HEAVY MOVABLE STRUCTURES, INC.
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Unionport Bridge Replacement Design
Twin Single Leaf Bascules

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Introduction

The current Unionport Bridge is the third in a series of movable bridges at this site, replacing an earlier swing span (circa 1870's) and double leaf bascule (circa 1915). The existing Unionport bridge is a double leaf bascule built in the 1950's over Westchester Creek, an industrial waterway in New York City. For roughly 20 years there were a pair of double leaf bascules at the site, but the northerly span was removed in the late 1960's when NYSDOT owned, elevated highways were built adjacent to both sides of the southerly span. At the time, the elevated highways diverted much of the traffic from the lower level bascule, but it continued to serve local city streets and as a connector to the Hutchinson River Parkway while traffic continued to grow. Because of this, the remaining bascule proved too vital to traffic to take it out of service for major rehabilitation and the bridge continued to deteriorate over time. Alternate replacement schemes involving temporary movable bridges and complex work phasing also were eliminated from consideration due to cost and schedule implications, constructability concerns and because the final configuration would involve numerous machinery sets confined to tight work spaces making maintenance challenging.

An innovative phasing plan was developed which allowed twin single leaf bascules to be built in two major construction stages, while maintaining traffic on the existing bridge. The new, wider roadway maximizes use of the space between the elevated structures. The single leaf bascule built in the open position, offset from and behind the existing bascule will allow traffic to continue on a skewed alignment across the existing bridge as the new span is built. The resulting twin bascules will allow one span to be taken out of service if required for future maintenance or reconstruction while providing ample room for traffic on the remaining span.

This paper describes the design refinements that have allowed this project to advance through final design and permitting and to procurement. Emphasis is given to constructability issues and overcoming the many challenges of this confined urban site. The single leaf bascule built in the open position, offset from and behind the existing bascule. The resulting twin bascules will allow one span to be taken out of service if required for future maintenance or reconstruction while providing ample room for traffic on the remaining span. The basic scheme developed at preliminary design was used but refinements were made to accelerate construction and minimize impacts to navigation. Elements of the existing piers are incorporated into the new bridge in order to minimize navigation restrictions and eliminate the need for channel realignment. Temporary fixed bridges were used to minimize traffic impacts during a key period.


Existing Unionport Bridge

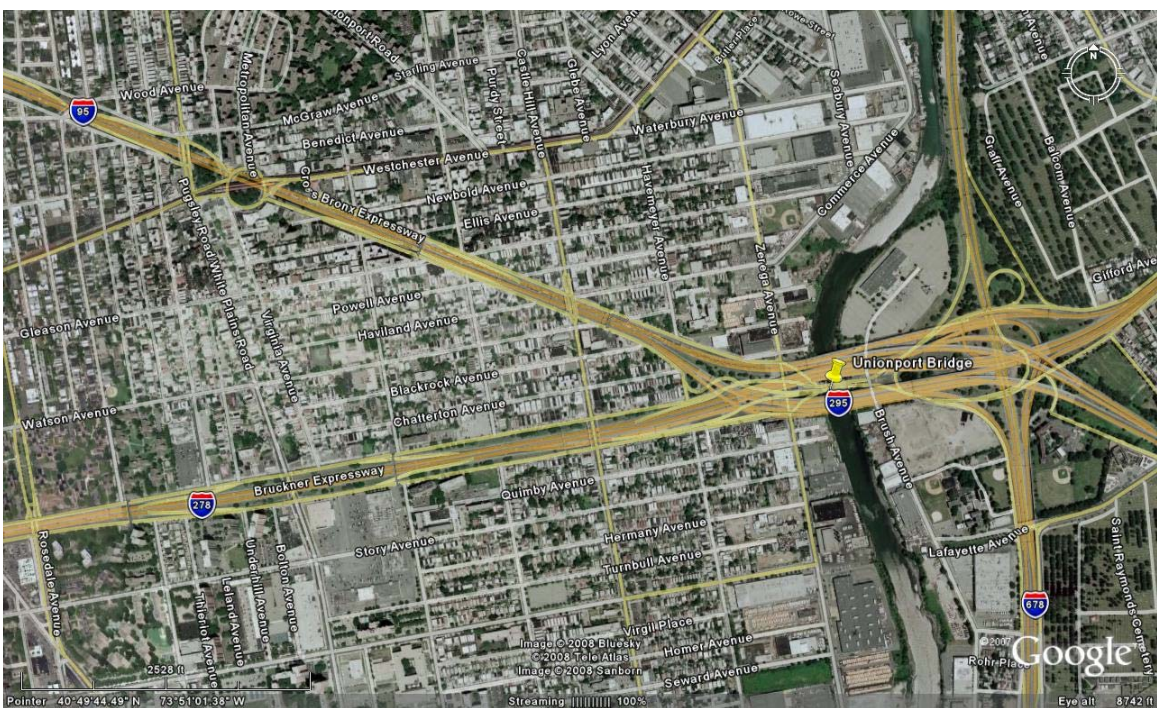
Background

Westchester Creek has been in use as an industrial waterway since the 1800's. However, there were limitations due to shallow water and shoaling prior to adopting a federal project at the waterway in the early 1900's. The Creek was originally part of Westchester County prior to the annexation of the area into New York City in 1895. Westchester County built the first bridge at the site of the current Unionport Bridge. That original bridge was a swing bridge connecting local streets. The bridge has become so important to traffic in the area that by the time the area was annexed by the City a new bridge was needed. The second generation replacement bridge was a double leaf bascule completed in 1915 in coordination with channel improvements being made by the Army Corps. This bridge was built on the prior bridge alignment while maintaining traffic on a temporary swing span built to the north. The area to the east of Westchester Creek was less developed until the completion of the Bronx Whitestone Bridge in 1939 and the associated extension of the Hutchinson River Parkway. By this time, the street passing over the Unionport Bridge had been renamed Bruckner Boulevard and had become a major thoroughfare in need of expansion.

The existing, third generation Unionport Bridge was constructed in the early 1950's following design plans created in the late 1940's. It consisted of two parallel, independently operable, double leaf trunnion bascules carrying the Bruckner Boulevard over the Westchester Creek in the Bronx. The longitudinal centerline of the north bascule leaves was 82 ft. to the north of the center line of the south bascule leaves. A portion of the bascule piers in the creek were constructed on foundations of an earlier bridge that had been built circa 1915.

Twin Double Leaf Bascules Prior to Construction of the Expressway

In 1971, the Cross Bronx and the Bruckner Expressway structures were built above the existing Bruckner Boulevard and that roadway was renamed the Bruckner Expressway Service Road. At that time the north bascule bridge superstructure and abutments were demolished to accommodate the interstate highway alignments. The approach roadways, ramp structures, and south bascule span were altered accordingly to accommodate two way traffic. The resulting condition placed a maze of elevated highways around the legacy double leaf bascule.



Project Location

In addition to maintenance over the years, several more significant repairs were made in the 1990's. Ten years later, the plan was to do a major rehabilitation of the bridge. During the development of the rehabilitation plans, it became apparent that there was no practical way to maintain traffic during the construction. Temporary movable bridges were considered to allow the rehabilitation work but there were no good locations for these temporary movable bridges due to the columns supporting the adjoining state owned interchange structures. Further, the Coast Guard was not in favor of the two temporary movable bridges in close proximity along the waterway. In spite of the efforts to keep the existing bridge in service, it became apparent that replacement would be needed and traffic would have to be maintained during replacement.

Project Development

The main span of the existing Unionport Bridge is a double leaf bascule that carries three eastbound lanes and two westbound lanes of the Bruckner Expressway Service Road vehicular traffic over the Westchester Creek. The bascule is tightly constrained and is interconnected with numerous roadways. The west approach structure connects a westbound off-ramp designated Ramp A down to grade at Zerega Avenue which connects to the Cross Bronx westbound service road directly across Zerega Avenue. The westbound service road also connects to Ramp C which consists of two westbound Bruckner Expressway Service Road lanes that subsequently cross over Zerega Avenue. Two eastbound lanes of the Bruckner Expressway Service Road originate from the eastbound Bruckner Expressway Service Road merging with the Cross Bronx service road and span over Zerega Avenue to form Ramp D and connect to the Unionport Bridge. An eastbound on-ramp from Zerega Avenue designated Ramp B also connects to the Unionport Bridge. The east approach carries two westbound lanes from the Bruckner Expressway Service Road, which receives traffic from Hutchinson River Parkway and two eastbound lanes of the Bruckner Expressway Service Road which feed traffic to the Hutchinson River Parkway and a right turn lane for Brush Avenue. Traffic on Brush Avenue has seen significant growth over recent years.

The bridge is flanked on the north and south sides by the high-level mainline structures of the Bruckner Interchange, which serves both the Bruckner and Cross Bronx Expressways. The service roads crossing over the bascule span are relied upon to connect between the Hutchinson River Parkway and the two expressways, and also provide access to and from the local community. The bridge is the only crossing of Westchester Creek readily accessible to the local residential, industrial, and commercial areas on either side of the creek.

Until 2006, NYCDOT was considering the rehabilitation of the Unionport Bridge; however ongoing deterioration caused NYCDOT to re-evaluate rehabilitation measures. The main structural members of the bascule span framing were found to be severely deteriorated. NYCDOT then considered the replacement of the bascule span starting in 2007; however, it was determined that such a replacement would require the construction of at least two temporary movable bridges to accommodate traffic - this option was determined infeasible for a variety of reasons including right of way issues, utility conflicts, navigation needs, and cost. Finally, based on a 2010 feasibility study, NYCDOT determined that the entire existing bridge, including approaches and ramps, would be replaced with a new widened bridge that would eliminate or improve nonstandard geometric features, provide a longer life-span for the bridge, and benefit the community more than a rehabilitated bridge. The widened bridge would need to be built while maintaining two lanes of traffic in each direction on the bridge and one lane of traffic on Ramps A through D, throughout the construction duration.

Once the rehabilitation alternate was eliminated from consideration, NYCDOT reassessed the project goals to better define the direction of the project. In the course of this reassessment, Hardesty & Hanover was selected to develop plans for a replacement bridge. The information collected during the project's long history was reviewed and validated. Care was taken to avoid sticking with prior decisions if they were not still valid based on current conditions. Based on this updated assessment, the project purpose and need was more clearly defined.

The primary purpose of this project is to improve the safety and serviceability of the bridge while maintaining traffic and improving traffic level of service. To this end the following scope was identified: a) Provide a new bridge with a 75 year service life, b) improve traffic and safety conditions with geometric improvements and elimination of the open grid deck, c) improve pedestrian and cyclist access, d) minimize life cycle costs by utilization of fill at the approaches in lieu of structure whenever possible, e) use twin movable spans to facilitate future maintenance of traffic during reconstruction, f) Maintain navigation in Westchester Creek by use of a new movable span with clearances matching the existing, and g) provide the following ancillary elements: control house, utilities, machinery and electrical systems, traffic control equipment, fender system and dolphins, street lighting, sign structures; and traffic signals.

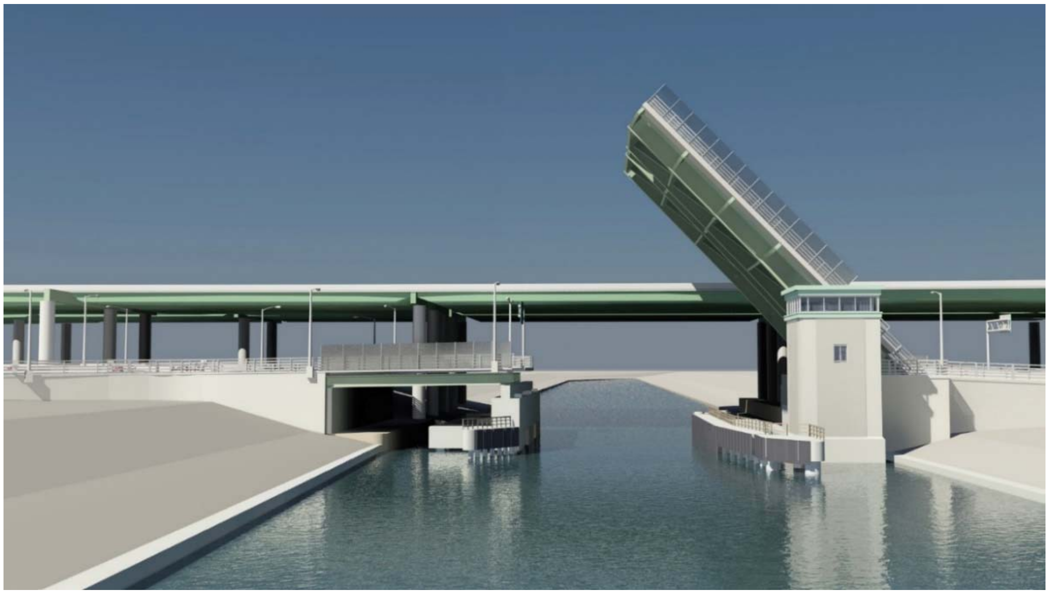
The proposed new Unionport Bridge project will include new widener bascule bridges, the addition of a bikeway, and the replacement of the associated on and off ramps. Due to overhead and lateral site constraints, other movable bridge types such as swing spans or vertical lift bridges were not deemed feasible.

A concept that was developed prior to Hardesty & Hanover's involvement in the project included the staged construction of eight bascule leaves and later joining them to form a total of four bascule leaves in a twin double leaf arrangement. The bascules were proposed to be short rolling lift spans rather than trunnion type bascules. The thought was that the new bascule piers could be built between the existing bascule piers and the adjacent shoreline and be elevated above the channel bottom. This baseline concept was reviewed and compared to other potential design solutions as discussed in the prior HMS presentation in 2014. The previously discussed baseline eight leaf concept consisted of multi-stage construction of short rolling lift spans around the existing bridge. This solution, although plausible, created a series of challenges including a tight work zone, complex maintenance of traffic, installation and span alignment concerns, and long term maintenance issues due to the tight maintenance workspaces available. Tight construction areas, including construction areas in the middle of live traffic, and a long staging process would have increased the complexity and cost of the bridge. In addition to the staging issues, the resulting bridge would have been very difficult to maintain due to the confined work spaces and large number of machinery sets and there were other issues associated with the channel hydraulic opening and an existing major box sewer outfall beneath the existing bridge. The decision to avoid these complexities and go with the alternate twin single leaf bascule concept was made at preliminary design and that design was subsequently refined during the final design phase.

Existing Unionport Bridge confined Machinery spaces

Twin Single Leaf Bascule

A twin single leaf bascule bridge will replace the Unionport Bridge and meet the project objectives. Two parallel single leaf bascule spans will be used to facilitate staged construction while maintaining the use of the existing double leaf bridge. Each single leaf bascule will be a simple trunnion bascule span with a closed pit bascule pier. The southerly bascule pier is positioned behind and offset from the existing bridge to facilitate staged construction in the open position while maintaining traffic diagonally across the existing bridge. The advantages and project challenges of this alternative are further described as below:



Twin Single Leaf Bascule

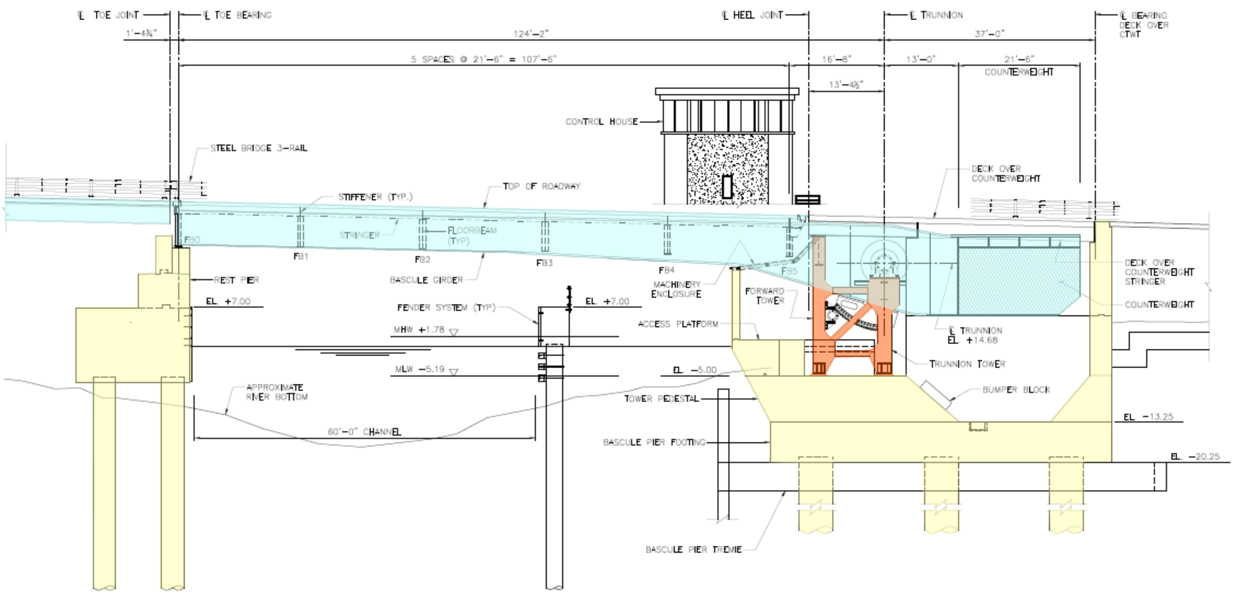
Advantages

1. Vertical and Horizontal Clearances

A single leaf bascule bridge will be designed to provide the necessary vertical clearance within the navigable channel as required by USCG. The existing Unionport Bridge is located between two parallel high level fixed bridge structures which define the vertical clearance requirements of the channel at this location. A single leaf bascule bridge will be designed with approximately 45 degrees angle of opening to provide the required 52 foot minimum vertical clearance and match the clearance afforded by the adjoining NYSDOT fixed interstate structures. Limiting the angle of opening allows for a single leaf bascule bridge with a shallower bascule pier. The depth of the bascule pier for the single leaf bridge will be comparable to that of a double leaf bascule bridge designed for the same location.

2. Bascule Span Alignment (Structural and Mechanical Components)

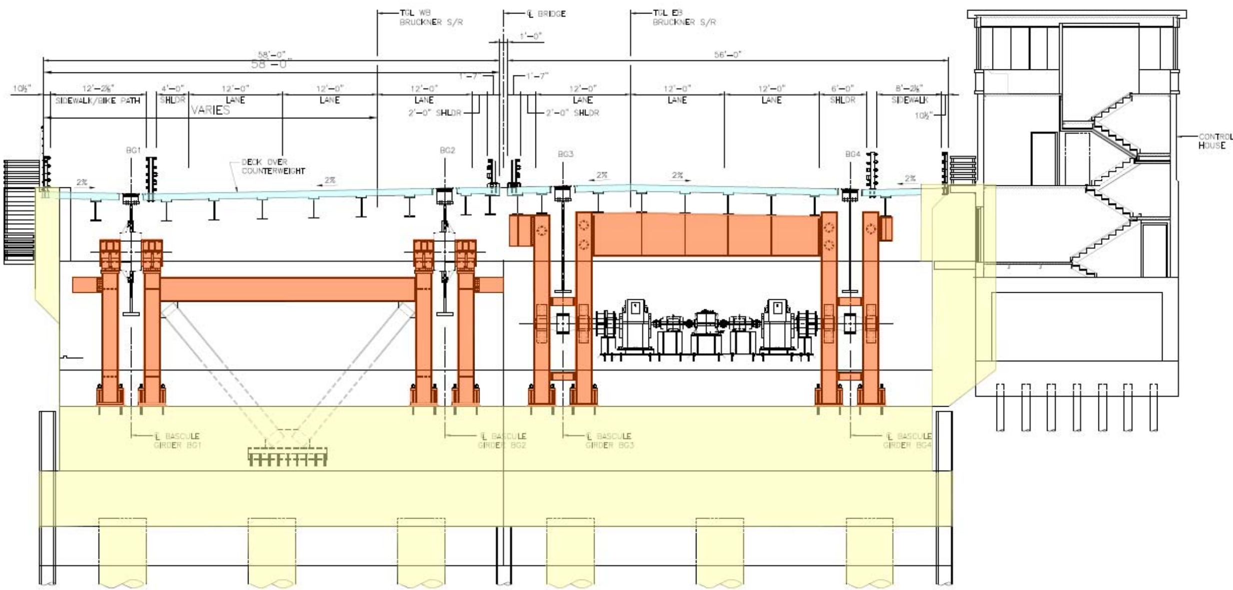
A single leaf bascule bridge requires fewer machinery alignment concerns as there are only half the number of moving components as compared to a double leaf bascule bridge. Two parallel single leaf bridges will require installation of two moving leaves, as opposed to eight leaves for a double leaf bridge previously proposed. The toe of the single leaf rests on a solid pier which reduces deflections and makes maintaining alignment easier. Span operation will be more reliable over the life of the bridge.



New Unionport Bridge Longitudinal Section

3. Machinery Access and Maintenance

The proposed single leaf bascule bridge allows for all of the bridge operating machinery to be located in one larger, centralized location on one side of the navigable channel, as compared to a double leaf bascule bridge which has machinery on both sides of the channel to operate multiple opposing leaves. Maintenance crews will only be required to work in one primary location. This also simplifies electrical connections and conduit routings and simplifies access for the Bridge Operator, since the Control/Operator’s House will be located on the same side of the channel as the machinery room.



New Unionport Bridge Cross Section (split section)

A single leaf bascule bridge is modeled and performs as a simple span under live load; lock machinery will not be required to provide live load shear transfer between the moving leaf and the fixed pier. However, lock bars will be used to function as a safety “hold down” mechanism, providing for a redundant system to ensure safety in the event of operating machinery limit switch failure.

Maintenance access will also be improved in the vicinity of the lock bar machinery for a single leaf bridge. The lock machinery will be placed on the fixed rest pier with the lock bar driven to a receiving socket on the single leaf toe floorbeam. This will allow maintenance crews to access the lock machinery from the fixed flanking span with the movable span in the opened or closed position. Access platforms will be situated outside the navigation channel with sufficient head room clearance to allow for simplified access for routine maintenance including inspection and lubrication.

Project Challenges

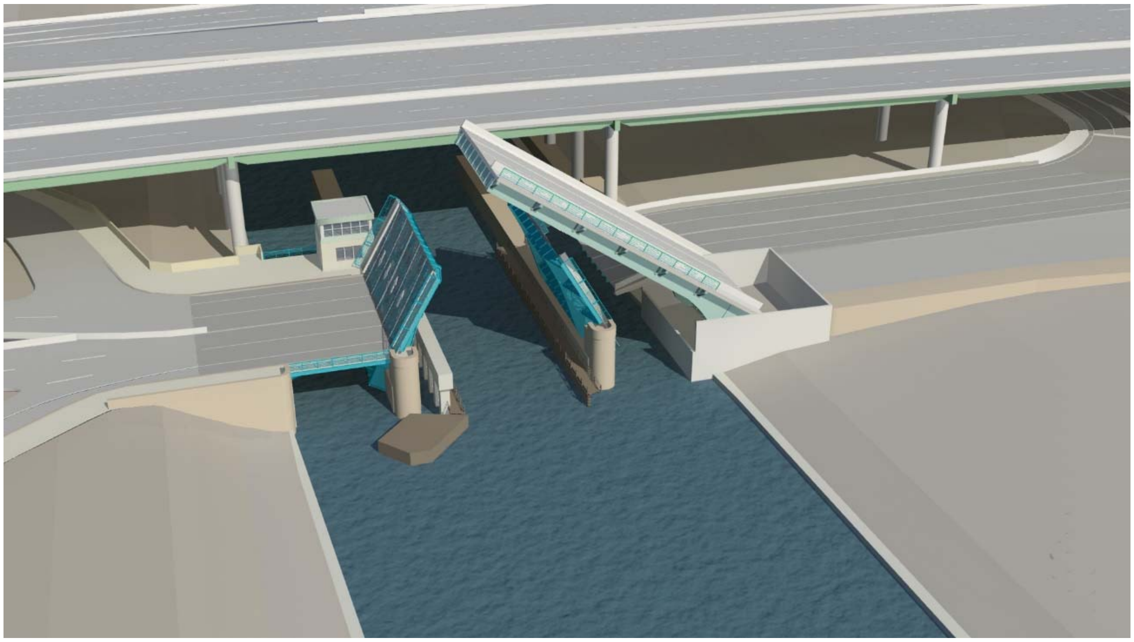
1. Structural Geometry

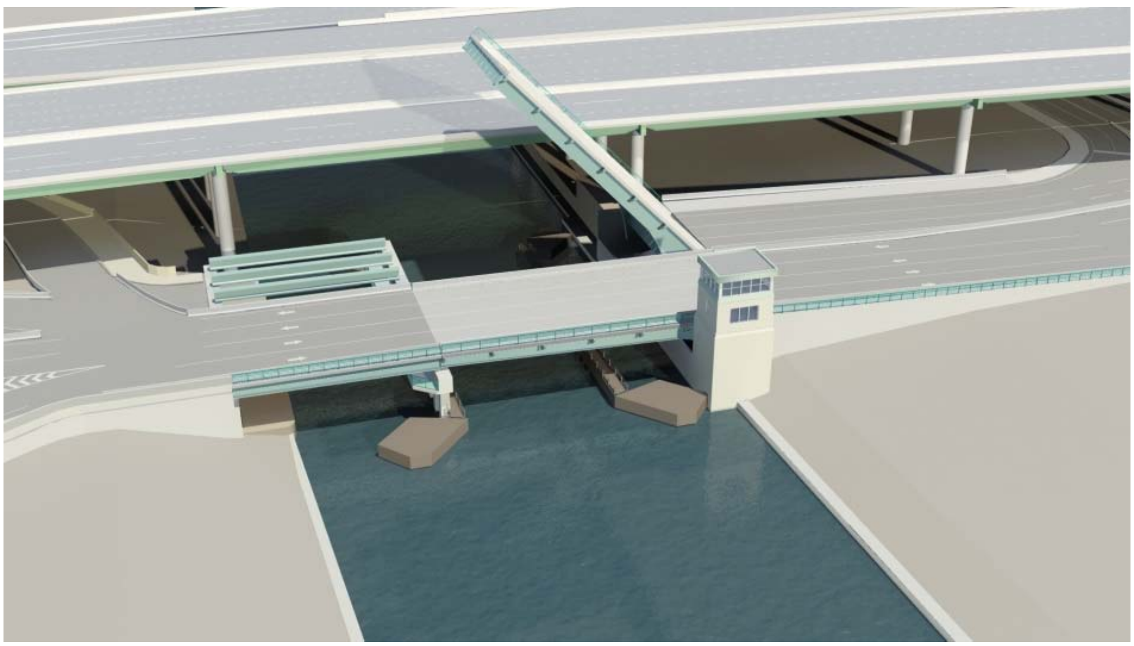
A single leaf bascule bridge requires a longer girder rear of the trunnion to balance the forward moment arm as compared to a double leaf bascule bridge crossing the same navigable channel width. Since the vertical profile of the bridge is not high enough to accommodate the longer girder while remaining above the water level, a closed pit bascule pier is required to allow for the longer girder to rotate in an enclosed area below the water level. The closed pit pier for this bridge will be located mostly on land and its size will be controlled by limiting the span opening angle and use of a smaller, higher-density counterweight including a steel box with concrete and steel as well as some selectively placed lead blocks. The close proximity to the state foundations involved challenging foundation construction including secant pile walls.

2. Staged Construction

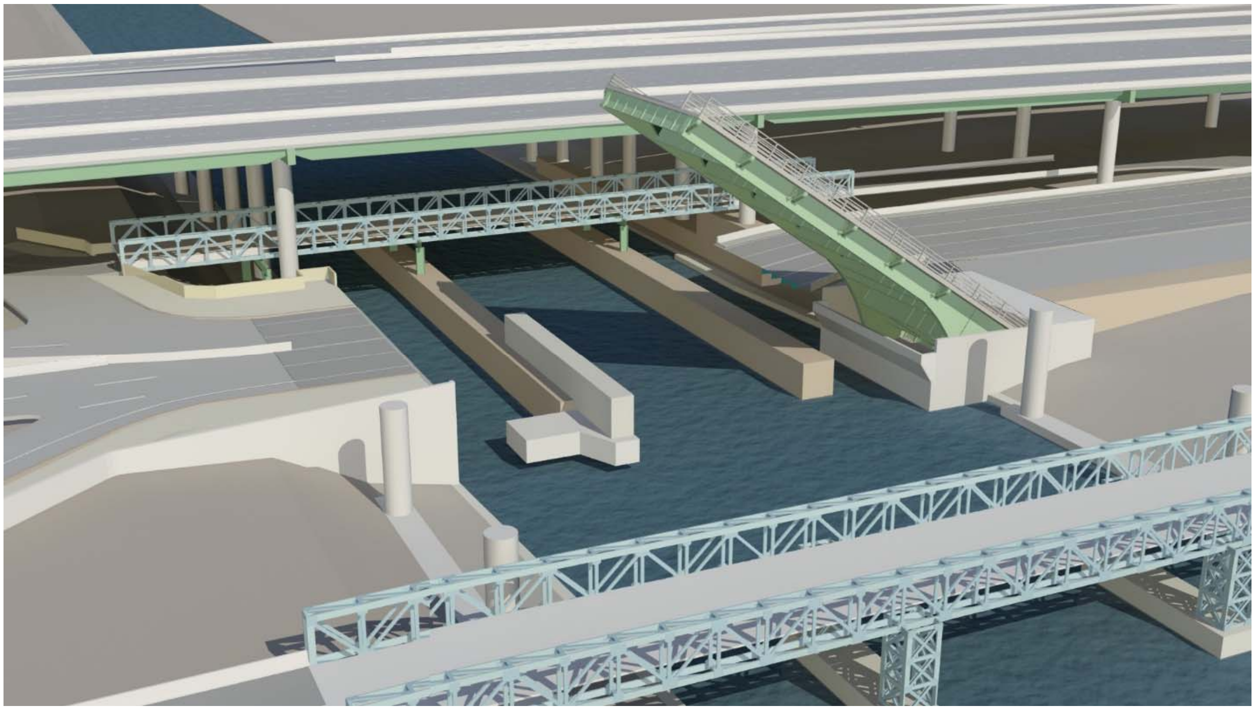
Staged construction is feasible for the twin single leaf bascule bridge alternative. Two main construction stages will occur. During the first stage traffic will remain on the existing structure and a new bascule bridge will be constructed on the south side of the existing bridge. The new south bascule leaf will be built in the open position such that marine traffic can continue to navigate along the Westchester Creek. As insufficient space exists to build a bridge capable of carrying four lanes of traffic without interfering with either the overhead state structure or the existing bridge, the new south leaf will be diagonally offset from the existing span to the greatest extent possible. Traffic will run across the existing bridge in a diagonally opposite direction. Some localized modification of the North East corner of the existing bridge is needed in order to make this happen.

The new rest pier will be built in line with the existing rest pier to provide a place for the toe of the new leaf to land. This avoids the need for any temporary narrowing of the navigation channel and eliminates channel dredging. However, incorporation of parts of the existing bascule piers into the new rest pier and east fender is necessary. A critical step in construction is the shifting of traffic from the existing to the new bridge. During a short term navigation restriction, the old movable span will be removed to make space for the new bascule to be lowered onto the rest pier and traffic to be shifted. The second stage would involve moving traffic to the newly built south bascule leaf, demolishing the remaining portions of the existing Unionport Bridge and constructing the new north bascule leaf. The duration of this critical operation is limited by the duration of the channel height restriction permitted by the USCG and roadway traffic must be maintained continuously throughout the entire project.


Phase 1 – Construct South Leaf


Phase 2 – Construct North Leaf

A constructability review concluded that the steps needed to remove the existing bridge, lower the new south leaf onto the rest pier, place the deck infill concrete and prepare the south leaf and flanking span to receive traffic would take 60 days. During this period, traffic could no longer pass over the existing bridge so temporary bridges would be needed to avoid traffic disruption. Temporary movable bridges were ruled out due to the site geometric constraints and the cost of the movable spans. However, a sixty day channel height restriction during the summer was allowed and temporary fixed bridges will be used to maintain traffic. The north temporary fixed bridge will be supported on the existing unused bascule pier and the south temporary bridge will be supported on independent foundations. This option allows for marine traffic to be undisturbed during the majority of construction. However, special care will need to be taken while constructing the new bascule leaves in the open position. The bridge will need to be tied back and supported in the open position. The grid deck will be installed while the span is open but the concrete infill will be placed concurrent with other activities after the span has been lowered.



Twin Temporary Fixed Bridges for 60-day period

3. Interim Bridge Operating Systems

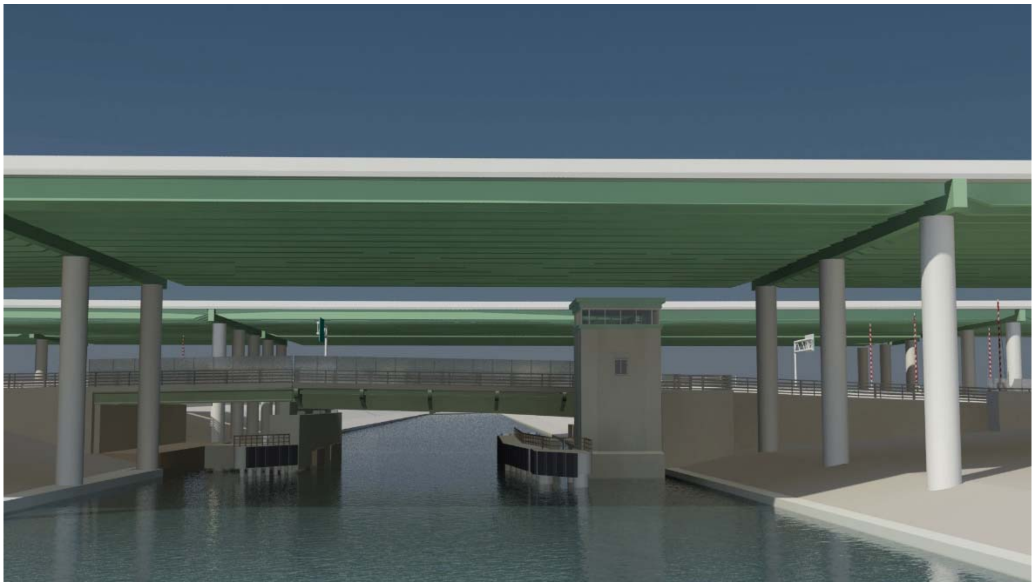
In order to minimize the time needed to commission and put the new bridge into operation, an interim bridge operating system incorporating hydraulic cylinders will be used initially. Similarly, the existing bridge will be run using an interim operating system after the old electrical system is decommissioned.

4. Cellular Abutment Replacement

The west cellular abutment is particularly problematic to replace. The roadway geometry will be changed and traffic along the four ramps crossing it must be maintained. In order to do this, a new micropile supported mat foundation will be built within the old abutment and a fill section constructed working from inside the abutment.

5. Relocation of Sewer and Outfall

The storm sewer outfall at the pier at the east bulkhead line needs to be rerouted in order for the proposed bridge to be constructed. The storm sewer is a 10 foot wide by 8.5 foot deep reinforced concrete box sewer supported on piles. The new sewer outfall will be moved such that it discharges into the Westchester Creek just north of the proposed Bascule Pier and south of the existing state footings. The staggered pier locations inherent in the single leaf bascule staging conveniently create a space for the new outfall.



Proposed Twin Single Leaf Bascule

Conclusion

The existing Unionport Bridge is in need of replacement but is confined by tight site constraints. By considering all available space, innovative staging can be used to replace the existing double leaf bascule with a new twin single leaf bascule and achieve the project goals including maintaining both marine and vehicular traffic and building a new movable span which is easy to construct and maintain. This project is scheduled to be bid for construction in late 2016 and completion in 2021.