MEMO

TO: Jane Canada, Justin Stuehrenberg, and Ben Smith (IndyGo)

CC: Will Tolbert (WSP)

FROM: Matt Duffy and Ericka Miller (WSP)

SUBJECT: Blue Line BRT, Evaluation of Injury/Fatality and Bicycle/Pedestrian Crashes and Safety-Related Recommendations

DATE: May 8, 2019

Overview

The Blue Line Bus Rapid Transit (BRT), IndyGo's third BRT line in Indianapolis, will run from the Indianapolis International Airport, east through downtown along Washington Street, to the Town of Cumberland. WSP prepared a safety memo in May, 2018 that summarized all crashes along Washington Street within I-465, excluding crashes on the downtown one-way pairs of Washington Street and Maryland Street. This first safety memo summarized potential mitigating impacts that exclusive center running BRT lanes may have on the frequency of certain types of crashes along the Blue Line corridor.

This second memo serves to bolster previous safety analysis efforts along the Blue Line corridor by investigating the causes and factors related to all injury/fatality and pedestrian/bicyclist-related crashes along the corridor (2015-2017) and recommending improvements to mitigate existing issues/deficiencies related to these crashes. It should be noted that 89% of the pedestrian/bicyclist-related crashes along the corridor were also injury/fatality crashes. The scope of this assessment excluded the review of Property Damage Only (PDO) crashes along the corridor due to the effort required to investigate each of the 2,700+ PDO crashes and the fact that these crashes are the least severe/impactful.

Crash Data

Crash data for the corridor was extracted from ARIES, the statewide crash database, for years 2015-2017. Crashes that occurred in parking lots or outside of public right-of-way were removed from consideration. Table 1 below summarizes 2015-2017 fatal and injury crashes along the Blue Line corridor from High School Road to Hugo Street. It should be noted that, according to Indiana standards in 2015-2017, a crash was considered an incapacitating injury crash if a person was transported from the crash scene in an ambulance.

Table 1: Summary of Injury and Fatal Crashes (2015-2017)
Blue Line Corridor from High School Rd to Hugo St

Number of Fatal Crashes	15
Number of Incapacitating Injury Crashes	85
Number of Non-Incapacitating Injury Crashes	611
Number of People Killed	18
Number of People Injured	957

Trips via public transportation require users to rely on infrastructure within the public right-of-way, including sidewalks, crosswalks, and curb ramps to access stations. As such, pedestrian activity along Washington Street is anticipated to increase with the implementation of the Blue Line. In general, pedestrian and bicyclist related crashes tend to be more severe, especially at higher speeds. Because of this, all pedestrian/bicyclist-related crashes that occurred along the corridor from 2015-2017 were reviewed in detail, with the goal of identifying existing issues/deficiencies that might be mitigated or improved. Along the Blue Line corridor, 8 of the 15 fatal crashes and 23 of the 85 incapacitating injury crashes involved a pedestrian or a bicyclist. Table 2 below summarizes 2015-2017 pedestrian and bicyclist related crash data for the Blue Line corridor from High School Road to Hugo Street.

Table 2: Summary of Pedestrian/Bicyclist Crashes (2015-2017)
Blue Line Corridor from High School Rd to Hugo St

Severity	Pedestrian/Bicyclist Crashes	Total Injury/Fatality Crashes	Percentage Pedestrian/Bicyclist Crashes of Total Injury/Fatality Crashes
Fatal Crash	8	15	53%
Incapacitating Injury Crash	23	85	27%
Non-Incapacitating Injury Crash	88	611	14%
Total	119	711	17%

Table 3 below summarizes 2015-2017 crash data by intersection; intersections where less than 5 crashes occurred in that period were not included in the summary, unless a fatal crash or pedestrian/bicyclist-related crash occurred at that location. It should be noted that the pedestrian/bicyclist-related crashes summarized in the last column of the table are not different crashes than those listed in the columns to the left. All pedestrian/bicyclist-related crashes are also classified as fatal, incapacitating injury, non-incapacitating injury or PDO – they are simply summarized separately in the last column of the table to highlight the fact that they occurred.

Table 3: 2015-2017 Summary Crash Data by Intersection

Intersection	Fatal Crashes	Incapacitating Injury Crashes	Non-Incapacitating Injury Crashes	PDO Crashes	Pedestrian Crashes	Bicyclist Crashes
Alabama & Maryland		1	5	12		3
Alabama & Washington			2	15		
Alton & Washington	1				1	
Arlington & Washington		3	15	53		1
Auburn & Washington		2	4	10		
Audobon & Washington		1	5	29	1	3
Bazil & Washington		1	3	2	1	
Belleview & Washington		1	4	8		
Belmar & Washington			1	8		
Belmont & Washington			5	37		
Biltmore & Washington			1	2	1	
Bolton & Washington			2	2		1
Capitol & Maryland	1	1	6	27	1	4
Capitol & Washington		1	3	27	1	3
Catherwood & Washington		1		1		1
Cecil & Washington			4	9		
Cherry Tree & Washington		1	4	3		1
College & Washington	1		20	75	2	1
Colorado & Washington	1		3			1
Davidson (I-65 SB) & Washington	1	1	13	58	1	3
Delaware & Maryland			6	34	1	2
Delaware & Washington		1	5	60	1	3
Delbrick & Washington	2	1	2	5		1
Denison & Washington			1		1	
Devon & Washington			1	4		1
East & Washington			3	35		2
Eaton & Washington	1		1			1
Elder & Washington			3		1	
Emerson & Washington		2	17	51		3
Fenton & Washington			4	4		
Fleming & Washington		2	2	5	1	1
Franklin & Washington		2	13	69		
Fuller & Washington			4	2		
Galeston & Washington				4		1
German Church & Washington		2	3	23		
Gerrard & Washington			4			1
Hancock & Washington			2			1

Table 3 (Cont'd): 2015-2017 Summary Crash Data by Intersection

Intersection	Fatal Crashes	Incapacitating Injury Crashes	Non-Incapacitating Injury Crashes	PDO Crashes	Pedestrian Crashes	Bicyclist Crashes
Harding & Washington	1		7	54		
Hawthorne & Washington			1	6		
High School & Washington			23	61		2
Holmes & Washington			2		1	
Holt & Washington		2	14	62		3
Illinois & Maryland			5	50	1	3
Illinois & Washington			6	42	1	1
Kealing & Washington		2	3		1	2
Keystone & Washington		2	1	9		
Kitley & Washington		1	5	15		1
LaSalle & Washington	1		4	21		2
Layman & Washington		1	1	1		1
Linwood & Washington		1	3	9		1
Luette & Washington			2			1
Lynhurst & Washington		2	16	65		
Mcclure & Washington	1		3			
Meridian & Maryland		1	5	23	1	1
Meridian & Washington		1	3	41	1	2
Missouri & Maryland			2	16		1
Missouri & Washington		1	2	28		4
Mitchner & Washington			5	13		
Mitthoeffer & Washington		2	8	87	2	
Morris/Waldemere & Washington		1	7	25		1
N Tibbs & Washington			9			1
NB 465 & E Washington St		1	9	6		
New Jersey & Washington			2	15		
Oakland & Washington		1				1
Oriental & Washington			4	16		
Park & Washington			1	10		
Pennsylvania & Maryland			3	19		2
Pennsylvania & Washington			2	27		1
Pine (NB 65) & Washington			6	38	1	1
Post & Washington		3	12	62		
Randolph & Washington			1			1
Ridgeview & Washington		1	5	7		
Ritter & Washington		2	6	21		2
Rockville & Washington			4	13		

Table 3 (Cont'd): 2015-2017 Summary Crash Data by Intersection

Intersection	Fatal Crashes	Incapacitating Injury Crashes	Non-Incapacitating Injury Crashes	PDO Crashes	Pedestrian Crashes	Bicyclist Crashes
Roena & Washington			2		1	
Rural & Washington		7	16	43	1	3
S Tibbs & Washington		1	2			
S White River & Washington			3		1	
SB 465 & W Washington	1	1	15	4		
Schumacher & Washington			4	9		
Senate & Washington				6		
Shadeland & Washington	1		3	1		1
Sherman & Washington			8	64		1
Shortridge & Washington		3	5	18		2
Southeastern & Washington			6	21	1	
State & Washington		2	10	35	1	1
Temple & Washington			2	1	1	1
Tremont & Washington			2	12		
Walmart Drive & Washington		3	5	8		4
Wallace & Washington	1		3	4		
Walmart & Washington		1	5	3	1	
Warman & Washington		1	8	13		1
Washington Pointe & Washington		2	6	27		
Washington Square & Washington		1	1	3		1
Webster & Washington			1	1	1	
West & Maryland			15	68		4
West & Washington	1	1	16	78	4	3
Whitcomb & Washington			1	3		
White River Pkwy West & Washington			10	13		
Wing & Washington		1				1
Wittfield & Washington			1	6		
Woodrow & Washington			4		1	

Issues and Recommendations

Though all injury/fatality and pedestrian/bicyclist-related crashes along the corridor were reviewed, the summary below does not include recommendations for every intersection along the corridor, because the Blue Line design already mitigates some of the existing issues/deficiencies related to these crashes. Recommendations and observations herein are based on the 30% design plans for the Blue Line, the most recent design available at the time that this memo was prepared. Table 4 below summarizes issues and companion recommendations at intersections along the corridor (from west to east) based on evaluation of existing crash data and review of current Blue Line design, from a safety perspective. Additionally, safety recommendations from previous studies were considered, including those outlined in Health by Design's Walking Audits (completed in 2015 and 2018) and those included in Road Safety Assessments (RSAs) completed by WSP in 2011 and 2016 for the Indianapolis Metropolitan Planning Organization (MPO).

In addition to the intersection-specific recommendations summarized in Table 4, the following improvements related to raised crosswalks and Leading Pedestrian Intervals (LPIs) should be considered at identified locations throughout the corridor, as described below.

Raised Crosswalks

It is recommended that raised crosswalks be constructed at all unsignalized crossings (including driveways) along the multi-use path on the south side of Washington Street between Morris Street & S Tibbs Avenue. Raised crosswalks provide a safety benefit for pedestrians because they have been shown to decrease motorist speeds while traversing the crossings, and they improve motorist yielding by making pedestrians more visible. Raised crosswalks have been shown to reduce pedestrian crashes by up to 45%[1]

Leading Pedestrian Intervals (LPIs)

Three-to-five (3-5) second LPIs should be considered for pedestrian crossings across both legs of Washington Street during times when higher pedestrian volumes are expected (ex. 7am to 7pm) at all proposed station locations within I-465. LPIs are also recommended at non-station signalized intersections as noted in Table 4. LPIs associated with pedestrian phases across Washington Street are recommended for the following reasons:

- The current design generally includes shortened pedestrian crossings that are further back from the intersections, where possible. Under these conditions, pedestrians are potentially less visible to turning motorists from the cross-streets, and pedestrians are also crossing in locations where vehicles may be accelerating after a making a turning movement; thus, potential pedestrian-related crashes could be more severe/impactful.
- Many of the left-turns from the cross-streets are currently controlled by permitted-only phasing or protected/permitted phasing, and this operation is not expected to change with implementation of the Blue Line. This operation can create conflicts between left-turning traffic from the cross-streets and pedestrians crossing Washington Street because the pedestrian crossing and the turning movement may occur simultaneously during permitted phasing.

LPIs will improve safety for pedestrians crossing Washington Street, as they will be more visible to nearby motorists. The utilization of LPIs is one of the Federal Highway Administration's (FHWA) proven safety countermeasures, and it is shown to result in a 60% reduction in pedestrian/vehicle crashes at intersections.[2] The implementation of LPIs will require lagging left-turn phases where dedicated left-turn phases currently exist. At

1 Pedestrian Safety Guide and Countermeasure Selection System: Raised Pedestrian Crossings (http://www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=7)

2 Proven Safety Countermeasures: Leading Pedestrian Intervals. FHWA (https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int/)

locations where LPIs are recommended, vehicular capacity has been evaluated, and it has been confirmed that Level of Service (LOS) criteria established for the project can be maintained.

Table 4: Issues and Recommendations

Intersection	Issue(s)	Recommendation(s)
Washington St & Morris St	Set-back crosswalks across the east and west legs may make pedestrians less visible to motorists turning from Morris St/Waldemere Ave onto Washington St	12' crosswalk width on the east and west legs
Washington St & Lynhurst Dr	Set-back crosswalks across the east and west legs may make pedestrians less visible to motorists turning from Lynhurst Dr onto Washington St	- 12' crosswalk width on the east and west legs - Move crosswalk on the east leg closer to the intersection
Washington St & Auburn St	Set-back crosswalks across the east and west legs may make pedestrians less visible to motorists turning from Auburn St onto Washington St	- Move crosswalk on the west leg closer to the intersection - 12' crosswalk width on the east and west legs
Washington St & Fleming St	Set-back crosswalks across the east and west legs may make pedestrians less visible to motorists turning from Fleming St onto Washington St	12' crosswalk width on the east and west legs
Washington St & Holt Rd	Set-back crosswalks across the east and west legs may make pedestrians less visible to motorists turning from Holt Rd onto Washington St	12' crosswalk width on the east and west legs
Washington St & S Tibbs Ave	Channelized eastbound right-turn lane creates higher speed turning movement, which is more dangerous for pedestrians	Remove channelized eastbound right-turn lane (negligible impact on LOS/delay)
Washington St & Rockville Rd	- Driveway within the intersection creates confusion and adds signal phase to cycle - Large curb radius on the northeast corner creates potential for higher speed turning movement, which is more dangerous for pedestrians	- Close driveway on the northeast corner that extends into the intersection - Tighten radius on the northeast corner to better channelize the westbound right-turn and slow turning traffic
Washington St & N Tibbs Ave	Driveway within the intersection on the south leg creates confusion and adds signal phase to cycle	Close driveway on the south leg through the intersection and construct sidewalk along the south side of Washington St where driveway was
Washington St & Warman Ave	Right angle crashes in all directions	Ensure that clearance intervals are timed according to ITE recommended lengths
Washington St & Harding St	Crash pattern involving westbound left-turning motorists and eastbound through motorists	Implement protected-only signal phase for the westbound left-turn. Though this is recommended from a safety perspective, it should be noted that impacts to capacity may make this change infeasible during peak hours. A flashing yellow arrow (FYA) signal indication at this location will allow for changes to left-turn phasing throughout the day.

Table 4 (Cont'd): Issues and Recommendations

Intersection	Issue(s)	Recommendation(s)
Washington St & West St	- Pedestrians struck in the south and north leg crosswalks - Right angle crashes in all directions	- Post No Turn on Red for southbound and westbound right-turns (negligible impact on LOS/delay) - Install flashing LED border around existing R10-15 "Turning Vehicles Yield to Peds" sign to be timed with concurrent green activation on west leg cantilever for westbound right-turns - Install R10-15 "Turning Vehicles Yield to Peds" sign for westbound left-turn - Ensure clearance intervals are timed according to ITE recommended lengths - Over easternmost southbound through lane on north leg: install sign "To Maryland" (lane becomes left-turn lane south of intersection)* - Install one-way sign in median of south leg for southbound traffic* - Install/paint guidelines for westbound right-turn movement (dual lane turning movement)*
Maryland St & West St	- Eastbound left-turning motorists turning into pedestrians in the crosswalk across the north leg - Right angle crashes in all directions	- Install R10-15 "Turning Vehicles Yield to Pedestrians" with flashing LED border to be timed with concurrent green activation on northeast corner signal pole for eastbound left-turns - Ensure clearance intervals are timed according to ITE recommended lengths
Washington St & Missouri St	Pedestrian crashes involving northbound left-turning vehicles and pedestrians in the crosswalk on the west leg	- LPI for pedestrians crossing Washington St - Install R10-15 "Turning Vehicles Yield to Pedestrians" with flashing LED border to be timed with concurrent green activation on north leg cantilever for northbound left-turning traffic
Washington St & East St	Lane destination confusion for southbound motorists	Install/refresh guidelines for southbound left and through vehicles*
Washington St & College Ave	Right angle crashes involving eastbound, westbound, and northbound vehicles	- Install 'No Left Turn' (R3-2) sign for eastbound traffic on west side of railroad bridge with embedded solar powered LED border* - Install LED illuminated 'No Left Turn' (R3-2) signs on signal span for eastbound and northbound traffic* - Replace 'No turns' sign on east side of bridge with 'No Left Turn' sign* - Add thru arrow pavement markings to all lanes of eastbound Washington St west of College Ave* - For eastbound signal heads, install green through arrow instead of green ball* - Reconstruct curb along north side of Washington St west of College Ave* - Ensure that clearance intervals are timed according to ITE recommended lengths

* Recommendation developed as a part of a Road Safety Assessment (RSA) completed by WSP for the Indianapolis MPO

Table 4 (Cont'd): Issues and Recommendations

Intersection	Issue(s)	Recommendation(s)
Washington St & Davidson St/I-65 SB JCT	- Right angle crashes involving westbound vehicles; according to INMUTCD, there is insufficient visibility for existing signal heads in the westbound direction due to the I-65 overpass - Long crossing distance and exposure time for pedestrians crossing Washington St on the east leg	- Install horizontal signal heads for westbound traffic and possibly supplemental ground-mounted signal head on the northeast corner - Construct pedestrian refuge island on the east leg, just south of the bus only lane; install guidelines for eastbound through traffic
Washington St & Pine St/I-65 NB JCT	Long crossing distance and exposure time for pedestrians crossing Washington St	Extend raised median on the east leg to include a pedestrian refuge island
Washington St & State Ave	Right angle crashes in all directions	Ensure that clearance intervals are timed according to ITE recommended lengths
Washington St & Rural St	Anticipated added traffic associated with the CJC may create a safety issue for northbound/southbound left-turning vehicles, assuming permitted phasing shown in 30% plans	Implement northbound & southbound protected/permitted left-turn phasing
Washington St & Kealing Ave	Three crashes involving a pedestrian or bicyclist where the non-motorist was crossing Washington St	Install mid-block pedestrian crossing across Washington St (as described in the Mid-Block Pedestrian Crossing section of this memo below)
Washington St & Ritter Ave	Potential opportunity to shorten pedestrian crossing distance across the west leg	Construct pedestrian refuge island between bus only lanes on the west leg (this would require the westbound bus only lane be shifted to the north)
Washington St & Ridgeview Dr	Potential opportunity to shorten pedestrian crossing distance across the east leg	Construct pedestrian refuge island between bus only lanes on the east leg (this would require the eastbound bus only lane be shifted to the south)
Washington St & Shadeland Interchange	Crosswalks across interchange ramps involving potentially high speed motorists who may not expect pedestrians	- Install fluorescent yellow-green W11-2 pedestrian warning signs with supplemental fluorescent yellow-green W16-7P diagonal arrow signs pointing towards the crosswalks - Install continental crosswalks - If pedestrian activity increases in the future, consider installing Rapid Rectangular Flashing Beacons (RRFBs) on either side of the crosswalks to draw attention to pedestrians
Washington St & Shortridge Rd	Long pedestrian crossing distance and exposure time for pedestrians crossing Washington St	Construct pedestrian refuge islands on the east and west legs
Washington St & Sadlier Dr	Long pedestrian crossing distance and exposure time for pedestrians crossing Washington St on the west leg (station planned on the east leg)	Construct pedestrian refuge island on the west leg
Washington St & Mitchner Ave/Old Trail Dr	Long pedestrian crossing distance and exposure time for pedestrians crossing Washington St	Construct pedestrian refuge islands on the east and west legs
Washington St & Franklin Rd	Long pedestrian crossing distance and exposure time for pedestrians crossing Washington St on the west leg (station planned on the east leg)	Construct pedestrian refuge island on the west leg
Washington St & Cecil Ave	Long pedestrian crossing distance and exposure time for pedestrians crossing Washington St	Construct pedestrian refuge islands on the east and west legs

Mid-Block Pedestrian Crossings

The anticipated, increased pedestrian activity along the Blue Line corridor, mentioned above, may necessitate a need for safer and more closely-spaced pedestrian crossings across Washington Street. The Institute of Transportation Engineers (ITE) indicates that crosswalks should be located no greater than 200 to 300 feet apart in high pedestrian areas, and should not exceed 600 feet in less dense areas.[3]

The need for new/additional, defined mid-block pedestrian crossings was evaluated based on a review of existing land uses and distance between safe crossings (a traffic signal or planned pedestrian crossing). The following locations have been identified as potential locations for mid-block pedestrian crossings along the corridor (from west to east):

- Worth Avenue, east leg (Segment 1)
- Woodrow Avenue, east leg of eastern T-intersection (Segment 1)
- Rybolt Avenue, west leg (Segment 1)
- Pershing Avenue, east leg (Segment 2 – serving George Washington High School)
- Between Traub Avenue & Elder Avenue (Segment 2 – serving a strip mall with several businesses)
- Temple Avenue, west leg of eastern T-intersection (Segment 4)
- Gray Street (Segment 4 - serving Purdue Polytechnic; the location of this crossing may change depending on stakeholder feedback)
- Kealing Avenue (Segment 4 – serving a strip mall with several businesses)
- Bolton Avenue, west leg (Segment 4 – serving several apartment complexes)

Ideally, each of the mid-block pedestrian crossings would include the following treatments:

- Curb bump-outs
- Pedestrian refuge island
- Continental crosswalks (10' minimum width)
- Three Rapid Rectangular Flashing Beacons (RRFB's) at each crossing. One on each side of the street and one in the refuge island

It should be noted that it may be difficult to design/construct each of these treatments at every mid-block pedestrian crossing location because of existing constraints.

3 Designing Walkable Urban Thoroughfares: A context Sensitive Approach. Pgs. 32 and 153