AECOM

Flooding Resilience Plan for Bus Operations

Project Executive Summary for the Chicago Transit Authority

Prepared for the Regional Transportation Authority of Northeast Illinois

May 18, 2018

Project Background and Summary

In Fall 2015, as a continuation of its Green Transit program, the Regional Transportation Authority (RTA) initiated a project to prepare a bus route flooding resilience plan for the RTA service area composed of its six-county jurisdiction in northeastern Illinois, including Cook, DuPage, Kane, Lake, McHenry, and Will Counties. The objective of this project was to identify CTA and Pace bus routes that are prone to flooding during both average rain events and extreme weather events and to develop recommendations to address flooding issues and reroute service during flooding to minimize impacts and inconvenience to riders. Aside from hampering citizens' mobility, flood-driven service interruptions can also have negative impacts on operating costs and ridership revenues.

Summary of Tasks and Themes

Based on observations of significant flood events during the last five to 10 years, flood events in the RTA service area are a combination of water body overflows, as well as stormwater runoff and localized drainage issues. Bus transit is most obviously impacted when roads are wholly flooded and impassible, and viaducts and underpasses around the region's railroad and highway network are particularly vulnerable. As part of the Chicago Climate Action Plan—one of the key precursor studies to the RTA Flooding Resilience Plan for Bus Operations—the CTA noted that their bus service is particularly vulnerable to flood events because of the more than 1,500 railway viaducts, of which more than 10 percent are troubled by frequent flooding. After a kickoff meeting in **Task 1**, in **Task 2**, the project team identified and reviewed datasets describing the natural systems across the region—primarily the floodplains and floodways—as the starting point for identifying areas that present risk based on riverine and overbank flooding.

In addition to conclusions that can be inferred from an overlay of viaduct locations, conditions and bus routes, the project team supplemented its understanding of risk with anecdotal reports of flooding from the front lines—the CTA and Pace bus drivers who call in flooded roads and detours. Areas with recurring problems for boarding and alighting were provided by the drivers and operations management, as well as from passengers who make reports of access difficulties. Additionally, insight from emergency management stakeholders and local departments of stormwater management and transportation provided further insight into troubled areas, impact, and the status of mitigation work.

In **Task 3**, the project team examined the effects of changing climate patterns on the flood risk landscape in the region. Research conducted in 2008 for the Chicago Climate Action Plan indicated that increases in winter and spring precipitation are likely, with projected increases of about 10 percent by the year 2050, and of about 20 to 30 percent by 2099. At present, even minor storms are enough to overwhelm the stormwater system of some parts of the region, and these are expected to occur even more often. Additionally, the intensity of heavy precipitation events (storms with 5-, 10-, and 25-year recurrence intervals) is likely to continue to increase. Effects of these trends will vary across the region according to watershed and sub-watershed hydrological patterns. With input from county and local stormwater management departments, the project team assessed whether these forecasted increases are likely to worsen risk conditions for the bus routes selected by the agencies.

In **Task 4**, the project team prepared responses to the identified risks in three major categories:

- Reroute plans for impacted bus routes,
- Communications strategies for updating impacted stakeholders of service interruptions, and
- Inventories of potential mitigation projects and recommendations, with suggested next steps for items outside agencies' control.

The resiliency strategies are composed of some projects that fall under the jurisdiction of CTA and Pace, but the majority are located in the public right-of-way or on private property. For these projects, the RTA, CTA, and Pace can influence other entities' actions but cannot control the outcome of these plans and may be able to participate from a funding or advocacy perspective.

The project completed work in 2017 and documentation in early 2018. This document represents an executive summary of the full project report and its accompanying technical appendices, which are available from the RTA. This document is tailored to the CTA, with a similar executive summary document for Pace also available.

Flood Risk Areas and Hotspots

Current Flooding Concerns

This plan's analysis of current and future flood risk areas categorized two types of flooding: **urban**, with origins in the built environment and ability of infrastructure to manage large amounts of stormwater; and **riverine**, resulting from overbanking of water bodies (rivers, streams, reservoirs, etc.) from large amounts of stormwater. To identify flood risk areas and hotspots across the RTA service area, the project team collected a variety of data:

Problems Experienced by the Transit Agencies

- Locations of bus service interruption and route-level comments on typical flood problems reported by CTA staff
- Locations of bus service interruption and route-level comments on typical flood problems reported by Pace staff

Specific to Urban Flooding

- Locations of road closures due to flooding reported by departments of transportation (municipal, county, state)
- Locations of viaducts, particularly "problematic" or "flood-prone" viaducts, by CDOT, CTA and Pace
- City of Chicago 311 reported flood calls, including water on pavement and flooded viaducts

Specific to Riverine Flooding

- FEMA 100-year and 500-year floodplain boundaries
- Local updates on floodplain boundaries / inundation areas from counties (Cook/MWRD, DuPage, Will)

Future Flooding Concerns

Stormwater and water resource engineers on the project team evaluated the potential increases in rainfall using the climate change scenarios from the Chicago Area Climate Action Plan and applying the increases for future climate change scenarios to the Illinois State Water Survey's Bulletin 70 24-hr rainfall amounts. The project team interpolated existing and future rainfall frequency curves to identify the equivalent storm frequency for future rainfall events at mid-century 2017 and late-century 2017. This generalized modeling of anticipated rainfall suggests storms of greater severity may occur more frequently in the future. That is….

The term "Storm Recurrence Interval" refers to the chance or probability that a storm of a certain magnitude may occur or be exceeded in a given year. For example, a "100-year storm" has a 1 in 100 chance of occurring in any given year, or 1% chance (called the "Annual Exceedance Probability"). It does not mean that such a storm only occurs once every 100 years, and once happened, won't happen again in the same 100-year period.

For severe storms:

A 100-year storm mid-century could be like today's 150-year storm
A 100-year storm late-century could be like today's 240-year storm

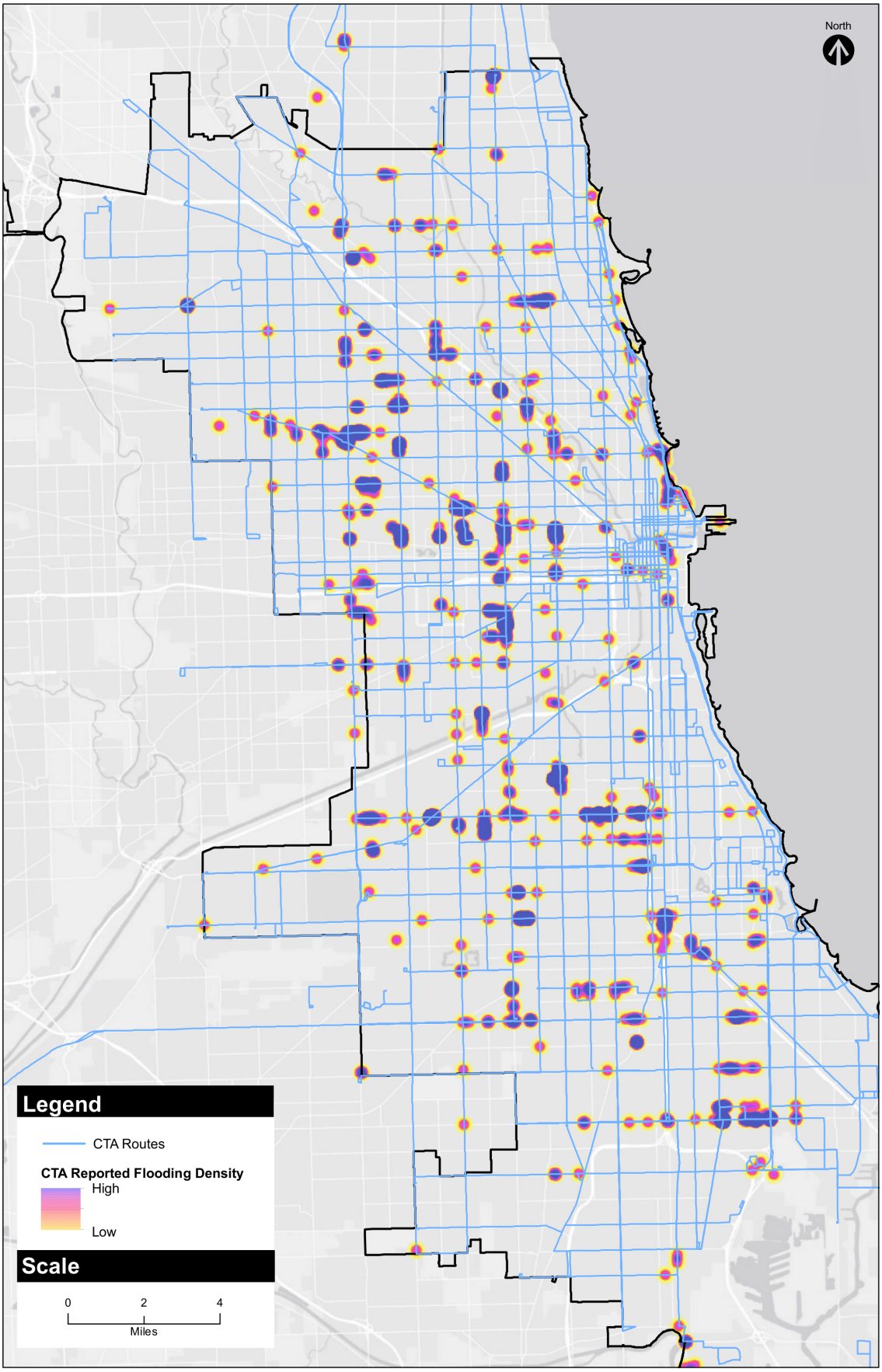
For moderate storms:

A 5-year storm mid-century could be like today's 11-year storm
A 5-year storm late-century could be like today's 14-year storm

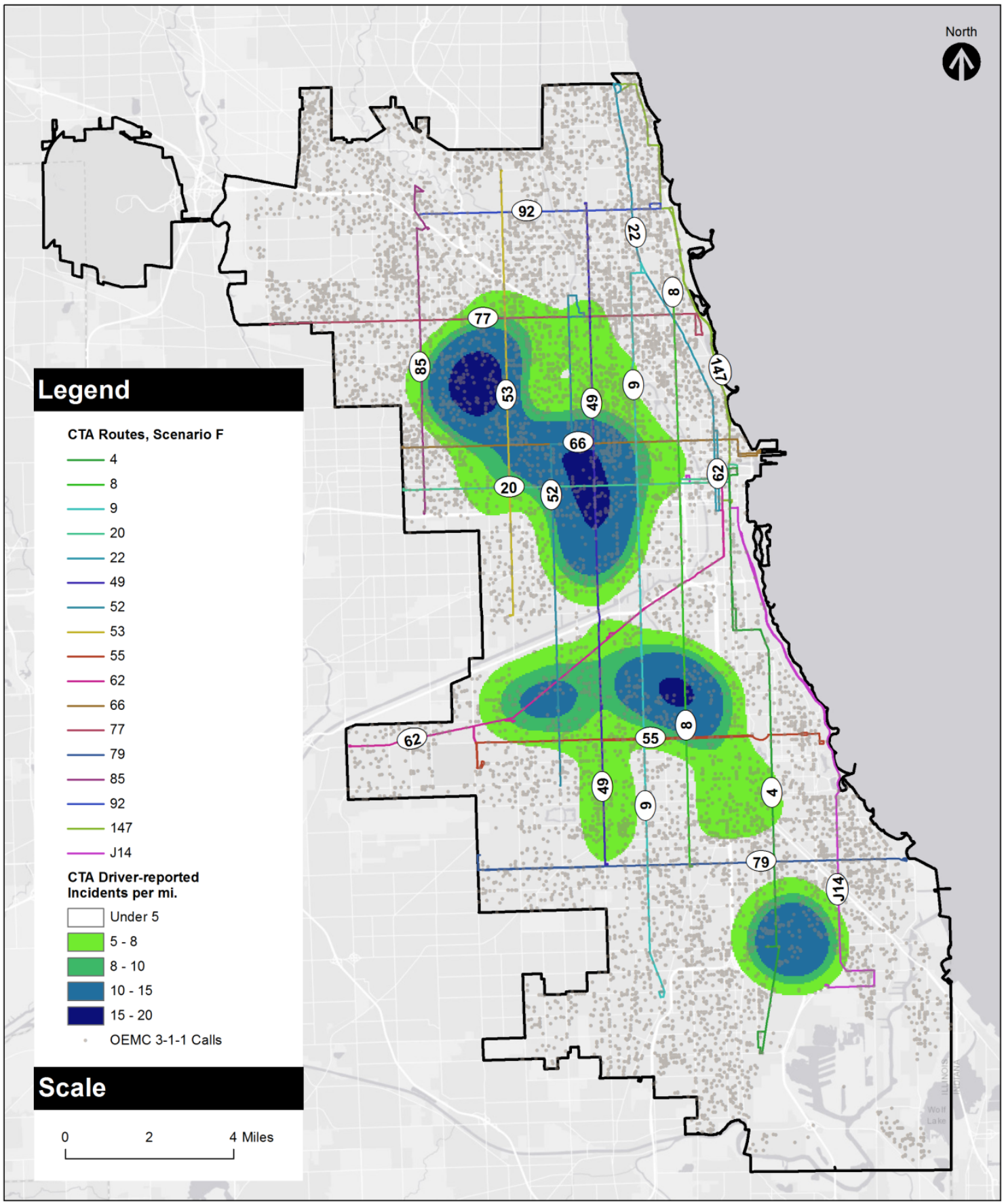
A 1-year storm mid-century could be like today's 2-year storm
A 1-year storm late-century could be like today's 2.5-year storm

To analyze the potential impact of future climate change and rainfall events of increasing severity and frequency on urban flooding patterns, the project team correlated rainfall data from recent storm events with recorded flood incidents from the CTA and the City of Chicago's Office of Emergency Management & Communications (OEMC), using a subset of recent storm events of varying frequencies from the period 2013-2016 when CTA recorded flood incidents and OEMC 311 call data were available on the same dates. The project team observed that the density of OEMC 311 calls complaining about water on roadway and/or flooded viaducts increased with storm type. CTA drivers' reports of flood incidents were generally found to correlate with moderate or more severe storms, that is, storms with 1-year recurrence intervals or greater. While drawing on a finite sample set of rainfall data *and* data documenting actual flood incidents reported by CTA staff or through OEMC via 311, the analysis provides valuable insight to areas of future risk for flooding that might impact CTA bus operations. Although this study cannot draw broad spatial conclusions that areas currently prone to flooding will be larger or wider in the future – it appears that the intensity of flooding may become worse and/or more frequent. The degree of severity of urban flooding is subject to interventions by water departments to manage stormwater and sewer capacity across their networks and discharge decisions at any given time.

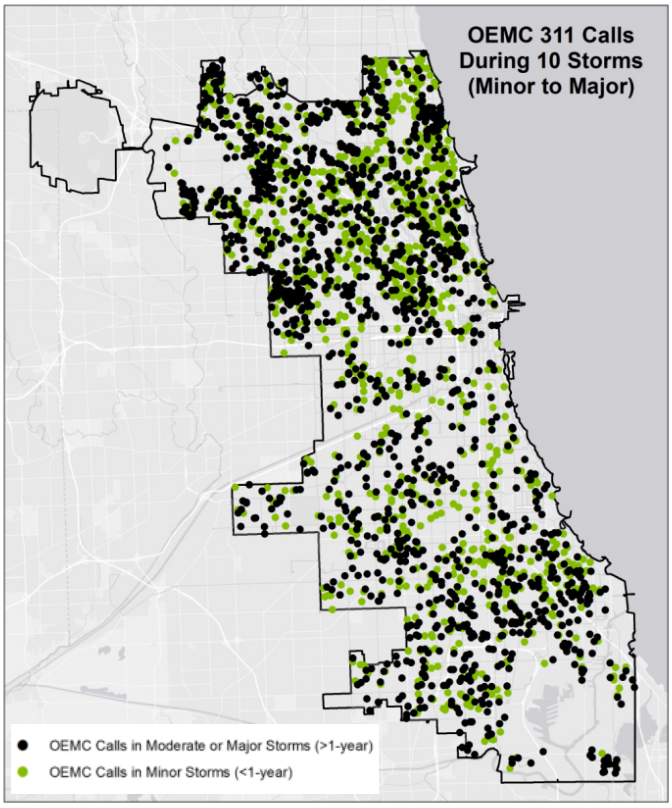
Density of CTA-Reported Flooding Incidents, 2011-2016



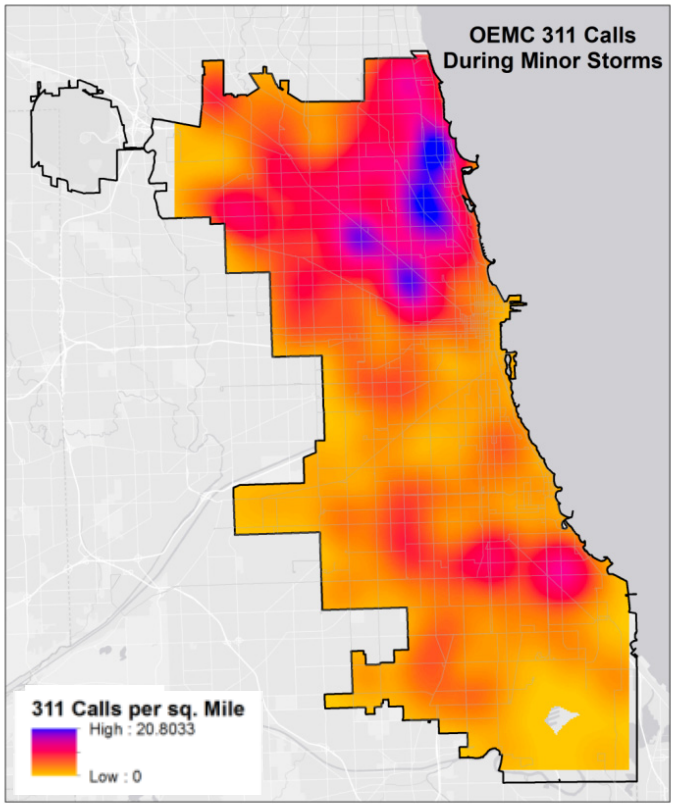
OEMC Calls, Density of CTA Flood Reports, and Selected CTA Routes



OEMC 311 Calls By Storm Type

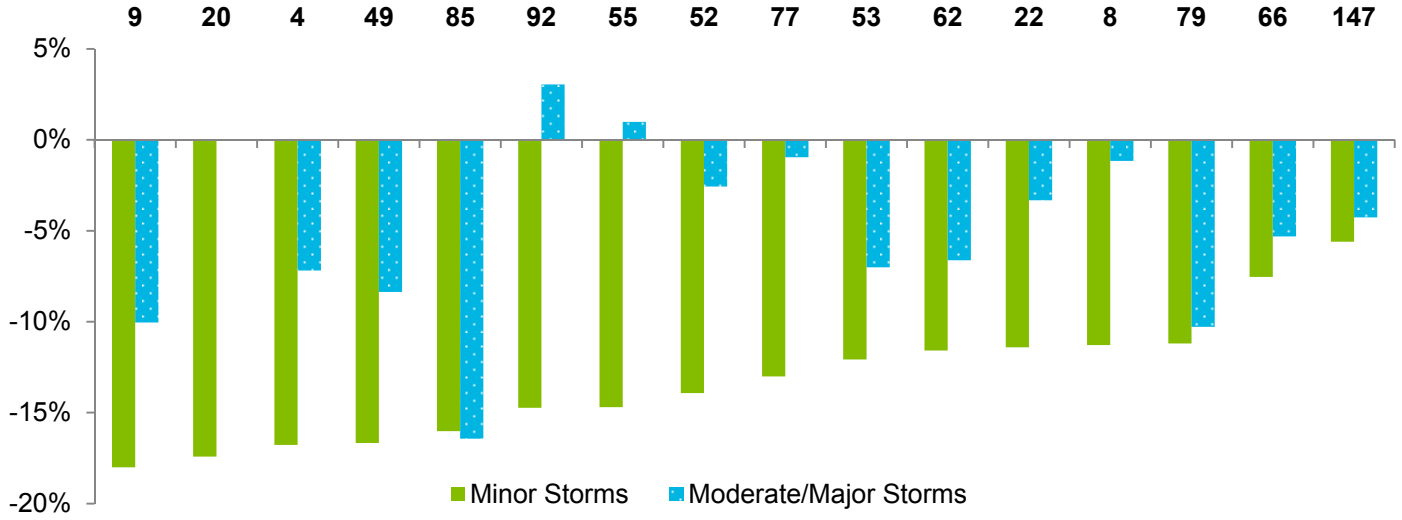


Density of Calls During Minor Storms (<1-Year Storm Recurrence Interval)



As shown below, larger decreases in ridership are seen on minor storm days (recurrence intervals of one year or less) than during moderate or major storms. This is most likely because people are unwilling to risk driving themselves during moderate or major storms and thus are more likely to rely on transit if they cannot avoid traveling entirely. Furthermore, analysis of Ventra data for selected routes shows that during moderate and major storms, ridership falls by an average of 7.8 percent on weekend storm days, but only 4.7 percent on weekday storms, illustrating the elasticity of discretionary travel.

Percent Ridership Change by Storm Type on Selected Routes, 2013-2017



Reroutes and Impact Analysis

Due to the size of the RTA service area and breadth of CTA's service area, this project was unable to analyze each and every bus route for flood impacts and plan for reroutes. The project team provided a variety of prioritization criteria to CTA and Pace to select a subset of routes for further analysis. Routes were filtered and sorted based on criteria such as: actual reports of flooding by drivers, number of intersections with flood zones (based on the 100- and 500-year flood plains), ridership, and number of connections with the regional transit network. CTA decided to apply a different selection mechanism, focusing flooding impact analysis on the routes they consider to be the "workhorses" of the CTA network, which move large volumes of passengers across the city, make vital connections between transit modes, and connect residential communities to downtown and other employment centers. This selected group of routes has been named Scenario F.

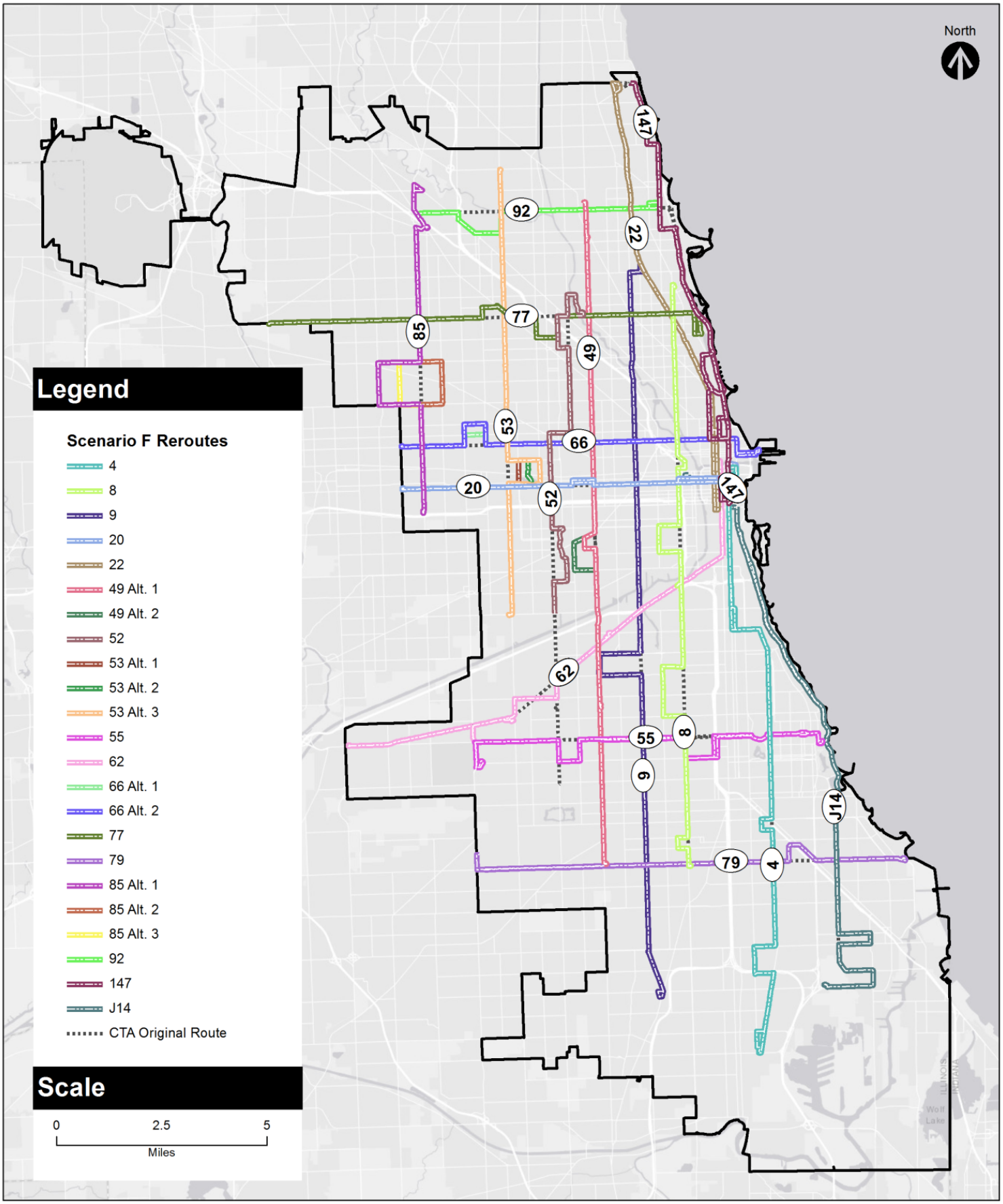
CTA Scenario F Routes

4	Cottage Grove	66	Chicago
8	Halsted	77	Belmont
9	Ashland	79	79th
20	Madison	85	Central
22	Clark	92	Foster
52	Kedzie/California	147	Outer Drive Express
53	Pulaski	J14	Jeffery Jump
55	Garfield	X49	Western Express
62	Archer		

The project team estimated quantitative impacts of the Scenario F reroutes, including changes in stops serviced based on the reroute alignment, associated changes in ridership, travel time, and operating costs. The estimates presented assume full implementation of reroutes as documented, including situations where a route may have multiple diversions.

- The number of bus stops on the original routing skipped by the reroute ranges from nominal to many; a few routes are truncated instead of rerouted due to major barriers that would require a significant diversion.
- In most cases, the reroute diversions reduce the number of locations where a route alignment encounters a flood risk area. However, there are a few instances where the reroute touches one or two additional areas. Because stormwater management is very dynamic, this is a point to monitor rather than a concern; in some cases, multiple reroute options were sketched and modeled.
- The change in estimated ridership for most reroutes is less than 1 percent of average weekday ridership on the standard routes, with only one line (52) experiencing substantial numbers of riders potentially impacted (diverted or potentially lost) due to a significant route truncation. These estimates do not take into account counteracting communications mechanisms that would direct impacted riders to alternate stop locations on the reroute or alternate transit routes, thus reducing the potential lost system ridership.
- Operational impacts to reroutes are estimated based on travel times for the altered routes. Changes in per-trip travel times between the standard route and the reroute vary substantially. In some cases, a reroute is longer than the standard route, and incurs greater travel time; in other cases, a reroute runs shorter and faster. Estimates of impacts to operating costs are calculated using each route's cost per-hour metric.
- As with the changes in travel times, increased costs may be incurred in some situations, and savings in other situations. Impacts from the base reroutes are presented here, with more travel time and cost projections accounting for additional low, moderate or high travel delay factors on top of the base reroute included in the full project report.

CTA Scenario F Reroutes



Estimated Key Performance Indicators for Reroutes

Route	# of CTA-reported Flooding Incident Areas on Original Route	Change in # CTA Flooding Incident Areas with Reroute	Missed Bus Stops with Reroute	Riders Impacted by Reroute	Change in Travel Time in Minutes (Base Reroute)	Change in Cost per Trip (Base Reroute)
4	34	0	16	2	6	$10
8	21	-7	36	336	12	$20
9	47	-6	4	63	7	$11
J14	7	0	0	0	5	$8
20	8	+1	7	44	2	-$29
22	3	0	0	N/A	0	$-
49	89	-23	3	11	2	$3
49a	89	-29	8	98	4	$6
52	113	-24	98	750	-10	-$17
53	36	-9	9	155	3	$4
53 Alt 1	36	-9	9	155	5	$7
53 Alt 2	36	-3	9	155	6	$10
55	10	-6	18	253	8	$13
62	38	0	15	87	4	$6
66	22	-1	5	21	2	$3
66 Alt 1	22	+9	5	21	4	$7
77	11	-3	14	224	10	$17
79	24	-3	12	87	2	$3
85 E	2	+4	14	72	4	$7
85 W	2	+2	14	72	4	$7
85 Nar	2	-2	14	72	7	$12
92	9	+3	15	31	4	$6
147 Alt 1	21	-3	5	78	13	$21
147 Alt 2	21	-2	5	78	18	$29
147 Alt 1 & 3	21	-1	2	78	11	$18
147 Alt 2 & 3	21	+1	2	78	16	$26

Interesting Comments about Certain Routes

22 Clark – Identified by CTA as a route of interest; no reroute was designed due to the low-risk nature of the potential flood-prone areas that it intersects and lack of historic reports of flood-diversion

52 Kedzie/California – Numerous flood-prone viaducts and intersections exist between 31st Street and 48th Street; reroute significantly truncates service in lieu of trying to drive a wide berth around potential flood spots and the Corwith Rail Yard

53 Pulaski, 66 Chicago, 85 Central, 147 Outer Drive Express — Several reroute alternatives were modeled to reflect different options available to the driver, due to the presence of potential flood spots on the diversion(s) as well

Communications and Coordination Plans

In the event that severe rain events disrupt regular bus service, communications and coordination plans are critical for notifying the public about service changes, including reroutes. CTA has well-established procedures tested and refined over the course of numerous severe rain events as well as other types of service interruptions, weather-related and not. Recommendations from this project include identification of areas for new or deeper collaboration among interested agencies, as well as suggestions for consideration of additional technological resources; both of which are subject to available financial and human resources. Key activities include:

Pre-Flooding Preparedness Operations

CTA Communications/Power Control Center will:

- Monitor weather forecast for rainfall that may produce flood water impediments to bus operations.
- Regularly coordinate with OEMC and monitor OEMC push notification traffic to evaluate the potential for flooding along city streets and viaducts.
- Participate in multi-agency conference calls to monitor weather conditions and identify the need for Streets and Sanitation to clean sewer grates and culverts and for Water Management to pre-check at-risk drains and pumps.
- Coordinate with Customer Information and Media Relations as necessary and in a timely fashion to convey the potential for bus re-routes.

CTA Safety will:

- As deemed necessary, deploy a representative to sit at the OEMC to participate in city-wide planning efforts and coordinate with CTA C/PC, Dispatch.

Flood Operations

CTA Communications/Power Control Center will:

- Receive notification from CTA field supervisors and OEMC on flood conditions.
- Re-route bus operations as necessary and practical along routes that experience flooding.
- Inform operators of route changes who, in turn, will provide such information to patrons, as necessary.
- Provide updates to CTA website and bus shelter variable messaging sign updates to direct passengers to temporary alternate stop locations.
- Coordinate with staff deployed to OEMC.
- Dispatch will coordinate with field supervisors and OEMC to respond to route flood conditions that are not historically typical.
- Coordinate with CTA Customer Information and Media Relations to publish and relay bus service updates to the public.

CTA Safety will:

- For major rain events, coordinate with city-wide storm/rainfall operations with OEMC.
- As deemed necessary, deploy a representative to sit at OEMC to monitor the WebEOC interface for city-wide flooding incidents and occurrences and coordinate with CTA C/PC, Dispatch.

CTA Customer Information will:

- Provide supplemental information beyond standard Customer Alert information on CTA's website, Twitter, digital signage and other online communication outlets as deemed necessary.
- Provide information to RTA, for its Travel Info Center.

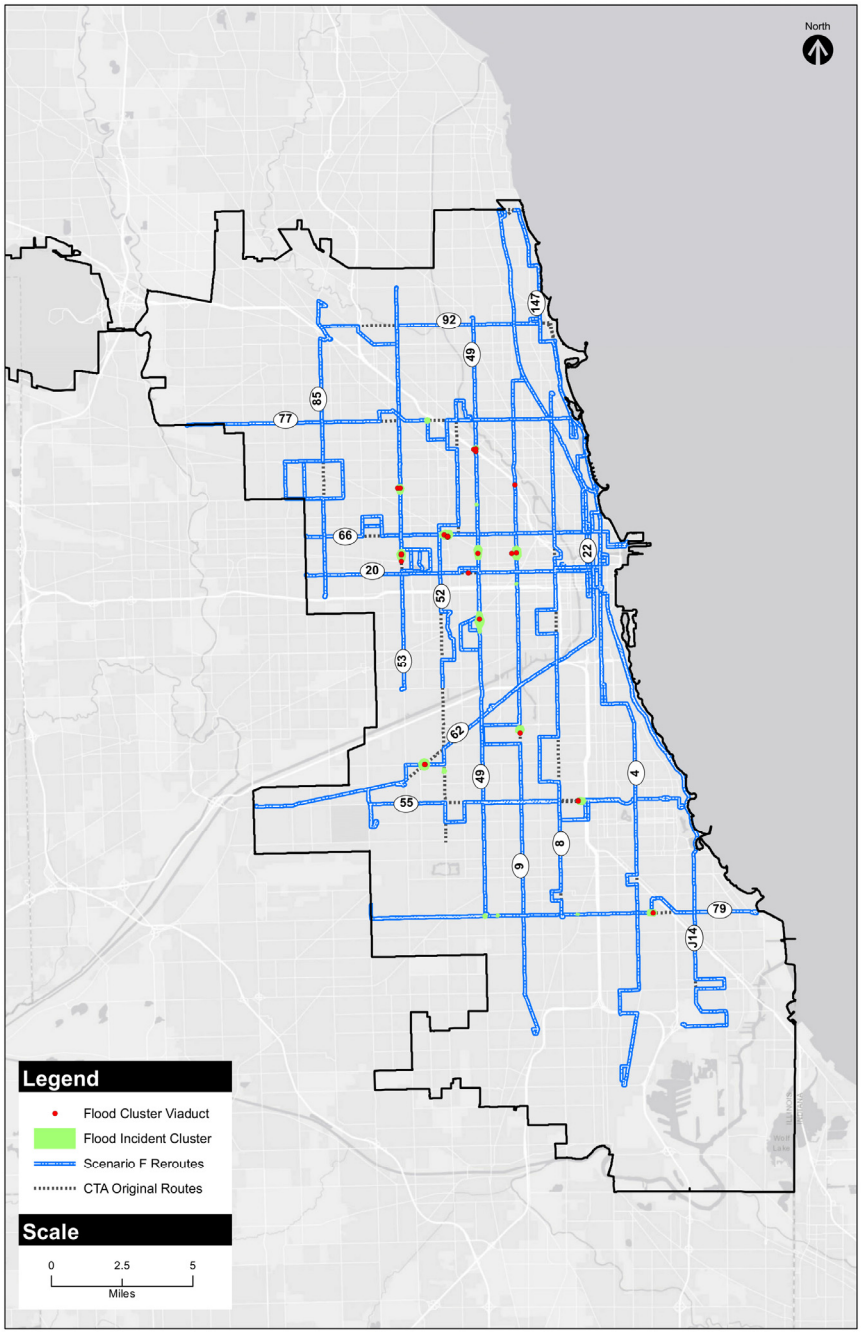
CTA Media Relations will:

- Convey news about CTA implementing service reroutes as flooding circumstances require, to television, radio and other media outlets as deemed necessary.

Mitigation Projects

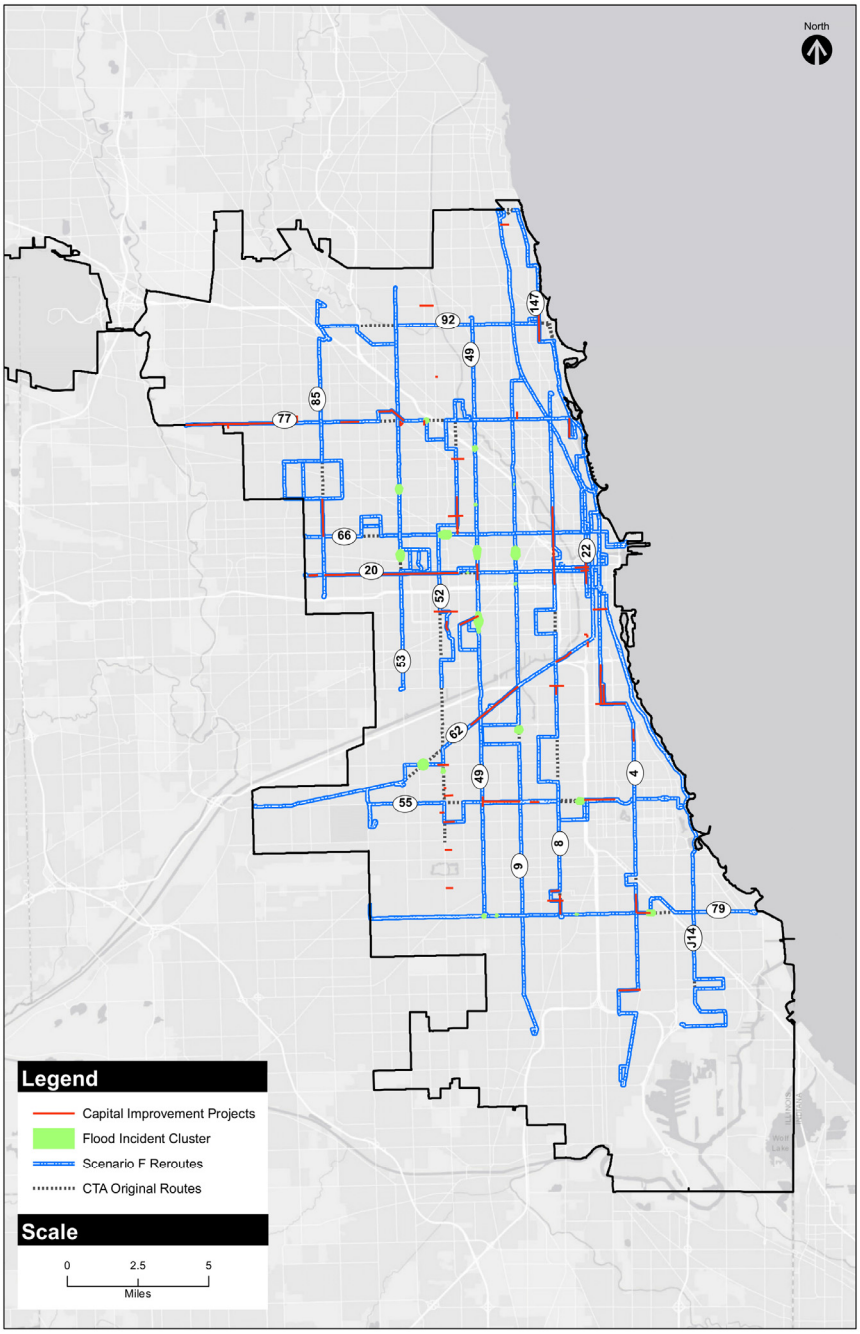
By analyzing CTA-reported flooding events that were within 100 feet of a Scenario F route, the project team was able to generate a map of dense flood incident clusters in the City of Chicago (below left). In most cases the larger clusters with a higher density of flooding reports (depicted below in green) also have a viaduct (red dot) in the vicinity. All of the largest flooding clusters (more than five CTA-reported incidents) studied here have a rail crossing or facility nearby. They also have 86 percent of the OEMC 311 calls reporting flooding or water on street, and 25 of the 30 viaducts in the sample set. It would be difficult to fully remediate these pervasive problems areas via green infrastructure mitigation—construction projects to address stormwater infrastructure or roadway design are probably needed. Consultation with CDOT planners and engineers suggests that for many of these rail-adjacent and viaduct-adjacent flooding problems, an effective avenue for pursuing mitigation projects is to coordinate such improvements through CDOT's Office of Underground Coordination (OUC) or in conjunction with larger projects in the Chicago Region Environmental and Transportation Efficiency Program (CREATE).

CTA Flood Incident Clusters and Flood Cluster Viaducts



Comparing these cluster locations with the 2014-2018 Capital Improvement Plan shows that seven clusters are in proximity of a project completed since 2013 (below right). These projects either involved water infrastructure or arterial surfacing, as noted in the table. There are no future projects nearby at this time, but it is possible that completed projects may already be resolving some of the historical flooding problems in the area (CTA flood incident data from 2011-2016 was used in this analysis). These areas should be monitored for ongoing problems that would be scheduled for future capital projects.

CTA Flood Incident Clusters and Capital Improvement Projects



Action Plan Matrix

CTA can coordinate with a broad range of partners to pursue short and long term flood mitigation actions.

Project/Policy	Agency/ Organization	Cost	Notes
Viaduct improvement projects	CREATE public and private partners; Metra; railroads; CDOT; CDWM	$$$	CREATE Viaduct Improvement Program completed in 2015. Negotiate additional funding for expansion of that program along with remaining CREATE projects.
Underground construction projects	CDWM, sister water departments	$$$	Such projects may be initiated through Mayoral, Aldermanic, sister-agency and/or public (311) requests.
Clearance of drains of debris prior/during storm	OEMC; Chicago Streets & Sanitation	$	Proactive pre-storm preparation.
Coordination with other development/ utility/ roadwork projects	CDOT DOIM	$	Potential participation in dotMaps system. Submittal of a project “hot list” for consideration by the Office of Underground Coordination (OUC). The benefit would be potential remediation of infrastructure-induced flooding while other capital projects are being carried out, thus minimizing costs and potential conflicts.
Green infrastructure	Chicago DPD and CDOT (Resilient Corridors Program)	$$	As the Resilient Corridors program is expanded to additional corridors, CTA’s priority routes can be considered.
Ongoing monitoring and data collection	CTA (CleverCAD); OEMC 311 data	$	Use of flood report data to identify and monitor problem areas can be used to generate hot list for participation in OUC meetings (above) or to provide to Streets and Sanitation for debris clearance (above).
	CMAP; CDWM; CDOT; OEMC; MWRDGC; IDNR; FEMA; CNT; MPC	$$	Develop and enhance/maintain City and/or regional database of flood incidents, forecasts, risk factors, and mitigation measures.

Decode of Agency / Organization Abbreviations

CDOT – Chicago Department of Transportation
CDPD – Chicago Department of Planning and Development
CDWM – Chicago Department of Water Management
CMAP – Chicago Metropolitan Agency for Planning
CNT – Center for Neighborhood Technology
CREATE - Chicago Region Environmental and Transportation Efficiency Program
DOIM – Division of Infrastructure Management within CDOT
FEMA – Federal Emergency Management Agency
IDNR – Illinois Department of Natural Resources
MPC – Metropolitan Planning Council
MWRDGC – Metropolitan Water Reclamation District of Greater Chicago
OEMC – Chicago Office of Emergency Management & Communications
OUC – Office of Underground Coordination managed by CDOT DOIM
RTA – Regional Transportation Authority