Appendix

APPENDIX
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Level of Service Description

TRAFFIC LEVELS OF SERVICE

Analysis of traffic volumes is useful in understanding the general nature of traffic in an area, but by itself indicates neither the ability of the street network to carry additional traffic nor the quality of service afforded by the street facilities. For this, the concept of *level of service* has been developed to subjectively describe traffic performance. Level of service can be measured at intersections and along key roadway segments.

Level of service categories are similar to report card ratings for traffic performance. Intersections are typically the controlling bottlenecks of traffic flow and the ability of a roadway system to carry traffic efficiently is generally diminished in their vicinities. Levels of Service A, B and C indicate conditions where traffic moves without significant delays over periods of peak travel demand. Level of service D and E are progressively worse peak hour operating conditions and F conditions represent where demand exceeds the capacity of an intersection. Most urban communities set level of service D as the minimum acceptable level of service for peak hour operation and plan for level of service C or better for all other times of the day. The *Highway Capacity Manual* provides level of service calculation methodology for both intersections and arterials.[1] The following three sections provide interpretations of the analysis approaches.

1 *2000 Highway Capacity Manual*, Transportation Research Board, Washington D.C., 2000, Chapters 16 and 17.

ALL-WAY STOP CONTROLLED INTERSECTIONS

Unsignalized intersections and all-way stop controlled intersections are each subject to a separate capacity analysis methodology. All-way stop controlled intersection operations are reported by leg of the intersection.

This method calculates a delay value for each approach to the intersection. The *2000 Highway Capacity Manual* describes the detailed methodology. The following table describes the amount of delay associated with each level of service.

Delay (Seconds)	Level of Service
0 - 10	A
10 - 15	B
15 - 25	C
25 - 35	D
35 - 50	E
> 50	F

Source: 2000 *Highway Capacity Manual*, Transportation Research Board, Washington, D.C.

UNSIGNALIZED INTERSECTIONS (Two-Way Stop Controlled)

Unsignalized intersection level of service is reported for the major street and minor street (generally, left turn movements). The method assesses available and critical gaps in the traffic stream which make it possible for side street traffic to enter the main street flow. The *2000 Highway Capacity Manual* describes the detailed methodology. It is not unusual for an intersection to experience level of service E or F conditions for the minor street left turn movement. It should be understood that, often, a poor level of service is experienced by only a few vehicles and the intersection as a whole operates acceptably.

Unsignalized intersection levels of service are described in the following table.

Level of Service	Expected Delay	(Sec/Veh)
A	Little or no delay	0-10.0
B	Short traffic delay	>10.1-15.0
C	Average traffic delays	>15.1-25.0
D	Long traffic delays	>25.1-35.0
E	Very long traffic delays	>35.1-50.0
F	Extreme delays potentially affecting other traffic movements in the intersection	> 50

Source: 2000 *Highway Capacity Manual*, Transportation Research Board Washington, D.C.

SIGNALIZED INTERSECTIONS

For signalized intersections, level of service is evaluated based upon average vehicle delay experienced by vehicles entering an intersection. Control delay (or signal delay) includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. In previous versions of this chapter of the HCM (1994 and earlier), delay included only stopped delay. As delay increases, the level of service decreases. Calculations for signalized and unsignalized intersections are different due to the variation in traffic control. The *2000 Highway Capacity Manual* provides the basis for these calculations.

Level of Service	Delay (secs.)	Description
A	≤10.00	**Free Flow/Insignificant Delays:** No approach phase is fully utilized by traffic and no vehicle waits longer than one red indication. Most vehicles do not stop at all. Progression is extremely favorable and most vehicles arrive during the green phase.
B	10.1-20.0	**Stable Operation/Minimal Delays:** An occasional approach phase is fully utilized. Many drivers begin to feel somewhat restricted within platoons of vehicles. This level generally occurs with good progression, short cycle lengths, or both.
C	20.1-35.0	**Stable Operation/Acceptable Delays:** Major approach phases fully utilized. Most drivers feel somewhat restricted. Higher delays may result from fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level, and the number of vehicles stopping is significant.
D	35.1-55.0	**Approaching Unstable/Tolerable Delays:** The influence of congestion becomes more noticeable. Drivers may have to wait through more than one red signal indication. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. The proportion of vehicles not stopping declines, and individual cycle failures are noticeable.
E	55.1-80.0	**Unstable Operation/Significant Delays:** Volumes at or near capacity. Vehicles may wait though several signal cycles. Long queues form upstream from intersection. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are a frequent occurrence.
F	≥80.0	**Forced Flow/Excessive Delays:** Represents jammed conditions. Queues may block upstream intersections. This level occurs when arrival flow rates exceed intersection capacity, and is considered to be unacceptable to most drivers. Poor progression, long cycle lengths, and v/c ratios approaching 1.0 may contribute to these high delay levels.

Source: *2000 Highway Capacity Manual*, Transportation Research Board, Washington D.C.

ARTERIAL LEVEL OF SERVICE

Arterial level of service is based on the average travel speed for the segment, section, or entire arterial under consideration. The average travel speed is computed from the running time on the arterial segment(s) and the intersection approach delay. It is strongly influenced by the number of signals per mile and the average intersection delay. On a given facility, factors such as inappropriate signal timing, poor progression, and increasing traffic flow can substantially degrade the arterial LOS.[2]

Arterial levels of service are summarized in the following table.

Arterial Levels of Service

Arterial Class	**I**	**II**	**III**
Range of Free Flow Speeds (mph)	45 to 35	35 to 30	35 to 25
Typical Free Flow Speed (mph)	40 mph	33 mph	27 mph
Level of Service	**Average Travel Speed (mph)**		
A	35	30	25
B	28	24	19
C	22	18	13
D	17	14	9
E	13	10	7
F	< 13	< 10	< 7

[2] *1994 Highway Capacity Manual*, Special Report 209, Transportation Research Board, Washington D.C., 1994, Chapter 11.

The three arterial classes (I, II, and III) used to find the appropriate level of service are based on design and functional characteristics shown in the table below.

Definition of functional categories

Functional Category	**Characteristics**
Principal Arterial	• Mobility very important • Heavily restricted access • Connected to freeways, important activity centers, major traffic generators • Relatively long trips between above points and through trips entering, leaving,and going through the city.
Minor Arterial	• Mobility important • Substantially restricted access • Connected to principal arterials • Trips of moderate lengths within relatively small geographical area

Design Category	**Characteristics**
Suburban	• Low access density • Multilane divided; undivided or two-lane with shoulders arterial • No parking • Separate left turn lanes • 1 to 5 signals per mile • 40 to 45 mph speed limits • Little Pedestrian activity • Low to medium roadside development density
Intermediate	• Moderate access density • Multilane divided or undivided; one way or two lane arterial • Some parking • Usually separate left turn lanes • 4 to 10 signals per mile • 30 to 40 mph speed limits • Some pedestrian activity • Medium to moderate roadside development density
Urban	• High access density • Undivided one way; two way, two or more lanes arterial • Much parking • Some separate left-turn lanes • 6 to 12 signals per mile • 25 to 35 mph speed limits • Usually pedestrian activity • High density roadside development

Once the arterial is classified using the functional and design categories, the table below can be used to find the associated arterial class.

Arterial Class According to Design and Functional Categories

	FUNCTIONAL CATEGORY	
DESIGN CATEGORY	**PRINCIPAL ARTERIAL**	**MINOR ARTERIAL**
TYPICAL SUBURBAN	I	II
INTERMEDIATE	II	II OR III
TYPICAL URBAN	II OR III	III

Glossary

COMMON TERMS

Access Management: Refers to measures regulating access to streets, roads and highways from public roads and private driveways. Measures may include but are not limited to restrictions on the type and amount of access to roadways, and use of physical controls such as signals and channelization including raised medians, to reduce impacts of approach road traffic on the main facility.

Accessway: Refers to a walkway that provides pedestrian and or bicycle passage either between streets or from a street to a building or other destination such as a school, park, or transit stop.

ADT: Average Daily Traffic. This is the measurement of the average number of vehicles passing a certain point each day on a highway, road or street.

Alternative Modes: Transportation alternatives other than single-occupant automobiles such as rail, transit, bicycles and walking.

Arterial (Street): A street designated in the functional class system as providing the highest amount of connectivity and mostly uninterrupted traffic flow through an urban area.

Bicycle Facility: Any facility provided for the benefit of bicycle travel, including bikeways and parking facilities.

Bicycle Network: A system of connected bikeways that provide access to and from local and regional destinations.

Bike Lane: A portion of the roadway which has been designated by striping and pavement markings for the preferential or exclusive usr of bicyclists.

Capacity: The maximum number of vehicles or individuals that can traverse a given segment of a transportation facility with prevailing roadway and traffic conditions.

CBD: Central Business District. This is the traditional downtown area, and is usually characterized by slow traffic speeds, on street parking and a compact grid system.

Collector (Street): A street designated in the functional class system that provides connectivity between local and neighborhood streets with the arterial streets serving the urban area. Usually shorter in distance than arterials, designed with lower traffic speeds and has more traffic control devises than the arterial classification.

Congestion Mitigation/Air Quality (CMAQ): A program within the federal ISTEA and TEA-21 regulations that address congestion and transportation-related air pollution.

Crosswalk: Portion of a roadway designated for pedestrian crossing and can be either marked or unmarked. Unmarked crosswalks are the national extension of the shoulder, curb line or sidewalk.

Demand Management: Refers to actions which are designed to change travel behavior in order to improve performance of transportation facilities and to reduce need for additional road capacity. Methods may include subsidizing transit for the journey to work trip, charging for parking, starting a van or car pool system, or instituting flexible work hours.

Grade Separation: The vertical separation of conflicting travel ways.

Grade: A measure of the steepness of a roadway, bikeway or walkway, usually expressed in a percentage form of the ratio between vertical rise to horizontal distance. (eg. a 5% grade means that the facility rises 5 feet in height over a 100 feet in length.)

Impervious Surfaces: Hard surfaces that do not allow water to soak into the ground, increasing the amount of storm water running into the drainage system.

Level of Service (LOS): A qualitative measure describing the perception of operation conditions within a traffic steam by motorists and or passengers. An LOS rating of “A” to “F” describes the traffic flow on streets and at intersections, ranging from LOS A, representing virtually free flow conditions and no impedance to LOS F representing forced flow conditions and congestion.

Local (Street): A street designated in the functional class system that’s primary purpose is to provide access to land use as opposed to enhancing mobility. These streets typically have low volumes and are very short in relation to collectors and arterials.

Metropolitan Planning Organization (MPO): An organization in each federally recognized urbanized area (population over 50,000) designated by the Governor which has the responsibility for planning, programming and coordinating the distribution of federal transportation resources.

Multi-Modal: Involving several modes of transportation including bus, rail, bicycle, motor vehicle etc.

Multi-Use Path: A path separated from motor vehicle traffic by open space or barrier used by bicyclists, pedestrians, joggers, skaters and other non-motorized travelers.

National Highway System (NHS): The National Highway System is interconnected urban and rural principal arterial and highways that serve major population centers, ports, airports and other major travel destinations, meet national defense requirements and serve interstate and interregional travel.

Peak Period or Peak Hour: The period of the day with the highest number of travelers. This is normally between 4-6 PM on weekdays.

Pedestrian Connection: A continuous, unobstructed, reasonability direct route between two points that is intended and suitable for pedestrian use. These connections could include sidewalks, walkways, accessways, stairways and pedestrian bridges.

Pedestrian District: A comprehensive plan designation or implementing land use regulation, such as an overlay zone, that establishes requirements to provide a safe and convenient pedestrian environment an area planned for a mix of uses likely to support a relatively high level of pedestrian activity.

Pedestrian Facility: A facility provided for the benefit of pedestrian travel, including walkways, crosswalks, signs, signals and benches.

Pedestrian Scale: Site and building design elements that are oriented to the pedestrian and are dimensionally less than those sites designed to accommodate automobile traffic.

Right-Of-Way (ROW): A general term denoting publicly-owned land or property upon which public facilities and infrastructure is placed.

Shared Roadway: A type of bikeway where bicyclists and motor vehicles share a travel lane.
Sight Distance: The distance a person can see along an unobstructed line of site.

Traffic Control Devices: Signs, signals or other fixtures placed on or adjacent to a travel way that regulates, warns or guides traffic. Can be either permanent or temporary.

Transportation Analysis Zone (TAZ): A geographic sub-area used to assess travel demands using a travel demand forecasting model. Often defined by the transportation network and US Census blocks.

Transportation Disadvantaged: Individuals who have difficulty obtaining transportation because of their age, income, physical or mental disability.

Transportation System Plan: Is a comprehensive plan that is developed to provide a coordinated, seamless integration of continuity between modes at the local level as well as integration with the regional transportation system.

Urban Area: The area immediately surrounding an incorporated city or rural community that is urban in character, regardless of size.

Transportation Survey

Richland TRANSPORTATION PLAN SURVEY

Please take a few minutes to complete this City of Richland survey on transportation issues. City Council will consider the results in finalizing the Citywide Transportation Plan. You may return this survey with your utility payment or mail it separately to City of Richland, P.O. Box 190 MS 26, Richland, WA 99352. Please return the survey by June 4, 2004. If you have questions about this survey, please call 942-7492.

Vehicular Improvement Projects

Downtown Couplet: A couplet is a pair of adjacent, one-way streets that allow traffic to flow in opposite directions. Because one-way streets are inherently more efficient, improved traffic flow can be accommodated with fewer lanes of travel. Between the Jadwin Avenue/George Washington Way intersection and Williams Boulevard, the City Council is considering converting George Washington Way to a one-way northbound street and Jadwin Avenue to a one-way southbound street to form a couplet. Both streets would accommodate three travel lanes plus on-street parallel parking. This couplet would likely improve traffic flow, improve pedestrian movements by creating narrower streets to cross and provide for additional on-street parking and landscaping. Some negative consequences experienced by some communities that have converted to couplets are a tendency for drivers to increase speeds and potential loss of business due to the shift in traffic patterns.

The following questions relate to the Downtown Couplet proposal. Please circle your answers.

1. Do you consider traffic flow in the downtown area to be a problem? Yes No

   Yes 811 (41.7%) No 1045 (53.7%) N/A 91 (4.7%)

   Total 1947

2. Does the City of Richland need to improve safety for pedestrians and bicyclists in the downtown area? Yes No

   Yes 742 (38.1%) No 1034 (53.1%) N/A 171 (8.8%)

   Total 1947

3. Is more parking needed in the downtown area? Yes No

   Yes 718 (36.9%) No 1072 (55.1%) N/A 157 (8.1%)

   Total 1947

4. Do you support the idea of improving traffic flow, pedestrian access and parking through the use of a couplet on George Washington Way and Jadwin Avenue? Yes No

   Yes 629 (32.3%) No 1184 (60.8%) N/A 134 (6.9%)

   Total 1947

5. Would you be less likely to visit a business located on a one-way street? Yes No

Yes	**1009**	**(51.8%)**	**No**	**840**	**(43.1%)**	**N/A**	**98**	**(5.0%)**
Total	**1947**							

Duportail Bridge: The City of Richland is considering the construction of a bridge over the Yakima River that would connect Duportail Street near the SR-240 By-Pass to Duportail Street in front of Wal-Mart in South Richland. A review of bridge performance shows that it would relieve congestion at the Queensgate Interchange on Interstate 182 and at the Aaron Drive/SR-240 By-Pass intersection. It would also provide for improved emergency service response times. The primary negative consequence would be increased traffic through the residential area on Duportail Street between Thayer Drive and SR-240. Cost for the project would be about $13 million, much of which might come from state and federal sources.

Do you believe the City of Richland should pursue this as a priority project? Yes No

Yes	**1150**	**(59.1%)**	**No**	**698**	**(35.9%)**	**N/A**	**99**	**(5.1%)**
Total	**1947**							

(Please complete questions on reverse side)

Pedestrian Improvement Projects: Provided below is a list of pedestrian projects that were developed in the Citywide Transportation Plan. Please rank the projects from 1 (high) to 6 (low) in the order of importance you think the City should construct them.

3.3 Sidewalk on east side of George Washington Way from Columbia Point Drive to Bradley Avenue

3.6 Sidewalk on south side of Williams Boulevard between Thayer Drive and Wright Avenue

4.1 Pathway along Stevens Drive from Spengler Street to Horn Rapids Road

3.8 Sidewalk along the east side of Leslie Road from Gage Boulevard to Broadmoor Street

3.7 Sidewalk and/or pathway along Aaron Drive from SR-240 to Adams Street

3.6 Sidewalk on the east side of Wellsian Way from Aaron Drive to Elliot Street

List below any other pedestrian projects you think should be a high priority for Richland.

Comments listed separately

Bicycle Improvement Projects: The City of Richland has very few routes with designated bike lanes. The City's goal is to provide safe and connected bike routes for a variety of users.

Should provisions for bikes be made on George Washington Way and Jadwin Avenue? Yes No

Yes	**442**	**(22.7%)**	**No**	**578**	**(29.7%)**	**N/A**	**927**	**(47.6%)**
Total	**1947**							

Provided below is a list of bicycle projects that were developed in the Citywide Transportation Plan. Please rank the projects from 1 (high) to 5 (low) in the order of importance you think the City should construct them.

3.3 Construct bike lanes on Aaron Drive from Thayer Drive to Adams Street

2.9 Extend the pathway along Keene Road from Queensgate Drive to the west city limits

4.4 Reduce the number of lanes on Lee Boulevard to provide one lane in each direction and stripe for bike lanes

2.9 Widen Columbia Point Drive to provide room for bike lanes from George Washington Way to the Columbia River

2.6 Construct multi-use pathway behind the sound wall along SR-240 from Van Giesen Street to Coast Street

List below any other bike projects you think should be a high priority for Richland.

Comments listed separately

Thank you for completing this City of Richland survey. Please be sure to return it with your utility payment or mail it separately to City of Richland, P.O. Box 190 MS 26, Richland, WA 99352. Please return the survey by June 4, 2004. If you have questions about this survey, please call 942-7492.

Horn Rapids Industrial Development Analysis

DKS Associates

TRANSPORTATION SOLUTIONS

MEMORANDUM

TO:	Steve Stairs, City of Richland
FROM:	Carl Springer, P.E.; Sean Kennedy
DATE:	October 22, 2004
SUBJECT:	Horn Rapids Industrial Park Sensitivity Analysis P/A No. 03081-000

This memo reviews the transportation impacts associated with the anticipated development in the Horn Rapids Industrial Park. Congestion along the SR 240 Bypass and Interstate 182 between the Yakima River and George Washington Way is forecast to reach unacceptable levels by the year 2020, according to the City's Draft Transportation Plan. The purpose of this analysis is to identify how effective changes in the planned employment or aggressive transportation demand management programs might reduce the amount of traffic that can be attributed to the Horn Rapids Industrial Park development, and help mitigate the forecasted severe congestion levels experienced on SR 240 and Interstate 182 by the year 2020.

ANALYSIS

Future transportation conditions were analyzed using the regional transportation model refined during completion of this Transportation Plan. The model assumed 8,300 new employees by 2020 in the Horn Rapids Industrial Park. This represents over 80 percent of the city's planned employment growth. The model also takes into account planned transportation network improvements that are scheduled to take place over the next 20 years, such as the widening of First Street between George Washington Way to Stevens Drive.

The regional transportation demand model was analyzed in order to estimate the number of motor vehicle trips from the Horn Rapids Industrial Park area that travel on SR 240 approaching I-182, where the most severe congestion is expected. These trips were then compared with the total number of trips to determine their respective percentage of traffic along SR 240 and Interstate 182. There are two Transportation Analysis Zones (TAZ) in the transportation model that represent Horn Rapids Industrial Park (TAZ 5 and 6), each of which produced trips that would use the state facilities in question.

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As shown in Table 1, number of vehicle trips generated from the Horn Rapids Industrial Park account for about 600 trips in the PM peak hour. This is approximately 12 percent of the total volume using this section of highway.

Table 1: Horn Rapid Industrial Park trips on I-182 and SR 240

Origin of Trips	Number of PM Peak Hour Trips	Percentage of Total Trips
Horn Rapid Industrial Park	600	12%
Total Traffic	4,900	100%

The Thayer Drive/Aaron Drive/I-182 westbound on ramp intersection is forecasted to be approximately 45% over capacity in the future. Reduction in the Horn Rapids development would not solve the capacity issue faced at this intersection, as the Horn Rapids development accounts for 12% of future traffic at this intersection.

CONCLUSIONS

While reducing employment in the Horn Rapids Area will reduce trips , unacceptable congestion will continue to be expected along the SR 240 Bypass and Interstate 182 for reasons other than employment increases in the Horn Rapids Industrial Park. For example, reducing the employment growth by 50% would only mean a 6% reduction in traffic along SR240 Bypass and Interstate 182, equating to demand approximately 39% above capacity.

Visual Simulations of Proposed Street Projects

Visual Simulations of Proposed Street Projects

SR 240 at Van Giesen Street Single-Point Urban Interchange

Before

After

Comments:

* Additional right-of-way needed on SR 240
* Van Giesen St. goes over SR 240 and RR
* Local circulation/access changed
* Construction staging with live traffic

*** Estimated Cost: $15 to 20 million**

Thayer Road Re-Alignment to Wellsian Drive

Before

After

Comments:

* Additional right-of-way for street extension downhill
* Thayer Road connection to Aaron Drive eliminated
* New traffic signal at Aaron/Wellsian
* New traffic signal at Wellhouse Loop/Wellsian

*** Estimated Cost: $1 to 2 million**

GWW / Jadwin One-Way Couplet

Before

After

Comments:

* GWW one-way northbound
* Jadwin one-way southbound
* Each has 3 travel lanes plus bike lanes
* Curb extensions at key intersections

*** Estimated Cost: $1 to 1.5 million**

Visual Simulations of Proposed Street Projects

Leslie Road Connections to Clearwater Avenue

Before

After

Comments:

* Existing Reata Road connection too close to I-82 ramps.
* New extension of Leslie Road would have grade-separated overcrossing to RR.
* New connection to Clearwater opposite 10th Avenue.

*** Estimated Cost: $4 to 8 million**

Van Giesen Street Conversion to 3-Lanes (GWW to Stevens)

Before

After

Comments:

* No additional right-of-way required
* Landscape median optional
* Adds bike lanes
* Provides access controls/ improves safety

*** Estimated Cost: $ 0.2 to 1 million**

Duportail Extension to Wellsian and Lee

Before

After

Comments:

* Extends Duportail from Thayer to Wellsian
* Parallel connection from Wellsian to Stevens
* Precise alignment requires further study

*** Estimated Cost: $3 to 4 million**