LONE TREE OVERPASS

SUSTAINABILITY and INTERSECTION REFINEMENTS

January 25, 2022

AGENDA

- Project Updates
- Approach
- Sustainability
- Intersection Refinements

Project Updates

Project Updates

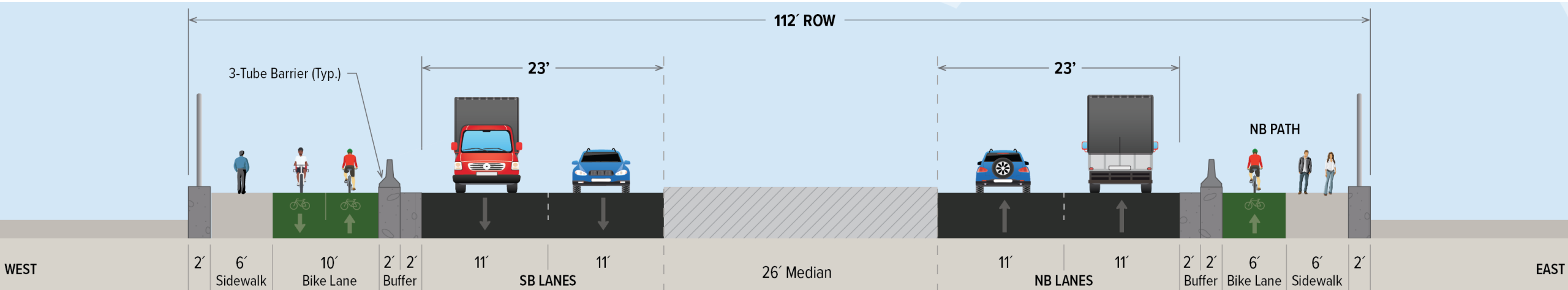
- **Coordination with Beautification, Arts & Sciences**
  - » Staff meeting held on December 9th, 2021
  - » Presentation to the BPAC commission occurred on January 10
  - » Planning Outreach for a Community Forum to seek input early 2022
- **Pedestrian and Bicycle Advisory Committees**
  - » City staff discussed project and permissive / controlled rights at intersections
- **Coordination with BNSF and USACE regarding the RDF Flood Control Project**
  - » Meeting held on December 8th, 2021
- **Additional City staff and Commission Coordination Meetings**
  - » Meeting held with Sustainability staff on December 8th, 2021
  - » Meeting held with Transportation/Pedestrian/Bicycle/Inclusion and Adaptive Living Commissions and Committees on January 13th, 2022

Approach

- Team Experience
- Project Overview
- Approach to Analysis
  - Respond to Feedback
  - Provide Data for Evaluation

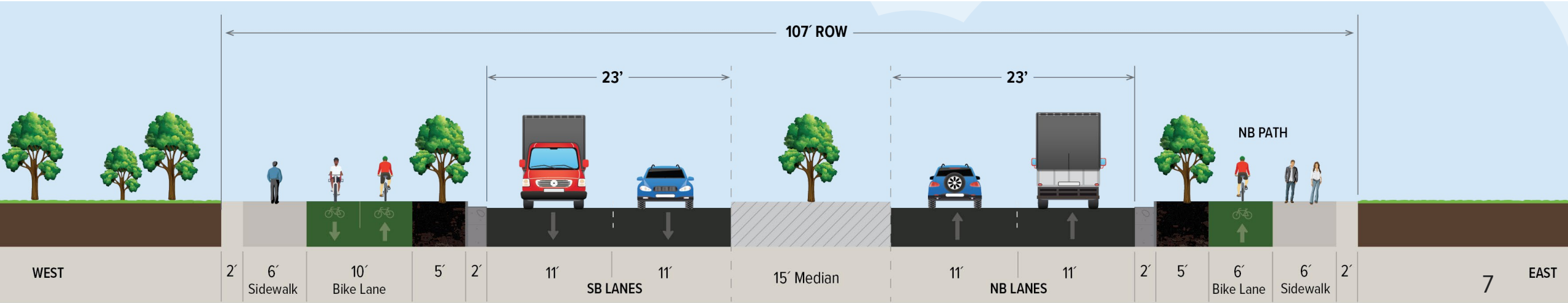
Project Summary – What this Project Provides

- 1.8 Miles of new Bicycle Lane Miles (Off-Roadway)
- 1.2 Miles of new Pedestrian Sidewalk
- 0.6 Miles of new FUTS connecting Route 66 to Sawmill
  - » Designed for E-Bikes, Class 2
- Protected bike and pedestrian facilities along full length of Lone Tree Road



Project Summary – What this Project Provides

- 0.3 Miles of new roadway between Butler Avenue and Route 66
- 0.3 Miles of roadway widening between Butler Avenue and Sawmill Road
- 1.8 new Roadway Lane Miles
- 1 New Intersection at Lone Tree and Route 66
- 3 New Rebuilt Intersections at Butler Avenue, Sawmill Road, and Franklin Avenue



Sustainability

GOALS

- **Project approach to Vehicle Miles Traveled (VMT)**
- **Approach to VMT in Public Works and Transportation Infrastructure**
- **Alternative look using greenhouse gases**

Sustainability – VMT Goals

- **City of Flagstaff Goal**
  - Reduce Vehicle Miles Traveled (VMT) to 2019 VMT Levels
  - VMT is measured/analyzed using regional network traffic models
- **Regional tools available for measuring VMT**
  - Project used MetroPlan's Regional Model
    - ☑ Developed before formal adoption of the Sustainability Goals
  - Scenarios
    - ☑ 2019 No-Build Scenario (36,004 dwelling units, 12,093 commerce(ksf))
    - ☑ 2026 Build / No-Build Scenario | 37,768 dwelling units | 12,630 commerce(ksf) (~0.7%/yr)
    - ☑ 2040 Build / No-Build Scenario | 46,556 dwelling units | 16,357 commerce(ksf) (~1.3%/yr)

Sustainability – Modeling Approach and Results

✧ MetroPlan Regional Model Updates

- » Incorporated Land-Use Changes (Hospital, Zoning, Etc.)
- » Incorporated Identified Funded Capital Infrastructure into the 2040 model
- » Evaluated a 2-Lane and 4-Lane Lone Tree Overpass Scenario for Greenhouse Gas (GHG) analysis

✧ Regional VMT Results (Given as per day)

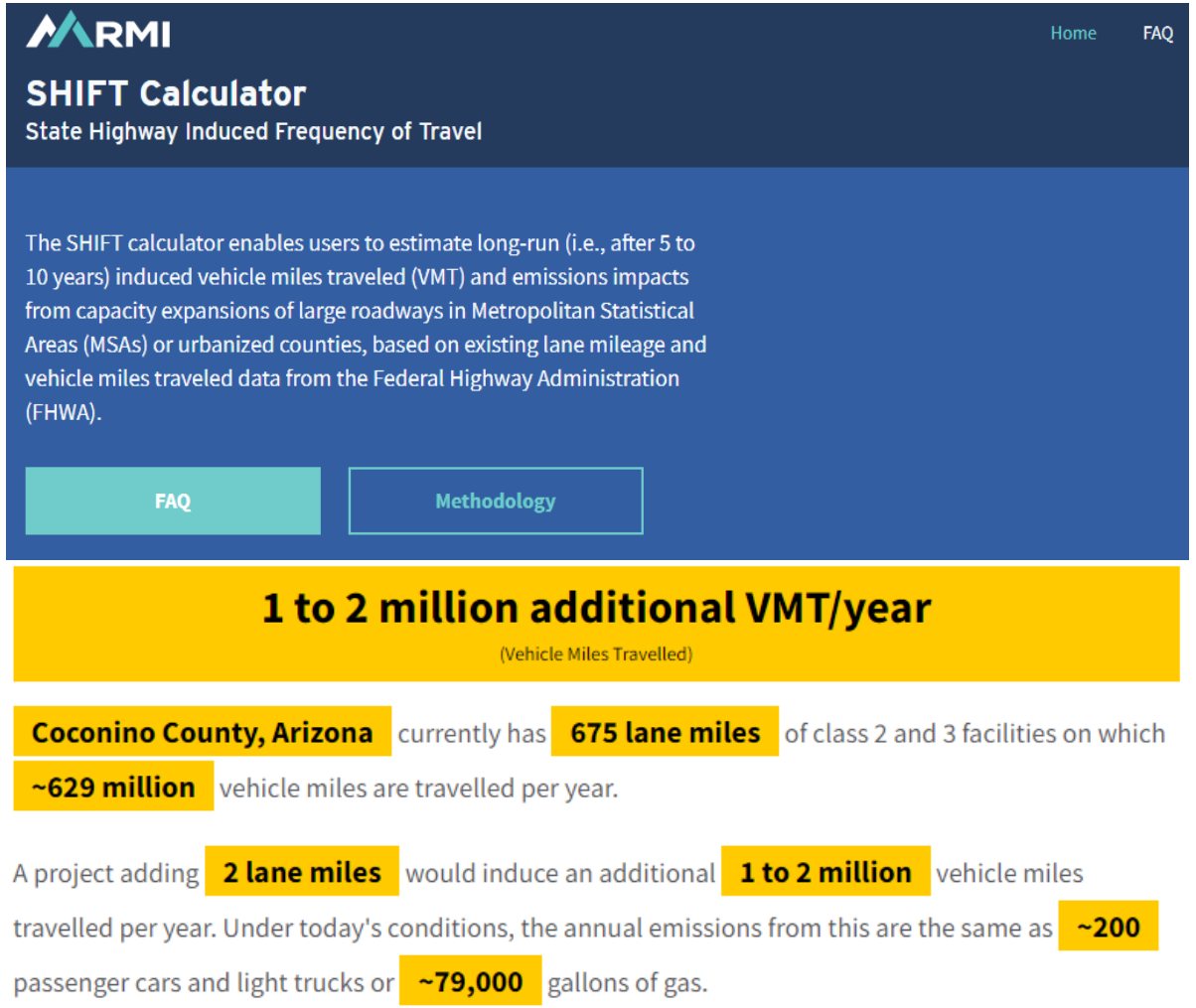
- » No significant change with Build Scenario (Lone Tree Overpass)
- » 2040 Increases due to regional growth projections (standard approach)

Year	No-Build VMT		Build VMT	
2019	2,560,198		--	
2026	2,604,834	+ 2%	2,603,984	+ 2%
2040	3,423,404	+ 34%	3,434,924	+ 34%

Sustainability – Induced Demand

✧ Induced Demand

- » Induced Demand is increase in travel based on additional capacity / improved network
- » RMI "SHIFT" Calculator based on new roadway capacity
- » The City is working on their own calculator, not yet available
- » LTO Project adds 1.8 lane-miles
- » Increase of 2,800 – 5,500 VMT/day
  - ☑ ~0.2% increase in network modeled
  - ☑ Less than the 2026 Build year modeled

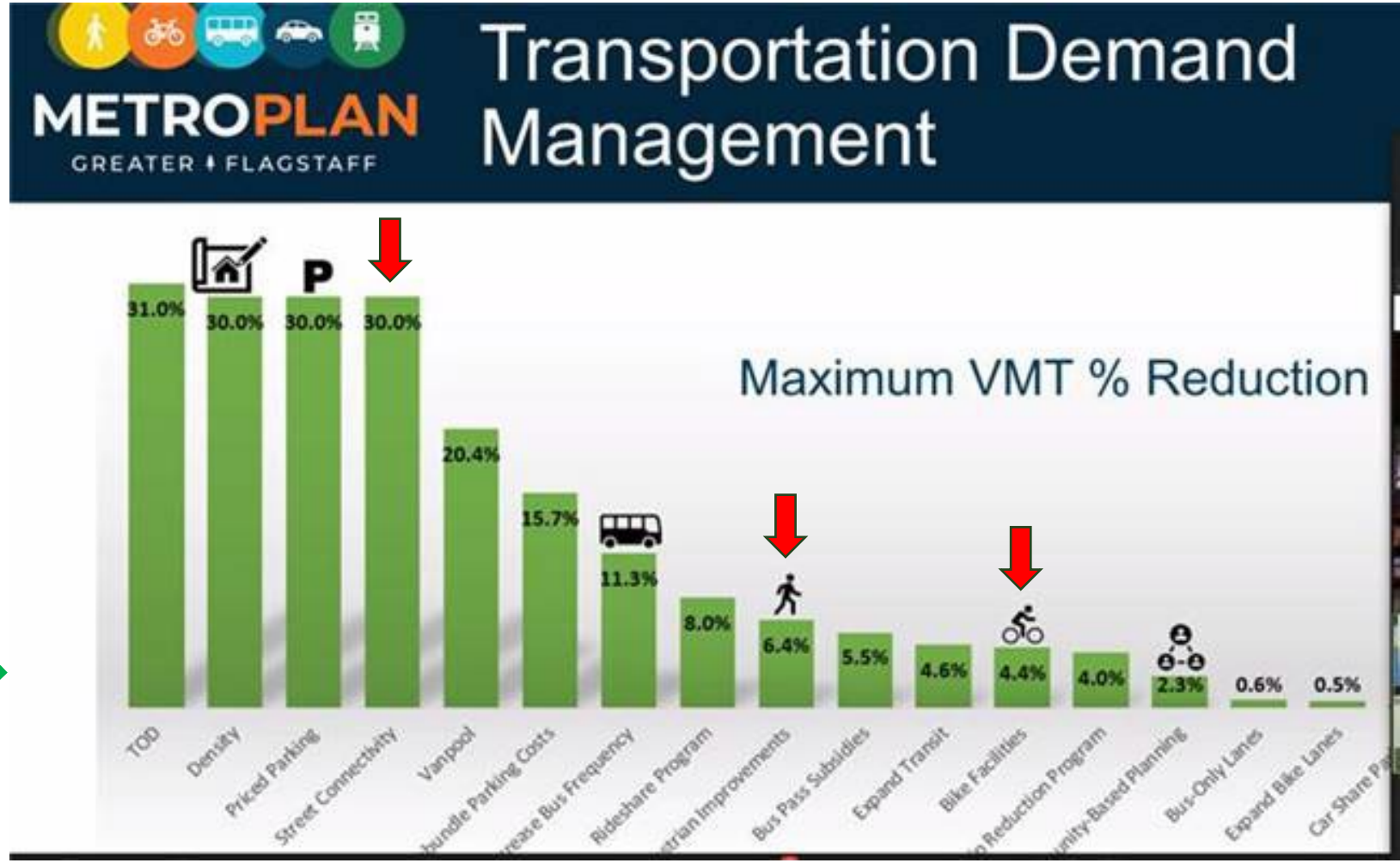


Sustainability – VMT Goals

- **How can VMT be incorporated into Public Works**
  - Typically, VMT is a PLANNING level decision
  - Public Works projects involving roadway capacity balance new roadways with offsets elsewhere. For example, a new roadway is offset by:
    - ☑ Roadway lane reductions on other street networks
    - ☑ Increased Public Transportation
    - ☑ Carpool and Ride Share Programs
    - ☑ Increase Bicycle and Pedestrian Infrastructure (Reduce Vehicle Trips)
  - At a project level (after planning), it is difficult to reduce VMT impacts on a project.
  - We can still evaluate greenhouse gas impacts at the intersection and network level, a secondary component of the City's Carbon Neutrality Plan.

Sustainability – VMT Reductions

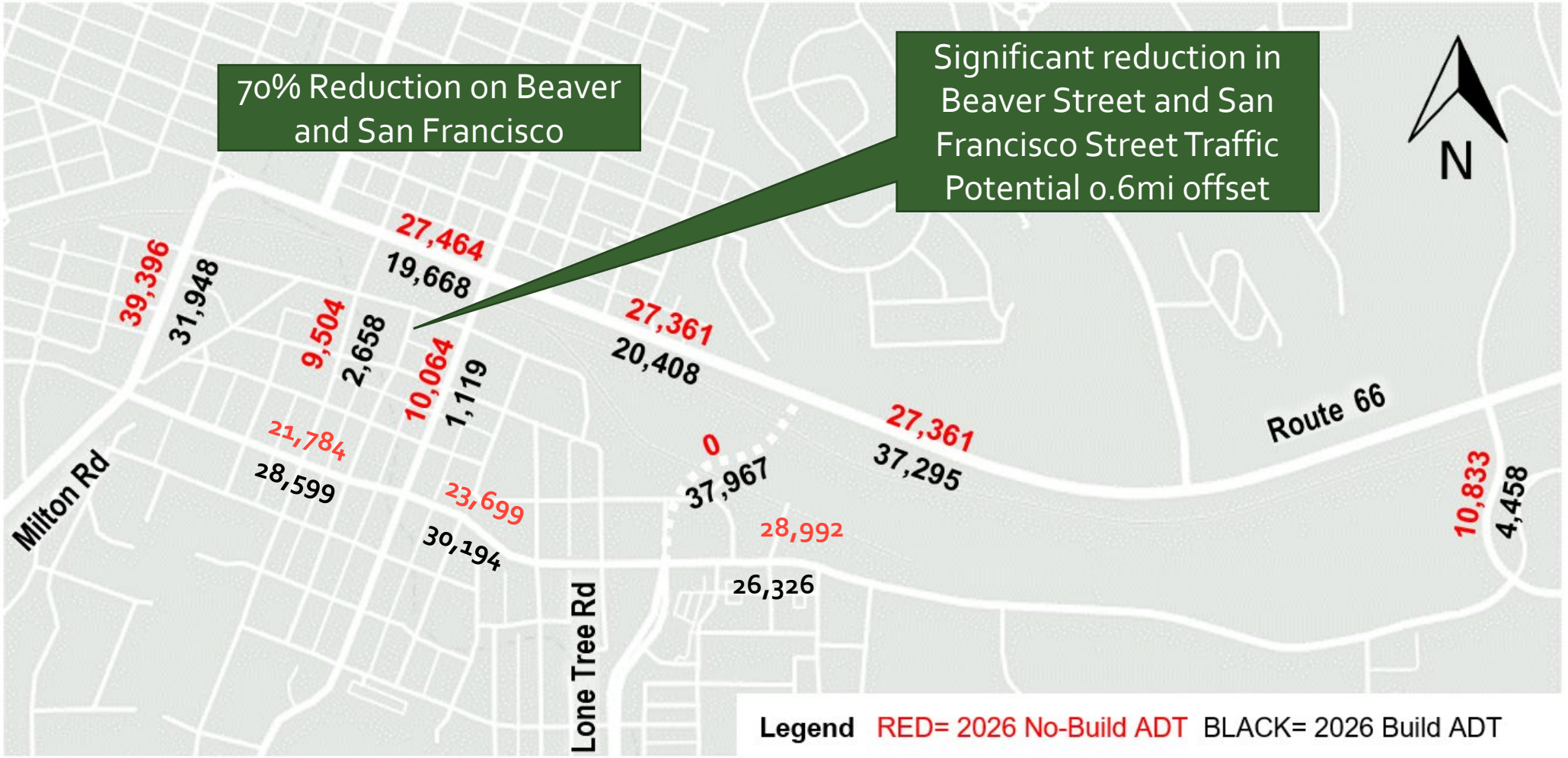
- **Options to reduce VMT Regionally**
  - » Increased transit (bus)
  - » Increased FUTS connectivity / Pedestrian Improvements / Bike Facilities – PROJECT GOAL ✓
  - » Street Connectivity ✓
  - » Corridor Changes Elsewhere



Sustainability – VMT in Network Model

Year	VMT
2019	2,560,000
2026 B	**2,605,000**
2026 NB	**2,604,000**
2040 B	3,423,000
2040 NB	3,435,000

B = Build
NB = No-Build



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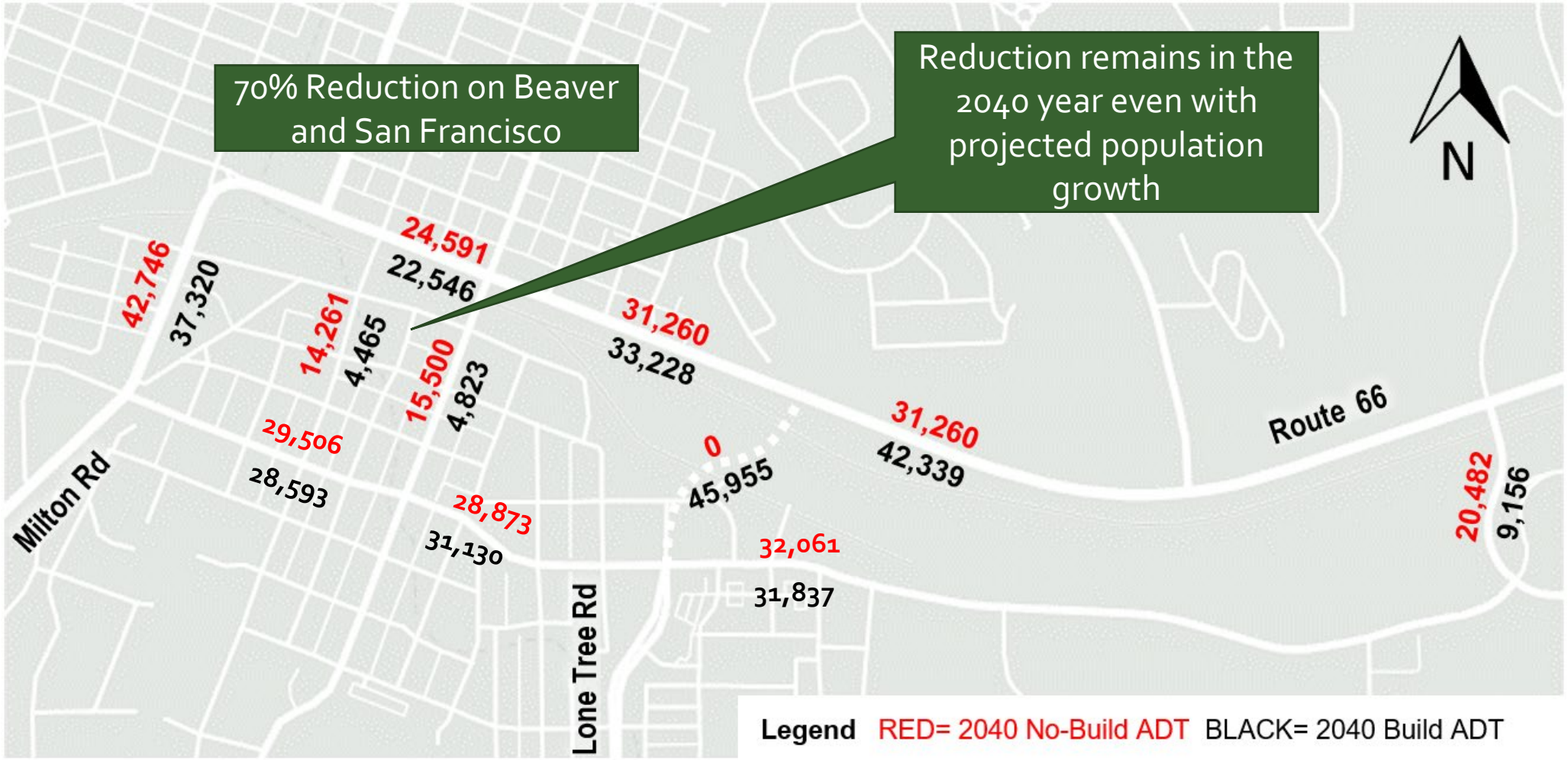


Sustainability – GHG Emissions

✧ Greenhouse Gas (GHG) Emissions Evaluation

- » Compared 2-Lane LTO and 4-Lane LTO options
- » Fuel consumption and emissions based on volume and congestion
- » Based on MetroPlan Regional Model outputs

Estimated Yearly Savings – 2026 Build Year				
2026 Year	2-Lane LTO	4-Lane LTO	2-Lane LTO	4-Lane LTO
Fuel Used (Gallons)	122,100	285,900	43,100	206,900
CO_2 Emissions (Tons)	1,100	2,600	390	1,860
			With Induced Demand GHG Impacts Included	

With continued VMT growth, savings diminish over time. Per models used, savings reverse with 4-Lane scenario by 2040 and with 2-Lane scenario by 2047

Sustainability – Takeaways

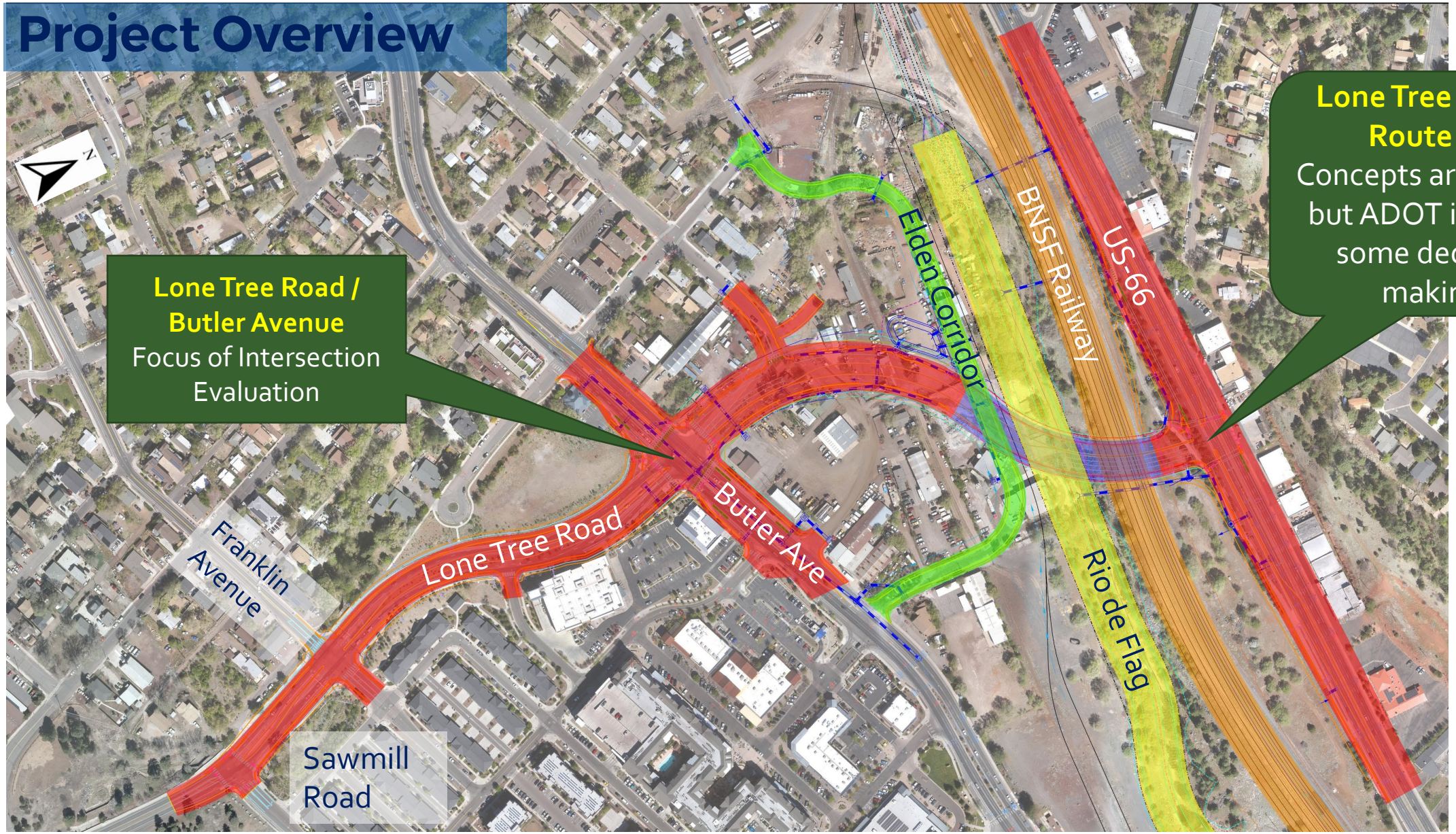
- 2026 VMT is approximately the same to 2019 VMT numbers (2% change overall)
- Lone Tree Overpass project has a minimal impact on VMT compared to regional growth assumptions (0.2% vs 2% 2026 VMT growth)
- There are offsets that are difficult to quantify that reduce impacts and others that can be taken to further reduce VMT impacts
  - Project provides FUTS connectivity, Pedestrian and Bike facilities
- 4-Lane Lone Tree Overpass project potentially reduces greenhouse gas emissions compared to no-build or 2-Lane scenarios even with a conservative Induced Demand assumption

✧ Intersection Refinements and Analysis

GOALS

- Review 4 refined intersection alternatives at Butler
- Identify Pedestrian/Cyclist User Impacts
- Identify Driver Impacts
- Identify Cost Impacts

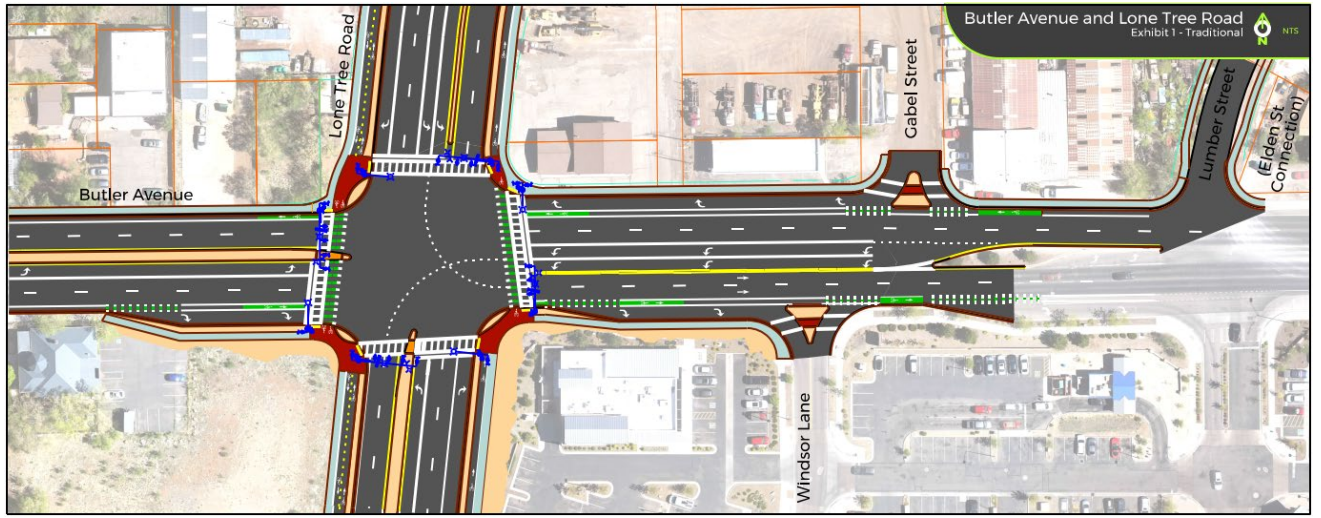
Project Overview



LTO & Butler – Intersection Options

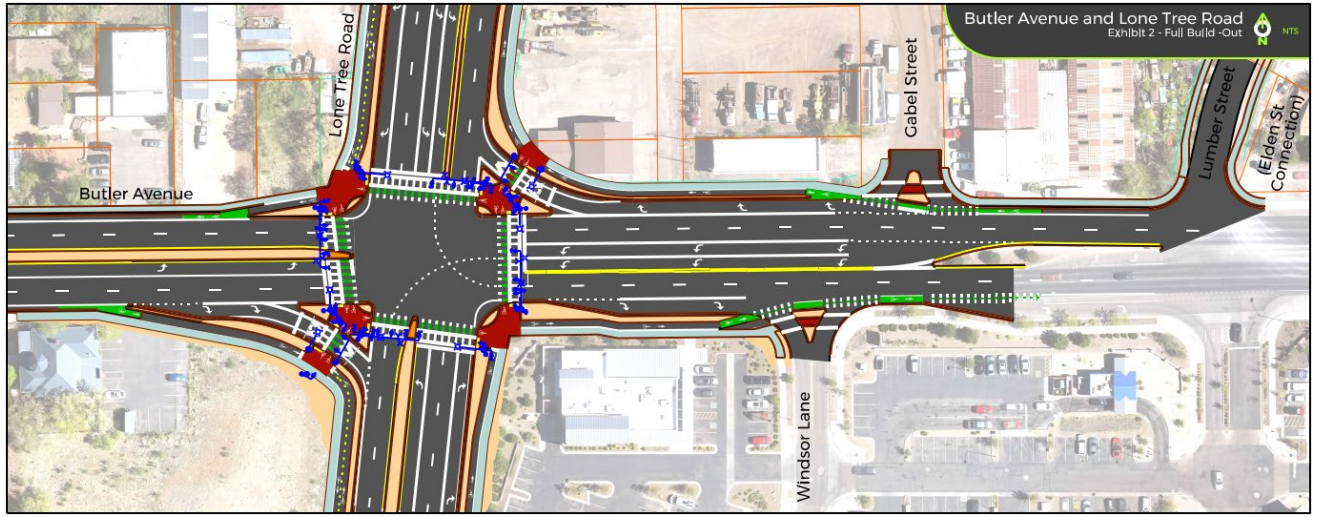
Typical Approach 1

- Two left-turn lanes (SB, WB)
- Channelized right-turn lanes (None)
- Separated bike lanes (LTO)
- Raised median (S, W)



Full Build-Out 2

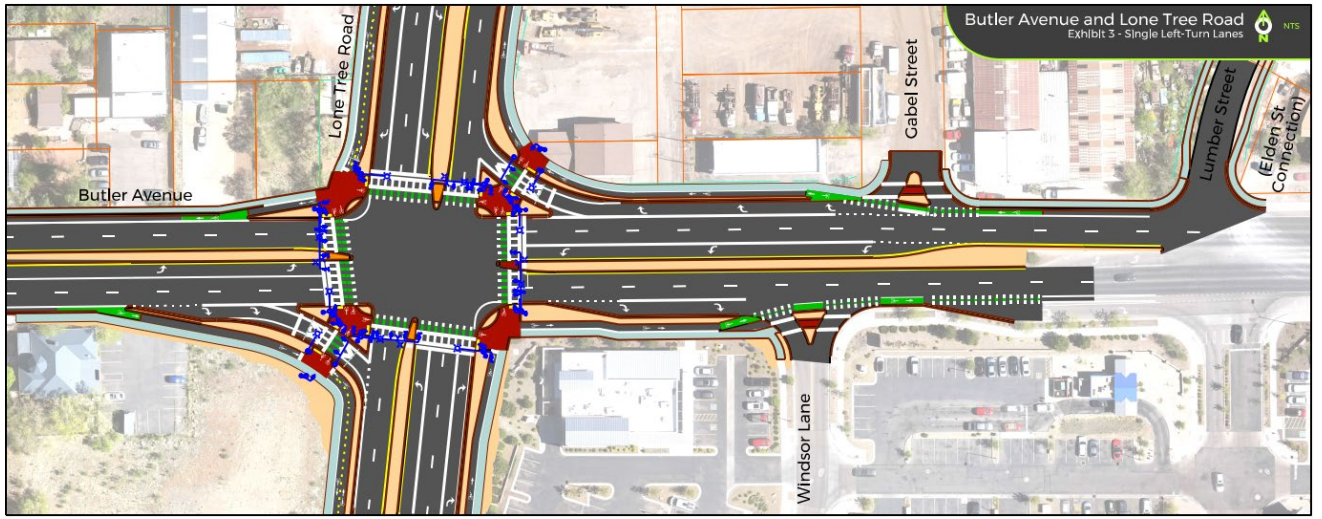
- Two left-turn lanes (SB, WB)
- Channelized right-turn (EB, WB)
- Separated bike lanes (LTO & Butler)
- Raised median (S, W)



LTO & Butler – Intersection Options

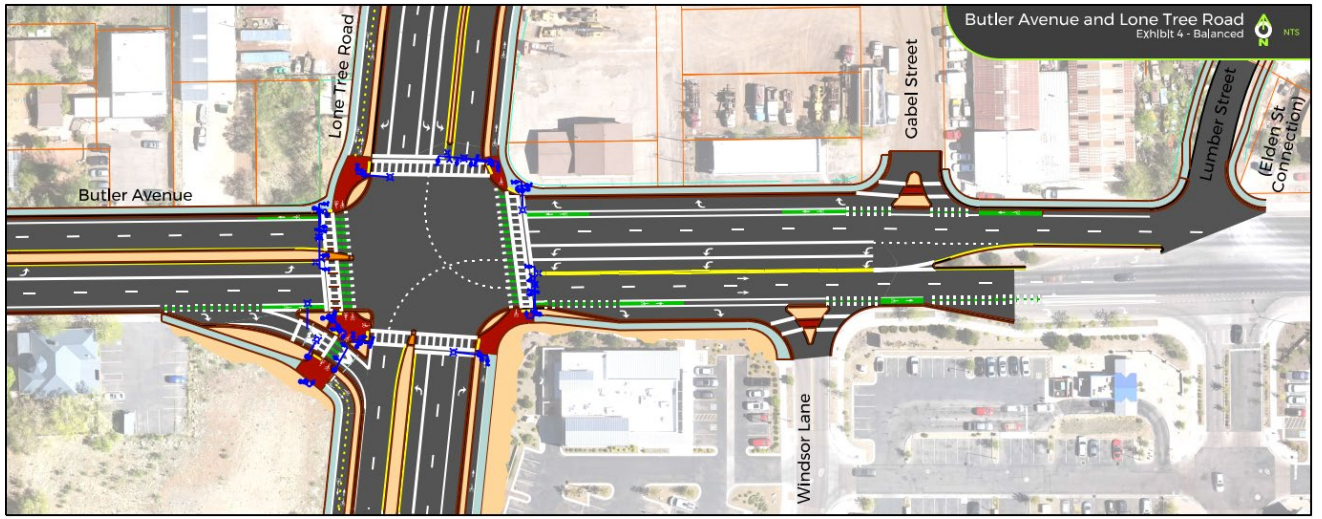
Single Left-Turn Lanes 3

- One left-turn lane (All)
- Channelized right-turn (EB, WB)
- Separated bike lanes (LTO & Butler)
- Raised median (All)



Balanced 4

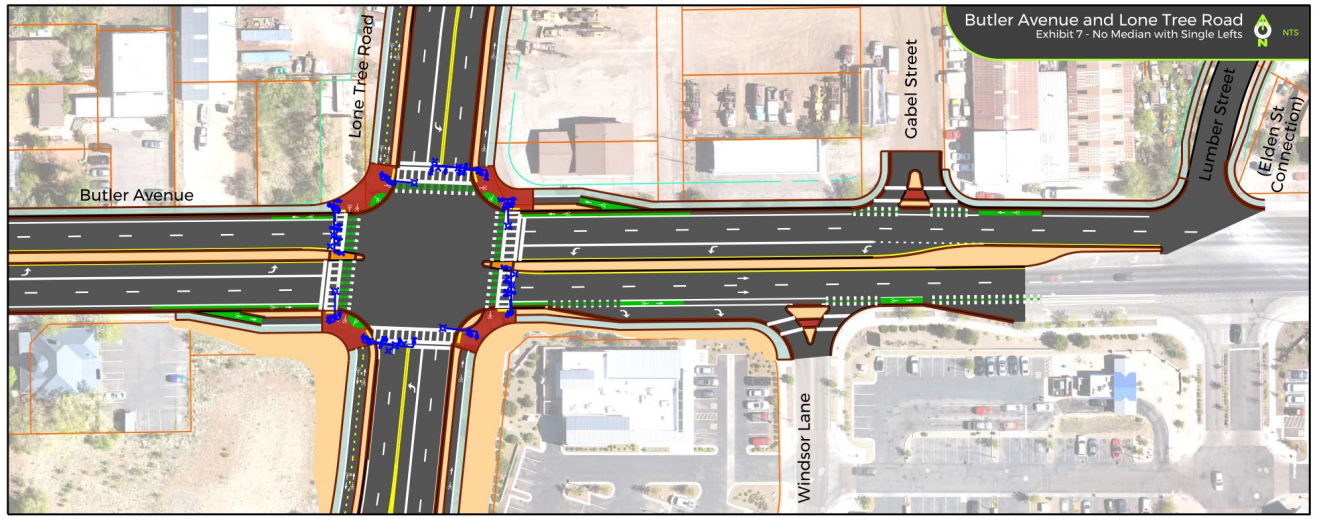
- Two left-turn lanes (SB, WB)
- Channelized right-turn (EB)
- Separated bike lanes (LTO)
- Raised median (S, W)



LTO & Butler – Intersection Options

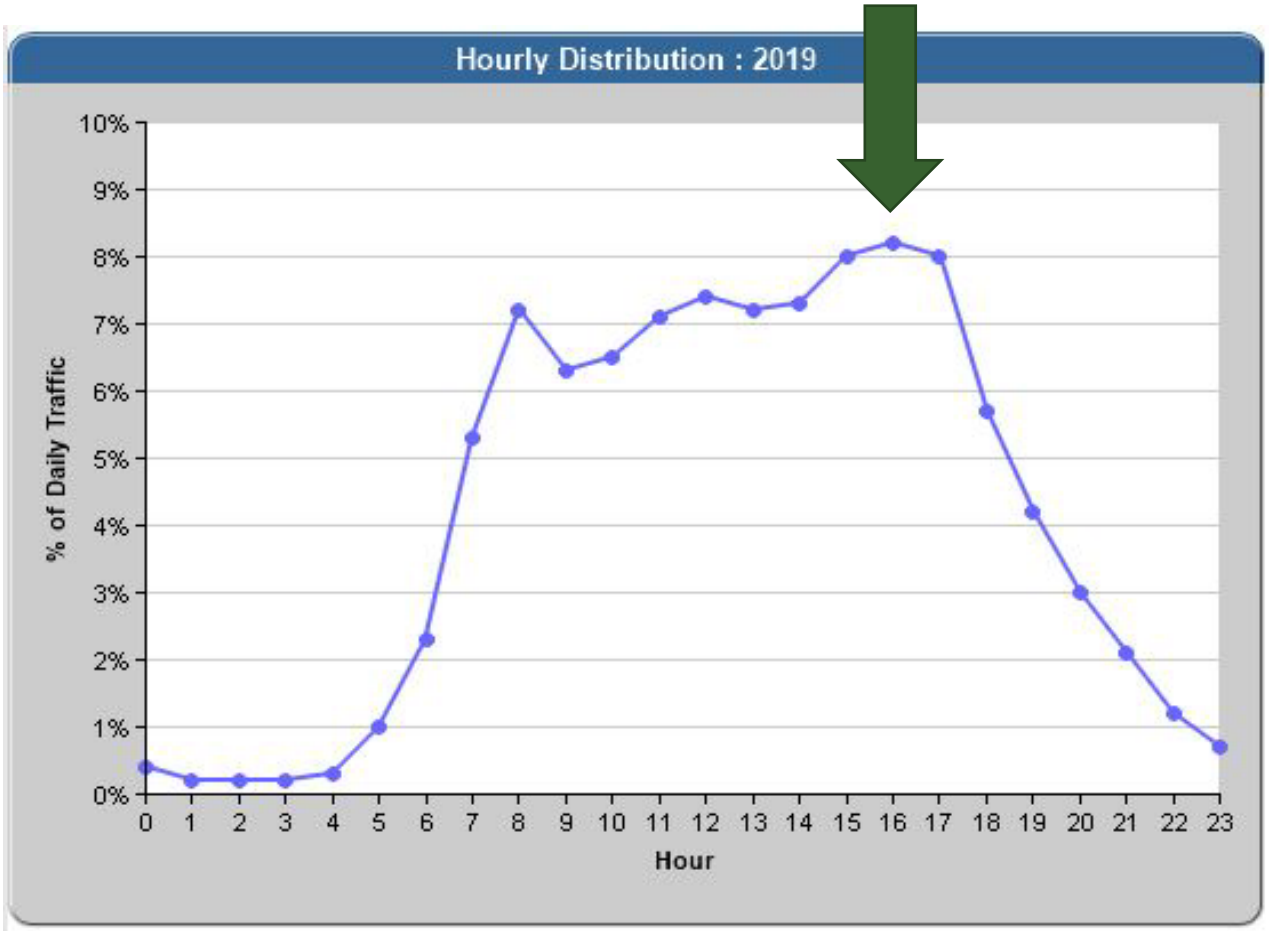
Traditional Intersection 5

- Single left-turn lanes (All)
- Shared Through/Rights (All)
- Separated bike lanes (LTO)
- Raised median (E, W)

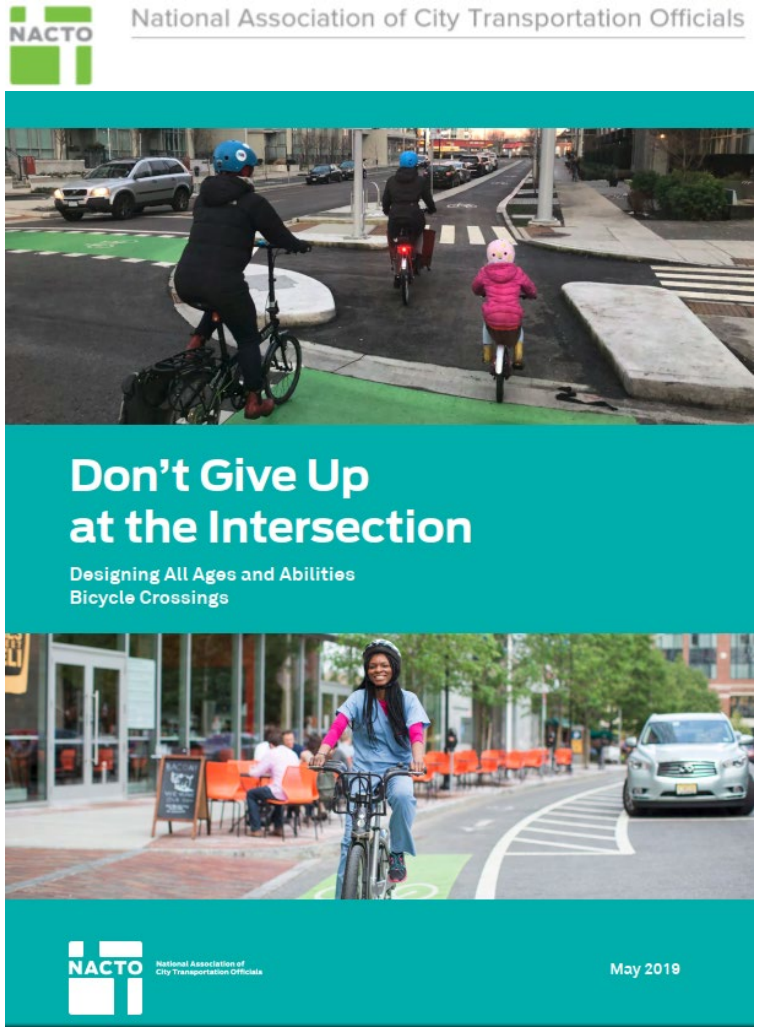


Modeling Approach – Peak Hour Analysis

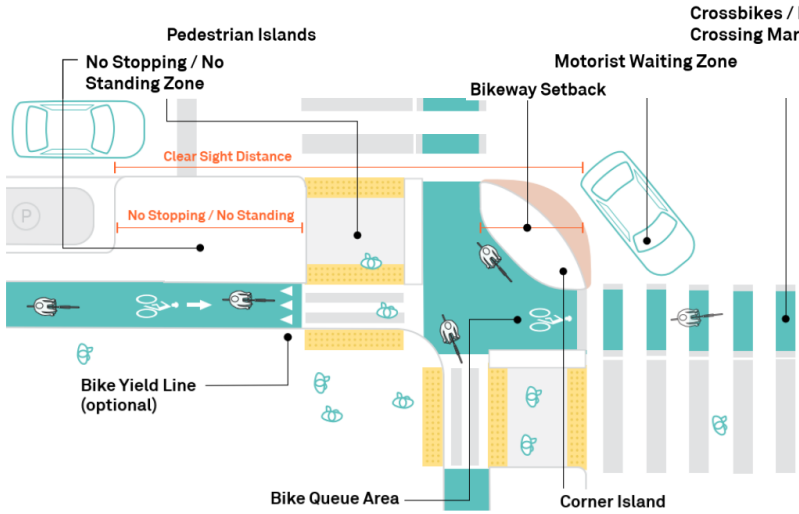
- Peak Hour is a Standard Modeling Approach
- Ensures functionality for worst hour on AVERAGE day
- Not worst hour of worst day of the year
- Approximately 8.1% of ADT
- Representative of 8%-15% increase over normal hourly traffic between 8am and 6pm



Approach to Multi-Modal Safety

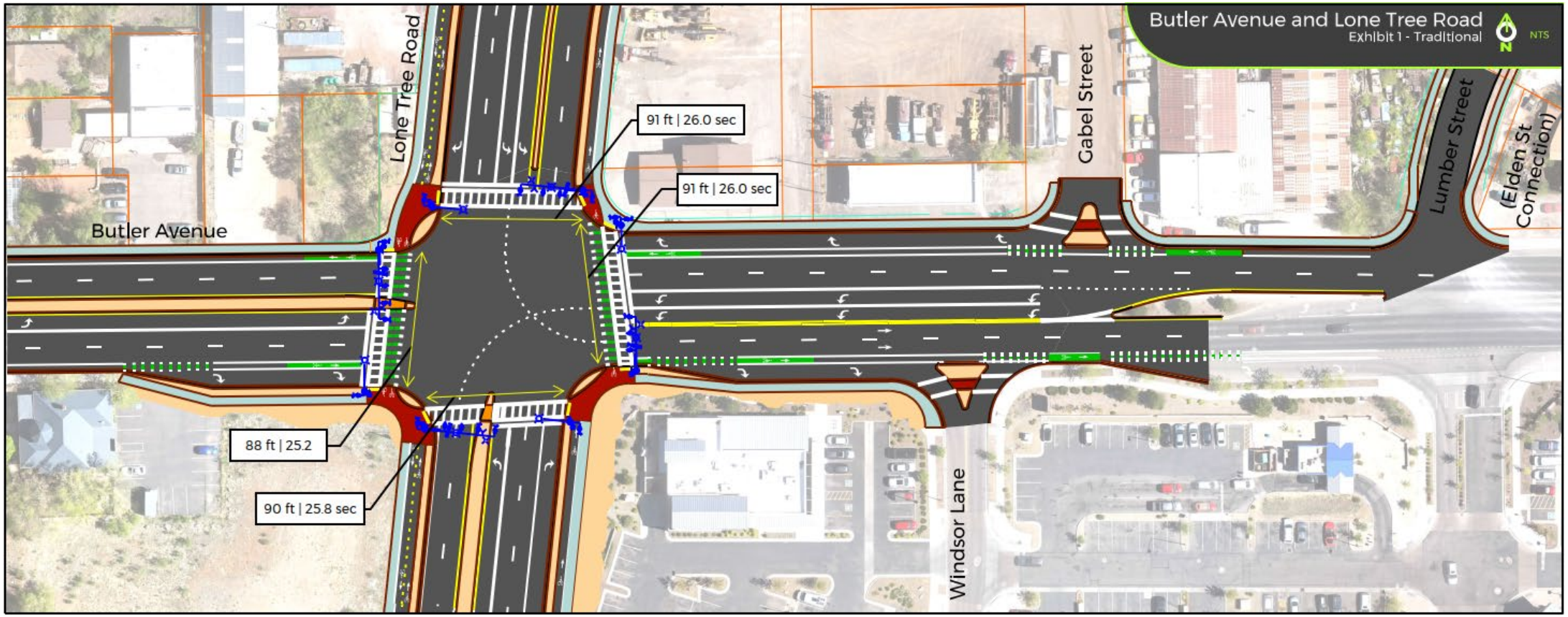


- NACTO considered most current standard for "safe" intersection
- Geared towards designing for safety for all users and abilities
- Off-System Bicycle Facilities follows ATMP



LTO & Butler – Typical Approach

1



Vehicle Features

- Two left-turn lanes (SB, WB)
- Channelized right-turn lanes (None)

Bicycle Features

- Separated bike lanes (LTO)

Pedestrian Features

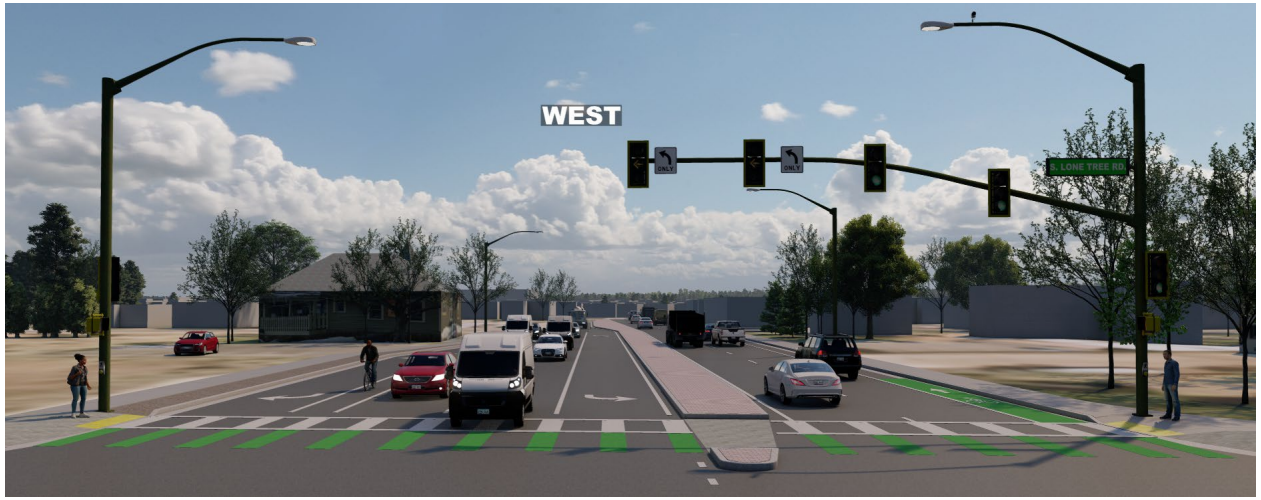
- Raised median (S, W)

LTO & Butler – Typical Approach | Looking NE

1

LTO & Butler – Typical Approach

1



Facing West | EB Approach

Facing East | WB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
East Leg	91	26.0	5.0
West Leg	88	25.2	4.8

Refuge Island only on Eastbound Approach.
Protected Cyclist Crossing.

LTO & Butler – Typical Approach

1

Facing North | SB Approach

Facing South | NB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
North Leg	91	26.0	5.0
South Leg	90	25.8	4.9

Refuge Island only on Northbound Approach. Cyclist Crossing on roadway or with pedestrians.

LTO & Butler – Typical Approach

1

- **Design Feature**
  - Pedestrian longest crossing distance 91 ft
  - Pedestrian longest crossing time 26.0 s
  - Bike longest crossing time 5.0 s
  - Available Green Time 33.7s (EB/WB Thru-PM)

Ped /Bike Crossing	Distance (ft)	Ped Time (sec)	Min. Bike Time (sec)
North Leg	91	26.0	5.0
South Leg	90	25.8	4.9
East Leg	91	26.0	5.0
West Leg	88	25.2	4.8

- **Pedestrian crossing times are based on 3.5 ft/s | 2.4 mph**
  - Per the Manual for Uniform Traffic Control
  - Assumes complete crossing during one single green phase
  - Older Pedestrians, 2.8 ft/sec.(FHWA) Longest Crossing time 32.5 sec
- https://view.mylumion.com/?p=bjlavl98e9j4eceb

LTO & Butler – Typical Approach

1

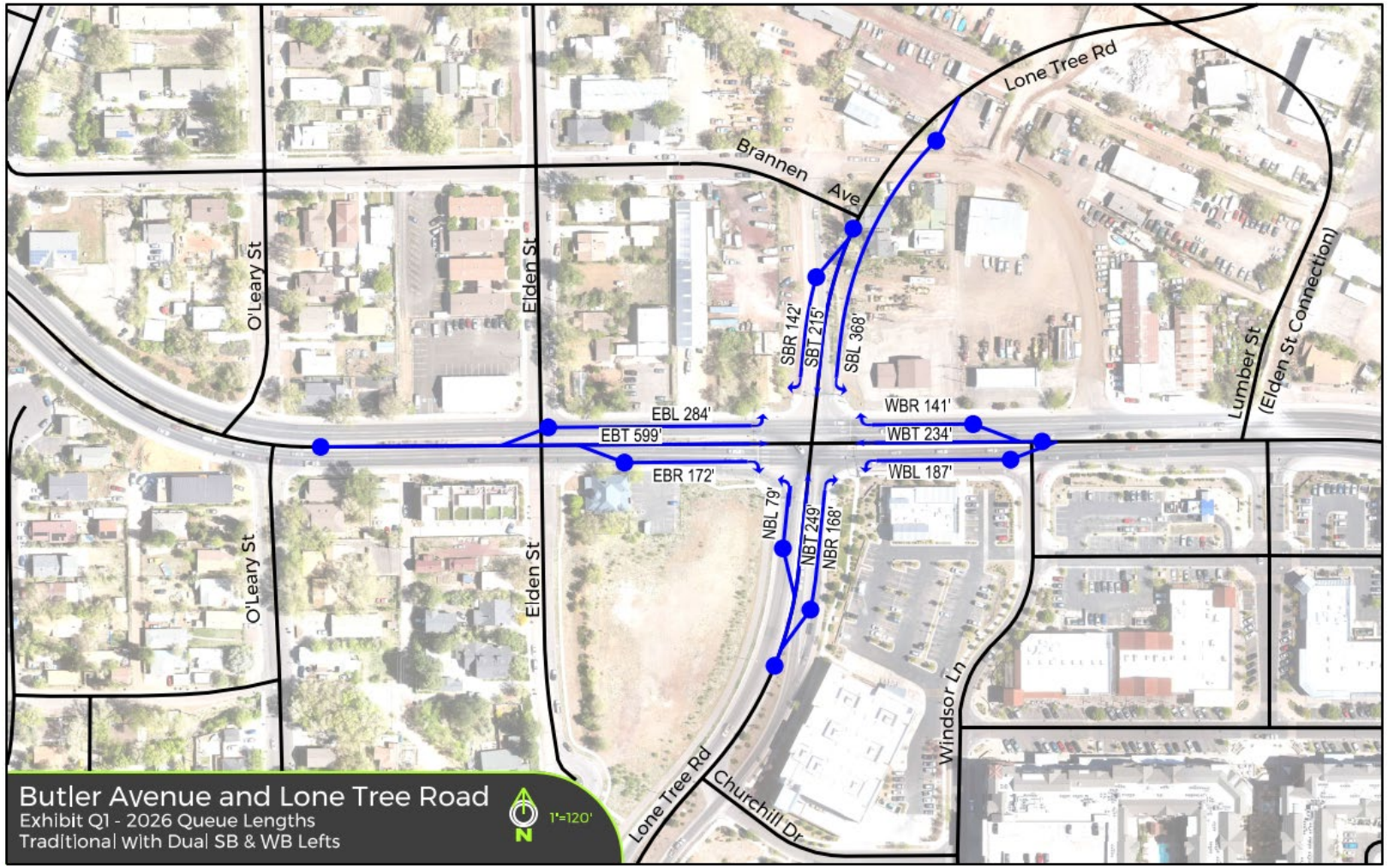
- **Performance (2026 PM Peak)**
  - Overall Level of Service D
  - Average Vehicle Delay: 46.9 sec
  - Queuing: Longest queue 599 ft
- **Performance (2040 PM Peak)**
  - Overall Level of Service E
  - Average Vehicle Delay: 70.7 sec
  - Queuing: Longest queue 772 ft

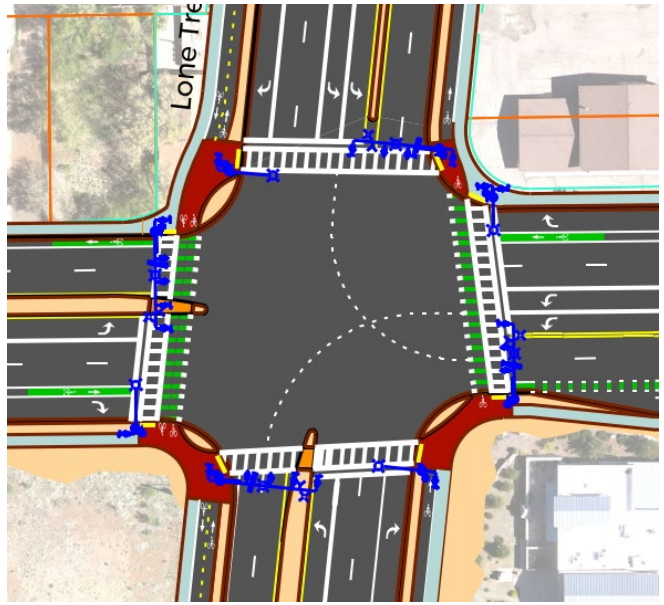
Year	Total Vehicle Delay (hours)	Fuel Used (gallons)
2026 (PM)	58	57.0
2040 (PM)	111	91.8

LTO & Butler – Typical Approach

1

» Maximum Queues - 2026

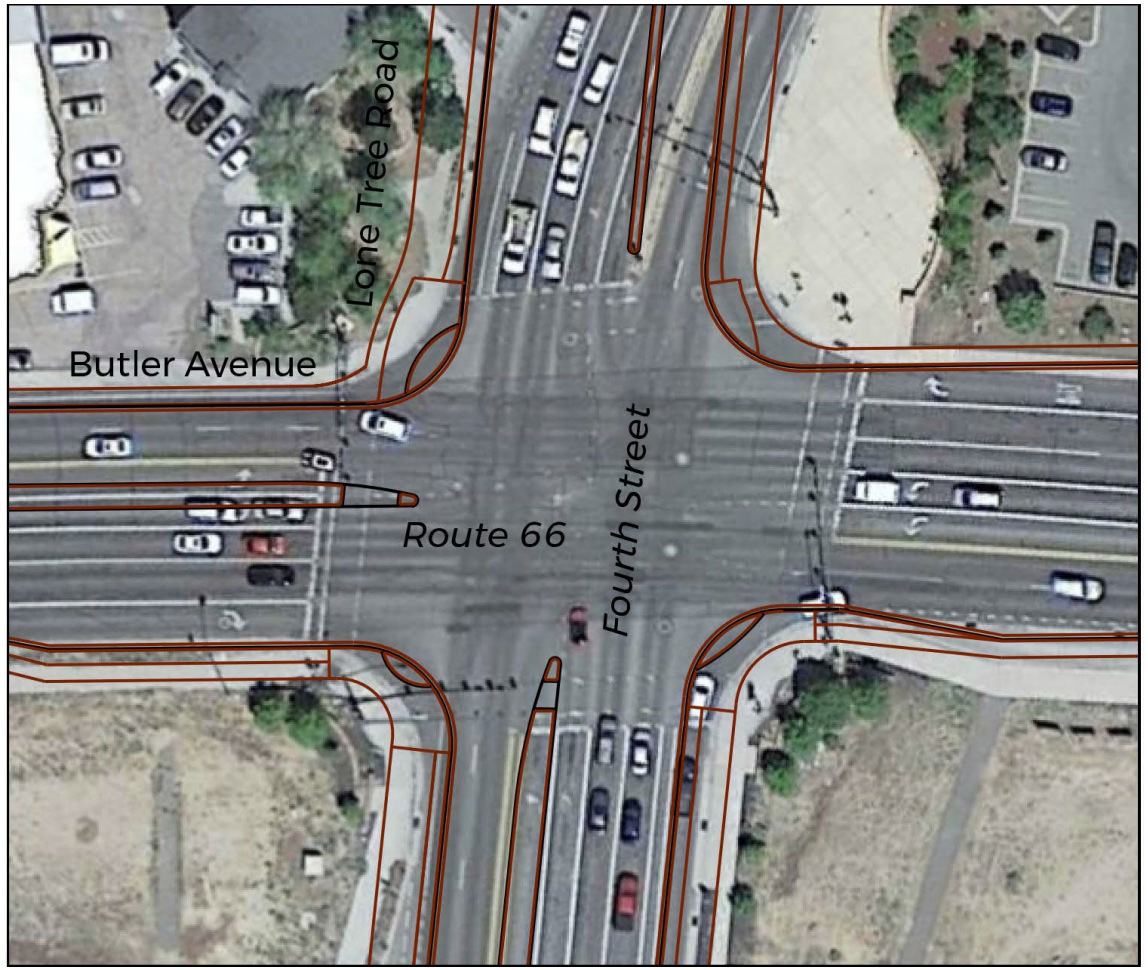




LTO & Butler – Typical Approach

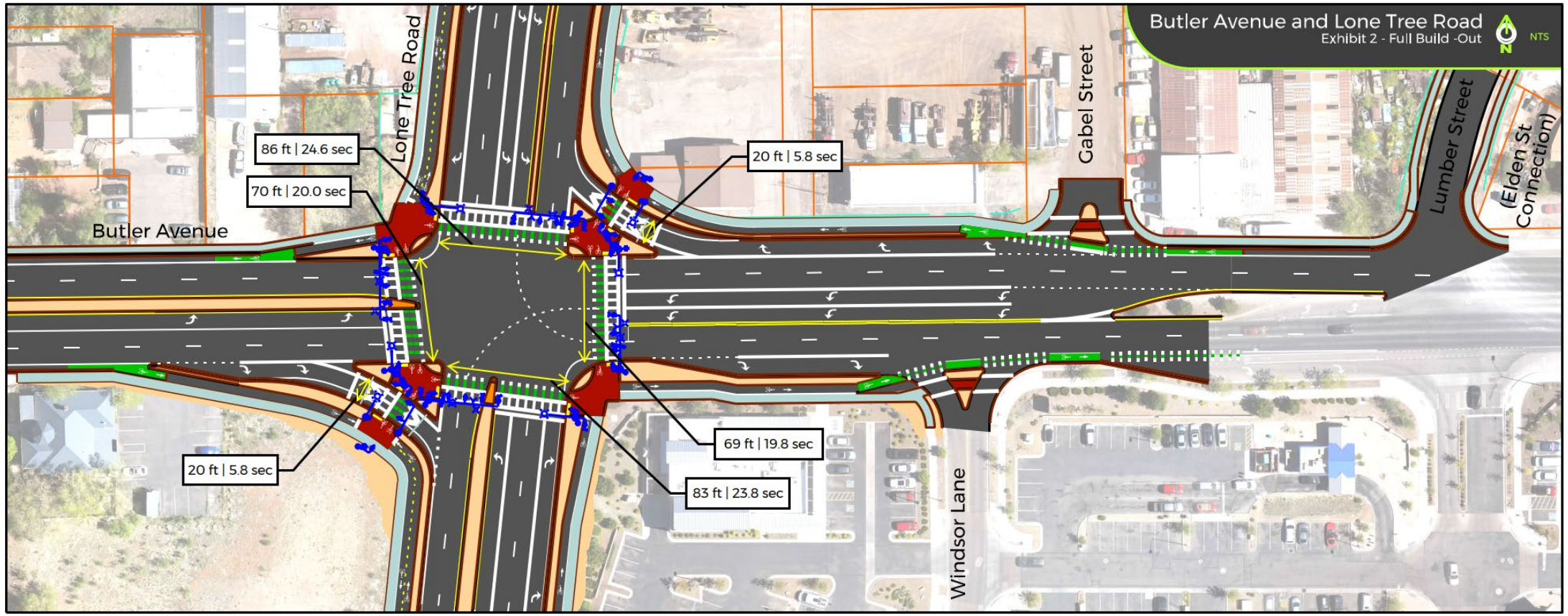
1

- **Comparison to Existing Intersection: Rte 66 & Fourth Street**
  - » Smaller roadway footprint
  - » Shorter crossing distances
  - » LTO & Butler has median refuge on West and South legs



LTO & Butler – Full Build-Out Intersection

2



Vehicle Features

- Two left-turn lanes (SB, WB)
- Channelized right-turn lanes (SW, NE)

Bicycle Features

- Separated bike lanes (LTO) and Butler at the intersection

Pedestrian Features

- Raised median (S, W)

LTO & Butler – Full Build-Out Intersection | Looking NE

2

LTO & Butler – Full Build-Out Intersection

2

Facing West | EB Approach

Facing East | WB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
East Leg	69	19.8	3.8
West Leg	70	20.0	3.8

Refuge Island only on Eastbound Approach.
Protected Cyclist Crossing.

LTO & Butler – Full Build-Out Intersection

2

Facing North | SB Approach

Facing South | NB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
North Leg	86	24.6	4.7
South Leg	83	23.8	4.6

Refuge Island only on Northbound Approach. Cyclist Crossing on roadway or with pedestrians.

LTO & Butler – Full Build-Out Intersection

2

- **Design Feature**
  - Pedestrian longest crossing distance 86 ft
  - Pedestrian longest crossing time 26.4 s
  - Bike longest crossing time 4.7 s
  - Available Green Time 32.1s (EB/WB Thru-AM)

Ped /Bike Crossing	Distance (ft)	Ped Time (sec)	Min. Bike Time (sec)
North Leg*	86	24.6	4.7
South Leg*	83	23.8	4.6
East Leg*	69	19.8	3.8
West Leg*	70	20.0	3.8

* Not including distance/time to channelization island

- **Pedestrian crossing times are based on 3.5 ft/s | 2.4 mph**
  - Per the Manual for Uniform Traffic Control
  - Assumes complete crossing during one single green phase
  - Older Pedestrians, 2.8 ft/sec.(FHWA) Longest Crossing time 30.7 sec
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LTO & Butler – Full Build-Out Intersection

2

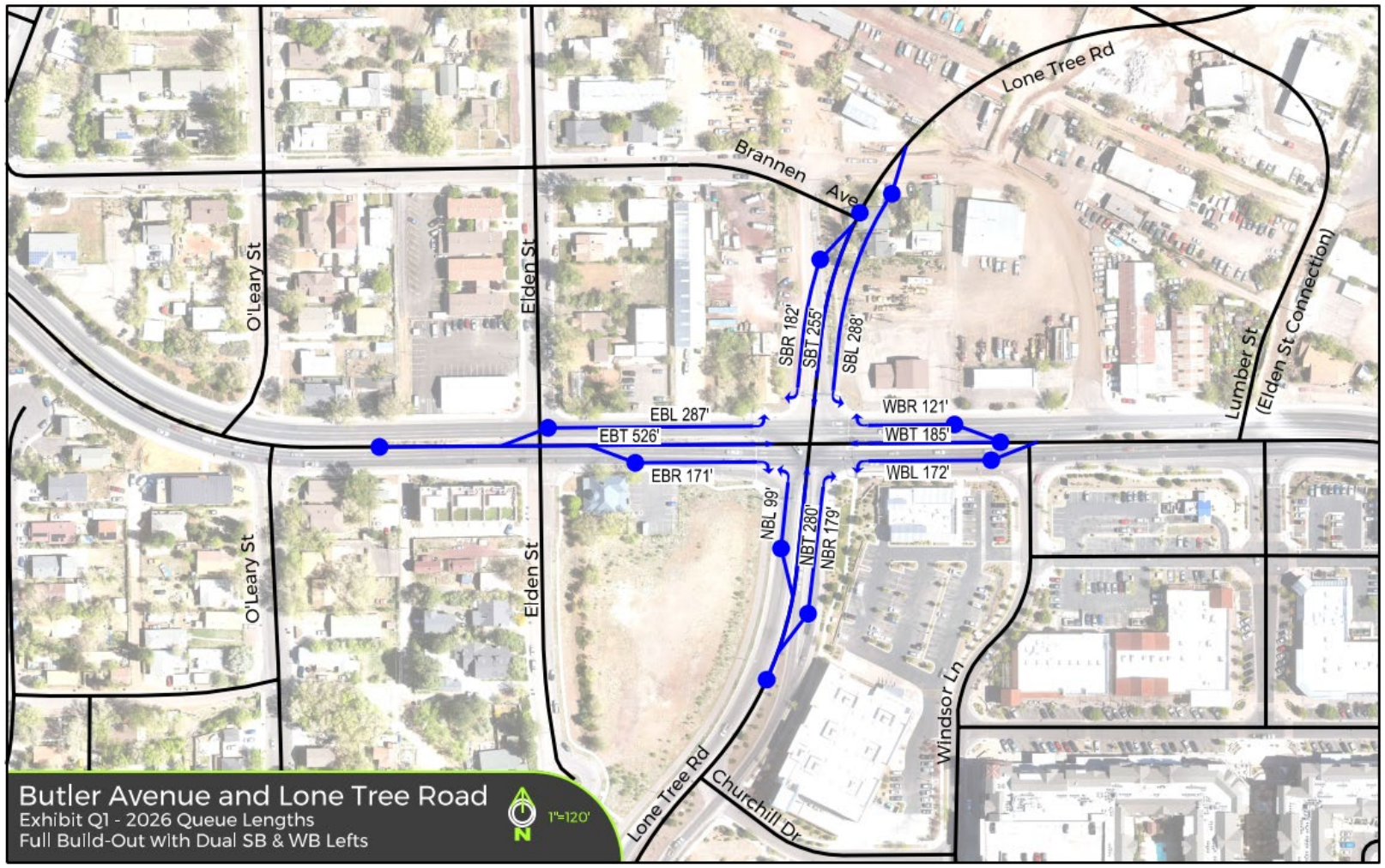
- **Performance (2026 PM Peak)**
  - Overall Level of Service D
  - Average Vehicle Delay: 47.8 sec
  - Queuing: Longest queue 526 ft
- **Performance (2040 PM Peak)**
  - Overall Level of Service E
  - Average Vehicle Delay: 70.7 sec
  - Queuing: Longest queue 800 ft

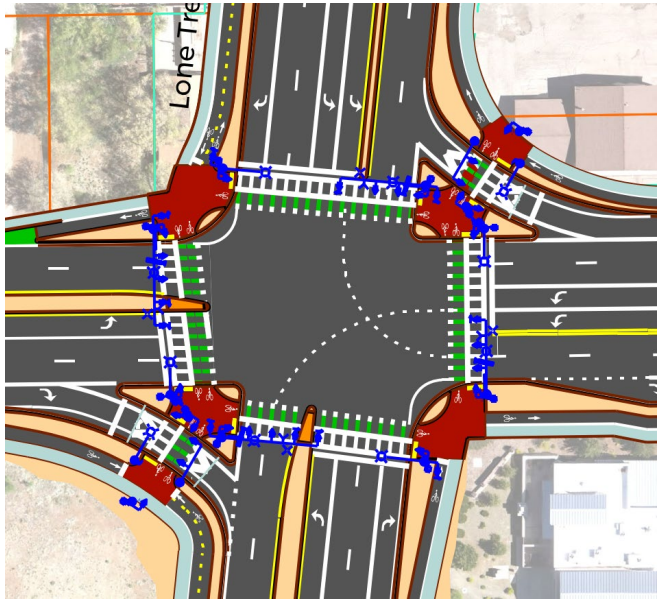
Year	Total Vehicle Delay (hours)	Fuel Used (gallons)
2026 (PM)	59	58.2
2040 (PM)	111	74.7

LTO & Butler – Full Build-Out Intersection

2

» Maximum Queues - 2026



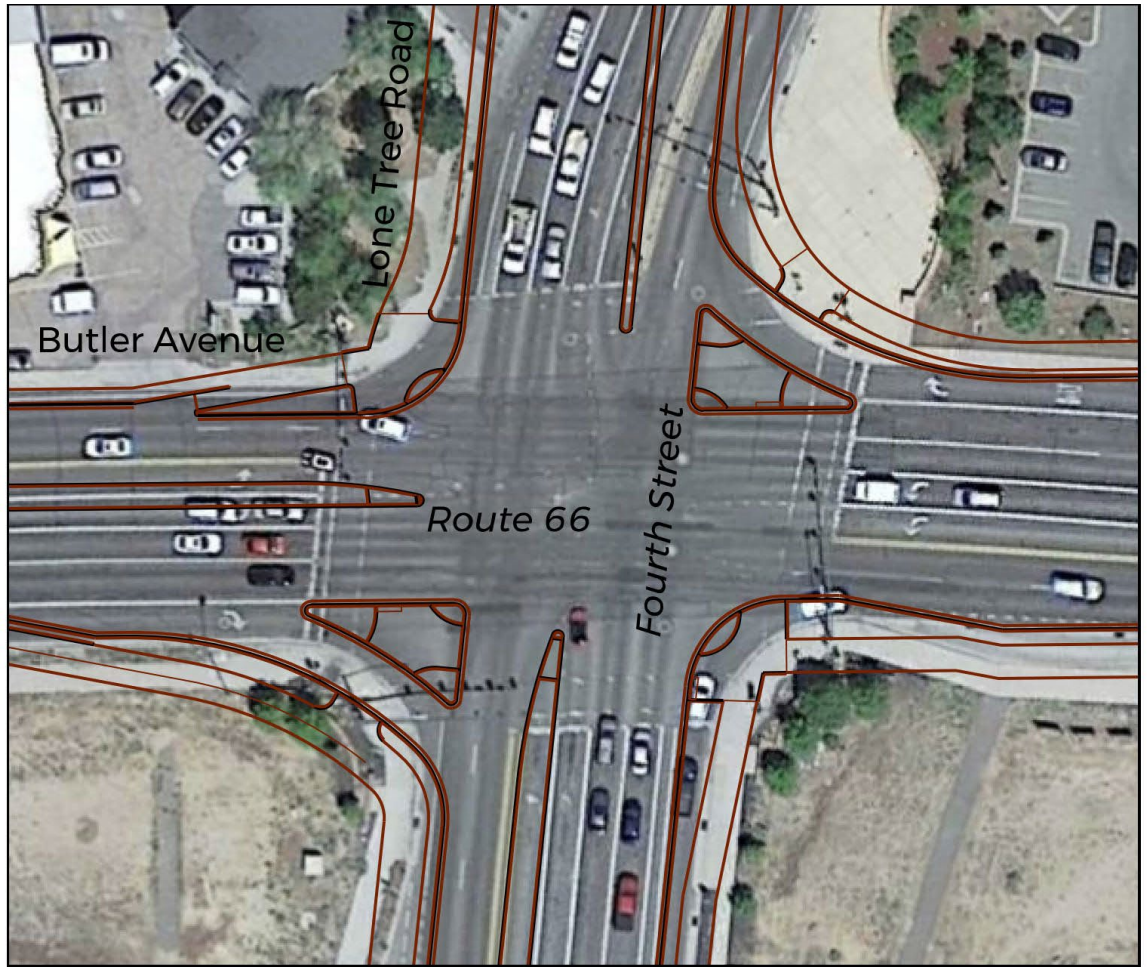


Queues are similar to the Traditional intersection

LTO & Butler – Full Build-Out Intersection

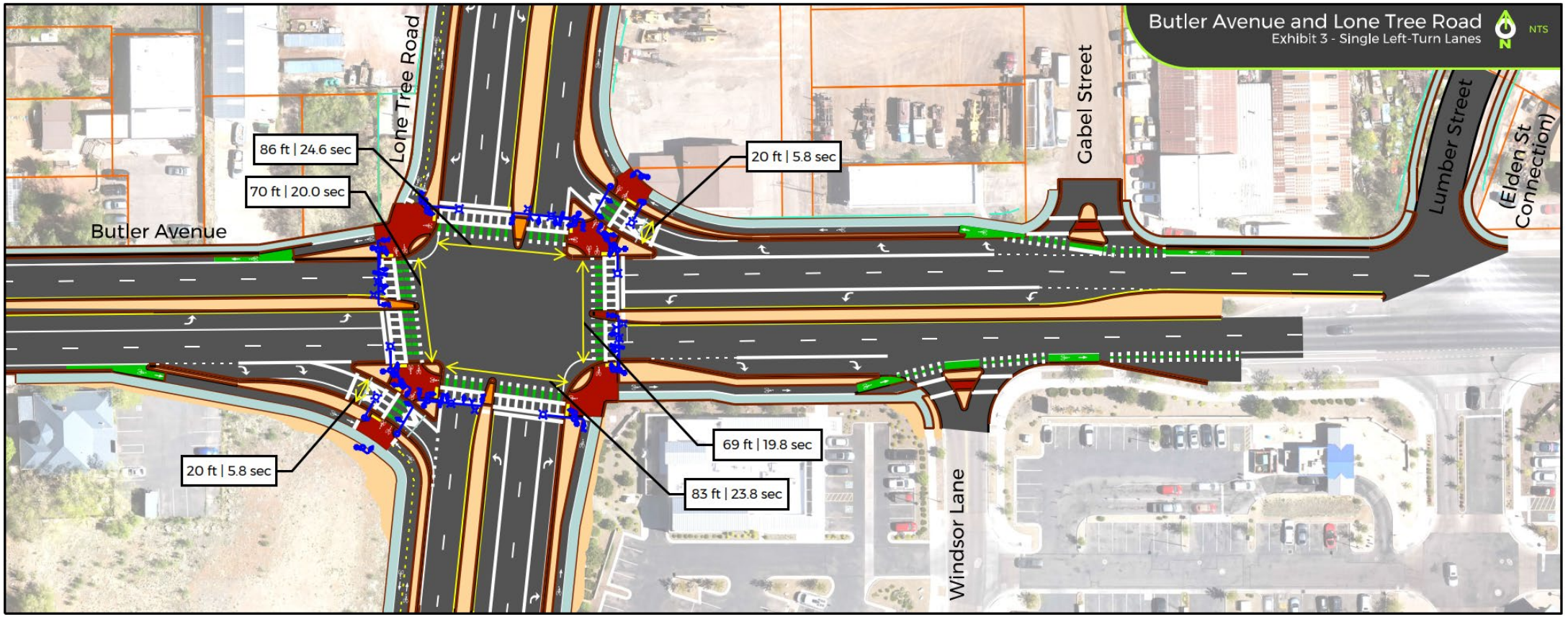
2

- **Comparison to Existing Intersection: Rte 66 & Fourth Street**
  - » Smaller roadway footprint
  - » Shorter crossing distances
  - » LTO & Butler has median refuge on West and South approaches
  - » LTO & Butler has (2) Right Turn Channelized Islands to further reduce crossing distances



LTO & Butler – Single Left Intersection

3



Vehicle Features

- Single left-turn lanes (NB,SB, EB,WB)
- Channelized right-turn lanes (SW, NE)

Bicycle Features

- Separated bike lanes (LTO) and Butler at the intersection

Pedestrian Features

- Raised median (N,S,E, W)

LTO & Butler – Single Left Intersection | Looking NE

3

LTO & Butler – Single Left Intersection

3

Facing West | EB Approach

Facing East | WB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
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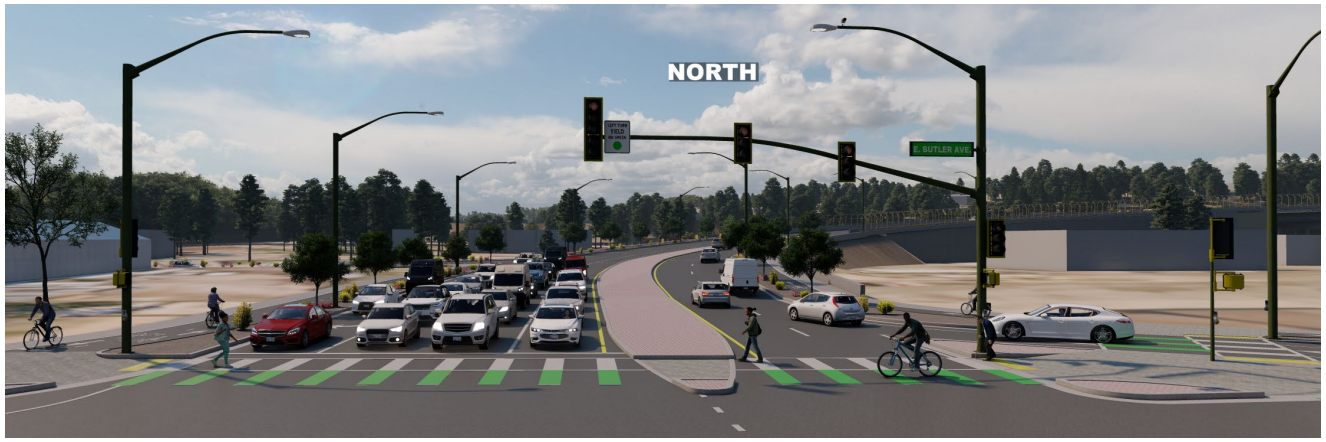
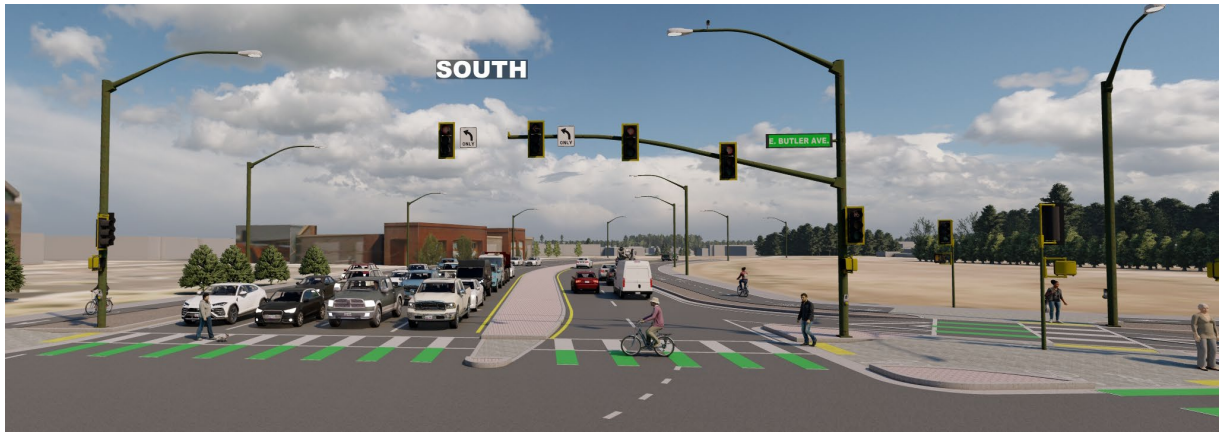
Refuge Island only on Eastbound Approach.
Protected Cyclist Crossing.

LTO & Butler – Single Left Intersection

3





Facing North | SB Approach

Facing South | NB Approach

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LTO & Butler – Single Left Intersection

3

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  - Pedestrian longest crossing time 24.6 s
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Ped /Bike Crossing	Distance (ft)	Ped Time (sec)	Min. Bike Time (sec)
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  - Assumes complete crossing during one single green phase
  - Older Pedestrians, 2.8 ft/sec.(FHWA) Longest Crossing time 30.7 sec
- https://view.mylumion.com/?p=wo9hasekuwi9j76n

LTO & Butler – Single Left Intersection

3

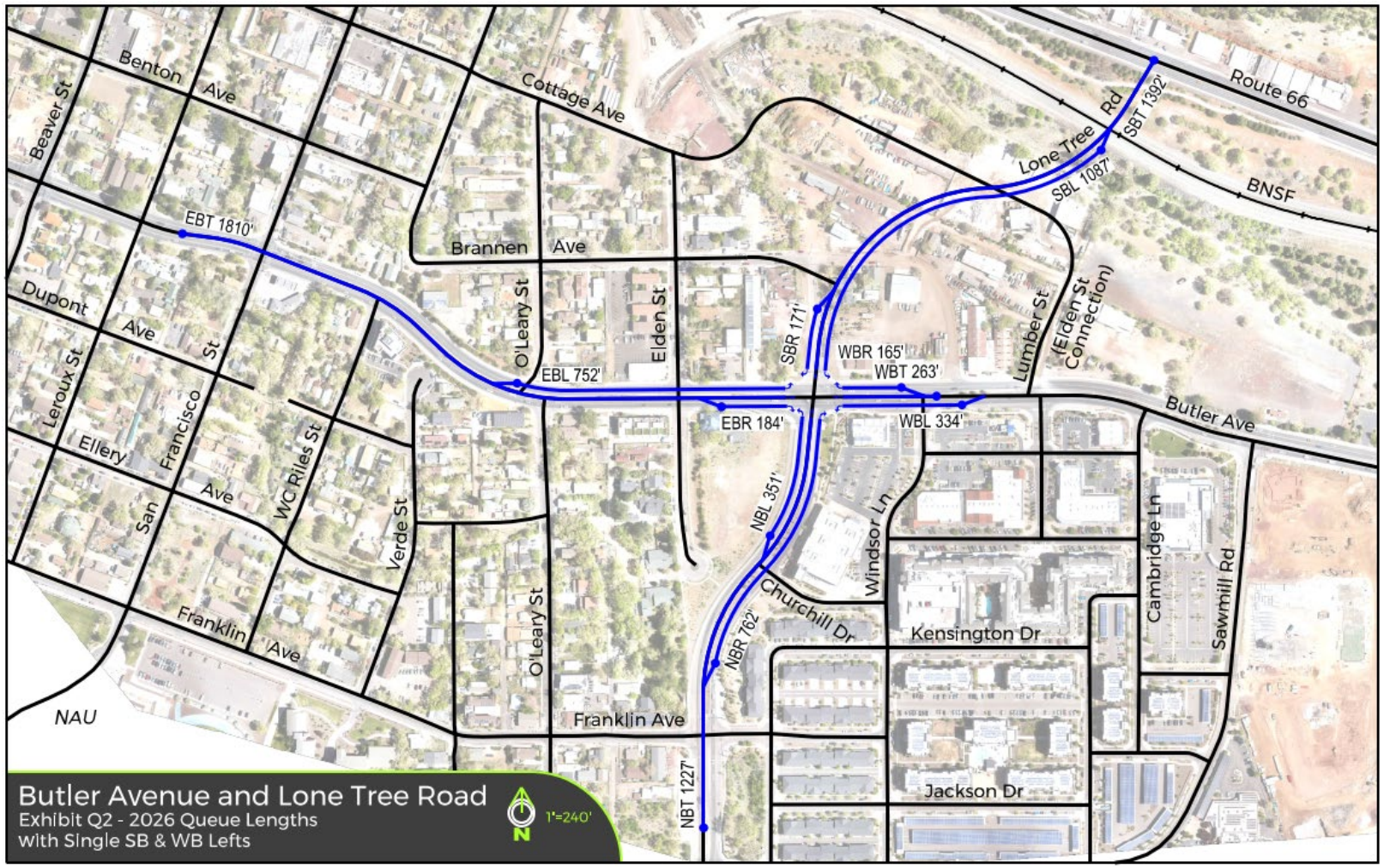
- **Performance (2026 PM Peak)**
  - Overall Level of Service E
  - Average Vehicle Delay: 73.9
  - Queuing: Longest queue 1,971 ft
- **Performance (2040 PM Peak)**
  - Overall Level of Service F
  - Average Vehicle Delay: 135.7
  - Queuing: Longest queue 2,041 ft

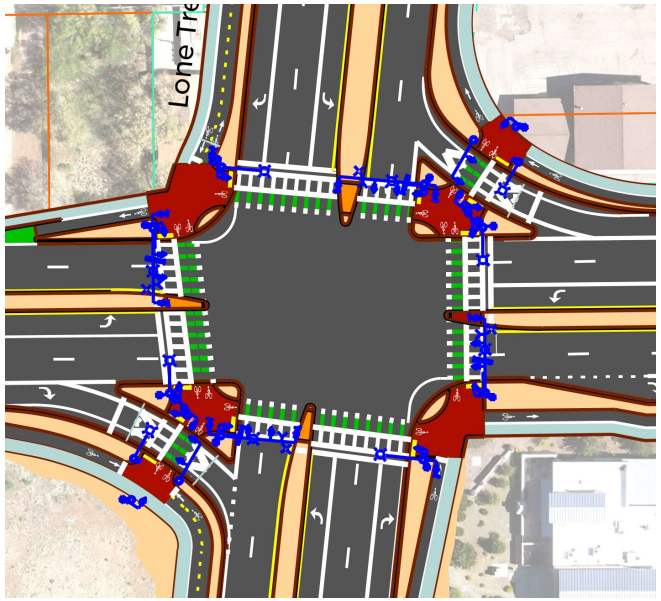
Year	Total Vehicle Delay (hours)	Total Emissions (gallons)
2026 (PM)	92	91.8
2040 (PM)	213	139.9

LTO & Butler – Single Left Intersection

3

» Maximum Queues - 2026



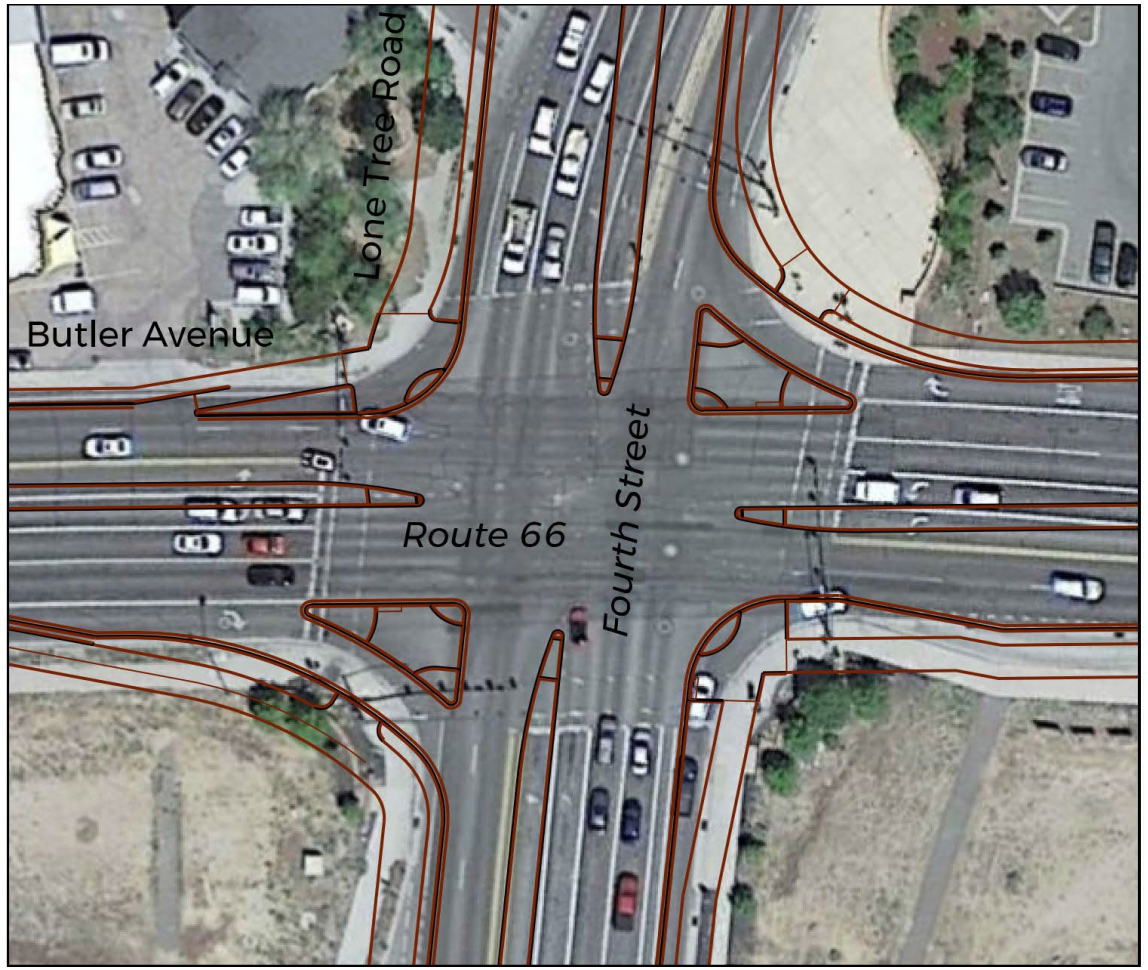


Queues extend back:
- North approach to Rte 66
- South approach past Franklin Ave
- East approach nearly to Beaver St

LTO & Butler – Single Left Intersection

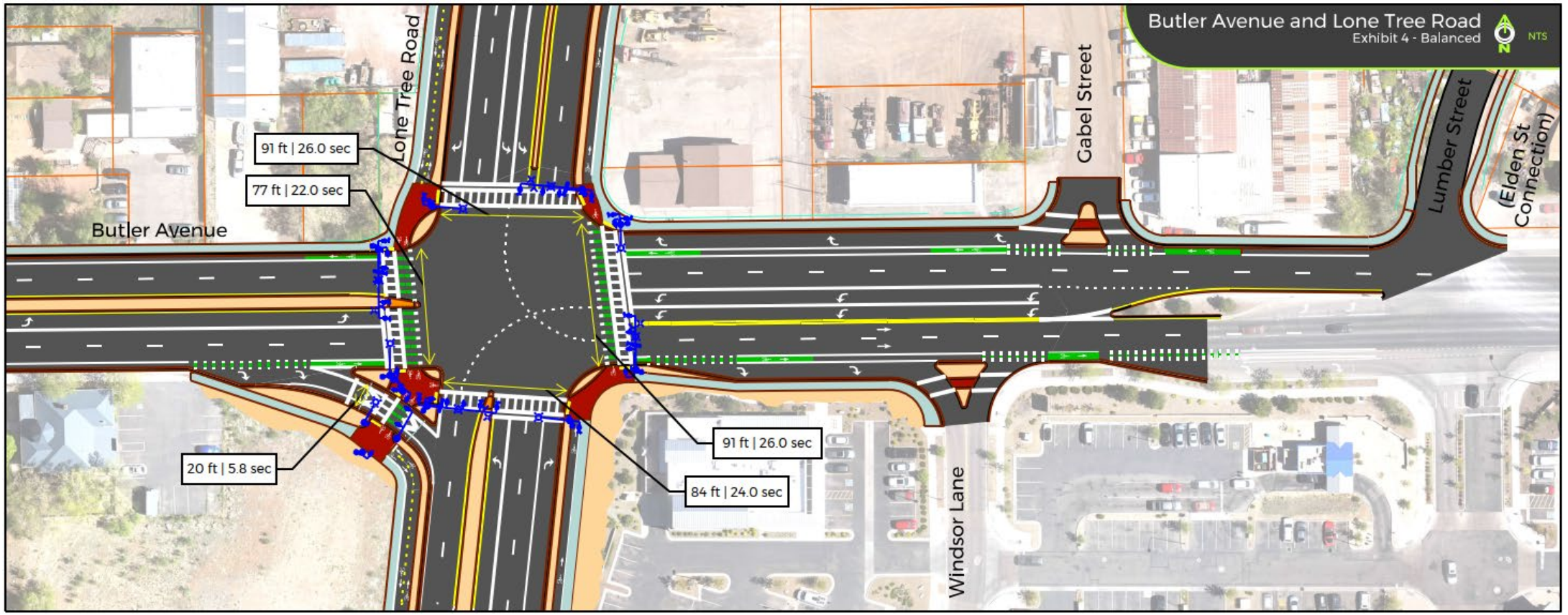
3

- **Comparison to Existing Intersection: Rte 66 & Fourth Street**
  - Similar to Full Build-Out
  - Smaller roadway footprint
  - Shorter crossing distances
  - LTO & Butler has median refuges on North, South, East and West approaches
  - LTO & Butler has (2) Right Turn Channelized Islands to further reduce crossing distances



LTO & Butler – Balanced Intersection

4



Vehicle Features

- Single left-turn lanes (NB, EB)
- Channelized right-turn lanes (SW)

Bicycle Features

- Separated bike lanes (LTO)

Pedestrian Features

- Raised median (S, W)

LTO & Butler – Balanced Intersection | Looking NE

4

LTO & Butler – Balanced Intersection

4

Facing West | EB Approach

Facing East | WB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
East Leg	91	26.0	5.0
West Leg	77	22.0	4.2

Refuge Island only on Eastbound Approach.
Protected Cyclist Crossing.

LTO & Butler – Balanced Intersection

4

Facing North | SB Approach

Facing South | NB Approach

Walking Speed
2.4 mph
Riding Speed
12.4 mph

Pedestrian / Cyclist Crossing	Distance (ft)	Walking Time (sec)	Riding Time (sec)
North Leg	91	26.0	5.0
South Leg	84	24.0	4.6

Refuge Island only on Northbound Approach.
Cyclist Crossing on roadway or with pedestrians.

LTO & Butler – Balanced Intersection

4

- **Design Feature**
  - Pedestrian longest crossing distance 91 ft
  - Pedestrian longest crossing time 26.0 s
  - Bike longest crossing time 5.0 s
  - Available Green Time 32.1s (EB/WB Thru-PM)

Ped /Bike Crossing	Distance (ft)	Ped Time (sec)	Min. Bike Time (sec)
North Leg	91	26.0	5.0
South Leg*	84	24.0	4.6
East Leg	91	26.0	5.0
West Leg*	77	22.0	4.2

* Not including distance/time to channelization island

- **Pedestrian crossing times are based on 3.5 ft/s | 2.4 mph**
  - Per the Manual for Uniform Traffic Control
  - Assumes complete crossing during one single green phase
  - Older Pedestrians, 2.8 ft/sec.(FHWA) Longest Crossing time 32.5 sec
- https://view.mylumion.com/?p=a6f9737rtzjabsq5

LTO & Butler – Balanced Intersection

4

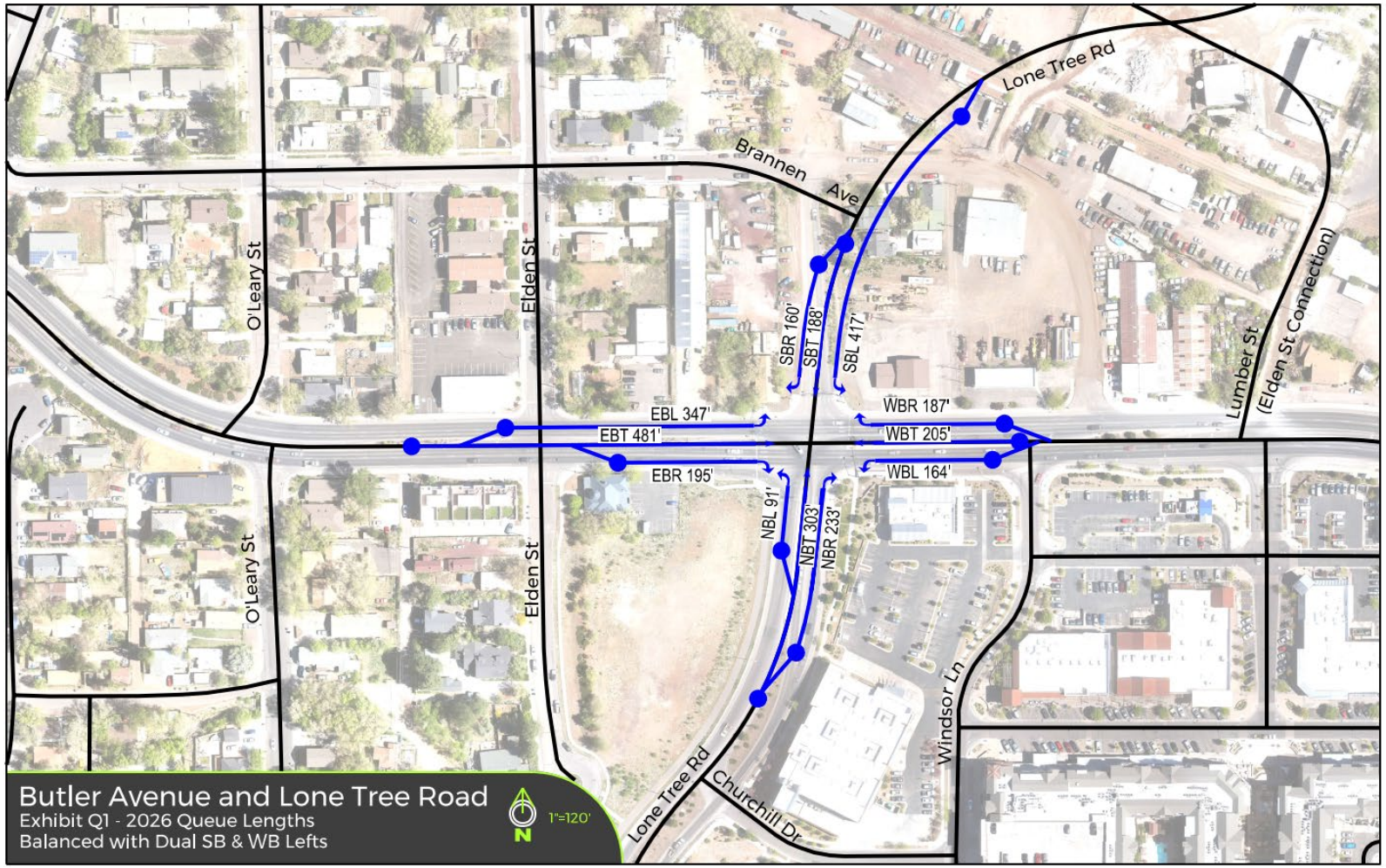
- **Performance (2026 PM Peak)**
  - Overall Level of Service D
  - Average Vehicle Delay: 47.0 s
  - Queuing: Longest queue 481 ft
- **Performance (2040 PM Peak)**
  - Overall Level of Service E
  - Average Vehicle Delay: 70.2
  - Queuing: Longest queue 1,225 ft

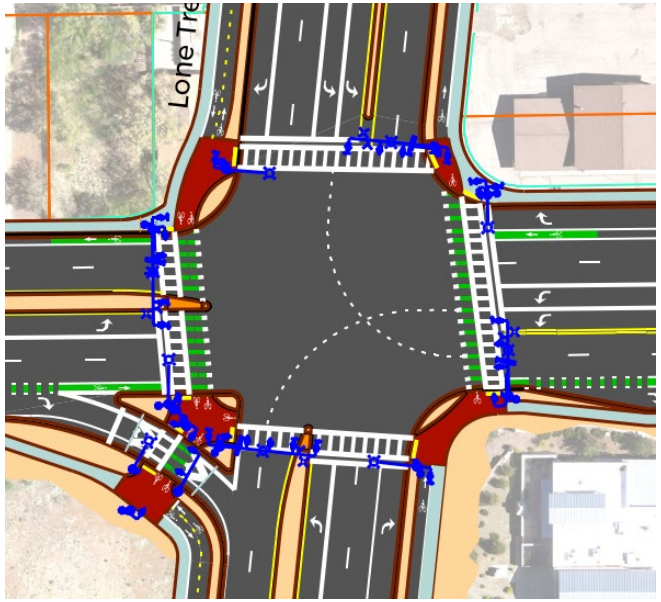
Year	Total Vehicle Delay (hours)	Total Emissions (gallons)
2026 (PM)	59	56.3
2040 (PM)	110	78.1

LTO & Butler – Balanced Intersection

4

» Maximum Queues - 2026



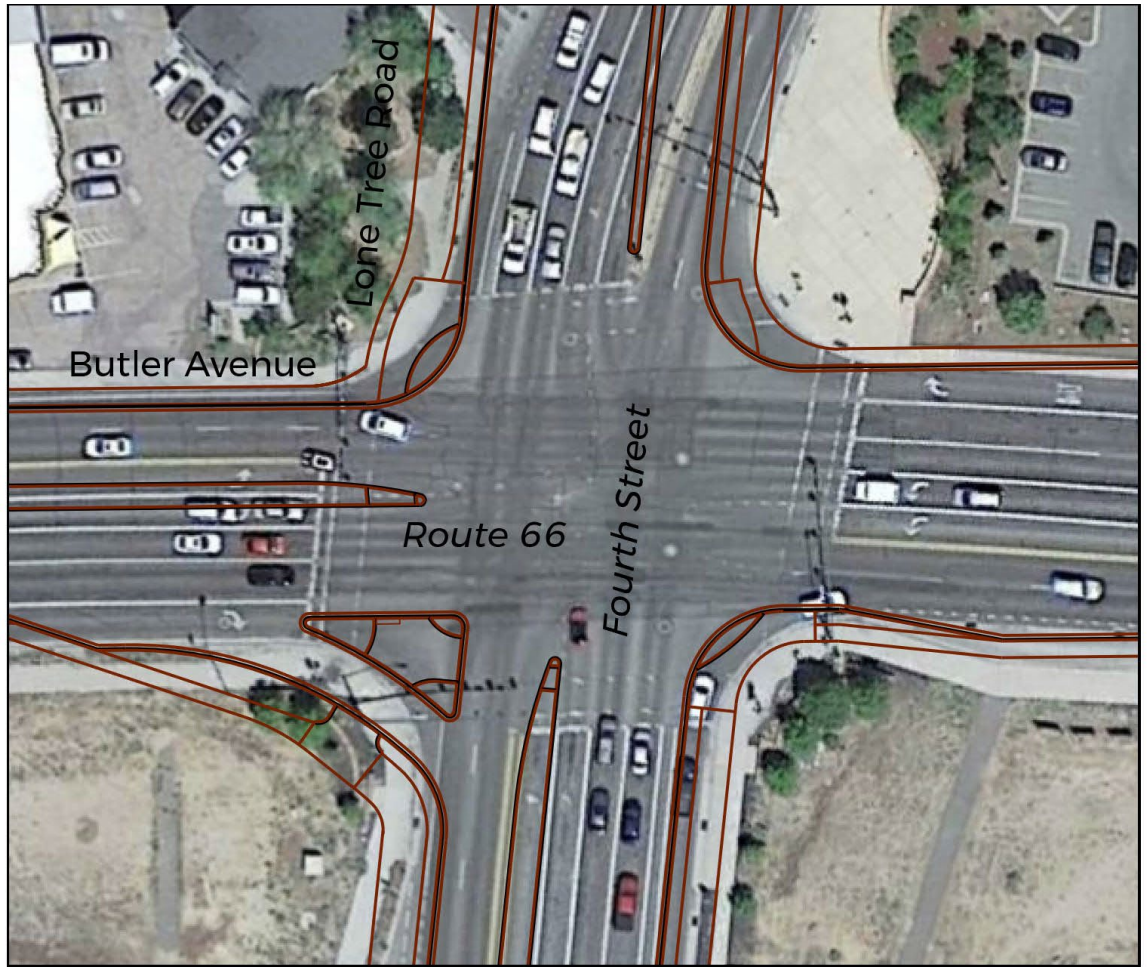


Queues are similar to the Traditional and Full Build-Out intersections

LTO & Butler – Balanced Intersection

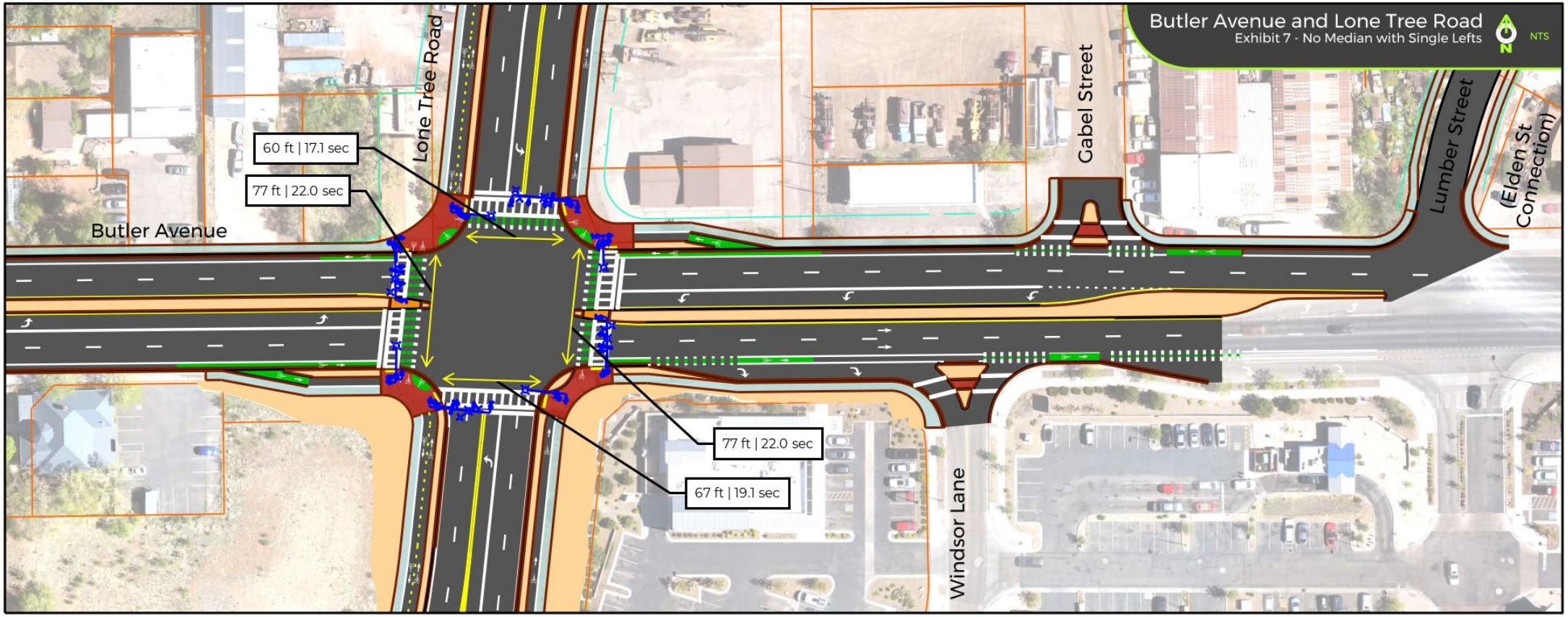
4

- **Comparison to Existing Intersection: Rte 66 & Fourth Street**
  - Smaller roadway footprint
  - Shorter crossing distances
  - LTO & Butler has refuge median on West and South approaches
  - LTO & Butler has (1) Right Turn Channelized Islands to further reduce crossing distances



LTO & Butler – Traditional Intersection

5



Vehicle Features

- Single left-turn lanes (All)
- Shared Through/Rights (All)

Bicycle Features

- Separated bike lanes (LTO)

Pedestrian Features

- Raised median (E, W)

LTO & Butler – Traditional Intersection

5

- **Design Feature**
  - Pedestrian longest crossing distance 77 ft
  - Pedestrian longest crossing time 22.0 s
  - Bike longest crossing time 4.1 s
  - Available Green Time 45.2s (EB/WB Thru-PM)

Ped /Bike Crossing	Distance (ft)	Ped Time (sec)	Min. Bike Time (sec)
North Leg	60	17.2	3.3
South Leg	67	19.1	3.7
East Leg	77	22.0	4.2
West Leg	77	22.0	4.2

- **Pedestrian crossing times are based on 3.5 ft/s | 2.4 mph**
  - Per the Manual for Uniform Traffic Control
  - Assumes complete crossing during one single green phase
  - Slower Pedestrians, 2.8 ft/sec.(FHWA) Longest Crossing time 27.5 sec

- https://view.mylumion.com/?p=a6f9737rtzjabsq5

LTO & Butler – Traditional Intersection

5

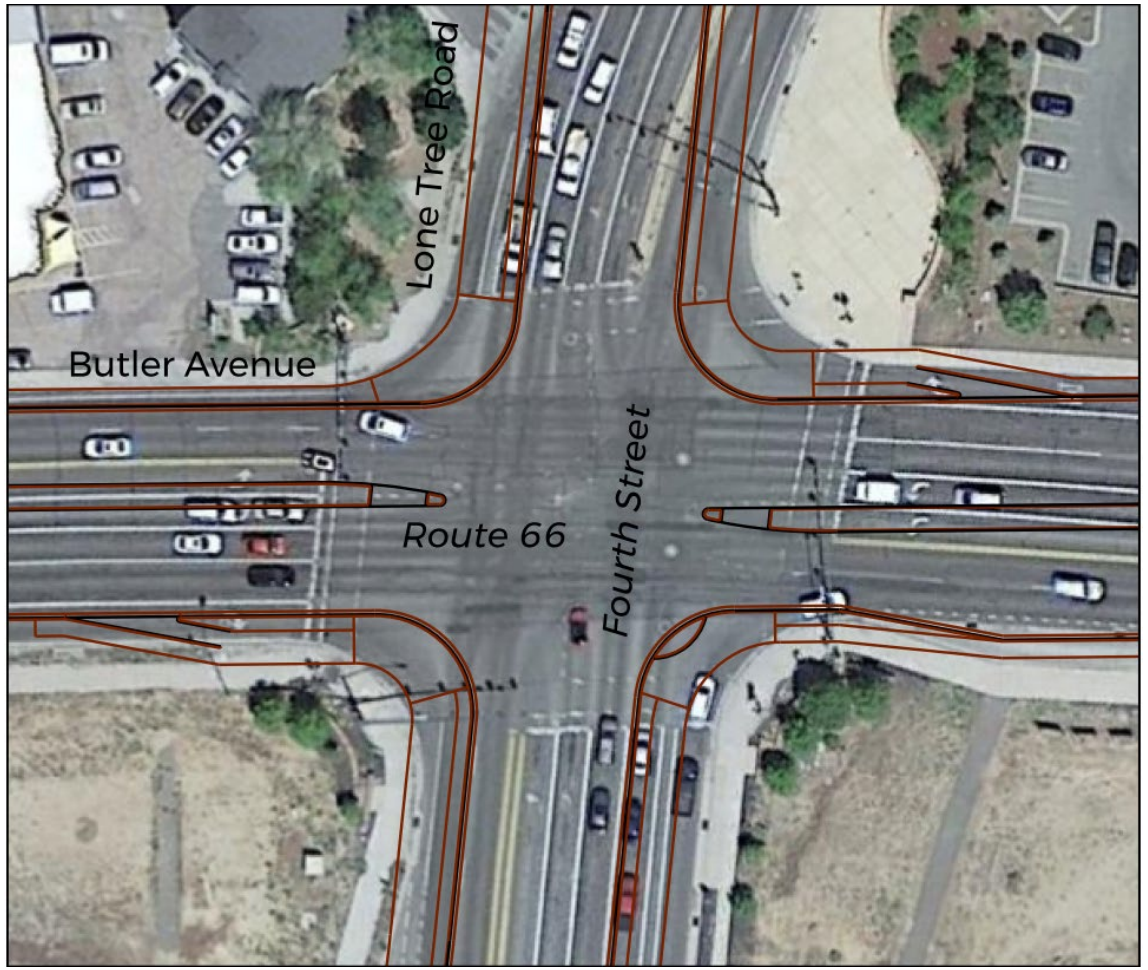
- **Performance (2026 PM Peak)**
  - Overall Level of Service F
  - Average Vehicle Delay: 117.4 s
  - Queuing: Longest queue 1822 ft

Year	Total Vehicle Delay (hours)	Total Emissions (gallons)
2026 (PM)	145.5	100.3

LTO & Butler – Traditional Intersection

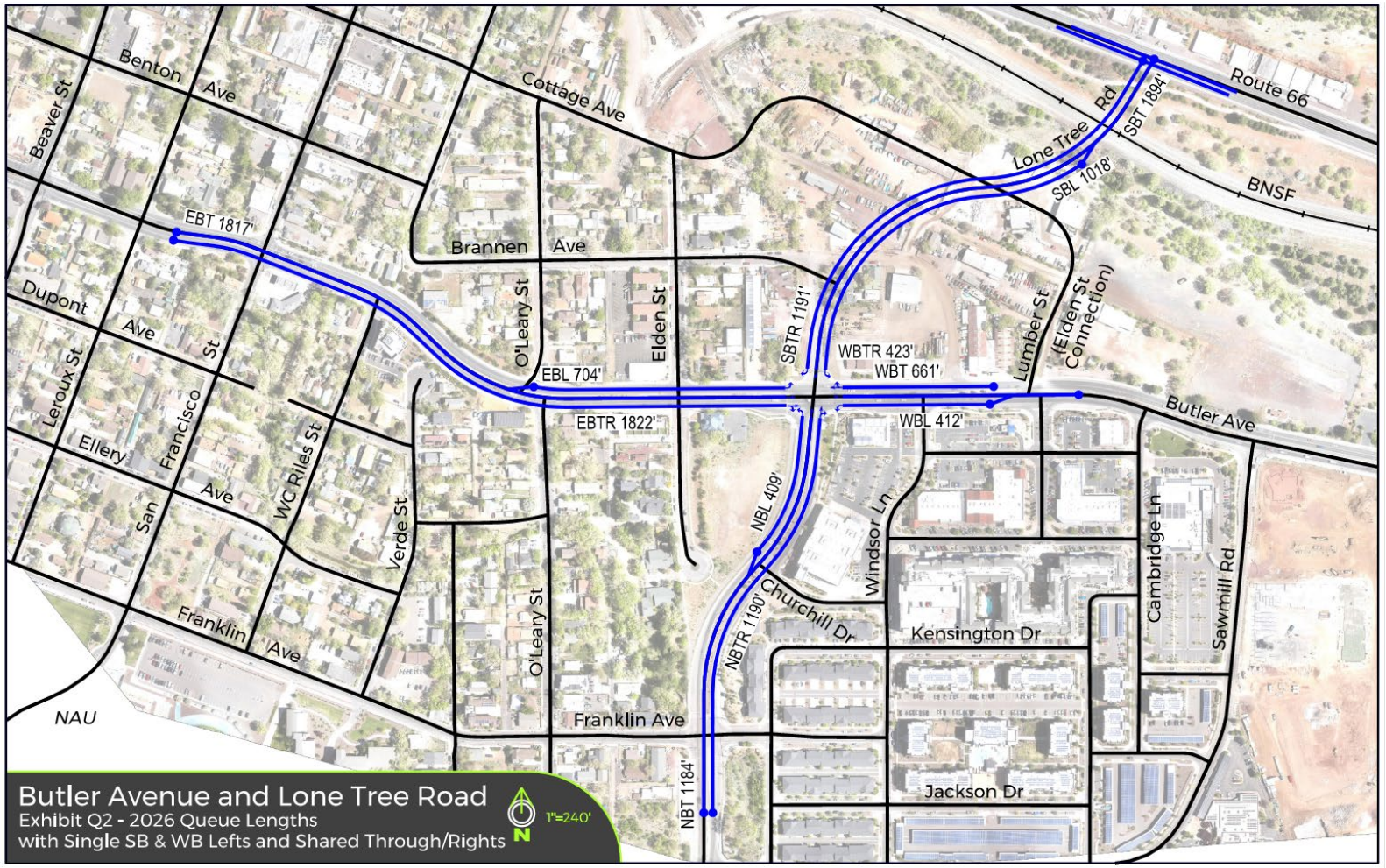
5

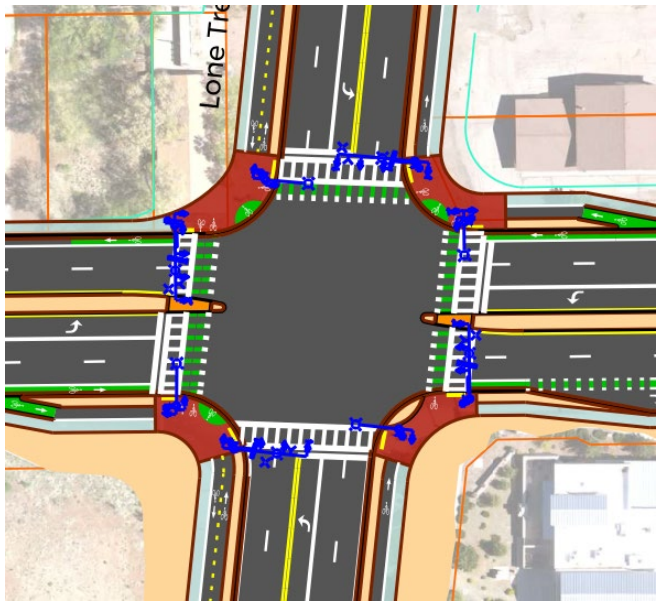
- **Comparison to Existing Intersection: Rte 66 & Fourth Street**
  - Smallest roadway footprint
  - Shortest crossing distances
  - Butler has refuge median on East and West approaches
  - Shared Through and Right Turns to reduce crossing distances



LTO & Butler – Traditional Intersection

5

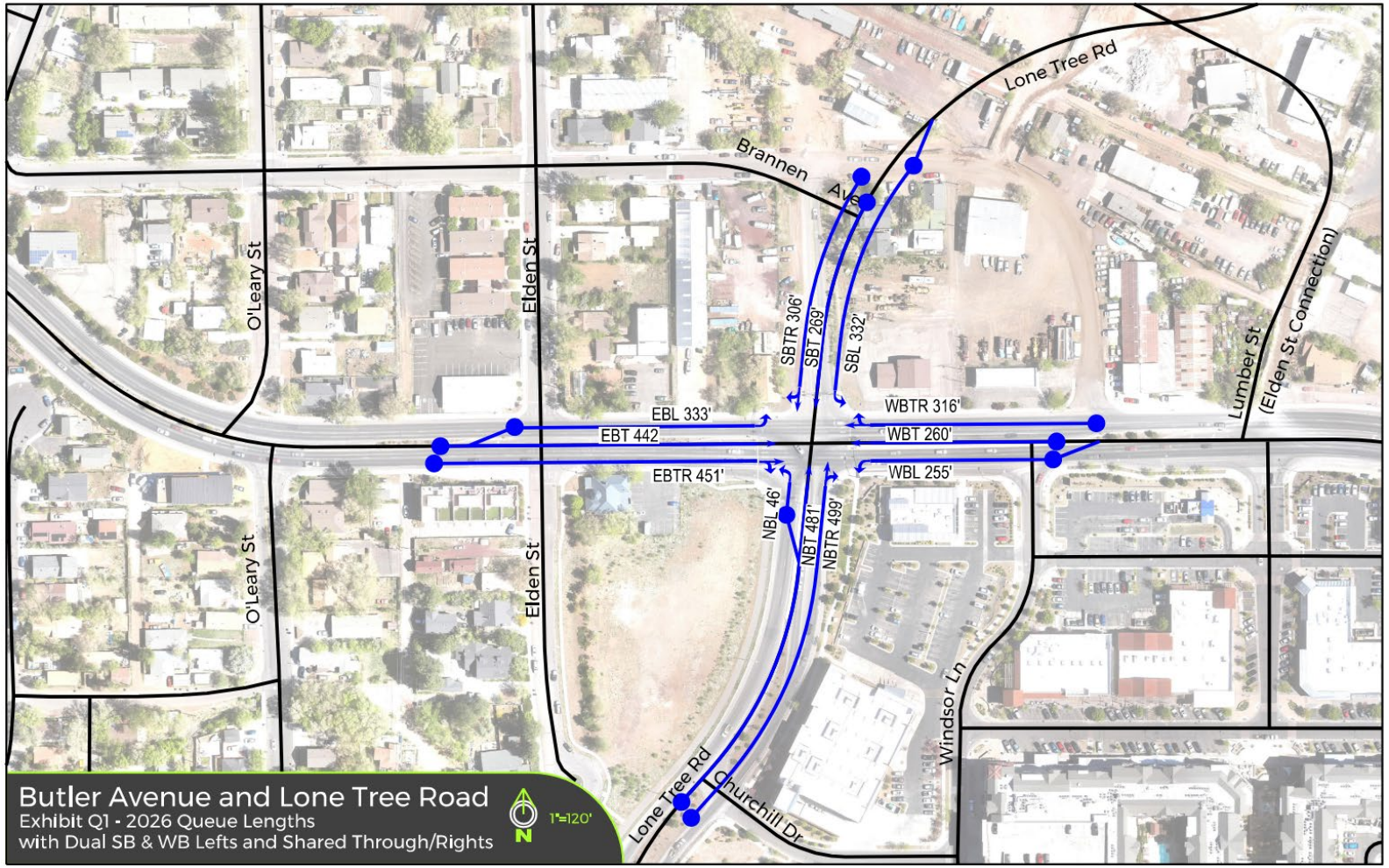




- Eastbound queues extend back past San Francisco St
- Southbound queues extend onto Route 66
- Northbound queues extend back past Franklin Ave

LTO & Butler – Traditional Intersection

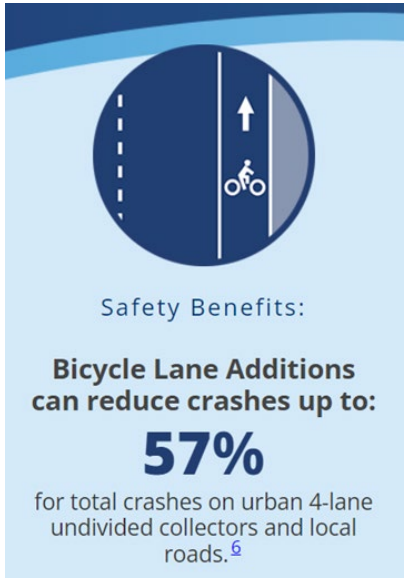
5



- SIMILAR CONCEPT BUT WITH DOUBLE SB AND WB DOUBLE LEFTS

Approach to Safety – Bicycle Features

On-Street Bicycle Lanes



Source: FHWA Office of Safety

Crash Reduction
Up to 49%

Source: CMF Clearinghouse (ID 10738)

- Most common bicycle facility in use in the US.
- Creates separation between bicyclists and automobiles.
- Increases predictability of user positioning and interaction.

Source: NACTO

Separated Bicycle Paths

Separated bicycle lanes may provide further safety benefits. FHWA is anticipating completion of research in Fall 2022.

Source: FHWA Office of Safety

Further Crash Reduction
Up to 25%

Source: CMF Clearinghouse (ID 9250)

- Fully separates bicycles users from vehicular roadway.
- ATMP provides corridors for vertical and horizontal separated bicycle facilities
  - Lone Tree Road and Butler Avenue are to be vertical separated facilities in the project area

Source: AASHTO Guide for the Development of Bicycle Facilities

Approach to Safety – Bicycle Features

Raised Median (Refuge Area)

Source: FHWA Office of Safety

Crash Reduction
Up to 77%

Source: CMF Clearinghouse (ID 2219)

- Provide a refuge for pedestrians, particularly those who are wheelchair-bound, elderly, or otherwise unable to completely cross an intersection within the provided signal time.
- Streets with raised medians, in both CBD and suburban areas, have lower pedestrian crash rates.

Source: ITE Design and Safety of Pedestrian Facilities

Leading Pedestrian Interval

Source: FHWA Office of Safety

Crash Reduction
Up to 10%-19%

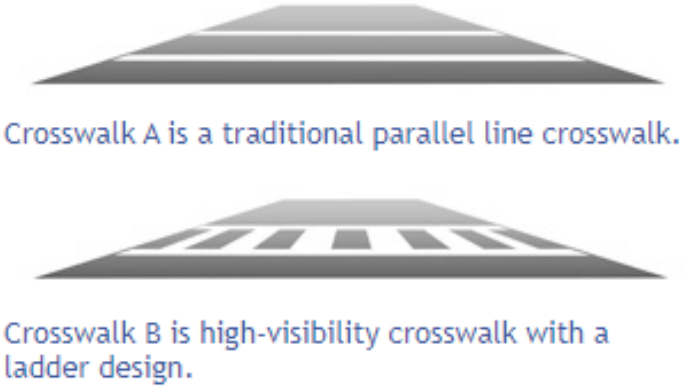
Source: CMF Clearinghouse (ID 9901-9918)

- Enhance the visibility of pedestrians in the intersection and reinforce their right-of-way over turning vehicles.
- Reduce pedestrian-vehicle collisions as much as 60% at treated intersections

Source: NACTO

Approach to Safety – Crossing Features

High Visibility Crosswalk



Source: saferoutesinfo.org

Source: FHWA Office of Safety

Crash Reduction
Up to 19%-40%

Source: CMF Clearinghouse (ID 4123-4124)

- High visibility crosswalks are visible from farther away compared to traditional crosswalks.

Colored Bike Lane at Signalized Intersection

Source: FHWA Bikeway Selection Guide

- Installation across turning conflict areas such as vehicle right turn lanes.
- Motorists increase yielding after colored lane treatment was installed.

Source: NACTO

Approach to Safety – Turn Lane Features

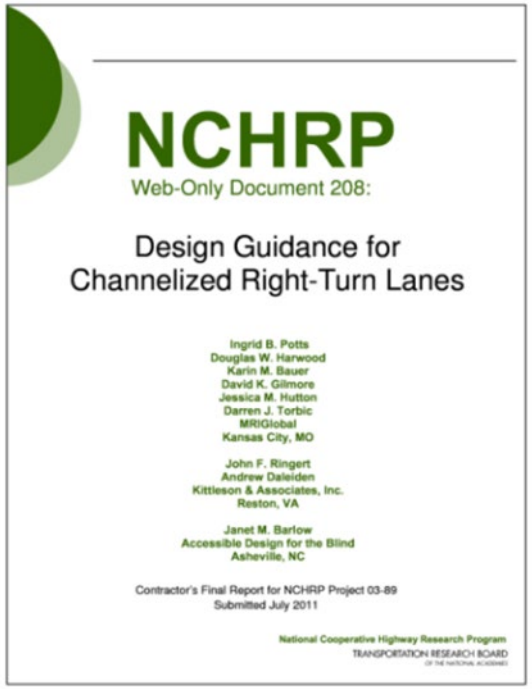
Dual Left-Turn Lanes

- Appropriate for high left-turn volumes that cannot be adequately served in a single lane.
- Protected-only left-turn phasing is used for most double-lane movements.
- Dual left-turn lanes with protected-only phasing generally operate with minimal negative safety impacts.

Source: FHWA Signalized Intersection Guide

Channelized Right Turn

- Vehicular crash *prediction* for channelized right turn lane was slightly lower than traditional right-turn lanes but not statistically significant.
- Pedestrian crash *prediction* for channelized right turn lane was approximately 70 to 80 percent lower than traditional right-turn lanes.
- Pedestrians did not appear to have any difficulty crossing channelized right-turn lanes.



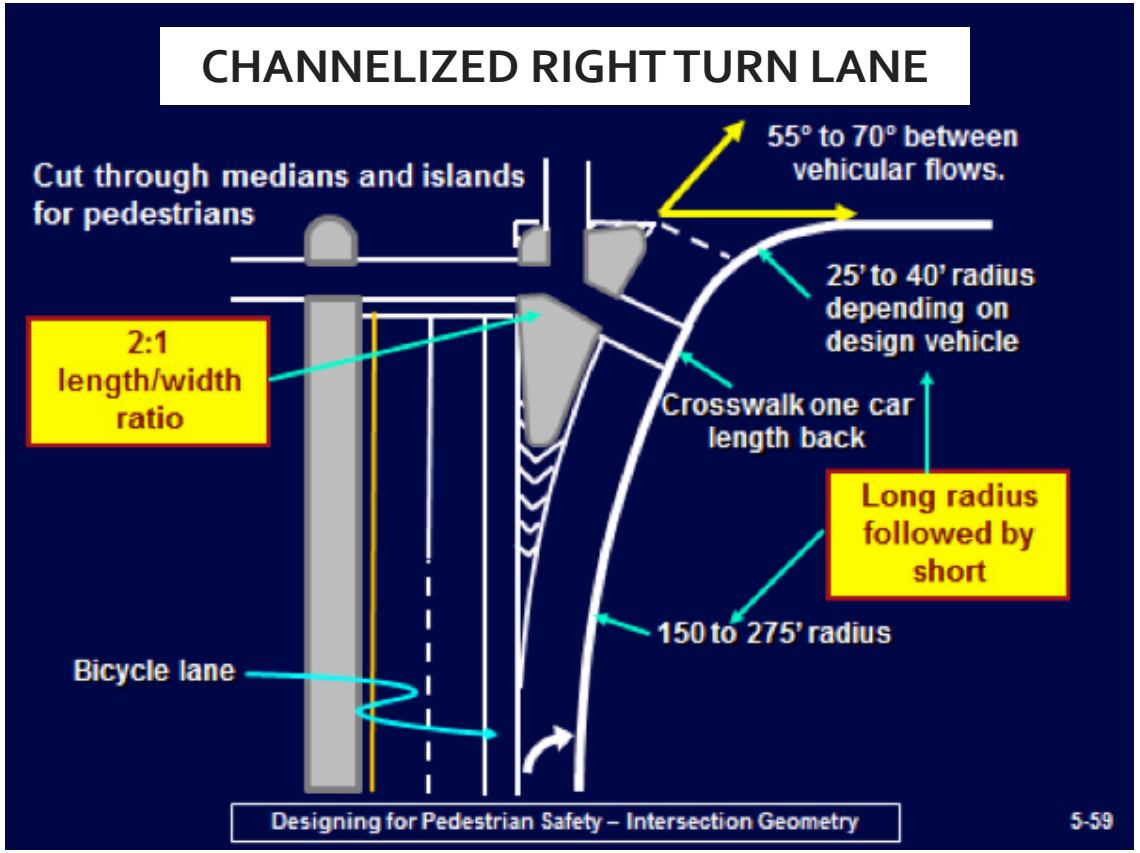
Crash Reduction
Up to 2% - 19%

Source: CMF Clearinghouse (IDs 282, 283, 284)

Source: NCHRP Design Guidance for Channelized Right-turn Lanes

Intersection Alternatives – Channelized Right Lanes

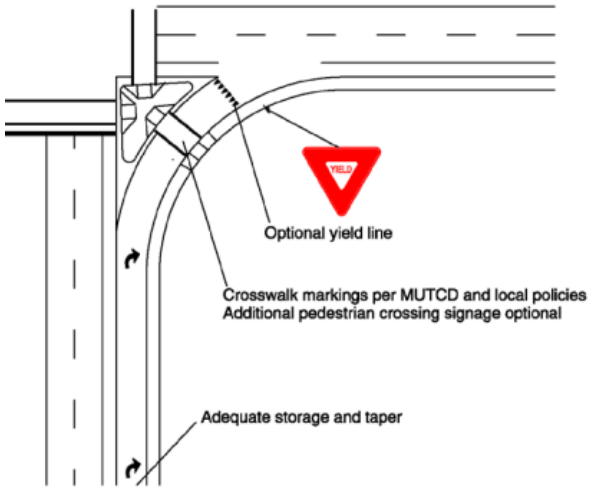
- **Pedestrian Benefits:**
  - Reduces distance for crossing main road
  - Geometric Design limits vehicle speeds
    - Not a Free-Flow Turn Lane
  - Optimizes driver sight line to crosswalk
- **Pedestrian Challenges:**
  - Difficulty for visually impaired to detect oncoming traffic



Source: FHWA PEDSAFE Pedestrian Safety Guide and Countermeasure Selection System

Intersection Alternatives – Dedicated Right Lanes

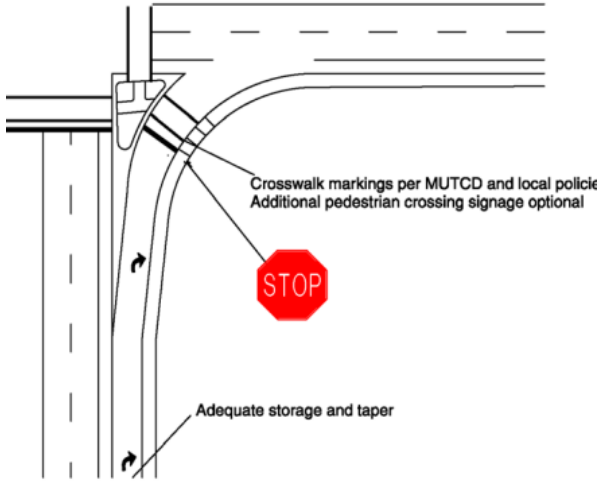
Yield Control



Pros: Minimal delay for pedestrians and vehicles.

Cons: Challenging for visually impaired
Need for additional ped warning signs.

Stop Control

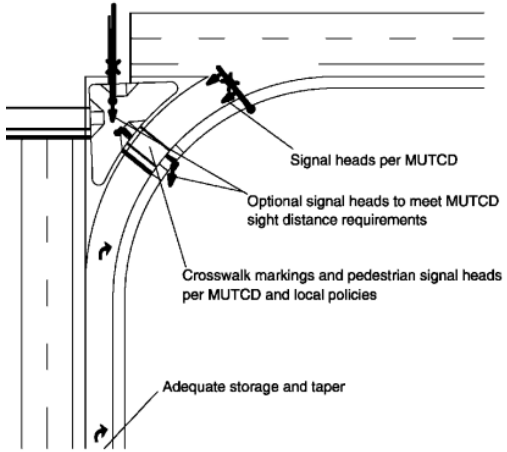


Pros: Vehicles to stop, rather than yield at crosswalk.

Cons: Vehicles potentially stop twice and queues backing across crosswalk.

Signalized

(High Right Turn Volume and Ped Volume)



Pros: Provisions for visually impaired. Signals to stop vehicles at crossing.

Cons: Pedestrians likely to cross against signal if there are delays to the ped call.

Recommendation for either Yield Control or Signalized Control for Channelized Right Turn Lanes at LTO & Butler

Source: NCHRP Design Guidance for Channelized Right Turn Lanes 2014

Example in Action – Boulder, Colorado

- **Boulder, Colorado**
  - Standard Practice – Yield Control
  - Can use Raised Crossings to further control speeds

Other Safety Features

Advanced Signals

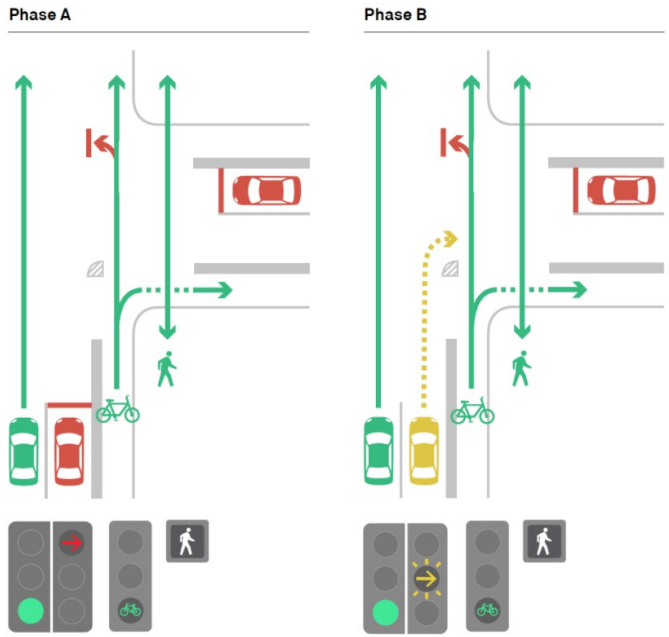
Increases understanding / signalization to multi-modal crossers

Extended Crossing

Extends time for slower crossers

Additional guidance for users of intersection

Leading Ped Phase with Right Turn Lane



Allows peds/bikes to have a protected phase

Intersection Alternatives – Takeaways

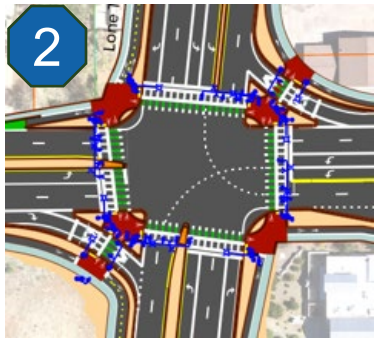
- All intersection alternatives have sufficient green time to allow pedestrians to cross in one cycle
- Intersection footprints are all smaller than the comparable 4th and Route 66 intersection in Flagstaff (and Ponderosa with Butler and Route 66)
- All intersection alternatives have protected pedestrian/cyclist crossings along Lone Tree Road / FUTS across Butler Avenue
- Channelized right islands and refuge islands decrease crossing distances for pedestrians and improve safety
- Stop or yield control at channelized right could allow pedestrians to cross to island independent of traffic signal
- There is significant increase in vehicle delays and queue lengths in single left intersection alternative

LTO & Butler – Intersection Summary

Evaluation Criteria	1 Typical	2 Full Build-Out	3 Single Left-Turn Lanes	4 Balanced	5 Traditional
Protected/Separated Bicycle Facilities	N/S Legs ◑	All Legs ●	All Legs ●	N/S Legs ◑	N/S Legs ◑
Pedestrian Crossing Length/Time	26.0 s ◕	24.6 s* ●	24.6 s* ●	26.0 s ◕	21.5 s ●
Total Fuel Used (Gallons/Hr) (2026)	57.0 ◕	58.2 ◕	91.8 ◔	56.3 ◕	100.3 ◔
Vehicle User Delays (2026)	46.9 s ◑	47.8 s ◑	73.9 s ○	47.0 s ◑	117.4 s ○
ROW Impacts	None ●	SW/NE/NW ◑	SW/NE/NW ◑	SW ◕	None ●
Construction Cost**	$1,800,000 ◕	$2,100,000** ◔	$2,100,000** ◔	$1,900,000** ◑	Sim to Alt 1 ◕

Legend:

- ● 5 – Great
- ◕ 4 – Good
- ◑ 3 – Average
- ◔ 2 – Below Ave
- ○ 1 - Poor

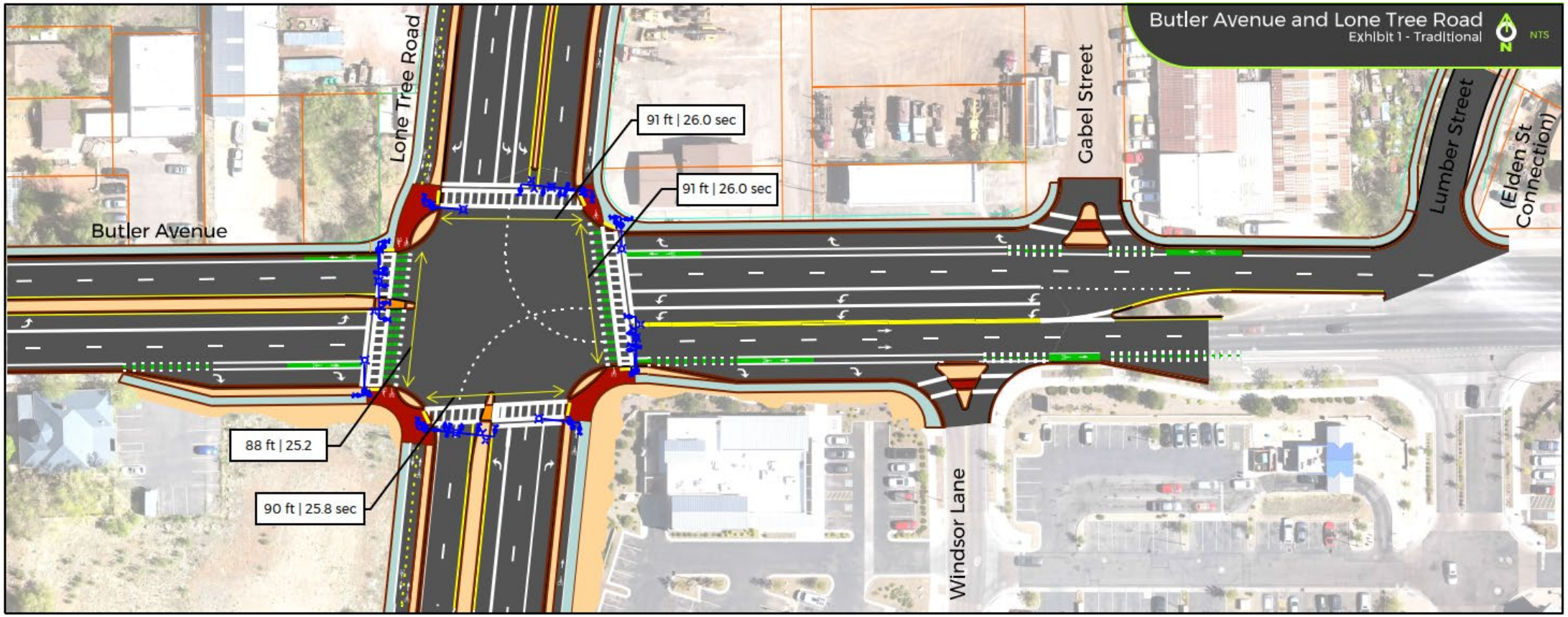


* Time is from channelized island to opposite curb

** Does not include additional right-of-way costs

LTO & Butler – Typical Approach

1



Vehicle Features

- Two left-turn lanes (SB, WB)
- Channelized right-turn lanes (None)

Bicycle Features

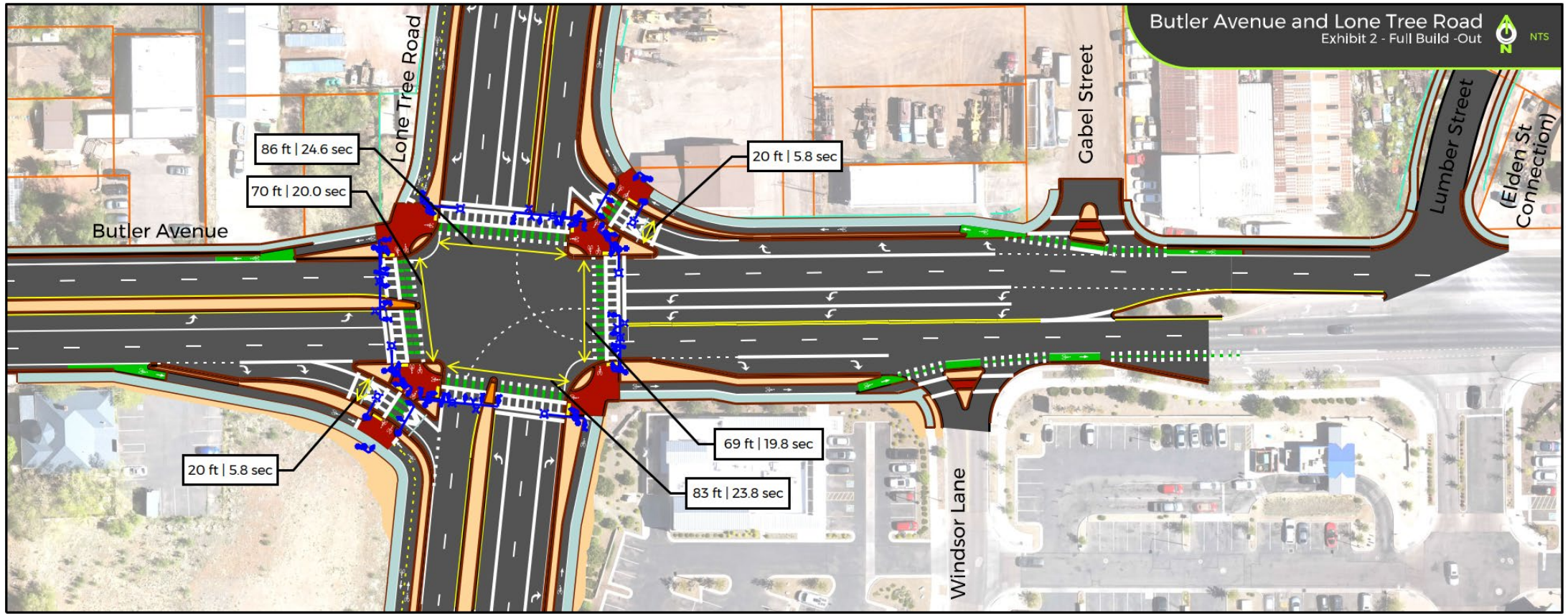
- Separated bike lanes (LTO)

Pedestrian Features

- Raised median (S, W)

LTO & Butler – Full Build-Out Intersection

2



Vehicle Features

- Two left-turn lanes (SB, WB)
- Channelized right-turn lanes (SW, NE)

Bicycle Features

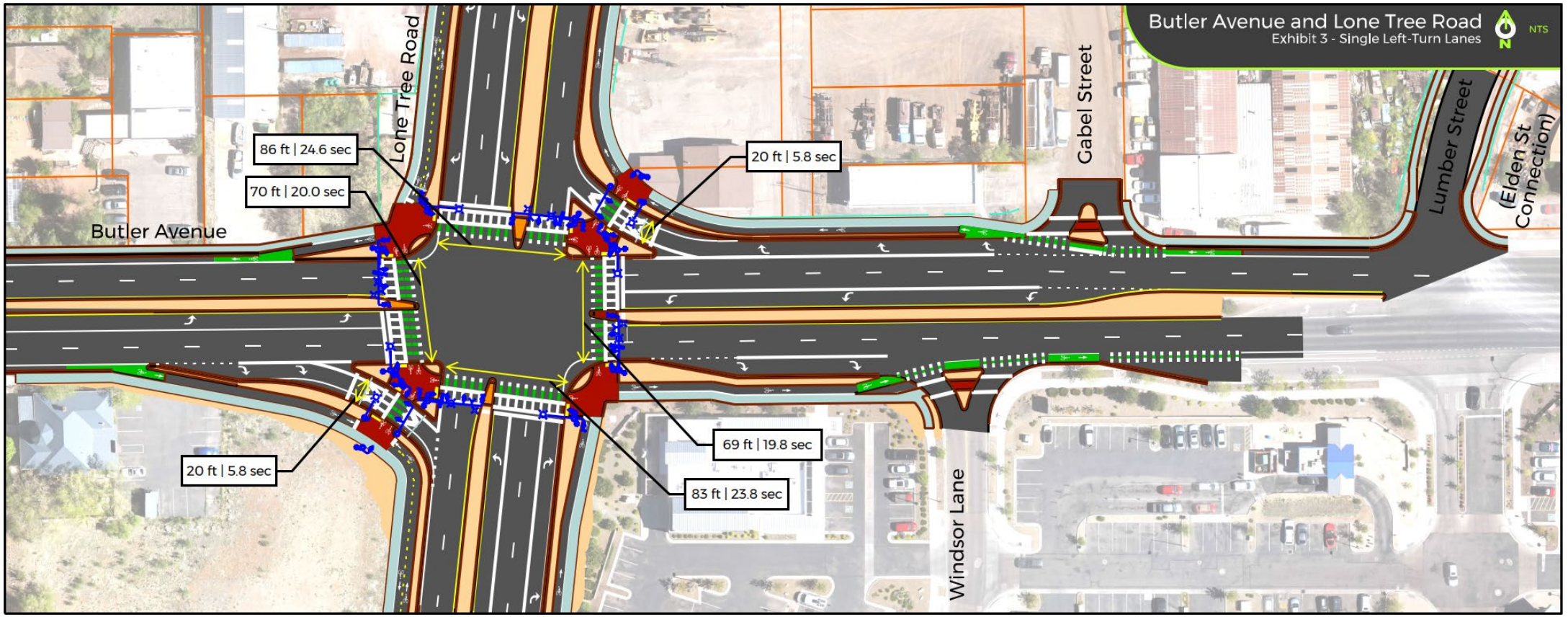
- Separated bike lanes (LTO) and Butler at the intersection

Pedestrian Features

- Raised median (S, W)

LTO & Butler – Single Left Intersection

3



Vehicle Features

- Single left-turn lanes (NB,SB, EB,WB)
- Channelized right-turn lanes (SW, NE)

Bicycle Features

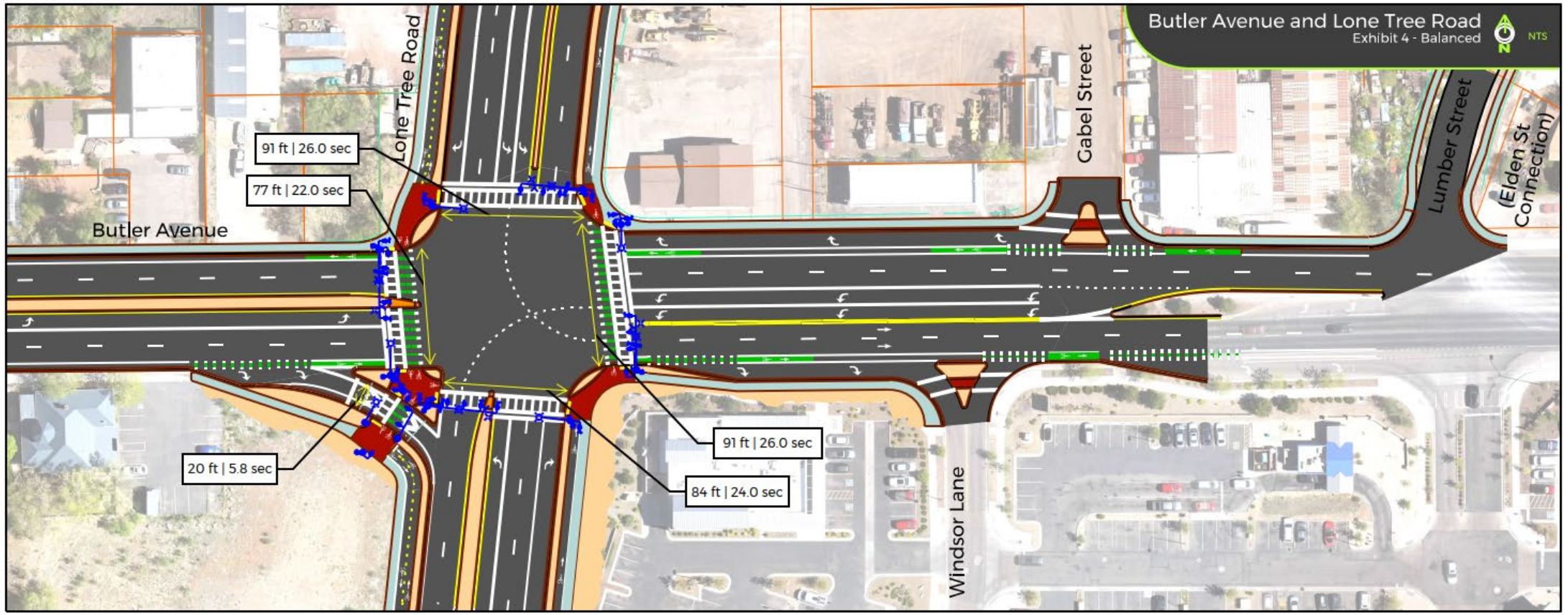
- Separated bike lanes (LTO) and Butler at the intersection

Pedestrian Features

- Raised median (N,S,E, W)

LTO & Butler – Balanced Intersection

4



Vehicle Features

- Single left-turn lanes (NB, EB)
- Channelized right-turn lanes (SW)

Bicycle Features

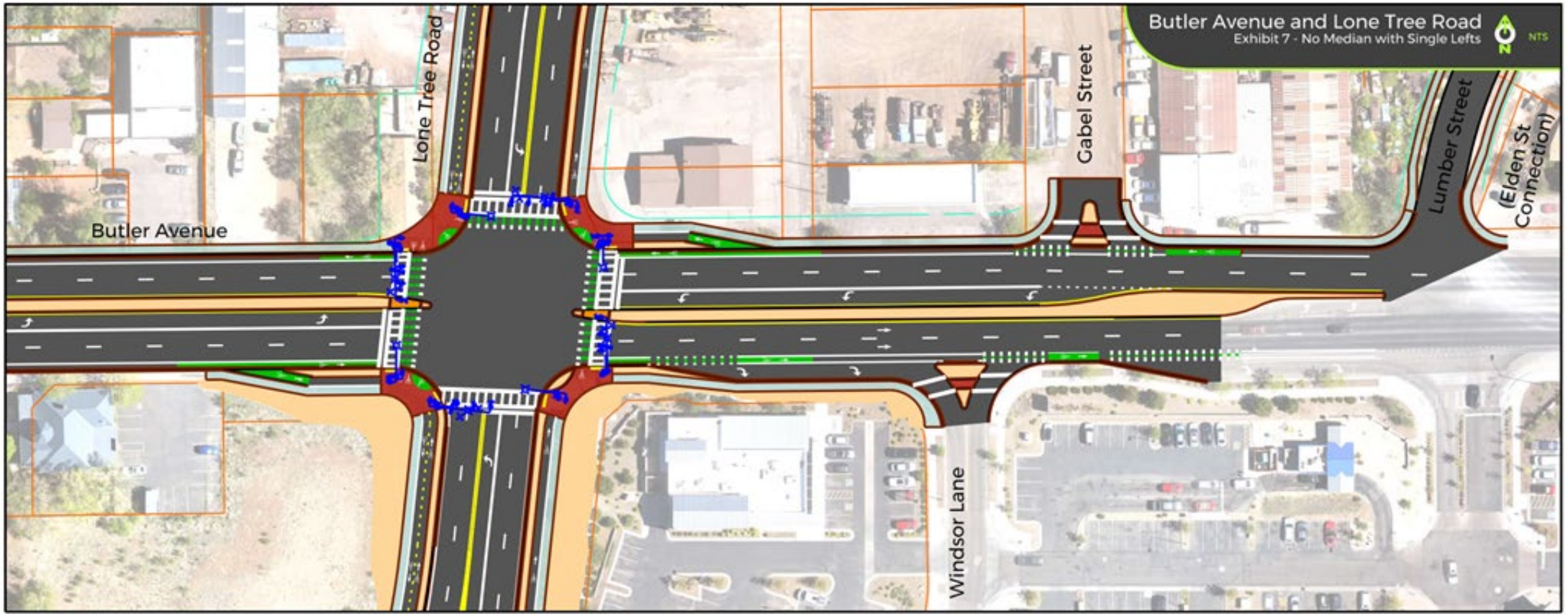
- Separated bike lanes (LTO)

Pedestrian Features

- Raised median (S, W)

LTO & Butler – Traditional Intersection

5



Vehicle Features

- Single left-turn lanes (All)
- Shared Through/Rights (All)

Bicycle Features

- Separated bike lanes (LTO)

Pedestrian Features

- Raised median (E, W)