DESIGN SUMMARY REPORT

FOR

IH-635 MANAGED LANES PROJECT

WEST SECTION
REFERENCE SCHEMATIC

PREPARED FOR:
TEXAS DEPARTMENT OF TRANSPORTATION

December 2006
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THIS DOCUMENT IS INTENDED FOR USE FOR INFORMATIONAL PURPOSES ONLY AND NOT FOR CONSTRUCTION. THE DOCUMENT SHALL BE CONSIDERED AS PART OF THE OVERALL ENGINEERING DOCUMENTATION IN CONNECTION WITH THE "IH 635 WEST SECTION REFERENCE SCHEMATIC".

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IH 635 Managed Lanes Project – West Section
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CHAPTER 1 - PROJECT DESCRIPTION

1.1 Purpose of Design Summary Report
The purpose of this Design Summary Report (DSR) is to document the major engineering and environmental decisions that were made during the development of the Reference Schematic. The report documents Project design criteria and engineering decisions, environmental constraints and the status of environmental issues or permit requirements. The report also explains the inconsistencies between the Environmental Schematic alignments and the alignments shown in the Reference Schematic.

1.2 Environmental Schematic

1.2.1 IH 35E/Loop 12 Corridor
An Environmental Assessment (EA)\(^1\) was prepared by others and approved with a Finding of No Significant Impact (FONSI) in December 2002. The Preferred Alternative depicted in the EA document defines the ultimate configuration of the corridor from Loop 12 at Spur 408 to just south of the IH 35E/IH 635 interchange. The corridor includes eight main lanes; six frontage road lanes; and a two-lane, reversible, managed system between US 183 and the IH 35E merge. The ultimate configuration along IH 35E between Loop 12 and IH 635 consists of eight main lanes; four to six frontage road lanes; two three-lane elevated direct connectors; two concurrent, managed lanes at grade; and one elevated, reversible, managed lane.

1.2.2 IH 635 Corridor (West Section)
An Environmental Assessment (EA)\(^2\) was prepared by others and approved with a FONSI in April 2004. The Preferred Alternative depicted in the EA document defines the ultimate configuration of the corridor from Luna Road to US 75. The corridor improvements include main lane reconstruction including a 36 foot wide median for an additional lane in each direction in the future, replacing the existing High Occupancy Vehicle (HOV) lanes with two managed lanes from east of Luna Road to Josey Lane and from Hughes Lane to near Coit Road, adding three subterranean managed lanes from west of Welch Road to east of Preston Road in each direction, and constructing two- and three-lane continuous frontage roads in each direction.
1.3 Reference Schematic Description

1.3.1 Limits
The ultimate IH 35E and IH 635 facility limits are described as a series of letters from A to J. The Reference Schematic depicts the A, B, and C portion of the ultimate facility as described below:

Segment A – Development of the managed lanes within the IH 635 right-of-way from the IH 35E interchange to the Dallas High Five interchange (DHF). The managed lanes may consist of surface and subterranean elements. This segment will include portions of the IH 635 main lanes from east of Denton Drive to east of Webb Chapel Road and from Preston Road to the DHF. The segment also includes improvements to develop a continuous frontage road system with appropriate ramp connections to and from the existing IH 635 main lanes. The continuous frontage road system consists of new or reconstructed frontage roads from the IH 35E interchange to Midway Road and from Preston Road to Hillcrest Road. The functionality of the existing IH 635 general-purpose lanes will not be modified for this segment.

Segment B – Development of direct connector ramps within the limits of the existing IH 635/IH 35E interchange necessary to facilitate traffic movement to and from the IH 635 managed lane system. This segment includes the elevated sections of the northbound to eastbound and westbound to southbound connector ramps from the IH 635/IH 35E interchange to Webb Chapel Road. Segment B will include some adjustments to the existing roadways to ensure existing connection are preserved.

Segment C – Development of the elevated direct connector roadways within the proposed IH 35E right-of-way. The elevated roadways will be located adjacent to the existing IH 35E main lanes and will extend from the Loop12/IH 35E interchange to the IH 635/IH 35E interchange. This segment also includes intermediate connections to the elevated roadways at Walnut Hill Road. The IH 35E main lanes, managed lanes and continuous frontage roads are not included in this segment.

The station limits of the Reference Schematic are as follows:
a) Loop 12 from Northwest Highway to IH 35E (STA 1498+60 to STA 1512+42)
b) IH 35E from Joe’s Creek to the IH 35E/IH 635 Interchange (STA 984+00 to STA 1172+85)
c) IH 635 West Section from East of Farmers Branch Tributary to East of Park Central (STA 10575+85 to STA 413+76.97)

The section along IH 635 does not have any roadway work west of the IH 35E interchange. This section is included to allow the drainage facilities required for the interim and ultimate configurations to be constructed.

1.3.2 Interim Configuration
The interim configuration improvements to the corridor consist of the construction of three-lane elevated managed lane connectors and the necessary interchanges in each direction along IH 35E between the Loop 12/IH 35E merge and the IH 35E/IH 635 Interchange. Access to the elevated managed lanes would be constructed to Walnut Hill Lane in the southbound direction and from Walnut Hill Lane in the northbound direction. This facility would be constructed to remain in service as part of the ultimate configuration as described in the EA.

The improvements along IH 635 generally consist of the completion of the non-continuous frontage roads in each direction and the addition of three-lane managed lane tunnel facilities in each direction between approximately Josey Lane to the west and east of Preston Road to the east. The ultimate configuration would be built from east of Denton Drive to east of Webb Chapel and from east of Preston Road to the tie in to the IH 635/US 75 Interchange. The ultimate configuration is constructed in these sections because the constraints of traffic maintenance, during ultimate configuration construction, would not allow the managed lane facilities to operate uninterrupted. The only improvements in the section between west of the Dallas North Tollway (DNT) and just east of Preston Road are the addition of the managed lane tunnels and the supporting facilities.

The interim configuration does not preclude the construction of the ultimate configuration and requires minimal impacts to complete the remaining elements of the ultimate configuration.
1.4 Reference Schematic Goals

The Reference Schematic goals include the preparation of a plan that functions as one unified schematic of the proposed interim and ultimate configurations and establishes the baseline configuration for inclusion in the Comprehensive Development Agreement (CDA) procurement documents. The Reference Schematic also provides a constructible design that integrates the interim and ultimate Configurations into the existing system while maintaining efficient traffic operations and maximizing public safety. Previously defined right-of-way and utility impacts are verified while the managed lane facilities of declaration lanes and enforcement areas lanes are incorporated. The Reference Schematic identifies structure type, location and length for the above grade structures and the subterranean facilities. These facilities include roadway transition sections into the cut-and-cover tunnel sections, mined tunnels and their supporting facilities. The Reference Schematic also serves as the basis for preparation of construction cost estimates. The Reference Schematic goals are derivatives of the overall Project goals listed below:

a) Safety – Promoting Public Safety
b) Minimizing Public Impacts – Emphasis placed on:
   • Minimizing impact to Mobility
   • Minimizing impact to Air Quality
   • Minimizing impact from Noise
   • Creating an Aesthetically pleasing facility
c) Delivering within Schedule & Budget – Develop a Project conscious of Schedule & Budget

1.5 Reference Schematic Constraints

The constraints for the Reference Schematic were developed based on a few underlying themes established throughout the planning and environmental approval process. These themes are as follows:

a) Perception about impacts to the community, property, elevation, noise and construction sequencing.
b) Desire to limit impact to existing freeway until after the managed lane tunnels opened.

c) Desire to minimize property acquisition and utility relocations between Midway Road and Preston Road.

d) Desire to minimize the overall impact to the most heavily traveled portion of the freeway adjacent to the densest development.

e) The direct construction cost was not the over riding factor in developing these constraints.

The development of the Reference Schematic adhered to the following constraints:

a) Maintain, as shown in the Environmental Schematic, the same alignment and arrangement for two managed lane tunnels with three lanes in each direction. The tunnels are a combination of u-wall transitions, box and mined sections.

b) Avoid any additional linear right-of-way acquisition. Match the approved schematic EA FONSI footprint. Additional right-of-way for tunnel support systems is anticipated.

c) Maintain one existing HOV and four general-purpose lanes in each direction during construction.

d) Assure both interim (ABC) Project and ultimate facility constructability.

e) Maintain access locations in accordance with the approved schematic, Environmental Assessment Level of Service (LOS) analysis, the existing interchange access justification and the applied traffic and revenue study3 (T&R) assumptions.

f) Incorporate toll/gantry and declaration lanes at every access point to the managed lanes facility. Provide an all-electronic toll collection managed lane facility compatible with Texas Turnpike Authority (TTA) statewide, and North Texas Tollway Authority (NTTA) local Electronic Toll Collection (ETC) Systems.

g) Provide an envelope for a possible future transit tunnel(s) north of the IH-635 centerline between Midway Road and Preston Road.

h) Develop interim schematic alignments and typical sections to meet Texas Department of Transportation (TxDOT) & Federal Highway Administration (FHWA) design criteria, including applicable National Fire Protection Association (NFPA) Standards.
i) Use the DHF Interchange urban design components, existing adjacent and connecting facilities, and the LBJ Corridor Urban Design Report as a basis to produce a consistent corridor look.

j) Ensure elevation of proposed surface roadways stay consistent with those contained within the approved schematic.

k) Match existing approved Environmental Schematic dimensions for the paved center median (within the limits of subsurface managed lanes in Segment A).
CHAPTER 2 - REFERENCE SCHEMATIC DESIGN CRITERIA

2.1 Geometric Design Criteria

A summary of the Geometric Design criteria is presented in Table 2-1.

Table 2.1 Geometric Design Criteria

<table>
<thead>
<tr>
<th>Description</th>
<th>HOV/Mainlines</th>
<th>Subsurface Managed Lanes (SML)</th>
<th>Direct Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadway Classification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadway Classification</td>
<td>Urban Freeway</td>
<td>Urban Freeway</td>
<td>Urban Freeway</td>
</tr>
<tr>
<td><strong>Design Speed</strong></td>
<td>60 mph</td>
<td>60 mph</td>
<td>50 mph</td>
</tr>
<tr>
<td><strong>Horizontal Alignment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Location</td>
<td>Centerline</td>
<td>Inside edge of lane</td>
<td>Outside edge of lane</td>
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<td>Stopping Sight Distance (SSD)</td>
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<td>570 ft</td>
<td>425 ft</td>
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<td>2210 ft</td>
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<td>e(max) = 6%</td>
<td>e(max) = 6%</td>
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<tr>
<td><strong>Vertical Alignment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Location</td>
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<td>Inside edge of lane</td>
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</tr>
<tr>
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<td>3.00%</td>
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<td>84</td>
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</tr>
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<td>16.5 ft</td>
<td>16.5 ft</td>
<td>16.5 ft</td>
</tr>
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<td>Under Sign Structure</td>
<td>16.5 ft</td>
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<tr>
<td><strong>Cross Sectional Elements</strong></td>
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<td>Lanes-per direction</td>
<td>Schematic</td>
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<td>Lane Widths</td>
<td></td>
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<td>11 ft</td>
<td>12 ft</td>
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<td>e(max) = 6%</td>
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<td>Lanes-per direction</td>
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<td></td>
</tr>
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Table 2.1 Cont.

<table>
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<tr>
<th>Description</th>
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<td>Urban Arterial</td>
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<td>Design Speed[3]</td>
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<td><strong>Horizontal Alignment</strong></td>
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<td></td>
</tr>
<tr>
<td>Control Location[3]</td>
<td>Outside edge of lane</td>
<td>Centerline</td>
</tr>
<tr>
<td>Stopping Sight Distance[4]</td>
<td>360 ft</td>
<td>360 ft</td>
</tr>
<tr>
<td>Minimum Radius[5]</td>
<td>830 ft</td>
<td>660 ft</td>
</tr>
<tr>
<td>Superelevation[6]</td>
<td>e(max) = 4%</td>
<td>NC</td>
</tr>
<tr>
<td>Superelevation Runoff[7]</td>
<td>1:185</td>
<td>1:185</td>
</tr>
<tr>
<td><strong>Vertical Alignment</strong></td>
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</tr>
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<td>Sag Curve K-Value[11]</td>
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<tr>
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<td>16.5 ft</td>
</tr>
<tr>
<td>Under Sign Structure</td>
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<td>16.5 ft</td>
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<tr>
<td><strong>Cross Sectional Elements</strong></td>
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<td></td>
</tr>
<tr>
<td>Lanes (per direction)</td>
<td>Schematic</td>
<td>Schematic</td>
</tr>
<tr>
<td>Lane Widths[2]</td>
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<td></td>
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<tr>
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<td>12 ft</td>
<td>11 ft</td>
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<tr>
<td>Turning Lanes</td>
<td>20 ft</td>
<td>12 ft</td>
</tr>
<tr>
<td><strong>Usable Shoulder Widths[2,12]</strong></td>
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<td></td>
</tr>
<tr>
<td>Inside</td>
<td>2 ft</td>
<td>4 ft</td>
</tr>
<tr>
<td>Outside</td>
<td>2 ft</td>
<td>6 ft</td>
</tr>
<tr>
<td>Cross Slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lanes and Shoulder</td>
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<td>2.00%</td>
</tr>
<tr>
<td><strong>Median[13]</strong></td>
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<tr>
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<td>Inside</td>
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</tr>
<tr>
<td>Outside</td>
<td>2 ft</td>
<td></td>
</tr>
<tr>
<td><strong>Side Slopes</strong></td>
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<td></td>
</tr>
<tr>
<td>Within Clear Zone</td>
<td>4.17%</td>
<td>6:1</td>
</tr>
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<tr>
<td>Clear Zone Width</td>
<td>3 ft</td>
<td>1.5 ft</td>
</tr>
</tbody>
</table>

**NOTES:**
2. Criteria based on the Environmental Schematic Plans (ESP).
3. Control locations based on the ESP except for the Subsurface managed lanes that are based on the Functional Plans.
4. SSD based on level terrain and the RDM Table 2-1.
5. Minimum Radius based on RDM Table 2-3.
6. Information taken from AASHTO pg 141-142.
7. Criteria based on Table 2-8 in the RDM.
8. Criteria based on Table 2-9 in the RDM.
10. Criteria based on Figure 2-7 in the RDM.
11. Criteria based on Figure 2-9 in the RDM.
12. Sight distance criteria may require greater shoulder widths.
2.2 Bridge Design Criteria

The proposed superstructure type, substructure types, and foundations are to be consistent with the geometric, aesthetic, and structural design requirements set forth in this section. As part of the aesthetic requirements an effort was made to minimize the number of straddle bents and asymmetric single column bents.

For design of bridge elements, the AASHTO Standard Specifications for Highway Bridges\textsuperscript{5} was used with supplement information on shear design used from ACI 318\textsuperscript{9} building code. Load Factor Design (LFD) is required for all design except the design of prestressed concrete elements and structural steel elements which utilize Allowable Stress Design (ASD). TxDOT Standards are also used as reference in the design.

The live loads are the HS-25 truck/lane loading for the vehicular structures and the standard pedestrian loading for the Joe Ratcliff Walkway, both are found in the AASHTO Standard Specifications for Highway Bridges\textsuperscript{5}.

2.3 Cut-and-Cover Tunnel Design Criteria

Cut-and-Cover tunnel designs including geometric, structural, and fire and life safety requirements are to be consistent with other criteria in this section.

For Cut-and-Cover tunnel geometric design, fire and life safety requirements from NFPA 502\textsuperscript{5} and equipment envelopes must be added to the roadway design requirements to determine the overall opening required within the tunnel. The structural element design within the cut-and-cover tunnel, LFD was used for concrete members and ASD was used for structural steel members and prestressed concrete members.

For live loads, the HS 20-44 truck/lane load from the AASHTO Standard Specifications for Highway Bridges\textsuperscript{5}. The earth and hydrostatic pressures are to be derived from the Phase 1 Geotechnical Data and Baseline reports\textsuperscript{6,7}. Waterproofing design shall be limited to 0.005 gal/day-ft, or approximately 25 gal/day for a 50 foot reference section and 0.0025 gal/day-ft, or approximately 120 gal/day for a 500 foot reference section.
2.4 Mined Tunnel and Underground Structures Design Criteria

Mined tunnel and underground structures designs including geometric, structural, and fire and life safety requirements are to be consistent with other criteria in this section.

For mined tunnel geometric design, fire and life safety requirements from NFPA 502 and equipment envelopes must be added to the roadway design requirements to determine the overall opening required within the tunnel. The structural elements design within the mined tunnel and underground structures follow the ACI 318 building code.

The earth and hydrostatic pressures are to be derived from the Phase 1 Geotechnical Data and Baseline reports.
CHAPTER 3 - REFERENCE SCHEMATIC DESCRIPTION

3.1 Segment A – IH 635 West Section
The Reference Schematic configuration includes portions of the main lanes, frontage roads, bypass lanes, and ramps; declaration lanes; and the managed lanes from the IH 35E interchange to the DHF. These elements are added to the existing main lanes with impacts to existing elements as described herein.

3.1.1 West Gateway
The Reference Schematic west gateway extends from west of Denton Drive to west of Marsh Lane and includes freeway main lanes, managed lanes, frontage roads, declaration lanes, bypass lanes and ramps. Respectively, entrance into and exit out of the eastbound and westbound managed lanes are located in this section.

From Denton Drive to Webb Chapel Road, the Reference Schematic configuration includes the IH 635 main lanes, managed lane u-wall and cut-and-cover sections, continuous frontage roads, ramps and bypass lanes. From west of the existing Denton Drive bridge to east of Webb Chapel Road, the IH 635 main lanes profile is raised with transitions to existing grade at each end. The westbound side of the existing bridge over Denton Drive is widened to provide four freeway main lanes for the westbound IH 635 main lane traffic. The Reference Schematic configuration includes the ultimate Josey Lane and Webb Chapel Road overpasses and the ultimate Marsh Lane underpass. West of Denton Drive, existing westbound IH 635 pavements are widened to provide a continuous HOV lane to the southbound IH 35E exit ramp.

Unlike the Environmental Schematic configuration, the Reference Schematic provides two lanes on each of the wishbone ramps located west of Josey lane to provide direct access between the managed lanes and the IH 635/IH 35E direct connectors to enhance traffic operations.

Interim ramps from Josey Lane to the westbound IH 635 main lanes and from eastbound IH 635 to Josey Lane are including in the Reference Schematic. Access from the eastbound exit ramp to the ultimate grade separated bypass lane for traffic exiting to Webb Chapel Road is added for the interim configuration. Both of these ramps require reconstruction in the when the ultimate configuration is constructed.
From east of Webb Chapel Road to Midway Road, the ultimate IH 635 main lanes are not included in the Reference Schematic. In this segment, the Reference Schematic configuration provides an entrance ramp from the eastbound and westbound frontage roads to the managed lanes tunnel including a declaration lane toll collection gantry system and enforcement area. Accommodating these items requires an alignment shift for the existing IH 635 centerline and the tunnel alignments as provided in the Environmental Schematic.

An alternative configuration that was considered is shown as Option I in the Reference Schematic Plans. This configuration connected the elevated direct connectors west of the IH 35E / IH 635 interchange directly to the managed lanes in the area between the existing main lanes and frontage roads. There is not any ramping from or to the IH 635 main lanes tying the elevated connectors along IH 35E (Segment C). The wish bone connection to the managed system in the center of IH 635 in the ultimate configuration was accommodated. The cut-and-cover portion of the ultimate configuration tunnels that crossed under the main lanes was left to be completed during ultimate buildout. A U-wall section in each direction was to be constructed during the interim configuration and will be removed during ultimate buildout. Option 1 was the least impact to IH 635 during interim construction, but the ultimate configuration could not be constructed within the traffic management constraints that imposed on the construction phasing.

3.1.2 East Gateway
The Reference Schematic east gateway configuration extends from east of Preston Road to west of Coit Road and includes freeway main lanes, managed lanes, frontage roads, declaration lanes, and ramps. Respectively, exit out of and entrances into the westbound and eastbound managed lanes are located between Preston Road and Hillcrest Road.

The managed lanes tunnels are transitioned eastward through cut-and-cover and u-wall sections to tie to the at-grade managed lanes in the center of IH 635. Horizontal and vertical alignments for IH 635 main lanes are realigned and transitioned back to existing, east of Preston Road. Freeway main lanes remain at grade and eliminate the need for the IH 635 bridges as proposed in the Environmental Schematic between Hillcrest Road and Preston Road.
Cut-and-cover tunnel ramps under the at-grade IH 635 main lanes connect the managed lanes tunnels to the frontage roads and to the IH 635 main lanes. The westbound IH 635 main lane traffic enters the managed lanes tunnel from an exit ramp connected to a u-wall section and through a cut-and-cover tunnel section under the IH 635 main lanes. This ramp also provides a declaration lane toll gantry system and enforcement area. The Reference Schematic configuration also provides at grade ramps from the IH 635 main lanes to Hillcrest Road and Coit Road.

The Option 1 configuration in the east gateway section reflects the configuration shown in the Environmental Schematic. The difference in Option 1 is the addition of declaration lanes and the corresponding required geometric changes. This option is not used because of the operational deficiencies and potential construction difficulties as compared to the Reference Schematic.

3.1.3 Tunnel Alignment

From the west, the Environmental Schematic provides the cut-and-cover managed lane tunnels adjacent to the existing right-of-way between Webb Chapel Road and Marsh Lane. Because a major drainage trunk line is to be located in this area, the tunnel alignment is shifted. Similarly from the east, the Environmental schematic does not accommodate declaration lanes, toll collection, sign gantry locations and enforcement areas for westbound traffic entering the managed lanes tunnels without the acquisition of additional right-of-way. In the Environmental schematic for the section east of Preston road, the managed lanes were separated on each side of the IH 635 main lanes and were proposed to be u-walls sections. As a remedy to the issues discussed above, the managed lane tunnels are realigned as part of the Reference Schematic configuration.

In the Reference Schematic configuration, from Webb Chapel to Marsh Lane, the eastbound tunnel is shifted 12 ft northward to provide room for the drainage trunk line and provide construction access. Also, based on geotechnical data it was determined that the mined tunnels could be extended from west of Midway Road to east of Preston Road. These extensions would allow placement of the mined tunnel sections closer to the IH 635 main lanes and would provide a smoother alignment of the mined tunnel throughout the segment. The mined tunnel alignment generally follows the centerline of IH 635, leaving space for a proposed
Dallas Area Rapid Transit (DART) tunnel along the north side of IH 635 main lanes. Refer to Figure 1, DART Tunnel Envelope.

The mined tunnel alignment transitions from the portal locations to a parallel alignment with 60’ between the two tunnels. As the tunnels approach Preston Road, this dimension would transition to 40’ east of Preston Road. The managed lanes transition from the mined tunnel portals through cut-and-cover and u-wall sections to connect to the at-grade managed lanes at the center of IH 635 near Hillcrest Road.

3.1.4 Main Lane Alignment
From Webb Chapel Road to Marsh Lane, the tunnel alignment shift in the Reference Schematic configuration coupled with the need to provide a declaration lane with gantry system and enforcement area, requires a northward shift for the IH 635 main lanes in this segment. Similarly, main lane alignments are revised from Preston Road to Hillcrest Road to accommodate the tunnel realignment to the center of IH 635.

Thus, in the Reference Schematic configuration, the IH 635 centerline is shifted 16 ft to the north from Webb Chapel Road to Marsh Lane to accommodate the tunnel shift and ties back to the Environmental Schematic configuration centerline at both ends. From Rosser Road to Midway Road, IH 635 centerline would be shifted 16’ to the south to avoid additional right-of-way takes and to provide room for a declaration lane and enforcement area on the westbound tunnel entrance ramp west of Midway Road.

In addition, the IH 635 main lane alignments are revised from east of Preston Road to Hillcrest Road and tie to the Environmental Schematic design at both ends. This allows the managed lane tunnels to be realigned to the center between the eastbound and westbound IH 635 main lanes.

3.1.5 Declaration Lanes
Managed lane tolling operations require a gantry system for electronic toll collection (ETC) so that HOV and single passenger vehicles will have separate lanes at the approach to all tunnel entry points. The Reference Schematic configuration provides declaration lanes on the entrance ramps that transition to two twelve-foot declaration lanes with a two-foot buffer between them.
Adjacent to the declaration lanes is a 120 ft by 12 ft wide enforcement area and toll collection gantry system. The declaration lanes transition to a single lane ramp as they approach the entrance to the tunnel. Refer to Figure 2, Declaration Lane Detail.

3.1.6 Frontage Roads
The Reference Schematic configuration provides continuous frontage roads beginning from Harry Hines Boulevard on the eastbound side and Denton Road on the westbound side to Midway Road. The Reference Schematic configuration also provides continuous frontage roads from Preston Road to Hillcrest Road that tie to existing frontage roads at each end.

3.2 Segment B – IH 35E / IH 635 Interchange
The Reference Schematic configuration for the IH 635/IH 35E interchange includes the elevated sections of the IH 35E northbound to IH 635 eastbound and the IH 635 westbound to IH 35E southbound connector ramps. These proposed direct connectors are added to the elements of the existing interchange with minimal impacts to the existing IH 35E main lanes. The existing interchange remains functional with the existing configuration maintained. The northbound to eastbound connector alignment was modified to reduce reconstruction of existing roadways, reduce span length, and reduce encroachments from the proposed structure foundations onto existing facilities. The westbound to southbound connector vertical alignment was revised to meet clearance requirements in the interim and ultimate configurations.

3.3 Segment C – IH 35E

3.3.1 IH 35E / Loop 12 Interchange
The Reference Schematic configuration for the IH 35E/Loop 12 interchange includes the northbound and southbound direct connectors for IH 35E and Loop 12. These proposed direct connectors are added to the elements of the existing interchange with minimal impacts to the existing IH 35E and Loop 12 main lanes. The direct connector alignments were modified to reduce reconstruction of existing roadways, reduce span length, and reduce encroachments from the proposed structure foundations onto existing facilities. Temporary transitions on retained fill sections are required at the south ends of the IH 35E and Loop 12 direct connectors. The Reference Schematic configuration is developed so that the ultimate interchange configuration could be constructed with minimal loss of interim infrastructure.
The existing local access is maintained in the Reference Schematic configuration by modifying or shifting various ramps. The existing exit ramp from northbound IH 35E to Northwest highway was realigned because the proposed northbound IH 35E direct connector cuts across the existing exit ramp. This interim ramp’s alignment avoids the widening of the existing main lane bridge over Joe’s Creek. Because the southbound IH 35E direct connector impacts the IH 35E southbound entrance ramp from Northwest Highway, a realigned entrance ramp is also provided that consists of part of the ultimate frontage road/ramp bridge over Joes’ Creek. To enhance interim traffic operations, the Loop 12 southbound exit ramp to Northwest Highway is replaced with a ramp north of the existing southbound IH 35E/Loop 12 divergence, but its design does not address the ultimate configuration operational issues. The Reference Schematic configuration also requires that the northbound IH 35E exit ramp to Mañana Road be moved south and realigned to clear the direct connector structures, but the final design was not performed and the ramp design is not included in the Reference Schematic drawings. Widening of existing main lane pavement will be required at these ramp locations.

The Reference Schematic includes the retention or addition of frontage roads in specific locations to maintain existing local access. The existing northbound IH 35E frontage road is maintained from Northwest Highway to Mañana Road. A part of the southbound Loop 12 frontage road is added to maintain access between the relocated ramp and the Northwest Highway.

3.3.2 IH 35E Elevated Direct Connectors

The Reference Schematic includes the northbound and southbound elevated direct connector roadways that parallel the existing IH 35E main lanes between the IH 35E /Loop 12 and the IH 635/IH 35E interchanges. The proposed elevated structure foundations are spaced to reduce encroachments onto existing facilities. In the Reference Schematic configuration, adding frontage roads and modifying or adding various ramps preserves the existing local access. The existing interchanges at Walnut Hill and Royal Lane are retained with minor adjustments to the ramps to avoid the elevated structures. Final design was not performed on these ramps.

Local access is also maintained by the addition of a northbound IH 35E frontage road from Walnut Hill to a proposed northbound ramp that ties to the northbound IH 35E elevated direct...
connector. An additional southbound IH 35E frontage road extends from Walnut Hill to Joe Field Road to replace the section of Joe Field Road impacted by the southbound IH 35E elevated direct connector. An exit ramp that provides access to Walnut Hill from the southbound IH 35E elevated structure is included in the Reference Schematic configuration.
CHAPTER 4 - MINED TUNNEL

4.1 General
Mined tunnels and associated underground structures include the mined tunnels for the main roadways and all intersecting and associated structures created by underground construction methods including boring, mining, microtunneling, directional drilling, raise boring, and shaft sinking. This includes, but is not limited to tunnels, cross passages, utility rooms, ventilation shafts and associated equipment rooms and duct passages, niches, sumps and low-point pump stations. Preliminary configurations of these elements are shown in the Reference Schematic drawings.

4.2 Tunnel Length and Portal Locations
Various lengths of tunnel have been studied throughout the history of the Project. The configuration represented in the Reference Schematic was designed to accomplish several objectives:

a) Extend the tunnel west of Midway Road and east of Preston Road (cross streets with grade separation structures) to lessen construction impacts to mobility at these locations.
b) Lengthen the tunnel as much as was practicable considering coordination of the overall geometric design and locations constraints for access ramps.
c) Coordinate the previous objective with the practical limitation of the extent of the Austin Chalk, considered an excellent host material for construction of tunnels of large cross-section.
d) Provide at least 20 feet of Austin Chalk between the mined tunnel invert and the top of the Eagle Ford Shale, a substantially less favorable material for tunnel construction than the Austin Chalk.
e) Orient the tunnel vertical alignment so as to minimize the distance over which the Bentonite Marker Bed would be encountered in close proximity to the tunnel crown. Earlier configurations had sloped from both ends of the tunnel to a low point near the center of the tunnel length. To accomplish this objective, the entire main portion of the tunnel was deepened, the ramp sections were lengthened, and the low point was shifted to near the east end of the tunnels with a long gentle slope rising to the west.
Based on the above discussion, the extent of the mined tunnels are depicted in the Reference Schematic.

4.3 Tunnel Rock Properties for Design

For preliminary design, geomechanical properties of each of the material layers were based on available analyses and previous modeling efforts in the Austin Chalk. The material properties used in the numerical analysis are presented below:

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Residual Soil</th>
<th>Weathered Austin Chalk</th>
<th>Fresh Austin Chalk</th>
<th>Bentonite Marker Bed</th>
</tr>
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<tr>
<td>Density</td>
<td>slugs/ft^3</td>
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<td>1.0</td>
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</table>

4.4 Tunnel Excavation

The configuration represented in the Environmental Schematic, included a tunnel estimate based on use of roadheaders to excavate the large-span, non-circular tunnel in the Austin Chalk. The majority of the tunnel was planned to be excavated in a two-pass, heading and bench approach. During the Reference Schematic development, the critical component of excavation equipment selection was re-examined in light of the increased production capabilities available with the newest roadheader machines. A second excavation technique that has been employed in the past in the Austin Chalk is excavating the tunnel bench with a pavement milling machine. The final excavation option that was considered, but not fully investigated, was to use a TBM to bore one, two, or perhaps more, circular openings through in the tunnel cross-section with the final tunnel shape being “trimmed-out “ by roadheaders. This application may prove useful to a Developer who wished to make use of a TBM already in his
fleet. It was felt to be a possibility; however, a remote one, due to the additional complexities necessarily added to the excavation sequence and potential schedule and logistics impacts.

4.5 Tunnel Initial Support

The ground classifications and initial ground support designs were developed using the empirical, analytical and numerical methods described below, and based on a review of ground support schemes from previous underground excavations in the Austin Chalk (including the Addison Toll Tunnel, DART LRT tunnel - specifically the tunnels and excavation for City Place Station, the Cole Park Detention Vaults, and the Superconducting Super Collider, SSC).

For this preliminary effort the two primary factors governing the ground response of the massive, soft, relatively low strength Austin Chalk stresses and potential stress controlled failures that can develop in response to tunnel excavation; and the location, thickness and strength of the Bentonite Marker Bed within, above and below the tunnel envelope.

This response is quite different than the mechanisms of ground response in hard rock in which stability is controlled largely by the frequency and orientation of discontinuities in the rock mass and by the characteristics and shear strength of these discontinuities. In general, available empirical design techniques are most applicable to hard rock conditions and to rock masses controlled largely by discontinuities and the presence of key blocks or wedges that must be supported. However, for this level of design, several of these techniques were still utilized and were helpful in developing design support concepts and in categorizing “ground responses” to excavation.

The analysis methods used included:

a) Recommendations for rock reinforcement length and spacing were evaluated using the US Army Corps of Engineers’ empirical rules for support.10

b) Recommendations for initial ground support including rock reinforcement length and spacing, and shotcrete thickness were evaluated using the Rock Tunneling Quality Index or “Q” system11. Ranges of input parameters were evaluated in an attempt to bound the range of ground conditions and ground support expected.
c) Rock Arch Capacity – The thickness of rock arch necessary to support the roof pressure defined by Terzaghi’s method of rock load\textsuperscript{12} was evaluated.

d) Rock Beam Analysis – When located in the crown of the tunnel, the Bentonite Marker Bed was assumed to have insufficient strength to develop a rock arch, and therefore the structural capacity of rock “beams”, located in the crown, both above and below the Bentonite Marker Bed, were evaluated.

e) Rock Dowel Capacity – a check was made to verify that the rock dowel indicated in the reference drawings would be capable of resisting forces calculated in the numerical analysis.

f) Shotcrete Thickness – a simplified analytical analysis was performed to determine the thickness of shotcrete required to support rock wedge fallout between patterned rock dowels.

In addition to these empirical and analytical techniques, the finite difference, continuum model FLAC (Fast Lagrangian Analysis of Continua) was used to develop an understanding of the overall rock mass response to excavation and to investigate the impact of the Bentonite Marker Bed on stability when located at various positions within and above the tunnel envelope. For the most part these numerical analyses were simplified and conservative where possible, and were used to identify the mechanisms of response and items to be addressed during the final design.

The following FLAC analyses were performed:

a) Elastic Analysis – Investigated the general pattern of stress redistribution and range of elastic deformation in response to tunnel excavation.

b) Pillar Analysis – Investigated the stability of the “pillar” between the two parallel mined tunnels at distance of approximately 40 ft apart, the closest spacing considered at this design level.

c) Ubiquitous Joint Analysis – Due the presence of high angle joints that occur in the weathered Austin Chalk and that extend down into the fresh Austin Chalk, an analysis was performed to investigate the impact of these planes of weakness on the stability of the mined tunnel at a shallow cover condition (i.e., portal locations).
d) Settlement Analysis – Investigated the amount of surface settlement in response to parallel mined tunnels beneath the Dallas North Tollway.

e) Bentonite in Crown of Tunnel – Investigated the ground response and mechanisms of failure in the rock mass with the Bentonite Marker Bed located above the crown of the tunnel. For this analysis, the assumed location of the bentonite above the crown was varied from approximately 1 inch to several feet. The analysis was performed in conjunction with an analysis to investigate the minimum thickness of fresh Austin Chalk in the crown required to maintain stability.

f) Bentonite in Sides of Excavation – Investigated the response of the rock mass to mined tunnel excavation when the Bentonite Marker Bed was located near springline of the tunnel cross-section.

4.6 Tunnel Final Lining
For preliminary design of the final tunnel lining, FLAC was utilized to calculate the thrusts, moments and shear forces in the lining utilizing the loadings described in previous reports. These forces where then compared to the structural capacity of the proposed final liner section and reinforcement.

4.7 Tunnel Invert and Pavement Structure
The tunnel invert in excavated Austin Chalk should permit maintenance of good conditions for trafficability with reasonable attention to handling of water inflow and grading of the excavated invert. Argillaceous zones within the Austin Chalk could result in softer invert conditions locally. The pavement structure within the mined tunnels considered for the Reference Schematic consists of gravel underdrains with piping to low-point pump stations, with a geotextile separation layer above the gravel, followed by 8-inches of stabilized base material and 13-inches of reinforced concrete pavement. This pavement structure was not designed for the Reference Schematic.

4.8 Waterproofing for Mined Tunnels and Underground Structures
For the Reference Schematic, a PVC membrane waterproofing system is assumed. This includes a layer of leveling shotcrete to ensure a suitable substrate for application of the waterproofing system. After the leveling shotcrete is applied, a layer of drainage/cushioning fabric is placed and detailed to conduct intercepted groundwater flow to the tunnel drainage
system. The PVC membrane is then placed prior to casting of the final reinforced concrete structural liner.
CHAPTER 5 - CUT-AND-COVER TUNNEL

5.1 General
Cut-and-cover tunnels, as defined in the Reference Schematic, are fully enclosed box sections. Gateway locations were based on existing ground profiles and the proposed PGL. Gateway locations were selected such that the cut-and-cover tunnel would have a minimum of one to two feet of cover above the top of the tunnel roof structure.

5.2 Structural Systems

5.2.1 General
Right-of-Way constraints, soil conditions and construction methods are the major consideration influencing selecting the structural systems for cut-and-cover facilities in the Reference Schematic design.

The horizontal alignment, tunnel horizontal clearance requirements, on/off ramps, emergency egresses, and a proposed drainage structure on the south side of the east-bound tunnel reduce available room for construction within the established ROW limits from west of Webb Chapel Road to west of Valley View Lane for the eastbound and westbound Managed Lanes tunnels. These factors prevent the use of a temporary (separate) excavation support that would result in infringement into private property. A system incorporating drilled shaft walls was therefore selected, which would be utilized as temporary excavation support as well as permanent structure.

In the east gateway portion, between Preston Road and Hillcrest Road, the tunnels are shifted sufficiently far enough from the Right-of-way that other temporary support methods may be assumed. Within this section, the Reference Schematic indicates a continuous reinforced concrete box structure with a temporary excavation support system utilizing temporary tiebacks.
5.2.2 Walls

Except for the east gateway section, the walls of cut-and-cover tunnels and transition (u-wall) sections utilize permanent tangent drilled shaft walls. The walls have been designed to resist at-rest earth pressure, hydrostatic pressure and the effects of roof structure loads. They have not been designed to resist the effects of swelling soil. The drilled shaft walls’ design was performed utilizing L-Pile software and the following soil and rock properties (note that the base slab is isolated from the walls and does not support the walls horizontally):

Table 5.2.2-1

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>WEATHERED EFS</th>
<th>WEATHERED (AS)</th>
<th>EAGLE FORD SHALE (ES)</th>
<th>AUSTIN CHALK (AS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Wt.</td>
<td>63 pcf</td>
<td>78 pcf</td>
<td>78 pcf</td>
<td>78 pcf</td>
</tr>
<tr>
<td>E</td>
<td>10,000 psi</td>
<td>70,000 psi</td>
<td>73,000 psi</td>
<td>450,000 psi</td>
</tr>
<tr>
<td>qu</td>
<td>72 psi</td>
<td>500 psi</td>
<td>200 psi</td>
<td>1,000 psi</td>
</tr>
<tr>
<td>RQD</td>
<td>75</td>
<td>75</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Krm</td>
<td>0.0005 in/in</td>
<td>0.0005 in/in</td>
<td>0.0001 in/in</td>
<td>0.00005 in/in</td>
</tr>
</tbody>
</table>

Results of L-Pile analysis indicate that tangent, 3'-0” diameter reinforced concrete drilled shafts are adequate to resist at-rest earth pressures, hydrostatic pressures, and roof structure loads. Larger diameter piles will be required to resist the effects of swelling soils. Tangent, 3’-6” diameter reinforced concrete drilled shafts are required for cantilevered transition (u-wall) sections that are up to 20- ft high, without transverse permanent struts.

The drilled shaft embedment length was determined using L-Pile software and the soil properties shown in Table 3.3.2. All drilled shafts are embedded in Austin Chalk or Eagle Ford Shale. Minimum embedment of the drilled shafts used in cut-and-cover tunnels and transition (u-wall) sections with permanent struts is 6.0 ft for Austin Chalk and 11.0 ft for Eagle Ford Shale. Drilled shaft embedment for transition (u-wall) sections without struts, embedded in Eagle Ford Shale or residual soils derived from Eagle Ford, is equal to length of shaft above the roadway slab.
5.2.3 Roof Structure

Roof structure alternatives for cut-and-cover tunnels with drilled shaft walls are simple span structures. The following alternatives are shown on the Reference Schematic drawings:

a) Cast-in Place Reinforced Concrete Slab
b) Precast, Prestressed Box Girders with Composite Cast-in-Place Slab
c) Precast, Prestressed AASHTO Girders with Composite Cast-in-Place Slab
d) Structural Steel Sections or Plate Girders with Composite Cast-in-Place Slab

The first two options are economical for spanning the typical section, while the third and fourth options are appropriate for the much longer spans.

5.2.4 Base Slab

The roadway slab for all cut-and-cover tunnels that utilize drilled shaft walls is isolated from the walls. The width of the isolation joint must be sufficient to accommodate movements caused by swelling soils. The Reference Schematics indicate a reinforced concrete slab approximate 13 in. thick with no wearing surface. A roadway base and a drainage course and drain pipes to relieve groundwater from below the slab are also shown. The pavement structure was not designed for the Reference Schematic.

5.3 Waterproofing

The Reference Schematic depicts a conceptual method for control of ground water as described below.

Cut-and-cover tunnels with permanent drilled shaft walls include a pressure relief system whereby groundwater adjacent to walls and base slab is drained to a low-point pump station. Drilled shaft walls include slotted PVC pipes between drilled shafts, surrounded by free-draining material and drainage composite all of which extend to below the roadway slab. Below the base slab, free-draining material and drainpipes collect water and channel it to low point pump stations.

The roof structure of cut-and-cover tunnels with permanent drilled shaft walls, and continuous reinforced concrete cut-and-cover tunnels are shown waterproofed with HDPE (sheet)
membrane waterproofing. The membrane could be of the type that fully adheres to concrete such that localized defects will not allow water to propagate beneath the membrane. A liquid membrane could also be utilized.
CHAPTER 6 - TRANSITION U-WALL

6.1 General

Transition (u-wall) sections, are subsurface structures without a continuous roof structure. Depending on wall depth and soil pressure magnitude, permanent struts and wales are required near the tops of walls. All transition (u-wall) sections shown in the Reference Schematic are shown with Drilled Shaft walls.
CHAPTER 7 - BRIDGE STRUCTURES

7.1 General
For ramps and direct connectors, the bent locations are proposed in coordination with roadway geometry and the need to minimize the number and size of straddle bents or asymmetric single column bents. For cross street bridges, bent locations were proposed in coordination with roadway and managed lanes tunnel geometry. The general substructure is single column bents for the direct connectors and elevated managed lane structures that vary in size based on overall roadway width. The bent caps are inverted “T” type with a constant ledge thickness for multicolumn bents and varying ledge thickness on the longer cantilevers of the single column bent caps. The foundations for all of the structures are drilled shafts with pile caps of different sizes based on column size and corresponding roadway width. The superstructure for all bridges are Type U-40 or Type U-54 prestressed concrete beams or precast, segmental box beam structures. The assumed superstructure depth of the Type U-40 and U-54 is 4.17ft and 5.33ft, respectively plus any additional depth required by the cross slope (superelevation).

The preliminary sizes of the segmental box beam superstructure were established using FHWA Article 6.0 General guidelines for Preliminary Design for Segmental Concrete Box Girder Superstructure\textsuperscript{13}.

7.2 IH 35E/Loop 12 Interchange
The direct connectors proposed in the Reference Schematic are the northbound and southbound structures for IH 35E and Loop 12. The direct connectors are proposed as additions to the existing interchange and are continuations of the elevated direct connector roadways along IH 35E. These structures are coordinated with ultimate configuration requiring only minor modifications at the tie-in points. The northbound IH 35E connector is a single lane (28-ft overall width) bridge and the remaining structures are 2-lane (40-ft overall width) bridges.

The gore between the northbound Loop 12 connector and the northbound IH 35E connector was relocated from the location shown in the Environmental Schematic to reduce the main span length from approximately 400 ft to 330 ft. The reduction in span length allowed the overall structure depth to be reduced to approximately 16’ 6” from 20’ 0” for the segmental box beam superstructure. This realignment also required the exit ramp to Manana Drive to be relocated to the south.
The southbound connector to IH 35E from the managed lane structure also is shifted to avoid column encroachment onto the existing southbound IH 35E main lanes. This shift allowed the use of Type U-54 prestressed concrete beams throughout the structure. It was assumed that the spans over the Loop 12 main lanes would utilize false bents during construction to lengthen the spans to approximately 150 ft. The segmental box beam spans are estimated at a depth of L/40 (330ft / 40 = 8.25ft) for midspan and corresponding end span depths and L/20 (330ft / 20 = 16.5ft) for the depth at the interior bents of the units.

The assumed columns are 5ft x 6ft for the northbound IH 35E structure, 5ft x 8ft for the other structures, except at the segmental box beam superstructure section, which requires the use of 5ft x 12ft columns.

7.3 IH 35E Elevated Direct Connectors
The elevated direct connectors along IH 35E are structures that directly connect IH 35E and Loop 12 main lanes to the managed lane tunnels along IH 635. The connectors are generally on the same alignment that is shown in the Environmental Schematic, except for revisions near the entrance and exit ramps that pass under the elevated connectors. The changes allow the span lengths to be reduced and columns to be placed between the main lanes and frontage roads. The reduction of span and introduction of a minimum number of asymmetric bents allowed the use of Type U-54 prestressed concrete beams throughout the structure. A few spans require support during construction at ramp locations. However, because of the proposed ramp relocations, there is minimal impact to existing traffic.

The structures are typically 56 ft wide overall and are supported by single column bents with 5 ft x 12 ft columns. In the areas where straddle bents are required column sizes are generally 5 ft x 4.5 ft.

7.4 IH 635 / IH 35 Interchange
The existing interchange will be left intact, but a westbound to southbound connector and a northbound to eastbound connector are added to the interchange. The connectors tie the elevated IH 35E direct connectors to the managed lanes west of Josey Lane. The connector alignments and foundations are designed for both the existing and ultimate configurations.
To minimize the span lengths for the westbound to southbound connector, one column is placed at the centerline of IH 635 and will require the alignments of the East/West HOV lanes to be modified. These alignment revisions have not been included in the Reference Schematic.

The Reference Schematic connectors have stub-outs at the gore locations to allow future construction of the west to north and the north to west connectors. The typical sections for the interim connectors are the same as the elevated managed lane structures along IH 35E. The structure depths for the segmental box beam spans on the west to south connector are the same as described in the IH 35E/Loop 12 Interchange. The portions of the structures along IH 635 primarily have multicolumn bents and are up to 5 lanes wide. These structures are all Type U-54 prestressed concrete beam spans.

7.5 IH 635

The traffic management during interim and ultimate configuration construction dictates that portions of the ultimate configuration to be constructed as part of the interim configuration. The structures replaced in IH 635 corridor will be Type U-54 or Type U-40 superstructures with inverted “T” bent caps and typically 5ft x 6ft column. The horizontal placement of bents is controlled by the geometry of the intersection and sometimes by the traffic control sequence. The bent foundations are in some cases the same drilled shafts used as the support structure for the cut-and-cover tunnel sections or u-wall sections.

The Denton Drive / DART Overpass requires widening of the westbound lanes to allow the facilities for the managed lanes and the main lanes to be operational. This structure will be widened with like superstructure and bent types.

The Josey Lane overpass is replaced by the ultimate configuration structure that includes the ramp/bypass structures, the main lane structures, and the managed lane structures.

The Webb Chapel Road overpass will be reconstructed in the interim configuration to allow the construction of the u-wall/cut-and-cover tunnel sections and the realignment of the frontage roads. This structure will be constructed to accommodate the ultimate configuration.
The Joe Ratcliff Walkway is replaced utilizing Type U-40 beams and span lengths that allow the minimum structure depth and still maintain consistency in the corridor.

The Marsh Lane and Rosser Road underpasses will be replaced to provide connection to new frontage roads and allow the construction of tunnel segments below. These structures require the use of the drilled shaft foundations for the tunnel or retaining wall section to also support the underpass. The Rosser Road underpass requires the use of Type U-40 beams to maintain proper clearance at the new frontage roads and the existing main lanes.

The eastbound Valley View overpass bridge is widened with the same cast-in-place slab/frame structure to allow the construction of a relocated ramp from Rosser Road to merge with the main lanes. The westbound frontage road will also be added and the north half of the ultimate frontage road structure will be constructed. The width and beam spacing of this structure is based on the ultimate structure configuration.

The Hillcrest Road overpass is constructed as shown in the ultimate configuration to facilitate the construction and connection of the manage lane tunnels to the surface west of the DHF.

The Park Central Drive / White Rock Creek overpass is also constructed to the ultimate configuration to complete the connection of the managed lane facilities to the DHF and the IH 635 main lanes.
CHAPTER 8 - TUNNEL ELECTRICAL AND MECHANICAL SYSTEMS

8.1 General
Three critical areas associated with roadway tunnel electrical are lighting, power supply and distribution, and Supervisory Control and Data Access (SCADA)/controls. Fire and Life Safety requirements within NFPA 502 provide the guidelines for roadway tunnel electrical needs and power supply reliability. Additional detail pertaining to the three major areas is provided in the subsections below.

8.2 Tunnel Electrical Design Tasks Overview
Tunnel Electrical efforts during the Reference Schematic preliminary design include the following:

a) Sizing of light fixtures and determination of approximate number of lights required for the Reference Schematic tunnel configuration
b) Sizing light fixtures and determination of approximate number of surface roadway lights
c) Determination of approximate power loads based on all electrical needs including ventilation fans, etc.
d) Determination of a potential main power supply and emergency power electrical system and layout
e) Development of a preliminary Power supply diagram for Reference Schematic
f) Development of a preliminary SCADA functional diagram for the Reference Schematic
g) Preliminary layout of a typical power center
h) Preliminary sections for cut-and-cover and Mined Tunnel cross sections with electrical components.

8.3 Tunnel Lighting

8.3.1 Calculations
Calculations were prepared to estimate the lighting requirements of the Project. Preliminary design was based on the ANSI / IESNA RP-22-96, Recommended Practices for Tunnel Lighting\textsuperscript{14}. 
8.3.2 Baseline Fixture Choice
For purposes of estimating costs for lighting the roadway u-wall sections of the Project, it was assumed that fixtures would be mounted in a staggered configuration across the roadway. Based on current industry standards, a tunnel lighting system was used that utilized fluorescent and HID fixtures. The fluorescent fixture type and the high intensity discharge (HID) fixture type used as our basis for preliminary design was chosen for its ability to withstand the harsh conditions found in a tunnel environment along with its ease of maintenance.

8.4 SCADA System
The major characteristics for the Reference Schematic preliminary design for SCADA are as follows:

a) The SCADA system will monitor and control various life safety equipment. The system must function under all operating conditions.

b) A dual ring topology will ensure that at least one data path between each field node and the server node is always available. All hardware is redundant.

c) Only equipment necessary for life safety is being monitored.

d) Monitoring equipment may be connected directly to the backbone; or it may be connected to an intermediary distributed I/O cabinet.

8.5 Electrical System
The following describes components and characteristics of the Reference Schematic.

8.5.1 Tunnel Electrical Demand
The tunnel ventilation system baseline for the Reference Schematic is a longitudinal system incorporating in-tunnel jet fans and vane axial fans located at ventilation structures along the tunnel length.

8.5.2 Tunnel System Electric Utility Service
Major electrical utility improvements are anticipated in order to bring two (2) separate sources, each capable of carrying the entire tunnel demand load to the site.
Improvements, extending as far as two (2) miles into TXU’s electrical distribution network may be necessary to handle the demand load.

For source reliability and redundancy the tunnel electrical service must meet the NFPA 502 requirement to maintain two (2) separate sources of power to all life safety and/or emergency loads throughout the tunnel length. The utility should be required to certify that the sources brought in to the Project meet these requirements.

The primary distribution system configuration is based on the requirement to furnish a service and distribution system at a voltage level commensurate with the demand and the availability of service from TXU Electric Delivery.

The secondary distribution system configuration is based on a secondary selective system with both Source “A” and Source “B” made available to all distribution substations serving the tunnel and tunnel ancillary facility essential systems.

The electrical power system classification is based on the need to serve three (3) distinct classifications of loads: essential, standby and emergency.

a) Essential loads are those loads that have a supply requirement for two (2) separate and distinct sources of power.

b) Standby loads are those loads that have been deemed to offer enhanced tunnel and tunnel ancillary facility operations and protection through their continued availability during a total loss of commercial (utility) electrical supply.

c) Emergency loads are those loads legally required and classed as emergency to meet municipal, state, federal or government codes, or to meet any authority having jurisdiction requirements.
8.6 Tunnel Ventilation System

8.6.1 General Background Information

The tunnel ventilation system is a critical life safety system that is used to provide a tenable environment during normal operations of the tunnel and to remove and control smoke and heated gases in the event of a tunnel fire event.

The ventilation system design concept has been developed with the goal of identifying a system concept that will meet the design requirements. The design of the ventilation system utilized many fundamental assumptions that will require re-evaluation as the Project evolves. The ventilation system design was generated using basic tunnel ventilation system design tools and it is expected that the developer’s final design will be generated through the latest technology such that the system can be optimized. The ventilation system conceptual design prepared for and reflected in the Reference Schematic was not optimized due to conceptual nature of the design effort and in no way represents a final design configuration.

8.6.2 Assumptions

The tunnel alignment shown on the mechanical plans was used for the conceptual level design effort; however the current tunnel alignment, which is shown on the civil and structural plans within the Reference Schematic, is different and was not analyzed from a tunnel ventilation perspective. The latest configuration includes tunnel profile and alignment changes, as well as portal location changes and cut-and-cover tunnel height changes, all of which must be reconciled in any further systems design on this configuration.

The analyzed tunnel alignment includes eastbound and westbound tunnels with both mined and cut-and-cover construction types. These tunnels are relatively long from a tunnel ventilation standpoint (approximately 4.8 miles) and therefore present many challenges with respect to the ventilation system design.

8.6.3 Design Standards & Design Objectives

The governing standard for the design of tunnel ventilation systems in the United States is the NFPA 502. The design fire size (heat release rate) produced by a vehicle within the tunnel is a major element used to design the emergency ventilation system. The selection of the design fire size shall consider the types of vehicles that are expected to utilize the tunnel. The fire heat
release rate for this Project was originally identified as 20 MW. Many tests performed in Europe indicate that bus fires are 30 MW or higher and other recent research performed in Europe indicates that heavy goods vehicle fires can reach up to 100 MW. A fire size of 30 MW was utilized for the preliminary ventilation system conceptual design for the Project.

8.6.4 Other Design Considerations - Vehicle Distribution

The Vehicle Class Distribution Table (Table 8.6.4-1) below is provided in March 2002 Traffic and Revenue Study 25 was used in determination of the traffic makeup to utilize for the ventilation system design.

<table>
<thead>
<tr>
<th>Location/Period</th>
<th>Vehicle Type</th>
<th>Average Hourly</th>
<th>Light Trucks</th>
<th>Heavy Trucks</th>
<th>Total</th>
<th>Average Hourly</th>
<th>Light Trucks</th>
<th>Heavy Trucks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Highway</td>
<td>80.710</td>
<td>12.87%</td>
<td>15.38%</td>
<td>28.26</td>
<td>15.38%</td>
<td>28.26%</td>
<td>15.38%</td>
<td>28.26</td>
</tr>
<tr>
<td></td>
<td>others</td>
<td>30.069</td>
<td>4.93%</td>
<td>7.56%</td>
<td>11.49</td>
<td>7.56%</td>
<td>11.49%</td>
<td>7.56%</td>
<td>11.49</td>
</tr>
<tr>
<td>MONTFORT DR</td>
<td>AM Peak</td>
<td>46.066</td>
<td>18.24%</td>
<td>12.90%</td>
<td>26.33</td>
<td>12.90%</td>
<td>26.33%</td>
<td>12.90%</td>
<td>26.33</td>
</tr>
<tr>
<td></td>
<td>Highway</td>
<td>80.710</td>
<td>12.87%</td>
<td>15.38%</td>
<td>28.26</td>
<td>15.38%</td>
<td>28.26%</td>
<td>15.38%</td>
<td>28.26</td>
</tr>
<tr>
<td></td>
<td>others</td>
<td>30.069</td>
<td>4.93%</td>
<td>7.56%</td>
<td>11.49</td>
<td>7.56%</td>
<td>11.49%</td>
<td>7.56%</td>
<td>11.49</td>
</tr>
<tr>
<td>ABRAMS RID-FOREST LN</td>
<td>AM Peak</td>
<td>29.467</td>
<td>10.73%</td>
<td>3.31%</td>
<td>14.04</td>
<td>3.31%</td>
<td>14.04%</td>
<td>3.31%</td>
<td>14.04</td>
</tr>
<tr>
<td></td>
<td>Highway</td>
<td>80.710</td>
<td>12.87%</td>
<td>15.38%</td>
<td>28.26</td>
<td>15.38%</td>
<td>28.26%</td>
<td>15.38%</td>
<td>28.26</td>
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<tr>
<td></td>
<td>others</td>
<td>30.069</td>
<td>4.93%</td>
<td>7.56%</td>
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<td>7.56%</td>
<td>11.49%</td>
<td>7.56%</td>
<td>11.49</td>
</tr>
<tr>
<td>LA PRADA LN</td>
<td>AM Peak</td>
<td>26.106</td>
<td>9.97%</td>
<td>2.70%</td>
<td>12.67</td>
<td>2.70%</td>
<td>12.67%</td>
<td>2.70%</td>
<td>12.67</td>
</tr>
<tr>
<td></td>
<td>Highway</td>
<td>80.710</td>
<td>12.87%</td>
<td>15.38%</td>
<td>28.26</td>
<td>15.38%</td>
<td>28.26%</td>
<td>15.38%</td>
<td>28.26</td>
</tr>
<tr>
<td></td>
<td>others</td>
<td>30.069</td>
<td>4.93%</td>
<td>7.56%</td>
<td>11.49</td>
<td>7.56%</td>
<td>11.49%</td>
<td>7.56%</td>
<td>11.49</td>
</tr>
</tbody>
</table>

The Marsh Lane Peak Hour traffic mix was the traffic mix utilized as the expected traffic makeup of vehicles within the tunnel. Table 8.6.4-2 represents the traffic mix that was used in the emissions analysis portion of the ventilation system design. The emission analysis was performed for the idle traffic condition (or moving at 2.5 mph).

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Percentage</th>
<th>Cars</th>
<th>Heavy Trucks</th>
<th>Light Trucks/Buses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>93.02%</td>
<td>3.58%</td>
<td>3.4%</td>
<td></td>
</tr>
</tbody>
</table>

* Assumed that 3.4% of busses/trucks consisted of 1.4% school busses and 2% transit and urban busses.
8.6.5 Tunnel Ventilation System Modeling

The basic computational model utilized for the conceptual level ventilation system is the US Department of Transportation’s Subway Environmental Simulation program (USDTSES). This program was developed for subway tunnel ventilation systems, however there are modeling techniques commonly used that adapt the program for modeling road tunnel ventilation systems. The conceptual level ventilation system design proposed is a combination of an ejection type system with capabilities to exhaust air along the tunnel; however it also is supported by a jet fan ventilation system. A ventilation system must generate sufficient longitudinal air velocity to prevent back layering of smoke (movement of smoke and hot gases against ventilation airflow in the tunnel roadway). The ventilation system conceptual design consists of small vent structures that are combined with the emergency evacuation stair structures and are distributed along the tunnel at 1000 ft intervals. The vent structures house one or two axial flow tunnel ventilation fans of approximately 220,000 CFM that may operate via a two-speed motor or a variable frequency drive to conserve energy during normal operation. The fans are capable of delivering a volume of 220,000 CFM which, when distributed at 1000’ intervals across 3 lanes, equates to approximately 73 CFM/lane/foot of fresh air into the tunnel. The fan also will have exhaust capabilities of the approximately the same volume. The configuration of the fan and dampers within the vent structure allow the fan to perform either the supply or the exhaust mode, while operating in one direction, however the fan arrangement does not allow for the vent structure to both supply air to, and exhaust air from the tunnel simultaneously.

The system is supported with reversible jet fans that will aid in:

a) Ejecting air from the entrance portal  
b) Improving the supply ejection nozzle operation  
c) Mitigating the adverse wind effect  
d) Meeting and maintaining the critical air velocities  
e) Reversing the tunnel airflow if and when necessary for fire fighting operations  
f) Meeting the safety requirements at tunnel ramps
Based upon the results of initial simulations with the US EPA’s Subway Environmental Simulation (SES) analysis, the following tunnel ventilation system concept was developed for the particular tunnel alignment shown on the mechanical Reference Schematic drawings:

   a) Equip every emergency stair structure with mechanical/electrical rooms and house a single uni-directional multi-speed tunnel ventilation fan in each structure;
   b) Provide the first ventilation structure at approximately 1000’ from the west end of the cut-and-cover tunnel.
   c) Locate 4-ft diameter jet fans in sets of three in a row along the tunnel as follows:
      • At a 300-ft distance apart between the entrance portal (west gateway) and first vent structure, located approximately 1000’ into the cut-and-cover tunnel
      • At a distance of 500’ apart for the next 2000’ (near the first exit ramp)
      • Next to each of the ventilation structures going east until the alignment passes Rosser Road
      • Locate two jet fans in a row at each ramp. (Further analysis on ramp ventilation will be required when detailed ramp information is available).

The following mechanical plan descriptions identify in general the tunnel ventilation plans that are included as a part of the Reference Schematic:

   a) Tunnel plans with the locations of vent structures and jet fans in Eastbound Tunnel. Westbound Tunnel jet fans are shown, however this analysis has not been optimized to reduce the jet fan quantity, which may be possible.
   b) A typical tunnel cross section shows the minimum vertical clearance to accommodate the jet fans, the jet fan installation details and vehicle clearance criteria.
   c) Tunnel cross passage ventilation details.
   d) Two different emergency egress stair structure configurations are shown, with tunnel ventilation fans (single or dual fan), fan room arrangement and other mechanical equipment.
8.6.6 Tunnel Fire Ventilation Analysis Results

Several iterations were necessary to analyze the tunnel ventilation system for fire emergencies. The basic method of analyzing the fire scenarios was to select fire locations that are known to be the worst cases, while analyzing other fire locations to confirm the suspected worst-case fire locations and confirm that in all cases the critical velocity criteria required per NFPA 502 were met.

8.6.7 Vehicular Emissions

The tunnel ventilation system is a critical system for controlling smoke propagation during a fire emergency; however it also has a critical role during normal operation of the tunnel. The tunnel ventilation system is relied upon to dilute and/or remove vehicular emissions such that safe conditions are maintained within the tunnel.

a) Acceptable Levels of Vehicular Emissions

Table 8.6.7-1 represents the EPA’s 1989 recommendations for the maximum CO levels in tunnels located at or below an altitude of 5000 ft\(^{19}\).

<table>
<thead>
<tr>
<th>Maximum Exposure of Carbon Monoxide (CO), (parts per million)</th>
<th>Duration of Exposure (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>15</td>
</tr>
<tr>
<td>65</td>
<td>30</td>
</tr>
<tr>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>35</td>
<td>60</td>
</tr>
</tbody>
</table>

Tunnels that are staffed 24 hours per day fall under the jurisdiction of the US Occupational Safety and Health Association (OSHA) requirements. OSHA has established the Threshold Limit Value (TLV) as adopted by the American Conference of Governmental and Industrial Hygienists, as the environmental level for the working environment. These permissible levels can be applied to the tunnel environment. Table 8.6.7-2 below illustrates the application of these time-weighted averages to the tunnel environment.
Table 8.6.7-2 Permissible Excursions as applied to Tunnel Environment

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Threshold Limit Value (TLV)</th>
<th>Permissible Excursion limit (ppm)</th>
<th>Short Term Excursion Limit (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>50</td>
<td>75</td>
<td>400</td>
</tr>
<tr>
<td>Nitric Oxide (NO)</td>
<td>25</td>
<td>37.5</td>
<td>35</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>


b) Vehicular Emissions Predictions-General

Vehicle emissions of CO, oxides of nitrogen (NOx), and hydrocarbons (HC) for any given calendar year can be predicted for cars and trucks operating in the US by using the MOBILE modeling software developed by the US Environmental Protection Agency. The current version is MOBILE 6 (EPA 2002). The MOBILE program is used to estimate HC, CO, and NOx emission factor for gasoline fueled and diesel engine vehicles. The program estimates the current and future emissions from various types of highway vehicles. The estimates of emissions are based upon factors such as ambient temperature, vehicle speed, vehicle age, and based upon the calendar year 2015 (anticipated opening date). The MOBILE program produces the resulting contaminant emission rates in grams per mile per vehicle.

The following practice and assumptions typically are used when performing the contaminant emission rate analysis:

- CO emissions are higher during accelerations and deceleration than at constant speed. This affect is accounted for by adding a 10% safety factor to the computations.
- The affect of negative or positive grades up to 2% is usually neglected. Engineers should use judgment or available data in applying correction factor for positive grades greater than 2%. This Project will utilize a 4% factor due to the grades in the working schematic.
- Traffic is assumed to move as a unit, with a constant space interval between vehicles, regardless of the grade.
• The average passenger vehicle dimensions are assumed where specific vehicle data is unavailable.
• A general practice safety factor can be applied due to various levels of uncertainty for the Project. The Reference Schematic will utilize a 10% factor to account for the unknowns associated with this conceptual level analysis.

c) Vehicular Emissions Results
The analysis was performed using idle traffic conditions (0-2.5 mph) for summer time, and using the traffic mix previously identified. The results indicate an average CO emission for the summer season of 17.1 grams/mile/vehicle and average NOx emissions of 1.191 grams/mile/vehicle. The winter season emissions are less from previous sensitivity analyses conduct for other tunnels. The results that have been adjusted via the previously mentioned correction factors for acceleration/deceleration, grade, are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Carbon Monoxide (CO) gram/veh/mile</th>
<th>Oxides of Nitrogen (NOx) gram/veh/mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOBILE 6.2 Base Result</td>
<td>17.1</td>
<td>1.191</td>
</tr>
<tr>
<td>With Acceleration &amp; Deceleration Adjustment: +10%</td>
<td>18.8</td>
<td>1.31</td>
</tr>
<tr>
<td>With Tunnel Grade Adjustment: +3%</td>
<td>19.5</td>
<td>1.36</td>
</tr>
<tr>
<td>With General Safety Factor Adjustment: + 10%</td>
<td>21.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

d) Dilution of Contaminants
The tunnel ventilation system must dilute the vehicle emissions sufficiently over the length of the tunnel such that acceptable levels are maintained within the tunnel. This review entails a calculation of the total contaminant level in the tunnel as well as calculation of the air volume necessary to provide sufficient dilution. The ventilation system’s dilution effectiveness requires various iterations of ventilation shaft locations, fan sizes, and fan operating modes to ultimately determine a ventilation scheme that
meets the dilution requirements. In the case of the specific alignment depicted in the Reference Schematic, the ventilation system’s capacity to handle fire emergencies was less than that required to provide the necessary dilution air. Many portions of the tunnel ventilation system design concept were required due to the air volume necessary for contaminant dilution.

The conceptual level design did not include a stack emissions analysis to determine the impacts or contaminant levels in the areas adjacent to the ventilation stacks. There were no environmental criteria identified at the conceptual level, therefore no consideration was given to this aspect of the system design.

8.6.8 Ambient Temperature Within the Tunnel

a) General Background
The hot climate in the Dallas area and the expectation of congested traffic/stopped traffic within the tunnel require consideration to be given to the expected ambient temperature in the tunnel. The outdoor air design data, based upon American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) design data, identifies the summer outdoor air design dry bulb temperature as 105° F and the wet bulb temperature as 74° F. Preliminary calculations were performed for congested or stopped traffic conditions occurring in the summer season, to determine if the heat input to the tunnel from vehicle exhaust and air conditioners. The amount of heat input to the tunnel cannot be cooled with 105° F supply air delivered by the ventilation system at rates that accommodate the CO dilution and fire emergency requirements. A significant increase in the ventilation system capacity would be necessary to cool the tunnel with supply air at a temperature of 105° F therefore a cooling system may be warranted.

NFPA 502 identifies the maximum tunnel ambient temperature during fire incidents to be 140° F. The ASHRAE Handbook for underground facilities does not list a maximum acceptable ambient temperature for underground roadway tunnels; however there is some general information available regarding underground subway stations. Since there is no specific temperature requirement, the design temperature used was 105° F as defined by the “Apparent Temperature”, which defines various temperature and humidity combinations. Further information regarding these criteria is provided below.
b) Ambient Temperature Criteria within the Tunnel

The heat index combines the effects of heat and humidity. Overheating can cause serious, even life-threatening conditions such as heat stroke. The apparent temperature, which combines the temperature and relative humidity, is a guide to the danger of heat and humidity. Table 8.6.8-1 is the heat stress index based on the apparent temperature.

<table>
<thead>
<tr>
<th>Category</th>
<th>Apparent temperature</th>
<th>Dangers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caution</td>
<td>80-90°F</td>
<td>Exercise more fatiguing than usual</td>
</tr>
<tr>
<td>Extreme caution</td>
<td>90-105°F</td>
<td>Heat cramps, exhaustion possible</td>
</tr>
<tr>
<td>Danger</td>
<td>105-130°F</td>
<td>Heat exhaustion likely</td>
</tr>
<tr>
<td>Extreme danger</td>
<td>Greater than 130°F</td>
<td>Heat stroke imminent</td>
</tr>
</tbody>
</table>

Based on Table 8.6.8-1 and Heat Index Table, Figure 8.6.8-1, we suggest an “apparent temperature” of 105° F as an ambient design temperature for inside the tunnel during worst case traffic scenarios; and also requiring the fire scenario ambient temperature to not exceed 130° F (normal temperature) per the NFPA 502 design criteria.
Figure 8.6.8-2 is a modified psychrometric chart to indicate an extreme danger zone, a danger zone and outside design conditions. It is desirable to stay within the extreme caution zone, avoiding the danger zone and never getting to the extreme danger zone under normal operating conditions, hence the use of the 105°F Apparent Temperature Criteria.
Figure 8.6.8– 2 Psychrometric Chart\textsuperscript{20}
CHAPTER 9 - ANCILLARY TUNNEL FACILITIES

9.1 General
Ancillary Tunnel Facilities are essential secondary structures that are required to support the primary function of the tunnel, that being to move vehicles. Ancillary Tunnel Facilities include the following:

a) Emergency Exits  
b) Ventilation Shafts  
c) Utility Rooms  
d) Structures Combining Emergency Exits, Ventilation Shafts, Utility Room  
e) Cross Passages  
f) Low-Point Pump Station

9.1.1 Emergency Exit  
NFPA 5028 requires emergency exits at specified spacing. For cut-and-cover tunnel facilities, the Reference Schematic includes thirteen emergency exits adjacent to north side of westbound tunnel and thirteen emergency exits adjacent to south side of eastbound tunnel. Emergency exits to surface are pressurized to protect the exiting public from smoke. Stair widths are 6 ft wide, based on preliminary calculations that indicate 275 people exiting during an emergency event. A head-house is included at surface level to facilitate exit and safety.

9.1.2 Ventilation Shaft  
Two ventilation shafts are anticipated at each of the ventilation rooms. A 10’ x 10’ inside dimension is assumed. The ventilation shafts provide the path for air to pass between the roadway level ventilation equipment and the above grade air. The height of the ventilation structure above grade has not been confirmed. The assumed height is 12’.

9.1.3 Utility Room  
Roadway level utility rooms are provided at intervals of 325 to 500 feet along each of the Reference Schematic managed lane tunnels. The rooms are located at roadway level and anticipated to be a minimum inside dimension of 12’x12’. The purpose of the room is to house electrical distribution equipment.
9.1.4 Structures Combining Emergency Exits, Ventilation Shafts, Utility Room

Two major elements of the design were identified during preparation of the Reference Schematic. The two elements are the large number of required ancillary items and lack of available space between the tunnels and the ROW line. To mitigate the impact of the number of ancillary spaces required, various functions were combined into one ancillary structure. Two layouts for the combined structure containing functions for the ventilation equipment, ventilation shafts, utility rooms, and emergency exit stairs are included in the Reference Schematic drawings. The combined structure has a long and narrow configuration to minimize space requirements outside of the cut-and-cover tunnel limits.

9.1.5 Cross Passage

Cross passageways are added to the Reference Schematic, per NFPA 5028, where the tunnel alignments are located closer to each other. The indicated cross passageways are wide enough for two self-closing swing doors, with one opening in each direction. Utility rooms may be located off of a cross passageway. A removable panel above the 1-hour rated fire doors is indicated for the possibility of moving equipment to utility rooms. SCADA points for the doors, lighting, and pressurization of the interior space is anticipated. Cross passageways are shown on cut-and-cover mined tunnel, mechanical, and electrical Reference Schematic drawings.

9.1.6 Low-Point Pump Station

Low-Point Pump Stations, as the name implies, are located at low-points in the alignment profile. Their function is to collect groundwater and water from other sources and discharge it to outside drains by means of pumps. Low Point Pump stations are an essential component of the pressure relief system. Groundwater from walls and base slab drains by gravity to Low Point Pump Station where it is retained and then pumped-out by means of electrically controlled submersible pumps. Hatches for Low Point Pump Stations, needed to remove and/or maintain pumps, are located either out of the traffic lanes or in the center of a traffic lane to maximize distance from live traffic in adjacent lanes.
CHAPTER 10 - DRAINAGE

10.1 Drainage Design Criteria

A summary of the drainage design criteria is presented in Table 10.1-1.

Table 10.1-1 Drainage Design Criteria

<table>
<thead>
<tr>
<th>Description</th>
<th>Mainlines</th>
<th>Managed Lanes</th>
<th>Direct Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadway Classification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Urban</td>
<td>Urban</td>
<td>Urban</td>
</tr>
<tr>
<td><strong>Method for Determining</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peak Runoff</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Culvert Crossings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Storm&lt;sup&gt;[4]&lt;/sup&gt;</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
</tr>
<tr>
<td>Check Storm&lt;sup&gt;[4]&lt;/sup&gt;</td>
<td>100-year</td>
<td>100-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Headwater Control&lt;sup&gt;[5]&lt;/sup&gt;</td>
<td>&lt; Or = Existing Headwater Elevation</td>
<td>&lt; Or = Existing Headwater Elevation</td>
<td>&lt; Or = Existing Headwater Elevation</td>
</tr>
<tr>
<td>Maximum Outlet Velocity&lt;sup&gt;[6]&lt;/sup&gt;</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
</tr>
<tr>
<td>Minimum Outlet Velocity&lt;sup&gt;[7]&lt;/sup&gt;</td>
<td>2 and 2.5 fps</td>
<td>2 and 2.5 fps</td>
<td>2 and 2.5 fps</td>
</tr>
<tr>
<td><strong>Storm Sewers and Inlets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Storm&lt;sup&gt;[6]&lt;/sup&gt;</td>
<td>50-year</td>
<td>50-year</td>
<td>50-year</td>
</tr>
<tr>
<td>Check Storm&lt;sup&gt;[6]&lt;/sup&gt;</td>
<td>100-year</td>
<td>100-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Design Storm Allowable Ponding Width&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>No encroachment into the travel lanes</td>
<td>2 feet of encroachment into the travel lanes</td>
<td>2 feet of encroachment into the travel lanes</td>
</tr>
<tr>
<td>Check Storm Allowable Ponding Width&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>One lane free of encroachment</td>
<td>One lane free of encroachment</td>
<td>One lane free of encroachment</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Pipe Material&lt;sup&gt;[10]&lt;/sup&gt;</td>
<td>Concrete</td>
<td>Concrete</td>
<td>Concrete</td>
</tr>
<tr>
<td>Minimum Pipe Size&lt;sup&gt;[11]&lt;/sup&gt;</td>
<td>18 and 24 inch</td>
<td>18 and 24 inch</td>
<td>18 and 24 inch</td>
</tr>
<tr>
<td>Minimum Pipe Velocity&lt;sup&gt;[12]&lt;/sup&gt;</td>
<td>2 fps</td>
<td>2 fps</td>
<td>2 fps</td>
</tr>
<tr>
<td>Maximum Pipe Velocity&lt;sup&gt;[12]&lt;/sup&gt;</td>
<td>12 fps</td>
<td>12 fps</td>
<td>12 fps</td>
</tr>
</tbody>
</table>

Table 10.1-1 (Continued) Drainage Design Criteria<sup>[11]</sup>

<table>
<thead>
<tr>
<th>Description</th>
<th>Ramps</th>
<th>By-Passes</th>
<th>Elevated Collectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Classification</td>
<td>Urban</td>
<td>Urban</td>
<td>Urban</td>
</tr>
<tr>
<td>Method for Determining Peak Runoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culvert Crossings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Storm&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
</tr>
<tr>
<td>Check Storm&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>100-year</td>
<td>100-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Headwater Control&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>&lt; Or = Existing Headwater Elevation</td>
<td>&lt; Or = Existing Headwater Elevation</td>
<td>&lt; Or = Existing Headwater Elevation</td>
</tr>
<tr>
<td>Maximum Outlet Velocity&lt;sup&gt;[8]&lt;/sup&gt;</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
</tr>
<tr>
<td>Minimum Outlet Velocity&lt;sup&gt;[7]&lt;/sup&gt;</td>
<td>2 and 2.5 fps</td>
<td>2 and 2.5 fps</td>
<td>2 and 2.5 fps</td>
</tr>
<tr>
<td>Storm Sewers and Inlets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Storm&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>50-year</td>
<td>50-year</td>
<td>50-year</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>100-year</td>
<td>100-year</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Check Storm</strong>[^8]**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design Storm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable Ponding Width[^9]**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 feet of encroachment into the travel lanes</td>
<td>2 feet of encroachment into the travel lanes</td>
<td>2 feet of encroachment into the travel lanes</td>
</tr>
<tr>
<td><strong>Check Storm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowable Ponding Width[^9]**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>One lane free of encroachment</td>
<td>One lane free of encroachment</td>
<td>One lane free of encroachment</td>
</tr>
<tr>
<td><strong>Pipe Material</strong>[^10]**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Pipe Size[^11]**</td>
<td>18 and 24 inch</td>
<td>18 and 24 inch</td>
<td>18 and 24 inch</td>
</tr>
<tr>
<td><strong>Minimum Pipe Velocity[^12]</strong></td>
<td>2 fps</td>
<td>2 fps</td>
<td>2 fps</td>
</tr>
<tr>
<td><strong>Maximum Pipe Velocity[^12]</strong></td>
<td>12 fps</td>
<td>12 fps</td>
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</tr>
</tbody>
</table>
### Table 10.1-1 (Continued) Drainage Design Criteria[^1]

<table>
<thead>
<tr>
<th>Description</th>
<th>Frontage Roads</th>
<th>Cross Streets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadway Classification</strong></td>
<td>Urban</td>
<td>Urban Arterial</td>
</tr>
<tr>
<td><strong>Method for Determining</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peak Runoff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Culvert Crossings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Storm[^4]</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
</tr>
<tr>
<td>Check Storm[^4]</td>
<td>100-year</td>
<td>100-year</td>
</tr>
<tr>
<td>Headwater Control[^5]</td>
<td>&lt; Or = Existing Headwater Elevation</td>
<td>&lt; Or = Existing Headwater Elevation</td>
</tr>
<tr>
<td>Maximum Outlet Velocity[^6]</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
<td>6 and 8 fps for unlined channels 12 fps for lined channels</td>
</tr>
<tr>
<td>Minimum Outlet Velocity[^7]</td>
<td>2 and 2.5 fps</td>
<td>2 and 2.5 fps</td>
</tr>
<tr>
<td><strong>Storm Sewers and Inlets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Storm[^8][^14]</td>
<td>50- and 100-year</td>
<td>50- and 100-year</td>
</tr>
<tr>
<td>Design Storm Allowable Ponding Width[^9]</td>
<td>One-lane for a 2-lane frontage road One-and-a-half lanes for a 3-lane frontage road</td>
<td>One lane open to traffic in each direction</td>
</tr>
<tr>
<td>Check Storm Allowable Ponding Width[^9]</td>
<td>50-year – no overtopping of curb</td>
<td>50-year – no overtopping of curb</td>
</tr>
<tr>
<td>Pipe Material[^10]</td>
<td>Concrete</td>
<td>Concrete</td>
</tr>
<tr>
<td>Minimum Pipe Velocity[^12]</td>
<td>2 fps</td>
<td>2 fps</td>
</tr>
<tr>
<td>Maximum Pipe Velocity[^12]</td>
<td>12 fps</td>
<td>12 fps</td>
</tr>
</tbody>
</table>

**Notes:**

1. Design criteria taken from the *Drainage Criteria Manual for the Proposed IH 635 (LBJ Freeway) Improvements Luna Road to U.S. 80 (IH 635 DCM)*, which was prepared for TxDOT Dallas District based on the *TxDOT Hydraulic Design Manual, November 2002*. Refer to the IH 635 DCM for more detailed drainage design criteria.
2. Refer to the IH 635 DCM, Chapter 4.5.
3. Refer to the IH 635 DCM, Chapter 4.6.
4. Design for the 100-year event will be required for drainage areas greater than 200 acres. Refer to the IH 635 DCM, Table 4.2.1.

5. This applies to cross structures. Refer to the IH 635 DCM, Chapter 7. The same headwater controls that apply to storm sewer apply to internal culverts. For internal drainage hydraulic grade line requirements, refer to the IH 635 DCM, Chapter 6.

6. Velocities of 6 and 8 fps apply to vegetated sandy and clay channels, respectively. Refer to the IH 635 DCM, Table 5.5.1.

7. Velocities of 2 and 2.5 fps apply to proposed unlined and lined channels, respectively. Any modifications to existing channels shall match the existing channel as close as possible. Refer to the IH 635 DCM, Table 5.5.1.

8. Refer to the IH 635 DCM, Table 4.2.1.

9. Refer to the IH 635 DCM, Table 6.4.1.

10. Refer to the IH 635 DCM, Table 6.7.1.

11. Pipe sizes 18 and 24 inch refer to laterals and trunks, respectively. Refer to the IH 635 DCM, Table 6.7.1.

12. Refer to the IH 635 DCM, Table 6.7.1.

13. For frontage roads and side streets along IH 35E south of Crown Road, the 10-year design frequency applies. In all cases for depressed sections, design will be for the 50-year event. For further discussion, refer to the IH 635 DCM, Chapter 6.2.

14. 100-year HGL allows for one travel lane to be free of encroachment. Refer to the IH 635 DCM, Table 6.7.1.

10.2 Preliminary Drainage Design

The majority of the preliminary hydrologic analysis and hydraulic design are provided in the Drainage Design Report for the Proposed IH 635 (LBJ) Freeway) Improvements, West Section – Luna Road to Skillman Street which includes IH 35E from Royal Lane to Valwood Parkway. The study was performed prior to the start of the Reference Schematic design and is based on the ultimate configuration, as presented in the Environmental Schematic. Westbound Frontage Road trunk line design is extended to match the updated frontage road profile and analyze critical points along the frontage road. The final report will reflect these changes.

The Reference Schematic design assumes that the drainage design includes a system of open channels and culverts to daylight the proposed trunk lines and conveys runoff to Farmers Branch Tributary although the construction limits of the Reference Schematic do not extend west of IH 35E, the proposed drainage system is intended to outfall at Farmers Branch tributary near Luna Road. Refer to the Drainage Design Report for the Proposed IH 635 (LBJ) Freeway Improvements, West Section – Luna Road to Skillman. Differences between the Reference Schematic and the Final Design may require additional hydrologic analysis and hydraulic design within the area covered by the above report.

The IH 35E corridor south of Crown Road is not included in the drainage report mentioned above, however, preliminary hydrologic analysis for the Reference Schematic includes the cross culvert located between Walnut Hill and Royal Lane on IH 35E is included in the Reference
Schematic. The drainage boundary with the 100-year flow is shown in the Reference Schematic Plans on the Drainage Area Map.
CHAPTER 11 - TRAFFIC ANALYSIS

Preliminary traffic analyses were performed to study the operations of the west gateway area and the relocated entrance/exit ramps caused by the addition of declaration lanes for managed lane tolling. Brief descriptions of these analyses are shown below. Traffic volumes used in the analysis originated from two sources. Year 2020 design volumes from the IH 635 Environmental Assessment for the IH 635 main lanes and ramp volumes. Peak hour volumes were developed by applying a K-factor of 8 percent. For managed lane volumes, 2025 traffic Projections from the February 2005 Toll and Revenue analysis were used for the peak hour period.

11.1 IH 635 West Gateway

11.1.1 Configuration
The initial functional design for the managed lane tunnels and resulting Traffic And Revenue Studies were based on tunnel and facility improvements extending westerly past Webb Chapel Road. This initial functional design is configured differently from the Environmental Schematic. The managed lane tunnels tied into the proposed IH 35E direct connector ramps along the outside edge of the existing IH 635 main lane pavement and continued through the existing IH 35E interchange. This initial design did not reconstruct the IH 635 main lanes between Denton Drive and Webb Chapel Road. More detailed design efforts extended the western tunnel gateways westward to a terminal point along the IH 635 centerline between Josey Lane and Webb Chapel Road as depicted in the Environmental Schematic and Reference Schematic. The relocation of the western tunnel gateway was required because of the difficulties in constructing the ultimate IH 635 section in this area after the configuration of the initial functional design gateways and access structures are built. Because the tunnel gateways were extended westward and terminate along the IH 635 centerline, the Reference Schematic includes construction of the ultimate IH 635 section between Denton Drive and Webb Chapel Road. For the Reference Schematic configuration, the westbound direction between IH 35E and Webb Chapel Road has numerous merge and weave sections that occur in a relatively short distance. These weave sections indicate a congestion bottleneck and unacceptable Levels of Service.
11.1.2 Traffic Analysis

At this location two major weaving movements occur. The first involves the westbound Josey Lane on-ramp to IH 635 and westbound IH 635 to northbound IH 35E connector ramp. Weaving volumes are heavy for both movements and the ramp spacing and number of lanes is constrained. The second weaving movement involves the left-hand connector ramp from westbound IH 635 to southbound IH 35E and the termination of the tunnel managed lanes as they merge into the westbound IH 635 main lanes from the median area. Volumes for each of these movements, while not as heavy as the other weaving section, create conflict due to the short separation between the two gore areas and the existing heavy volume of traffic on the westbound through lanes of IH 635.

The results of the analyses indicate that several movements will operate at unacceptable LOS F. The heavy merge between vehicles associated with the Josey Lane and IH 35E northbound movements create substantial queue backup along the westbound through lanes. The introduction of the termination of the managed lanes just up-stream from the left-hand IH 35E southbound connector ramp creates further congestion on the IH 635 main lanes as well as on the merging managed lanes.

To reduce or eliminate these weaving conflicts and resulting congestion, alternative design configurations should be considered.

11.2 IH 635 Ramp Declaration Lane Configuration

11.2.1 Configuration

Four on-off ramps along IH 635 between Webb Chapel Road and Midway Road were relocated from the initial configuration in the Environmental Schematic. These ramps were relocated to accommodate declaration lanes associated with toll collection stations at the on-ramps to the managed lanes. The addition of declaration lanes resulted in longer taper and merges areas at the entrance points to the managed lane system. Consequently, the locations of on-off ramps to the main lanes of IH 635 were relocated from their original locations. Traffic analysis was conducted at these merge and diverge locations to assess any negative impact in traffic operations, level of service, or access to/from cross streets and abutting land uses.
11.2.2 Analysis

The traffic analysis concluded that the relocated ramps will not degrade traffic operations or the level of service at these locations from what was reported in the Interstate Access Justification Report\textsuperscript{23}. In addition access to/from the cross streets or abutting lands uses will not change.
CHAPTER 12 - TOLLING

12.1 Declaration Lanes
Declaration lanes are a method of providing Electronic Open Road Tolling at managed lane entrances. The declaration lanes are designed to provide un-impeded access to the managed lane facility by separating the tolled and non-tolled vehicles prior to entrance into the facility. The separated traffic will be re-combined after passing through a gantry system for electronic toll collection. The Reference Schematic assumed the non-tolled target vehicle group is to be multi-occupant vehicles (carpools & vanpools).

In addition Declaration Lanes are intended to be enforcement zones whereby visual observation determines the occupancy of the entering vehicle as well as those who fail to have valid Electronic Toll Collection Tags.

Declaration lanes are provided at all entrances to the managed lane system in the referenced schematic. An optional strategy to eliminate declaration lanes is to charge all vehicles that utilize the managed lanes the same initial cost. Reimbursement or credits could then be available to targeted vehicle groups. This option is not considered in the Reference Schematic and will require further investigation.

12.2 Gantry System
The Gantry System is the physical systems and area where field electronic toll collection (ETC) equipment is located. The Reference Schematic was designed such that a gantry could be constructed over each Declaration Lane housing the various ETC components. These ETC components include: Automatic Vehicle Classification (AVC), Automatic Vehicle Identification (AVI), and Violation Enforcement System (VES). The design of the gantry and ETC systems is not provided in the Reference Schematic.
CHAPTER 13 - GEOTECHNICAL DATA

13.1 Geologic Environment
The geologic environment for the mined tunnels and cut-and-cover tunnels portions of the Project consists primarily of two rock formations of the Gulfian series of Cretaceous age; the Austin (commonly known as Austin Chalk) and the Eagle Ford (commonly known as Eagle Ford Shale). The contact between the two formations occurs in the vicinity of Marsh Lane, with the Austin overlying the Eagle Ford, and both dipping to the east at about 50 feet per mile. The geologic environment also consists of weathered rock and residual soil of two rock formations mentioned above. The residual soil, which is fairly shallow on Austin Formation and on the softer Eagle Ford Formation tends to be deeper, exhibits the characteristics of relatively high plasticity and expansive. Finally the geologic environment includes alluvium deposited by the ancestral Trinity River and tributary stream system, with some terrace deposits, as well as streambed deposits and reworked materials derived from the bedrock formations.

13.2 Austin Formation – Mined Tunnel
The Austin Formation which will contain the mined tunnel is known to be a favorable host material for construction of relatively large underground openings as shown in several other projects including the Superconducting Super Collider, DART running tunnels and DART City Place Station, and the Addison Airport Tunnel. This formation contains seams of bentonite up to several inches in thickness, including a prominent bed of 8 to 12 inches in thickness regionally known as the Bentonite Marker Bed, occurring in the Project vicinity about 95 feet above the Austin-Eagle Ford contact, and considered to mark the boundary between the Lower Austin and the Middle Austin, which exhibit some stratigraphic differences.

13.3 Overburden soils – Cut-and-Cover Box Tunnel
Cut-and-Cover Box Tunnels, as shown in the Reference Schematic in a mixed environment consisting of overburden soils above either the Austin or Eagle Ford formation. The soil cover thickens west of the Austin-Eagle Ford contact near Marsh Lane. The expansive nature of the rocks of the Eagle Ford formation and its soil derivatives presents potential challenges to wall design and construction that will need additional testing and study during the final design effort as outlined in the Geotechnical Baseline Report.
13.4 Geological and Geotechnical Criteria

Frequently referred to as the “Austin Chalk” due to its high calcium carbonate percentage, the Austin Group is comprised of three members, of which, only the middle and bottom members will be encountered in the construction of the mined tunnels and open cut portions of this Project. The middle member is primarily a marl or argillaceous (containing layers of material bearing clay minerals) limestone. The bottom member consists of limestone with interbedded marl and argillaceous limestones and shales. A regionally persistent “Bentonite Marker Bed” derived from weathering of volcanic ash layers separates the middle and lower members.

As currently planned, the mined tunnels will be excavated entirely within the Austin Chalk. Starting at the west end of the alignment, the tunnels will encounter the bottom member of the Austin at a distance of approximately 15 to 20 feet above the Eagle Ford Shale (a required minimum distance due the soft, low strength and expansive nature of the shale). Progressing to the east, the excavation will encounter the Bentonite Marker Bed, and rise into the middle member of the Austin at the east end of the tunnels.

The Eagle Ford Group underlies the Austin Group and is frequently referred to as the “Eagle Ford Shale.” It consists of three primary members, of which only the topmost, known as the Arcadia Park, will be encountered on this Project. The Arcadia Park in the Dallas area is described as consisting of gray to dark gray, fissile, calcareous mudstone or clay shale with thin laminae of siltstone, sandstone, and fragmental limestone (Surles 1987).

Overall, the Austin Chalk is considered an excellent medium for tunneling; high production rates are possible in the relatively soft limestone, and due to the massive nature of the material, substantial standup times and initial ground support consisting mainly of rock dowels and shotcrete is usually sufficient. In addition, groundwater inflow into the mined tunnels and ancillary underground excavations is expected to be minimal. Measurable inflows are likely to occur at only point sources, where identification and collection of will be simplified.
CHAPTER 14 - ENVIRONMENTAL DATA AND INFORMATION

14.1 Environmental Approvals
The Reference Schematic design is based on the environmental constraints included in the following TxDOT provided approvals.

a) Environmental Assessment: Loop 12 From Spur 408 to IH 35E and IH 35E From Spur 482 to IH 635, Dallas County, CSJ 0581-02-077 and 0196-03-1371
b) Environmental Assessment: Interstate Highway (IH) 635 From: Luna Road To: US 75, Dallas County, CSJ: 2374-01-068 and 2374-07-0462
d) “Finding of No Significant Impact, I.H. 635 (LBJ Freeway – West Section): From Luna Road to U.S. 75,” April 29, 20042

14.2 Environmental Permits
TxDOT is in the process of submitting the Clean Water Act Section 404 Pre-Construction Notice and obtaining approval of Nationwide Permit #14 (NWP14) for Linear Transportation Projects based on the Reference Schematic configuration. The impacts to waters of the U.S. as delineated in the Environmental Assessments listed above, have been determined to be less the 0.5 acres per crossing. Many impacted waters were less than 0.1 acres per crossing. The proposed permit assumes the impacts to waters of the U.S. will be mitigated through the use of mitigation banks.
CHAPTER 15 - RIGHT-OF-WAY DATA AND INFORMATION

TxDOT is in the process of obtaining the right-of-way delineated in the Environmental Schematic. The Reference Schematic was developed to stay predominantly within these right-of-way limits. However, some minor corner clips are anticipated at the east end of the Project near Hillcrest Road.

Right-of-way maps based on the Environmental Schematic will be available in the near future.
CHAPTER 16 - UTILITIES

A layout depicting some of the corridor utilities is included in the Drainage Design Report for the Proposed IH 635 (LBJ) Freeway Improvements, West Section – Luna Road to Skillman Street. TxDOT is currently verifying and updating the utility information within the Project corridors using contracted Subsurface Utility Engineering firms. These Subsurface Utility Engineering documents are anticipated to be available for the IH 635 corridor (west section) and the IH 35E corridor by the end of 2005. The design of the Reference Schematic did not include analysis of utility conflicts.
CHAPTER 17 - URBAN DESIGN

17.1 Guidelines
Aesthetic guidelines are anticipated to be completed by the end of December 2005. These guidelines will define strategies for Project-wide transportation enhancements. Design strategies will focus on achieving a recognizable, overall design theme for the Reference Schematic. A comprehensive approach to built elements is envisioned incorporating color scheme, landscaping, as well as selected specialty treatments for bridges, tunnel lining, lighting, signage, buildings, and ancillary structures. The goal is to provide a consistent, recognizable, and a defined Project appearance.

17.2 Design Theme
The design theme will build upon the previous *LBJ Urban Design Report* for the IH 635 corridor studies. The IH 635’s design will establish a continuity in formliners, color, vertical, and horizontal elements. Revisions to the original guidelines will update, add and/or enhance the guidelines for bridge aesthetics, abutment walls, noise walls, sound walls, fencing, ROW landscaping, artwork, lighting, grading and drainage, pedestrian facilities, signs, tunnel walls, median plantings, intersection hardscape and landscape, storm water treatment facilities, and control buildings. Upon completion of design concepts, an overall theme that uses material that will stand the test of time shall be visually pleasing, and compliment the surrounding developments.

The stylistic approach to the architectural character of the corridor aesthetic is one that reflects a progressive understated attitude to shape, form and character. The new design aesthetic will be indicative of the contemporary character of the Project corridor, current construction technology and techniques that are responsive to the era in which the Project is built.
CHAPTER 18 - FIRE & LIFE SAFETY

18.1 General
Proper Fire & Life Safety systems design is a critical element to the successful design, construction and eventual operation of the Project. The Fire & Life Safety systems are required to provide protection from loss of life and property due to fire and its associated hazards. The current state of technology has allowed Fire & Life Safety systems to become very sophisticated, therefore the system components and the associated installation and testing will comprise a significant portion of the Project development.

A Fire and Life Safety Committee was formed during the Reference Schematic Design period. The Committee consists of TxDOT, Fire, Emergency Response and Law Enforcement representatives. The purpose of the committee is to share information pertaining to the Project and coordinate potential response issues. Coordination with this committee will continue throughout the development of the Project.

18.2 Design Standards/Criteria/Requirements
The governing standard for Fire and Life systems is National Fire Protection Association (NFPA), Standard NFPA 502, Standard for Road Tunnels, Bridges, and Other Limited Access Highways. This standard defines and details the fire protection requirements for road tunnels including: fire detection, communication systems, traffic control, fire apparatus, standpipe and water supply, portable fire extinguishers, tunnel ventilation during fire emergencies, tunnel drainage systems, emergency response plans, and emergency egress.

18.3 Design Discussions and Decisions
The following issues were discussed during the preliminary Fire and Life Safety committee meetings.

18.3.1 Emergency Response
Expeditious response to emergency events in the managed lane tunnels is extremely important for TxDOT, Police, fire, and emergency response personnel. Emergency response time is evaluated with various tunnel enhancements including potential turnarounds in cut-and-cover and mined tunnels. Turnarounds were evaluated for the Reference Schematic, but were
determined they may not be feasible due present space constraints. In addition, the openings would compromise the integrity of the emergency exits and ventilation. Other solutions to minimize the response time are possible and may include the use of emergency exit stairways for emergency response access, response equipment/stations located in or near the tunnel, the use of variable message signs, the use of emergency access ramps, and/or the procurement of specialized equipment.

18.3.2 Central Supervisory Station (CSS), Alternate Central Supervisory Station (ACSS), Fire Management Panel (FMP), and Command Center

A Central Supervisory Station (CSS) and an Alternate Central Supervisory Station (ACSS) are required per NFPA 502. A potential location for the CSS is at the northwest corner of IH 635 and Welch Road on TxDOT owned property. Monitoring and control of a major emergency incident (Command Center) can be conducted at this facility in coordination with the trained permanently stationed operators. A FMP for Fire Response personnel will not be made available due to the potential complexity of the tunnel systems. The ACSS is anticipated to operate in the same manner as and as a backup to the CSS, but on a much smaller scale.

18.3.3 Emergency Response Agency Communications

In addition to the emergency communications facilities required by NFPA 502, emergency response agencies prefer an interagency two-way radio system in the tunnel to allow all emergency response agencies to communicate directly with each other while resolving an emergency incident. This system should allow personnel to utilize the equipment of their respective agency for seamless communications.
CHAPTER 19 - FIELD SURVEY DATA

Survey information used during the production of the Reference Schematic will be available on data sheets by the end of 2005. These data sheets will contain coordinate information on the control points as well as individual control point location sketches.

19.1 Control Points

19.1.1 Primary Control Points
The five (5) nearest existing TxDOT GPS Satellite Stations will be re-verified using a combination of GPS and digital levels. The Project control will be tied into the existing TxDOT GPS Satellite Stations that are based on the Texas State Plane Coordinate System (NAD83 – Texas North Central Zone 4202).

19.1.2 Secondary Control Points
Approximately thirty (30) secondary control points will be tied into the existing TxDOT GPS Satellite Stations. These secondary control points will be bronze or aluminum markers with Project specific markings.

19.1.3 Vertical Bench Marks
Approximately fifteen (15) vertical benchmarks for the Project will be tied into the existing TxDOT GPS Satellite Stations. The locations of the benchmarks will be strategically distributed along the IH 635 and IH 35E corridors and placed far enough away from the existing centerline to prevent disruption by anticipated roadway construction, but close enough for practical use. These benchmarks will be bronze or aluminum markers with Project specific markings.

19.2 Additional Survey Information
In addition to the control points, soil boring locations along the IH 35E corridor and the western section of IH 635 will be located using GPS. The location of these borings will be shown on survey plan sheets and be available by the end of 2005.
DECLARATION LANE DETAIL
NOT TO SCALE

NOTE:
DECLARATION LANE SHALL BE DESIGNED
ACCORDING TO APPLICABLE AASHTO AND TxDOT STANDARDS.

LEGEND
A - APPROACH ZONE
B - QUEUING AREA, GANTRY AREA AND GAP
ACCEPANCE DISTANCE
C - DEPARTURE ZONE
D - ETC GANTRY/ENFORCEMENT ZONE
CITED REFERENCES


19. U.S. Environmental Protection Agency (EPA). 1989. EPA recommendations for the maximum CO levels in tunnels located at or below an altitude of 5000 ft. Environmental Protection Agency.

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   IH 635 (LBJ Freeway) Improvements, West Section – Luna Road to Skillman Street (Draft). 
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23. Texas Department of Transportation Dallas District LBJ Project office. 2003. Access 
   Justification IH 635 Corridor, West Section. Dallas: Texas Department of Transportation.

24. Wilber Smith Associates. February 9, 2005. Investment-Grade Traffic and Revenue Study, 
   LBJ Managed Lanes. Texas Department of Transportation, Dallas District.