Oregon Department of Transportation

Oregon Bridge Delivery Partners

Work Zone

Traffic Analysis

Manual

Spring/Summer 2007

OREGON DEPARTMENT of TRANSPORTATION
OREGON BRIDGE DELIVERY PARTNER
TRAFFIC ENGINEERING & OPERATION
TRAFFIC CONTROL PLAN
http://www.oregon.gov/ODOT/HWY/TRAFFIC/Traffic_Control.shtml

Oregon Department of Transportation
Oregon Bridge Delivery Partners

Work Zone Traffic Analysis

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DATE: January 2007

TO: Work Zone Traffic Analysis Associates

FROM: Scott McCanna, P.E.
State Traffic Control Plans Engineer

SUBJECT: Work Zone Traffic Analysis Manual

PURPOSE

The purpose of this manual is to familiarize analysts and their leaders with ODOT's Work Zone (WZ) Analysis methodologies, guidelines, policies, and procedures to use in their determination of lane closure restriction recommendations.

The manual is intended to be utilized by analysts within ODOT; as well as analysts for local authorities, consultant analysts and other professionals outside the Department.

Care should be taken in applying any portions of this manual to projects developed outside the Department. Differences may exist between the ODOT WZ Traffic Analysis Manual lane closure policies and those policies established by other agencies. These differences may lead to inconsistencies in the analysis and subsequent lane closure restrictions of a particular project.

This manual is not intended to replace any existing ODOT analysis policy. It is intended to supplement existing ODOT policies, yet enhance the specific discipline of WZ Traffic Analysis. This manual is to be used as a resource, a technical reference and a teaching aide in the area of temporary WZ Traffic Analysis. Please contact ODOT's Traffic Engineering and Operations Department for clarification or interpretation of any policies and standards within this manual.

UPDATES

This manual is meant to be a living document. It is intended that this manual will be updated on a regular basis; however, suggestions for changes or additions will be accepted at any time. Any analyst may make recommendations with the expectation that the concern may be incorporated into this document.

TABLE OF CONTENTS

ACRONYM LIST

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ADA	Americans with Disabilities Act
ADT	Average Daily Traffic
ATR	Automatic Traffic Recorders
ATSSA	American Traffic Safety Service Association
BMP	Beginning Mile Point
CTWLTL	Continuous Two-Way Left Turn Lane, “Twiddle”
DEQ	Department of Environmental Quality
DHV	Design Hourly Volume
DMV	Driver and Motor Vehicle Services
E&C	Engineering and Contingencies
EA	Environmental Assessment
EA	Expenditure Account
EAC / HMAC	Emulsified Asphalt Concrete / Hot Mix Asphalt Concrete
EIS	Environmental Impact Statement
EMP	Ending Mile Point
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
GIS	Geographic Information System
HCM	Highway Capacity Manual
HOV	High Occupancy Vehicle
I/D	Incentives / Disincentives
ISTEA	Intermodal Surface Transportation and Efficiency Act
ITE	Institute of Transportation Engineers (formerly Traffic)
ITS	Intelligent Transportation System
LOS	Level of Service
MCTD	Oregon Motor Carrier Transportation Division
MP	Milepoint, Milepost
MPO	Metropolitan Planning Organization
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NCL	North City Limits
NEPA	National Environmental Protection Act
NHS	National Highway System
OAR	Oregon Administrative Rules
ODOT	Oregon Department of Transportation
OHP	Oregon Highway Plan
ORS	Oregon Revised Statutes
OSHA	Occupational Safety and Health Administration (U.S.)
OSP	Oregon State Police
OTC	Oregon Transportation Commission
OTIA	Oregon Transportation Investment Act
OTP	Oregon Transportation Plan
OVWS	Overheight Vehicle Warning System
Oxing or O’xing	Overcrossing

PCE	Passenger Car Equivalents
PCMS	Portable Changeable Message Sign
PDT	Project Development/Design Team (also PT for Project Team)
PE	Preliminary Engineering
PE	Professional Engineer (registered licensed)
PM	Project Manager
PMC	Polymer-modified Concrete
PS&E	Plans, Specs, and Estimates
PT / PDT	Project Team / Project Development Team
PUC	Public Utility Commission
QPL	Qualified Products List
RFP	Request for Proposal
SPIS	Safety Priority Index System
STIP	Statewide Transportation Improvement Plan
SU	Single Unit Truck
TAC	Technical Advisory Committee
TCD	Traffic Control Devices
TCP	Traffic Control Plan
TCS	Traffic Control Supervisor
TEOS	Traffic Engineering and Operations Section
TMA	Truck Mounted Impact Attenuator
TP & DT	Temporary Protection & Direction of Traffic
TPAU	Transportation Planning Analysis Unit
TS&L	Type, Size, and Location
TSP	Transportation System Plan
TVT	ODOT’s Transportation Volume Tables
UGB	Urban Growth Boundary
V/C	Volume to Capacity Ratio
VMT	Vehicle Miles Traveled
Xing	Crossing

1.0 Introduction to Work Zone Traffic Analysis

Work Zone Traffic Analysis is an tool that lets contractors know when lanes can be closed for construction while maintaining stable and efficient traffic operations and to estimate the anticipated project delay. This analysis is critical because lane closure restrictions can preserve highway safety, alleviate expensive staging and reduce lengthy travel delays.

The purpose of this manual is to:

- Introduce the concepts of work zone traffic analysis,
- Explain how ODOT's lane closure restrictions are incorporated into section 220.40(f) of the Special Provisions.
- Describe project delay concepts, and
- Introduce the MS Excel spreadsheet tool that is used do the analysis.

In addition to the theory and practice of WZ Traffic Analysis, this manual contains **examples of analysis and exercises** that will help readers gain experience. At the end of the manual are examples of forms, report letters, and other useful reference materials.

Note: This methodology is designed for ***segment analysis****. If* ***an intersection*** *needs to be analyzed for work zone lane closures, a different methodology must be used. Contact the Central TCP Unit or OBDP's analysis engineers for information on intersection analysis.*

As stated above, the purpose of the WZ Traffic Analysis is twofold:

- Identify the windows of time during which lane or shoulder restrictions can take place without significant adverse effects to traffic operations, and
- Determine estimated delays resulting from project staging strategies.

Concerning WZ traffic analysis and the project schedule - It is important that the WZ Traffic Analysis be performed **early** in the project development process, preferably prior to Design Acceptance Phase (DAP). The analyst will also be involved throughout the project life as new staging concepts and alternatives are developed. Restrictions on work hours can have significant impacts to the project staging and schedule. On key mobility corridors (see Chapter Five), what may appear to be minor delays, may cause the cumulative segment delay to exceed the delay threshold. This would necessitate project scheduling changes or the initiation of a delay exception request[1].

The basic steps of Work Zone Traffic Analysis concepts are straightforward:

[1] Refer to the *ODOT Highway Mobility Operations Manual* for additional details regarding thresholds and exceptions as they pertain to travel time and delay.

- Establish the volume of vehicles expected on the highway.
- Determine the appropriate traffic volume threshold for the roadway type, location, and proposed work zone staging strategy.
- If the volume is larger than the threshold, recommend the time windows during which the proposed lane restrictions can be safely applied.
- Estimate the delay based on the staging strategy to be applied and the traffic volumes expected during work hours.

This process results in two "deliverables":

- Lane restrictions, which are written into the Project's Special Provisions 220.40(e)[2], and
- The estimated delay, which is reported to the project's traffic control plans design engineer and the Project Manager/Project Engineer. This delay data is coordinated with the leaders of other projects on the highway corridor, the Region Mobility Liaison, and/or the Region Mobility Committee.

"The Spreadsheet" has been developed to do work zone traffic analysis and to produce the two deliverables. At the beginning of the OTIA III program, OBDP was tasked with developing flexible delay estimates for each of the 365 bridge projects. To help them accomplish this huge undertaking, the OBDP analysis engineers developed an Excel spreadsheet that combined ODOT's lane restriction methodologies with traffic microsimulation analyses regressed to fit exponential curves. The result is an Excel spreadsheet that requires minimal input from the analyst to develop lane closure restrictions and estimated project delay

A note about the degree of accuracy of the analysis output – the analysis output is developed from factors that can be highly variable; as a result the analysis output may not be precise. Depending on the level of confidence that an analyst has in the data, they may be revisited to see how sensitive they are to change.

In the next sections we will look at the analysis process to see how the deliverables are developed.

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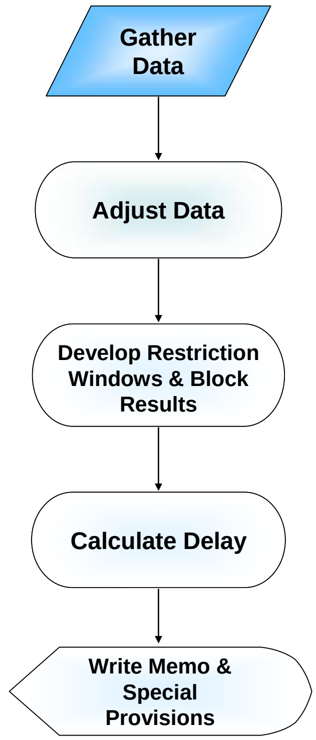
[2] A sample of the special provisions is included in **Appendix B**.

2.0 Input Data



The steps of WZ Traffic Analysis are shown at the right.

The first step is to gather traffic data:

- Traffic Count volumes
- Average Daily Traffic
- Truck percentage
- Annual growth rate
- ATR trend data

2.1 Where to Find Traffic Volumes

Traffic volume data is available from ODOT, city, and county sources. In most cases, volume data from several sources are required to make a reasonable assessment of work zone traffic analysis. The following sources show the best choices listed first:

ODOT Manual Counts – ODOT has an extensive library of manual traffic counts all over the state. A good place to start looking is on the ODOT Traffic Data web site at http://www.oregon.gov/ODOT/TD/TDATA/ . At this time, ODOT's individual manual counts cannot be retrieved by those outside of ODOT; however, please contact the ODOT Regional Tech Centers, the TCP Central Unit or the OBDP Analysis Engineers if manual traffic count data is needed.

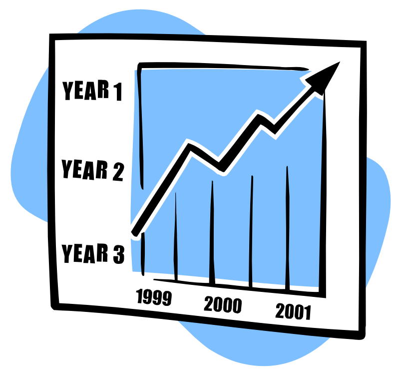
City and County manual and machine counts are also available. Contact the local agencies directly for this count data.

If count data is not available from other sources, new counts will need to be gathered. ODOT traffic counts are typically performed by ODOT's Regional Technology Centers. (Check with your project leader on who to contact to have new counts done.)

One of the best ways to get traffic volume data is to go to the project site and record the count information yourself. Look at the TPAU website for Developing Traffic Data for information on when and how to count traffic. This will provide limited duration count information and it will provide an opportunity to observe the dynamics of the traffic in the area. Also, talk to the Area Maintenance Manager or other Region personnel to see if there are any unique characteristics in the area.

ODOT's Transportation Volume Tables (TVTs) are available at http://www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml#Traffic_Volume_Tables. These tables give valuable highway average daily traffic (ADT) volumes and traffic volume trends that are recorded from ODOT Automatic Traffic Recorders (ATRs) and counts performed every third year at each location. ATR data, also included on the TVT site, is useful in determining traffic trends. Because much of this data is "smoothed" and extrapolated, it does not substitute for manual classification counts.

2.2 Traffic Count Data Types and Duration



Clarification on any issues concerning traffic count can be directed to the ODOT Data Section.
http://www.oregon.gov/ODOT/TD/TDATA/index.shtml

Ideally, use 24 hour ODOT manual full vehicle classification counts. If these are not available, use 14 to 16 hour counts. Do not use 6 or 8 hour counts.

Use counts that are no older than 5 years, if it all possible.

Use full federal vehicle classification counts for complete heavy vehicle information. These are available from ODOT's Data Section or from private traffic data consultants.

Use "Straightaway" counts if possible since the analysis is being done on the highway segment. These are counts taken on a segment of highway with no access or turn movement data included. Ramp counts can be confusing and inaccurate and would be a poor second choice.

What **not** to use:

- ODOT's TVT's with ADT and ATR data are a great source of traffic trend information but, because much of this data is "smoothed" and extrapolated, they do not substitute for manual classification counts.

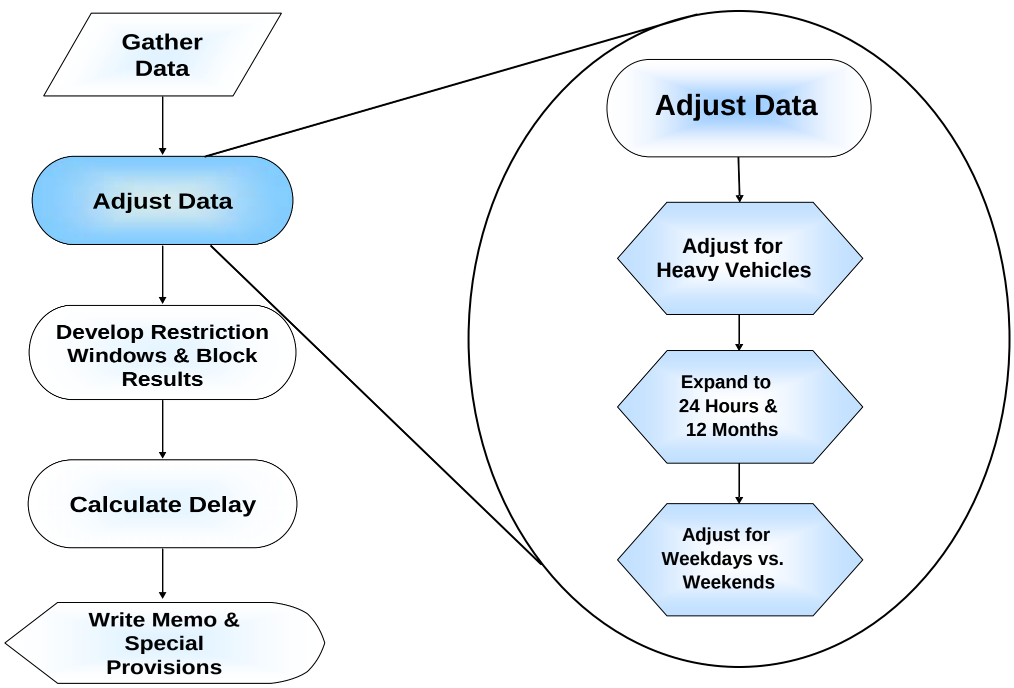
- Avoid tube or loop counts. Depending on the source and post-processing, they may not be accurate. The types of counts listed above are preferable to tube or loop counts.

3.0 Volume Adjustments

3.1 Overview

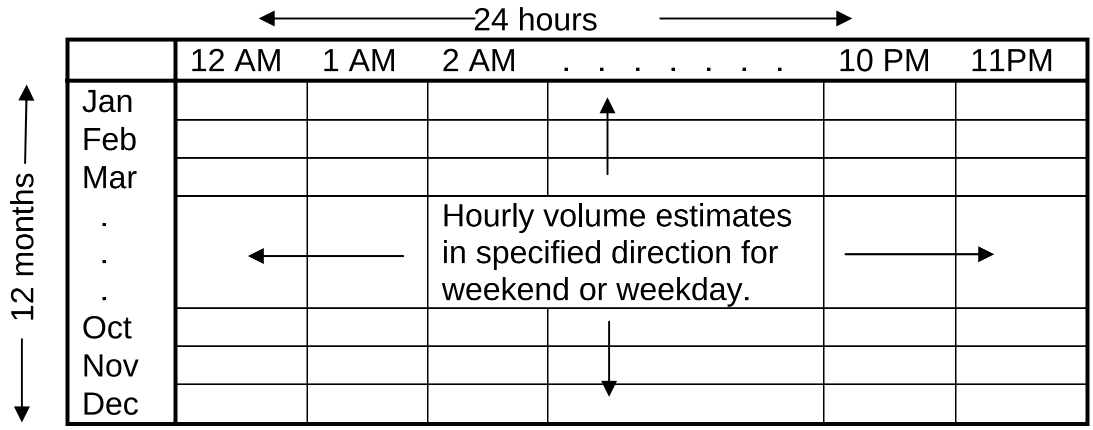
WZ Traffic Analysis data is needed for twenty-four hours a day, seven days a week, for everyday, week and month during the project period. Therefore, the following adjustments are made to the manual traffic count data:

- The appropriate percentage of heavy vehicles is accounted for[3].
- The count data is "grown out" using an annual growth rate.
- Seasonal adjustments are made to reflect traffic volumes for each month of the project period.
- Weekday and weekend differences are accounted for[4].



[3] Based on the FHWA Type F Vehicle Classification Scheme, classes four through thirteen would be considered heavy vehicles for this analysis.
[4] For the purposes of this methodology, weekdays are defined as Mondays through Thursdays. Weekends are Fridays through Sundays.

When all the count data is adjusted, a matrix is produced that shows 24 hours of traffic data for each month of the project life.



A particular section of highway may have four such matrices; two for each direction of travel, with weekdays and weekends shown for each direction. Weekday and weekend traffic traffic data can vary significantly.

3.2 How the Volume Adjustments are Made

3.2.1 Heavy Vehicle Adjustments

For the purposes of work zone traffic analysis, traffic volumes are discussed in terms of passenger car equivalents (PCEs). Truck volumes are converted to passenger car equivalents by applying a truck equivalency (or PCE) factor. The selection of the proper PCE factor roughly follows Exhibit 23-8 in the *Highway Capacity Manual (2000)*. The factors used in this analysis range from 1.5 to 4.0 with a truck factor of 2.5 being used most commonly. For most I-5 applications, a 2.5 factor is appropriate to account for the substantial number of larger trucks (double and triple trailers) or rolling terrain.

3.2.2 Yearly Growth Rate Adjustments

If the traffic was counted in a different year than the proposed construction year or if the construction will take more than 12 months, traffic volumes need to be “grown out” to represent the additional traffic on the roadway between the time that the count was taken and the construction year. Annual growth rates for all state highways are available from ODOT’s Transportation Planning Analysis Unit’s (TPAU) Growth Rate Tables at:
http://www.oregon.gov/ODOT/TD/TP/docs/TADR/Primary2023FVT.pdf

3.2.3 Traffic Volumes for 24 Hours

Ideally, hourly traffic volumes are taken from manual traffic counts that are less than three years old or from ATR's within or near the project site. Often, 24 hours of traffic data is not available in manual counts, so the matrix may be abbreviated to 14 or 16 hours. See the TPAU web-site for the latest methodology on data procedures.
http://www.oregon.gov/ODOT/TD/TP/Analysis.shtml#Analysis_Procedures_Methods

3.2.4 Seasonal Adjustments

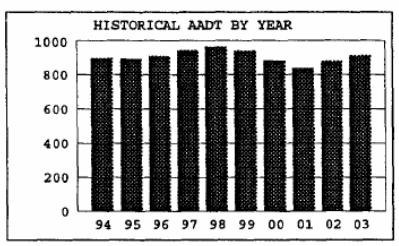
This is used to correct the traffic count volumes from the date the count was taken to the date of construction and throughout the year. These seasonal adjustments can be calculated from ODOT's ATR data found in the Traffic Volume Tables (TVT). TVTs can be found at:
http://www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml.

On the next page is a sample of ATR data from an ODOT TVT.

Location: US 30 MP 33.20, LA GRANDE-BAKER HIGHWAY, NO. 66 Recorder: NORTH POWDER, 01-001
0.34 mile south of Union-Baker County Line Installed: October, 1957

HISTORICAL TRAFFIC DATA

Year	Average Daily Traffic	Percent of ADT: Max Day	Max Hour	10TH Hour	20TH Hour	30TH Hour
1994	896	136	13.3	11.7	11.3	10.9
1995	891	179	19.4	13.4	12.3	11.7
1996	908	179	18.5	12.6	11.7	11.2
1997	942	162	16.3	11.9	11.2	11.0
1998	963	156	16.6	12.2	11.5	10.9
1999	939	151	16.3	11.8	11.3	11.1
2000	881	***	****	****	****	****
2001	837	***	****	****	****	****
2002	879	181	18.3	13.5	12.6	12.1
2003	91[illegible]	***	****	****	****	****



2003 TRAFFIC DATA

	Average Weekday Traffic	Percent of ADT	Average Daily Traffic	Percent of ADT
January	782	86	724	79
February	800	88	792	87
March	857	94	837	92
April	966	106	962	106
May	1050	115	1050	115
June	1050	115	1050	115
July	1150	126	1100	121
August	1100	121	1026	113
September	1050	115	1000	110
October	892	98	874	96
November	832	91	780	86
December	784	86	733	80

Classification Breakdown	Percent of ADT
Passenger Cars	56.0
Other 2 axle 4 tire vehicles	37.0
Single Unit 2 axle 6 tire	1.0
Single Unit 3 axle	2.1
Single Unit 4 axle or more	0.0
Single Trailer Truck 4 axle or less	0.7
Single Trailer Truck 5 axle	2.0
Single Trailer Truck 6 axle or more	0.2
Dbl-Trailer Truck 5 axle or less	0.3
Dbl-Trailer Truck 6 axle	0.1
Dbl-Trailer Truck 7 axle or more	0.0
Triple Trailer Trucks	0.0
Buses	0.0
Motorcycles & Scooters	0.0

The ATR chosen should be on the project highway and be near the project site or on a nearby highway with similar characteristics. If an ATR is chosen that is not on the work zone highway, be sure that the ATR highway has the same attributes, such as, similar ADT, truck percentages, commuter vs. recreational traffic mix, etc. If no ATR is close, TPAU has developed a spreadsheet method to choose an appropriate ATR based on highway characteristics. The methodology and spreadsheet may be found under the Analysis Data Resources heading at:
http://www.oregon.gov/ODOT/TD/TP/Analysis.shtml#Analysis_Procedures___Methods

TPAU's Seasonal Factor Table can also be used to calculate the seasonal factors. This table and methodology are available at:
http://www.oregon.gov/ODOT/TD/TP/docs/TADR/2003SFT.pdf .

If TPAU's Seasonal Factor Table is used, the Function Class and Zone of the highway in question will need to be known. This information is available on the table at:
http://www.oregon.gov/ODOT/TD/TDATA/rics/docs/ORStateHwysFCandNHS.pdf

3.2.5 Weekday vs. Weekend Traffic Volumes

If the project will involve possible lane closures on the weekend, separate matrices need to be developed for the weekday and weekend traffic. Weekend traffic tends to have a distribution of the volume through the day that is much different than the volume distribution on weekdays. Estimates of hourly volumes on the weekend are ideally derived from weekend manual counts on or near the project site. Alternatively, weekend counts from a representative facility may be combined with ADT and ATR information to approximate hourly volumes. The ATR should be on the project highway and near the work area or on a nearby highway with similar characteristics.

As shown, the ATR data shows two columns for monthly adjustments for the ADT, one for *Average Weekday Traffic* and one for *Average Daily Traffic*. The difference, of course, is that the *Average Daily Traffic* includes the weekend traffic volumes which are on Friday, Saturday and Sunday. So…

$$7 \times \text{Avg Daily Traffic} = 3 \times \text{Avg Weekend Traffic} + 4 \times \text{Avg Weekday Traffic}$$

Using some basic algebra, we can solve for *Average Weekend Traffic* and we get the following formula:

$$\textbf{Average Weekend Traffic} = \frac{\textbf{7} \times \textbf{Avg Daily Traffic} - \textbf{4} \times \textbf{Avg Weekday Traffic}}{\textbf{3}}$$

3.2.6 Low Volume Roads

If the highway ADT is below 3000 vehicles per day (vpd) and the seasonal factor is below 1.30, a full matrix may not need to be completed. An acceptable option is to show that the highest ADT expected during the year doesn't come close (approximately 25%) to reaching the capacity of the road. If the ADT is over 3000 vpd, the full analysis must be completed.

3.2.7 Example of a Work Zone Traffic Analysis

Here is an example of how the analysis would be done step-by-step if it were done "by hand".

The Project Leader for the Irrigation Creek Suspension Bridge Project, M.P. 120 on US97, ODOT #7 The Dalles / California Highway, Redmond, Deschutes County calls and asks for a Work Zone Traffic Analysis to see if there will be any lane closure restrictions during construction of the bridge during June, July and August of 2005.

Staging is planned such that one-half of the bridge will be built at a time, thereby reducing the travel lanes from four to two.

1. Gather Data - Call the Regional Tech. Center and the ODOT Transportation Systems Monitoring (TSM) folks to see if there are recent counts for you to use. Also see where the closest and most appropriate ATR is. In this case, there is a recent count and a close ATR.

   Also, get maps of the area, straightline charts, ADT data, etc. Go out to the site and watch traffic, do a couple of one to two hour counts during critical times such as the AM or PM peak and get a feel for the highway capacity and the dynamics of the area.

2. To keep the example short, we are only going to go through one of the matrices, the southbound weekday. Actual analysis would involve developing four matrices, southbound weekday and weekend, and northbound weekday and weekend.

3. Make adjustments to the counts for:
   - The appropriate percentage of heavy vehicles.
   - Current year data by "growing out" the volumes.
   - Each direction of traffic.
   - Twenty-four hours of the day.

- Seasonal factors for the months of construction.

The N-S count data looks like this for Total Vehicles. The traffic volume for 6 am represents the number of vehicles passing a point in the work zone between 6:00 a.m. and 6:59.99 a.m. If the count had been broken down into 15 minute segments, it would need to be combined into 1 hour increments. Also, lucky for us, the count was a straightaway (segment) count instead of an intersection count. This way we don't have to add the side street traffic to the main street volumes.

Sisters at US97, 7-03, Southbound, Weekday Volumes														
	6 am	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 am**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**
N-S	424	578	668	742	784	850	866	988	1170	1316	1112	876	530	454

- **Adjust for Heavy Vehicles** – This changes the total vehicles into Passenger Car Equivalents (PCEs). Sum all of the vehicles in the count except passenger cars, other two axle vehicles and motorcycles. There are several ways that this can be done. You can calculate the truck percentage for each individual hour or add all the heavy vehicles and divide by the total vehicles to get an average truck percentage. In this example, and the way it is usually done by experienced analysts, we will calculate an average truck percentage. For this count, the number of heavy vehicles is 1054 / 5679 total vehicles = 18.6%.

  To adjust the 6 am total volume of 424, for heavy vehicles:

  - Subtract out 18.6% of the total, which is 79 heavy vehicles, this leaves 345 passenger cars
  - Multiply the heavy vehicles by the PCE factor, 2.5 (2.5 × 79 = 197)
  - Add the adjusted heavy vehicles back into the passenger cars (345 + 197 = 542) vehicles
  - Repeat the technique for each hour

- **Adjust the volumes to the build year of 2005 –** Check TPAU's historic growth rates for this highway and find it is 2.0%. Assume a linear growth method rate and project each hour of traffic volume.

- **Develop a matrix** for each direction for weekdays and weekends. (For our example, we are only going to do one direction for weekdays.)

- Ideally we would have a **24 hour count** for the work zone, but since we only have a 14-hour count, we will not be able to account for all 24 hours.

- **Seasonal Adjustments** – Adjust the volumes for the months of the construction. This is where the ATR data comes in. See the ATR data example below:

ATR:	09-020		
Location	Redmond	Ave. Week	Ave. Daily
	JANUARY	0.900	0.860
	FEBRUARY	0.980	0.930
	MARCH	1.010	0.960
	APRIL	1.050	1.010
	MAY	1.060	1.020
	JUNE	1.140	1.090
	JULY	1.170	1.080
	AUGUST	1.150	1.100
	SEPTEMBER	1.100	1.040
	OCTOBER	1.060	1.010
	NOVEMBER	1.010	0.960
	DECEMBER	0.980	0.940

Note that the ATR data has a column for Average Weekday Traffic and one for Average Daily Traffic. To calculate volumes for weekends, use the following formula:

$$\textbf{Average Weekend Traffic} = \frac{7 \times \text{Avg Daily Traffic} - 4 \times \text{Avg Weekday Traffic}}{3}$$

Our count was taken in July and our construction months are June, July and August. We need to adjust the volumes for June and August. The methodology for calculating seasonal factors from ATR data is available from TPAU's web site at http://www.oregon.gov/ODOT/TD/TP/docs/TAPM/DevDHV.pdf.

The closest appropriate ATR is very close to the build location. If no ATR is close, use TPAU's Seasonal Factor Table to calculate the seasonal factors. This table is available at http://www.oregon.gov/ODOT/TD/TP/docs/TADR/2003SFT.pdf .

If TPAU's Seasonal Factor Table is used, the Function Class and Zone of the highway in question will be needed. This information is available on the table at http://www.oregon.gov/ODOT/TD/TDATA/rics/docs/ORStateHwysFCandNHS.pdf

After checking the last five years of ATR data, averaging and adjusting the July count for June and August volumes, we get the following adjustment factors: June = 1.03, August = 1.02. We now have 3 sets of adjusted southbound weekday volumes: one each for June, July and August. A complete analysis would have nine additional sets of data: 3 for southbound weekends, 3 for northbound weekdays, and 3 for northbound weekends. The weekend traffic would need to be estimated from a weekend count on this road or a road with similar travel characteristics.

Sisters at US97, 7-03, Southbound, Weekday Volumes

Time	6 am	7 am	8 am	9 am	10 am	11 am	12 am	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm
Seasonal Adjust June = 1.03	581	792	915	1017	1074	1165	1186	1354	1603	1803	1524	1200	726	622
Seasonal Adjust July = 1.00	564	769	889	987	1043	1131	1152	1314	1556	1750	1479	1165	705	604
Seasonal Adjust Aug. = 1.02	575	784	906	1007	1064	1153	1175	1340	1587	1786	1509	1189	719	616

By now, our volumes look like this:

Sisters at US97, 7-03, Southbound, Weekday Volumes														
Time	**6 am**	**7 am**	**8 am**	**9 am**	**10 am**	**11 am**	**12 pm**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**	**7 pm**
Original Total Vehicles	424	578	668	742	784	850	866	988	1170	1316	1112	876	530	454
Truck & = 18.6	542	739	854	949	1003	1087	1108	1264	1496	1683	1422	1120	678	581
Growth Rate (Linear) 2% * 2 Yrs = 1.04	564	769	889	987	1043	1131	1152	1314	1556	1750	1479	1165	705	604
Seasonal Adjust June = 1.03	581	792	915	1017	1074	1165	1186	1354	1603	1803	1524	1200	726	622
Seasonal Adjust July = 1.00	564	769	889	987	1043	1131	1152	1314	1556	1750	1479	1165	705	604
Seasonal Adjust Aug. = 1.02	575	784	906	1007	1064	1153	1175	1340	1587	1786	1509	1189	719	616

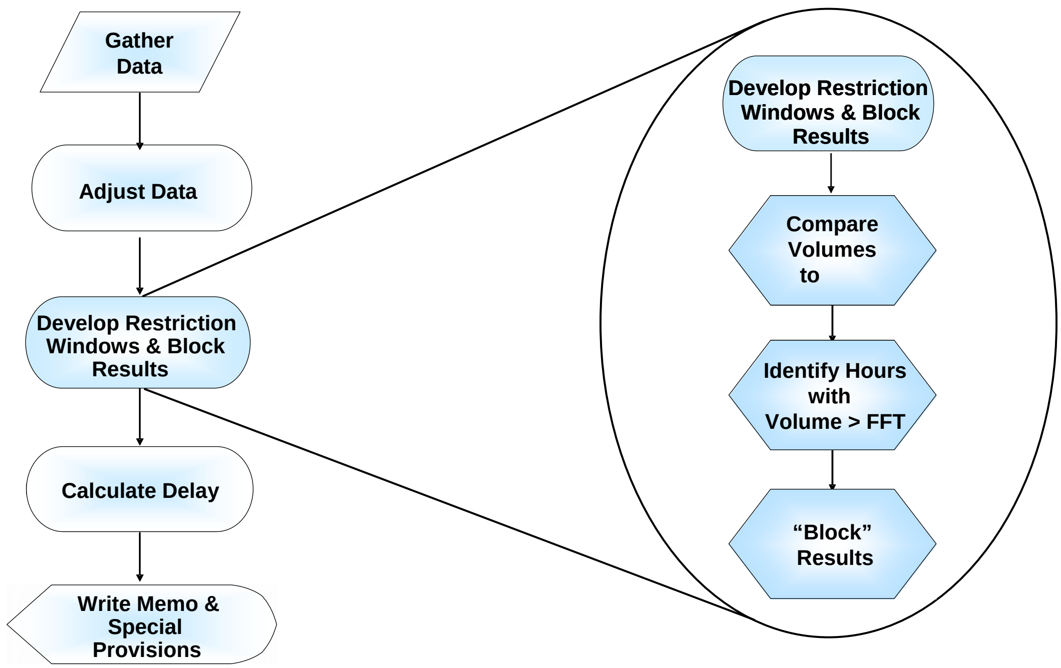
The free flow threshold for Multi-Lane Highways and Freeways is between 1400 and 1600 PCEs/hr for each remaining lane in areas with one lane closed. This is the free flow threshold of a one-lane, one-way section with *continuous flow* – with no interruptions such as signals, stop signs, or flaggers. These thresholds are based on 12-foot lanes with at least 2 feet of clearance on each side. Narrower lanes or clearances will result in reduced thresholds. Other factors that could reduce capacity are steep grades, relaxed or unfamiliar driver population, and poor pavement conditions. If we had a signalized intersection in the work area, the analysis would be completely different.

Now all we have to do is compare the volume to the free flow threshold. The Free Flow Threshold will be discussed in the following section. On the following table, the cells with gray show that the adjusted volume falls below the 1400 to 1600 threshold; the black cells represent hours in which the free flow threshold is exceeded. When the highway exceeds the threshold with one lane closed, recommend appropriate lane restrictions.

4.0 Determining Restriction Windows

4.1 Overview

The processes of gathering and adjusting the data have now been completed. The following section describes how to go about using the matrices of traffic data that have been generated to determine the windows during which certain types of staging should be avoided.



4.2 Free Flow Threshold

A key concept in this methodology is understanding the difference between the **free flow threshold** and **capacity**. The free flow threshold is a concept unique to this methodology and represents the traffic flow rate beyond which traffic can no longer operate at free flow condition. *The free flow threshold is the point at which stable flow is no longer assured.*

> ***Key Concept***
>
> The **FREE FLOW THRESHOLD** is the point beyond which stable flow is no longer assured.

At traffic flow rates above the free flow threshold, traffic begins to increase in density and decrease in speed. Queuing begins to form upstream of the work zone. Traffic may not come to a stop or even to stop and go conditions. However, when viewed from a "big picture" perspective, an area in which traffic is denser and slower than free flow begins to form near the start of the work zone. Traffic flow in this area becomes unstable as the influence of the work zone combined with the traffic volume begins to hamper efficient traffic operations. This area of greater density and lower speeds will continue to expand if traffic flow rates remain above the free flow threshold. Once traffic volumes begin to exceed the threshold by significant amounts, stopped queues will begin to form as traffic operationally breaks down.

An important fact to note is that you may easily observe traffic volumes that exceed the free flow threshold passing through a work zone at free flow speeds. This may seem to indicate that the free flow threshold may not be accurate. However, it is critical to understand that the free flow threshold is intended to be set at a point at which the traffic flow rate can be sustained with free flowing operations for extended periods of time.

> ***Key Concept***
>
> The **CAPACITY** of a work zone is the maximum volume that can pass through a work zone. A work zone operating at capacity will incur delays and queues and will be operating well below free flow speed.

Once traffic volumes exceed the free flow threshold and traffic operations break down, queues will form. The traffic volume that passes through the work zone is less than the traffic demand (the traffic volume that *wants* to pass through). The volume that *actually* passes through the work zone is the **capacity** of the work zone. The queue will continue to grow until the traffic *demand* is less than the work zone *capacity*.

EXHIBIT 23-2. LOS CRITERIA FOR BASIC FREEWAY SEGMENTS

Criteria	LOS A	LOS B	LOS C	LOS D	LOS E
FFS = 75 mi/h					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Minimum speed (mi/h)	75.0	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.90	1.00
Maximum service flow rate (pc/h/ln)	820	1350	1830	2170	2400
FFS = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70.0	70.0	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.90	1.00
Maximum service flow rate (pc/h/ln)	770	1260	1770	2150	2400
FFS = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65.0	65.0	64.6	59.7	52.2
Maximum v/c	0.30	0.50	0.71	0.89	1.00
Maximum service flow rate (pc/h/ln)	710	1170	1680	2090	2350
FFS = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60.0	60.0	60.0	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	660	1080	1560	2020	2300
FFS = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55.0	55.0	55.0	54.7	50.0
Maximum v/c	0.27	0.44	0.64	0.85	1.00
Maximum service flow rate (pc/h/ln)	600	990	1430	1910	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

Figure 4-1: HCM exhibit showing LOS and v/c ratios

The *Highway Capacity Manual* describes the concept of *level of service (LOS)*. Many other states use LOS as a design criterion. In fact, most use LOS C as the minimum LOS for rural roads and LOS D as the minimum for urban roadways. ODOT uses volume to **capacity** (v/c) ratios between 0.6 (rural) and 0.85 (urban) for highway design purposes. These v/c ratios correlate with LOS C or LOS D as shown in the table replicated from the *Highway Capacity Manual* that is included on the previous page as Figure 4-1.

The *Highway Capacity Manual* describes LOS C and LOS D in the following manner.

> "LOS C provides for flow with speeds at or near the FFS [free flow speed] of the freeway. Freedom to maneuver within the traffic stream is noticeably restricted, and lane changes require more care and vigilance on the part of the driver. Minor incidents may still be absorbed, but the local deterioration in service will be substantial. Queues may be expected to form behind any significant blockage.
>
> LOS D is the level at which speeds begin to decline slightly with increasing flows and density begins to increase somewhat more quickly. Freedom to maneuver within the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort levels. Even minor incidents can be expected to create queuing, because the traffic stream has little space to absorb disruptions."

The sections above taken from the *Highway Capacity Manual* clearly show that free flow operations begin to deteriorate at LOS C. Further, the inability to absorb minor incidents in LOS D imply that the traffic flow has become unstable. With that information, it is clear that the free flow threshold is equivalent to a point somewhere between LOS C and LOS D. Looking at Exhibit 23-2 taken from the *Highway Capacity Manual,* the v/c ratio that is associated with LOS C and LOS D is less than one. If the free flow threshold is reached at a v/c ratio of less than one, **the capacity must be greater than the free flow threshold**.

> ***Key Concept***
>
> The **CAPACITY** of a work zone is **ALWAYS** higher than the free flow threshold.

4.3 Free Flow Threshold Values

When possible, lane closures are restricted during those hours when the traffic volumes are expected to exceed the free flow threshold of the reduced highway. Several default values for this threshold have been developed through many years of workzone observations, experience and engineering capacity studies.

4.3.1 Threshold Reducing Factors

The above capacities are based on 12 foot lanes with at least 2 feet of clearance on each side. Narrower lanes or clearances will result in reduced capacities. Other factors that could reduce capacity are steep grades, relaxed or unfamiliar driver population, and poor pavement conditions and visually complex surrounding environments.

4.3.2 Free Flow Threshold for Bi-directional Work Zones

A lane closure on a two-lane roadway results in a work zone that maintains a single lane of traffic that carries traffic in both directions. These *bi-directional* work zones are typically controlled by flaggers, pilot cars, or temporary signals. The free flow thresholds listed include the ***sum of both directions of traffic***:

550 Total PCEs/hr (**includes both directions)**, Closure Length 2.0 miles

750 Total PCEs/hr (**includes both directions)**, Closure Length 1.0 mile

900 Total PCEs/hr (**includes both directions)**, Closure Length 0.5 mile

Closures in excess of 2.0 miles should be avoided since they can lead to dangerous access conflicts and other unsafe situations, and because the traffic stream begins to form discrete packs.

Figure 4-2: Example of a bi-directional work zone

4.3.3 Free Flow Threshold for Multi-Lane Highway and Freeway Work Zones

Figure 4-3: Example of a Freeway Lane Drop

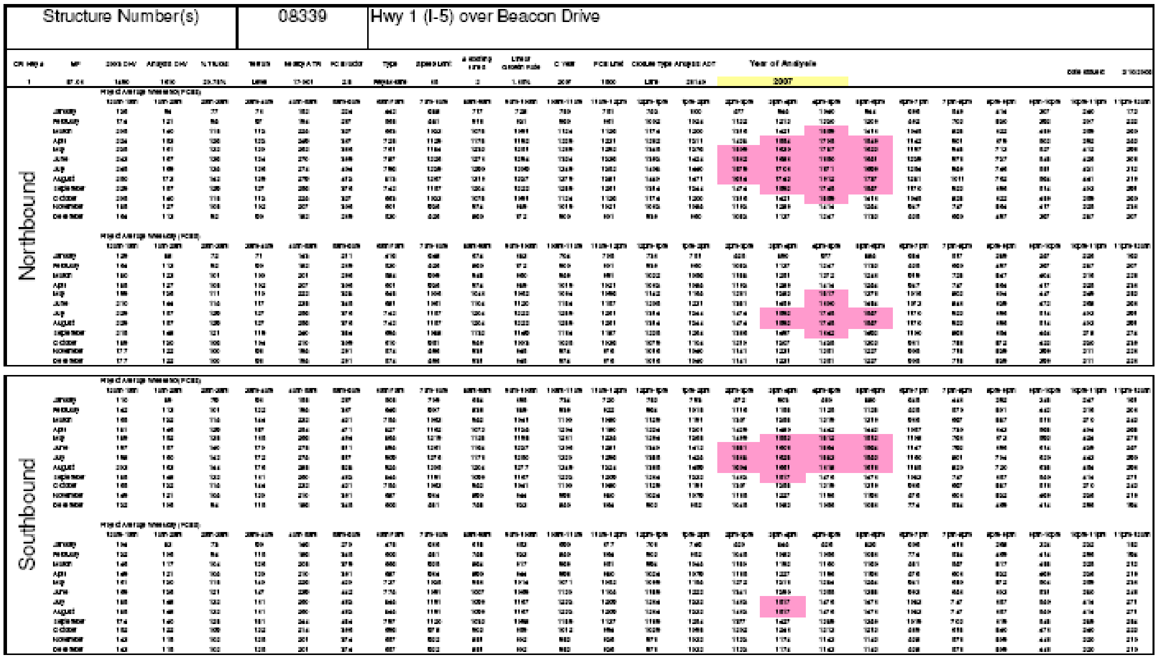
This is the free flow threshold for a one-lane, one-way section with **continuous flow.** At this traffic level we assume that there are no interruptions (signals, stop signs, flaggers, etc.) for the highway traffic. Signalized intersections and other interrupted flows are analyzed separately. These thresholds are in PCEs per hour per lane ***for a single direction***.

1200 - 1400 PCEs for rural freeway & multi-lane roadways

1400 - 1600 PCEs for suburban and urban freeways and multi-lane roadways

4.4 Analysis Results and Closure Recommendations

Once the analysis as been completed, the result is a set of four matrices of traffic flow rates in PCEs per hour. As discussed in Chapter Three, these matrices were completed by taking the hourly volumes, adjusting for seasonal and weekly trends as well as heavy vehicles. The matrices represent both directions of travel, weekends and weekdays, every month of the year, and every hour of the day. Select the appropriate free flow threshold for the roadway type and location and compare the traffic flow rates in the matrices to the appropriate free flow threshold. Highlight each of the hours during which the flow rate exceeds the free flow threshold. An example of the resulting matrix is shown below.



In the example chart above, the four matrices are shown with the hours exceeding the free flow threshold highlighted. The calculation portion of the analysis is now complete. However, the results are not yet fit for use. The following steps need to be taken to complete the analysis:

Check for any extreme differences month to month or between the weekends and weekdays. In some locations, such differences should be expected. In others, they should not.

Check that the general ebb and flow of traffic fits historical observations or expectations of the area. For example, OR 22 east of Salem should see heavy westbound traffic during weekday mornings and heavy eastbound traffic in weekday evenings.

Check that peak volumes are within reason. The volumes in the matrix are developed from ATR trend data and other sources. Errors in source data or calculation mishaps may cause very obvious errors in the hourly volumes that can be easily identified.

Smooth out the results to make *practical* recommendations. Through the concept of **blocking**, try to make uniform recommendations. The practice (or more accurately, art) of blocking will be discussed in the next section.

When possible, confirm your results with local observations.

4.4.1 Blocking

The goal of blocking is to make more uniform recommendations that also take into account what is actually practical in the field. The idea behind blocking is fairly simple. Some of the closure charts that may be developed will be very jagged, with almost every month and weekend/weekday scenario yielding a different result. In other cases, the chart may be almost completely blank with the exception of a scattered few hours here and there. Blocking should utilize common sense and engineering judgment.

For example, even if the analysis indicates that one hour **will not be** over the free flow threshold while the hours immediately before and immediately after **are** over free flow threshold, there is little point in allowing a lane to be closed for that particular hour. One hour is seldom long enough to accomplish enough work to justify the opening. Traffic control set up and take down needs to be considered as well.

11am-12pm	12pm-1pm	1pm-2pm	2pm-3pm	3pm-4pm	4pm-5pm	5pm-6pm
677	708	746	820	848	826	826
864	903	952	1045	1083	1056	1056
951	994	1048	1150	1192	1160	1160
980	1024	1079	1185	1227	1196	1196
1052	1099	1158	1272	1318	1284	1284
1108	1159	1222	1341	1390	1355	1355
1209	1264	1332	1463	1517	1476	1476
1209	1264	1332	1463	1517	1476	1476
1137	1189	1254	1377	1427	1389	1389
994	1039	1095	1202	1246	1213	1213
936	978	1032	1133	1174	1143	1143
936	978	1032	1133	1174	1143	1143

On the flip side, the chart to the left is a part of the previous example.

In this case, the free flow threshold being used is 1500 PCEs/hr. No other hours are blocked out except for the two shown above. The results taken literally would imply that lanes should not be closed during July and August between 3 and 4pm. Since the flow rate is only 1517, the recommendation was made at this particular location to allow lane closures during July and August, even during the 3-4pm hour.

In the example below, the area outlined in black indicates the time period that was recommended during an analysis. The squares in light blue were actually under the free flow threshold, but were included during the *blocking* process to create a more uniform recommendation and to account for what is practical in the field.

Structure Number(s)	07538A	Hwy 1 (I-5) over Boone Road SE
Closure Type	Lane	
Year of Analysis	[illegible]	
Northbound	[illegible]	
Southbound	[illegible]	

The most important concept behind blocking is that engineering judgment is required. The calculation is only the first step. The results of the calculations must be looked at by a qualified analyst and common sense must be employed to translate the jumble of numbers into a meaningful and practical set of recommendations.

4.5 Special Operations

Certain work zone operations and construction strategies that are employed in the field that have significant impacts on Work Zone Traffic Analysis. The free flow thresholds discussed earlier in this section apply to typical lane closures. Work zone operations such as beam swings or other intensive work near the travel lanes have a significantly lower free flow threshold than an ordinary lane closure due to the slower speeds and/or rubbernecking. Analysis requests may also be made asking for shoulder closure opportunities or windows during which rolling slowdowns or stop and hold operations may be used. For these circumstances, the free flow thresholds that follow are being recommended for use based on observations and may change in the future as additional data is collected.

4.5.1 Shoulder Closures

The free flow thresholds listed below are in PCEs per hour *per lane*.

1600 PCEs/hr/lane in the Portland metropolitan area

1500 PCEs/hr/lane in the Salem and Eugene metropolitan areas

1400 PCEs/hr/lane in all other locations

4.5.2 Beam Swings

This threshold applies to beam swings and other intensive work that causes significant rubbernecking when taking place next to live traffic. The threshold is based on observations made during beam swing operations during 2005. Observations specifically to determine the free flow threshold for beam swings were made after observing significant delays occurring repeatedly while traffic volumes were below the free flow thresholds typically used for lane closures. These observations have led to the beam swing free flow threshold of **1200 PCEs/hr/lane**.

4.5.3 Rolling Slowdowns

These thresholds were established based on a limited number of observations made during rolling slowdown operations on Oregon interstates. Future changes to this threshold will be made as additional data is collected. For obvious reasons, the term *free flow threshold* is not entirely accurate for this operation. The threshold refers more accurately to the highest traffic flow rate at which the queues that developed during the slowdown quickly dissipate without the lingering impacts cause by residual queues. The threshold to be used for these operations is **500 PCEs/hr/lane**.

4.6 Unique Project Circumstances

4.6.1 Special Events That Draw Additional Traffic

Determine if there are local events which will seriously impact the flow of traffic through the work zone if lanes are closed during the event. Special events would include school athletic events, i.e. an OSU football game, community celebrations such as the Rose Festival, Seattle to Portland bicycle event, Washington County Fair, Eugene Celebration, etc. Talk to the Area Maintenance Manager or other Region personnel to see if there any special events in the area.

4.6.2 What Happens If The Volume Always Exceeds The Free Flow Threshold?

Some projects may have no construction alternatives that would lessen impacts to the traveling public. In those cases, the objective of the Work Zone Traffic Analysis is to identify the best times of the day and months of the year for lane closures. Analysts should make assessments of possible queue lengths and delays, as well as the potential for traffic diversion or reduction of demand in these over-capacity situations. See Chapter Five for how this is done.

5.0 Delays

5.1 Delay and Statewide Mobility

From the Highway Mobility Operations Manual (July 2005):

> "Mobility is best defined as the ease with which people and goods move throughout their community, state, and world. Mobility is valuable because it provides access to jobs, services, and markets. Without question, transportation's most essential function is to provide mobility for people and goods.
>
> Construction work zones represent another obstruction to mobility. Nationally, work zones account for about 10 percent of all delays. FHWA research shows that the traveling public is demanding increased mobility, while showing less tolerance for delays, increased travel times, and inconveniences resulting from construction-related congestion.
>
> ODOT is embarking on an historic period of road and bridge work over the next 10 years. Keeping traffic and freight moving during this time of unprecedented construction in Oregon is one of the top priorities of the Governor, Legislature, and the Director. The budget note to House Bill 2041 directed ODOT to develop a strategy that maximizes the ease of traffic and freight movement throughout the state.
>
> ODOT Director Bruce Warner has set forth the goal for ODOT to maintain freight mobility and keep traffic moving during construction. He has noted that ODOT's *customers will base their impressions on delay times* and detour effectiveness." (emphasis added)

Mobility, as described in the *Highway Mobility Operations Manual* can be simplified into two primary facets: delay and physical restrictions (such as weight, width, and height). For the purposes of Work Zone Traffic Analysis, we are obviously more concerned with the former. It should be noted that delays may be a result of physical restrictions (narrow lanes, little or no shoulder, etc.).

With the start of the OTIA III Bridge Program, the following mobility corridors were identified:

I-5 North/OR 58 (Portland to US 97 north of Chemult)

I-5 South (Eugene to California)

US 26/97 (Portland to Madras to California)

I-84

Coastal Network (US 101 and all state routes between I-5 and US 101)

For each of these corridors, mobility will be managed from a corridor perspective, with the "big picture" as the primary focus. Mobility management is the concept that construction schedules, staging strategies, detours, and other work zone activities will be coordinated along the mobility corridors to minimize disruptions to traffic operations. To aid in the management process, the corridors were broken in to smaller segments. Each segment was assigned a delay or travel time threshold. Construction activities are meant to be scheduled or staged in such way that delays or travel times would not exceed these predetermined limits. If these thresholds cannot be met, delay exceptions are required before the project can proceed.

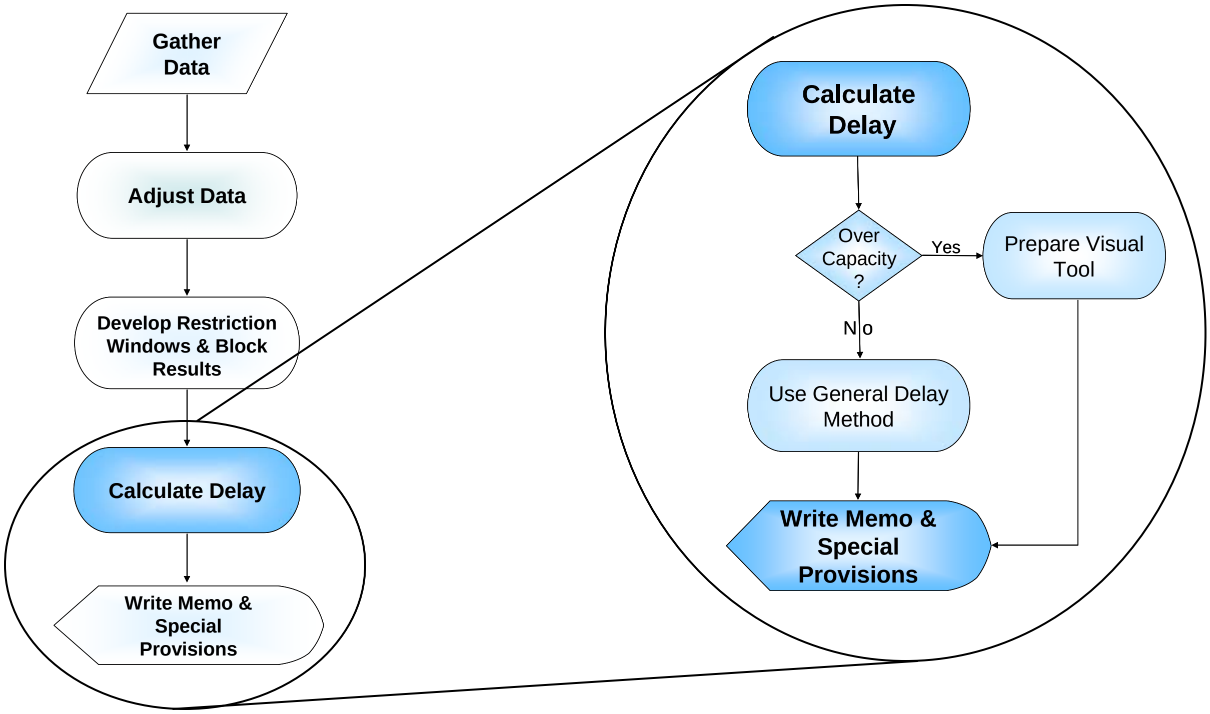
These mobility requirements led to the need to be able to estimate the delays for each project along these corridors, projects that would vary in their location, surrounding lane use, terrain, traffic volumes, truck percentages, and construction schedule. The delay and travel time thresholds are to be enforced 24/7/365, meaning that delays would need to be estimated at all hours of the day and would also potentially impact off-peak construction activity. The mobility guidelines that have been developed that are outlined in the *Highway Mobility Operations Manual* does not only apply to the Bridge Program, but will be adhered to as a matter of standard practice from this point forward. This further emphasizes the need to develop delay estimates for each project. The following analysis methodology can be applied to any roadway and is not limited to use on the mobility corridors.

5.2 Overview of Delay Analysis Types

Before delving into the details of delay analysis, it is important to discuss a few basics. As a general rule, the relationship between volume and delay is exponential. As volumes increase, delays increase by small amounts before hitting a critical point after which the delay grows exponentially. Academically, the delay approaches infinity. Strictly by the numbers, it is possible to get results that show *years* of delay. Realistically, of course, this would never happen.

There are two different types of delay analysis that are used by ODOT for work zones. **The *general* methodology is appropriate for traffic volumes that are near or below the capacity of the work zone.** Traffic volumes well over the work zone capacity will result in unrealistic results as the exponential portion of the delay curve approaches infinity.

The *over-capacity* methodology is best in situations where the traffic volumes are *well in excess* of the work zone capacity. This analysis type is a basic comparison between the cumulative demand and the cumulative capacity.



5.3 General Delay Analysis

For the purposes of Work Zone Traffic Analysis, mobility management, and delay estimation, the concept of travel delay is defined as the additional travel time that will be required to travel from one point to another as a result of construction activities. With this definition, existing delays resulting from current capacity and geometric deficiencies and from incidents are excluded. To estimate delays, traffic microsimulation tools were used in combination with regression analysis to create best-fit curves to the analysis results.

Traffic microsimulation was performed using the Federal Highway Administration (FHWA)'S Traffic Software Integrated System (TSIS) software (also known as CORSIM, short for corridor simulation). Each project area was modeled twice, once with no restrictions on traffic flow, and once with construction restrictions in place. In this manner, the additional travel time resulting from construction activities could be estimated. Each of the models is simplistic, taking into account the construction restrictions only, without consideration of project-specific characteristics such as access points, ramps, or signals that may also impact traffic flow.

Model runs for the pre-construction scenario utilized industry-accepted lane capacities and a free-flow speed equal to the posted speed limit plus 5 miles per hour. Model runs for construction scenarios utilized a free flow speed equal to the free flow speed of the pre-construction scenario less 10 miles per hour. Work zone lane capacities for the construction scenarios were set equal to 1,400 PCEs per hour[5] for work zones with a lane drop. For construction scenarios which maintain the existing number of lanes, a 5 percent reduction in the pre-construction lane capacity was utilized, based on field data and a literature review conducted by the Oregon Bridge Delivery Partners (OBDP).

Within CORSIM, OBDP modeled simple work zone scenarios for almost 14,000 combinations of roadway types, traffic volumes, truck percentages, terrain, and staging strategies. The additional travel time between two points could be determined, yielding the travel delay for the work zone. This methodology also avoids the need to calibrate each of the 5,000 plus models[6].

A rubbernecking factor was used to restrict the capacity of the work zone by a given percentage. A sensitivity analysis was performed to find what percent reduction in the base roadway capacity would provide a capacity of 1,400 PCEs per hour per lane (see footnote). This figure was historically used by ODOT as construction zone capacity. It was found that a 24% reduction in capacity in conjunction with the reduction in free-flow speed provided this level of capacity in the work zone. In future work, OBDP intends to increase this percent reduction in capacity to enable the modeling of high intensity work and the increased gawking effects of such work within close proximity or high visibility from the traveled lanes.

The results of each individual analysis were grouped by model characteristics to allow for the development of volume vs. delay graphs for sets of model runs. For example, one set contains all of the freeway runs with two lanes in each direction in level terrain with a lane drop, no crossover, and truck percentages between 10 and 15 percent with hourly traffic volumes between 0 and 3500 vehicles per hour (vph).

The data within these groupings were exponentially regressed. The plot of the regression results forms a best-fit exponential curve through the microsimulation results. The regression results are compiled in lookup tables that allow a delay

[5] It is now recognized that the 1,400 PCEs per hour capacity is too conservative. This figure is acceptable for use as a threshold for stable and efficient operations, but is not applicable as a value for capacity. For example, the 2000 Highway Capacity Manual (HCM) states that the capacity of a long-term lane closure on a two lane freeway is close to 1550 vehicles per hour. The HCM figure is based on a very limited number of studies, but adjustments have been made to increase the physical capacity of the roadway within the model. Ongoing data collection of active work zones as well as base data from unhindered freeway segments continues to provide data with which our models and the regressed best-fit volume/delay curves can be adjusted.

[6] Calibration of a microsimulation model typically involves modeling the existing conditions within a model and collecting data on delays, travel times, speeds, or other parameters in the field and comparing the collected data to the model results. The model's parameters are then modified to calibrate the model so that the model of the existing conditions matches existing performance. The model, with modified parameters, is then used to predict proposed conditions. By modeling both the existing and proposed conditions using identical parameters, OBDP intended to minimize the loss of accuracy created by skipping the calibration step, which, for the sheer number of models that were analyzed, would have been impractical.

estimate to be easily provided for any combination of staging type, traffic volume, truck percentage, and terrain type.

These tables are embedded in the Work Zone Traffic Analysis spreadsheet files discussed in Chapter Six.

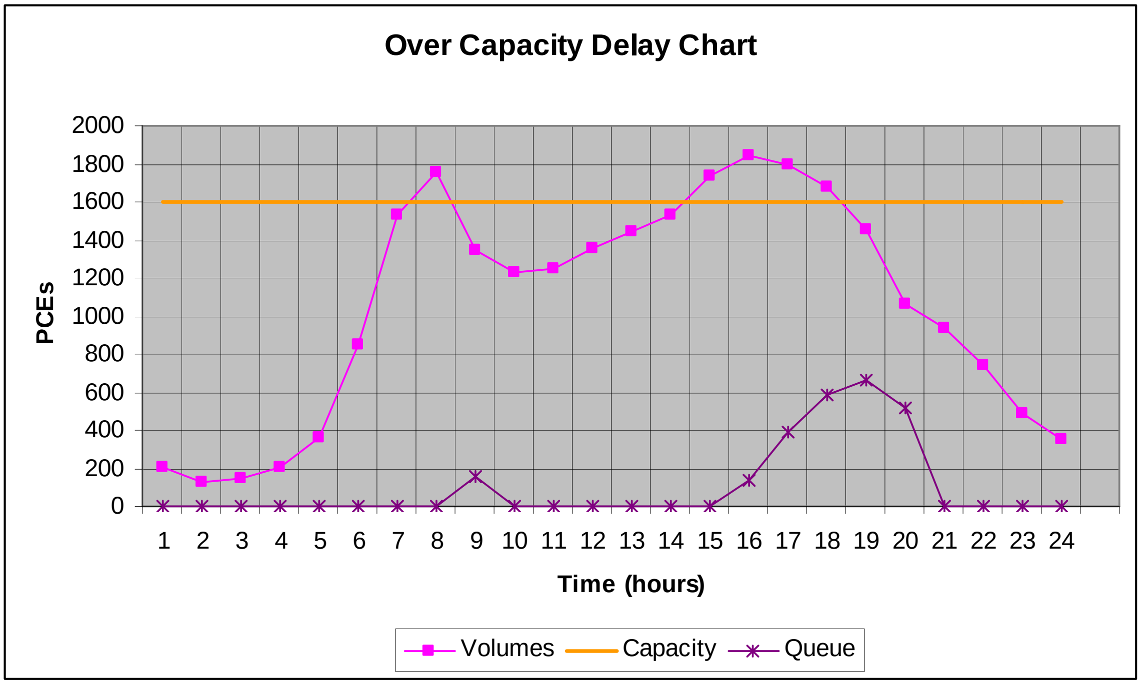
5.4 Over-Capacity Delay Analysis

The over-capacity methodology described in the following section should be applied when traffic volumes are well in excess of the capacity of the work zone. In these instances, long queues and substantial delays should be expected. Delays will be significant enough to be described in vehicle-hours. Queues built during the peak hours may take hours to dissipate. In these situations, the analysis loses quantitative accuracy as a number of factors begins to impact the quality of the traffic projections.

Queuing and vehicle delay are an important part of the Work Zone Traffic Analysis. There are several ways to calculate these factors, including setting up a spreadsheet to graph the traffic volume over time to develop a visual representation of queuing as shown in Figure 5-1.

The graph shows how traffic volumes compare with highway **capacity** over time. When the volumes exceed the capacity, it means that not all of the demand is being served. This can result in driver inconvenience, delay and congestion. The bottom line on the graph shows how queuing can develop when traffic volumes exceed capacity, as shown starting at about hour 6. Once the queue starts to build, it will continue to grow cumulatively, and will not decrease until the traffic volumes are lower than the capacity, as seen at about hour 10. The queue will not totally dissipate until approximately hour 21.

Figure 5-1: Example Over-Capacity Delay Chart



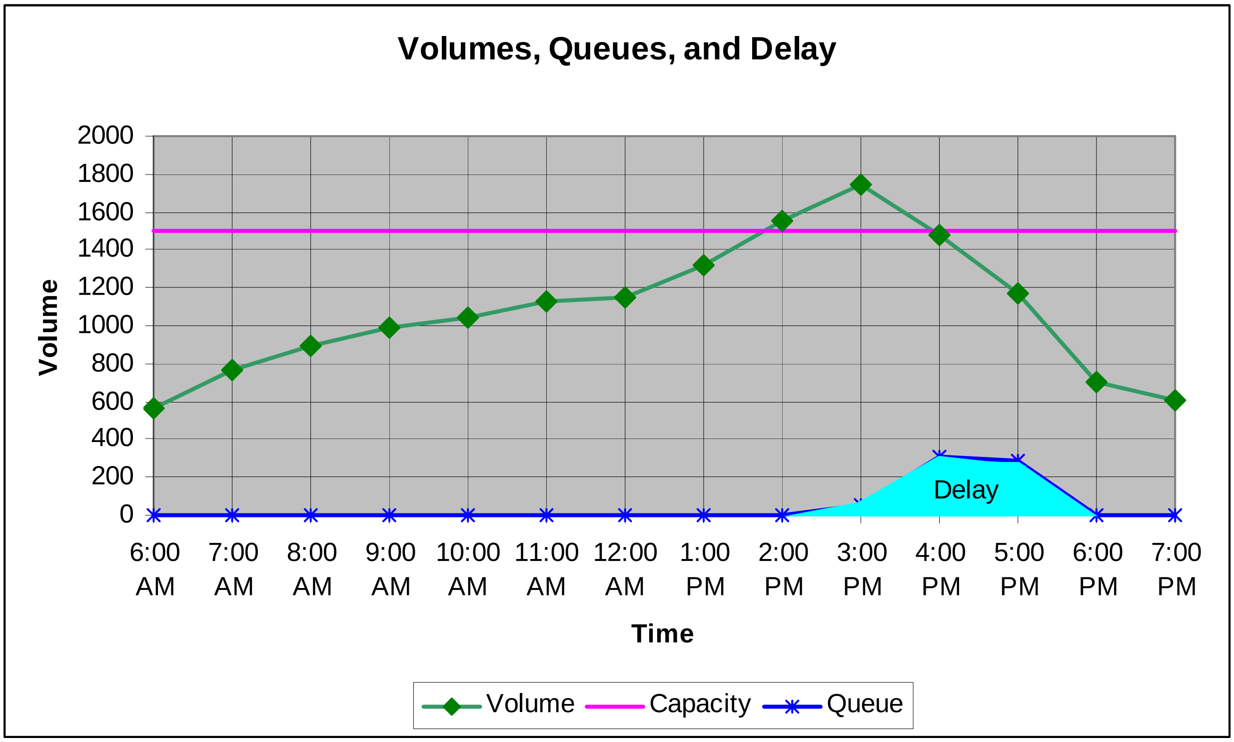
The graph shows how traffic volumes compare with highway **capacity** over time. When the volumes exceed the capacity, it means that not all of the demand is being served. This can result in driver inconvenience, delay and congestion. The bottom line on the graph shows how queuing can develop when traffic volumes exceed capacity, as shown starting at about hour 6. Once the queue starts to build, it will continue to grow cumulatively, and will not decrease until the traffic volumes are lower than the capacity, as seen at about hour 10. The queue will not totally dissipate until approximately hour 21.

Delay, defined as "vehicle-hours of delay", can be seen on the graph from hour 6 to hour 21. The area under the queue line represents vehicle-hours of delay. This graphing technique can give a quick visual evaluation of the hours when there is insufficient highway capacity to meet the demands.

5.4.1 Choosing a Capacity

Based on the limited data gathered to this point, as a default, the capacity chosen for the graphic delay analysis should be 100 PCEs/hr higher than the free flow threshold. The actual capacity will vary, sometimes significantly. The capacity of an over-capacity work zone can be directly measured by determining the throughput volume. Data collection is ongoing to establish more specific guidelines for this value.

The queuing and delay can be derived from graphing the volumes and capacity. This graph shows July's volumes.



What the Volume – Queue – Delay graph shows:

- **The queue** is shown as the lowest line on the graph. The queue begins to build when the demand exceeds capacity and builds ***cumulatively*** until the demand no longer exceeds the capacity.
- **The delay in vehicle-hours** is seen as the area below the queue line. If we use 1500 for capacity, the area and our **total delay** is roughly **630 vehicle-hours**.
- The **time that a queue is present** will be about 4 hours. During that time, some vehicles will be slowed to a stop. The amount of **individual vehicle wait time** will vary based on queue length. The wait time at 2 pm for 60 vehicles will be shorter than at 3 pm for 250 vehicles.
- **The longest queue** can be seen as around 250 vehicles at 3 pm. The longest **wait time may be estimated** by dividing the longest queue by the saturation flow rate, or 250 veh/1500 vehicles per hour which is about 10 minutes.

The values shown by the graph are very rough estimations, and may not to used to report delay numbers – only relative amounts for comparisons.

5.5 Key Concepts

The relationship between volume and delay is exponential. The higher the volume becomes, particularly when reaching the exponential portion of the delay curve, the more inaccurate the analysis results will become.

For one time events, if delays are severe enough, drivers may find other ways to arrive at their destination. For a work zone that will be in place for more than a day, this phenomenon, known as traffic **diversion**, where drivers find alternate routes, as well as change their schedules or simply avoid making the trip, significantly alters traffic patterns. Long term work zones, especially work zones that do not involve lane closures, may lose their impact on traffic operations as drivers become more familiar with the new traffic pattern.

For projects in which lane closures are unavoidable with volumes well in excess of the free flow threshold and significant delays are expected, an intensive public information campaign should be employed to further reduce travel demand during peak periods.

6.0 The Spreadsheet

A "cheat sheet" with step-by-step data entry instructions for the spreadsheet is attached to the end of this manual.

6.1 Developing the Spreadsheet

OBDP was tasked with developing delay estimates for each of the 365 bridges in the OTIA III State Bridge Delivery Program (Program). The first step was to determine the methodology that should be used to estimate the delays. Literature reviews yielded few options. What little information existed mostly dealt with a very specific set of conditions. A new methodology needed to be developed.

The second step in determining the estimated delay is to establish the calculation method. The method to be used depends on the level of detail of the results that is required. Initially, it was thought that calculating the delay for the Design Hour Volume (DHV) would suffice. This would result in the need to calculate one delay per work zone. However, this caused certain problems:

There would be no way to account for off-peak staging strategy changes.

Traffic volumes vary depending on weekday vs. weekend as well as seasonally.

The Design Hour at different locations may not be the same.

OBDP's approach was then revised to identify peak and off-peak delays. The revised approach would require two calculations per work zone. However, "off-peak" hours may differ from location to location. To properly manage delays "24/7/365", it is necessary to develop much more detailed traffic volume information. This approach requires the development of estimated traffic volumes for each hour of a weekday and weekend for each month of the project duration. ODOT had methodology that is used regularly to perform such a task. It was a component of the existing Work Zone Traffic Analysis methodology (described in Chapters Two through Four and the Over Capacity section of Chapter Five).

The ODOT methodology generates a traffic volume matrix in passenger car equivalents that is used to determine when lanes or shoulders should or should not be closed. OBDP developed, in conjunction with ODOT, a methodology that expands on the existing that is used for both delay analysis purposes as well as for the traditional lane restriction analysis.

A spreadsheet was created to automate the development of the closure charts for the hundreds of OTIA III bridges. Close cooperation with ODOT's Traffic

Control Plans Unit led to the incorporation of additional features and the ability to run the analysis based on highway number and milepost. The general methodology was developed and added to the spreadsheet to create the current version.

The following sections provide additional discussion of the processes that take place within the spreadsheet as outlined below.

A matrix of hourly volumes for weekdays and weekends is generated for every month of the project duration.

Matrices of flow rates (adjusted for trucks) are used to establish acceptable windows for shoulder or lane closures.

Staging strategies are determined for the duration of the project from the work zone traffic analysis results, the project TCP, or some combination thereof.

The construction staging, hourly traffic volume, truck percentage, and terrain are used to lookup the estimated delay for every hour of the day for the average weekday or weekend for each month from a lookup table containing delay estimates.

The lookup table contains the delay results from traffic microsimulation analyses that have been regressed to fit exponential curves.

6.2 Source Data

The following section describes the data used in the spreadsheet files. There are minor differences between the data sources used by the spreadsheet and the data sources discussed in Chapter Two.

6.2.1 Traffic and Location Data

The data sources used to establish traffic volumes and other location information were provided by various ODOT departments. Almost all of the data that is available system-wide has been formatted to show data by Oregon highway number and milepost. The OR Hwy # does not correspond with the marked route number. Cross reference tables can be found in the Oregon Bridge Log as well as on the ODOT website.
http://www.oregon.gov/ODOT/TD/TDATA/otms/Route_Hwy_CrossRef.shtml

The Transportation Systems Monitoring (TSM) Unit provided the following data:

Truck percentages listed by highway number and milepost

Manual traffic counts

The Transportation Planning and Analysis Unit (TPAU) provided the following data:

Existing traffic volumes from 2001, 2002, and 2003 and 2023 Average Annual Daily Traffic (AADT) projections for all Oregon Highways under ODOT jurisdiction.

The Traffic Control Plans Unit (TCP) provided the following data:

Automatic Traffic Recorder (ATR) Trend Data for each of the ATRs in the state broken into weekday and weekend trends for every month of the year.

A list of each highway number and milepost combination that shows the appropriate ATR that should be used for each location.

ODOT GIS sources were used to develop:

Roadway functional classification

Terrain

Metropolitan Planning Organization (MPO) and Urban Growth Boundary (UGB) locations

ODOT Region and county boundary information

6.2.2 Updates

As time passes, new information will become available. ATR trend data will be updated, existing and proposed traffic volumes will be updated, and new manual counts will be taken. New data will be incorporated into the source files associated with the spreadsheet and will be distributed accordingly. However, the spreadsheet has built in overrides that allow the user to use user-inputted data as opposed to data taken from the source tables. The overrides will be discussed in a later section.

The anticipated update frequency is quarterly.

6.3 User Inputs

The following information is required for input into the spreadsheet:

OR Hwy # and MP

The Oregon highway number and milepost. As previously stated, the OR Hwy # *does not* correspond to the marked route number.

Work Zone Length

Depending on the staging type, this should be entered in either feet or miles. Bi-directional[7] work zone information should be entered in feet.

Analysis Year

The anticipated year of construction. The closure chart is output for a single calendar year at a time. Thus, if you have a project that spans multiple years, you need to run the analysis multiple times to get each closure chart.

lanes/direction

The number of existing lanes in each direction, *not* the number of lanes that will be open during construction.

Posted Speed

The non-construction posted speed limit. Again, *not* the speed limit during construction.

Figure 6-1: Example of a 2-lane roadway

Roadway Type

Freeway, Multi-Lane, or 2-lane. 2-lane refers to rural two-lane roadways with one lane in each direction. (See Figure 6-1.)

Start Month and End Month

This input is used for the general delay calculations only. Unlike the closure chart, the delay analysis portion can be run over multiple calendar years at once. The maximum

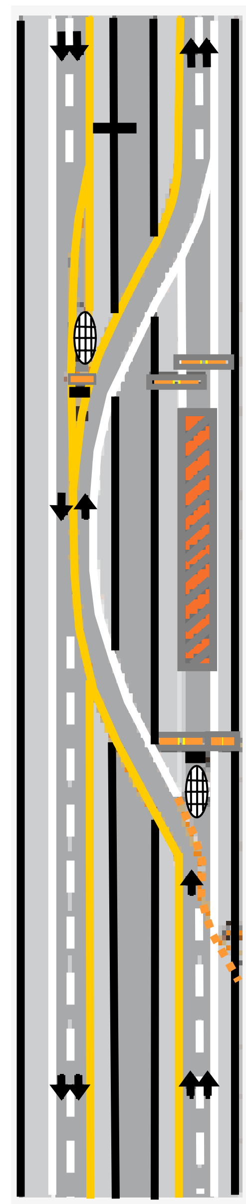
[7] A bi-directional work zone is a work zone in which traffic is reduced to a single bi-directional lane that is controlled by flaggers or temporary signals. See the example shown in Figure 4-3.

project duration is forty months. The output for the delay has been arranged in such a way as to facilitate the use of a summary file that sums the delays generated by multiple projects. A separate report file can be used to create a more printer-friendly delay output.

Lane drops and crossovers

A lane drop is a work zone that includes a reduction in the number of available traffic lanes. Crossovers refer to situations in which traffic will be required to further reduce its speed to shift to a detour bridge or to the opposite side of a median. See Figure 6-2 for an example of a work zone crossover.

Figure 6-2: Example of a Work Zone Crossover



6.4 Brief Overview of Spreadsheet Calculations

The traffic data contained in ODOT's TPAU Growth Table was used to determine the linear growth rate for the AADT at each location. The linear growth rate is then used to interpolate the ADT during the analysis year.

For each location, an appropriate ATR was then identified as well as an appropriate manual count. 24-hour counts were used wherever possible. The truck percentage was taken from the tables provided by the ODOT TSM Unit.

The ATR trend data consists of ratios. There is a weekend and weekday ratio for every month of the year. The ratio represents the traffic volume for each weekday or weekend for each month compared to the ADT. (For example, a ratio of 0.8 for weekends in March indicated that the average traffic volume for March weekends is 80% of the AADT).

The AADT during the analysis year was then compared to the total number of vehicles counted during the 24-hour manual count. The result was an adjustment ratio that relates the manual count data to the projected AADT. This adjustment ratio was then multiplied into the ATR trend ratios. The results are adjustment factors that account for variations from month to month and between weekdays and weekends. There were 24 adjustment factors; each month of the year has two adjustment factors, one for weekdays and one for weekends.

The manual count data includes traffic volumes in each hour for each direction of travel. The adjustment factors were multiplied into the manual count volumes to create four matrices of traffic volumes that cover 24 hours a day for the average weekday and weekend for each month of the year of analysis and both directions of travel. These hourly matrices were used as part of the delay estimation process.

6.5 Overrides

User overrides are provided for almost every input value into the calculation process. They have been provided to allow for such things as user-collected manual counts, more recent data, or to help analyze roadways off of the ODOT network. They can also help to show the sensitivity of the closure windows and delays to certain location or traffic factors. These overrides also provide the ability to tweak the analysis to account for your local experiences.

The available overrides are all entered in the “Data Entry” tab and are as follows:

ATR – changes the ATR whose trend data will be used for calculation

PCE limit – changes the free flow threshold used to develop the closure chart

Percent trucks

Existing and Proposed Year and ADT – allows user defined data to be projected to the correct year

Linear growth rate

Work zone speed reduction (mph)

Terrain – level, rolling, or mountainous[8]

Manual count – the manual count can be changed to a different manual count in the database or the count can be manually inputted into the spreadsheet. For manual entry of an hourly count, go to the “Manual Count” tab.

Staging – the default staging, the staging type that is automatically entered in for every hour or every month, is based on the user inputs for lane drops and crossovers. The staging can and *should* be modified directly in the “Staging List” tab to reflect any potential changes in staging such as off-peak staging or planned changes from one phase of a project to another.

[8] Mountainous terrain should be used very sparingly as the PCE factor is 4. This will have significant impacts on the available closure window. On the other hand, dropping a lane on a steep slope, either uphill or downhill, has its own safety and operational concerns and should also be avoided, when possible.

6.6 Understanding the Output

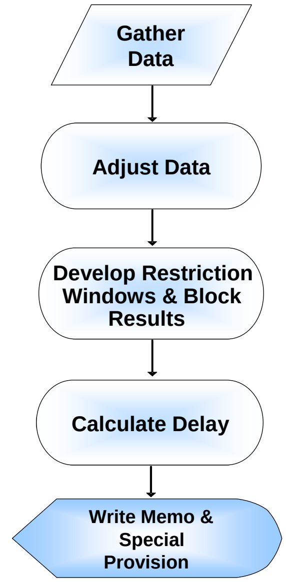
The output comes in different forms. The output from the closure chart is different for lane drops on multi-lane facilities than it is for two-lane roadways. When a lane is dropped on two-lane roadways, as noted in Chapter Four, three different thresholds come into play based on the length of the work zone. The three thresholds show up in different colors. This closure chart can be found in the “Bidirectional” tab.

The basic lane closure chart can be found in the “Multilane” tab. For roadways that have more than two lanes, the basic closure chart will show when the roadway can be dropped to a single lane. That means that on a six-lane facility, the hours that are not highlighted are the hours where *two* lanes can be dropped. Check the “Restriction Chart” tab. This chart will list the *number* of lanes that can be closed during different hours.

The “Delay List” tab shows the delays that would result from the proposed staging for the duration of the project. A separate file is used to format the delays into a cleaner, more printer-friendly format similar to the closure chart that can be printed out of either the “Multilane” or “Bidirectional” tabs.

Delays in the “Delay List” tab may sometimes show up as extraordinarily high values. These delays are listed in seconds, but it should be obvious that delays that reach five or six digits are probably not realistic. These are the result of the volume being somewhere on the exponential portion of the curve. At these levels, it is more accurate to use the graphing method included in a separate file. Bear in mind that at very high volumes, diversion and other traffic reducing variables begin to significantly impact traffic volumes, and therefore delays.

7.0 Summary



The steps for performing a Work Zone Traffic Analysis are similar, regardless of whether it is done by hand or by spreadsheet.

- Location and traffic data is collected.
- Traffic data is developed, projected, and adjusted to cover heavy vehicles, terrain, peak hours, peak seasons, and peak times of the week.
- Engineering judgment is used to select the appropriate free flow threshold and capacity.
- Windows for lane restrictions are developed. The resulting closure chart must be "blocked" to create practical restriction windows.
    - These adjusted restrictions are included in the project's special provisions.
    - Staging strategies are developed that fit the lane restriction windows.
- The estimated delays for the construction staging strategies chosen are developed. These delays need to be coordinated with adjacent projects, project leaders, the Region Mobility Liaison, and Region Mobility Committee.

The results of the lane restriction portion of the analysis should be included in the project's special provisions to ensure that the time windows are adhered to during construction. A memo should accompany the results of the analysis and should include and location-specific or other pieces of information that significantly impacted the analysis. The traffic analysis memo should also contain the delay analysis results. Sample memo that have been used by ODOT in the past are included in **Appendix C**.

The analysis methods are not a "black box". The output from the methodology *must* be reviewed to ensure that the results make sense. Potential problems may result from incorrect data input or unrealistic choices for the free flow threshold or capacity. Skill and engineering judgment are required is needed to properly interpret the results. *The automation provided by the spreadsheet does not absolve the analyst of incorrect results.* Numerous overrides have been provided to properly tailor the analysis to specific projects or regions. Use your own experience or the experiences of other to help tweak your analysis to fit your needs.

Analysis Resources

- *ODOT Traffic Manual* **–** Within the "Practices" section, see topic titled "Workzone Zone Analysis" at:

  http://www.odot.state.or.us/traffic/trafficmanual041015.pdf

- *ODOT Highway Design Manual* **–** See Section 5.6 "Traffic Control" for discussion regarding detours, restricted lane width, and other aspects of traffic control plans at:

  http://www.odot.state.or.us/tsroadway/2003-english-hdm.htm

- *Highway Capacity Manual* **–** trb.org/news/blurb_detail.asp?id=1166

- Highway Cross reference tables.
  http://www.oregon.gov/ODOT/TD/TDATA/otms/Route_Hwy_CrossRef.shtml

- *Manual on Uniform Traffic Control Devices* (MUTCD) **–** The manual itself can be downloaded from: http://mutcd.fhwa.dot.gov/pdfs/2003/pdf-index.htm

- Home (Internet): www.odot.state.or.us/home/

- Traffic Volume Tables:
  www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml#Traffic_Volume_Tables

- ODOT Manual Counts: www.oregon.gov/ODOT/TD/TDATA/

- Future Volume Trend Data:

  http://www.oregon.gov/ODOT/TD/TP/TADR.shtml

- Traffic Volume Tables Seasonal Adjustments:

  www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml#Traffic_Volume_Tables

- Design Hour Volume Development Methodology:
  http://www.oregon.gov/ODOT/TD/TP/Analysis.shtml#Analysis_Procedures___Methods

  http://www.oregon.gov/ODOT/TD/TP/TAPM.shtml

- Seasonal Adjustment Tables:
  www.oregon.gov/ODOT/TD/TDATA/rics/docs/ORStateHwysFCandNHS.pdf

- Oregon Bridge Delivery Partners (OBDP): www.obdp.org

- *ODOT Standard Spec.*

  http://www.odot.state.or.us/tsspecs/2002-std-specs.htm

- OTIA Home: http://www.oregon.gov/ODOT/HWY/OTIA/
- Special Provisions www.odot.state.or.us/tsspecs/special-prov.htm
- Unique Specifications
  http://www.oregon.gov/ODOT/HWY/SPECS/unique.shtml
- Traffic Management: www.odot.state.or.us/traffic/
- Transportation System Monitoring Unit:
  www.odot.state.or.us/tdb/traffic_monitoring/default.asp
- Transportation Safety Division: http://www.oregon.gov/ODOT/TS/
- Oregon Maps: www.oregon.gov/ODOT/TD/TDATA/gis/odotmaps.shtml
- TripCheck: www.tripcheck.com/
- ODOT Employee Phone Book: phonebook.odot.state.or.us/cf/ein/
- Oregon Department of Transportation – "**Highway Design Manual**":

www.oregon.gov/ODOT/HWY/ROADWAY/

FHWA Sites

2003 MUTCD: mutcd.fhwa.dot.gov/kno-millennium.htm

Standard Highway Signs: mutcd.fhwa.dot.gov/ser-shs_millennium.htm

OTHER Sites

AASHTO Home: www.transportation.org/

Institute of Traffic Engineers (ITE): www.ite.org

GLOSSARY OF TERMS

TERM	DEFINITION
Alignment	Geometric arrangement of a roadway (curvature, etc.).
Approach	[OAR 734-020-0420(1)] All lanes of traffic moving toward an intersection or mid-block location from one direction.
Average Daily Traffic (ADT)	Average Daily Traffic (ADT) – The average 24-hour volume of traffic, the total during a stated period divided by the number of days in that period, usually a year.
Capacity	The maximum number of vehicles that can pass a given section of roadway during a given period of time under prevailing roadway and traffic conditions.
Clear Zone	Roadside border area starting at the edge of the traveled way that is available for safe use by errant vehicles. Rigid objects and other hazards should be removed and relocated outside the clear zone to make it safely traversable.
Continuous Two-Way Left-Turn Lane	A traversable median to accommodate left-turn egress movements from opposite directions; aka "Twiddle"
Delay –	Additional travel time experienced by a vehicle; this value can also be determined graphically, as show on page 7 of this report.
Cross Section	The exact image formed by a plane cutting through an object, usually at right angles to a central axis or alignment.
Demand	The number of users wanting use of the highway system.
Design Speed	A speed determined by traffic volumes, the geographic characteristics of the area, number of traffic lanes, and the posted speed for use in designing a project.
Design (Hourly) Volume	A volume representing traffic expected to use the highway. ODOT uses the 30th highest hour as its design hour.
Freeway	A fully access controlled highway.
Highway	(ORS 801.305) Every public way, road, street, thoroughfare and place, including bridges, viaducts and other structures within the boundaries of this state, open, used or intended for use of the general public for vehicles or vehicular traffic as a matter of right.
Lane Closure Restrictions	ODOT often limits the hours that work zone traffic lanes and roads may be closed in an effort to reduce motorist delay, inconvenience and crash potential.

TERM	DEFINITION
Manual Traffic Counts	Performed by ODOT personnel and available from ODOT Traffic Data Section in the Transportation Development Branch. Traffic counts used for analysis should be close to the work area and on the same type of highway designation and should also have been taken in the last three years.
Median	An island which separates opposing traffic and may be used to separate left turn traffic from through traffic in the same direction as well. Medians may be designated by pavement markings, curbs, guideposts, pavement edge or other devices. May be traversable or non-traversable
MUTCD	The Manual of Uniform Traffic Control Devices and the ODOT supplements are standard handbooks used by all designers in the state. Traffic Control Plans are guided by these standards.
OAR	Oregon Administrative Rules – Rules written by a government agency intended to clarify the intent of an adopted law.
ORS	Oregon Revised Statues – The laws that govern the State of Oregon.
Passenger Car Equivalent (PCE)	Accounting for the presence of heavy vehicles in the traffic stream. For the purposes of workzone traffic analysis, traffic volumes are discussed in terms of passenger car equivalents (PCEs). A truck factor of 2.5 is used most commonly. Most I-5 applications would use a 2.5 factor to account for the substantial number of large trucks
Peak Hour	Hour of the day with the most traffic, usually during morning and evening commute times. Generally not the design hour.
Queue	A line of vehicles waiting to be served by the highway system. The queue can be determined graphically, as shown in the WZ Traffic Analysis Guide, Chapter 2.
Raised Median	A non-traversable median where curbs delineate the median and the adjacent traffic lane.
Roadway	That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the berm or shoulder.
Seasonal Adjustments	Adjusting the traffic count data so that it reflects the time of year during which construction will take place, if different from the traffic count date.
Shoulder(s)	[ORS 801.480] The portion of a highway, whether paved or unpaved, contiguous to the roadway that is primarily used by pedestrians, stopped vehicles, for emergency use, exclusive of auxiliary lanes, curbs, and gutters.
Shy Distance (E-Distance)	The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard. Often it is an extra 2' added to the right shoulder.

TERM	DEFINITION
Sight Distance	The length of roadway ahead visible to the driver.
Special Event	Any planned activity including, but not limited to, parades, bicycle races, athletic events and other activity that result in increases to traffic volumes.
Special Provisions aka “Specials”	The specifications for a project that augment and have authority over the standard and supplemental specifications.
Specifications, aka “Specs.”	The body of directions, provisions, and requirements, together with written agreements and all documents pertaining to performing the work, the quantities, and the quality of materials to be furnished under the contract.
Standard Drawings	Detailed drawings for work or methods of construction that are selectively included in a project book.
Standard Specifications	Detailed specifications for project work, found in the Oregon Standard Specification Construction Book.
Traffic Control Device	(1) Any sign, signal, marking, or device placed, operated or erected for the purpose of guiding, directing, warning or regulating traffic. (2) Any device that remotely controls another traffic control device by electrical, electronic, sound or light signal. (3) Any sign that is held by a highway maintenance or construction crew working in the highway.
V/C Ratio	Volume to Capacity Ratio – A measure of roadway operation, calculated by dividing the number of vehicles by the capacity of the section. V/C is the mobility criteria for Oregon highways in the Oregon Highway Plan.
Work Zone (WZ)	An area of a highway with construction, maintenance or utility work activities. It extends from the first warning sign to the “End Road Work” sign or the last traffic control device.

Appendix A: WZ Traffic Analysis Report Memos

Two Lane Highway Lane Restrictions

Oregon Department of Transportation **INTEROFFICE MEMO**
Region X Traffic Unit (xxx) xxx-xxxx
Fax (xxx) xxx-xxxx

DATE: XXX

TO: XXX
Title (Traffic Control Plans Designer?)

FROM: Your Name

Title

SUBJECT: Workzone Restrictions
Project Name
XX Highway No. X (Route No.), M.P. xx.xx – M.P. xx.xx
Key #XXXXX

Recommendations on lane restrictions for the subject project are shown below.

00220.40(e) Lane Restrictions:

Do not close any traffic lanes as follows:

XXX Highway (Route No.)

- No lane closures are allowed between X:XX p.m. and X:XX p.m. on weekdays.
- Lane closures may be allowed at any time on weekends.
- Alternating one-way traffic operations controlled by flaggers would be needed during lane closures.

Cross Streets (as applicable)

- No lane closures are allowed between 4:00 p.m. and 6:00 p.m. on weekdays.
- Lane closures may be allowed at any time on weekends.
- Alternating one-way traffic operations controlled by flaggers would be needed during lane closures.

In addition, do not close any traffic lanes between:

- Noon on the day preceding legal holidays or holiday weekends and 12:00 midnight on legal holidays or the last day of holiday weekends, except for Thanksgiving, when no lanes may be closed between 12:00 noon on Wednesday and 12:00 midnight on the following Sunday.

For the purposes of this section, legal holidays are as follows:

- New Year's Day on January 1
- Memorial Day on the last Monday in May
- Independence Day on July 4
- Labor Day on the first Monday in September
- Thanksgiving Day on the fourth Thursday in November
- Christmas Day on December 25

When a holiday falls on Sunday, the following Monday shall be recognized as a legal holiday. When a holiday falls on Saturday, the preceding Friday shall be recognized as a legal holiday.

Also, do not close any traffic lanes during the following special events:

- List of special events, festivals, sports events

Roadways shall be free of barricades or other objects and all lanes opened during these periods.

Please call me at (xxx) xxx-xxxx if you have any questions or need additional information.

Cc: John Smith
Mary Jones

Two Lane Highway Lane Restrictions

Oregon Department of Transportation **INTEROFFICE MEMO**
Region X Traffic Unit (xxx) xxx-xxxx
Fax (xxx) xxx-xxxx

DATE: XXX

TO: XXX
Title (Traffic Control Plans Designer?)

FROM: Your Name

Title

SUBJECT: Workzone Restrictions
Project Name
XX Highway No. X (Route No.), M.P. xx.xx – M.P. xx.xx
Key #XXXXX

Recommendations on lane restrictions for the subject project are shown below.

00220.40(e) Lane Restrictions:

Do not close any traffic lanes as follows:

<u>XXX Highway (Route No) Northbound and Southbound</u>

No single lane closures are allowed:

- between 6:00 a.m. and 7:00 p.m., Monday - Friday
- between 10:00 a.m. and 6:00 p.m., Saturday - Sunday

No two-lane closures are allowed:

- between 5:00 a.m. and 8:00 p.m., Monday - Friday
- between 9:00 a.m. and 7:00 p.m., Saturday - Sunday

In addition, do not close any traffic lanes between:

- Noon on the day preceding legal holidays or holiday weekends and 12:00 midnight on legal holidays or the last day of holiday weekends, except for Thanksgiving, when no lanes may be closed between 12:00 noon on Wednesday and 12:00 midnight on the following Sunday.

For the purposes of this section, legal holidays are as follows:

- New Year's Day on January 1
- Memorial Day on the last Monday in May
- Independence Day on July 4
- Labor Day on the first Monday in September
- Thanksgiving Day on the fourth Thursday in November
- Christmas Day on December 25

When a holiday falls on Sunday, the following Monday shall be recognized as a legal holiday. When a holiday falls on Saturday, the preceding Friday shall be recognized as a legal holiday.

Roadways shall be free of barricades or other objects and all lanes opened during these periods.

Short-Term Road Closure – The Contractor will be permitted to close all travel lanes of Pacific Highway East (OR99E) for periods not to exceed 20 minutes in duration during bridge steel arch segments and precast deck panels erection over the travel lanes between 11:00 p.m. and 5:00 a.m., Monday – Sunday. Succeeding roadway closures will not be permitted until traffic clears from preceding closure.

Please call me at (xxx) xxx-xxxx if you have any questions or need additional information.

Cc: John Smith
Mary Jones

Appendix B: ODOT's Special Provisions

ODOT's Lane Closure Restrictions
Section 220.40(e) of the Special Provisions

SECTION 00220 - ACCOMMODATIONS FOR PUBLIC TRAFFIC

(Unless otherwise indicated by instruction, use all the subsections, paragraphs, and sentences on all projects.)

Comply with Section 00220 of the Standard Specifications supplemented and/or modified as follows:

00220.02 Public Safety and Convenience - Replace the last bulleted item with the following bullet:

- Allow emergency vehicles and incident response units immediate passage at all times.

(Use the following lead in sentence when adding bulleted items. Remove the "(s)" if only adding one bullet. Remove the parentheses if adding more than one bullet.)

Add the following bulleted item(s) to the end of this subsection:

(Use the following two bullets when sidewalks or sidewalk ramps are closed and alternate pedestrian routes are used. Modify the second bullet by filling in the blank with the city or county name and removing the city or county text that is not required.)

- When construction requires the closure of a sidewalk or sidewalk ramp, place a Type "W1" "SIDEWALK CLOSED" (OR22-12-533) sign at each point of closure. Use a Type "W1" directional arrow (M6-1-381) rider, as needed, to direct pedestrian traffic. Mount each sign above the striped panel of a Type II barricade placed across the sidewalk, facing pedestrians approaching the work area. Close the sidewalk at a point where there is an alternate way to proceed or provide an alternate pedestrian route. Pave the alternate pedestrian route surface or provide an approved, non-slip 910 mm (36 inch) minimum wide surface meeting the requirements of the Americans with Disabilities Act (ADA). If appropriate, delineate this route and protect pedestrians by placing pedestrian workzone delineation fencing. Fencing is to remain in place, except as required for actual work, until the sidewalk is reopened to pedestrian traffic. Reopen the sidewalk during non-work hours or continue to provide an alternate route for pedestrians.

- When construction requires the closure of a sidewalk, notify, in writing, the City of _____________ (County Public Works Department) at least 14 days in advance of the closure. Do not close the sidewalk until the City (County) provides written approval. After approval, provide 48 hour public notification prior to closing the sidewalk.

(Use the following bulleted item with the portable changeable message signs pay item.)

- Use portable changeable message signs to provide appropriate workzone information to the public. Place signs and display messages as directed or approved. When signs are in use, protect them according to 00225.46(b) and the "Portable Changeable Message Sign (PCMS) Installation" detail shown on Standard Drawing RD945.

00220.40(a) Traffic Nuisance Abatement - Replace the first bulleted item with the following bullet:

- Use flaggers or flaggers with pilot car(s)

(Use the following lead in heading with any of the following subsections .40(e), .40(f), and .40(g). Remove "(s)" or the parentheses when appropriate.)

Add the following subsection(s):

(Use the following subsection .40(e) with lane restrictions. To obtain the restrictions and information to fill in the blanks, submit a written request as follows: For Portland and Region 1 projects, contact the Region Traffic Office, Fax 503-731-8259. For Regions 2 through 5 projects, contact the Traffic Engineering and Operations Section, Fax 503-986-4063 or the local Traffic Office. ODOT staff submits a Traffic Analysis Work Request Form to the appropriate office listed above.)

00220.40(e) Lane Restrictions - Do not close any traffic lanes on ___________ Highway, Monday through Friday, between:

__:00 a.m. - __:00 a.m.
and
__:00 p.m. - __:00 p.m.

In addition, do not close any traffic lanes between:

- 3:00 p.m. on Fridays and midnight on Sundays.
- Noon on the day preceding legal holidays or holiday weekends and midnight on legal holidays or the last day of holiday weekends, except for

Thanksgiving, when no lanes may be closed between noon on Wednesday and midnight on the following Sunday.

For the purposes of this section, legal holidays are as follows:

- New Year's Day on January 1
- Memorial Day on the last Monday in May
- Independence Day on July 4
- Labor Day on the first Monday in September
- Thanksgiving Day on the fourth Thursday in November
- Christmas Day on December 25

When a holiday falls on Sunday, the following Monday shall be recognized as a legal holiday. When a holiday falls on Saturday, the preceding Friday shall be recognized as a legal holiday.

(Use the following paragraph and bullet for special events. Obtain times and dates from the Designer.)

Also, do not close any traffic lanes between ___(time)___ on ___(date)___ and ___(time)___ on ___(date)___ during the following special events:

- ____________________

Roadways shall be free of barricades or other objects and all lanes opened to traffic during all the restrictive periods listed above.

SPECIAL PROVISIONS - LANE RESTRICTION EXAMPLE

SIMPLE PROJECT EXAMPLE

00220.40(e) Lane Restrictions - Do not close any traffic lanes on Example Highway (US XX), Monday through Friday, between:

10:00 a.m. - 6:00 p.m.

<u>Milepoints -0.04 to 7.00 and Milepoints 27.20 to 56.06</u>

Maintain a minimum of one lane with maximum closure length of 4000 m (2.5 miles), except through the towns of Valley and Townsend the maximum closure length shall be reduced to 800 m (1/2 mile).

In addition, do not close any traffic lanes between:

- 3:00 p.m. on Fridays and midnight on Sundays.
- Noon on the day preceding legal holidays or holiday weekends and midnight on legal holidays or the last day of holiday weekends, except for Thanksgiving, when no lanes may be closed between noon on Wednesday and midnight on the following Sunday.

For the purposes of this section, legal holidays are as follows:

- New Year's Day on January 1
- Memorial Day on the last Monday in May
- Independence Day on July 4
- Labor Day on the first Monday in September
- Thanksgiving Day on the fourth Thursday in November
- Christmas Day on December 25

When a holiday falls on Sunday, the following Monday shall be recognized as a legal holiday. When a holiday falls on Saturday, the preceding Friday shall be recognized as a legal holiday.

Roadways shall be free of barricades or other objects and all lanes opened to traffic during the restrictive periods listed above.

SPECIAL PROVISIONS - LANE RESTRICTION EXAMPLE

NOT-SO-SIMPLE EXAMPLE

S00220.40 General Requirements - Add the following subsection(s):

Lane Restrictions - Do not close any traffic lanes on Caine Highway (ORE XXX) and Bluebird Highway (ORE XXX), as follows:

Caine Highway (ORE XX) MP 0.00 to MP 4.31

Single Lane Closure:

	Westbound	Eastbound
Weekdays	6:00 AM – 7:00 PM	6:00 AM – 7:00 PM
Saturdays	10:00 AM – 6:00 PM	10:00 AM – 6:00 PM
Sundays	11:00 AM – 6:00 PM	11:00 AM – 6:00 PM

Caine Highway (ORE XXX) / Landfall Freeway (I-XXX) MP 4.31 to MP 4.91 And Clear Highway North (ORE XXX) / 2nd Ave.

Single Lane Closure:

	Northbound	Southbound
Weekdays	5:30 AM – 8:00 PM	6:00 AM – 8:00 PM
Saturdays	9:00 AM – 8:00 PM	9:00 AM – 8:00 PM
Sundays	11:00 AM – 8:00 PM	11:00 AM – 8:00 PM

Two Lane Closure:

	Northbound	Southbound
Weekdays	5:00 AM – 12 Midnight	5:00 AM – 12 Midnight
Saturdays	6:00 AM – 12 Midnight	12 Midnight Friday – 12 30 AM

6:30 AM – 12 Midnight

Sundays 8:00 AM – 12 Midnight 8:00 AM – 12 Midnight

Caines Highway (ORE XXX) MP 4.91 to MP 5.06

Single Lane Closure:

	Westbound	Eastbound
Weekdays	5:00 AM – 8:00 PM	5:00 AM – 8:00 PM
Saturdays	10:00 AM – 7:00 PM	10:00 AM – 7:00 PM
Sundays	11:00 AM – 7:00 PM	11:00 AM – 7:00 PM

In addition, do not close any traffic lanes between:

12:00 noon on the day preceding legal holidays or holiday weekends and 12:00 midnight on legal holidays or the last day of holiday weekends, except for Thanksgiving, when no lanes may be closed between 12:00 noon on Wednesday and 12:00 midnight on the following Sunday.

For the purposes of this section, legal holidays are as follows:

New Year's Day on January 1

Memorial Day on the last Monday in May

Independence Day on July 4

Labor Day on the first Monday in September

Thanksgiving Day on the fourth Thursday in November

Christmas Day on December 25

When a holiday falls on Sunday, the following Monday shall be recognized as a legal holiday. When a holiday falls on Saturday, the preceding Friday shall be recognized as a legal holiday.

Roadways shall be free of barricades or other objects and all lanes opened to traffic during these periods.

Appendix C: Regional Mobility Liaisons

ODOT REGIONAL MOBILITY LIAISONS				
Eileen Phelan	Region 1 Mobility Liaison	123 NW Flanders St Portland , OR 97209	503.731.8480	Eileen.j.phalen@state.or.us
Erik Havig	Region 2 Mobility Liaison	455 Airport Rd SE Bldg B Salem , OR 97301	503 986-2632	erik.m.havig@state.or.us
Matt Malone	Region 3 Mobility Liaison	3500 NW Stewart Parkway Roseburg , OR 97470	541 957-3505	Richard.malone@state.or.us
Joel McCarroll	Region 4 Mobility Liaison	PO Box 5309 Bend , OR 97708	541 388-6189	joel.r.mccarroll@state.or.us
Michael Buchanan	Region 5 Mobility Liaison	3014 Island Ave. La Grande , OR 97850-9497	541 963-8406	Michael.r.buchanan@state.or.us