Monorail Support Structure Cost		
	Concept A	**Concept B**
Mobilization	$ 1,879,755	$ 1,613,278
Guide beam system	$15,707,171	$13,042,401
Emergency walkway	$ 3,090,383	$ 3,090,383
Subtotal	$20,677,311	$17,746,062
Contingency at 30%	$ 6,203,193	$ 5,323819
Total Estimated Cost (2004$)	**$26,880,504**	**$23,069,881**

All costs are in 2004 dollars. Costs do not include Washington State sales tax, engineering and construction management, electrical modifications/temporary services and monorail system installation costs. Costs reported in the previous LRT study included bridge conversion costs only and were in 2001 dollars. Costs for the LRT rail system were not included.

It should be noted that the long-term maintenance requirements for the running surface on the top of the guide beams for the proposed options might be different. It is recommended that a comparison of life-cycle maintenance costs be used as one of the methods to evaluate the feasibility of using one guide beam system over the other.

5. MONORAIL ELEVATED OVER THE CENTRAL MEDIAN

During the course of the monorail conversion study, it was suggested that the feasibility of centralizing and elevating a future monorail system over the I-90 floating bridge should be investigated, as shown in Figure 11. The main purpose for such a study would be to center the dead load of any additional public rapid transit system close to the center of buoyancy of the floating pontoons and also to maintain the existing traveled way for vehicles across Lake Washington.

a. MONORAIL GUIDE BEAM DESIGN

The support structure will consist of an elevated lightweight monorail beam, similar to the Concept A beam designed for the monorail at grade option in Section 4a above. This guide way beam consists of an all steel box-beam with a metalized non-skid surface applied to the top plate of the beam and weighs 1,109 plf.

b. DEAD LOAD ANALYSIS AND FREEBOARD LOSS MITIGATION

A number of options to mitigate the loss of freeboard were identified in the previous LRT study. As the elevated monorail option will maintain traffic flow within the two HOV lanes on the south side of the I-90 Homer Hadley bridge, certain weight mitigation measures (M5 and M12) utilized for the monorail at grade scenario will no longer apply to the elevated monorail. It was determined that the maximum amount of freeboard loss that can be mitigated without the use of auxiliary buoyancy approximately 3.15 inches. Refer to Figure 11 for details. The preferred combinations include the following:

Mitigation Type	***Description***
M3	*Replace the existing concrete barrier along the south edge of the bridge with a steel median barrier.*
M4	*Replace the existing concrete median barrier with a steel median barrier.*
M6	*Remove the existing pontoon gravel ballast.*

The assumed support system for an elevated monorail will consist of the previously detailed light weight guide way beam founded upon a lightweight hammerhead pier. These piers are to be set at 35 feet centers, placed along the central median and centered over the floating pontoon interior wall bulkheads. Initially, concrete hammerhead piers were investigated but it soon became clear that these would be too heavy. Instead, a lighter steel hammerhead configuration consisting of HSS Tubes 30 feet x 30 feet x 5/8-inches was selected. The total dead load for the support structure of the elevated monorail will be approximately 1,898 plf, which is significantly higher than the 1,176 plf for the monorail at grade proposal.

Using this system, it was determined that the maximum allowable dead load of the monorail support system that can be mitigated without the use of auxiliary buoyancy is 931 plf. This is less than the at grade option because it will be necessary to maintain a continuous barrier along the south edge of the floating bridge and it will not be possible to remove any overlay from the HOV lanes as traffic will still be maintained within these areas. So even though the dead load of the system will be located closer to the center of buoyancy of the floating bridge, and will therefore require less trim ballast than for the monorail at-grade scenario, the overall weight mitigation that can be implemented is approximately half of the monorail at-grade scenario.

The result of this investigation was that all loss of bridge pontoon freeboard due to the weight of the monorail support structure could not be completely recovered by utilizing bridge weight mitigation measures. A total freeboard loss of 4.9 inches would be experienced versus a total of 3.15 inches that can be mitigated without the use of auxiliary buoyancy. Therefore, the use of 670 plf additional buoyancy would be required to maintain the existing freeboard conditions. As stated earlier the weight and balance criteria are that all loss of freeboard due to implementation of any design alternative is to be mitigated to a final net loss of zero without the use of auxiliary buoyancy. The elevated monorail scenario does not meet this requirement.

c. Live Load Analysis

The live load analysis is similar to that described in section 4c. A hydrostatic analysis of the floating bridge with the Monorail vehicle live load was performed to determine bridge list, freeboard loss, vertical bending moment and torsion resulting from monorail traffic. The fact that the elevated monorail will be located closer to the floating bridge center of buoyancy will lessen the impact on bridge roll. As concluded previously, live load bridge responses do not create structural performance problems on the floating bridge because they are transitory in nature, but they will need to be reviewed for conformance to monorail train operational requirements.

d. Structural Impacts

Structural impacts due to the hammerhead piers were not investigated since these piers are located directly over the transverse bulkhead walls of the pontoons. For weight calculations it was assumed that the piers extend through the deck and follow the bulkheads down to the bottom slab of the pontoons.

e. Estimated Construction Costs Of Improvements

No construction costs of improvements to the floating bridge for an elevated monorail over the central median were conducted, as this proposed scenario does not meet the criteria that all loss of freeboard due to implementation be mitigated to a final net loss of zero without the use of auxiliary buoyancy. The cost of the proposed light weight rail which is a component of the elevated monorail scenario will be similar to that determined for the Concept A beam detailed previously.

6. VERTICAL CLEARANCE REVIEW

In conjunction with the structural evaluation of the floating bridge, a vertical clearance review was conducted to investigate potential conflicts between a future monorail and existing overhead structures along the I-90 corridor defined between Airport Way South in Seattle and Bellevue Way Southeast in Bellevue. The Hitachi and Bombardier Monorail trains and associated dynamic envelopes were the assumed test vehicles used. Critical cross sections along the corridor were defined and compared to the monorail envelopes to investigate potential conflicts. Several locations along the corridor were identified where conflicts occur. For further information refer to the "Monorail Vertical Clearance Review" located in Appendix D of this report.

7. RECOMMENDATIONS FOR ADDITIONAL WORK

The following additional tasks are recommended to complete the structural feasibility study for converting the Homer Hadley Floating Bridge for monorail use:

- Further optimization of the monorail guide beam system. Additional information regarding the monorail bogey system will be required.