Brooklyn-Queens Waterfront

Streetcar/Light Rail Rapid Assessment

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1.0 SUMMARY

The New York City Economic Development Corporation (NYCEDC) and the New York City Department of Transportation (NYCDOT), with assistance from a consultant team led by HDR, conducted this Brooklyn-Queens Waterfront Streetcar/Light Rail Rapid Assessment in order to evaluate the Brooklyn-Queens Connector (BQX) Technical Feasibility and Impact Study, completed in 2015 by the *Friends of the BQX* ("2015 BQX Study" or "2015 Study"). The Rapid Assessment was conducted to determine whether a new transit system could improve transportation access along the growing Brooklyn and Queens waterfront. Its findings will inform further study.

The Rapid Assessment of the 2015 BQX Study confirmed or supported the following analyses:

- A streetcar/Light Rail hybrid is the most appropriate transit intervention along this corridor
- The general alignment identified in the 2015 BQX Study, with some modifications, can support street-running rail infrastructure
- Bridges along the alignment may be capable of accommodating streetcar operations, but would require substantial modifications. Additional analysis is required to make this determination. In the event that the existing bridges cannot be used, alternatives including construction of new streetcar bridges are also available.
- Modern streetcars are the right vehicle technology for this application rather than larger light rail vehicles
- The operating and maintenance plan is reasonable
- The ridership forecasts are reasonable
- The potential to "self-finance" through value capture is reasonable

The Rapid Assessment updates some aspects of the 2015 BQX Study, including:

- Higher estimated capital and operating costs
- Fully battery-operated streetcar technology may not be suitably developed for this project's implementation timeline
- The spur to Atlantic Terminal unnecessarily complicates the operating plan and duplicates existing transit routes
- The potential need for phased implementation
- Broad review of underground utility challenges

The Rapid Assessment conceptualized a 16-mile streetcar alignment with a total capital cost estimated at $2.5 billion (in current dollars) and a $31.5 million annual operations and maintenance budget. The streetcar line would serve 45,000-50,000 daily riders resulting in over $26 million in annual fare revenues. The $2.5 billion cost was determined to be reasonably covered through value creation and capture. The overall conclusion of the Rapid Assessment is that the 2015 BQX Study's methodologies and conclusions were reasonable and provide a starting point for the development of a detailed plan for a streetcar-based transit system to support this dynamic section of the City. All aspects of this project require detailed further study.

1.1 Study Background

Brooklyn and Queens have been transformed by new investment and development in recent years, nowhere more dramatically than in East River waterfront neighborhoods close to Manhattan. With the exception of the recently announced expansion of Citywide Ferry Service, the transportation network connecting these neighborhoods to each other and to the rest of the city has not received a similar level of attention. As these areas continue to grow, it will be increasingly important to meet the needs of workers and residents taking transit between Brooklyn and Queens and connecting to the rest of the city without having to rely on crowded, Manhattan-centric transit lines. Current bus routes do not provide comprehensive service along this north-south corridor, and subway lines are some distance inland from many growing areas. Population and employment growth is expected to continue in this corridor in the years ahead, further intensifying the need for improved transit access.

This study investigates the feasibility of a modern streetcar/light rail transit (LRT) to serve the Brooklyn-Queens waterfront, connecting Astoria, Ravenswood, Long Island City, Greenpoint, Williamsburg, the Brooklyn Navy Yard, DUMBO, Downtown Brooklyn, Red Hook and Sunset Park. Preliminary analysis of this corridor was undertaken in the 2015 Study. This study will further refine and assess performance of route options by investigating issues including potential "fatal flaws," typical and proposed propulsion technologies, major traffic issues, bridge crossing infrastructure needs, and utility relocation, among others. The ultimate purpose of this effort is to further understand the feasibility of streetcar/LRT service on New York City's streets, while providing a foundation for additional project development, design and construction.

1.2 BQX Proposal: 2015 Study

The Friends of the Brooklyn-Queens Connector, Inc. ("Friends of the BQX" or "The Friends") is a registered 501(c)3 non-profit that seeks to create connectivity and generate economic development along the East River waterfront corridor between Sunset Park and Astoria through the implementation of a modern streetcar system. This Rapid Assessment reviews the 17-mile Brooklyn-Queens streetcar line conceptualized in the 2015 Study. The 2015 Study recommended a streetcar system over other technologies such as bus rapid transit or higher capacity light rail. A conceptual alignment was developed in the 2015 Study and can be found in Figure 1-1.

The system would include a transfer in DUMBO to a two-mile spur terminating in Downtown Brooklyn. The Downtown Brooklyn spur would operate with a timed transfer in DUMBO. Trains operating on the spur would be scheduled to meet trains operating on the waterfront mainline.

Figure 1-1: Friends of the BQX Alignment

The 2015 Study recommended approximately 30 stops spaced at roughly half-mile intervals, operating 24 hours a day with peak period service at five-minute headways. The service would operate in exclusive lanes for approximately 70% of its length. On the remainder of the corridor, the BQX would share the road with cars, and would receive priority treatments such as expedited traffic signals in order to maintain system reliability. The system would provide intermodal connections to 8 ferry landings, 37 bus routes, 17 subway lines, and 116 CitiBike stations.

The 2015 Study recommended streetcars operating on tracks flush with the existing roadway with traction power provided by emissions-free hydrogen fuel cells and/or on-board batteries that enable it to serve the entire corridor without overhead catenary wires. The system would cross two navigable waterways, the Gowanus Canal and Newtown Creek, requiring the existing structures to be retrofitted or new purpose built bridges to be constructed.

The 2015 Study proposed the use of streetcars that would be approximately 80 feet long and have the capacity for 150 passengers and on-board bicycles. All vehicles and stations would be American with Disabilities Act- (ADA) compliant for riders with disabilities. The BQX would feature real-time geo-locating so that arrival and location information would be available on smart phones and other personal devices. Riders would also have access to Wi-Fi.

The 2015 Study projected ridership by assuming a certain share of bus ridership in the existing corridor would be captured by the BQX. Some additional ridershipwould be induced. The 2015 Study projected ridership of between 27,500 and 29,000 in 2020 and between 49,400 and 52,000 in 2035.

The Friends proposed that the construction of the system be funded through a value capture mechanism.

1.3 Outline of this Rapid Assessment Report

This Rapid Assessment reviews the 2015 Study, specifically addressing the proposed transit alignment, streetcar vehicle technologies and facilities, key infrastructure and construction factors, transportation and environmental impacts, costs, ridership, and economic development/value capture benefits.

2.0 ALIGNMENT ASSESSMENT

In addition to concerns about the operational viability of the proposed Downtown Brooklyn spur, this rapid assessment found conflicts that would potentially shift the 2015 BQX alignment to nearby streets. The overall objective of using streetcar/LRT to connect waterfront neighborhoods is affirmed in this assessment, but the issues discussed in the rest of this report point to a thorough alignment alternatives screening to maximize transit benefit, to take place as part of a future in-depth planning effort. The Rapid Assessment does not review a spur to Atlantic Terminal because it would unnecessarily complicate the operating plan and duplicate existing traffic routes.

2.1 Right-of-Way Type (Exclusive, SBS Type, Shared)

The Rapid Assessment reviewed available traffic data and design concepts presented in the 2015 Study, Brooklyn Streetcar Feasibility Study (URS), and New York City Department of Transportation’s (NYCDOT’s) Traffic Information Management System (TIMS) and Traffic Safety Viewer Database.

Subsequent to the review of available traffic data and design concepts, field visits were conducted of the 2015 Study corridor. The field visit also observed parking maneuvers, freight activity, pedestrian activity, bike lanes, and other potential “fatal flaw” activities. Potential critical hotspots or locations were identified and critical locations identified in the 2015 Study were verified.

2.2 Parking and Traffic Operational Impacts

Traffic feasibility factors were assessed and potential impacts of the alignment were identified, and are described in this section.

2.2.1 Parking

On-street parking may be reduced at points along the alignment. Future detailed planning work, including street design and potential off-street parking, will determine the best options for mitigation. Parking assessments will be made with respect to usage, space and other on-street activity such as bike lanes, sanitation services, and loading and delivery.

2.2.2 Street Operations

The streetcar/LRT is proposed to operate on a dedicated lane and right-of-way to provide reliable service. In order to accommodate the dedicated streetcar/LRT lane, traffic elements such as parking and roadway capacity would potentially have to be altered along the proposed corridor. Operational changes may be experienced along the new alignment and the adjacent streets. Considerable lane reductions will be necessary on many streets to accommodate dedicated right-of-way for the streetcar/LRT. Traffic may potentially be diverted to adjacent streets. The potential diversions will be subsequently assessed.

2.2.3 Bicycle Activity

Existing bicycle lanes along the study corridor include both dedicated bike lanes and sharrows, and are assumed to be maintained along the alignment or shifted in the street layout to accommodate streetcar/LRT lanes.

2.2.4 Truck Routes

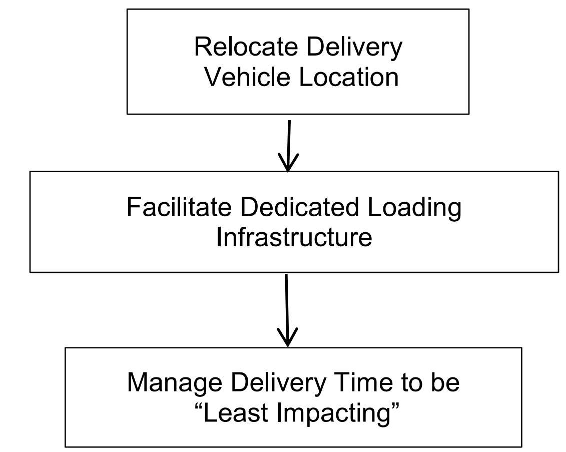
It is not expected that the alignment, in itself, will require any changes to the truck route network designation. However, challenges such as street width restrictions that limit truck access or a requirement to divert truck traffic volume away from the alignment may require a change to the truck route network. Further analysis will be conducted.

2.2.5 Loading, Delivery and Servicing

Where the alignment reduces the capacity for trucks to load/unload, be it where a streetcar/LRT lane runs against a curb or the parking lane is converted to a travel lane, loading and delivery activity must be coordinated. The BQX is expected to reduce capacity at the curb for trucks and vans engaged in delivery and service in specific locations. The extent and scale of this impact largely depends upon the type of delivery required. For some deliveries, the truck or van can be parked away from the delivery location and the goods walked to the building, while this is not possible for other areas because the vehicle has to be parked close to the final delivery point

Figure 2-1 identifies a hierarchy of solutions to facilitate the different delivery types along the BQX corridor. The first is to relocate the delivery vehicle to another location, and for most deliveries this is expected to be a suitable solution. However, relocation places more loading demand on side streets, which may not have suitable large truck geometric access or sufficient curb space. Changes to the curbside regulations in these locations may also be necessary to ensure suitable space is available. These regulations may only allow vehicles engaged in loading activity to park at these locations rather than allow access by vehicle type such as commercial vehicles, because some commercial vehicles are not engaged in loading activity, including food vans, ice cream vans and maintenance vehicles. It may also be necessary to introduce regulations associated with the dwell time of vehicles to ensure vehicle turnover.

Figure 2-1: Facilitation of Different Delivery Types



If loading activity cannot be displaced, or there is sufficient sidewalk space, some space could be reallocated for loading. This may be shared space, where the loading facility is incorporated into the sidewalk. Consideration needs to be given to this type of facility, but such facilities work where there is a balance between pedestrian and delivery vehicle volumes. Strength of the sidewalk surface and utilities structures must also be investigated.

Where delivery vehicles cannot be displaced or loading infrastructure cannot be installed, the only other component of the delivery process that can be influenced is the delivery time. Strategies such as permits and off-hour delivery solutions maybe appropriate.

2.2.6 Accessibility

There are particular facilities such as schools, fire stations, a New York City Department of Sanitation (DSNY) Marine Transfer Station (MTS), gas stations, hospitals and industrial locations along the alignment that require a more in depth review to determine how vehicle access to those premises will be maintained.

2.2.7 Safety

The NYCDOT Traffic Safety Data Viewer was used to examine the area along the corridor. The data includes both crash type and injury severity. The most recent 5-year data set was downloaded (2010-2014). 59 locations were evaluated along the alignment.

A high crash location is defined by the City Environmental Quality Review (CEQR) Technical Manual screening criterion of 48 or more reportable or non-reportable incidents or 5+ pedestrian/bicycle injury crashes in any consecutive 12 months of the most recent 3-year data. Two locations along the proposed alignment meet this criterion.

2.2.8 Next Steps

Additional screening for parking and traffic impacts for the proposed alignment will be conducted, including a detailed parking analysis along the study corridor and a detailed traffic analysis for critical intersections along the proposed alignment. Detailed analyses and clarifications for the following issues will be undertaken:

- Parking
  - Quantitative analysis of parking changes along the proposed alignments for each roadway
  - Further contextualization of changes to parking by parking type (metered, commercial loading, etc.)
  - Identification of potential parking mitigations, including additional parking on adjacent streets
- Traffic
  - Review of Environmental Impact Statements in the area including previous traffic analysis
  - Update of past analysis at critical locations along the proposed alignment
  - Qualitative review of feasibility of each roadway segment
  - Qualitative review of impacts on transportation access to all major facilities along the route
- Freight
  - Identification of critical roadways along the proposed alignment
  - Identification of strategies to avoid, minimize, mitigate, eliminate, or reduce impacts to freight systems
- Other
  - Evaluation and map of bike lane network in relation to alignment development
  - Review of impacts on school bus and paratransit (Access-A-Ride) services
  - Review of impacts on neighborhood activities and character
  - Consideration of an alternative lane for loading/unloading, construction, and other roadside activities
  - Review of impacts associated with trash collections, fuel and other heavy curb-side deliveries along the proposed alignment

2.3 Track Location and Geometry

The proposed transit route defined in the 2015 Study was reviewed for high-level geometric challenges. Several locations along the proposed transit corridor have geometric challenges related to the turning radii and the potential for the alignment to clip corners. Possible solutions include changing the route such that it would minimize turns, introducing an alignment bulb out that would provide a greater sweep angle for a 90-degree turn, or placing the alignment in a left turn lane where a streetcar can turn right with a transit-only signal phase. The minimum turning radius for a 60- to 66-foot-long streetcar vehicle is 66 feet. The minimum turning radius for a 90-foot or greater light rail transit (LRT) vehicle is 82 feet.

2.4 Transit Operations (Schedule, Travel Time, Fleet Size, Transfer)

2.4.1 Proposed Travel Times

Travel operation evaluations indicated that the shuttle alignment in Downtown Brooklyn should be eliminated, reducing the overall travel length of the Streetcar/LRT alignment. Eliminating the Downtown Brooklyn shuttle results in fewer route miles, less overall transit vehicle travel time and ultimately lower operating requirements (i.e., service hours and miles, peak and fleet vehicles) and operating costs.

Northbound and southbound travel time estimates were developed assuming similar station locations and vehicle speeds/performance characteristics as those used in the 2015 BQX Study.

2.4.2 Travel Time Calculations

Overall Rapid Assessment streetcar travel times are very similar to those developed under the 2015 BQX Study.

The following assumptions were applied:

- A minimum dwell time of 20 seconds at all stations, assuming off-board fare collection
- A minimum of 10 minutes of recovery time is required at each end of the alignment to ensure consistent, high-quality service and system reliability
- A maximum operation speed of 30 mph

Northbound travel speeds average 10.5 mph with an end-to-end travel time of approximately 81 minutes for weekday peak periods. Southbound travel speeds average 10.6 mph with an end-to-end travel time of approximately 82 minutes for weekday peak periods. Recovery time and cycle time assumptions are described below under the Service Levels section. Table 2-1 identifies assumed travel times for weekday peak and off-peak, Saturdays and Sundays.

Table 2-1: Projected Travel Times by Day and Time Period

Day and Time Period	One-Way Travel Time (min)	Average Speed (mph)
Weekday Peak (7–10 am, 3–6 p.m.)	82	10.6
Weekday Off-Peak (10 am–3 p.m.)	79	10.7
Weekday Off-Peak (5–7 a.m., 6–10 p.m.)	74	11.5
Nights (10 p.m.–5 a.m.)	66	12.9
Saturday Peak (10 a.m.–5 p.m.)	79	10.7
Saturday Off-Peak (5 a.m.–10 a.m., 5pm–10 p.m.); Sunday	72	11.8

2.4.3 Service Levels

Consistent with previous analysis assumptions, preliminary service levels by time period are defined below in

Table **2-2** for the purposes of project evaluation. Service frequencies, time periods, and hours of service will need to be adjusted once ridership demand is determined under refined travel demand estimation.

Table 2-2: Table 2: Streetcar Service Periods and Frequencies

Time Period	Hours	Service Frequency (min)
WEEKDAY		
00:00-05:00	5	20
05:00-07:00	2	10
07:00-10:00	3	5
10:00-15:00	5	10
15:00-19:00	4	5
19:00-22:00	3	10
22:00-24:00	2	15
SATURDAY		
00:00-02:00	2	15
02:00-06:00	4	20
06:00-08:00	2	15
08:00-11:00	3	10
11:00-18:00	7	6
18:00-22:00	4	10
22:00-24:00	2	12
SUNDAY & HOLIDAYS		
00:00-02:00	2	12
02:00-04:00	2	15
04:00-07:00	3	20
07:00-10:00	3	15
10:00-12:00	2	12
12:00-19:00	7	10
19:00-22:00	3	12
22:00-24:00	2	15

2.4.4 Operating Plan Requirements

Operating requirements include daily and annual revenue miles and hours of service, vehicles required during peak service and total vehicles in the fleet. BQX operating requirements have been estimated using the travel time estimates and levels of service defined above.

Table 2-3 provides a summary of daily and annual operating requirements per day of the week. Future adjustments in alignment and service levels will result in changes to these estimates. Peak vehicles assume one-car streetcars. Once travel demand results are refined, peak vehicle sizing will be determined and overall Streetcar/LRT vehicle requirements will need to be adjusted.

Table 2-3: Daily and Annual Operating Requirements

Day	Daily Revenue Miles	Daily Revenue Hours	Annual Revenue Miles	Annual Revenue Hours	Peak Vehicles	Fleet Vehicles
Weekday	4,785	514	1,220,100	131,070	39	47
Saturday	3,323	326	172,800	16,950		
Sunday	1,633	156	94,700	9,050		
Annual Totals			1,487,600	157,070	39	47

Table 2-4: Estimated Travel Time Savings

Route	Current Travel Time	Current Transit	New Travel Time	Time Savings (mins)
Astoria - Williamsburg	61	N/L	27	34
Queensbridge - Navy Yard	59	F, B62, B57	27	32
Greenpoint/Williamsburg	51	B62	27	24
DUMBO - Red Hook	48	B61, F	20	28
LIC - Red Hook	67	G, B57	50	17
LIC - Downtown Brooklyn	50	Q39, G, B41	40	10
Navy Yard - Downtown Brooklyn	30	B62, R	20	10
Navy Yard - Red Hook	67	B62, B61	52	15

2.5 Environmental Challenges

The 2015 Study conceptual corridor was reviewed at a high level for potential environmental regulatory requirements.

The environmental considerations identified in the 2015 Study included potential environmental regulatory processes, limited environmental concerns, and potential permitting actions required by City and state agencies. The study assumed that a CEQR Environmental Impact Statement (EIS) and a Uniform Land Use Procedure (ULURP) review process would be necessary. The study also identified the need for potential permitting with NYCDEP, NYSDEC, NYSDOT, NYCDOT, NYCDOB and NYCDPR. Facility and station stop designs will likely require consultation with the Landmarks Preservation Commission and the State Historic Preservation Office.

Based on a preliminary review of the project corridor, multiple transportation corridor constraints and environmentally sensitive areas should be considered in the planning process of the alignment, station and maintenance facility locations. At this stage in project evaluation, the key environmental considerations include, but are not limited to, the following:

- Federal Emergency Management Agency (FEMA) 100-year flood zone areas. Portions of the alignment are within 100-year flood zone. Avoidance and flood protection measures should be considered in these areas. The flood zone areas of the alignment and potential storage yards are located in the following neighborhoods: Old Astoria, Hunters Point, Newtown Creek, Greenpoint, Williamsburg, Brooklyn Navy Yard, Red Hook, and Sunset Park West.

- Potential hazardous materials disturbances within potential foundation work at bridges, yards, station stops and facilities. In particular, the alignment passes through a minimum of two Superfund sites: the Gowanus Expressway/Hamilton Avenue Bridge over the Gowanus Canal and the Pulaski Bridge over Newtown Creek. Highly contaminated sites may require significant remediation measures, if ground disturbance is necessary.

In addition to flooding, the New York City Office of Emergency Management designated Hurricane Evacuation Zones also consider wind loading, safety and other factors. Subsequent analysis will address these issues.

2.6 Utility Issues

Surface and subsurface utility conflicts can affect a route's alignment, and will generally require utility relocation along the final alignment to enable future access. While local utility lines and their services will be encountered, the Rapid Assessment focused on the following large capacity utility lines that are difficult to relocate and may potentially conflict with the proposed route, such as:

- Trunk water mains
- Combined sewers
- Interceptor sewers
- Gas transmission mains
- Underground electric transmission cables

The 2015 Study addressed utility conflicts in a broad generalization, estimating relocations would be $25M per mile of streetcar track (based on previous case studies). No utility mapping was investigated, and no inventory or analysis of affected utilities was performed.

2.6.1 Utility Assessment

The Rapid Assessment reviewed water and sewer mapping from NYCDEP and completed a preliminary assessment of the existing water and sewer conflicts along the proposed alignment. A full topographic and utility survey of the proposed alignment (and any possible alternate route) would be the ideal baseline information on which to perform this assessment, but is outside of the scope of this Rapid Assessment. The assessment in this report is augmented with reasonable assumptions based on information from prior experience in the corridor area, information from the 2015 BQX Study, and publicly available resources.

2.6.1.1 Water/Sewer

The Rapid Assessment assumes that streetcar tracks cannot be built immediately above the length of any sewer or water main along with assumptions regarding the required track and utility clearances. Given that the streetcar alignment runs generally along the Brooklyn and Queens waterfront, that large diameter combined sewers, combined sewer overflows and outfalls to the East River, and large/deep interceptor sewers may also run along or near the same alignment. This was confirmed upon review of the utility mapping provided by NYCDEP. These utilities were analyzed to determine whether a specific alignment might be problematic based on the size of the utility, the width of the right of way, and the presence of additional adjacent water mains and sewers in the same alignment.

2.6.1.2 Gas/Electrical Transmission

Utility mapping and coordination meetings with Con Edison and National Grid to determine the future layout of their existing gas and electrical transmission lines should be undertaken as part of a detailed planning exercise. As the 2015 BQX study alignment passes adjacent to the Ravenswood power plant, it is reasonable to expect to encounter utilities in the streets surrounding the plant as well as a network diverging away from the plant.

2.6.2 Conclusions and Recommendations

This study classifies and sewer utility conflicts under three categories:

- Case #1 – Typical Conflicts
- Case #2 – Moderate Conflicts
- Case #3 – Major Conflicts

<u>Typical conflicts</u> are characterized as having sparse and/or relatively small water and sewer utilities that can be relocated or reconstructed with a typical amount of design effort and construction cost. These scenarios usually have adequate space for rerouting either on the roadway or between the utilities such that track geometry and clearance is not expected to be an issue.

<u>Moderate conflicts</u> involve persistent utility crossings throughout the length of alignment. Conditions usually involve sewer utilities that might be difficult to relocate due to their relatively large size, proximity to other numerous utilities, or a relatively narrow roadway width.

<u>Major conflicts</u> involve crossings of water and sewer utilities that are extremely large in diameter, a high density of utilities, and inadequate roadway width for alternate routing of utilities. This means that accommodating both the required track and utility clearances would be difficult, costly, or infeasible and would require alignment adjustment.

The Rapid Assessment observed 70% typical, 20% moderate, and 10% major water and sewer utility conflicts along the proposed 2015 BQX alignment.

2.6.3 Further Study

Future analysis will refine our water and sewer utility analysis by coordinating closely with NYCDEP, and assessing costs and schedule impacts for the required improvements.

In addition, a detailed analysis of ConEd and National Grid gas and electrical transmission lines will be undertaken. Cost and schedule impacts for any required improvements will be quantified. Traction power requirements will be coordinated with ConEd to determine if adequate grid capacity exists where needed. Spacing and siting for traction power substations will be investigated and vetted with ConEd and City agencies. Lastly, future planning will review data derived from telecom companies (Verizon, Time Warner, Cablevision), NYCDOT (street lighting and traffic signals), and NYCT (coordination for street “railroad” ducts, and coordination of potential shallow cover conditions at subway crossings).

2.7 Bridges

This Rapid Assessment for the Brooklyn-Queens Waterfront streetcar/LRT project evaluated two movable bridge structures along the alignment: the Hamilton Avenue Bridge and the Pulaski Bridge. The Rapid Assessment performed analysis into possible fatal flaws in the alignment concerning these structures. The bridge structure components, mechanical systems and electrical systems were investigated. Extensive analysis of the bridge structures and necessary retrofits would be needed to fully understand structural feasibility.

2.7.1 Structural Findings

The Rapid Assessment reviewed the bridge maintenance reports and performed a field visit on January 7, 2016, in an effort to discover possible fatal flaws that would prevent the modification of the existing bridges to accommodate the proposed streetcar/LRT. A summary of the bridge conditions and proposed changes that require further study are included herein.

2.7.1.1 Hamilton Avenue Bridge

The Hamilton Avenue Bridge over the Gowanus Canal was originally constructed in 1942 and reconstructed in 2007–2009. The bridge consists of two single leaf bascule spans, one leaf for each direction of travel. The bridge carries four lanes of traffic in each direction, and is located below Interstate I-278, the Gowanus Expressway. The bridge is a unique skewed structure known as knee-girder bascule or Hanover Bascule Bridge.

REQUIRED CHANGES FOR ADDITION OF STREETCAR/LIGHT RAIL

In order to accommodate the proposed streetcar/LRT, the following modifications to the bridge would be required:

- The far right lane of each direction of travel would become a dedicated or shared use Streetcar/LRT lane.
- At least two existing stringers would be removed and one modified on both bascule spans to accommodate the new deck
- Initial assumptions include the usage of 115-pound/yard rail for the running rail contained within a reinforced lightweight concrete deck with a thickness of 9.5 inches. Miter rails would be required at the heel and toe of the bascule deck.
- The light rail train would be supported preliminarily by W16x57 stringers, which combined with the proposed concrete deck creates a deeper floor system than the existing. These stringers would need to be tied into the floorbeam webs as opposed to resting atop the floorbeams.
- The bolster at the right curbline on the east bascule span would be modified to incorporate the new concrete deck being installed at that location.

2.7.1.2 Pulaski Bridge

The Pulaski Bridge carries McGuinness Boulevard over the Newton Creek and was opened in 1954, with a major reconstruction in 1994. The bridge consists of two double leaf bascule bridges, one bridge for each direction of travel. The bridge originally carried three lanes of traffic in each direction. Recently, the right lane on the southbound side of the bridge was converted to a multi-use pathway.

REQUIRED CHANGES FOR ADDITION OF STREETCAR/LRT

In order to accommodate the proposed Streetcar/LRT, the following modifications to the bridge would be required, which need further evaluation to determine feasibility

Northbound (Queens Bound) Structure:

- The far right lane of travel will become a dedicated streetcar/LRT lane.
- At least two existing stringers will be removed and two existing stringers will be modified on both bascule leafs to accommodate the new deck.
- The light rail train will be supported preliminarily by W18x86 stringers. These stringers will be attached atop the floor beams.
- Initial assumptions include the usage of 115-pound/yard rail for the running rail contained within a reinforced lightweight concrete deck with a thickness of 9.5 inches. Miter rails will be required at the heel and toe of the bascule deck
- Since the bridge is currently a closed deck, there will be minimal changes to the wind loading affecting the trunnions in the span open position.

Southbound (Brooklyn Bound) Structure:

- The far right lane of travel will become a multi-use path.
- The center lane will become with a shared use Light Rail lane.

- At least two existing stringers will be removed and two existing stringers will be modified on both bascule leafs to accommodate the new deck.
- The light rail train will be supported preliminarily by W18x86 stringers. These stringers will be attached atop the floorbeams, as is currently laid out.
- Initial assumptions include the usage of 115-pound/yard rail for the running rail contained within a reinforced lightweight concrete deck with a thickness of 9.5 inches. Miter rails will be required at the heel and toe of the bascule decks.
- Since the bridge is currently a closed deck, there will be no changes to the wind loading affecting the trunnions in the span open position.

2.7.2 Mechanical Findings

An expedited mechanical system check was conducted at the Pulaski and Hamilton Avenue Bridges. The purpose of this effort was to assess the feasibility of installing a light rail system on existing bridge structures. Overall, there are some design related challenges that require deeper analysis. Pertinent findings as well as discussion of possible design and construction issues are included herein.

2.7.2.1 Mechanical System Issues

There were several conditions that needed to be assessed in order to determine if issues could arise in the execution of this project. The following is a list of these conditions and a brief description of the associated concern:

- Operating Machinery Condition:
    - Check if the general wear on existing machinery is heavy enough to reduce the operating capacity well below designed values.
    - Check if the existing machinery was sized conservatively enough to continue to function with increased loads introduced by installing a Streetcar/LRT system (further analysis needed).
- Machinery Room Size and Access:
    - Check if there is sufficient access to the machinery room to install new equipment.
    - Check if there is additional space for increases to equipment size.
- Span Locks:
    - Check their general wear condition. When excess wear is present at the guide and the sockets the leaves can shift relative to each other under load and this would be very undesirable for rail traffic.
    - Check if the system as designed can provide the reliable continuous surface required for rail traffic.
- Counterweight:
    - Check the material and amount of counterweight blocks at each leaf to determine if there is room for adjustment if need be as weight may be added or subtracted from the span.
- Trunnion:
    - Assess the difficulty of trunnion replacement if increasing dead or live load requires it.
- Deck:
    - Design guidelines require the application of a load factor to operating resistances for wind based on whether or not the deck is filled or open grid. Assess the increase in operating loads due to the use of a partially filled deck vs. an open deck.

2.7.3 Electrical Findings

An electrical system inspection was performed during the Rapid Assessment. This inspection included an overview of the existing electrical systems at the Pulaski Bridge over Newtown Creek and Hamilton Avenue Bridge over the Gowanus Canal. No fatal flaw was evident on the electrical system. While no specific fatal flaw was identified, modifications to the existing bridge electrical system would be required for the addition to accommodate a Streetcar/LRT system.

The determinations of the Rapid Assessment electrical inspection have been broken down into two separate sections, one per bridge. The existing conditions, as well as possible design modifications are included under each bridge section.

2.7.3.1 Pulaski Bridge Over Newtown Creek

The necessary modification to the bridge electrical system includes the following:

1) Addition of rail traffic signal and integration into the bridge control system. A new traffic signal should be installed alongside the existing vehicular traffic signal. The rail traffic signal should be operated by the operator from the control desk, similar to the existing vehicular traffic control signal. The new rail traffic signal should be interlocked with the bridge control system to ensure that a safe order is followed prior to raising the span or allowing rail traffic to travel across the span.
2) Modification to the bridge control system to include rail signal interlocking: Miter rail systems may need to be added to the toe and heels of the bridge. Miter rails are a tapered rail that meshes with the rails on either side of a joint. Due to the way that these rails slide past each other, if a piece of the rail becomes dislodged, the rails may not seat, could bend and stick out above the roadway. If the miter rails are not fully seated at each location, there is a chance of train derailment or damage to vehicles crossing the bridge. Either situation must be avoided, so the miter rails must be interlocked with traffic control system to ensure that the miter rails are seated in proper position before any traffic can proceed over the movable span. The miter rails must include sensors to determine their position, (whether fully seated or not). These sensors would be integrated into the control system such that if any of the sensors do not indicate fully seated, the following items would be restricted from happening:

a. Driving the span locks
b. Raising of the traffic gates
c. Changing the traffic lights green or turning the streetcar signal to “Go.”

2.7.3.2 Hamilton Avenue Bridge Over Gowanus Canal

No fatal flaw was found at this location. The Hamilton Avenue Bridge is relatively new, it was rehabilitated fairly recently. To accommodate Streetcar traffic, some repairs and modification are required on the bridge electrical system. The required modification includes addition of rail traffic signal and rail signal interlocking and integration into the bridge control system. This is typical for movable bridges that carry rail traffic; hence, it applies to both bridges.

2.7.3.3 New Vernon Bridge

The Rapid Assessment looked at the possibility of a double-leaf bascule structure for an alternative alignment that would utilize Vernon Avenue to cross the Newtown Creek. Without further criteria regarding navigational needs it was assumed that the clear channel opening as well as vertical height requirements in the bridge open position would be the same as the nearby Pulaski Bridge. Movable span dimensions would be approximately 180 feet trunnion to trunnion with a width that can adequately carry two light rail tracks and the possibility for a multiuse pathway. Approach structures were limited to approximately 500 feet in length for estimating purposes. While this structure would have the same channel width and vertical clearances as Pulaski while in the open position, it is assumed that a much lower profile would be used resulting in lower vertical clearances in the bridge down position.

2.8 Phasing/Scalability

The BQX Study corridor is up to 17 miles in length connecting major neighborhoods and communities along the Brooklyn-Queens waterfront including Astoria, Ravenswood, Long Island City, Greenpoint, Williamsburg, Brooklyn Navy Yard, DUMBO, Downtown Brooklyn, Red Hook, and Sunset Park. It is common for transit infrastructure projects of similar length and complexity to be implemented in distinct phases rather than one construction project along the entire corridor. The decision of whether or not to phase construction is dependent on a number of factors including project budget, timing of funding and financing, potential conflicts with other major infrastructure construction in the corridor, project delivery method design/construction timetable, any schedule constraints on vehicles and materials, and other issues.

The specific identification of recommended project phases will be based on a review of technical, cost and schedule factors addressing travel patterns and ridership estimates, transit network connectivity, operational efficiencies, anticipated utility relocations and constructability within each phase, identification of logical termini, and other issues.

2.8.1 Snow Removal and Salt Spreading

Operational considerations include potential damage to tracks due to snowplows and corrosion from salt. In addition, potential conflicts of curbside streetcar alignments with standard snow removal practices employed by DSNY requires further analysis. Experiences from streetcar/light rail systems in other cities with comparable weather conditions are investigated in Section 9.0, “Peer City Research,” of this report. Potential solutions will be further explored. Commonly used salt compounds may not have a significant corrosive effect on rails. Select snow removal practices are noted below:

- The Minneapolis Nicollett LRT has a unique detail for the cross streets to minimize the impact of the plow blade when crossing the rail. The rail is set ¼ to ¾ inch above the top of the adjacent pavement for the first several of inches of pavement, and then raised to be level with the top of rail so that the blade can avoid impact when crossing the tracks.

- Though snow removal along the streetcar ROW may be performed by the same entity responsible for general street snow removal operations, the clearing of the streetcar ROW needs to be prioritized. The City of Toronto initially plows streetcar routes on a priority basis, and when snow storage space is limited they load and truck snow for proper disposal. Toronto Transit Commission, the agency responsible for streetcar operations, is responsible for clearing special track work, including de-icing points. Snow removal and salt spreading is handled by operator crews per Standard Operating Procedures detailed in a Winter Operations Manual.

- Rubber-flanged plows should be used.

2.8.2 Vibration

Vibration impact can be mitigated with the installation of a “rubber boot” around rail. The gaps in the rail associated with typical special track work can cause vibration levels to increase. To mitigate for operational vibration, low-impact frogs can be installed at the special track work near vibration-sensitive receivers. Low impact frogs can reduce vibration levels by creating a smoother transition through the gap in the rails at the special track work.

2.8.3 Streetcar Vehicle Breakdown

Potential disruption to streetcar operations due to vehicle breakdowns is typically mitigated with system design features, including additional vehicles available for deployment, design of crossover tracks to route trains around disabled vehicles, and equipment to tow disabled vehicles. Many streetcar vehicles are capable of towing disabled vehicles to maintenance yards.

3.0 VEHICLE TECHNOLOGY/PROPULSION

3.1 Vehicle Requirements

The operation described in the 2015 Study matches up more closely with current US light rail lines than streetcar systems, due to its length and operational frequency. However, it is intended for 100% in-street running, albeit in a dedicated lane. The Rapid Assessment thus evaluates both light rail vehicles (LRVs) and streetcars.

3.2 Streetcars versus LRVs

There are differences between LRVs and streetcars. Generally, LRVs are bigger, carry more passengers, operate at higher performance levels and are used on both mixed-use and dedicated right of way, where higher speeds are more practical. Streetcars are generally used in mixed traffic, although they may also be used on dedicated right of way. In addition, streetcar dimensions can generally negotiate tighter curves than LRVs (18-20m curves versus 25m curves), which may make this type of car more attractive for in-street running.

Streetcars and LRVs generally consist of three sections. With the exception of the Siemens' S70 Short model, streetcars are generally designed to operate using two trucks (bogies) with a cantilevered center section. While most streetcars have high floor and low floor sections to provide space for the bogies, and meet ADA requirements, some manufacturers have designed streetcars that are 100% low floor cars, which promotes better passenger movement and distribution within the car. Figure 3-1 provides a comparison of the characteristics generally attributable to each type of vehicle. There are other possible configurations available for use on the proposed BQX alignment. Alstom, Bombardier, and CAF are manufacturers that can provide streetcars with five segments, rather than the three segment streetcars typically seen in the U.S. Cars with this configuration operate with three bogies, one powered bogie under each cab car and one unpowered bogie under a center car. While the overall car weight would be greater, the axle loading would not be significantly higher for this type of car. With this car configuration, the station stop length would have to be increased. There are examples of cars with this configuration operating in Europe and Canada.

Any of the streetcar configurations should be able to negotiate the 20m curves contemplated in the 2015 Study. However, curves at Lorraine St, Cadman Plaza, and 21st and Astoria Boulevard may present a problem that may require further investigation.

In terms of the width of the vehicle, the streets are wide enough to accommodate the wider streetcar width (2.46m).

Given the corridor and operating speeds, the streetcar configuration would be more beneficial than LRVs, providing they can deliver the as-yet-to-be-determined capacity required in passengers per hour at an optimal service frequency.

Figure 3-1: Streetcar / LRT Comparison

Vehicle Data	**Generic LRV**	**Generic Modern Streetcar**
Length	90 ft. or more	66 to 82 ft.
Width	8' 8" to 9'	7' to 8'-8"
Seats	70 +/-	30 +/-
Passenger Load (AW3)	230 +/-	150 +/-
Acceleration/Brake Rate	3 mphps	3 mphps
Max speed	65 mph (High Performance Service)	43 mph (70 km/h)
Vehicle Type	High Floor; High Floor/Low Floor	High Floor/Low Floor; 100% Low Floor
Number of Bogies	Typically 3	2 or 3
Off Wire Operation	Not currently in US operation	Currently in US operation
ADA Compliant	Yes; Level Boarding/Bridgeplates	Yes; Level Boarding/Bridgeplates
Alignment Description		
Distance Between Stations	2500 ft to 5000 ft	600 ft to 1000 ft
Length of alignment	10+ miles	1 to 2 miles
Power Delivery	OCS (Catenary)	Trolley Wire
Operating Voltage	750 to 1500v dc	750 vdc
Traction Power Substations	1-2 MW	Typically 500 kW
Min Curve Radius	25 m (82 ft)	18m (60 ft) to 20m (66 ft)
Grade Separation	Predominantly Dedicated ROW	Predominantly Mixed Traffic
Construction	Full depth	Shallow slab
Operations		
Headways	5-10 minutes; may be 2.5 to 5 min	10 to 15 minutes; may be 5 minutes
Signal System	Yes; preemption; traffic signals in mixed traffic	Limited; preemption possible; traffic signals
Train Configuration	1 to 4 cars operating in consist	Typically 1 car
Location Served	One seat commuter lines	Urban circulators

3.3 Off-Wire Operation

The 2015 Study recommended wire-free operation. While this is possible, it must be studied closely to weigh the advantages and disadvantages with respect to this particular project. Currently there are very few fully wire-free systems worldwide, and none in the US. Most systems that have wire-free operation do so to solve a local problem, and use traditional overhead wiring systems where possible. Rather than the being fully "wire-free", these systems have "off-wire" sections, where the vehicle runs for a short distance without the support of overhead wiring.

There are different approaches that may be considered when operating in the off-wire mode. These include embedded rail, which is a variant of a third rail system. Examples include the Alstom APS, Breda TramWave and Bombardier PriMove systems. All of these systems still require wayside traction power substations similar to conventional wired systems. Substation locations will be dictated by the needs of the system, adding to the technical complexity and project cost, thus traction power substations must be included in the next phase of the study.

The 2015 Study avoided the requirement for a wayside traction power system by suggesting the use of hydrogen fuel cell powered vehicles. This has been studied for other locations and has been consistently deemed 1) impractical to store adequate quantities of hydrogen on a small vehicle, 2) developmental rather than proven technology, 3) both risky and expensive in terms of acquisition cost, and 4) likely to result in high operating costs. This has been confirmed in the data from the small number of North American transit systems operating hydrogen-powered buses. Furthermore, the current practice of processing natural gas to obtain the hydrogen produces substantial amounts of greenhouse gas, making this technology less “green” than one might expect. As this and other means of storing adequate energy onboard are improved over the coming years, this topic can be revisited. The availability of off-wire solutions will be further assessed as part of subsequent study.

To support shorter off-wire operation, the streetcars can be provided with Onboard Energy Storage Systems (OESS) to permit the streetcars to operate in non-overhead wire line segments. Current OESS consist of batteries, supercapacitors, or a combination of batteries and supercapacitors. Though the use of OESS becomes more practical when an alignment is on a dedicated right-of-way, OESS will require recharging at various intervals along the right-of-way. The charging stations will provide the source of power required to replenish the energy in the OESS. The charging stations will consist of substations (each smaller than the typical substation size for OCS/trolley wire operation), ranging somewhere between 375kW and 1MW, and the means of delivering the power to the car. The locations and number of charging stations will depend upon the expected power usage during operation. This will in turn affect the cost of the system.

Wire-free segments are a proven and practical solution in dedicated right of way operation. The designer may more easily size the OESS, as they will be able to calculate the time that the vehicle will be off wire between charging stations. If it is determined that there will be segments of the alignment which will be provided with trolley wire, this will provide a means to recharge the onboard batteries at a much slower rate, which is a preferred method of charging batteries. The cost of an OESS presently is in the range of $500,000 per streetcar. The costs will continue to decline, as the use of these technologies increases and the technology continues to develop.

3.4 Dimensions/Weight/Capacity

The majority of US streetcars are 20m (66ft) in length. This length is popular for a variety of reasons. Initially, these were the standard product of car builders who were willing to provide streetcars to the US market. For the same reason, the cars were also of the narrow width (2.46m/8.1 ft). More recently, streetcars have been ordered with a length of 20m and a width of 2.65m (8.7 ft), specifically for Detroit, Milwaukee DPW, and Oklahoma City. Other cars purchased by Cincinnati and Kansas City are 24m (77ft) long and 2.65m wide. Atlanta purchased the Siemens shortened S70 LRV which is 25m (82ft) long and 2.65m wide. The weights of these cars vary from 29,000 kg for the narrow 20m long streetcar to 35,000 kg for the CAF, 24m streetcar to the 45,000kg, 25m Siemens streetcar (shortened LRV). OESS also adds weight. With the exception of the Siemens streetcar, the cars generally have a seating capacity in the range of 30 to 38 seats. The total capacity for the cars range between 150 to 200 passengers, including seated and standing passengers.

Table 3-1 provides critical details for the streetcars currently operating in the US.

Table 3-1: US Streetcar Dimensional/Weight/Capacity Details

City	Carbuilder	Length	Width	OESS	Tare Wt (lbs.)	Seated Capacity	Total Passengers
Dallas, TX	Brookville	65’-7”	8’	Yes	82,673	30	135
Detroit, MI	Brookville	65’-7”	8’-8”	Yes	88,185	32	149
Milwaukee, WI	Brookville	65’-7”	8’-8”	No	77,162	32	149
Oklahoma City, OK	Brookville	65’-7”	8’-8”	Yes	88,185	32	149
Cincinnati, OH	CAF	78’-9”	8’-8”	No	77,162	38	213
Kansas City, KS	CAF	78’-9”	8’-8”	No	77,162	38	213
Seattle, WA	Inekon	20	2.46	Yes	34,000	33	155
Washington, DC	Inekon/USC	20	2.46	No	32,000	30	155
Portland, OR	Skoda/Inekon/ USC	20	2.46	No	32,000	30	155
Tucson, AZ	USC	20	2.46	No	32,000	30	155
Atlanta, GA	Siemens	25	2.65	No	45,000	69	159

A benchmarking table is provided in Table 3-2, showing key features of streetcar systems in the US and abroad with some level of off-wire operation. In addition, two of the largest streetcar networks in the world are listed as a comparison. Neither operates off-wire sections.

Table 3-2: Streetcar Systems with Off-Wire Operation

Location	Project	Route Length (mi/km)	Off-wire Segment (mi/km)	Off Wire Operation (Mixed Traffic) Y or N	Car Builder	OESS Tech.	Charging source	Fleet Size	In-Service Date	Reasons for Off-wire Segment
Domestic Projects										
Dallas	Oak Cliff Streetcar	1.6/2.6	1.0/1.6	N	Brookville	Lithium Ion Batteries	OCS	2+2	2015	Historic bridge
Seattle	First Hill Streetcar	2.5/4.0	~50% of the line in total	Y	Inekon	Lithium Ion Batteries	OCS	7	2016	Trolleybus O/H wire interference, aesthetics, emergency recovery
Detroit	M-1 Rail	3.3/5.3	~50% of the line in total	Y	Brookville	Lithium Ion Batteries	OCS	6	Late 2016	Aesthetics, parade route, signature downtown park
Oklahoma City	MAPS 3 Modern Streetcar	4.5/7.2	TBD	Y	Brookville	Lithium Ion Batteries	OCS	5	Late 2017	Low clearance under overhead RR structures
Fort Lauderdale	The Wave	2.7/4.3	0.6/0.9	Y	TBD	TBD	OCS	4	TBD	Bascule lift bridge
Charlotte	CityLYNX Gold Line Ph2	4.0/6.4	0.3/0.5	Y	TBD	TBD	OCS	8	Late 2019	Aesthetics; signature downtown intersection
International Projects										
Zaragosa, Spain	Tranvía de Zaragoza	8.0/12.8	0.6/1	N	CAF	Battery and Supercaps	ACR at stations	21	2013	Historic old town
Kaohsiung, Taiwan	KMRT Circular Line	13.7/22.1	Full	N	CAF	Battery and Supercaps	ACR at stations	36	2016 (Ph I only)	
Bordeaux, France	Bordeaux Tramway	49/79	7.5/12	N	Alstom	NA	APS (in-ground power rail)	105	2003	Aesthetics/Historical preservation. Technology demonstration as a partnership between local government and supplier.
Sydney, Australia	CBD and Southeast	7.5/12	1.2/2	Y	Alstom	NA	APS (in-ground power rail)	60	2019	Wire free for downtown pedestrian zone - not required but proposed by winning bidder
Zhuhai, Guandong, China	Zhuhai Tram Phase I	5.5/8.9	Full	N	Ansaldo / Dalian Loco	NA	Tramwave	10	2016	Technology demonstration as a partnership between local government and supplier.
Nanjing, China	Qilin Line	5.6/9	0.9	N	Bombardier / CSR	Lithium Ion Batteries	Induction at stations	15	2014	Technology demonstration as a partnership between local government and supplier.
Largest International Streetcar/Tram Systems -- Wired										
Melbourne, Australia	Yarra Trams	155/250	NA	NA	Multiple	NA	NA	1763	474	NA
Vienna, Austria	Wiener Linien	110/171	NA	NA	Multiple	NA	NA	1070	525	NA

3.5 Power/Substations

With few exceptions, streetcar and LRT systems operate using a 750vdc system. AC power is provided by the local power utility company to the traction power substations, where the power is converted to 750vdc. The input to the traction power substations may be provided at different voltage levels, depending upon the primary feeder power levels available in the utilities power grid in the area and the requirements for the transit system's power usage.

Presently, power for wired streetcar operations is delivered to the vehicles through an overhead trolley system or Overhead Contact System (OCS). The overhead trolley system is typically used on streetcar systems, as streetcar service is typically lighter in terms of frequency of service, vehicle weight, and size of consist, which translates into lower levels of power usage. The streetcar systems typically will require substations in the range of 500 kW and be placed at intervals between ½ and 1 mile. These substations can be powered by 480V utility power or 13kV sources.

3.6 Signals and Communications

Streetcar systems generally rely on automotive traffic signals. However, there are portions of an alignment that require dedicated streetcar signals that are interlocked with the traffic signals. For instance, if the alignment requires a change of lane or turning onto a different street with a change of lane, the streetcar requires a dedicated proceed signal with all other traffic held with a red phase. Light Rail, operating on dedicated right of way, requires a signal system to maintain separation between trains. The BQX system will operate on dedicated right of way, but will cross many high-capacity, high-usage streets that may require some dedicated signals. For the most part, it will operate using the street traffic signals, possibly with pre-emption.

3.7 Vehicle Cost

The 2015 Study estimated a vehicle cost of approximately $5 million. This is reasonable for an off-the-shelf vehicle acquisition. If the vehicle is customized, the cost will increase. As previously noted, addition of OESS will increase the cost by about $500k. It is likely that a highly customized vehicle, with a developmental OESS, like a hydrogen fuel cell, might be twice the price of an off-the-shelf vehicle. At this stage of the project, it would be prudent to maintain a relatively high contingency on all cost estimates due to the limited amount of system design information.

3.8 Conclusions

- Streetcar sized vehicles are appropriate for the proposed service and route, but larger LRVs should not be dismissed until the final alignment and operating requirements are established.
- Wire-free operation is not fatally flawed but should be considered based on environmental requirements and cost.
- Hydrogen fuel cell streetcars are not commercially mature, and are not expected to prove viable.

4.0 PRELIMINARY CONCEPTUAL CAPITAL COST ESTIMATE

The 2015 BQX Study presented a capital cost estimate for the proposed 17-mile system, including the Downtown Brooklyn shuttle, totaling $1.7B. It is assumed that this estimate is reported in 2015 dollars. The 2015 Study estimate is based on a number of key assumptions, including a budget of $262M for 52 modern streetcar vehicles (hybrid off-wire technology), $427.5M for utility relocations, and a 15% contingency.

As part of the Rapid Assessment, a high-level review of the 2015 BQX Study capital costs was performed, including an updated cost estimate range based on a preliminary and conceptual assessment of the corridor.

Capital costs presented for the Rapid Assessment are reported in current year dollar values (2016), and have not been escalated to year of expenditure (YOE) dollars. Costs are reported applying format and categories as presented in 2015 BQX Study and are based on the 17 mile alignment and project description as outlined in the 2015 BQX Study, minus the downtown shuttle. A summary of the major assumptions in the Rapid Assessment cost range include:

- Overall contingency increased from 15% to 30% for both low and high cost range.
- Professional services reported as two cost categories: "Design and Environmental Review" reflecting 10% of construction costs for low and high range, and "Project/Construction Management" reflecting 15% (low) and 20% (high) range of construction costs.
- No right-of-way costs assumed.
- Assumed that 50% of utility relocation costs were for public utilities and included in project budget. Private utility costs not included in project budget.
- Costs reported for 60 modern streetcar vehicles to account for service plan and adequate spare fleet – estimated cost for hybrid off-wire capable vehicles.
- Applied preliminary NYCDOT cost estimates for bridge retrofit and replacement in low and high range costs.

Based on these considerations, the Rapid Assessment estimates a streetcar/LRT along a corridor similar to the 2015 BQX Study would cost approximately $2.5B in 2016 dollars. Further refinement will take place in the detailed plan to follow.

Table 4-1: Preliminary Conceptual Capital Cost Estimate

Category	Quantity	Unit	Cost per unit	Total Cost
Removals and Earthwork	16	miles	$1,200,000	$19,200,000
Bridges	2	units	$85,000,000	$170,000,000
Infrastructure/Superstructure	16	miles	$11,000,000	$176,000,000
Stations	40	units	$920,000	$36,800,000
Electrification	20	units	$2,505,000	$50,100,000
Signaling	1	units	$112,500,000	$112,500,000
Telecommunications Network	1	units	$25,000,000	$25,000,000
Operating Systems	1	units	$19,625,000	$19,625,000
Primary Depot, Workshop, Offices	1	units	$70,000,000	$70,000,000
Secondary Depot	1	units	$30,000,000	$30,000,000
Utility Relocation	16	miles	$16,000,000	$256,000,000
Landscaping/Urban Integration	16	miles	$10,185,000	$162,960,000
Rolling Stock	60	units	$5,375,000	$322,500,000
Construction Costs Subtotal				$1,429,185,000
Design and Environmental Review	0.15	percentage		$214,377,750
Project/Construction Management	0.15	percentage		$214,377,750
TEA/Force Accounts	0.05	percentage		$71,459,250
Soft Costs Subtotal				$500,214,750
Estimated Capital Cost				$1,929,399,750
Contingency (30%)	0.3	percentage		$578,819,925
TOTAL ESTIMATED PROJECT COST				**$2,529,719,675**

A brief discussion of the differences in each of the reported cost categories follows.

4.1 Components

4.1.1 Removals and Earthworks

The 2015 Study estimated $0.8 million per route mile. Based on similar projects and knowledge of the BQX corridor, the high range was estimated at $1.6 million per route mile to account for uncertainty in this early phase of project feasibility.

4.1.2 Bridges

The 2015 Study included a $50 million estimate for retrofitting the Pulaski Bridge and notes that up to an additional $100 million may be necessary if a new bridge is required. NYCDOT provided input to the 2016 Rapid Assessment on costs for bridge retrofit and replacement for Pulaski and Vernon Boulevard, as well as for the Hamilton Bridge, resulting in higher estimates that require further refinement.

4.1.3 Infrastructure/Superstructure

The 2015 Study estimated $8.0 million per route mile. Based on similar projects, the 2016 Rapid Assessment applied a high range of $14.0 million per route mile, and maintained the $8.0 million per route mile as low range.

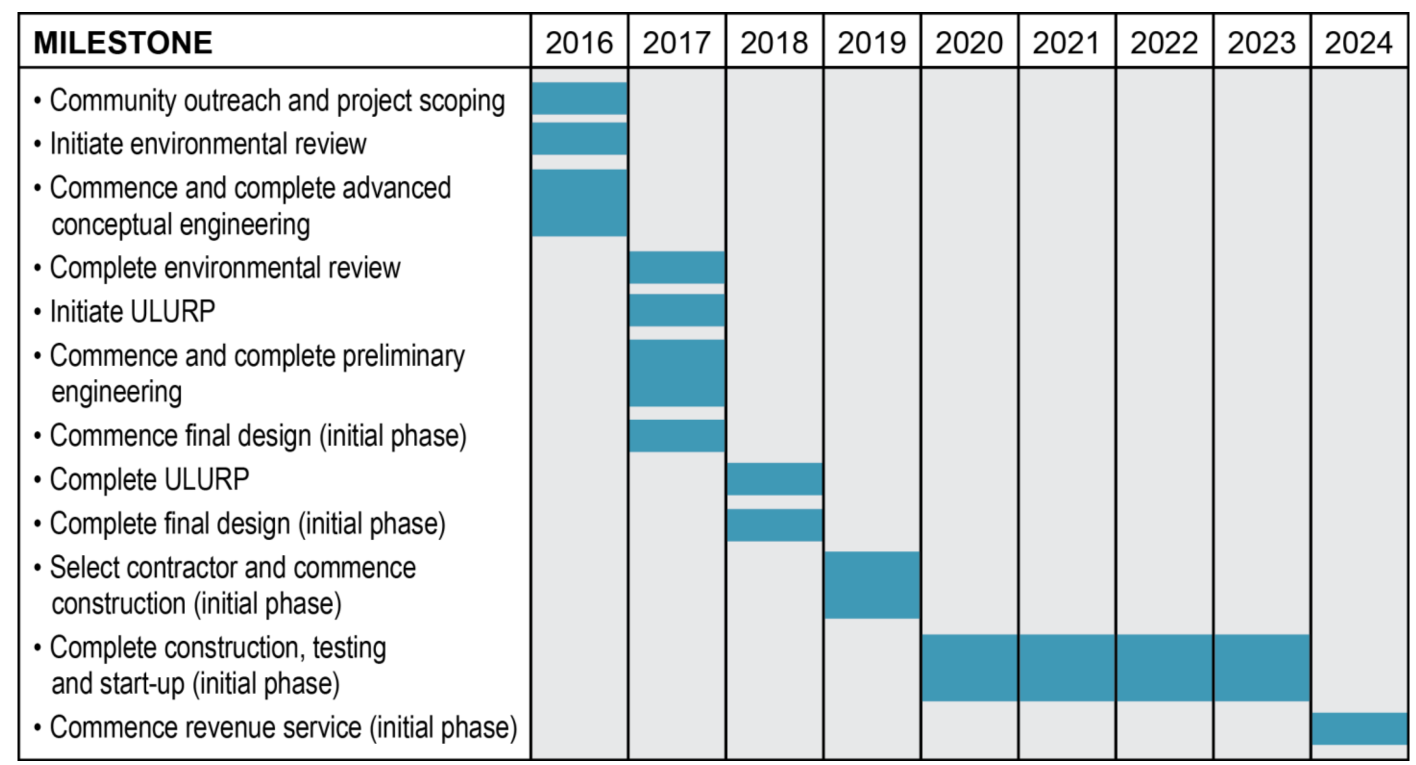
4.1.4 Stations

The 2015 Study estimated $0.840 million per station and 70 stations. The 2016 Rapid Assessment maintained this cost as the low range and increased the high range to $1.0 million per station.

4.2 Construction Planning/Schedule Considerations

Key schedule and implementation steps are illustrated in Figure 4-1. Community engagement, planning, design, and preliminary engineering are scheduled to take place through the end of 2016. In addition, an environmental review would be undertaken to support discretionary actions required under the City's Uniform Land Use Review Procedure (ULURP). ULURP will conclude in 2018 at the time of completion of final design. Contractor selection and construction commencement will occur in 2019 followed by a construction period resulting in start of operations by 2024.

Figure 4-1: Preliminary Schedule



5.0 OPERATING COST ESTIMATE

5.1.1 Review of 2015 Study Plan and O&M Cost Estimate

The 2015 Study completed an initial streetcar/LRT operating plan and annual operating and maintenance (O&M) cost estimate. The 2015 BQX Study estimated annual O&M costs at $26 million.

In order to examine the reasonableness of the $26 million annual estimate, a comparison to operating costs from modern streetcar systems and comparable light rail systems in the United States was completed. This comparison provides insights to the upper and lower bounds for the potential operating costs of the BQX system.

The BQX O&M cost estimate reflects $0.8 million per track mile. BQX is within the low end of the range reported for U.S. modern streetcar systems, ranging from $0.7 to $1.0 million per track mile. BQX is within the low end of the range reported for comparable U.S. light rail systems, ranging from $0.8 to $1.2 million per track mile.

The BQX O&M cost estimate reflects $0.5 million per vehicle. BQX is lower than the range reported for U.S. modern streetcar systems, ranging from $0.8 to $1.1 million per vehicle. This is not surprising, given economies of scale and the fact that the BQX fleet size is larger than the typical U.S. modern streetcar system by a factor of 5x to 10x. BQX is within the low end of the range for comparable U.S. light rail systems, ranging from $0.5 to $0.7 million per vehicle. Further analysis of these costs will be necessary.

6.0 RIDERSHIP FORECAST

The ridership review conducted in the Rapid Assessment was a two-step process. The first step consisted of a review of the ridership methodology used to develop preliminary estimates of ridership as part of the 2015 Study.

As a second step, a preliminary ridership assessment was conducted for this Rapid Assessment. The ridership and revenue forecasting is based on explicitly modeling the modal choice of users in the BQX market areas. The modal choice calculations are based on the relative attractiveness of the BQX service relative to the existing transit modes in the corridor, in particular access time, wait time, travel time and fare associated with the BQX and the various existing transit options in the corridor – subway, bus and ferry.

Review of the 2015 BQX Study drew upon ridership estimates previously developed for the Citywide Ferry Study 2013. This model has proven to be reliable in forecasting journey-to-work (JTW) transit usage for markets served by passenger ferry, subways or express bus. For the BQX ridership exercise, the model was updated to include additional transit choices that reflect those in the BQX corridor, namely bus as well as the proposed BQX. The resulting model (the BQX Ridership Model, or "BRM") is a standard mode choice model that allows the estimation of detailed ridership by station area based on existing origin-destination patterns for JTW as well as the actual travel cost advantages that the BQX will confer for these JTW markets. These estimates for JTW are then converted into daily ridership estimates based on patterns of observed hourly transit usage in the corridor.

There are several advantages to using the BRM for at least the current stage of the analysis: The model is based on surveys of residents and commuters residing in the BQX corridor, and the initial model was further calibrated to analyze observed travel behavior in the corridor. The resulting model parameters are reflective of conditions in the markets that would use the BQX. The BRM is by extension consistent with the model used for forecasting the East River Ferry ridership, and as such will produce ridership demand forecast for the BQX that will be internally consistent with East River Ferry forecasts.

The following sections review the methodology used to develop the existing preliminary ridership forecasts developed for the BQX. This is followed by a detailed analysis of JTW patterns in the BQX corridor, as well as a description of the BRM. Later sections include preliminary estimates of BQX ridership for selected station stops on the proposed BQX route using the BRM. These estimates confirm the results of the 2015 BQX Study estimates, which form the basis for system-wide ridership estimates in 2020. These are then grown to 2035 ridership estimates based on an analysis of projected population increase in the corridor.

6.1 Review of BQX Assumptions and Methodology

This section provides an overview of the methodology used within the 2015 Study and reviews some of the assumptions used to develop the 2015 Study estimates.

6.1.1 Methodology and Approach

The methodology used for the 2015 BQX Study primarily developed estimates of existing bus ridership in the corridor that serve as the basis for estimated BQX usage. The methodology differed slightly by the line segment (mainline section or downtown shuttle) being considered for the analysis.

For both the mainline and downtown shuttle sections, the methodology considered stop-by-stop bus ridership based on boarding and alighting passengers for different bus routes. Different bus passenger capture rates were assumed in the 2015 BQX Study depending on how closely the routes were being replicated by the BQX. Current year 2015 potential ridership was developed by multiplying the capture rates by the number of average daily riders based on the bus ridership data. The ridership estimates also included a 10 to 20% increase in induced ridership based on NYCDOT findings from the introduction of Select Bus Service (SBS) in New York City.

In estimating the base year demand for the Downtown Brooklyn shuttle, a significant induced demand component was added to the base ridership estimate to account for the improved connectivity offered by the downtown shuttle.

For future years, ridership estimates were developed based on aggregate increases in population and employment – projected by a separate analysis within the 2015 BQX Study that considered future development in the corridor due to the BQX. The 2015 BQX Study estimated the current population and employment in the corridor, and daily bus trips in the corridor accounted for approximately 5%. For 2020, additional increases in population and employment were assumed to increase ridership by a similar proportion.

In the longer term (2035), the 2015 BQX Study assumed that BQX riders would mirror average bus ridership in New York City. The 2015 BQX Study estimated that, for New York City, bus ridership was at 17% of total population and employment. BQX and bus ridership in the corridor would increase from the current estimated weekday bus ridership of approximately 6% to approximately 17% – the citywide bus ridership relative to population. Approximately 2.6% of the 17% would continue to use existing bus service while the remainder, approximately 14%, would use the BQX. The increase in population and employment in the corridor from current 2015 population and employment was assumed to reflect approximately 14% ridership for the BQX.

6.1.2 Current Corridor Ridership

Along the proposed alignment in Queens, the major bus routes currently operating are the Q69 and Q100 bus routes. They provide the majority of the 2015 ridership that was projected to use the BQX service. In Brooklyn, the B62 and B61 routes mostly provide current bus service, and bus stops included in the analysis indicate that these are primarily located along the proposed BQX alignment.

For each bus stop considered in the analysis of average daily boarding passengers, average daily alighting passengers and an estimated total ridership leaving the bus stop is available. For example for the northbound (NB) leg of a bus route, segment ridership is calculated by considering the number of riders entering the southernmost bus stop and the number of riders leaving the northernmost bus stop along with the passengers boarding in between. Ridership is calculated in each direction, and different captures rates are assigned by direction. Table 6-1 presents a summary of the estimated ridership. A 10 to 20% induced ridership was included based on Select Bus Service observed ridership increases in New York City.

Table 6-1: 2015 Study Estimated Mainline Average Daily 2015 Ridership

Mainline	Selected Ridership	Base Level of Captured Riders	BQX Riders (Low) - 10% Induced	BQX Riders (High) - 20% Induced	% Capture of Base Level
B57	1,508	528	581	633	35%
B61	3,417	2,050	2,255	2,460	60%
B32	591	532	585	638	90%
B62	8,619	4,309	4,740	5,171	50%
B37	1,783	1,516	1,667	1,819	85%
B67	118	47	52	56	40%
Brooklyn	**16,035**	**8,982**	**9,880**	**10,778**	**56%**
Q103	1,185	592	651	711	50%
Q69	5,340	4,005	4,406	4,806	75%
Q100	3,618	2,171	2,388	2,605	60%
Queens	**10,143**	**6,768**	**7,445**	**8,122**	**67%**
Total	**26,178**	**15,750**	**17,325**	**18,900**	**60%**

Source: Steer Davies Gleave Analysis, SSE GIS Layers

Overall capture rates seem reasonable, but these rates are based on expert opinion rather than the result of formal modeling. Brooklyn bus services with relatively high capture rates are the B37[1] and B32, both of which mostly operate along the BQX corridor. Ridership from the B62 and B61 account for most of the captured ridership (71%) in Brooklyn. In Queens, the Q69 and Q100 have high capture rates, but both routes provide service immediately in the vicinity of the corridor. Based on existing bus users about 16,000 – 19,000 riders might use the mainline BQX service.

Table 6-2 shows the estimated ridership for the shuttle service. The shuttle service assumed a high induced demand component for ridership due to the BQX.

Table 6-2: 2015 Study Estimated Shuttle Ridership

[1] Detailed ridership was not available for this route and was estimated by based on field observation

Shuttle	Selected Ridership	Captured Riders	% Capture	BQX Riders + Induced
B25	1,175	705	60%	
B26	667	400	60%	
B38	1,661	996	60%	
B41	1,515	909	60%	
B45	708	425	60%	
B52	1,094	657	60%	
B67	726	436	60%	
B103	617	370	60%	
Total	**8,163**	**4,898**	**60%**	**7,898**

Source: Steer Davies Gleave Analysis, 2015 Study GIS Layers

6.1.3 Growth in Future Ridership

Future ridership growth in the BQX corridor was essentially based on two components. The first component considered increased growth in population and employment in the corridor. Projected population and employment growth in the corridor are compared to historical growth rates below. The second component consisted of increased mode share for the BQX for the population and employment that would be using the corridor.

6.1.4 Historical Growth Rates

Historical county population growth rates are shown in Table 6-3. Queens's population at the county level remained relatively constant during the 2000 to 2010 Census at 2.23M. Total population in Brooklyn during the last decade increased modestly, growing at an annualized 0.2% per annum from 2.4M to 2.5M in 2010. Total Manhattan population increased by 0.3% per annum.

Table 6-3: Historical County Population Growth Rates

County	2000	2010	CAGR
Brooklyn	2,465,689	2,504,700	0.16%
Queens	2,229,394	2,230,722	0.01%
New York	1,538,096	1,585,873	0.31%

Source: United States Census Bureau

Table 6-4 presents historical employment growth rates at the county level. Employment increased 2% per annum in Brooklyn, growing from 0.43M to 0.57M in 2014. In Queens, employment increased significantly as well though less than in Brooklyn, increasing from 0.47M in 2001 to 0.55M in 2014, a 1.1% growth rate per annum.

Table 6-4: Historical County Employment Growth Rates

County	2001	2010	2014	2001-10	2010-14	2001-14
Brooklyn	439,343	492,125	568,298	1.3%	3.7%	2.0%
Queens	478,661	492,558	552,912	0.3%	2.9%	1.1%
New York	2,342,338	2,280,092	2,495,683	-0.3%	2.3%	0.5%

Source: United States Census Bureau

6.1.5 Conclusion

The methodology within the 2015 BQX Study to generate ridership forecasts relies heavily on identifying a potential ridership base from existing bus routes. To this end, the bus routes considered under the 2015 BQX Study within the BQX corridor were reasonable choices.

The capture rates of key bus services analyzed in the 2015 BQX Study are reasonable, but these capture rates require formal modeling. In addition, potential diversion to the BQX from other transit options in the corridor, notably subway and ferries, require further analysis.

Lastly, it appears that the increase in induced demand in the 2015 analysis is high.

Despite the need for further analysis, the review of the ridership estimates prepared in the 2015 Study finds that the general approach is appropriate for the feasibility-level of analysis, and the independent ridership analysis described below confirms their magnitude.

6.2 The Ridership Forecasting Approach

6.2.1 Methodology

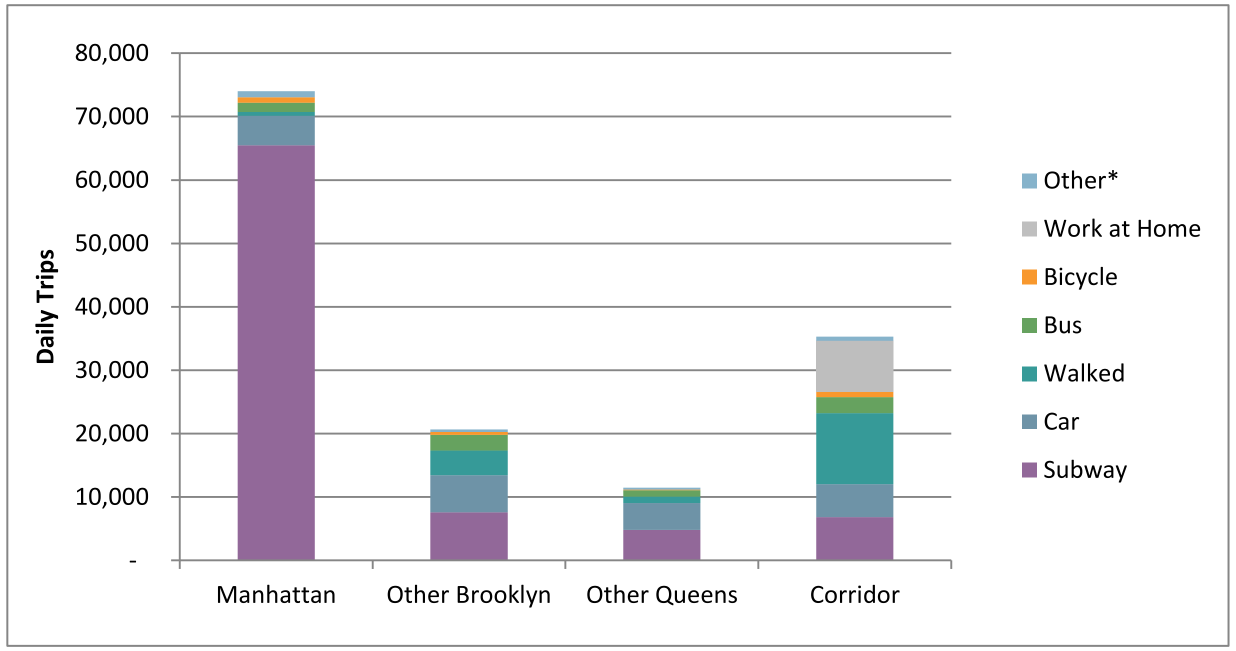
Preliminary validation of the ridership projections in the 2015 BQX Study are based on an existing mode choice model developed in the context of the Citywide Ferry Study 2013. The model (the Ferry Ridership Model or FRM) is described extensively in the Final Report for the Citywide Ferry Study 2013[2].

For the current work, the FRM was modified to include not just the transit choices of bus and passenger ferry but also subway and streetcar/LRT to represent the proposed BQX.

The process is a standard one in transit ridership modeling, and involves generalizing the response access time, wait time, in-vehicle time and fare to the added modes.

[2] Steer Davies Gleave, 2014. *Comprehensive Citywide Ferry Study 2013.*Report Submitted to New York City Economic Development Corporation.

Figure 6-1: Daily Commute Trips From the Corridor by Mode and Destination



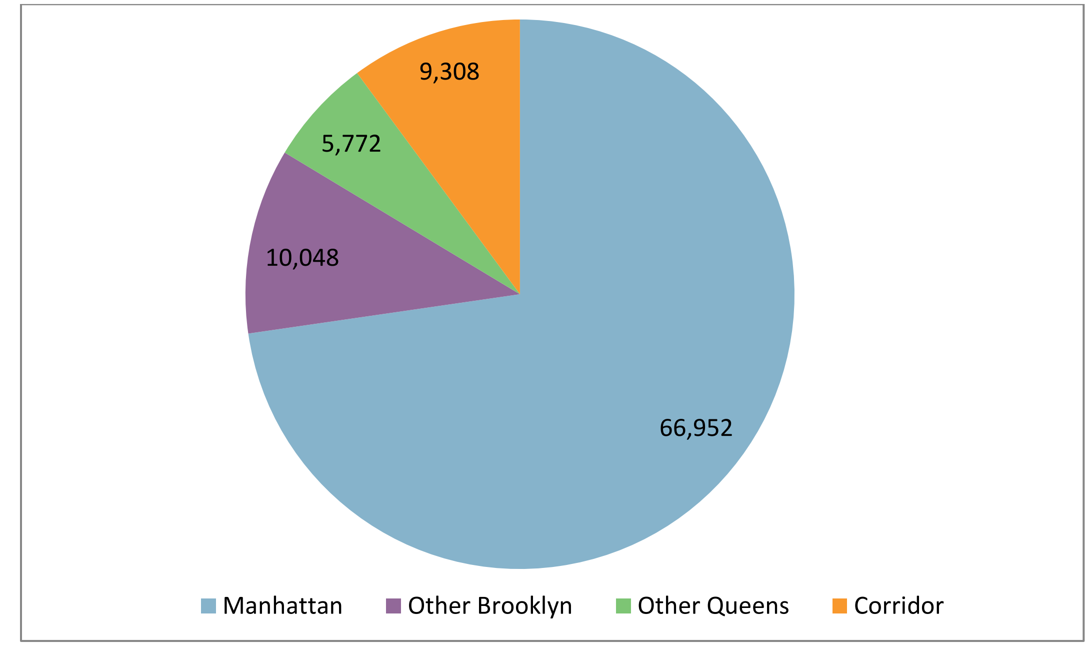
**Taxi, Railroad, Ferry, Motorcycle*

Only transit trips were assumed in-scope for the analysis. It is assumed, as was the case with the Citywide Ferry Study 2013, that it is more likely for a user to shift from another transit mode to light rail than to switch from a car, walking trip or bicycle.

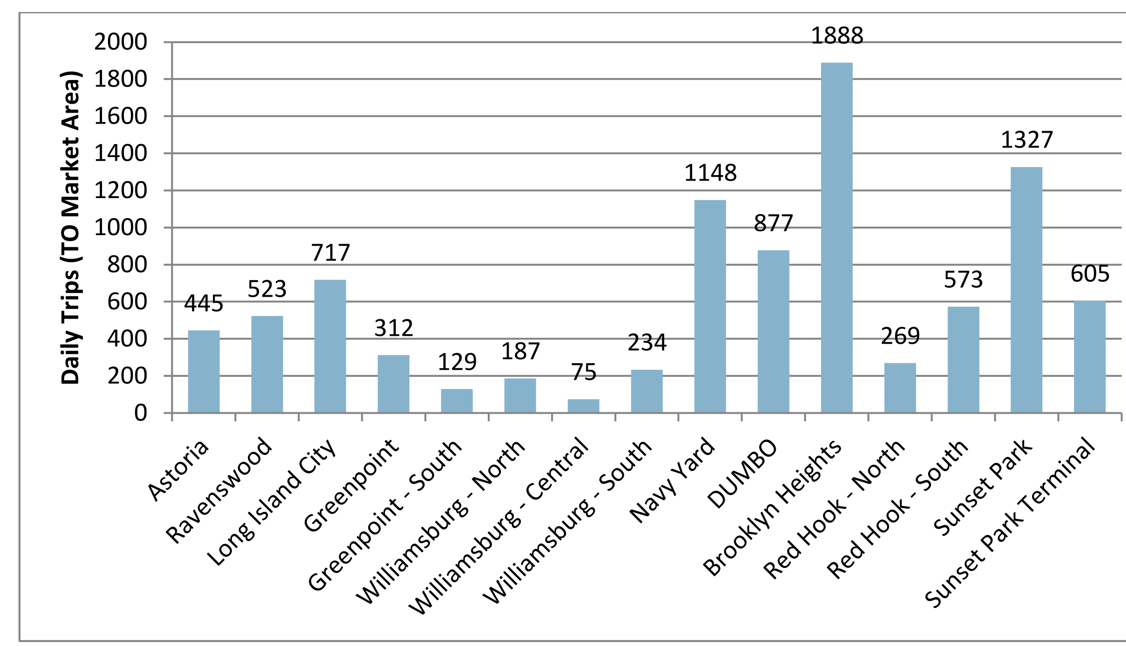
Figure 6-2 lists the number of trips from one market area to other points in the corridor, and from each market area outside of the corridor. While trips within the corridor could be made exclusively on BQX, trips outside the corridor would require users to transfer to another transit mode.

Zones like Red Hook – South and Navy Yard have many commuters because their secondary market areas are so large, while those like Long Island City and DUMBO are smaller in area but have high population density.

Figure 6-2: Destination of Commute Trips Originating in Corridor



For trips that both begin and end in the corridor, there are some common origins, destinations, and OD pairs.



Source: SDG Analysis

Table 6-5 shows total JTW transit demand for the selected markets. Within the BQX corridor, approximately 51 people travel from the Astoria MA to DUMBO MA and approximately 241 people travel from the Astoria MA to Midtown Manhattan MA.

Table 6-5: Total Journey to Work Transit Demand (CTPP)

Origin	Destination	Total Transit Demand
Astoria	DUMBO	51
Astoria	Midtown Manhattan (42th Street / 7th Avenue)	241
Red Hook - South	DUMBO	117
Red Hook - South	World Trade Center	148

Source: SDG Analysis of CTPP 2010

6.2.2 Select Ridership for BQX

For the selected origins and destinations, a mode choice analysis that compared different mode options for selected regions was completed. Mode characteristics involved considering travel times, headways and access time to the different modes. For existing modes, origin/destination pairs required a transfer and a penalty based on NJTPA mode choice model included in the analysis. A summary of the results is presented in Table 6-6 below. For trips going to Manhattan, BQX trips required a transfer to existing transit or ferry service while the BQX eliminated the need for transfers when travelling to DUMBO from Red Hook or from Astoria.

Table 6-6: Summary of Select Ridership Results

Origin	Destination	Total Transit Demand	BQX Ridership	Other Transit	BQX Share
Astoria	DUMBO	51	21	30	41%
Astoria	Midtown Manhattan (42th Street / 7th Avenue)	241	94	147	39%
Red Hook - South	DUMBO	117	73	44	63%
Red Hook - South	World Trade Center	148	79	69	53%

6.2.3 Projected Growth in the Corridor

Projected growth in the corridor was based on Department of City Planning (DCP) data for recently completed, approved, and anticipated residential and commercial developments. Population in Brooklyn is expected to increase rapidly, growing at 2.25% per annum. Population growth in Queens is more modest.

Table 6-7: Projected Population Growth Rates in the Corridor

Population	2015	2035	CAGR (15-35)
Queens	100,007	142,800	1.8%
Brooklyn	305,663	477,000	2.25%
Total	405,670	589,800	2.1%

Source: SDG calculations and 2015 Study Projections

The resulting growth rates for population reflect observed trends in the corridor, which have seen some of the highest increases in density in the city in the last decade.

6.2.4 Projected System-wide Ridership and Revenue

Systemwide ridership and revenue were based on the 2015 BQX Study that developed current bus ridership for the corridor. These estimates were discussed in detail in Table 6-1 and are reproduced below. Major transit investments have been repeatedly shown to prompt “induced ridership” as accessibility engenders more travel as the cost of that travel is reduced. Following observed trends, we assume that BQX will include a 10% induced ridership factor – a more conservative assumption than the 10-20% assumed in the 2015 BQX Study.

Table 6-8: 2015 Base Bus Ridership

Mainline	Selected Ridership	Base Level of Captured Riders	BQX Riders - 10% Induced	% Capture of Base Level
Brooklyn	**16,035**	**8,982**	**9,880**	**56%**
Queens	**10,143**	**6,768**	**7,445**	**67%**
Total	**26,178**	**15,750**	**17,325**	**60%**

Source: Steer Davies Gleave Analysis, 2015 Study(SSE)

For future year ridership projections, adjustments were made to anticipated 2015 base ridership based on the DCP data described at the beginning of this section. These resulted in forecasts for the year 2020 for the entire system. In order to estimate future ridership in 2035, an additional analysis of growth in the corridor was completed, including both official City Planning development plans as well as proposed developments. This analysis confirms existing trends of rapid residential and commercial growth in the corridor.

Ridership projections also incorporate three other important factors. First, a careful analysis of the impacts of the East River Ferry Service demonstrated that locations within walking distance of an East River Ferry stop saw a 7% increase in residential and commercial development compared to adjacent locations outside the ferry market areas. This increase in development is assumed to occur in the BQX corridor following opening of service.

Second, transit usage in New York City has been increasing over time. In Brooklyn, per capita transit usage has increased over 1% per year in the last decade, while in Queens the comparable figures has been 0.4%. This increase in transit usage is assumed to continue in the corridor to 2035.

According to this analysis, average weekday ridership is expected to be 24,500 in 2020 for the complete alignment from Sunset Park to Astoria. By 2035, ridership is projected to increase to 48,900, based on rapid expected growth in the corridor.

Table 6-9: Ridership and Revenue Forecasts

	2020	2035
Average Daily Ridership	24,500	48,900
Annual Ridership	7,605,000	15,186,000
Annual Revenue	$13,360,365	$26,678,567

Revenue forecasts for these years were based on the following assumptions. The average revenue per trip would be the same as the current New York City Subway yield, $1.80 (National Transit Database). This value is less than the actual fare, $2.75, as it accounts for reduced price trips and travel passes. Fare evasion was assumed to occur at a rate of 3%, similar to other light rail systems in the US. Finally, BQX riders were assumed to not have to pay an additional fare if they transfer to subway, bus, or ferry.

6.3 Conclusions

The work described in this section confirmed the existing base ridership estimates developed in the 2015 BQX Study, using an existing mode choice model developed for the East River Ferry, and based on JTW data contained in the CTPP. The analysis also developed a separate estimate of future growth in the corridor from the initial estimates carried out in the 2015 BQX Study.

A more detailed analysis is needed to better understand the following issues:

- Sensitivity factors related to connecting subway and ferry proximity
- The effects of various transfer policies on ridership
- Coordination with any ongoing or future development initiatives

Table 6-10: Full Origin-Destination Matrix

	Astoria	Ravenswood	Long Island City	Greenpoint	Greenpoint - South	Williamsburg - North	Williamsburg - Central	Williamsburg - South	Navy Yard
Astoria	232	154	368	15	13	3	0	0	27
Ravenswood	112	116	68	1	0	0	0	0	6
Long Island City	9	34	10	0	0	11	4	0	2
Greenpoint	0	40	11	28	2	0	0	29	80
Greenpoint - South	0	1	2	7	14	16	3	32	44
Williamsburg - North	0	13	27	14	3	23	11	13	42
Williamsburg - Central	1	24	23	12	2	39	13	0	62
Williamsburg - South	35	6	60	32	7	15	2	78	86
Brooklyn Navy Yard	11	19	26	11	55	6	6	23	155
DUMBO	0	8	0	0	0	0	0	1	6
Brooklyn Heights	0	6	41	10	1	10	4	8	40
Red Hook - North	0	17	17	0	6	22	8	3	87
Red Hook - South	0	6	0	23	6	5	5	12	143
Sunset Park	5	28	7	80	7	21	16	24	173
Sunset Park Terminal	41	51	56	78	13	15	1	12	196
Total	**445**	**523**	**717**	**312**	**129**	**187**	**75**	**234**	**1148**

	DUMBO	Brooklyn Heights	Red Hook - North	Red Hook - South	Sunset Park	Sunset Park Terminal	Manhattan	Other Brooklyn	Other Queens	Total
Astoria	51	91	1	0	0	2	12401	208	2197	15,762
Ravenswood	11	39	0	0	3	7	3570	117	1008	5059
Long Island City	14	26	0	1	4	2	2305	0	109	2531
Greenpoint	16	71	11	38	56	15	3142	546	183	4269
Greenpoint - South	27	38	5	45	4	5	3209	337	150	3939
Williamsburg - North	29	17	0	7	5	0	2788	182	50	3227
Williamsburg - Central	104	49	0	0	13	3	3205	397	220	4165
Williamsburg - South	54	64	13	10	52	65	1247	617	208	2650
Navy Yard	54	214	13	70	70	45	5224	1083	370	7455
DUMBO	35	33	8	18	48	0	2264	73	36	2532
Brooklyn Heights	63	180	21	19	13	32	7796	403	143	8789
Red Hook - North	76	154	61	71	42	9	4185	598	47	5404
Red Hook - South	117	243	37	82	92	34	4934	870	123	6733
Sunset Park	117	374	63	95	557	243	5757	2503	357	10,425
Sunset Park Terminal	108	296	35	117	370	145	4924	2113	572	9142
Total	**877**	**1888**	**269**	**573**	**1327**	**605**	**66,952**	**10,048**	**5772**	**92,081**

7.0 ECONOMIC DEVELOPMENT/VALUE CAPTURE

7.1 Review of 2015 BQX Study Assumptions and Methodology

As a part of the Rapid Assessment related to evaluating fiscal and economic impacts, NYCEDC requested a review and testing of certain assumptions used in the property tax model developed for the Friends of the BQX. That model estimates property tax revenues, over a 40-year period, associated with streetcar/LRT system proposed in the 2015 BQX Study. The model calculates increased property taxes, both those associated with existing and yet-to-be developed properties, in ½-mile radius geography around stations, also referred to below as "buffer areas."[3]

The following sections more completely discuss the assumptions, methodology and results of the original economic benefit analysis completed under the 2015 BQX Study, and the adjustments made to that methodology and the base model during this Rapid Assessment.

7.1.1 Assumptions and Methodology of the 2015 BQX Study Benefit-Cost Analysis and Base Model

The 2015 BQX Study benefit-cost analysis was based on a comparison of the system's costs, both capital related to laying of tracks and other infrastructure work as well as the streetcars themselves, compared to the incremental property tax revenues generated as a result of the transportation investment.

For the calculation of tax impact from yet-to-be-developed property in the buffer areas, forward historic growth rates were applied, by neighborhood[4], to obtain baseline new annual square footage. This approach assumes that New York City's demand for residential and commercial property will continue to grow linearly, on average, at historic rates based on 11 years of data (2004 to 2015), which included a significant period of economic recession. In addition to the ½-mile premium, an 8% increase in the value of new development (the transit premium) and all of the value associated with the 5% immediate increase in development and a 5% increase in the overall pace or rate of development was assigned to the streetcar.[5]

In calculating development capacity in future years, the original analysis assumed that existing zoning constraints were in place, or in other words, there would be no rezonings to increase allowable square footage for development and that development potential was in essence "capped." The term "capped" appears throughout the analysis and is contrasted with the term "uncapped," which means growth that is not constrained by zoning.

[3] Increase in property values associated with transportation improvements can be viewed as the capitalized ridership benefits associated with that improvement. A portion of these private capitalized benefits accrues to municipalities in the form of increased property taxes. The benefit-cost analysis did not take into account other municipal benefits including potential income or sales tax impacts associated with increased employment due to the streetcar.

[4] Historic growth rates are calculated in 11 neighborhoods, defined by groupings of census tracts, along the alignment.

[5] In the first year after the streetcar is announced, for the purposes of this analysis, it is assumed that new development of 5% of total square footage would result. This 5% increase may likely occur over a period of several years. Every year after the first year, the historic growth rate is increased by 5%.

The 2015 BQX Study presented a property tax revenue estimate for the proposed 17-mile corridor, including the Downtown Brooklyn shuttle, totaling $3.7 billion[6].

Other inputs to the original tax model are as follows:

Table 7-1: Inputs to Original Tax Model

Input	Assumption
Tax Classes	2 and 4
Transit Premium	8%
AV Growth Rate	3.5%
Stream 2 Baseline Development Growth Rate	By neighborhood
Stream 2 New Development Immediate Growth in Development	5%
Stream 2 Increase in Pace of Development	5%
421a Program Participation	27.5%
ICAP Program Participation	50%
Discount Rate	6.25%
Year Impact Realized (in reality will be phased in over several years)	2017

7.1.2 Modifications to Base Model Assumptions for the Rapid Assessment

- Table 7-2 shows induced property tax estimates from the 2015 Study after modifications made to the model during this Rapid Assessment. Stream 1 is the additional tax value of BQX on existing properties; Stream 2 is the additional value of BQX related to new development. The modifications are as follows: Increase in the 421a participation rate from 27.5% to 50% for new development (Stream 2)
- Included the current properties participating in the 421a program and associated abatements (Stream 1)[7]
- Addition of Tax Class 1:1 to 3 Family Residences in Stream 1 (original model included only Tax Class 2: Multifamily, and Tax Class 4: Commercial)
- Removal of the Downtown Brooklyn spur from the analyzed geography or transit corridor
- Addition of 2015 PLUTO data to trend analysis
- Transit premium lowered from 8% to 2%-3.5%.
- Modified Assessed Values to reflect the maximum growth per year and existing exemptions

[6] The 2015 Study calculated this NPV at an inflated 6.25% discount rate.

[9] It is anticipated that the 421a program will be renewed.

[7] The 2015 BQX Study calculated this NPV at an inflated 6.25% discount rate.

Table 7-2: Tax Classes 1, 2 and 4 - 1/2 Mile Buffer

Revenue Generated: 40 Year NPV, 4.25% Discount Rate, Capped LIC, ($B)		
Transit Premium	**Segment**	**Total**
2%	Total Route	$2.439
3.5%	Total Route	$3.039

*Includes Tax Class 1, No Spur data, and 2015 data. Assumes 3.5% AV inflation over the period; 6.25% discount rate.

7.1.3 Conclusions and Recommendations

- Based on review and testing of the real estate impact model - with adjustments related to the 421a participation rate, inclusion of Tax Class 1, removal of the Downtown Brooklyn spur, and addition of 2015 data it is assumed that the project generate a minimum of $2.4B to 3.0B in incremental property tax revenue. In addition to financial feasibility, greater economic development of the corridor is an important consideration. As cited in the 2015 Study, hundreds of thousands of people of diverse incomes live and work in the study area. Adding transit can help the City retain and compete for residents and businesses, which can spur even greater growth.

8.0 GOVERNANCE

The City, as the owner of the project must make the final determination of the optimal governance structure as well as the funding and financing strategy that is put into place for capital and operating funding. The project delivery method to be applied in the design, construction and operation/maintenance of the system must also be assessed and determined by the City.

One possible structure was suggested in the 2015 BQX Study and reviewed for fatal flaws in the Rapid Assessment. Below is a summary of that approach:

- Creation of a Local Development Corporation (LDC) that would competitively procure a franchisee

- The franchisee would establish a Design Build Operate Maintain (DBOM) structure

- A separate LDC would be established to finance the project

- The financing LDC would enter into a funding agreement with the contracting LDC

- Further coordination with the City Corporation Counsel and involved agencies will be necessary to refine this approach.

9.0 PEER CITY RESEARCH

Peer streetcar and LRT systems were reviewed to identify best practices and lessons learned that would be applicable to the proposed system in Brooklyn and Queens. An overview of information available for key features from streetcar and LRT systems in the following international and U.S. cities is provided in Appendix:

- Barcelona, Spain;
- Dubai, United Arab Emirates;
- Jerusalem, Israel;
- Rio de Janeiro, Brazil;
- Toronto, Canada (including both legacy streetcar systems and proposed LRT system);
- Detroit, Michigan;
- Los Angeles, California;
- Seattle, Washington; and
- Washington, DC.

Key features that were examined included “hard” characteristics:

- System length;
- Number of stops;
- Alignment/ROW type;
- Vehicle technology and size;
- Snow removal;
- Utility interaction;
- Land use changes;
- Parking;
- Maintenance and storage yards; and
- Number of vehicles.

In addition, the following “soft” characteristics were examined:

- Construction cost;
- Operating cost;
- Source of funding;
- Ridership;
- Construction period;
- Headway;
- Travel time;
- Governance; and
- Fare characteristics.

10.0 CONCLUSIONS AND RECOMMENDATIONS

NYCEDC, NYCDOT and HDR prepared this Brooklyn-Queens Waterfront Streetcar/Light Rail Rapid Assessment. The overall conclusion is that the 2015 BQX study's conclusions were reasonable and form a good starting point for the development of a streetcar based transit system to support this dynamic section of the City.

The conclusions are organized as follows:

- Section 10.1 describes those areas where the Rapid Assessment confirmed or supported the analyses documented in the prior study
- Section 10.2 assesses potential issues identified during the Rapid Assessment
- Section 10.3 reviews project implementation and phasing options
- Section 10.4 summarizes the study's recommendations

10.1 Confirmed Findings

The Rapid Assessment identified a number of significant findings that confirmed or supported the analyses documented in the 2015 BQX Study. These include the findings that the alignment can support street-running rail infrastructure with some modifications to sections of the alignment; acceptable sites are potentially available to locate one or more vehicle maintenance and storage facilities; bridges along the alignment may have the structural capacity to support streetcar vehicle operations with some modifications; modern streetcars are the right vehicle technology given the geometric constraints posed by the street system; the concept of operations can be simplified with elimination of the Downtown Brooklyn Shuttle; operating and maintenance costs are reasonable; ridership forecasts are reasonable; and there is an opportunity to "self-finance" through value creation/capture. These findings are described in detail in the following sections.

10.1.1 Alignment Works With Some Modifications

The review of the BQX alignment assessed the following elements:

- Right-of-way, curve radii, grades
- Bridges and utilities
- Traffic, parking, and curbside impacts
- Environmental issues

Our preliminary findings are:

- Vertical curvature and grades should not be a problem
- Vertical clearances in the vicinity of elevated structures need to be confirmed but should not be a problem
- Dedicated travel lanes are preferred to improve service reliability. Having significant portions of the streetcar operating in mixed traffic would slow travel speeds.
- The Downtown Brooklyn Shuttle duplicates existing transit, and would be difficult to operate reliably with a timed transfer at the mainline.

Alignment alternatives for areas with difficult curvature or slower operations will be addressed in the in-depth assessment.

10.1.2 Potential Sites Identified for a Vehicle Maintenance and Storage Facility

Vehicle maintenance and storage facility requirements and site selection criteria were developed in order to assess potential development sites. It was estimated that one or more facilities would be required to support a fleet of 50 to 60 vehicles.

10.1.3 Bridges Appear Capable of Supporting Streetcars with Modifications

Bridges along the corridor (listed below) were reviewed during the Rapid Assessment. Existing bridges may have the structural capacity to support streetcar operations with some modifications, but require further study. New streetcar bridges may be constructed as an alternative should the existing bridges require extensive modification.

- Pulaski Bridge over Newtown Creek
- Hamilton Avenue Bridge over the Gowanus Canal

10.1.4 Streetcars are the Right Vehicle Technology

As part of the Rapid Assessment, streetcars and light rail vehicles were assessed in terms of a number of factors, including vehicle dimensions and operating specifications (e.g., length, width, turning radius, weight), available propulsion technologies and systems, and the requirements for the vehicle maintenance and storage facility.

The Rapid Assessment determined that:

- Streetcar sized vehicles are appropriate for the proposed service and route.
- Hybrid wire-free and overhead catenary system (OCS) operation should be considered based on environmental requirements and life cycle cost.
- Most off-wire systems require traction power substations and re-charging locations similar in spacing to conventional OCS traction power substations.
- Hydrogen fuel cell streetcars are not commercially mature, and are not expected to prove viable in the very near future.

10.1.5 Concept of Operations Simplified With Elimination of Downtown Brooklyn Shuttle

The Rapid Assessment reviewed the proposed Downtown Brooklyn Shuttle and recommended that it be eliminated to simplify the concept of operations. A timed transfer operation in DUMBO as originally conceived would be extremely difficult to operate reliably given the mix of dedicated, semi-exclusive, and shared rights-of-way. In addition, the Downtown Brooklyn Shuttle duplicates existing transit over much of its route.

10.1.6 Operating & Maintenance Cost Estimates and Plan are Reasonable

The Rapid Assessment reviewed the 2015 BQX Study operating plan and O&M cost estimate. The operating plan is reasonable given the conceptual definition of the project to date and will be refined in the in-depth assessment. Schedule adjustments may be needed to peak and off-peak period definitions and frequencies, and to the recovery/layover time at the end of line stations. Travel time and operating speed adjustments may be needed to account for traffic signals and bridge openings. The spare vehicle fleet and operations staffing will be re-examined.

The 2015 BQX Study estimates annual O&M cost at $26 M. The Rapid Assessment estimates the annual O&M cost at $31.2M. A comparison to other U.S streetcar and light rail systems was completed.

- BQX O&M reflects $0.8miillion per track mile, within low end of range of U.S. modern streetcar systems ($0.7M-$1.0M) and comparable U.S. light rail systems ($0.8M-$1.2M).
- BQX O&M reflects $0.5M per vehicle, lower than U.S. modern streetcar systems ($0.8M to $1.1M) and within low end of range of comparable U.S. light rail systems ($0.5M-$0.7M).

10.1.7 Ridership Forecast Appears Reasonable

The Rapid Assessment reviewed the 2015 BQX Study base year ridership forecasts, and determined that they are reasonable for this stage of conceptual planning. Ridership represents roughly 60% capture from corridor bus ridership. Current year (2015) potential ridership captured by BQX increased by 10%-20% given the significant portion of exclusive right-of-way and the increased speeds of the BQX. The Rapid Assessment estimates the 2035 daily ridership to be 48,900 and annual ridership to be 15.2M resulting in annual revenue of $26.7M.

10.1.8 Potential to “Self-Finance” Through Value Capture

The Rapid Assessment confirmed that the BQX project has the potential to fund the proposed level of infrastructure with value capture.

10.2 Potential Issues

In the Rapid Assessment, potential issues were identified that need significantly more study. These include utility challenges, potential public concerns regarding parking and traffic and more definition for capital cost estimation as described in the following sections.

10.2.1 Utility Challenges

The Rapid Assessment has reviewed NYCDEP water and sewer plans and categorized the streets along the potential alignment as typical (minimal) conflicts, moderate conflicts, and major conflicts based on the width of the roadway, number of utilities, and sizes of utilities.

10.2.2 Capital Costs Need Better Definition

The Rapid Assessment included a high-level review of the capital cost estimate within the 2015 BQX Study. The overall estimate appears reasonable for this conceptual level, but more detailed review is required. The Rapid Assessment identified some areas of risk in the $1.7B BQX estimate. The 15% contingency applied in the 2015 Study estimate appears low for this conceptual level of design, and a 30% contingency is recommended. Timing and escalation need to be defined. Based on the Rapid Assessment, the preliminary conceptual capital cost for a 16-mile system is estimated to be about $2.5B. All capital costs assumptions require further detailed analyses.

10.3 Phasing Options

The BQX project may be built in phases dependent on project budget, corridor construction conditions, and other factors. The location of vehicle maintenance and storage yard facilities is a critical factor in the physical definition of construction and operating phases. Further assessment of phasing opportunities is needed. A successful initial operating section, or starter service, would reduce initial implementation and operating costs, as well as implementation time, while demonstrating the benefits of streetcars. Construction could then continue without interruption on incremental extensions, which could help manage costs and impacts.

10.4 Recommendations

Based on the results of the Rapid Assessment, it is recommended that the in-depth assessment for the Brooklyn-Queens Waterfront Streetcar/Light Rail focus on the following project elements:

- Assess alignment options to identify a single preferred alignment
- Investigate private utilities and telecommunications infrastructure to refine the construction cost estimate
- Prioritize potential initial operating section based on ridership/revenue potential, value creation, and cost. Develop a comprehensive ridership model to evaluate alignment alternatives and initial operating sections
- Refine and test the value creation model to evaluate alignment alternatives and initial operating sections
- Develop an operating plan for the streetcar to facilitate ridership forecasting and determine fleet requirements and vehicle maintenance and storage facility requirements.

- Assess traffic operations, parking impacts, and goods movement/delivery requirements to inform alignment decisions
- Conduct detailed bridge studies to confirm adequacy of bridges and develop required modifications
- Develop street design alternatives for specific streets within the alignment.
- Analyze adequacy of existing and future power capacity along the corridor and identify steps to address any capacity shortfalls

11.0 APPENDIX

Table 11-1: Peer City Overview – Hard Characteristics

	Project "Hard" Characteristics														
	System Name and Year Opened	**Length (miles)**	**Number of Stops**	**Alignment Type/Right-o-Way (ROW) Characteristics**	**ROW range of dimensions (feet)**	**Vehicle Technology**	**Vehicle Dimensions (feet)**	**Snow/Ice Management Solutions**	**Utility Interaction**	**Land Use Changes**	**Parking Solutions**	**Does Peer City have a BRT system?**	**Maintenance Yard Size**	**Number of Vehicles**	**Key Lessons Learned**
Barcelona, Spain	The TRAM; 2004	18.1	56	*	*	*	L: 105 W: 8.2	*	*	*	One dedicated parking garage	*	*	41	
Dubai, United Arab Emirates	Dubai Tram (Phase 1); 2014	6.6	11	Separated & Mixed	*	Ground electric cables	L: 144.6	NA	*	*	*	*	*	11	
Jerusalem, Israel	Red Line (Existing opened: 2012; Extension opening scheduled: 2018)	Existing: 8.6; After extension: 13	Existing: 23; After extension: 35	Majority of system is in exclusive ROW adjacent to travel lanes. Within the City Center area, there is a stretch of approximately 3 Km in a pedestrian only area (Jaffa Street).	Information currently not available	Catenary (ALSTOM CITADIS Model 302 100% low-floor five-module units. All axles are driven to handle up to 9% inclines.)	L: 106.3 W: 8.7 H: 10.5	NA	The LRT is constructed in two phases, Infra 1 and Infra 2. Infra 1 consists of all utility relocations and associated civil work such as roads and sidewalks, lateral OCS poles foundations, retaining walls, trees and urban furniture. Infra 2 is the track work and systems (power supply, low voltage, overhead cable, railways signaling) work.	Unknown	Parking removal was not mitigated.	Yes	Existing facility has storage for 46 cars with capacity to add additional storage for 28 cars. The Neveh Yaakov facility is planned as part of the northern Red Line extension and is located approximately 500m north of the terminal station. This facility would be a car storage facility only. Exact size is to be determined.	46	Vehicle includes features related to security such as bulletproof window, which makes the vehicle heavier than a standard type low-floor car.
Rio de Janeiro, Brazil	Veiculo Leve Sobre Trilhos (VLT); Under construction 2016 completion (Projected)	17.4	32	Separated & Mixed		Off-wire (energized third rail and battery)	L: 144.4 W: 8.7 H: 12.5	NA				Yes		32 trains (7 articulated modules each)	
Toronto, Canada (Legacy Streetcar)	Streetcar (legacy)	67	424	Mixed & Semi-Exclusive		ALRV/CLRV/Flexity		Snow clearing on streetcar routes running in mixed traffic is handled as part of the City's roadway snow clearing operations. Cleaning out of special track work, including de-icing points, is handled manually by TTC crews as required (per SOP for ploughing/spreader).	When temporary access to utilities across tracks is required, streetcars are rerouted (where possible) or replaced by buses. Due to the age of these lines, most utilities other than City Sewer and Water were constructed after the streetcar, and are therefore already outside of the track bed footprint.	*	*	Yes	Three existing maintenance and storage facilities: Harvey Main Shop, Russell Carhouse and Roncesvalles Carhouse. A new facility (Leslie Barns) is currently under construction (and partially in service) and will accommodate 100 of the new Flexity LRV's.	*	

	Project "Hard" Characteristics														
	System Name and Year Opened	**Length (miles)**	**Number of Stops**	**Alignment Type/Right-o-Way (ROW) Characteristics**	**ROW range of dimensions (feet)**	**Vehicle Technology**	**Vehicle Dimensions (feet)**	**Snow/Ice Management Solutions**	**Utility Interaction**	**Land Use Changes**	**Parking Solutions**	**Does Peer City have a BRT system?**	**Maintenance Yard Size**	**Number of Vehicles**	**Key Lessons Learned**
Toronto, Canada (LRT)	Toronto Light Rail Transit Projects; 2020 completion (Projected)	26.7	26	Semi-Exclusive (automobile may only cross the tracks at specific intersections, but otherwise do not share traffic lanes.)	*	Flexity	*	Snow clearing on semi-exclusive right-of-ways is handled by TTC per SOP for ploughing/spreader.	Relocation of all utilities beyond the track bed footprint to avoid impacts to rail service when access to utilities (open cuts) is required. The terms of any easements for utilities crossing the path of the tracks describe the rights and obligations of each party and may dictate the timing and methods used, as well as the compensation, if any.	*	*	Yes	*	*	
Detroit, MI	M-1 RAIL: 2016 completion (Scheduled)	3.3	20	*	*	Catenary and off-wire	L: 66 W: 8.5	*	*	Land acquisition needed for maintenance yard	On-street parking removed in one direction	*	3 acres	6	
Los Angeles, CA	LA Streetcar (Scheduled opening: 2020)	3.8	16-23	Mixed (with 300 feet of separate ROW)	11-13	*	*	NA	*	No	*	Yes	No publically owned land along the streetcar route, with high development activity. It is assumed that the MSF will be the ground floor of a high-rise development. They will not have employee parking, or maintenance of way on-site—just streetcars and shop.	7-8	

	Project “Hard” Characteristics													
	System Name and Year Opened	**Length (miles)**	**Number of Stops**	**Alignment Type/Right-o-Way (ROW) Characteristics**	**ROW range of dimensions (feet)**	**Vehicle Technology**	**Vehicle Dimensions (feet)**	**Snow/Ice Management Solutions**	**Utility Interaction**	**Land Use Changes**	**Parking Solutions**	**Does Peer City have a BRT system?**	**Maintenance Yard Size**	**Number of Vehicles**	**Key Lessons Learned**
Seattle, WA	South Lake Union segment (opened 2007); First Hill segment (scheduled opening 2016)	South Lake Union: 1.3: First Hill: 2.5	South Lake Union: 11; First Hill: 10	Mixed with small section of exclusive right of way through a park. South Lake Union will be mostly transit-exclusive in March 2016 to accommodate increase in bus service	11 (minimum)	South Lake Union: Catenary; First Hill: Outbound (uphill) trains are on wire, inbound (downhill) trains are off-wire. Vehicles feature Li-ion battery OESS. Thanks to stellar battery performance, additional off-wire operations on outbound trains being considered to increase speed though streetcar/trolley OCS intersections.	L: 66 W: 8 H: 11	TBD. No switch heaters since it does not snow often in Seattle	Utility relocation avoided as much as possible. Installed girder rail embedded track slabs that are 8 feet wide and 12-16 inches thick (depending on soil conditions), reinforcing cage is incorporated into the design with the intent that the track slab would act as a 'structural bridge' allowing utility work to occur under the track slab while maintain service. This feature has never been employed; the City of Seattle has felt it posed too much risk so they stop streetcar service anytime they have to work under the track slab.	NA	*	Yes	South Lake Union: 2 tracks, up to 6 vehicles; First Hill: 3 tracks, up to 8 vehicles	South Lake Union: 4; First Hill: 6	Streetcar design tried to avoid utility relocation as much as possible, frequently shifting the track alignment and even reverse running to avoid them. This combined with mixed use running has severely degraded streetcar service to the point that it is faster to walk than take the streetcar.
Seattle, WA	Center City Connector (scheduled 2019)	1.25	5	Center-lane, exclusive and transit-only. Mimics light rail.	10 (minimum)	Off-wire	L: 66 W: 8 H: 11	TBD. No switch heaters since it does not snow often in Seattle	*	TBD	Parking removal minimized with use of tunnels. Frequent public outreach to message the public about why taking parking in this area makes sense and the streetcar service will replace the need to drive a car. On a bigger picture the mayor and transportation director frequently mention in the press how much garage parking capacity the City of Seattle has.	Yes	Will require expansion of South Lake Union or First Hill yard.	TBD	The City of Seattle is no longer interested in the above-described approach to utilities for its initial two streetcar segments. The Center City Connector segment will be semi-exclusive running (train only lane) they will have to take parking and relocate more utilities, thereby driving up costs.

	Project “Hard” Characteristics													
	System Name and Year Opened	**Length (miles)**	**Number of Stops**	**Alignment Type/Right-o-Way (ROW) Characteristics**	**ROW range of dimensions (feet)**	**Vehicle Technology**	**Vehicle Dimensions (feet)**	**Snow/Ice Management Solutions**	**Utility Interaction**	**Land Use Changes**	**Parking Solutions**	**Does Peer City have a BRT system?**	**Maintenance Yard Size**	**Number of Vehicles**	**Key Lessons Learned**
Washington, D.C. – Union Station to Georgetown	Rapid Streetcar. In Project Development	3.5	9	1 mile mixed; 2.54 miles separated (median operation)	Varies	Rigid Catenary On Board Storage. Goal is wireless in the Old City Planning area	L: 80 W: 8	Not determined for US/GT. See H Street	H Street utility interface rules	None proposed	On-street parking removal in some areas. Bus stops shared with streetcar stops in some areas.	There are forms of BRT in the DC region	8 acres storage only	9 vehicles	NEPA Coordination is critical. PMC may be needed. Early coordination with utility companies Realistic cost estimate Project needs champion Exclusive or separated guideway needs to be considered. ITS is critical.
Washington, D.C. – H Street Benning Road Streetcar	H Benning Streetcar; Projected opening February 2016	2.5	There are twelve (12) streetcar platforms on the H Benning Streetcar Segment. Eight (8) are one-direction curbside platforms with four (4) in the eastbound and four (4) in the westbound directions on H Street NE. Three (3) are bi-directional median platforms on Benning Road NE and one (1) is a bi-directional (one sided) platform atop the Hopscotch Bridge.	Shared, Exclusive	Shared ROW varies based on corridor.	DC Traction Power, Substations, and OCS distribution for pantograph. OCS is auto tensioned	L: 66 W: 8 (Inekon Skoda Tram & United Streetcar Tram)	None: Switch heaters were considered but were too much investment for in street running system. Special trackwork is maintained and treated through freezing events. Corridor is maintained, treated and plowed like a typical corridor	Utility Standards of Practice; Track Allocation process; Roadway worker safety training process; Streetcar Operator integrated in existing ROW permitting process-- includes track allocation and roadway worker safety training.	None	Parking was not eliminated; however parking code was changed to ticket for “blocking the box”	No	2+ acres; 15 vehicle storage capacity; 30,000-square foot facility with offices, car wash, and training center (for public use)	6 vehicles	

Table 11-2: Peer City Overview – Soft Characteristics

	Project "Soft" Characteristics													
	Construction Cost (US dollars) - Estimated vs. Actual	**Annual Operating Cost (US dollars) – Estimated vs. Actual**	**Funding Streams – Construction**	**Funding Streams – Maintenance**	**Ridership**	**Construction Period (years)**	**Headways (minutes)**	**Travel Time – Estimated vs. Actual (minutes)**	**Governance (City/Private/Transit Authority)**	**Economic Development Impact (US dollars)**	**Fare subsidies (Yes/No)**	**Integrated Fare System (Yes/No)**	**Farebox Recovery Rate**	**Key Lessons Learned**
Barcelona, Spain	*	*	*	*	16 million/year	7	*	*	Owner: Autoritat del Transport Metropolità (Public) Operator: TRAM (Private consortium)	*	*	Yes	*	
Dubai, United Arab Emirates	*	*	*	*	*	*	Peak: 6 Off Peak: 8	42 (actual/round trip)	Owner and operator: Roads and Transport Authority (Public)	*	*	Yes	*	
Jerusalem, Israel	$1.5 billion (estimated)	TBD	Federal	Federal	140,000/day	Existing: 4; Extension: 5	Peak: 5	*	The Jerusalem Transport Management Team (JTMT) was established by the Government of Israel (GOI) and Jerusalem municipality to oversee the planning, design, construction and operation of the Jerusalem transit system. A private concessionaire runs the day-to-day operation. The federal government monitors the JTMT.	*	*	No – different mode fares using same smart card	*	
Rio de Janeiro, Brazil	$450 million (estimated)	*	Federal ($245 million); P3	*	300,000/day	*	2.5 – 10	*	Operator: Companhia de Desenvolvimento Urbano da Região do Porto do Rio de Janeiro (Cdurp) (Public Authority)	*	*	Yes	NA	
Toronto, Canada (Legacy Streetcar)	NA	NA	NA	NA	*	NA	2-12 (minimum)	*	Toronto Transit Commission (City)	NA	*	Yes	*	

Toronto, Canada (ECLRT)	$6 billion (estimated)	*	*	*	2031 Projections: Eglinton Crosstown line: 5,400/hour; Scarborough line: 10,000/hour; Sheppard East line: 3,000/hour; Finch West line: 2,800/hour	5	2 (minimum)	*	Owner: Metrolinx (State); Operator: Toronto Transit Commission (City); Built and maintained by a concessionaire for 30 years	*	*	Yes	*	

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