Appendix A
Engineering and Operations Memorandum

Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

Final
2016 Revised Operational Analysis Report

Revised: October 18, 2016

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Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

Contents

Appendices

List of Tables

List of Figures

1. Introduction

The Oregon Department of Transportation (ODOT) requested that the simulations previously performed for Alternative 1 and Alternative 2 of the Oregon Passenger Rail project be revised to standardize certain aspects of simulated passenger and freight operations. The initial simulations were performed in 2013 and 2014. The Alternative 1 simulations focused passenger operations on Union Pacific Railroad's (UPRR's) Brooklyn Subdivision between Eugene and Portland, OR, and on BNSF's Fallbridge Subdivision between Portland, OR, and Vancouver, WA. The Alternative 2 simulation focused on a route that was mainly a greenfield route along the Interstate (I-5) corridor with some operations on the Union Pacific Railroad's Brooklyn Subdivision north of Oregon City. Although the simulation network ended at Vancouver, WA, the Amtrak Cascades trains actually continue to Vancouver, British Columbia.

2035 freight volumes were developed from previous project experience and discussions with Class 1 Railroads. It was determined that an increase of 1.7% for domestic intermodal and 1.5% for manifest traffic and international intermodal an appropriate growth target for this project. Growth was projected using a compounded annual rate of 1.5 to 1.7% for the through freight movements. UP and BNSF intermodal and manifest trains were also increased using this method. Union Pacific unit train growth was projected based on anticipated growth of new classes of traffic. Projected growth of oil and grain trains to California from the upper Midwest and Canada drove this growth. Two to three loaded trains per day (and their associated empty trains) were included to represent the potential traffic levels in this corridor.

The alternatives analyzed are briefly summarized below:

- Base Case Alternative is modeled for the current year, with existing freight traffic and passenger rail service and schedules.
- No Action – the No Action Alternative is modeled for the 2035 year and assumes increase in freight traffic of 1.5-1.7% compounded annually and no change in passenger rail service.
- Alternative 1 - Alternative 1 generally follows the existing Amtrak Cascades route, along or near the Union Pacific Railroad line between Eugene-Springfield and Portland. It crosses the Willamette River in Portland near Union Station before continuing north, either on or near existing BNSF tracks, to Vancouver, Wash.
- Alternative 2 - Alternative 2 runs along or near Interstate 5 from Eugene-Springfield to Keizer, then follows the Oregon Electric rail line from Keizer to Wilsonville, follows I-5 and I-205 between Wilsonville and Oregon City, where it merges with the existing Amtrak alignment.

In the 2013 and 2014 analyses, the number of Amtrak Cascades round trips between Portland and Vancouver were varied between simulations. Base and No Action train volumes included two Amtrak Cascades and one Amtrak Coast Starlight round trip per day (2+1); in other simulations, three, four and six Amtrak Cascades round trips were analyzed (3+1, 4+1 and 6+1).

For this latest round of revised simulations, the following aspects were standardized between the runs:

1. All passenger operations between Portland and Vancouver, WA, were standardized to six Amtrak Cascades round trips per day, one Coast Starlight round trip per day and one Empire Builder (Spokane/Portland Section) round trip per day. This schedule will be referred to as the 6+2 passenger schedule.

2. Operations at the Eugene Amtrak Station were also standardized in the revised simulations. In the Revised Base and Revised No Action simulations, the existing infrastructure configuration for the station was left in place and operations reflected that configuration. In the Amtrak Cascades growth simulations, a new infrastructure configuration for the station was included (Option 4) and passenger operations were modified accordingly.

3. The configuration of Eugene Yard was also standardized in all simulations to better reflect actual operations. The configuration that was utilized is described later in the report and is shown in the schematics that are associated with each simulation network.

4. Track improvements that UPRR has recently completed were also included in the Revised Base simulation; in previous work, these improvements were not known and therefore were not included in the Base simulation. The track upgrade improvements were included in all of the subsequent simulations of alternatives that were performed in 2013 and 2014, and were also included in all of the revised simulations.

5. Improvements included between Portland and Vancouver primarily were the planned upgrade improvements at North Portland Junction (NPJ)/Peninsula Junction and Willbridge Junction to allow 25 mph operations. Both projects are under development for PE/NEPA and were assumed to be constructed by 2035 for this analysis. The No Action and Base Case scenarios are the only simulations that did not include the improvements.

It should be noted that a newer version of the RTC model was used for the 2015 analyses than was used for the 2013 and 2014 analyses. Berkeley Simulation Software updated the model based on issues that had been identified over time with previous versions of the model. Once a new version is released, all license holders are expected to upgrade to that version, and support for previous versions is discontinued.

Primary Conclusions for the Revised Simulations

- All three of the expanded passenger service cases for Alternative 1 (3+1, 4+1 and 6+1) over the Brooklyn Subdivision between Portland and Eugene showed an improvement in freight operations compared to the No Action alternative, based on the assumptions used in the revised simulations. Because the 4+1 and 6+1 alternatives used the same network, and the 3+1 alternative is a subset of that network, infrastructure will not be wasted under any alternative if an incremental approach is considered.
- The improvements at Peninsula Junction and NPJ (increasing the speeds to 25 mph for freight traffic) proved to be very beneficial to all rail operations in North Portland on

UPRR's and BNSF's networks in the area of the connection track under the six Amtrak Cascades*,* Coast Starlight and Empire Builder (6+2) passenger schedules.

The main alternatives for this study—Alternative 1 (revised), Alternative 2 and the No Action with Minimums Alternative—are detailed in the body of this report. Other Alternative 1 options that vary by schedule and infrastructure were run through the modeling software and analyzed. Although these other options are mentioned throughout this report in comparisons, the description of these options and the results of their analysis are included in the supplemental material attached to this report (see Appendices A–F).

2. Revised Alternative 1

Introduction

Alternative 1 (6+1) was revised to standardize the assumptions that were included in the analysis. Like all of the revised analyses, the number of passenger trains between Portland and Vancouver were standardized at six Amtrak Cascades round trips, and the station configuration at Eugene was standardized to the Option 4 configuration. In addition, between Portland and Vancouver, the planned track and the turnouts at NPJ/Peninsula Junction and Willbridge Junction were assumed to be upgraded to allow 25 mph operation.

In addition, six Amtrak Cascades round trips were included between Portland and Eugene in the Revised Alternative 1 (6+1) analysis. However, a major difference between the initial 6+1 case and the Revised 6+1 case was the infrastructure, which was included in an attempt to mitigate the impacts of the additional passenger trains. In the initial 6+1 analysis, a second main track was included for the entire distance between Portland and Eugene. This configuration was found impractical because of the cost to improve certain locations, including those portions going through cities and across major rivers. Instead, the Alternative 1 (4+1) network was utilized in the analysis for the Revised Alternative (6+1). The Analysis Team was asked to utilize this network for the analysis in order to determine whether the improvements associated with the 4+1 network(s) would accommodate six Amtrak Cascades round trips while still improving UPRR's operations over the Revised No Action alternative (for which no additional round trips and no improvements would be added).

Revised Alternative 1 (6+1) Operating Modifications

The only freight modification made on either UPRR's Brooklyn Subdivision or on BNSF's Fallbridge Subdivision was the addition of the Albina Yard to Lake Yard Local. All other projected freight traffic, including growth traffic, was carried over from the Revised No Action simulation, the Revised 3+1 simulation or the Revised 4+1 simulation.

Portland to Eugene Amtrak Cascades round trips were increased to six per day. At the same time, Portland to Vancouver (and north) Amtrak Cascades round trips were reduced from 12 in the initial 6+1 analysis to six in the Revised 6+1 analysis. No other operating modifications were made in this revised Alternative 1 (6+1) case.

Revised Alternative 1 (6+1) Network Modifications

As described previously, the Revised Alternative 1 (6+1) case utilized the Revised Alternative 1 (4+1) improvements that are listed in Appendix D for UPRR's Brooklyn Subdivision. The schematic included in Appendix D for the Revised 4+1 network also reflects the improvements made along the Brooklyn Subdivision that were included in the analysis for the Revised 6+1 case.

Between Portland and Vancouver, the same planned improvements that were included in the Revised 4+1 network were also included in the Revised 6+1 network, primarily the track and the turnout improvements at NPJ/Peninsula Junction and Willbridge Junction to allow 25 mph operation.

Revised Alternative 1 (6+1) Brooklyn Subdivision Results

The premise that the improvements associated with the Alternative 1 (4+1) network could support up to six Amtrak Cascades round trips was correct. The results of the analysis showed that the delay minutes per 10 miles operated were 3.0 for the Revised Alternative 1 (6+1) case. This level of delay remained more than 20% below the delay minutes associated with the Brooklyn Subdivision under the 2035 Revised No Action alternative (see Figure 1, below).

That level of delay minutes per 10 miles operated indicates that the Brooklyn Subdivision was running efficiently under the Revised Alternative 1 (6+1) case on the 4+1 network. Analysis of the major delays and their locations confirms this conclusion.

The Revised Alternative 1 (6+1) case had 3.3 delays per day that exceeded 30 minutes (see Figure 2, below). As Figure 3 below shows, most of those delays were the result of Amtrak meets or freight meets. There were some delays associated with on-line switching, and there were also delays that occurred around various rail yards.

The 6+1 passenger schedules created meets that varied widely over the course of a day. Unlike the 4+1 case, under which most meets occurred between Clackamas and East Milwaukie, the 6+1 meets occurred in five different locations. These were:

- Between Steel Bridge (MP770) and East Milwaukie (MP765)
- Between Coalca (MP750) and Canby (MP746)
- Between Salem (MP718) and Renard (MP714)
- Between Marion (MP704) and Albany (MP690)
- Between Halsey (MP672) and Shedd (MP666)

Analysis of the meet/pass data showed that only one or two freight trains per day were delayed in a single location near where two passenger trains met. This analysis was confirmed by the data on the number of delays exceeding 30 minutes that were caused by Amtrak trains: In the Revised 6+1 analysis, there were only 1.3 such delays per day (see Figure 3, below). Because essentially the same number of delays that exceeded 30 minutes per day could be attributed to freight meets, passenger-passenger meets were not a major cause of repetitive delays in the Revised Alternative (6+1) case analysis.

The Analysis Team believes that the amount of second main track that was included in the 4+1 network protected freight traffic from the passenger meets. Many of the passenger-passenger meets occurred in a segment that featured a second main track, allowing the two trains to pass each other quickly and without a major impact to following or opposing freight traffic. This same benefit was observed on the 4+1 network when only four Amtrak Cascades round trips were included in the Revised Alternative 1 (4+1) case analysis.

Figure 5 also confirms that there was no systematic issue with any single location along the Brooklyn Subdivision. The delays that occurred were spread relatively evenly between Portland and Eugene.

The delays associated with on-line switching occurred at Labish and Albany. As in a previous case, the Labish delay was caused by two trains that had on-line switching duties arriving simultaneously, causing one train to wait. At Millersburg, a train working the industries around Albany (picking up or delivering cars) blocked the Millersburg train from entering Albany Yard. A Portland & Western Railroad (PNWR) train also contributed to this particular conflict. That train had to wait on UPRR's main line for traffic at PNWR's Millersburg Yard to clear. The PNWR train could not leave the Brooklyn Subdivision until switching at that yard ceased, which created additional congestion around Albany on UPRR's track.

Finally, there were some delays associated with entering and exiting yards. One such conflict occurred around Eugene when a single southbound train trying to enter the yard at Irvin was delayed by two northbound trains departing the yard at that same location. As was discussed previously, this is a feature of Eugene Yard that is likely to create additional conflicts as traffic volumes increase.

The other yard conflict occurred at Albany when two southbound trains arrived as a northbound train arrived, and another train tried to depart the yard. The model held the departing train in the yard to clear the through traffic, which led to the delay.

Even with the isolated delays that occurred, the Analysis Team believes that, based on the analysis, the 4+1 network efficiently accommodated the 2035 projected freight volumes with the six Amtrak Cascades round trips.

Revised Alternative 1 (6+1) Brooklyn Subdivision Velocity Comparison

The following table provides the velocity of the various train classes on the Brooklyn Subdivision for the Revised Alternative 1 (6+1) case analysis.

Table 1. Revised Alternative 1 (6+1) on 4+1 Infrastructure

Group	Delay	Dwell	Elapsed Time	Miles	Del/10*	Total Elapsed Velocity	Velocity Minus Delay and Dwell
Passenger	2:44:47	11:33:57	103:47:00	5273.8	0.3	50.8	58.9
PNWR	2:29:27	14:48:00	26:09:44	463.3	3.2	17.7	52.2

UP Expedited	8:12:11	7:36:09	76:30:35	2413.9	2.0	31.6	39.8
UP Local	9:10:37	60:26:04	95:41:49	699.6	7.9	7.3	26.8
UP Manifest	19:51:33	68:24:10	210:35:31	4313.3	2.8	20.5	35.3
UP Unit	12:31:18	21:01:11	111:35:48	2609.1	2.9	23.4	33.4
Total Freight	**52:15:05**	**172:15:34**	**520:33:26**	**10499.2**	**3.0**	**20.2**	**35.5**

*Delay/10 = delay minutes per 10 miles operated.

Passenger trains continued to operate at a high velocity using the Revised 6+1 network. Both total elapsed, and elapsed minus delay and dwell velocities were slightly greater than the velocities for the Revised No Action alternative and Revised 4+1 case. The Analysis Team believes that meets that occurred primarily on two main tracks as well as the higher number of passenger trains contributed to this result.

Similar to the results of unit train velocity in the No Action alternative analysis versus the Base analysis, there were additional passenger trains in the Revised Alternative 1 (6+1) case analysis. Since these additional passenger trains added miles where trains were operating at higher speeds, the average velocity of all passenger trains in the network was increased.

Freight velocity was also greater than for the Revised No Action alternative; however, it was slightly lower than for the Revised Alternative 1 (4+1) case. The freight velocity numbers were very similar to those of the Revised Alternative 1 (3+1) case, and, not surprisingly, the delay minutes per 10 miles operated for the Revised Alternative 1 (6+1) and (3+1) cases were very similar as well.

Based on these results, it appears that network configurations used in the Revised Alternative1 (6+1) analysis and the Revised Alternative 1 (3+1) analysis provided approximately the same additional freight capacity with the varied passenger train volumes.

Revised Alternative 1 (6+1) Portland to Vancouver Results

Delays exceeding 30 minutes (D>30 delays) associated with the Revised Alternative 1 (6+1) case analysis were the same as the D>30 delays in the Revised Alternative 1 (3+1) and (4+1) cases. For all of these cases, the delays were notably reduced from the Revised No Action alternative simulation. With the same amount of freight traffic on the segment, the number of delays was reduced to 1.3 per day from 4.7 per day in the Revised No Action alternative (see Figure 7, below). As described previously, the number of Amtrak Cascades and Amtrak round trips (Cascades and Empire Builder) remained the same between the two cases.

As with the Revised Alternative 1 (3+1) and (4+1) cases, the main contributor to the improved performance was the increased speed on UPRR's connection between Peninsula Junction and NPJ, along with the upgraded turnouts at each end of the connecting track. Movements that could continue from BNSF's Fallbridge Subdivision onto the UPRR connection track at 25 mph cleared the area much more quickly, thus reducing delays for UPRR traffic and BNSF traffic operating in the area.

Also, as in the previous cases, the local train working between Willbridge Yard and Lake Yard experienced delay in the Revised Alternative 1 (6+1) case analysis. As previously described, this is a timing issue rather than a specific capacity issue.

The results of the Revised Alternative 1 (6+1) case again support the conclusion that Brooklyn Subdivision passenger and freight operations have little to no effect on Fallbridge Subdivision operations (and vice versa), under the assumptions that were used for these revised analyses.

3. Revised Alternative 2

Two aspects of the Alternative 2 simulation that was performed and analyzed in 2013 were not consistent with other analyses of the various track and train configurations between Vancouver, WA, and Eugene, OR. These two aspects were: the number of passenger trains between Portland and Vancouver (continuing on to Seattle or Spokane) and an analysis of train velocity over the Brooklyn Subdivision.

Reduced Amtrak Cascades Schedules between Portland and Vancouver

At the time the original Alternative 2 analysis was performed, the Analysis Team was directed to include 12 Amtrak Cascades round trips in addition to one Coast Starlight round trip and one Empire Builder (Spokane Section) round trip between Portland and Vancouver. These numbers of round trips were based on Washington Department of Transportation's long-range projection of passenger round trips that potentially would operate between Portland and Seattle. In subsequent simulations, the Analysis Team was instructed to reduce the number of Amtrak Cascades round trips between Portland and Seattle to six, and to keep the Coast Starlight and Empire Builder round trips the same (one each).

This reduction of Amtrak Cascades round trips was tested in multiple scenarios that focused on Portland to Eugene passenger trains using the Brooklyn Subdivision (as described in other sections of this report and in the appendices), but was never tested for the Alternative 2 network. The results from the multiple Brooklyn Subdivision simulations with the reduced Amtrak Cascades operations between Portland and Vancouver were very similar: the reduced number of passenger trains improved the operation of freight traffic between Vancouver and Portland, and had little impact on freight operations south of Portland.

The Analysis Team strongly believes this same result would be seen if the number of Amtrak Cascades round trips in Alternative 2 was reduced from twelve to six. The main support for this belief is that the track improvements and operational modifications that were used in all of the subsequent Brooklyn Subdivision simulations were also included in the Alternative 2 simulation.

The Alternative 2 network included the planned track improvements at NPJ/Peninsula Junction and near Willbridge Yard between Portland and Vancouver. These improvements were critical in the simulated operations in all scenarios, with or without the reduced Amtrak Cascades operations, because they allowed freight traffic to operate at higher speeds between Portland and Vancouver. Along with reduced passenger operations in the corridor, freight trains encountered fewer conflicts with both passenger and other freight operations, which led to improved performance for all freight traffic. The Analysis Team believes that this effect would be replicated in the Alternative 2 simulation if the Amtrak Cascades round trips were reduced to six.

Additionally, in the Alternative 2 analysis, PNWR trains running from Albany to Vancouver were routed via Beaverton, Banks, United Junction and Willbridge Junction rather than via Labish, Willsburg Junction and the Steel Bridge. This rerouting of PNWR trains improved operations around Portland Union Station in subsequent simulations, whether the Portland to Eugene passenger trains were routed via the Brooklyn Subdivision or via the Alternative 2 network. The Analysis Team has no reason to believe that this improvement in operations would not occur, or would be different, if the number of Amtrak Cascades round trips between Portland and Vancouver were reduced in the Alternative 2 scenario.

Therefore, although the Alternative 2 simulation was never tested with only six Amtrak Cascades round trips between Portland and Vancouver, the Analysis Team is confident that a simulation that reduced the number of round trips would show results similar to the other five scenarios for which the reduced passenger volumes were used. For this reason, the decision was made to not rerun the entire Alternative 2 simulation, but to rerun only that portion that would provide the velocity output needed for further comparisons.

Alternative 2 Velocity Analysis

The second analysis that was not included in the initial Alternative 2 simulation is a comparison of train velocity of various train groups over the Brooklyn Subdivision. Velocity was not analyzed during the initial Alternative 1 and 2 simulations; it was added in later simulations as an additional comparative analysis to complement the delay analyses that were performed.

The Analysis Team conducted the velocity analysis for the Alternative 2 simulation to standardize the analysis of all simulations. The statistics were available in the output of the model; therefore, with some additional breakout of train types, the velocity figures could be developed. The following tables include those velocity figures and a brief analysis of how they compare with the velocities from the other simulations.

Table 2. Brooklyn Subdivision Alternative 2 Train Velocities

Group	Delay	Dwell	Elapsed Time	Miles	Del/10	Total Velocity Elapsed	Velocity Minus Delay and Dwell
Passenger	0:00:00	5:39:00	23:22:46	738.6	0.0	31.6	41.7
PNWR	2:04:11	13:18:00	25:29:21	463.3	2.7	18.2	45.8
UP Expedited	6:53:47	6:06:08	66:03:22	2125.2	1.9	32.2	40.1
UP Local	7:00:22	60:19:04	91:22:41	693.3	6.1	7.6	28.8
UP Manifest	29:23:08	79:54:03	270:46:04	5680.7	3.1	21.0	35.2
UP Unit	10:02:13	11:00:04	68:33:01	1513.7	4.0	22.1	31.9
Total Freight	**55:23:41**	**170:37:19**	**522:14:29**	**10476.1**	**3.2**	**20.1**	**35.4**

Table 3. PNWR OE (Oregon Electric) District Alternative 2 Train Velocities

Group	Delay	Dwell	Elapsed Time	Miles	Del/10	Total Velocity Elapsed	Velocity Minus Delay and Dwell
Passenger	0:54:54	1:12:00	16:10:09	1096.2	0.5	67.8	78.0
PNWR / Total Freight	59:08:23	215:03:15	441:08:43	3588.4	9.9	8.1	21.5

Brooklyn Subdivision

In the following table, the last two columns of Table 2 above have been recreated using the same last two columns from the Revised No Action alternative analysis. The Revised No Action alternative analysis is the simulation that is most similar to the Alternative 2 simulation with respect to infrastructure and train volumes on the Brooklyn Subdivision.

Table 4. Brooklyn Subdivision Alternative 2 Train Velocities vs. Revised No Action Alternative

Group	Alternative 2		Revised No Action	
	Total Velocity Elapsed	Velocity Minus Delay and Dwell	Total Velocity Elapsed	Velocity Minus Delay and Dwell
Passenger	31.6	41.7	47.9	56.9
PNWR	18.2	45.8	18.3	46.0
UP Expedited	32.2	40.1	31.6	39.9
UP Local	7.6	28.8	7.4	27.4
UP Manifest	21.0	35.2	19.6	34.9
UP Unit	22.1	31.9	22.4	33.2
Total Freight	**20.1**	**35.4**	**19.7**	**35.2**

As can be seen in the comparison of the two analyses, the velocities of the various freight train types are similar. This result was expected in the Alternative 2 analysis, because most of the Brooklyn Subdivision was left as a single-track railroad with sidings in the simulation, which was the same configuration that was used in the Revised No Action alternative simulation.

There was a slight improvement in velocities of the Expedited, Local, and Manifest freight categories in the Alternative 2 analysis, because, in the Revised No Action simulation, there were two Amtrak Cascades round trips and a Coast Starlight round trip that continued to operate between Portland and Eugene. In the Alternative 2 simulation, the increased passenger trains operated on the Brooklyn Subdivision only between their layover facility and the I-5 connection in Eugene (approximately 1 mile), and between Oregon City and Portland Union Station. The rest of the subdivision saw no passenger trains, which created fewer conflicts for the freight traffic between Oregon City and Eugene Yard, thus leading to slightly higher velocities over the entire route between Portland and Eugene.

The differences in the passenger velocities stem from the different locations where the passenger trains operated in the Alternative 2 simulation compared to the Revised No Action alternative simulation. As mentioned previously, in the Alternative 2 simulation, the passenger trains were on the Brooklyn Subdivision only between Portland Union Station and the connection just south of Oregon City, whereas in the Revised No Action alternative simulation, the two existing Amtrak Cascades round trips and the Coast Starlight round trip operated over the entire distance between Portland and Eugene. The maximum track speeds between Portland and Oregon City were generally lower than across other locations of the Brooklyn Subdivision, which is why the passenger velocities in the Alternative 2 simulation were less than the passenger velocities in the Revised No Action alternative simulation.

PNWR OE (Oregon Electric) District

Unlike previous simulations that were focused on the Brooklyn Subdivision, passenger operations in the Alternative 2 simulation utilized the PNWR's OE District between Wilsonville and Keizer (North Salem). Therefore, in the Alternative 2 simulation, velocity was calculated for PNWR OE District freight traffic as well as for the UPRR's Brooklyn Subdivision freight traffic.

However, in the previous velocity analyses, no OE District traffic was analyzed, because passenger operations did not operate over the District, nor did they affect OE District freight operations. Therefore, the Analysis Team revisited the Revised No Action alternative simulation and calculated the PNWR freight velocity over the OE District, which provided some comparison to the Alternative 2 velocity that is shown Table 5, below.

The following table compares the PNWR Alternative 2 velocity with the Revised No Action alternative velocity for PNWR's OE District:

Table 5. PNWR Velocities for OE District

	Alternative 2		Revised No Action	
Group	**Total Velocity Elapsed**	**Velocity Minus Delay and Dwell**	**Total Velocity Elapsed**	**Velocity Minus Delay and Dwell**
Passenger	67.8	78.0	n/a	n/a
PNWR	8.1	21.5	8.2	20.5
Total Freight	**8.1**	**21.5**	**8.2**	**20.5**

As can be seen in Table 5, the PNWR Alternative 2 total elapsed velocity was essentially equal to the Revised No Action alternative total elapsed velocity. However, the Alternative 2 velocity minus delay and dwell was higher than the Revised No Action alternative velocity. The explanation for these results is provided by examining the area that the passenger trains operated over.

There are multiple industries that PNWR serves between Keizer and Wilsonville. In the model, these are simulated by having a local (or multiple locals) stop at the appropriate locations and dwell for a period of time. This was done in both the No Action alternative and the Alternative 2 simulations.

In addition, there was some delay to PNWR trains that had to wait for passenger trains entering or exiting the section between Keizer and Wilsonville. Both the dwell for industry work and the occasional delays at Keizer or Wilsonville are included in the total velocity elapsed statistics.

When total elapsed velocity is considered with the stoppages and delays, the increased track speed that was associated with introducing the passenger operations had little impact on the velocity of PNWR's freight operations. However, when the delays and dwells were removed from the calculations, the increased freight operating speed is apparent. Because only the portion of the OE District between Keizer and Wilsonville was upgraded for the passenger trains, the rest of the OE District remained at existing track speeds. The Analysis Team believes that is why there is only a small increase in velocity.

It is also interesting to note that the average passenger velocity over the PNWR in the Alternative 2 simulation is 78.0 mph when dwell at the proposed Wilsonville station is removed from the calculation. This velocity is very close to the maximum track speed of 79 mph that was assigned to the PNWR track that hosted the passenger trains. The loss of 1 mile per hour is likely due to the acceleration and deceleration of the passenger trains from the Wilsonville station stop.

There was no passenger operation in the Revised No Action alternative simulation on PNWR's OE District; therefore, there is nothing to compare that velocity to in any other simulation scenario.

4. All Revised Simulation Graphics

The following section contains the revised graphics referenced in this report for all of the revised simulations, including those in the appendices.

Figure 1. Freight Delay Minutes/10 miles Operated

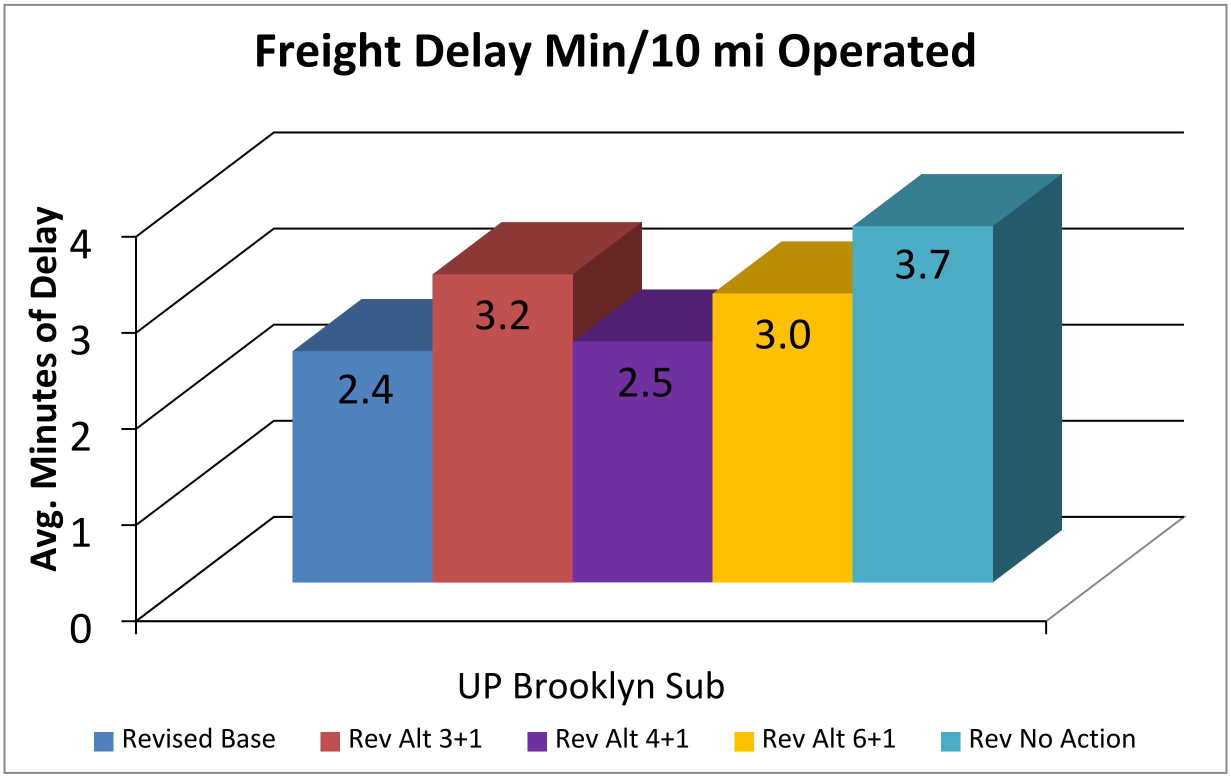


Figure 2. Daily Freight Only Delays Exceeding 30 Minutes (D>30)

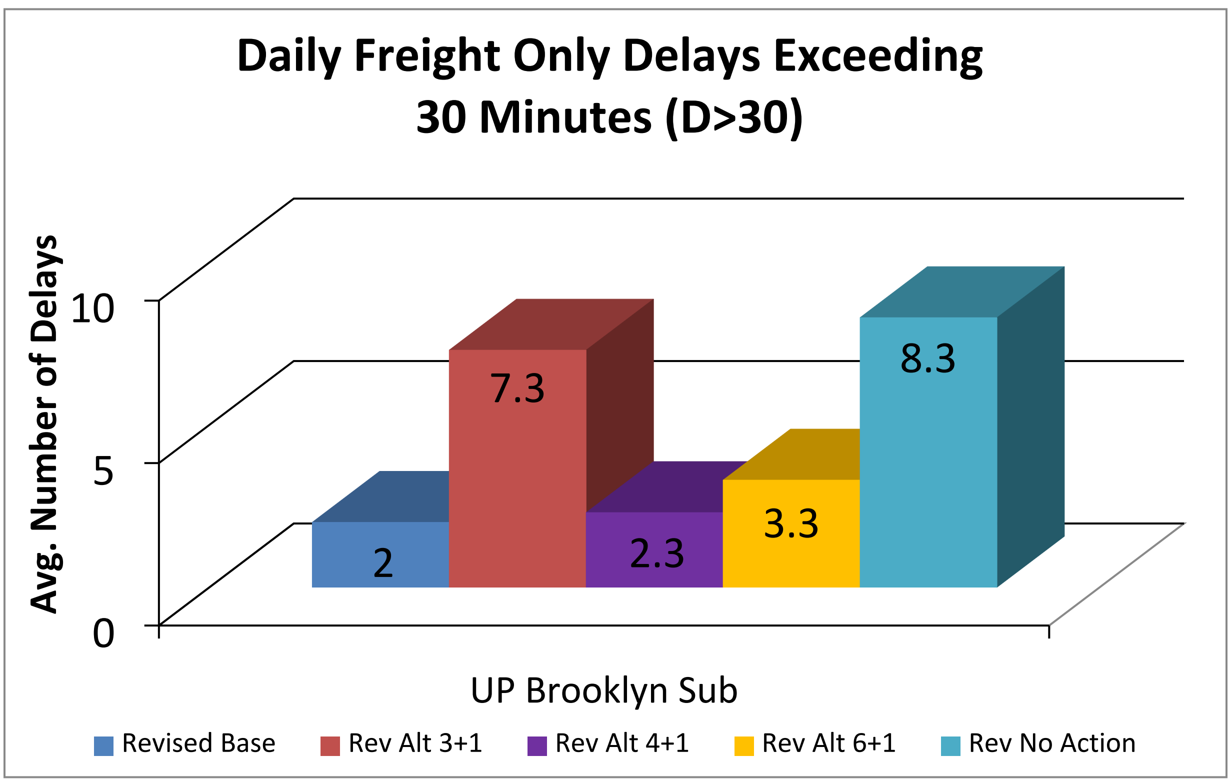


Figure 3. UP Average Freight Only Daily D>30 Causes (3+1, 4+1, 6+1)

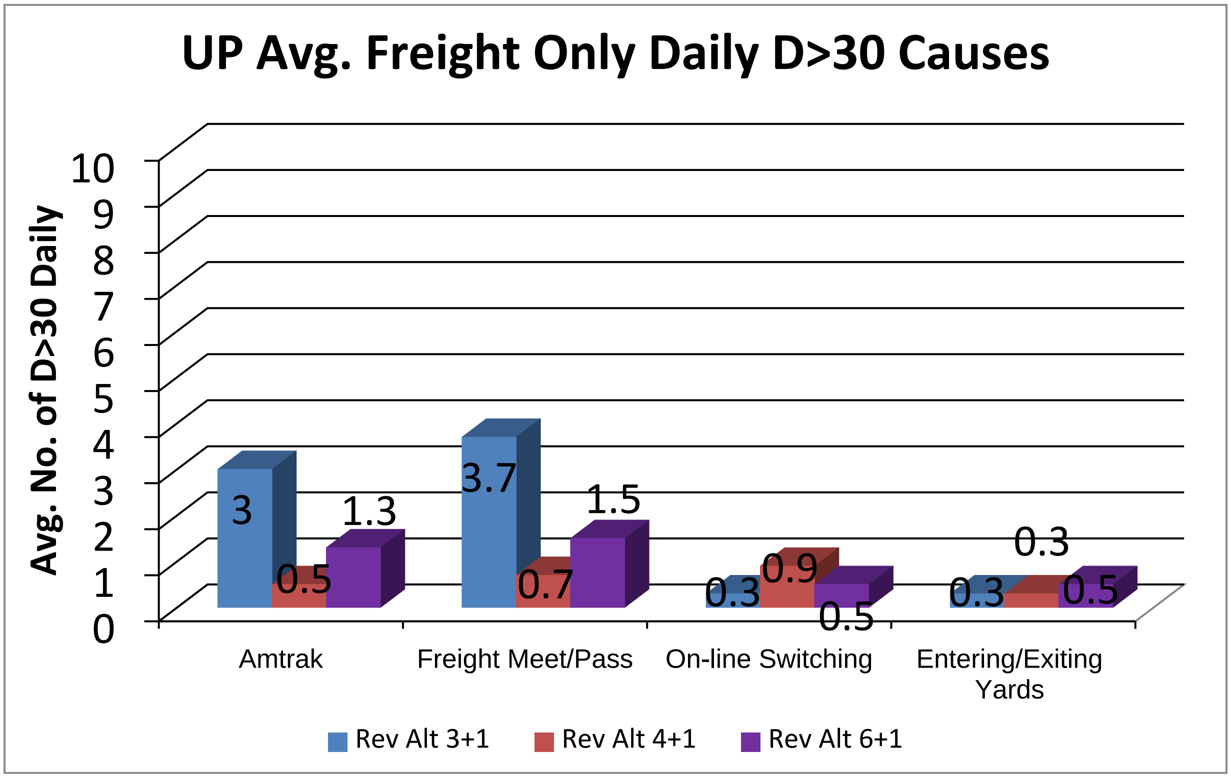


Figure 4. UP Average Freight Only Daily D>30 Causes (Revised Base, Revised No Action)

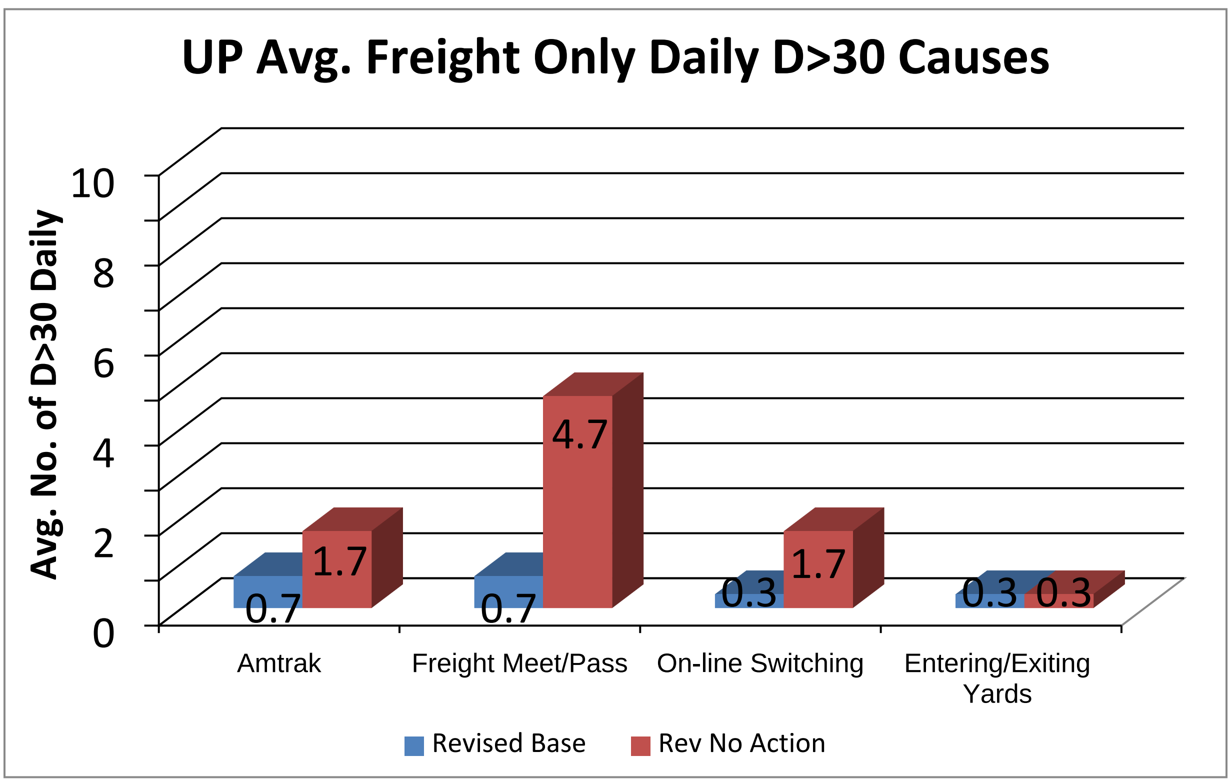


Figure 5. UP Average Freight Only Daily D>30 Locations

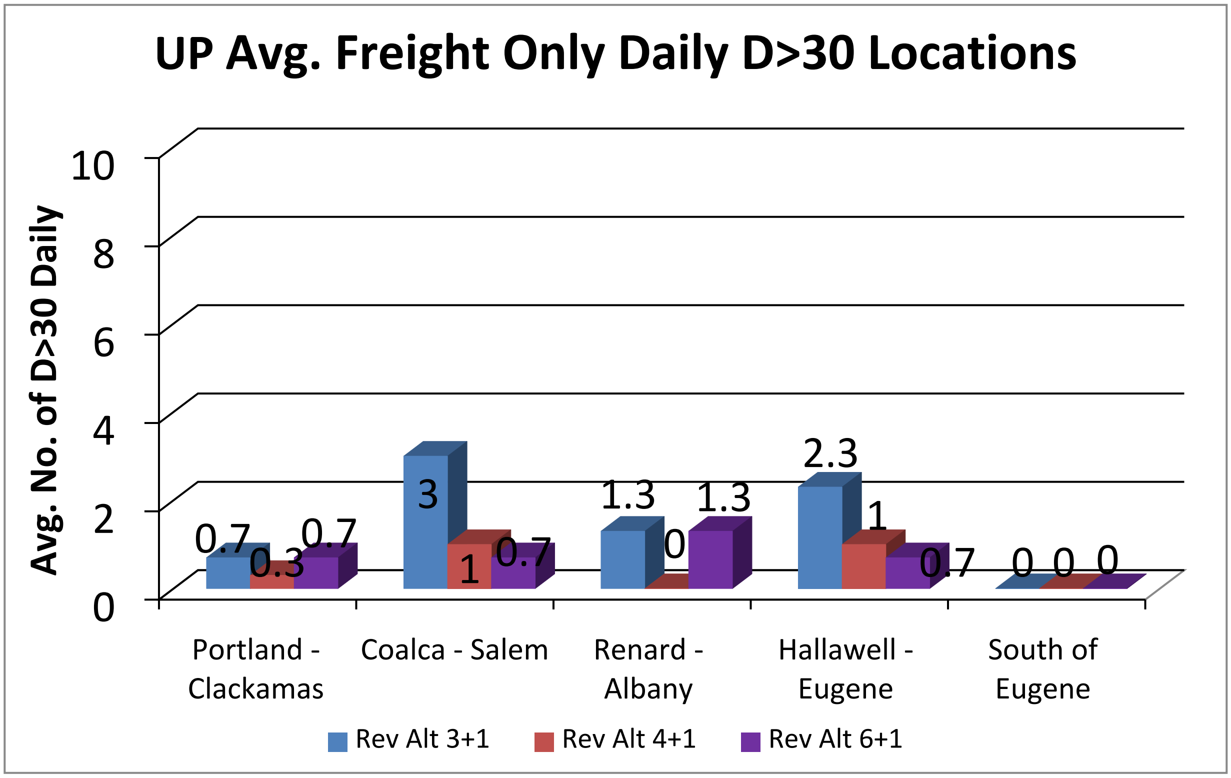


Figure 6. UP Average Freight Only Daily D>30 Locations

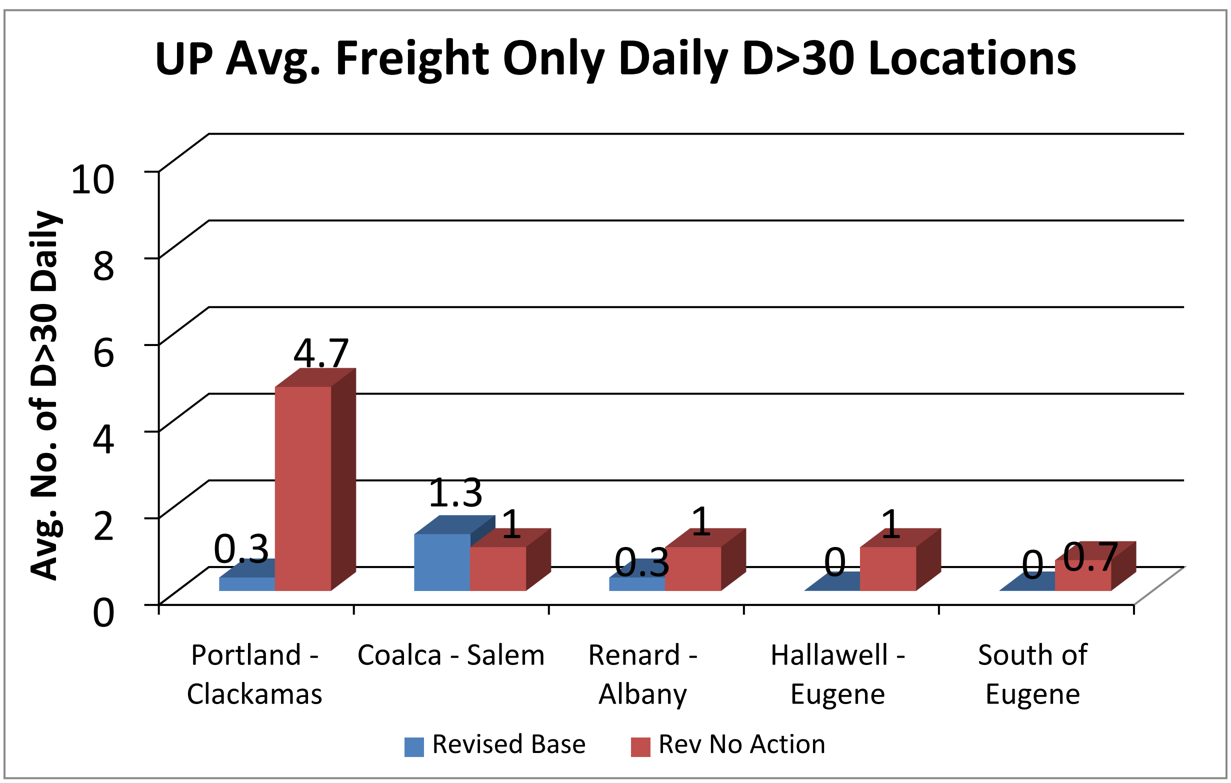


Figure 7. Average Daily D>30 Delays, Portland to Vancouver

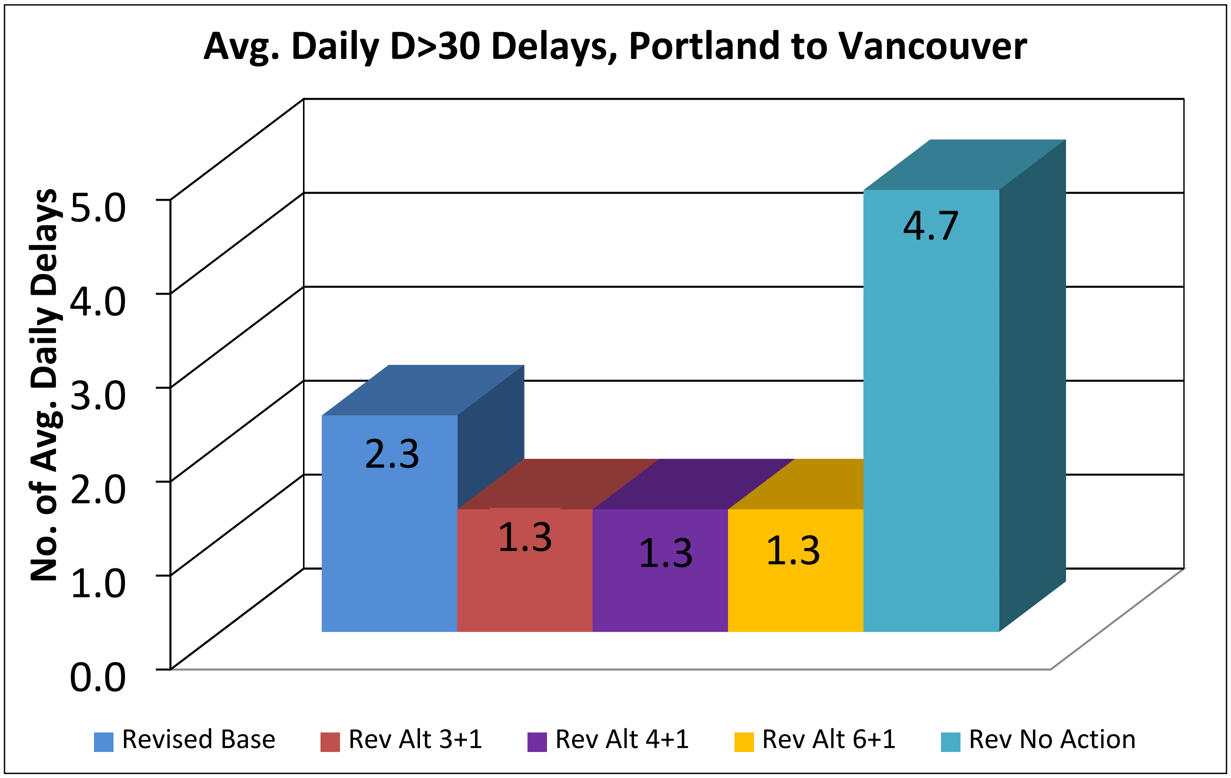


Figure 8. Initial Cause of D>30 Delays, Portland to Vancouver

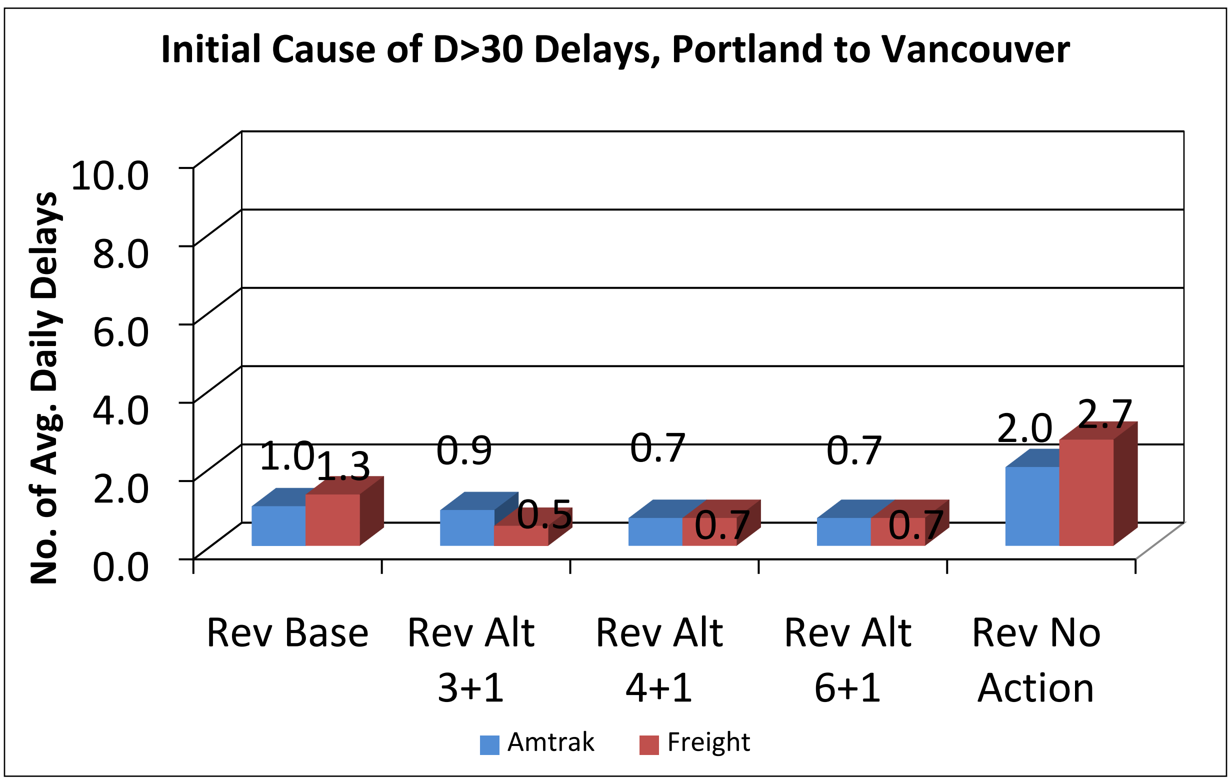
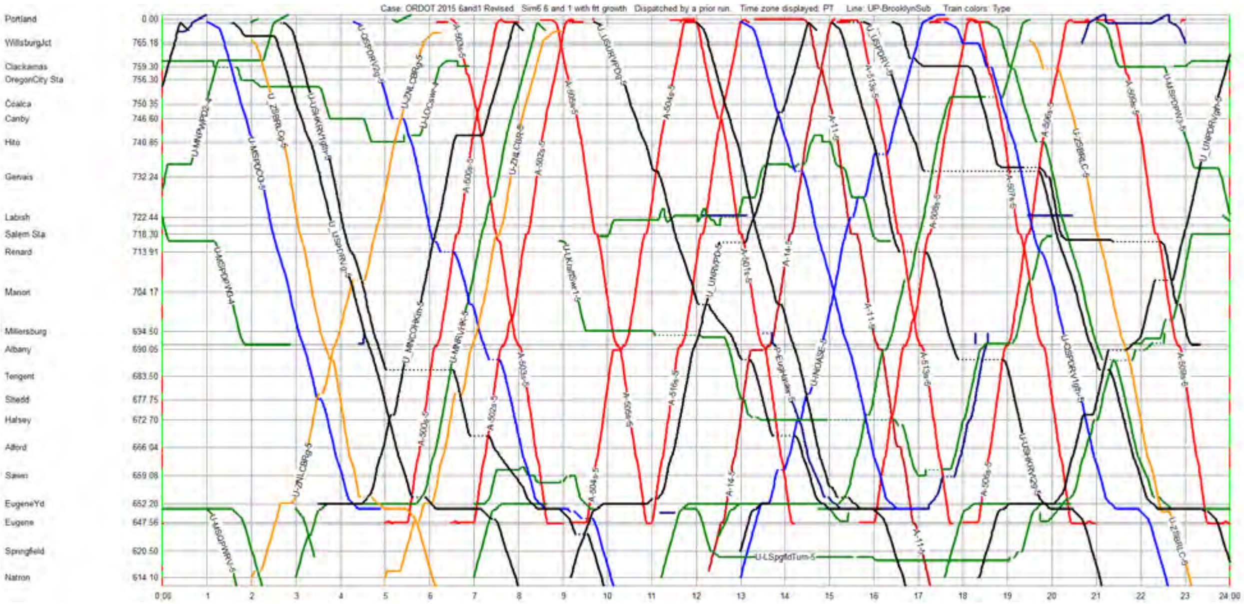
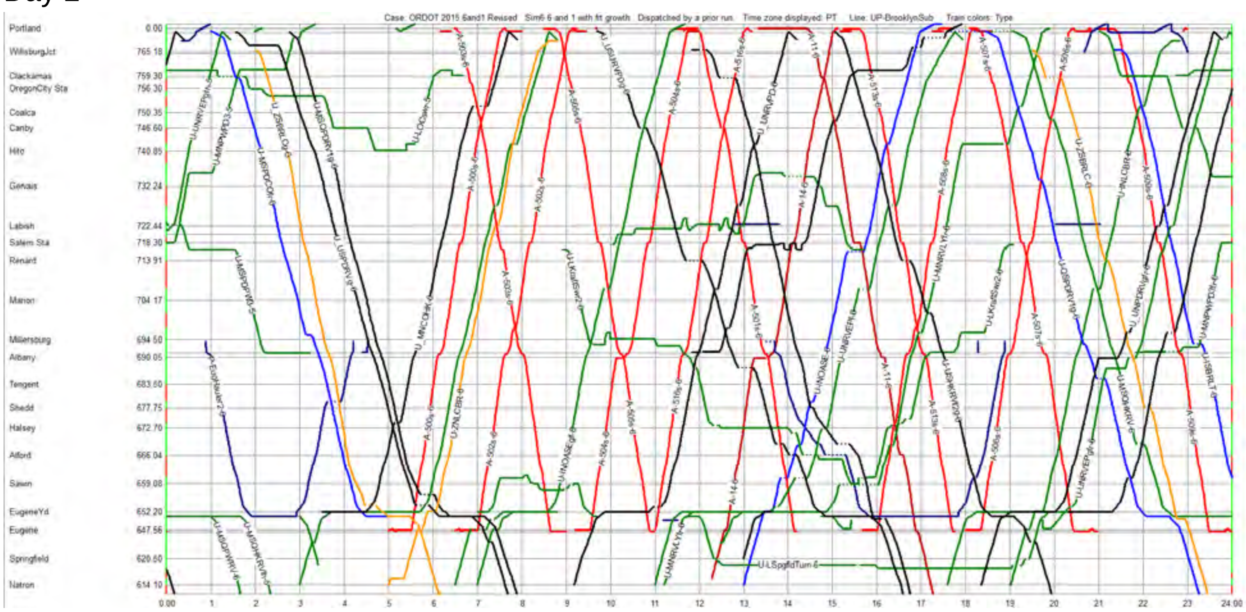


Figure 9. Revised Alternative 1 Stringlines – Day 1-3

Day1

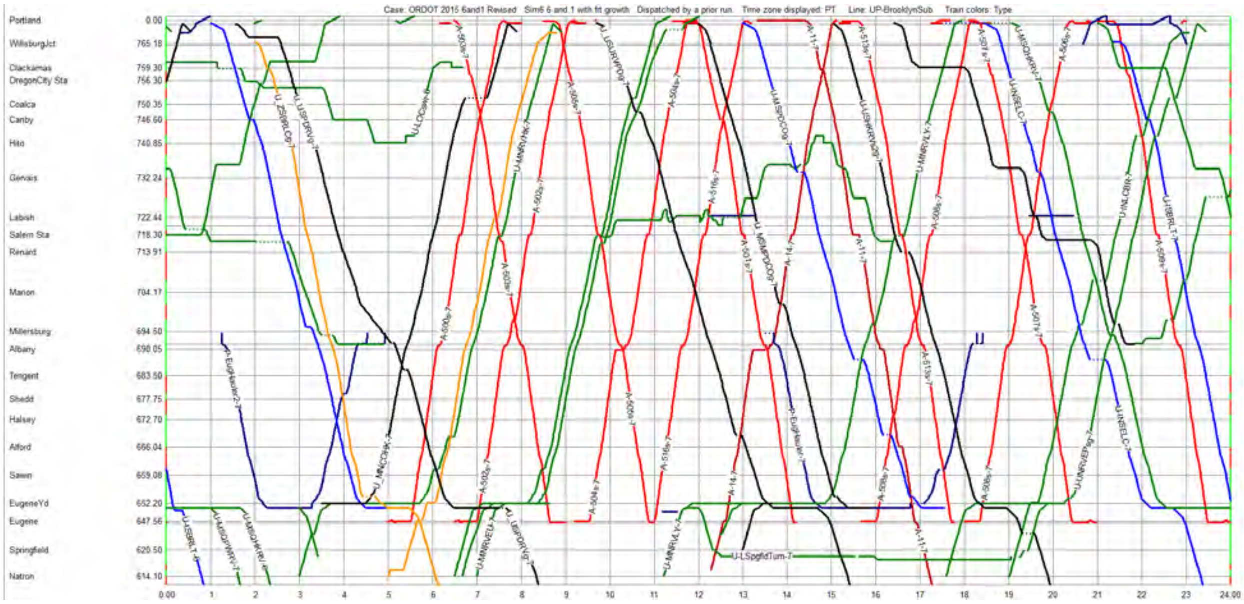


Day 2



Color	
	Passenger Trains
(red line)	Red - Amtrak Cascades trains
(reddish brown line)	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
(gold line)	Gold – (Z trains) High priority containers for intermodal
(black line)	Black – Unit Trains
(blue line)	Blue – (Q trains - Doublestack) Priority Intermodal
(green line)	Green – Local and Merchandise trains

Day 3



Color	
	Passenger Trains
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Table 6. Summary Table of Delays by Type

Delay/10 Miles (Minutes)	**Base**	**No Action**	**Alternative 1** Rev 3+1	Rev 4+1	Rev 4+1 On 3+1 Net	**No Action Minimum**
Passenger	0.6	0.5	1.0	0.3	0.3	0.6
PNWR	1.3	2.5	3.6	1.4	1.4	1.7
UP Expedited	1.5	2.1	1.8	1.7	1.3	1.4
UP Local	5.2	7.2	10.2	6.1	5.9	8.3
UP Manifest	1.7	4.2	2.8	2.6	2.2	2.1
UP Unit	6.9	3.9	3.0	2.3	3.0	3.2
Total Freight	2.4	3.7	3.2	2.5	2.5	2.6

Avg. Velocity (mph)	**Base**	**No Action**	**Alternative 1** Rev 3+1	Rev 4+1	Rev 4+1 On 3+1 Net	**No Action Minimum**
Passenger	47.9	47.9	43.8	49.3	48.6	48.3
PNWR	11.3	18.3	17.7	19.0	19.2	18.9
UP Expedited	34.5	31.6	32.4	32.2	33.7	33.1
UP Local	7.7	7.4	7.1	7.5	7.6	7.4
UP Manifest	19.7	19.6	20.6	20.7	21.0	21.0
UP Unit	20.3	22.4	23.4	24.2	23.4	23.0
Total Freight	17.6	19.7	20.2	20.7	20.8	20.6

Velocity minus Dwell and Delay (mph)	**Base**	**No Action**	**Alternative 1** Rev 3+1	Rev 4+1	Rev 4+1 On 3+1 Net	**No Action Minimum**
Passenger	57.0	56.9	59.1	58.5	58.3	58.2
PNWR	22.3	46.0	46.0	54.7	47.5	46.6
UP Expedited	41.8	39.9	40.4	40.1	40.9	40.3
UP Local	28.9	27.4	27.3	27.2	27.6	27.7
UP Manifest	35.0	34.9	35.5	35.6	35.5	35.0
UP Unit	32.9	33.2	33.8	34.1	34.0	33.5
Total Freight	34.2	35.2	35.7	35.9	35.9	35.4

Delays > 30 min	Base	No Action	Alternative 1 Rev 3+1	 Rev 4+1	 Rev 4+1 On 3+1 Net	No Action Minimum
Passenger	0.0	0.0	0.0	0.0	0.0	0.0
PNWR	0.0	0.0	0.3	0.0	0.3	0.0
UP Expedited	0.7	1.7	1.3	1.0	0.0	0.3
UP Local	0.0	0.7	2.7	0.3	1.0	0.7
UP Manifest	0.3	4.3	1.7	0.7	0.7	0.7
UP Unit	1.0	1.7	1.3	0.3	2.7	1.3
Total Freight	2.0	8.3	7.3	2.3	4.7	3.0

Table 7. Table of Infrastructure Improvements by Case, Alternative 1

	Infrastructure Improvements By Case													Scenarios Included In		
Project Name	**Existing Passing Track Begin MP**	**Existing Passing Track End MP**	**Existing Passing Track Length (ft.)**	**Road Crossings on Existing Passing Track**	**New Passing Track Begin MP**	**New Passing Track End MP**	**New Passing Track Length (ft.)**	**New Track Construction Length (ft.)**	**New Track on Existing Roadbed (ft.)**	**New Track on New Roadbed**	**Undergrade Bridges for New Roadbed**	**Culverts on for New Roadbed**	**Road Crossings on New Track**	**No Action with Mins**	**4+1 on 3+1 , Revised 3+1**	**Revised 6+1, Revised 4+1**
Judkins Siding Extension	644.6	645.68	5702.4	0	644.6	660.06	81628.8	75926.4	5390	70536.4	6	3	21	✓	✓	✓
Alford Siding Extension	666.1	667.6	7920	1	666.1	670.32	21489.6	13833.6	0	13833.6	3	1	3			✓
Halsey New Passing track					670.32	674.07	19800	19800	5096	14704	1	3	4		✓	✓
Hallawell Extension	687.2	688.8	8448	1	683.5	687.28	19958	20064	4753	15311	4	4	4			✓
Hallawell to Albany Extension					687.28	690	14361.6	1108.8	0	1108.8	2	1	1		✓	✓
Millersburg Extension	694.33	696.12		0	693	697.5	23760	23760	0	23760	2	3	2			✓
Marion Siding Extension	704.2	705.8	8448	0	701.17	705.8	24446.4	16843.2	0	16843.2	5	0	3		✓	✓
Marion Siding Extension II				0	705.8	706.95	6072	6072	0	6072	-	-	2			✓
Reynard Siding Extension	713.93	715.5	8289.6	0	713.93	716.76	14942.4	6758.4	0	6758.4	1	0	1	✓		✓
Labish Siding Extension	720.4	721.8	7392	2	719.5	727.5	42240	35323.2	8117	27206	1	1	8	✓		✓
Gervais Siding Extension	732.3	733.8	7920	0	732.3	738	30096	22492.8	5733	16759	1	3	5			✓
Coalca Siding Extension	750.1	751.89	9451.2	0	746.48	751.89	28564.8	20380	0	20380	1	3	5		✓	✓
Clackamas/ Brooklyn Yard Extension					758.21	765	35851.2	35851.2	0	25757.25	2	1	5	✓	✓	✓
Clackamas/ Brooklyn Yard New Passing Track					765	770.17	27297.6	27297.6	10094	27297.6	2	0	11		✓	✓

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Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

Appendix A – Revised Base Case

Revised: October 18, 2016

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

Revised Base Case

The initial Base Case simulation was performed in 2013. The existing track network at the time was included in the model; as discussed below, that network was revised for the latest Base Case simulation.

Traffic data for the initial Base Case was gathered from various internet sources as well as local knowledge and developed into the simulation. There were only minimal modifications to those train files that were made in the Revised Base Case as noted below.

Revised Base Case Operational Modifications

Two operational modifications were made to the Revised Base Case. The first was the addition of an Amtrak Cascades dead head movement between the Eugene Station and Eugene Yard. The move was made each night and morning to represent storing the last Amtrak Cascades train set in Eugene Yard overnight and repositioning it back to the station for the first movement out in the morning.

The second operational change was inclusion of a Union Pacific local from Albina Yard to Lake Yard and return to handle BNSF interchange traffic. All other trains remained the same between the Revised and initial 2013 Base Cases.

Since a Base Case reflects current operations, but current operations will change between Portland and Vancouver in in 2017, the 2+1 passenger schedule was utilized between Portland and Eugene and the six Amtrak Cascades round trips were included between Portland and Vancouver, WA in the Revised Base Case..

Revised Base Case Network Configuration Modifications

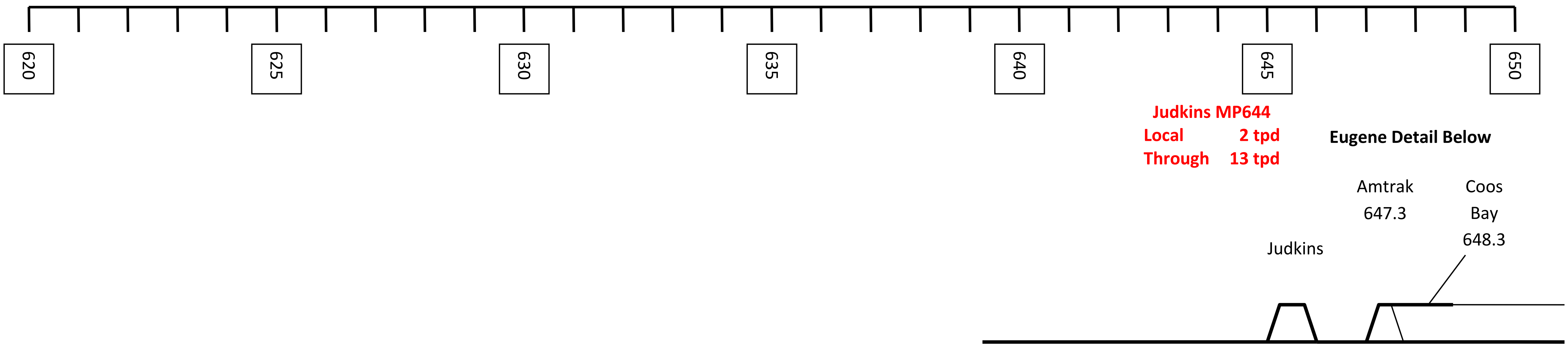
The Revised Base Case network featured two major modifications from the original 2013 Base Case. The first was the inclusion of increased track speeds that UP provided ODOT. These track speed increases affected high priority intermodal trains and passenger trains. The freight trains' maximum speeds were increased from 60 mph to 70 mph and speed zones were set to UP proposed limits for freight and passenger.

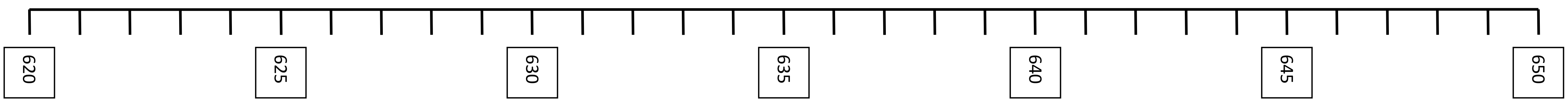
The second improvement was the reconfiguration of UP's Eugene Yard. In the original Base Case, a simplified yard was included because the Analysis Team did not have current track schematics of the yard. Once those schematics were acquired, the yard was updated in all subsequent ODOT/Amtrak Cascades simulations. Upon revising the Base Case, Eugene Yard was reconfigured to match all other simulation cases.

The new configuration of the yard provided more arrival and departure tracks and an additional route to enter or depart the yard. This eased congestion in the Eugene area in the Revised Base Case analysis. An updated schematic representation of the yard and the Eugene Station is shown on the last page of the Base Analysis Network track schematic that is included below.

Freight train counts over various segments have also been included on the schematic; they have been broken into Local movements and Through movements. A Local movement included road switchers that returned to the station they originated from and were responsible for serving local industry along a section of the route. A Through movement ran from one station and terminated at another station, regardless of how far apart those stations were.

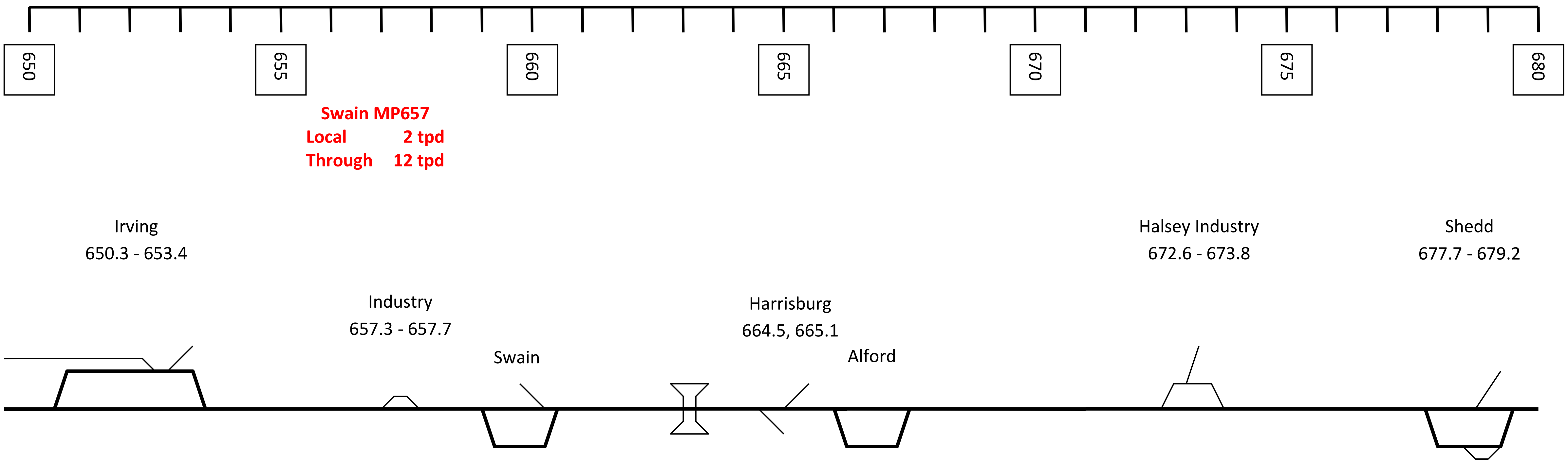
As a general rule, train counts are provided on either side of a yard or terminal. Counts are provided north and south of Eugene, Albany, Salem and Brooklyn Yard. Counts into Albina, across the Steel Bridge and from the Graham Line to/from the south are also included. Passenger train counts have been excluded because those numbers vary by scenario and are described in the Introduction to each scenario.



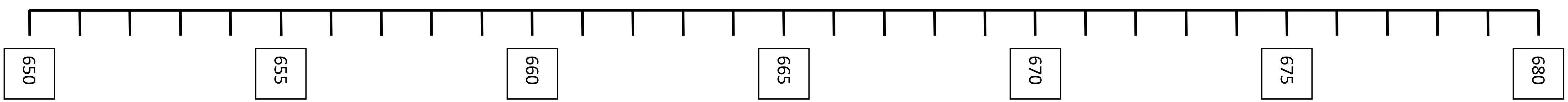


Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Base Analysis Network



Eugene Detail Below



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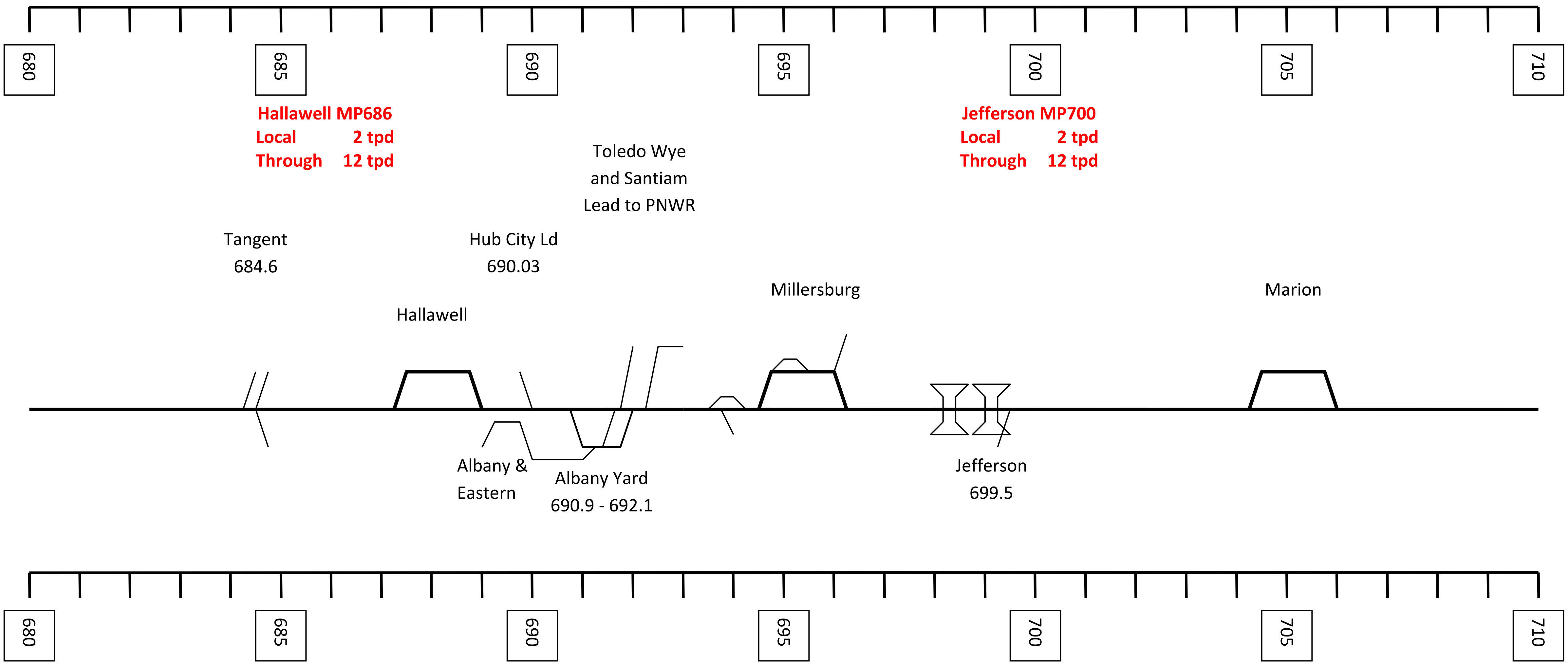
Base Analysis Network



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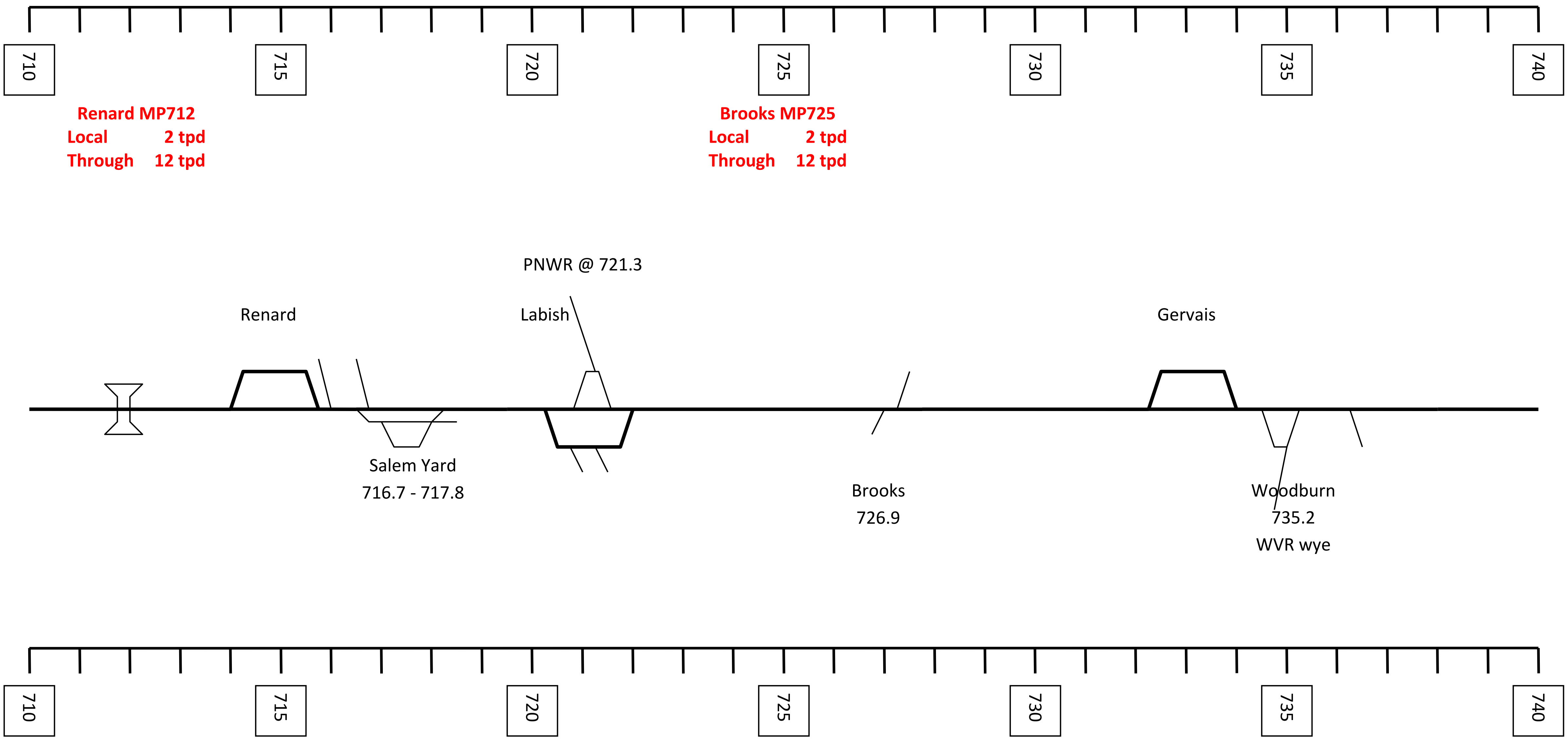
Base Analysis Network



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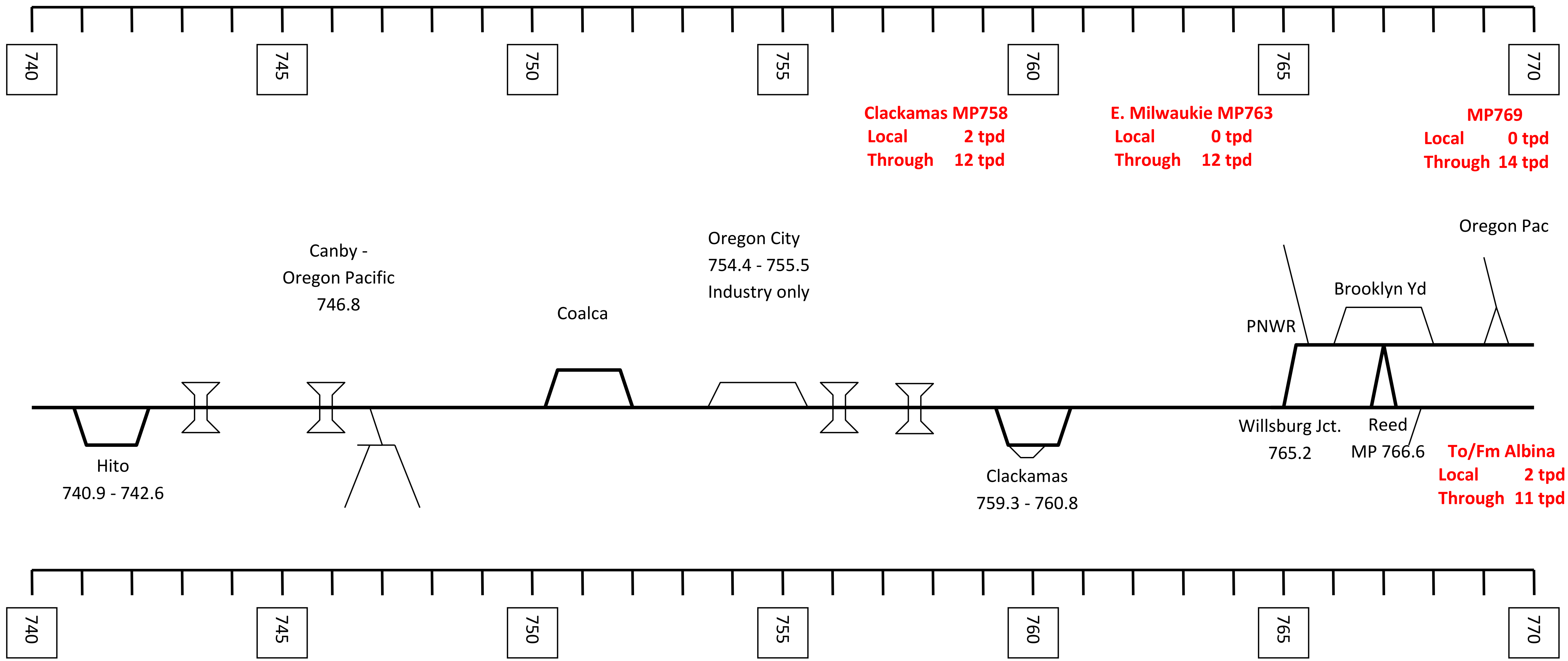
Base Analysis Network



To/From Steel Bridge
Local 2 tpd
Through 3 tpd

Graham to/from South
Local 0 tpd
Through 0 tpd

Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
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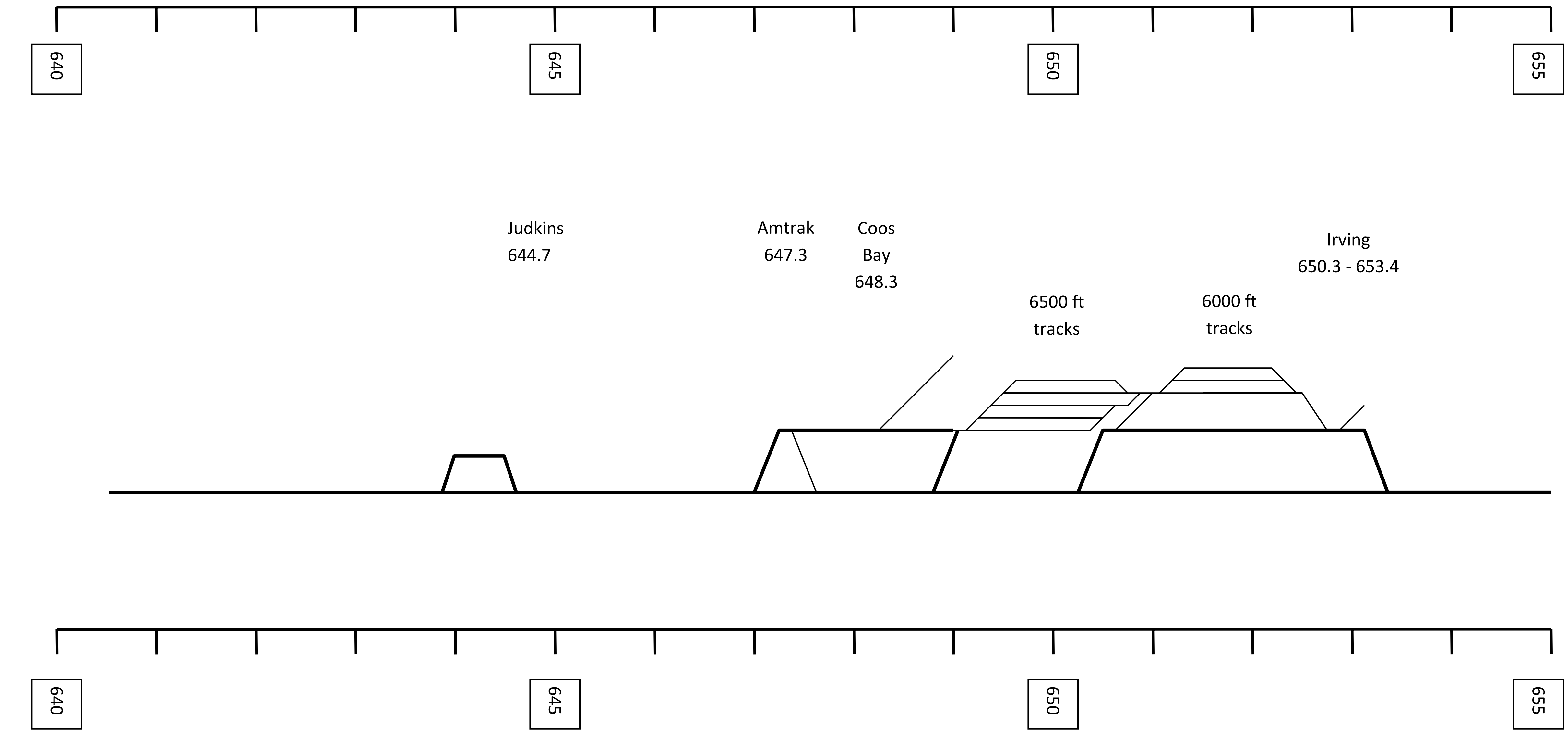
Base Analysis Network



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Eugene Detail

Revised Base Case Brooklyn Subdivision Results

Per the attached track schematic, the Revised Base Case configuration remained a single track railway with sidings from Natron (MP 616) to East Milwaukie (MP 765). There was a second main track from East Milwaukie to the Steel Bridge (MP 770). As was seen in the initial Base Case analysis, this long section of single track resulted in multiple meet or overtake (meet/pass) delays as trains had to stop in sidings to allow other trains to pass.

There was a reduction in D/10 delay minutes between the initial Base Case and the Revised Base Case. In the initial case, D/10 was 3.3 minutes/10 miles operated as compared to 2.4 minutes/10 miles in the revised case. This suggests the line was operating efficiently under the Revised Base traffic levels.

At the same time, delays exceeding 30 minutes were reduced from seven per day to two per day between the initial and the Revised Base Cases. Analysis of the results indicated that there were two reasons that the Revised Base Case experienced a reduction in delays and delay minutes. The first was the speed increases that UP provided and the second was the updating of the Eugene track network and yard configuration. The most prominent reductions occurred in two areas; between Clackamas (MP 760) and Salem (MP 718) and between Hallawell (MP 687) and Natron.

As previously mentioned, the speed increases affected the passenger trains and the highest priority intermodal trains. Those speed increases reduced delays to other UP traffic that was waiting for either of those train types. Overtakes by the faster trains required less time than in the previous model because of the track speed increases. Also, meet delays with higher priority trains were reduced because of the increased speed of the approaching trains.

This was particularly evident between Clackamas and Salem. In the initial Base Case, there were four delays per day that exceeded 30 minutes. In the Revised Base Case, that number dropped to 0.7 per day. The increase in speeds changed the timing of trains over the entire Brooklyn Sub network, and with those changes, some of the longer delays were reduced.

It also appeared that the new version of the model did not hold freight trains as far away from meet points with Amtrak trains as did the previous model version. There were fewer Amtrak/freight meets that exceeded 30 minutes in the Revised Base Case as compared to the initial Base Case.

Another factor was the modification of the Eugene Yard complex to better represent movements into and from the yard. In the initial 2013 Base Case, there were 2.5 delays per day that exceeded 30 minutes in the general area of the Eugene Yard. Based on analysis, it appeared that many of those delays were associated with entering or exiting the yard because of the simplified infrastructure configuration that was used. In the Revised Base Case, the yard infrastructure configuration was expanded to better represent the actual track lay-out, and that reduced the D>30 to no occurrences in the three days of the most recent simulation.

Revised Base Case Portland to Vancouver Results

In the Revised Base Case, the line segment between Portland and Vancouver was operating efficiently. There were 2.3 delays per day that exceeded 30 minutes during the 2015 simulation.

Review of the delays showed there was a split between the initial causes of the delays. Just under half the delays that exceeded 30 minutes were caused by passenger train conflicts, while just over half were caused by freight conflicts.

The delays initiated by freight movements occurred in two particular locations. The first was in the area of North Portland Jct. and involved UP operations. Since the Revised Base Case did not feature the improved connection between Peninsula Jct. and NPJ, UP trains operated into and over that segment at speeds below 10 mph. This created delays to UP traffic moving from BNSF's Fallbridge Sub to Peninsula Jct., and to BNSF movements trying to leave from the Port of Portland's T6 facility.

The other location that experienced repetitive freight initiated conflicts was in the area of Willbridge Yard. A local switch engine that had to work at Lake Yard was regularly held at Willbridge because another switch assignment was already working in Lake Yard. The second main track could not be used because of an Amtrak Cascades train departing from Portland towards Seattle at the same time. Therefore, the second local movement had to wait until both the Amtrak Cascades train and the switch engine cleared before being able to advance.

Delays initiated by Amtrak trains occurred in multiple locations ranging from Vancouver Yard to Willbridge. The timing of the freight movements and the 6+2 Amtrak Cascade/Coast Starlight/Empire Builder (Spokane/Portland Section) schedules determined where many of the delays occurred. The new local that was added that operated between Albina Yard and Lake Yard (and return) was not affected by either passenger or freight operations in the simulation.

Graphs comparing the Revised Base Case statistics with other cases are included later in the report.

Revised Base Case Brooklyn Sub Velocity

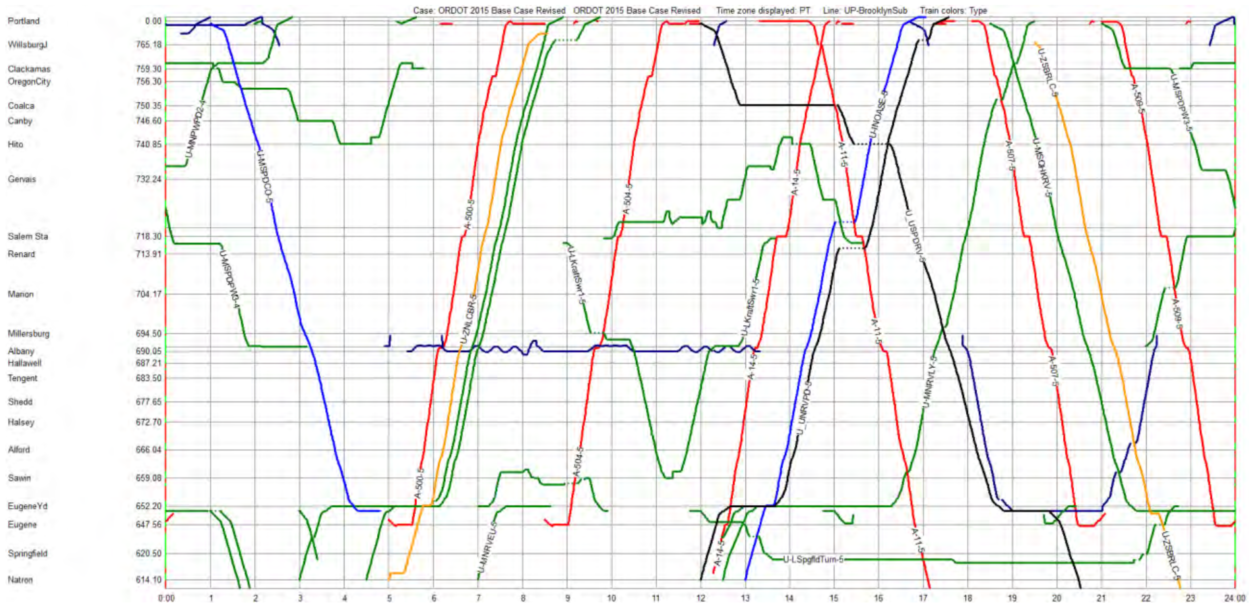
The following table breaks down the velocity of traffic types that operated over the Brooklyn Sub in the Base Case. Velocity of each train group was calculated using the miles that the group operated divided by either 1) the Elapsed Time for the group or 2) the Elapsed Time minus the Delay and Dwell totals for the group. The Total Freight velocity is the same calculations using a sum of all freight mileage, Elapsed Time, Delay and Dwell.

The Portland & Western (PNWR) statistics included in the table refer to only PNWR operations that occurred on UP's Brooklyn Sub. Other PNWR operations on PNWR's OE District or on the Westside District were not analyzed or included in the velocity calculations that are included in this report.

Alternative Revised Base							
Group	**Delay**	**Dwell**	**Elapsed Time**	**Miles**	**Del/10**	**Velocity Total Elapsed**	**Velocity minus Delay and Dwell**
Passenger	2:08:21	5:36:21	48:35:48	2330.0	0.6	47.9	57.0
PNWR	0:52:43	16:25:00	34:50:56	392.1	1.3	11.3	22.3
UPExp	4:05:49	4:02:05	46:23:04	1599.1	1.5	34.5	41.8
UPLocal	6:03:42	61:08:51	91:28:21	700.1	5.2	7.7	28.9
UPMani	7:46:46	54:00:33	141:38:27	2794.0	1.7	19.7	35.0
UPUnit	4:47:57	3:00:02	20:24:54	414.6	6.9	20.3	32.9
Total Freight	23:36:57	138:36:31	334:45:42	5899.9	2.4	17.6	34.2

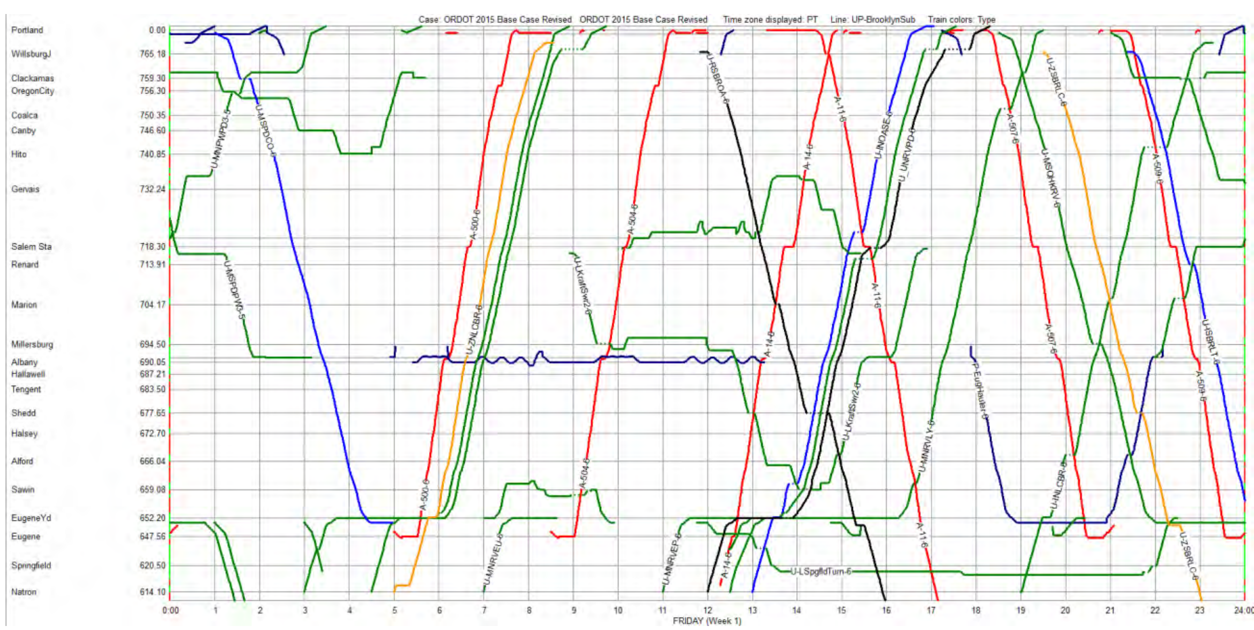
Base Case Stringlines

Day 1

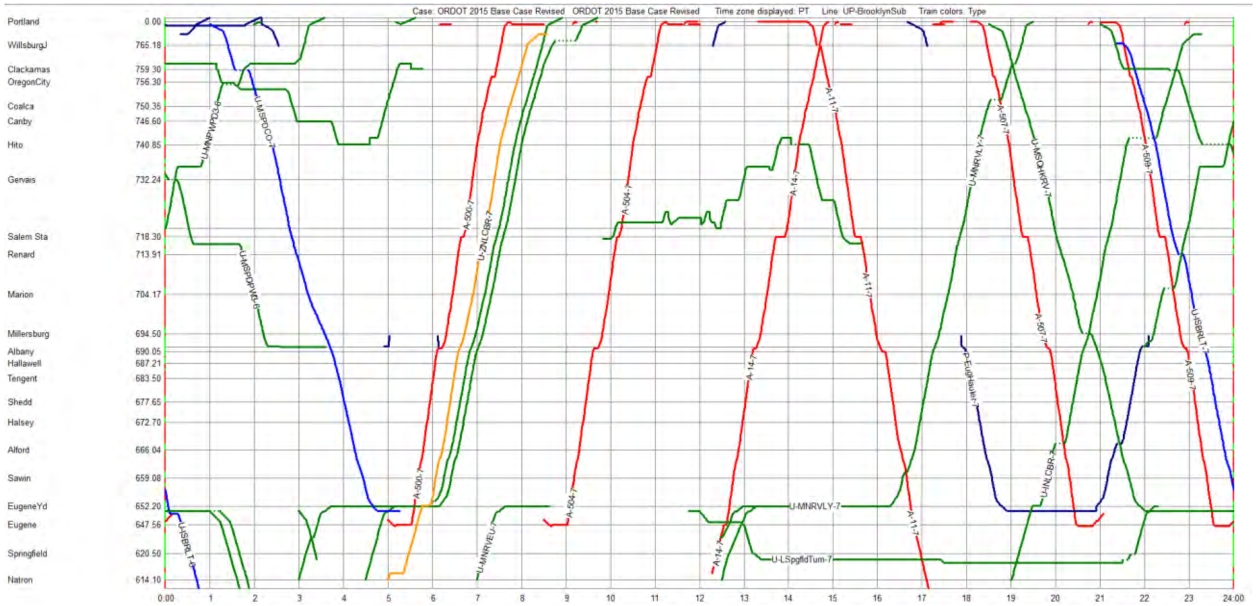


Color	**Passenger Trains**
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Day 2



Day 3



Color	**Passenger Trains**
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	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Oregon Passenger Rail
Eugene - Portland
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Appendix B – Revised No Action

Revised: October 18, 2016

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

2035 Revised No Action Alternative

Introduction

Under the 2035 Revised No Action simulation, the existing Base Case track infrastructure was used, however freight traffic was increased to projected 2035 freight growth levels. This scenario represented the level of service that UP and BNSF would be expected to experience if no further action was pursued to expand passenger operations.

2035 Revised No Action Operational Modifications

Freight growth was added to the 2035 Revised No Action Case. Growth was projected using a compounded annual rate of 1.5 to 1.7% for the through freight movements. UP and BNSF intermodal and manifest trains were increased using this method.

Union Pacific unit train growth was projected based on anticipated growth of new classes of traffic. Projected growth of oil and grain trains to California from the upper Midwest and Canada drove this growth. Two to three loaded trains per day (and their associated empty trains) were included to represent the potential traffic levels in this corridor.

The local between Albina Yard and Lake Yard was also added to the 2035 Revised No Action Case.

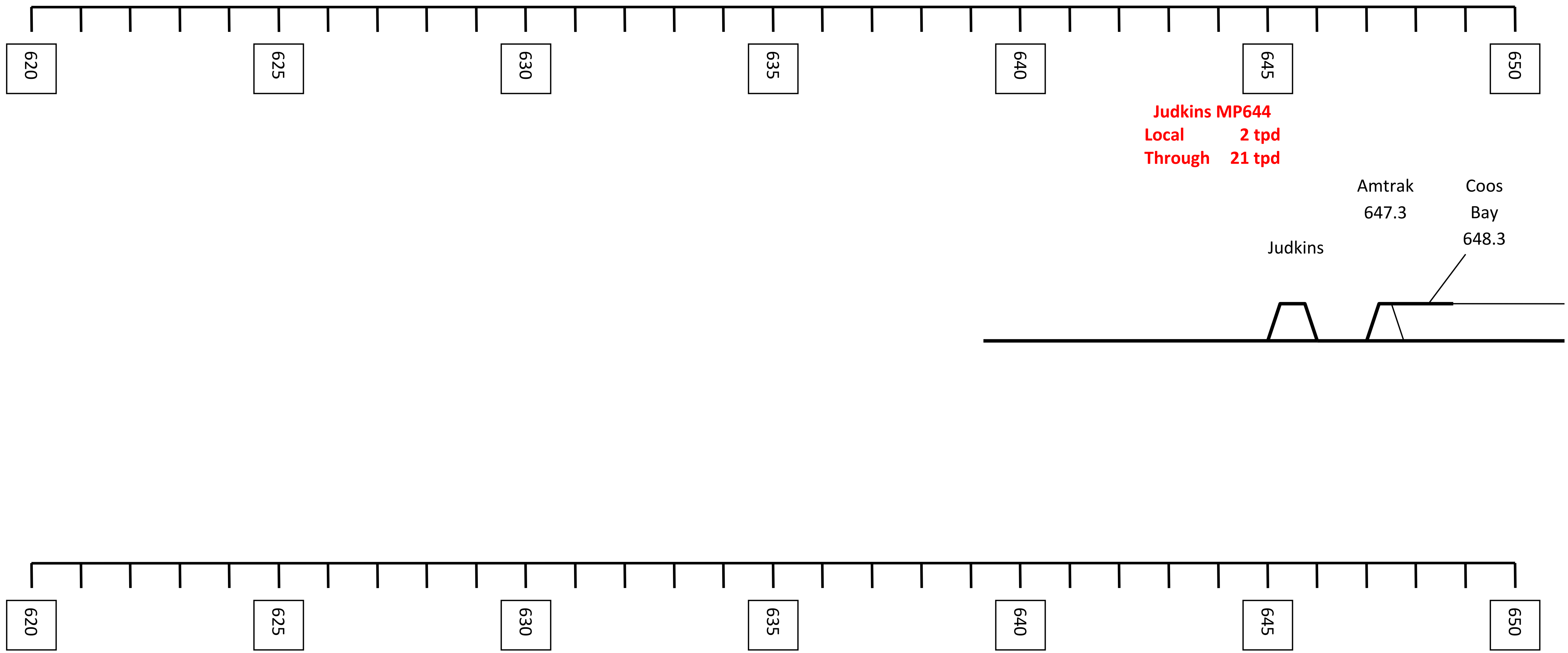
Portland to Eugene passenger traffic was not modified in this analysis. Two Amtrak Cascades round trips and the single Coast Starlight round trip (2+1) were included in the simulation over the Brooklyn Sub. Portland to Vancouver passenger operations continued to use the 6+2 schedule of the Revised Base Case as well. This was a reduction of passenger traffic in this corridor from the initial No Action Case, which included 13 Amtrak Cascades round trips between Portland and Vancouver (and continuing north.

2035 Revised No Action Infrastructure Modifications

There were no infrastructure modifications between the Revised Base Case and the 2035 Revised No Action alternative along the Brooklyn Sub. There were also no improvements made to the network between Portland and Vancouver on either BNSF's Fallbridge Sub or on UP's connection track between Peninsula Jct. and NPJ.

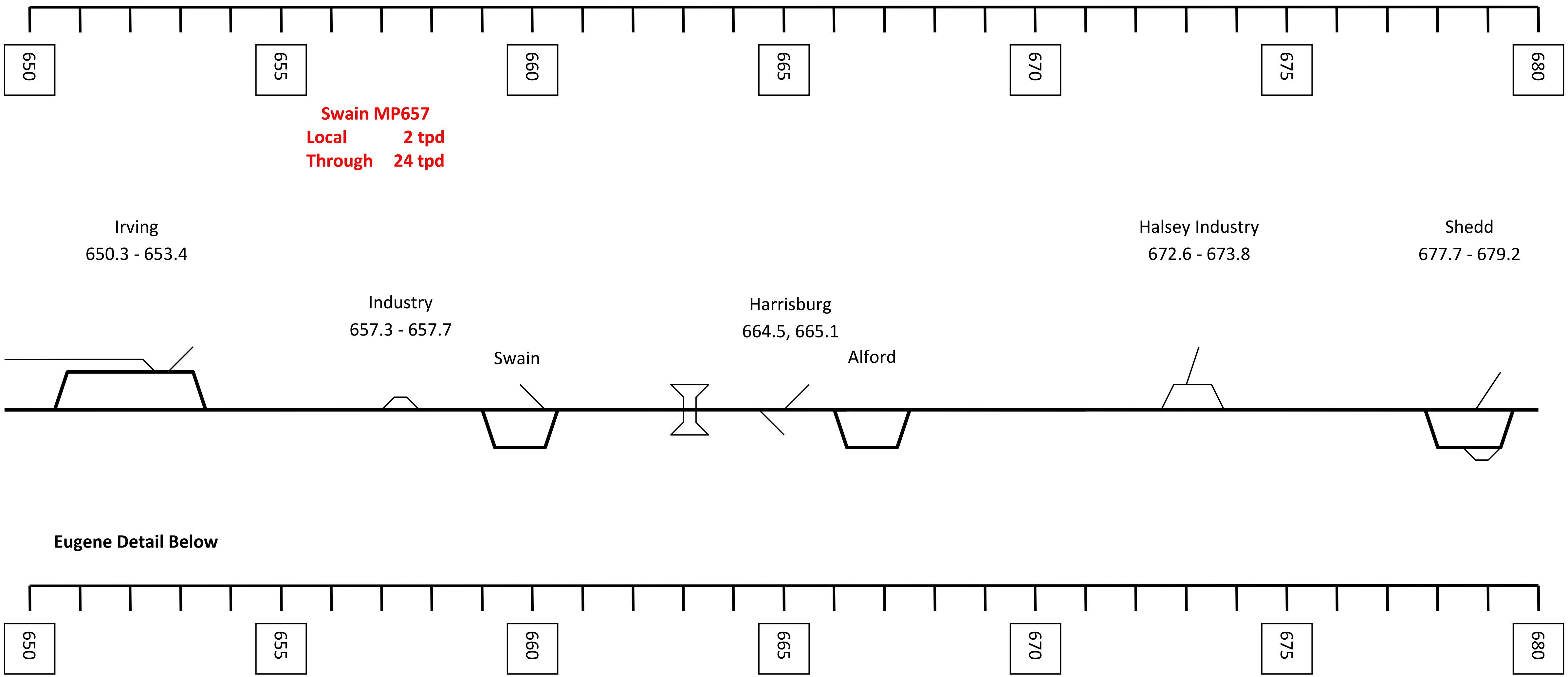
Freight train counts over various segments have again been included on the 2035 Revised No Action schematic, which has been included below. As with the Base Network Schematic, the train volumes have been broken into Local movements and Through movements, which are described above. The locations of where the train counts were taken are the same as in the Base Network, so a comparison of growth can be made from location to location.

The train counts in the 2035 Revised No Action also represent the train volumes that were included in all additional 2035 passenger scenarios. These counts can be referenced for all of the following alternatives if train volumes are required.



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

No Action Analysis Network



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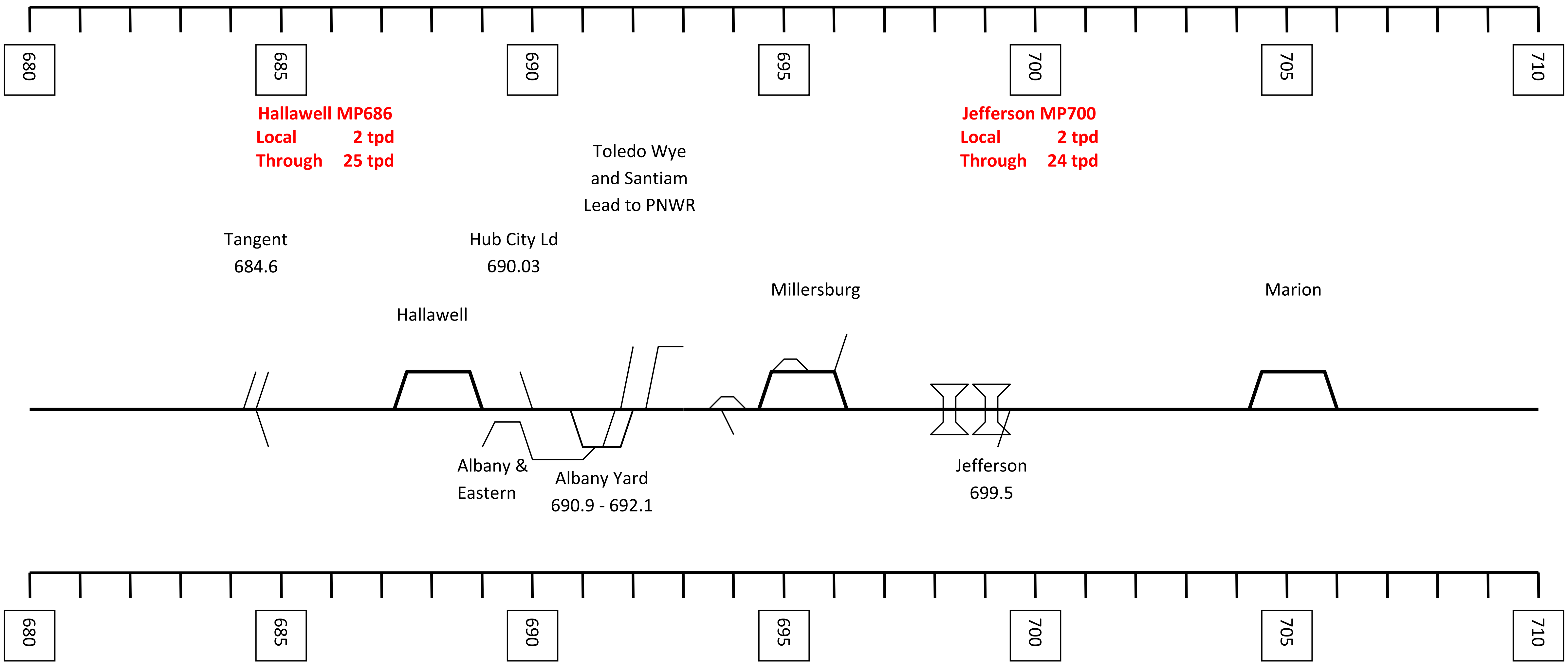

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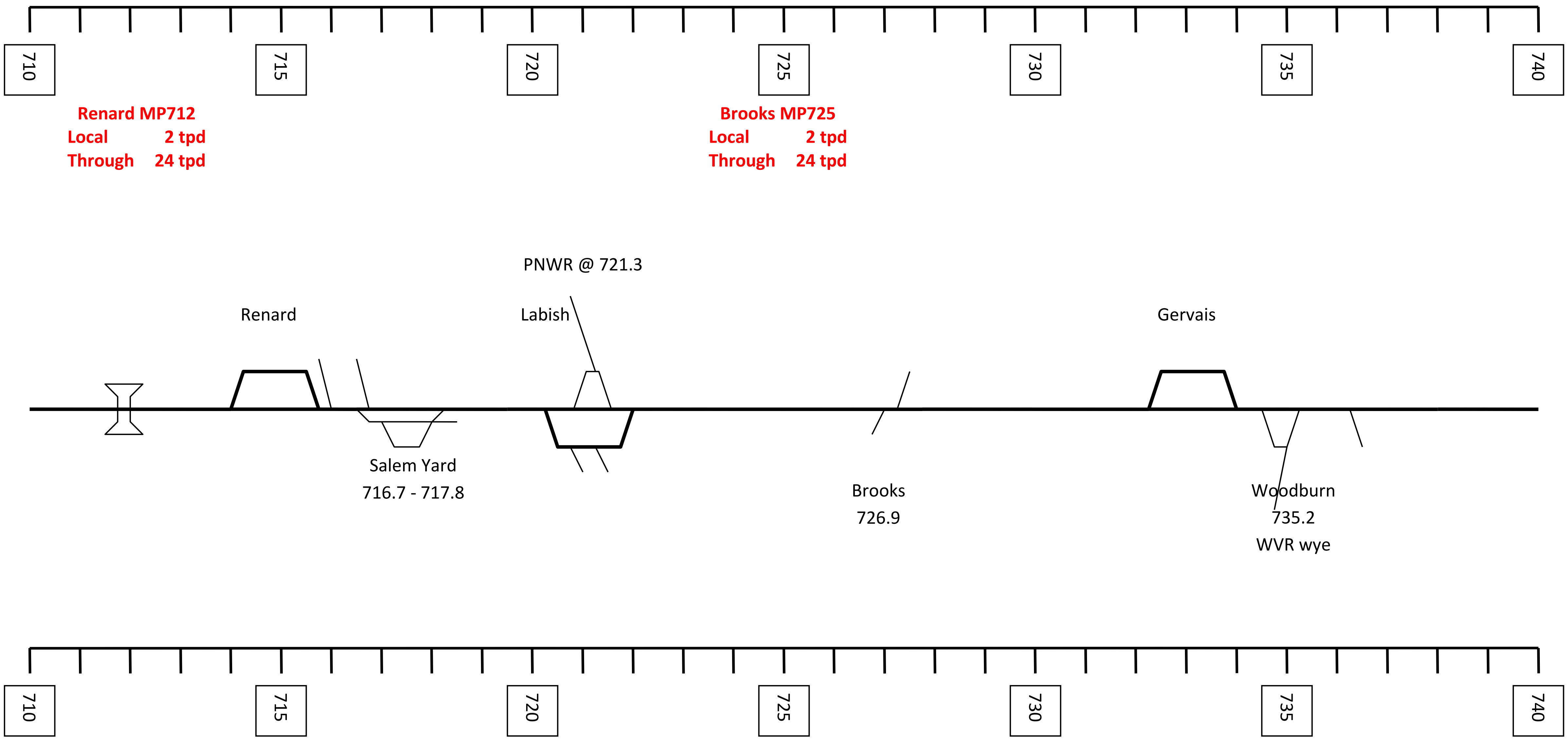
No Action Analysis Network



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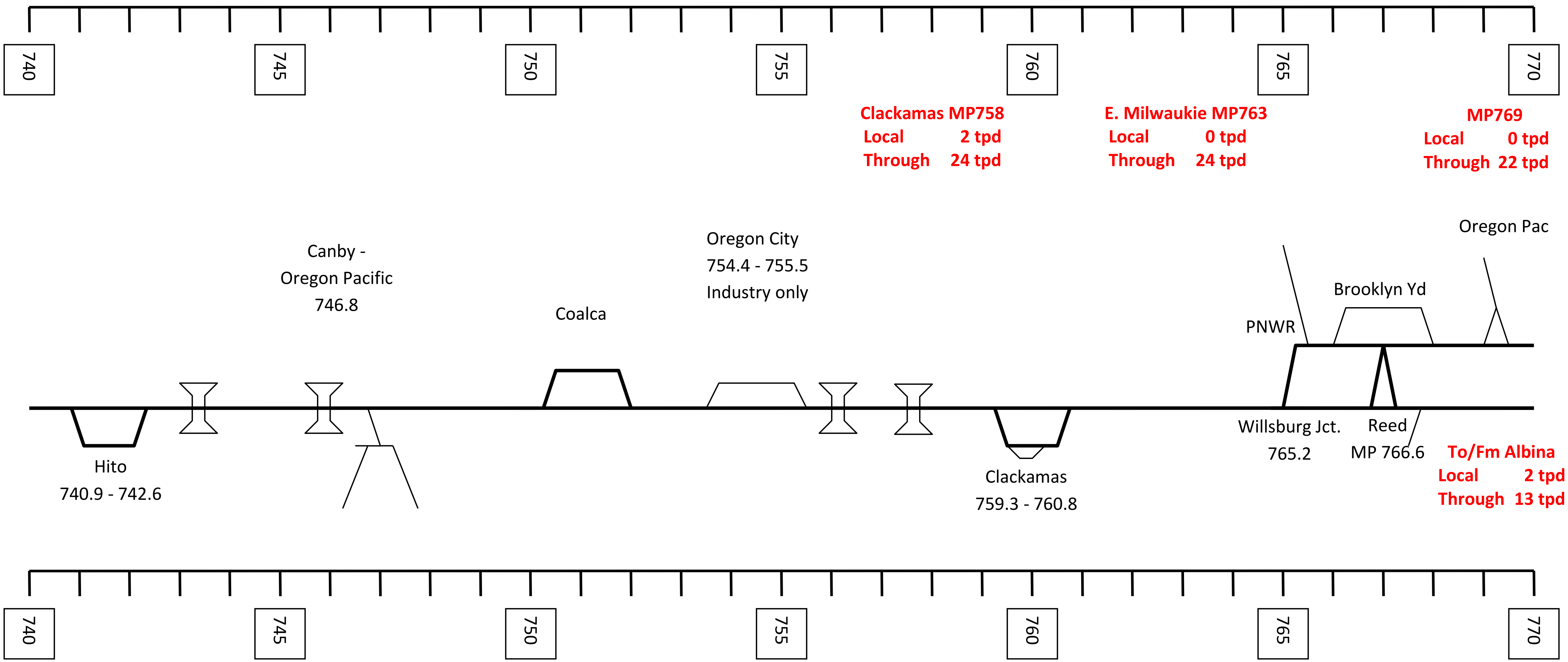
No Action Analysis Network



To/From Steel Bridge
Local 2 tpd
Through 1 tpd

Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
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Graham to/from South
Local 0 tpd
Through 8 tpd

No Action Analysis Network

2035 Revised No Action UP Brooklyn Sub Results

The delay minutes per 10 miles operated (D/10) increased in the 2035 Revised No Action Case compared to the Revised Base Case. D/10 was 3.7 minutes per 10 miles operated vs. 2.4 minutes per 10 miles in the Revised Base Case (Graph 1 below). This result indicated that while the line segment was more congested with the freight growth, the line continued to operate efficiently.

The increase in delay was not unexpected. 2035 growth projections added additional trains to the line segment which created more potential conflicts. Since the line remained a single track network with sidings between East Milwaukie and Natron, all meets and passes had to occur at a siding, which caused a delay to one of the trains involved. With greater freight traffic levels, more meets or overtakes that involved three or more trains occurred.

Delays that exceeded 30 minutes increased from two per day to 8.3 per day under the 2035 Revised No Action Case (Graph 2 below). Many of these delays occurred from meets/overtakes that involved more than a single train meeting or overtaking another single train. Delays associated with on line switching or entering yards also caused some of the delays that exceeded 30 minutes (Graph 4 below).

With additional freight trains on the route, there was an increase in meets with passenger and other freight traffic. As Graph 4 shows, there were many more freight-freight meets that caused delays than freight-passenger meets. Since passenger train volumes were not increased in this analysis on the Brooklyn Sub, this was not unexpected. Most of the conflicts that led to delays that exceeded 30 minutes were meets or overtakes by multiple trains; single train meets rarely caused a delay that exceeded 30 minutes.

There were delays caused by on line switching in the 2035 Revised No Action Case. With increased on line freight work and through trains, there were more opportunities for one group to be delayed by the other group. In some cases, the through trains waited until the on line switching was completed, and in other cases, the switching trains were delayed until the through trains completed their operations.

This was particularly true around Clackamas in the 2035 Revised No Action Case, where there were a number of on line switching and meet delays. When multiple trains were switching in the area (the local trains switching industry and through trains that were setting out or picking up cars), other through trains became blocked. The blocked trains remained between East Milwaukie and the Steel Bridge, or in the Coalca (MP 750) and Hito (MP 741) sidings.

In the evening, a high priority intermodal train from Brooklyn Yard was scheduled to operate to the south at the same time that much of the switching was taking place. That train forced some of the switching activities to be delayed until the high priority freight was clear of the area. This further delayed trains in the sidings or on the second main track on either side of Clackamas.

Graph 6 shows the location of many of the delays that exceeded 30 minutes. The results reflect the delays that were caused by the track configuration and traffic levels around Clackamas.

Another location that experienced some delays associated with on line switching was between Eugene and Hallawell. Again, a local that was assigned to work at locations between those two points conflicted with through traffic moving to or from Eugene. In most cases, RTC delayed the local in the Alford (MP 666) or Swain (MP 660) sidings until the through train traffic cleared.

The single track section between the south end of Eugene Yard (MP 649, MP 650) and Natron also contributed to some delays that exceeded 30 minutes. Northbound trains waiting in Natron siding for trains coming out of Eugene Yard experienced those types of delays. Frequently, the northbound train had to wait for at least two southbound trains from Eugene to clear before being able to proceed. In many cases, the southbound trains had to run first to clear tracks in Eugene Yard so the northbound train had a clear track in which to arrive.

Judkins Siding is between Natron and Eugene. The siding is only 5,200 feet in length. Since all of the through trains in the analysis exceeded 6,000 feet in length, only local trains that were less than 5,000 feet could utilize Judkins in the model. In reality, some through trains are less than 5,000 feet, so they would be able to use that siding which was not reflected in the model.

Revised No Action Brooklyn Sub Velocity Comparisons

The following table provides the velocities of the various traffic groups for the 2035 Revised No Action analyses. As previously discussed, the PNWR results only reflect PNWR operations that occur on UP's Brooklyn Subdivision.

Alternative Revised No Action							
Group	**Delay**	**Dwell**	**Elapsed Time**	**Miles**	**Del/10**	**Velocity Total Elapsed**	**Velocity minus Delay and Dwell**
Passenger	2:04:34	5:36:21	48:38:18	2330.4	0.5	47.9	56.9
PNWR	1:55:29	13:18:00	25:17:51	463.3	2.5	18.3	46.0
UPExp	8:15:50	7:46:09	76:34:19	2418.3	2.1	31.6	39.9
UPLocal	8:21:57	60:26:04	94:17:23	699.7	7.2	7.4	27.4
UPMani	30:53:49	69:24:11	228:12:45	4466.5	4.2	19.6	34.9
UPUnit	16:48:57	21:02:05	116:17:54	2608.3	3.9	22.4	33.2
Total Frt	66:16:01	171:56:29	540:40:11	10656.0	3.7	19.7	35.2

The velocities in the Revised No Action Case are somewhat mixed compared to the Revised Base Case. Passenger velocities are essentially the same between the two cases. This indicates that passenger traffic in both cases was treated equally by the model on the Brooklyn Sub.

From the freight perspective, PNWR and UP unit train velocities are slightly greater in the No Action Case, and UP expedited and UP local velocities are slightly less in the No Action Case. UP manifest traffic velocity remained essentially constant between the two cases.

The overall average velocity (total elapsed time) actually increases in the Revised No Action Case as compared to the Revised Base Case. This is because the total velocity of freight trains is a weighted average of all trains on the corridor. In particular, the increase in UP unit traffic in the Revised No Action Case (2608 miles operated vs. 414 miles operated in the Revised Base Case) created a higher overall freight velocity by outweighing the types of trains where velocity was equal or slightly less in the No Action Case. The higher velocity for unit traffic in the Revised No Action Case is a function of how this category of trains was dispatched, when they ran and the number of conflicts that they incurred in the simulation.

Revised No Action Portland to Vancouver Results

Similar to the Brooklyn Sub, BNSF's Fallbridge Sub experienced an increase in delays exceeding 30 minutes in the 2035 Revised No Action Case (Graph 7 below). The number of delays increased from 2.3 to 4.7 between the Revised Base Case and the 2035 Revised No Action Case. The increase in freight traffic in the corridor was responsible for this upsurge.

As Graph 8 below shows, the breakdown between delays initially caused by passenger trains vs. those caused by freight trains indicates that freight traffic initiated a greater number of those delays. There were three locations that experienced repetitive freight congestion.

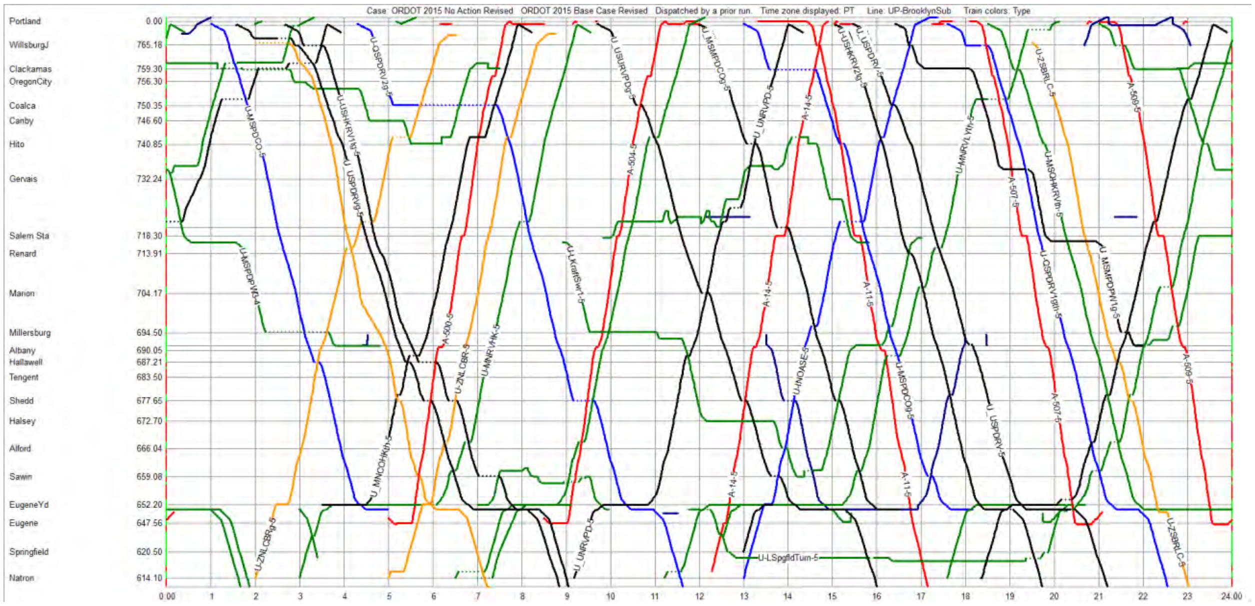
The first area was Vancouver for southbound trains. Southbound UP and BNSF traffic as well as westbound BNSF traffic from the Fallbridge Sub frequently stopped and waited on northbound UP trains entering the network at North Portland Junction. The southbound traffic coming from Seattle waited at Vancouver until the traffic cleared; the westbound trains from the Fallbridge Sub waited between the Columbia River Bridge and McLoughlin until the train traffic cleared. Some of the southbound trains also affected switch engines that could not leave BNSF's Vancouver Yard until the traffic cleared.

North Portland Jct. was another location that experienced multiple delays. Again, since no infrastructure improvements were included on UP's connection between Peninsula Jct. and NPJ, trains operated at less than 10 mph into, over and through that segment of track. This led to trains being stopped on BNSF's Fallbridge Sub waiting for UP trains coming from Portland via Peninsula Jct. Some of the trains waiting at NPJ delayed other train traffic in the Vancouver area which was previously discussed.

UP trains also had to wait around Peninsula Jct. for passenger and other high priority north-south traffic on BNSF's Fallbridge Sub at NPJ. The increased traffic flow combined with the slow track speed contributed to many of the delays around this area.

Revised No Action Stringlines

Day 1



Color | **Passenger Trains**

Red - Amtrak Cascades trains

Reddish Brown – Amtrak Coast Starlight

Freight Trains

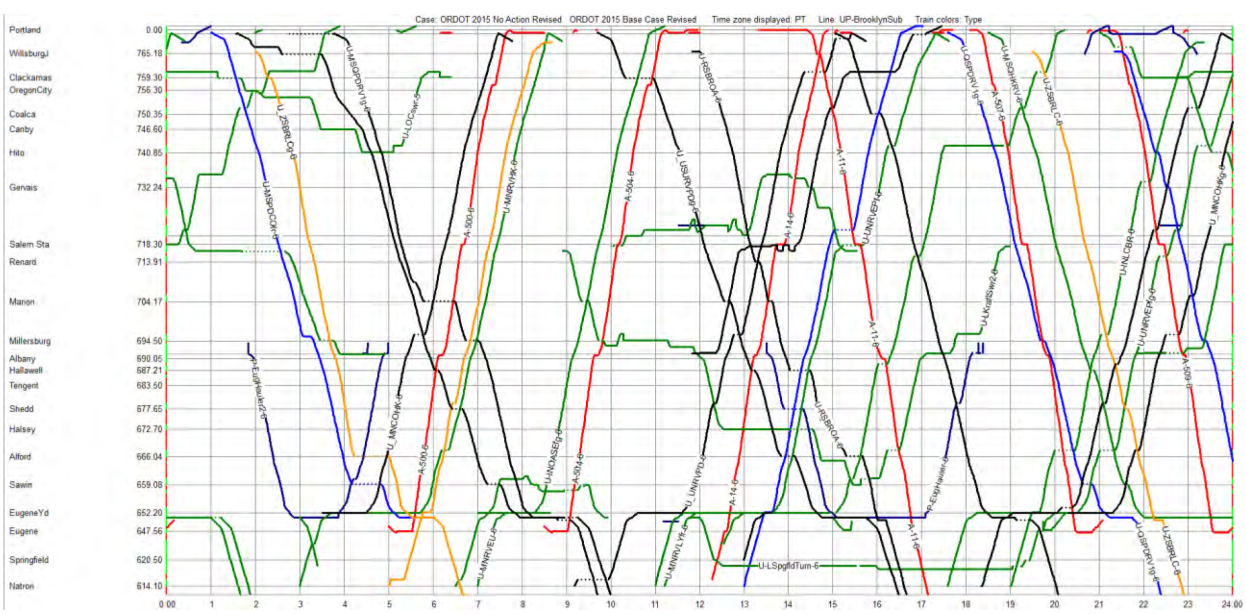
Gold – (Z trains) High priority containers for intermodal

Black – Unit Trains

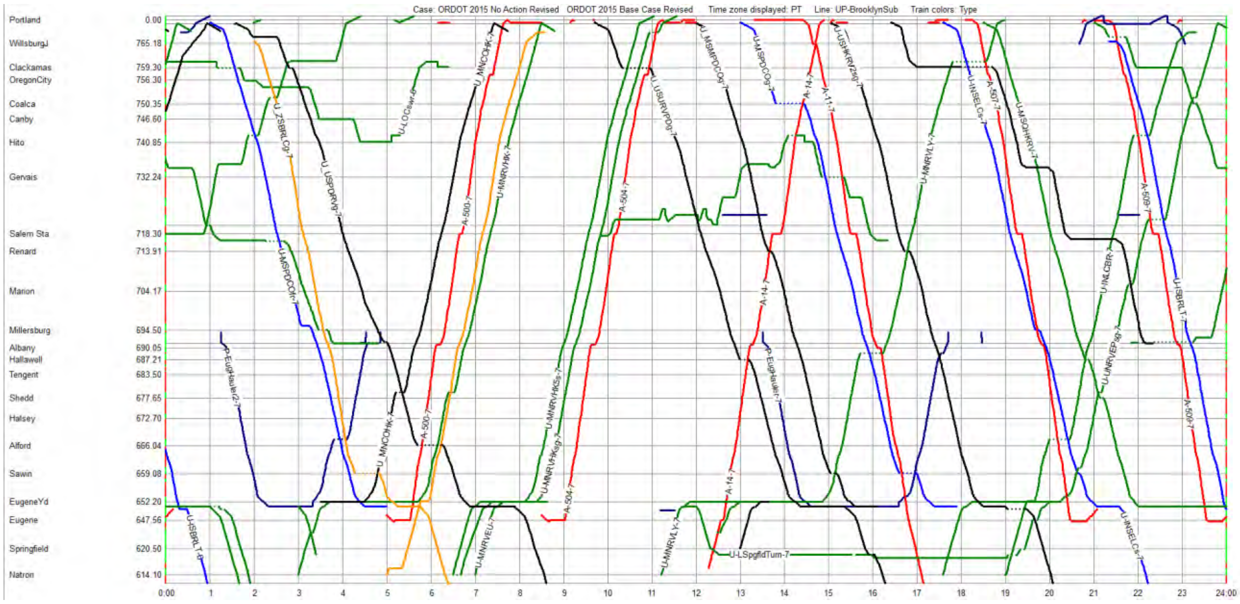
Blue – (Q trains - Doublestack) Priority Intermodal

Green – Local and Merchandise trains

Day 2



Day 3



Color	Passenger Trains
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

Appendix C – Revised Alternative 1 (3+1)

Revised: October 18, 2016

Prepared by: Mainline Management

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

Revised Alternative 1 (3+1) Analysis

Introduction

A Revised Alternative 1 (3+1) Analysis was also performed to standardize assumptions between all cases. The analysis featured the inclusion of one additional Amtrak Cascades round trip between Portland and Eugene. It also included estimated infrastructure that would likely be required to support that additional train.

In addition to the Amtrak Cascades train and associated infrastructure, the Revised Alternative 1 (3+1) analysis also included an updated track design at the Eugene Station. The new track design (Option 4) would allow for two Amtrak Cascades trains to be staged at the station overnight so they would not have to transit to Eugene Yard in the evening and from the yard in the morning.

Revised Alternative 1 (3+1) Operational Modifications

There were no operational modifications for UP traffic on the Brooklyn Sub in the Revised Alternative 1 (3+1) simulation other than the projected increase in freight traffic to 2015 levels as previously discussed. The Albina Yard to Lake Yard local was added in this case as in the Revised Base and Revised No Action cases. No changes were made to BNSF traffic between Vancouver and Portland as well.

The only operational changes were the additional Amtrak Cascades round trip that was added between Eugene and Portland, the staging of the Amtrak Cascades trains within the Eugene Station tracks at night. Portland to Vancouver passenger trains continued to operate under the 6+2 schedule as described earlier.

Infrastructure Modifications

The following is a list of modifications from the initial Alternative 1 (3+1) analysis. These same modifications were included in the Revised Alternative 1 (3+1) Case.

- *Southern Section*

  1. Second Main Track (SMT) from Judkins (644.66) to Swain (660.6)
  2. Crossovers from SMT to existing crossovers or yard entrance tracks (MP647, MP648, MP650, MP653.2, MP653.5)
  3. Universal crossover MP658.0
  4. SMT from MP 670.0 to MP 674.0.
  5. SMT south end Hallawell (MP 687.3) to Albany Yard (690.9).
  6. Crossover MP 690.1.

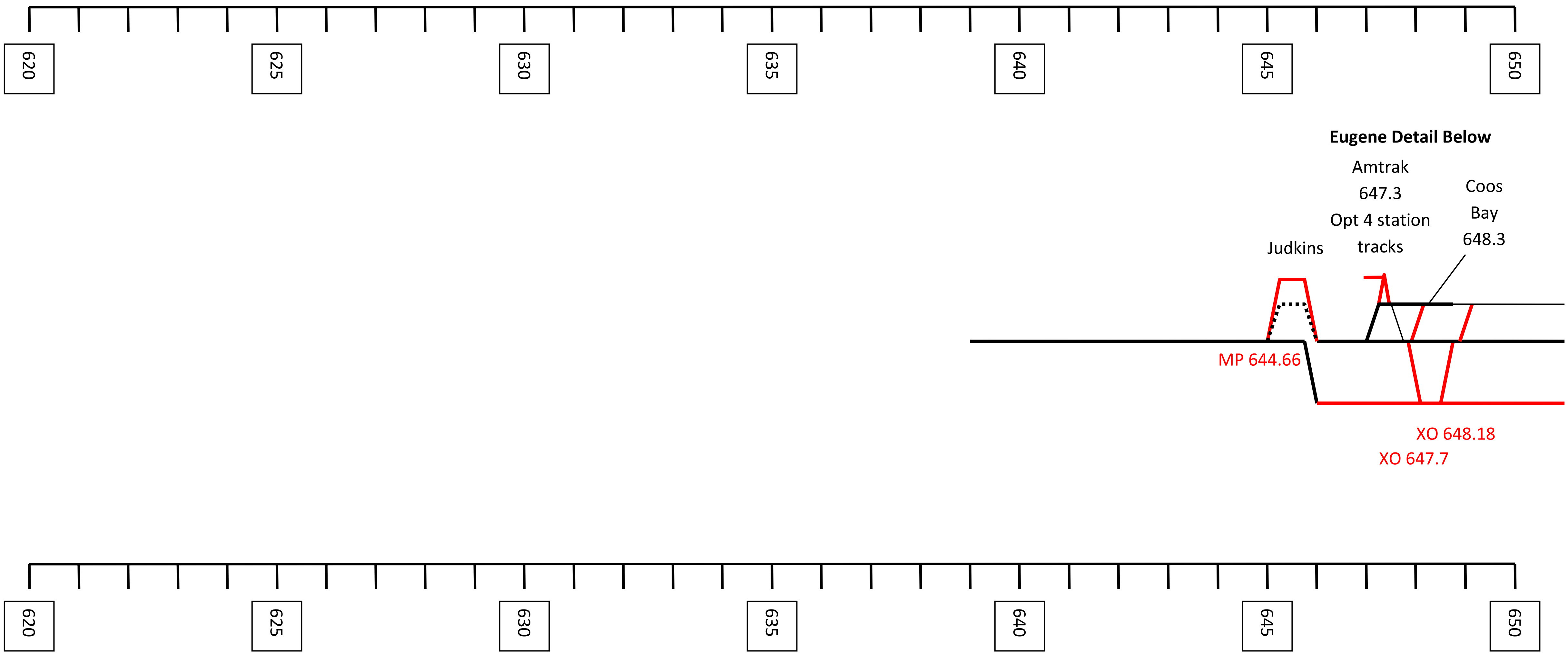
- *Central Section*

1. SMT MP 701.0 to north end Marion (705.76).
2. Add new siding at Brooks, MP 725.0 to MP 727.0.

- *Northern Section*

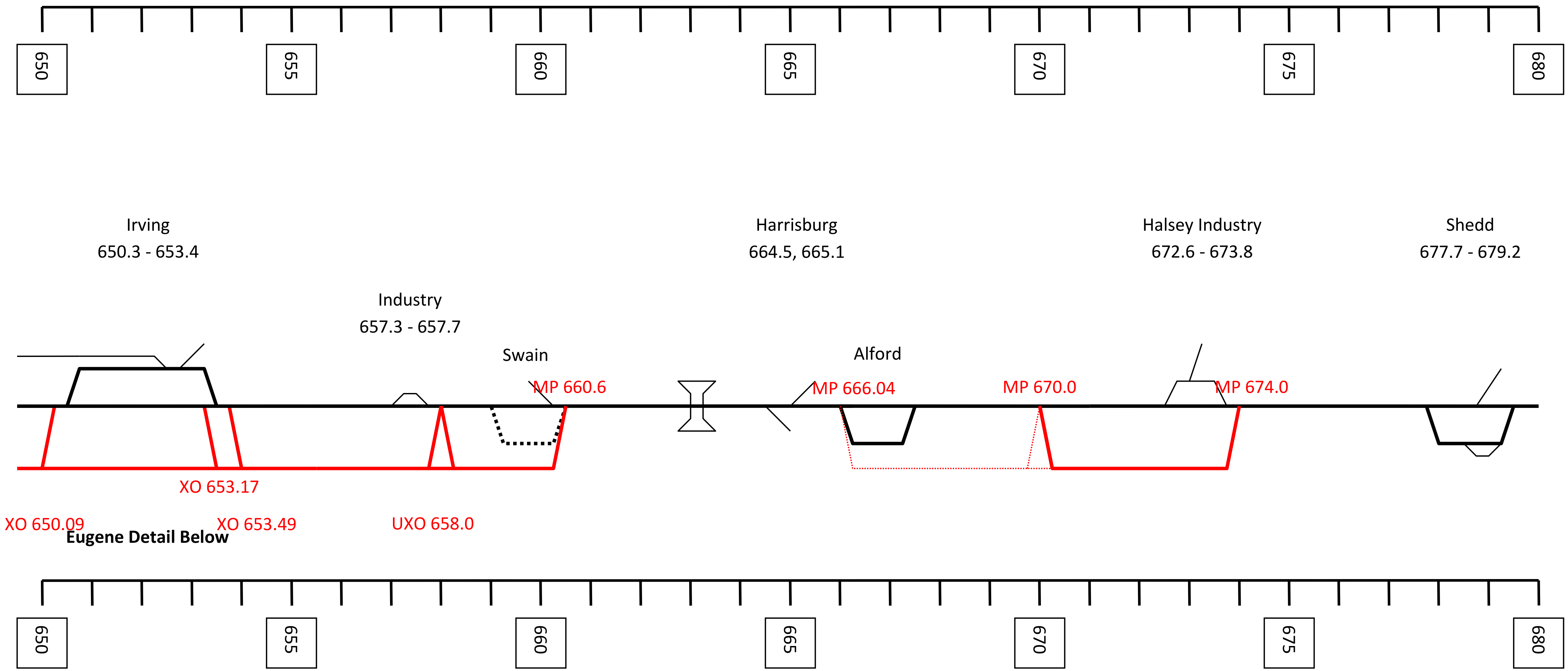
1. Second main track Canby (746.48) to north end Coalca (751.89).
2. Universal crossovers MP 748.39
3. Second main track Clackamas (758.68) to East Milwaukie (MP764.5).
4. Single crossover MP 761.22
5. Third main track East Milwaukie to Steel Bridge (770.0)
6. Universal crossovers Reed MP764.41
7. Universal crossovers MP768.72

The following schematic shows the improvements that were included in the Revised Alternative 1 (3+1) analyses. The Alternative 1 (3+1) infrastructure improvements were a subset of the Alternative 1 (4+1) analysis that was performed prior to the Alternative 1 (3+1) analysis in 2014. The thin red lines are the improvements included in the Alternative 1 (4+1) analysis, while the heavy red lines are the improvements that were included in the Alternative 1 (3+1) analysis. The Revised 4+1 analysis will be described later in this memo, but the associated improvements have been left on the Revised 3+1 schematic to assist a reader to understand how the Alternative 1 (3+1) improvements are a subset of the Alternative 1 (4+1) improvements.



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (3+1) Network



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
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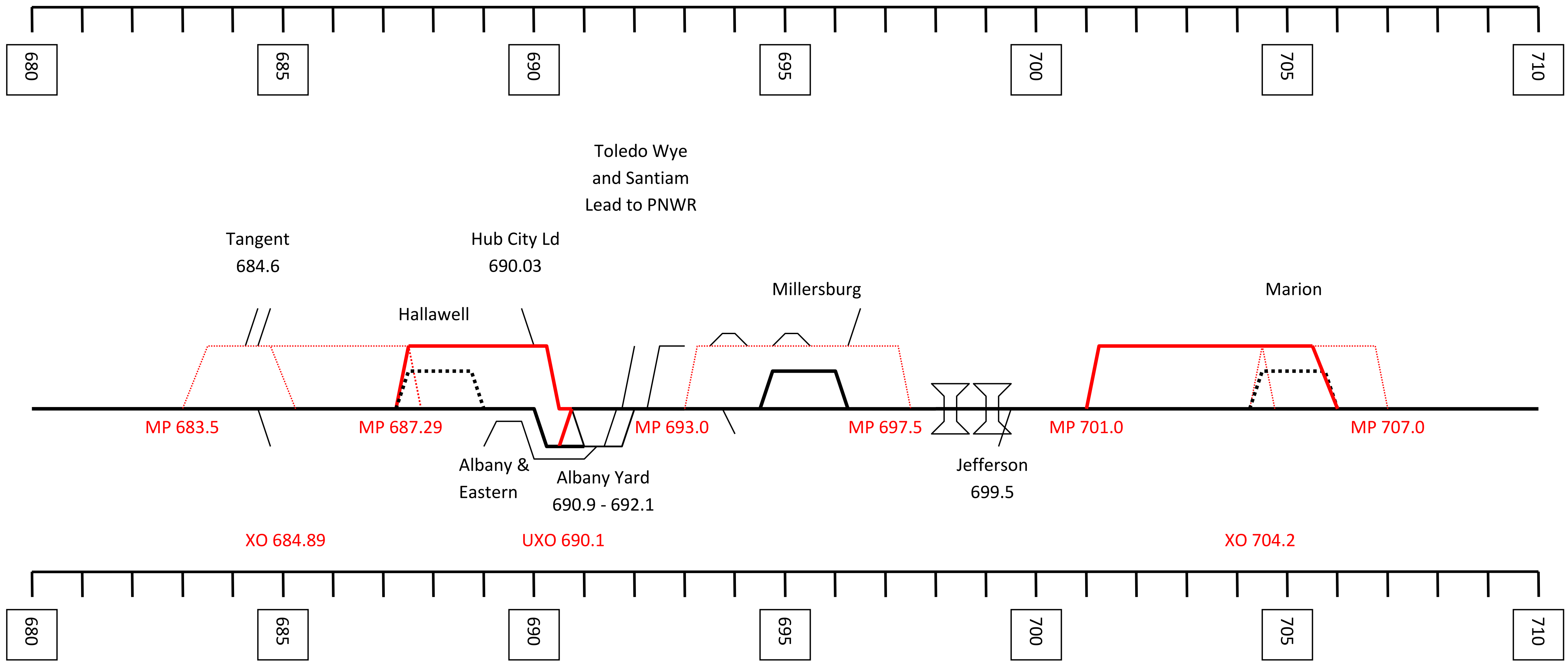
Revised Alternative 1 (3+1) Network



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
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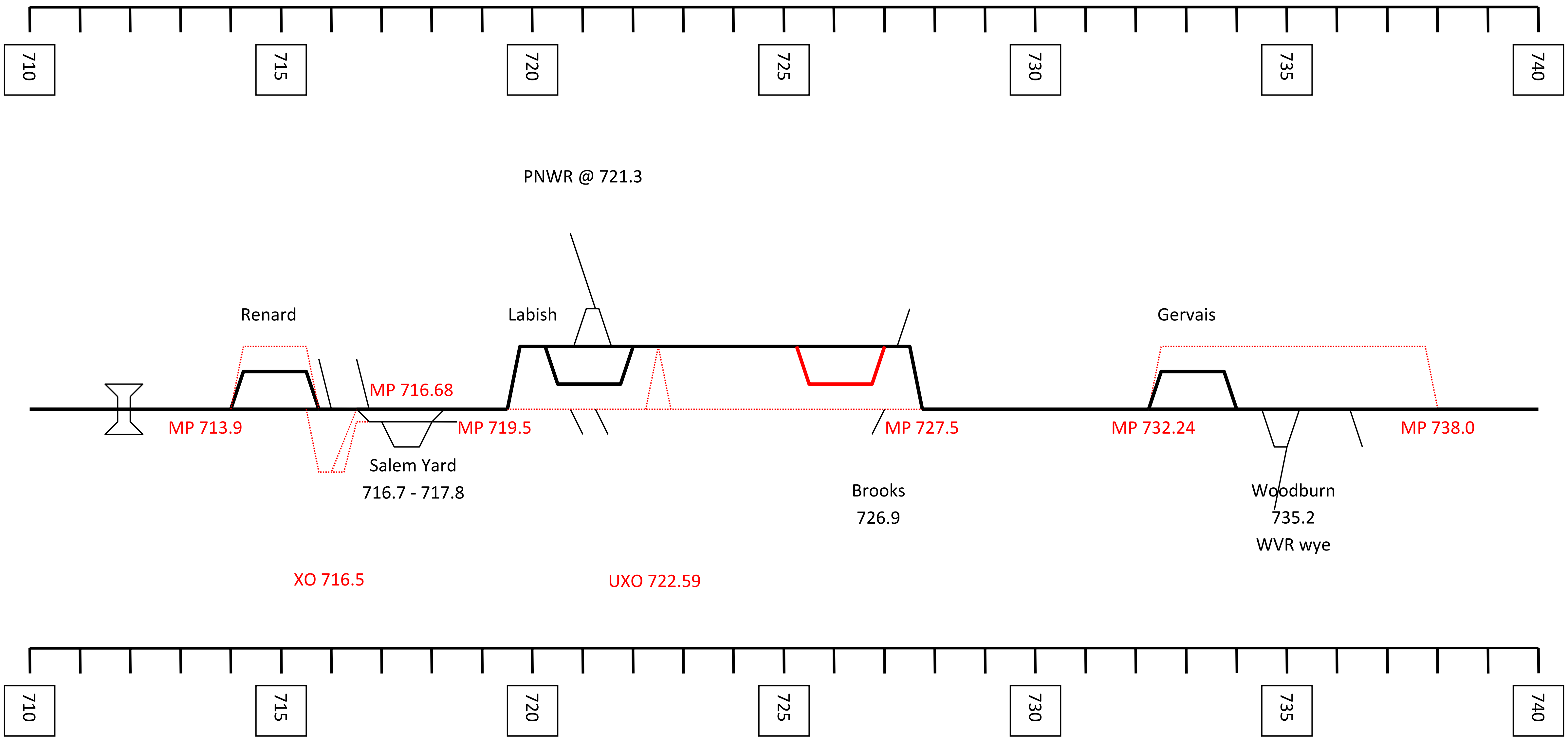
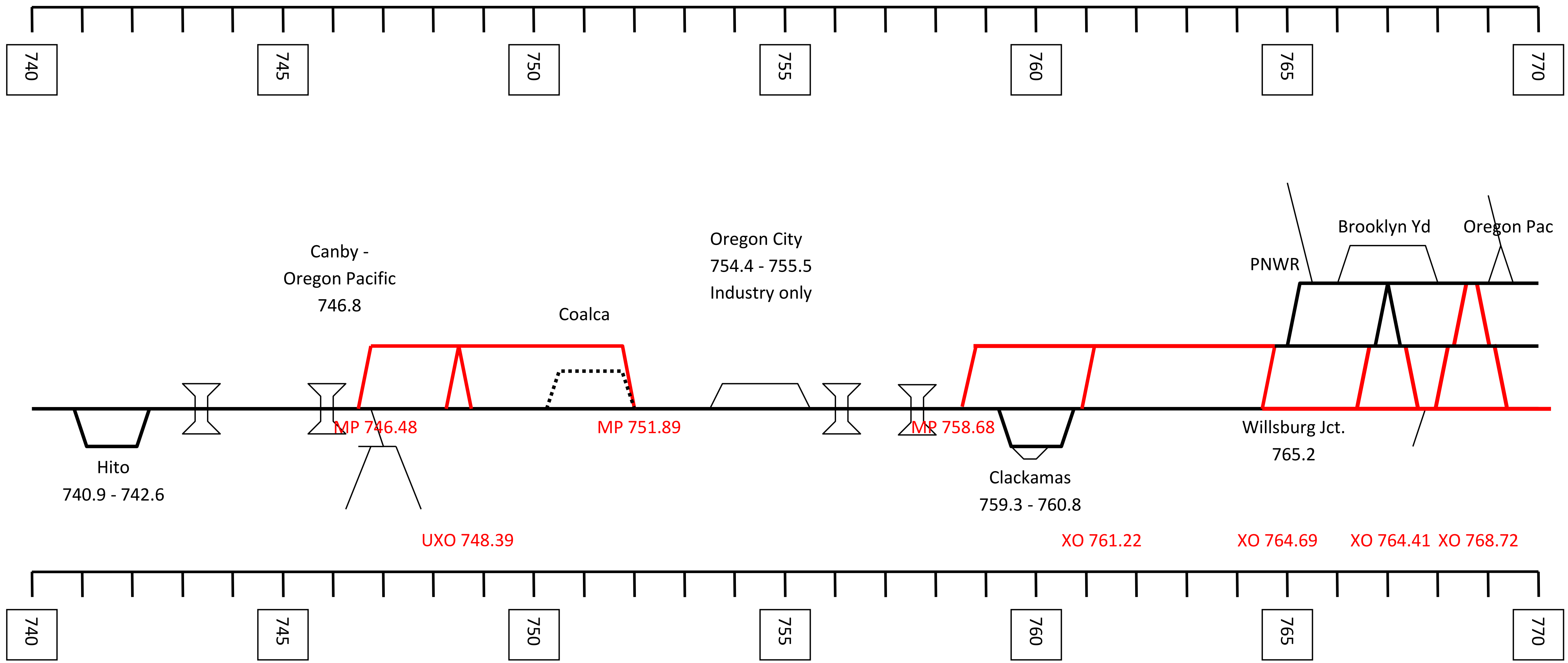
Revised Alternative 1 (3+1) Network



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (3+1) Network



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
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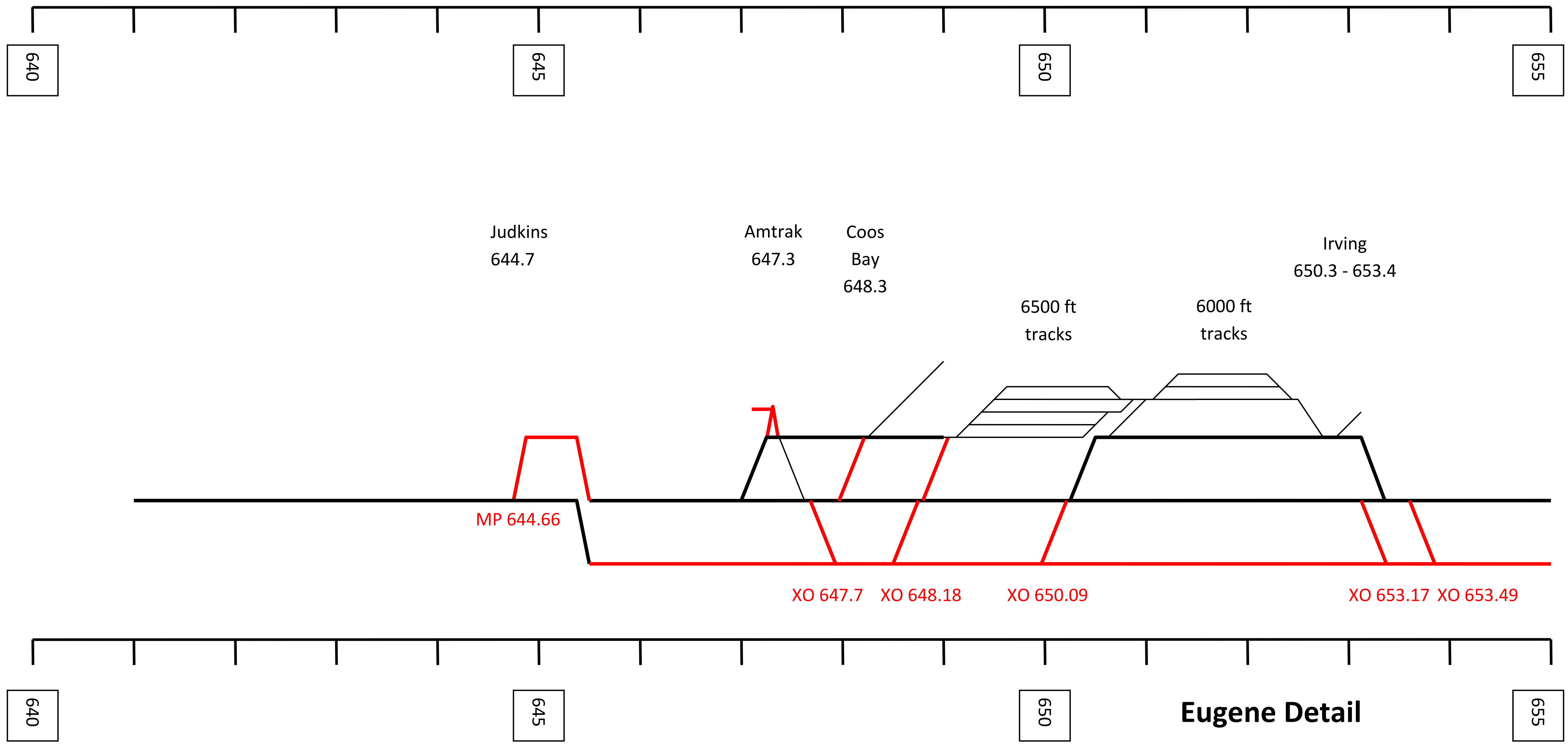
Revised Alternative 1 (3+1) Network



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (3+1) Network

In addition to the capacity improvements that were included between Portland and Eugene, the Eugene Amtrak Station was modified to reflect the Option 4 design provided to the Analysis Team. In that design, the station platforms were moved from the east side of the station (adjacent to the main track and siding) to the west side of the station. One track was connected to the existing tracks at both ends, while the second track was a stub track capable of holding an entire Amtrak Cascades train set. This modification is reflected by the inverted red "V" with the short stub in the preceding schematic.

Between Portland and Vancouver, the track and turnout upgrades at UP's North Portland/Penninsula Jct. and upgrades to Willbridge Junction on BNSF's Fallbridge Subdivision was improved to support 25 mph movements. This compares to the Revised Base and Revised No Action Cases where trains using this connection were limited to 10 mph or less.

Revised Alternative 1 (3+1) Brooklyn Sub Results

There were 3.2 minutes of delay per 10 miles operated (D/10) for the Revised Alternative 1 (3+1) simulation. This result was greater than the Revised Base Case, but less than the Revised No Action Case (Graph 1 below). Therefore, the additional second main track and sidings that were added improved UP's freight performance as compared to the Revised No Action analysis, even with the inclusion of one additional Amtrak Cascades round trip. This was the primary goal of the Revised 3+1 network.

The results fell within an expected range of results because even with the improvements, the network remained primarily a single track network with sidings and some sections of second main track. The results of the simulation suggested the network will not be quite as efficient as the existing Brooklyn Sub network under assumed existing traffic levels; however the results of the analysis included projected freight growth as well as an additional Amtrak Cascades round trip.

The number of delays that exceeded 30 minutes increased to 7.3 per day in the Revised 3+1 Analysis (Graph 2 below). Most of the delays that exceeded 30 minutes were meet/pass delays. There was a slight bias towards freight meets and overtakes (Graph 3 below) as compared to passenger meets or overtakes.

The passenger schedules that were utilized and the adjusted network infrastructure dictated where many of the longest delays occurred in the Revised Alternative 1 (3+1) analysis. Many of the longer meet or overtake delays occurred to freight traffic near where passenger trains met other passenger trains. In the Revised 3+1 analysis, passenger-passenger meets occurred in Hito Siding, at Salem and between Albany (MP 690) and Eugene. These schedules led to many of the longer freight delays occurring between Coalca (MP 750) and Salem and between Hallawell and Eugene (Graph 5 below).

This effect was explained in the initial 3+1 analyses. As discussed, freight trains approaching the location of the passenger train meet were stopped to allow the first approaching passenger train to meet or pass the freight train. After the first passenger train passed, the freight train remained stopped in the same location until the second passenger train passed or met it from the other direction. Waiting for the two passenger trains created long delays which were captured by the D>30 analysis.

There were additional repetitive delays that exceeded 30 minutes besides those associated with passenger-passenger meets. Some congestion remained around Clackamas because of locals switching industry, trains stopping on line for setouts or pickups, and higher priority through freight traffic. However, the extended second main track from East Milwaukie to just beyond Clackamas alleviated many of the exceptionally congested periods that were observed in the Revised No Action Case.

Some on line switching delays continued to occur between Halsey (MP672) and Swain (MP660). This was a function of local trains needing to hold a main line for industrial switching, trains entering and exiting Eugene Yard and passenger operations in or near the area. In multiple cases, lower priority locals were not allowed to access the industry locations until after passenger trains had passed. However, since other freight traffic was also waiting for the passenger trains to clear, those trains followed the passenger trains. The locals then had to wait for some of the freight traffic to clear as well before being allowed to access the industrial locations.

There were no delays between Eugene and Natron in the Revised Alternative 1 (3+1) analysis. As has been described in the results of previous analyses, the extension of a second main track from Judkins to Swain (MP 644 to MP 660) through Eugene provided additional capacity for UP freight operations, minimizing conflicts with other freight trains and expanded passenger operations into and from Eugene's Amtrak station.

The new configuration for the Amtrak Cascades layover tracks was operationally effective in the Alternative 1 (3+1) simulation. There were no major delays associated with passenger operations into or around the Eugene Station.

Revised Alternative 1 (3+1) Brooklyn Sub Velocity Comparison

The following table provides the velocity of the various train classes on the Brooklyn Sub for the Revised Alternative 1 (3+1) analysis. As previously discussed, the PNWR results only reflect PNWR operations that occur on UP's Brooklyn Subdivision.

Alternative Revised 3+1						**Velocity**	**Velocity**
						Total	**minus Delay**
Group	**Delay**	**Dwell**	**Elapsed Time**	**Miles**	**Del/10**	**Elapsed**	**and Dwell**
Passenger	5:18:02	12:45:12	69:38:09	3047.3	1.0	43.8	59.1
PNWR	2:47:51	13:18:00	26:10:26	463.3	3.6	17.7	46.0
UPExp	7:09:06	7:36:10	74:18:46	2407.7	1.8	32.4	40.4
UPLocal	11:51:07	60:26:04	97:54:09	699.8	10.2	7.1	27.3
UPMani	20:14:59	68:22:10	210:41:05	4334.1	2.8	20.6	35.5
UPUnit	13:11:12	21:01:05	111:27:20	2611.0	3.0	23.4	33.8
Total Freight	55:14:14	170:43:29	520:31:45	10516.0	3.2	20.2	35.7

Passenger train elapsed time velocity decreased as compared to the Revised No Alternative and Base Case levels. The Analysis Team believes the primary reason for this is that four of the meets that the eight Amtrak trains experienced were in sidings, rather than on a second main track. When the meets occur in sidings, there is some delay to one of the trains. This decreased the elapsed time velocity by four mph.

When delay and dwell were removed from the calculation, the velocity of the passenger trains increased. The additional second main track contributed to this improvement. With a second main track in place, the passenger trains had more opportunities to meet or overtake freight traffic without slowing down. In the previous analyses, the passenger trains did slow because they were following or meeting freight trains that were diverging into sidings.

Brooklyn Sub freight traffic velocity also increased showing an improvement in the Revised Alternative 1 (3+1) case. It appears that the sections of second main track allowed most types of UP trains to decrease their total delay, while running miles remained relatively constant. This led to increased velocity over the subdivision.

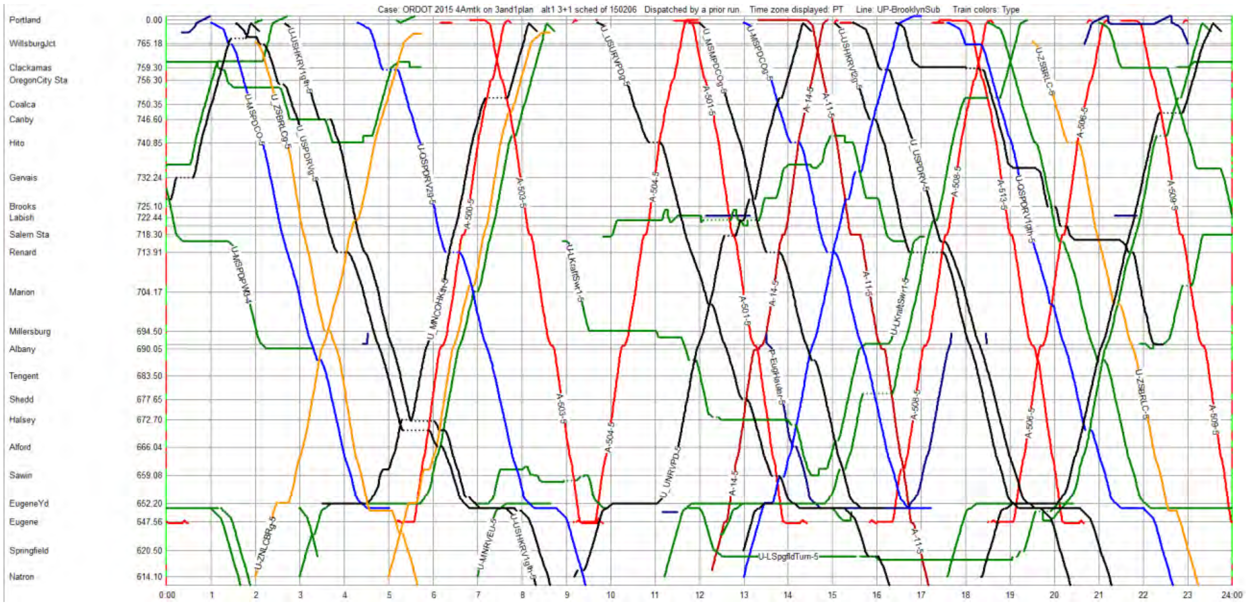
Revised Alternative 1 (3+1) Portland to Vancouver Results

Delays exceeding 30 minutes were notably reduced in the Revised Alternative 1 (3+1) analysis case as compared to the Revised No Action Case. With the same amount of freight traffic on the segment, the number of delays was reduced to 1.3 per day from 4.7 per day in the Revised No Action Case. The main contributor to the improved performance was the increased speed on UP's connection between Peninsula Jct. and NPJ, along with the upgraded turnouts at each end of the connecting track. Movements that could continue from BNSF's Fallbridge Sub onto the UP connection track at 25 mph cleared the area much more quickly, which reduced delays for UP traffic and for BNSF traffic operating in the area.

The one location that did see repetitive delay was at Willbridge. The local working at Willbridge was repeatedly delayed by a switch engine working at Lake Yard. As previously described, a passenger train leaving Portland towards Vancouver contributed to this delay. It appears it is strictly a timing issue; if either of the two locals is a little earlier or later, the delay would likely not occur.

Revised Alternative 3+1 Stringlines

Day 1



Color

Passenger Trains

Red - Amtrak Cascades trains

Reddish Brown – Amtrak Coast Starlight

Freight Trains

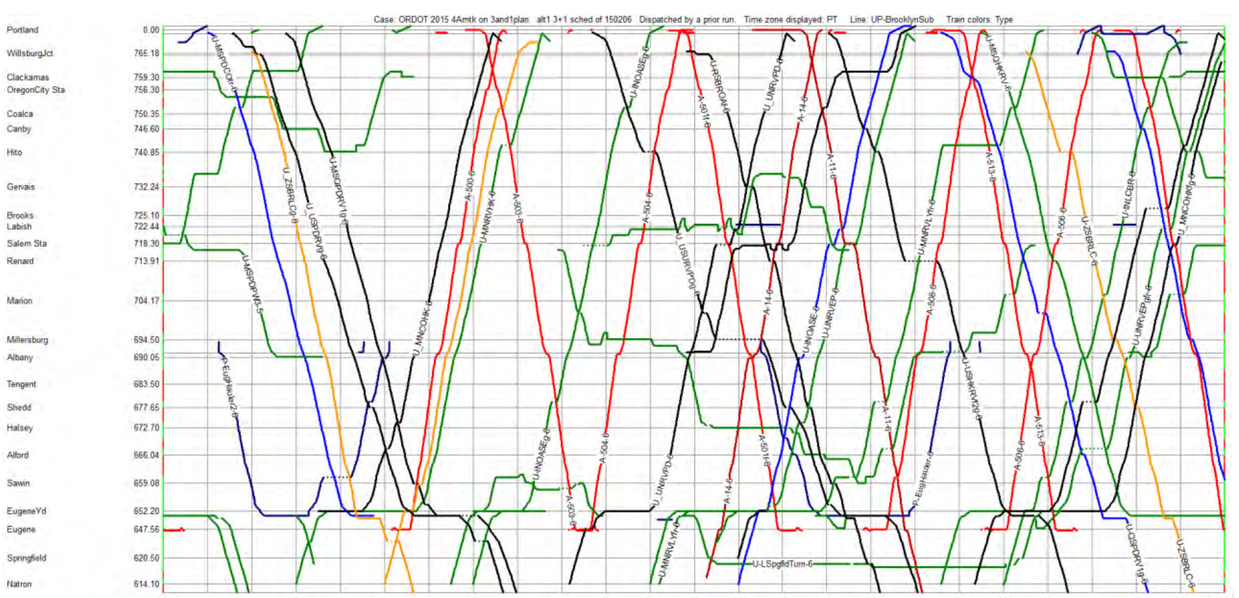
Gold – (Z trains) High priority containers for intermodal

Black – Unit Trains

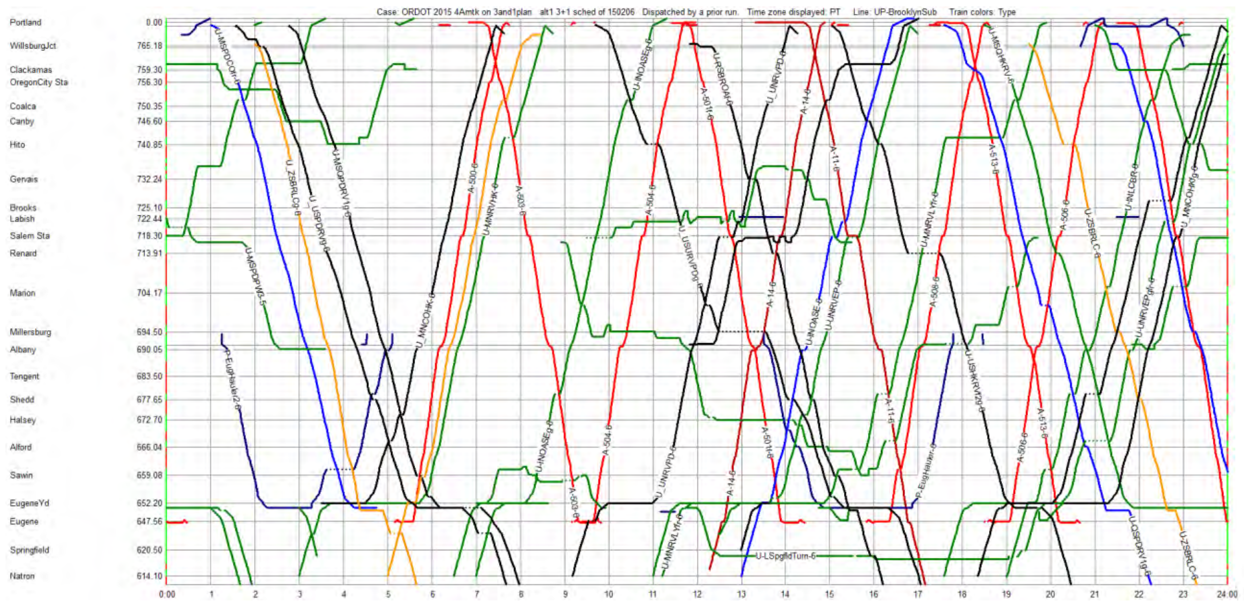
Blue – (Q trains - Doublestack) Priority Intermodal

Green – Local and Merchandise trains

Day 2



Day 3



Color	Passenger Trains
(red line)	Red - Amtrak Cascades trains
(reddish brown line)	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
(gold line)	Gold – (Z trains) High priority containers for intermodal
(black line)	Black – Unit Trains
(blue line)	Blue – (Q trains - Doublestack) Priority Intermodal
(green line)	Green – Local and Merchandise trains

Oregon Passenger Rail
Eugene - Portland
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Appendix D – Revised Alternative 1 (4+1)

Revised: October 18, 2016

Prepared by: Mainline Management

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

Revised Alternative 1 (4+1) Analysis

Introduction

Another alternative that was analyzed previously and then revised to standardize all assumptions was the Revised Alternative 1 (4+1) option. As implied by the name, the Revised 4+1 option increased the number of Amtrak Cascades round trips from two in the Revised Base Case to four. This required a different configuration of track that will be discussed later in this section.

The Revised Alternative 1 (4+1) analysis was standardized by modifying three aspects of the initial 4+1 analysis. First, Eugene Station was modified to reflect the Option 4 configuration that was developed to allow overnight lay over capability for up to two Amtrak Cascades train sets at the station. As previously discussed, this eliminated the need to dead head a train set from the station to UP's Eugene Yard at night and then return it to the station in the morning. The second modification was to standardize the number of Portland to Vancouver (and beyond) Amtrak Cascades round trips from 12 in the initial analysis to six in the Revised Alternative 1 (4+1) analysis. The third modification was the inclusion of the track upgrades at Peninsula Junction and Willbridge, allowing 25 mph operation for UP traffic.

Revised Alternative 1 (4+1) Operational Modifications

As briefly discussed, the only freight modification that was made in the Revised Alternative 1 (4+1) analysis was the addition of the Albina Yard to Lake Yard local that was added to all of the revised simulations. All other projected 2035 UP and BNSF freight operations remained the same, whether on UP's Brooklyn Sub or BNSF's Fallbridge Sub.

Passenger operations on the Brooklyn Sub were modified to the extent that a fourth Amtrak Cascades round trip was added to the Revised 3+1 option (or two round trips were added to the Revised Base or No Action options).

The modification at the Eugene Amtrak station also allowed the dead head (positioning passenger equipment to the station for use in the morning) movement to be modified. As briefly discussed, the Option 4 configuration allows up to two Amtrak Cascade train sets to be staged at night at the station without affecting the main lines. Therefore, no dead head moves to or from Eugene Yard were required in the Revised analysis.

Finally, Portland to Vancouver Amtrak Cascades round trips were reduced from 12 round trips in the initial 4+1 analysis to six round trips in the Revised analysis.

Revised Alternative 1 (4+1) Network Modifications

The initial Alternative 1 (4+1) network was a subset of the initial Alternative 1 (6+1) track configuration. The 6+1 configuration was requested by UP; they asked for a continuous additional main track from the Steel Bridge to Eugene. This was referred to as the “Alternative 1 Plan”.

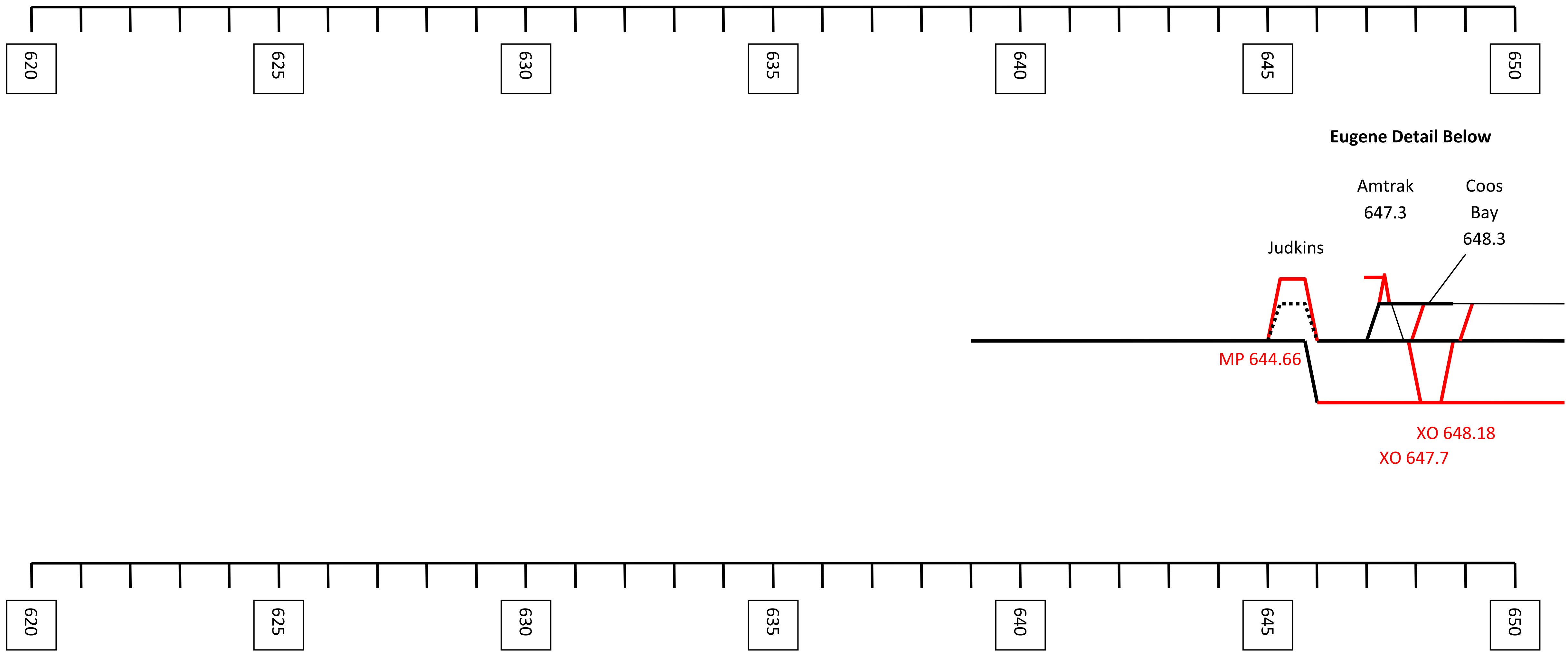
To reduce cost, the number of projected Amtrak Cascades round trips was reduced from six to four, and the Analysis Team was instructed to reduce the infrastructure accordingly in an attempt to reduce its infrastructure cost. The additional main track was removed from high cost locations such as large bridges and through cities such as Salem, Albany and Oregon City. The four round trip Amtrak Cascades trains were then operated on the reduced infrastructure to ascertain the impact of those reductions.

A list of the improvements from the initial 4+1 analysis is included below.

1. Second Main Track (SMT) from MP 644.66 (south end Judkins) to MP 660.6. It utilized the Judkins Siding as the south end of the SMT and Swain Siding as north end of the SMT. Crossovers from SMT to existing crossovers or yard entrance tracks (MP 647, MP 648, MP 650, MP 653.2, MP 653.5) were added. Universal crossovers were added at MP 658.0 +/-.
2. Single track MP 660.6 to 666.04.
3. SMT from MP 666.04 to 674.0 utilizing Alford Siding as the south end of SMT. Universal crossovers were added at MP 670 +/-.
4. Single track MP 674.0 to 683.5. Shedd Siding was included per the UP track chart.
5. SMT 683.5 to 690.1 utilizing Hallawell Siding as part of the SMT. All crossovers remained per the Alternative 1 plan (single crossover at MP 684.89 and universal crossovers at MP 687.29). The new SMT was connected to the Albany lead track and universal crossovers were added at MP 690+/- so northbound freight trains can be operated from either of the main tracks onto an existing single main track through Albany.
6. Single track from MP 690.1 to 693.0 (Albany Yard). All crossovers between the Albany Lead and main track as well as the connection to the Toledo Branch were included.
7. SMT MP 693.0 to MP 697.5 utilizing the Millersburg Siding as part of SMT.
8. Single track MP 697.5 to MP MP 701.0.
9. SMT MP 701.0 to MP 707.0 utilizing Marion Siding as part of the SMT. Universal crossovers were added at MP 704.2 (existing south end Marion Siding).
10. Single track MP 707.0 to MP 713.9.
11. SMT MP 713.9 to MP 716.68 utilizing Renard Siding as south end of SMT. The SMT was connected to the Salem Yard Lead at MP 716.68. Universal crossovers were added at MP 716.5 +/- to allow northbound freight trains from either track to operate over the existing single main track through Salem.
12. Single track MP 716.68 to MP 719.5. All yard leads and connections through Salem per UP’s track charts were included.
13. SMT MP 719.5 to MP 727.5 utilizing Labish Siding as part of the SMT. All other industry tracks at Labish were per the Alternative 1 concept which included universal crossovers at MP 722.59. The “new” Brooks siding per the Alternative 1 plan was removed at MP722.8.
14. Single track MP 727.5 to MP 732.24.

15. SMT MP 732.24 to MP 738.0 utilizing Gervais Siding as the south end of SMT. The "new" Gervais siding from the Alternative 1 plan (MP732.3) and the universal crossovers at MP 736.74 were removed. The industrial siding at Woodburn (MP 734.51) and all of the connections were included.
16. Single track MP 738.0 to MP 746.48. Hito Siding was included per UP's track charts.
17. SMT MP 746.48 to MP 751.89 utilizing Coalca Siding as the north end of the SMT. The Canby industrial siding at MP 746.60 and all of the connections to and from the industrial siding were included, along with universal crossovers at MP 748.39.
18. Single main track MP 751.89 to MP 758.68.
19. SMT MP 758.68 to MP 764.94 and a third main track from East Milwaukie at MP 764.94 to the Steel Bridge at MP 770.17. All crossovers and connections per the Alternative 1 plan between Clackamas and Steel Bridge were included as well as an additional siding and multiple industrial sidings at Clackamas (MP 759.23). All connections and the drill track at Willsburg Junction and Brooklyn were also included.

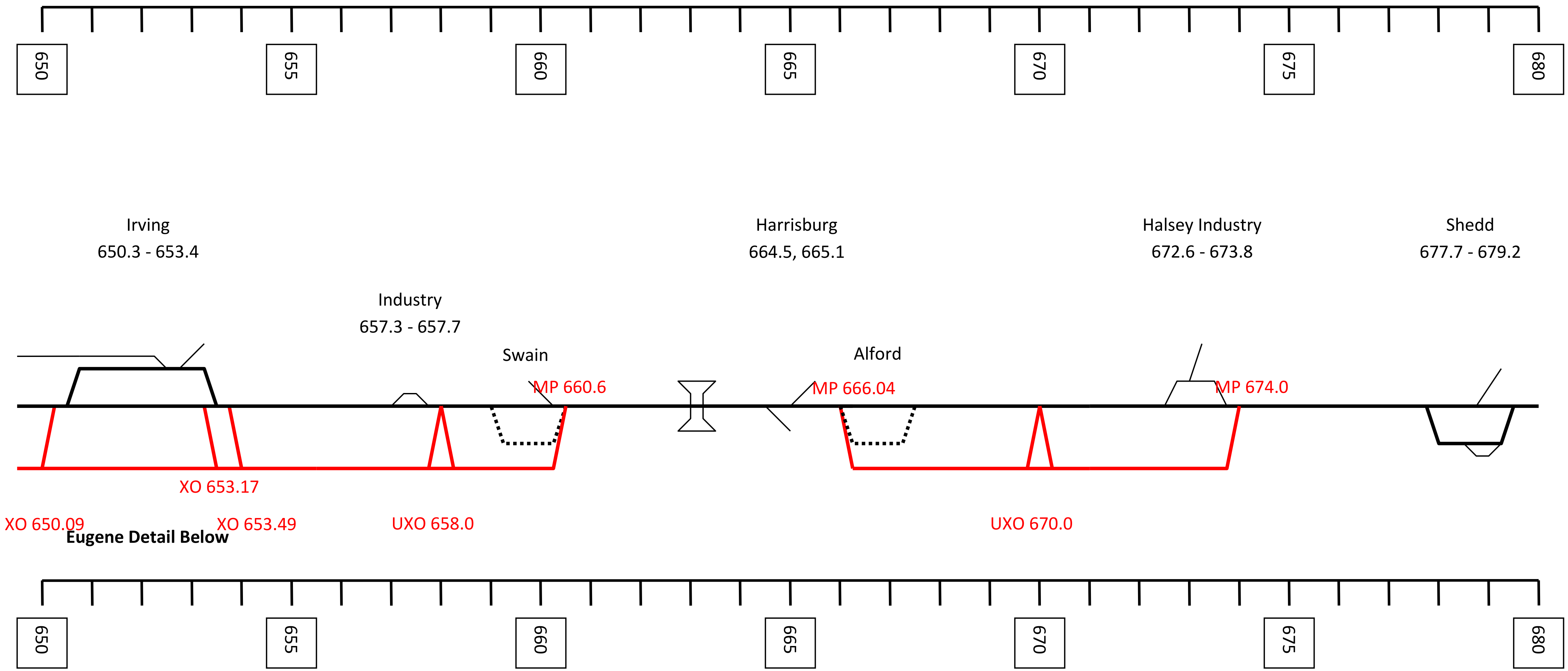
A schematic representation of the improvements follows to provide a visual review of the modifications.



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

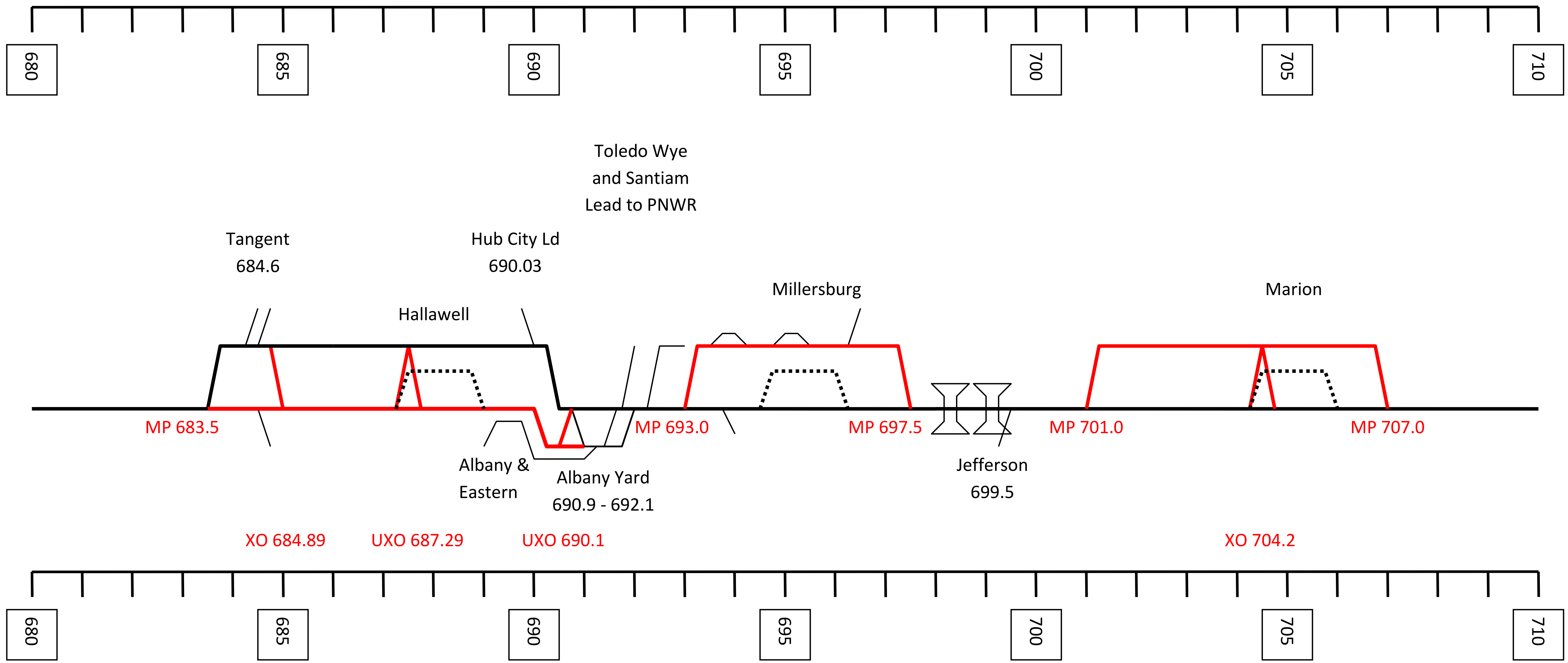
October 18, 2016 Final



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

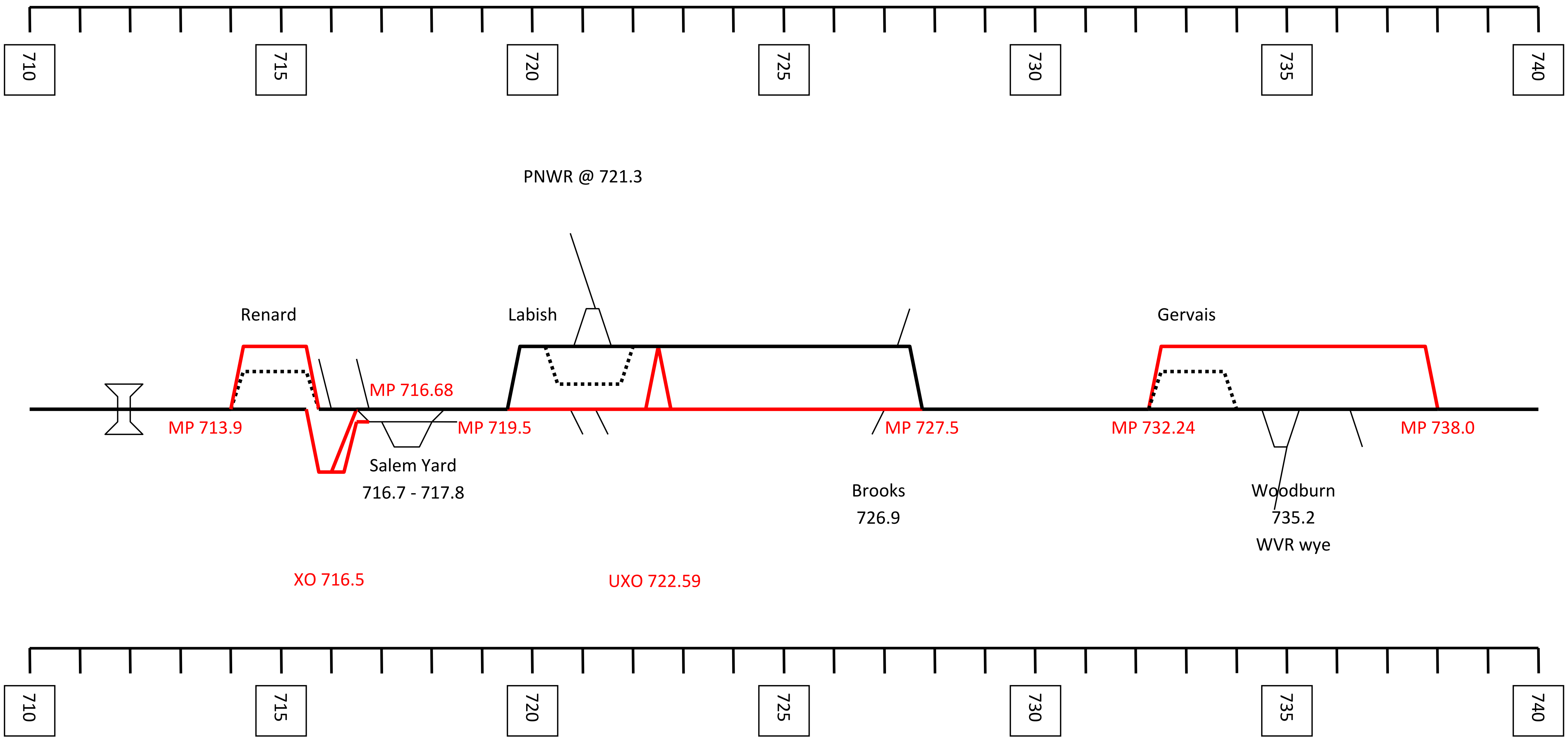
October 18, 2016 Final



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

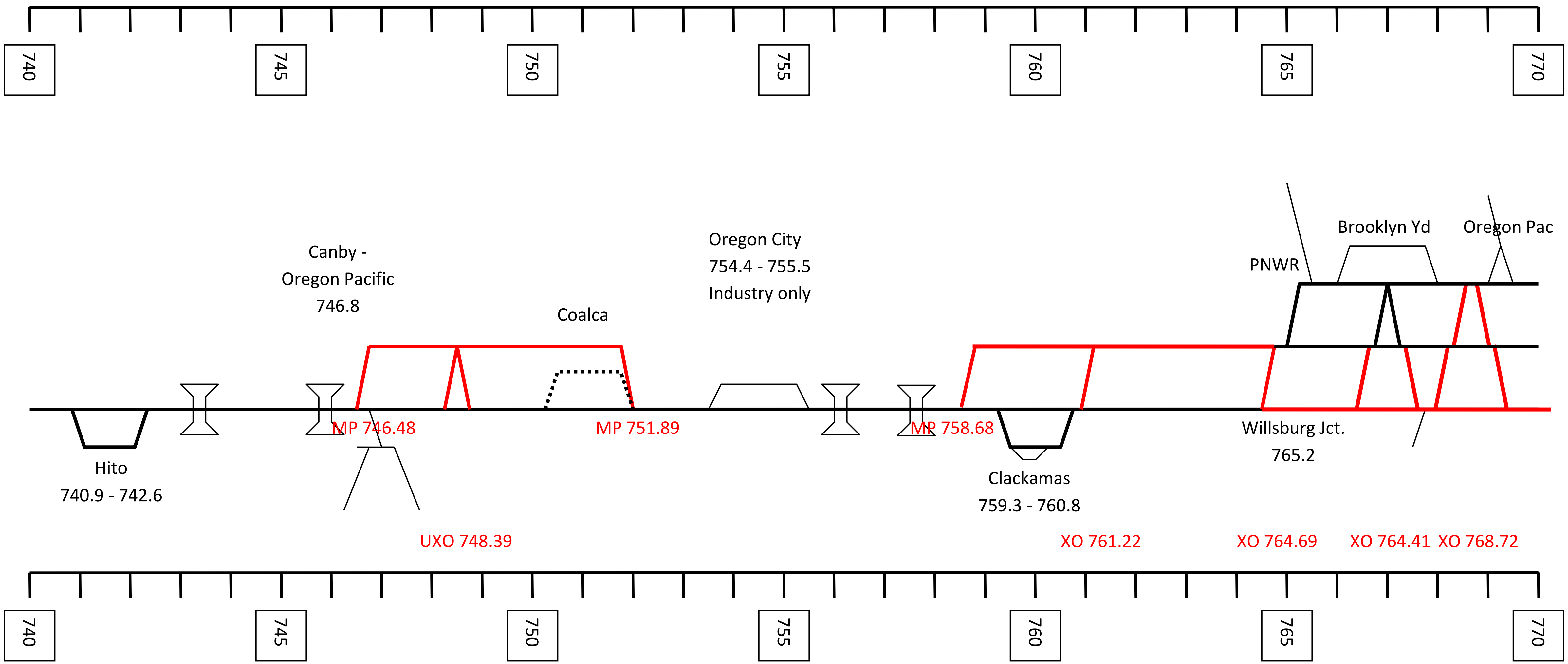
October 18, 2016 Final



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

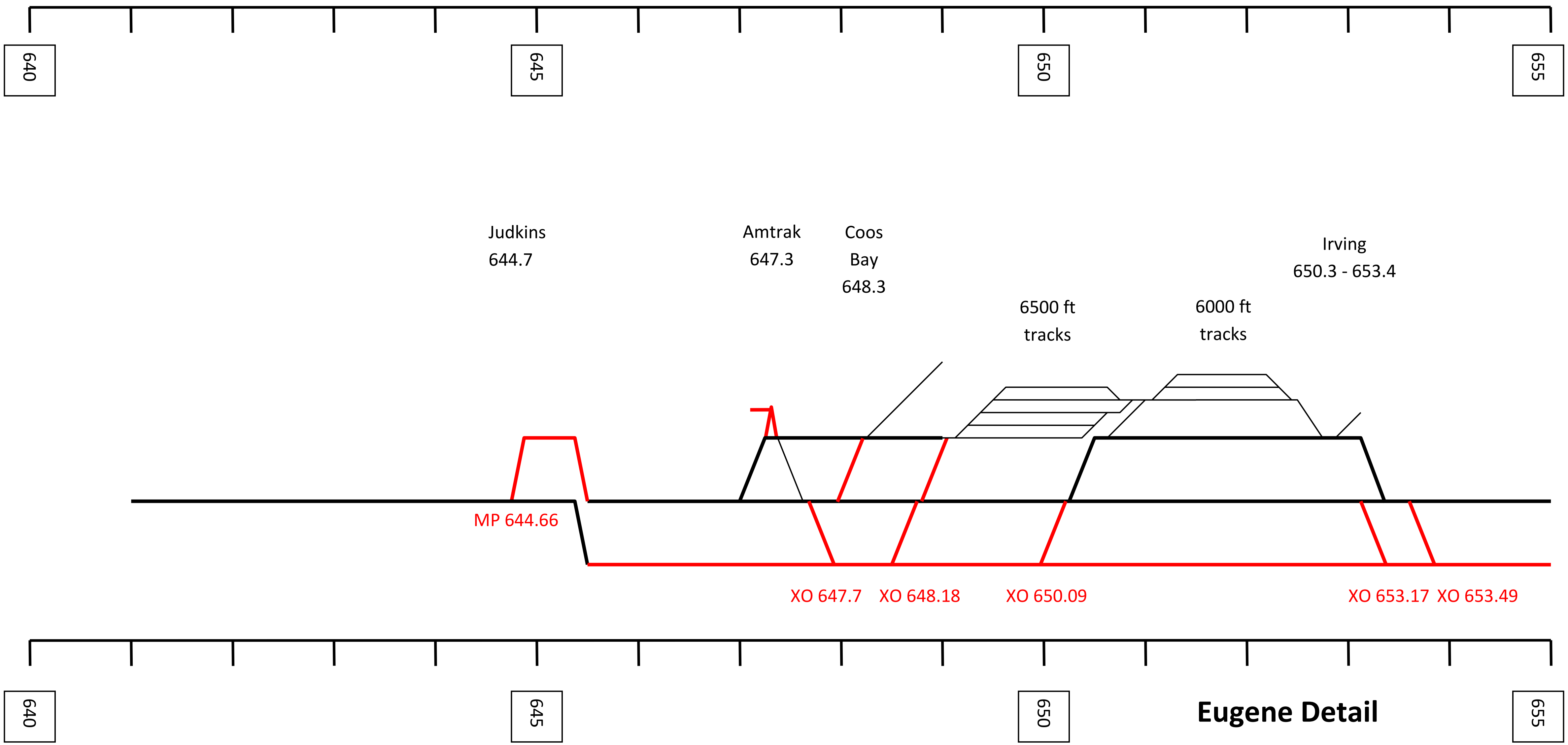
October 18, 2016 Final



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

October 18, 2016 Final



Eugene Detail

Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised Alternative 1 (4+1) Network

Between Portland and Vancouver, the Revised Alternative 1 (4+1) analysis included the upgraded connection between UP's North Portland/Peninsula Jct. and Willbridge. as well as the upgraded turnout connections at both of those locations. As has been previously described, this allowed UP trains to operate at speeds up to 25 mph as compared to the existing connection which is restricted to 10 mph.

Revised Alternative 1 (4+1) Brooklyn Sub Results

There were 2.5 minutes of delay per ten miles operated for the Revised 4 + 1 simulation (Graph 1 below). As the graph shows, this was slightly greater than the Revised Base Case but less than the Revised No Action Case. This was the primary goal of the Revised 4+1 configuration.

The level of delay indicates that the Brooklyn Sub was operating efficiently with the increased Amtrak Cascades round trips and the associated infrastructure. The numbers suggest that the projected operation was almost as efficient as the existing operation that features far fewer freight and passenger trains. The results also indicate that UP's operation would be notably improved with the additional passenger trains and infrastructure as compared to the Revised No Action alternative.

The number of delays per day that exceeded 30 minutes was 2.3 (Graph 2 below). This too is an indication of how efficiently the route was operating. Compared to the Revised No Action case, this represents a reduction of six major delays per day.

The causes of the delays exceeding 30 minutes that did occur were spread evenly over the various categories (Graph 3 below). Combined, freight and passenger meets were the largest contributor to the delays; however there were delays associated with on line switching and yard congestion as well. The relatively small number of those occurrences each day suggests that there was not a systematic problem.

Even the location of the delays suggested there was no reoccurring issue with the track configuration. Delays were distributed across the line segment, with no one area experiencing a high volume of delays. This result confirms that the track infrastructure that was utilized in the Revised 4+1 analysis was sufficient to accommodate the increased passenger operations while at the same time maintaining or even improving UP's freight operation.

Under the Revised 4+1 passenger schedules, the Amtrak Cascades and Amtrak trains were scheduled to meet between Clackamas and East Milwaukie and between Albany and Alford. The trains met at locations where a second main track had been added. There was little delay introduced for passenger-passenger meets in this analysis.

The locations of the passenger-passenger meets also improved freight operations. Since the meets were mostly in locations of second main track, the number of delays to freight traffic waiting for those meets to occur and the second passenger train to pass was greatly reduced. The Analysis Team believes this is one reason why passenger and freight meet delays that exceeded 30 minutes were reduced as compared to other analyses.

The on line switching delays occurred around Labish and Swain in the Revised Alternative 1 (4+1) analysis. The delay at Swain occurred when a local was working an industry on one of the main tracks while two northbound trains were leaving Eugene Yard. The southbound train following the local had to wait for the two northbound trains to pass before being able to go around the local train.

At Labish, the delay occurred because two trains (one northbound, one southbound) that both had "work" at Labish arrived at the same time. Since both could not access the industrial tracks at the same time, one of the trains was delayed until the first train finished its operation and departed.

There was also one delay at Irvin (north end of Eugene Yard). It occurred when a southbound train had to wait for two northbound trains to leave the yard at the same location. One flaw in the design of Eugene Yard is that all northbound trains must depart the yard at Irvin (because of the yard lead configuration), and this is also the only yard access route for southbound trains. Therefore, congestion is likely to occur in this location if a high percentage of Brooklyn Sub trains are required to enter the yard.

Revised Alternative 1 (4+1) Brooklyn Sub Velocity Comparison

The following table provides the velocity of the various train classes on the Brooklyn Sub for the Revised Alternative 1 (4+1) analysis. As previously discussed, the PNWR results only reflect PNWR operations that occur on UP's Brooklyn Subdivision.

Alternative Revised 4+1							
Group	**Delay**	**Dwell**	**Elapsed Time**	**Miles**	**Del/10**	**Velocity Total Elapsed**	**Velocity minus Delay and Dwell**
Passenger	1:53:54	10:20:33	77:25:38	3814.6	0.3	49.3	58.5
PNWR	1:05:33	14:48:00	24:21:30	463.3	1.4	19.0	54.7
UPExp	6:59:19	7:36:09	74:39:31	2406.7	1.7	32.2	40.1
UPLocal	7:08:42	60:26:04	93:19:35	699.6	6.1	7.5	27.2
UPMani	18:23:12	68:24:10	208:10:38	4318.1	2.6	20.7	35.6
UPUnit	10:12:14	21:01:10	107:43:54	2609.0	2.3	24.2	34.1
Total Freight	43:48:59	172:15:33	508:15:07	10496.6	2.5	20.7	35.9

As the table indicates, the passenger velocities were increased in the 4+1 alternative as compared with the Revised 3+1 and Revised No Action alternatives. As described, the Analysis Team believes this is because the passenger schedules created passenger-passenger meets on sections of two main tracks rather than in sidings. This allows both trains to continue running at track speed, rather than slowing or stopping in a siding.

Freight velocities in the Revised 4+1 alternative were very similar to those in the Revised 3+1 alternative. There was a small improvement in the amount of delay local, manifest and unit trains experienced, while the expedited category experienced a very slight increase in delay. This affected the velocities of the four traffic groups, however, the impact was slight. The overall consequence to freight traffic was that velocities were slightly increased in the Revised Alternative 1 (4+1) analysis as compared to the Revised 3+1 and the Revised No Action Cases.

Revised Alternative 1 (4+1) Portland to Vancouver Results

Delays exceeding 30 minutes were notably reduced in the Revised Alternative 1 (4+1) analysis case as compared to the Revised No Action Case, and were the same as the D>30 delays in the Revised Alternative 1 (3+1) case. With the same amount of freight traffic on the segment, the number of delays was reduced to 1.3 per day from 4.7 per day in the Revised No Action Case (Graph 7 below). As described previously, the number of Amtrak Cascades and Amtrak round trips remained the same between the two cases.

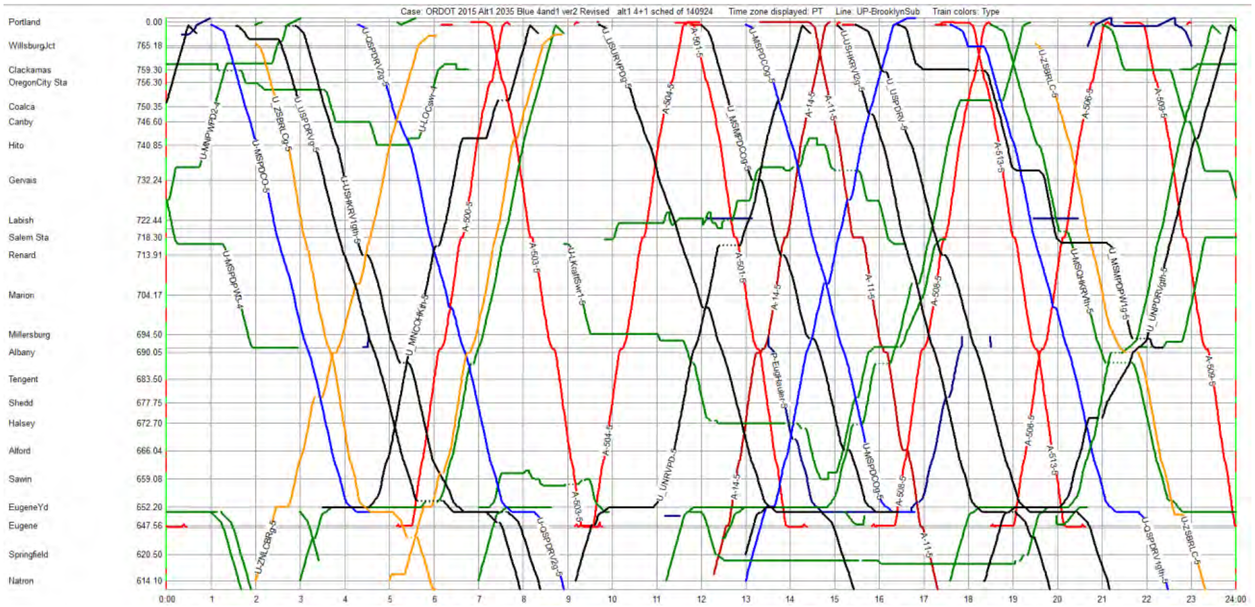
As with the Revised Alternative 1 (3+1) Case, the main contributor to the improved performance was the increased speed on UP's connection between Peninsula Jct. and NPJ, along with the upgraded turnouts at each end of the connecting track. Movements that could continue from BNSF's Fallbridge Sub onto the UP connection track at 25 mph cleared the area much more quickly, which reduced delays for UP traffic and for BNSF traffic operating in the area.

Also, the local train working between Willbridge Yard and Lake Yard again experienced delay in the Revised Alternative 1 (4+1) analysis. As described previously, this is a timing issue with the three trains that are involved in the delay. If the locals' operations were slightly adjusted, the delay would not have occurred. Since the model can only use what was included in the input files, the delay is repetitive from day to day as well as between analysis cases.

The similarity in delays between the Revised 3+1 and Revised 4+1 analyses in the Portland to Vancouver corridor underscores how separated the two corridors segments are. Even though passenger traffic and infrastructure were modified on the Brooklyn Sub, there was no change in the operational patterns between Portland and Vancouver. It can therefore be concluded that Brooklyn Sub operations have little to no effect on Fallbridge Sub operations, or vice versa using current freight train operations and simulated Amtrak schedules provided by ODOT.

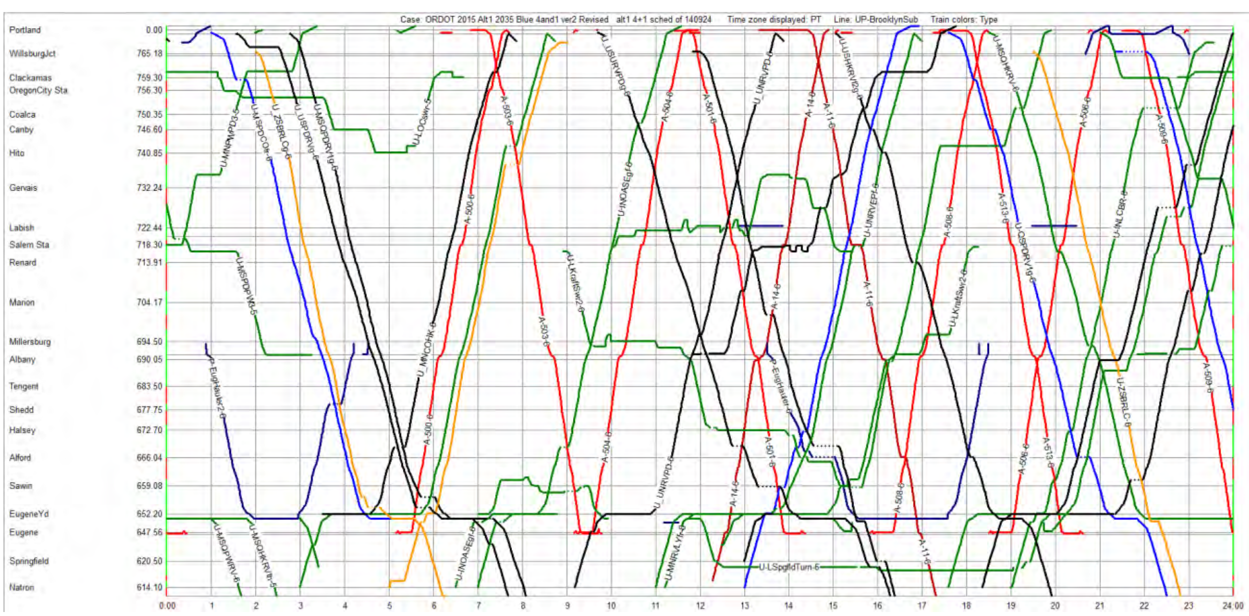
Revised Alternative 4+1 Stringlines

Day 1

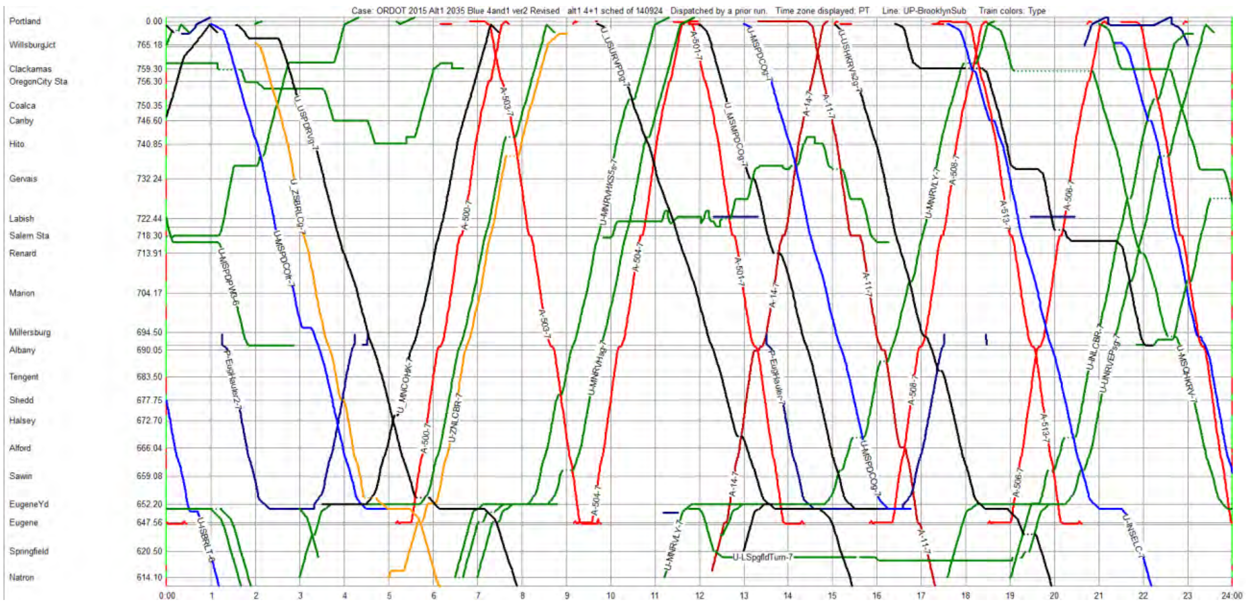


Color	**Passenger Trains**
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Day 2



Day 3



Color	Passenger Trains
(red line)	Red - Amtrak Cascades trains
(reddish brown line)	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
(gold line)	Gold – (Z trains) High priority containers for intermodal
(black line)	Black – Unit Trains
(blue line)	Blue – (Q trains - Doublestack) Priority Intermodal
(green line)	Green – Local and Merchandise trains

Oregon Passenger Rail
Eugene - Portland
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Appendix E – Revised Alternative 4+1 Operations on Alternative 1 (3+1) Infrastructure

Revised: October 18, 2016

Prepared by: Mainline Management

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

4+1 Passenger Operations on Alternative 1 (3+1) Infrastructure

Introduction

The Analysis Team was tasked with simulating a four Amtrak Cascades, one Coast Starlight round trip schedule (4+1) on the same Brooklyn Sub track network that was utilized in the Revised Alternative 1 (3+1) analysis. The goal of this analysis was to determine if additional track infrastructure could be reduced while maintaining an efficient freight operation over the Brooklyn Subdivision between Portland and Eugene.

4+1 Passenger Operations on Alternative 1 (3+1) Network Operational Modifications

The only operational modification that was made in the 4+1 Passenger Operations on Alternative 1 (3+1) Network (referred to as "4+1 on 3+1") was the change in passenger trains between Portland and Eugene. The train input files from the Revised Alternative 1 (3+1) simulation were utilized except the passenger train files for the Revised Alternative 1 (4+1) analysis were substituted into the train input files. This was significant because it meant that the freight files were exactly the same between the 4+1 on 3+1 analysis and the Revised Alternative 1 (3+1) analysis. The relevance of having a replicated freight train file will be explained in more detail in the Results section below.

4+1 Passenger Operations on Alternative 1 (3+1) Network Infrastructure Modifications

The Revised Alternative 1 (3+1) Network for the Brooklyn Sub was used in the 4+1 on 3+1 analysis. The track infrastructure improvements that were made to the existing Brooklyn Sub network can be reviewed in the Revised Alternative 1 (3+1) Analysis notes above. There is also a schematic representation of the improvements for the 3+1 network in those notes that can be reviewed.

4+1 Passenger Operations on Alternative 1 (3+1) Network Brooklyn Sub Results

There were 2.5 minutes of delay per ten miles operated for the 4+1 on 3+1 simulation (Graph 13 below). There were also 4.7 delays per day that exceeded 30 minutes (Graph 14 below). This result was less than the Revised No Action Case, which was an expected outcome of the analysis.

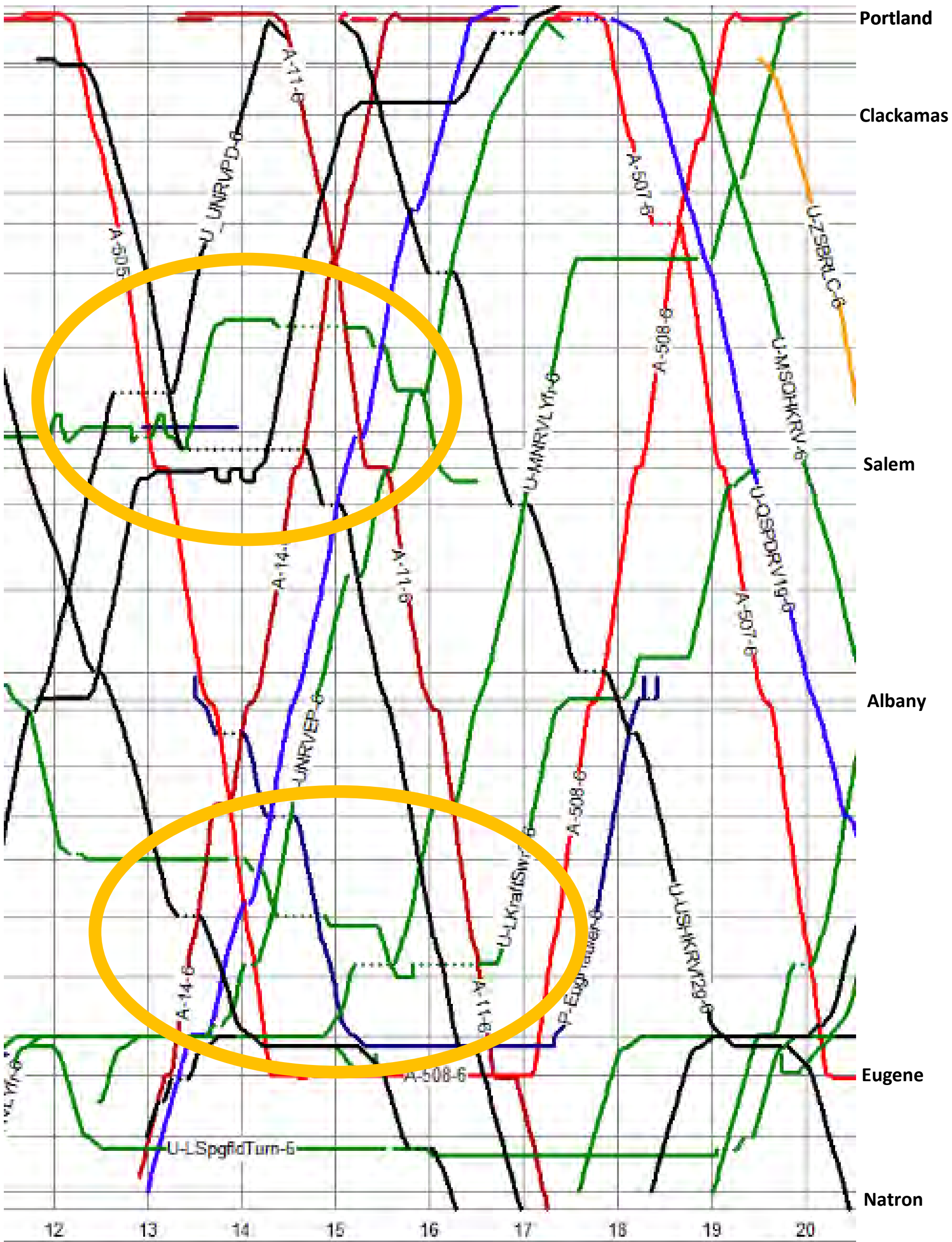
However, the D/10 delay minutes and the D>30 delays were also less than the Revised Alternative 1 (3+1) results, which was an unexpected result. Considering that the track network was the same, the freight operations were the same, but the latest simulation had one additional Amtrak Cascades round trip, a D/10 that was slightly greater than the Alternative 1 (3+1) result was expected. After detailed review of the results output, the Analysis Team believes the reduced D/10 delay minutes outcome occurred because of the passenger schedules used in the 4+1 on 3+1 simulation as compared to those used in the Alternative 1 (3+1) simulation.

A review of the passenger - passenger meets and where they occurred was undertaken for both the Revised Alternative 1 (3+1) analysis and the 4+1 on 3+1 Network analysis. As described in the Revised Alternative 1 (3+1) analysis notes above, there were four passenger - passenger meets that occurred. These occurred at Hito Siding (two), Renard Siding (one) and Shedd Siding (one). In the 4+1 on 3+1 Network simulation, six meets between passenger trains occurred because of the additional set of Amtrak Cascades trains. The meets occurred near East Milwaukie on second main track (three), between Albany and Hallawell on second main track (two) and between Swain and Irvin on second main track (one).

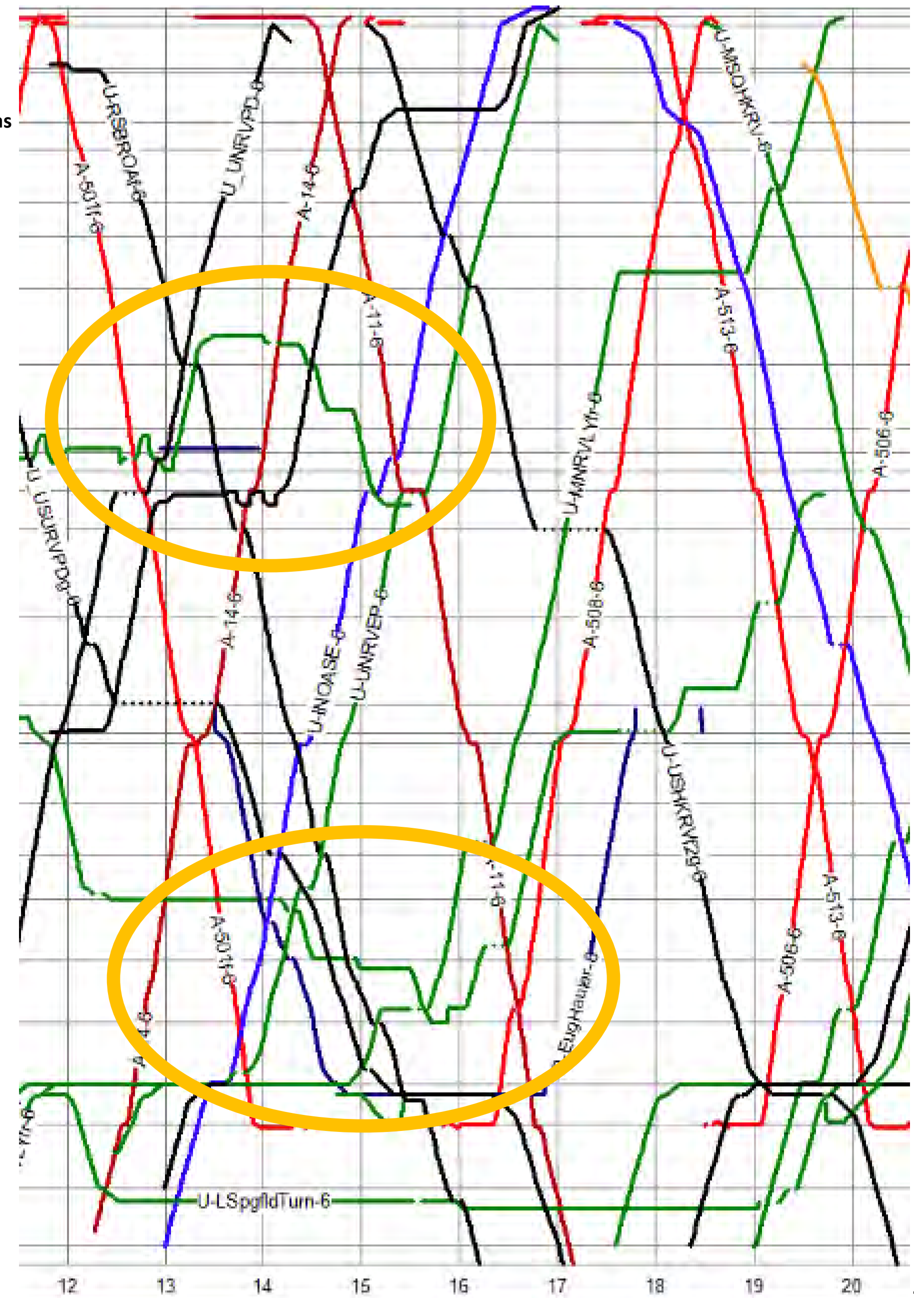
As can be seen, the 4+1 on 3+1 simulation meets occurred on multiple main tracks. As has been previously described, when a passenger - passenger meet occurred where there are mostly sidings in the area, a freight train in that same area frequently had to wait for the first passenger train to meet (or overtake) it, then remain in the siding until the second passenger train overtook (or met) it. The simulation results indicated that this is what happened in the Revised Alternative 1 (3+1) simulation, where the passenger-passenger meets occurred in sidings.

In the 4+1 on 3+1 simulation, however, with the passenger-passenger meets occurring on sections of second main track, there was not the same impact on the freight operations. With a second main track, the freight trains only had to intermittently wait for one of the passenger trains, and in some cases, did not have to stop at all. This modification in meet/pass resolution also changed the freight train running times, which affected other freight meets and passes throughout the simulation. So even though there were more passenger-passenger meets in the 4+1 on 3+1 analysis, the impact to freight traffic was notably less than in the Revised Alternative 1 (3+1) analysis.

The Analysis Team has included small sections of the time-distance graphs (“string line graphs”) for the Revised Alternative 1 (3+1) analysis and the 4+1 on 3+1 simulation to demonstrate this point. As described previously, the freight departure schedules were the same in the Alternative 1 (3+1) and the 4+1 on 3+1 simulations. Also as described, the track network used for the two simulations was identical. The only operating change that was made was the modification of the passenger schedules from the 3+1 configuration to the 4+1 configuration. Therefore, any change in freight operations had to be caused by the passenger changes. The time-distance graphs show this effect.



Revised Alt 1 (3+1), 1200 to 2000 Day 2



4+1 on 3+1 Network, 1200 to 2000 Day 2

In the time-distance graphs, red (Amtrak Cascades) and reddish brown (Coast Starlight) lines represent passenger trains as they move between Portland (top of graph) and Natron (bottom of graph) over time, which is shown along the horizontal axis at the bottom of each graph. The other blue, green and black lines represent different types of freight traffic. Trains are stopped when a line is horizontal; trains are delayed when the horizontal line is dotted.

The change in timing of the passenger trains (the additional pair of trains as well as the departure times of the sets of Amtrak Cascades trains) is obvious between the Revised Alternative 1 (3+1) time-distance graph on the left and the 4+1 on 3+1 Network graph on the right. Additionally it is obvious that the passenger train count and schedule modification changed the meet patterns for freight traffic.

It can be seen that the freight trains begin their trip at Albina Yard (near Portland) or Natron at the same times in both time-distance graphs, but the meet patterns change once they interact with the passenger trains. In the Revised Alternative 1 (3+1) time-distance graph, there are multiple delays to freight traffic (dotted horizontal lines) in both of the highlighted areas. The delays all occur to freight traffic operating between passenger train movements (red and reddish brown lines). At the same time, in the 4+1 on 3+1 graph, there are very few delays in those same time periods (almost no horizontal dotted lines).

These graphs illustrate the impact passenger schedules and meets had on freight trains in the Revised Alternative 1 (3+1) analysis as compared to the 4+1 on 3+1 simulation. Similar differences between the two analyses occurred on other days of the simulations as well. The Analysis Team believes these differences are responsible for the reduction in D/10 delay minutes and D>30 delays between the two analyses.

Even with the change in the location of passenger - passenger meets, some delays continued to be caused by passenger and freight meets (Graph 15 below). Many of the delays caused by passenger meets occurred when a freight - freight meet took place and then the stopped freight train had to wait on a following passenger train. In some of those cases, the delayed freight train was a local waiting to switch an on-line industry on single track, so the model could not allow the local switcher out until the passenger train had passed.

The distribution of delays over the line segment continued to indicate that there was no repetitive issue with the 3+1 configuration under the 4+1 passenger schedules (Graph 16 below). No one segment of the Brooklyn Sub experienced a high number of delays that exceeded 30 minutes, which indicated that there was nothing associated with the network track configuration that promoted delays.

Overall, it appears that the schedule of the projected Amtrak Cascades trains has a notable consequence on UP's freight performance over the Brooklyn Sub. The timing between departures from Portland and Eugene as well as where passenger trains meet will have an impact on where capital improvements will be necessary to maintain or improve UP's freight operations as additional Amtrak Cascades roundtrips are added.

4+1 Passenger Operations on Alternative 1 (3+1) Network Brooklyn Sub Velocity Comparison

The following table provides the velocity of the various train classes on the Brooklyn Sub for the 4+1 on 3+1 analysis.

4+1 on 3+1 Network						Velocity	Velocity
						Total	minus Delay
Group	Delay	Dwell	Elapsed Time	Miles	Del/10	Elapsed	and Dwell
Passenger	1:48:39	11:20:00	78:33:24	3816.0	0.3	48.6	58.3
PNWR	1:02:35	13:18:00	24:05:58	463.3	1.4	19.2	47.5
UPExp	5:15:59	7:27:05	71:35:31	2409.6	1.3	33.7	40.9
UPLocal	6:51:48	59:41:05	91:54:27	699.8	5.9	7.6	27.6
UPMani	16:18:06	68:24:08	207:41:40	4360.4	2.2	21.0	35.5
UPUnit	13:10:16	21:31:03	111:30:57	2610.2	3.0	23.4	34.0
Total Frt	42:38:43	170:21:21	506:48:32	10543.2	2.5	20.8	35.9

Passenger train velocities are slightly less in the 4+1 on 3+1 simulation as compared to the Revised Alternative 1 (4+1) simulation (48.6 mph vs 49.3 mph). Both of these simulations included the same number of passenger round trips between Portland and Eugene. The slight reduction in passenger velocity was likely because the passenger trains were slowed somewhat by freight traffic that had to meet and pass over the 3+1 network, which included fewer track infrastructure improvements than the Alternative 1 (4+1) network.

However, the passenger velocities were notably higher in the 4+1 on 3+1 simulation as compared to the passenger velocities in the Revised Alternative 1 (3+1) simulation (48.6 mph vs 43.8 mph). This again supports the conclusion that the location of the passenger - passenger meets plays a major role in the efficiency of a conceptual rail network. As described, the 4+1 on 3+1 simulation featured passenger meets on multiple main tracks, while the Revised Alternative 1 (3+1) analysis featured those meets in sidings. As has been previously described, when a meet occurs in a siding, one passenger train usually has to stop to wait which reduces the velocity of the entire group.

The average freight velocities were also greater in the 4+1 on 3+1 simulation compared to the Revised Alternative 1 (3+1) analysis (20.8 mph vs 20.2 mph). This also reflects the previous discussion about how freight traffic did not receive the level of delay in the 4+1 on 3+1 simulation because the passenger schedules were less disruptive to freight operations.

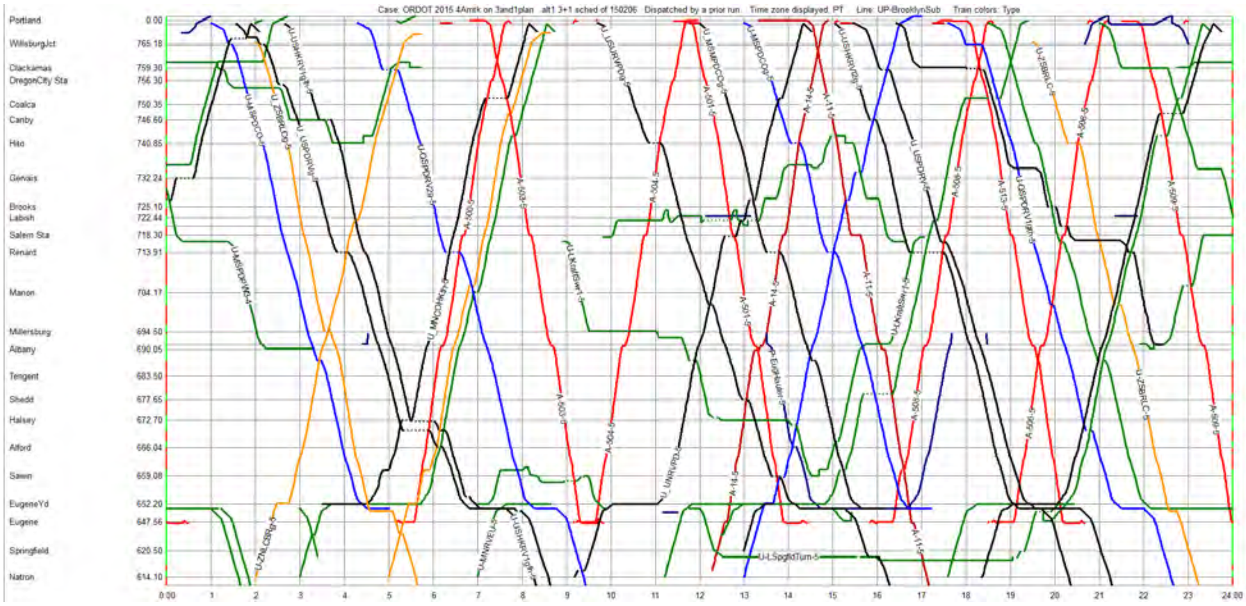
The 4+1 Passenger Operations on Alternative 1 (3+1) Network - Portland to Vancouver Results

Similar to both the Revised 3+1 and 4+1 analyses, there were few delays between Portland and Vancouver under the six Amtrak Cascades, one Coast Starlight and one Empire Builder (6+2) passenger schedules. The greatest contributor to this development was the track speed modifications to UP's connection between Peninsula Jct. and North Portland Jct., which continued to facilitate more efficient freight movements in the Portland - Vancouver corridor.

The one repetitive delay that was experienced in the 4+1 on 3+1 simulation was at Willbridge Yard. As has been noted previously, this appeared to be a timing issue between two locals that are scheduled to work in Lake Yard at the same time. This delay has been seen in many of the previous analyses and likely would be eliminated with a change in either of the locals' schedule or a more fully developed Lake Yard configuration in the model.

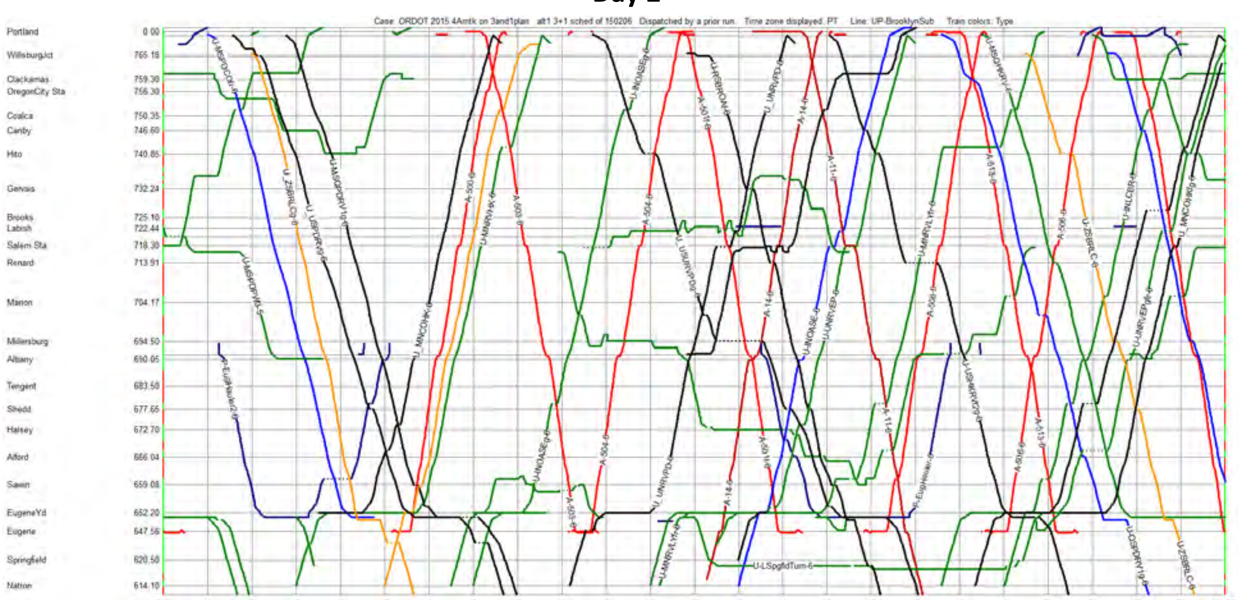
Revised Alternative 1 (4+1) on (3+1) Infrastructure

Day 1

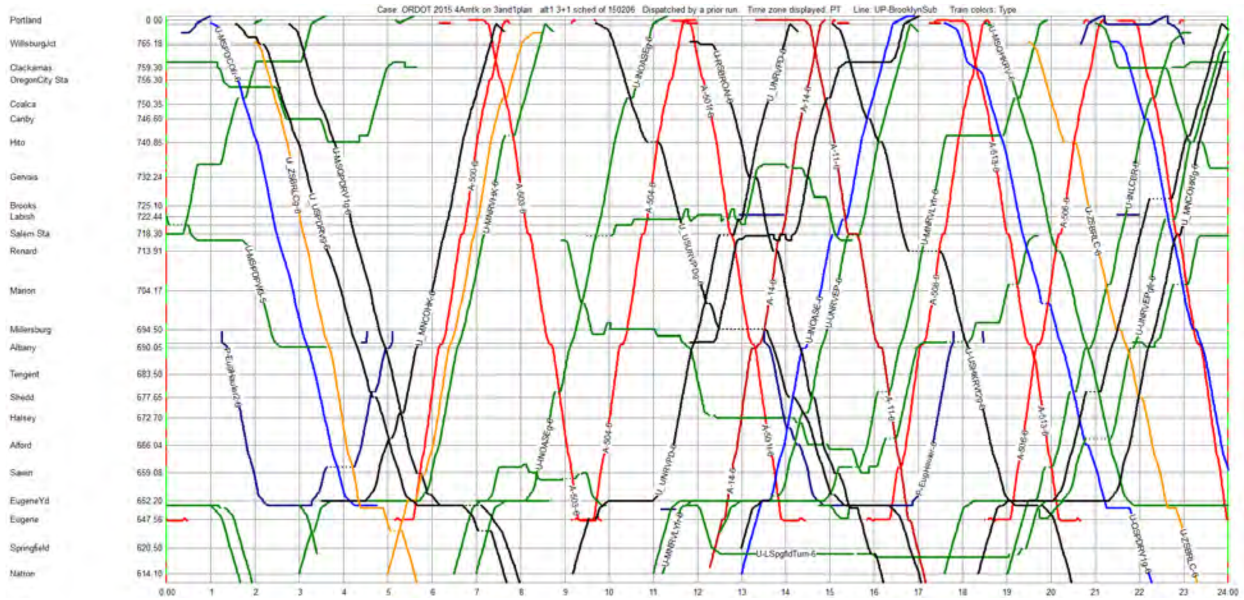


Color	Passenger Trains
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Day 2



Day 3



Color	Passenger Trains
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Oregon Passenger Rail
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Appendix F – 2035 No Action Minimum

Revised: October 18, 2016

Prepared by: Mainline Management

Oregon Department of Transportation

U.S. Department of Transportation
Federal Railroad Administration

2035 No Action Minimum Simulation

An additional simulation that was suggested by FRA to ODOT was to take the 2035 No Action simulation and add enough infrastructure to return the delay statistics to within 10% of the Base Case delay statistics. The Analysis Team was told this simulation's results were to be used at some later time.

The Analysis Team estimated some improvements for a first iteration of the 2035 No Action Minimum simulation based on results from previous simulations. At the conclusion of the first iteration, the statistics were not within 10% of the Base Case results, so some additional infrastructure improvements were added to the simulation network. The final results of the second iteration were within 10% of the Base Case statistics, and those results will be described below.

2035 No Action Minimum Operating Modifications

There were no freight operating modifications made in the 2035 No Action Minimum simulation as compared to the 2035 No Action simulation. All projected 2035 growth was included for UP, BNSF and PNWR traffic on the network.

Similarly, there were no modifications to passenger operations between the two simulations. 2+1 passenger operations were included between Portland and Eugene (two Amtrak Cascades, one Coast Starlight round trip) and 6+2 passenger operations were included between Portland and Vancouver (six Amtrak Cascades, one Coast Starlight and one Spokane Section Empire Builder round trip).

2035 No Action Minimum Network Modifications

As described, the total track infrastructure modifications that were made in the 2035 No Action Minimum simulation were included in two iterations. In the first iteration, there were two areas that received additional track. These were between East Milwaukie and Clackamas and between Judkins and Swain.

A second main track was added between East Milwaukie and MP 758.7 (south of the south end of Clackamas Siding). A universal crossover was also added at MP 761.2. The purpose of the infrastructure improvement was to facilitate traffic flow between Clackamas and Brooklyn Yard. Industry switching, access and egress from Brooklyn Yard and heavy traffic flows created delays in this segment in previous simulations. The improvements included in the 2035 No Action Minimum first iteration were designed to address those conflicts.

A second main track between Judkins (MP 644.7) and Swain (MP 660.6) was also included in the first iteration along with multiple crossovers. The purpose of this track was to create additional routes past and to or from Eugene Yard. The configuration between Judkins and Swain used in the 2035 No Action

Minimum network was the same improved configuration that was used in the Revised Alternative 1 (3+1), (4+1) and (6+1) networks.

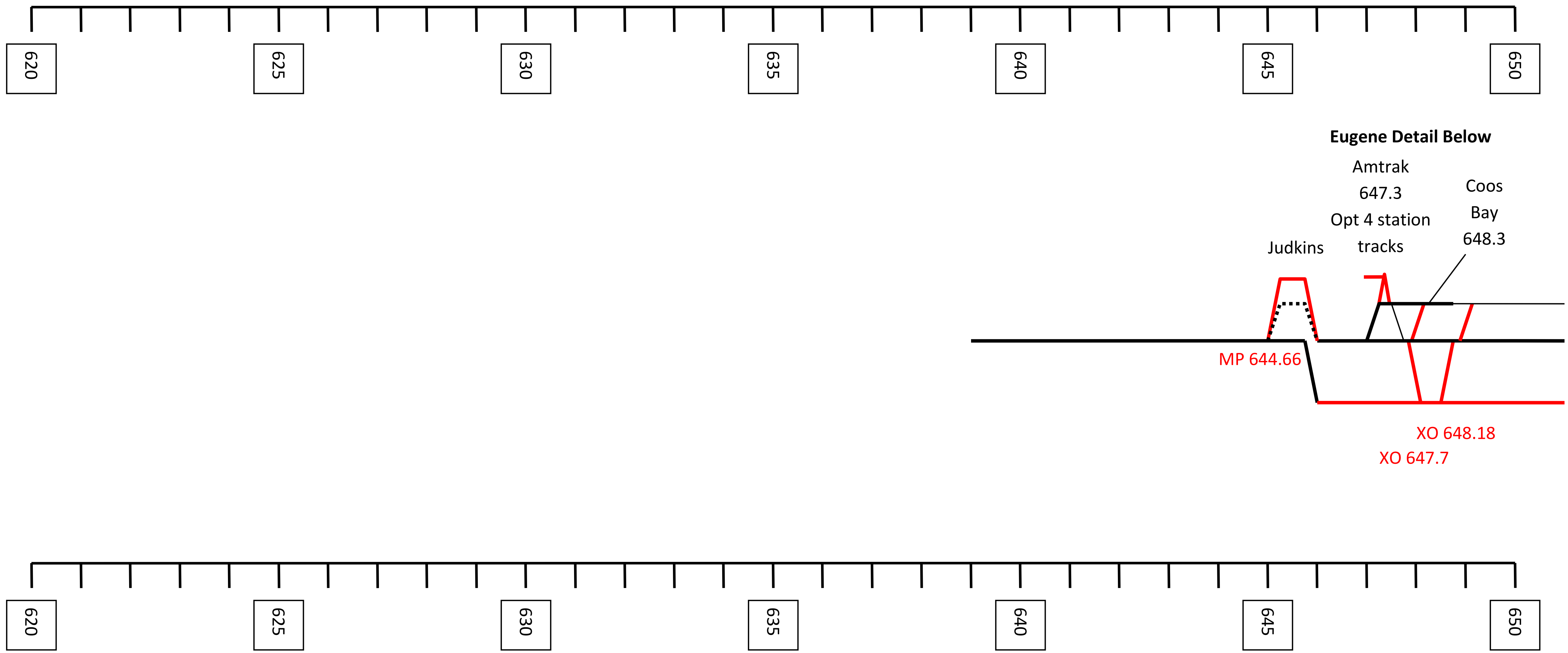
These two areas of infrastructure improvements reduced the first iteration of the 2035 No Action Minimum simulation's D/10 delay minutes from 3.7 minutes per 10 miles operated to 2.9 minutes per 10 miles operated. With Base Case D/10 minutes calculated at 2.4 minutes per 10 miles operated, the results did not meet the "within 10%" requirement.

The output from the first iteration of the 2035 No Action Minimum simulation was reviewed and multiple repetitive delays were identified around Salem. Therefore, in the second iteration, two additional improvements were added and the simulation was rerun.

The first additional infrastructure improvement that was added was a second main track connecting the north end of Renard Siding (MP 715.6) to the south lead track into Salem Yard (MP 716.68). A crossover was added at MP 716.5 to allow through trains to enter the single main track through the city.

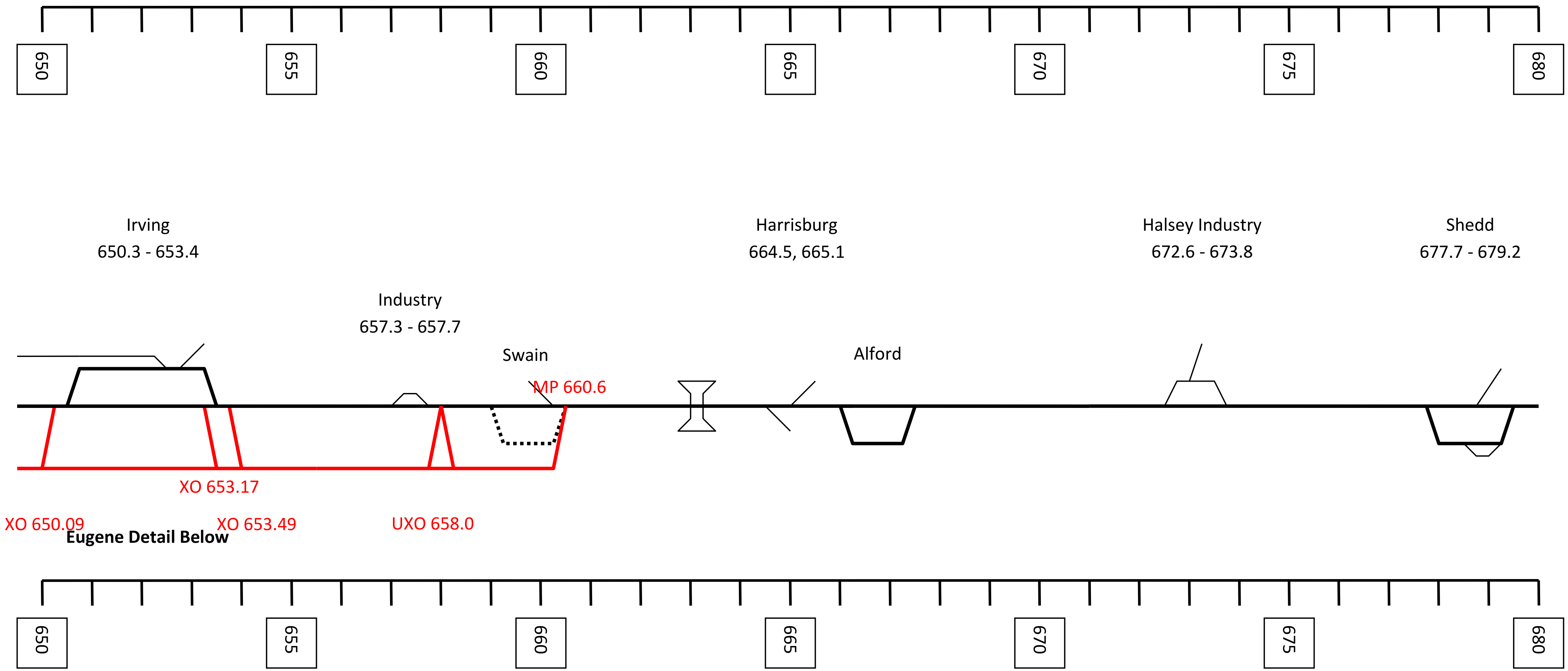
The second additional infrastructure improvement was a second main track from MP 719.5 at the south end of Labish to Brooks at MP 727.5. A universal crossover was also added at MP 722.6. This improvement allowed trains that were switching between Labish and Brooks to stop on a main track, while leaving the second main track available for through trains. The crossovers at MP 722.6 further allowed through trains to be routed around trains that were stopped for switching.

Both of the improvements that were added as part of the second iteration of the 2035 No Action Minimum simulation were used in the Revised Alternative 1 (4+1) and (6+1) simulations. The following schematic represents the modifications that were included in the 2035 No Action Minimum network.



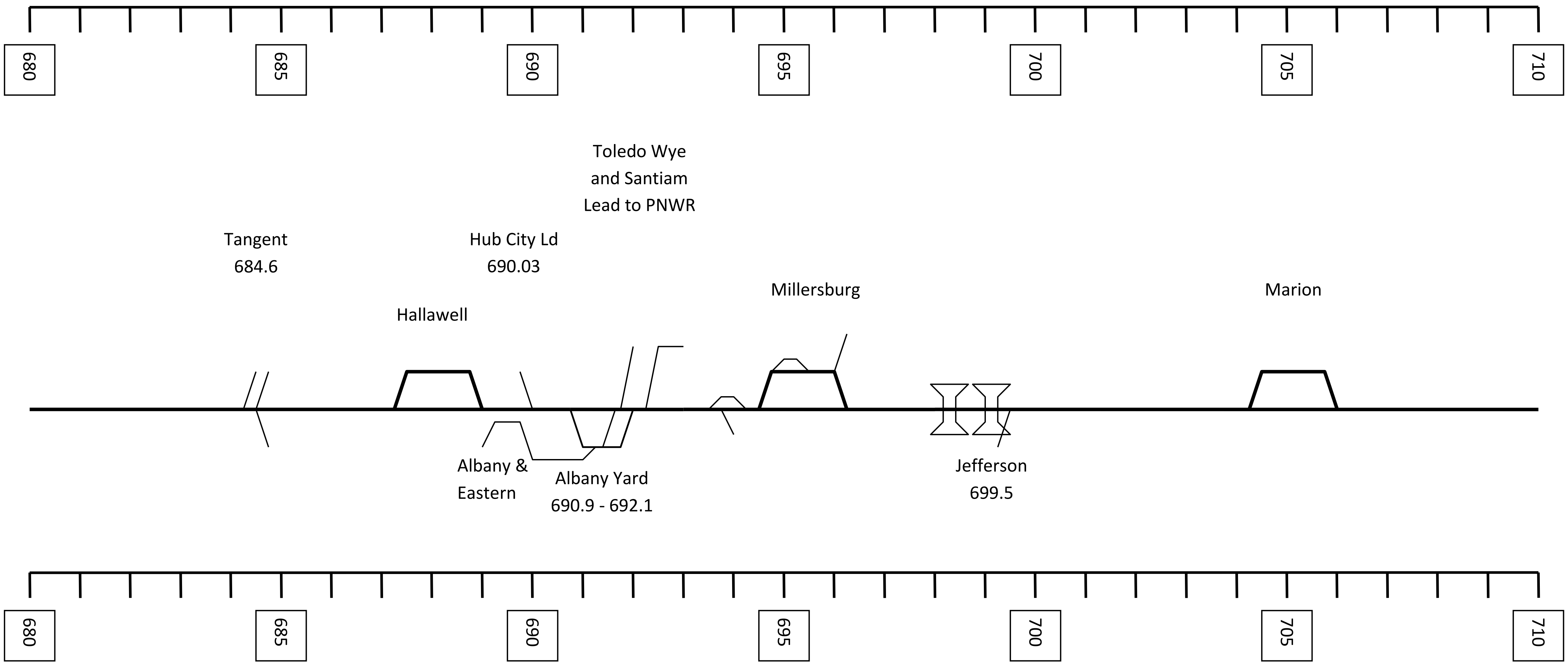
Heavy black is main line, or passing siding. Thin black is industry track
or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum



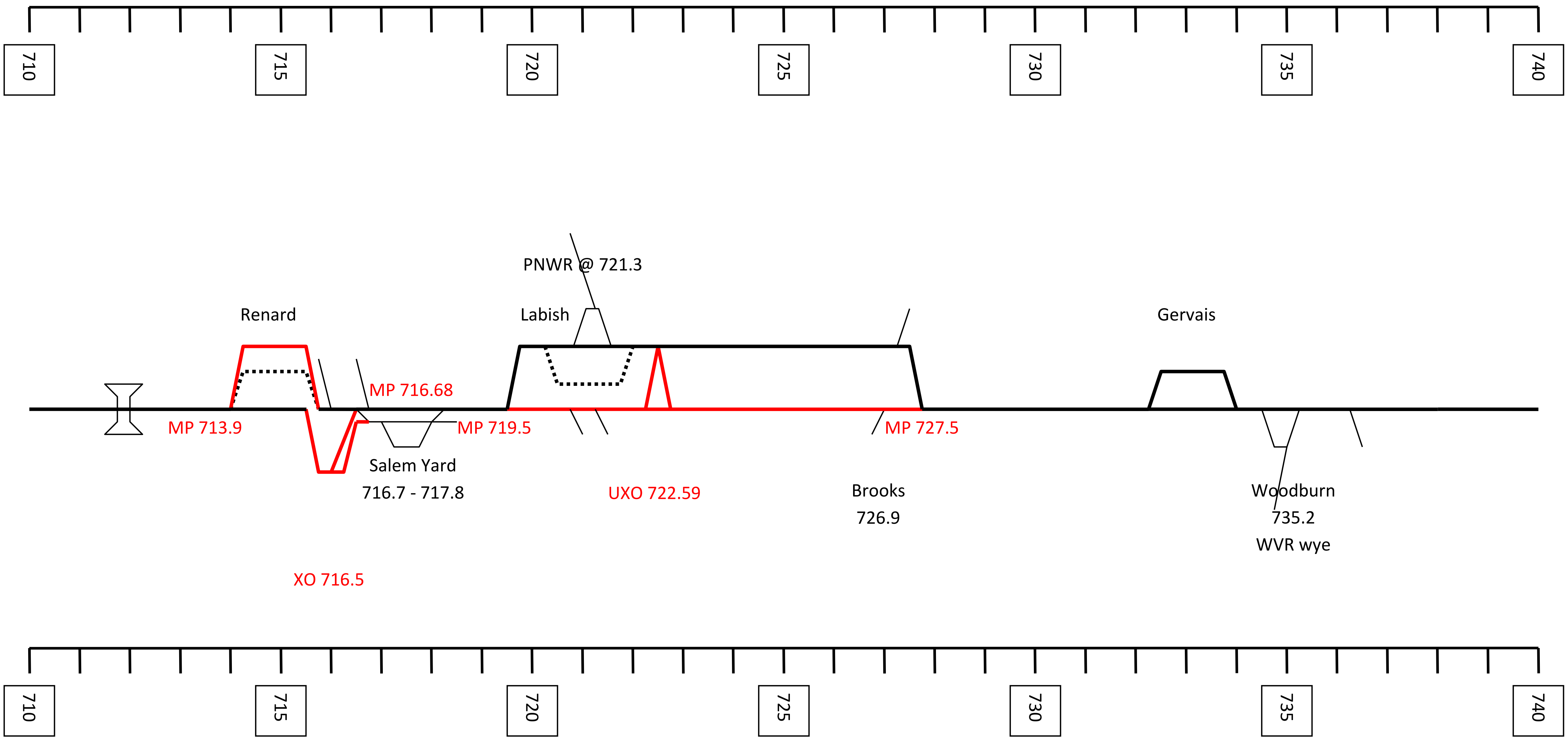
Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum



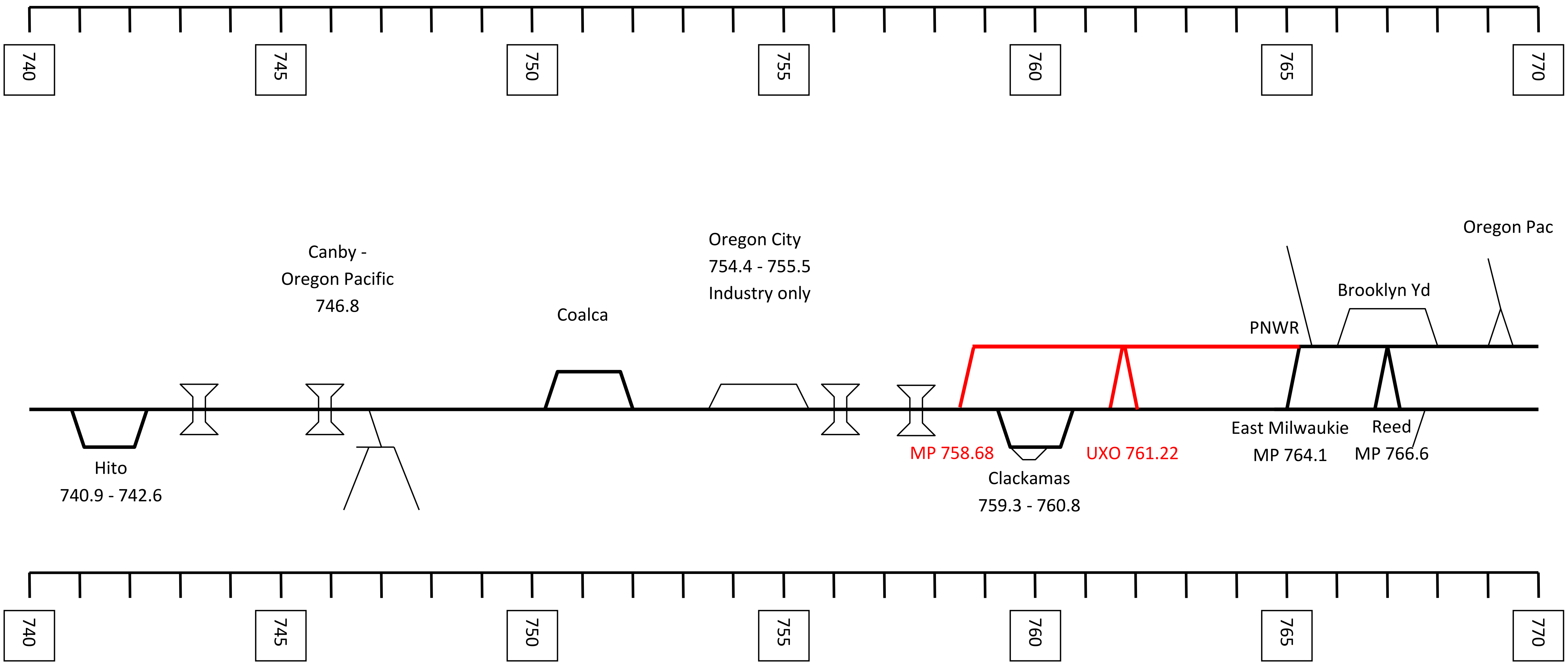
Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum



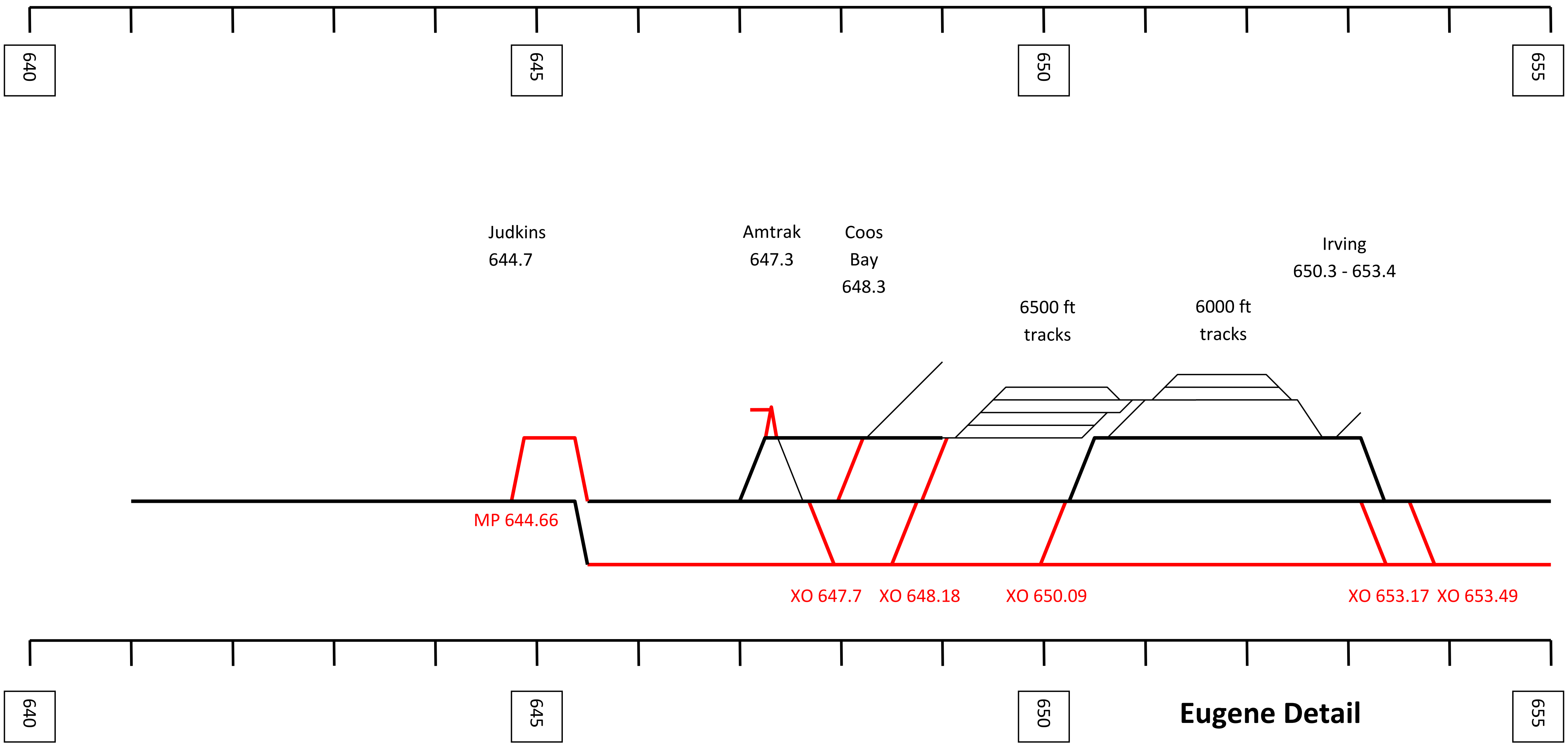
Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum



Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum



Eugene Detail

Heavy black is main line, or passing siding. Thin black is industry track or yard. Dotted black is siding that becomes part of second main track.
Heavy red is new main track or crossovers
UXO = universal crossover (double XO)

Revised No Action with Minimum

Brooklyn Sub 2035 No Action Minimum Results

The infrastructure improvements that were included in the second iteration of the 2035 No Action Minimum simulation reduced the D/10 minutes to 2.6 minutes per 10 miles. This can be compared to the 2035 No Action case, which had a D/10 figure of 3.7 minutes per 10 miles and the Base Case, which was 2.4 minutes per 10 miles (Graph 9 below). The second iteration of the 2035 No Action Minimum simulation met the criteria of reducing the delay to within 10% of the Base Case delay.

Conflicts remained even with the infrastructure improvements. There continued to be delays where a single train met two or more opposing trains; in some of these cases, a passenger train was one of the two opposing trains. Also, on line switching continued to delay through trains (or vice versa) in multiple locations (Graph 11 below).

There were two locations that experienced the major delays associated with meeting two or more opposing trains. The first location was at the end of the second main track just south of Clackamas (MP 758.7). In all three days of the simulation, a single freight train met an opposing freight and passenger train at this location. Each delay exceeded 30 minutes.

The second location where a single train met multiple trains was in Hallawell Siding. At that location, two freight trains met an opposing freight that was holding in the siding. Again, the delay that resulted exceeded 30 minutes.

The other type of conflict that regularly occurred on the Brooklyn Sub was delay associated with on line switching. This occurred at least once per day for all three days of the simulation. The locations varied, but the highest percentage occurred between Oregon City and the new second main track at Brooks.

Local trains and through trains were affected by on line switching delays. In some cases, the model dispatched the local onto a single track segment, which caused delays to a through train. In other cases, the through train was allowed to proceed and the local had to wait for the area to clear.

Graph 12 below illustrates the location of many of the longer delays. As can be seen, there were an average of two delays exceeding 30 minutes per day between Clackamas and Salem. This result reflects the delay that occurred at the end of the second main track south of Clackamas, as well as the on line switching delays that occurred between Oregon City and Brooks.

It appears that multiple segments of second track will be required if 2035 projected growth traffic is expected to operate to approximately the same levels of delay as current delay levels on the Brooklyn Sub. It is unclear whether UP will attempt to pursue this result. However, if they do, tracks around terminal areas and in locations where there appears to be a high level of on line industrial switching should be considered to achieve that goal.

Portland to Vancouver 2035 No Action Minimum Results

There was no track or operational changes made between Portland and Vancouver in the 2035 No Action Minimum simulation as compared with the 2035 No Action simulation. Therefore, there were no improvements made around North Portland Jct. on either the UP's connection track between Peninsula Jct. and NPJ or on BNSF's Fallbridge Sub at NPJ.

As expected, the lack of improvement in the NPJ area led to multiple daily delays that exceeded 30 minutes in the area. Some trains were delayed as far back as BNSF's Vancouver Yard, while other trains were delayed between East St. Johns and the Columbia River Bridge. Regardless of where the affected trains were held, the lack of improvement at NPJ was the cause of the conflicts.

There were also some continuing delays around Willbridge Yard in the 2035 No Action Minimum simulation. Many of these delays were similar to delays that were previously experienced. At times, some of the delays involved Amtrak trains using both main tracks moving to and from Portland Union Station. In other cases, other locals working adjacent yards had an impact on some of the delayed trains. This type of delay was less common than the delays that occurred at NPJ, but they were still evident.

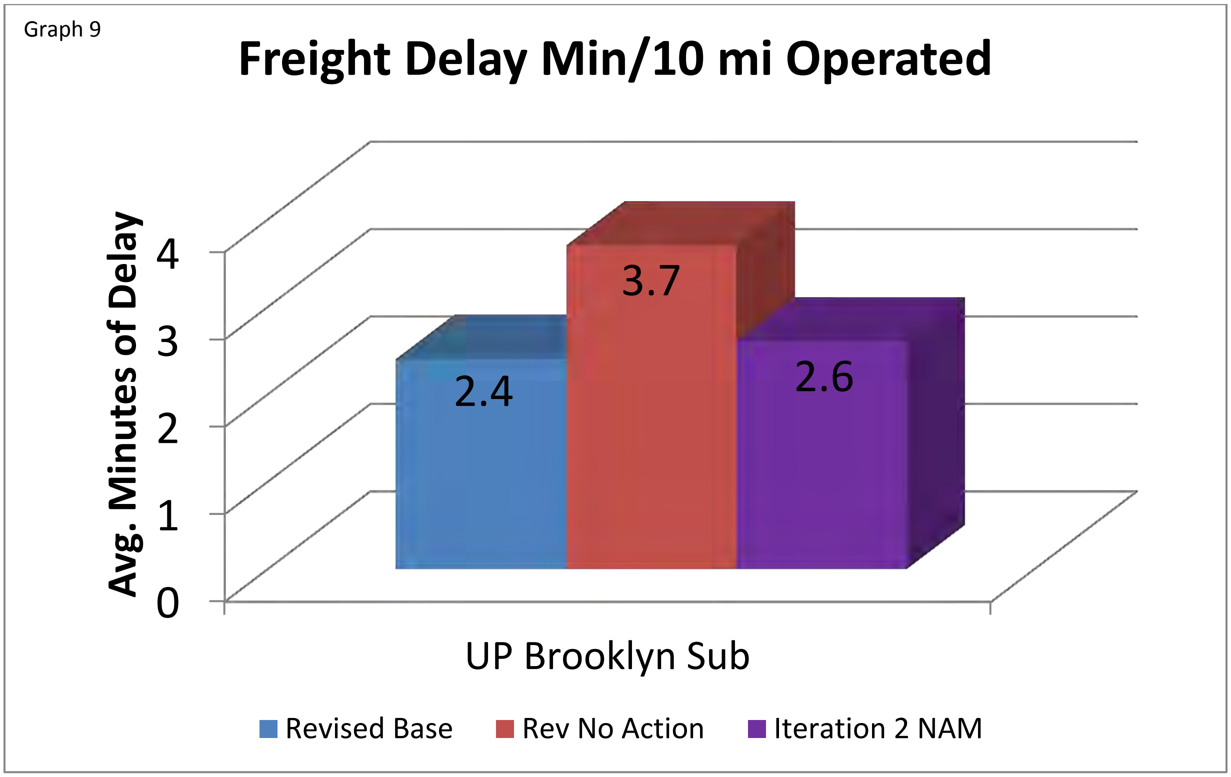
No Action Minimum Brooklyn Sub Velocity Comparison

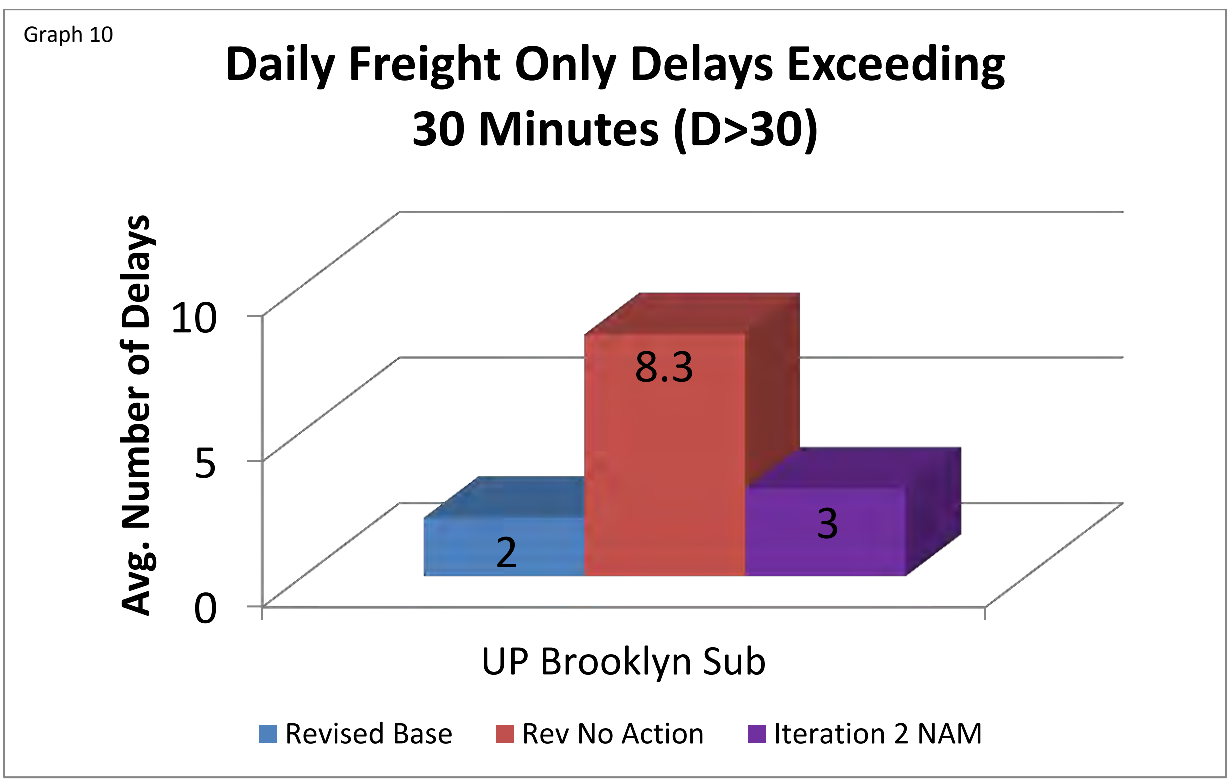
The following table provides the velocity of the various train classes on the Brooklyn Sub for the No Action Minimum analysis.

No Action Minimum						**Velocity**	**Velocity**
						Total	**minus Delay**
Group	**Delay**	**Dwell**	**Elapsed Time**	**Miles**	**Del/10**	**Elapsed**	**and Dwell**
Passenger	2:10:48	6:00:21	48:00:40	2316.6	0.6	48.3	58.2
PNWR	1:18:53	13:18:00	24:32:50	463.3	1.7	18.9	46.6
UPExp	5:28:12	7:38:09	72:56:46	2412.4	1.4	33.1	40.3
UPLocal	9:42:23	59:41:06	94:36:38	699.6	8.3	7.4	27.7
UPMani	15:25:12	69:03:07	211:20:49	4440.7	2.1	21.0	35.0
UPUnit	14:03:51	21:32:05	113:39:22	2611.5	3.2	23.0	33.5
Total Frt	45:58:30	171:12:27	517:06:24	10627.5	2.6	20.6	35.4

Comparison of the train velocities between the 2035 No Action Minimum simulation and velocities from the 2035 No Action simulation shows the value of the three areas of infrastructure improvements. Not only was the delay reduced from 3.7 minutes per 10 miles operated to 2.6 minutes per 10 miles operated, but the velocity of all freight trains improved from 19.7 mph to 20.6 mph. Every train type benefitted from the infrastructure improvements that were included in the 2035 No Action Minimum analysis.

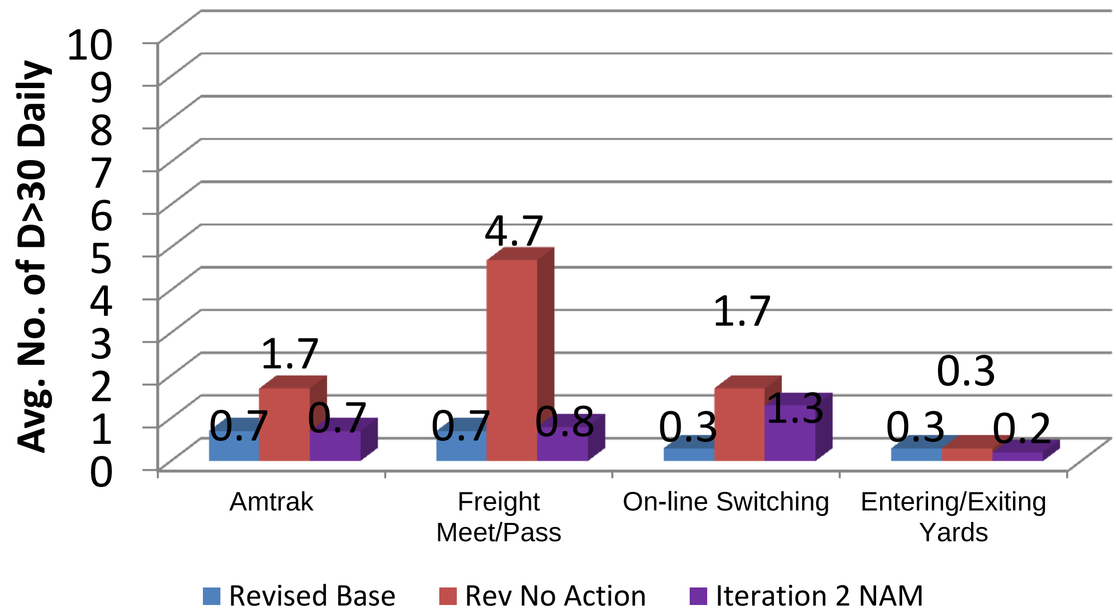
2035 No Action Minimum Graphics





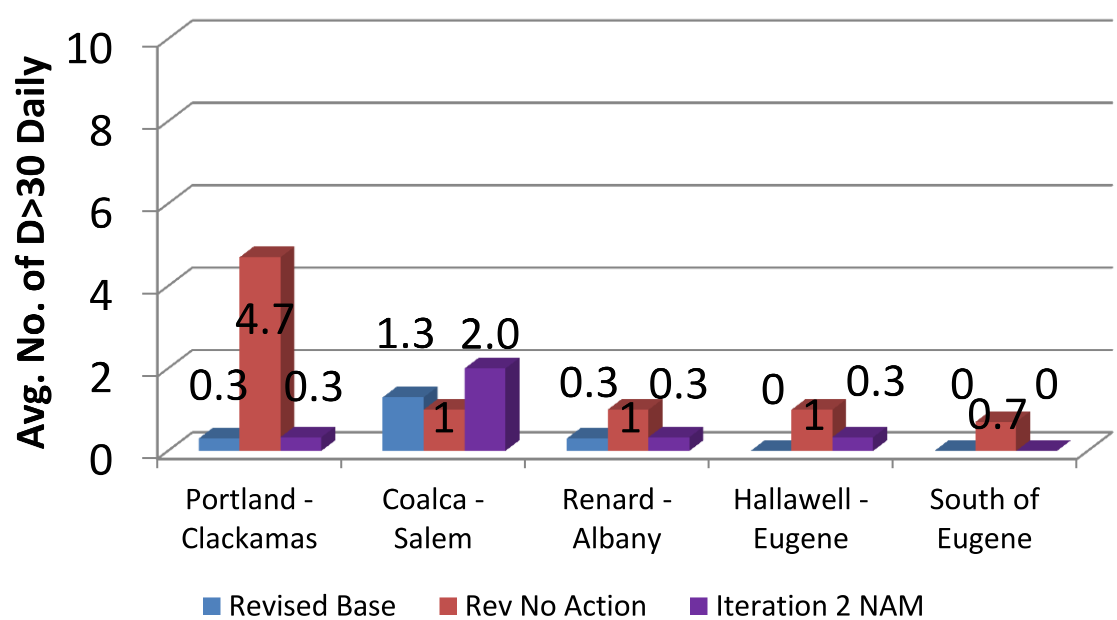
Graph 11

UP Avg. Freight Only Daily D>30 Causes



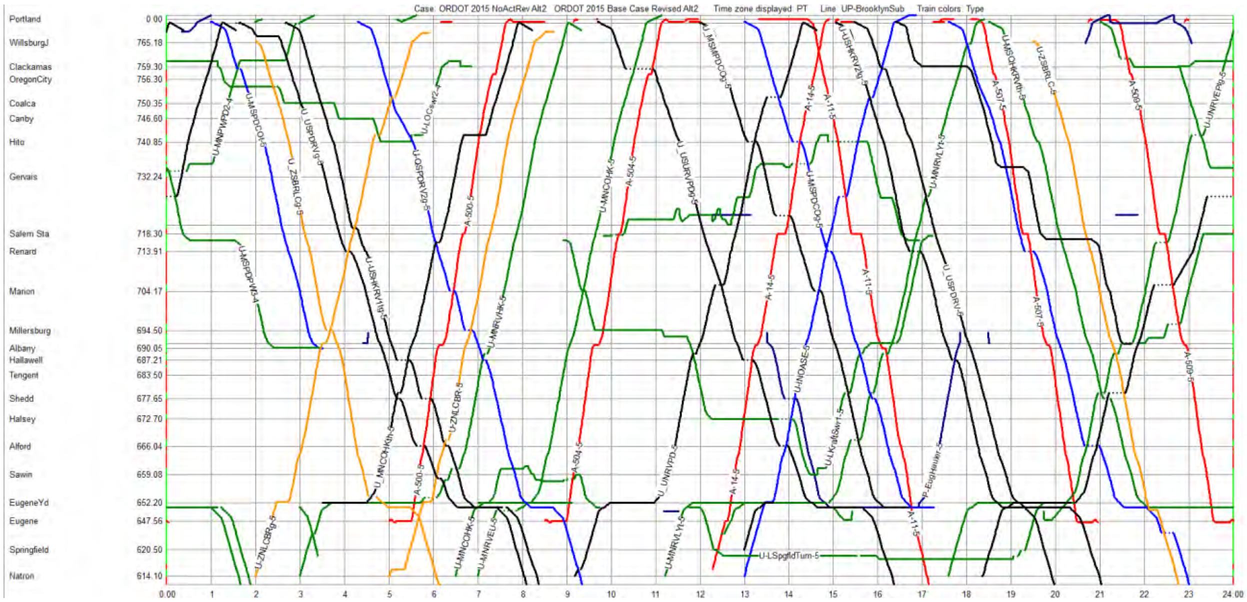
Graph 12

UP Avg. Freight Only Daily D>30 Locations



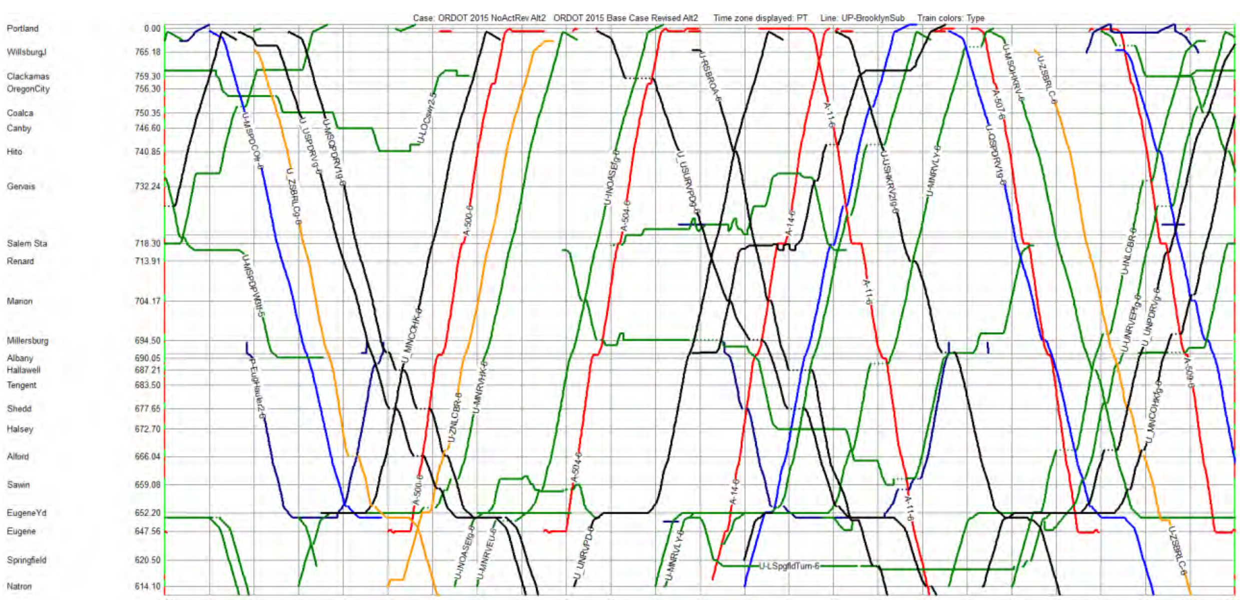
No Action with Minimums Stringlines

Day 1



Color	**Passenger Trains**
	Red - Amtrak Cascades trains
	Reddish Brown – Amtrak Coast Starlight
	Freight Trains
	Gold – (Z trains) High priority containers for intermodal
	Black – Unit Trains
	Blue – (Q trains - Doublestack) Priority Intermodal
	Green – Local and Merchandise trains

Day 2



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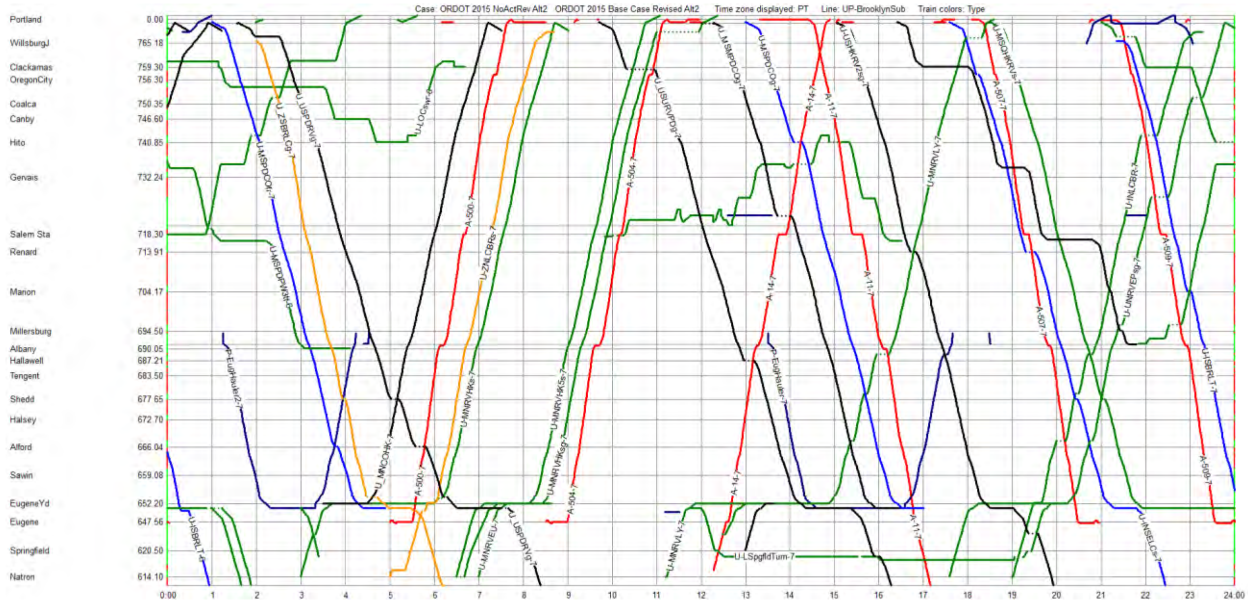


Color

Passenger Trains

Red - Amtrak Cascades trains

Reddish Brown – Amtrak Coast Starlight

Freight Trains

Gold – (Z trains) High priority containers for intermodal

Black – Unit Trains

Blue – (Q trains - Doublestack) Priority Intermodal

Green – Local and Merchandise trains

Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

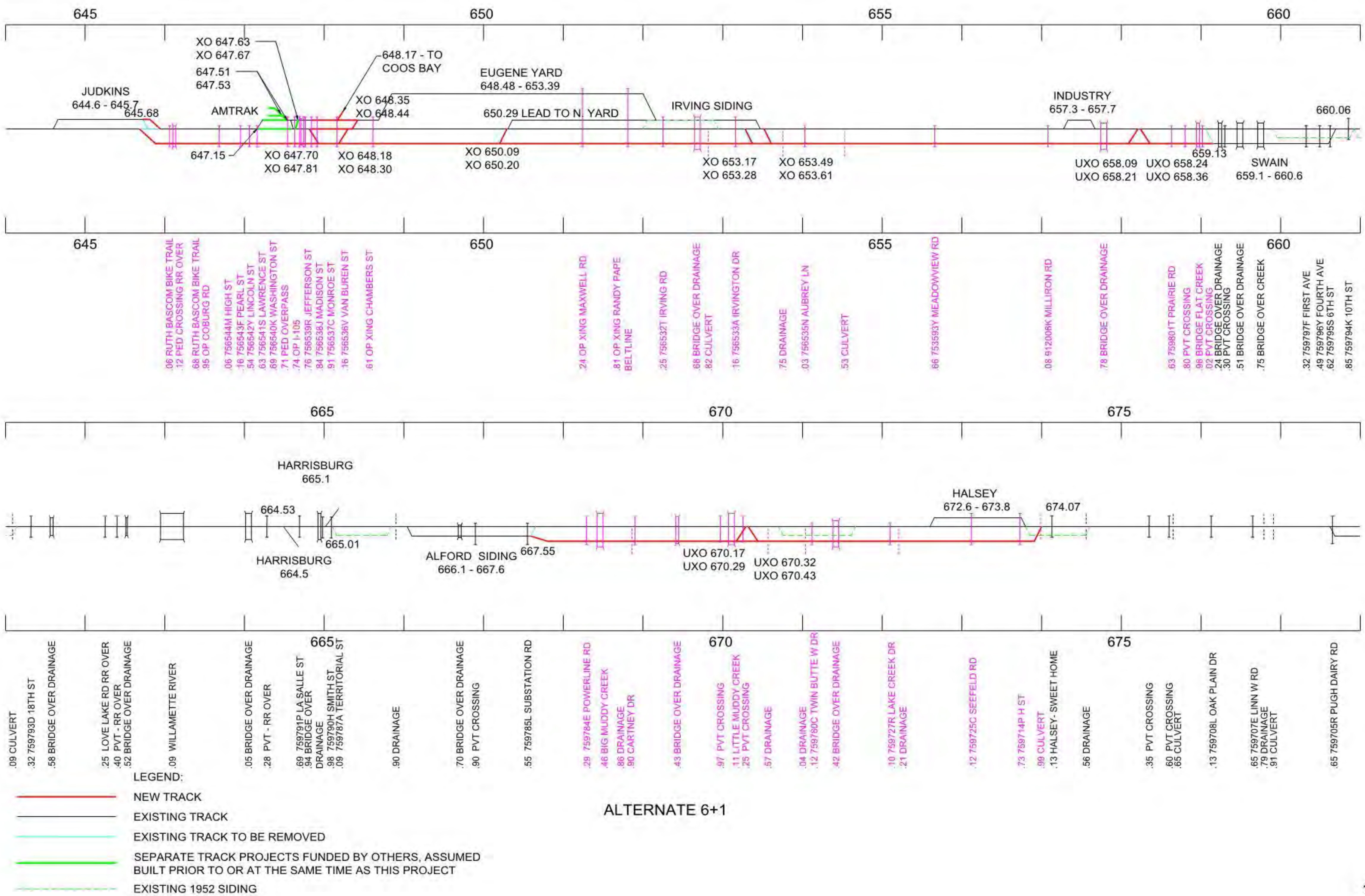
Appendix G – Updated Schematics with Infrastructure Improvements

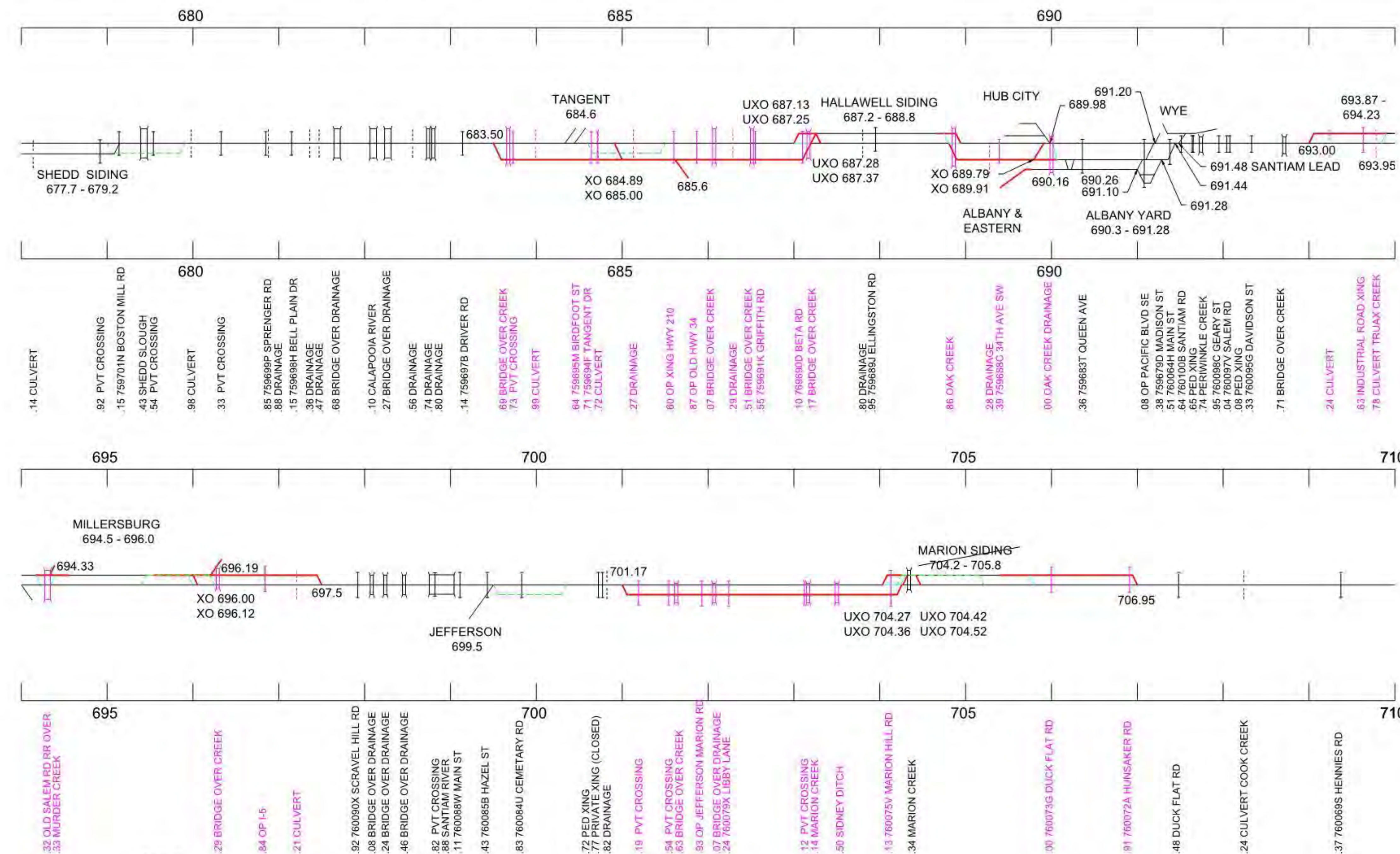
Revised: October 18, 2016

Oregon
Department
of Transportation

U.S. Department
of Transportation
Federal Railroad
Administration

Revised Alternate 1 6+1 and 4+1





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EXISTING TRACK

EXISTING TRACK TO BE REMOVED

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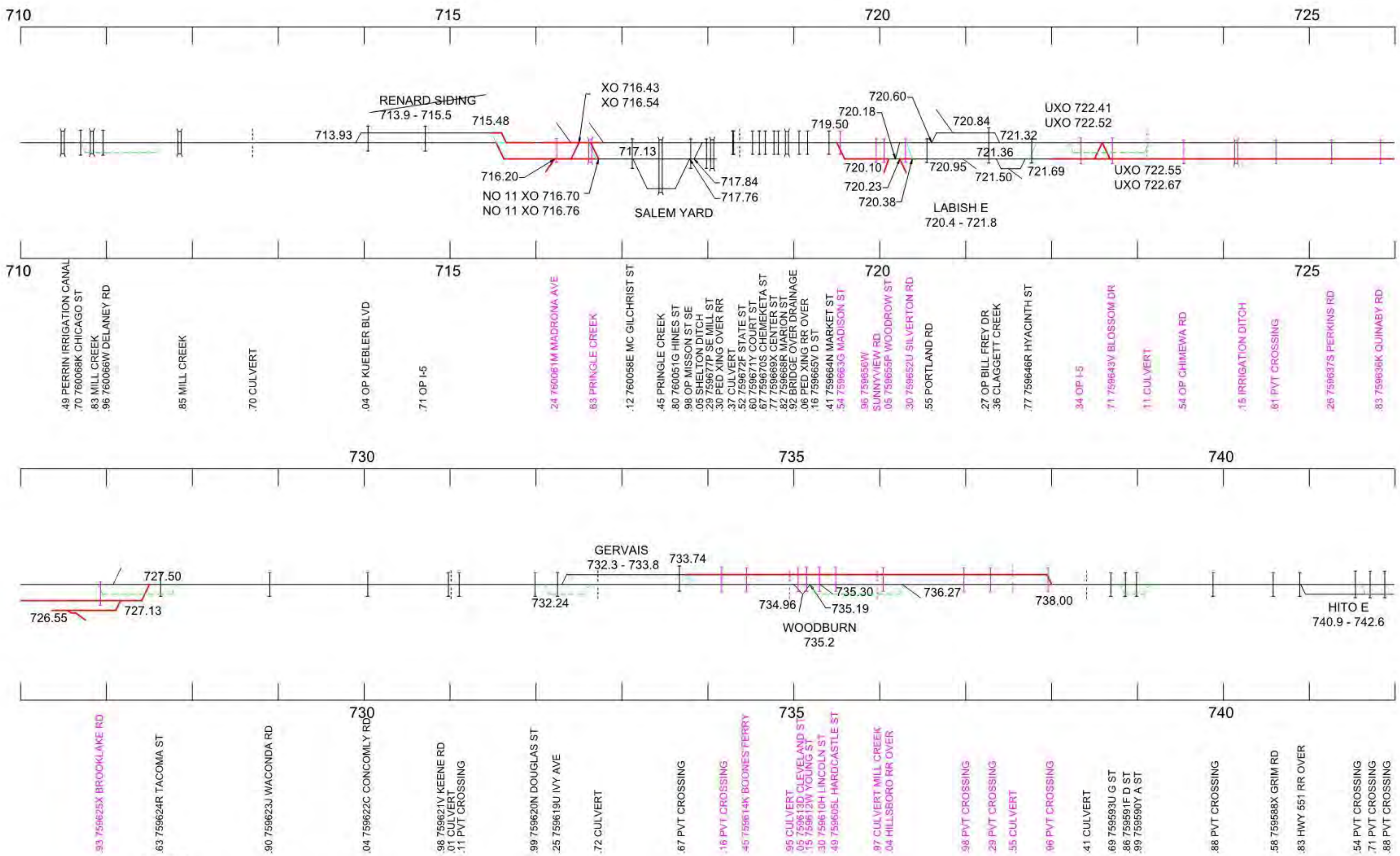
EXISTING 1952 SIDING

ALTERNATE 6+1

2



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ALTERNATE 6+1

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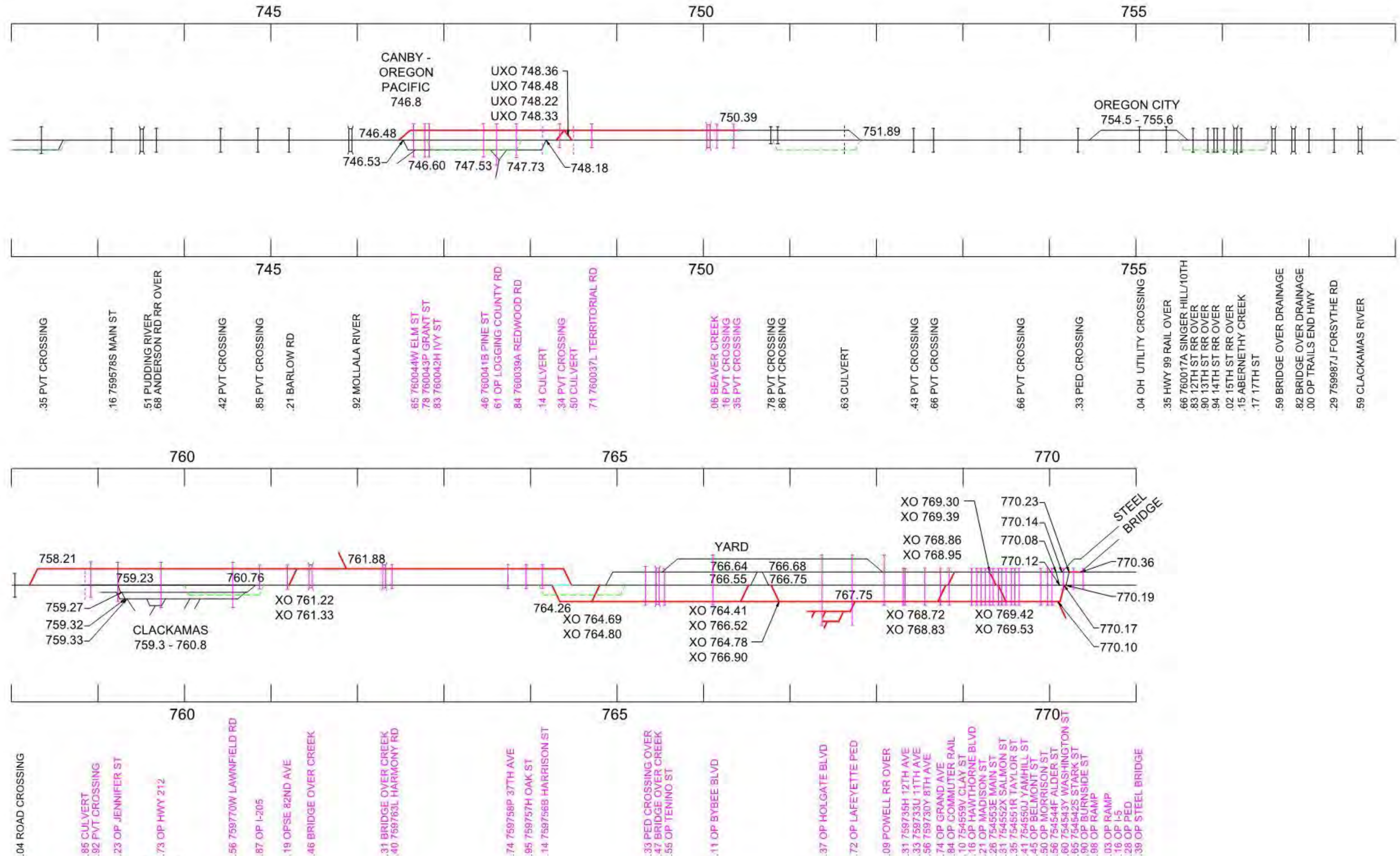

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ALTERNATE 6+1

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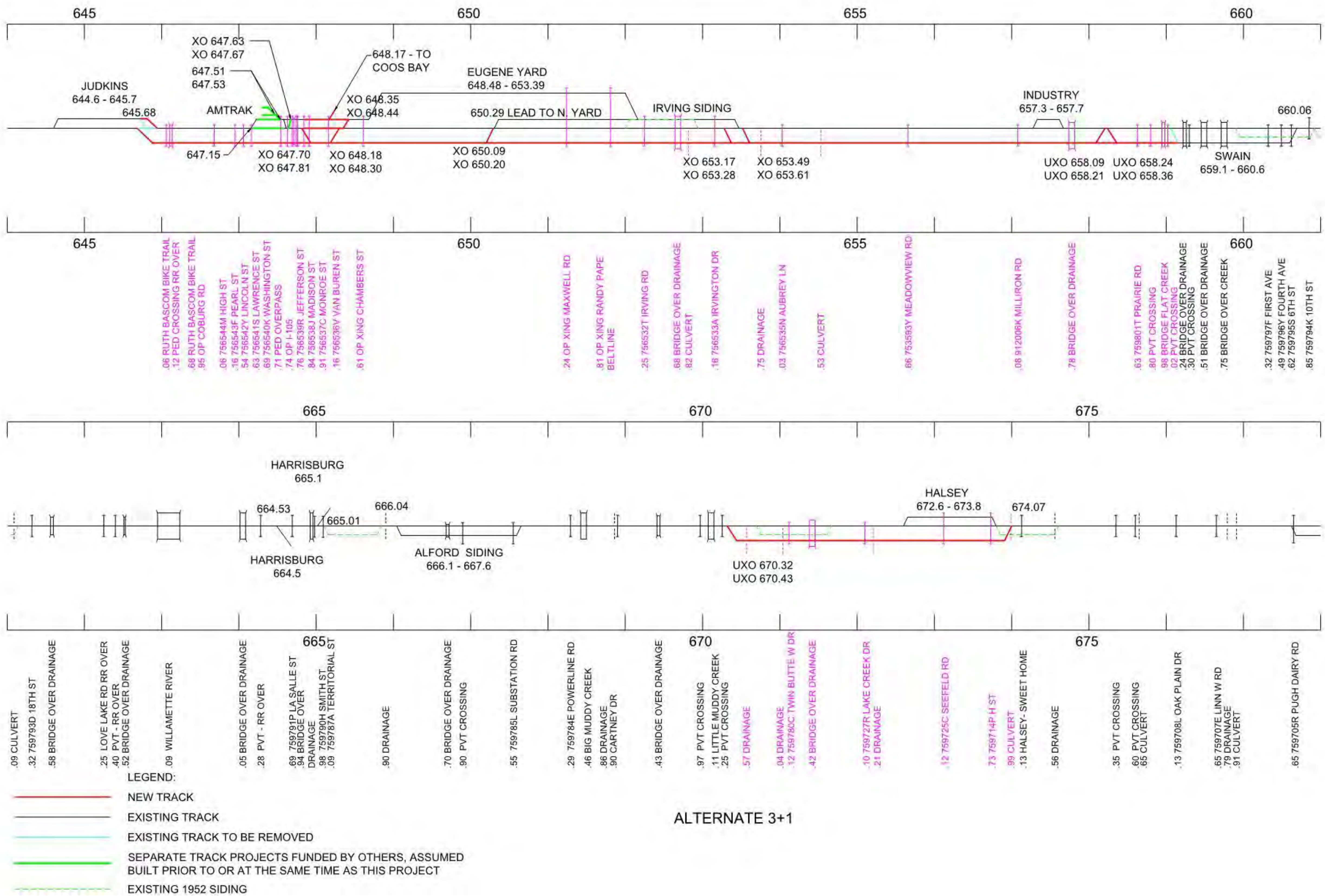
Alternate 4+1 on 3+1 Infrastructure / Revised Alternate 1 3+1



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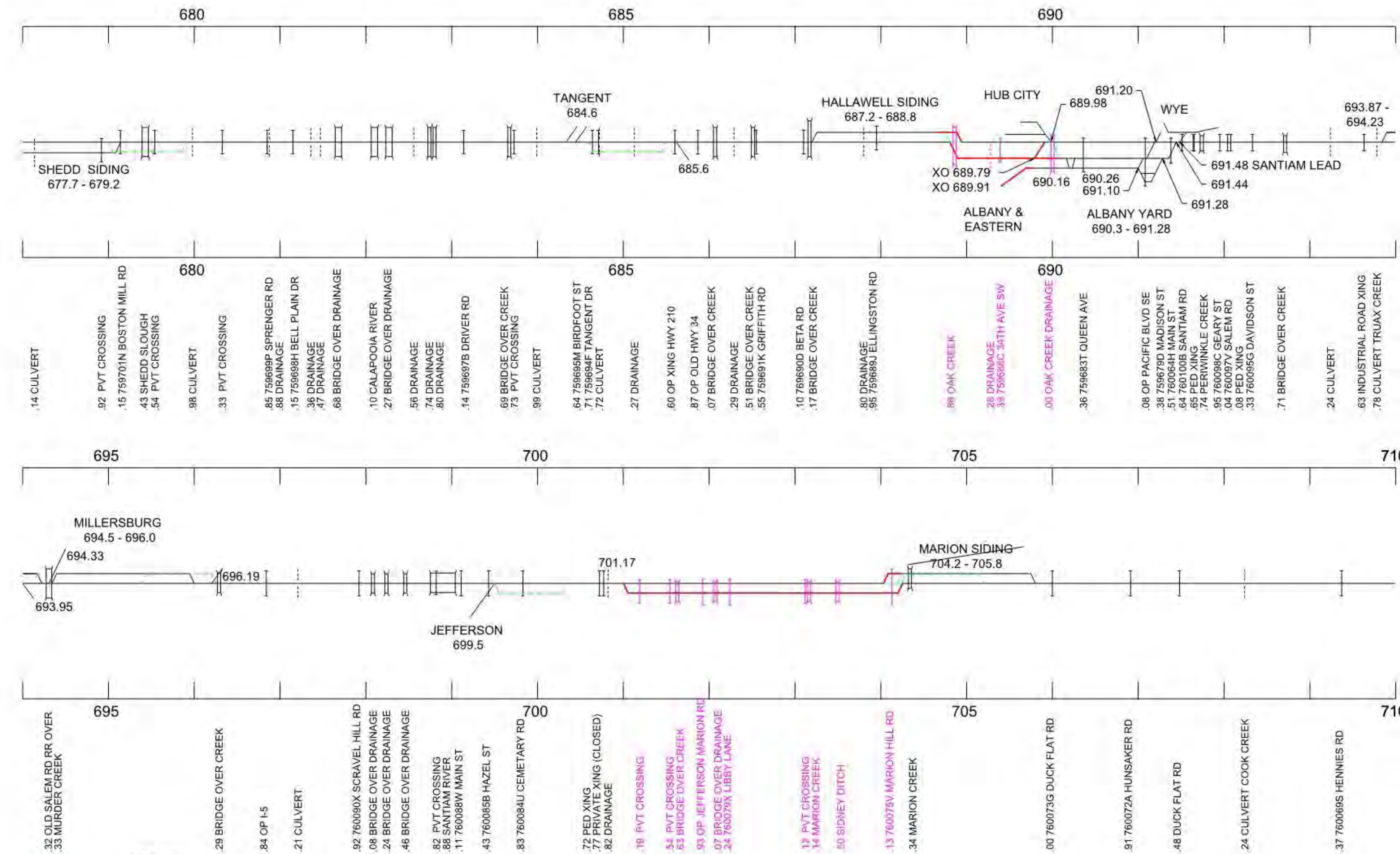

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EXISTING 1952 SIDING

ALTERNATE 3+1

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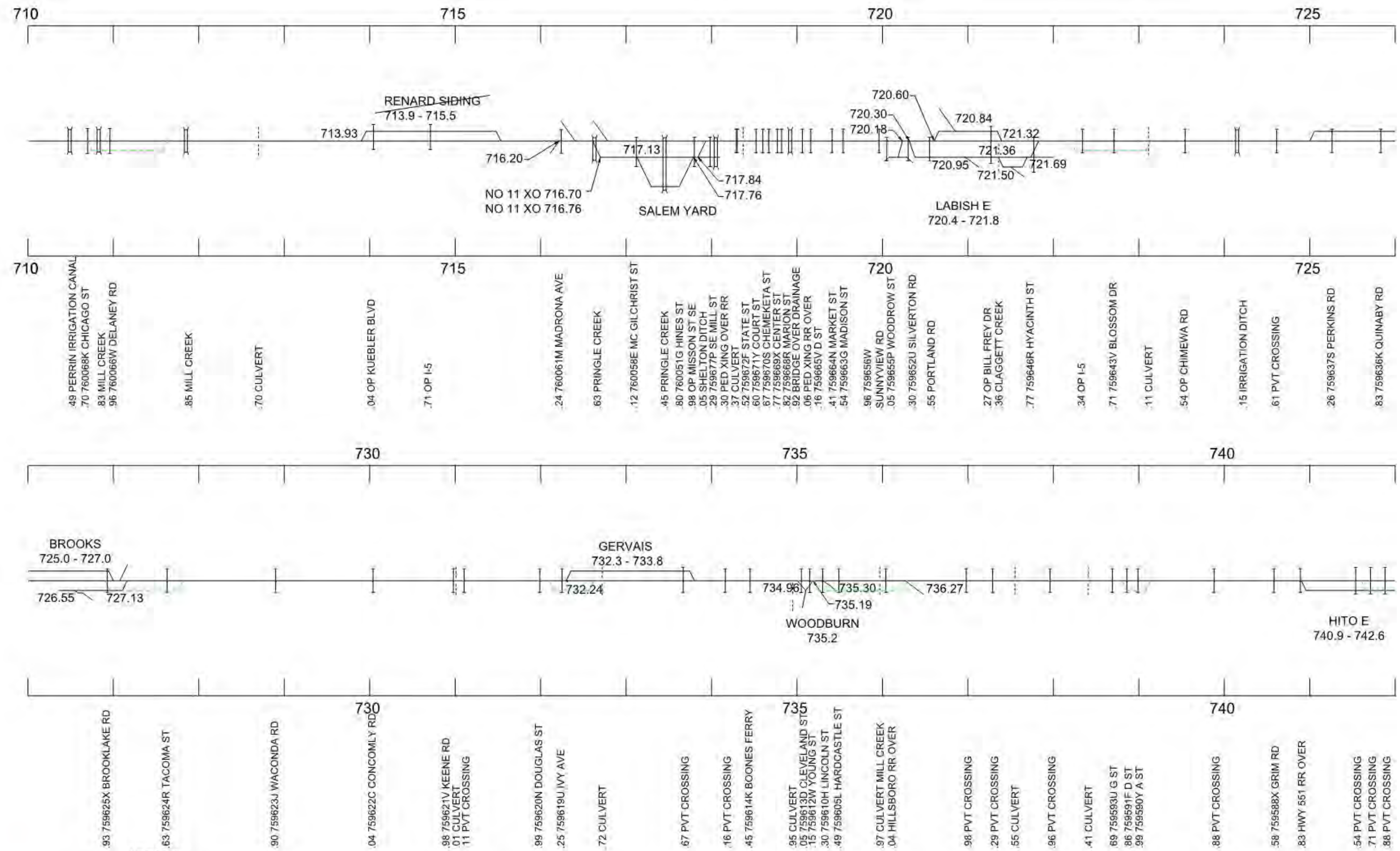

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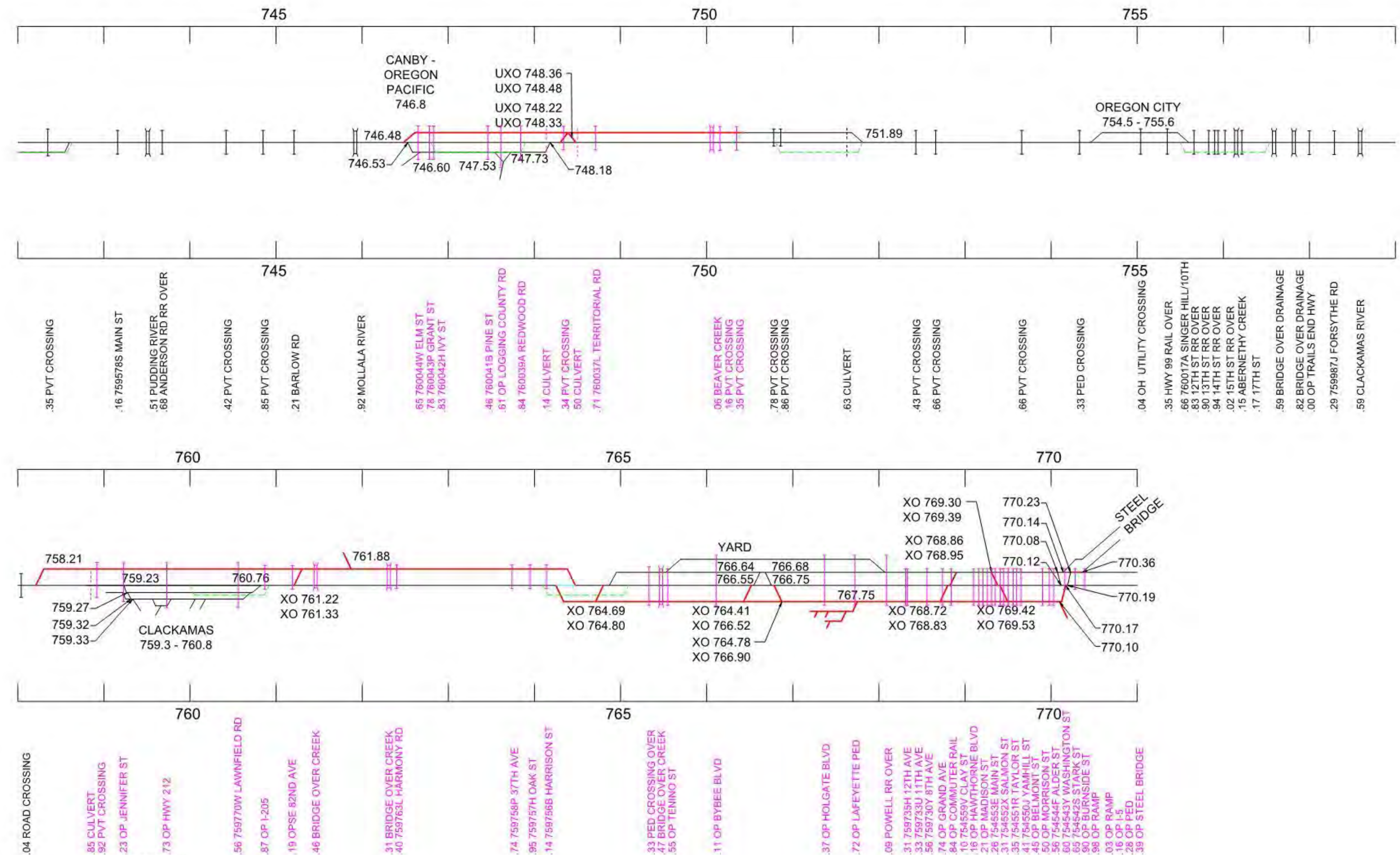
- EXISTING 1952 SIDING

ALTERNATE 3+1

3



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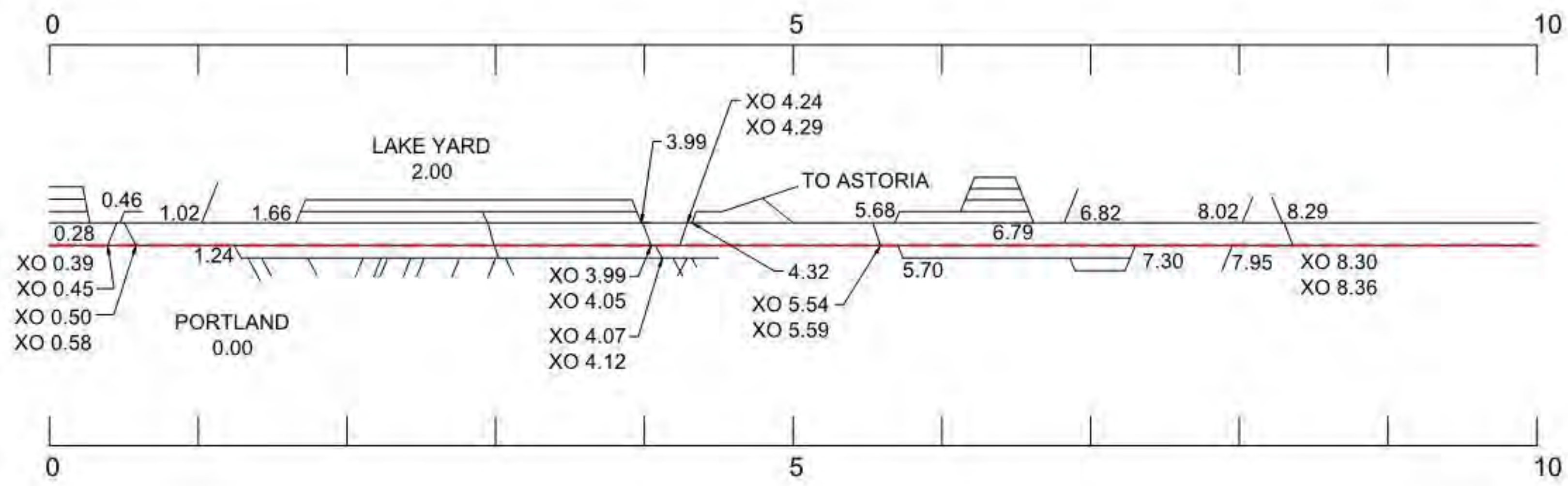
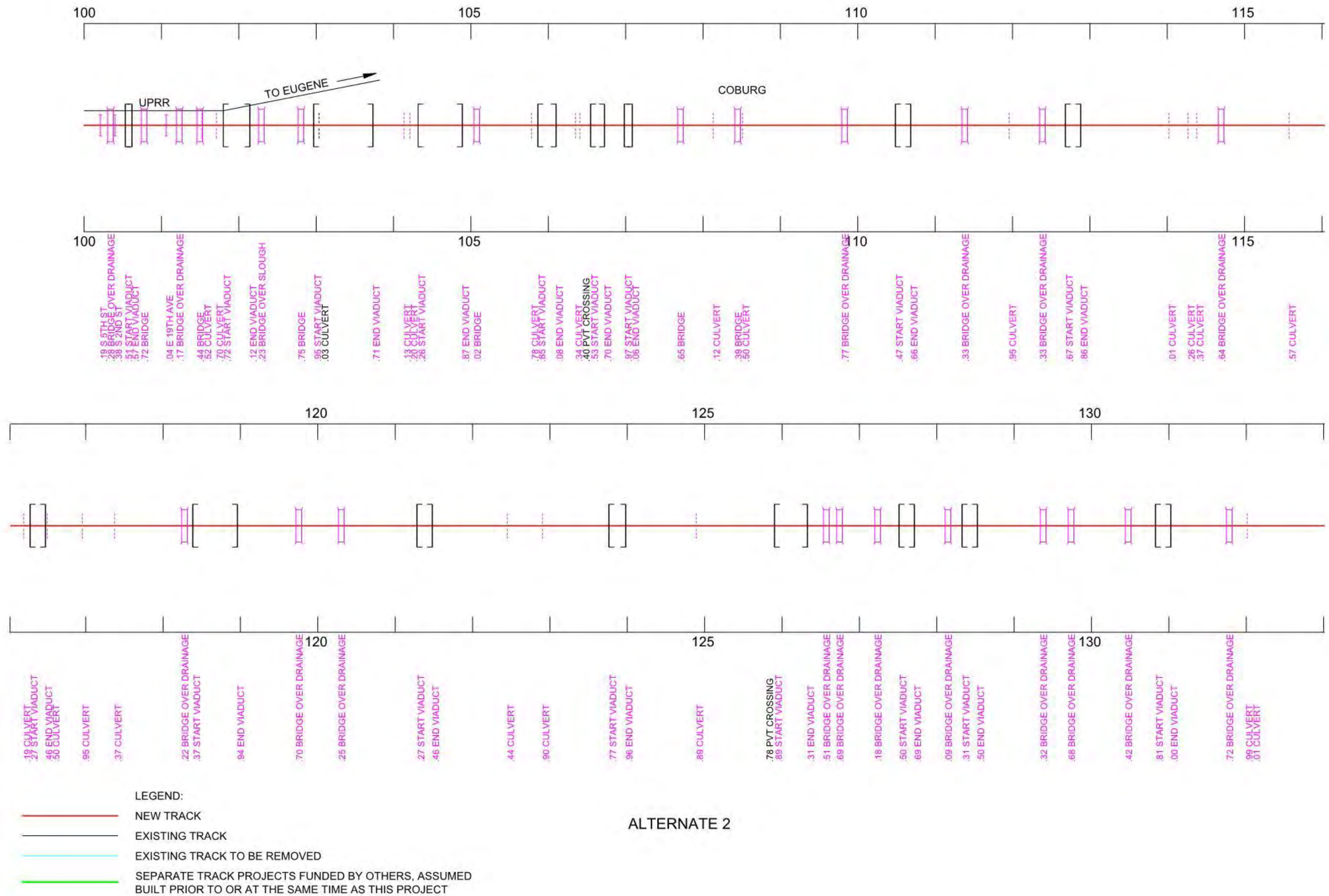


ALTERNATE 3+1

5

Revised Alternate 2



ALTERNATE 2

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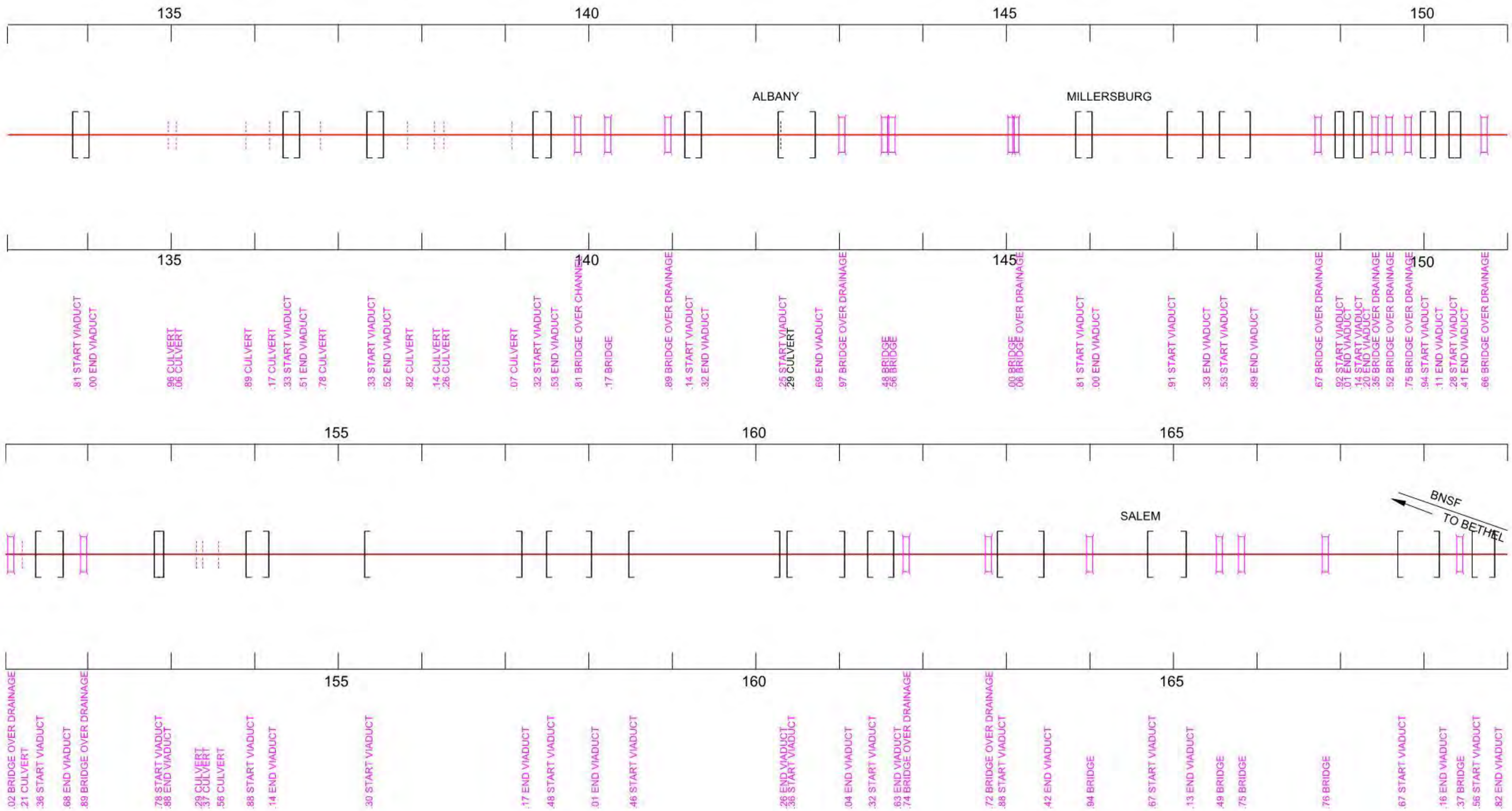

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ALTERNATE 2

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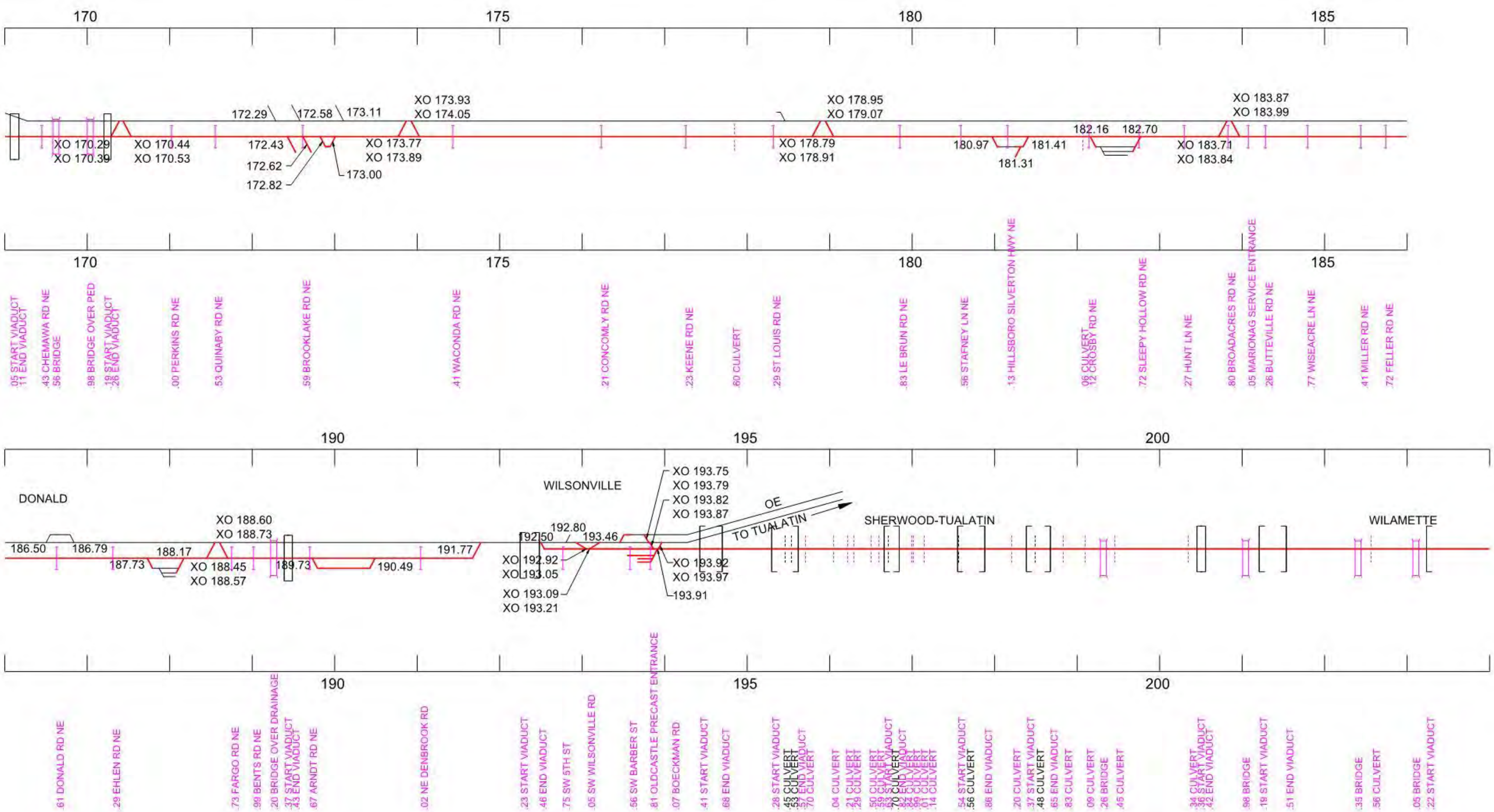

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ALTERNATE 2

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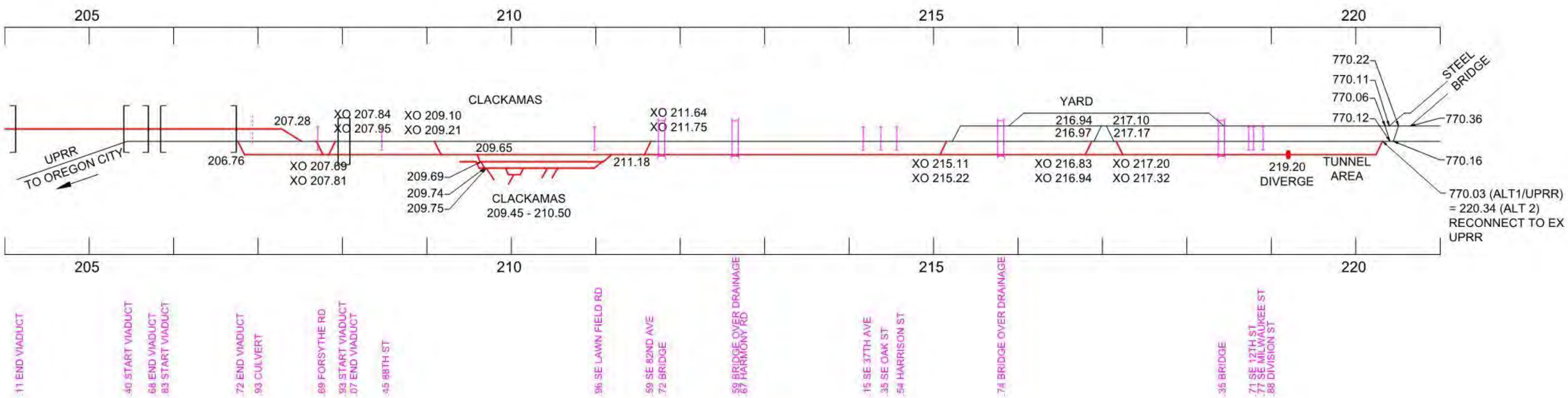

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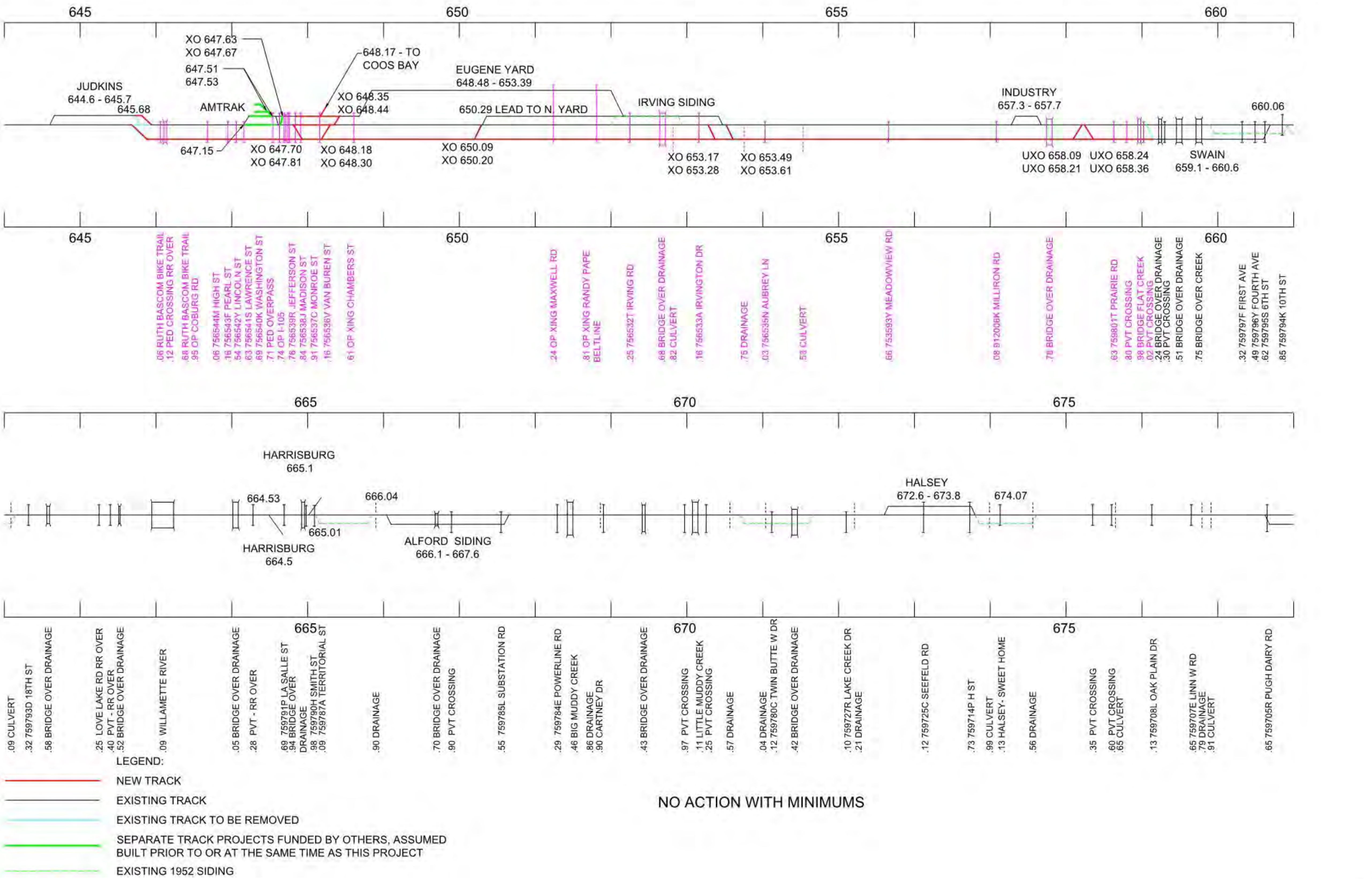
ALTERNATE 2

4


645
650
655
660
XO 647.63
XO 647.67
647.51
647.53
648.17 - TO
COOS BAY
EUGENE YARD
648.48 - 653.39
JUDKINS
644.6 - 645.7
645.68
AMTRAK
XO 648.35
XO 648.44
650.29 LEAD TO N. YARD
IRVING SIDING
INDUSTRY
657.3 - 657.7
660.06
647.15
XO 647.70
XO 647.81
XO 648.18
XO 648.30
XO 650.09
XO 650.20
XO 653.17
XO 653.28
XO 653.49
XO 653.61
UXO 658.09
UXO 658.21
UXO 658.24
UXO 658.36
SWAIN
659.1 - 660.6
.06 RUTH BASCOM BIKE TRAIL
.12 PED CROSSING RR OVER
.68 RUTH BASCOM BIKE TRAIL
.95 OP COBURG RD
.06 756544M HIGH ST
.16 756543F PEARL ST
.54 756542Y LINCOLN ST
.63 756541S LAWRENCE ST
.69 756540K WASHINGTON ST
.71 PED OVERPASS
.74 OP I-105
.76 756539R JEFFERSON ST
.84 756538J MADISON ST
.91 756537C MONROE ST
.16 756536V VAN BUREN ST
.61 OP XING CHAMBERS ST
.24 OP XING MAXWELL RD
.81 OP XING RANDY PAPE BELTLINE
.25 756532T IRVING RD
.68 BRIDGE OVER DRAINAGE
.82 CULVERT
.16 756533A IRVINGTON DR
.75 DRAINAGE
.03 756535N AUBREY LN
.53 CULVERT
.66 753593Y MEADOWVIEW RD
.08 912008K MILLRON RD
.78 BRIDGE OVER DRAINAGE
.63 759801T PRAIRIE RD
.80 PVT CROSSING
.98 BRIDGE FLAT CREEK
.02 PVT CROSSING
.24 BRIDGE OVER DRAINAGE
.30 PVT CROSSING
.51 BRIDGE OVER DRAINAGE
.75 BRIDGE OVER CREEK
.32 759797F FIRST AVE
.49 759796Y FOURTH AVE
.62 759795S 6TH ST
.85 759794K 10TH ST
665
670
675
HARRISBURG
665.1
664.53
666.04
HALSEY
672.6 - 673.8
674.07
665.01
ALFORD SIDING
666.1 - 667.6
HARRISBURG
664.5
.09 CULVERT
.32 759793D 18TH ST
.58 BRIDGE OVER DRAINAGE
.25 LOVE LAKE RD RR OVER
.40 PVT - RR OVER
.52 BRIDGE OVER DRAINAGE
.09 WILLAMETTE RIVER
.05 BRIDGE OVER DRAINAGE
.28 PVT - RR OVER
.69 759791P LA SALLE ST
.94 BRIDGE OVER DRAINAGE
.98 759790H SMITH ST
.09 759787A TERRITORIAL ST
.90 DRAINAGE
.70 BRIDGE OVER DRAINAGE
.90 PVT CROSSING
.55 759785L SUBSTATION RD
.29 759784E POWERLINE RD
.46 BIG MUDDY CREEK
.86 DRAINAGE
.90 CARTNEY DR
.43 BRIDGE OVER DRAINAGE
.97 PVT CROSSING
.11 LITTLE MUDDY CREEK
.25 PVT CROSSING
.57 DRAINAGE
.04 DRAINAGE
.12 759780C TWIN BUTTE W DR
.42 BRIDGE OVER DRAINAGE
.10 759727R LAKE CREEK DR
.21 DRAINAGE
.12 759725C SEEFELD RD
.73 759714P H ST
.99 CULVERT
.13 HALSEY- SWEET HOME
.56 DRAINAGE
.35 PVT CROSSING
.60 PVT CROSSING
.65 CULVERT
.13 759708L OAK PLAIN DR
.65 759707E LINN W RD
.79 DRAINAGE
.91 CULVERT
.65 759705R PUGH DAIRY RD
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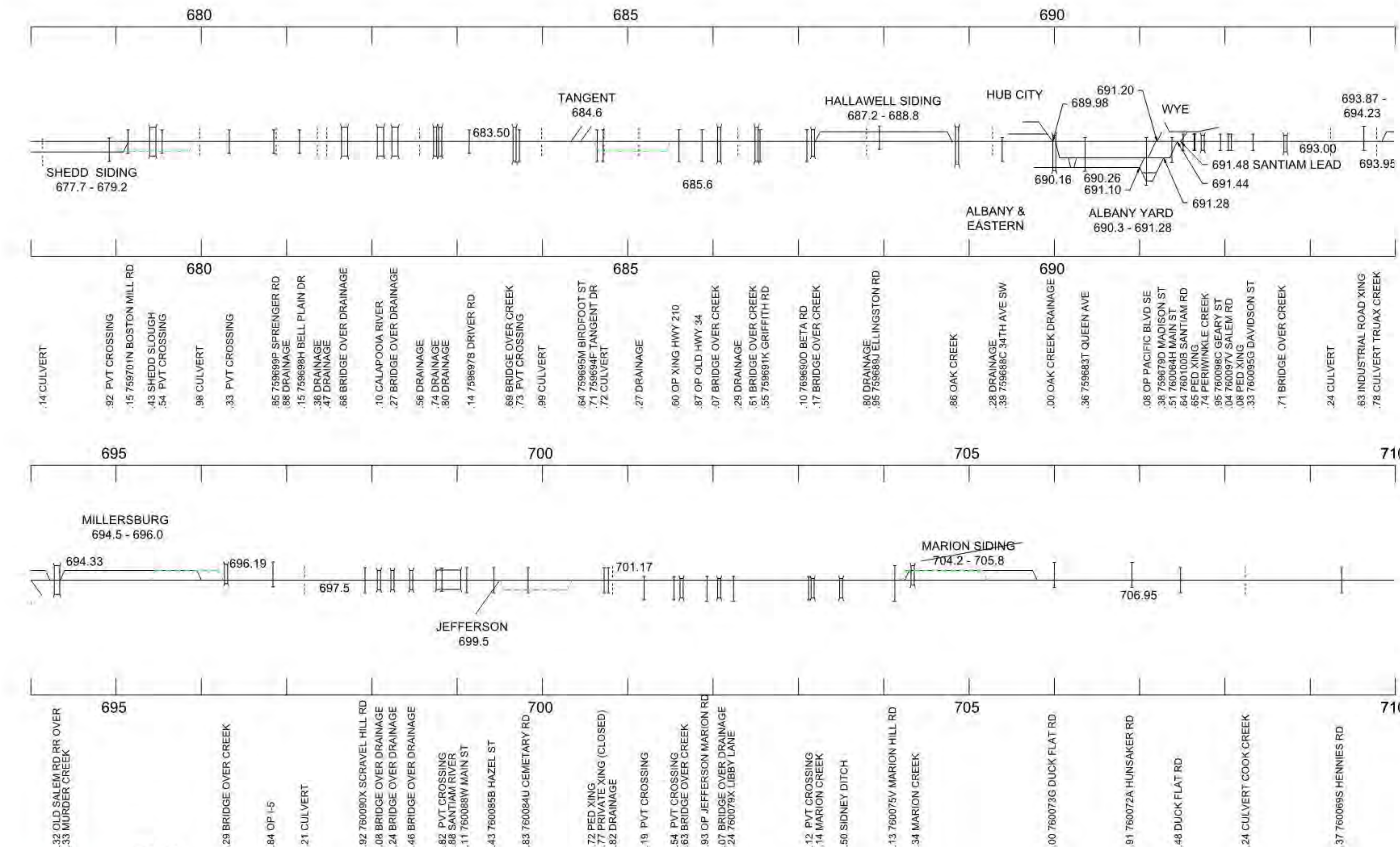
EXISTING TRACK
EXISTING TRACK TO BE REMOVED
SEPARATE TRACK PROJECTS FUNDED BY OTHERS, ASSUMED
BUILT PRIOR TO OR AT THE SAME TIME AS THIS PROJECT
EXISTING 1952 SIDING
NO ACTION WITH MINIMUMS
1



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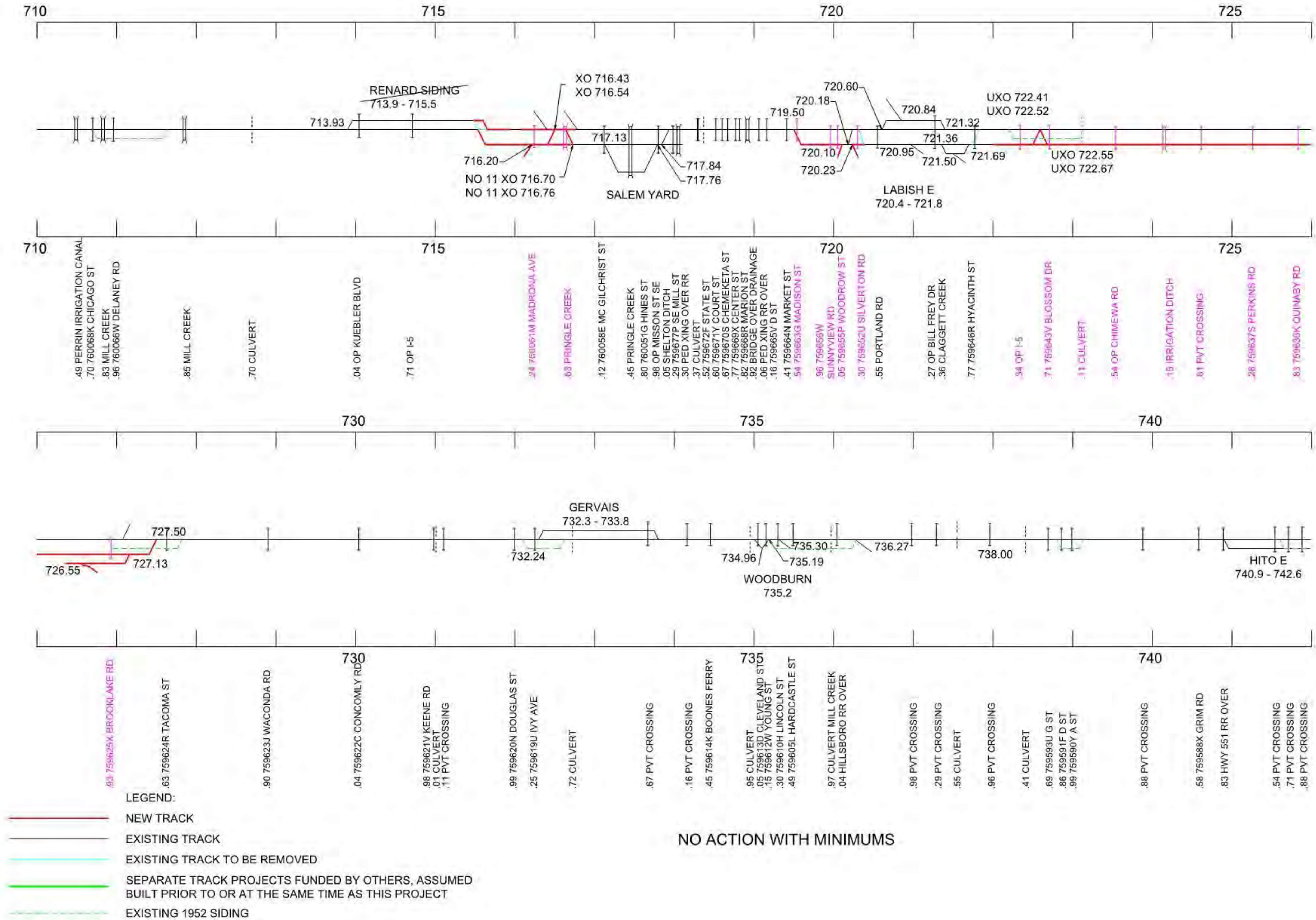
EXISTING TRACK TO BE REMOVED

SEPARATE TRACK PROJECTS FUNDED BY OTHERS, ASSUMED BUILT PRIOR TO OR AT THE SAME TIME AS THIS PROJECT

EXISTING 1952 SIDING

NO ACTION WITH MINIMUMS

2


710
715
720
725
RENARD SIDING
713.9 - 715.5
713.93
716.20
XO 716.43
XO 716.54
NO 11 XO 716.70
NO 11 XO 716.76
717.13
717.84
717.76
SALEM YARD
719.50
720.18
720.60
720.10
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.04 OP KUEBLER BLVD
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.24 760061M MADRONA AVE
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.45 PRINGLE CREEK
.80 760051G HINES ST
.98 OP MISSON ST SE
.05 SHELTON DITCH
.29 759677P SE MILL ST
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.06 PED XING RR OVER
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HITO E
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.54 PVT CROSSING
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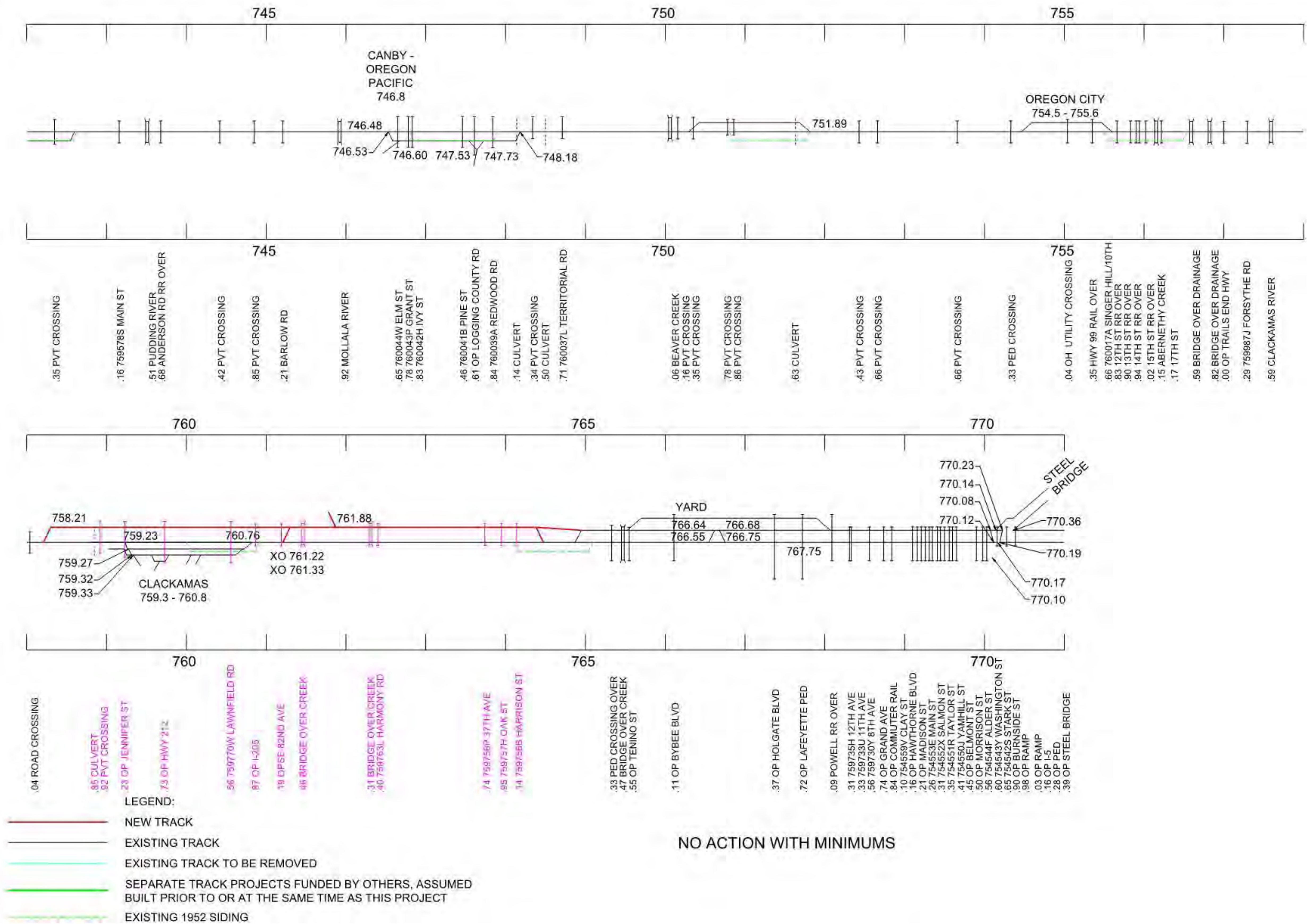
EXISTING TRACK TO BE REMOVED
SEPARATE TRACK PROJECTS FUNDED BY OTHERS, ASSUMED BUILT PRIOR TO OR AT THE SAME TIME AS THIS PROJECT
EXISTING 1952 SIDING
NO ACTION WITH MINIMUMS

3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.31 BRIDGE OVER CREEK
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.74 759756P 37TH AVE
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.33 PED CROSSING OVER
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.09 POWELL RR OVER
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.60 754543Y WASHINGTON ST
.65 754542S STARK ST
.90 OP BURNSIDE ST
.98 OP RAMP
.03 OP RAMP
.16 OP I-5
.28 OP PED
.39 OP STEEL BRIDGE
LEGEND:
NEW TRACK
EXISTING TRACK
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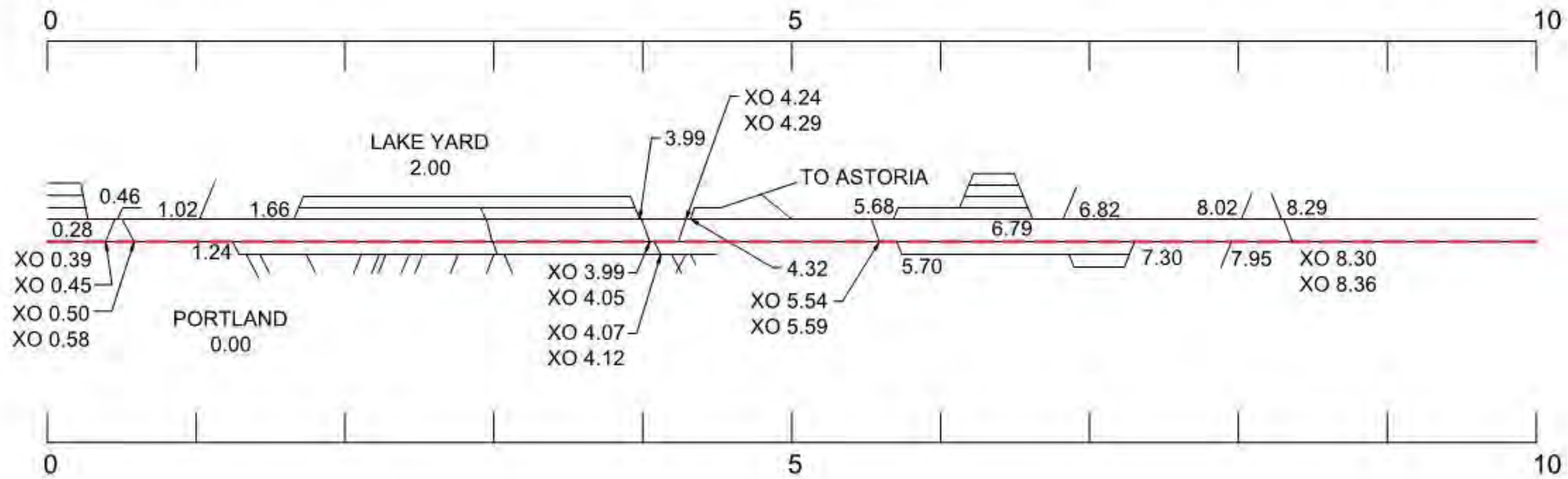


NO ACTION WITH MINIMUMS

5

Appendix B
Capital and Operations Costs Memorandum

DRAFT

Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

Cost Estimate Methodology

Oregon Department of Transportation

U.S. Department of Transportation Federal Railroad Administration

December 13, 2016

Contents

Acronyms and Abbreviations

BNSF	Burlington Northern Santa Fe Railway
I-205	Interstate 205
I-5	Interstate 5
mph	miles per hour
OPR	Oregon Passenger Rail
PNWR	Portland & Western Railroad
PNWRC	Pacific Northwest Rail Corridor
ROW	right-of-way
TF	Track feet
UPRR	Union Pacific Railroad

CHAPTER 1

Introduction

This report identifies the assumptions and methodology used to calculate planning-level cost estimates for the DEIS alternatives developed for the Oregon Passenger Rail Project.

The purpose of this report is to summarize the planning-level conceptual cost estimates for each alternative and identify the capital investment requirements, such as new rail lines, roads, bridges, signals and other crossing treatments, utility systems, etc. that would be required to construct the project. This documentation includes:

- Anticipated list of improvements necessary to meet the service characteristics assumptions
- Identification of typical infrastructure improvements and rail equipment cost estimates
- Basis and assumptions used to develop cost estimates

The report is divided into 5 sections:

- Section 1 – Introduction
- Section 2 – DEIS Alternatives – brief summary of infrastructure assumptions made for each alternative and options
- Section 3 – Cost Estimates – methodology for estimating construction unit costs and quantities, non-construction costs (professional services, utility relocation, and mitigation), and contingency costs
- Section 4 – Operations and Maintenance Costs – presents methods and calculation of anticipated operations and maintenance costs for the DEIS alternatives
- Section 5 – Conclusions and Next Steps – presents brief summary of findings and look forward to refinements that would be made in future (Tier 2) project development.

The attachments provide supporting documentation, including alternative maps, design assumptions, and unit cost estimates.

CHAPTER 2

DEIS Alternatives: Capital Improvements

The DEIS alternatives include new and existing alignments and new and existing station areas. Passenger and freight operations were modeled for each of the preliminary alternatives using projected demand for 2035. The results of the modeling were used to identify where infrastructure improvements were needed to maintain operations. The following section provides a brief description of each alternative. Descriptions are presented south to north.

Attachment A contains maps of the alternatives, including assumed stations and Attachment B contains the design criteria used by the engineering team.

2.1 Alternative 1

Alternative 1 would be constructed parallel to the existing Amtrak Cascades passenger rail route (i.e., the Union Pacific Railroad (UPRR) line) between Eugene and Portland. Sections of mainline track and sidings would be added where needed to accommodate additional passenger rail service while maintaining the current level of freight rail operations. The route would serve seven passenger rail round trips per day—six on the Amtrak Cascades and one on the Coast Starlight (a “6+1” schedule). Alternative 1 would serve existing stations (Eugene, Albany, Salem, Oregon City, and Portland). Crossovers would be included that would allow passenger and freight trains to operation on both existing and new track.

2.2 Alternative 2

Alternative 2 would involve construction of new mainline track and sidings throughout the majority of the route where it would be adjacent to the existing I-5 and I-205 alignments. New mainline track would also be added adjacent to the existing Portland and Western Railroad (PNWR) line between Keizer and Wilsonville and to the existing UPRR line in Springfield and between Oregon City and Portland Union Station. The route would serve seven round trips per day—six on the Amtrak Cascades and one on the Coast Starlight (a “6+1” schedule). Alternative 2 would serve the existing Portland Union Station, and would have new stations in Springfield, Albany, Salem or Keizer, and Wilsonville or Tualatin. For sections adjacent to existing rail lines, crossovers would be included that would allow passenger and freight trains to operation on both existing and new track. Sections of new mainline away from existing rail lines would be reserved for passenger service.

2.3 Alternative A-2: Central Albany Option

The Alternative 2 with Central Albany Option would be the same as Alternative 2 except in the vicinity of Albany, where the route would diverge from the I-5 area to serve the existing Albany station. New mainline track would be build adjacent to the existing Albany and Eastern Railroad and UPRR lines.

CHAPTER 3

Construction and Capital Cost Estimates

This section describes the methods used to develop cost estimates for the alternatives in the DEIS.

The cost estimates are based on the conceptual designs and thus a number of assumptions were used when developing the cost estimates. In addition, a 30% contingency factor was used to account for the uncertainty at this stage of the project. This section describes the three components of the total estimated cost: construction costs, right-of-way costs, and non-construction costs.

3.1 Construction Costs

Using the conceptual designs for each of the preliminary alternatives as described above, the Rail Design Team analyzed track characteristics within each 100-foot segment to develop construction cost estimates for the proposed track improvements and/or new alignments.

Using five major construction cost categories and twelve subcategories (see Table 1), the Design Team developed quantities estimates for track, sidings, and other improvements proposed within each 100-foot segment of the preliminary alternatives. Using these quantities and unit costs (described below), segment cost estimates were calculated. When aggregated, these segment estimates form the low end for each alternatives' Design Cost Estimates. The estimated cost of potential new stations was based on the same basic cost categories for each potential station (platforms, canopies, ticket kiosks, and an at-grade station building with park and ride). The rail design team established "Design Contingency Cost Factors" for each Cost Category. These Design Contingency Cost Factors were applied to the low costs to establish the high cost.

Note that ROW costs were tabulated separately and are not included in the Design Cost Estimates (see Right-of-Way Cost section below).

Unit costs were based on previous engineering cost estimates for similar projects and relied on historical data, labor indices, equipment, and 2015 construction material costs. A full description of unit cost assumptions is included as Attachment C: Unit Cost Estimate Assumptions.

Table 1. Construction Cost Categories Used in OPR Cost Estimates

Track Structure and Track	At-grade Track
	At-grade Track w/ Earthwork
	Retained Fill
	Elevated/Viaduct
	Open Trench/Retained Cut
	Tunnel
	Railroad Bridges
Stations, Terminals, Intermodal	Stations
Site work, Land, Existing Improvements	Roadway Bridge
	Grade Crossings
Communications and Signaling	Wayside Signaling Equipment

Note: Attachment C: Unit Cost Estimate Assumptions offers a unit or per-mile cost for each major cost category.

3.2 Right-of-Way Costs

The Design Team coordinated with geographic information system (GIS) and right-of-way (ROW) specialists to develop a methodology for estimating costs associated with acquiring ROW. The Design Team provided "ROW footprint" computer aided design (CAD) design files for each alternative. The footprint for each preliminary alternative is location-specific based on anticipated improvements and whether or not the alternative is a new alignment or an existing rail corridor. A limited number of ROW widths were assumed in the analysis, due to the planning-level design completed to date. These ROW widths are assumed to be averages to develop cost estimates, and are expected to vary when project development progresses in Tier 2.

Using a GIS mapping system, these ROW footprints were overlaid onto generalized land use zoning maps to identify any new ROW that may be required. The GIS analysis resulted in a calculation of the total square footage and acreage of each zoning area within each preliminary alternative's "ROW footprint." Using the zoning characteristics (described below), the ROW specialist assigned cost per square foot for each of the generalized zones, accounting for both improved and vacant sites. The ROW cost estimates were added to the design cost estimates for each alternative, thereby forming a total cost estimate.

3.2.1 Zoning Category Development

The ROW assessment used generalized zoning categories instead of individual zones within each local jurisdiction to show consistency throughout the corridor and to match the level of detail needed at this level of analysis.

Generalized zoning categories were created using the following methodology:

- Existing zoning districts for all jurisdictions were loaded into GIS;
- The GIS team analyzed the zoning information to identify generalized zones;
- Detailed zoning information was aggregated into generalized zoning categorizes to encompass all zoning categories along each route. The GIS analysis also differentiated between urban and rural areas, as that would have an impact on cost by land use type.

These generalized zoning categories included:

- Agricultural
- Residential,
- Commercial,
- Industrial.

Using the zoning characteristics as a guide, in 2013 a ROW specialist completed a search of recent sale data along each preliminary alternative using RealQuest Professional, an online search of sales going back two years. The vicinity of the preliminary alternative was used as a starting place for collecting sales data. The ROW specialist identified both urban and rural sales data and used the sales data to develop a final generalized zoning list that was provided to the GIS team. The final list included:

- Agriculture > 20 acres
- Rural residential < 20 acres
- Residential
- Commercial – Portland
- Commercial and Industrial – outside Portland

In areas of mixed use through small communities, the commercial zoning category was used both for area and valuation.

For the value analysis, a minimum of three sales per County, per zoning category (when available) was included. Additionally, the value did not include any costs of relocation for the acquisition. The right-of-way unit costs are included in Attachment C.

3.2.2 ROW Assumptions per Alignment

Due to the variance between each of the alternatives, the Design Team and ROW specialist developed the following set of assumptions when developing the ROW cost estimates.

Alternative 1 ROW Assumptions

- When proposed track is adjacent to the existing UP line (throughout the route for Alternative 1), a 30-ft wide acquisition is assumed (excluding the Portland Eastside industrial area, which assumed a half-block wide acquisition on average due to the constrained conditions and anticipated need for additional track).

Alternative 2 ROW Assumptions

- Through greenfields and river crossings, ROW is assumed to require a 100-foot wide acquisition. The 100-foot ROW take lines are offset 50-ft to each side of the proposed alignment.
- When the proposed alignment is located in the existing freeway median (I-5 and I-205), it is assumed that no additional ROW is required.
- When the proposed alignment is located in a tunnel (SE Portland), it is assumed that no additional ROW is required.
- In areas where the track follows an existing railroad (the PNWR line between Keizer and Wilsonville), ROW is assumed to require a 30-foot wide acquisition.
- When proposed track is adjacent to I-205, ROW is assumed to require a 50-ft wide acquisition. The increased width is due to the double track proposed along this corridor. The 50-ft ROW take line is offset to the east of the eastern edge of the alignment.
- When proposed track is adjacent to the existing UP line (in Springfield and between Oregon City and Portland Union Station), a 35-ft wide ROW acquisition is assumed. The increased width was chosen to account for potential offset requirements by UP as well as steep terrain that is adjacent to large portions of their track.

3.3 Other Costs

This section describes the following additional costs: non-construction costs, contingency cost, cost of new equipment, and the cost of infrastructure projects pursued independently of the Oregon Passenger Rail project.

3.3.1 Non-Construction Costs

Non-construction costs have been grouped into three major categories: professional services, utility relocation, and environmental mitigation. Table 2 outlines the sub-categories and the assigned percentages that were uniformly applied to the total estimated construction cost:

Table 2. Non-Construction Cost Categories Used in OPR Cost Estimates

PROFESSIONAL SERVICES	**Item Total**	**Category Total**
Design Engineering	10%	
Insurance and Bonding	2%	
Program Management	4%	
Construction Management & Inspection	6%	
Engineering Services During Construction	2%	
Integrated Testing and Commissioning	2%	
Sub-total Professional Services		26%
UTILITY RELOCATION		
If route is through Urban Areas (% of sub-total construction elements)	6%	6%
If route is outside of Urban Areas (% of sub-total construction elements)	3%	3%
ENVIRONMENTAL MITIGATION	**2.5%**	**2.5%**

3.3.2 Contingency Cost Estimates

The construction and non-construction costs were summed for each alternative, and then a 30% contingency was applied to develop a total estimated cost. The 30% contingency provides the recognition that there are uncertainties and provides the necessary placeholder until more information is available to identify and differentiate risks for the project. The 30% value is reasonable at this stage of development.

3.3.3 Cost of New Equipment

ODOT estimates that two additional passenger rail trainsets would be needed to accommodate increased service between Eugene/Springfield and Portland. A trainset is composed of passenger cars and service cars (e.g., dining car, baggage car) that would serve the passenger line. The cost of procuring each new trainset is assumed to be $20 million, which would account for a FRA-compliant DMU trainset or a locomotive hauled trainset. If DMU technology is used for future increased passenger rail service, this EIS assumes that the entire fleet would not be converted to that technology; instead, the new DMUs would be used alongside the existing locomotive fleet. This mixed-use approach would require different maintenance procedures and associated training than used for the existing diesel locomotive hauled technology.

3.3.4 PE / NEPA Projects

The operations modeling for the OPR Project assumed that three PE/NEPA projects currently under separate development would be constructed by the time the OPR Project is fully constructed. However, construction funding has not been identified for those projects. Therefore, construction costs for the PE/NEPA projects are included in the OPR Project cost estimate to ensure they will be constructed by the time the OPR project is fully built. Construction cost for Alternative 1 includes estimated cost of three PE/NEPA: Willbridge: $8.1 million; Penn Junction $4.1 million; Eugene Stub Tracks $23.4 million. Funding for the North Portland project ($13.2 million) has been identified via a Connect Oregon grant and matching funds from UPPR.

Construction cost for Alternative 2 and Alternative 2 with Central Albany Option include estimated cost of the Willbridge and Penn Junction PE/NEPA projects as described above.

3.4 Total Cost

Initial planning-level capital costs for each of the build alternatives are provided in Table 3. As described above, the capital cost estimates for each build alternative include the cost to construct infrastructure improvements along the route, including track and station improvements, ROW costs, the cost to buy train equipment and a contingency factor of 30 percent.

Note that in Table 3, the construction cost for Alternative 2 is an estimate of the cost to build that alternative all at one time. If Alternative 2 were built in phases, the Amtrak Cascades trains would continue to use parts of the existing UPRR alignment. To add more daily round trips before full build-out, ODOT would have to construct improvements to the UPRR alignment to accommodate the increased passenger trips. The cost of those improvements would depend on which phase of Alternative 2 was built first and the number of new round trips that were added. With a phased construction of Alternative 2, all improvements to the UPRR south of Oregon City would be abandoned by passenger rail service when Alternative 2 was fully built.

Table 3. Estimated Capital Costs of Build Alternatives (dollars in millions, 2015 dollars)

Section	Alternative 1		Alternative 2		Alternative 2 with Central Albany Option	
	Low	**High**	**Low**	**High**	**Low**	**High**
Train Overhaul	$5	$12	$5	$12	$5	$12
Construction Cost	$870[a, b]	$1,025[a, b]	$3,622[c]	$4,442[c]	$3,657	$4,537
Trainsets (2)[d]	$40	$40	$40	$40	$40	$40
Total[e]	$915	$1,077	$3,667	$4,494	$3,702	$4,599

[a] Total cost to construct improvements to accommodate both increased passenger service and estimated freight growth in 2035. ODOT estimates that the construction of improvements to accommodate increased passenger service would cost between $695 million and $801 million.

[b] Construction cost for Alternative 1 includes estimated cost of the PE/NEPA projects identified in the operational modeling for the project. Willbridge: $8.1 million; Penn Junction $4.1 million; Eugene Stub Tracks $23.4 million.

[c] Construction cost for Alternative 2 includes estimated cost of the PE/NEPA projects identified in the operational modeling for the project. Willbridge: $8.1 million; Penn Junction $4.1 million

[d] Trainset costs are based on ODOT’s recent purchase of two Talgo Series 8 trainsets.

[e] Numbers may not sum because of rounding.

CHAPTER 4

Operations and Maintenance Costs

Operating and maintenance (O&M) costs have been approximated for the two build alternatives for the Oregon Passenger Rail Project. These alternatives evaluate increasing the number of daily Amtrak Cascades roundtrips between Eugene/Springfield and Portland, Oregon from two daily roundtrips to six daily roundtrips. These daily roundtrips are in addition to the Amtrak Coast Starlight which has one daily roundtrip. Oregon currently shares the O&M costs of the Amtrak Cascades with Washington. The actual split between Oregon and Washington will be developed through negotiations between ODOT, WSDOT, Amtrak and the host railroads based on the conditions at the time of the negotiations. The numbers developed here stem from high level O&M costs and maintenance costs on the 2 Oregon-owned train sets contained in a passenger rail briefing developed by the ODOT Rail Division dated Jan 5, 2015. They are intended to be a reasonable approximation of those costs. The O&M costs in this document are in 2014 dollars. A summary table is provided at the end of this section.

4.1 Operating and Maintenance Costs Calculation Methodology

The current operating costs for existing Amtrak Cascades service for Oregon's two daily roundtrips is approximately $12 million per year. Alternative 1 will add four additional round trips in the full build out essentially tripling the operating costs to $36 million per year. Train maintenance cost on the two train sets currently owned by Oregon is approximately $5.27 million per year. It is anticipated that two additional train sets will be required in order to accommodate the increased schedules which effectively doubles the train maintenance costs to $10.54 million per year. The operating and train maintenance costs will be the same for Alternate 2 as it also will consist of six round trips and a total of four Oregon-owned train sets.

ODOT also pays the host railroads, through Amtrak, for maintenance costs associated with Amtrak Cascades passenger service use of the track. Currently those costs are approximately $525,000 per year. Basing this cost on the number of train miles used the cost per mile would be:

$525,000 / (123.9 miles of host railroad x 4 trips per day x 365 days/year) =

$525,000/180,894 train miles per year = $2.90 per train mile

Increasing the round trips for Alternative 1 to six roundtrips and using the $2.90 per track mile as a base unit cost the shared maintenance of way cost calculates out to:

123.9 track miles x 12 trips per day x 365 days per year x $2.90 per train mile =

$1,573,778 per year

Alternate 2 carries approximately 41.1 miles of shared track. Using the same unit cost for the shared track as was used for Alternative 1, the shared maintenance of way cost for Alternative 2 calculates out to:

41.1 train miles x 12 trips per day x 365 days x $2.90 per train mile =

$522,052 per year

Alternative 2 also has 80.1 miles of ODOT owned track. According to Chicago-Detroit Tier 1 EIS, a conservative estimate of $58,438 / mile was used as a unit cost for maintaining a mile of track to FRA Class 6 standard. Applying this unit cost to the ODOT owned track:

80.1 miles x $58,438 =

$4,680,884 for maintenance of ODOT owned track.

Table 4. Operating and Maintenance Costs - Summary

	Current (2+1)	Alternative 1 (6+1)	Alternative 2 (6+1)
Operating Costs	12,000,000	36,000,000	36,000,000
Train Maintenance Costs	5,270,000	10,500,000	10,500,000
Shared Costs	525,000	1,573,778	522,052
Maintaining FRA Class 6	0	0	4,680,884
Total	17,795,000	48,073,778	51,702,936

CHAPTER 5

Conclusions and Next Steps

This analysis developed high level cost estimates based on limited project development and are primarily intended for comparison of the two build alternatives. These costs are not intended to represent the actual cost to build, maintain, or operate either build alternative. If a build alternative is selected through the Tier 1 EIS, subsequent projects would develop detailed capital cost estimates. In addition, actual O&M costs would be negotiated with Amtrak, Washington DOT, and the appropriate host railroads.

Attachment A
Maps of Alternatives

Figure 3-2
(Map 1 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1 and 2

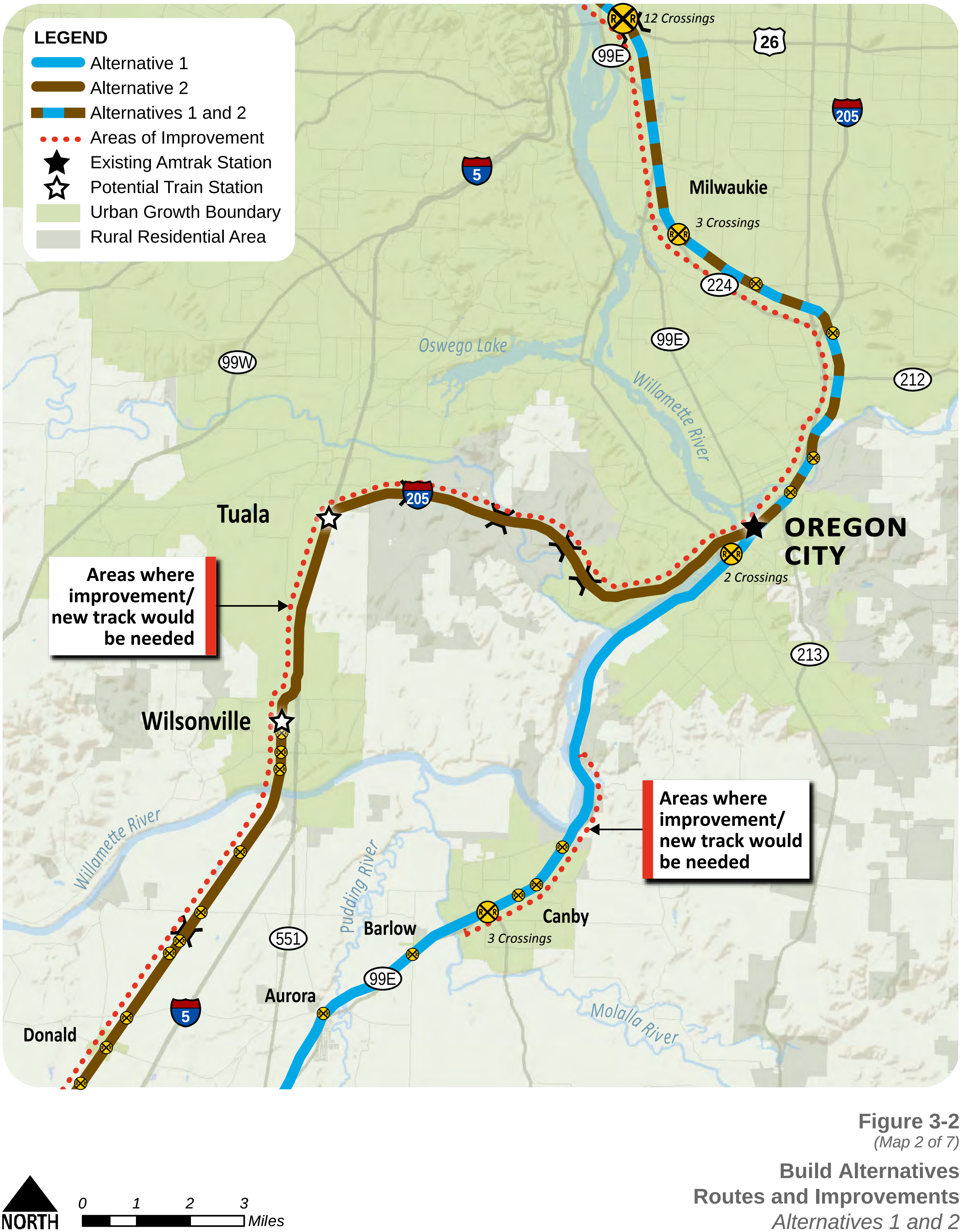


Figure 3-2
(Map 2 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1 and 2

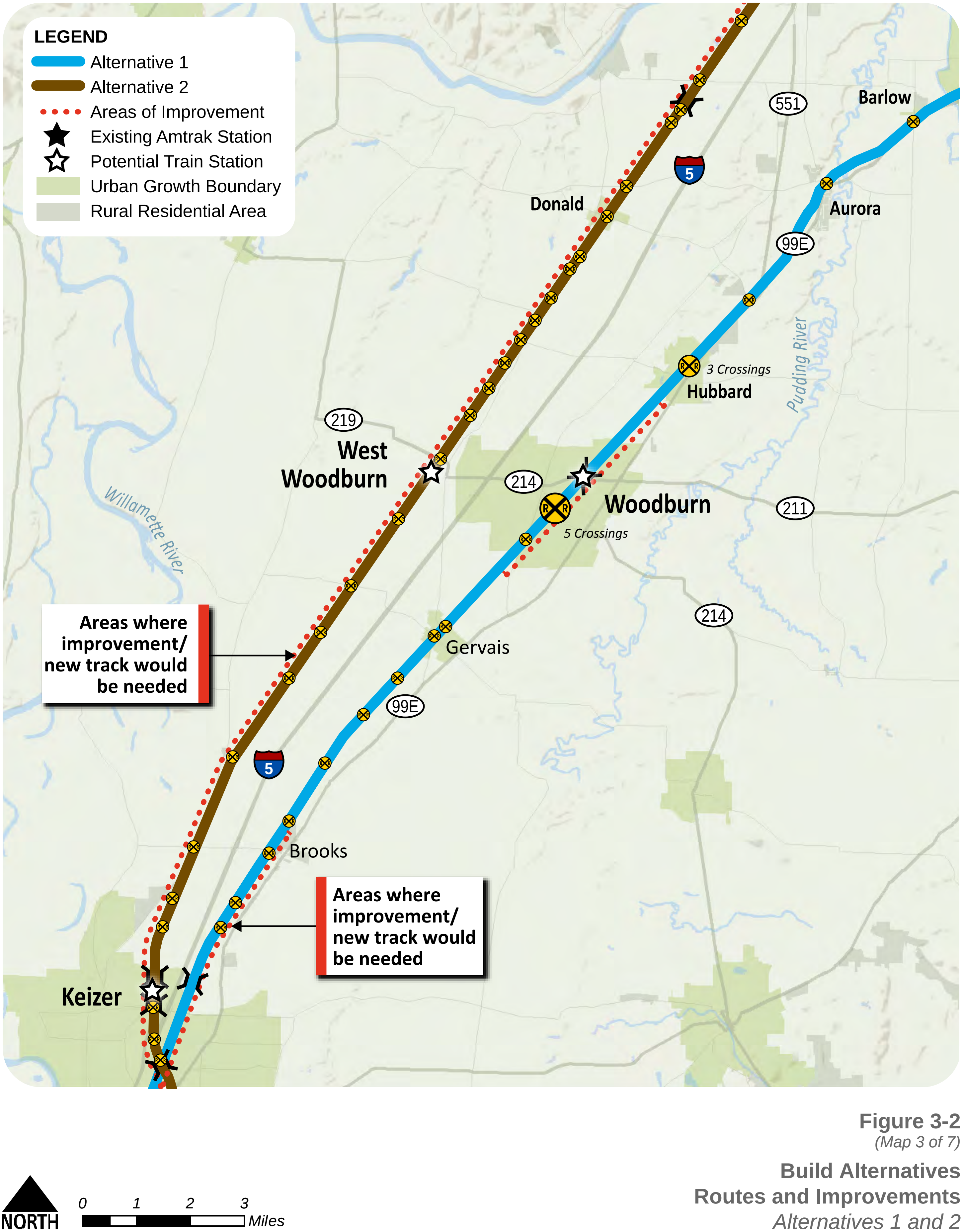


Figure 3-2
(Map 3 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1 and 2

Tier 1 DEIS Alternatives

Oregon Passenger Rail
Eugene–Portland
CHOOSING A PATH FORWARD

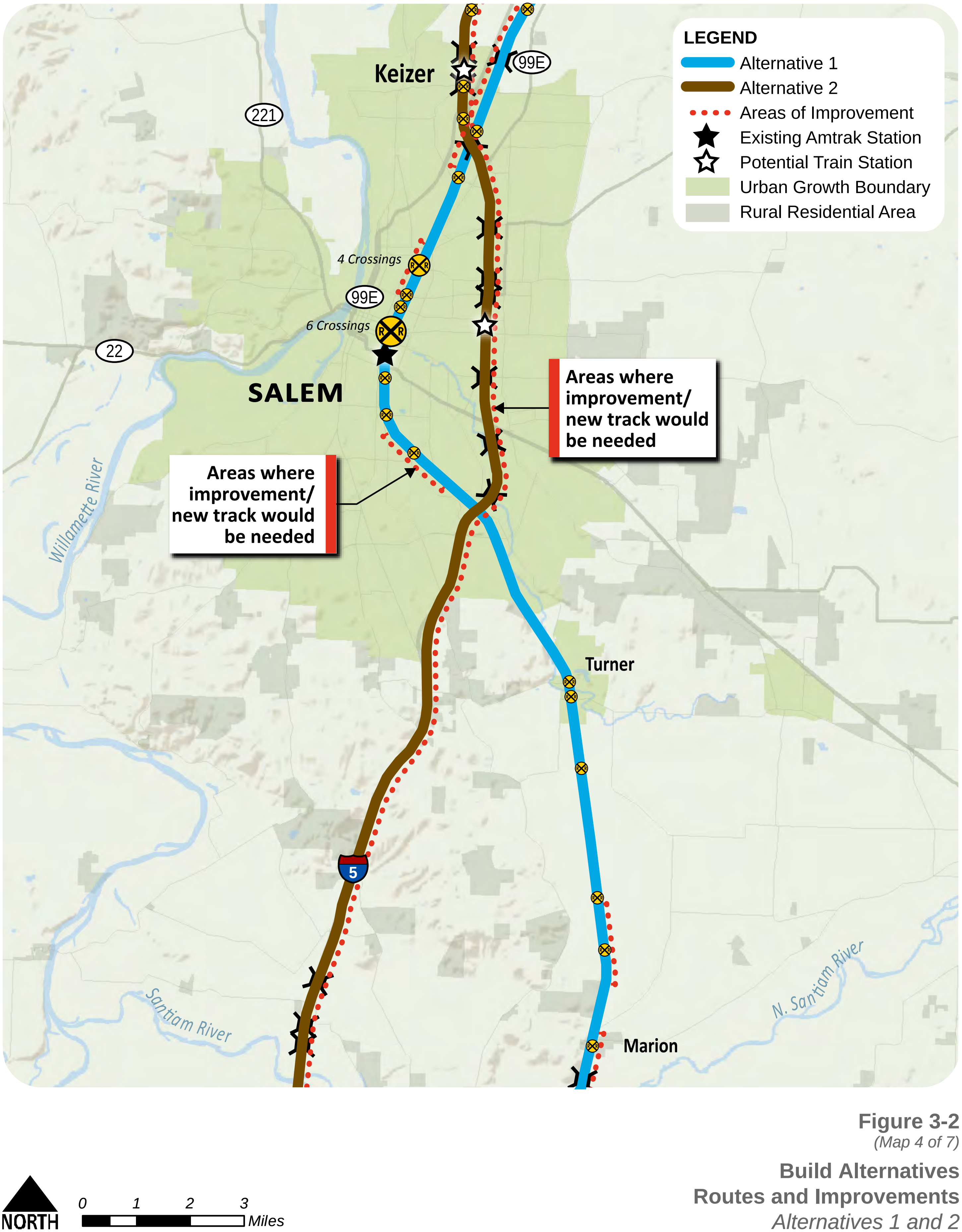


Figure 3-2
(Map 4 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1 and 2

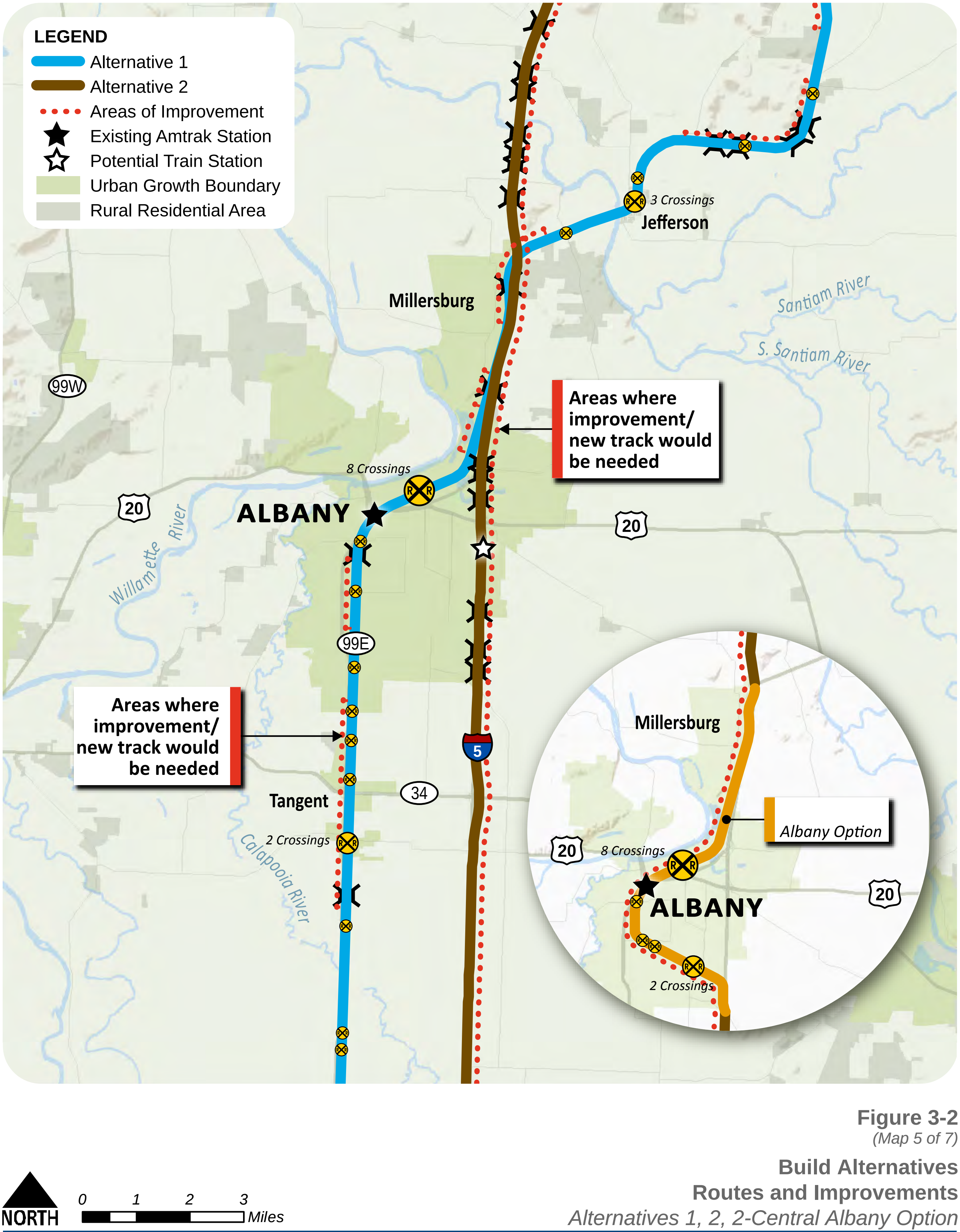


Figure 3-2
(Map 5 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1, 2, 2-Central Albany Option

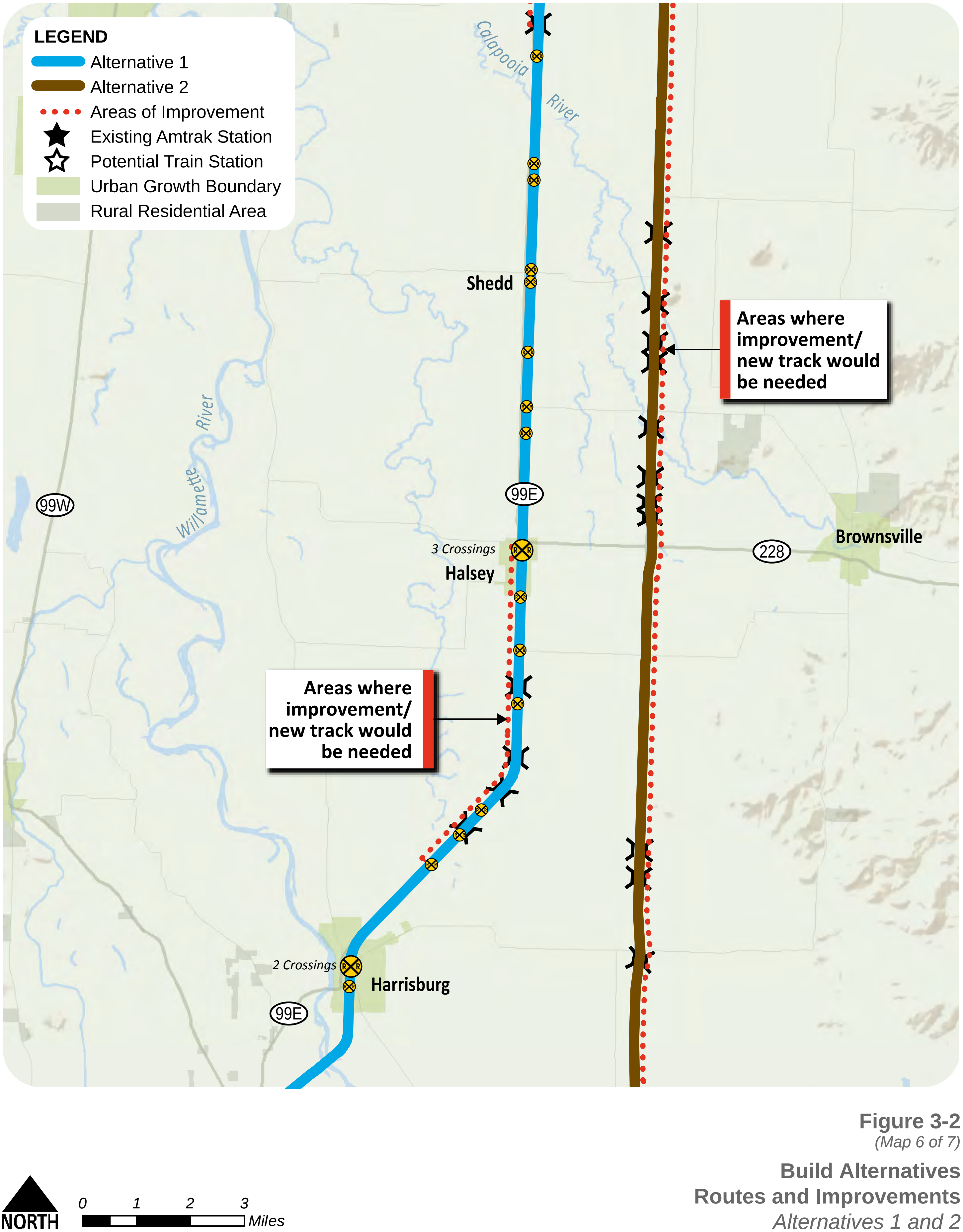


Figure 3-2
(Map 6 of 7)

Build Alternatives
Routes and Improvements
Alternatives 1 and 2

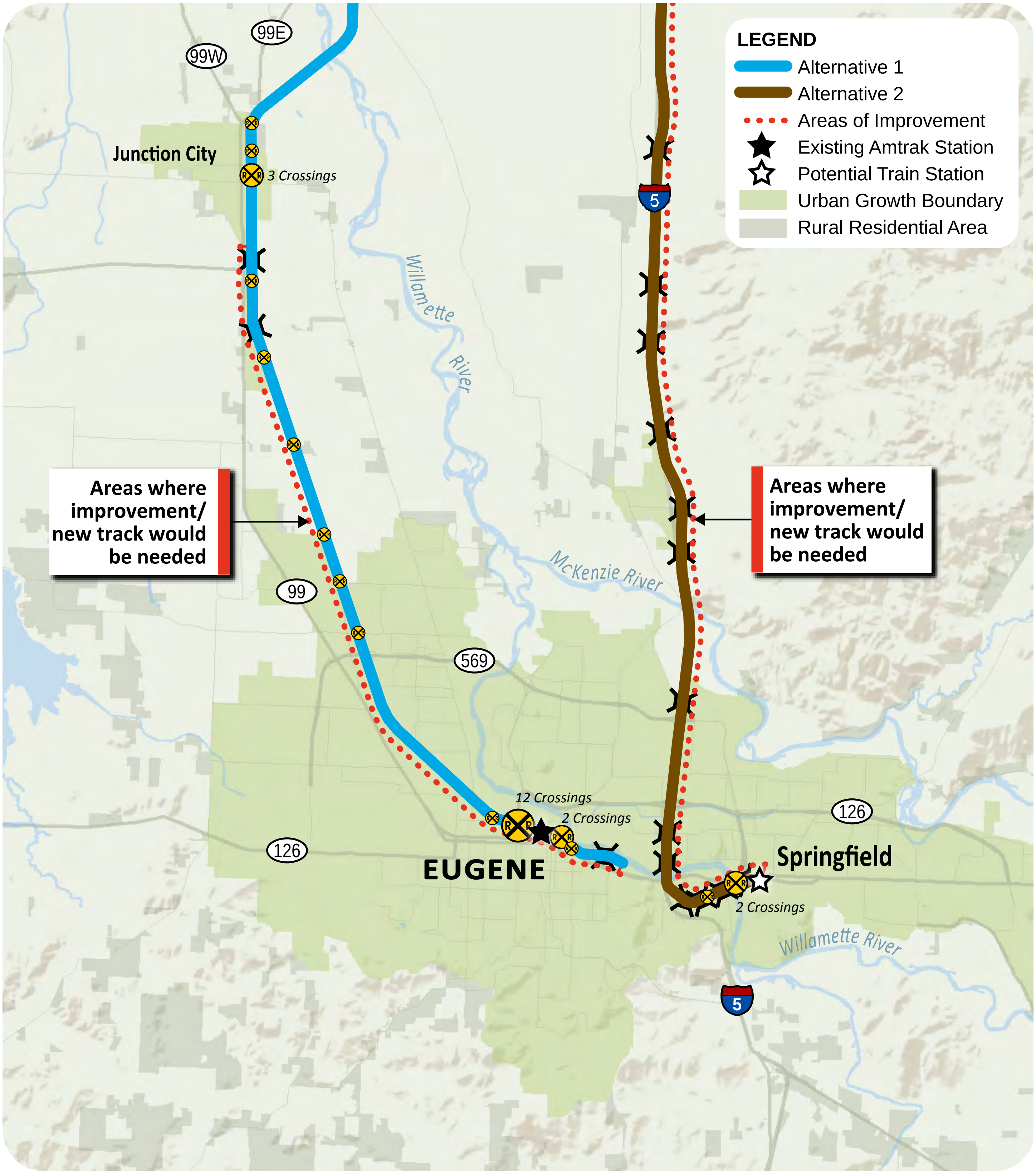


Figure 3-2

(Map 7 of 7)

Build Alternatives Routes and Improvements

Alternatives 1 and 2

Attachment B
Design Criteria

Oregon Passenger Rail
Eugene - Portland
CHOOSING A PATH FORWARD

Memorandum

To	Jim Cox, ODOT Major Projects John Schnaderbeck, ODOT Major Projects
From	Jim Ellerbroek, David Evans and Associates, Inc.
Date	2/12/2013
Subject	Oregon Passenger Rail Environmental Impact Statement Project – PA #28370 WOC #3 – Task 6.3 Phase 2 Conceptual Design Criteria Narrative – DRAFT

This memorandum describes the Conceptual Engineering Design Criteria to be considered during development of alternatives. These criteria will be utilized in preparation of conceptual engineering and in evaluation of alternatives in Phase 3, 4, and 5 of the Environmental Impact Statement Project. The alternatives developed will provide information for environmental, operational, and other assessments for the project.

The criteria address the following:

I. General design criteria
II. Track with shared freight and passenger rail operations, including freight-only track modified or added.
III. Track for passenger-only operations.
IV. Vehicle roadways, including at-grade or grade-separated crossings, and modified roadways.

I. General design criteria – For the purposes of conceptual design, the following criteria will be used to prepare planning-level alignments and other improvements.
   A. Train Speeds
      1. Speeds will be grouped by Federal Railroad Administration (FRA) Class of track for passenger and freight trains. The Design Criteria Tables (see below) will be used as the basis for the speeds on a given segment of track.
   B. Horizontal Alignment
      1. Horizontal curves will be based on those listed in the Design Criteria Tables. In general, the degree of curve (and the resulting curve radius) for each speed in the table is based on the maximum superelevation.
      2. Superelevation of tracks is limited to no greater than 5 inches and shall be no less than ¾ inch. The superelevation of curves will be based upon the formulae:
         S = ((E + U) / 0.0007 * D)^½
         E = 0.0007*D*S^2-U

Where:
S = velocity in mph
D = degree of curve in decimals
U = unbalanced elevation in inches

The unbalanced elevation (U) will be a maximum of:

- Freight trains: 2 inches
- Conventional (non-tilting) passenger trains: 3 inches
- Tilting passenger trains: 5 inches

3. Minimum curve lengths in feet shall be based on five times the train speed in miles per hour (5*V, i.e., 5*79 mph = 395 feet) to allow for spirals in later design phases.

4. Minimum tangent lengths in feet shall be the greater of 100 feet or five times the train speed in miles per hour (5*V, i.e., 5*79 mph = 395 feet).

C. Station Platforms

1. For the platforms on tracks that include freight service, the Oregon Administrative Rules (OAR) will be followed; specifically, they will be no higher than 8 inches above the top of the rail being served, as allowed under the U.S. Department of Transportation (USDOT) Americans with Disabilities Act (ADA) level boarding guidelines (http://www.fra.dot.gov/eLib/Details/L03698). For the platforms on tracks that serve only passenger trains, level boarding will be provided, the height of which will be determined based on the equipment selected.

2. Platforms will be located on tangent track.

II. Track with shared passenger rail operations – The existing passenger rail operation utilizes track owned by several private railroads and other public or private entities. Train speeds, curvatures, gradients, turnout sizes, superelevation, and other criteria for alternatives in the study must be consistent with the host railroad's standards and compatible with the existing rail network. The two Class I railroads in the corridor, BNSF Railway and Union Pacific Railroad (UPRR), are primary owners of the existing mainline track. If affected, the numerous shortline, port, and private industrial track will utilize the standards of the serving Class I railroads. Where joint service exists, the more restrictive of the Class I standards will be used.

A. BNSF Railway (BNSF) – BNSF criteria will be utilized for alternatives that affect the current route from Portland Union Station north to Vancouver, Washington, and portions of what is known as the Oregon Electric (OE) line. Unless otherwise noted, engineering shall comply with BNSF Railway Mainline Design Guidelines for Track Projects.

1. Turnout Size and Type – The minimum size for mainline turnouts is No. 11. See BNSF standards Appendix L Standard Plans for No. 11, 15, 20, and 24 turnout details. Turnouts will not be placed within a vertical curve or, if possible, on structures. The Design Criteria Tables list the maximum speeds through the diverging side of turnouts.

2. Track Spacing – Track centers for parallel mainline tracks shall be 25 feet minimum.

3. Track Curvature – The maximum degree of curvature allowed for mainline track is generally 3 degrees. In locations where existing curves are tighter than 3 degrees, that curve will be the minimum. The minimum tangent between curves is 200 feet. No turnouts may be placed in curves or within 200 feet of a curve.

4. Superelevation – In accordance with BNSF standards Appendix C, Design Superelevation for Freight Trains/Spiral Lengths. The maximum unbalanced superelevation will be 5 inches. Note: For conceptual engineering, spirals will not be designed, although the tangent, curve, and other geometry will be designed to allow for final design of required superelevation/spirals.

5. Vertical Curvature – The "V/L" values for crest and sag vertical curves shall be a minimum length of 100 feet with V/L not to exceed 0.05 for sags and 0.1 for crests, where V is the difference of grades and L is the length of curve in stations.

6. Maximum Gradient – 1% for mainline track.

7. Materials – All materials for rail, ballast, ties, and OTM (other track material) shall conform to BNSF standards. See Appendix A Standard Plan for Roadbed/Ballast Section. The minimum acceptable mainline rail shall be new 136 lb. rail or greater.

8. Control Points – In accordance with BNSF standards Appendix J Signal Design and Standard Construction Specification and Combined BNSF/UPRR and UPRR Signal Standard Drawings. The design shall allow for implementation of PTC or CTC controls.

9. Horizontal Clearances – Horizontal clearances shall comply with OAR 741-310-0010 and OAR 741-310-0020 and with BNSF standards for clearances found in Appendices G, H, and I Minimum Clearances. In general, the required clearances are:
   a. Tangent Track: 8.5 feet from centerline
   b. Curved Track: 8.5 feet plus (+) 1.5 inches per degree of curvature

10. Vertical Clearances – All vertical clearances are measured from the highest rail at any given point along the length of the overhead obstruction unless noted otherwise. See also BNSF standards for clearances found in Appendices G, H, and I Minimum Clearances. In general, the required clearances are:
    a. Obstructions: 23 feet and 4 inches
    b. Overhead Wires: 27 feet

11. Industry Track – BNSF Design Guidelines for Industrial Track Projects. Track centers for sidings and industry track shall be 15 feet minimum to comply with OAR 741-315-0010(a).

12. Structures – Structure criteria are:
    a. Culverts shall comply with the BNSF Railway Mainline Design Guidelines for Track Projects and American Railway Engineering and Maintenance-of-Way Association (AREMA), where noted by BNSF.
    b. Bridges shall be designed to E80 loading and utilize BNSF Standard Bridge Plans and structure types.
    c. Shoring structures shall comply with the Joint BNSF-UPRR Guidelines for Temporary Shoring and AREMA where noted by BNSF.
    d. Grade-separated structures shall comply with the Joint BNSF-UPRR Guidelines for Railroad Grade Separation Projects.
    e. Oregon Department of Transportation (ODOT) Standard Bridge Drawings and Specifications.

13. Utilities – In accordance with BNSF standards Appendix F Utility Accommodation Policy.

B. Union Pacific Railroad (UPRR) – UPRR criteria will be utilized for alternatives that affect the current route from Portland Union Station south to Springfield, Oregon, and portions of what is known as the Tillamook Branch line. Unless otherwise noted, engineering shall comply with UPRR Mainline Design Guidelines for Track Projects.

1. Turnout Size and Type – The UPRR minimum size for mainline turnouts is No. 11, per UPRR Standard Drawing 0080D Standard Turnout Applications. No. 24 turnouts and crossovers shall be utilized for high-speed passenger operations. Turnouts will not be placed within a vertical curve or, if possible, on structures.

2. Track Spacing – Track centers for parallel tangent mainline tracks will be 20 feet.

3. Track Curvature – The maximum degree of curvature required by UPRR is based on the superelevation and train speed. A minimum tangent length between curves of 200 feet will be used wherever possible. No turnouts may be placed in curves or within 300 feet of a curve.

4. Superelevation – Horizontal curves and superelevation shall comply with UPRR Standard Drawings 0019A, 0020B, 0021C, 0022C, and 0023C for superelevation of curves.

5. Spirals – In accordance with UPRR Standard Drawing 0019A Superelevation of Curves. Note: For conceptual engineering, spirals will not be designed, although the tangent, curve, and other geometry will be designed to allow for final design of required superelevation.

6. Vertical Curvature – The “V/L” values for crest and sag vertical curves shall comply with UPRR Standard Drawing 0016 Vertical Curve Design. UPRR requires a minimum length of 100 feet and V/L not to exceed 0.06 for sags and 0.1 for crests, where V is the difference of grades and L is the length of curve in stations.

7. Maximum Gradient – 1% for mainline track.

8. Materials – All materials for rail, ballast, ties, and OTM (other track material) shall conform to UPRR Standard Drawing 0001A Roadbed Sections for Track Construction. The minimum acceptable rail shall be new 136RE rail or greater. Continuously welded rail and concrete ties will be used.

9. Control Points – The design shall allow for implementation of PTC or CTC controls.

10. Stations – In accordance with UPRR Network Planning – New Passenger Station Guidelines.

11. Horizontal Clearances – Horizontal clearances shall comply with OAR 741-310-0010 and OAR 741-310-0020 and UPRR Standard Drawings 0035 and 0038F Standard Minimum Operating Clearances.
    a. Tangent Track: 9.5 feet from centerline
    b. Curved Track: 9.5 feet plus (+) 1.5 inches per degree of curve where facility is located within 80 feet of turnout or curve limits

12. Vertical Clearances – All vertical clearances are measured from the highest rail at any given point along the length of the overhead obstruction, unless noted otherwise. See UPRR Standard Drawings 0035 and 0038F Standard Minimum Operating Clearances.
    a. Obstructions: 23 feet and 4 inches
    b. Overhead Wires: 27 feet

13. Industry Track Criteria – In accordance with UPRR Industrial Track Standards found at http://www.uprr.com/aboutup/operations/specs/track/index.shtml.

14. Structures – Structure criteria are:
    a. Culverts shall comply with the UPRR Mainline Track Standard Drawings and AREMA, where noted by UPRR.
    b. Bridges shall be designed to E80 loading and utilize UPRR Standard Bridge Plans and structure types.
    c. Shoring structures shall comply with the Joint BNSF-UPRR Guidelines for Temporary Shoring and AREMA, where noted in the shoring guidelines found at http://www.uprr.com/aboutup/operations/specs/shoring/index.shtml.
    d. Grade-separated structures shall comply with the Joint BNSF-UPRR Guidelines for Railroad Grade Separation Projects found at http://www.uprr.com/aboutup/operations/specs/attachments/grade_separation.pdf.
    e. ODOT Standard Bridge Drawings and Specifications.

15. Utilities – In accordance with UPRR, local, federal, and state standards; see http://www.uprr.com/reus/pipeline/install.shtml for UPRR utility guidelines.

III. Track for passenger-only operations – The American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering, 2012, will be generally followed for alternatives located on new alignments that do not interact with freight rail operations. In general, this includes “greenfield” routes or those adjacent to, but not in, existing freight railroad rights-of-way.

1. Turnout Size and Type – In accordance with AREMA Chapter 5 Part 3.4 and Chapter 11 Part 3.5.11. Turnouts will not be placed within a vertical curve or, if possible, on structures.

2. Track Spacing – Track centers for parallel mainline tracks shall be 15 feet minimum to comply with OAR 741-315-0010(a).

3. Track Curvature – In accordance with AREMA Chapter 5 Part 3 Curves.

4. Superelevation – In accordance with AREMA Chapter 5 Part 3 Curves.

5. Spirals – In accordance with AREMA Chapter 5 Part 3.1 Spirals. Note: For conceptual engineering, spirals will not be designed, although the tangent, curve, and other geometry will be designed to allow for final design of required superelevation.

6. Vertical Curvature – In accordance with AREMA Chapter 5 Part 3.6 Vertical Curves.

7. Maximum Gradient – In accordance with AREMA Chapter 5 Part 3.7 Compensated Gradients.

8. Materials – All materials for rail, ballast, ties, and OTM (other track material) shall conform to AREMA Chapter 1 Roadway and Ballast and Chapter 4 Rail.

9. Control Points – In accordance with AREMA Chapter 11 Part 3.2.9 Signal Systems and Part 3.5.9 Signal Considerations.

10. Horizontal Clearances – Horizontal clearances shall comply with OAR 741-310-0010 and OAR 741-310-0020.
    a. Tangent Track: 8.5 feet from centerline
    b. Curved Track: 8.5 feet plus (+) 1.5 inches per degree of curvature

11. Vertical Clearances – All vertical clearances are measured from the highest rail at any given point along the length of the overhead obstruction, unless noted otherwise.
    a. Obstructions: 23 feet and 4 inches
    b. Overhead Wires: 27 feet

12. Crossings – In accordance with AREMA Chapter 5 Part 8 Highway/Railway Grade Crossings and ODOT standards.

13. Industry Track – See applicable BNSF or UPRR standards for industry track.

14. Structures – Structure criteria are:
    a. Culverts shall comply with AREMA Chapter 4 Track.
    b. Structures shall comply with AREMA Volume 2 – Structures.
    c. ODOT Standard Bridge Drawings and Specifications.

15. Utilities
    a. In accordance with AREMA Chapter 5 for pipelines.
    b. In accordance with utility agency standards as applicable.

IV. Vehicle roadways, including at-grade or grade-separated crossings, and modified roadways

A. At-grade vehicle crossings of railroads – In accordance with Railroad-Highway Grade Crossing Handbook, 2007, USDOT Federal Highway Administration (FHWA) Crossings, BNSF standards Appendix Q Requirements for Standard Road Crossings, and ODOT standards. At-grade crossings shall comply with UPRR Standard Drawing 0304E Installation of Road Crossing with Precast Concrete Panels and ODOT standards.
B. Grade-separated crossings – Grade-separated structures shall comply with the Joint BNSF-UPRR Guidelines for Railroad Grade Separation Projects and ODOT Standard Bridge Drawings and Specifications.
C. Roadways – In accordance with A Policy on Geometric Design of Highways and Streets, 6th Edition, 2011, AASHTO, ODOT Highway Design Manual (HDM), or applicable design criteria set forth by the local road authority.

List of Referenced Standards

- BNSF Railway Mainline Design Guidelines for Track Projects including Appendices A, C, F, G, H, I, J, L
- BNSF Design Guidelines for Industrial Track Projects
- Joint BNSF-UPRR Guidelines for Temporary Shoring
- Joint BNSF-UPRR Guidelines for Railroad Grade Separation Projects
- The Association of Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering
- AASHTO Policy on Geometric Design of Highways and Streets
- ODOT Highway Design Manual (HDM)
- FHWA Railroad-Highway Grade Crossing Handbook
- Oregon Administrative Rules 741-310-0010 and 741-310-0020
- ODOT Standard Bridge Drawings and Specifications
- UPRR Industrial Track Standards
- UPRR Signal Standard Drawings
- UPRR Mainline Design Guidelines for Track Projects
- UPRR Standard Drawings 0001A, 0080D, 0019A, 0020B, 0021C, 0022C, 0023C, 0304E, 0035, and 0038F
- U.S. Department of Transportation (USDOT) Americans with Disabilities Act (ADA) Level Boarding Guidelines

Horizontal Design Criteria Table - UPRR Shared Freight / Passenger Rail

For speeds up to 79 mph

$$Speed = ((Super + Imb)/(0.0007D))^{0.5}$$

Max. Speed with 5" Imb Passenger	Max. Speed with 1" Imb UPRR Freight	Track Class	Superelevation (5" Max.)	Degree of Curve D	Radius R	Min. Tangent for Rev Curves (Includes Spirals)	Minimum Size Turnout
169	79	5	2.75	0.5	11,459.19'	618	
120	79	5	5.00	1.0	5,729.65'	829	
98	75	5	4.50	1.5	3,819.83'	940	
85	65	5	5.00	2.0	2,864.93'	880	
72	55	4	4.25	2.5	2,292.01'	576	
65	50	4	4.25	3.0	1,910.08'	551	24
61	45	4	5.00	3.5	1,637.28'	512	24
53	45	3	4.25	4.0	1,432.69'	552	24
50	40	3	5.00	4.5	1,273.57'	488	20
48	40	3	4.25	5.0	1,146.28'	512	20
46	35	3	4.75	5.5	1,042.14'	315	20
44	35	3	3.75	6.0	955.37'	337	20
42	35	3	4.00	6.5	881.95'	348	20
40	35	3	4.50	7.0	819.02'	370	20
39	30	3	4.75	7.5	764.49'	315	15
38	30	3	5.00	8.0	716.78'	326	15
36	30	3	4.00	9.0	637.27'	337	15
32	25	2	4.50	10.0	573.69'	304	15

Horizontal Design Criteria Table - BNSF Shared Freight / Passenger Rail
For speeds up to 90 mph Freight

$$\text{Speed} = ((\text{Super} + \text{Imb})/(0.0007D))^{0.5}$$

Max. Speed with 5" Imb Passenger	Max. Speed with 2" Imb BNSF Freight	Track Class	Superelevation (5" Max.)	Degree of Curve D	Radius R	Min. Tangent for Rev Curves (Includes Spirals)	Minimum Size Turnout
130	90	5	0.88	0.5	11,459.19'	280	
112	90	5	3.75	1.0	5,729.65'	600	
96	80	5	4.75	1.5	3,819.83'	660	
84	70	4	4.88	2.0	2,864.93'	600	
73	60	3	4.38	2.5	2,292.01'	495	
67	55	3	4.38	3.0	1,910.08'	520	
61	50	3	4.13	3.5	1,637.28'	430	20
60	50	3	5.00	4.0	1,432.69'	500	20
55	45	2	4.50	4.5	1,273.57'	425	20
50	40	2	3.63	5.0	1,146.28'	370	20
49	40	2	4.25	5.5	1,042.14'	390	20
48	40	2	4.75	6.0	955.37'	420	20
44	35	2	3.63	6.5	881.95'	360	15
43	35	2	4.13	7.0	819.02'	380	15
42	35	2	4.25	7.5	764.49'	380	15
42	35	2	4.88	8.0	716.78'	410	15
37	30	2	3.75	9.0	637.27'	360	15
37	30	2	4.38	10.0	573.69'	390	15

Horizontal Design Criteria Table - AREMA
For High Speed Passenger-Only Rail

Speed = ((5" Max Super + Imb)/(0.0007D))$^{0.5}$

Max. Speed with 5" Imb Passenger	Track Class	Degree of Curve D	Radius R	Min. Tangent for Rev Curves (Includes Spirals)	Minimum Size Turnout
169	9	0.5	11,459.19'	845	
120	7	1.0	5,729.65'	598	
98	6	1.5	3,819.83'	488	
85	5	2.0	2,864.93'	423	
76	4	2.5	2,292.01'	378	
69	4	3.0	1,910.08'	345	
64	4	3.5	1,637.28'	319	24
60	3	4.0	1,432.69'	299	24
56	3	4.5	1,273.57'	282	24
53	3	5.0	1,146.28'	267	24
51	3	5.5	1,042.14'	255	24
49	3	6.0	955.37'	244	20
47	3	6.5	881.95'	234	20
45	3	7.0	819.02'	226	20
44	3	7.5	764.49'	218	20
42	3	8.0	716.78'	211	20
40	3	9.0	637.27'	199	20
38	3	10.0	573.69'	189	15

Attachment C
Unit Cost Estimate Assumptions

Bid Item	Description	Bid Quantity	Unit	Unit Cost	Total	General Conditions (15%)	Subtotal	OH&P (15%)	Grand Total
1001000 10.01	AT GRADE TRACK								
1001010 10.01.01	**SGL TRACK - BALLASTED**	**1.0**	**RM**	**$2,059,000**	**$2,059,000**	**$308,850**	**$2,367,850**	**$355,178**	**$2,723,000**
1001020 10.01.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$62,000	$62,000				
1001030 10.01.01.02	SUBBALLAST - SGL TRACK	1.0	RM	$329,000	$329,000				
1001040 10.01.01.03	BALLAST - SGL TRACK	1.0	RM	$348,000	$348,000				
1001050 10.01.01.04	SGL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$1,320,000	$1,320,000				
1001060 10.01.02	**DBL TRACK - BALLASTED**	**1.0**	**RM**	**$4,012,000**	**$4,012,000**	**$601,800**	**$4,613,800**	**$692,070**	**$5,306,000**
1001070 10.01.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$77,000	$77,000				
1001080 10.01.02.02	SUBBALLAST - DBL TRACK	1.0	RM	$598,000	$598,000				
1001090 10.01.02.03	BALLAST - DBL TRACK	1.0	RM	$697,000	$697,000				
1001100 10.01.02.04	DBL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$2,640,000	$2,640,000				
1002000 10.02	AT GRADE TRACK W/ EARTHWORK								
1002010 10.02.01	**SGL TRACK - BALLASTED**	**1.0**	**RM**	**$2,795,000**	**$2,795,000**	**$419,250**	**$3,214,250**	**$482,138**	**$3,696,000**
1002020 10.02.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$616,000	$616,000				
1002030 10.02.01.02	GUIDEWAY EARTHWORK - SGL TRACK	1.0	RM	$182,000	$182,000				
1002040 10.02.01.03	SUBBALLAST - SGL TRACK	1.0	RM	$329,000	$329,000				
1002050 10.02.01.04	BALLAST - SGL TRACK	1.0	RM	$348,000	$348,000				
1002060 10.02.01.05	SGL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$1,320,000	$1,320,000				
1002070 10.02.02	**DBL TRACK - BALLASTED**	**1.0**	**RM**	**$4,825,000**	**$4,825,000**	**$723,750**	**$5,548,750**	**$832,313**	**$6,381,000**
1002080 10.02.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$632,000	$632,000				
1002090 10.02.02.02	GUIDEWAY EARTHWORK - DBL TRACK	1.0	RM	$258,000	$258,000				
1002100 10.02.02.03	SUBBALLAST - DBL TRACK	1.0	RM	$598,000	$598,000				
1002110 10.02.02.04	BALLAST - DBL TRACK	1.0	RM	$697,000	$697,000				
1002120 10.02.02.05	DBL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$2,640,000	$2,640,000				
1003000 10.03	RETAINED FILL								
1003010 10.03.01	**SGL TRACK, BALLASTED, 15' AVE WALL HEIGHT**	**1.0**	**RM**	**$11,428,000**	**$11,428,000**	**$1,714,200**	**$13,142,200**	**$1,971,330**	**$15,114,000**
1003020 10.03.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$62,000	$62,000				
1003030 10.03.01.02	GUIDEWAY EARTHWORK - SGL TRACK	1.0	RM	$182,000	$182,000				
1003040 10.03.01.03	RETAINING WALL (FILL)	1.0	RM	$9,187,000	$9,187,000				
1003050 10.03.01.04	SUBBALLAST - SGL TRACK	1.0	RM	$329,000	$329,000				
1003060 10.03.01.05	BALLAST - SGL TRACK	1.0	RM	$348,000	$348,000				
1003070 10.03.01.06	SGL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$1,320,000	$1,320,000				
1003080 10.03.02	**DBL TRACK, BALLASTED, 15' AVE WALL HEIGHT**	**1.0**	**RM**	**$13,457,000**	**$13,457,000**	**$2,018,550**	**$15,475,550**	**$2,321,333**	**$17,797,000**
1003090 10.03.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$77,000	$77,000				
1003100 10.03.02.02	GUIDEWAY EARTHWORK - DBL TRACK	1.0	RM	$258,000	$258,000				
1003110 10.03.02.03	RETAINING WALL (FILL)	1.0	RM	$9,187,000	$9,187,000				
1003120 10.03.02.04	SUBBALLAST - DBL TRACK	1.0	RM	$598,000	$598,000				
1003130 10.03.02.05	BALLAST - DBL TRACK	1.0	RM	$697,000	$697,000				
1003140 10.03.02.06	DBL TRACK INSTALL - TIES/RAIL/FASTENERS - 1	1.0	RM	$2,640,000	$2,640,000				
1004000 10.04	ELEVATED/VIADUCT								
1004010 10.04.01	**SGL TRACK, DF, 30' T/R**	**1.0**	**RM**	**$38,726,000**	**$38,726,000**	**$5,808,900**	**$44,534,900**	**$6,680,235**	**$51,215,000**
1004020 10.04.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$24,000	$24,000				
1004030 10.04.01.02	AERIAL STRUCTURE - SGL TRACK	1.0	RM	$36,960,000	$36,960,000				
1004040 10.04.01.03	DF SGL TRACK - TIES/RAIL/FASTENERS - 136# C	1.0	RM	$1,742,000	$1,742,000				

Bid Item	Description	Bid Quantity	Unit	Unit Cost	Total	General Conditions (15%)	Subtotal	OH&P (15%)	Grand Total
1004050 10.04.02	**DBL TRACK, DF, 30' T/R**	**1.0**	**RM**	**$82,709,000**	**$82,709,000**	**$12,406,350**	**$95,115,350**	**$14,267,303**	**$109,383,000**
1004060 10.02.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$24,000	$24,000				
1004070 10.02.02.02	AERIAL STRUCTURE - DBL TRACK	1.0	RM	$79,200,000	$79,200,000				
1004080 10.02.02.03	DF DBL TRACK - TIES/RAIL/FASTENERS - 136# C	1.0	RM	$3,485,000	$3,485,000				
1005000 10.05	OPEN TRENCH/RETAINED CUT								
1005010 10.05.01	**RETAINED CUT - SGL TRACK, BALLASTED, 20' AVE DEPTH**	**1.0**	**RM**	**$14,934,000**	**$14,934,000**	**$2,240,100**	**$17,174,100**	**$2,576,115**	**$19,750,000**
1005020 10.05.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$62,000	$62,000				
1005030 10.05.01.02	GUIDEWAY EARTHWORK - SGL TRACK	1.0	RM	$532,000	$532,000				
1005040 10.05.01.03	RETAINING WALL (CUT)	1.0	RM	$12,672,000	$12,672,000				
1005050 10.05.01.04	BALLAST - SGL TRACK	1.0	RM	$348,000	$348,000				
1005055 10.05.01.05	SGL TRACK INSTALL - TIES/RAIL/FASTENERS - 136# CWR	1.0	RM	$1,320,000	$1,320,000				
1005060 10.05.02	**RETAINED CUT - DBL TRACK, BALLASTED, 20' AVE DEPTH**	**1.0**	**RM**	**$16,983,000**	**$16,983,000**	**$2,547,450**	**$19,530,450**	**$2,929,568**	**$22,460,000**
1005070 10.05.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$77,000	$77,000				
1005080 10.05.02.02	GUIDEWAY EARTHWORK - DBL TRACK	1.0	RM	$897,000	$897,000				
1005090 10.05.02.03	RETAINING WALL (CUT)	1.0	RM	$12,672,000	$12,672,000				
1005100 10.05.02.04	BALLAST - DBL TRACK	1.0	RM	$697,000	$697,000				
1005110 10.05.02.05	DBL TRACK INSTALL - TIES/RAIL/FASTENERS - 136# CWR	1.0	RM	$2,640,000	$2,640,000				
1006000 10.06	TUNNEL								
1006010 10.06.01	**CUT & COVER BOX - 1 TRACK / 1 BOX (45' AVG. EXC. D**	**1.0**	**RM**	**$91,009,000**	**$91,009,000**	**$13,651,350**	**$104,660,350**	**$15,699,053**	**$120,359,000**
1006020 10.06.01.01	GUIDEWAY PREPARATION - SGL TRACK	1.0	RM	$62,000	$62,000				
1006030 10.06.01.02	GUIDEWAY EARTHWORK - SGL TRACK	1.0	RM	$3,299,000	$3,299,000				
1006040 10.06.01.03	CUT & COVER BOX STRUCTURE - SGL TRACK	1.0	RM	$85,536,000	$85,536,000				
1006050 10.06.01.04	DF SGL TRACK - TIES/RAIL/FASTENERS - 136# CWR	1.0	RM	$2,112,000	$2,112,000				
1006060 10.06.02	**CUT & COVER BOX - 2 TRACK / 1 BOX (45' AVG. EXC. D**	**1.0**	**RM**	**$128,165,000**	**$128,165,000**	**$19,224,750**	**$147,389,750**	**$22,108,463**	**$169,498,000**
1006070 10.06.02.01	GUIDEWAY PREPARATION - DBL TRACK	1.0	RM	$77,000	$77,000				
1006080 10.06.02.02	GUIDEWAY EARTHWORK - DBL TRACK	1.0	RM	$4,536,000	$4,536,000				
1006090 10.06.02.03	CUT & COVER BOX STRUCTURE - DBL TRACK	1.0	RM	$121,440,000	$121,440,000				
1006100 10.06.02.04	DF DBL TRACK - TIES/RAIL/FASTENERS - 136# CWR	1.0	RM	$2,112,000	$2,112,000				
1006110 10.06.03	**BORED SGL TRACK TUNNEL 30FT ID IN SOFT ROCK (POOR)**	**1.0**	**RM**		**$119,475,000**	**$17,921,250**	**$137,396,250**	**$20,609,438**	**$158,006,000**
1006120 10.06.03.01	TBM PURCHASE	2.0	EA	$21,695,000	$4,339,000				
1006125 10.06.03.02	TUNNEL LINER PURCHASE	10.0	RM	$29,040,000	$29,040,000				
1006130 10.06.03.03	LAUNCH SHAFT	2.0	EA	$29,158,000	$5,831,600				
1006140 10.06.03.04	BORED SGL TRACK TUNNEL - 30FT ID	10.0	RM	$37,182,000	$37,182,000				
1006150 10.06.03.05	EXTRACTION SHAFT	1.0	EA	$57,584,000	$5,758,400				
1006152 10.06.03.06	EMERGENCY ACCESS SHAFT	10.0	EA	$9,000,000	$9,000,000				
1006153 10.06.03.07	VENTILATION SHAFT	21.0	EA	$6,000,000	$12,600,000				
1006155 10.06.03.08	CROSS PASSAGES	53.0	EA	$0	$0				
1006156 10.06.03.09	MECH/VENT/ELECT ALLOWANCE	10.0	RM	$13,600,000	$13,600,000				
1006160 10.06.03.10	DF SGL TRACK - TIES/RAIL/FASTENERS - 136# CWR	10.0	RM	$2,124,000	$2,124,000				
1006170 10.06.04	**BORED DBL TRACK TUNNEL 50FT ID IN SOFT ROCK (POOR)**	**1.0**	**RM**		**$246,984,000**	**$37,047,600**	**$284,031,600**	**$42,604,740**	**$326,636,000**
1006180 10.06.04.01	TBM PURCHASE / SET UP	2.0	EA	$35,195,000	$7,039,000				
1006185 10.06.04.02	TUNNEL LINER PURCHASE	10.0	RM	$39,600,000	$39,600,000				
1006190 10.06.04.03	LAUNCH SHAFT	2.0	EA	$40,648,000	$8,129,600				
1006200 10.06.04.04	BORED TUNNEL - 50FT ID	10.0	RM	$138,120,000	$138,120,000				

Bid Item		Description	Bid Quantity	Unit	Unit Cost	Total	General Conditions (15%)	Subtotal	OH&P (15%)	Grand Total
1006210	10.06.04.05		1.0	EA	$57,584,000	$5,758,400				
1006212	10.06.04.06		10.0	EA	$9,000,000	$9,000,000				
1006213	10.06.04.07	EXTRACTION SHAFT	21.0	EA	$6,000,000	$12,600,000				
1006215	10.06.04.08	EMERGENCY ACCESS SHAFT	53.0	EA	$0	$0				
1006220	10.06.04.09	VENTILATION SHAFT	10.0	RM	$22,300,000	$22,300,000				
1006240	10.06.04.10	CROSS PASSAGES	10.0	RM	$4,437,000	$4,437,000				
1007000	10.07	RAILROAD BRIDGES MECH/VENT/ELECT ALLOWANCE								
1007010	**10.07.01**	**SGL TRACK BRIDGE - BALLASTED, UP TO 300' LONG** DF DBL TRACK - TIES/RAIL/FASTENERS - 136# CWR	**1.0**	**EA**	**$2,559,000**	**$2,559,000**	**$383,850**	**$2,942,850**	**$441,428**	**$3,384,000**
1007020	10.07.01.01		300.0	TF	$1,200	$360,000				
1007030	10.07.01.02		300.0	TF	$7,000.00	$2,100,000				
1007040	10.07.01.03		300.0	TF	$330.00	$99,000				
1007050	**10.07.02**	GUIDEWAY PREPARATION - SGL TRACK **DBL TRACK BRIDGE - BALLASTED, UP TO 300' LONG**	**1.0**	**EA**	**$5,058,000**	**$5,058,000**	**$758,700**	**$5,816,700**	**$872,505**	**$6,689,000**
1007060	10.07.02.01	AERIAL STRUCTURE - SGL TRACK	300.0	TF	$1,200	$360,000				
1007070	10.07.02.02	AERIAL SGL TRACK - TIES/RAIL/FASTENERS - 136# CWR	300.0	TF	$15,000.00	$4,500,000				
1007080	10.07.02.03		300.0	TF	$660.00	$198,000				
2001000	20.01	STATIONS GUIDEWAY PREPARATION - DBL TRACK								
2001010	**20.01.01**	**STATION BUILDINGS: PRIMARY (500 PARKING SPACES)** AERIAL STRUCTURE - DBL TRACK	**1.0**	**EA**	**$5,891,000**	**$5,891,000**	**$883,650**	**$6,774,650**	**$1,016,198**	**$7,791,000**
2001020	20.01.01.01	AERIAL DBL TRACK - TIES/RAIL/FASTENERS - 136# CWR	1.0	EA	$1,890,000	$1,890,000				
2001030	20.01.01.02		1.0	EA	$538,000	$538,000				
2001040	20.01.01.03	AT-GRADE SIDE PLATFORM - 2 VEHICLE	1.0	EA	$213,000	$213,000				
2001050	20.01.01.04	AT-GRADE SIDE PLATFORM - CANOPIES	1.0	LS	$3,250,000	$3,250,000				
2001100	**20.01.02**	**STATION BUILDINGS: SECONDARY** AT-GRADE STATION - TICKET KIOSKS	**1.0**	**EA**	**$250,000**	**$250,000**	**$37,500**	**$287,500**	**$43,125**	**$331,000**
2001110	20.01.02.01	STATION BUILDINGS: SECONDARY AT-GRADE STATION PARK & RIDE	1.0	EA	$250,000	$250,000				
3001000	**30.01**	**LAYOVER FACILITY**	**1.0**	**EA**	**$5,000,000**	**$5,000,000**	**N/A**	**$5,000,000**	**N/A**	**$5,000,000**
3001010	30.01.01		1.0	LS	$1,000,000	$1,000,000				
3001020	30.01.02		1.0	LS	$3,000,000	$3,000,000				
3001030	30.01.03	EARTHWORK & PREPARATION	1.0	TF	$1,000,000	$1,000,000				
3002000	30.02	HEAVY MAINTENANCE FACILITY BUILDINGS & AMENITIES								
3002010	**30.02.01**	**MAINTENANCE FACILITY** YARD/STORAGE TRACK	**1.0**	**EA**	**$23,000,000**	**$23,000,000**	**N/A**	**$23,000,000**	**N/A**	**$23,000,000**
3002020	30.02.01.01		1.0	LS	$2,000,000	$2,000,000				
3002030	30.02.01.02		1.0	LS	$20,000,000	$20,000,000				
3002040	30.02.01.03	EARTHWORK & PREPARATION	1.0	TF	$1,000,000	$1,000,000				
4001000	40.01	ROADWAY BRIDGE BUILDINGS & AMENITIES								
4001010	**40.01.01**	**ROADWAY OVER RAILROAD - UP TO 200'** YARD/STORAGE TRACK	**1.0**	**EA**	**$4,283,000**	**$4,283,000**	**$642,450**	**$4,925,450**	**$738,818**	**$5,664,000**
4001020	40.01.01.01		1.0	LS	$360,000	$360,000				
4001030	40.01.01.02		15,920.0	SF	$58	$923,000				
4001040	40.01.01.03	EARTHWORK & PREPARATION	200.0	LF	$15,000	$3,000,000				
4002000	40.02	GRADE CROSSINGS RETAINING WALLS (FILL)								
4002010	**40.02.01**	**GRADE CROSSING - UP TO 4 LANES OF TRAFFIC** AERIAL STRUCTURE	**1.0**	**EA**	**$356,000**	**$356,000**	**$53,400**	**$409,400**	**$61,410**	**$471,000**
4002020	40.02.01.01		60.0	TF	$750	$45,000				
4002030	40.02.01.02		60.0	TF	$600	$36,000				
4002040	40.02.01.03	EARTHWORK & PREPARATION	1,000.0	SF	$75	$75,000				
4002050	40.02.01.04	GRADE CROSSING SGL TRACK INSTALLATION - 136#	1.0	EA	$200,000	$200,000				
4002060	**40.02.02**	**GRADE CROSSING - MORE THAN 4 LANES OF TRAFFIC** STREET MODIFICATIONS	**1.0**	**EA**	**$558,800**	**$558,800**	**$83,820**	**$642,620**	**$96,393**	**$739,000**
		GATED CROSSING SIGNALS								

Bid Item		Description	Bid Quantity	Unit	Unit Cost	Total	General Conditions (15%)	Subtotal	OH&P (15%)	Grand Total
4002070	40.02.02.01		84.0	TF	$750	$63,000				
4002080	40.02.02.02		84.0	TF	$1,200	$100,800				
4002090	40.02.02.03	EARTHWORK & PREPARATION	1,600.0	SF	$75	$120,000				
4002100	40.02.02.04	GRADE CROSSING DBL TRACK INSTALLATION - 136#	1.0	EA	$275,000	$275,000				
5001000	**50.01**	**WAYSIDE SIGNALING EQUIPMENT** STREET MODIFICATIONS	**1.0**	**LS**	**$1,898,000**	**$1,898,000**	**N/A**	**$1,898,000**	**N/A**	**$1,898,000**
5001010	50.01.01	TRAIN CONTROL (ETCS L2), WAYSIDE PTN SYS, FO BACKB GATED CROSSING SIGNALS	1.0	RM	$1,898,000	$1,898,000				
6003000	**60.03**	**TRACTION POWER DISTRIBUTION: CATENARY AND THIRD RA**	**1.0**	**LS**	**$1,842,900**	**$1,842,900**	**N/A**	**$1,842,900**	**N/A**	**$1,842,900**
6003010	60.03.01	TRACTION POWER DISTRIBUTION CATENARY	1.0	RM	$1,842,900	$1,842,900				

Right-of-Way Unit Costs, 2013

Property Type	Land & Imp	Unit
Agricultural > 20 ac	$6,000	AC
Rural Residential < 20 ac	$4.00	SF
Residential	$35.00	SF
Commercial Portland	$130.00	SF
Commercial (outside Portland)	$35.00	SF
Industrial Portland Area	$21.00	SF
Industrial (outside Portland)	$13.00	SF

Appendix C
At-Grade Railroad Crossing Locations

Oregon Passenger Rail – At-grade Crossing for Alternatives

Crossing ID	Operating Railroad	Location	Street Name	Tracks	Device Type	AADT	County	Functional Classification (Generalized)	Alternative
C-690.40	UP	Albany	Queen Ave	4	Active	16,000	Linn	Arterial	A1/A2a
C-689.40	UP	Albany	34th Av	1	Active	11,000	Linn	Arterial	A1
C-692.04	UP	Albany	Salem Ave	1	Active	9,000	Linn	Arterial	A1/A2a
C-692.30	UP	Albany	Davidson St	1	Active	1,500	Linn	Local	A1/A2a
C-691.60	UP	Albany	Santiam Rd	1	Active	9,000	Linn	Arterial	A1/A2a
C-691.50	UP	Albany	Main St	1	Active	2,700	Linn	Collector	A1/A2a
C-691.96	UP	Albany	Geary St	1	Active	2,400	Linn	Arterial	A1/A2a
C-691.40	UP	Albany	Madison St	2	Active	1,500	Linn	Local	A1/A2a
C-692.10-E	UP	Albany	Burkhart St Ped Xing	1	Passive	N/A	Linn	Local	A1/A2a
C-691.70-E	UP	Albany	Pine St Ped Xing	1	Passive	N/A	Linn	Local	A1/A2a
CLA-690.10	AERC	Albany	34th Ave	1	Active	11,000	Linn	Arterial	A2a
CLA-690.40	AERC	Albany	Marion St	1	Active	1,700	Linn	Collector	A2a
CLA-691.40-E	AERC	Albany	Columbus St Ped Xing	1	Passive	N/A	Linn	Local	A2a
CLA-691.55	AERC	Albany	Waverly Dr	1	Active	8,500	Linn	Arterial	A2a
C-668.30	UP	Alford	Powerline Rd S 218	1	Active	350	Linn	Collector	A1
C-668.90	UP	Alford	Cartney Dr224(Bond Butte)	1	Active	149	Linn	Local	A1
C-667.50	UP	Alford	Substation Dr 227	2	Active	84	Linn	Local	A1
C-743.20	UP	Aurora	Ehlen Road (Main Street)	1	Active	8,800	Marion	Arterial	A1
C-745.20	UP	Barlow	Barlow Rd 41025	1	Active	6,950	Clackamas	Arterial	A1
3E-51.40	PNWR	Broadacres	Butteville-Gervais Rd 65	1	Active	2,700	Marion	Collector	A2
3E-51.90	PNWR	Broadacres	Broadacres Rd 417	1	Passive	620	Marion	Local	A2
3E-52.40	PNWR	Broadacres	Hunt Ln Ne 3051	1	Passive	50	Marion	Local	A2
C-726.90	UP	Brooks	Brooklake Rd 609	2	Active	8,600	Marion	Arterial	A1
C-725.80	UP	Brooks	Quinaby Rd 613	1	Active	1,400	Marion	Collector	A1
C-728.90	UP	Brooks	Waconda Rd 602	1	Active	1,140	Marion	Collector	A1
C-727.60	UP	Brooks	Tacoma St NE 608	1	Active	250	Marion	Local	A1
C-746.90	UP	Canby	Ivy St	2	Active	8,902	Clackamas	Arterial	A1
C-746.60	UP	Canby	Elm St	2	Active	5,482	Clackamas	Collector	A1
C-746.80	UP	Canby	N Grant Street	2	Active	4,400	Clackamas	Collector	A1
C-747.50	UP	Canby	NE Fourth Ave (N Fair St)	2	Active	3,286	Clackamas	Collector	A1
C-748.70	UP	Canby	Territorial Rd 31010	1	Active	3,250	Clackamas	Local	A1
C-747.90	UP	Canby	N Redwood St 31017	1	Active	430	Clackamas	Collector	A1
C-760.80	UP	Clackamas	Lawnfield Rd 22004	3	Active	10,250	Clackamas	Collector	A1/A2
3E-46.00	PNWR	Curtis	Arndt Rd 11	1	Active	2,420	Marion	Collector	A2
3E-44.70	PNWR	Curtis	Denbrook Rd(Ehland)(Yergen)	1	Passive	50	Clackamas	Local	A2

Crossing ID	Operating Railroad	Location	Street Name	Tracks	Device Type	AADT	County	Functional Classification (Generalized)	Alternative
3E-48.40	PNWR	Donald	Ehlen Rd 96	1	Active	7,580	Marion	Arterial	A2
3E-49.10	PNWR	Donald	Donald Rd 10 (Main St)	2	Active	1,300	Marion	Collector	A2
3E-50.90	PNWR	Donald	Wiseacre Ln 437	1	Passive	440	Marion	Local	A2
3E-50.00	PNWR	Donald	Fellers Rd 433	1	Passive	390	Marion	Local	A2
3E-50.40	PNWR	Donald	Miller Rd 3057	1	Passive	20	Marion	Local	A2
C-648.20	UP	Eugene	Van Buren St	2	Active	9,700	Lane	Collector	A1
C-647.05	UP	Eugene	High St At E 5th	1	Active	4,800	Lane	Collector	A1
C-647.68	UP	Eugene	Washington St	2	Active	4,100	Lane	Collector	A1
C-647.61	UP	Eugene	Lawrence St	2	Active	3,300	Lane	Local	A1
C-647.84	UP	Eugene	Madison St	2	Active	2,300	Lane	Local	A1
C-647.92	UP	Eugene	Monroe St	2	Active	2,300	Lane	Local	A1
C-647.76	UP	Eugene	Jefferson St	3	Active	1,950	Lane	Collector	A1
C-647.50	UP	Eugene	Lincoln St	2	Active	550	Lane	Local	A1
C-646.68	UP	Eugene	8th Ave & Hillyard St	1	Active	99	Lane	Arterial	A1
C-653.20	UP	Eugene (Irving)	Irvington Dr 3195	2	Active	3,500	Lane	Collector	A1
3E-46.70	PNWR	Fargo	Bents Rd 425	1	Active	800	Marion	Collector	A2
3E-47.00	PNWR	Fargo	Fargo Rd 426	1	Passive	500	Marion	Local	A2
C-731.96	UP	Gervais	Douglas St Ne	1	Active	2,600	Marion	Collector	A1
C-732.20	UP	Gervais	Ivy Ave 72	1	Active	2,200	Marion	Collector	A1
C-730.00	UP	Gervais	Concomly Rd 526	1	Active	480	Marion	Local	A1
C-731.00	UP	Gervais	Keene Rd 524	1	Active	440	Marion	Local	A1
C-758.12	UP	Gladstone	Edgewater Rd At 82nd Drive	1	Active	268	Clackamas	Local	A1/A2
C-687.90	UP	Hallawell	Ellingson Rd 350	2	Active	1,836	Linn	Arterial	A1
C-687.10	UP	Hallawell	Beta Rd 351	1	Passive	10	Linn	Local	A1
C-686.60	UP	Hallawell	Griffith Rd 352	1	Passive – upgrade planned	10	Linn	Local	A1
C-674.10	UP	Halsey	OSH 228	1	Active	5,000	Linn	Arterial	A1
C-672.10	UP	Halsey	Lake Crk-Brownsville Rd 23	1	Active	431	Linn	Collector	A1
C-673.80	UP	Halsey	H St	2	Active	127	Linn	Local	A1
C-671.10	UP	Halsey	Twin Butte W Dr 29	1	Passive – closure planned	70	Linn	Local	A1
C-673.10	UP	Halsey	Seefeld Rd 504	2	Active	68	Linn	Local	A1
C-676.10	UP	Halsey	Oak Plain Dr 212	1	Passive – upgrade planned	10	Linn	Local	A1
C-664.70	UP	Harrisburg	La Salle St	1	Active	5,010	Linn	Collector	A1
C-665.10	UP	Harrisburg	Territorial St	1	Active	3,666	Linn	Arterial	A1
C-665.00	UP	Harrisburg	Smith St	1	Active	1,230	Linn	Local	A1
C-740.60	UP	Hito	Grim Rd 441	1	Active	1,600	Marion	Collector	A1
3E-63.10	PNWR	Hopmere	Brooklake Rd NE 609	1	Active	7,610	Marion	Arterial	A2
C-738.90	UP	Hubbard	D St	1	Active	3,816	Marion	Collector	A1
C-738.70	UP	Hubbard	G St	1	Active	3,003	Marion	Collector	A1
C-739.00	UP	Hubbard	A Street	1	Active	1,460	Marion	Collector	A1

Crossing ID	Operating Railroad	Location	Street Name	Tracks	Device Type	AADT	County	Functional Classification (Generalized)	Alternative
C-652.20	UP	Irving	Irving Rd 3268	2	Active	5,400	Lane	Arterial	A1
C-654.00	UP	Irving	Awbrey Ln E 3440	1	Active	1,050	Lane	Collector	A1
C-655.70	UP	Irving	Meadow View Rd E 3446	1	Active	380	Lane	Collector	A1
C-699.10	UP	Jefferson	Main St	1	Active	4,300	Marion	Collector	A1
C-699.40	UP	Jefferson	Hazel St	1	Active	1,670	Marion	Collector	A1
C-697.90	UP	Jefferson	Cnty Rd 33 (Scravel Hill Road)	1	Active	408	Linn	Collector	A1
C-699.80	UP	Jefferson	N Cemetery Hill Rd (North Av)	1	Active	300	Marion	Collector	A1
C-699.30-E	UP	Jefferson	Third St Ped Xing	1	Passive	N/A	Marion	Local	A1
C-660.30	UP	Junction City	First Ave E 3100	2	Active	4,400	Lane	Arterial	A1
C-658.63	UP	Junction City	Prairie Rd 3470	1	Active	3,450	Lane	Collector	A1
C-660.60	UP	Junction City	6th St (Main)	1	Active	2,650	Lane	Collector	A1
C-660.90	UP	Junction City	10th Ave W	1	Active	950	Lane	Collector	A1
C-660.50	UP	Junction City	4th Ave W	2	Active	250	Lane	Local	A1
C-661.30	UP	Junction City	18th Ave E 3475	1	Active	220	Lane	Collector	A1
3E-66.25	PNWR	Keizer	Chemawa Rd	1	Active	13,793	Marion	Arterial	A2
C-725.30	UP	Lake Labish	Perkins St NE 615	1	Active	520	Marion	Local	A1
C-706.00	UP	Marion	Duck Flat Rd 929	1	Passive	614	Marion	Local	A1
C-704.12	UP	Marion	Marion Hill Road	1	Active	99	Marion	Local	A1
C-702.20	UP	Marion	Libby Lane 933	1	Passive	90	Marion	Local	A1
C-762.40	UP	Milwaukie	SE Harmony Rd At Linnwood	1	Active	15,500	Clackamas	Arterial	A1/A2
C-764.30	UP	Milwaukie	Harrison St	1	Active	10,500	Clackamas	Arterial	A1/A2
C-764.10	UP	Milwaukie	Oak St	1	Active	9,500	Clackamas	Collector	A1/A2
C-763.90	UP	Milwaukie	37th Ave	1	Active	6,800	Clackamas	Collector	A1/A2
C-755.70	UP	Oregon City	10th St	1	Active	12,300	Clackamas	Arterial	A1
C-755.79-E	UP	Oregon City	11th St Ped Xing	1	Passive	N/A	Clackamas	Local	A1
C-757.30	UP	Park Place	Forsythe Rd (First St)	1	Active	375	Clackamas	Local	A1/A2
2A-0.30	UP	Portland	NW Front Ave	2	Active	12,130	Multnomah	Arterial	A1/A2
C-768.50	UP	Portland	SE 11th Ave	2	Active	10,040	Multnomah	Arterial	A1/A2
C-768.43	UP	Portland	SE 12th Ave	2	Active	9,340	Multnomah	Arterial	A1/A2
C-769.24	UP	Portland	SE Clay St	2	Active	5,630	Multnomah	Collector	A1
C-768.68	UP	Portland	SE 8th Ave	4	Active	4,500	Multnomah	Collector	A1/A2
C-769.73	UP	Portland	SE Washington	2	Active	4,470	Multnomah	Local	A1
C-769.78	UP	Portland	SE Stark	2	Active	4,350	Multnomah	Collector	A1
C-769.58	UP	Portland	SE Belmont	2	Active	3,740	Multnomah	Local	A1
5D-0.60	PTO	Portland	NW 15th Near NW Front Ave	2	Active	3,500	Multnomah	Local	A1/A2
C-769.48	UP	Portland	SE Taylor	2	Active	2,900	Multnomah	Collector	A1
C-769.53	UP	Portland	SE Yamhill	2	Active	2,600	Multnomah	Collector	A1
7A-0.29	PTO	Portland	NW 9th Av	2	Active	2,398	Multnomah	Collector	A1/A2
5D-1.20	BNSF	Portland	NW 21st Av	2	Active	2,345	Multnomah	Collector	A1/A2
5D-1.29	BNSF	Portland	NW Nicolai St	3	Active	2,130	Multnomah	Collector	A1/A2
C-769.68	UP	Portland	SE Alder	2	Active	1,500	Multnomah	Local	A1

Crossing ID	Operating Railroad	Location	Street Name	Tracks	Device Type	AADT	County	Functional Classification (Generalized)	Alternative
C-769.63	UP	Portland	SE Morrison	2	Active	1,400	Multnomah	Local	A1
C-769.29	UP	Portland	SE Hawthorne	2	Active	1,300	Multnomah	Local	A1
C-769.33	UP	Portland	SE Madison	2	Active	1,300	Multnomah	Local	A1
C-769.38	UP	Portland	SE Main	2	Active	1,140	Multnomah	Local	A1
5D-0.80	BNSF	Portland	NW 17th	2	Active	1,007	Multnomah	Local	A1/A2
C-769.43	UP	Portland	SE Salmon St	2	Active	500	Multnomah	Local	A1
2A-0.32-E	UP	Portland	Willamette Greenway Path	2	Active	N/A	Multnomah	Arterial	A1/A2
3E-64.20	PNWR	Quinaby	Quinaby Rd 613	1	Active	1,280	Marion	Collector	A2
3E-64.70	PNWR	Quinaby	Perkins St 615	1	Passive	620	Marion	Collector	A2
C-716.20	UP	Salem	Madrona Ave Se	1	Active	18,849	Marion	Arterial	A1
C-719.40	UP	Salem	Market St	1	Active	17,990	Marion	Arterial	A1
C-720.30	UP	Salem	Silverton Rd	1	Active	16,710	Marion	Arterial	A1
C-721.79	UP	Salem	Hyacinth St	3	Active	15,540	Marion	Arterial	A1
C-718.76	UP	Salem	Center St	1	Active	13,555	Marion	Arterial	A1
C-717.10	UP	Salem	McGilchrist Street	2	Active	11,327	Marion	Arterial	A1
C-718.52	UP	Salem	State St	1	Active	10,550	Marion	Arterial	A1
C-718.60	UP	Salem	Court St	1	Active	9,350	Marion	Arterial	A1
C-718.83	UP	Salem	Marion St	1	Active	9,185	Marion	Arterial	A1
C-719.20	UP	Salem	D St	1	Active	7,270	Marion	Arterial	A1
C-717.80	UP	Salem	Hines St Se	2	Active	5,110	Marion	Collector	A1
C-720.00	UP	Salem	Sunnyview Rd (Tile)	1	Active	4,160	Marion	Arterial	A1
C-718.30	UP	Salem	Mill St SE	1	Active	3,320	Marion	Collector	A1
C-718.67	UP	Salem	Chemeketa	1	Active	2,900	Marion	Collector	A1
C-720.10	UP	Salem	Woodrow St	2	Active	2,350	Marion	Local	A1
C-722.70	UP	Salem	Blossom Drive NE	1	Active	2,320	Marion	Collector	A1
C-719.80	UP	Salem	Madison St	1	Active	2,250	Marion	Collector	A1
3E-66.80	PNWR	Salem	Keizer Rd At Ridge Rd Ne	1	Passive	261	Marion	Local	A2
C-676.60	UP	Shedd	Linn-West Rd 26	1	Active	896	Linn	Collector	A1
C-679.10	UP	Shedd	Boston Mill Dr (Mr 13)	2	Active	402	Linn	Collector	A1
C-681.20	UP	Shedd	Bell Plain Dr 419	1	Active	100	Linn	Local	A1
C-677.60	UP	Shedd	Pugh Dairy Dr (421)	1	Passive – upgrade planned	50	Linn	Local	A1
C-680.90	UP	Shedd	Sprenger Rd 433	1	Passive	50	Linn	Local	A1
C-679.00	UP	Shedd	C St (Public Rd)	3	Passive – closure planned	43	Linn	Local	A1
CF-620.70	UP	Springfield	2nd St	2	Active	2,307	Lane	Collector	A2
CF-620.50	UP	Springfield	5th St	1	Active	1,732	Lane	Collector	A2
CF-621.40	UP	Springfield Jct	19th Ave E	2	Active	950	Lane	Collector	A2
3E-57.40	PNWR	St. Louis	St Louis Rd 7	1	Active	1,180	Marion	Collector	A2
3E-58.40	PNWR	St. Louis	Keene Rd 524	1	Passive	390	Marion	Local	A2
C-657.30	UP	Swain	Milliron Rd E 3450	1	Active	500	Lane	Local	A1

Crossing ID	Operating Railroad	Location	Street Name	Tracks	Device Type	AADT	County	Functional Classification (Generalized)	Alternative
C-684.80	UP	Tangent	Tangent Dr Mr 22	1	Active	1,079	Linn	Collector	A1
C-684.60	UP	Tangent	Bird Foot Dr 401("B" St)	1	Active	835	Linn	Collector	A1
C-685.90	UP	Tangent	Old Hwy 34 (Frontage Rd)	1	Active	400	Linn	Collector	A1
C-683.20	UP	Tangent	Driver Rd 418	1	Active	114	Linn	Local	A1
C-711.00	UP	Turner	Delaney Rd Se	1	Active	2,800	Marion	Arterial	A1
C-710.70	UP	Turner	Chicago St ("C" St)	1	Active	1,018	Marion	Collector	A1
C-706.90	UP	Turner	Hunsaker Rd SE 940	1	Active	520	Marion	Local	A1
C-709.40	UP	Turner	Hennies Rd SE 927a	1	Active	400	Marion	Local	A1
3E-54.60	PNWR	W Woodburn	Hillsb-Silverton Hwy 219	2	Active	4,300	Marion	Arterial	A2
3E-53.60	PNWR	W Woodburn	Crosby Rd 505	1	Active	1,080	Marion	Local	A2
3E-53.00	PNWR	W Woodburn	Sleepy Hollow Rd 419	1	Passive	410	Marion	Local	A2
3E-55.90	PNWR	W Woodburn	Lebrun Rd 518	1	Passive	200	Marion	Local	A2
3E-61.30	PNWR	Waconda	Waconda Rd 602	1	Passive	880	Marion	Collector	A2
3E-59.50	PNWR	Waconda	Concomly Rd 526	1	Passive	360	Marion	Local	A2
3E-42.60	PNWR	Wilsonville	Wilsonville Road	1	Active	19,000	Clackamas	Arterial	A2
3E-42.10	PNWR	Wilsonville	Barber St	1	Active	6,400	Clackamas	Collector	A2
3E-43.00	PNWR	Wilsonville	5th St (Nutting Rd)	1	Passive	100	Clackamas	Local	A2
C-735.50	UP	Woodburn	Hardcastle Street	1	Active	4,100	Marion	Collector	A1
C-735.29	UP	Woodburn	Lincoln St	2	Active	3,670	Marion	Collector	A1
C-735.16	UP	Woodburn	Young St	3	Active	3,638	Marion	Arterial	A1
C-735.05	UP	Woodburn	Cleveland St	2	Active	3,271	Marion	Collector	A1
C-734.50	UP	Woodburn	Boones Fy Rd 38 & Front St	1	Active	2,779	Marion	Arterial	A1

Shaded rows indicate passive crossings. Three crossings (shaded orange) are planned for upgrades by ODOT and included in the No Action Alternative. Two crossings, shaded in peach, are planned for closure by ODOT and included in the No Action Alternative.

Appendix D
Map Book

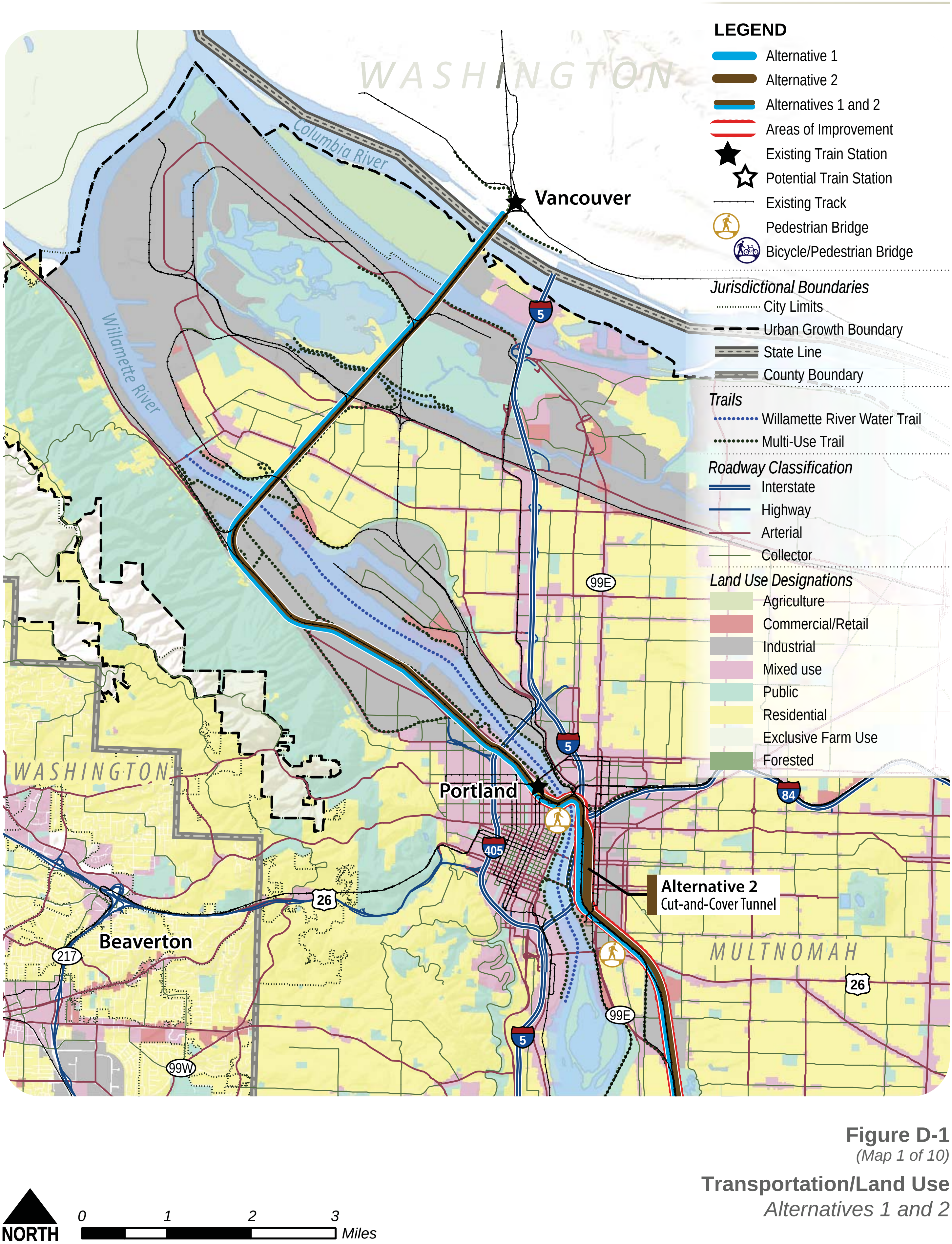


Figure D-1
(Map 1 of 10)

Transportation/Land Use
Alternatives 1 and 2

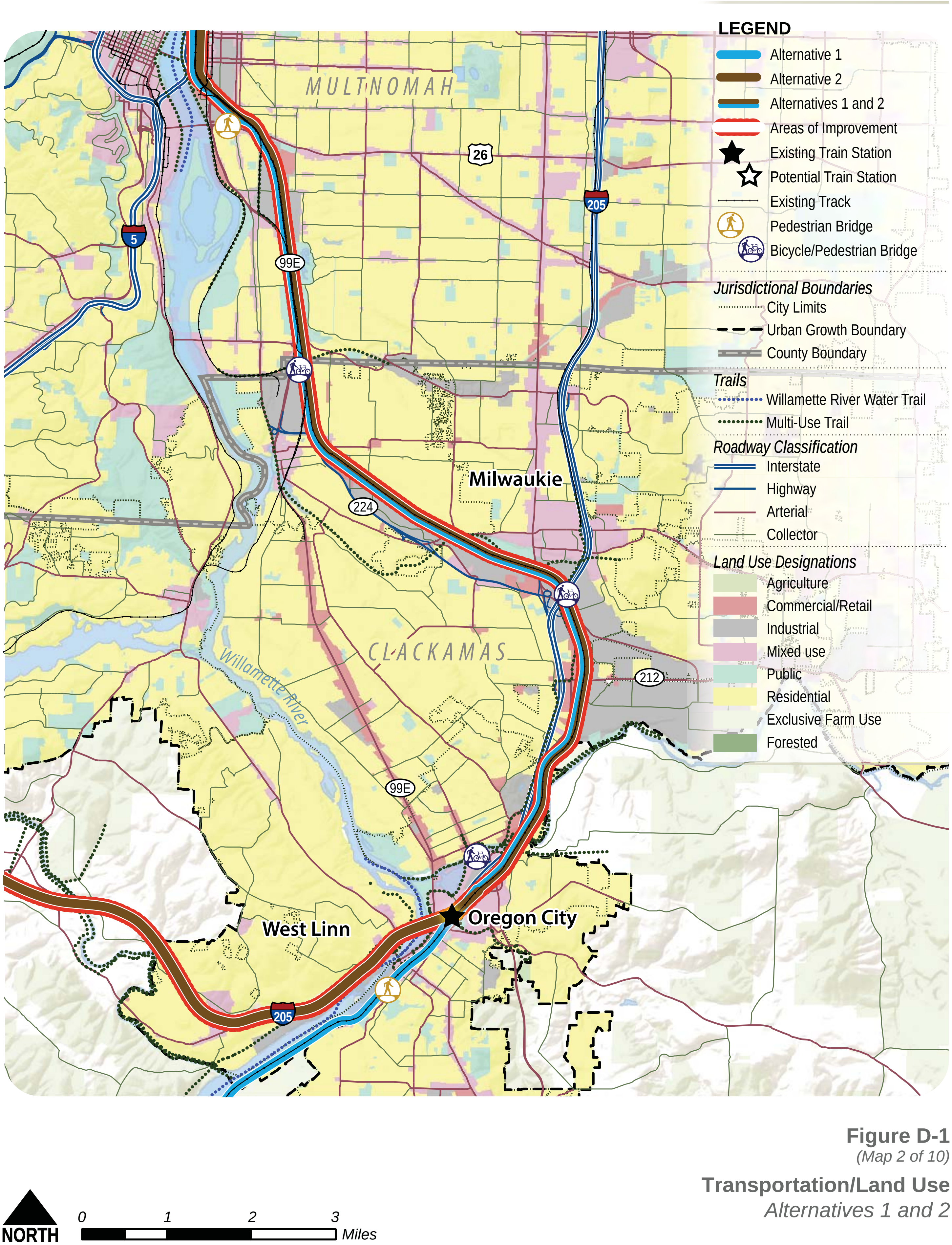


Figure D-1
(Map 2 of 10)

Transportation/Land Use
Alternatives 1 and 2

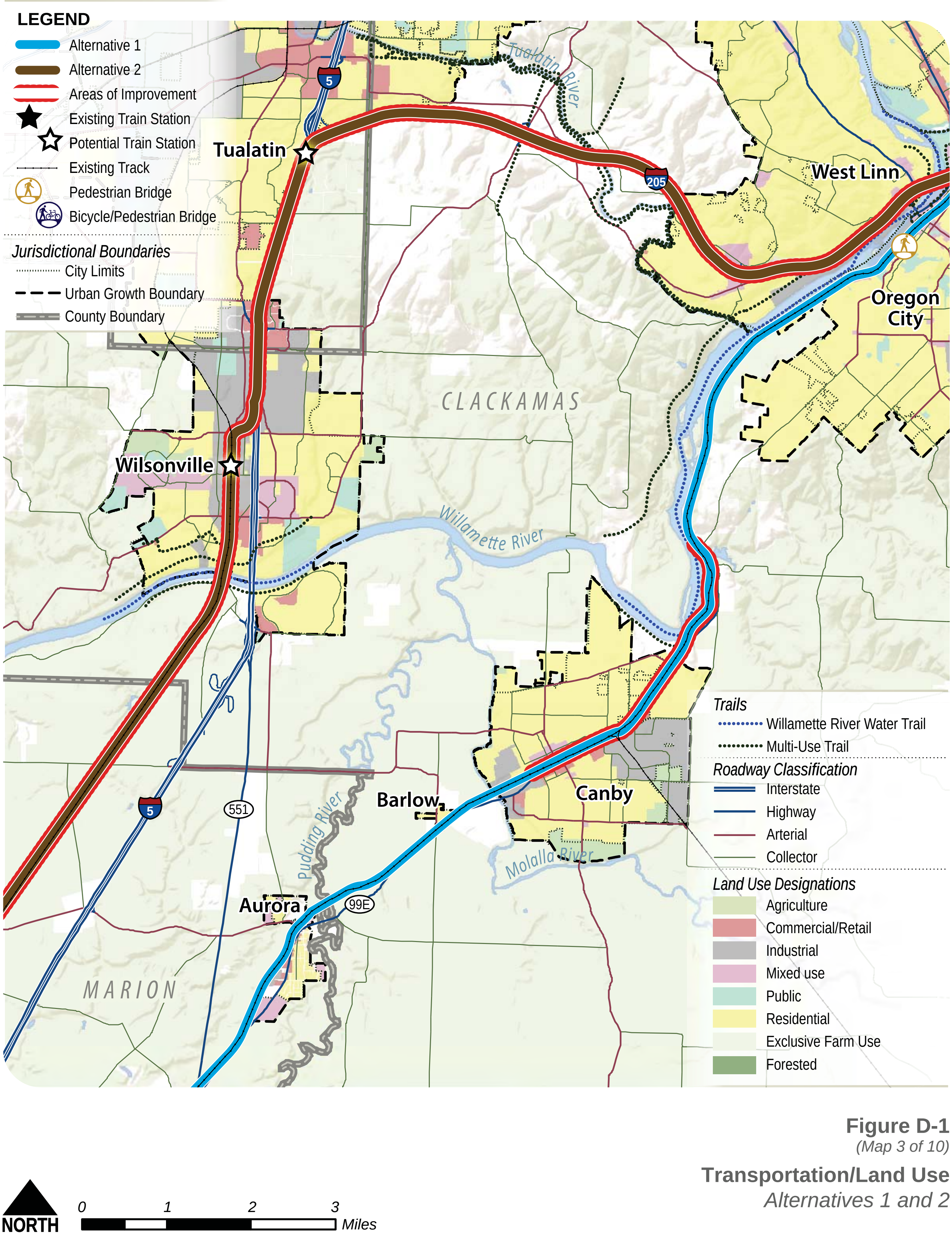


Figure D-1
(Map 3 of 10)

Transportation/Land Use
Alternatives 1 and 2

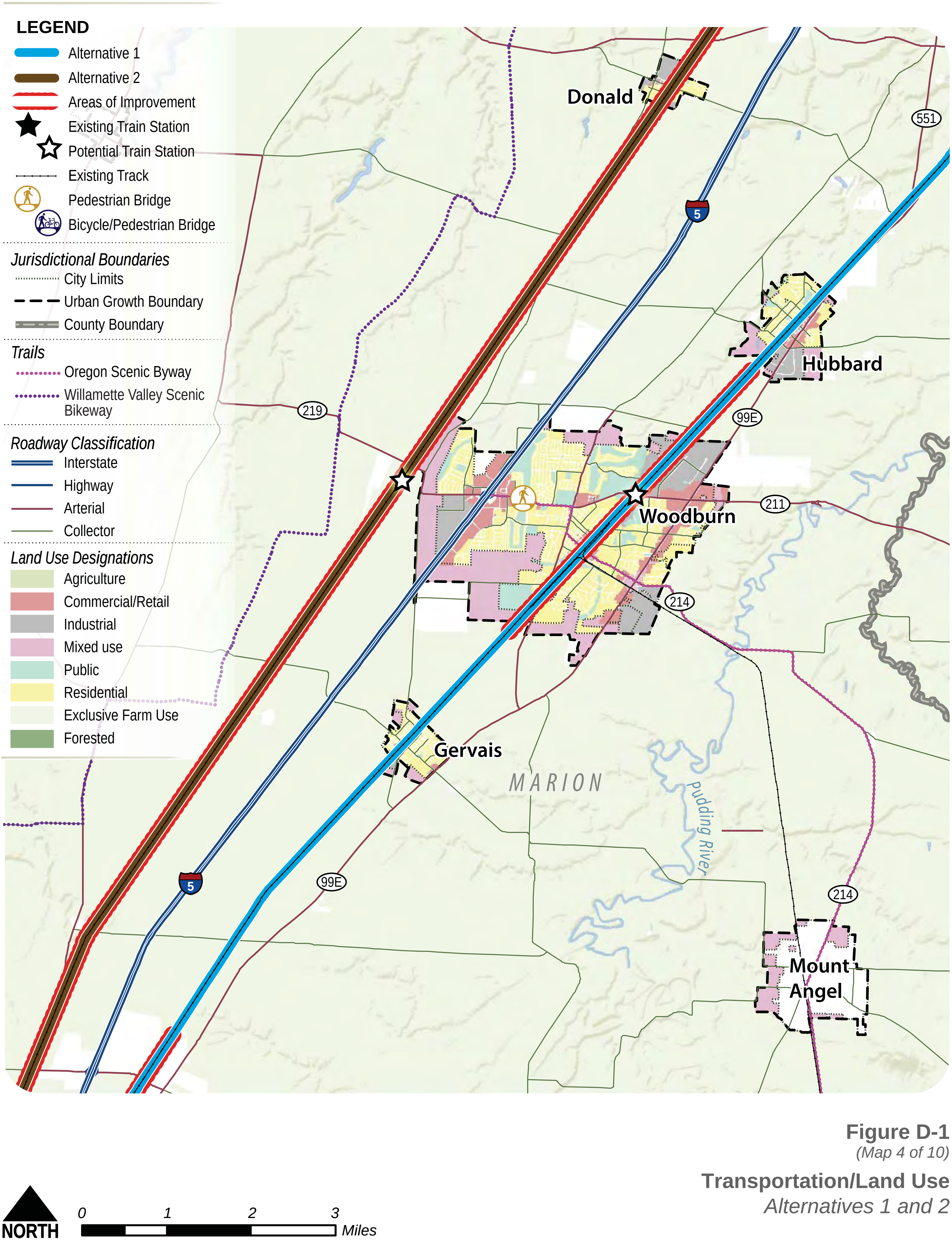


Figure D-1
(Map 4 of 10)

Transportation/Land Use
Alternatives 1 and 2

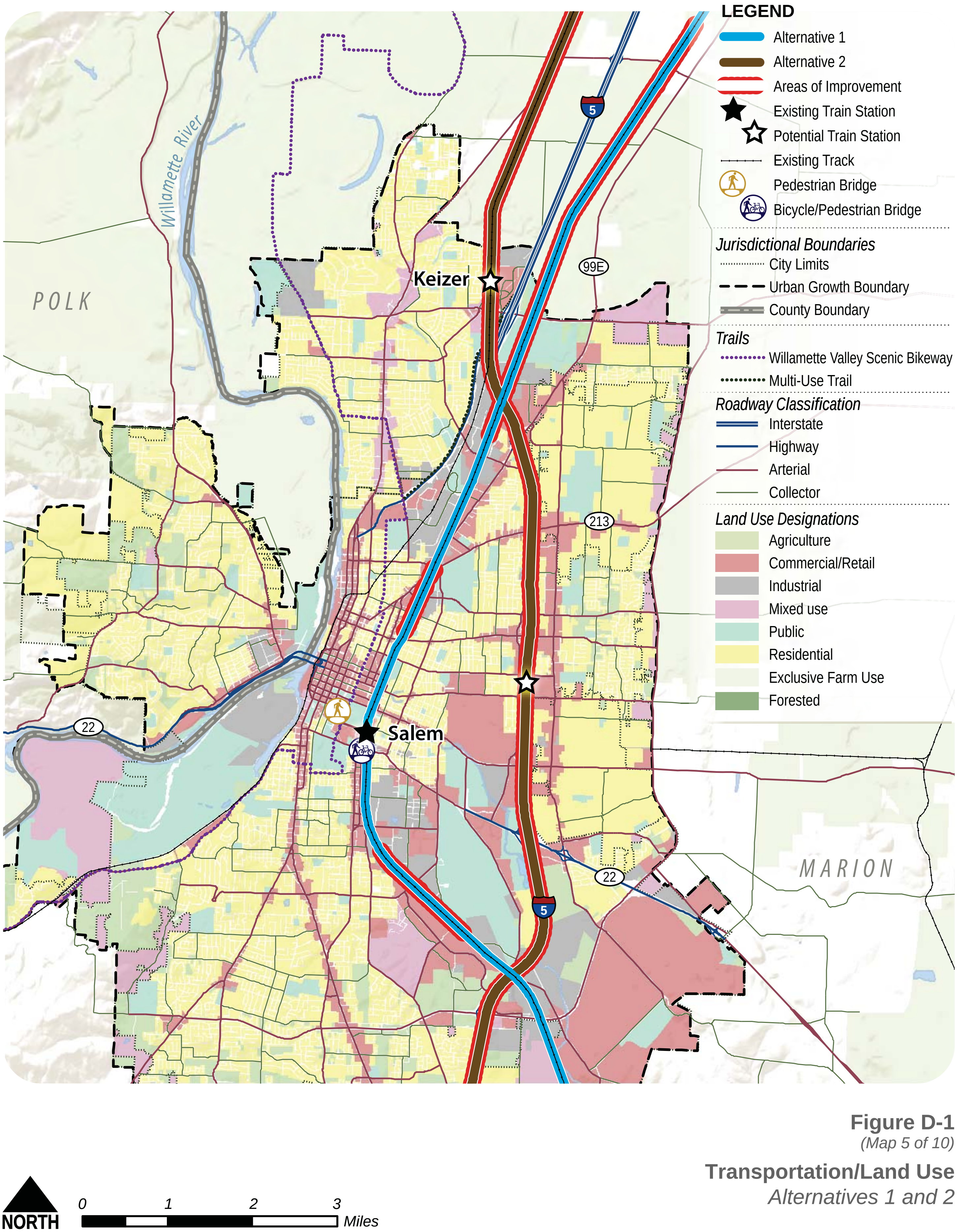


Figure D-1
(Map 5 of 10)

Transportation/Land Use
Alternatives 1 and 2

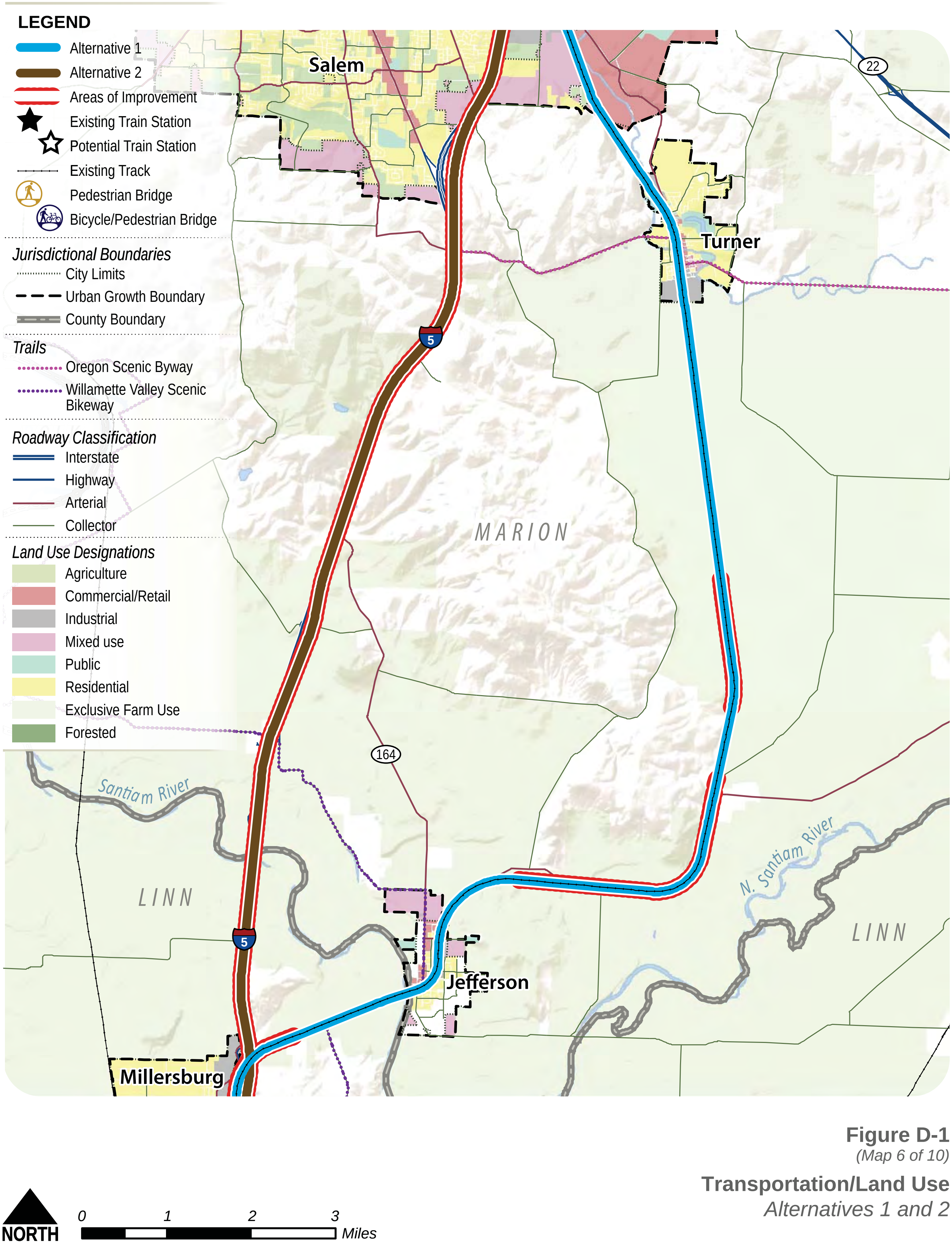


Figure D-1
(Map 6 of 10)

Transportation/Land Use
Alternatives 1 and 2

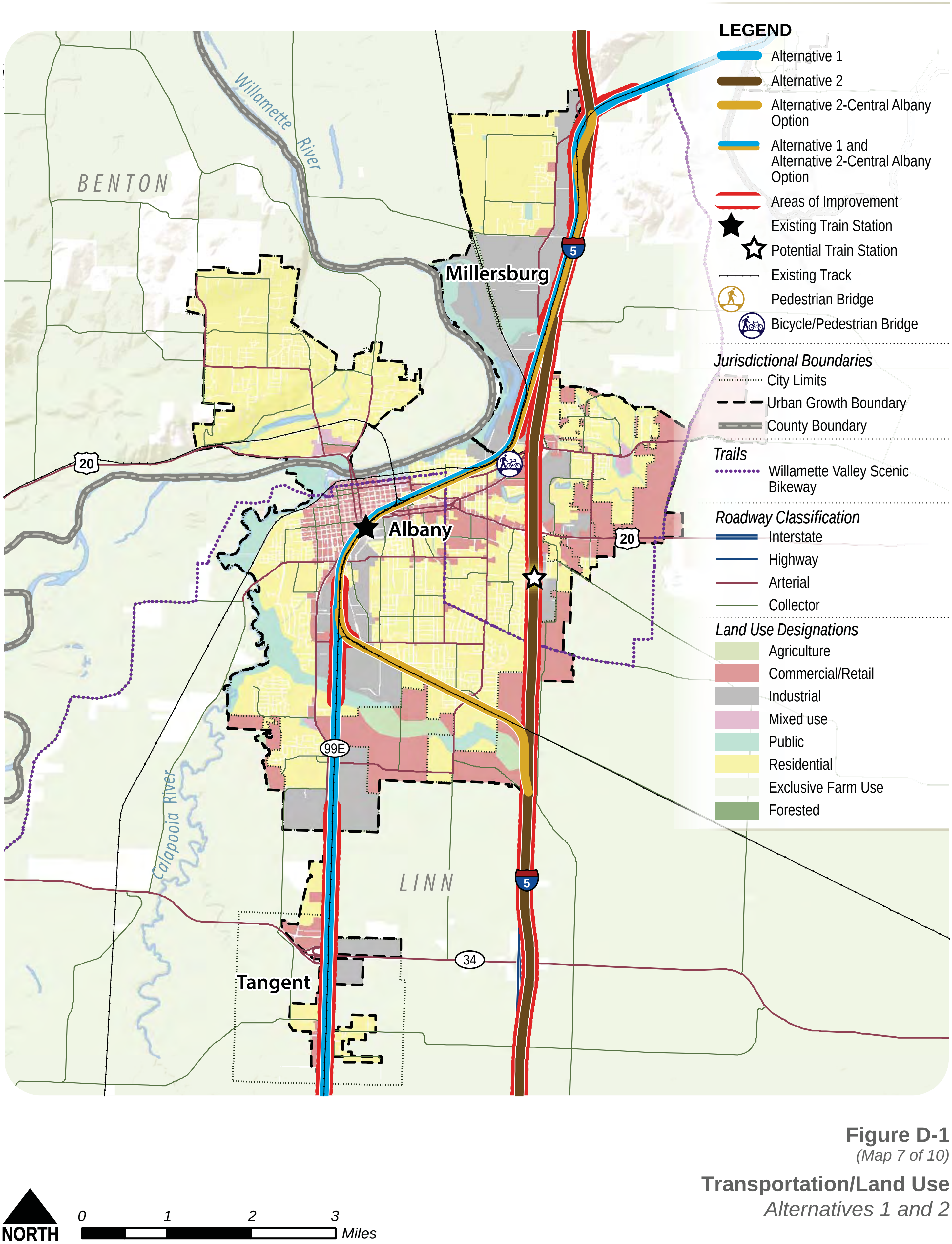


Figure D-1
(Map 7 of 10)

Transportation/Land Use
Alternatives 1 and 2

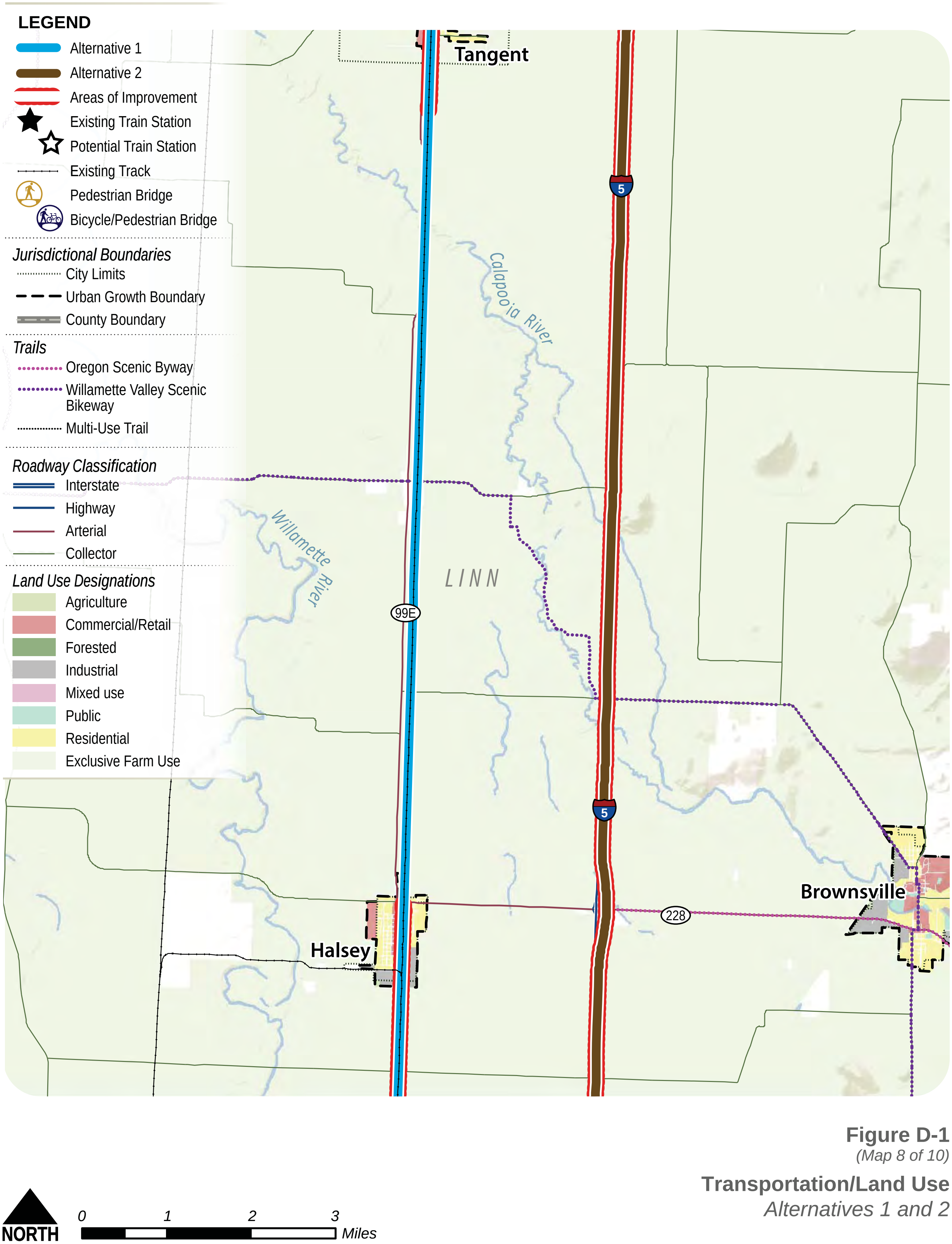


Figure D-1
(Map 8 of 10)

Transportation/Land Use
Alternatives 1 and 2

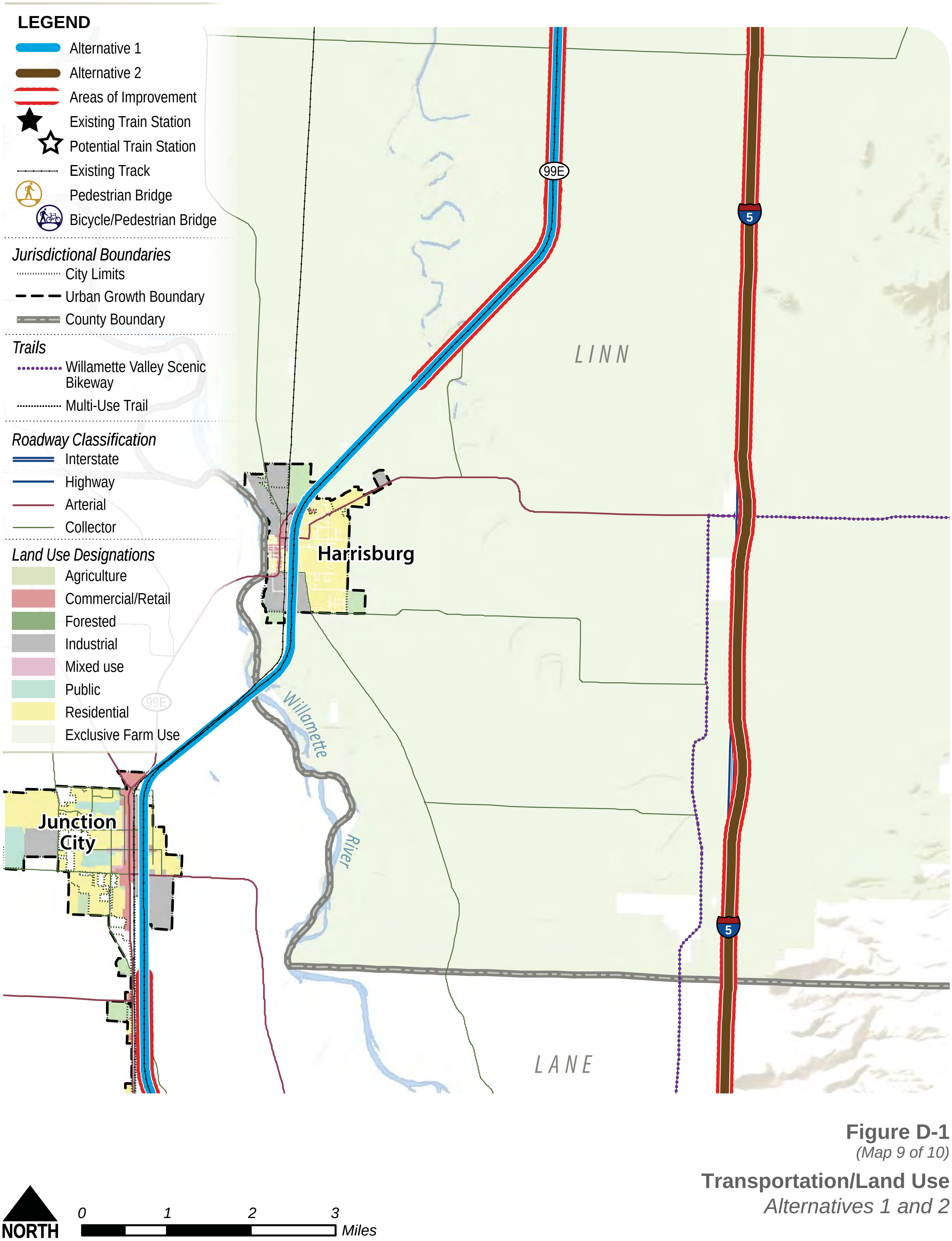


Figure D-1
(Map 9 of 10)

Transportation/Land Use
Alternatives 1 and 2

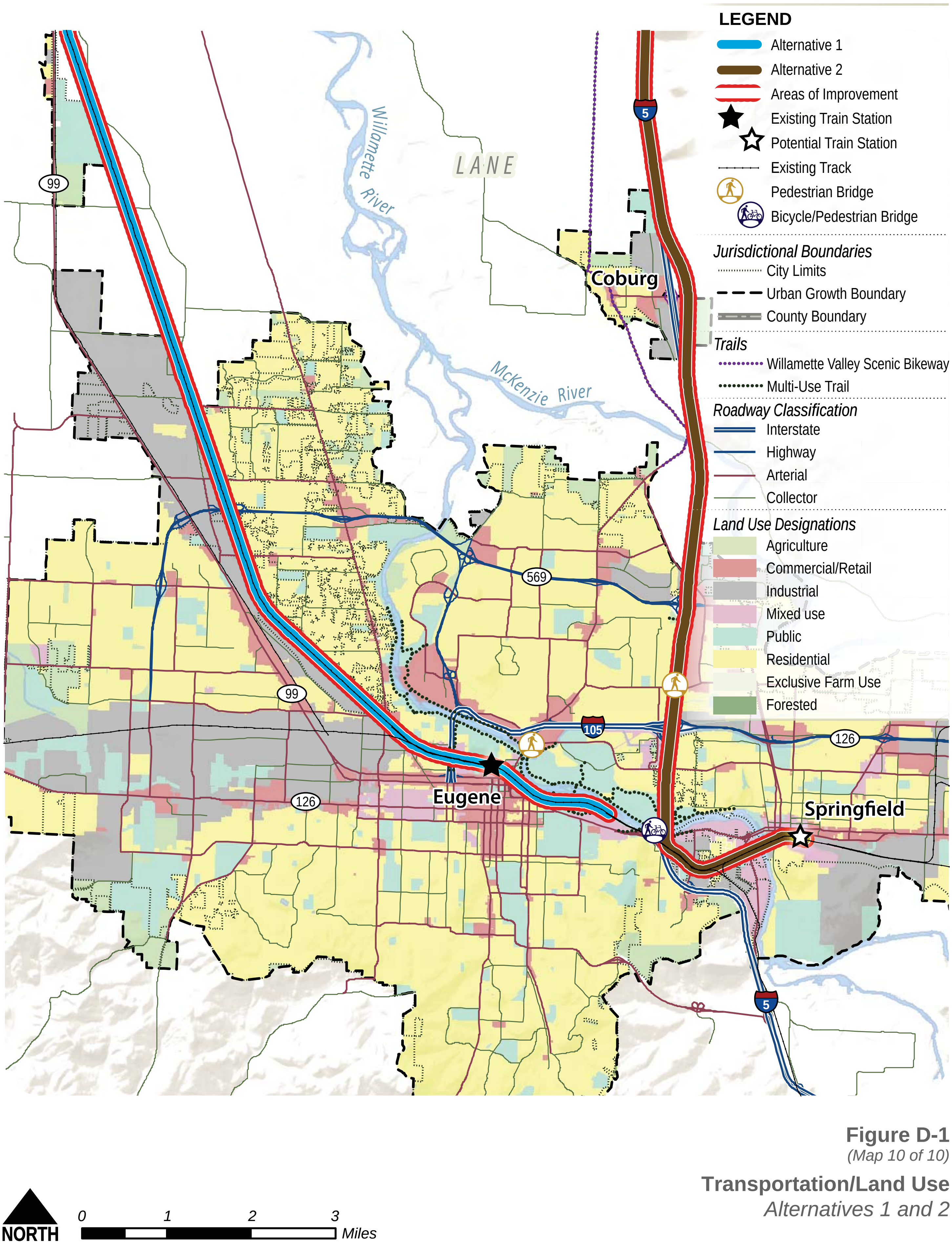


Figure D-1
(Map 10 of 10)

Transportation/Land Use
Alternatives 1 and 2

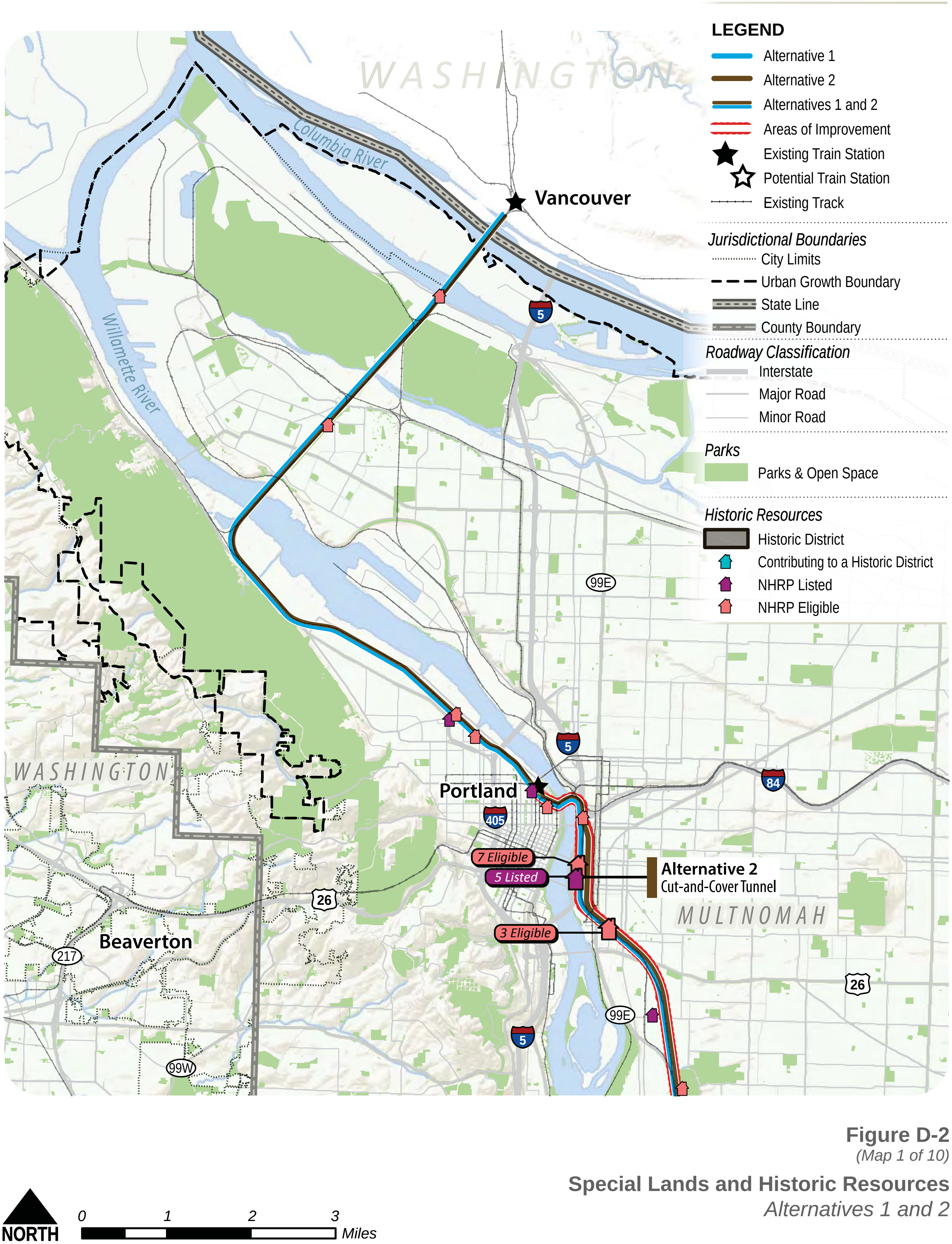


Figure D-2
(Map 1 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

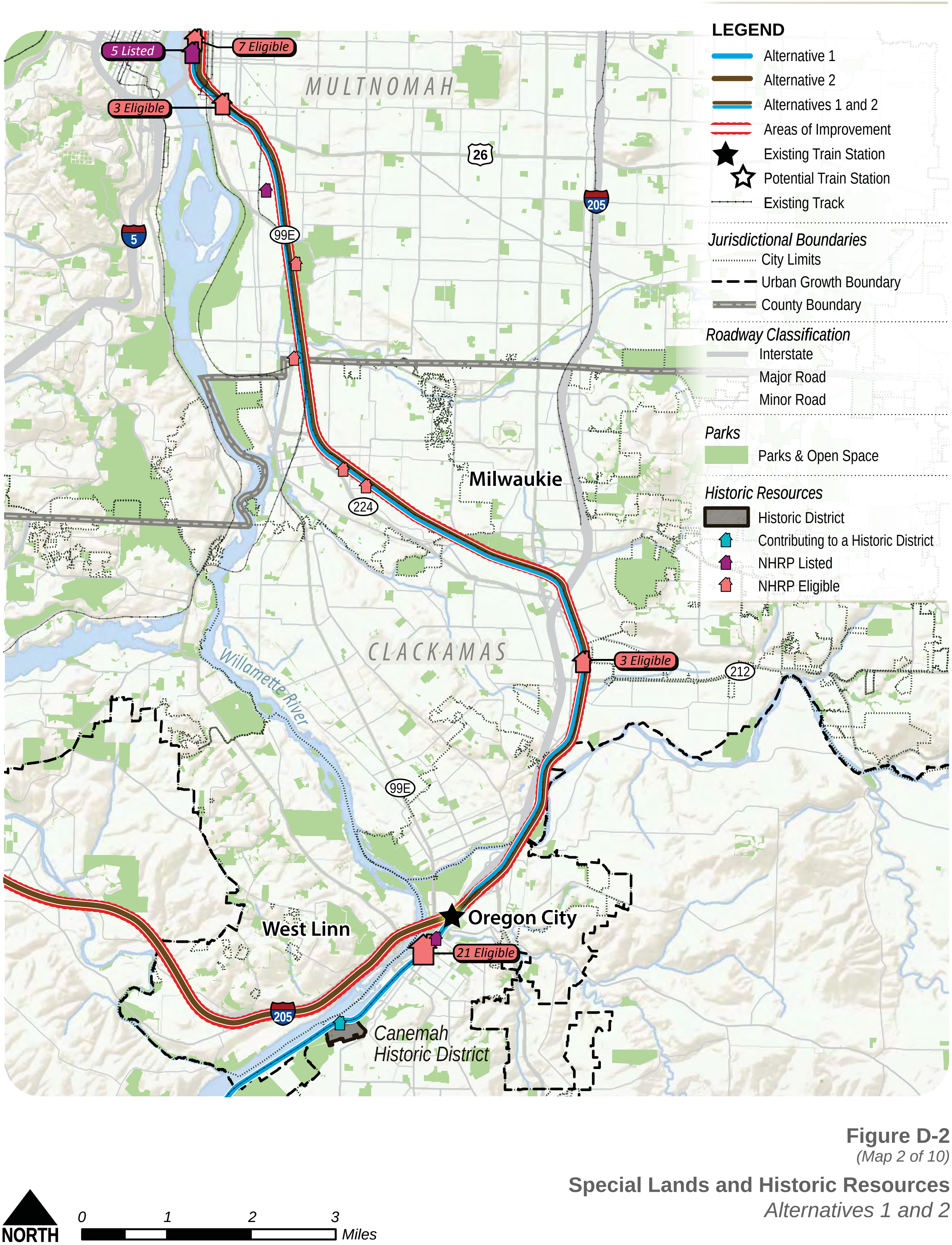


Figure D-2
(Map 2 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

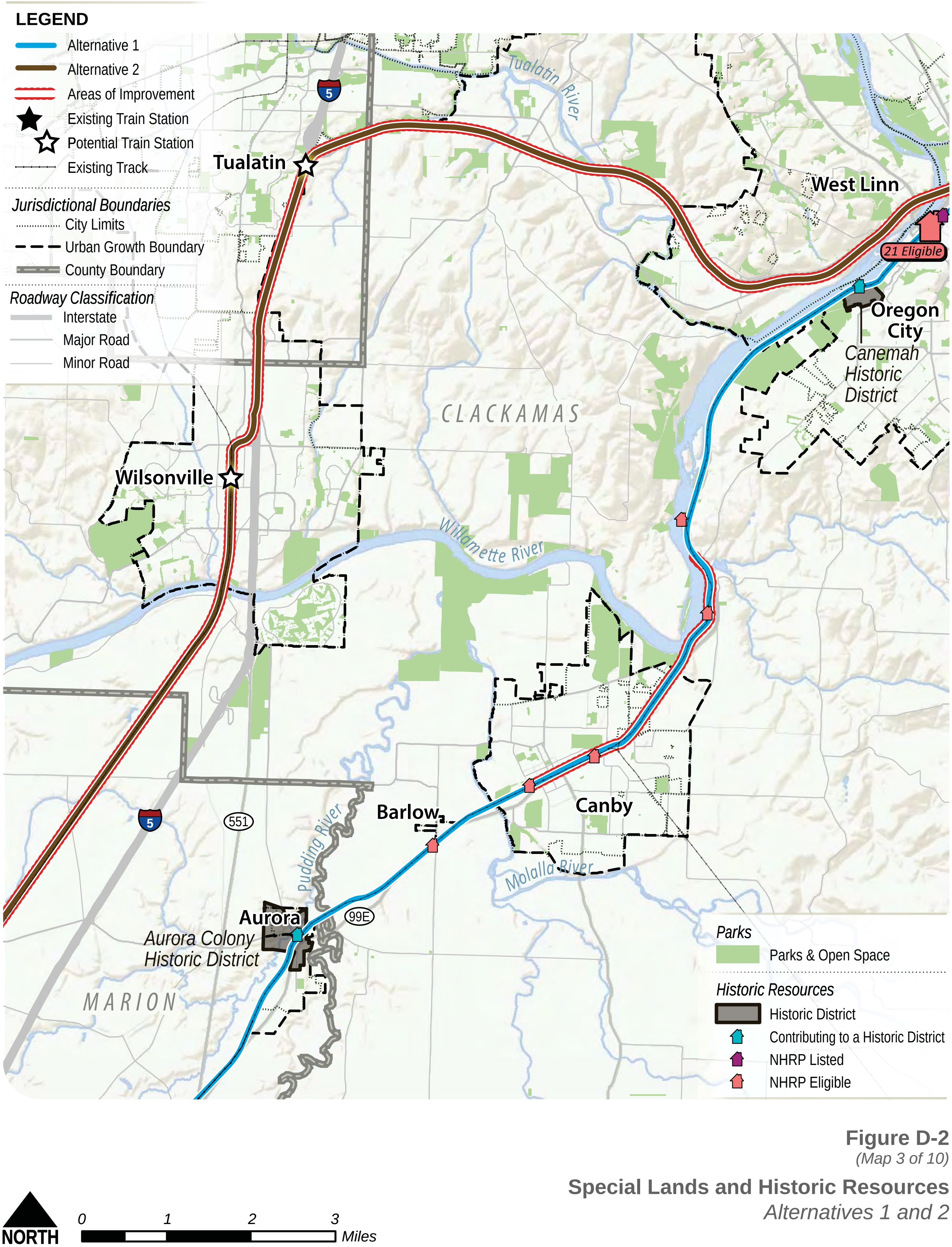


Figure D-2

(Map 3 of 10)

Special Lands and Historic Resources

Alternatives 1 and 2

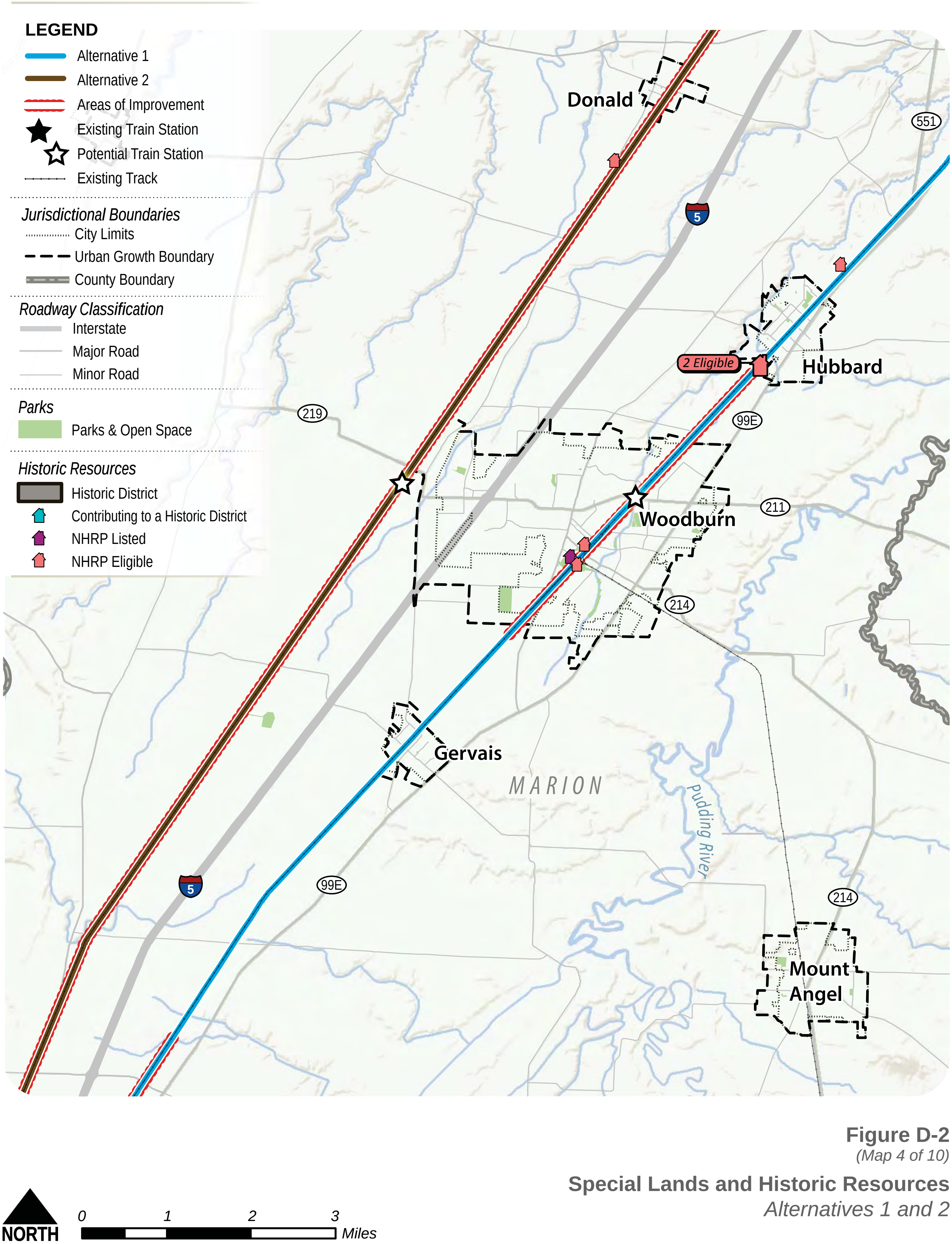
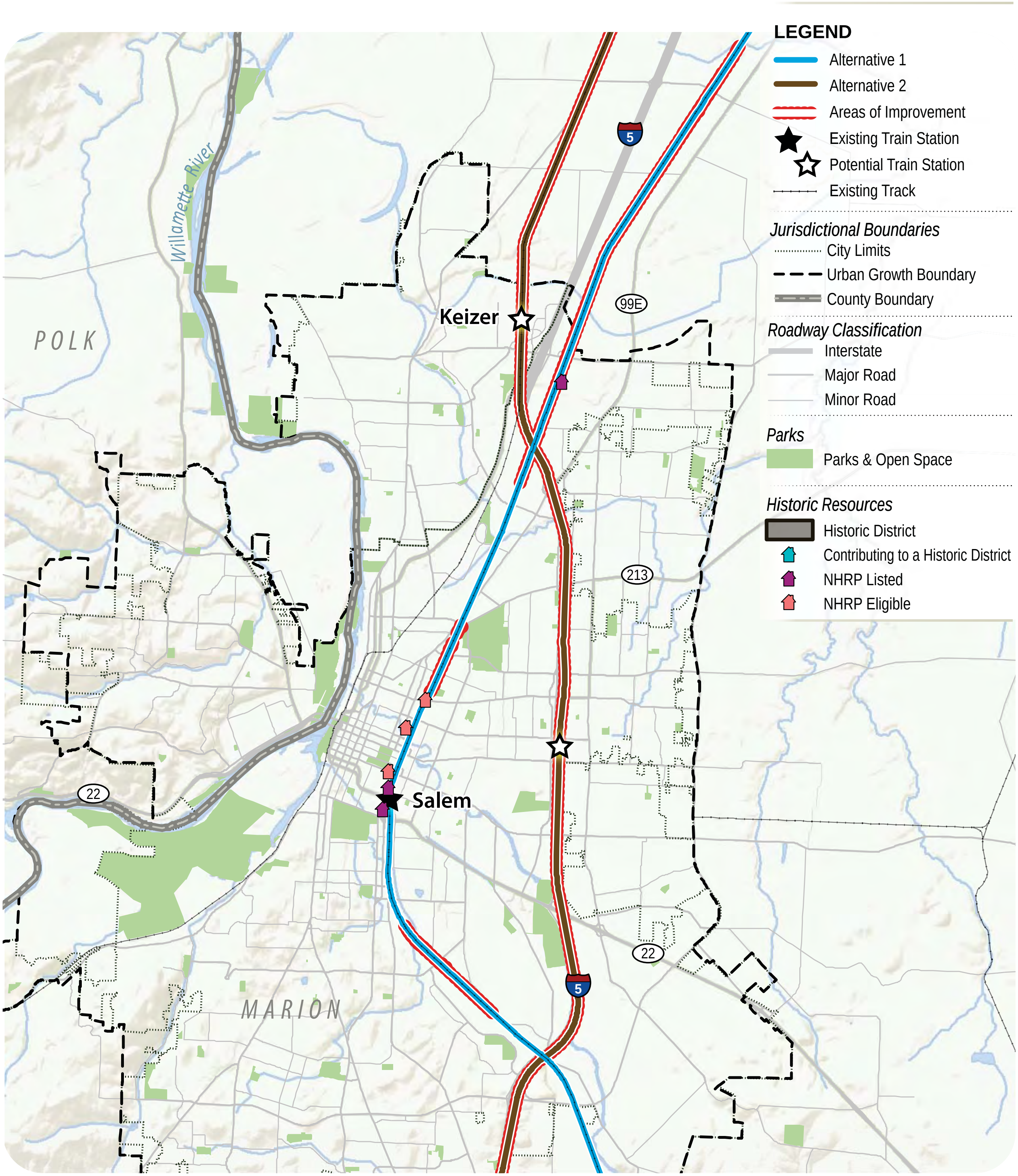


Figure D-2
(Map 4 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2



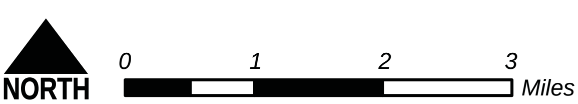


Figure D-2
(Map 5 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

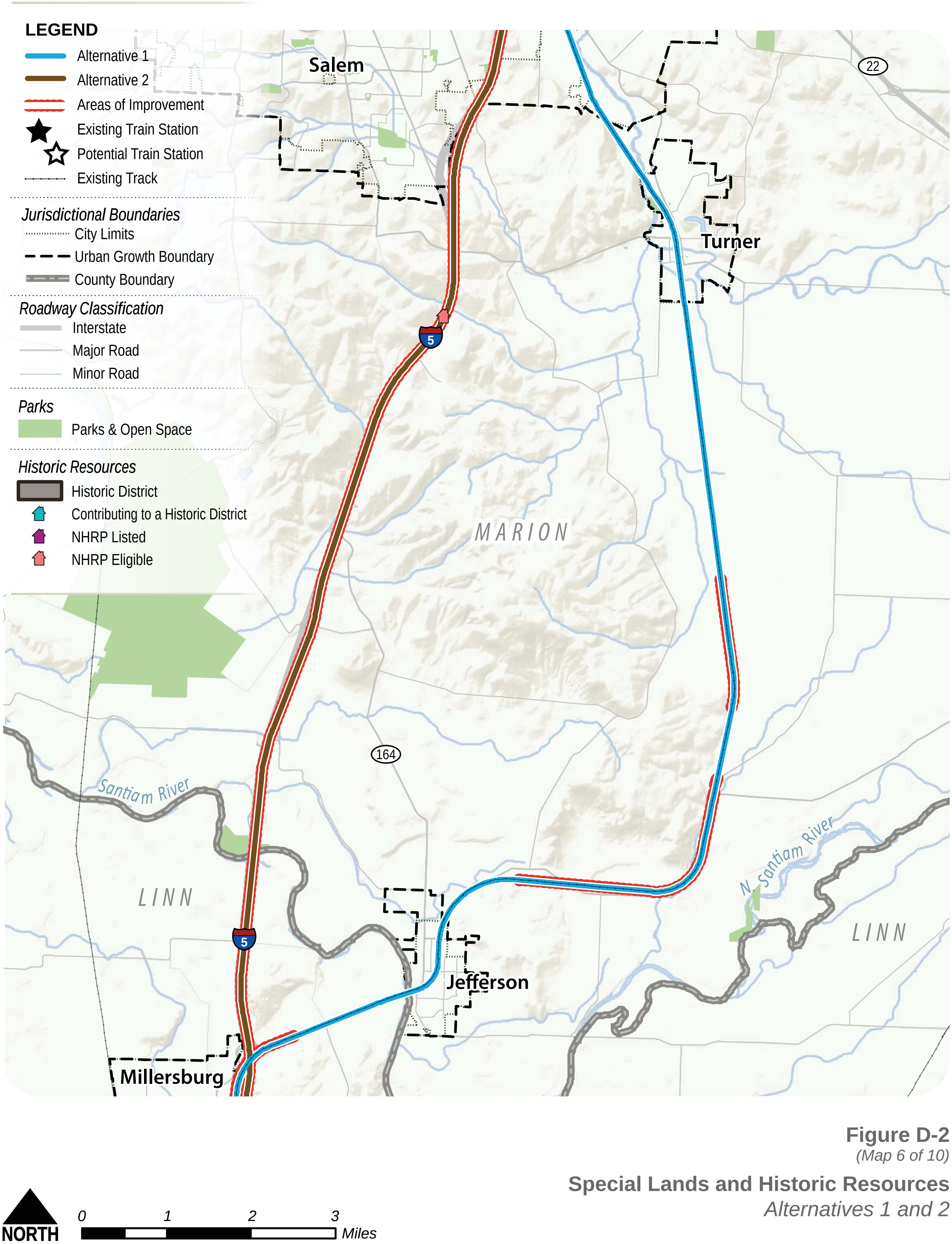


Figure D-2
(Map 6 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

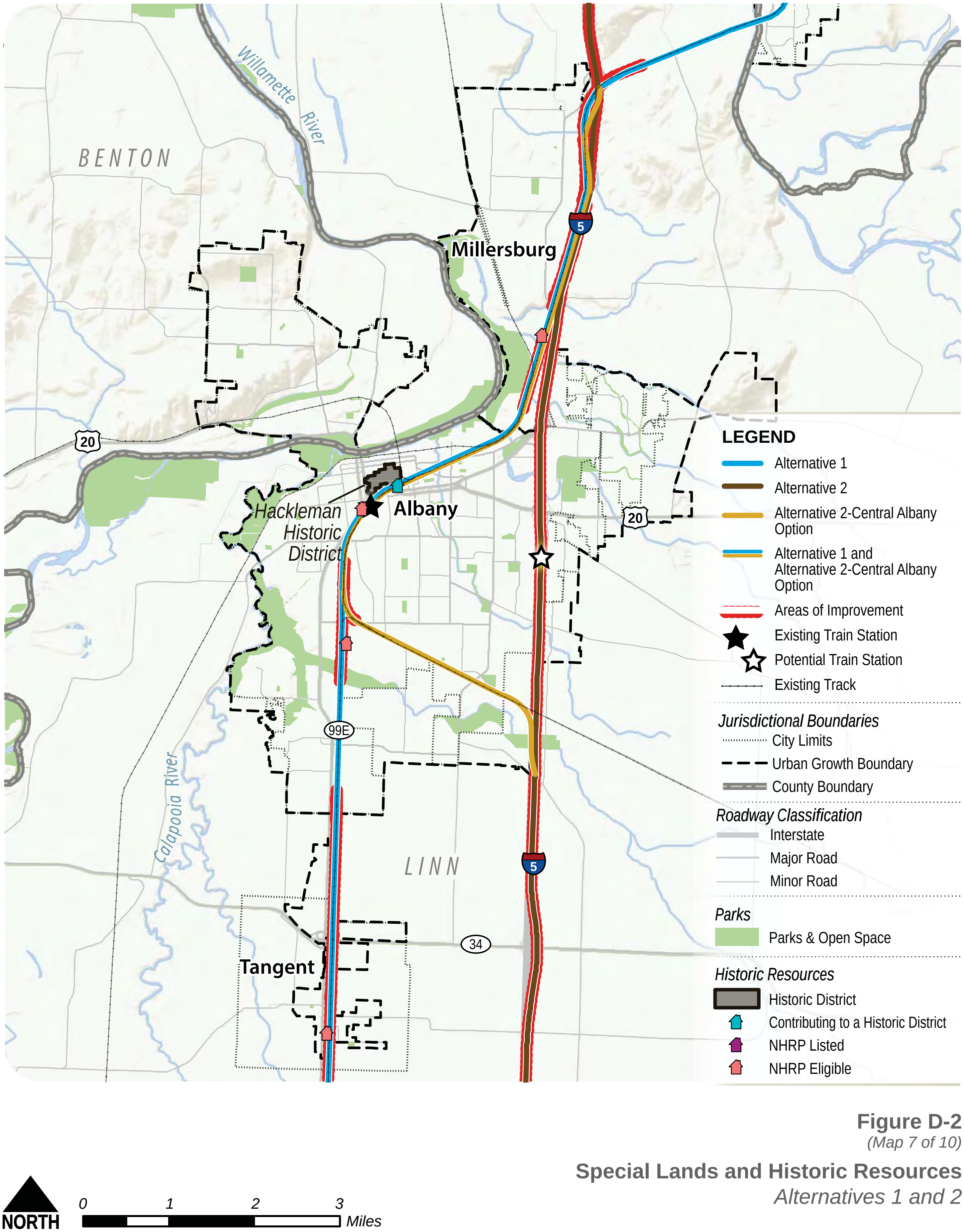


Figure D-2
(Map 7 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

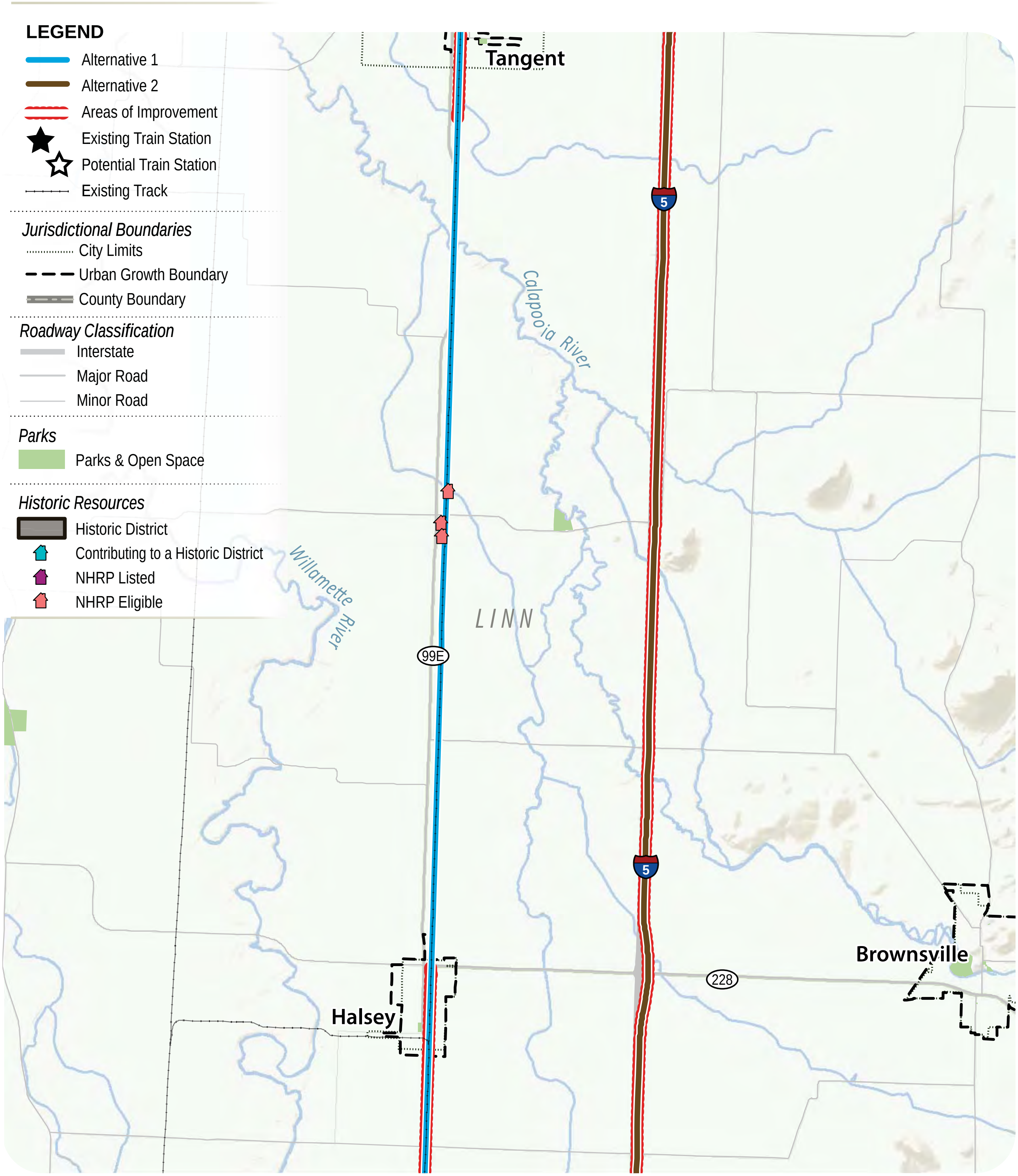


Figure D-2
(Map 8 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

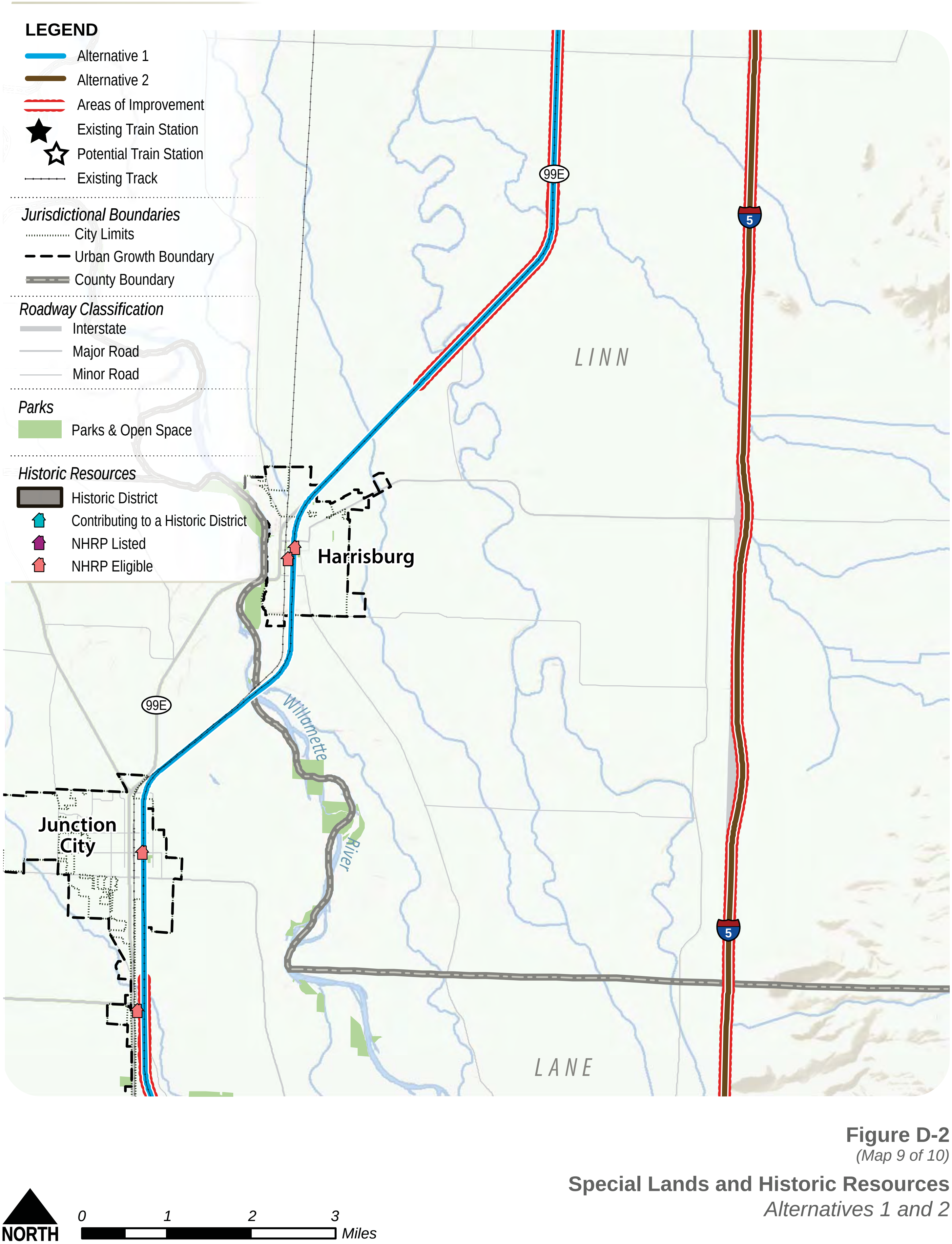


Figure D-2

(Map 9 of 10)

Special Lands and Historic Resources

Alternatives 1 and 2

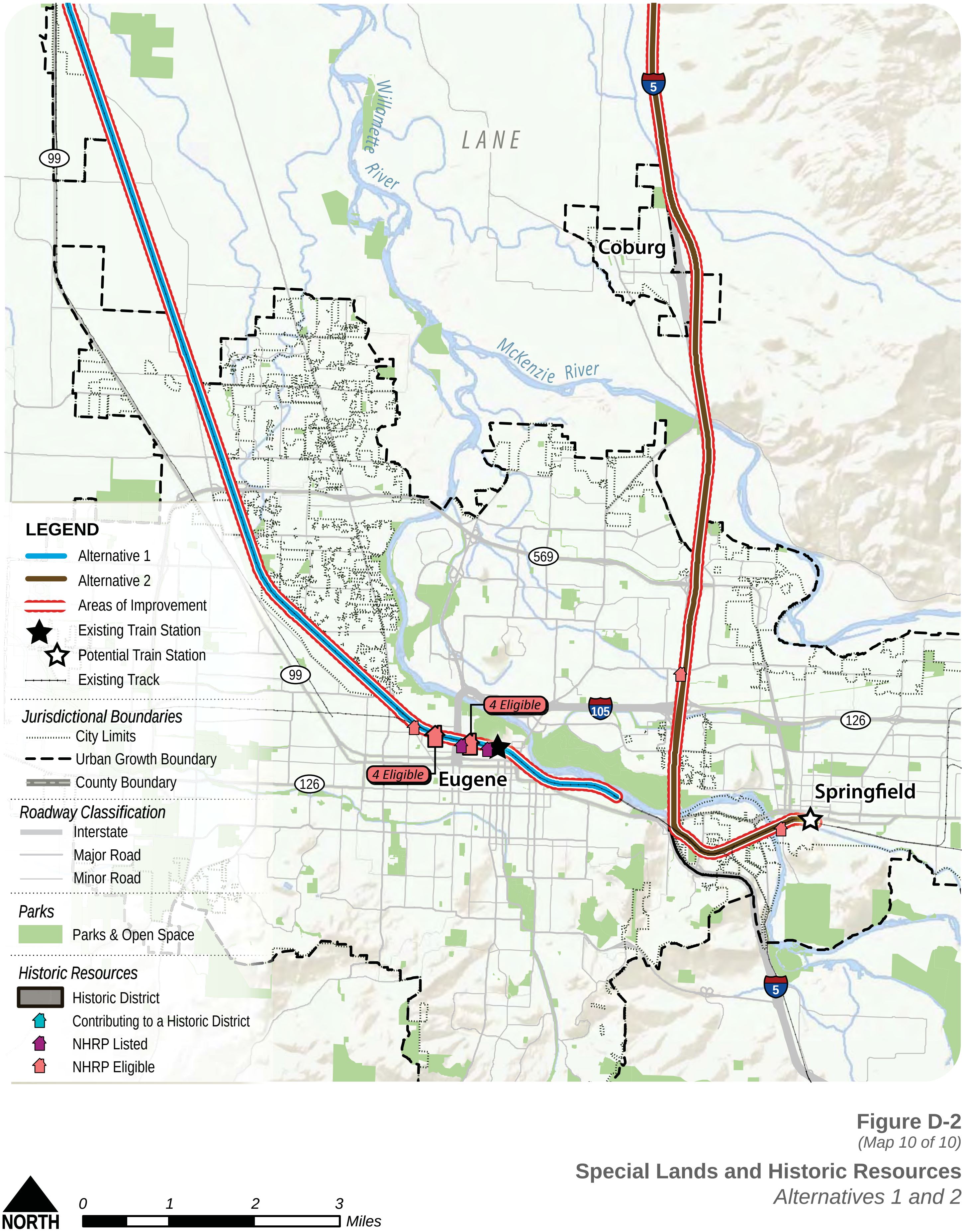


Figure D-2
(Map 10 of 10)

Special Lands and Historic Resources
Alternatives 1 and 2

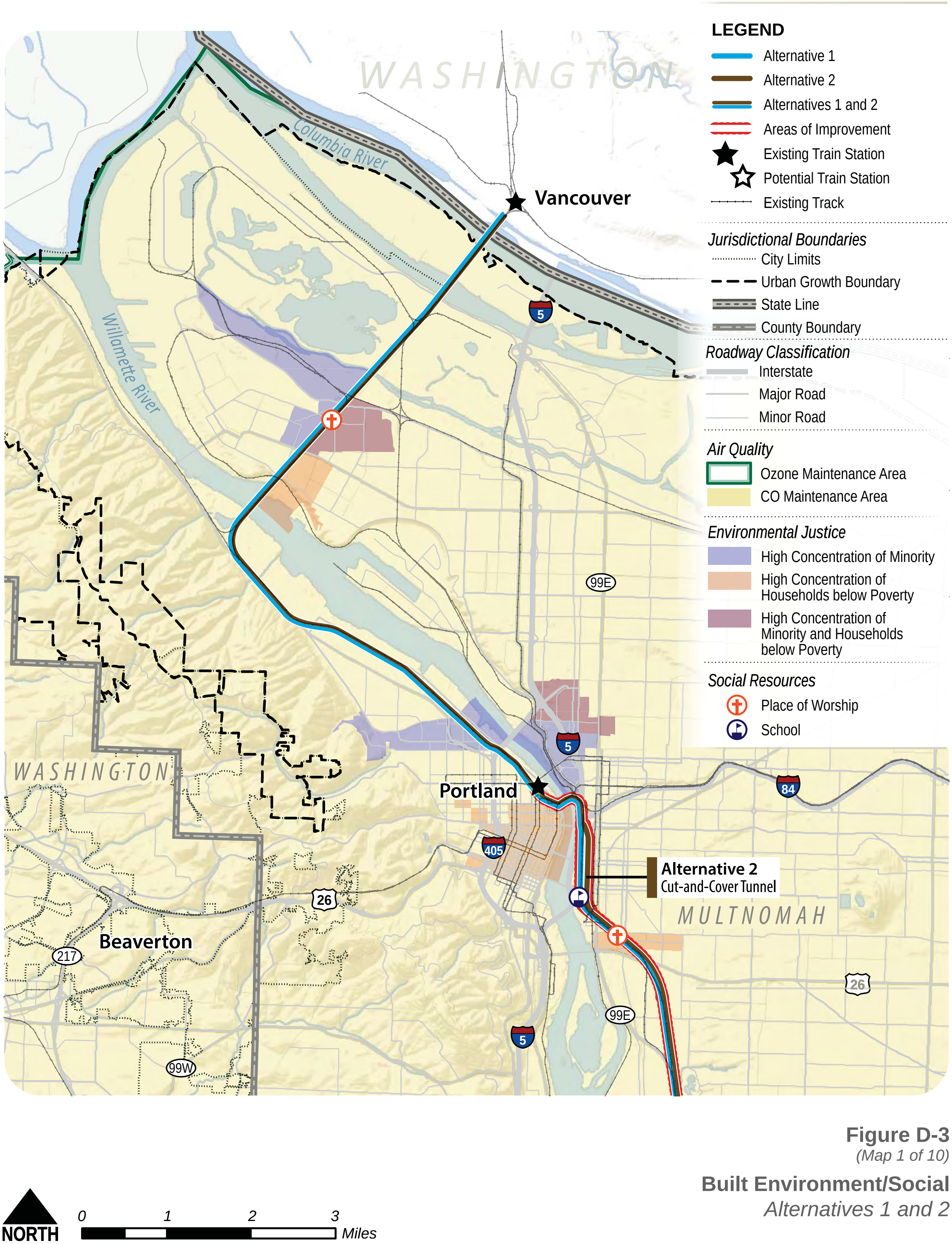
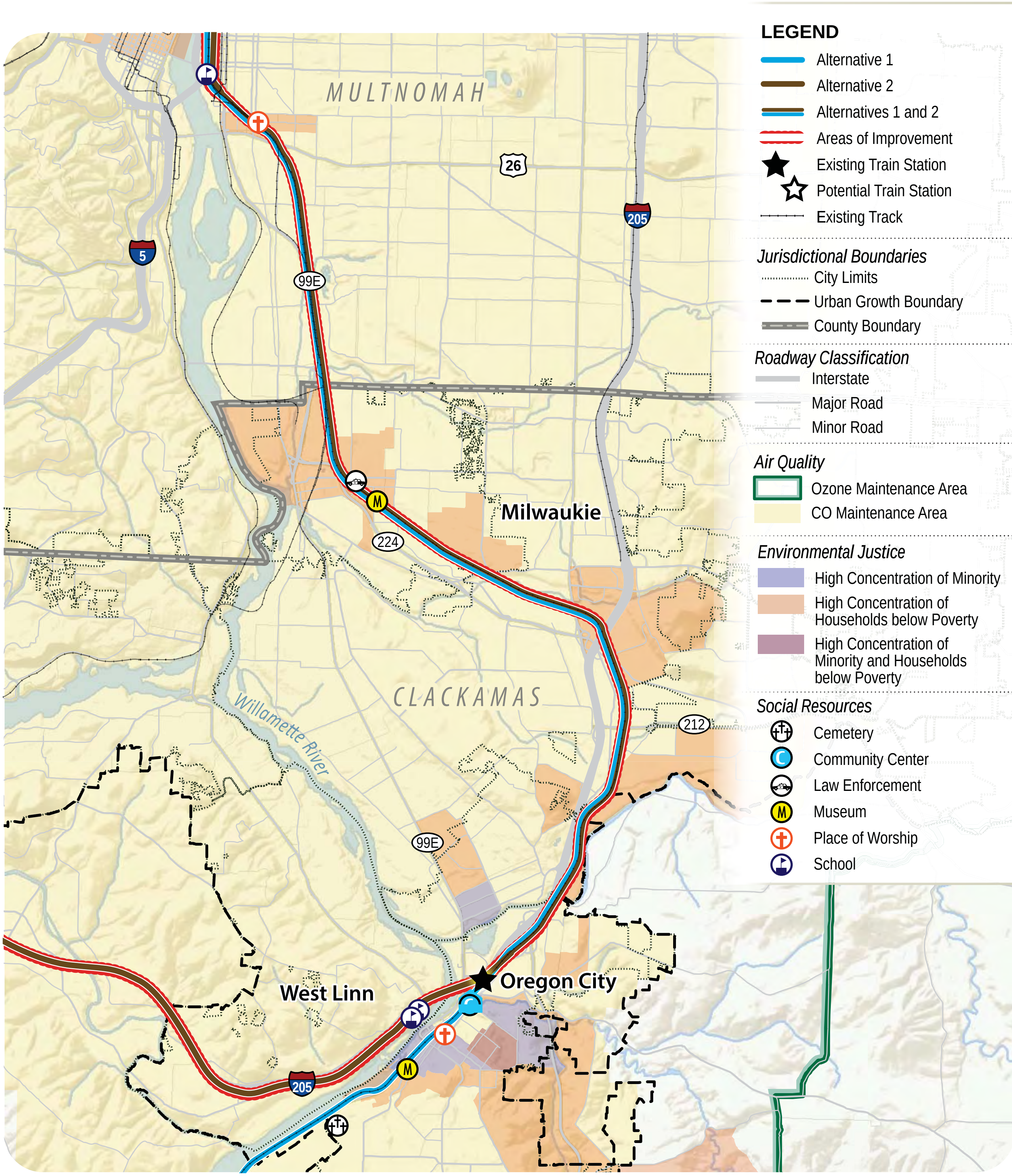


Figure D-3
(Map 1 of 10)

Built Environment/Social
Alternatives 1 and 2



NORTH

0 1 2 3 Miles

Figure D-3
(Map 2 of 10)

Built Environment/Social
Alternatives 1 and 2

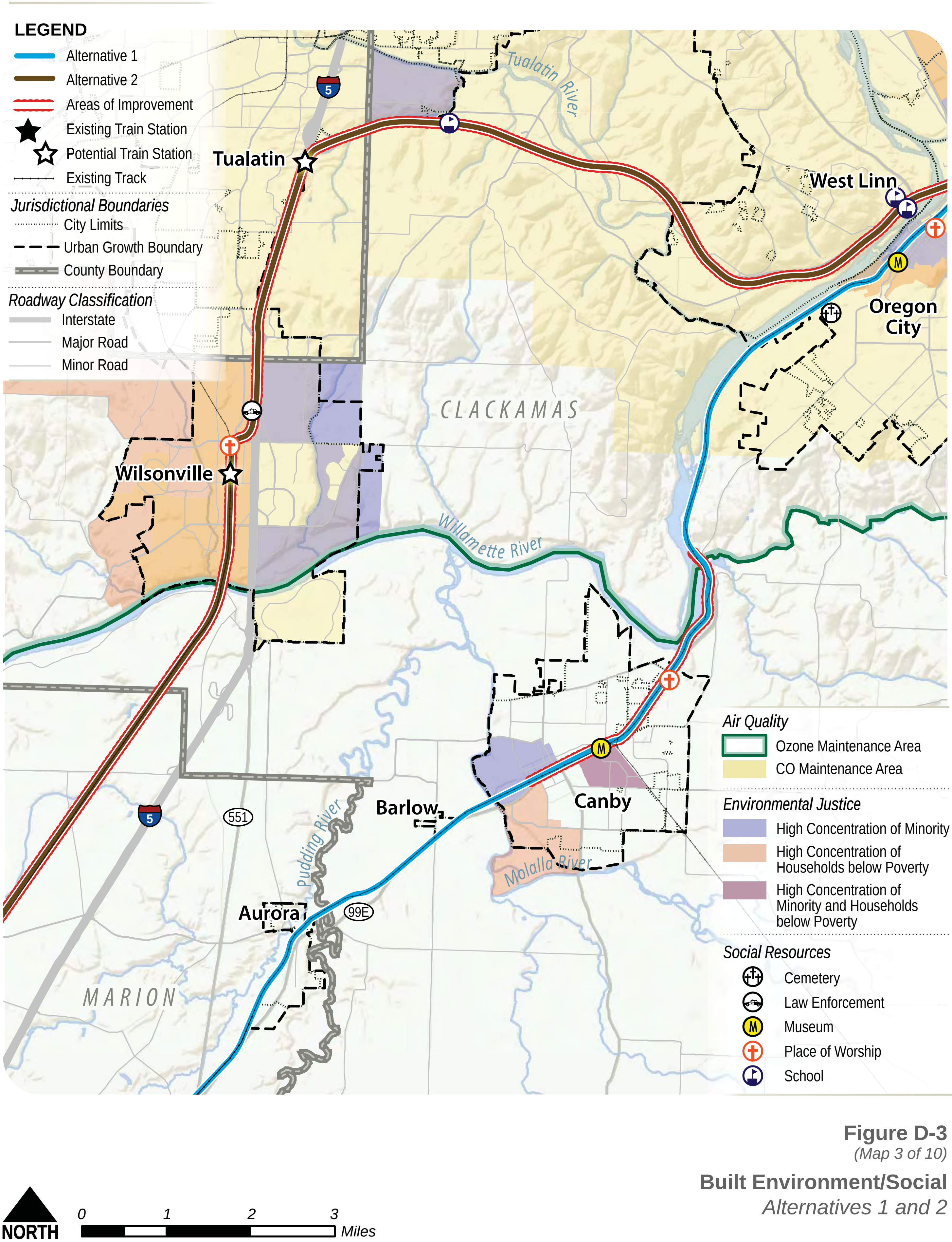


Figure D-3
(Map 3 of 10)

Built Environment/Social
Alternatives 1 and 2

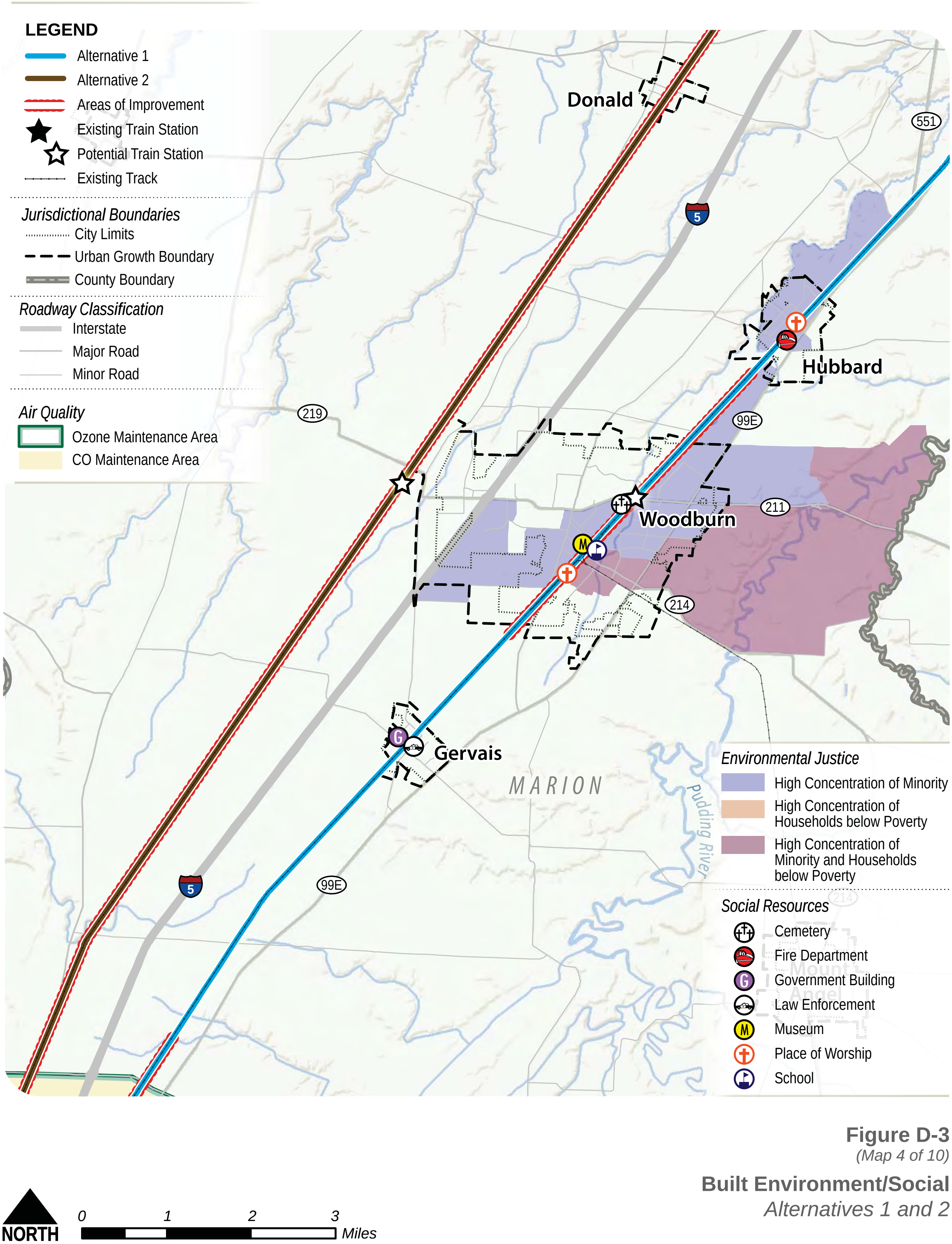


Figure D-3
(Map 4 of 10)

Built Environment/Social
Alternatives 1 and 2

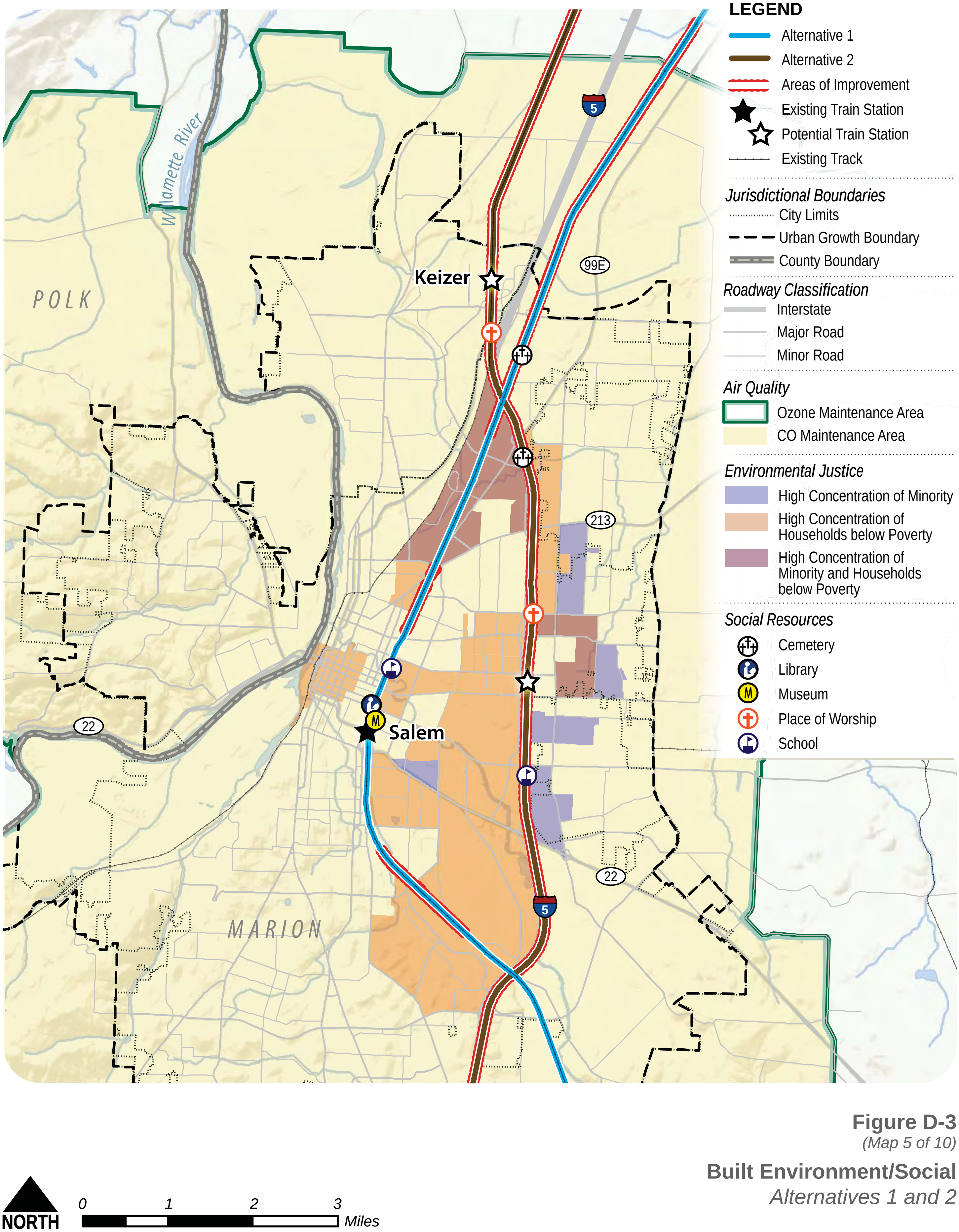


Figure D-3
(Map 5 of 10)

Built Environment/Social
Alternatives 1 and 2

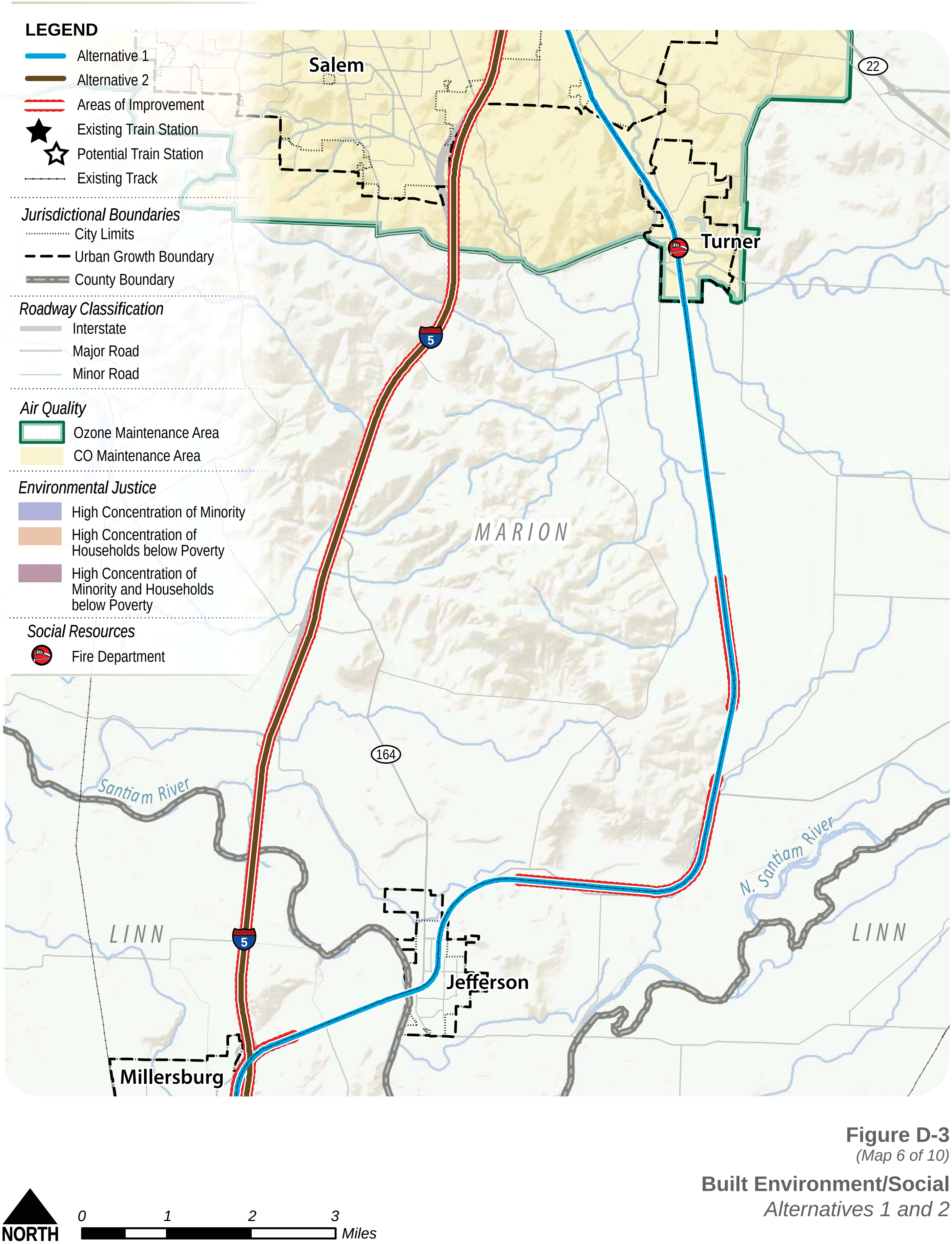


Figure D-3
(Map 6 of 10)

Built Environment/Social
Alternatives 1 and 2

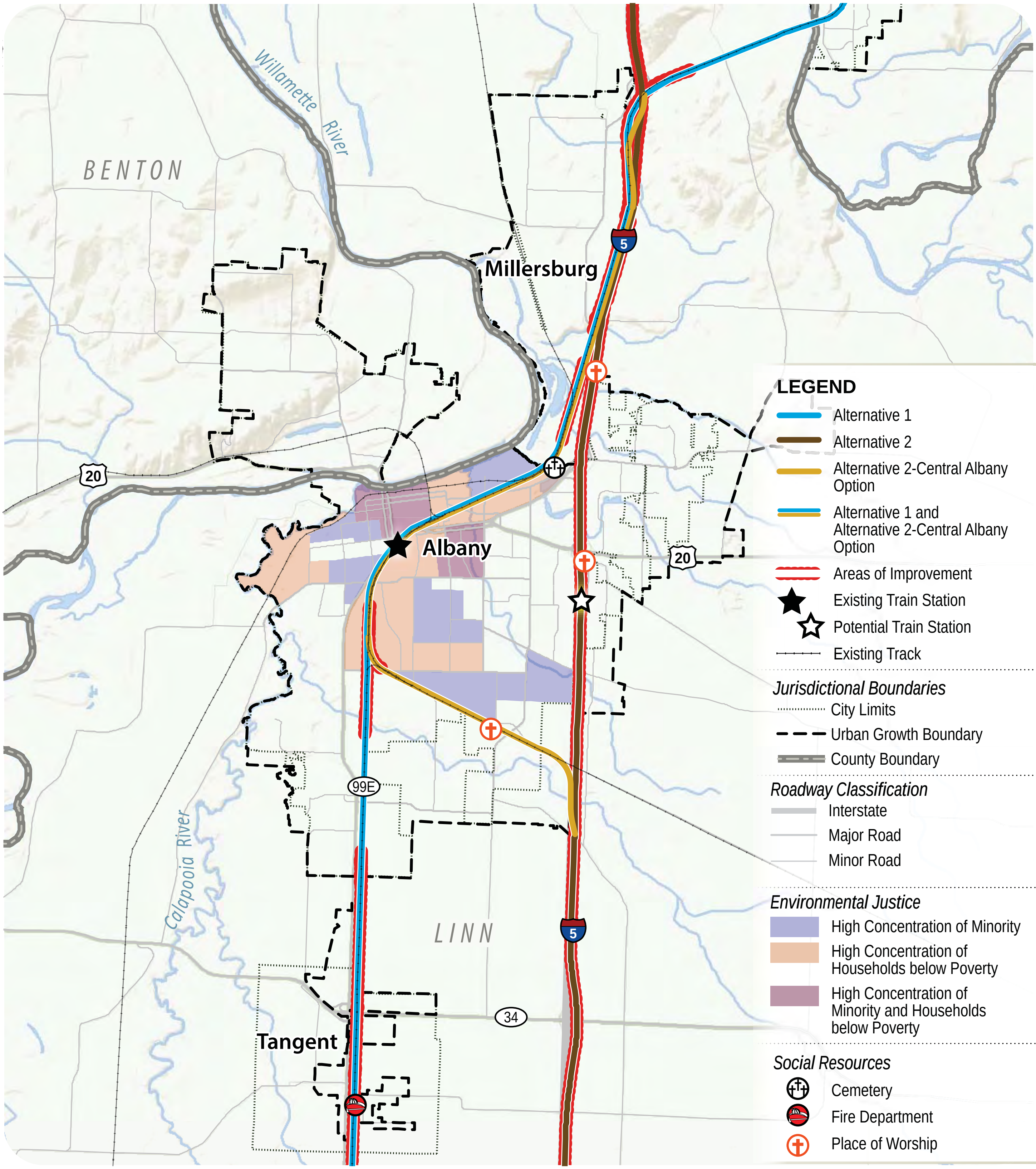


Figure D-3
(Map 7 of 10)

Built Environment/Social
Alternatives 1 and 2

NORTH
0 1 2 3 Miles

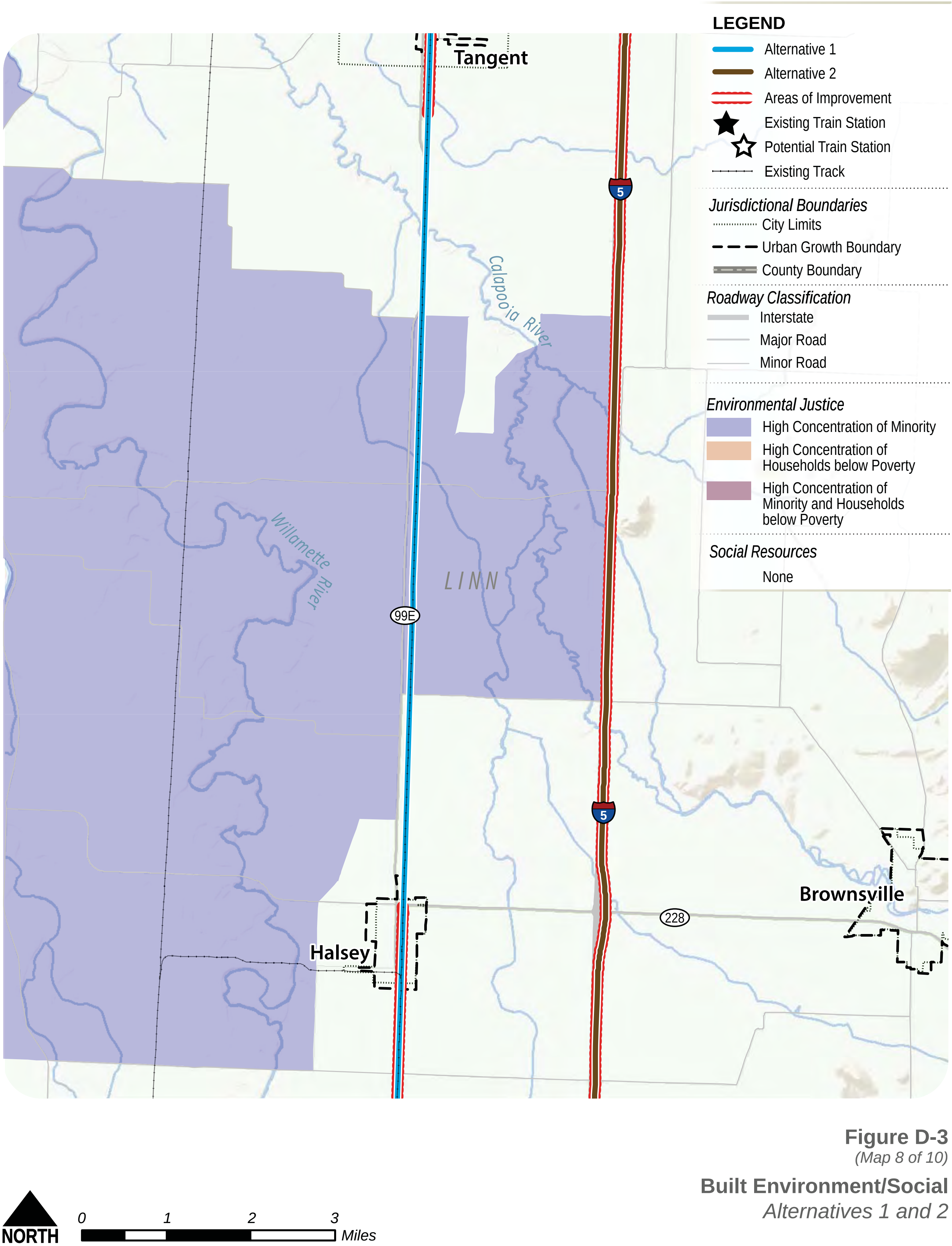


Figure D-3
(Map 8 of 10)

Built Environment/Social
Alternatives 1 and 2

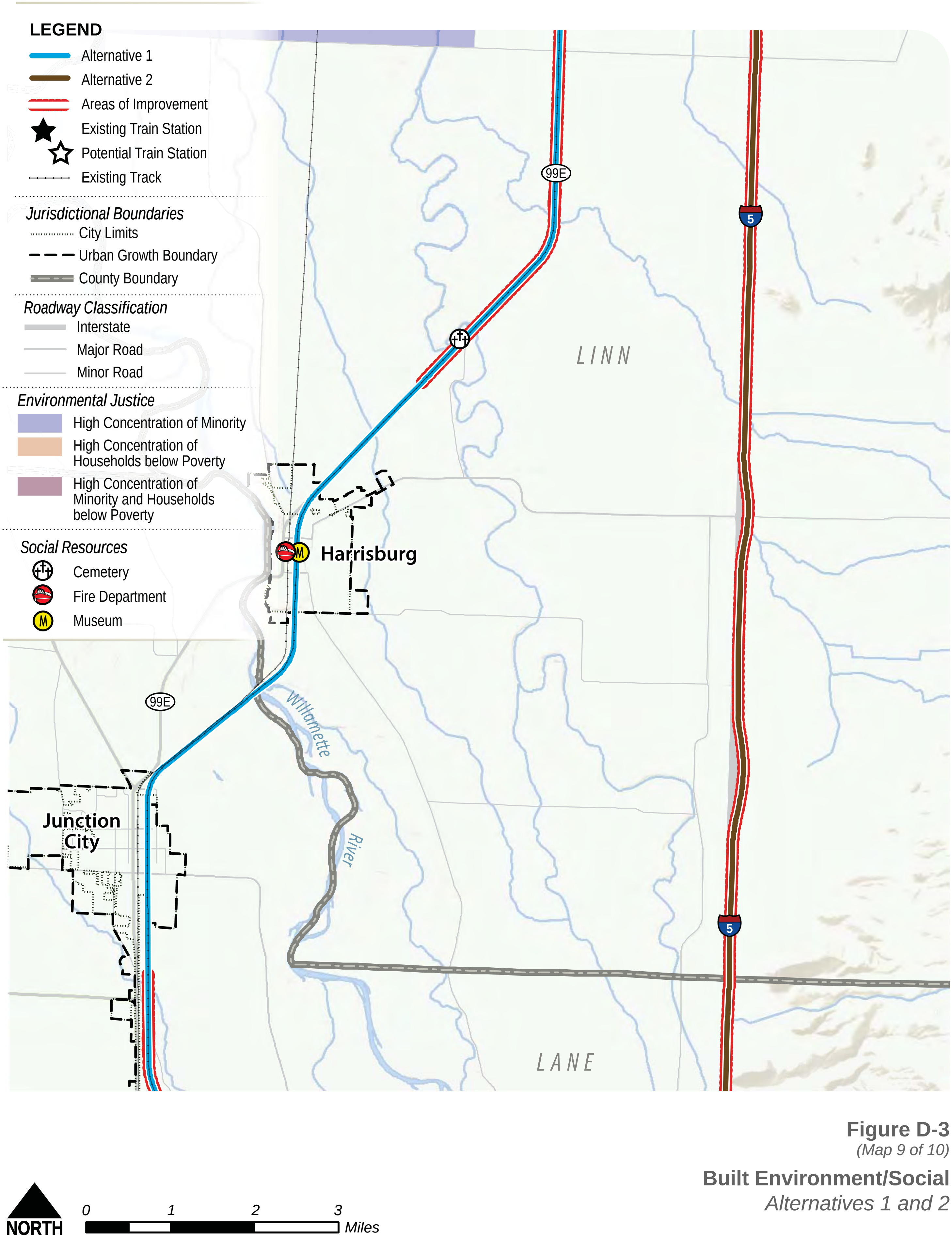


Figure D-3
(Map 9 of 10)

Built Environment/Social
Alternatives 1 and 2

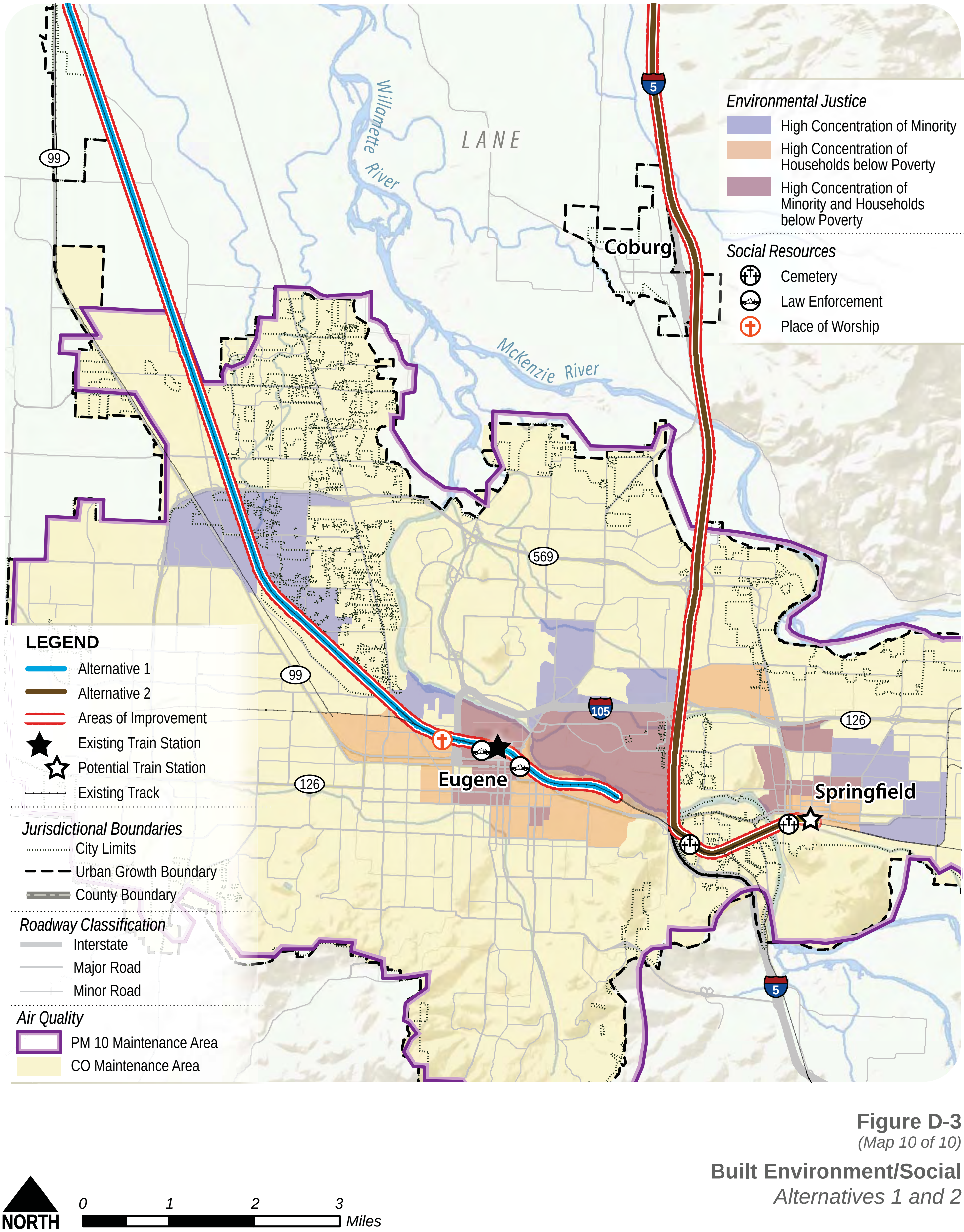


Figure D-3
(Map 10 of 10)

Built Environment/Social
Alternatives 1 and 2

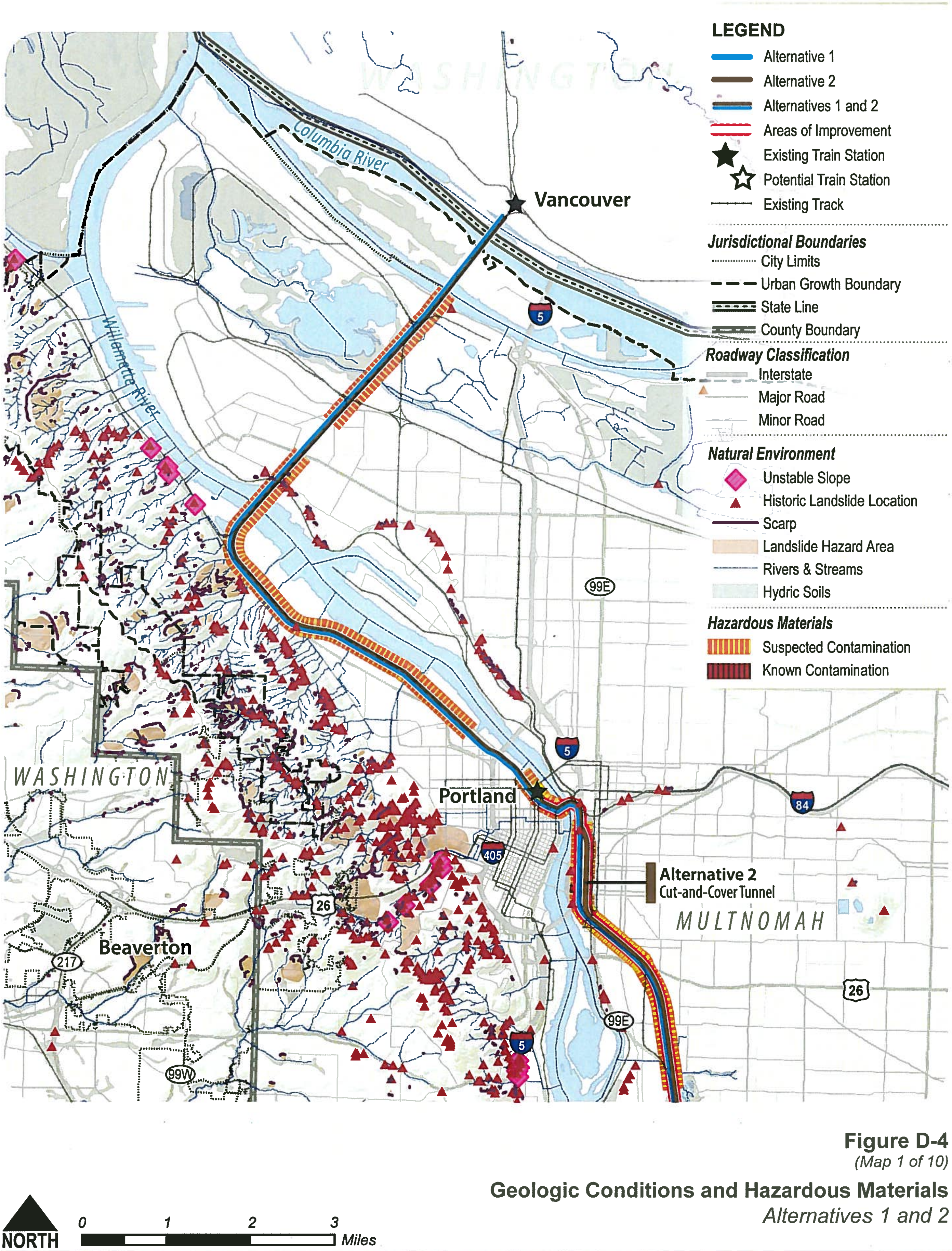


Figure D-4
(Map 1 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

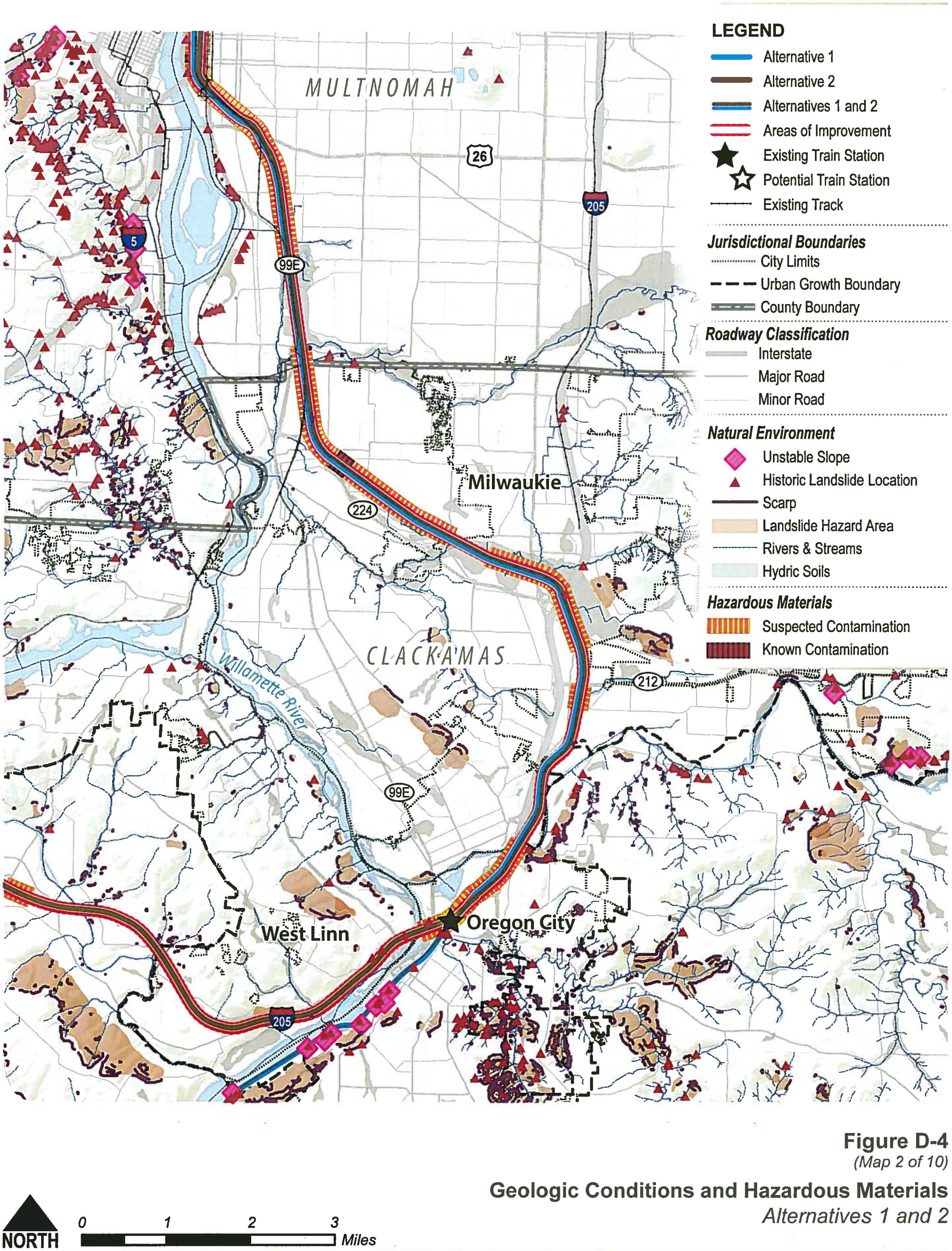


Figure D-4
(Map 2 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

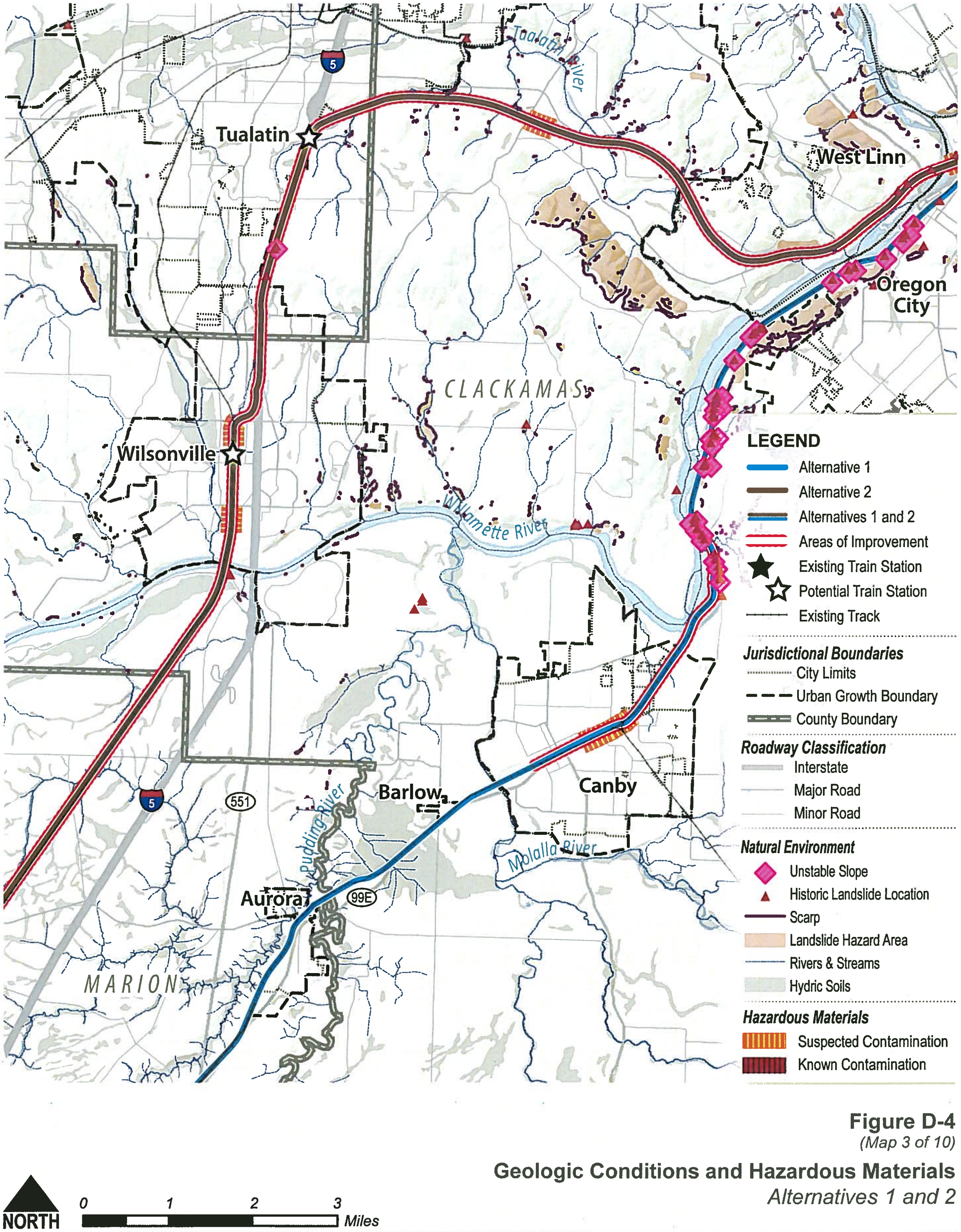


Figure D-4
(Map 3 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

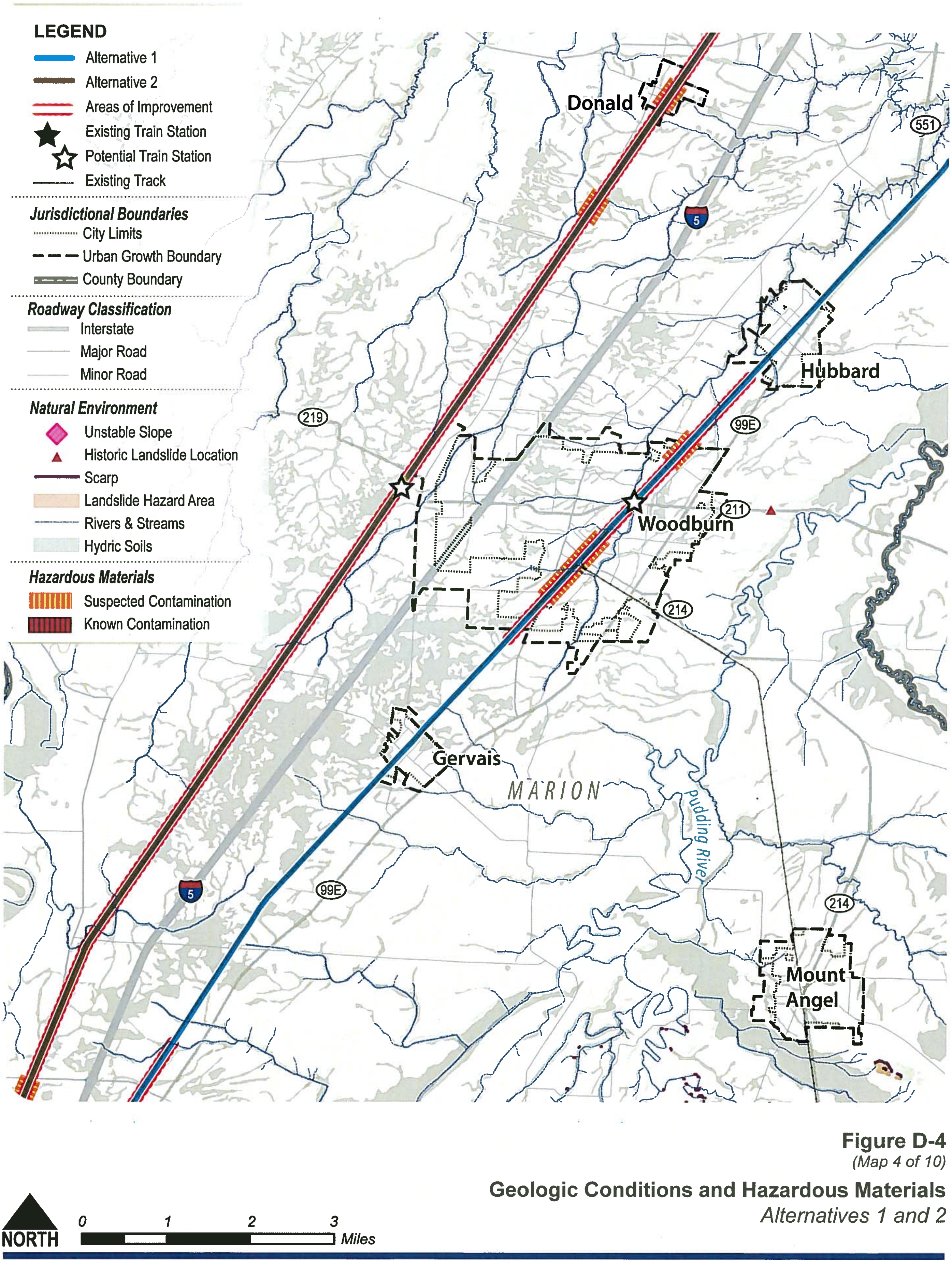


Figure D-4
(Map 4 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

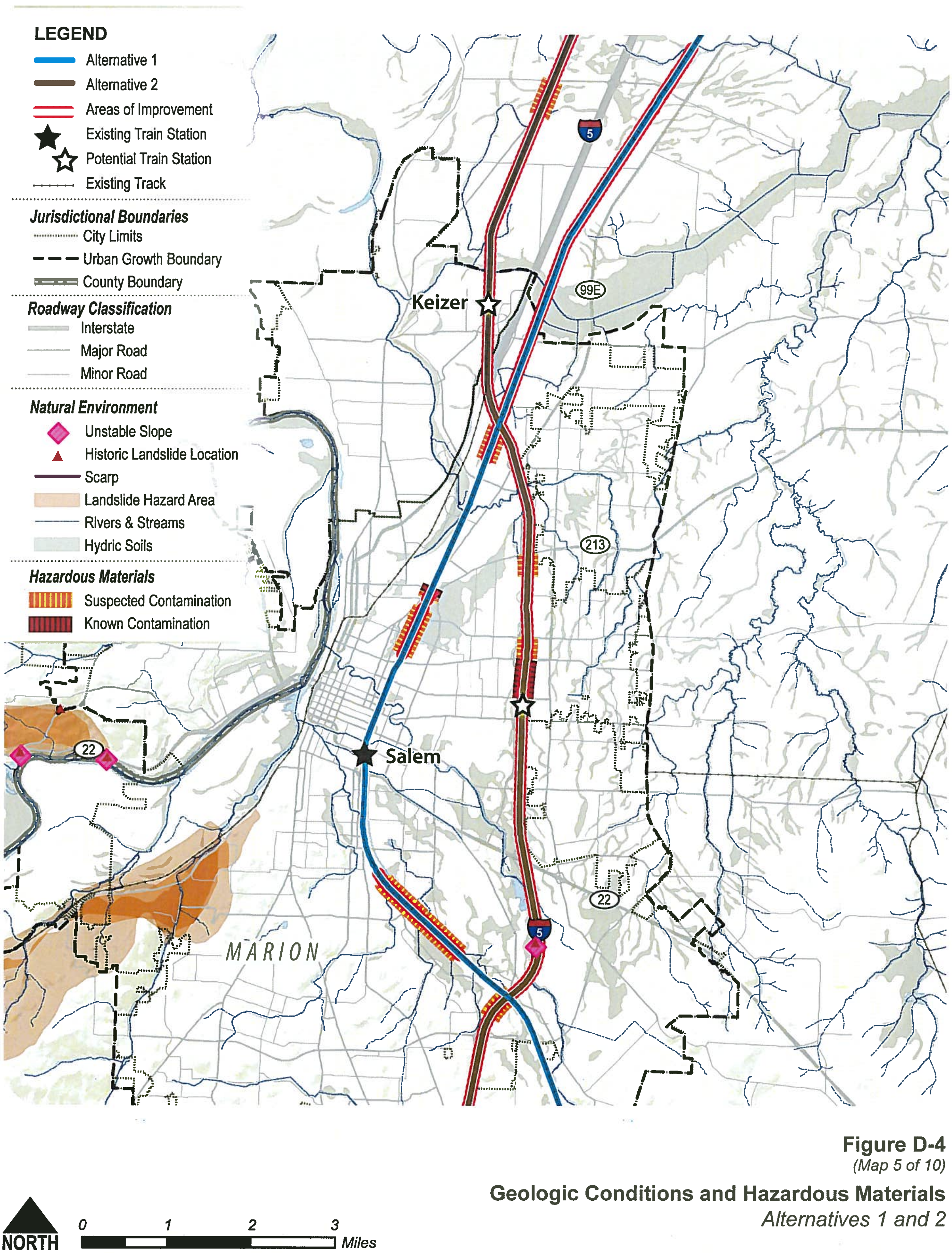


Figure D-4
(Map 5 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

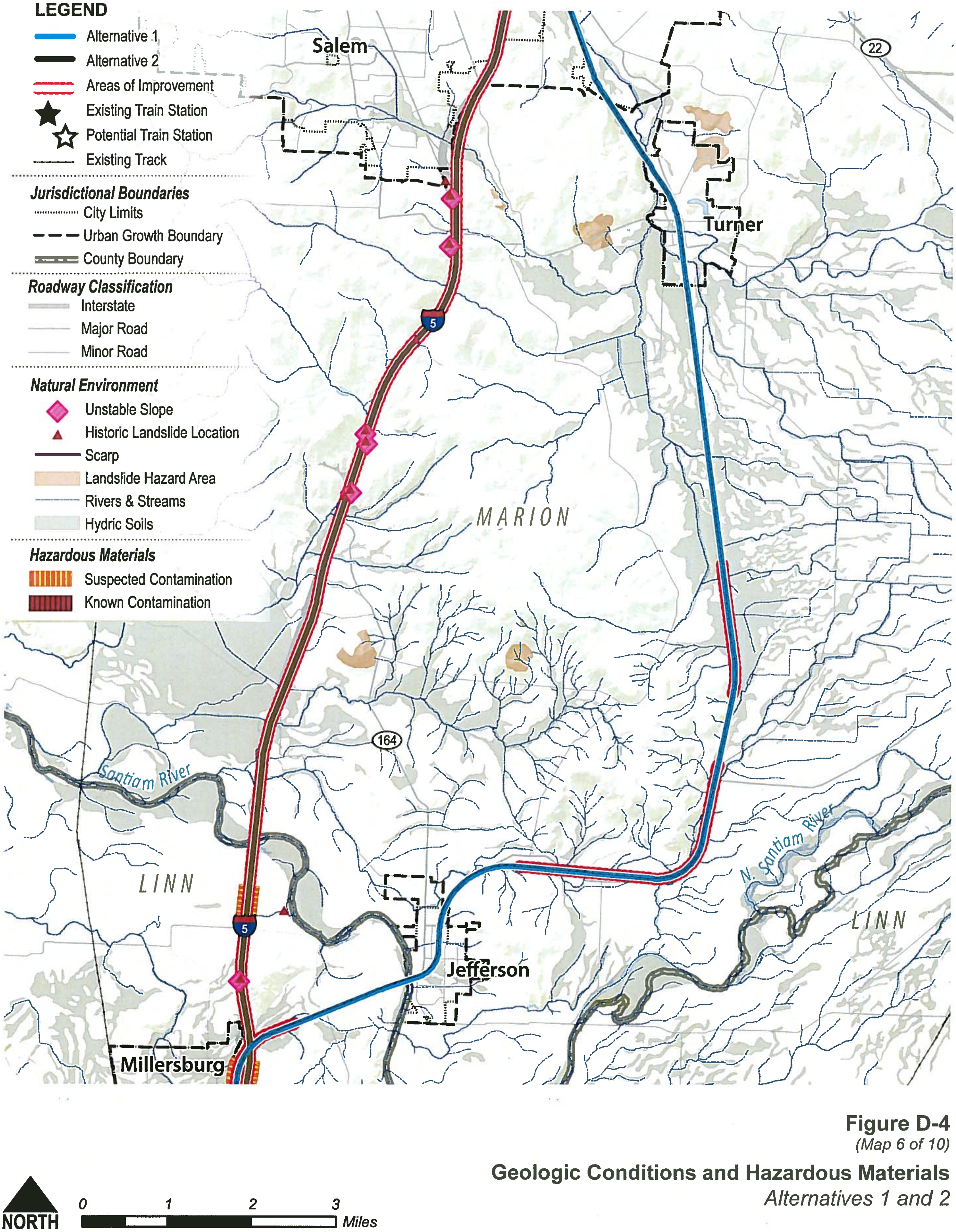


Figure D-4
(Map 6 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

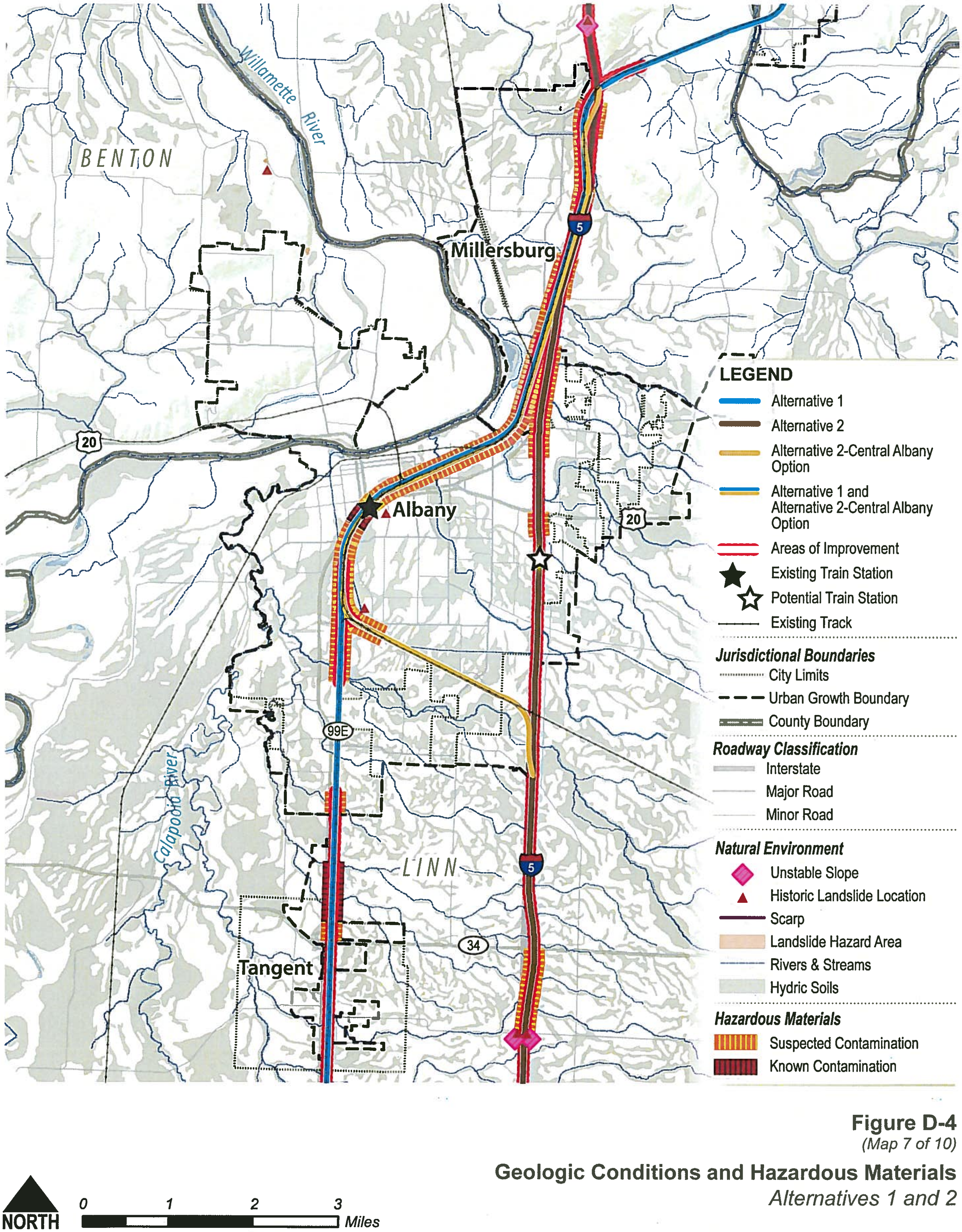


Figure D-4
(Map 7 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

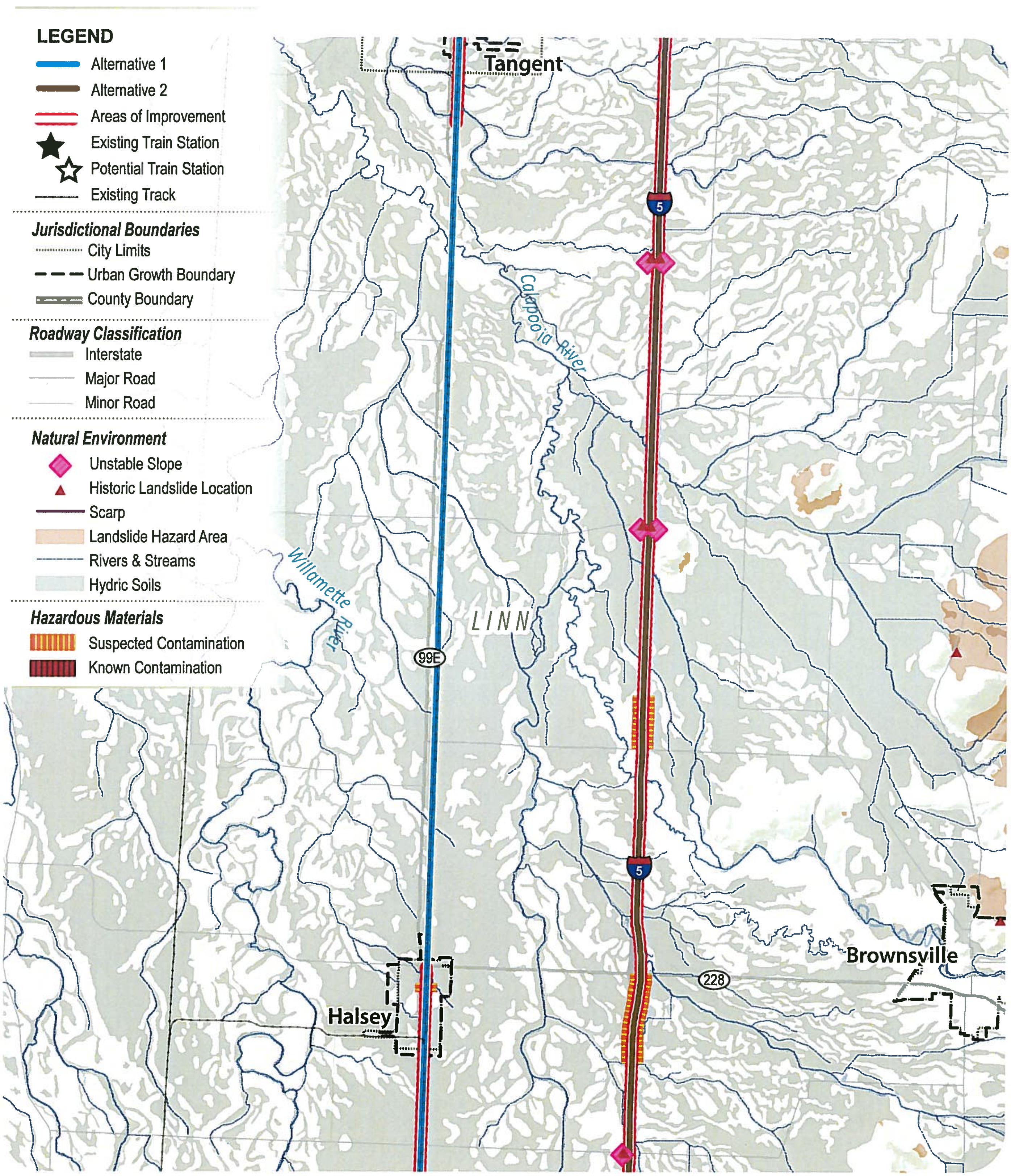


Figure D-4
(Map 8 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

NORTH
0 1 2 3 Miles

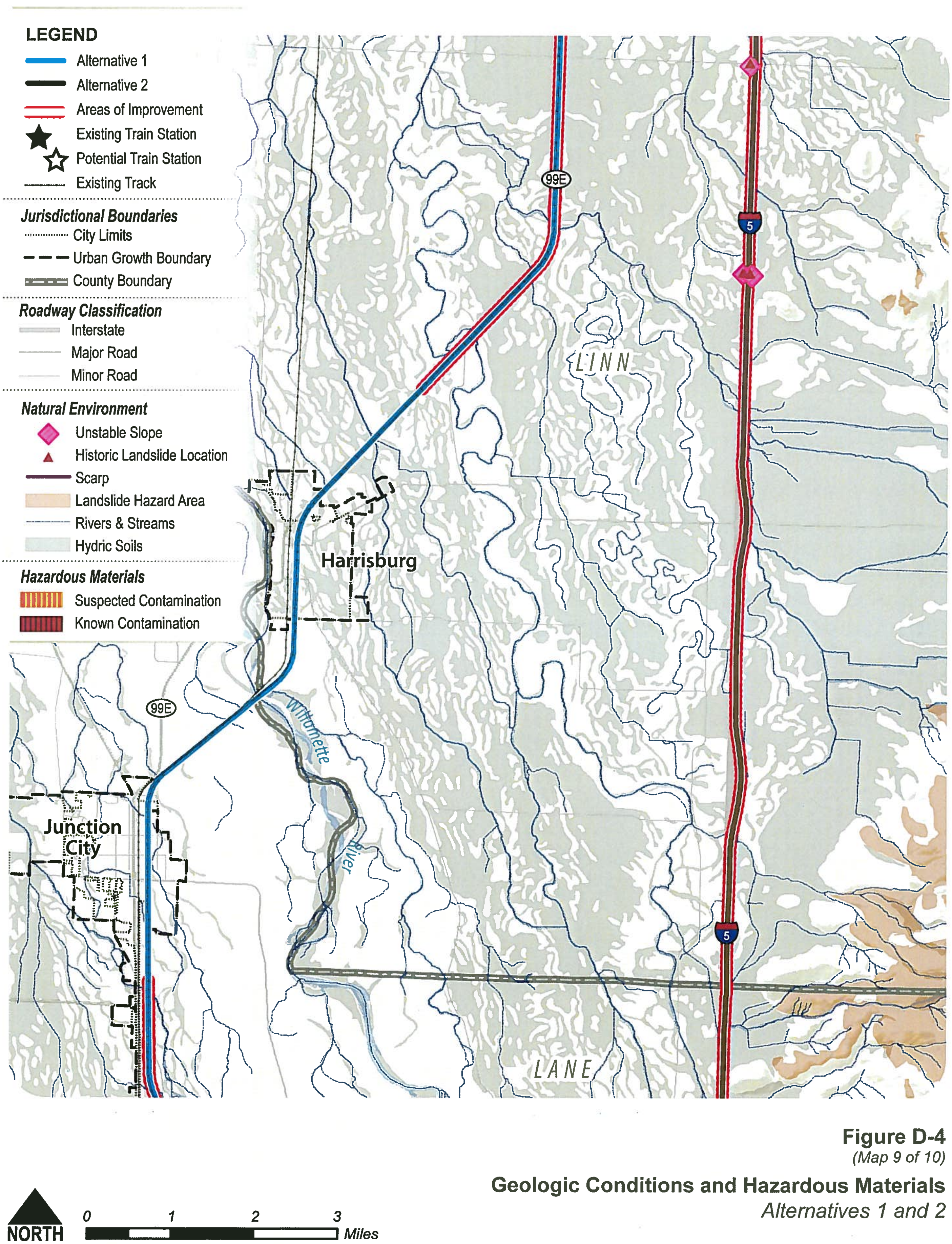


Figure D-4
(Map 9 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

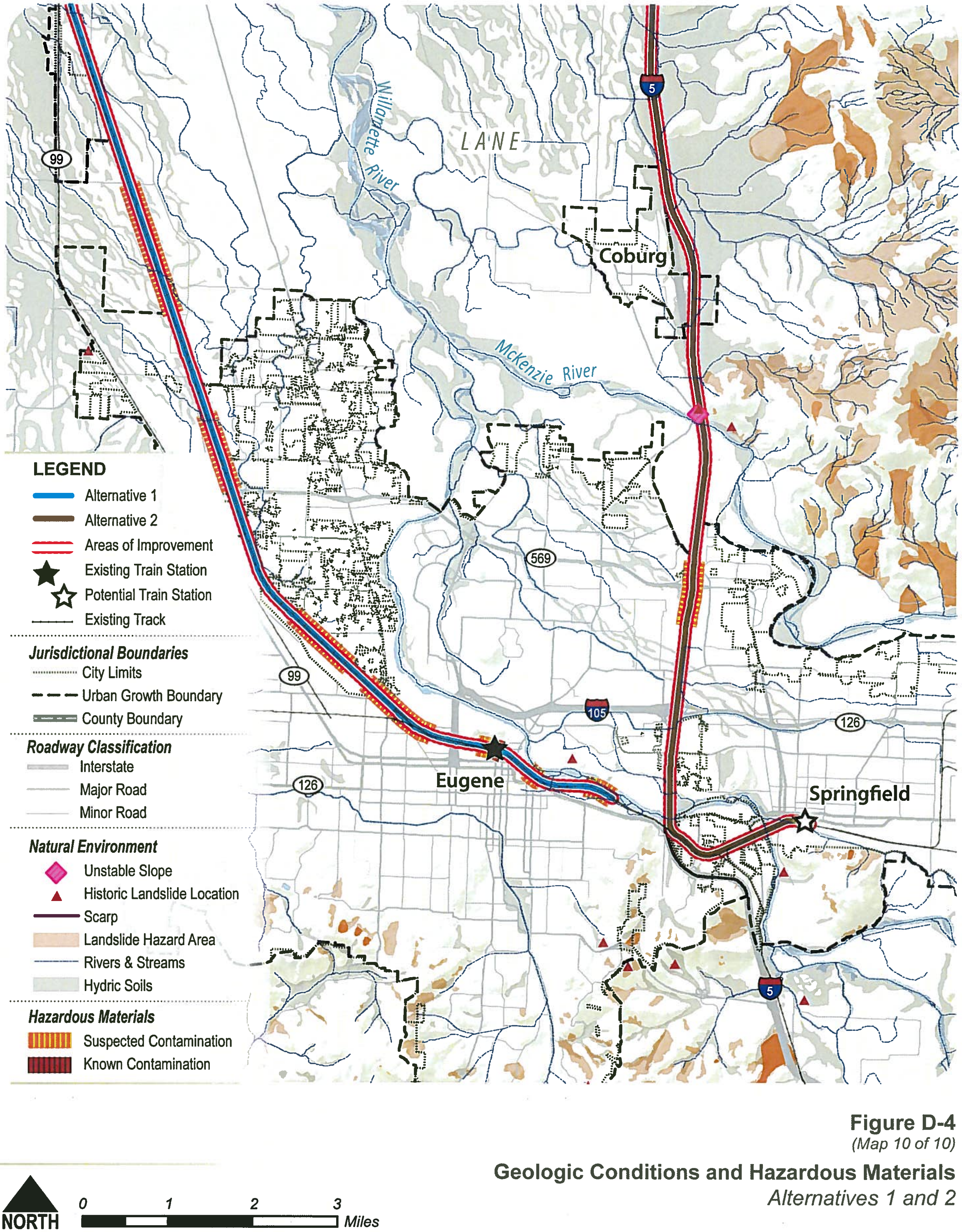


Figure D-4
(Map 10 of 10)

Geologic Conditions and Hazardous Materials
Alternatives 1 and 2

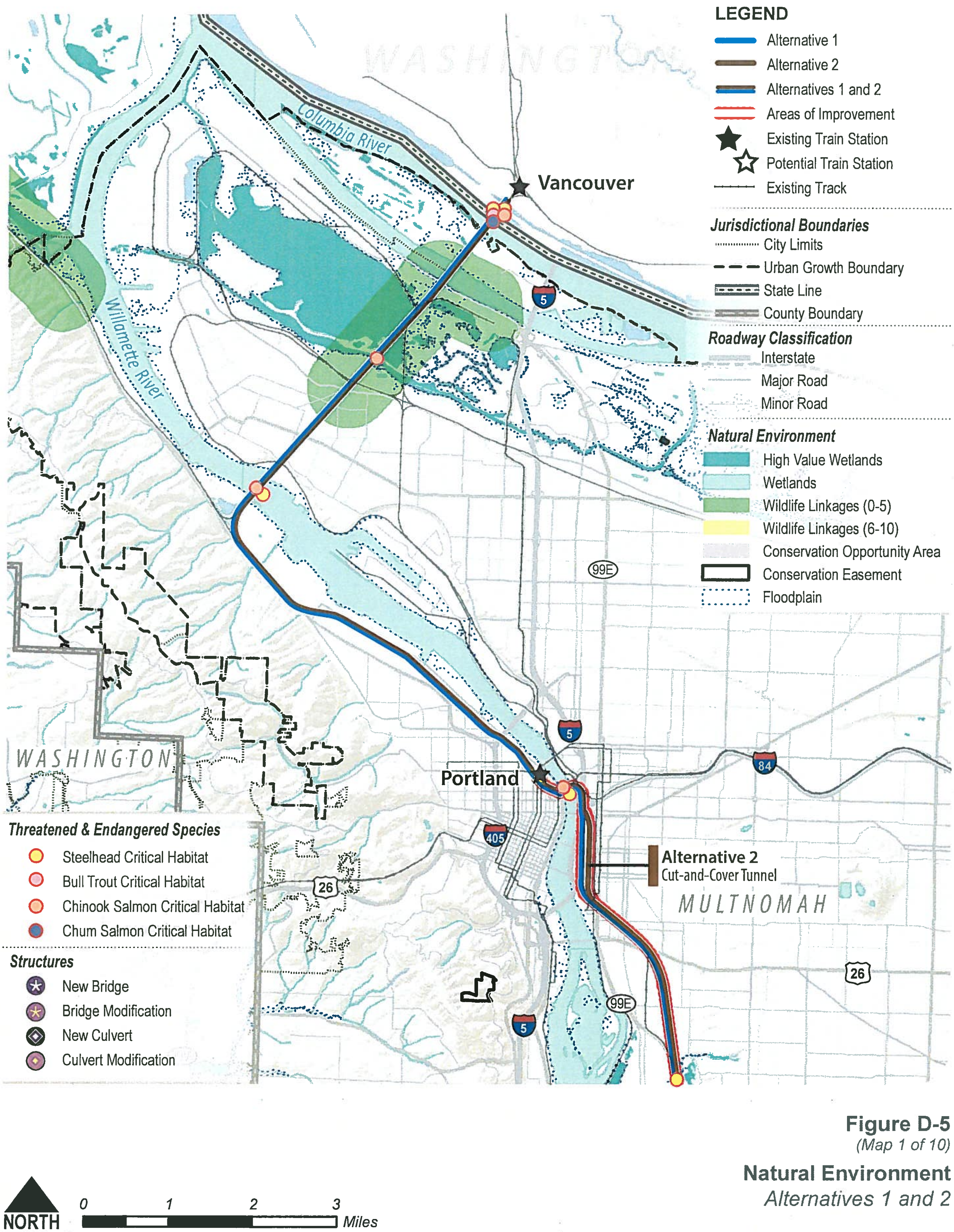


Figure D-5
(Map 1 of 10)

Natural Environment
Alternatives 1 and 2

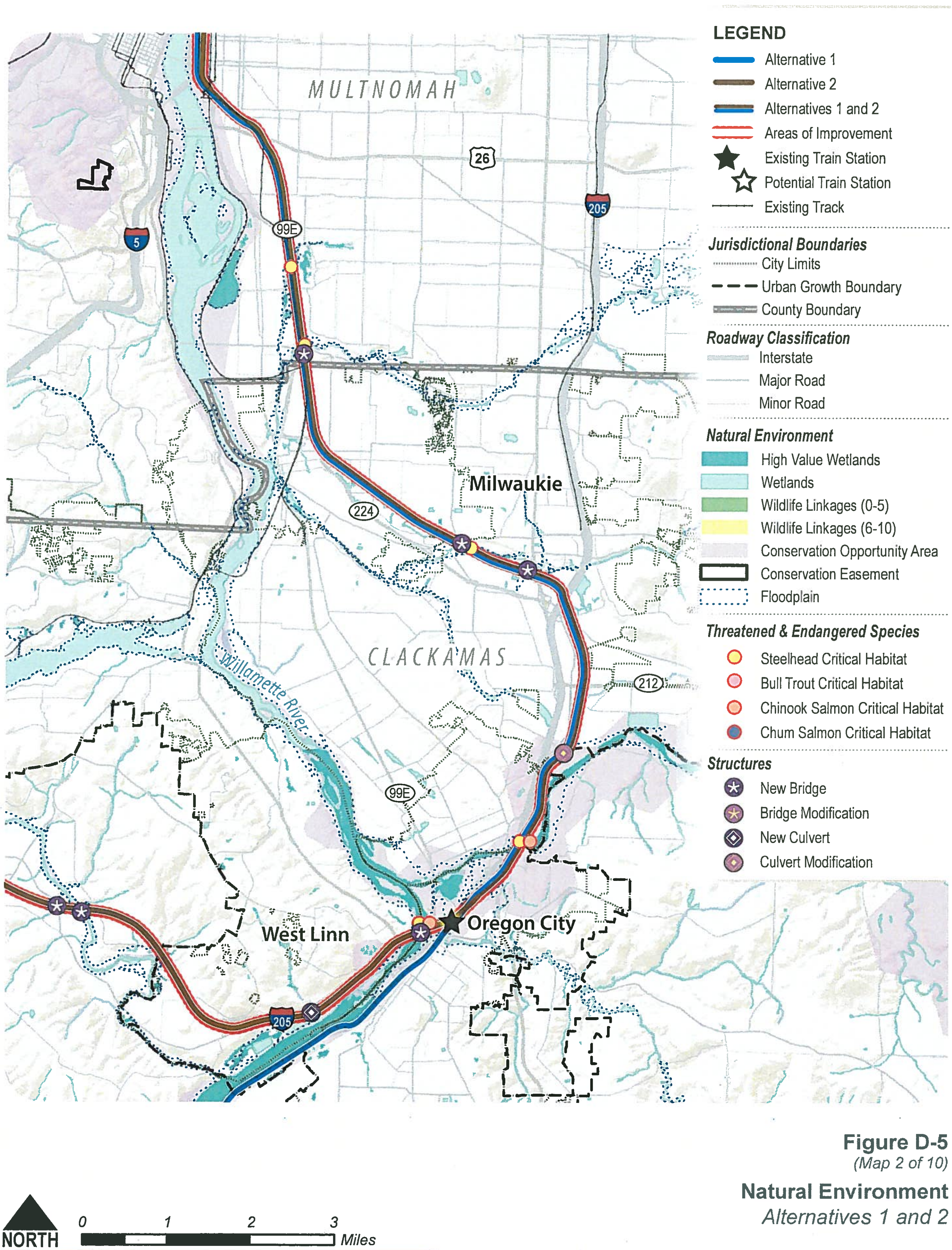


Figure D-5
(Map 2 of 10)

Natural Environment
Alternatives 1 and 2

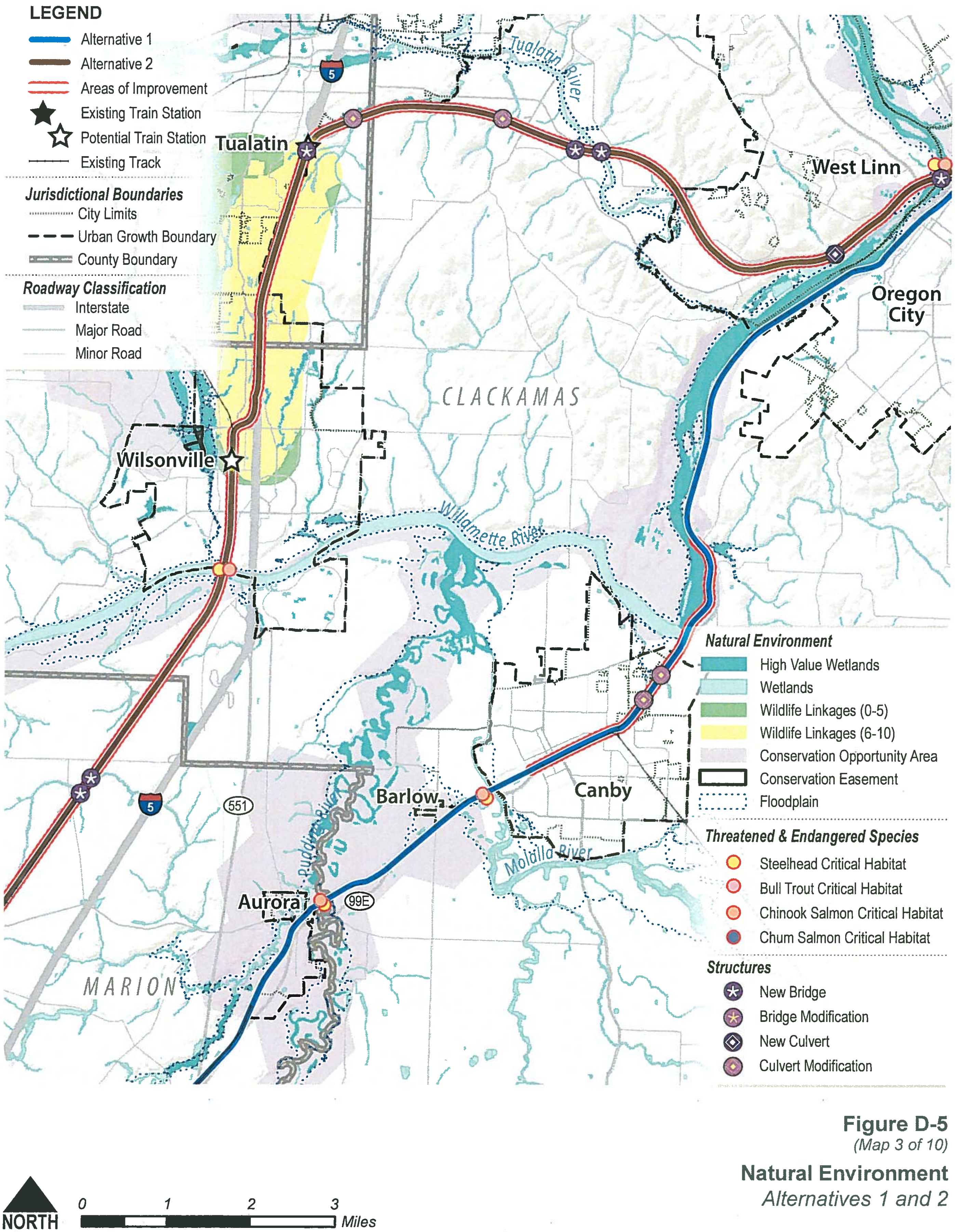


Figure D-5
(Map 3 of 10)

Natural Environment
Alternatives 1 and 2

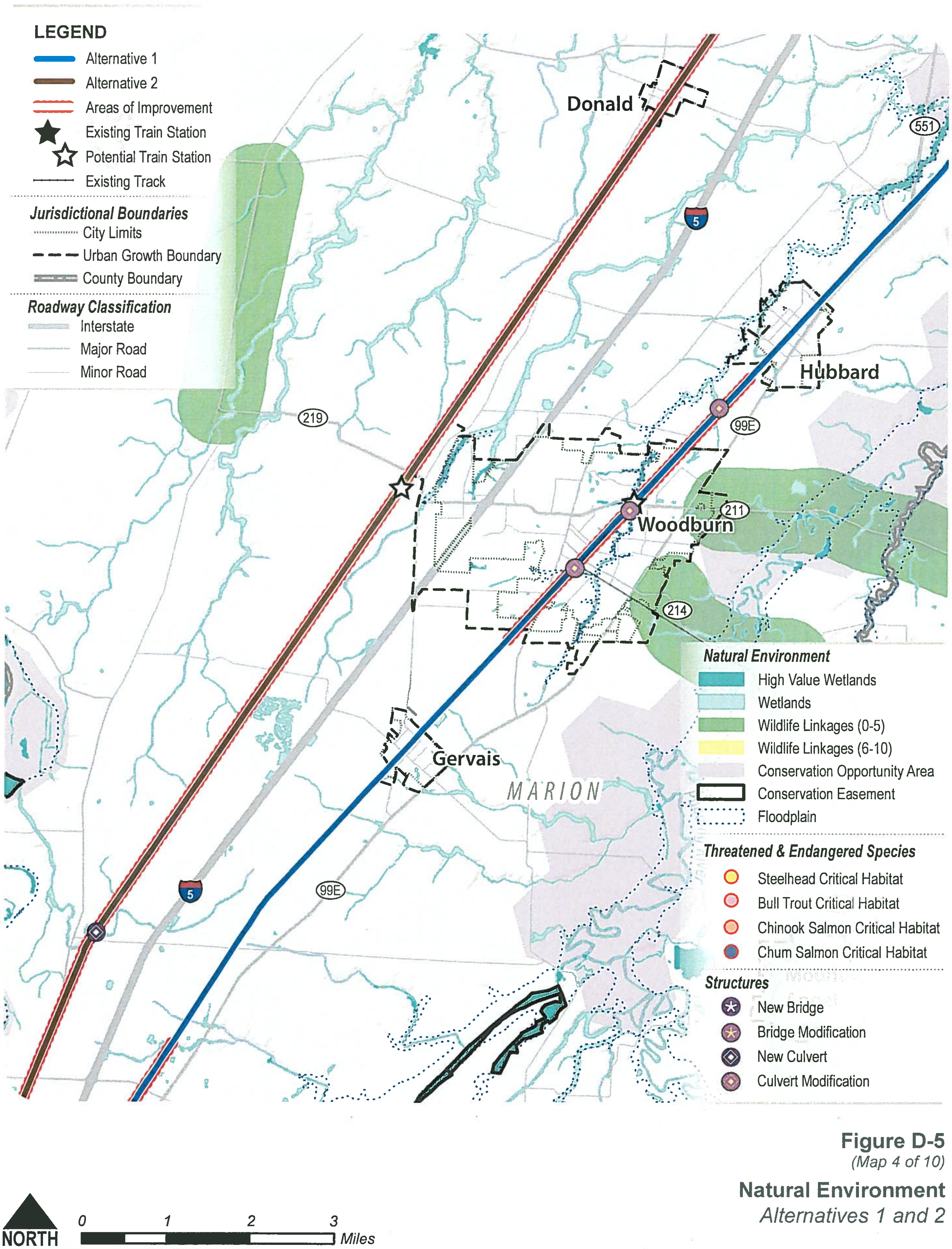


Figure D-5
(Map 4 of 10)

Natural Environment
Alternatives 1 and 2

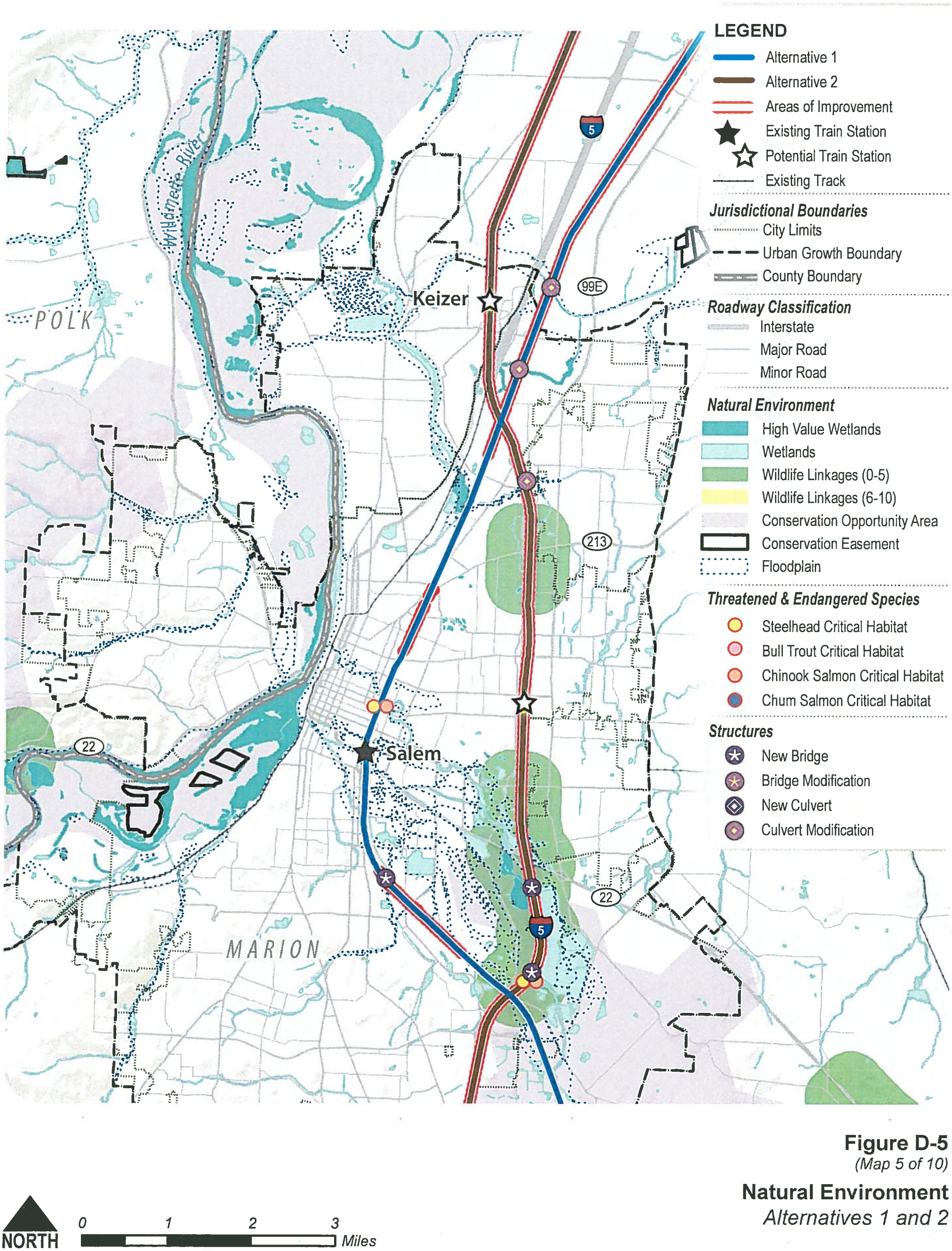


Figure D-5
(Map 5 of 10)

Natural Environment
Alternatives 1 and 2

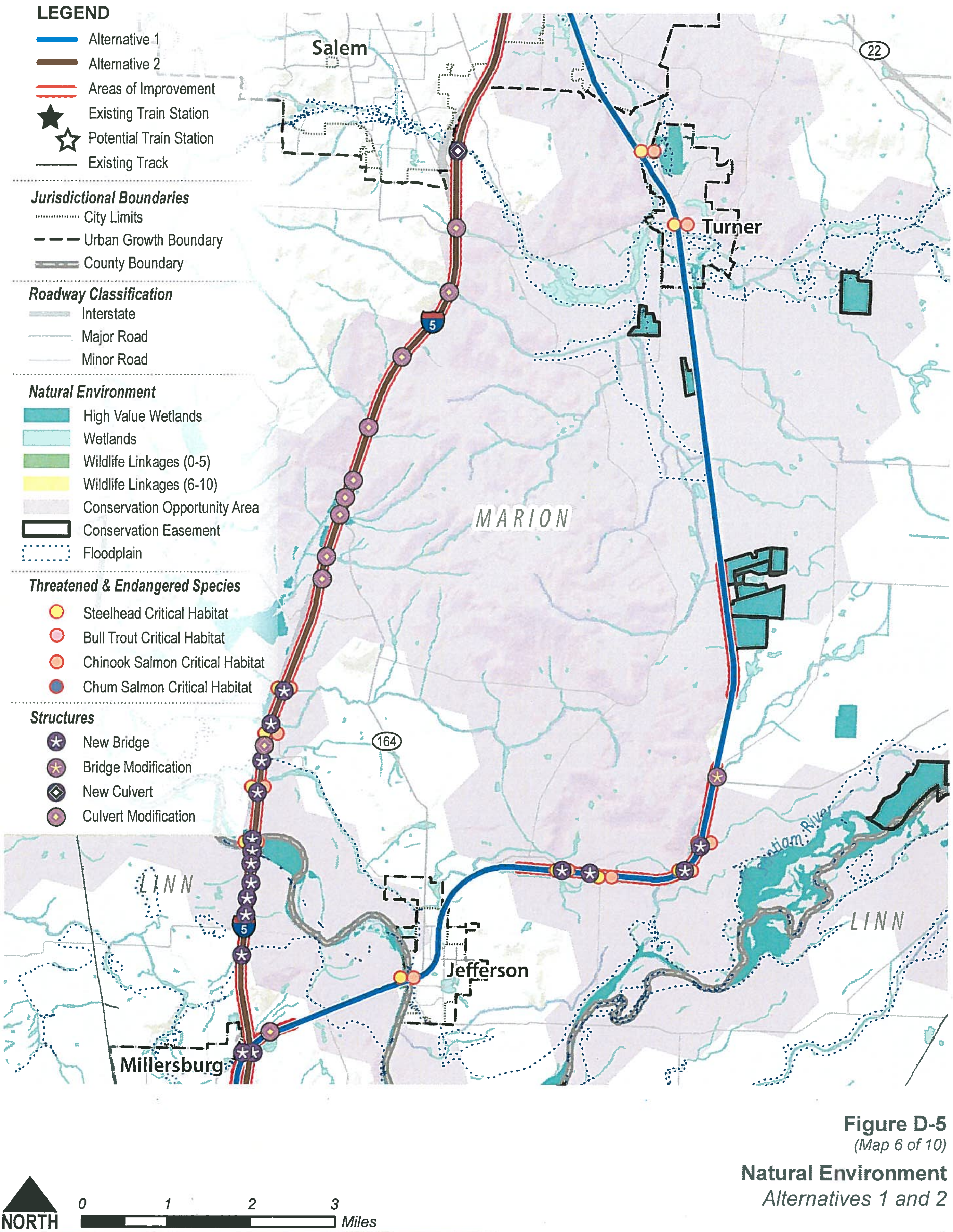


Figure D-5
(Map 6 of 10)

Natural Environment
Alternatives 1 and 2

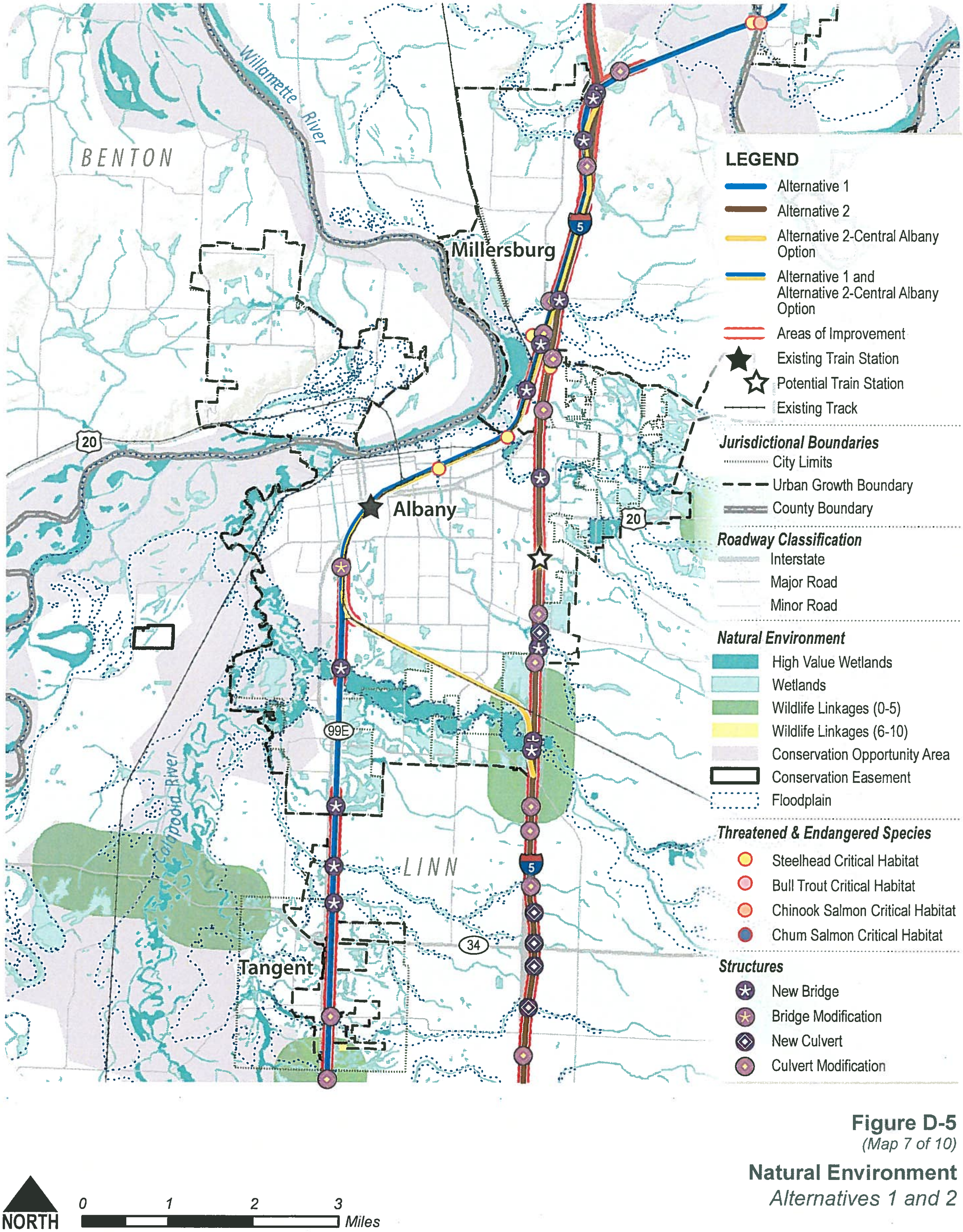


Figure D-5
(Map 7 of 10)

Natural Environment
Alternatives 1 and 2

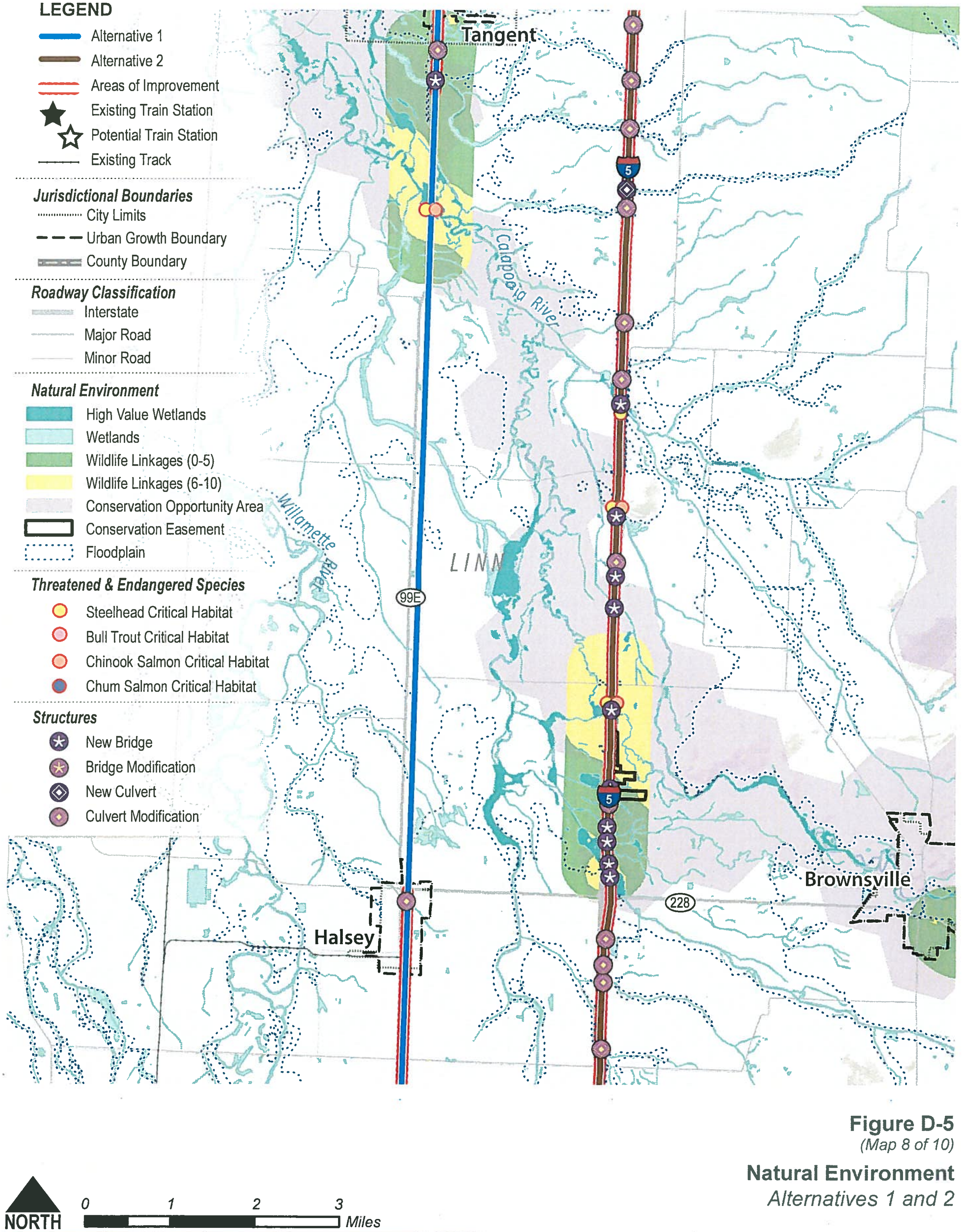


Figure D-5
(Map 8 of 10)

Natural Environment
Alternatives 1 and 2

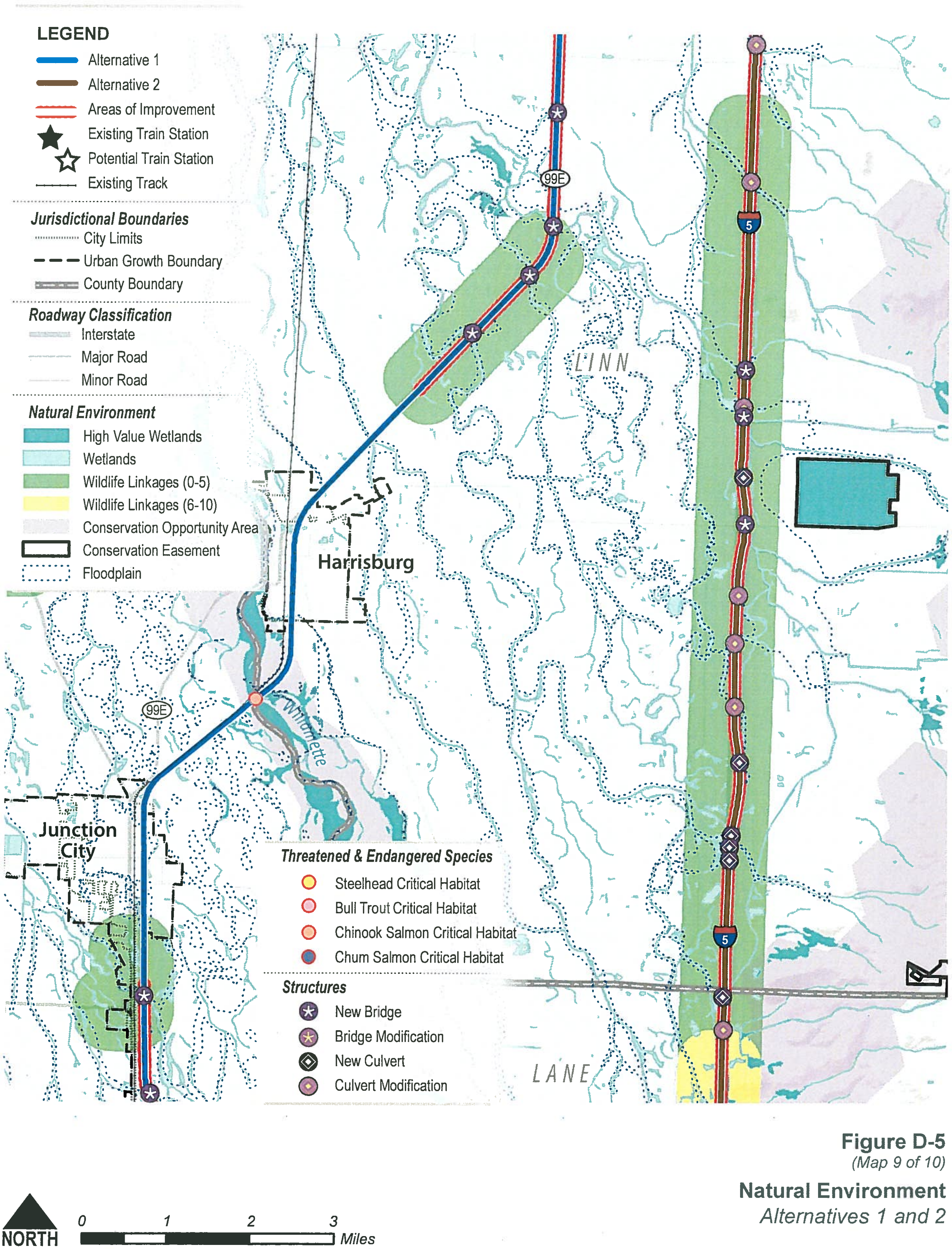


Figure D-5
(Map 9 of 10)

Natural Environment
Alternatives 1 and 2

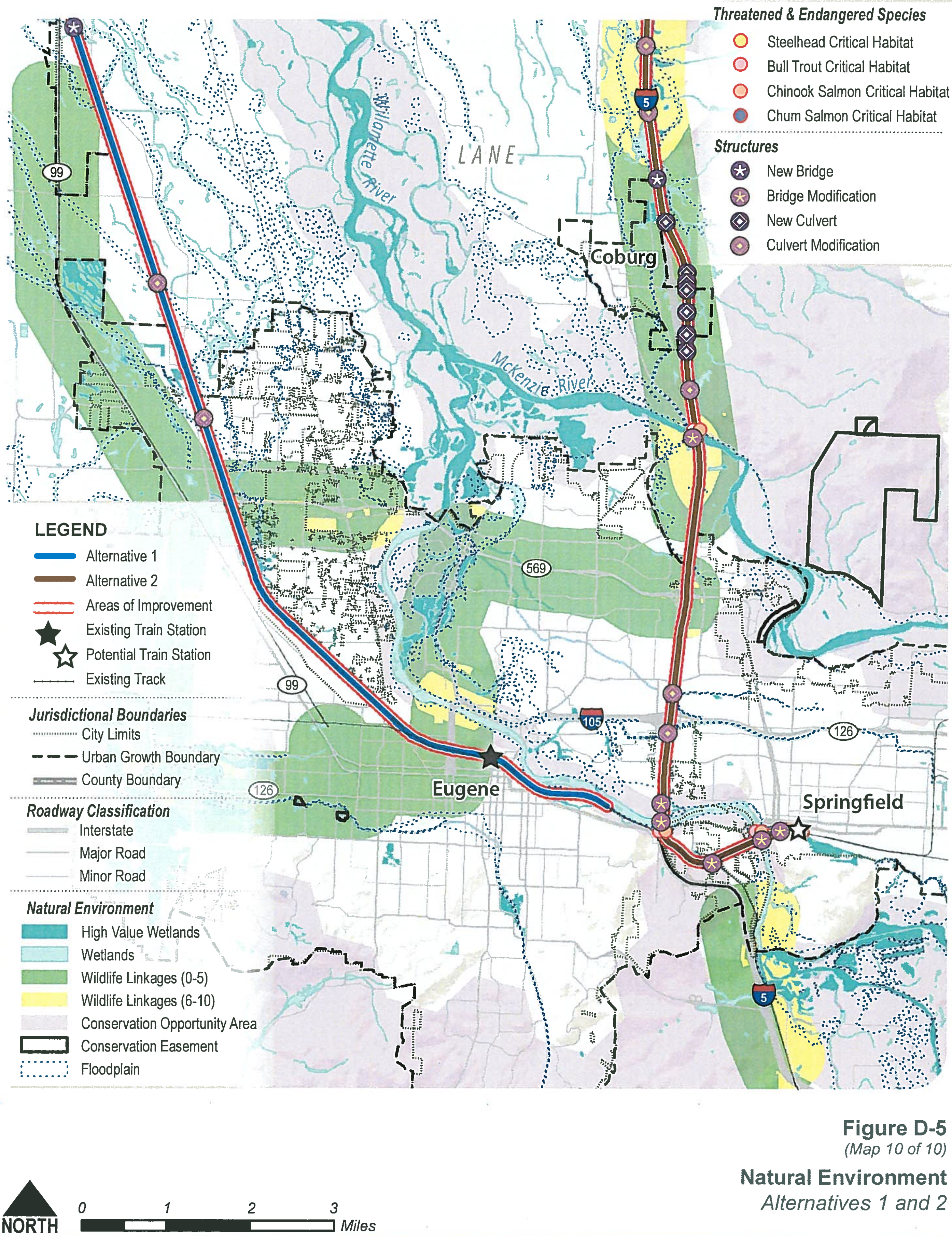


Figure D-5
(Map 10 of 10)

Natural Environment
Alternatives 1 and 2