A HYDROLOGIC STUDY OF THE EFFECTS OF URBAN DEVELOPMENT ON STORM RUNOFF: A CASE STUDY IN QUEENS, NY

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ABSTRACT

Just after the repaving of Hillside Avenue in the late 1980's, the New York City Transit Authority's (NYCTA) 153rd Street pump room has reportedly experienced significant flooding problems. The pump room was constructed in the early 1930's to drain the water that enters the subway line from groundwater seepage and rain falling into the subway line through the air ventilation system (gratings). It is located south of the intersection of Hillside Avenue and 153rd Street at the base of the subway line. Repaving Hillside Avenue in the late 1980's, increased the height of the crown of the road. This increased in a few inches of crown height across the street has allowed stormwater to accumulate along the street and then enter the subway line through the ventilation gratings rather than flowing across the crown down into the lower portion of the basin. The stormwater entering the subway line then flows down to the sump of the NYCTA pump room. The objective of this study was to characterize the hydraulic conditions of the site and to propose a solution to the problem of flooding through the subway gratings. The critical section of the study site was selected between 144th Street and 160th Street based on historical knowledge of the flooding locations and the slope of the subway line (Figure 1). Modification of the low-lying NYCTA gratings located within the critical section was proposed to prevent future flooding.

The reconstruction of Hillside Avenue increased the height of the street crown by several inches, forcing stormwater to accumulate above the curb before reaching the crest of the crown and flowing to the south side of the street (Figure 2). As a result, in the low-lying section of Hillside Avenue, stormwater accumulates at the north side of the street and enters into the subway line through ventilation gratings located in this area. Flood water accumulates on the subway tracks, interrupting services and creating a potential hazard to NYCTA workers.

Hydrologic analysis was conducted at the critical section of the study site. The three main drainage basins in this area were defined as 1, 2, and 3 on Figure 1. Basin 1, which has a total area of 39.6 acres, has an average slope of 6.05% and a maximum slope of 30%. The lowest point of this basin is located at the intersection of Hillside Avenue and Sutphin Boulevard. Basin 2, which has a total area of 23.8 acres, has an average slope of 7.3% and a maximum slope of 33%. The lowest point of this basin is located at the intersection of Hillside Avenue and 153rd Street. Basin 3, which has a total area of 73.8 acres, has an average slope of 9.7% and

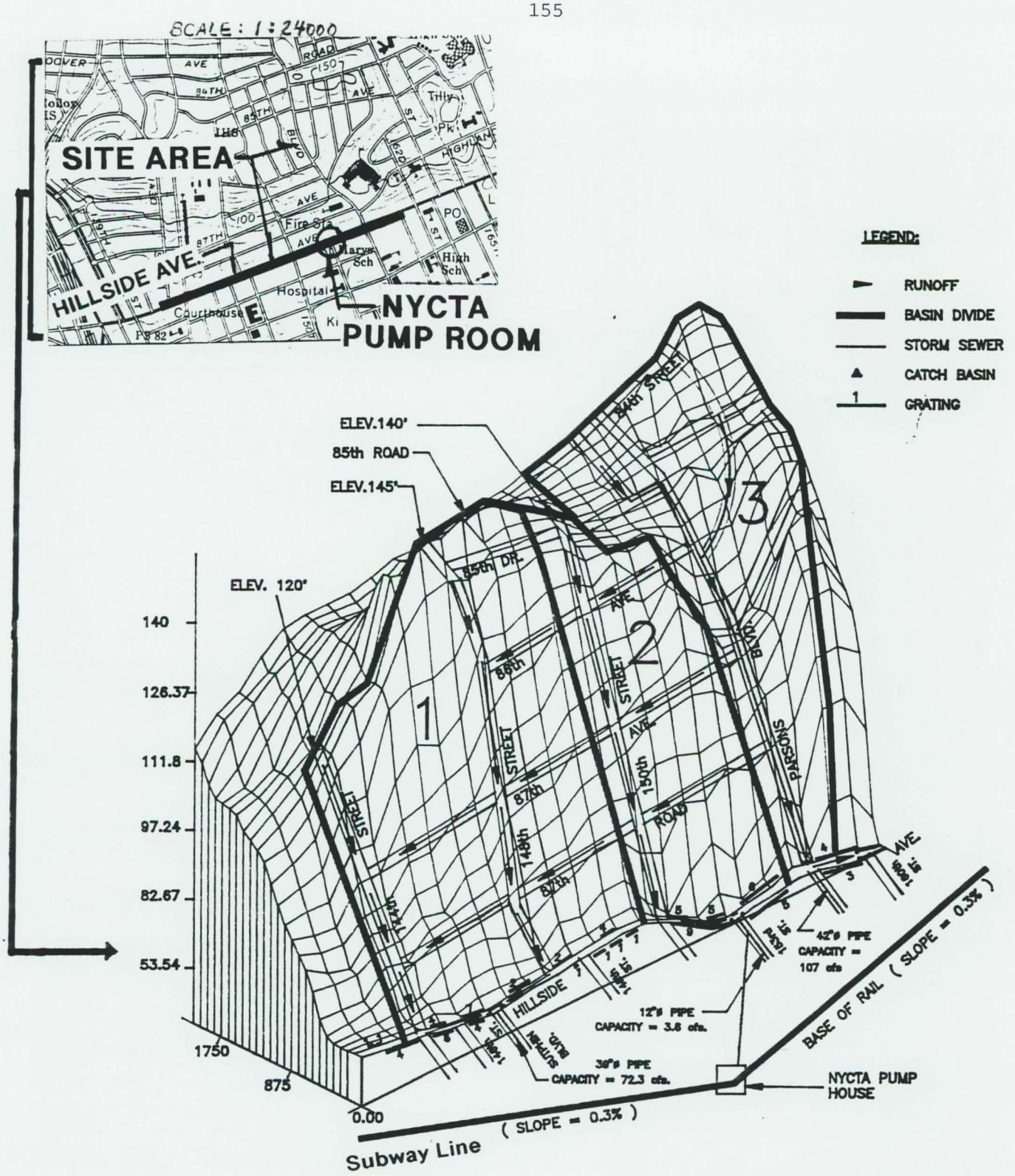

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FIGURE 1 SITE LOCATION		
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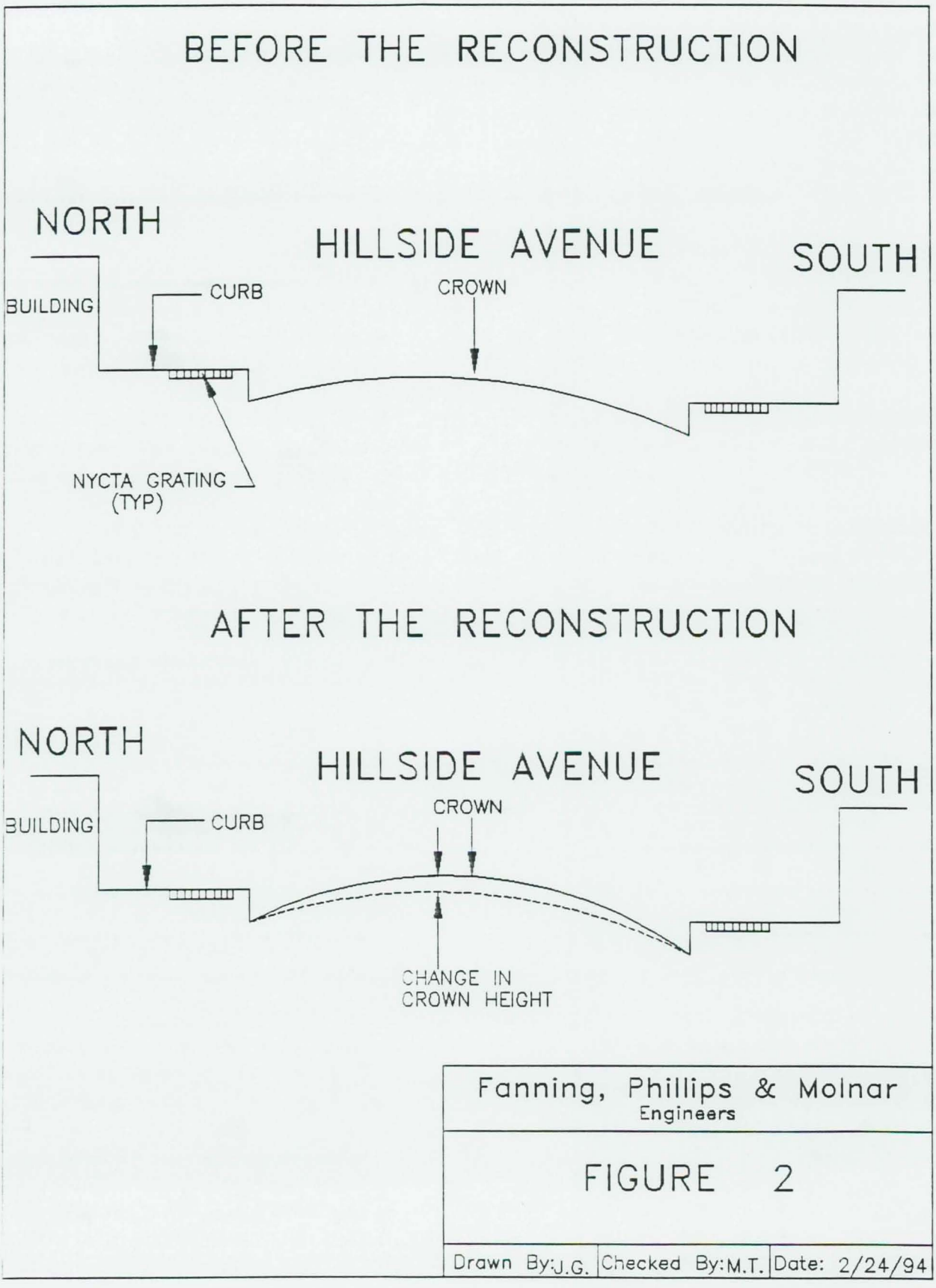
BEFORE THE RECONSTRUCTION
NORTH
HILLSIDE AVENUE
SOUTH
BUILDING
CURB
CROWN
NYCTA GRATING
(TYP)
AFTER THE RECONSTRUCTION
NORTH
HILLSIDE AVENUE
SOUTH
BUILDING
CURB
CROWN
CHANGE IN
CROWN HEIGHT
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Engineers
FIGURE 2
Drawn By:J.G.
Checked By:M.T.
Date: 2/24/94

a maximum slope of 14%. The lowest point of this basin is located at the intersection of Hillside Avenue and 160th Street. During a rain storm, stormwater runoff travels over the impervious roads from high elevations to low elevations, gathers along the north side of Hillside Avenue. The accumulation of stormwater begins at the lowest points (i.e., at the intersections of Hillside Avenue and Sutphin Boulevard, and Hillside Avenue and 153rd Street) until the water level reaches the crest of the curb of the sidewalk and flows into the ventilation gratings that are open and flush-to-grade with the sidewalks. Typical ventilation gratings are 3-feet wide and 10-feet long, providing a large surface for draining even the high frequency storms.

The amount of stormwater (input) was calculated using the Rational Method based on the area of the drainage basin, runoff coefficient, and intensity of rainfall. At a return period of 5 years, stormwater flow was calculated at 163.35 cfs, 71.4 cfs, and 199.2 cfs at Basins 1, 2, and 3, respectively. At a return period of 100 years, stormwater flow was calculated at 282.15 cfs, 128.52 cfs, and 376.2 cfs at Basins 1, 2 , and 3, respectively.

The stormwater output amounts were calculated using the Manning's Equation, based on the storm sewer inflow pipes located at Basins 1, 2, and 3. The outputs were calculated to be 72.3 cfs, 3.6 cfs, and 107 cfs at Basins 1, 2, and 3, respectively.

The difference between the stormwater input and the output amounts represents the change in flooding per unit time of stormwater on the street and into the ventilation gratings on Hillside Avenue. This stormwater flooding increases until it spills over the crown of Hillside Avenue and flows to the south side. The results are summarized below:

Basin ID	Output (cfs)	Input 5-year Storm (cfs)	Input 100-year Storm (cfs)	5-year Storm Change in Flooding Per Unit Time (cfs)	100-year Storm Change in Flooding Per Unit Time (cfs)
1	72.3	163.35	282.15	91.05	209.85
2	3.6	71.4	128.52	67.8	124.92
3	107	199.2	376.2	92.2	269.2
Total	182.9	433.95	786.87	251.05	603.97

Stormwater will not build up at the low points because the gratings represent a huge sink to the system. In order to estimate how high the water would build up under this condition, the stormwater elevation for the 5-year and 100-year storms were calculated using the Manning's Equation, using the predetermined stormwater output, profile of the crown and its storage volume, and the hydraulic wetted perimeter. The stormwater elevation will continue to increase until the amount of water discharging over the crown balances the stormwater input. The result indicates that with all the grates closed stormwater accumulates up to 3 inches above the crown during a 5-year storm, and up to 5 inches above the crown during a 100-year storm on the north side of Hillside Avenue at Basin 1 at the low point. Similarly, stormwater accumulates up to 2.7 inches

above the crown during a 5-year storm and up to 3 inches above the crown during a 100-year storm on the north side of Hillside Avenue at Basin 2. Flooding of the cross street on the south side of Hillside Avenue was also analyzed using the Manning's Equation. Stormwater accumulates up to 2.5 inches above the cross street crown at the south side of Hillside Avenue at Basin 1 during a 5-year storm, and up to 5.4 inches above the cross street crown during a 100-year storm. Stormwater accumulates up to 5 inches and 7.2 inches above the cross street crown at the south side of Hillside Avenue at Basin 2 during a 5-year and 100-year storm, respectively. The flooding elevations at the north side and south side of Hillside Avenue were determined based on detailed surveyed map of the area.

Based on the present configurations of the ventilation gratings and the calculated 5-year and 100-year storm flooding elevations, modification of low-lying ventilation gratings was proposed. In order to prevent flooding of the ventilation gratings during a 5-year or 100-year storm, gratings with elevations below the storm flooding elevations should be closed or raised to above storm flooding elevations.

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