DAVID EVANS
AND ASSOCIATES INC.

MEMORANDUM

DATE:	November 20, 2001
TO:	Kate Deane
FROM:	Jay Lyman, PE
	Mike Baker, PE
	Ryan LeProwse, EIT
SUBJECT:	**Preliminary Traffic Operations of I-5 River Crossing Alternatives**
PROJECT:	PORTLAND VANCOUVER I-5 TRANSPORTATION AND TRADE PARTNERSHIP
PROJECT NO:	ODOT0000-0364
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BACKGROUND

The Portland/Vancouver I-5 Transportation and Trade Partnership Study is considering a number of corridor alternatives to address existing and long-term mobility issues in the I-5 corridor from the I-84 junction in Portland, Oregon to the I-205 junction north of Vancouver, Washington. The alternatives have been conceptually designed and modeled to support preliminary transportation operations analysis with a range of Columbia River bridge crossing variations. In a planning level effort to better understand potential traffic operations associated with each Columbia River bridge crossing alternative, the consultant team developed computer models using the FREQ software tool.

STUDY AREA

The I-5 corridor extends from the I-84 junction in Portland, Oregon to the I-205 junction north of Vancouver, Washington. However, each of the bridge alternatives under consideration involves physical modifications to the freeway only between Columbia Boulevard in Portland and SR 500 in Washington. This shorter corridor area was therefore chosen as the preliminary study area. It is expected that future analysis will consider a longer corridor to fully account for queuing and other traffic operations.

APPROACH

The level of capacity increase across the Columbia River and the manner in which access is balanced across existing and supplemental bridges affect corridor operations. To better understand how a decision to increase Columbia River bridge affects corridor traffic operations, the consultant team analyzed each of the four bridge alternatives currently under consideration. A brief description of each follows:

- **New Four-Lane Supplemental Bridge:** Under this variation, a new four-lane bridge would supplement the existing I-5 Columbia River bridges for a total of 10 lanes of river crossing capacity. The supplemental bridge would operate one general purpose and one HOV lane per direction. Existing Hayden Island access would be moved from the I-5 mainline to the new supplemental bridge, resulting in increased bridge capacity at the existing bridgehead. In addition to Hayden Island, access to/from the supplemental bridge is provided for Mill Plain, Vancouver City Center, and Victory Boulevard. This bridge variation was modeled upon a three through lane corridor.

- **New Six-Lane Supplemental Bridge:** Under this variation, a new six-lane bridge would supplement the existing I-5 Columbia River bridges for a total of 12 lanes of river crossing capacity. The supplemental bridge would operate two general-purpose lanes and one HOV lane per direction. In the northbound direction, traffic would access the new bridge just north of the Marine Drive off-ramp and merge back into the I-5 mainline just north of the SR 14 on-ramp. In the southbound direction, traffic would access the new bridge just north of the Mill Plain on-ramp and merge back into the I-5 mainline just south of the Interstate Avenue off-ramp. Access to/from SR 14 to the new bridge would only be provided for HOV vehicles. Access to Marine Drive, Hayden Island, SR 14, Vancouver City Center, and Mill Plain/4th Plain would be provided via the existing I-5 mainline. This bridge variation was modeled upon a four through lane corridor.

- **New 10-Lane Replacement Bridge:** Under this variation, a new 10-lane bridge would replace the existing I-5 Columbia River Bridges that provide only six lanes of river crossing capacity. The new bridge would operate three general-purpose lanes and one HOV lane for through traffic and one auxiliary ramp lane between Hayden Island and SR 14 per direction. Local access to and from the new bridge would be similar to today's access. This bridge variation was modeled upon a four through lane corridor.

- **New Four-Lane Supplemental Tunnel:** Under this variation, a new four-lane tunnel would supplement the existing I-5 Columbia River bridges for a total of 10 lanes of river crossing capacity. The supplemental tunnel would operate one general purpose and one HOV lane per direction. In the northbound direction, traffic would enter the tunnel just north of the Marine Drive off-ramp and merge back into the I-5 mainline just north of the Mill Plain/4th Plain off-ramp. In the southbound direction, traffic would enter the tunnel just south of the Vancouver City center off-ramp and merge back into the I-5 mainline just south of the Interstate Avenue off-ramp. No intermediate tunnel access would be provided in either direction. This bridge variation was modeled upon a four through lane corridor.

SUMMARY OF FINDINGS

Southbound

- New bridges shift bottleneck to SR 500 (except 10-lane alternative where bottleneck remains at Columbia River)

- With SR 500 bottleneck, two new supplemental lanes (bridge or tunnel) will be adequate.

- If SR 500 bottleneck is addressed, the demand requires 6 SB lanes across Columbia River. Six southbound lanes as modeled may not be optimal configuration, because it does not balance local access trips vs. through trips with demands. Local access between Marine Drive and Mill Plain requires 4-lanes with the remaining 2-lanes for "bypass" or through trips.

Northbound

- For bridge alternatives with four corridor through lanes, the I-5 mainline bridge is a bottleneck for all configurations.

- Under a four-lane supplemental bridge alternative modeled with three corridor through lanes, the I-5 corridor bottleneck occurs at SR 500. If modeled and analyzed under a three through lane corridor, it is expected that the four-lane supplemental tunnel and six-lane supplemental bridge alternatives would also result in an SR 500 bottleneck. Under a 10-lane bridge alternative, the bottleneck remains at the Columbia River.

- Under the six-lane supplemental bridge and four-lane tunnel alternatives, the I-5 mainline corridor lacks adequate capacity to serve local access trips. As a result, the existing bridge operates over capacity while the supplemental bridge/tunnel facilities operate under capacity. The supplemental facilities would be unable to effectively balance local access trips versus through trips with demands.

- The junction where the I-5 mainline and supplemental facility split is expected to operate better under a four-lane tunnel alternative relative to a six-lane supplemental bridge because the I-5 mainline remains three lanes up to the Columbia River with a tunnel versus operating with the equivalent of one to 1.5 lanes under the six-lane supplemental bridge alternative.

Bridge Specific Findings

- The range of potential I-5 Columbia River crossing alternatives would increase current directional river crossing capacity by 60 to 111 percent. Per direction, a 10-lane replacement bridge alternative would provide the least river crossing capacity at approximately 8,500 vehicles per hour (vph) and a six-lane supplemental bridge alternative would provide the greatest river crossing capacity at 11,200 vph.

- The 10-lane replacement bridge alternative provides the least river crossing capacity of all alternatives. Even though it carries 10 lanes between Hayden Island and SR 14, it carries only eight lanes beyond these points.

Each of the other Bridge alternatives provides capacity increases between Columbia Blvd. and the Mill plain/SR 500 vicinity.

- The limited access nature of the new six-lane supplemental bridge limits use to longer distance trips. The concentration of shorter length trips using I-5 will cause the existing I-5 bridge to operate as a bottleneck in the evening peak period. Northbound queues from the I-5 bridge are expected to extend beyond Columbia Boulevard and would affect driver ability to access to the new supplemental bridge. Southbound in the morning peak period, increases in mainline and SR 500 on-ramp traffic will cause the SR 500 on-ramp weave section to operate as a bottleneck. This SR 500 bottleneck will meter downstream traffic flow toward the Columbia River and provide relatively smooth access to the new supplemental bridge. This metering effect will result in the new bridge operating well below capacity.

- The new four-lane supplemental tunnel would experience similar traffic flow characteristics as the six-lane supplemental bridge. However, northbound where the supplemental tunnel splits from the I-5 mainline, the mainline would carry three through lanes to the Columbia River. The six-lane bridge alternative carries the equivalent of one through lane at the split before adding a lane at the Interstate on-ramp. As a result, the duration and intensity of congestion related to queuing from the existing I-5 Bridge should be less under the tunnel alternative relative to a six-lane bridge alternative. Southbound, the tunnel alternative is expected to be more full than the six-lane supplemental bridge alternative relative to capacity.

- The 10-lane replacement bridge would result in corridor traffic flow similar to traffic flow experienced today while serving the fewest number of trips. Although bridge capacity would be increased, corridor traffic demands would also increase such that the bridge would operate as a bottleneck southbound during the morning peak period and northbound during the evening peak period. The duration and intensity of congestion associated with a 10-lane bridge would be comparable or perhaps slightly less than levels experienced today based on comparison of demand to capacity ratios across the bridges.

- The four-lane supplemental bridge was designed and modeled assuming a three-lane overall corridor, whereas the other three bridge alternatives were modeled under a four-lane corridor. Traffic demand increases under a four-lane supplemental bridge alternative results in the formation of an SR 500 bottleneck during the morning and evening peak periods. Notwithstanding the SR 500 bottleneck, the existing and supplemental bridges would operate near capacity during morning and evening peak periods.

DISCUSSION OF FINDINGS

Each bridge alternative was evaluated under year 2020 volumes to gain a planning level insight into traffic operations. At this preliminary review level, analysis focused on identifying the following:

- Bottleneck locations (primary and secondary)
- Travel speeds
- On and off-ramp constraints
- Traffic volumes served
- Queuing

The FREQ model analyzes and reports freeway operations directionally. Results reflect peak hour operations only and do not indicate the duration of congestion outside of the peak hour.

Results are preliminary only. They reflect initial operational trends but are subject to refinement upon further review.

New Four-Lane Supplemental Bridge

Northbound

- Increased Columbia River crossing capacity improves corridor accessibility and therefore enables higher traffic demands to be served. Increased demands along the mainline and along SR 500 result in the formation of a bottleneck at the Mill Plain on-ramp to SR 500 off-ramp weave section.
- The bottleneck results in peak hour queues extending near or beyond Victory Boulevard.
- Traffic demands are such that adding one more lane of mainline capacity within the weave section could alleviate the bottleneck. Alternatively, braiding the Mill Plain on-ramp so that it enters the mainline north of SR 500 off-ramp, similar to the 4th Plain on-ramp braid, would eliminate the weave as well as the bottleneck in this location. If this ramp modification was completed, it is expected that a third mainline general purpose lane would be required up to 78th Street to accommodate on-ramp demands from Mill Plain, 4th Plain, 39th Street, and Main Street.
- Removal of the existing Hayden Island interchange from the I-5 mainline to the new supplemental bridge will increase existing mainline bridge capacity to approximately 6000 vehicles per hour (vph).
- Increased demands throughout the corridor cause the existing I-5 bridge and the new four-lane supplemental bridge to operate near capacity.
- Even at increased meter rates relative to today, on-ramps at Interstate Avenue, Marine Drive, and Mill Plain would operate with long delays due to ramp metering. In some cases, queues are expected to spill over onto arterial roadways unless ramp meter rates are increased to serve demand.

Southbound

- Increased demands along the mainline and SR 500 on-ramp result in the formation of a bottleneck at the SR 500 on-ramp to 4th Plain/Mill Plain off-ramp weave section.
- Capacity increases in the SR 500 weave section would move the bottleneck north to the 39th off-ramp vicinity.
- Traffic demands within the SR 500/I-5 junction are high enough that the bottleneck would not be eliminated by simply adding one more lane of mainline capacity to diffuse traffic flow in this area.
- The downstream metering affect of the SR 500 bottleneck eliminates the existing I-5 Columbia River bridge bottleneck and improves the ability of traffic to enter the freeway south of the bottleneck from 4th Plain, Mill Plain, and SR 14.
- Removal of the existing Hayden Island interchange from the I-5 mainline to the new four-lane supplemental bridge will increase existing mainline bridge capacity to approximately 6000 vehicles per hour (vph).

- Increased bridge capacity in concert with corridor ramp metering and an upstream bottleneck at the SR 500 weave section should allow the existing I-5 Columbia River bridge and the new four-lane supplemental bridge to operate under capacity.
- The SR 14 on-ramp would operate over capacity with long delays due to ramp metering. The SR 500 on-ramp, although not modeled under ramp meter control, is expected to experience long queues and associated delays.

New 6-Lane Supplemental Bridge

Northbound

- The new 6-Lane supplemental bridge is estimated to operate under capacity. This is largely due to its limited access. For example, trips originating in downtown Portland with destinations south of SR 500 in Vancouver will not be able to use the new supplemental bridge.
- The concentration of I-5 mainline traffic traveling across the Columbia River with destinations south of SR 500 would cause the existing I-5 Columbia River bridge to operate over capacity. Northbound queues would be expected to extend beyond Columbia Boulevard and limit the ability of traffic to access the new supplemental bridge.
- To accommodate merging of the two bridges back into the mainline near SR 14, the existing I-5 mainline will taper to two travel lanes before the SR 14 on-ramp. As a result, this stretch of freeway is shown to operate near capacity.
- The I-5 lane drop from six to five lanes just south of the SR 500 off-ramp is shown to operate near capacity.
- On-ramps at Interstate Avenue, Marine Drive, Hayden Island, and Mill Plain would operate with long delays due to ramp metering. In some cases, queues would be expected to spill over onto arterial roadways unless ramp meter rates were increased to serve demand.

Southbound

- The SR 500 on-ramp to Mill Plain off-ramp weave section operates as a bottleneck.
- Capacity increases in the SR 500 weave section without associated upstream ramp metering to reduce mainline flow would move the bottleneck north to the 4^{th} Plain off-ramp vicinity.
- Tighter ramp metering control north of 39^{th} Street may eliminate bottlenecks between 39^{th} Street and the Columbia River.
- The new 6-Lane supplemental Bridge is estimated to operate under capacity. This is largely due to its limited access. For example, trips originating in north Clark County with destinations in Oregon north of Columbia Boulevard will not be able to use the new bridge.
- Diversion of traffic to the new supplemental bridge, plus the metering effect of the SR 500 weave section bottleneck are shown to allow the existing I-5 bridge to operate under but near capacity.
- The merge point of the new bridge and I-5 mainline is shown to operate acceptably.

- The Mill Plain, and SR 14 on-ramps would operate over capacity with long delays due to ramp metering. The SR 500 on-ramp, although not modeled under ramp meter control, is expected to experience long queues and associated delays.

New 10-Lane Replacement Bridge

Northbound

- General-purpose lanes on the new 10-Lane replacement bridge are shown to operate over capacity. Queues are shown to extend beyond Columbia Boulevard.
- North of the bridge, the mainline is shown to operate acceptably due to the metering effect of the bridge bottleneck.
- If I-5 bridge capacity were increased, latent bottleneck locations would be created between Columbia Boulevard and Hayden Island. The impact of these bottlenecks may or may not eliminate bottlenecks which could form in Washington.
- On-ramps at Interstate Avenue, Marine Drive, Hayden Island, and Mill Plain would operate with long delays due to ramp metering. In some cases, queues would be expected to spill over onto arterial roadways unless ramp meter rates were increased to serve demand.

Southbound

- The new 10-lane replacement bridge operates as a bottleneck with general-purpose demand exceeding capacity. Queues extend beyond 39th Street by the end of the peak hour.
- Traffic demands crossing the Columbia River are high enough that simply adding one more lane of mainline capacity would not eliminate the bottleneck.
- If I-5 bridge capacity were increased, adding additional mainline lanes, the bottleneck would move north to the Mill Plain on-ramp section. Tighter ramp metering at Mill Plain would not eliminate this bottleneck due to high mainline demand. Capacity increases in the Mill Plain on-ramp area would move the bottleneck north to the SR 500 on-ramp to Mill Plain off-ramp weave section.
- The I-5 mainline is shown to operate near capacity between the Columbia River and the Marine Drive off-ramp even with the metering effect of the new I-5 bridge bottleneck.
- The Mill Plain, and SR 14 on-ramps would operate over capacity with long delays due to ramp metering. The SR 500 on-ramp, although not modeled under ramp meter control, is expected to experience long queues and associated delays.

New 4-Lane Supplemental Tunnel

Northbound

- As a limited access facility, the new 4-Lane supplemental tunnel is shown to operate under capacity. For trips originating in downtown Portland, the tunnel serves only traffic with destinations north of Mill Plain.

- The concentration of I-5 mainline traffic traveling across the Columbia River with destinations south of SR 500 would cause the existing I-5 Columbia River bridge to operate over capacity. Northbound queues are shown to extend near or beyond Columbia Boulevard and may hinder access to the tunnel.
- North of the existing bridge, the mainline is shown to operate near capacity at certain locations including the lane drop south of SR 500.
- If I-5 bridge capacity were increased, latent bottleneck locations would be created between Columbia Boulevard and Hayden Island. The impact of these bottlenecks may or may not eliminate bottlenecks which could form in Washington.
- On-ramps at Interstate Avenue, Marine Drive, Hayden Island, and Mill Plain would operate with long delays due to ramp metering. In some cases, queues would be expected to spill over onto arterial roadways unless ramp meter rates were increased to serve demand.

Southbound

- The SR 500 on-ramp to Mill Plain off-ramp weave section operates as a bottleneck.
- Capacity increases in the SR 500 weave section without associated upstream ramp metering to reduce mainline flow would move the bottleneck north to the 4th Plain off-ramp vicinity.
- Tighter ramp metering control north of 39th Street may eliminate bottlenecks between 39th Street and the Columbia River.
- Total traffic demand approaching the Columbia River exceeds river crossing capacity. However, presence of an upstream bottleneck at SR 500 and the effect of ramp metering allow the Columbia River bridges to operate slightly below capacity.
- As designed, this alternative would not serve corridor travel demand across the Columbia River if upstream bottlenecks were eliminated.
- The Mill Plain, and SR 14 on-ramps would operate over capacity with long delays due to ramp metering. The SR 500 on-ramp, although not modeled under ramp meter control, is expected to experience long queues and associated delays.

SUMMARY

The following tables compare some key corridor performance indicators among the various bridge alternatives. Unconstrained demand across the river reflects the raw demand seeking to cross the Columbia River during the peak hour. The service flow reflects actual traffic demand served accounting for congestion relating to bottlenecks and ramp metering. The average corridor speed reflects peak hour operations between Columbia Boulevard and a location just north of 39th Street.

PRELIMINARY NORTHBOUND BRIDGE OPERATIONS SUMMARY							
	Unconstrained Demand Across Col. River		**Constrained Service Flow Across Col. R.**		**River Crossing Capacity**		**Average Corridor**
Alternative	**Mainline/ Supplemental**	**Total**	**Mainline/ Supplemental**	**Total**	**Mainline/ Supplemental**	**Total**	**Speed[1]**
4-Lane Bridge	5900/3400	9300	5500/3300	8800	6000/3400	9400	32.3
6-Lane Bridge	8450/3350	11800	5300/3350	8650	5300/5900	11200	42.0
10-Lane Bridge	11800/0	11800	8200/0	8200	8500/0	8500[2]	37.1
4-lane tunnel	9150/2650	11800	5300/2650	7950	5300/3700	9000	28.3

1. Mainline speed only.
2. GP lanes running over capacity but HOV lanes under capacity.

Source: FREQ model developed by DEA.. Volumes generated by Metro and adjusted by DEA.

PRELIMINARY SOUTHBOUND BRIDGE OPERATIONS SUMMARY							
	Unconstrained Demand Across Col. River		**Constrained Service Flow Across Col. R.**		**River Crossing Capacity**		**Average Corridor**
Alternative	**Mainline/ Supplemental**	**Total**	**Mainline/ Supplemental**	**Total**	**Mainline/ Supplemental**	**Total**	**Speed[1]**
4-Lane Bridge	6000/3250	9250	5200/2800	8000	6000/3300	9300	43.0
6-Lane Bridge	5700/5100	10800	4900/4500	9400	5300/5900	11200	42.6
10-Lane Bridge	10800/0	10800	8400/0	8400	8500/0	8500[2]	28.9
4-lane tunnel	6500/4300	10800	4950/3550	8480	5300/3700	9000	42.0

1. Mainline speed only.
2. GP lanes running over capacity but HOV lanes under capacity.

Source: FREQ model developed by DEA.. Volumes generated by Metro and adjusted by DEA.

Initials: MJBA

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