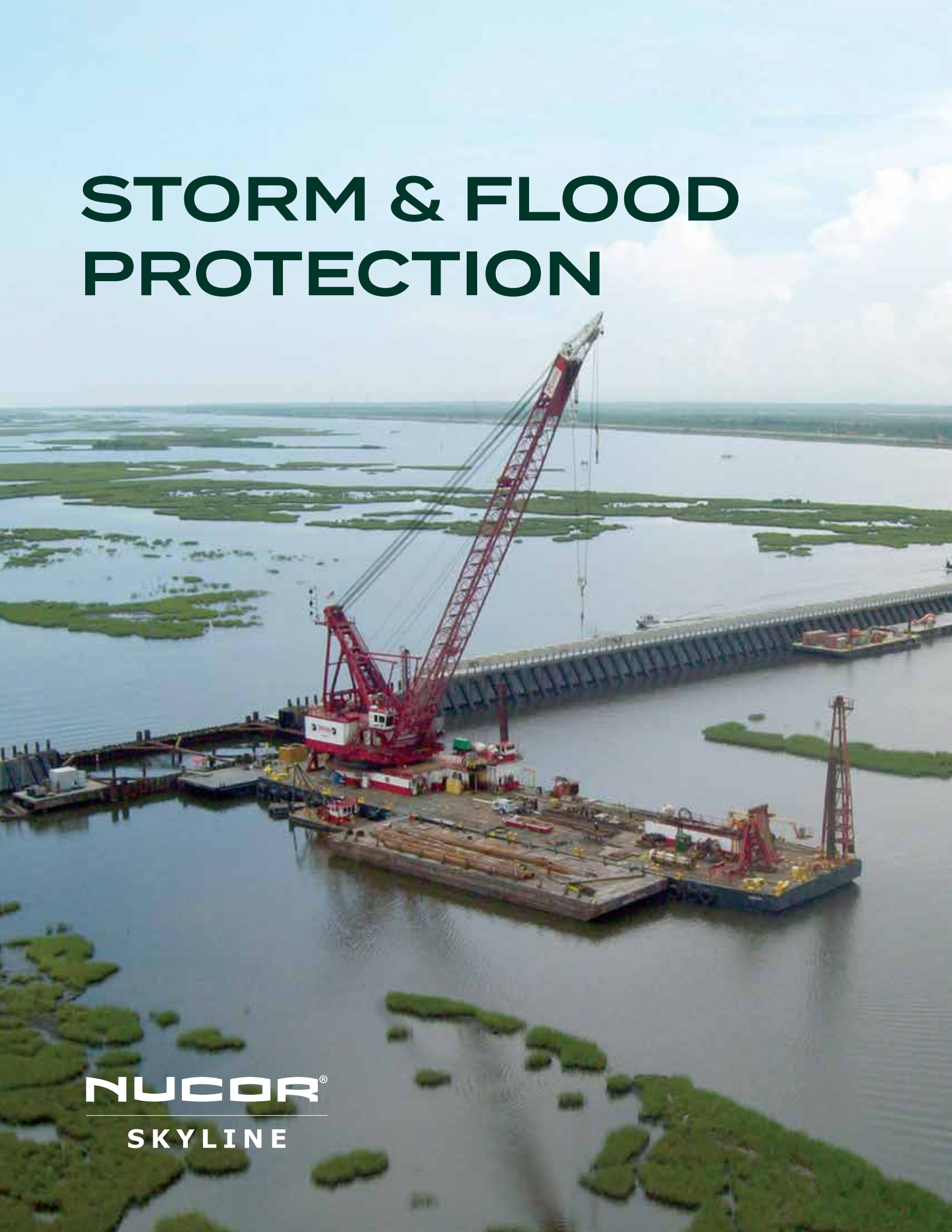
STORM & FLOOD PROTECTION



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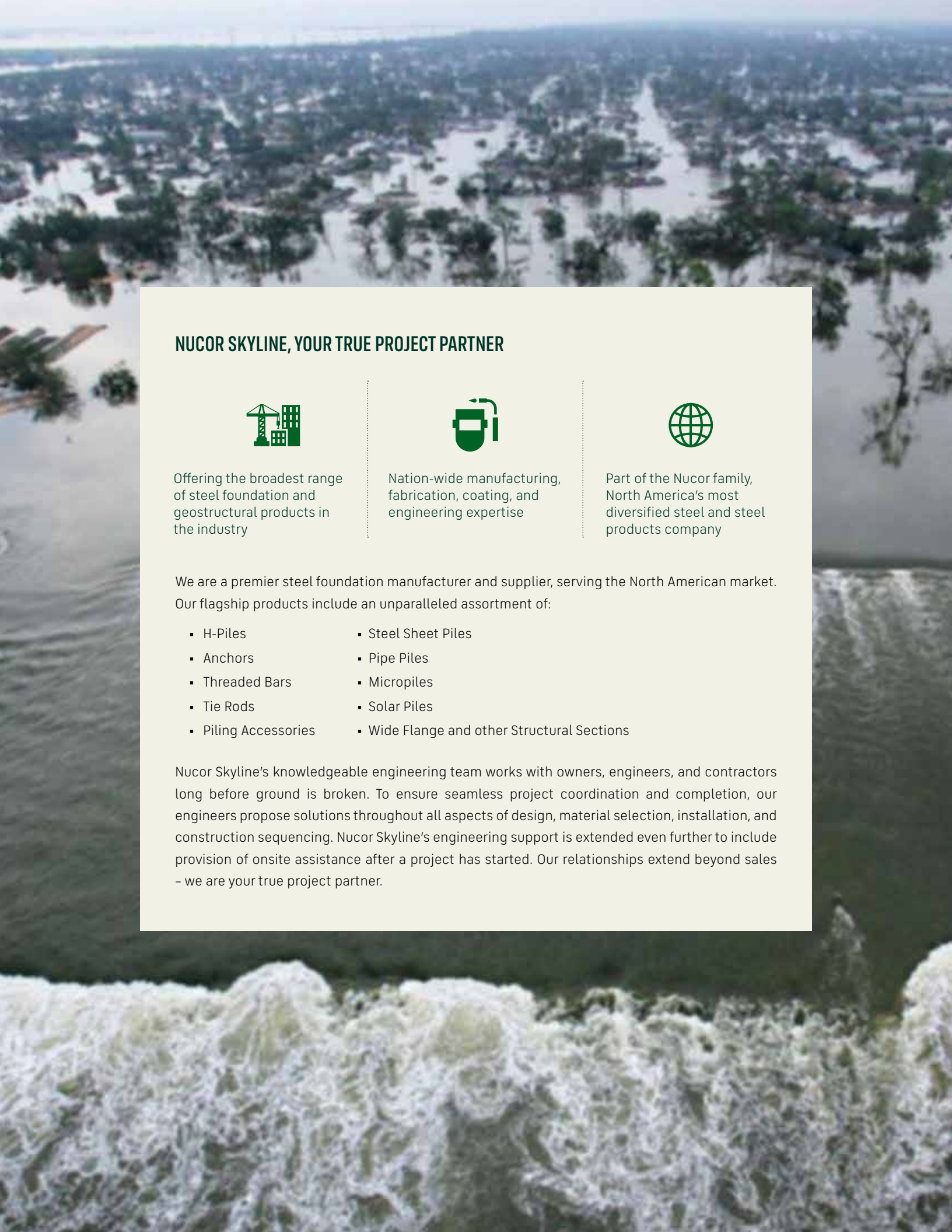

NUCOR SKYLINE, YOUR TRUE PROJECT PARTNER

Offering the broadest range of steel foundation and geostructural products in the industry

Nation-wide manufacturing, fabrication, coating, and engineering expertise

Part of the Nucor family, North America's most diversified steel and steel products company

We are a premier steel foundation manufacturer and supplier, serving the North American market. Our flagship products include an unparalleled assortment of:

- H-Piles
- Anchors
- Threaded Bars
- Tie Rods
- Piling Accessories
- Steel Sheet Piles
- Pipe Piles
- Micropiles
- Solar Piles
- Wide Flange and other Structural Sections

Nucor Skyline's knowledgeable engineering team works with owners, engineers, and contractors long before ground is broken. To ensure seamless project coordination and completion, our engineers propose solutions throughout all aspects of design, material selection, installation, and construction sequencing. Nucor Skyline's engineering support is extended even further to include provision of onsite assistance after a project has started. Our relationships extend beyond sales – we are your true project partner.

STORM & FLOOD PROTECTION SOLUTIONS FROM NUCOR SKYLINE

Storms cause billions of dollars of damage each year, and water is responsible for the majority of the destruction. Whether the ruin comes as a result of a stream that overtops its levee or from a coastal surge, water damage, at its most basic level, is a result from one of two things: flooding and/or erosion.

As your true project partner, Nucor Skyline can work with you to alleviate problems caused by soil erosion and flooding, reduce future costly expenditures and bring peace of mind to commercial and residential property owners.

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STORM PROTECTION

Patrick Whittemore/Boston Herald

EROSION

Soil erosion takes place when moving water has enough energy to remove more soil than it deposits. The faster the water is moving, the more soil it can hold in suspension. Soil is constantly being redistributed by water, and as long as it does not affect infrastructure or create disturbances in busy shipping lanes, it is not a problem.

However, when erosion occurs at an inopportune place, the effects can be devastating. More than half of all bridge failures in the United States are due to scour. Scour is the erosion of soil around a bridge foundation. During Hurrican Katrina, floodwaters overtopped the levees, eroded the soil, and led to the eventual failure of the walls.

FLOODING

Simply stated, flooding occurs when water is somewhere it should not be.

- Minor floods happen regularly and are little more than a nuisance.
- Major floods are natural disasters which can cause major structural damage and potential loss of life.
- River floods occur when heavy rainfall causes a rise in the water level beyond the capacity of the natural or artificial levees. Water overtops the levees and spreads into the flood plain.
- Coastal flooding is typically the result of a hurricane or earthquake. High winds from tropical storms force water into the coastline. Earthquakes can shift large columns of water, resulting in tsunamis. In both cases, the result is the inundation of water along coastal areas.

Flood damage can be prevented by relocating vital industry or residents, or through the development of flood control infrastructure.

As was seen in the New Orleans levee system breach during Hurricane Katrina in 2005, it is vital, for many reasons, to protect the soil on the levee from scour.

LEVEES

For centuries, civilizations have settled around rivers as a source of water, transportation, and trade. Today, these advantages still exist but climate change has introduced a new risk, flooding.

Natural levees are formed during previous flood events and can offer some protection.

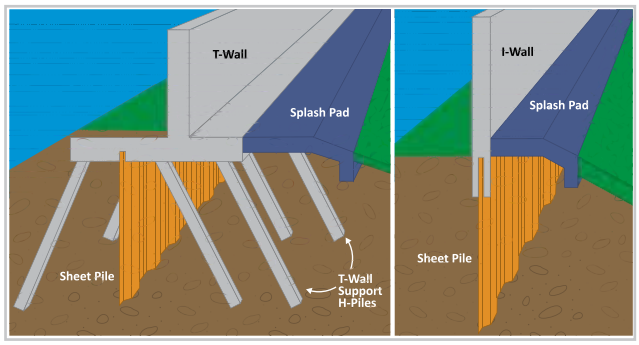
- Heavier soil deposits, sands and gravels, settle on the river bank while the silts and clays spill out over the flood plains.
- Over thousands of years, soil left by flooding rivers slowly creates levees on the river banks and good farmland in the flood plains.
- Cyclical flooding also tends to slowly raise the river in relation to the flood plain, and eventually the height difference is enough to fail the natural levee. As a result, the river changes course.

Modern navigation requirements and nearby development make the avoidance of arbitrary levee failure imperative. To protect critical resources from floods, levees can be raised and reinforced.

Steel bearing piles and steel sheet piles can be placed within a levee to increase global stability, decrease permeability, add height and prevent damage from plant or wildlife. The sheet piles can be used on their own or in conjunction with earth levees.

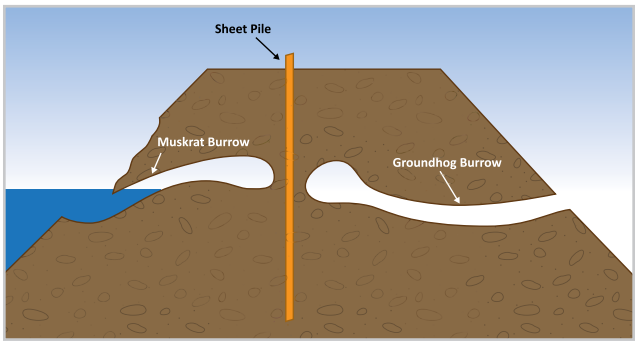
Additional Height

Increased Stability



H-Piles and Steel Sheet Piles

Steel Sheet Piles Only

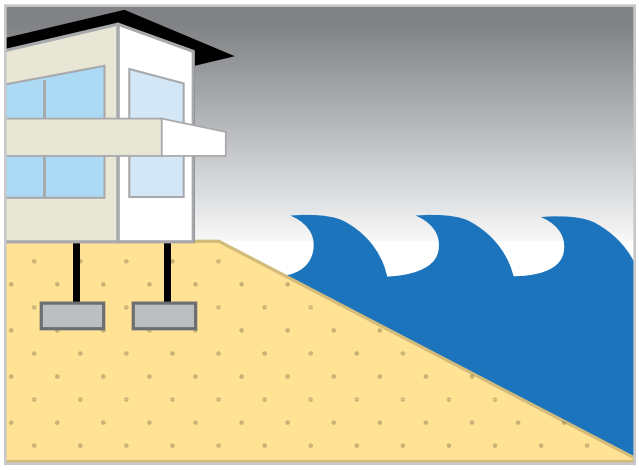


Sheet piles add stability and prevent animal burrows from becoming a conduit for water.

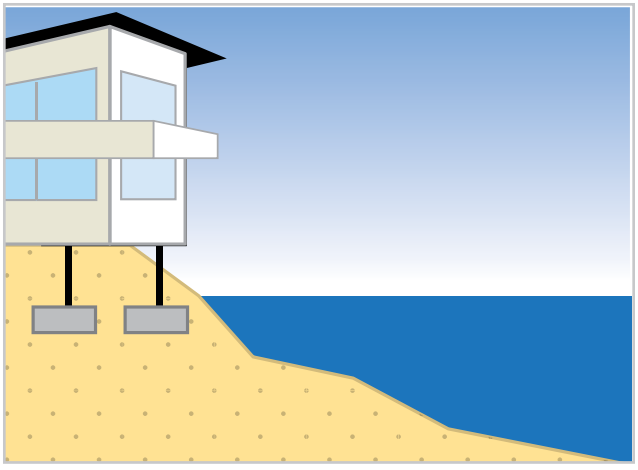
Residential Steel Sheet Pile Seawall – Manalapan, Florida

SEAWALLS AND FLOODWALLS

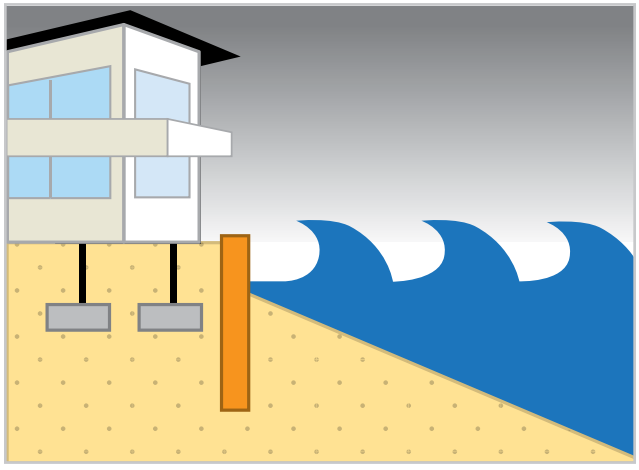
Storm surge is the result of offshore winds pushing water against the coastline. The surge, combined with heavy wave action, has a devastating effect on low-lying coastal developments, both residential and commercial. Tsunamis and tidal waves, resulting from earthquakes, are as equally damaging and often occur with little advance warning.



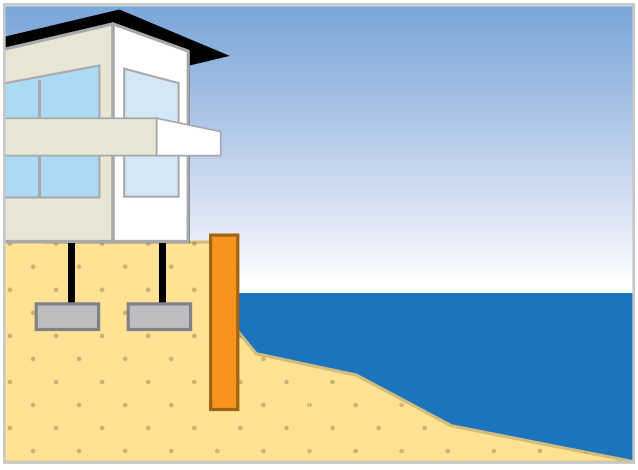
During storm (without seawall)



After storm (without seawall): The erosion caused by the storm undermines the foundation of the structure and could lead to failure.



During storm (with seawall)



After storm (with seawall): Erosion still occurs, but the sheet pile prevents failure and ensures longevity of the structure.

Cantilevered Wall

The most effective method for preventing flood damage is to divert water away from critical infrastructure. Steel sheet piles are designed to carry the loads from earth and water pressure, while also creating a nearly impermeable barrier. Seawalls, constructed at the natural crest of the beach, protect the foundations of the buildings immediately adjacent to the beach from erosion and prevent water from moving further inland. Furthermore, sheet piles provide vertical support for a boardwalk. In cases where the wall is particularly high or the scour is expected to be deep, the sheet pile walls can be anchored to a secondary wall. In addition, sheet piles are also very effective in the protection of individual installations.

Wastewater treatment plants, power plants, refineries and public utilities are all critical infrastructure that must be protected during major flood events.

- Sheet pile walls can be constructed around the entire facility to ensure they remain fully operational.
- In most cases, a simple sheet pile wall can hold back 15 feet of water without the need for bracing or anchors.
- If the soils are too weak to support a high cantilevered wall, battered piles can be placed on the inside of the enclosure, or a double wall or gravity wall can be used.
- Double wall systems are relatively simple to construct. The sheet piles act as a cutoff wall, decreasing the amount of water that permeates through or under the wall. Double walls are constructed by installing two parallel walls of Z-type piles, tying the walls together with threaded bar, and filling the space between the walls with soil. A gravity wall is built with flat steel sheet piles in a cellular or diaphragm configuration. Cellular construction is more difficult to perform, but the sheet piles tend to be shorter and there is no anchorage system. Gravity walls are advantageous at sites with shallow rock. A double wall or gravity wall can also be designed to carry vertical loads such as road or other transportation loads.

Stage 1: Parallel Z-type sheet piles are installed and tied together with a threaded bar.

Stage 2: Soil is placed between the two walls and compacted.

Stage 3: The structure is able to carry vertical loads as well as provide flood protection.

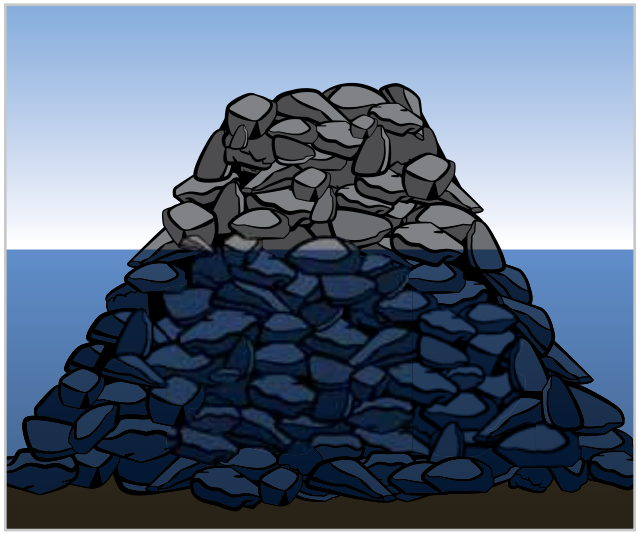
Steel Sheet Pile
Wave Barrier

WAVE BARRIERS

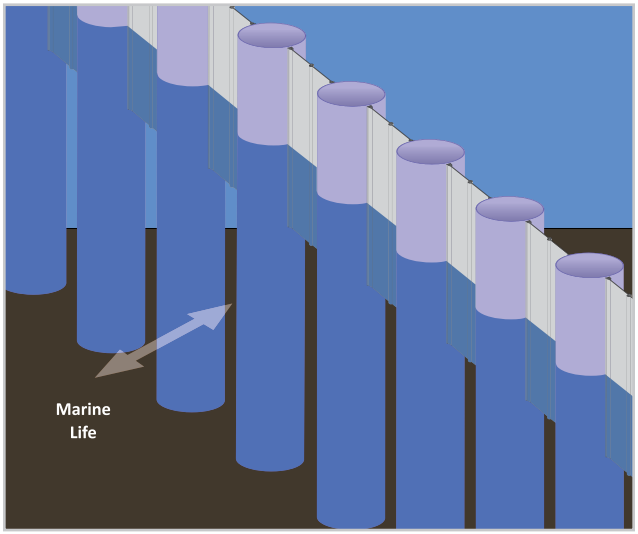
Natural harbors are rare, and as coastal development continues to increase, the space suitable for marinas and shipping terminals becomes increasingly difficult to find. Artificial harbors are created to protect moored vessels from large storm driven waves.

One method for protecting coastal areas is with sheet pile wave barriers. Wave barriers are:

- Effective at dissipating wave energy.
- Minimally invasive to the local environment due to their limited physical footprint that allows marine life to pass through them, unlike other solutions, such as rock jetties.
- Quick, easy to install, and removable with ease.
- Constructed using king piles (beam or pipe) with intermediate sheet piles. The king piles are driven deep into the soil, while the sheet piles are placed only at elevations impacted by low and high tide. The gap between the bottom of the sheet pile and the mud-line allows the hydrostatic pressure to equalize, minimizing the overall load on the structure.



Rock jetties have a wide base on the ocean floor.



A pipe-sheet pile wave barrier has a small footprint and allows marine life to travel through the wall without disruption.

Permanent steel sheet piles protecting bridge abutments and piers from scour related problems.

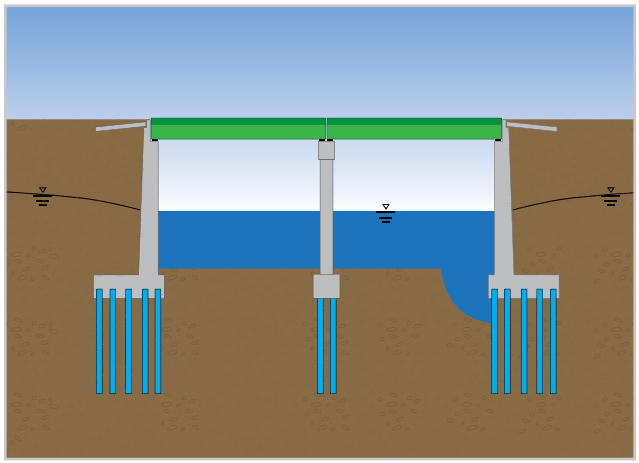
BRIDGE ABUTMENTS AND PIERS

Although most storm damage is associated with major river flooding and coastal storm surges, the overflow of smaller streams can cause significant damage as well. The remnants of Hurricane Irene brought heavy rains and caused widespread damage in Vermont, a state rarely associated with hurricanes or tropical storms. The hurricane collapsed bridges and washed out roadways.

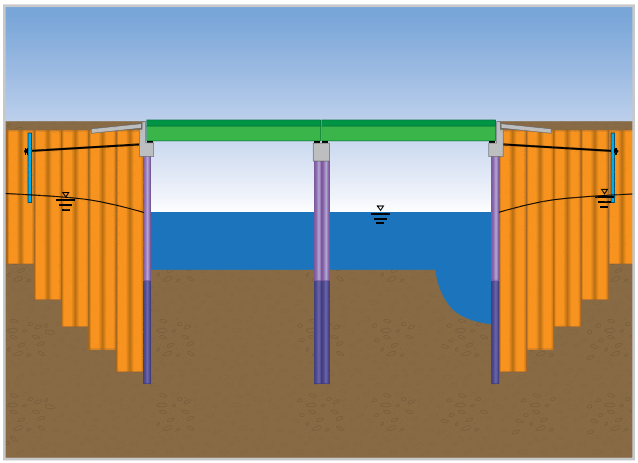
River flooding causing higher-than-normal flow in a river creates scour holes around bridge abutments and piers. Bearing piles exposed by scour holes are susceptible to buckling, which is not a concern when the piles are fully supported by the soil.

There are a few typical solutions to this issue such as the use of stronger bearing piles. Another solution is to use steel sheet piles as a permanent abutments, as the piles are able to carry both vertical and lateral loads.

Visit **nucorskyline.com/abutment** to download our technical design manual for steel sheet pile bridge abutments.



Piers/Bridge Abutments without sheet piling: Scour exposes piles and decreases passive pressure in front of abutment, requiring repair or the risk structural failure.



Piers/Bridge Abutments with sheet piling: Sheet piles protect the bridge from scour related problems.

Rockaway River flooding from Hurricane Irene caused homes to be condemned and wiped out the entire shoulder of I-287 North in NJ.

SLOPE STABILIZATION

During storm events, slope stabilization should also be considered. Swollen streams can undercut their banks, destabilizing the slope. Additionally, rain can saturate the soil and loosen the ground, also destabilizing a slope.

- Steel sheet piling can protect stream banks most prone to scour or in areas that have at-risk infrastructure. The outside curve of a river is always more vulnerable to erosion than the straight sections or inside curve.
- Slopes of rivers can also be stabilized with soil nails or other piling to interrupt the failure plane.
- Hillsides and rock faces can be reinforced with soil and rock anchors. In some cases, micropiles and driven piles can be used if the loads and the soil conditions warrant it.

Anchors stabilize the rock face of the Holtwood Dam.

Soil nails used at the Moretrench Avonworth Primary Center

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