PARSONS BRINCKERHOFF

# *Design Basis Report*

## Port of Miami Tunnel & Access Improvements

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**Miami-Dade County, Florida**

**DRAFT**

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*Prepared For:*

*FLORIDA'S TURNPIKE ENTERPRISE*

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# 1. INTRODUCTION AND PROJECT OVERVIEW

## 1.1 Purpose

The Design Basis Report (DBR) describes the assumptions, rationale and selection of specific structural components, mechanical and electrical systems, traffic control systems, operational philosophy, tunnel finishes and architectural themes that will be included in the design-build plans and specifications for the Port of Miami Tunnel and Access Improvements Project. The report describes the constraints that will be placed on the contractor, such as limits of operation, minimal levels for maintenance of traffic during construction, environmental monitoring and required submittals in order to control the work so that Florida's Turnpike Enterprise (FTE) receives the product it desires. The report also highlights where waivers to codes and/or standards are required.

For this report, it is assumed that the Design-Build method of procurement and execution will be used to perform the design and construction of the project. This report is intended for use by Florida's Turnpike Enterprise (FTE) and by not the prospective Design-Build firms or contractors who will be selected. It is also assumed that a public agency, the Florida Department of Transportation (FDOT), will operate the facility. If in the event that a private firm is procured in a Design-Build-Operate-Maintain or concession type of contract, this report may require revision.

## 1.2 Project Description

### 1.2.1 Existing Conditions

#### 1.2.1.1 MacArthur Causeway Bridge

There are separate parallel eastbound and westbound bridges that extend from I-395 on the Miami mainland to Watson Island. Each bridge is 2,468 feet long with 18 spans at a maximum span length of 145 feet. Each bridge provides three traffic lanes with a total width of 38 feet, 10 foot inside and outside shoulders, and a six-foot sidewalk. The existing opening between bridges is 30'-4". The maximum vertical clearance over the channel is 65.27 feet to mean high water (MHW).

The design speed for traffic on the existing bridges is 45 mph. The bridge is on tangent, except for the last three spans at Watson Island, where the bridges are on a curve. In this segment the eastbound and westbound bridge's horizontal geometry is non-concentric; therefore, the open spacing between the bridges throughout the curved section is reduced to a minimum width of approximately 20'-0".

The existing bridge foundations over water were designed to accommodate a proposed future Metrorail in the median (Bay Link). However the geometry to place a future rail line in the center has proved difficult so it became feasible to locate roadway widening in the median area. The top of existing pile caps and column stubs for these spans are above the water elevation allowing easier construction of the future columns connections No foundations or piers have been constructed for the proposed Metrorail.

1.2.1.2 Watson Island

Watson Island is a man-made island constructed of spoil material from the dredging of the shipping channel through Biscayne Bay. The six-lane divided roadway in the FDOT right-of-way cuts diagonally through the island. The Parrot Jungle attraction is located on the north side of the island along with the Miami Outboard Club, Miami Yacht Club and Ichimura Miami-Japan Gardens. The Miami Children's Museum building and parking lot are currently on the south side of the island. Island Gardens is a new development with a mega yacht marina, two hotels, retail and restaurants planned to begin construction on the west side of the island before the end of 2005. An existing heliport will be relocated along the south side of the island where a new park is also planned.

1.2.1.3 Port of Miami

The Port of Miami is a 518 acre island with both cruise terminals and cargo handling facilities. Cruise and administration facilities are mostly located on the northwest quadrant of the Port with Royal Caribbean offices on the southwest corner. Container yards and terminals comprise the rest of the island. Located in Biscayne Bay just east of downtown Miami, The Port of Miami was originally set on two separate islands: Dodge Island (west) and Lummas Island (east).

New roadway improvements and Security Gate complexes for the Port are scheduled to be complete by early 2006. All traffic currently enters and exits the island along Port Boulevard Bridge connecting to Miami. Cargo and cruise traffic are routed onto separate roadways from a point just to the east of the foot of the Port Bridge.

### 1.2.2 Proposed Project Improvements

The primary objective of the Port of Miami Tunnel and Access Improvements Project is to provide an alternate access for the Port to accommodate the projected increase in Port traffic and to remove Port truck and bus traffic from the congested downtown street network. The proposed new tunnel connection to the MacArthur Causeway and I-395 will provide direct access for Port traffic to the freeway system and the Miami International Airport.

The Port of Miami Tunnel and Access Improvement Project consists of three primary components:

- Tunnel connection between Watson Island and the Port of Miami
- Widening of the MacArthur Causeway Bridge
- Port of Miami Roadway Network and Bridges

A new tunnel between Watson Island and Dodge Island is designed to run beneath the Main Channel in Biscayne Bay to provide direct access to the Port of Miami. The project improves access by diverting cargo trucks and buses carrying cruise passengers away from downtown streets and providing direct access from I-395 and MacArthur Causeway through a dedicated roadway connector directly to the Port. The planned improvements take heavy truck traffic off the streets of Miami, thereby eliminating a major source of congestion.

### 1.2.3 Design Life and Protection Against Corrosion and Deterioration

The Port of Miami Tunnel and Access Improvements Project will be designed for the following structure design lives:

- 100-year design life for the tunnel structure.
- 50-year design life for the bridge structures.

A key component to enhance the life of the structures is to provide proper corrosion protection and the use of properly specified materials that will resist deterioration from exposure to water and the elements. Corrosion protection systems will be specified consistent with the structure design lives noted above.

# 2. PROJECTWIDE DESIGN COMPONENTS

## 2.1 Traffic Engineering

### 2.1.1 Traffic and Demand Studies

The following traffic studies are used as the design basis for this project:

- "Revised Traffic Operational Analysis Evaluation – Port of Miami Tunnel," by Andrew Velasquez and Patricia Palumbo, dated May 2004 provided an updated traffic operational analysis of the design concepts for the proposed connection of the Port of Miami Tunnel with MacArthur Causeway/I-395 with recommendations for the tunnel entrance and exit ramps. The report studied the weaving conditions between the ramp entrance and exit locations and the western end of the bridge at I-395. The recommended westbound configuration was for left hand tunnel ramp entrance. Although a left hand exit to the eastbound tunnel was suggested, a traditional right hand entrance was determined to be the best solution.
- "Port of Miami Traffic and Demand Study," by Shaw Environmental and Infrastructure, Inc. was finalized in August 2001. A September 2003 update of the original study reviewed the previous assumptions and checked the initial forecasts for accuracy and generating forecasts. This latest study outlined and re-estimated the statistical forecasting methodology that was applied to the cargo and passenger flows through the Port of Miami.

Additionally, the following studies will be required:

- As a part of the Reevaluation Study, the ultimate build-out conditions were used for the roadway alignment layout on the MacArthur Causeway Bridge. However, the future conditions (I-395 widened to three lanes in each direction and Bay Link located on the south side of the bridge) will not yet be in place. Therefore, the specific configuration to be built as part of this project will need to be reevaluated. Several alternative alignment configurations for the westbound lanes will need to be analyzed.
- It is anticipated that a new traffic simulation will be performed for the modified roadway network on the Port of Miami. The purpose of this evaluation will be to provide data to the administration at Port of Miami showing that the rerouted roads will function similarly to the existing traffic.

### 2.1.2 Design Traffic

In 2004, FTE produced the Annual Average Daily Traffic (AADT) estimated for the design year 2030, along with the design traffic parameters (Design Hour factor $K_{30}$, the Directional Distribution $D_{30}$ and the Daily Truck Factor $T$) to be used for this project. Table 2-1 summarizes this information.

**Table 2-1. Design Traffic Parameters**

| Section | AADT | $K_{30}$ | $D_{30}$ | $T_{(Daily)}$ |
|---|---|---|---|---|
| MacArthur Causeway (East of Tunnel Ramps) | 103,800 | 9.4% | 51.5% | 7.0% |
| Port Boulevard and Tunnel | 34,500 | 9.2% | 52.5% | 29.3% |
| I-395 (West of Tunnel Ramps) | 138,800 | 9.35% | 51.74% | 12.5% |

### 2.1.2 Summary of Criteria and Assumptions

From the previously completed traffic studies, the following criteria and assumptions are to be used:

- Three continuous through lanes in each direction will remain on the MacArthur Causeway.
- Two lanes for each of the westbound and eastbound tunnels.
- On the Port of Miami, two eastbound through lanes from the tunnel for Cargo traffic with a single lane exit for Cruise traffic.
- On the Port of Miami, one continuous westbound lane for Cargo traffic and a one lane ramp for Cruise traffic entering the tunnel.

## 2.2 Civil Design

### 2.2.1 Design Criteria

The roadway and tunnel design criteria as shown on Table 2-2 are established primarily from Florida Department of Transportation's (FDOT) Plans Preparation Manual (PPM) and American Association of State Highway and Transportation Officials (AASHTO) criteria and standards, and will be used for this project.

### 2.2.2 Stormwater Drainage Design

2.2.2.1 Drainage Design Criteria

The stormwater drainage design criteria and design aspects will be developed from FDOT Drainage & Hydrology Manuals, *Drainage Manual Jan. 2005; Drainage Handbook Hydrology Jan. 2004; Drainage Handbook Stormwater Management Facility Jan. 2004; Drainage Handbook Storm Drains Jan. 2004;* as well as other criteria specific to this project as defined in the Port of Miami Tunnel Project Development and Environmental Re-Evaluation Study Conceptual Plans – DRAFT, May 21, 2004. The Dade County Water Management personnel will be consulted for conformity of all pertinent aspects of the project. The following elements of the FDOT drainage & hydrology regulations will be emphasized with respect to this project:

- Design Tailwater Determination
  - Tidal Bays – Mean High Tide.
  - Existing Systems – Elevation of the Hydraulic Grade line at the point of connection.
- Protective Treatment - For systems with full or partial submergence.
  - Fencing may be required for any stormwater retention or detention facilities.
- Tidal Crossings
  - The design for tidal effects will be tailored to the 100 year storm elevation at El. 18.2 feet, which includes the 100-year storm surge plus the breaking wave crest. However, with reference to current meteorological history, attention to an extreme tidal event will be considered. The U.S. Army Corps. of Engineers typically do such studies for projects which are not "FAIL SAFE" such as a tunnel. The FDOT district engineer must review the tidal criteria for this project.
- Bridge Deck - Calculations of the gutter flow and the scupper locations.
- Bridge Widening - Field review and hydraulic/hydrologic review including scour analysis.

**Table 2-2. Summary of Civil Design Criteria**

| Criteria | Value | Reference |
|---|---|---|
| Functional Classification | Urban Principal Arterial (Direct Connection Ramp) | AASHTO, pg. 10 |
| Access Class | 3 (Restrictive) | FDOT PPM Vol. I, (Table 1.8.2) |
| Design Speed - MacArthur Cswy<br>Tunnel<br>POM Roadways | 55 mph<br>35 mph<br>Varies: 20-45 mph | FDOT PPM Vol. I, (Table 1.9.1)<br>Note: Tunnel section (38' inside dia.) results in restricted horizontal sight distance |
| Posted Speed - MacArthur Cswy<br>Tunnel<br>POM Roadways | 50 mph<br>30 (or 35 mph)<br>Varies: 15-40 mph | FDOT PPM Vol. I, (pg. 1-15) |
| Level of Service | LOS D | as per *Highway Capacity Manual* |
| Maximum Superelevation | 8.0% | AASHTO, Pgs. 144-145 and (Exhibit 3-27) |
| Lane Widths - Travel Lane | 12.0' | FDOT PPM Vol. I, (Table 2.1.1) |
| Ramp Lane Widths -: 1-lane<br>2-lane | 15.0'<br>24.0' | FDOT PPM Vol. I, (Table 2.1.3) |
| Shoulder Widths - 1-Lane (Inside)<br>1-Lane (Outside)<br>2-Lane (Inside)<br>2-Lane (Outside) | 6’<br>6’<br>8’<br>10’ | FDOT PPM Vol. I, (Table 2.3.1)<br>AASHTO Pgs. 314-315 |
| Tunnel Shoulder Widths – Inside (Lt.)<br>Outside (Rt.) | 1.5'<br>2.5' | AASHTO, (Exhibit 4-17), pg. 354 |
| Radius (Minimum) | 960' | AASHTO (Exhibit 3-27), pg. 170 |
| Stopping Sight Distance - Horizontal Alignment: Tunnel (min) | 235’ | AASHTO (Exhibit 3-2), pg. 115; pgs 128-231 (35 mph, 5% upgrade) |
| Vertical Grade (Max.)<br>MacArthur Cswy and Tunnel<br>Port of Miami (ramps | <br>5.5%<br>7.5% | FDOT PPM Vol. I, (Table 2.6.1)<br>Use, 55 mph (Urban Arterial - Flat Terrain)<br>Use, 35 mph (Urban Arterial - Flat Terrain) |
| Vertical Grade (Min.) | 0.30% | FDOT PPM Vol. I, (Table 2.6.3) |
| Tunnel Walkways | 2-'6" (min.) | AASHTO, pg. 359 |
| Minimum Vertical Travelway Clearance | 16'-6" | FDOT PPM Vol. I, (Table 2.10.1) |
| Minimum Hurricane Surge Elevation | 18.2’ | Ref. 1. Pg. 32, "100-Year Storm Elevation" |
| Mean High Water (MHW) Elevation | + 2.50’ | NOAA, Tidal Datum, 7/21/03 |
| Main Channel Dredge Depth | 400' wide, 36’ deep (Existing); Future Dredging to 42' planned with 1’ Over-dredge Allowance; Total depth = 43’ | Future Dredging planned by U.S. Army Corps of Engineers |
| Minimum Tunnel Cover | 20’ preferred, 17’ min. | *From General Design Practice, use 1/2 diam.* |

Ref. AASHTO: "A Policy on Geometric Design of Highways and Streets", 5th Edition, American Association of State Highway and Transportation Officials, 2004 (ISBN 1-56051-263-6).

Ref: FDOT PPM: Florida Department of Transportation “Plans Preparation Manual”, Volume 1, January 1, 2005 (Revised).

Ref. 1: "One-Hundred-Year Storm Elevation Requirements for Habitable Structures Located Seaward of a Coastal Construction Control Line", (Elevation Certification and Instructions), Florida Department of Environmental Protection, Office of Beaches and Coastal Systems, November 1999.

#### 2.2.2.2 Integration of Existing Drainage Systems

The design will consider the use of existing systems that are expected to remain intact and available for continued usage. These systems will be analyzed utilizing the 10 year storm frequency and a minimum time of concentration of 10 minutes. The design will also consider situations where an existing outlet is grandfathered along with its treatment system.

#### 2.2.2.3 New Drainage System Configuration

The drainage system design configurations will be considered with the emphasis on salvaging any existing systems and/or treatment areas and treatment systems, wherever possible. Newly proposed system designs will maximize gravity flow, and minimize the contributory areas feeding the stormwater pumping station (SWPS), with the emphasis on minimizing new discharge outlets, and as previously stated, maximizing the use of existing outlets. Portions of the project may require a new trunk storm sewer outfall constructed adjacent and parallel to an existing low capacity outfall. The low capacity pipe could, in this situation, carry the first one inch of the storm flow which is the "first flush", which will go to treatment.

#### 2.2.2.4 Pipe Design

The pipe design is based upon an assumed 10-year frequency storm, with a minimum duration time of 10 minutes. The pipe design will indicate the system elements including pipe, manholes, catch basins/inlet grates, etc, however the design will not identify the specific locations of the inlets/catch basins as these are derived via inlet spacing calculations in final pavement/highway surface design. The drainage systems at the tunnel portals will be designed for a 50 year storm frequency.

#### 2.2.2.5 Design Hydrographs for Pumps

Discussions with appropriate FDOT and other regulatory agencies will be accomplished to obtain the appropriate interpretation of hydrologic methodology to construct 50 year design hydrographs. The hydrologic methods used for this construction of design hydrographs will be one of the following:

- Modified Rational Method
- Soil Conservation Service Method

The rainfall distributions used for either hydrologic methodology will be obtained from the Suwannee River Water Management District.

#### 2.2.2.6 Storm Water Pumping Station Design

The design of each Storm Water Pumping Station (SWPS) will incorporate the following elements:

- Each SWPS will have the same basic design and will be configured with the pumps located in a common wet well.
- All SWPS will have standard control logic for uniform sequence of operation.
- Each SWPS will have three (3) main pumps each sized to accommodate 30% of the 50 year design flow.
- Each SWPS will have a sump pump that will accommodate the remaining 10% of the 50 year design flow.

- All SWPS will have main pumps that are the propeller axial flow type and the sump pumps that are the submersible type.
- Electrical power serving all SWPS shall be supplied by two independent sources. Automatic transfer switches shall engage the second source upon failure of the first source.
- The SWPS shall have three single-speed electrical pumps, capable of operating separately or in parallel to accommodate stormwater inflow. The sump pump will also be single-speed. A lead-lag control feature shall be provided in the pump station controls so that the first pump on is rotated from pump to pump in order to equalize pump wear.
- The system curves for the main pumps will be plotted in parallel and modified by the flow reduction due to piping and fixture losses associated with their connection to the common discharge header. The sump pump will have a separate system curve for its discharge header that will be sized for 10% of the station design capacity.
- The hydrologic routing analysis will be performed after the pump station inflow hydrograph is computed, to determine the peak capacity.

2.2.2.7 Storm Water Pumping Station Drawings

A Locus Plan drawing will be prepared to show the location of each SWPS and to show its two (2) force mains with their point of discharge location. Each force main discharge location will be ended with a tide gate. The drawings will identify the size of the wet well, a pump schedule identifying the preliminary pump sizing parameters including discharge head, flow rate, horsepower, etc, and the controlled water elevations.

2.2.2.8 Treatment Methodology & Design

The South Florida Water Management District (SFWMD) and the Miami-Dade County Department of Environmental Resources Management (DERM) have established stormwater quality and quantity requirements for all new projects. The Florida Department of Environmental Protection (FDEP) may perform the drainage review and permitting, and therefore the FDEP criteria will be reviewed. The specific drainage permitting requirements will be determined through meetings and coordination with all agencies as necessary. The most stringent requirements will be used for the design basis; however the initial design will consist of the previously recommended drainage system that has been analyzed for compliance to the current regulatory controls of the aforementioned agencies.

Most projects within Miami-Dade County utilize a system of subsurface drainage with emergency overflow to nearby water bodies in order to satisfy stormwater drainage requirements. Coastal areas predominantly utilize drainage wells as the subsurface drainage method. The drainage system design and treatment methodology is similar in concept; however the final configuration will be achieved via coordination with the appropriate agency responsible for the review and permitting.

- Drainage System

  DERM requires the on-site retention and treatment of the first inch of stormwater runoff from the impervious surfaces of the proposed roadway corridor. Standards set by Miami-Dade County are, in most cases, more stringent than those of the State agencies and therefore must be followed. The FDEP requires water quality treatment for one inch over the entire project area or 2.5 times the portion of impervious area. A system of FDOT standard 24 inch drainage wells interconnected with 24 inch overflow pipes that have outfalls into Biscayne Bay was selected as the drainage system for this project in order to accommodate the County's design criteria. This selection was based on the poor infiltration and percolation values that are commonly found on man-made silt filled islands such as Watson and Dodge Islands. These soil conditions make the selected subsurface drainage method more suitable than the use of ponds or French drains. The use of devices to enhance water quality (such as Stormceptors or Continuous Deflective Separation (CDS) Units) will be considered in the design, as well as deep wells equipped with oil and grease interceptors that satisfy DERM's stormwater disposal criteria. Emergency overflow structures will allow excess water to be discharged to adjacent surface water bodies. Further agency coordination and initial design review will determine the final design configuration of the drainage system.

- MacArthur Causeway Bridge

  Drainage wells will be used at the east and west roadway approaches to the MacArthur Causeway Bridge. A portion of the midspan of the bridge will drain into Biscayne Bay. The construction of additional lanes on the bridge to accommodate tunnel traffic will require adjustments to the midspan scuppers and connections to the drainage well/exfiltration trench system at either end of the bridge.

- Watson Island

  The proposed drainage system on Watson Island will include deep wells interconnected by 24 inch overflow pipes. The system will be located on the eastbound portion of the road. A portion of the system west of the tunnel will be located beneath the pavement. The remaining portion east of the tunnel would be located on the tree lawn. The overflow pipes will be positioned with the slope necessary to obtain a velocity of 2.5 feet/second. This velocity is recommended to prevent siltation from occurring in the pipes during dry seasons.

  The system will be designed to satisfy DERM's water quality requirements for approximately 10.87 acres of impervious area. A control structure and outlet would be considered for overflow purposes.

- Dodge Island

  The proposed drainage system for Dodge Island includes drainage wells interconnected by 24 inch overflow pipes. One of the drainage wells proposed is not anticipated to be connected to the network due to location conditions. This well will operate as a self - contained well. This condition was deemed appropriate since the well would be capable of disposing several times the volume of runoff generated by the contributing area. The drainage wells will be contained on drainage structure boxes equipped with baffles serving as grease interceptors. The design will use existing outfall pipes on the north side of Dodge Island to the maximum extent possible.

  A control structure with a weir and outlet will be included in the design to discharge any overflow from storms of greater intensities than the design storm or in case of any other emergency.

2.2.2.9 Drainage Design Report

A Drainage Design Report will be prepared for reporting to FTE, and for obtaining the required approvals from various regulatory agencies. This will include in tabular form the maximum discharge rates of the various SWPS. The ongoing process of outlining the drainage design will be useful for the actual Design-Build process.

### 2.2.3 Pavement Design – Surface Roadways

It is anticipated that all roadway pavement will be asphalt and follow the design criteria in the FDOT *Flexible Pavement Design Manual* (January 2005). The pavement design will conform to the FDOT policies, procedures and guidelines. New pavement will include a structural section with a friction course, structural course and base course over stabilized subbase. Some existing roadway segments will also require milling and resurfacing. It is assumed that no repaving allowance will be included in the pavement design of the tunnel segments.

The proposed pavement structure will be based on the AASHTO model for calculating a required Structural Number (SN) for the proposed pavement strength (adopted by FDOT). A factor in determining the SN is the vehicle loading expressed in 18-kip Equivalent Single Axle Loads (ESALs).

## 2.3 Geotechnical Engineering

### 2.3.1 Introduction

Requirements for geotechnical final design will be in general accordance with the State of Florida Department of Transportation Soils and Foundations Handbook, April 2004. For types of construction not included in the Handbook, such as cut and cover and bored tunnels, the Design-Build Firm will be responsible for developing acceptable design criteria in combination with specific design criteria provided in the contract documents.

### 2.3.2 Subsurface Data

Preliminary design borings and geophysical data will be provided to the Design-Build Firm for their information and use. Subsurface data for nearby projects in the possession of the preliminary design team will also be provided to the design build team. The Design-Build Firm will be responsible to obtain any additional subsurface data required for final design. Interpretation and analysis of the data will be the sole responsibility of the Design-Build Firm. Data will be required to be collected and analyzed in accordance with the FDOT Soils and Foundation Handbook.

### 2.3.3 Bored Tunnel Geotechnical Requirements

A pressure face tunnel boring machine (TBM) will be required for construction of this tunnel. The TBM will be required to operate in the closed mode at all times. If an earth pressure balanced TBM is selected, it will be required to have a piston pump in addition to the conventional screw conveyor to facilitate the control of excess water inflows at the face. The TBM will be required to be equipped with drill rigs to permit grouting through the cutter head as well as pattern holes around the perimeter to control water inflows. Selection of additives for conditioning the muck will be the responsibility of the TBM subcontractor to the Design-Build Firm.

### 2.3.4 Boat Sections and Cut and Cover Sections Temporary Earth Support

The roadway transition ramps from at-grade to below-grade will require portions of the alignment to be constructed by braced excavation. Construction of this portion of the alignment will require temporary earth support systems.

The Design-Build Firm will have sole responsibility for the selection and design of the temporary earth support system. The Design-Build Firm will be required to perform detailed design for each type of temporary earth support system they select. The design shall be submitted for review to confirm that contract and technical requirements are being met.

In selecting temporary earth support systems the major items to be considered by the Design-Build Firm include but are not limited to the following:

- Deformations
- Proximity of adjacent structures
- Groundwater control
- Site access
- Soil and rock characteristics

Earth support can be provided by a variety of methods including but not limited to:

- Steel sheeting
- Soldier pile and lagging
- Slurry walls
- Soil mixing
- Secant pile walls
- Soldier Pile and Tremie Concrete (SPTC)
- Soil nailing

Secant pile walls, SPTC walls and slurry walls are considered ‘rigid’ walls which can serve as both temporary support and as part of the permanent structure. Employing the walls as part of the permanent structure is a Design-Build Firm decision. A key element to this decision process by the Design-Build Firm will be based on the evaluation of the risks/costs associated with meeting the design criteria for permissible tunnel leakage.

### 2.3.5 Design Criteria for Cut-and-Cover Structures

- Earth Pressures

  The Design-Build Firm shall have the responsibility to develop subsurface design parameters for temporary loading conditions.

  For permanent conditions, at-rest pressures will be required. The Design-Build Firm will be responsible for determining at-rest soil/rock properties. Long term surcharge loads and maximum groundwater levels that will affect the earth pressure parameters will be provided to the Design-Build Firm.

  All earth pressure parameters and loading conditions shall be submitted by the Design-Build Firm for review and approval.

- Buoyancy

  Cut-and-cover structures will be located below normal and flood water elevations. Therefore, the design needs to address buoyancy conditions. The final design shall be required to provide a long term minimum factor of safety against buoyancy of 1.1 on all permanent cut and cover sections assuming normal groundwater levels and a minimum factor of safety of 1.05 during flood conditions. The buoyancy factors of safety shall rely on water levels and dead weight of structure and soil surcharge as well as foundation elements specifically designed to resist uplift such as tie-downs and tension piles. These foundation elements will require load testing and an appropriate factor of safety. The final design to address buoyancy shall be submitted for review and approval.

  Friction/adhesion along the walls of the structure will be neglected when calculating the buoyancy factor of safety.

### 2.3.6 Design Criteria for Bored Tunnel

- Earth Pressures

  The Design-Build Firm shall be responsible for designing the tunnel liner for all construction loading conditions.

  For permanent conditions, at-rest pressures will be required. The Design-Build Firm will be responsible for determining at-rest soil/rock properties. Long term surcharge loads for portions of the bored tunnel located on Dodge Island and Watson Island will be provided to the Design-Build Firm.

  All earth pressure parameters and loading conditions shall be submitted by the Design-Build Firm for review and approval.

- Buoyancy

  The entire length of the bored tunnel will be located beneath ground that is underwater and in some cases there are conditions with minimum ground cover. A final design factor of safety against buoyancy of 1.4 is required for the empty tunnel. Buoyancy forces may be resisted from dead weight of the tunnel structure, overburden and, if required, tie-down anchors. If tie-down anchors are used, load testing and appropriate factors of safety will be required to be developed for these elements. Design to resist buoyancy shall be the responsibility of the Design-Build Firm. Their design shall be submitted for review and approval

### 2.3.7 Bridge Foundations

Modifications to the MacArthur Causeway Bridge require the review of existing foundations to determine their ability to accommodate load revisions resulting from the proposed bridge modifications and/or the need for additional foundations. Final foundation bridge design will be in accordance with the State of Florida Department of Transportation Soils and Foundations Handbook, 2004. The Design-Build Firm shall be responsible for providing final design criteria for review and approval.

### 2.3.8 Above Grade Ramp Structures

Above grade construction includes ramps leading to and from the proposed tunnel. Final design will be in accordance with the Florida's DOT 2004 Soils and Foundations Handbook. Should the use of temporary earth support be required, the Design-Build Firm shall be responsible for providing final design criteria for review and approval.

### 2.3.9 Instrumentation and Monitoring

The Design-Build Firm shall have the responsibility for protecting all existing adjacent utilities, structures and adjacent property during design as well as providing field testing as required to confirm foundation designs are acceptable. However, during preliminary design, if there are critical areas which require special attention, location-specific criteria will be developed and provided to the Design-Build Firm. Typical criterion may include threshold and limiting values regarding vibrations, horizontal and vertical deformations, groundwater drawdown and minimum standards for instrumentation location and types of instrumentation. A detailed instrumentation and monitoring plan shall be submitted by the Design-Build Firm for review. Included with the submitted monitoring plan shall be proposed mitigation measures to be taken in the event deformations exceed those predicted and/or observations of existing structures indicate additional deformation is unacceptable.

### 2.3.10 Groundwater Control

The Design-Build Firm shall be responsible for developing and implementing groundwater control systems for the entire project and for obtaining all permits and designing all facilities for the legal discharge of groundwater. Minimum requirements of the groundwater/dewatering systems developed by the Design-Build Firm shall include:

- Maintaining water levels within the excavation at least five feet below subgrade during construction;
- Limiting drawdown outside of the excavation to prevent damage to existing structures and utilities;
- Submitting detailed dewatering/groundwater control plans including predicted groundwater flows and drawdown as well as mitigation measures should actual drawdown exceed predicted levels.

If, during the preliminary design phase, areas are revealed that are considered especially sensitive to drawdown, maximum drawdown criteria will be provided for these specific locations to the Design-Build Firm.

Environmental and discharge permits shall be obtained by the Design-Build Firm, as required for discharge and/or groundwater recharge of water pumped by the dewatering systems.

## 2.4 Landscape Architecture

Landscape Architecture will be the responsibility of the City of Miami and the Port of Miami. The responsibility of the Design-Build Firm shall be to provide loam and seed for all areas only.

### 2.4.1 Loam and Seed Requirements

The loam and seed requirements shall conform to the guidelines of the Florida Highway Landscape Guide. In general, a sandy loam is considered to be the best all-around soil for planting in Florida. Similarly, common Bermuda grass grows well in almost any soil and being relatively salt tolerant is recommended for use in coastal areas.

A. Sandy loam:

- Susceptibility to Compaction: Limited to moderate
- Nutrient holding capacity: Moderate
- Available water: 15.6%
- Infiltration Rate: 25 mm per hour
- Drainage: 2 days
- Reaeration time: 2 days

B. Bermuda grass seed:

- Depth of seed placement: 3-6 mm
- Seed application rate: 6.8 kg per hectare

In the event additional detail on Landscape Architecture is desired, the following section is included, as a reference source in terms of a suggested option.

### 2.4.2 Suggested Option for Landscape Design Criteria

2.4.2.1 Theme: Garden Parkways

A. It is suggested that an overall theme for the landscaping of the project be tropical in nature, and that it draw exclusively from indigenous plant material found in South Florida and be accented with low maintenance tropical palms and flowering trees.

B. The landscaping should complement that of its neighbors, both on Watson Island and on the Port of Miami (Dodge Island). This is particularly important on the Watson Island side, where the neighbors include Parrot Jungle, the Children's Museum, Chalk's Seaplane apron, the Convention and Tourism Center, and especially the new Flagstone Properties multi-use hotel and marina complex, Island Gardens.

C. The roads surrounding Island Gardens will be heavily landscaped to turn them into what are being called Garden Parkways. In addition, Island Gardens intends that their landscaping be used to help conceal the bridge abutment and the façade of the parking garage, filtering the views of these elements from tenants and visitors. The Port of Miami Tunnel project landscaping should blend seamlessly into this effort, and use planting to soften views of the bridge abutments, boatwalls, and ancillary structures.

D. The landscaping should also respond generally to the natural and man made conditions along the alignment. Emphasis should be placed on providing a naturalistic and picturesque drive to motorists. The landscaping should provide continuity, sense of scale, spatial definition and visual accents.

2.4.2.2 Suggested General Requirements

A. The landscape plans package should be prepared in conformance with the latest edition of the FDOT Design Standards Manual, Plans Preparation Manual, and the Design Criteria Handbook. All plans should be to be prepared in accordance with the latest design standards and practices, Department's Standard Specifications, Indexes, Department's Roadway Plans Preparation Manual, and should be accurate, legible, complete in design, drawn to the scale indicated in the Department's manuals and furnished in reproducible form.

B. The landscaping should meet traffic safety requirements as mandated by the Florida Department of Transportation.

C. The landscaping should provide for ease of maintenance for maintenance crews.

D. Tree planting should allow for adequate setbacks for utilities.

E. The landscaping should be coordinated with the surface elements of the tunnel egress system, walkways, and parking and service drives for the ancillary structures.

2.4.2.3 Plant Material

The following is a suggested list of native and tropical plants that could be used for the project area. The list contains plant species appropriate for dry conditions. A complete list would include plants complementing those of the neighboring uses, especially Island Gardens.

A. Native trees
- Gumbo Limbo (Bursera simaruba) 12' height x 6' spread.
- Live Oak (Quercus virginiana) 12' height x 6' spread Satin leaf (Chrysophyllum oliviforme) 10' height x 5' spread.
- Pigeon Plum (Coccoloba diversifolia) 10' height x 5' spread.
- Yellow Elder (Tecoma stans) 8' height x 4' spread.

B. Native Palms
- Royal Palm (Roystonia elata)10' – 18' grey wood, staggered heights.
- Sabal Palm (Sabal palmetto) 12' – 24' clear trunk, staggered heights.

C. Native shrubs:
- Cocoplum (Chrysobalanus icaco) 24''height x 18'' spread, plant 48'' on center.
- Spanish Stopper (Eugenia foetida) 24''height x 18'' spread, plant 48'' on center.
- Firebush (Hamelia patens) 24''height x 18'' spread, plant 48'' on center.
- Wild Coffee (Psychotria nervosa) 24''height x 18'' spread, plant 48'' on center.
- Fakahatchee Grass (Tripsicum dactiloides) 18''height x 12''spread, plant 48'' on center.
- Saw Palmetto (Serenoa repens) 18''height x 12'' spread, plant 48'' on center.
- Giant Swordfern (Nephrolepsis biserrata) 18''height x 12'' spread, plant 36'' on center.

D. Tropical flowering accents:
- Royal Poinciana (Delonix regia) 12' height x 6' spread.

E. Tropical flowering accents:
   - Royal Poinciana (Delonix regia) 12' height x 6' spread.

## 2.5 Environmental Issues

The 2000 Environmental Assessment/Finding of No Significant Impact (EA/FONSI) and the 2004 Preliminary Design and Environment (PD&E) Re-Evaluation reviewed the potential construction period and operational impacts of the proposed project. Activities associated with construction and operation of the project were expected to have air, noise and vibration, land use, traffic, visual/lighting, stormwater, and construction material disposal impacts as described below.

### 2.5.1 Dust/Air Quality

No significant changes in air quality were expected to occur during construction or operation of the project. Minor short-term air quality impacts during construction were expected in the form of dust from earthwork and unpaved roads. These impacts will be mitigated by adherence to state and local regulations and to the latest edition of FDOT's Standard Specifications for Road and Bridge Construction. Federal and state air quality standards will be complied with.

### 2.5.2 Noise and Vibration

2.5.2.1 Noise & Vibration Concerns

2.5.2.1.1 Traffic Noise

Potential traffic noise consequences associated with the project were evaluated previously and reported in the PD&E Re-evaluation Report (July 2004). Four noise receptor locations were evaluated with noise measurements in 2003 as well as with traffic noise modeling (TNM) for the design year 2030. When the predicted traffic noise levels were evaluated against FHWA and FDOT traffic noise criteria, only the Japan Gardens receptor was found to be potentially impacted by future traffic noise. However, the cost to build a noise barrier could not be justified in accordance with FDOT's cost-effectiveness criteria.

However, in the time since the PD&E Re-evaluation report was developed there may be additional noise-sensitive receptors, specifically such as the Island Gardens hotels and condos, that should be evaluated as well for potential traffic noise impacts. If additional noise-sensitive receptors are identified they will be evaluated for potential traffic noise impact and potential mitigation measures based on current FHWA methods as found in 23 CFR Part 772 as well as current FDOT policy as summarized below.

2.5.2.1.2 Construction Noise & Vibration

In general, construction noise, and to a lesser extent construction vibration, has the potential to disturb community members to the point that it can hinder a project's schedule. While there are no pre-existing residences within about a mile of the project, there may be new residential areas that will soon encroach, such as the Island Gardens condos. In addition there currently are outdoor commercial recreation areas, a museum, and other outdoor beach and park areas within close proximity to the project. Therefore, it shall be the policy of this project to balance the needs of the community for peace and quiet against the Design-Build Firm's needs to progress the work without undue or unattainable restrictions. Construction noise and vibration levels associated with various phases of work will be predicted and evaluated against criteria described below in order to identify potential consequences. Where significant noise or vibration impacts are expected, suitable noise and vibration mitigation measures will be proposed and evaluated for potential cost and effectiveness.

Based on the results of the noise and vibration predictions, comprehensive construction noise and vibration control programs will be evaluated for implementation before construction activities commence in the field. As part of these control programs suitable noise and vibration control specifications will be developed for inclusion in the Design-Build documents. The specifications will address such issues as (1) the measurement of baseline and actual noise and vibration levels, (2) the establishment of specific construction noise and vibration criteria limits, (3) a detailed listing of any work hours, equipment or operational constraints, (4) a description of related submittals required from the Design-Build Firm, (5) guidance on how to prepare noise and vibration mitigation plans, (6) a listing of potential noise and vibration mitigation measures, (7) costs of mitigation measures, and (8) the financial consequences of compliance or non-compliance by the Design-Build Firm.

2.5.2.1.3 Mechanical Systems Noise

The potential noise consequences associated with project mechanical systems will be predicted, evaluated, and if necessary, mitigation measures will be developed to avoid disturbing nearby residents or businesses. Examples of potential noise producing mechanical systems includes diesel generators, storm water pump stations, and noise emissions from the multiple jet fans intended for use inside the tunnels.

2.5.2.2 Noise and Vibration Assumptions

2.5.2.2.1 Noise and Vibration Criteria Limits

Traffic noise criteria limits, as stated above, have already been established in the PD&E Re-evaluation Report. Future traffic noise levels associated with the project will be evaluated against the FHWA's Noise Abatement Criteria (NAC) as found in 23 CFR Part 772 which defines an absolute limit for Category B receptors of "approaching" 67 dBA Leq(h). FDOT policy has defined "approaching" to mean within 1 decibel, so the absolute noise limit for Category B receptors becomes 66 dBA Leq(h). In addition, FDOT policy defines a relative increase criteria limit in which future traffic noise levels should not exceed existing traffic noise levels by more than 15 dBA. FDOT's policy also states that for noise mitigating barriers to be justified they must provide at least 5 decibels insertion loss (dBIL) and cost less than $35,000 per receptor.

Construction noise criteria limits will be receptor-specific and will be consistent with the new construction noise guidelines FHWA Roadway Construction Noise Model (RCNM) being released by FHWA in October 2005 (which were primarily derived from other construction noise control programs successfully implemented by PB on other tunneling projects). The noise criteria will define allowable relative increases of 3 to 5 dBA above pre-existing L10 baseline noise levels for each noise-sensitive receptor within the project area; necessitating the measurement of baseline noise levels by the D/B team prior to construction. L10 noise limits, evaluated at the property lot-line of each receptor, will vary based on time of day and on the receptors' land-use sensitivity as shown in Table 2-3. In addition there will be category-specific equipment noise emission limits, expressed as an Lmax limit at 50 feet, to which all equipment on site will need to comply.

Where and whenever possible, construction noise limits will also be as consistent as possible with the City of Miami Noise Ordinance 11483, Section 36-6, which significantly restricts construction operations from occurring at night from 6pm to 8am and all day on Sundays and holidays. The

Ordinance does allow for work in the daytime providing the noise level at the receiving property's lot-line does not exceed 79 dBA Leq(d).

However, recent legislation [Ref. Florida Statute 335.02(4)] exempts FDOT from having to comply with local municipality ordinances if they are unreasonable and costly (which would clearly be the case here if tunnel construction could not occur at night).

**Table 2-3. Receptor Lot-Line Construction Noise Criteria**

| Noise Receptor Locations and Land-Uses | Lot-Line Construction Noise Limits in L10 dB(A), RMS slow | | |
|---|---|---|---|
| | Daytime (7 AM - 6 PM) | Evening (6 PM - 10 PM) | Nighttime (10 PM - 7 AM) |
| Noise-Sensitive Locations: (residences, institutions, hotels, etc.) | 75 or (*) Baseline L10 + 5 | Baseline L10 + 5 | Baseline L10 + 5 *(if Baseline < 70)* Baseline L10 + 3 *(if Baseline >= 70)* |
| Commercial Areas: (businesses, offices, stores, schools, etc.) | 80 or (*) Baseline L10 + 5 | None | None |
| Industrial Areas: (Factories, Plants, etc.) | 85 or (*) Baseline L10 + 5 | None | None |

Notes: (*) To allow for some necessarily noisy operations the louder of the two daytime criteria shall apply. Baseline L10 noise levels will be measured and established prior to work commencing.

In addition, the FDOT Standard Specifications for Road & Bridge Construction, Division II, Section 100, provides some noise-related requirements for construction equipment. In general the specification only requires that construction equipment be well maintained to minimize noise and to be used behinds noise screens if and whenever possible.

2.5.2.2.2 Construction Vibration Criteria Limits

To evaluate high vibration operations such as impact pile driving the project will adopt criteria limits developed by the U.S. Bureau of Mines (BOM) for ground vibration peak particle velocity (PPV) in order to avoid potential structural damages. BOM recommends a ground vibration PPV threshold of 0.5 inches per second to avoid minor damage to buildings, and a limit of 2.0 inches per second to avoid major damage to structures.

The project will also adopt construction vibration limits to avoid human annoyance based on the Federal Transit Administration's (FTA) "Transit Noise and Vibration Impact Assessment Manual" (1995). The guidelines provide for evaluation of both building occupant annoyance and the potential for minor structural damages based on the susceptibility of the structure and land-use category of the building. FTA recommends a vibration criteria limit of 72 to 75 VdB in order to avoid building occupant annoyance and a limit of 95 to 100 VdB to avoid minor structural (cosmetic) damages.

Mechanical systems noise criteria limits will be taken from the City of Miami Noise Ordinance 11483, Section 36-8, which sets noise limits for mechanical equipment producing steady-state noise output such as exhaust (jet) fans, compressors and (water) pumps. The Ordinance limits mechanical equipment noise not to exceed a level of Ambient + 10 dBA, or a maximum of 60 dBA, at the lot-line of a residential receptor during the daytime hours of 7am to 10pm; and Ambient + 5 dBA, or a maximum of 55 dBA, during the nighttime hours of 10pm to 7am. Noise limits for less sensitive receptors, such as institutional buildings, parks, apartments, commercial businesses and industrial sites, are generally increased by 5 dBA for each land-use category.

2.5.2.3 Noise & Vibration Prediction Models

If any further predictions are needed, traffic noise level modeling will be performed using the current version of the FHWA Traffic Noise Model (TNM) [Ref. FHWA TNM Model, version 2.5, DOT-VNTSC-FHWA-98-1, 2004]. The TNM model will make use of input data and site configurations generated previously for this project during the PD&E Re-evaluation Report.

Construction noise levels will be predicted using the soon-to-be-released FHWA Roadway Construction Noise Model (RCNM) which is scheduled for announcement to the acoustics industry in October 2005. The RCNM model is primarily derived from the construction noise model and equipment noise emissions databases developed at the Central Artery/Tunnel (CA/T) Project in Boston [Ref. CA/T Construction Noise Control Specification 721.560].

Construction vibration levels for potential structural damage as well as human annoyance will be predicted using a spreadsheet model developed at the Central Artery/Tunnel (CA/T) Project in Boston [Ref. CA/T Design Policy Memo No.1, Rev.4, 1994]. The model is derived from Swiss Standard 8008 and German Standard DIN 4150.

Mechanical noise levels will be predicted using spreadsheet models based on equipment source strength emissions, noise propagation patterns, and the affects of intervening structures. In particular the model for predicting jet fan noise levels escaping out of the tunnels will be taken from the model developed at the Central Artery/Tunnel (CA/T) Project in Boston [Ref. Modeling Highway Tunnel Ventilation System Noise, AWMA Conference, 2001].

### 2.5.3 Land Use

Under its current construction schedule, the Island Gardens development would be completed in 2008, and would overlap for a period of two years with the scheduled completion of construction of the project in 2010. During this two-year period, construction activities may impact residents of Island Gardens. The design and construction of the project must take into account these potential impacts.

The Design-Build Firm will be required to develop a traffic circulation plan that is consistent with the current changes to the Port roadway network and the main objectives of the original plan identified in the PD&E Study.

### 2.5.4 Lighting/Visual Impacts

Lighting, if required for nighttime construction activities, may have an impact on nearby residences to be built as part of the planned Island Gardens development. As noted above, the Island Gardens development is currently scheduled to be completed in 2008, two years prior to the completion of construction of the project. The design and construction should anticipate and plan for controlling these impacts, to the maximum extent feasible.

Point source luminaires which provide a full-cutoff distribution will be required for construction site lighting and temporary roadway lighting to ensure that light trespass to surrounding areas is minimized. Construction site floodlights will be aimed and shielded to keep light within the confines of the construction site. This will be addressed in the specification requirements for the Design-Build Firm.

### 2.5.5 Potential for Existing Contamination

The Project Re-Evaluation (9/9/05) noted that, "…there have been no significant changes in site activities on Watson Island or Dodge Island that would impact the proposed tunnel construction. No apparent soil or groundwater contamination or other recognized environmental conditions have been identified in the proposed tunnel construction area."

The specifications for the Design-Build Firm will require that, if construction operations encounter or expose any abnormal condition that may indicate the presence of contamination, such operations will be discontinued until clean-up efforts are completed. Contamination control measures will include those contained in the FDOT's most current edition of "Standard Specifications for Road and Bridge Construction."

Although soil and groundwater contamination has not been documented in the proposed tunnel construction area, releases may have occurred from past storage and handling of fuel for aircraft, vehicles, and marine applications. Therefore, preliminary sampling and analysis for petroleum constituents is recommended prior to disposal of groundwater or soil from dewatering or soil excavation activities. Sampling should be limited to contiguous properties with onsite fuel storage and any other areas where odors or soil staining observed during excavation indicate that a release may have occurred. This will be included as a requirement in the specifications for the Design-Build Firm.

### 2.5.6 Water Quality/Stormwater/Dewatering

Potable water quality will not be degraded since the project will not impact any groundwater recharge areas. The proposed stormwater facility design will include, at a minimum, the water quantity requirements for water quality impacts as required by DERM in Section 28-13 of the Dade County Code. Therefore no further mitigation for water quality impacts will be needed. Water quality during construction will be maintained by strict adherence to the water quality standards applicable to Biscayne Bay (an Aquatic Preserve and Outstanding Florida Water), ongoing coordination with DERM and FDEP and the implementation of a stringent monitoring program.

As noted in the EA/FONSI (p 4-44), "the minimization of water quality impacts during construction has been of critical concern throughout project development." The PD&E Study *Construction Water Quality Issues Technical Memorandum* was used as a baseline in the Re-Evaluation Report (9/9/05) to determine if the water quality findings had changed under the current study plans and construction methods being considered for the tunnels. The purpose of the original study was to identify potential water quality impacts associated with construction of the tunnel project and the methods identified to minimize the impacts. The construction was to take place in "Outstanding Florida Waters" subject to Class III water quality criteria. The project area in Biscayne Bay is also designated Critical Habitat for the endangered West Indian Manatee. Special provisions are also included in the EA/FONSI (p. 4-46) such as procedures for notifying the DERM project manager prior to commencement of the project and measures to protect manatees before, during and after construction. These measures include maintaining a log of manatee sightings, reporting of any collision or injury to a manatee, special signage, and removal of debris from the water.

In order to insure compliance with the permitting requirements of FDEP and DERM, special provisions will be added to the Design-Build contract which require specific actions by the Design-Build Firm and its personnel. Specific conditions pertinent to the protection of manatees and sea turtles are listed in Section 4.3.13 and on page 4-46 of the EA/FONSI. Appropriate best management practices will be implemented to satisfy permit requirements and minimize secondary construction impacts.

The PD&E requires that a water quality protection plan be submitted by the Design-Build Firm and approved by DERM prior to project commencement. This plan is required to detail all methods for controlling and minimizing turbidity, filling, bulkheading, and spoil transport/disposal. Methods to prevent turbidity plumes are to be detailed in this plan or in the required environmental protection plan. This will be included in the specifications requirements for the Design-Build Firm.

The PD&E states that turbidity impacts are not anticipated during construction. As a precautionary measure however, turbidity monitoring equipment and trained personnel will be required to be available on site during times when conditions exist for generating turbidity. If monitoring by the project staff reveals apparent violations of State Water Quality Standards for turbidity, construction activities are to cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels. Any such occurrence is to be immediately reported to the FDEP. This will be included in the specifications requirements for the Design-Build Firm.

Existing turbidity criteria state that turbidity will not exceed 29 Nephelometric Turbidity Units (NTU) above the natural background conditions during construction.

A sedimentation monitoring plan shall be developed and implemented by the Design-Build Firm to identify potential sedimentation impacts caused by the project.

### 2.5.7 Construction Materials Disposal

There will be a significant volume of excavated materials generated from tunnel boring operations, also known as tunnel muck or spoil. The tunneling subcontractor to the Design-Build Firm shall be responsible for disposal of the tunnel muck and the means and materials of construction, which will influence the nature of the materials to be disposed.

The tunneling subcontractor to the Design-Build Firm may elect to use additives, as necessary, to seal the chamber to prevent water inflow to the tunnel during construction. The natural moisture content of the excavated soils are generally increased by the addition of water, foams and polymers into the cutterhead chamber in order to optimize the operation of the tunnel boring machine (TBM). Consequently the material transported from the TBM to the surface will often not be suitable for direct compaction without a drying out period or a mixing of the material with dry soil. The physical characteristics of the soil and chemical nature of the additives used in tunnel operations may limit disposal options.

Preliminary information from DERM’s Solid Waste Section indicates that there is no regulatory issue related to the disposal of the tunnel cuttings or other excavated materials upland in an unlined landfill site if the material is virgin limestone. If the material is clean according to DERM criteria, it can also be used in the FDOT’s and the FTE’s other Turnpike’s roadwork projects as base material. This would allow recycling the material with a positive benefit.

Excavated materials from vertical tunnel shafts and excavated tunnel spoil may not be clean enough to be used as uncontrolled fill. Specifications will require the Design-Build Firm to comply with Florida solid waste and hazardous waste regulations or the regulations of other states, if materials are disposed of at out-of-state locations. The Design-Build Firm will be required to identify the facility and to submit acceptance letters from the selected facilities and bills of lading (BOL) or shipping papers prior to transport.

For any material that comes into contact with any of the TBM drilling fluids, the Design-Build Firm will need to determine if the fluids contain any possible contaminants that would be present in excess of regulatory standards. This will determine if the materials need to be treated at a Rinker or Magnum type incineration facility. Thus there would be an incentive for the Design-Build Firm to require its tunneling subcontractor to use non-contaminating or less contaminating additives.

The Design-Build Firm shall be required to provide sufficient space to handle and temporarily store the muck spoil. Storage capacity needed for excavated spoil at the surface can be estimated from the expected daily advance rates of the TBM in conjunction with any local restrictions imposed on trucking hours and routes. Progress rates will likely vary and allowance is often made to provide for up to a required three (3) days of TBM progress to accommodate materials and spoils storage on-site. Containment measures must be taken to prevent the runoff from the spoil stockpiles. When limited space is available, the Design-Build Firm may be required to make provisions for additional space off site or outside project limits and include this consideration in its schedule and cost estimates.

Acquiring necessary permits for disposal of the muck will be the responsibility of the Design-Build Firm.

## 2.6 Permitting

Major regulatory permits required for the project have been identified as follows:

- Florida Department of Environmental Protection (FDEP) Environmental Resource Permit for surface water encroachments, sovereign submerged lands lease or other consent of use for tunnel crossing, stormwater treatment (and dewatering plan approval if dewatering is contemplated).
- Miami-Dade County Department of Environmental Resource Management (DERM) permit for marine construction and stormwater treatment.
- U.S. Army Corps of Engineers (USACE) permit for surface water encroachments and possibly offshore disposal of excavated material.
- Department of Environmental Resource Management (DERM) Tree Removal Permit.
- National Pollutant Discharge Elimination System (NPDES) permit for construction activity and stormwater discharge.
- U.S. Coast Guard (USCG) permit for bridge construction.

Preparation and acquisition of these and any other permits will be the responsibility of the Design-Build Firm.

## 2.7 Existing Utilities and Relocations

### 2.7.1 Watson Island Utilities

Existing utilities on Watson Island include a 36-inch water main, sanitary sewer, telephone/communications conduits and power conduits. The existing water main currently runs along a local access roadway on the south side of the island. There is an existing underground power system for street lights along the causeway as well as both frontage roads. As part of the Island Gardens development, this water main along with an electrical duct bank will be relocated under the frontage road just south of the MacArthur Causeway and on the north side of Island Gardens.

Utility relocations will be required where the project roadways are shifted to new alignments. There do not appear to be any major utilities requiring relocation at the proposed bridges, boat sections and tunnel portal areas on Watson Island.

### 2.7.2 Port of Miami Utilities

Existing Utilities on the Port of Miami include water lines, sanitary sewer, communications/fiber optics conduits and power conduits. An existing 20-inch water main, sanitary sewer line and adjacent fiber optic duct bank run on the south side of Port Boulevard. Other water, sanitary sewer, electric and fiber lines cross the proposed project roadways. There is an existing Florida Power & Light (FPL) service point along the retaining wall on the northeast side of the existing bridge flyover. There is an extensive underground electrical system for the street lights.

Relocations will include the water, sanitary sewer and fiber optic lines south of Port Boulevard as well as the service point and many of the utilities crossing the proposed cut-and-cover and boat sections. Existing power and communications also serve the existing entry/exit security gate. However new security gates will be located to the east in early 2006. The existing gate will then be used by Seaboard Marine. New project roadways will require that the existing gate be removed and replaced with a new gate facility constructed for Seaboard's use.

## 2.8 Governing Regulations

The services performed by the Design-Build Firm shall be in compliance with all applicable Manuals and Guidelines including the Department, FHWA, AASHTO, and additional requirements specified in this document. Except to the extent inconsistent with the specific provisions in this document, the current edition, including updates, of the following Manuals and Guidelines shall be used in the performance of this work. Current edition is defined as the edition in place at the date of advertisement of this contract. It shall be the Design-Build Firm's responsibility to acquire and utilize the necessary manuals and guidelines that apply to the work required to complete this project. The services will include preparation of all documents necessary to complete the project.

### 2.8.1 Technical Standards

Florida Department of Transportation Standards:

1. Florida Department of Transportation Turnpike Enterprise Plans Preparation and Practices Handbook (TPPPH), (http://www.dot.state.fl.us/turnpikepio/production/ p3handbook1.html)
2. Florida Department of Transportation *Roadway Plans Preparation Manual* http://www.dot.state.fl.us/rddesign/PPM%20Manual/2003/PPM%20Vol%20I.htm
3. Florida Department of Transportation Roadway Design Standards

http://ombnet.dot.state.fl.us/procedures/bin/625010003.pdf
4. Florida Department of Transportation Surveying Procedure
   http://ombnet.dot.state.fl.us/procedures/bin/550030101.pdf
5. Florida Department of Transportation EFB User Guide (Electronic Field Book)
   http://www.dot.state.fl.us/surveyingandmapping/data.htm#Electronic%20Field%20 Book
6. Florida Department of Transportation Drainage Manual
   http://ombnet.dot.state.fl.us/procedures/bin/625040001.pdf
7. Florida Department of Transportation Soils and Foundations Handbook
   http://www.dot.state.fl.us/structures/Manuals/sfh.04-22-2004.pdf
8. Florida Department of Transportation LRFD Structures Design Guidelines
   http://www.dot.state.fl.us/structures/manlib.htm
9. Florida Department of Transportation Computer Aided Design and Drafting (CADD) Roadway Standards Manual
   http://www.dot.state.fl.us/ecso/manual/default.htm
10. Florida Department of Transportation CADD Structures Standards Manual
    http://www11.myflorida.com/ecso/manual/criteria.htm
11. Florida Department of Transportation Structures Manual
    http://www.dot.state.fl.us/structures/manlib.htm
12. Florida Department of Transportation Roadway CADD Handbook
    http://www11.myflorida.com/ecso/manual/criteria.htm
13. MUTCD
    http://mutcd.fhwa.dot.gov/
14. American Disabilities Act http://ombnet.dot.state.fl.us/procedures/bin/625020015.pdf
15. Florida Department of Transportation Standard Specifications for Road and Bridge Construction, Supplemental Specifications, and/or Special Provisions.
    http://infonet.dot.state.fl.us/tlspecificationsoffice/
16. Florida Highway Landscape Guide http://ombnet.dot.state.fl.us/procedures/bin/650050001.pdf
17. Florida Department of Transportation Structures Design Standard Drawings
    http://ombnet.dot.state.fl.us/procedures/bin/625020300.pdf
18. Florida Department of Transportation Florida Sampling and Testing Methods
    http://materials.dot.state.fl.us/SMO/Administration/Publications/fstm/FSTMHome.htm
19. Florida Department of Transportation Pavement Coring and Evaluation Procedure
    http://materials.dot.state.fl.us/SMO/Administration/Publications/materialsmanual/se on34.pdf
20. Florida Department of Transportation District Design Guidelines
    http://www.dot.state.fl.us/rddesign/updates/files/updates.htm
21. Florida Department of Transportation Utility Accommodation Manual
    http://ombnet.dot.state.fl.us/procedures/bin/710020001.pdf
22. Florida Department of Transportation Construction Project Administration Manual
    http://www.dot.state.fl.us/construction/manuals/cpam/CPAM70000000/cpamman.ht m
23. Florida Department of Transportation Flexible Pavement Design Manual
    http://infonet.dot.state.fl.us/PavementManagement/pcs/2002%20Flexible%20Pavem t%20Manual.pdf
24. Florida Department of Transportation Rigid Pavement Design Manual
    http://infonet.dot.state.fl.us/PavementManagement/publications.htm
25. Florida Department of Transportation Pavement Type Selection Manual
    http://infonet.dot.state.fl.us/PavementManagement/pcs/Pavement%20Type%20Sele ction.pdf
26. Florida Department of Transportation Right of Way Manual
    http://tlrws1.dot.state.fl.us/rwmanual.asp
27. Florida Department of Transportation Intelligent Transportation System Guide Book
    http://www.dot.state.fl.us/trafficoperations/temanual/Chapter5/5.1.pdf
    Florida Department of Transportation Bicycle Facilities Planning and Design Handbook

http://ombnet.dot.state.fl.us/procedures/bin/625010050.pdf
http://www.dot.state.fl.us/emo/pubs/pdeman/pt2ch14.pdf

29. Florida Department of Transportation Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways
http://www.dot.state.fl.us/rddesign/florida%20greenbook/florida%20greenbook%20 2002.htm
30. Florida Department of Transportation Preparation and Documentation Manual
http://www.dot.state.fl.us/construction/manuals/finalest/p&d/P&D%20manual.htm
31. Florida Department of Transportation Review and Administration Manual
http://www.dot.state.fl.us/construction/manuals/finalest/review%20&%20admin/chapters/audit%20&%20admin.htm
32. Florida Department of Transportation Computation for Design, Construction and Final Estimate
http://www.dot.state.fl.us/construction/manuals/finalest/newcompbook/New%2-Sample%20Compbook.htm
33. Florida Building Code, 2001 Edition with Latest Amendments
http://www.floridabuilding.org
34. Florida Statues
http://www.leg.state.fl.us/

Additional Standards:

1. AASHTO – Specifications for Highway Bridges
http://www.transportation.org/community/bridges/site.nsf/SearchSite/1E31C2AA26650A56866BBA00201DEB?OpenDocument&Highlight=Specification
2. AASHTO – A Policy on Geometric Design of Highways and Streets
https://www.transportation.org/publications/bookstore.nsf/SearchSite/3A972E72E445BF01862A380057D6F7?OpenDocument&Highlight=Publications
3. Federal Highway Administration Hydraulic Engineering Circular Number 18 (HEC 18).
http://www.fhwa.dot.gov/bridge/hyderra.htm
4. Federal Highway Administration Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications
http://www.dot.state.fl.us/structures/Manuals/sfh2000.pdf
5. Other relevant and pertinent standards required by geotechnical, structural, architectural, traffic controls, landscaping and environmental are listed in their respective sections of this report.

### 2.8.2 Specifications

The Florida DOT Standard Specifications for Road and Bridge Construction will be used as a basis for site/civil and bridge structural engineering disciplines. The Florida DOT Facilities Design Manual and the Facilities Design Guidelines shall be utilized for the bored tunnels, cut and cover tunnels, open boat structures, ancillary support buildings, and mechanical and electrical systems. Site components that relate to the building facilities shall also be governed by the Facility Design Guidelines. Technical Special Provisions will be prepared using the Construction Specification Institute (CSI) 3 part format. It is anticipated that the following list of Technical Special Provisions (specifications) will be required for the work.

### 2.8.3 CADD Standards

This project will use the standards and procedures required by Florida's Turnpike Enterprise for Computer Aided Design and Drafting (CADD) production, delivery and processing of electronic files. The following will be utilized:

- FDOT CADD Manual
- FDOT CADD Production Criteria Handbook

- FDOT 2004 CADD Software with programs and support files to be used in CADD production.

FDOT standards will be modified and adapted for new disciplines that will be required for the tunnel project. Additional file naming and leveling assignments will need to be developed. These CADD production criteria, guidelines and conventions will be used to prepare digital design data and electronic files. The uniform and consistent standards will establish a consistent standard that will allow for easy and transfer of files and data.

The Design-Build Firm will be required to prepare all drawings including as-built drawings using CADD in accordance with these same standards.

# 3. TUNNEL REQUIREMENTS

## 3.1 Structural Design

### 3.1.1 Design Criteria

Preliminary design and the structural design performed by the Design-Build Firm will need to be in compliance with all applicable Manuals and Guidelines including the Department, FHWA, AASHTO, and additional requirements specified in this document. Unless noted otherwise in the specific provisions in this document, the current edition, including updates, of the following Manuals and Guidelines shall be used in the performance of this work. Current edition is defined as the edition in place at the date of advertisement of this contract. It shall be the Design-Build Firm's responsibility to review and utilize the necessary manuals and guidelines that apply to the work required to complete this project, as listed below.

1. Florida Department of Transportation Soils and Foundations Handbook
2. Florida Department of Transportation LRFD Structures Design Guidelines
3. Florida Department of Transportation Computer Aided Design and Drafting (CADD) Roadway Standards Manual
4. Florida Department of Transportation CADD Structures Standards Manual
5. Florida Department of Transportation Structures Manual
6. Florida Department of Transportation Standard Specifications for Road and Bridge Construction, Supplemental Specifications, and/or Special Provisions.
7. Florida Department of Transportation Structures Design Standard Drawings.
8. Florida Department of Transportation Florida Sampling and Testing Methods.
9. AASHTO – LRFD Bridge Design Specifications, referred to in these design criteria as “AASHTO Bridges”.
10. Florida Building Code, 2001 Edition with Latest Amendments, referred to in these `design criteria as “State Code”.
11. Building Code Requirements for Structural Concrete, ACI 318, of the American Concrete Institute, including its commentary, referred to in these design criteria as “ACI 318”.
12. Building Code Requirements for Masonry Structures, ACI 530 and Specifications for Masonry Structures, ACI 530.1 of the Masonry Standards Joint Committee, including their commentary, referred to in these design criteria as “ACI 530”.
13. Manual of Steel Construction of the American Institute of Steel Construction, referred to in these design criteria as “AISC Specifications”.
14. Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, published by the American Association of State Highway and Transportation Officials.

In general, the design of structures carrying highway traffic will be in accordance with AASHTO Bridges as modified by the FDOT Design Guidelines, Manuals, Specifications, and/or Special Provisions listed above.

The design of above ground buildings and miscellaneous structures not subject to highway loads will be in accordance with the State Code, AISC Specifications, ACI 318 and ACI 530.

### 3.1.2 Bored Tunnel

3.1.2.1 Cross Sectional Requirements

Figure 3-1 graphically depicts the tunnel cross-section and the required clearance envelope to accommodate a two lane roadway, safety walk and super elevations. The minimum excavated diameter and internal diameter of the tunnel are 40-feet and 36-feet respectively. Construction tolerance for the overall tunnel cross section as shown in Figure 3-1 will be limited to 2 inches. If the Design-Build Firm ascertains that additional tolerance is required, the cross sections may require modification.

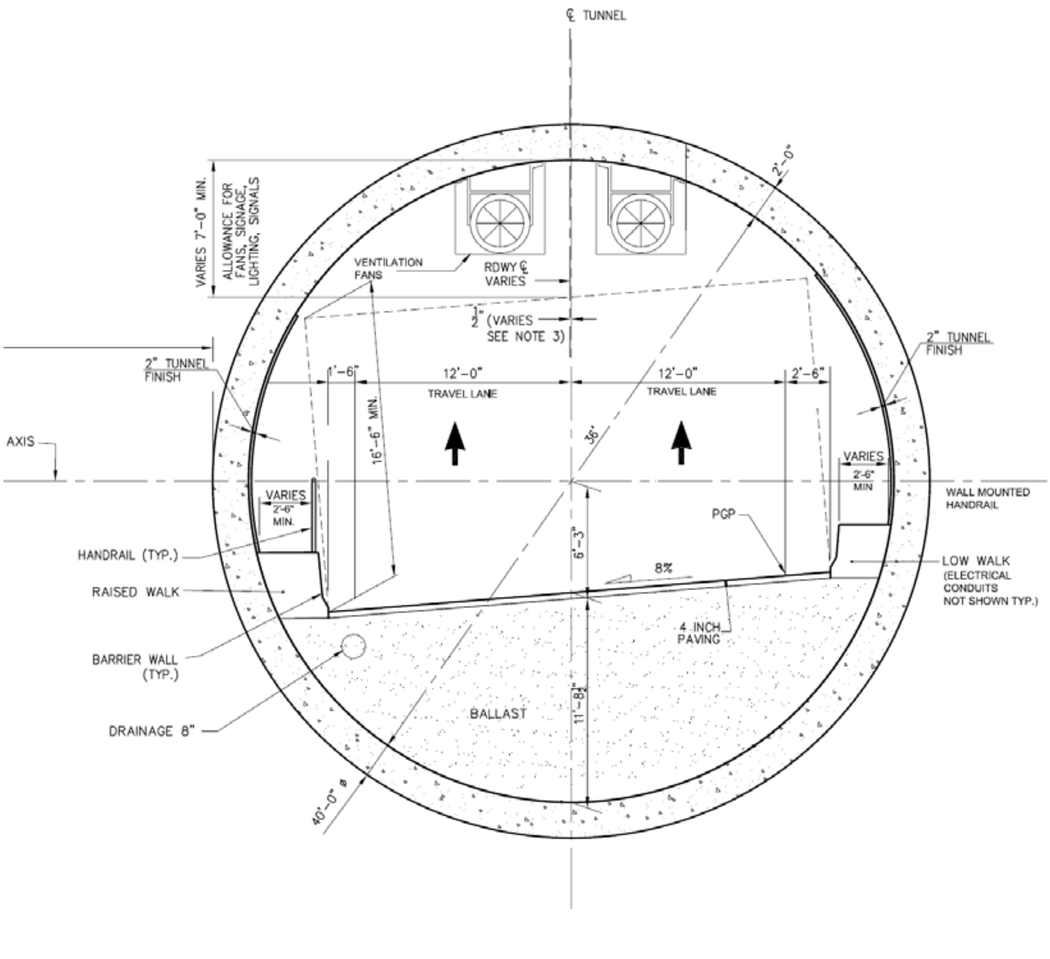



**Figure 3-1. Bored Tunnel Cross-Section and Clearance Envelopes**

3.1.2.2 Tunnel Excavation System Requirements

The selection of the tunneling system and the operating, supervising, and management personnel for tunneling will control the success of constructing the bored tunnels for the project. Methods must be selected for suitability considering the geologic and hydrologic conditions, possible impacts on the adjacent structures, compatibility with final ground support, safety and economy. Once the Design-Build Firm's means, methods, equipment, procedures, and sequences have been chosen and the tunnel is underway, changes usually are extremely costly and difficult, and may not be possible. Therefore, selection of all construction means, methods, sequences, equipment, and systems requires consideration of the full range of ground conditions. Also, the excavation and support systems must be capable of adapting quickly to very extreme conditions to ensure the safety and stability of the tunnels at all times.

It is critical to the success of tunneling that the excavation's face and its full perimeter be controlled at all times to minimize losses of ground and movements of the overlying ground. A pressurized face tunnel boring machine (TBM) is required to minimize the possibility of large uncontrolled ground losses and resulting subsidence.

The Design-Build Firm, after evaluation of all the geotechnical data, overall project economics, and the chosen means and methods of tunnel support, will have the final responsibility for the TBM, and for the design, operation, and selection of the tunnel excavation system. Considering the size and low cover of these tunnels and the unique geology (vuggy limestone), the TBM will have to be unique and custom-built specifically for this project.

3.1.2.3 TBM Requirements

The Port of Miami Tunnel Project will require the development of a specialized pressure face TBM. The following general performance criteria and minimum machine requirements should be incorporated to help ensure successful tunnel excavation:

- Tunnel Interior Diameter –approximately 36 feet
- Machine Bore Diameter – approximately 40 feet

The above dimensions include a 2 inch construction tolerance. The Design-Build Firm may modify the machine diameter as necessary to reflect final tolerances. Specific requirements for components of the TBM and its operation are provided below:

<u>Cutter Head and Shield Requirements</u>

- Required to be provided with a closed head with disc cutters for the hard rock and appropriate drag cutters for sand.
- All cutter head cutters shall be replaceable from behind the cutter head.
- The cutter head is required to be retractable.
- Cutter head bearing and seals should be replaceable from within the tunnel, and replacements readily available.
- Required to be provided with positive closure or flood doors/valve
- Required to be provided with a compressed air lock for man entry into cutter head chamber
- Required to be provided with multiple probe, grout/freeze ports on cutter head for ground stabilization, or for void detection

<u>Tail Seals and Annular Grouting Requirements</u>

- Required to be provided with multiple rows of seals and grease injection system, repairable and maintainable from within the machine

- Required to be provided with multiple grouting ports.
- Required to be provided with a computer operated integrated grouting system which considers rate of advance, grout quantities, prevailing external pressure and related variables. The grouting system must be able to handle very large and variable grout quantities at very low pressure, using a hydrophilic grout which solidifies quickly to avoid grout migration and free flow into the solution channels or voids.

Foams and Additives

- Bentonite, foams, polymers, or similar additives are required to condition the muck, and to reduce both torque requirements and cutter wear
- Foam and additive ports are required on the cutter head, in the cutter head chamber, and in the screw conveyor
- An automated and computer controlled injection system is required.
- Use of foams and additives are required to be in conformance with environmental regulations and to be biodegradable.

Grouting of the annular void between the excavated ground and liner must be controlled and monitored carefully to avoid grout migration and pollution of the channel. Experience with grouting Karstic limestone in Kuala Lumpur for the Light Rail Transit tunnels found that using a bentonite cement mix combined with a water gel (sodium silicate) added at the injection point was successful in grouting the open vugs in the limestone. Special consideration must be given to ensure that the void around the lining is completely filled. This will ensure that the liner is fully supported and that the requisite ground reactions develop to maintain liner stability.

A two-stage grouting process will be required. Significant bedrock overbreak, particularly in the crown of the tunnel is anticipated because of the horizontal bedding of the limestone and the highly variable nature of the material. This rock overbreak will create voids above the lined tunnel that will not be filled by the first stage grouting at the tail shield. The second stage grouting takes place behind the trailing gear of the machine where grout holes are drilled through the grout ports in the lining, through the first stage grout, and up into the bedrock zone behind the lining so that the overbreak voids can be fully grouted. This will ensure that complete ground-to-tunnel lining contact is established, and that soil-structural interaction is established between the ground and the tunnel lining. The design of the grout ports is a critical detail in the segment design in order to minimize the potential for these ports to be a source of leakage.

#### 3.1.2.4 Tunnel Lining Recommendations

Since water bearing ground is anticipated in the Port of Miami Tunnel Project, the initial support system must be watertight. The use of a precast segmental, bolted and gasketed concrete one-pass lining system is considered the most practical and economical for this project. The tunnel liner consists of segmental concrete rings that are erected and bolted together within the trailing gear of the tunnel boring machine, under the tail shield. Gaskets between the joints provide a compression seal against the intrusion of water. Ethylene Propylene Diene Monomer (EDPM) rubber compression gaskets and hydrophilic gaskets are recommended. A caulking groove may also be provided on the inside of the segment for maintenance against future leaks.

The tunnel boring process will require construction of reinforced concrete segments measuring approximately 4 to 6 feet wide and 2 feet thick. These initial support systems or linings are to be designed to sustain the earth and hydrostatic loads imposed by the surrounding ground and surcharges above, as well as loads imposed during the tunneling process, including jacking forces, handling, and erection loads. Jacking loads are induced as the shield is thrust forward by reaction against the initial support elements. Erection and handling loads result from the transporting, lifting, and erection of the segments as they are cured, transported and erected within the tunnel. The jacking loads and loads induced from handling and erection may control the design of the segments.

Due to the shallow cover over the tunnel, special lining segments made either with heavy aggregate for added weight, or by adding ballast concrete to the invert are required to resist buoyancy.

Because of the harsh environment and high strength requirements during tunneling, it is recommended that the concrete be low permeability, sulfate-resistant concrete, to resist corrosion and reaction with seawater. These properties can be achieved with the addition of fly ash, blast furnace slag aggregate, condensed silica fume, hydrophobic pore blocking and/or corrosion inhibiting additives. The unconfined compressive strength of the concrete should be 8,000 psi. These requirements represent state-of-the-art and would be incorporated into the specifications for the Design-Build Team.

Segments are generally produced in a special fabrication facility or yard which may be off site, or on-site, if conditions permit. Using high tolerance fabricated and machined steel forms, the segments are cast, cured and stored for use. Recent experience for projects (including the St. Claire, San Diego, Boston Harbor Outfall, Los Angeles EEIS, MWD Inline System, and Toronto Subway projects) has demonstrated the use of highly mechanized and automated plants for segment production. Use of such facilities has resulted in high quality, interchangeable segments that are durable, extremely impermeable to salt water, and resistant to chloride and sulfate attack.

3.1.2.5 Requirements for Watertightness – Bored Tunnels

The following criteria are required to be established for the bored tunnels:

- Maximum overall infiltration 1gpm per 1000 feet of tunnel
- Local infiltration limit 0.25 gallon per day for 10 square feet of area, and 1 drip per minute at any location

3.1.2.6 Cross Passageways

The National Fire Protection Association - Standard for Road Tunnels, Bridges and Other Limited Access Highways (NFPA 502) guidelines recommend cross passageways between parallel tunnels. These cross passageways would be smaller tunnels, in the range of 14-16 feet in outside diameter, and in the range of about 10 to 12 feet inside diameter, spaced every 650 feet apart, and driven from one main tunnel to the other main tunnel in ground which will be required to be fully grouted and stabilized. One of these cross passageways is required to be constructed at the lowest point in the tunnel.

Cross passageways will be constructed using the sequential excavation method. To permit open-face excavation, ground improvement will be required to either stabilize the ground and/or prevent ground water inundation. Options for ground improvement include grouting or ground freezing, depending on the localized geotechnical conditions.

Localized site investigation at the cross passageways are required to be carried out from the tunnels to determine the integrity of the ground between the two parallel tunnels. If there are no large voids detected, a water cut-off barrier in the form of a grout curtain may be all that is required to enable excavation. In this case, grouting would be carried out through an envelope of predrilled grout tubes around the perimeter of the cross passageway excavation to isolate the excavation from the surrounding ground water.

Alternatively, as used in construction of the cross passageways on the Westerschelde Tunnel in the Netherlands, ground freezing may be required. Container size refrigeration plants can be positioned inside the tunnel directly beside the cross passageways, and would allow the ground between the two cross passageways to be frozen.

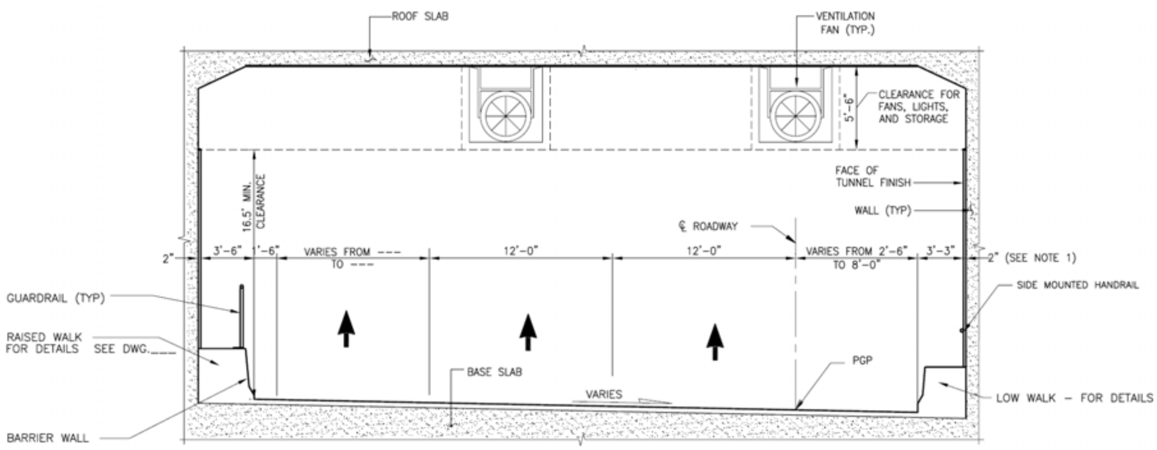
Following pretreatment of the ground, the construction sequence for each cross passageway would be as follows: Erection of temporary support for the pre-cast linings, such as with steel ribs, in each tunnel adjacent to the cross passageway; core-cutting and removal of pre-cast segments at one end of the cross passageway entrance; excavation of the cross passageway with a top heading and bench sequence – and as excavation advances, provide an initial ground support with steel-reinforced shotcrete lining.

Breakthrough of the cross passageway excavation into the other tunnel will require removal of segments at the other tunnel. The permanent lining will require installation of a polyvinyl chloride (PVC) membrane, placement of a cast-in-place concrete final lining and installation of cross passageway utilities, as required.

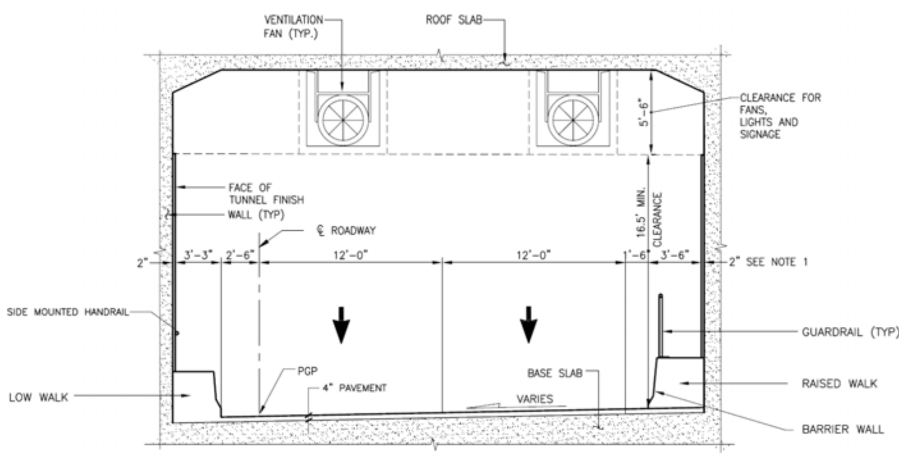
### 3.1.3 Cut and Cover Tunnel and Open Boat Structures

3.1.3.1 Cross Sectional Requirements

Figure 3-2 graphically depicts the cut-and-cover tunnel cross-sections and the required traffic clearance envelope to accommodate a two-lane roadway, safety walkway and super elevations.




CROSS SECTION RAMP 1A (EB) FROM STA. 445+00± TO STA 447+00
CUT AND COVER CONCRETE TUNNEL




SECTION RAMP 1B(WB) FROM STA. 548+30 TO STA. 552+00

**Figure 3-2. Cut and Cover Tunnel Cross-Sections and Clearance Envelopes**

Figure 3-3 graphically depicts the typical open boat cross section.

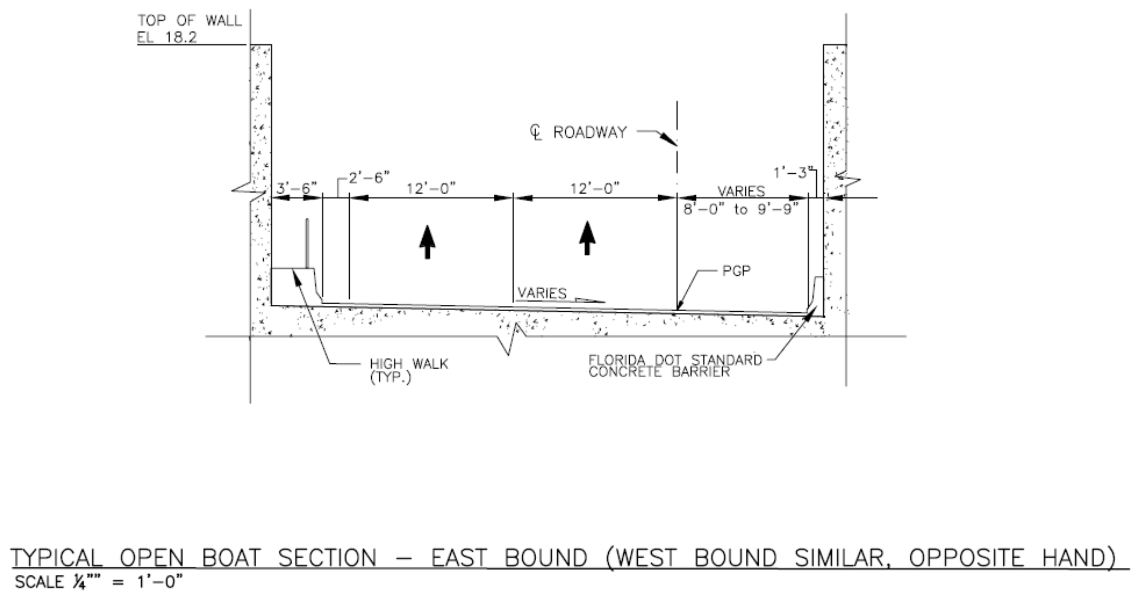



**Figure 3-3. Open Boat Cross-Section and Clearance Envelopes**

3.1.3.2 Structure Type and Materials

A cast-in-place concrete structure with external waterproofing membrane on the outside is recommended for the tunnel box structure, and the base slab and side walls of the open boat structures.

All materials will conform to the applicable specifications and codes listed in this Section. However, should the Design-Build Firm believe that significant economies can be achieved by the use of different materials than those specified in this section while providing at least the same level of performance and durability, the Design-Build Firm may substitute alternate material standards after receiving written approval from FTE.

Unless otherwise noted, normal weight, Portland cement concrete shall have a minimum specified compressive strength ($f_c$') of 4,000 psi at 28 days. All reinforcement shall be ASTM A615 Grade 60 epoxy coated.

Unless otherwise noted, structural steel shall conform to AASHTO M270, Grade 50. High strength bolts for structural steel connections shall conform to AASHTO M164. Anchor bolts shall conform to ASTM A307.

Concrete masonry units (CMU) shall meet the requirements of ASTM C145 and C90, Grade N, Type 1, normal weight, and shall have a minimum compressive strength of 2,000 psi on the net bedded area. Mortar shall meet the requirements of ASTM C270, Type N above grade and Type M below grade. All grout shall have a minimum compressive strength of 2,500 psi at 28 days.

#### 3.1.3.3 Construction Methods for Cut and Cover Tunnels

The connecting cut-and-cover tunnels leading up to the bored tunnel sections will be a major part of construction for the Port of Miami Tunnel. The construction of the cut-and-cover tunnels will require excavations to depths in excess of 70-feet below the groundwater level (El. 0 or sea level in Biscayne Bay). The high horizontal and vertical permeability of the limestone bedrock requires the control of water inflows to be an essential consideration of any construction method to be used on this project.

In addition, measures have to be taken to limit the vertical permeability of the bedrock layer at subgrade levels. During excavation, the water levels below the bottom of the excavation will have to be maintained well below (5-feet or more) the bottom of the excavation at all times to prevent unacceptably high water inflows or possible uplifting of the invert due to high hydrostatic pressures acting on the bottom of the excavation. The feasible methods to overcome the permeability issues of the subsurface materials in the invert of the cut-and-cover tunnel sections include:

- Excavation of the material in the wet (using controlled drilling and blasting to loosen the bedrock strata) and over-excavation of the invert to permit casting of a tremie concrete counter-buoyancy slab to resist uplift pressures;

- Excavation in the wet as described above, and use of anchor piles or drilled shafts to anchor the invert slab against the hydrostatic uplift pressures.

- Installation of a grouted soil/rock plug between the slurry walls that can reduce the water inflows to an acceptable level while resisting uplift forces so that the excavation can be done in the dry with front-end loaders and rippers to break up the harder bedrock layers and a structural slab placed on the excavated sub-grade.

The type of excavation support system and means of controlling the water levels during construction will be the responsibility of the Design-Build Firm.

#### 3.1.3.4 Requirements for Watertightness – Cut and Cover Tunnels

##### 3.1.3.4.1 Joints

Construction joints will be required at spacings not exceeding 50 feet to control shrinkage stresses in concrete slabs and walls and to minimize cracking. All construction joints will be required to have continuous reinforcing steel, keys, or other positive means of shear transfer. Joints will be required to have non-metallic waterstops for all exterior elements in contact with soil. Expansion joints will be required at locations of major changes in structural cross-section.

##### 3.1.3.4.2 Infiltration Limits

The maximum acceptable overall infiltration rate into the tunnel structure will be 1gpm per 1000 feet of tunnel. A procedure for contractual acceptance will be developed including inspection criteria and acceptance criteria.

### 3.1.4 Sign Supports

Sign supports will be detailed in accordance with FDOT standards, and will be designed in accordance with Standard Specifications for Structural Supports for Highway Signs, Luminaries and

Traffic Signals, published by the American Association of State Highway and Transportation Officials.

### 3.1.5 Flood Gate Structures

In accordance with FTE's request, flood gates will be provided at all tunnel portals to prevent surge tides from entering the tunnel. The predicted 100-year storm high water level for this area is elevation 18.2 feet. In addition, three tunnel approaches have been elevated above the 100 year storm surge elevation. For the fourth tunnel approach at the Dodge Island portal on the westbound tunnel, there is insufficient space to construct additional height of embankment necessary to prevent surge tides from rising above the highest roadway elevation at the open approaches and running down the tunnel.

The structure of the gates will be designed to take full hydrostatic pressure of the highest water level anticipated. The loads from the gate will be distributed from the main vertical and horizontal beams onto bearing plates in the wall, roadway and soffit. Headhouses for the flood gates will have watertight doors.

### 3.1.6 Other Structures

The Operations Support Facility on Dodge Island and other ancillary structures will be designed as concrete structures with standards similar to those described in Section 3.1.3.2 of this Design Basis Report.

## 3.2 Architectural Design

### 3.2.1 Architectural Context and Elements

The Port of Miami Tunnel Project is being located in an aesthetically sensitive part of Miami, and will function as a gateway to the Port of Miami. The project will also be experienced and viewed in context with the contemporary architecture of downtown Miami, and with the "Tropical Modern" architecture of Miami Beach. The bridges and tunnels will be used by, and their appearance judged by, large numbers of Miami residents and cruise ship tourists, both domestic and foreign. The architectural design of what are relatively utilitarian structures in the midst of such an environment must show sensitivity and creative innovation.

The range of architectural design elements includes the following:

- Highway Architecture: Surface highway elements, including bridges, piers, retaining walls, boat walls, portals, and tunnel finishes elements such as walls, ceilings, walkways, and egress system cross passageways and egress stairs.

- Buildings: Ancillary structures such as headhouses, electrical substations, flood gate structure, and the Operations Support Facility.

Architectural design and plans shall be required to be prepared in conformance with the latest edition of the FDOT Design Standards Manual, Plans Preparation Manual, and the Design Criteria Handbook.

3.2.1.1 Design Criteria

The design criteria for the architectural elements and finishes include the following considerations:

A. Aesthetic: The selection, integration, and implementation of the architectural palette should be done with sensitivity to the adjoining uses as much as possible, while maintaining a unique and versatile design identity. The Port of Miami Terminal buildings, the Children's Museum, and the Island Gardens mixed-use hotel/marina complex are all designed in what may be loosely described as a "Tropical Modern" style. The current project should attempt to be sensitive to this style and complement it in architectural features, finishes, and ornaments.

B. Driver Safety and Orientation: Textures, colors and patterns of roadway structures, and of tunnel ceilings, walls, and walkways should be designed to create safe exterior and interior driving environments for the motorist and assist driver orientation. Architectural finishes should provide lane definition, assist in the legibility of signage through sign placement, and support rapid identification of cross passageways and emergency exits.

C. Ease of Maintenance: Selection of finish materials should include those which are durable and economic to maintain. This includes tunnel surfaces which are easy to clean with standard tunnel wash equipment, and which resist corrosion related to entry of water into the finishes and connections. Materials shall be impact resistant as far as is practical and shall be easily replaceable in the event of damage.

D. Graphics: In general, the design and integration of graphics with the roadway and tunnel finishes should provide a pleasing aesthetic experience for drivers while supporting functional requirements, including the following considerations:

   - The graphics should provide visual interest but not be distraction to drivers. The goal of the architectural design is to provide overall integration of primary and secondary structures, their materials, and connections between them.

   - The graphics should convey information regarding orientation and the location of emergency tunnel facilities. In particular, the location of cross passageways, emergency egress facilities, and fire protection cabinets should be clearly identified.

E. Wall reflectivity: Wall reflectivity in the tunnels should be 30% to 60% including any graphic design.

3.2.1.2 Codes and Standards

The design shall be governed by the following codes, standards and regulations listed below with all addenda, supplements and revisions as applicable, and shall be supplemented by other applicable national and local codes.

- General Requirements and Highway Codes:

  A. Finding of No Significant Impact (FONSI) report approved by the Federal Highway Administration (FHWA) on December 13, 2000

  B. FDOT-Standard Specifications for Road and Bridge Construction

C. Americans with Disabilities Act of 1990

- Buildings, including Operations Support Facility and Ancillary Structures:

A. U.S. Occupational Safety and Health Regulations (OSHA)

B. U.S. Environmental Protection Agency Regulations

C. National Fire Protection Association - Life Safety Code (NFPA 101)

D. National Fire Protection Association – Standard for Portable Fire Extinguishers (NFPA 10)

E. National Fire Protection Association - Installation of Sprinkler Systems (NFPA 13)

F. National Fire Protection Association - Installation of Standpipe, Private Hydrants and Hose Systems (NFPA 14)

G. National Fire Protection Association - Standard for the Installation of Stationary Fire Pumps for Fire Protection (NFPA 20)

H. National Fire Protection Association - National Electrical Code (NFPA 70)

I. National Fire Protection Association - National Fire Alarm Code (NFPA 72)

J. National Fire Protection Association - Clean Agent Fire Extinguishing Systems (NFPA 2001)

K. National Fire Protection Association - Standard for Road Tunnels, Bridges, & Other Limited Access Highways (NFPA 502)

L. National Fire Protection Association - Standard for the Installation of Lightning Protection Systems (NFPA 780)

M. Florida State Building Code, 2004 Edition

N. Florida DOT Facilities Design Manual, March 2002 Edition

O. Americans with Disabilities Act – Accessibility Guidelines for Building and Facilities; Architectural and Transportation Barriers Compliance Board, most recent edition.

P. Underwriters Laboratories Standards test investigations, lists of building material, fire protection and extinguishing equipment and devices and electrical equipment.

Q. Factory Mutual Laboratories test investigations, reports and lists of fire protection equipment, electrical equipment and building construction.

### 3.2.2 Tunnel Finishes

3.2.2.1 Tunnel Ceilings and Walls

Requirements for tunnel ceilings and walls shall include the following:

A. Finish materials and colors: Tunnel wall finishes shall be light-colored direct applied glazed ceramic tunnel tile or surface attached lightweight metal veneer panels. Finishes shall extend from the top of the maintenance walkway to a point near the upper limit of the travel envelope. Above this point, dark finishes (paint, stain, and fireproofing) and uniformly colored covers over utilities will be used to unify and simplify the appearance.

B. Doors and frames for cross passageways, and egress stairs: Stainless steel, Type 316. A fire rating of 2 hours is included as part of the criteria. Doors and frames shall comply with Steel Door Institute (SDI) "Recommended Specifications: Standard Steel Doors and Frames" (SDI-100) and shall be fabricated to comply with SDI-117, "Manufacturing Tolerances, Standard Steel Doors and Frames." Rated doors shall comply with NFPA #80 and have fire resistance characteristics which meet acceptable performance requirements when tested in accordance with ANSI/UL 10B7 and NFPA #252; labeled and listed by U.L., Warnock Hersey, or Factory Mutual approved.

C. Coordination with mechanical and electrical systems, including devices for concealment of conduit, fireproofing, standpipes, etc. These devices will be designed to be lightweight and easily removable for easy access to utilities.

D. Maintenance walkway railings and handrails: Stainless steel tubes 1½" diameter, Type 316. Height 3 feet-6 inch minimum.

E. Fire hose valve cabinets: Stainless steel, Type 316, minimum 16 gauge, with hinged doors.

F. Signage for cross passageways, and egress stairs doors: Graphics will comply with Miami Fire Department requirements. Material will be porcelain enamel on steel, complying with "Specification for Architectural Porcelain Enamel on Steel for Exterior Use" – Porcelain Enamel Institute, PEI S-100(65) inorganic coating bonded to metal by fusion at temperatures above 1400 Fahrenheit.

G. Interior finish in tunnels, boat sections and all stairways shall be ASTM E84 Class A (frame spread, 25 or less; smoke development, 100 or less) throughout.

#### 3.2.2.2 Tunnel Emergency Egresses and Stairs

Requirements for tunnel emergency egresses and stairs shall include the following:

A. Finish materials and colors: Walls and ceilings shall be painted concrete, white or light pastel colors. We recommend 4 inch or 6 inch exposed CMU veneer wall for egresses and stairs, with either exposed gunite ceilings or a Promat-type board on stainless steel sub-framing.

B. Lighting Fixtures: The selection and placement of lighting fixtures shall be coordinated

C. Signage: Same as Section 3.2.2.1, item 6, above.

D. Guardrails and handrails shall be stainless steel.

#### 3.2.2.3 Tunnel Cross Passageways

Requirements for tunnel cross passageways shall include the following:

A. Finish materials and colors-walls and ceilings painted concrete, white or light pastel colors. As with egress stairs, we recommend 4 inch or 6 inch exposed CMU veneer for cross passageway walls, with either exposed gunite or Promat-type board ceilings, on stainless steel subframing.

B. Coordination of lighting selection and placement

C. Signage: Same as Section 3.2.2.1, Item F, above.

### 3.2.3 Entrance and Exit Portals

Portals occur at the threshold zone marking both the entrance and exit of the tunnel. The Port of Miami Tunnel has two entrance and two exit portals. Two of the portals are to bored tunnel sections and two portals are to cut and cover tunnel sections. The portal design theme shall be consistent with that of the overall architectural design, i.e., “Tropical Modern”, and may employ actual tropical emblems such as flamingos, palm trees and Port or City of Miami logos. These emblems could be done in bas-relief, or in metal. The portals should emphasize common characteristics in order to:

A. Maintain a uniformity of perception in the driving experience and visually ease the transition from boat section to tunnel.

B. Maximize the tunnel entrance recognition by the driver.

C. Coordinate with Mechanical/Electrical/Plumbing systems to embed or otherwise conceal conduit, fireproofing, standpipes, etc, from the view of motorists.

D. Blend in aesthetically with the boat sections and other tunnel ancillary structures, especially those on the surface, and with the neighboring structures and architecture on Watson Island and Dodge Island.

Entrance portals are viewed directly and axially by the driver approaching the tunnel. Entrance portals should be instantly recognizable and shall be designed to support tunnel lighting design criteria which call for enhanced lighting levels at the threshold in order to minimize the “black hole effect”, which is the perceived contrast between the relatively dark interior of the tunnel and the bright exterior daylight. Architectural design features which support and enhance illumination of the tunnel threshold are to be incorporated.

Exit portals are seen by the driver as the transition between the relatively dark interior of the tunnel into the light exterior and are not normally viewed from the exterior except in the rear view mirror. The westbound exit portal of Ramp 1B will, however, be visible from the Island Gardens hotel towers, and special architectural consideration should be given to this exit portal

### 3.2.4 Boat Sections

Boat sections are formed when both edges of open roadways run below grade. The minimum height of boat wall sections is generally established by the required datum levels for the flood risk area. In the case of the Port of Miami Tunnel Project, three of the boat sections are above flood risk datum. The westbound Ramp 1B boat section is below flood risk datum and consequently requires a flood gate structure. However, flood gate structures will be provided at all four tunnel portals. Boat section walls are typically cast-in-place concrete with formwork on interior and exterior faces.

The boat section architecture shall be consistent with the aesthetic treatment of the other elements, shall be stucco-covered concrete painted white or light pastel colors, and shall attempt to echo architectural forms found elsewhere on the islands, such as the serrated edge of the Island Gardens parking and commercial structure abutting MacArthur Causeway. This serrated effect could be integrated into the boat wall pilaster treatment.

Architectural requirements for the boat section design shall include the following:

A. Design integration of the boatwalls, boatwall top railing, and boatwall battering with the overall project design criteria.

B. The roadway faces of the formed concrete retaining walls will be profiled to include a batter, or inclined face, within the top section of the wall to create the visual impression of opening up the space. The batter will incline away from the vertical to reflect daylight, creating a contrast with the lower vertical face which will be more in shadow.

C. Coordination of lighting, lighting pilasters, and embedded utility cabinets with the overall boat section design.

D. Design and integration of boatwall rustication strips with the overall design.

E. Other ornamental graphics or elements.

The purpose of architectural integration is to maintain a uniformity of perception in the driving experience, visually ease the transition from open road to portal, and blend in with the architecture of the neighboring structures on both Watson and Dodge Islands. This includes finishes and colors of the various elements.

### 3.2.5 Operations Support Facility on Dodge Island

The operation of the Traffic Surveillance Control System (TSCS), which is described in detail Section 3.5, and the tunnel Supervisory Control and Data Acquisition (SCADA) system, which is described in Section 3.4, are critical to maintaining mobility in the Port area and to maintaining safe environmental conditions within the tunnel. The TSCS system, which contains a vast array of traffic surveillance cameras and control devices as well as automated functions, is designed to present information to the control center operator. The SCADA system, which monitors the tunnel systems including the tunnel ventilation system, fire alarms, pumps stations, and other general alarms, also presents information to the control center operator. Due to the criticality of maintaining the functionality of the TSCS and SCADA systems, the design assumes that there are two control rooms with duplicate capabilities:

- A “remote” control room that will be integrated within an existing control center such as FDOT’s SunGuide Transportation Management Center located in Miami, or Florida Turnpike Enterprise’s (FTE) Pompano Operation Center located in Pompano Beach, Florida.

- A “local” control room that is required to be located within the Operations Support Facility (OSF) on Dodge Island. The OSF will be located at or near both of the Dodge Island portals, and will provide access from the “local” control room to both tunnel bores via egress stairs leading from the maintenance walkways in the tunnels to the surface.

The remote control room will provide the primary monitoring and control function for the Port of Miami roadway network but the local control room will function as a fully operational redundant backup. This section of the Design Basis Report is concerned primarily with the local control room.

The Operations Support Facility located on Dodge Island, in addition to housing the local control room, will have other functional requirements that are defined in the facility program. The facility design also will provide a physical connection between the facility and the tunnel bores thereby providing the pathway for the tunnel system conduits as well as maintenance access.

The program for the Operations Support Facility includes the following:

A. Tunnel Operations Control Room (Local Control Room)
B. Electrical substation-switchgear and emergency generator
C. Generator Room
D. Generator Fuel Tank Area
E. Fan Control Room
F. ADA Compliant Toilet Facilities/Locker room
G. Uninterruptible Power Supply (UPS) Room
H. Battery Room
I. Fire Pump Room
J. Tunnel Drainage Tank and Pump Room
K. Service Entrance Room
L. Storage Room/Shop
M. Day Room
N. Incident Management/Conference Room
O. Mechanical Equipment Room
P. Access to both tunnel bores
Q. Loading Dock
R. Parking

The architectural theme of the Operations Support Facility, will be required to be consistent with "Tropical Modern", and will be designed to blend aesthetically with the neighboring structures and architecture on Watson Island and Dodge Island. The facility will be constructed of reinforced concrete, and concrete masonry units. The exterior walls will be stucco painted white or light pastel, or tropical colors. The facility will have a low-slope membrane roofing system and roof parapets.

### 3.2.6 Ancillary Structures

Several ancillary structures varying in size and location, are required to be at various locations along the length of the alignment. They include the following:

A. Pump stations: The portal pump station facilities will be located below grade, adjacent to the portals, and will be accessible from the maintenance walkway and the surface. The accessibility from the surface will be combined with the portal egress stairs. The design will co-locate these facilities with other facilities to the greatest extent possible (such as egresses and the Operations Support Facility). A low point tunnel pump station will be provided at the low point of each bored tunnel. Interior finishes would be similar to the subsurface portions of the egresses and cross passageways.

B. Portal egress stairs and headhouses: These occur at each portal and are intended to allow for evacuation of the tunnel in the event of an incident at or near the boat sections. The stairs begin at the maintenance walkway and join together to lead to a common headhouse at the surface. The headhouse doors must be above flood elevation or be provided with pressure doors. Headhouse doors must be accessible and operable to rescue emergency personnel. Headhouse exit doors should have bollards placed in front of them to prevent their operation from being blocked by vehicles.

C. West entry portal electrical substation (Ramp 1A eastbound): This structure will be combined together with the 2 portal egress stair structures to create a common headhouse/substation structure. A partial program for this structure is as follows:

1. Electrical substation-switchgear
2. Uninterruptible Power Supply (UPS) Room
3. Battery Room
4. Storage Room/Shop
5. Fan Control Room
6. Mechanical Equipment Room
7. Tunnel Drainage Tank and Pump Room
8. Tunnel access to both bores
9. Generator Room
10. Generator Fuel Tank Area

D. Intermediate egress stairs and headhouses: These are located in the cut and cover tunnel sections between the portals and the bored tunnel. Their purpose is to provide a means for motorists to safely evacuate from the tunnel in the event of an incident within the tunnel. Their quantity and spacing are determined per National Fire Protection Association - Standard for Road Tunnels, Bridges, & Other Limited Access Highways (NFPA 502).

E. Portal flood gate structures: These are approximately 26' tall structures housing the flood gates at the portals. These are large, monolithic, and highly visible structures and must be treated architecturally in a way that integrates them into their surroundings and with adjacent structures and buildings.

### 3.2.7 Tunnel Egress

The objectives of this section are to provide a system of egress criteria to:

- Protect those who use the tunnel and other related structures, including motorists, maintenance workers, and emergency personnel.

- Create the design and integration of a tunnel evacuation system with a logical and clearly marked path of egress from the tunnel, boat sections, and ancillary structures to safe refuges.

- To protect roadways, structures, equipment, and ancillary buildings or spaces so as to minimize the occurrence and consequence of a fire incident.

This section outlines the general guidelines to be used for the egress considerations for the Port of Miami Tunnel project. Applicable codes, standards, and other sections of the project design criteria establish the basic design criteria for individual systems. The prevailing standard for the tunnel egresses is National Fire Protection Association Standard for Roads, Tunnels, Bridges, and Other Limited Access Highways (NFPA 502).

3.2.7.1 Egress Assumptions

A. Tunnels: In the event of a fire in a tunnel, traffic downstream of the fire and traffic in the adjacent tunnel bore will continue to exit the tunnel while incoming traffic to both bores is stopped.

B. Buildings: Clearly marked signage, lighting, and alarm systems will be provided to alert the occupants of the buildings and mark the path of egress travel to exits leading to safety.

3.2.7.2 Tunnel Occupant Load Calculations

A. In roadways, the normal occupant load shall be 80 persons per lane per 1000 feet of length.

B. Tunnel occupant load calculations shall incorporate the following assumptions:

- A single incident occurs in one bore.
- Traffic downstream of the incident continues to exit the tunnel.
- Adjacent tunnel bore will be allowed to empty; traffic will be stopped from entering.
- Occupants from vehicles in the immediate area of an incident may utilize available cross passageways to access an adjacent bore.

3.2.7.3 Egress Design Criteria

A. Reaching Egress

- The primary means of egress in the tunnel shall be for people to leave the site of a fire incident via the roadway. Secondary means of egress shall be the use of Cross passageways and Egress Stairs.

- The requirements of ADA regulations and the Florida Building Code Accessibility requirements shall apply within the tunnel as much as is practical and reasonable. It is assumed that handicapped individuals will require assistance to gain access to the egress systems via the maintenance walkway and the Egress Stairways. This assistance is assumed to be offered by other motorists and emergency responders.

B. Egress Stairways

Tunnel Egress Stairways will be used to provide a continuous protected route to grade for tunnel users. These are spaced near the portals and at intermediate locations in the tunnel bores.

- The minimum actual clear width of all tunnel stairways shall be 44 inches. Allowable projections into this clear width shall be 1.5 inches maximum for stair stringers and 3.5 inches maximum for handrails on each side.

- Areas of refuge for slower evacuees shall be provided at each stair landing. These areas shall be 22 inches in depth and extend the full width of the stairway.

- Headhouses shall be provided at the top of tunnel stairways; tunnel stairways will exit to areas leading to safety as part of an overall evacuation plan. No headhouse will exit to a surface area between active roadways.

- Panic hardware shall be provided on the inside of all headhouse doors.

- Design minimum headroom in tunnel egress stairways shall be 8'-0". Minimum headroom shall be 6'-8".

C. Cross Passageways

Cross passageways allow motorists and maintenance personnel to leave the incident bore and cross over into the separate smoke-free and fire-free area in the adjacent bore. They are spaced approximately 600 feet apart and are located in the central area of the tunnels not served by egress stairs. The cross passageway design will also include space to accommodate the fire protection system cross over connections. The tunnel low point cross passageways will be oversized to accommodate the low point pump station control room.

- The minimum actual clear width of all cross passageway egress routes shall be 44 inches.

- The required width of cross passageways shall not be restricted, including the swing of doors to panels, cabinets, or rooms.

- Mechanical and electrical equipment located in the cross passageways shall be in suitable metal enclosures and shall not project into the egress route.

D. Cross Passageway Door Details

- The preferred design for the cross passageway doors is the sliding type; however, their use will be fully evaluated during the preliminary design.

- The minimum actual clear width of all cross passageways and tunnel egress stair doors shall be 36 inches.

E. Maintenance Walkway Width and Details

We are proposing a raised walkway and a low walkway be located in each tunnel bore. The raised walk is intended to be used by maintenance staff, emergency personnel and patrol officers (the raised walk is often times referred to as a "patrol walk"). The raised walk is approximately 3 feet-4 inches high and is eight inches higher than the standard walk. The additional height provides better protection for the personnel using it and enhances the ability to observe traffic. The face of the raised walk is the shape of a standard jersey barrier. The jersey barrier shape is provided to redirect errant traffic. A handrail with a minimum height of 42 inches is provided along the face of the walk adjacent traffic. Minimum horizontal width is normally 2 feet 6 inches. Toe holes for mounting the raised walk are normally provided every 160 feet. A removable chain is provided at these toe holes for easy access to the top of the walk. The raised walkway width of 2 feet 6 inches is in conformance with AASHTO standards, although this width will require a waiver of NFPA guidelines.

The standard walkway, also commonly referred to as the low walk when a raised walk is also provided in the same bore, measures some 2 feet-8 inches high. The low walk provides safe haven should access to the raised walk be hindered. The horizontal surface is also 2 feet-6 inches minimum. The face of the low walk is also that of a jersey barrier shape. A wall mounted handrail is also provided. Similar to the raised walk, toe holes are provided in the face of the walk for mounting of the walk.

In the past, the face of the raised and low walk consisted of a ceramic tiled finish. The tiled face became a constant maintenance issue as vehicles would constantly strike these surfaces. More recent tunnel projects have eliminated the tile finish and have opted for bare concrete. We recommend a concrete cast-in-place surface for the walks.

## 3.3 Mechanical Systems Design

### 3.3.1 Tunnel Ventilation

3.3.1.1 Introduction

Ventilation is generally required in road tunnels to provide a safe environment for motorists. This objective can be achieved by the following:

- Preventing the dangerous accumulation of vehicle-emitted pollutants (i.e., carbon monoxide, CO, and oxides of nitrogen, $NO_x$)
- Maintaining visibility in the tunnel by preventing the accumulation of haze-producing pollutants.
- Providing life/safety support during a vehicle fire incident in a tunnel.

During normal tunnel operations, the tunnel length, the traffic density, and the direction of traffic movement (i.e., uni-directional vs. bi-directional) are some of the key factors in determining whether the ventilation requirements can be achieved by passive means (e.g., the piston action airflow generated by the moving vehicles) or whether mechanical ventilation is required.

The tunnel length is also a key factor in determining the need for mechanical ventilation during emergency operations, since it affects the egress time from the tunnel and the number of motorists that could be exposed to the hazards of a fire. Current Standards (NFPA 502) indicate that ventilation for smoke control is required for tunnels longer than 800 feet.

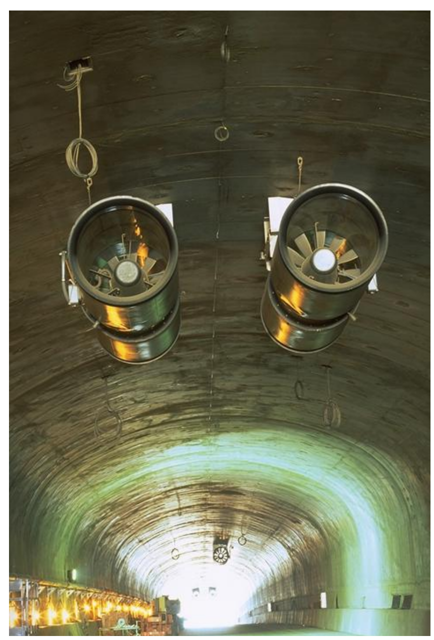


**Figure 3-4. Illustration of Jet Fan Installation in a Tunnel**

3.3.1.2 Ventilation System Types

Tunnel ventilation schemes are categorized as either natural or mechanical systems. Natural systems rely on the piston-effect of moving vehicles, external wind, and temperature and pressure differentials between the portals to produce airflow through the tunnel. Mechanical systems use fans to produce airflow. Mechanical systems can be further classified as longitudinal, semi-transverse, or transverse systems as follows:

- Longitudinal systems have air introduced to a tunnel or removed from a tunnel at a limited number of points, such as at portals or at ventilation shafts. A popular example of this type of system employs ceiling mounted jet fans to produce the required airflow through the tunnel. Longitudinal systems are typically used in tunnels with uni-directional traffic to take advantage of the vehicle piston action.

- Semi-Transverse systems use an air duct to either distribute air (supply) or remove air (exhaust) uniformly along the length of a tunnel. In practice, the supply system is the more widely used type, since it provides more uniform dilution of pollutants throughout a tunnel. In this configuration, reversible fans are typically used to allow for smoke exhaust.

- Transverse systems use both a supply and an exhaust air duct to uniformly distribute air to and remove air from a tunnel. Typically, air is supplied low near the roadway level to promote the rapid dilution of the vehicle-emitted pollutants. Air is exhausted along the tunnel ceiling which is advantageous for exhausting hot smoke in the event of a vehicle fire.

The longitudinal ventilation system is not recommended for use in tunnels with bi-directional traffic, since in the event of a fire, motorists can be trapped on both sides of the fire location while the ventilation system can protect only one of those sides. Longitudinal systems however, are appropriate for tunnels with uni-directional traffic. The semi-transverse and transverse systems that use an air duct to capture and remove the smoke from the roadway are the recommended systems with bi-directional traffic.

With regard to cost, the longitudinal system, which uses jet fans, is the most economical, since air ducts and ventilation buildings are not required and jet fans are located within the tunnel. The transverse system is the highest cost solution, since both supply and exhaust air ducts are required and ventilation buildings to house the fans are required. Furthermore, the size of the air ducts can significantly increase the overall tunnel cross-section.

A longitudinal system using jet fans is proposed for the Port of Miami tunnel roadways which are assumed to handle only uni-directional traffic in each bore. This system is considered the most appropriate type for this project, since it is the most economical system and is well suited for a tunnel handling uni-directional traffic.

3.3.1.3 Standards and References

The design of road tunnel ventilation systems will be required to conform to the latest issues of the following standards and references:

A. National Fire Protection Association - Standard for Road Tunnels, Bridges, & Other Limited Access Highways (NFPA 502)

B. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) – Enclosed Vehicular Facilites

3.3.1.4 Proposed Ventilation System Design

The proposed ventilation system for the Port of Miami tunnels will consist of a longitudinal system using jet fans. The jet fans will be mounted in the tunnel and supported from the ceiling as illustrated in Figure 3-4. As a preliminary estimate, a total of approximately 40 jet fan units will be required – 20 in the eastbound tunnel and 20 in the westbound tunnel. The fan units will be installed in pairs at a nominal longitudinal spacing of 300 feet. The preliminary estimate will be required to be confirmed by the Design-Build Firm during final design.

The estimate for the number of jet fans assumes that each fan unit consists of a 40-inch I.D. reversible axial fan and a sound attenuator on the entry and discharge sides of the fan. The sound attenuators are each nominally 2 fan diameters long with an approximate outside diameter of 48-inches. The overall length of each fan unit is about 17 feet long and weighs approximately 2,700 pounds. Reversible jet fans are proposed to allow for tunnel operation flexibility should it be necessary to reverse the direction of traffic through a tunnel bore.

Preliminary analysis indicates a required design flow rate per fan unit of approximately 54,200 cubic feet per minute which will result in a discharge air velocity of 6,420 feet per minute and will produce a static thrust of 215 pounds in the forward or reverse direction when tested at standard conditions.

The fan impellers will be coupled directly to a single-speed motor, operating at 1,780 rpm and rated at 50 hp.

The jet fan units will be rated for high temperature operation, since they are mounted in the tunnel and the fan units will be exposed to elevated temperatures in the event of a vehicle fire. In accordance with NFPA 502, the fans, their motors, and all related components that are exposed to the air stream must be able to remain operational for a minimum of 1 hour in an air stream temperature of 482 °F (250 °C).

Fan operation during normal tunnel operations will be determined primarily on the basis of the carbon monoxide (CO) level in the tunnel. The tunnels will be continuously monitored for CO at a suitable number of locations.

In addition, the relatively large percentage of diesel powered trucks and buses anticipated passing through the tunnel and the steep tunnel grade will require the monitoring of the opacity of the tunnel air (i.e., haze) to ensure a safe level of visibility.

The monitored data will be transmitted to both the remote located control room and the local control room in the Operations Support Facility on Dodge Island, where the data will be displayed for use by the system operators. The remote control room will be located within an existing control center such as FDOT's Sun Guide Transportation Management Center in Miami, or Florida's Turnpike Enterprise (FTE) Pompano Operation Center in Pompano Beach Florida. See Section 3.5.2 of this Design Basis Report for additional descriptions of the control room operations.

It is anticipated that the piston-action ventilation caused by traffic movement will be sufficient to maintain safe CO and opacity levels in the tunnels during free-flowing traffic conditions. However, some jet fans may need to be operated during heavy traffic periods, when traffic speeds fall below 10 to 15 mph, and during adverse outdoor wind conditions. If rising CO or opacity levels indicate the need for more ventilation, then additional pairs of fans would be activated.

In the event of a vehicle fire, all the fans in the tunnel roadway containing the incident would be operated to purge smoke from the tunnel and to protect any motorists trapped upstream of the fire location. It is anticipated that traffic downstream of the fire site would have exited the tunnel.

3.3.1.5 Design Considerations

The installed ventilation system capacity is typically determined by the requirement for smoke control during a tunnel fire incident (emergency operations). The ventilation requirements during normal tunnel operation (i.e., non-fire conditions) are significantly less and will be determined by the prevailing traffic conditions.

The performance of the tunnel ventilation system during a fire incident was determined on a preliminary basis by applying the Subway Environment Simulation (SES) computer program to establish the number of jet fans required. This was followed by a more detailed analysis using SOLVENT which is a computational fluid dynamics (CFD) computer program to evaluate the expected in-tunnel environment during a fire incident.

The SES program is a one-dimensional network model that can simulate the overall effects of a fire on a ventilation system. By comparison, SOLVENT is a 3-dimensional model which can predict the airflow, temperature and smoke concentration throughout the tunnel and can provide more detail regarding the smoke and temperature patterns during a fire incident.

The final analysis and selection of the number and size of jet fans required for the Port of Miami tunnels will be performed by the Design-Build Firm and shall include the considerations discussed below.

3.3.1.5.1 Pollutant Concentrations

The ventilation system must be sufficient to dilute the vehicle-emitted pollutants to safe levels. The limiting pollutant concentrations during normal tunnel operations have been established as indicated in Table 3-2:

**Table 3-2. Limiting Pollutant Concentrations for Ventilation Systems Design**

| Pollutant | Limiting Value |
|---|---|
| Carbon Monoxide (CO) | 120 ppm* for up to 15 minutes<br>65 ppm for up to 30 minutes<br>45 ppm for up to 45 minutes<br>35 ppm for up to 60 minutes |
| Oxides of Nitrogen ($NO_x$)** | |
| Nitric Oxide (NO) | 25 ppm |
| Nitrogen Dioxide ($NO_2$) | 3 ppm |
| Haze | K = 0.005 1/m*** |

* Parts per million
** The main constituents of $NO_x$ are NO and $NO_2$
*** K is an extinction coefficient which is a measure of the amount a light beam is attenuated.

Guidelines for carbon monoxide levels in tunnels have been established jointly by the FHWA and EPA. The guidelines are given in terms of allowable average CO concentration versus exposure time.

3.3.1.5.2 Design Fire Size

Trucks carrying hazardous cargo will not be permitted to use the Port of Miami tunnels. Therefore, a single vehicle fire size could range from about 3 MW to as much as 20-30 MW which are representative of fire heat release rates from the burning of a passenger car and a bus or a large truck, respectively. However, the relatively high percentage of buses and heavy goods trucks projected to use the tunnels could result in a multi-vehicle fire. Accordingly, a design fire heat release rate of 100 MW has been tentatively selected for this project pending a better definition of the type of truck cargo anticipated through the tunnel.

3.3.1.5.3 Smoke Control

With a longitudinal ventilation system, smoke control is achieved by producing a sufficient air velocity along the roadway to force smoke movement downstream away from the section of a tunnel most likely occupied by trapped motorists. The minimum air velocity required for smoke control is referred to as the critical velocity, i.e. that velocity which prevents reverse flow or back-layering of smoke. The magnitude of the critical velocity is a function of the design fire heat release rate (i.e., fire size), the tunnel dimensions and the tunnel grade. Accordingly, the critical velocity for the Port of Miami tunnels is about 720 feet per minute.

3.3.1.5.4 External Wind

External wind conditions can have a significant effect on the operation of the longitudinal ventilation system. If the wind is acting opposite to the direction of ventilation, then the tunnel airflow will be reduced. The jet fan selections include the effect of a 20 mph adverse wind acting on the exiting portal.

3.3.1.5.5 Fan Redundancy

The preliminary jet fan selections include an additional pair of fans along each tunnel bore to allow for the potential loss of a pair of fans by heat damage during a fire.

### 3.3.2 Tunnel Fire Suppression System

3.3.2.1 Introduction

National Fire Protection Association (NFPA) 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways is recommended as the governing document for establishing minimum fire protection and life safety requirements within the Port of Miami tunnels. As such, the preliminary design will adhere to these requirements unless dictated otherwise by the local Authority Having Jurisdiction (AHJ) on matters of fire protection and life safety.

According to NFPA 502, Annex D, the installation of sprinklers should only be considered applicable where the passage of hazardous cargo is considered. Since trucks carrying hazardous cargo will not be permitted to use the Port of Miami tunnels, the fire suppression system does not include a sprinkler type of fire suppression system.

Accordingly, a standpipe system is proposed for use as the primary fire suppression system within the proposed tunnels. In addition, portable multi-purpose fire extinguishers will be conspicuously located and easily accessible within both tunnels.

3.3.2.2 Design Considerations

The following are design considerations for a tunnel fire suppression system:

- Standpipe System Type - Standpipe systems within road tunnels are allowed by NFPA 502 to be either "wet" or "dry" meaning that the systems may be continuously kept full and pressurized or remain empty until needed. Dry standpipe systems are most commonly used in climates subjected to freezing conditions and must be capable of being fully charged by a reliable water source in less than ten minutes.

- Water Supply – NFPA 502 requires provision of a water supply capable of sustaining the standpipe system demand for one hour. Storage tanks, municipal waterworks or private water services are all acceptable provided that they have an adequate flow rate and residual pressure and are of an acceptable integrity and reliability.

- Hose Connection Valves – Special consideration must be given to the location and placement of hose connection valves within the tunnel. It is important to locate the valves so that they are conspicuous and convenient yet still adequately protected from damage. Provision of fire hose within the tunnel is also an option to be considered although many fire departments insist on utilizing only hoses that they maintain.

3.3.2.3 Design Codes and Standards

Local building and fire codes will be reviewed during development of preliminary design to ensure full compliance of the tunnel fire suppression system. As a minimum, the design of the road tunnel fire suppression system will be required to conform to the latest issue of the following standards:

*National Fire Protection Association*
NFPA 10 – Standard for Portable Fire Extinguishers
NFPA 14 – Standard for the Installation of Standpipe and Hose Systems
NFPA 20 – Standard for Installation of Stationary Fire Pumps for Fire Protection
NFPA 22 – Standard for Water Tanks for Private Fire Protection
NFPA 24 – Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways
NFPA 1963 – Standard for Fire Hose Connections

3.3.2.4 Proposed Tunnel Fire Suppression System Design

3.3.2.4.1 Standpipe System Type and Demand Capacity

The proposed tunnel standpipe system will be a Class 1 "automatic-wet" type system, as defined by NFPA 14, since a preliminary evaluation of a dry type system determined that a ten minute fill time could not be achieved. The system will be required to be designed to maintain a flow of 500 gallons/minute at a residual pressure of 100 pounds/square-inch to the outlet of the most physically remote hose connection valve. All pumps, piping, valves and trim will be listed by Underwriters

Laboratories Standards (UL) and approved by Factory Mutual (FM) for fire protection system service.

3.3.2.4.2 Water Supply

The water supply will be from the municipal service available on Dodge Island. The water service entrance will be made at the proposed tunnel Operations Support Facility on Dodge Island. Hydrant flow tests will be required to be conducted on the service line to determine if a fire pump will be required. A two-way Siamese fire department connection to the standpipe system will be required to be provided at both ends of the tunnel as a means of back up to the water service. The fire department connections will be located such that they are accessible by fire department responding apparatus and within 100 feet of a fire hydrant or other approved water supply.

3.3.2.4.3 Piping Arrangement

The standpipe system will consist of a 6-inch main embedded below the roadway slab in both the eastbound and westbound tunnels. The two mains will originate from the same service entrance at the Operations Support Facility and then run the full length of the tunnel. A cross-connection between the two mains will be made at each cross passageway. The cross-connections will be valved in a manner to allow sectionalizing of the system for maintenance purposes without taking down the entire system. Four-inch vertical risers extending from the embedded main will feed each hose valve cabinet. A drain line connecting to the mid-channel low point pump station will be included in the design to allow for the ability to drain down the entire standpipe main in either tunnel.

3.3.2.4.4 Hose Connection Stations

The fire department hose connection stations in each tunnel will be spaced in accordance with NFPA 502 so that no location on the tunnel roadways is more than 150 feet away. Hose connection stations will also be provided in each cross-passageway allowing for access and use to either tunnel. Each hose connection station will consist of two 2-½ inch hose valves and a 20-pound multi-purpose fire extinguisher in a protective enclosure. Hose valves will be external thread type in accordance with NFPA 1963 unless dictated otherwise by the responding fire department. No hoses will be stored in the tunnel. Pressure restricting valves will be installed at hose connections where hydraulic head exceeds 100 psi.

3.3.2.4.5 Identification Signage

Conspicuous identification signage will be developed for the components of the standpipe system. As a minimum, identification signage will be affixed to all fire department connections and hose stations. Signs will be permanently marked and will be constructed of weather-resistant metal or rigid plastic materials as required by NFPA 14, "Standard for the Installation of Standpipe, Private Hydrant and Hose Systems".

### 3.3.3 Tunnel Drainage

3.3.3.1 Introduction

Drainage systems are generally required in road tunnels to collect and discharge water inflow that primarily results from tunnel washing, use of fire suppression systems, and the normal seepage that can be expected with an underground/underwater structure. However, tunnel drainage systems must be designed and equipped to accommodate the potential of a flammable fuel spill. Tunnel drainage systems are typically designed to be independent of inflow from sources outside the tunnel. For example, the open approaches at exit and entrance portals are generally provided with independent stormwater handling systems designed to intercept and prevent stormwater accumulation from entering the tunnel.

3.3.3.2 Design Considerations

The sources of inflow to a tunnel that must be considered are as follows:

- Washdown water - The quantity of water resulting from tunnel washing can vary in the range of 150 to 500 gpm depending on the maintenance equipment used.
- Fire Fighting - Water inflow from a fire-fighting event is predictable based on the code requirement for system availability of 500 gpm.
- Fuel Spill - In the case of a fuel spill, the pumps would be shut down so as to contain the spill within the pump station in order that it may be collected and legally disposed of as hazardous material.
- Bulk Liquid Spill - In the event of a rupture to a bulk liquid tanker, temporary low point flooding can be expected to occur due to the restrictive capacity of the roadway drain inlets. However, based on the assumption that such a scenario will result in an emergency tunnel closure, the pump station would be capable of handling this inflow quantity in the normal fashion.
- Tunnel Seepage - Normal amounts from structural seepage (< 1 gallon/minute/1,000 feet of tunnel) and rainwater carried in by vehicles is negligible to the drainage system design capacity.

Tunnel drainage effluent can be considered to consist of water contaminated with detergents, particulates and minor oily waste that are not legally permitted to be discharged through an open outfall. Therefore, road tunnel drainage discharge is normally connected to a sanitary or industrial wastewater sewer system under special permit to ensure proper treatment.

3.3.3.3 Standards and References

The design of the road tunnel drainage system will conform, as a minimum, to the latest issue of the following standards and references:

*National Fire Protection Association:*
NFPA 502 – Standard for Road Tunnels, Bridges, and Other Limited Access Highways
NFPA 70 – National Electrical Code
NFPA 820 – Fire Protection in Wastewater Treatment and Collection Facilities

*Federal Highway Administration:*
Highway Engineering Circular 12 (HEC 12) - Drainage of Highway Pavements

3.3.3.4 Proposed Tunnel Drainage System Design

3.3.3.4.1 Design Capacity

The proposed tunnel drainage system will be designed to collect, settle and discharge effluent based on a capacity equal to the concurrent operation of two fire standpipe hose valves plus a safety factor equal to the total accumulation of water from a 50-year rain storm with a ten minute duration onto a paved area equivalent to the width of each portal approach roadway over a distance extending twenty five feet from the portal.

3.3.3.4.2 Pumping Station Locations

The profile of the proposed tunnel alignment indicates that the low point for both the eastbound and westbound bores occurs at about the middle of the Main Channel. The physical separation of the eastbound and westbound bores will require that each tunnel have its own independent mid-channel pump station. Both mid-channel low point pump stations will discharge to a settling/surge tank in the proposed tunnel Operations Support Facility on Dodge Island. From here the system will be connected to a local municipal sewer that is legally permitted for industrial waste disposal.

3.3.3.4.3 Collection

The collection system in each tunnel will consist of cast iron grated drop inlets designed for 20 ton (minimum) truck loading and hydraulically spaced to minimize water spread into the travel lanes, and to allow for cleaning between inlets. The drop inlets will connect to a 10-inch (min. diameter) main drainpipe embedded below the roadway slab that will convey all water to the mid-channel pump station. The longitudinal profile of the tunnel allows the collection system to operate by gravity. The minimum super elevated cross-slope of 2-percent requires inlets on only one side of each roadway. Miscellaneous drains from walkway gutters, cross passageways and electrical pull boxes will drain directly to the road surface only when occurring on low side the roadway super elevation. Miscellaneous drains occurring on the high side of the roadway super elevation will be piped directly to the main drain to prevent water from sheeting onto the roadway.

3.3.3.4.4 Primary Settling

At the mid-channel low point pump station, the main drains will empty into a settling basin. The settling basin will be designed to retain any inflow for a minimum of 10 minutes at full design flow condition to allow for sand, grit and heavy particulates to separate and settle before discharge. A bar screen will also be installed in the settling basin to protect the pumps against damage from any large floatable which may enter the system. The settling basin will normally be full. As additional water enters from the roadway drains, the existing water in the basin is displaced through a weir into the pumping wet-well. For maintenance (clean out) purposes, the setting basin will be equipped with a manually operated valve to allow for drain down and clean out.

3.3.3.4.5 Pumps

The wet-well will be equipped with three non-clogging, submersible, centrifugal type pumps. Each pump will be sized for 50 percent of the total pump station capacity. This will ensure full capacity availability should any one pump become unavailable due to planned or unplanned maintenance/repair. The pumps will be automatically operated by float control and the operational sequence will be alternated to equalize run times. As the water displaces from the settling basin and accumulates in the wet-well, the pumps will be started in sequence, based on the water elevation. The pump control system will ensure minimum run time of pumps to prevent frequent cycling. A local control panel will be provided for each mid-channel low point pump station. The local control panels will be housed in a secure, designated room within the tunnel cross-passage located adjacent to the mid-river low point and easily accessible from the walkway. The pump control panel will be linked so as to communicate key operational data/status remotely to the Operations Support Facility.

3.3.3.4.6 System Classification

Since the potential exists for collection of petroleum based fuels and oils within the settling tanks and wet wells, the mid-channel low point pump station, including all components and equipment, shall be designed to comply with the requirements of NFPA and the National Electrical Code for a Class I, Division II type hazard location. Gas-tight closure of all accesses to the wet well and settling basin will be provided.

3.3.3.4.7 Hydrocarbon Monitoring

A hydrocarbon monitoring system within each mid-channel low point pump station will be provided to detect unsafe vapor levels. Should hydrocarbon levels exceed safe values, all pumps will be shut down to ensure against discharge. A ventilation system will be provided to purge both the settling basin and the wet-well to maintain hydrocarbon vapors at safe levels.

3.3.3.4.8 Pump Station Access

Access to the mid-channel low point pump station wet wells and settling basins will be provided through manholes located in the roadway. The manholes will be centered in a travel lane so as to be outside of the normal vehicle wheel track.

3.3.3.4.9 Secondary Settling and Discharge

The mid-channel low point pumps will discharge through 8-inch (min. diameter) force main embedded below the roadway slab. Both pump stations will discharge to a single settling/surge tank arrangement located in a designated room within the tunnel operations facility currently proposed on Dodge Island. At this location additional settling time will be provided and a single set of pumps, similar in capacity and arrangement to the mid-channel low point pump stations, will be used to discharge the tunnel effluent to the permitted municipal sanitary/wastewater sewer system on Dodge Island.

### 3.3.4 Mechanical Systems for Ancillary Facilities

3.3.4.1 Codes and Standards

The design of the mechanical systems will be governed by the applicable local and national codes and standards in effect at the time the design is performed. If the local authorities having jurisdiction (AHJ) establish a more stringent requirement, the more stringent requirement shall apply. The mechanical systems design will be governed by the following codes, standards and regulations:

- Building Officials and Code Administration (BOCA) International
- National Building Code (NBC)
- Occupational Safety and Health Act (OSHA)
- American Society of Heating, Refrigerating and Air Conditioning Engineers, (ASHRAE)
- Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA)
- American National Standard Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- National Fire Protection Association (NFPA)
- American Society of Mechanical Engineers (ASME)
- Air Moving and Control Association (AMCA)

- National Electrical Code (NEC)
- Underwriters Laboratories Standards (UL)
- American Water Work Association (AWWA)

3.3.4.2 Types of Mechanical Systems

The design of the ancillary facilities will require various types of mechanical systems to provide an appropriate and safe environment for the various types of functional spaces within the facility. The requirements and standards for mechanical systems will include the following:

A. Heating Ventilating, and Air Conditioning (HVAC)

   The following outdoor design conditions will be used, based on the Climatic Design Information provided by ASHRAE Handbook, Fundamentals, 2001 Edition, for the Miami International Airport, assuming 0.4% summer and 99.6% winter, annual cumulative frequency of occurrence:

   - Summer: 91F dry bulb (db), 77F wet bulb (wb)
   - Winter: 46F db

   Specific indoor temperatures will be established after the facility occupancy criteria (equipment and personnel) is determined. Various HVAC equipment will be provided, such as air supply and exhaust fans, air conditioning units of various types, heating units (either electric or hot water), humidifiers or dehumidifiers, as required. An air distribution system consisting of sheet metal ducts, dampers, grilles, registers and diffusers will be provided.

B. Plumbing and Drainage

   The plumbing and drainage systems for the ancillary buildings will include water service, domestic hot and cold water, fuel (oil or gas as applicable), sanitary and storm drainage, as necessary.

   Water service for the buildings will be connected to the nearest municipal water main. The connecting pipe will be sized based on the peak water demand of the plumbing fixtures and heating boiler if provided. Water meters and/or reduced pressure backflow preventers will be provided as required.

   Hot and cold water will be supplied to various plumbing fixtures located within the buildings as necessary. The hot water will be provided by a domestic hot water tank.

   Fuel oil or gas may be required if a boiler is used. Natural gas is preferred for the heating system. If gas service is not available, fuel oil may be used for building and domestic water heating.

   Sanitary drainage will be provided for the plumbing fixtures and will be sized and installed in accordance with the code requirements. The sanitary drainage, including floor drainage will discharge by gravity to the city sanitary or combined sewer system. If the sanitary drains are located below the elevation of the city sewer main, a sewage ejector would be provided.

Storm drainage will be provided to drain ancillary building roofs as necessary. The roof drains will be connected into the city storm drainage or combined sewer main. Should the drains be located below the city main, a sump pit and pumps will be required.

C. Fire Protection

The Fire Protection system design for the ancillary buildings will be based on the applicable NFPA standards and in accordance with the requirement of the local authorities having jurisdiction. The ancillary facility sprinkler and standpipe systems and/or portable fire extinguishers will be provided based on the type of area to be protected and occupancy. Note that sprinkler systems may be required for ancillary facility buildings only, and are not applicable to be included within tunnels, which however will be required to have a standpipe system.

Water for the systems operation will be provided by the city water supply main. A hydrant flow test will be required to determine the flow and pressure capacity of the main supply line. In the unlikely event that the city water supply is not adequate, a fire pump may be required.

## 3.4 Electrical Systems Design

### 3.4.1 Lighting

3.4.1.1 Purpose

The purpose of the lighting system is to provide an approaching motorist adequate contrast to perceive hazards within the tunnel, as well as sufficient illumination to maintain a consistent traffic flow throughout the tunnel. During daylight hours, a driver’s visual adapted state is such that the tunnel interior can appear like a “black hole”, and hence, obstructions within the portal effectively become invisible. High levels of artificial lighting are typically required to compensate for these ambient daytime threshold conditions and the driver’s visual adapted state. In order to minimize the costs associated with installing and maintaining these systems, careful analysis is required of each tunnel’s physical features, orientation, construction, and operational requirements. There are various approaches for providing the required illumination which need to be evaluated, with due consideration for visual performance, driver safety, and both initial capital and life cycle costs.

3.4.1.2 Design Criteria

The following series of standards will be utilized to ensure that the current design practices for tunnel lighting and approach lighting systems are followed:

- ANSI/IESNA RP-22-96, American National Standard Institute/ Illuminating Engineering Society of North America, American National Standard Practice for Tunnel Lighting.
- ANSI/IESNA RP-8-00, American National Standard Institute/ Illuminating Engineering Society of North America, American National Standard Practice for Roadway Lighting.
- CIE 88, International Commission on Illumination, Guide for the Lighting of Road Tunnels
- AASHTO Informational Guide for Roadway Lighting – 1984, American Association of State Highway and Transportation Officials

- ANSI/NFPA-502, American National Standard Institute/National Fire Protection Association, Standard for Road Tunnels, Bridges, and Other Limited Access Highways – 2002
- NFPA 70, National Electrical Code (NEC)
- UL, Underwriters Laboratories Standards, UL Listing

3.4.1.3 Determination of Lighting Levels

Typical tunnel lighting design practice utilizes ANSI/IES RP-22-96, American National Standard Practice for Tunnel Lighting, which divides a tunnel into four separate adaptation zones plus an exit zone.


**Figure 3-5. Tunnel Lighting Zones**

The geometry of these zones and their associated lighting levels are based on the design criteria, and reference the dark adaptation rate of the human eye. These zones are the Approach Zone, the Threshold Zone, Transitions Zone(s), the Interior Zone, and the Exit Zone. (NOTE: Different luminance levels are used for the Interior Zone during daytime and nighttime operations.) The Exit Zone, like the Approach Zone, extends nominally one Safe Sight Stopping Distance (SSSD), beyond the portal.

The length of each zone and the associated lighting requirements vary with the SSSD, the exterior daylight conditions, and the driver’s current adapted visual state. The required pavement luminance in each zone also depends on the reflectance of the materials used for both the road and tunnel. For example, by using darker finishes for the boat walls and portal facades, the lower the luminance requirement. In addition, if a more reflective (whiter), more diffuse (less specular) roadway surface is used, such as Portland cement concrete, fewer fixtures would be required to provide the required luminance level.

3.4.1.3.1 Approach Zone

The Approach Zone is the area of open road immediately prior to the tunnel entry portal. The length of this zone is nominally one Safe Sight Stopping Distance (SSSD). Here, the phenomenon of pre-adaptation occurs. As the portal increasingly fills more of the field of view, the driver’s eye begins to adapt from the luminance of the wider general view to the significantly lower luminance within the approaching threshold. The International Commission on Illumination (CIE) recommendation for this distance at which pre-adaptation occurs is when the portal occupies more than 40% of a driver's vision.

For nighttime conditions, ANSI/IES RP-22-96 (American National Standard Practice for Tunnel Lighting) requires a pavement luminance on both the Approach and Exit roadways, of at least one-third of the pavement luminance level within the tunnel. Based on an assumed nighttime interior tunnel lighting level of 2.5 candelas per square meter (cd/m$^2$), both roadways should be illuminated to provide a minimum average maintained pavement luminance of 0.9 cd/m$^2$.

3.4.1.3.2 Threshold Zone

The required values for pavement luminance ($L_{th}$) in the Threshold Zones are dependent on the posted or design speed, orientation of the tunnel, pavement type, the ambient daylight conditions, and most importantly, the visual environment immediately adjacent to the tunnel portal. Current standard practice provides two methods for determining this value.

The first, which has been used for this preliminary design, is the method which allows the designer to obtain a preliminary luminance value ($L_{th}$) by using Table 3 in RP-22-96, with appropriate references to Figure 3 and Table 2 in RP-22-96. For example, an east-west tunnel, with a visual field similar to urban tunnel, and a posted speed of 40 mph, the threshold luminance would be designed to 200-230 cd/$m^2$, using a Safety Rating Number (SRN), of 4.7.

The second method calculates the threshold luminance ($L_{th}$) based on using the Equivalent Veiling Luminance ($L_{SEQ}$) procedure included in Annex B of RP-22-96. The emphasis behind the $L_{SEQ}$ process is to use the measured (or anticipated) surface luminance(s) to average the approach surface luminance, and to identify a relationship between the average approach luminance and the required threshold luminance.

During the final design process, once the final portal designs are completed, a complete $L_{SEQ}$ evaluation will be required.

3.4.1.3.3 Transition Zones

The transition from the end of the threshold zone to the beginning of the interior zone requires that the luminance level is limited to one third of the previous zone. Since the Illuminating Engineer Society of North America (IESNA) curve will be used, light will be transitioned gradually in order to reduce the number of fixtures. This method aids in using fewer fixtures and steadily reduces the luminance level at a more rapid rate.

Transition Zones continue the adaptation process from the bright Threshold Zone to the relatively darker conditions in the Interior Zone. Depending on the number of transitions required, each zone is approximately one third of a SSSD in length, and the light levels are allowed to drop to approximately 1/3 of those in the preceding zone. Generally, the last luminance step between Transition Zone Three and the Interior Zone is limited to 2 to 1. Given the starting exterior levels, and the length of each tunnel, we anticipate the need for three full Transition Zones, in addition to the Threshold Zone, for each tunnel.

3.4.1.3.4 Interior Zone (Day & Night)

The interior luminance level of the tunnel is based upon the speed and volume of traffic within the tunnel. Table 4 from RP-22-96 indicates the interior level for the Port of Miami Tunnel should be 6-8 cd/$m^2$ during the day, with levels during nighttime operation being reduced to 2.5 cd/$m^2$.

3.4.1.4 System Considerations

A combination of both linear fluorescent and High Intensity Discharge (HID) point sources are proposed for use in the Port of Miami Tunnel. Linear fluorescent offers very high uniformity, excellent optical guidance, minimal flicker effects, white light, and good performance. Point sources, which are available in both the white light of Metal Halide and the yellow/orange light of High Pressure Sodium (HPS), offer very high system efficacy and excellent lamp life. As the design proceeds, the specific luminaires to be used will be specified appropriately to ensure that the luminaires provide the necessary illumination while physically staying outside the dynamic traffic envelope.

3.4.1.4.1 Design Considerations for Luminaire Maintenance

A tunnel atmosphere is normally dirty, infrequently cleaned, and highly corrosive. Repairs and maintenance occur at non-peak hours in a closed travel lane. Workers must labor for prolonged periods, working overhead and exposed to oncoming traffic.

Dirt depreciation of the luminaire and the tunnel surfaces combined, reduce the design light output by nominally 25 to 35%. Theoretically one quarter of the fixtures in the tunnel are needed simply to make up for the eventual decrease due to road grime, salt and diesel exhaust. A periodic cleaning of the tunnel by high pressure wash down at 100 psi is recommended at least twice a year. The luminaires should be internally cleaned as lamps are replaced, with an inspection of seals/gaskets no less than once every two years. These measures will increase the light output dramatically, particularly towards the end of lamp life.

Routine maintenance for burned out lamps and failed ballasts can be accounted for in readily accessible luminaire components. Tool-less entry, readily removable ballasts and lamp holders, quick release connections, and interchangeable housings are minimum requirements for maintenance. All electrical connections should be made in the maintenance shop, and via quick connect/disconnect plugs in the field.

3.4.1.4.2 Controls

The ambient light level varies hour-by-hour, day-to-day, throughout the year, and is dependent upon inclement weather, where cloudy days are significantly darker than clear sunny ones. Proper control of the threshold lighting can take advantage of these lower adaptation requirements by reducing energy consumption. The most effective way to control the lighting within the tunnel is through use of luminance meters located outside the tunnel that view the portal area. This type of meter will give the best indication of driver's adaptation, and therefore more effectively control the tunnel lighting.

The luminaires within the tunnel will be switched on or off in steps, depending on the ambient levels.

3.4.1.5 Design Requirements

3.4.1.5.1 Lighting System

The Port of Miami Tunnel should be provided with a tunnel lighting system, controlled by a luminance based control system which provides threshold, interior, and night levels as indicated in this report.

3.4.1.5.2 Lighting Fixtures

Based upon the design criteria, geometry, initial visibility analysis and internal discussion, a linear lighting system for the daytime and nighttime interior illumination levels is proposed. This base utilizes continuous rows of pendant mounted symmetrically distributing fluorescent fixtures, supplemented with point source high intensity discharge (HID) fixtures in the Threshold Zone.

During the design process, the actual placement for the luminaires will be determined in order to ensure that the luminaires remain outside the dynamic vehicular envelope, provide a clean organized line of guidance through the tunnel, and most importantly, the required illumination levels.

The proposed fluorescent fixtures have multi lamp cross sections that include both T8 32 Watt lamps and T5HO 54 Watt lamps. The Port of Miami tunnels will utilize a row of fluorescent luminaires that are mounted on both sides of the tunnel. These rows of luminaires will be continuous throughout the Threshold, Transitions and Interiors zones of the tunnel. A single row of T8's shall be used for night interior levels, supplemented with a second row of T8's for the day interior levels. Other configurations consist of the following: Ttwo rows of T8's with two rows of T5's, and one row of T8's with four4 rows of T5's will be used in the Threshold and Transition zones. In addition to the fluorescent, single lamp high pressure sodium (HPS) fixtures will be used to supplement the fluorescent fixtures in the Threshold and Transition Zones.

3.4.1.6 Emergency Lighting

3.4.1.6.1 Roadway Tunnel

Approximately every fourth fluorescent lighting fixture will be supplied from an Uninterruptible Power Supply (UPS) which will provide critical emergency and egress lighting.

Egress doors, fire hose cabinets and emergency phones will be clearly delineated with local lighting, strobes, and/or light emitting diode (LED) type markers to maximize visibility of the safety systems under both normal and emergency conditions, and to facilitate easy access by users, staff, and emergency personnel.

3.4.1.6.2 Ancillary Spaces

In accordance with NFPA 70, a portion of the general lighting will be supplied from the emergency power source to provide continuous work light in all critical areas supporting emergency operations. This could include, but not be limited to the cross passageways, emergency egress passageways, control room, electrical equipment and communications rooms, and pump rooms.

### 3.4.2 Electrical Power Distribution

3.4.2.1 Standards and References

Electrical systems design will conform to the latest issues of the following standards and references:

| | |
|---|---|
| NFPA | National Fire Protection Association<br>NFPA 502 – Standard of Road Tunnels, Bridges, and Other Limited Access Highways<br>NFPA 70 – National Electrical Code (NEC) |
| UL | Underwriters Laboratories Standards, UL Listing |

3.4.2.2 Electrical Service

NFPA 502 requires that reliable power be provided for many of the tunnel systems. This requirement is satisfied by providing a primary and a secondary or back-up power source. Therefore, the electrical design for the project is predicated upon two supply feeders, each supplying a double-ended unit substation, one at each end of the tunnel. The roadway tunnel area lies within the service area of Florida Power & Light (FPL). It will be required to discuss with FPL their ability to provide power feeders of sufficient capacity to project electrical substations at each end of the tunnel alignment. The utility system configuration will be reviewed to verify that a single event within the utility system cannot affect both the primary and secondary sources. The assumption for the balance of this report is that primary and secondary power sources will be available.

3.4.2.3 Power Distribution

Each utility company service feeder will terminate in a fused disconnect switch, which in turn will supply a 15 kV-480GndY/ 277V dry type transformer. Each transformer will then supply one end of a double-ended 480GndY/277V distribution section. The transformers will be indoor, K rated, cast coil type. Additional dry-type transformers will provide 208/120V power for receptacles, and 480V/277V power for certain special systems, as required. The unit substations will serve the power requirements of the tunnel lighting system, exterior roadway lighting system, supervisory control and data acquisition system (SCADA), communication, traffic surveillance and control systems, miscellaneous lighting and power, tunnel ventilation fans, and mechanical and electrical systems for the tunnel ancillary areas.

Upon loss of either utility service power source, normal loads will be interrupted momentarily while the automatic throw-over to the alternate source occurs. Designated critical loads will remain in service even with the loss of a service feeder. These loads will be served through an uninterruptible power supply (UPS) for short outages. A standby generator will supply the UPS system during extended outages.

The following scenario will be used to determine the demand loads for the facility that, in turn, will be used to determine the preliminary equipment ratings. These loads will be utilized to determine physical sizes of the equipment, which in turn, will dictate the amount of space required. The worst case loading scenario is driven by the tunnel ventilation fans, assuming a fire in one of the bores. This would require all fans in that bore to operate. In addition, it is assumed that 10% of the capacity of the tunnel fans in the other bore will be used simultaneously for Carbon Monoxide (CO) control. Further, the tunnel lighting system load for this scenario will be configured for time of day operation at morning, near the summer solstice. This would require the maximum lighting level in the threshold and, consequently, in the transition zones.

3.4.2.4 Standby Power Systems

The combination of two independent supply feeders in conjunction with an UPS satisfies NFPA 502 and would normally preclude the need for a standby generator. However, due to the criticality of certain loads during severe weather conditions when the probability of total loss of utility power is increased, a standby generator will be provided. If a total utility power failure were to occur, the flood gate motors, storm water pumps and tunnel drainage pumps would be picked up by the standby generator. The loads supplied by the UPS (e.g. emergency tunnel lighting, Closed Circuit Television (CCTV), Variable Message Signs (VMS) and Lane Usage Signals (LUS) systems, fire alarm, security) would allow for an orderly shut down of traffic operations, if necessary.

The diesel powered standby generator will be located at the Operations Support Facility. The standby generator will be installed indoors to minimize possible interruptions to the back-up service at the facility. The diesel fuel storage reserve will be sized to allow operation for 24 hours or more before required refueling. If the generator fails to start, the UPS System will be sized to provide power to the critical loads for fifteen minutes.

3.4.2.5 Panelboards

Distribution, power, and lighting panelboards will be of the bolt-on circuit breaker type. Panelboards will be sized to withstand available short circuit current. Each panelboard will be equipped with a minimum of 20 percent spare breakers and 10 percent spaces.

3.4.2.6 Conduit, Wire and Cable

Rigid, hot-dip galvanized steel conduit will be used for all exposed work. Rigid, hot-dip galvanized steel conduit will also be embedded in slabs where subjected to high impact. The 15kV raceway in the roadways will be rigid, hot-dip galvanized steel conduit.

Nonmetallic (fiberglass) conduit will be embedded in the tunnel walkways. Nonmetallic (fiberglass) conduit will be used only for embedment or in ductbanks.

PVC conduit shall not be used anywhere on this project.

Flexible liquid-tight conduit will be used for final connection to all motors.

Minimum size conduit used throughout the project will be ¾" for exposed and, 1" for all embedded installations.

All raceways will have 20 percent spare conduit capacity.

All conductors will be copper. Minimum conductor size will be #12 AWG for power and lighting branch circuits. Underground medium voltage service conductor insulation will be ethylene-propylene-rubber (EPR), 15kV class, with 133 percent insulation level, shielded, with outer jacket. Conductor insulation for power, lighting and communication systems will be RHH/RHW rated, 600 volt, 75 degrees C wet, 90 degrees C dry. Conductors #10 AWG and smaller will be solid and # 8 AWG and larger will be stranded.

3.4.2.7 Voltage Drop

The maximum voltage drop on both feeders and branch circuits to the farthest outlet of a load will not exceed five percent. Feeder and branch circuits will be designed so that a maximum of three percent voltage drop occurs from the panelboard to the center of the connected load and two percent voltage drop in the feeders to the panelboard.

The voltage drop at motor terminals during starting will not exceed 10 percent.

3.4.2.8 Grounding

Service and equipment grounding will be in accordance with the National Electric Code (NEC) and the National Electrical Safety Code requirements. All metallic non-current carrying parts of electrical equipment, devices, panelboards, and metallic raceways, will be connected to the equipment grounding system.

A service grounding system grid will be provided adjacent to the incoming service transformers and will be coordinated with the requirements of Florida Power & Light (FPL) and IEEE 80, as required. Separate grounding conductors will be installed in raceways for lighting and power feeders, and all branch circuits.

The neutrals of transformer secondaries will be solidly grounded.

3.4.2.9 Motor Protection and Control

Each motor for tunnel ventilation, pumping station, and environmental conditioning equipment will be provided with a controller and devices that will protect the equipment and perform the function required.

All motors, except for the tunnel roadway ventilation system, will have thermal overload protection in ungrounded phases. Overloads will be sized in accordance with the NEC. Full voltage starting will be utilized for motors rated less than 60 HP. Reduced voltage, or soft start, as required by application, will be utilized for motors rated 60 HP and above.

- Tunnel roadway ventilation fans will be provided with magnetic overload relays.
- Motor control circuits will operate at 120 Volts AC.

Circuitry for both power and control of the tunnel roadway ventilation fans will consist of fireproofed rigid galvanized steel conduits, enclosing copper conductors as described earlier. In keeping with the fireproof scheme for the ventilation fans, Service Disconnect Switches will not be employed at the individual fan locations. Before work can proceed on a particular fan, its corresponding supply circuit breaker at the substation will be required to be opened, locked-open, and tagged open, following approved tagging procedures.

3.4.2.10 Lighting Circuitry

The main run circuitry for the tunnel lighting system will be enclosed within fireproofed rigid galvanized steel conduits. In addition, the luminaires within any tunnel cross section will be supplied from multiple circuits running on both sides of the individual tunnel bores. Approximately every fourth luminaire will be supplied from a separate emergency conduit system, with an Uninterruptible Power Supply (UPS) as the source.

### 3.4.3 Communication Systems

3.4.3.1 General

The communication systems will be designed to provide voice, video and data communications from the tunnel and ancillary spaces to the local onsite operations control room located in the Operations Support Facility and the remotely located operations control room.

The design of the communication systems will include the following:

- Telephone
- Emergency Telephone System (Within Motorists Aid Cabinets)
- Closed Circuit Television (CCTV)

- Two-way FM Radio Communications
- AM/FM/HAR (Highway Advisory Radio) radio rebroadcast
- Supervisory Control and Data Acquisition System (SCADA) - Data communication between field equipment (traffic surveillance and control, mechanical and electrical equipment) and both the local and remote operations control rooms. See Section 3.5.2 of this Design Basis Report for a description of the Operations Control Rooms.

Additionally, outside service provider voice, video and data services, as required, will be provided by the local telecommunications company. The service provider demarcation point will be in the communications room, located within one of the substation areas, or in a separate dedicated demarcation closet. It is anticipated that only voice and data service will be required to support "outside" voice telephone lines, and data subscriber service lines to support FDOT's Wide Area Network (WAN) data links.

3.4.3.2 Telephone System

The telephone system will consist of local instruments strategically located throughout the facility, for internal communication between maintenance personnel and remote FDOT offices, and designated response agencies. Dedicated telephone extensions will be provided to designated emergency response agencies as required.

3.4.3.3 Emergency Telephones

Emergency telephones will be located within cabinets which will be provided at each fire standpipe location in the tunnel, and along the open approach roadway, approximately 500 feet outside of each portal. Within the tunnel system, the emergency telephones will be grouped with other life safety systems such as fire alarm pull stations, fire extinguishers and hose valve stations. Each emergency telephone instrument will automatically ring down to a console in both the local and remote operations control rooms. Telephone instruments will be hands-free and Americans with Disabilities Act (ADA) compliant.

3.4.3.4 Closed Circuit Television (CCTV)

The CCTV system will be utilized for security purposes relative to the tunnels proper, the portal areas, ancillary areas, and the substation/control room areas. It will also function as a part of the traffic surveillance system. In addition, the CCTV system will be used to monitor the tunnels for evidence of fire, providing one of the means required by NFPA 502 to detect, identify or locate a fire in the tunnels.

This system will provide complete coverage of the interior of the tunnel and approach roadways. Display monitors will be located at both local and remote operations control rooms. The display monitors will be interconnected with emergency telephones, and manual fire alarm pull stations, so that they would automatically provide a view of the location on the "spot" monitor from where an emergency signal has originated. Digital video recorders with storage servers will be provided for the capture and storage of all video for incident documentation and investigations. Cameras will also be placed around the portal areas and in the ancillary areas, for security purposes.

### 3.4.3.5 Two-Way FM Radio Communication Systems

A two-way FM radio communications system will be provided for continuous radio communication for FDOT maintenance personnel while traveling through or working at the tunnel, as well as certain selected agency frequencies such as police, fire department and Emergency Medical Services (EMS). Frequency requirements, cable type and head end equipment requirements will be coordinated with users and agencies. The system will receive externally generated radio signals at the respective existing agency's frequency and re-transmit them inside the tunnel. It will also receive signals generated within the tunnel and re-transmit them to the respective existing agency radio transmission network. The transmission will be via antenna and receiving/transmitting equipment located at the Operations Support Facility. The system will permit unrestricted two-way communications for FDOT and other respective agency personnel during normal and emergency conditions within the tunnel. The system will provide two-way communication using hand-held transceivers or vehicle mobile radios.

### 3.4.3.6 AM/FM/HAR (Highway Advisory Radio) Radio Rebroadcast System

An AM-FM radio rebroadcast system will be provided to receive local AM and FM commercial radio broadcasts and re-transmit them within the tunnel. The control room operators will have the capability to interrupt these re-transmitted broadcasts with emergency information, including instructions for motorist egress during an incident, or instructions to turn off engines during an incident for those vehicles inside the tunnel. Variable Message Signs (VMS) located in the tunnel can be used instead of, or in addition to, the AM-FM HAR (Highway Advisory Radio) radio rebroadcast system. Fixed dedicated messages can be developed to allow control room operators to pass information to motorists in the tunnels.

### 3.4.3.7 Dedicated Short Range Communications (DSRC)

Dedicated Short Range Communications (DSRC) is a general purpose radio frequency that provides a vehicle to roadside communications link. DSRC provides the communications link between an onboard vehicle transponder and roadside equipment consisting of a wireless communication antenna, the antenna controller and a vehicle detector sensor. The communication takes place with onboard equipment reflecting the radio waves being emitted from the roadside antenna and equipment. The criteria for this system are described in Section 3.5.7 of this Design Basis Report.

### 3.4.3.8 Supervisory Control and Data Acquisition (SCADA) System

The SCADA System will provide the monitoring and control of electrical and mechanical equipment, including tunnel fans, drainage pumps, main switchboard, UPS system, electrical room, fire detection and alarm systems, CCTV system, VMS system, and Lane Use Signals (LUS) system. The SCADA System will bring all video and data signals to the facility console located at the local operations control room, and will also transmit them to the remote operations control room. Under normal conditions, all data will be collected and evaluated at the local operations control room. The data processing and control commands will also be executed at this location. The control room operators will have the ability to monitor system performance. All alarms will be immediately transmitted to the operations control rooms where the operators will have the capability to implement corrective action or notify response personnel. At both the local and remote operations control rooms, three workstations will provide coverage: one will be dedicated for the shift supervisor's use; one will serve as the primary operator's workstation; and the remaining one used for a backup workstation.

Flat panel LCD (Liquid Crystal Display) monitors will be provided for the systems at both local and remote operations control rooms.

Starting of the tunnel jet fans for smoke control and life safety system commands will require operator intervention.

### 3.4.4 Fire Detection and Alarm Systems

3.4.4.1 Standards and References

Fire detection and alarm systems design will conform to the latest issues of the following standards and references:

| | |
|---|---|
| NFPA | National Fire Protection Association<br>NFPA 502 – Standard of Road Tunnels, Bridges, and Other Limited Access Highways |
| | NFPA 70 – National Electrical Code (NEC) |
| | NFPA 72 – National Fire Alarm Code |
| | NFPA 101 – Life Safety Code |
| UL | Underwriters Laboratories Standards, UL Listing |

3.4.4.2 Tunnel

Manual fire alarm pull stations within the tunnels will be mounted alongside each fire standpipe hose valve cabinet location within the tunnels, and will be supervised by the Fire Alarm Control Panel (FACP) located in the Operations Support Facility. Pull stations will also be provided in ancillary areas. The SCADA System will transmit a fire alarm signal to the local and remote operations control rooms. The control room operators will contact the local fire department or designated emergency response agency. This system will be interconnected with the CCTV for visual confirmation of the alarm. The manual fire alarm pull stations provide the second means required by NFPA 502 to detect, identify or locate a fire in the tunnels.

Linear heat detectors will not be provided.

The monitoring of alarm status and control of support equipment/devices will be accomplished at the local and remote operations control rooms through the SCADA system. See Section 3.5.2 of this Design Basis Report for a description of the Operations Control Rooms.

The FACP and control room graphic screens will display the location or zone of an activated fire alarm or manual fire alarm pull station.

3.4.4.3 Ancillary Buildings and Tunnel Cross Passageways

An electronically supervised, zoned, fire detection and alarm system will be installed in the Operations Support Facility, other ancillary structures and the tunnel cross passageways. This system will consist of the Fire Alarm Control Panel, manual pull stations, ionization, smoke, and heat detectors, sprinkler water flow switches, standpipe flow switches, bells, and horns.

The monitoring of alarm status and control of support equipment/devices will be accomplished at the local and remote operations control rooms through the SCADA system.

The FACP and control room graphic screens will display the location or zone of an activated fire alarm or manual fire alarm pull station.

3.4.4.4 Intrusion Detection and Access Control

The purpose of the system is to provide detection of unauthorized access to tunnel facilities and ancillary spaces, and to control access to secure site facilities. All access doors will be provided with magnetic contacts, electro-magnetic locks, and card readers, to limit access to only authorized personnel. Entry doors to the Operations Support Facility and other ancillary areas will also be provided with CCTV camera coverage to allow operators to identify personnel attempting access. CCTV cameras will also be configured to provide building perimeter surveillance and coverage of the tunnel portals. Inside the tunnels, the cabinets containing the motorist emergency telephone, fire extinguisher and fire standpipe connection will be provided with magnetic door switches that shall alarm the system when the cabinet door is opened. Furthermore, access into the substations, control room, pumps stations, etc., will also be monitored for intrusion.

The system will interface with the SCADA system.

### 3.4.5 Electrical Systems for Ancillary Facilities

3.4.5.1 Codes and Standards

The design of the electrical systems will be governed by the applicable local and national codes and standards in effect at the time the design is performed. If the local authorities having jurisdiction (AHJ) establish a more stringent requirement, the more stringent requirement shall apply.

The electrical systems design will be governed by the following codes, standards and regulations:

- Building Officials and Code Administration (BOCA) International
- National Building Code (NBC)
- Occupational Safety and Health Act (OSHA)
- American Society of Heating, Refrigerating and Air Conditioning Engineers, (ASHRAE)
- Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)
- American National Standard Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- National Fire Protection Association (NFPA)
- American Society of Mechanical Engineers (ASME)
- Air Moving and Control Association (AMCA)
- National Electrical Code (NEC)
- Underwriters Laboratories Standards (UL)
- American Water Work Association (AWWA)
- National Electrical Safety Code (NESC)
- Institute of Electrical and Electronic Engineers (IEEE)

3.4.5.2 Types of Electrical Systems

The electrical systems to be included for the ancillary facilities consist of the necessary power to serve all mechanical loads, as well as convenience outlets, lighting, and special systems such as fire alarm and detection, intrusion/security/access control, communication, and lightning protection if deemed necessary. The system design for all will be in accordance with the codes and standards listed in the following sections of this Design Basis Report: Section 3.2 - Architectural Design, Section 3.3 - Mechanical Systems Design, and Section 3.4 - Electrical Systems Design.

## 3.5 Traffic Surveillance and Control Systems (TSCS)

### 3.5.1 Introduction

The Traffic Surveillance and Control System (TSCS) will consist of the hardware and software necessary to monitor and control traffic and improve the safety and quality of traffic flow by preventing or relieving congestion. The primary functions of the system are to provide:

- Efficient movement of traffic on and around the Port of Miami Tunnel roadways.
- Early detection of traffic incidents that cause slowdowns and/or blockages using video based incident detection.
- Motorist alerts to incidents by means of variable message signs (VMS), highway advisory radio (HAR), and AM/FM Override.
- Systematic lane control for shifting, or redirecting, traffic through the roadways and tunnels by means of lane use signals (LUS) and VMS.
- Continuous monitoring and logging of traffic conditions using Toll Tag Transponders and Dedicated Short Range Communications (DSRC) devices.
- Communications with emergency services such as fire, police, and first aid.
- Visual traffic monitoring by means of a closed circuit television system (CCTV)
- Improved uniformity and stability of traffic flow, thereby forestalling the onset of congestion
- Reduced potential for rear-end collisions in areas of poor sight distance if congestion is present
- Diversion of freeway traffic to alternate routes to maximize roadway through-put and utilization of total freeway capacity

The principal benefits of the TSCS are enhanced motorist safety, reduced incident response and clearance time, and efficient use of available roadway capacity. The TSCS allows response procedures and strategies to be developed in advance to deal safely with various traffic operations and environmental conditions that will occur. Some of these conditions are reoccurring such as peak hour traffic congestion; some are non-reoccurring, such as accidents. Continuous monitoring of traffic and environmental conditions allows significant changes to be identified and the appropriate pre-planned response (i.e. strategy) to be initiated in a timely manner to reduce the severity of the traffic congestion and help mitigate the impact to motorists.

#### 3.5.1.1 Design Considerations

The generally recognized standard is to detect, verify and respond to the incident site on average within five (5) minutes. The TSCS will be designed around this five (5) minute detect and response time policy. The TSCS will minimize the time required to detect an incident, notify appropriate responders, and for those responders to arrive at the scene of the incident. This quick detection and on-scene response will mitigate motorists exposure to vehicle pollutants such as carbon monoxide and allow the roadway to return to normal operation as soon as possible.

To facilitate this policy, the TSCS will:

- Gather real time data and video images from surveillance devices and sensors throughout the Port of Miami tunnels and roadways.
- Process gathered data for the purpose of providing notification, coordinating response and supplying event information.
- Control of all TSCS devices in a coordinated fashion, to provide safe and reliable operations and maximize roadway efficiency.

Although the TSCS will contain a vast array of traffic surveillance and control devices and many automated functions, the key component of the TSCS is the Control Room Operator. The TSCS is designed to present information to the Control Room Operator. The Control Room Operator will be responsible for monitoring all the tunnel and approach roadways, TSCS and facility device alarms and for notifying appropriate response personnel in a timely manner.

#### 3.5.1.2 Design Codes and Standards

The design of the TSCS will conform to applicable Florida Department of Transportation guidelines and standards that have been developed for Intelligent Transportation Systems (ITS). As these continue to be advanced, the design will adhere to the most current version of guidelines and standards adopted by FDOT. Minimum specifications and standard drawings for ITS devices and are currently being developed by FDOT. When finalized this information will be provided to the FDOT Specifications Office for inclusion within the *FDOT Standard Specifications for Road and Bridge Construction* and *Design Standards* publication. As applicable, the design will also adhere to the *Minimum Specifications for Traffic Control Signal Devices*.

The design of the TSCS will conform to the following guidelines as established by FDOT:

- Florida's Statewide Intelligent Transportation System Architecture and Standards (SITSA)
- Guidelines for the Implementation of Part 940 in Florida
- Districts 4 and 6 Regional ITS Architecture and Standards

Florida guidelines and standards have been prepared to comply with the *Federal Register, Part IV, 23 CFR Parts 655 and 940, Federal Highway Administration – Intelligent Transportation System Architecture and Standards*. The *National Architecture, Version 5.1* is available through USDOT and provides a common framework for planning, defining, and integrating intelligent transportation systems.

The following Standards Development Organizations (SDO) participate in ITS standards activities:

- AASHTO (American Association of State Highway and Transportation Officials)
- ANSI (American National Standards Institute)
- ASTM (American Society for Testing and Materials)
- IEEE (Institute of Electrical and Electronics Engineers)
- ITE (Institute of Transportation Engineers)
- NEMA (National Electrical Manufacturers Association)
- SAE (Society of Automotive Engineers)

Table 3-3 provides a list of ITS standard development organizations as well as some of the specific ITS standards efforts being advanced.

**Table 3-3. ITS Standard Development Organizations**

| **Standard Development Organizations** | **Applicable Interfaces in the National ITS Architecture** | **ITS Standards** |
|---|---|---|
| AASHTO, ITE NEMA | Traffic Management Center to other Centers | National Transportation Communications for ITS Protocol Protocol (NTCIP) |
| | Traffic Management Center to Field Devices | |
| | Transit Center to other Centers and Vehicles | |
| ANSI | Commercial Vehicle Operations (CVO) related system interfaces | Commercial Vehicle Information Systems Network (CVISN) |
| ASTM | Archived Data Management Center Interfaces | Archived Data |
| ASTM,IEEE | Vehicle to Vehicle; Vehicle to Roadside | Dedicated Short Range Communications (DSRC) |
| IEEE | Emergency Management Center to other Centers | Incident Management |
| EIA/CEA | Information Service Provider radio broadcast to mobile users | Mobile Interfaces |
| ITE | Traffic Management Center to other Centers | Traffic Management (TMDD and Controller (ATC) |
| | Roadside Signal Controllers | Advanced Transportation Controller (ATC) |
| SAE | Traveler Information (Information Service Provider interfaces) | Advanced Traveler Information Systems (ATIS) |
| | Location Referencing | |
| | Vehicle interfaces | ITS Data Bus |

#### 3.5.1.3 Concept of Operations

The TSCS will consist of the following sub-systems:

- Fixed Signs
- Closed Circuit Television (CCTV)
- Lane Use Signals (LUS)
- Variable Message Signs (VMS)
- Overheight Vehicle Detection System (OHVD)
- Dedicated Short-Range Communications System (DSRC)
- Portal Traffic Signals (PTS)
- Operations Control Rooms
  - Remotely Located (main control room)
  - Local Onsite (backup control room)
- Radio Communications

Each sub-system performs a vital monitoring or control function that, when deployed in a coordinated fashion can significantly improve the traffic flow conditions on the roadway and facilitate quick incident response criteria. The Control Room Operator will interact with each sub-system via a centralized computer system that will integrate these elements into a single unified system. This integrated system will provide all monitoring and control functions that are necessary for the operation of the tunnel roadway network. All TSCS system components will be monitored for various status and diagnostic indications by the TSCS computer system. The system will notify the Control Room Operator when a component has malfunctioned or otherwise become unavailable.

The first step in the TSCS design process is to develop a Concept of Operations plan. This plan will serve as the foundation and starting point, for the systems engineering process. The major emphasis behind developing the concept of operations is:

- The identification of system stakeholders as well as the assurance that they will communicate in a common forum and format relative to the system in question;
- The formulation and documentation of a high-level system definition relative to the system in question;
- The foundation for all lower-level sub-system descriptions;
- The definition of all major user group and activities.

The primary elements of the concept of operations document are:

- Scope
- Referenced Documents
- User-Orientated Operational Description
- Operational Needs
- System Overview
- Operational and Support Environments

- Operational Scenarios

Some of these elements are preliminarily addressed in this design basis report. As the preliminary design is advanced, the concept of operations document will be advanced to insure that TSCS design meets the operational needs of all project stakeholders.

### 3.5.2 Operations Control Rooms

The Port of Miami operations control rooms provide locations from where all the facility monitoring and traffic surveillance and control activities for the Port of Miami roadway network will be conducted. The concept plan calls for two redundant operational locations, the remotely located operations control room and the local onsite operations control room. These facilities will house the following systems at a minimum:

- Facility control computer servers and workstations
- TSCS computer servers and workstations
- Video displays
- Agency radios
- Telephones
- Rest rooms
- HVAC
- Fire detection and suppression system

The remote control room will be integrated within an existing control center such as FDOT's SunGuide Transportation Management Center located in Miami, or Florida Turnpike Enterprise's (FTE) Pompano Operation Center located in Pompano Beach, Florida. The remote control room will provide the primary monitoring and control function for the Port of Miami roadway network. Since the CCTV system will dually be used as a fire detection device, the control room will be staffed 24 hour per day, seven days per week by operators trained to deal with traffic and facility events as required by NFPA 502. The remotely located control room will contain all components necessary for the continuous monitoring and control of traffic and environmental conditions throughout the Port of Miami roadways.

The local onsite control room will be incorporated within the planned Operation Support Facility (OSF) on Dodge Island. This facility will be used as a backup control room in the event that the remote control room is not functional or communications between the tunnel and the remote control room have been lost. The local onsite control room will house a completely functional control facility from which the tunnel can be fully monitored and controlled and will contain the requisite services for a facility that will be staffed 24 hour per day, seven days per week.

Past experience indicates that the most expedient path to a successful deployment requires that the facility control and traffic surveillance and control functions be performed on separate workstations. Therefore, two separate systems will be provided. The operation will however require that some alarm indications be passed to both systems. During the preliminary design phase, opportunities for fully integrating these systems into a single unified operational system will be explored.

#### 3.5.2.1 Operator Workstations

Port of Miami Tunnel Operations will be divided into two distinct functional categories:

- Traffic Surveillance and Control (TSCS) functions
- Facility Control and Monitoring functions

TSCS functions will be performed from a TSCS operator workstation using existing control center software systems such as FTE's SunNav, or FDOT's SunGuide. TSCS hardware will be integrated into these existing systems as much as possible. Existing hardware elements such as CCTV and communications system components will be leveraged as much as possible. Where necessary, modifications such as new hardware drivers and user interface enhancements will be developed. During the preliminary design phase, a determination will be made as to whether the traffic surveillance and control activities are performed at a dedicated workstation, or distributed to existing workstations. No more than one dedicated TSCS operator workstation will be required at either the remotely located or local onsite control rooms.

The TSCS workstation will provide monitor and control capability for the following sub-systems:

- VMS
- LUS
- PTS
- CCTV
- Radio

The TSCS workstation will provide "monitoring only" capability for the following sub-systems:

- DSRC
- OHVD

Facility monitoring and control functions will be performed from a dedicated operator workstation running the requisite facility control software. The facility control and monitoring workstation will provide monitor only capability for the following systems:

- SCADA
- Carbon Monoxide Monitoring
- Fire Alarm and Detection
- Fire Suppression
- Tunnel Drainage
- Hydrocarbon Monitoring
- Tunnel Lighting
- Electrical Distribution
- Communications Systems

Monitoring and control capability will be provided for the following systems:

- Tunnel Ventilation
- Intrusion Detection/Access control

No more than one dedicated facility control and monitoring operator workstation will be required at both the remotely located or the local onsite control rooms. A complete description of all facility monitoring and control systems is described in this Design Basis Report in Section 3.3 – Mechanical Systems and in Section 3.4 – Electrical Systems.

### 3.5.3 Closed Circuit Television (CCTV)

The primary means of detecting and verifying incidents, and monitoring the roadway network, will be the closed circuit television (CCTV) system. The system will include remotely controlled color cameras with pan and tilt movement capability and zoom lenses (pan, tilt, zoom - PTZ). These cameras will be located at strategic intervals throughout the tunnel and exterior roadway system.

Cameras in the tunnel are placed nominally at regular intervals to allow continuous overlapping visual coverage of the tunnel roadway such that the entire roadway can still be viewed if any single camera is incapacitated. Cameras located outside the tunnel will be located to minimize the number of cameras required to provide full visual coverage. Camera views will be monitored at both the local onsite control room and the remotely located operations control room. Access to each camera view will be controlled so as to prevent unauthorized viewing of sensitive areas. All cameras will have continuous digital video recording capabilities. Because many cameras will be needed to cover the entire roadway network, camera touring and multiplexing techniques will be employed for displaying cameras views and video.

CCTV cameras will also be used as the primary means of detecting incidents by employing state-of-the-art video incident detection software. This method of incident detection is easily deployed and utilizes the same cameras already deployed for the manual surveillance system. This type of video based system avoids the inherent problems of utilizing inductive loop based systems, such as high loop failure rates, maintenance difficulties and challenges incorporating incident detection algorithms.

The security and fire detection functions of the CCTV system are described in Section 3.4.3.4 of this Design Basis Report.

### 3.5.4 Variable Message Signs (VMS)

Variable Message Signs (VMS) will be located at regular intervals throughout the tunnel sections and at strategic locations on the external roadways. These message boards are the primary means of communication with the general motoring public. Variable message signs will inform motorists of real-time conditions on or prior to the tunnel roadways. Such up-to-date information relieves motorist frustration and aggravation, increases safety and motorist comfort, and improves the overall travel efficiency of the corridor. These signs will enable the TSCS to exert control over a wide spectrum of traffic conditions throughout the corridor. Working in concert with LUS, they provide a powerful tool in controlling the flow of traffic around an incident or maintenance activity location. Typically, VMS will be used to provide traffic advisory, speed control, and alternate route messaging. In addition, VMS are ideal for conveying timely information and instructions to motorist during an emergency situation.

At a minimum, these signs will be light emitting diode (LED), line matrix displays. Full matrix sign technology will be required to be examined during the design phase to determine applicability in this application and should be allowed as a Design-Build Firm option. The VMS can be controlled both from the local onsite operations control room and the remotely located operations control room.

On the tunnel portion of the roadway, the VMS will be co-located with Lane Use Signals (LUS) on the same sign structure to minimize the number of sign bridges in the tunnel. The signs will be single line twenty-four character displays spaced at approximately 800 foot intervals and bracketed on either end by LUS. VMS characters will be a minimum 12 inches in height so as to be readable at a distance of at least 600 feet. A VMS will also be located at the entry portal of each tunnel bore.

On exterior roadways, the VMS will be deployed at strategic locations to provide alternate path information to motorists in advance of decision points. These locations include the I-95/I-395 interchange, I-395/ Port of Miami Tunnel Interchange, Port Boulevard/ Port of Miami Tunnel Interchange, and the Port Boulevard/SR-1 Intersection. In addition, VMS will be provided downstream of Overheight Vehicle Detector (OHVD) locations to display the appropriate overheight warning message.

### 3.5.5 Lane Use Signals (LUS)

Lane Use Signals (LUS) will be located over each roadway lane at regular intervals throughout the tunnel. The primary functions of the LUS are to increase the efficiency and safety of freeway operations during periods of reduced capacity by controlling access to closed roadway lanes and to smoothly channel traffic around the closed lane. Working in concert with VMS, LUS provide a powerful tool in controlling the flow of traffic around incident or maintenance activity locations. In addition, LUS will be used to provide a means for flushing the residual traffic out of the tunnel downstream of a fire location as required by NFPA 502.

The lane use signal heads will be 12-inch high LED displays indicating either a downward green arrow, a yellow “X” or a red “X” and will be visible from a distance of at least 600 feet. Control room operators will have the ability to close sections of lanes relevant to the lateral space required for maintenance activities or roadway emergencies. A LUS will be centered above each travel lane at approximately 400 foot intervals within the tunnel. The spacing of the LUS will support the Federal MUTCD (Manual of Uniform Traffic Control Devices) standard setup distance for a lane closure and buffer zone. The LUS will be controlled both from the local onsite operations control room and the remotely located operations control room

A standard lane closure setup requires a minimum of 300 feet for a roadway with a speed of 35 mph and a 12 foot travel lane. Lane closures will use a minimum of 2 yellow “X” before 2 red “X”. This strategy will ensure that if a particular LUS is inoperable, at least one red or yellow X is visible during a lane closure. An example of the combined use of LUS and VMS to manage a lane blockage is shown below in Figure 3-5.

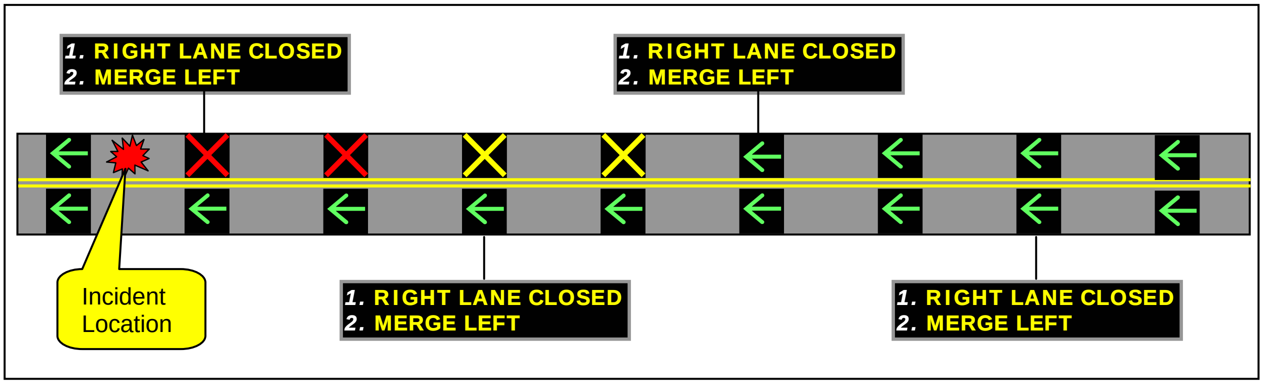



**Figure 3-6. Schematic of Lane Use Signals/Variable Message Signs Operation**

The lane indications will be more closely spaced on curves than on tangent sections to compensate for sight distance limitations. The specific spacing will be computed based on horizontal and vertical curvature with the signal centered over the lane and above the clearance envelope.

As dictated by the MUTCD, a downward green arrow over a particular lane will indicate to the motorist that the lane is open to traffic. A yellow X will indicate that the motorist should move to the right or left because the lane is closing ahead, while a steady red X will indicate the lane is closed.

### 3.5.6 Overheight Vehicle Detectors (OHVD)

Overheight vehicles pose a serious threat of damage to tunnel ceilings, LUS, VMS, and other tunnel appurtenances and hence to motorist safety. Overheight vehicles will be identified by means of paired infrared beam detectors placed at strategic locations prior to the Port of Miami Tunnel portals and upstream of the last alternate route decision point. These detectors, capable of identifying the passage of moving overheight vehicles, will consist of an infrared device that transmits a continuous beam of light across a roadway to a receiver.

When the beam is interrupted by an overheight vehicle, the VMS located immediately downstream of the OHVD will illuminate with the appropriate "Overheight Vehicle" warning message and the local warning alarm bell will sound, in an attempt to notify the driver that their vehicle height exceeds the safe vertical clearance in the tunnel. An OHVD alarm will also be generated at the local onsite operations control room and the remotely located operations control room on the Control Room Operator's workstation computer.

For each possible entrance to the Port of Miami tunnels, at least two detector locations will be identified, one in advance of the latest available decision point where a vehicle can choose not to enter the tunnel (Outer Ring), and one after that decision point, where a vehicle is committed to entering the tunnel (Inner Ring).

#### 3.5.6.1 Outer Ring Detection

The presence of an overheight vehicle at the "Outer Ring" detector indicates only a possible overheight vehicle incident as it is possible that the vehicle may not enter the Port of Miami tunnel at all. The Outer Ring acts as an early warning system for the Control Room Operator so that an overheight vehicle can be identified and monitored before it actually presents a threat to the tunnel.

The "Overheight Vehicle" warning message for the Outer Ring locations will simply warn the vehicle that they are overheight for the Port of Miami Tunnel. The Control Room Operator will generally not dispatch response personnel for an "Outer Ring" alarm.

3.5.6.2 Inner Ring Detection

The presence of an overheight vehicle at the "Inner Ring" location represents an actual overheight vehicle threat. The "Overheight Vehicle" warning message will instruct the driver to pull to the side of the road, stop and await police. Upon receiving an Inner Ring alarm the Control Room Operator will respond by dispatching response personnel appropriate to the severity of the incident. The Control Room Operator will use the TSCS to expedite the arrival of response personnel to the incident scene and to manage or reroute traffic as necessary. The inner ring detection locations will also include physical overheight vehicle detection devices such as vertical chains. These devices will be used to detect overheight vehicles in the event that the infrared devices are inoperable.

An OHVD enforcement plan should be developed early in the design process. This plan will detail enforcement strategies that will be used in the operation of the OHVD system. Consideration should be given to defining appropriate enforcement locations, identifying and training enforcement personnel, and procedures for physically monitoring for overheight vehicles at the tunnel portals in the event that the infrared devices are in operable.

### 3.5.7 Dedicated Short-Range Communications (DSRC)

Dedicated Short Range Communications (DSRC) systems use microwave communications over very short distances to allow moving vehicles to communicate with roadside equipment. DSRC systems have been developed to support a wide range of public safety and private operations in roadside-to-vehicle and vehicle-to-vehicle environments for the transportation industry. In the electronic tolling industry, DSRC provides the communications link between the toll tag transponder and the roadside reader. Since Florida's Turnpike Enterprise (FTE) has a significant number of current toll tag users, these toll tags will be used to gather traffic flow statistics via a series of DSRC readers located at strategic locations throughout the Port of Miami roadways.

The roadside equipment consists of a communication antenna, an RF (radio frequency) module and reader controller. The roadside antenna locations communicate with the onboard vehicle equipment in either a passive mode (i.e. reflective using the reader's own power) or an active mode (i.e. the tag is capable of independent transmit and receive functions). FTE currently uses passive DSRC technology on their roadways.

DSRC reader locations will be established so that the system can be used to monitor current traffic flow conditions, average travel times and vehicle speeds, by collecting data between successive reader locations. Using a proven statistical sampling process, the toll tag data will be collected and processed without retaining tag specific information. Data collected from the reader locations will be sent back to the Control Room where it will be centrally processed and made available for display in the form of average vehicle speeds and travel times.

### 3.5.8 Portal Traffic Signals (PTS)

Portal Traffic Signals (PTS) will be installed at the entrance portals to the eastbound and westbound tunnels. The primary purpose of these signals is to close the tunnel in the event of an emergency so as to prevent the additional traffic from entering. As specified in NFPA 502, all tunnels longer than 800 feet shall be equipped with portal traffic controls. These signals will be 12 inch diameter LED traffic signal heads mounted over the center line of each lane and affixed to the portal face in accordance with the Manual of Uniform Traffic Control Devices (MUTCD). When the tunnel is open, these signals will display a steady green ball. When the tunnel is closed, the signals will display a steady red ball. A 5 second yellow transition phase will automatically be displayed when switching between the red and green phases as specified in the MUTCD. The PTS will be controlled from both the remotely located and local onsite operations control rooms.

#### 3.5.9 AM/FM Rebroadcast / Highway Advisory Radio

The TSCS will employ an AM/FM Rebroadcast /Highway Advisory Radio system to communicate with motorists. This system provides commercial radio rebroadcast within the tunnel where normally it would be unavailable. The system also allows the control center operator to directly target tunnel motorist with specific instructions during an emergency situations such as fire, or an evacuation. This system is generally used in conjunction with VMS to convey critical information to motorists during an emergency situation. This system is more fully described in section 3.4.3.6.

#### 3.5.10 Incident Detection and Management

The primary function of the TSCS is incident detection and management. The major objective is to minimize the time between occurrence of an incident and the resumption of normal traffic flow on the roadway. The generally recognized standard is to detect, verify and respond to the incident site on average within five (5) minutes. The TSCS will be designed to meet this standard by assisting the Control Room Operator in performing the following tasks during an incident:

- Incident Detection

  Incidents can be detected in four different ways:

  - By the CCTV system – Traffic incidents will be automatically detected by the video based detection system. This type of system detects traffic incidents motion detection technology. The control room operator will receive an incident alarm via the operator workstation and be prompted to respond to the incident.
  - By an operator - The TSCS provides the operator with scan the road network for incidents using the CCTV system. The camera views will be displayed on CCTV monitors at the operator's console.
  - Facility system alarm – The Facility control workstation will generate alarms for conditions such as high Carbon Monoxide (CO) concentrations, and fire. These alarms are indications of roadway incidents or events and should be evaluated by the control center operator.
  - By an external source - Incidents can be detected by a variety of external sources such as motorists, police and maintenance staff.

- Confirmation and gathering of information

  Operator confirmation is accomplished primarily through the use of the closed CCTV system. For facilities related events which cannot be verified with CCTV, confirmation is defined as verification that the condition which generated the event alarm has continued to persist. Event confirmation can also be made through communication with on-site emergency response personnel.

The system will facilitate the confirmation process by providing the operator with:

- Location information in the form of mile markers or other relevant location devices that can be visually confirmed via CCTV or in the field by response staff..
- Automatic camera selection, where CCTV coverage of the location of a detected incident is available for the camera nearest to the incident location, pan/tilt of the cameras to preset positions for viewing of the incident location, and display at the operator's workstation console video monitors.

- Notifications

The control room operator will notify appropriate emergency response personnel of the incident. These notifications will include at a minimum:

- Florida State Police
- Miami Fire Department
- Port Fire Department
- Miami City Police
- Maintenance Staff
- FDOT Road Rangers

- Response

The TSCS can be used to respond to an incident in two ways:

- Automatically – Direct response without operator intervention, e.g. display the "Overheight Vehicle" warning message on variable message signs in response to an OHVD alarm.
- Manually –The control room operator prepares and activates a response plan in response to a detected and confirmed incident.

The notified responders will respond to the location of the incident to perform on-scene incident response activities. For incidents in the eastbound tunnel bore, emergency personnel will respond with the flow of traffic from the mainland. For incidents in the westbound bore, emergency personnel will respond from Dodge Island. During the design process more definitive response protocols will be developed. The control room operator will use the TSCS to facilitate response and removal activities as directed by on-scene responders.

- Monitoring

The control room operator will monitor the on-scene activities and provide any requested assistance.

- Logging/follow-up.

The control room operator will log all activities.

Established incident response and notification structures and protocols will be used where practical. However, new protocols will need to be established to address the multi-jurisdictional nature of the location and the new Port of Miami tunnel roadway network.

### 3.5.11 First Responder Staging Areas

Rapid response time to tunnel incidents is critical to the operation of any traffic tunnel. Rapid response times will mitigate:

- Traffic congestion
- Exposure to vehicle pollutants such as carbon monoxide
- Residual accidents

A five (5) minute quick detection and response time policy will mitigate the occurrence of these negative effects. To achieve this policy, staging areas will be designated at each end of the tunnel for first responders to station tow trucks or other motorist assistance vehicles. These staging areas can be formalized locations that are created for this specific purpose, or can be informal locations such as existing parking lots. These areas must provide easy access to the tunnel portals, be safe, and provide access to rest room facilities.

For the eastbound tunnel, the closest opportunity for a staging area is at the interchange of SR-1 and I-395 (MacArthur Causeway) and is approximately 1 ¼ miles from the center of the tunnel. For the westbound tunnel the closest opportunity for a staging area is in the area the Port Boulevard/Asia Way intersection which is approximately ½ miles from the center of the tunnel. These locations seem to afford opportunities for creating formal or informal staging areas and show promise for achieving the quick response policy.

The design, staffing, hours of operation and equipment needs for these staging areas will be determined during the design phase of this project.

### 3.5.12 Fixed Signs

Roadway signs will provide the primary interface with motorists on the Port of Miami roadways. Motorists will be notified of corridor regulations, forewarned of existing or potentially hazardous conditions on or adjacent to the corridor, furnished with advisory instructions, and informed of intersecting routes and pertinent destinations so they may make timely and appropriate decisions. A well planned fixed signage plan will enhance the safety and efficiency of traffic operations within the corridor.

The Manual of Uniform Traffic Control Devices (MUTCD) and FDOT standards will be employed to design and locate all fixed guide, regulatory, and warning signs. However, due the unique challenges presented by the constrained tunnel spaces, various design exceptions to the MUTCD standards will be necessary. These exceptions will be identified during the design phase of the project.

#### 3.5.12.1 Guide Signs

Conventional, fixed-message freeway guide signs will be installed along the corridor to display the required destination and route guidance information. These signs will be designed and installed in accordance with the principles and standards prescribed in the MUTCD.

Signs located outside the tunnel may require dedicated structures including sign bridges and cantilevered structures. The placement and structural capacity of the signs must be fully accounted for during the design phase. In addition, construction-staging scenarios should be integrated into the structural design and location selection to minimize the need for temporary structures and mountings. Locating guide signs within the tunnel presents a unique set of challenges. These overhead signs must compete for space in the clearance envelop (above 16' 6") with Variable Message Signs (VMS), lane use signals (LUS), jet fans and tunnel lighting, while maintaining adequate horizontal sight distances and letter sizes.

Signs for interchanges and major fork configurations will align motorists in the appropriate lanes well in advance of the exits/splits. Signage on the MacArthur Causeway will provide enough advanced warning to minimize weaving turbulence at the Port of Miami Tunnel/MacArthur Causeway interchange. Each mainline exit ramp will have three advance guide signs with a distance associated with the subject exit. An exit direction sign and an exit sign at the exit diverge will also be required for each exit, resulting in a total of 5 signs dedicated to each exit.

New or modified guidance signs will be required at the following locations at a minimum:

- Port of Miami Tunnel/MacArthur Causeway interchange
- I-95/I-395 Interchange
- Port Boulevard/SR-1 Intersection
- Port Boulevard/Port of Miami Tunnel intersection
- Port Boulevard on Dodge Island
- Port of Miami Tunnel

Lighting may be required for night operation in the uncovered roadway sections. Supplemental lighting may be required for guide signs in covered roadway sections, depending on the type of lighting system deployed.

#### 3.5.12.2 Regulatory Signs

Conventional fixed-message regulatory signs will all be installed to inform motorists of roadway regulations. The standard regulatory sign panel (except for STOP and YIELD signs) is rectangular in shape with a white background and black letters. Overhead regulator signs may be used rather than side-mounted signs due to horizontal clearance restrictions. Signalized Intersections typically require many regulatory signs. Their placement will be carefully coordinated with the traffic signal designs. Freeway regulatory signs will be required for speed limit and hazardous materials prohibitions. Hazardous materials trailblazing signage will be required to designate alternate routes for vehicles carrying these prohibited materials. These alternate routes will be developed in close coordination with local agencies.

#### 3.5.12.3 Warning Signs

Warning signs are used to warn traffic of existing or potentially hazardous conditions on or adjacent to a highway or street. Warning signs may call for a reduction in speed, a maneuver in the interest of safety, or to inform the motorist of an upcoming change in the geometry of the roadway. These black on yellow signs will be used on the Port of Miami Tunnel roadways to warn of unusual vertical and horizontal curves and entrance ramp locations.

# 4. MAC ARTHUR CAUSEWAY BRIDGE

## 4.1 Bridge Widening

The existing MacArthur Causeway Bridge will need to be widened from the current three lanes to four lanes in each direction to improve capacity and operational requirements. Bridge widening options were evaluated in a report, "MacArthur Causeway Bridge Widening Study" by EAC Consulting, Inc., dated March 2004, as part of the project Environmental Re-evaluation Study. For the Re-evaluation phase of the project, the roadway alignment assumed an "ultimate bridge widening" option where all bridge lanes were shifted to the north allowing a future light rail line to run on the south side of the bridge. However, the bridge will now be improved using the "Interim, Alternative 1" option where both the westbound and eastbound directions are widened by 12 feet to the inside (left).

Bridge widening will consist of demolishing an approximately two-feet wide segment on the inside of each bridge and constructing a new widening section extending 14 feet. The roadway section will then consist of: a 10 feet inside shoulder; four -12 feet traffic lanes; a 10 feet outside shoulder; and a 6 feet sidewalk on the outside. The overall clear roadway width on each of the bridges will be 68 feet. The total bridge width for each of the bridges will be 78 feet-1/2 inch.

The existing bridge has 18 spans with piers numbered 2 through 18. Requirements for inside widening of the spans is described as follows:

- Spans 2 and 3 (western segment located adjacent to Miami mainland) – There are two existing concrete columns stubs extending 10' above the existing pile cap. New work includes construction of new concrete pedestals with pre-cast prestressed concrete beam (Prestressed Concrete Institute PCI Designations, Bulb T72 beams) for eastbound and westbound bridge widening.
- Spans 4 to 15 (mid segment over waterway) – Demolish the two existing 10 feet concrete columns stubs on the existing pile cap. Construct new column between eastbound and westbound bridges. Place Bulb T72 beams for widening in each direction.
- Spans 15 and 16 (eastern segment located at Watson Island) – Construct center column on new foundation with piles and pile cap. Place Bulb T72 beams for widening in each direction.

Additional outside widening is required for the bridge at Spans 15 and 16 on Watson Island to accommodate the additional roadway lanes in each direction:

- The eastbound widening of Span 16 is anticipated to require a new column and extension of the abutment.
- Both Spans 15 and 16 in the westbound direction are to be widened to match to the alignment for the "ultimate" bridge configuration that will be required to accommodate the future Bay Link (to be placed on the south side of the bridge).

An evaluation of alternative concepts for the westbound lane configuration on the bridge is still under consideration. Depending on the alternative selected, there may be additional widening for a segment of the westbound lanes. A concrete jacket for exterior post-tensioning would be needed to support the required widening on the north side of the bridge.

## 4.2 Interface with Bay Link

Bay Link is the Light Rail Transit system in Miami-Dade Transit's master plan to be constructed between downtown Miami and Miami Beach. The line is to run over the MacArthur Causeway Bridge and along the south side of the causeway. The Re-evaluation Study identified a bridge widening scheme where the proposed rail could be located on the south side of the existing bridge. However, the "ultimate" configuration for Bay Link included post-tensioning retrofitting to widen the north side of the bridge and shifting all lanes to the north allowing space on the south side for the rail. Bay Link is not currently scheduled to be under construction until after the bridge widening for this project. Therefore, the design guidelines established for the Port of Miami Tunnel Project are that the Bay Link alignment be incorporated, and a corridor for future construction shall not be precluded. Bay Link will stay elevated on its own structure at the easternmost span of the bride and on Watson Island. Bay Link will be located adjacent or over the south access road on Watson Island (between the Port of Miami Tunnel roadways and the Island Gardens Development).

## 4.3 Bridge Design

Design for the bridge widening will be required to conform to the latest editions of the relevant codes, manuals and standards listed in Section 2.8, Governing Regulations. The existing bridge structure will be required to be analyzed using AASHTO Load and Resistance Factor Design Specifications (LRFD), as modified by FDOT Structures Design Guidelines, unless written approval is obtained from FDOT for an alternate design method.

## 4.4 Roadway Lighting

### 4.4.1 Purpose

The purpose of bridge lighting is to illuminate the roadway surface to ensure that the motorist can clearly identify objects on the roadway surface. In addition, many bridge structures, due to the highly visible nature also are illuminated to provide an aesthetical appeal, congruent with the surrounding architecture and landscape.

In order to minimize the costs associated with installing and maintaining these systems, careful analysis is required of each travel way's physical features, construction, and operational requirements. There are various approaches for providing the required illumination which need to be evaluated, with due consideration for visual performance, driver safety, and both initial capital and life cycle costs.

### 4.4.2 Design Criteria

The following standards will be required for current design practices for roadway/approach lighting systems:

- ANSI/IESNA RP-8-00, American National Standard Institute/ Illuminating Engineering Society of North America, American National Standard Practice for Roadway Lighting.
- AASHTO Informational Guide for Roadway Lighting – 1984, American Association of State Highway and Transportation Officials
- NFPA 70, National Electrical Code (NEC)
- UL, Underwriters Laboratories Standards, UL Listing

### 4.4.3 Determination of Lighting Levels

ANSI/IES RP-8-00, American National Standard Practice for Roadway Lighting will be the major design document used in determining the illumination requirements for this project. This roadway being a major access way to the Port will require higher levels of illumination. The roadway illumination levels will be based on a "Major Roadway, with Low Pedestrian Conflict Category" and a R3 (Asphalt) surface: the illuminance level will be a minimum of 0.8 $lms/ft^2$ with an average to minimum uniformity of 3 to 1, a maximum glare rating of 0.3 $L_{vmax}/L_{avg}$ and a luminance level of 0.6 $cd/m^2$ with an average to minimum of 3.5 to 1, a maximum to minimum of 6 to 1 uniformity.

In terms of the aesthetical illumination requirements, many environmental issues will require investigation as whether they play a key role in determining the illumination requirements. The basis for our design will be consistent with the existing illumination currently installed on the bridge structure.

### 4.4.4 System and Maintenance Considerations

High Intensity Discharge (HID) point source luminaires including a full-cutoff distribution will be utilized to ensure that the lighting system illuminates the roadway and not unnecessary surrounding properties. Glare from the lighting onto the roadway will also be a key element in choosing the appropriate system. Point sources, which are available in both the white light of Metal Halide and the yellow/orange light of High Pressure Sodium (HPS), offer very high system efficacy and excellent lamp life. It is recommended that high pressure sodium lamps be utilized due to the high efficacies and efficient luminaire designs. In addition, to minimize the number of lighting assemblies, the use of high mast poles is proposed.

A bridge atmosphere is normally windy, infrequently cleaned, and highly corrosive due to the salt water environment. Repairs and maintenance occur at non-peak hours in a closed travel lane. Workers must labor for prolonged periods, working overhead and exposed to oncoming traffic.

Combined dirt depreciation of the luminaire and the roadway surfaces, reduce the design light output by nominally 25%. Theoretically one-quarter of the fixtures are needed simply to make up for the eventual decrease due to environmental conditions.

Readily accessible luminaire components, and routine maintenance for burned out lamps and failed ballasts should be accounted for in the design. Tool-less entry, readily removable ballasts and lamp holders, quick release connections, and interchangeable housings are minimum design requirements for maintenance. The design should also require that electrical connections can be made at the maintenance shop, or via quick connect/disconnect plugs in the field.

### 4.4.5 Design Requirements

4.4.5.1 Lighting System

The MacArthur Causeway Bridge lighting should be provided with a roadway lighting system, controlled by an illuminance based photo-control system which provides the appropriate illuminations levels as indicated in this report and a complementing aesthetical lighting system design to coordinate with the existing system.

#### 4.4.5.2 Lighting Fixtures

On the basis of the design criteria, geometry, and initial visibility analysis, an HID point source, full cutoff luminaires mounted on a pole specifically designed to support twin fixtures mounted at approximately 60’-0” above the bridge/roadway surface, is proposed. In addition to the standard criteria of supporting the roadway fixtures, a decorative element will also be incorporated into the pole design to maintain the sleek Miami skyline. As the final design progresses, if the possibility exists to reuse the existing poles and luminaires, all efforts will be made to do so. Otherwise, the existing roadway lighting system will be removed and replaced with a new system while the aesthetical lighting on the underside of the structure will be designed to match existing illumination criteria.

## 4.5 Electrical Service and Raceways

### 4.5.1 Standards and References

Electrical systems design will conform to the latest issues of the following standards and references:

| | |
|---|---|
| NFPA | National Fire Protection Association<br>NFPA 502 – Standard of Road Tunnels, Bridges, and Other Limited Access Highways<br>NFPA 70 – National Electrical Code (NEC) |
| UL | Underwriters Laboratories Standards |

### 4.5.2 Electrical Service

The existing electrical service to the existing bridge lighting will be evaluated to determine whether it can be utilized to provide power to the redesigned bridge structure lighting system. If required, a new service for the bridge structure lighting system will be derived from the tunnel unit substation described in Section 3.4.2 of this Design Basis Report. As described in that Section 3.4.2, the lighting load of the bridge structure lighting system is being included in the total electrical load assumptions in sizing the unit substation equipment and in determining the total load requirements for discussions with the utility. In addition to lighting, traffic surveillance and control systems equipment along the roadway will require electrical service. These loads are also being accounted for in sizing of the required electrical service.

### 4.5.3 Raceway Systems

Raceway systems on the MacArthur Causeway Bridge are required for the installation of power and communications wiring for lighting fixtures and communications and traffic surveillance and control systems equipment. The raceway systems for power and communications wiring will consist of separated sets of ducts. Minimum conduit sizes for each type of service will be established. The existing raceway systems on the bridge will be evaluated and will be used if they are in an acceptable condition. Roadway raceway system requirements will follow FDOT standards.

# 5. PORT OF MIAMI ROADWAY NETWORK AND BRIDGES

## 5.1 Roadway Network and Bridges

### 5.1.1 Roadway Network

The primary considerations for design of the roadway network and bridges at the Port of Miami are to maintain the existing circulation patterns while keeping the cargo (truck) and cruise (buses, vans, taxis and passenger vehicles) traffic movements separate.. This is accomplished by the following:

- Prior to emerging from the new eastbound (inbound) tunnel, the cargo and cruise traffic is split into separate roadways. Westbound (outbound) traffic from cruise and cargo are separate until they merge on the tangent section before going into the tunnel.
- Routing access duplicates the existing movement for both the inbound and outbound cargo traffic. The inbound cargo truck traffic is routed directly onto the roadway leading to the Port's new Entry Security Gate complex. Exiting trucks have a direct connection from the Exit Security Gate complex to the outbound tunnel.
- New ramps connect to the existing collector/distributor roadway system to allow access to terminals and parking areas for cruise traffic.
- Inbound cruise traffic is routed into the existing roadway network and access to the "inner" (western) and "outer" (eastern) loops for circulation at the terminals. Exiting cruise traffic has a direct connection to the tunnel from the "outer" loop. Traffic on the "inner" loop roadway segments may also exit by traveling to the "outer" loop ramp connector however the "inner" loop cruise traffic will be signed to exit on the existing Port Boulevard Bridge.

Access from all areas of the Port to and from the Port Boulevard Bridge is maintained. Both cruise and cargo traffic would be able to utilize the existing bridge instead of the tunnel route.

### 5.1.2 Bridges

An existing bridge on the Port of Miami provides a grade separation for inbound cruise and outbound cargo traffic. This bridge will need to be removed to construct the tunnel. New bridges will be located as follows:

- Bridge for exiting cargo traffic duplicating the movement of the existing bridge. Provides grade separation over the inbound cruise traffic.
- Bridge for inbound cruise traffic that will diverge to the "inner" and "outer" cruise loops. Provides grade separation over the outbound traffic going to the tunnel.
- Bridge for the outbound cruise traffic. Provides grade separation over both the inbound cruise traffic (to the "outer" loop) and exiting cargo traffic.

## 5.2 Bridge Design

The design of Port of Miami roadway network and bridges will be required to be in compliance with the latest editions of the relevant codes, manuals and standards listed in Section 2.8, Governing Regulations. All new bridge structures will be required to be designed by the Load Resistance Design Specifications (LRFD) method in accordance with FDOT Structures Design Guidelines and AASHTO LRFD Design Specifications.

## 5.3 Roadway Lighting

### 5.3.1 Purpose

The purpose of roadway/interchange lighting is to illuminate the roadway surface to ensure that the motorist can clearly identify objects on the roadway surface. In addition, many bridge structures, due to the highly visible nature also are illuminated to provide an aesthetical appeal, congruent with the surrounding architecture and landscape.

In order to minimize the costs associated with installing and maintaining these systems, careful analysis is required of each travel way's physical features, construction, and operational requirements. There are various approaches for providing the required illumination which need to be evaluated, with due consideration for visual performance, driver safety, and both initial capital and life cycle costs.

### 5.3.2 Design Criteria

The following standards will be required the current design practices for roadway/approach lighting systems are followed:

- ANSI/IESNA RP-8-00, American National Standard Institute/ Illuminating Engineering Society of North America, American National Standard Practice for Roadway Lighting.
- AASHTO Informational Guide for Roadway Lighting – 1984, American Association of State Highway and Transportation Officials
- NFPA 70, National Electrical Code (NEC)
- UL, Underwriters Laboratories Standards, UL Listing

### 5.3.3 Determination of Lighting Levels

ANSI/IES RP-8-2000 American National Standard Practice for Roadway Lighting will be the major design document used in determining the illumination requirements for this project. This roadway being a major access way to the Port will require higher levels of illumination. The roadway illumination levels will be based on a Major Roadway, with Low Pedestrian Conflict and a R3 (Asphalt) surface: the illuminance level will be a minimum of 0.8 $lms/ft^2$ with an average to minimum uniformity of 3 to 1, a maximum glare rating of 0.3 Lvmax/Lavg and a luminance level of 0.6 $cd/m^2$ with an average to minimum of 3.5 to 1, a maximum to minimum of 6 to 1 uniformity.

### 5.3.4 System and Maintenance Considerations

High Intensity Discharge (HID) point source luminaires including a full-cutoff distribution will be utilized to ensure that the lighting system illuminates the roadway and not unnecessary surrounding properties. Glare from the lighting onto the roadway will also be a key element in choosing the appropriate system. Point sources, which are available in both the white light of Metal Halide and the yellow/orange light of High Pressure Sodium (HPS), offer very high system efficacy and excellent lamp life. It is recommended that high pressure sodium lamps be utilized due to the high efficacies and efficient luminaire designs. In addition, to minimize the number of lighting assemblies, the use of high mast poles is proposed.

A port environment is normally windy, infrequently cleaned, and highly corrosive due to the salt water environment. Repairs and maintenance occur at non-peak hours in a closed travel lane. Workers must labor for prolonged periods, working overhead and exposed to oncoming traffic.

Combined dirt depreciation of the luminaire and the roadway surfaces, reduce the design light output by nominally 25% to 35%. Theoretically one quarter of the fixtures are needed simply to make up for the eventual decrease due to environmental conditions.

Readily accessible luminaire components, routine maintenance for burned out lamps and failed ballasts should be accounted for. Tool-less entry, readily removable ballasts and lamp holders, quick release connections, and interchangeable housings are minimum requirements for maintenance. Electrical connections can be made at the maintenance shop, or via quick connect/disconnect plugs in the field.

### 5.3.5 Design Requirements

5.3.5.1 Lighting System

The Port of Miami bridges and highways lighting should be provided with a roadway lighting system, controlled by an illuminance based photo-control system which provides the appropriate illuminations levels as indicated in this report.

5.3.5.2 Lighting Fixtures

On the basis of the design criteria, geometry and initial visibility analysis, we propose an HID point source, full cutoff luminaires mounted on a pole specifically designed to support twin fixtures mounted at approximately 100’-0” above the bridge/roadway surface. The purpose for the use of high mast poles is to provide a clean uncluttered environment. High mast poles, specifically designed to withstand high wind loads, will provide the proper illumination levels required to ensure safe motorist activity.

## 5.4 Electrical Service and Raceways

### 5.4.1 Standards and References

Electrical systems design will conform to the latest issues of the following standards and references:

| | |
|---|---|
| NFPA | National Fire Protection Association<br>NFPA 502 – Standard of Road Tunnels, Bridges, and Other Limited Access Highways<br>NFPA 70 – National Electrical Code (NEC) |
| UL | Underwriters Laboratories Standards, UL Listing |

### 5.4.2 Electrical Service

A new electrical service for the Port of Miami roadway network and bridges lighting system will be derived from the tunnel unit substation located in the Operations Support Facility as described in Subsection 3.4.2 of this Design Basis Report. As described in Section 3.4.2, the lighting load of the exterior roadway lighting system is being included in the total electrical load assumptions in sizing the unit substation equipment and in determining the total load requirements for discussions with the utility. In addition to lighting, traffic surveillance and control systems equipment along the roadway network will require electrical service. These loads are also being accounted for in sizing of the required electrical service.

#### 5.4.3 Raceway Systems

Raceway systems on the Port of Miami roadway network and bridges are required for the installation of power and communications wiring for lighting fixtures and communications and traffic surveillance and control systems equipment. The raceway systems for power and communications wiring will consist of separated sets of ducts. Minimum conduit sizes for each type of service will be established. Roadway raceway system requirements will follow FDOT standards.

# 6. PROGRAM MANAGEMENT

## 6.1 Design-Build Documents

The following documents will be submitted to Florida's Turnpike Enterprise as part of the Design-Build Request for Proposal documents:

- Request for Proposal with required forms and other required documents
- Design Criteria
- Technical Special Provisions (Specifications)
- Project Conceptual Plans
- Quantity Takeoff Calculations and Preliminary Cost Estimate
- Geotechnical and Geophysical Data Reports

## 6.2 Construction Phasing and Schedule

The Design-Build Firm shall be required to submit a detailed schedule, taking into account the integration of final design and construction to achieve an optimal timeframe for completion balanced with the cost. The project schedule will be dependent on the phasing plan. Considerations of alternatives relative to phasing of the project are provided below.

### 6.2.1 Bored Tunnel

6.2.1.1 Tunnel Drive from Watson Island

The current assumption in the PD&E Report is that the direction of tunnel drive will start on Watson Island at the eastbound tunnel, advance southwards under the Main Shipping Channel and finish at Dodge Island, where the boring machine would be partially disassembled, turned around to the westbound tunnel portal, and construction of the westbound tunnel will commence from Dodge Island to Watson Island. While the eastbound tunnel is being driven, work could proceed on preparation of a receiving mined shaft on Dodge Island. This construction sequence was chosen for the following reasons:

1. Driving the tunnel southward from Watson Island provides a convenient and less invasive means for removal of muck off of Watson Island directly onto I-395, thus avoiding dust and heavy truck traffic mixed with port or with city street traffic.
2. Muck removal for the westbound tunnel drive, and transportation of segment rings, grout materials and other necessary supplies will be transported through the completed eastbound tunnel to the shaft on Dodge Island.
3. Driving in this direction provides the longest and straightest length of tunnel for the tunneling crews to become experienced with the operation of the tunnel boring machine (TBM), before boring under the shipping channel where the cover over the machine is minimal.

6.2.1.2 Tunnel Drive from Dodge Island

It is our understanding that the construction of the Island Gardens development is scheduled to commence in 2006, with an estimated four years total construction schedule. This means the construction of this development would be concurrent with the roadwork and tunneling activities of the Port of Miami Tunnel and Access Improvement Project.

Another tunnel boring sequence to consider is to start both tunnel drives from Dodge Island in order to mitigate any coordination issues related to the Island Gardens construction. Coordination will be required with the Port of Miami and other Agencies to locate feasible construction lay-down areas on Dodge Island. A more detailed sequence of construction for the Watson Island roadways and ramps and the Port of Miami cut and cover tunnels, bridges and roadways would be required to be developed and to design to incorporate this alternative tunneling sequence.

### 6.2.2 MacArthur Causeway Bridge

We recommend that the widening of MacArthur Causeway Bridge be a separate early construction contract. The addition of lanes in each direction to the existing bridge will mitigate the added traffic that the Port of Miami tunnel construction will bring to the Watson Island area. Both the eastbound and westbound bridges will be required to be widened by 14 feet to the inside.

### 6.2.3 Watson Island

The following suggested construction phasing is based upon driving first the eastbound tunnel from Watson Island, and then the westbound tunnel from Dodge Island.

Phase I

1. Relocate Frontage Road to new alignment closer to Children's Museum and Island Gardens Development.
2. Construct the TBM access starter chamber shaft structure at the eastbound tunnel.
3. Receive and assemble TBM, fans, service equipment, power and water treatment facility.
4. Start tunneling eastbound towards Port of Miami (Dodge Island)
5. Start construction on relocated MacArthur Causeway, eastbound and westbound traffic lanes.
6. See Port of Miami (Dodge Island) construction sequence by phases for construction of TBM receiving shaft.

Phase II

1. Complete construction relocation of MacArthur Causeway eastbound and westbound lanes.
2. Construct TBM receiving shaft for the westbound tunnel.
3. Once the TBM has "holed through" the westbound receiving shaft wall, disassemble the TBM and equipment and remove from the site.
4. Construct open boat ramp sections to complete tunnel, construct permanent tunnel portals and the open roadway sections to bridge approach.
5. Construct ancillary structures.

Phase III

1. Complete Mechanical/Electrical/Architectural/Landscaping

### 6.2.4 Port of Miami Roadway Network and Bridges

The following construction phasing is based upon driving first the eastbound tunnel from Watson Island, and then the westbound tunnel from Dodge Island.

Phase I

1. Construct temporary detours as needed to maintain traffic on Port of Miami roadways. Demolish existing bridge structure lying within the tunnel alignment.
2. Construct part of eastbound and westbound cut-and-cover tunnels that will serve as the TBM receiving/turn-around shaft. Traffic on "cruise terminal turnback" roads will have to be maintained during construction.
3. After the TBM breeches the receiving headwall, reassemble the TBM for the westbound tunnel bore (and all related equipment). Commence tunneling of the westbound bore back towards Watson Island.

Phase II

1. Construct cast-in-place tunnel sections outside of shaft and open boat ramp sections to complete tunnel. Construct permanent tunnel portals.
2. Once tunnel sections under new bridge alignment have been completed to the point where bridge construction can proceed, commence bridge construction with bridge piers and foundations.
3. Construct Operations Support Facility and Tide Gate structures and other ancillary structures.
4. Complete construction of flyover bridges.
5. Once bridge and tunnel structures are complete, re-establish road network and open to traffic.

Phase III

1. Complete Mechanical/Electrical/Architectural/Landscaping

## 6.3 Schedule Reporting Specifications

The Design-Build Firm will be responsible for providing schedule oversight throughout the lifecycle of the Project. An outline delineating the Integrated Cost/Schedule Controls Program, is required as described below:

### 6.3.1. Project Schedule Program

The project will require an Integrated Cost/Schedule Controls Program that the Design-Build Firm shall fully comply with until Final Acceptance, at no increase in Contract Price. The Integrated Cost/Schedule Controls Program will require the Design-Build Firm to provide the following types of schedules:

a. Baseline Schedule
b. Schedule Updates
c. Progress Schedule Submittals
d. Baseline Schedule Revisions
e. Short Term Construction Schedules
f. Proposal/Recovery Schedules

### 6.3.2 Schedule Type

All Schedules required by the Integrated Cost/Schedule Controls Program shall be a computer generated, Critical Path Method (CPM) network utilizing the precedence diagram method of scheduling.

### 6.3.3 Software

The software utilized to generate the CPM schedule shall be capable of producing Schedules in accordance with the requirements of the Contract Documents and fully compatible with software utilized by the Engineer currently Primavera Project Planner (P3), Version 3.

### 6.3.4 Resource Loading

The accepted Project Schedule(s) shall be resource loaded, to include all work performed by the Design-Build Firm per the contract requirements or as otherwise specified by FTE or FDOT.

### 6.3.5 Cost Loading

The Project Schedule(s) shall be Cost Loaded to include all work performed by the Design-Build Firm. The summed value of that portion of the activities allocated to each bid item shall equal the total value of the corresponding bid item.

### 6.3.6 Logic

The Design-Build Firm shall be responsible for developing the logic of the Baseline Schedule and for updating that logic each month to accurately reflect the progress of the Work to-date and the Design-Build Firm’s current plan for the timely completion of the project.

### 6.3.7 Schedule Narratives

All schedule submissions by the Design-Build Firm shall include a detailed Schedule Narrative describing the planned flow of work throughout the lifecycle of the Contract.

### 6.3.8 Schedule Updates and Progress Schedule Submittals

The Design-Build Firm shall update the Current Baseline Schedule on a monthly basis. The purpose of Schedule Updates shall be to accurately document the progress of the Work to-date and to correct the schedule to accurately reflect the Design-Build Firm’s current plan for the timely completion of the project.

The Schedule Update Submittal shall be due with, and be a requisite to, the first Application for Payment in a month; and the Progress Schedule Submittal shall be due with the second Application for Payment in the month.

### 6.3.9 Payments

Payments to the Design-Build Firm shall be based on the physical progress of activities, as requested by the Design-Build Firm and approved by FTE or FDOT, in relation to the cost allocation to each activity. Cost reports shall show the earned cost as the activity cost earned to date.

## 6.4 Maintenance of Traffic

The construction period will likely result in the need to create both long and short term work zones, and therefore, Maintenance of Traffic (MOT) plans will be required to support these work zones. These MOT plans will ensure that traffic flow is disrupted as little as possible on existing roadways and that a safe environment for both motorists and construction personnel is provided during construction of the Port of Miami Tunnel Project. Several factors are integral to the development and implementation of these MOT plans. The plans will reflect the requirements of the Manual of Uniform Traffic Control Devices (MUTCD), Florida's Traffic Engineering Manual (TEM) and any other applicable FDOT, City of Miami and Port of Miami standards. Equivalent or replacement traffic flow patterns will be maintained during construction on the following roadways as a minimum for:

- MacArthur Causeway
- Port Boulevard
- Florida Way
- Atlantic Way
- Europe Way
- North America Way
- North/South Cruise Boulevards
- Bahama Drive
- Tropic Drive

During the design process, a comprehensive MOT program will be developed to manage construction-related traffic impacts. This program will identify the following requirements:

- Placement of construction zone warning signs.
- Establish minimum traffic operational thresholds for highway and intersection levels of service, speeds and accidents. Also establish mutually agreed upon methods of assessment.
- Establish minimum requirements for truck and bus operations associated with reduced widths and reduced turning radii.
- Establish a process for providing advanced notification of road closures, geometric changes, traffic pattern changes and capacity reductions to allow motorists to choose optional routes.
- Establish a process for coordination with media outlets to provide notices of both scheduled and unplanned events that affect traffic.
- Establish a rapid means of contact with adjacent agencies that could be affected by construction activities.
- Provide a forum for daily review of operations including the potential to supplement or improve existing plans. It is important that damaged and missing elements of the MOT plan be identified quickly and replaced.