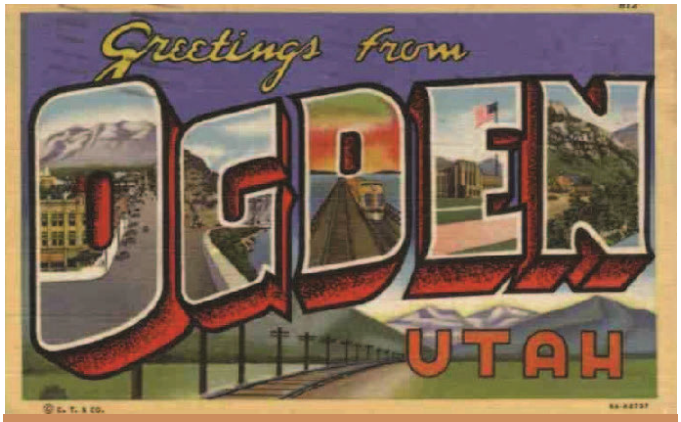
APPENDIX B4

Traffic and Transportation Technical Report



Traffic and Transportation Technical Report

Ogden/Weber State University Transit Project

Ogden, Weber County, Utah

October 10, 2018

Contents

Tables

Figures

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1.0 Introduction

This technical report describes the transportation system and traffic in the traffic and transportation evaluation area for the Ogden/Weber State University Transit Project and evaluates how those resources would be affected by the Action Alternative. The Action Alternative is the Bus Rapid Transit on 25th Street Alternative, which was selected by the Ogden/Weber State University Transit Project partners and adopted by the Ogden City Council as the Locally Preferred Alternative.

Implementation of the No-Action Alternative would not result in adverse impacts to the transportation system or traffic. The affected environment (existing conditions) would remain unchanged from current conditions.

Project Study Area. The project study area encompasses a 5.3-mile corridor between downtown Ogden, Weber State University, and McKay-Dee Hospital. The project study area is located in the city of Ogden in Weber County, Utah. The project study area encompasses a portion of downtown central Ogden bounded by the Union Pacific Railroad line to the west, 20th Street (State Route [S.R.] 104) to the north, the city limits at the base of the Wasatch Mountains to the east, and about 4600 South to the south, the southwestern part of which follows the Ogden/South Ogden municipal boundary (Figure 1).

This project study area includes the following major destinations and Ogden neighborhood districts that could be served by the Action Alternative (Figure 2):

- The Ogden Intermodal Transit Center (FrontRunner operates frequent service from Ogden to Provo, an 88-mile route)
- Lindquist Field, a minor-league baseball stadium with an 8,262-person capacity
- The Junction, a 20-acre entertainment, residential, retail, and office mixed-use redevelopment
- The Ogden downtown central business district, which includes city, county, and federal offices
- Seven neighborhood districts: Central Business (downtown), East Central, Taylor, Jefferson, T.O. Smith, Mt. Ogden, and Southeast Ogden
- Ogden High School, with an annual enrollment of about 1,000 students in grades 10–12
- Weber State University, with about 2,500 faculty and staff and about 25,000 students (up from 17,000 in 2007), 840 of whom lived on campus as of September 2016 (Sears 2016)
- The Dee Events Center, a 12,000-seat sports and entertainment venue with a 3,000-space parking lot
- The McKay-Dee Hospital Center (at 2,300 employees, the fourth-largest hospital in Utah)

Figure 1. Project Study Area

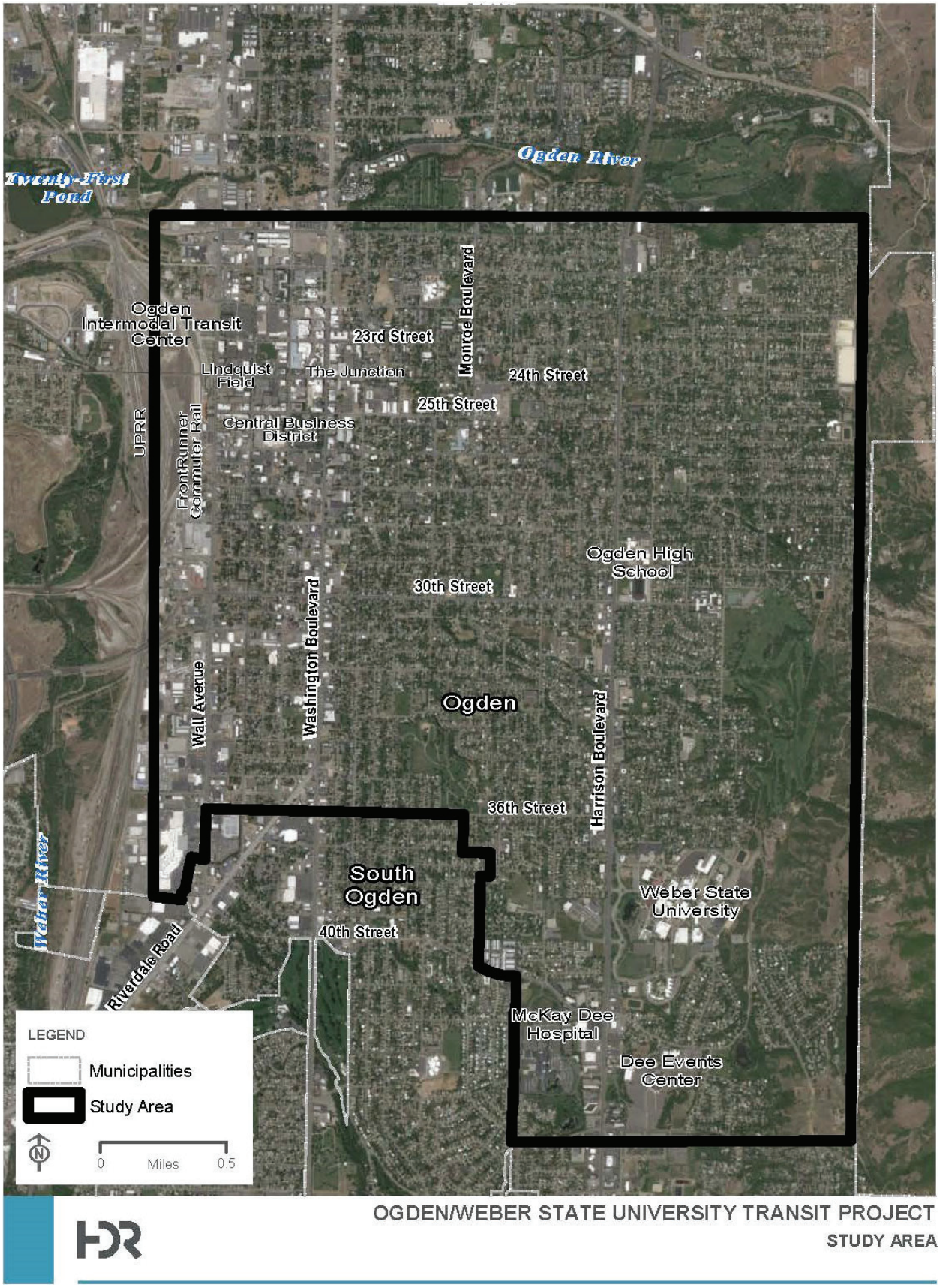
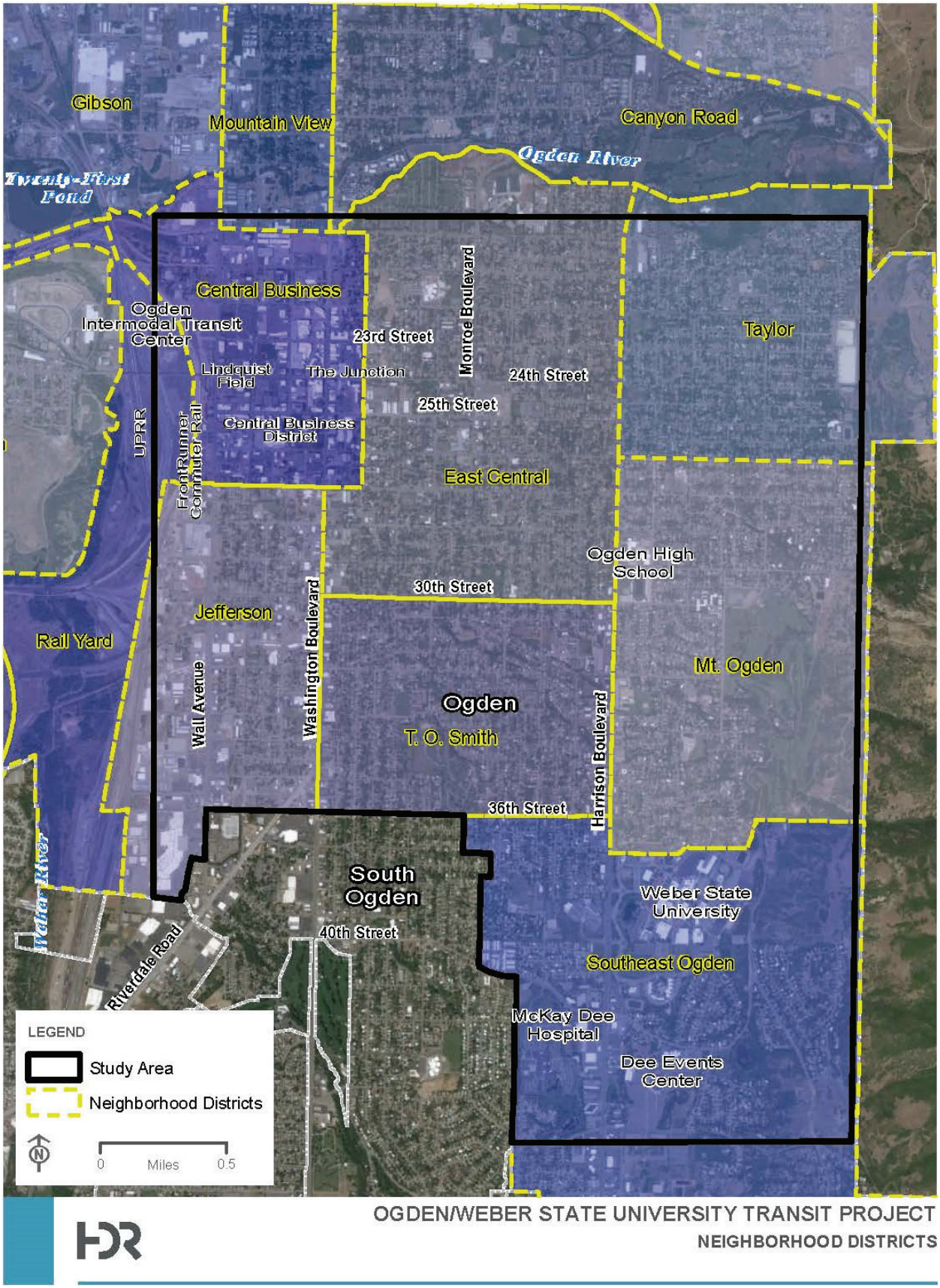


Figure 2. Neighborhood Districts



Ogden is one of the oldest communities in Utah and has a number of historic districts and neighborhoods. Much of central Ogden is served by a traditional grid street system, and a number of the major arterials are state highways managed by the Utah Department of Transportation (UDOT) which serve regional travel through Ogden. These major arterials are Washington Boulevard (S.R. 89), Harrison Boulevard (S.R. 203), and 30th Street (S.R. 79). Harrison Boulevard is part of the National Highway System and is a major north-south arterial that serves an important statewide transportation function through Utah by connecting Washington Boulevard (S.R. 89), Weber State University, and 12th Street (S.R. 39). The Union Pacific Railroad (UPRR) line and the Ogden Intermodal Transit Center are on the western edge of the city, and Interstate 15 (I-15) is just west of the city.

Traffic and Transportation Evaluation Area. The traffic and transportation evaluation area includes the roads and transit, bicycle, and pedestrian facilities along the Action Alternative alignment that would be affected by project construction and operation.

2.0 Project Description

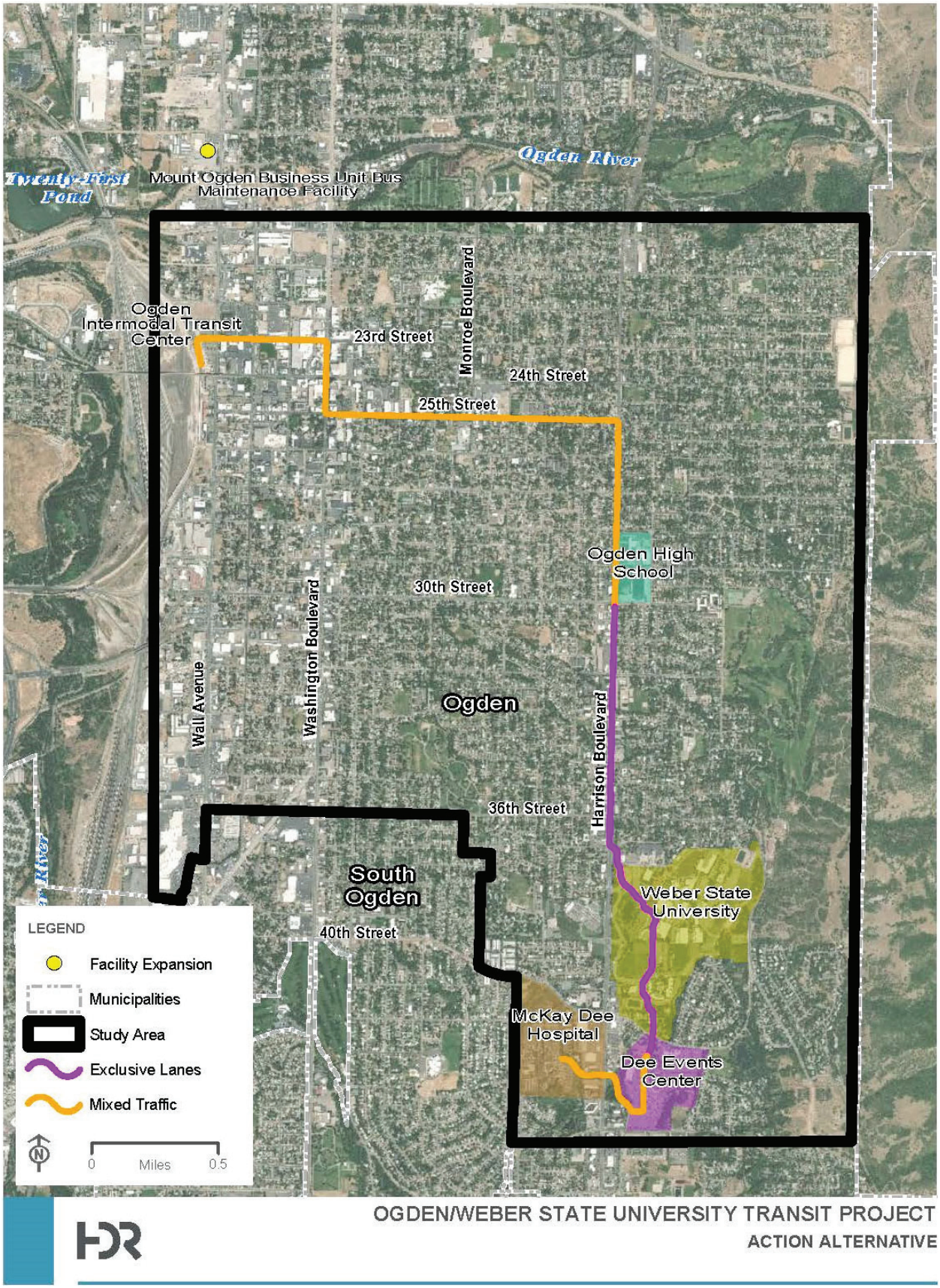
The Federal Transit Administration (FTA) and the Utah Transit Authority (UTA), in cooperation with project partners Ogden City, Weber County, WFRC, UDOT, Weber State University, and McKay-Dee Hospital, are preparing an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA; 42 United States Code §§ 4321–4347) for the Ogden/Weber State University Transit Project.

Proposed Transit Corridor. The proposed transit corridor is the alignment of the Action Alternative (Figure 3). The bus rapid transit (BRT) route for the Action Alternative would be about 5.3 miles long (10.6 miles round trip), with a western terminus at the Ogden Intermodal Transit Center. From there, the BRT route would head east in mixed-flow traffic on 23rd Street to Washington Boulevard, south on Washington Boulevard to 25th Street, east on 25th Street to Harrison Boulevard, and south on Harrison Boulevard. At about 31st Street and Harrison Boulevard, the BRT route would transition to center-running, bus-only lanes. It would continue on a dedicated busway through the Weber State University campus and then travel west to McKay-Dee Hospital, where it would again travel in mixed-flow traffic. The BRT route would loop back on the same route.

Station Locations. The Action Alternative includes 16 brand-identified stations. The station locations were chosen during the project's Alternatives Analysis update process. Station spacing ranges from about 0.25 mile apart to about 0.50 mile apart; several stations on Harrison Boulevard would be farther apart because of the spacing of major destinations.

Of the proposed 16 stations, 11 are existing bus route 603 stations (including the termini at the Ogden Intermodal Transit Center and McKay-Dee Hospital) that would be enhanced as part of the Action Alternative. The project team agreed that not all 16 stations would be constructed for the BRT service's opening day (2020). Three of the 16 stations are designated as future stop locations. The existing route 603 bus currently stops at two of these three locations, and those locations would be discontinued and new enhanced stations would be constructed in their place in the future based on ridership and station demand.

Figure 3. Action Alternative



Station Amenities. The Action Alternative stations would include a platform, canopy, landscaped planter, and station amenities. The station would sit on a concrete bus pad elevated above the sidewalk curb height between 6 and 9 inches above the street grade. Stations would be about 125 feet long, with a platform length of 100 feet to accommodate two 40-foot-long BRT vehicles. Station shelters would be roughly comparable in size to existing UTA bus passenger shelters in the area, though somewhat longer.

At present, UTA anticipates that the shelters would be designed to include a combination of glass panels and solid support members that would have a minimal visual "footprint." Station canopies would be opaque features that provide shelter from sun and rain and would be about 10 to 15 feet high, depending on the incorporation of decorative architectural features that would be determined during final design.

The platform provides the area for passenger waiting, boarding, and station amenities. The station platform would range from 8 to 25 feet wide, depending on the station location and the need for a platform to accommodate either single-direction travel or both southbound and northbound travel. Station amenities could include ticket vending machines, seating, lighting, a canopy and wind screens, garbage receptacles, and wayfinding information (maps and signs).

Mount Ogden Business Unit Bus Maintenance Facility Expansion. In conjunction with the Action Alternative, UTA would expand the existing Mount Ogden Business Unit Bus Maintenance Facility located at 175 W. 17th Street in Ogden. The Mount Ogden facility is currently operating at maximum capacity and cannot accommodate the additional eight BRT vehicles needed for the Action Alternative. As a result, the existing Mount Ogden facility would be renovated and expanded.

Operations at the Mount Ogden facility would continue to include maintenance, repairs, inspections, and cleaning for the existing bus fleet and the additional BRT vehicles. The BRT vehicles would be maintained and stored overnight at this facility. The north maintenance building would be expanded to the east by about 8,000 square feet, remaining within property currently owned by UTA and remaining within the existing parking lot pavement area; no additional right-of-way would be required. The expansion would consist of four new bus maintenance bays, which are covered areas for maintaining the new BRT vehicles as well as buses already in the fleet. The expansion would bring the existing facility from about 32,000 square feet to just under 40,000 square feet.

23rd Street and 25th Street Roadway Improvements. To further support the Action Alternative, Ogden City would upgrade portions of 23rd Street and 25th Street to better accommodate the Action Alternative. 25th Street would be rebuilt from the bottom up, and, in certain instances, water mains would be replaced, storm sewers would be installed, and sanitary sewers would be repaired. Depending on the extent of the utility work, curbs might be fully replaced. Ogden City would also upgrade the roadway infrastructure on portions of 23rd Street between Wall Avenue and Kiesel Avenue to better support the Action Alternative and active transportation (walking and bicycling). Improvements would include adding a traffic signal at Lincoln Avenue, restriping, adding bicycle lanes, adding crosswalks, reconstructing curbs, and reconfiguring parking.

3.0 Regulatory Setting

Because Harrison Boulevard is a state highway, the project team followed Technical Advisory T 6640.8A, *Guidance for Preparing and Processing Environmental and Section 4(f) Documents*, from the Federal Highway Administration (FHWA 1987), which recommends an analysis of travel patterns and accessibility in NEPA documents such as the EA for this project.

4.0 Affected Environment

4.1 Traffic Analysis Approach

Mixed Flow. North of 31st Street, the BRT would operate similarly to a conventional bus in the mixed-flow segments of the Action Alternative alignment. Because the Action Alternative would operate like the existing route 603 bus in the mixed-flow segments of the alignment, it would have no new traffic impacts in those mixed-flow segments. Because of the relatively low impact of BRT vehicles in mixed-flow operations and potential improvements to traffic due to improved boarding and alighting, the project team crafted an approach for the traffic analysis that focused primarily on the bus-only segment of the alignment south of 31st Street on Harrison Boulevard.

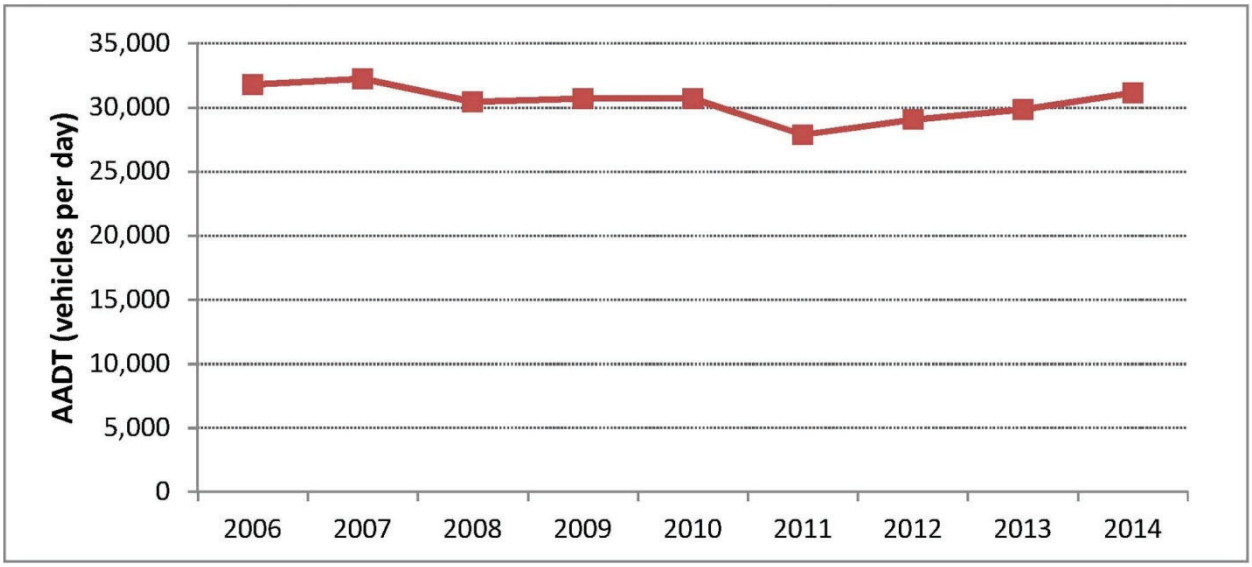
Bus-Only Lanes. Since Harrison Boulevard is a state highway and a north-south principal arterial, the project team developed the traffic analysis approach in cooperation with UDOT. The models, results, and conclusions of the analysis, including the traffic microsimulation models, were reviewed and vetted by UDOT staff. The assumptions used in the traffic evaluation included 10-minute headways in each direction, a 40-mile-per-hour (mph) transit vehicle speed (the same as the posted speed limit on Harrison Boulevard), and 20-second station dwell times. In addition, existing signal timing parameters from UDOT were assumed for base conditions.

Finally, the project team assumed far-side intersection station locations at both the 32nd Street Harrison and 36th Street Harrison Boulevard intersections to allow the BRT vehicle to travel through the signalized intersection before stopping to deliver and collect passengers. At the transition point between mixed-flow operation and bus-only lanes on Harrison Boulevard at 32nd Street, the BRT vehicle would move in and out of the bus-only lanes on the north side of the intersection. This layout would allow the BRT vehicle to take advantage of bus-only lanes through the intersection when traveling either northbound or southbound. Additionally, this layout offers the opportunity to place the station platforms in the center of Harrison Boulevard at the traffic signal itself and so would provide riders with a signalized pedestrian crossing to the curb.

4.2 Data Collection

Exhaustive traffic data collection was conducted (mostly during 2009) for the alignment options in the Alternatives Analysis conducted for the project in 2011. Because traffic volumes on Harrison Boulevard have remained steady over the past several years, the project team used the traffic volume data collected in 2009 as the initial basis for the current analysis. Then, the project team performed additional traffic counts on Harrison Boulevard in 2014 and 2015 to verify the appropriateness of using the volumes from 2009. In most cases, the volumes from 2009 were actually higher than those collected in 2014 and 2015, and the project team used the data source with the higher traffic volumes for this analysis. Historic average annual daily traffic (AADT) volumes on Harrison Boulevard from UDOT confirm this trend (Figure 4).

Figure 4. Historic Daily Traffic Volumes on Harrison Boulevard (56th Street to 24th Street)



Source: UDOT 2014

4.3 Traffic Forecasts

The project team used the existing (2015) traffic volumes at intersections on Harrison Boulevard (Figure 5) and regional roadway forecasts to develop traffic forecasts for these intersections in 2040 (Figure 6). These forecasts were used to analyze traffic conditions and BRT performance in 2040 with and without the Action Alternative.

Regional roadway forecasts were obtained from the WFRC regional travel demand model. The WFRC model includes growth assumptions about socioeconomic conditions as well as planned roadway network and transit projects according to WFRC's 2015–2040 Regional Transportation Plan (RTP).

What is a travel demand model?

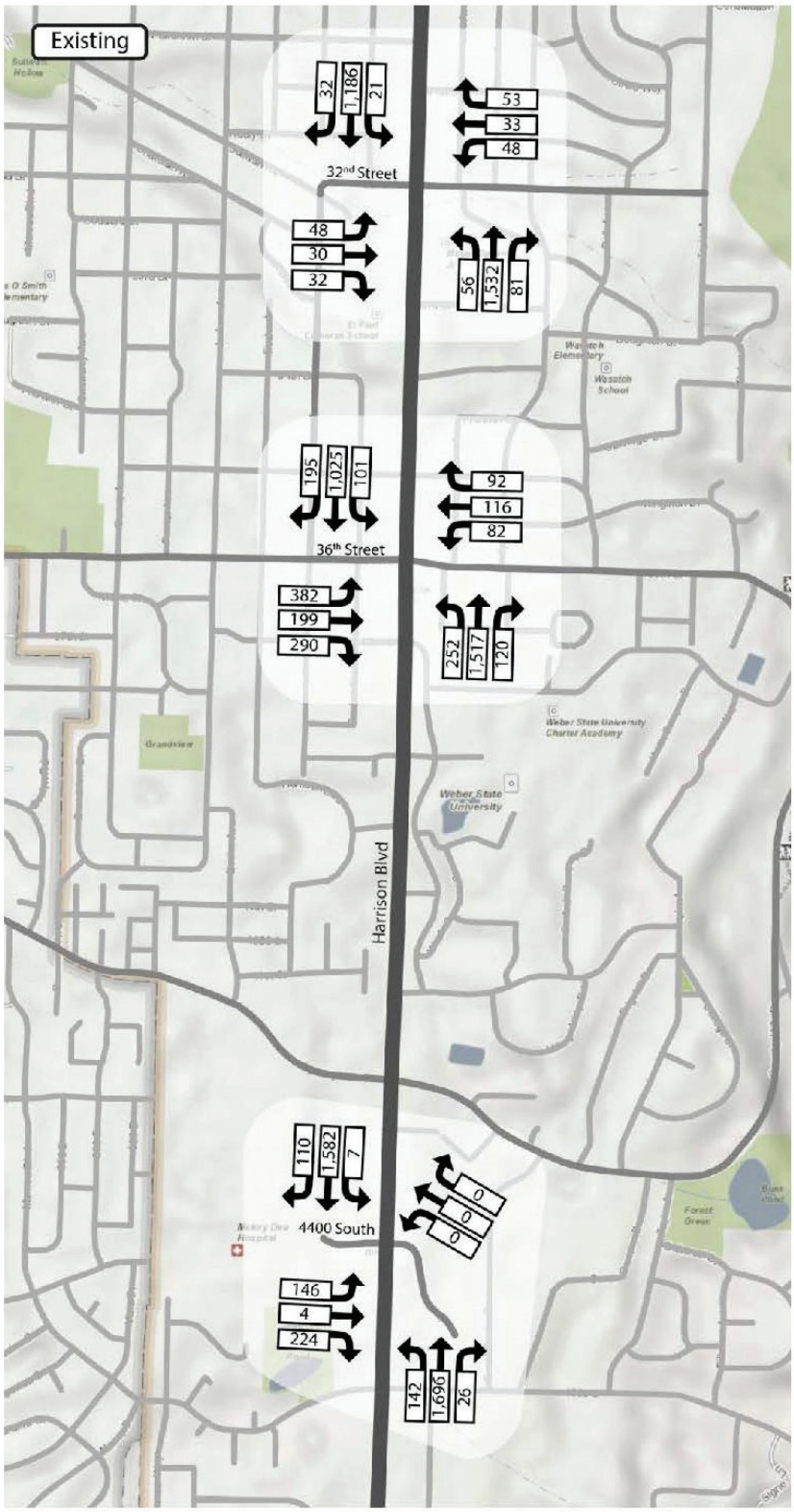
Travel demand refers to the forecasted amount of travel on existing and future roads. A travel demand model predicts future travel demand based on projections of land use, socioeconomic patterns, and transportation system characteristics.

As noted in Section 4.2, Data Collection, traffic growth projections for much of the project study area are moderate. Most of Harrison Boulevard is expected to have an annual traffic growth rate of less than 1%. However, because of the aforementioned future widening project on Harrison Boulevard between U.S. Highway 89 (U.S. 89) and Country Hills Drive, Harrison Boulevard south of Country Hills Drive is projected to have increased traffic volumes (Table 1).

Table 1. Existing (2015) and Projected (2040) Traffic Volumes on Harrison Boulevard

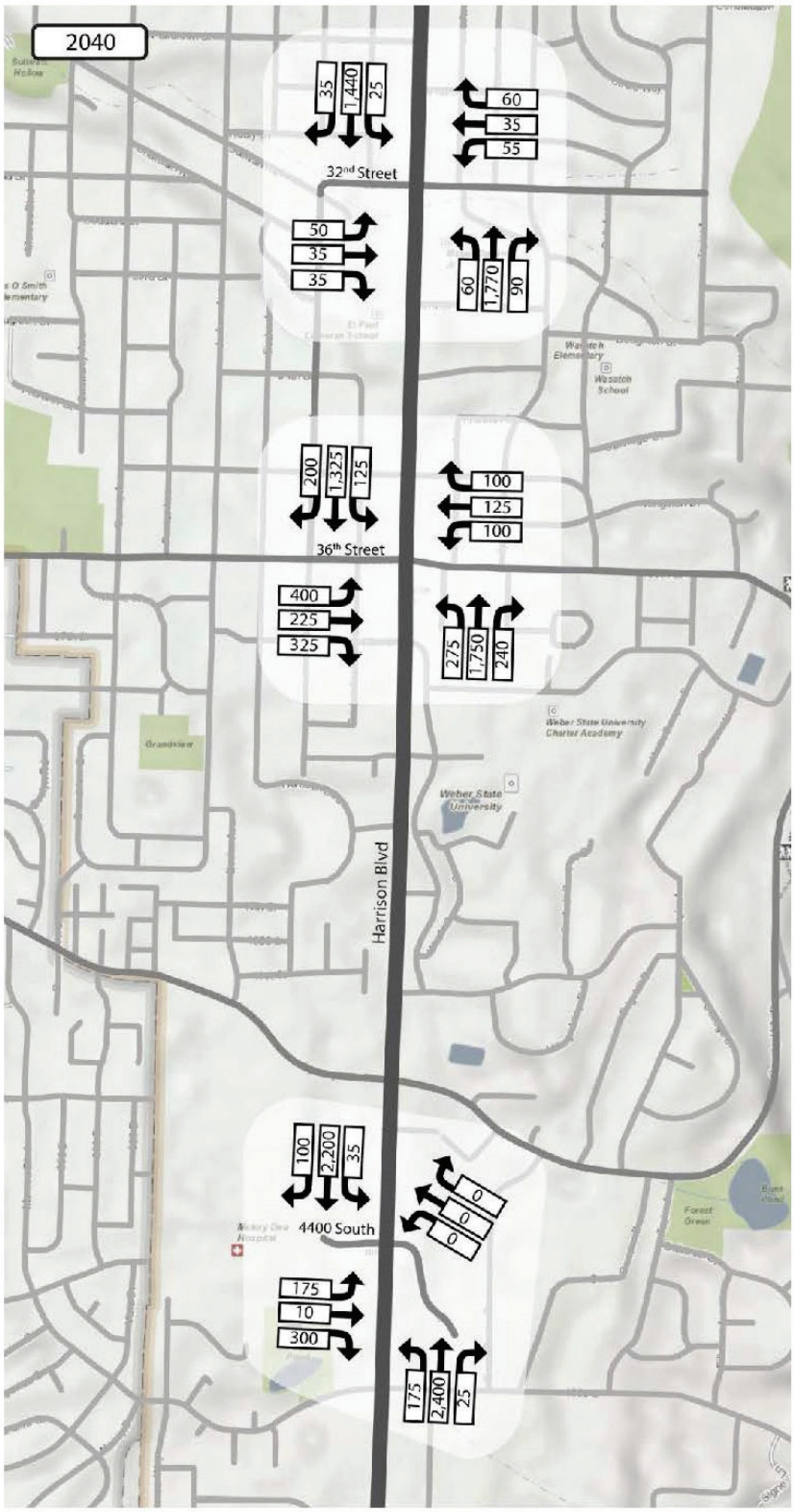
Segment	Average Annual Daily Traffic (vehicles per day)		Total Percent Growth (%)	Annual Growth Rate (%)
	Existing	2040		
24th Street to 30th Street	28,000	33,000	18	<1
30th Street to 36th Street	28,000	32,000	14	<1
36th Street to Country Hills Drive	34,000	40,000	18	<1
Country Hills Drive Street to 44th Street	33,000	46,000	40	1.3

Figure 5. Existing (2015) PM Peak-Hour Traffic Volumes at Intersections on Harrison Boulevard



OGDEN/WEBER STATE UNIVERSITY TRANSIT PROJECT
EXISTING (2015) PM PEAK-HOUR TRAFFIC VOLUMES

Figure 6. Projected (2040) PM Peak-Hour Traffic Volumes at Intersections on Harrison Boulevard



OGDEN/WEBER STATE UNIVERSITY TRANSIT PROJECT
PROJECTED (2040) PM PEAK-HOUR TRAFFIC VOLUMES

5.0 Environmental Consequences

5.1 No-Action Alternative

The project team modeled the expected traffic along the proposed transit corridor on the project's opening day (2020) but without the Action Alternative. This traffic analysis serves as a baseline scenario and provides comparative measures to help quantify the traffic and transportation impacts of the Action Alternative. The traffic growth projections for much of the project study area are moderate.

With the No-Action Alternative, the Ogden/Weber State University Transit Project would not be built, but other improvements identified in WFRC's 2015–2040 RTP would continue to be implemented. The RTP identifies a limited number of major roadway improvements in the project study area, including future widening of Harrison Boulevard between U.S. 89 and Country Hills Drive. This widening project is planned for phase 2 (2025 to 2034) of the RTP and includes widening Harrison Boulevard from a five-lane roadway to a seven-lane roadway between U.S. 89 and Country Hills Drive.

In addition, on the western edge of the project study area, 24th Street between I-15 and Lincoln Avenue (one block west of Wall Avenue) is identified for widening from two lanes to four lanes, and the I-15 interchange at 24th Street is also identified for improvements. These improvements would increase the capacity of 24th Street and make it the primary regional link to downtown Ogden from I-15.

Existing transit use in the project study area is focused primarily at four major areas: the Ogden Intermodal Transit Center, downtown Ogden (25th Street and Washington Boulevard), the Weber State University main campus, and McKay-Dee Hospital. These four stops produce over half of the total transit ridership in the project study area. In addition, UTA bus routes 603 and 612, which offer frequent service, experience steady ridership, especially along 25th Street, Washington Boulevard, and Harrison Boulevard.

The primary local bus route, 603, provides service between all four major destinations and is one of the most-used local routes in the UTA system. Route 603 is the route that the Action Alternative would replace with the enhanced service and amenities of a BRT system. With the No-Action Alternative, the existing route 603 bus would continue to operate on its existing route. Those people who are transit-dependent would continue to ride the route 603 bus and other local buses but would not have the opportunity to experience the faster, more frequent and reliable service afforded by the Action Alternative.

Strong existing transit ridership on the Weber State University campus and in the project study area overall, and the projections for significantly increased travel demand, would require that the capacity of the local bus service be increased substantially in the project study area. The capacity needed will eventually exceed UTA's capability to satisfy the demand with the existing conventional bus service.

The university's Wildcat Express Shuttle would continue to serve university riders between the Dee Events Center and Stewart Library, and, based on campus ridership projections, the shuttle service's capacity would likely need to be increased in the future as well. In addition, with the No-Action Alternative, parking on campus would likely become increasingly difficult, and the University would not be able to fully implement its Master Plan.

Most of Harrison Boulevard is expected to have about a 14% to 18% increase in traffic volumes over existing (2015) conditions, which equals an annual growth rate of less than 1%. The segment of Harrison Boulevard with the greatest projected increase in traffic is south of Country Hills Drive. This increase is mainly due to the assumed roadway widening project on Harrison Boulevard. The widening would allow this segment of Harrison Boulevard to serve an increased share of north-south traffic in the region.

With the No-Action Alternative, the intersections on Harrison Avenue that would have bus-only lanes with the Action Alternative would continue to operate at acceptable levels of service of LOS D or better, though by 2040 the 36th Street and Harrison Boulevard intersection would degrade to LOS E due to the growth in traffic.

What is level of service?

Level of service is a measure of the operating conditions on a road or at an intersection. Level of service is represented by a letter "grade" ranging from A (free-flowing traffic and little delay) to F (extremely congested, stop-and-go traffic and excessive delay). LOS B through LOS E represent progressively worse operating conditions.

5.2 Action Alternative

5.2.1 Traffic Analysis

The nature of the BRT guideway affects the impacts of the Action Alternative on the transportation system. For mixed-flow areas, the Action Alternative would have impacts on par with the existing bus service. In contrast, the bus-only segments of the Action Alternative could have a substantial effect on traffic signal phasing and operation, intersection footprints, and lane configurations. For this reason, this section provides a more detailed evaluation of the transportation impacts of the Action Alternative's bus-only lanes.

5.2.2 Mixed-Flow Lanes

North of 31st Street, the BRT would operate similarly to a conventional bus in the mixed-flow segments of the Action Alternative alignment. Because the Action Alternative would operate like the existing route 603 bus in the mixed-flow segments of the alignment, it would have no new traffic impacts in those mixed-flow segments.

Currently, the speed limit on 25th Street varies depending on the direction of travel. Eastbound from Washington Boulevard to Harrison Boulevard, the speed limit is 30 mph, while westbound from Harrison Boulevard to Washington Boulevard, the speed limit is 35 mph. Ogden City officials have said that 25th Street will eventually be 30 mph in both directions (Anderson 2018). The project team assumed an operating speed of 30 mph in mixed-flow traffic for the Action Alternative on 25th Street.

At most stops, the BRT vehicles would use the shoulder or a transit pull-out. At a few locations, the BRT vehicle would stop in the travel lane. However, these locations either are in a downtown area with slow-moving traffic (23rd Street) or already have existing bus service (25th Street), meaning that the BRT service would not create any additional impacts beyond those from the current bus service. Furthermore, the off-board ticketing and floor-level platforms offered by the BRT system would reduce boarding and alighting times at stops, potentially improving traffic conditions in the portion of the alignment north of 31st Street and Harrison Boulevard.

5.2.3 Bus-Only Lanes

Transition Points

The transition points from mixed-flow lanes to bus-only lanes are the areas with a greater potential for BRT impacts. During the EA process, two possible locations for the north BRT transition point on Harrison Boulevard were identified:

- 30th Street
- 32nd Street

After discussions with stakeholders, the project team eliminated the 30th Street transition point from further consideration due to right-of-way constraints and impacts to existing businesses and properties. Thus, only the 32nd Street transition point was evaluated.

At the 32nd Street transition point, the BRT vehicle would move in and out of the bus-only lanes on the north side of the intersection. This would allow the BRT vehicle to take advantage of bus-only lanes through the intersection both northbound and southbound. Additionally, this layout allows UTA to place the station platforms in the center of Harrison Boulevard at the signal itself and thus give riders a signalized pedestrian crossing to the curb. Furthermore, if the BRT vehicle were to transition to mixed flow south of 32nd Street, the vehicle would have to make several quick lane changes to reach the accompanying curb-side stations at 32nd Street.

The BRT transition point on the south end of the proposed transit corridor is in the Dee Events Center parking lot, where vehicle speeds and activity levels are typically low. Thus, few impacts are expected at this transition point.

Microsimulation Methodology

What is the PM peak hour?

The PM peak hour is the 1-hour period of the afternoon during which there is the greatest number of vehicles on the roadway system.

In order to analyze BRT impacts to the transportation system, the project team conducted microsimulation analysis with the traffic analysis program VISSIM 5.4. The project team analyzed "opening-day" conditions with and without the Action Alternative as well as conditions in 2040 with and without the Action Alternative for the signals and intersections on Harrison Boulevard that would be affected by the bus-only lanes. Because the PM peak hour has much higher traffic volume than the AM peak hour, the analysis focused on the PM peak hour as the representative peak timeframe for the day. This analysis included the following locations:

- 32nd Street/Harrison Boulevard
- 36th Street/Harrison Boulevard
- 37th Street/Harrison Boulevard (north BRT entrance/exit to Weber State University)
- 44th Street/Harrison Boulevard (south BRT entrance/exit to Weber State University)

In analyzing how well an intersection operates, the project team determined the capacity and/or operational level of service (LOS) for the intersection. Typically, LOS D service flow rates are used as minimally acceptable standards in order to ensure acceptable traffic operations.

The project team calculated levels of service from VISSIM-generated outputs. VISSIM methods are comparable with the methods and procedures of the 2010 *Highway Capacity Manual* (TRB 2010) to calculate vehicle delay on the roadway network. Table 2 lists the level of service definitions for signalized intersections.

Table 2. Level of Service Criteria for Signalized Intersections

Level of Service	Average Control Delay (seconds/vehicle)
A	0 – 10
B	> 10 – 20
C	> 20 – 35
D	> 35 – 55
E	> 55 – 80
F	> 80

Source: TRB 2010

For microsimulation analysis, the project team incorporated BRT operational assumptions consistent with the environmental analysis. Specifically, the project team assumed that the BRT vehicles would operate with 10-minute headways during the peak hours and that the BRT vehicles would be capable of traveling near or at the posted speed limit of 40 miles per hour on Harrison Boulevard. Finally, the project team assumed far-side intersection station locations at both the 32nd Street/Harrison Boulevard and 36th Street/Harrison Boulevard intersections. Far-side stations allow the BRT vehicle to progress through the signal before stopping to deliver and collect passengers.

Coordination with UDOT

Because the proposed BRT alignment would operate in bus-only lanes on a state highway (Harrison Boulevard), the project team coordinated with UDOT staff to develop a traffic analysis approach that meets UDOT's expectations. During the analysis process, the project team vetted alignment concepts and incorporated input from UDOT staff. The project team also submitted models to UDOT staff for their review and addressed their comments.

In particular, UDOT staff asked the project team to incorporate transit signal priority assumptions that reflect the current approach by UDOT on transit corridors. This approach consists of global positioning system (GPS)-enabled transponders on transit vehicles that communicate with signal controllers. When the transit vehicle is behind schedule, the transponder alerts the signal controller, which is allowed to provide 5 to 15 seconds of extra or early green light time for the movement serving the BRT vehicle.

At most Harrison Boulevard intersections this priority system likely would not apply, either the BRT vehicles would already be part of the major through movement (north-south), which already receives the majority of the green light time, or because the cycle lengths would be

too short to take green light time from the side streets without dropping below the minimum green light times necessary for pedestrian crossings.

A potential location where a priority system would likely apply would be the 44th Street/ Harrison Boulevard intersection, where the Action Alternative would cross Harrison Boulevard east-west between the Weber State University campus and McKay-Dee Hospital. Because the primary traffic movement is north-south on Harrison Boulevard, east-west traffic experiences long waits to receive a green light. Thus, if a BRT vehicle were behind schedule, it could benefit from a longer east-west green phase to get through the intersection slightly faster or else catch the end of the green phase and not have to wait through an additional signal cycle.

At UDOT staff's suggestion, the project team included a sensitivity test for this signal by diverting 10 seconds of north-south green time to the east-west phase. This change was applied to all modeling scenarios to provide a conservative estimate of the effect of any transit signal priority system.

Other assumptions used in the traffic evaluation included 10-minute headways in each direction, a 40-mph transit vehicle speed (the same as the posted speed limit on Harrison Boulevard), and 20-second station dwell times. In addition, existing signal timing parameters from UDOT were assumed for base conditions. Finally, the project team assumed far-side intersection station locations at both the 32nd Street Harrison and 36th Street Harrison Boulevard intersections to allow the BRT vehicle to travel through the signalized intersection before stopping to deliver and collect passengers.

Opening-Day Conditions

The project team analyzed intersection performance for opening-day conditions with and without the Action Alternative. The opening-day analysis without the Action Alternative serves as a baseline scenario and provides comparative measures to help quantify the effects of the Action Alternative. Traffic volumes on Harrison Boulevard have remained stable over the last several years. In many cases, traffic counts performed in 2009 had higher volumes than counts performed for the same location in 2014 or 2015. Thus, the project team used the data source with the higher traffic volumes to develop existing conditions (2015) traffic volumes on Harrison Boulevard. Considering the stability of traffic volumes in the last several years, and assuming an opening day for the project within the next 5 years, the project team applied the existing conditions volumes for the opening-day volumes.

Table 3 summarizes the intersection level of service for signalized intersections with bus-only lanes. As shown in Table 3, the Action Alternative would cause increased delay at each intersection. The most substantial increase would be at the 32nd Street/Harrison Boulevard intersection. This is due primarily to a switch from permitted phasing to protected-only phasing for the northbound and southbound left turns.

Table 3. Levels of Service at Signalized Intersections in the PM Peak Hour on Opening Day

Intersection	Without Action Alternative		With Action Alternative	
	LOS	Average Delay at Traffic Signal (seconds/vehicle)	LOS	Average Delay at Traffic Signal (seconds/vehicle)
32nd Street/Harrison Blvd.	A	9	C	27
36th Street/Harrison Blvd.	D	38	D	41
44th Street/Harrison Blvd.	C	24	D	38

Though less flexible than permitted left-turn phasing, protected-only phasing is a safety necessity at all signals with center-running BRT lanes. Protected-only left-turn phasing provides a separate phase for left turns and eliminates the conflicts between left turns and BRT vehicles.

What are permitted and protected-only phasing?

Permitted phasing is a type of traffic signaling in which left-turning traffic may turn left after yielding to conflicting traffic and pedestrians.

Protected-only phasing is a type of traffic signaling in which left-turning traffic may turn left only on a green left arrow signal, and no pedestrians or other traffic conflict with the left turn.

For example, with the existing permitted left-turn phasing, drivers turning left from Harrison Boulevard may turn on a green light whenever there is a gap in the opposing traffic. With center-running BRT lanes, drivers making a left turn from Harrison Boulevard would have to cross both BRT lanes in addition to the two opposing travel lanes. Not only does this increase the left-turn crossing distance by the width of two lanes, BRT vehicles would be approaching from behind in the lane adjacent to the left-turning vehicle. In summary, it would be very difficult for left-turning drivers to find gaps in the opposing traffic, turn across four lanes, and check for BRT vehicles approaching from behind.

The increase in delay at the 44th Street/Harrison Boulevard intersection is a result of the assumed transit-priority timing schemes discussed in the section titled Coordination with UDOT on page 15. Though the Action Alternative would result in increased delay, all intersections would continue to operate at acceptable levels of service (LOS D or better).

2040 Conditions

The project team analyzed intersection performance for conditions in 2040 assuming the background traffic growth and planned roadway network improvements discussed in Section 1.0, Introduction. Table 4 summarizes the levels of service with and without the Action Alternative. In Table 4, failing intersection levels of service are shown in **red**.

Table 4 shows that the 36th Street/Harrison Boulevard intersection would reaches a failing level of service in 2040 without the Action Alternative and that the Action Alternative would add only slightly to the delay (an average of 5 seconds per vehicle). At the other intersections, the Action Alternative would add substantial delay (up to 27 seconds per vehicle), though the overall level of service would remain at an acceptable level. The conditions at the 44th Street/ Harrison Boulevard intersection are similar to the opening-day conditions shown in Table 3

above because the assumed Harrison Boulevard widening project would increase roadway capacity to match the increase in traffic.

Table 4. Levels of Service at Signalized Intersections in the PM Peak Hour in the Design Year (2040)

Intersection5	Without Action Alternative		With Action Alternative	
	LOS	Average Delay at Traffic Signal (seconds/vehicle)	LOS	Average Delay at Traffic Signal (seconds/vehicle)
32nd Street/Harrison Blvd.	B	11	D	38
36th Street/Harrison Blvd.	**E**	**62**	**E**	**67**
44th Street/Harrison Blvd.	C	27	D	37

Red indicates a failing intersection level of service (LOS E or F).

37th Street Access

In addition to intersection level of service, the project team evaluated the lengths of vehicle queues because of concerns that queues might block the north BRT entrance to the Weber State University campus. Traffic modeling shows that, by 2040, northbound vehicle queues from the 36th Street/Harrison Boulevard intersection would become long enough to extend across the BRT entrance at about 37th Street, blocking the BRT vehicle's movements into and out of the campus.

Table 5 shows the average vehicle queue length for the northbound approach to 36th Street for the Action Alternative on opening day and in 2040. The table shows that, with the Action Alternative, vehicle queues would exceed the available 540 feet of storage by 2040.

Table 5. Vehicle Queues on Harrison Boulevard South of 36th Street in the PM Peak Hour

Intersection	Average Queue Length (ft)
Vehicle queue storage on Harrison Boulevard between 36th and 37th Streets	540
Action Alternative on opening day	375
Action Alternative in 2040	625

One option to mitigate the blocked access for the BRT vehicles is to add a BRT-only signal at the 37th Street access. The signal could keep the BRT access clear and provide a protected movement for the BRT vehicle into and out of the campus. Because the Action Alternative would not cross the southbound lanes at this location, the signal would have to stop northbound traffic only.

Since Harrison Boulevard is a state highway, the project team coordinated with UDOT personnel to vet the 37th Street signal concept and to model a signal that would operate according to UDOT's specifications and desires. UDOT staff said that the signal should be

modeled to operate in coordination with other signals on Harrison Boulevard. Specifically, the signal should not provide an immediate green light anytime a BRT vehicle arrives. Instead, the signal should provide a green light to the BRT vehicle only in coordination with the corridor timing pattern so as to minimize the disruption to north-south traffic. Additionally, UDOT staff suggested that the modeling should assume a signal-detection system that's tied to a transponder on the BRT vehicle itself. That way the signal would change for a BRT vehicle only and not for drivers who accidentally or intentionally try to use the BRT access. Such a system is being investigated for use on the Provo-Orem BRT project currently under design by UTA.

The project team implemented UDOT's desired operational assumptions into the microsimulation evaluation of a 37th Street signal. Table 6 summarizes the effect of the new signal on intersection level of service for conditions on opening day and in 2040. As shown in the table, the signal would have little effect on the opening-day conditions. For conditions in 2040, delay at the 36th Street/Harrison Boulevard intersection appears to be reduced. However, this is likely because the total delay from the 36th Street intersection is split between the 36th and 37th Street intersections. In summary, a new signal at 37th Street would neither improve nor worsen conditions at 36th Street.

The timing of when to potentially install a signal at 37th Street should be discussed. The queuing analysis suggests that vehicle queues from 36th Street would not block the BRT access at 37th Street on opening day. However, safety and transit reliability considerations might make installing a signal for opening-day considerations worthwhile.

For example, absent a signalized movement, a BRT vehicle would have to make a left turn across three lanes of oncoming traffic in order to turn into the Weber State University campus. Traffic modeling shows that the upstream signal at 3850 South would create gaps in the northbound traffic, which would help the BRT vehicle make a left turn. However, the length of an articulated BRT vehicle and its slower acceleration make left turns more challenging than for conventional vehicles.

Additionally, for the right turn out of campus and onto Harrison Boulevard, the BRT vehicle would need to merge and maneuver across three lanes of traffic to reach the entrance to the center-running BRT lane. This entrance might need to be positioned well in advance of the 36th Street signal so that it is not blocked by northbound through traffic or the queue of left-turning vehicles.

Having protected signalized movements into and out of the Weber State University campus would help the BRT vehicles make safer and more-reliable turns during peak hours. Note that, because Harrison Boulevard is a state highway, any efforts to plan for or install a new signal at 37th Street would require coordination with UDOT and are subject to UDOT's signal warrant analysis processes.

Table 6. Levels of Service at Intersections with the Action Alternative in the PM Peak Hour with and without a 37th Street Signal

Intersection	Opening Day				2040			
	No 37th Signal		With 37th Signal		No 37th Signal		With 37th Signal	
	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)
32nd Street/Harrison Boulevard	C	27	C	27	D	38	D	39
36th Street/Harrison Boulevard	D	41	D	41	**E**	**67**	D	51
37th Street/Harrison Boulevard	Not applicable		A	7	Not applicable		A	10
44th Street/Harrison Boulevard	D	38	D	38	D	37	D	39

Red indicates a failing intersection level of service (LOS E or F).

Weber State Campus Alignment

The Action Alternative through the Weber State University campus follows a combination of bus-only and mixed-flow lanes adjacent to or on campus roads and parking lots. In some locations the Action Alternative crosses campus roads, but these roads are low-volume roads, and the BRT approaches to the roads would be stop-controlled. The Action Alternative also traverses a small residential area between the north and south halves of campus. At this point, the BRT vehicle would cross Country Hills Drive, an east-west public street. Again, the BRT approaches would be stop-controlled, and the BRT vehicle would yield to traffic on Country Hills Drive.

Finally, the BRT alignment would follow 44th Street from the Dee Events Center parking lot down the hill to Harrison Boulevard. This road currently supports one-way eastbound traffic only. To facilitate bidirectional BRT movement, the roadway would be widened to add a lane for westbound traffic as well. Both lanes would serve the BRT vehicles and general-purpose traffic.

Signs, Pavement Markings, and Traffic Control

In general, a median busway is readily apparent to other users, so there should be limited need to mark the center–running, bus-only lanes in an aggressive manner. The bus-only lanes would be physically separated from mixed-flow traffic and demarcated by the use of a different material (such as asphalt for the roadway and concrete for the dedicated busway), pavement striping, rumble strips, or any combination of these elements.

Signs indicating bus use only in the dedicated busway would be included. In addition, a 9-inch-high median barrier would be installed between the two bus-only lanes to prevent automobiles from using the bus lanes as turning lanes and to prevent left turns at unsignalized intersections. Access to Fire Station #5 (at 3450 S. Harrison Boulevard) would be maintained (that is, there would be a gap in the median barrier to allow emergency vehicles to safely cross the bus-only lanes when necessary).

UTA would work with UDOT during the final design phase of the project to properly sign and mark intersections in order to make sure that other vehicles do not mistakenly enter the busway. Further, left turns from side streets onto Harrison Boulevard would be allowed at signalized intersections only. Left turns onto Harrison Boulevard from 33rd, 34th, and 35th Streets would be eliminated, and signs for right turns only would be posted. Additionally, left turns across the bus-only lanes from Harrison Boulevard onto cross streets at unsignalized intersections would also be restricted via the median barrier described above as well as by the addition of no-left-turn signs.

5.3 Conclusions

The project team analyzed the impacts and operation of a BRT alternative connecting the Ogden Intermodal Transit Center with Weber State University and McKay-Dee Hospital (the Action Alternative). The analyzed alignment has segments of mixed-flow travel and segments of bus-only lanes. The areas of mixed flow would not have substantial effects on the transportation system because the BRT vehicles would operate similarly to the existing conventional bus service.

The segments of the Action Alternative with bus-only lanes were evaluated with detailed microsimulation analysis. The results show that the Action Alternative would not cause failing levels of service at any of the analyzed intersections on the project's opening day. For conditions in 2040 without the Action Alternative, the 36th Street/Harrison Boulevard intersection would have a failing level of service (LOS E) because of projected growth in the volume of traffic. Adding the BRT service to the intersection would add a slight delay (5 seconds) to this already-failing intersection.

Because of expected PM peak-hour vehicle queues at the 36th Street/Harrison Boulevard intersection by 2040, the project team recommends adding a transit-only signal at the Action Alternative's northern entrance to the Weber State University campus (at about 37th Street). The signal would help prevent the BRT vehicles' movements into and out of the campus from being blocked by vehicle queues.

Although this traffic signal is not merited from a queuing standpoint for opening day, the project team nonetheless recommends considering adding the signal during project construction to improve safety and transit reliability. The project team modeled signal performance for conditions on opening day in coordination with UDOT staff and found that a 37th Street signal can operate adequately within the signal timing scheme on Harrison Boulevard. Whenever a 37th Street signal might be installed, the installation would be subject to UDOT's signal warrant analysis processes.

6.0 References

Anderson, Justin

2018 Personal communication between Justin Anderson of Ogden City and Heidi Spoor of HDR, Inc., regarding the operating characteristics on 25th Street. March 9.

[FHWA] Federal Highway Administration

1987 Technical Advisory T 6640.8A, Guidance for Preparing and Processing Environmental and Section 4(f) Documents. https://www.environment.fhwa.dot.gov/legislation/nepa/guidance_preparing_env_documents.aspx.

Sears, Craig

2016 Personal communication between Heidi Spoor of HDR and Craig Sears of Weber State University regarding Weber State University student demographics. September 12.

[TRB] Transportation Research Board

2010 Highway Capacity Manual, Fifth Edition.

[UDOT] Utah Department of Transportation

2014 Traffic on Utah Highways.