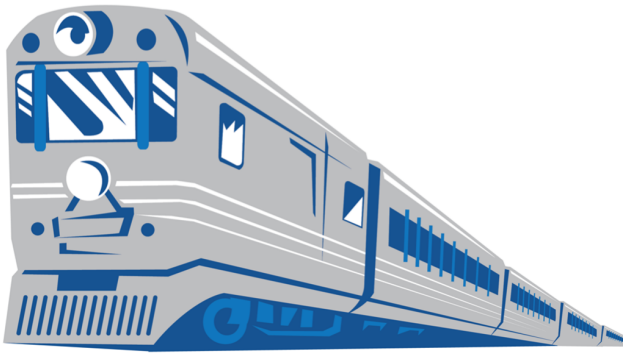
BROWARD COMMUTER RAIL (BCR)
PROJECT DEVELOPMENT & ENVIRONMENT (PD&E) STUDY

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT), DISTRICT 4
BROWARD COUNTY, FLORIDA • FPID: 417031-5-22-01



# Initial Draft Opinion of Probable Construction Cost Estimate v1.0

New River Crossing Tunnel Alternative

## Subject to Change

December 3, 2021

## Revision History

| Revision Date | Revision Number | Sections Affected | Comments |
|---|---|---|---|
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## ABBREVIATIONS AND ACRONYMS

| Abbreviation | Description |
|---|---|
| STA | Station |
| Project | BCR Corridor |
| OPCC | Opinion of Probable Construction Cost |
| ROW | Right-of-way |
| SCC | Standard Cost Category |
| NCR | New River Crossing |

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# 1 Introduction

The purpose of this memorandum is to provide an opinion of probable capital costs related to the construction of the Tunnel Alternative for the BCR corridor project based on historical pricing of a typical commuter rail system. This includes engineering, tunneling, track, utilities, structures, and communication systems, fare collection equipment, professional services, and contingencies. Capital costs were developed to support the Tunnel Alternative alignment and are intended to be order of magnitude costs consistent with the level of conceptual design development and details available during this conceptual phase. In general, development of the OPCC comprised the following steps, which are described in Sections 1.1 through 1.5:

- Establish Project segmentation
- Identify Project elements and measure quantities
- Develop a cost library
- Compile the cost estimate
- Validate data

## 1.1 Tunnel Alternative Description

The tunnel alternative consists of the construction of a commuter rail line within twin, 23-ft diameter TBM bored tunnels crossing under the New River and Tarpon River, with a cut-and-cover station and open approach portals spanning a total alignment length of approximately 1.8 miles.

The proposed tunnel alternative plans and typical sections are shown in Appendix C.

## 1.2 Identify Project Elements and Measure Quantities

A list of project elements was established from the concept drawings. Additional items not defined at this time were added based on data from other existing project documentation and from the estimator and project team experience with similar projects.

## 1.3 Develop Cost Library

The cost library is a compilation of all construction and non-construction items contained within the cost estimate, with the items presented in 2021 dollars. Each item is characterized as either bid item, parametric item, composite item, or percentage item.

### 1.3.1 Bid Items

Bid items represent basic construction elements such as tunnel bore, dewatering, and precast concrete lining, which are typically bid by a contractor on a given project.

### 1.3.2 Parametric Items

Parametric items are included in the estimate to provide pricing for large groups of items that are known to exist in similar projects but cannot be easily quantified based

on the level of development of the design information. Examples include various civil improvements such as excavations, demolition, ventilation, roadway improvements, utility relocations, and dewatering, as well as systems components communications and fare collection. Costs for these elements are summed up and divided by key parameters such as track-feet (TF), route-feet (RF), or route-miles (RM) that are known from the source project and applied to similar parametric quantities on the current project.

### 1.3.3 Composite Items

Composite items are a single item that is composed of multiple bid items that have been grouped together allowing for a single price allowance to be determined.

### 1.3.4 Percentage Items

Percentage-based items are intended to capture elements known to be a part of this type of Project, but not known and/or defined at the time the OPCC was prepared (e.g., mobilization, traffic control, contractor indirect costs). Allowances for items such as professional services are also captured within this category.

## 1.4 Compile Cost Estimate

An Excel workbook was developed to compile the various components of the OPCC. In general, individual tables were created to hold specific information such as the cost library, segmentation, quantity takeoff, work categorization, SCC coding, schedule association, etc. These tables were compiled in the Base Cost Estimate worksheet via lookup or other formulaic methodology. This approach provides consistency for elements that are distributed in a variety of locations throughout the estimate. In addition, it provides a single database from which various summaries can be easily generated to provide response to a wide variety of potential information requests.

## 1.5 Validate Data

This OPCC utilizes parametric pricing based on current estimates for similar type projects as well as historical cost data from Florida Department of Transportation (FDOT).

## 1.6 Assumptions

The following is a list of major assumptions used while developing the OPCC. Other assumptions have been made as part of the quantification of the Project and are included in other sections of this report.

- The project will be competitively bid.
- Sales tax, if any, is assumed to be part of the purchase price of permanent materials.
- Single mobilization for any/all contractors
- Imported construction materials, such as aggregate, fill and concrete, are assumed to be available in sufficient quantities from local suppliers, and waste material can be disposed of within a reasonable haul distance from the Project location.

- Assumed labor force is available and no consideration for work stoppage due to labor strikes or other negotiations affects the completion of the project.
- Estimate based conceptual drawings and parametric pricing. Station platforms have not been designed and geotechnical conditions have not been assessed.
- Design & Construction contingency has been included in estimate costs.
- Allocated Contingency 20% for SCC 10 through 80.
- Unallocated Contingency 5% for SCC 10 through 80.
- Professional Services are included in SCC 80.

# 2 Major Items of Work

The following section is intended to describe the major elements of work. It is not intended to describe all elements. Rather, it is intended to capture the key cost drivers associated with the Project as currently described in the Project plans and documents. Discussion within each section identifies how the cost element was developed along with included versus excluded items and unit of measure. A complete list of items included in each Standard Cost Category (SCC) section is contained in Appendix A.

## 2.1 10.00 Guideway and Track Elements

### 2.1.1 10.01 Guideway: At-Grade Exclusive Right-of-Way

Consists of new Guideway Ballasted Single and Double track for commuter rail on grade. Pricing was developed based on a composite build of elements that make up the bid item. An example of the guideway composite is shown below.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 100100110 | Guideway Ballasted Double Track (On Grade) - Freight Rail | RF | Composite |
| 100100215 | Guideway Ballasted Double Track (On Grade) - Commuter Rail | RF | Composite |

| Activity | Quantity | | Unit Cost | Extension | Comments |
|---|---|---|---|---|---|
| **Guideway Ballasted Single Track** | | | | | 12' Wide |
| Excavate to subbase | 0.89 | CY | $50.00 | $44.50 | Assume 12" average excavation. |
| Haul to Waste | 0.89 | CY | $15.00 | $13.35 | Assume Haul less than 10 miles |
| Finish Subgrade | 2.67 | CY | $15.00 | $40.00 | |
| Subballast | 1.42 | TN | $50.00 | $71.00 | Assume 12" average |
| Ballast | | TN | $50.00 | | Included in track |
| Geotextile | 2.67 | SY | $1.38 | $3.68 | |
| Track underdrain, 6" diameter | 1.00 | LF | $15.13 | $15.13 | |
| Minor unmeasured items | 5.00 | % | | $9.38 | |
| **Total cost** | 1.00 | RF | | **$197.00** | Rounded to three significant figures |

### 2.1.2 10.02 Guideway: At-Grade Semi-Exclusive

This category is not applicable.

### 2.1.3 10.03 Guideway: At-Grade in Mixed Traffic

This category is not applicable.

### 2.1.4 10.04 Guideway: Aerial Structure

This category is not applicable.

### 2.1.5 10.05 Guideway: Built-Up Fill

This category is not applicable.

### 2.1.6 10.06 Guideway: Underground Cut and Cover

Consists of a 90' deep and 1,208' long open cut for the underground station. Work includes secant wall shoring, excavation, jet grouting, placement of concrete walls, deck, and ceiling, backfill and dewatering. For the secant walls assumed 3' diameter at 120' deep. Based on the preliminary drawings walls and deck are assumed to be 4' thick and the invert assumed to be 10.5' thick.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 100601005 | SECANT WALLS/SHORING (ASSUMED 3' DIA @ 120' DEEP) | LF | Parametric |
| 100601010 | EXCAVATE OPEN-CUT TUNNEL | CY | Parametric |
| 100601015 | JET GROUT IF REQUIRED | SF | Parametric |
| 100601020 | MUD/WORKING SLAB | SF | Parametric |
| 100601025 | FPS CUT & COVER INVERT | CY | Parametric |
| 100601030 | FPS CUT & COVER WALLS | CY | Parametric |
| 100601035 | FPS CUT & COVER DECK | CY | Parametric |
| 100601040 | BACKFILL - STRUCTURAL | CY | Parametric |
| 100601045 | BACKFILL - EARTH TO FINISH GRADE | CY | Parametric |
| 100601050 | DEWATERING | LS | Parametric |

### 2.1.7 10.07 Guideway: Underground Tunnel

This category consists of work to build the tunnel and approaches. This includes secant walls, excavation, jet grouting, working slab, approach slab, and dewatering for the northbound and southbound portals. The bored tunnel portion includes a tunnel boring machine (TMB) which consists of purchase, setup, boring, maintenance, and cleanup. The boring operation also includes rock bolts, shotcrete, waterproof membrane, and precast concrete lining of the tunnel. Dewatering, lighting, and ventilation are also included in this price. The northbound tunnel will be constructed and then the TBM will be relocated and positioned to construct the southbound tunnel. The total tunnel boring length for each tunnel is 8,189'.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 100701005 | TBM PURCHASE | EA | Parametric |
| 100701010 | TBM SET-UPS | TF | Parametric |
| 100701015 | TWIN BORE TUNNELING DRIVE | TF | Parametric |
| 100701020 | TWIN BORE MAINTENANCE | TF | Parametric |
| 100701025 | TWIN BORE CLEAN-UP | TF | Parametric |
| 100701050 | PRECAST CONCRETE LINING (SUPPLY & DELIVERY) | LF | Parametric |
| 100701055 | CLEAN & PATCH CONCRETE LINING | TF | Parametric |
| 100701060 | TUNNEL VENTILATION (TEMP) | LF | Parametric |
| 100701065 | TUNNEL LIGHTING (TEMP) | LF | Parametric |
| 100701070 | DEWATERING | LS | Parametric |
| 100701075 | CROSS PASSAGES | EA | Parametric |
| 100703005 | SECANT WALLS/SHORING (ASSUMED 3' DIA @ 60' DEEP) | LF | Parametric |
| 100703010 | EXCAVATE APPROACH/DEPARTURE PORTAL | CY | Parametric |
| 100703015 | JET GROUT IF REQUIRED | SF | Parametric |
| 100703020 | MUD/WORKING SLAB | SF | Parametric |
| 100703025 | FPS APPROACH/DEPARTURE PORTALS | CY | Parametric |
| 100703030 | DEWATERING | LS | Parametric |

### 2.1.8 10.08 Guideway: Retained Cut or Fill

This category is not applicable.

### 2.1.9 10.09 Track: Direct Fixation

Consists of track and drainage for the tunnel and portal sections.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 100901100 | TRACK & DRAINAGE | TF | Parametric |

### 2.1.10 10.10 Track: Embedded

This category is not applicable.

### 2.1.11 10.11 Track: Ballasted

Pricing was developed based on a composite build of elements that make up the bid item. An example of the 115lb (Commuter) rail composite is shown below.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 101100020 | Commuter Rail 115 RE | TF | Composite |

| Activity | Quantity | | Unit Cost | Extension | Comments |
|---|---|---|---|---|---|
| **Single trackway, 2 rails** | | | | | **Assume 90% of Total Length** |
| Supply rail - Standard 115RE | 0.03 | TN | $1,050.00 | $36.23 | |
| Supply precast cross ties - w/restraining holddown | 0.45 | EA | $120.00 | $54.00 | (24" ctrs) |
| Ballast | 1.01 | TN | $50.00 | $50.63 | Assume 12' wide, 12" Deep |
| Install All | 0.90 | TF | $110.00 | $99.00 | Based on matl distribution, welds, skeletonize, SL&D & |
| **Single trackway, 2 rails + 1 restraining rail** | | | | | **Assume 10% of total Length** |
| Supply rail - Standard 115RE - pre-curved | 0.00 | LF | $1,300.00 | $4.98 | |
| Supply rail - Standard 115RE - pre-curved restraining rail | 0.01 | LF | $1,300.00 | $7.48 | |
| Supply precast cross ties - w/restraining holddown | 0.06 | EA | $120.00 | $7.20 | (20" ctrs) |
| Ballast | 1.01 | TN | $50.00 | $50.63 | Assume 12' wide, 12" Deep |
| Install All | 0.10 | TF | $165.00 | $16.50 | Based on matl distribution, welds, skeletonize, SL&D & |
| | | | | | |
| Minor unmeasured items | 5.00 | % | | $16.33 | |
| **Total cost** | 1.00 | LF | | **$343.00** | Rounded to three significant figures |

### 2.1.12 10.12 Track: Special (Switches, Turnouts)

Special track work includes embedded turnouts. Special track is quantified by “each” and is made up of costs to furnish and install the turnout.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 101200110 | #20 Turnout | EA | Parametric |

### 2.1.13 10.13 Track: Vibration and Noise Dampening

No costs are included for vibration and noise dampening in this OPCC.

## 2.2 20.00 Stations, Stops, Terminals, Intermodal

### 2.2.1 20.01 At-Grade Station, Stop, Shelter, Mall, Terminal, Platform

This category is not applicable.

### 2.2.2 20.02 Aerial Station, Stop, Shelter, Mall, Terminal, Platform

This category is not applicable.

### 2.2.3 20.03 Underground Station, Stop, Shelter, Mall, Terminal, Platform

This work consists of the construction of a 1000' station platform. No detailed information has been designed for this station. Costs were developed by using parametric pricing based on other similar type of stations from other projects. This pricing includes elevators, stairs, escalators, power, pluming, HVAC, fire system, pump station, and a mezzanine. An allowance was also included to account for a connection to the existing Brightline station walkway.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 200301005 | CONSTRUCT 1000' STATION PLATFORM | EA | Parametric |
| 200301010 | MEZZANINE | EA | Parametric |
| 200301015 | EMPLOYEE FACILITY ROOM | EA | Parametric |
| 200301020 | ELEVATORS | EA | Parametric |
| 200301025 | ESCALATORS | EA | Parametric |
| 200301030 | STAIRS | EA | Parametric |
| 200301035 | HVAC SYSTEM | EA | Parametric |
| 200301040 | POWER & LIGHTING | LS | Parametric |
| 200301045 | PLUMBING - WATER & SEWER | LS | Parametric |
| 200301050 | PUMP ROOM - PUMPS, PIPING, POWER, ETC. | LS | Parametric |
| 200301055 | FIRE SYSTEM | LS | Parametric |
| 200301060 | EMERGENCY GENERATOR | LS | Parametric |
| 200301065 | CONNECTION TO BRIGHTLINE WALKWAY | LS | Parametric |

### 2.2.4 20.04 Other Stations, Landings, Terminals: Intermodal, Ferry, Trolley, Etc.

This category is not applicable.

### 2.2.5 20.05 Joint Development

This category is not applicable.

### 2.2.6 20.06 Automobile Parking Multi-Story Structure

This category is not applicable.

### 2.2.7 20.07 Elevators, Escalators

This category is not applicable.

## 2.3 30.00 Support Facilities

### 2.3.1 30.01 Administration Building: Office, Sales, Storage

This category is not applicable.

### 2.3.2 30.02 Light Maintenance Facility

This category is not applicable.

### 2.3.3 30.03 Heavy Maintenance Facility

This category is not applicable.

### 2.3.4 30.04 Storage or Maintenance of Way Building

This category is not applicable.

### 2.3.5 30.05 Yard and Yard Track

This category is not applicable.

## 2.4 40.00 Sitework and Special Conditions

### 2.4.1 40.01 Demolition, Clearing, and Earthwork

Consists of demolition of track, demolition of crossing, pavement removal, miscellaneous roadway items, and embankment of track on grade. For demolition of crossings assumed 4,100 LF of crossings at 12' wide for a total of 50,000 SF priced at $5/SF. Pavement removal and the miscellaneous roadway allowance are to cover the costs of the adjustments for the roadway that will be required at the portals and cut and cover sections.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 400101100 | MISC ROADWAY ITEMS | LS | Parametric |
| 400110100 | Crossing Removal | LS | Allowance |
| 400110200 | Track Removal | TF | Bid Item |
| 400110400 | Remove Pavement | SY | Bid Item |
| 400140100 | Embankment | CY | Bid Item |

### 2.4.2 40.02 Site Utilities and Utility Relocation

This includes allowances for utility relocation and connection to the existing sewer and water systems for the underground station.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 400291100 | UTILITY RELOCATION | LS | Parametric |
| 400294100 | CONNECTION TO EXISTING SEWER & WATER | LS | Parametric |

### 2.4.3 40.03 Hazardous Material, Contaminated Soil Removal/Mitigation

This category is not applicable.

### 2.4.4 40.04 Environmental Mitigation

This category is not applicable.

### 2.4.5 40.05 Site Structures Including Retaining Walls, Sound Walls

This includes the pricing for a new bridge at Andrews Ave. to span the approach portal. Bridge assumed to be 88' x 120' for a total 10,560 SF. Pricing is based on the FDOT historical costs data and costs from other recent estimated projects.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 400510100 | Andrews Ave Bridge | SF | Bid Item |

### 2.4.6 40.06 Pedestrian/Bike Access and Accommodation, Landscaping

This category is not applicable.

### 2.4.7 40.07 Automobile, Bus, Van Accessways Including Roads and Parking Lots

Includes work for sidewalk, curb and gutter, median, and asphalt paving for side roads. Pricing is based on FDOT historical costs data and costs from similar projects.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 400720010 | SUPERPAVE ASPHALTIC CONCRETE, TRAFFIC C, PG76-22 | TON | Bid Item |
| 400720020 | ASPHALT CONCRETE FRICTION COURSE, TRAFFIC C, FC-9.5, PG 76-22 | TON | Bid Item |
| 400710010 | CONCRETE SIDEWALK AND DRIVEWAYS, 4" THICK | SY | Bid Item |
| 400710020 | CONCRETE CURB & GUTTER, TYPE F | LF | Bid Item |
| 400710030 | TRAFFIC SEPARATOR CONCRETE-TYPE I, 4' WIDE | SY | Bid Item |

### 2.4.8 40.08 Temporary Facilities and Other Indirect Costs During Construction

This category includes costs associated with contractor indirect costs and profit, traffic control/maintenance of traffic, and temporary erosion control. It is an allowance and based on a percentage of the direct costs in SCC 10-50.

Contractor Indirect Costs are assumed to include fixed costs and time-related costs associated with mobilization, demobilization, and project management and supervision. A portion of these costs and the profit are applied to the Mobilization pay item with the remainder spread throughout the pay items in the contract.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 400810100 | Mobilization | % | Percentage |
| 400840500 | Traffic Control | % | Percentage |

## 2.5 50.00 Systems

### 2.5.1 50.01 Train Control and Signals

Parametric pricing was used to cover the costs of train control signals within the tunnel portion of the work.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500110100 | Train Control And Signals | RF | Parametric |

### 2.5.2 50.02 Traffic Signals and Crossing Protection

Grade crossings and signals. Items and pricing were from the feasibility study were used for these items for the at grade crossings and escalated to 2021 dollars.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500230100 | Grade Crossing Programming | EA | Bid Item |
| 500230200 | Grade Crossing DAXing & Programming | EA | Bid Item |
| 500230600 | Grade Crossing Panels | LF | Bid Item |
| 500230700 | Grade Crossing Gates | EA | Bid Item |
| 500230800 | Interlocking | EA | Bid Item |
| 500231000 | Signal Interface Modifications | EA | Bid Item |

### 2.5.3 50.03 Traction Power Supply: Substations

This category is not applicable.

### 2.5.4 50.04 Traction Power Distribution: Catenary and Third Rail

Includes allowances for power, lighting and ventilation for the bored tunnel portions and the approach portals.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500401100 | PERMANENT VENTILATION,POWER & LIGHTING | TF | Parametric |
| 500401200 | FAN PLANT | EA | Parametric |
| 500403100 | POWER & LIGHTING | TF | Parametric |

### 2.5.5 50.05 Communications

Includes communication items located within the station. Also includes the fiber optic lines for the tunnel and approach portals. Pricing is parametric based from similar transit projects.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500501100 | COMMUNICATIONS/FIBER | TF | Parametric |
| 500505100 | PUBLIC ADDRESS SYSTEM & COMMUNICATIONS | LS | Parametric |
| 500505200 | CCTV SYSTEM & FIBER OPTICS | LS | Parametric |

### 2.5.6 50.06 Fare Collection System and Equipment

Includes ticket vending machines and fare card validators at the station. Pricing is parametric based on similar transit projects.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500602100 | TICKET VENDING, ETC. | EA | Parametric |

### 2.5.7 50.07 Control Center

Central control allowance added based on similar projects.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 500791100 | Central Control, Allowance | EA | Parametric |

## 2.6 60.00 Right-of-Way (ROW)

### 2.6.1 60.01 Purchase or Lease of Real Estate

This category is not applicable.

### 2.6.2 60.02 Relocation of Existing Households and Businesses

This category is not applicable.

## 2.7 70.00 Vehicles

This category is not applicable

## 2.8 80.00 Professional Services

### 2.8.1 80.01 Project Development

This category includes allowances for Project Development.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800100100 | Project Development | % | Percentage |

### 2.8.2 80.02 Engineering

This category includes unquantified allowances for final design.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800200100 | Engineering | % | Percentage |

### 2.8.3 80.03 Project Management for Design and Construction

This category includes allowances for agency and consultant project management efforts and public relations costs throughout the life of the project.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800300100 | Project Management | % | Percentage |

### 2.8.4 80.04 Construction Administration and Management

Construction administration and management includes an allowance for an expected consultant construction management contract.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800400100 | Construction Management | % | Percentage |

### 2.8.5 80.05 Professional Liability and Other Non-Construction Insurance

This category includes an allowance for expected liability insurance costs for the project.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800500100 | Professional Liability and other Non-Construction Insurance | % | Percentage |

### 2.8.6 80.06 Legal, Permits, Review Fees by Other Agencies, Cities, Etc.

This category includes an unquantified allowance for legal representation and permitting and review fees by other outside agencies.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800600100 | Legal, Permits, Review Fees | % | Percentage |

### 2.8.7 80.07 Surveys, Testing, Investigation, Inspection

This category includes an allowance for end of project survey and inspection.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800700100 | Surveys, Testing, Investigation, Inspection | % | Percentage |

### 2.8.8 80.08 Start Up

Startup efforts include preparation of standard operating procedures, rulebooks, emergency preparedness and training, operator training, integrations support, and simulation of services.

| Bid Item | Activity | Unit | Price Type |
|---|---|---|---|
| 800800100 | Start up | % | Percentage |

# 3 Results

## 3.1 Base Year Cost

Base year cost is considered the cost in 2021 year dollars including risk. The base year cost estimate is summarized by major SCC category in Table 3-1.

**Table 3-1: Base Year Cost by Major SCC Category (Millions)**

| SCC Category | | Base Cost | Allocated Contingency | Unallocated Contingency | Base Year Cost |
|---|---|---|---|---|---|
| **10** | Guideway & Track Elements | $782.08 | $156.42 | $39.10 | $977.60 |
| **20** | Stations, Stops, Terminals, Intermodal | $81.49 | $16.30 | $4.07 | $101.87 |
| **40** | Sitework & Special Conditions | $80.49 | $16.10 | $4.02 | $100.61 |
| **50** | Systems | $177.25 | $35.45 | $8.86 | $221.56 |
| **80** | Professional Services | $336.39 | $67.28 | $16.82 | $420.49 |
| **Total Cost** | | **$1,457.71** | **$291.54** | **$72.89** | **$1,822.13** |

Source: HDR, 2021

## 3.2 Contingency

Contingency is included in the program cost estimate based on guidance recommended by FTA and estimator experience with providing opinions of cost at conceptual levels. Contingency is broken into allocated and unallocated categories as required by FTA guidelines. Table 3-2 presents the percentage of allocated and unallocated contingency applied with each SCC Category. The percentages shown were applied to the base cost elements to build up overall contingency values shown in Table 3-1.

**Table 3-2: Contingency Percent by SCC Category**

| SCC Category | | Allocated Contingency | Unallocated Contingency |
|---|---|---|---|
| **10** | Guideway & Track Elements | 20.00% | 5.00% |
| **20** | Stations, Stops, Terminals, Intermodal | 20.00% | 5.00% |
| **40** | Sitework & Special Conditions | 20.00% | 5.00% |
| **50** | Systems | 20.00% | 5.00% |
| **80** | Professional Services | 20.00% | 5.00% |
| **Total Contingency Percentage** | | 20.00% | 5.00% |

## 3.3 Escalation

Escalation has not been calculated in this OPCC.

# 4 Summary

## 4.1 Opinion of Probable Construction Cost

The Base Cost analysis resulted in base year cost of $1,822.13M. Using data based on a AACE International Class 4 estimate an expected accuracy rang of -10% and +35% was

assigned to this estimate. The resulting range of the Opinion of Probably base cost can be seen in table 4-1 below. A detailed breakdown of a class 4 estimate can be found in Appendix C.

### Table 4-1: Summary of Opinion of Probable Base Year Cost

| Summary of Opinion of Probable Construction Cost Base Year 2021 (Millions) | | |
|---|---|---|
| **Low Range** | | **High Range** |
| **-10%** | **Tunnel Alternative** | **35%** |
| $1,640 M | $1,822 M | $2,460 M |

# Appendix A. Detailed Base Cost OPCC Summary Tunnel Alternative

(See Excel spreadsheet for additional detail)

| SCC Categories | | | L4 Header | Bid Item | Description | Quantity | UOM | Unit Cost | Base Cost |
|---|---|---|---|---|---|---|---|---|---|
| 10 GUIDEWAY & TRACK ELEMENTS (route miles) | 10.01 | Guideway: At-grade exclusive right-of-way | | 100100210 | Guideway Ballasted Single Track (On Grade) | 2,208.00 | RF | $247.08 | $545,543 |
| | | | | 100100215 | Guideway Ballasted Double Track (On Grade) | 3,155.00 | RF | $387.54 | $1,222,704 |
| | | **Guideway: At-grade exclusive right-of-way Total** | | | | | | | **$1,768,246** |
| | 10.06 | Guideway: Underground cut & cover | OPEN-CUT TUNNEL | 100601005 | SECANT WALLS/SHORING (ASSUMED 3' DIA @ 120' DEEP) | 102,480.00 | LF | $1,686.89 | $172,872,031 |
| | | | | 100601010 | EXCAVATE OPEN-CUT TUNNEL | 302,000.00 | CY | $94.06 | $28,407,404 |
| | | | | 100601015 | JET GROUT IF REQUIRED | 90,600.00 | SF | $75.25 | $6,817,777 |
| | | | | 100601020 | MUD/WORKING SLAB | 90,600.00 | SF | $18.81 | $1,704,444 |
| | | | | 100601025 | FPS CUT & COVER INVERT | 35,233.33 | CY | $815.22 | $28,723,039 |
| | | | | 100601030 | FPS CUT & COVER WALLS | 32,853.33 | CY | $940.64 | $30,903,238 |
| | | | | 100601035 | FPS CUT & COVER DECK | 13,422.22 | CY | $2,132.12 | $28,617,824 |
| | | | | 100601040 | BACKFILL - STRUCTURAL | 10,066.67 | CY | $188.13 | $1,893,828 |
| | | | | 100601045 | BACKFILL - EARTH TO FINISH GRADE | 117,444.44 | CY | $81.52 | $9,574,347 |
| | | | | 100601050 | DEWATERING | 1.00 | LS | $6,270,950.00 | $6,270,950 |
| | | **Guideway: Underground cut & cover Total** | | | | | | | **$315,784,881** |
| | 10.07 | Guideway: Underground tunnel | NB - Twin Bore Tunnel | 100701005 | TBM PURCHASE | 0.50 | EA | $36,873,186.00 | $18,436,593 |
| | | | | 100701010 | TBM SET-UPS | 4,138.50 | TF | $376.26 | $1,557,140 |
| | | | | 100701015 | TWIN BORE TUNNELING DRIVE | 9,397.00 | TF | $5,267.60 | $49,499,618 |
| | | | | 100701020 | TWIN BORE MAINTENANCE | 9,397.00 | TF | $125.42 | $1,178,562 |
| | | | | 100701025 | TWIN BORE CLEAN-UP | 9,397.00 | TF | $313.55 | $2,946,406 |
| | | | | 100701050 | PRECAST CONCRETE LINING (SUPPLY & DELIVERY) | 9,397.00 | LF | $2,257.54 | $21,214,122 |
| | | | | 100701055 | CLEAN & PATCH CONCRETE LINING | 9,397.00 | TF | $6.27 | $58,928 |
| | | | | 100701060 | TUNNEL VENTILATION (TEMP) | 9,397.00 | LF | $125.42 | $1,178,562 |
| | | | | 100701065 | TUNNEL LIGHTING (TEMP) | 9,397.00 | LF | $125.42 | $1,178,562 |
| | | | | 100701070 | DEWATERING | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | | | 100701075 | CROSS PASSAGES | 5.00 | EA | $1,003,352.00 | $5,016,760 |
| | | | SB - Twin Bore Tunnel | 100702005 | TBM PURCHASE | 0.50 | EA | $36,873,186.00 | $18,436,593 |
| | | | | 100702010 | TBM SET-UPS | 4,138.50 | TF | $376.26 | $1,557,140 |
| | | | | 100702015 | TWIN BORE TUNNELING DRIVE | 9,397.00 | TF | $5,267.60 | $49,499,618 |
| | | | | 100702020 | TWIN BORE MAINTENANCE | 9,397.00 | TF | $125.42 | $1,178,562 |
| | | | | 100702025 | TWIN BORE CLEAN-UP | 9,397.00 | TF | $313.55 | $2,946,406 |
| | | | | 100702050 | PRECAST CONCRETE LINING (SUPPLY & DELIVERY) | 9,397.00 | LF | $2,257.54 | $21,214,122 |
| | | | | 100702055 | CLEAN & PATCH CONCRETE LINING | 9,397.00 | TF | $6.27 | $58,928 |
| | | | | 100702060 | TUNNEL VENTILATION (TEMP) | 9,397.00 | LF | $125.42 | $1,178,562 |
| | | | | 100702065 | TUNNEL LIGHTING (TEMP) | 9,397.00 | LF | $125.42 | $1,178,562 |
| | | | | 100702070 | DEWATERING | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | | | 100702075 | CROSS PASSAGES | 5.00 | EA | $1,003,352.00 | $5,016,760 |
| | | | NB - APPROACH/DEPARTURE PORTALS | 100703005 | SECANT WALLS/SHORING (ASSUMED 3' DIA @ 60' DEEP) | 54,540.00 | LF | $1,686.89 | $92,002,738 |
| | | | | 100703010 | EXCAVATE APPROACH/DEPARTURE PORTAL | 50,983.33 | CY | $94.06 | $4,795,709 |
| | | | | 100703015 | JET GROUT IF REQUIRED | 59,850.00 | SF | $75.25 | $4,503,796 |
| | | | | 100703020 | MUD/WORKING SLAB | 119,700.00 | SF | $18.81 | $2,251,898 |
| | | | | 100703025 | FPS APPROACH/DEPARTURE PORTALS | 13,373.89 | CY | $815.22 | $10,902,709 |
| | | | | 100703030 | DEWATERING | 1.00 | LS | $627,095.00 | $627,095 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 100704005 | SECANT WALLS/SHORING (ASSUMED 3' DIA @ 60' DEEP) | 54,300.00 | LF | $1,686.89 | $91,597,885 |
| | | | | 100704010 | EXCAVATE APPROACH/DEPARTURE PORTAL | 50,408.33 | CY | $94.06 | $4,741,622 |
| | | | | 100704015 | JET GROUT IF REQUIRED | 59,175.00 | SF | $75.25 | $4,453,002 |
| | | | | 100704020 | MUD/WORKING SLAB | 118,350.00 | SF | $18.81 | $2,226,501 |
| | | | | 100704025 | FPS APPROACH/DEPARTURE PORTALS | 13,223.06 | CY | $815.22 | $10,779,749 |
| | | | | 100704030 | DEWATERING | 1.00 | LS | $627,095.00 | $627,095 |
| | | **Guideway: Underground tunnel Total** | | | | | | | **$439,057,068** |
| | 10.09 | Track: Direct fixation | NB - Twin Bore Tunnel | 100901100 | TRACK & DRAINAGE | 8,277.00 | TF | $752.51 | $6,228,558 |
| | | | SB - Twin Bore Tunnel | 100902100 | TRACK & DRAINAGE | 8,277.00 | TF | $752.51 | $6,228,558 |
| | | | NB - APPROACH/DEPARTURE PORTALS | 100903100 | TRACK & DRAINAGE | 1,330.00 | TF | $752.51 | $1,000,844 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 100904100 | TRACK & DRAINAGE | 1,315.00 | TF | $752.51 | $989,556 |
| | | | OPEN-CUT TUNNEL | 100905100 | TRACK & DRAINAGE | 2,416.00 | TF | $752.51 | $1,818,074 |
| | | **Track: Direct fixation Total** | | | | | | | **$16,265,590** |
| | 10.11 | Track: Ballasted | | 101100020 | Commuter Rail 115 RE | 13,822.00 | TF | $430.19 | $5,946,047 |
| | | **Track: Ballasted Total** | | | | | | | **$5,946,047** |
| | 10.12 | Track: Special (switches, turnouts) | | 101200110 | #20 Turnout | 10.00 | EA | $326,089.40 | $3,260,894 |
| | | **Track: Special (switches, turnouts) Total** | | | | | | | **$3,260,894** |
| **GUIDEWAY & TRACK ELEMENTS (route miles) Total** | | | | | | | | | **$782,082,726** |
| 20 STATIONS, STOPS, TERMINALS, INTERMODAL (number) | 20.03 | Underground station, stop, shelter, mall, | UNDERGROUND STATION | 200301005 | CONSTRUCT 1000' STATION PLATFORM | 1.00 | EA | $9,754,462.73 | $9,754,463 |
| | | | | 200301010 | MEZZANINE | 1.00 | EA | $10,033,520.00 | $10,033,520 |
| | | | | 200301015 | EMPLOYEE FACILITY ROOM | 1.00 | EA | $6,270,950.00 | $6,270,950 |

| SCC Categories | | | L4 Header | Bid Item | Description | Quantity | UOM | Unit Cost | Base Cost |
|---|---|---|---|---|---|---|---|---|---|
| 20 STATIONS, STOPS, TERMINALS, INTERMODAL (number) | 20.03 | Underground station, stop, shelter, mall, | UNDERGROUND STATION | 200301020 | ELEVATORS | 2.00 | EA | $1,881,285.00 | $3,762,570 |
| | | | | 200301025 | ESCALATORS | 4.00 | EA | $2,508,380.00 | $10,033,520 |
| | | | | 200301030 | STAIRS | 2.00 | EA | $5,016,760.00 | $10,033,520 |
| | | | | 200301035 | HVAC SYSTEM | 1.00 | EA | $2,759,218.00 | $2,759,218 |
| | | | | 200301040 | POWER & LIGHTING | 1.00 | LS | $8,779,330.00 | $8,779,330 |
| | | | | 200301045 | PLUMBING - WATER & SEWER | 1.00 | LS | $3,762,570.00 | $3,762,570 |
| | | | | 200301050 | PUMP ROOM - PUMPS, PIPING, POWER, ETC. | 1.00 | LS | $4,389,665.00 | $4,389,665 |
| | | | | 200301055 | FIRE SYSTEM | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | | | 200301060 | EMERGENCY GENERATOR | 1.00 | LS | $3,135,475.00 | $3,135,475 |
| | | | | 200301065 | CONNECTION TO BRIGHTLINE WALKWAY | 1.00 | LS | $6,270,950.00 | $6,270,950 |
| | | **Underground station, stop, shelter, mall, terminal, platform Total** | | | | | | | **$81,494,131** |
| **STATIONS, STOPS, TERMINALS, INTERMODAL (number) Total** | | | | | | | | | **$81,494,131** |
| 40 SITEWORK & SPECIAL CONDITIONS | 40.01 | Demolition, Clearing, Earthwork | NB - APPROACH/DEPARTURE PORTALS | 400101100 | MISC ROADWAY ITEMS | 1.00 | LS | $1,254,190.00 | $1,254,190 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 400102100 | MISC ROADWAY ITEMS | 1.00 | LS | $1,254,190.00 | $1,254,190 |
| | | | OPEN-CUT TUNNEL | 400103100 | MISC ROADWAY ITEMS | 1.00 | LS | $3,762,570.00 | $3,762,570 |
| | | | | 400110100 | Crossing Removal | 1.00 | LS | $313,547.50 | $313,548 |
| | | | | 400110200 | Track Removal | 2,490.00 | TF | $24.00 | $59,760 |
| | | | | 400110400 | Remove Pavement | 13,830.00 | SY | $10.03 | $138,764 |
| | | | | 400140100 | Embankment | 10,000.00 | CY | $17.00 | $170,000 |
| | | **Demolition, Clearing, Earthwork Total** | | | | | | | **$6,953,021** |
| | 40.02 | Site Utilities, Utility Relocation | NB - APPROACH/DEPARTURE PORTALS | 400291100 | UTILITY RELOCATION | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 400292100 | UTILITY RELOCATION | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | | OPEN-CUT TUNNEL | 400293100 | UTILITY RELOCATION | 1.00 | LS | $6,270,950.00 | $6,270,950 |
| | | | UNDERGROUND STATION | 400294100 | CONNECTION TO EXISTING SEWER & WATER | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | **Site Utilities, Utility Relocation Total** | | | | | | | **$13,796,090** |
| | 40.05 | Site structures including retaining walls, sound walls | | 400510100 | Andrews Ave Bridge | 10,560.00 | SF | $200.00 | $2,112,000 |
| | | **Site structures including retaining walls, sound walls Total** | | | | | | | **$2,112,000** |
| | 40.07 | Automobile, bus, van accessways including roads, parking lots | | 400720010 | SUPERPAVE ASPHALTIC CONCRETE, TRAFFIC C, PG76-22 | 3,601.00 | TON | $100.00 | $360,100 |
| | | | | 400720020 | ASPHALT CONCRETE FRICTION COURSE,TRAFFIC C, FC-9.5, PG 76-22 | 343.00 | TON | $129.00 | $44,247 |
| | | | | 400710010 | CONCRETE SIDEWALK AND DRIVEWAYS, 4" THICK | 639.00 | SY | $44.00 | $28,116 |
| | | | | 400710020 | CONCRETE CURB & GUTTER, TYPE F | 1,928.00 | LF | $26.00 | $50,128 |
| | | | | 400710030 | TRAFFIC SEPARATOR CONCRETE-TYPE I, 4' WIDE | 182.00 | SY | $91.00 | $16,562 |
| | | **Automobile, bus, van accessways including roads, parking lots Total** | | | | | | | **$499,153** |
| | 40.08 | Temporary Facilities and other indirect costs during construction | | 400810100 | Mobilization | 345,405,924.05 | % | 5.0% | $17,270,296 |
| | | | | | | 681,706,776.00 | % | 5.0% | $34,085,339 |
| | | | | | | 94,199,570.50 | % | 5.0% | $4,709,979 |
| | | | | 400840400 | Traffic Control | 1.00 | LS | $1,063,650.65 | $1,063,651 |
| | | **Temporary Facilities and other indirect costs during construction Total** | | | | | | | **$57,129,264** |
| **SITEWORK & SPECIAL CONDITIONS Total** | | | | | | | | | **$80,489,528** |
| 50 SYSTEMS | 50.01 | Train control and signals | | 500110100 | Train Control And Signals | 17,251.00 | RF | $1,693.16 | $29,208,643 |
| | | **Train control and signals Total** | | | | | | | **$29,208,643** |
| | 50.02 | Traffic signals and crossing protection | | 500230100 | Grade Crossing Programming | 3.00 | EA | $11,100.00 | $33,300 |
| | | | | 500230200 | Grade Crossing DAXing & Programming | 3.00 | EA | $59,400.00 | $178,200 |
| | | | | 500230600 | Grade Crossing Panels | 821.00 | LF | $1,560.00 | $1,280,760 |
| | | | | 500230700 | Grade Crossing Gates | 2.00 | EA | $332,100.00 | $664,200 |
| | | | | 500230800 | Interlocking | 2.00 | EA | $1,375,000.00 | $2,750,000 |
| | | | | 500231000 | Signal Interface Modifications | 1.00 | EA | $41,500.00 | $41,500 |
| | | **Traffic signals and crossing protection Total** | | | | | | | **$4,947,960** |
| | 50.04 | Traction power distribution: catenary an | NB - Twin Bore Tunnel | 500401100 | PERMANENT VENTILATION,POWER & LIGHTING | 9,397.00 | TF | $3,135.48 | $29,464,059 |
| | | | | 500401200 | FAN PLANT | 1.00 | EA | $22,575,420.00 | $22,575,420 |
| | | | SB - Twin Bore Tunnel | 500402100 | PERMANENT VENTILATION,POWER & LIGHTING | 9,397.00 | TF | $3,135.48 | $29,464,059 |
| | | | | 500402200 | FAN PLANT | 1.00 | EA | $22,575,420.00 | $22,575,420 |
| | | | NB - APPROACH/DEPARTURE PORTALS | 500403100 | POWER & LIGHTING | 1,330.00 | TF | $2,508.38 | $3,336,145 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 500404100 | POWER & LIGHTING | 1,315.00 | TF | $2,508.38 | $3,298,520 |
| | | **Traction power distribution: catenary and third rail Total** | | | | | | | **$110,713,622** |
| | 50.05 | Communications | NB - Twin Bore Tunnel | 500501100 | COMMUNICATIONS/FIBER | 9,397.00 | TF | $1,254.19 | $11,785,623 |
| | | | SB - Twin Bore Tunnel | 500502100 | COMMUNICATIONS/FIBER | 9,397.00 | TF | $1,254.19 | $11,785,623 |
| | | | NB - APPROACH/DEPARTURE PORTALS | 500503100 | COMMUNICATIONS/FIBER | 1,330.00 | TF | $1,254.19 | $1,668,073 |
| | | | SB - APPROACH/DEPARTURE PORTALS | 500504100 | COMMUNICATIONS/FIBER | 1,315.00 | TF | $1,254.19 | $1,649,260 |
| | | | UNDERGROUND STATION | 500505100 | PUBLIC ADDRESS SYSTEM & COMMUNICATIONS | 1.00 | LS | $1,881,285.00 | $1,881,285 |
| | | | | 500505200 | CCTV SYSTEM & FIBER OPTICS | 1.00 | LS | $2,508,380.00 | $2,508,380 |
| | | **Communications Total** | | | | | | | **$31,278,244** |
| | 50.06 | Fare collection system and equipment | UNDERGROUND STATION | 500601100 | TICKET VENDING, ETC. | 1.00 | EA | $156,773.75 | $156,774 |

| SCC Categories | | | | L4 Header | Bid Item | Description | Quantity | UOM | Unit Cost | Base Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 | SYSTEMS | 50.06 | **Fare collection system and equipment Total** | | | | | | | **$156,774** |
| | | 50.07 | Central Control | UNDERGROUND STATION | 500791100 | Central Control, Allowance | 1.00 | EA | $940,642.50 | $940,643 |
| | | | **Central Control Total** | | | | | | | **$940,643** |
| | **SYSTEMS Total** | | | | | | | | | **$177,245,886** |
| 80 | PROFESSIONAL SERVICES (applies to Cats. 10-50) | 80.01 | Project Development | | 800100100 | Project Development | 345,405,924.05 | % | 4.0% | $13,816,237 |
| | | | | | | | 681,706,776.00 | % | 4.0% | $27,268,271 |
| | | | | | | | 94,199,570.50 | % | 4.0% | $3,767,983 |
| | | | **Project Development Total** | | | | | | | **$44,852,491** |
| | | 80.02 | Engineering | | 800200100 | Engineering | 345,405,924.05 | % | 6.0% | $20,724,355 |
| | | | | | | | 681,706,776.00 | % | 6.0% | $40,902,407 |
| | | | | | | | 94,199,570.50 | % | 6.0% | $5,651,974 |
| | | | **Engineering Total** | | | | | | | **$67,278,736** |
| | | 80.03 | Project Management for Design and Construction | | 800300100 | Project Management | 345,405,924.05 | % | 6.0% | $20,724,355 |
| | | | | | | | 681,706,776.00 | % | 6.0% | $40,902,407 |
| | | | | | | | 94,199,570.50 | % | 6.0% | $5,651,974 |
| | | | **Project Management for Design and Construction Total** | | | | | | | **$67,278,736** |
| | | 80.04 | Construction Administration & Management | | 800400100 | Construction Management | 345,405,924.05 | % | 8.0% | $27,632,474 |
| | | | | | | | 681,706,776.00 | % | 8.0% | $54,536,542 |
| | | | | | | | 94,199,570.50 | % | 8.0% | $7,535,966 |
| | | | **Construction Administration & Management Total** | | | | | | | **$89,704,982** |
| | | 80.05 | Professional Liability and other Non-Construction Insurance | | 800500100 | Professional Liability and other Non-Construction Insurance | 345,405,924.05 | % | 2.0% | $6,908,118 |
| | | | | | | | 681,706,776.00 | % | 2.0% | $13,634,136 |
| | | | | | | | 94,199,570.50 | % | 2.0% | $1,883,991 |
| | | | **Professional Liability and other Non-Construction Insurance Total** | | | | | | | **$22,426,245** |
| | | 80.06 | Legal; Permits; Review Fees by other agencies, cities, etc. | | 800600100 | Legal, Permits, Review Fees | 345,405,924.05 | % | 2.0% | $6,908,118 |
| | | | | | | | 681,706,776.00 | % | 2.0% | $13,634,136 |
| | | | | | | | 94,199,570.50 | % | 2.0% | $1,883,991 |
| | | | **Legal; Permits; Review Fees by other agencies, cities, etc. Total** | | | | | | | **$22,426,245** |
| | | 80.07 | Surveys, Testing, Investigation, Inspection | | 800700100 | Surveys, Testing, Investigation, Inspection | 345,405,924.05 | % | 1.0% | $3,454,059 |
| | | | | | | | 681,706,776.00 | % | 1.0% | $6,817,068 |
| | | | | | | | 94,199,570.50 | % | 1.0% | $941,996 |
| | | | **Surveys, Testing, Investigation, Inspection Total** | | | | | | | **$11,213,123** |
| | | 80.08 | Start up | | 800800100 | Start up | 345,405,924.05 | % | 1.0% | $3,454,059 |
| | | | | | | | 681,706,776.00 | % | 1.0% | $6,817,068 |
| | | | | | | | 94,199,570.50 | % | 1.0% | $941,996 |
| | | | **Start up Total** | | | | | | | **$11,213,123** |
| | **PROFESSIONAL SERVICES (applies to Cats. 10-50) Total** | | | | | | | | | **$336,393,681** |
| **Grand Total** | | | | | | | | | | **$1,457,705,952** |
| **Allocated Contingency** | | | | | | | | | | $291,541,190 |
| **Unallocated Contingency** | | | | | | | | | | $72,885,298 |
| **Total Base Year (2021) Cost** | | | | | | | | | | **$1,822,132,440** |

# Appendix B. AACE Cost Estimate Classification System

(See Excel spreadsheet for additional info)

AACE International Recommended Practice No. 18R-97

# COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

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# COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES

TCM Framework: 7.3 – Cost Estimating and Budgeting

February 2, 2005

## PURPOSE

As a recommended practice of AACE International, the Cost Estimate Classification System provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The Cost Estimate Classification System maps the phases and stages of project cost estimating together with a generic maturity and quality matrix, which can be applied across a wide variety of industries.

This addendum to the generic recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the process industries. This addendum supplements the generic recommended practice (17R-97) by providing:

- a section that further defines classification concepts as they apply to the process industries;
- charts that compare existing estimate classification practices in the process industry; and
- a chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic standard, an intent of this addendum is to improve communications among all of the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the process industries.

It is understood that each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways. This guideline provides a generic and generally acceptable classification system for process industries that can be used as a basis to compare against. It is hoped that this addendum will allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

## INTRODUCTION

For the purposes of this addendum, the term process industries is assumed to include firms involved with the manufacturing and production of chemicals, petrochemicals, and hydrocarbon processing. The common thread among these industries (for the purpose of estimate classification) is their reliance on process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) as primary scope defining documents. These documents are key deliverables in determining the level of project definition, and thus the extent and maturity of estimate input information.

Estimates for process facilities center on mechanical and chemical process equipment, and they have significant amounts of piping, instrumentation, and process controls involved. As such, this addendum may apply to portions of other industries, such as pharmaceutical, utility, metallurgical, converting, and similar industries. Specific addendums addressing these industries may be developed over time.

This addendum specifically does not address cost estimate classification in nonprocess industries such as commercial building construction, environmental remediation, transportation infrastructure, “dry” processes such as assembly and manufacturing, “soft asset” production such as software development, and similar industries. It also does not specifically address estimates for the exploration, production, or transportation of mining or hydrocarbon materials, although it may apply to some of the intermediate processing steps in these systems.

The cost estimates covered by this addendum are for engineering, procurement, and construction (EPC) work only. It does not cover estimates for the products manufactured by the process facilities, or for research and development work in support of the process industries. This guideline does not cover the

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significant building construction that may be a part of process plants. Building construction will be covered in a separate addendum.

This guideline reflects generally-accepted cost engineering practices. This addendum was based upon the practices of a wide range of companies in the process industries from around the world, as well as published references and standards. Company and public standards were solicited and reviewed by the AACE International Cost Estimating Committee. The practices were found to have significant commonalities that are conveyed in this addendum.

## COST ESTIMATE CLASSIFICATION MATRIX FOR THE PROCESS INDUSTRIES

The five estimate classes are presented in figure 1 in relationship to the identified characteristics. Only the level of project definition determines the estimate class. The other four characteristics are secondary characteristics that are generally correlated with the level of project definition, as discussed in the generic standard. The characteristics are typical for the process industries but may vary from application to application.

This matrix and guideline provide an estimate classification system that is specific to the process industries. Refer to the generic standard for a general matrix that is non-industry specific, or to other addendums for guidelines that will provide more detailed information for application in other specific industries. These will typically provide additional information, such as input deliverable checklists to allow meaningful categorization in those particular industries.

| | ***Primary Characteristic*** | ***Secondary Characteristic*** | | | |
|---|---|---|---|---|---|
| **ESTIMATE CLASS** | **LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition | **END USAGE** Typical purpose of estimate | **METHODOLOGY** Typical estimating method | **EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a] | **PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b] |
| **Class 5** | 0% to 2% | Concept Screening | Capacity Factored, Parametric Models, Judgment, or Analogy | L: -20% to -50%<br>H: +30% to +100% | 1 |
| **Class 4** | 1% to 15% | Study or Feasibility | Equipment Factored or Parametric Models | L: -15% to -30%<br>H: +20% to +50% | 2 to 4 |
| **Class 3** | 10% to 40% | Budget, Authorization, or Control | Semi-Detailed Unit Costs with Assembly Level Line Items | L: -10% to -20%<br>H: +10% to +30% | 3 to 10 |
| **Class 2** | 30% to 70% | Control or Bid/ Tender | Detailed Unit Cost with Forced Detailed Take-Off | L: -5% to -15%<br>H: +5% to +20% | 4 to 20 |
| **Class 1** | 50% to 100% | Check Estimate or Bid/Tender | Detailed Unit Cost with Detailed Take-Off | L: -3% to -10%<br>H: +3% to +15% | 5 to 100 |

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

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**Figure 1. – Cost Estimate Classification Matrix for Process Industries**

## CHARACTERISTICS OF THE ESTIMATE CLASSES

The following charts (figures 2a through 2e) provide detailed descriptions of the five estimate classifications as applied in the process industries. They are presented in the order of least-defined estimates to the most-defined estimates. These descriptions include brief discussions of each of the estimate characteristics that define an estimate class.

For each chart, the following information is provided:

- **Description:** a short description of the class of estimate, including a brief listing of the expected estimate inputs based on the level of project definition.
- **Level of Project Definition Required:** expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.
- **End Usage:** a short discussion of the possible end usage of this class of estimate.
- **Estimating Methods Used:** a listing of the possible estimating methods that may be employed to develop an estimate of this class.
- **Expected Accuracy Range:** typical variation in low and high ranges after the application of contingency (determined at a 50% level of confidence). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.
- **Effort to Prepare:** this section provides a typical level of effort (in hours) to produce a complete estimate for a US$20,000,000 plant. Estimate preparation effort is highly dependent on project size, project complexity, estimator skills and knowledge, and on the availability of appropriate estimating cost data and tools.
- **ANSI Standard Reference (1989) Name:** this is a reference to the equivalent estimate class in the existing ANSI standards.
- **Alternate Estimate Names, Terms, Expressions, Synonyms:** this section provides other commonly used names that an estimate of this class might be known by. These alternate names are not endorsed by this Recommended Practice. The user is cautioned that an alternative name may not always be correlated with the class of estimate as identified in the chart.

| CLASS 5 ESTIMATE | |
|---|---|
| **Description:**<br>Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.<br><br>**Level of Project Definition Required:**<br>0% to 2% of full project definition.<br><br>**End Usage:**<br>Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc. | **Estimating Methods Used:**<br>Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.<br><br>**Expected Accuracy Range:**<br>Typical accuracy ranges for Class 5 estimates are - 20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.<br><br>**Effort to Prepare (for US$20MM project):**<br>As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used.<br><br>**ANSI Standard Reference Z94.2-1989 Name:**<br>Order of magnitude estimate (typically -30% to +50%).<br><br>**Alternate Estimate Names, Terms, Expressions, Synonyms:**<br>Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb. |

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**Figure 2a. – Class 5 Estimate**

| CLASS 4 ESTIMATE | |
|---|---|
| **Description:**<br>Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists.<br><br>**Level of Project Definition Required:**<br>1% to 15% of full project definition.<br><br>**End Usage:**<br>Class 4 estimates are prepared for a number of purposes, such as but not limited to, detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage. | **Estimating Methods Used:**<br>Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques.<br><br>**Expected Accuracy Range:**<br>Typical accuracy ranges for Class 4 estimates are -15% to -30% on the low side, and +20% to +50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.<br><br>**Effort to Prepare (for US$20MM project):**<br>Typically, as little as 20 hours or less to perhaps more than 300 hours, depending on the project and the estimating methodology used.<br><br>**ANSI Standard Reference Z94.2-1989 Name:**<br>Budget estimate (typically -15% to + 30%).<br><br>**Alternate Estimate Names, Terms, Expressions, Synonyms:**<br>Screening, top-down, feasibility, authorization, factored, pre-design, pre-study. |

**Figure 2b. – Class 4 Estimate**

| CLASS 3 ESTIMATE | |
|---|---|
| **Description:**<br>Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding. As such, they typically form the initial control estimate against which all actual costs and resources will be monitored. Typically, engineering is from 10% to 40% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, preliminary piping and instrument diagrams, plot plan, developed layout drawings, and essentially complete engineered process and utility equipment lists.<br><br>**Level of Project Definition Required:**<br>10% to 40% of full project definition.<br><br>**End Usage:**<br>Class 3 estimates are typically prepared to support full project funding requests, and become the first of the project phase "control estimates" against which all actual costs and resources will be monitored for variations to the budget. They are used as the project budget until replaced by more detailed estimates. In many owner organizations, a Class 3 estimate may be the last estimate required and could well form the only basis for cost/schedule control. | **Estimating Methods Used:**<br>Class 3 estimates usually involve more deterministic estimating methods than stochastic methods. They usually involve a high degree of unit cost line items, although these may be at an assembly level of detail rather than individual components. Factoring and other stochastic methods may be used to estimate less-significant areas of the project.<br><br>**Expected Accuracy Range:**<br>Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.<br><br>**Effort to Prepare (for US$20MM project):**<br>Typically, as little as 150 hours or less to perhaps more than 1,500 hours, depending on the project and the estimating methodology used.<br><br>**ANSI Standard Reference Z94.2-1989 Name:**<br>Budget estimate (typically -15% to + 30%).<br><br>**Alternate Estimate Names, Terms, Expressions, Synonyms:**<br>Budget, scope, sanction, semi-detailed, authorization, preliminary control, concept study, development, basic engineering phase estimate, target estimate. |

**Figure 2c. – Class 3 Estimate**

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| CLASS 2 ESTIMATE | |
|---|---|
| **Description:**<br>Class 2 estimates are generally prepared to form a detailed control baseline against which all project work is monitored in terms of cost and progress control. For contractors, this class of estimate is often used as the "bid" estimate to establish contract value. Typically, engineering is from 30% to 70% complete, and would comprise at a minimum the following: process flow diagrams, utility flow diagrams, piping and instrument diagrams, heat and material balances, final plot plan, final layout drawings, complete engineered process and utility equipment lists, single line diagrams for electrical, electrical equipment and motor schedules, vendor quotations, detailed project execution plans, resourcing and work force plans, etc.<br><br>**Level of Project Definition Required:**<br>30% to 70% of full project definition.<br><br>**End Usage:**<br>Class 2 estimates are typically prepared as the detailed control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. | **Estimating Methods Used:**<br>Class 2 estimates always involve a high degree of deterministic estimating methods. Class 2 estimates are prepared in great detail, and often involve tens of thousands of unit cost line items. For those areas of the project still undefined, an assumed level of detail takeoff (forced detail) may be developed to use as line items in the estimate instead of relying on factoring methods.<br><br>**Expected Accuracy Range:**<br>Typical accuracy ranges for Class 2 estimates are -5% to -15% on the low side, and +5% to +20% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.<br><br>**Effort to Prepare (for US$20MM project):**<br>Typically, as little as 300 hours or less to perhaps more than 3,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes.<br><br>**ANSI Standard Reference Z94.2-1989 Name:**<br>Definitive estimate (typically -5% to + 15%).<br><br>**Alternate Estimate Names, Terms, Expressions, Synonyms:**<br>Detailed control, forced detail, execution phase, master control, engineering, bid, tender, change order estimate. |

**Figure 2d. – Class 2 Estimate**

| CLASS 1 ESTIMATE | |
|---|---|
| **Description:**<br>Class 1 estimates are generally prepared for discrete parts or sections of the total project rather than generating this level of detail for the entire project. The parts of the project estimated at this level of detail will typically be used by subcontractors for bids, or by owners for check estimates. The updated estimate is often referred to as the current control estimate and becomes the new baseline for cost/schedule control of the project. Class 1 estimates may be prepared for parts of the project to comprise a fair price estimate or bid check estimate to compare against a contractor's bid estimate, or to evaluate/dispute claims. Typically, engineering is from 50% to 100% complete, and would comprise virtually all engineering and design documentation of the project, and complete project execution and commissioning plans.<br><br>**Level of Project Definition Required:**<br>50% to 100% of full project definition.<br><br>**End Usage:**<br>Class 1 estimates are typically prepared to form a current control estimate to be used as the final control baseline against which all actual costs and resources will now be monitored for variations to the budget, and form a part of the change/variation control program. They may be used to evaluate bid checking, to support vendor/contractor negotiations, or for claim evaluations and dispute resolution. | **Estimating Methods Used:**<br>Class 1 estimates involve the highest degree of deterministic estimating methods, and require a great amount of effort. Class 1 estimates are prepared in great detail, and thus are usually performed on only the most important or critical areas of the project. All items in the estimate are usually unit cost line items based on actual design quantities.<br><br>**Expected Accuracy Range:**<br>Typical accuracy ranges for Class 1 estimates are -3% to -10% on the low side, and +3% to +15% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.<br><br>**Effort to Prepare (for US$20MM project):**<br>Class 1 estimates require the most effort to create, and as such are generally developed for only selected areas of the project, or for bidding purposes. A complete Class 1 estimate may involve as little as 600 hours or less, to perhaps more than 6,000 hours, depending on the project and the estimating methodology used. Bid estimates typically require more effort than estimates used for funding or control purposes.<br><br>**ANSI Standard Reference Z94.2 Name:**<br>Definitive estimate (typically -5% to + 15%).<br><br>**Alternate Estimate Names, Terms, Expressions, Synonyms:**<br>Full detail, release, fall-out, tender, firm price, bottoms-up, final, detailed control, forced detail, execution phase, master control, fair price, definitive, change order estimate. |

**Figure 2e. – Class 1 Estimate**

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## COMPARISON OF CLASSIFICATION PRACTICES

Figures 3a through 3c provide a comparison of the estimate classification practices of various firms, organizations, and published sources against one another and against the guideline classifications. These tables permits users to benchmark their own classification practices.

INCREASING PROJECT DEFINITION

| AACE Classification Standard | ANSI Standard Z94.0 | AACE Pre-1972 | Association of Cost Engineers (UK) ACostE | Norwegian Project Management Association (NFP) | American Society of Professional Estimators (ASPE) |
|---|---|---|---|---|---|
| Class 5 | Order of Magnitude Estimate -30/+50 | Order of Magnitude Estimate | Order of Magnitude Estimate Class IV -30/+30 | Concession Estimate<br>Exploration Estimate<br>Feasibility Estimate | Level 1 |
| Class 4 | Budget Estimate -15/+30 | Study Estimate | Study Estimate Class III -20/+20 | Authorization Estimate | Level 2 |
| Class 3 | | Preliminary Estimate | Budget Estimate Class II -10/+10 | Master Control Estimate | Level 3 |
| Class 2 | Definitive Estimate -5/+15 | Definitive Estimate | Definitive Estimate Class I -5/+5 | Current Control Estimate | Level 4 |
| Class 1 | | Detailed Estimate | | | Level 5<br>Level 6 |

**Figure 3a. – Comparison of Classification Practices**

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INCREASING PROJECT DEFINITION

| AACE Classification Standard | Major Consumer Products Company (Confidential) | Major Oil Company (Confidential) | Major Oil Company (Confidential) | Major Oil Company (Confidential) |
|---|---|---|---|---|
| **Class 5** | Class S<br>Strategic Estimate | Class V<br>Order of Magnitude Estimate | Class A<br>Prospect Estimate<br>Class B<br>Evaluation Estimate | Class V |
| **Class 4** | Class 1<br>Conceptual Estimate | Class IV<br>Screening Estimate | Class C<br>Feasibility Estimate<br>Class D<br>Development Estimate | Class IV |
| **Class 3** | Class 2<br>Semi-Detailed Estimate | Class III<br>Primary Control Estimate | Class E<br>Preliminary Estimate | Class III |
| **Class 2** | Class 3<br>Detailed Estimate | Class II<br>Master Control Estimate | Class F<br>Master Control Estimate | Class II |
| **Class 1** | | Class I<br>Current Control Estimate | Current Control Estimate | Class I |

**Figure 3b. – Comparison of Classification Practices**

INCREASING PROJECT DEFINITION

| AACE Classification Standard | J.R. Heizelman, 1988 AACE Transactions [1] | K.T. Yeo, The Cost Engineer, 1989 [2] | Stevens & Davis, 1988 AACE Transactions [3] | P. Behrenbruck, Journal of Petroleum Technology, 1993 [4] |
|---|---|---|---|---|
| **Class 5** | Class V | Class V<br>Order of Magnitude | Class III* | Order of Magnitude |
| **Class 4** | Class IV | Class IV<br>Factor Estimate | Class II | Study Estimate |
| **Class 3** | Class III | Class III<br>Office Estimate | | Budget Estimate |
| **Class 2** | Class II | Class II<br>Definitive Estimate | | |
| **Class 1** | Class I | Class I<br>Final Estimate | Class I | Control Estimate |

[1] John R. Heizelman, ARCO Oil & Gas Co., 1988 AACE Transactions, Paper V3.7
[2] K.T. Yeo, The Cost Engineer, Vol. 27, No. 6, 1989
[3] Stevens & Davis, BP International Ltd., 1988 AACE Transactions, Paper B4.1 (* Class III is inferred)
[4] Peter Behrenbruck, BHP Petroleum Pty., Ltd., article in Petroleum Technology, August 1993

**Figure 3c. – Comparison of Classification Practices**

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## ESTIMATE INPUT CHECKLIST AND MATURITY MATRIX

Figure 4 maps the extent and maturity of estimate input information (deliverables) against the five estimate classification levels. This is a checklist of basic deliverables found in common practice in the process industries. The maturity level is an approximation of the degree of completion of the deliverable. The degree of completion is indicated by the following letters.

- None (blank): development of the deliverable has not begun.
- Started (S): work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.
- Preliminary (P): work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.
- Complete (C): the deliverable has been reviewed and approved as appropriate.

| | ESTIMATE CLASSIFICATION | | | | |
|---|---|---|---|---|---|
| **General Project Data:** | **CLASS 5** | **CLASS 4** | **CLASS 3** | **CLASS 2** | **CLASS 1** |
| Project Scope Description | General | Preliminary | Defined | Defined | Defined |
| Plant Production/Facility Capacity | Assumed | Preliminary | Defined | Defined | Defined |
| Plant Location | General | Approximate | Specific | Specific | Specific |
| Soils & Hydrology | None | Preliminary | Defined | Defined | Defined |
| Integrated Project Plan | None | Preliminary | Defined | Defined | Defined |
| Project Master Schedule | None | Preliminary | Defined | Defined | Defined |
| Escalation Strategy | None | Preliminary | Defined | Defined | Defined |
| Work Breakdown Structure | None | Preliminary | Defined | Defined | Defined |
| Project Code of Accounts | None | Preliminary | Defined | Defined | Defined |
| Contracting Strategy | Assumed | Assumed | Preliminary | Defined | Defined |
| **Engineering Deliverables:** | | | | | |
| Block Flow Diagrams | S/P | P/C | C | C | C |
| Plot Plans | | S | P/C | C | C |
| Process Flow Diagrams (PFDs) | | S/P | P/C | C | C |
| Utility Flow Diagrams (UFDs) | | S/P | P/C | C | C |
| Piping & Instrument Diagrams (P&IDs) | | S | P/C | C | C |
| Heat & Material Balances | | S | P/C | C | C |
| Process Equipment List | | S/P | P/C | C | C |
| Utility Equipment List | | S/P | P/C | C | C |
| Electrical One-Line Drawings | | S/P | P/C | C | C |
| Specifications & Datasheets | | S | P/C | C | C |
| General Equipment Arrangement Drawings | | S | P/C | C | C |
| Spare Parts Listings | | | S/P | P | C |
| Mechanical Discipline Drawings | | | S | P | P/C |
| Electrical Discipline Drawings | | | S | P | P/C |
| Instrumentation/Control System Discipline Drawings | | | S | P | P/C |
| Civil/Structural/Site Discipline Drawings | | | S | P | P/C |

**Figure 4. – Estimate Input Checklist and Maturity Matrix**

## REFERENCES

ANSI Standard Z94.2-1989. **Industrial Engineering Terminology: Cost Engineering**.
AACE International Recommended Practice No.17R-97, **Cost Estimate Classification System**.

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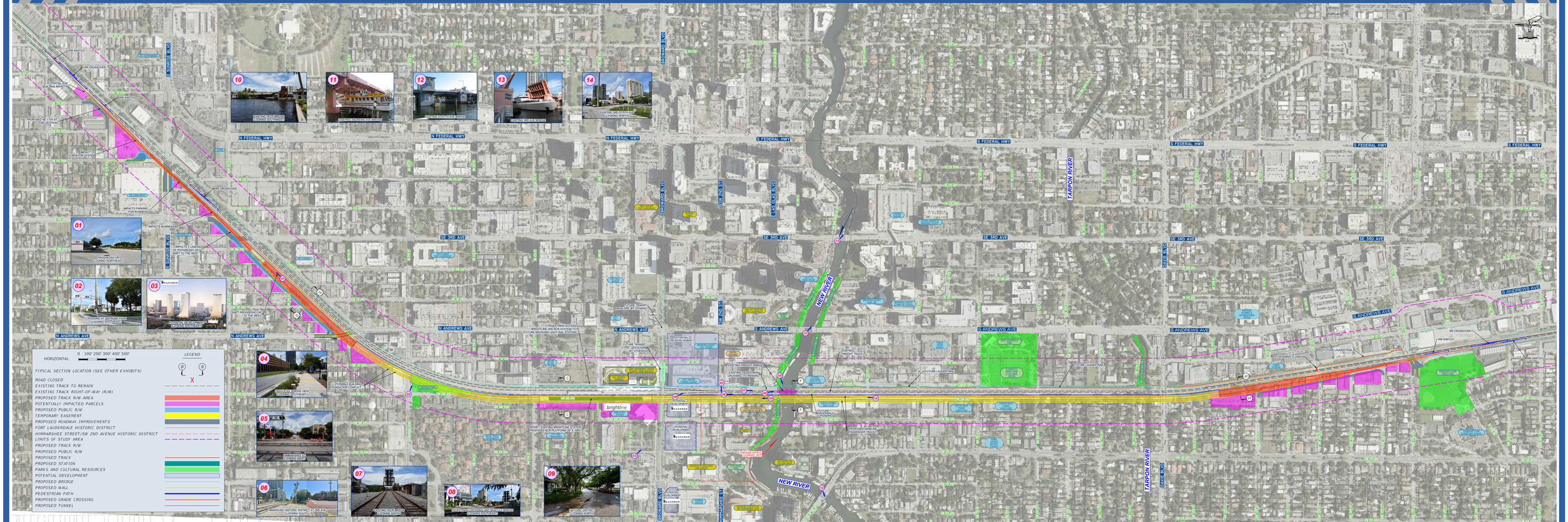
# Appendix C. Tunnel Concept Drawings

(See Excel spreadsheet for additional info)

# NEW RIVER TUNNEL ALTERNATIVE PLAN




**BROWARD COMMUTER RAIL (BCR)**

**PROJECT DEVELOPMENT & ENVIRONMENT (PD&E) STUDY**

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT), DISTRICT 4 • BROWARD COUNTY, FLORIDA • FPID: 417031-5-22-01

FDOT

BROWARD COUNTY FLORIDA

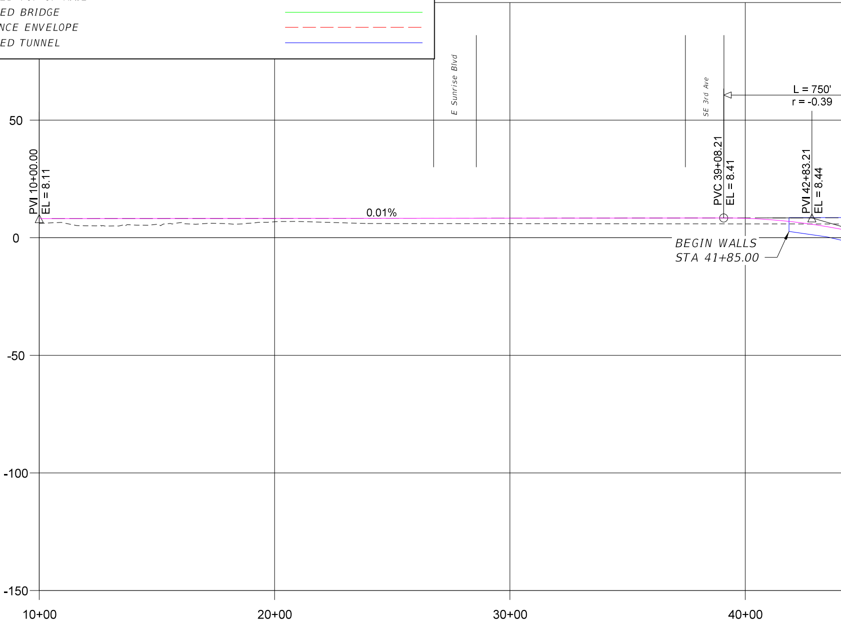
CAM 23-1101
Exhibit 1
Page 37 of 45

LEGEND

- *EXISTING GROUND*
- *EXISTING TOP OF RAIL*
- *EXISTING BRIDGE*
- *MEAN HIGH WATER*
- *PROPOSED TOP OF RAIL*
- *PROPOSED BRIDGE*
- *CLEARANCE ENVELOPE*
- *PROPOSED TUNNEL*

FOR REFERENCE ONLY
NOT FOR CONSTRUCTION
NOV 4, 2021

JENNIFER D. CRUMBLISS, P.E.
P.E. LICENSE NUMBER 50721
HDR ENGINEER INC.
3250 WEST COMMERCIAL BLVD, Suite 100
FORT LAUDERDALE, FL 33309
CERTIFICATE OF AUTHORIZATION


E Sunrise Blvd
SE 3rd Ave
L = 750'
r = -0.39
50
0
-50
-100
-150
PVI 10+00.00
EL = 8.11
0.01%
PVC 39+08.21
EL = 8.41
PVI 42+83.21
EL = 8.44
BEGIN WALLS
STA 41+85.00
10+00
20+00
30+00
40+00

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

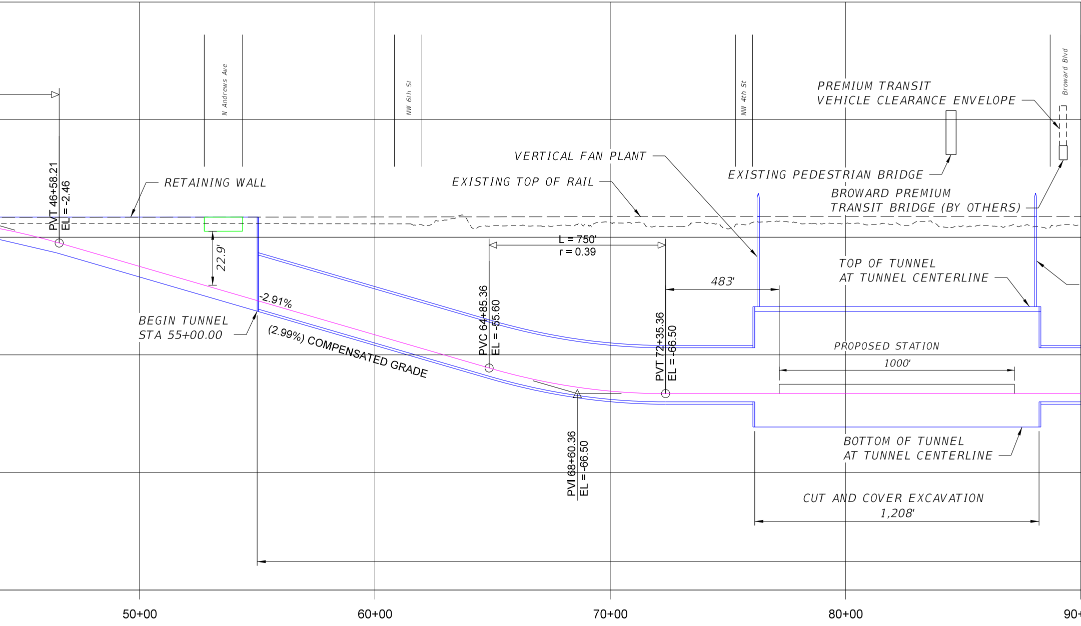
ROAD NO.	COUNTY	FINANCIAL PROJECT ID
N/A	BROWARD	448942-1

SHEET TITLE:

NEW RIVER TWIN BORE TUNNEL ALTERNATIVE PROFILE

PROJECT NAME:

BROWARD COMMUTER RAIL (BCR) PD&E STUDY


N Andrews Ave
NW 6th St
NW 4th St
Broward Blvd
PREMIUM TRANSIT
VEHICLE CLEARANCE ENVELOPE
VERTICAL FAN PLANT
EXISTING PEDESTRIAN BRIDGE
EXISTING TOP OF RAIL
BROWARD PREMIUM
TRANSIT BRIDGE (BY OTHERS)
RETAINING WALL
PVT 46+58.21
EL = -2.46
22.9'
L = 750'
r = 0.39
483'
TOP OF TUNNEL
AT TUNNEL CENTERLINE
-2.91%
BEGIN TUNNEL
STA 55+00.00
(2.99%) COMPENSATED GRADE
PVC 64+85.36
EL = -55.60
PVT 72+35.36
EL = -66.50
PROPOSED STATION
1000'
PVI 68+60.36
EL = -66.50
BOTTOM OF TUNNEL
AT TUNNEL CENTERLINE
CUT AND COVER EXCAVATION
1,208'
50+00
60+00
70+00
80+00
90+

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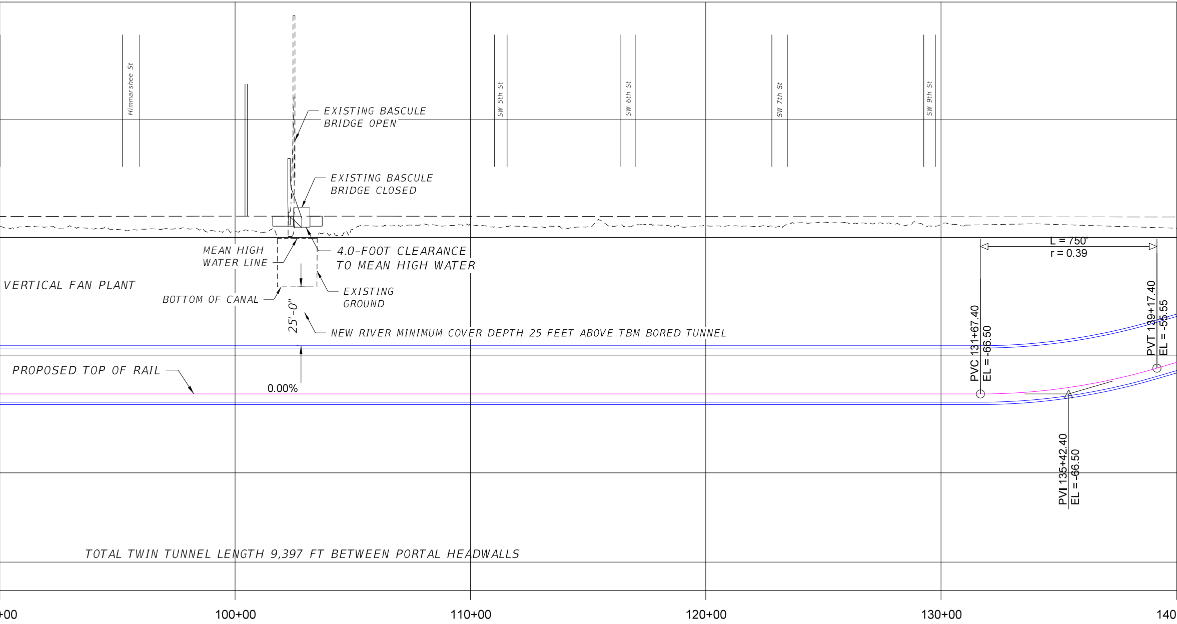
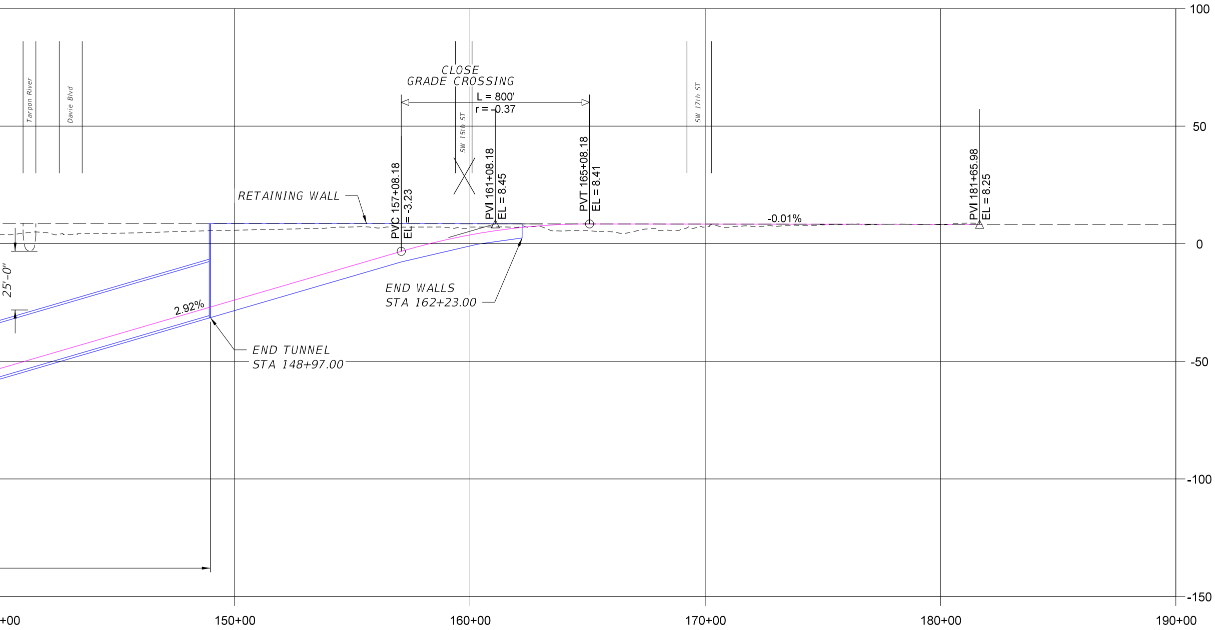


Himmarshee St
SW 5th St
SW 6th St
SW 7th St
SW 9th St
EXISTING BASCULE BRIDGE OPEN
EXISTING BASCULE BRIDGE CLOSED
MEAN HIGH WATER LINE
4.0-FOOT CLEARANCE TO MEAN HIGH WATER
VERTICAL FAN PLANT
BOTTOM OF CANAL
EXISTING GROUND
25'-0"
NEW RIVER MINIMUM COVER DEPTH 25 FEET ABOVE TBM BORED TUNNEL
L = 750'
r = 0.39
PVC 131+67.40
EL = -66.50
PVT 139+17.40
EL = -55.55
PROPOSED TOP OF RAIL
0.00%
PVI 135+42.40
EL = -66.50
TOTAL TWIN TUNNEL LENGTH 9,397 FT BETWEEN PORTAL HEADWALLS
+00
100+00
110+00
120+00
130+00
140


Tarpon River
Davie Blvd
CLOSE
GRADE CROSSING
L = 800'
r = -0.37
SW 15th ST
SW 17th ST
RETAINING WALL
PVC 157+08.18
EL = -3.23
PVI 161+08.18
EL = 8.45
PVT 165+08.18
EL = 8.41
PVI 181+65.98
EL = 8.25
-0.01%
25'-0"
2.92%
END WALLS
STA 162+23.00
END TUNNEL
STA 148+97.00
100
50
0
-50
-100
-150
+00
150+00
160+00
170+00
180+00
190+00

## General Tunnel Design Requirements:

1. Design tunnel facilities and systems to relevant codes and standards for safe operation.
2. 100 year minimum design life for tunnels and underground structures.
3. Minimize right-of-way/easements and environmental impacts where practical.
4. Existing utilities protected in place where rail facilities are not in conflict.
5. Efficient interchange of passengers to and from private and public transportation modes.
6. Passenger access for pedestrians, mobility-impaired patrons and bus transfers.
7. Seamless integration of visual and aesthetic treatments into facilities.
8. Cost-effective, environmentally sensitive and socially responsible “design to cost”philosophy.
9. Buy America conformance with Federal Transit Administration (FTA) for manufactured products.
10. Competitive bidding by established suppliers for standard equipment and proven technology.
11. Design internal dimensions to accommodate vehicles, track, super elevations, emergency egress, walkways, diesel ventilation, maintenance and systems infrastructure.
12. Incorporate spatial, clearance and tolerance requirements for services and equipment, including emergency egress to NFPA 130 requirements.
13. Assess need for additional tunnel opening size for tunnel construction tolerances.
14. Design to maintain structural integrity of existing utility infrastructure and third party facilities, and maintain ground movement to acceptable limits.
15. Design to provide a safe working environment, maintain stability during tunnel excavation, and minimize ground movements and detrimental impacts of groundwater flow.
16. Design support of excavation for cut and cover structures to facilitate owner requirements and mitigate impacts to existing utility infrastructure and third party facilities.
17. Demonstrate mitigation of potential settlement and damage to infrastructure with 2D or 3D numerical modelling with finite element or finite difference software.
18. Tunnel Boring Machines (TBMs) shall be designed to excavate and support the ground while complying with all health and safety regulations.
19. TBM design shall incorporate directional guidance, gas detection, groundwater monitoring, karst void grouting, ground support, and others necessary for safe TBM operation.
20. TBMs can operate in all possible ground and groundwater conditions indicated in the Geotechnical Data Report (GDR) and Geotechnical Baseline Report (GBR).
21. TBMs shall be new (not refurbished), and shall undergo proving trials at the manufacturer's facility, and on site after TBM launch.
22. TBM manufacturer's representative shall be on site to monitor TBM assembly, testing, and the first 0.5 mile of TBM excavation.
23. TBM lining shall be designed to ACI 533.5R-20 "Guide for Precast Concrete Tunnel Segments" and ACI 544.7R-16 "Design of Fiber-Reinforced Precast Concrete Tunnel Segments".
24. Prepare design reports, drawings, specifications and supporting documents to demonstrate that tunnel design meets all requirements over the design life.
25. Demonstrate that design accounts for geology, ground support to maintain worker health and safety, variability in ground conditions, geotechnical properties, rock mass strength and behavior, ground movements, groundwater inflow, insitu stress, earthquake resistance, support and lining durability, and mitigation of foreseeable risks.

## Tunnel Design Shall Conform to the Following Standards:

1. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems
2. Geotechnical Baseline Reports for Underground Construction, ASCE Research Council, 2007
3. ACI 201.2R - Guide to Durable Concrete
4. ACI 365.1R-00 - Service Life Prediction 2000
5. ACI 533.5R-20 - Guide for Precast Concrete Tunnel Segments 2020
6. ACI 544.7R-16 - Design and Construction of Fiber-Reinforced Precast Concrete Tunnel Segments
7. ACI 544.8R-16 - Indirect Method to Obtain Stress-Strain Response of Fiber-Reinforced Concrete
8. ACI 506.1R-08 - Guide to Fiber Reinforced Shotcrete 2008
9. ACI 506.2-13 - Specification for Shotcrete 2013
10. ACI 506R-16 - Guide to Shotcrete 2016
11. ASTM A1064 - Standard Specification for Carbon-Steel and Welded Wire Reinforcement, Plain and Deformed, for Concrete
12. ASTM D4879-08 - Standard Guideline for Geotechnical Mapping of Large Underground Openings in Rock
13. BS 6164:2019 Health and Safety in Tunnelling Construction Code of Practice
14. Specification for Tunnelling, British Tunnelling Society and Institution of Civil Engineers

## Tunnel Lining Shall be Designed and Constructed as Follows:

1. No identifiable or visible flow of water.
2. Water shall not drip or flow onto track, walkways, escalators, electrical services, mechanical equipment, signals, lighting, communications or controls equipment.
3. No water ingress causing entry of soil particles.
4. Tunnel interfaces designed such that the joint between any two structures is fully watertight.
5. Drainage water volume to be measured at discharge low points to check cumulative inflows.
6. Railway tunnels waterproofing shall meet or exceed Haack’s Tightness Class 3.
7. Underground station waterproofing shall meet or exceed Haack’s Tightness Class 2.
8. Groundwater inflow limits shall be achieved prior to handover to the owner.

## Tunnel Portals Shall be Designed and Constructed as Follows:

1. All works shall be within the right-of-way and easements obtained for the project.
2. Minimize visual impacts and blend in with the natural surroundings and environment.
3. Engage architects to improve portal visual impact and aesthetics.
4. Limit disturbance to existing conditions including groundwater and surface water drainage.
5. Design to mitigate risks to public safety during construction and future operation.
6. Minimize excavations, cut slopes, property take and environmental impacts.
7. Provide stable permanent cut and fill slopes with erosion protection above portals.
8. Maintain slope stability and prevent water from flowing into the tunnel throughout construction.
9. Prevent tunnel flooding from existing surface water runoff, drainage courses and streams.
10. Provide drainage measures to prevent surface water ponding, slope instability and flooding.
11. Direct drainage away from the tunnel entrance into appropriate drainage facilities.
12. Provide landslip/rockfall containment below slopes such as catch ditches or rockfall fences.
13. Provide sufficient space for maintenance access to slope toes for rockfall cleanout.
14. Provide high fences or other control measures to prevent public access to track.
15. Tunnel portal design shall consider topography, geotechnical conditions, method of tunnel construction, tunnel muck treatment and removal, geologic hazards, slope stability, seismic hazards, space for construction and operation, right-of-way, easements, access roads, environmental constraints and local regulatory requirements.

BASE MAP YEAR: JULY 2021
AERIAL PHOTOGRAPHY SOURCE: FDOT AERIAL PHOTO LOOK UP SYSTEM (APLUS)
YEAR OF AERIAL PHOTOGRAPHY: 2019

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | DATE | BY | DESCRIPTION |
| | | | | | FOR REFERENCE ONLY<br>NOT FOR CONSTRUCTION |

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

| ROAD NO. | COUNTY | FINANCIAL PROJECT ID |
|---|---|---|
| N/A | BROWARD | 417031-5-22-01 |

SHEET TITLE: FORT LAUDERDALE DOWNTOWN STATION TUNNEL SECTIONS
TUNNEL DESIGN ASSUMPTIONS

PROJECT NAME: BROWARD COMMUTER RAIL (BCR) PD&E STUDY

REF. DWG. NO.

SHEET NO.

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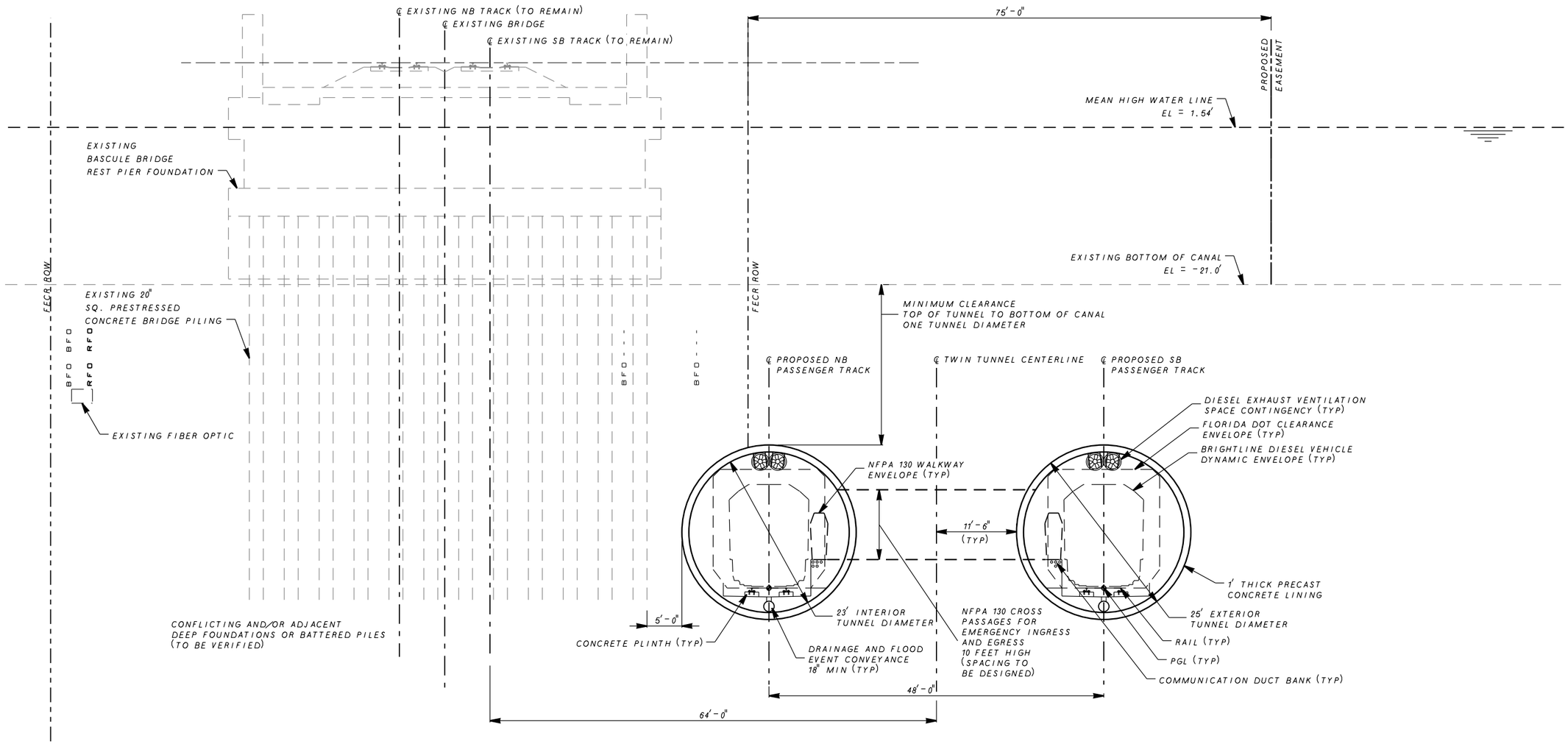


CONCEPT ONLY BASED ON VEHICLE ENVELOPE
MINIMUM TUNNEL DIMENSIONS
SUBJECT TO DESIGN VERIFICATION

NOTES:

1) TYPICAL SECTIONS LOOK SOUTH
2) GEOTECHNICAL INFORMATION TO BE EVALUATED
3) VENTILATION TO BE DESIGNED
4) FLOOD CONTROL MEASURES TO BE DESIGNED
5) STORM SURGE PROTECTION TO BE DESIGNED

NEW RIVER CROSSING TWIN BORED TUNNEL SECTION F

DEC 03, 2021
NOT TO SCALE

BASE MAP YEAR: JULY 2021
AERIAL PHOTOGRAPHY SOURCE: FDOT AERIAL PHOTO LOOK UP SYSTEM (APLUS)
YEAR OF AERIAL PHOTOGRAPHY: 2019

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STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

| ROAD NO. | COUNTY | FINANCIAL PROJECT ID |
|---|---|---|
| N/A | BROWARD | 417031-5-22-01 |

SHEET TITLE: FORT LAUDERDALE DOWNTOWN STATION TUNNEL SECTIONS TWIN TBM TUNNEL OPTION

PROJECT NAME: BROWARD COMMUTER RAIL (BCR) PD&E STUDY

REF. DWG. NO.

SHEET NO.

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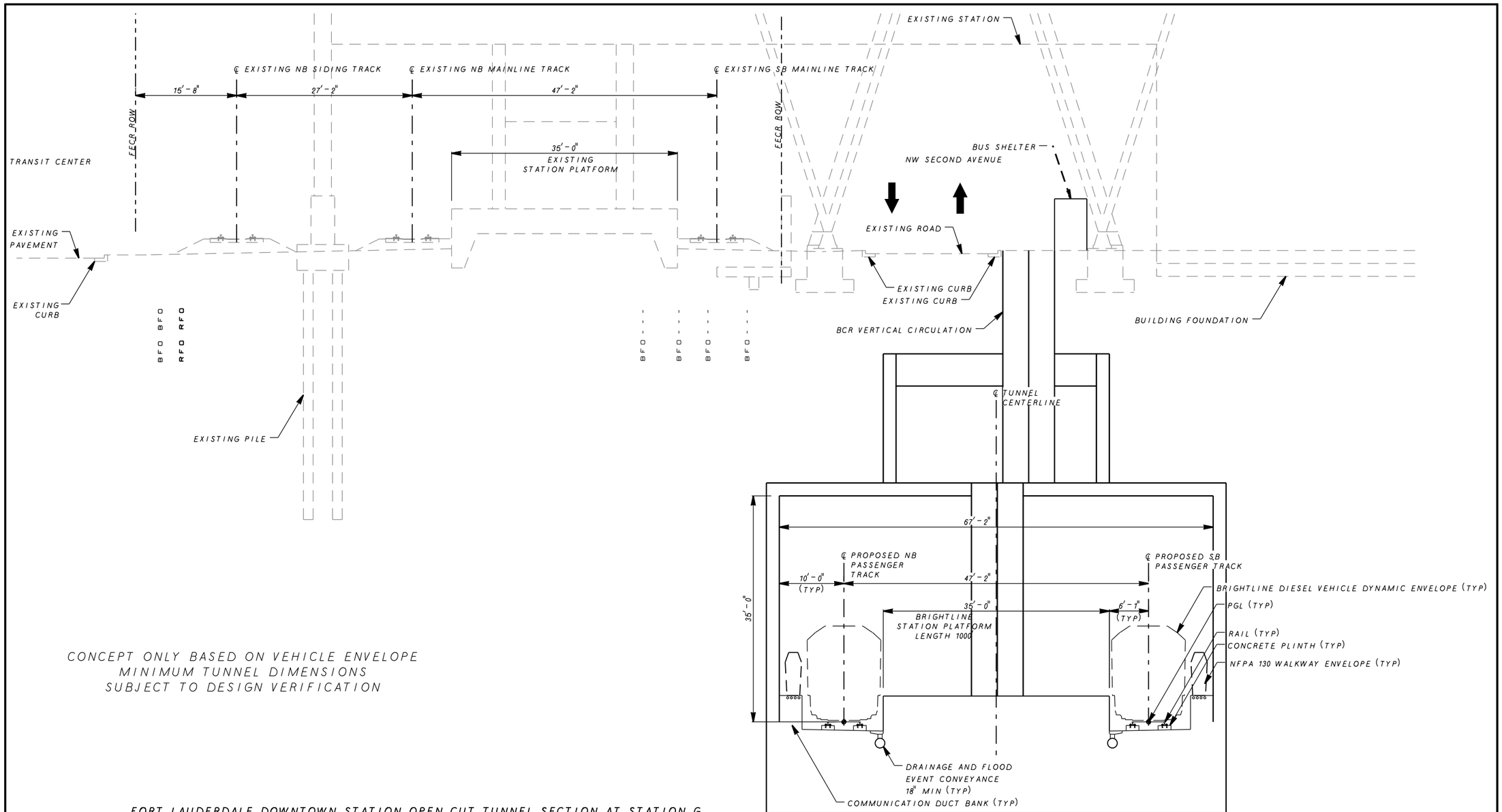


CONCEPT ONLY BASED ON VEHICLE ENVELOPE
MINIMUM TUNNEL DIMENSIONS
SUBJECT TO DESIGN VERIFICATION

FORT LAUDERDALE DOWNTOWN STATION OPEN CUT TUNNEL SECTION AT STATION G

NOTES:

1) TYPICAL SECTIONS LOOK SOUTH
2) GEOTECHNICAL INFORMATION TO BE EVALUATED
3) VENTILATION TO BE DESIGNED
4) FLOOD CONTROL MEASURES TO BE DESIGNED
5) STORM SURGE PROTECTION TO BE DESIGNED

DEC 03, 2021
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BASE MAP YEAR: JULY 2021
AERIAL PHOTOGRAPHY SOURCE: FDOT AERIAL PHOTO LOOK UP SYSTEM (APLUS)
YEAR OF AERIAL PHOTOGRAPHY: 2019

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | DATE | BY | DESCRIPTION |
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STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

| ROAD NO. | COUNTY | FINANCIAL PROJECT ID |
|---|---|---|
| N/A | BROWARD | 417031-5-22-01 |

SHEET TITLE: FORT LAUDERDALE DOWNTOWN STATION TUNNEL SECTIONS OPEN CUT TUNNEL OPTION

PROJECT NAME: BROWARD COMMUTER RAIL (BCR) PD&E STUDY

REF. DWG. NO.

SHEET NO.

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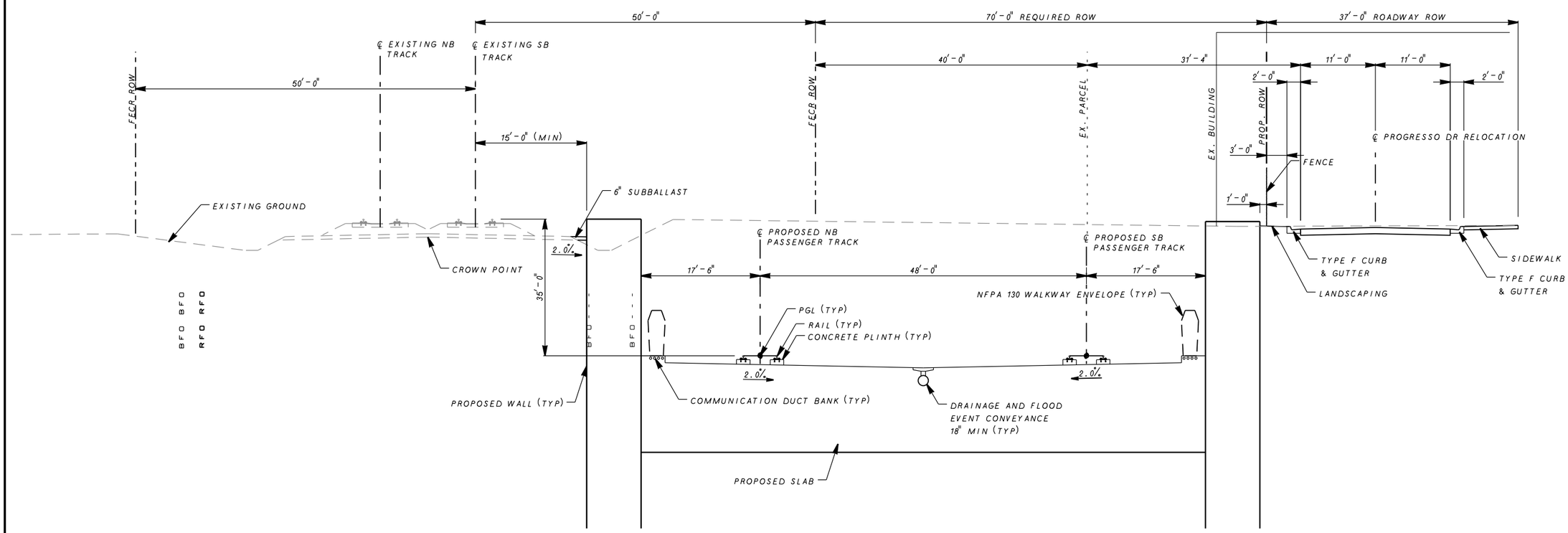


FORT LAUDERDALE DOWNTOWN STATION CUT WALL SECTION H
35 FOOT VERTICAL TRACK SEPARATION

NOTE: TYPICAL SECTIONS LOOK SOUTH

DEC 03, 2021
NOT TO SCALE

BASE MAP YEAR: JULY 2021
AERIAL PHOTOGRAPHY SOURCE: FDOT AERIAL PHOTO LOOK UP SYSTEM (APLUS)
YEAR OF AERIAL PHOTOGRAPHY: 2019

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | DATE | BY | DESCRIPTION |
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STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

| ROAD NO. | COUNTY | FINANCIAL PROJECT ID |
|---|---|---|
| N/A | BROWARD | 417031-5-22-01 |

SHEET TITLE: FORT LAUDERDALE DOWNTOWN STATION TUNNEL SECTIONS CUT WALL SECTION

PROJECT NAME: BROWARD COMMUTER RAIL (BCR) PD&E STUDY

REF. DWG. NO.

SHEET NO.

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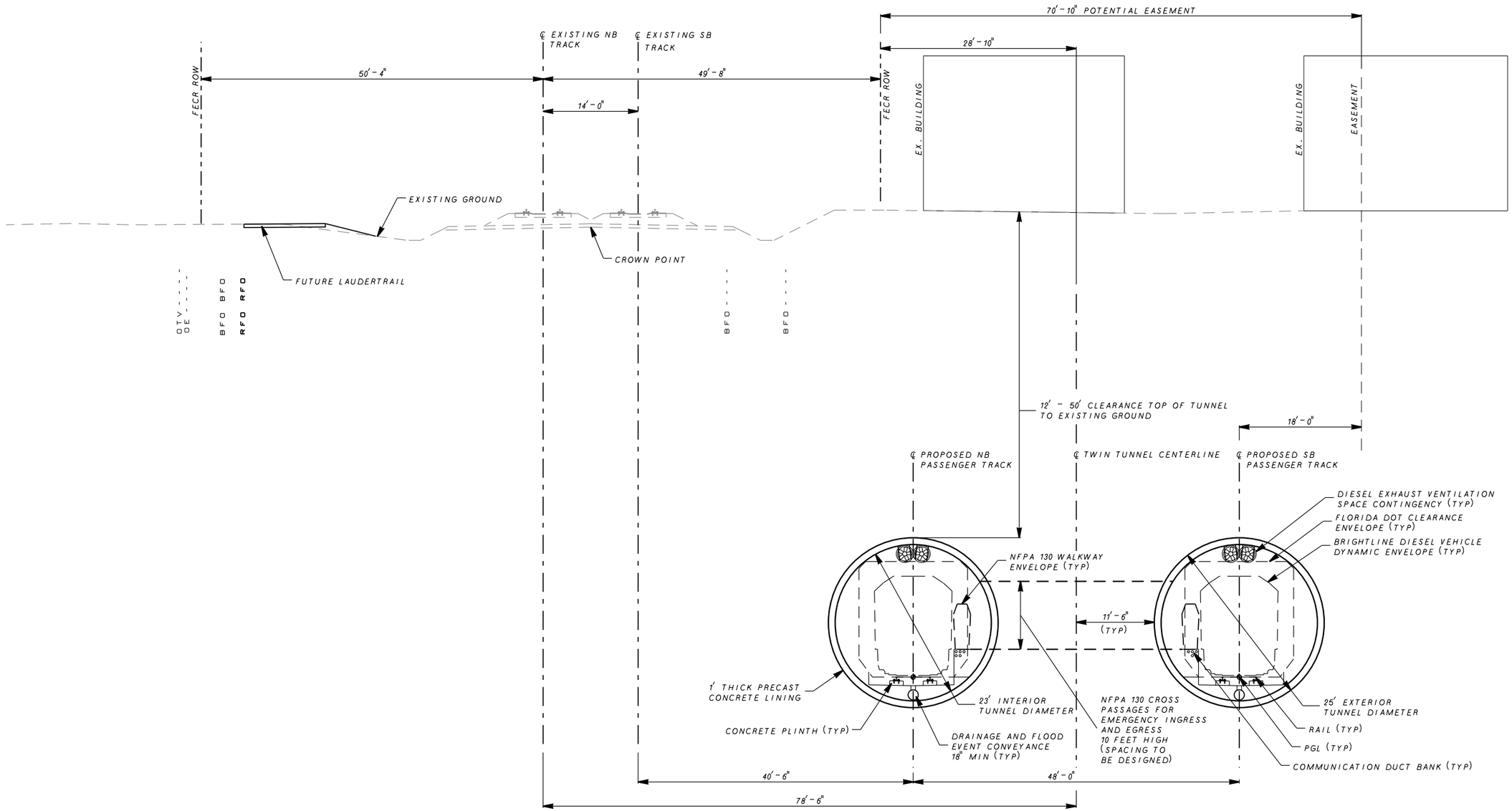


TUNNEL ALTERNATIVE

FORT LAUDERDALE DOWNTOWN STATION SECTION Z1
NEW RIVER CROSSING TWIN BORED TUNNEL

DEC 03, 2021
NOT TO SCALE

BASE MAP YEAR: JULY 2021
AERIAL PHOTOGRAPHY SOURCE: FDOT AERIAL PHOTO LOOK UP SYSTEM (APLUS)
YEAR OF AERIAL PHOTOGRAPHY: 2019

REVISIONS

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STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

| ROAD NO. | COUNTY | FINANCIAL PROJECT ID |
|---|---|---|
| N/A | BROWARD | 417031-5-22-01 |

SHEET TITLE:

PROJECT NAME: BROWARD COMMUTER RAIL (BCR) PD&E STUDY

REF. DWG. NO.

SHEET NO.

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