



U.S. Department
of Transportation
**Federal Highway
Administration**

U.S. DOT Gulf Coast Study, Phase 2

Engineering Case Study 3: Bridge Approach Embankment Exposure to Sea Level Rise

This is one of 11 engineering case studies conducted under the Gulf Coast, Phase 2 Project. This case study focused on whether the current riprap embankment protection along the US 90/98 Tensaw-Spanish River Bridge approach is sufficient to protect against increased wave impacts from sea level rise.

Description of the Site and Facility

This case study looked at the western approach to a bridge carrying US routes 90 and 98 (Battleship Parkway) over the Tensaw and Spanish Rivers. The south side of the embankment is exposed to wind-generated wave impacts. The approach roadway is reinforced with riprap revetment to protect against these wave impacts, but rising sea levels will increase the wave heights to which it is exposed. This case study evaluated whether the current riprap protection is sufficient to protect the approach from increased erosion due to wave impacts and overtopping associated with rising sea levels.

The bridge approach is located on Blakeley Island, just east of downtown Mobile. It represents the beginning of the Battleship Parkway Causeway (the "Causeway"), a combination of causeways and bridges allowing US 90/98 to traverse the nearly eight mile (12.5 kilometer) wide Mobile Bay. The Causeway provides an important alternate route across Mobile Bay in the event of an incident that limits the use of I-10. It is also a key link serving the USS Alabama Battleship Memorial Park and commercial businesses on the islands along the Causeway. This bridge was also studied in Case Study #4.

Climate Stressors and Scenarios Evaluated and Impacts on the Facility

The embankment is exposed to wave action from Mobile Bay. The size of the waves that can hit the embankment is limited by the available water depth directly in front of the embankment. As sea level rises, the water depth will increase, enabling the formation of larger waves.

The appropriate size and extent of riprap needed for embankment protection is correlated with the size and run-up of the waves hitting the embankment. Therefore, this study evaluated the riprap needed for slope protection under the following sea level rise scenarios:

- 0.9 foot (30 centimeters) of relative sea level rise by 2050
- 2.3 feet (75 centimeters) of relative sea level rise by 2100
- 6.4 feet (200 centimeters) of relative sea level rise by 2100

The study found that the existing riprap slope protection meets the design standards of the U.S. Army Corps of Engineers Coastal Engineering Manual under the 2050

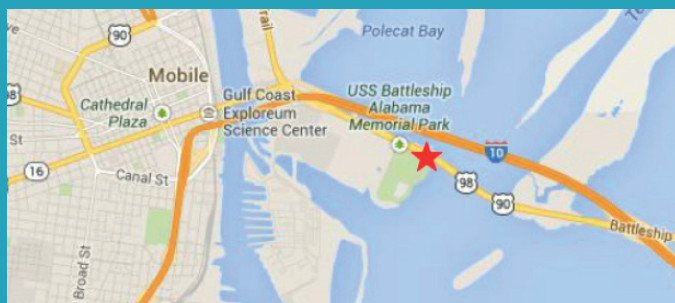


Figure 1: Location of the US 90/98 Tensaw-Spanish River Bridge

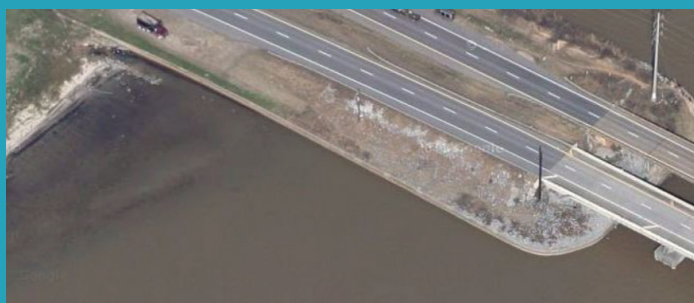


Figure 2: Aerial Image of the South Side of the US 90/98 Tensaw-Spanish River Bridge West Abutment

one foot (0.3 meter) and the 2100 2.5 feet (0.75 meter) projected sea level rise scenarios. There could be some roadway inundation from the run up of larger waves, but this inundation would probably be temporary. In the 2100 6.6 feet (2.0 meters) sea level rise scenario, the existing riprap slope protection is neither large enough or at a high enough elevation to protect against wave impacts. Permanent inundation could also occur.

Identification and Evaluation of Adaptation Options

Since the current riprap protection would not be sufficient under a 6.6 ft (2 meter) sea level rise scenario, some sort of adaptation would be needed. Furthermore, continued maintenance of the current riprap protection would be needed to maintain protection under the lesser sea level rise scenarios. The analysis considered the following adaptation options:

- Option 1: Maintain existing riprap slope protection
- Option 2: Raise the elevation of the riprap slope protection, approach road, and bridge to prevent overtopping and use larger riprap
- Option 3: In addition to the Option 2 improvements, extend the embankment slope to decrease the wave height and run-up exposure

A summary of the protection offered by these adaptation options is shown in Table 1. Both Option 2 and Option 3 would provide sufficient protection under all sea level rise scenarios.

There are other important factors to consider when evaluating the adaptation options:

- Will sea level rise affect land use on Blakely Island and/or the traffic volume traveling across the Causeway? If traffic is lessened, it may not be necessary to adapt US 90/98 if the primary route (I-10) can sustain the traffic patterns.
- Are there concerns about having a higher bridge adjacent to USS Alabama Battleship Memorial Park? This park is on the Alabama Register of Landmarks and Heritage, and it contains two ships that are National Historic Landmarks. There may be aesthetic concerns with raising the nearby bridge.
- Will sea level rise cause other problems on the roadway? There are low points along this roadway that could be inundated regardless of the riprap protection. Consideration should be taken regarding whether the roadway needs a more extensive redesign.

Table 1: Potential Adaptation Measures

Sea Level Rise	Impact Considered	Option 1	Option 2	Option 3
Current Conditions	Provides Embankment Protection	Yes	Yes	Yes
	Provides Overtopping Protection	Yes	Yes	Yes
	Type Of Inundation	None	None	None
Projected Year 2050 1-Foot (0.3 Meter) Sea Level Rise	Provides Embankment Protection	Yes	Yes	Yes
	Provides Overtopping Protection	Yes	Yes	Yes
	Type Of Inundation	Temporary	None	None
Projected Year 2100 2.5-Foot (0.8 Meter) Sea Level Rise	Provides Embankment Protection	Yes	Yes	Yes
	Provides Overtopping Protection	Yes	Yes	Yes
	Type Of Inundation	Temporary	None	None
Projected Year 2100 6.6-Foot (2.0 Meter) Sea Level Rise	Provides Embankment Protection	No	Yes	Yes
	Provides Overtopping Protection	No	Yes	Yes
	Type Of Inundation	Permanent	None	None

Potential Course of Action

Since the current riprap protection is sufficient under present day conditions and the projected sea level rise scenario for 2050, the recommended course of action is only to provide maintenance to ensure the riprap continues to provide adequate protection. Since it is only under a longer term, more extreme sea level rise scenario that the current protection may not be adequate, additional adaptive measures are not necessary at this time. Sea level rise should be monitored, and additional adaptive measures should be taken if sea level rise trends indicate additional protection is needed.

Lessons Learned

Problems associated with sea level rise would likely occur late in the design life of the approach. Therefore, it may be cost-effective to wait until a replacement is due before making major structural changes.

Also, this analysis considered only one bridge along the Causeway, which is comprised of many other bridges. Adaptation efforts should ideally be handled in a coordinated manner to ensure that all bridges along the route are adequately protected.

For More Information

Resources:

Gulf Coast Study:

[Engineering Assessments of Climate Change Impacts and Adaptation Measures](#)

Contacts:

Robert Hyman
Sustainable Transport and Climate Change Team
Federal Highway Administration
robert.hyman@dot.gov, 202-366-5843

Robert Kafalenos
Sustainable Transport and Climate Change Team
Federal Highway Administration
robert.kafalenos@dot.gov, 202-366-2079

Brian Beucler
Hydraulics and Geotechnical Engineering Team
Federal Highway Administration
brian.beucler@dot.gov, 202-366-4598

