SOUTH FLORIDA FREIGHT & PASSENGER RAIL ENHANCEMENT PROJECT

Phase 1B · IRIS NE Connection

November 2013

Grade Crossing Analysis

U.S. Department of Transportation
Federal Railroad Administration

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

TECHNICAL MEMORANDUM

South Florida Freight and Passenger Rail Enhancement Study

Phase 1B - IRIS NE Connection; FPID: 433514-1

Miami-Dade County, Florida

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COPIES:	
DATE:	November 20, 2013
SUBJECT:	GRADE CROSSING ANALYSIS

The Florida Department of Transportation (FDOT), in coordination with the Federal Railroad Administration, is conducting the *South Florida Freight and Passenger Rail Enhancement Study* to evaluate improved freight connectivity between the existing South Florida Rail Corridor (SFRC) and the Florida East Coast (FEC) Railway. The project will enhance freight connectivity between the existing SFRC and the FEC Railway to accommodate existing freight traffic and the projected growth in freight rail operations following the expansion of the Panama Canal and freight intermodal improvements at the Port of Palm Beach, Port Everglades, and PortMiami. The study is being conducted in compliance with federal and state regulations that require engineering and environmental analysis in compliance with the National Environmental Policy Act (known as NEPA).

The *South Florida Freight and Passenger Rail Enhancement Study* project involves three interrelated and independent projects being studied concurrently including:

- Phase 1A: Rehabilitate Existing Northwood Connection, Financial Project Number: 434948-1; ETDM Number: N/A; Palm Beach County, Florida
- Phase 1B: IRIS Northeast Connection, Financial Project Number: 433514-1; Miami-Dade County, Florida
- Phase 2: New Northwood Connection, Financial Project Number: 434948-2; ETDM: 14093; Palm Beach County, Florida

The Phase 1B proposed action for the IRIS NE Connection involves the construction of a single track connection within the existing FDOT right-of-way between the SFRC and FEC Railway. The Phase 1B proposed improvements include: the construction of approximately 1,700 linear feet of new single track providing a new connection to the FEC and SFRC and a modified grade crossing at NW 37th Avenue/FEC Railway to accommodate the new track.

While the *South Florida Freight and Passenger Rail Enhancement* project would facilitate future passenger rail serve by providing connections between the SFRC and the FEC Railway, the project does not involve the development of a station or passenger rail service. The Tri-Rail

Coastal Link Study (http://www.Tri-RailCoastalLinkStudy.com) proposes reintroducing passenger service along an 85-mile stretch of the FEC Railway corridor between Jupiter and Miami.

Introduction

A Categorical Exclusion (CE) is being prepared consistent with federal requirements. In support of the CE, an analysis of grade crossings has been conducted about the effects the proposed action may have upon the local roadway network. One of the crossings that has been evaluated is the existing IRIS Crossing (Phase 1B) located in the City of Hialeah, Florida.

The existing IRIS NE Crossing straddles the eastern edge of the City of Hialeah. The north-south railroad in the vicinity of the crossing is the SFRC, while the east-west railroad is the Little River subdivision of the FEC. The proposed action will provide a new connection in the northeast quadrant of the SFRC/FEC interlocking. This new connection will facilitate freight operations between the FEC and the SFRC.

Study Area

Figure 1 provides a location map of the project study area in the City of Hialeah. The project study area is defined as NW 79th Street to the north, the SFRC rail line to the west, the FEC Railway to the south, and NW 34th Court to the east.

Existing Conditions

The IRIS NE Crossing is an active junction between the FEC Railway and the SFRC located in the City of Hialeah. The primary grade crossing occurs at NW 37th Avenue south of NW 76th Street. An analysis of the impacts the proposed action would have upon this crossing given current traffic volumes was performed. This includes queuing and vehicular delay analyses based on existing (2013) conditions. The following provides details of the methodology followed to evaluate the impacts upon local roadways at select grade crossings. A summary of the results of the analysis is also provided.

Assumptions

The Post-Panamax expansion, PortMiami deep dredging, and proposed action at IRIS are not expected to affect freight levels on the FEC and SFRC, although longer trains may occur. Historical freight levels on the FEC and SFRC are not anticipated to increase due to the proposed project. Several assumptions have been provided by the FEC Railway for the Proposed Actions concerning the expected train operations. These are noted below, along with several assumptions utilized for the calculation of queues and vehicular delay.

- The length of the trains using the proposed Connection will be up to 14,000 feet.
- The maximum speed of the trains through the IRIS NE Connection will be 20 miles per hour.
- Trains will be traveling through this connection during nighttime, off-peak hours beginning after 7:00 pm.

SOUTH FLORIDA FREIGHT AND PASSENGER RAIL ENHANCEMENT PROJECT

LEGEND

IRIS Railroad Crossing

Phase 1B - IRIS Connection

PHASE 1B - IRIS CONNECTION
GRADE CROSSING LOCATION MAP

- A maximum of two train crossings will occur during any one hour.
- No residual vehicle queues carry over from the first train crossing to the second train crossing.
- Hourly truck percentages along the surface streets are conservatively assumed to be 5%.
- Saturation flow rates for surface streets are estimated to be 1,900 vehicles per hour per lane. This is consistent with values used in the Highway Capacity Manual 2010.
- Opening Year for IRIS NE Connection Phase 1B is 2015.
- Design Year is 2035.

Data Collection

Given the current and proposed rail alignments, one location, NW 37th Avenue south of 76th Street, was identified where hourly traffic volume data would be collected. It is within the IRIS NE Connection study area in the City of Hialeah, and corresponds to a mid-block roadway location that reflects current or proposed crossings. Data on this two-lane road was collected in 15-minute intervals over a 48-hour period for both directions of travel on the roadway on Tuesday, September 10, 2013 and Wednesday, September 11, 2013. The collected data is included in Appendix A.

Since trains are assumed to run after 7:00 pm, hourly volumes at this location were reviewed to identify the period with the highest hourly volume recorded after 7:00 pm. By using the period with the highest hourly volume, the subsequent analysis is considered to be conservative. These hourly volumes are summarized in tabular format in Appendix A.

Queue Analysis

When trains travel through an at-grade crossing, the vehicular traffic on the surface street must stop. With no vehicular flow, queues begin to form on the local streets at the grade crossing. An estimation of those queues given the duration of the grade crossing closure will provide an assessment of the impact the trains will have upon local street operations.

Based on the *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007,* published by the Federal Highway Administration (FHWA), the following 95th Percentile Queue Length formula was used to estimate queues formed at each grade crossing.

$QL = 2*q*r*(1+p)*25$

Where, QL = *95th percentile queue length*
q = *vehicle flow rate (vehicles per lane per second)*
r = *effective red time (or effective gate closure time) in seconds*
p = *proportion of heavy vehicles in the traffic stream*
25 = effective length of a passenger vehicle (feet)

To determine the gate closure time, several variables must be included in the estimation. These include the train's length, the train's speed, and time needed to lower and raise the gates in advance of the train. Consistent with the *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007*, the effective gate closure time formula is provided below.

$r = 35 + (\text{train length} / (1.47 * \text{train speed in mph})$

With results of the gate closure calculation reported in seconds, the required minimum time to lower the gate prior to the arrival of the train and raise the gate after the train has completed its crossing is embedded in the equation as the '35' second adjustment factor. Assuming a train length of 14,000 feet and a speed of 20 miles per hour at the IRIS NE Crossing, the overall time that the crossing gate would be closed is 511 seconds. This means that when a train is present and traveling through the IRIS NE Crossing area, the crossing gates will be activated and stopping vehicular traffic for approximately 8.5 minutes.

Only the crossing at NW 37th Avenue south of NW 76th Street is impacted at the IRIS NE Crossing site. Given a 14,000-foot train that travels at 20 miles per hour, a vehicular queue will form on NW 37th Avenue waiting for the train to clear the grade crossing. With current hourly volumes at 7:00 pm of 38 northbound vehicles and 27 southbound vehicles, it is calculated that the 95th Percentile Queue would be 284 feet for the northbound approach and 202 feet for the southbound approach. Neither of these queues would affect traffic operations at any nearby roadways. Results of the queuing analysis for existing conditions are included in Appendix B.

Vehicle Delay Analysis

When a train approaches a grade crossing and the flow of vehicular traffic is halted to allow the train to continue unimpeded along its path, drivers experience delay. During the hour analyzed, a large portion of drivers will not experience any delay at all since the trains are assumed to traverse a crossing a maximum of two times during any one hour. As a result, vehicular delay is calculated as an average delay for all vehicles during the hour, and includes delay for drivers stopped by the train and drivers who were not. The delay formula utilized for this calculation is based on the *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007.* It is the same formula used in the Highway Capacity Manual to estimate delay at a traffic signal.

The following Vehicular Delay formula was used to estimate average delay at each grade crossing.

$D = ½ * [(q*Tg^2) / (1-q/d)]$

Where, D = *vehicular delay (vehicle-minutes)*
q = *vehicle arrival rate (vehicles per minute)*
Tg = *effective red time (or effective gate closure time) in minutes*
d = *vehicle departure rate, or saturation flow rate (vehicles per minute)*

Vehicle delay and queues are related results with similar variables used for the calculation. However, where queues are based on the analysis of a single event, delay is typically reported as an average over an entire hour. If these stoppage events occur on a regular, cyclical basis, such as a traffic signal, the resulting delay is used as a measurement to report a level of service.

However, because the train crossings at IRIS are a relatively infrequent event, occurring at most twice during an hour and only after 7:00 pm, a level of service assignment at the crossing location based solely on delay would skew the perceived impact to the motoring public. The trains are expected to be approximately 14,000 feet long and require approximately 8.5 minutes to clear the grade crossing in the IRIS study area; drivers would experience no delay during the remainder of the hour analyzed.

Delay at the NW 37th Avenue crossing was calculated based on current volumes, which are less than 40 vehicles per hour between 7:00 pm and 8:00 pm. Analysis indicated that the accumulated vehicle delay (reported in vehicle-minutes of delay) at the northbound approach is less than 95 vehicle-minutes, while at the southbound approach the vehicular delay is approximately 65 vehicle-minutes. The average delay calculated for both approaches is about 150 seconds per vehicle during the entire hour. Results of the delay analysis for existing conditions are included in Appendix C.

Future Conditions

For the IRIS NE Connection (Phase 1B), the construction of the proposed improvements is expected to be operational by 2015, with the design year as 2035. An analysis of both future years was performed to assess the impacts the proposed action will have upon the local roadway network. This includes projecting future directional hourly traffic volumes, as well as queuing and vehicular delay analyses.

Travel Demand Forecasting and Growth Rate Analysis

The Southeast Regional Planning Model (SERPM) was used to generate growth rates to be applied to existing hourly volumes in the study area. Model files were obtained for the Base Year 2005 and Horizon Year 2035. Subareas for IRIS were defined and socio-economic and model output volumes were reported from those smaller areas. Results of the 2005 Model to 2035 Model comparative analysis indicated that model volumes would increase approximately 2.27% compounded annually near the IRIS NE Connection site. Results of the comparative model analysis are included in Appendix D.

The model-based growth rates were then applied to the maximum existing directional hourly volumes that occur after 7:00 pm at each crossing location, which is generally between 7:00 pm and 8:00 pm. The growth rate was compounded annually to calculate a conservative directional hourly volume estimate for 2015 and 2035. These future year volumes are summarized and presented in Appendix D.

Queue Analysis

As noted previously, the estimation of queues at railroad crossings was conducted consistent with the *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007.* The 95th Percentile Queue Length formula was used to estimate queues formed for each direction of travel at the grade crossing. Analysis was conducted for both directions of traffic flow that is impacted by the railroad crossing at Phase 1B IRIS.

Future year (2015) directional hourly volumes were forecasted for the crossing at NW 37th Avenue south of NW 76th Street. Given the closure event assumptions, a vehicular queue will form in 2015 on NW 37th Avenue between 7:00 pm and 8:00 pm of 299 feet for the northbound approach and 209 feet for the southbound approach. Projecting the directional hourly volumes on NW 37th Avenue to 2035 conditions reveals that the queue between 7:00 pm and 8:00 pm would increase to 463 feet for the northbound approach and 328 feet for the southbound approach. These queues estimated for 2015 and 2035 would not affect traffic operations at any nearby roadways. Results of the queuing analysis are included in Appendix B.

Vehicle Delay Analysis

Future year analysis was conducted for the Phase 1B IRIS NE Connection to evaluate the amount of vehicular delay that would be accumulated because of the expected rail crossings. Since it was assumed that trains would not operate prior to 7:00 pm, the delay analysis incorporates the largest and most conservative directional hourly traffic volume after 7:00 pm.

As noted previously, a large portion of drivers will not experience any delay during the study hour since the trains are assumed to traverse a crossing a maximum of only two times during any one hour. As a result, an accumulation of vehicular delay was calculated. Future year vehicular delay was also calculated as an average delay for all vehicles, including those that were stopped by the train and those that were not. The delay formula utilized for this calculation is based on the *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007.*

Future year vehicular delay at the NW 37th Avenue crossing was calculated based on projected volumes between 7:00 pm and 8:00 pm. Analysis of 2015 conditions indicates that the accumulated vehicle delay at the northbound approach is less than 100 vehicle-minutes, while at the southbound approach the vehicular delay is nearly 70 vehicle-minutes. The average delay calculated for both approaches continues to remain about 150 seconds per vehicle during the entire hour, which is similar to existing conditions.

Analysis of 2035 projected volumes between 7:00 pm and 8:00 pm revealed that the accumulated vehicular delay increased for the northbound approach to 155 vehicle-minutes, and for the southbound approach to nearly 110 vehicle-minutes. Results of the 2015 and 2035 future year delay analysis are included in Appendix C.

Traffic Control Devices

A variety of safety treatments exist for at-grade rail crossings to minimize train-vehicle crashes that often lead to fatalities. Some devices warn drivers that an upcoming decision must be made whether or not to cross. Others attempt to influence drivers directly by physically restricting the ability to cross when a train is present. These are referred to as passive and active traffic control devices, and they influence driver behavior and actions at rail crossings.

Active traffic control devices give advance notice to drivers of a train's approach. As a train passes over a detection circuit on a track, flashing lights, automatic gates, traffic signals and advance warning devices are activated. These types of devices dictate the action that a driver must take. Passive traffic control devices, however, only inform the driver that a crossing is present. The driver is responsible for identifying an approaching train and taking an appropriate action. Passive traffic control devices include signs and pavement markings.

Although a standardized set of warrants to justify the installation of flashing light signals has not been established, there are several criteria that should be considered when deciding the type of traffic control device to be installed. These include[1]:

- Volume of vehicular traffic
- Volume of railroad traffic
- Speed of vehicular traffic
- Speed of railroad traffic
- Volume of pedestrian traffic
- Collision history
- Sight distance limitations.

At crossing locations where improved visibility for approaching traffic of the crossing is desired, cantilevered flashing light signals are typically used. Cantilevered flashing light signals are generally used when the following conditions are present[2].

- Multilane roadways (two or more lanes in one direction)
- Roadways with paved shoulders or a parking lane that would require a post-mounted light to be more than 10 feet from the edge of the travel lane.
- Roadside foliage obstructing the view of post-mounted flashing light signals.
- Roadside obstacle, such as utility poles, that obstruct visibility, and where minor lateral adjustments do not improve visibility.
- Distracting backgrounds such as an excessive number of neon signs.
- Horizontal or vertical curves where the extension of flashing lights over the travel lane would provide sufficient visibility for the required stopping sight distance.

A typical cantilevered installation consists of one pair of cantilevered lights on each roadway approach. These are supplemented by a pair of lights mounted on the supporting mast, consistent with Chapter 8C of the *Manual on Uniform Traffic Control Devices, 2009* (MUTCD 2009).

Automatic gates provide a physical barrier across the travel lanes of a roadway when a train is approaching or within a crossing. They are combined with flashing light signal to provide additional warning for drivers. Typically, within three seconds of the activation of flashing lights due to the presence of a train, the automatic gates will begin their descent across the roadway. They remain in this down position while the train traverses the crossing and rise upward in no more than 12 seconds when the train clears the crossing.

On two-way streets, automatic gates should cover enough of the roadway's approach to physically block motorists from driving around the gate. On multi-lane roadways, an opening

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[1] *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007*, FHWA.
[2] *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007*, FHWA.

of approximately six feet may be provided to accommodate emergency vehicles. Traffic control devices at the NW 37th Avenue rail crossing currently include cantilevered flashing light signals and automatic gates.
The need for automatic gates should consider the following factors[3]:

- Multiple mainline railroad tracks.
- Multiple tracks where a train on or near the crossing can obscure the movement of another train approaching the crossing.
- High speed train operation combined with limited sight distance.
- A combination of high speed and moderately high volume roadway and railroad traffic.
- Presence of school buses, transit buses, or farm vehicles in the traffic flow.
- Presence of trucks carrying hazardous materials, particularly if sight distance is obstructed.
- Continuance of collisions after installing flashing lights.
- Presence of passenger trains.

The implementation of four quadrant gates is a variation of automatic gates where gates extend across both the approach and departure lanes of a roadway. They provide additional visual constraints for motorists, and restrict nearly all movements over the crossing when the gates have been lowered. Four quadrant gates are considered a supplemental safety treatment for quiet zones.

A quiet zone is a section of a rail line at least one-half mile in length that contains one or more consecutive public highway-rail grade crossings at which locomotive horns are not routinely sounded. Under the Train Horn Rule (49 CFR Part 222), locomotive engineers must begin to sound train horns at least 15 seconds, and no more than 20 seconds, in advance of all public grade crossings. In a quiet zone, railroads have been directed to cease the routine sounding of their horns when approaching public highway-rail grade crossings.

Conclusions

The grade crossing analysis at IRIS NE Connection Phase 1B was based on certain assumptions about the length and speed of the proposed trains. It also assumed that trains would be active only during nighttime, off-peak hours beginning after 7:00 pm, and that no more than two train crossings would occur in a single hour. Given these parameters, results indicate that for both the opening year (2015) and the design year (2035) vehicular queues and delay incurred at the rail crossing near IRIS at NW 37th Avenue are nominal and can be accommodated without impacting roadway traffic operations at adjacent locations.

Adequate clearance time of approximately 20 minutes is needed between the two crossing events to allow drivers in queue to complete the rail crossing prior to the next rail crossing event. This ensures that no driver is affected by both crossing events without the opportunity to cross.

Traffic control devices at the NW 37th Avenue rail crossing currently include cantilevered

[3] *Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007*, FHWA.

flashing light signals and automatic gates. An evaluation of the IRIS NE Connection crossing should be performed to ensure drivers are stopping at the crossing. Further, the equipment should be reviewed to confirm it is functioning properly and achieving its intended goal of actively influencing driver behavior.

Appendix A

Traffic Volume Data

County: 87
Station: 0010
Description: NW 37TH AVE BTWN NW 76TH ST AND RR TRACKS
Start Date: 09/10/2013
Start Time: 0000

	Direction: N					Direction: S					Combined
Time	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total	Total
0000	5	0	1	1	7	0	0	0	1	1	8
0100	0	1	0	0	1	0	0	2	1	3	4
0200	0	0	0	2	2	3	0	1	1	5	7
0300	0	2	0	0	2	1	1	4	0	6	8
0400	1	3	3	1	8	1	2	4	2	9	17
0500	1	7	8	16	32	1	1	4	5	11	43
0600	6	9	18	25	58	9	16	13	25	63	121
0700	24	21	47	28	120	15	25	25	28	93	213
0800	35	33	34	37	139	42	37	29	29	137	276
0900	26	38	34	44	142	36	25	32	25	118	260
1000	35	27	49	51	162	31	43	39	39	152	314
1100	37	32	36	38	143	30	37	38	49	154	297
1200	42	37	43	39	161	29	47	39	44	159	320
1300	47	34	33	39	153	30	33	47	30	140	293
1400	45	30	32	50	157	35	38	34	32	139	296
1500	52	47	47	45	191	36	34	37	33	140	331
1600	34	41	53	34	162	34	24	33	31	122	284
1700	69	43	35	35	182	54	29	19	17	119	301
1800	26	16	13	7	62	28	8	14	11	61	123
1900	7	10	6	8	31	3	8	5	7	23	54
2000	4	2	4	6	16	5	8	3	3	19	35
2100	1	3	0	4	8	3	3	4	3	13	21
2200	1	0	0	3	4	2	1	0	1	4	8
2300	1	1	2	0	4	1	1	1	0	3	7
24-Hour Totals:					1947					1694	3641

Peak Volume Information

	Direction: N		Direction: S		Combined Directions	
	Hour	Volume	Hour	Volume	Hour	Volume
A.M.	730	143	800	137	800	276
P.M.	1630	199	1215	160	1630	346
Daily	1630	199	1145	164	1630	346

Generated by SPS 5.0.21

County: 87
Station: 0010
Description: NW 37TH AVE BTWN NW 76TH ST AND RR TRACKS
Start Date: 09/11/2013
Start Time: 0000

	Direction: N					Direction: S					Combined
Time	1st	2nd	3rd	4th	Total	1st	2nd	3rd	4th	Total	Total
0000	0	0	2	1	3	0	0	1	0	1	4
0100	0	2	1	1	4	0	0	0	1	1	5
0200	3	1	1	0	5	2	0	0	0	2	7
0300	0	1	0	0	1	1	1	0	0	2	3
0400	2	2	2	1	7	0	2	1	2	5	12
0500	5	4	5	10	24	0	1	3	6	10	34
0600	10	11	20	26	67	15	9	14	26	64	131
0700	33	21	19	25	98	21	16	24	38	99	197
0800	31	38	34	34	137	30	34	26	30	120	257
0900	21	33	36	35	125	30	36	46	25	137	262
1000	37	32	36	37	142	31	36	29	37	133	275
1100	38	37	38	51	164	44	46	34	32	156	320
1200	36	45	32	44	157	41	43	41	32	157	314
1300	29	45	39	42	155	43	24	34	35	136	291
1400	43	38	34	29	144	38	25	40	30	133	277
1500	38	42	51	48	179	40	30	45	35	150	329
1600	35	41	81	51	208	44	29	34	40	147	355
1700	61	44	36	22	163	43	26	29	21	119	282
1800	33	22	13	15	83	27	16	10	15	68	151
1900	16	9	5	8	38	9	6	4	8	27	65
2000	3	7	1	3	14	7	3	5	0	15	29
2100	7	2	4	2	15	6	2	2	5	15	30
2200	4	0	3	1	8	0	0	0	0	0	8
2300	0	1	0	1	2	5	1	1	0	7	9
24-Hour Totals:					1943					1704	3647

Peak Volume Information

	Direction: N		Direction: S		Combined Directions	
	Hour	Volume	Hour	Volume	Hour	Volume
A.M.	800	137	845	142	845	266
P.M.	1630	237	1215	159	1615	380
Daily	1630	237	1045	161	1615	380

Generated by SPS 5.0.21

Appendix B

Queuing Analysis

TABLE B-1
QUEUING ANALYSIS
EXISTING CONDITIONS (2013)
IRIS NE CONNECTION

LOCATION	Number of Lanes	Train Length (feet)	Gate Down Time (seconds)		Northbound/Eastbound Approach: NB Max Hourly Volume (after 7 pm)	Northbound/Eastbound Approach: Vehicle Flow Rate (vehicles per lane per second)	Northbound/Eastbound Approach: Queue Length (95th Percentile)		Southbound/Westbound Approach: SB Max Hourly Volume (after 7 pm)	Southbound/Westbound Approach: Vehicle Flow Rate (vehicles per lane per second)	Southbound/Westbound Approach: Queue Length (95th Percentile)
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		38	0.0106	284		27	0.0075	202

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*****, August 2007, FHWA**

Queue Length (95th Percentile) = QL (feet)

QL = 2*q*r*(1 + p)*25

q = vehicle flow rate (vehicles per lane per second)
r = effective red time (seconds)
p = proportion of heavy vehicles in traffic flow

'25' represents the effective length of a passenger car

TABLE B-2
QUEUING ANALYSIS
OPENING YEAR CONDITIONS (2015)
IRIS NE CONNECTION (PHASE 1B)

					Northbound/Eastbound Approach				Southbound/Westbound Approach		
LOCATION	Number of Lanes	Train Length (feet)	Gate Down Time (seconds)		NB Max Hourly Volume (after 7 pm)	Vehicle Flow Rate (vehicles per lane per second)	Queue Length (95th Percentile)		SB Max Hourly Volume (after 7 pm)	Vehicle Flow Rate (vehicles per lane per second)	Queue Length (95th Percentile)
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		40	0.0111	299		28	0.0078	209

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*****, August 2007, FHWA**

Queue Length (95th Percentile) = QL (feet)

QL = 2*q*r*(1 + p)*25

q = vehicle flow rate (vehicles per lane per second)
r = effective red time (seconds)
p = proportion of heavy vehicles in traffic flow

'25' represents the effective length of a passenger car

TABLE B-3
QUEUING ANALYSIS
DESIGN YEAR CONDITIONS (2035)
IRIS NE CONNECTION (PHASE 1B)

					Northbound/Eastbound Approach				Southbound/Westbound Approach		
LOCATION	Number of Lanes	Train Length (feet)	Gate Down Time (seconds)		NB Max Hourly Volume (after 7 pm)	Vehicle Flow Rate (vehicles per lane per second)	Queue Length (95th Percentile)		SB Max Hourly Volume (after 7 pm)	Vehicle Flow Rate (vehicles per lane per second)	Queue Length (95th Percentile)
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		62	0.0172	463		44	0.0122	328

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Queue Length (95th Percentile) = QL (feet)

QL = 2*q*r*(1 + p)*25

q = vehicle flow rate (vehicles per lane per second)
r = effective red time (seconds)
p = proportion of heavy vehicles in traffic flow

'25' represents the effective length of a passenger car

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*, August 2007, FHWA**

Appendix C

Vehicular Delay Analysis

TABLE C-1
DELAY ANALYSIS
EXISTING CONDITIONS (2013)
IRIS NE CONNECTION (PHASE 1B)

					Northbound/Eastbound Approach						Southbound/Westbound Approach				
LOCATION	**Number of Lanes**	**Train Length (feet)**	**Gate Down Time per Event (seconds)**		**NB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**		**SB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		38	0.6333	31.67	93.8	148.0		27	0.4500	31.67	66.2	147.2

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*** **, August 2007, FHWA**

Vehicular Delay = V (vehicle minutes of delay)

$V = 1/2 * [(q*T_G^2)/(1 - q/d)]$

q = arrival rate (vehicles per minute)
T_G = Gate down time (minutes)
d = departure rate, or saturation flow rate (vehicles per minute)

TABLE C-2
DELAY ANALYSIS
OPENING YEAR CONDITIONS (2015)
IRIS NE CONNECTION (PHASE 1B)

					Northbound/Eastbound Approach						Southbound/Westbound Approach				
LOCATION	**Number of Lanes**	**Train Length (feet)**	**Gate Down Time per Event (seconds)**		**NB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**		**SB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		40	0.6667	31.67	98.8	148.2		28	0.4667	31.67	68.7	147.2

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Vehicular Delay = V (vehicle minutes of delay)

$V = 1/2 * [(q*T_G^2)/(1 - q/d)]$

q = arrival rate (vehicles per minute)
T_G = Gate down time (minutes)
d = departure rate, or saturation flow rate (vehicles per minute)

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*** **, August 2007, FHWA**

TABLE C-3
DELAY ANALYSIS
DESIGN YEAR CONDITIONS (2035)
IRIS NE CONNECTION (PHASE 1B)

					Northbound/Eastbound Approach						Southbound/Westbound Approach				
LOCATION	**Number of Lanes**	**Train Length (feet)**	**Gate Down Time per Event (seconds)**		**NB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**		**SB Max Hourly Volume (after 7 pm)**	**Arrival Rate (vehicles per minute)**	**Departure Rate (vehicles per minute)**	**Vehicular Delay (vehicle-minutes)**	**Average Vehicular Delay (seconds per vehicle)**
NW 37th Avenue between NW 76th St and RR Crossing	2	14,000	511		62	1.0333	31.67	155.0	150.0		44	0.7333	31.67	108.9	148.5

ASSUMPTIONS

Train length is 14,000 feet
Train speed at IRIS is 20 mph
Trains will run after 7:00 pm
A maximum of 2 train crossings per hour
Saturation Flow Rate is 1,900 vehicles per hour per lane
Truck percentage assumed to be 5%
Roadway traffic volume data was collected on 9/10/2013 and 9/11/2013
r, Time gate is down = 35 + (Train Length/(1.47*train speed in mph))

Vehicular Delay = V (vehicle minutes of delay)

$V = 1/2 * [(q*T_G^2)/(1 - q/d)]$

q = arrival rate (vehicles per minute)
T_G = Gate down time (minutes)
d = departure rate, or saturation flow rate (vehicles per minute)

Source: ***Railroad-Highway Grade Crossing Handbook, Revised Second Edition*** **, August 2007, FHWA**

Appendix D

Transportation Model Growth Rate Analysis

IRIS NE Connection (Phase 1B)

	Total Population (POP_05/35)	Total Employment (TOTE_05/35)	Traffic Volume
2005	706,985	513,328	54,005,811
2035	873,285	800,224	90,790,789
Growth Rate	0.78%	1.86%	2.27%

SUMMARY OF EXISTING AND FUTURE YEAR VOLUMES

LOCATION	Existing Conditions (2013) Max Hourly NB/EB Volume (after 7 pm)	Existing Conditions (2013) Max Hourly SB/WB Volume (after 7 pm)	Opening Year Conditions (2015) 2015 Hourly NB/EB Volume (after 7 pm)	Opening Year Conditions (2015) 2015 Hourly SB/WB Volume (after 7 pm)	Design Year Conditions (2035) 2035 Hourly NB/EB Volume (after 7 pm)	Design Year Conditions (2035) 2035 Hourly SB/WB Volume (after 7 pm)	Lane Geometry	COMMENT
IRIS NE Connection (Hialeah) NW 37th Avenue between NW 76th St and RR Tracks	38	27	40	28	62	44	2L	

- Volumes collected on Tuesday, September 10th and Wednesday, September 11th.
- ADTs reported from day with highest recorded volume.
- Peak hour volumes are reported from the day with the highest volume at each location, and from the hour with the highest volume at each location
- Maximum hourly volumes after 7 pm are reported from the day with the highest volume at each location.
- IRIS NE Connection compound growth rate used to forecasts future year volumes is 2.27%.