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Worst CASE SCENARIO

Using a sewer-modeling program, engineers analyze the effects of a 25-year storm on city streets.

A mere 80 hours. That's how long it took DMJM Architects and Engineers, using an intuitive sewer-modeling program, to determine the effect of a proposed pump station on an existing storm drainage system. The engineer who performed the computer analysis was able to set up the problem, run multiple analyses, and prepare the report in less than the budgeted time. Hydrographs and schematics generated by the software in DWG format were read into AutoCAD® software where they were used to produce a graphic depiction of the storm system. The data also served as input to the process of designing the repairs. These clearly indicated to the client, the Port Authority of New York and New Jersey, headquartered in New York City, that the addition of the pumping station would not overload the existing drainage system—even in the event of a 25-year storm.

The redevelopment of the Elizabeth Port Authority Marine Terminal includes relocating and expanding an existing "expressrail" rail facility. This intermodal facility handles both container and rail freight, so redevelopment is expected to increase both truck and rail traffic in the area. As a result, the Port Authority of New York and New Jersey has included a number of planned road and rail improvements as part of the terminal redevelopment project.

One of the improvements is to relocate the railway line with a flyover to cross above McLester Street. Currently the railway line crosses the main North-South roadway, Corbin Street, at the same grade level, causing daily traffic delays as trains travel through the intersection. Due to design constraints related to how steeply this rail track can rise, it

will be necessary to depress McLester Street below its current level to create the flyover. To ensure adequate drainage for the depressed area, Port Authority engineers proposed a pumping station that would remove water from the section of the road that will be lowered. Storm runoff will flow into a 2,000-gallon wet well and then pumps will direct it into the area's existing drainage system. This system runs south into a large box culvert that discharges into Newark Bay.

Determining Feasibility

The Port Authority of New York and New Jersey hired DMJM Architects and Engineers of Newark, New Jersey, to determine the hydraulic feasibility of the pumping station. In particular, Port Authority engineers wanted to know how the addition of the pumping station would affect the existing drainage system, a gravity flow system designed for a 10-year storm. Because the depressed section of road will have no gravity outlet, the Port Authority wanted to look at the performance of the entire drainage system during a more severe, 25-year storm. The concern was what would happen when very heavy rainfall exceeded the capacity of the gravity flow system, causing pipes to fill up and water to flow out of the catch basins. The water would travel overland and, because the depressed area of the road was the lowest spot in the area, the water would flow in that direction. The pumps would remove it, but more water would flow back in. This continual recycling would eventually wear out the pumps, which were designed to handle only the small drainage area for the depressed section of the street—not the flow from the entire drainage area.

This study required DMJM to determine water surface elevations in the drainage area during 25-year-storm conditions. The firm was asked to evaluate for both the current drainage system and one featuring the proposed pumping station. The Port Authority had used HYDRA™, a sewer-modeling program from Pizer Inc., Seattle, Washington, when evaluating the storm water drainage system at Newark International Airport. The Port Authority specified that DMJM use this software to maintain consistency with sewer models created for the airport project. HYDRA models the hydraulics in municipal storm, sanitary, and combined sewer systems. Developed to be an analysis and planning tool for municipal engineers, the program strikes a balance between simplistic static models and complex dynamic models.

Sewer Modeling Process

With HYDRA installed on his laptop computer, the DMJM engineer assigned to the project first created a digital model of the collection system. He needed to model the area that discharged into the box culvert at the south end of the marine terminal. This included a major arterial sewer serving McLester Street, the street where the future pumping station would be located, as well as several collector sewers on either side of McLester. The engineer used record drawings and aerial photographs provided by the Port Authority to create the model, which included all pipes 30 inches in diameter and larger. As collection system models go, this one was fairly simple because it involved uniform drainage areas with one catch basin per acre and all areas uniformly paved.

The next step was loading the sewer model with rainfall amounts. The engineer used the Soil Conservation Service's Type 3 distribution. The distribution type is based on geographic location and determines how the rainfall is spread over 24 hours. The Type 3 distribution represents the northeastern coast of the United States, which is subject to high-intensity tropical storms.

The engineer also needed to enter information related to the tailwater in the box culvert. This represents the hydraulic grade line at the final discharge point into the bay. Tailwater is affected by tidal fluctuations, so it was necessary to enter a starting point for the tailwater. In this way, the analysis could take into account the effect of the bay water on the discharge from the culvert. The engineer used mean tide level, elevation 297.35 feet, as the starting tailwater.

Setting up the analysis model and providing the required information went quickly, even though this was the engineer's first use of the software. Its user interface enabled him to perform most functions through the use of icons and menus.

Multiple Analyses

The engineer ran the first analysis evaluating the ability of the existing collection system to handle the 25-year storm. HYDRA features a powerful 32-bit hydraulic analysis engine that performs the necessary calculations quickly, making it possible to use sewer models on a day-to-day basis. The graphical results depicted the hydraulic grade line, or elevation of the water surface, at every pipe in the model. If the system had been unable to handle the rainfall, the engineer would have seen hydraulic grade lines that were higher than the ground elevations at the catch basins, indicating water coming out of the catch basins. The analysis showed a surcharge, indicating water rising higher than the tops of the pipes and putting them under pressure, but not overflowing at any point in the system.

The next step was to add the proposed pumping station to the computer model. The engineer preliminarily sized a 2,000-gallon wet well with two 450 gpm pumps. The volume of the wet well, the small reservoir that feeds water to the pumps, was entered into the model as well as the discharge capacity of the two pumps. The pumping action would cause water to enter the existing drainage system in "slugs" of larger volume and velocity than the relatively consistent pattern of rainfall. The software accounted for the slugs automatically during its calculations.

The engineer then repeated the analysis with the same Type 3 rainfall distribution. The new results plot showed no appreciable increase in the hydraulic gradient due to the pumping, leading DMJM to conclude that no overflow would occur during a big storm. This information was provided in a report to the Port Authority. The engineer pasted results plots from the HYDRA analyses into the report so Port Authority engineers could easily visualize the data on which DMJM had based its conclusions.

DMJM had budgeted more than 300 hours for this study. The ability to run analyses and prepare the report in only 80 hours convinced the firm of the efficiency of using this software for evaluating drainage system performance. For the Port Authority of New York and New Jersey, the study demonstrated that the original design for the McLester Street pumping station was feasible. That aspect of the flyover development is ready to go, and construction of the flyover is scheduled to begin in 2001. The Elizabeth Marine Terminal redevelopment project will be completed in 2003.

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