KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
610 SW Alder Street, Suite 700, Portland, OR 97205 P 503.228.5230 F 503.273.8169

# MEMORANDUM

Date: March 19, 2014

Project #: 13893

To: Rebecca Houghtaling, Oregon State University

From: Phill Worth, Shaun Quayle P.E., Kelly Laustsen, and Karla Kingsley

Project: Base Transportation Model Update: 2013-2014

Subject: Summary of Existing Intersection Operating Conditions for Vehicles

## EXECUTIVE SUMMARY

A technical assessment of vehicular operations has been completed at 28 street intersections surrounding the Oregon State University (OSU) campus. These intersections are the focus of an annual monitoring program, required by the City of Corvallis (City), as a condition of approval of the OSU Master Plan. Results of the annual assessment are used by OSU and the City to determine (1) whether or not it is appropriate to make improvements at any of these intersections and (2) the proportional fair share (if any) that OSU should contribute toward the cost of the improvement.

Seven study intersections are currently not meeting the applicable standards during the a.m. and/or p.m. peak hour, based on traffic volumes measured in November 2013. Three of these intersections were previously reported to not meet standards (2011-2012 OSU Base Transportation Model Update: Technical Letter #3 – Operations Analysis). An improvement has been identified at one of those intersections (15th Street/Washington Way), with construction being anticipated in summer 2014. Options and the associated trade-offs have been developed for each of the remaining six intersections and are presented at the conclusion of this document.

Results of the technical assessment and the options summarized in this document will inform discussions between OSU and the City regarding the appropriate actions moving forward. Outcomes of these discussions could include revisions to the methods of measuring transportation system performance and determining mutually agreeable solutions and fair share proportionality of responsibility.

# INTRODUCTION

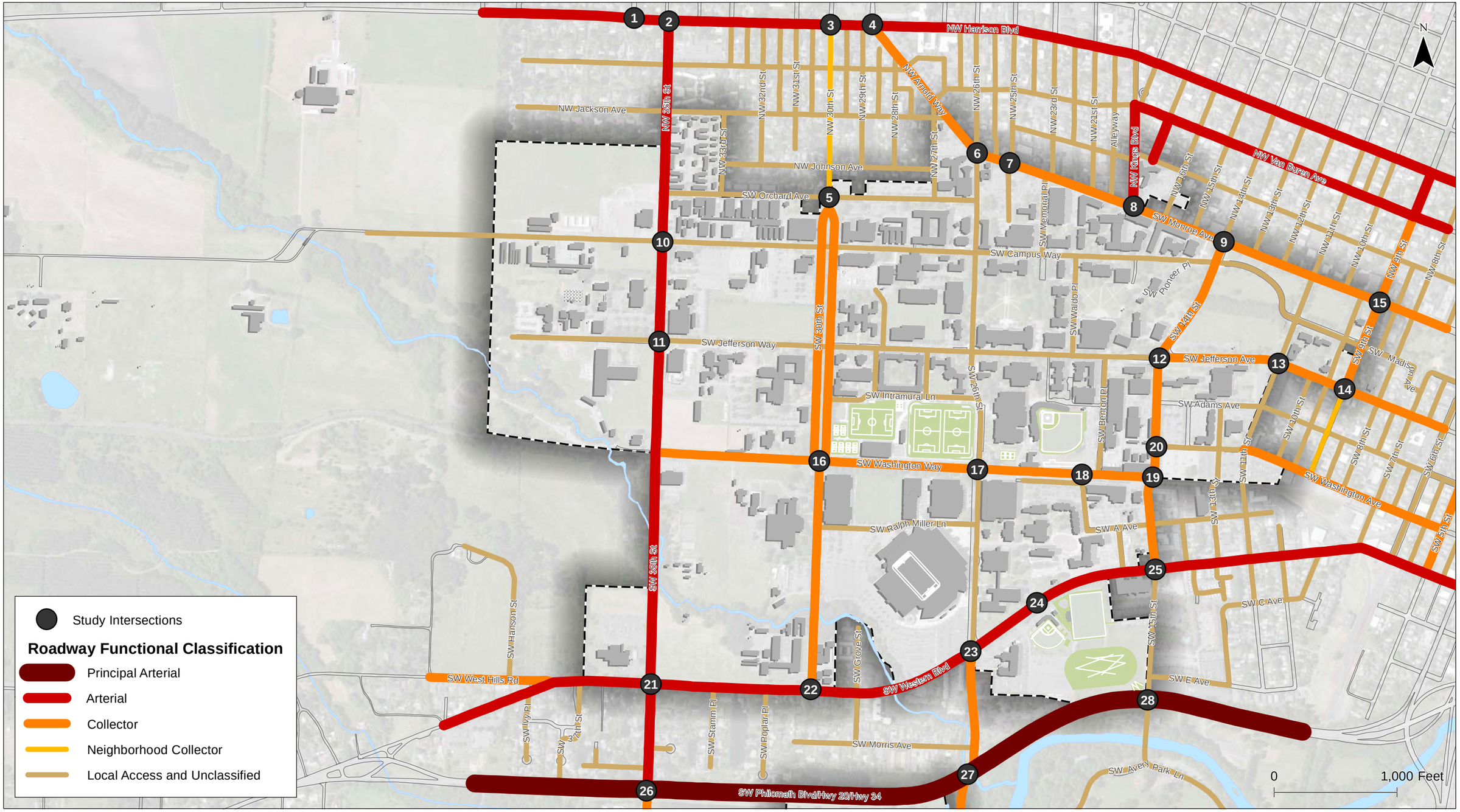
This memorandum summarizes a technical assessment of vehicular performance at 28 study intersections surrounding the Oregon State University (OSU) campus in Corvallis, Oregon. Documentation of this assessment satisfies an annual City of Corvallis (City) reporting requirement that is referred to as the Base Transportation Model (BTM) Update. The City of Corvallis and OSU agreed that the BTM Update for academic year 2013-2014 would analyze the established set of public street intersections, but it would complete the analysis using different analysis tools and procedures. As such, special care should be taken when attempting to compare current results to previous annual reports.

This memorandum is organized as follows:

- **Study Intersections** – a map of the study area showing the location of study intersections and the functional classification of public streets and a set of diagrams illustrating the configuration and method of control at each intersection.
- **2013-2014 Analysis Methodology** – a description of the procedures used to analyze the collected data. Descriptions of the changes in methodology from previous BTM Updates are provided, as well as the likely implications of these changes on the reported results.
- **2013-2014 Analysis Results** – maps and diagrams that summarize the vehicular demands measured at the study intersections and on key roadway segments, tables and diagrams that summarize the vehicular operations analysis results at each intersection, and tables that allow a fair comparison of traffic volumes and vehicular operations results across multiple BTM reports.
- **Options for Intersections Not Meeting Standards** – a summary description of potential approaches to addressing vehicular performance issues, supplemented with vehicular operations analysis of certain improvement options.

# STUDY INTERSECTIONS

Study intersections were selected to maintain consistency with past BTM Update reports. Intersections were originally selected by the City and OSU to identify changes in traffic flows and operations that might be associated with campus development, city and regional growth, and changes to community travel patterns. **Figure 1** maps the study intersections and functional classifications of streets within the study area. Existing lane configurations and traffic control devices at the study intersections are diagramed in **Figures 2a** and **2b**. Where driveways are in close proximity to the intersection and influence operations at the intersection, they are included in the analysis.




**Roadway Functional Classification and Vehicle Operations Study Intersections**
**Oregon State University Vehicle Operations Update**
**Corvallis, Oregon**

Figure
**1**

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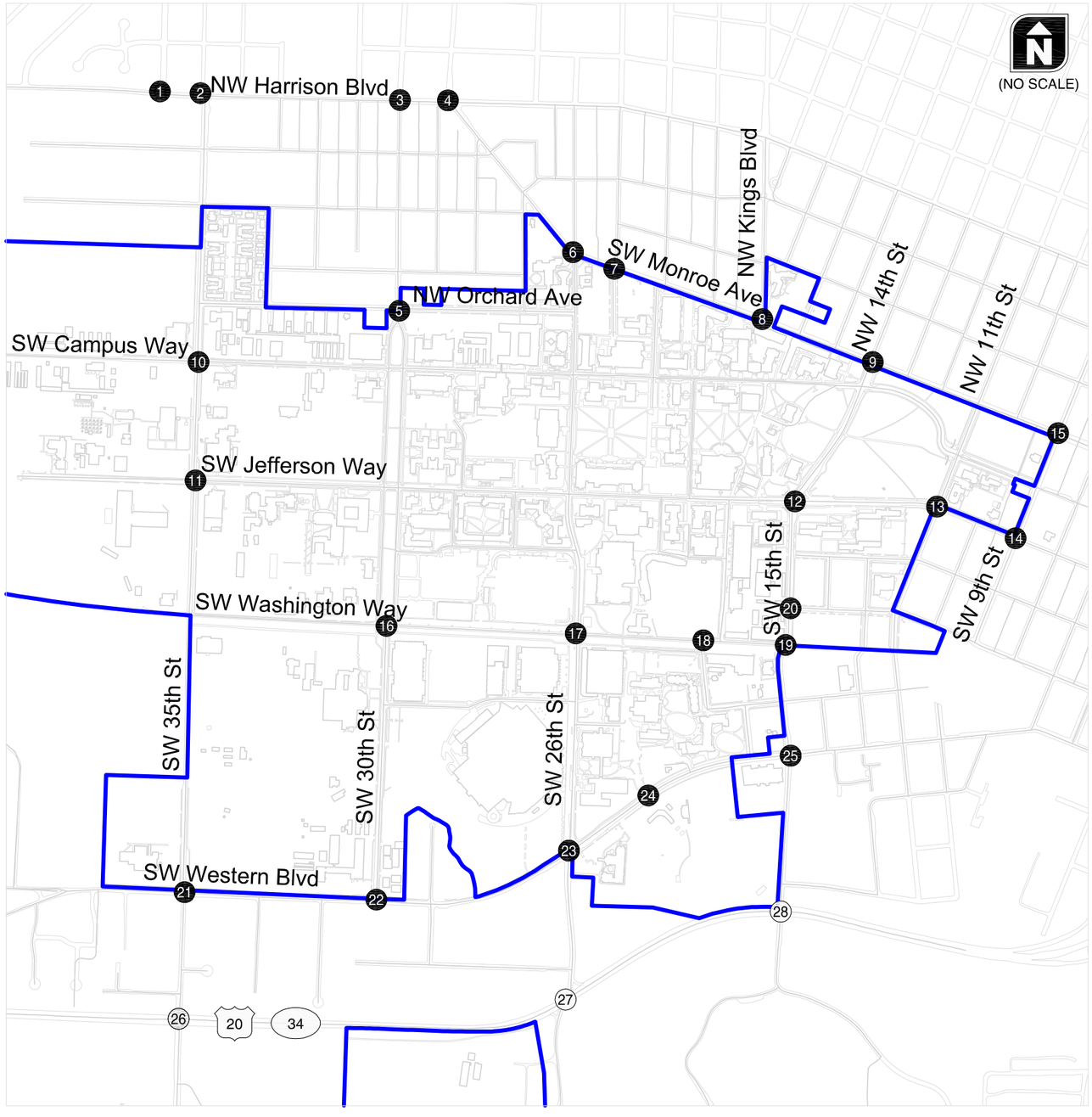
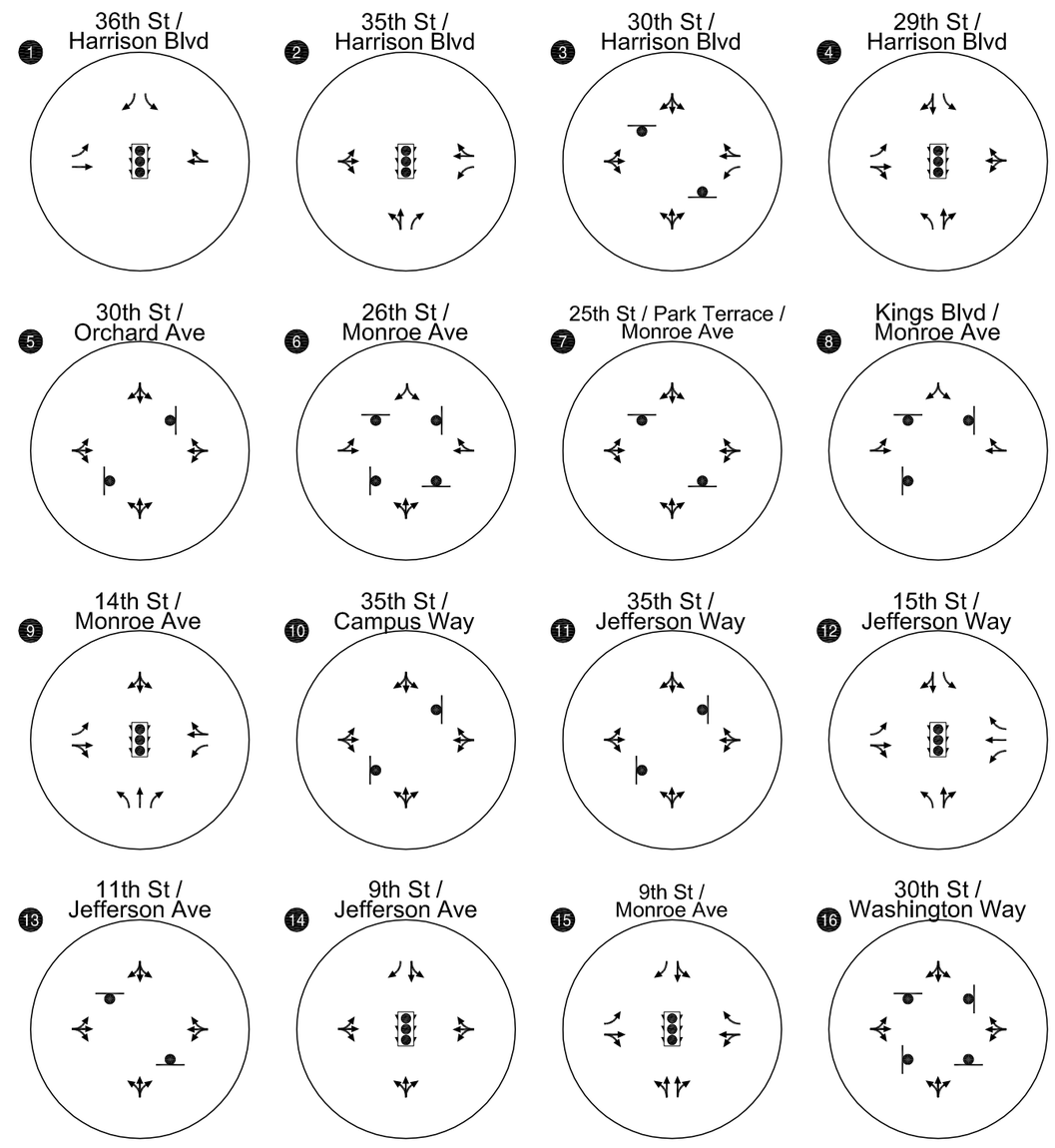
*Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl*

*Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community*

*Data provided by Oregon State University.*




- Campus Boundary
- ## - Study Intersection (City)
- ## - Study Intersection (ODOT)
- Stop Sign
- Traffic Signal

Existing Lane Configurations and Traffic Control Devices
Corvallis, Oregon

Figure 2a

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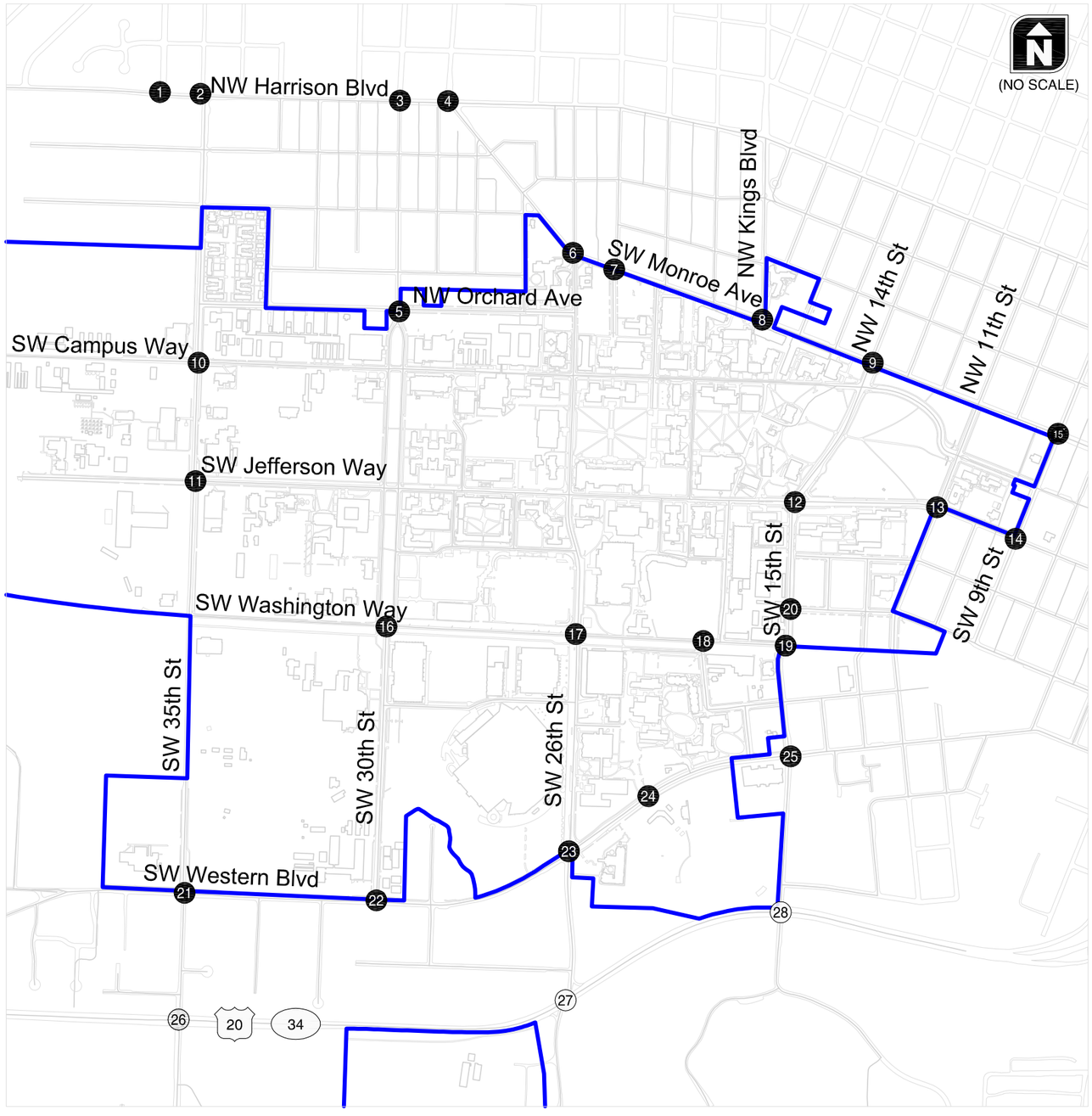


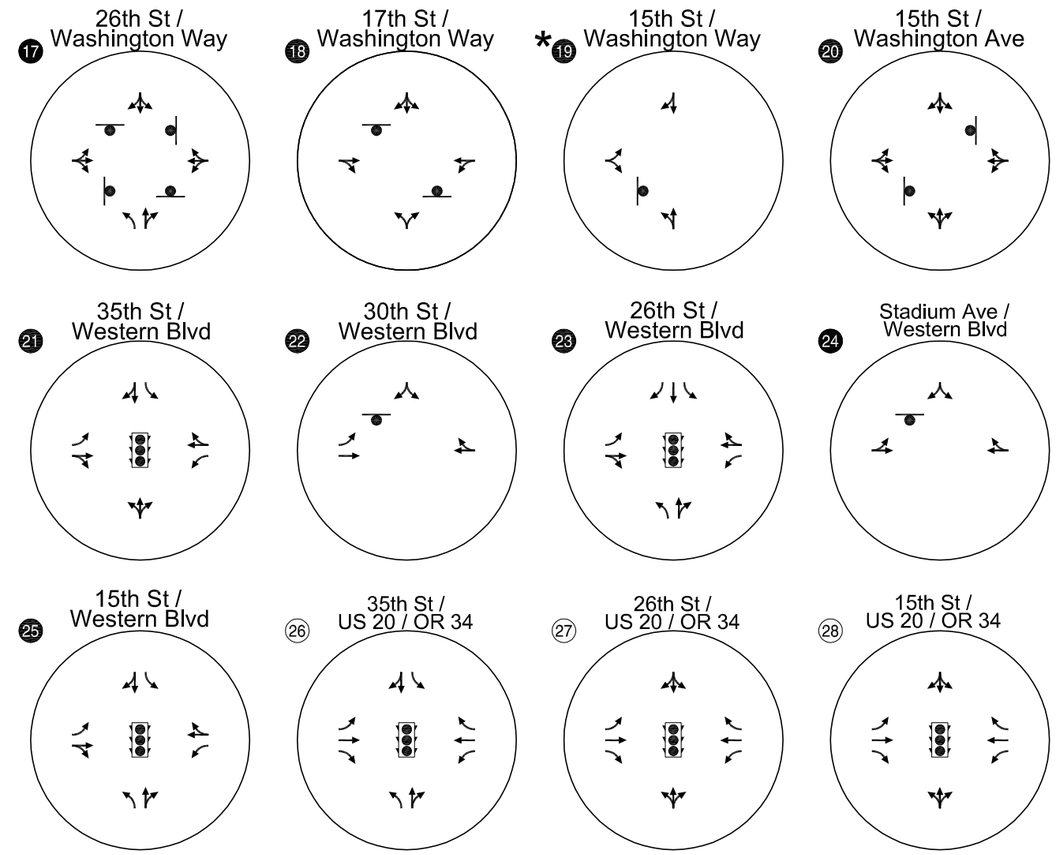


* Planned installation of signal and turn lanes in 2014.

- Campus Boundary
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Existing Lane Configurations and Traffic Control Devices
Corvallis, Oregon

Figure 2b

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# 2013-2014 ANALYSIS METHODOLOGY

The City and the Oregon Department of Transportation (ODOT) have jurisdiction over the primary public streets in the study area. Each agency has established vehicular intersection performance as an important criterion for evaluating the effectiveness of the roadway network in meeting vehicular demands. Both agencies rely on analytical methods that are defined in the *2000 Highway Capacity Manual* (Reference 1), specifically methods of calculating intersection level of service (LOS) and volume-to-capacity ratio. *Appendix A* provides a description of level of service and how it is measured. LOS is directly based on delay, with each LOS grade corresponding to a range of delay. Volume-to-capacity is a comparison of measured (or estimated) vehicular volumes in a given period of time against the estimated capacity of the intersection to accommodate vehicular demand.

At signalized and all-way-stop-controlled intersections, LOS, delay, and volume-to-capacity ratio are measured and reported for the overall intersection. At two-way-stop-controlled intersection, LOS, delay, and volume-to-capacity ratio are reported for the critical movement, defined as the movement with the longest delay. Typically, the critical movement is the left-turn from the stop-controlled approach.

## Intersection Performance Standards

The acceptable City performance standard is LOS “D” or better for all public intersections, regardless of how they are controlled (e.g., stop sign, traffic signal). This standard is established in Section 11.3.9 of the City of Corvallis Comprehensive Plan (Reference 2). LOS “D” corresponds to a delay between 35 and 55 seconds at signalized intersections and a delay between 25 and 35 seconds at unsignalized intersections.

ODOT uses volume-to-capacity (V/C) ratio to assess intersection operations on state facilities. Table 6 of the *Oregon Highway Plan* (OHP, Reference 3) establishes maximum volume-to-capacity ratios for all signalized and unsignalized intersections on state facilities. The OHP ratios are used to support planning efforts to identify and address future system deficiencies. The ODOT-controlled intersections within the study area are located along the Newport-Corvallis Highway (US 20 / OR 34), which is designated as an urban principal arterial and statewide freight route within a Metropolitan Planning Organization (Corvallis Area Metropolitan Planning Organization). Therefore, the intersection performance standard on this highway is a volume-to-capacity ratio of 0.85 or lower.

## Analysis Tool

Previous BTM Updates relied on the BTM Tool for forecasting and analysis of intersection operations. The City and OSU agreed to use a different software analysis tool known as Synchro 7 for the 2013-2014 operational analysis. Synchro fully applies the *2000 Highway Capacity Manual* intersection analysis methodologies required by the City and ODOT and specifically accounts for peak hour traffic patterns, the level of pedestrian and bicycle activity, the signal timing, intersection geometry, and lane

configurations. As such, this tool provides the ability to more accurately measure and report vehicular intersection performance than is available through the current version of the BTM Tool. As such, caution should be used when attempting to compare 2013-2014 results with previous BTM Update reports. Additional information about the ability and appropriateness of comparisons is offered later in this memorandum, in the section "Cautions Regarding Comparisons to Previous Analyses."

# TRAFFIC VOLUME DATA

Analysis of intersection operations during typical weekday morning and evening peak conditions have been completed based on volumes measured during fall term of the OSU 2013-2014 academic year.

## Measured Volumes

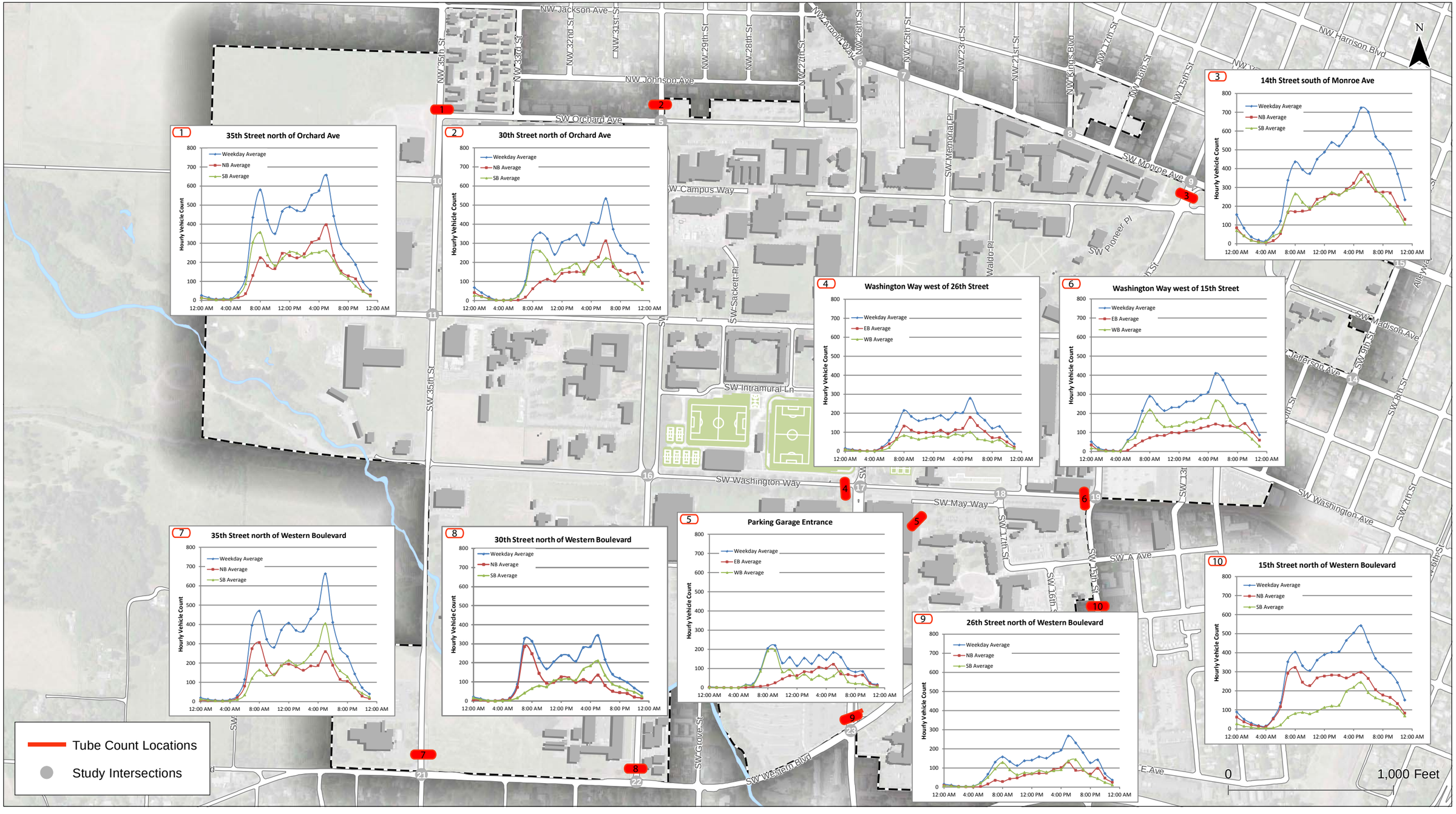
Two types of traffic volume counts were completed in order to establish an understanding of traffic flows on key streets in the area (tube counts), as well as peak traffic demands at each study intersection (intersection counts). Twenty-four hour vehicle classification counts (tube counts) were collected at many locations on and near campus. Examination of this data reveals a profile of vehicular demand over the course of a day and the relationship of peak periods of demand (such as morning and evening commuter peaks) to demands throughout the day. This data also was used to identify when peak period counts (a.m. and p.m.) should be taken at the study intersections.

### *Tube Counts*

Vehicular demand data was collected in 15-minute intervals from approximately November 13, 2013 through November 22, 2013[1] at 10 locations, as shown in **Figure 3**. The data includes vehicle volume, classification (e.g., motorcycle, auto, light truck, bus, and heavy vehicle), direction of travel, and speed. Graphs contained within **Figure 3** show the average hourly directional (red and green lines) and bi-directional weekday traffic volume profile at each tube count location. **Table 1** provides a summary of the average weekday total volume and peak hour volume at each location. As seen in **Table 1** and **Figure 3**, of the locations where data was collected, traffic volumes are highest on 14$^{th}$ Street, south of Monroe Avenue. Only one street[2] (30$^{th}$ Street, north of Western Avenue) experiences the highest vehicular demand during the weekday morning commuter peak (beginning at 7:45 a.m.). The data collected is provided in *Appendix B.*

[1] The dates of data collection varied slightly at some locations due to complications with the equipment.

[2] This excludes the data collection point at the entrance/exit to the parking garage.




**Tube Count Locations and Hourly Volume Profiles**
**Oregon State University Vehicle Operations Update**
**Corvallis, Oregon**

Figure
**3**

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*Coordinate System: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl*
*Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community*

**Table 1: Average Weekday Volumes**

| Location | Average Daily Traffic (ADT)[1] | Peak Hour Volume[1] | Start of Peak Hour |
|---|---|---|---|
| 35th St, north of Orchard Ave | 7,020 | 675 | 4:45 PM |
| 35th St, north of Western Ave | 5,925 | 670 | 4:45 PM |
| 30th St, north of Orchard Ave | 5,400 | 535 | 6:00 PM |
| 30th St, north of Western Ave | 3,670 | 395 | 7:30 AM |
| 15th St, north of Western Ave | 6,700 | 545 | 4:45 PM |
| 14th St, south of Monroe Ave | 8,830 | 725 | 5:00 PM |
| 26th St, north of Western Ave | 2,680 | 270 | 5:00 PM |
| Washington Way west of 26th Ave | 2,915 | 280 | 5:00 PM |
| Washington Way west of 15th Ave | 3,870 | 410 | 5:00 PM |
| Parking Garage (Main entrance/exit) | 2,210 | 225 | 9:15 AM |

[1]Rounded to the nearest 5 vehicles

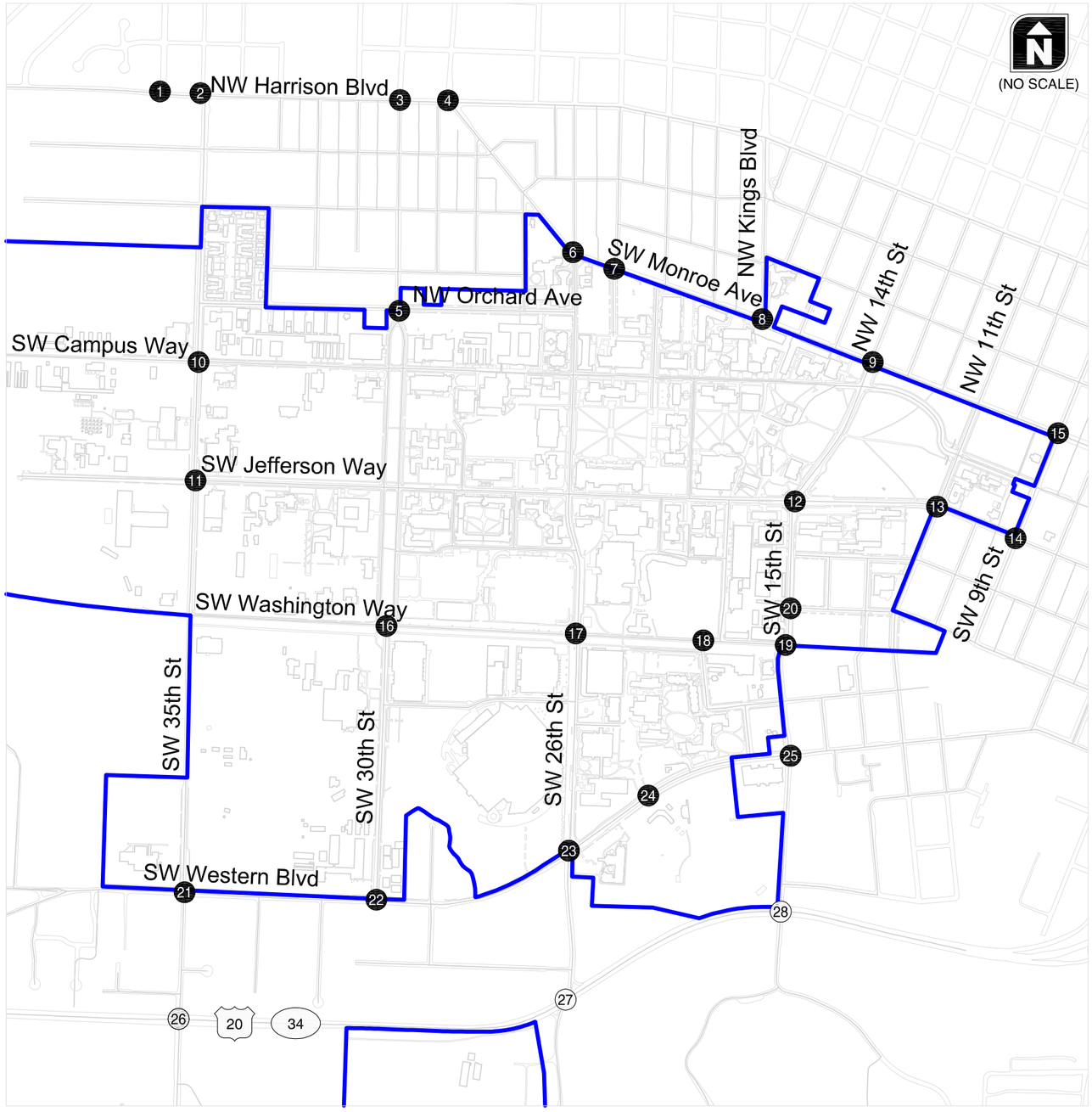
### *Intersection Counts*

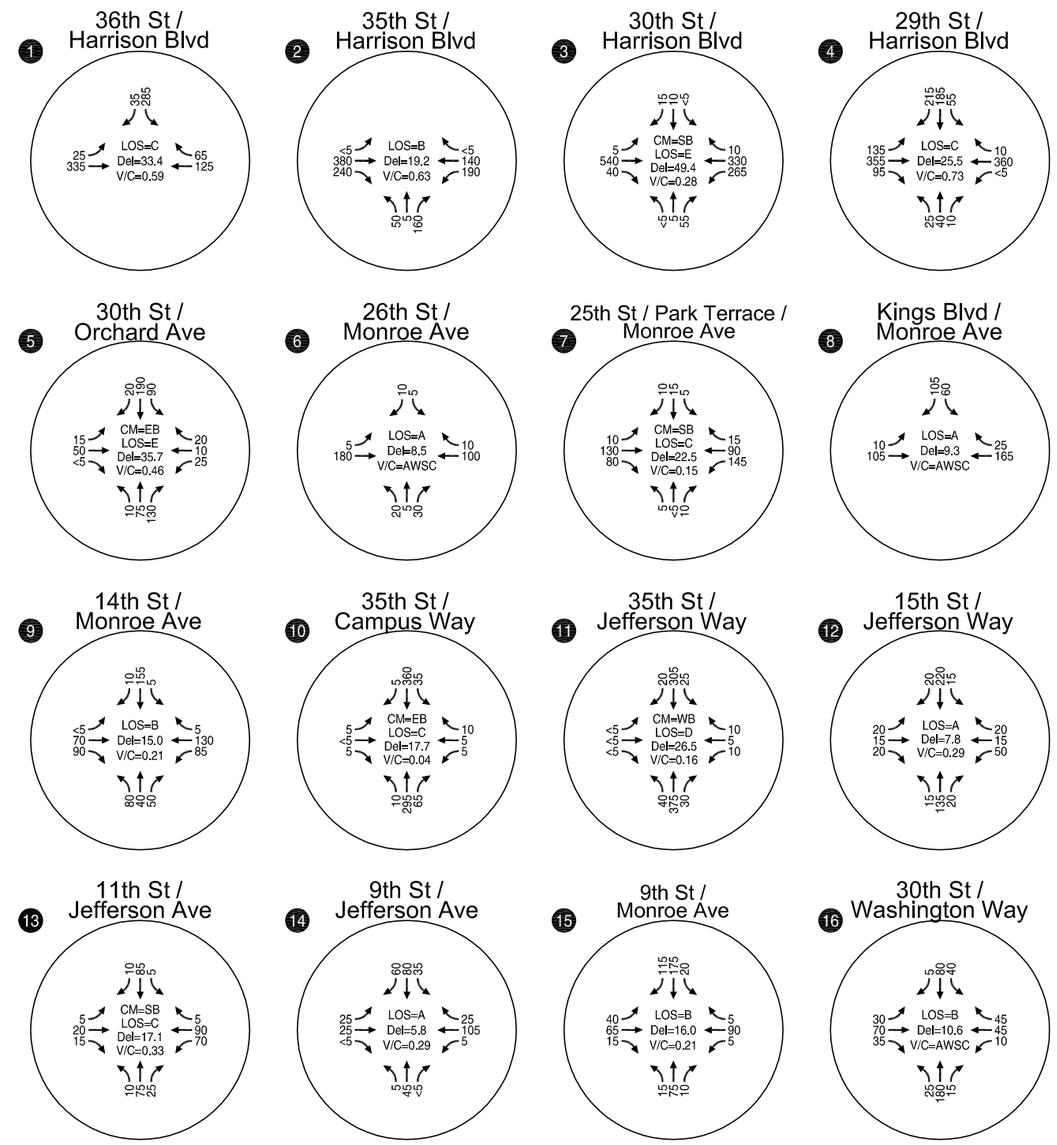
**Figures 4a**, **4b**, **5a**, and **5b** provide a summary of the intersection turning movement counts (rounded to the nearest five vehicles per hour) that were collected at each of the 28 study intersections for the weekday a.m. and p.m. peak hours, respectively. Data was collected on Wednesday, November 13, 2013. Not shown in the figures is pedestrian and bicycle demand data that also was collected at each intersection during each peak period. As previously noted, these pedestrian and bicycle demands were incorporated into the vehicular intersection analysis.

## 2013-2014 INTERSECTION ANALYSIS RESULTS

Vehicular level-of-service (LOS) and volume-to-capacity (v/c) ratios were calculated for each of the study intersections, based on the volume of vehicles, pedestrians, and bicyclists measured on a typical weekday in November 2013. An assessment of traffic volumes at key locations[3] identified the weekday a.m. peak hour as 7:35-8:35 a.m. and the weekday p.m. peak hour as 5:00-6:00 p.m. **Figures 4a**, **4b**, **5a**, and **5b** provide a summary of the 2013-2014 operations analysis results for the weekday a.m. and p.m. peak hours, respectively.

[3] Key locations included the intersections that did not meet standards in the 2011-2012 OSU Base Transportation Model Update report (15th Street/Washington Way, 30th Street/Western Boulevard, and 30th Street/Harrison Boulevard). Peak hours were corroborated with twenty-four hour vehicle classification counts (tube counts).

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LOS - Intersection Level-of-Service (Signalized/ AWSC) / Critical Movement Level-of-Service (TWSC)
Del - Intersection Average Control Delay (Signalized/ AWSC) / Critical Movement Control Delay (TWSC)

V/C - Critical Volume-to-Capacity Ratio
TWSC - Two-Way Stop Control
AWSC - All-Way Stop Control

Existing Intersection Operations - Weekday AM Peak Hour
Corvallis, Oregon

Figure 4a

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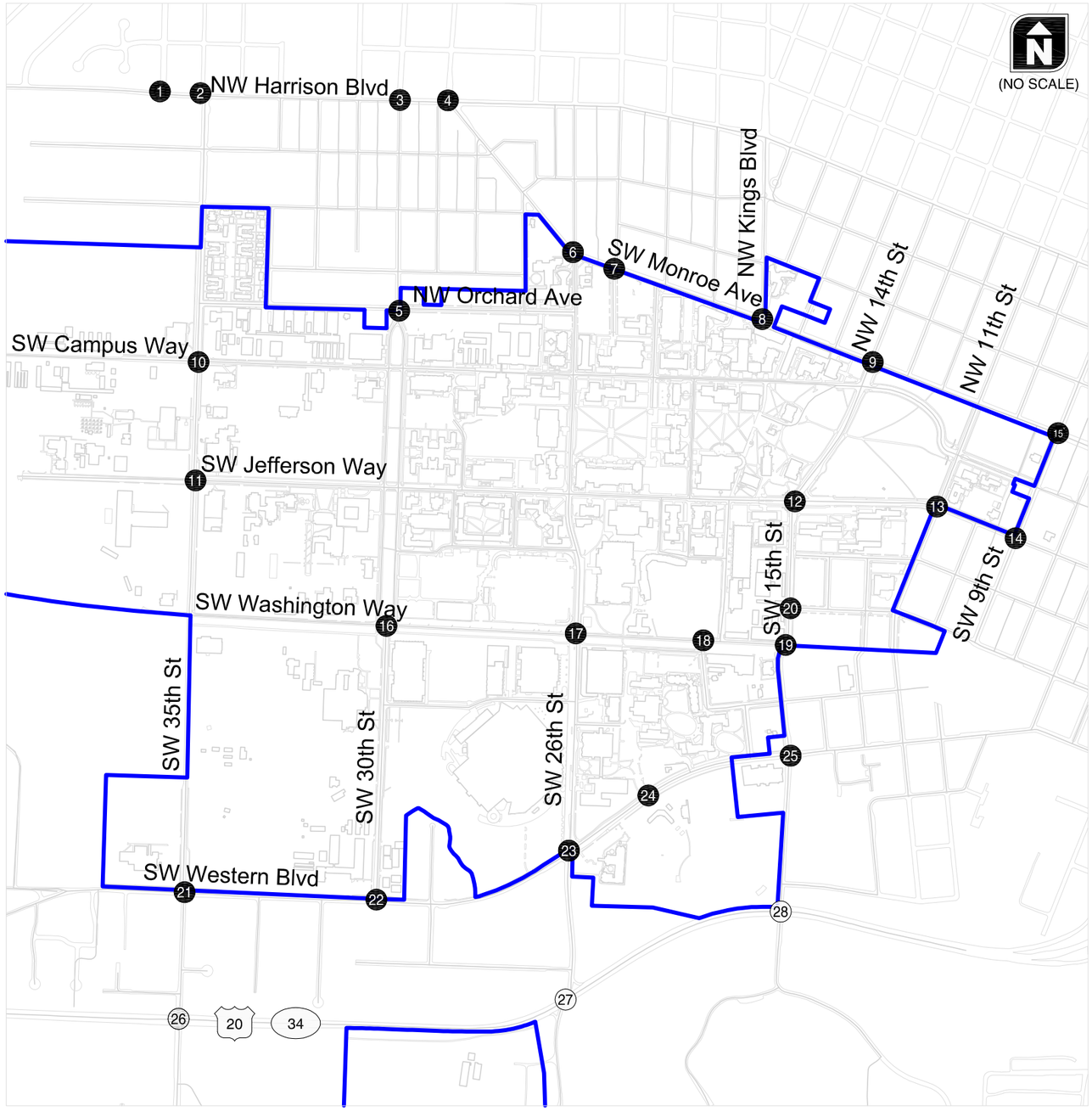


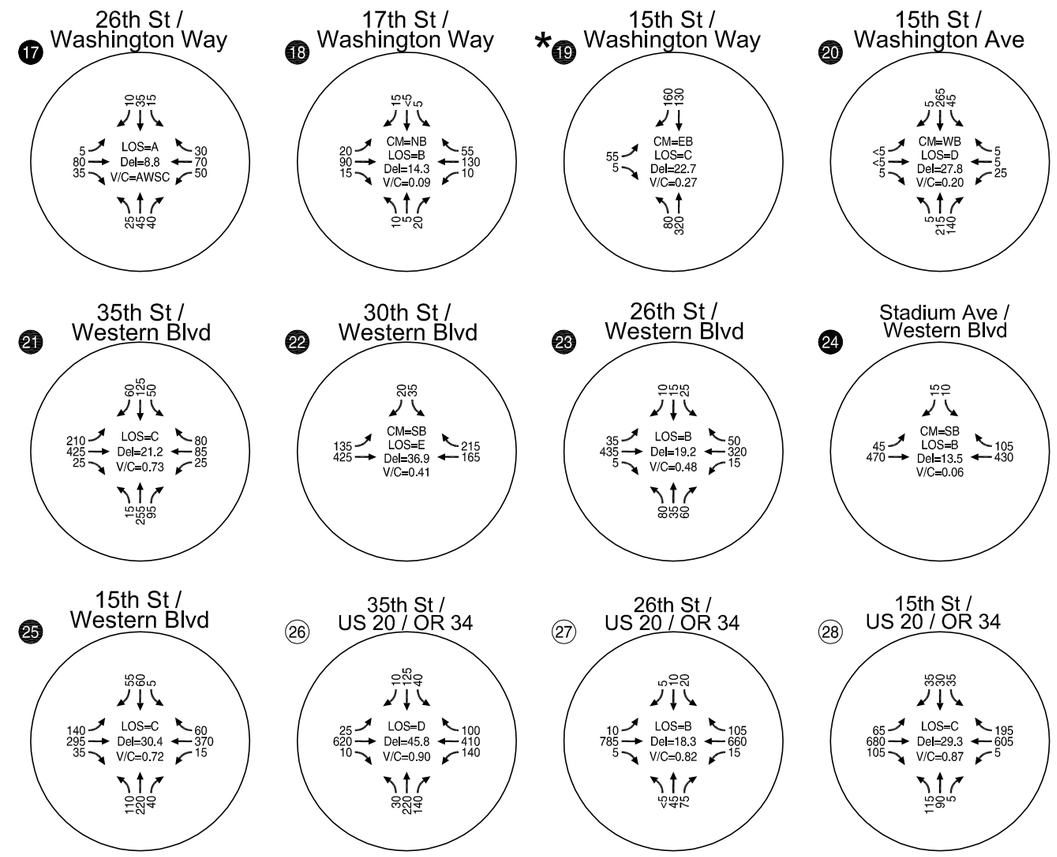


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Existing Intersection Operations - Weekday AM Peak Hour
Corvallis, Oregon

Figure 4b

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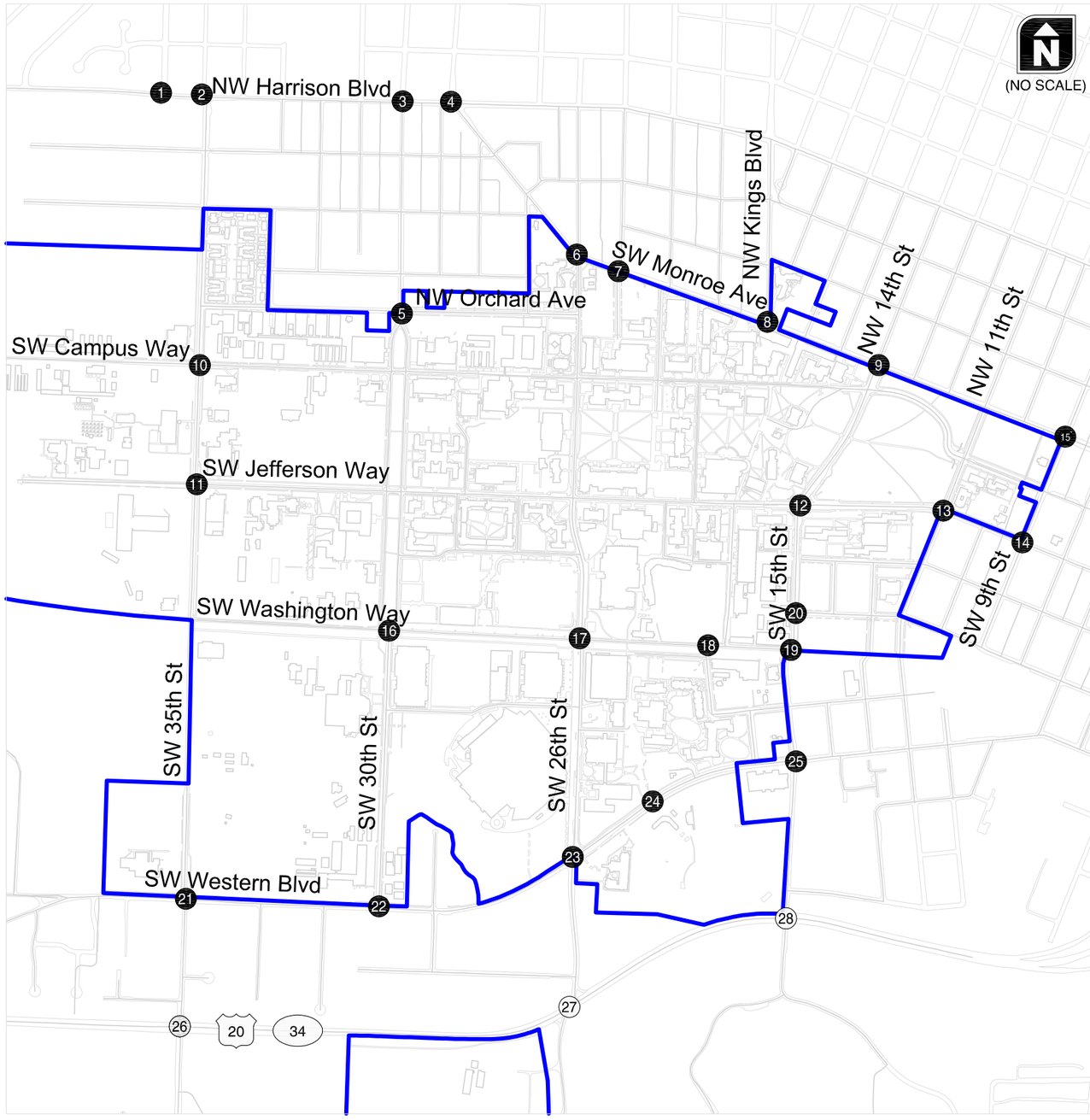


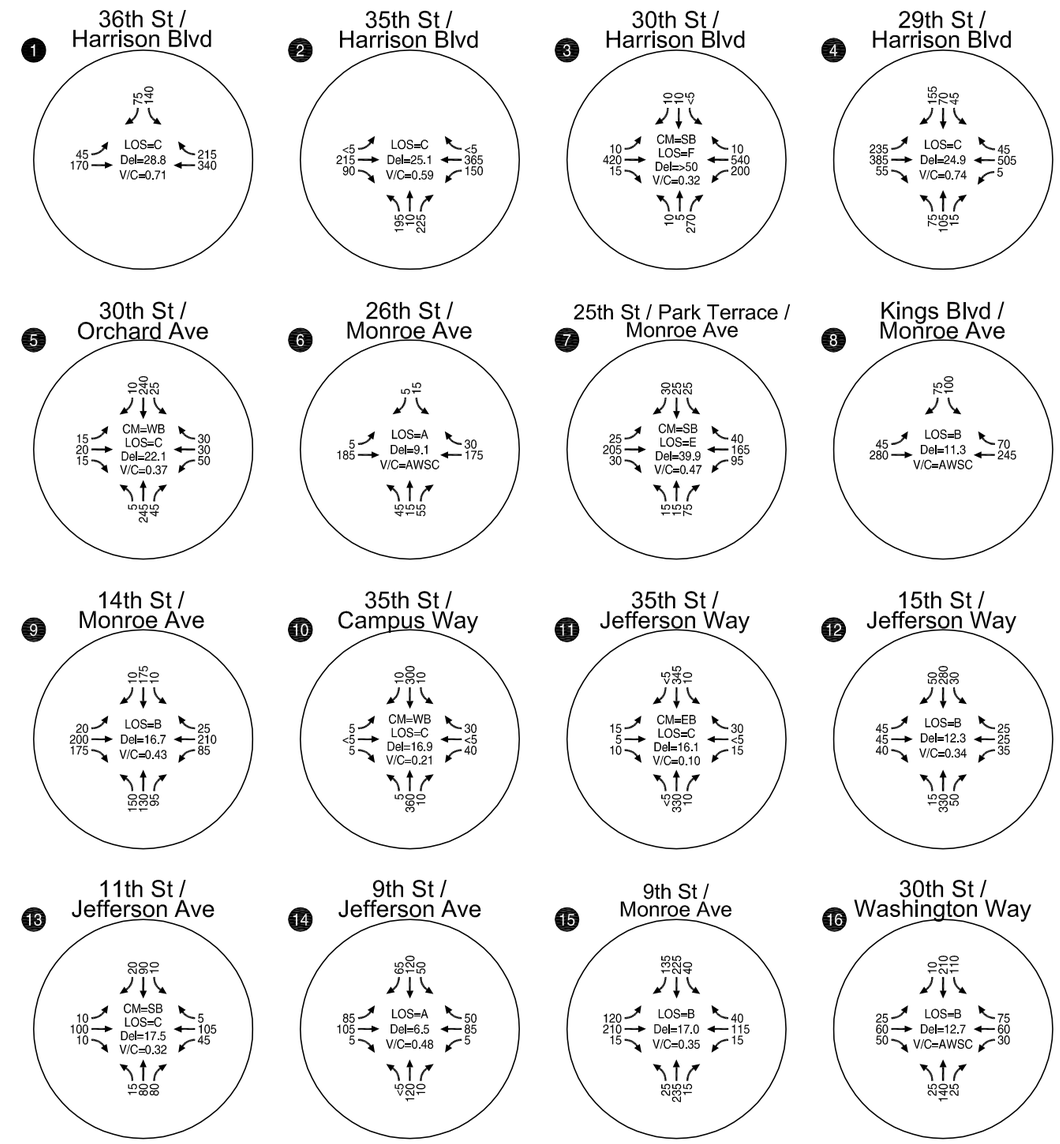


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V/C - Critical Volume-to-Capacity Ratio
TWSC - Two-Way Stop Control
AWSC - All-Way Stop Control

Existing Intersection Operations - Weekday PM Peak Hour
Corvallis, Oregon

Figure 5a

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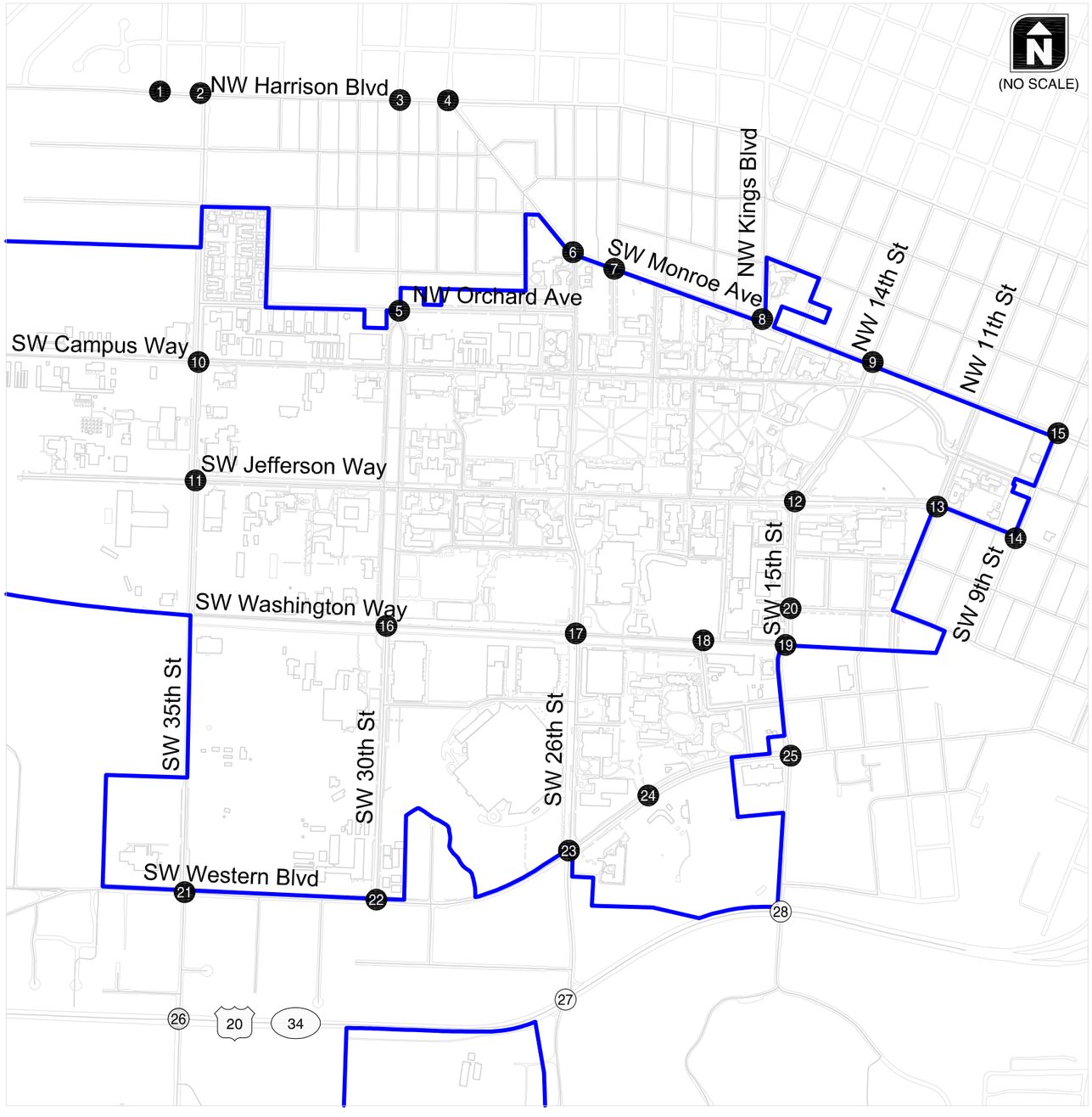


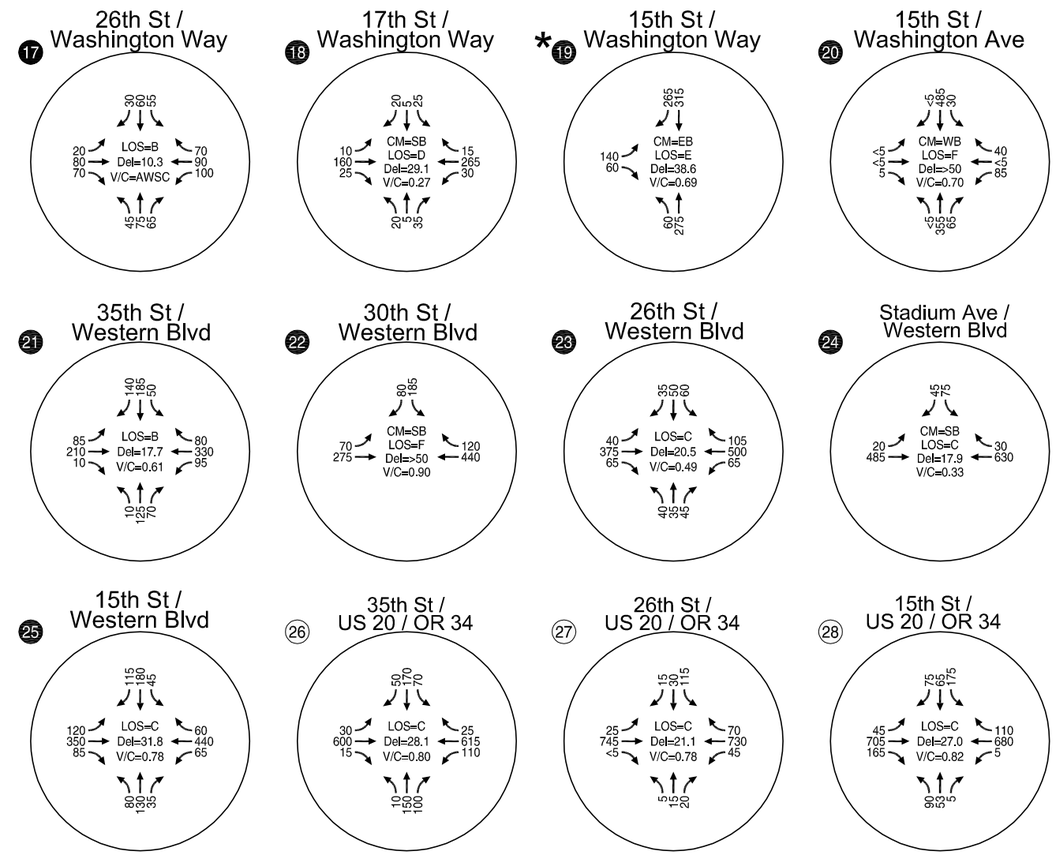


* Planned installation of signal and turn lanes in 2014.

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V/C - Critical Volume-to-Capacity Ratio
TWSC - Two-Way Stop Control
AWSC - All-Way Stop Control

Existing Intersection Operations - Weekday PM Peak Hour
Corvallis, Oregon

Figure 5b

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A total of seven intersections do not meet performance standards during the a.m. peak hour and/or p.m. peak hour. **Table 2** provides a summary of vehicular operations at these intersections. As noted in the table, three of the intersections that are not meeting standards in the 2013-2014 analysis also did not meet standards in the 2011-2012 analysis. Of the three intersections previously identified as not meeting standards, only the 15th Street/Washington Way intersection has been identified for improvement, which is anticipated for construction in 2014. The following section provides some detail regarding the methodological differences between this analysis and the 2010-2011 and 2011-2012 analyses.

*Appendix C contains the traffic count worksheets used in this study. Appendix D contains the existing conditions traffic operations worksheets.*

**Table 2: Intersections not Meeting Standards under 2013-2014 Conditions**

| Intersection | Intersection Control | Critical Movement[1] | Performance Standard | Critical Peak Period(s)[2] | Delay[3] (sec) | v/c Ratio[3] | LOS[3] |
|---|---|---|---|---|---|---|---|
| **3. 30th St & Harrison Blvd *** | TWSC | SB | LOS D[4] | AM/PM | 49.4/70.7 | 0.28/0.33 | E/F |
| 5. 30th St & Orchard Ave | TWSC | EB | LOS D[4] | AM | 35.7 | 0.46 | E |
| 7. 25th St/Park Terrace & Monroe Ave | TWSC | SB | LOS D[4] | PM | 39.9 | 0.47 | E |
| **19. 15th St & Washington Way *** | TWSC (3-leg) | EB | LOS D[4] | PM | 38.6 | 0.69 | E |
| 20. 15th St & Washington Ave | TWSC | WB | LOS D[4] | PM | 57.8 | 0.70 | F |
| **22. 30th St & Western Blvd *** | TWSC (3-leg) | SB | LOS D[4] | AM/PM | 36.9/66.0 | 0.41/0.90 | E/F |
| 26. 35th St & US 20/OR 34 | Signal | - | V/C=0.85 | AM | 45.8 | 0.90 | D |

*Did not meet standards in 2011-2012 Base Transportation Model operations analysis.
[1]Defined as the movement with the longest delay.
[2]Critical peak period refers to peak period(s) during which intersection does not meet standards.
[3]At TWSC intersections, delay, v/c ratio, and LOS are determined by the critical movement, not the delay to all vehicles.
[4]At unsignalized intersections, LOS D is associated with a delay between 25 and 35 seconds.

## Cautions Regarding Comparisons to Previous Analyses

Care has been taken to conduct this analysis by thorough application of the *2000 Highway Capacity Manual* methodology. In so doing, a more complete understanding of operational performance is established for each study intersection. However, the additional technical accuracy precludes certain comparisons from being made to past BTM Update reports. Listed below are the main differences in technical approach and their effects on the analysis results.

- **Pedestrian and bicycle activity.** Intersection analysis prepared for previous reports (e.g., 2010-2011 and 2011-2012) did not consider pedestrian and bicycle activity. Such activity is present at every study intersection and does have a measurable influence on the vehicular performance of the intersection. Their inclusion in the analysis will often result in a higher vehicular delay and sometimes a worse LOS than when they are omitted.

- **Measured versus estimated traffic volumes.** The 2013-2014 analysis uses empirical counts rather than an estimate produced through the forecasting component of the BTM Tool. The volume differences, in total, on one approach, and even to one movement at an intersection can have a measureable effect on the vehicular performance of the intersection.
- **Intersection geometry.** The number of lanes on each approach to an intersection and how they are configured (e.g., through lanes, turn lanes, shared through and turn lanes) has an effect on the total capacity of the intersection. Thus, proper representation of each approach at each intersection is crucial to accurate results. The 2013-2014 analysis has verified all intersection configurations are accurately represented in the analysis. Review of previous BTM Update reports revealed errors that impacted the reported intersection performance results.
- **Default values and assumptions.** The analysis procedures provide default values, based on national research, which can be used when actual data is unavailable for key variables. The 2013-2014 analysis has used measured data to replace the majority of possible default values that may have been used in previous analysis. Examples of the variables include the percent of heavy vehicles in the traffic stream and the specific phasing and timing of traffic signals and their platooning effect on traffic streams at down-stream intersections. Unlike the influence of including pedestrian and bicycle volumes in the intersection analysis, it is far more difficult to estimate the effect of replacing the default values with actual data. This is largely due to multiple variables dynamically interacting within the analysis process.

## Initial Comparisons

### *Volume Growth Compared to Population Growth*

**Table 3** provides greater context for comparing the most recent three analysis years. The total number of vehicles entering an intersection during the critical peak hour (referred to as Total Entering Vehicles) is provided for the seven intersections of concern, for three years of reporting. This comparison reveals small changes in study area traffic volumes over the three-year period from 2010 to 2013. Volumes have increased at some intersections and decreased at others. In the aggregate, traffic volumes have only increased by 0.39% per year. This is a substantially lower rate of growth as compared to total campus population growth (3.98% per year) and a marginally lower rate than the city's overall growth rate (0.54% per year) during the same period.

**Table 3: Volumes and Operations Comparisons for Intersections Not Meeting Standards in 2013**

| Intersection | Peak Period | Total Entering Vehicles (TEV) | | | |
|---|---|---|---|---|---|
| | | 2010 Count | 2011-2012 BTM Volumes[1] | 2013 Count | Annual Growth (2010-2013) |
| 3. 30th St & Harrison Blvd | AM | 1,226 | 1,236 | 1,273 | 1.26% |
| | PM | 1,517 | 1,467 | 1,507 | -0.22% |
| 5. 30th St & Orchard Ave | AM | 640 | 613 | 642 | 0.10% |
| 7. 25th St/Park Terrace & Monroe Ave | PM | 750 | 755 | 744 | -0.27% |
| 19. 15th St & Washington Way | PM | 1,099 | 1,110 | 1,112 | 0.39% |
| 20. 15th St & Washington Ave | PM | 1,122 | 1,119 | 1,066 | -1.69% |
| 22. 30th St & Western Blvd | AM | 928 | 895 | 998 | 2.49% |
| | PM | 1,115 | 1,128 | 1,169 | 1.59% |
| 26. 35th St & US 20/OR 34 | AM | 1,872 | 1,827 | 1,879 | 0.12% |
| Aggregate Traffic Activity | - | 10,269 | - | 10,390 | 0.39% |

[1] Intersection operations reported only for base year 2006 in the 2010 BTM update report.

# CONSIDERATIONS FOR INTERSECTIONS NOT MEETING STANDARDS

As noted above, seven intersections do not meet standards under existing conditions. This section provides detail on the operational characteristics of those intersections. It identifies potential actions at each intersection and the associated pros and cons of each action.

## Two-way Stopped Controlled (TWSC) Intersections

Intersections are controlled by a variety of devices. The device is chosen to best suit the function of the roadways, the type and amount of demand occurring at the intersection, the interconnectedness of the roadways, and the character of surrounding land uses. Control devices can be thought of in a continuum and ordered as follows: no control, yield control, two-way stop control (TWSC), all-way stop control (AWSC), roundabout, and traffic signal. Each type of control creates a degree of delay to some or all users of the intersection and also reduces the capacity of the roadway(s) that are controlled. Thus, the general approach of transportation professionals is to install the lowest order (or least impactful) control device necessary to provide safe operating conditions without undue delay.

Six of the seven intersections not meeting standards are controlled by stop signs on just the side-street approach(es). This type of intersection control is chosen for locations where traffic demands to and from the side streets are considerably lower than on the main street. Such intersection controls are very effective, particularly in areas where a network of streets provides motorists with route options. Such options allow drivers to avoid high-delay intersections and/or to access intersections that give them better certainty of access, such as all-way stop controlled or signalized intersections.

Vehicles traveling on the main street through a TWSC intersection are not controlled and, therefore, experience no delay to their movements. For this reason, the vehicular analysis procedure was developed to reveal the amount of delay that vehicles experience when approaching from the side street [*NOTE: By comparison, the vehicular analysis procedure for a signalized intersection (where all vehicles are controlled by the signal), measures the stopped delay for all vehicles*].

Often, the percentage of vehicles experiencing the delay reported at a TWSC intersection is very low (less that 5% of all vehicles using the intersection). When the analysis is done on volumes during the highest hour of intersection use (referred to as the peak hour), the reported result becomes even less representative of what the majority of intersection users experience throughout the day. In addition, the tolerances for delay that are used to establish the level-of-service (LOS) grade (A through F) for TWSC intersection analysis are the most stringent, as compared to all other intersection analysis procedures. Thus, it is not prudent to solely rely on TWSC LOS to determine whether or not a deficiency exists that must be mitigated.

Transportation professionals have developed additional methods to determine when it is appropriate to consider a change in intersection configuration or traffic control device. One such method is the use of "warrants" to substantiate the benefit of switching from TWSC to AWSC or traffic signal. ***It becomes advisable to investigate the need to modify a TWSC intersection when (1) route options do not exist for those using the side-street approach and (2) volumes on the side-street approach regularly exceed 10% (or 30%, depending on the warrant) of the main street volume.***

The TWSC analysis procedure is sometimes referred to as being very conservative for the reasons described above. Additional screening is advised, before conducting further technical analysis. The two screens highlighted above are broadly accepted and have been included as a part of the following considerations for each intersection currently not meeting standards.

### *Intersection 3: 30th Street & Harrison Boulevard*

**Operations detail:** This is a four-legged, TWSC intersection that stop-controls both approaches of 30th Street, each being equipped with single-lane approaches. The Harrison Boulevard approaches are not controlled and each is equipped with a shared through/right-turn lane and the westbound approach has an exclusive left-turn lane. Delays for the stop-controlled southbound and northbound approaches cause vehicles on these approaches to experience a poor LOS, with the southbound direction experiencing the highest delay (LOS F). However, volumes in the southbound direction are low, with just 11 vehicles in the a.m. peak hour and 14 vehicles in the p.m. peak hour making through or left turn movements; each volume is less than 1% of the total volume of vehicles using the intersection during the respective peak hour. The grid network of streets in this area of the city provides route options for northbound and southbound vehicles, including some with signalized intersections on Harrison Boulevard. The screens for TWSC intersections discussed above would strongly suggest that no further analysis or action be taken at this time. Further, installing all-way stop control or a traffic signal would introduce delay on Harrison Boulevard, which is an arterial roadway with much higher traffic volumes

that is intended to provide high mobility for through traffic. In contrast, 30th Street is a low-volume collector intended to link adjacent land uses to Harrison Boulevard and other arterials. Therefore, installing all-way stop control or a traffic signal at this location would measurably increase system delay and vehicle emissions, adversely impacting the neighborhood and the broader community.

**Table 4** provides a number of potential actions that could be taken at the 30th Street and Harrison Blvd intersection. Each option includes an evaluation of associated trade-offs.

**Table 4: Potential Actions at 30th Street & Harrison Boulevard**

| Potential Action | Pros | Cons |
|---|---|---|
| **Take no action.**<br>*NOTE: The surrounding community has been reluctant to consider geometric or traffic control changes at this intersection. Issues raised include concerns for the potential loss of mature trees that line the streets in this neighborhood, the increased exposure that pedestrians may experience if 30th Street was widened at the intersection, and the change in neighborhood character that may result from a traffic signal.* | • No cost.<br>• No right-of-way impacts.<br>• No change that would affect mobility, connectivity or exposure for vehicles, pedestrians, and bikes.<br>• No physical change that may affect neighborhood character.<br>• Preserves mature trees.<br>• Minimizes system delay and vehicle emissions, as compared to any other traffic control measure. | • For 15 to 30 minutes of a typical day, the intersection would not meet standards for less than 1% of all vehicle users at the intersection. |
| **Prohibit certain movements**.<br><br>Install signage to prohibit through and left-turn movements for the northbound and southbound directions *during peak periods only.* | • Restores intersection to acceptable standard.<br>• Considered to be a low-cost action to meet the standard.<br>• Would reduce the number of auto/ped conflicts during peak periods on 30th Street. | • Reduces connectivity for vehicles whose turn movement is restricted.<br>• May cause some out-of-direction travel, as vehicles that previously turned left from 30th Street during the peak periods will have to find new routes.<br>• Could increase the frequency of drivers not obeying traffic control signs, as drivers wishing to turn left from 30th Street could disregard the restriction.<br>• Does not meet driver expectation, as most two-way-stop controlled intersections allow all movements. Drivers not familiar with the area could overlook the turn-restriction. |

| Potential Action | Pros | Cons |
|---|---|---|
| **Modify City policy**.<br><br>The current City LOS standard for TWSC intersections establishes a performance threshold that is exceedingly difficult to maintain and defines a "problem" that have few, if any, practical and cost-feasible solutions. Options include:<br>- - requiring warrants to be met, in addition to the current standard<br>- - lowering the threshold from D to E or F<br>- - or converting to a multimodal standard[4]. | Depending on the policy change:<br><br>• Would avoid prematurely raising concerns.<br>• Would avoid identifying "problems" that lack practical solutions.<br>• Would save staff time, city resources and avoid overbuilding public infrastructure.<br>• Would allow the city to consider multimodal operations and broader goals, in addition to vehicle mobility. | • Would require efforts by the City to determine and implement the appropriate policy and/or procedural changes. |

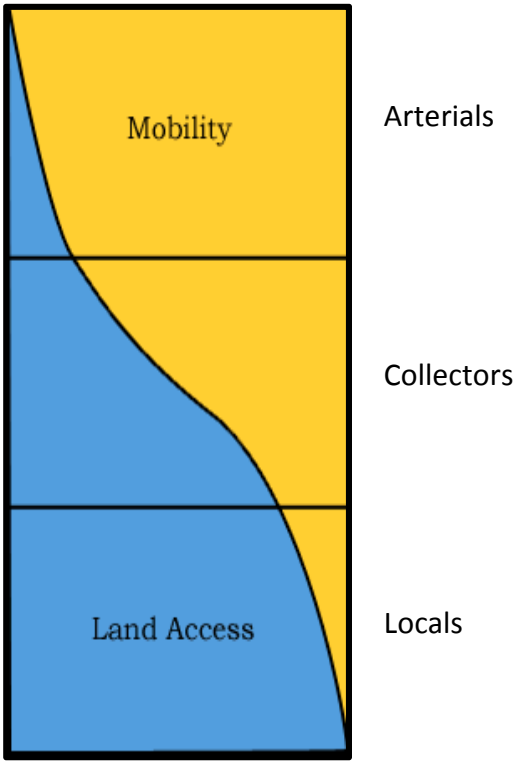
### *Intersection 5: 30th Street & Orchard Avenue*

**Operations detail:** This intersection is currently stop-controlled on Orchard Avenue, with a single shared lane for all movements on all approaches. The delay standard of 35 seconds is exceeded by 0.70 seconds (measured at an average of 35.7 seconds for 31 through and left-turning vehicles) on the eastbound approach during the a.m. peak hour. Less than 5% of the vehicles using this intersection experience this delay during the hour. A relatively low peak hour factor of 0.71 indicates that this level of delay is limited to only the peak 15 minutes of the peak hour. A sensitivity analysis revealed that with a small increase of the peak hour factor to 0.75, the intersection would operate at LOS D. This means that the failure at the intersection is largely due to a sharp increase in volumes on Orchard Street for less than 15 minutes of the peak hour.

The grid network of streets in this area provides route options for eastbound and westbound vehicles. Side street volumes are too low to warrant consideration of alternative intersection control devices. These screens would strongly suggest that no further analysis or action be taken at this time. Further, installing all-way stop control or a traffic signal would increase system delay on 30th Street and vehicle emissions, adversely impacting the neighborhood and the broader community. 30th Street is a neighborhood collector while Orchard Avenue is a local street. As illustrated in the graph in **Exhibit 1**, mobility is a higher priority on collectors than local streets. Thus, when possible, delayed should be minimized on higher order (arterial and collector) roadways.

[4] Other Oregon cities have already adopted different standards for two-way stop controlled intersections, including the City of Tigard, which requires LOS E and a v/c of 0.95 or better for the critical approach, and the City of Albany, which requires a v/c ratio of 0.85 or better for the critical movement.

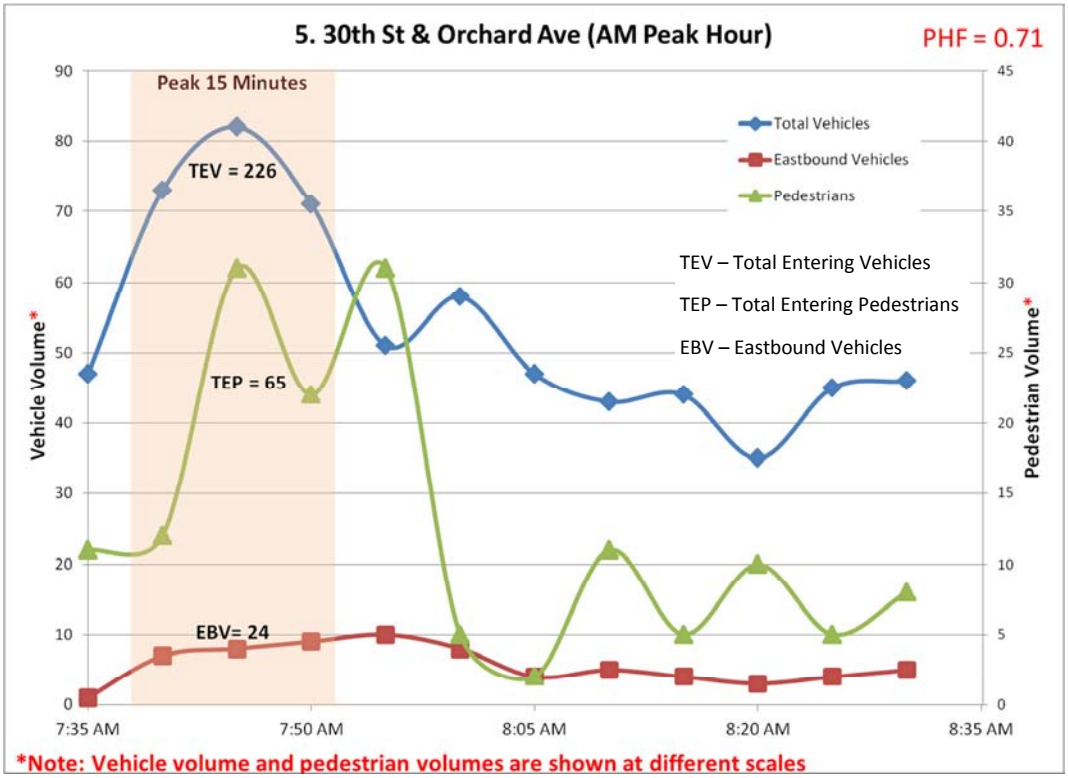
**Exhibit 1: Relationship between Access, Mobility, and Functional Classification**




### *Multimodal Perspectives and Peaking Characteristics*

The graph in **Exhibit 2** illustrates the peaking nature of volumes at this intersection. The orange shading indicates the peak 15 minutes of the peak hour. The blue line indicates the total entering volume of the intersection as counted in five-minute intervals. The graph also illustrates through the red line the relatively low volume of vehicles on the eastbound approach, which has the longest delays. The green line indicates pedestrian volumes at the intersection, which are measured based on the y-axis on the right-side of the graph. Similar graphs for all intersections not meeting standards are provided in *Appendix E*.

**Exhibit 2: Vehicle and Pedestrian Volumes at 30th Street & Orchard Avenue**




The 30th Street/Orchard Avenue intersection appears to operate with longer delays than in the 2011/2012 analysis; however, this is attributable to the inclusion of pedestrians in the 2013-2014 analysis. Vehicle delay is impacted by the more than 150 pedestrians crossing in the a.m. peak hour.

**Table 5** provides a number of potential actions that could be taken at the intersection. Each option includes an evaluation of associated trade-offs.

**Table 5: Potential Actions at 30th Street & Orchard Avenue**

| Potential Action | Pros | Cons |
|---|---|---|
| **Do nothing**.<br>*NOTE: The surrounding community has been reluctant to consider geometric or traffic control changes at this intersection. Issues raised include concerns for the potential loss of mature trees in the area, the increased exposure that pedestrians may experience if Orchard Avenue was widened at the intersection, and the change in neighborhood character that may result from a change in traffic control.* | • No cost.<br>• No right-of-way impacts.<br>• No change that would affect mobility, connectivity or exposure for vehicles, pedestrians, and bikes.<br>• No physical change that may affect neighborhood character or parking.<br>• Preserves mature trees.<br>• Minimizes system delay and vehicle emissions, as compared to any other traffic control measure. | • For 15 minutes on a typical day, the intersection would not meet standard for less than 5% of all intersection users (31 out of 642 vehicles). |

| Potential Action | Pros | Cons |
|---|---|---|
| **Prohibit certain movements**.<br><br>Install signage to prohibit through and left-turn movements for the eastbound and westbound directions **during peak periods only**. | • Restores intersection to acceptable standard.<br>• Considered to be a low-cost option to meet the standard.<br>• Would reduce the number of auto/ped conflicts (during peak periods) on Orchard Avenue. | • Reduces connectivity for vehicles due to turn- restriction.<br>• May cause some out-of-direction travel, as vehicles that previously turned left from Orchard Avenue during the peak periods will have to find new routes.<br>• Could increase the frequency of drivers not obeying traffic control signs, as drivers wishing to turn left from Orchard Avenue could disregard the restriction.<br>• Does not meet driver expectation, as most two-way-stop controlled intersections allow all movements. Drivers not familiar with the area could be unaware of the turn-restriction. |
| **Convert intersection to all-way stop-control.**<br><br>This potential action is considered for its pedestrian and bicycle benefit. | • Relatively inexpensive change.<br>• Would allow intersection to meet existing standard.<br>• Would enhance pedestrian crossing opportunities of 30th Street. | • Would introduce stop control for vehicles on 30th Street, creating delays for vehicles and bikes on the higher volume street.<br>• Would increase vehicle emissions. |
| **Modify City policy**.<br><br>The current City LOS standard for TWSC intersections establishes a performance threshold that is exceedingly difficult to maintain and defines a "problem" that have few, if any, practical and cost-feasible solutions. Options include:<br>- - requiring warrants to be met, in addition to the current standard<br>- - lowering the threshold from D to E or F<br>- - or converting to a multimodal standard. | Depending on the policy change:<br><br>• Would avoid prematurely raising concerns.<br>• Would avoid identifying "problems" that lack practical solutions.<br>• Would save staff time, city resources and avoid overbuilding public infrastructure.<br>• Would allow the city to consider multimodal operations and broader goals, in addition to vehicle mobility. | • Would require efforts by the City to determine and implement the appropriate policy and/or procedural changes. |

### *Intersection 7: 25th Street/Park Terrace-Monroe Avenue*

**Operations detail:** This intersection is currently stop-controlled on 25th Street and Park Terrace, with a single shared lane for all movements on all approaches. The delay standard of 35 seconds is exceeded by 4.9 seconds (measured at an average of 39.9 seconds for 52 through and left-turning vehicles) on the southbound approach during the p.m. peak hour. Less than 7% of the 744 vehicles using this

intersection experience this delay during the hour. Additionally, 445 pedestrians enter the intersection during the peak hour.

The 25th Street/Park Terrace-Monroe Avenue intersection appears to operate with significantly longer delays than in the 2010-2011 or 2011-2012 analysis; however, this is attributable to the inclusion of pedestrians in the 2013-2014 analysis. A sensitivity analysis revealed that analyzing the intersection with existing vehicle volumes and no pedestrian volumes produces a LOS C result, but is not reflective of actual conditions.

**Table 6** provides a number of potential actions that could be taken at the intersection and includes an evaluation of associated trade-offs.

**Table 6: Potential Actions at 25th Street/Park Terrace-Monroe Avenue**

| Potential Action | Pros | Cons |
|---|---|---|
| **Do nothing.** | • No cost or right-of-way impacts.<br>• No change that would affect mobility, connectivity or exposure for vehicles, pedestrians, and bikes.<br>• No physical change that may affect area character or parking.<br>• Minimizes system delay and vehicle emissions, as compared to any other traffic control measure. | • For 15 minutes of a typical day, the intersection would not meet standard for less than 7% of all vehicle users (52 out of 744 vehicles) or less than 5% of all intersection users (including pedestrians). |
| **Prohibit certain movements**.<br><br>Install signage to prohibit through and left-turn movements for the southbound direction **during peak periods only**. | • Restores intersection to acceptable standard.<br>• Considered to be a low-cost option to meet the standard.<br>• Would reduce the number of auto/ped conflicts (during peak periods) on 25th Street. | • Reduces connectivity for vehicles due to turn- restriction.<br>• May cause some out-of-direction travel, as vehicles that previously turned left from 25th Street during the peak periods will have to find new routes.<br>• Could increase the frequency of drivers not obeying traffic control signs, as drivers wishing to turn left from 25th Street could disregard the restriction.<br>• Does not meet driver expectation, as most two-way-stop controlled intersections allow all movements. Drivers not familiar with the area could be unaware of the turn-restriction. |

| Potential Action | Pros | Cons |
|---|---|---|
| **Convert intersection to all-way stop-control.**<br><br>This potential action is considered for its pedestrian and bicycle benefit. | • Relatively inexpensive change.<br>• Would allow intersection to meet existing standard.<br>• Would enhance pedestrian crossing opportunities of Monroe Street. | • Would introduce stop control for vehicles on Monroe Street, creating delays for vehicles and bikes on the higher volume street.<br>• Would increase vehicle emissions. |
| **Modify City policy**.<br><br>The current City LOS standard for TWSC intersections establishes a performance threshold that is exceedingly difficult to maintain and defines a "problem" that have few, if any, practical and cost-feasible solutions. Options include:<br>- - requiring warrants to be met, in addition to the current standard<br>- - lowering the threshold from D to E or F<br>- - or converting to a multimodal standard. | Depending on the policy change:<br><br>• Would avoid prematurely raising concerns.<br>• Would avoid identifying "problems" that lack practical solutions.<br>• Would save staff time, city resources and avoid overbuilding public infrastructure.<br>• Would allow the city to consider multimodal operations and broader goals, in addition to vehicle mobility. | • Would require efforts by the City to determine and implement the appropriate policy and/or procedural changes. |

### *Intersection 19: 15th Street & Washington Way*

**Operations detail:** This three-legged T-intersection is currently stop-controlled on Washington Way with a single shared lane for all movements on all approaches. Average delays of 38.6 seconds for 139 left-turning vehicles on the eastbound approach cause the intersection to not meet standards in the p.m. peak hour, with a LOS E. This is more than 12% of all entering vehicles at the intersection.

Approximately 100 pedestrians pass through the intersection during the peak hour. A sensitivity analysis revealed that analyzing the intersection with existing vehicle volumes and no pedestrian volumes produces a LOS D result, but is not reflective of actual conditions.

**Potential actions at 15th Street & Washington Way:**

The installation of a signal and turn lanes at 15th Street & Washington Way is planned, with construction anticipated in summer 2014. The intersection will meet standards once the project is complete.

### *Intersection 20: 15th Street & Washington Avenue*

**Operations detail:** This intersection is currently stop-controlled on Washington Avenue with a single shared lane for all movements on all approaches. The eastbound approach to the intersection serves as a driveway to the facilities services shop. Average delays of 57.8 seconds for 85 left-turning vehicles on the westbound approach (less than 8% of the 1,066 vehicles using the intersection) cause the intersection to not meet standards in the p.m. peak hour, with a LOS F. Vehicles entering the

intersection are likely to encounter pedestrians during the peak hour, when 300 pedestrians also pass through the intersection.

A sensitivity analysis revealed that analyzing the intersection with existing vehicle volumes and no pedestrian volumes produces a LOS D result, but is not reflective of actual conditions.

**Potential actions at 15th Street & Washington Avenue:**

While there are currently no improvements planned at 15th Street and Washington Avenue, there are improvements planned for the area that are anticipated to impact this intersection. Specifically, the installation of a signal at 15th Street and Washington Way (Intersection 19) to the south is planned, with construction anticipated in summer 2014. There also are future plans to extend Washington Way from 15th Street to 10th Street. These future projects are expected to reduce traffic volumes at 15th Street and Washington Avenue, particularly the westbound left-turn movement (which is currently a LOS F), as vehicles utilize the new signal and connection. With a reduction in traffic volumes at 15th Street & Washington Avenue, operations will likely improve. In addition, the new signal downstream will likely create gaps in northbound traffic, making the critical minor-street left-turn movement from Washington Way onto 15th Street easier. With these projects and the anticipated change in traffic volumes and patterns, the intersection of 15th Street & Washington Avenue will likely meet standards in the future.

### *Intersection 22: 30th Street & Western Boulevard*

**Operations detail:** This three-legged T-intersection is currently stop-controlled on 30th Avenue with a single shared lane for all movements on the southbound and westbound approaches, and exclusive left-turn lane in the eastbound direction. Delays on the southbound approach cause the intersection to not meet standards in the a.m. and p.m. peak hours, with a LOS E and F respectively. Pedestrian activity at this intersection is among the lowest of all intersections studied, and the intersection delay is attributable to relatively high vehicle volumes southbound, with 186 left-turning vehicles in the p.m. peak hour (nearly 16% of the total entering vehicles during the p.m. peak hour). The intersection has likely been operating at LOS F for several years and was reported at LOS F in both the 2010-2011 and 2011-2012 BTM reports. **Table 7** provides a number of potential actions that could be taken at the intersection, which includes an evaluation of associated trade-offs.

**Table 7: Potential Actions at 30th Street & Western Boulevard**

| Potential Action | Pros | Cons |
|---|---|---|
| **Do nothing.** | • No cost or right-of-way impacts.<br>• No change that would affect mobility, connectivity or exposure for vehicles, pedestrians, and bikes.<br>• Minimizes system delay and vehicle emissions, as compared to any other traffic control measure. | • For at least 30 minutes of a typical day, the intersection would not meet standard. |

| Potential Action | Pros | Cons |
|---|---|---|
| **Emphasize and enhance route options.**<br><br>Southbound vehicles on 30th Street have route options that include signalized access to Western Boulevard at 35th Street and 26th Street. These streets can be accessed from 30th Street via Washington Way. SW Ralph Miller Lane also provides access to 26th Street, south of Washington Way, particularly for the areas that surround Reser Stadium. | • Optimizes existing transportation system capacity.<br>• Several low-cost methods of enhancing the route options are available, such as restricting left-turns from Ralph Miller Lane to 30th Street (except during major events) and directing daily users of Reser Stadium parking to exit via 26th Street or Western Boulevard.<br>• May allow intersection to meet existing standard. | • May create some out-of-direction travel. |
| **Convert intersection to all-way stop-control.** | • Would allow intersection to meet existing standard.<br>• Relatively inexpensive change.<br>• Would enhance pedestrian crossing opportunities of Western Blvd. | • Would introduce stop control for vehicles on Western Boulevard, creating delays for vehicles and bikes on the higher volume street. |
| **Explore the practicality of installing a roundabout at this intersection.** | • Would allow intersection to meet existing standard.<br>• Would introduce the least delay to the system of all improvement options.<br>• Potential safety benefits in reduction of quantity and severity of crashes[5]. | • Would require substantial financial investment.<br>• Potential ROW impacts on surrounding properties. |
| **Explore the practicality of installing a traffic signal at this location.** | • If practical, would identify an improvement that is constructible, cost-feasible, with favorable benefit-cost ratio, and funded by proportional shares from multiple parties<br>• Would allow intersection to meet existing standard.<br>• Would enhance pedestrian crossing opportunities of Western Boulevard.<br>• Potential decrease in frequency of angle crashes[5]. | • Would require substantial financial investment.<br>• Potential ROW needs.<br>• Creates close signal spacing from 35th Street through 15th Street on Western Boulevard; may result in queuing issues.<br>• Would introduce delay for vehicles and bikes on Western Boulevard and increase vehicle emissions.<br>• Potential increase in frequency of rear-end crashes[5].<br>• The intersection narrowly meets warrant 3 (peak hour) during the p.m. peak hour, but does not meet warrants during the a.m. peak hour[6]. |

[5] Based on Crash Modification Factors (CMFs) provided in the *Highway Safety Manual* (Reference 4).
[6] Based on traffic counts collected and an assessment of the Manual of Uniform Traffic Control Devices (MUTCD, Reference 5) warrants for installing a traffic signal.

### *Intersection 26: 35th Street & US 20/OR 34*

**Operations detail:** This signalized intersection has exclusive left-, through-, and right-turn lanes in the eastbound and westbound directions, where the heaviest through volumes are found. In the northbound and southbound directions, it has exclusive left- and shared through-/right-turn lanes. During the a.m. peak hour, the intersection operates at LOS D with a v/c ratio of 0.90 and has a relatively low peak hour factor of 0.81, indicating that this level of capacity utilization is likely limited to the peak 15-minute period of the a.m. peak. The eastbound through lane and northbound through-/right-turn lane show the highest volume-to-capacity ratios at this intersection, indicating that additional capacity to address volumes in these lanes would allow the intersection to operate at a lower v/c ratio.

In the previous analyses with the Base Transportation Model, the intersection of 35th Street and US 20/OR 34 appeared to operate at a v/c ratio of less than 0.70, even though traffic volumes were very similar, as shown in Table 3. Based on a review of the Base Transportation Model documentation, it appears that the saturation flow rate for the northbound and southbound shared through-/right-turn lane was coded at twice the level that would be expected for this lane – 3,800 vehicles per hour. The 2013-2014 analysis used a standard saturation flow rate of 1,900 vehicles per hour, which is more likely to reflect actual operations. Therefore, the apparent deterioration of operations at this intersection is not attributable to growth in traffic volumes between 2010 and 2013.

**Table 8** provides a number of potential actions that could be taken at the intersection and includes an evaluation of associated trade-offs.

**Table 8: Potential Actions at 35th St & US 20/OR 34**

| Potential Action | Pros | Cons |
|---|---|---|
| **Do nothing.**<br><br>The v/c ratio is primarily used for planning purposes to identify long-term improvement needs. Delay at this intersection remains at acceptable levels, even during peak periods. | • No cost or right-of-way impacts.<br>• No change that would affect mobility, connectivity or exposure for vehicles, pedestrians, and bikes. | • For 15 to 30 minutes of the a.m. peak hour and p.m. peak hour, the intersection would not meet standards. |

| Potential Action | Pros | Cons |
|---|---|---|
| **Pursue a variance.**<br><br>Engage in discussions with ODOT about the potential flexibility of the 0.85 v/c standard[7]. | Depending on the policy change:<br><br>• No physical changes may be needed and no costs incurred.<br>• No change would occur that affects mobility, connectivity or exposure for vehicles, pedestrians, and bikes.<br>• Would allow the City/ODOT to consider multimodal operations and broader goals, in addition to vehicle mobility.<br>• Modified v/c standard would alleviate the unintended consequence of prematurely designating a need that cannot be cost-effectively addressed. | • Would require efforts by ODOT to determine and implement the appropriate policy change. |
| **Explore the practicality of installing an exclusive northbound right-turn lane at this location.** | • Would allow intersection to meet existing standard.<br>• Separates northbound right-turning vehicles from through vehicles, allowing for more right-turns on red, right-turn overlap phasing and less delay for northbound vehicles. | • Potentially requires acquiring ROW and reconstructing southeast corner of the intersection.<br>• Would increase crossing distance and exposure for pedestrians on the south leg of the intersection.<br>• Depending on design details, may increase the level of traffic stress (LTS)[8] for bicycles. |

## NEXT STEPS

Analysis conducted to date has found that only seven intersections fail to meet operational standards during peak periods. Of these, the intersection of 15th Street and Washington Way is already planned and funded for improvement. The signalization of this intersection and future extension of Washington Way east is anticipated to change traffic patterns so that less vehicles utilize the intersection of 15th Street and Washington Avenue, thereby improving operations.

Four intersections appear to have several options that include doing nothing, with limited impact to transportation users. These intersections include the following:

- 30th Street & Harrison Boulevard
- 30th Street & Orchard Avenue

[7] ODOT allows for v/c ratios of up to 0.99 on their facilities in other parts of Oregon.
[8] ODOT is in the process of incorporating the Level of Traffic Stress (LTS) to evaluate roadway conditions for bicyclists into the Analysis Procedures Manual.

- 25th Street/Park Terrace-Monroe Avenue
- 30th Street & Western Boulevard

These intersections are all two-way stop controlled. There are alternative routes for vehicles using the side-street approaches. Volumes on the side-street approaches experiencing the highest delay are generally low, with the exception of the intersection of 30th Street and Western Boulevard, where a relatively high number of vehicles experiencing delay on the stop-controlled southbound approach. These intersections are designed to prioritize mobility on the higher order roadway, so changing the traffic control would introduce delay for the higher volume roadway. Therefore, given the presence of alternative routes, lower-volumes on the side-streets, and priority of mobility on the main streets, it may be most beneficial to the community to make no changes at these locations. Much larger delays and higher vehicle emissions would be avoided by taking limited or no action at this time.

Finally, the intersection pf 35th Street and US 20/OR 34 may warrant further monitoring or assessment (possibly on a biennial basis) to determine whether or not an improvement is feasible and practical. It will be important for OSU to coordinate with the City and ODOT, particularly during long-range planning efforts, to ensure that appropriate solutions are found and that partners contribute proportionally to their impacts.

## REFERENCES

1. Transportation Research Board. *2000 Highway Capacity Manual*. 2000.
2. City of Corvallis Comprehensive Plan. 2000.
3. Oregon Department of Transportation (ODOT). Oregon Highway Plan. 2012.
4. American Association of State Highway Transportation Officials. Highway Safety Manual. 2010.
5. Federal Highway Administration. Manual on Uniform Traffic Control Devices (MUTCD). 2009.