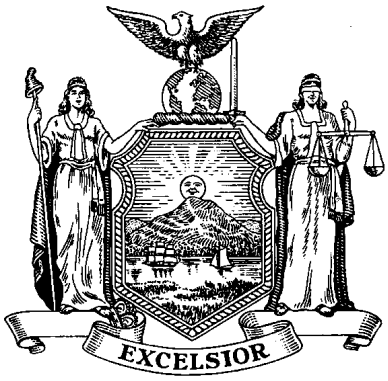
STATE OF NEW YORK



OFFICE OF THE INSPECTOR GENERAL
METROPOLITAN TRANSPORTATION AUTHORITY

Subway Flooding During Heavy Rainstorms: Prevention And Emergency Response

MTA/OIG #2005-64 **FEBRUARY 2006**

Matthew D. Sansverie
INSPECTOR GENERAL

February 6, 2006

Mr. Lawrence Reuter
President
MTA New York City Transit
2 Broadway
New York, NY 10004

Re: Subway Flooding During Heavy Rainstorms: Prevention and Emergency Response
MTA/OIG #2005-64

Dear Mr. Reuter:

This Office has completed an audit of how MTA New York City Transit Subways maintenance departments responded to widespread service disruptions experienced on September 8, 2004, as well as the routine maintenance activities that serve to prevent or mitigate such service disruptions. The present report, the first of two related to the storm of September 8, focuses on the drainage infrastructure itself; the problems of trash and silt; the procedures governing workers responding to flooded conditions; the equipment used for emergency response; and the supervisory structures providing control and coordination. A second, forthcoming report will focus on communications provided to customers on that day.

We are pleased by your apparent concurrence with the report's major findings and recommendations as indicated in your response, which is included as Appendix A. We would also like to note the positive manner in which Maintenance of Way senior managers responded to information brought to their attention by auditors and took active measures to rectify a number of weaknesses. While heavy rainstorms will no doubt cause service disruptions in the future, we trust the implementation of these recommendations will help keep down the number of problem areas and the duration of the service outage.

Our audit was performed pursuant to the MTA Inspector General's authority as set forth in Section 1279 of the Public Authorities Law. We thank managers and staff at NYC Transit for the cooperation extended in the course of our review.

Very truly yours,

Matthew D. Sansverie

EXECUTIVE SUMMARY

Subway Flooding During Heavy Rainstorms: Prevention and Emergency Response

In the Fall of 2004, a significant rain storm hit New York City just before the morning rush hour causing lasting service outages, train evacuations, long delays and serious platform crowding. This report details our findings including the chances of a similar storm in the foreseeable future, the causes of the flooding and MTA New York City Transit's (NYC Transit) overall preparedness to deal with such conditions. Our recommendations include a call for increases in NYC Transit's cleaning and maintenance programs, the acquisition of new equipment, as well as better communication and information availability to NYC Transit workers tasked with flood response.

We make special note of our findings regarding efforts to deal with accumulating trash and garbage in the subway environment. What has been referred to as "littering" can no longer be relegated to "quality of life" enforcement. Trash and garbage accumulation is a real service and safety threat, one that greatly aggravates service interruptions under storm stress and plays a role in the recent increase in the number of smokey and dangerous track fires. As one transit official candidly conceded, "no one is going to drown in a subway flood, but people could die as a result of a track fire." A customer-based, "Safe and Clean Subway" education and awareness campaign in the subways is an essential prong in the attack on this issue, along with other strategies coordinated to control the effects of garbage in the subway environment.

Wednesday, September 8, 2004

On this date as much as 1.76 inches of rain fell on New York City between 6:51 and 7:51 a.m., as measured in Central Park. We counted at least 15 different locations where flooding significantly affected service during the morning rush hour on the 1, 2, 3, 4, 5, 6, A, B, C, D, E, F, M, N, Q, R, V and W routes. On some routes, service was not restored until late afternoon. There were 1,156 reported subway train cancellations, virtually all of them in the morning rush hour. Hundreds of thousands of subway riders experienced long delays and serious crowding conditions, some of which required evacuation of passengers and emergency medical assistance.

Some NYC Transit officials referred to the September 8, 2004, rainfall as a 50 or 100-year storm or as "an act of God," which suggests an event that

cannot be prepared for. The MTA Office of the Inspector General (OIG) analyzed rainfall intensity records to see how rare this storm was. According to the Northeast Regional Climate Center (NRCC) at Cornell University, the rainfall measured for one hour at Central Park could be expected to recur every 10 years and the rainfall measured at LaGuardia Airport could be expected every 2 to 5 years. A storm in August 1999 had a similar impact on the subway system. Experts have forecasted a heightened period of hurricane activity over the next decades. While we agree they are exceptional events, we disagree with the implication that it would be fruitless to actively prepare for them and to take all reasonable steps to mitigate or prevent their effects.

In its immediate reaction to the impact of the storm NYC Transit insisted there was nothing that subway operations managers could do in the face of so much rain and that the primary cause of flooding incidents was the inadequacy of New York City's sewer system. A NYC Transit spokesperson said the incidents underscored the need for increased investment in the subway system's aging pump plants. Our detailed analysis of operations on that day led OIG to conclusions that differ in substantive ways from those public remarks.

We found no reported failures at the 300 or so subway pumping facilities. Instead, water accumulated because the drains leading to some pump rooms were blocked by trash, soda bottles, MetroCards and mud. We also found that routine maintenance was insufficient to adequately clean some parts of the drainage system. Thus, while capacity limitations of the City sewers may have hampered drainage for a time while it was raining, those limits were not the sole cause of delays of 4 or 7½ hours, as actually occurred in some places on September 8, 2004.

In addition to the impact on flood related service interruptions, we found that littering by subway customers, including the disposal of recently introduced free newspapers targeted to subway riders, is associated with the recent trend of an increase in subway track fires, a significant safety risk.

We also found that subway tunnels are vulnerable to storm water backing up from sewers, not because of a problem with New York City's sewers, but because of an historical neglect of check valve maintenance. Check valves are devices with flappers which allow water to drain from the subway tunnel to the sewer but prevent flow in the other direction. In particular, service on the Westside IRT was suspended because tens of thousands of gallons of water came through broken check valves at 81st Street and Broadway. Once the water was in the tunnel, the drains were then sealed by trash that kept it there until NYC Transit maintainers could clear the drains. There are 33 locations where the subway drainage system connects directly with the sewer system, and there appears to be no record to demonstrate that these check valves have been inspected or serviced for decades.

OIG also studied how NYC Transit maintenance departments responded to the many water conditions being reported. The emergency response capability was clearly hampered in that weather forecasts gave NYC Transit no clear warning of the timing and magnitude of the storm. Under the action plan currently in place, such advance notice is essential before the plan can be put into effect. When weather circumstances unfold suddenly or deviate significantly from predictions, the plan as written puts maintenance forces at a disadvantage. Logic dictates that a flooding response plan that is premised on significant advance notice of the precise timing and accumulation of rainfall is not adequate. Clearly, this event demonstrates that NYC Transit must develop a greater capacity for effective, rapid emergency flooding response, independent of weather predictions received well in advance of the storm's impact.

In this storm, NYC Transit faced a large number of flooding incidents, yet lacked a sufficient means of tracking and responding to them. Poor supervision, coordination, communication and control unjustifiably increased response time. For example, it took 1 hour 39 minutes for the first responding maintainers to arrive at a 42nd Street flooding location, during which time all uptown 6th Avenue service was suspended. In other cases, we noted that the number of staff sent to flooding incidents were either too many or too few. In still another example of poor deployment of resources, a large contingent of maintainers spent the entire day pumping in the Coney Island Yard, even though there were many conditions affecting passenger service that needed attention.

The response to the conditions at 79th Street and Broadway, analyzed in detail on page 13, encapsulates many of the shortcomings of the current emergency response approach: (1) it took too long for maintainers to get there; (2) essential information was not provided to the maintainers; (3) there was no supervision for a significant time period; and (4) there were no emergency response procedures to guide the maintainers into taking effective action. Service on the No. 1, 2, and 3 routes could have been restored in much less than 4½ hours.

During multiple-incident events, communication between the maintenance divisions and the transportation Control Center needs to be made more robust and reliable. There were instances of poor communication on September 8, 2004, but the most striking example occurred 10 days later on September 18. While it seems inconceivable that service would be out in both directions of the Broadway IRT for nearly two hours before maintainers responded to a water condition, this is what happened, once again at 79th Street and Broadway.

Another factor contributing to protracted track flooding is that NYC Transit's emergency pumping equipment inventory is poorly suited for quick deployment and timely restoration of service. The portable pumps available on September 8, 2004, appear to be too heavy for these applications, requiring too many maintainers and too much time to bring them to bear on the problem. Supervisors elected to try and clear drains

manually instead of pumping. In fact, the awkward portable emergency pumps were used on few occasions.

Our review also identified recurrent flooding problems where engineering solutions and better collaboration with agencies of the City of New York could mitigate or prevent service impact. For example, the Hillside Avenue F Line stations are notorious for flooding under intense rainfall. The water comes into the subway through sidewalk air vents because of roadway changes made by New York City Department of Transportation (NYCDOT) that cause water to pool up over the sidewalks. Additionally, the sewer pipe near Parsons Boulevard is merely 12 inches in diameter, rendering it one location where the City's sewer capacity actually is inadequate. Mid-level managers at NYC Transit stated that some years ago they tried, unsuccessfully, to get NYCDOT's cooperation in addressing the sidewalk flooding problem. Our report mentions a few other vulnerable locations where cooperative engineering solutions may eliminate future flooding.

OIG also learned of a number of significant initiatives that are being or have been implemented by NYC Transit to prevent or lessen future problems. NYC Transit's response to the report, which is attached as Appendix A, discusses these in some detail, but we specifically note the following. First, NYC Transit's maintenance division had already undertaken many corrective measures by the time our audit began. Second, after OIG expressed our findings about the vulnerability to flooding at 81st Street and Broadway, NYC Transit repaired the check valves there in August 2005. As a result, during the intense October 2005 rains, flooding there was avoided while numerous other locations experienced floods.

Among other things, we recommend that NYC Transit:

- Establish clear operational control in flooding situations;
- Track individual incidents and communication better;
- Use lightweight, yet powerful pumps for quick and efficient flooding relief;
- Create written emergency response procedures for maintainers and supervisors;
- Document unusual maintenance issues and their locations to assist unfamiliar emergency response maintainers;
- Adequately fund the maintenance budget to ensure optimal drainage system performance;
- Reprioritize the trash problem as the system safety and service related issue it is instead of allowing it to be relegated to a "quality of life" concern; and
- Develop a process for regular inspection and maintenance of all direct connections to the New York City sewer system.

The current report focuses on maintenance and emergency response issues; a companion report discusses NYC Transit's communications with customers during the flooding incidents.[1]

[1] See *NYC Transit's Customer Communications During the Subway Flooding Incidents of September 8, 2004*, MTA/OIG report # 2005-65L.

TABLE OF CONTENTS

BACKGROUND

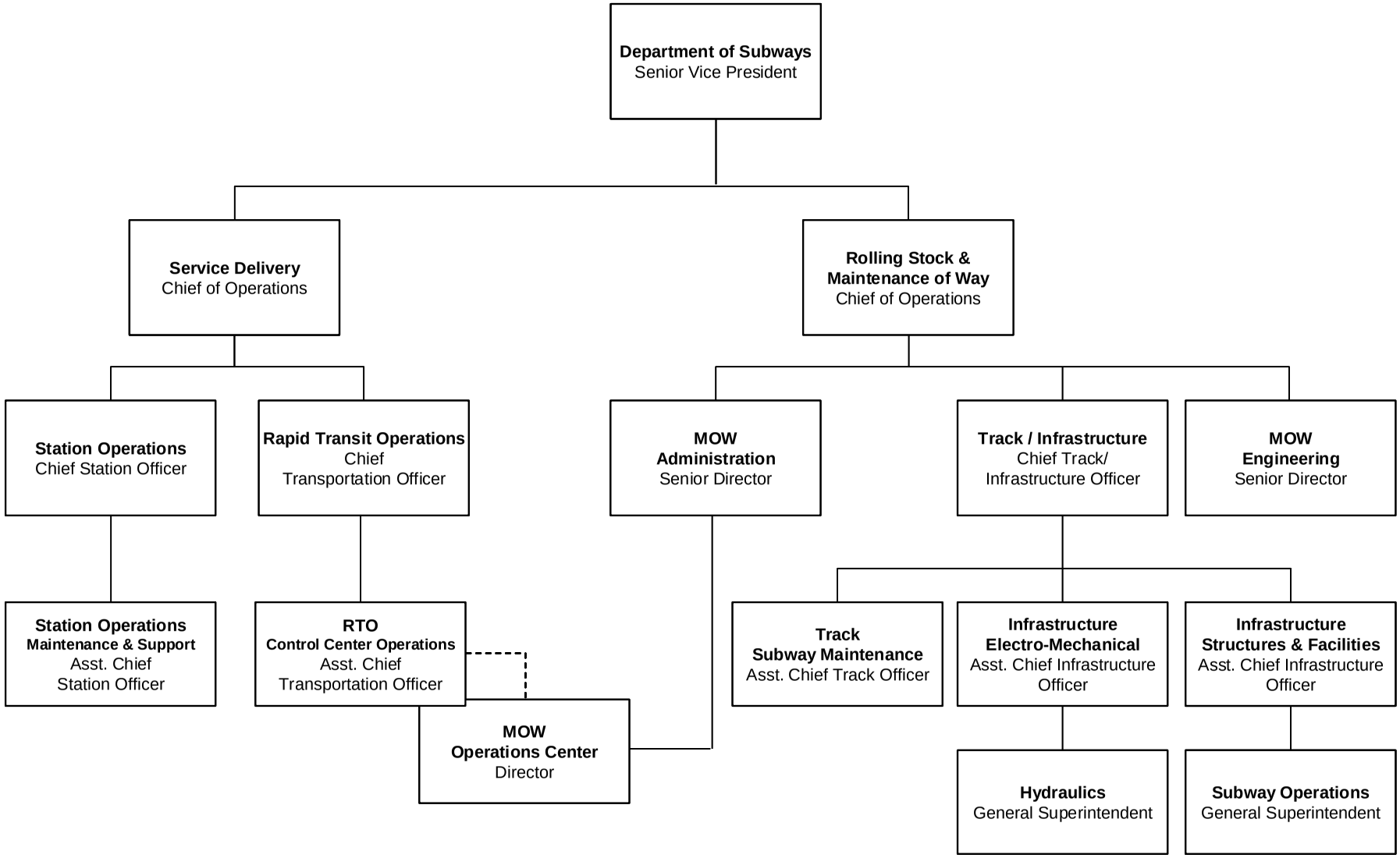
Subway tunnels lie beneath the streets of the City and in most cases beneath the City's network of sewers. There are hundreds of thousands of leaks from faulty water pipes and groundwater, and on a dry day NYC Transit pumps out 13 million gallons of water into the sewer system. When there is heavy rainfall, there are myriad ways for storm water to enter the subway system, and in many locations water can pour through the fresh air vents in sidewalks due to clogged sewer catch basins or adversely designed street grading. When water enters the system it should be contained and channeled away by the concrete trough between the tracks to drains that route the water into a system of drainage pipes either to pump rooms which discharge the water to a City sewer or to drains which take water directly into a sewer pipe. NYC Transit has about 300 pump rooms and 33 direct connections to the sewers where water runs off by gravity.

Maintenance preparedness for heavy rains and the response to the water conditions that result involve several NYC Transit Department of Subways (Subways) units, particularly within Rolling Stock and Maintenance of Way's (RS/MOW) Track/Infrastructure Division and within Service Delivery's Rapid Transit Operations (RTO) Division. To be consistent with terminology used within Subways, we will refer collectively to the maintenance units not related to subway cars as Maintenance of Way (MOW). The organization chart in Exhibit 1 is tailored to show the divisions involved in responding to and preventing water conditions. The chart reflects the large number of different units involved in resolving flooding-related service disruptions and suggests the need for a high degree of inter-unit coordination. Track and Infrastructure units are important in responding to flooding incidents, but scheduled maintenance and inspection are their day-to-day responsibilities, not emergency response.

The Hydraulics group is responsible for maintaining the pump facilities and for cleaning the drains in front of the pump rooms.[2] The Structures and Facilities (S&F) Subway Operations unit has responsibility at night for cleaning the rest of the drainage system, stopping leaks, and protecting equipment from water intrusion. Other daytime S&F units have maintenance workers who regularly inspect and repair conditions within structures. The Track Subway Maintenance unit (Track) regularly picks up trash and debris from the subway tracks, particularly in front of stations, scrapes away silt buildup on the trackbed by the rails and runs vacuum trains that clean the trackbed. Station Operations is responsible for cleaning the sidewalk vent bays and secures sewer manhole covers in its platforms. When heavy rains are expected, Station Operations covers critical sidewalk vents with plywood and even puts sandbags at vulnerable stairwells to keep water out.

[2] Though the unit is called "Hydraulics" it is also responsible for maintaining ventilation fans throughout the subway system.

EXHIBIT 1: Overview of Main Responsible Department



RTO's supervisors and train crews are the frontline for reporting where the water conditions are and updating the Control Center, which makes decisions on rerouting service and how to communicate with customers. At the Control Center, MOW has an Operations Desk (MOW Desk) which relays information to and from MOW personnel in the field.

Flooding of tracks creates situations where it is difficult to operate service in a safe manner. Sensors in signals and switches can malfunction. Water completes circuits that cause signals to show red, when they should be green. Water can also cause electricity to arc from the third rail, potentially starting fires and producing smoke. At best, service must operate slowly through water conditions, probably with manual flagging. At worst, service must be suspended, and trains, sometimes by traveling backwards, must be brought into stations where passengers can get out safely.

When flooded tracks are reported, Hydraulics, S&F, and Track maintainers and/or supervisors are dispatched to assess the problem and report back on what is needed to fix it. Water will often drain off by itself or be pumped away without maintenance action. However, if the drains are blocked with debris, maintainers will need to clear them, which can be done by any of these departments. On the other hand, if drains or pipes running from one track to another are clogged with silt and/or debris, Hydraulics or S&F will need to "snake" them. If portable pumps are necessary to remove the water, Hydraulics will respond with trucks specially equipped with an array of pumps and related gear. Hydraulics also has powerful pumps that it brings to handle emergencies on behalf of New York City. Hydraulics has provided this equipment and its skilled maintainers to help the City's Office of Emergency Management on numerous occasions, e.g., when water mains break.

OBJECTIVES, SCOPE AND METHODOLOGY

The OIG undertook this in-depth study of the events of September 8, 2004, to determine the causes of particular severe incidents of flooding, to review Subways' plans to prepare for storms and the response by subway maintenance and operations personnel to flooding conditions, and to recommend, as appropriate, measures to help safeguard against future incidents or to lessen their severity or duration.

OIG auditors interviewed managers at all levels within Subways Service Delivery and Rolling Stock and Maintenance of Way. We examined Hydraulics emergency equipment and trucks, visited pump rooms, and surveyed locations with direct sewer connections. We examined maps of the system which showed pump room locations and possible direct sewer connections. We examined architectural and engineering drawings of the drainage system, some dating from the early 20th century. We interviewed engineers at NYC Transit about specific locations and general policies. We reviewed maintenance records and emergency plans. For September 8, 2004, we reviewed all available records, including internal reports

produced by Hydraulics. We interviewed operations people and engineers from the NYC Department of Environmental Protection's (NYCDEP) Bureau of Water and Sewer Operations. They discussed diagrams with us and assisted us by taking photographs and videotape of the sewers at 81st Street and Broadway, where flooding occurred with some frequency in recent years. To examine Subway's response to the water conditions experienced on September 8, 2004, we selected several locations and interviewed the individual supervisors and some of the maintainers who responded to the scene. We also looked at MOW budget records to understand trends in resources related to the maintenance of the subway drainage infrastructure.

OIG auditors obtained RTO's Train Incident Reports for specific flooding incidents, not only dating from September 8, 2004, but from other dates after 1997 where intense rainfall was recorded by the National Weather Service's National Climatic Data Center (NCDC). In many cases, we reviewed MOW's Operations Log for the same days. We also researched rainfall records kept by the NCDC for a period of 11 years, beginning in 1994, and we compared rainfall on September 8 to the rainfall intensity-duration analyses produced by the Northeast Regional Climate Center to determine how frequently rainfall of this intensity can be expected.

The objectives of the audit were to find out:

1. What happened on September 8, 2004?
2. How frequently could a storm of this magnitude be expected?
3. Did Subways implement a heavy rain plan prior to the storm?
4. How effectively did Subways respond to flooding on Sept. 8?
5. What are the causes of flooding and the reasons for its duration?
6. How are resources allocated for maintenance activities related to preventing water conditions?

The following sections will address each of these objectives. This audit was conducted in compliance with Generally Accepted Government Auditing Standards.

Place Holder for Exhibit 2

What Happened on September 8, 2004?

Exhibit 2 maps out the major incidents of track flooding.

> *Between 5:51 and 6:51 a.m., 0.83 and 0.92 inches of rain were recorded at LaGuardia and JFK, respectively.*

At 6:10 a.m., fire and smoke were reported on the Brooklyn 4th Avenue Line. Water caused electricity to arc across the third rail insulators, causing them to smoke. Under current procedures, smoke from arcing insulators is considered fire. Other third rail insulator fires occurred that day: for example, at 45th and 53rd Street Stations of the 4th Avenue Line; the 34th Street Station of the N, Q, R, and W Broadway Line; and Parsons Boulevard on the F Line.

At 6:33 a.m., flooding on the F Line at Parsons Boulevard, Sutphin Boulevard, 169th Street, and 179th Street required a shutdown of service. Passengers were being advised to take buses to other stations and lines. Forty-one trains were cancelled, and service disruptions reached all the way to the Brooklyn Stillwell Avenue terminal causing a shortage of trains for returning northbound service. After a 1½ hour delay, service had resumed, but by then flooded tracks near the 65th Street Station along Queens Boulevard allowed only a handful of F trains to reach Manhattan until about 11:00 a.m.

At 6:40 a.m., flooding was reported on 19 tracks at the Coney Island Yard. Flooding was subsequently reported at the Westchester, 148th St.-Lenox, and Pitkin Yards.

> *Between 6:51 and 7:51 a.m., 1.76 inches of rain fell in Central Park and 1.39 inches at LaGuardia Airport.*

At 7:18 a.m., water rose above the rail at Nevins Street causing numerous cancellations in No. 2, 3, 4 and 5 service. The Westside No. 2 and 3 routes were also delayed by water at Fulton Street in Lower Manhattan, where signals malfunctioned. Between 7:00 a.m. and 12:00 p.m. on September 8 service capacity through Nevins Street was only 61 percent of the 170 scheduled trains. The lost capacity from 7:18 a.m. to 12:00 p.m. resulted in the absence of a train for an estimated 28,000 passengers who take IRT trains to Manhattan via Nevins Street.

Beginning at 7:21 a.m., signal failures due to high water caused E, F, R and V service reductions on the Queens Boulevard Line. Although the water condition was cleared by track workers, signal problems continued and only a fraction of the scheduled number of trains provided service to Manhattan. Full service for the F route did not resume for 3½ hours. Between 7:30 and 11:00 a.m. on a normal day, about 104,000 passengers enter Manhattan from Queens on those routes. For purposes of comparison, the MTA Long Island Rail Road brings 65,000 customers to Penn Station on all branches combined over the same time period.

At 7:33 a.m., water on the tracks at Lawrence Street caused all service through the Montague Tunnel, a key Brooklyn crossing, to be suspended until the evening rush. Of the 39 local M and R trains scheduled during the 8:00 a.m. to 12:00 p.m. time period, 9 brought passengers into Manhattan via the Manhattan Bridge tracks. Service capacity had already been reduced at Brooklyn's IRT crossings, and D, N, B, Q service over the Manhattan Bridge would be sharply curtailed a short time later. Between 7:33 a.m. and 12:00 p.m. on a normal day, about 24,000 passengers enter Manhattan via the Montague Tunnel. Trains were backed up and crowded along 4th Avenue. Some passengers became ill after 9:00 a.m. and had to be evacuated by EMS, creating further delays.

At 7:36 a.m., at Canal Street on the northbound A and C routes, water caused signal malfunctions. Manhattan-bound service was re-routed for a time along the F line from Jay Street to West 4th Street. After 39 minutes signal maintainers arrived and flagged trains through.

At 7:38 a.m., flooding stopped service on the No. 1 downtown local at 79th Street. By 8:10 a.m., the water condition had grown to cause the suspension of service on all four tracks for the Nos. 1, 2 and 3 trains. Service in the southbound direction alone on these routes was lost that day for 96,000 passengers, and did not resume until 12:46 p.m. Later in the report we will discuss why flooding occurred here and why service disruptions continued for 2 hours before MOW responded effectively.

Due to the loss of Westside IRT service, No. 2 trains were re-routed to the Lexington Avenue Line, which was already compromised by signal trouble caused by water conditions at 86th Street at 7:29 a.m. and 23rd Street at 7:41 a.m. Service continued, but trains were manually flagged through at reduced speeds. There were 161 terminal cancellations on the Lexington Avenue Line. The 23rd Street Station provided another case study for OIG auditors.

At 7:41 a.m. flooded tracks were reported by a train operator on an uptown F train just north of 42nd Street. Due to miscommunications, it took about 2 hours for MOW to begin to resolve this condition. Compounding this delay, at 8:00 a.m. water was reported over the switches by the 5th Avenue-53rd Street Station; at 8:17 a.m. water was reported over the rails on the southbound tracks south of 34th Street; and at 9:19 a.m. high water was reported on the southbound track at 47th-50th Street Station. Ultimately, there was a suspension of uptown service for 7½ hours and downtown service for 2½ hours, with 278 train cancellations. The scheduled F service from Brooklyn calls for 52 trains between 7:00 a.m. and 12:00 p.m. On September 8, so many F trains were cancelled or rerouted onto the G Line that only 17 trains got through to Manhattan, meaning 19,000 riders lost service or had to make connections to other lines.

B, D, N and Q service over the Manhattan Bridge was significantly reduced between 8:00 a.m. and 12:00 p.m. due to flooding at Canal Street

and Grand Street on the Manhattan side. Some trains were stranded on the Bridge for a time. Of 56 N and D trains scheduled to cross the Bridge, records show that only 19 made it. Of 28 Q trains scheduled, 11 were cancelled, while most B service (28 scheduled trains) was suspended. After this, all the subway routes serving the critical Atlantic and Pacific Avenue Stations had severely reduced capacity, and LIRR passengers hoping to get to Flatbush to avoid the reported 20-30 minute delays into Manhattan announced on the LIRR found, along with thousands of subway riders, that there were few trains going to Manhattan.[3] Records show that no one from MOW responded during this time period. Between 8:00 a.m. and 12:00 p.m., trains crossing the Manhattan Bridge carry over 56,000 passengers.[4]

Explanations Given By Public Officials in the Media

On the day after September 8, 2004, newspaper articles carried various statements from NYC Transit spokespeople and City officials. They blamed the City sewer system's limited capacity. The Mayor was reported to say "the systems that take water away just cannot handle that quantity." NYC Transit President Lawrence Reuter reportedly said there was little his workers could have done because the city's drainage system was overwhelmed. A public affairs person said NYC Transit could do a better job in the future if $126 million for new pumps were approved by the MTA and state legislators; he reportedly said some pumps were used during the building of the Panama Canal.

The City's sewer system that handles storm water runoff can become temporarily overtaxed when such storms strike. NYC Transit pumps water into the sewers and also has a multitude of points where water drains directly to the sewer without pumps. If the sewer is "charged," drainage will not occur and water will pool in the low-lying drainage areas in the subway tunnels. The key questions then arise: Are there ways to prevent water from entering the subway, and once it gets there and pools, are there ways to ensure it can be expelled quickly when the rain ends to minimize the disruptions? Were there actions NYC Transit should have taken that it did not take?

Regarding NYC Transit's stationary pumps, OIG's research found no connection between them and the water conditions that resulted and persisted on September 8. Subways' pumps are rated 90 percent in a state of good repair, and for September 8, internal reports show no defects in pump operation.[5]

[3] NYC Transit did not notify the LIRR that there was little service from Brooklyn to Manhattan. Customer communications during the September 8 flooding are discussed in MTA/OIG Report #2005-65L.

[4] The passenger volumes are based upon ridership data collected in 2003: "Year 2003 Weekday Cordon Count," NYC Transit. In September 2004, both sides of the Manhattan Bridge were open and more service was provided than in 2003.

[5] According to Hydraulics, the story about the Panama Canal pump is false; the pump in question was decommissioned in the 1980s.

How Frequently Can A Storm of this Magnitude Be Expected?

Some Transit officials referred to the September 8, 2004, storm as a 50 or 100-year storm or as "an act of God." Viewed in this way, most plans or investments to prevent the flooding experienced that day could not be cost-effective. However, our review of rainfall data shows that this is the wrong view to take, and there is much to be learned from the experience of September 8.

While the rain on September 8 was very intense, heavy rains have been experienced in New York City with some frequency. For the 11-year period from January 1994 to December 2004, official data show that rainfall exceeding one inch in one hour fell on 19 separate days at one or more of the three main New York City weather stations.

To learn how often a storm of September 8's magnitude can be expected to occur in New York City, we contacted the United States Geological Survey, which directed OIG to a website for the Northeast Regional Climate Center at Cornell University. The NRCC's statistical analysis of rainfall data answers questions of this sort.[6] Our analysis, see Exhibit 3, shows that storms of this intensity can be expected more frequently than NYC Transit officials indicated. The most intense hour of measured rainfall at Central Park -- closely approximates a 10-year storm, while at LaGuardia Airport we could expect a storm of this intensity every two to five years, and at JFK Airport almost every year. The September 8 storm was also notable for its sustained intensity over two hours. However, as mentioned before, flooding had already occurred during the most intense hour, and as we shall see, similar flooding was experienced on September 18, 2004, which was a less intense storm.

EXHIBIT 3: Rainfall Intensity on September 8, 2004

	1-Hour Rainfall (inches)	How Often Will This Recur On Average?	2-Hour Rainfall (inches)	How Often Will This Recur on Average?
Central Park	1.76	10 years	2.52	25-50 years
LaGuardia Airport	1.39	2-5 years	2.16	10 years
JFK Airport	0.92	Less than 2 years	1.26	Less than 2 years

Source: OIG Analysis of Curves Produced by the Northeast Regional Climate Center at Cornell University, compared with rainfall data from the National Climatic Data Center, National Weather Service.

[6] The NRCC data can be seen at http://www.nrcc.cornell.edu/pptext/. The NRCC analysis was done using information over the years 1953 through 2003 and therefore does not include four intense storms during August and September 2004. Moreover, some experts recently forecast a heightened period of hurricane activity over the next decades.

Another way to look at the vulnerability of the subway system to heavy rainstorms is to look at the history of a key location. On September 8, 2004 the tracks were flooded just north of the 79th Street station on the Nos. 1, 2 and 3 routes. Service was suspended for 4½ hours. OIG learned that this location flooded at least 6 times in the past 7 years, and it did not take 1.76 inches of rain to flood all four tracks of the Westside IRT. Exhibit 4 shows the dates, intensity of the storms that flooded this location in the past seven years, and the duration of the service loss. This data supports the conclusion that heavy rains can cause subway service disruptions, even without a "hundred year storm."[7]

EXHIBIT 4: Known Dates of Flooding at 79th Street and Broadway (1998-2004)

	1-Hr. Rainfall Intensity (inches) in Central Park	Time of Day	Hours of Service Lost
June 13, 1998	0.85	Midday	2 hours, 36 min.
Aug. 17, 1998	0.79	Midday	1 hour, 39 min.
Aug. 26, 1999	0.89	AM Rush	15 hours, 16 min.*
Aug. 4, 2003	0.77	PM Rush	1 hour, 22 min.
Sept. 8, 2004	1.76	AM Rush	4 hours, 36 min.
Sept. 18, 2004	1.15	Weekend	3 hours, 2 minutes

* Time to restore service includes other delays on the same line.

Sources: National Climatic Data Center, NYC Transit, OIG Analysis

Did Subways Implement A Heavy Rain Plan Prior to the Storm?

When there is a clear forecast of heavy rains with specific amounts of rain in a short interval, Subways may choose to implement a plan to prevent flooding conditions and facilitate a response to problems that arise. A Hydraulics storm center is sometimes set up to coordinate the response (at least by its own workforce) and to enable a higher volume of communications. Under the "Heavy Rains Action Plan," pumping equipment and drains are inspected at designated "critical" areas, places where flooding seems a special risk. Certain vent gratings are covered with plywood and some station entrances are protected with sandbags. The plan counts on a lot of work being done during the shift prior to the expected arrival of the storm. Emergency equipment and personnel are pre-deployed to sectors of the system for rapid response. Additionally, maintenance crews from the prior shift can be held over on overtime and pre-deployed, along with pumping equipment. Unfortunately, the weather forecasts just before Wednesday, September 8, 2004, did not provide a

[7] 79th Street flooded again, just after midnight on July 6, 2005. The condition lasted for nearly an hour. However, as we will discuss later, MOW repaired its sewer connections here in August 2005.

clear prediction. There were statements that heavy rain was possible, but the amounts of rain projected in inches were not exceptional, and so the preparations provided in the plan were not made.

The intensity and timing of the storm was unforeseen by the National Weather Service (NWS). Although the remnants of Hurricane Frances approached from the southwest, the main body of the storm was not predicted to arrive before Wednesday night into Thursday. However, a line of storms, denser than the main body, developed over the ocean and swung toward the City and Long Island in advance of the main body. By 3:00 a.m. Wednesday morning, satellite radar images showed clouds with densities indicating light to moderate rainfall directly over the City. The NWS 4:40 a.m. forecast said "locally heavy rain possible," but the 6:00 a.m. forecast that MOW received from its contractor, Weatherdata Network, forecast only "showers … moderate at times." NWS issued an urban flood advisory for New York City at 6:19 a.m., but heavy rain was already falling. Virtually no preparations were taken by Subways in advance of the storm, and to make things worse, the unfortunate timing of the storm meant that the night shift for dozens of maintenance workers and plumbers ended at 6:00 a.m., before problems began to develop. They were on their way home when the storm broke.

How Effectively Did Subways Respond to Flooding on September 8?

Even though the subway system experienced a large number of problems, the RTO Control Center relied upon its usual means of tracking incidents. RTO has no plan to trigger in events of this type, and did not set up an emergency storm control center, so it treated the day as a typical day, albeit with more incidents to cope with than usual. Moreover, in our discussions with RTO managers, they did not seem to grasp how significant these disruptions were and seemed to think they did a good job of getting riders at least close to their destinations.

To communicate with MOW, RTO relies primarily upon an open radio connection monitored simultaneously by several operating departments.[8] On typical days, with a small number of incidents, these radio communications may be an adequate means of informing MOW and ensuring that all incidents are handled, but, as we will show in the discussion that follows, on a day like September 8 or September 18, 2004, the sheer volume of incidents and radio transmissions overwhelmed RTO and the MOW Desk within the Control Center, and some incidents slipped through the cracks. Operations logs from that day reflect confusion about flooding incidents that appears to have hampered and delayed an effective response; several incidents received no response from MOW. As we will discuss later, over time there have been significant budget reductions in MOW's control capability, and this may have played a role in some of the problems we found.

[8] Internally, this is known as the "six-wire."

The Assistant Chief Officer, Infrastructure, (ACIO) for Electro-Mechanical and the General Superintendent for Hydraulics did not set up a storm center at Sands Street to help handle communications with the field and to provide supervision to units there. As a result, a special procedure for tracking each reported incident they are responding to was unavailable on September 8. Consequently, the use of equipment was ineffectively managed and personnel in the field received inadequate supervision.

In some instances MOW responded to the incident quickly. For example, Hydraulics was on the scene at Lawrence in 11 minutes and at Nevins Street in 14 minutes. Track responded to 65th Street on Queens Boulevard in 39 minutes. However, in other instances, even the initial response to assess the situation was woefully slow. For example, the first respondents to 79th Street and Broadway took one hour 12 minutes and the first (unsuccessful) response to 42nd Street and 6th Avenue took one hour and 39 minutes. There was no record of a response from Hydraulics, S&F, or Track to some locations. As trains crept slowly past red signals at 86th Street on the Lexington Line, RTO was told that MOW had no one to spare to help at that location. At Canal Street on the 8th Avenue Line, water caused signal malfunctions. Signal maintainers appeared after 40 minutes to flag trains through and eventually to repair the signals. Personnel who could have attempted to clear the drains did not appear. When all service going over the Manhattan Bridge was suspended at 8:00 a.m. because of water at Canal Street and Grand Street, there was no timely response from MOW. Hydraulics sent someone 7 hours later to Canal Street, but no one went to Grand Street. The RTO Control Center compiled a report discussing the problem at Canal Street and thus the suspension of N and Q service, but did not record the loss of B and D service going to Grand Street, which, however, was noted by a dispatcher on the route. Similarly, the MOW Operations Log has no record of a problem at Grand Street.

Use of Emergency Pumps and Emergency Vehicles

Hydraulics possesses an array of emergency pumps for removing water pooled on the tracks. Onboard their emergency trucks there are gas-powered 275 gallon per minute (gpm) pumps, 600 gpm pumps, and some smaller pumps. There are specialized pump trains that are kept in rail yards in the Bronx and Brooklyn. There are also two powerful pumps that must be towed to the scene that are used for emergency requests by the City for flooding from things such as water main breaks. After a review of MOW records and interviews of Hydraulics supervisors and maintainers, we have concluded that these pumps are not well-suited to address problems from heavy rains in a timely manner. They are more suitable for handling much heavier accumulations of water, such as for water main breaks. In fact, very little pumping was done on September 8, 2004, because of the difficulties in deploying these emergency pumps.

Subways' three specialized pump trains could provide no assistance on September 8. They were ready, but Hydraulics did not call upon them.

These trains are not considered useful for getting at water below the third rail, and Subways believed it would be too time-consuming to deploy them. Any use of the pump trains implies that service will be out for an extended period.

The largest portable pumps that are towed to the scenes of water main breaks cannot, as a rule, be used for water conditions in subway tunnels. The hoses cannot make the necessary turns to reach the trackbed, and the pumps cannot be brought close enough to the water to work.

The 600 gpm pumps, the most powerful ones on the two Hydraulics emergency vehicles, were also not used. These pumps take about 10 men to carry them. They are useful when a station is flooded and the pumps can be set down on the station platform, but for water in the subway tunnels they would be impractical and would require lots of time and manpower. They offer no hope of resolving a condition in order to restore service quickly.

The 275 gpm pumps were used on the 6th Avenue Line north of 42nd Street and in the vicinity of Lawrence Street in Brooklyn. The supervisor at 79th Street and Broadway decided not to use a pump because it would take too long to set up the equipment and would require all of his maintainers to stop their work of clearing the drains in order to carry them.

Pumping also took place at Coney Island Yard and Chambers Street. Hydraulics records do not show what kinds of pumps were used at these locations.

Many Hydraulics employees start their day at a facility at the Broadway-Lafayette Station in Manhattan. Hydraulics' emergency vehicles and pumping equipment are kept at Sands Street in Brooklyn; there is no secure parking at Broadway-Lafayette. Therefore, maintainers typically must travel on subway lines that may be disrupted by the same emergency water condition they are responding to. Travel can be slow and unreliable, with precious time lost. Service disruptions on the subway have a huge impact on the City and affect tens of thousands of riders, yet when Hydraulics' emergency vehicles are dispatched for subway emergencies they do not receive police escorts, and currently there is no protocol with the New York City Police Department's (NYPD) Transit Bureau for police escorts to help Hydraulics emergency vehicles get to the scene, although they have received escorts when they performed emergency pumping for the City outside of their NYC Transit duties.

On September 8, the two Hydraulics emergency vehicles were not used to maximum effect as far as we can tell. It is hard to be certain because Hydraulics does not keep the basic records to track where its vehicles are on a given day. From the available data it appears that the emergency trucks were not doing anything productive until after 10:00 a.m. Truck 31 was sent to Parsons Boulevard, but could not reach its destination due to traffic. After returning to Sands Street at 8:15 a.m., it was not sent out

elsewhere until 10:40 a.m. Truck 14 was, as far as we can determine from the poor records kept by Hydraulics, not used until it arrived at 79th Street at 10:55 a.m., too late to do anything. It was then sent to help at 6th Avenue and 42nd Street. To some extent this ineffectual use of resources is an unavoidable result of the uncertainty that surrounds water conditions; but we believe it also shows a lack of effective management of resources by Hydraulics.

Hydraulics has long sought to acquire a third emergency truck, but the purchase has been delayed for over a year. The new truck would be equipped with a generator, which could provide power to a lighter electrical pump that, we were told, could be deployed at water conditions more quickly and easily.

The Response to Flooding at Coney Island Yard

On September 8, the first major problem was reported at Coney Island Yard at 6:40 a.m., where numerous tracks were flooded. Hydraulics dispatched a crew and a small truck at 7:00 a.m. to Coney Island. Six Hydraulics maintainers were at Coney Island until 9:00 p.m. They turned on a manual pump and set up pumps to clear various locations in the Yard. These personnel and equipment were therefore unavailable for the rest of the morning to do other work on the main lines where trains carried passengers. The decision to deploy these people to Coney Island was made without consulting RTO. From the RTO Control Center's perspective, once trains were out and available for service, pumping in the yard would not be the number one priority when there were conditions on the main lines serving customers that needed attention. The Hydraulics General Superintendent could not have assessed whether that many people were necessary; in interviews with OIG it became apparent that he did not know how many maintainers were there or what specifically they were doing.

The Response to Parsons Boulevard

At 6:45 a.m., Hydraulics also committed significant resources to handle flooding conditions at Parsons Boulevard and other F train stations along Hillside Avenue, a known trouble spot when it rains. Hydraulics dispatched 6 maintainers and a supervisor to assess the situation and rectify it if possible. They left separately from the Broadway-Lafayette facility by subway and did not arrive for about one hour and 15 minutes. Presumably, they could not get there sooner since subway service was out. Additionally, at 6:50 a.m., Hydraulics dispatched two more maintainers from Sands Street in emergency truck 31, which never reached Parsons Boulevard as discussed above. When the Hydraulics supervisor arrived about 8:00 a.m., the water condition was already gone; service resumed at 8:06 a.m. Workers from the Track Department had arrived at 7:36 a.m. and had cleared it up. The maintainers checked the pump room and found it working properly. The Hydraulics personnel remained in the area until the evening rush.

The Response to High Water at 79th Street and Broadway

The flooding in Manhattan near 79th Street and Broadway points to significant operational issues within Hydraulics. Sands Street first heard of the trouble at 79th Street at 7:50 a.m. and dispatched a crew in a truck with pumps and other equipment from a work site in Greenpoint, Brooklyn, and a maintenance supervisor from Broadway-Lafayette. A superintendent was sent at 8:30 a.m., but due to subway delays on the 6th Avenue Line he was diverted to problems developing there. Another superintendent was not sent until much later, arriving at 11:15 a.m.

The supervisor, though sent at 8:05 a.m., did not arrive at 79th Street until about 9:30 a.m. He encountered subway delays and had to walk part of the way. He had never been to this location and did not know there were sewer connections. He found a shovel when he got there. The crew from Greenpoint, unaccompanied by a supervisor, got there at 8:50 a.m., 40 minutes ahead of the supervisor. By the time they arrived at 79th Street, approximately 34,700 downtown local and express riders were without service or had to seek alternative transportation.

As a matter of practice, crews call in their movements in the field to a Hydraulics dispatcher, who merely records them. On this day, when they called in at 8:50 they did not speak with a supervisor, even though their designated supervisor had not yet arrived. Hydraulics maintainers are trained to do their regular maintenance jobs without direct supervision, so this was not a failure to follow procedures on anyone's part. In fact, there are no written procedures for how maintainers are to respond to emergency flooding conditions. However, this incident demonstrates the importance of supervision.

The Hydraulics dispatcher gave no instructions to the maintainers to help them overcome the particular condition at 79th Street. He knew little about the location and did not have any specific details to share. He assumed the maintainers would know what to do, but they told OIG they had no prior experience at this location. The maintainers were not idle, but in the absence of supervision and useful instructions, they were ineffective. The result was a significant loss of time while thousands of customers in both directions along Broadway at this time waited in vain for service to be restored. The quickest way to resolve the problem was to have power turned off and to walk into the watery tunnel about 250 feet north of the station. Here they could remove drain covers blocked with debris and let the water out into the sewer.

Instead, while three maintainers remained in the truck on the street above, two entered the 79th Street Station. From the north end of the platform they saw the edge of the water condition. The drain was only about 250 feet away, but they did not know this. The power was still on so no one could enter the tunnel. The Hydraulics maintainers did not request power to be shut off at this time, which would have allowed them to enter the tunnel and check the condition of the drains. They said such a request

must come from a supervisor. Hydraulics managers and supervisors said the maintainers had the responsibility for doing this but acknowledged there is no written procedure requiring or authorizing them to do it. Hydraulics has detailed maintenance procedures, but not emergency response procedures. When workers respond to flooded tracks, managers assume they will know what to do.

The unsupervised Hydraulics maintainers then embarked on a lengthy survey expedition. Making note of the location of the southern shore near 79th Street of the lake that covered all four tracks, two maintainers exited the station and walked to 86th Street, while the others remained in the truck at 79th Street. From the 86th Street Station, the two maintainers walked south along the dry part of the tunnel until they found the northern shore of the lake. Then, at 9:23 a.m., they phoned in the exact location and expanse of the water condition. They walked back along the tracks to 86th Street Station and exited the subway and then walked along the street back to 79th Street to rejoin the others. At about 9:30 a.m., the supervisor arrived at 79th Street and requested that power be turned off, which was done at 9:48 a.m., two hours and 10 minutes after the incident began and an hour after the maintainers first arrived on the scene. From the time the maintainers first arrived to the time when power was shut off, an additional 28,000 downtown passengers lost service on these routes.

Unfortunately, now that the power was off, the supervisor and his crew still did not pursue the most expedient and effective course of action simply because they were not given the information they needed. Lacking the necessary information, rather than walking into the tunnel 250 feet and clearing the large drains that take water directly to the sewer, they drove north about 1,000 feet to an emergency exit where they began clearing all the drains they found with shovels as they approached the sewer connections. However, this wasted time since these drains simply feed into the blocked drains at the sewer connection; they were superfluous with such high water. Unblocking the drains above the sewer connections would drain all the water.

At 10:07 a.m. the Hydraulics supervisor requested an emergency truck in case it became necessary to pump. In the meantime, the Hydraulics maintainers continued clearing drains. When they finally cleared the critical drains above the 81st Street sewer, the water began to rush out. When truck 14 arrived from Brooklyn at 11:07 a.m., it was too late to do anything here. By 11:15 a.m. the water had receded enough to see the rails. After another 24 minutes of draining, other MOW departments began to inspect, clean, and in some cases replace burned out signaling equipment. Service resumed at 12:46 p.m. Overall, 96,000 downtown passengers lost subway service or had to find alternative transportation on overcrowded buses, in taxis, or on other highly congested subway routes.

The ineffectiveness of this response is illustrated by what happened 10 days later on Saturday, September 18, 2004. The tracks flooded again, but in this case, the Assistant Chief Infrastructure Officer (S&F), after coming

from home on his day off and working on another water condition in northern Manhattan, went to 79th Street, where fortunately the power was already shut off. The ACIO went directly into the tunnel, located the sewer drains beneath a large sign with an arrow pointing to them and saw they were blocked with debris. He pried the debris away and then lifted up the drain cover so it would not be covered again with debris. The water gushed out and receded. He accomplished what six people did on September 8 in much less time. The water was down 50 minutes after the power was shut off.

Unfortunately, the response on September 18 was bungled by poor communication, which caused the water condition to persist for three hours. On that Saturday morning, the water condition was first noted at 8:56 a.m. RTO says that it notified all other departments on the internal radio connection at 9:00 a.m. However, there were multiple incidents, and many people may have tried to speak at once, which could cause some reports to be blocked without people knowing it. This may explain why MOW did not react to this condition until 10:45 a.m., where their records complain about a "late report" from RTO. RTO reviewed its tapes for that day but found no evidence of notification of flooding around 9:00 a.m. However, MOW's control desk stands close to the RTO superintendents handling the incident, so the miscommunication is hard to understand. Somehow, though, MOW did not learn for nearly two hours that Westside IRT service was suspended due to flooding at 79th Street. When MOW found out, Hydraulics sent an emergency truck, which again arrived too late to do anything. The S&F ACIO arrived before the truck, corrected the condition, and reported the water was down at 11:35 a.m.

Response to the Shutdown of the Sixth Avenue Line

At 7:41 a.m., flooded tracks blocked a northbound F train at 42nd Street and Sixth Avenue. The MOW Desk at the RTO Control Center apparently did not know about this delay. MOW's Operations Log confuses this water condition with a separate one that occurred around 9:19 a.m. near Rockefeller Center and refers only to a water problem in the station passageway at 42nd Street. Though the water condition was reportedly announced by RTO to several departments, there is no record that the MOW Desk passed the word to MOW managers before 10:15 a.m. Hydraulics learned about it because a superintendent on his own called RTO for an update. The Hydraulics superintendent and three maintainers reached 42nd Street at 9:20 a.m. and went to the pump room at 44th Street on the downtown local track where water drains to a low spot.

Hydraulics expected to find the water at this low point, but instead found it to be dry. The uptown tracks cannot be seen from the downtown tracks at this unusual location, and so they did not know of the small lake, about 200 feet long with an estimated 29,000 gallons of water on the other side of the wall. From the pump room, they contacted the RTO Control Center at 9:35 a.m. and, through some miscommunication were advised, not to look for the water on the northbound track, but to go further north by 47th

Street. It is unfortunate the Hydraulics superintendent did not consider the possibility that the water was on the other tracks, blocked by clogged drains and did not ask the RTO Control Center specifically where the problem was at 42nd Street. As the maintainers headed toward 47th Street, two hours after the condition was reported at 42nd Street, MOW had not yet found it, much less assessed it or begun to clear it. Had they known, emergency truck 31 could have gotten there at least 40 minutes earlier with the needed pumps and tools.

There were inadequate resources at these locations. The four Hydraulics workers at the scene could not handle both conditions and no one else was sent. An S&F employee was at the 42nd Street Station at this very moment. He could have provided assistance in checking out the problem with the drainage in the tunnel; however, he merely reported to the MOW Desk that water was entering the station through sidewalk vents and flooding a passageway. He could have provided assistance in checking out the problem with the drainage in the tunnel; however, since the MOW Desk is merely a conduit for information, there was no one to think to instruct the S&F employee to look into the water condition on the track. S&F superintendents could not recall this incident at all and their record for the trouble call could not be found, so we were unable to determine which individual responded.

The S&F superintendent said this employee could not have helped anyway, not without a team of co-workers, a supervisor, lights for flagging, and a device for ensuring that power was off. He said he would not ask his maintenance workers to go onto flooded tracks otherwise and said S&F workers from the "Fire Suppression" group have less familiarity with work on the tracks. All these conditions would make a timely repair impossible. We question whether they should be necessary in an emergency situation when the power has been turned off. The ACIO for S&F did not require them on September 18. Few S&F workers were involved in responding to the water conditions on September 8 on the morning shift. There appears to be a lack of a plan that includes them in emergency response, along with a lack of procedures and training.

An additional source of confusion may be that the RTO Control Center officially recorded the location of the incident as 34th Street rather than 42nd Street, where the original water condition was observed. There were missed opportunities because of missteps in monitoring the incidents by RTO and MOW at the Control Center.

The Hydraulics crew walked north to the flooded downtown tracks just south of the 47th Street-50th Street Station and set to work with shovels from the pump room. Several drain-boxes had so much silt accumulated in them that water could not reach the pipes that drain it off. They mucked out the drain-boxes, and the water receded. Thus, southbound service was able to resume sooner than northbound service after the removal of the water here.

An RTO supervisor then told them of the small, "lost" lake to the south that was blocking all northbound service, and the superintendent left to survey the situation at 9:51 a.m., now over two hours after the condition was reported. At 10:15 a.m. Hydraulics established that the cross-drain that should take this water to the pump room across the tracks was clogged and requested an emergency truck. They also requested assistance from S&F. In the meantime, the Hydraulics crew worked unsuccessfully to clear the clogged cross-drains. They did not yet have the equipment they needed to do this, and they could not clear the cross-drains until the water was pumped away. The S&F maintainers, the same crew that had responded to the Parsons Boulevard area earlier, arrived at 11:36 a.m. The pumps and tools arrived at 11:39 a.m. with emergency truck 31, four hours since the condition was first encountered. Hydraulics set up portable pumps and at 12:20 p.m. they were pumping water onto the local track next to the pump room, where the drain was working. Around 1:40 p.m., Hydraulics succeeded in unclogging the cross-drains with rods and the condition cleared up. After other MOW departments inspected equipment in the area, service resumed at 3:20 p.m.

What are the Causes of Flooding and the Reasons for its Duration?

Garbage and Silt on the Trackbed

In examining the available information for specific incidents, we found in numerous instances that water pooled and then drained poorly because of debris and silt accumulation, issues directly related to the effectiveness of maintenance operations and, of course, to the behavior of subway passengers and others who leave garbage in the system. MOW managers particularly complained of newspapers that are distributed for free in subway stations that are frequently left there and blown onto the tracks by passing trains and the discarding of MetroCards onto subway tracks. Stations Operations is currently working with the newspaper vendors to stop the practice of leaving undistributed papers in stations.

Trash in the system prolongs service disruptions due to flooding. Subways officials say the NYPD has never enforced the littering laws to the extent that NYC Transit has requested. Littering is seen as a "quality-of-life" violation. However, in the subway environment the presence of litter on the trackbed is a safety concern due to the potential for track fires and water-related service disruptions. Track fires caused by trash increased from 459 in 2003 to 568 in 2004. As of December 1, there were already 618 fires during 2005 directly related to the presence of trash.

We studied incidents on other days besides September 8 and found evidence of drains being blocked by debris or pipes and drain-boxes being clogged by trash or silt. On September 8, the following locations exhibited one of these problems:

- Parsons Boulevard (drains blocked by debris and plastic bags used by the Track Department to collect garbage);

- 65th Street on the Queens Boulevard Line (drains blocked by debris);
- 79th Street & Broadway on the Westside IRT Line (drains blocked by trash);
- 42nd Street & 6th Avenue on the 6th Avenue Line (pipes crossing from track to track clogged);
- 47th Street-50th Street on the 6th Avenue Line (drain boxes clogged with silt);
- 23rd Street on the Lexington Line (crossing pipes clogged and drains blocked);
- Lawrence Street (crossing pipes clogged and silt buildup in the sump room);
- Nevins Street on the IRT (blocked drains);
- Canal Street on the Broadway BMT Line (blocked drains);
- Dyckman Street on 8th Avenue Line (clogged drains);
- Lexington Avenue Station on the Queens Boulevard Line (blocked drains);
- Hunts Point Avenue on the Pelham No. 6 Line (blocked drains);
- Near Court Square on the G Line (drains clogged).
- 36th Street on the 4th Avenue Line (drains blocked); and
- West 4th Street on the 6th Avenue Line (drains blocked).

Even at locations where NYC Transit had questioned sewer capacity, such as north of the 79th Street and Broadway station, debris plays a crucial role in causing and prolonging flooding incidents. Water flowing inside the subway tunnel carries a large amount of debris, which seals the drains. We reviewed records for several incidents at this location and found that debris blocked the drains. For example, on September 8, the rain diminished to a small amount, according to the National Weather Service, by 8:51 a.m., but the water did not drain until the debris was moved after 10:00 a.m. During a previous incident here, a sneaker was found among the debris blocking the drain.

When we observed conditions in the subway tunnel one night near 79th Street and Broadway, we found that the key sewer connections were protected with new, larger, raised drain covers, but the drain boxes on the other three tracks were caked with grime and debris. Troughs between the tracks were clogged with silt and blocked with debris, ranging from newspapers and bottles to a folded up shopping cart. Beneath signal equipment, trash and debris blocked the trough.

To make it more difficult for debris to block the drains on the trackbed, S&F and Hydraulics have installed numerous extended drain covers. These are already being installed, including 79th Street, Parsons

Boulevard, 44th Street and at 7 drain boxes at 47th Street-50th Street. Hydraulics will use machines that use water pressure to clean the cross-drains by pump rooms each year so silt will not build up and the drains will be opened to their full diameter. S&F has established a list of "hot spots" where drains will be cleaned and inspected on a quarterly basis, and they have identified all the cross-drains that are not directly in front of pump rooms so they can be cleaned regularly.

Key Locations Prone to Flooding

OIG studied several locations where flooding occurred on more than one occasion in greater detail. At 79th Street and Broadway and at 23rd Street on the Lexington Line, we were interested in understanding where the water came from, in particular whether, as some NYC Transit employees told us, storm water flowed up into the subway from pressurized sewer lines. We also studied the Parsons Boulevard F Line station on Hillside Avenue, where street flooding and low sewer capacity often lead to service disruptions when heavy rain falls, and 86th Street on the Lexington Avenue Line. Finally, we studied the 28th Street station on the 7th Avenue Line, where on at least two occasions water burst through sewer manhole covers located on subway platforms and flooded the tracks.

Direct sewer connections such as those near 79th Street and 23rd Street pose special issues for Subways. There are no pumps. Water drains by gravity directly into sewer pipes below the subway. During our fieldwork, Subways managers, we found, did not know how many direct connections there are, where they all are, or if they have check valves or not. Check valves are devices that prevent water from flowing up into the system from "charged," i.e., pressurized, sewer pipes. OIG found there was no list of the locations of these direct connections available to any Subways division on September 8. The lack of ready information on the direct connections can waste precious time in responding to flooding incidents. The Hydraulics General Superintendent had a list in his office. Even though a note on the list advised "In the event of Heavy Rains, the following locations may flood due to charged sewers," he had not made it available to supervisory staff or maintainers.

OIG found a series of diagrams where NYC Transit employees had sketched in the locations of the "direct connects" along with some description of them. No one at Subways knows who sketched them on the diagrams or when they did it. OIG combined our list of direct connects with the one held by Hydraulics into a single list, which we provided to NYC Transit under separate cover. MOW's review of this list determined there are 33 locations with direct sewer connections.

While MOW officials believe the direct connections were maintained in earlier years, they acknowledged that this type of maintenance was discontinued many years ago. No one currently at MOW could remember routine inspections or maintenance on them ever being done. Similarly, the direct connections have not been included in any condition survey that

MOW engineers can recall. We believe these are significant lapses. If there is no check valve or if it is in poor condition, then water will gush into the subway tunnel from a charged sewer. Alternatively, a broken check valve could keep water from draining out of the tunnel. The ACIO for S&F said he had not heard of problems with the direct connections, yet 79th Street and Broadway and 23rd Street on the Lexington Avenue Line have had recurrent flooding problems.

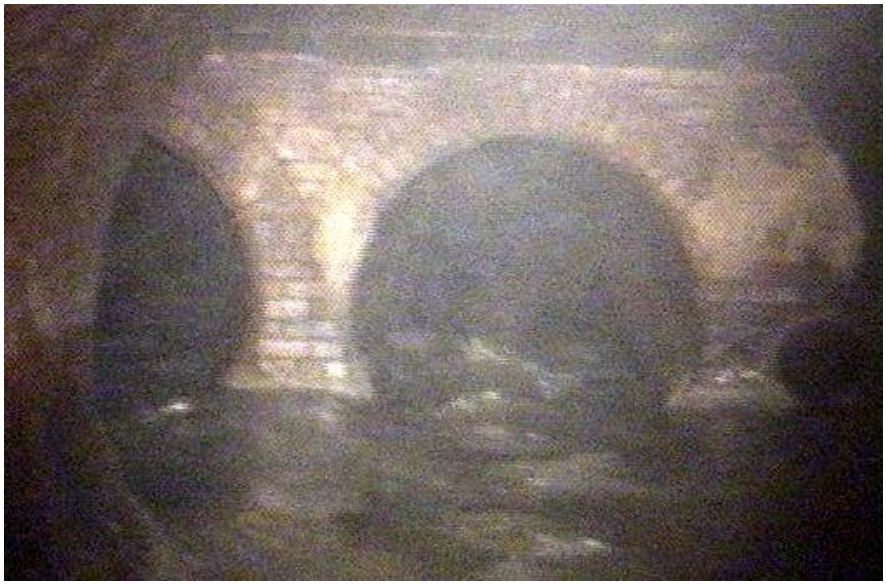
Direct Connect North of 79th Street and Broadway

Where 81st Street crosses Broadway, water drains from the subway directly into a large sewer pipe. Over 100 years ago, the Interborough Rapid Transit Company cut out a section of the 5'7" sewer pipe below 81st Street because its top was higher than the planned subway track level and replaced it with two 48" pipes that go beneath Broadway and the subway tracks. The IRT Company installed drainage pipes which lead from the subway tracks to the sewer pipes west of Broadway in 1904 and added check valves to prevent backflow from the sewer in 1931. As discussed earlier, we found that this location flooded at least six times in the seven years from 1998 through 2004. NYC Transit officials were unaware of a recurring problem at this location. They were also uncertain about whether there were check valves, since they have not been maintained in so long and were mostly covered by an accumulation of silt. However, following up on concerns raised by OIG's analysis, MOW found and repaired the check valves in August 2005.

Both check valves were found to be disabled by debris and rust. The flappers, which must close all the way to keep pressurized sewer water out and open all the way to drain water from the subway tunnel most efficiently, were stuck partially open. Without a functioning check valve, NYCDEP engineers told us that during a severe rainstorm water could back up into the subway tunnel. Due to lack of maintenance over many years, these check valves failed on September 8, 2004, and on many occasions. Since they were repaired, flooding has not occurred at this location, including on a day of heavy rainfall in October 2005, when flooding occurred at other locations.

Exhibit 4 gives a view, looking from the west, of the two 48 inch pipes running beneath the subway tunnel on a dry day. The smaller circle to the lower right of the sewer pipes, just above the water level, is one of the pipes that come from the subway tunnel. Another subway outflow pipe, not visible in this photo, is to the left of the sewer pipes. At OIG's request NYCDEP workers entered the chamber to inspect the outlet on the left and found a heavy flow of water. OIG shared a videotape with NYC Transit, whose inspectors then found a significant leak from City water pipes near 84th Street, which emptied water into the subway tunnel. NYCDEP and NYC Transit worked together to fix this leak, which had been there for years. This leak could have added as much as 18,000 gallons of water per hour to the storm water that entered the subway tunnel on September 8, 2004, making it take much longer to drain the tunnel and restore service.

EXHIBIT 4: The Sewer Beneath the Broadway IRT at 81st Street (from the West)



Source: NYC Department of Environmental Protection, Bureau of Water and Sewer Operations

Direct Connect at 23rd Street on the Lexington Avenue Line

Another sewer connection where trouble occurs is at the 23rd Street Station of the Lexington Avenue Line. On September 8, water caused signals to malfunction and trains to move slowly. Maintainers could do very little here, since subway service ran continually. Most of the drains are situated close to the third rail, and they could not be tested while the power remained on. The water condition remained into the evening, even though the rain had stopped long before. After the evening rush hour, when maintainers were allowed to work on the tracks, they determined that cross-drains in the area were clogged. Subways personnel were unsure whether water flowed up from the sewer, but said the area has poor drainage because the trackbed is level so water does not run off toward a drain. The sewer pipes running beneath the tracks actually rise above the trough and obstruct drainage. OIG auditors visited this site some months later and found heavy accumulations of silt in the trackbed, which blocked and clogged drains. There was standing water on the express tracks, even though it did not rain that day.

The F Line Along Hillside Avenue

The F Line along Hillside Avenue is notorious for water problems, according to Subways, since the street was re-graded by NYC Department of Transportation (NYCDOT) about 15 years ago. Unfortunately, Subways has but one pump room (at Parsons Boulevard) to handle all the

water it receives from a stretch of the four-track subway extending over 7,500 feet, and virtually the entire area is prone to flooding with questionable sewer capacity. Hillside Avenue was "crowned" by NYCDOT; i.e., the center of the roadway is raised to remain above the water when it rains hard. As a result, the crown acts as a dam; water pools above the sidewalk ventilation gratings and can even pour down entrance steps to the station. NYC Transit enhanced its pumping capacity at Parsons Boulevard, but the sewer pipe it pumps into is small. NYC Transit tried in 2000 to work with the City to have ventilation gratings raised; NYCDOT did not respond to their requests for a meeting and stated an unwillingness to remove the roadway crown of the street. In the absence of cooperation, NYC Transit constructed some raised ventilators. NYCDOT did not object to these, but NYC Transit did not follow up and build more ventilators as it had planned, leaving the area exposed to flooding problems when there is heavy rain. The MOW Engineering Director of Infrastructure said that other priorities occupied his attention.

Water pouring through sidewalk-level ventilation gratings will bring much of the accumulated dirt and debris in these drip pans onto the subway track bed. MOW has seen evidence that local restaurants illegally dump cooking grease into the vents north of 169th Street, clogging up drains. Station Operations Maintenance and Support established a regular maintenance schedule to clean the drip pans in these vents once every three years, although additional cleanings may be done in special circumstances. The current schedule treats each of the vents as equally important. It does not prioritize or allow for a greater frequency of cleaning for certain spots, even though some vents may require more frequent cleaning than others.

Water Intrusion at 86th Street on the Lexington Avenue Line

We noted five occasions where flooding disrupted service at this location, beginning in 1999. On September 8, 2004, an RTO supervisor reported "water coming into the system through what seems to be a manhole [at] tracks 2 and 3 north of 86th Street." This condition repeated on September 18, 2004. A signal superintendent reported that "water is entering the system from a 3-inch hole in the wall." A maintainer effected a temporary repair by putting a sheet of plywood over the hole "to prevent it from gushing out on the track." However, a more permanent repair seems necessary. On October 12, 2005, heavy rainstorms caused flooding at 86th Street in a similar fashion. An RTO supervisor reported that "water was gushing from the wall on track 1 at survey markers 137+30 and 137+50."

Sewer Manholes in Subway Platforms

We learned of another flooding problem that involves sewer manholes, although this type of problem did not occur on September 8. On September 18, 2004, water gushed up through a sewer manhole on a platform at the 28th Street Station on the 7th Avenue IRT. The same problem occurred on August 26, 1999. The tracks were flooded by water

gushing from the sewer pipe running beneath the platform. The manhole had been welded down, but the force of the water was so great that it burst the manhole cover off. Station Operations reported this problem to NYCDEP on that date, but NYCDEP mistakenly assigned the problem to its water supply division instead of the sewer division. No work was done to determine whether there is a particular problem with the sewer at this location or how it might be addressed.

How are Resources Allocated for Maintenance Activities Related to Preventing Water Conditions?

OIG analyzed Subways budgets for the maintenance functions directly related to drainage and pumping. We looked at historical patterns so we could keep recent events in perspective. In general, the MOW functions responsible for maintenance and cleaning of tracks, drains, and pump rooms faced budget reductions from 1996 to 1998. From 2001 to 2003 MOW made certain reinvestments, and so headcounts rose. However, reductions were again put into effect during 2004-05. It is difficult for MOW departments to increase their budget for maintenance. Each year the MTA requires a percentage budget reduction for Subways. Nevertheless, Subways reinvested in track cleaning and leak remediation in its proposed 2006 budget.

Exhibit 5 shows that overall the number of positions for the Hydraulics group fell from 180 in 1994 to 154 in 2005. Most of the 14 percent reduction seems to represent productivity enhancements that would not impact maintenance effectiveness. However, there are fewer people than in 1994 available to respond to flooding incidents. No budget increases were proposed for 2006 for Hydraulics.

EXHIBIT 5: Historical Trend in Subway Infrastructure Maintenance Staffing

	1994	1997	1999	2001	2004	2005	1994-2005 Change	2006* Proposed	1994-2006* Change
Hydraulics	180	151	151	158	162	154	(14 %)	154	(14 %)
Track Cleaning	151	155	132	139	139	139	(8 %)	188	+ 25 %
Subway Operations	26	26	25	34	28	30	+ 15 %	34	+ 31 %
MOW Control	49	28	28	28	27	30	(39 %)	30	(39 %)

*Based upon the 2006 proposed budget submitted by NYC Transit but not yet approved by MTA.

Source: NYC Transit, Department of Subways and OIG

Trash brought in by customers accumulates mostly along the tracks in stations, MOW's track cleaners' are responsible to bag it and remove it. Trash removal is a high priority, because trash can cause track fires. There are two vacuum trains employed by MOW to clean up trash and dirt along the tracks. However, they move very slowly and can only do 1.5 times the mileage of the entire tunnel system each year. By contrast, trash is removed manually from tracks at stations every one to three weeks. MOW is exploring the purchase of another vacuum train. The Chief Officer for Rolling Stock and Maintenance of Way recognized the need for more cleaning trains, but noted that these trains are expensive.

Overall, we see an eight percent decline in track cleaning resources between 1994 and 2005. A budget cut was implemented in 1998 related to the introduction of the vacuum trains. Fifteen positions were reassigned to support the vacuum train operations, especially to go in front of the train and prepare the roadbed for vacuuming and remove objects that would harm the train. However, 37 other positions were cut. During 2002 MOW reinvested in 18 positions set aside for three "scraping" gangs. These maintainers are involved in removing silt, but their primary purpose is to protect against derailments. These workers scrape away layers of sediment that can accelerate oxidation of the rails, causing derailments. In 2004, 12 scraping positions (two gangs) were eliminated for planned budget reductions, along with five other positions lost or, perhaps, saved as a result of organizational efficiencies. With each gang capable of scraping 42,000 linear feet of track per year, the mid-2004 budget cut reduced production from 126,000 linear feet per year to 42,000. NYC Transit has proposed restoring one gang in 2006. At the proposed production rate of 84,000 feet scraped per year, it could take 28 years to scrape the entire system of tunnels.

The most essential means of cleaning debris from the system is simply to work in stations at night manually picking up trash. The bagged trash is stowed in the tunnels to be picked up later by work trains. Track's current goal is to clean trash from 350 station-tracks each week and there are two work trains available to pick up all this trash over the entire system. While some stations with a high density of trash, i.e., a high volume of passenger activity, are cleaned more frequently than others, current resources allow for an average station cleaning rate of about once every 3.6 to 4 weeks. Even for stations cleaned once a week, the rate may not be adequate to protect drainage systems; the General Superintendent of Hydraulics said that at many places enough trash could accumulate within just 2 days to block drains when water flows in the tunnel. The proposed budget for 2006 adds 34 track cleaning positions and increases the rate of cleaning to 525 station-tracks per week. A third train and 7 more positions were proposed to help with the removal of this trash. Although the 2006 proposed budget for track cleaning workers, if it is approved, will be 25 percent higher than in 1994, there is no way to estimate what impact that will have on mitigating flooding, since management has no measure to gauge the extent of flooding as a problem.

The S&F Subway Operations group has an annual goal of cleaning 90,000 feet of drainage pipe a year. Unfortunately, MOW officials do not know how many feet of drainage pipe there are in the system and no one could tell us how this goal was arrived at. There are approximately 2,376,000 feet of track within the system of subway tunnels, a lot of it with drainage pipe beneath it, and numerous cross-drains. Potentially, it will take over 20 years to clean the whole system once. There were 26 maintenance workers in 1994, which increased to 30 by 2005, primarily due to the addition of a team of maintainers designated to eliminate or redirect leaks. The primary purpose is to prevent the deterioration of electrical and electronic equipment on the wayside, but our discovery of leaks near 79th Street and Broadway and Roosevelt Avenue on Queens Boulevard demonstrates that leaks contribute to flooding incidents. The budget proposed for 2006 added another 4 workers to fix leaks.

We found no way to determine whether flooding was a more frequent problem now than in years past. Subways' primary source of statistical reporting, the Train Incident Reports produced by the RTO Control Center, often group different flooding incidents in one report. For example, on September 18, the flooding incident at 79th Street and Broadway was combined with the one originating at 28th Street, which was caused by water coming through a sewer manhole in the station platform. Unlike subway car mechanical defects, the number of water conditions and the cause of them cannot be tracked. Furthermore, MOW does not assign a cause or a delay time for flooding incidents so that they can be studied or tracked for management purposes. Therefore, measuring success or decline is not possible, so there is no way to assess the impact of budget reductions or particular maintenance strategies.

In consideration of improved tracking of water conditions, both during a day filled with emergency conditions such as September 8, 2004, and in later reporting, we must point out the significant budget cuts in MOW's control capability. MOW control has 39 percent fewer personnel now than it had in 1994. This translates into many fewer people available to monitor flooding incidents, to track and coordinate the movements of MOW's workforce, and to communicate with managers and maintenance workers both in the field or at home if workers are needed to be called in.

While the reductions in headcount have brought budgetary savings to Subways, flooding incidents can be costly. Subways estimated the overtime costs in the aftermath of the September 8 rainstorm to exceed $220,000 for MOW and Stations workers, not including the overtime expenses for train crews or the cost of replacing damaged signal and power equipment. Of course it also does not take into consideration the enormous cost to subway riders, some of whom may have lost pay for missing work and suffered other business losses.

CONCLUSION

The service impact of the September 8, 2004 storm was enhanced by NYC Transit's then current preparedness plan which relied heavily on less than precise weather information, putting Transit too greatly at the mercy of the elements. At about the same time that the storm was at its worst, hundreds of thousands of subway riders were already in the system or on their way to their station. While the timing of events clearly broke badly against NYC Transit and its ridership, the response was insufficient and ineffective. Our analysis conclusively proves that there was room for improvement in NYC Transit's response on that day such that some flooding could have been avoided and other flooding could have been abated sooner. Thus, it would be wrong to dismiss the service impact of September 8, 2004 as an "act of God" or bad timing and fail to take steps to address avoidable problems.

RECOMMENDATIONS

We offer the following recommendations to reduce the number and duration of flooding incidents in future intense rainstorms.

1. Rolling Stock & Maintenance of Way should develop a formal emergency response plan that establishes clear operational control over all MOW forces during rainstorms and improves communication and coordination between the MOW Operations Desk and MOW field units.
2. RTO and MOW managers at the RTO Control Center should improve communication between RTO and MOW's Operations Desk. Improvements in this area would include the use of maps or lists of incidents. This simple tool would allow for the orderly tracking of incident progress, better coordination between departments and more efficient assignment of resources. The end result should be that all incidents are addressed according to the priorities set by RTO.
3. Rolling Stock & Maintenance of Way's Track and Infrastructure Unit should explore the acquisition of more suitable flooding abatement equipment, including lightweight, yet powerful pumps for Hydraulics. Such equipment will arrive sooner and be more efficiently applied to the task, allowing for more ease in re-deployment to other problem locations, leading to a more robust response.
4. During Hurricane Season, the Department of Subways should pre-deploy at least one Hydraulics emergency truck and perhaps other assets in a secure location in the vicinity of Broadway-Lafayette to avoid traffic related delays in responding to flooding incidents in that part of the NYC Transit service area.
5. In view of the clear public safety implications of severe system flooding, NYC Transit should explore a protocol with NYPD to get police escorts for Hydraulics emergency trucks or establish Hydraulics trucks as bona fide "emergency vehicles" with lights and siren status.

6. Hydraulics management should collect all relevant data in order to undertake an after-action analysis and critique of flooding response action.

7. Hydraulics should produce written emergency response procedures for maintainers and supervisors responding to a flooding incident. These procedures must ensure effective supervision and detail the responsibility of maintainers and supervisors to have power removed, if necessary, so they may enter a tunnel as soon as possible to evaluate the situation.

8. Structures and Facilities should produce written emergency response procedures for all its divisions, so their maintainers and supervisors will be available to assist in an effective, unit-integrated plan to eliminate flooding on subway tracks.

9. Rolling Stock & Maintenance of Way should maintain a list of all areas with special problems, especially direct sewer connections, and provide it to all relevant MOW departments as well as the MOW Control Desk. The list should contain detailed site information and agreed upon procedures effectively advising responding maintainers how to proceed.

10. Rolling Stock & Maintenance of Way's maintenance budget must provide sufficient resources to: (a) coordinate and control the activities of emergency workers; and (b) keep drainage systems working properly. Capital and operating strategies must result in more effective trash and silt removal.

11. Track and Infrastructure, with RTO's assistance, should develop a way to record and monitor the frequency, causes, and duration of water conditions that disrupt service, especially problems recurring at specific locations, in order to better understand the flooding problem and fashion responses.

12. Given the serious threat posed by track fires, as well as the impact of trash on flooding, NYC Transit should work with NYPD to coordinate a new approach to littering in the Subway System, as part of NYC Transit's upward reprioritization of the trash problem as a bona fide safety and service problem, instead of a lesser, "quality of life" matter.

13. A "Clean and Safe Subway" rider education program should be considered as an essential prong of combating the trash problem and reducing the number of track fires.

14. Additional station cleaning and more trash receptacles should also be considered as necessary elements in reducing the threat of track fires.

15. NYC Transit should also actively encourage the distributors of newspapers within the system not to leave undistributed papers on NYC Transit property. In the event that voluntary cooperation is not forthcoming, all legal means should be aggressively pursued to compel responsible behavior and enhance the safety of the Subway operating environment.

16. MOW should survey all locations with direct sewer connections to develop a complete inventory, determine whether there is a check valve or not, assess valve condition and regularly inspect, repair or improve valves as needed.
17. MOW should study flooding abatement strategies at the 23rd Street Station of the Lexington Avenue Line.
18. NYC Transit executive management should work with the New York City Department of Transportation to solve the persistent subway flooding regularly affecting riders who travel along Hillside Avenue.
19. MOW should devise a permanent solution to the water intrusion problem near the 86th Street station on the Lexington Line.
20. Station Operations should reassess its schedule for sidewalk vent cleaning so that cleaning frequency will correspond to need.
21. MOW Engineering should find a permanent solution to the water intrusion related to platform manholes at the 28th Street and 7th Avenue station.

APPENDIX A: MTA OFFICIALS' COMMENTS ON THIS REPORT

APPENDIX B: CONTRIBUTORS TO THIS REPORT

Audit Manager

GARY HENDERSON

Audit and Analysis Team

DONNALYNN GAZZA
NAVON HIRSHAUT
SAMUEL OWUSU
ALBERT YEE

Quality Assurance

RUTH L. R. LEVY

Word Processing

JULIA CONNER

Production and Distribution

MERYL HUGHES
ELIANA PEÑA
ALICIA POPPE