Technical Memorandum

To: Wasatch Front Central Corridor Study Management Team

From: Wasatch Front Central Corridor Study (WFCCS) Technical Team

Date: April 2017

Subject: Transportation Evaluation of Investment Scenarios Memorandum

Purpose of this Memorandum

This memorandum describes the process of evaluating the three investment scenarios based on the WFCCS transportation-specific goals and metrics. For the purposes of this memorandum, "project team" is used to describe the Management Team and the consultant technical and communication teams combined. The analysis presented here is specific to the transportation-related metrics; analysis conducted by the WFCCS economics specialists (addressing benefit/cost analysis, employment growth, personal income levels, gross regional product, and household transportation costs) will be provided in a separate technical memorandum.

Organization of this Memorandum

Figures 1, 2 and 3 compare results for the transportation analysis of the WFCCS scenarios. The WFCCS scenarios are arranged along a spectrum of transportation demand, with Scenario 1 representing a blend of transportation demand management strategies and capacity improvements; Scenario 2 focusing on management strategies; and Scenario 3 focused primarily on capacity improvements. Figure 1 below summarizes the performance of the quantified transportation metrics analysis for the three WFCCS scenarios. Scenarios receive a "best", "moderate", or "worst" score depending on how they performed for each metric. Figure 2 shows PM peak period person throughput and seat utilization for several screenline locations throughout the WFCCS study area, as well as travel times from selected origin/destination pairs in the PM peak period. Figure 3 shows the results of the transportation analysis for the following select metrics.

- Injuries and fatalities
- Access to employment
- Daily vehicle miles traveled (VMT) and air quality
- Share of households within a walking or bicycling distance of transit
- Transit access mode split
- Peak period and daily mode split.

The following pages of this document describe the analysis of each transportation metric, addressing the following topics:

- Data Sources and Assumptions

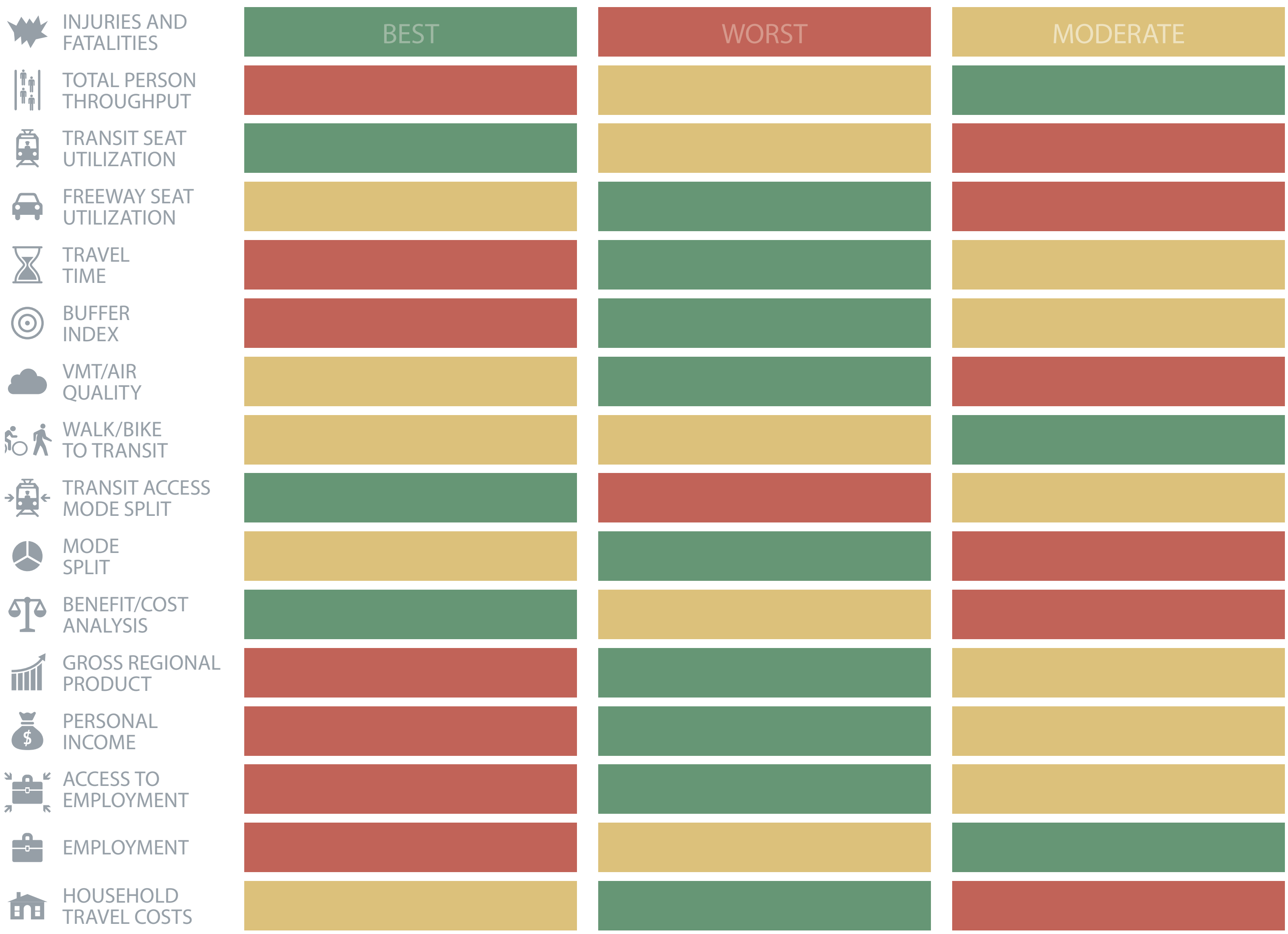
- Methodology
- Evaluation
- Conclusions

SUMMARY OF SCENARIO EVALUATIONS

FIGURE 1

SCENARIO	1	2	3
	Balances managing existing infrastructure more efficiently with building more infrastructure	Tightly manages the existing transportation network to use available travel space and seats more efficiently	Invests significant funding into building more infrastructure to meet projected travel demands
SUMMARY	SCENARIO 1 sees a modest shift towards transit and away from single-occupancy vehicles on I-15 through more efficient management of freeway and roadway capacity and incentivizing transit use.	SCENARIO 2 optimizes utilization of the transportation network through freeway pricing and expanding/ incentivizing transit.	SCENARIO 3 adds freeway and transit capacity without improvements in efficiency.

SCORING

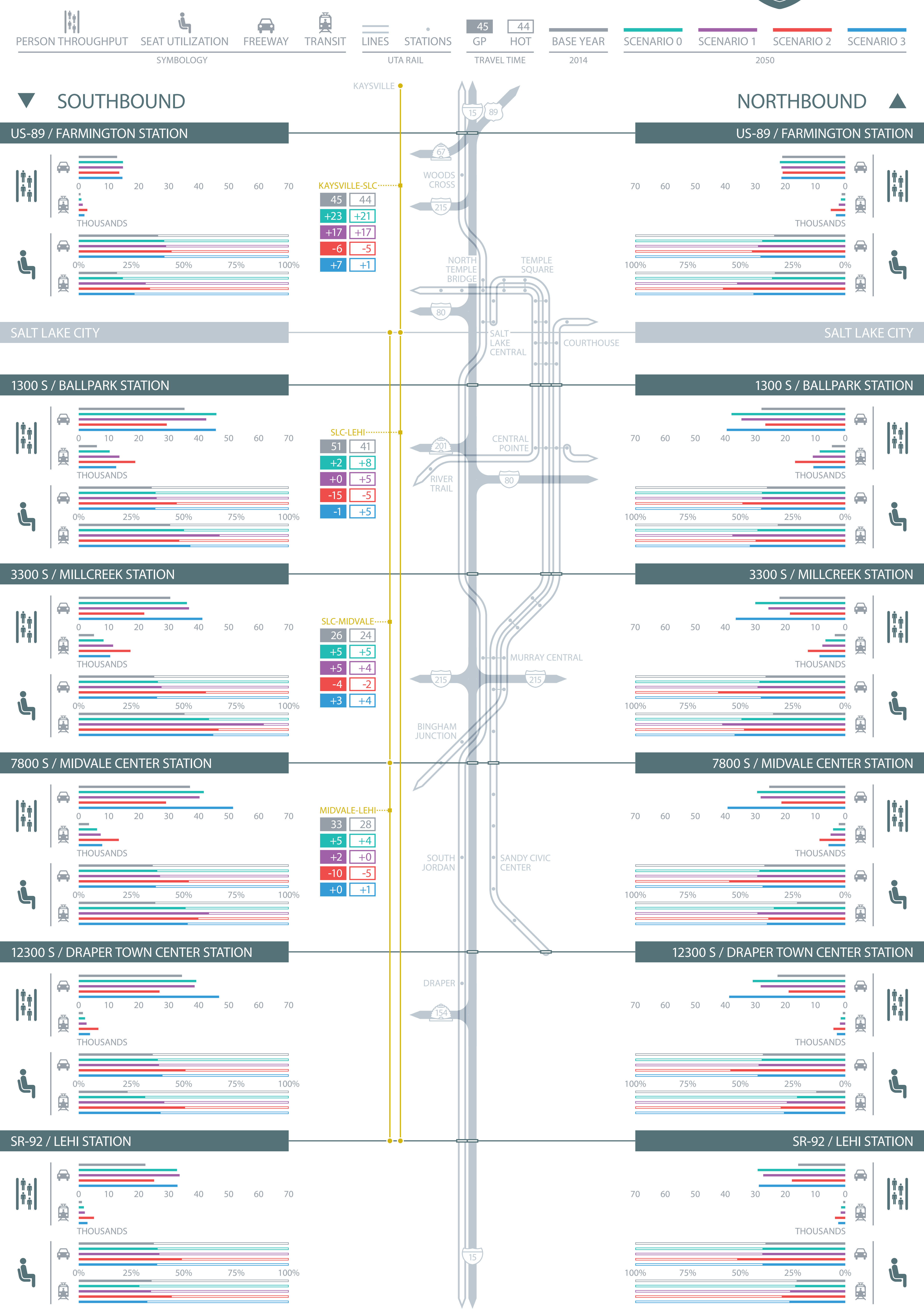


OVERALL RANKING	WORST	BEST	MODERATE

SCENARIO COMPARISON

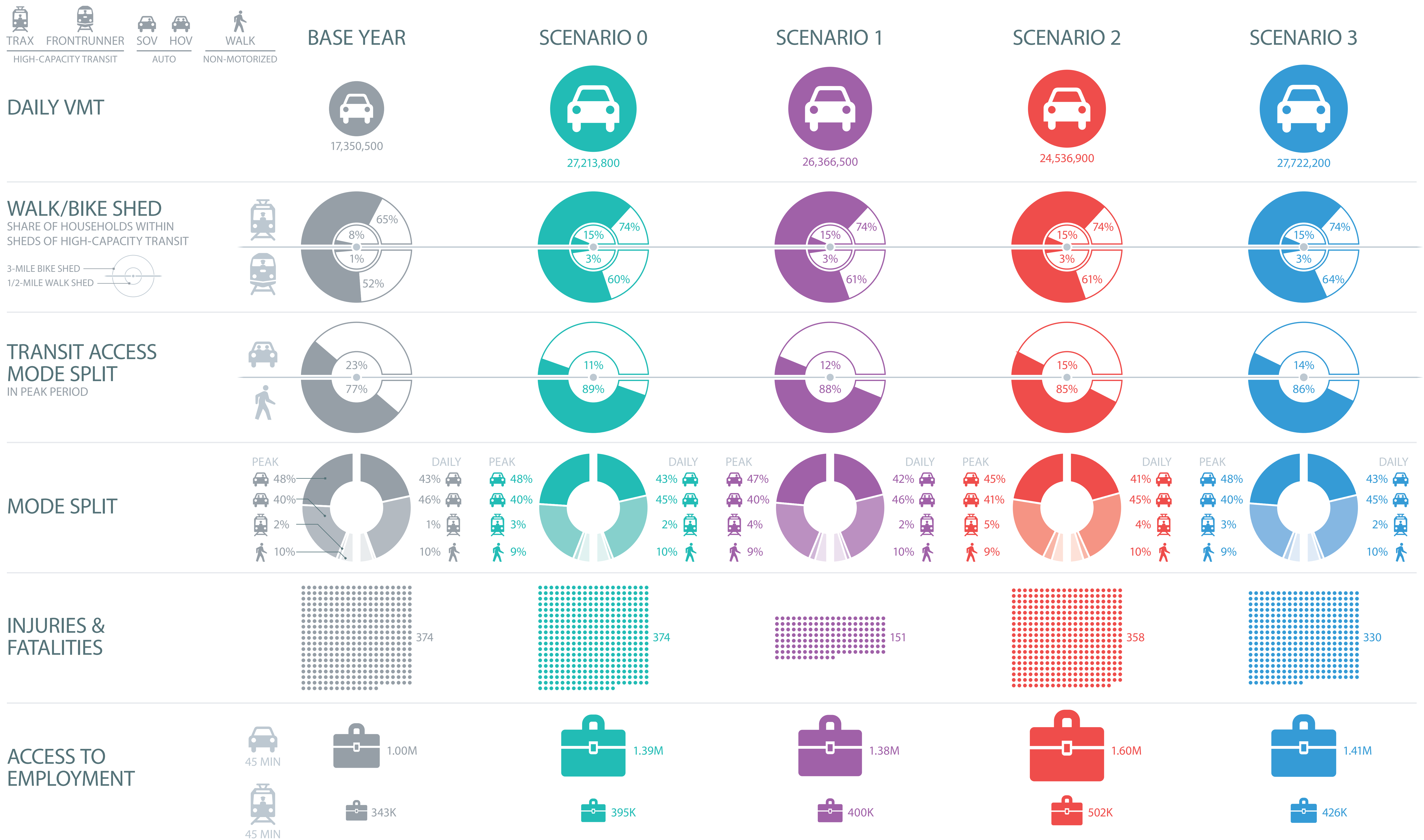
PM PEAK PERIOD TRAVEL CONDITIONS

FIGURE 2



STUDY AREA METRIC COMPARISON

FIGURE 3

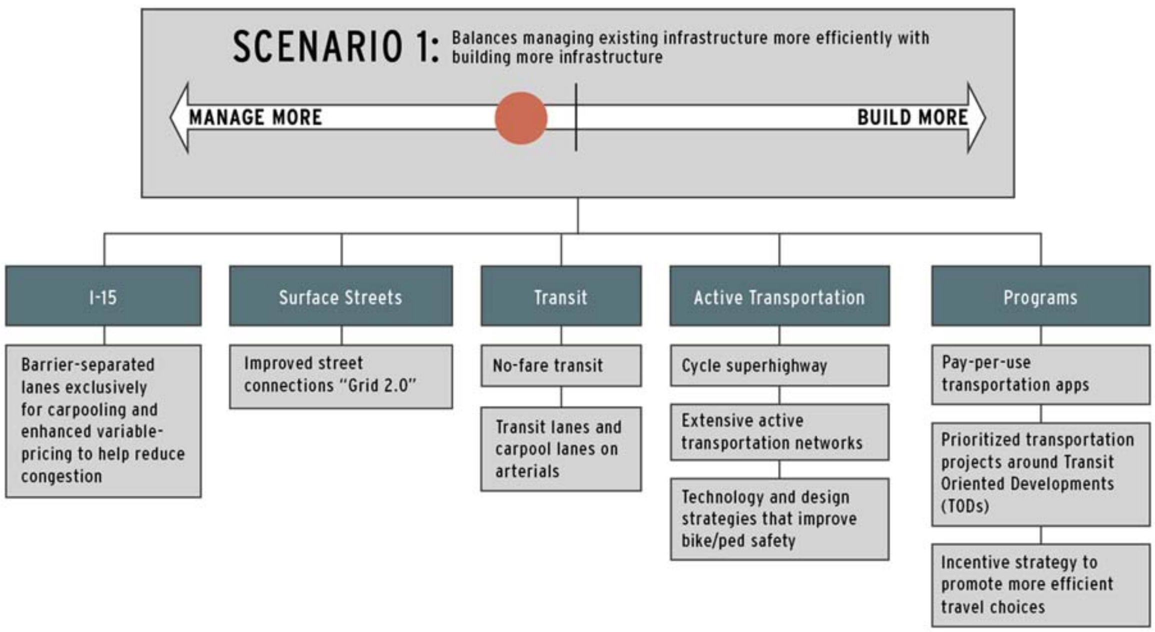


Scenario Evaluations

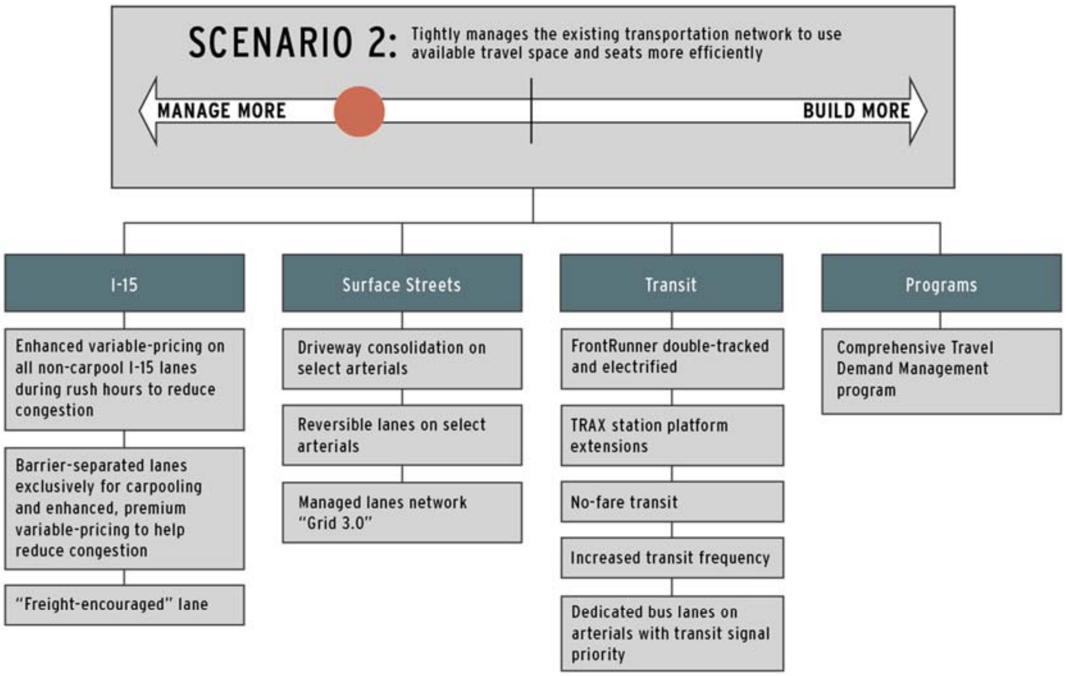
This section provides an overview of the key elements within each WFCCS scenario, and a detailed discussion of each scenario's performance on the transportation metrics.

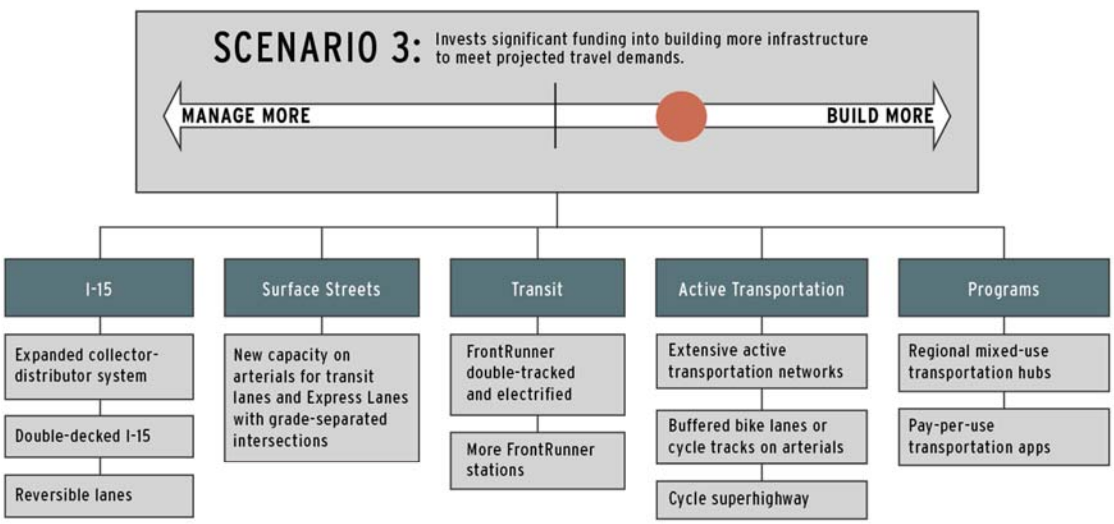
Overview of Scenario Contents

The graphics below illustrate the key elements of each WFCCS scenario. The *Initial Scenarios Development and Screening Technical Memorandum*[1] describes the scenario development process in detail. Each scenario was analyzed using the Wasatch Front Regional Council (WFRC)/Mountainland Association of Governments (MAG) travel demand model or other methods such as collision countermeasures analysis or GIS-based network analysis. Specific information on the development and refinement of the travel demand model and the Real Estate Market Model can be found in the *Data and Modeling Technical Memorandum*[2].



[1] Wasatch Front Central Corridor Study Initial Scenarios Development and Screening Technical Memorandum, October 2016. Fehr & Peers.
[2] Wasatch Front Central Corridor Study Data and Modeling Technical Memorandum, March 2017.RSG.


SCENARIO 2: Tightly manages the existing transportation network to use available travel space and seats more efficiently
MANAGE MORE
BUILD MORE
I-15
Enhanced variable-pricing on all non-carpool I-15 lanes during rush hours to reduce congestion
Barrier-separated lanes exclusively for carpooling and enhanced, premium variable-pricing to help reduce congestion
"Freight-encouraged" lane
Surface Streets
Driveway consolidation on select arterials
Reversible lanes on select arterials
Managed lanes network "Grid 3.0"
Transit
FrontRunner double-tracked and electrified
TRAX station platform extensions
No-fare transit
Increased transit frequency
Dedicated bus lanes on arterials with transit signal priority
Programs
Comprehensive Travel Demand Management program


SCENARIO 3: Invests significant funding into building more infrastructure to meet projected travel demands.
MANAGE MORE
BUILD MORE
I-15
Expanded collector-distributor system
Double-decked I-15
Reversible lanes
Surface Streets
New capacity on arterials for transit lanes and Express Lanes with grade-separated intersections
Transit
FrontRunner double-tracked and electrified
More FrontRunner stations
Active Transportation
Extensive active transportation networks
Buffered bike lanes or cycle tracks on arterials
Cycle superhighway
Programs
Regional mixed-use transportation hubs
Pay-per-use transportation apps

Goal: Improve Safety

Metric: Injuries and Fatalities

This metric analyzes how the WFCCS scenarios could reduce injuries and fatalities if specific collision countermeasures are applied. For this analysis, each scenario was evaluated based on how it would reduce collisions based on the number of reported collisions between 2012 and 2014, unless otherwise noted. Each WFCCS scenario has different safety countermeasures assigned to it, based on their compatibility with that scenario's guiding philosophy (which are stated briefly in Figure 1).

Data Sources and Assumptions

Collision data was downloaded from the UDOT Numetric website[3]. Collisions were selected based on a severity scale (see Table 1).

Table 1: Collision Severity Scale	
Numeric Scale	**Severity Type**
1	No Injury
2	Possible Injury
3	Minor Injury
4	Serious Injury
5	Fatal

Unless otherwise noted, only those that had a severity of 3 (minor injury) or higher were selected. This allowed the project team to focus on collisions that caused harm to travelers. The data analyzed included all collisions between 2012 and 2014 for all roads within the study area. Table 2 summarizes the number of collisions by severity.

Table 2: Study Area Collisions by Severity	
Severity	**Number of Collisions**
Minor Injury	4,820
Serious Injury	731
Fatal Injury	102
TOTAL	**5,653**

Methodology

A Crash Modification Factor (CMF) is a multiplicative factor used to compute the expected number of collisions after implementing a safety related countermeasure. Using the observed collision data and CMFs, reductions to the 2012-2014 collision data were calculated for each WFCCS scenario to estimate potential effects of proposed safety strategies.

[3] www.udot.numetric.com. This data is protected under 23 USC 409.

Several sources provided guidance on estimating collision reductions. These included the AAA Foundation for Traffic Safety's *Impact Speed and a Pedestrians Risk of Serious Injury or Death*[4], the Institute of Transport Economics' *The Power Model of the Relationship Between Speed and Road Safety*[5], UDOT Crash Modification Factors (CMFs), which include CMFs developed from the Federal Highways Administration's CMF Clearing House and the Highway Safety Manual, as well as a literature review of other countermeasures. This literature review incorporated FHWA's *Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes*[6], Pedestrian and Bicycle Information Center's *Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research*[7], and an Effectiveness Summary Memo developed for the San Francisco Municipal Transportation Agency (SFMTA)[8].

For each scenario, specific countermeasures were selected from the sources listed above, where each countermeasure had an estimated CMF associated with it. The countermeasures analyzed were limited to those with associated CMF's, for the purpose of quantifying safety improvements. There may be additional safety strategies that would be appropriate for the WFCCS scenarios that have not been analyzed here.

Evaluation

Table 3 summarizes each scenario's estimated collision reduction. Safety strategies studied for each WFCCS scenario are outlined following the table.

Table 3: Collision Reduction Estimates by Scenario	
Scenario 1	
Collision Type	Reduction
Minor Injury	164
Serious Injury	46
Fatal	13
Total	**223**
Scenario 2	
Collision Type	Reduction
Minor Injury	10
Serious Injury	4
Fatal	2
Total	**16**

[4] AAA Foundation for Traffic Safety. (2011). *Impact of Speed and Pedestrian's Risk of Severe Injury or Death.* Washington DC: AAA
[5] Elvik, R. (2009). *The Power Model of the Relationship Between Speed and Road Safety.* Oslo, Norway: Institute of Transport Economics: Norwegian Centre for Transport Research.
[6] Available online at https://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/. Accessed March 17 2017.
[7] Available online at http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf. Accessed March 17 2017.
[8] San Francisco Municipal Transportation Agency (2013). *Effectiveness Summary Memo.*

Scenario 3	
Collision Type	Reduction
Minor Injury	35
Serious Injury	9
Fatal	0
Total	**44**

Scenario 1 Strategies

Scenario 1 includes three quantifiable countermeasures that could potentially improve safety for bicyclists, pedestrians, and drivers/passengers based on observed collision data:

- Reduce posted speeds by five miles per hour on Redwood Road and State Street;
- Improve lighting at locations where collisions are caused by low visibility; and
- Install of Pedestrian Hybrid Beacons at mid-block crossing collision locations, including:
  - State Street and Lagoon Drive in Farmington
  - 500 West and 1880 South in Bountiful
  - Redwood Road and Earnshaw Lane in Salt Lake City
  - 400 South at the entrance to Sherwood Park in Salt Lake City
  - Glendale Street and California Avenue in Salt Lake City
  - 700 East and 3900 South in Millcreek
  - State Street and approximately 5700 South in Murray
  - Center Street and Jefferson Street in Midvale

Table 4 summarizes total collision reductions for each strategy type in Scenario 1.

Table 4: Scenario 1 Collision Reduction Summary	
Speed Reduction	
Collision Type	Reduction
Minor Injury	134
Serious Injury	40
Fatal	12
Sub-Total	*186*
Adding Lighting	
Collision Type	Reduction
Minor Injury	26
Serious Injury	5
Fatal	0
Sub-Total	*31*
Pedestrian Hybrid Beacon (HAWK)	
Collision Type	Reduction
Minor Injury	4

Serious Injury	1
Fatal	1
Sub-Total	*6*
TOTAL	***223***

Scenario 2 Strategies

Scenario 2 includes a key element of "increased access management and driveway consolidation". To determine the safety effects of this element, analysts interpreted this as installing raised medians along Redwood and State Street (since crash modification factors were available to quantify the effects of raised medians on safety). Collisions analyzed included head-on (front to front), opposite direction sideswipe, and angle collisions. Angle collisions only included collisions where the vehicle maneuver was identified as a left-turn or U-turn movement. The UDOT CMFs provided collision reduction rates by severity – 0.88 for collisions with a severity of 3 or 4, and 0.61 for collisions with a severity of 5. Table 5 summarizes the results of the CMF calculation.

Table 5: Scenario 2 Collision Reduction Summary

Collision Severity	Number of Collisions	CMF	Expected Collisions	Collision Reduction
Minor Injury	85	0.88	75	10
Serious Injury	30	0.88	26	4
Fatal	2	0.61	3	2
			TOTAL	**16**

While mid-block collisions would be reduced in this scenario, more collisions might occur at intersections since more turning movements (especially U-turns that conflict with right-turn movements) would be forced to these locations.

Scenario 3 Strategies

Scenario 3 contains a key element of exclusive lanes on Redwood Road and State Street for transit and high-occupancy vehicles or tolled vehicles, with grade separated interchanges at 4500 South, 5400 South, 7000 South, 9000 South, and 10600 South. These locations represent the highest daily east-west volumes at cross streets along the corridor. Analysts identified collisions with minor or serious injuries or fatalities that occurred within 500' of the proposed interchange locations. Collisions were further refined to only include those that occurred at 4-legged intersections, to remove collisions that were not attributable to the intersection. The UDOT CMFs for the countermeasure "Convert at-grade intersection to grade separated interchange" were applied based on collision severity – 0.58 for collisions with a severity of 3 or 4, and 0.43 for collisions with a severity of 5. Table 6 summarizes the results of the CMF calculation.

Table 6: Grade Separated Interchange Collision Reduction Summary				
Collision Severity	Number of Collisions	CMF	Expected Collisions	Collision Reduction
Minor Injury	83	0.58	48	35
Serious Injury	21	0.58	12	9
Fatal	0	0.43	0	0
			TOTAL	**44**

Conclusions

Scenario 1 would have the largest effect on reducing collision rates, particularly for bicycle and pedestrians who are more vulnerable, and for serious injuries and fatalities. Scenario 3 would have the second largest effect. Scenario 2 would have the smallest effect.

Metric: Cycling Trips

An increase in cycling (and walking) trips in an area can be an indicator of improved safety. People are more inclined to use non-motorized transportation if they feel safe in their environment. This discussion of cycling trips focuses on qualitative benefits rather than quantitative. Some research suggests that for each additional mile of on-street bicycle lanes per square mile that is added to a transportation network, an increase of roughly one percent in the share of workers commuting by bicycle can be realized[9]. However, this statistic may not be appropriate in large-scale regional applications and for that reason is not used here.

Similar to vehicles on interstate freeways, cycling for the purpose of commuting can be best facilitated on high mobility routes with limited access points and start/stop requirements. By implementing buffered north/south and east/west cycling corridors on existing arterials, which are designed with fewer disruptions and intersections, an increase in bicycle commuting could be achieved. This metric addresses cycling accessibility by identifying appropriate arterials for buffered bicycle lanes, which was contained as a key element of Scenario 3.

Data Sources and Assumptions

Buffered bicycle lanes were chosen as the treatment of choice for this analysis because they offer a greater separation from cars without the maintenance concerns of a cycle track. In addition, "nearly nine in 10 cyclists preferred a buffered bike lane to a standard lane, and seven in 10 cyclists indicated they would go out of their way to ride on a buffered bike lane over a standard bike lane"[10]. A buffered bicycle lane is defined as a conventional bicycle lane paired with a designated painted buffer space, 18 inches wide or greater, separating the bicycle lane from the adjacent motor vehicle travel lane along the existing road right-of-way[11]. While not required, it is recommended that the bicycle lane also have a buffer space separating it from the adjacent

[9] Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look (2003). Dill, J., Carr,T. Portland State University

[10] Portland State University, Center for Transportation Studies. (2011). Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT. Portland Bureau of Transportation, Portland, OR.

[11] Urban Bikeway Design Guide (2014). National Association of City Transportation Officials. New York, NY.

parked cars to prevent "dooring". For this analysis the type and exact width of the buffer space was not determined but could consist of internal chevron markings, or diagonal cross hatching.

The WFCCS technical team conducted a GIS exercise mapping the locations of recommended buffered bicycle lanes on arterials within the study area. GIS road data from the Utah AGRC was used to determine where the major arterials within the study boundary are located. Proposed cycling facilities from the Regional Transportation Plans were reviewed to ensure that proposed facilities were consistent with those already planned.

Methodology

The following evaluation criteria determined suitable locations for buffered bike lanes on arterials:

- State Street was chosen as a site for a bicycle super highway within a separate portion of the overall study. Therefore, this section of analysis assumes a bicycle super highway on State Street.
- Priority was given to arterials providing connections to existing or proposed light rail or commuter rail stations, for the purposes of facilitating fist/last mile linkages. The existing rail stations within the study area in addition to new rail stations proposed in Scenario 3 were used within the analysis.
- Priority was given to arterials with existing or proposed cycling facilities located along the route, for the purposes of making regional cycling connections.
- Priority was given to routes that connect underserved areas to the larger network of cycling facilities.

Evaluation

The GIS analysis produced buffered bicycle lane recommendations on 80 miles of existing arterials. The recommended routes provide north/south and east/west connections, sometimes providing direct access to transit stations, and connecting to existing or proposed bicycle facilities whenever possible. Recommended routes are shown in the WFCCS webmap for the scenarios.

Conclusions

While there is research to suggest that there are quantitative benefits associated with adding buffered bicycle lanes, the uncertainty in cause and effect leave an exact percentage difficult to produce with confidence. The recommended buffered bicycle lanes on arterials that were produced in this GIS exercise could facilitate more bicycle commute trips within the study area, through increased comfort and safety for cyclists along major corridors.

Goal: Increase Person Throughput in the Corridor

Metrics: Person Throughput and Seat Utilization by Mode in Peak Period

This metric addresses capacity and efficiency of both the freeway and transit system, comparing the number of people who move through the I-15 corridor at key screenline locations in 2050. Person throughput and seat utilization metrics demonstrate how well public infrastructure carries people (versus vehicles), and how efficiently transportation infrastructure is being used. For instance, observations for 2014 revealed that roughly 25-30% of all seats on the freeway and the rail network in the WFCCS study area were occupied in the peak period and direction, leaving opportunities for improving the efficiency of the network.

Data Sources and Assumptions

Using the WFRC/MAG travel demand model output network, the WFCCS Technical Team analyzed passenger vehicle volumes for each screenline location by auto mode type (i.e. drive alone, shared ride, and external), and used the following vehicle occupancy rates:

- Drive alone vehicles have 1 person per vehicle.
- Shared ride vehicles have 2.74 persons per vehicle
- External vehicles, or those that travel through the model network but do not begin or end their trip in the model area, have 1.55 persons per vehicle.

These occupancy rates are based on data from the 2012 Utah Household Travel Survey[12]. To estimate the number of seats passing through the screenline locations it was assumed that each car had four seats per vehicle. The WFRC/MAG travel demand model was also used for transit analysis, providing ridership by each node along the transit network. Seating capacity was based on data provided by UTA for each transit mode and is shown in Table 7 below. For rail modes, FrontRunner and TRAX, a four car consist was assumed for each trip.

Table 7: Transit Seats per Trip

Mode	Seats per Trip
Local Bus	38
Enhanced Bus	38
Light Rail	240
Commuter Rail	495
BRT	55

The travel demand model does not differentiate between AM and PM transit peak volumes, but provides one set of volumes to represent bi-directional transit passengers for the two three-hour peak periods combined. Therefore, total peak volumes were used and reduced by half to reflect a three-hour PM peak volume. The travel demand model also does not specifically identify transit passengers by direction, so other assumptions were necessary to identify peak period person throughput on the transit network. The travel demand model highway network was used to obtain a directional split at each screenline location, assuming that the same split that occurs on the highway network occurs on the transit network. The Route database output, which includes information on route headways, was also used to determine the number of trips during the 3 hour PM peak period.

Methodology

Six screenline locations along the I-15 corridor were identified for this analysis.

[12] Utah Travel Study (2013). RSG. Accessed online at http://www.wfrc.org/publications/Utah_FinalReport_130228.pdf

- US 89 in Farmington
- 1300 South
- 3300 South
- 7800 South
- 123000 South
- State Route 92

For the freeway analysis, model network links at these locations provided passenger car volumes. Using the estimated occupancy rates discussed previously, person throughput was calculated for each location for both northbound and southbound lanes for the three-hour PM peak period, and then divided by the total seats to provide a seat utilization percentage.

For transit, the Technical Team analyzed each north/south rail and bus route operating in the study area. The transit nodes that most closely matched the freeway link screenline location were used to obtain the peak passenger volume. The freeway directional split was applied to the transit passenger volumes to determine the transit passenger directional split (northbound/southbound). This process resulted in an estimated transit person throughput for each location for the 3 hour PM peak period. To determine the number of transit seats available, the number of trips was calculated using the peak route headway. For example, routes with a headway of 15 minutes were assumed to have 12 trips during the peak period. The number of trips were then multiplied by the seating capacity for each mode type provided by UTA. The passenger throughput was then divided by the total seats available to provide a seat utilization percentage.

Evaluation

The results of the person throughput analysis are shown in Figure 2 earlier in this document. As observed in Figure 2, the following trends are visible:

Person Throughput:

- Scenario 3 has the highest person throughput on the freeway at nearly all locations in both directions.
- Scenario 2 has the highest person throughput on the transit network at every location in both directions
- Scenario 3 has the highest combined person throughput at nearly all screenline locations.

Seat Utilization:

- Scenario 2 has the highest seat utilization on the freeway network at all screenline locations in both directions.
- Scenarios 1 and 2 both perform well for transit seat utilization, but Scenario 1 has the highest transit seat utilization at most screenline locations.
- Scenario 2 has the highest combined seat utilization.

Conclusions

Based on this analysis, Scenario 3 moves the most people through the screenline locations. However, seat utilization in Scenario 3 is lower than in Scenario 2 for both the freeway and the transit network. Additionally, transit person throughput is much lower under Scenario 3 than other scenarios, especially compared with Scenario 1.

From a transit system perspective, Scenario 2's combination of electrifying and double tracking of FrontRunner, no-fares transit, increased transit frequencies, and freeway tolling lead to the highest transit person throughput. In comparison, Scenario 3's lack of management strategies results in a lower degree of transit person throughput despite heavy investments in the rail network. Meanwhile, although Scenario 2 presents the highest transit person throughput, transit seat utilization is not as high as the results of Scenario 1. In Scenario 2, the number of transit seats moving through the corridor has doubled due to the increased transit frequency, so although more riders use the system, there are also more empty seats to fill.

Goal: Improve Travel Time Reliability for Trips Using the Corridor

Metric: Freeway Peak Commute Congested Travel Times

This metric addresses travel times for trips on I-15 between major centers along the Wasatch Front, comparing the time it takes to make these trips today to projected conditions in 2050. Travel time measurements indicate the typical trip times in the peak period – the "reliably congested" times of day. Predicting future travel times helps decision-makers understand the degree of change between scenarios, and the scale of change from "reliably congested" times today. The WFCCS partner agencies believe that reliability is important, but that trip times are important too: for instance, a reliable three-hour trip from Salt Lake City to Lehi is not acceptable, even if it's consistent.

Data Sources and Assumptions

The WFRC/MAG travel demand model was used to project future travel times for each 2050 WFCCS scenario. Travel times are identified separately for general purpose (GP) and high-occupancy/toll (HOT) lanes. Scenario 1 has two I-15 HOT lanes per direction with enhanced variable pricing to maintain desired travel speeds; Scenario 2 has two I-15 premium HOT lanes per direction, which are priced at a higher level than the priced general purpose lanes; and Scenario 3 has one HOT lane per direction without enhanced variable pricing.

Methodology

Travel time reports were extracted from the model runs for a selected subset of origin/destination pairs representing major employment centers and residential areas. These included the following locations (identified in the model using Traffic Analysis Zones, or TAZ's):

- Downtown Salt Lake City (the City County Building, TAZ #828) to Lehi (Thanksgiving Point office park, TAZ #1775);

- Downtown Salt Lake City (the City County Building, TAZ #828) to Kaysville (200 North/Flint Street, TAZ #369);
- Downtown Salt Lake City (the City County Building, TAZ #828) to Midvale (the Bingham Junction master planned community, TAZ #1296); and
- Midvale (the Bingham Junction master planned community, TAZ #1296) to Lehi (Thanksgiving Point office park, TAZ #1775).

Evaluation

Figure 2 in this memorandum shows the travel times between specific origin/destination pairs for each scenario for the evening commute (PM peak period) in the general purpose and barrier-separated high-occupancy/transit/toll lanes. Table 8 below provides both AM and PM peak period travel time results for the GP and HOT lanes in each scenario. Peak direction travel is highlighted in ***bold italic***.

Table 8: Travel Time by Scenario							
Selected Origin/Destination Pairs, Time Period, and Direction			**Travel Time (minutes) by Scenario GP/HOT**				
From	To	AM/PM, NB/SB	2014	2050 - 0	2050 - 1	2050 - 2	2050 - 3
Lehi	***SLC***	***AM NB***	***41/33***	***44/37***	***44/35***	***31/33***	***41/36***
SLC	Lehi	AM SB	31/30	33/31	34/32	29/32	33/32
SLC	Kaysville	AM NB	29/29	30/30	30/30	28/31	30/30
Kaysville	***SLC***	***AM SB***	***37/36***	***47/42***	***46/40***	***34/34***	***43/37***
Midvale	***SLC***	***AM NB***	***24/21***	***27/23***	***25/23***	***20/22***	***25/23***
SLC	Midvale	AM SB	18/18	20/20	20/20	19/21	20/20
Lehi	***Midvale***	***AM NB***	***26/22***	***29/24***	***30/21***	***20/21***	***27/22***
Midvale	Lehi	AM SB	20/20	23/21	23/21	20/20	22/21
Lehi	SLC	PM NB	38/32	46/40	47/35	34/34	42/39
SLC	***Lehi***	***PM SB***	***51/41***	***53/49***	***51/46***	***36/38***	***50/46***
SLC	***Kaysville***	***PM NB***	***45/44***	***68/65***	***62/61***	***43/41***	***52/45***
Kaysville	SLC	PM SB	32/31	33/31	35/33	29/33	35/35
Midvale	SLC	PM NB	22/20	26/24	26/23	22/23	25/24
SLC	***Midvale***	***PM SB***	***26/24***	***31/29***	***31/28***	***22/25***	***29/28***
Lehi	Midvale	PM NB	25/23	32/27	33/22	23/21	30/26
Midvale	***Lehi***	***PM SB***	***33/28***	***38/32***	***35/28***	***24/23***	***33/29***

The table shows that Scenario 2 has lower travel times than the other scenarios (in fact, lower than current conditions on I-15 in some instances). Scenario 2 includes full pricing of I-15 in the peak period and direction: all users would pay a toll, regardless of whether they use the GP lanes or the HOT lanes. Drivers in the HOT lanes would pay a higher rate to guarantee free flowing traffic speeds, and could potentially see a further benefit in their travel time compared to the GP lanes that is not evident in the model results. One limitation of this analysis is that modeling efforts for this analysis coded different free flow speeds for the tolled GP lanes and the premium-priced HOT lanes: 77 mph and 70 mph, respectively. This resulted in faster trip times between multiple origin-destination pairs in the GP lanes than in the HOT lanes. In reality, the HOT lanes are intended to be managed to maintain a speed benefit for the increased price of use. If the travel model were coded to represent faster free flow speeds in the HOT lanes than in the GP lanes, then the point-to-point travel times would be shorter in the HOT lanes.

The model results also indicate that traffic volumes decrease on I-15 in Scenario 2, likely as a result of the tolling features. This decrease also contributes to Scenario 2's lower travel times compared to the other scenarios. The decrease in I-15 volumes in Scenario 2 is partially reflected in the increase in transit ridership also associated with Scenario 2, but also likely reflects some degree of demand reduction due to a higher travel cost, changes to walking and bicycling modes, and distribution of trips onto other routes on the network.

Peak PM transit trip times were also evaluated for several of these zone pairs. Table 9 below provides a summary of results.

Table 9: Transit Trip Times					
From	**To**	**S0**	**S1**	**S2**	**S3**
SLC	Lehi	67	67	57	59
Draper	Lehi	43	41	32	34
SLC	Midvale	39	39	37	39
Midvale	Lehi	54	54	43	45

Scenario 2 has the fastest transit travel time between these zone pairs. Scenario 2 includes FrontRunner double tracking and electrification as well as increased transit frequencies, which means that trains run faster and transfer times are shorter. Scenario 3 also has lower transit travel times than the baseline scenario, as a result of investments in FrontRunner. However, the addition of infill stations make these trips slightly longer than in Scenario 2, which also has heavy investments in FrontRunner.

Conclusions

Scenario 2 contains the fastest freeway travel times in the evening commute period throughout the study area, due to its management strategies. In addition, Scenario 2 also has the fastest transit travel times, due to investments like double tracking and electrifying FrontRunner and changing peak service frequencies from every half hour to every 15 minutes.

Metric: Buffer Time Index

Buffer Time Index (BTI) measures travel time reliability by accounting for the extra or "buffer" time needed to arrive at a destination on time 95% of the time. This can be interpreted as the extra time a traveler needs to add to their typical commute to account for unexpected, adverse driving conditions due to weather or incident one day a month, assuming 20 working days per month. As reliability decreases, buffer time increases to compensate.

The basic formulation for calculating BTI comes from FHWA[13] which compares 95th percentile and average travel rates in minutes per mile multiplied by some measure of distance and volume, as seen in the following equation.

$$\text{Buffer Time Index} = \begin{matrix}\text{Weighted}\\ \text{Average of}\\ \text{All Sections}\\ \text{(Using VMT)}\end{matrix} \left[\frac{\begin{matrix}\text{95th Percentile Travel Rate}\\ \text{(in minutes per mile)}\end{matrix} - \begin{matrix}\text{Average Travel Rate}\\ \text{(in minutes per mile)}\end{matrix}}{\begin{matrix}\text{Average Travel Rate}\\ \text{(in minutes per mile)}\end{matrix}} \times 100\% \right]$$

While 95th percentile and average travel rate in minutes per mile can be measured using observed data, it is harder to know what these would be in the future when demand changes. In addition, the travel model only measures average congested travel conditions, not the 95th percentile. An alternate method to estimate BTI was used where BTIs were calculated based on observed data and correlated to volume-to-capacity (V/C) ratio, which can easily be measured in

[13] BTI equation source: http://ops.fhwa.dot.gov/congestion_report_04/appendix_C.htm

the travel model and related to current and future conditions. This method used speed instead of a travel rate in minutes per mile. This was done because the observed data measured spot location speed and not corridor travel time (i.e. minutes per mile). The fifth percentile speed, which correlates to the 95th percentile travel rate, was used in the calculations.

Data Sources and Assumptions

Observed data from UDOT's Performance Monitoring System (PeMS) provided the 5th percentile and average speeds used to calculate existing conditions BTI. Raw data was downloaded from UDOT's PeMS website[14] by station for each month (January through December) in 5 minute bins for the year 2014. The raw data was combined and aggregated into one hour bins and a field was added to indicate the day of the week. Only data with 100% observations were used.

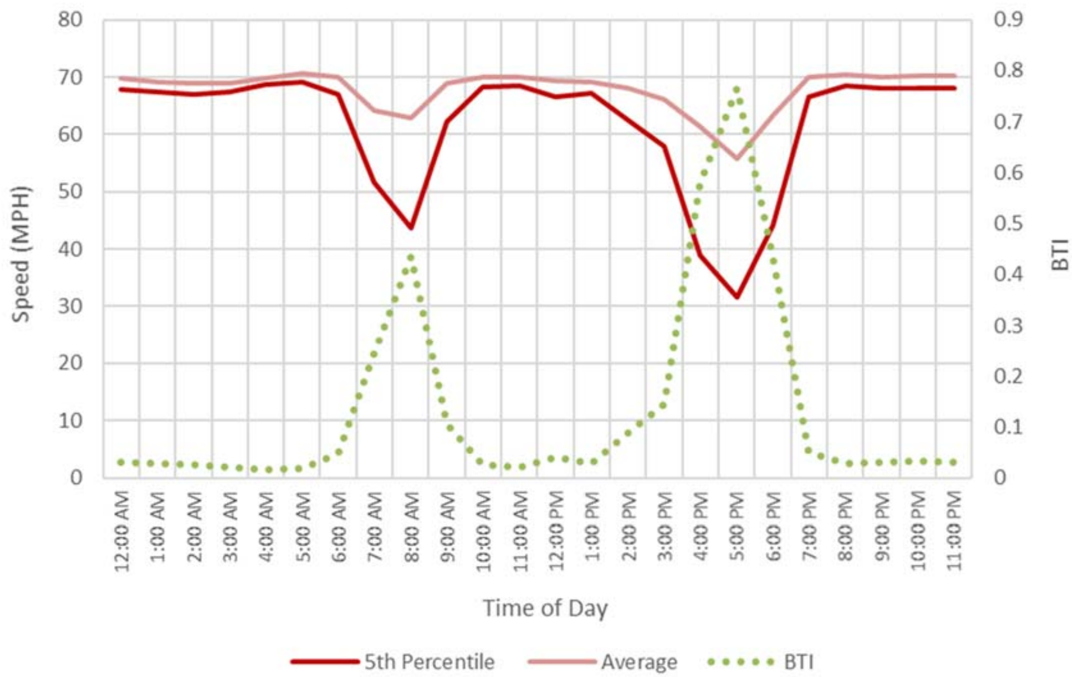
Methodology

Buffer times were calculated based on observed data and correlated to volume-to-capacity (V/C) ratio. It should be acknowledged that in the real world, roadway capacity is fluid and can be influenced by changes in traffic flow: capacity is higher when flows are stable but lower when the freeway breaks down and cars move more slowly. For the purpose of this analysis, the theoretical capacity thresholds from the travel demand model were used to calculate V/C ratios. This allowed for a consistent comparison between current and future conditions. The travel demand model capacities in the future do not include features such as autonomous and connected vehicles, which could also affect lane capacities.

A random selection of 21 PeMS general purpose freeway locations were used in the BTI calculations. The combined data set contained just over 100,000 data points (21 locations x 200 weekdays x 24 hours). The 5th percentile and the average speeds were calculated for each PeMS location. Speeds were calculated independently for each hour using the 200 weekday observations resulting in unique speed profiles for each hour of the day, as seen in the following figure. The more congested hours of the day have lower speed profiles as well as lower average and 5th percentile speeds.

[14] Accessible online at http://udot.bt-systems.com/

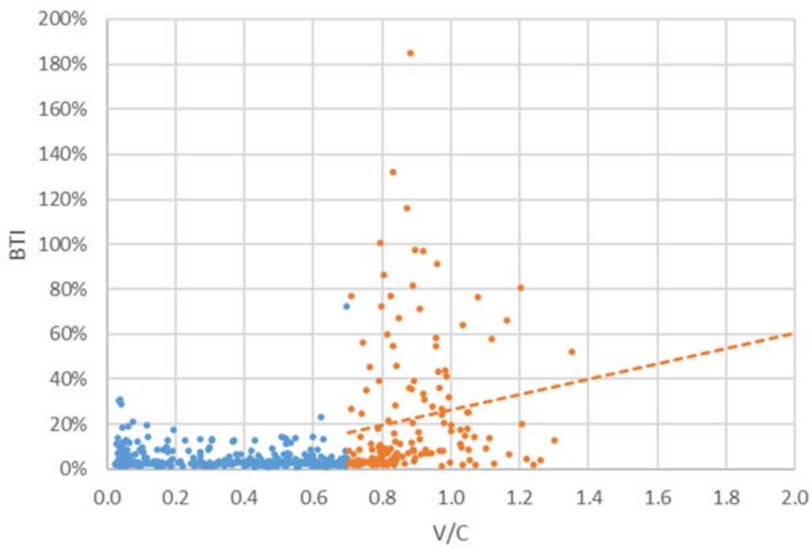
Figure 4: Speed and BTI by time of Day at Southbound I-15 in Sandy



Because 5th percentile speeds are nearer average speeds in less congested hours, BTI calculations for less congested hours yield lower buffer time percentages. In more congested hours, larger difference between the average and 5th percentile speeds are observed resulting in higher BTI percentages. This reflects that non-recurring events, such as incidents or weather, are more impactful on speeds in more congested conditions than in less congested conditions. Larger BTI percentages mean travelers would need to add more time to their normal congested commuting time in order to account for unforeseen events that might occur.

The volume-to-capacity (V/C) ratio was used to correlate BTI to congestion. Average hourly volumes were calculated by averaging all flow rates for each hour across all weekdays in 2014 where data was available from PeMS. The capacity for each PeMS location was estimated based on the general purpose freeway lane capacity from the travel model. The calculated BTI was then matched to its corresponding V/C ratio. Analyzing the BTI vs. V/C data revealed that BTI tended to remain low up to a V/C ratio of 0.6 to 0.8, at which point BTI tended to grow rapidly and become more disperse.

Figure 5: BTI vs. V/C FOR ALL 504 DATA POINTS



A BTI vs. V/C model was created with phases representing the three unique areas seen in the observed data:

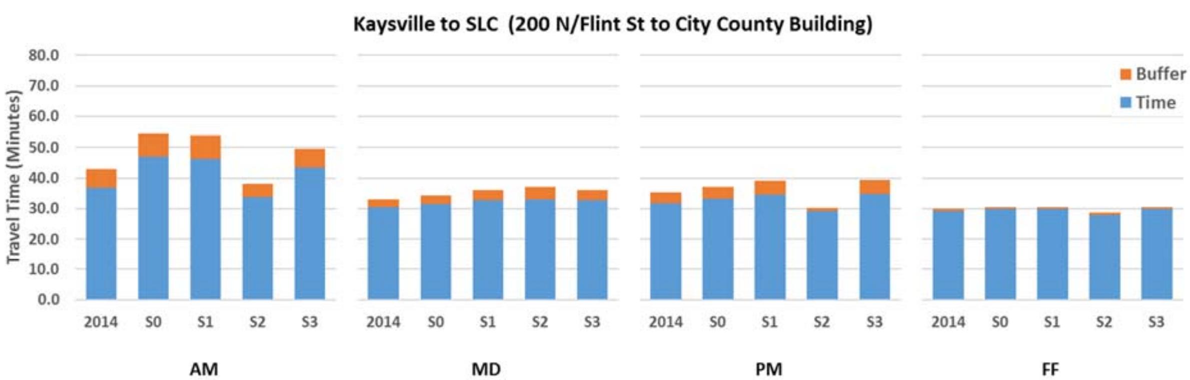
- **Phase 1** covers the area of low congestion with low and more stable BTI values. The observed data for this phase had an average BTI value of 3-5% (median=3% and mean=4.9%). A uniform 4% BTI for V/C values less than 0.6 was chosen for Phase 1.
- **Phase 2** covers the area from V/C of 0.6 to 0.8 where the model transitions between the Phase 1 and Phase 3 curves.
- **Phase 3** represents the congested area of the curve where the data is more scattered. This portion covers the area for V/C's greater than 0.8. The modeled BTI for this range is based on linear regression drawn through the data (see previous figure).

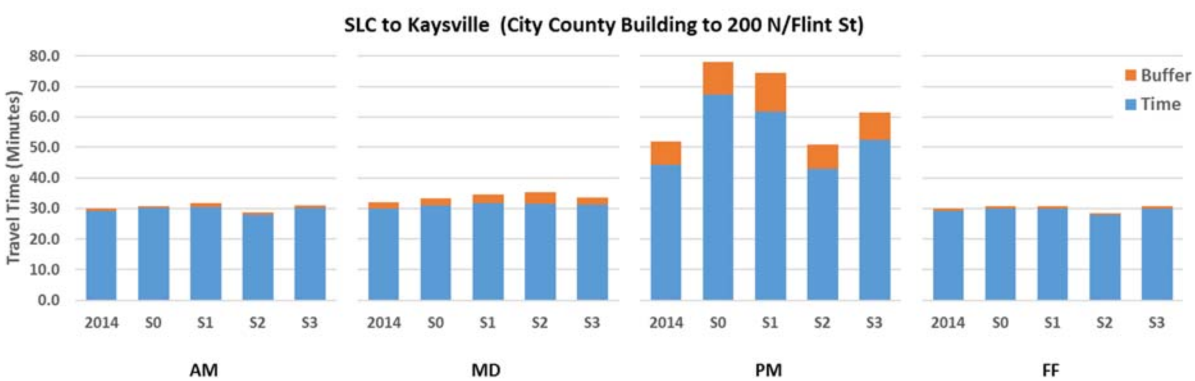
Buffer times are calculated for each link in the model by looking up the percent BTI from the link's V/C ratio and multiplying by the link's travel time. Buffer times are calculated only for general purpose and Managed Motorway freeway lanes. All other link functional types have a buffer time of zero. This was done since the data used to estimate the BTI model used only freeway general purpose lanes. Zone-to-zone buffer times are then skimmed and reported.

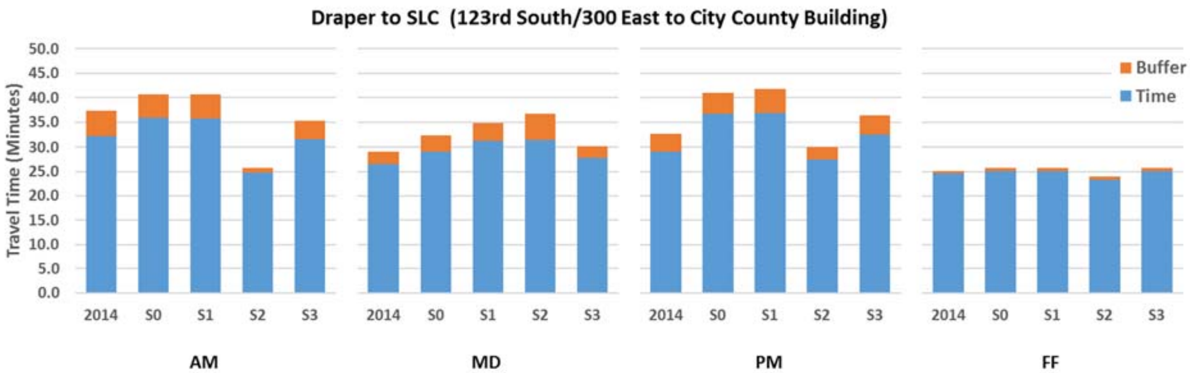
Evaluation

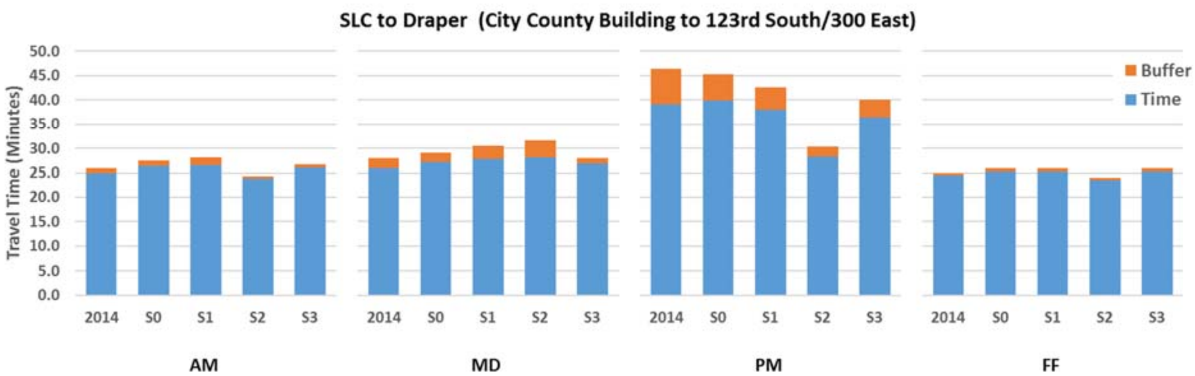
The following figures show results from the buffer time calculations for select origins and destinations in the study area. Results are shown for base year 2014, 2050 Base Scenario (S0), 2050 Scenario 1 (S1), 2050 Scenario 2 (S2) and 2050 Scenario 3 (S3). Results are stratified by the following time periods:

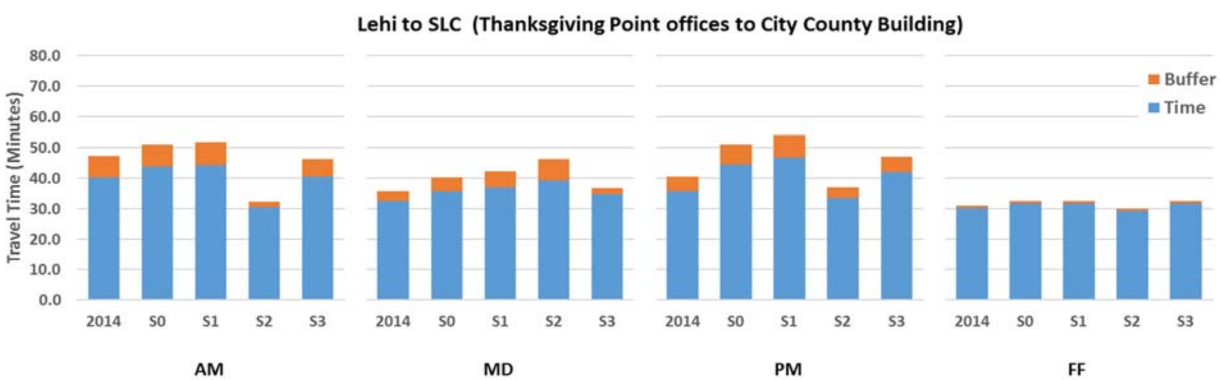
- AM Peak Period – 6 AM to 9 AM
- Midday (MD) Period – 9 AM to 3 PM
- PM Peak Period – 3 PM to 6 PM
- Free Flow (FF) – represents free flow conditions

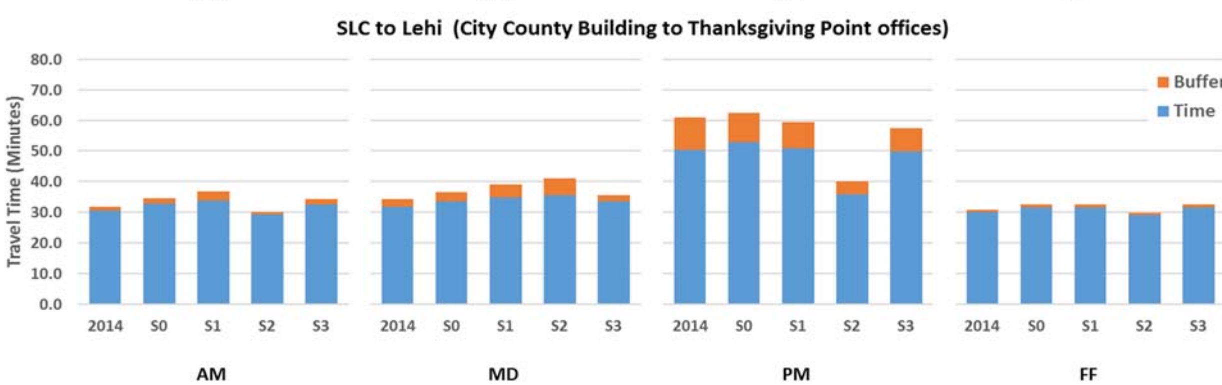





Draper to SLC (123rd South/300 East to City County Building)
Travel Time (Minutes)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Buffer
Time
2014 S0 S1 S2 S3
AM
MD
PM
FF

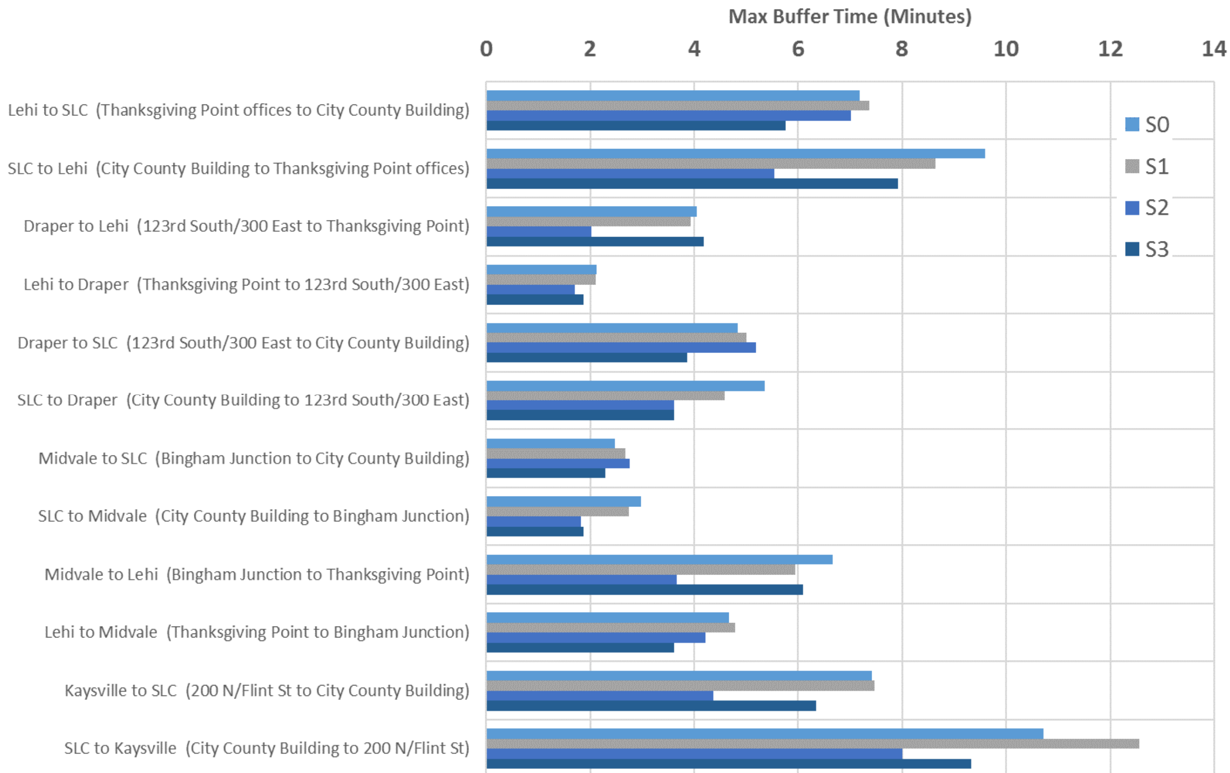

SLC to Draper (City County Building to 123rd South/300 East)
Travel Time (Minutes)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Buffer
Time
2014 S0 S1 S2 S3
AM
MD
PM
FF


Lehi to SLC (Thanksgiving Point offices to City County Building)
Travel Time (Minutes)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Buffer
Time
2014 S0 S1 S2 S3
AM
MD
PM
FF


SLC to Lehi (City County Building to Thanksgiving Point offices)
Travel Time (Minutes)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Buffer
Time
2014 S0 S1 S2 S3
AM
MD
PM
FF

Conclusions

The PM commute between Salt Lake and Davis Counties has among the highest buffer times. In general, Scenario 2 has a lower buffer time and Scenario 1 has a higher buffer time, as seen in the following chart.



Goal: Increase Regional Accessibility to Jobs, Particularly for Economically Disadvantaged Populations

Metric: Jobs Accessible within a 45-Minute Driving or Transit Trip

This metric addresses the effect of each scenario on accessibility to jobs within a 45-minute travel time either by driving or using public transportation. The ability of the transportation network to connect people to important destinations efficiently is one of its most important functions. Accessibility to more jobs provides benefits to both employers and employees.

For employees, this means access to more employment opportunities as well as greater choice in the types of employment available. Access to larger employment opportunities, especially within a reasonable transit travel time, is particularly important for economically disadvantaged populations that may have no access or limited access to an automobile. A larger share of jobs within a reasonable transit trip time also makes transit more competitive, potentially lowering the use of single occupancy vehicles, especially during peak times.

For employers the better the accessibility the larger the labor pool. Demonstrating access to labor markets is key in maintaining and enhancing economic development in the region.

Data Sources and Assumptions

The WFRC/MAG travel demand model was used to estimate job accessibility within a 45-minute automobile or transit travel time for each scenario. Travel times for both freeway and transit were derived from the loaded model networks (i.e., networks where roadway and transit links have assigned volumes of passengers and vehicles). Accessibility was analyzed for economically disadvantaged or vulnerable populations, as well as the rest of the overall population. Staff from WFRC provided the WFCCS Technical Team with a GIS shapefile of "Communities of Concern". These are areas that currently have higher shares of economically vulnerable populations.

Methodology

The travel demand model was applied to measure the weighted average number of jobs accessible in a 45-minute automobile or transit trip for TAZ's that were considered part of a "Community of Concern", compared to all TAZ's within the study area. This methodology was used for WFCCS Scenarios 0, 1, 2, and 3, as well as Base Year 2014.

Evaluation

The table below provides the weighted average number of jobs accessible for vulnerable populations and the overall population within the study area TAZ's for each scenario.

Table 10: Average Number of Jobs Accessible for Households within the Study Area

	Scenarios	Accessible Jobs (auto)	Access Jobs (transit)
Vulnerable Populations	Base Year 2014	1,002,194	343,379
	Scenario 0	1,391,115	395,155
	Scenario 1	1,378,281	400,435
	Scenario 2	1,601,658	502,366
	Scenario 3	1,405,564	426,422
All Populations within Study Area	Base Year 2014	950,213	232,956
	Scenario 0	1,255,675	254,595
	Scenario 1	1,269,588	252,210
	Scenario 2	1,580,188	352,486
	Scenario 3	1,329,395	298,603

Scenario 1 had the smallest effect, due to its relative lack of roadway and transit capacity projects. While there was some improvement in terms of job accessibility in Scenario 1 using transit, the number of jobs within a 45-minute automobile trip in Scenario 1 was less than the number of jobs accessible in Scenario 0. Scenario 2 has the largest change in the number of jobs accessible compared to the baseline scenario. This is true for both drivers and transit users. While Scenario 3 also improved job accessibility, the relative change was much smaller.

Job accessibility for the vulnerable "Community of Concern" populations is generally better than for the population as a whole within the study area. This is because the "Communities of Concern" identified by WFRC are generally located closer to the I-15 and FrontRunner corridor than the rest of the study area population, so they have quicker access to the transportation infrastructure and are therefore able to travel farther in the 45-minute time window, by driving or by taking transit.

Conclusions

Scenario 2 generally had the largest improvement in accessibility to jobs for vulnerable members of the population. More jobs are accessible to the average household within a 45-minute trip for both transit users and automobile users. For automobile trips this is likely due to reduced congestion on I-15 due to enhanced variable pricing in the barrier-separated lanes and pricing of general purpose lanes in the peak period and direction. However, while this analysis suggests that tolling would improve job accessibility for economically disadvantaged populations, it could also increase household transportation costs for these populations although travelers would have alternative route and time of day choices not to mention other mode choices.

Transit system accessibility improved in Scenario 2 through increased frequencies on all routes and more dedicated bus lanes on major arterials, reducing wait times and in-vehicle trip times. Double tracking and electrification of the FrontRunner system also reduced transit travel times.

Goal: Improve Air Quality

Metric: Vehicle Miles Traveled (VMT) and Air Pollutant Emissions

This metric addresses the effect of each scenario on key air quality emissions resulting from vehicle miles traveled (VMT). Pollutants analyzed include:

- Carbon Monoxide – CO
- Carbon Dioxide Emissions – CO2e
- Nitrogen Oxides – NOX
- Particulate Matter 2.5 – PM2.5
- Sulfur Oxides – SOX
- Volatile Organic Compounds - VOC

The Environmental Protection Agency (EPA) has established air quality standards for some of these pollutants. The study area is considered a non-attainment area for PM2.5 and sections of the study area are also designated as a non-attainment areas for SO2, which is a Sulfur Oxide (SOX). VOCs and NOX are considered precursor pollutants for Ozone for which Salt Lake County is also designated a nonattainment area and Davis County is designated as a maintenance area. Salt Lake City is also designated as a maintenance area for CO. Nonattainment areas must develop plans to address nonattainment pollutants and implement steps to improve conditions to meet the EPA standards or these areas may lose some forms of federal funding.

In addition to the need to meet current federal standards, air quality can have a tremendous influence on public health, quality of life, and economic development.

Data Sources and Assumptions

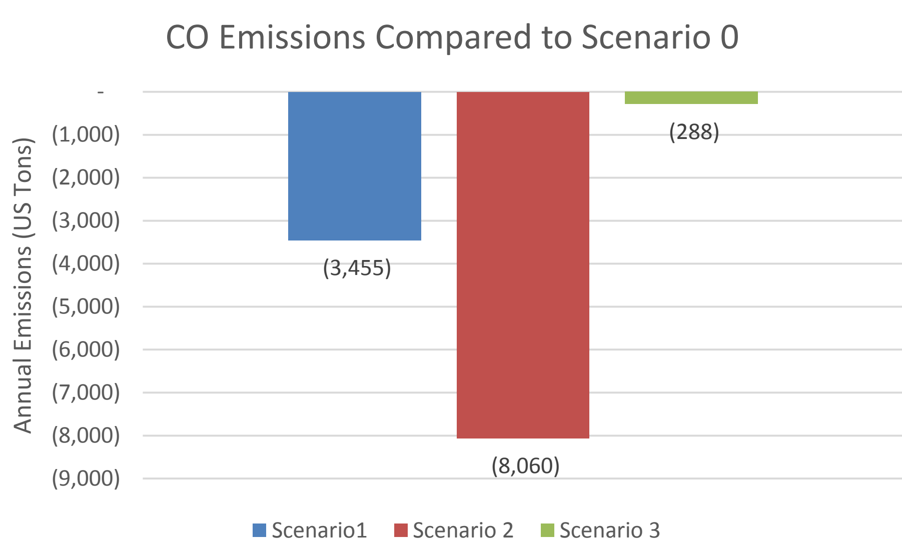
To estimate air quality affects, the WFRC/MAG travel demand model was used in conjunction with the EPA's Motor Vehicle Emissions Simulator (MOVES) software which estimates emissions for mobile sources for criteria air pollutants, greenhouse gases, and air toxins.

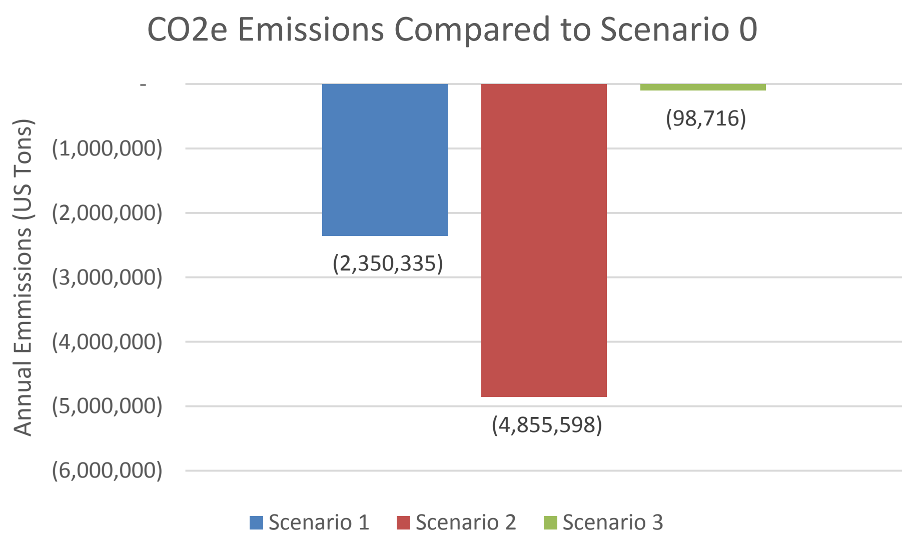
Methodology

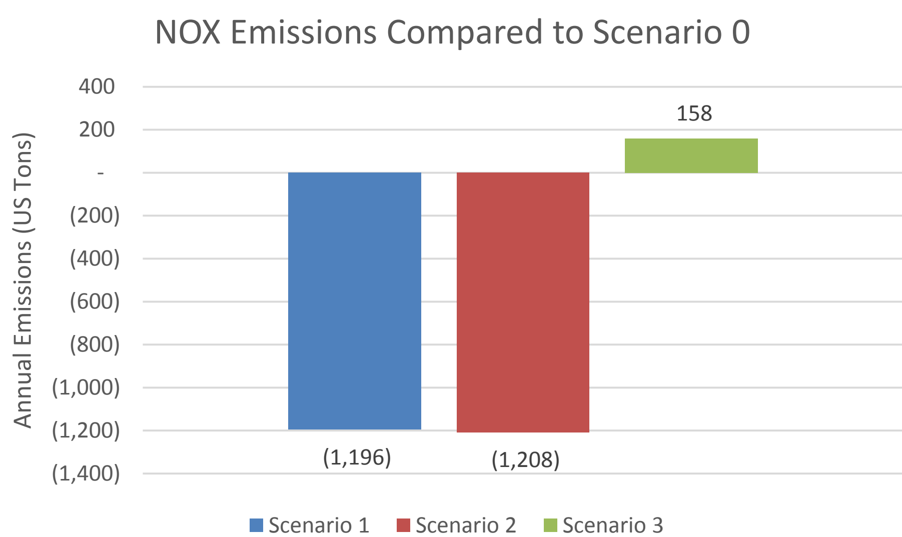
Outputs from the Regional Travel Demand Model for each scenario were processed into MOVES inputs. Specifically, this included VMT and average speed data. The WFCCS Technical Team then analyzed MOVES outputs and compared them to Scenario 0, evaluating how much emissions would change in each WFCCS scenario.

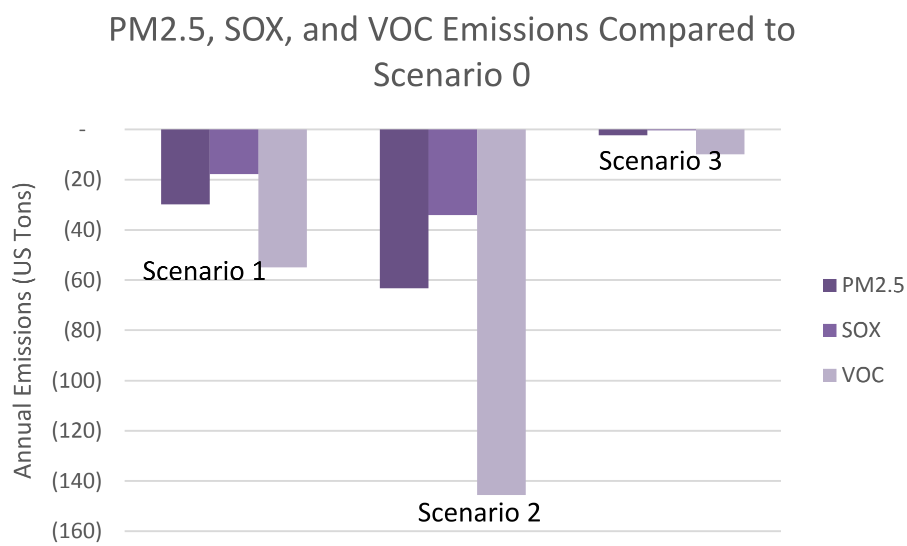
Evaluation

The following figures summarize results of the MOVES analysis. Results represent annual emissions saved in 2050 in US Tons. Scenario 3 results for most pollutants are lower than the baseline despite this scenario having higher total VMT. Yet, VMT is occurring at speeds that result in more efficient operations in terms of emissions.




CO2e Emissions Compared to Scenario 0
Annual Emmissions (US Tons)
-
(1,000,000)
(2,000,000)
(3,000,000)
(4,000,000)
(5,000,000)
(6,000,000)
(2,350,335)
(4,855,598)
(98,716)
Scenario 1
Scenario 2
Scenario 3


NOX Emissions Compared to Scenario 0
Annual Emissions (US Tons)
400
200
-
(200)
(400)
(600)
(800)
(1,000)
(1,200)
(1,400)
158
(1,196)
(1,208)
Scenario 1
Scenario 2
Scenario 3



Conclusions

Based on this analysis, Scenario 2 has the greatest amount of emissions savings for all emission types. However, Scenario 1 and 2 were comparable in terms of NOX emissions saved. Scenario 3 had the fewest savings for all emissions types, and NOX emissions increased under this scenario. These results are consistent with expectations: Scenario 2 has higher transit use and lower VMT, while Scenario 3 includes roadway capacity improvements that result in higher VMT. These results may not fully capture induced vehicle travel effects but any limitations of the modeling would not alter the general relationship between the scenarios.

Goal: Improve Mode Balance

Metric: Share of Households in Study Area within ½-mile Walking Distance and 3-mile Biking Distance of Rail Transit

This metric evaluates the number of households within the WFCCS study area that are within a one-half walking distance or three-mile biking distance of rail stations. Land use has a significant effect on transportation needs, and increased population density around transit nodes provides more people with the option to consider transit a viable and competitive transportation choice. Shifting density to transit walk- and bike-sheds could result in higher transit mode split and reduced VMT.

Data Sources and Methodology

The technical team analyzed walk and bike sheds using GIS, which required transit station data, road and trail data, and Traffic Analysis Zone (TAZ) socioeconomic data. Socioeconomic data represented the population density in the study area for the existing base year (2014) in addition to the socioeconomic data sets developed for each WFCCS scenario (including Scenario 0). Point data of existing and proposed commuter rail and light rail stations for all scenarios was acquired from UTA, WFRC, and MAG. Road data was acquired from AGRC and the existing trails alignment data was acquired from WFRC Long Range Plan. The road and trail data were used to establish a network for evaluating connectivity. The active transportation networks analyzed include:

- Preferred trail alignments identified in the Salt Lake County East-West Trails Master Plan
- Pedestrian and bicycle network improvements identified in UTA's First/Last Mile Strategies Study, which were submitted for TIGER funding
- Proposed trail alignments identified in WFRC and MAG RTP's

The walk- and bike-shed distance assumptions were based on Federal Transit Administration (FTA) recommendations that bicycle and pedestrian catchment areas represent "…one-half mile for pedestrian improvements and three miles for bicycle improvements near public transportation stops and stations"[15].

A GIS Network Analysis exercise produced service area polygons depicting areas accessible to all the commuter rail and light rail stations within a half mile and three-mile radius. The service areas and the population estimates from the TAZ datasets were then spatially joined for each scenario to create one layer with all the information on the service areas linked spatially to the TAZs. Models then assigned a proportion of households to each service area, comparing them to the total number of households within the overall study area for each scenario.

Evaluation

Model results produced the total number of households computed for each scenario, to offer baseline comparisons. Table 11 outlines the model results.

Table 11: Share of Households in WFCCS Study within Walking or Bicycling Distance of Rail Transit

	Base Year 2014	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Total Households in Study Area	215,540	295,667	295,716	295,854	296,185
Within ½-mile of TRAX	7.8%	14.7%	14.8%	14.8%	14.9%
Within 3 miles of TRAX	65.3%	73.5%	73.9%	73.7%	73.4%
Within ½-mile of FrontRunner	0.9%	3%	3%	3.1%	3.4%
Within 3 miles of FrontRunner	52.4%	60.4%	61.1%	60.8%	63.6%

[15] Department of Transportation, Federal Transit Administration. *Final Policy Statement on the Eligibility of Pedestrian and Bicycle Improvements Under Federal Transit Law.* Vol.76, No. 161 / Friday, August 19, 2011

The results demonstrate that all WFCCS scenarios increase the number of households accessible to transit stations over Scenario 0. Scenarios 1 and 3 have the highest overall percent change compared to Scenario 0 for accessibility to commuter and light rail stations for both half mile and three mile sheds. The increase for Scenario 1 is due to the emphasis the scenario places on developing within transit centers and nodes and providing options to utilize active transportation to access transit stations. The increase in transit accessibility within the walk and bike sheds for Scenario 3 is due to the emphasis this scenario places on creating new capacity for all modes, including walking, cycling and transit use. This scenario adds additional commuter rail stations and mobility hubs to the network, thereby increasing the number of people near transit stations in this scenario. It also aims to make transit more accessible by improved walking and cycling networks.

Scenario 3 has fewer households within a three mile walk/bike shed of light rail stations than Scenarios 1 or 2. This is primarily due to assumptions built into the assignment of socioeconomic growth around transit stations: the socioeconomic allocations in Scenario 3 are distributed such that potential growth is shifted away from light rail stations and toward commuter rail stations, to reflect the concept of regional mobility hubs in Scenario 3. While real-world conditions may demonstrate that the demand for transit-oriented development is limited, another outcome with increased growth around both light rail and commuter rail development may also be possible.

Conclusions

All WFCCS scenarios demonstrated a modest increase in the number of households accessible to both light rail and commuter rail stations within a half mile walk shed and three-mile bike shed. However, the differences in accessibility between the three scenarios is minimal.

Metric: Transit Access Mode Split to Rail Stations in Peak Periods

This metric addresses the means of transportation used to access high-capacity transit stations in the study area. This metric is one way of assessing mode balance: the desired direction of change would be lower rates of drive-alone trips to rail stations and higher rates of walking trips to rail stations.

Data Sources and Assumption

The WFRC/MAG travel demand model was used to analyze the percent of people walking or driving to rail transit stations within the study area. The data was extracted from travel demand model runs representing WFCCS Scenarios 1, 2, and 3, in addition to Scenario 0 and Base Year 2014. Trips identified as "walk" trips also included cycling trips, since cycling trips are not identified separately in this model output. Driving trips also included carpool trips. Transfers from other transit modes are based on the initial access mode. For example, trips that walked to a bus stop and then transferred to TRAX would be classified as a walk trip. However, trips that drove to a bus stop and then transferred to TRAX would be classified as a drive trip.

Methodology

This analysis was limited to those light rail and commuter rail stations located within the WFCCS primary study area boundary. This captured the benefits of improvements made within the study area that could increase accessibility to the stations and thereby affect mode of access to transit. For rail stations within the study area, the travel demand model identified the number of trips accessing those stations by driving or by walking. These figures were then used to calculate the percentage of access trips made by each mode.

Evaluation

The access to transit mode splits for driving compared to walking are provided in Table 12 below.

Table 12: Mode of Access to Rail Transit

Scenario	Percent Driving	Percent Walking
Base Year 2014	23%	77%
Scenario 0	11%	89%
Scenario 1	12%	88%
Scenario 2	15%	85%
Scenario 3	14%	86%

Observers will note that the percent of people driving to rail transit is higher in Scenario 2 than the other 2050 scenarios, but Scenario 2 also has the highest mode split for transit of all the future scenarios (as discussed in the Peak and Daily Mode Split section below). Several key elements of Scenario 2 (doubling transit frequency, improving FrontRunner service, tolling all I-15 lanes in the peak, and reducing transit fares) result in high transit ridership increases in Scenario 2 compared to other scenarios. These new transit riders contribute to the shift in peak and daily mode split towards transit, but many of them access the rail system by driving to a park and ride lot and boarding the train for their trip. The Scenario 2 key elements draw a far wider group to the system, more of which live outside a walking distance to the stations than in the other scenarios.

Conclusions

As shown in the table above, all 2050 scenarios have a higher share of access to transit via walking than by driving. However, when comparing among the 2050 scenarios, they all perform at a similar level, with Scenario 0 having the highest access to transit by walking of all the 2050 scenarios. Due to model limitations, this metric is not able to capture improvements such as the active transportation networks proposed in Scenarios 1 and 3; the finer-grain nature of these accessibility improvements cannot be reflected in a large, regional-scale travel model. This may be one reason for little differentiation between scenarios for this metric.

Metric: Peak and Daily Mode Split

This metric identifies the percentage of people traveling within the WFRC/MAG model by a variety of modes: driving alone, carpooling, transit, or non-motorized trips. Results for this metric are reported both in terms of peak period mode split, and daily mode split.

Data Sources and Assumptions

The Regional Travel Demand Model was used to extract peak and daily mode split data from model runs representing Scenarios 1, 2, and 3, in addition to Scenario 0 and Base Year 2014. Non-motorized trips represent both walking and cycling trips grouped together; the travel demand model does not currently account for these trips by individual mode.

Methodology

Using a travel demand model script, the peak period and daily mode splits were calculated for the region. This analysis did not differentiate between work trips and other kinds of trips; rather, all trips were accounted for in this analysis.

Evaluation

The results of the peak period and daily mode split analysis are provided in Table 13.

Table 13: Peak Period and Daily Mode Split

Time Period	Mode	Base Year 2014	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Peak Period	Auto SOV	48.5%	47.9%	47.1%	45.1%	47.5%
	Auto HOV	39.6%	40.1%	40.3%	40.6%	40.1%
	Transit	2.2%	3.0%	3.6%	5.3%	3.4%
	Non-Motorized	9.7%	9.0%	9.0%	9.0%	9.0%
Daily	Auto SOV	43.2%	42.8%	42.2%	41.4%	42.5%
	Auto HOV	45.5%	45.4%	45.6%	45.1%	45.5%
	Transit	1.4%	2.0%	2.5%	3.7%	2.3%
	Non-Motorized	10.0%	9.8%	9.7%	9.8%	9.7%

Conclusions

As shown in the table, Scenarios 1 and 3 are generally within a percentage point of Scenario 0 for each mode, for both peak period and daily mode split. Scenario 2 sees a modest shift – around 2% - away from single-occupancy vehicles and towards transit in the peak period, and a smaller shift in the same direction for the daily mode split.

While overall transit system boardings was not official metric selected for analysis by the WFCCS Management Team, it nevertheless tells a compelling story about mode shift (one that is only hinted at in the numbers in the table above). Table 14 below shows daily transit system boardings for the Base Year 2014 in addition to Scenarios 0, 1, 2, and 3.

Table 14: Daily Systemwide Transit Boardings by Scenario

	Base Year 2014	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Daily Transit Boardings	142,000	332,000	405,000	656,000	384,000
		Increase from Scenario 0	22%	97%	15%

As shown in the table, daily systemwide transit boardings increase by 97% in Scenario 2 when compared to Scenario 0. This is due to several combined factors in Scenario 2: no-fare transit, doubled transit frequency, and tolling of all lanes on the freeway in the peak period. More information on the contributions of these individual factors is in the “Sensitivity Tests” portion of this memorandum.

Sensitivity Tests

This section describes sensitivity tests conducted to better understand the influence of individual strategies within WFCCS Scenarios. As a caveat, the analysis does not evaluate all aspects of how a particular strategy may influence travel; rather, this discussion provides a high-level assessment of the obvious impacts in terms of common evaluation metrics. The sensitivity tests toggle one variable and compare the results to the "parent" scenario, and it's possible that the test variable would perform differently with different background assumptions. Table 5 summarizes the sensitivity tests and their effect on particular indicators.

Table 15: Sensitivity Test Summary

Transit Investment		
Double Track/Electrify Frontrunner	Transit ridership	+ 6%
Free Transit Fare	Transit ridership	+ 16 to 17%
Transit Frequency (2x)	Transit ridership	+ 31%
Free Transit Fare and Frequency (2x)	Transit ridership	+ 43%
Arterial Management Strategies		
Grid 2.0	Employment Accessibility	No meaningful change
	Transit ridership	No meaningful change
	Vehicle Throughput*	No meaningful change
	VMT (study area)	No meaningful change
Grid 3.0	Employment Accessibility	No meaningful change
	Vehicle Throughput*	+ 49,000
	Transit ridership	+ 1.2%
	VMT (study area)	+ 4.2%
New I-15 Infrastructure		
Expanded I-15 CD System	Transit ridership	No meaningful change
	Vehicle Throughput*	+ 2,000
	VMT (study area)	+ 3.6%
Elevated Lanes	Transit ridership	No meaningful change
	Vehicle Throughput*	+ 23,500
	VMT (study area)	+ 1.8%
I-15 Management		
Managed Motorways	Transit ridership	- 1.4%
	Vehicle Throughput	+10,300
	VMT (study area)	+ 2.9%
Tolled GP Lanes	Transit ridership	No meaningful change
	Vehicle Throughput*	- 57,000
	VMT (study area)	- 6%

*average for I-15 screenlines at SR-92, 12300 S, 7800 S, 3300 S, 1300 S

Key Takeaways of Sensitivity Tests

- Double Tracking and Electrifying the FrontRunner system has little impact on transit ridership (6%). However, it should be noted that the scenario in which this was tested also included major investments in the highway system, specifically adding an elevated lane to I-15. This may have dampened the ridership impacts that would have otherwise occurred.
- When other strategies are held constant, free fare does not have a dramatic impact as a stand-alone strategy (16-17%); reducing headways is more significant (31%). The overall impact of combining the strategies results in a substantial benefit to transit ridership (43%).
- Grid 2.0 produced little change on major indicators.
- Grid 3.0 had a significant effect of vehicle throughput and also raised VMT in the study area.
- Elevated lanes on I-15 significantly improved vehicle throughput and only raised study are VMT by 1.8%
- Managed motorways improved vehicle throughput.
- Tolled general purpose lanes had a significant effect on vehicle throughput, reducing it by almost 60,000
- Tolling also reduced study area VMT by 6%.

In addition to these sensitivity tests, the project team assessed the potential influence that autonomous vehicles (AVs) may have on network performance. These tests were performed by changing model parameters related to travel time and travel costs. In general, AVs have the potential to lower travel and parking costs and change the perception of time while traveling in the vehicle (i.e., instead of being focused on driving, other activities are possible). Capacity (and safety) may also increase with vehicles that can communicate with one another and to other transportation infrastructure not to mention reacting more quickly than human drivers. Lowering the cost, while improving the safety and convenience, of vehicle use had the expected effect of increasing vehicle trips and VMT while decreasing transit use, especially bus transit. The results highlight the potential disruption that new technology may cause and the potential for existing network capacity to be better utilized in the future.

References

1. Fehr & Peers (2016). *Wasatch Front Central Corridor Study Initial Scenarios Development and Screening Technical Memorandum*.
2. RSG (2017). *Wasatch Front Central Corridor Study Data and Modeling Technical Memorandum*.
3. Utah Department of Transportation Safe Map collision data. Available online at www.udot.numetric.com.
4. AAA Foundation for Traffic Safety. (2011). *Impact of Speed and Pedestrian's Risk of Severe Injury or Death.* Washington DC: AAA
5. Elvik, R. (2009). *The Power Model of the Relationship Between Speed and Road Safety.* Oslo, Norway: Institute of Transport Economics: Norwegian Centre for Transport Research.
6. Federal Highway Administration, *Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes*. Available at https://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/. Accessed March 17 2017.
7. Mead, J., Zeeger, C., and Bushell, M. (2014). *Evaluation of Pedestrian-Related Roadway Measures: A Summary of Available Research.* Chapel Hill, NC: Pedestrian and Bicycle Information Center.
8. San Francisco Municipal Transportation Agency (2013). *Effectiveness Summary Memo.*
9. Dill, J., Carr,T. (2003). *Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look.* Portland, OR: Portland State University.
10. Portland Bureau of Transportation (2011). *Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT*. Portland, OR: Portland State University, Center for Transportation Studies.
11. National Association of City Transportation Officials (2014). *Urban Bikeway Design Guide*. New York, NY.
12. RSG (2013). *Utah Travel Study*. Salt Lake City, Utah: Wasatch Front Regional Council.
13. Cambridge Systematics (2004). *Traffic Congestion and Reliability: Linking Solutions to Problems.* Washington DC: Federal Highway Administration.
14. Utah Department of Transportation. *Performance Measurements System (PeMS).* Accessible online at http://udot.bt-systems.com/.
15. Federal Transit Administration (2011). *Final Policy Statement on the Eligibility of Pedestrian and Bicycle Improvements Under Federal Transit Law.* Vol.76, No. 161. Washington DC: United States Department of Transportation.