MIAMI RIVER TUNNEL FEASIBILITY STUDY

Miami River Tunnel Feasibility Study

Executive Summary

Miami-Dade TPO GPC VI-6

Prepared by:

ATKINS

August 2017

TPO

Miami-Dade Transportation Planning Organization

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1.0 Introduction

This report documents the investigation of the feasibility of constructing a tunnel facility connecting Brickell Avenue and Biscayne Boulevard under the Miami River in Downtown Miami. This section of the report introduces the background for this study and describes the study area.

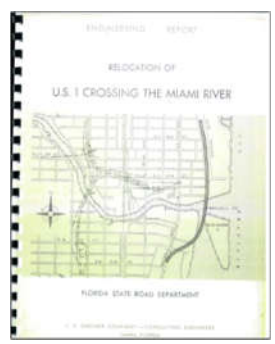
1.1 Study Background

There have been considerable concerns expressed in recent times over continuing and mounting congestion near the existing Brickell Avenue bridge crossing over the Miami River in Downtown Miami. The recurring surface street congestion associated with the bridge openings has led to extensive deliberations on this topic involving several governmental entities and agencies as well as stakeholder interests. This coordination is seeking short-term betterment of traffic operations in conjunction with vessel movements along the river, in relation to published Federal bridge curfew regulations governing the opening of the bridges for marine traffic.

The Miami-Dade Transportation Planning Organization commissioned this study of a tunnel facility under the Miami River from a long-term solution perspective to examine the feasibility of a tunnel facility under the Miami River in the vicinity of Brickell Avenue and Biscayne Boulevard. Such a tunnel would provide relief to traffic using the Brickell Avenue bridge, and lessen the severity of congestion near the bridge. The traffic movements through the tunnel would be unimpeded by marine navigation.

The specific focus of the study was to identify alternatives that were technically feasible in regard to geometric alignment and construction method. While the study touches upon environmental and traffic circulation elements associated with a tunnel in this area, those elements were limited in their scope. The primary mission was to develop conceptual tunnel configurations that could be implemented, and that could be further investigated in subsequent more detailed studies.

As a frame of reference, in 1964 the Florida Department of Transportation conducted a study of both bridge and tunnel options connecting Biscayne Boulevard to Brickell Avenue. The 1964 construction cost estimate for the high-level bascule bridge was $4.8 million with right-of-way cost of $3.5 million, for a total capital cost of $8.3 million. For the tunnel option, the construction cost estimate was $16.4 million, with right-of-way cost of $4.3 million, for a total capital cost of $20.7 million.



1.2 Study Area

The project study area is bounded on the north by NE 6th Street, on the west by the Metrorail line, on the south by SE 13th Street, and on the east by Biscayne Bay. The targeted alignment for a tunnel was a connection between the Brickell Avenue and Biscayne Boulevard corridors, but the study area was defined to encompass a larger influence area. A project location map is depicted in **Figure** 1-1.

Figure 1-1 Study Area Map

2.0 Existing Conditions

Cataloguing the existing conditions provides context for the study, setting the foundation for the feasibility analysis. Described in this section are general corridor characteristics, cultural features, natural and biological features, roadway characteristics, and bridge characteristics.

2.1 Corridor Characteristics

The study area setting is likely the most complex within the state of Florida for developing a major infrastructure project. The study area is characterized by a set of distinguishing characteristics, including:

- The epicenter of Florida high-rise development with announced projects topping 80 stories, and the most costly riverside properties topping $100 million per acre ($230/square foot) in land cost.
- Dozens of high rise projects in the development pipeline: just completed, under construction, in planning, or proposed.
- A dramatic transformation of Downtown Miami and Brickell from an employment destination to a mixed use, live/work/play environment with a large residential population.

At the same time, the study area is denoted by other features that complicate the development of a major infrastructure project such as the proposed tunnel project, including a congested street environment; several sensitive land use sites including parks, historic sites, public walkways; limited width street rights-of-way; and numerous property access points for high-density land developments. These circumstances contribute to several challenges to constructing such a major infrastructure project, including, maintenance of traffic; mitigation of construction disruption; constraints to construction for the working area, staging area, and construction site access and egress for workers, materials, and waste products; and avoidance of right-of-way impacts to sensitive or expensive properties.

Figure 2-1 illustrates the high-density setting of the study area. There is a high concentration of Commercial/ Office land uses (red) in the study area. Brickell Key is almost entirely residential. The land use north of the Miami River is more diverse with a mix of residential, commercial/ office, institutional, governmental and parks/open space. The future land use north of the Miami River is predominately low-density restricted commercial. The future land use south of the Miami River is almost entirely restricted commercial. Other common future land uses designation are public parks and recreation.

The study documents community services present within the study arear, demographic profiles, housing, and income. Population in the study area has been trending up significantly, with 4,049 people in 1990 expanding to 21,661 people in 2015. There are 10,839 households with an average of 1.69 persons per household.

Figure 2-1 Representative High-Rise Projects

Mobility elements within the study area include Metrobus transit services, Metromover, City of Miami trolley service, as well as bicycle and pedestrian facilities, some of which operate over the existing Brickell Avenue Bridge. Also, there are proposed premium transit service improvements in the planning phases.

2.2 Cultural Features

There are several culturally significant sites, including 12 archaeological sites, three historic bridges, nine resource groups, and 289 historic structures within the study area. One archaeological site, the Miami Circle at Brickell Point, is listed in the National Register of Historic Places and has been designated a National Historic Landmark (NHL). The property containing the Miami Circle at Brickell Point (8DA12) was purchased by the State of Florida. One of the historic bridges within the study area is the Brickell Avenue Bridge which has not been evaluated for NRHP eligibility by the State Historic Preservation Office. There are identified historic structures, historic districts, and other features which should be reviewed in any further project study. There are also numerous park and recreational facilities as well as trails, greenways, and Section 4(f) and Section 6(f) historic resources which will require further review.

2.3 Natural and Biological Features

Natural features include wetlands, water quality and surface waters, floodplains, aquatic preserve/outstanding Florida waters, and coastal zones. These features were inventoried and will need further analysis if affected by the project. Biological features include wildlife and their habitat along with essential fish habitat. The study provided a summary of these aspects which will need to be addressed, including a preliminary review of potential contamination sites. Traffic noise will need to be considered for the entire project limits with attention to the areas in proximity to the tunnel openings if sensitive receptors are nearby. Construction vibration will also need to be considered in regard to the methods to be used for tunnel construction. The two navigable waterways in the study area are the Miami River and Atlantic Intercostal Waterway. The Miami River was dredged approximately 10 years ago to its Federally authorized channel depth of –15 feet mean low water (MLW).

2.4 Roadway Characteristics

This section provides details on the roadway features within the project area. Details include a narrative description and examples of typical sections, functional classification, and other existing roadway conditions such as drainage, signalization, and lighting. Typical sections for Brickell Avenue and Biscayne Boulevard are shown in **Figures 2-2, 2-3 and 2-4**.

The functional classification of the roadways within and around the study area are displayed in **Figure 2-5.** The roadways displayed in green (minor arterial urban), red (principal arterial, other, urban), or blue (principal arterial interstate, urban) on the map are the roadways typical for freight traffic that traverse through the study area.

Figure 2-2 Brickell Avenue South of SE 8th Street

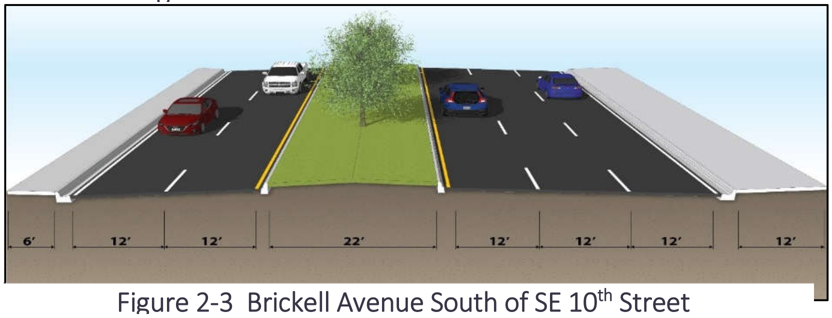


Figure 2-3 Brickell Avenue South of SE 10th Street

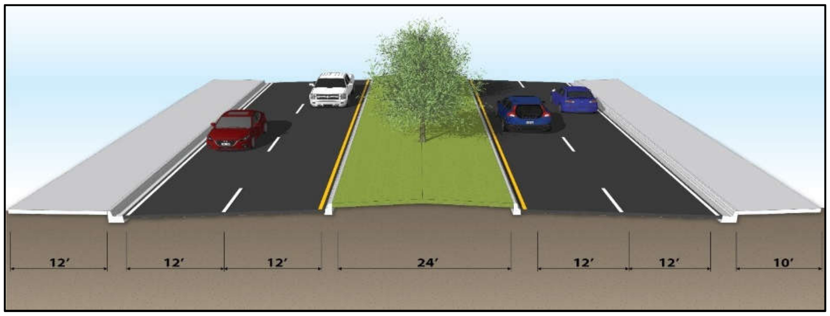


Figure 2-4 Biscayne Boulevard North of NE 2nd Street

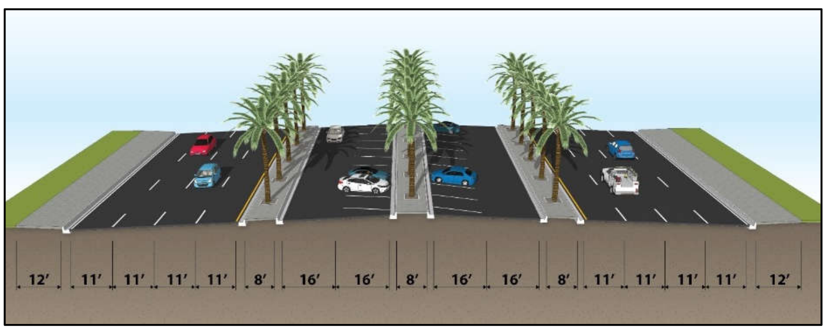


Figure 2-5 FDOT Functional Classification

The functional classification of a road is the class or group of roads to which the road belongs. As defined by the FHWA, the three main functional classes are arterial, collector, and local. Moreover, FDOT identifies roads classified as principal or minor arterial urban roadways.

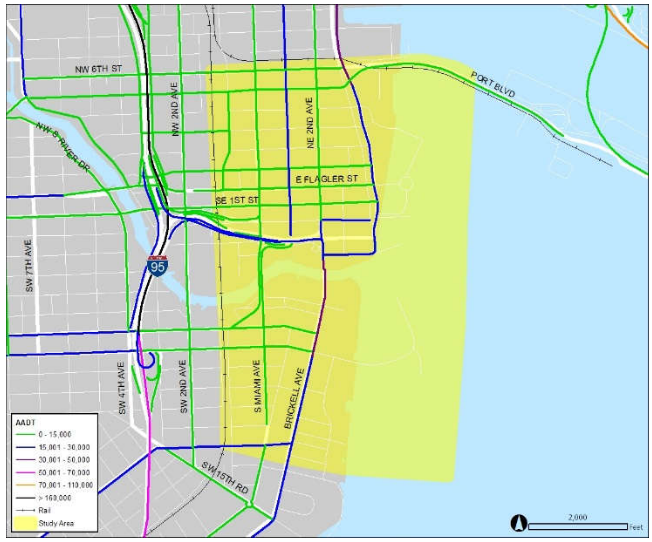
The Average Annual Daily Traffic (AADT) of a roadway is a general measure of how busy a road is based on the average volume of the roadway. The most recent FDOT results (2016) for the study area for are displayed in **Figure 2-6**. The roadways shown in green or blue have the lower volumes, whereas those shown in pink or black have higher volumes.

The existing right-of-way limits near and around the study area were identified. Except for Biscayne Boulevard, street rights-of-ways are relatively narrow.

Drainage within the project area is handled primarily by curb inlets that collect the roadway stormwater runoff and a closed pipe system that conveys the untreated stormwater directly to the Miami River. Runoff from the existing Brickell Avenue bridge and approaches falls through the grating of the lift spans or sheet flows to scuppers located along the outside edges of pavement and discharges directly to the Miami River. The project area is located entirely within the tidal Biscayne Bay drainage basin.

The existing utilities along the corridor include American Traffic Solutions, AT&T, Comcast, Miami Dade County Public Works and Traffic, Fiberlight, FDOT District 6 ITS, FPL, Fibernet, FPL Trans., Hotwire, Level 3, MCI, Miami Dade Water and Sewer, TECO, CenturyLink, XO Communications, AT&T Distributions, Central Support Facility, Zayo Group, and Miami Dade Enterprise Technology Services Department.

Figure 2-6 Annual Average Daily Traffic (AADT), 2016



2.5 Existing Brickell Avenue Bridge

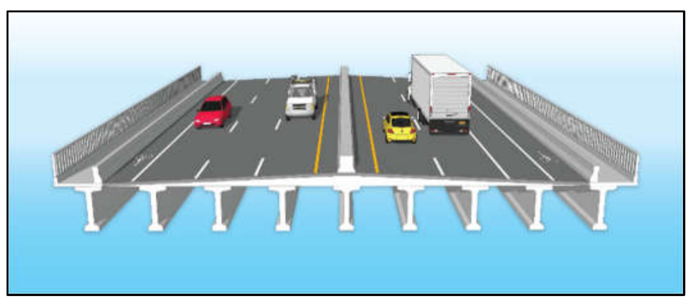
The original Brickell Avenue Bridge was built in 1929, and replaced in 1995 by the Florida DOT. This section provides details on the current bridge facility, bridge traffic volume, and bridge openings.

The Brickell Avenue Bridge was widened by one additional northbound lane in 2006 to reduce the traffic bottleneck through downtown. Presently, that northbound lane is striped for a bicycle lane and buffer. There are also barrier-protected pedestrian walkways on both sides of the bridge. With the 1995 reconstruction, the bridge was reconfigured to 6% grades on both sides to provide a higher river clearance when closed. There are approach roadway segments on both sides of the river channel on fill with retaining walls. The bridge approach structures are 118 feet long supported on 48-inch drilled shafts taken down to -45 feet below grade, and 50 feet long. The bridge bascule piers on both sides are 34-feet long and supported on 30-inch square piles. There are a pair of bascule leaves each 57.5 feet long for a combined length of 115 feet over the river channel. **Figure 2-7** displays a typical section of the Brickell Avenue Bridge.

According to the bridge plans for the 1995 replacement project, the average daily traffic on the Brickell Avenue bridge was 36,000. The Florida DOT Traffic Online website provides the following additional Average Annual Daily Traffic (AADT) volumes:

2016	37,000	**2011**	36,500
2015	36,500	**2010**	36,500
2014	34,000	**2005**	34,000
2013	36,500	**2001**	36,000
2012	34,000		

Figure 2-7 Brickell Avenue Bridge Typical Section



It is seen that the AADT volumes have been consistently in the 34,000 to 37,000 vehicles per day range for years. This is likely indicative of the capacity of the roadway network near the bridge being reached under peak hour demand when the bridge is locked down, with some traffic equilibrium being reached with the nearby Miami Avenue bridge given downtown travel patterns.

The Brickell Avenue bascule bridge opens its leaves according to Federally prescribed operation regulations, for vessels whose air draft exceeds the bridge clearance under tidally influenced water elevations, typically with a two-foot clearance margin. The bridge was required to open 4,990 times in 2010, according to a cited reference. According to bridge tender records reviewed for the Miami River

Freight Improvement Study being prepared by the Florida DOT presently for the Brickell Avenue bridge for the one-year period of July 2015 to June 2016, the bridge was opened 5,928 times. Note that bridge tender data includes only those vessel movements requiring the opening of a lift bridge, and not total vessel movements. This recent data is an increase over the 2010 figure of nearly 1,000 openings in approximately five years, or an increase of 18.8% overall, or about 3.5% growth per year compounded. A portion of this is likely due to lowered marine traffic during the Great Depression years.

2.5.1 Geotechnical Data

The subsurface conditions along the various study corridors are expected to be consistent with those found at the Brickell Avenue Bridge, the Metrorail and Metromover crossings of the Miami River, and the PortMiami Tunnel. These conditions must be considered to establish the feasibility of construction methods for the tunnel.

Several of the proposed tunnel alignments traverse under the approach spans of the Brickell Avenue bridge, and close to several Metromover piers along Biscayne Boulevard. The Brickell Avenue approach spans are founded on non post-grouted drilled shafts, and the Metromover piers in this area are founded on augercast piles. Both of these deep foundation systems achieve their load carrying resistance through side friction. The conceptual profiles of the tunnel achieve a minimum of 10 feet of clearance from the top of tunnel excavation to the as-built plan drilled shaft/augercast pile tip elevations. It is expected that this separation will have minimal effect on the resistance of these foundations.

3.0 Conceptual Facility Planning Factors

3.1 Roadway Design Criteria

The roadway design criteria used in the preliminary design of the project are those for federally-funded urbanized area facilities with a design speed of 35 mph. Other geometric design criteria for vertical and horizontal curvatures and other elements were defined in the study. It is assumed that neither pedestrian nor bicycle movements would be allowed within the tunnel, but the cross-section of the tunnel would include emergency walkways. Additionally, as for the PortMiami tunnel, movements of vehicles with hazardous cargos or oversize and overweight loads, would be prohibited from transit through the tunnel.

3.2 Roadway Typical Section Analysis

The development of alignment alternatives for this study was undertaken with several key assumptions:

- Provide an alignment connection between Biscayne Boulevard and Brickell Avenue:
- Provide two two-lane roadways:
- Avoid any right-of-way encroachments:
- Retain the existing Brickell Avenue Bridge in operation:

Roadway design criteria were applied to develop roadway typical sections. These typical sections were then compared to the Brickell Avenue setting to test compatibility, as Biscayne Boulevard has a much wider typical section. One of the core assumptions of the study was that a four-lane tunnel facility would be needed. These typical sections are shown in **Figures 3-1 and 3.2** for a four-lane rectangular tunnel and a four-lane twin bore tunnel.

Figure 3-1 RectangularTypical Section, 4-Lanes

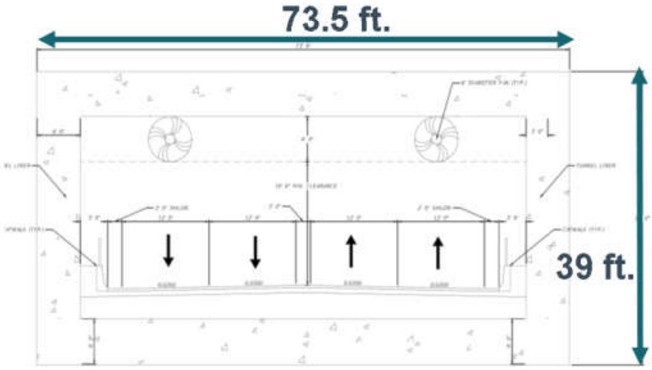
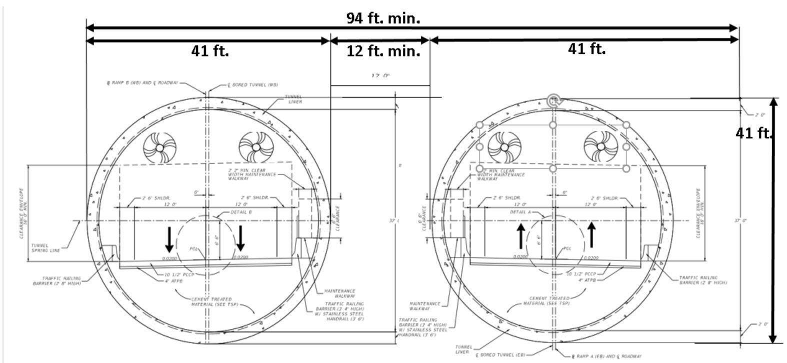


Figure 3-2 Twin Bored Tunnel Cells, 4-Lanes



These typical sections were then compared to the width of Brickell Avenue (approximately 100 feet). Biscayne Boulevard is much wider at 200 feet and does not pose the same constraint. A four-lane single-cell tunnel section with a nominal width of 76 feet with a center barrier would leave a 12-foot margin on either side (which would not accommodate a sidewalk and travel lane), and would place the construction zone relatively close to building foundations. Consequently, tunnel sections in a stacked configuration were developed. as shown in Figures 3-4 and 3-5.

The stacked tunnel configurations were found necessary due to lateral right-of-way constraints along Brickell Avenue and elsewhere.

Figure 3-3 Rectangular 2-Cell Tunnel, 4-Lanes, Stacked

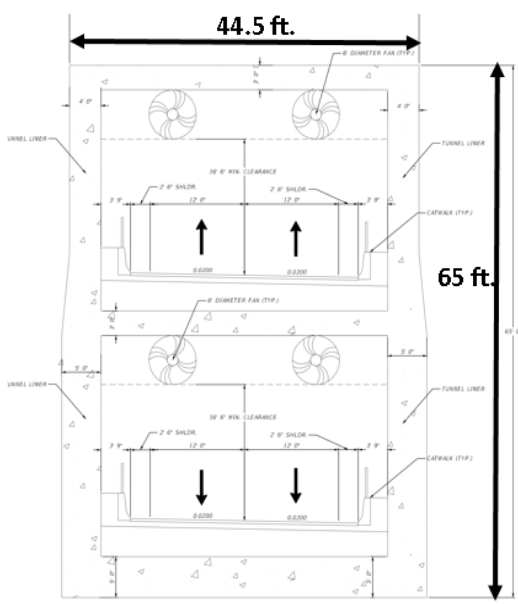
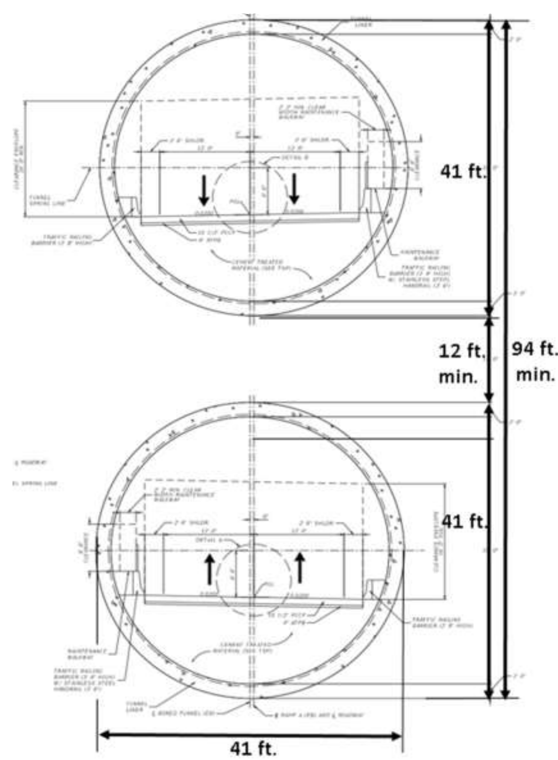


Figure 3-4 Stacked Bored Tunnels, 4 Lanes

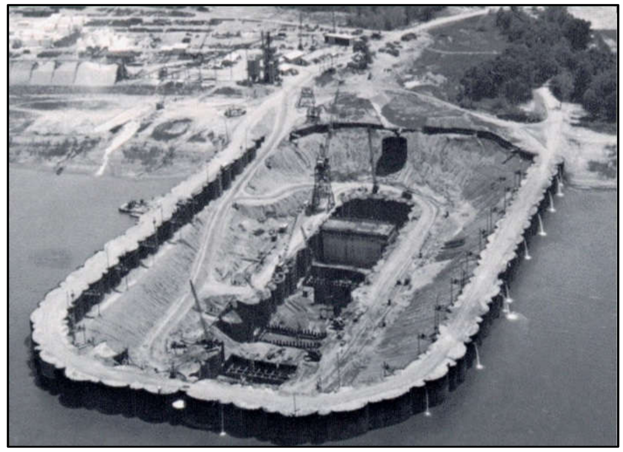


3.3 Tunnel Construction Technologies

The subsurface conditions in the area are considered soft ground. Appropriate methods of soft ground tunnel construction include: (1) cut-and-cover construction, (2) immersed tube tunnel construction, (3) bored tunnel using a tunnel boring machine, and (4) mined tunnel using the sequential excavation method. The following sections describe the feasibility of each construction method.

Cut-and-Cover Construction

Figure 3-1 Cut and Cover Construction



Cut-and-cover construction methodology provides a means to allow construction of the tunnel within an open dewatered pit, like that shown in **Figure 3-5**. The tunnel shell would consist of conventional reinforced cast-in-place concrete, cast in dry conditions. Due to limited space within the corridor right-of-way, the open pit would need to be bounded by walls to allow a vertical faced excavation, thereby minimizing the footprint of construction and allowing local access traffic to be maintained within the corridor. The walls will be subjected to significant hydrostatic pressures due to the permeability of the sand and limerock that will be encountered.

This methodology is problematic due to limitations in its working depth in relation to expected tunnel profiles, the narrow working area outside of the river bed, and interruption of marine traffic on the river. In conclusion, the cut-and-cover construction is not considered feasible for construction of the roadway approaches to the tunnel and the tunnel portals.

Immersed Tube Tunnel Construction

The immersed tube methodology for tunnel construction provides a means to construct the main shell of the tunnel off-site. Tunnel sections are pre-fabricated with end bulkheads, sealing them from water intrusion and allowing them to float. Immersed tube tunnel sections are typically about 300 feet in length. They are floated to the project site. Once properly positioned, the sections are lowered into a dredged trench to achieve the desired profile of the roadway within the tunnel**.** Once immersed, they are connected together, and the bulkheads are removed to form a continuous tunnel.

Figure 3-6 Positioning and Final Placement of Immersed Tube

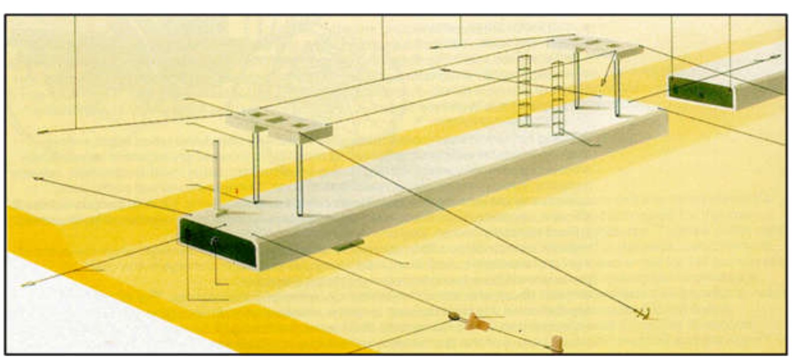
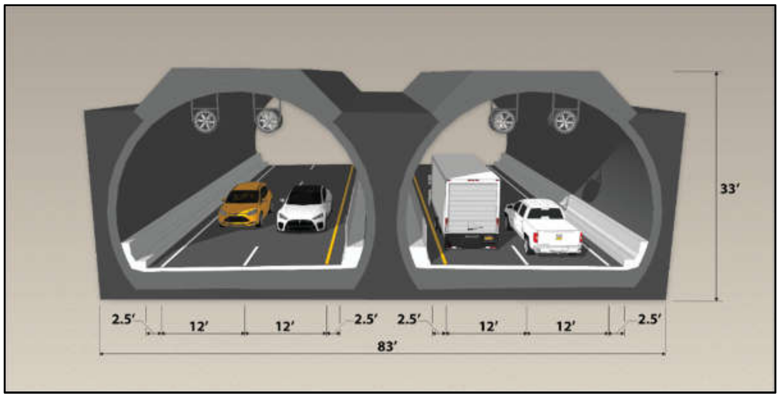


Figure 3-6 shows a representation of an immersed tube section, which typically have the directional roadways in a side-by-side configuration. As will be discussed later, the width of Brickell Avenue does not accommodate the width of this typical section while maintaining traffic lanes on Brickell Avenue.

Figure 3-7 Immersed Tube Section



The immersed tube tunnel methodology is not considered a feasible alternative for this project because the expected alignments are curved, the expected depth of the alignment profile, the relatively short length, possible permitting issues, and likely interruptions to marine traffic on the Miami River. In conclusion, the immersed tube construction is dropped from consideration for the construction of a tunnel under the Miami River.

Bored Tunnel Construction

The bored tunnel methodology for tunnel construction excavates the earth along the alignment of the tunnel while permanent facing supporting the excavation is installed behind the excavating machinery. Shielding is provided for temporary support of the excavation while the permanent facing is placed. Bored tunnels are typically circular in shape, with precast concrete segments placed to form an annual ring within the excavation. The area between the outside of the facing panels and the exposed face of the excavation is grouted to provide a uniform pressure around the ring to keep it in compression.

Figure 3-8 Tunnel Boring Machine

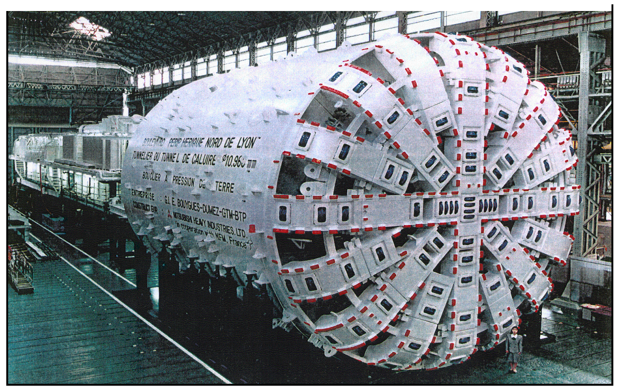


Figure 3-9 Breakthrough of First of Two PortMiami Tunnel Bores

A tunnel boring machine (TBM), as shown in **Figure 3-8**, is an example of a drilled application where a rotating disk with cutter heads excavates the material in front of the bore. To minimize impacts at the surface and maximize the benefits from an investment in the TBM, it is desirable to extend the bored tunnel to its maximum limits. Tunnel boring also requires a boring pit to accommodate assembly and launch of the TBM into a bore alignment. For the PortMiami tunnel (see **Figure 3-9**), a boring pit of 100 feet in width, over 400 feet in length, and 40 feet deep at the boring face was needed. This area is needed to assemble the boring machine and trailing support gear (total of 428 feet).

Large bore tunnels of the diameter required for the Miami River tunnel have not been constructed with TBMs at as small of a turning radius as proposed in this alignment. However, with advances in technology, it is believed that the issues related to this radius can be resolved, making a TBM feasible for this project.

Figures 3-10 and 3-11 depict the bored tunnel in side-by-side and stacked configurations.

Figure 3-10 Bored Tunnel Side-by Side

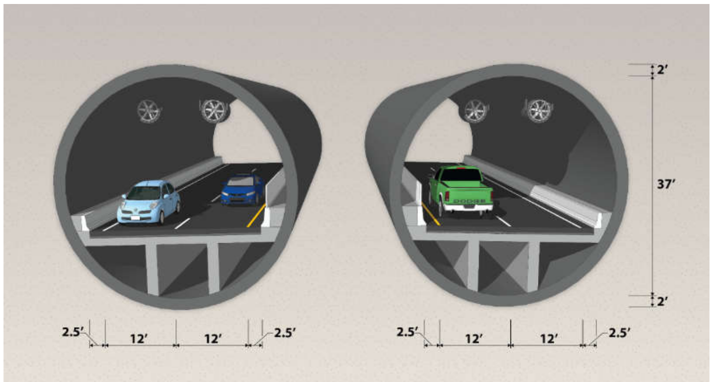
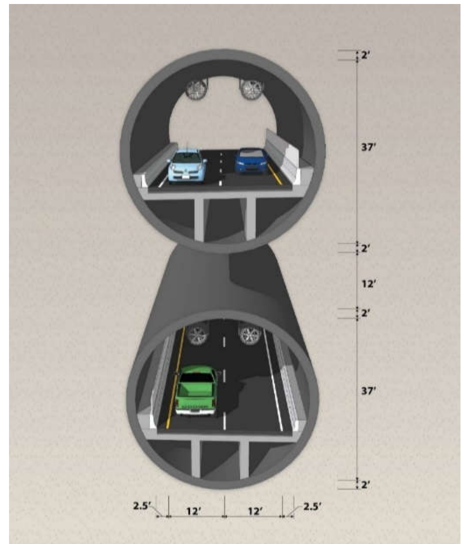


Figure 3-11 Bored Tunnel Stacked



Sequential Excavation Method

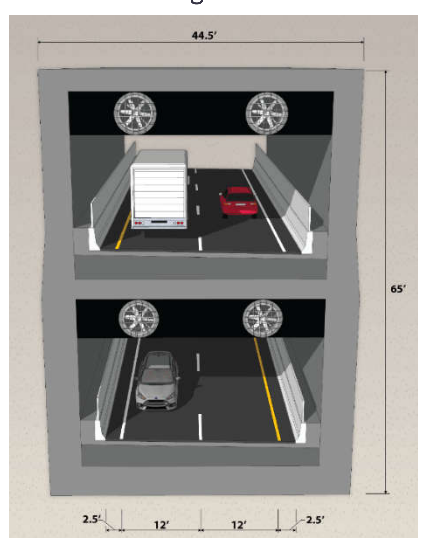
The Sequential Excavation Method (SEM) for tunnel construction utilizes the self-supporting capability of the ground to an optimum, maximizing economy in ground support. In this method, a series of smaller tunnels, commonly referred to as drifts, are advanced to form a load-carrying arch. Grouting and/or freezing in advance of the excavation would most likely be required to prevent water intrusion for the mining operation. The arch is reinforced with shotcrete and steel reinforcement or mesh, arched steel lattice girders, and/or grouting. This method allows for the construction of tunnels with complex geometry and/or changes in section, as the method is not dependent on an annular ring for strength. More efficient concrete sections can also be utilized. **Figure 3-12** shows tunnel mining in the 2nd Avenue Subway transit project in New York City with favorable rock formations. **Figure 3-13** illustrates a rectangular stacked tunnel section that would result from this tunnel construction method.

Figure 3-12 Tunnel Mining in the 2nd Avenue Subway Project

Limiting settlement with this construction method will be essential since the tunnel alignment is located near existing buildings, bridges, and the Metromover. These settlements can be controlled using shorter drifts and rapid completion of the tunnel arch support. Monitoring of the behavior/movement of the excavation is essential for the performance of this method, such that adjustments to the number of drifts and drift lengths can be made during construction.

In conclusion, the sequential excavation method for tunnel construction is considered feasible for the construction of the tunnel under the Miami River.

Figure 3-13 Mined Tunnel Configuration



3.4 Ventilation, Drainage and Systems

Ventilation is generally required in road tunnels to provide a safe environment for motorists. A mechanical ventilation system is a requirement by the National Fire Protection Association (NFPA) for tunnels exceeding 800 feet in length. A jet fan longitudinal ventilation approach would be the least costly method for ventilating the tunnel. No parallel ducts, fan structure, air intakes of exhaust stacks are required. While the jet fan system requires increased headroom for the roadway, the absence of dedicated supply and exhaust ducts and the need for ventilation building renders this system less costly than other ventilation systems. It is anticipated that jet fans would be adequate for this tunnel facility as the length of tunnel sections should be in the range of the 4,200-foot twin tunnels at PortMiami.

Drainage provisions for the tunnel were not specifically developed in this study, but the requirements and general configuration of the tunnel drainage system, including inlets, pipe runs, and pump stations was discussed. Tunnel drainage will conform to applicable requirements of the South Florida Water Management District (SFWMD), the Miami-Dade County Department of Environmental Resources Management (DERM), the City of Miami, the Florida DOT, the EPA, and other involved agencies.

3.5 Tunnel Infrastructure and Control Systems

The tunnel facility will require a comprehensive set of supporting infrastructure and control systems to provide for facility management, operations, and incident response. These systems will include the following elements: drainage system and pump stations, lighting, information and messaging signs, ventilation, fire suppression and smoke removal, operations video and monitoring system, and vehicle emissions monitoring.

These systems are typically monitored and managed from a central tunnel control center staffed with personnel to oversee operations and participate in traffic management and response to hazardous situations and incidents. The control center would typically be sited in a building sited along the project corridor. However, there may be an opportunity to house these functions with the PortMiami tunnel control center, assuming that space could be constructed for the requirements of the second tunnel and that a contractual arrangement could be struck. As for the PortMiami tunnel, a traffic operations response team including tow trucks would need to be situated near the project in order to address traffic crashes or other vehicle breakdowns.

3.6 Portal Closure Options

Surface street elevations in the study area range from 8 to 10 feet above sea level, making the tunnel possibly subject to flooding during high intensity rain and storm surge events. Methods for sealing the tunnel entrances will need to be considered to protect the tunnel. Flooding can be prevented by (1) raising the portals and roadway elevations above the flood stages, (2) designing flood gates to cover the portal openings, or (3) a combination of both these methods. it is expected that portal gates of some sort would be incorporated into the final facility design. There are vertical drop flood gates as included in the PortMiami tunnel design, swing gates, and sliding gates, as well as inflatable tunnel plugs being considered for New York transit tunnels in the aftermath of Tropical Storm Sandy. Drop or swing flood gates seem the most likely prospects for this project setting.

3.7 Recommended Tunnel Construction Methodologies

For the proposed Miami River Tunnel, the following tunnel construction methods are recommended and are reflected in the remaining sections of this report: **Bored Tunnel Method -** This is the technology utilized successfully for the PortMiami tunnel, and **Sequential Excavation Method -** This method is considered feasible for this corridor based on consultation from tunnel engineering resources and input from contracting firms.

There have been significant advances in recent years in the methods and machinery applied to tunnel projects. The single-bore 53-foot diameter tunnel boring machine in operation in Seattle is one of the largest to date. Contractors have devised improved processes to construct tunnels using mining techniques supplemented by grouting, soil freezing, tiebacks and other approaches. It is anticipated that these advancements and innovations would be in play if this project were advanced.

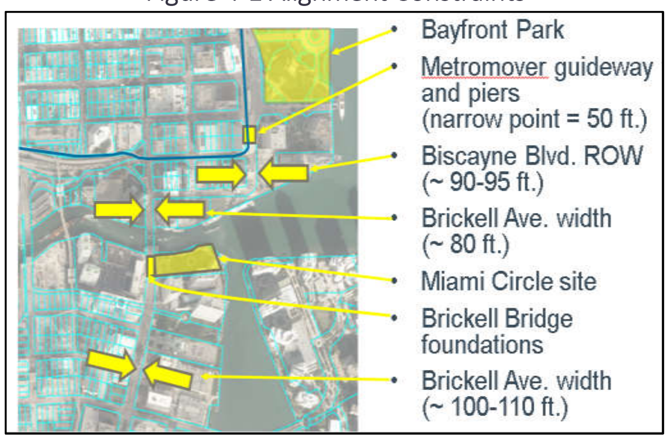
4.0 Alternatives Analysis

The prime objective of this study was to investigate and identify technically feasible tunnel alignments consisting of two travel lanes in each direction across the Miami River connecting Biscayne Boulevard and Brickell Avenue. These feasible alignments could then be examined in greater detail in a subsequent and more comprehensive Project Development and Environmental (PD&E) Study per standard Florida DOT protocols. The alignments needed to avoid right-of-way encroachments due to the high cost of land in Downtown Miami as well as potential adverse effects on property improvements ranging into the hundreds of millions of dollars in value. A final key goal was to retain the existing Brickell Bridge in operation during and after the construction of the tunnel. This section presents the following: the process of alignment definition and review, and identification of technically feasible alignments that might be advanced through further study.

4.1 Initial Considerations

Development of the preliminary alternatives was focused on locations east of the Metromover corridor. The corridor characteristics compiled in Section 2 were reviewed to inform this process, as well as the design criteria and related considerations described in Section 3. Coupled with field review, several key conditions were identified as influencers on the development of potential alignments across the river. **Figure 4-1** summarizes key constraints on that were identified.

Figure 4-1 Alignment Constraints



4.2 Crossing Location Screening

While the focus was on connecting the Brickell Avenue and Biscayne Boulevard corridors, all possible crossing locations within the study area east of the Metromover were initially identified. These six potential locations are presented in **Figure 4-2.** These were reviewed for suitability for further development as an alignment concepts, including preliminary profiles. This review is summarized in this section. Based on this screening, Alternatives 1 and 2 are retained for further consideration.

- *Alternative 1: Reverse Curve Alignment Connecting Brickell Avenue to Biscayne Boulevard*
  - **Disposition:** Retained for further consideration

Alternative 2: Brickell Avenue to Biscayne Boulevard Under Bayfront Park

- **Disposition:** Retained for further consideration

Alternative 3: Shallow Alignment Under the Existing Brickell Avenue Bridge

- **Disposition:** Dropped from further consideration

Alternative 4: Deep Alignment Under the Existing Brickell Avenue Bridge

- **Disposition:** Dropped from further consideration

Alternative 5: Brickell Key Drive at Brickell Avenue to Biscayne Boulevard

- **Disposition:** Dropped from further consideration

Alternative 6: Reverse Curve Alignment Connecting Brickell Avenue to NE 1st Street:

- **Disposition:** Dropped from further consideration

Figure 4-2 Potential River Crossing Locations

4.3 No-Build Alternative

In addition to the Build Alternatives, a No-Build Alternative was recognized as an option, but was not analyzed as the focus of the study was on construction options. The No-Build Alternative would not entail the development of additional cross-river capacity in the form of a tunnel. However, this option could embrace of variety of action items that have been developed in dialogue between the involved stakeholders in downtown traffic congestion, Brickell Avenue bridge operations, and Miami River marine operations. These alternatives include pedestrian gates on the lift bridge, “white glove” downtown ambassadors to guide pedestrian movements, refinements to bridge opening management within published Federal regulations on bridge opening curfews, and other traffic operations related improvements. This option would embrace the objective of trying to optimize bridge area traffic operations on a short-term basis, but would not provide a long-term capacity increase.

4.4 Alternative 1: Reverse Curve Alignment

The reverse curve alignment connecting Brickell Avenue to Biscayne Boulevard (‘Alignment 1’) is the most direct connection between Brickell Avenue and Biscayne Boulevards. This alternative is presented with the cross-section for the bored tunnel excavation technology with a corresponding stacked twin bore cross section and is referred to as Alternative 1A. The mined tunnel alignment profile would be similar in vertical gelometry. This option has the following general characteristics:

- General Description
    - Two stacked bored tunnels, separation at the portals of 12 feet, but increased along the tunnel length

    - Deeper tunnel bore is considered to be southbound, and shallower tunnel bore is northbound
    - Both tunnel bore profiles are lower than would otherwise occur, because they are profiled to pass under the Metromover foundations on Biscayne Boulevard between SE 3rd and SE 2nd Streets, and under a corner of the south approach span to the Brickell Avenue bridge
    - This alternative passes under the northwest corner of the Miami Circle site, though it is well below surface grade

- Southbound tunnel:
    - North portal section open roadway begins just south of NE 4th Street and ends just north of NE 2nd Street, where the southbound tunnel section begins.
    - Tunnel section runs from just north of NE 2nd Street at Biscayne Boulevard south to a point 230 feet south of SE 10th Street on Brickell Avenue
    - South portal open roadway section begins at a point 230 feet south of SE 10th Street on Brickell Avenue and ends just south of SE 12th Street
    - Dimensions
        - North portal: 590 feet
        - Tunnel: 5,310 feet
        - South portal: 590 feet
        - TOTAL 6,490 feet

- Northbound tunnel:
    - South portal open roadway section begins just north of NE 10th Street on Brickell Avenue and ends just south of SE 8th Street, where the northbound tunnel section begins.
    - Tunnel section runs from just south of SE 8th Street to Flagler Street on Biscayne Boulevard
    - North portal open roadway section begins at Flagler Street and ends at a point 200 feet north of NE 1st Street on Biscayne Boulevard
    - Dimensions
        - South portal: 564 feet
        - Tunnel: 3,622 feet
        - North portal: 564 feet
        - TOTAL 4,750 feet

- The combined bi-directional length of this alternative, including both portal sections is 11,240 feet, or 2.128 miles. This is about the same as the combined total length of the PortMiami tunnel bores and approaches.

Figure 4-3 presents the plan view of this alternative, while **Figures 4-4** to **4-6** depict the profiles of the directional roadways. While both the tunnel boring machine and sequential excavation methods of tunneling are both considered feasible, this alternative is presented with the tunnel boring machine alignment profile configuration. This alternative has a maximum depth below grade of approximately 150 feet. In comparison, the PortMiami tunnel has a maximum depth below grade of 120 feet.

Figure 4-3 Build Alternative 1A – Plan View

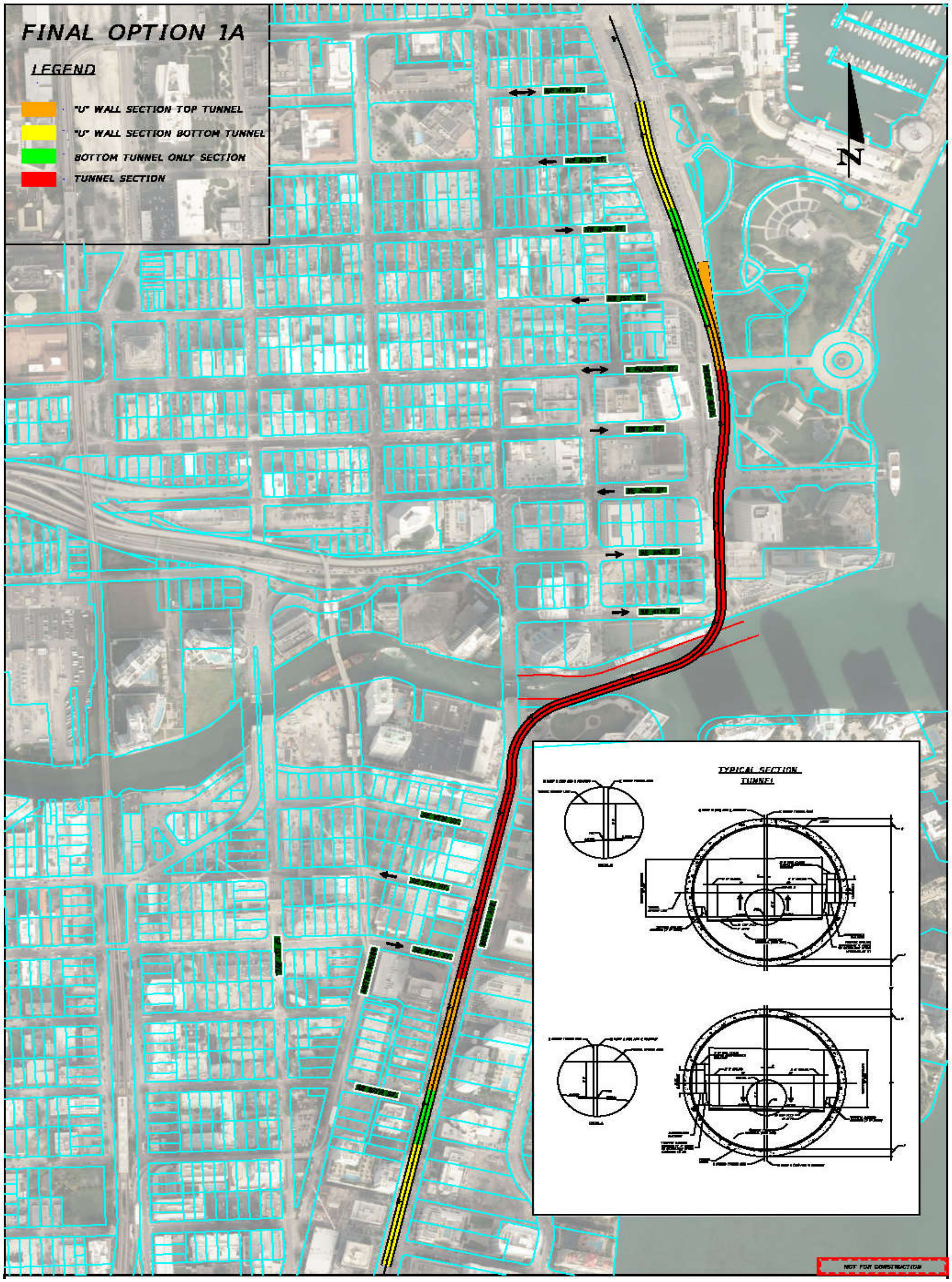


Figure 4-4 Build Alternative 1A – Profile (Section 1)

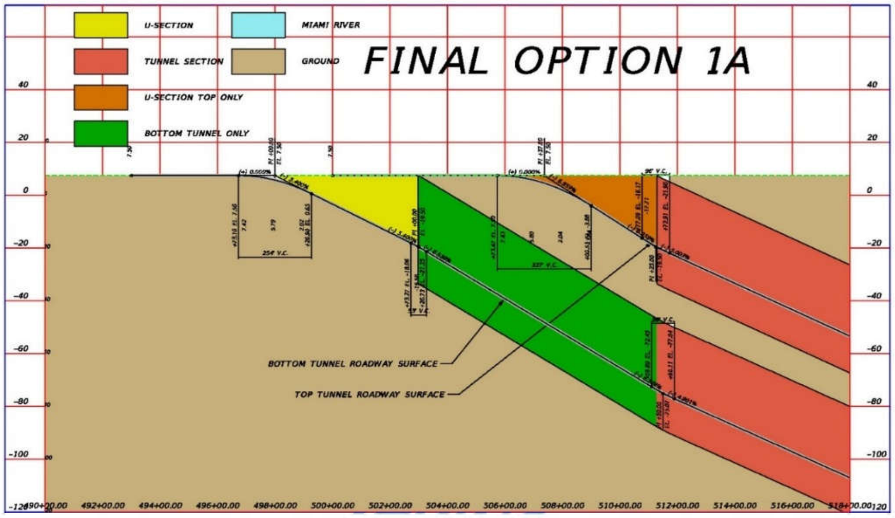


Figure 4-5 Build Alternative 1A – Profile (Section 2)

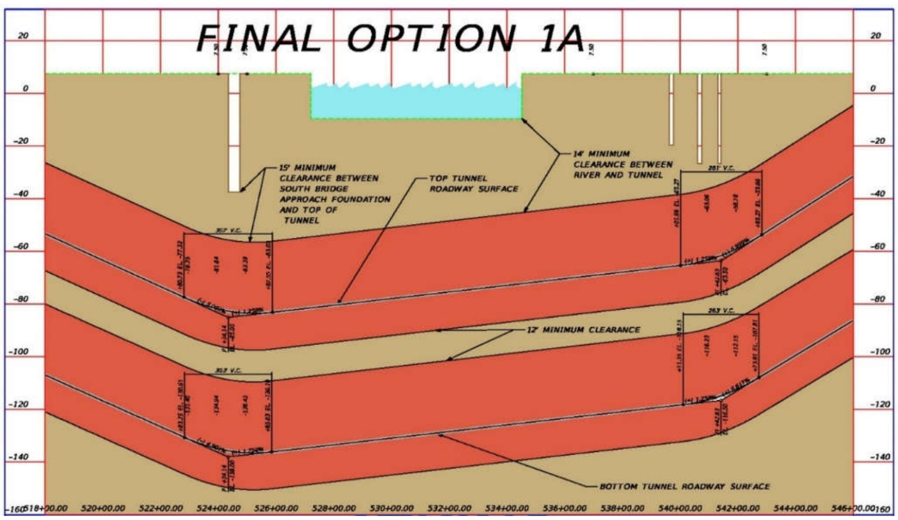
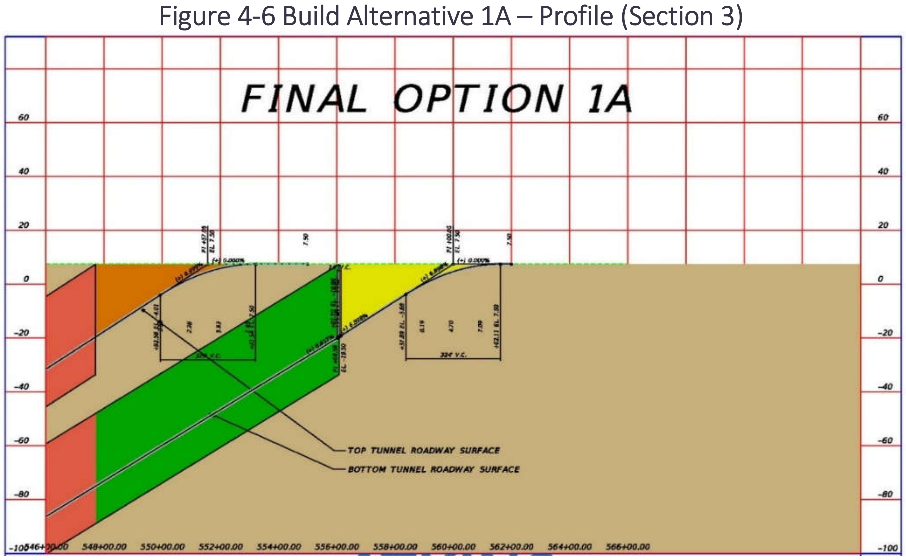


Figure 4-6 Build Alternative 1A – Profile (Section 3)



4.5 Alternative 2: Brickell Avenue to Biscayne Boulevard Under Bayfront Park

The second alternative alignment traverses from Brickell Avenue under the Miami River mouth and under Bayfront Park to link with Biscayne Boulevard ('Alternative 2'). This alternative is presented with the cross-section for the mining tunnel excavation alternative with a corresponding stacked rectangular cross section and is referred to as Alternative 2B. The bored tunnel alignment profile would be somewhat similar. Alternative 2 has the following characteristics:

- General Description
  - Two rectangular cells in a stacked configuration denote this alternative, but these are transitioned to a side-by-side configuration under Bayfront Park so that they enter Biscayne Boulevard as a four-lane section in the median of the street
  - The deeper tunnel bore is considered to be southbound, and the shallower tunnel bore is northbound
  - Both tunnel bore profiles are lower than would otherwise occur south of the Miami River because they are profiled to pass under a corner of the south approach span to the Brickell Avenue bridge
  - This alternative passes under the northwest corner of the Miami Circle site, though it is well below surface grade
  - This alternative passes under a narrow swath of private property at the foot of Biscayne Boulevard where it almost meets the Miami River

- Southbound tunnel:
  - South portal open roadway section begins just south of NE 4th Street on Biscayne Boulevard and ends just north of NE 2nd Street, where the southbound tunnel section begins
  - Tunnel section runs from just north of NE 2nd Street at Biscayne Boulevard south to a point 230 feet south of SE 10th Street on Brickell Avenue
  - North portal open roadway section begins at a point 230 feet south of SE 10th Street on Brickell Avenue and ends just south of SE 12th Street
  - Dimensions:
    - North portal: 632 feet
    - Tunnel: 6,190 feet
    - South portal: 632 feet
    - TOTAL 7,454 feet

- Northbound tunnel:
  - South portal open roadway section begins just north of NE 10th Street on Brickell Avenue and ends just south of SE 8th Street, where the northbound tunnel section begins
  - Tunnel section runs from just south of SE 8th Street to just north of NE 2nd Street on Biscayne Boulevard
  - North portal open roadway section begins just north of NE 2nd Street on Biscayne Boulevard and ends just south of NE 4th Street
  - Dimensions:
    - South portal: 710 feet
    - Tunnel: 5,092 feet
    - North portal: 710 feet
    - TOTAL 6,512 feet

- The combined bi-directional length of this alternative, including both portal sections is 13,966 feet, or 2.645 miles. This is about ½-mile longer than the combined total length of the PortMiami tunnel bores and approaches.

Figure 4-7 presents the plan view of this alternative, while **Figures 4-8** to **4-10** depict the profiles of the directional roadways. While both the tunnel boring machine and sequential excavation (mined) methods of tunneling are both considered feasible, this alternative is presented with the mined methodology alignment profile configuration. This alternative has a maximum depth below grade of approximately 120 feet. In comparison, the PortMiami tunnel also has a maximum depth below grade of 120 feet.

Figure 4-7 Build Alternative 2B - Plan

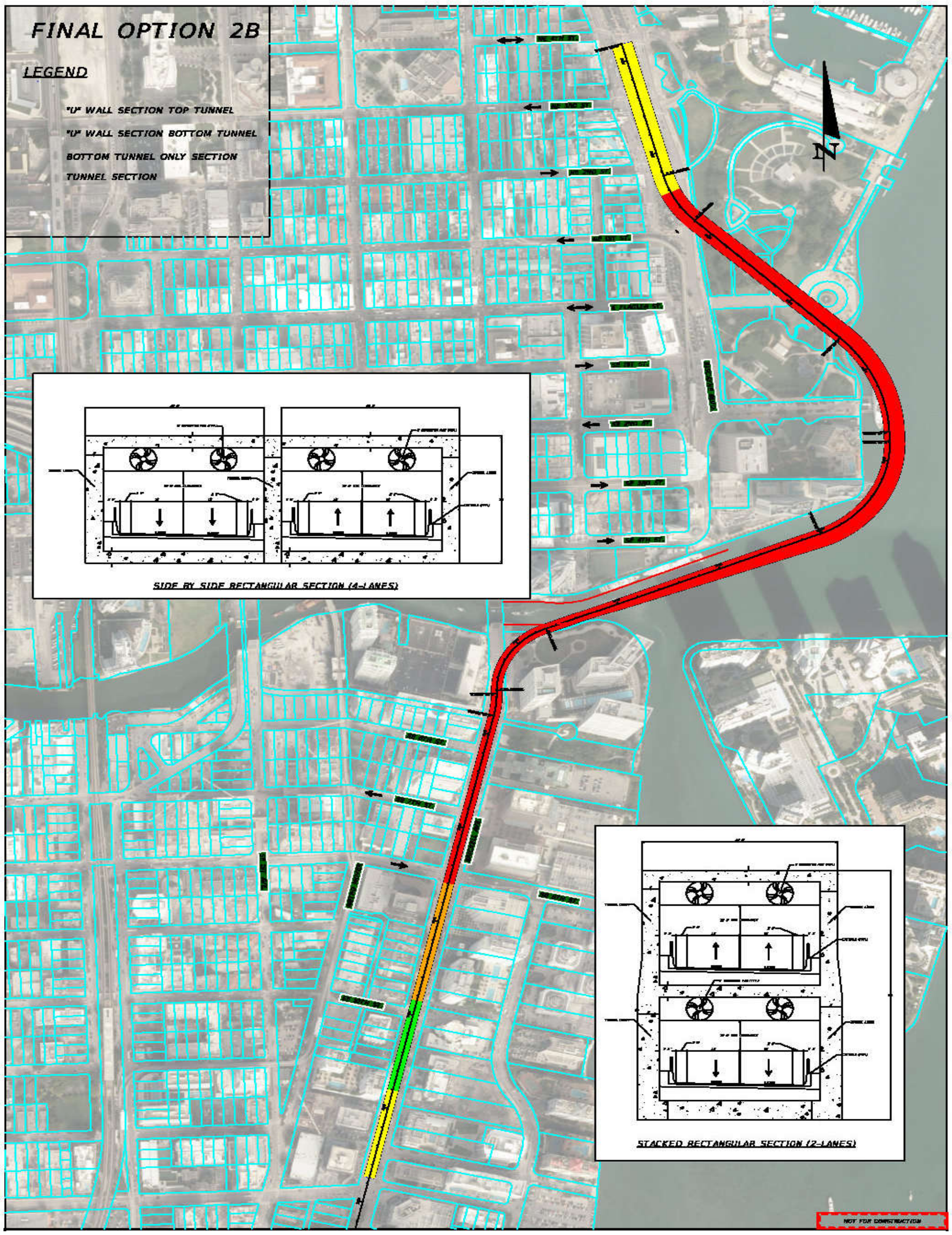


Figure 4-8 Build Alternative 2B – Profile (Section 1)

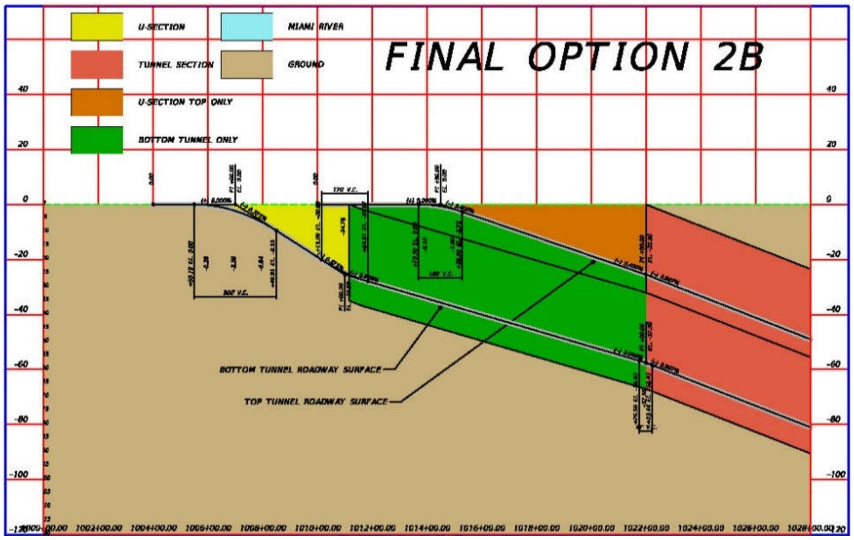


Figure 4-9 Build Alternative 2B – Profile (Section 2)

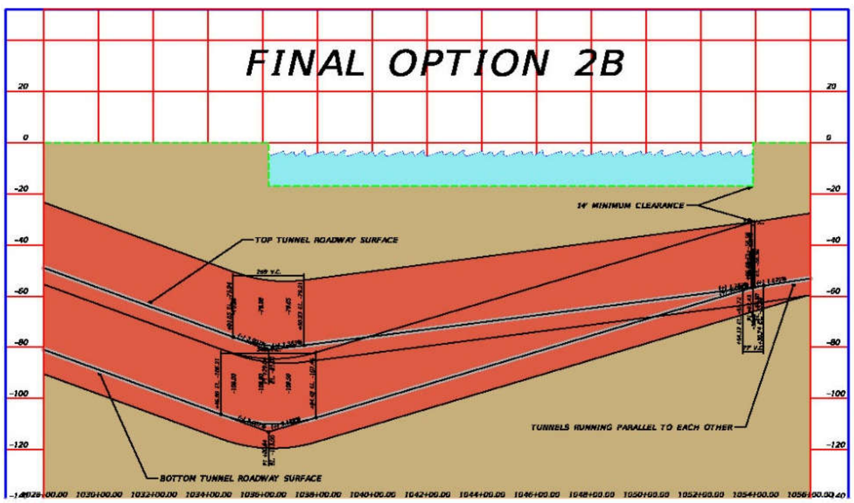
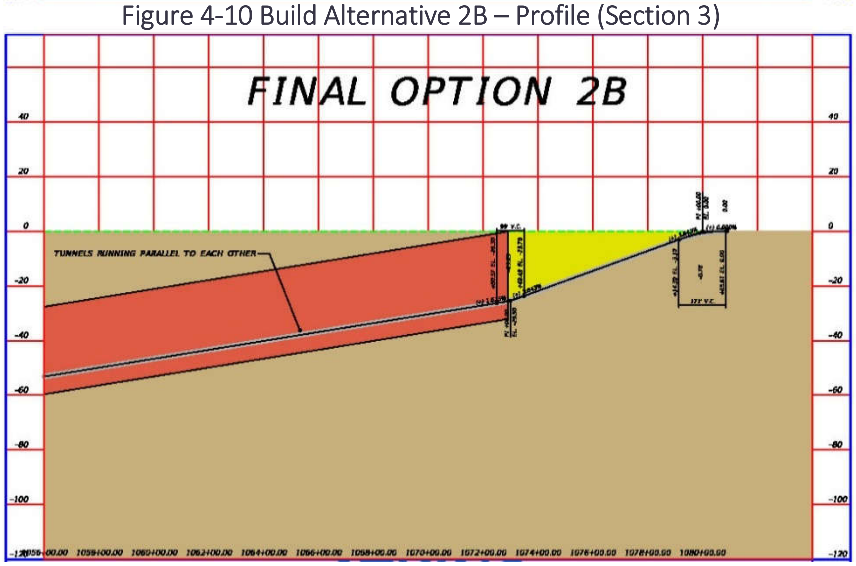


Figure 4-10 Build Alternative 2B – Profile (Section 3)



4.6 Other Considerations

Miami Circle Site

The Miami Circle site, also known as the Brickell Point site, was listed in the National Register of Historic Places in 2001 and designated a National Historic Landmark in 2009. The site is believed to be the southern part of the pre-Columbian village of Tequesta that used to exist on both the north and south banks of the Miami River. The Miami Circle is the only complete cut-in-rock prehistoric structural footprint discovered in eastern North America. Due to the importance of this discovery, the State purchased the property in 1999. The Alternative 1 and Alternative 2 tunnel alignments both are positioned underneath Brickell Avenue, and are proposed to turn to the east as they approach the Brickell Avenue bridge to proceed easterly under the Miami River a short distance before turning northward under Biscayne Boulevard. To execute the northbound-to-eastbound turn at the river, the alignment would pass under the northwest corner of the Miami Circle site as shown in **Figure 4-11**.

Figure 4-11 Miami Circle Site

The figure illustrates that the tunnel alignment would pass under the improved end of the site where there is a street cul-de-sac and riverside walkways. In this area, the top of the upper Alternative 1 tunnel bore is approximately 50-60 feet below the ground level elevation of the improved corner of the site. This is considered to be a relatively minimal type of encroachment that would have no material effect upon the historic site. Regardless, research indicates that several governmental agency consultations would likely be necessary to obtain clearances for this encroachment. These would include the State Historic Preservation Office & Advisory Council on Historic Preservation, review of Section 4(f) applicability and implications, and review of the Natural Resource land designation. Completion of these actions is considered feasible given the nature of the proposed encroachment. However, additional research and early consultation is recommended in order to properly resolve the open topics in a timely manner.

For both Alternatives 1 and 2, **Figure 4-11** also illustrates the extent of the conflict with the approach structure of the Brickell Avenue bridge. The approach structure is supported by pile foundations which extend to -45 feet. The tunnel has been profiled to avoid these pile tips by at least 15 feet of clearance.

Brickell Avenue Status

Brickell Avenue is designated as a State Historic Highway per Senate Bill 138 and improvements related to the tunnel project will need to be found in conformance with this language. It is also appropriate to note that while Brickell Avenue from I-95 northward to the Miami River was previously entirely under the jurisdiction of the Florida DOT, the portion of the street south of SE 8th Avenue was transferred back to the City of Miami at the City's request. So it is noted that a portion of the proposed tunnel alternative alignments do not fall within a street under Florida DOT responsibility. For Alternative 1, that is a length of 1,520 feet of the overall alternative length of 6,492 feet, or about 23.5% of that alternative's length.

Portal Connections to Existing Streets

For Alternative 1, a review of tunnel portal connections with Biscayne Boulevard and Brickell Avenue was made. While there are alternative geometry layouts to accomplish these merge and diverge elements, those developed are reasonable and can be refined should the project move forward.

Compatibility with Biscayne Boulevard and the Biscayne Green Project

The Downtown Development Authority has been studying Biscayne Boulevard in the Downtown Miami area south of I-395 with a vision to create a Grand Promenade. The concept has evolved to become the Biscayne Green with further refined design concepts. In January 2017, a portion of the median was temporarily converted into a "Green" setting as a demonstration of the overall concept. The Florida DOT has recently approved funding for a lane elimination study which has long been a component of the improvement vision. The proposed tunnel portals would affect the Biscayne Green concept in terms of their footprint and the number of lanes on Biscayne Boulevard, but it is considered that the design concept could be adjusted to accommodate the tunnel portals. While the northern tunnel portals of either alternative would alter the Biscayne Green layout as originally conceived, it appears that reasonable accommodations could be made for the tunnel portals. A detailed resolution is not possible in this study, and there remain several open variables as to the outcome of the lane reduction study and the accommodation of a potential transit guideway in order to integrate tunnel portals into the proposed Biscayne Boulevard corridor improvement concept.

Project Staging and Disposal Sites

While this conceptual study cannot anticipate project construction conditions years into the future, it is still considered useful to discuss possible staging sites for the project and disposal sites for the spoil materials. The tunnel project will require substantial staging areas which may be close or distant from the project site depending on the nature of the materials. For example, supplies and equipment related to the tunnel boring machine will need to be proximate to the project site, while tunnel liner concrete segments could be produced offsite and trucked in on a just-in-time basis. In the constrained setting of Downtown Miami, staging sites will be scarce. A number of current possible staging sites were identified; these would need to be evaluated for feasibility, and clearly would change over the time before actual tunnel construction would commence.

Another component of the construction staging is employee parking. It is anticipated that a project of this scale will require several hundred workers, many of them directly onsite. Options to address site access workers could include remote parking sites with shuttle buses, leasing of underused parking spaces in proximity to the project, and encouraging the use of Metrorail, Metromover, and Metrobus for access to the site.

It is estimated that approximately 600,000 cubic yards of rock and soil would be removed from the tunnel project for Alternative 1 with bored tunnels. This material would be transported from both ends of the tunnel corridor one or more disposal sites. Some of the material excavated could be clean, crushed rock, which could be reused beneficially at other locations, subject to testing for contamination. Reuse opportunities for quality uncontaminated rock could include filling rock mining pits in west Miami-Dade

County, development site raising, building artificial offshore reefs, reinforcing bulkheads, construction of berms, or use in road paving materials, depending on the consistency of the spoils materials. The project development team should would work with federal, state, and local agencies to identify reuse and disposal opportunities. Materials excavated from soil and loose material portions of the project are more likely to be contaminated because they are typically nearer the surface, where contaminants from previous or current industrial uses can collect or be carried by groundwater.

Numerous factors would affect the selection of the ultimate destination of the tunnel excavation spoil materials. The crushed rock could be used at numerous different locations, particularly since it would be removed over a period of almost two years. A spoils management plan should be developed to address the ultimate management of the project's spoils. The spoils management plan will need to be consistent with federal and state requirements for solid and hazardous waste management

At this early stage, the final destination for the spoils materials cannot yet be determined. Depending on the location of the use or disposal, they may be transported by local trucks, by drayage to rail cars, or by barge to coastal or offshore destinations.

4.7 Traffic Considerations

Tunnel Traffic

A limited analysis of travel demand patterns as influenced by the presence of the tunnel facility was performed using the latest version of the regional travel demand model for 2040 conditions. The key observations noted are as follows:

- The 2040 No-Build scenario shows the Brickell Avenue bridge with a daily traffic volume of 36,100 similar to recent daily volumes. There is directionality favoring the southbound over the northbound, similar also to recent counts.
- With Alternative 1 portal locations as described, the resulting 2040 daily volumes are:
    - Brickell Avenue bridge: 18,900 vehicles, a 17,200-vehicle reduction (-48%)
    - Miami River tunnel: 43,600 vehicles
- This indicates that the tunnel as Alternative 1 is attracting 26,400 trips from other pathways. There is a reduction in traffic using the SW 2nd Avenue bridge by 4,300 vehicles compared to the No-Build condition, and by 5,000 vehicles on the Miami Avenue bridge.
- Volumes increase on Biscayne Boulevard north of the portals by approximately 21,800 vehicles, and on Brickell Avenue south of the portals by about 14,600 vehicles.
- The tunnel itself exhibits significant directionality between the two roadways, expected because portal locations are not symmetrical and thus cause different diversions, and because of the directionality and circuitry involved with Brickell Avenue bridge access north of the river. Northbound volumes are about twice those of southbound, in part owing to its portal locations being closer to the river and intercepting more traffic.

These figures, though preliminary, demonstrate the traffic diversion capacity of the tunnel to divert half the Brickell Avenue bridge traffic to the tunnel route. A "select link" analysis that was performed shows for the selected link – the one including the existing bridge – the orientation of those trips across the network. For those trips crossing the bridge, they constitute 50% or more of the traffic on segments of Biscayne Boulevard as far north as Port Boulevard, and on segments of Brickell Avenue as far south as SW 15th Road. In addition, those trips crossing the bridge sustain a 20% share threshold of bridge trips on road segments extending as far south as Rickenbacker Causeway, as far north at I-395, and as far west as I-95 via the downtown connector ramps. Thus, the market for a tunnel is not just short trips in the immediate vicinity of the bridge.

Tolling Potential

A cursory review of the possibility of tolling was conducted. Tolling is typically utilized when there is a need to underwrite the capital cost of the facility. Tolls can also be used to cover the ongoing operations and maintenance of a facility. It should be noted that these uses relate to the use of “net” tolls after the cost of toll collection. Generally, the introduction of tolling to a roadway facility will diminish the number of users and thus the revenue generated. The user response to a toll is captured within an “elasticity” measure which gauges the rate of diversion in response to a given tolling level. That rate is typically a function of the time saved on the tolled facility in relation to other routing options and the user’s perceived value of time.

No direct tolling analysis was conducted in this study, but a somewhat similar and recent case study was identified in Seattle. The Alaskan Way viaduct on the city waterfront is being replaced by a 2.2-mile long tunnel and short connecting road segments. For that project, a very detailed tolling analysis was performed. The information in this report was distilled into a high-level rate of trip diversion from the tunnel based on the tolling cost. Applying this data to Alternative 1 yielded an estimated traffic diversion of 16% for a 25¢ one-way toll, and 32% for a 50¢ one-way toll. The resulting level of toll revenue would be only a small fraction of the debt service on a construction finance instrument. However, .tolling ultimately could be used to defray a large portion of capital and operating costs.

4.8 Conceptual Cost Estimates

Given the conceptual level of project definition and study resources, an in-depth buildup cost analysis was not possible. However, a comparative cost analysis was performed in relation to the capital costs for the PortMiami tunnel project.

The capital cost for the PortMiami tunnel was used as a basis for estimating the Miami River tunnel cost in the bored tunnel configuration, with certain adjustments and escalation to a 2017 cost basis. Because of the lack of alignment specific geotechnical information and the lack of tunnel mining experience locally for the scale of this project, a premium of 20% was applied to tunnel mining alternatives; while tunnel mining avoids the cost of a tunnel boring machine in the range of $55-60 million, and contractor contacts suggested that the project cost could be less, there is no demonstrable information to that effect locally, so a more conservative estimate was made, based on literature research which suggests that tunnel mining could be more expensive that tunnel boring depending upon circumstances.

With the approach taken, the cost estimation process includes the labor and materials associated with all construction elements and systems intrinsic to the PortMiami tunnel project; mobilization, basic utilities, maintenance of traffic, and similar costs; boring machine fabrication, shipping, assembly, operations, disassembly, return shipping; tunnel liners, tunnel finish out, tunnel systems; tunnel excavation spoil disposal; ancillary roadway improvements; and a control center building. The cost estimation process excludes cost associated with right-of-way, environmental mitigation, spoil contamination remediation, extaordinary spoil disposal costs, extraordinary utility relocations, and financing costs related to loans and debt paybacks. There are several additive costs for front end work to further plan the facility and conduct the detailed alternatives analysis: preliminary studies (PD&E,

geotechnical, cultural resources, ROW elements) , final design and engineering, construction oversight, and legal, permitting, procurement

Table 4-1 presents the estimated conceptual costs for several final alternatives, including:

- Alternative 1A: Reverse Curve Alignment – Bored Tunnel
- Alternative 1B: Reverse Curve Alignment- Mined Tunnel
- Alternative 2A: Brickell Avenue to Biscayne Boulevard Under Bayfront Park – Bored Tunnel
- Alternative 2B: Brickell Avenue to Biscayne Boulevard Under Bayfront Park – Mined Tunnel

The actual project configuration, cost, and duration may vary depending on final project scope, final design, construction sequencing, and production rates. Costs shown are in 2017 dollars.

Table 4-1 Conceptual Costs ($millions)

Alternative	1A	1B	2A	2B
Technology	Bored	Mined	Bored	Mined
Configuration	Circular Stacked	Rectangular Stacked	Circular Stacked	Rectangular Stacked
2017 Base Capital Cost	**$894.2**	**$1,050.7**	**$1,129.5**	**$1,327.1**
Additive Costs				
Preliminary Studies (PD&E, geotechnical, etc.) at 4%	$40.00	$40.00	$40.00	$40.00
Final Design at 10%	$89.4	$105.1	$112.9	$132.7
Construction Oversight at 12%	$107.3	$126.1	$135.5	$159.3
Other (legal, permitting, procurement, etc.) at 0.5%	$8.9	$10.5	$11.3	$13.3
Subtotal - Additives	**$245.7**	**$281.7**	**$299.8**	**$345.2**
Grand Total	***$1,139.9***	***$1,332.3***	***$1,429.2***	***$1,672.4***

NOTE: Excludes right-of-way, environmental mitigation, spoil contamination remediation, extraordinary spoil disposal costs, extraordinary utility relocations, and financing costs related to loans and paybacks.

An important element of the investment in a tunnel facility is the recognition that such infrastructure requires multiple systems components for traffic and incident monitoring, emergency communications, incident management, messaging, drainage and pumps, ventilation for air quality, fire suppression, portal flood protection, lighting, and others. These systems are managed at an operations control center housing administrative and operations staff, including incident response staff. There are also utility costs for electricity to power lighting and ventilation systems, video monitoring, the ITS information system, and other elements. In addition, there are routine and periodic maintenance activities as well as certain facility and equipment repair and renewal aspects that are included.

The cost of providing for the operations and maintenance functions are a necessary and ongoing feature of keeping the tunnel in a good state of repair and readiness to address vehicle breakdowns, traffic incidents and crashes, and other emergency conditions for the safety and security of tunnel users.

Based on a review of the literature and information for the PortMiami tunnel, it is estimated that the annual operations and maintenance cost for the proposed tunnel in the Alternative 1 configuration would be in the range of $4-6 million per year in 2017 dollars.

4.9 Alternatives Comparison

Table 4-2 presents a comparison of the final alternatives considered. Five evaluation categories were identified, each with multiple criteria relating to the evaluation category. Evaluation categories were weighted in terms of relative consequence to alternative suitability. Each criterion was scored on a 5-step scale of 0 to 4, with 4 representing very good satisfaction of a criterion, and 0 representing weak satisfaction of a criterion. The resulting scores indicate that Alternative 1A: Reverse Curve Alignment – Bored Tunnel best addresses the purpose of the project with the lowest cost.

While Alternative 2 in either form avoids certain issues with reduced proximity to buildings along Biscayne Boulevard, its increased length translates into nearly $300 million in additional cost, and with a horizontal alignment that introduces additional length of roadway curvatures. Its advantages are outweighed by the cost differential.

Mining alternatives due to the costing approach receive a lower overall score. However, it is recommended that as the tunnel project advances, that the procurement vehicle could incorporate the mining alternative as a construction method to ascertain contractor insight and innovation as to the cost-effectiveness of that method in the study area setting, given new or improved techniques that may be available at the time of procurement.

Table 4-2 Alternative Comparison

EVALUATION CRITERIA	MEASURE	**Option 1A** Reverse Curve Alignment [Bored Tunnel]	**Option 1B** Reverse Curve Alignment [Mined Tunnel]	**Option 2A** Brickell Avenue to Biscayne Boulevard Under Bayfront Park [Bored Tunnel]	**Option 2B** Brickell Avenue to Biscayne Boulevard Under Bayfront Park [Mined Tunnel]
Transportation					
Portal Connections	Workability of portal connections to surface streets	◕	◕	◕	◕
Existing Brickell Bridge	Preserves existing bridge	●	●	●	●
Directness	Provides a direct alignment	●	●	◑	◑
Subtotal		11	11	9	9
Weighted Subtotal	3.00	33	33	27	27
Planning					
Traffic Volumes at River Crossing	Reduces traffic volumes at existing bridge	●	●	●	●
Subtotal		4	4	4	4
Weighted Subtotal	1.50	6	6	6	6
Social/Environmental Impacts					
Cultural/Historic Resource Impacts	Avoids impacts to ultural/historic resources	◑	◑	◔	◔
Noise and Vibration	Relative level of noise and vibration potential	◕	◕	●	●
Subtotal		5	5	5	5
Weighted Subtotal	0.75	3.75	3.75	3.75	3.75
Site Characteristics					
Street Disturbance	Extent of street disruption during construction	◕	◕	◕	◕
Utilities	Extent of utility conflicts	◕	◕	◕	◕
Subtotal		6	6	6	6
Weighted Subtotal	0.75	4.5	4.5	4.5	4.5
Conceptual Costs					
Construction Cost	Consruction cost relative to lowest cost	●	◕	◕	◑
Ground Settlement	Potential for issues and costs associated with ground settlement	◕	◕	●	●
Potential Right-of-Way Issues	Extent of problematic right-of-way issues	◕	◕	◑	◑
Subtotal		10	9	9	8
Weighted Subtotal	4.00	40	36	36	32
Total		36	35	33	32
Weighted Total	10.00	87.25	83.25	77.25	73.25

● Fully addresses the measure, or is the best alternative relative to the criteria.

◕ Largely addresses the measure, or is an acceptable but not a preferred alternative relative to the criteria.

◑ Partially addresses the measure, or is an acceptable but not a preferred alternative relative to the criteria.

◔ Somewhat addresses the measure, or not a preferred alternative relative to the criteria.

○ Fails to address the measure, or the alternative is lowest ranked relative to the criteria.

5.0 Implementation Elements

This section of the report addresses several project development elements related to the ultimate implementation of the proposed project.

5.1 Agency Coordination, Consultation, and Permitting

A project of this complexity would necessarily involve dozens of agencies and jurisdictions in relation to coordination and agreements, as well as consultation and permitting to satisfy regulatory requirements. Coordinating transportation agency partners will most likely include the Florida DOT, Miami-Dade County, and the City of Miami.

The study report identifies a variety of key aspects of the project which would require significant coordination and further development over the planning and project development phase. The range of items would run from developing interim and ultimate traffic plans, a noise and vibration monitoring program, devising a robust community outreach program, locating spoil disposal sites, and developing project work sites, among others.

In addition, there is a spectrum of agencies to be involved in environmental clearances/permits and related consultations, design details, the control facility, and other elements. A plan for this coordination should be crafted early in the development process.

It is understood that a project of this scale will have significant impacts to the infrastructure of the roadway network in and around the limits of the project. It is essential for final project limits to be based on detailed conceptual traffic control and construction analysis to achieve the following:

- Implement the project
- Minimize potential conflicts between projects
- Implement other possible permanent network changes to address shifts in travel patterns in response to the new network capacity represented by the tunnel

Also, during construction adjustments in traffic circulation around construction zones must be accommodated. Finally, a traffic control plan would be developed and implemented in consultation with local jurisdictions, FDOT and the City of Miami.

5.2 Implementation Timetable

The development of this project, if advanced, could occur in several ways. The traditional approach would be a sequenced progression of project development activities, with basic steps and timelines as follows:

PHASE	DURATION
• PD&E Study/EIS (1)	3 – 4 years
• Final Design	2 – 2-1/2 years
• ROW clearance (if required)	2 – 3 years
• Construction	4 – 4-1/2 years
• Identification of funding sources For construction and operations	To be determined

(1) Project Development and Environmental Study & Environmental Impact Study

These phases can be fast-tracked to some extent to reduce overall duration. An alternative approach would be some form of public-private partnership (P3) ranging from a design-build procurement to a full concession agreement as was struck for the PortMiami tunnel implementation. Often a long-term P3 procurement can accelerate portions of the project development process, though as explained further in Section 5, requires a strategy for debt retirement, and may likely have a higher total project financial cost for this reason.

5.3 Funding and Finance

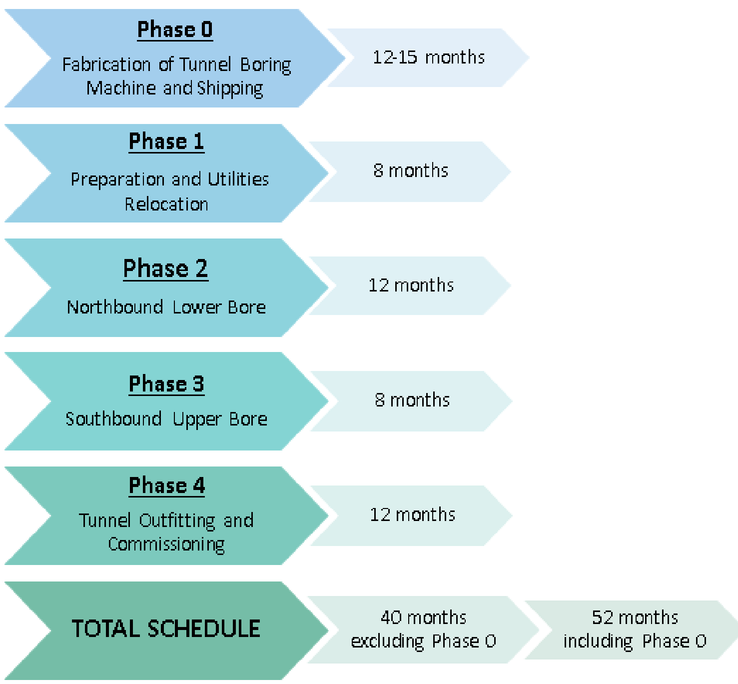
The proposed Miami River tunnel project, as defined, is on the scale of the PortMiami tunnel completed and opened to traffic in 2014, though slightly longer in overall length, and in a more complex and constrained physical setting. The future implementation of this project, if advanced, could proceed in one of two general ways. The first approach is the traditional infrastructure project development where the necessary set of steps is accomplished in a more or less sequential manner, led by a public jurisdiction. The recent Miami-Dade TPO publication (Public-Private Partnership (P3) Reference Guide, 2016) provides very useful reference material contrasting traditional versus the alternative approach through some form of public-private partnership (P3). There are several different levels of P3 procurement integration of private sector involvement with the traditional project development process, covering the basic steps of designing, building, financing, maintaining, operating, or a full turnkey package of a concession agreement. It is noted that the PortMiami tunnel was implemented through a concession agreement.
For the PortMiami tunnel project, the corridor planning and alignment development steps occurred much earlier, with approved environmental documents on hand. The selected concessionaire updated those documents and prepared the final design plans. The planning baton could be passed to the private sector earlier in the process, though integrated public agency involvement would be critical.

The P3 process if well-conceived, planned, and executed, can accelerate the pace of project development and implementation, and can incentivize the identification of more cost-effective project solutions and construction strategies by shifting certain risks to the concessionaire. However, besides the deployment of an optimal technical solution to the project, it is vital to consider the project sources of funds and financing strategy. If the project is financed with private sector capital equity or some form of loans or bonds, these will translate into cash flow commitments offsetting potential initial capital cost savings. It is important to perform a Value-for-Money analysis to identify and contrast the financial commitments of alternative project funding/financing strategies.

5.4 Construction Phasing Strategy

A construction sequence for Alternative 1 was defined at a conceptual level as a prospective program for the significant elements of the tunnel construction program, based in part on experience from the recent PortMiami tunnel project, and is divided into four onsite phases. These phases do not include tunnel boring machine fabrication and delivery (Phase 0), which could require 12-15 months for fabrication, partial assembly, and shipping from Europe (as was the case for the PortMiami tunnel boring machine). The tunnel manufacturing and subsequent four onsite phases are summarized below.

Figure 5-1 Tunnel Construction Phasing and Timelines



5.5 Conclusion and Next Steps

The potential impact of the Miami River tunnel studied in this report is significant in terms of relief to surface street congestion in the vicinity of the Brickell Avenue bridge, especially when exacerbated by bridge openings for marine traffic in the river. Limited travel demand modeling suggests that the tunnel will attract sufficient traffic to justify a four-lane facility and that traffic crossing the existing bridge will be significantly diminished. These benefits would be accrued only with a significant investment in the capital cost and ongoing operations cost of the tunnel facility. Relatively short vehicular trips between lower Downtown and northern Brickell will likely remain bridge users given the locations of the tunnel portals as necessitated by existing foundation conditions at the bridge and along Metromover on Biscayne Boulevard. The tunnel as proposed would also trigger some shifts in travel movement patterns across the lower section of Downtown Miami and in the Brickell District. These shifts need to be identified and analyzed further as part of any further planning and development of this proposed project.

The purpose of this study was mainly to identify technically feasible alignments as a basis for considering pursuit of further project development activities. The project with its location within the dense urban setting is in significant contrast to the recently executed PortMiami tunnel. However, that completed project is very instructive to the advancement of this new tunnel proposal. The implementation of the 2nd Avenue transit subway project in New York City is also informative for its execution of a major twin-tube underground transportation project within the constrained setting of an urban street with approximately the same right-of-way width as Brickell Avenue.

The next steps identified for the development of this tunnel corridor are incorporation into the currently adopted Miami-Dade TPO Long Range Transportation Plan as an unfunded project, and pursuit of funds for further corridor study and analysis within the adopted 5-year Transportation Improvement Program. Such studies can undertake more detailed analysis of various facets of tunnel planning and design, as well as construction, identified in this study and will like identify possible technical and cost-effective refinements leading to an improved project definition. Should the project be advanced, it would capture the intent of the tunnel and bridge options first identified in the 1966 study sponsored by the Florida DOT to connect Biscayne Boulevard with Brickell Avenue.