

2024-2050 SEA LEVEL RISE PROJECTIONS

AT DIAMOND COVE PIER

What are HATs?

High astronomical tides (HAT), also known as king tides, are natural tidal events that create some of the highest water levels along Maine's coast.

Why tide heights matter!

Scientists and coastal practitioners monitor king tides because they preview the higher everyday water levels coastal communities will experience as sea levels rise. They also approximate Maine's shoreland zoning boundary, making them an important benchmark for visualizing future coastal change.

King tide heights in Portland!

King tides typically occur a few times each year when the tidal range is especially large. Tides exceeding 12 feet are often associated with "sunny day" flooding that can overtop Portland's piers and inundate low-lying coastal infrastructure such as the commercial and residential buildings on the Portland Pier. Portland's daily high tides, by comparison, average around 9ft 10".

What these graphics will show!

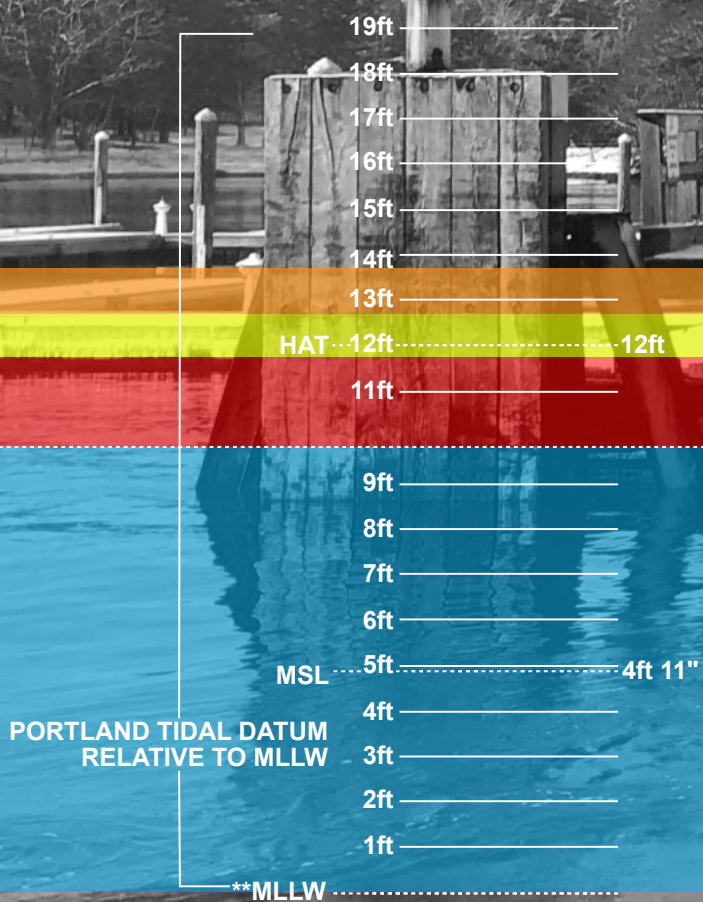
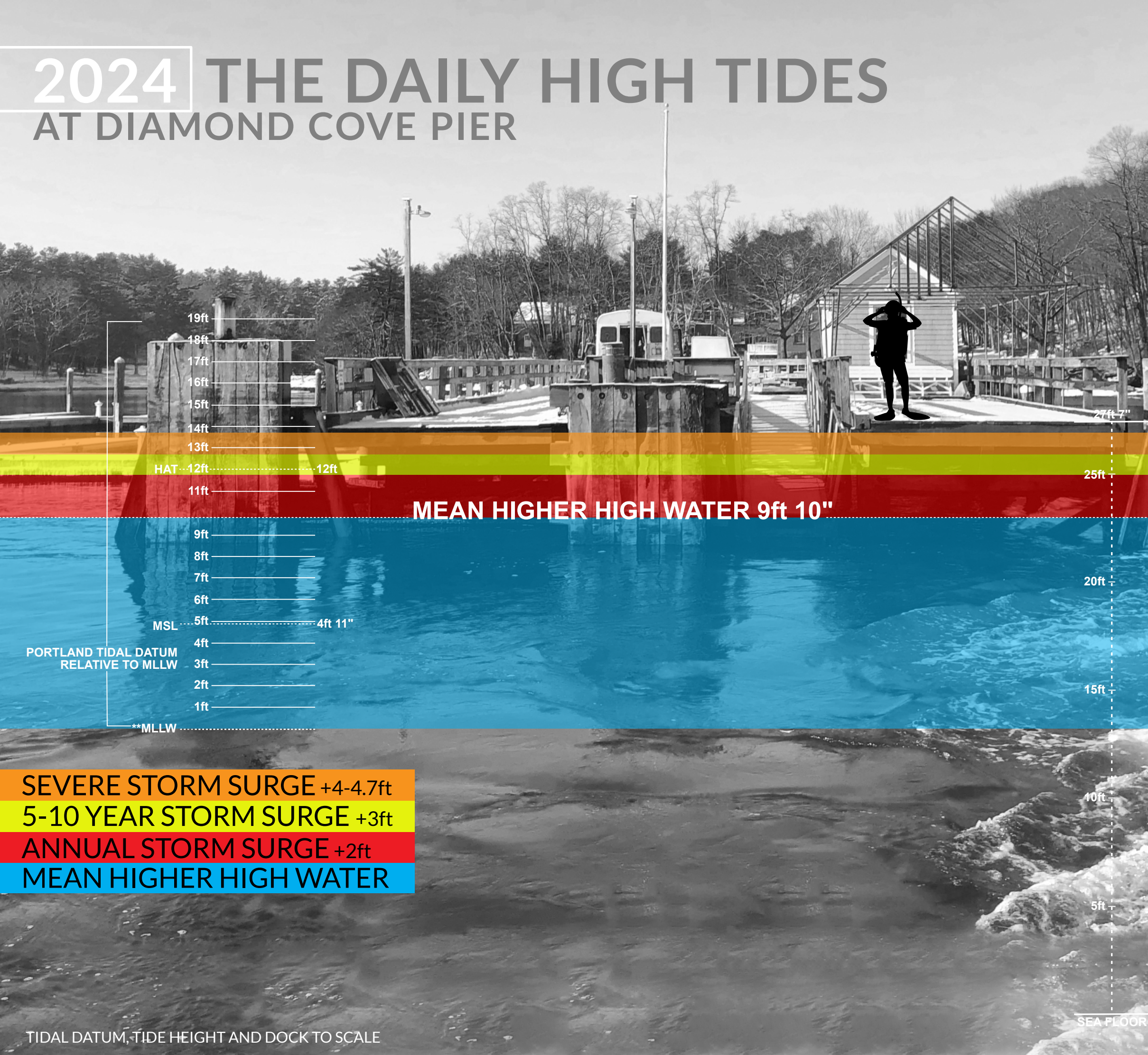
The following pages illustrate how projected sea level rise will influence water levels at the pier, and how rising baseline water levels, together with storm surge will shape future flooding at the cove.

Also shown are storm profiles from 2022–2024 documenting the water levels and coastal impacts observed throughout the cove.



Sea level rise projections are from Portland and South Portland's One Climate Future plan, as recommended by the Maine Geological Survey and Maine Climate Council. The tidal datum for the Diamond Cove pier, along with all storm tide and storm surge elevations shown in these graphics, are referenced to NOAA's Portland Tide Station [8418150] and field measurements of the pier were collected on February 16, 2022 @8:11am.

2024 THE DAILY HIGH TIDES AT DIAMOND COVE PIER



MEAN HIGHER HIGH WATER 9ft 10"

- SEVERE STORM SURGE +4-4.7ft**
- 5-10 YEAR STORM SURGE +3ft**
- ANNUAL STORM SURGE +2ft**
- MEAN HIGHER HIGH WATER**

TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE

UNDERSTANDING THE DAILY HIGH TIDES

This graphic illustrates Portland's mean higher high water (MHHW) tidal datum. A tidal datum is a standard reference elevation based on a specific phase of the tide. MHHW is the average height of the higher of the two daily high tides measured over a 19-year tidal cycle and represents the typical elevation reached by daily high tides.

The colored bands illustrate Portland's typical storm surge heights and their annual probability of occurrence, showing how often different surge levels can be expected over time. As sea levels rise, storm-driven water levels will build upon this higher tidal baseline, increasing the frequency of coastal flooding.

The SLR projections below are based on Portland and South Portland's One Climate Future recommendations and guidance from the MGS and Maine Climate Council.

YEAR	SLR
2030	+8"
2050	+1.5'
2070	+2.4'
2100	+4'

STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)		
frequency	storm surge (ft)	storm tide (ft)
every year	2	11.7
every 5 years	2.9	12.6
every 10 years	3.3	12.9
every 25-100yrs	+4	13.4-14.1

TIDAL STATS DO NOT INCLUDE WAVE HEIGHT OR SWELLS. TYPICAL WAVE HEIGHTS IN CASCO BAY RANGE FROM 1-3 FEET.

SOURCE LINKS:
[2019 ONE CLIMATE FUTURE: PORTLAND MGS SEA RISE TICKER](#)
[PORTLAND TIDAL STATION 8418150](#)
[NOAA 2022 SLR TECHNICAL REPORT](#)

**MLLW (mean lower low water) is the reference vertical tidal datum used for predictions, surveying, benchmark publications and nautical charting. The National Weather Service uses MLLW as a reference for its water level forecasts and for SLR projections.



2024 CURRENT SEA LEVEL AT DIAMOND COVE PIER



UNDERSTANDING SLR AND STORM SURGE

Sea levels in Portland have risen roughly 8" over the last century. Historically, they rose at about 1.93mm/yr, but recent measurements show that rate accelerating.

Storm surge is the abnormal rise in water above the predicted astronomical tide. Storm tide is the total water level produced when storm surge combines with the astronomical high tide. As a result, the largest storm surges do not always produce the highest storm tides. Maine's highest storm surge of 4ft 7" occurred on March 3, 1947, but because it coincided with a low tide, the resulting storm tide was modest.

The sea level rise projections below are based on Portland and South Portland's One Climate Future recommendations and guidance from the MGS and Maine Climate Council.

YEAR	SLR
2030	+8"
2050	+1.5'
2070	+2.4'
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SEVERE STORM SURGE +4-4.7ft
5-10 YEAR STORM SURGE +3ft
ANNUAL STORM SURGE +2ft
MEAN HIGHER HIGH WATER



This image shows conditions at the pier during a storm when the predicted tide was 9ft 7" and the storm surge reached 3ft, producing a storm tide of 12ft 8". It illustrates the water levels and wave conditions associated with this storm.

[Link to the January 17, 2022 winter storm graphic to review the storm's profile.](#)

2030 SLR HIGH TIDE PROJECTIONS AT DIAMOND COVE PIER

UNDERSTANDING SLR ON DAILY HIGH TIDES

This graphic illustrates how projected sea level rise (SLR) will influence the daily high tides in Diamond Cove. Although Portland's mean higher high water (MHHW) remains a fixed tidal datum of 9ft 10", sea levels are already about 8" higher. Adding the projected 2030 SLR of another 8" to Portland's MHHW shows how higher baseline water levels will cause future storm surges to reach higher elevations.

MHHW is the average height of the higher of the two daily high tides measured over a 19-year tidal cycle. Portland's current tidal datum is based on observations collected from 1983-2001 and serves as the reference elevation used here for measuring tides and water levels.

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2050	+1.5'
2070	+2.4'
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SEVERE STORM SURGE +4-4.7ft
5-10 YEAR STORM SURGE +3ft
ANNUAL STORM SURGE +2ft
MEAN HIGHER HIGH WATER



This image shows conditions during a storm tide of 13ft 9" and a predicted tide of 10ft. It is a good example of how rising base sea levels will amplify future flooding at the pier. With 8" of sea level rise, annual storms occurring during typical high tides will produce water levels and flooding impacts similar to this and the January 10, 2024 storm.

[Link to the December 23, 2022 winter storm graphic to review this storm's profile.](#)

2030 SEA LEVEL RISE PROJECTIONS AT GREAT DIAMOND ISLAND PIER

UNDERSTANDING SLR IMPACTS ON KING TIDES

This graphic illustrates how projected sea level rise (SLR) will influence annual king tides in Diamond Cove. Although Portland's HAT remains a fixed tidal datum of 12ft, sea levels are already about 8" higher. Adding the projected 2030 SLR of another 8" to Portland's HAT shows how higher baseline water levels will raise the water levels reached during future storm surges.

HAT elevations have been established along Maine's coastline using NOAA tidal observations, tidal prediction stations, and land elevation data. Together, these measurements provide a continuous coastal reference for mapping the landward extent of king tides and serve as an important benchmark for visualizing projected sea level rise.

The SLR projections below are based on Portland and South Portland's One Climate Future recommendations and guidance from the MGS and Maine Climate Council.

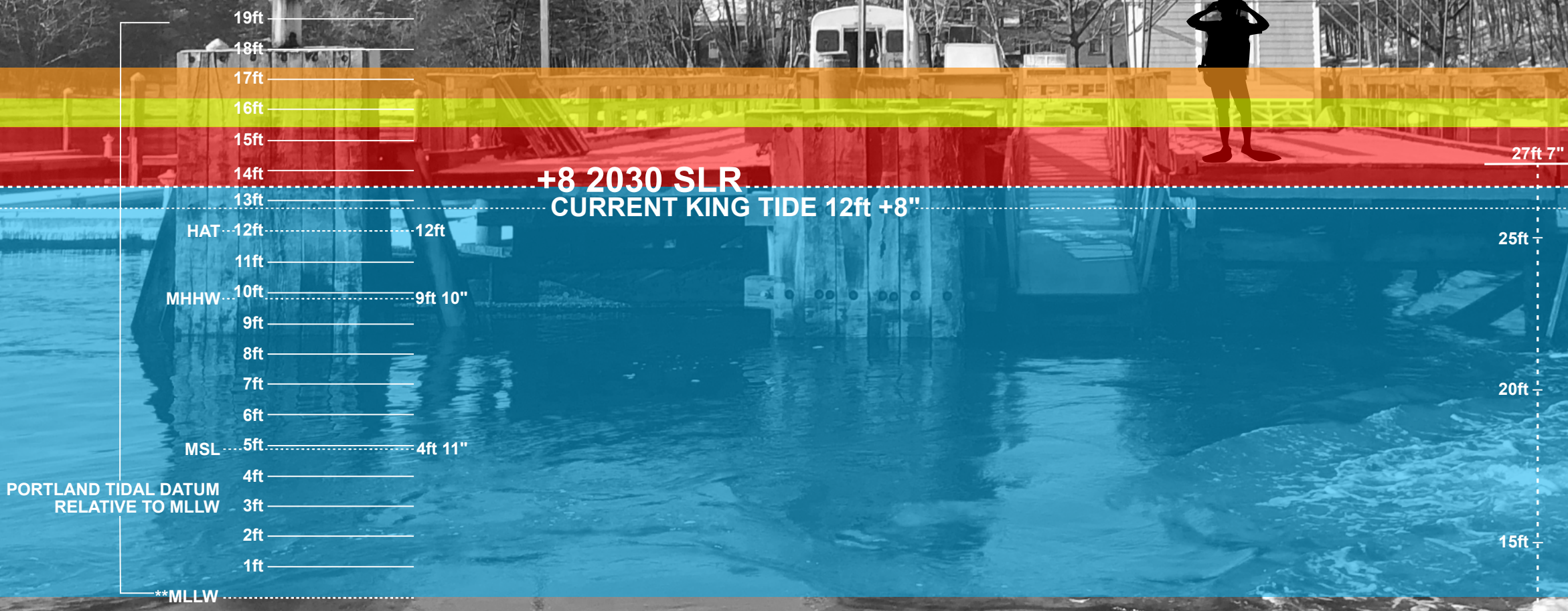
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SEVERE STORM SURGE +4-4.7ft
5-10 YEAR STORM SURGE +3ft
ANNUAL STORM SURGE +2ft
KING TIDE



This image shows a high water mark of approximately 16ft 3". By 2030, projected SLR of 8" would raise that high water mark to approximately 17ft—higher than the water levels experienced during Maine's record 2024 coastal storm. Such levels would create severe flooding risks for the pier and nearby low-lying infrastructure.

[Link to the January 13, 2024 winter storm graphic to review this storm's profile.](#)

TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE

2050 SEA LEVEL RISE PROJECTIONS AT DIAMOND COVE PIER

UNDERSTANDING SLR IMPACTS ON KING TIDES

This graphic illustrates how projected sea level rise (SLR) will influence annual king tides in Diamond Cove. Although Portland's HAT remains a fixed tidal datum of 12ft, sea levels are already about 8" higher. Adding the projected 2050 SLR of another 1ft 6" to Portland's HAT shows how higher baseline water levels will raise the water levels reached during future storm surges.

HAT elevations have been established along Maine's coastline using NOAA tidal observations, tidal prediction stations, and land elevation data. Together, these measurements provide a continuous coastal reference for mapping the landward extent of king tides and serve as an important benchmark for visualizing projected sea level rise.

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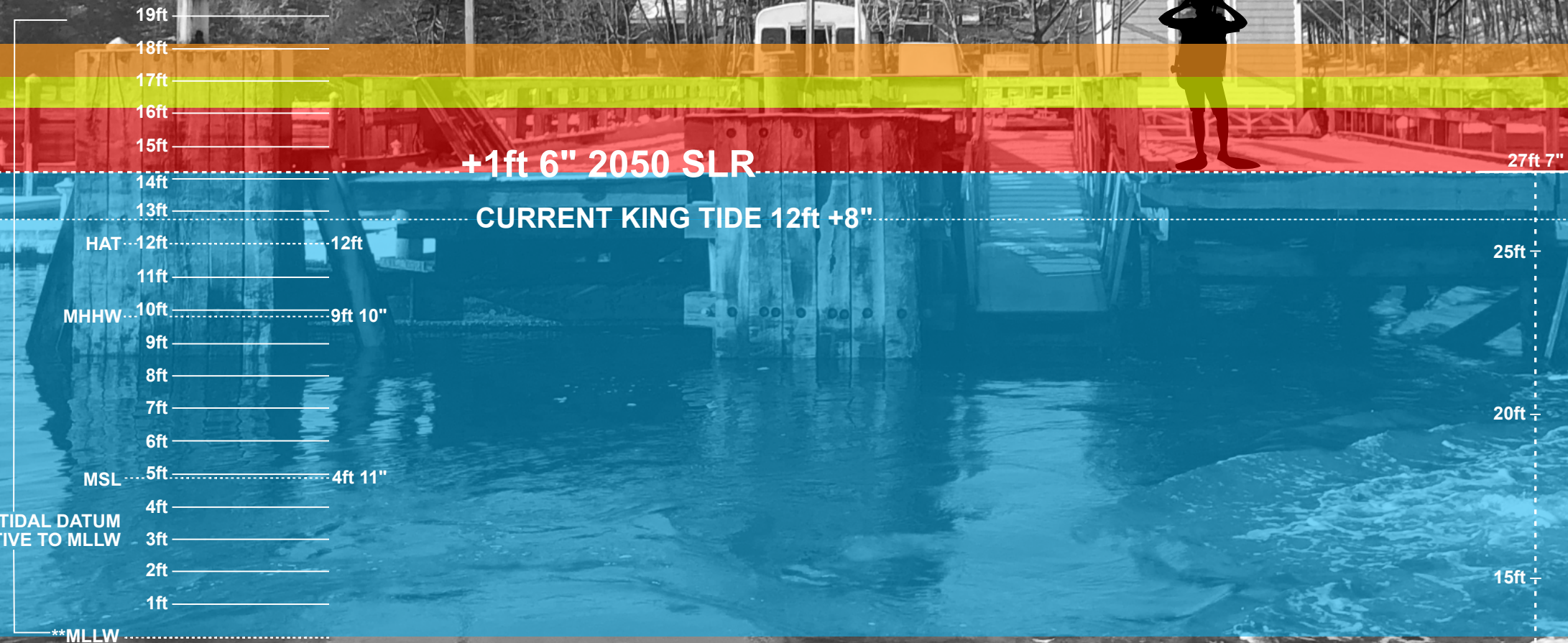
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- SEVERE STORM SURGE +4-4.7ft
- 5-10 YEAR STORM SURGE +3ft
- ANNUAL STORM SURGE +2ft
- KING TIDE



This image shows conditions during a storm tide of 14ft 7". The high water mark visible in this image reached approximately 16ft 6". By 2050, the projected sea level rise of 1ft 5" would raise that same high water mark to nearly 18ft, substantially increasing flooding risks for the pier and nearby low-lying infrastructure.

[Link to the January 13, 2024 winter storm graphic to review this storm's profile.](#)

WINTER STORMS OF DIAMOND COVE

AT DIAMOND COVE PIER

What is storm surge?

Storm surge is an abnormal rise in water level generated by a storm, over and above the predicted astronomical tide. In Portland, annual storm surges of approximately 2 feet are common, while storm surges approaching 3 feet statistically occur every 5 to 10 years. Storm tides occur when storm surge combines with a predicted astronomical tide. In Portland, flood stage is considered 12 feet—a level at which seawater will overtop piers, roads, and other low-lying waterfront areas, creating the "sunny day" flooding that is becoming increasingly common along the coast.

Timing is everything!

The severity of coastal flooding depends on both the storm surge and the astronomical tide. A large storm surge occurring during a low tide may produce limited impacts, while a smaller surge arriving during a king tide or other elevated tide can create significant flooding. For example, Maine's highest recorded storm surge—4.61 feet on March 3, 1947—occurred during a relatively low tide and resulted in a comparatively modest storm tide.

What these graphics will show!

The following pages document coastal storms that have affected Diamond Cove from 2022-2024. By showing the storm tide, storm surge, and predicted tide for each event, these profiles help explain why some storms produce greater flooding impacts than others. As base sea levels rise, the flooding impacts associated with today's 5-, 10-, and 100-year storm tides will occur more frequently as these water levels are added to a higher tidal baseline.



Sea level rise projections are from Portland and South Portland's One Climate Future plan, as recommended by the Maine Geological Survey and Maine Climate Council. The tidal datum for the Diamond Cove pier, along with all storm tide and storm surge elevations shown in these graphics, are referenced to NOAA's Portland Tide Station [8418150] and field measurements of the pier were collected on February 16, 2022 @8:11am.

2022 JANUARY 17 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

The January 17, 2022 storm produced a storm tide of 12ft 8" in which the water levels nearly overtopped the pier at Diamond Cove.

Winter Storm Izzy was part of a large extratropical cyclone that developed as warm and cold air masses collided over eastern North America. Unlike hurricanes, which are warm-core systems fueled by ocean heat, extratropical cyclones are cold-core systems. They get their strength from the clash between warm tropical air and cold polar air.

Along Maine's coast, sustained winds of 30-40mph with gusts reaching 54mph contributed to coastal flooding, rough seas, and widespread snowfall across portions of New England and Canada. As the storm tracked northward, its broad circulation generated strong onshore winds and wave action along the Gulf of Maine. These conditions elevated swells and increased wave heights at Diamond Cove.



STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)

frequency	storm surge (ft)	storm tide (ft)
every year	2	11.7
every 5 years	2.9	12.6
every 10 years	3.3	12.9
every 25-100 yrs	+4	13.4-14.1

TIDAL STATS DO NOT INCLUDE WAVE HEIGHT OR SWELLS. TYPICAL WAVE HEIGHTS IN CASCO BAY RANGE FROM 1-3 FEET.

HIGH WATER MARK

SEVERE STORM SURGE +4-4.7FT

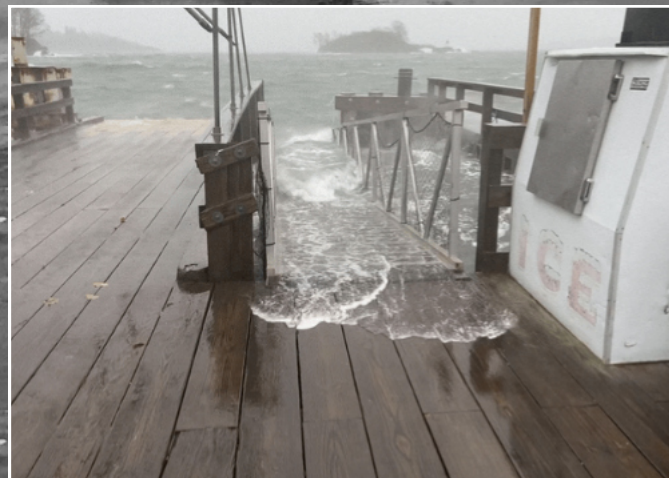
5-10 YEAR STORM SURGE +3FT

ANNUAL STORM SURGE +2FT

PREDICTED TIDE HEIGHT

SOURCE LINKS:

- MGS STORM SURGE AND TIDE FAQs
- PORTLAND TIDAL STATION 8418150
- DIAMOND COVE SEA LEVEL RISE PROJECTIONS



TIDAL-DATUM, TIDE HEIGHT AND DOCK TO SCALE



2022 DECEMBER 23 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

The December 23, 2022 storm produced a storm tide of 13ft 9" at the Diamond Cove pier, making it the third-highest water-level event recorded in Portland, Maine.

Winter Storm Elliott evolved into a powerful bomb cyclone as warm and cold air masses collided over eastern North America. A bomb cyclone is an intense low-pressure storm that rapidly intensifies over a short period of time. Meteorologists classify a storm as a bomb cyclone when its central pressure drops at least 24 millibars within 24 hours, a process known as bombogenesis. This rapid intensification can significantly increase wind speeds, wave heights, and coastal flooding impacts.

Elliott developed into one of the most powerful winter storms of 2022, affecting much of North America as it tracked from the Great Lakes into eastern Canada. Along Maine's coast, heavy rainfall, coastal flooding, and strong winds caused widespread impacts, with wind gusts ranging from 30-40mph along the immediate shoreline.



STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)		
frequency	storm surge (ft)	storm tide (ft)
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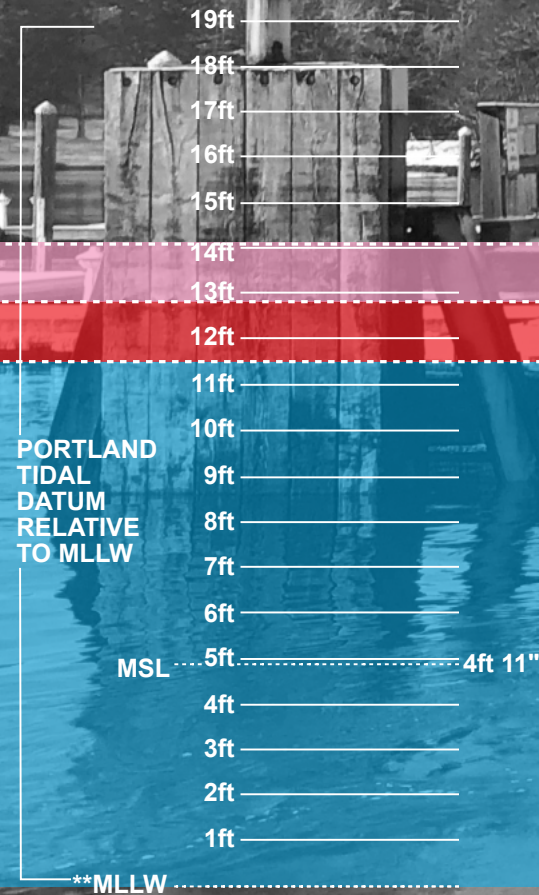
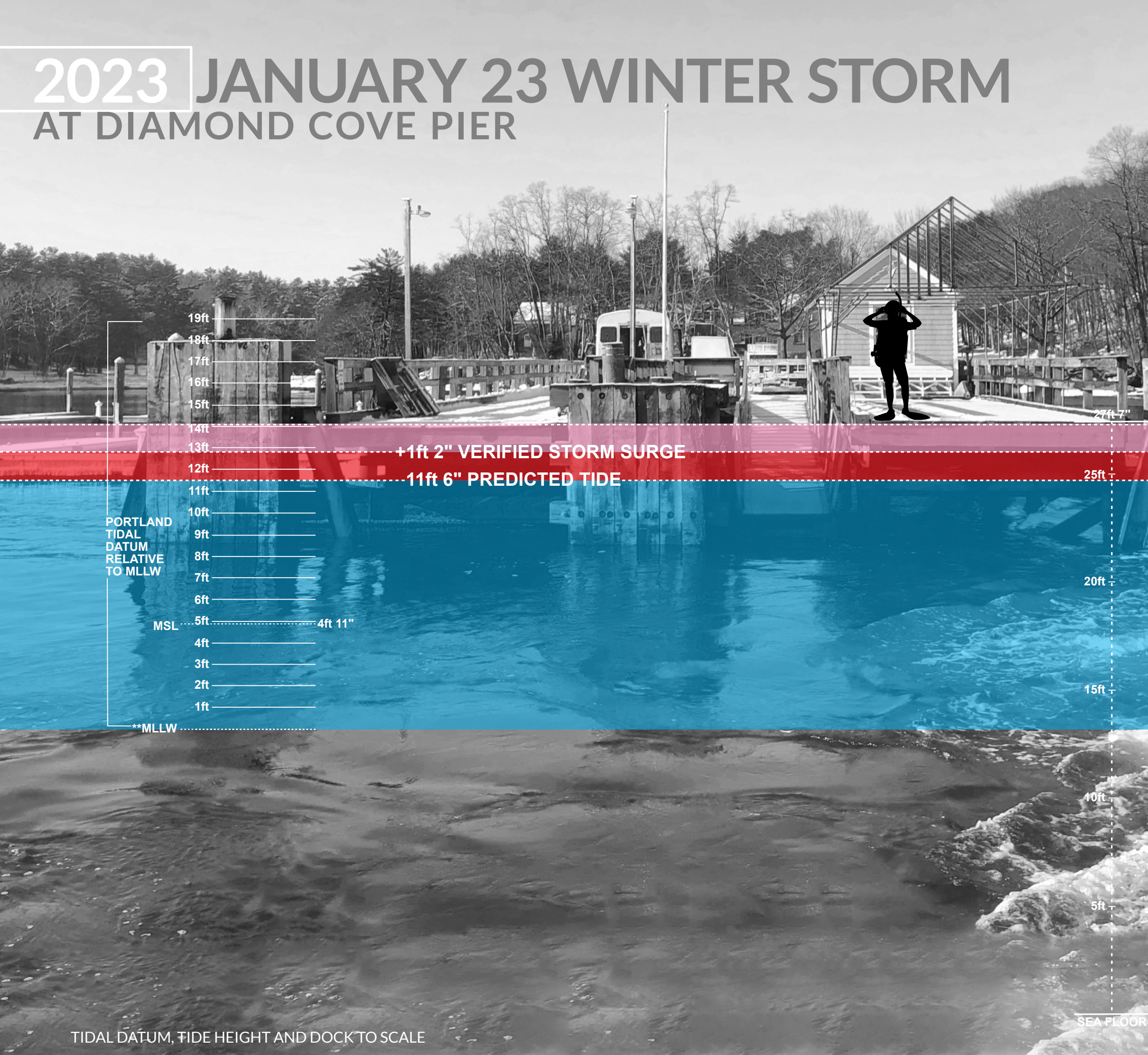


HIGH WATER MARK
SEVERE STORM SURGE +4-4.7FT
5-10 YEAR STORM SURGE +3FT
ANNUAL STORM SURGE +2FT
PREDICTED TIDE HEIGHT

SOURCE LINKS:
[MGS STORM SURGE AND TIDE FAQs](#)
[PORTLAND TIDAL STATION 8418150](#)
[DIAMOND COVE SEA LEVEL RISE PROJECTIONS](#)

TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE

2023 JANUARY 23 WINTER STORM AT DIAMOND COVE PIER



+1ft 2" VERIFIED STORM SURGE
-11ft 6" PREDICTED TIDE

27ft 7"

25ft

20ft

15ft

10ft

5ft

SEA FLOOR

HOW BAD WAS IT?

The January 23, 2023 storm produced a storm tide of 12ft 8" and developed into a large nor'easter known as Fern. Water levels of 12ft and higher are considered flood stage in Portland.

A nor'easter is a powerful extratropical cyclone that forms along the East Coast of the United States. These storms are named for the strong northeasterly winds that often impact coastal areas. Most common between September-April, nor'easters typically track north-northeastward and reach peak intensity near New England and the Canadian Maritimes.

Nor'easters can produce heavy rain, snow, or a mix of both, along with gale-force winds and significant coastal impacts. Because northeasterly storms are a recurring feature of Maine's climate, much of the state's coastline has evolved under their influence. Shoreline features, sediment patterns, and coastal landforms have been hardened by generations of northeasterly wave action, making these shorelines naturally resilient to this storm direction.

STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)

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HIGH WATER MARK

SEVERE STORM SURGE +4-4.7FT

5-10 YEAR STORM SURGE +3FT

ANNUAL STORM SURGE +2FT

PREDICTED TIDE HEIGHT

SOURCE LINKS:

MGS STORM SURGE AND TIDE FAQS
 PORTLAND TIDAL STATION 8418150
 DIAMOND COVE SEA LEVEL RISE PROJECTIONS

2023 DECEMBER 18 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

The December 18, 2023 storm produced a storm tide of 12ft at Diamond Cove. This storm was part of a rapidly strengthening extratropical cyclone that underwent bombogenesis as warm and cold air masses collided over eastern North America. Along Maine's coast, sustained southeasterly winds of 30-40mph, generating large waves and prolonged wave attack on coastal shorelines.

The Grinch Storm was part of a recent pattern of powerful coastal storms that approached Maine from the southeast rather than the more typical northeast direction. Referred to as "sou'easters," these storms drive wave energy toward shorelines that are less frequently exposed to storm-force winds and waves. Because much of Maine's coastline has evolved under prevailing northeasterly storm conditions, southeasterly storms can expose shorelines and infrastructure to wave energy from a direction to which they are less adapted.



STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)		
frequency	storm surge (ft)	storm tide (ft)
every year	2	11.7
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- HIGH WATER MARK
- SEVERE STORM SURGE +4-4.7FT
- 5-10 YEAR STORM SURGE +3FT
- ANNUAL STORM SURGE +2FT
- PREDICTED TIDE HEIGHT

SOURCE LINKS:
[MGS STORM SURGE AND TIDE FAQs](#)
[PORTLAND TIDAL STATION 8418150](#)
[DIAMOND COVE SEA LEVEL RISE PROJECTIONS](#)



TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE

SEA FLOOR

2023 DECEMBER 18 WINTER STORM AT MOON GARDEN PIER

HOW BAD WAS IT?

The December 18, 2023 storm produced a storm tide of 12ft at Diamond Cove. With an open exposure to Hussey Sound, the Moon Garden is particularly vulnerable to wave and swell action, and storm tides between 11ft and 12ft frequently overtop this infrastructure.

While much of Maine's coastline has evolved under prevailing northeasterly storm conditions, southeasterly storms can concentrate wave energy on shorelines that experience less frequent exposure to severe wave action.

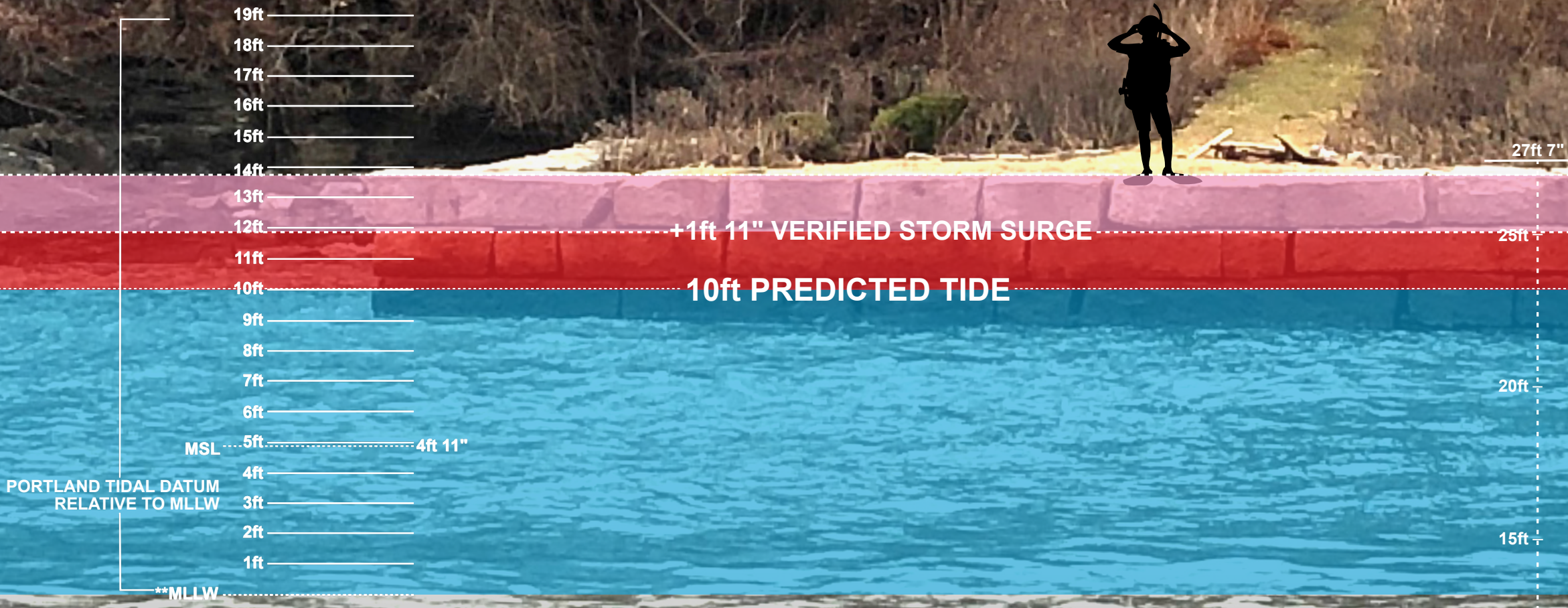
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HIGH WATER MARK
SEVERE STORM SURGE +4-4.7FT
5-10 YEAR STORM SURGE +3FT
ANNUAL STORM SURGE +2FT
PREDICTED TIDE HEIGHT

SOURCE LINKS:
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TIDAL DATUM, TIDE HEIGHT AND PIER TO SCALE

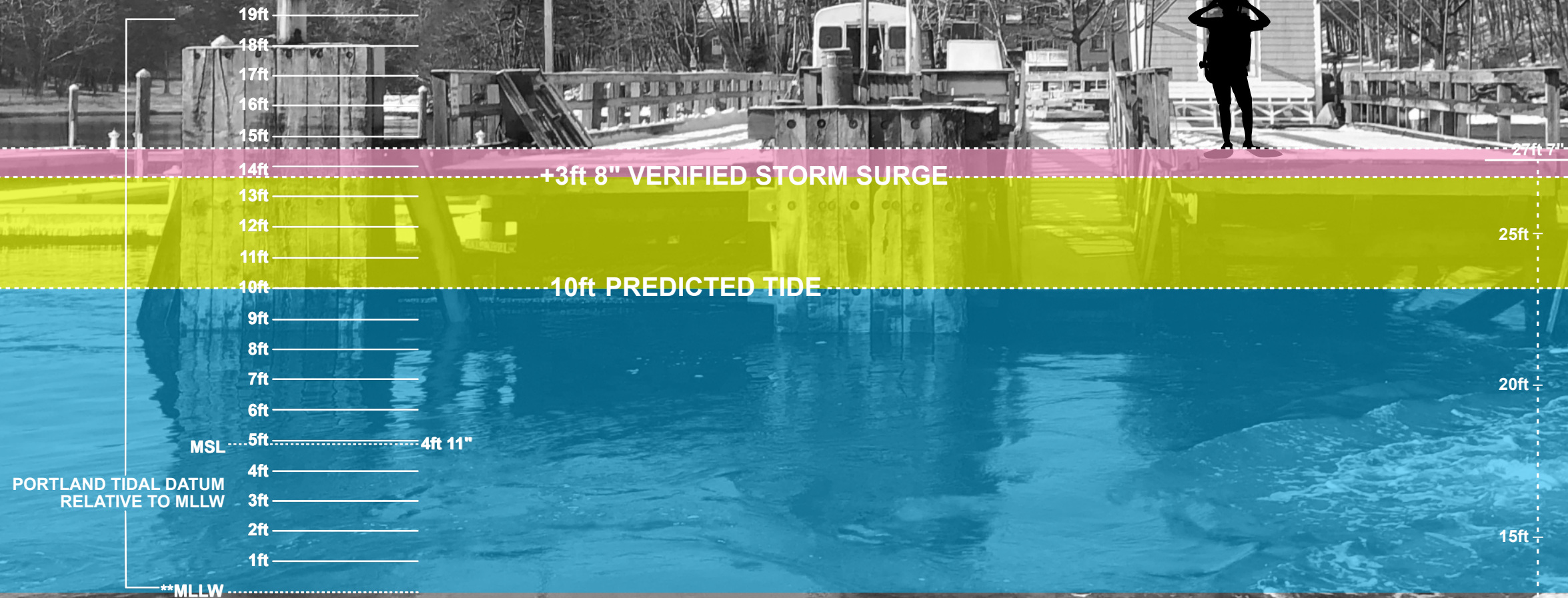
2024 JANUARY 10 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

The January 10, 2024 storm produced a storm tide of 13ft 8" at Diamond Cove, making it the fourth-highest water-level events recorded in Portland Maine.

This powerful coastal storm arrived during a period of exceptionally high astronomical tides associated with the January 11 new moon. A storm surge of 3ft 4" generated by strong southeasterly winds and heavy rainfall raised water levels to record heights.

Along Maine's coast, 2.9" of rain, wind gusts approaching 60 mph, and waves reaching 15-20ft in Casco Bay contributed to widespread flooding, erosion, and infrastructure damage. The storm serves as an example of how the coincidence of an elevated astronomical tide and a significant storm surge can produce record-setting coastal flooding.



STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)		
frequency	storm surge (ft)	storm tide (ft)
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TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE



2024 JANUARY 13 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

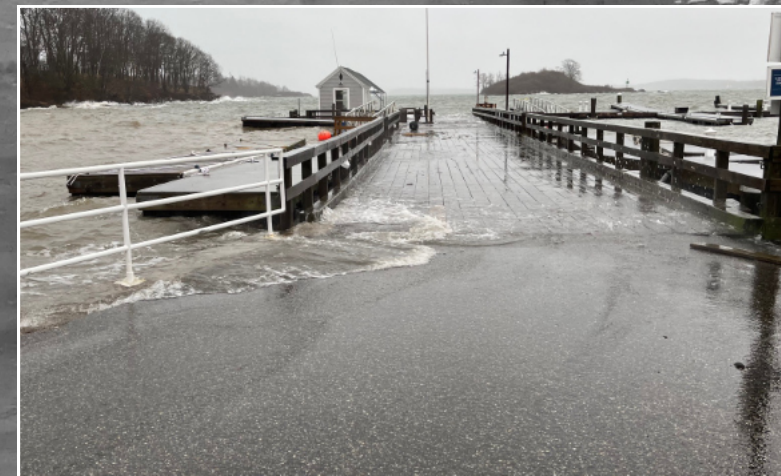
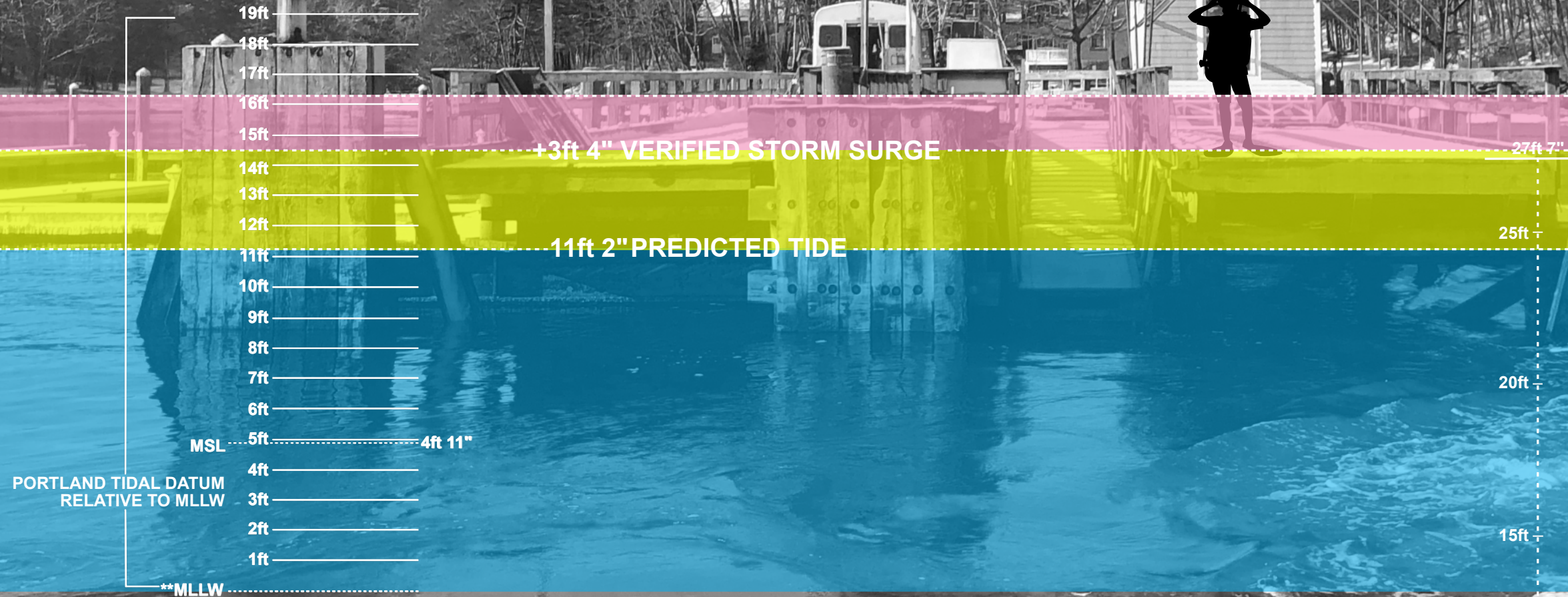
The January 13, 2024 storm produced a storm tide of 14ft 8", making it the highest water-level event recorded along Maine's coast since record-keeping began in 1912, surpassing the previous record set during the February 1978 storm.

Winter Storm Heather was a powerful extratropical cyclone that arrived during a period of exceptionally high astronomical tides associated with the January new moon. Strong southeasterly winds, nearly 3" of rain, and swells reaching 15-20ft in Gulf of Maine combined to create prolonged coastal impacts throughout Casco Bay. These elevated winds pushed water directly into Portland Harbor and prevented it from receding during the peak of the storm.

The impacts were felt throughout Maine's coastal communities. Water levels rose so high that DiMillo's massive floating restaurant in Portland nearly lifted off its securing pilings, requiring staff to use a boat to keep the restaurant from floating free and colliding into harbor infrastructure.

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TIDAL STATS DO NOT INCLUDE WAVE HEIGHT OR SWELLS. TYPICAL WAVE HEIGHTS IN CASCO BAY RANGE FROM 1-3 FEET.



HIGH WATER MARK

SEVERE STORM SURGE +4-4.7FT

5-10 YEAR STORM SURGE +3FT

ANNUAL STORM SURGE +2FT

PREDICTED TIDE HEIGHT

SOURCE LINKS:
[MGS STORM SURGE AND TIDE FAQs](#)
[PORTLAND TIDAL STATION 8418150](#)
[DIAMOND COVE SEA LEVEL RISE PROJECTIONS](#)

TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE

SEA FLOOR



2024 MARCH 10 WINTER STORM AT DIAMOND COVE PIER

HOW BAD WAS IT?

The March 10, 2024 storm produced a storm tide of 13ft 4", making it the seventh-highest water-level event recorded along Maine's coast since record-keeping began in 1912.

The third major sou'easter of 2024 to set records, this powerful storm brought 2.4" of rain to Portland, setting a new daily rainfall record that surpassing the previous record established in 1891. Along Portland's waterfront, seawater flooded parking lots and overtopped sections of the Portland Pier, affecting numerous businesses just two months after the record coastal storms of January 2024.

STORM AND SURGE TIDAL STATS FROM 1912-2023 (MGS)		
frequency	storm surge (ft)	storm tide (ft)
every year	2	11.7
every 5 years	2.9	12.6
every 10 years	3.3	12.9
every 25-100 yrs	+4	13.4-14.1

TIDAL STATS DO NOT INCLUDE WAVE HEIGHT OR SWELLS. TYPICAL WAVE HEIGHTS IN CASCO BAY RANGE FROM 1-3 FEET.

HIGH WATER MARK

SEVERE STORM SURGE +4-4.7FT

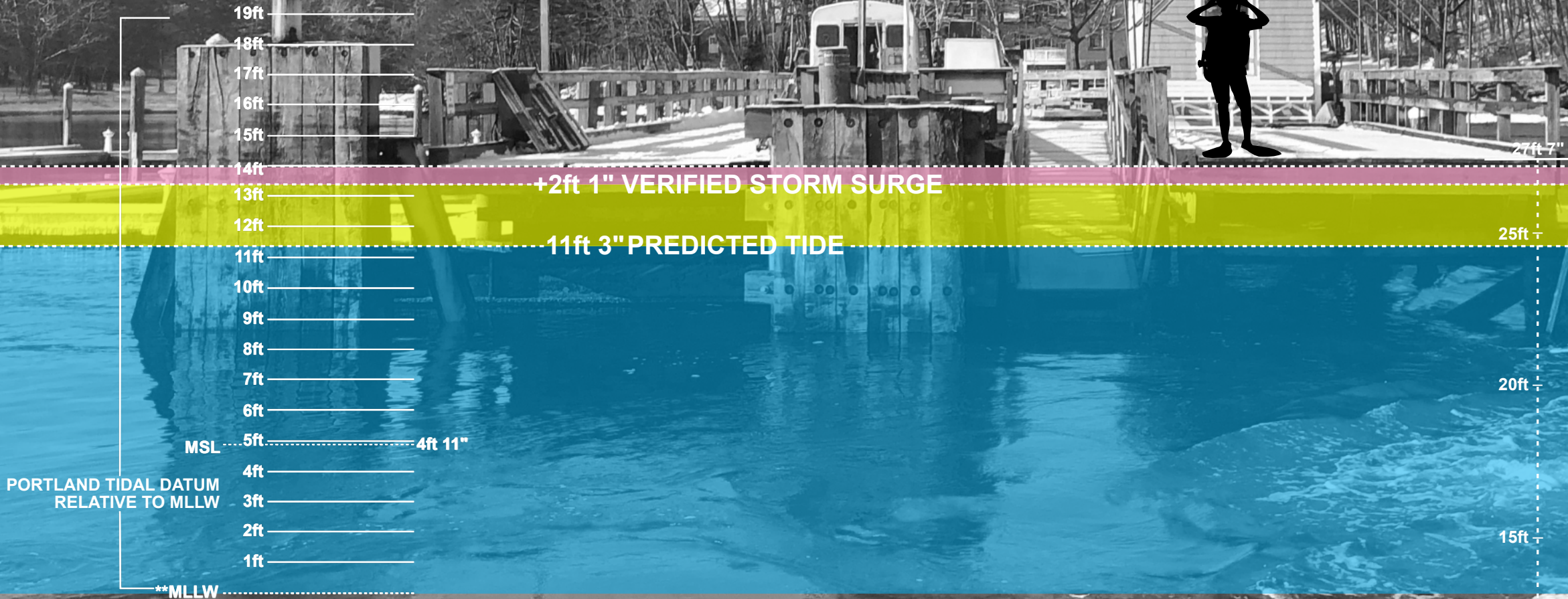
5-10 YEAR STORM SURGE +3FT

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TIDAL DATUM, TIDE HEIGHT AND DOCK TO SCALE