Milton ROAD

Alternatives Operations Analysis
Micro-Simulation Modeling

FLAGSTAFF METROPOLITAN PLANNING ORGANIZATION

FINAL REPORT

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Kimley»Horn

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INTRODUCTION

PROJECT BACKGROUND

As Flagstaff has developed and evolved, the Milton Road/Route 66/Business Route 40 corridor has transitioned from a state highway primarily serving regional vehicular traffic to a multi-functional roadway that also serves local pedestrian, bicycle, and transit travel and adjacent land uses. As an example, Milton Road serves a statewide function as it provides access to the Grand Canyon, a regional function as it connects to Northern Arizona University (NAU), and a local function as it serves businesses located along the corridor. Milton Road is used by vehicles, transit, bicyclists, and pedestrians. Inherent in a multi-functional roadway are competing priorities, be it regional traffic mobility vs. local access or vehicular capacity vs. multimodal accommodations. These competing priorities, combined with existing corridor constraints, have resulted in operational and safety issues on Milton Road that need to be addressed.

Many previously completed plans and studies have made recommendations or identified opportunities for ways to improve the Milton Road corridor. These documents include:

- Flagstaff Regional Land Use and Transportation Plan (2001)
- Flagstaff Urban Mobility Study (2004)
- Flagstaff Metropolitan Planning Organization (FMPO) Regional Transportation Plan Update: Safety Component (2008)
- FMPO Regional Transportation Plan 2030 (2009)
- FMPO U.S. 180 Winter Congestion Study (2012)
- Flagstaff Regional 5-Year and Long-Range Transit Plan (2013)
- Flagstaff Regional Plan 2030 (2014 – update to 2001 Plan)
- Flagstaff Transit Spine Route Study (2016)

Most of these previously completed documents utilized a variety of qualitative and quantitative criteria to evaluate a wide range of potential improvement alternatives. These evaluations were typically presented to stakeholders and public for review and input and refined and prioritized accordingly.

This project will be informed by these previously completed projects but will differ from them in that it will be a more technical evaluation measured primarily in quantifiable terms derived from micro-simulation models. This project also will not include extensive stakeholder and public involvement as the goal is to determine the operational effectiveness of alternative mobility treatments for a technical audience. The findings from this project will be incorporated into a more detailed corridor study that FMPO plans to conduct in the future that will include more extensive stakeholder and public involvement.

PROJECT PURPOSE AND OBJECTIVES

The purpose of this project is to assess the operational effectiveness of alternative mobility treatments for the Milton Road/Route 66/Business Route 40 corridor (including cross-streets) between Forest Meadows Street and San Francisco Street. Project objectives include:

- Document existing and planned conditions for inclusion in Synchro and VISSIM micro-simulation modeling
- Develop and calibrate an Existing Condition Baseline micro-simulation baseline model
- Develop a Future Condition Baseline micro-simulation baseline model
- Determine appropriate measures of effectiveness such as delay, queues, and travel time
- Use micro-simulation modeling to evaluate and document the performance of various improvement alternatives that represent different combinations of access management/network treatments, transit service treatments, and intersection treatments
- Provide preliminary materials to the FMPO Technical Advisory Committee (TAC) for review and input
- Document the findings of the alternatives evaluation in such a manner that they can easily be incorporated into the planned corridor study for Milton Road

PROJECT STUDY AREA

The project study area is the Milton Road/Route 66/Business Route 40 corridor between Forest Meadows Street and San Francisco Street.

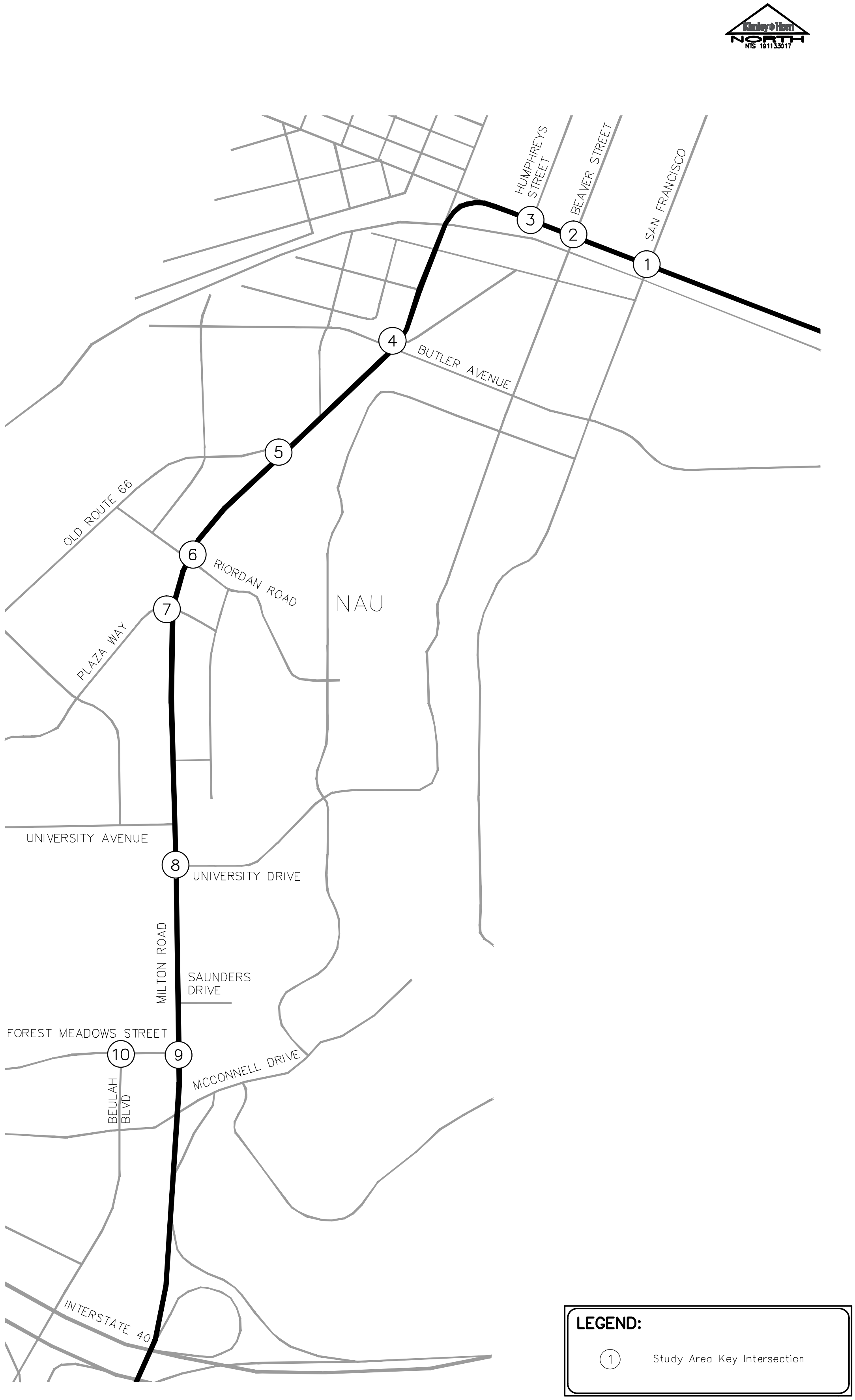
The key study area intersections are as follows:

1. Milton Road/San Francisco Street
2. Milton Road/Beaver Street
3. Milton Road/Humphreys Street
4. Milton Road/Butler Avenue
5. Milton Road/Route 66
6. Milton Road/Riordan Road
7. Milton Road/Plaza Way
8. Milton Road/University Drive
9. Milton Road/Forest Meadows Street
10. Forest Meadows Street/Beulah Boulevard

The project vicinity and key study area intersections are shown in **Figure 1**.

PROJECT REVIEW TEAM

The project review team (PRT) for this project is the FMPO TAC. This committee is comprised of representatives from FMPO, the City of Flagstaff, Coconino County, Northern Arizona Intergovernmental Public Transportation Authority (NAIPTA), and Arizona Department of Transportation (ADOT).



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
STUDY AREA VICINITY MAP

FIGURE 1

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EXISTING CONDITION BASELINE SCENARIO

COLLECTION AND REVIEW OF DATA

Data collected for input into the VISSIM and Synchro simulation models was provided by FMPO, City of Flagstaff, ADOT, and NAIPTA, or was collected directly by Kimley-Horn. This data includes the following items:

- Previously completed plans and studies
- Historical Fall afternoon (PM) peak hour intersection movement counts
- New Fall PM peak hour intersection counts conducted by FMPO
- Pedestrian and bicycle volumes
- Train frequency and crossing closure durations
- Information pertaining to transit routes, stops and frequencies
- Traffic signal timing, phasing, and coordination information
- Field visits to confirm timing data, perform travel time runs, and visually assess the corridor during PM peak hour conditions

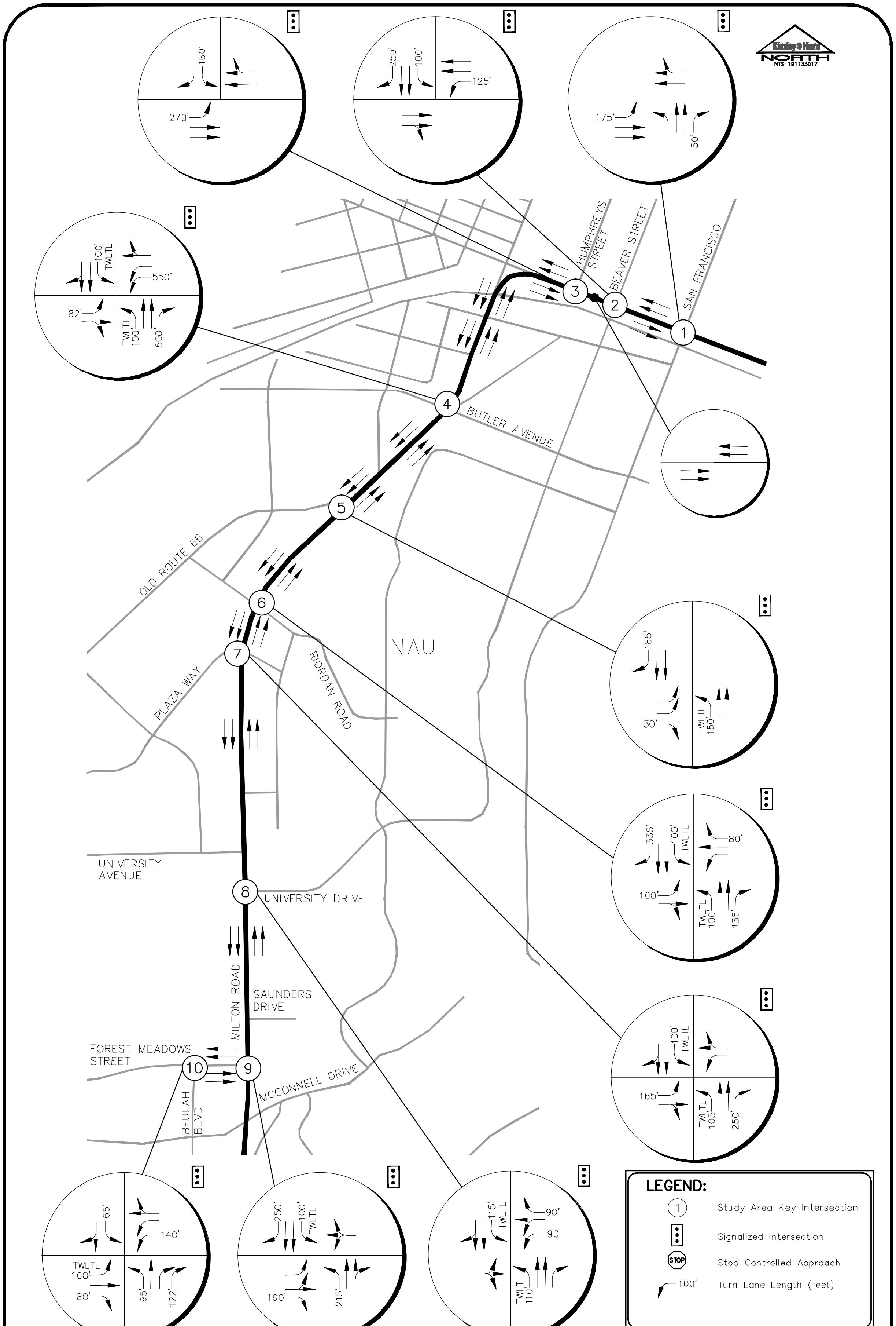
DEVELOPMENT OF EXISTING CONDITION BASELINE VISSIM AND SYNCHRO MODELS

A VISSIM model developed as part of another project that contained the northern portion of the study area was provided by FMPO. A Synchro model that contained parts of the middle and southern portion of the study area was provided by the City of Flagstaff. These partial models were used as a basis for creating complete Existing Condition Baseline models of the entire study corridor using both software packages.

Existing signal timing data and lane configuration information was coded into the models. A field review of the corridor during the PM peak period on Wednesday, September 10, 2015 was completed to confirm existing conditions. The Existing Condition Baseline lane configurations are shown in **Figure 2**.

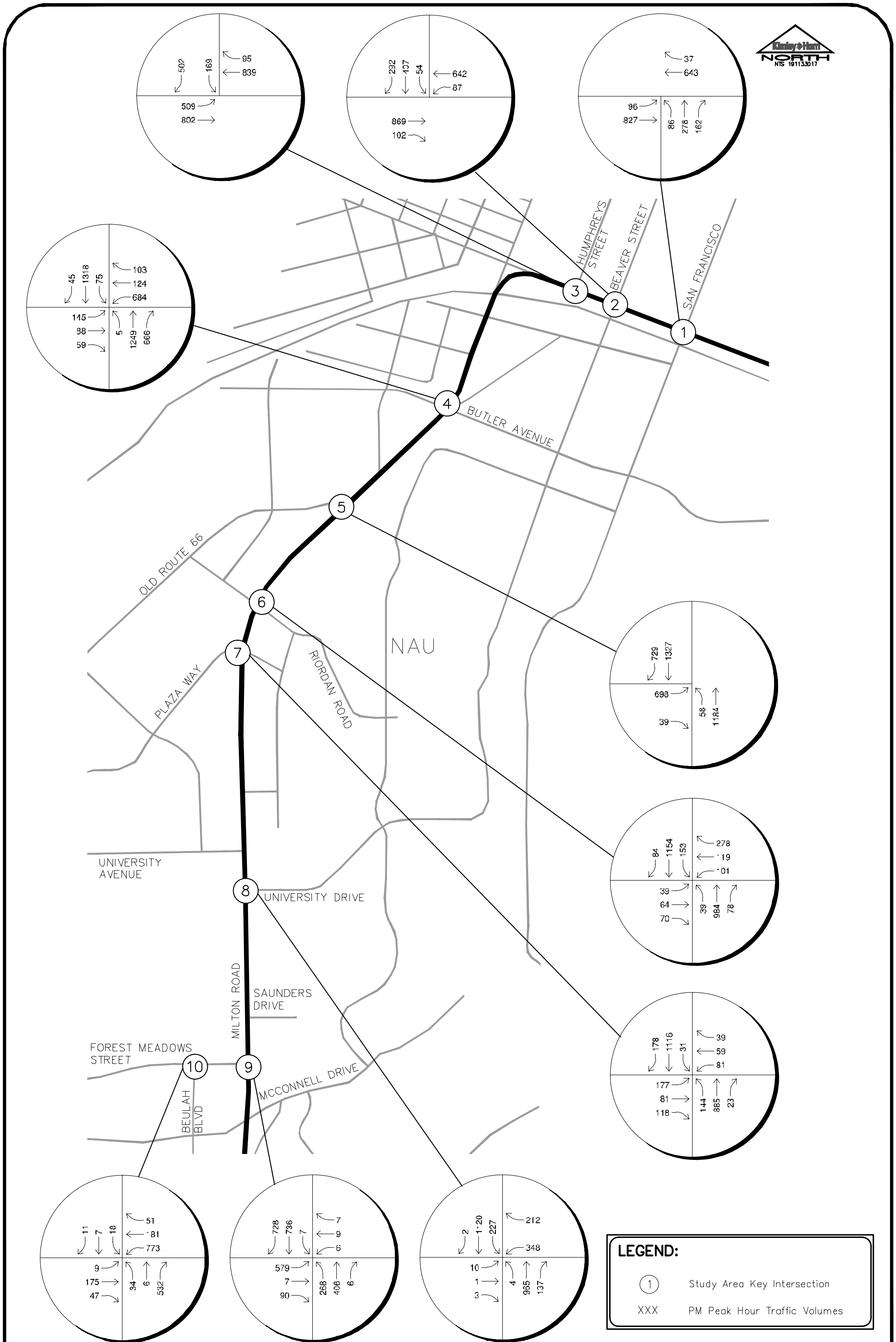
DEVELOPMENT OF EXISTING CONDITION BASELINE DESIGN HOURLY VOLUMES

The Fall PM peak hour traffic period from 5:00PM-6:00PM was chosen as the design hour. The existing peak hour traffic counts were balanced between intersections at 15-minute intervals. This was done using the volume-balancing feature in Synchro. If the upstream and downstream intersections were closely spaced, then the volumes were balanced directly between the two intersections. However, if the intersections were farther apart, with multiple access points between them, a right-in/right-out only “dummy” node or driveway was used to balance the traffic volumes between these intersections, thus preserving the actual count volumes at these locations. The balanced Existing Condition Baseline design hourly volumes shown in **Figure 3** were then used as inputs into the Existing Condition Baseline VISSIM and Synchro models.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
EXISTING CONDITION BASELINE LANE CONFIGURATIONS

FIGURE 2



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
EXISTING CONDITION BASELINE PM PEAK HOUR DESIGN VOLUMES

FIGURE 3

CALIBRATION OF EXISTING CONDITION BASELINE VISSIM AND SYNCHRO MODELS

The aforementioned field review of the corridor during the PM peak period was completed to aid in calibrating the Existing Condition Baseline models by comparing results from the models with what was observed in the field in terms of delay, queues, and intermodal interactions.

The VISSIM model is the primary model for this study because of its capability to model interactions between vehicles, trains, buses, pedestrians, and bicyclists and to model queue delay and interactions in oversaturated conditions. As such, most of the calibration effort concentrated on getting the Existing Condition Baseline VISSIM model to reflect existing conditions with reasonable accuracy.

The following steps were taken to help calibrate the Existing Condition Baseline VISSIM model:

- A more cooperative lane change behavior was created for congested arterial links, such as southbound (SB) Milton Road between Humphreys Street and Route 66 and northbound (NB) Milton Road between Route 66 and Butler Avenue
- The peak hour existing counts and 15-minute seeding volumes were balanced along Milton Road in 15-minute intervals
- Lane change distance for the SB right-turn at Milton Road/Route 66 was modified to reflect the existing imbalance in lane utilization as during congested times traffic shifts to the outside through lane early to ensure easy access to the right-turn lane at Route 66
- Pedestrian volumes at signalized intersections were updated to model the field observation that there were pedestrians crossing almost every cycle at signalized intersections in the study area
- Permissive left-turn and right-turn gap acceptance at high-volume locations, such as the eastbound (EB) left-turn at Milton Road/Humphreys Street, were adjusted to better reflect observed conditions
- Keep-clear zones were included for driveways and intersections along SB Milton Road between Route 66 and Humphreys Street
- The default VISSIM car-following parameters (Wiedemann 74 for arterial) were not modified because the default parameters produce good representation of the existing saturation flow rate
- Five (5) simulation runs (sample size) with different random seeds were determined to be sufficient to provide 95% confidence level for model output randomness (sample error)

The Existing Condition Baseline VISSIM model calibration achieved the following targets derived from the *FHWA Traffic Analysis Toolbox Volume III* calibration guidelines produced in July 2004:

- Volume percentage difference:
    - Simulated and measured link approach volumes are within 15% of each other for more than 85% of links

    - Sums of simulated and measured link approach volumes within the calibration area are within 5% of each other
- Travel time
    - Average NB model travel time along Milton Road from south of Forest Meadows Street to east of San Francisco Street is within 7% of field measured travel time
    - Average SB model travel time along Milton Road from east of San Francisco Street to south of Forest Meadows Street is within 3% of field measured travel time
- Existing Condition Baseline VISSIM model runs were observed to represent field conditions in terms of:
    - Signal operations
    - Pedestrian activities at intersections
    - Locations of bottlenecks or critical movements
    - Patterns and extent of queues at intersection and congested links
    - Lane utilization/choice

While the model calibrated well overall, there are specific movements that did not calibrate quite as well, most notably the following:

- EB movements at Milton Road/Butler Avenue – modeled queues were much longer than observed queues, likely due to modeled right-turn volumes not turning right if the downstream SB queue on Milton Road backs up to the intersection whereas field observations noted EB right-turning vehicles joining the downstream SB queue, even if it meant they partially blocked part of the intersection
- SB movements at Milton Road/Beaver Street – modeled queues were much longer than observed queues, likely due to modeled vehicles not interacting as efficiently with the at-grade railroad crossing closure as field observations noted (due to vehicles continuing to cross while the gate arms were in motion or diverting to the left or right on Milton Road instead of waiting for trains to pass)

The movements that did not calibrate well are lower-volume, less-critical movements from a corridor perspective. As such, these discrepancies are not anticipated to have a significant impact on the corridor analysis findings.

Because five simulation runs were conducted for each VISSIM model with different random seeds for each model run, no two model runs provided identical results. Small changes in intersection delay (e.g., 0-10 seconds) and queuing (e.g., 0-150 feet) between model runs are typical in VISSIM and reflect normal model variability, similar to how actual traffic conditions vary slightly from day to day due to variabilities in volumes, arrival rates, and vehicle speeds.

Once the Existing Condition Baseline VISSIM model was calibrated, the Existing Condition Baseline Synchro model was calibrated to generally approximate the overall intersection level of service and delay calculated by VISSIM so that the Synchro model can be used to test improvement alternatives (as Synchro is more efficient than VISSIM at testing non-transit related alternatives). It should be noted that the queue lengths in Synchro are generally not as long as the VISSIM model queue lengths due to Synchro not being able to model queue delay and interactions in oversaturated conditions as well as VISSIM.

The following steps were taken to help calibrate the Existing Condition Baseline Synchro model:

- Reduced the saturation flow rate from 1900 to 1700 vehicles per hour of green (vphg)
- Reduced the link speeds from 30 miles per hour (mph) to 20 mph
- Reduced the SB through lane utilization factor at Milton Road/Route 66 from 0.95 to 0.70 to account for observed lane imbalance
- Reduced the SB through lane utilization factor at Milton Road/Butler Avenue from 0.95 to 0.80 to account for observed lane imbalance

EXISTING CONDITION BASELINE VISSIM MODEL MEASURES OF EFFECTIVENESS

Table 1 shows the intersection measures of effectiveness (MOEs) derived from the Existing Condition Baseline VISSIM model. The MOEs consist of level of service (LOS), average delay per vehicle (in seconds), and 95th percentile queue length (in feet). LOS is related to average delay per vehicle as follows: LOS A: 0-10, LOS B: 10-20, LOS C: 20-35, LOS D: 35-55, LOS E: 55-80, and LOS F: >80. **Table 2** shows the network MOEs (vehicles, travel time, speed, delay, and stops) derived from the Existing Condition Baseline VISSIM model.

EXISTING CONDITION BASELINE ANALYSIS FINDINGS

A review of data collected on existing conditions and the Existing Condition Baseline VISSIM model MOEs resulted in the following findings:

- Total intersection LOS is considered acceptable (LOS D or better) at all study intersections except for Milton Road/Butler Avenue, which has LOS E
- Excessive (where “excessive” is defined as queue lengths greater than 1,000 feet in through lanes or more than 250 feet beyond the existing storage length in turn lanes) SB queuing on Milton Road between the railroad bridge and Plaza Way
- Excessive SB queuing at Milton Road/Beaver Street
- Excessive EB queuing at Milton Road/Humphreys Street
- Excessive NB and EB queuing at Milton Road/Butler Avenue
- Inefficient traffic signal phasing and coordination – constrained by required minimum pedestrian crossing times
- Vehicle congestion and queuing adversely impact bus travel times and maneuverability
- Long distances between some signalized pedestrian crossings
- No dedicated bicycle facilities
- Uncontrolled access and driveways spaced close together
- While not modeled, field observations noted that the AM peak period generally operates at a better LOS than, and exhibits queuing for the opposite movements from, the PM peak period (e.g., NB through queue in the AM peak period versus SB through queue in the PM peak period)

Table 1: Existing Condition Baseline Intersection MOEs

Intersection	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Milton Road/San Francisco Street																	
LOS	D	D	C	C	B	B	-	B	-	-	-	-	-	B	B	B	C
Average Delay (s)	42	39	22	31	17	15	-	15	-	-	-	-	-	20	16	18	21
95% Queue (ft)	143	143	203	-	33	113	-	-	-	-	-	-	-	138	0	-	-
Milton Road/Beaver Street																	
LOS	-	-	-	-	-	B	B	B	D	D	F	E	E	C	-	C	D
Average Delay (s)	-	-	-	-	-	12	19	12	44	55	99	60	62	32	-	31	36
95% Queue (ft)	-	-	-	-	-	194	113	-	42	821	835	-	244	444	-	-	-
Milton Road/Humphreys Street																	
LOS	-	-	-	-	D	B	-	C	E	-	E	E	-	D	D	D	D
Average Delay (s)	-	-	-	-	49	10	-	24	75	-	60	58	-	52	43	45	42
95% Queue (ft)	-	-	-	-	531	75	-	-	226	-	386	-	-	605	462	-	-
Milton Road/Butler Avenue																	
LOS	E	C	E	D	F	F	F	F	F	F	F	F	D	C	C	D	E
Average Delay (s)	61	34	58	40	85	134	202	108	82	99	98	82	47	28	20	40	63
95% Queue (ft)	0	852	1087	-	734	1220	1030	-	1655	1656	1656	-	229	120	0	-	-
Milton Road/Route 66																	
LOS	D	B	-	B	C	-	C	C	-	D	C	C	-	-	-	-	C
Average Delay (s)	39	20	-	19	24	-	24	24	-	42	32	35	-	-	-	-	30
95% Queue (ft)	26	288	-	-	172	-	0	-	-	1645	1462	-	-	-	-	-	-
Milton Road/Riordan Road																	
LOS	C	B	A	B	B	C	D	C	E	F	B	E	C	B	A	B	D
Average Delay (s)	29	20	5	19	18	22	36	25	58	97	15	79	26	15	7	12	46
95% Queue (ft)	23	466	282	-	21	58	0	-	1054	1185	0	-	0	48	0	-	-
Milton Road/Plaza Way																	
LOS	E	C	C	C	D	D	D	D	C	C	C	C	D	D	C	D	C
Average Delay (s)	63	30	24	34	46	52	52	47	28	26	23	25	40	41	20	36	33
95% Queue (ft)	269	328	0	-	163	159	0	-	459	475	417	-	74	87	0	-	-
Milton Road/University Drive																	
LOS	D	C	A	C	E	D	F	F	D	B	B	C	C	-	A	B	C
Average Delay (s)	43	28	7	25	76	36	382	107	37	18	12	21	26	-	10	20	23
95% Queue (ft)	0	294	64	-	49	49	0	-	167	512	393	-	106	106	0	-	-
Milton Road/Forest Meadows Street																	
LOS	C	A	A	B	C	D	A	C	B	C	C	C	D	E	A	D	C
Average Delay (s)	24	9	10	15	33	40	4	29	18	22	26	23	50	57	6	40	23
95% Queue (ft)	134	64	0	-	199	199	0	-	0	208	371	-	25	25	0	-	-
Forest Meadows Street/Beulah Boulevard																	
LOS	C	C	A	A	C	C	A	C	C	C	A	C	C	B	A	C	B
Average Delay (s)	26	27	3	4	34	33	3	27	28	31	1	20	30	10	6	25	19
95% Queue (ft)	24	0	0	-	19	116	0	-	20	0	0	-	356	46	0	-	-

Table 2: Existing Condition Baseline Network MOEs

Network	Number of Vehicles	11,072
	Total Travel Time (h)	752
	Total Distance (mi)	10,410
	Total Delay (h)	407
Per Vehicle	Average Northbound Speed (mph)	17
	Average Southbound Speed (mph)	11
	85th Percentile Northbound Speed (mph)	25
	85th Percentile Southbound Speed (mph)	22
	Average Northbound Travel Time (s)	448
	Average Southbound Travel Time (s)	755
	Average Delay (s)	132
	Average Number of Stops	4
	Average Stop Delay (s)	69

FUTURE CONDITION BASELINE SCENARIO

DEVELOPMENT OF FUTURE CONDITION BASELINE VISSIM AND SYNCHRO MODELS

Future Condition Baseline VISSIM and Synchro models were originally developed in June 2015. In Fall 2015, signal timing and phasing improvements were implemented along Milton Road within the study area. The Future Condition Baseline models were updated and reanalyzed to reflect these changes. All results or discussion of the Future Condition Baseline models within this Final Report document refer to these more recent, updated models rather than the initially developed models discussed in the interim draft document Working Paper 1.

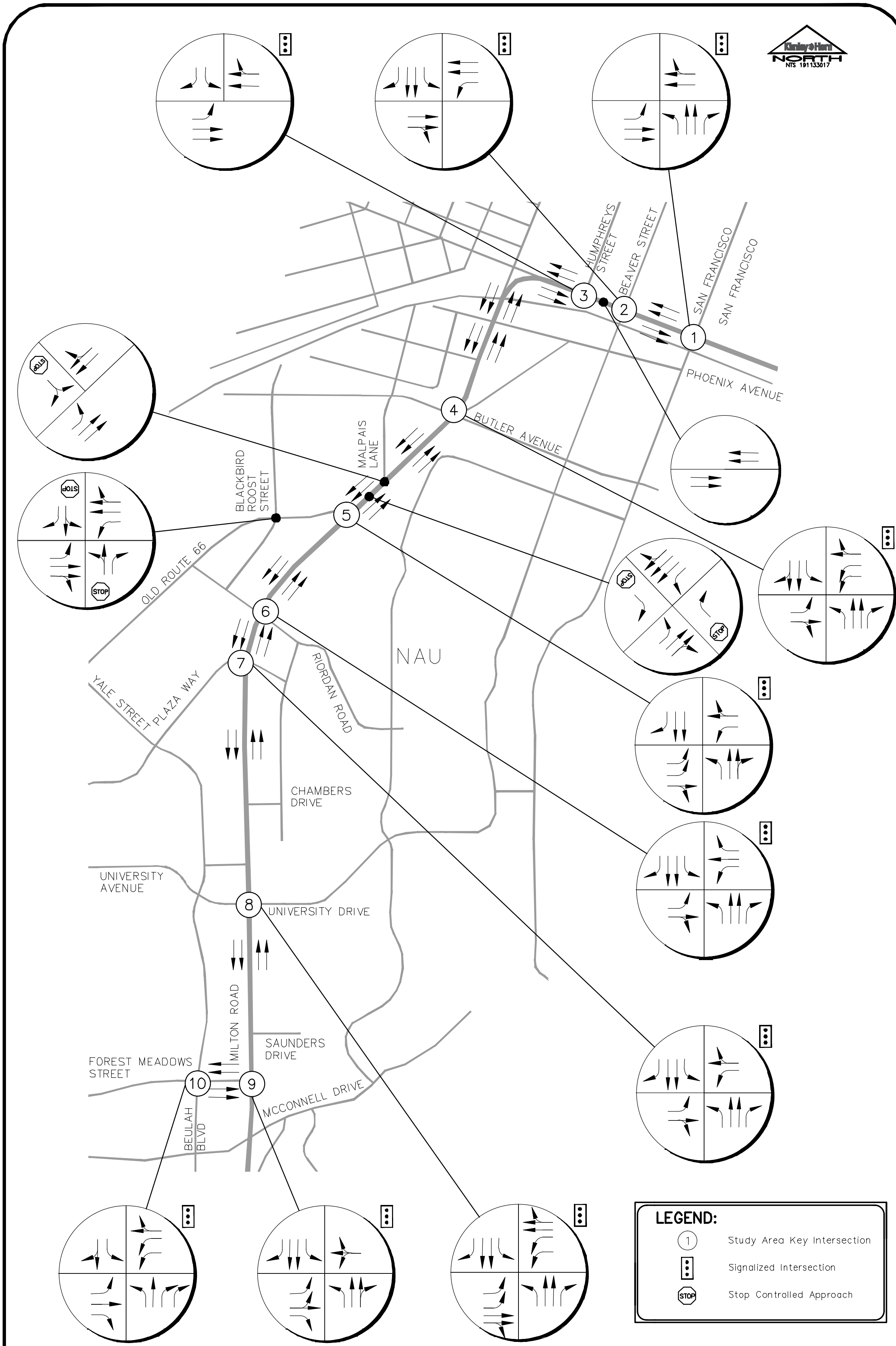
The Future Condition Baseline VISSIM and Synchro models incorporate the existing conditions information plus the aforementioned Fall 2015 updates to existing conditions and committed/programmed improvements, as described below:

- Eliminated split signal phasing at Milton Road/Butler Avenue and at Milton Road/Plaza Way
- Adjusted EB existing traffic volumes at Milton Road/Butler Avenue to account for significantly higher volumes observed during field reviews
- Updated traffic signal timing splits and signal coordination offsets on Milton Road between Butler Avenue and Forest Meadows Street
- Changed Bus Route 4 (SB on Milton Road) from 30-minute headways to 20-minute headways
- Extended Beulah Boulevard to University Avenue
- Realigned and connected University Avenue and University Drive at Milton Road and updated the signal phasing and timing to accommodate the new geometric configuration
- Added a SB right-turn lane on Milton Road at Plaza Way
- Added a new east intersection leg at Milton Road/Route 66 as a driveway to a planned development

The Future Condition Baseline lane configurations are shown in **Figure 4**.

DEVELOPMENT OF FUTURE CONDITION BASELINE DESIGN HOURLY VOLUMES

In conjunction with the FMPO TAC, it was determined that Future Condition Baseline design hourly volumes should reflect a 20% growth over existing volumes rather than a specific horizon year. Not using a specific horizon year removes the issue of trying to predict when growth will occur and instead looks at the scenario when traffic grows by 20% – whatever timeframe that may be in. It should be noted that modeled future volumes for certain movements may not reflect a full 20% increase due to queued vehicles blocking other vehicles from entering the network.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BASELINE LANE CONFIGURATIONS

FIGURE 4

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The 20% growth also acts as a sensitivity analysis for existing volumes in that if there are seasonal peaks that approach a 20% increase over typical Fall volumes, the 20% growth provides a sense of how the network will operate under those seasonal peak conditions.

The 20% value was derived after reviewing historical volumes on Milton Road and Route 66 over the last five years (per the ADOT Traffic Data Management System (TDMS) website). There was not a consistent pattern of growth from year to year at the same location, nor a consistent pattern of growth between locations, but the average annual growth was generally in the 1%-3% range. The 20% growth factor is equivalent to 1% growth over 18 years, or 2% growth over 9 years, or 3% growth over 6 years. These timeframes (6-18 years) align with the desired timeframe of this study being the near-term and mid-term future rather than the long-term future because the focus of this analysis is on operational improvements rather than large-scale network changes.

The planned extension of Beulah Boulevard to University Avenue and the realignment of University Avenue/University Drive will alter travel patterns in the vicinity of these improvements. The FMPO travel demand model was utilized to estimate how traffic volumes will change once these improvements are implemented. New PM peak hour volumes at the Milton Road/University Drive intersection and adjacent intersections were developed in conjunction with FMPO.

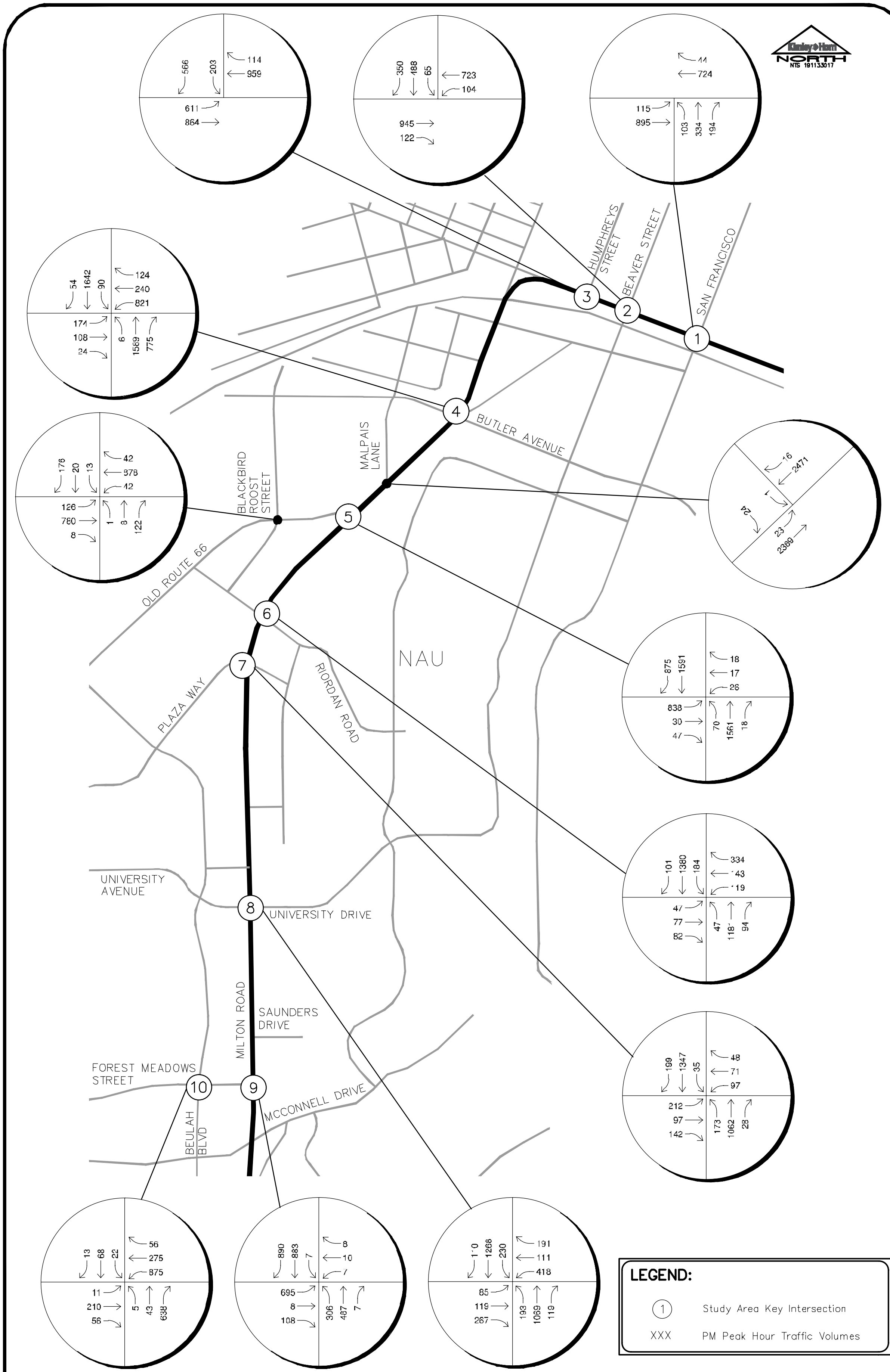
The Existing Condition Baseline design hourly volumes were updated to account for the programmed Beulah Boulevard/University Avenue improvements, grown by 20%, and rebalanced between intersections, thereby creating the Future Condition Baseline design hourly volumes. The Future Condition Baseline design hourly volumes shown in **Figure 5** were then incorporated in the Future Condition Baseline VISSIM and Synchro models and the traffic signal timing splits in the models were adjusted to optimally accommodate the 20% growth in traffic volumes.

FUTURE CONDITION BASELINE VISSIM MODEL MEASURES OF EFFECTIVENESS

Table 3 shows the intersection MOEs derived from the Future Condition Baseline VISSIM model. Similar to the Existing Condition, the Future Condition Baseline MOEs consist of LOS, average delay per vehicle (in seconds), and 95th percentile queue length (in feet). **Table 4** shows the network MOEs derived from the Future Condition Baseline VISSIM model.

Table 5 shows a summary of the intersection MOEs derived from the Existing Condition Baseline and Future Condition Baseline VISSIM models for comparison purposes.

Table 6 shows a summary of the network MOEs derived from the Existing Condition Baseline and Future Condition Baseline VISSIM models for comparison purposes. Bus-related MOE information was generated for the Future Condition Baseline VISSIM model but was not available for the Existing Condition Baseline VISSIM model.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BASELINE PM PEAK HOUR DESIGN VOLUMES

FIGURE 5

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Table 3: Future Condition Baseline Intersection MOEs

Intersection	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Milton Road/San Francisco Street																	
LOS	D	D	C	D	B	B	-	B	-	-	-	-	-	B	B	B	C
Average Delay (s)	43	41	26	37	19	18	-	18	-	-	-	-	-	13	15	13	22
95% Queue (ft)	446	446	456	-	127	379	-	-	-	-	-	-	-	235	80	-	-
Milton Road/Beaver Street																	
LOS	-	-	-	-	-	B	C	B	F	F	F	F	D	C	-	C	E
Average Delay (s)	-	-	-	-	-	13	21	14	145	160	347	225	54	29	-	32	79
95% Queue (ft)	-	-	-	-	-	351	279	-	836	1368	1103	-	213	341	-	-	-
Milton Road/Humphreys Street																	
LOS	-	-	-	-	D	B	-	C	F	-	D	D	-	D	D	D	D
Average Delay (s)	-	-	-	-	50	17	-	31	83	-	39	50	-	42	39	42	39
95% Queue (ft)	-	-	-	-	744	201	-	-	637	-	396	-	-	598	462	-	-
Milton Road/Butler Avenue																	
LOS	F	D	F	E	E	F	F	F	F	F	F	F	F	E	E	F	F
Average Delay (s)	92	49	80	59	79	83	112	83	141	130	139	131	109	68	61	96	89
95% Queue (ft)	32	1302	1338	-	417	523	348	-	1110	1602	1587	-	1139	651	372	-	-
Milton Road/Route 66																	
LOS	F	F	E	F	E	D	E	E	-	D	D	D	E	E	D	E	E
Average Delay (s)	131	80	61	82	62	50	77	62	-	41	52	45	55	72	49	59	60
95% Queue (ft)	661	1453	1214	-	630	614	437	-	-	1364	1383	-	78	78	13	-	-
Milton Road/Riordan Road																	
LOS	B	C	A	C	D	D	C	C	E	C	A	C	E	F	F	F	D
Average Delay (s)	18	30	5	28	50	36	20	33	55	28	9	30	76	110	96	95	40
95% Queue (ft)	56	466	291	-	109	200	0	-	670	727	0	-	175	748	329	-	-
Milton Road/Plaza Way																	
LOS	D	B	A	C	F	F	F	F	B	A	B	B	A	D	C	C	D
Average Delay (s)	43	17	9	20	262	183	178	219	16	9	16	10	2	46	24	21	40
95% Queue (ft)	225	252	35	-	877	857	857	-	47	354	201	-	9	191	5	-	-
Milton Road/University Drive																	
LOS	F	C	A	C	E	E	D	D	C	C	A	C	F	E	D	F	D
Average Delay (s)	103	25	5	34	67	56	49	54	29	24	5	23	164	59	52	116	48
95% Queue (ft)	508	498	280	-	315	371	278	-	295	598	0	-	847	819	655	-	-
Milton Road/Forest Meadows Street																	
LOS	C	A	A	B	D	D	A	D	D	D	F	E	D	E	B	D	D
Average Delay (s)	31	8	6	17	45	52	3	40	35	35	89	62	46	61	15	42	45
95% Queue (ft)	300	138	20	-	232	232	0	-	24	783	577	-	66	66	0	-	-
Forest Meadows Street/Beulah Boulevard																	
LOS	C	C	A	A	D	D	A	D	C	C	A	B	D	B	A	C	C
Average Delay (s)	27	23	4	5	47	42	5	36	23	20	1	18	41	15	10	34	24
95% Queue (ft)	22	73	0	-	47	241	74	-	13	23	0	-	694	251	197	-	-

Table 4: Future Condition Baseline Network MOEs

Network	Number of Vehicles	12,464
	Total Travel Time (h)	922
	Total Distance (mi)	10,045
	Total Delay (h)	583
Per Vehicle	Average Northbound Speed (mph)	15
	Average Southbound Speed (mph)	12
	85th Percentile Northbound Speed (mph)	20
	85th Percentile Southbound Speed (mph)	17
	Average Northbound Travel Time (s)	495
	Average Southbound Travel Time (s)	649
	Average Delay (s)	156
	Average Number of Stops	3
	Average Stop Delay (s)	89
Bus	Average Northbound Speed (mph)	11
	Average Southbound Speed (mph)	8
	85th Percentile Northbound Speed (mph)	13
	85th Percentile Southbound Speed (mph)	10
	Average Northbound Travel Time (s)	693
	Average Southbound Travel Time (s)	1,030
	Average Delay (s)	390
	Average Number of Stops	8
	Average Stop Delay (s)	190

Table 5: Comparison of Existing and Future Baseline Intersection MOEs

Intersection	Existing Baseline	Future Baseline
Milton Road/San Francisco Street		
LOS	C	C
Average Delay (s)	21	22
Longest 95% Queue (ft)	203	1,010
Milton Road/Beaver Street		
LOS	D	E
Average Delay (s)	36	79
Longest 95% Queue (ft)	835	1,538
Milton Road/Humphreys Street		
LOS	D	D
Average Delay (s)	42	39
Longest 95% Queue (ft)	605	1,629
Milton Road/Butler Avenue		
LOS	E	F
Average Delay (s)	63	89
Longest 95% Queue (ft)	1,656	1,660
Milton Road/Route 66		
LOS	C	E
Average Delay (s)	30	60
Longest 95% Queue (ft)	1,645	1,653
Milton Road/Riordan Road		
LOS	D	D
Average Delay (s)	46	40
Longest 95% Queue (ft)	1,185	1,306
Milton Road/Plaza Way		
LOS	C	D
Average Delay (s)	33	40
Longest 95% Queue (ft)	475	1,602
Milton Road/University Drive		
LOS	C	D
Average Delay (s)	23	48
Longest 95% Queue (ft)	512	1,073
Milton Road/Forest Meadows Street		
LOS	C	D
Average Delay (s)	23	45
Longest 95% Queue (ft)	371	410
Forest Meadows Street/Beulah Boulevard		
LOS	B	C
Average Delay (s)	19	24
Longest 95% Queue (ft)	356	311

Table 6: Comparison of Existing and Future Baseline Network MOEs

	Scenario	Existing Baseline	Future Baseline
Network	Number of Vehicles	11,072	12,464
	Total Travel Time (h)	752	922
	Total Distance (mi)	10,410	10,045
	Total Delay (h)	407	583
Per Vehicle	Average Northbound Speed (mph)	17	15
	Average Southbound Speed (mph)	11	12
	85th Percentile Northbound Speed (mph)	25	20
	85th Percentile Southbound Speed (mph)	22	17
	Average Northbound Travel Time (s)	448	495
	Average Southbound Travel Time (s)	755	649
	Average Delay (s)	132	156
	Average Number of Stops	4	3
	Average Stop Delay (s)	69	89
Bus	Average Northbound Speed (mph)	-	11
	Average Southbound Speed (mph)	-	8
	85th Percentile Northbound Speed (mph)	-	13
	85th Percentile Southbound Speed (mph)	-	10
	Average Northbound Travel Time (s)	-	693
	Average Southbound Travel Time (s)	-	1,030
	Average Delay (s)	-	390
	Average Number of Stops	-	8
	Average Stop Delay (s)	-	190

FUTURE CONDITION BASELINE ANALYSIS FINDINGS

A review of the Future Condition Baseline VISSIM model MOEs resulted in the following findings:

- Total intersection LOS is considered acceptable (LOS D or better) at all study intersections except for:
  - Milton Road/Beaver Street, which has LOS E
  - Milton Road/Route 66, which has LOS E
  - Milton Road/Butler Avenue, which has LOS F
- Excessive SB queuing on Milton Road between the railroad bridge and Riordan Road
- Excessive NB queuing at Milton Road/San Francisco Street
- Excessive SB queuing at Milton Road/Beaver Street
- Excessive EB and SB queuing at Milton Road/Humphreys Street
- Excessive NB, EB, and WB queuing at Milton Road/Butler Avenue
- Excessive NB and EB queuing at Milton Road/Route 66
- Excessive EB queuing at Milton Road/Plaza Way

- Excessive NB and WB queuing at Milton Road/University Drive
- Excessive SB queuing at Milton Road/Forest Meadows Street
- Excessive WB queuing at Forest Meadows Street/Beulah Boulevard

The changes in MOEs resulting from the Future Condition Baseline (compared to the Existing Condition Baseline) are summarized as follows:

- Longer queues in general throughout the Milton Road corridor
- The total intersection LOS worsens at five intersections
- At intersections where the total intersection LOS did not worsen, longer queues were generally reported
- Decreased speed and increased travel time and delay for overall traffic
- While bus MOEs were not available for the Existing Condition Baseline, it is reasonable to infer that the bus MOEs for the Future Condition Baseline generally worsened compared to the Existing Condition Baseline in a similar manner to what happened to the overall traffic MOEs
- It should be noted that the number of stops and stop delay for bus MOEs are higher than the number of stops and stop delay for overall traffic MOEs within the same model scenario because the bus idling that occurs at bus stops as passengers board and alight counts as "stop time"
- As was previously mentioned, because VISSIM models use different random seeds for each model run, small changes in delay (e.g., 0-10 seconds) and queuing (e.g., 0-150 feet) at a given intersection between the Existing Condition Baseline and Future Condition Baseline model scenarios likely reflect normal model variability rather than significant changes in operations, especially where geometric and signal timing conditions remain constant between scenarios.

FUTURE INVESTMENT ALTERNATIVE SCENARIOS

DEVELOPMENT OF PRELIMINARY ALTERNATIVE BUNDLES

Based on the needs identified in the baseline analyses as well as improvements recommended in relevant previously completed studies and plans, three categories of potential corridor improvement alternatives were considered:

- Access management/network treatments: Examples include turn restrictions, traffic signal coordination, new roadway connections, backage roads, and expansion to six general purpose lanes
- Transit service treatments: Examples include expansion to six general purpose lanes with buses mixing with other traffic in the outside lane; expansion to six lanes with the outside lane dedicated to buses, bicycles, and right-turning vehicles; exclusive bus lanes; use of backage roads by buses with potential exclusive bus access at key points; and transit signal priority with bus queue jump lanes
- Intersection treatments: Examples include roundabouts, quadrant left turns, indirect left turns, and additional through or turn lanes

A total of 12 preliminary alternative improvement “bundles” were developed that included various components from the three aforementioned categories. Six of the bundles were initially developed and evaluated. After this initial evaluation, the FMPO TAC requested that six additional bundles and corresponding analyses be completed. These additional bundles were slight variations on the initial six bundles. Each bundle had a different objective, or priority, that influenced which components were included.

FMPO’s TransCAD travel-demand model was utilized where applicable to identify significant shifts in traffic volumes on Milton Road that might be generated by the proposed improvements. The Future Condition Baseline design hour traffic volumes were modified for each bundle as needed to reflect the anticipated shifts in volumes. Synchro micro-simulation traffic models were developed that incorporated the adjusted future design hour traffic volumes and the changes to lane configuration and network geometry associated with the proposed improvements in each bundle. Synchro was used instead of VISSIM at this point in the analysis because it is much less labor-intensive to develop 12 Synchro models than 12 VISSIM models. Synchro does not model transit-related features as well as VISSIM but can provide valuable information on the impacts of potential improvements on overall traffic conditions. The MOEs derived from the Synchro analysis for all 12 bundles were compared against each other as well as against Synchro MOEs for the Existing Condition Baseline and the Future Condition Baseline models. The **Appendix** contains detailed information on the components, lane configurations, traffic volumes, and MOEs of each of the 12 bundles.

It should be noted that Synchro and VISSIM MOE results for the same location in the same scenario will not match exactly as the two micro-simulation models utilize slightly different parameters and algorithms to model traffic flow, so any comparison between scenarios should be done using models from the same micro-simulation program.

DEVELOPMENT OF FUTURE INVESTMENT ALTERNATIVES VISSIM MODELS

Based on the Synchro analysis results for the 12 bundles and input from the FMPO TAC, the following three alternatives with differing levels of investment and targeted treatments were selected for analysis using VISSIM:

- Low Investment Alternative
- Auto-Focused High Investment Alternative
- Transit-Focused High Investment Alternative

The Low Investment Alternative improves upon the Future Condition Baseline scenario by addressing spot-location capacity constraints through relatively low-cost improvements to improve both automobile and transit travel.

The Auto-Focused High Investment Alternative improves upon the Future Condition Baseline scenario by primarily widening Milton Road to three lanes in each direction between Humphreys Street and University Drive. Automobile travel is expected to get the most benefit from this improvement alternative but transit travel would also benefit from the overall reduction in congestion.

The Transit-Focused High Investment Alternative improves upon the Future Condition Baseline scenario by primarily widening Milton Road to provide designated transit lanes between Beaver Street and University Drive. Transit travel is expected to get the most benefit from this improvement alternative but automobile travel would also benefit from the improvement in transit travel.

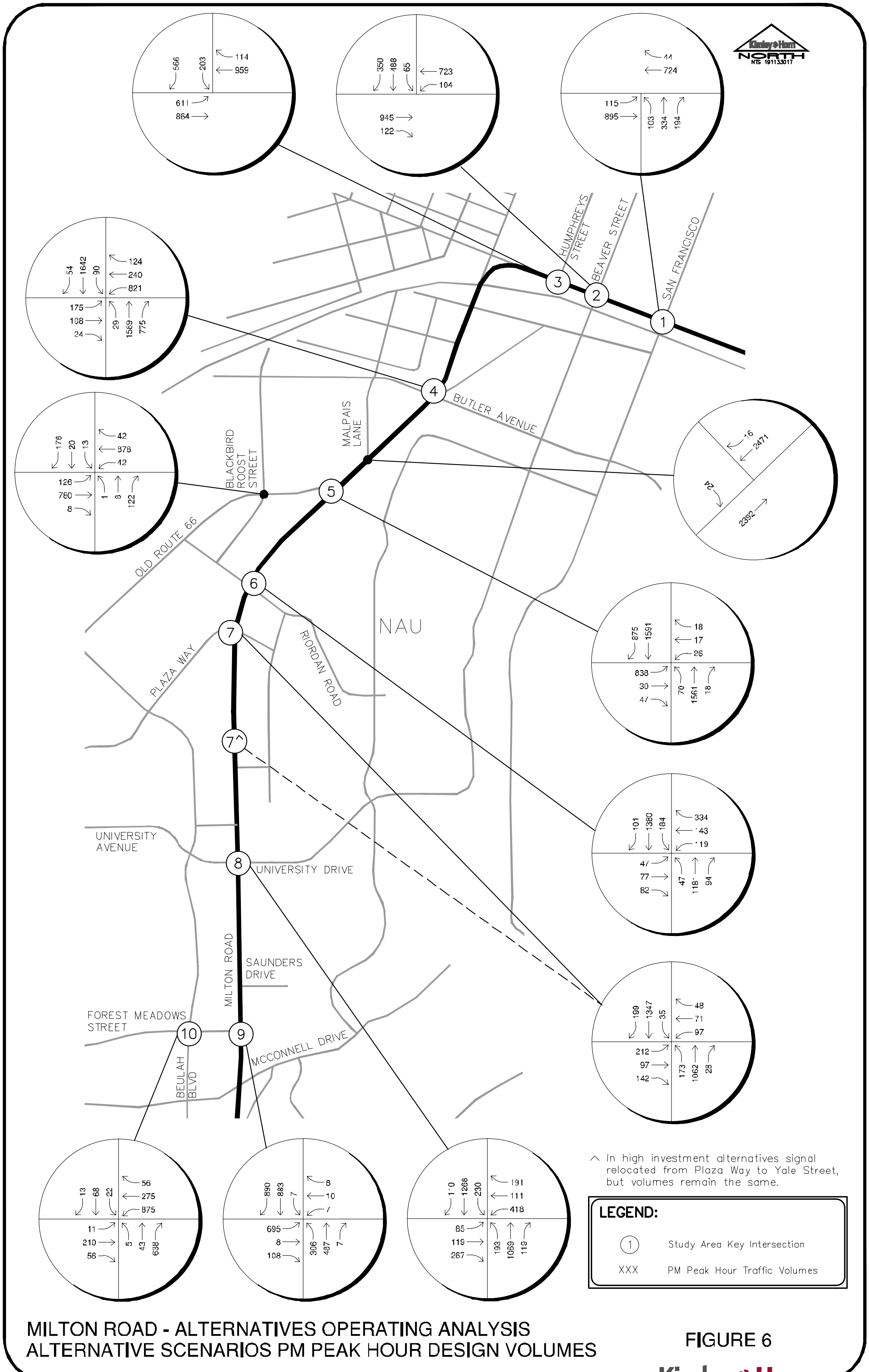
The features and assumptions that pertain to each of the future investment alternatives are described more fully within subsequent sections pertaining to each alternative.

DEVELOPMENT OF FUTURE INVESTMENT ALTERNATIVES DESIGN HOURLY VOLUMES

As explained previously, the Future Condition Baseline design hourly volumes reflect a 20% growth over existing volumes rather than a specific horizon year. The Future Condition Baseline volumes were also used in the future investment alternatives except at the following locations:

- Milton Road/Malpais Lane and Milton Road/Butler Avenue: SB left turns were prohibited at the Milton Road/Malpais Lane intersection in all future investment alternatives, so vehicles that had originally made this movement at this intersection were shifted north and added to the corresponding turning movement volumes at the Milton Road/Butler Avenue intersection.

Volumes for the future investment alternatives were kept consistent between the three investment alternatives to help isolate the impacts of the proposed improvements, although it is recognized that some variations in volumes would likely occur depending on which improvements are implemented. The future investment alternatives PM peak hour design volumes are shown in **Figure 6**.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
ALTERNATIVE SCENARIOS PM PEAK HOUR DESIGN VOLUMES

FIGURE 6

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DEVELOPMENT OF LOW INVESTMENT ALTERNATIVE VISSIM MODEL

The Low Investment Alternative VISSIM model modifies the Future Condition Baseline VISSIM model to include the following proposed improvements:

Roadway Modifications

- Provide dual SB right-turn lanes at Milton Road/Humphreys Street
- Provide dual EB left-turn lanes at Milton Road/Humphreys Street
- Add third NB general purpose lane on Milton Road from south of Route 66 to Butler Avenue
- At Butler Avenue, the third NB through lane becomes a transit-only queue jump lane, which terminates just north of Butler Avenue on Milton Road
- Provide triple WB left-turn lanes at Milton Road/Butler Avenue by reducing the number of EB receiving lanes on the east leg from two to one
- Add third SB general purpose lane on Milton Road from south of Butler Avenue to Route 66
- At Route 66, the third SB through lane becomes a transit-only queue jump lane, which terminates just south of Route 66
- Prohibit southeastbound and northeastbound left turns at Milton Road/Malpais Lane
- Provide triple EB left-turn lanes at Milton Road/Route 66
- Channelize SB right-turn movement at Milton Road/Route 66 with yield control
- Add midblock signalized pedestrian crossing at the north edge of Target property north of University Drive
- Add midblock signalized pedestrian crossing north of Saunders Drive

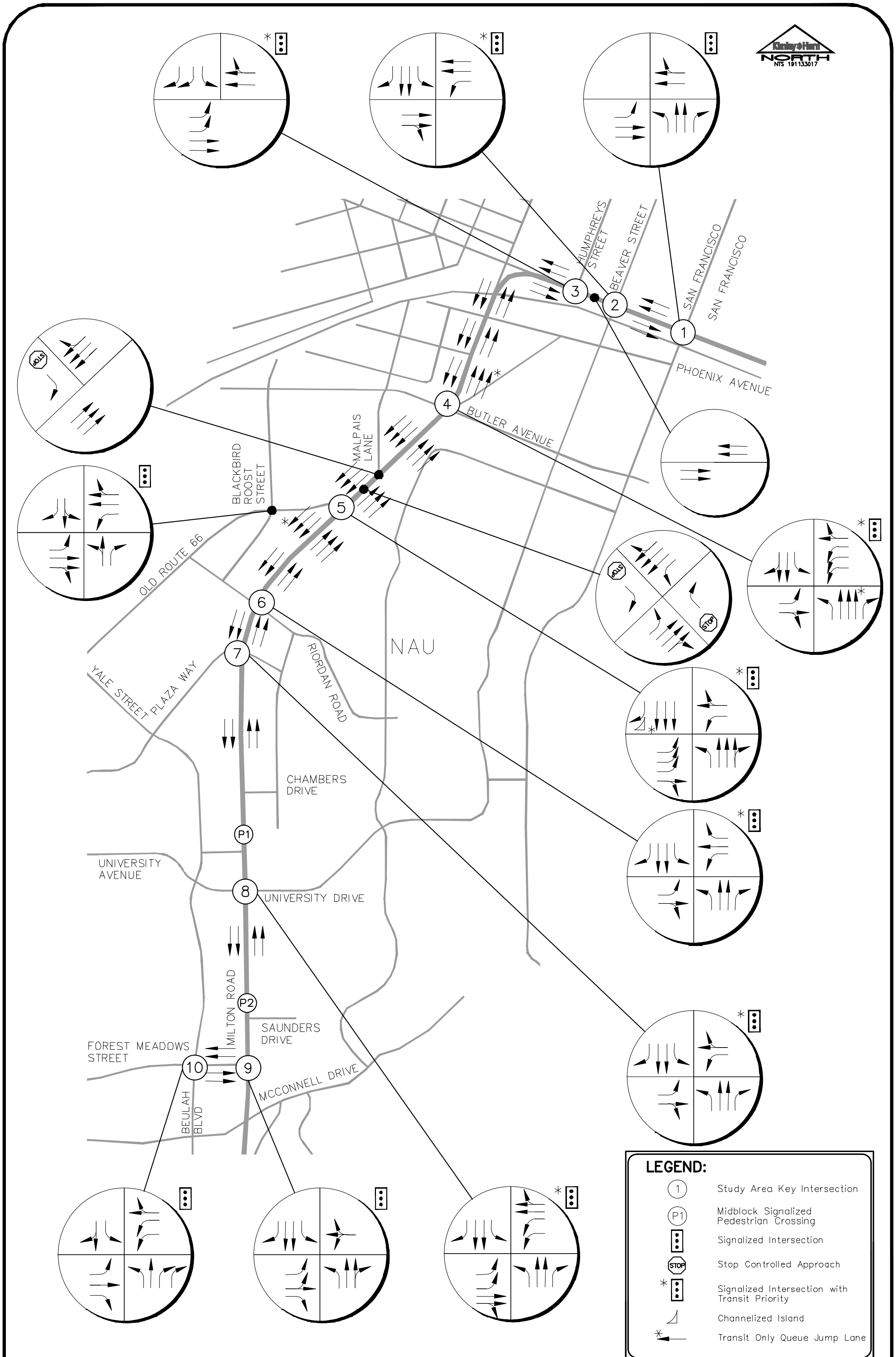
Traffic Signal Modifications

- Add traffic signal at Route 66/Blackbird Roost Street and coordinate the new traffic signal with the Milton Road/Route 66 traffic signal
- Coordinate the two new signalized midblock pedestrian crossings with adjacent signals
- Add NB right-turn overlap signal phase at Milton Road/Butler Avenue
- Include transit signal priority in signal phasing on Milton Road between Beaver Street and University Avenue

Multimodal Operations Modifications

- Change Route 4 (SB) and Route 14 (NB) bus route between Milton Road/University Avenue and Beulah Boulevard/Forest Meadows Street to use Beulah Boulevard and University Avenue instead of Forest Meadows Street and Milton Road and change the name of the routes to Bus Rapid Transit (BRT)
- Change NB/SB bus headways on Route 4/Route 14/BRT to 15 minutes
- Deploy equipment to detect arriving buses for transit signal priority on Milton Road between Beaver Street and University Avenue

The Low Investment Alternative lane configurations are shown in **Figure 7**.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
LOW INVESTMENT ALTERNATIVE LANE CONFIGURATIONS

FIGURE 7

LOW INVESTMENT ALTERNATIVE VISSIM MODEL MEASURES OF EFFECTIVENESS

Table 7 shows the intersection MOEs derived from the Low Investment Alternative VISSIM model. The Low Investment Alternative MOEs consist of LOS, average delay per vehicle (in seconds), and 95th percentile queue length (in feet). **Table 8** shows the network MOEs derived from the Low Investment Alternative VISSIM model.

Table 9 shows a summary of the intersection MOEs derived from the Existing Condition Baseline, Future Condition Baseline, and Low Investment Alternative VISSIM models for comparison purposes.

Table 10 shows a summary of the network MOEs derived from the Existing Condition Baseline, Future Condition Baseline, and Low Investment Alternative VISSIM models for comparison purposes. Bus-related MOE information was not available for the Existing Condition Baseline VISSIM model.

LOW INVESTMENT ALTERNATIVE ANALYSIS FINDINGS

A review of the Low Investment Alternative VISSIM model MOEs resulted in the following findings:

- Total intersection LOS is considered acceptable (LOS D or better) at all study intersections except for Milton Road/ University Drive, which has LOS E
- Excessive SB queuing on Milton Road between the railroad bridge and Butler Avenue
- Excessive NB queuing at Milton Road/San Francisco Street
- Excessive SB queuing at Milton Road/Beaver Street
- Excessive SB queuing at Milton Road/Humphreys Street
- Excessive NB queuing at Milton Road/Butler Avenue
- Excessive EB queuing at Milton Road/Route 66
- Excessive SB queuing at Milton Road/Riordan Road
- Excessive EB queuing at Milton Road/Plaza Way
- Excessive NB, EB, SB, and WB queuing at Milton Road/University Drive
- Excessive SB queuing at Milton Road/Forest Meadows Street
- Excessive WB queuing at Forest Meadows Street/Beulah Boulevard

The changes in MOEs resulting from the Low Investment Alternative (compared to the Future Condition Baseline) are summarized as follows:

- Much shorter queues in general throughout the Milton Road corridor, particularly between Humphreys Street and Route 66
- The total intersection LOS worsens at one intersection and improves at five intersections
- Increased speed and decreased travel time and delay for overall traffic and for buses
- Significant reductions in delay at Milton Road/Beaver Street, Milton Road/Butler Avenue, and Milton Road/Route 66

Table 7: Low Investment Alternative Intersection MOEs

Intersection	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Milton Road/San Francisco Street																	
LOS	D	D	C	D	C	B	-	B	-	-	-	-	-	B	B	B	C
Average Delay (s)	44	41	25	36	20	18	-	18	-	-	-	-	-	13	15	13	21
95% Queue (ft)	342	342	449	-	117	421	-	-	-	-	-	-	-	237	83	-	-
Milton Road/Beaver Street																	
LOS	-	-	-	-	-	B	C	B	E	E	E	E	D	B	-	B	D
Average Delay (s)	-	-	-	-	-	14	20	15	67	76	79	76	51	12	-	17	36
95% Queue (ft)	-	-	-	-	-	341	263	-	209	1141	877	-	266	278	-	-	-
Milton Road/Humphreys Street																	
LOS	-	-	-	-	C	B	-	C	F	-	C	D	-	C	C	C	C
Average Delay (s)	-	-	-	-	34	16	-	23	89	-	25	41	-	21	24	21	27
95% Queue (ft)	-	-	-	-	308	266	-	-	640	-	411	-	-	590	454	-	-
Milton Road/Butler Avenue																	
LOS	F	D	C	D	E	D	C	E	E	C	D	D	D	E	E	D	D
Average Delay (s)	207	43	28	40	76	54	34	64	77	33	38	35	46	66	60	51	42
95% Queue (ft)	329	1177	973	-	307	257	151	-	1019	1284	1066	-	301	536	258	-	-
Milton Road/Route 66																	
LOS	D	B	B	B	D	D	E	D	-	B	B	B	D	E	B	D	C
Average Delay (s)	54	14	11	16	47	35	65	47	-	19	16	18	54	68	15	49	23
95% Queue (ft)	158	480	244	-	586	563	394	-	-	648	0	-	68	68	6	-	-
Milton Road/Riordan Road																	
LOS	C	A	A	A	D	D	C	D	D	C	B	C	E	D	B	C	C
Average Delay (s)	22	9	2	9	44	43	33	39	51	33	11	34	70	39	12	30	25
95% Queue (ft)	63	485	322	-	103	213	13	-	839	950	0	-	243	289	13	-	-
Milton Road/Plaza Way																	
LOS	D	A	A	B	F	F	F	F	C	B	B	B	A	D	C	C	D
Average Delay (s)	50	9	8	14	240	174	171	204	20	14	18	15	4	46	23	22	38
95% Queue (ft)	287	282	39	-	876	856	856	-	47	528	468	-	4	188	5	-	-
Milton Road/University Drive																	
LOS	F	C	A	D	E	E	E	E	D	D	B	D	F	D	D	F	E
Average Delay (s)	99	28	6	36	78	72	77	76	43	43	12	41	152	49	42	105	56
95% Queue (ft)	521	544	318	-	691	708	615	-	636	659	0	-	853	779	660	-	-
Milton Road/Forest Meadows Street																	
LOS	D	A	A	B	D	D	A	D	D	D	F	E	D	E	B	D	D
Average Delay (s)	35	8	7	18	45	39	4	39	43	41	101	70	45	61	15	42	51
95% Queue (ft)	361	142	62	-	240	240	0	-	27	789	582	-	65	65	0	-	-
Forest Meadows Street/Beulah Boulevard																	
LOS	C	C	A	A	D	D	A	D	C	C	A	C	D	B	A	C	C
Average Delay (s)	25	24	4	6	50	42	5	36	21	27	1	24	41	14	10	33	24
95% Queue (ft)	29	89	0	-	47	241	74	-	13	44	0	-	693	352	298	-	-

Table 8: Low Investment Alternative Network MOEs

Network	Number of Vehicles	13,007
	Total Travel Time (h)	810
	Total Distance (mi)	10,571
	Total Delay (h)	454
Per Vehicle	Average Northbound Speed (mph)	19
	Average Southbound Speed (mph)	14
	85th Percentile Northbound Speed (mph)	23
	85th Percentile Southbound Speed (mph)	18
	Average Northbound Travel Time (s)	395
	Average Southbound Travel Time (s)	552
	Average Delay (s)	118
	Average Number of Stops	3
	Average Stop Delay (s)	72
Bus	Average Northbound Speed (mph)	12
	Average Southbound Speed (mph)	10
	85th Percentile Northbound Speed (mph)	14
	85th Percentile Southbound Speed (mph)	11
	Average Northbound Travel Time (s)	617
	Average Southbound Travel Time (s)	769
	Average Delay (s)	232
	Average Number of Stops	6
	Average Stop Delay (s)	117

Table 9: Comparison of Low Investment Alternative and Prior Models Intersection MOEs

Intersection	Existing Baseline	Future Baseline	Low Investment
Milton Road/San Francisco Street			
LOS	C	C	C
Average Delay (s)	21	22	21
Longest 95% Queue (ft)	203	1,010	449
Milton Road/Beaver Street			
LOS	D	E	D
Average Delay (s)	36	79	36
Longest 95% Queue (ft)	835	1,538	1,141
Milton Road/Humphreys Street			
LOS	D	D	C
Average Delay (s)	42	39	27
Longest 95% Queue (ft)	605	1,629	640
Milton Road/Butler Avenue			
LOS	E	F	D
Average Delay (s)	63	89	42
Longest 95% Queue (ft)	1,656	1,660	1,284
Milton Road/Route 66			
LOS	C	E	C
Average Delay (s)	30	60	23
Longest 95% Queue (ft)	1,645	1,653	648
Milton Road/Riordan Road			
LOS	D	D	C
Average Delay (s)	46	40	25
Longest 95% Queue (ft)	1,185	1,306	950
Milton Road/Plaza Way			
LOS	C	D	D
Average Delay (s)	33	40	38
Longest 95% Queue (ft)	475	1,602	876
Milton Road/University Drive			
LOS	C	D	E
Average Delay (s)	23	48	56
Longest 95% Queue (ft)	512	1,073	853
Milton Road/Forest Meadows Street			
LOS	C	D	D
Average Delay (s)	23	45	51
Longest 95% Queue (ft)	371	410	789
Forest Meadows Street/Beulah Boulevard			
LOS	B	C	C
Average Delay (s)	19	24	24
Longest 95% Queue (ft)	356	311	693

Table 10: Comparison of Low Investment Alternative and Prior Models Network MOEs

	Parameter	Existing Baseline	Future Baseline	Low Investment
Network	Number of Vehicles	11,072	12,464	13,007
	Total Travel Time (h)	752	922	810
	Total Distance (mi)	10,410	10,045	10,571
	Total Delay (h)	407	583	454
Per Vehicle	Average Northbound Speed (mph)	17	15	19
	Average Southbound Speed (mph)	11	12	14
	85th Percentile Northbound Speed (mph)	25	20	23
	85th Percentile Southbound Speed (mph)	22	17	18
	Average Northbound Travel Time (s)	448	495	395
	Average Southbound Travel Time (s)	755	649	552
	Average Delay (s)	132	156	118
	Average Number of Stops	4	3	3
	Average Stop Delay (s)	69	89	72
Bus	Average Northbound Speed (mph)	-	11	12
	Average Southbound Speed (mph)	-	8	10
	85th Percentile Northbound Speed (mph)	-	13	14
	85th Percentile Southbound Speed (mph)	-	10	11
	Average Northbound Travel Time (s)	-	693	617
	Average Southbound Travel Time (s)	-	1,030	769
	Average Delay (s)	-	390	232
	Average Number of Stops	-	8	6
	Average Stop Delay (s)	-	190	117

It should be noted that for the Milton/University intersection, the increase in total intersection delay (and corresponding change from LOS D to LOS E) and increase in queuing between the Future Condition Baseline and Low Investment Alternative appear to primarily be due to model variability between the various model runs conducted as intersection conditions remain constant between the Future Condition Baseline and Low Investment Alternative except for some minor transit-related changes.

DEVELOPMENT OF AUTO-FOCUSED HIGH INVESTMENT ALTERNATIVE VISSIM MODEL

The Auto-Focused High Investment Alternative VISSIM model modifies the Future Condition Baseline VISSIM model to include the following proposed improvements:

Roadway Modifications

- Provide dual SB right-turn lanes at Milton Road/Humphreys Street
- Provide dual EB left-turn lanes at Milton Road/Humphreys Street

- Add third NB general purpose lane on Milton Road from north of University Drive to Humphreys Street
- At Humphreys Street, the inside third NB through lane becomes an EB left-turn only lane
- Add third SB general purpose lane on Milton Road from west of Humphreys Street to Yale Street extension
- At Yale Street extension, the third SB through lane becomes a right-turn only lane
- Provide a connector road along the McCracken Street alignment between Malpais Lane and Blackbird Roost Street south of Clay Avenue
- Provide dual NB right-turn lanes at Milton Road/Butler Avenue
- Prohibit southeastbound and northeastbound left turns at Milton Road/Malpais Lane
- Provide dual SB right-turn lanes at Milton Road/Route 66
- Provide triple EB left-turn lanes at Milton Road/Route 66
- Convert Milton Road/Plaza Way signalized intersection into a midblock signalized pedestrian crossing and realign Plaza Way to connect to Riordan Road/Metz Walk
- Add midblock signalized pedestrian crossing north of Saunders Drive
- Create a new signalized intersection at Milton Road/Yale Street extension (effectively shifting intersection on Milton Rd from Plaza Way to Yale St extension)
- While not included in the model, it is assumed that raised center medians with periodic median breaks would be provided between the railroad bridge and Forest Meadows Street with the widening of Milton Road to six lanes per standard industry practice for six-lane facilities

Traffic Signal Modifications

- Add traffic signal at Route 66/Blackbird Roost Street and coordinate the new traffic signal with the Milton Road/Route 66 signal
- Coordinate the two new midblock signalized pedestrian crossings with adjacent signals
- Add NB right-turn overlap signal phase at Milton Road/Butler Avenue
- Include transit signal priority in signal phasing on Milton Road between Beaver Street and University Avenue
- Create signal timing and coordination for the new signalized intersection at Milton Road/Yale Street extension

Multimodal Operations Modifications

- Change Route 4 (SB) and Route 14 (NB) bus route between Milton Road/University Avenue and Beulah Boulevard/Forest Meadows Street to use Beulah Boulevard and University Avenue instead of Forest Meadows Street and Milton Road and change the name of the routes to BRT
- Change NB/SB bus headways on Route 4/Route 14/BRT to 15 minutes
- Remove SB bus stops on Milton Road north of University Avenue and north of Forest Meadows Street
- Remove NB bus stops on Milton Road north of Forest Meadows Street and south of Butler Avenue

- Change all remaining bus stops on Milton Road to be in the outside third through lane rather than in right-turn pockets
- Add NB and SB bus stops on Beulah Boulevard south of University Avenue
- Deploy equipment to detect arriving buses for transit signal priority on Milton Road between Beaver Street and University Avenue

The Auto-Focused High Investment Alternative lane configurations are shown in **Figure 8**.

AUTO-FOCUSED HIGH INVESTMENT ALTERNATIVE VISSIM MODEL MEASURES OF EFFECTIVENESS

Table 11 shows the intersection MOEs derived from the Auto-Focused High Investment Alternative VISSIM model. The Auto-Focused High Investment Alternative MOEs consist of LOS, average delay per vehicle (in seconds), and 95th percentile queue length (in feet). **Table 12** shows the network MOEs derived from the Auto-Focused High Investment Alternative VISSIM model.

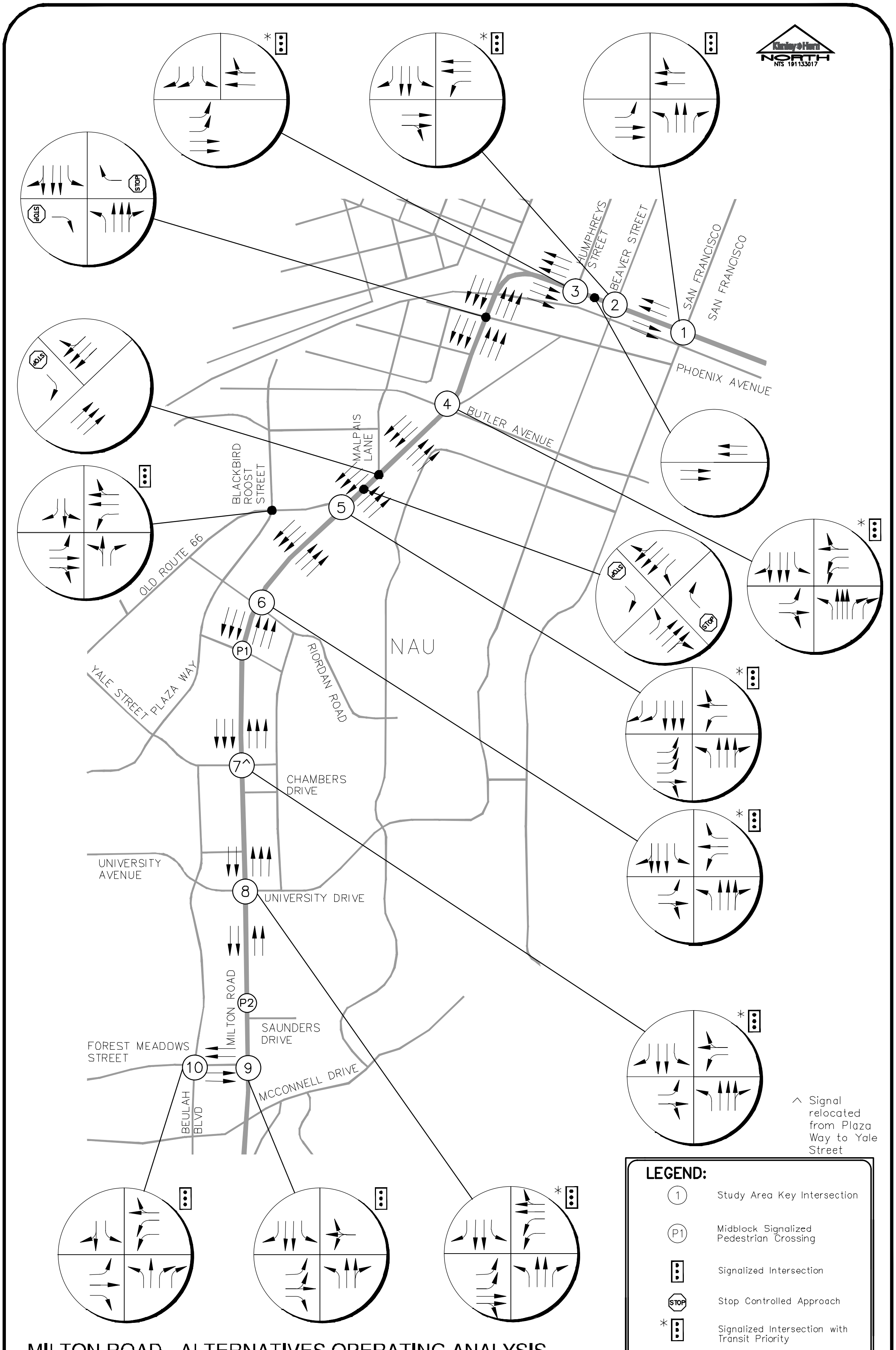
Table 13 shows a summary of the intersection MOEs derived from the Existing Condition Baseline, Future Condition Baseline, Low Investment Alternative, and Auto-Focused High Investment Alternative VISSIM models for comparison purposes.

Table 14 shows a summary of the network MOEs derived from the Existing Condition Baseline, Future Condition Baseline, Low Investment Alternative, and Auto-Focused High Investment Alternative VISSIM models for comparison purposes. Bus-related MOE information was not available for the Existing Condition Baseline VISSIM model.

AUTO-FOCUSED HIGH INVESTMENT ALTERNATIVE ANALYSIS FINDINGS

A review of the Auto-Focused High Investment Alternative VISSIM model MOEs resulted in the following findings:

- Total intersection LOS is considered acceptable at all study intersections
- Excessive NB queuing at Milton Road/San Francisco Street
- Excessive SB queuing at Milton Road/Beaver Street
- Excessive SB queuing at Milton Road/Humphreys Street
- Excessive EB queuing at Milton Road/Route 66
- Excessive EB queuing at Milton Road/Yale Street
- Excessive SB and WB queuing at Milton Road/University Drive
- Excessive SB queuing at Milton Road/Forest Meadows Street
- Excessive WB queuing at Forest Meadows Street/Beulah Boulevard



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
AUTO-FOCUSED HIGH INVESTMENT ALTERNATIVE
LANE CONFIGURATIONS

FIGURE 8

Table 11: Auto-Focused High Investment Alternative Intersection MOEs

Intersection	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Milton Road/San Francisco Street																	
LOS	D	D	C	D	B	B	-	B	-	-	-	-	-	B	B	B	C
Average Delay (s)	45	40	22	35	18	17	-	17	-	-	-	-	-	13	15	13	21
95% Queue (ft)	373	373	426	-	122	425	-	-	-	-	-	-	-	245	90	-	-
Milton Road/Beaver Street																	
LOS	-	-	-	-	-	B	C	B	E	E	F	F	E	B	-	B	D
Average Delay (s)	-	-	-	-	-	14	23	15	62	71	97	80	55	14	-	19	38
95% Queue (ft)	-	-	-	-	-	359	281	-	539	1193	928	-	269	249	-	-	-
Milton Road/Humphreys Street																	
LOS	-	-	-	-	C	B	-	B	F	-	C	D	-	C	C	C	C
Average Delay (s)	-	-	-	-	27	14	-	19	96	-	22	41	-	21	24	21	25
95% Queue (ft)	-	-	-	-	320	244	-	-	633	-	304	-	-	592	456	-	-
Milton Road/Butler Avenue																	
LOS	E	B	C	B	E	E	D	E	D	C	C	C	E	E	E	E	C
Average Delay (s)	68	18	21	20	62	57	37	58	47	21	25	22	59	63	56	59	31
95% Queue (ft)	78	428	251	-	295	270	145	-	275	461	241	-	558	494	216	-	-
Milton Road/Route 66																	
LOS	C	A	A	B	E	D	E	E	-	B	A	A	E	E	C	D	B
Average Delay (s)	34	10	10	11	57	50	74	57	-	12	5	9	55	68	22	51	19
95% Queue (ft)	129	305	64	-	549	501	356	-	-	305	97	-	90	90	27	-	-
Milton Road/Riordan Road																	
LOS	A	A	A	A	D	D	C	C	C	C	A	C	D	D	A	C	B
Average Delay (s)	10	7	2	7	43	39	21	33	25	22	5	21	47	39	8	23	17
95% Queue (ft)	47	181	45	-	112	203	0	-	353	463	0	-	176	281	0	-	-
Milton Road/Yale Street																	
LOS	C	A	A	B	F	E	D	F	C	C	B	C	B	D	C	C	C
Average Delay (s)	22	9	8	11	168	57	47	104	25	24	14	23	11	53	24	28	29
95% Queue (ft)	153	269	212	-	544	544	521	-	40	571	545	-	193	193	176	-	-
Milton Road/University Drive																	
LOS	F	C	A	D	E	D	D	D	C	C	B	C	F	E	D	F	D
Average Delay (s)	103	27	5	35	59	49	43	48	34	33	12	32	137	56	48	100	47
95% Queue (ft)	448	494	268	-	268	358	265	-	615	659	0	-	749	700	557	-	-
Milton Road/Forest Meadows Street																	
LOS	C	A	A	B	D	D	A	D	C	C	E	D	D	E	B	D	D
Average Delay (s)	28	8	8	15	45	37	4	40	25	33	77	55	48	61	17	43	41
95% Queue (ft)	299	138	0	-	249	249	0	-	25	782	576	-	68	68	0	-	-
Forest Meadows Street/Beulah Boulevard																	
LOS	C	C	A	A	C	C	A	C	A	C	A	C	C	A	A	C	B
Average Delay (s)	21	28	3	5	30	34	3	28	7	24	1	21	31	10	6	25	19
95% Queue (ft)	24	83	0	-	38	250	83	-	5	52	0	-	685	191	137	-	-

Table 12: Auto-Focused High Investment Alternative MOEs

Network	Number of Vehicles	13,017
	Total Travel Time (h)	737
	Total Distance (mi)	10,748
	Total Delay (h)	373
Per Vehicle	Average Northbound Speed (mph)	21
	Average Southbound Speed (mph)	16
	85th Percentile Northbound Speed (mph)	24
	85th Percentile Southbound Speed (mph)	19
	Average Northbound Travel Time (s)	366
	Average Southbound Travel Time (s)	498
	Average Delay (s)	98
	Average Number of Stops	2
	Average Stop Delay (s)	61
Bus	Average Northbound Speed (mph)	14
	Average Southbound Speed (mph)	14
	85th Percentile Northbound Speed (mph)	15
	85th Percentile Southbound Speed (mph)	15
	Average Northbound Travel Time (s)	556
	Average Southbound Travel Time (s)	580
	Average Delay (s)	174
	Average Number of Stops	4
	Average Stop Delay (s)	72

Table 13: Comparison of Auto-Focused High Investment Alternative and Prior Models Intersection MOEs

Intersection	Existing Baseline	Future Baseline	Low Investment	Auto-Focused High Investment
Milton Road/San Francisco Street				
LOS	C	C	C	C
Average Delay (s)	21	22	21	21
Longest 95% Queue (ft)	203	1,010	449	426
Milton Road/Beaver Street				
LOS	D	E	D	D
Average Delay (s)	36	79	36	38
Longest 95% Queue (ft)	835	1,538	1,141	1,193
Milton Road/Humphreys Street				
LOS	D	D	C	C
Average Delay (s)	42	39	27	25
Longest 95% Queue (ft)	605	1,629	640	633
Milton Road/Butler Avenue				
LOS	E	F	D	C
Average Delay (s)	63	89	42	31
Longest 95% Queue (ft)	1,656	1,660	1,284	558
Milton Road/Route 66				
LOS	C	E	C	B
Average Delay (s)	30	60	23	19
Longest 95% Queue (ft)	1,645	1,653	648	549
Milton Road/Riordan Road				
LOS	D	D	C	B
Average Delay (s)	46	40	25	17
Longest 95% Queue (ft)	1,185	1,306	950	463
Milton Road/Plaza Way (Yale Street for High Investment scenarios)				
LOS	C	D	D	C
Average Delay (s)	33	40	38	29
Longest 95% Queue (ft)	475	1,602	876	571
Milton Road/University Drive				
LOS	C	D	E	D
Average Delay (s)	23	48	56	47
Longest 95% Queue (ft)	512	1,073	853	749
Milton Road/Forest Meadows Street				
LOS	C	D	D	D
Average Delay (s)	23	45	51	41
Longest 95% Queue (ft)	371	410	789	782
Forest Meadows Street/Beulah Boulevard				
LOS	B	C	C	B
Average Delay (s)	19	24	24	19
Longest 95% Queue (ft)	356	311	693	685

Table 14: Comparison of Auto-Focused High Investment Alternative and Prior Models Network MOEs

	Parameter	Existing Baseline	Future Baseline	Low Investment	Auto-Focused High Investment
Network	Number of Vehicles	11,072	12,464	13,007	13,017
	Total Travel Time (h)	752	922	810	737
	Total Distance (mi)	10,410	10,045	10,571	10,748
	Total Delay (h)	407	583	454	373
Per Vehicle	Average Northbound Speed (mph)	17	15	19	21
	Average Southbound Speed (mph)	11	12	14	16
	85th Percentile Northbound Speed (mph)	25	20	23	24
	85th Percentile Southbound Speed (mph)	22	17	18	19
	Average Northbound Travel Time (s)	448	495	395	366
	Average Southbound Travel Time (s)	755	649	552	498
	Average Delay (s)	132	156	118	98
	Average Number of Stops	4	3	3	2
	Average Stop Delay (s)	69	89	72	61
Bus	Average Northbound Speed (mph)	-	11	12	14
	Average Southbound Speed (mph)	-	8	10	14
	85th Percentile Northbound Speed (mph)	-	13	14	15
	85th Percentile Southbound Speed (mph)	-	10	11	15
	Average Northbound Travel Time (s)	-	693	617	556
	Average Southbound Travel Time (s)	-	1,030	769	580
	Average Delay (s)	-	390	232	174
	Average Number of Stops	-	8	6	4
	Average Stop Delay (s)	-	190	117	72

The changes in MOEs resulting from the Auto-Focused High Investment Alternative (compared to the Future Condition Baseline and Low Investment Alternative) are summarized as follows:

- Much shorter queues in general throughout the Milton Road corridor
- All excessive NB and SB queuing on Milton Road between the railroad bridge and Yale Street has been eliminated
- The total intersection LOS improves at six intersections
- Increased speed and decreased travel time and delay for overall traffic and for buses
- The significant improvement in MOEs resulting from the Auto-Focused High Investment Alternative is primarily attributable to the significantly increased capacity provided by the addition of the third general purpose through lane in each direction, which benefits both overall traffic and buses

DEVELOPMENT OF TRANSIT-FOCUSED HIGH INVESTMENT ALTERNATIVE VISSIM MODEL

The Transit-Focused High Investment Alternative VISSIM model modifies the Future Condition Baseline VISSIM model to include the following proposed improvements:

Roadway Modifications

- Provide dual SB right-turn lanes at Milton Road/Humphreys Street
- Provide dual EB left-turn lanes at Milton Road/Humphreys Street
- Add NB shared lane for buses, bikes, and vehicles turning right on Milton Road from north of University Drive to Phoenix Avenue
- At Butler Avenue, the NB shared lane for buses, bikes, and vehicles splits into a transit/bike queue jump lane and a right-turn lane
- Add third NB general purpose lane on Milton Road from Phoenix Avenue to Humphreys Street
- At Humphreys Street, the inside third NB through lane becomes an EB left-turn only lane
- Add a bi-directional transit lane to the outside of the existing outside NB through lane on Milton Road from Phoenix Avenue to Beaver Street
- Add SB shared lane for buses, bikes, and vehicles turning right on Milton Road from Phoenix Avenue to south of Route 66
- At Butler Avenue, the SB shared lane for buses, bikes, and vehicles splits into a transit/bike queue jump lane and a channelized right-turn lane with yield control
- At Route 66, the SB shared lane for buses, bikes, and vehicles splits into a transit/bike queue jump lane and a right-turn lane
- Provide a connector road along the McCracken Street alignment between Malpais Lane and Blackbird Roost Street south of Clay Avenue
- Prohibit southeastbound and northeastbound left turns at Milton Road/Malpais Lane
- Provide triple EB left-turn lanes at Milton Road/Route 66
- Convert Milton Road/Plaza Way signalized intersection into a midblock signalized pedestrian crossing and realign Plaza Way to connect to Riordan Road/Metz Walk
- Add midblock signalized pedestrian crossing north of Saunders Drive
- Create a new signalized intersection at Milton Road/Yale Street extension (effectively shifting intersection on Milton Rd from Plaza Way to Yale Street extension)

Traffic Signal Modifications

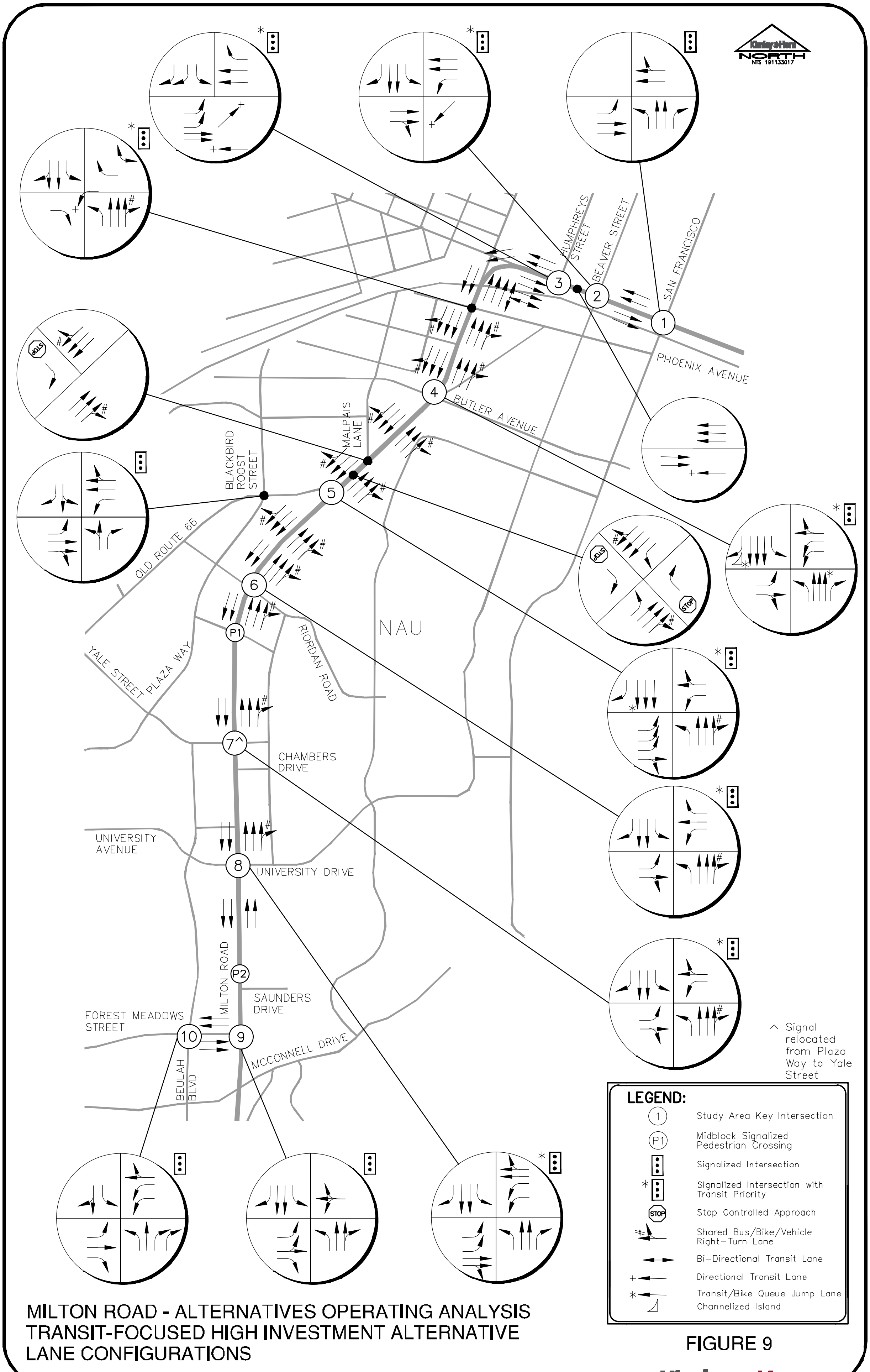
- Add traffic signal at Route 66/Blackbird Roost Street and coordinate the new traffic signal with the Milton Road/Route 66 signal
- Coordinate the two new midblock signalized pedestrian crossings with adjacent traffic signals
- Add NB right-turn overlap signal phase at Milton Road/Butler Avenue
- Include transit signal priority in signal phasing on Milton Road between Beaver Street and University Avenue

- Create signal timing and coordination for the new signalized intersection at Milton Road/Yale Street extension
- Add traffic signal at Milton Rd/Phoenix Avenue for bi-directional transit lane and WB left-turn transit-only movement
- Insert new EB left-turn transit-only phase in traffic signal phasing at Milton Road/Humphreys Street

<u>Multimodal Operations Modifications</u>

- Change Route 4 (SB) and Route 14 (NB) bus route between Milton Road/University Avenue and Beulah Boulevard/Forest Meadows Street to use Beulah Boulevard and University Avenue instead of Forest Meadows Street and Milton Road and change the name of the routes to BRT
- Change NB/SB bus headways on Route 4/Route 14/BRT to 15 minutes
- Remove SB bus stops on Milton Road north of University Avenue and north of Forest Meadows Street
- Remove NB bus stops on Milton Road north of Forest Meadows Street and south of Butler Avenue
- Change remaining NB bus stop on Milton Road north of University Avenue to be in the shared lane for buses, bikes, and vehicles turning right rather than in a right-turn pocket
- Change remaining NB and SB bus stops on Milton Road south of existing Plaza Way to be a bi-directional median stop adjacent to the midblock signalized pedestrian crossing at the existing Milton Road/Plaza Way intersection rather than in a right-turn pocket
- Add NB and SB bus stops on Beulah Boulevard south of University Avenue
- Deploy equipment to detect arriving buses for transit signal priority on Milton Road between Beaver Street and University Avenue
- Add SB bike lane on Milton Road from Humphreys Street to Phoenix Avenue and from south of Route 66 to University Drive

The Transit-Focused High Investment Alternative lane configurations are shown in **Figure 9**.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
TRANSIT-FOCUSED HIGH INVESTMENT ALTERNATIVE
LANE CONFIGURATIONS

FIGURE 9

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TRANSIT-FOCUSED HIGH INVESTMENT ALTERNATIVE VISSIM MODEL MEASURES OF EFFECTIVENESS

Table 15 shows the intersection MOEs derived from the Transit-Focused High Investment Alternative VISSIM model. The Transit-Focused High Investment Alternative MOEs consist of LOS, average delay per vehicle (in seconds), and 95th percentile queue length (in feet). **Table 16** shows the network MOEs derived from the Transit-Focused High Investment Alternative VISSIM model.

Table 17 shows a summary of the intersection MOEs derived from the Existing Condition Baseline, Future Condition Baseline, Low Investment Alternative, Auto-Focused High Investment Alternative, and Transit-Focused High Investment Alternative VISSIM models for comparison purposes.

Table 18 shows a summary of the network MOEs derived from the Existing Condition Baseline, Future Condition Baseline, Low Investment Alternative, Auto-Focused High Investment Alternative, and Transit-Focused High Alternative VISSIM models for comparison purposes. Bus-related MOE information was not available for the Existing Condition Baseline VISSIM model.

TRANSIT-FOCUSED HIGH INVESTMENT ALTERNATIVE ANALYSIS FINDINGS

A review of the Transit-Focused High Investment Alternative VISSIM model MOEs resulted in the following findings:

- Total intersection LOS is considered acceptable (LOS D or better) at all study intersections except for Milton Road/University Drive, which has LOS E
- Excessive NB queuing at Milton Road/San Francisco Street
- Excessive SB queuing at Milton Road/Beaver Street
- Excessive SB queuing at Milton Road/Humphreys Street
- Excessive SB queuing at Milton Road/Butler Avenue
- Excessive EB and SB queuing at Milton Road/Route 66
- Excessive SB queuing at Milton Road/Riordan Road
- Excessive EB queuing at Milton Road/Yale Street
- Excessive NB, SB, and WB queuing at Milton Road/University Drive
- Excessive SB queuing at Milton Road/Forest Meadows Street
- Excessive WB queuing at Forest Meadows Street/Beulah Boulevard

Table 15: Transit-Focused High Investment Alternative Intersection MOEs

Intersection	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Milton Road/San Francisco Street																	
LOS	D	D	C	C	B	B	-	B	-	-	-	-	-	B	B	B	C
Average Delay (s)	44	39	21	34	18	17	-	17	-	-	-	-	-	14	15	14	21
95% Queue (ft)	359	359	440	-	128	514	-	-	-	-	-	-	-	247	93	-	-
Milton Road/Beaver Street																	
LOS	-	-	-	-	-	B	C	B	E	F	F	F	D	C	-	C	D
Average Delay (s)	-	-	-	-	-	15	24	16	78	87	158	113	54	26	-	30	51
95% Queue (ft)	-	-	-	-	-	353	353	-	277	1209	945	-	192	340	-	-	-
Milton Road/Humphreys Street																	
LOS	-	-	-	-	D	C	-	C	E	-	C	C	-	C	C	C	C
Average Delay (s)	-	-	-	-	36	21	-	27	60	-	24	33	-	27	31	27	29
95% Queue (ft)	-	-	-	-	507	390	-	-	542	-	455	-	-	598	462	-	-
Milton Road/Butler Avenue																	
LOS	F	C	B	C	E	E	D	E	F	C	B	D	D	E	E	E	D
Average Delay (s)	158	32	16	28	71	61	40	65	81	34	16	36	53	69	61	57	38
95% Queue (ft)	280	943	662	-	293	255	137	-	434	872	678	-	478	524	246	-	-
Milton Road/Route 66																	
LOS	F	C	B	C	F	F	F	F	-	D	B	C	E	E	B	D	D
Average Delay (s)	85	20	15	23	91	147	122	95	-	43	15	33	56	63	16	47	41
95% Queue (ft)	282	889	648	-	653	636	461	-	-	943	766	-	75	75	9	-	-
Milton Road/Riordan Road																	
LOS	C	B	A	B	D	D	C	D	E	E	C	E	B	D	B	C	D
Average Delay (s)	31	16	7	16	48	40	26	36	60	67	21	63	13	41	14	20	38
95% Queue (ft)	54	400	229	-	113	207	7	-	1031	1252	0	-	4	285	4	-	-
Milton Road/Yale Street																	
LOS	D	B	A	B	F	E	E	F	D	D	D	D	A	D	C	C	D
Average Delay (s)	39	15	9	18	211	74	62	132	51	43	42	43	9	53	29	31	43
95% Queue (ft)	358	466	407	-	602	602	578	-	56	813	787	-	192	192	175	-	-
Milton Road/University Drive																	
LOS	F	E	B	E	E	E	D	D	E	D	B	D	F	D	C	E	E
Average Delay (s)	146	59	18	67	70	59	42	52	69	45	17	47	91	38	28	66	57
95% Queue (ft)	953	951	725	-	242	312	219	-	1427	1522	0	-	664	513	472	-	-
Milton Road/Forest Meadows Street																	
LOS	D	B	B	C	D	D	A	D	C	C	E	D	D	E	C	D	D
Average Delay (s)	37	11	11	21	42	41	7	37	26	31	72	51	45	67	20	46	40
95% Queue (ft)	365	156	59	-	459	459	0	-	29	753	555	-	68	68	0	-	-
Forest Meadows Street/Beulah Boulevard																	
LOS	C	C	A	A	C	D	A	C	A	C	A	C	C	A	A	C	B
Average Delay (s)	22	27	4	6	28	35	3	29	8	28	2	24	30	10	6	24	19
95% Queue (ft)	26	86	0	-	43	235	68	-	5	45	0	-	678	217	163	-	-

Table 16: Transit-Focused High Investment Alternative Network MOEs

Network	Number of Vehicles	12,883
	Total Travel Time (h)	885
	Total Distance (mi)	11,035
	Total Delay (h)	518
Per Vehicle	Average Northbound Speed (mph)	16
	Average Southbound Speed (mph)	13
	85th Percentile Northbound Speed (mph)	19
	85th Percentile Southbound Speed (mph)	16
	Average Northbound Travel Time (s)	470
	Average Southbound Travel Time (s)	623
	Average Delay (s)	136
	Average Number of Stops	3
	Average Stop Delay (s)	85
Bus	Average Northbound Speed (mph)	12
	Average Southbound Speed (mph)	10
	85th Percentile Northbound Speed (mph)	12
	85th Percentile Southbound Speed (mph)	12
	Average Northbound Travel Time (s)	644
	Average Southbound Travel Time (s)	768
	Average Delay (s)	257
	Average Number of Stops	6
	Average Stop Delay (s)	122

Table 17: Comparison of Transit-Focused High Investment Alternative and Prior Models Intersection MOEs

Intersection	Existing Baseline	Future Baseline	Low Investment	Auto-Focused High Investment	Transit-Focused High Investment
Milton Road/San Francisco Street					
LOS	C	C	C	C	C
Average Delay (s)	21	22	21	21	21
Longest 95% Queue (ft)	203	1,010	449	426	514
Milton Road/Beaver Street					
LOS	D	E	D	D	D
Average Delay (s)	36	79	36	38	51
Longest 95% Queue (ft)	835	1,538	1,141	1,193	1,209
Milton Road/Humphreys Street					
LOS	D	D	C	C	C
Average Delay (s)	42	39	27	25	29
Longest 95% Queue (ft)	605	1,629	640	633	598
Milton Road/Butler Avenue					
LOS	E	F	D	C	D
Average Delay (s)	63	89	42	31	38
Longest 95% Queue (ft)	1,656	1,660	1,284	558	943
Milton Road/Route 66					
LOS	C	E	C	B	D
Average Delay (s)	30	60	23	19	41
Longest 95% Queue (ft)	1,645	1,653	648	549	943
Milton Road/Riordan Road					
LOS	D	D	C	B	D
Average Delay (s)	46	40	25	17	51
Longest 95% Queue (ft)	1,185	1,306	950	463	1,252
Milton Road/Plaza Way (Yale Street for High Investment scenarios)					
LOS	C	D	D	C	D
Average Delay (s)	33	40	38	29	43
Longest 95% Queue (ft)	475	1,602	876	571	813
Milton Road/University Drive					
LOS	C	D	E	D	E
Average Delay (s)	23	48	56	47	57
Longest 95% Queue (ft)	512	1,073	853	749	1,522
Milton Road/Forest Meadows Street					
LOS	C	D	D	D	D
Average Delay (s)	23	45	51	41	40
Longest 95% Queue (ft)	371	410	789	782	753
Forest Meadows Street/Beulah Boulevard					
LOS	B	C	C	B	B
Average Delay (s)	19	24	24	19	19
Longest 95% Queue (ft)	356	311	693	685	678

Table 18: Comparison of Transit-Focused High Investment Alternative and Prior Models Network MOEs

	Parameter	Existing Baseline	Future Baseline	Low Investment	Auto-Focused High Investment	Transit-Focused High Investment
Network	Number of Vehicles	11,072	12,464	13,007	13,017	12,883
	Total Travel Time (h)	752	922	810	737	885
	Total Distance (mi)	10,410	10,045	10,571	10,748	11,035
	Total Delay (h)	407	583	454	373	518
Per Vehicle	Average Northbound Speed (mph)	17	15	19	21	16
	Average Southbound Speed (mph)	11	12	14	16	13
	85th Percentile Northbound Speed (mph)	25	20	23	24	19
	85th Percentile Southbound Speed (mph)	22	17	18	19	16
	Average Northbound Travel Time (s)	448	495	395	366	470
	Average Southbound Travel Time (s)	755	649	552	498	623
	Average Delay (s)	132	156	118	98	136
	Average Number of Stops	4	3	3	2	3
	Average Stop Delay (s)	69	89	72	61	85
Bus	Average Northbound Speed (mph)	-	11	12	14	12
	Average Southbound Speed (mph)	-	8	10	14	10
	85th Percentile Northbound Speed (mph)	-	13	14	15	12
	85th Percentile Southbound Speed (mph)	-	10	11	15	12
	Average Northbound Travel Time (s)	-	693	617	556	644
	Average Southbound Travel Time (s)	-	1,030	769	580	768
	Average Delay (s)	-	390	232	174	257
	Average Number of Stops	-	8	6	4	6
	Average Stop Delay (s)	-	190	117	72	122

The changes in MOEs resulting from the Transit-Focused High Investment Alternative (compared to the Future Condition Baseline, Low Investment Alternative, and Auto-Focused High Investment Alternative) are summarized as follows:

- Shorter queues in general than the Future Condition Baseline scenario
- Longer queues in general than the Low Investment Alternative and Auto-Focused High Investment Alternative
- The total intersection LOS is generally better than the Future Condition Baseline scenario but worse than the Low Investment Alternative and Auto-Focused High Investment Alternative
- Increased speed and decreased travel time and delay for overall traffic and for buses compared to the Future Condition Baseline scenario
- Decreased speed and increased travel time and delay for overall traffic and for buses compared to the Low Investment Alternative and Auto-Focused High Investment Alternative

ROUTE 66/BLACKBIRD ROOST STREET VISSIM MODELS MEASURES OF EFFECTIVENESS

One of the proposed improvements in all three future investment alternative scenarios was the signalization of Route 66/Blackbird Roost Street to help develop an alternate north-south route on the west side of Milton Road. **Table 19** shows a summary of the intersection MOEs derived from the three future investment alternatives for Route 66/Blackbird Roost Street. The total intersection LOS and delay at this intersection are acceptable with no excessive queuing issues (including on Route 66 between Blackbird Roost Street and Milton Road) for all three investment alternatives.

It should be noted that the poor LOS for the EB left-turn movement at Route 66/Blackbird Roost Street in the Low Investment Alternative is likely attributable to the lack of acceptable gaps in WB traffic due to the free-flow channelized SB right-turn at Milton Road/Route 66. This could be addressed by making the SB right-turn movement at Milton Road/Route 66 signal controlled or by providing a protected EB left-turn movement at Route 66/Blackbird Roost Street.

Table 19: Comparison of Route 66/Blackbird Roost Street Signalized Intersection MOEs

Scenario	NB Approach				EB Approach				SB Approach				WB Approach				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Low Investment																	
LOS	A	D	A	A	F	A	A	B	D	D	A	B	B	B	B	B	B
Average Delay (s)	5	38	7	9	98	8	8	20	48	45	10	16	15	13	15	13	12
95% Queue (ft)	52	52	31	-	288	152	111	-	87	87	91	-	63	146	122	-	-
Auto-Focused High Investment																	
LOS	C	D	A	A	C	A	A	A	D	D	A	B	B	B	B	B	A
Average Delay (s)	24	36	5	8	21	6	8	8	40	47	5	11	13	13	15	13	7
95% Queue (ft)	33	33	21	-	126	181	143	-	84	84	51	-	45	193	179	-	-
Transit-Focused High Investment																	
LOS	C	D	C	C	D	C	A	C	E	E	A	B	D	B	B	B	B
Average Delay (s)	23	37	21	22	39	27	8	28	63	73	6	16	46	14	15	15	18
95% Queue (ft)	33	33	91	-	184	444	405	-	122	122	69	-	92	161	149	-	-

CONCLUSIONS

ANALYSIS FINDINGS

Principal findings from the micro-simulation modeling analysis are summarized as follows:

Existing Condition Baseline

- The Milton Road corridor currently experiences significant congestion (intersection total LOS of E or F) and excessive queuing (where “excessive” is defined as queue lengths greater than 1,000 feet in through lanes or more than 250 feet beyond the existing storage length in turn lanes), particularly between Humphreys Street and Plaza Way
- Current traffic signal phasing and coordination is constrained by required minimum pedestrian crossing times
- Vehicle congestion and queuing adversely impact bus travel times and maneuverability
- There are long distances between some signalized pedestrian crossings
- There are generally no dedicated bicycle facilities on Milton Road
- Uncontrolled access and driveways spaced close together contribute to congestion and queuing

Future Condition Baseline

- A 20% growth in traffic volumes is anticipated to result in more congestion and longer queues in general throughout the Milton Road corridor unless improvements are implemented
- The projected increases in congestion and queuing will result in decreased speed and increased travel time and delay for overall traffic and buses

Low Investment Alternative

- Addressing strategic spot-location capacity constraints through relatively low-cost improvements significantly reduces congestion and queuing compared to the Future Condition Baseline scenario
- The projected decreases in congestion and queuing will result in increased speed and decreased travel time and delay for overall traffic and buses compared to the Future Condition Baseline scenario

Auto-Focused High Investment Alternative

- Widening Milton Road to three lanes in each direction between Humphreys Street and University Drive further reduces congestion and queuing compared to the Low Investment Alternative
- The projected additional decreases in congestion and queuing will result in increased speed and decreased travel time and delay for overall traffic and buses compared to the Low Investment Alternative

- The Auto-Focused High Investment Alternative improves bus performance more than the Transit-Focused High Investment Alternative because bus travel time and speed benefit greatly from the reduced congestion and queuing for overall traffic in the corridor
- Improvements associated with the Auto-Focused High Investment Alternative will cost more, have more right-of-way impacts, and affect access to adjacent properties more than the Low Investment Alternative

Transit-Focused High Investment Alternative

- Widening Milton Road to provide designated transit lanes between Beaver Street and University Drive reduces congestion and queuing compared to the Future Condition Baseline scenario but is not as effective at reducing congestion and queuing compared to the Low Investment Alternative and the Auto-Focused High Investment Alternative
- The projected decreases in congestion and queuing will result in increased speed and decreased travel time and delay for overall traffic and buses compared to the Future Condition Baseline scenario, but not to the degree achieved by the Low Investment Alternative or Auto-Focused High Investment Alternative
- Improvements associated with the Transit-Focused High Investment Alternative will cost more and have more right-of-way impacts than the Low Investment Alternative and cost about the same but with fewer right-of-way impacts than the Auto-Focused High Investment Alternative
- The Transit-Focused High Investment Alternative improves bus performance at the spot locations that have transit-related operational enhancements. Because this alternative doesn't generally improve conditions for all vehicles (and actually makes conditions worse in some cases like during transit-only signal phases or bus weaving movements associated with the median bus stop at Plaza Way), however, buses would still be impacted by long queues when they are not near the intersections with dedicated transit lanes. For buses to operate best under the Transit-Focused High Investment Alternative, this alternative would need to be modified to include dedicated bus facilities the length of the corridor so that buses are not impacted by the long queues where no general traffic improvements are made

Additional information on the analysis findings and comparisons between scenarios is provided in a "Frequently Asked Questions" format in the **Appendix**.

RECOMMENDATIONS

Based on a review of the micro-simulation analysis findings, the following recommendations have been developed:

- The findings from this micro-simulation analysis should be incorporated into the planned corridor study for Milton Road and other ongoing or planned studies that affect the Milton Road corridor
- The Low Investment Alternative proposed improvements should be considered for near-term implementation as funding and right-of-way availability allow because they are relatively low-cost/low-impact yet significantly improve travel conditions

- Improving multimodal (bus, bike, pedestrian) travel should be a priority for the corridor
- Future improvements should address not only typical daily traffic issues but also seasonal peak traffic conditions such as on holidays and winter “snow play” weekends
- Access management should be integrated with improvements, particularly any improvements that widen Milton Road

APPENDIX

Milton Road Alternative "Bundles" Analysis Summary

Description of Bundles

Bundle 1 – Improve signal timing

- Improve signal timing, phasing, and coordination
- No geometric improvements

Bundle 1A – Improve signal timing with redistributed Beulah-University volumes

- Same as Bundle 1 except the volumes in the University-Beulah-Yale-Milton "complex" are redistributed based on the volumes developed as part of the Beulah-University Alignment Study

Bundle 2 – Widen to six lanes – Phoenix Avenue to Forest Meadows Street

- Widen Milton Road to six general purpose lanes between Phoenix Avenue and Forest Meadows Street
- Raised median
- Bike lanes
- Signal timing improvements from Bundle 1

Bundle 2A – Widen to six lanes – Butler Avenue to Forest Meadows Street

- Same as Bundle 2 except that the widening of Milton Road to three lanes in the northbound direction stops at Butler Avenue as a trap right-turn lane instead of at Phoenix Avenue as a trap right-turn lane

Bundle 3 – Add bus/bike/right-turn lane – Phoenix Avenue to Forest Meadows Street

- Widen Milton Road to six lanes between Phoenix Avenue and Forest Meadows Street
- Outside lane in each direction dedicated to buses, bicycles, and right-turning vehicles
- Raised median
- Signal improvements from Bundle 1

Bundle 4 – Develop backage roads with new east leg at Milton Road/Route 66

- Develop north-south backage roads on both sides of Milton Road; preliminary improvements include:
    - New roadway connecting Plaza Way and Metz Walk through existing parking lot
    - Traffic signal at Route 66/Blackbird Roost Street
    - Extension of Riordan Ranch Street from Riordan Road to Route 66 (includes addition of 4th leg at Milton Road/Route 66 but excludes connection to NAU via Knoles Drive)

    - Extension of Riordan Ranch Street to University Drive through existing parking lot
    - Transit routes shifted from Milton Road to backage roads
- Signal improvements from Bundle 1.

Bundle 4A – Develop backage roads with restricted east leg at Milton Road/Route 66

- Same as the initial Bundle 4 except that the new east leg of the Milton Road/Route 66 intersection is only for local business access (i.e., planned CVS pharmacy) and does not connect to Riordan Ranch Street or Knoles Drive

Bundle 5 – Make conventional intersection improvements including additional eastbound left-turn lane at Milton Road/Humphreys Street and at Milton Road/Route 66

- Make conventional improvements to intersections; preliminary improvements include:
    - 2nd southbound right-turn lane at Route 66/Humphreys Street
    - 2nd eastbound left-turn lane at Route 66/Humphreys Street
    - Geometric changes to allow for elimination of split phasing at Milton Road/Butler Avenue/Clay Avenue
    - Geometric changes to allow for elimination of split phasing at Milton Road/Plaza Way
    - 2nd eastbound left-turn lane at Milton Road/Butler Avenue
    - 2nd eastbound through lane at Milton Road/Butler Avenue
    - Mid-block at-grade pedestrian/bicycle signalized crossings at:
        - South edge of ADOT property north of Saunders Drive
        - North edge of Target property north of University Avenue
- Signal improvements from Bundle 1

Bundle 5A – Make conventional intersection improvements excluding additional eastbound left-turn at Milton Road/Humphreys Street

- Same as the initial Bundle 5 except that at the Humphreys Street/Route 66 intersection, the only assumed geometric improvement is the addition of a second southbound right-turn lane

Bundle 5B – Make conventional intersection improvements with Clay Avenue extended to Kaibab Street

- Same as the initial Bundle 5 except that Clay Avenue is extended to Kaibab Street

Bundle 5C – Make conventional intersection improvements including additional eastbound left-turn lane at Milton Road/Route 66

- Same as the initial Bundle 5 except that a third eastbound left-turn lane is added at the Milton Road/Route 66 intersection

Bundle 6 – Make unconventional improvements at select locations

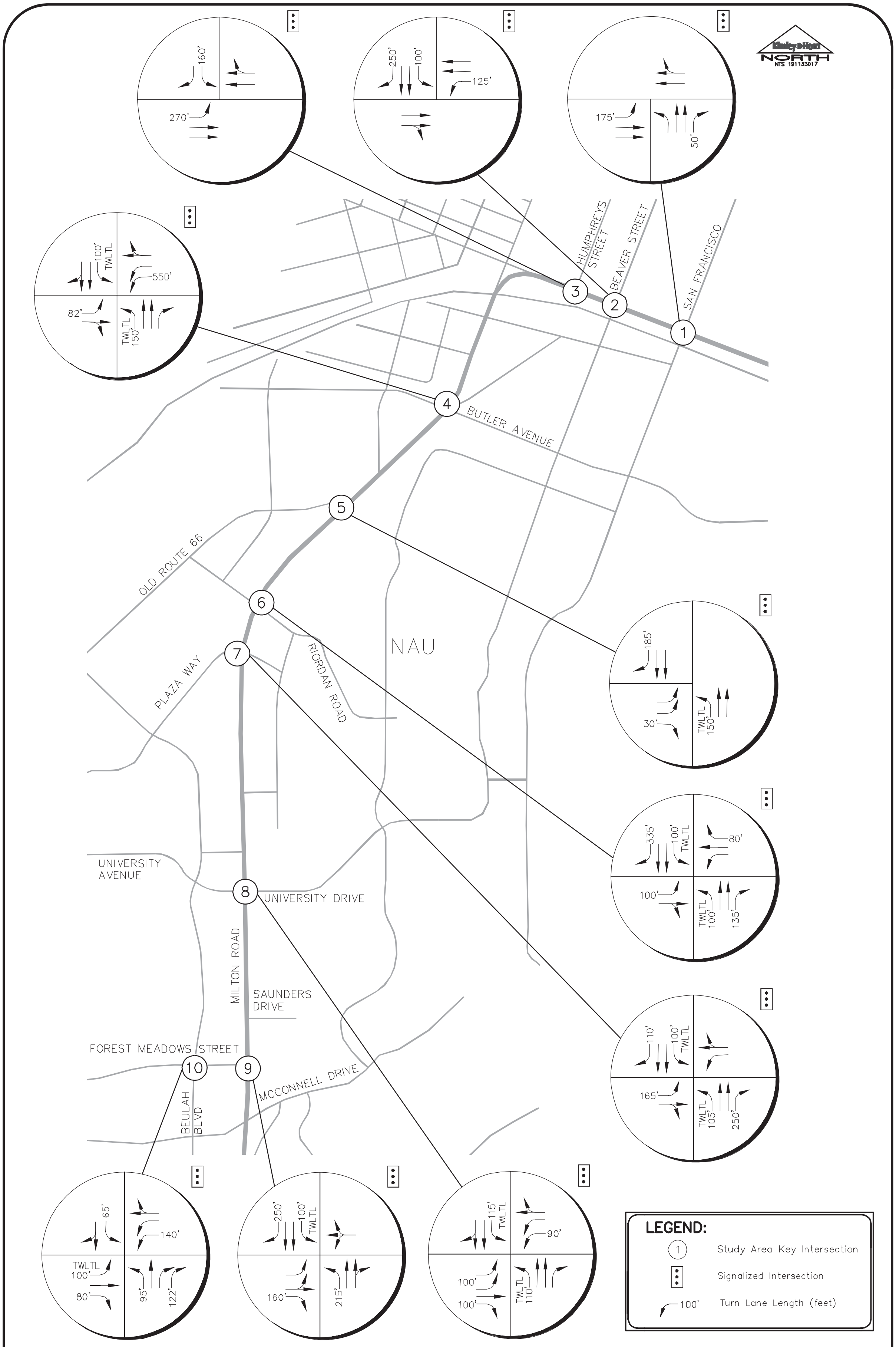
- Make unconventional improvements at select locations; preliminary improvements include:
  - Prohibit westbound left at Milton Road/Butler Road by forcing westbound left-turn traffic from Butler Avenue to Milton Road to instead go through the intersection and turn left later. Associated improvements include:
    - Prohibit left turn out from Malpais Lane to Milton Road
    - Westbound right-turn lane at Milton Road/Butler Road
    - Westbound left-turn lane at Clay Avenue/Malpais Lane and southbound right-turn lane at Milton Road/Route 66/Malpais Lane
    - Westbound left-turn lane at Clay Avenue/Blackbird Roost Street and southbound right-turn lane at Route 66/Blackbird Roost Street
    - Traffic signal at Route 66/Blackbird Roost Street
    - Extension of Clay Avenue to Kaibab Lane
  - Increase signal spacing on Milton. Preliminary improvements include:
    - Realign Yale Street and extend it east to Riordan Ranch Rd and create a new signalized intersection about 400 feet north of Chambers Drive
    - Remove the existing signal at the Milton Road/Plaza Way intersection and convert the intersection to right-in/right-out only movements
    - Install a mid-block at-grade pedestrian/bicycle signalized crossing just south of the existing Milton Road/Plaza Way intersection
- Raised median on Milton Road
- Signal improvements from Bundle 1

Figures of Bundles

Two figures were developed for each of the six initial bundles – one figure showing the assumed lane configurations and a second figure showing the assumed PM peak hour design volumes. These figures are labeled Figure 1 through Figure 12 in the Appendix. Figures were not developed for the second set of six bundles as they are minor variations on the initial six bundles.

Bundles Summary Measures of Effectiveness (MOEs)

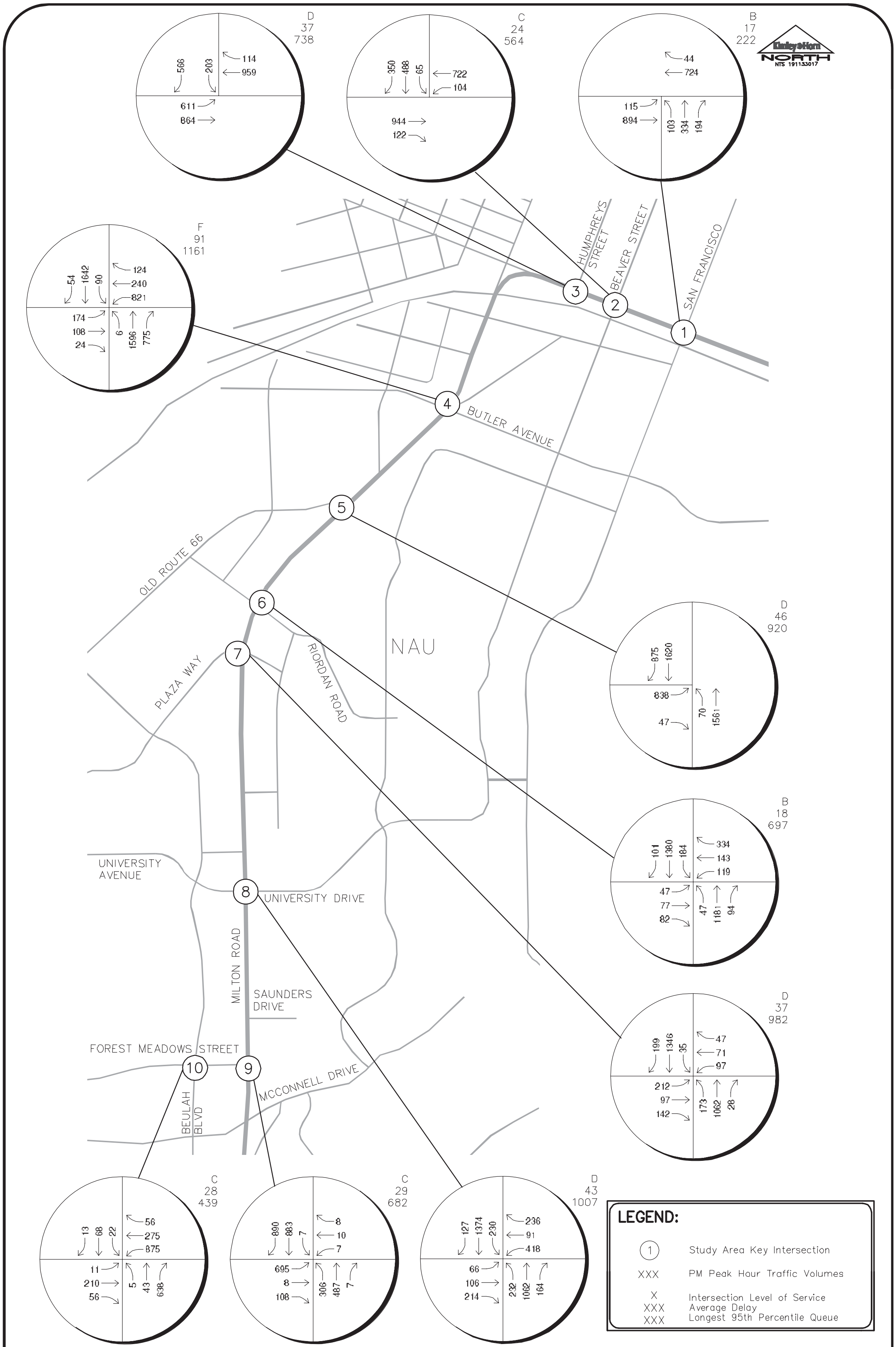
Table 1 in the Appendix shows a summary of the intersection MOEs derived from the Synchro analysis conducted for the 12 bundles for comparison purposes. Table 2 in the Appendix shows a summary of the network MOEs derived from the Synchro analysis conducted for the 12 bundles for comparison purposes.



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 1 LANE CONFIGURATIONS

FIGURE 1

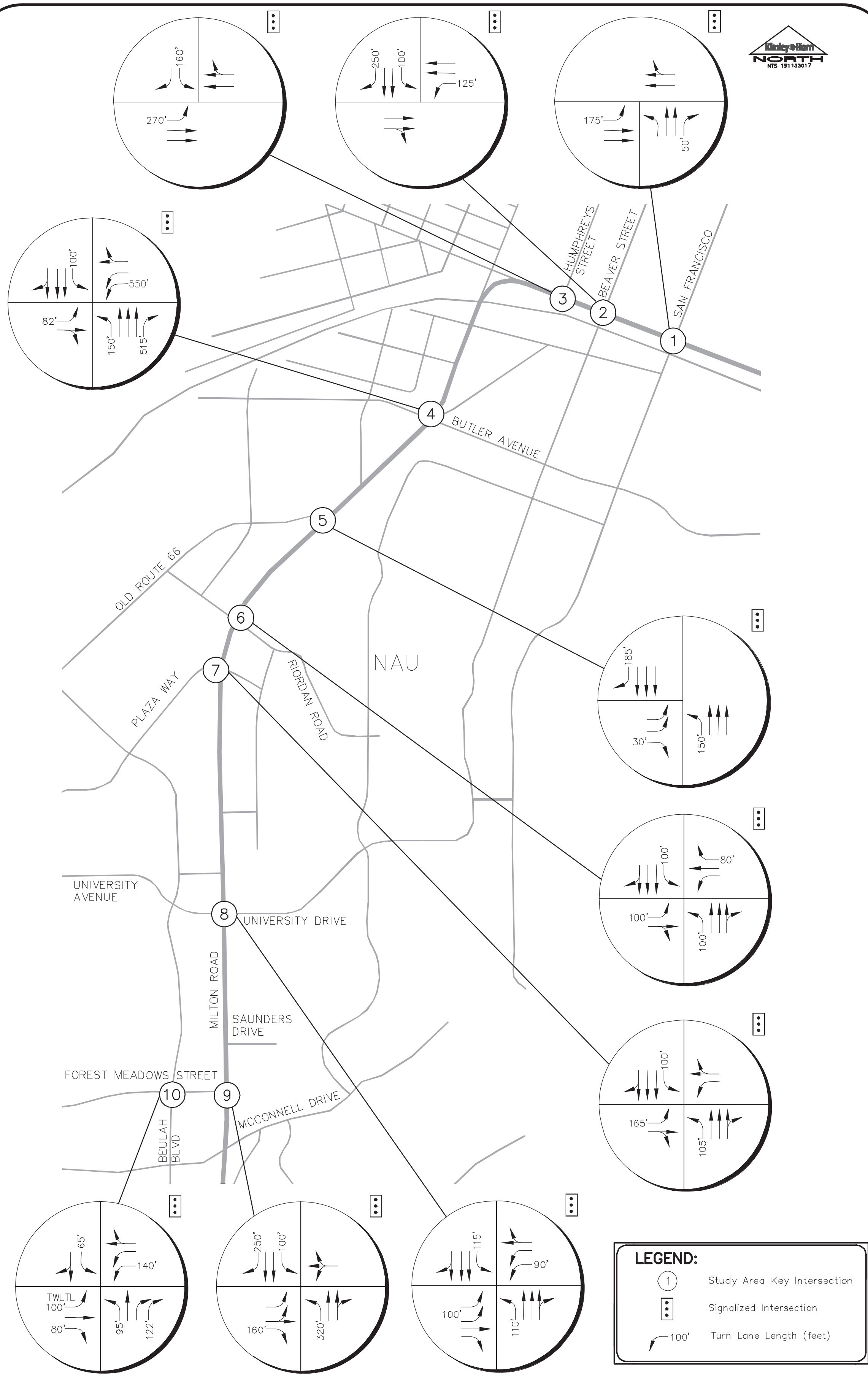
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 1 PM PEAK HOUR DESIGN VOLUMES

FIGURE 2

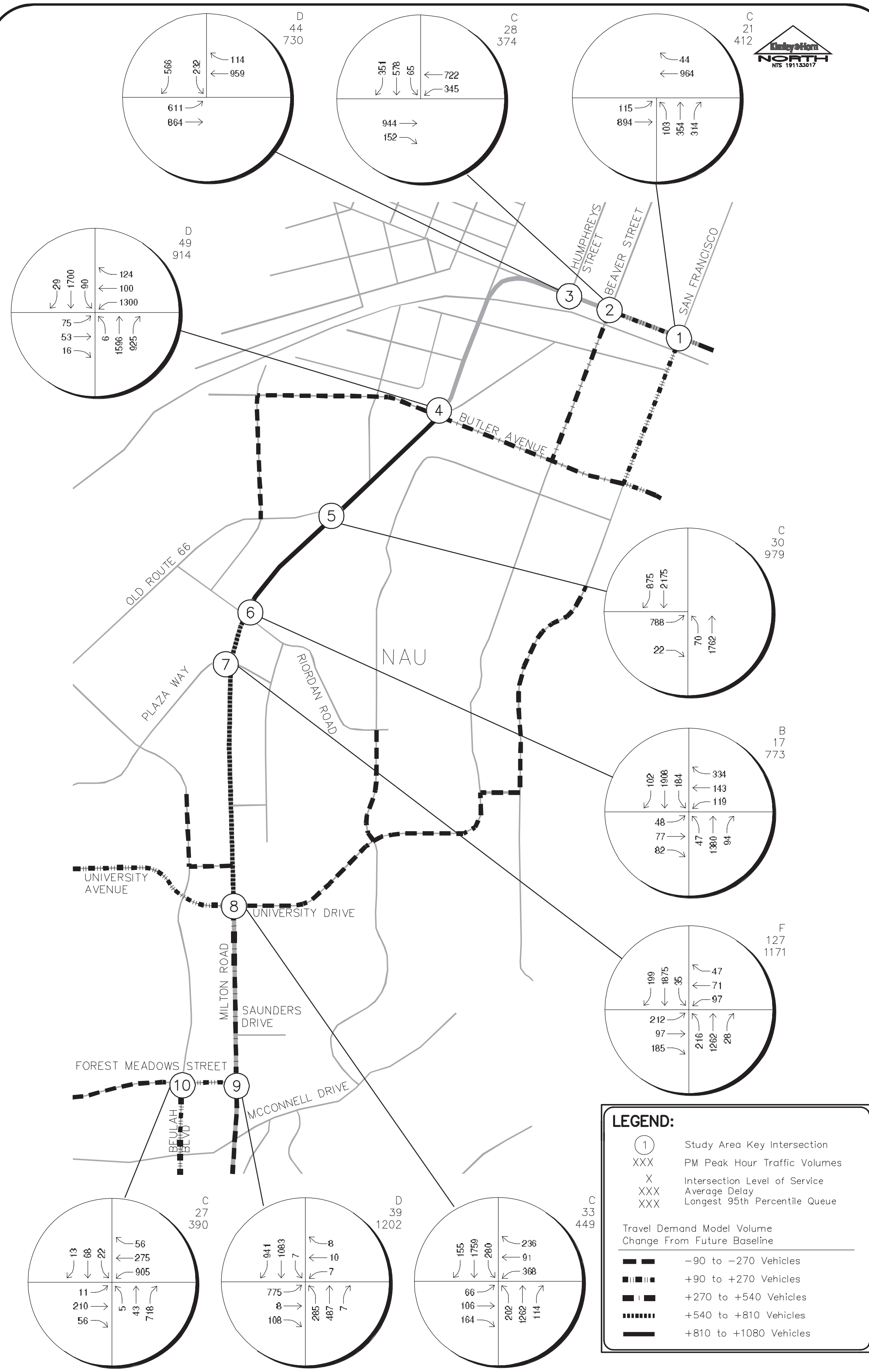
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 2 LANE CONFIGURATIONS

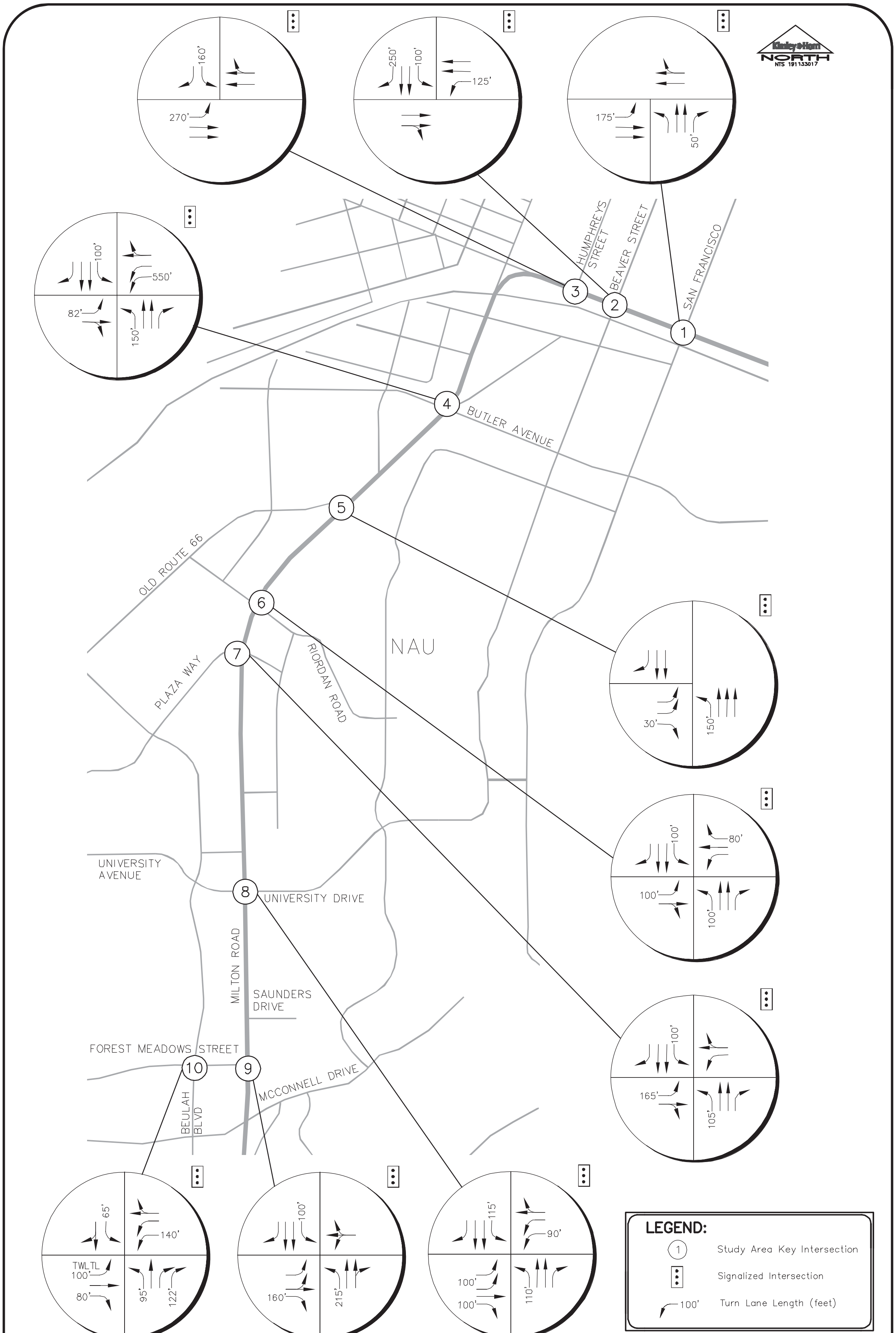
FIGURE 3

Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 2 PM PEAK HOUR DESIGN VOLUMES

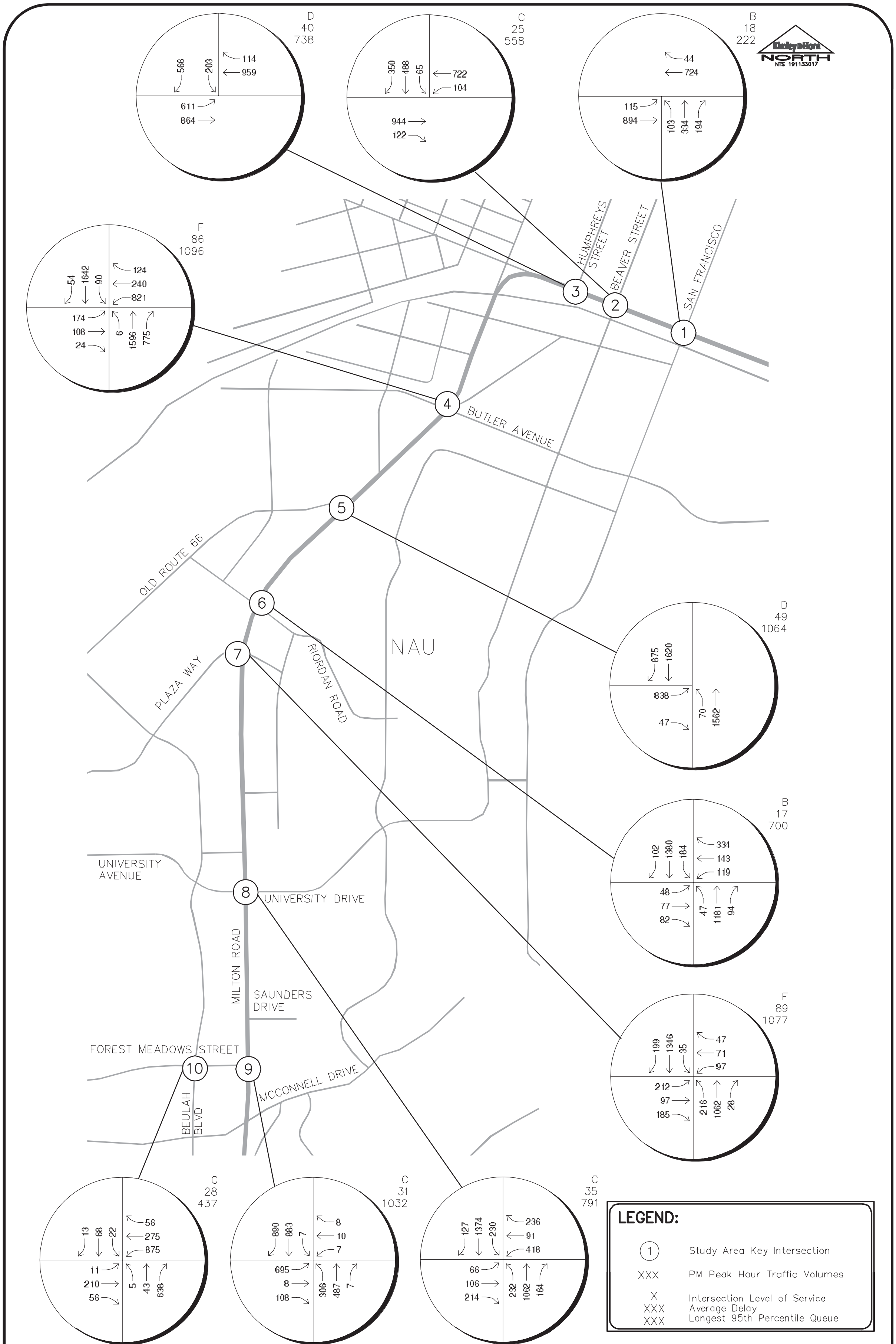
FIGURE 4



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 3 LANE CONFIGURATIONS

FIGURE 5

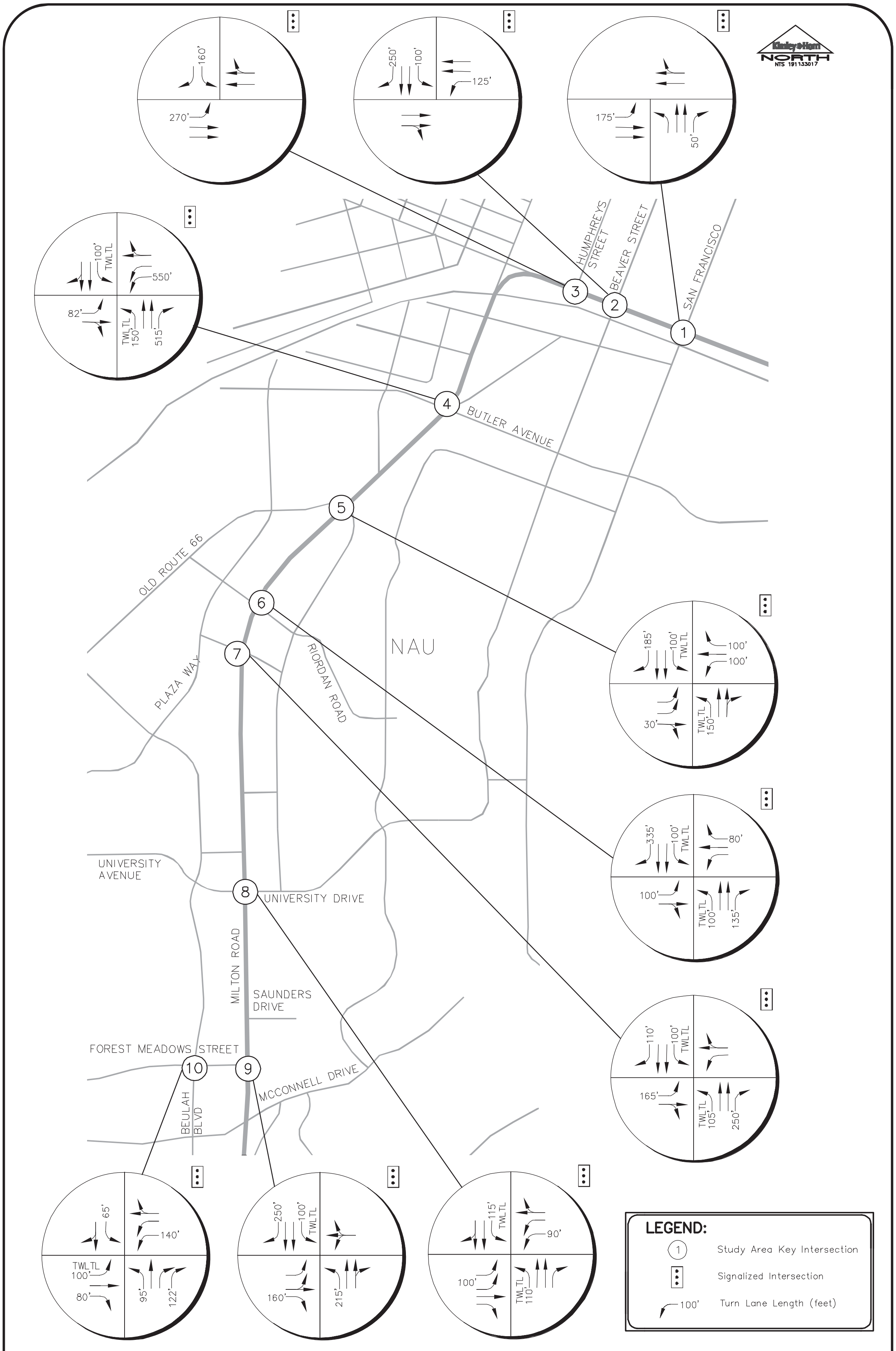
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 3 PM PEAK HOUR DESIGN VOLUMES

FIGURE 6

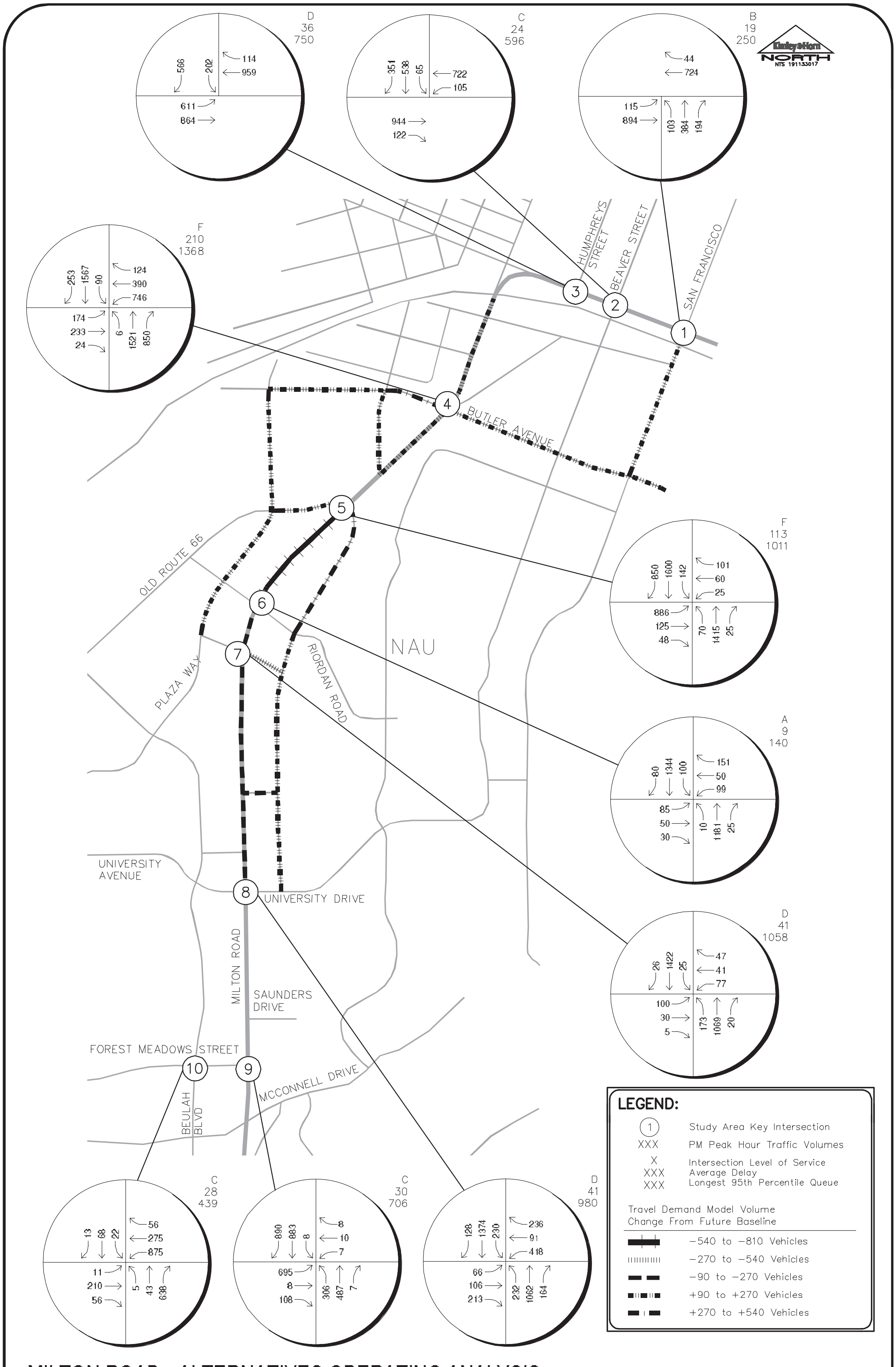
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 4 LANE CONFIGURATIONS

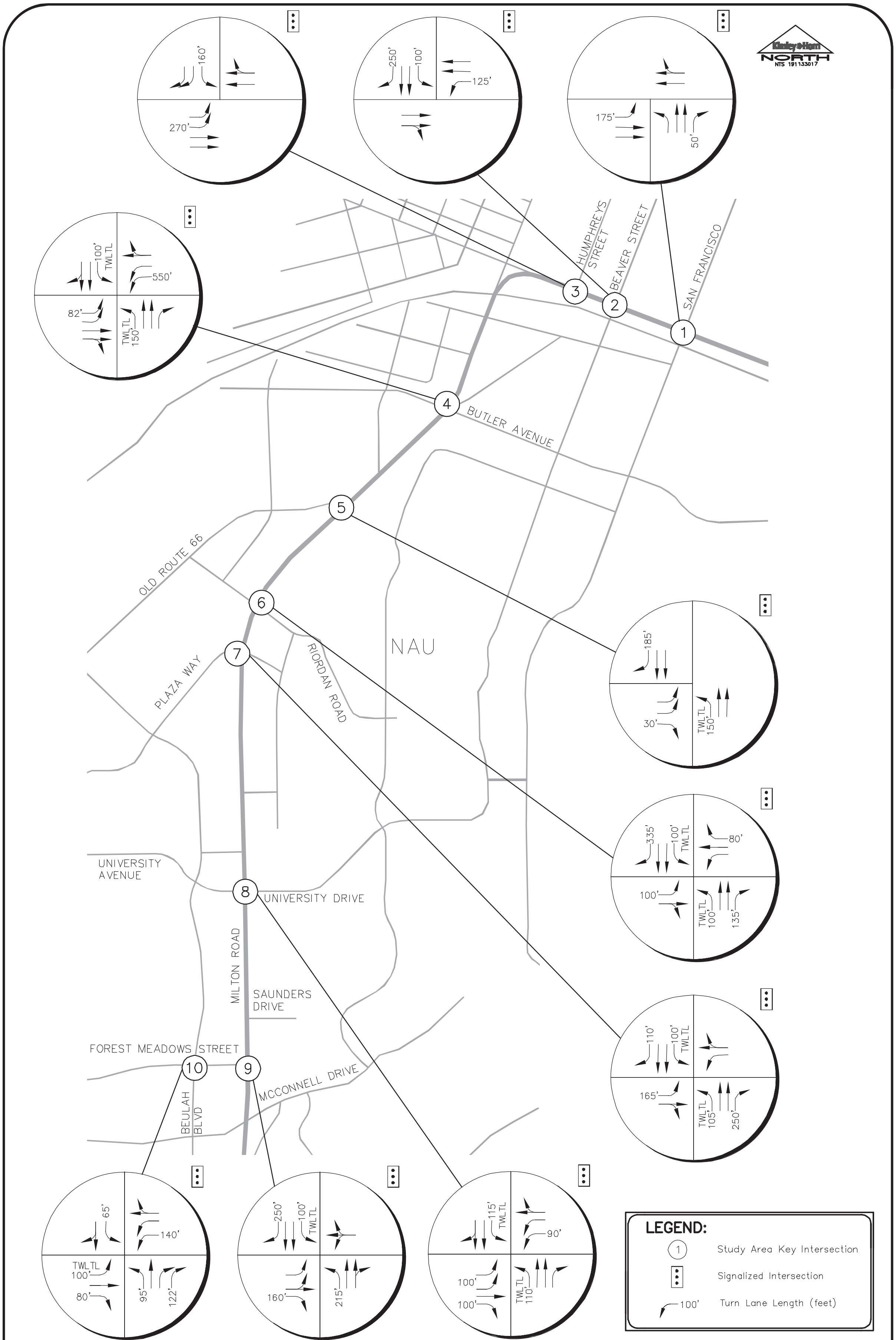
FIGURE 7

Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 4 PM PEAK HOUR DESIGN VOLUMES

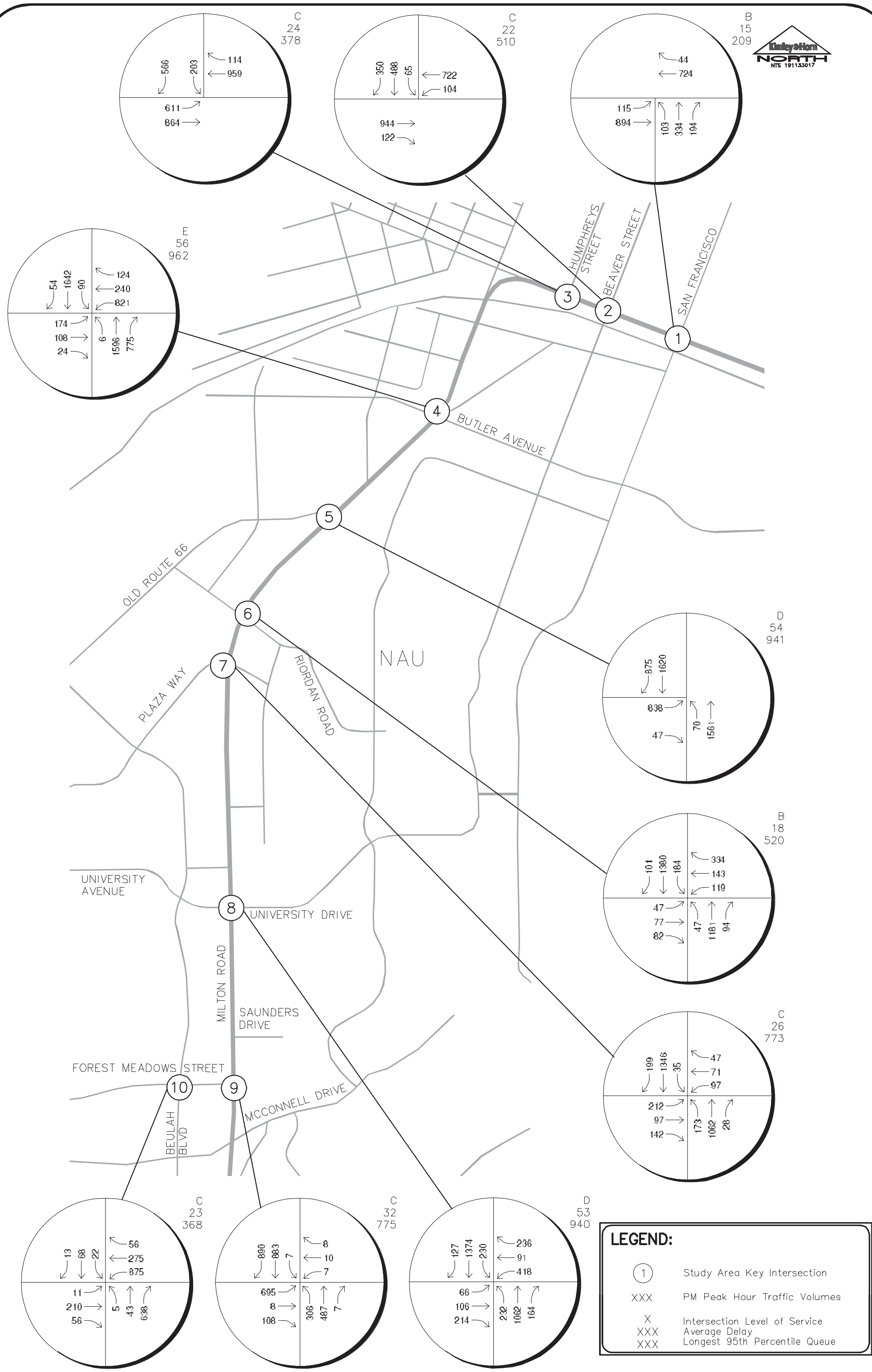
FIGURE 8



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 5 LANE CONFIGURATIONS

FIGURE 9

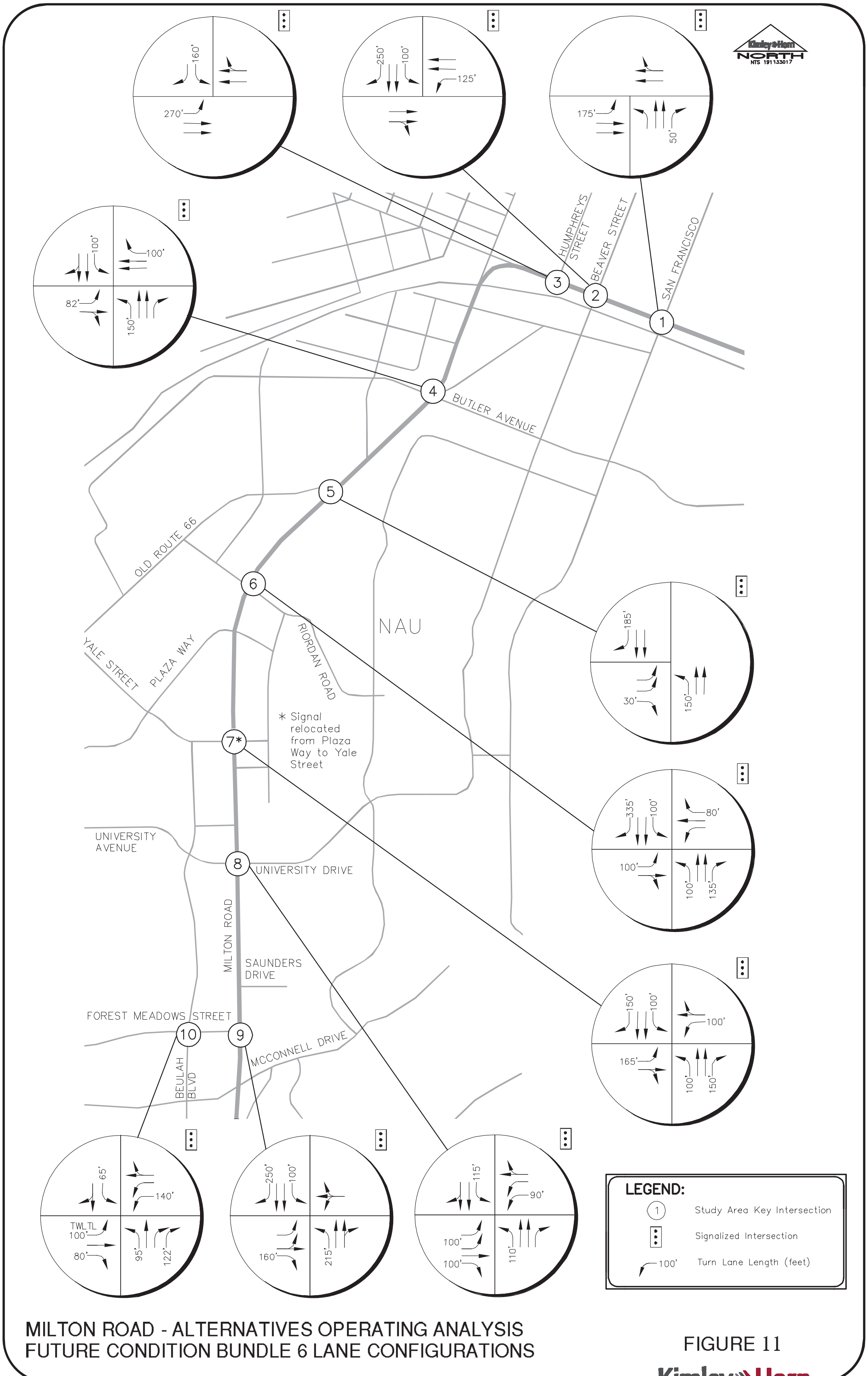
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 5 PM PEAK HOUR DESIGN VOLUMES

FIGURE 10

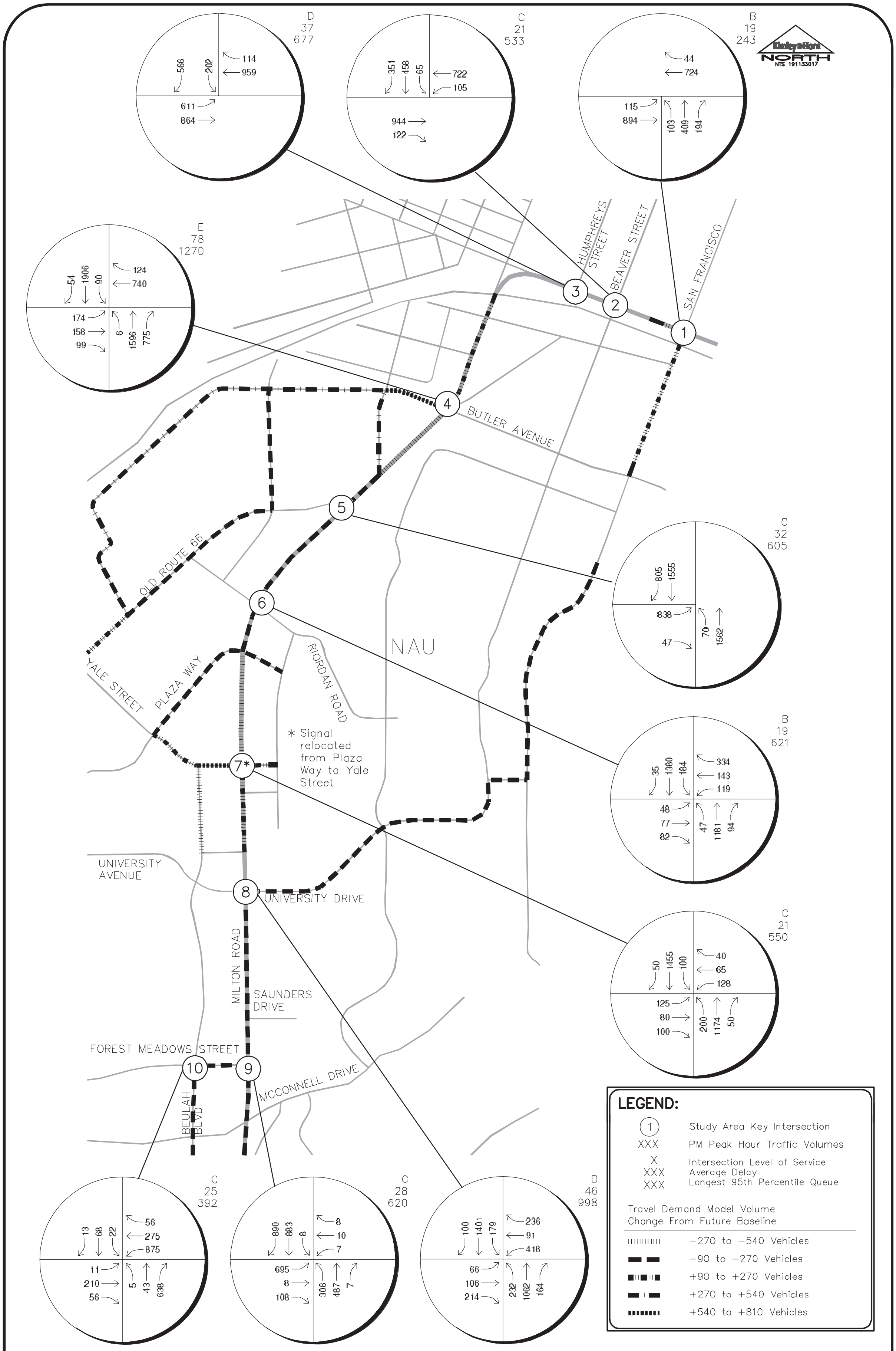
Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 6 LANE CONFIGURATIONS

FIGURE 11

Kimley»Horn



MILTON ROAD - ALTERNATIVES OPERATING ANALYSIS
FUTURE CONDITION BUNDLE 6 PM PEAK HOUR DESIGN VOLUMES

FIGURE 12

Milton Road Alternatives Operations Analysis Micro-Simulation Modeling

Table 1 - Synchro Bundle Scenarios LOS, Delay, and Queue Comparison

Intersection	Existing Baseline	Future Baseline	Bundle 1	Bundle 1A	Bundle 2	Bundle 2A	Bundle 3	Bundle 4	Bundle 4A	Bundle 5	Bundle 5A	Bundle 5B	Bundle 5C	Bundle 6
Milton Rd/San Francisco St														
LOS	B	B	B	B	C	C	B	B	B	B	B	B	B	B
Average Delay (s)	13	14	17	19	21	20	18	19	18	15	16	14	14	19
Longest 95% Queue (ft)	200	234	222	212	412	414	222	250	250	209	209	209	209	243
Milton Rd/Beaver St														
LOS	B	C	C	C	C	C	C	C	C	C	C	C	C	C
Average Delay (s)	16	20	24	24	28	31	25	24	24	22	20	20	20	21
Longest 95% Queue (ft)	243	297	564	590	374	513	558	596	596	510	274	487	452	533
Milton Rd/Humphreys St														
LOS	C	E	D	D	D	D	D	D	D	C	E	C	C	D
Average Delay (s)	27	73	37	37	44	44	40	36	36	24	64	22	21	37
Longest 95% Queue (ft)	491	666	738	739	730	730	738	750	752	378	659	388	385	677
Milton Rd/Butler Ave														
LOS	E	F	F	F	D	F	F	F	F	E	D	D	E	E
Average Delay (s)	63	101	91	91	49	179	86	210	212	56	55	50	57	78
Longest 95% Queue (ft)	1119	1064	1161	1161	914	1204	1096	1368	1368	962	873	976	967	1270
Milton Rd/Route 66														
LOS	C	E	D	D	C	C	D	F	F	D	D	D	C	C
Average Delay (s)	28	57	46	46	30	27	49	113	132	54	52	39	24	32
Longest 95% Queue (ft)	942	969	920	883	979	767	1064	1011	1112	941	941	949	894	605
Milton Rd/Riordan Rd														
LOS	D	E	B	B	B	B	B	A	B	B	B	B	B	B
Average Delay (s)	38	59	18	17	17	17	17	9	16	18	18	18	18	19
Longest 95% Queue (ft)	202	260	697	688	773	773	700	140	485	520	480	613	480	621
Milton Rd/Plaza Way*														
LOS	D	D	D	D	F	F	F	D	D	C	C	C	C	C
Average Delay (s)	41	47	37	37	127	125	89	41	35	26	27	26	27	21
Longest 95% Queue (ft)	1008	1046	982	981	1171	1171	1077	1058	1054	773	773	773	773	550
Milton Rd/University Dr														
LOS	C	D	D	C	C	C	C	D	D	D	D	D	D	D
Average Delay (s)	24	46	43	25	33	32	35	41	41	53	53	53	53	46
Longest 95% Queue (ft)	619	850	1007	355	449	470	791	980	857	940	940	940	940	998
Milton Rd/Forest Meadows St														
LOS	C	D	C	C	D	D	C	C	C	C	C	C	C	C
Average Delay (s)	23	37	29	23	39	38	31	30	30	32	32	32	32	28
Longest 95% Queue (ft)	596	862	682	629	1202	697	1032	706	706	775	825	825	825	620
Forest Meadows St/Beulah Blvd														
LOS	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Average Delay (s)	23	32	28	29	27	27	28	28	28	23	23	23	23	25
Longest 95% Queue (ft)	449	517	439	427	390	379	437	439	439	368	361	361	361	392

Level of Service definitions in seconds per vehicle: A≤10, B >10-20, C>20-35, D>35-55, E>55-80, F>80

*For Bundle 6, signal is relocated from Plaza Way to Yale Street

Milton Road Alternatives Operations Analysis Micro-Simulation Modeling

Table 2 - Synchro Bundle Scenarios Overall Statistics

Scale	Measure of Effectiveness	Existing Baseline	Future Baseline	Bundle 1	Bundle 1A	Bundle 2	Bundle 2A	Bundle 3	Bundle 4	Bundle 4A	Bundle 5	Bundle 5A	Bundle 5B	Bundle 5C	Bundle 6
Network	**Total Delay (h)**	273	551	427	387	489	701	470	748	770	373	407	337	331	395
	Total Travel Time (h)	488	814	690	636	758	970	716	1012	1035	643	677	605	601	649
	Cycle Length (s)	130/100/90	130/100/90	140	140	140	140	140	140	140	120	120	120	120	130
Per Vehicle	**Control Delay (s)**	22	33	30	28	19	44	33	52	53	24	24	22	21	25
	Queue Delay (s)	2	5	0	0	1	1	0	0	0	0	2	0	0	0
	Total Delay (s)	23	39	30	29	20	45	33	52	53	24	26	22	21	25
	Average Speed (mph)	9	6	8	8	9	6	7	5	5	8	8	9	9	8
Pedestrian and Bicycle	**Maximum Pedestrian Crossing Time Across Milton Rd (s)**	24	24	24	24	31	31	28	24	24	24	24	24	24	24
	Number of Milton Rd Segments with Less Than 1/4-Mile Spacing Between Signalized Pedestrian Crossings	4	4	4	4	4	4	4	4	4	7	7	7	7	6
	Number of Milton Rd Signalized Pedestrian Crossings	8	8	8	8	8	8	8	8	8	10	10	10	10	9

Description of Bundles

Bundle 1 – Improve signal timing

Bundle 1A – Improve signal timing with redistributed Beulah-University volumes

Bundle 2 – Widen to six lanes – Phoenix Avenue to Forest Meadows Street

Bundle 2A – Widen to six lanes – Butler Avenue to Forest Meadows Street

Bundle 3 – Add bus/bike/right-turn lane – Phoenix Avenue to Forest Meadows Street

Bundle 4 – Develop backage roads with new east leg at Milton Road/Route 66

Bundle 4A – Develop backage roads with restricted east leg at Milton Road/Route 66

Bundle 5 – Make conventional intersection improvements including additional eastbound left-turn lane at Milton Road/Humphreys Street and at Milton Road/Route 66

Bundle 5A – Make conventional intersection improvements excluding additional eastbound left-turn at Milton Road/Humphreys Street

Bundle 5B – Make conventional intersection improvements with Clay Avenue extended to Kaibab Street

Bundle 5C – Make conventional intersection improvements including additional eastbound left-turn lane at Milton Road/Route 66

Bundle 6 – Make unconventional improvements at select locations

Milton Road Micro-Simulation Modeling
Frequently Asked Questions & Observations

PRELIMINARY ALTERNATIVE BUNDLES SYNCHRO-RELATED QUESTIONS & OBSERVATIONS

SYNCHRO BUNDLE-SPECIFIC QUESTIONS & OBSERVATIONS

- **Bundle 1 (Timing)** – How do Bundle 1 mitigations affect the Milton corridor analysis results?
  - Signal timing and coordination offset refinements reduce total delay and travel time compared to the Future Baseline but split phasing at Milton/Butler and Milton/Plaza inhibit ability to improve signal timing and coordination further.
- **Bundle 1A (1+Beulah fix)** – How do Bundle 1A mitigations differ from Bundle 1 and how does that affect the Milton corridor analysis results?
  - Bundle 1A is the same as Bundle 1 except the volumes in the University-Beulah-Yale-Milton "complex" match the refined volumes developed as part of the Beulah-University Alignment Study. Bundle 1A has lower volumes on University Avenue and Milton Road with higher volumes on Beulah Boulevard and University Drive than Bundle 1. For Bundle 1A, operations improve significantly at Milton/University and improve slightly at Milton/Forest Meadows due to the reduced volumes on Milton Road compared to Bundle 1.
- **Bundle 1A (1+Beulah fix)** – Did the revised figures become part of the base for the other Synchro models, or is there a need to extrapolate their impacts? For example, there is a 40 second improvement in total delay from Bundle 1 to Bundle 1A. Would this improvement also apply to Bundle 5, meaning its total delay would be closer to 407-40 = 367?
  - The revised figures are not part of the base for the other Synchro models. This was not done, thereby allowing the incremental changes in the six alternate bundles compared to the original six bundles to be shown. If the volumes/timing from Bundle 1A were applied to other bundles, such as Bundle 5, it would reduce the total delay by a value likely similar to the change between Bundle 1 and Bundle 1A.
- **Bundle 2 (6 GPL)** – How do Bundle 2 mitigations affect the Milton corridor analysis results compared to Bundle 1?
  - Widening Milton to six general purpose lanes (GPL) reduces delay on a per vehicle basis more than Bundle 1, indicating improved performance on a per vehicle basis, but total delay reduction for the network is not as great as Bundle 1. This occurred because the added capacity of a six-lane facility attracts more vehicles to Milton who today are using alternate routes due to the capacity constraints on Milton. North of Route 66, almost all of the added capacity gets used up by existing and newly attracted demand. South of Route 66, the added capacity is only partially used up by existing and newly attracted demand.
- **Bundle 2A (2+stop at Butler)** – How do Bundle 2A mitigations differ from Bundle 2 and how does that affect the Milton corridor analysis results?
  - Bundle 2A is the same as Bundle 2 except widening Milton Road to three northbound lanes stops at Butler as a trap right-turn lane instead of at Phoenix as a trap right-turn lane. Both Bundle 2 and Bundle 2A have higher volumes on Milton than the other bundles as more regional traffic is attracted to Milton due to its overall increased capacity caused by widening. For Bundle 2A, operations worsen significantly at Milton/Butler due to the reduced northbound capacity at Milton/Butler compared to Bundle 2. While Bundle 2 only continues the third northbound lane for approximately

800 feet beyond Butler, the distance is long enough to allow vehicles to use the third lane at Milton/Butler and then merge over when the third lane ends. This third lane in Bundle 2 significantly reduces the northbound queue at Milton/Butler.

- **Bundle 3 (Bus-bike-turn)** – How do Bundle 3 mitigations affect the Milton corridor analysis results compared to other scenarios?
  - Adding a bus/bike/right-turn lane reduces total delay and travel time more than the Future Baseline scenario but less than Bundle 1. This is because the improvements add minimal additional vehicular capacity but the wider Milton cross-section requires more pedestrian crossing time. This equates to more green time for the cross-streets and less green time for Milton.
- **Bundle 3 (Bus-bike-turn)** – How would the removal of split phasing at Plaza affect the analysis results for Bundle 3 (similar to Bundle 2)? A potential hybrid solution could be that north of Route 66 has six general purpose lanes and south of Route 66 has 6 lanes, but the curb lane in each direction is designated for transit/bike/right-turn use. However, there are two conflicting concerns with this solution: 1) The relief of 6 general purpose lanes between Route 66 and Butler brings traffic that overwhelms the south end; or 2) The south end operates well and there is not much to be gained by transit operating in a separate lane. It may be that the two work to support each other.
  - The removal of split phasing at Plaza would significantly reduce the delay for both Bundle 2 and Bundle 3. This same configuration of six lanes with transit/bike/right-turn south of Route 66 and general purpose lanes north of that to Phoenix could be a potential option. The concerns are valid, but the benefits of the configuration would most likely outweigh the potential disbenefits.
- **Bundle 4 (Backage+4th leg)** – Why did the Bundle 4 delay increase compared to the Future Baseline?
  - The addition of backage roads between University and Butler in Bundle 4 results in significant increases in delay at Milton/Butler and Milton/Route 66, which increases total delay and travel time for the network compared to the Future Baseline. The decreased performance at Milton/Butler is primarily due to increased eastbound through, westbound through, and southbound right-turn volumes. This increase in volumes can be attributed to a combination of new traffic attracted to the area by the backage roads and existing traffic shifting from the westbound left-turn and northbound/southbound through movements. The movements experiencing increases in volumes only have one travel lane whereas the movements experiencing decreases in volumes have two travel lanes, resulting in a less efficient use of green time. The decreased performance at Milton/Route 66 is primarily due to a combination of the new signal phasing needed to serve the new east leg of the intersection and an overall increase in volumes due to new traffic being attracted to the area by the backage roads.
- **Bundle 4A (4+weak 4th leg) –** How do Bundle 4A mitigations differ from Bundle 4 and how does that affect the Milton corridor analysis results?
  - Bundle 4A is the same as Bundle 4 except the new east leg of Milton/Route 66 is only for local business access and does not connect to Riordan Ranch or Knoles. Bundle 4A has lower volumes to and from the new east leg and higher volumes on Milton than Bundle 4. Modifying the 4th leg to only be for local access (Bundle 4A) instead of connecting to Riordan Ranch (Bundle 4) shifts some of the southbound left-turn volume back to the southbound through movement – which is the over-capacity movement – as well as shifts some of the westbound through volume to the northbound left-turn movement

(which must yield to the over-capacity southbound through movement). The result is that the delay gets worse at Milton/Route 66 with Bundle 4A compared to Bundle 4.

- **Bundle 5 (Minor intersections)** – How do Bundle 5 mitigations affect the Milton corridor analysis results?
    - Removing split phasing at Milton/Butler and Milton/Plaza and adding dual southbound right-turn and eastbound left-turn lanes at Milton/Humphreys reduce total delay and travel time more than any other bundle. This is because the corridor-wide signal cycle length can be reduced to 120 seconds, which reduces delay now that the least efficient intersections have become more efficient. Bundles 1-4 have cycle lengths of 140 seconds and Bundle 6 has cycle lengths of 130 seconds.
- **Bundle 5A (5+no 180 dual left)** – How do Bundle 5A mitigations differ from Bundle 5 and how does that affect the Milton corridor analysis results?
    - Bundle 5A is the same as Bundle 5 except Milton/Humphreys has only one eastbound left-turn lane instead of two. For Bundle 5A, operations worsen significantly at Milton/Humphreys due to reduced eastbound left-turn capacity compared to Bundle 5.
- **Bundle 5B (5+Clay ext.)** – How do Bundle 5B mitigations differ from Bundle 5 and how does that affect the Milton corridor analysis results?
    - Bundle 5B is the same as Bundle 5 except Clay is extended to Kaibab to provide additional east-west connectivity. Bundle 5B has lower volumes on Milton and Route 66 and higher volumes on Clay than Bundle 5. For Bundle 5B, operations improve moderately at Milton/Route 66 and slightly at Milton/Butler due to the reduced volumes on Milton compared to Bundle 5.
- **Bundle 5B (5+Clay ext.)** – Does Bundle 5B include a traffic signal at Blackbird Roost? A 30% reduction in delay at Route 66 could be described as more than moderate. The reduction at Butler seems contradictory to earlier thoughts that increasing east-west through volumes would increase delays here (see the effects of Bundle 4 and Bundle 6 on Butler). Adding a traffic signal at Blackbird Roost is an important item for discussions with the La Plaza Vieja neighborhood and for long-term connectivity value if it creates excessive delay at this intersection.
    - Bundle 5B does not include a signal at Blackbird Roost. There is a "tension" between the conflicting eastbound-westbound movements and the northbound-southbound movements. Any volume shift from eastbound-westbound to northbound-southbound, or vice versa, results in a change in delay at these movements. When the intersection and coordination offsets are re-optimized, Synchro seeks to balance the delay to get the lowest overall delay. Increasing the eastbound-westbound volumes by shifting them from the northbound-southbound volumes reduces the delay up to a point, but after that, further increases will begin increasing delay. There is an optimal level in the middle that balances the delay. This optimal volume shift is influenced by things such as minimum and maximum green times, pedestrian crossing times, phasing, coordination "green bands", etc. It is important to not make the Clay/Blackbird Roost alternate route so attractive that things get outside of the optimal level and result in making operations worse at Butler/Milton by having so much eastbound-westbound traffic that the northbound-southbound movements don't get sufficient green time.
    - It is important to recognize that Bundle 4 includes the completion of the east leg at Route 66/Milton and that Bundle 6 includes a prohibited westbound left-turn at Butler/Milton. These are significant changes that affect intersection splits and overall corridor coordination offsets. These can affect individual movement delay at Butler/Milton and Route 66/Milton. There is more going on than just the additional signal at Blackbird Roost or the Clay extension.

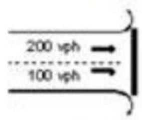
- Synchro modeling tends to show that the signal at Blackbird Roost will improve operations and safety for Route 66, Milton, Butler, and the La Plaza Vieja neighborhood. The extension of Clay is also beneficial, but it needs to be done carefully so it does not draw too much traffic. It should not have more than one lane in each direction. Traffic calming features could be added to reduce the amount of "cut-through" traffic, while still providing the needed connectivity. A McCracken Lane alternative to Clay Avenue, such as what was developed during the La Plaza Vieja Neighborhood Plan, may address some of these concerns.

- **Bundle 5C (5+66 triple left)** – How do Bundle 5C mitigations differ from Bundle 5 and how does that affect the Milton corridor analysis results?
  - Bundle 5C is the same as Bundle 5 except a third exclusive eastbound left-turn lane is added at Milton/Route 66. For Bundle 5C, operations improve significantly at Milton/Route 66 due to increased eastbound left-turn capacity compared to Bundle 5.
- **Bundle 5C (5+66 triple left)** – How many drivers will use the outside turn lane and then seek to merge to an inside lane (and vice-versa)? Can this be captured more vividly in VISSIM if this is part of a final analysis? Also, what are the lane utilization assumptions?
  - Based on the proportional size of the eastbound left-turn movement vs. the northbound through movement at Route 66/Milton and the northbound through movement vs. the northbound right-turn movement at Butler/Milton, it is estimated that about 1/3 of the eastbound left-turning vehicles at Route 66/Milton will subsequently become a northbound right-turning vehicle at Butler/Milton. The three eastbound left-turn lanes will be relatively balanced.
  - Most drivers making the eastbound left-turn movement at Milton/66 during the PM peak hour will be familiar drivers who will very quickly figure out which lane they want to be in. Signage could be added if desired to indicate to unfamiliar drivers that the rightmost left-turn lane is for those who will eventually be turning right at Butler. There are almost 1,200 feet between Route 66 and Butler, which is a long distance for merging/weaving.
  - Yes, VISSIM will capture the impacts of merging/weaving better than Synchro. Lane utilization refers to how traffic volumes assigned to a lane group are distributed across each lane. A value of 1.0 means equal distribution across all lanes. The table below is from the Synchro user's guide and indicates the default lane utilization factors and shows how to calculate a lane utilization factor. The only lane utilization factor that was modified at this intersection was the southbound through lane group, which was reduced from 0.95 to 0.78 in the Existing Conditions Baseline model to better match the actual observed conditions and the VISSIM results. This 0.78 factor was maintained in all bundles.

Table 5-2 Lane Utilization Factors

Lane Group Movements	# of Lanes	Lane Utilization Factor
Thru or shared	1	1.00
Thru or shared	2	0.95
Thru or shared	3	0.91
Thru or shared	4+	0.86
Left	1	1.00
Left	2	0.97
Left	3+	0.94
Right	1	1.00
Right	2	0.88
Right	3	0.76

This field can be overridden. If, for example, there is a busy shopping center entrance just after this intersection on the right side, most of the vehicles will be using the right lane and cause a lower lane utilization factor. If the actual per lane volumes are known, the lane utilization factor can be calculated as follows:



$$f_{LU} = \frac{\text{Total App. Vol.}}{\text{(No. of Lanes)} \times \text{(High Lane Vol.)}} = \frac{(100 + 200)}{(2 \times 200)} = 0.75$$

f_{LU} = Lane Utilization Factor

- **Bundle 6 (Major intersections)** – How do Bundle 6 mitigations affect the Milton corridor analysis results?
    - Prohibiting the westbound left-turn at Milton/Butler, extending Clay to Kaibab, and relocating Milton/Plaza reduce total delay and travel time more than any other bundle except Bundle 5. Clay sees a large increase in volume, which may not be compatible with the neighborhood context. The relocation of Milton/Plaza improves operations, not due to the relocation of the intersection, but rather due to the elimination of the split phasing.
- **Bundle 6 (Major intersections)** – Why does Bundle 6 show improvements at both Butler and Route 66? Does removal of the west to south left-turns have that significant of an impact?
    - Yes, removal of the west to south left-turns frees up green time for other movements in Bundle 6 at Butler and results in fewer southbound vehicles at Route 66 as some have taken Clay and Blackbird to go west.
- **Bundle 6 (Major intersections)** – Would quadrant left-turns be feasible at Malpais/Milton?
    - It is possible to model a one-way southbound two-lane Malpais with a signal as a quadrant left with the Butler westbound left prohibited without needing an additional travel demand model run. The out-of-the-way travel distance is fairly small, so it is possible to assume all of the Butler westbound lefts instead go through and then come back to Milton at Malpais. The main concern with this alternative is the section of Clay between Malpais and Milton. Is Clay between Malpais and Milton one-way or two-way? If it is two-way, two westbound lanes (for capacity reasons) that both can turn left at Malpais will be needed – a split phase traffic signal at Malpais/Clay will be needed to safely allow that movement plus the westbound through/right from a shared left/through/right lane unless the adjacent building is demolished to make room for a separate through/right lane – these two signals so close together could result in queuing issues between the Clay/Malpais and Clay/Milton/Butler intersections. If it is one-way westbound, signalized access from the La Plaza Vieja neighborhood to Milton is eliminated unless a left at Malpais/Milton is permitted, in which case the out-of-the-way travel distance is long for drivers wanting to go north/east on Milton, signal progression

on Milton would become more restricted due to the closely spaced signals, and the Clay/Malpais intersection geometry would be unconventional (using with a diverter to force eastbound traffic to go left or right without conflicting with the westbound dual left movement). Either option is possible – just not without some drawbacks to consider.

SYNCHRO CORRIDORWIDE SIGNAL TIMING QUESTIONS & OBSERVATIONS

- What is the recommended traffic signal cycle length based on the initial optimization analysis?
    - The recommended traffic signal cycle length as a result of the optimization is 110 seconds for the AM, MD, and PM peak periods. The timings and offsets are not identical between time periods, but the cycle lengths are.
- Could the signals on Milton be coordinated with the downtown Flagstaff signals?
    - The 110-second cycle length is close to the 100-second cycle length the City is running in downtown during the PM peak hour – the City may want to revise their PM peak hour downtown intersection cycle lengths to match the 110-second cycle length of Milton if the ADOT signal cycle lengths at Humphreys, Beaver, and San Francisco are also revised to be 110 seconds. The same would apply to Beulah/Forest Meadows. It is unclear what cycle lengths the City signals are running in the AM and MD peak hours and if it would make sense to revise those as well.
- Do the Synchro models include the split phasing at Butler/Milton?
    - The Synchro models include assumed timing and phasing for Butler/Milton that removes the split phasing. The key to the new phasing is to only have the east-west pedestrian crossing phase tied to the westbound traffic signal phases. This way the lower-volume eastbound traffic signal phase can be much shorter than the pedestrian crossing time, making the intersection operate more efficiently than it does now. Protected left-turn phasing was assumed for both the eastbound and westbound left-turns, but there is an opportunity to make the eastbound left-turn protected/permitted (or implement the flashing yellow left-turn) to improve intersection operations further if ADOT is comfortable with the eastbound left being protected/permitted while the westbound left is protected only. Some agencies in the Phoenix area have been experimenting with this mixed phasing set-up and it has been working well.
- Would the removal of split-phasing at Butler and Plaza have a negative impact on pedestrians? If so, under what conditions would a nearby mid-block pedestrian crossing help mitigate them?
    - Removing split-phasing will most likely not have a negative impact on pedestrians. It will most likely have a positive impact on pedestrians as it will allow for a shorter corridor-wide cycle length, which means less delay for pedestrians waiting for the WALK phase.
- What are the benefits of the signal optimization?
    - Benefits of optimization are most pronounced in the PM peak hour and generally affect queuing more than delay or level of service. Benefits of optimization are less dramatic than they would have been if the removal of split phasing at Milton/Butler and Milton/Plaza was not already accounted for in the Existing scenarios.
- Why are the LOS, delay, and queues sometimes worse in the optimization scenarios?
    - This is because intersection operational efficiency is sacrificed to provide better corridor progression.
- How would lagging left-turn phasing affect results?
    - Changing some of the intersection left-turn phases from leading to lagging would reduce the average delay by a couple of seconds at some intersections, but this minimal improvement most likely is not worth the effort/expense to train drivers to become

familiar with lagging left-turns at just a few of the intersections along the corridor. If ADOT is interested in introducing lagging left-turns, the timing plans could easily be re-optimized accordingly.

- Is adding Humphreys to the Milton corridor a feasible option?
    - The Milton sector will reliably handle between 120 and 130 second cycle lengths before the side streets begin to have operational issues. The downtown sector, discounting Aspen and Birch, equalize at around 90 to 100 seconds. Given the close proximity of Beaver, and the need to half cycle Aspen and Birch to prevent pedestrians walking against the red, it does not seem feasible.

INVESTMENT ALTERNATIVES VISSIM-RELATED QUESTIONS & OBSERVATIONS

GENERAL QUESTIONS & OBSERVATIONS

- Does a large standard deviation on the VISSIM speed table equate to less reliability?
    - Yes, a high standard deviation also relates to how queues increase throughout the peak analysis period.
- There was supposed to be an overall 20% increase in traffic for all future scenarios, but the number of simulated vehicles for one scenario only increases by 12.5%. Where is the other 7.5% of the vehicles?
    - The full 20% increase in vehicles is not seen in the model due to some vehicles being blocked from entering the modeled network because of long queues that extend to the edge of the model network limits. The investment scenarios show higher volumes than the Future Baseline, indicating there is less queue blocking in those scenarios. For example, the Auto-Focused High Investment scenario shows 13,017 simulated vehicles in the network. This is close to the 13,286 simulated vehicles, which would represent a full 20% increase.

TRANSIT-RELATED QUESTIONS & OBSERVATIONS

- What is happening at the signals with a queue-jump lane and transit signal priority (TSP). The transit performs much worse than others that a better understanding is needed.
    - The queue jump lane and TSP parameters have been updated so that the bus gets the indication to go before the adjacent general purpose lanes. This improves the transit performance at the intersections with queue jump lanes, but the overall bus performance is still worse under the Transit-Focused High Investment scenario than the Auto-Focused High Investment scenario. This is due to the increased capacity in the Auto-Focused High Investment scenario, which reduces overall congestion, which benefits the buses more than the couple of queue jump lanes in the Transit-Focused High Investment scenario do. It should be noted that the Auto-Focused High Investment scenario uses the same traffic volumes as the Transit-Focused High Investment scenario, but it is recognized that widening portions of Milton Road may induce slightly higher traffic volumes on Milton Road, which could adversely affect overall traffic performance.
- What is the definition of average delay for the bus. Why is it so much higher than for all vehicles? Does it have an assumed dwell time at each stop?
    - The average delay for buses includes dwell time at each bus stop plus stop delay, which is the delay caused by having to stop due to traffic control devices and congestion. Subtracting the stop delay for buses form the average delay for buses in each scenario results in an average delay that is close to the average delay for all vehicles. This

indicates most of the discrepancy in average delay for buses vs. all vehicles is related to dwell time delay at each bus stop.

- Can operating speed for buses be extracted from VISSIM?
  - Yes. Speed and travel time for buses can be extracted from VISSIM and were added to all future scenarios.
- Where do the transit delays in the Transit-Focused High Investment scenario come from? Comparing them to the Low Investment scenario it would appear that several improvements are made that should gain time and reduce bus delay including queue-jump lanes. Does the bi-directional bus lane not function as expected? If so, can this be isolated, including the overall delay that comes with a signal at Phoenix?
  - The bi-directional bus lane and queue jump lanes reduce delay for buses in that part of the corridor containing those facilities while increasing delay for non-bus traffic due to the extra signal phases for the bi-directional bus lane and queue jump lanes. In the rest of the corridor, however, where the bus does not have its own dedicated lane, the bus delay is higher because the overall traffic delay is higher, resulting in a net increase in transit delay for the Transit-Focused High Investment scenario compared to the Low Investment scenario. The Low Investment scenario delay being less than the Transit-Focused High Investment delay can also be attributed in part to the fact that the Low Investment scenario includes the triple westbound left-turn at Butler – the benefits of which accrue to all vehicles (including buses).
- Will the bus system need a signal at Phoenix for any of the other scenarios?
  - Southbound buses were modeled using the existing Phoenix-Beaver route east of the transit center and across the at-grade railroad crossing for all scenarios except the Transit-Focused High Investment scenario. Buses cannot make the westbound left out of Phoenix unless they have a signal due to congestion on Milton. Therefore, this route was only used for the Transit-Focused High Investment scenario and it does include a signal at Phoenix.
- Is the northbound bus/bike/right-turn lane helpful for the bus and general operations – especially at the south end?
  - The northbound bus/bike/right-turn lane in the Transit-Focused High Investment scenario improves northbound flow and queues compared to the Low Investment scenario, although the Auto-Focused High Investment scenario improves northbound (and southbound) flow and queues much more than the other scenarios.
- From an operational and geometric perspective, would it be possible to have triple left-turn lanes in the Transit-Focused High Investment scenario?
  - The triple westbound left-turn at Butler could be done in the Transit-Focused High Investment scenario if the third outside lane being added on Milton between Butler and Route 66 becomes a general purpose lane instead of being a bus/bike/right-turn lane. However, the triple westbound left-turn at Butler was not added in the Transit-Focused High Investment scenarios so as to better separate out the benefits of the triple westbound left-turn.
- Transit appears to operate better under the Auto-Focused High Investment scenario than the Transit-Focused High Investment scenario. Can this be due in part to the more aggressive southbound treatment for autos? Is it correct to conclude that transit "fixes" like TSP and queue-jump lanes do little to help and may actually hurt operations for that scenario?
  - Yes, buses do perform best in the VISSIM model under the Auto-Focused High Investment scenario. This is because the additional capacity provided by a third general

purpose lane in each direction in the Auto-Focused High Investment scenario reduces queues significantly for all vehicles, including buses. The Transit-Focused High Investment scenario improves transit performance at the spot locations that have transit operational enhancements, but because the Transit-Focused High Investment scenario doesn't improve conditions for all vehicles (and makes it worse in some cases), the buses still encounter long queues when they are not near the intersections with dedicated transit lanes. Even the Low Investment capacity improvements provide more benefit to buses in terms of reduced queues compared to the Transit-Focused High Investment scenario. For buses to operate best under the Transit-Focused High Investment scenario, this scenario would need to be modified to include dedicated bus facilities the entire length of the corridor so that buses are not impacted by the long queues where no general traffic improvements are made.

- What input from the NAIPTA Transit Spine Study was considered in developing the Transit-Focused High Investment scenario?
    - Per the Nelson-Nygaard Project Manager:
        - There is a decided benefit to connecting the existing Route 10 with the Transit Spine at Woodlands Village and again at the Downtown Connection Center. This leverages the significant Route 10 ridership and affords opportunity to enhance transit mobility through transfers between Route 10, the Transit Spine, and the local route network.
        - There is not an advantage for using the east corridor alternative either as a bi-directional service or as part of a one-way couplet. One-way pair couplets, especially for higher frequency/higher quality service do not well serve transit riders. Splitting direction of travel and multiple stop locations is both expensive and confusing and results in lower effective transit accessibility than for a bi-directional service. Using the Riordan Ridge option as a bi-directional alignment is also not very attractive because it is too close to Route 10 and moves transit riders further away from desired activity along Milton and Beulah.
        - Milton as a bi-directional Transit Spine is an acceptable alternative. This is made even more attractive with the development of a continuous parallel roadway along Plaza and Beulah.
        - Beulah/Plaza as a bi-direction Transit Spine is also an attractive alternative.
        - Using Milton or Beulah/Plaza should be modeled based on policy service levels - 10-minute peak/20-minute off-peak or 15-minute all day bi-directional service frequency. This will help better understand the relative attractiveness of each in terms of ridership and travel time.
        - Other things to be considered:
            - Runningway configuration – curb-running or median with off-set stations – these assume Bus Only operations. Curb running may also assume operations in mixed traffic.
            - Operational scheme for local buses mixed with Bus Rapid Transit (BRT).
            - Local and BRT stop locations, spacing, consolidation (no more frequent than ⅓ mile and no further than ½ mile) if BRT operates with local buses or in place of local buses.
            - Station configuration – local buses may have a bus pullout bay while BRT will do the opposite and use bulb-outs to minimized dwell time and delays associated with getting back in traffic.

- TSP and queue jump lanes – which intersections generate the most benefit? The queue jump lane needs to be sufficient for the bus to bypass the queue.

INTERSECTION-SPECIFIC VISSIM & SYNCHRO QUESTIONS & OBSERVATIONS

SAN FRANCISCO/MILTON

- VISSIM – With a 20% increase in traffic and no improvements in the immediate vicinity, why would there be no change at San Francisco/Milton from Existing Baseline to Future Baseline?
    - A comparison of the queues between the Existing Baseline and Future Baseline models shows that queues are significantly longer for the Future Baseline. The reason why the delay and LOS don't change significantly is that the green time is long enough so that the queues still clear in one cycle. In other words, there is a significant amount of "unused" green time in the Existing Baseline where the signal is green but there aren't many vehicles passing through the intersection every second because those that were queued initially cleared early in the green phase. In the Future Baseline, the amount of "unused" green is reduced, but not to the point where vehicles are not clearing on each phase. Also, the Future Baseline does include the signal timing and coordination improvements implemented by ADOT. This gave the network extra capacity to handle the increase in traffic.

HUMPHREYS/MILTON

- Synchro Bundle 5 (Minor intersections) – Is widening Humphreys/Milton to include dual eastbound left-turn lanes an improvement that should be included in all scenarios?
    - Yes, widening of Humphreys/Milton is an improvement that has the potential to improve this intersection in all scenarios.
- Synchro Bundle 5A (5+no 180 dual left) – This appears to show value in providing dual eastbound left-turn lanes, right?
    - Yes, the dual left-turn lanes at this intersection are valuable during the typical PM peak, but will be even more valuable during snowplay events when volumes are much higher.
- VISSIM – With a 20% increase in traffic and no improvements in the immediate vicinity, why would there be improvement at Humphreys/Milton from Existing Baseline to Future Baseline?
    - A comparison of the queues between the Existing Baseline and Future Baseline models shows that queues are significantly longer for the Future Baseline. The reason why the delay and LOS don't change significantly is that the green time is long enough so that the queues still clear in one cycle. In other words, there is a significant amount of "unused" green time in the Existing Baseline where the signal is green but there aren't many vehicles passing through the intersection every second because those that were queued initially cleared early in the green phase. In the Future Baseline, the amount of "unused" green is reduced, but not to the point where vehicles are not clearing on each phase. Also, the Future Baseline does include the signal timing and coordination improvements implemented last year by ADOT. This gave the network extra capacity to handle the increase in traffic.

- VISSIM – Is the southbound left-turn deterioration due to the shortened time needed for the southbound dual right-turn lanes? Are the lengthened queues problematic?

- The southbound left-turn doesn't improve much between scenarios because any time that is freed up by improvements is given to the southbound right-turn and eastbound left-turn movements as these are much higher-volume movements.
- VISSIM – Could a queue jump lane that permits buses to leave Phoenix northbound, stay in the right lane, exit to a queue jump lane and position themselves to head north on Humphreys with a special phase be possible?
  - Yes, it likely could be done, but it would most likely not be cost-effective and would have adverse operational impacts on Humphreys/Milton.

BUTLER/MILTON

- Synchro Bundle 2 (6 GPL) – How many cars are turning right at Phoenix in Bundle 2? How does that compare to existing conditions? How many are then making the merge into the through lane? Are the assumptions here reasonable and is the merge safe?
  - The right-turning volume at Phoenix is not the issue here as it is independent of the Bundle 2 geometry. The real question is whether merging from three to two lanes should happen before or after Butler. There are approximately 1,600 northbound vehicles going through at Butler. Bundle 2 currently assumes the third northbound through lane turns into a right-turn trap lane at Phoenix, which is about 900' to the north. If instead the third northbound through lane turns into a trap right-turn lane at Butler, the intersection performance at Milton/Butler will worsen as there will only be two lanes servicing northbound vehicles instead of three. It is true that if there is a third northbound lane at Butler that becomes a trap right-turn at Phoenix, it will not be fully utilized as drivers will know of the upcoming merge. When traffic backs up significantly, however, some drivers will decide they would rather get through the traffic signal at Butler and then figure out how to merge over rather than wait through additional cycles of the signal. Typical distances for a lane drop into a trap right-turn lane are 800'-1,000' downstream of the intersection. The 900' between Butler and Phoenix is in that typical range.
- Synchro Bundle 2A (2+stop at Butler) – Regarding the northbound through lane drop at Phoenix: The 800' appears to be tolerable. The widening of Milton at Humphreys is most likely an important addition to avoid merging into the same lane. Are there any implications or opportunities related to Mike's Pike resulting from this?
  - Widening Milton would have impacts on the buildings on the northeast corner of Milton/Mike's Pike. As part of mitigating those impacts (e.g., building removals), there may be opportunities to realign Mike's Pike to connect to Milton farther north, moving it farther from the Butler/Milton intersection.
- Synchro Bundle 6 (Major intersections) – Should a Clay/Malpais/McCracken connection appear in at least one of the final scenarios? If the signal at Blackbird is not in the model and would add significant volume then this might be reconsidered.
  - The Clay connection should be in at least one final scenario and may be used as a proxy for a McCracken Lane alternative. The traffic signal at Blackbird Roost should be in all final scenarios – this will correct an existing safety and operational problem for northbound-southbound traffic trying to cross Route 66.
- VISSIM – In the Auto-Focused High Investment scenario, the westbound left-turn is poor compared to the Low Investment. This shows value of the triple lefts. What is the assumed lane utilization for each lane?
  - VISSIM parameters determine lane utilization based on driver behavior at decision points. There is not a place to input lane utilization factors in VISSIM or an output that

    provides lane utilization factors. This is different from Synchro where the user inputs the assumed lane utilization. Lane utilization in VISSIM was visually observed in the Low Investment microsimulation model runs at the Butler/Milton intersection and appeared to be relatively balanced, which seems reasonable considering the proportion of vehicles that turn right vs. go straight at the downstream Route 66/Milton intersection.

ROUTE 66/MILTON

- Synchro Bundle 2 (6 GPL) – Six general purpose lanes on Milton from Route 66 to Phoenix appears to be a great improvement. However, south of this location the effect is not as noticeable. Should this section appear in at least one of the VISSIM alternatives?
    - Yes, this section should appear in at least one of the VISSIM alternatives. It is also recommended that the six-lane section extend far enough north of Butler and south of Route 66 so drivers will actually use the third through lane at the Milton/Route 66 and Milton/Butler intersections. Ideally, this would be at least 500' on the approach side and 1,000' on the departure side of each intersection. On the departure sides, a northbound trap right-turn at Phoenix and a southbound trap right-turn at Riordan Road is recommended.
- Synchro Bundle 2 (6 GPL) – Are turning movements restricted at the Malpais/Milton intersection?
    - Bundle 2 assumes the southbound left-turn from Malpais is prohibited from a safety and operations standpoint. The northbound left-turn (and southbound left-turn) from Milton are assumed to be permitted in Bundle 2 (as it will siphon traffic away from the busy Butler/Milton intersection). Maintaining this opening allows for U-turns here if Milton is widened to six lanes through this area.
- Synchro Bundle 4 (Backage+4th leg) – Is a full fourth legged intersection detrimental in the long run? Are there gained connectivity benefits? Does this work with the triple left-turns where some of those gains are "borrowed" to offset the loss created by the fourth leg?
    - No, a full fourth leg is not detrimental to the intersection in the long run. It will be more beneficial in the long-term future than just the local access as long as it is not too attractive that it begins to take away green time from the northbound-southbound movements. The triple left-turns will help offset some of the loss created by adding a fourth leg.
- Synchro Bundle 4A (4+weak 4th leg) – Earlier analyses indicated that the full connection to NAU and Riordan Ranch would have severe consequences. This was in the range of 28 to 36 seconds vs. 28 to 54 seconds. The Bundle 4A analysis indicates that it won't have as many negative impacts: 113 to 132 (future condition vs. the other being the current condition). How can the impact of this connectivity be measured? Does it start to gain value (or lose disbenefit) in the future? The overall corridor appears to operate better with the full connection. This is counterintuitive where the sum of the intersection delay increases delay by 22 seconds for Bundle 4A. This is an important question for discussions with the landowner and for long-term value of connectivity.
    - The comparison between existing and future is not an apples-to-apples comparison and therefore it is not valid to draw conclusions from change in average delay of a few seconds between those two timeframes. A 20% increase in volumes (from existing to future) results in a high magnitude volume increase for the northbound through and southbound through movements as the existing volumes are already high for those movements. Modifying the 4th leg to only be for local access (Bundle 4A) instead of connecting to Riordan Ranch (Bundle 4) shifts some of the southbound left volume back to the southbound through movement – which is the over-capacity movement – as well as shifts some of the westbound through volume to the northbound left movement

(which must yield to the over-capacity southbound through movement). That is why the delay gets worse at Milton/Route 66 with Bundle 4A compared to Bundle 4. The overall corridor delay correspondingly is worse for Bundle 4A than for Bundle 4. Therefore, yes, under existing conditions, making the 4th leg for local access only is better than connecting to Riordan Ranch because there is still some excess capacity on the movements most impacted by that change. As volumes grow in the future on Milton, the critical movements like the southbound through movement are over-capacity, and connecting to Riordan Ranch relieves some of those movements more than just connecting to local access.

- Synchro Bundle 5 (Minor intersections) – Is modeling triple eastbound left-turns at Milton/Route 66 a valid alternative to consider?
    - Yes, modeling triple eastbound left-turns at Milton/Route 66 is a valid alternative to consider. Typical distances for a lane drop into a trap right-turn lane in Phoenix-area cities are 800’-1,000’ downstream of the intersection. There is approximately 1,150’ between Route 66 and Butler along Milton, which provides ample space for a lane drop. SimTraffic accounts for downstream changes like lane drops and can provide an estimation of how utilized the third eastbound left-turn lane would be compared to the other two lanes. This alternative would result in the need for a wider east 4th leg at the intersection to still get the eastbound through/right-turn lane to line up with the receiving lane on the east leg. The bus stop on Milton would likely need to be pushed farther to the outside to create a bus pullout rather than having the bus stop right where the through lane would transition to a trap right-turn lane.
- VISSIM – What happened to the Transit-Focused High Investment eastbound left-turn? Did it lose time to the northbound-southbound movements relative to the Low Investment and the Auto-Focused High Investment scenarios?
    - Yes, the triple eastbound left-turns and different southbound right-turn treatments result in different allocations of signal timing splits. The Low Investment scenario includes a channelized southbound right; the Auto-Focused High Investment scenario includes dual southbound right-turn lanes; the Transit-Focused High Investment scenario only includes a single southbound right-turn lane. This is why the performance is worse for the Transit-Focused High Investment scenario.
- VISSIM – Why did eastbound left-turn at Route 66 deteriorate so much?
    - While the eastbound left movement delay increases from 47 seconds to 57 seconds, the queues decrease from 586’ to 549’, and the overall intersection LOS/delay improves from LOS C (23 seconds) to LOS B (19 seconds). These changes are most likely due to model variability. Every time a run is completed in VISSIM, slightly different results will be generated due to the use of random number generators in determining arrival of vehicles. At the intersection level, a change in total delay of a few seconds is not uncommon between model runs of the same scenario. The queue lengths are generally a better indicator of what is going on for a congested corridor like Milton (except for peculiarities like when a vehicle gets “stuck” in the model) as they reflect cumulative effects of congestion over multiple signal cycles.

RIORDAN/MILTON

- VISSIM – With a 20% increase in traffic and no improvements in the immediate vicinity, why would there be improvement at Riordan/Milton from Existing Baseline to Future Baseline?
    - A comparison of the queues between the Existing Baseline and Future Baseline models shows that queues are significantly longer for the Future Baseline. The reason why the

delay and LOS don't change significantly is that the green time is long enough so that the queues still clear in one cycle. In other words, there is a significant amount of "unused" green time in the Existing Baseline where the signal is green but there aren't many vehicles passing through the intersection every second because those that were queued initially cleared early in the green phase. In the Future Baseline, the amount of "unused" green is reduced, but not to the point where vehicles are not clearing on each phase.

UNIVERSITY/MILTON

- VISSIM – What caused the eastbound and southbound queuing that emerged at Milton/University?
    - Everything at this intersection is constant between the Future Baseline and the Low Investment scenarios except for the transit-related improvements of a change in bus routing (turn at University instead of Forest Meadows), increased frequency of buses to 15-minute headways, and the addition of transit signal priority phasing, which can extend the green time for a movement containing a bus by up to 10 seconds. These transit-related differences could be contributing to the change in queuing, but don't seem to be significant enough to cause a dramatic increase in queuing. The more likely potential contributing factor is model variability. Each of the five model runs conducted for this scenario were examined. Three of the runs have eastbound queues less than 400', while the other two runs have eastbound queues greater than 1,000'. It appears something unusual occurred in the two runs with queues greater than 1,000'. For example, a vehicle "stuck" at the end of the link trying to change lanes when the lanes are running close to capacity, which resulted in an abnormally long queue. The 8-second change in intersection delay from 48 seconds to 56 seconds is not very large, but it does happen to cross the level of service (LOS) D to LOS E threshold of 55 seconds.

BLACKBIRD/ROUTE 66

- VISSIM – How is Blackbird/Route 66 working in all of these scenarios?
    - No major queuing issues were observed. Specific level of service and delay data can be extracted from the node data. This data is shown in the report.
- VISSIM – Why did the Low Investment scenario eastbound left increase so much? This is an important movement for the La Plaza Vieja neighborhood. It is somewhat comparable to the Clay eastbound left-turn at 85 and 78 seconds in the Existing and Future Baselines. Given concerns about this intersection, it is worth noting the 95% queue for the WB approach is 193 feet compared to approximately 600' distance to Milton.
    - It is important to note that the poor LOS for the eastbound left-turn movement at Route 66/Blackbird Roost in the Low Investment scenario is likely attributable to the lack of acceptable gaps in westbound traffic due to the free-flow channelized southbound right-turn at Milton/Route 66.

YALE EXTENSION

- Synchro Bundle 6 (Major intersections) – Is the relocation of the Plaza intersection more land use dependent than operational?
    - Yes, the relocation of the Plaza intersection is more land use dependent. Moving this intersection is not recommended unless there is a definitive land use reason for doing so.
- Synchro Bundle 6 (Major intersections) – Are there other options for improving pedestrian crossing spacing on Milton besides extending Yale east to Milton?

- A potentially less-disruptive solution to providing better pedestrian crossing spacing on Milton would be providing a pedestrian signal at this same general location or wherever pedestrian activity is highest between University and Riordan. This would most likely be more cost-effective and would not require right-of-way acquisition or reconfiguration of land uses. The Bundle 6 analysis indicated moving the Plaza signal to the Yale alignment, but doesn't do much for corridor progression. There are enough variables in the bundles between backage roads, transit options, widening options – removing the extension of Yale will help make it easier to discern what changes occur and why between the different bundles. The Bundle 5 analysis indicated pedestrian signals can be added on Milton without significantly impacting corridor progression.