EXECUTIVE SUMMARY

The primary goal of the Bridgehead Engineering Study is to devise, test, evaluate, and report on possible solutions (operational and/or physical improvements) to improve traffic conditions and prolong acceptable levels of service for traffic using the Marion Street and Center Street Bridges. In achieving this goal, the study focuses on the bridge ramps and other streets and facilities within the study area.

A secondary goal of the study is to accurately identify and quantify the maximum volume of peak hour traffic that can be accommodated in each direction on the existing bridges and on the bridges after implementing any of the "possible solutions." Determining these maximum volumes helps planners, policy makers, and the public understand the need for reducing or shifting travel demand, the need for implementing one or more of the possible solutions evaluated in this study, and/or the need for an alternative river crossing.

Two groups were formed to review the study results: a Project Steering Group, consisting of engineers and planners from ODOT, City of Salem, Mid-Willamette Valley Council of Governments, and Salem Area Transit District; and an 18 member Citizens Advisory Committee, representing business and community interests.

A consultant team was selected to study possible improvements for the bridges, determine their effectiveness for improvement traffic flow over the bridges, and develop a recommended set of improvements with cost estimates. The consultant team produced six reports:

1. Reconnaissance Report of the Study Area
2. Related Planning Studies
3. Task 1 Report - Data Collection
4. Task 2 Report - Capacity Analysis of the Existing System
5. Task 3 Report - Possible Solutions
6. Task 4 Report - Microscopic Simulation Analysis of "Most Promising" Possible Solutions

The study began in September 1997, with the consultant's field reconnaissance of the study area. The consultant prepared a **Reconnaissance Report** (January 1998) containing initial observation of problems at specific intersections with the study area, along with a qualitative discussion of the benefits and limitations of potential solutions.

The information in this report was used as a starting point for identifying and analyzing possible solutions in the Task 3 report.

Data collection for the study (detailed in the **Task 1** report) included traffic counts, accident counts, a sign inventory, and videos of traffic flows across both bridges. For locations where historical data were not available, new turning movement traffic counts were conducted in September 1997, for the three hours in the morning and three hours in the afternoon.

The A.M.-peak hour traffic flow period occurred between 7:15 a.m. and 8:15 a.m., and the P.M.-peak hour between 4:40 p.m. and 5:40 p.m. The peak hours were used to establish the time to collect origin/destination data and to evaluate intersection and system traffic operations.

A unique Origin-Destination (O/D) study was conducted to collected detail information on traffic patterns, travel times, and weaving across the two bridges. Video cameras in helicopters were used to record O/D information during the P.M.-peak hour. Ground-based video cameras were used to record the entry and exit points of vehicles crossing the bridges during the A.M.-peak hour.

Lane changes, a component of weaving, have a negative effect on capacity. Making a lane change requires a motorist to find a gap in an adjacent lane. Under congested conditions, a motorist may even stop in a lane and wait for someone to let him in. Lane changes, therefore, reduce capacity since traffic typically must slow down, especially under congested conditions. Results of the lane change analysis are shown in below.

- Approximately 60 percent of the vehicles entering the study area during either peak hour make at least one lane change to reach their destination.
- More lane changes occur on the Marion Street Bridge (65 percent) than on the Center Street Bridge (57 percent).
- Combining both peak hours results in the following lane change distribution:

Number of Lane Changes	Marion Street Bridge	Center Street Bridge
0	35%	43%
1	36%	42%
2	21%	11%

3	8%	4%

Before the O/D data was collected, there was some question about whether eastbound Highway 22 traffic was selecting the most appropriate lane to continue either northbound or southbound on Front Street. Ideally, eastbound Highway 22 traffic wanting to continue northbound on Front Street should use the inside (left) lane. Similarly, Highway 22 traffic desiring to continue southbound on Front Street should use the outside (right) lane. Weaving maneuvers and lane changes are reduced if motorists select the appropriate lane. Results indicate that approximately 15 to 16 percent (51 to 64 vehicles/hour) of the Highway 22 traffic destined for northbound Front Street choose an inappropriate lane. Approximately four to five percent (15 to 35 vehicles/hour) of the Highway 22 traffic destined for southbound Front Street choose the wrong lane. Based on this information, it was concluded that most drivers do select the appropriate lane on Highway 22 and that the "braid" design on the west end of Center Street bridge does operate effectively, although a change to the signs further west of the Center St. bridge may be needed.

ODOT supplied collision data for the Willamette River Bridges on State Highway 22 and all study area intersections. The accident search covers five years and four months from January 1, 1992 to April 30, 1997. As shown in Table E-1, 74 of the total 80 accidents occured either on the Center Street bridge or one of the Center Street bridge exit ramps to Front Street bypass, and only six accidents were on the Marion Street bridge. Accidents were not reported on the section where the Wallace Road entrance ramp joins Highway 22 or on the entrance ramp from Front Street. The Task 1 report also gives accident rates for the other intersections within the study area, with the Center @ Liberty and Commercial @ Trade intersections having the highest accident rates. The intersection of State St. and Front St. bypass had a relatively lower accident rate.

Table E-1. Accident Summary for Willamette River Bridges and Ramps[1]

Location	**Accident Type**			
	Sideswipe	**Rear-End**	**Fixed Object**	**Total**
Marion St. Bridge				
Wallace Rd. – Bridge center	2	1		3
Bridge center – Commercial St.		3		3
Subtotal	2	4		6
Center St. Bridge				
Wallace Rd. – Bridge center	4	1	2	7
Bridge center – SB Front St exit ramp.	3	18		21

SB Front St. exit ramp – NB Front St. exit ramp	1	8	1	10
Subtotal	8	27	3	38
Exit ramp to SB Front St.		4		4
Exit ramp to NB Front St.		32		32
Total	**10**	**67**	**3**	**80**

1Accident search period covered January 1, 1992 through April 30, 1997.

Following the data collection task, the **Task 2 Report** conducted an analysis of the Level of Service (LOS) for individual intersections. The software program used to calculate the intersection degree of saturation and LOS was ODOT's SIGCAP. For intersections with actuated signals, the consultant used SIGCAP to determine LOS for intersections both with and without pedestrian present at each signal cycle. At the lower end of the range is the LOS assuming no pedestrians during the peak hour. At the upper end is the LOS when pedestrians are assumed to be present each cycle. It is within this range that the true LOS lies for intersections with pedestrian push-buttons. The following list shows intersections where either the A.M. or P.M. has a LOS of D-E (corresponding to a saturation of 86-89%) or higher.

- Wallace Road at Orchard Heights Road, A.M. (LOS F) and P.M. (LOS F)
- Wallace Road at Glen Creek Road
  - without pedestrians, A.M. (LOS D-E) and P.M. (LOS E)
  - with pedestrians every cycle, A.M. (LOS F) and P.M. (LOS F)
- Wallace Road at Edgewater Road
  - without pedestrians, A.M. (LOS E)
  - with pedestrians every cycle, A.M. (LOS E)
- Front Street at Center Street Bridge Northbound Exit Ramp, A.M. (LOS F) and P.M. (LOS F)
- Front Street at Court Street
  - without pedestrians, A.M. (LOS D-E)
  - with pedestrians every cycle, A.M. (LOS E-F)

The Task 2 report also evaluated intersection operations within a coordinated system, using TRANSYT-7F software and basing LOS on intersection delay. This allows the analysis to consider the impact that progression has on individual intersection operations. In general, critical intersections identified in the isolated intersection analysis are the same as those identified in the signal system analysis (refer to Table E-2).

Table E-2. Critical Intersections[1]

Isolated Intersection Analysis	Signal System Analysis
Wallace Rd. at Orchard Heights Rd.	Not signalized
Wallace Rd. at Glen Creek Rd.	Wallace Rd. at Glen Creek Rd.
Wallace Rd. at Edgewater St.	Wallace Rd. at Edgewater St.
Front St. at Center St. Bridge NB Exit Ramp	Not signalized
Front St. at Court St.	Front St. at Court St.

1 Critical intersections are: (1) signalized intersections in the isolated analysis exceeding LOS D-E; (2) stop controlled intersections exceeding LOS D; (3) signalized intersections in the signal system analysis exceeding LOS D; and (4) any intersection not exceeding LOS D in the signal system analysis, but had at least one individual movement operating at LOS F.

Additional findings in the isolated intersection and signal system analyses are highlighted below:

- Current signal timings for the most part appear to be optimal. Adjusting the signal timings does not appear to improve LOS. LOS improvements need to be addressed through either geometric modifications or reduced traffic volumes (i.e., travel demand management strategies).
- Intersection LOS degraded when pedestrians were considered.
- Evaluating intersection operations with and without pedestrians usually resulted in only one letter change in LOS (e.g., LOS B to LOS C). In a few cases, however, the LOS changed by two letters.
- Progression exists, for the most part, on all major roadways within the study area. Minor streets typically have progression through a few signals with progression terminating at higher volume intersecting streets.
- Currently, only Glen Creek Road and 7th Street are coordinated on Wallace Road. With the future installation of a signal at Orchard Heights Road and relocation of the 7th Street signal, consideration should be given to coordinating all signals along Wallace Road.

Lastly, the Task 2 report did a quantitative analysis to determine which intersections were the most and least critical to overall bridge capacity. Table E-3 shows the ranking of critical intersections, from most to least critical, for the A.M. and P.M. peak periods.

Table E-3. Ranking of Most Critical Intersections

Rank	A.M. Period	P.M. Period
1	Front St. @ NB Exit Ramp	Front St. @ NB Exit Ramp
2	Front St. @ Court St.	Wallace Rd. @ Glen Creek Rd.
3	Wallace Rd. @ Glen Creek Rd.	Marion St. @ Commercial St.
4	Wallace Rd. @ Edgewater St.	Front St. @ Court St.
5	Wallace Rd. @ 7th St.	Wallace Rd. @ 7th St.
6	Center St. @ Commercial St.	Wallace Rd. @ Edgewater St.
7	Center St. @ Liberty St.	Marion St. @ Liberty St.
8	Marion St. @ Commercial St.	Center St. @ Liberty St.
9	Marion St. @ Liberty St.	Center St. @ Commercial St.

Improvements should first be considered at the most critical intersections; the ones at the top of the A.M.- and P.M.-peak hour lists. The intersection of Front Street and the northbound exit ramp from the Center Street Bridge is the most critical intersection during both time periods. Increasing capacity at this intersection may cause it to drop out of the list of critical intersections. If this were the case, the second intersection would become the most critical intersection. Therefore, the list of critical intersections is a guide to where improvements need to be made first to increase river crossing capacity. As the most critical intersections are improved, river crossing capacity is increased.

The **Task 3 Report** began the process of identifying possible solutions for the critical intersections within the study area. The initial list contained 28 solutions, and included solutions such as new on-ramps and off-ramps, changes to intersections, adding lanes to intersections, widening arterials, changing circulation patterns, and changing traffic control at intersections. Each of these were described and illustrated in the draft Task 3 report and reviewed by the Project Steering Group and Citizens Advisory Committee. The initial set was pared down to 18 possible solutions that were examined in more detail, including descriptions, qualitative benefits and limitations of the possible solution, and level of service capacity analysis. The consultant team also prepared preliminary cost estimates for all 18 solutions. The objective of this task was to consider all possible solutions that could increase the capacity of the bridgeheads and determine the most promising of these possible solutions for more detail microsimulation analysis in Task 4.

The **Task 4 Report** is an analysis of the remaining nine solutions considered most promising at the end of task 3. These "most promising" solutions were at five locations and, except for area 2, consisted of a lower cost ("minimum build") and higher cost ("maximum build") possible solution at each location (see table E-4).

Table E-4. Minimum Build and Maximum Build Possible Solutions

Area	Location	Minimum build solution	Maximum build solution
1	Center St. Bridge exit ramp @ northbound Front St.	Traffic Signal	Free flow ramp with third northbound lane on Front
2	Commercial St. @ Marion St.	Exclusive double right turn lanes for Commercial St.	Exclusive double right turn lanes for Commercial St.
3	Center St. Bridge exit ramp @ southbound Front/Court	Stepped pedestrian crossing	Remove signal, build bicycle and pedestrian underpass
4	Marion St. bridge exit ramp	Option lane for Wallace ramp	New ramp from Marion bridge to Glen Creek
5	Wallace Rd./Edgewater	Double lanes for Edgewater on-ramp and off-ramp	Round-about

To analysis these possible solutions, the consultant used a microsimulation model and combined solutions into five scenarios. Briefly described, a microsimulation model attempts to replicate actual study area traffic conditions, by modeling individual vehicles (cars and trucks) each with their individual origin and destination, travel speed, and driver aggressiveness. In addition, detailed street and intersection geometries are used as well as the signal timing, pedestrian crossing, and signal progression found in the study area. The traffic count and O/D study information was used to create the traffic volumes and traffic patterns in the model. The net result is a model that fairly accurately mimics actual conditions found in the study area, and can be used to test combinations of possible solutions at existing and future traffic volumes. Future traffic volumes came from the SKATS 2015 transportation model.

Further analysis of the possible solutions, including some initial microsimulation modeling, demonstrated that three of the nine remaining possible solutions had less benefits than originally conceived.

- Area 3 - The stepped pedestrian intersection at Front and Court Street would significantly improve traffic flow, but instead of the current average pedestrian crossing time of 91 seconds (an average wait of 57 seconds plus 34 seconds to cross), the crossing time (wait plus actual crossing) would between 117 seconds and 203 seconds. This added delay for pedestrians, plus the fact that pedestrians would be waiting on the center median for up to 100 seconds, was unacceptable to the Citizens Advisory Committee.

- Area 4 - The minimum build possible solution was converting one of the lanes on the Marion St. bridge to an option lane, i.e. vehicles could either continue on that lane to eastbound Highway 22 or use that lane to exit to Wallace Road and Edgewater St. The exit ramp would be widened to provide enough clearance for this option lane. It was hoped that this would decrease weaving on the Marion St. bridge, as vehicles coming from Front St. would only have one lane to change to exit to Wallace or Edgewater. During the microsimulation modeling, this option was shown to create additional weaving on the exit ramp itself. In addition, the estimated cost of $1 million to widen the exit ramp was a factor in eliminating this possible solution.

- Area 5 - The roundabout possible solution for the Edgewater Street and Wallace Road intersection was examined by the consultant but eventually dropped from the analysis. A typical 4-legged intersection has 12 turning movements (right, through, and left from each approach); a roundabout was considered at this location because there are only 5 turning movements at Wallace and Edgewater. Although roundabouts are common in Europe, there aren't many examples in the United States that can be used to calculate their capacity characteristics, especially of two lane roundabouts. The consultant attempted to model a roundabout at this location, but concluded that it was unclear whether or not it improved traffic flow. In addition, ODOT is presently preparing design guidelines for roundabouts with the intention of implementing and testing roundabouts in the near future, and were concerned that a roundabout at this location, if unsuccessful, would set a poor precedent for future roundabout projects.

The consultant prepared simulation models for 1997 No Build, 2015 No Build (which includes any planned projects, such as the improvements to the Glen Creek/Wallace Rd. intersection and moving the traffic signal from 7th/Wallace to

6th/Wallace), and five "options" with combinations of six remaining possible solutions at year 2015 volumes. As shown in Table E-5, Option 1 contained the remaining possible solutions for areas 2, 3, and 5. These solutions were tentatively approved by the CAC and Project Steering Group in August. Options 2 to 5 built upon Option 1 by adding either the minimum or maximum solution for area 1 (traffic signal or free flow ramp, respectively), and the maximum solution for area 4 (new exit ramp from Marion St. bridge to Glen Creek Road.)

Table E-5. Summary of Scenario Improvements

Area	Improvement	1997 No Build	2015 No Build	Option				
--				1	2	3	4	5
--	Signal @ Wallace/Orchard Heights	X	X	X	X	X	X	X
--	Median on Front @ Court	X	X					
--	Signal @ Wallace/7th relocated		X	X	X	X	X	X
--	Wallace Rd. signal coordination		X	X	X	X	X	X
--	Extra turn lanes @ Wallace/Glen Creek		X	X	X	X	X	X
2	Dual right @ Commercial/Marion			X	X	X	X	X
3	Pedestrian underpass @ Court/Front			X	X	X	X	X
5	Dual Lanes @ Edgewater/Wallace			X	X	X	X	X
1	Traffic Signal @ exit ramp to northbound Front				X		X	
1	Free flow 3rd lane @ exit ramp to northbound Front					X		X
4	New westbound ramp from Marion Bridge to Glen Creek						X	X

The Task 4 report used travel time as the primarily measure of effectiveness (MOE) for comparing the five options to each other and the no build option. To compare travel times, seven routes (4 westbound, 3 eastbound) across the bridges were selected (e.g. from Glen Creek west of Wallace Road to Commercial St. north of Division). A.M. peak and P.M. peak travel times for all scenarios were collected using the microsimulation model. Table E-6 shows travel time savings for each of the scenarios, compared to the 2015 No-Build travel times. In general, each of the options (with the exception of Option 1 during the A.M. period) show travel time savings over the 2015 No-Build option, ranging from 1 minute to almost 5 minutes.

Table E-6. Network Travel Time Savings[1] (minutes:seconds)

Peak Period	1997	2015					
	No Build	No Build	Option 1	Option 2	Option 3	Option 4	Option 5
A.M.	1:45[2]	Baseline	-0:07	1:47	1:55	1:47	1:59
P.M.	2:57[2]	Baseline	1:05	2:31	3:05	4:47	4:51

1. All travel time savings values are relative to the 2015 No Build option. A positive time indicates a travel time reduction, "savings". A negative number indicates an increase in travel time.
2. These numbers reflect the travel time difference between the 1997 No Build and the 2015 No Build baseline, i.e. travel time in 2015 A.M. period will be 1:45 longer than in 1997, and 2015 P.M. will be 2:57 longer than in 1997.

The average travel time savings in Table E-6 is somewhat deceptive, as uncongested travel (such as westbound routes in the A.M. period) will see very little travel time savings but congested travel will see substantial time savings. For example, route 6 (starting on southbound Wallace Road north of Glen Creek, traveling east over the Center Street bridge, and heading north on Front Street past Division Street) will see the substantial differences in travel time (Table E-7). In the A.M. peak, Options 2 and 4 (which contain the signal at the end of the Center Street bridge exit ramp to Front Street) show over a three minute travel time reduction from the 2015 No Build, and Options 3 and 5 (inclusive of the free flow exit ramp from Center St. bridge to northbound Front Street) show a four to five minute travel time reduction. In this example, P.M. peak travel times are also substantially reduced. Other routes show substantial travel time reductions, depending on the direction and time of day.

Table E-7. Travel Times for Route 6 (minutes : seconds)

Scenario	A.M. Peak	P.M. Peak
1997 No Build	7:46	6:52
2015 No Build	9:01	9:42
Option One	9:31	10:33
Option Two	5:51	7:36
Option Three	4:32	4:16

Option Four	5:52	6:14
Option Five	4:05	3:58

The final task by the consultant was an analysis for determining the maximum capacity of the bridges with the recommended improvements. A year 2025 model was constructed for the no-build and Option 3 scenario to see if capacity was maximized by 2025. Using the microsimulation model, the consultant reported that the maximum Center Street bridge capacity that includes the Option 3 improvements is approximately 6000 vehicles per hour, which is a 25 to 30 percent increase over the existing capacity.

The maximum Marion Street bridge capacity that includes the Option 3 improvements is approximately 5000 vehicles per hour, which is a 10 percent increase over the existing capacity. The Option 5 improvements, which includes the new exit ramp to Glen Creek Road, would increase the Marion St. bridge capacity to 5900 vehicles per hour, which is a 25 to 30 percent increase over the existing capacity.

CONSULTANT RECOMMENDATIONS

Based on the analysis of the No Build scenario and five Build options, the consultant recommended the improvement projects proposed under Option 3. This includes the following projects:

- **Area 1** - *Front Street (northbound) at Center Street Bridge exit ramp*: Construct a free flow exit ramp that continues as a third northbound lane on Front Street and Commercial Street. In order to accommodate this additional lane, a considerable amount of construction is needed. The most significant construction impact would occur to the Marion Street Bridge. The columns, adjacent to the east side of Front Street, supporting the Marion Street Bridge would need to be relocated to accommodate the additional lane on Front Street. Relocating these columns may require either two or three spans of the Marion Street Bridge to be rebuilt as well as possibly the entrance ramp from Front Street to the Marion Street Bridge. The past bridge widening and critical column relocations has resulted in minimum standard truck turning movements at this location and any improvements would be a significant impact to the structure. Assuming that at least two spans would be reconstructed, construction staging would become a major issue. Also, assuming that at least two lanes would need to remain open on the bridge, a detour bridge would be required. In order to minimize impacts to right-of-way along Front Street between Union Street and Division Street, some shifting of the Front Street alignment and lane reconfiguration will be required. Estimated cost: $4,425,000.

It is further recommended to build a traffic signal at the intersection of the Center Street Bridge exit ramp and northbound Front Street (Estimated cost: $130,000) as an interim, short term solution towards the improvement project proposed above. This traffic signal is predicted to reach level of service F by the year 2012, thus exhibiting a project life of 15 years.

- **Area 2** - *Commercial Street at Marion Street*: Provide two exclusive southbound right turn lanes on southbound Commercial Street. A traffic count found that two-thirds of southbound Commercial St. traffic turn right onto Marion Street bridge. Providing two southbound right turn lanes involves some lane widening and sidewalk improvements along the northwest corner of the intersection. The lane widening is needed to accommodate two trucks making simultaneous right turns from adjacent lanes. Some minor retaining wall improvements will be required as well. Bulbed corners are proposed for the two corners on the south side of the intersection. Estimated cost: $130,000.

- **Area 3** - *Front Street at Court Street*: Construct a pedestrian and bicycle underpass to Riverfront Park beneath Front Street. The proposed solution would provide three structures (two for Front Street and one for the railroad crossing), which would eliminate all conflicts between vehicles and pedestrians crossing Front Street. Slopes along the underpass would be laid back and separation between the structures would be provided to allow for natural light and an "open feeling." A cul-de-sac at the entrance to the underpass from Court Street would allow vehicles to turn around. The ramp grade along the underpass would meet ADA standards. The final underpass grade will be determined by geological features, water table, utility location, and other geometric design features. Estimated cost: $2,465,000.

- **Area 4** - No recommended solution. See discussion below.

- **Area 5** - *Wallace Road at Edgewater Street*: Increase the westbound right turn radius at Wallace Road and Edgewater Street to 250 feet in order to comfortably accommodate traffic speeds up to 25 mph; widen the westbound approach to two lanes; construct two exclusive eastbound right turn lanes; remove the eastbound Edgewater Street to northbound Wallace Road left turn pocket and route vehicles via Murlark Ave. to the relocated signal at 6th Street and Wallace Road. The removal of the left turn phase and the capacity increases to the Edgewater off-ramp and on-ramp will allow adjusting the signal timing to give additional green time for the higher volume southbound Wallace Road traffic. Lane widening will be required along the outer edge of the exit ramp to Wallace Road in order to minimize impacts to the slopes along the embankment for Highway 22 and to provide proper lane alignment with Edgewater Street. A building in the northeast corner where the exit ramp radius is increased will require relocation. Musgrave Lane will also need to be closed. The dual right turn movement from Edgewater Street will require some approach lane widening and retaining wall modification under the Highway 22 grade separation. Estimated cost: $1,325,000.

These projects are expected to significantly improve traffic operations at all critical areas, except for **Area 4** (Marion Street exit to Wallace Road). The study clearly identified the need for an improvement project to alleviate congestion on northbound Wallace Road during the P.M.-peak period. The microsimulation analysis shows that Options 4 and 5 (which both include the new exit ramp from the Marion Street Bridge to Glen Creek Road) result in substantial travel time savings for westbound traffic from downtown Salem to West Salem. However, there were several concerns that ODOT had with this possible solution, including the additional weaving that will likely occur on the Marion Street bridge, the impact of additional traffic to Wallace Marine Park and Glen Creek, environmental impacts to Wallace Marine Park, impacts to the pedestrian facilities on the north side of Marion Street bridge, and the potential of the new north-south collector (Marine Drive NW) to become a bypass facility to Wallace Road. The estimated cost of this new ramp ($5.5 million) was also a factor. In addition, there was the opinion that solution alternatives outside the scope of this study (such as a median on Wallace Road between Edgewater and Glen Creek as well as further access management, a new interchange at Eola Drive and Highway 22, a new bridge north of the existing bridges) have not yet been fully explored.