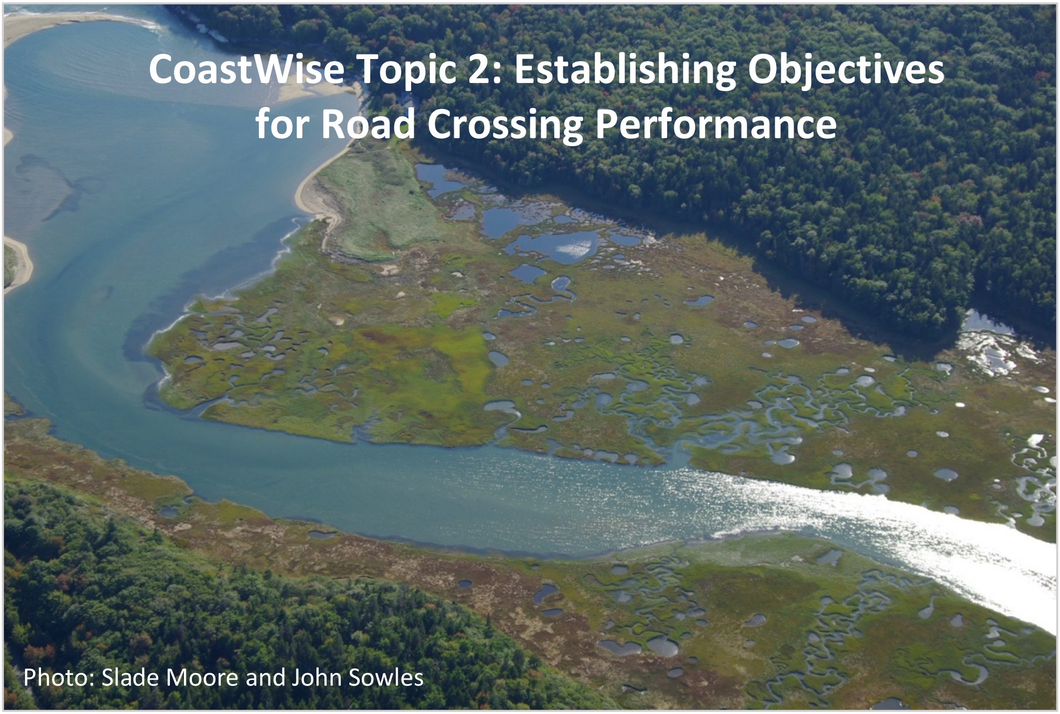

Photo: Slade Moore and John Sowles

Background

Clearly stated objectives articulate expectations for the crossing's performance. Objectives address considerations ranging from how well the new crossing will safely provide access throughout its expected service life, to whether it will facilitate improvements in wetland health and aquatic organism passage, now and in the future. Objectives are eventually refined to the extent that they inform engineering design criteria and also identify metrics used by the project team to evaluate and compare design alternatives.

1. Identify Potential Risk Factors

Improved tidal exchange is among the typical objectives recommended for tidal road crossing replacement projects. Before objectives for the new crossing's performance are identified, the Project Team conducts an assessment of potential risk factors. Potential risk factors are conditions that can lead to undesired consequences if not identified early in the crossing design process. Potential risk factors most often point to the site-specific potential for undesired consequences related to shifts tidal flooding patterns. These shifts can be associated with sea level rise over the long term, but also more immediately if a new crossing's tidal exchange performance is designed to exceed that of the existing structure, which is often a tidal restriction. Potential risk factors include:

- Roads and other infrastructure like houses, wells, and public and commercial facilities
- Properties used for timber growth, agriculture, or other land use
- Wetlands where dammed or highly restricted conditions have attracted resource uses including aquaculture, shellfish harvesting, freshwater storage, and recreation
- Damaged salt marshes that have lower than normal ground elevations and are likely to respond poorly if unimpaired tidal exchange is re-established at the crossing
- Buried or above ground utilities, like sewer mains, that are located so close to the crossing structure that upsizing its dimensions would require moving the utility.

Knowing the crossing's potential area of upstream influence now and in the future is critical for identifying potential risk factors. This can be assessed using the Highest Astronomical Tide and sea level rise layers provided in Maine Coastal Program's Maine Tidal Restriction Atlas and also by using The Nature Conservancy's Coastal Risk Explorer, among other mapping tools on the internet. Links are provided below:

https://maine.maps.arcgis.com/apps/webappviewer/index.html?id=8f7fc922c464482d8fe946ca5b17c7ea

https://maps.coastalresilience.org/maine/

Where present, potential risk factors can narrow the range of crossing design options for a site. Most notably, they can limit the degree to which the crossing structure can be upsized and correspondingly, the extent to which tidal exchange can be improved and upstream wetlands made more resilient to sea level rise. Risk factors warrant strict attention throughout the project process, from identification of objectives to post-construction monitoring. Lastly, the presence of potential risk factors does not automatically constrain the design process. Each site is different, and in some instances landowners or the local community will consider re-establishing unimpaired tidal exchange that promotes wetland resilience as the "greater good". This approach is likely to be more attractive at sites where restricting tidal flow at the road crossing to protect upland assets from increased tidal flooding is a temporary solution that can result in permanent loss of wetland resilience in exchange for another few years of postponing the full effects of sea level rise.

2. Establishing Objectives

The tidal road crossing design process typically results in an alternatives analysis where two or more conceptual crossing designs are evaluated to determine which one best meets project objectives and will be advanced to the final design phase. To enable that process, it's wise to establish provisional objectives for the proposed crossing's performance after selection of one or more sea level rise scenarios and reviewing potential risk factors.

Establishing provisional objectives (Table 1) early in the project process is a participatory process that communicates what the road owner and community expect from the crossing. It also identifies what kinds of questions the in-depth field assessment project phase should answer. Provisional objectives are refined as the understanding of site conditions and constraints improves. These refined objectives (Table 2) inform the development of design criteria used in the engineering design.

Table 1. Examples of provisional objective categories for the proposed crossing's performance. Objectives are framed within the context of present and future conditions.

Category	Examples of optimal performance of provisional objectives
Crossing Longevity	The crossing provides full performance for the desired service life.
Crossing Climate Readiness	The crossing and road meet design criteria for projected flow capacity, flooding frequency, structural stability, and other factors projected during the service life.
Incidental Flooding Potential	The crossing does not cause undesired tidal flooding of adjacent roads, other infrastructure, properties, or resource uses, beyond what would be expected by the present crossing and sea level rise.
Wetland Health and Resilience	The crossing re-establishes fundamental processes related to tidal exchange that maintain tidal wetland health and resilience.
Aquatic Organism Passage	The crossing maximizes passage of fish and other organisms.
Vulnerable Species Habitat	The crossing benefits the recovery of imperiled species that are sensitive to changes in hydrology, and the habitats they rely upon
Cost-Effectiveness	The crossing meets goals and objectives for long-term cost-effectiveness

Table 2. Examples of structural objectives and associated design criteria. Note than some objectives may conflict. At some sites, concerns related to property or infrastructure flooding may subordinate the priority of objectives for improved tidal exchange.

Objective	**Design Criteria**	**Target Value**
Crossing Longevity – The crossing provides the desired performance during its service life	Planning Horizon/Service Life in years	75 years, or site specific
Crossing Structure Resilience – The crossing is climate-ready for the selected planning horizon. This includes the ability to accommodate sea level rise, future flow capacity, inundation frequency, structure stability, and other factors	Projected Sea Level Rise Elevations	Site-specific, based on risk and planning horizon, but at least the Intermediate scenario
	Design Flooding Criteria Base Flood (Current) Design Flood Elevation (Future)	FEMA Base Flood, or combination of tide/flow/storm Base Flood Elevation + sea level rise
	Design Freeboard Road Embankment Crossing Structure	Site specific, risk-based value: X' Site specific, risk-based value: X'
	Maximum Upstream - Downstream Water Surface Elevation Difference at Design Flood	Site specific value: X'
	Maximum Scour Depth at Design Flood	Site specific value: X'
	Maximum Interior Water Level in Structure	Less than 90% of interior structure height at 50-year return period peak future water level
Adjacent Flooding Risk - The crossing won't cause unapproved tidal flooding of infrastructure, properties, or resource uses	Maximum Water Level Adjacent to Site-Specific Infrastructure or Private Property	Site-specific max. water elevation – XX feet
	Maximum Tidal Inundation Extent Adjacent to Site-Specific Infrastructure or Private Property	Site-specific buffer from infrastructure or private property – XX feet
Infrastructure Risk – The crossing won't cause increased erosion potential adjacent to low-lying infrastructure.	Maximum Allowable Velocity Adjacent to Site-Specific Infrastructure	Site-specific, max. water velocity < XX ft/s Max. velocity at structure

Table 3. Examples of ecological objectives and associated design criteria. At some sites, the potential for flooded property, infrastructure, species habitats, and impaired wetlands may subordinate the priority of objectives for improved tidal exchange.

Objective	Design Criteria	Target Value
Wetland Resilience - The crossing re-establishes fundamental processes that maintain tidal wetland health and resilience to sea level rise, like unimpaired tidal exchange. Listed design criteria target values often require comparing simulated upstream conditions associated with each crossing alternative with simulated unrestricted conditions, under present and future Highest Astronomical Tide (HAsT) sea level elevations.	Projected Sea Level Rise Elevations	Based on risk/planning horizon; at least the Intermediate scenario
	Upstream-Downstream Water Levels Slack high and low tide Flood or ebb (running) tide Time lag in tidal flow	 0" difference Maximum of 2-3" difference at any time Hydrograph plots indicate little to no time delay
	Upstream Tidal Inundation Extent Residence Time/Duration	 100% of extent under unrestricted conditions 100% of unrestricted duration
	Upstream Inundation Frequency	100% of unrestricted frequency
	Upstream Salinity Concentration	100% of unrestricted salinity
	Wetland Plant Community Criteria	Site-specific wetland community targets
Aquatic Organism Passage - The crossing will maximize organism passage for a list of selected species or the species with least relative swimming performance	Time duration	90% of the time below HAsT tide level
	Allowable Hydraulic Drop Height	0" (no perch) other than bedrock features
	Maximum Allowable Velocity	Based on species and life stages utilizing the crossing
	Minimum Depth	Based on species and life stages utilizing the crossing
Vulnerable Species /Impaired Marshes - Avoid adverse impacts to marshes with elevation deficits and vulnerable species	Maximum frequency, depth, and duration of tidal inundation	Site specific, identify values that encourage tidal exchange to support marsh resilience processes without exceeding inundation tolerance of imperiled species and plant communities at impaired marshes