NOAA Technical Report NOS CO-OPS 094

RECAPITALIZATION PLAN

NATIONAL WATER LEVEL OBSERVATION NETWORK

Silver Spring, Maryland
July 2021

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) provides the National infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U. S. harbors, and the National Current Observation Program consisting of current surveys in near shore and coastal areas utilizing bottom mounted platforms, subsurface buoys, horizontal sensors and quick response real time buoys. The Center: establishes standards for the collection and processing of water level and current data; collects and documents user requirements, which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

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Recapitalization Plan

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EXECUTIVE SUMMARY

This report documents the National Water Level Observation Network (NWLON) recapitalization requirements needed to maintain the NWLON in a state of continuous operational readiness that can be executed within a stable, level-funded budget profile.

The geographic location of each NWLON station is guided by the A Network Gaps Analysis for the NWLON (Gill, 2014), which serves to provide the nation's coastal vertical reference framework, through authoritative tidal and Great Lake datums. Most NWLON stations are sited on a pier, wharf, bulkhead, seawall, or similar coastal infrastructure that is owned by another entity and from whom permission has been obtained.

The present size of the NWLON is 210 stations, and the scope of this plan addresses systematic recapitalization at all of these stations. This recapitalization strategy used in this plan is based on a thorough understanding of component end-of-life gained by operating the NWLON over a long period of time.

A typical NWLON station consists of three distinct groups of components: sensors and electronics, support elements, and base platforms. Using the typical life expectancies for these major components, CO-OPS developed a three-tiered framework for NWLON recapitalization.

- **Tier 1** NWLON stations have a life expectancy of 20 years, and there are presently 151 NWLON stations in Tier 1.
- **Tier 2** stations have a life expectancy of 25 years, and there are presently 25 NWLON stations in Tier 2.
- **Tier 3** stations have a life expectancy of 50 years, and there are presently 34 NWLON stations in Tier 3.

This plan outlines three major types of NWLON station recapitalization: planned end-of-life replacement (to replace prior to failure), service life extension work (to ensure that the structure attains its full planned life expectancy of at least 50 years) and forced station relocation (when CO-OPS is notified of the need to remove a station).

This plan is greatly needed at this time, since a considerable number of coastal and Great Lakes NWLON stations are at or approaching their planned end of life. It facilitates an agile, proactive recapitalization program that continuously evaluates past, present, and future capabilities, as well as requirements and risk. Requirements support a staggered recapitalization schedule for Tier 2 and Tier 3 stations. Work among Tier 3 stations is staggered such that CO-OPS does not initiate more than one recapitalization project in any given year.

This recapitalization plan does not address the total destruction of, or major damage to, an NWLON station caused by a hurricane or other extreme event.

1. BACKGROUND AND PURPOSE

The National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) is the authoritative source of accurate, reliable, and timely tide, water level, and other oceanographic information to support safe and efficient maritime navigation, coastal hazards preparedness and response, and sound ecosystem management. To achieve this mission, CO-OPS operates and maintains the National Water Level Observation Network (NWLON), a network of highly precise, long-term tide and water level monitoring stations along the shorelines of the 48 conterminous U.S., including the Great Lakes, Alaska, Hawaii; and U.S. territories (includes the U.S. Virgin Islands, Puerto Rico, Midway Island, Wake Island, the Marshall Islands, and Guam).

The NWLON supports NOAA's primary mission essential functions. Specifically, NWLON water level observations provide the foundation of the nation's coastal vertical reference framework—that is, authoritative tidal and Great Lakes datums. NWLON observations also support many other NOAA mission areas, as well as other federal agency missions, including coastal weather forecasting, emergency response, storm surge and tsunami warnings, climate monitoring, coastal resilience planning, and habitat restoration.

CO-OPS designs and builds each NWLON station to be:

- Robust – NWLON stations meet or exceed local building codes and are designed and constructed to withstand local flood, wind, ice, and other environmental conditions, as well as extremes, in order to provide oceanographic and meteorological observations before, during, and after events.
- Reliable – NWLON stations are configured with redundant sensors, power supplies, and communication paths to ensure data availability and reliability. Near-real-time data communications occur via automated acquisition over satellite networks (Geostationary Operational Environmental Satellite (GOES) or Iridium), with backup landline and other communication capabilities, as well as onsite data storage.
- Long-term – NWLON stations are designed, constructed, and maintained to operate over the long-term, defined by the timeframes of the two principal NWLON missions: observing continuous water level measurements for a minimum of 19 years to support the development of authoritative tidal datums, and observing continuous water level measurements for a minimum of 30 years to support the development of authoritative sea level trends at the station.
- Serviceable – NWLON stations are designed for continual preventative maintenance to station components, which is significantly less expensive than periodic whole replacement of the station.

CO-OPS routinely monitors and assesses both network-wide and individual station condition and performance, with the goal of ensuring continuous operations and maximizing data reliability and quality. CO-OPS uses this information as the foundation of a comprehensive life-cycle management system of all NWLON station components. In addition, CO-OPS continually researches, develops, tests, evaluates, and integrates emerging technologies into the NWLON, with the goals of reducing operation and maintenance costs; increasing data reliability and quality; and reducing environmental risks to the station (e.g., reducing the overall station footprint and equipment sail areas to improve the likelihood of surviving severe weather).

CO-OPS documented the complete requirements to provide the foundation of the nation's coastal vertical reference framework in Gill (2014). This study showed the need for 324 NWLON stations to comprehensively meet this mission. The present size of the NWLON is 210 stations, and the scope of this plan addresses systematic recapitalization at all stations.

The purpose of this plan is to document the NWLON recapitalization requirements needed to maintain the NWLON in a state of continuous operational readiness that can be executed within a stable, level-funded budget profile. This can be achieved through a sound understanding of the costs involved and a staggered station-replacement schedule. This plan is greatly needed at this time, since a considerable number of coastal and Great Lakes NWLON stations are at or approaching their planned end-of-life. This plan will facilitate an agile, proactive recapitalization program that continually evaluates past, present, and future capabilities, requirements, and risk.

CO-OPS periodically assesses risks posed by both natural and anthropogenic hazards (e.g., fire), and has incorporated this risk assessment into overall station design and the selection of specific components that contribute to more robust and resilient NWLON stations. However, this recapitalization plan does not address the total destruction of, or major damage to, an NWLON station caused by a hurricane or other extreme event. Typically, mitigation of these unexpected events is funded through targeted congressional supplemental appropriations.

2. OVERVIEW OF NWLON CAPITAL ASSETS

Every NWLON station is a mission-critical asset. Each NWLON is sited, designed, installed, equipped, and maintained to operate continuously over the long term at each unique coastal or Great Lakes location, with its own set of environmental conditions and extremes. While there is a high degree of standardization across the entire network, every station is unique, and the high variability of environmental conditions and underlying physical infrastructure requires different design approaches in different regions.

The geographic location of each NWLON station is guided by Gill (2014), which serves to provide the nation's coastal vertical reference framework, through authoritative tidal and Great Lake datums. Within a geographic location, a specific site is selected based upon its ability to provide physical infrastructure upon which to mount the equipment, experience oceanographic conditions representative of the larger area, provide security for the station, offer access to power and communications, and other factors. Most NWLON stations are sited on a pier, wharf, bulkhead, seawall, or similar coastal infrastructure that is owned by another entity and from whom permission has been obtained. In areas where there is a lack of an existing base platform, it may need to be constructed and designed to withstand local environmental conditions and extremes (such as hurricanes). In the Great Lakes, most of the NWLON stations rely on a substantial below-ground heated sump system that enables year-round measurements through the harsh winter ice conditions.

A typical NWLON station consists of three distinct groups of components: sensors and electronics, support elements, and base platform.

- Sensors and electronics – oceanographic and meteorological sensors and supporting electronic components that are integrated to acquire observations and supply power and data communications.

  a. Primary and redundant data collection platforms (DCP)
  b. Primary and backup water level sensors
  c. Other oceanographic sensors, typically conductivity
  d. Meteorological sensors, typically wind (dual and single), water temperature, air temperature, and barometric pressure
  e. Data communications, typically Satlink (GOES or Iridium), IP modem and phone line (including cable, antenna, and transmitter, etc.)
  f. Power system, typically 12 Volt (12V)/40 Amp hour (Ah) Absorbent Glass Mat (AGM) battery, solar panels or Alternating Current (AC) 12V battery charger with associated surge protectors, etc.

- Support elements – components that mount, house, and protect the oceanographic and meteorological sensors and electronics at the station.

  a. Fiberglass shelter/environmental enclosure/NEMA 4X aluminum watertight enclosure housing the electronics
  b. 5-foot to 25-foot-high aluminum frame structures on concrete pads to elevate the enclosure above projected flood elevations
  c. A fiberglass utility pole or steel towers for mounting meteorological sensors, communication antennas, and other electronics
     - Mounting frames to support above- and below-water sensors

➢ Hardware including conduits, pipes, brackets, fasteners, etc.

- Base Platform – the physical base upon which the NWLON station is sited.

   a. Most coastal NWLON stations are sited on a pier, wharf, bulkhead, seawall, or other coastal infrastructure owned and managed by another entity from whom permission has been obtained. (Figure 1)
   b. Some nearshore coastal NWLON stations are on four-pile wooden or steel platforms when local piers, wharves, bulkheads, or seawalls do not provide sufficient elevation or strength. Some open coast stations are on a hurricane-hardened base platform, typically a steel or concrete monopile. Currently, NOAA owns four steel monopiles in the Gulf of Mexico region, and NWLON stations are located on six steel monopiles owned and managed by NOAA partners. (Figure 2)

Due to significant winter ice conditions, most Great Lakes NWLON stations use a heated sump system (see Figure 3). The sump is a vertical 6-foot diameter concrete pipe extending 20–40 feet into the ground, with a horizontal small diameter intake pipe that is below the lowest expected lake level and may extend out tens to thousands of feet offshore where it terminates into a concrete block that protects the intake. The sump is typically overtopped with a brick gauge house that shelters the sensors and electronics from harsh winter weather and ice conditions.

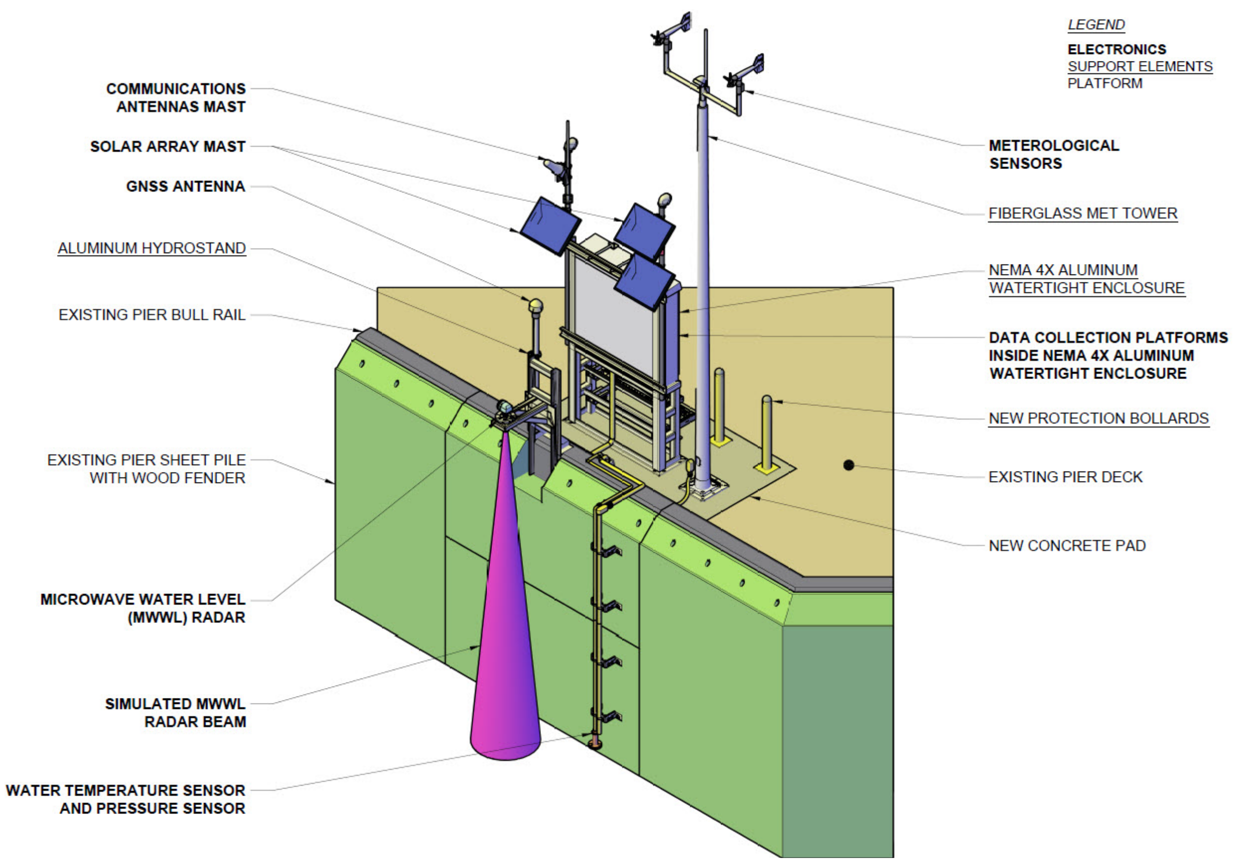

Figure 1. Typical coastal NWLON station configuration

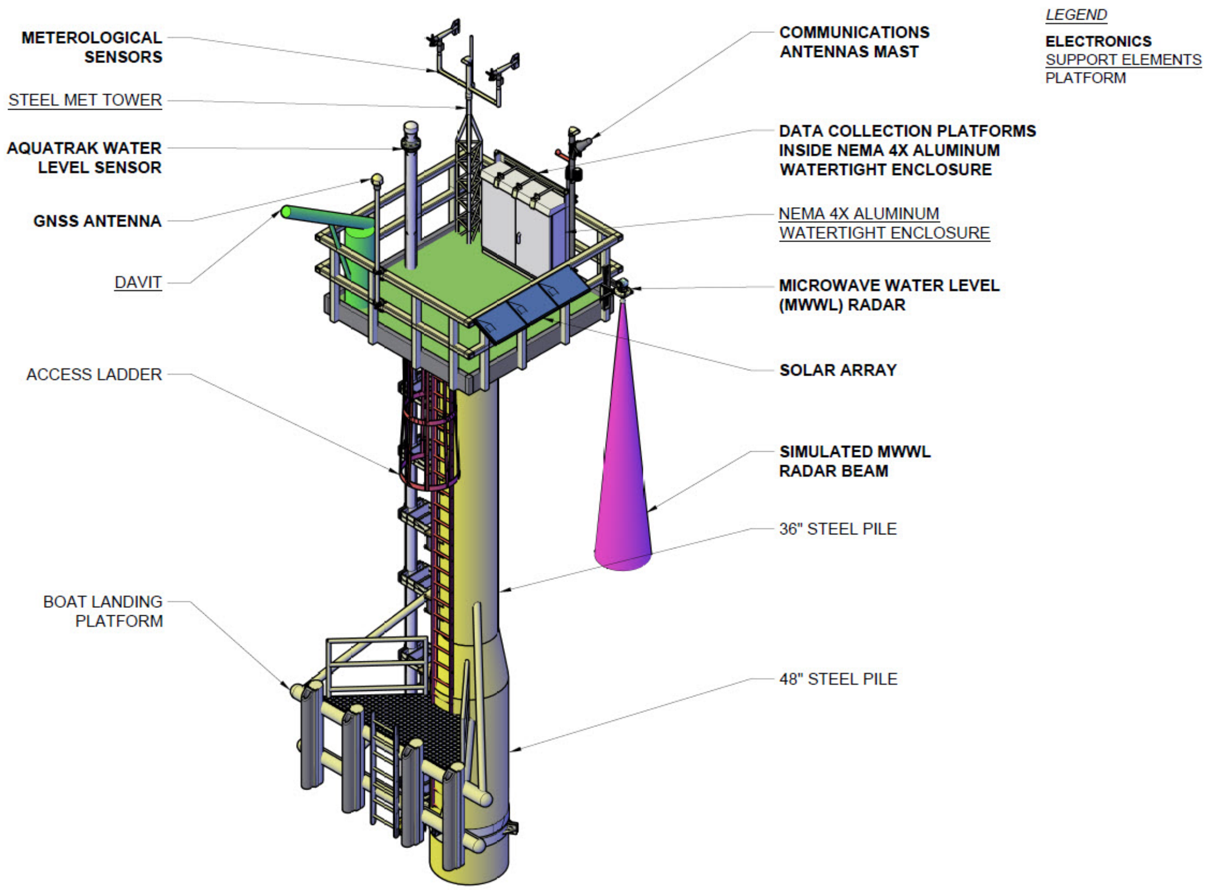

Figure 2. Typical nearshore NWLON station on a hurricane-hardened steel monopile

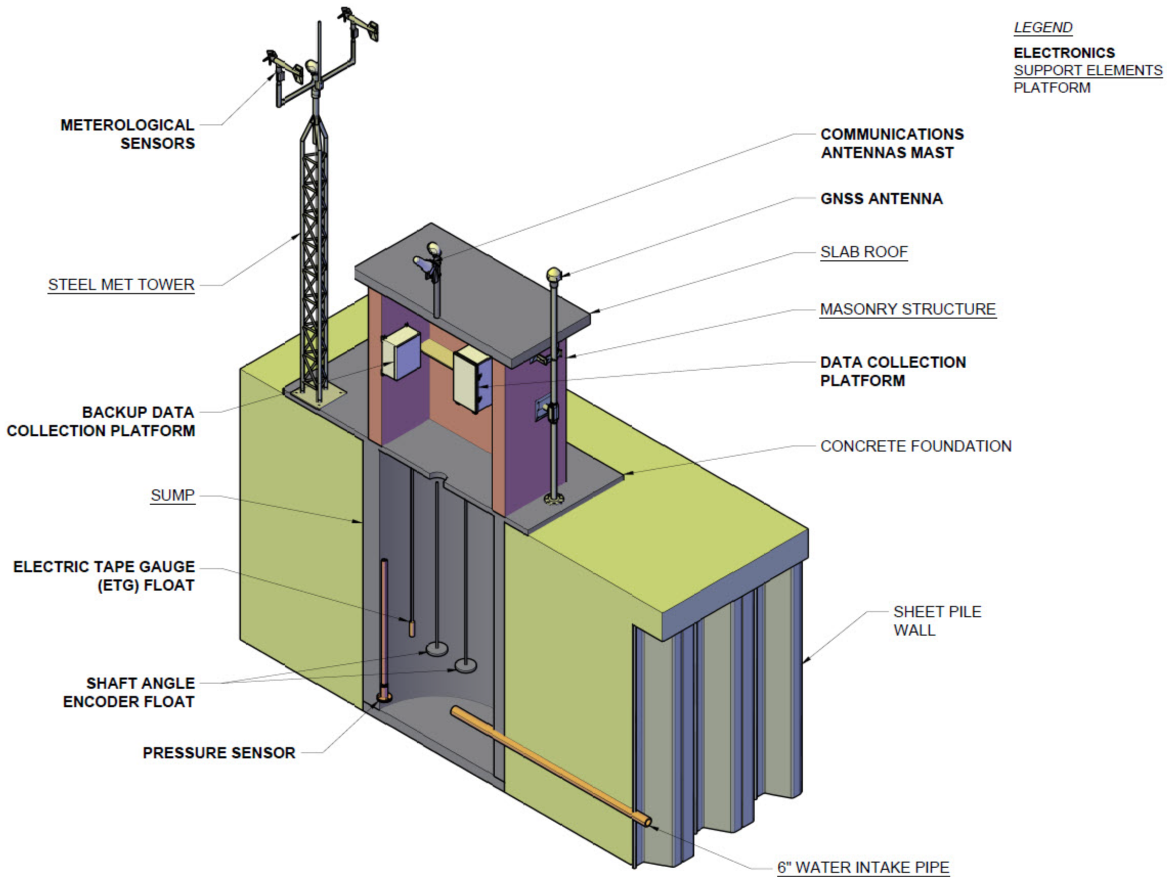

Figure 3. Typical Great Lakes gauge house and sump NWLON station

3. THE NWLON RECAPITALIZATION FRAMEWORK

In assessing the recapitalization requirements of the NWLON, CO-OPS considers the life expectancy of each station component with the goal of maintaining operational readiness of both the full network and individual stations.

All sensors and electronics at an NWLON station are typically replaced at least once during a 10-year period. CO-OPS plans and executes proactive replacement of aging components prior to their end-of-life date. In other instances, components are replaced to maintain compliance with frequent technology advances in both sensors and electronics. In general, NWLON electronics are well protected from the external environment through proven environmental enclosures; failure from external causes is rare. This maintenance is appropriately supported by the operations, research, and facilities budget.

Support elements such as fiberglass shelters, environmental enclosures, aluminum and steel support frames, masts/poles for meteorological instruments and communications antennas, sensor mounts, etc., are exposed to harsh environmental conditions and are prone to degradation. Marine corrosion, temperature extremes, ice, biofouling, wind and wave action, extreme weather events, etc. gradually degrade these components, so typically, all station platform components must be replaced within a 20-year period. This maintenance is appropriately supported by the operations, research, and facilities budget.

CO-OPS usually sites NWLON stations on available base platforms, for example, existing piers, wharves, bulkheads, or seawalls, and seeks permission from the local owner/manager for long-term access. CO-OPS-constructed base platforms are sometimes required at an NWLON station because no other physical infrastructure is available upon which to site a NWLON station. In other cases, available base platforms will not ensure operation of the NWLON station during extreme conditions and/or weather events. CO-OPS-constructed base platforms typically have a life expectancy of 25–50 years, depending upon their specific location, design, and construction material. Service life extensions are required to cost effectively attain or extend the life span of these base platforms by, for example, periodically repairing cracked concrete pads and building foundations.

Using the typical life expectancies for the major components of an NWLON station, CO-OPS developed a simple three-tiered framework for NWLON recapitalization.

- **Tier 1** NWLON stations have a life expectancy of 20 years. Tier 1 stations are one- to three-story, elevated frame structures installed on private and public concrete piers, wharves, bulkheads, or seawalls. This tier primarily addresses recapitalization – that is, proactive end-of-life replacement – of support element components. Examples include environmental enclosures, elevated frame structures, mounts for various sensors (such as utility poles or steel towers for mounting meteorological sensors), and other components (such as conduits, pipes, cables, and mounting hardware) to support underwater sensors. At present, 151 NWLON stations are in Tier 1, with 106 stations located in the 48 conterminous U.S. (Tier 1A) and 45 stations located in Alaska, the Caribbean, and the South Pacific, where recapitalization costs are higher due to significantly increased logistical expenses (Tier 1B).

- **Tier 2** NWLON stations have a life expectancy of 25 years. Tier 2 stations are typically one of two types. They are standalone four-pile timber structures in nearshore coastal areas, or Great Lakes non-sump stations that have prefabricated, heavily insulated fiberglass shelters with heated protective wells. These stations are typically protected from extreme storm surge but are still exposed to localized flooding, shore-fast ice, and/or high winds. This tier primarily addresses recapitalization – that is, proactive end-of-life replacement – of the four-pile timber base platforms in nearshore coastal areas, and the substantial support element components required for non-sump type Great Lakes stations. **At present, 25 NWLON stations are in Tier 2, and all 25 stations are located within the 48 conterminous U.S.**

- **Tier 3** NWLON stations have a life expectancy of 50 years. Tier 3 stations typically include Great Lakes brick gauge houses with sumps, as well as the large diameter (40-to-50--inch) Single Pile Instrumentation Platforms (SPIPs) that are Category 4+ hurricane-hardened base platforms. At the time of this report, there are 10 SPIPs along the Texas, Louisiana, and Mississippi coasts, four owned and maintained by NOAA, and six others constructed using the NOAA design, but owned and maintained by NOAA partners. This tier primarily addresses recapitalization—that is, both periodic service life extension work, as well as proactive end-of-life replacement—of the substantial base platforms required for these stations. **At present, 34 NWLON stations are in Tier 3, with 30 stations located in the Great Lakes region and four SPIP stations located in the Gulf of Mexico region.**

To provide further clarity on the types of activities that need to occur within the three tiers of the NWLON recapitalization framework, at least one example of the stations in each tier is described below.

Tier 1 Figure 4 shows the Sandy Hook, New Jersey NWLON station. It has a single-story metal frame sited on a U.S. Coast Guard (USCG) concrete pier. This pier replaced one severely damaged by Hurricane Sandy and was designed to support large USCG vessels for the next 50 years. CO-OPS was able to take advantage of the new elevated concrete pier design to site this NWLON station higher above typical storm surge levels.

Figure 4. Tier 1 Sandy Hook, New Jersey station

Tier 1 Figure 5 shows the Galveston, Texas Pier 21 NWLON station. It has a three-story elevated metal frame structure built on a reinforced concrete pier owned and managed by the City of Galveston. The DCP is elevated well above projected storm surge levels, minimizing the potential impacts of future hurricanes.

Figure 5. Galveston, Texas Pier 21 station

Tier 2 Figure 6 shows the Alexandria Bay, New York Great Lakes NWLON station. It has an insulated pitched-roof, timber-framed and sided insulated shelter with 24-inch diameter heated PVC wells. The station is located on a caisson-style concrete pier at a USCG Station.

Figure 6. Alexandria Bay, New York station

Tier 2 Figure 7 shows the Apalachicola, Florida NWLON station. The base platform is a typical multiple-timber pile structure constructed by CO-OPS, located in an area with no substantial piers or other coastal structures with suitable elevations for expected storm surge levels.

Figure 7. Apalachicola, Florida station

Tier 3 Figures 8 shows the Holland, Michigan Great Lakes NWLON station. It has a brick shelter that sits on top of a 6-foot diameter concrete sump and a thick concrete foundation that was integrated with the city's construction project for this waterfront area. This base platform provides a stable station able to deal with extreme Great Lakes ice and storms. The intake pipe extends 15 feet offshore at this station.

Figure 8. Holland, Michigan Great Lakes station on a clear day and during a typical annual storm

Tier 3 Figure 9 shows the Shell Beach, Louisiana NWLON station. The base platform is a SPIP, which is designed to withstand waves and wind generated by Category 4 hurricanes. The steel pile is 44 inches in diameter with a wall thickness of 2½ inches.

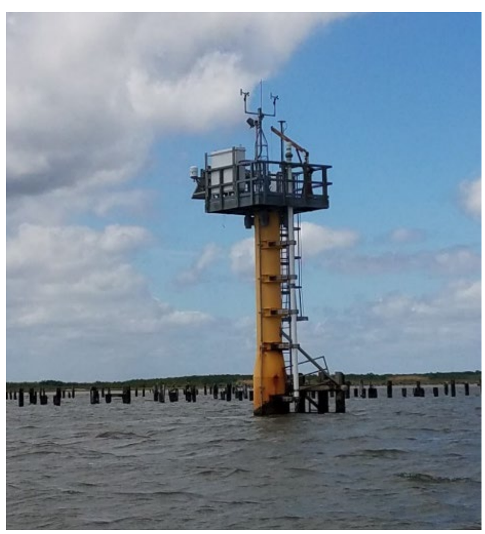

Figure 9. Shell Beach, Louisiana SPIP Station

4. NWLON STATION RECAPITALIZATION ACTIVITIES

This plan outlines three major types of NWLON station recapitalization: planned end-of-life replacement, service life extension work, and forced station relocation. A description and one or more examples are provided below for each of major type of NWLON station recapitalization.

4.1 Planned End-of-Life Replacement

Planned end-of-life replacement is the need to physically replace a discrete station component, or completely replace and rebuild a multiple-pile timber/steel structure or a Great Lakes gauge house and sump. Given typical timeframes to plan and execute these major construction activities, replacement must be done well in advance of the structure failing or becoming unsafe for personnel to access. Ideally, end-of-life replacements are implemented prior to structure failure but after the point where the investment in the support elements and base platform has been maximized. End-of-life replacement costs typically include both the costs of replacing the existing station and the costs of demolishing and removing the original station. The timelines for replacement activities can be significant, often multiyear, given the need to tailor station design for the local environment, obtain permits, conduct environmental compliance analysis, conduct advance geotechnical work needed to inform a contract solicitation, advertise and award the contract, perform construction, inspect and accept delivery, and then finally install sensors and electronics to achieve an operational station.

Examples

The multiple-pile timber structure at the Dauphin Island, Alabama NWLON station was originally constructed in 1980 (Figure 10). Over time, marine borer damage significantly degraded the structural capacity of the structure. NOAA divers found that six of the eight piles had more than 50-percent reduction in cross-section area (Figure 11). In addition, a recent storm destroyed the access pier, making the structure no longer safe for personnel to access and conduct maintenance. Using FY19 congressionally directed funds, this station is currently being removed and replaced with a new four-pile steel structure. The timeline required to replace Dauphin Island is projected to take 4 years.

Figure 10. Dauphin Island, Alabama timber structure

Figure 11. Dauphin Island Base platform damage found in an underwater survey of the station's timber piles

The Ogdensburg, New York NWLON station consists of a gauge house and sump in the Great Lakes region that is over 60 years old (Figure 12). The roof and siding are heavily weathered, and shoreline flooding and erosion have compromised its foundation on the city's bulkhead. The station's sump is framed by 1920s Erie Canal flat steel sheet piles (Figure 13). The station has major structural, safety, security, and sustainability issues. Using FY19 congressionally directed funds, this station is currently being removed and completely replaced. CO-OPS worked closely with the city to plan the replacement structure, in coordination with the repair of the bulkhead. The timeline to replace Ogdensburg is projected to be 4 years.

Figure 12. Ogdensburg, New York station and bulkhead erosion

Figure 13. Ogdensburg, New York station sheet pile corrosion

4.2 Service Life Extension Work

In the case of Tier 3 base platforms, such as SPIPs or Great Lakes gauge houses and sump stations, infrequent yet periodic major maintenance and refurbishment called service life extension work is required to ensure that the structure attains its full planned life expectancy of at least 50 years. In fact, service life extension work can often extend the service life of the station.

The SPIPs are designed and maintained in accordance with the American Petroleum Institute's API RP-2 (2014) and API 2SIM (2014). This guidance requires periodic surveys to be performed, from rudimentary visual surveys above and below the water line to destructive testing, both of which are important to extending the service life of each structure. During scheduled site visits, CO-OPS field crews and engineers regularly conduct Level 1 visual surveys. At least every 15 years or after scheduled maintenance finds excessive corrosion, CO-OPS contracts out for professional marine surveyor support for a detailed Level 2 structural survey above and below the water line. This survey can identify necessary service life extension work, such as replacing severely corroded nonstructural members on boat landings and access platforms, renewing aluminum anode cathodic protection, renewing electrical grounding systems, and recoating with specialized marine coating systems from below the lowest low water to above the highest splash zone. This survey is important to maintaining structural integrity, protecting the original significant investment made in this base platform, and ensuring it will operate through major storm events.

Service life extension work for Great Lakes gauge houses and sump stations can include completely draining the sumps, repairing any water damage, replacing sealant, repairing the mortar joint, flushing the intake pipe, replacing the brick, replacing the concrete slab roof, and retrofitting weeps, ties, and flashing. While some of this work is done reactively and incrementally during regular maintenance visits, complete and thorough service life extension work should be performed every 10 years.

Examples

The Calcasieu Pass, Louisiana NWLON station is one of four identical SPIPs structures – constructed in the Gulf of Mexico in 2008 using hurricane supplemental funds. Recent visual inspections of this structure, as well as the other three SPIPs owned and managed by NOAA, indicate the need for service life extension work due to corrosion issues. Figures 14 and 15 illustrate the corrosion and resulting safety concerns experienced at this station.

Figure 14. Corrosion issues on the Calcasieu Pass SPIP boat landing

Figure 15. – Corrosion issues at the Calcasieu Pass SPIP boat landing doubler plates and support pipe beams

4.3 Forced Station Relocations

Forced station relocations occur when CO-OPS is notified by the owner of the property upon which the NWLON station is sited that the station must be moved. This happens for a variety of reasons, such as the owner will be renovating their property, demolishing the structure, or repurposing the site for another use. Sometimes the requests for station relocation occur with very short notice. In most cases, prior to removing the NWLON station, CO-OPS installs a temporary water level station (from existing inventory) nearby in order to maintain critical data continuity. This temporary station is typically in operation while waiting for the original base platform to be rebuilt or renovated, or while locating a new site, obtaining owner permission, and re-establishing the NWLON station at this new site. It should be noted that these temporary stations are typically not designed or constructed to survive environmental extremes over longer time scales. Based on historical information, CO-OPS executes two forced station relocations per year on average.

5. STATION-BY-STATION CONDITION ASSESSMENT

NWLON station site visits are typically performed annually to conduct scheduled maintenance, level the station to a local benchmark network to document sensor stability and assess the station's operational condition. Operational condition is documented in digital site reports by the CO-OPS Field Operations Division and verified by the CO-OPS Engineering Division.

In FY20, NOAA officially adopted the Department of Defense U.S. Army Corps of Engineers Builder Program for facility condition assessments. Based on this program, CO-OPS adopted the Operational Condition Assessment flow chart scoring logic (Figure 16) to augment recapitalization planning priorities simply based on the age of the station. This facilitates a more thoughtful approach to assessing and identifying CO-OPS recapitalization needs and priorities for all NWLON capital assets. Appendix A presents the result of this approach, which is a list of relative station priorities for recapitalization across all three tiers of the NWLON recapitalization framework.

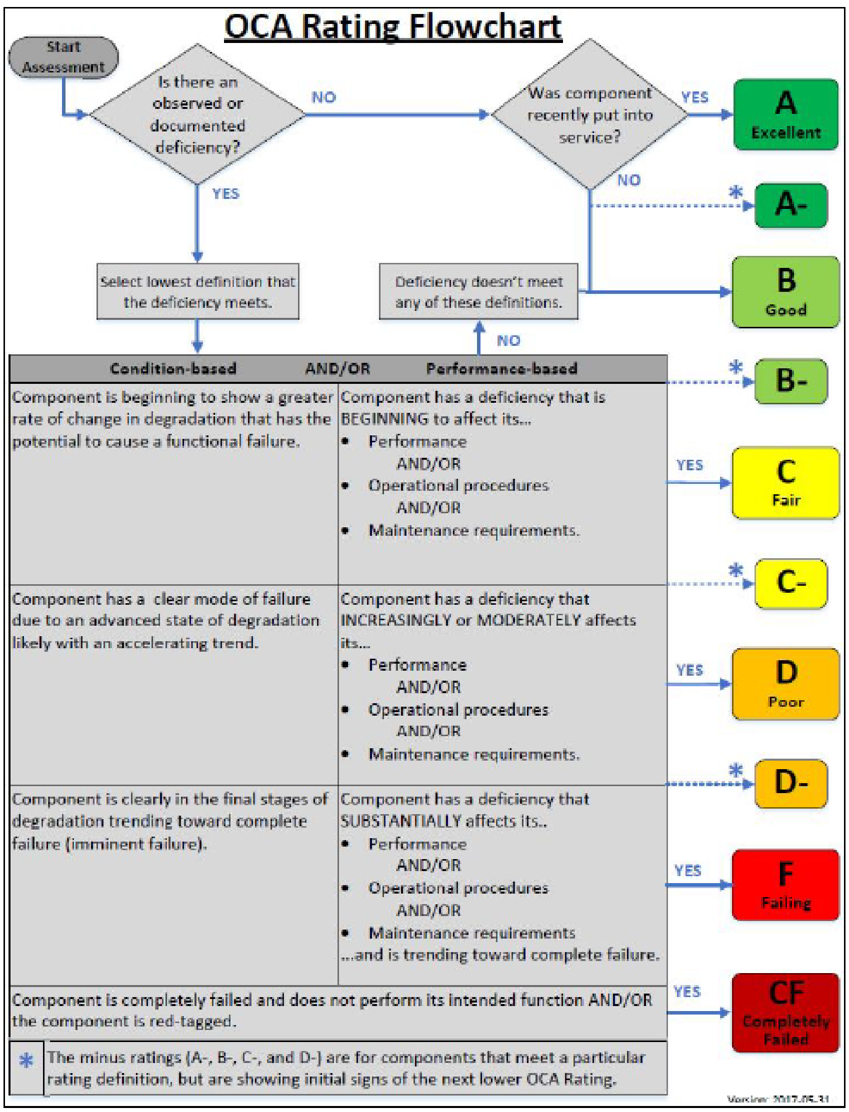

Figure 16. Builder Program Operational Condition Assessment rating flowchart

6. RECAPITALIZATION SCHEDULE

As stated in the *Background and Purpose* section of this report, the purpose of this plan is to outline NWLON recapitalization requirements to support a staggered station recapitalization schedule for Tier 2 and Tier 3 stations that can be executed within a stable, level-funded procurement, acquisition and construction budget profile. Table 1 presents a 25-year schedule (that is, it repeats at 25-year intervals) that addresses recapitalization needs for the current 210 NWLON stations over the 20-, 25-, and 50-year timescales outlined in the three-tier NWLON Recapitalization Framework. Work among Tier 3 stations is staggered such that CO-OPS is not initiating more than one of these recapitalization projects in any given year.

Table 1. NWLON Recapitalization Schedule

Year	Tier 1A	Tier 1B	Tier 2	Tier 3 Great Lakes	Tier 3 SPIP
1	4	2	1	1	SLE
2	4	2	1	SLE	
3	5	2	1	1	
4	4	3	1	SLE	1
5	4	2	1	1	
6	4	2	1	SLE	
7	4	2	1	1	
8	5	2	1	SLE	
9	4	3	1	1	
10	4	2	1	SLE	
11	4	2	1	1	SLE
12	4	2	1	SLE	
13	5	2	1	1	
14	4	3	1	SLE	1
15	4	2	1	1	
16	4	2	1	SLE	
17	4	2	1	1	
18	5	2	1	SLE	
19	4	3	1	1	
20	4	2	1	SLE	
21	4	2	1	1	SLE
22	4	2	1	SLE	
23	5	2	1	1	
24	4	3	1	SLE	1
25	4	2	1	1	

SLE = Service Life Extension work

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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APPENDIX A. STATION-BY-STATION NWLON CONDITION ASSESSMENT

Station ID	Station Location	Year shelter or supporting structure Installed	Expected Infrastructure Renewal Year	Tier	2020 Operational Condition Assessment Score
8311030	Ogdensburg, NY	1949	1999	3	F
8735180	Dauphin Island, AL	1986	2011	2	F
8766072	Freshwater Canal Locks, LA	2009	2029	1	F
1770000	American Samoa Disabled Oct2020 for pier work COVID travel impact	2009	2029	1	F
9087079	Green Bay, WI (Demolished Nov 2020. Temp Installed)	1996	2046	3	F
8768094	Calcasieu Pass, LA	2008	2058	3	D
8747437	Bay Waveland YC, MS	2009	2059	3	D
8761305	Shell Beach, Lake Borgne, LA	2009	2059	3	D
8764227	LAWMA, Amerada Pass, LA	2008	2058	3	D
8551910	Reedy Point, DE	1994	2014	1	D
9014096	Dunn Paper, MI	2000	2020	1	D
9455760	Nikiski, AK	2002	2022	1	D
9076024	Rock Cut, MI	2001	2026	2	D
8670870	Fort Pulaski, GA	1977	1997	1	C
9014087	Dry Dock, MI	1956	2006	3	C
8635750	Lewisetta, VA	1990	2010	1	C
1611400	Nawiliwili, HI	1993	2013	1	C
8656483	Beaufort (Duke Marine Lab), NC	1994	2014	1	C
8454000	Providence, RI	1995	2015	1	C
8637689	Yorktown USCG Training Ctr, VA	2004	2024	1	C
9052000	Cape Vincent, Lake Ontario	2004	2024	1	C
8741533	Pascagoula, MS	2007	2027	1	C
9432780	Charleston, OR	2008	2028	1	C
9451600	Sitka, AK	2008	2028	1	C
9455920	Anchorage, AK	2008	2028	1	C
9411340	Santa Barbara, CA	2009	2029	1	C
8729210	Panama City Beach, FL	2013	2033	1	C
9468756	Nome, AK	2016	2036	1	C
9099004	Point Iroquois, MI	1995	2045	3	C

Station ID	Station Location	Year shelter or supporting structure Installed	Expected Infrastructure Renewal Year	Tier	2020 Operational Condition Assessment Score
9063038	Erie, PA	1955	1980	2	B
9063090	Fermi Power Plant, MI	1961	1986	2	B
9044030	Wyandotte, MI	1962	1987	2	B
9063063	Cleveland, OH	1963	1988	2	B
9052076	Olcott, NY	1966	1991	2	B
9044036	Fort Wayne, MI	1968	1993	2	B
9014080	St Clair State Police, MI	1970	1995	2	B
9454050	Cordova, AK	1976	1996	1	B
9063028	Sturgeon Point, NY	1950	2000	3	B
9075099	De Tour Village, MI	1977	2002	2	B
1890000	Wake Island	1982	2002	1	B
9099018	Marquette C.G., MI	1979	2004	2	B
9063007	Ashland Ave., NY	1957	2007	3	B
9063053	Fairport, OH	1982	2007	2	B
8311062	Alexandria Bay, NY	1983	2008	2	B
9099044	Ontonagon, MI	1983	2008	2	B
8545240	Philadelphia, PA	1989	2009	1	B
9412110	Port San Luis, CA	1989	2009	1	B
9454240	Valdez, AK	1989	2009	1	B
9410660	Los Angeles, CA	1990	2010	1	B
9435380	South Beach, OR	1990	2010	1	B
9439040	Astoria, OR	1990	2010	1	B
9052058	Rochester, NY	1961	2011	3	B
9453220	Yakutat, AK	1992	2012	1	B
9044049	Windmill Point, MI	1963	2013	3	B
9087044	Calumet Harbor, IL	1963	2013	3	B
8721604	Trident Pier, FL	1994	2014	1	B
9044020	Gibraltar, MI	1989	2014	2	B
9075014	Harbor Beach, MI	1964	2014	3	B
9087072	Sturgeon Bay Canal, WI	1964	2014	3	B
8658120	Wilmington, NC	1995	2015	1	B
9063009	American Falls, NY	1965	2015	3	B
9063020	Buffalo, NY	1965	2015	3	B
9410840	Santa Monica, CA	1995	2015	1	B
9414750	Alameda, CA	1995	2015	1	B
9452400	Skagway, AK	1995	2015	1	B
9052030	Oswego, NY	1991	2016	2	B
8557380	Lewes, DE	1997	2017	1	B
8651370	Duck, NC	1997	2017	1	B

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9099064	Duluth, MN	1997	2017	1	B
9014098	Fort Gratiot, MI	1968	2018	3	B
1619910	Sand Island, Midway	1998	2018	1	B
9034052	St Clair Shores, MI	1968	2018	3	B
9087096	Port Inland, MI	1993	2018	2	B
9410230	La Jolla, CA	1998	2018	1	B
8632200	Kiptopeke, VA	1999	2019	1	B
1617433	Kawaihae, HI	2000	2020	1	B
8725110	Naples, FL	2000	2020	1	B
9087057	Milwaukee, WI	1970	2020	3	B
8447930	Woods Hole, MA	2001	2021	1	B
8534720	Atlantic City, NJ	2002	2022	1	B
9416841	Arena Cove, CA	2002	2022	1	B
9459450	Sand Point, AK	2002	2022	1	B
8410140	Eastport, ME	2003	2023	1	B
8536110	Cape May, NJ	2003	2023	1	B
8762482	West Bank 1, Bayou Gauche, LA	2003	2023	1	B
9455090	Seward, AK	2003	2023	1	B
8594900	Washington, DC	2004	2024	1	B
8658163	Wrightsville Beach, NC	2004	2024	1	B
8729840	Pensacola, FL	2004	2024	1	B
9452210	Juneau, AK	2004	2024	1	B
9063079	Marblehead, OH	2000	2025	2	B
9419750	Crescent City, CA	2005	2025	1	B
9452634	Elfin Cove, AK	2005	2025	1	B
1615680	Kahului, HI	2006	2026	1	B
8570283	Ocean City Inlet, MD	2006	2026	1	B
8638610	Sewells Point, VA	2006	2026	1	B
8761927	USCG New Canal Station, LA	2006	2026	1	B
9444090	Port Angeles, WA	2006	2026	1	B
9457804	Alitak, AK	2006	2026	1	B
9461710	Atka, AK	2006	2026	1	B
9464212	Village Cove, Pribilof Is, AK	2006	2026	1	B
9751381	Lameshur Bay, St Johns, VI	2006	2026	1	B
9751401	Lime Tree Bay, VI	2006	2026	1	B
1820000	Kwajalein, Marshall Islands	2007	2027	1	B

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8737048	Mobile State Docks, AL	2007	2027	1	B
9063012	Niagara Intake, NY	2002	2027	2	B
9075035	Essexville, MI	1977	2027	3	B
9087023	Ludington, MI	1977	2027	3	B
9087068	Kewaunee, WI	2007	2027	1	B
9449424	Cherry Point, WA	2007	2027	1	B
1612340	Honolulu, HI	2008	2028	1	B
1612480	Mokuoloe, HI	2008	2028	1	B
8449130	Nantucket Island, MA	2008	2028	1	B
8452660	Newport, RI	2008	2028	1	B
8767816	Lake Charles, LA	2008	2028	1	B
9413450	Monterey, CA	2008	2028	1	B
9414290	San Francisco, CA	2008	2028	1	B
9418767	North Spit, CA	2008	2028	1	B
9431647	Port Orford, OR	2008	2028	1	B
9440422	Longview, WA	2008	2028	1	B
9441102	Westport, WA	2008	2028	1	B
9442396	La Push, WA	2008	2028	1	B
9451054	Port Alexander, AK	2008	2028	1	B
9455500	Seldovia, AK	2008	2028	1	B
9462450	Nikolski, AK	2008	2028	1	B
9462620	Unalaska, AK	2008	2028	1	B
9415144	Port Chicago, CA	2009	2029	1	B
9437540	Garibaldi, OR	2009	2029	1	B
9449880	Friday Harbor, WA	2009	2029	1	B
8411060	Cutler Farris Wharf, ME	2010	2030	1	B
8631044	Wachapreague, VA	2010	2030	1	B
8722670	Lake Worth Pier, FL	2010	2030	1	B
8725520	Fort Myers, FL	2010	2030	1	B
9457292	Kodiak Island, AK	2010	2030	1	B
9459881	King Cove, AK	2010	2030	1	B
9491094	Red Dog Dock, AK	2010	2030	1	B
9497645	Prudhoe Bay, AK	2010	2030	1	B
9759110	Magueyes Island, PR	2010	2030	1	B
8720218	Mayport, FL	2011	2031	1	B
8779770	Port Isabel, TX	2011	2031	1	B
9014070	Algonac, MI	2011	2031	3	B
9076027	West Neebish Island, MI	2006	2031	2	B
8652587	Oregon Inlet, NC	2012	2032	1	B

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9461380	Adak Island, AK	2012	2032	1	B
1630000	Apra Harbor, Guam	2013	2033	1	B
8771450	Galveston Pier 21, TX	2013	2033	1	B
9063085	Toledo, OH	2008	2033	2	B
9076033	Little Rapids, MI	2008	2033	2	B
8510560	Montauk, NY	2014	2034	1	B
8516945	Kings Point, NY	2014	2034	1	B
8518750	The Battery, NY	2014	2034	1	B
8726724	Clearwater Beach, FL	2014	2034	1	B
8413320	Bar Harbor, ME	2015	2035	1	B
8577330	Solomons Island, MD	2015	2035	1	B
8635027	Dahlgren, VA	2015	2035	1	B
9443090	Neah Bay, WA	2015	2035	1	B
9450460	Ketchikan, AK	2015	2035	1	B
9755371	San Juan, PR	2015	2035	1	B
8764044	Berwick, LA	2011	2036	2	B
8461490	New London, CT	2016	2036	1	B
8467150	Bridgeport, CT	2016	2036	1	B
8531680	Sandy Hook, NJ	2016	2036	1	B
8661070	Springmaid Pier, SC	2016	2036	1	B
8720030	Fernandina Beach, FL	2016	2036	1	B
8726520	St. Petersburg, FL	2016	2036	1	B
9440910	Toke Point, WA	2016	2036	1	B
9444900	Port Townsend, WA	2016	2036	1	B
9468333	Unalakleet, AK	2016	2036	1	B
9751364	Christiansted, St Croix, VI	2016	2036	1	B
9751639	Charlotte Amalie, VI	2016	2036	1	B
9752695	Vieques Island, PR	2016	2036	1	B
9410170	San Diego, CA	2017	2037	1	B
9447130	Seattle, WA	2017	2037	1	B
8574680	Baltimore, MD	2017	2037	1	B
8723214	Virginia Key, FL	2017	2037	1	B
8724580	Key West, FL	2017	2037	1	B
8760922	Pilots Station, SW Pass, LA	2017	2037	1	B
8638863	Chesapeake Bay Br. Tunnel, VA	2018	2038	1	B
1617760	Hilo, HI	2018	2038	1	B
8571892	Cambridge, MD	2018	2038	1	B

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8575512	Annapolis, MD	2018	2038	1	B
8665530	Charleston, SC	2018	2038	1	B
8723970	Vaca Key, FL	2018	2038	1	B
8774770	Rockport, TX	2018	2038	1	B
9415020	Point Reyes, CA	2018	2038	1	B
9759394	Mayaguez, PR	2021	2041	1	B
8728690	Apalachicola, FL	1992	2042	2	B
8775870	Bob Hall Pier, Corpus Christi, TX	2017	2042	2	B
9099090	Grand Marais, MN	1999	2049	3	B
9075065	Alpena, MI	2005	2055	3	B
9014090	Mouth of the Black River, MI	2008	2058	3	B
9075002	Lakeport, MI	2008	2058	3	B
9075080	Mackinaw City, MI	2008	2058	3	B
8727520	Cedar Key, FL	2009	2059	1	B
9087088	Menominee, MI	2009	2059	3	B
9087031	Holland, MI	2010	2060	3	B
9752235	Culebra, PR	2018	2038	1	A
9759938	Mona Island, PR	2018	2038	1	A
8418150	Portland, ME	2019	2039	1	A
8443970	Boston, MA	2019	2039	1	A
8571421	Bishops Head, MD	2019	2039	1	A
8654467	USCG Station Hatteras, NC	2019	2039	1	A
8729108	Panama City, FL	2019	2039	1	A
8761724	Grand Isle, LA	2019	2039	1	A
9463502	Port Moller, AK	2020	2040	1	A

ACRONYMS

CO-OPS	Center for Operational Oceanographic Products and Services
DCP	Data collection platform
FY	Fiscal year
GOES	Geostationary operational environmental satellite
NEMA	National Electrical Manufacturers Association
NOAA	National Oceanic and Atmospheric Administration
NWLON	National Water Level Observation Network
SPIP	Single Pile Instrumentation Platform
USCG	United States Coast Guard