HURRICANE PREPAREDNESS: NYC TRANSIT CAN IMPROVE OVERSIGHT OF FLOOD CONTROL DEVICES – FINAL REPORT

Elizabeth Keating
Acting MTA Inspector General
State of New York

I. EXECUTIVE SUMMARY

On October 29, 2012, Hurricane Sandy caused record coastal flooding and wind damage to Metropolitan Transportation Authority (MTA) assets in New York City (NYC), Long Island, and areas of New York and Connecticut served by Metro-North Railroad. MTA's resulting losses were estimated in January 2013 at $5 billion in infrastructure damage and lost revenue. In response, the Federal Transit Administration (FTA) approved $5.8 billion in grants to the MTA for repairs and resiliency projects. These grants, supplemented by funding from New York State and NYC, are allowing the MTA to both repair the damage and harden its systems to mitigate future harm from storm surges. The agency has allocated the bulk of the monies to protect the NYC Transit subway system. Most of these funds have paid for permanent structures, such as seawalls and flood walls, along with the elevation of critical equipment.

Water intrusions occurring through yard portals, sidewalk vents, and manholes, however, cannot be permanently prevented without affecting transportation services. To protect these vulnerable locations, NYC Transit has purchased over 3,500 flood control devices, at a cost of approximately $350 million, and 97% have been installed. Each of these devices must be manually deployed ahead of a storm.

This report focuses on the installation, testing, maintenance, and tracking of such flood control devices – as well as the training provided to employees – to determine whether the agency could improve its handling of this critical equipment. By monitoring the acceptance and incorporation of these devices into NYC Transit's hurricane response plan, Office of the MTA Inspector General (OIG) gained insight into the status of the agency's preparedness.

Overall, OIG found that NYC Transit, and its Emergency Management & Preparedness Group in particular, have taken substantive and appropriate steps to address this large and complex task. The agency expedited its plans and designs after Hurricane Sandy and executed contracts to initiate the hardening projects within a very short time period. The basic mechanisms for tracking and controlling the work are in place and adequate; however, the agency should formalize and fine-tune its efforts as it transitions from the task of constructing and installing these critical devices to the long-term responsibility of maintaining and monitoring them. OIG found that each user group has been tasked with coordinating its own procedures and

preparations independently of the other groups and that a more coordinated approach would be beneficial to all involved. The responsibilities that overlap between the groups would also benefit from centralization, such as maintenance checklists, training, scheduling mock deployments, and spare parts inventory and control.

A. Summary of Findings and Recommendations

- **NYC Transit should improve its information system and procedures to better support the maintenance and deployment of all flood protection devices.** The NYC Transit Department of Subways (DOS) needs better information on the number, type, and location of each device in order to perform proper maintenance and assign responsibility for specific tasks.

  Enterprise Asset Management (EAM) software should include all of the flood control devices – including those managed by DOS as well as those located in bus depots, maintenance facilities, storage yards, and on the premises of the Staten Island Rapid Transit Operating Authority (SIRTOA). (*See* pp. 10-14.)

- **NYC Transit should improve the training provided to employees responsible for maintaining and activating the devices.** OIG found that employee training on deploying and maintaining the flood control devices was haphazard and the agency had not documented the training that had been completed. In addition, installation contractors were not required to provide in-person, hands-on training. To improve its readiness, and in light of turnover in key maintenance positions, the agency should establish a method for ensuring adequate staffing and training of the field crews that must deploy devices in preparation for a storm. (*See* pp. 14-16.)

- **NYC Transit should have established clearer and more rigorous standards for contractors installing the devices.** OIG's review found that installation contracts could have been strengthened to include standards for the contractors' detailed testing procedures. (*See* pp. 16-18.)

- **To improve its Hurricane Plan, NYC Transit should develop efficient deployment routes and accurate time estimates.** NYC Transit has not gathered sufficient information on deployment timelines, which is necessary to verify that all required deployments are feasible in the time allotted in the agency's Hurricane Plan (described in the Background section, below). For example, the estimates that OIG reviewed did not take into account employees' travel time between device locations, thus underestimating the time required to deploy each device to reach a specified level of preparedness. In

addition, the agency would benefit from planned deployment routes, with designated personnel and devices, to ensure that every device has been assigned to a specific team and all devices are deployed in the event of a storm. (*See* pp. 19-21.)

- **To ensure that flood control devices remain in a state of good repair, NYC Transit should improve its management of spare parts.** Currently, each user group must maintain its own inventory of critical spare parts. Assigning this function to a centralized location, insofar as it is feasible, would be more efficient and would give the agency a more accurate understanding of its inventory needs. (*See* pp. 22-23.)

- **Lastly, NYC Transit should schedule deployment exercises regularly to train the field crew members and assess the condition of the flood control devices.**Every device should be activated at least once over a reasonable time period. These deployments should also yield dependable estimates – akin to time and motion studies – of how many teams will be necessary to deploy all of the devices in the timeframe allotted in the agency's Hurricane Plan. (*See* pp. 23-24.)

In addition to taking these steps, NYC Transit should authorize a central group to oversee certain critical tasks – including employee training, maintenance procedures, mock deployment, and spare parts management – to increase efficiency and improve consistency among the user departments. This recommended approach appears in several places throughout this Report. OIG believes that the centralization of authority and responsibility will improve NYC Transit's overall hurricane preparedness.

Our detailed suggestions for improvement appear in the Recommendations section at the end of this Report. (*See* pp. 25-27.)

B. Summary of Agency Response

NYC Transit was receptive to the findings and recommendations made in the OIG report and it accepted 14 of the 15 recommendations. Four of the accepted recommendations were reported as already having been completed with implementation of the remaining 10 anticipated by end of year 2023. The recommendation to centralize responsibility for the plan under one entity was rejected in favor of Subways and Buses maintaining autonomy over their own plans with quarterly coordination meetings.

II. BACKGROUND

The damage caused by Hurricane Sandy was primarily due to high winds and storm surge, defined by the National Oceanic and Atmospheric Administration (NOAA) as "the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore." Four of the MTA's agencies – NYC Transit, Metro-North Railroad (MNR), Long Island Railroad (LIRR), and the Triborough Bridge and Tunnel Authority (TBTA) – have all since developed hurricane plans to be activated in preparation for a forecasted storm surge. Because storm surge primarily impacts NYC Transit, $4.5 billion of the $5.8 billion provided by the FTA is being spent to harden NYC Transit assets.[1]

NYC Transit is using the funds both to repair the initial damage from Hurricane Sandy and to implement resiliency measures to minimize damage from future storms. Resiliency efforts include improvements to the system based on lessons learned from Hurricane Sandy as well as studies prepared by the National Hurricane Center (NHC), a division of NOAA. The NHC develops topographical maps showing the areas affected by storm surges at differing levels of flood height; the maps illustrate different zones, showing which areas will be flooded at different water levels. This information allows the MTA to prioritize its system shutdown protocols and preventive hardening activities. Hurricane Sandy made landfall at Atlantic City, New Jersey, as a Category 1 hurricane with sustained winds of 90 miles an hour. NYC Transit DOS designed its Hurricane Plan predicated on a Category 2 hurricane storm surge, plus three feet.

A. NYC Transit's Actions in Response to Hurricane Sandy

Immediately following Hurricane Sandy's tremendous impact, NYC Transit needed to develop and implement a plan both to harden the system against future hurricanes and to prepare for a future storm when one was imminent. To mitigate future storm surge damage, NYC Transit initiated a program to identify areas vulnerable to flooding, proactively design and install hardening measures to protect those areas, and institute a response protocol for forecasted hurricanes affecting the MTA service area. The result is the NYC Transit Department of Subways Hurricane Plan (the Hurricane Plan or the Plan).

[1] NYC Transit is the focus of this report; we discuss MNR, LIRR, TBTA, and SIRTOA only briefly in the report and its appendices.

1. Addressing Vulnerabilities

Before NYC Transit could design any mitigation efforts, it had to categorize the types of water intrusion points into the system. These included subway station entrances, manholes, sidewalk vents, and yard portals. DOS had to quantify how many of each type needed to be mitigated and protected and then determine the best protection options. The goal of these efforts was to minimize water intrusion to the extent possible, thereby minimizing damage to at-risk assets. The devices discussed in this Report are designed specifically to limit the amount of water infiltrating the subway system (and other assets) via vulnerabilities that cannot be permanently sealed. The subway system is already designed to handle the equivalent of 1.5 inches of rain per hour using pumps which direct the water into city drains. Amounts above that level will tax the subway system's ability to clear the water.

Wherever a permanent improvement could feasibly protect multiple penetration spots, NYC Transit implemented such options (e.g. seawalls or other constructed barriers). Penetration locations that could not be sealed, covered, or otherwise secured permanently, however, required protective devices that could be deployed and activated in the event of a storm. Significantly, for the day-to-day operation of the system, such devices must also be used anywhere that openings in the system are necessary and must be quickly deployable to seal and protect the system. Typical types of openings requiring these devices are station stairwell entrances, sidewalk vents that allow air to circulate underground, fan plants, and track portals from the yards into the subways. In addition, some above-ground facilities in low-lying areas require these devices.

Once NYC Transit determined the types and quantities of devices it needed for all its vulnerable locations, it completed the designs for protecting each water penetration point and then executed construction contracts with a number of general contractors to fabricate, test, and install the various devices. As of February 2022, approximately 97% of the 3,500 devices were installed and are ready for use when needed. Once all devices are installed and accepted, DOS will become responsible for their maintenance and deployment. Within DOS two groups – Stations, and Maintenance of Way (MOW) Infrastructure – will perform the ongoing maintenance and deployment functions.

2. The Department of Subways Hurricane Plan

With the implementation of the hardening program underway, NYC Transit needed a formal plan to guide its preparations for a hurricane, including the activation of the devices. The agency therefore developed a Hurricane Plan to coordinate the agency's response.

The DOS Hurricane Plan, updated annually in June prior to the New York hurricane season, lays out specific steps that must be accomplished prior to any anticipated storm surge.[2] All timelines are in reference to the anticipated "zero hour," the date and time that sustained winds are projected to reach 39 miles per hour. Weather forecasts and advisories from the NHC are monitored and plans are established accordingly. The plan begins 72 hours prior to a storm's predicted arrival and lays out in specific detail what steps must be taken 72, 48, 12 and 8 hours prior. All activities that NYC Transit can accomplish on its own authority are started as early as possible. The staging of people and equipment, deployment of portable generators and pumps to anticipated areas of need, inspection and cleaning of drains and pump rooms, and other key tasks are all scheduled before any preventive shutdown of the subway system. The agency can also begin activating and deploying any devices that do not affect services to the public.

The effectiveness of the Hurricane Plan is contingent on the agency's ability to start deploying its protective devices and taking other actions to protect subway stations and tunnels at least 12 hours before zero hour. When a forecast is particularly dire, the complete shutdown of operations would include the sealing of subway and tunnel entrances and cessation of train services. Because this action impedes the evacuation of people from low-lying areas and raises other safety concerns, MTA leaders can make such a decision only in conjunction with local and state counterparts. Any delay in the implementation of the Plan can adversely affect the agency's ability to complete its myriad steps in time and puts NYC Transit field personnel at higher risk.

B. Types of Devices: Department of Subways

To fully describe the scope of the work involved when NYC Transit prepares for a storm surge requires a summary of the most prevalent types of devices, the quantities of each device, and how they are used. The six most common types of devices are described below, and a photo of each type of device appears in Appendix 1. There are, however, several other device types in addition to those discussed here; they are used in smaller numbers in specialty applications such as fan houses and circuit breaker houses. The devices discussed below are for DOS locations only, excluding those at train yards, SIRTOA, and bus depots. The estimates of how long deployment will take for each category of device come from observations reported to OIG of mock deployments, which were limited in number and conducted in controlled environments.

[2] The DOS Hurricane Plan relies on topographical maps prepared by the NHC. These maps show the anticipated rise in sea level for each category of storm for the NY metropolitan area. (See Appendix 2.)

The devices are installed across the system in accordance with a flood map developed by the NHC showing projected areas of storm surge. (*See* Appendix 2.)

1. Mechanical Closure Devices (approx. 2,230 devices)

While sidewalk vents are necessary to allow airflow into the subways, they become open pathways for above-ground water to flow unobstructed into the subway system during hurricanes. A Mechanical Closure Device (MCD) is typically installed inside a vent and seals off the opening when triggered. The devices are spring-loaded and must be manually tripped by subway personnel in the event of an anticipated flood condition, thus protecting the vent shaft from water intrusion. These devices must then be reset by hand into the open position after flooding recedes.

In the event of a storm, NYC Transit will be responsible for closing 2,230 MCDs. How many will need to be closed – and where – will depend on the expected severity and path of the storm. During a mock deployment, NYC Transit personnel observed crews of seven individuals and reported that the crew required an average of slightly less than one minute to close each of these devices. (link to photo)

2. Deployable Vent Covers (approx. 680 devices)

Because not all vents can accommodate permanently installed MCDs without restricting airflow, deployable vent covers are sometimes used to seal subway air vents. The covers are reusable but cannot be permanently installed. Unlike MCDs, these covers are applied over the existing grates and installed in sections, utilizing watertight gaskets and panels attached with hooked connection bolts. These bolts connect through the panel to the metal grate below. Vent covers are stored at or near their locations when possible; otherwise, they are stored in a centralized warehouse and trucked to their locations during the staging period prior to any subway system shutdown. These vent covers are custom-made for specific locations and must be manually installed.

Approximately 680 vents need such covers. During a mock deployment, the agency assigned crews of six employees to set up the covers. NYC Transit observers reported that the crews required an average of 28 minutes per location to deploy these devices. (link to photo)

3. Stop Logs (approx. 50 devices)

Stop logs, like vent covers, cannot be permanently installed. These devices are modular walls made of aluminum sections reminiscent of logs. The logs can be of varying lengths and are typically 9 to 12 inches high. These are used to seal off the door frames of subway entrances and to protect assets such as elevators. Each log connects to the log below it, and a rubber gasket seals the stacked logs into one watertight face. The bottom log has a larger, more flexible gasket to create a better seal with the uneven concrete surface bordering station entrances or outside elevators, shop doors, and bus depot entrances.

Permanent mounting plates are installed in the walls and floor of the asset to be protected, and the individual logs are stored on-site or at a warehouse. The logs must be pre-staged at their respective locations prior to deployment. Notably, each station entrance or other site is unique in length and mounting requirements, so the logs are specially manufactured for each site.

There are approximately 50 stop log locations. During a mock deployment exercise, NYC Transit observers witnessed two crews of 11 employees each and reported that the crews needed an average of 50 minutes to deploy each device. (link to photo)

4. Station Entrance and Portal Flex Gates (approx. 75 devices)

Designed to seal subway entrance stairwells, flex gates are permanently installed protective devices. They consist of a water-resistant membrane that rolls up into an enclosure when not in use. When needed, these gates can be deployed by opening a steel cover plate above the top step and turning a pulley, which uses cables to pull the membrane over the steps in preinstalled tracks. The membranes are designed to withstand up to several feet of water and the hardware is resistant to corrosion. NYC Transit observers witnessed three flex gate deployments during a mock deployment test and reported an average time of 45 minutes to deploy each device.

Portal gates are larger versions of the flex gates – they are designed for larger openings, such as doorways and garage openings, and can be deployed in a vertical or horizontal position. These gates are always permanently installed and are sealed at the bottoms and sides after deployment. Approximately 75 flex gates and portal gates are currently installed across the system; however, none of the portal gates were included in the mock deployment exercise, and thus NYC Transit has no time estimates for their deployment. (link to photo)

5. Watertight Hatches (approx. 150 devices)

Watertight hatches are essentially steel plate covers which seal off openings in the system where water penetration may occur (e.g., underground air vents), allowing water to bypass other protective devices. Typically, threaded studs are installed, and the hatch is mounted through the studs and tightened down with nuts. The hatch typically has a sealing gasket to afford a watertight seal. The hatches are stored at their needed locations. Because these hatches may need to be mounted in locations that are not readily accessible, the equipment and material required for employees to work with these heavy devices – such as scaffolds – are also stored at each hatch's location. There are approximately 150 hatches throughout the system, and, during a mock deployment, NYC Transit observers reported witnessing a crew of four workers deploy two hatches in five minutes. (link to photo)

6. Watertight Marine Doors (approx. 150 devices)

Unlike many of the other deployable devices discussed above, watertight marine doors vary in design and size. These doors are constructed of steel and fitted with gaskets at sealing points. They are typically side-hinged and designed to swing closed, similar to any other door. Watertight marine doors can range from standard door sizes (e.g., at the entrances to electrical rooms) to large doors protecting an entire subway entrance. Larger doors will have locking latches when closed and can also have sealing pins, which are activated by sliding them into receptacles in the ceiling and floor for strength. Watertight marine doors are capable of withstanding much more water weight than simple membrane gates and are installed in low-lying locations where more water is anticipated.

All of the MTA's watertight marine doors are permanently installed in their locations. They are used at subway stairwell entrances, yard entrances, and tunnel locations such as the Hugh Carey Tunnel and the Queens Midtown Tunnel. There are approximately 150 watertight marine doors throughout the system, and, during a mock deployment, NYC Transit observers reported witnessing a crew of five deploy one door in 10 minutes. (link to photo)

III. FINDINGS

OIG identified opportunities for improvement in five areas:

A. NYC Transit's Management Systems for Asset Maintenance and Deployment
B. Contractor and In-House Training
C. Contractual Requirements
D. Hurricane Plan Deployment Times & Routes
E. Maintenance

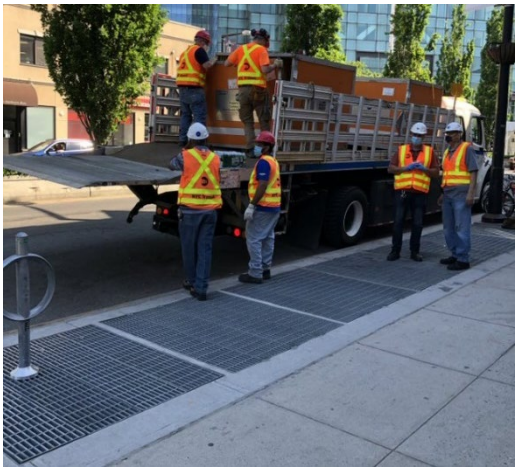
A. NYC Transit's Management Systems for Asset Control, Maintenance, and Deployment Tracking

NYC Transit is currently populating its Electronic Asset Management system (EAM) with information on the deployable devices. The agency's goal is to use EAM as DOS's primary tool for electronically scheduling and tracking maintenance of virtually all of its critical assets. Once the data on all flood control devices has been moved into the system, Stations and MOW Infrastructure will be able to schedule and track routine maintenance activities via electronic work orders. Ensuring that all devices receive proper maintenance will increase the likelihood that they will function as intended. EAM will also allow the agency to track deployment when devices in hurricane-prone areas are activated or closed during an event. By having work orders generated in EAM, crews can complete their tasks and update the work orders in the field. In addition, DOS will use a Geographic Information System (GIS) feature with EAM to generate interactive mapping tools to help work crews in the field easily locate assets requiring maintenance or deployment. There are, however, logistical challenges to ensuring that EAM will operate as desired.

1. DOS does not have an accurate count or list of all its devices but expects to by the end of 2022.

To generate timely maintenance work orders, DOS needs a complete and accurate list of all its flood control devices and their unique locations. The older tracking software – the Resiliency Event Management System (REMS) – tracked the vulnerabilities needing protection and multiple vulnerabilities can be protected by a single device, so one device may be listed in REMS more than once. REMS recognized each device entry as unique, thus any list of devices generated in the system could have included duplicates.

Conversely, multiple devices may be needed to protect one vulnerability. This is especially true for sidewalk vents, which allow air to circulate in subways. One vent consists of several individual "vent bays" attached end to end; several connected vent bays constitute one "vent battery." Protecting one vent battery can therefore require multiple vent cover devices, which need to be tracked and maintained individually. *(See photo below.)*



Vent battery in Queens, with boxes of covers being offloaded from truck for installation

NYC Transit also maintains a second list of devices generated by contract quantities; it includes every item furnished by each contractor. Because each vent cover is made up of multiple panels, and this list includes every panel as a separate contract item, the reported number of devices on this list is inflated.

Neither of these information sources currently yields data DOS can use to generate an accurate list for creating electronic maintenance work orders. To prevent both double-counting and under-counting its devices, NYC Transit needs to track each *device* in EAM, rather than each *vulnerability*, as it did in REMS.

Appropriately, the Emergency Management & Preparedness Group has been reconciling the two data sources to accurately identify the number of vent bays in each battery and the protection at each vent bay, whether by MCD, deployable vent cover, or permanent sealing of the vent. This level of detail is imperative to allow DOS to assign unique identifiers to each vent bay, so that individual deployable devices within each battery can be tracked during maintenance and deployments. Once EAM is in use for inspections and maintenance, DOS will conduct field surveys to verify the EAM entries for all devices and locations within a year. Only when this step is completed will DOS be able to initiate work orders electronically.

2. NYC Transit has not adequately accounted for devices outside DOS's jurisdiction.

While this Report concentrates on the over 3,500 devices for which DOS is responsible, it is important to note that NYC Transit also is responsible for additional devices in yards, bus depots, and SIRTOA facilities. NYC Transit has installed permanent hardening features such as seawalls at these locations, but deployable devices are also in use. Yards have installed flex gates, watertight doors, and stop logs; bus depots have watertight doors and stop logs, and SIRTOA has installed marine doors and stop logs.

NYC Transit plans to identify all deployable flood control devices in train yards and upload their locations to EAM. Emergency Management & Preparedness has initiated this process, but it has not yet been completed. Like the DOS device locations, the placement of these devices must be independently verified via field surveys after the data is uploaded.

OIG learned that each of these subway yards – such as Coney Island and 148th Street Yards – has created an individualized plan for activating the devices in preparation for a storm. In contrast, four bus depots and two SIRTOA locations with flood control protection devices on their premises are not addressed in the NYC Transit DOS plan nor have they drafted plans of their own. In addition, devices already installed at bus depots and SIRTOA assets are not listed in REMS or EAM, and agency officials told OIG that they do not plan to include them in EAM. As noted above, however, without ready access to data on the devices in yards, bus depots, or SIRTOA facilities, the agency's deployment in preparation for a storm will not take these critical devices into account. Excluding these devices from EAM will prevent NYC Transit from initiating and tracking maintenance work orders, monitoring the training of personnel, and managing the supply and usage of spare parts effectively.

It is essential for the agency to create and maintain a complete source of accurate data on all its protective devices – including those at yards, bus depots, and SIRTOA – for maintenance and deployment purposes.

3. The lack of electronic work orders hindered the assignment and tracking of maintenance work, resulting in device malfunctions.

NYC Transit could not generate any electronic work orders until the devices and their locations were uploaded into EAM, and the completion of this effort is expected by June 2022. Without this key tool, the agency's lack of up-to-date and accurate maintenance records has led to deficiencies over the past several years. Some of these effects were apparent in May 2021 when NYC Transit conducted a mock deployment exercise observed by OIG.

The agency had selected a small geographic area in Queens containing at least one of several types of flood control devices, and during the mock deployment exercise, teams from Stations and Infrastructure attempted to activate the selected devices. While most of the devices deployed without issue, several did not, including two of the three subway entrance flex gates included in the exercise. One flex gate was very difficult to deploy due to a lack of lubrication on the pulleys and cables – a maintenance oversight. After deployment, DOS personnel could not return the gate to its open position because they could not close the cover plate; the plate required additional adjustment afterwards by the contractor who had installed it. *(See photos below.)*

Crew could not re-close a steel plate after flex gate deployment.

Workers trying to deploy a flex gate with a hammer and chisel, which could damage the membrane.

Moreover, one of the 2 remaining flex gates deployed in approximately 20 minutes with no issues, while another flex gate would not deploy at all because it had fouled pulleys and cables and stripped screws. The installation contractor had to make repairs and claimed the gate's failure was caused by a lack of DOS maintenance. However, DOS Stations claimed that the installation had been faulty. Notably, because the flex gates would have needed to be deployed during maintenance, DOS personnel should have documented any deficiencies at that time. Due to the lack of contractor and DOS Stations maintenance records for this gate – or any of the devices – DOS could not determine whether the flex gates had ever been activated prior to the mock deployment exercise. This lack of critical documentation prevents NYC Transit from holding contractors accountable.

In addition, because necessary data had not yet been migrated into EAM, MOW Infrastructure was unable to electronically issue or track maintenance work orders for any devices. Infrastructure did track the *cleaning* of each vent, however, and issued standing instructions that for any vent containing an MCD – that MCD should receive maintenance and be test-deployed at the same time. While this was helpful guidance to field personnel, Infrastructure could not generate separate electronic work orders on the individual devices. Fortunately, during the Queens mock deployment only one MCD had an issue, which was quickly corrected in the field.

OIG learned that MOW Infrastructure dispatches crews to the Tiffany Warehouse in the Bronx, where several stop logs and vent covers are stored awaiting deployment to perform maintenance twice each year. No records of maintenance exist, however, for any devices, regardless of where they are stored.

The lack of records will be resolved when EAM begins generating electronic work orders for both Stations and Infrastructure. These work orders will be created automatically, based on a preset schedule, and will include a checklist of maintenance steps to be performed during each maintenance event for each device; the owner's manuals and technical specifications for each device indicate the manufacturer's recommended schedule for maintenance, as well as what steps should be performed each time. The system will generate this checklist and assign it to the field manager, who must complete the listed steps and enter the results into EAM to confirm that maintenance was completed. A record would then be created, allowing NYC Transit to research the device's history if a problem arises.

B. Contractor and In-House Training

1. Training on deployment and maintenance of the devices is insufficient, and documentation is lacking.

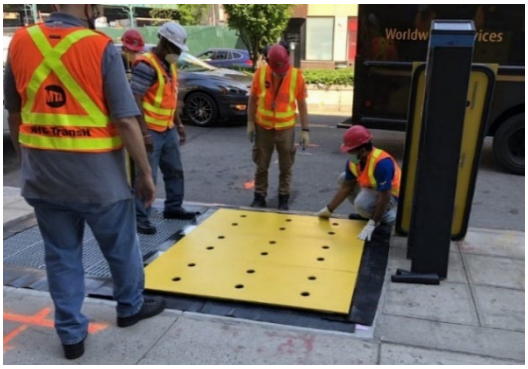
Each type of device has its own unique requirements for maintenance and how it is to be deployed. Because the user groups become responsible for the devices only after contractors have installed all the units in their respective contracts and the agency has accepted the devices, NYC Transit employees have no hands-on experience with the devices during installation. While user group personnel can observe the devices being installed, the contracts require no training from the manufacturers or installers beyond providing videos for staff reference. In OIG's opinion, these steps do not constitute adequate training.

Training should focus on the maintenance and deployment guidance provided by the owner's manual for each device, which describes the necessary frequency of maintenance and the individual maintenance steps required. For example, one manual for a MCD includes these important instructions:

> To be performed annually:
>
> 1. Check entire MCD for visible damage or misuse.
> 2. Check for excessive debris buildup.
> 3. Ensure the panels rotate freely through the full path of travel.
> 4. Check flexibility and integrity of gasket.
>
> ***Note: No lubrication of parts is required***. *Damage could occur if improper lubricants or other substances are applied*.

The field personnel who will be expected to maintain and deploy the devices in the event of a storm are represented employees, and their job assignments are periodically open to "picks" based on employee's seniority levels. Staffing changes resulting from picks, reassignments, retirements, and promotions result in a very dynamic workforce. For this reason, each employee should receive adequate training on each type of device for which they may become responsible.

The 2021 mock deployment highlighted the need for more formalized training that should be tracked and documented for each employee. For example, during the exercise, OIG saw the value of field crews' familiarity and experience in their deployment of vent covers. For each vent that receives a cover, employees must manually install a perimeter membrane before placing the cover's panels and fastening them to the metal grate below the vent. *(See photo below.)* The first vent cover took longer than expected to deploy because the installers were unsure of the precise steps to follow. But after installing the first vent's cover, the workers were more familiar with the technique and the remaining installations went smoothly.



Vent cover panels being deployed over perimeter membrane. The holes are for mounting bolts.

To ensure consistency and accountability, NYC Transit should provide and monitor training through a centralized administrative function. In addition, training could be improved by:

- Having employees train on the actual equipment, ensuring that one of each device is available so that employees get hands-on training on each type of device that field teams will encounter.
- Maintaining records on who has received training and who still needs to be trained on both the maintenance and deployment of each device.
- Establishing appropriate schedules for initial and refresher training as necessary.
- Including Bus Depot, SIRTOA, and Yard personnel to ensure that all devices are adequately maintained, and personnel are cross trained as appropriate on all devices.

C. Contractual Requirements

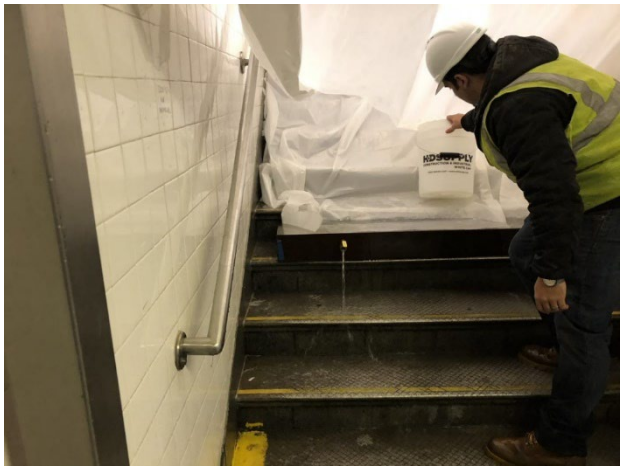
1. Installation contracts with the individual vendors could have protected MTA's interests more effectively.

Maintenance Records. DOS manages approximately 55 separate contracts with vendors to perform flood-protection hardening work. Many of the agreements require contractors to furnish and install protective devices across the system, and a single contract can include hundreds of devices and last several years. Because none of the devices covered by a given contract are accepted by the MTA until the last device is installed, devices installed early in the contract's term might have been installed for years before the agency becomes responsible for their maintenance. Under the terms of the contracts, each contractor is responsible for maintaining the devices it has installed until the devices are formally transferred to the MTA. The contracts do not require the contractor to give MTA documentation of any maintenance performed, however, and, in fact, no such records are available. This leaves DOS without critical information about the first – potentially years-long – stage of each device's operation.

Selection of Test Sites. Another contractual weakness concerns the flex gates protecting station entrances. OIG learned that these contracts required contractors to test only about 10% of the flex gates in the field. In addition, the contractors responsible for installing the flex gates were allowed to choose which locations they would test. Allowing the contractor to make the selection could result in the bypassing of locations which the vendor knows may have deficiencies. This permissive stance is inconsistent with the contractual field-testing requirements for MCDs, which clearly state that the engineer in

charge will select the devices to be tested. Furthermore, when OIG reviewed a contract governing the installation of 23 flex gates, it found that the contract's "Stairway Protection Device Field Test" clause does not authorize the contractor to select the test sites and is in fact silent as to whether MTA or the contractor should select the locations.

Specifications for Field Tests. While the contracts require certain field tests, some of the stated standards are not specific enough to ensure adequate test results. For example, OIG found that the contracts do not instruct vendors as to how to capture water during device testing, beyond merely collecting water at the base of the stairs. Lack of specific instruction led to inadequate practices by the vendors, which became apparent when OIG witnessed several flex gate tests in the field. As the picture below illustrates, at one location the contractor collected water that bypassed the flex gate in five-gallon buckets, a method that appeared to be ineffective at capturing all the water for testing purposes.



Flex gate test at Court Square station.

During several flex gate tests observed by OIG, the contractor deployed the gate before NYC Transit personnel arrived. Such unobserved preparations could allow a contractor to take steps necessary to pass the test which would not be available to NYC Transit crews during the agency's own deployment of the devices. OIG witnessed an example of this improper activity during the testing of a flex gate at the 148th Street Yard entrance. The flex gate was to be deployed in front of NYC Transit workers for training purposes. When OIG and agency personnel arrived, however, the gate was already in place and had been pre-tested by the contractor. Two water tests were then conducted for 30 minutes each, and only five gallons of water were collected after each test, well below the 300-gallon maximum allowable under the test parameters.

In light of the contractors' unsupervised preparations, however, the NYC Transit General Superintendent refused to accept the flex gate unless he witnessed its full deployment and the agency's field crew received hands-on training. The contractor then removed the gate, and NYC Transit workers redeployed it. At this point, NYC Transit workers observed that the contractor had applied silicone sealant to one bottom corner of the gate when the contractor deployed it the day before the test, which, according to the manufacturer's specifications, was not allowed during the test. *(See photo below.)*

Silicone observed applied to flex gate during water leak test.

When retested after deployment without the silicone, the gate leaked 100 gallons of water in 30 minutes – 20 times the amount that leaked during the contractor's test. While this result was still below the allowed 300-gallon maximum, the initial results had been significantly manipulated without NYC Transit's knowledge. In addition, during the field crew's deployment of the flex gate, NYC Transit workers observed that two screws would not fully seat; the contractor agreed to re-thread the mounting plate and change a drop-in shield. If NYC Transit had agreed to accept the contractor's own unobserved "pre-test" results, DOS would not have understood the actual condition of this device, and the contractor would not have been held accountable for its shortcomings. Strong agency oversight of the installation tests is critical.

Therefore, NYC Transit would have benefitted by including more detailed specifications in the contracts, ensuring that the agency had full information about the devices' maintenance history and outlining testing instructions to the contractors.

D. Hurricane Plan Deployment Times & Routes

1. NYC Transit lacks sufficient and reliable information on deployment timelines.

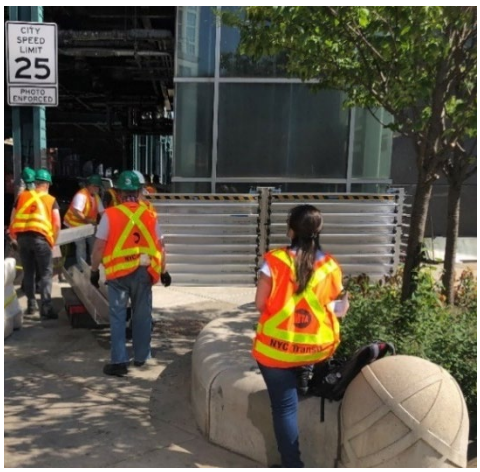
For the DOS Hurricane Plan to work as intended, NYC Transit must be able to deploy all the devices in the time allotted. To verify that the timeline is viable, the agency must develop reasonable expectations for (1) how long each device requires for deployment, (2) the travel times and routes between devices, and (3) the staffing levels available for deployment. Unfortunately, this estimation process has been hampered by competing demands on labor resources due to the Covid-19 pandemic and other factors.

The agency correctly attempted to use the May 2021 mock deployment exercise to start to address the timeline issue. DOS assigned observers to accompany deployment teams in the field, record time estimates for device deployments, and report the information to the Emergency Management & Preparedness group. The observers, however, witnessed only a very small number of deployments, under tightly controlled circumstances, and did not estimate the travel time between locations. For example, during the exercise, 41 MCDs were activated by a team of seven personnel in nine minutes, or approximately 15 seconds per MCD. This timing is reasonable once the crew is physically at the vent battery closing the MCDs, as each device is simply tripped with a special tool which spring-activates the closure. This time estimate, however, does not include the time for the crew to travel from one vent battery to another under actual conditions. With approximately 2,230 MCDs in the system, spread across a much larger area than that encompassed during the test exercise, these activation-only figures cannot be used to estimate the necessary time to deploy the entire population of MCDs.

The deployment exercise also included vent covers on three vent batteries. The NYC Transit observers reported that the average deployment time was approximately 30 minutes per cover. As with the MCD activations, this estimate is technically accurate; however, the number of vents per battery differs from location to location, necessitating different numbers of covers. In addition, the locations covered during the exercise were all in close proximity to each other, and travel time between them was not factored into the observations. Given that there are approximately 680 different locations for the vents, DOS will need to test deployments on a larger sample and include all travel times in order to develop a more accurate estimate of how long an actual deployment effort may take.

OIG learned that the NYC Transit observers' estimated time for deployment of station entrance flex gates included times for three individual gates; however, one of the gates was never fully deployed. The field crew spent 50 minutes trying to deploy a flex gate at the Vernon Jackson subway station but was unsuccessful. Nevertheless, the 50-minute figure was included in the observers' report. While the number accurately reflects the time expended by the crew, it skews the calculation when developing an average time for (successful) deployments.

The same issue arose during the test deployment of stop logs. Only two of the 55 locations which require stop logs could be included during the May 2021 exercise – one was a station entrance, and the second was an outdoor elevator protection site. *(See photo below.)*



Outside elevator stop log protection showing multiple sections.

The elevator location requires several sections of logs, effectively building a wall around the elevator, and the barrier extends around a street corner and down a side street to protect additional assets. Because this location has one of the highest log counts of all locations, its deployment time may skew the agency's reasonable expected timeframe above what is required for a more typical location. An estimate that is too high will lead NYC Transit to miscalculate the number of personnel required to install all the devices across its systems.

The Emergency Management & Preparedness group knows how to quantify the time necessary for deployment. The group's estimates, however, would be more accurate if it tests larger groups of devices, includes crews' travel time between devices, and quantifies anticipated crew sizes during preparation for a storm. Taking such additional measures will allow NYC Transit to determine more reliably whether the deployment can be completed in the timeframe allotted by the Hurricane Plan.

2. NYC Transit would benefit from planned deployment routes with designated personnel and devices in the event of a storm.

OIG conducted interviews with senior DOS staff involved in the device deployment process. They all expressed confidence that they can perform their assigned responsibilities under the DOS Hurricane Plan if they are actually given the time allotted for deployment; however, officials in both Stations and Infrastructure said they could benefit from additional resources such as trucks, tools, and supplies, in order to more efficiently and timely perform their jobs. Both user groups believe they have adequate staff to deploy in the field using an "all hands-on deck" protocol.

To manage snow removal during winter storms, NYC Transit has established zones for its field crews, and the agency is using this as a model for its assignment of teams to deploy flood control devices. Following this model, however, has challenges. Unlike winter storms, a hurricane storm surge is localized and progresses from the low-lying zones most at risk of impact to higher ground. Storm surge also differs from snowstorms in terms of the potential severe damage to critical assets and the interdependency of the protective devices -- failing to activate even one device before a hurricane can compromise the entire subway system. For these reasons, it is imperative for NYC Transit's plan to include defined routes to be followed by field teams, with a complete list of the devices to be activated by each team. Ensuring that every device is part of a route, and that every route has an assigned deployment team, is the best way to ensure that all devices are accounted for and activated.

Implementing this approach had not been feasible prior to the installation of all the devices because all device locations and their GIS coordinates must be available electronically for DOS to implement the plan. This information will soon be available in EAM, and the designation of routes should be viable. DOS Infrastructure has started to assign work crews into five areas, with each device assigned to one of the teams. The agency has not yet designed specific optimal routes, including travel time between all deployable devices, and prioritized by flood zone, to accomplish the deployment within the allotted timeframe.

E. Maintenance

1. The agency lacks an efficient process for managing its inventory of spare parts.

To keep the devices in a state of good repair and ready for deployment, NYC Transit must maintain an adequate inventory of the manufacturer-recommended spare parts for each type of device. The agency expects to have approximately 3,750 deployable devices in place when installation is complete, so creating and managing this inventory will be a significant undertaking. Each manufacturer furnishes an owner's manual with every device, including information about spare parts, and is also available to consult with the agency to develop recommended spare parts inventory levels. NYC Transit should develop the required inventory of spare parts based on the number of each type of device in the system.

For example, the manufacturer's *Operations and Maintenance Manual* for one model of MCD describes the necessary tools and parts for maintenance and operation of the device. Specifically, the device requires a "special activation tool" for opening and closing; three separate gaskets are used on the device and require replacement due to age deterioration or damage; a retractable ladder can be purchased as an option for access to the vent battery; and a separate "adjustable maintenance stand" is available to support the device after it is removed from a vent bay. *(See photo below.)* In total, the manual lists 44 separate spare parts, along with the quantities of each part necessary for every MCD device – and approximately 2,230 MCDs will be in place across the system. All the other device types have similar spare part requirements.

MCD pulled out for maintenance.

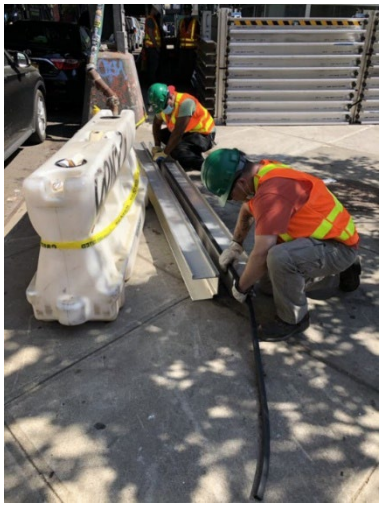
The responsibility for maintaining the devices is divided among NYC Transit user groups, primarily MOW Infrastructure and Stations. Each user group must currently maintain its own individual inventory of spare parts, and because different groups manage similar device types, this decentralized structure results in a significant duplication of effort. Centralizing the processes for procuring, storing, and managing the spare parts would be more efficient and would also assist the user groups that lack the resources to perform these functions effectively.

NYC Transit should maintain a central database of all devices showing the quantity of each device type, the spare parts necessary for each device, and the minimum reorder point for each part. In addition, the agency should establish a universal inventory to store spare parts and tools, from which the user groups can draw as needed. This centralized inventory should be available to *all* the user groups responsible for maintaining and deploying flood control devices, including the NYC Transit Department of Buses (Buses), SIRTOA, and the subway Yards. A single inventory management process, with clear accountability at each level, would improve the agency's maintenance of the devices and its hurricane readiness.

2. The agency should conduct more mock deployment exercises.

Preparedness is greatly enhanced by holding mock deployments of flood control devices. During the May 2021 exercise, Stations was responsible for deploying stop logs that protect an outside elevator in Queens. The logs, which are stored in the Court Square subway station, had to be loaded onto trucks and driven to the elevator's location. During the trip, the logs' rubber gaskets became dislodged.[3] Field personnel had to reinsert the gaskets before they could construct the protective barrier, slowing the deployment process. *(See photo below.)*

[3] The gaskets are an integral component of the device, as they seal the logs to the ground and seal the joints between logs.



Workers reinstalling rubber gaskets into stop log channels during a mock deployment. (A stop log "wall" is visible in background.)

Overall, this exercise helped NYC Transit personnel identify a risk in transporting logs and assess reasonable estimates of its deployment timeframe, provided hands-on training to field crews, and allowed NYC Transit to gauge the level of effort needed for the ongoing maintenance and deployment of the various device types. The agency identified many lessons learned from the exercise, which strengthened its ability to respond effectively to a severe storm. More frequent mock deployments should be a central feature of DOS's storm preparedness activities.

However, conducting these exercises requires extraordinary planning and coordination to reap these benefits. During the Queens mock deployments, DOS had to close station entrances, manage street and sidewalk impacts, and take elevators out of service. The agency also had to coordinate its activities with various New York City agencies, public utilities, and other outside entities. For these reasons, it is particularly difficult to perform deployment exercises in areas with high traffic, tunnels, or parts of the subway system that would require the closure of stations or even entire lines. This type of effort would be handled most effectively by one entity with the ability and authority to conduct larger mock deployments across all NYC Transit facilities equipped with devices. OIG found that the Emergency Management & Preparedness group has done an exemplary job on the smaller-scale exercises they have been able to schedule thus far and recommends that the group play a leading role in any future mock deployments.

IV. RECOMMENDATIONS

New York City Transit appreciated the recognition of the substantive accomplishments taken towards emergency preparedness discussed in this report and welcomed our recommendations to improve the plan. Our recommendations and the agency's responses follow:

To improve its preparedness for severe weather events, New York City Transit should take the following actions:

- **Clarify managerial accountability for managing the Hurricane Plan:**

1. Authorize one individual or department within NYC Transit to oversee and direct specific activities under the Plan. This entity should be responsible for such activities as planning periodic mock deployment exercises covering all locations and types of devices; standardizing device maintenance frequencies and checklists among user groups; ensuring that adequate training is provided to employees, tracked, and monitored; and establishing and maintaining agency-wide inventories of spare parts for the devices.

Agency Response: NYC Transit rejects this recommendation. Preparedness activities between the Department of Buses and Subways are significantly different, and NYC Transit therefore contends that control over the plans should stay within the respective departments. However, NYC Transit proposes continued coordination between the two departments by holding formal preparedness discussions on a quarterly basis.

- **Improve its information management system related to flood control activities:**

2. Consolidate information on all of NYC Transit's flood control devices – including yards, bus depots, and SIRTOA – into one database listing each device's type, unique tag number, and GIS location; the MTA asset(s) it protects; and the department(s) responsible for its maintenance and deployment. The list of devices should be maintained in EAM once the data migration is complete.

Agency Response: NYC Transit accepts this recommendation and estimates implementation by the end of the 3rd quarter of 2022. Information will be consolidated within EAM.

3. Authorize the Emergency Management & Preparedness group to have access to all EAM databases in order to monitor maintenance work orders and provide real-time monitoring

during mock deployment exercises and actual storm events.

Agency Response: NYC Transit accepts this recommendation and has implemented it.

4. Develop and analyze data on the time required for employees to complete their routes and deployments and refine the times allowed for activation in the Hurricane Plan as necessary.

Agency Response: NYC Transit accepts this recommendation. Projected implementation in Subways and the Department of Buses is the end of the 4th quarter, 2022. NYCT Subways Emergency Preparedness and Response Unit will estimate times required for activation and refine the hurricane deployment timeline based upon confirmed deployment via ongoing drills.

- **Improve the process for maintaining the devices:**

5. Establish a requirement for every device to be activated at least once annually by NYC Transit personnel during maintenance or a mock deployment exercise when feasible, to ensure it is operational.

Agency Response: NYC Transit accepts this recommendation. NYCT Subways Emergency Preparedness and Response Unit and the Department of Buses will oversee, when feasible, the activation of all DOS, SIR TOA, Buses devices, at least once annually, via maintenance or mock deployment exercises.

6. Establish procedures, to be included in any future contracts for flood control devices, to ensure that the NYC Transit user group responsible for each new device inspects each device prior to the agency's acceptance verifying that it is operable and without defects.

Agency Response: NYC Transit accepts this recommendation. The MTA has an existing acceptance procedure to ensure that the devices are inspected and turned over in proper working order and will ensure that this procedure is included in any future contracts.

7. In any future contracts for flood control devices, require contractors to provide hands-on training to NYC Transit personnel on the maintenance and deployment of any new type of device or a known type produced by a new manufacturer to the MTA that will require maintenance and deployment in the event of a hurricane. A training manual for each device for use by NYC Transit Training should also be required.

Agency Response: NYC Transit accepts this recommendation. The MTA will ensure future contracts for flood control devices require contractors to provide the appropriate training to NYC Transit personnel on the maintenance and deployment of devices, including hands-on

training for any new types of devices, and a training manual for each device. The MTA will implement this recommendation by the end of the 4th quarter, 2022.

8. In any future contracts for flood control devices, require contractors to give NYC Transit documentation of all maintenance performed on each device before it is accepted by the agency. As part of this process, create a method to determine whether contractors are performing required maintenance during the pre-acceptance period.

Agency Response: NYC Transit accepts this recommendation. They stated, "By the end of the 4th quarter, 2022, verification of contractor maintenance before user acceptance of flood control devices when required, will be added to the contract specifications."

9. Ensure that any future contracts for flood control devices: (a) require the contractor to submit the means and methods they will use when measuring water leakage for NYCT approval, and (b) state that NYC Transit personnel must oversee field tests conducted by installation contractors, including the erection of any containment barriers and the device deployment.

Agency Response: NYC Transit accepts this recommendation. MTA contracts currently specify the performance requirements for measuring water leakage. The MTA will ensure that future contracts specify that the MTA, or its agent, must approve the means and methods for measuring water leakage and oversee the field testing. The MTA will implement this recommendation by the end of the 4th quarter, 2022.

10. Field testing of 100% of flood logs, Portal flex gates and portal walls should be required. For all other devices, NYC Transit should require 10% to be field tested with NYC Transit selecting the devices to test.

Agency Response: NYC Transit accepts this recommendation. The MTA already requires in its contracts field testing of 100% of flood logs, portal flex gates and portal walls, upon installation. For all other flood control devices, the MTA will select an appropriate sample size and which devices to test, on a recurring basis.

- **Formalize the training available to employees responsible for maintaining the devices:**

11. Assign a centralized training group to schedule and conduct training on the deployment and maintenance of each type of device. The responsible unit should create a process to: (a) train each employee tasked with maintenance or deployment; (b) document the type of training, the date, and the device(s) each employee has been trained on; and (c) develop a plan for periodic refresher training inclusive of subway yards, bus depots, and SIRTOA facilities.

Agency Response: NYC Transit accepts this recommendation. The Subways Operations Training Unit will work with the NYC Transit Subways Emergency Preparedness & Response Unit and the relevant DOS and SIR divisions to develop an appropriate training program and identify the best learning management or program to track training. Projected implementation by year-end 2023. The Department of Buses implemented centralized training in 2nd quarter, 2022.

12. As part of the Hurricane Plan, each user group should establish teams that will be responsible for deploying specific devices. Each user group should document its protocol in writing, including the number of employees in each team, the specific devices each team will deploy, and the routes they will follow to address the highest-priority locations first. Each user group should also create a process to update these lists to reflect job picks, retirements, and other staffing changes. The work unit responsible for the overall Hurricane Plan should ensure that every deployable device is assigned to one of the user group's teams.

Agency Response: NYC Transit accepts this recommendation. The NYC Transit Subways Emergency Preparedness & Response Unit will coordinate with DOS and SIR divisions to develop and document the appropriate deployment scheme, assign personnel, and ensure that deployment teams/rosters are up to date and reflect job picks, retirements, and staffing changes. Projected implementation is by year-end 2023. The Department of Buses will update the Hurricane Plan for appropriate deployment scheme, personnel assignments, and ensure that deployment teams/rosters are current by 3rd quarter, 2022.

- **Improve the procurement and inventory management of spare parts:**

13. Generate lists of recommended spare parts based on the manufacturers' operations and maintenance manuals and the number and types of devices installed across the system, including in subway yards, bus depots, and SIRTOA facilities.

Agency Response: NYC Transit accepts this recommendation. The NYC Transit Subways Emergency Preparedness & Response Unit will coordinate with DOS and SIR divisions to generate a list of
recommended spare parts. Projected implementation by year-end 2023. The Department of Buses has the manufacturers' recommended parts available on site at each depot.

14. Establish a centralized spare parts inventory process to support all the user groups responsible for flood control devices, including subway yards, bus depots, and SIRTOA.

Agency Response: NYC Transit accepts this recommendation. The NYC Transit Subways Emergency Preparedness & Response Unit will work with NYCT's Materiel Department to establish a centralized spare parts inventory process to support all Subways user groups responsible for flood control devices. Projected implementation by year-end 2023. The Department of Buses has the manufacturers' recommended parts available on site at each depot.

15. To facilitate rapid deployment, determine which of the deployable devices not permanently installed can feasibly be stored at the devices' deployment locations. As part of this process, create a method to properly document these devices and maintain them in a state of good repair.

Agency Response: NYC Transit accepts this recommendation. The Subways' MOW and Stations Divisions will determine which of the deployable devices not permanently installed can feasibly be stored at their deployment locations and develop scopes of work for maintenance repair contracts for these devices. Projected implementation is by year-end 2023. All the Department of Buses flood control devices are stored on location, and readily available parts are on site.

Appendix Summary

Appendix 1: Flood Control Devices

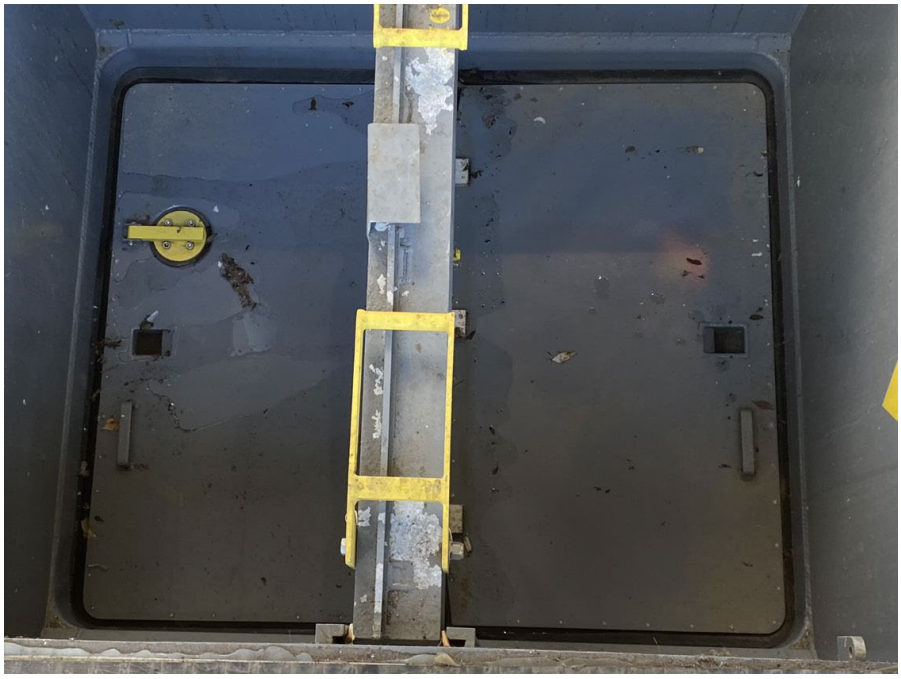
1. Mechanical Closure Devices (MCDs)
2. Deployable Vent Covers
3. Stop Logs
4. Flex Gates
   a. Station Entrances
   b. Side Deployment
   c. Portal
5. Watertight Hatch
6. Watertight Marine Door

Appendix 2: Flood Zones Map

Appendix 1 - Flood Control Devices

1) Mechanical Closure Devices (MCDs)

MCD in the "open" position at South Ferry



MCD in the "closed" position at South Ferry

2) Deployable Vent Covers

Flood covers over vents at Court Square Station

3) Stop Logs

Section of stop logs protecting side of Court Square Station elevator, moments before spray test

4 a) Station Entrance Flex Gate

Partially closed flex gate at Court Square Station

4 b) Side Deployment Flex Gate

Side deployment flex gate at 148th Street Yard entrance

4 c) Portal Flex Gate

Portal flex gate undergoing water test at manufacturer

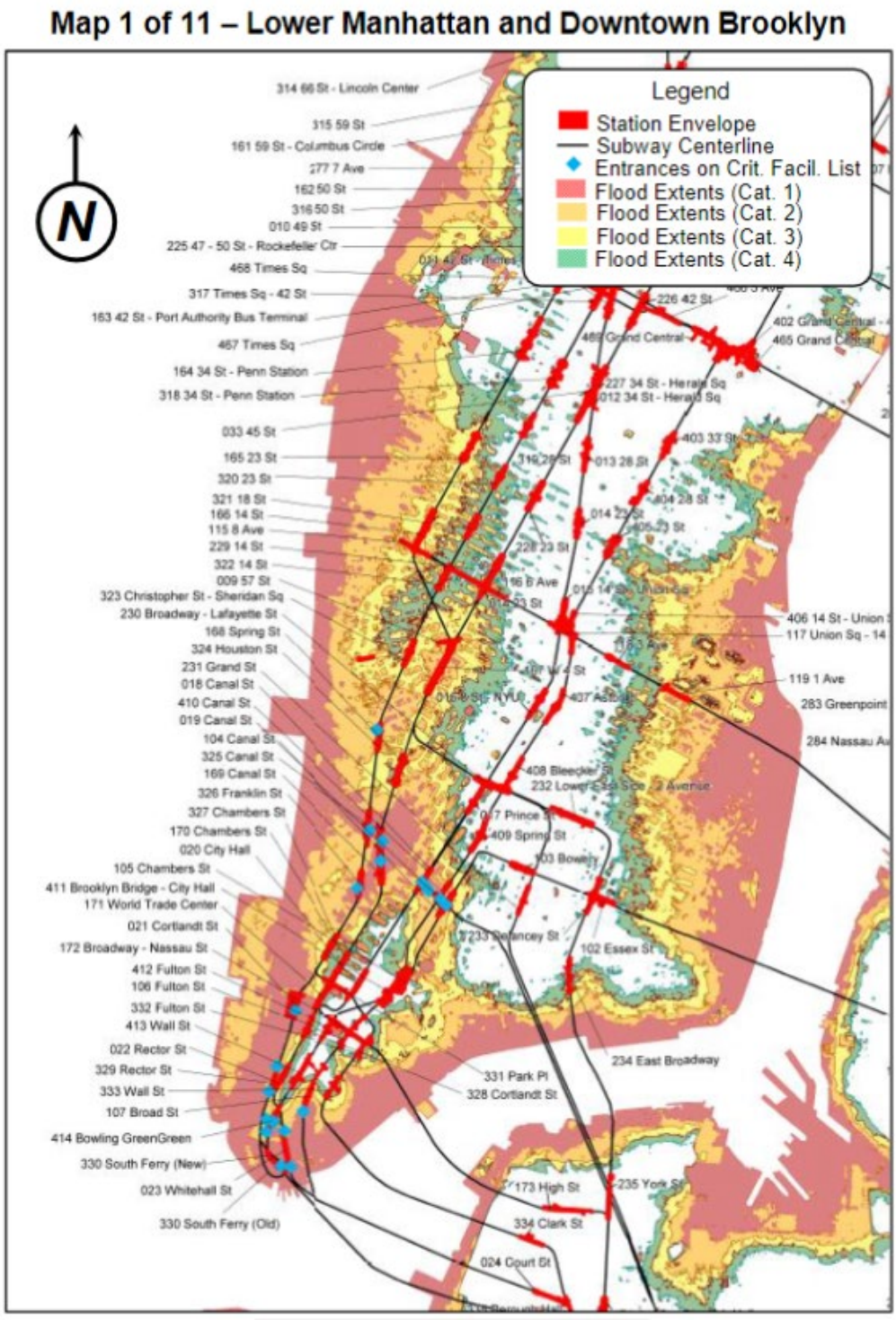
5) Watertight Hatch

Watertight hatch covering wall vent in station stairwell, Vernon Boulevard–Jackson Avenue Station

6) Watertight Marine Door

Activated marine door at Vernon Boulevard–Jackson Avenue Station

Appendix 2 - Flood Zones Map



Sea, Lake, and Overland Surge from Hurricanes (SLOSH) map showing station envelopes and flood zones (National Weather Service)