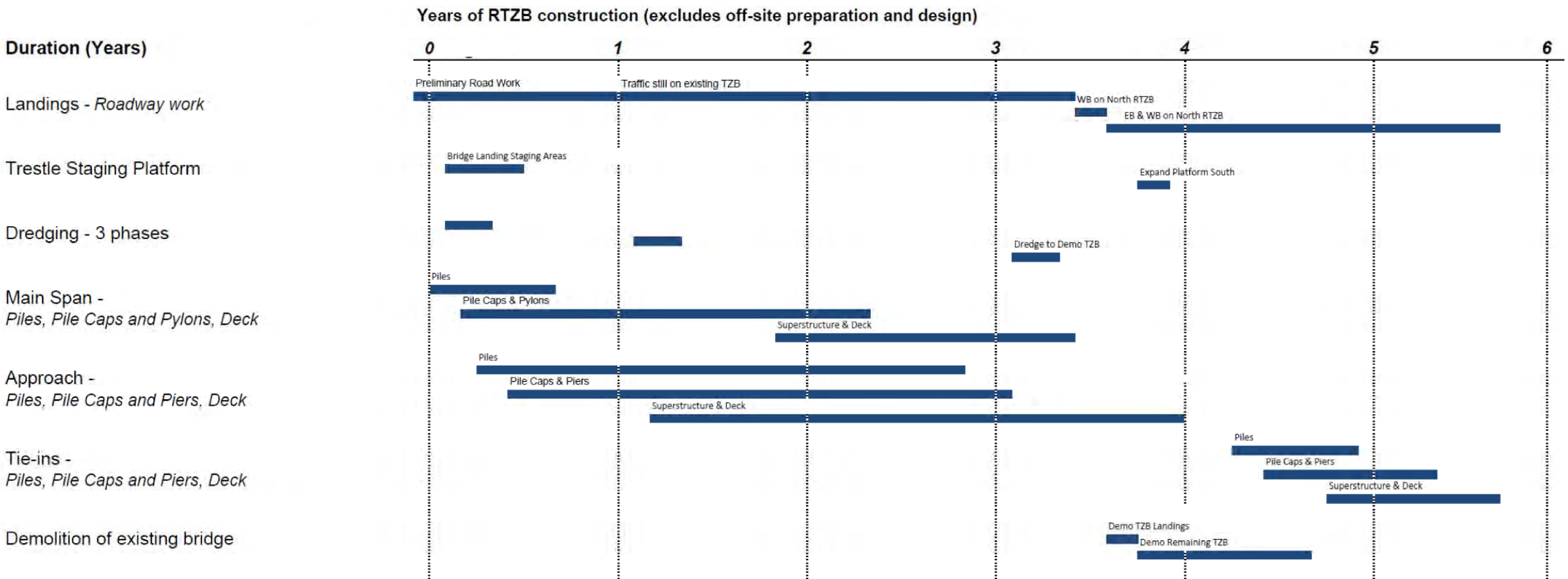


Figure 3.9 - Short Span Global Schedule

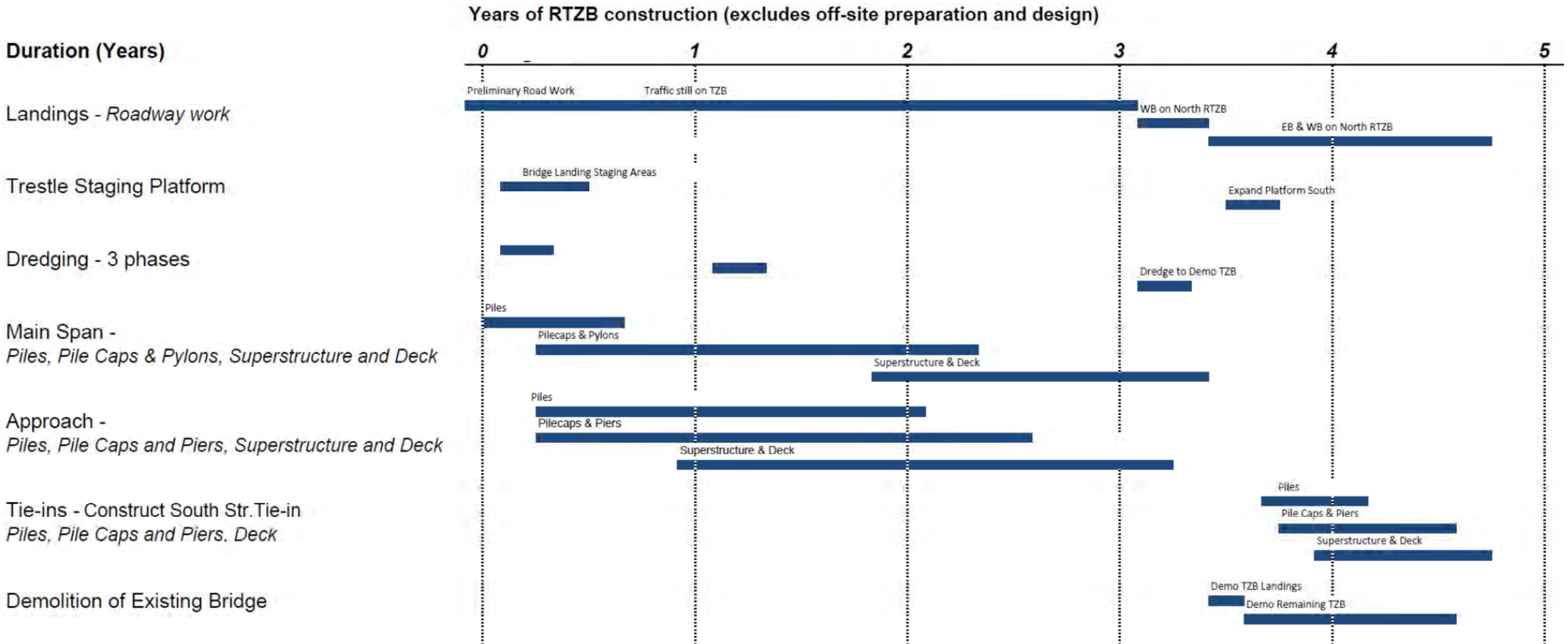


Figure 3.10 - Long Span Global Schedule

4 Preliminary Construction Activities

As soon as the notice to proceed for construction is given, the following two major activities will commence:

1. Setting up of staging areas.
2. Implementation of access to all parts of the proposed bridge. Access will include temporary platform trestles, dredging and haul roads.

This chapter addresses staging areas, access requirements, dredging and temporary platforms.

It is noted that all staging areas are the responsibility of the contractor, and those described within this chapter and the remainder of the report are put forward as potential sites only. The contractor is responsible for the selection of potential staging areas required for the construction of the project, and would be required to obtain all of the necessary permits and approvals for each and any site.

4.1 Staging Areas

Staging areas can be defined as a space in the vicinity of the construction site where a contractor sets up a "base camp" to support the construction activities that take place at the bridge site. Where possible it is preferable for the support facilities to be located in one site adjacent to the bridge as was the case for the San Francisco Oakland Bay Bridge (SFOBB) shown in Figures 4.1 and 4.2. This 26 acre site was located along the approach to the bridge site and contained all the support facilities required.

Operationally, there are three types of staging areas required in the construction of the RTZB. The following types of areas will be needed (possible locations are depicted in Figure 4.3 and further discussion of specific sites is provided in Chapter 0):

1. River Staging Area
2. Bridge Staging Areas
3. Inland Staging Areas

The River Staging Area fronts directly on the Hudson River, has adequate draft for ocean-going barges to dock and laydown area sufficient to handle and store superstructure components.

The Bridge Staging Areas are docks located just north of the RTZB alignment that extend from the Rockland and Westchester shores and support the transfer of crews and material (concrete particularly) to the work vessels supporting the in-river construction. Finger piers extend south from these docks to provide access to construct the near-shore RTZB foundations.

The Inland Staging Areas are located anywhere from ¼ mile to 5 miles from the RTZB and are large enough to accommodate the supporting services and operations necessary to construct the RTZB. These include concrete batch plants, materials storage and lay down areas, crew and contractors facilities, administrative and support facilities, and parking.

4.1.1 River Staging Areas

The River Staging Area is an expansive shoreline area potentially located at some remote distance (1-25 miles) from the RTZB (as the Bridge Staging Areas are too small for this function) that is able to provide river-borne support to the construction of the RTZB. Its principal function is to provide temporary storage and preparation of bridge components prior to erection that may have been fabricated elsewhere. It also provides for materials storage for bulk components, and depending upon distance from the RTZB could support concrete production. Basing of vessels, in-river crews and associated engineering and management oversight functions can be located there as well. Four possible locations in the vicinity of the RTZB have been identified and include the following sites depicted on Figure 4.3:

a. GM site (90 Acres)
b. Hastings-on-Hudson site (30 Acres)
c. Haverstraw Tilcon Quarry site (15 Acres)
d. New York Harbor (various)

Any one, or a combination, of these facilities would be suitable to support the RTZB construction.

Figure 4.1 - Staging Area for San Francisco Oakland Bay Bridge

Figure 4.2 - Concrete batch plant for San Francisco Oakland Bay Bridge

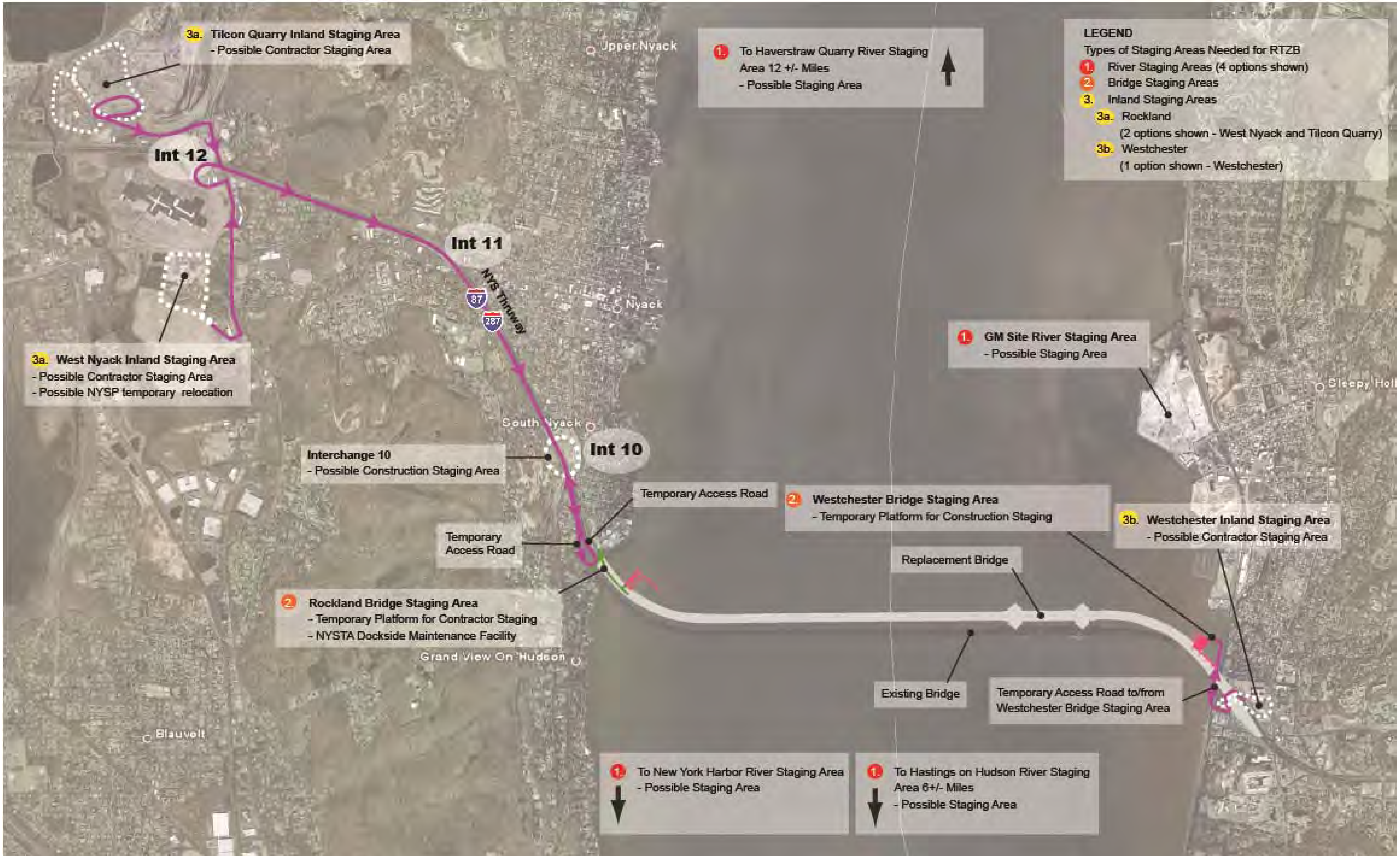


Figure 4.3 - Potential Staging Areas

GM Site

The former 90 acre GM Tarrytown plant is located along the Hudson River just north of Tarrytown, where River St. becomes Beekman Avenue. The site is about 0.9 miles north of the TZB. Redevelopment to convert the currently empty site to other uses has been proposed, although at the current time there is no active project there. The site is separated into two sections by the MNR Hudson Line, and rail yards exist on both sides of the railroad ROW. A review of bathymetry collected as part of the project in 2006 indicates an existing access channel to allow waterborne access to the site. Part of the GM site is a structural slab founded on piles. Prior to using it as a staging area, its load carrying capacity will have to be evaluated.

Road access to the site is limited, via local roads through Sleepy Hollow or Tarrytown to get back to Route 9. Construction of either the temporary access road to the in-river Westchester Bridge Staging area temporary platform would provide a means to directly access the GM waterfront area from I-287, bypassing downtown Tarrytown.

Hastings-on-Hudson

Located about 7.6 miles from the RTZB, this is a private property formerly owned by Anaconda Wire & Cable Company and now is in the process of being remediated. The site is located about 5 miles south of Tarrytown in Westchester between the east bank of the Hudson River and the MNR Hudson Line tracks. The total area of this site is about 30 acres.

If available, this site is ideal as an all encompassing staging area that could include the laydown area, the concrete batch plant, administrative and engineering offices (interconnected trailers) and parking.

With some minor modifications, boat and barge access for this site would be very convenient. Delivery of batched concrete from this site to the farthest end of the bridge is expected to take about 75 minutes which is well within the 90 minute window. From a construction perspective, the site is particularly attractive because provides barge access. The site is also accessible by trucks as well as by rail. Some local dredging may be required for barge access.

Haverstraw Tilcon Quarry

The site is located between Riverside Avenue and the Hudson River at Short Clove Road in Haverstraw, approximately 12 miles north of the TZB. The site is privately owned and currently used by Tilcon as a load-out facility for quarried material. Based on aerial photography and observation, the southern half of the site appears fully utilized by the materials handling operation. In the middle portion of the site are several ponds, which are presumed to be stormwater management features. At an empty area on the north end, heavy construction equipment is presently being stored. North of the Tilcon quarry is a newly built housing development which is connected by a ramp directly to Route 9W. There is existing barge access at the southern end of the site. Truck access would be via Route 9W (and possibly via Route 303) to I-87.

If available, this site offers a good opportunity to locate the laydown area which will use about 15 acres of this site. Convenient access by barge and truck makes this site suitable for deliveries to and from this site. The site, however, may not be suitable for locating a concrete batch plant as the duration of delivery and placement of concrete may easily exceed the permitted 90 minute limit. Therefore this site will also be used in combination with other sites.

New York Harbor

There are a number of sites in the NY Harbor that have adequate draft and sufficient upland area to store and undertake preparation work on RTZB superstructure elements. The travel distance of approximately 25 miles from the RTZB along with the tidal flows would be a cost factor both the delivery of superstructure elements for erection and for the storage of RTZB vessels and the staging of their crews.

4.1.2 Bridge Staging Areas

The Rockland and Westchester shoreline areas under the RTZB are small; hemmed in by adjacent development and on the Westchester side by the MNR's Hudson Line tracks. As a result, the landing staging areas are extended over the Hudson River by temporary work platforms. The landing staging areas provide docking for vessels, facilitate the transfer of material (such as concrete) and personnel and are a work site for preparation of construction elements, such as rebar cages.

To enable continuing maintenance of the existing TZB by NYSTA, the Rockland landing will also support the continued operation of the NYSTA Dockside Maintenance facility and associated watercraft. In addition to the temporary platforms required for construction, approximately 2 acres is provided for vehicle circulation and fabrication at each shore.

The footprint area of the platforms would vary depending on the landing and the bridge option selected.

Rockland Bridge Staging Area (RBSA)

The Rockland Bridge Staging Area (RBSA) would be located on a trestle-type temporary platform at the same location and north of the existing NYSTA Dockside facility which would be accommodated within the RBSA. Its docks would extend north of the RTZB alignment (Figure 4.4). The RBSA would include:

- New ramp and Haul Road access to and from the facility directly from the Thruway
- Docking and roll-on/roll-off facility for vehicle access and materials movement to barges
- Multiple mooring locations to support the approximate 60 barges and 8-10 tugs with crews in the river
- Work platform of approximately 2 acres to facilitate final fabrication of reinforcement cages etc
- Contractor compound including site offices, briefing area, amenities and security gates.
- Temporary and (post-construction) permanent location for the existing NYSTA Dockside facility

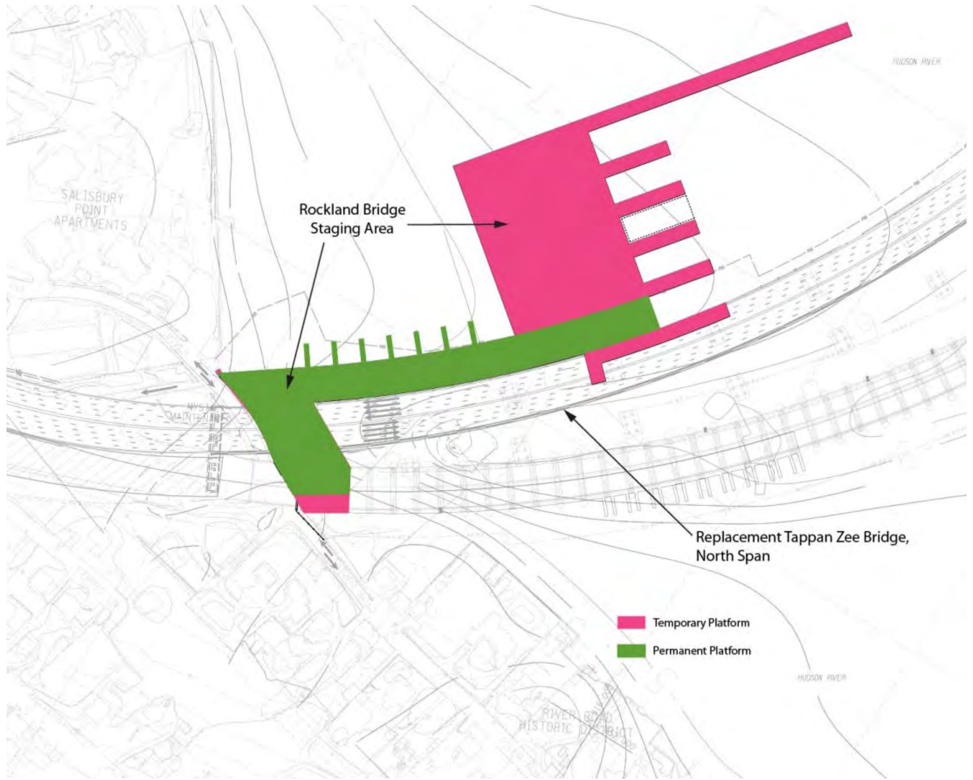


Figure 4.4 - Rockland Bridge Staging Area (RBSA)

Westchester Bridge Staging Area (WBSA)

The Westchester Bridge Staging Area (WBSA) would be located on a trestle-type temporary platform outboard of the MNR Hudson Line track north of the RTZB alignment. The footprint of this facility would extend from the existing TZB to just south of the marina located north of the TZB (Figure 4.5). The WBSA would include:

- Access between the WBSA and the Westchester Inland Staging Area located north of the Toll Plaza in the current NYSTA TZB Maintenance facility.
- Docking and roll-on/roll-off facility for vehicle access and materials movement to barges
- Multiple mooring locations to support the approximate 60 barges and 8-10 tugs with crews in the river
- Contractor compound including site offices, briefing area, amenities and security gates.
- Work platform of approximately 2 acres to facilitate final fabrication of reinforcement cages etc.

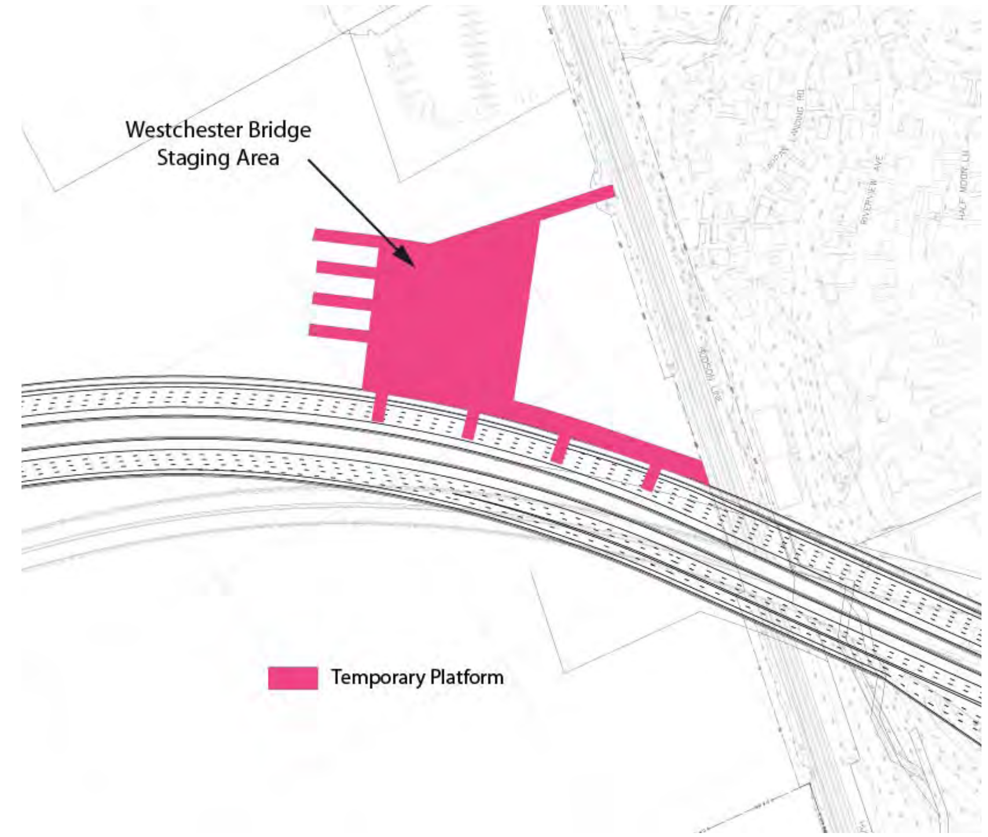


Figure 4.5 - Westchester Bridge Staging Area (WBSA)

4.1.3 Inland Staging Areas

Just as it is more practical for some components to arrive and move by water, it is also more practical for other components to be trucked in, stored, prepared and then brought to the site either by way of transfer at the Bridge Staging Areas, or directly to the point of construction by way of already completed superstructure. This may include concrete from an on-site batch plant, roadway deck for Long Span structures, and conceivably even Short Span superstructure segments for gantry erection.

The Inland Staging Areas will be used to house the following five types of temporary construction and administrative facilities:

- Concrete batch plant – 3 acres
- Temporary storage otherwise referred to as a laydown area – 16 acres.
- Office space for administration and engineering staff - up to 30,000 square feet (0.7 acres)
- Parking for all office and construction staff. – 500 spots – 160,000 square feet (3.7 acres) at 320 square feet per space
- Site services including fuelling, waste management, utilities and security.

Concrete Batch Plant

A complete concrete batch plant facility is expected to occupy a total area of 3 acres (Figure 4.2). The actual machinery of the concrete batch plant, by itself, occupies a rather small footprint, however it is the storage of raw materials, such as fine and coarse aggregates, cement, admixtures and water that takes up much of the space.

Construction specifications require that fresh concrete be poured in place within 90 minutes of being batched. This criterion would dictate the maximum distance of the batch plant from the farthest end of the bridge. Concrete trucks from the Inland Staging Area facility would travel to the bridge site via the Thruway or partially on Route 59 where they would access the landing facility and potentially use a roll on-roll off ferry system to bring the concrete truck on a barge to the delivery point in the river.

Laydown/Storage Area

Unassembled construction equipment would be delivered to the laydown area and will be assembled prior to delivery to the bridge site. This may include elements of crawler cranes, segments of tower cranes, segments of overhead gantries, foundation truss templates, pneumatic hammers, large deliveries of timber for formwork construction.

Light duty bridge elements such as sheet piles, reinforcing bars, prestressing and stay cables, may be delivered here as well. Reinforcing bar cages for columns or piles may be fabricated here prior to installation at the site. Electrical and mechanical equipment may be stored here prior to installation on the bridge. The site would be equipped with its own fleet of moderate size straddle cranes and crawler cranes to handle materials and equipment described above.

Additionally, this site may be used for assembling mock ups necessary for ironing out conflicts in complicated construction details. Training on technically complex tasks such as prestressing operations, grouting and complex welding procedures may be imparted here. A multitude of material tests required by the construction specification may be conducted in this area.

This site is unlikely to be used for storage of fabricated steel trusses required for the Long Span bridge decks, or for the storage of concrete segments required for the Short Span bridge deck. Storage of piles in this area is also unlikely. These materials are expected to be delivered from the manufacturer or the fabrication yard either to the River Staging Area or directly to the bridge site without the need for temporary storage.

Office Space

Up to 30,000 square feet of office space is anticipated for construction administration and engineering staff and for office equipment. This assumes up to 200 office personnel.

Parking

At the peak of the project a crew work force between 350 (Long Span) to 600 (Short Span) strong is anticipated on the construction site. Additional workers and oversight personnel will be needed in the staging areas and offsite fabricating yards. Parking facilities for up to 500 cars is anticipated. All parking would be located in either the Westchester or Rockland Landside facilities with personnel brought to the bridge site by bus along the Thruway.

NYSTA and NYSP Facility relocated from Westchester

A combined NYSTA and New York State Police (NYSP) facility currently exists at the Thruway touchdown area above the Westchester landing, just north of the TZB Toll Plaza. It encompasses a NYSTA maintenance yard, an emergency vehicle storage yard, NYSP facilities and parking facilities. The approximate total area of this site is 4.5 acres.

It is likely that the current NYSTA and NYSP facilities will be relocated to a site within the NYSTA right-of-way for the duration of construction of the bridge. A number of alternative options have also been identified for the relocation, including the (West Nyack Staging Area) WNSA and Tilcon Quarry Staging Area (TQSA) sites described below. Once construction is completed, NYSTA and NYSP could be relocated back to the Thurway touchdown area at the Westchester landing.

Possible Inland Staging Area Sites

A number of locations have been identified as possible sites for an Inland Staging Area (Figure 4.3). In Westchester, the area currently occupied by the NYSTA TZB maintenance facility is intended to be used as the Westchester Inland Staging Area (WISA). In Rockland two potential locations have been identified for the Rockland Inland Staging Area (RISA):

a. West Nyack Staging Area (WNSA) site, located south of the Palisades Mall
b. Tilcon Quarry Staging Area (TQSA) site, north of Interchange 12

Westchester Inland Staging Area (WISA)

This site makes use of the triangle of land located north of I-187 opposite the Toll Plaza. This site is currently used by the NYSTA's TZB maintenance facility, Bridge Patrol, Equipment Maintenance, along with the NYSP Troop T unit. It is anticipated that these operations will be relocated to another site within the NYSTA right-of-way, such as Interchange 10, and/or the site selected for the Rockland Inland Staging Area. The site also contains a westbound on-ramp from southbound Route 9. As volumes on this ramp are low and the movement is redundant within Interchange 9, this ramp will not be operational during RTZB construction.

Highway access to the site is available directly from the westbound I-287 shoulder, from South Broadway via Interchange 9, and from eastbound I-287 by a short restricted use ramp leading to the administrative area south of the Toll Plaza. From there, a north-south access road under the TZB provides access to the WISA north of I-287.

Access from WISA to WBSA makes use of the north-south access road under the TZB to move trucks to the south side of the TZB. From there a temporary Haul Road will be constructed to bring trucks over the MNR Hudson Line and down to the WBSA (Figure 4.7).

West Nyack Staging Area (WNSA) Site

The West Nyack site is located near Interchange 12 just south of the Palisades Mall at the intersection of Route 59 and Route 303. It is 3.7 miles from the RBSA. This site occupies an area of about 33 acres and part of it is presently occupied by a concrete batch plant. It is considered suitable for a land based staging area of 28.5 acres for the construction of the bridge.

To access the RBSA, and thus the bridge, vehicles from this site will travel on Route 303 and enter the Thruway at Interchange 12. Vehicles will exit the Thruway via a temporary ramp located west of the TZB. From there, they will drive onto River Road, pass under the existing TZB and drive onto the temporary platforms of the RBSA from where they will either deliver their payload to waterborne vessels or, as in the case of concrete trucks, drive directly on to barges by way of the docks. Delivery of batched concrete from the West Nyack site to the farthest end of the bridge, i.e., Tarrytown abutment, is expected to take about 90 minutes.

The relatively large area of this site allows it to be used for office trailers and parking lots as well. The light duty items discussed in section 4.1.2, such as smaller rebar cages, may be assembled or stored here. This site may not be suitable for heavy duty bridge elements and construction equipment which cannot be trucked on the Thruway either because of their weight or bulk.

Tilcon Quarry Staging Area (TQSA) Site

Directly north of the Thruway and opposite the Palisades Mall, is an exceptionally large quarry site operated by Tilcon. This site measures approximately 120 acres. It is presently in operation; however, it may be feasible to lease a portion of the site for the duration of the construction. It may also provide the material to be used in the construction of the RTZB. Adjacent to the site is the CSX West Shore Line. If the quarry site itself is unavailable, an alternative site at this location could be put together from the commercial properties (currently used for waste haulage) located adjacent the quarry, west and south of Snake Hill Road, the access road to the site.

Access to and from the TQSA to the RTZB would also be via Interchange 12 and along the Thruway.

Interchange 10

The vacant land included within the footprint of the existing interchange may be utilized for construction support for the RBSA, or for the relocation of NYSTA and NYSP facilities during the temporary phase. This site measures approximately 7.4 acres.

4.1.4 Access Requirements

Access to all parts of the RTZB and its surroundings is essential for its construction. The key access requirements for this project are anticipated to be as follows:

1. Delivery of heavy duty bridge elements, e.g. steel piles, superstructure concrete segments and superstructure steel truss segments, directly from their offsite fabrication facility or waterside staging area to the bridge site point of construction (POC).
2. Allowance for movement of barge mounted cranes to enable erection of heavy bridge elements at the bridge site POC.
3. Delivery of raw materials for batching of concrete to a dedicated concrete batch plant.
4. Delivery of batched concrete from the concrete batch plant to the bridge site POC.
5. Delivery of unassembled construction equipment, e.g. constituent elements of gantries, tower cranes, crawler cranes, foundation templates, form work, pneumatic hammers etc., from manufacturers and suppliers to the laydown landside staging area.
6. Delivery of construction equipment, e.g. assembled gantries, tower cranes, crawler cranes foundation templates, form work and pneumatic hammers, from the landside staging area to temporary platforms and thence to the bridge site POC.
7. Delivery of light duty bridge elements, e.g. sheet piles, reinforcing bars, cables and miscellaneous structural steel, mechanical and electrical elements, from manufacturers and suppliers to the staging area.
8. Delivery from the staging area to the bridge site temporary platforms then POC of light duty bridge elements e.g. assembled reinforcing cages, assembled cables in their installation configuration and other items described above.
9. Transportation of construction personnel from parking to multiple bridge site POCs.

The annual allowable time period for dredging in the Hudson River is brief, thus limiting the quantity of dredging that can be accomplished in a given year. As a result, the dredging will be conducted in annual stages from deeper water towards the shores and the bridge will be constructed from the center of the shipping channel moving west and east towards the shores.

To minimize the quantity of initial dredging and enable shoreline access to construct the foundations of the RTZB, it is anticipated that access will be provided by a combination of barges moving in a channel dredged along the alignment of the RTZB and construction vehicles moving on a trestle-type temporary platform structure extending 1200-1500 feet from both shorelines out to deeper water.

Access to construct the bridge will thus have a water borne component for which it will be necessary to dredge an initial access channel (where water depths are inadequate to provide requisite clearance under barges and the propellers of the tugs that move them) to the temporary platforms.

Rockland Access

As shown in Figure 4.6, for the construction of the RTZB, it is anticipated that the existing NYSTA access ramps from the Thruway to River Road will be employed to provide access from staging areas west of and including Interchange 10 to the RBSA. The existing westbound NYSTA access ramp from River Road to the Thruway will also be employed to provide access from the RBSA to the RISA.

From the RBSA, a channel will be dredged to provide an accessway from the docks at the staging area to the initial worksites in the deeper portions of the Hudson River. Seasonally, each year a portion of the worksites in shallower water will be dredged to progressively provide access to pier locations approaching the Rockland shoreline. At the shallowest locations, immediately proximate to the shoreline, access to pier locations will be provided by temporary platforms that branch from the RBSA.

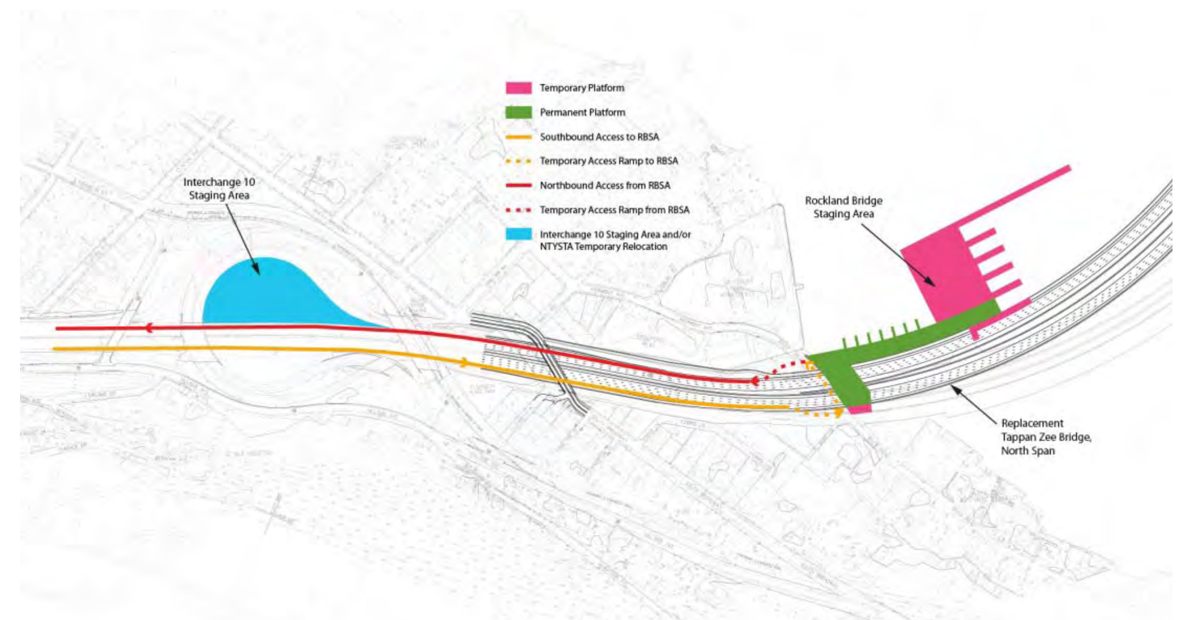


Figure 4.6 - Rockland Landing Construction Access

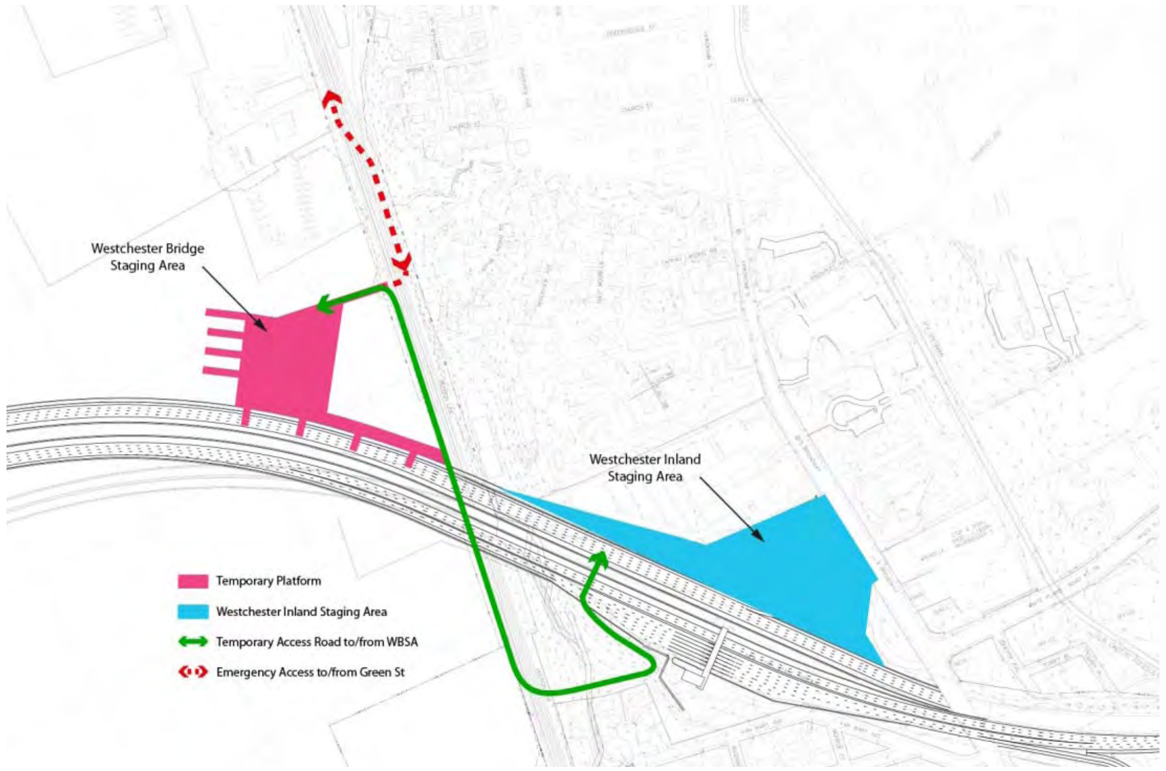


Figure 4.7 - Westchester Landing Construction Access

Westchester Access

As shown in Figure 4.7, to reach the WBSA from the WISA, it is first necessary to upgrade the connection from the existing NYSTA Bridge maintenance area located north of the Toll Plaza (which will become the WISA) to the NYSTA Highway Maintenance area south of the Toll Plaza. From south of the Toll Plaza a temporary access road with a crossing over the Hudson Line which then descends down to the WBSA will be constructed. This temporary road will be almost entirely on structure would be approximately at elevation 80 feet where it crosses the Hudson Line and will have to support concrete trucks for thousands of trips. From the WBSA, a broad channel will be dredged to provide access and manoeuvring space around the pier locations on the Westchester side that presently would be in shallow waters. Emergency access to/from Green Street will also be provided.

4.2 Dredging and Armoring

To provide access and safe operating conditions to construct and erect the new bridge, it is necessary to create a channel along the alignment of the proposed RTZB structure. Vessels will need to move freely from the shorelines to the bridge work sites, and will need to have a suitable working area around the foundations and under the alignment of the RTZB. Dredging will also be required to provide access and remove the existing TZB as it is demolished. Because the water is shallow along two-thirds of the new bridge alignment it will necessary to dredge material from the river bottom.

Before settling on the choice of dredging and its configurations, two alternate construction methods wherein dredging could have been avoided were evaluated. These include the use of overhead gantries for construction of foundations and the implementation of a full length temporary trestle for access.

Both of these alternates were found to be impractical: the former because of its lack of track record with the heavy duty piling anticipated for the proposed RTZB and the latter because of insufficient strength of the upper layers of soil to economically support temporary structures.

Tug boats are used to push, pull and manoeuvre a variety of delivery and crane barges operating at the construction site. Between seven to ten tug boats and upwards of seventy barges may be operating at any time during peak construction periods.

Because the soils of the river bed are so soft, it is easy for the material to be stirred up by the propellers of tug boats and other construction vessels. This would lead to increased levels of turbidity, which could significantly impact the various aquatic species that inhabit or pass through this portion of the Hudson River. To avoid stirring up the river bottom, the bed of the dredged channel will be armored with a 2-foot layer of sand and gravel so as to significantly reduce the potential for scouring of the river bed sediment caused by the movement of vessels. Absent this armoring, the depth of dredging necessary to assure similar non-disturbance of the river bottom would have had to be increased on the order of 10 feet or more.

Preliminary investigations have indicated that dredging will be carried out in three stages spread over three permitted annual dredging windows. Duration for the dredging operation at each stage is not expected to exceed 90 calendar days.

A total of approximately 1.8 million cubic yards (CY) of material for the current design options is anticipated to be dredged during the construction of the RTZB.

Available test results indicate that at least 80 % of the dredged material will qualify for disposal at the Historic Area Remediation Site (HARS) described further in section 4.2.11 Disposal Strategy. The remainder of the material, which may contain contaminants, will be transported to an available permitted upland site where it will be treated and then transferred to an appropriate disposal site.

4.2.1 Basis for the Configuration of the Dredged Channel

The configuration of the dredged channel depends on many factors, chief among them the nature of the vessel movements. The width of the channel is influenced by the size of the barges and tugs and the anticipated vessel traffic in the channel. The depth is influenced by the draft of the vessels and the choice of armor is guided by the potential for propeller induced scour of the river bed sediment.

This section reviews the construction procedures that influence the design configuration of the dredge channel. Complete details of the construction procedures are given in Chapters 5 and 6.

The Dredging Itself

A variety of equipment may be used for the dredging including barge mounted cranes with specialized clamshell buckets and hopper scows to contain the material for transport. The depth of these hopper scows is significant and they must be able to freely move through the channel whose dredging they are supporting.

Foundation Construction

Construction of foundations involves installation of cofferdams, installation of driven circular steel piles, mucking out the piles, placement of a concrete water seal using tremie methods, dewatering, installation of reinforcing bar cages and formwork, and, finally, a substantial concreting operation required to pour the piles and the pile cap followed by removal of the cofferdams. Figures in Chapter 5 illustrate the nature of the tasks to be performed for foundation construction. Within the context of dredging, the most notable features of foundation construction are the use of large barge mounted cranes to lift, place and drive piles, barges carrying deliveries of fabricated piles, tug boats, support barges and concrete barges.

Deck Erection

Two superstructure erection methods have been considered in this report:

- Segmental Erection Using Gantry

  This method of construction would be suitable for the Short Span Option. Precast deck segments would be assembled to construct the deck. Segments would be the full height and width of deck and 10-15 feet long with 15-23 segments required to complete a single span. Multiple segments would be delivered to the bridge location on a single barge. A gantry spanning across multiple piers would lift and place segments directly from the barge below.

- Whole Span Erection Using Winches

  This method of erection would be suitable for the Long Span Option where superstructure spans will likely be comprised of prefabricated steel truss decks. The majority of a truss span would be erected from winches attached to smaller truss segments that are initially lifted in position atop piers using cranes. The majority of a span can be brought to the bridge location upon a barge, slotted into position using tugs, then lifted into position and secured.

It is recognized that many other alternative erection methods are also feasible with more available options for the Short Span Option than for Long Span Option. Alternative erection methods may result in an alternative structural design as well.

The two erection methods described above, segmental and whole span, represent likely construction scenarios leading to realistic estimates of dredging quantities.

4.2.2 Design Vessels

Based upon the construction procedures, the following vessels were identified as design vessels representing an upper range of the type of vessels that would operate in the channel during construction.

Crane Barge

The critical crane barge considered for this analysis was the Weeks 533 barge. This is the largest floating revolving heavy lift crane presently on the eastern seaboard. It has the following characteristics:

- Hull length: 300 feet
- Breadth: 90 feet
- Depth: 22 feet
- Operating Draft: 7 feet
- Maximum Draft: 10.5 feet.
- Crane type: Clyde revolver Model 52
- Capacities:
  - 210 foot boom – 500 tons at 70 feet full revolving
  - 290 foot boom – 225 tons at 90 feet full revolving.

Conversations with operators of this barge indicate that up 10 to 10.5 feet of draft may occur at corners of the barge when the crane is revolving with its full load.

This crane may be necessary for hoisting the large diameter piles and handling the hammer during pile driving. It may also be necessary for the erection of the superstructure pier segments of the Long Span Option. The contractors may choose to use such a crane for hoisting the column rebar cages; however, smaller cranes would likely be suitable. A draft of 11 feet has been considered for this analysis taking into consideration the possibility of using even bigger crane barges such as the 700 Ton DB General owned by Kiewit on the west coast.

A 3-foot clearance between the bottom of the barge and the top of channel armoring during a heavy lift is considered reasonable for this crane barge.

Tugs

A variety of tugs are expected to be used on this project. Their propulsion capacities are expected to range from 800 to 1800 horsepower. It is likely that the crane barges would be steered with two tugs when moving in the dredge channel. A possible combination could be a 1200 HP tug on the sides for steering and an 1800 horsepower tug for the longitudinal push.

For this analysis Weeks Marine's Shelby tug has been used and it has the following characteristics:

- Propulsion capacity: 1800 horsepower
- Length: 73 feet
- Beam: 24 feet
- Vertical clearance: 37.75 feet
- Standard Operating draft: 8 feet
- Maximum draft: 10.5 feet
- Propellers: two 72 inch diameter 4 blade stainless steel
- Maximum Speed : 11 knots
- Cruising speed: 9 knots

Hopper Scows

Hopper scows, driven by tugs, will be used for removing the spoil material from the dredge channel. The spoil material will either be transferred from the hopper scows into ocean dump scows or to upland treatment facilities. The larger, deeper draft ocean dump scows would be moored in the deep water sections of the river and would not enter the dredged channels (thus are not considered for a design vessel). Details of the disposal strategy are provided in subsequent sections of this report.

The following Weeks Marine Hopper scow was considered for this analysis:

- Maximum Capacity: 2500 Tons
- Maximum Volume: 2500 CY
- Length: 250 feet
- Breadth: 47 feet
- Max Possible Draft : 13 to14 feet
- Max Allowable Draft : 12 feet

A maximum allowable draft of 12 feet is assumed. This draft will be achieved by imposing a restriction on the maximum load carried by the scow. The Weeks scow, described above, loaded at about 80% of its full capacity is expected to meet the 12 foot draft requirement.

4.2.3 Channel Depth and Clearance

Based upon the maximum allowable draft of the aforementioned design vessels, a nominal maximum draft of approximately 12 feet is identified. This includes the swing depth of the crane barge under heavy load, and the fully laden depth of the hopper scows. To avoid any potential for grounding, an additional clearance of 2 feet is added leading to a working channel depth of 14 feet. This distance provides a typical clearance of 6 feet under the propellers of the tugs, and a minimal clearance of 3.5 feet for the same. These clearances are anticipated to provide satisfactory dispersion of the hydraulic energy of the propellers while producing minimal disturbance to the protective armoring layer.

The clearance under the propellers was selected after exploring its relationship with possible stone sizes. Local scour analysis was conducted with clearance values of 2, 3 and 4 feet in conjunction with the two stone sizes. Since, to minimize dredging quantities, the target value for clearance should be the minimum feasible, it was determined - in consultation with maritime experts including Dr Don

Hayes of University of Louisiana - that neither the larger nor the smaller stone offered any distinct advantage in terms of reduction in clearance. While the smaller stone was attractive from the point of view of safety of the tug operations, at smaller clearance, it was found to be, not surprisingly, more vulnerable to being dislodged by the propeller jet than the larger stone. While the larger stone was more stable and less vulnerable to being dislodged by the propeller jet, it was considered a hard bottom and, therefore, a safety hazard, if used with a smaller clearance. Based on these reasons, the smaller stone – ¾ inch crushed stone or 1 inch river gravel – was eventually chosen.

A minimum clearance of 3.5 feet under the tug propellers was considered appropriate based on insight gained from the local scour analysis. It was recognized that this clearance would be reached very infrequently during the course of construction and even if it was exceeded accidentally, and the propeller were to make contact with the stone, the small stone would be unlikely to damage the tug.

4.2.4 Armoring

A crushed stone size of ¾ inch (or a gravel size of 1 inch) was selected after comparing it with larger stone sizes of up to 6 inches. The smaller size was selected because avoids a hard bottom and it lends itself to placement and maintenance much better than the larger rock.

If the need for maintenance dredging arises due to re-deposition of sediment in the years after the initial dredge, the smaller stone will be far more conducive to the use of maintenance dredging equipment such as clamshell buckets. If maintenance dredging was found necessary, it would be performed during the permitted dredging windows.

Creating and maintaining a flat surface using appropriate underwater rakes is much easier with the smaller gravel size than it is with the larger stone size. While adequate clearance will be provided to prevent it, it is possible that in selected areas where high thrusts are required routinely, the stone may get dislodged from the force the propeller jets resulting in an undulated shape of the channel bed. Both the larger and the smaller stones are susceptible to this action but the ability to be conveniently raked back to its original grade makes the smaller stone size a more favorable choice for armor.

The smaller stone size, proposed for this channel, is also much safer for construction vessels in the rare event that a tug propeller or the hull makes accidental contact with the channel bed.

A rock/gravel layer of approximately 1-1½ feet will be placed on top of a 6 inch layer of sand layer placed directly upon the dredged surface of the soil. The sand's purpose is to prevent the stone from sinking into the upper sediment whose shear strength is known to be extremely small.

4.2.5 Depth of Dredging

The dredging depth is one of the most important factors that influencing the total quantity of the dredged material. The depth of the dredging is determined by the following (Table 4.2):

- A working channel depth of 14 feet
- The 2-foot thickness of the armor.
- The lowest water condition

Because the Hudson River in the area of the RTZB is tidal, the lowest water elevation is not determined by the rainfall influenced flow of the Hudson River itself, but by the ocean driven tides of the Hudson bight. The greatest tidal range occurs during the Spring Neap Tide, when the sun and moon and inclination of the earth are aligned. This water elevation, referred to as Mean Low Low Water is -1.89 below datum.

The bottom of dredged channel elevation is determined to be -17.89 feet corresponding to 16 feet below MLLW. An additional foot depth of over dredging has been allowed for in calculating the overall volume of removed soil, taking the channel elevation down to -19 feet (see Table 4.2).

	Barge Crane	1800 Hp tug	Hopper Scow
	feet	feet	feet
Maximum Draft	11	10.5	12
Clearance 2		3.5	2
Required Channel Depth	13	14	14
Adopted Channel Depth	**14**	**14**	**14**
Armoring 2		2	2
Dredging Depth	16	16	16
MLLW Elevation	-1.89	-1.89	-1.89
Dredging Elevation	**-17.89**	**-17.89**	**-17.89**
Over dredge*	1	1	1
Paid dredging depth	-18.89	-18.89	-18.89

*Customary over cut to ensure target dredge depth
All dimensions are in feet. Elevations are NAVD88

Table 4.2 - Dredge Channel Depth Details

4.2.6 Channel Width

A required dredge channel width of 523 and 473 feet has been estimated for access and manoeuvring of construction and delivery barges and tugs for the Long and Short Span respectively.

Thus the portion of the channel outside of the footprint of the new bridge has a width of 250 feet for the Short Span Option and the portion of the channel outside of the footprint of the new bridge has a width of 300 feet for the Long Span Option. It is in this part of the channel where free movement of barge and tug traffic will occur. This access way has been set on the north side of the bridge.

It is anticipated that if a larger craft, such as the 300 x 100 foot Crane Barge is moving in this part of the channel, other barges will not be permitted to pass or cross it. For the smaller craft, however, such as the concrete barges and the vast majority of the vessels on the job, two-way traffic will be the norm.

The choice of the width of the channel reflects the assumption that the movement of larger vessels, such as the 300 x 100 foot barges is infrequent and the one way traffic condition imposed by such a vessel movement is also infrequent. Barge traffic in the channel will be monitored and controlled closely. Advantage will be made of the large lengths under the spans where appropriate water depths are available and where vessels could be shifted briefly in case traffic congestion does occur.

As for the adequacy of the channel for the large vessel alone, consideration has been given to the fact that such a barge is often accompanied by a tug at the stern for propulsion and a tug on the side for steering. Consideration is also given to the effect of wind on the barges carrying large payloads, to cross water currents of up to 3 knots and to the bends in the channel near the shores that require more intricate manoeuvring of the watercraft.

The larger 300-foot width of the access-way for the Long Span Option reflects the fact that the use of the 300 x100 barges are more likely to be used in the case of this bridge type than in the case of the Short Span Option. It allows for the delivery of larger trusses on tandem barges which may be a more complex operation relative to the delivery of smaller concrete segments on single moderate size barges.

4.2.7 Side Slopes

The steepness of the slope was developed upon geotechnical evaluations of the soil which have established that while the upper sediment is extremely soft, it does possess a small but finite amount of shear strength. The slope of 1:10 is an angle of repose corresponding to its low shear strength and will be attained by the soil in a natural way.

A slope of 1:10 will be assumed for edges of the dredged channel. The armor will extend only about 20 feet into the slope measured from its toe. For normal operations, tugs and barges will not be permitted to veer into the slope

4.2.8 Configuration of the Dredged Channel

Typical sections of the dredged channel for the Short Span and the Long Span options are shown in Figures 4.8 and 4.9. The overall layout of the dredged channel including the three stages of dredging is shown in Figure 4.12. The details of the dredging channel including multiple sections are shown in Appendix A.

Notable aspects of the channel are as follows:

1. The overall depth of water available for navigation would be 14 feet measured from the Mean Low Low Water (MLLW, Spring neap tide) elevation of -1.89 feet. [All elevations are based on North American Vertical Datum, 1988 (NAVD88)].
2. The dredged channel bed elevation will be at -17.89 feet. The Stage 3 "demolition" dredging near the Westchester shore would be dredged to -14.89 feet.
3. The channel bed would be armored with a 6 inch thick layer of fine grain sand overlain by a 1½-foot thick layer of either 1-inch rounded river gravel or ¾-inch crushed stone.
4. The typical channel bed width will be 523 feet and 473 feet for the Long Span and Short Span options respectively. In the case of the Long Span Option, the width of the channel under the footprint of the replacement bridge will be 217 feet leaving 300 feet for vessel traffic. In the case of the Short Span Option, the width of the channel under the footprint of the replacement bridge will be 244 feet leaving 250 feet for vessel traffic.
5. The side slopes of the channels in both cases would be 1:10.
6. Near each shore, the width of the channel would flare to accommodate a temporary docking facility with multiple slips including slips for the NYSTA bridge maintenance vessels.
7. With the exception of the demolition dredging discussed above, all dredging would take place under the footprint of the RTZB and its north.

The following (Table 4.1) summarizes the quantity of material expected to be dredged.

Note that the quantity represents 1 foot of over-dredging which may occur because of lack of precision in the dredging equipment. This additional quantity is typically included and paid for in most dredging contracts.

Critical Project Depths	Proposed Project Dredging Depths (MLLW)	Stage 1 (M CY)	Stage 2 (M CY)	Stage 3 (M CY)	Total
Proposed Project Dredging Dpeths	-16.00 (-15.89)	1.01	0.32	0.22	1.55
Dredgingh Overdepths (1ft allowance)	-17.00 0.12		0.06	0.03	0.21
Total Maximum Dreding Depth	-17.00 1.13		0.38	0.25	1.8

*Dredging for bridge demolition includes that portion of the bridge which must be removed to complete the RTZB tie-in.

Table 4.1 - Dredging Quantities for RTZB Options

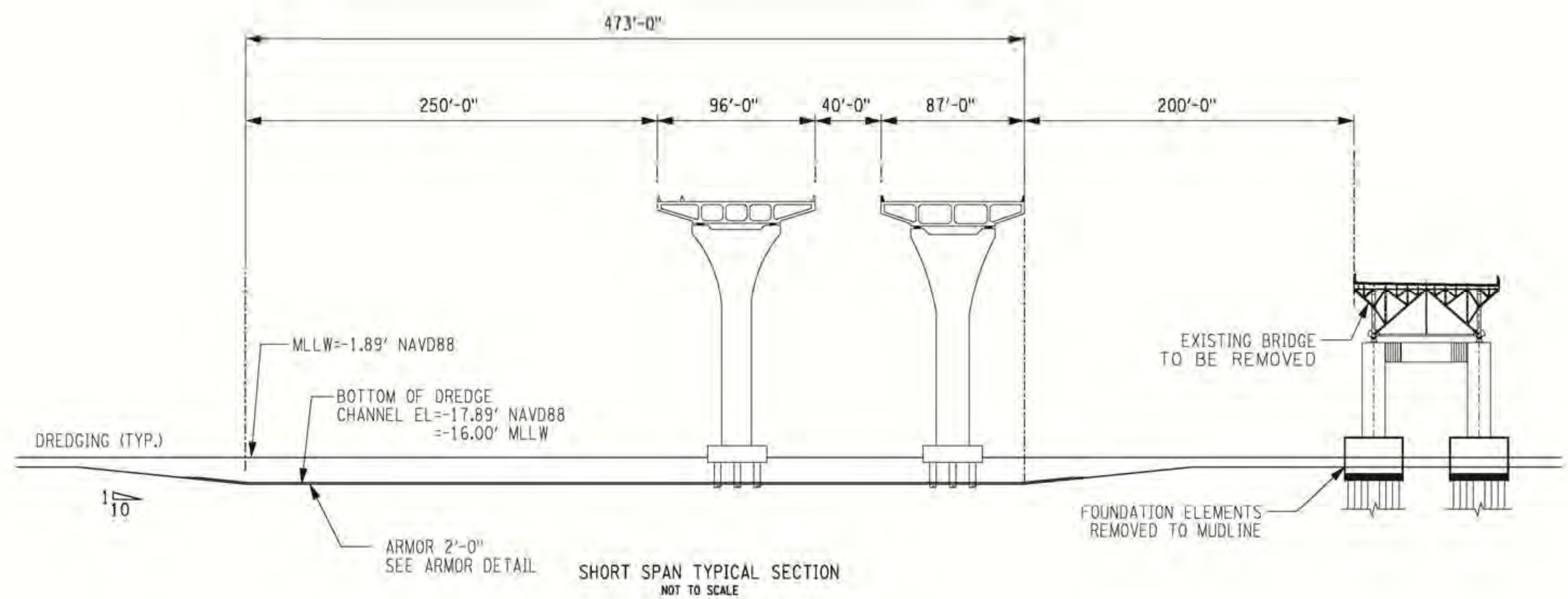


Figure 4.8 - Dredge Channel for Short Span Bridge Option

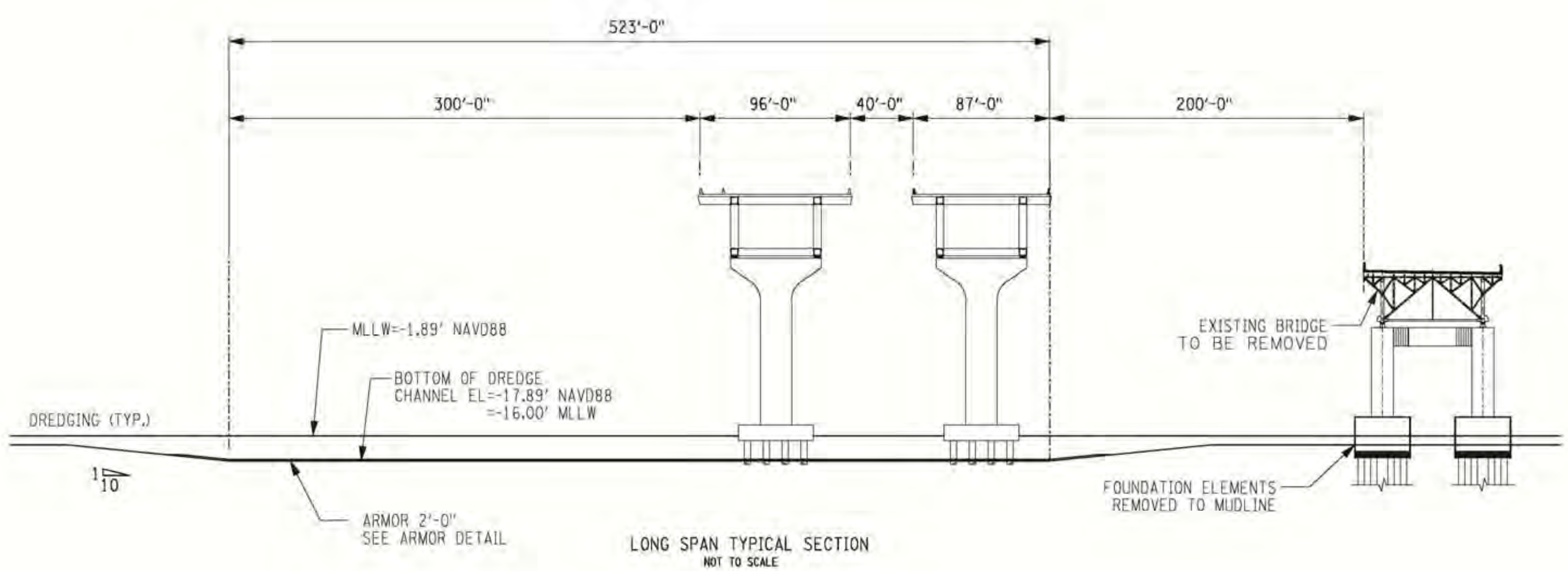


Figure 4.9 - Dredge Channel for Long Span Bridge Option

4.2.9 Dredging and Armoring Procedure

The dredging procedure is summarized in Figure 4.10 and Figure 4.11. Dredging would occur in 'lifts.' The first lift would remove the upper industrial era contaminated material across the extent of the dredge prism for that stage. This material would be segregated and disposed of at a permitted upland treatment and disposal site (as described in section 4.2.11). Subsequent lifts would remove the underlying uncontaminated material. Dredged material would be placed in hopper scows which would transfer the material to the appropriate disposal site as described below.

For a given section of the channel, the installation of the armor material will take place as soon as dredging for that section of the channel is satisfactorily completed. The armor material will likely be delivered on barges or scows and barge mounted cranes will deposit it where it is required. A raking operation will then be performed to level the surface within tolerances.

The armor material need not be removed after construction. It is anticipated that with time, it will be fully buried by the gradual re-deposition of river sediment.

4.2.10 Dredging Stages

While it would be ideal to complete all the dredging at once, this might not be possible. Dredging, despite advances in technology to minimize the loss of material during excavation, does experience losses that lead to suspended solids and turbidity in the water. While loss rates on the order of only 1 percent of removed material are achievable, the quantity of dredging is still significant. Based upon identified concerns related to the migration and spawning of the numerous fish species in the Hudson River, it is anticipated that dredging will be permitted during only a limited period of time. A nominal period of 3 months from 1st August through 1st November has been assumed for the purposes of the DEIS and the development of the construction schedules herein.

Because the dredging effort involves not merely the removal of material but also the placing and distribution of an armor layer, dredging production will be slower than typical. To encompass the significant quantities involved the dredging is anticipated to be performed in three stages as follows. The quantity of dredged material removed in each stage is summarized in Table 4.2:

1. Stage 1 dredging occurs at the very beginning of construction. Approximately 64 % of the total dredged material volume will be removed in this stage. Stage 1 dredging will provide immediate access from the bridge staging areas to the entire construction site. Among many other tasks, this link will be used for delivery of concrete if the concrete batch plant is located inland.

While the offset distance from the pile caps of the existing bridge is variable given the bathymetric contours, for this stage of dredging this distance is expected to be well above 100 ft.

2. Stage 2 dredging would occur exactly one year from Stage 1 dredging. Approximately 25 % of the total dredged material volume will be removed in this stage. Stage 2 dredging has been introduced simply to reduce the quantity of dredged material in one season so that an adequate time window is available to perform dredging comfortably. Small adjustments to the overall schedule were necessary because of the introduction of this stage but were found to have no appreciable impact on the overall duration of construction.

   While the offset distance from the pile caps of the existing bridge is variable given the bathymetric contours, for this stage of dredging, this distance may become small (theoretically zero) in some near shore areas where the alignment of the existing bridge just begins to converge towards the alignment of the new bridge. Such close proximity of the top of the slope of the dredge prism to the existing bridge foundations is not expected to have any adverse impact on the structural integrity of the existing bridge.

3. Stage 3 dredging would occur just prior to and after the demolition of the existing bridge. This corresponds to three years from the time of the first stage of dredging. Approximately 11 % of the total dredged material volume will be removed in this stage.

Figure 4.10 – Dredging Operation

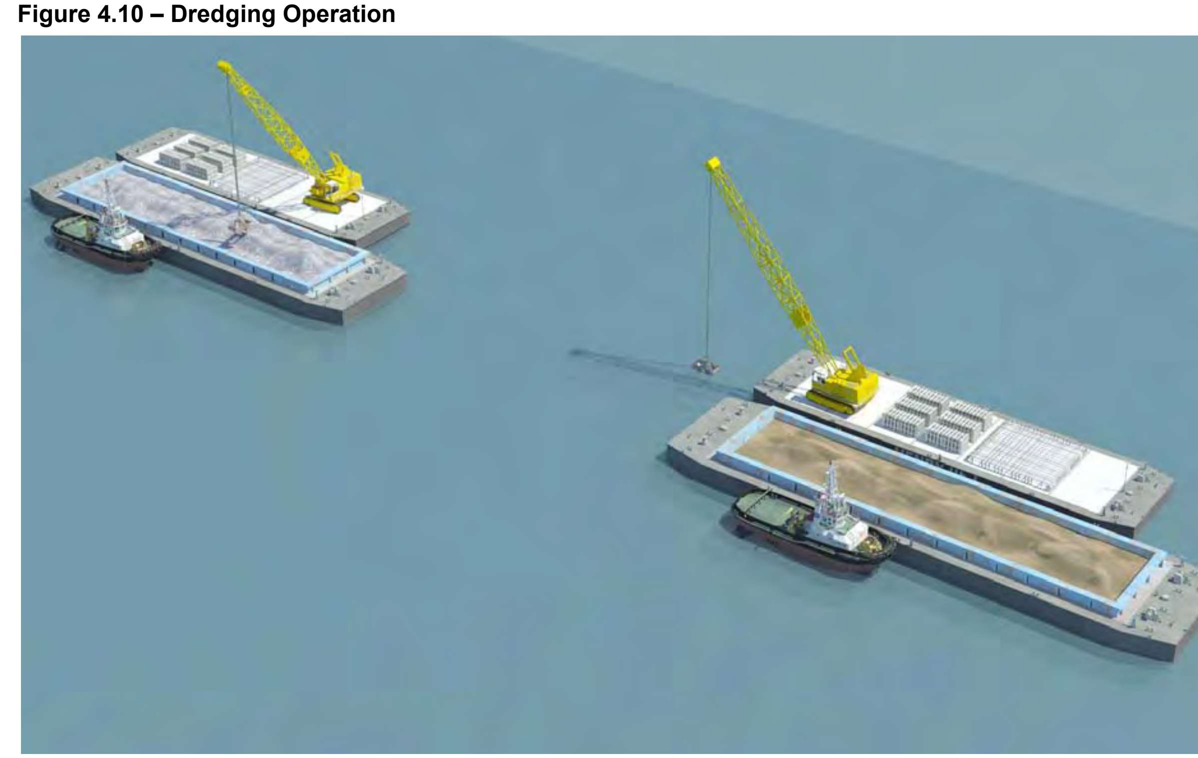


Figure 4.11 – Armoring Operation

Quantity (million CY)	Current Design
Stage 1	**1.01**
Stage 2	**0.32**
Stage 3	**0.22**
Allowance for 1 foot over	0.21
Total	**1.8**

Note: Numbers have been rounded

Table 4.2 - Quantity of Dredge Material by Stage

The demolition of the existing bridge would begin immediately after the North structure of the RTZB has been fully constructed and all traffic from the existing TZB has been diverted onto it. A large portion of this stage consists of “demolition” dredging which would occur near the Westchester shore south of the existing bridge. The main purpose of this dredging is to provide access for large crane barges to the south side of the existing bridge should the demolition contractor choose to simply lift and remove the trusses of the existing bridge

4.2.11 Disposal Strategy

While the choice of disposal sites is an extremely important environmental consideration, it also dictates the duration of the overall dredging program. This is an important consideration given that the dredging windows available during the course of a calendar year are limited.

Based upon available test results, at least 80 % of the dredged material appears to be non-contaminated and is expected to qualify for disposal at the Historic Area Remediation Site (HARS) located about 9 miles off the coast of Long Island and 5 miles off the coast of New Jersey in the Atlantic Ocean. The HARS site is about 55 miles from the RTZB. The remainder of the material, which may contain contaminants, would be transported to an available permitted upland site where it will be treated and then transferred to an appropriate disposal site.

Ocean Disposal - HARS site

The HARS site is capable of accommodating large quantities of dredged material. Disposing of material at this site is a relatively fast process and desirable from the perspective of the limited duration of the dredge window.

The type of vessel most suitable for moving the dredged material to the HARS site is a large capacity (up to 4500 CY) ocean going dump scow. Typically, such vessels have large drafts – up to 17 to 18 feet – and would exceed the intended dredging channel depth. A transfer operation would be necessary to employ the ocean going dump scows.

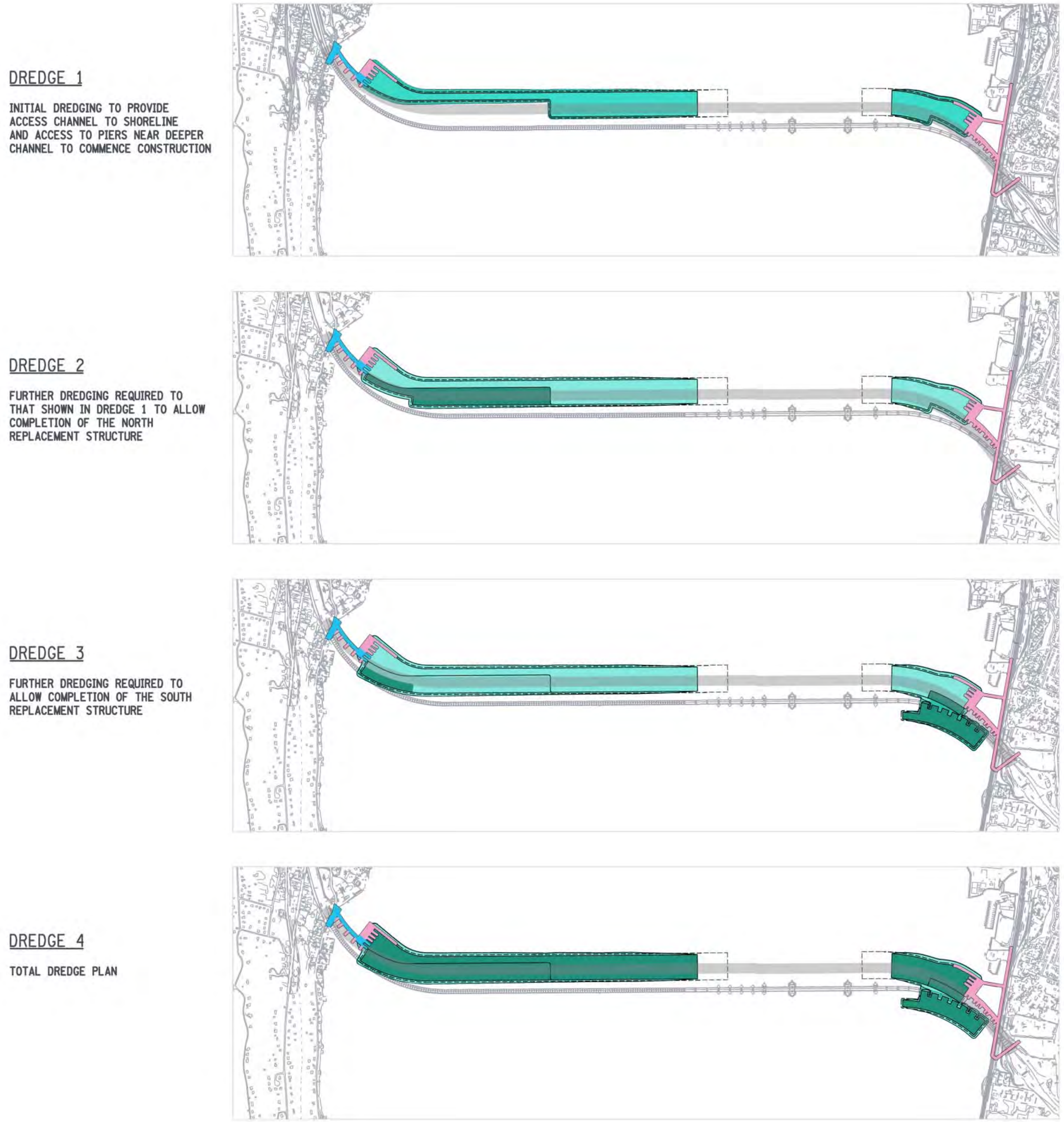


Figure 4.12 - Dredging Stages

4.2.12 Rate and Duration of Dredging

Research of the NY dredging industry has established that it is reasonable to assume that each dredge deployed at the project site would be able to dredge 7500 CY per day. A 24-hour operation is considered normal for most large scale dredging operations in the area and is not a particularly noisy operation. Ultimately, the effective rate of dredging would depend on a combination of the performance rate of the dredges and the rate at which removal and disposal of the spoil takes place.

The following factors were taken into consideration to estimate the duration of each stage of dredging:

1. Quantity of dredged material
2. Capacity of dredges
3. Number of dredges
4. Number of hopper scows in circulation
5. Number of ocean dump scows in circulation
6. Travel speed of scows
7. Durations of material transfer from hopper scows to dump scows.

The expected durations and the requirements of the number of dredges and scows required for the first stage of dredging are summarized below (Table 4.4). The values were calculated for the Short Span Option and they can be considered valid for the Long Span Option given the similarity in the total magnitude of the quantity for both bridge options. Note that there is more volume of material in Stage 1 than in any other stage and, therefore, it can be assumed that the requirements for all other stages of dredging will be less onerous.

Dredging	No of dredges	2
	Duration of dredging (days)	74
Ocean disposal	No of dump scows	3
	Duration of disposal (days)	74
Transfer from Hopper Scow to Ocean Dump Scow	No of hopper scows	6
	Duration of disposal (days)	74
Upland Disposal	No of hopper scows	2
	Duration of disposal (days)	56

Allowable window of dredging is assumed to be 90 days

Table 4.3 - Vessel Requirements and Dredging Durations

4.2.13 Construction Methods not Requiring Dredging

Overhead Gantry

The unique deep and soft foundation soils dominate the design and hence the construction of the RTZB. The consequence of these poor soils is the use of large diameter deep piles that require dredging for equipment access to install them. Though there are pile installation techniques that have been used to eliminate dredging on other bridge projects, a no-dredging solution is not feasible for the RTZB.

An example of the use of a no dredging construction project is the recent construction of the Highway 17 Bypass around the town of Washington for the North Carolina Department of Transportation.

Figure 4.13 - Gantry Used in the Construction of the Pamlico-Tar River

Figure 4.14 - 10 foot Diameter Steel Pile as used on the San Francisco Oakland Bay Bridge

Beginning in 2007, the contractors for this project developed a unique gantry for this low level 3-mile trestle bridge over the Pamlico-Tar River. This gantry (Figure 4.13) was not only capable of constructing the superstructure from above the deck, which is common, it was also capable of installing the substructure as well, including the precast concrete piles. The uniqueness of the construction method was its ability to drive piles from the cantilevered end of the gantry. As a result no dredging or cofferdams were required and disruption of the existing wetlands was kept to an absolute minimum.

This state of the art gantry was capable of installing 3-foot square precast concrete piles (weighing from 70-100 tons) into the riverbed 30 feet below. When compared to the steel shell piles for the Replacement Bridge (Figure 4.14) that may weigh up to 400 tons and which would be constructed from a deck as much as 200 feet above the riverbed, it is apparent that this state of the art technique is not practicable for the RTZB.

Overall, construction of the foundations and superstructure for the Replacement Bridge requires the use of heavy equipment that accesses the bridge location via dredged channels.

Full Length Trestle Platform

Another alternative construction methodology explored for the sake of completeness, would use a long length temporary access trestle that could obviate the need for dredging. It was quickly found to be impractical for the RTZB application.

The trestle would have extended from each shoreline all the way to areas where barge and tug movements could take place without the need for dredging. The prefabricated bridge elements will either be delivered on trucks using the highway system or on barges. For the latter condition, the trestle would be constructed from deep water toward the shore. Prefabricated elements along with erection equipment and vehicles will be hoisted off of barges and delivered to the area under construction by trucks moving on the platform.

It was established that given the loads involved in supporting sizable cranes and heavy piles, the deep soft soils in a large portion of the shallow water zones would require expensive foundations and would render a long length temporary trestle uneconomical. The practicality of such a long trestle was also questionable given the amount of time and resources required to construct it. Trestle structures are commonly used in the very shallow portion of waterways where they generally offset the cost of dredging.

For this reason the dredging plan developed in the earlier sections assumes the presence of a short temporary trestle structure extending from each shore as a staging platform to provide upland access to vessels moored in deepwater dredged areas. Its details are provided in Section 4.3.

4.3 Bridge Staging Areas – Access Platforms

The Staging Area Access Platforms are low-level short span trestle-type bridges whose deck are typically composed of timber beams and whose foundations are typically made from a single row of H piles or small diameter circular steel piles. Access Platforms enable access to the river and the barges therein for most delivery trucks including concrete mixer trucks and long haul flat bed trucks. Access Platforms also facilitate land-based construction in shallow areas where dredging quantities for marine construction would otherwise be exceptionally large. Access Platform is usually capable of carrying moderate size crawler cranes and can be strengthened to carry heavier loads, as necessary.

The Access Platform would be aligned outside of the permanent bridge foundation footprints, so as not to interfere during their construction, but close enough to be within a crane's reach of the foundations. The alignment of the Access Platform would be offset slightly to north of the permanent bridge alignment for the Short Span Option. For the Long Span Option the Access Platform may be located between the new bridge piers.

While delivery of material may be convenient on land based trucks once the Access Platforms are available, it is also possible to deliver material on barges. In such instances material will be hoisted off the barges from a crane placed on the trestle and then hauled to its destination on a truck driving on the trestle. See Figure 4.16.

Access Platforms are often constructed with appendages, also known as “fingers” that are perpendicular to the main platform structure and are used to provide access to the foundations of the bridge.

For the bridge options considered in this report, it will be assumed that delivery of all major elements of the bridge will be made by way of barges. In the shallow parts of the river outside the dredged areas, the driving of smaller diameter piles and the construction of substructure elements will be carried out from the temporary trestle structures.

4.3.1 Construction of Access Platforms

An Access Platform will be installed near the shoreline where the bridge alignment crosses from land onto water in order to limit dredging. The Access Platform would provide a staging area for transporting equipment and materials from land to the new structure under construction in the river (see discussion on staging areas, Section 4.1). The Access Platform would be an alternative to using barges for transporting equipment and materials within portions of the river where the water depths are shallowest and where extensive dredging of river bottom deposits would be necessary to accommodate the vessels. Figure 4.15 depicts the construction of an Access Platform structure for the SFOBB.

The construction of the Access Platform would begin on land, near the edge of the river. Only after construction of the first trestle span is complete can the equipment required to construct the Access Platform drive onto the completed trestle span and begin work on the next segment. With the completion of each trestle span, the Access Platform structure gradually advances further out into the river, one span at a time (Figure 4.16).

Installation of Temporary Piles

The first step to construct the Access Platform would involve creating an access road and work area along the shore. Once a work area is created, the driving of the steel piles to support the trestle deck could be started. The first span would require the installation of two rows of piles, one row for each end of the span. Each subsequent span would require driving only one additional row of piles, as one half of the trestle deck is supported on piles shared by the previously completed trestle span. Pile rows would be spaced about 50 feet apart. After each row of piles is installed, the excess length of pile would be flame cut and removed.

The piles driven for the Access Platform would likely be two-foot diameter open-ended steel pipe piles. The piles would be driven as a single section, in lengths up to 150 feet. Pile sections would be delivered to the site by truck in sections up to 75 feet in length. To achieve the required pile length, field welding of the sections in an on-shore lay down area near the trestle may be necessary. The pile driving rig would include a hammer suspended from a crawler crane. The crane would lift the piles and support the hammer during pile driving. A high efficiency hydraulic impact hammer or vibratory hammer would be used to advance the piles and to obtain the final driving resistance.

Below the edge of the river, the anticipated depths to competent bearing strata are not as deep as in other portions of the river crossing, making the piles a practical solution for the near shore areas, despite the poor upper level soils. The platform piles would bear on glacial till or bedrock and would develop most of their resistance from end-bearing with raking piles as needed to develop lateral stability.

A small pontoon boat which can operate in shallow water conditions would be required to support the pile driving operations. Such a boat could assist construction personal during work such as checking the plumb-ness of each pile during installation or cutting the trestle pile to the final cutoff elevation.

Construction of Access Platforms

At the top of each pile, a cap and bearing plate would be attached by welds to create a level pad which can support a transverse girder. The girder sits above each row of piles and distributes loads from the trestle deck onto the foundation piles. The girder is secured with welds to the bearing plates above each pile.

To span between the transverse girders, steel stringers would be positioned with each end supported by a girder. The stringers would span between the pile piers to create a continuous structure. The stringers would also be secured with welds and would likely require bracing. The placement of the timber deck above the girders would be the final step for the construction of each Access Platform span. After completion of each span, the procedure would be repeated for the next span. See Figure 4.16

Typical crew sizes required during this construction of the Access Platform would range between 10 to 15 construction workers and 2 to 5 engineers and safety personnel per platform.

Temporary Trestle Removal

When the permanent bridge is finally completed the Access Platform deck and piles can be removed one section at a time starting at the end furthest from land. The Access Platform piles could remain in-place and be cut off below the mudline or could be removed using a vibratory hammer.

Figure 4.15 - Trestle for San Francisco Oakland Bay Bridge

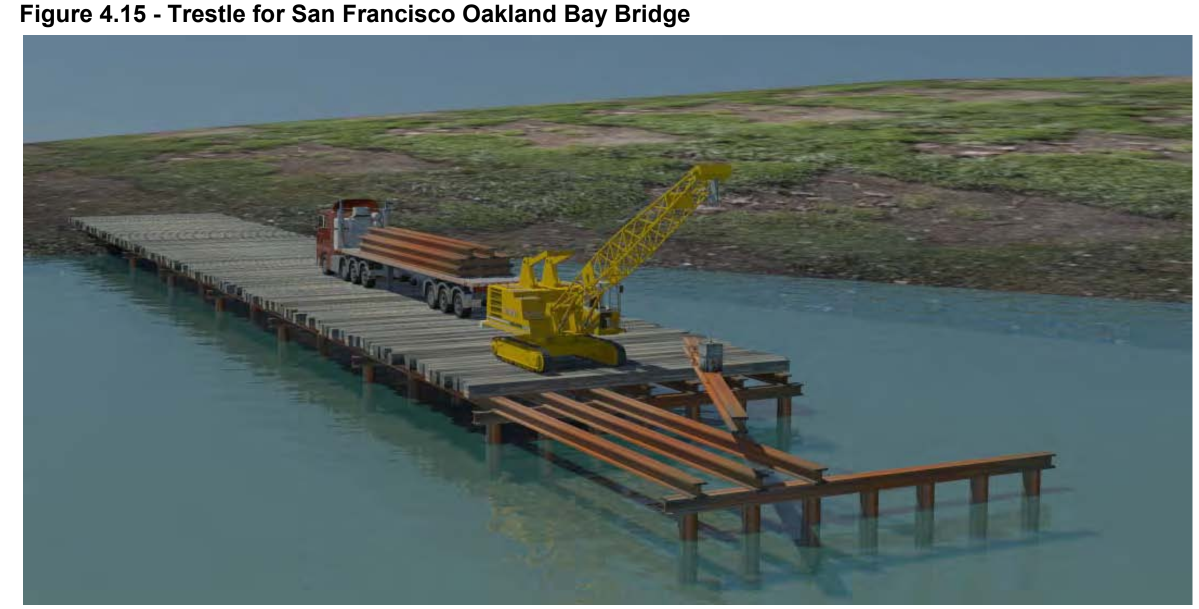


Figure 4.16 - Trestle Construction

5 Substructure Construction

This chapter outlines the construction activities required to complete all substructure components. These components include piles and pile caps in all foundations, and rock sockets in selected foundations associated with the Main Span.

Variation in construction methods along the length of the RTZB is partially a function of water depth. For the purposes of this DEIS, the length of the bridge is divided into three substructure construction zones (A, B and C) which are defined in detail in Chapter 2.

This chapter will focus on construction methods only. The duration of each activity and key sub activities along with local construction schedules are presented in detail in Appendix B for each type of substructure. A summary of required crews and their sizes associated with these activities are presented in Chapter 9 of this report.

Cofferdams

An important consideration in the construction of the foundations is the provision of “dry” working conditions for installing reinforcement and pouring foundation concrete for the pile cap. This is accomplished by using cofferdams.

There are several different construction techniques that can be used for cofferdam construction in marine environments. Factors such as depth to mudline, pile cap size, pile cap elevation, access restrictions and schedule often affect the type of cofferdam implemented. Two types of cofferdams are considered in this report; a standard cofferdam and a hanging cofferdam.

Figure 5.1 depicts a typical standard cofferdam. Standard cofferdams are used in shallower water depths up to 25-30 feet maximum. The cofferdam is constructed from interlocking sheet piles. Sheet piles are Z-shaped lengths of steel that form a corrugated wall that can resist the force of the water pressure at depth. To help resist these significant forces, the sheeting (the sheet piles forming a wall) is reinforced with steel whalers (horizontal beams) and the foot of the piles are firmly embedded into the river bottom. The interlocking joints between sheet piles keep out most of the water, though small quantities of leakage still occur.

Water can also come in via the river bottom, percolating through the soil and under the sheeting. This infiltration can be significant and is prevented by sealing the bottom of the cofferdam with a thick pour of concrete designed to counter the hydrostatic force through the greater weight of the concrete mass. Depending upon the depth, a concrete thickness of 8-10 feet (across the entire bottom of the cofferdam) can be required. This sealing concrete pour is referred to as a “tremie pour,” after the “tremie” method of placing concrete under water using a tubular chute whose lower end is always embedded in the ever growing mass of concrete, thus keeping the water in the cofferdam from mixing with the concrete while it is being placed. If the cofferdam is in deep water, the “ground” upon which the tremie pour is placed can be raided by filling the bottom of the cofferdam with sand to the desired level. The tremie pour has to occur after the piles are placed

Figure 5.2 shows a hanging cofferdam. This type of cofferdam is used for deep water conditions and is typically fabricated off-site and floated into position. The hanging cofferdam also uses interlocking sheet piles but they do not extend into the riverbed but only extend into the river water by 10-20 feet depending on the depth of the pile cap.

5.1 Construction Activities in Zone A

Zone A encompasses the shallowest water depths (less than 7 feet) at the Rockland shoreline (Zone A1) and Westchester shoreline (Zone A2). Substructure components in Zone A would be constructed within cofferdams from adjacent temporary trestle platforms with direct upland access from the landing areas.

5.1.1 Construction of Foundations

In Zone A near the shoreline, standard sheet pile cofferdams would be used. This type of cofferdam would be installed prior to driving the foundation piles for the bridge.

The following sections describe typical construction activities, equipment and personnel levels associated with the construction of bridge foundations with the sheet pile cofferdam method.

Cofferdam Construction

The construction of a cofferdam begins with the placement of reference piles. Offset from these, surveyors locate the position of the proposed pile cap. The survey crew would be required at various stages of the pile cap construction. Once the cap location is established a steel template would be installed to guide the installation of the steel sheet piles that make up the perimeter of the cofferdam.

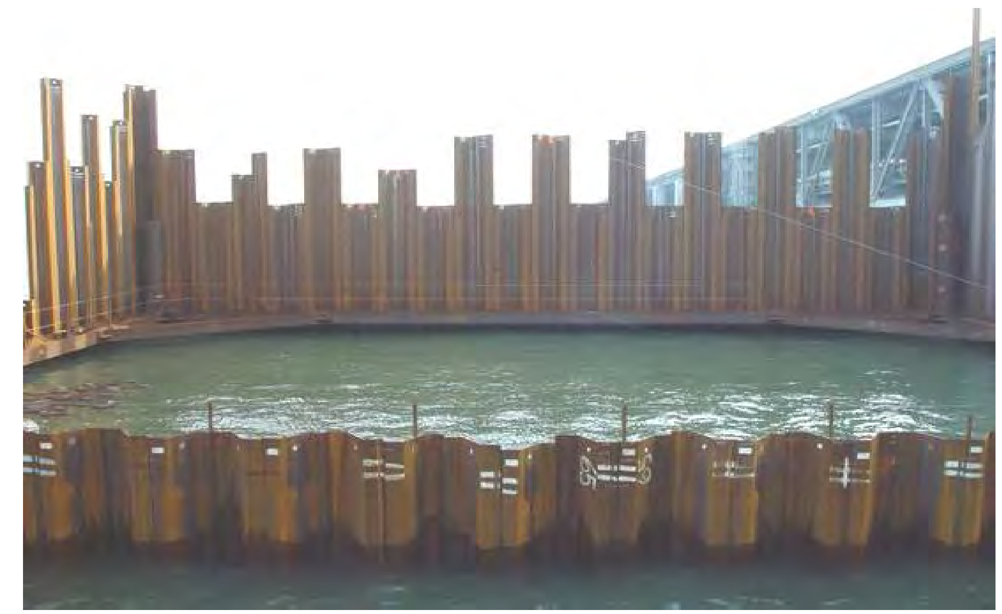


Figure 5.1 - Standard Cofferdam

Figure 5.2 - Hanging Cofferdam

The standard type cofferdam constructed from interlocking sheet piles extend into the riverbed by up to 20 feet. Once completed, the water inside the cofferdam can be pumped out to create a dry and safe working area for the construction of the pile caps and piers.

The template is sometimes called “falsework” and consists of small diameter piles driven sufficiently into the mudline to be stable and linked with horizontal steel members called whales. These whales act as a guide for installation of the vertical steel sheet piles. The whales also provide lateral bracing to the wall of sheet piles to resist water pressure when the cofferdam is pumped out. With the falsework set, installation of the steel sheets for the cofferdam would commence. The sheet piles would be installed using a crane moving upon the trestles, with a vibratory hammer attachment. Support equipment such as material barges and personnel barges would also be required. Welding would have to be performed to connect the piles and the whales during installation of the falsework.

Sheet piles are Z-shaped interlocking steel sheets, typically ½ to ¾ inches thick, which are connected to provide a relatively water tight barrier. Sheet piles are installed into the river mud to a sufficient depth (about 20 feet) to limit water infiltration into the cofferdam and provide the embedment needed to resist lateral pressures when the cofferdam is dewatered. The finished sheet piles form a continuous wall that surrounds the pile cap about five feet beyond its perimeter.

Sheet piles are typically installed by vibrating them into place using barge mounted hydraulic vibratory hammers. The “falsework” guides the sheet piles during installation. Welding and flame cutting may be necessary during installation of the sheeting. If forms are not used sheet piles would be treated with a de-bonding agent to facilitate their removal at the completion of the pile cap construction.

Pile Installation

Prior to pile driving, the river bottom inside the cofferdam would be excavated with crane operated clam shell buckets supported on the trestle. Material recovered from the river bottom would be placed in scows then in dump trucks for transport to an off-site disposal facility or re-used for other purposes within the project. Figure 5.4 illustrates the typical Zone A construction sequence. Figure 5.3 shows how delivery of piles may occur for Zone A foundation after the north bridge has been constructed.

Foundation piling can start immediately upon completion of the cofferdam construction. Typically, the cofferdam would remain flooded during pile installation.

It is likely that the approach foundations would be large diameter open ended steel pipe piles. The piles for the bridge foundations within Zone A would likely be driven as a single section, in lengths up to 150 feet. This should be possible since competent bearing stratum is relatively shallow at this portion of the site compared to other locations along the river crossing.

Prior to pile installation, a pile template which aligns and laterally supports the piles to be driven would be positioned above the cofferdam with the help of surveyors. The template would be supported on header beams, which in turn are supported off the cofferdam and its framing whales.

Given the form of the template, pile installation is typically performed one row of piles at a time. The actual pile driving is done one pile at a time. Once a row of piles are installed, the template is repositioned and the process is repeated with the next group of piles until all piles in the pile cap are placed. The template and its supports are then moved to the next cofferdam.

The pile driving rig includes a crane located on the temporary trestle with adequate boom length and capacity to lift and place the piles. Once a pile is set in the template, the crane may begin driving using a vibratory hammer placed atop the pile. The vibratory hammer provides a quick, low noise and moderate energy method to install much of the intended length of a pile. To develop the final pile bearing capacity, a high efficiency hydraulic impact hammer, which provides on the order of 100 kip feet of energy during driving, would be used to obtain the final driving resistance. It is anticipated that a 300-ton crawler crane would be necessary to lift the pile sections and support the hammer during pile driving.

Because the exact depth where the pile develops adequate end bearing against the underlying rock is unknown, the piles placed would typically be longer than their specified length. Excess pile length is typically cut off to final elevation after the cofferdam is dewatered; however, if remaining length is excessive or interferes with placement of the template, a portion of the excess may be removed.

Following installation of all the piles, and removal of the pile template, the soil within each pile is removed. Equipment used to remove the material from the pile could include clam shell, bailer or auger. Material recovered from the piles would be placed in dump trucks for transport to an off-site disposal facility or re-used for other purposes within the project. Following the removal of this material, a tremie concrete plug is pumped inside the pile at the lowest point where the soil was removed to seal the bottom of the pile from water intrusion (Figure 5.6).

Prior to the construction of the pile cap the temporary piles and remaining falsework used during the installation of the sheet piles and foundation piles would be removed. Pile driving cycle in this zone is similar to the pile driving cycle in Zone B. See section 5.3.2.

Pile Cap Construction

It is desirable to complete the rest of the pile operations in the dry. Given the poor cohesion of the riverbed sediments, pumping out the cofferdam is an endless effort, since despite the length of sheeting in the ground, it is still quite easy for water to migrate in from the soil within the cofferdam. To prevent this, no effort is initially made to pump out the standing water, which is at the same height as the surrounding river. Instead, a tremie pour of concrete is placed directly on the river bottom around the piles and inside the sheet piling. The tremie concrete serves two functions; it braces the bottom of the sheet pile cofferdam and it provides a seal at the base of the cofferdam to allow for dewatering of the cofferdam.

The tremie pour fills the cofferdam to an elevation typically equivalent to the underside of where the eventual pile cap would be. A tremie pour places concrete under pressure using a hose. The end of the hose is kept within the growing mass of soft concrete so there is no mixing of the concrete with the overlying water (e.g., the concrete doesn't "fall" through the water). Instead, the outer surface of the soft concrete mass (which is in contact with the water) simply rises as concrete is pumped in from below.

The tremie concrete mixture consists of ready-mix concrete with additives to prevent segregation of the mix during under-water placement and to regulate setting time. It is likely that the concrete would be batched on land and transported by truck on the trestle to the cofferdams. Pump trucks located on the trestle would be used to pump the concrete from the trucks into the tremie seal within the cofferdam. Concrete placement can occur anytime during the day and may take many hours as the volume is sizable.

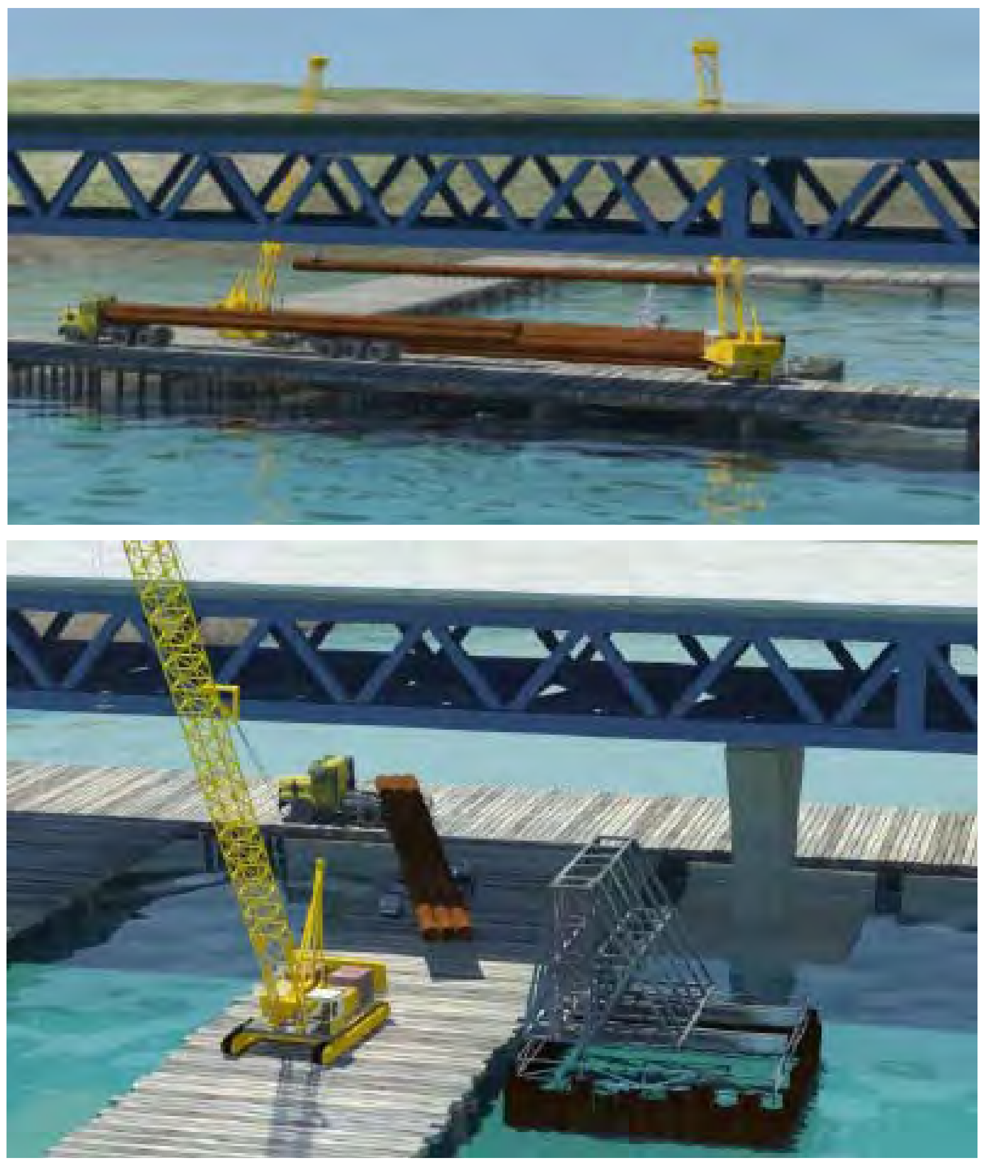
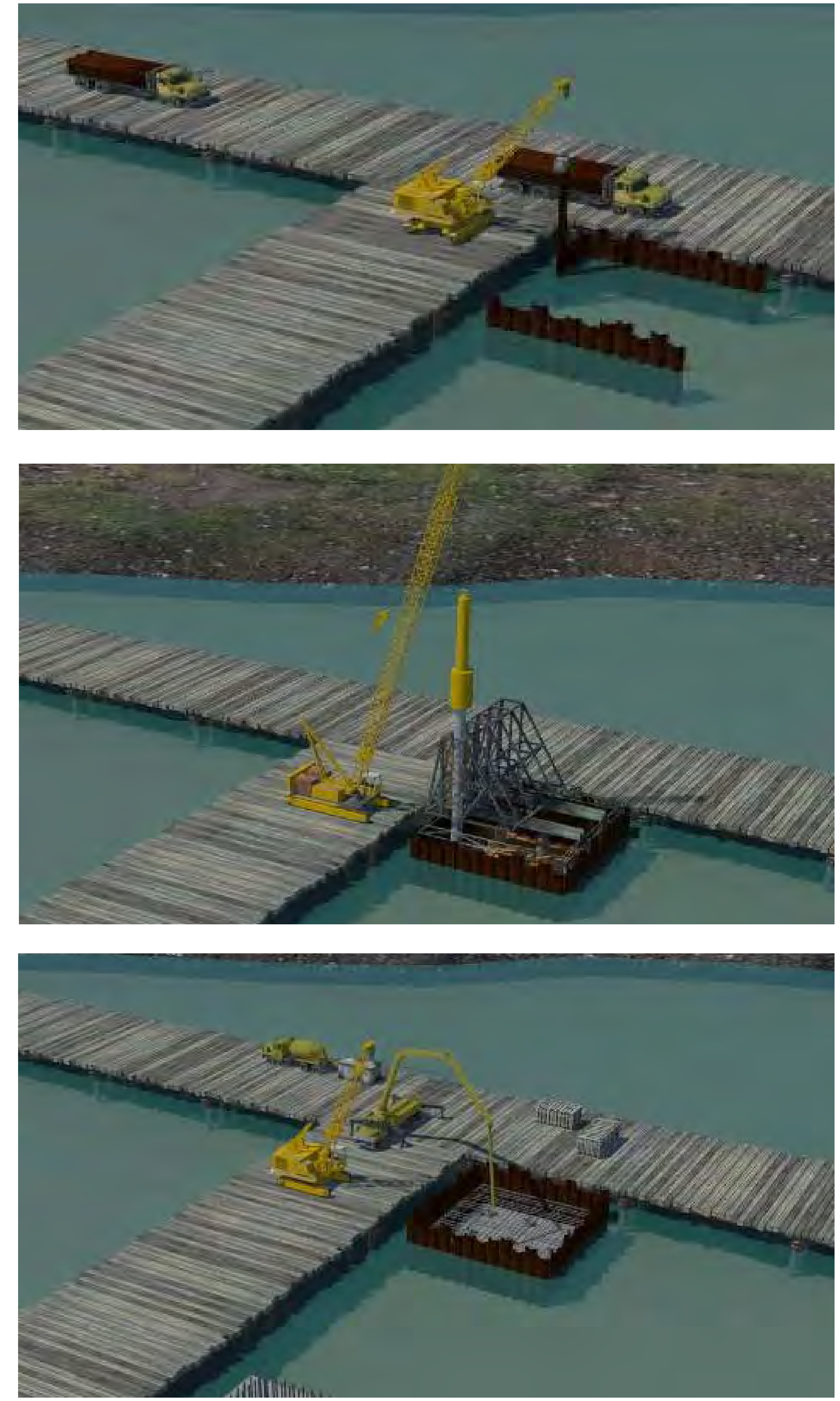


Figure 5.3 - Pile delivery in Zone A



A. Construct cofferdam

B. Install Pile template on sheet piles then drive foundation piles

C. Pour tremie concrete seal slab, dewater cofferdam, install reinforcing and pour pile cap concrete

Figure 5.4 - Construction of Zone A Foundations

The slab thickness is influenced by the thickness required to provided groundwater cut-off at the base of the cofferdam and must also provide sufficient lateral resistance to oppose hydrostatic forces on the cofferdam after it is dewatered and to create a work surface near the finished bottom elevation of the pile cap. The pumping stops when the desired height is reached. Because hydrostatic pressures can be quite high, typically seven days pass as the concrete, still under water, cures to required strength. In the meantime, internal bracing would be installed along the uppermost portion of the sheet pile wall.

Once required strength is obtained, the cofferdam can be pumped out and rest of the operations can be conducted in “somewhat” dry conditions. [Cofferdams still leak, but with the tremie seal, a typical construction pump can handle the minor infiltration of water that enters through the slab and sheet pile walls.]

Following the pumpout of the cofferdam, the remaining water is also pumped out of the piles. The excess length of the piles is cutoff using flame cutting. Following their trimming to desired elevation, a rebar cage to provide stiffness and prevent buckling is installed within the pile. Given the length of the pile, this may be composed of several sections spliced together.

While the pile rebar is installed, the formwork for the pile cap would be constructed. The cofferdam provides a bracing frame for the formwork required to construct the pile cap. Pile reinforcing, pile cap reinforcing, pier reinforcement and post tensioning ducts are all installed prior to pouring concrete. It is likely that several cranes operating from the trestle would feed the reinforcing steel to the lathers working on the pile cap.

A significant amount of activity would occur at this point. First the concrete in the piles would be cast, followed by the pile cap concrete. The concrete for the pile cap would be poured in one or two lifts using a concrete pump or crane with buckets. The pile cap concrete would be supplied by trucks from the concrete batch plant nearby on land or possibly from a purpose built batch plant. The concreting operation continue on an around the clock basis to provide a monolithic pour of the cap. The pile cap would require approximately seven days of curing before the pile cap formwork could be stripped.

Once the formwork is removed the cofferdam can be flooded. The internal bracing and sheet piles can be removed using equipment similar to that used during installation. Upon removal, cofferdam components can be re-used at other pile cap location along the bridge alignment.

5.1.2 Foundation Construction Duration

A typical pier in this substructure construction zone would have two foundations. Notable construction durations include:

- Cofferdam construction: 13 days
- Pile installation: 50 days
- Pilecap construction: 47 days

A day in the above list represents a calendar day. Typically, seven calendar days are equibvalent to five work days. See bar chart in Appendix B for details of local schedule.

5.1.3 Foundation Construction Crew Requirements

Details of crew strengths and their requirements have been developed in Appendix B. Effective crew sizes are computed by taking the weighted average of the crew strengths over the duration of an aggregate “roll up”of activities. It is assumed that each activity is associated with its own dedicated crew. The following is an effective crew strength for each of the aggregate activities listed:

- Cofferdam construction: 5-7 workers
- Pile installation: 10-12 workers
- Pilecap construction: 6-8 workers

5.2 Construction Activities in Zone B

Substructure construction in Zone B would be in water depths ranging from 7feet near the Rockland County shoreline (Zone B1) or the Westchester County shoreline (Zone B2) out to 18 feet in the middle of the river approaching the shipping channel. Substructure components would be expected to be constructed from within cofferdams directly from barges using barge mounted cranes, concrete delivery scows and other support vessels in the river.

Construction activities in Zone B that are similar to Zone A include sheet pile installation (though from barges rather than temporary platforms) and pile cap construction. These activities are not repeated in this subsection. This sub-section focuses only on the differences which occur only with respect to pile installation and some aspects of the pile cap construction. Schematics of the construction sequence in Zone B are shown in Figure 5.8.

5.2.1 Pile installation

Foundation piling would be started immediately upon completion of the cofferdam construction. Typically the cofferdam would remain flooded during pile installation. The foundation piles would be large diameter open ended steel pipe piles up to 10 feet in diameter. Due to the relatively deep soft soil profile at the site, installed pile lengths would be on the order of 250 to 300 feet. The piles would be transported to the site by barge in two parts, upper and lower sections. The lower sections would be up to 200 feet long. This length would be the longest pile length that can be picked-up with a conventional barge mounted crane that can operate on a barge with relatively shallow draft. Longer piles may be used if off-shore type cranes and equipment are used, however, this equipment is less readily available, may have clearance issues relative to the existing TZB, would carry significant additional costs and would reduce overall constructability.

The pile driving rig would include a hammer suspended from a barge mounted crane, as shown in Figure 5.7. The lower pile section would be advanced with a vibratory hammer. A high efficiency hydraulic impact hammer which provides on the order of 100 kip-feet of energy during driving would be used to obtain the final driving resistance. A 300-ton crawler crane would be necessary to lift the pile sections and support the hammer during pile driving. The minimum dimensions of the barge for the crane would be on the order of 60x160x10 feet. To anchor and position the rig, the barge would include spuds (temporary piles) and/or anchor winches and anchors for positioning. Other equipment on the barge would include air and hydraulic compressors, electric power generator, automated welding equipment, cutting torches, and pumps and tanks containing diesel fuel. The standard inventory would also include safety and personnel barge, environmental protection equipment, such as floating containment booms to contain accidental spills. The pile driving rig would also be equipped with GPS navigation technology.

Prior to pile installation the pile template would be positioned above the cofferdam with the help of surveyors. The template would be supported on header beams and has lateral bracing which supports it to the falsework above the temporary piles. The lower pile section would then be slowly lowered into the soft organic clay stratum under its own weight in a controlled manner. The penetration depth achieved without external loading would be expected to be considerable. The remaining length of the lower pile section would be driven until the required depth is achieved using a vibratory hammer.

Pile installation would likely be performed a row at a time with the need to move the support barges. Most activities, such as pile driving must be performed with only one pile at a time. Once a row of piles are installed, the process would be repeated with the next group of piles until all piles in the pile cap are completed.

After the lower pile sections are set, preparations would proceed for welding the upper and lower pile sections together. This would include grinding the top edge of the lower pile sections. A collar would be pre-welded onto the interior surface of the upper pile section to help align it when it is placed above the lower pile section. It is assumed that the upper pile section would arrive at the cofferdam in a condition already prepared for welding with the end of the pile machined to form a bevel.

With the lower pile section ready to receive the upper pile section, the upper section can be lifted by crane and positioned atop the lower section. The template would support the upper pile section while the weld is made. Welding huts, as shown in Figure 5.7, would be constructed around the joint to provide the necessary temperature and environmental controls required for optimum welding conditions. Automated welding equipment or manual welding would require multiple passes around the circumference of the pile to form a full penetration weld between the upper and lower pile sections. Quality Assurance and Quality Control would be performed on the welds by qualified testing agencies during the progress of the work. When the pile sections are properly welded and inspected, the remaining length of pile would be driven with a hydraulic hammer to the specified penetration resistance.

After being driven to required loading resistance, excess pile length interfering with remaining operations (e.g., placement of the template for the next row) would be cut off. After the cofferdam is dewatered, remaining excess pile length would be cut-off to final elevation.

Following the pile installation, the upper 120 feet of soil within the pile would be removed so that a steel reinforcing cage can be installed within that portion of the pile. Equipment used to remove the material from the pile could include clam shell, bailer or auger. The material recovered from the pile would be dumped onto scows for transport to an off-site disposal facility or would be re-used for other purposes within the project. Following the removal of this material a tremie concrete plug would be poured inside the pile at the lowest point where the soil was removed.

At this stage, the temporary piles and false work used during the installation of the sheet piles and foundation piles would be removed, prior to the construction of the pile cap.

5.2.2 Pile Driving Cycle

For the 4-foot diameter piles, a hammer capable of delivering 270 to 440 kip-feet of energy per blow is anticipated. For larger piles, larger hammers delivering up to 550 kip-feet may be used. Barring any unexpected conditions, such a hammer would be able to drive a the final 150 plus feet of a 300-foot pile comfortably within the duration of a shift. Pile driving of the upper pile segments consists of four major activities as follows:

1. Setting upper pile in position.
2. Installing welding hut to create an enclosure necessary for welding.
3. Welding operation, followed by inspection/QA check on the weld.
4. Hammer operation resulting in the driving of the piles.

These four operations are conducted repetitively in a logical pattern such that the 4 crews performing the 4 operations remain busy daily without any need for interruption.

In the case of the approach structures, this results in a pattern in which the crews work on one row on piles on one pile cap followed by work on another row of piles on the adjacent pile cap. This cycle is repeated until piles for both pile caps are finished more or less simultaneously. Once the cycle is completed for a row, the pile supporting templates are repositioned for the next row.

The summary of this activity and a similar activity for the Short Span Option is graphically summarized in Appendix B.

Figure 5.5 - Sheet pile detail

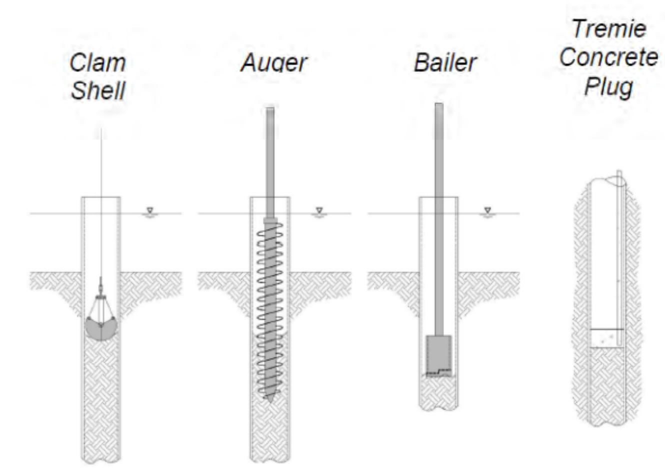


Figure 5.6 - Soil Removal and Construction of Tremie Plug

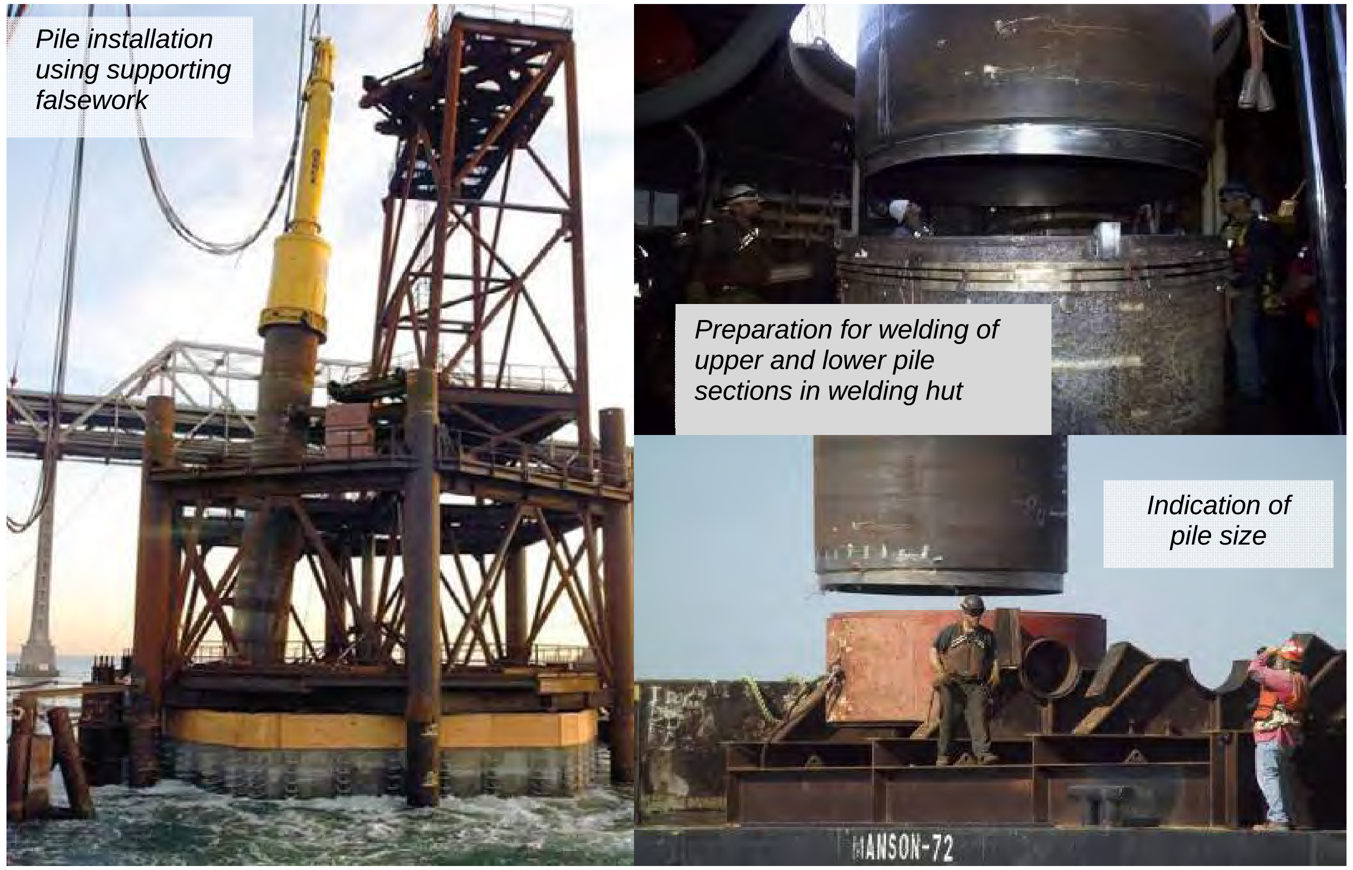


Figure 5.7 - Pile Installation

5.2.3 Pile cap construction

Pile cap construction in Zone B would be similar to that in Zone A with the exception of the presence of granular fill below the tremie seal pour. This fill material would be placed inside the cofferdam to raise the internal elevation of the bottom of the tremie pour and conserve concrete. The depth of the tremie pour would remain the same as this depth is tied to balancing the weight of the concrete mass against the hydrostatic uplift created by its volume and the empty volume within the cofferdam. This buoyant volume is tied to the high tide and the intended underside elevation of the pile cap which is coincident with the top surface of the tremie pour. Once the pile cap is constructed and the sheet piles removed, this granular material would slump on to the river bed.

5.2.4 Foundation Construction Duration

A typical pier in this substructure construction zone would have two foundations. Notable construction durations include:

- Cofferdam construction: 13 days
- Pile installation: 50 days
- Pilecap construction: 47 days

A day in the above list represents a calendar day. Typically, seven calendar days are equibvalent to five work days. See bar chart in Appendix B for details of local schedule.

5.2.5 Foundation Construction Crew Requirements

Details of crew strengths and their requirements have been developed in Appendix B. Effective crew sizes are computed by taking the weighted average of the crew strengths over the duration of an aggregate “roll up” of activities. It is assumed that each activity is associated with its own dedicated crew. The following is an effective crew strength for each of the aggregate activities listed:

- Cofferdam construction: 5-15 workers
- Pile installation: 9-15 workers
- Pilecap construction: 6-10 workers

5.3 Construction Activities in Zone C

Zone C is the portion of the river crossing where river water depths are greatest – ranging from 18-45 feet. The zone includes the Main Span over the shipping channel and approach spans on either side.

Different from the construction activities in Zones A and B, the first construction activity is the installation of piles. It is only once the foundation piles are installed that a cofferdam is constructed around the installed piles to provide a dry environment in which to construct the pile cap. This subchapter focuses on only those activities that are different from those in Zones A and B –the installation of the hanging cofferdam. Activities associated with the pile cap construction and pile installation are not repeated here as these are the same as those outlined for Zone B.

A. Construct cofferdam

B. Install Pile template on sheet piles and drive piles

C. Pour tremie concrete seal slab, dewater cofferdam, install reinforcing and pour pile cap concrete

Figure 5.8 - Construction of Zone B Foundations

5.3.1 Hanging Cofferdam Construction

The hanging cofferdam method requires the installation of a temporary support structure above the foundation piles on which the cofferdam can be assembled. This support structure allows the cofferdam to be built “in the dry” by suspending the cofferdam above water during its assembly.

The temporary structure that supports the hanging cofferdam would be comprised of four pile extensions and two top beams. The pile extensions would be located at the corners of the cap and would be secured to the ends of the foundation piles as shown in Figure 5.9. The top beams would each be supported on a pair of the pile extensions and span the entire width of the pile cap. The cofferdam components would be assembled while supported above the water from pulleys secured to the top beams. Small barges would deliver and position the cofferdam components during assembly.

The various cofferdam pieces would be assembled while suspended from the top beams above the water. The cofferdam components would include tremie beams and struts, side walls, and the soffit (deck with deck beams) on the bottom. The hanging cofferdam sidewalls would be typically constructed from steel sheeting used to create the cofferdam’s stiff walls.

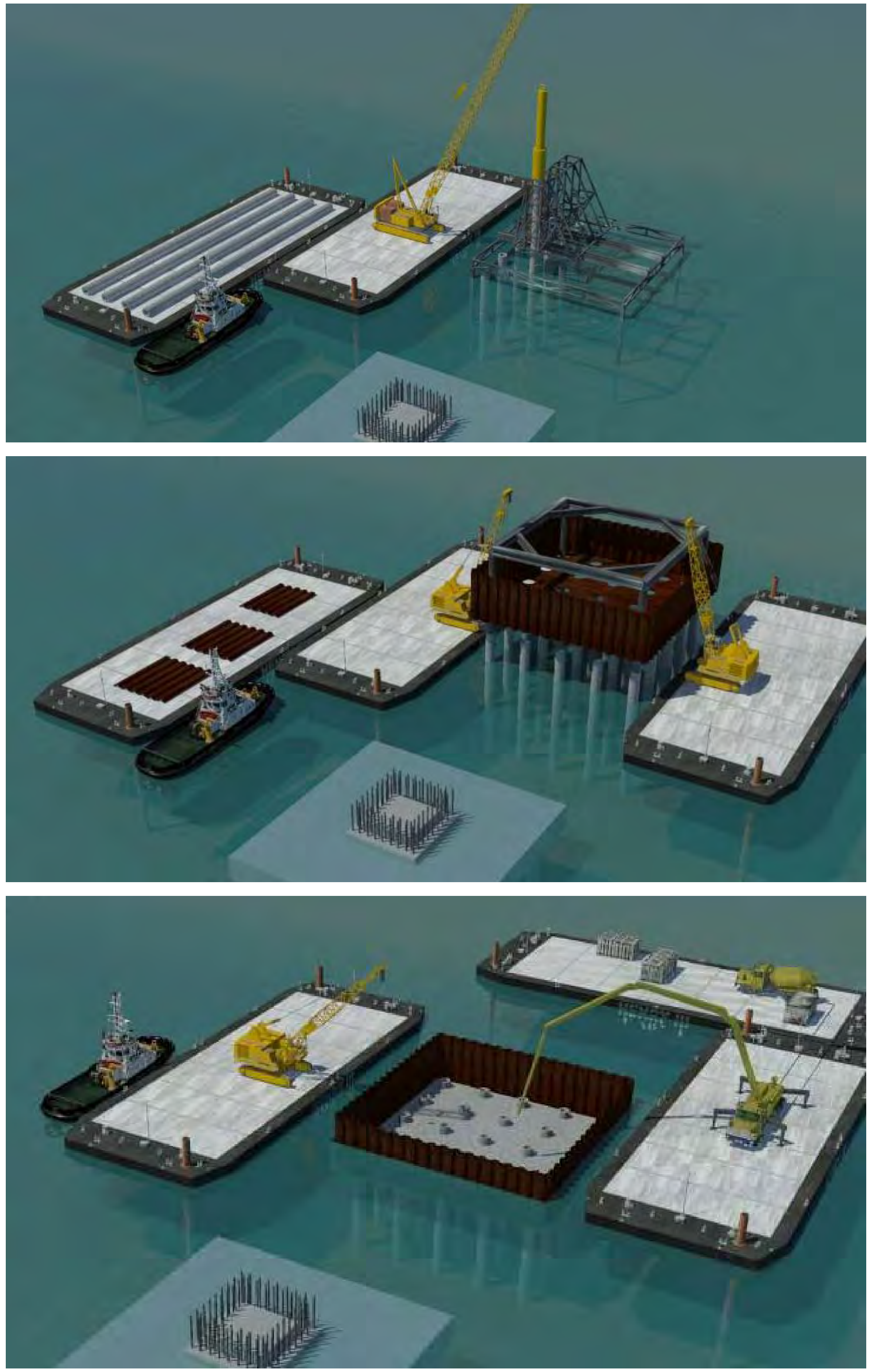
When the cofferdam construction is complete, the suspended structure would be lowered from the top beams onto pile post extensions secured above the remaining foundation piles. As the cofferdam is lowered into the water, the uppermost portion of the foundation piles would protrude up through the openings in the soffit at the base of the cofferdam. The final position of the cofferdam would be reached when the tremie beams on the roof of the cofferdam are lowered onto the pile posts.

With the weight of the cofferdam transferred onto the pile posts, the extensions and top beams can be removed for reuse at another hanging cofferdam.

Before the cofferdam can be dewatered divers must seal gaps between piles and cofferdam soffit so that tremie concrete slab will not leak when it is poured in the base of the cofferdam. The unreinforced slab of the tremie pour bonds the piles to the cofferdam until the reinforced pile cap is constructed. This also creates a cut-off at the base of the cofferdam for dewatering of the cofferdam and piles.

The tremie concrete mixture would consist of ready-mix concrete with additives to regulate setting time and to prevent segregation of the mix during under-water placement. In typical fashion, it would be placed from the bottom up by tremie pipes. The tremie pipes would be fed by concrete pumps or crane buckets into a hopper above the water.

The tremie slab would require approximately 7 days to cure to sufficient strength before the cofferdam can be dewatered. Piles would also be dewatered down to their tremie concrete plugs. Sump pumping must continue after initially dewatering the cofferdam to remove minor water infiltration entering through the slab and cofferdam walls. When the tremie slab cures connecting the cofferdam to the foundation piles, the pile posts can be removed and reused at another hung cofferdam location along the bridge alignment.



A. Install pile template drive piles long

B. Construct hanging cofferdam on temporary frame

C. Lower cofferdam and pour seal slab

Figure 5.9 - Construction of Zone C Foundations I

The advantages of the hanging cofferdam include:

- Allows pile installation prior to cofferdam construction
- Reduces the length of sheet piling required for each cap
- Eliminates temporary filling within the cofferdam to support the pile cap while it is being cast
- Reduces the thickness of tremie concrete slab
- Reduces the scour around the pile cap

An alternative to the hanging cofferdam method not described in detail in this text, but which may be considered for the relatively deep water condition would be to float a prefabricated cofferdam into position above previously driven piles. The cofferdam could then be lowered onto the piles by reducing the buoyancy of the floating structure. Once positioned on the foundation piles the remaining construction sequence would be similar to that of the hung cofferdam method. This method would reduce the time required to construct the cofferdam over open water.

5.3.2 Foundation Construction Duration

A typical pier in this substructure construction zone would have two foundations. Notable construction durations include:

- Pile installation: 50 days (TBC)
- Cofferdam construction: 75 days (TBC)
- Pilecap construction: 63 days (TBC)

A day in the above list represents a calendar day. Typically, seven calendar days are equibvalent to five work days. See bar chart in Appendix B for details of local schedule.

5.3.3 Foundation Construction Crew Requirements

Details of crew strengths and their requirements have been developed in Appendix B. Effective crew sizes are computed by taking the weighted average of the crew strengths over the duration of an aggregate “roll up” of activities. It is assumed that each activity is associated with its own dedicated crew. The following is an effective crew strength for each of the aggregate activities listed:

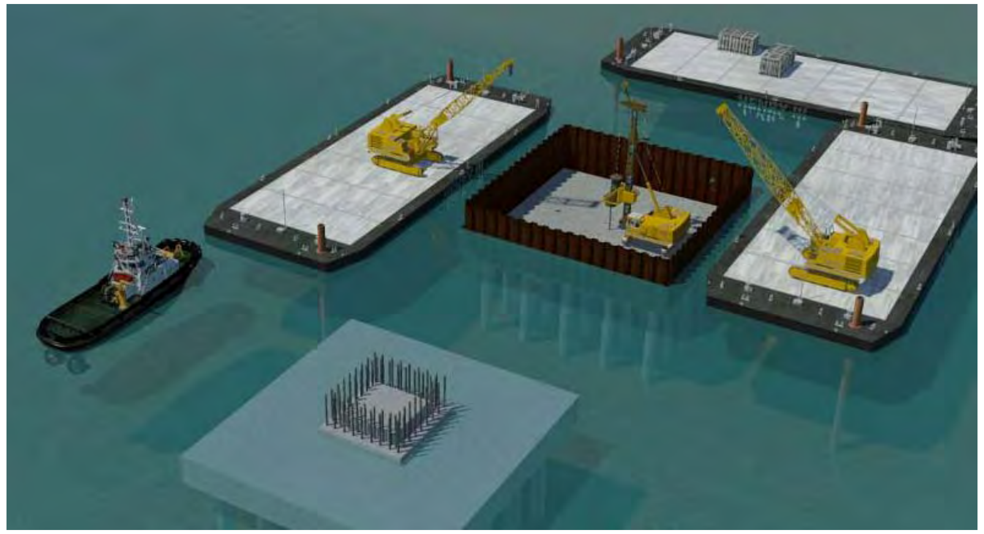
- Cofferdam construction: 8-10 workers
- Pile installation: 15-18 workers
- Pilecap construction: 9-12 workers

5.4 Construction Activities in Zone C (Main Span)

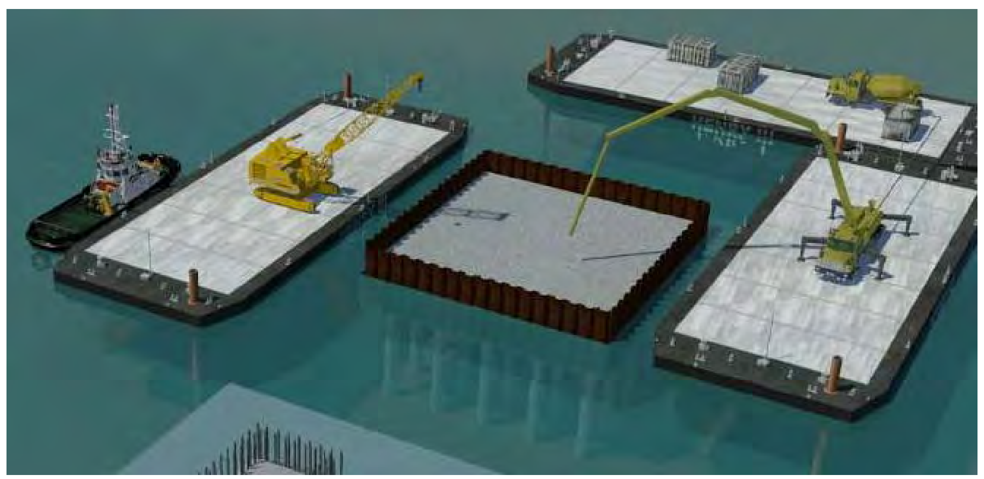
Zone C is the portion of the river crossing where river water depths are greatest – ranging from 18-45 feet. The zone includes the Main Span over the shipping channel and approach spans on either side. This sub-section presents details for the foundations for the Main Span only as the scale and duration of construction differ from that outlined for the example 12- pile foundation outlined in subsection 5.3. The Main Span foundations would also be constructed using the hanging cofferdam.

The Main Span foundations must support higher axial and lateral loads compared to the foundations along the approach spans due to the longer span length. As a result, the Main Span foundations would require more foundation elements and/or larger diameter members, with some featuring battered foundation elements to increase the lateral stiffness of the foundation. Up to 10 foot diameter piles may be used for these foundations.

Rock sockets would likely be used in combination with the large diameter piles in order to increase the axial capacity of the foundation. Piles and rock sockets may also be battered at 10V:1H.



D. Install rock socket



E. Install reinforcing and pour pile cap concrete

Figure 5.10 - Construction of Zone C Foundations II

Construction of the foundations for the Main Span would have a similar sequence to that outlined in subsection 5.3 for pile installation, hanging cofferdam construction and pile cap construction, though the scale of the construction would be somewhat larger, as indicated by Figure 5.10. The major difference in the construction activities would be the anticipated need for rock sockets in the foundations for the Main Span.

5.4.1 Rock Sockets

Rock sockets are an extension of the base of the steel shell piles up to 30 feet into the bedrock, located approximately 250 feet deep beneath the river bed.

Once the cofferdam is dewatered, rock socket construction would commence. Prior to drilling the rock socket, all the soil within the piles must be removed.

Drilling of the rock sockets at each shaft would require the use of percussion down-the-hole hammers powered by high pressure air, as shown in Figure 5.10. It is anticipated that multiple drill rigs would be used on the same pile cap to expedite the rock socket excavations. The material recovered while drilling the rock socket would be dumped onto scows for transport to an off-site disposal facility or re-used for other purposes within the project. When drilling of the rock sockets is complete, each socket would be flushed out with clean water and air and visually inspected by remote operated video camera prior to installation of reinforcement.

The steel reinforcement cage that would be installed in the rock socket and casing must be installed in several sections spliced together before being lowered into the shaft. The reinforcing would be continuous along the entire length of the pile. Once the reinforcing cage is installed, concrete can be poured from the bottom up using the tremie method. As the concrete is added, the water within the shaft would be displaced.

5.4.2 Foundation Construction Duration

A typical pier in this substructure construction zone would have three foundations. Notable construction durations include:

- Pile installation: 122 days
- Hanging cofferdam construction: 50 days
- Rock socket escavation and concrete: 90 days
- Pilecap construction: 63 days

A day in the above list represents a calendar day. Typically, seven calendar days are equibvalent to five work days. See bar chart in Appendix B for details of local schedule.

5.4.3 Foundation Construction Crew Requirements

Details of crew strengths and their requirements have been developed in Appendix B. Effective crew sizes are computed by taking the weighted average of the crew strengths over the duration of an aggregate “rolled up” activities. It is assumed that each activity is associated with its own dedicated crew. The following is an effective crew strength for each of the aggregate activities listed:

- Pile installation: 10-12 workers
- Hanging cofferdam construction: 8-10 workers
- Rock socket escavation and concrete: 13-15 workers
- Pilecap construction: 10-12 workers

5.5 Hydroacoustics

Hydroacoustics refers to noise in the river environment generated by construction activities. By far the most significant hydroacoustic impacts are due to the noise generated by hammering of piles. The noise levels are mostly dependent on the energy input into the system via the hammer,(i.e the hammer mass) the concurrent hammer operations, the spatial distribution of concurrent hammer operations and the duration of each hammer operation.

The spatial configuration of the piles and corresponding hammer sizes are given in Appendix D.

The temporal and sequential configuration of the hammer operations are extracted from the overall construction schedule and is summarized for the Short and Long Span options in Appendix D as well.

The charts in Appendix D summarize the spatial and temporal configuration of the hammer operations. The charts identify worst case scenarios of pile driving and account for the placement of spud piles in setting up the cofferdam, as well as the installation of the foundation piles for the spans.

The chart assumes that all piles are installed in two segments. Segment 1 is the lower segment, which generally can be installed with a vibratory hammer into the soft upper layers of the soil. Impact hammers may be used for this purpose as well. Segment 2 is the upper segment of the pile which is welded to segment 1 and then driven by an impact hammer. Most of the hydroacoustic impact is expected to emanate from the hammer operation on segment 2.

The chart shows the period of installation of segment 1 and 2 piles for each pier location. Based upon the schedule, within each calendar month, various possible combinations of lower (segment 1) piles, upper (segment 2) piles and spud piles could be driven simultaneously. The worksheets that follow each chart delineate the possible combinations and identify the maximum probable daily piling combinations for the three pile placement operations (upper, lower and spud).

For the Long Span Option, two piling rigs are used for segment 2 installation and additional driving rigs are used for segment 1 installation. For the Short Span Option, three piling rigs are used for segment 2 installation, reflecting the larger number of piles and additional rigs are used for segment 1 installation.

5.6 Construction of Columns and Pylons

This section outlines the construction activities required to complete all piers. Two types of pier systems are envisioned for the project:

Columns

Conventional concrete columns are anticipated at all pier locations except at the location of the Main Span pylons which would support the deck of the Main Span over the shipping channel. Columns would be composed of reinforced concrete and would likely be hollow in order to perform efficiently and minimize weight. There are a total of 122 columns in the Short Span Option and a total of 68 columns in the Long Span Option.

As an alternative, columns may be assembled using precast concrete elements clamped together by means of vertical post-tensioning tendons. Precast columns are not conventional and will not be considered for this report.

Pylons

In the event a cable-stayed bridge option is selected, pylons would be located on either side of the main channel and would be used to support the deck of the Main Span. For the Short Span Option, piers 44 and 45 constitute the pylons and for the Long Span Option piers 24 and 25 constitute the pylons. The pylons are expected to rise approximately 400 feet above the deck level and would anchor the stay cables used to suspend the deck. The term ‘tower’ is often interchangeably used with the term pylon.

Several configurations of pylons are possible. Simple straight independent pylons have been evaluated.

5.7 Construction Activities for Columns

Because of their size and difficulty in transporting overland, the reinforcement cages of the columns are likely to be assembled in either one of the Bridge Staging areas or the River Staging Area. With the possible exception of some of the tallest columns, the reinforcing cage would be assembled in one piece and stabilized with an internal structural steel frame. The length of each reinforcement cage assembly would correspond to the length of the column and the additional embedment length in the pile cap and the pier cap. This report assumes that for any column over 110 feet in length, two reinforcing cages would be used and the two cages would be spliced in the field. Placement of the rebar cages would employ a barge mounted crane with a boom of at least 200 feet and a capacity of 120 tons (Figure 5.11). Column rebar cages would be mechanically spliced to the protruding pile cap rebar and upper column sections would likewise be mechanically spliced to the lower sections.

Forms for casting the column concrete are likely to be standardized and made of robust reusable steel forms. Once rebar is installed, forms would be put in place and concrete would be placed from the top in well defined lifts. A 12-foot form height has been assumed for developing the schedule presented in this report. As concrete hardens, forms would be stripped, moved up one level and readied for the next pour. The cycle is repeated until the entire column is poured.

The top of the column, also referred to as the pier head, would have special details. Its reinforcement would likely be assembled on site. The final activity would be the installation of the bearings after which the column would be prepared to receive the superstructure elements.

In the event that an integral connection is chosen between the column and the deck, a superstructure pier table segment (monolithically combining pier head and deck section) would have to be cast in place. This segment would be cast in lieu of the pier head as described above. For the purposes of this report, integral moment connection will not be considered. Only bearing supported superstructure will be considered.

An expected construction schedule for a typical 110-foot tall column is shown in Appendix A. Notable aspects of the schedule are as follows:

1. A typical concreting cycle has a duration of 4 days.
2. One crew (10 workers) is required to build one column.
3. A typical 110 foot column takes about 71 calendar days to construct. Estimated duration of shorter columns may be computed by prorating the number of concreting cycles, noting the 12-foot typical forming height.
4. The tallest column, about 150 feet in height takes about 120 calendar days (17.5 weeks) to construct. Time for installation of two rebar cages and their field splice is included in this duration
5. The duration for the columns of the Short Span and Long Span options is anticipated to be similar.

See bar chart in Appendix A for further details on required work schedules.

5.8 Construction Activities for Pylons

The Short and Long Span Options will require 4 pylons on each side of the shipping channel for a total of 8 pylons. Self climbing slip forms are the technology of choice for the construction of the pylons. Typical of the slip form technique, once a segment of the tower has been poured and its concrete reaches a suitable strength, hydraulically interlinked jacks push against the hardened concrete and move the forms up by one slip form length (estimated at 12 feet in height). Pre-assembled reinforcement cages of requisite length would be hoisted from the ground and lapped to the reinforcing bars protruding from the previous pour.

Figure 5.11 - Column Construction

Concrete would be delivered either by pumps or by a bucket hoisted by an adjacent tower crane. The concrete is placed in the forms and the cycle is repeated.

The pylon section would be hollow and complete interior access for inspection would be assured via a system of elevators and appropriate openings specifically detailed in the design including access to the top of the pylon. Three main types of segments would be constructed: thin walled typical sections, cable segments with relative thicker walls and diaphragm segments with access openings. Transverse beams connecting the four pylon legs would be formed at the level of the deck. One additional transverse beam may also be added at the top of the pylon.

5.9 Construction duration for pylons

An expected construction schedule for one two legged pylon is shown in Appendix B. Notable aspects of the schedule are as follows:

1. A typical slip form cycle would be 6 days
2. Slip form cycle for segments carrying cable anchorages would be 7 days
3. Total duration of pylon construction would be 15 months.
4. Crews would build each leg of the pylon in parallel.

See bar chart in Appendix B

6 Superstructure Construction

6.1 Construction of superstructure

This chapter will develop further the concepts of the superstructure construction introduced in Chapter 3.

Short Span Option - Approach Structures

The approach structures of the Short Span Option are anticipated to be constructed using full width precast concrete deck segments each between 10 and 15 feet long. Multiple segments would be delivered to the bridge location on a single barge. For most of the approach structures, the segments would be hoisted directly off of the barge by an overhead gantry and would be erected in place.

For piers 1-5 and 55-61 near the shore, it is likely that the segments would be delivered by barge to a crane or low boy truck running on the trestle temporary work platform which would then deliver the segment to its final location on the bridge.

Short Span Option – Main Span Structures

If a cable-stayed bridge is chosen for the Main Span, segments similar to the ones described for the approach structure would be used. However, the**y** would be erected using balanced cantilever construction methods, the details of which are provided in the sections below.

These segments would also be full-width segments with lengths between 15 and 20 feet. Multiple segments would be delivered to the bridge location on a single barge.

If an arch bridge is chosen for the Main Span, alternative construction methods would be implemented. This chapter discusses pertinent feature of arch construction as well.

Long Span Option – Approach Structures

The Long Span Option lends itself to a truss-type steel structure. For such a structure, a reinforced or transversely pre-stressed concrete deck slab may be used and may be made composite with the truss underneath, using shear studs. Alternately, the upper plane of the trusses could be reinforced and the deck segments subsequently bolted into place. Over the life of the bridge this may reduce the costs of deck replacement.

A typical steel truss span would be split into two segments, a cantilevered pier segment and the drop-in segment lifted up from a barge below with lengths of 120 feet and 310 feet, respectively. Concrete deck slab elements would likely be full width segments of 10 to 15-foot lengths.

Long Span Option – Main Span Structures

Similar to the approach structures, the deck of the Main Span is anticipated to be a Long Span twin truss structure with a composite deck or an applied deck. For the Main Span, however, the Long Span truss would be supplemented by overhanging anchorage assemblies to enable a connection with the stay cables.

A balanced cantilever method, similar (though not identical) to the one described for the Short Span Option is anticipated. Prefabricated steel truss segments with lengths of 40 to 50 feet would be erected, a pair at a time, on either side of the pylon. Concrete deck panels would be placed immediately afterwards and stay cables would be stressed after pouring closures at the transverse concrete joints.

If an arch bridge is chosen for the Main Span, the construction of the arch would be similar to the construction methods of the arch developed for the Short Span alternative. This chapter discusses pertinent feature of arch construction as well.

6.2 Construction activities for Short Span Option – Approach Structures

The type of precast segmental construction most suitable for this bridge would encompass the following four major activities.

1. Casting of segments in the casting yard
2. Delivery of segments to the bridge site on barges
3. Erection of segments using an erection gantry
4. Post tensioning of segments with high-strength steel tendons.

The entire process of casting and erection is a large scale manufacturing process which benefits enormously from standardization of geometry and robustness of equipment. Thus considerable investment is made into the procurement of key high quality and precision construction machinery such as an erection gantry and casting machines. The overall goal of construction is to maximize erection speed and reduce on-site work to a minimum.

The methods of construction suggested in this report for the Short Span alternative are well established. Achievable speeds of erection and casting are well documented and the data available from them enables a reasonably sound estimate for construction durations.

Casting of Concrete Segments

As in the case of many large scale segmental bridge projects in North America, it is likely that the contractor awarded the job may either use a pre-existing casting yard or choose to set up his own dedicated casting yard so that he can use his specialized expertise to control the manufacturing and delivery of the segments (Figure 6.1).

The casting yard need not be located close to the bridge site and conceivably could be located anywhere on the eastern seaboard. Delivery of segments is anticipated to be via barges that enter the construction site from the existing shipping channel and then move along the alignment of the bridge inside the dredged channel to finally deliver the segments where they are needed.

The DEIS for this project will not analyze activities to take place at the casting yard. It is the contractor's responsibility to obtain the necessary permits required for setting up the operations of the casting yard. Clearly methods of delivery of the segments should be understood so that any impact from this activity may be evaluated.

Thus the following sections will deal briefly with the casting yard operations – enough to develop a conceptual understanding of the construction process.

Casting yard set up

The size of the casting yard is anticipated to be about 30 acres. It is anticipated that this acreage would be required to manufacture, store and ship a total of about 3000 segments.

A casting yard would contain typical segment casting machines, special segment casting machines, rail mounted cranes, reinforcement jigs, a concrete batch plant, survey towers, steam generation plants for concrete curing, segment haulers, a docking facility, engineering/staff offices and a large amount of space for storage of cast segments.

The personnel required at the casting yard include QA/QC inspectors, surveyors, form crews, reinforcing steel cage crews, transverse post-tensioning and grouting crews, finishers, operators, construction engineers, auxiliary employees to complete daily work and, of course, project managers and plant managers.

Match casting

Match casting is a process developed to create a high precision interface between two adjacent bridge segments. In a process known as the shortline method, one of the two faces of the segment is cast against a rigid bulkhead and the other is cast against the face of the already cast segment. Later, in the field, the segment being cast would be erected adjacent to the already cast segment and would be glued to it with epoxy then compressed through post-tensioning.

In the production line, once the new segment is cast, as described, its concrete is steam cured to achieve rapid and high levels of strength. Its forms are then stripped, the match cast segment is removed and the new segment, just cast, is pushed back to serve as the next match cast segment.

For the above cycle of activities to occur efficiently, well defined procedures and systems are put in place that include placement of preassembled rebar cages, geometrically accurate placement of post-tensioning ducts and post-tensioning anchorages, placement of embedded items, pouring of concrete, finishing and steam curing.

Additional tasks performed in the casting yard are handling, storage and transverse post-tensioning of the deck that is followed by a grouting operation.

The production output of the typical segment casting machines is the most critical element in the manufacturing of the segments. Contractors aim to produce one typical segment per machine per day. It is likely that for this project, up to four or more typical casting machines would be used. Casting machines used for special segments such as the pier segments and the expansion joint segments would have slower output rates.

The alternative method of casting is the longline method wherein the entire cantilever is cast, one segment at a time in the casting bed. In this method neither the “new” segment nor the “old” segments are moved, but rather the form itself is moved to the next segment after each casting. The process is repeated until all the segments of the entire cantilever are cast. At this point the segments are separated, placed in storage and prepared for delivery to the bridge site.

Figure 6.1 - Storage at a Casting Yard

Figure 6.2 - Delivery of cast segments on barges

Figure 6.3 - Overhead gantry installs segments

The casting bed for the longline method uses more footprint area relative to the shortline method but it is more suited to heavier segments such as the ones used in the San Francisco Oakland Bay Bridge.

6.2.1 Segment delivery

Barges are the method of choice for delivery of segments from the casting yard to the bridge site. Segment delivery on trucks is possible but will not be considered for this project. One barge can carry multiple segments and can be relatively easily steered to a location below the erection gantry to enable hoisting of segments (Figure 6.2). Small barges of 150 feet by 60 feet along with medium powered tugs of about 800 horsepower may be used to place a loaded barge under the gantry. If the segments are shipped from a very distant casting yard site, it is likely that different tugs would be used: a high powered ocean-going tug for the open water and a medium powered one in the project environs.

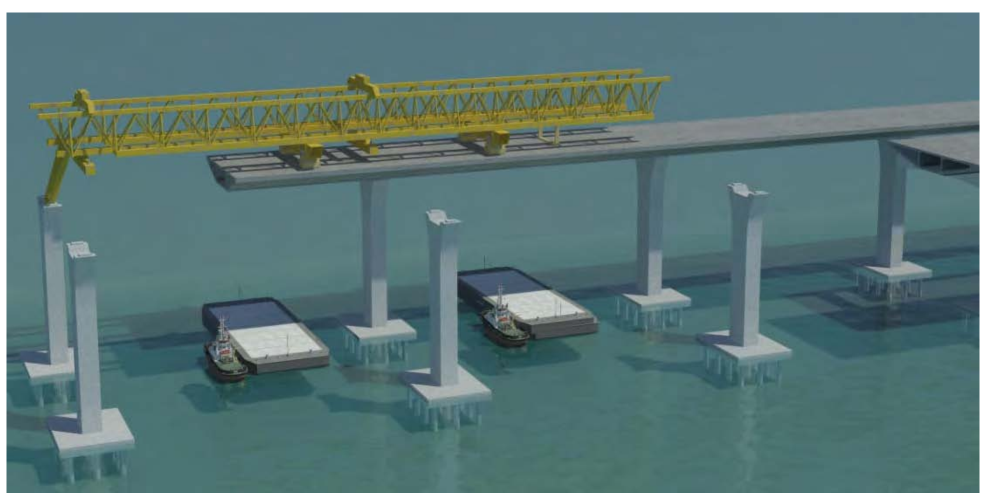
6.2.2 Segment erection

The Balanced Cantilever method using a self-launching erection gantry (Figures 6.3 and 6.4 would likely be employed for erection. In accordance with this method, for a typical span, the erection of the bridge segments starts at the pier and moves progressively outward in both directions – forward and backward forming two cantilever arms with the pier acting as a support. The two cantilevers approximately balance the gravity forces and the net unbalance (if any) is absorbed either by the column itself or stabilizing struts attached to the gantry. The following are some notable steps in the erection sequence. A schematic of selected construction steps are also shown in Figure 46.

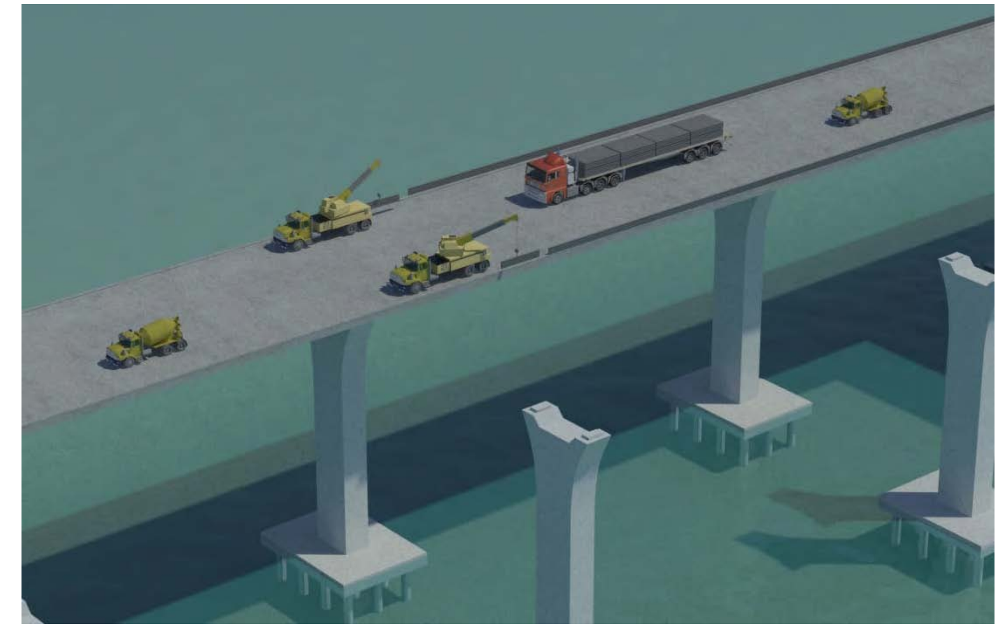
1. The erection gantry hoists a pier segment, also referred to as the starter segment, off the delivery barge and places it on the pier where it will be stabilized by post-tensioning rods.

2. Next the gantry hoists adjacent match cast segments which will be “glued” to the starter pier segment with epoxy. The epoxy will be compressed evenly by means of temporary reusable post-tensioning rods anchored on either side of the segmental joint between two adjacent segments.
3. Cantileve r post-tensioning tendons are then stressed.
4. The next pair of segments are erected and steps 2 and 3 are repeated until the full cantilever is erected.
5. A closure pour is then cast between the just erected cantilever and the previously erected bridge. This is the only place where cast in place concrete is used in the superstructure and often the designers minimize the size of this concrete pour.

A. Erect segments with overhead gantry



B. Launch gantry to next pier



C. Install barrier, overlay and other deck furniture

Figure 6.4 - Erection Stages of Short Span Bridge - Balanced Cantilever method

6. Once concrete in the closure pour achieves a pre-established strength, continuity post-tensioning tendons are stressed.
7. The gantry is then launched to the next pier. Forward launching requires a series of intricate steps as the gantry “leap frogs” from one pier to the next. Each step is monitored carefully to ensure that the freshly constructed permanent structure is not overstressed.

Given the large number of segments to be erected, it is envisioned that two identical gantries (A and B) would be needed to expeditiously erect the both approach structures. Gantry A would run on the North viaduct starting from pier 43 (west of the Main Span) working its way towards the Rockland shore. It would then be shifted onto pier 46 (east of the Main Span) of the North viaduct where it would make its way toward the Westchester shore. After it has completely erected the complete the north viaduct, the north viaduct would be opened and the gantry will be moved over to the south and central viaduct where it will perform its function by moving both laterally (from viaduct to viaduct) and by moving forward.

Gantry B would work on south viaduct operating independently but parallel to Gantry A in a similar fashion.

6.2.3 Construction duration for Short Span Option - Approach Structures

This section outlines the duration of construction of one cantilever of the approach structures. Superstructure construction is a highly repetitive activity where duration of each activity is carefully monitored and made as efficient as possible.

Construction activities of the superstructure may be broadly divided into two parts. Activities taking place in the casting yard and the activities taking place at the bridge site. Typically, manufacturing capability in the casting yard would be sufficient to not cause delays in the erection at the bridge site accounting for appropriate delivery and inventory requirements. Thus segment erection schedule is usually on the critical path which, in turn, is driven by the activities involving the use of the overhead gantry.

See bar chart in Appendix A

Assuming a nominal 10-foot segment length (providing flexibility of delivery by barge, rail or truck), a typical cantilever consists of a total of 23 segments: one pier segment and 11 typical segments for each cantilever arm. The erection sequence of one typical cantilever using an overhead gantry is shown in Figure 6.4. Notable aspects of the erection sequence are as follows:

1. A typical cantilever is erected in 12 shifts (equivalent to 15 calendar days). Additional activities incidental to the cantilever erection would take a few additional days.
2. One pair of segments is erected in half a shift.

6.3 Construction Activities for Short Span Option – Cable-stayed Main Span Structures

This section outlines the duration of construction of Main Span superstructure. Superstructure construction is a highly repetitive activity where duration of each activity is carefully monitored and made as efficient as possible.

As for the approach spans, construction activities of the Main Span superstructure may be broadly divided into two parts: activities taking place in the casting yard and the activities taking place at the bridge site. Typically, the manufacturing rate in the casting yard would be coordinated with the erection rate at the bridge site taking into account appropriate inventory requirements. Thus the segment erection schedule is usually on the critical path

6.3.1 Segment delivery

The precast segments for the cable-stayed bridge would almost certainly be delivered by barges. The Main Span crosses the shipping channel and water in this part of the river is deep and accessible eliminating the need for any dredging. The first pair of segments can be erected as soon as the pylon construction reaches the deck elevation.

Figure 6.5 - Stonecutter's Bridge, Hong Kong

6.3.1 Erection of segments and installation of stay cables

A balanced cantilever method of erection is anticipated for the construction of the Short Span Cable-Stayed Main Span. The starter segment would be the cast-in-place pier table which would be constructed together with the pylon. The principle of erection would be similar to the balanced cantilever construction of the approach spans except that rather than lifting segments from an overhead gantry the segments would be lifted with a winch type hoisting system that is installed on movable trusses and which launches forward progressively as the deck segments are erected.

The unbalance in the segments, if any, is fully absorbed by the pylon. With more advanced hydraulically linked heavy lifting systems, it is possible to do simultaneous lifts off the barges at each end of the cantilever and reduce bending in the towers to a minimum.

Figure 6.6 - Left: Cable Installation **Right: Stay Cable Anchorage**

A distinguishing feature of the cable-stayed bridge erection is the use of the stay cables which are installed and stressed as each anchorage carrying segment is installed (Figure 6.6). A stay cable is an advanced engineered element. The most common stay cable technology is a variant of the common seven wire high strength post-tensioning strand. Usually, it is supplied by the post-tensioning strand manufacturers.

The following are the important erection steps (Figure 6.7):

1. Once pylon construction has reached the deck level, a pier table is constructed. It is the first part of the deck and is equivalent to the starter precast pier segment in the approach span construction.
2. A pair of precast segments are then hoisted and connected with the pier table using a "wet" concrete pour. The wet pour is necessary because the first pair of segments is not match cast against the cast-in-place pier table.
3. Next, the first pair of segments are post-tensioned.
4. Adjacent match segments are hoisted in a similar manner and fitted to the already erected pair of segments using epoxy. The epoxy is compressed evenly by means of temporary reusable posttenioning rods. This is called a dry joint.
5. At this stage the first set of stay cables may be installed and stressed. Light cranes running on the deck are used to carry and connect the cable at the anchorages located in the pylon and the deck.

6. The above erection cycle will be repeated and deck work would be finished off with a mid-span cast in place closure pour. A total of 40 segments are anticipated in each cantilever arm of the Main Span.
7. Depending on the nature of the geometric control program, re-stressing of cable stays would be performed either during the cantilever erection or after the closure segment has been poured.
8. Finally a wearing surface would be placed on the deck and installation of bridge furniture such as barriers, light poles and lane striping would follow immediately thereafter.

As stated, a total of 40 segments are anticipated in each cantilever arm of the Main Span. Out of these about half the segments would have appendages for cable anchors. Each Main Span segment is expected to have a nominal length of 15 feet. It should be noted while the construction sequence given above assumes balanced cantilever erection, it is also possible that back spans are constructed using an overhead gantry and only the

A. Construct tower using tower cranes

B. Lift segments off barges and install stay cables

C. Close bridge, install barrier, overlay and other deck furniture

Figure 6.7 - Erection Stage of Short Span Main Span

central cantilever arms of the Main Span are erected by the methods described above. In such a case the construction duration may be slightly reduced.

6.3.2 Impact on Shipping Traffic

Erection of the Main Span is expected to pose a very small impact on shipping traffic. Barges carrying bridge segments need to be anchored under the part of the bridge deck under construction. Up to 40 segments may be delivered in the main channel with a further 20 in each of the adjacent spans. Delivery and installation of the segments would be coordinated with the Coastguard to minimize the effect on shipping. It is anticipated that two hours would be required for the delivery of each section with time included for the segments to reach the required clearance and be stabilized.

Temporary stabilizing tie downs (cables) running from the quarter point location of the deck to the pile caps of the pylon may be used during construction. If tie-downs are used, this may have an impact on the width of the shipping channel for a significant period of time (approximately one year). The purpose of the tie downs is to provide aerodynamic stability during construction when the bridge is most vulnerable to wind induced instability.

6.3.3 Construction Duration for Short Span Option – Main Span Structures

Erection of the cable-stayed Main Span is a relatively slower process compared to the approach structure where each step is finely tuned to be efficient. The learning curve is usually long on a cable-stayed bridge because of the complexity of the process. Further, adjustments in construction operations due to unanticipated aerodynamic instability of the partially completed deck or corrections to excessive deviations from theoretical camber could also have a negative impact on the speed of construction.

The erection of the deck is also dependent on the progress of the pylon construction. Any problems in pylon construction, in particular during the casting of the more complex anchorage zone, could impede erection of the deck.

As noted above, the cantilever arms of the cable-stayed bridge would each consist of a total of 40 segments with a total of 20 cable pairs. An erection cycle is defined as the duration between the stressing of one cable to the stressing of the same cable in the next segment. The erection sequence of a typical segment set is given in Appendix A and the erection sequence of the entire cable-stayed deck is given in Appendix A. Notable aspects of the erection sequence are as follows:

1. A typical erection cycle is completed in 10 shifts (equivalent to 14 calendar days),

2 A cantilever deck for one pylon is expected to take about 14 months to erect.

3. The entire cable-stayed bridge deck is expected to take a total of 18 calendar months to erect (per structure).

6.4 Construction Activities for Short Span Option – Arch Main Span Structures

An arch structure is a feasible alternative for the Main Span. The arch structure could be used in conjunction with the Short Span Option. The arch structure proposed is classified as a tied arch bridge.

This section briefly describes the essential features of the construction of an arch structure. The detailed construction schedule for the arch construction has not been developed though it is judged that the overall duration of the arch alternative would be similar to the duration of the cable-stayed bridge.

A number of possible methods exist to build an arch bridge. For this project it is likely that the arch rib would be constructed using a cable-stayed segmental method in which a temporary tower is erected at the springing (foundation) of the arch. Temporary stay cables would be used to support segments of the arch rib as they are erected incrementally from the two springings of the arch. After the arch is closed, the concrete deck segments would be erected starting from both ends of the span. As each segment is erected, it is supported by a suspender cable hanging from the arch rib itself. Longitudinal post-tensioning would be used to integrate the segments together.

The temporary towers and the stay cables would be removed after the deck is completed.

depicting an Arch structure was developed for the Long Span Option; however, the sequence shown in the figure is valid for the Short Span Option as well.

With regard to potential impacts on shipping traffic for the arch option, like the cable stay, segments may also be delivered by barge with similar number of segments required. However, instead of construction in segments there is the potential that the arch option may be constructed in one large span lift – a method that would require closure of the main shipping channel for 1-2 days.

6.5 Construction Activities for Long Span Option - Approach Structures

The type of construction most suitable for this Option would encompass the following four major activities.

1. Fabrication of truss segments in an offsite fabrication plant.
2. Delivery of truss to the bridge site on barges.
3. Erection of truss segments using barge mounted cranes and/or winch type lifters.
4. Laying of concrete deck – precast or cast-in-place.

6.5.1 Fabrication Yard and Its Activities

Typically these facilities are already permitted. If these facilities have to be expanded to cater to the scale of the RTZB, it is the Contractor's responsibility to address any issues related to environmental impacts.

Thus the following sections only deal briefly with the fabrication yard operations – enough to develop a conceptual understanding of the construction process.

Unlike the set up of a dedicated casting yard for the concrete segments, it is common in the steel industry to let out fabrication of the steel elements while maintaining significant oversight. Given the large scale of the project, complex fabrication set ups should be anticipated. A comparable example would be the Øresund Bridge in Denmark where steel plate was shipped from England, fabrication took place in Spain and assembled truss segments were shipped to the job site located between Sweden and Denmark. For that bridge, the fabrication requirements were beyond the pre-existing capabilities of one fabricator. The facility of the winning subcontractor had to be doubled in size to meet the requirements of the project.

For the RTZB, workshops of the fabrication subcontractor could be located as far away as the Gulf Coast or even the West Coast. If the "Buy America" requirements in the construction contract are waived, international fabrication facilities may be involved, which was the case for the main suspension span of the San Francisco Oakland Bay Bridge and the Tacoma Narrows Bridge in Seattle.

Typical fabrication yard activities include cutting of plate, welding of truss elements, shot blasting the exterior surfaces, and finally, painting. Modern fabrications shops use precise computerized numerically controlled cutting machines with multiple torches and heads. In addition to manual welding, the project of this size may also require the use of robotic submerged arc welding.

Due to their sheer size, the assembly of the truss may have to be performed in an outdoors. In such conditions portable enclosures with environmental control necessary for welding would be employed.

A typical truss unit fabricated in the yard would comprise of two vertical planes of trusses with diagonal elements, and a horizontal plane transverse Vierendeel truss with perpendicular elements – this forms the base of the U section – and temporary internal V bracing to stabilize the top chord until such time as the concrete deck is in place.

Erection methods suggest that each truss span be split into two steel segments as follows:

Pier segment: weight = 300 Tons, length = 60 feet

Drop in segment: weight =1600 Tons, length = 370 feet

6.5.2 Truss Segment Delivery

Delivery of segments of the sizes suggested would almost certainly be made on barges over water. A 300-foot by 100-foot barge would be ideal for the delivery of the drop in segments. The pier segments may be shipped on smaller barges. High horsepower ocean-going tugs would be used when moving on the open waters but light duty tugs would be allowed for barge movements in the project environs.

6.5.3 Erection Sequence

The erection method presented here utilizes one floating crane that picks the pier segment off the barges and erects them on the pier column. The pier segment is balanced atop the column and is secured using massive struts. For the erection of the first span, pier segments are balanced atop both columns. The longer drop-in segment on its barge is then slid between the pier caps below. This segment is then hoisted by means of a winch or strand jack assembly installed on the balanced pier segments and secured to the pier segments.

The strand jack assembly performs the same function as the traditional winch but is able to pick much heavier loads though more slowly. The strand jack apparatus is much lighter than winches and easy to move from one cantilever tip to the other.

The following detailed erection sequence is anticipated. Schematics of selected steps are shown in Figure 6.12:

1. A pier segment for the south viaduct is lifted from a delivery barge using a barge mounted crane and placed atop the south pier column. From the previous cycle, a pier segment, connected to the balance of the approach spans, would be overhanging the opposite south pier column.

2. The pier segment is then temporarily stabilized by making a moment connection with the pier using temporary struts or temporary post-tensioning rods.
3. Once the pier segment is erected, the barge mounted crane releases the pier segment and leaves.
4. Strand jack equipment is securely installed on top of the east and west pier segments between which the drop in segment is to be installed.
5. A delivery barge carrying the drop-in span for the south viaduct is then moved to a position directly under the alignment of the south structure.
6. The drop-in segment is lifted by means of the strand jacks. Temporary connections between the pier segment and the portion of the bridge erected in the previous cycle are made.
7. Finer corrections to any misalignment during erection are now made using hydraulic jacks and the drop-in segment is permanently spliced with the newly erected pier segment and the continuing part of the truss erected in the previous cycle. The splice could either be a full penetration weld or a bolted connection. In case of a weld, a temporary enclosure to provide a controlled environment is made around the connection. Of note, the US steel industry favors bolted connections.
8. Steps 1 through 7 are repeated for the north viaduct.
9. Now that the superstructure is stable, the temporary struts between the new pier segment and the column are removed.
10. As soon as the truss is made continuous, the concrete deck may be placed on the trusses.

The maneuvering of the delivery barges and barge mounted cranes is possible only after channels have been dredged and draft requirements have been met. The limits of the dredging channels are determined by the requirements of the barge movements necessary for the erection.

For the spans accessed by the temporary trestle platforms at the landings, trusses would be delivered in smaller pieces and assembled directly on the platforms. They would then be erected by the winches in the same as the trusses for the rest of the structure (Figure 6.14).

Figure 6.8 - Fabrication Yard – welding enclosure

Figure 6.9 - Fabrication Yard

Figure 6.10 - Fabricated Truss Unit

Figure 6.11 - Delivery of 145th St. Bridge, New York on barge

6.5.4 Construction of the Concrete Deck

Full depth and full width precast deck panels, fabricated in a casting yard are expected for the approach structure deck. It is noted that the usual US practice for conventional small scale steel stringer highway bridges is to use cast-in-place concrete for decks. A cast in place deck for the entire 32,000 feet of twin viaduct is an extremely large on-site concreting operation requiring a continuous flow of fresh concrete delivered on barges from a large scale concrete batch plant located in the vicinity of the bridge. This scenario can be avoided though it cannot be categorically ruled out. The discussion in this section will focus on the precast deck option only.

Full depth panels are light weight and are sized to suit available lifting equipment. They come with leveling screws and full depth block outs for developing composite action with shear studs on the top chord of the truss. Their geometry is simple and they can be fabricated by most pre-existing casting facilities in the area. These panels would be erected at precise locations scribed on the truss below.

The delivery of the concrete deck segments would be made on barges, or once on-shore access is available, by truck. A customized gantry that runs on specially detailed rails (designed to avoid conflict with shear studs) on the top chord of the truss may be fabricated for economically and efficiently laying the deck segments. Alternatively, a light crane mounted on the already erected panels may be used for precast panel lifts.

Erection would proceed sequentially and continuously from one end of the span to the next. Non shrink grout would be poured in the transverse gap between the panels.

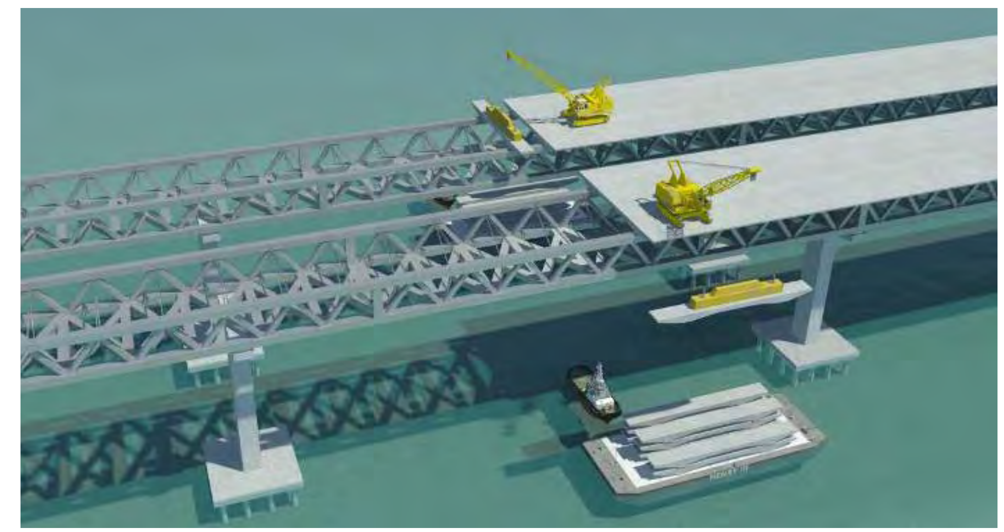
Once the grout has reached sufficient strength, longitudinal concentric post-tensioning tendons would be stressed and nominal uniform compression would be induced in the concrete deck.

Tendons would be stressed from the leading end – the end where the last precast panel was placed. Tendon couplers may be used to make the newly erected deck continuous with the concreted deck of the previous span. For both transverse and longitudinal tendons, three or four-strand flat ducts of about 1 inch thickness would likely be employed.

After post-tensioning is complete, shear key blockouts would be filled with non shrink grout and, finally, a suitable overlay would be poured to make the final finish

A Erect Pier Truss Segment

B Install winch and erect drop-in truss segment



C Erect precast deck segments

Figure 6.12 - Erection Stage of Dual Level Approach Structure

6.6 Construction Duration for Long Span Option - Approach Structures

This section outlines the duration of construction of two adjacent truss spans. The truss for the south viaduct is erected first and the truss for the north viaduct is erected next. Precast deck is placed on both south and north viaducts simultaneously by a customized gantry described in the sections above. The durations of each activity are summarized in Appendix B. The key aspects of the erection schedule are as follows:

1. The erection cycle of one steel truss span including the pier segment and the drop in (but not including the concrete deck) is 21 calendar days.
2. The total erection cycle of two adjacent steel truss spans is 42 calendar days.
3. Five deck segments are erected in one day.
4. The deck segments for the two viaducts are erected in 36 calendar days

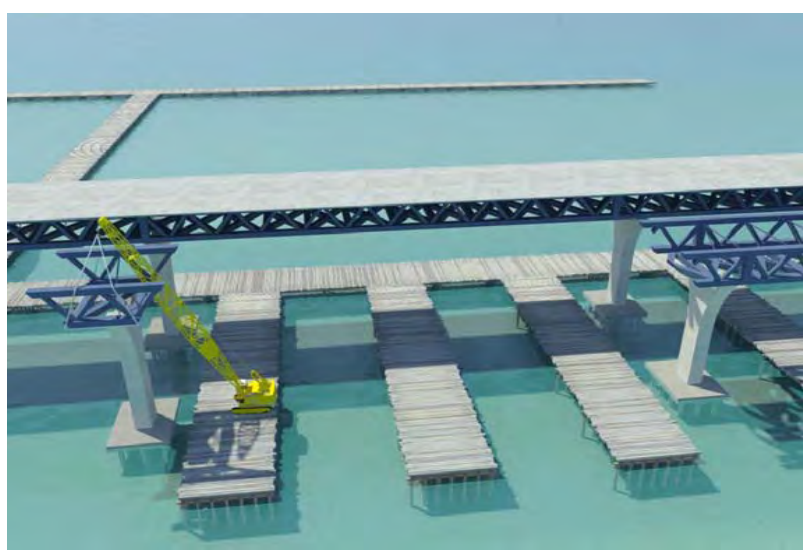
6.7 Construction Activities for Long Span Option – Main Span Structures

Just like the delivery of the approach viaduct trusses on barges, the truss segments of the Main Span would be delivered on barges as well. These truss segments being smaller in size, it is quite possible that each barge would carry more than one truss segment. The Main Span crosses the shipping channel and water in this part of the river is deep and accessible by barges and tugs without the need for any dredging.

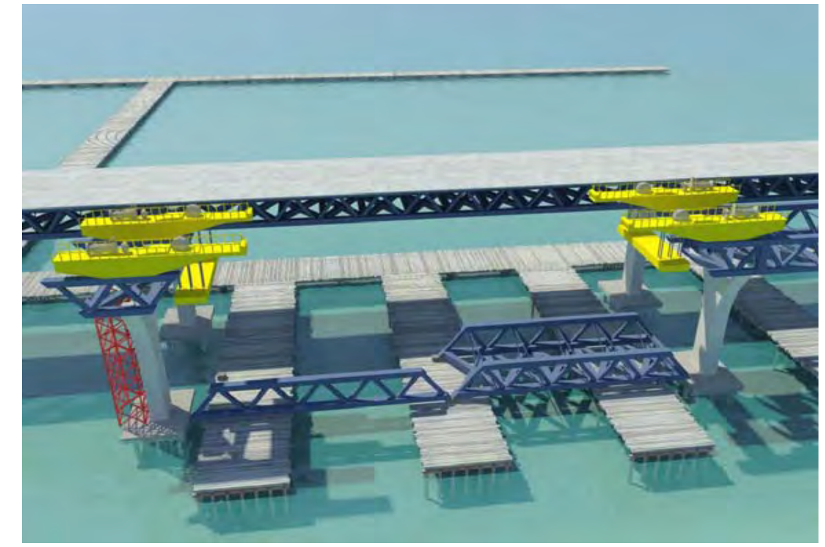
A balanced cantilever method of erection is expected for the construction of the Main Span. As soon as the pylon construction reaches the deck level, the deck trusses can be started. The type of stay cable used are the same as what has been described for the Short Span concrete option, though it is likely that the total strand used in the cables is less than that used in the cables of the concrete option, simply because of the relative lightness of the steel truss system.

The following are the important erection steps:

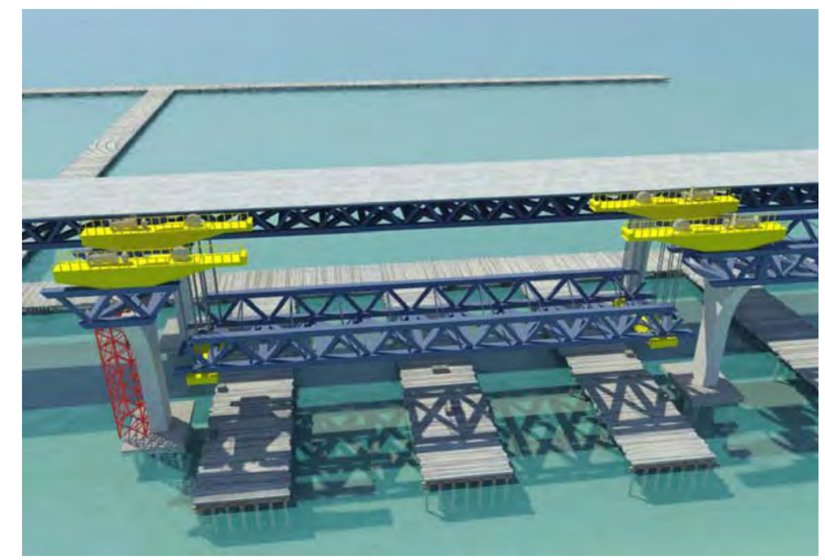
1. A starter truss segment is erected after the pylon height has reached an appropriate elevation, Precast concrete deck is then placed on the truss.
2. Segment lifters are placed on either end of the completed deck.
3. A pair of truss segments is hoisted and spliced with the starter truss segment.
4. Stay cables are stressed to a pre-established percentage of final force.
5. Deck is erected and transverse closures are poured. Shear key blockouts are grouted.
6. Stay cables are stressed to final force level.
7. The above erection cycle is repeated and deck work is finished off with a closing midspan truss segment and concrete deck.
8. Often, depending on the nature of the geometric control program, re-stressing of cable may be necessary either during the cantilever erection or after the bridge structure has been closed



A. Erect Pier Truss Segment



B. Assemble drop-in truss on trestle



C. *Install winch and erect drop-in truss segment*

Figure 6.13 - Erection of truss from temporary trestle

6.8 Construction Duration for Long Span Option – Cable-stayed Main Span Structures

Erection of the cable-stayed bridge is a relatively slower process compared to the approach structure where each step is finely tuned to be efficient (Figure 6.15). The erection of the deck is also dependent on the progress of the pylon construction.

Issues related to aerodynamic stability and non-linear geometric control are addressed during the course of erection. One erection cycle is defined as the sum of activities between the completion of stressing of one cable set to the completion of stressing of the next cable set. For this project it would be reasonable to assume an erection cycle of 10 days. At this level of design, a total of 20 cable pairs per cantilever arm may be assumed.

6.9 Construction Duration for Long Span Option – Arch Main Span Structures

An arch structure is a feasible alternative for the Long Span Option Main Span. The arch structure proposed is classified as a tied arch bridge.

This section briefly describes the essential features of the construction of the arch alternative. The detailed construction schedule for the arch construction has not been developed though it is judged that the overall duration of the arch alternative would be similar to the duration of the cable-stayed bridge discussed above.

A number of possible methods exist to build an arch bridge. For this project it is likely that the arch rib would be constructed using a cable-stayed segmental method in which a temporary tower is erected at the springing (foundation) of the arch. Temporary stay cables are used to support segments of the arch rib as they are erected incrementally from the two springings of the arch. After the arch is closed, the truss segments are erected by using strand jacks to lift truss segments off barges below starting from each end of the span. As each segment gets erected, it is supported by a suspender hanging from the arch rib itself. Concrete decking follows the erection of the truss in the same way as the concrete decking operation is performed in the approach structures. See .

The temporary towers and the stay cables are removed after the truss deck is closed.

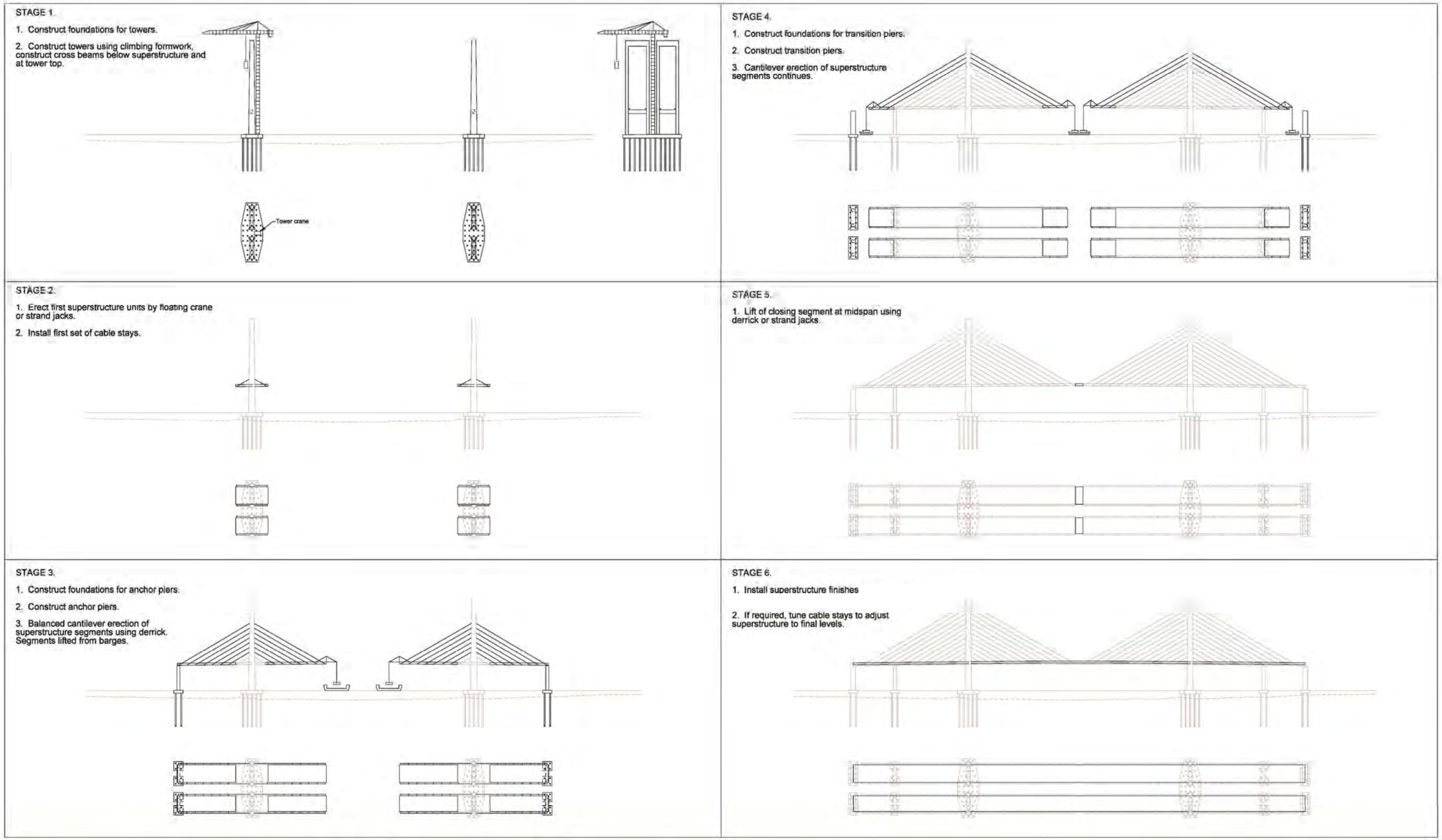


Figure 6.14 - Erection of Cable Stay Long Span Bridge

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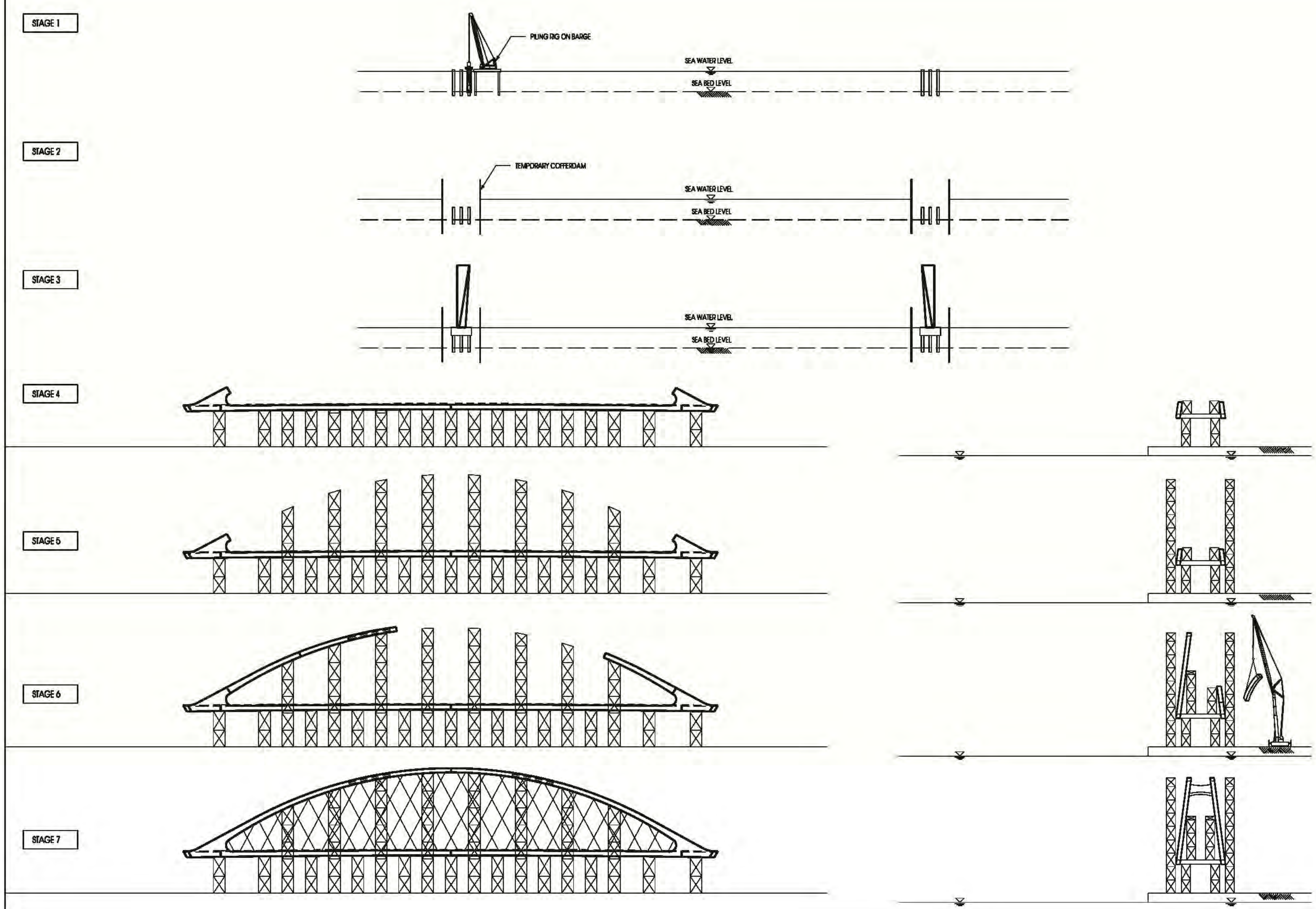

Stage 1 (On-site)
- Install piles using barge mounted piling rig

Stage 2 (On-site)
- Install temporary cofferdam
- De-water down to bottom of pile cap level
- Trim piles to cut off level

Stage 3 (On-site)
- Transport formwork and materials for approach and main piers using barges with cranes
- Construct pile caps and pier shafts
- Retain the cofferdam for casting of the piers

Stage 4 (Assembly Site)
- Fabircate steel superstructure and arch segments (possible at another location
- Erect temporary tressels to support superstructure segments
- Crane in deck segments and make slice connections

Stage 5 (Assembly Site)
- Complete erection of the superstructure
- Install temporary towers to support arch segments

Stage 6 (Assembly Site)
- Crane in arch segments onto temporary towers for support and make splice connections

Stage 7 (Assembly Site)
- Complete erection of arch
- Install hangers

Figure 6.15 - Construct Main Span arch alternative

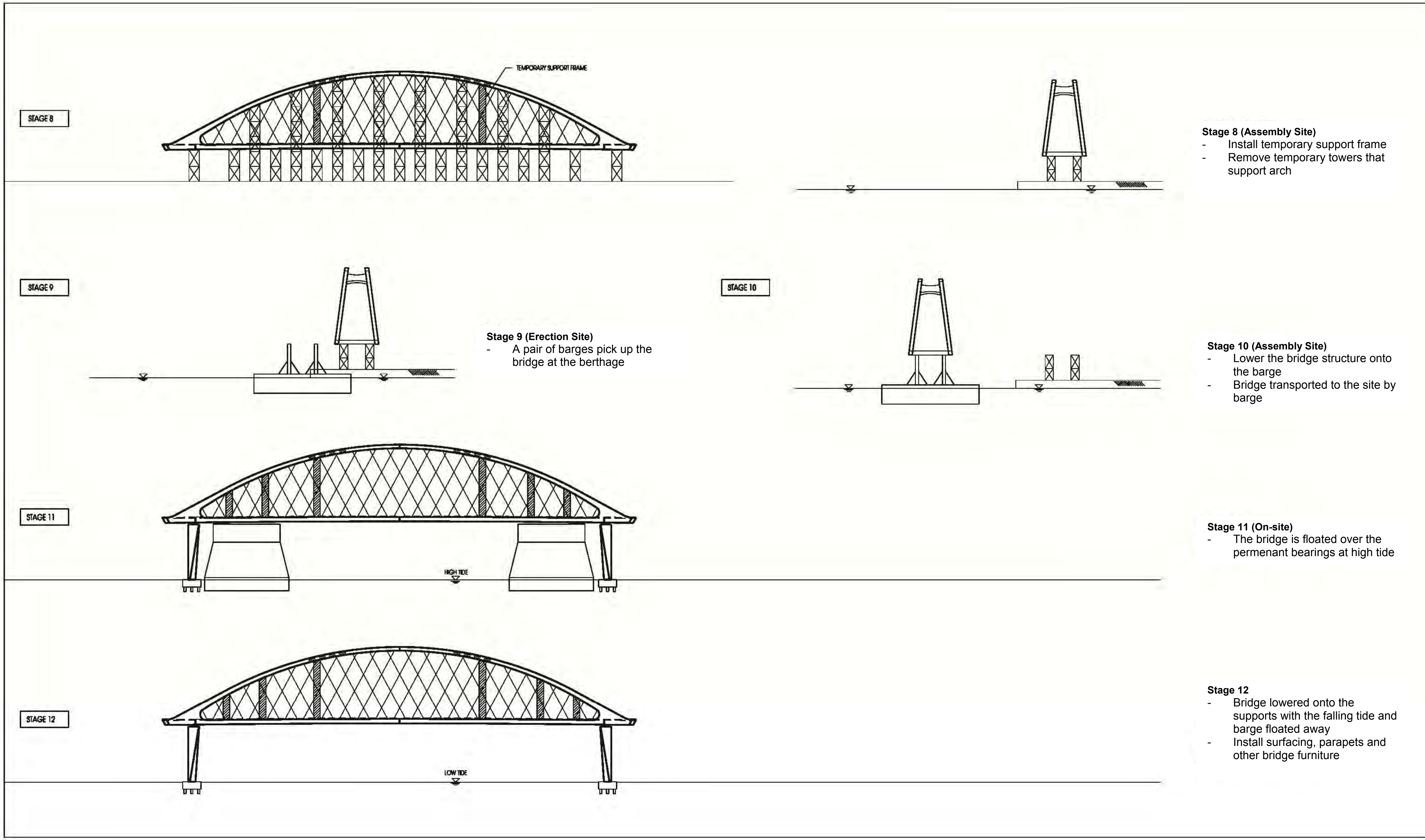

Figure 6.16 - Construct Main Span arch alternative

7 Landings

This chapter highlights some of the critical considerations involved in the construction of the landings and how the landings will support construction of the RTZB. The intent of this chapter is not to provide the step by step construction stages. These stages and the associated intermediate steps can be found in the landing drawings provided in Appendix E.

Organizing principles of the construction staging program are presented first, followed by the construction considerations specific to each landing. The differences between the Short Span and the Long Span Options are covered within these sections, as necessary.

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7.1 Organizing Construction at the Landings

Within each landing an upland staging area and associated in-water bridge staging area will be used to support the construction of the RTZB. Because traffic will be maintained over the existing TZB, a portion of these landing areas must be reserved to convey the existing traffic while these approach roadways (including the Toll Plaza in Westchester) are reconstructed in anticipation of the new bridge.

The foregoing leads to four distinct construction and construction support activities at six sites that need to be managed during construction of the RTZB:

1. Rockland Inland Staging Area (RISA) together with Rockland Bridge Staging Area (RBSA), supporting reconstruction of the RTZB
2. Rockland Approach Reconstruction Area (RARA)
3. Westchester Inland Staging Area (WISA) together with Westchester Bridge Staging Area (WBSA), also supporting reconstruction of the RTZB
4. Westchester Approach Reconstruction Area (WARA), including the Toll Plaza and Interchange 9 ramp.

These four areas each have different objectives, activities, personnel and schedules, yet have to work together in a coordinated way to deliver the RTZB and approaching roadways.

For the purposes of the DEIS, the Rockland landing is defined as the portion of the corridor that extends from the abutment of the bridge to just west of the South Broadway Bridge. It includes the NYSTA Dockside facilities located on the shore.

Even with the potential use of Interchange 10 as a staging support area, the immediate Rockland landing area is insufficient to support construction of a bridge of the size of the RTZB. As such two other facilities have been identified. The first, the RISA, is a large staging area of 28.5 acres, possibly located opposite the Palisades Mall, south of Route 59, and 3.8 miles (by way of Interchange 12) from the Hudson River. This area provides for laydown, storage, offices, parking, equipment storage and maintenance, concrete batch production, and material pre-assembly.

The second half of the staging scheme, the RBSA, is an in-water temporary platform and docks that support movement of material and personnel to and from construction vessels. Movement of material from RISA to RBSA would utilize Route 59, Route 303, Interchange 12, I-287 and, briefly, River Road. Temporary ramps between I-287 and River Road (from and to the west) would be constructed (and reconstructed for permanent maintenance access) from the reconfigured roadways of the RARA to provide access to the RBSA.

On the Westchester shore, the landing is defined as the portion of the corridor that begins at the transition point between the approach deck truss structure and the flared concrete bridge structure and then extends all the way east through Interchange 9. It also encompasses the Toll Plaza itself and the area to the north of the westbound lanes that presently houses NYSTA Bridge Maintenance facilities and NYSP facilities. As well, it includes the parking to the south of the existing Toll Plaza, the NYSTA Westchester Highway Maintenance facilities, and includes all the ramps associated with Interchange 9.

In Westchester, available space to support RTZB construction is even more limited. After relocation of the existing facilities, it is proposed to use the area north of the westbound lanes as the WISA. This would leave the entire roadway (westbound and eastbound Toll Plaza) along with the the ramps of Interchange 9 as part of the WARA Work Area. The WISA would connect with the WBSA by development of the existing underbridge roadway that enables access to the south side of the Toll Plaza. From there, a roadway would be constructed to descend from south of the Toll Plaza down to an elevation of approximately 80 feet whereupon it would cross the Hudson Line (HL) tracks on a temporary bridge and then descend to the WBSA.

7.2 Considerations in Reconstructing the Approach Roadways

The alignment of the RTZB has been developed such that the new crossing will overlap a small part of the existing TZB near the shores. One of the important goals of such a concept was to complete the construction of the north structure first and shift all the traffic from the existing TZB to this completed north structure. This would allow the overlapping portion of the existing TZB to be demolished, which would then be followed by the completion of the new south structure. At that point in the construction sequence, traffic would be rerouted to its final design configuration with westbound traffic on the new north structure and eastbound traffic on the new south structure.

The construction stages developed for the purposes of the DEIS are configured to support the sequence of construction of the RTZB as described above. The phasing of construction is developed so that traffic can continue to flow at design speed throughout the duration of construction. At no point during the construction would there be a reduction in the number of lanes in any portion of the landings or on the crossing itself.

The timing of the landing construction would be coordinated with the timing of the bridge construction such that a connection to the Thruway becomes available as soon as the north structure is completed.

During construction, the movable barrier on both landings would be retained while all lanes of the existing TZB are in full use. As soon as a portion of the traffic is moved to the new north bridge, the movable barrier would be decommissioned on both landings. The new north structure would be configured to carry a full eight lanes of traffic which would eliminate the need for a movable barrier.

On both shores, the footprint of the landings associated with the Long Span Option can be accommodated within the right of way. Construction stage drawings provided in Appendix E demonstrate that the right of way limits need not be exceeded during its construction either.

7.3 Rockland Landing Construction Activities

As noted above, the I-287 approach roadways would be fully reconstructed and support for the construction of the RTZB would be staged remotely, then travels through this area to the temporary platform just off-shore for transfer to vessels.

Details of the construction activities at the Rockland landing are described below.

7.3.1 Support for the Construction of the RTZB

Supporting construction of the RTZB from the Rockland landing involves four constructed elements:

1. Rockland Inland Staging Area (RISA)
2. Rockland Bridge Staging Area temporary platform (RBSA)
3. Eastbound temporary off-ramp from I-287 to River Road
4. Westbound temporary on-ramp from River Road to I-287

Rockland Inland Staging Area (RISA)

Because the space available adjacent to the Rockland landing is inadequate to support construction of the RTZB, a remote staging area would be employed. Two possible sites have been identified that are appropriate to the heavy vehicle activity typical of a staging area. A space requirement of 28.5 acres has been identified.

The first, the West Nyack Staging Area (WNSA) is located on the south side of Route 59, just west of Route 303 and opposite the Palisades Mall. This site presently contains a concrete batch plant, an earth materials processing facility and miscellaneous construction vehicle storage. It is proposed that a temporary east-west entrance access road be developed from southbound Route 303 to the site north of the Clarkstown Public Works facility. Egress from the site would be onto eastbound Route 59, thence to Route 303 north via the cloverleaf and to I-287 via Interchange 12. The site is approximately 3.7 miles from the RBSA.

The second site, the Tilcon Quarry Staging Area (TQSA) would be located either within the quarry area or west of the quarry area on the combined sites of several refuse haulage facilities. Improvements to the quarry floor site or to the upland sites would be necessary to provide an appropriate staging area facility. Access to and from the site would be by Snake Hill Road and north Palisades Center Drive from I-287 and to I-287 via Route 303 and Interchange 12. Including access into the quarry, the site is a similar distance from the RBSA.

Rockland Bridge Staging Area (RBSA)

To support construction activity in the river, and to limit the extent and quantity of dredging needed to enable vessels to dock, it is proposed to construct a temporary platform extending from the Rockland Shore past the first 5 or 6 pier locations. This platform would be sized to support construction activities for the RTZB including the staging and delivery of batch concrete, the preparation of rebar cages, the staging of formwork, and other miscellaneous moderate scale activities. It is not anticipated that bridge superstructure segments, for instance, would be handled at this location. Elements staged or fabricated at the RBSA would be transferred to vessels by dedicated cranes, or pumping equipment, or could use drive-on/drive-off methods (e.g. batch concrete).

To avoid additional dredging, the RBSA would also be used to provide access to construct the foundations and columns for the first 4 or 5 piers. As part of the RBSA, the present NYSTA Dockside facility would be accommodated. Improvements to the upland area including River Road would also be made to provide flexibility in staging operations off of River Road.

Eastbound Off-Ramp

There presently is an eastbound off-ramp just west of River Road for authorized vehicles only. This existing ramp would be improved to support truck movement and would to serve as the river-bound access ramp for movements of personnel and material from the RISA to the RBSA. This ramp may need to be reconstructed in order to facilitate reconstruction of the Rockland approach roadways.

The off-ramp would be maintained following completion of construction to provide direct access to the relocated Dockside facility located opposite River Road.

Westbound On-Ramp

A westbound on-ramp currently exists just west of River Road for authorized vehicles only. To support the construction of the RTZB, this westbound on-ramp will serve as an access ramp from River Road onto I-287 for vehicles (empty concrete trucks and material trucks) returning to the RISA.

The on-ramp would be maintained once construction has been completed to provide direct access to the relocated Dockside facility.

Relocation of Existing Facilities

At the present time, NYSTA operates a facility known as Dockside on the water under the existing bridge which comprises of about seven slips for maintenance vessels and a building and parking supporting the Dockside facility located just to the north of the existing bridge. These are accessed by a low elevation timber trestle platform.

Prior to construction of access ramps from I-287 to River Road to support truck movement between the RISA and the RBSA, these facilities would be likely relocated onto a portion of the RBSA. Upon completion of RTZB construction, the slips would be moved closer to their original location. The new NYSTA docking facility could be built on the foundations of the RBSA.

In Westchester, NYSTA's TZB maintenance facility is located just north of the Thruway opposite the Toll Plaza. To facilitate construction of the RTZB, this area would be used as the Westchester Inland Staging Area (WISA). It is proposed that the existing NYSTA TZB maintenance facility be relocated back to the Westchester landing following completion of construction activities.

Reconstruction of South Broadway Bridge

Immediately east of Interchange 10 is the South Broadway Bridge. During the course of reconstruction, this bridge would also be replaced. It is anticipated that reconstruction of this bridge would proceed in halves, maintaining traffic.

7.3.2 Approach Roadway Construction

Since the north structure must be constructed first, construction of the corresponding westbound lanes on the Rockland landing must be finished first as well. To achieve this, however, a number of other steps would have to precede it. Part of the challenge is to relocate traffic north or south to enable roadway to be rebuilt. Complicating this are locations of existing bridge abutments and piers and the limited widths they provide. Further, the replacement bridge and ramps have to be in place before the existing connections are demolished. Thus, starting from the beginning the following elements would be demolished, constructed or reconstructed:

1. The works begin with construction of the westbound and eastbound access ramps to and from River Road and demolition of the South Broadway Bridge.
2. The side slopes south of the existing Thruway from South Broadway to the river are removed, the retaining walls are constructed and temporary pavement placed. Replacement of South Broadway bridge is begun.
3. South Broadway Bridge is completed. Meanwhile, construction of the new westbound pavement is initiated.
4. The remainder of the westbound pavement/structure, the abutment and tie-in to the north structure is completed.

5. Westbound traffic is relocated to the north structure, and the area between the westbound and eastbound lanes is reconstructed.
6. All traffic is shifted to the north structure, the tie-in portion of the existing TZB is demolished, the new eastbound pavement, abutment and tie-in to the south structure is completed.
7. Eastbound traffic is shifted back to the south structure, and to the north and south edges of the available pavement.
8. All lanes and shoulders are restored to their proper configuration, the shared use path on the RTZB is established and walkways constructed to tie into the landing. Much of the RBSA is removed to develop a facility appropriate for NYSTA's Dockside bridge maintenance operation.

The operation of traffic phasing for the Long Span Option will be more challenging than for the Short Span Option. The significantly higher elevation of the Long Span Option requires substantially additional earthwork and the use of correspondingly taller retaining structures. The extent of this elevation difference extends from the abutment, where it reaches a maximum, to a location near the South Broadway Bridge where it smoothly transitions into the existing grade. For the Short Span bridge, which is significantly shallower than the Long Span bridge, this issue is less problematic. Sections developed in the drawings in Appendix E show a resolution of this engineering problem.

7.4 Westchester Landing Construction Activities

The Westchester landing area will both support the construction of the RTZB and include the construction and reconstruction of a significant number of elements. These include (in their approximate order of construction) the following:

1. Removal of NYSTA TZB Maintenance Facility and NYSP Facility
2. Westchester Inland Staging Area (WISA)
3. Access roadway and temporary bridge crossing of Hudson Line tracks
4. Westchester Bridge Staging Area (WBSA)
5. Trestle fan-like roadway structure to transition from typical RTZB cross section to the Toll Plaza and Westbound Lanes on grade
6. Toll Plaza including Administration and support facilities
7. We stbound lanes
8. Highway speed E-ZPass lanes
9. Interchange 9 ramps.

7.4.1 Relocation of NYSTA TZB Maintenance Facility and NYSP Facilities

About 4.5 acres of land located within the existing ROW currently supports the combined offices of NYSTA and NYSP Troop T, an NYSTA maintenance yard and an NYSTA emergency vehicle storage yard. A ramp accessible to the Thruway also passes through this area and is dedicated for official vehicles only.

During the construction of the bridge, this area will likely be converted into a construction support facility and staging area (WISA). At the completion of the project, this area would be the permanent NYSTA Maintenance Facility and the NYSP Troop T Facility.

With the exception of the NYSTA emergency vehicle storage yard, all of the maintenance facilities would be relocated at the start of the project. A new temporary ramp for access would be constructed and would remain in place until not required by NYSTA.

During this stage of construction, provision would be made for additional parking spaces just to the south of the existing parking for the Toll Plaza for satellite NYSTA and NYSP access.

7.4.2 Support for the Construction of the RTZB

An expanded discussion of access from the Westchester Inland Staging Area (WISA) to the Westchester Bridge Staging Area (WBSA) is provided in section 0. To provide access from the Thruway down to the WISA on the river, an elevated temporary access road would be constructed to the west of the of the railroad tracks. The access road would start at grade and would pass from under the existing bridge near its abutment then use a temporary bridge to cross the railroad tracks. Its details are provided in the Landings drawings in Appendix E. It would slope down to the water level and connect the temporary construction platforms with the staging area discussed above. The access road would continue past the WBSA to connect to Greene Street on the west side of the Hudson Line. However the Green Street connection would be used for emergency access only. It is noted that this access road would be approximately 80 feet high at its crossing of the Hudson Line. The temporary west access road and WISA would be decommissioned following the completion of the RTZB.

7.4.3 Approach Roadway Reconstruction

The following is the general sequence of construction to provide the various Westchester landing elements enumerated above. Details of the traffic phasing and accompanying shifting of the toll booths are shown in the drawings in Appendix E:

1. In line with the overarching philosophy behind the construction sequence of the bridge, the north RTZB structure would be constructed first.
2. The overlying westbound lanes can be shifted north and onto the new north structure.
3. The half temporary, half permanent Toll Plaza would then be constructed, north of the existing.
4. The remaining eastbound traffic would be shifted from the existing TZB to the join the westbound traffic on the north structure.
5. This frees up most of the Toll Plaza, continuing lanes and the ramps of Interchange 9 for reconstruction, and removing the tie-in portion of TZB so the new south structure tie-in can be constructed.
6. Once the tie-ins are completed on both Westchester and Rockland shores, the eastbound traffic can be brought back to the south structure, the fully reconstructed Toll Plaza opened, the temporary portions of the Toll Plaza converted to Highway Speed E-ZPass lanes.

The phasing of traffic lanes would be accompanied by a progressive shift in the toll booths such that the existing toll booths remain operational until the construction of the final toll plaza.

An important feature of the traffic phasing deals with a small, but programmatically significant, overlap of the north bridge structure with the existing bridge in a zone located very close to the Westchester shore. This potential problem will be overcome by constructing only a partial width deck on the north structure to begin with. Westbound traffic would then be transferred to this deck, which in this initial configuration would carry four westbound lanes.

In this configuration, the eastbound traffic would still run on the southern most lanes of the existing TZB. With traffic clear of the north side of the TZB, the northern edge of the TZB, in the zone of conflict with the new north structure, would be demolished while the balance of the TZB continues to carry the east bound traffic. This step will enable the remainder of the new north structure to be completed immediately thereafter. As soon as this is done, the east bound traffic would be shifted to the north structure. From this point on, the existing TZB may be fully demolished.

8 Demolition of the Existing TZB

This Chapter presents a brief outline of the major activities in the demolition of the existing TZB. The existing TZB is comprised of five different segments that provide the basis for demolition:

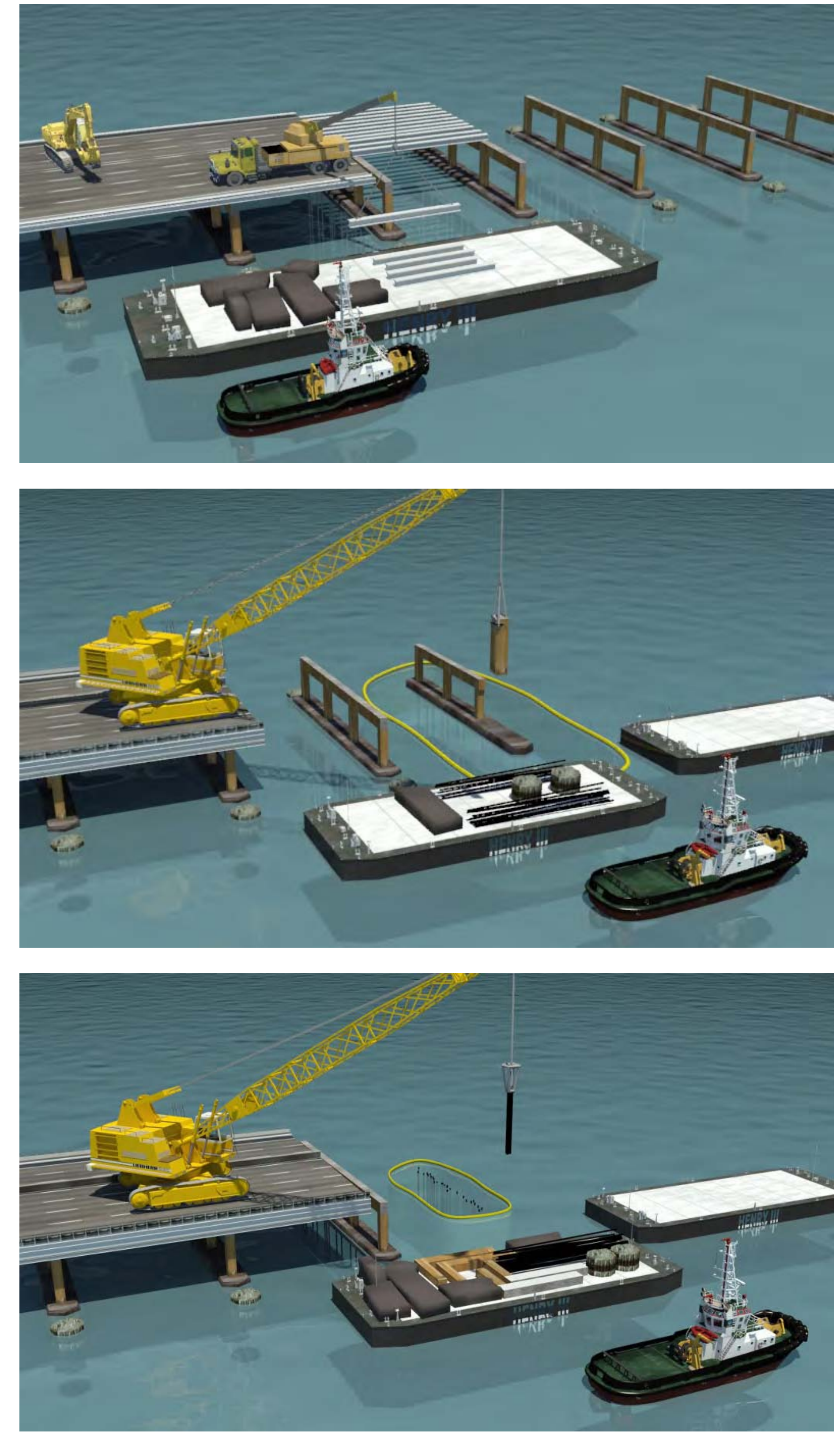
1. Causeway Spans (165 spans)
2. West Deck Truss Spans (7 spans)
3. Main Spans (3 spans)
4. East Deck Truss Spans (13 spans)
5. East Trestle Spans (6 spans)

Demolition of the Bridge would occur in two stages. The first includes partial demolition of the Causeway Spans (Figure 8.1) and all of the East Trestle Spans (Figure 8.2) to allow for construction of the RTZB. The second includes the demolition of all remaining components (Figure 8.3) and is expected upon completion of the RTZB.

8.1 Causeway Spans

The Causeway is comprised of 165 spans all with a span of 50 feet with the exception of one span, which is 100 feet. Structurally, the Causeway is of simple span construction with a simple stringer and deck superstructure and concrete columns and pile cap supported on timber piles. The demolition sequence for the Causeway would be as follows:

- Dolphins (collision protection devices) are the first elements that would be removed so that clear access to the bridge pier becomes possible. The concrete on the dolphins could be broken up using standard jack hammers and their piles removed in the same way as the piles for the pile caps as described below.
- Deck and stringers are lifted out in lengths of approximately 50 feet by 10 feet wide and would be placed directly onto trucks on the deck and removed. Alternatively, deck panels could be lifted directly on to an adjacent barge.
- Columns and pile caps may either be cut up using diamond cutting wire or may be broken up using standard pneumatic hammers. As concrete is broken off, it would be placed into an adjoining scow for removal. Netting would be used for safety and material capture, as necessary.
- The final step in the demolition of a timber pile foundation would be to cut the foundation timber piles just below the mudline. This work would be performed by a diver with an underwater saw. Alternatively, the timber piles could be cut with a hydraulic underwater self-gripping pile shear cutting device. The portion of the piles above the mudline would be loaded by crane into a scow and removed from the site.
- A turbidity curtain would be used to ensure that debris does not get dispersed in the river water. The curtains allow the passage of water through the fabric while preventing suspended solids from entering and fouling of the surrounding river. They are constructed from heavy woven filter fabric and are installed in overlapping panels. A floatation collar at the top of the curtain maintains its position several inches above the surface of the river. Weights at the bottom of the curtain secure it to the mudline.
- Side-scan sonar would be performed to verify the removal from the river of all concrete and debris generated during the demolition. If demolition debris is identified at the bottom of the river a crane operated clam-shell buckets may be used to remove that material.
- Demolition of the East Trestle Spans would be similar, however, these spans are on land between the Hudson Line and the east abutment. Their removal would coordinated with the transition staging at the Westchester landing.



A. Remove deck pavement and stringers

B. Remove columns and pile caps

C. Remove piles

Figure 8.1 - Causeway span demolition

8.2 Deck Truss Spans

This includes the 7 spans of the West Deck Truss and the 13 Spans of the East Deck Truss. Structurally the Deck Truss Spans are comprised of a deck slab, steel trusses, and concrete piers supported on either shaft or buoyant foundations. The demolition sequence for the Deck Truss is as follows:

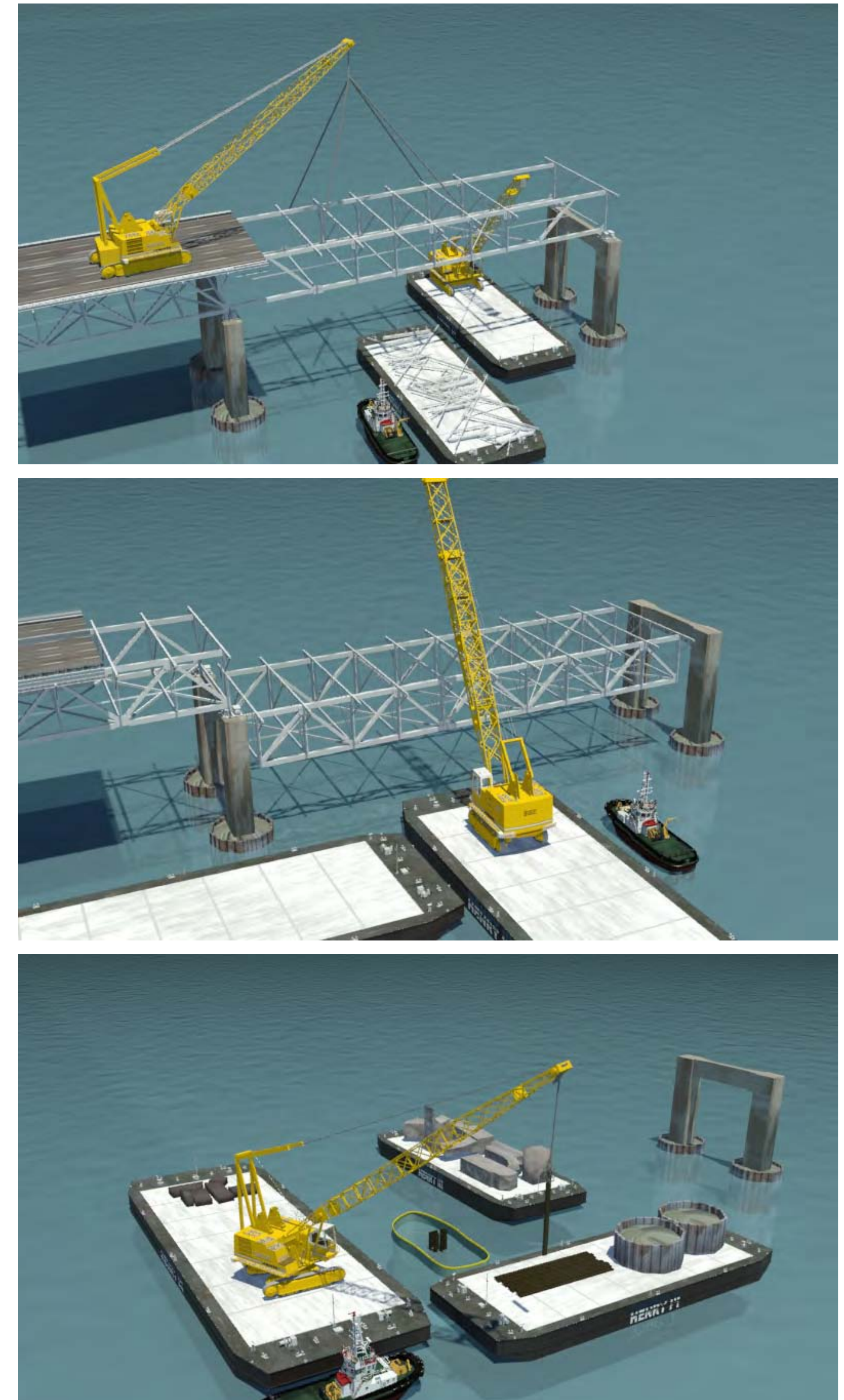
- Deck slab would be removed in panels from above and transported off-site by either truck or barge.
- A vessel access channel would be dredged on the south side of the existing Bridge at the Tarrytown shoreline. This operation is required for the eastern most trusses only.
- Truss steelwork may be removed in whole spans by large barge mounted cranes . Alternatively a crane may be set up on the adjacent intact span to support the to-be-demolished truss at its midspan, while another lighter crane is used to remove the truss pieces element by element.
- Piers supported on foundation shafts would be broken down in the same way as the piers for the causeway spans.
- Once piers are removed, the shaft can be demolished using pneumatic hammers or diamond cutting wire devices. The base slab of the shaft would be demolished and removed. The concrete would be demolished to the mudline. The steel H-piles below the shaft should not extend above the mudline and will not be affected by the demolition. However, if it is found that some steel H-piles do extend above the mudline, divers would cut the piles with underwater cutting torches.
- Netting could be installed for containing debris and for overall safety.

8.3 Main Spans

The Main Spans include the central and back spans with an overall length of approximately 2412 feet. Structurally, the Main Spans are comprised of a through truss above the Thruway deck supported on four steel latticework piers, which are in turn supported on buoyant foundations. Removal of the Main Spans would be coordinated with the USCG. Surrounding the buoyant shafts for the two central piers are ice deflectors and a ship impact protection system formed of pre-stressed concrete beams supported on 30-inch diameter steel piles.

The demolition sequence for the Main Spans is as follows:

- Deck slab removed in panels from above and transported off-site by either truck or barge in the same way as all other types of spans.
- Removal of the central suspended truss over the main shipping channel with associated joints, pin and hanger assembly. The entire suspended span would be lowered onto a barge below using a strand jack system or a winch system. Removed truss would be placed on barges for transportation to a recycling facility off-site.
- Removal of the cantilever and anchor span steelwork piece by piece working in the reverse order of construction. Conventional barge mounted cranes would be used for this purpose. Temporary barge mounted falsework may be necessary to support portions of the anchor spans during their removal.



A. Truss removed by crane on existing bridge

B. Truss removed by barge mounted crane

C. Remove columns and foundation

Figure 8.2 - Truss span demolition

- Ice breaker and fender structures would be demolished. First the timber, steel and concrete elements which laterally connect the piles near the surface of the water would be removed. This work would be performed by barge mounted cranes and excavators. It would require assistance from workers on the fender structure and divers within the river. Once all of the lateral bracing elements are removed, the piles may be cut off at the mudline. Steel H-piles in the ice breaker upstream of the shafts could be cut by divers using underwater cutting torches. The concrete filled pipe piles in the fender system would be more difficult to remove, as they would require torch cutting to cut through the 1¼ inch thick steel pipe casing and concrete saws to cut through the nearly 4 feet diameter concrete core. This work is complicated by the large diameter of the piles and the mudline depth of nearly 40 feet. This work would be performed by divers assisted by barge-mounted cranes.
- Removal of pier steelwork would be piece by piece. Conventional barge mounted cranes would be used for this purpose.
- Removal of pier foundations. At some point during the demolition of the superstructure the buoyant shafts would be cut and flooded. For the demolition of the shafts the top cover of the shafts would be removed first and the remainder of the shaft foundation would be cut and removed next. Because of its flooded condition, all work would be performed “in the wet”. The concrete shaft would be cut apart using diamond wire concrete saws, or may be broken apart with hydraulic jacks and pneumatic hammers. The entire concrete shaft would be demolished down to the base of the shaft.
- Steel H-piles foundation piles could then be cut off with underwater cutting torches down to just below the mudline.
- Following the complete demolition of the “floating” shafts, a crane operated clam-shell bucket would clean the river bottom of debris generated during the demolition. Side-scan sonar would be performed to verify that all concrete and debris is removed from the river. If demolition debris is identified at the bottom of the river a crane operated clam-shell bucket may be used to remove that material.

8.4 Miscellaneous Components

Other components of the existing bridge to be removed would include:

- Removal of the ice protection at each of the Causeway Spans

8.5 Demolition Duration

The demolition of the existing TZB is expected to occur in two steps after the initial relocation of traffic from the existing bridge on to the Replacement Bridge. The first step would include the demolition of each end of the existing TZB (approximately 1000 feet at each end) to allow for the completion of the Replacement Bridge. Given the desire to complete the Replacement Bridge as early as possible, it is expected that after this initial demolition a period of 6-9 months may pass before the remainder of the demolition is completed near the end of the project. Overall, demolition is expected to take 12-18 months.

A. Remove Central Main Span truss

B. Remove fender system

C. Flood and remove foundation

Figure 8.3 - Main Span demolition

9 Crews and Equipment

9.1 Work Areas

As identified in Chapter 0, the Rockland landing will have 2 specific but coordinated work activities.

- RTZB construction
- Rockland Approach Roadway reconstruction including South Broadway Bridge.

Two work sites will support these efforts:

1. Rockland Inland Staging Area (RISA) and the
2. Rockland Bridge Staging Area (RBSA), supporting construction of the RTZB

The Westchester landing will support two principal work activities:

- RTZB construction
- Westchester Approach Roadway, Toll Plaza and Interchange 9 ramps.

Two work sites will support these efforts:

3. Westchester Inland Staging Area (WISA)
4. Westchester Bridge Staging Area (WBSA),

The RTZB itself is a work site and is anticipated to have 3 concentrations of effort (points of construction, POCs) over its length:

1. Main Span
2. Westchester Approach
3. Rockland Approach

Crews and equipment at each of these areas can be determined based upon work activities and are described and listed below.

9.2 RTZB Crews

A number of crews will be required to construct the RTZB. For the purposes of identifying the work force required to construct the RTZB, composite crews were developed based upon construction activity (Table 9.1). These crews typically include a number of sub-crews which may involve different contractors and trades. For example, the Pile Driving Crew includes welders along with riggers, a crane operator and others. The number of supporting staff is increased as the project gets fully underway.

The project schedule was developed recognizing that crews and sub crews will move from location to location during the course of construction. Within each construction activity, however, there are critical steps that define when the next construction step can occur (e.g., the transition from pile driving to placing the pile cap is controlled by the time to weld the upper pile segments to the already driven lower segments). The tasks within the project schedule was arranged to make use of the crews' ability to progressively move from pier to pier. To ensure a balanced approach to the construction and that no one crew was holding up the work, multiple crews have been utilized.

Crew	Crew Size	Number of Crews
Cofferdam	5 – 15	1 – 2
Pile Driving	9 – 15	2 – 3
Rock Socket	13	4
Pile Cap	6 – 10	2 – 4
Column 10		4
Main Span Pylon	9	6
Approach Trusses	11	1 – 2
Approach Deck	16 4	
Main Span Truss & Deck	20	2 – 4
Demolition	30 1	
Staging Yard/Batch Plant	30 – 115	–
Boats	40 –	
Contractors Office Staff	60 – 120	–
Engineer/Owners Staff	40 - 80	–

Table 9.1 - RTZB Construction Crews

At the peak of construction, the Short Span Option will have approximately 600 persons working at both the RTZB and the inland staging areas. For the Long Span Option, the peak has approximately 350 persons on-hand. The Short Span Option has greater numbers of workers on site because it has significantly more piers than the Long Span Option.

For both options, the workforce builds to a peak about 14-18 months after the start of in-river construction and then begins to decrease. Because it is necessary for the landing portions of the existing TZB to be demolished before the south RTZB tie-in can be constructed, there is a significant lull in the work for approximately 6 months starting in the third year. Work then picks up again to finish out the south RTZB tie-in and complete the bridge.

9.3 Equipment

The RTZB will require a variety of equipment. For simplicity, two classes of equipment are defined: major equipment and minor equipment. As their names imply, major equipment includes large item such as the gantry and a concrete plant. Minor equipment includes construction vehicles, compressors and the like. Table 9.2 lists various major equipment that may be required to construct the RTZB. Table 9.3 lists minor construction equipment including site vehicles with associated noise data.

Equipment	Short Span Option	Long Span Option	Required
Concrete Batch Plant	X	X	2 x200 cy/hr
Crawler Cranes 50-100 T (Inland staging areas)	X	X	4
Temporary Bridge (Westchester Access)	X	X	2 lane x 80 ft.
Temporary Trestle Work Platforms	X	X	sq. ft.
Sheetpile vibratory hammer	X	X	2
Barge mounted 500Ton Ringer Crane	X	X	1
Barge mounted 200Ton Crane	X	X	2
Barge mounted 100 Ton Crane	X	X	4
Pile vibratory hammer	X	X	1
Pile driving hammer – 500 kJ	X	X	1
Pile driving hammer – 800 kJ	X	X 1	
Welding huts (supporting up to 10 welders)	X X		8 setups
Rock Socket Drilling Rig	X X		4
Tugboats (800 – 1800 HP)	X	X	8-10
Dredgers X		X	2
Hopper scows	X X		10
Dump scows (ocean going)	X	X	3
Flat deck barges (materials transport)	X	X	20
Concrete delivery barges	X	X	20
Concrete pumping barges	X	X	6
Pile delivery barges	X	X	3-5*
Segment delivery barges	X		5-10*
Truss delivery barges		X	3-5*
Deck segment erection gantry	X		2 units
Truss Lifting winches		X	2 sets
Jacking T-Cranes (pylons)	X	X	6-8
Temporary cable stayed pylon (arch Main Span)	X	X	6

*Supplier provided, number depends upon travel distance, capacity, and installation rates

Table 9.2 - Major RTZB Construction Equipment

Resource	Equipment Model Assumption	Estimated Horsepower	Noise Data			
			Sound Level (dB)	Distance (meters)	Distance (feet)	Reference
Compressors - surface tools	Sullair 750H	275	76	7.0	23.0	Manufacturer
Concrete pump - general	PTO-driven Putzmeister CP 2110 HP	250	81	15.2	50.0	NYCDEP (ID:M)
Concrete pump - tunnel grout	BSA 14000 HP-D (Putzmeister)	630	81	15.2	50.0	NYCDEP (ID:M)
Crane - all-terrain (80t)	Terex AC-100	175	81	15.2	50.0	NYCDEP (ID:O)
Crane - crawler (100t)	Liebherr HS 855 HD Litronic	603	81	15.2	50.0	NYCDEP (ID:O)
Excavator - long reach, tracked	Liebherr R 934 C Litronic	203	81	15.2	50.0	NYCDEP (ID:T)
Excavator - mini-excavator	Kobelco 115SRDZ	84	78	15.2	50.0	NYCDEP (ID:C)
Freeze pipe rotary drilling rig	Casagrande C7 NG hydraulic crawler drill	200	79	15.2	50.0	NYCDEP (ID:Q)
Freezing plant (construction)	***no information***	550				
Freezing plant (maintenance)	***no information***	550				
Front-end loader - wheeled, large	Caterpillar 980H	349	79	15.2	50.0	NYCDEP (ID:V)
Front-end loader - wheeled, mid	Caterpillar 950H	197	79	15.2	50.0	NYCDEP (ID:V)
Generator - large	Terex T360 Generator	426	72	7.0	23.0	Manufacturer
Generator - mid	Terex T90 Generator	110	66	7.0	23.0	Manufacturer
Jet grout - air compressor	Sullair 750H	275	76	7.0	23.0	Manufacturer
Jet grout - batching plant	ChemGrout CG-625	32	83	15.2	50.0	NYCDEP (ID:K)
Jet grout - drill rig	Casagrande C14 hydraulic crawler drill	256	79	15.2	50.0	NYCDEP
Jet grout - high pressure pump	Casagrande P 700 high pressure pump	540	81	15.2	50.0	NYCDEP (ID:AL)
Locomotives	Brookville tunneling locomotive	100	84	10.0	32.8	Previous job
Pump - general, water	Tsurumi TE3-100HA w/ Honda GX-240	8	72	10.0	32.8	Previous job
Shotcrete pump	Putzmeister TK 100 HP w/ Deutz TCD2012L62V	197	81	15.2	50.0	NYCDEP (ID:M)
Slurry wall - bentonite mixer	ChemGrout CG-625	32	83	15.2	50.0	NYCDEP (ID:K)
Slurry wall - bentonite pumps	Tsurumi EPT2-150DD w/ Deutz F3L1011	36	81	15.2	50.0	NYCDEP (ID:AL)
Slurry wall - de-sander	Sotres 2xD250-120 SC/F BOX	199	78	15.2	50.0	NYCDEP (ID:AT)
Slurry wall - hydromill rig	Liebherr HS 855 HD Litronic w/ hydromill	603	80	15.2	50.0	NYCDEP (ID:AU)
Telescopic boom - self-propelled	Genie S-40/S-45 (40-45 ft range)	75	75	15.2	50.0	NYCDEP (ID:AF)
Telescopic forklift handler	Terex Telelift 4514	101	80	10.0	32.8	Previous job
Vibratory Compactor Roller	Tremix Vibratory Compactor MRP 1400	18	78	7.5	25.0	Manufacturer
Compressors - tunnel supply	(for noise assessment only)	Electric	78	15.2	50.0	NYCDEP (ID:J)
Misc. hand tools	(for noise assessment only)	Pneumatic	85	15.2	50.0	NYCDEP (ID:AK)
Muck conveyor	(for noise assessment only)	Electric	70	10.0	32.8	Previous job
Pump - tunnel water	(for noise assessment only)	Electric	72	10.0	32.8	Previous job
Separation plant (slurry TBM)	(for noise assessment only)	Electric	78	15.2	50.0	NYCDEP (ID:AT)
TBM - EPB	(for noise assessment only)	Electric	83	15.2	50.0	NYCDEP (ID:F)
TBM - Slurry	(for noise assessment only)	Electric	83	15.2	50.0	NYCDEP (ID:F)
Tunnel grout - batching plant	(for noise assessment only)	Electric	83	15.2	50.0	NYCDEP (ID:K)
Tunnel grout - vibratory hopper	(for noise assessment only)	Electric	87	15.2	50.0	NYCDEP (ID:BA)
Tunnel ventilation fans	(for noise assessment only)	Electric	79	15.2	50.0	NYCDEP (ID:AZ)
Welder	(for noise assessment only)	Electric	74	15.2	50.0	NYCDEP (ID:BF)
Wheel wash	(for noise assessment only)	Electric	72	10.0	32.8	Previous job
Truck - concrete	McNeilus on Mack Truck MP7 405E	405				
Truck - delivery & haul-away	Mack Truck CHN602, AC-310/330 ASET	310				
Truck - muck-away	Mack Truck CV712, AMI-300 ASET	300				

Table 9.3 - Minor RTZB Construction Equipment

9.4 Work Area Activities

Of the range of activities that will be involved in constructing the RTZB, certain activities will be happening in the various work areas. Understand what these activities are and the extent of the activity are important in determining the levels of noise generated at each of the work areas.

Very similar activities are occurring at both landings and at both inland staging areas. The difference is the scale of activity. Rockland, with its bigger inland footprint, supports construction of the entire Rockland Approach and the Main Span. The Westchester side supports construction of only the Westchester Approach.

In both cases, labor and materials are moving from the inland areas to the bridge landing areas and then to the bridge. It is noted that use of one of the proximate River landing sites can eliminate the overland transfer of materials by combining the functions of the Inland and Bridge staging areas into one site directly on the river. This would have advantages from the potential reduction in noise, traffic, nuisance, risk, cost and necessary adulteration of the concrete mix to ensure continued workability during the long ride from West Nyack to the Main Span foundation.

It is noted that the in-river activities involved in constructing the RTZB will also occur at the Bridge Staging Areas. During construction of the North Structure tie-in, operations at the Bridge Staging Areas will be modified to provide land based access to undertake the same work of building cofferdams, driving piles and constructing pile caps and columns as was done from barges for the deeper water piers. After the North Structure is tied in and traffic transferred there to, these areas will be modified after the interfering portion of the existing TZB is removed. At that point, most of the in-river RTZB construction will have concluded.

The following section describes the work activities that may possibly generate noise that occur at each of RTZB work areas.

Maximum Work Intensity

Approximately 15 to 18 months after the start of in-river work, it is anticipated that the RTZB work efforts will reach their maximum intensity of effort with the greatest number of workers on site and the greatest production of concrete. At that point, work will be occurring on virtually all elements: piles, foundations and columns, Main Span pylons, and Approach superstructure and deck.

At the landings, the reconstruction of the Rockland South Broadway Bridge and the future westbound I-287 lanes on both sides will be in full swing. Recognizing the elevated level of work occurring simultaneously, it is recommended that this time period be used to assess maximum construction based impacts.

Hours of Working

The construction schedule assumes only single shifts for work crews. These shifts may last from 7 to 12 hours depending on the crew type and detail of the work to be completed. It should be anticipated, however, that some activities may required the contractor to work some late shifts or possibly at weekends on critical activities. Some of these activities would include cable erection of the main spans, heavy lifts or potentially delivery of material by barge.

Crew Travel

It is expected that significant proportions of construction personnel will park at the RISA and travel via bus to the Rockland and Westchester Bridge Staging Areas. A small portion of personnel may park at the WISA, as this space is small it is likely the majority of material lay down, staging and storage will occur at the WBSA, freeing up the WISA for parking.

Inland Staging Areas

The Inland Staging Areas support the majority of the RTZB construction. Principal noise generating activities that occur there include:

1. Clearing, preparing and construction of the Inland Staging Area facility itself
2. Arrival and departure of employees (crews and administration) in personal vehicles
3. Bussing of crews to and from the RTZB
4. Arrival and departure of trucks (tractor-trailer, dump truck, bulk powder) bringing in materials (steel, aggregate, cement, etc.)
5. Unloading of trucks using cranes, dumping, or pumping (powdered cement)
6. Fabrication of column rebar cages
7. Loading of trucks using cranes to convey materials to the RTZB
8. Movement of aggregates using pay-loaders
9. Production of concrete by the batch plant
10. Idling and cycling of concrete trucks awaiting, loading and departing
11. Cleaning of concrete trucks

The following Table 9.4 identifies expected equipment in operation at the Rockland and Westchester Inland Staging areas during a typical day at the peak of construction activity.

Equipment	Rockland	Westchester
Crew Buses (school bus style)	6	2
Trucks (tractor-trailer, dump truck, bulk powder)	10	4
Cranes (50-100T)	2	1
Pay-loaders	3	1
Concrete Batch Plant (200 cy/hr)	2	1
Concrete Trucks	30	12

Table 9.4 - Inland Staging Area Peak Construction Equipment Requirements

Bridge Staging Areas

The Bridge Staging Areas receive crews and materials staged from their adjoining Inland Staging Area. Principal noise generating activities that occur at the Bridge Staging Areas include:

1. Construction of the temporary trestle making up the Bridge Staging Area
2. Construction of the haul road and temporary access ramps from I-287 to River Road and from the Westchester Inland Staging Area over the Hudson Line to the Westchester Bridge Staging Area.
3. Bussing of crews from and to the Inland Staging Areas
4. Docking, loading and departure of crew barges
5. Arrival, staging, unloading and departure of trucks bringing materials (steel, rebar cages, etc.)
6. Fabrication of rebar cages
7. Loading of materials (steel, rebar cages, etc) onto barges

8. Arrival, idling, staging and departure of concrete trucks
9. Possible transfer of concrete from trucks to barge concrete vessels (optional method)
10. Cleaning of concrete trucks
11. Staging of tugs (docking, idling, driving) handling barges
12. Docking of barges handling materials, concrete and other items
13. Activities (tugs, work) of the NYSTA TZB Dockside facility.

The following Table 9.5 identifies expected equipment in operation at the Rockland and Westchester Bridge Staging areas during a typical day at the peak of construction activity.

Equipment	Rockland	Westchester
Crew Buses (school bus style)	6	2
Trucks (tractor-trailer)	4	2
Tugboats (800-1800 Hp)	7	3
Crew Barges	6	2
Materials Barges	6	2
Concrete Barges	10	4
Concrete trucks	30	12
Cranes (50-100T)	2	1
NYSTA Tugs and vessels	3	-
Compressor 1		1
Pay-loaders 1		0

Table 9.5 - Bridge Staging Area Peak Construction Equipment Requirements

RTZB Work Activities

This report has summarized in depth the work activities required to construct the RTZB. From the perspective of noise generation, the following in-river activities are noted.

1. Vibratory and minor pile driving noises associated with cofferdam construction
2. Vibratory and major pile driving noises associated with bridge pile driving
3. Diesel engine noises associated with the movement of tugs, crew barges and other watercraft
4. Diesel engine noises associated with compressors, pumps, hydraulic systems and generators.
5. Diesel engine noises associated with concrete pumping and vibrating.
6. Diesel engine noises associated with cranes and other lifting equipment (gantries, winches, etc.)
7. Diesel engine noises associated with Rock Drilling
8. Demolition of the concrete viaduct portions of the existing TZB
9. Demolition of the deck truss and Main Span portions of the existing TZB.

The following Table 9.6 identifies the major construction equipment that will be in operation along the length of the RTZB during the peak period of RTZB construction.

Equipment	Short Span Option	Long Span Option	Required
Sheetpile vibratory hammer	X	X	2
Barge mounted 500Ton Ringer Crane	X	X	1
Barge mounted 200Ton Crane	X	X	2
Barge mounted 100 Ton Crane	X	X	4
Pile vibratory hammer	X	X	1
Pile driving hammer – 500 kJ	X	X	1
Pile driving hammer – 800 kJ	X	X	1
Compressors X		X	20
Generators X		X	20
Water Pumps	X	X	20
Welding huts (supporting up to 10 welders) and associated electrical generators	X	X	8 setups
Rock Socket Drilling Rig	X	X	4
Tugboats (800 – 1800 HP)	X	X	8-10
Dredgers X		X	2
Hopper scows	X	X	10
Dump scows (ocean going)	X	X	3
Flat deck barges (materials transport)	X	X	20
Concrete delivery barges	X	X	20
Concrete pumping barges	X	X	6
Pile delivery barges	X	X	3-5*
Segment delivery barges	X		5-10*
Truss delivery barges		X	3-5*
Deck segment erection gantry	X		2 units
Truss Lifting winches		X	2 sets
Jacking T-Cranes (pylons)	X	X	6-8
Temporary cable stayed pylon (arch Main Span)	X	X	6
*Supplier provided, number depends upon travel distance, capacity, and installation rates			

Table 9.6 - Major RTZB Construction Equipment

Approach Roadway Reconstruction

Construction works include the reconstruction of the South Broadway Bridge on the Rockland side and modification of ramps at Interchange 9 on the Westchester side.

The interchange and bridge work at both east and west touchdown areas will be accompanied by modification and reconstruction of the I-287 approach roadways including the Toll Plaza. Together, five basic types of work are involved: demolition, overpass construction, grading and road building, retaining wall construction and cut and cover construction. Based upon these work efforts, the following noise generating activities would be expected:

1. Demolition, principally using jackhammers, saw cutting machines and pavement breakers with associated diesel compressors, excavators, cutting sheers (excavator mounted)
2. Dump truck and similar concrete truck idling, staging and operation
3. Materials excavation, handling, sorting, and movement using payloaders, graders, bulldozers, etc.
4. Bridge erection using cranes, trucks, etc.
5. Short pile driving for bridge foundations, retaining wall footings, noise walls, etc.
6. Ground preparation, grading, milling, concrete paving, asphalt paving and rolling operations.

The following Table 9.7 identifies anticipated equipment in operation at South Broadway Bridge and adjoining Rockland Approach Roadway areas; and in operation at Westchester Approach Roadway areas, Toll Plaza and Interchange 9 ramps.

Equipment	Rockland	Westchester
Crew Buses (school bus style)	2	0
Trucks (tractor-trailer)	3	3
Cranes (50-100T)	3	1
Dump Trucks (9-12 yd)	10	10
Dump Trucks (40T, articulated)	3	2
Pay-loaders 2		1
Bulldozers/graders 2		2
Backhoe (½ yard)	2	2
Excavator (2 ½ yard)	3	1
Rock/Concrete Crusher	1	1
Screeder (vibratory)	1	0
Sheepsfoot rolling compactor	1	0
Concrete trucks	6	6
Truck wash station	1	1
Milling Machine	1	1
Saw Cutting Machine	2	1
Concrete Paving Screed	1	1
Asphalt Paver	1	1
Asphalt Roller	1	1
Jack Hammers	8	8
Compressors 3		3
Pavement Breaker	2	2
H-pile driver	1	1
Personnel Boom Lifts	2	1
Highway Advisory Signs	4	4
Construction Lights	6	6
Construction generators (200A)	3	3
Maintenance & Protection of Traffic Trucks	4	4

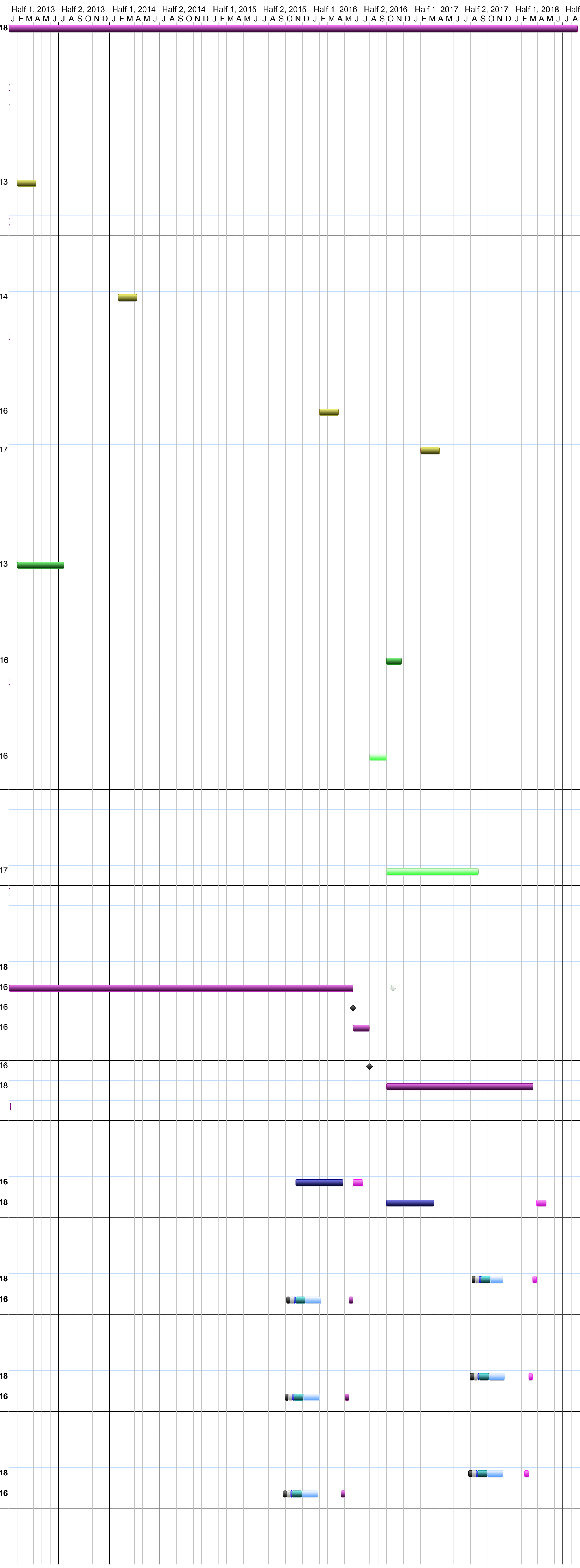
Table 9.7 Approach Roadway and Interchange Peak Construction Equipment Requirements

Appendix A

Schedules

Short Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
1		**Tappan Zee Bridge Const. Sequence Schedule**	**2134.25 days?**	**1/1/13**	**8/23/18**
2					
3					
4	**DREDGING 1**				
5		East and West Dredging Stage 1	71 days	2/1/13	4/10/13
6					
7	**DREDGING 2**				
8		East and West Dredging Stage 2	71 days	2/1/14	4/10/14
9					
10	**DREDGING 3**				
11		East and West Dredging for Demo	71 days	2/1/16	4/9/16
12		East and West Dredging for Demo	71 days	2/1/17	4/10/17
13					
14	**TRESTLE 1**				
15		East and West Trestle	175 days	2/1/13	7/19/13
16					
17	**TRESTLE 2**				
18		Trestle	55 days	10/1/16	11/22/16
19					
20	**DEMOLITION 1**				
21		TZB Nyack and Tarrytown Demolition	64 days	7/31/16	9/30/16
22					
23	**DEMOLITION 2**				
24		Main Spans Demo	345 days	10/1/16	8/29/17
25					
26	**Landings**				
27		**Westchester Landing**	**1966 days**	**1/2/13**	**3/15/18**
28		Landing	1290 days	1/2/13	6/1/16
29		Switch over Lanes	1 day	6/1/16	6/2/16
30		Const. Temp EB Lanes	60 days	6/2/16	7/30/16
31		Switch over Lanes	1 day	7/30/16	7/31/16
32		Finish Landing	550 days	10/1/16	3/15/18
33					
34	**ABUTMENT**				
35		**N Abutment**	**252.5 days**	**11/6/15**	**7/6/16**
41		**S Abutment**	**599.5 days**	**10/1/16**	**5/2/18**
47	**P1**				
48		**P1 S**	**243 days**	**8/5/17**	**3/27/18**
55		**P1 N**	**249.5 days**	**10/4/15**	**6/1/16**
62	**P2**				
63		**P2 S**	**234 days**	**7/30/17**	**3/13/18**
70		**P2 N**	**240.5 days**	**9/28/15**	**5/17/16**
77	**P3**				
78		**P3 S**	**225 days**	**7/24/17**	**2/26/18**
85		**P3 N**	**231.5 days**	**9/22/15**	**5/3/16**
92	**P4**				



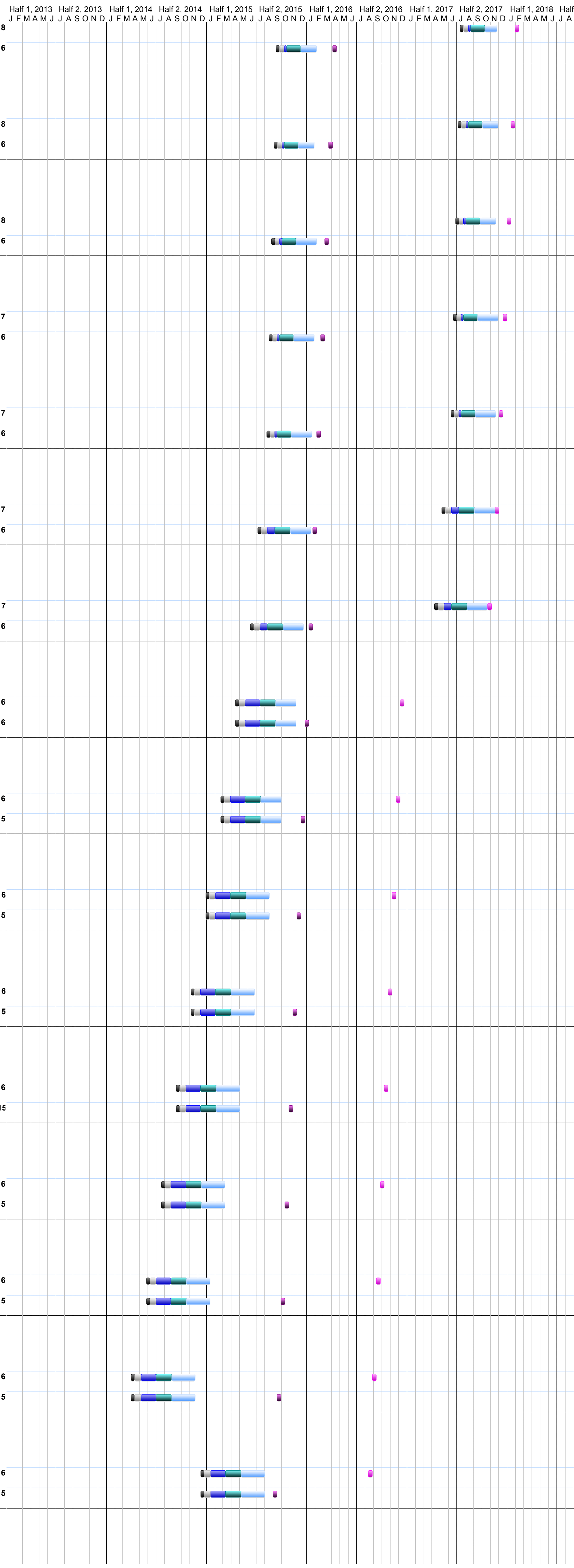
Short Span Option - Construction Schedule
Arup

Summary	Rock Sockets	Inactive Summary
Cofferdam Construction	Abutment	Manual Task
Pile Driving	Dredging	Duration-only
Pile Cap	Demolition	Manual Summary Rollup
Column	Initial Tasks	Manual Summary
Deck, Gantry #2	Inactive Task	Start-only
Deck, Gantry #1	Inactive Milestone	Finish-only

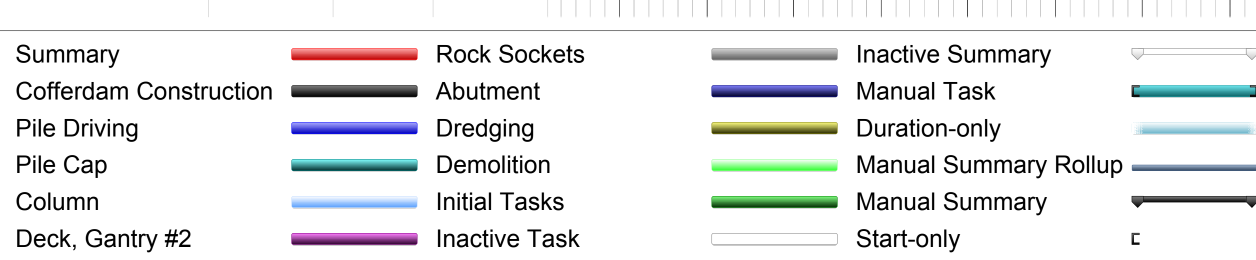
NOTE: Dredging is to be undertaken between August and November

Short Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
93		P4 S	222 days	7/13/17	2/12/18
100		P4 N	228.5 days	9/11/15	4/18/16
107	**P5**				
108		P5 S	215 days	7/5/17	1/28/18
115		P5 N	221.5 days	9/3/15	4/4/16
122	**P6**				
123		P6 S	209 days	6/26/17	1/14/18
130		P6 N	215.5 days	8/25/15	3/20/16
137	**P7**				
138		P7 S	203 days	6/18/17	12/31/17
145		P7 N	209.5 days	8/17/15	3/6/16
152	**P8**				
153		P8 S	197 days	6/9/17	12/16/17
160		P8 N	203.5 days	8/8/15	2/20/16
167	**P9**				
168		P9 S	216 days	5/7/17	12/2/17
175		P9 N	222.5 days	7/6/15	2/6/16
182	**P10**				
183		P10 S	216 days	4/10/17	11/5/17
190		P10 N	235.5 days	6/9/15	1/22/16
197	**P11**				
198		P11 S	636.5 days	4/16/15	12/20/16
205		P11 N	276.5 days	4/16/15	1/8/16
212	**P12**				
213		P12 S	677.5 days	2/21/15	12/6/16
220		P12 N	317.5 days	2/21/15	12/24/15
227	**P13**				
228		P13 S	718.5 days	12/29/14	11/21/16
235		P13 N	358.5 days	12/29/14	12/10/15
242	**P14**				
243		P14 S	759.5 days	11/5/14	11/7/16
250		P14 N	399.5 days	11/5/14	11/25/15
257	**P15**				
258		P15 S	800.5 days	9/12/14	10/23/16
265		P15 N	440.5 days	9/12/14	11/11/15
272	**P16**				
273		P16 S	841.5 days	7/20/14	10/9/16
280		P16 N	481.5 days	7/20/14	10/27/15
287	**P17**				
288		P17 S	882.5 days	5/27/14	9/25/16
295		P17 N	522.5 days	5/27/14	10/13/15
302	**P18**				
303		P18 S	925.5 days	4/1/14	9/10/16
310		P18 N	565.5 days	4/1/14	9/28/15
317	**P19**				
318		P19 S	648.25 days	12/10/14	8/27/16
325		P19 N	288.25 days	12/10/14	9/14/15
332	**P20**				



Short Span Option - Construction Schedule
Arup



NOTE: Dredging is to be undertaken between August and November

Short Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
333		P20 S	689.25 days	10/17/14	8/12/16
340		P20 N	329.25 days	10/17/14	8/30/15
347	**P21**				
348		P21 S	730.25 days	8/24/14	7/29/16
355		P21 N	370.25 days	8/24/14	8/16/15
362	**P22**				
363		P22 S	771.25 days	7/1/14	7/14/16
370		P22 N	411.25 days	7/1/14	8/2/15
377	**P23**				
378		P23 S	812.25 days	5/8/14	6/30/16
385		P23 N	452.25 days	5/8/14	7/18/15
392	**P24**				
393		P24 S	853.25 days	3/15/14	6/15/16
400		P24 N	493.25 days	3/15/14	7/4/15
407	**P25**				
408		P25 S	461.75 days	9/12/13	12/1/14
415		P25 N	668.5 days	9/12/13	6/19/15
422	**P26**				
423		P26 S	502.75 days	7/20/13	11/17/14
430		P26 N	709.5 days	7/20/13	6/5/15
437	**P27**				
438		P27 S	543.75 days	5/27/13	11/2/14
445		P27 N	750.5 days	5/27/13	5/21/15
452	**P28**				
453		P28 S	584.75 days	4/3/13	10/19/14
460		P28 N	791.5 days	4/3/13	5/7/15
467	**P29**				
468		P29 S	287 days	1/1/14	10/5/14
475		P29 N	493.75 days	1/1/14	4/22/15
482	**P30**				
483		P30 S	287 days	11/8/13	8/11/14
490		P30 N	534.75 days	11/8/13	4/8/15
497	**P31**				
498		P31 S	323 days	9/14/13	7/23/14
505		P31 N	575.75 days	9/14/13	3/24/15
512	**P32**				
513		P32 S	364 days	7/22/13	7/9/14
520		P32 N	616.75 days	7/22/13	3/10/15
527	**P33**				
528		P33 S	356 days	7/16/13	6/24/14
535		P33 N	608.75 days	7/16/13	2/23/15
542	**P34**				
543		P34 S	353 days	7/4/13	6/10/14
550		P34 N	605.75 days	7/4/13	2/9/15
557	**P35**				
558		P35 S	350 days	6/22/13	5/26/14
565		P35 N	602.75 days	6/22/13	1/25/15
572	**P36**				

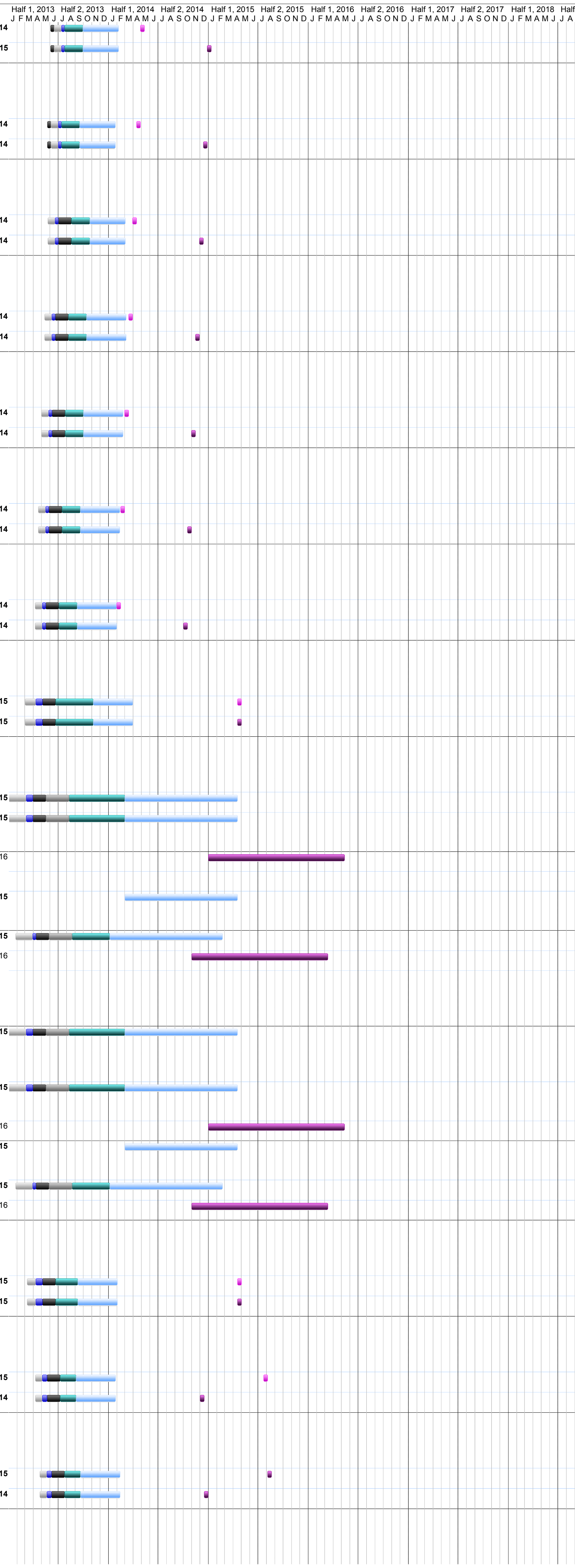
Short Span Option - Construction Schedule
Arup

Summary	Rock Sockets	Inactive Summary
Cofferdam Construction	Abutment	Manual Task
Pile Driving	Dredging	Duration-only
Pile Cap	Demolition	Manual Summary Rollup
Column	Initial Tasks	Manual Summary
Deck, Gantry #2	Inactive Task	Start-only
Deck, Gantry #1	Inactive Milestone	Finish-only

NOTE: Dredging is to be undertaken between August and November

Short Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
573		P36 S	355 days	6/3/13	5/12/14
580		P36 N	607.75 days	6/3/13	1/11/15
587	**P37**				
588		P37 S	352 days	5/23/13	4/27/14
595		P37 N	604.75 days	5/23/13	12/27/14
602	**P38**				
603		P38 S	336 days	5/24/13	4/13/14
610		P38 N	588.75 days	5/24/13	12/13/14
617	**P39**				
618		P39 S	333 days	5/12/13	3/29/14
625		P39 N	585.75 days	5/12/13	11/28/14
632	**P40**				
633		P40 S	330 days	4/30/13	3/15/14
640		P40 N	582.75 days	4/30/13	11/14/14
647	**P41**				
648		P41 S	327 days	4/19/13	2/28/14
655		P41 N	579.75 days	4/19/13	10/30/14
662	**P42**				
663		P42 S	324 days	4/7/13	2/14/14
670		P42 N	576.75 days	4/7/13	10/16/14
677	**P43**				
678		P43 S	819 days	3/2/13	5/1/15
685		P43 N	819 days	3/2/13	5/1/15
692	**P44**				
693		Main Pier 44 North	866 days	1/1/13	4/17/15
700		Main Pier 46 Center North	866 days	1/1/13	4/17/15
707		Deck Construction	515 days	1/1/15	5/12/16
708					
709		Main Pier 46 Center South	426 days	3/1/14	4/17/15
711		Main Pier 44 South	783 days	1/26/13	2/21/15
718		Deck Construction	515 days	11/1/14	3/12/16
719					
720	**P45**	Main Pier 45 North	866 days	1/1/13	4/17/15
727		Main Pier 45 Center North	866 days	1/1/13	4/17/15
734		Deck Construction	515 days	1/1/15	5/12/16
735		Main Pier 45 Center South	426 days	3/1/14	4/17/15
737		Main Pier 45 South	783 days	1/26/13	2/21/15
744		Deck Construction	515 days	11/1/14	3/12/16
745	**P46**				
746		P46 S	811 days	3/9/13	5/1/15
753		P46 N	811 days	3/9/13	5/1/15
760	**P47**				
761		P47 S	879 days	4/8/13	8/5/15
768		P47 N	639 days	4/8/13	12/16/14
775	**P48**				
776		P48 S	877 days	4/25/13	8/19/15
783		P48 N	637 days	4/25/13	12/30/14
790	**P49**				



Short Span Option - Construction Schedule
Arup

Summary	Rock Sockets	Inactive Summary			
Cofferdam Construction	Abutment	Manual Task			
Pile Driving	Dredging	Duration-only			
Pile Cap	Demolition	Manual Summary Rollup			
Column	Initial Tasks	Manual Summary			
Deck, Gantry #2	Inactive Task	Start-only			
Deck, Gantry #1	Inactive Milestone	Finish-only			

NOTE: Dredging is to be undertaken between August and November

Short Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
791		P49 S	875 days	5/11/13	9/3/15
798		P49 N	635 days	5/11/13	1/14/15
805	P50				
806		P50 S	873 days	5/27/13	9/17/15
813		P50 N	633 days	5/27/13	1/28/15
820	P51				
821		P51 S	884 days	5/31/13	10/2/15
828		P51 N	644 days	5/31/13	2/12/15
835	P52				
836		P52 S	882 days	6/17/13	10/16/15
843		P52 N	642 days	6/17/13	2/26/15
850	P53				
851		P53 S	880 days	7/3/13	10/31/15
858		P53 N	640 days	7/3/13	3/13/15
865	P54				
866		P54 S	613.75 days	4/1/14	11/14/15
873		P54 N	373.75 days	4/1/14	3/27/15
880	P55				
881		P55 S	611.75 days	4/17/14	11/29/15
888		P55 N	371.75 days	4/17/14	4/11/15
895	P56				
896		P56 S	236 days	9/7/17	4/22/18
903		P56 N	369.75 days	5/3/14	4/25/15
910	P57				
911		P57 S	242 days	9/16/17	5/7/18
918		P57 N	375.75 days	5/12/14	5/10/15
925	P58				
926		P58 S	245 days	9/27/17	5/21/18
933		P58 N	378.75 days	5/24/14	5/24/15
940	P59				
941		P59 S	254 days	10/3/17	6/5/18
948		P59 N	392.75 days	5/25/14	6/8/15
955	P60				
956		P60 S	263 days	10/9/17	6/19/18
963		P60 N	396.75 days	6/4/14	6/22/15
970	P61				
971		P61 S	272 days	10/14/17	7/4/18
978		P61 N	405.75 days	6/10/14	7/7/15
985	P62				
986		P62 S	281 days	10/20/17	7/18/18
993		P62 N	414.75 days	6/16/14	7/21/15
1000	ABUTMENT	Abutment N	1002 days	1/1/13	8/26/15
1006		Abutment C	216 days	11/7/16	6/4/17
1012		Abutment S	716.5 days	10/1/16	8/23/18

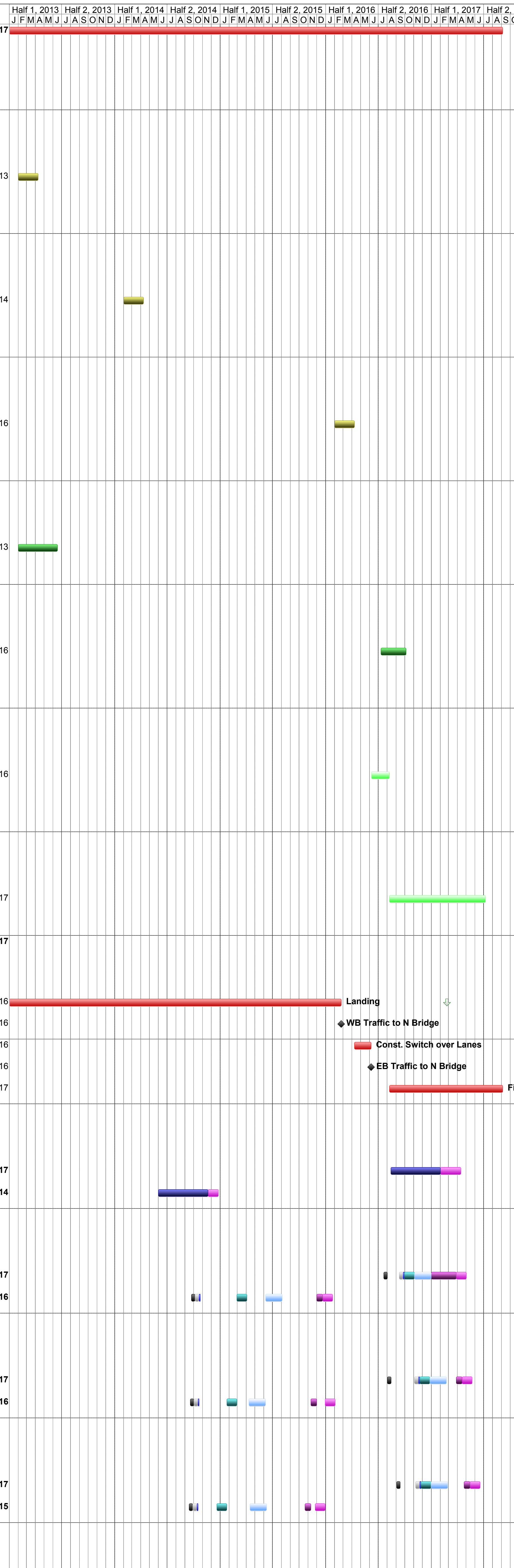
Short Span Option - Construction Schedule
Arup

Summary
Cofferdam Construction
Pile Driving
Pile Cap
Column
Deck, Gantry #2
Deck, Gantry #1
Rock Sockets
Abutment
Dredging
Demolition
Initial Tasks
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only

NOTE: Dredging is to be undertaken between August and November

Long Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
1		**Tappan Zee Bridge Const. Sequence Schedule**	**1769 days?**	**1/1/13**	**9/4/17**
2					
3					
4	**DREDGING 1**				
5		East and West Dredging Stage 1	71 days	2/1/13	4/10/13
6					
7	**DREDGING 2**				
8		East and West Dredging Stage 2	71 days	2/1/14	4/10/14
9					
10	**DREDGING 3**				
11		East and West Dredging for Demo.	71 days	2/1/16	4/9/16
12					
13	**TRESTLE 1**				
14		East and West Trestle	140 days	2/1/13	6/16/13
15					
16	**TRESTLE 2**				
17		East and West Trestle Construction	90 days	7/10/16	10/5/16
18					
19	**DEMOLITION 1**				
20		TZB Nyack and Tarrytown Demolition	64 days	6/7/16	8/8/16
21					
22	**DEMOLITION 2**				
23		Main Spans Demo	345 days	8/8/16	7/7/17
24					
25	**Landings**	**Westchester Landing**	**1769 days**	**1/1/13**	**9/4/17**
26		Landing	1190 days	1/1/13	2/23/16
27		WB Traffic to N Bridge	1 day	2/24/16	2/24/16
28		Const. Switch over Lanes	60 days	4/9/16	6/6/16
29		EB Traffic to N Bridge	1 day	6/6/16	6/7/16
30		Finish Landing	406 days	8/9/16	9/4/17
31	**ABUTMENT**				
32		**West Abut South**	**251.5 days**	**8/13/16**	**4/12/17**
38		**West Abut North**	**215 days**	**6/1/14**	**12/25/14**
44	**P1**				
45		**P1 S**	**296 days**	**7/20/16**	**5/1/17**
53		**P1 N**	**506.5 days**	**9/23/14**	**1/24/16**
61	**P2**				
62		**P2 S**	**304 days**	**8/1/16**	**5/21/17**
70		**P2 N**	**519.5 days**	**9/19/14**	**2/2/16**
78	**P3**				
79		**P3 S**	**299 days**	**9/2/16**	**6/18/17**
87		**P3 N**	**487.5 days**	**9/15/14**	**12/29/15**
95	**P4**				



Long Span Option - Construction Sche
Arup

Summary	Column Construction	Inactive Task	Manual Summary
Cofferdam Construction	Rock Socket Construction	Inactive Milestone	Start-only
Truss Erection	Abutment Construction	Inactive Summary	Finish-only
Deck Erection	Dredging	Manual Task	NOTE: Dredging is to be undertaken between August and November
Pile Installation	Demolition	Duration-only	
Pile Cap Construction	Trestle Construction	Manual Summary Rollup	

Long Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
96		P4 S	291 days	8/20/16	5/28/17
104		P4 N	455.5 days	9/11/14	11/25/15
112	**P5**				
113		P5 S	283 days	8/8/16	5/8/17
121		P5 N	481.5 days	7/28/14	11/4/15
129	**P6**				
130		P6 S	530.5 days	5/21/14	10/15/15
138		P6 N	530.5 days	5/21/14	10/15/15
146	**P7**				
147		P7 S	558.5 days	3/15/14	9/5/15
155		P7 N	558.5 days	3/15/14	9/5/15
163	**P8**				
164		P8 S	306.5 days	10/3/14	7/26/15
172		P8 N	306.5 days	10/3/14	7/26/15
180	**P9**				
181		P9 S	334.5 days	7/28/14	6/15/15
189		P9 N	334.5 days	7/28/14	6/15/15
197	**P10**				
198		P10 S	362.5 days	5/21/14	5/6/15
206		P10 N	362.5 days	5/21/14	5/6/15
214	**P11**				
215		P11 S	390.5 days	3/15/14	3/26/15
223		P11 N	390.5 days	3/15/14	3/26/15
231	**P12**				
232		P12 S	537 days	9/14/13	2/14/15
240		P12 N	537 days	9/14/13	2/14/15
248	**P13**				
249		P13 S	565 days	7/8/13	1/4/15
257		P13 N	565 days	7/8/13	1/4/15
265	**P14**				
266		P14 S	593 days	5/1/13	11/25/14
274		P14 N	593 days	5/1/13	11/25/14
282	**P15**				
283		P15 S	393 days	10/1/13	10/15/14
291		P15 N	393 days	10/1/13	10/15/14
299	**P16**				
300		P16 S	422 days	7/25/13	9/6/14
308		P16 N	422 days	7/25/13	9/6/14
316	**P17**				
317		P17 S	450 days	5/19/13	7/27/14
325		P17 N	450 days	5/19/13	7/27/14
333	**P18**				
334		P18 S	412 days	5/15/13	6/16/14
342		P18 N	412 days	5/15/13	6/16/14

Long Span Option - Construction Sche
Arup

Summary	Column Construction	Inactive Task	Manual Summary
Cofferdam Construction	Rock Socket Construction	Inactive Milestone	Start-only
Truss Erection	Abutment Construction	Inactive Summary	Finish-only
Deck Erection	Dredging	Manual Task	NOTE: Dredging is to be undertaken between August and November
Pile Installation	Demolition	Duration-only	
Pile Cap Construction	Trestle Construction	Manual Summary Rollup	

Long Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
350	**P19**				
351		**P19 S**	**381 days**	**5/4/13**	**5/7/14**
359		**P19 N**	**381 days**	**5/4/13**	**5/7/14**
367	**P20**				
368		**P20 S**	**350 days**	**4/24/13**	**3/27/14**
376		**P20 N**	**350 days**	**4/24/13**	**3/27/14**
384	**P21**				
385		**P21 S**	**319 days**	**4/13/13**	**2/15/14**
393		**P21 N**	**319 days**	**4/13/13**	**2/15/14**
401	**P22**				
402		**P22 S**	**386 days**	**4/7/13**	**4/15/14**
410		**P22 N**	**386 days**	**4/7/13**	**4/15/14**
418	**P23**				
419		**P23 S**	**487 days**	**3/2/13**	**6/15/14**
427		**P23 N**	**487 days**	**3/2/13**	**6/15/14**
435	**P24**				
436		**Main Pier 24 North**	**875 days**	**1/1/13**	**4/25/15**
443		**Main Pier 24 Center**	**875 days**	**1/1/13**	**4/25/15**
450		Deck Construction	538 days	12/1/14	5/3/16
451		**Main Pier 25 South**	**818 days**	**1/26/13**	**3/26/15**
458		Deck Construction	538 days	11/1/14	4/3/16
459					
460	**P25**				
461		**Main Pier 25 North**	**875 days**	**1/1/13**	**4/25/15**
468		**Main Pier 25 Center**	**875 days**	**1/1/13**	**4/25/15**
475		Deck Construction	538 days	12/1/14	5/3/16
476		**Main Pier 25 South**	**818 days**	**1/26/13**	**3/26/15**
483		Deck Construction	538 days	11/1/14	4/3/16
484					
485					
486	**P26**				
487		**P26 S**	**427 days**	**3/6/13**	**4/22/14**
495		**P26 N**	**427 days**	**3/6/13**	**4/22/14**
503	**P27**				
504		**P27 S**	**462 days**	**3/30/13**	**6/18/14**
512		**P27N**	**462 days**	**3/30/13**	**6/18/14**
520	**P28**				
521		**P28 S**	**487 days**	**4/15/13**	**7/29/14**
529		**P28 N**	**487 days**	**4/15/13**	**7/29/14**
537	**P29**				
538		**P29 S**	**290 days**	**9/24/14**	**6/30/15**
546		**P29 N**	**290 days**	**9/24/14**	**6/30/15**
554	**P30**				
555		**P30 S**	**314 days**	**9/15/16**	**7/15/17**
563		**P30 N**	**303 days**	**10/1/14**	**7/21/15**
571	**P31**				
572		**P31 S**	**327 days**	**9/27/16**	**8/9/17**
580		**P31 N**	**311 days**	**10/14/14**	**8/10/15**

Long Span Option - Construction Sche
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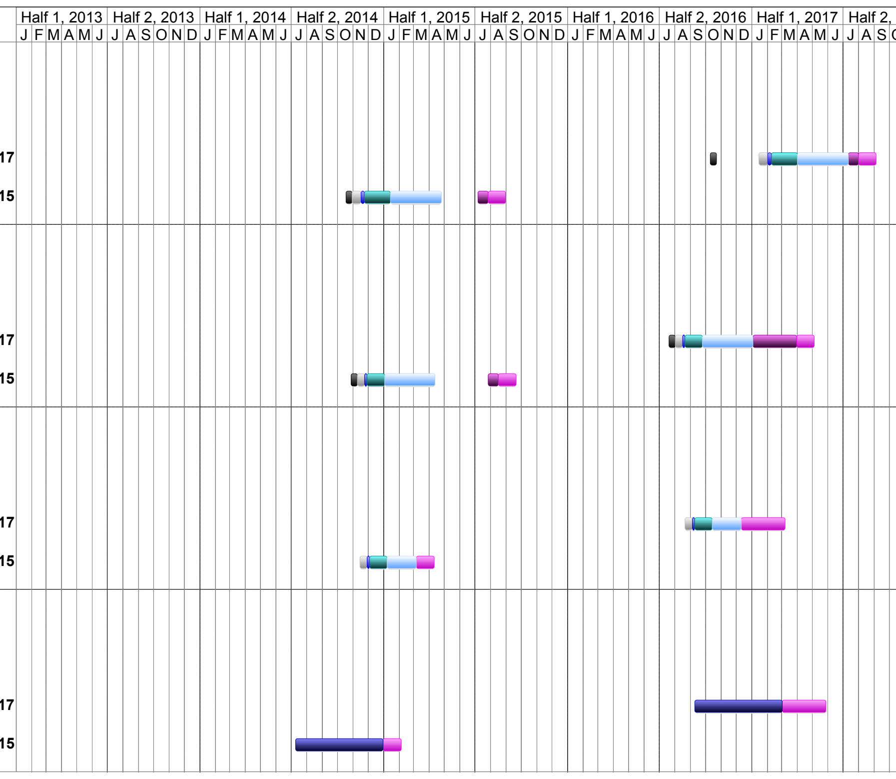
Summary	Column Construction	Inactive Task	Manual Summary
Cofferdam Construction	Rock Socket Construction	Inactive Milestone	Start-only
Truss Erection	Abutment Construction	Inactive Summary	Finish-only
Deck Erection	Dredging	Manual Task	NOTE: Dredging is to be undertaken between August and November
Pile Installation	Demolition	Duration-only	
Pile Cap Construction	Trestle Construction	Manual Summary Rollup	

Long Span Option - Construction Schedule

ID	Text1	Task Name	Duration	Start	Finish
588	**P32**				
589		**P32 S**	**341 days**	**10/10/16**	**9/4/17**
597		**P32 N**	**329 days**	**10/17/14**	**8/30/15**
605	**P33**				
606		**P33 S**	**299 days**	**7/20/16**	**5/4/17**
614		**P33 N**	**339 days**	**10/27/14**	**9/20/15**
622	**P34**				
623		**P34 S**	**226 days**	**8/1/16**	**3/7/17**
630		**P34 N**	**153 days**	**11/14/14**	**4/10/15**
636	**ABUTMENT**				
637		**East Abut South**	**270 days**	**9/9/16**	**5/27/17**
643		**East Abut North**	**791.38 days?**	**1/1/13**	**2/4/15**



Long Span Option - Construction Sche Arup	Summary	Column Construction	Inactive Task	Manual Summary
	Cofferdam Construction	Rock Socket Construction	Inactive Milestone	Start-only
	Truss Erection	Abutment Construction	Inactive Summary	Finish-only
	Deck Erection	Dredging	Manual Task	NOTE: Dredging is to be undertaken between August and November
	Pile Installation	Demolition	Duration-only	
	Pile Cap Construction	Trestle Construction	Manual Summary Rollup	

Appendix B

Sub Task Schedules

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ID	Task Name	Duration	Resource Names
1	erect one cantilever span	11 days	
2	hoist pier segment	1 day	
3	stbilize pier segment	1 day	other1
4	erect first typical segment pair	0.5 days	
9	erect 9 add'l segment pairs	4.5 days	
46	remove temp PT bars	7 days	bar1
47	pour closure	2 days	other1
48	stress span PT stage 1	1 day	pt1
49	launch gantry	1 day	gantry1
50	stress span PT stage 2	2 days	pt1
51	remove stiblizing rods	2 days	other 1
52	grout PT	10 days	other1

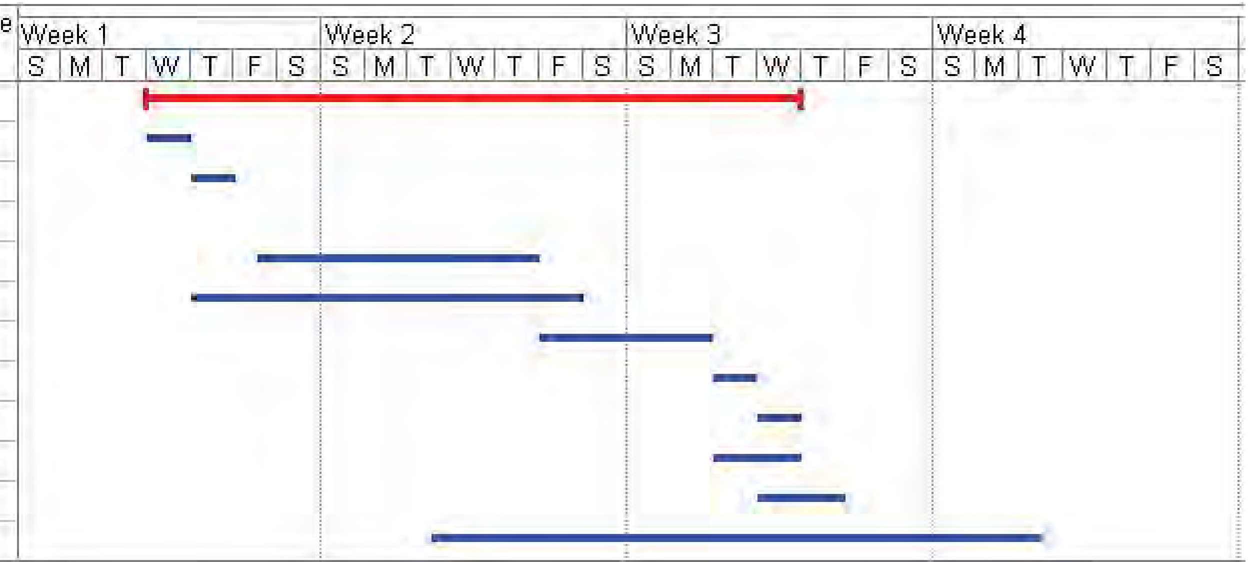

Figure B.1 - Erection of one Single Level Approach Cantilever Span

ID	Task Name	Duration
1	One cable stayed bridge	368 days
2	East Pytlon	293 days
3	cast pier table and stress	20 days
4	Erect first two segment pairs	10 days
21	erect add'l 26 x 2 segment pairs	263 days
444	WEST Pylon	293 days
885	closure	5 days
886	restress cables	20 days
887	overlay	20 days
888	barrier a	10 days
889	furniture	20 days

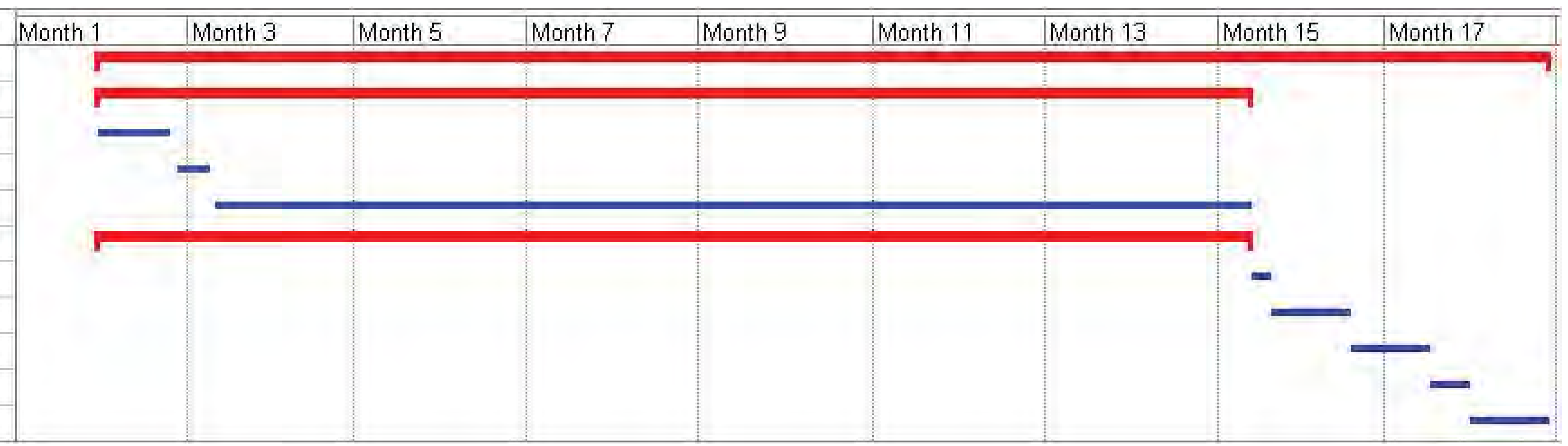

Figure B.2 - Construction of Single Level Main Span

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ID	Task Name	Duration	Resource Names
1	install temp towers n truss	7 days	cr1
2	erect south truss pier n - 21 cal days	15 days?	
3	install bearings	2 days	cr1
4	move pier seg barge in position	4 days	tug1
5	move barge mounted cranes in position	3 days	tug2
6	lift pier segment	0.5 days	tug2
7	move barge mounted cranes place pier seg	0.5 days	tug2
8	anchor and bolt pier segment	2 days	cr1
9	move barge mounted cranes out	1 day	tug2
10	install strand jack equipment on pier seg n	4 days	cr2
11	install strand jack equipment on pier seg n-1	4 days	cr3
12	move drop in seg barge in position	3 days	tug2
13	lift drop in segment via strand jacks end n	2 days	cr2
14	lift drop in segment via strand jacks end n -1	2 days	cr3
15	splice truss on end n	4 days	cr2
16	splice truss on end n - 1	4 days	cr3
17	move barges out	1 day	tug2
18	remove temp tower	2 days	cr1
19	install temp towers s truss	7 days	cr1
20	erect north truss pier n - 21 cal days	15 days	
21	install bearings	2 days	cr1
22	move pier seg barge in position	4 days	tug1
23	repeat activivities of south truss with same crews	19 days	
38	erect deck total 36 segs 10 segs (5 per brdieg) in 2 days ea seg =12.5 ft - 36 cal days	65 days?	
39	1 st 5 s bridge	2 days	dk1
40	1 st 5 n bridge	2 days	dk2
41	repeat above 6 times	13 days	dk 1 and dk 2
54	concentric posttension	3 days	dk1
55	pour at shear key	3 days	dk2
56	pour overlay	5 days	dk1
57			
58			
59			
60			
61			
62			

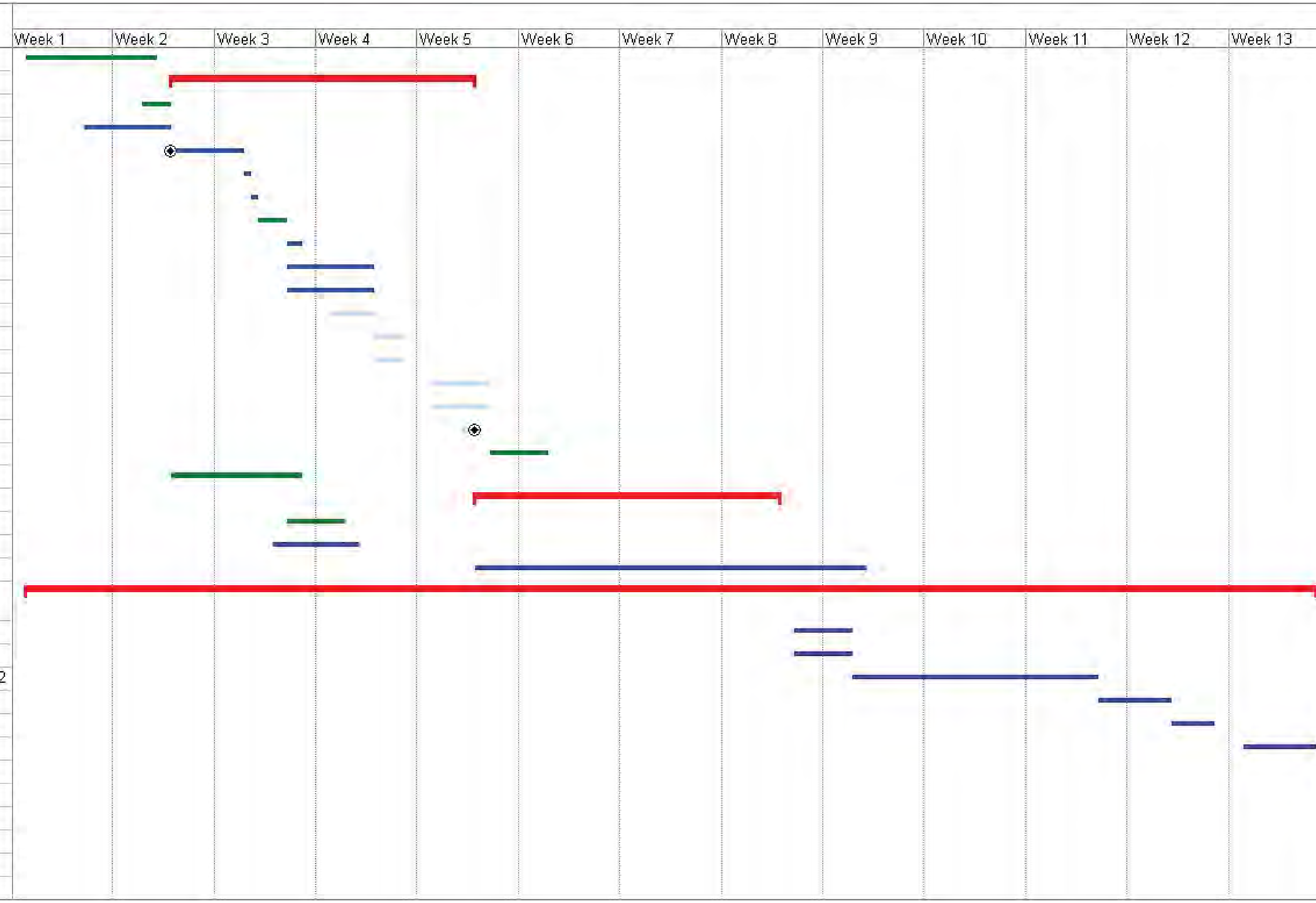

Figure B.3 - Construction of Dual Level Approach Span

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ID	Task Name	Duration	Resource Names
1	assemble rebar cage	20 days	not on cr path
2	transport to site	4 days	not on cr path
3	110 ft column - 75 cal days	51 days	
4	lift and install cage	4 days	cr1
5	1 st pour cycle	4 days	cr1
6	install form	2 days	cr1
7	pour concrete	1 day	cr1
8	strip form	1 day	cr1
9	8 add'l pour cycles	32 days	cr1
34	aseemble special f/w	3 days	cr1
35	assemble pier head steel	5 days	cr1
36	pour concrete	2 days	cr1
37	strip forms	1 day	cr1
38	install bearings	10 days	cr2

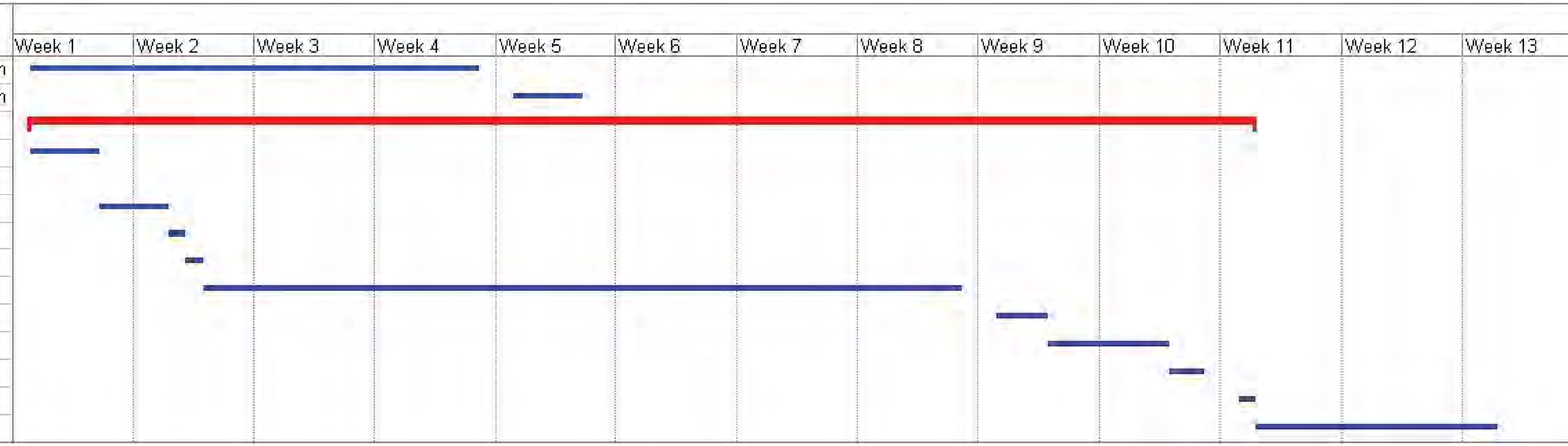

Figure B.4 - Construction of Pier Column

ID	Task Name	Duration	Resource Names
1	Pylon	304 days	
2	footing to pier table - 150 ft	78 days	cr1
3	install rebar	3 days	cr1
4	install form	1 day	cr1
5	pour concrete	1 day	cr1
6	slip form	1 day	cr1
7	repeat above cycle 12 add'l times	72 days	cr1
56	pier table to cable anchor - 250 ft	135 days	cr1
57	build pier table	15 days	cr1
58	install rebar	3 days	cr1
59	install form	1 day	cr1
60	pour concrete	1 day	cr1
61	slip form	1 day	cr1
62	repeat above cycle 19 times	114 days	cr1
139	cable anchor to top - 150 ft	91 days	cr1
140	install rebar	4 days	cr1
141	install form	1 day	cr1
142	pour concrete	1 day	cr1
143	slip form	1 day	cr1
144	repeat above cycle 12 times cable anchor to top - 150 ft	84 days	cr1

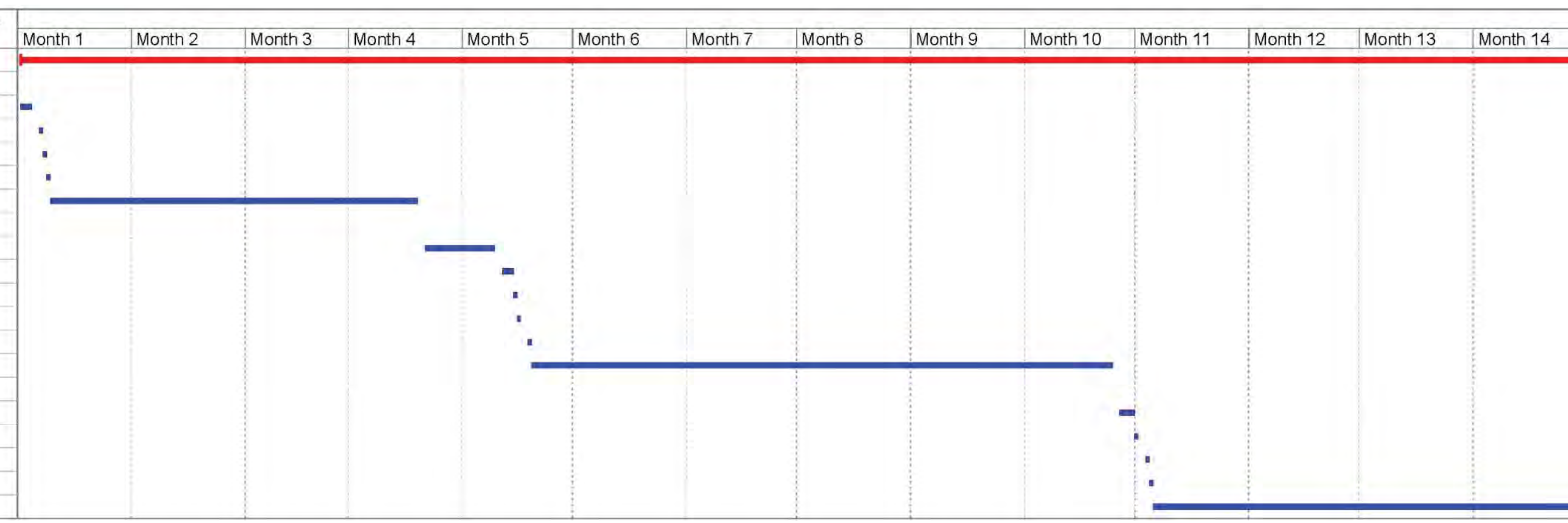

Figure B.5 - Construction Duration for a Pylon

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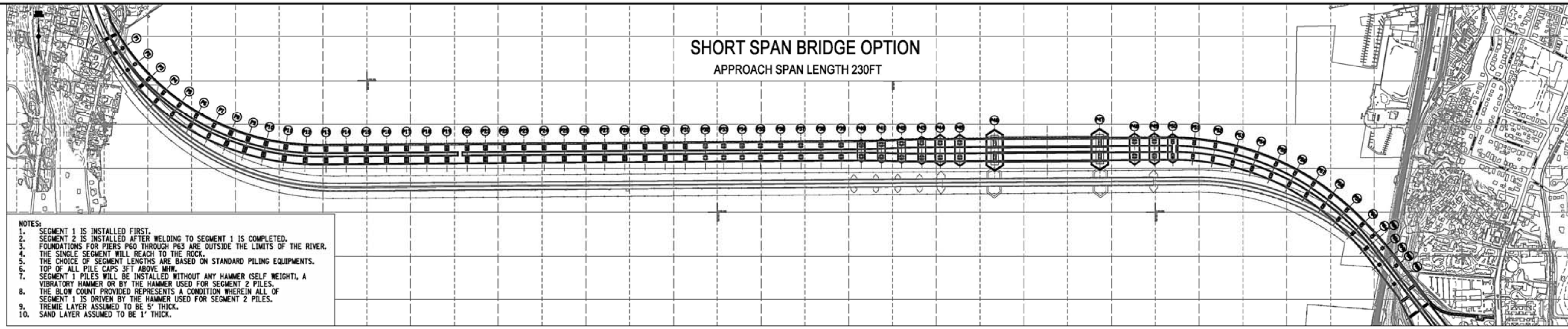
Appendix C

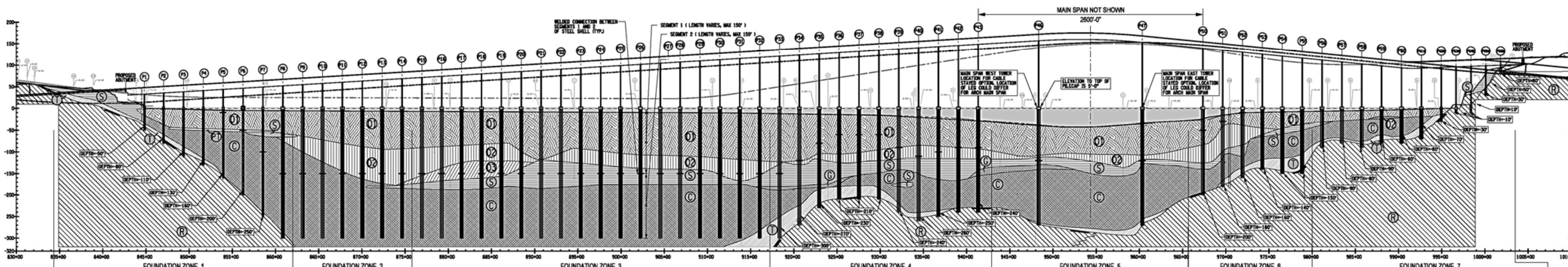
RTZB Foundation Drawings

SHORT SPAN BRIDGE OPTION

APPROACH SPAN LENGTH 230FT



NOTES:
1. SEGMENT 1 IS INSTALLED FIRST.
2. SEGMENT 2 IS INSTALLED AFTER WELDING TO SEGMENT 1 IS COMPLETED.
3. FOUNDATIONS FOR PIERS P60 THROUGH P63 ARE OUTSIDE THE LIMITS OF THE RIVER.
4. THE SINGLE SEGMENT WILL REACH TO THE ROCK.
5. THE CHOICE OF SEGMENT LENGTHS ARE BASED ON STANDARD PILING EQUIPMENTS.
6. TOP OF ALL PILE CAPS 3FT ABOVE MHW.
7. SEGMENT 1 PILES WILL BE INSTALLED WITHOUT ANY HAMMER (SELF WEIGHT), A VIBRATORY HAMMER OR BY THE HAMMER USED FOR SEGMENT 2 PILES.
8. THE BLOW COUNT PROVIDED REPRESENTS A CONDITION WHEREIN ALL OF SEGMENT 1 IS DRIVEN BY THE HAMMER USED FOR SEGMENT 2 PILES.
9. TREMIE LAYER ASSUMED TO BE 5' THICK.
10. SAND LAYER ASSUMED TO BE 1' THICK.



FOUNDATIONS 4' - 10' DIA PILES
• SEE NOTE 8

	P1 TO P3		P4 TO P8		P9 TO P14		P15 TO P32	
PILE LAYOUT	6' DIA. PILES • TOTAL NO. OF PILES/PILECAP=4 • 2x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		6' DIA. PILES • TOTAL NO. OF PILES/PILECAP=6 • 3x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		4' DIA. PILES • TOTAL NO. OF PILES/PILECAP=20 • 5x4 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2 • PILE PENETRATION LENGTH = 300FT		4' DIA. PILES • TOTAL NO. OF PILES/PILECAP=20 • 5x4 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2 • PILE PENETRATION LENGTH = 300FT	
STEEL SHELL THICKNESS	1.5IN		1.5IN		1.0IN		1.0IN	
TOTAL NO OF PILES	24		60		240		720	
NO OF ROCK SOCKETS	24 (LENGTH 30ft)		0		0		0	
SEGMENT 1 DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-750	JUNTTAN HHK 25S	IHC S-600	JUNTTAN HHK 25S	IHC S-600
SEGMENT 1 NO OF BLOWS/PILE	1000	600	1800	1200	1100	700	1100	700
SEGMENT 1 HAMMER ENERGY (k-ft)	347.2	550.8	347.2	550.8	271.2	443.5	271.2	443.5
SEGMENT 2 DRIVING HAMMER TYPE	SEE NOTE 4		BSP HA 40	IHC S-750	JUNTTAN HHK 25S	IHC S-600	JUNTTAN HHK 25S	IHC S-600
SEGMENT 2 NO OF BLOWS/PILE			1000	750	10000	3800	10000	3800
SEGMENT 2 HAMMER ENERGY (k-ft)			347.2	550.8	271.2	443.5	271.2	443.5
PILECAP THICKNESS (ft)	9		9		15		15	

	P33 TO P43		MAIN SPAN (P44 AND P45) NORTH LEG			CENTRAL LEGS			SOUTH LEG		
PILE LAYOUT	8' DIA. PILES • TOTAL NO. OF PILES/PILECAP=4 • 2x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		10' DIA. PILES ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2			10' DIA. PILES ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2			10' DIA. PILES ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2		
			VERTICAL AND BATTERED PILES			VERTICAL AND BATTERED PILES			VERTICAL AND BATTERED PILES		
STEEL SHELL THICKNESS	2.0IN		2.0IN			2.0IN			2.0IN		
TOTAL NO OF PILES	88		16			18			16		
NO OF ROCK SOCKETS	0		16 (LENGTH 70-90 ft)			18 (LENGTH 70-90 ft)			16 (LENGTH 70-90 ft)		
SEGMENT 1 DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750
SEGMENT 1 NO OF BLOWS/PILE	900	700	900	1200	700	1400	1200	900	900	1200	700
SEGMENT 1 HAMMER ENERGY (k-ft)	347.2	550.8	347.2	443.5	550.8	347.2	443.5	550.8	347.2	443.5	550.8
SEGMENT 2 DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750
SEGMENT 2 NO OF BLOWS/PILE	3500	2100	3500	4400	2100	5800	4400	2900	3500	4400	2100
SEGMENT 2 HAMMER ENERGY (k-ft)	347.2	550.8	347.2	443.5	550.8	347.2	443.5	550.8	347.2	443.5	550.8
PILECAP THICKNESS (ft)	12		23			23			23		

	P46 TO P51		P52 TO P57		P58 TO P62
PILE LAYOUT	6' DIA. PILES • TOTAL NO. OF PILES/PILECAP=6 • 3x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		6' DIA. PILES • TOTAL NO. OF PILES/PILECAP=6 • 3x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		SPREAD FOOTING DIRECTLY RESTING ON ROCK (SEE NOTE 3)
STEEL SHELL THICKNESS	1.5IN		1.5IN		
TOTAL NO OF PILES	72		72		
NO OF ROCK SOCKETS	0		0		
SEGMENT 1 DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-750	
SEGMENT 1 NO OF BLOWS/PILE	1000	600	1600	1000	
SEGMENT 1 HAMMER ENERGY (k-ft)	347.2	550.8	347.2	550.8	
SEGMENT 2 DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	SEE NOTE 4		
SEGMENT 2 NO OF BLOWS/PILE	700	500			
SEGMENT 2 HAMMER ENERGY (k-ft)	347.2	550.8			
PILECAP THICKNESS (ft)	9		9		

LEGEND:

- (O1) ORGANIC SILTY CLAY : SOFT DARK GRAY ORGANIC SILTY CLAY, TRACE SHELLS, VEGETATION, WOOD, ROOTS AND PEAT
- (O2) ORGANIC SILTY CLAY WITH TRACES OF SAND : SOFT GRAY ORGANIC SILTY CLAY, TRACE FINE SAND, FINE SAND SEAMS AND PARTINGS, PEAT.
- (O3) ORGANIC SILTY CLAY WITH SOME SAND : MEDIUM GRAY ORGANIC SILTY CLAY, TRACE TO SOME FINE SAND, SILT, TRACE FINE SAND SEAMS OR POCKETS
- (PT) PEAT : BROWN PEAT
- (S) SAND : MEDIUM COMPACT TO VERY COMPACT FINE TO MEDIUM SAND, SOME SILT, TRACE COARSE SAND AND GRAVEL
- (C) GLACIAL VARVED SILT AND CLAY : MEDIUM GRAY CLAY AND SILT, SOME FINE SAND VARVED WITH MEDIUM RED BROWN CLAYEY SILT, STIFF CLAY, FINE AND SILT PARTINGS
- (T) GLACIAL TILL : VERY COMPACT REDDISH GRAY FINE TO COARSE SAND, SOME GRAVEL, TRACE ROCK FRAGMENTS, SILT, GRAY BROWN SILTY CLAY LAYERS AND BOULDERS
- (R) ROCK : INTERMEDIATE TO HARD UNWEATHERED TO SLIGHTLY WEATHERED GRANITIC GNEISS OR SANDSTONE, BLOCKY TO CLOSELY JOINTED, WEATHERED TO IRON STAINED JOINTS

300 0 300 600
SCALE

REV	DATE	DESCRIPTION	BY
D			LB
C		INTERNAL DRAFT	LB
B		DRAFT	LB
A		DRAFT	LB

REVISIONS

DRAFT FOR DISCUSSION

TAPPAN ZEE BRIDGE / I-287 CORRIDOR PROJECT

ARUP

FOUNDATION DRAWING

SHORT SPAN BRIDGE REPLACEMENT TAPPAN ZEE BRIDGE

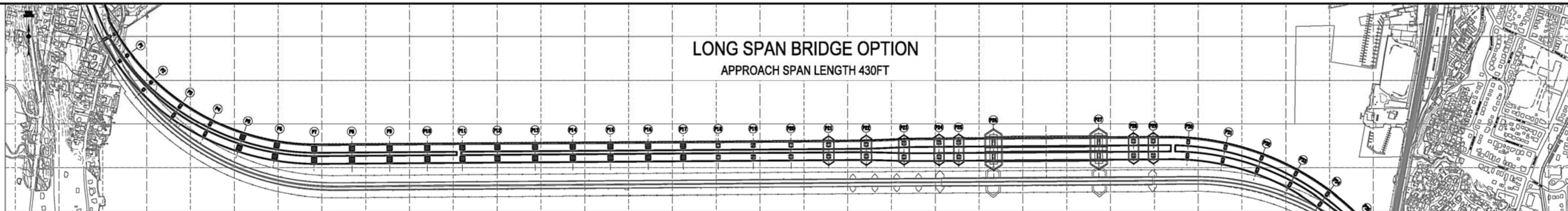
New York State Department of Transportation

Thruway Authority

217815	DEC 2011	B-4150

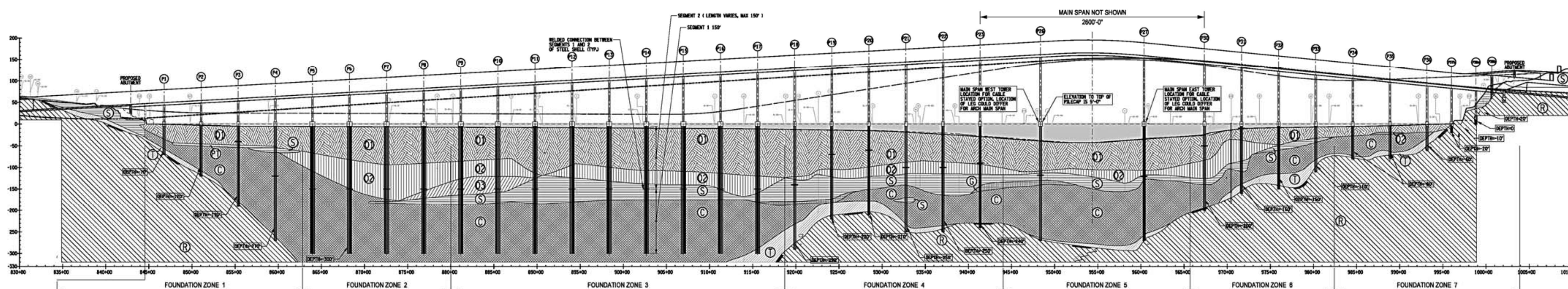
LONG SPAN BRIDGE OPTION

APPROACH SPAN LENGTH 430FT



NOTES:

1. SEGMENT 1 IS INSTALLED FIRST.
2. SEGMENT 2 IS INSTALLED AFTER WELDING TO SEGMENT 1 IS COMPLETED.
3. FOUNDATIONS FOR PIERS P33 THROUGH P35 ARE OUTSIDE THE LIMITS OF THE RIVER.
4. THE SINGLE SEGMENT WILL REACH TO THE ROCK.
5. THE CHOICE OF SEGMENT LENGTHS ARE BASED ON STANDARD PILING EQUIPMENTS.
6. TOP OF ALL PILE CAPS 3FT ABOVE MHW.
7. SEGMENT 1 PILES WILL BE INSTALLED WITHOUT ANY HAMMER (SELF WEIGHT), A VIBRATORY HAMMER OR BY THE HAMMER USED FOR SEGMENT 2 PILES.
8. THE BLOW COUNT PROVIDED REPRESENTS A CONDITION WHEREIN ALL OF SEGMENT 1 IS DRIVEN BY THE HAMMER USED FOR SEGMENT 2 PILES.
9. TREMIE LAYER ASSUMED TO BE 5' THICK.
10. SAND LAYER ASSUMED TO BE 1' THICK.



FOUNDATIONS 4' - 10' DIA PILES • SEE NOTE 8

	P1 TO P2		P3 TO P4		P5 TO P8		P9 TO P17		P18 TO P23	
PILE LAYOUT	6' DIA. PILES 36'-0" × 36'-0" • TOTAL NO. OF PILES/PILECAP=4 • 2x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		6' DIA. PILES 36'-0" × 54'-0" • TOTAL NO. OF PILES/PILECAP=6 • 2x3 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		4' DIA. PILES 60'-0" × 60'-0" • TOTAL NO. OF PILES/PILECAP=25 • 5x5 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2 • PILE PENETRATION LENGTH = 300FT		4' DIA. PILES 60'-0" × 60'-0" • TOTAL NO. OF PILES/PILECAP=23 • 5x5 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2 • PILE PENETRATION LENGTH = 300FT		8' DIA. PILES 48'-0" × 48'-0" • TOTAL NO. OF PILES/PILECAP=4 • 2x2 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2	
STEEL SHELL THICKNESS	1.5IN		1.5IN		1.0IN		1.0IN		2.0IN	
TOTAL NO OF PILES	16		24		200		414		48	
NO OF ROCK SOCKETS	16 (LENGHT 30ft)		0		0		0		0	
SEGMENT 1 – DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-750	JUNTTAN HHK 25S	IHC S-600	JUNTTAN HHK 25S	IHC S-600	BSP HA 40	IHC S-750
SEGMENT 1 – NO OF BLOWS/PILE	1000	600	1800	1200	1100	700	1100	700	900	700
SEGMENT 1 – HAMMER ENERGY (k-ft)	347.2	550.8	347.2	550.8	271.2	443.5	271.2	443.5	347.2	550.8
SEGMENT 2 – DRIVING HAMMER TYPE	SEE NOTE 4		BSP HA 40	IHC S-750	JUNTTAN HHK 25S	IHC S-600	JUNTTAN HHK 25S	IHC S-600	BSP HA 40	IHC S-750
SEGMENT 2 – NO OF BLOWS/PILE			1000	750	10000	3800	10000	3800	3500	2100
SEGMENT 2 – HAMMER ENERGY (k-ft)			347.2	550.8	271.2	443.5	271.2	443.5	347.2	550.8
PILECAP THICKNESS (ft)	9		9		15		15		12	

	MAIN SPAN (P24 AND P25)								
	NORTH LEG			CENTRAL LEGS			SOUTH LEG		
PILE LAYOUT	10' DIA. PILES 90'-0" × 90'-0" ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2			10' DIA. PILES 90'-0" × 90'-0" ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2			10' DIA. PILES 90'-0" × 90'-0" ● BATTERED PILES ○ VERTICAL PILES • TOTAL NO. OF PILE CAPS=2		
	VERTICAL AND BATTERED PILES			VERTICAL AND BATTERED PILES			VERTICAL AND BATTERED PILES		
STEEL SHELL THICKNESS	2.0IN			2.0IN			2.0IN		
TOTAL NO OF PILES	16			18			16		
NO OF ROCK SOCKETS	16 (LENGTH 70-90ft)			18 (LENGTH 70-90ft)			16 (LENGTH 70-90ft)		
SEGMENT 1 – DRIVING HAMMER TYPE	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750
SEGMENT 1 – NO OF BLOWS/PILE	900	1200	700	1400	1200	900	900	1200	700
SEGMENT 1 – HAMMER ENERGY (k-ft)	347.2	443.5	550.8	347.2	443.5	550.8	347.2	443.5	550.8
SEGMENT 2 – DRIVING HAMMER TYPE	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750	BSP HA 40	IHC S-600	IHC S-750
SEGMENT 2 – NO OF BLOWS/PILE	3500	4400	2100	5800	4400	2900	3500	4400	2100
SEGMENT 2 – HAMMER ENERGY (k-ft)	347.2	443.5	550.8	347.2	443.5	550.8	347.2	443.5	550.8
PILECAP THICKNESS (ft)	23			23			23		

	P26 TO P29		P30 TO P32		P33 TO P35
PILE LAYOUT	6' DIA. PILES 36'-0" × 54'-0" • TOTAL NO. OF PILES/PILECAP=6 • 2x3 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		6' DIA. PILES 36'-0" × 54'-0" • TOTAL NO. OF PILES/PILECAP=6 • 2x3 PILE ARRANGEMENT • TOTAL NO. OF PILE CAPS FOR EACH LOCATION = 2		SPREAD FOOTING DIRECTLY RESTING ON ROCK (SEE NOTE 3)
STEEL SHELL THICKNESS	1.5IN		1.5IN		
TOTAL NO OF PILES	48		36		
NO OF ROCK SOCKETS	0		0		
SEGMENT 1 – DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	BSP HA 40	IHC S-750	
SEGMENT 1 – NO OF BLOWS/PILE	1000	600	1600	1000	
SEGMENT 1 – HAMMER ENERGY (k-ft)	347.2	550.8	347.2	550.8	
SEGMENT 2 – DRIVING HAMMER TYPE	BSP HA 40	IHC S-750	SEE NOTE 4		
SEGMENT 2 – NO OF BLOWS/PILE	700	500			
SEGMENT 2 – HAMMER ENERGY (k-ft)	347.2	550.8			
PILECAP THICKNESS (ft)	9		9		

LEGEND:

- (O1) ORGANIC SILTY CLAY : SOFT DARK GRAY ORGANIC SILTY CLAY, TRACE SHELLS, VEGETATION, WOOD, ROOTS AND PEAT
- (O2) ORGANIC SILTY CLAY WITH TRACES OF SAND : SOFT GRAY ORGANIC SILTY CLAY, TRACE FINE SAND, FINE SAND SEAMS AND PARTINGS, PEAT.
- (O3) ORGANIC SILTY CLAY WITH SOME SAND : MEDIUM GRAY ORGANIC SILTY CLAY, TRACE TO SOME FINE SAND, SILT, TRACE FINE SAND SEAMS OR POCKETS
- (PT) PEAT : BROWN PEAT
- (S) SAND : MEDIUM COMPACT TO VERY COMPACT FINE TO MEDIUM SAND, SOME SILT, TRACE COARSE SAND AND GRAVEL
- (C) GLACIAL VARVED SILT AND CLAY : MEDIUM GRAY CLAY AND SILT, SOME FINE SAND VARVED WITH MEDIUM RED BROWN CLAYEY SILT, STIFF CLAY, FINE AND SILT PARTINGS
- (T) GLACIAL TILL : VERY COMPACT REDDISH GRAY FINE TO COARSE SAND, SOME GRAVEL TRACE ROCK FRAGMENTS, SILT, GRAY BROWN SILTY CLAY LAYERS AND BOULDERS
- (R) ROCK : INTERMEDIATE TO HARD UNWEATHERED TO SLIGHTLY WEATHERED GRANITIC GNEISS OR SANDSTONE, BLOCKY TO CLOSELY JOINTED, WEATHERED TO IRON STAINED JOINTS

300 0 300 600
SCALE

REV	DATE	DESCRIPTION	BY
D	12/08/11	pDEIS APPENDIX A ISSUE	LD
C	11/15/11	INTERNAL DRAFT	LD
B	10/13/11	DRAFT	LD
A	09/23/11	DRAFT	LD

REVISIONS

DRAFT FOR DISCUSSION

TAPPAN ZEE BRIDGE / I-287 CORRIDOR PROJECT

ARUP

FOUNDATION DRAWING

LONG SPAN BRIDGE REPLACEMENT TAPPAN ZEE BRIDGE

New York State Department of Transportation

Thruway Authority

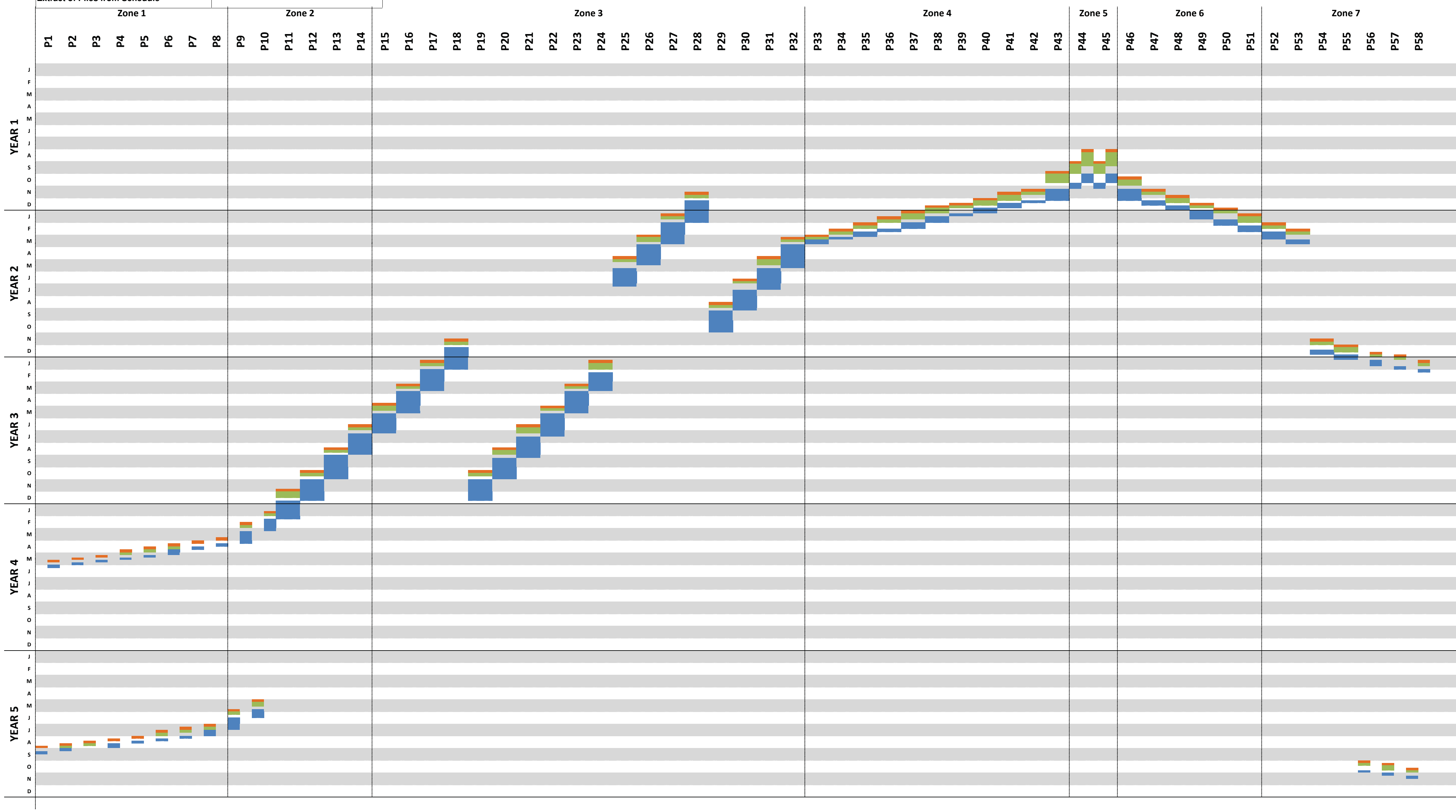
217815	DEC 2011	B-4250

z

Appendix D

RTZB Pile Driving

ARUP	Job No.	Sheet No.	Rev.
	131229	1 of 2	
	Member/Location		
Job Title: Tappan Zee Bridge Replacement **SINGLE LEVEL OPTION** **Extract of Piles from Schedule**	Drg. Ref.		
	Made by: MAS	Date: 11-14-10	Chd. RM



Segment 2 Piles / Month

		Pile Rig 1						Pile Rig 2						Pile Rig 3						
	MONTH	4FT	6 FT	8 FT	10 FT	Rig 1 Total	Rig 1 Avg/Day	4FT	6 FT	8 FT	10 FT	Rig 2 Total	Rig 2 Avg/Day	4FT	6 FT	8 FT	10 FT	Rig 3 Total	Rig 3 Avg/Day	TOTAL
YEAR 1	J					0	0.0					0	0.0					0	0.0	0
	F					0	0.0					0	0.0					0	0.0	0
	M					0	0.0					0	0.0					0	0.0	0
	A					0	0.0					0	0.0					0	0.0	0
	M					0	0.0					0	0.0					0	0.0	0
	J					0	0.0					0	0.0					0	0.0	0
	J					0	0.0					0	0.0					0	0.0	0
	A					0	0.0					0	0.0					0	0.0	0
	S					0	0.0					0	0.0					0	0.0	0
	O				19	19	0.9				19	19	0.9					0	0.0	38
	N			16	6	22	1.0		16		6	22	1.0					0	0.0	44
	D			22		22	1.0		22			22	1.0	20				20	0.9	64
YEAR 2	J			22		22	1.0		22			22	1.0	22				22	1.0	66
	F			22		22	1.0		22			22	1.0	22				22	1.0	66
	M	6		16		22	1.0		20			20	0.9	22				22	1.0	64
	A	22				22	1.0					0	0.0	22				22	1.0	44
	M	22				22	1.0					0	0.0	22				22	1.0	44
	J	22				22	1.0					0	0.0	22				22	1.0	44
	J	22				22	1.0					0	0.0	8				8	0.4	30
	A	22				22	1.0					0	0.0					0	0.0	22
	S	22				22	1.0					0	0.0					0	0.0	22
	O	22				22	1.0					0	0.0					0	0.0	22
	N					0	0.0					0	0.0					0	0.0	0
	D		14			14	0.6					0	0.0	20				20	0.9	34
YEAR 3	J		22			22	1.0					0	0.0	22				22	1.0	44
	F	18	4			22	1.0					0	0.0	22				22	1.0	44
	M	22				22	1.0					0	0.0	22				22	1.0	44
	A	22				22	1.0					0	0.0	22				22	1.0	44
	M	22				22	1.0					0	0.0	22				22	1.0	44
	J	22				22	1.0					0	0.0	22				22	1.0	44
	J	22				22	1.0					0	0.0	22				22	1.0	44
	A	22				22	1.0					0	0.0	22				22	1.0	44
	S	22				22	1.0					0	0.0	22				22	1.0	44
	O	22				22	1.0					0	0.0	22				22	1.0	44
	N	22				22	1.0					0	0.0	22				22	1.0	44
	D	22				22	1.0					0	0.0	22				22	1.0	44
YEAR 4	J	2				2	0.0					0	0.0	22				22	0.0	24
	F					0	0.0					0	0.0	22				22	0.0	22
	M					0	0.0					0	0.0	22				22	0.0	22
	A					0	0.0					0	0.0	10	12			22	0.0	22
	M					0	0.0					0	0.0		22			22	0.0	22
	J					0	0.0					0	0.0		8			8	0.0	8
	J					0	0.0					0	0.0					0	0.0	0
	A					0	0.0					0	0.0					0	0.0	0
	S					0	0.0					0	0.0					0	0.0	0
	O					0	0.0					0	0.0					0	0.0	0
	N					0	0.0					0	0.0					0	0.0	0
	D					0	0.0					0	0.0					0	0.0	0
YEAR 5	J					0	0.0					0	0.0					0	0.0	0
	F					0	0.0					0	0.0					0	0.0	0
	M					0	0.0					0	0.0					0	0.0	0
	A					0	0.0					0	0.0					0	0.0	0
	M					0	0.0					0	0.0	4				4	0.2	4
	J					0	0.0					0	0.0	22				22	1.0	22
	J					0	0.0					0	0.0	14	8			22	1.0	22
	A					0	0.0					0	0.0		22			22	1.0	22
	S					0	0.0					0	0.0		12			12	0.5	12
	O					0	0.0					0	0.0		7			7	0.3	7
	N					0	0.0					0	0.0		9			9	0.4	9
	D					0	0.0					0	0.0					0	0.0	0
		400	40	98	25	563		0	102	0	25	127		560	100	0	0	660		1350

Legend:

Indicates window of temporary piling.

Indicates window of segment 1 piling

Indicates window of segment 2 piling

Single Level - Possible Pile Combinations

Single Level

Year	Month	Max Probable Daily Segment 2 Piling Combinations	Max Probable Daily Segment 1 Piling Combinations	Max Probable Daily Spud Piling Combinations
Year 1	J			
	F			
	M			
	A			
	M			
	J			
	J			
	A		[P44 - 2x10']+ [P45 -2x10']	[P44 -2S]+[P45 -2S]
	S		[P44 - 2x10']+ [P45 -2x10']	[P44 -2S]+[P45 -2S] OR [P43 -2S]
	O	[P44 - 2x10']+ [P45 -2x10']	[P43-3x8']+[P46-4x6']	[P46 -2S]
	N	[P44 - 2x10']+ [P45 -2x10'] OR [P43-3x8']+[P46-4x6']	[P41 to P42-3x8']+[P47 to P48-4x6']+[P28 -3x4']	[P41 to P42 -2S]+[P47 to P48 -2S]+[P28 -2S]
	D	[P40 to P43-3x8']+[P46 to P48-4x6']+[P28 -3x4']	[P38 to P40-3x8']+[P48 to P49-4x6']	[P38 to P40 -2S]+[P49 to P50 -2S]
Year 2	J	[P38 to P40-3x8']+[P49 to P50-4x6']+[P28 -3x4']	[P36 to P37-3x8']+[P50 to P51-4x6']+[P27 -3x4']	[P36 to P37 -2S]+[P51 -2S]+[P27 -2S]
	F	[P35 to P37-3x8']+[P50 to P52-4x6']+[P27 -3x4']	[P34 to P35-3x8']+[P52 to P53-4x6']	[P34 to P35 -2S]+[P52 to P53 -2S]
	M	[P33 to P35-3x8']+[P52 to P53-4x6']+[P26 to P27 -4x6'] OR [P32 -3x4']+[P52 to P53-4x6']+[P26 to P27 -3x4']	[P32 to P33 -3x4']+[P26 -3x4']	[P32 to P33 -2S]+[P26 -2S]
	A	[P32 -3x4']+[P26 -3x4']		[P25 -2S]+[P31 -2S]
	M	[P31 to P32 -3x4']+[P25 to P26 -3x4']	[P31 -3x4']+[P25 -3x4']	
	J	[P31 -3x4']+[P25 -3x4']	[P30 -3x4']	[P30 -2S]
	J	[P30 to P31 -3x4']		
	A	[P30 -3x4']	[P29 -3x4']	[P29 -2S]
	S	[P29 to P30 -3x4']		
	O	[P29 -3x4']		
	N		[P18 -3x4']+[P54 -4x6']	[P18 -2S]+[P54 -2S]
	D	[P18 -3x4']+[P54 to P55 -4x6']	[P55 to P56 -4x6']	[P55 to P57 -2S]
Year 3	J	[P18 -3x4']+[P55 to P57 -4x6']	[P17 -3x4']+[P57 to P58 -3x4'] OR [P17 -3x4']+[P24 -3x4']	[P58 -2S] OR [P17 -2S]+[P24 -2S]
	F	[P17 -3x4']+[P58 -3x4'] OR [P17 -3x4']+[P24 -3x4']		
	M	[P16 to P17 -3x4']+[P23 to P24 -3x4']	[P16 -3x4']+[P23 -3x4']	[P16 -2S]+[P23 -2S]
	A	[P16 -3x4']+[P23 -3x4']		[P15 -2S]
	M	[P15 to P16 -3x4']+[P22 to P23 -3x4']	[P15 -3x4']+[P22 -3x4']	[P22 -2S]
	J	[P15 -3x4']+[P22 -3x4']	[P14 -3x4']+[P21 -3x4']	[P14 -2S]+[P21 -2S]
	J	[P14 to P15 -3x4']+[P21 to P22 -3x4']	[P14 -3x4']+[P21 -3x4']	
	A	[P14 -3x4']+[P21 -3x4']	[P13 -3x4']+[P20 -3x4']	[P13 -2S]+[P20 -2S]
	S	[P13 to P14 -3x4']+[P20 to P21 -3x4']		
	O	[P13 -3x4']+[P20 -3x4']	[P12 -3x4']+[P19 -3x4']	[P12 -2S]+[P19 -2S]
	N	[P12 -3x4']+[P19 -3x4']		[P11 -2S]
	D	[P11 to P12 -3x4']+[P19 -3x4']	[P11 -3x4']	
Year 4	J	[P11 -3x4']	[P10N -3x4']	[P10N -2S]
	F	[P10N to P11N -3x4']	[P9N -3x4']	[P9N -2S]
	M	[P9N to P10N -3x4']		[P8N -2S]
	A	[P9N -3x4'] OR [P6N to P8N -4x6']	[P5N to P8N -4x6']	[P4N to P7N -2S]
	M	[P2N to P6N -4x6']	[P1N to P4N -4x6']	[P1N to P3N -2S]
	J	[P1N -4x6']		
	J			
	A			
	S			
	O			
	N			
	D			
Year 5	J			
	F			
	M			
	A			
	M	[P10S -3x4']	[P10S -3x4']	[P9S to P10S -2S]
	J	[P9S to P10S -3x4']	[P9S -3x4']	
	J	[P9S -3x4'] OR [P8S -4x6']	[P6S to P8S -4x6']	[P6S to P8S -2S]
	A	[P4S to P7S -4x6']	[P2S to P5S -4x6']	[P1S to P5S -2S]
	S	[P1S to P3S -4x6']	[P1S -4x6']	
	O	[P56S -4x6']	[P56S to P58S -4x6']	
	N	[P56S to P57S -4x6']		
	D			

Maximum Pile Installation Per Day Within A Given Month

Single Level

		Possible Combination 1	Possible Combination 2	Possible Combination 3
Year 1	J			
	F			
	M			
	A			
	M			
	J			
	J			
	A	[P44 -2S]+[P45 -2S]	[P44 -2S]+[P45 -2S]	
	S	[P44 -2S]+[P45 -2S]	[P44 -2S]+[P45 -2S]	[P43 -2S]
	O	2x10']+ [P45 -2x10']+[P46 -2S] OR [P44 - 2x10']+ [P45 -2x10']+[P43-3x8']+[P46	[P44 - 2x10']+ [P45 -2x10']+[P46 -2S] OR [P44 - 2x10']+ [P45 -2x10']+[P43-3x8']+[P46-4x6']	[P44 - 2x10']+ [P45 -2x10']+[P46 -2S] OR [P44 - 2x10']+ [P45 -2x10']+[P43-3x8']+[P46-4x6']
	N	[P44 - 2x10']+ [P45 -2x10']	[P43-3x8']+[P46-4x6']+[P41 to P42 -2S]+[P47 to P48 -2S]+[P28 -2S]	[P43-3x8']+[P46-4x6']]+[P41 to P42-3x8']+[P47 to P48-4x6']+[P28 -3x4']
	D	[P40 to P43-3x8']+[P46 to P48-4x6']+[P28 -3x4']+ [P38 to P40-3x8']+[P48 to P49-4x6']	[P40 to P43-3x8']+[P46 to P48-4x6']+[P28 -3x4']+[P38 to P40 -2S]+[P49 to P50 -2S]	
Year 2	J	[P38 to P40-3x8']+[P49 to P50-4x6']+[P28 -3x4']+ [P36 to P37-3x8']+[P50 to P51-4x6']+[P27 -3x4']	[P38 to P40-3x8']+[P49 to P50-4x6']+[P28 -3x4']+[P36 to P37 -2S]+[P51 -2S]+[P27 -2S]	
	F	[P35 to P37-3x8']+[P50 to P52-4x6']+[P27 -3x4']+[P36 to P37-3x8']+[P50 to P51-4x6']+[P27 -3x4']	[P35 to P37-3x8']+[P50 to P52-4x6']+[P27 -3x4']+[P34 to P35 -2S]+[P52 to P53 -2S]	
	M	[P33 to P35-3x8']+[P52 to P53-4x6']+[P26 to P27 -4x6']+[P32 to P33 -3x4']+[P26 -3x4']	[P33 to P35-3x8']+[P52 to P53-4x6']+[P26 to P27 -4x6']+[P32 to P33 -2S]+[P26 -2S]	[P32 -3x4']+[P52 to P53-4x6']+[P26 to P27 -3x4']
	A	[P32 -3x4']+[P26 -3x4']+[P25 -2S]+[P31 -2S]		
	M	[P31 to P32 -3x4']+[P25 to P26 -3x4']+[P31 -3x4']+[P25 -3x4']		
	J	[P31 -3x4']+[P25 -3x4']+[P30 -3x4']	[P31 -3x4']+[P25 -3x4']+[P30 -2S]	
	J	[P30 to P31 -3x4']		
	A	[P30 -3x4']+[P29 -3x4']	[P30 -3x4']+[P29 -2S]	
	S	[P29 to P30 -3x4']		
	O	[P29 -3x4']		
	N	[P18 -2S]+[P54 -2S]	[P18 -3x4']+[P54 -4x6']	
	D	[P18 -3x4']+[P54 to P55 -4x6']+[P55 to P56 -4x6']	[P18 -3x4']+[P54 to P55 -4x6']+[P55 to P57 -2S]	
Year 3	J	[P18 -3x4']+[P55 to P57 -4x6']+[P17 -3x4']+[P57 to P58 -3x4']	[P18 -3x4']+[P55 to P57 -4x6']+[P17 -3x4']+[P24 -3x4']	[P18 -3x4']+[P55 to P57 -4x6']+[P58 -2S] OR [P17 -2S]+[P24 -2S]
	F	[P17 -3x4']+[P58 -3x4']	[P17 -3x4']+[P24 -3x4']	
	M	[P16 to P17 -3x4']+[P23 to P24 -3x4']+[P16 -3x4']+[P23 -3x4']	[P16 to P17 -3x4']+[P23 to P24 -3x4']+[P16 -2S]+[P23 -2S]	
	A	[P16 -3x4']+[P23 -3x4']+[P15 -2S]		
	M	[P15 to P16 -3x4']+[P22 to P23 -3x4']+[P15 -3x4']+[P22 -3x4']	[P15 to P16 -3x4']+[P22 to P23 -3x4']+[P22 -2S]	
	J	[P15 -3x4']+[P22 -3x4']+[P14 -3x4']+[P21 -3x4']	[P15 -3x4']+[P22 -3x4']+[P14 -2S]+[P21 -2S]	
	J	[P14 to P15 -3x4']+[P21 to P22 -3x4']+[P14 -3x4']+[P21 -3x4']	[P14 to P15 -3x4']+[P21 to P22 -3x4']+[P14 -3x4']+[P21 -3x4']	[P14 to P15 -3x4']+[P21 to P22 -3x4']+[P14 -3x4']+[P21 -3x4']
	A	[P14 -3x4']+[P21 -3x4']+ [P13 -3x4']+[P20 -3x4']	[P14 -3x4']+[P21 -3x4']+[P13 -2S]+[P20 -2S]	
	S	[P13 to P14 -3x4']+[P20 to P21 -3x4']		
	O	[P13 -3x4']+[P20 -3x4']+[P12 -3x4']+[P19 -3x4']	[P13 -3x4']+[P20 -3x4']+[P12 -2S]+[P19 -2S]	
	N	[P12 -3x4']+[P19 -3x4']+[P11 -2S]		
	D	[P11 to P12 -3x4']+[P19 -3x4']+[P11 -3x4']		
Year 4	J	[P11 -3x4']+[P10N -3x4']	[P11 -3x4']+[P10N -2S]	
	F	[P10N to P11N -3x4']+[P9N -3x4']	[P10N to P11N -3x4']+[P9N -2S]	
	M	[P9N to P10N -3x4']+[P8N -2S]		
	A	[P9N -3x4'] OR [P6N to P8N -4x6']+[P5N to P8N -4x6']	[P9N -3x4'] OR [P6N to P8N -4x6']+[P4N to P7N -2S]	
	M	[P2N to P6N -4x6']+[P1N to P4N -4x6']	[P2N to P6N -4x6']+[P1N to P3N -2S]	
	J	[P1N -4x6']		
	J			
	A			
	S			
	O			
	N			
	D			
Year 5	J			
	F			
	M			
	A			
	M	[P10S -3x4']+[P9S -2S]	[P10S -2S]	[P10S -3x4']
	J	[P9S to P10S -3x4']+[P9S -3x4']		
	J	[P9S -3x4']+[P6S to P8S -4x6']	[P8S -4x6']+[P6S to P8S -2S]	
	A	[P4S to P7S -4x6']+[P2S to P5S -4x6']	[P4S to P7S -4x6']+[P1S to P5S -2S]	
	S	[P1S to P3S -4x6']+[P1S -4x6']		
	O	[P56S -4x6']+[P56S to P58S -4x6']		
	N	[P56S to P57S -4x6']		
	D			

Legend:

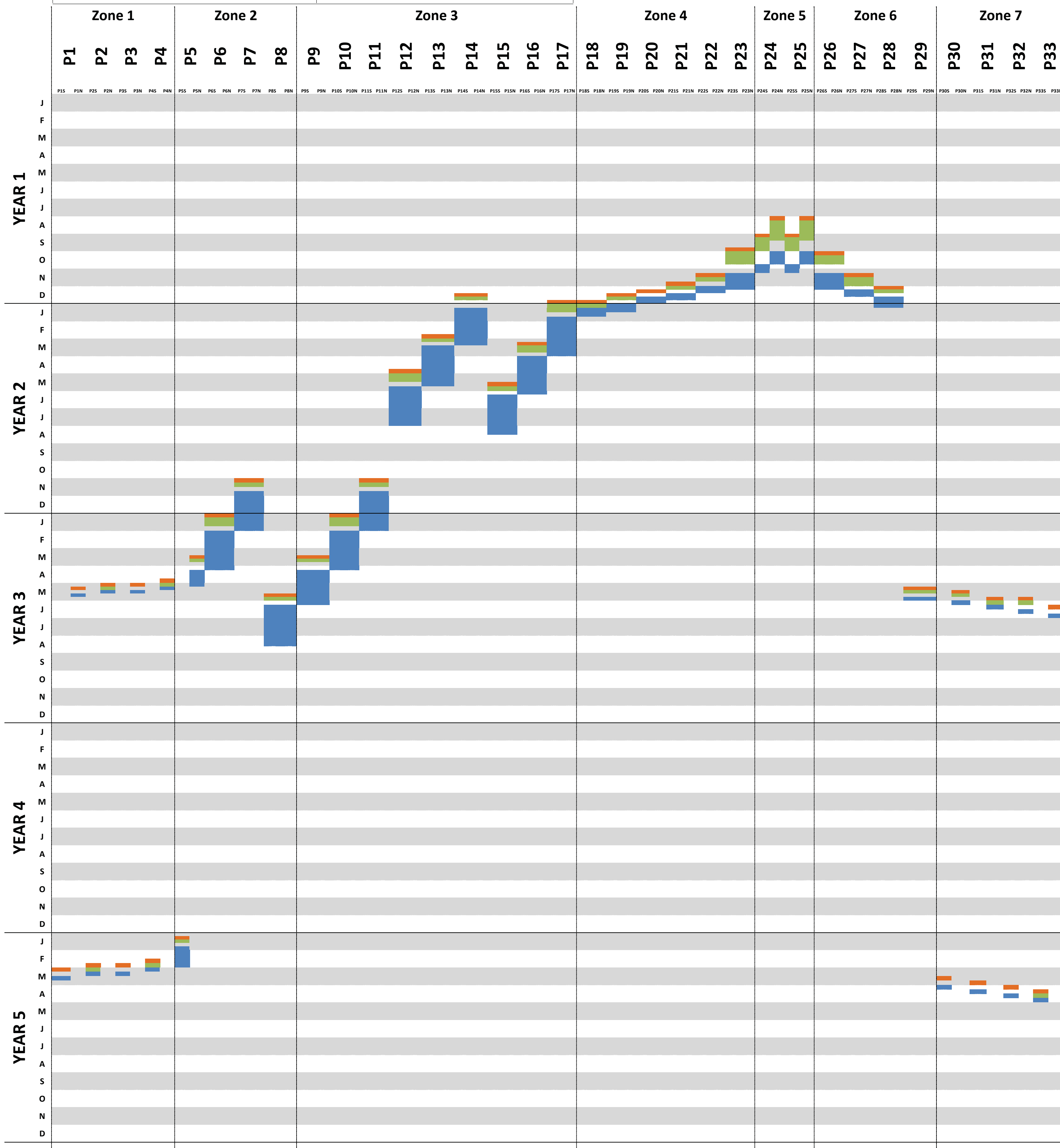
- [P1] - Pier 1 (both north and south)
- [P1N] - Pier 1 North (only)
- [P1S] - Pier 1 South (only)
- [3x4'] - Three 4 foot diameter piles
- [2S] - Two Spud (temporary) piles
- [Orange] - Spud (temporary) piles
- [Green] - Segment 1 piles
- [Blue] - Segment 2 piles
- [P12 to P14] - Piers 12 to 14 (inclusive)

Example:

[P20 to P21-3x8']+[P26 to P28-4x6']+[P17 to P19 -2S]+[P28 -2S]

On a given day in the month specified, three 8 foot diameter piles at either pier 20 OR 21, as well as four 6 foot diameter piles at either pier 26 OR 27 OR 28, and two spud (temporary) piles at either pier 17 OR 18 OR 19OR 28 could possibly be installed.

ARUP	Job No. 131229	Sheet No. 1 of 2	Rev.
	Member/Location		
Job Title: Tappan Zee Bridge Replacement	Drg. Ref.		
DUAL LEVEL OPTION	Made by: MAS	Date: 11-12-10	Chd. RM
Extract of Piles from Schedule			



Segment 2 Piles / Month

MONTH	Pile Rig 1 4FT	6 FT	8 FT	10 FT	Rig 1 TOTAL	Rig 1 Avg/Day	Pile Rig 2 4FT	6 FT	8 FT	10 FT	Rig 2 TOTAL	Rig 1 Avg/Day	TOTAL
J					0	0.0					0	0.0	0
F					0	0.0					0	0.0	0
M					0	0.0					0	0.0	0
A					0	0.0					0	0.0	0
M					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
A					0	0.0					0	0.0	0
S					0	0.0					0	0.0	0
O				20	20	0.9				20	20	0.9	40
N			17	5	22	1.0		17		5	22	1.0	44
D			22		22	1.0		22			22	1.0	44
J	3		19		22	1.0	16	5			21	1.0	43
F	22	0	0	0	22	1.0	22				22	1.0	44
M	22				22	1.0	22				22	1.0	44
A	22				22	1.0	22				22	1.0	44
M	22				22	1.0	22				22	1.0	44
J	22				22	1.0	22				22	1.0	44
J	22				22	1.0	22				22	1.0	44
A	15				15	0.7	2				2	0.1	17
S					0	0.0					0	0.0	0
O					0	0.0					0	0.0	0
N	8				8	0.4	15				15	0.7	23
D	22				22	1.0	22				22	1.0	44
J	22				22	1.0	22				22	1.0	44
F	22				22	1.0	22				22	1.0	44
M	22				22	1.0	22				22	1.0	44
A	22				22	1.0	22				22	1.0	44
M	22				22	1.0		22			22	1.0	44
J	22				22	1.0		22			22	1.0	44
J	22				22	1.0		6			6	0.3	28
A	16				16	0.7					0	0.0	16
S					0	0.0					0	0.0	0
O					0	0.0					0	0.0	0
N					0	0.0					0	0.0	0
D					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
F					0	0.0					0	0.0	0
M					0	0.0					0	0.0	0
A					0	0.0					0	0.0	0
M					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
A					0	0.0					0	0.0	0
S					0	0.0					0	0.0	0
O					0	0.0					0	0.0	0
N					0	0.0					0	0.0	0
D					0	0.0					0	0.0	0
J					0	0.0	3				3	0.1	3
F					0	0.0	22				22	1.0	22
M					0	0.0		16			16	0.7	16
A					0	0.0		22			22	1.0	22
M					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
J					0	0.0					0	0.0	0
A					0	0.0					0	0.0	0
S					0	0.0					0	0.0	0
O					0	0.0					0	0.0	0
N					0	0.0					0	0.0	0
D					0	0.0					0	0.0	0
	350	0	58	25	433	19.7	300	132	0	25	457	20.8	890

Legend:

- **Indicates window of Temporary.**
- **Indicates window of segment 1 piling**
- **Indicates window of segment 2 piling**

Maximum Pile Installation Per Day Within A Given Month

Dual Level

		Max Probable Daily Segment 2 Piling Combinations	Max Probable Daily Segment 1 Piling Combinations	Max Probable Daily Spud Piling Combinations
Year 1	J			
	F			
	M			
	A			
	M			
	J			
	J			
	A		[P24 - 2x10']+ [P25 -2x10']	[P24 -2S]+[P25 -2S]
	S		[P24 - 2x10']+ [P25 -2x10']	[P24 -2S]+[P25 -2S]
	O	[P24 - 2x10']+ [P25 -2x10']	[P23-3x8']+[P26-4x6']	[P23 -2S]+[P26 -2S]
	N	[P24 - 2x10']+ [P25 -2x10'] OR [P23-3x8']+[P26-4x6']	[P22-3x8']+[P27 to P28-4x6']	[P21 to P22 -2S]+[P27 -2S]
	D	[P20 to P23-3x8']+[P26 to P28-4x6']	[P14 -4x4'] +[P19 to P21 -3x8']	[P17 to P20 -2S]+[P28 -2S] OR [P17 to P20 -2S]+[P14 -2S]
Year 2	J	[P17 -3x4']+[P14 -3x4'] OR [P14 -3x4']+[P18 to P19 -3x8'] OR [P19 -3x8']+[P28 -4x6'	[P17 -4x4']	
	F	[P17 -3x4']+[P14 -3x4']		[P13 -2S]
	M	[P17 -3x4']+[P13 to P14 -3x4']	[P13 -4x4']+[P16 -4x4']	[P16 -2S]
	A	[P16 -3x4']+[P13 -3x4']		[P12 -2S]
	M	[P16 -3x4']+[P12 to P13 -3x4']	[P12 -4x4']+[P15 -4x4']	[P15 -2S]
	J	[P14 to P15 -3x4']+[P12 -3x4']		
	J	[P15 -3x4']+[P12 -3x4']		
	A	[P15 -3x4']+[P12 -2x4']		
	S			
	O			
	N	[P11 -3x4']+[P7 -3x4']	[P7 -4x4']+[P11 -4x4']	[P7 -2S]+[P11 -2S]
	D	[P11 -3x4']+[P7 -3x4']		
Year 3	J	[P11 -3x4']+[P7 -3x4']	[P6 -4x4']+[P10 -4x4']	[P6 -2S]+[P10 -2S]
	F	[P10 -3x4']+[P6 -3x4']		
	M	[P10 -3x4']+[P6 -3x4']	[P5 -4x4']+[P9 -4x4']	[P5 -2S]+[P9 -2S]
	A	[P9 to P10 -3x4']+[P5N to P6 -3x4']		[P4 -2S]
	M	[P9 -3x4']+[P5N -3x4'] OR [P9 -3x4']+[P1N to P4N -4x6'] OR [P9 -3x4']+[P29N -4x6']	[P8 -4x4']+[P1N to P4N -4x6'] OR [P8 -4x4']+[P29N to P30N -4x6']	[P1N to P3N -2S] OR [P8 -2S]+[P29 to P30N -2S]
	J	[P9 -3x4']+[P30N -4x6'] OR [P8 -3x4']+[P31N to P33N -4x6']	[P8 -4x4']+[P31N to P33N -4x6']	[P31N to P33N -2S]
	J	[P8 -3x4']		
	A	[P8 -3x4']		
	S			
	O			
	N			
	D			
Year 4	J			
	F			
	M			
	A			
	M			
	J			
	J			
	A			
	S			
	O			
	N			
	D			
Year 5	J	[P5S -3x4']	[P5S -4x4']	[P5S -2S]
	F	[P5S -3x4']	[P3S to P4S -4x6']	[P2S to P4S -2S]
	M	[P1S to P4S -4x6']	[P1S to P2S -4x6']	[P1S -2S] OR [P30S to P31S -2S]
	A	[P30N to P33N -4x6']	[P31S to P33S -4x6']	[P32S to P33S -2S]
	M			
	J			
	J			
	A			
	S			
	O			
	N			
	D			

Maximum Pile Installation Per Day Within A Given Month

Dual Level

Year	Month	Possible Combination 1	Possible Combination 2	Possible Combination 3	Possible Combination 4
Year 1	J				
	F				
	M				
	A				
	M				
	J				
	J				
	A	[P24 -2S]+[P25 -2S]	[P24 - 2x10']+ [P25 -2x10']		
	S	[P24 -2S]+[P25 -2S]	[P24 - 2x10']+ [P25 -2x10']		
	O	[P23 -2S]+[P26 -2S]+[P24 - 2x10']+ [P25 -2x10']	[P23-3x8']+[P26-4x6']+[P24 - 2x10']+ [P25 -2x10']		
	N	[P24 - 2x10']+ [P25 -2x10']	[P23-3x8']+[P26-4x6']+[P21 to P22 -2S]+[P27 -2S]	[P23-3x8']+[P26-4x6']+ [P22-3x8']+[P27 to P28-4x6']	
	D	[P20 to P23-3x8']+[P26 to P28-4x6']+[P17 to P20 -2S]+[P28 -2S]	[P17 to P20 -2S]+[P14 -2S]+[P20 to P23-3x8']+[P26 to P28-4x6']	[P20 to P23-3x8']+[P26 to P28-4x6']+[P14 -4x4'] +[P19 to P21 -3x8']	[P14 -4x4'] +[P19 to P21 -3x8']+[P20 to P23-3x8']+[P26 to P28-4x6']
Year 2	J	[P17 -3x4']+[P14 -3x4']	[P17 -4x4']+[P14 -3x4']+[P18 to P19 -3x8']	[P17 -4x4']+[P19 -3x8']+[P28 -4x6']	
	F	[P17 -3x4']+[P14 -3x4']+[P13 -2S]			
	M	[P17 -3x4']+[P13 to P14 -3x4']+[P16 -2S]	[P17 -3x4']+[P13 to P14 -3x4']+[P13 -4x4']+[P16 -4x4']		
	A	[P16 -3x4']+[P13 -3x4']+[P12 -2S]			
	M	[P16 -3x4']+[P12 to P13 -3x4']+[P15 -2S]	[P16 -3x4']+[P12 to P13 -3x4']+[P12 -4x4']+[P15 -4x4']		
	J	[P14 to P15 -3x4']+[P12 -3x4']			
	J	[P15 -3x4']+[P12 -3x4']			
	A	[P15 -3x4']+[P12 -2x4']			
	S				
	O				
	N	[P11 -3x4']+[P7 -3x4']+[P7 -2S]+[P11 -2S]	[P11 -3x4']+[P7 -3x4']+[P7 -4x4']+[P11 -4x4']		
	D	[P11 -3x4']+[P7 -3x4']			
Year 3	J	[P11 -3x4']+[P7 -3x4']+[P6 -2S]+[P10 -2S]	[P11 -3x4']+[P7 -3x4']+[P6 -4x4']+[P10 -4x4']		
	F	[P10 -3x4']+[P6 -3x4']			
	M	[P10 -3x4']+[P6 -3x4']+[P5 -2S]+[P9 -2S]	[P10 -3x4']+[P6 -3x4']+[P5 -4x4']+[P9 -4x4']		
	A	[P9 to P10 -3x4']+[P5N to P6 -3x4']+[P4 -2S]			
	M	[P9 -3x4']+[P5N -3x4']+ [P1N to P3N -2S]+[P1N to P4N -4x6']	[P9 -3x4']+[P1N to P4N -4x6']+[P1N to P4N -4x6'] +[P8 -2S]+[P29 to P30N 2S]	[P9 -3x4']+[P29N -4x6']+[P8 -4x4']+[P29N to P30N -4x6']+[P8 -2S]+[P29 to P30N - 2S]	
	J	[P31N to P33N -2S]+[P9 -3x4']+[P30N -4x6']+[P8 -4x4']+[P31N to P33N - 4x6']	[P31N to P33N -4x6']+[P8 -3x4']+[P31N to P33N -4x6']+[P31N to P33N - 2S]		
	J	[P8 -3x4']			
	A	[P8 -3x4']			
	S				
	O				
	N				
	D				
Year 4	J				
	F				
	M				
	A				
	M				
	J				
	J				
	A				
	S				
	O				
	N				
	D				
Year 5	J	[P5S -3x4']+[P5S -2S]	[P5S -3x4']+[P5S -4x4']		
	F	[P5S -3x4']+[P2S to P4S -2S]	[P5S -3x4']+[P3S to P4S -4x6']		
	M	[P1S to P4S -4x6']+[P1S -2S] OR [P30S to P31S -2S]	[P1S to P4S -4x6']+[P1S to P2S -4x6']		
	A	[P30N to P33N -4x6']+[P32S to P33S -2S]	[P30N to P33N -4x6']+[P31S to P33S -4x6']		
	M				
	J				
	J				
	A				
	S				
	O				
	N				
	D				

Legend:

[P1] - Pier 1 (both north and south)
[P1N] - Pier 1 North (only)
[P1S] - Pier 1 South (only)
[3x4'] - Three 4 foot diameter piles
[2S] - Two Spud (temporary) piles
[Orange] - Spud (temporary) piles
[Green] - Segment 1 piles
[Blue] - Segment 2 piles
[P12 to P14] - Piers 12 to 14 (inclusive)

Example:

[P20 to P21-3x8']+[P26 to P28-4x6']+[P17 to P19 -2S]+[P28 -2S] - On a given day in the month specified, three 8 foot diameter piles at either pier 20 OR 21, as well as four 6 foot diameter piles at either pier 26 OR 27 OR 28, and two spud (temporary) piles at either pier 17 OR 18 OR 19OR 28 could possibly be installed.

Appendix E

Landing Construction Staging Drawings