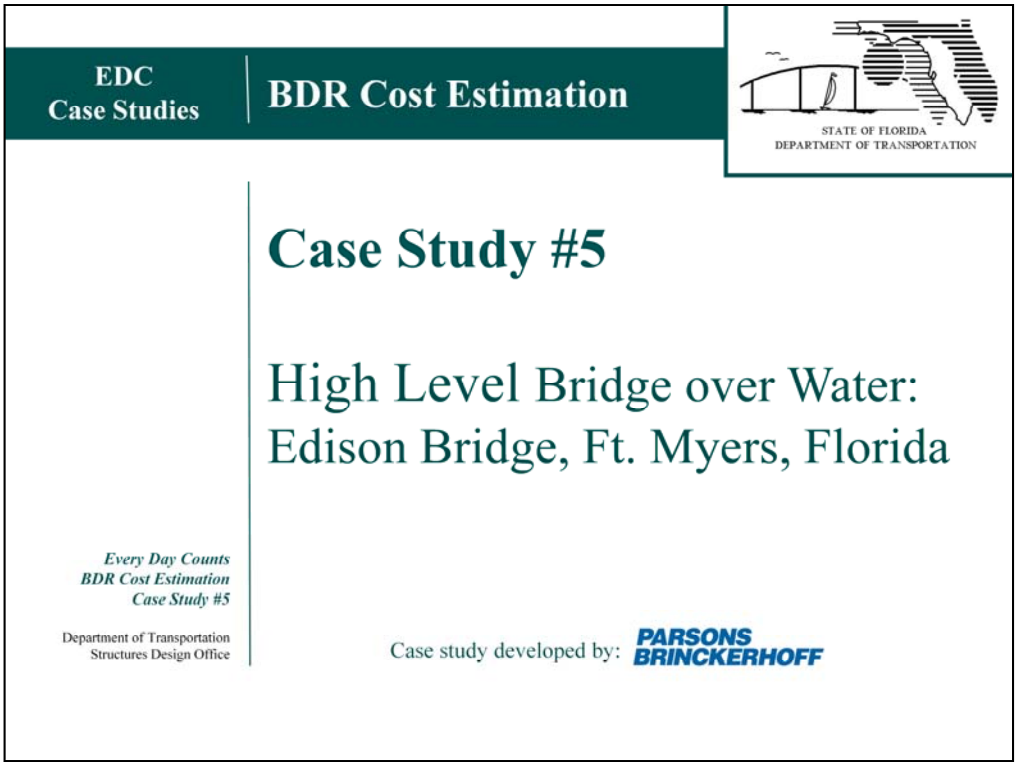
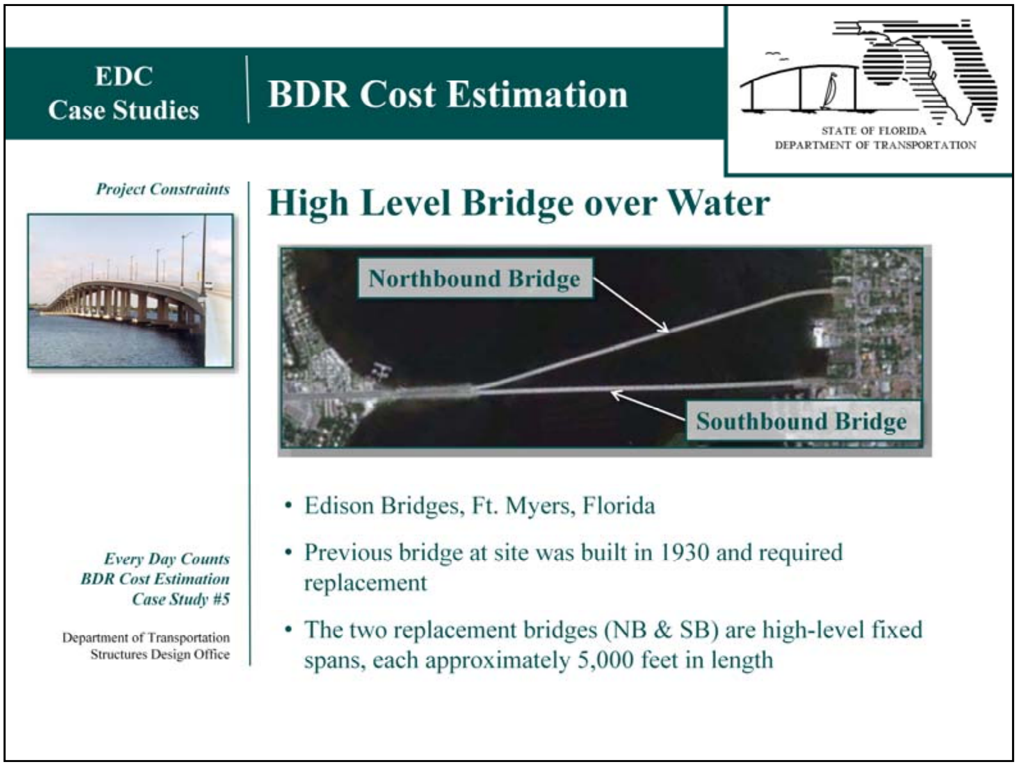


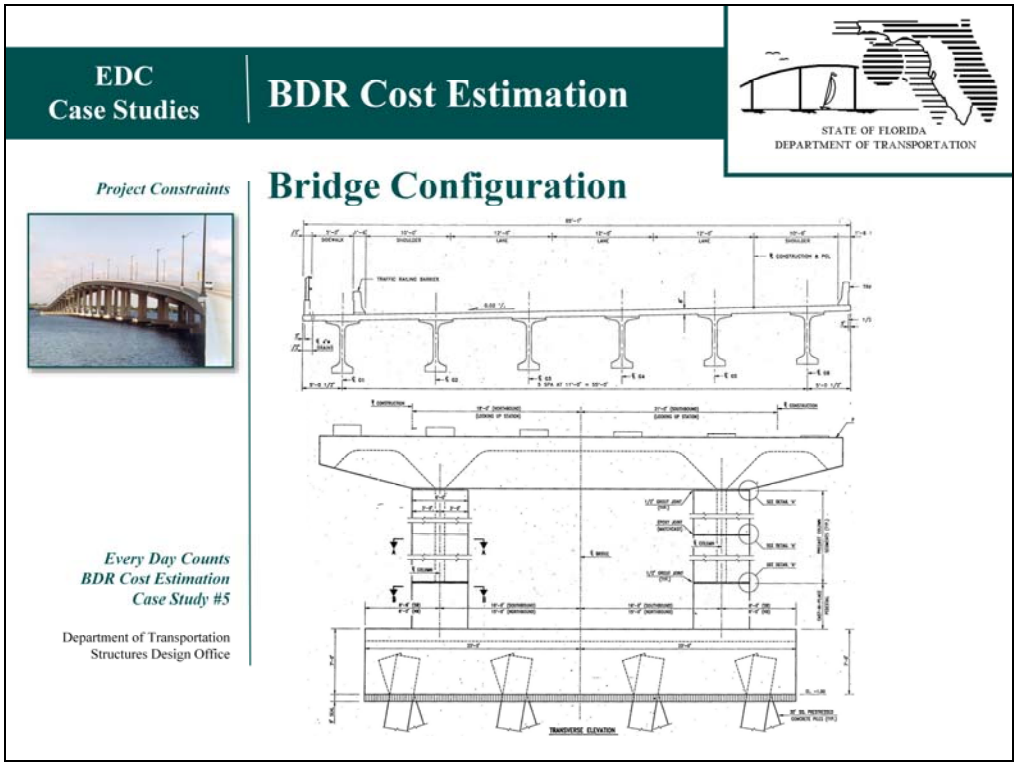
- Case Study #5 will investigate a high level fixed bridge over water. It is somewhat unique, as it analyzes an existing bridge which was constructed in Fort Myers, Florida in 1992 utilizing a precast substructure; however it will be addressed as if it were being constructed in the present.
- The goal of the case study will be to focus on differences in direct costs between conventional and prefabricated bridge construction for a major water crossing.



➢ This aerial view shows the Northbound and Southbound replacement Edison Bridges which cross the Caloosahatchee River in Fort Myers, Florida. The bridges were built in 1992, and serve as a replacement to the low-level two-lane bascule bridge constructed in 1930.

➢ The two replacement structures are high level fixed bridges, each carrying three lanes of traffic, and are both approximately 5,000 feet in length.

➢ The navigation channel requires 90 feet of horizontal clearance, and 55 feet of vertical clearance. Therefore long channel spans were not required, and a typical span length of 143 feet was used throughout.



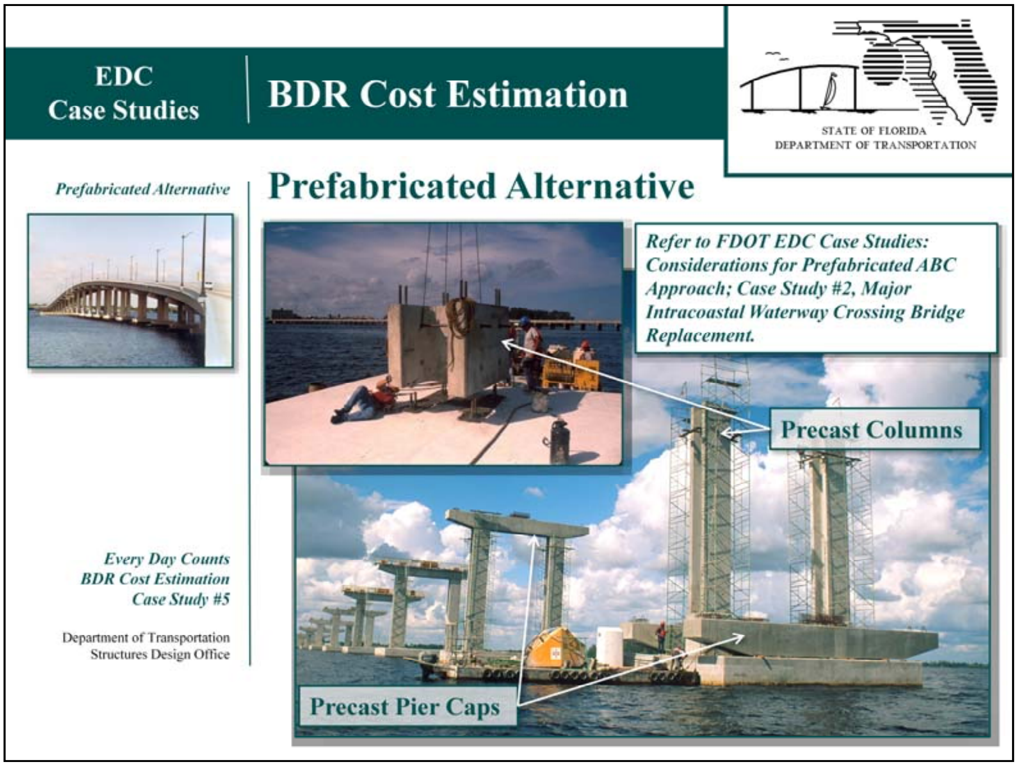
➢ A typical superstructure cross-section along with the pier configuration is shown here.

➢ As stated prior, navigational clearance for the channel did not require a long span, and hence the cross-section is comprised of six 72-inch Florida I-Beams, with a typical span of 143 feet.

➢ For simplicity, this case study assumes that the magnitude of ship impact design load does not require a continuous channel span per the requirement of Structures Design Guidelines 2.11.7.B.

➢ It should be noted that although 72-inch Florida Bulb Tees were used for the superstructure, the case study will assume Florida I-Beams.

➢ The substructure uses elements common to water crossings such as large pre-stressed piles embedded into a pile cap, and a two-column concrete pier configuration.



➢ This case study has an advantage when determining a prefabricated alternative, as the completed construction of the bridge incorporated non-standard prefabricated elements. Due to this, the prefabricated alternative will be discussed first, along with its objectives and advantages, then followed by a comparable conventional construction scenario.

➢ As can be seen in the photos, this bridge utilized precast columns and pier caps. It also used other prefabricated elements such as precast girders and precast piles, however these are considered standard construction practice in the State of Florida, and will not be discussed in detail.

➢ Many of the precast substructure concepts presented in this case study are also discussed in the Case Study Series entitled "Consideration for Prefabricated ABC Approach", Case Study #2. The audience is urged to also view this case study, as it provides a description of bridge elements suitable for prefabrication for high level water crossings.

EDC Case Studies

BDR Cost Estimation

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

Prefabricated Alternative

Every Day Counts
BDR Cost Estimation
Case Study #5

Department of Transportation
Structures Design Office

Prefabricated Alternative

Strategies for Overcoming Project Constraints	
Objective	**Solution**
Capitalize on uniformity and economies of scale	• Repetitive span lengths and details for most spans to ease construction. • Larger bridges afford opportunity to get past a learning curve for uncommon prefabricated components, therefore introduce precast columns and precast pier caps.
Take advantage of deep water access	Barge prefabricated components: • Precast columns • Precast pier caps • Precast girders • Precast piles
Reduce time working from barges	Precast substructure components will significantly reduce time spent working from barges

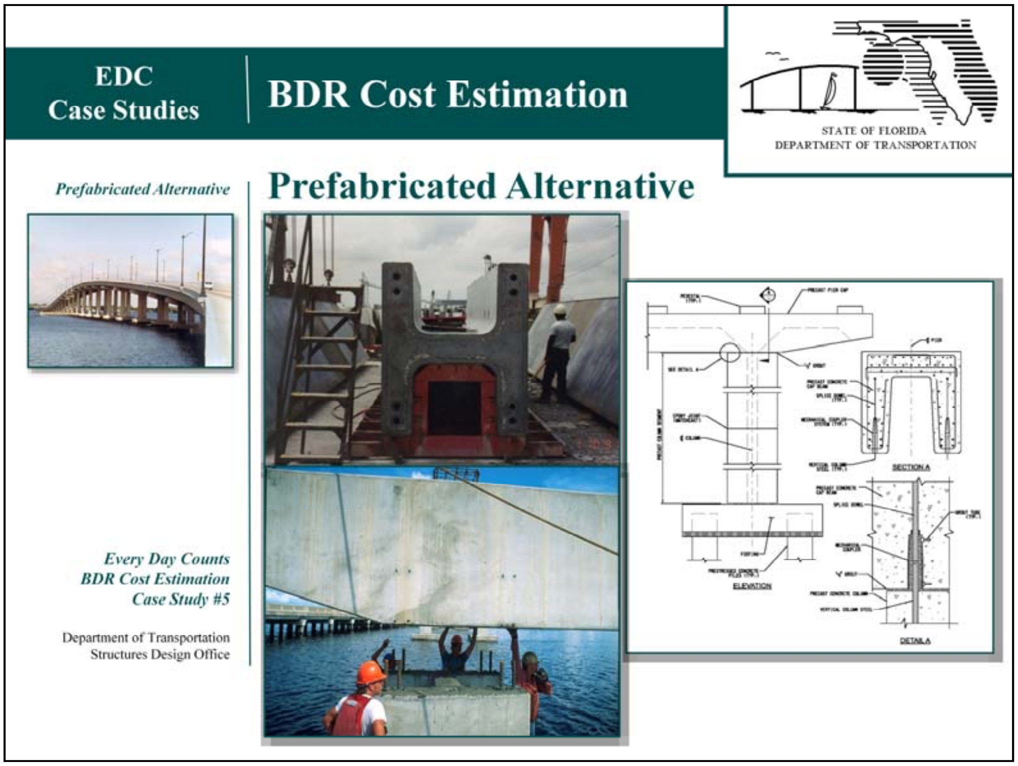
➢ The underlying theme of the prefabricated alternative is to reduce construction duration. For these specific bridges, the decision to incorporate prefabricated elements was made due to a number of factors. This slide presents a few objectives and solutions in support of this:

➢ Due to the scale of a larger bridge, we can capitalize on uniformity and economies of scale. For example, spans can be built with repetitive lengths and similar substructure details incorporated as much as possible. This increases the contractor’s efficiency during construction. Also along these lines, incorporating non-standard prefabricated components requires getting past a learning curve. For small bridges where there is little repetition of components, the use of non-standard details will not be appropriate since optimum production rates cannot be achieved. However for large bridges such as these, each with 35 piers, time associated with moving past an initial learning curve can be minimized.

➢ Second, due to the water depth, prefabricated components can be barged to the site. Since the superstructure girders will be barged and erected by crane, other elements could be easily prefabricated as well; however costs associated with additional crane-erected elements and the corresponding equipment costs will need to be accounted for.

➢ And lastly, although elements can be barged to the site easily, working from a barge increases labor and insurance rates. In spite of this, using the maximum amount of prefabricated components will reduce time spent working from barges, and will assist to keep direct costs down.

➢ For these reasons, precast columns and precast pier caps were chosen to be used on the project.



➢ This slide provides details of the precast columns and pier caps.

➢ The top photograph indicates the shape of the precast columns. The "I-shaped" member was chosen to reduce weight. It was felt this shape would provide economy over a hollow box shape due to simplicity of forming. The original design limited column segments to 15 feet in height to reduce lifting weight, and proposed match casting the column segments. The contractor, however, chose to make each column as one piece, with a maximum column height of 40 feet and a maximum weight of 45 tons.

➢ The connection of the precast columns to the foundation and pier caps was made using a grouted mechanical coupler. Using this technique, up to six columns were erected in a single day. An example of the precast connection is shown in the bottom photo where bars extend from the top of column, and fit into a grouted mechanical coupler recess.

➢ The precast pier cap details are shown in the drawing to the right. An "inverted U-shaped" cross-section was chosen to reduce weight, producing a maximum cap weight of 75 tons. Up to three pier caps were erected in a single day.

➢ The precast pier caps and columns can be erected using the same cranes needed for beam erection since their weights are less than the 78 ton Florida I-Beams.

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STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

Conventional Alternative

Every Day Counts
BDR Cost Estimation
Case Study #5

Department of Transportation
Structures Design Office

Conventional Alternative

	Similarities with Prefabricated Alternative
1	Construction phasing identical
2	Superstructure and substructure quantities identical
3	Superstructure construction identical for each scenario
	Dissimilarities with Prefabricated Alternative
1	Columns and pier caps assumed to be cast-in-place

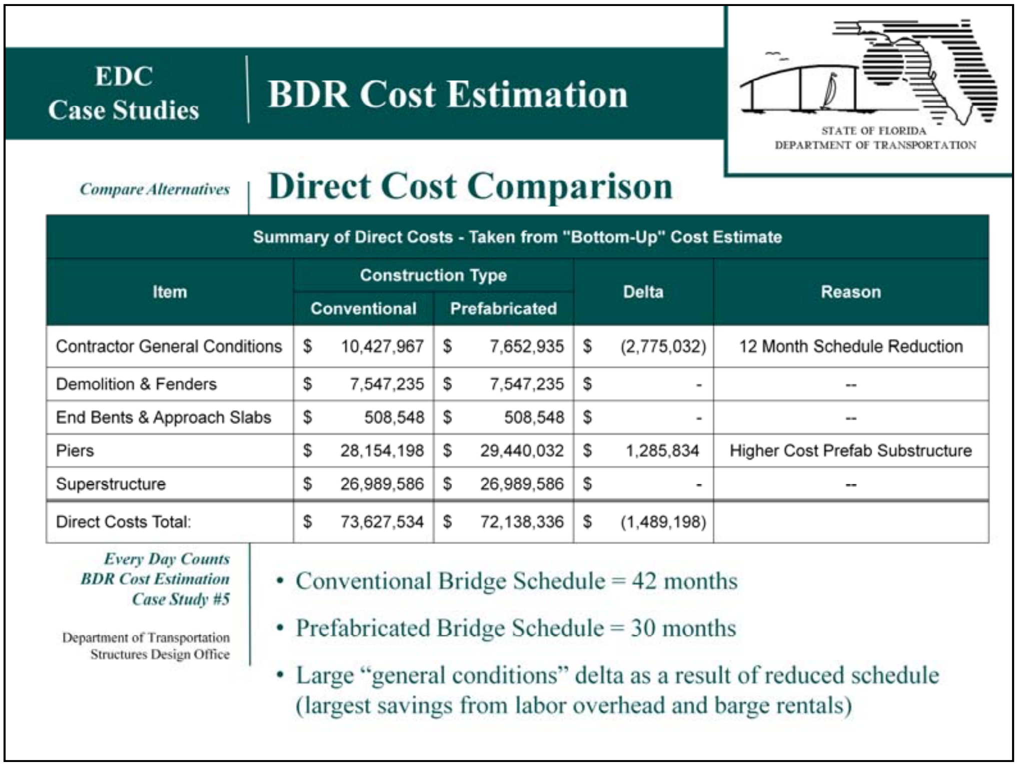
➢ This slide will detail the conventional construction alternative. For comparison with prefabricated construction, the following assumptions will be made:

➢ Construction phasing of the bridges will be identical.

➢ Superstructure and substructure quantities will also be identical. Although cast-in-place columns will be round and the pier caps solid for the conventional alternative, it is assumed the amount of concrete will be approximately equal.

➢ Superstructure construction will be identical for both alternatives, each using precast 72" Florida I-Beams.

➢ The only dissimilarity versus the prefabricated scenario will be using cast-in-place construction for the columns and pier caps.



➢ Direct cost for each alternative has been calculated by a construction estimator. The rightmost columns indicate cost deltas between alternatives, and list the prevailing reason for each difference.

➢ The largest cost difference can be seen in the top row of the table. This represents the contractor's general conditions, and reflects labor associated for permanent employees such as the project manager, the superintendent, and field engineers. It also accounts for field offices, barge rentals and associated insurance premiums, and other overhead items incurred by the contractor. This item is heavily in favor of the prefabricated alternate, and is a direct result of a reduced construction schedule.

➢ The conventional and prefabricated alternative schedules are 42 months and 30 months, respectively. Therefore reducing the schedule by 12 months indicates a $2.8 million dollar cost savings in the contractor's general conditions. This $2.8 million dollar difference is primarily composed of labor and barge rental savings; each constituting approximately half of this number.

➢ The fourth row represents cost associated with pier construction. As expected, costs for prefabricating the columns and column caps are higher versus the conventional option.

➢ Other rows in the table are listed as identical for each option, as there is no difference in construction material or construction method.

➢ Total price of bridge construction is approximately 2% less for the prefabricated alternative, or $1.5 million dollars. This is an interesting conclusion, as prefabricated methods are often perceived as more costly. The comparison indicates that a reduction in schedule can make big strides in overcoming material cost increases.

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BDR Cost Estimation

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

Compare Alternatives

Substructure Comparison

Cast-in-Place vs. Precast Substructure Concrete for Bridge Piers				
Alternative	Labor Cost	Material Cost	Equipment Cost	Total Cost
Conventional	$ 1,787,464	$ 1,172,392	$ 241,282	$ 3,201,138
Prefabricated	$ 690,550	$ 3,594,756	$ 237,390	$ 4,522,696
Delta	$ (1,096,914)	$ 2,422,364	$ (3,892)	**$ 1,321,558**

- **Labor:** base rates, fringes, tax, increased insurance for marine construction
- **Material:** final installed cost for all materials
- **Equipment:** equipment necessary for installation
(note: barge & tug rental included in contractor general conditions)

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BDR Cost Estimation
Case Study #5

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➢ This slide indicates how the cost of the concrete for the pier columns and cap was determined. The item has been divided into labor, material, and equipment costs.

➢ The conventional alternative total represents all costs associated with placing concrete, assembling and dismantling formwork, and the associated increased insurance rates for a marine working environment.

➢ The prefabricated alternative total represents the cost of precasting pieces, loading them onto barges, delivering them to the site and erecting by crane, as well as increased insurance rates for a marine working environment.

➢ It can be noted that there is significant difference in the labor and material costs among the alternatives. This is due to a large shift in labor required for cast-in-place concrete versus precast concrete; as well as the significant increase in purchase price for precast concrete.

➢ Total cost is given in the last two columns of the table, and indicates a $1.3 million dollar increase in substructure cost for the prefabricated alternate.

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Compare Alternatives

BDR Estimating Comparison

Cast-in-Place vs. Precast Substructure Concrete for Bridge Piers			
Alternative	Concrete Quantity (CY)	Unit Cost ($/CY)	Total Cost
Conventional	3,829.6	**$ 836**	$ 3,201,138
Prefabricated	3,829.6	**$ 1,181**	$ 4,522,696
Delta	--	$ 345	**$ 1,321,558**

- Precast substructure $1.3M more
- Contractor schedule reduction of 12 months saved $2.8M
- $1.3M (precast) - $2.8M (schedule) = $1.5M net savings
- **Stresses importance of accounting for schedule savings in estimate**

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➢ Here we present a comparison of the cost of pier concrete again, but provide it in a dollar amount per unit cost basis. When looking at these unit costs, results are not surprising.

➢ The $836 dollar per cubic yard rate for conventionally constructed substructure concrete is at the high end of cost when compared to FDOT's Bridge Development Report Cost Estimating guide. However it is not far out of range. Unit cost for the prefabricated substructure is $1,181 dollars per cubic yard. This is also expected, and is comparable to unit prices for precast segmental concrete.

➢ Although this comparison of unit costs is intuitive, there is a large missing component which has not been considered. Recalling the slide which compared total construction cost, a significant savings in costs for barge rentals and insurance premiums when work is performed over water is realized by a reduced construction schedule for the prefabricated alternate, and was approximately $2.8 million dollars. This savings more than offsets the increase associated with precasting the bridge piers, and exemplifies the importance of accounting for direct costs associated with schedule reduction.

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Compare Alternatives

Cost Summary

Alternative	Direct Costs	Indirect Costs					Direct + Indirect
		Delay in Increasing from 2 to 6 Lanes		Bascule Span Opening Delays		Indirect Costs	
		Days	$/Day	Days	$/Day		
Conventional	$ 73,627,534	365	$ 899	365	$ 9,260	$ 3,708,035	**$ 77,335,569**
Prefabricated	$ 72,138,336						**$ 72,138,336**

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- Conventional alternative has 12 month longer construction schedule
- Two indirect costs for increased construction schedule:
  - 12 month delay in increasing the number of lanes from 2 to 6
  - Additional 12 months of traffic delays for bascule span openings
- **Prefabricated Alternative is $5.2M (7%) less than Conventional**

➢ A summary of the direct and indirect costs are shown here for each alternative.

➢ Direct costs, summarized in the second column, show prefabricated construction as the more economical alternative.

➢ In addition to this, two indirect costs are associated with the 12 month longer construction schedule for the conventional alternative. The first is a result of the conventional alternative taking 12 more months than the prefabricated alternative to increase the number of traffic lanes from 2 to 6. The second results from 12 additional months of traffic delays associated with 8 daily bascule span openings on the existing bridge. Combining these two items produces an indirect cost of $3.7 million dollars.

➢ In summary, the prefabricated alternative has an advantage in both direct and indirect costs, and produces an overall savings of $5.2 million dollars, equating to a 7% lower total cost. Therefore, the use of precast piers for this project is more economical than cast-in-place concrete piers.