



## A New Role for Rail Transit: Evacuation

Urban areas in the U.S. and around the world are facing increasing extreme events often requiring decisions to move large numbers of people to safety. New York City (NYC) has experienced numerous extreme weather events associated with flooding, and one response by NYC is to provide evacuation resources. Following Hurricanes Irene and Sandy, NYC mandated evacuations. NYC has defined evacuation zones based on severity of flooding risks from storms and storm surges, and has located 64 hurricane evacuation centers outside of these zones.<sup>1</sup> Of NYC's six evacuation zones, Zone 1 is defined as having the most risk of exposure to that flooding. Other centers and shelters supplement evacuation centers.

Connectivity to public transportation is one factor that determines the ability of populations to move to safer areas prior to or during an extreme weather event. NYC has recommended using public transit for safety and to reduce delays from congestion during evacuations.<sup>2</sup> New York University's Wagner School, which is a consortium member of the U.S. DOT Region II University Transportation Research Center at the City University of New York is evaluating the proximity to evacuation centers of residential populations living in U.S. Census-defined block groups partially or completely in Zone 1 (the study area). This work also includes the demographic, socioeconomic and transportation characteristics of those populations and the proximity of rail transit stations to the centers. The objective is to identify those areas in need of better public transit access, especially for vulnerable populations, if a voluntary or mandatory evacuation occurs particularly prior to an impending extreme event. Many of the residents already use public transportation to commute to work, and NYC's population in general is one of the highest users of public transit in the U.S.<sup>3</sup> Figure 1 portrays the location of selected evacuation centers, the evacuation zones and subway stations.

One research objective is to evaluate whether access to evacuation centers varies for different population sectors.

<sup>1</sup> City of New York, NYC Hurricane Evacuation Zones, [http://www.nyc.gov/html/oem/downloads/pdf/hurricane\\_map\\_english.pdf](http://www.nyc.gov/html/oem/downloads/pdf/hurricane_map_english.pdf)

<sup>2</sup> NYC Emergency Management. Coastal Storms & Hurricanes. Be Ready Hurricane Evacuation Hurricane Evacuation Zones <http://www1.nyc.gov/site/em/ready/hurricane-evacuation.page>

<sup>3</sup> American Public Transportation Association 2015 Fact Book; U.S. Census, American Community Survey, <https://www.census.gov/hhes/commuting/>.

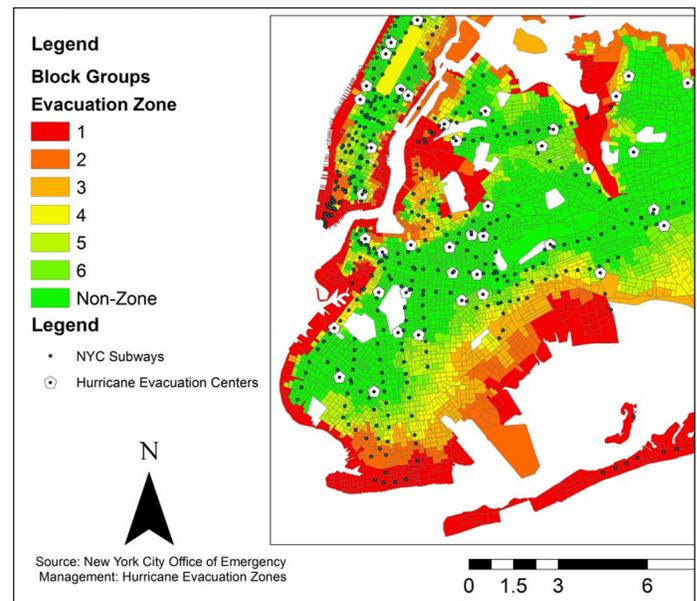


Figure 1: Selected Subway Station Location, Evacuation Zones and Evacuation Centers, Manhattan, Queens and Brooklyn

Source: This map is based on and is an extract of the NYCEM NYC Hurricane Evacuation Zones, [http://www.nyc.gov/html/oem/downloads/pdf/hurricane\\_map\\_english.pdf](http://www.nyc.gov/html/oem/downloads/pdf/hurricane_map_english.pdf), with selected subway station locations added using Geographic Information Systems.

This access is reflected in two ways: either in terms of the proximity of populations to the centers directly or the proximity of these populations to subway stations that are near evacuation centers. The research team compiled population information from the 2008-2012 U.S. Census for block groups in Zone 1<sup>4</sup> in order to analyze demographic characteristics and distance from evacuation centers at a finer geographic level. Since not all block groups in Zone 1 fall completely within that designation, all block groups that are partially or completely within Zone 1 were used in the analyses (referred to as the study area).

Regression modeling was used to analyze potential relationships between proximity to evacuation centers and demographic and other characteristics of populations in block groups partially or completely in Zone 1. Preliminary results suggest that distance to evacuation centers (the “dependent variable”) is largely related to characteristics

<sup>4</sup> U.S. Census Bureau, American Community Survey 2008-2012. The U.S. Census block group definition is a contiguous area with 600 to 3,000 people ([https://www.census.gov/geo/reference/gtc/gtc\\_bg.html](https://www.census.gov/geo/reference/gtc/gtc_bg.html)).

of the built environment, such as density of the county; that is, the denser the county, the closer the centers were to populations in the block groups included in the area studied. With respect to demographic characteristics, the initial analyses showed that the percentage Black population was positively related to distance, which suggests block groups with high percentages of Black populations tend to be further away from evacuation centers, while holding all else equal in the models. The opposite association was observed for percent Hispanic. The variables that measure percentage of poverty, those aged 65 and over, and English language skills, are not associated with the dependent variable (distance) for the models run for the study area. About 10-20% of the population in the study area is below the poverty line. Additional regression models will be conducted to further tease out these associations.

Figures 2 and 3 portray population density and income of block groups partially or completely in Zone 1 nearest to the evacuation centers. In those figures, the block groups are aggregated into catchment areas which are comprised of those block groups closest to each evacuation center.

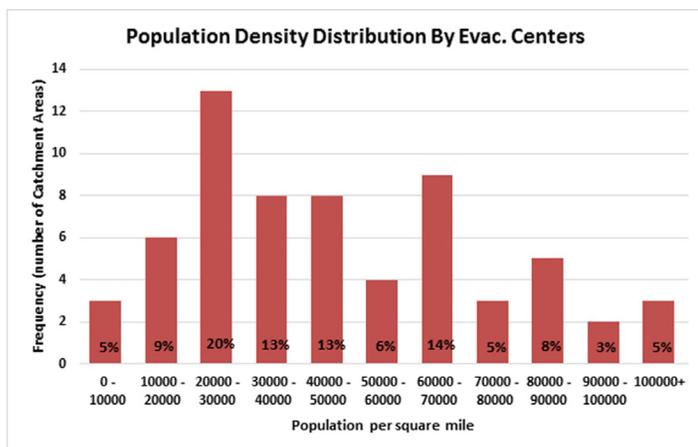


Figure 2: Population Density of Aggregated Block Groups Closest to Evacuation Centers

Source: This graph was computed from U.S. Census block group data for population density for block groups wholly or partly in Zone 1.

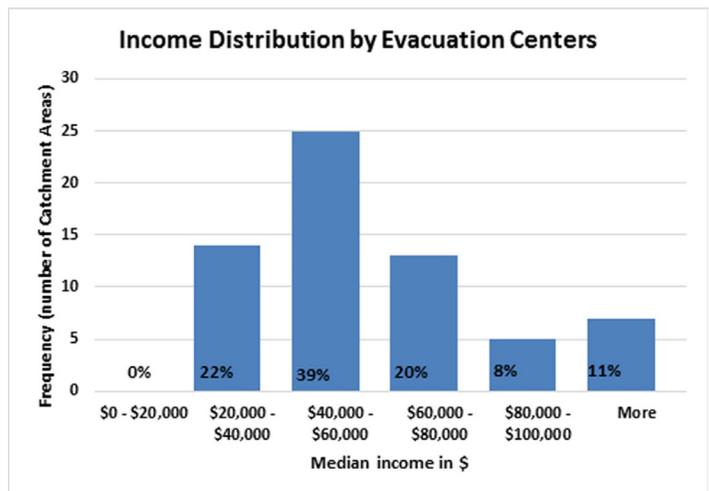


Figure 3: Median Income of Aggregated Block Groups Closest to Evacuation Centers

Source: This graph was computed from U.S. Census block group data for median income data approximated for block groups wholly or partly in Zone 1.

Another major aspect of access to evacuation centers was proximity of subway stations to study area populations and evacuation centers. Of the 64 evacuation centers, about a third were estimated to be within a half-mile of the study area and about a quarter were within a quarter-mile. Furthermore, there are 64 subway stations in the study area, and of those only 2 are within a quarter mile of an evacuation center, and four are within a half mile of a center.

This work provides the basis for evaluating other modes of transportation such as buses and bikes to subway stations<sup>5</sup> and how those connect with evacuation centers. It also provides the basis to develop a *transit evacuation vulnerability index*, which is part of the project, using block group Census data that could provide an important tool for decision-makers.

<sup>5</sup> R. Zimmerman, C.E. Restrepo, J. Sellers, A. Amirapu, and T. R. Pearson, "Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity," U.S. DOT, Region II UTRC, New York, NY: NYU-Wagner, June 2014. <http://www.utrc2.org/sites/default/files/pubs/Final-NYU-Extreme-Events-Research-Report.pdf>

## About This Project



This project, "Public Transit and Mandatory Evacuations Prior to Extreme Weather Events in NYC," was sponsored by the University Transportation Research Center (UTRC) at the City University of New York. The research team is from New York University (Wagner School), a member of the UTRC consortium, through its Institute for Civil Infrastructure Systems (ICIS), and consists of Professor Rae Zimmerman (PI and Director of ICIS); Senior Research Scientist Dr. Carlos E. Restrepo; and Senior Graduate Student Researchers Robert A. Joseph and Jimena Llopis. For additional information please contact [rae.zimmerman@nyu.edu](mailto:rae.zimmerman@nyu.edu).

