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The QUIETeD Methodology of Crumbling Infrastructure – An IT Approach

MOT Capstone - Final Presentation

12/19/2022

Agenda

1. Introduction
2. Data Analysis Model
3. Analysis on Incidents in NYC
4. Findings and Next Steps

Introduction

01

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Introduction

How urban planners can assess the impact of failed infrastructure?

- Currently, it is hard for urban planners to define the frequency, duration, and total economic impact of disasters caused by failed infrastructure
- Develop a methodology to analyze social cost associated with infrastructure failure, focusing on transit disruption
- Provide an insight on the city's Capital Expenditure Spending to address potential failures
- Foundation for growth in future versions

Data Analysis Model

02

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Data Analysis Model

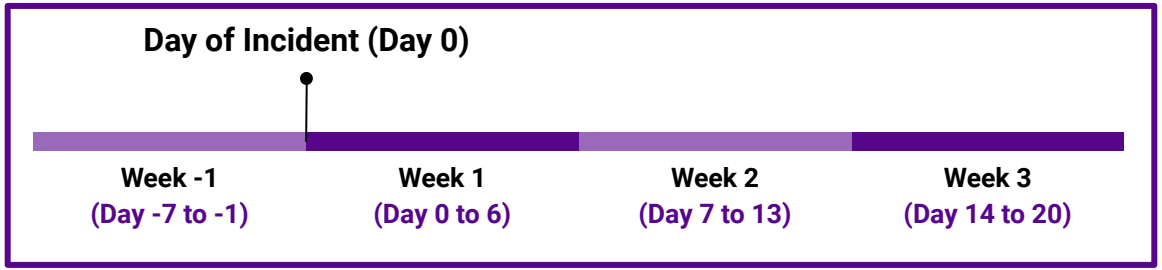
Data Collection

Data source: StreetLight Data
Analysis type: Zone activity
Traffic type: All traffic
Area: Impacted street + 4 most likely alternatives for detouring
Time frame: -1 week to +3 weeks from day of impact

Pre-processing: Calculate distribution of traffic among the 5 streets

Data Analysis

1. Day-to-day change of traffic volume / distribution before and after the incident happened.
2. Compare to baseline value - average traffic volume / distribution based on day of week for the 1 month prior to the incident.



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Data Analysis (cont.)

Capital Planning Analysis

What are we looking for?

- How are alternative routes picking up detoured traffic?
- How long does the impact last?

Tools

- Line graph to visualize daily change of traffic volume / distribution across affected streets and compare to baseline value
- Box plot to visualize the fluctuation throughout the whole period

1. Identify cause of incident.
2. Identify capital planning projects done by the agencies (DEP, DOT, DDC) in the community district.
3. Identify the Failure Community Districts' Needs Statements related to the failures.

Analysis on Incidents

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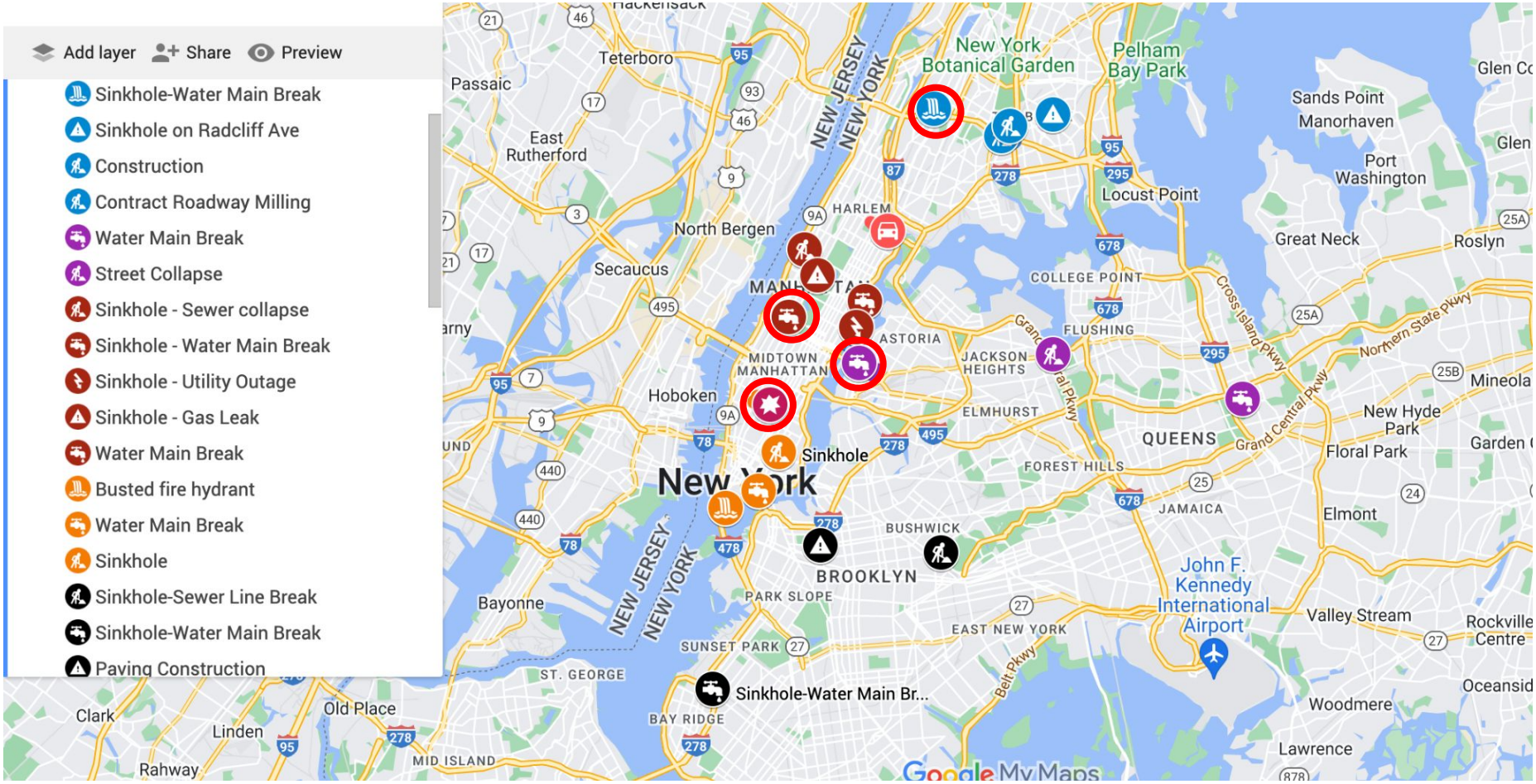

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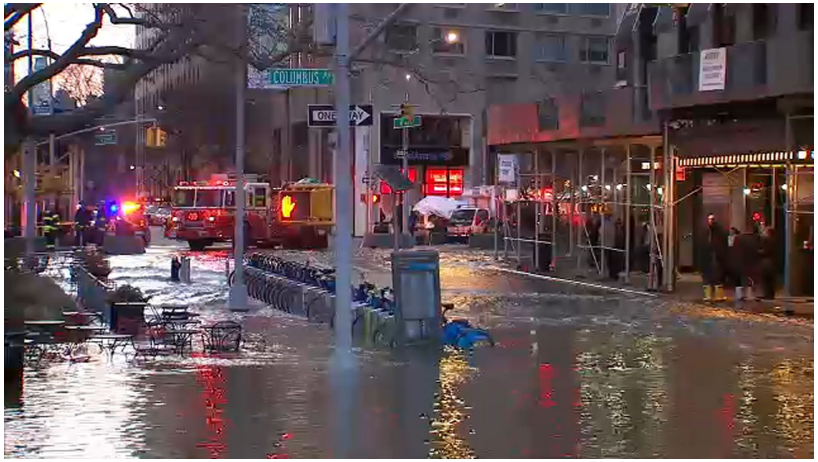
Link: https://www.google.com/maps/d/edit?mid=1KSbNmYDGFjhCndd8OFsYB6d1oz5T5WQ&usp=sharing

Water Main Break

Date and Time: Jan 13, 2020 5:00am (Monday)
Location: Broadway & W 72nd St, New York
Duration: 2-3 Weeks, Broadway southbound closed for at least a few days, the northbound side remained open
DOT Permit Number: M012020013A01 (Jan 13 - Jan 15 DEP, Repair Water), M012020013A34 (Jan 13 - Feb 07, DEP Contractor Major Installation Water)
Zoning: C4 (Commercial Center), R8 and R10 (High density)

Source:
https://www.cnn.com/2020/01/13/us/nyc-water-main-break-trnd/index.html
https://abc7ny.com/water-main-break-upper-west-side-flooded-streets-flooding/5844278/
https://twitter.com/i/status/1216700126871289856



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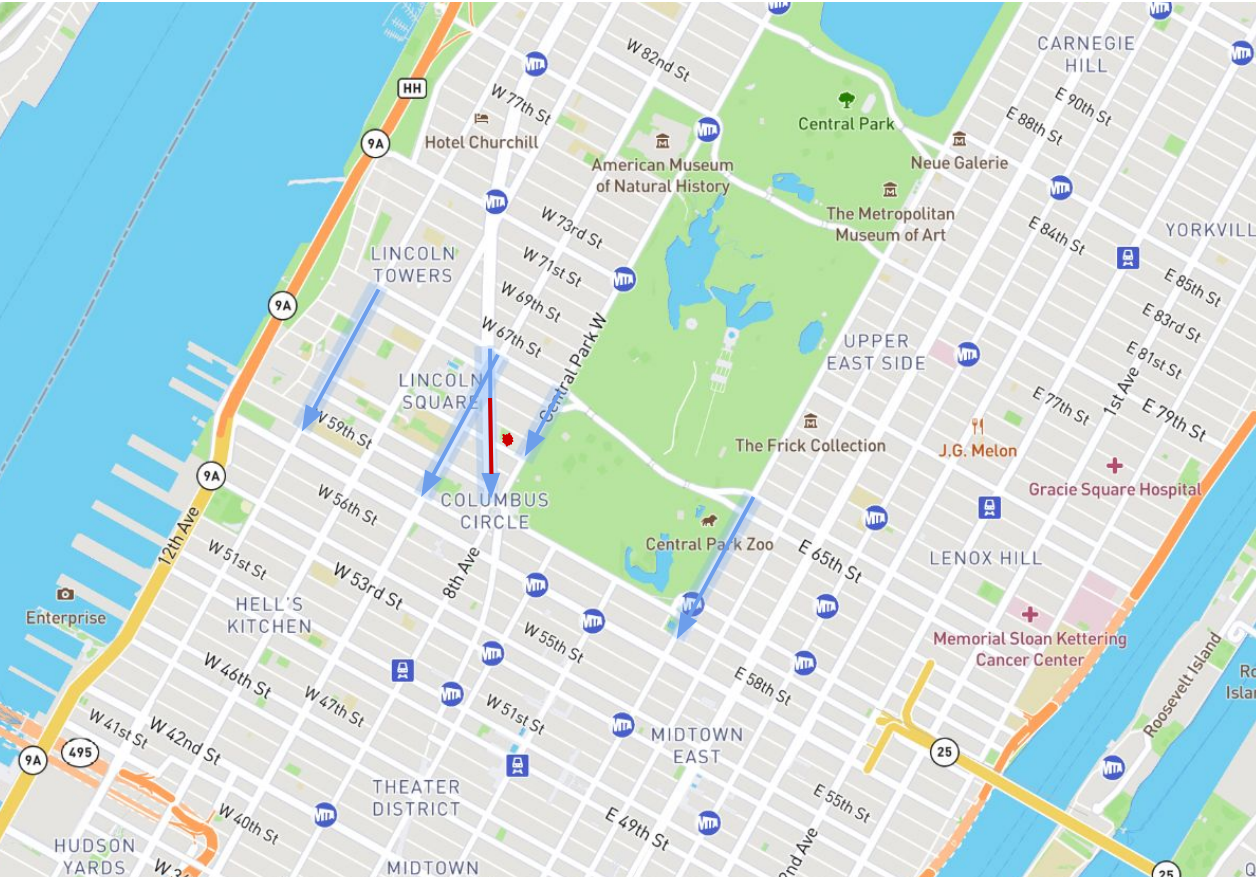


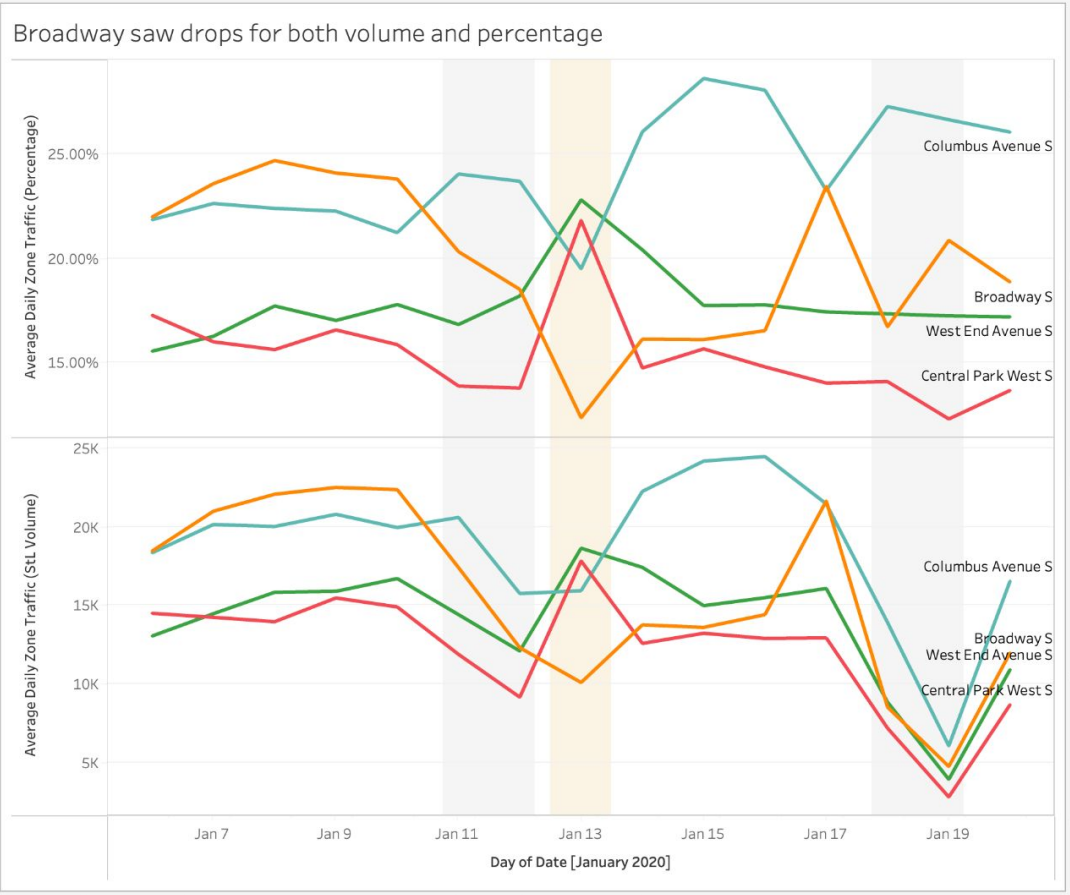
According to the news: Broadway southbound (66th - 58th) closed for at least a few days, the northbound side remained open.
Time Range: 01/06/2020 - 02/02/2020

Gather Data:
StreetLight: Zone Activity

Selected Zone: 5th Ave, Broadway Ave, Central Park West, Columbus Avenue, West End Avenue

Manipulate and Merge Data:

- Average Daily Zone Traffic (Percentage)
- Benchmark: Average traffic volume / percentage one month before the incident



Zone Activity Analysis (one day comparison)

On Jan 13, 2020, Broadway Southbound saw a traffic drop:

- 18.5% → 12.3% (-33.5%)
- 12,303 → 10,085 (-18%)

Neighboring streets picked up the traffic

- Central Park West:
  13.8% → 21.8% (57%)
  9149 → 17838 (94.9%)
- West End:
  18.2% → 22.8% (25.3%)
  12093 → 18649 (54.2%)
- Columbus Ave also affected:
  23.7% → 19.5% (-17.7%)
  15757 → 15938 (1.1%)

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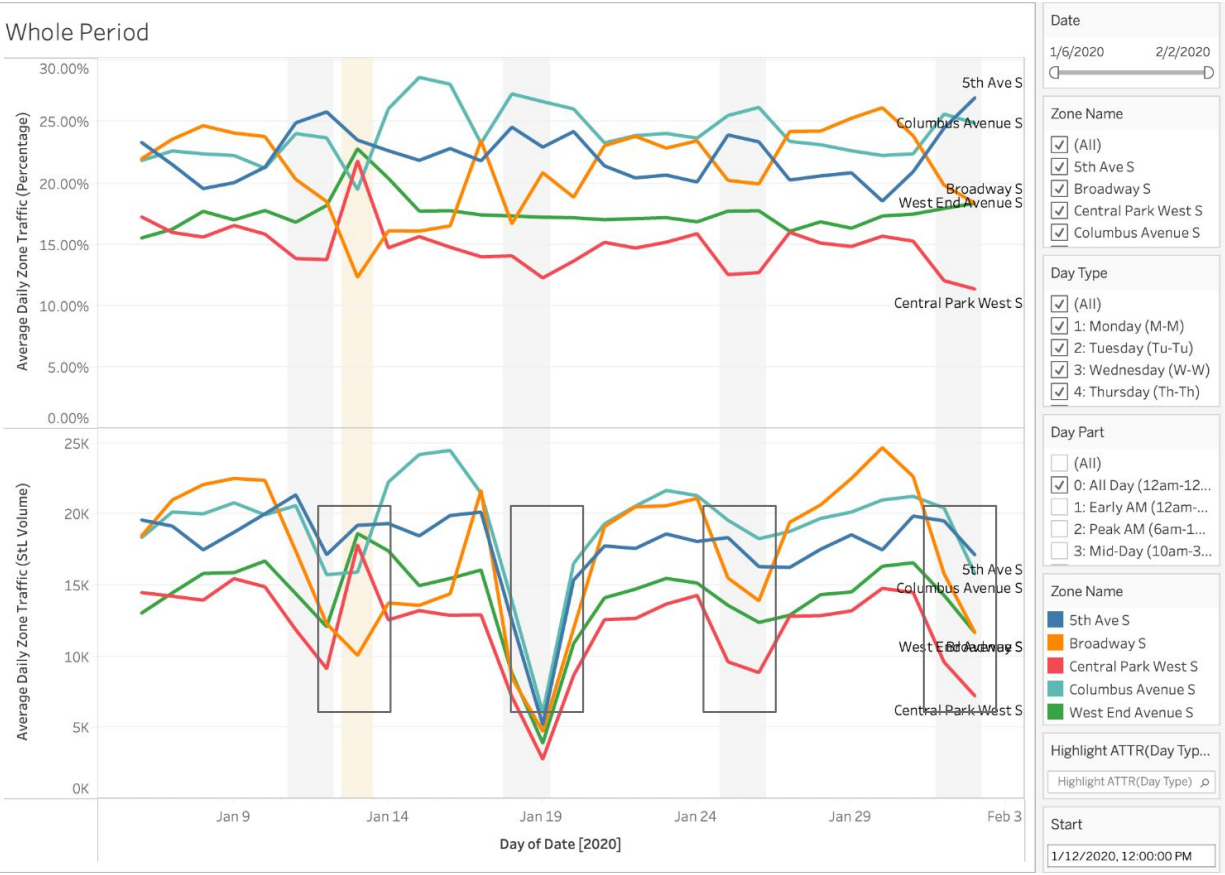

Zone Activity Analysis (one day comparison)

Broadway:

- 18.5% → 12.3% (-33.5%)
- 12,303 → 10,085 (-18%)

Columbus Ave:

- 23.7% → 19.5% (-17.7%)
- 15757 → 15938 (1.1%)

Central Park Ave:

- 13.8% → 21.8% (57%)
- 9149 → 17838 (94.9%)

West End Ave:

- 18.2% → 22.8% (25.3%)
- 12093 → 18649 (54.2%)

33.5% and 17.7% drop on Jan 13 for Broadway and Columbus Ave, but the volume did not change much (-18% and 1.1%)

- Volume for all selected routes:

  seasonality

  Monday – Highest, Weekends – Lowest

- The water main break led the traffic volume on Broadway drop instead [13]

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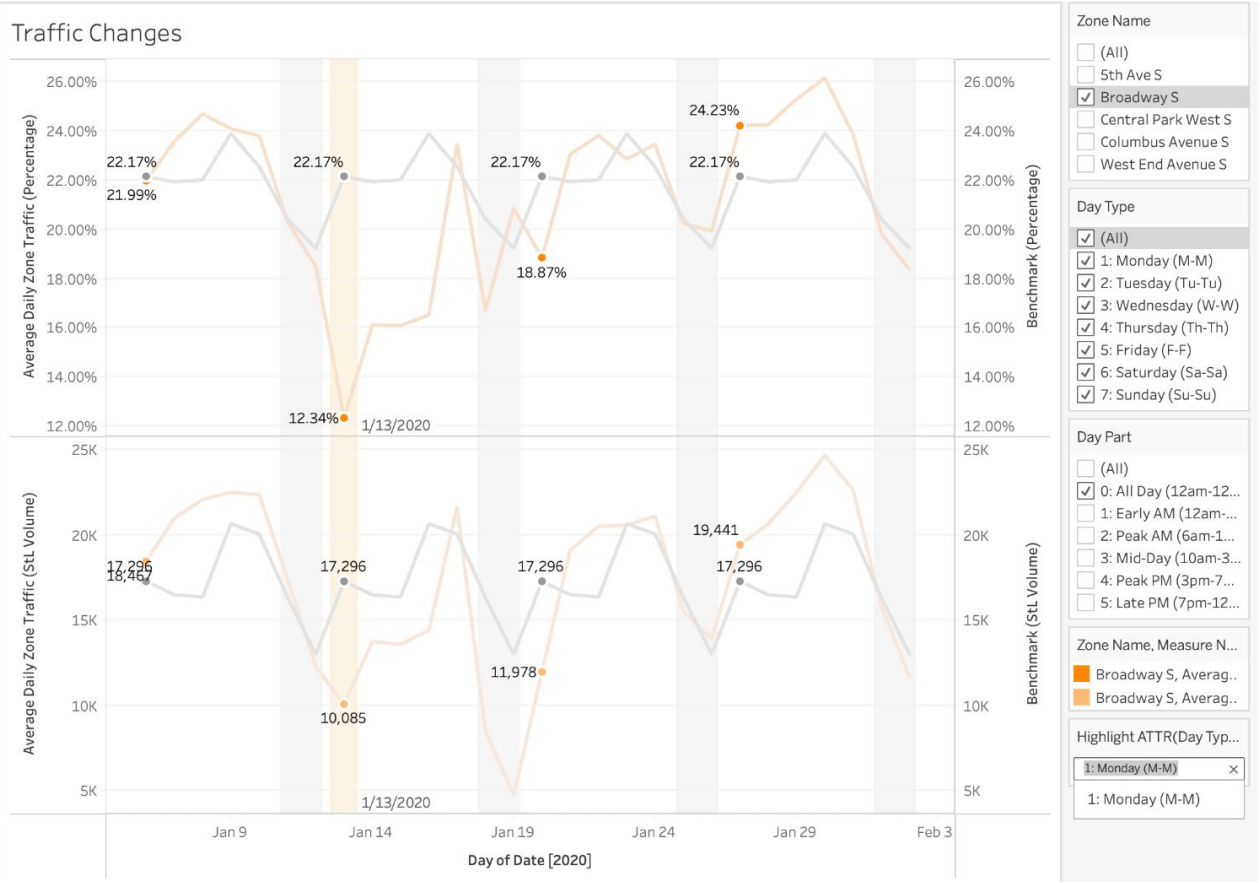


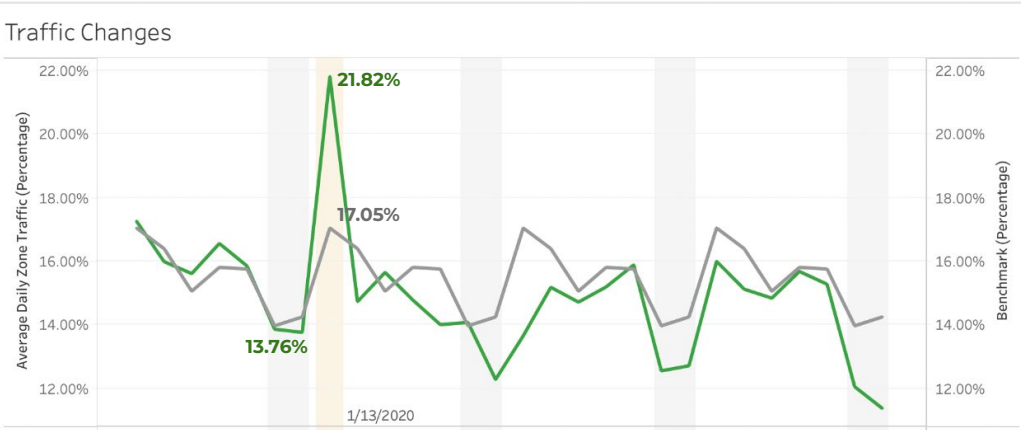
Traffic Changes With Baseline Comparison

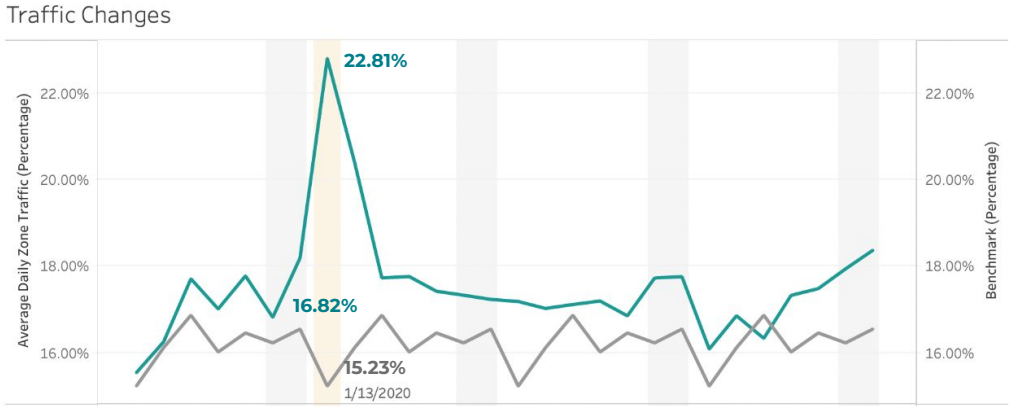
Broadway:

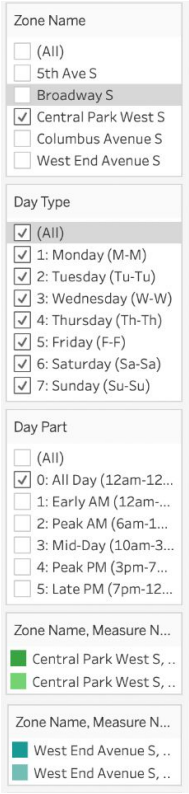
- 10% absolute difference comparing to the baseline, 41.7% decrease in traffic volume
- Taken 4 days to back to its capacity

Central Park Ave & West End Ave

Columbus Ave







Traffic Changes With Baseline Comparison

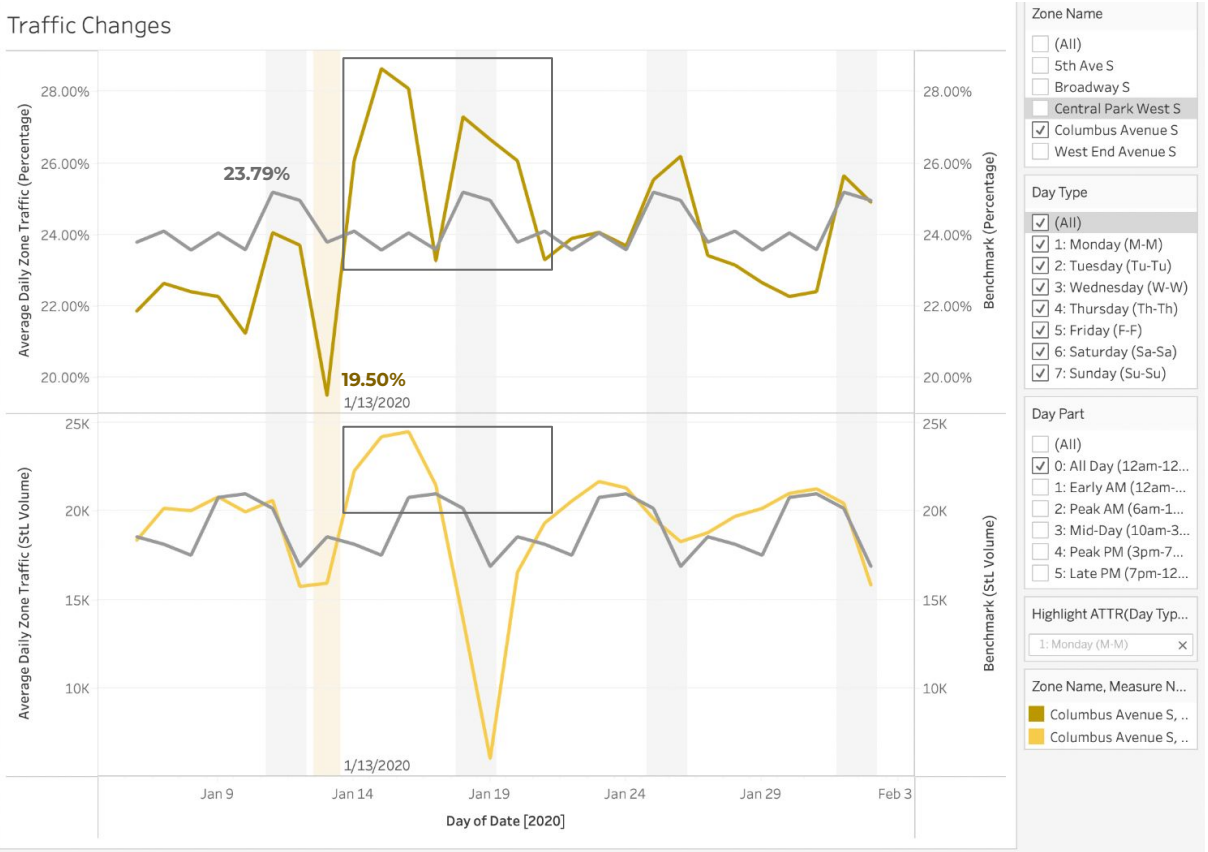
Broadway:

- 42% decrease in capacity
- Taken 4 days to back to its capacity

Central Park Ave & West End Ave:

- 34.11% (13301 – 17838)
- 56.99% (11879 – 18649)
- **Quickly adjust:** the impact only lasted for **one day**

Columbus Ave



Traffic Changes With Baseline Comparison

Broadway:

- 42% decrease in capacity
- Taken 4 days to back to its capacity

Central Park Ave & West End Ave

Columbus Ave:

- -14.12% difference (18559 – 15938)
- suggesting people change route to avoid travelling through the area near Broadway
- traffic increased after Monday
- If the situation improved, people would take the nearest route as the alternative.

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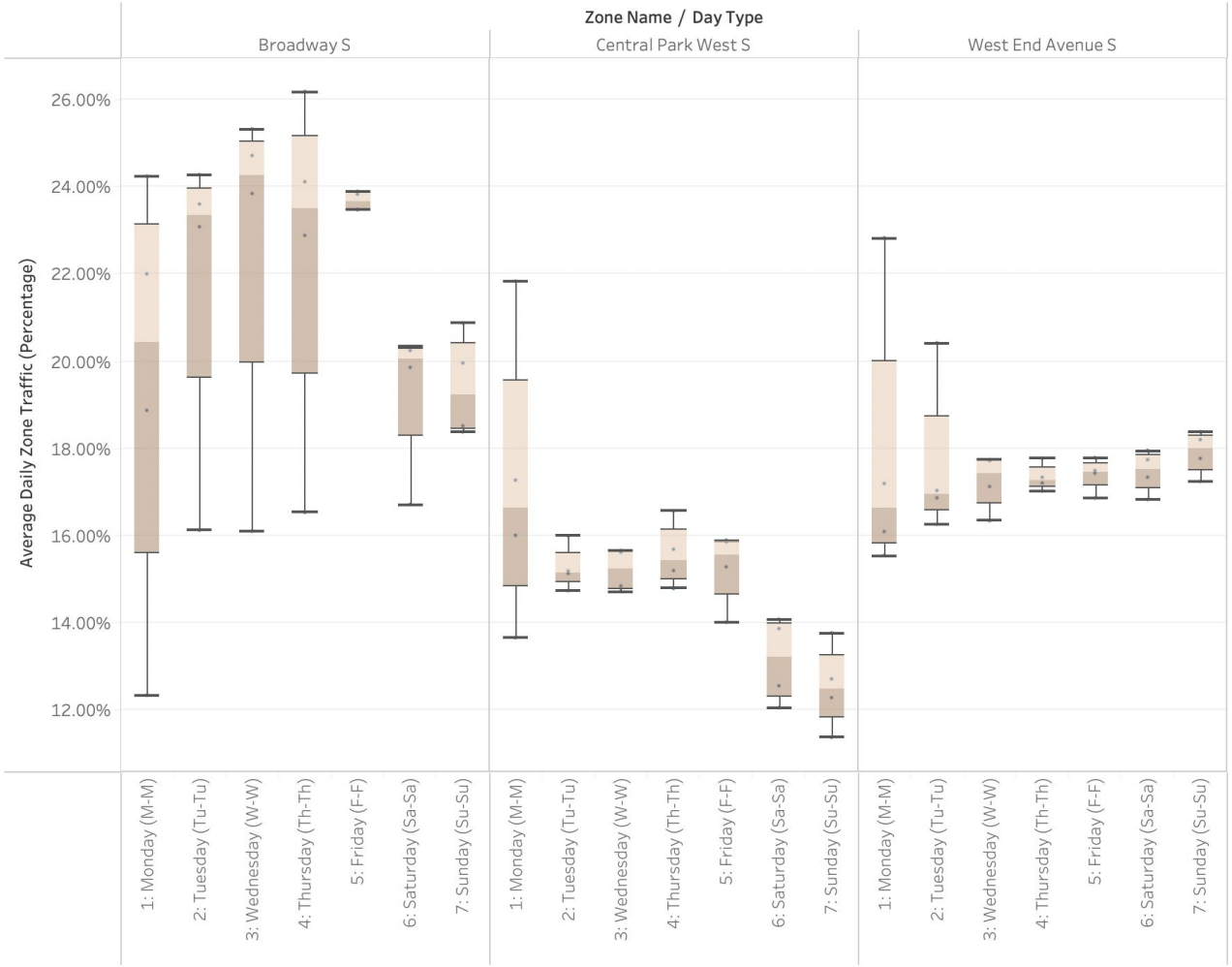


Zone Name

- [ ] (All)
- [ ] 5th Ave S
- [x] Broadway S
- [x] Central Park West S
- [ ] Columbus Avenue S
- [x] West End Avenue S

Day Part

- [ ] (All)
- [x] 0: All Day (12am-12...
- [ ] 1: Early AM (12am-...
- [ ] 2: Peak AM (6am-1...
- [ ] 3: Mid-Day (10am-3...
- [ ] 4: Peak PM (3pm-7...
- [ ] 5: Late PM (7pm-12...

Longer effect on the route where the incident happened

- Impact lasts for at least 4 days

Neighbouring streets could quickly adjust, the impact was less likely to last for one or two days.

Observation

- The dramatic water main break directly affected the whole related area for at least 2 days, and the influence would last 4 days for Broadway
- Neighbouring streets take responsibility of exceed capacity (e.g. Central Park Ave had 94.9% increase in traffic vol) but usually could quickly adjust and led the traffic back to “normal”
- People are more likely to select the nearest substituted road as the second choice if the repair would take at least 2 days
- Considering the classification of impacted area, the major affected groups are the neighboring residents and local retailers

Tableau Link: https://public.tableau.com/app/profile/yuqing.gao/viz/Broadway_16714842928480/DaytoDay?publish=yes

Capital Planning Analysis

Assess the structural capital infrastructure project planning gap

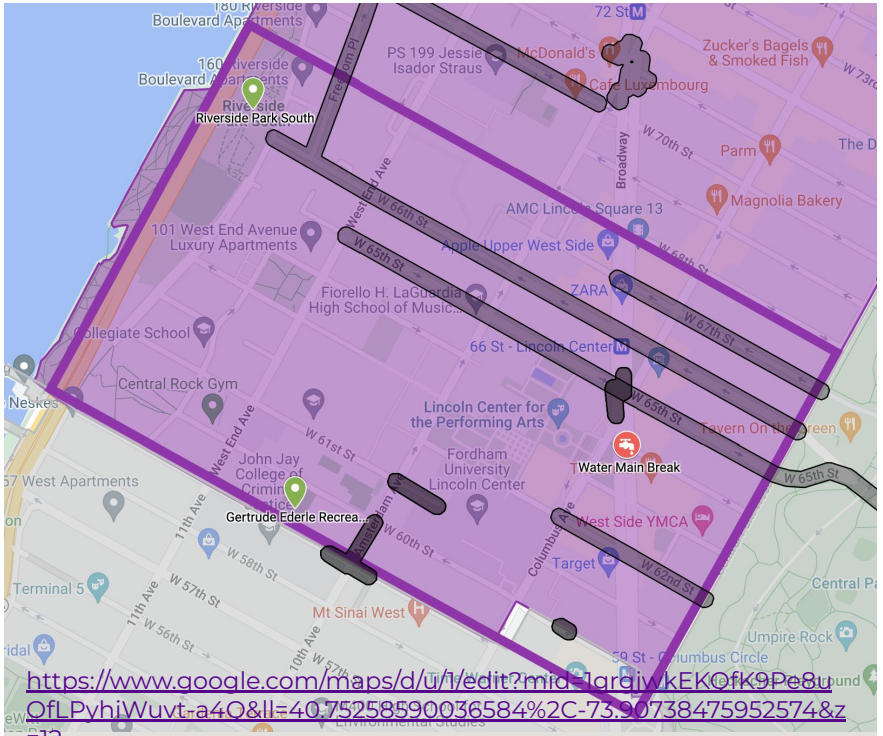
1. **Interagency Knowledge Transfer Gap**
   - Map the Community District where the infrastructure failure exists
   - Map infrastructure agency projects (DEP, DOT, DDC) in the City's Commitment Plan that are within the Failure Community Districts

1. **Local Community Knowledge Transfer Gap**
   - Review and analyze the Failure Community Districts' Needs Statements and prior to the Failure to see if the Community Boards had observed locally what could have been related to the Failures.

Manhattan 7 CD

307202110C
Request: Roadway maintenance
Explanation: Fund street and curb lane resurfacing, There are 193.6 lane miles of paved
streets in CD7, slightly more than 10% of the lane mileage of all of Manhattan.
Responsible Agency: Department of Transportation
Location Site Name: Entire district

307202113C
Request: Reconstruct or upgrade a building in a park
Explanation: Gertrude Ederle Recreation Center, West 60th Street. Replace skylight over the multi-purpose room.
Responsible Agency: Department of Parks and Recreation
Location Site Name: Gertrude Ederle Recreation Ctr



https://www.google.com/maps/d/u/1/edit?mid=1grqjwkEKOfK9Pe8uOfLPyhiWuvt-a4Q&ll=40.75258590036584%2C-73.99738475952574&z=12

Manhattan 7: From the analysis, the closest capital planning project was the street resurfacing in the entire CD in the same year. Hence, no sufficient evidence indicates the hidden danger of the water main break on Broadway was discovered nor prevented.

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Findings & Next Steps

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Findings

- Most obvious change in traffic volume can be seen **only on the day of impact**
  - 42%-80% drop on impacted streets compared to baseline
  - Neighboring streets picked up traffic, had a 34%-57% increase compared to baseline
- **2 days after the incident**, traffic volume in neighboring streets return to normal ranges
  - Influence on impacted street remains for 4 days.
  - The major affected groups are the neighboring residents and local retailers
- Impact to the neighboring traffic on different roads:
  - Impacted street with alternative road on only one side (e.g. Vernon Blvd in Queens):
    - This nearest alternative road picks up all the traffic.
  - Impacted street with alternative roads on both sides (e.g. Broadway in Manhattan):
    - Travelers have more options. All alternative roads share the traffic volume.
- None of the infrastructure failure was discovered nor prevented. Planners pay more attention to infrastructures that can be seen.

In the future

- **Analyze average speed of traffic across the area** - Traffic volume and traffic speed may show different patterns. Map out better detour plans to avoid traffic jams.
- **Quantify the economic impact** - Get access to more data of the impacted neighboring related to income or credit card transaction. Are people living / working in the area high or low income? How's the surrounding business/manufacturing been affected?
- **Analyze economic impact of the neighborhood** - Decide the nature of the areas, whether it is a financial district or a residential area. The cost of repairing the infrastructure failure.
- **Analyze the pedestrian, bikes and trucks traffic of impact area** - Pedestrian can be the major potential consumers for those retailers in impact area. Trucks have great commercial value.
- **Prevent ahead** - Use the methodology to help decide which community district should receive more attention,

Reflections

- It is important to have constant **sponsor meetings**
- Use **Milestone tracker** and **action tracker** as project management tools
- Get accurate data
- Keep close **communication** between team members
- Good methodology needs revising and refining.
    - It takes several tries to determine which incident and substitute roads should be and how could be analyzed.
    - During analysis on StreetLight Data, there are some unexpected situations, such as data missing.

Thank you!

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Q&A

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Appendix

Additional Analysis on Incidents

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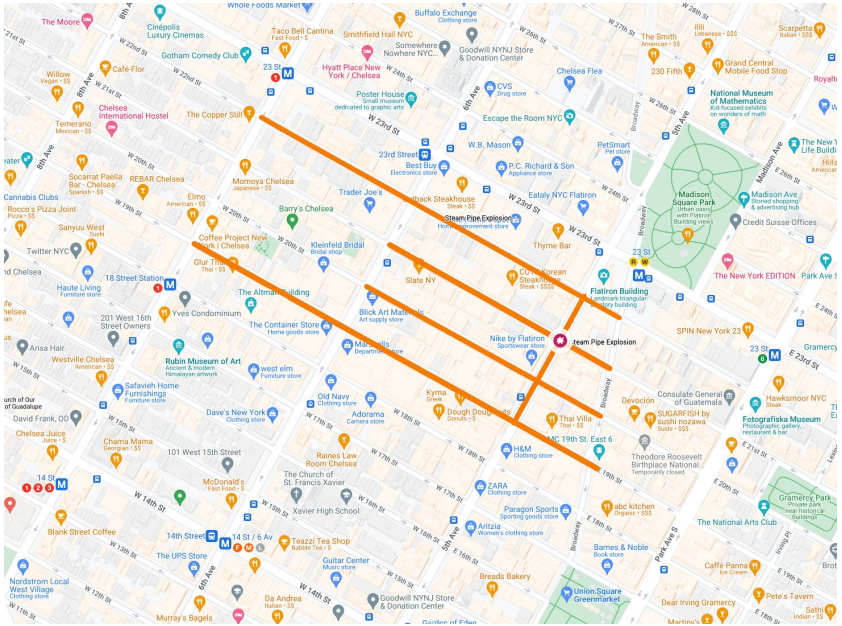
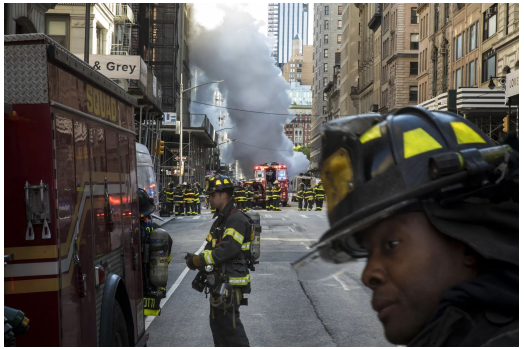
Steam Pipe Explosion



Date and Time: 19 July, 2018 6:30am (Thursday)
Location: 21st St & 5 Ave (Flatiron District)
Duration: Hot zone completely closed for 4 days
Zoning: C6-4 (Commercial) and M1-5 (Manufacturing)
Source:
https://www.nytimes.com/2018/07/19/nyregion/steam-explosion-pipe-flatiron-nyc.html
https://www.cnbc.com/2018/07/19/steam-pipe-explosion-in-manhattans-flatiron-spurs-evacuation.html



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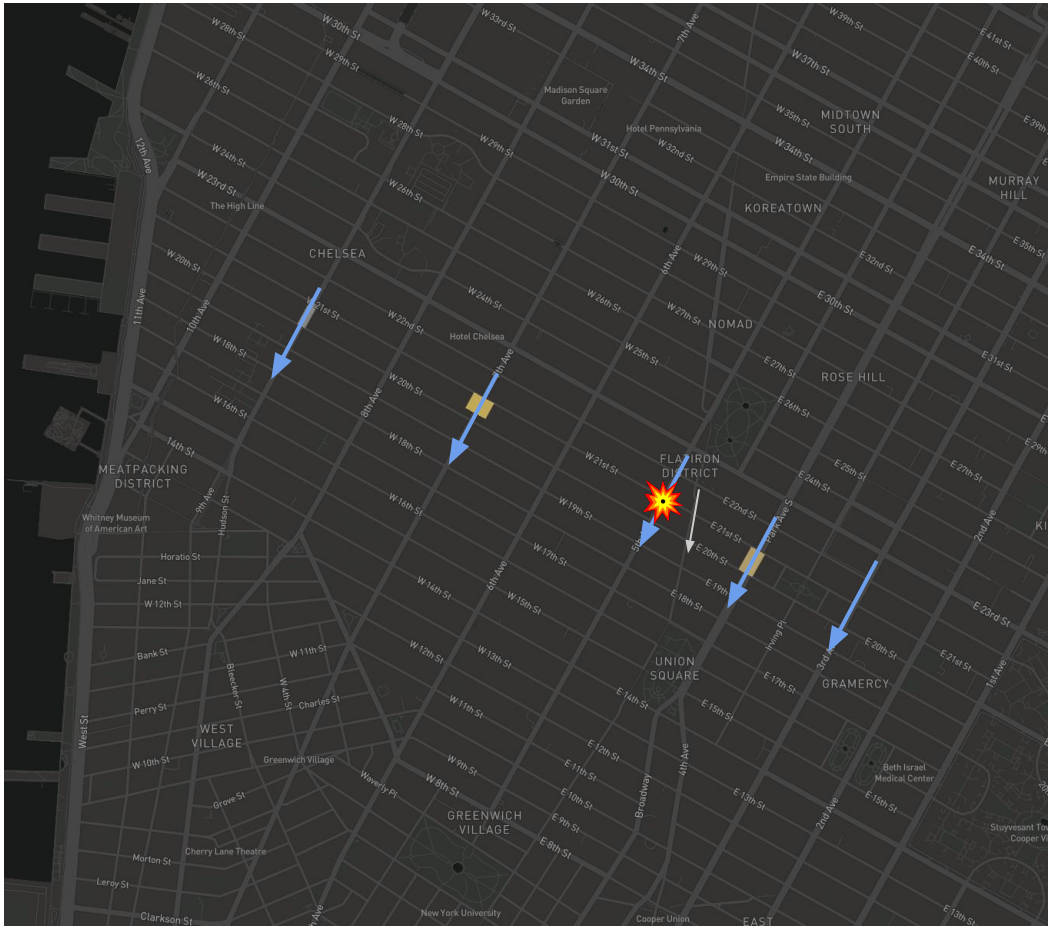
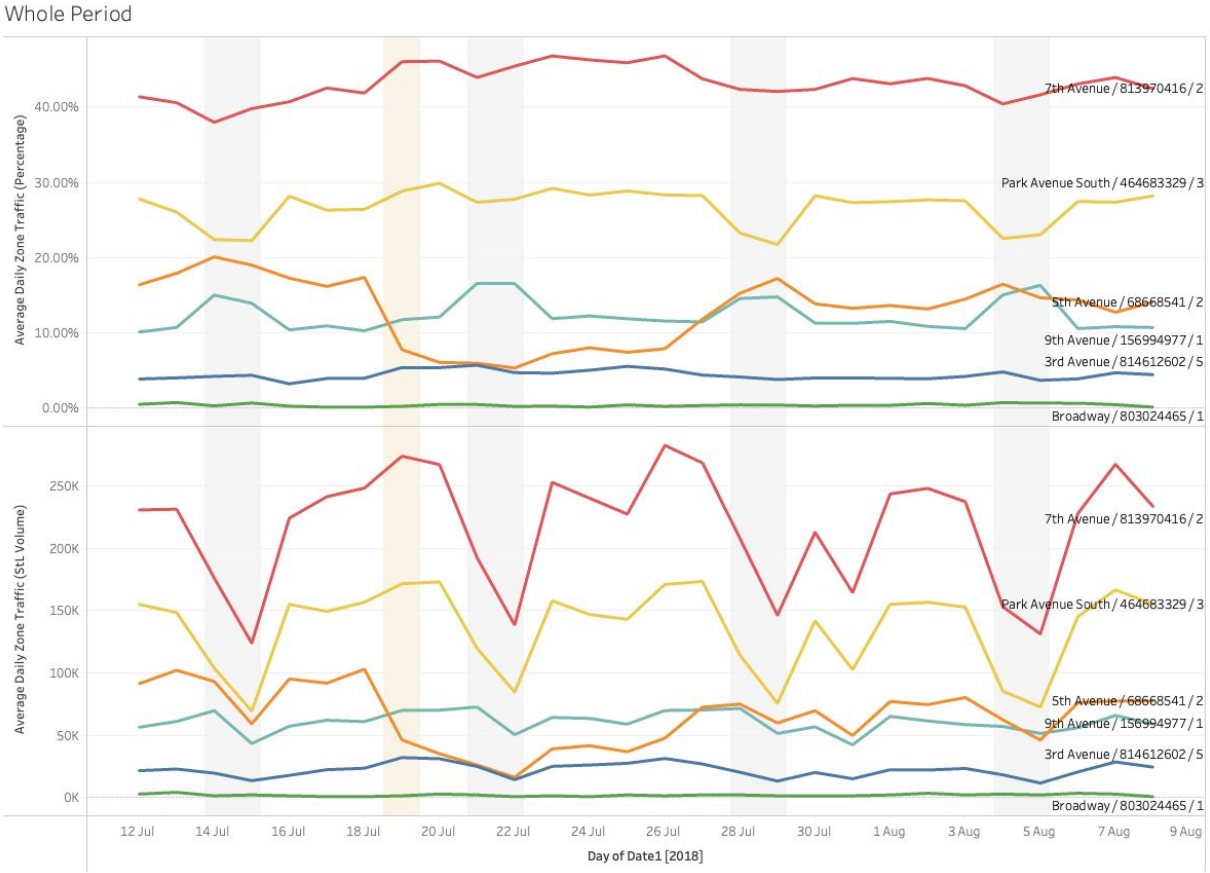


Time Range:
07/12/2018 - 08/08/2018

Selected Zones:
9th Ave, 7th Ave, 5th Ave, *Broadway#*, Park Ave S, 3rd Ave

Tableau Link:
https://public.tableau.com/views/1236639_Steam_Pipe_Explosion_Standard/DaytoDay

Traffic data on Broadway is incomplete during the time range, and thus not considered in further analysis



Zone Activity Analysis

On July 19, 2018, 5th Ave Southbound saw a traffic drop

- 17.36% → 7.77% (-9.59%)
- 102,984 → 46,225

7th Ave and Park Ave S picked up most traffic

- 41.87% → 46.04% (+4.17%)
- 26.41% → 28.83% (+2.42%)

Traffic on 9th Ave and 3rd Ave also increased

- 10.27% → 11.75% (+1.48%)
- 3.97% → 5.38% (+1.41%)

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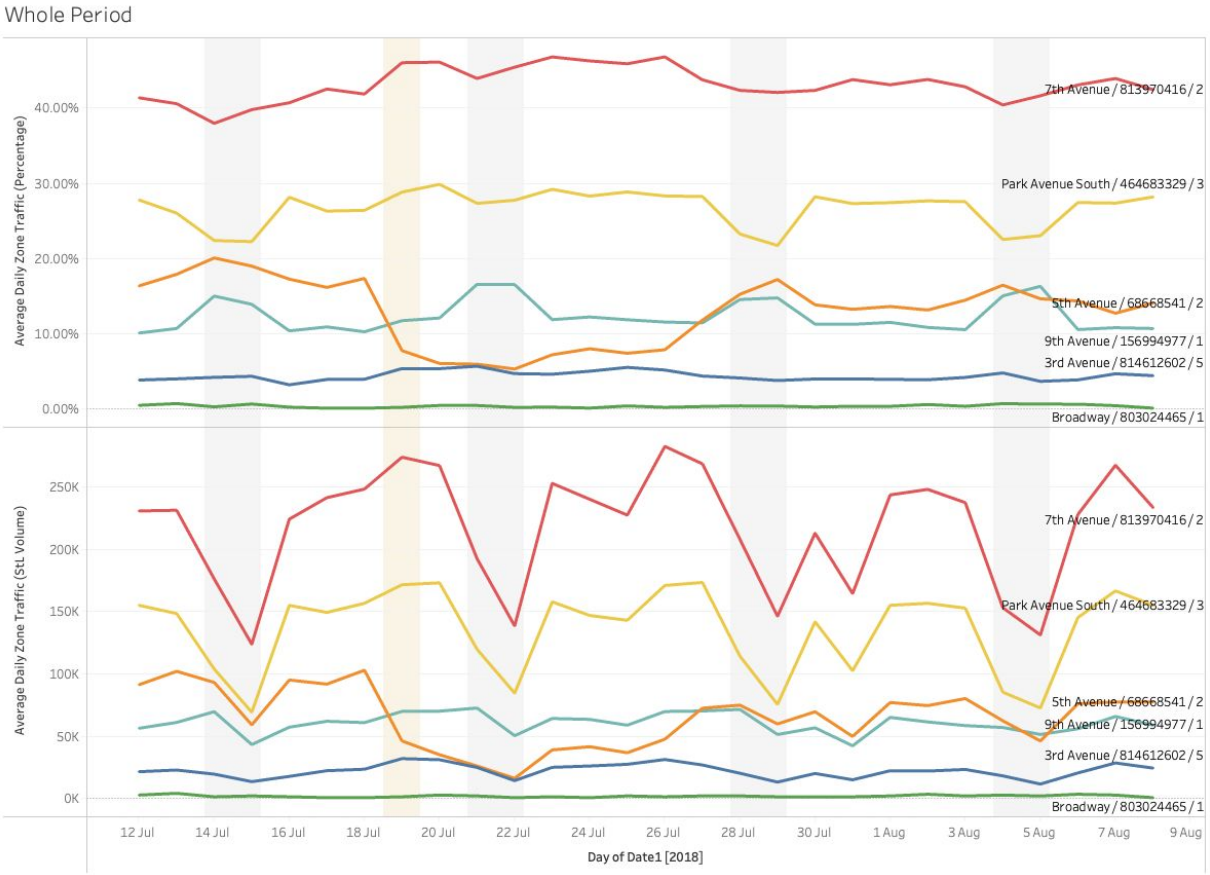

Arranged from West to East

9th Ave

- 10.27% → 11.75% (+1.48%)
- 60,937 → 69,920

7th Ave

- 41.87% → 46.04% (+4.17%)
- 248,368 → 273,993

5th Ave

- 17.36% → 7.77% (-9.59%)
- 102,984 → 46,225

Park Ave S

- 26.41% → 28.83% (+2.42%)
- 156,688 → 171,590

3rd Ave

- 3.97% → 5.38% (+1.41%)
- 23,521 → 32,049

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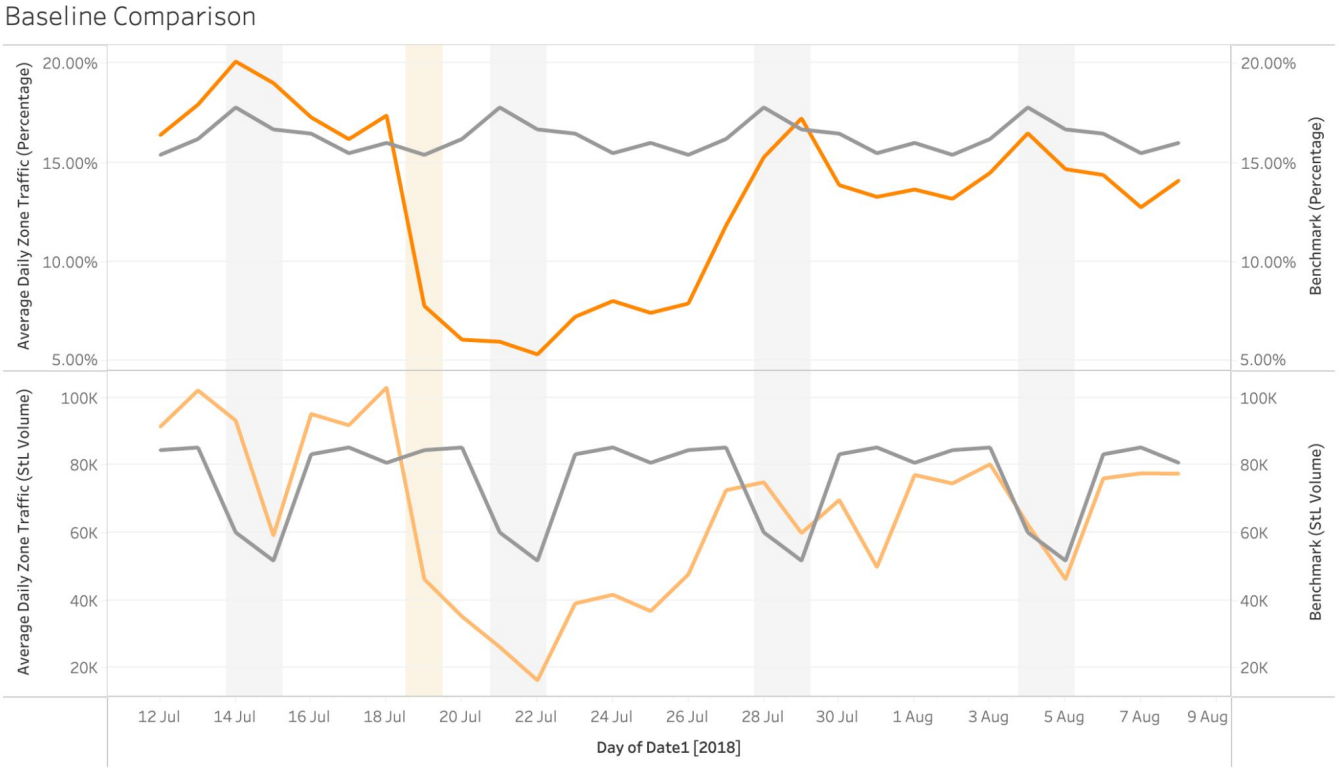

Traffic Changes With Baseline Comparison

5th Ave

- Distribution dropped by 7.61% compared to baseline value on Day 0
- Took 11 days to return to close-to-normal

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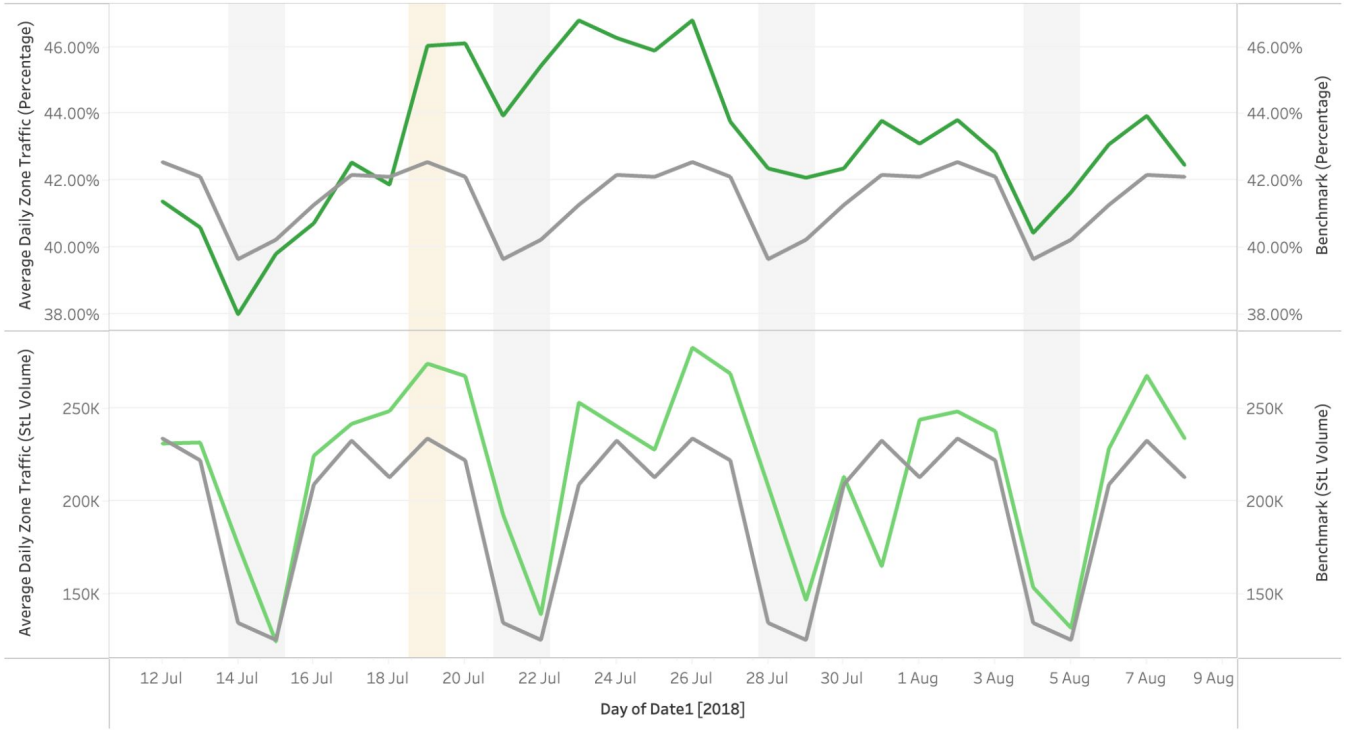
Baseline Comparison



Traffic Changes With Baseline Comparison

7th Ave

- Distribution increased by 3.5% compared to baseline value on Day 0
- Took 11 days to return to close-to-normal
- Traffic volume increased by 17% compared to baseline value on Day 0
- Percentage increase for traffic volume fluctuated from 11% to 21% for 11 days

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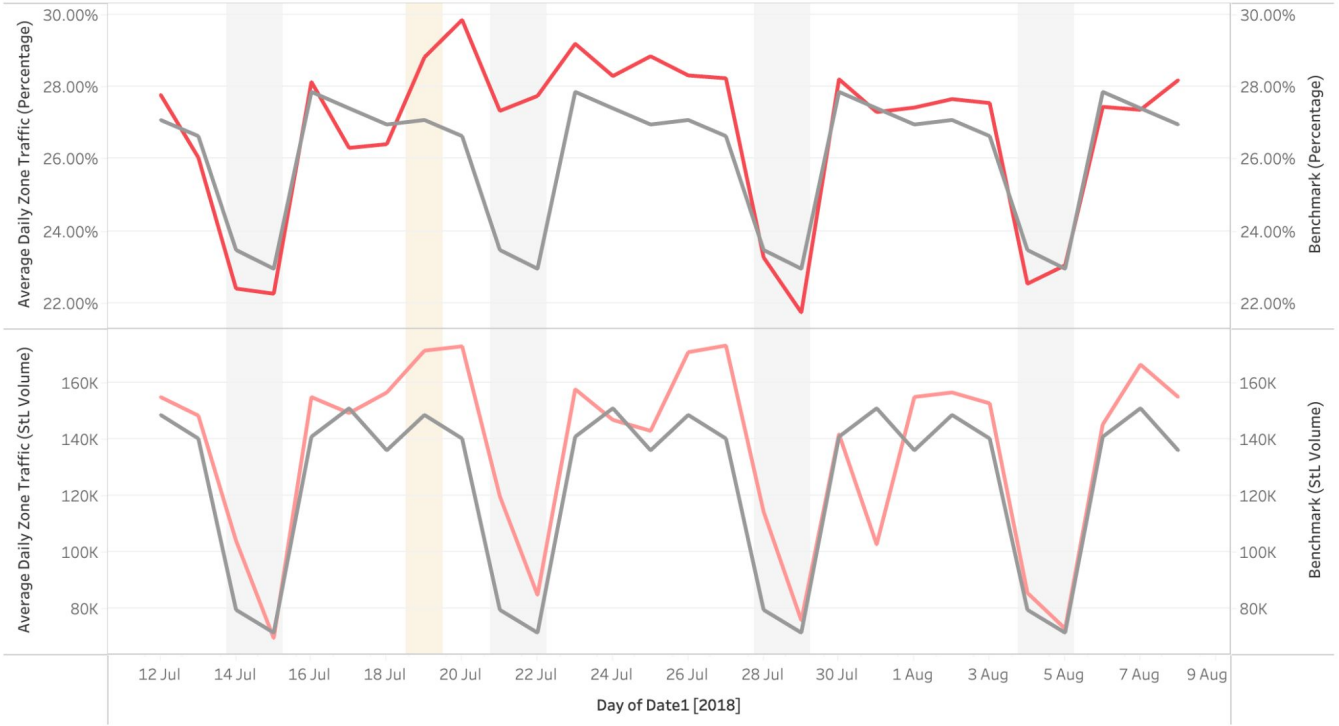
Baseline Comparison



Traffic Changes With Baseline Comparison

Park Ave S

- Distribution increased by 1.74% compared to baseline value on Day 0
- Took 10 days to return to close-to-normal
- Traffic volume increased by 15% compared to baseline value on Day 0
- Took 6 days to return to close-to-normal

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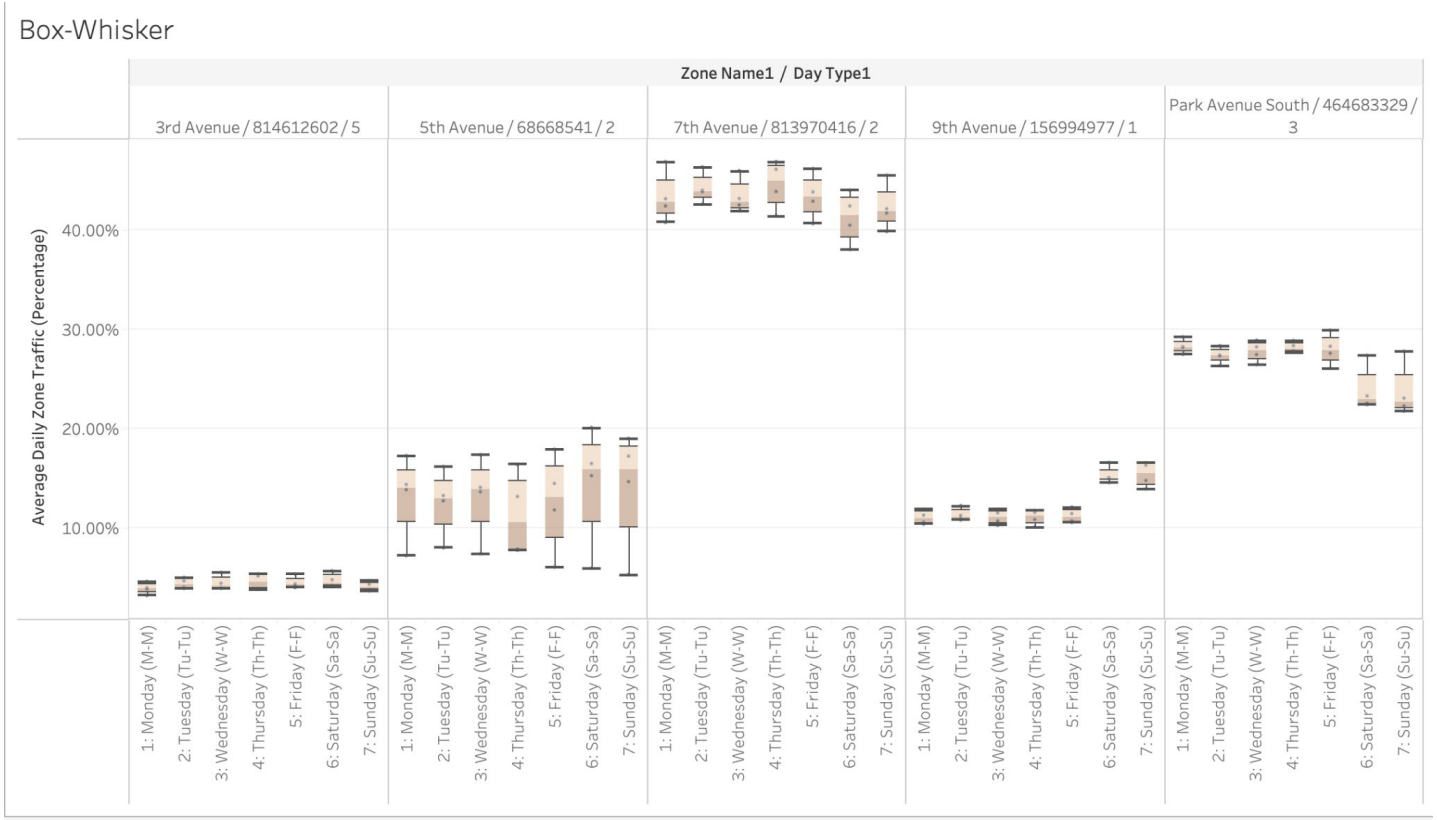

Traffic Fluctuation

- The impacted street sees most fluctuation
- Shorter effect on neighboring streets

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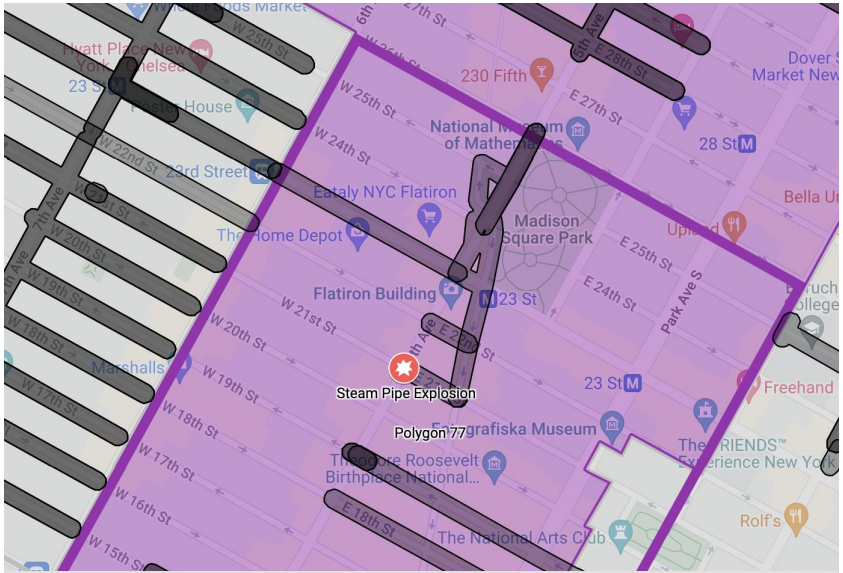
Observation

- Impact on the street where the incident happened lasted for ~11 days
  - Traffic distribution dropped by 10% compared to previous day / 8% compared to baseline
- The 2 neighboring streets picked up traffic on Day 0
  - Distribution increased by 4% and 2% respectively compared to the day before
  - Still near the range of baseline value
- Impact on traffic volume on neighboring streets not obvious from Day 1 onwards
- Limitation - StreetLight data is incomplete and fluctuates a lot

Manhattan 5 CD

305201908C
Request: Renovate or upgrade existing precinct houses
Explanation: Support additional funding for Precincts modernization.
Responsible Agency: Police Department

305201912C
Request: Improve streetscapes in business districts to attract / encourage commercial activity, e.g., lighting, sidewalk improvements
Explanation: Request Improve streetscapes in business districts including lighting and
sidewalk improvements and to attract/encourage commercial activity
Responsible Agency: Economic Development Corporation



Manhattan 5: From the analysis, the closest capital planning project was the streetscape improvement in the business district in the same year. Hence, no sufficient evidence indicates the hidden danger of the steam pipe explosion on W21 St was discovered nor prevented.

Water Main Break

Date and Time: January 28, 2021 4:03 am (Thursday); June 7, 2022 3:21 am (Tuesday)
Location: Vernon Blvd & 41st Ave, Queens, NY 11101
Duration: January 28 - April 30; June 7 - December 23
DOT Permit Number: Q012021028A24; Q012022158A07
Zoning: M1-6 (Light industries) & R6 (Medium density area) & C1-3 (residential districts to serve local retail needs)

Source:
https://www.cbsnews.com/newyork/news/massive-water-main-break-lic-queens/

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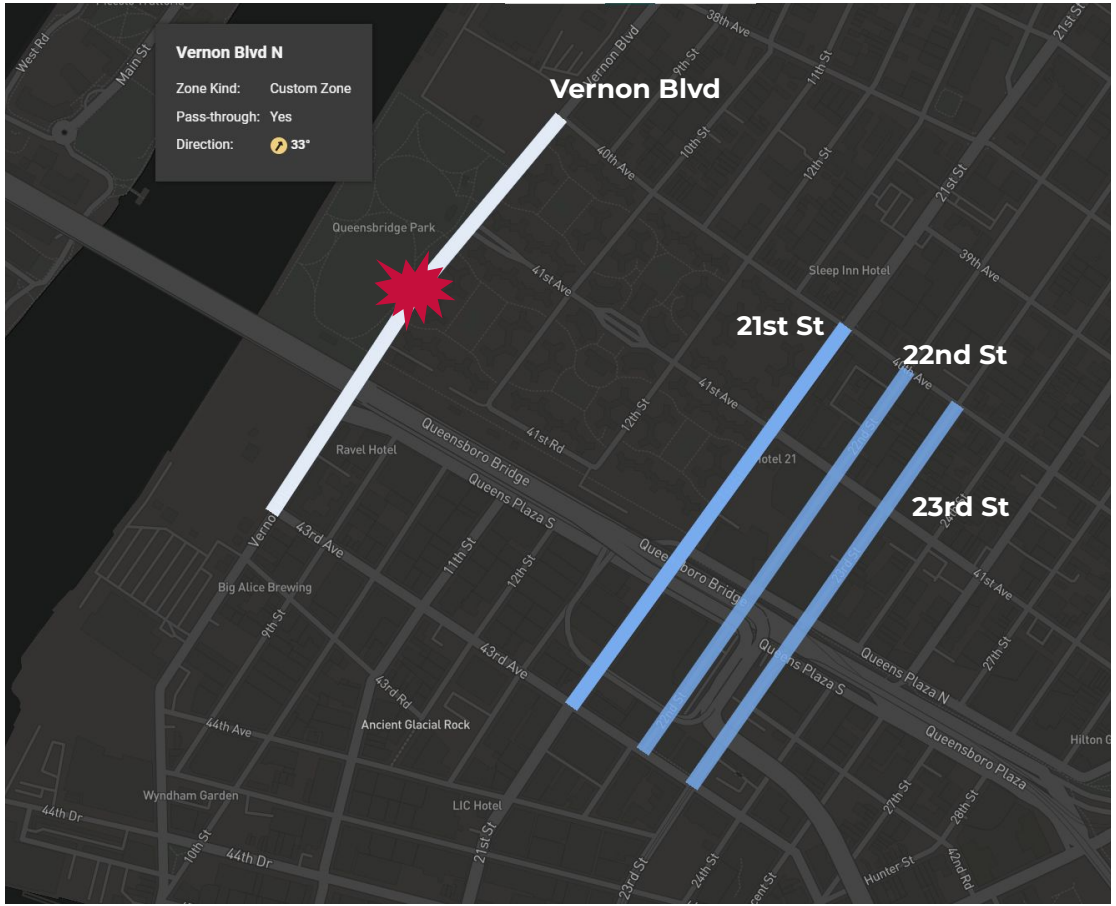
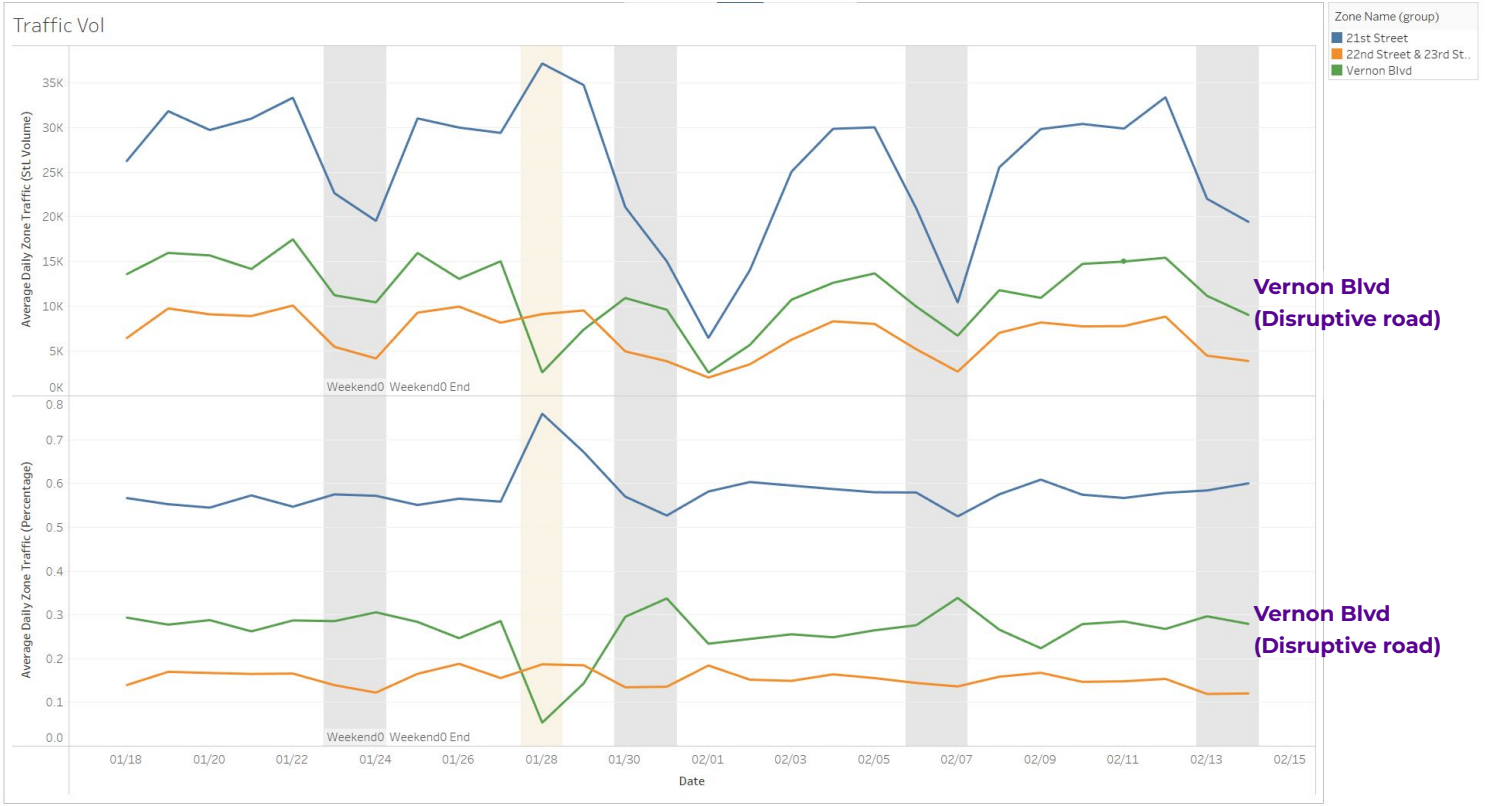


Time Range:
01/28/2021 - 04/30/2021

Selected Zone:
Vernon Blvd, 21st St, 22nd St, 23rd St

Tableau Link:
https://public.tableau.com/app/profile/zhen.wu7222/viz/VernonBlvdWaterMainBreak/DaytoDay?publish=yes

Zone Activity Analysis - Previous Day Comparison



Accident Date: Jan 28, 2021

Vernon Blvd saw a traffic drop

- 28.6% → 5.4% (-23.2%)
- 15045 → 2623 (12422/82.6%)

Traffic volume in 21st St climbed up

- 55.9% → 75.9% (20%)
- 29390 → 37148 (7758/26.4%)

Traffic volume in 22nd St remained stable

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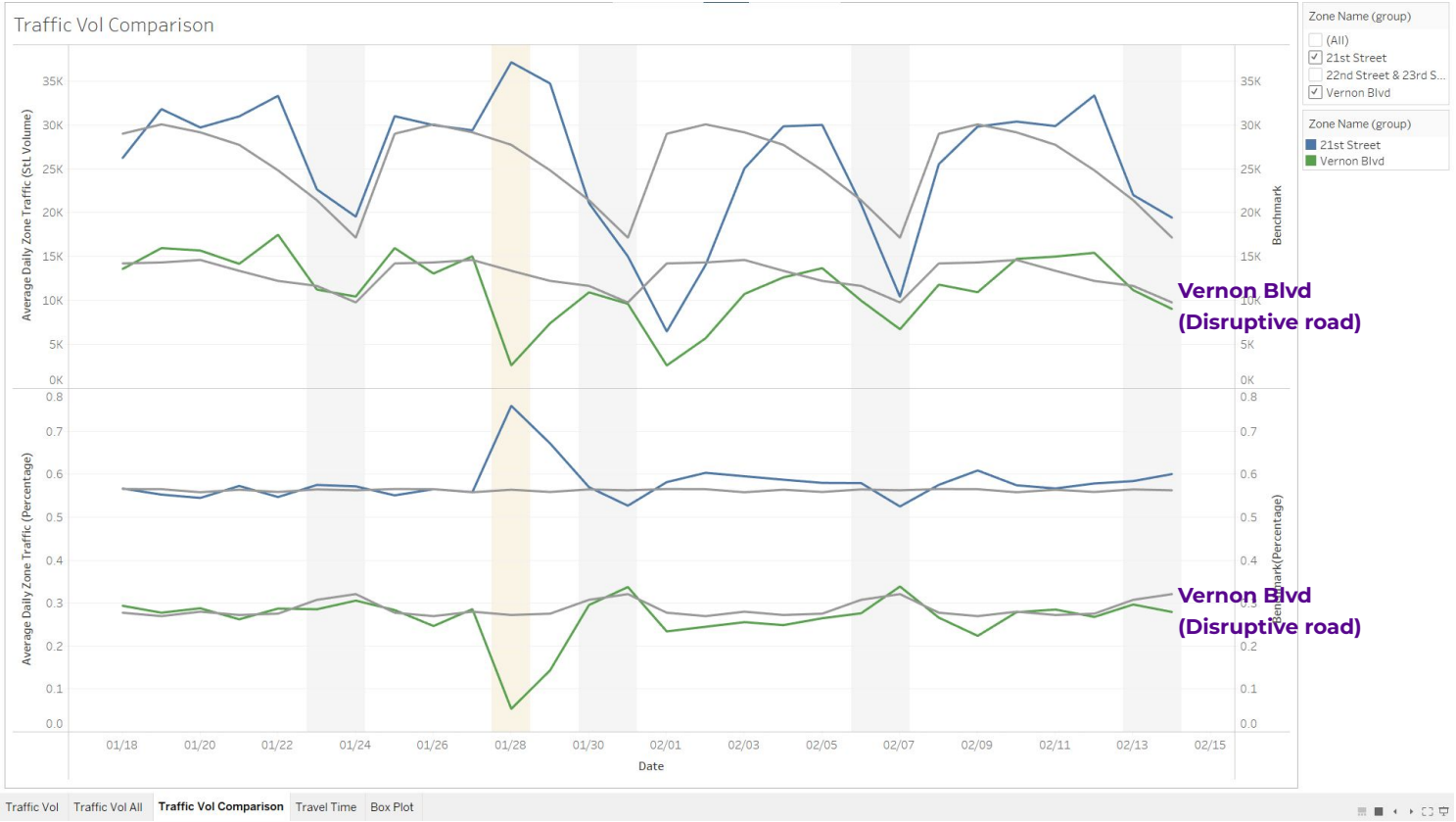
Zone Activity Analysis - Benchmark Comparison



Benchmark: Gray line

Vernon Blvd experienced less traffic volume than monthly average.

- 27.2% → 5.3% (-21.9%)
- 13389 → 2623 (-10766/-80.4%)

21st St picked up the traffic

- 56.4% → 75.9% (19.5%)
- 27740 → 37148 (9408/33.9%)

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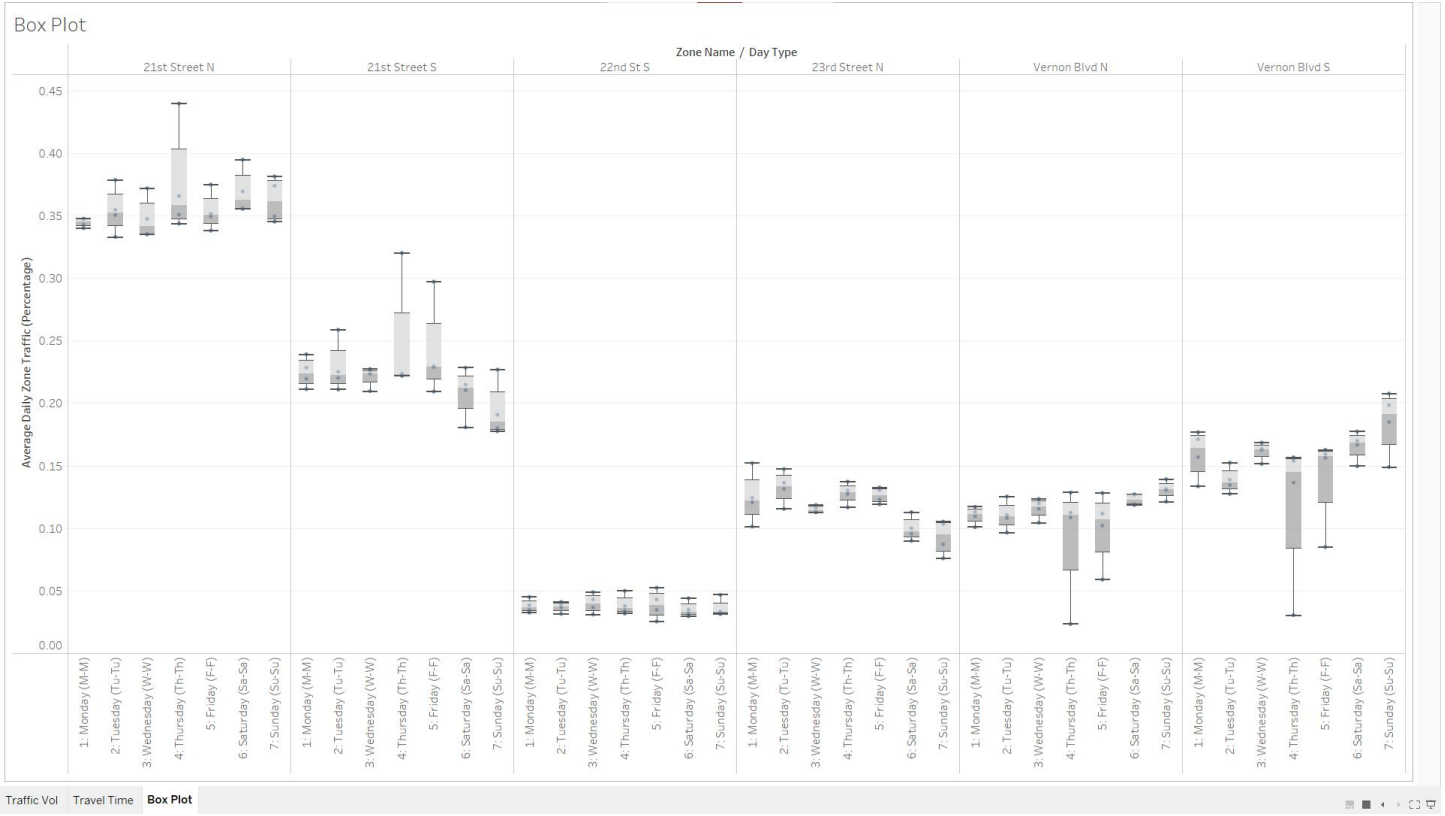
Zone Activity Analysis



Impacted roads and alternative roads witnessed heavier fluctuations.

Impact lasts for at least 2 days, and the road adjusted in the following days.

The impacted road may under repair, but won't affect the overall traffic for a long time.

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Observation

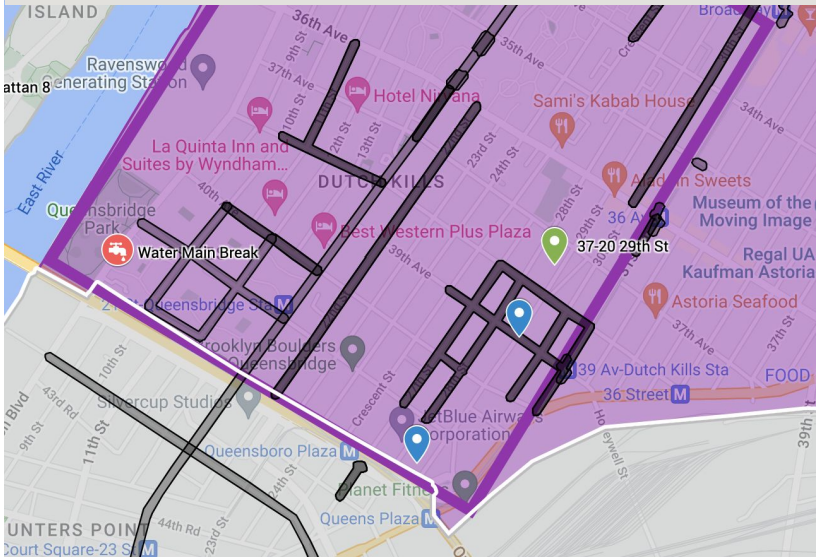
- The infrastructure failure would directly affect the related zone for at least 2 days, and the influence remain for several days, and back to normal in 5 days
- The infrastructure failure caused a 80% traffic vol drop of the impacted road and increased 30% traffic vol of the alternative road
- People are more likely to select the nearest substituted road as the second choice since there were no significant change in other roads
- Neighbouring streets would quickly pick up the traffic, no large impact to the overall traffic volume
- Major disruption focus on the neighboring residents and retailers

Queens 1 CD

401202201C
Request: Repair or provide new street lights
Explanation: Installation of lighting to improve safety and improve street usage is being requested at Main Avenue between Vernon Boulevard and 8th Street; Green Park on Main Avenue-North side of Astoria Boulevard from 8-31 to 8th Street-27th Avenue North side from 8th Street; Hallet's Point Playground; Astoria Houses.
Responsible Agency: Department of Transportation
Supported by: Councilman Constantinides
Location Address: Main Avenue between Vernon Blvd

401202211C
Request: Provide new facilities such as a firehouse or EMS station
Explanation: We Request to Re-open Firehouse 261, Ladder 116 at 29th Street Between 37th & 38th Avenues Due to the Immense Building in Our District. The Current Local Residents Safety Must be Addressed as Well as the People on Roosevelt Island.
Responsible Agency: Fire Department
Location Site Name: Firehouse 261 Ladder 116
Address: 37-20 29th St

Queens 1: From the analysis, the closest capital planning project was the reconstruction of Queensbridge park in the same year. Even though the water main break happened to close the exact location of the project, associated personnel did not find it or report an issue during the reconstruction.



Water Main Break

Date and Time: January 7, 2021 03:30 am(Thursday)
Location: Jerome Avenue near E 175th Street
Duration: Several weeks
DOT Permit Number:
Zoning: R7A (Medium density Residence Districts) & J(Special Jerome Corridor District) & C2-4(Commercial Districts)

Source:
https://www.nytimes.com/2021/01/07/nyregion/cross-bronx-expressway-flood.html
https://www.nbcnewyork.com/traffic/8-rescued-after-water-main-break-floods-nyc-expressway-leaving-cars-stranded/2817180/

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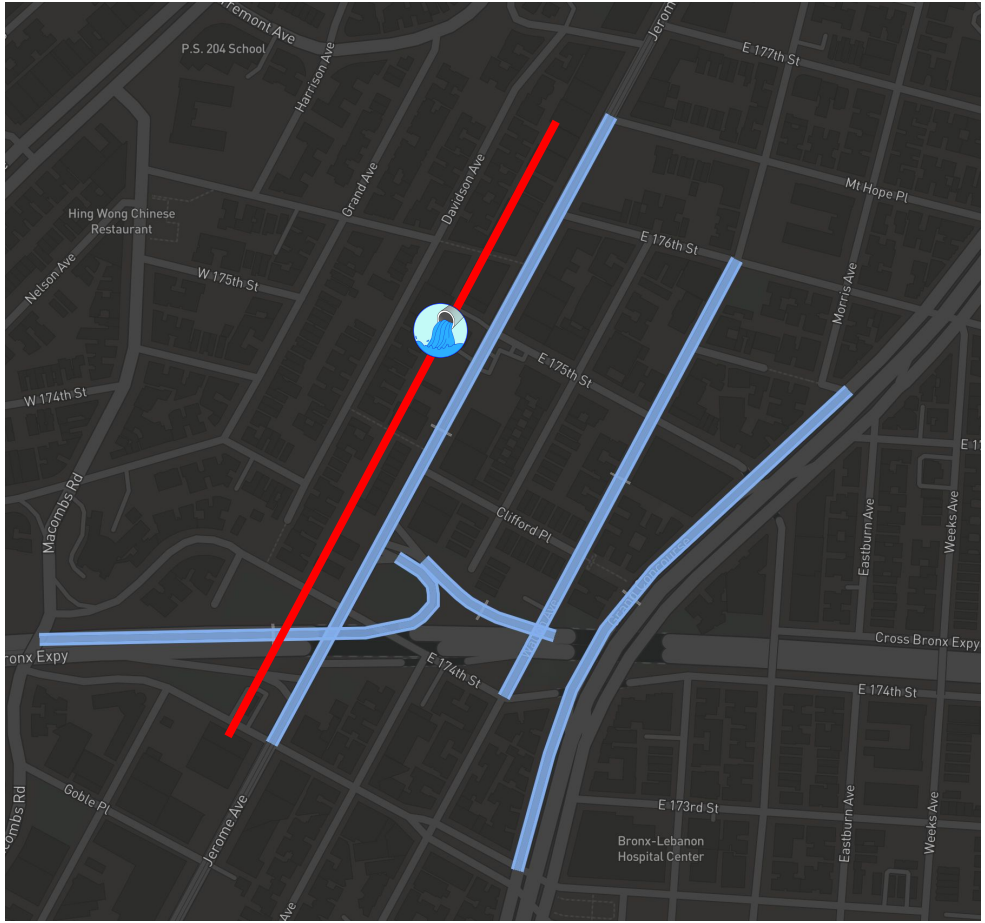
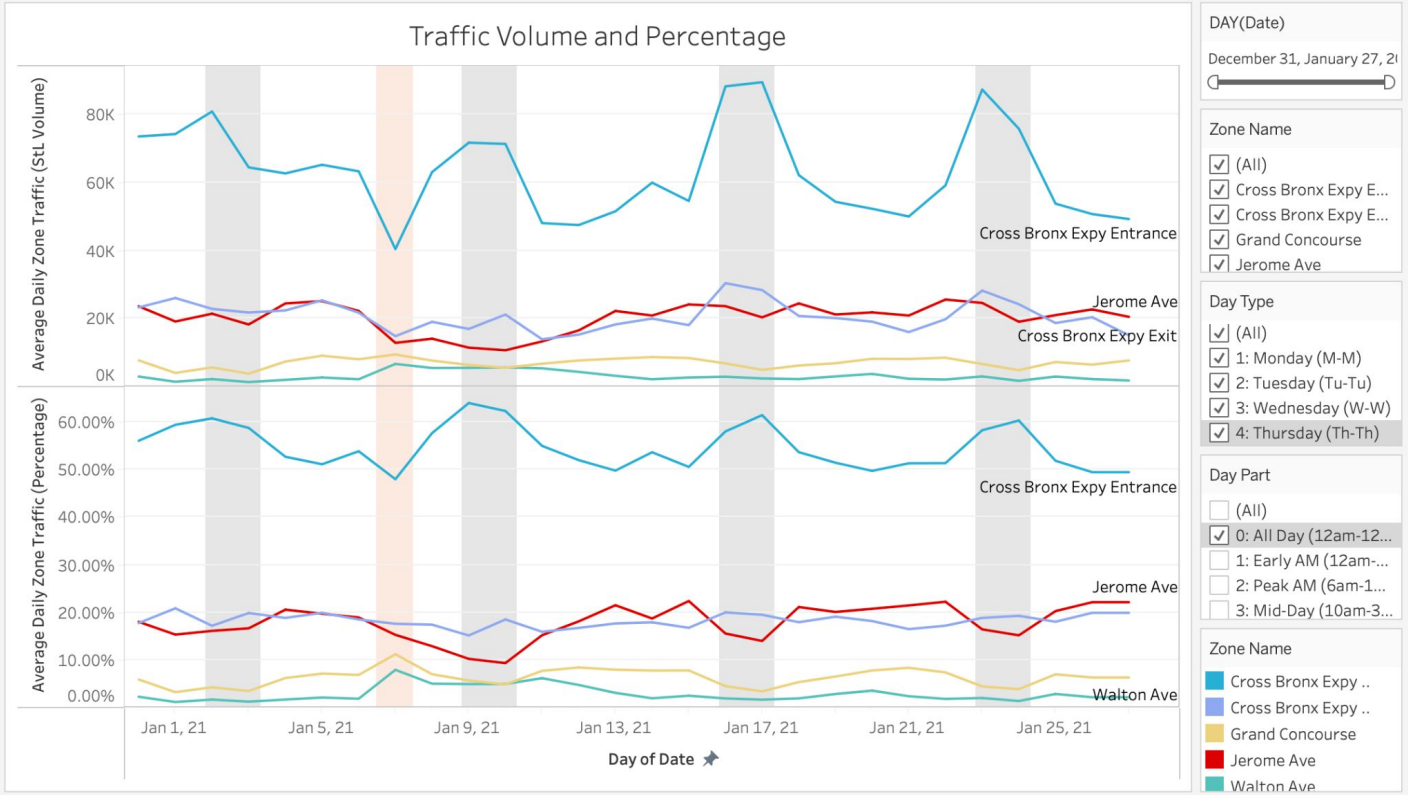


Time Range:
12/31/2020 - 01/27/2021

Selected Zone: Cross Bronx Expressway Entrance on Jerome Ave, Cross Bronx Expressway Exit on Jerome Ave, Jerome Ave, Grand Concourse, Walton Ave.

Tableau Link:
https://public.tableau.com/app/profile/xixuan.huang/viz/Jerome_16713062053430/DaytoDay

Zone Activity Analysis



Compared to the day before incident (1/6/2021)

Cross Bronx Expy Entrance

- 66,435 → 40,474 (-22,871)
- 53.89% → 48.01% (-5.88%)

Cross Bronx Expy Exit

- 21,748 → 14,837 (-6911)
- 18.50% → 17.60% (-0.9%)

Jerome Ave

- 22,253 → 12,869 (-9,384)
- 18.93% → 15.27% (-3.66%)

Grand Concourse

- 8,044 → 9,445 (+1,401)
- 6.84% → 11.20% (+4.36)

Walton Ave

- 2,162 → 6,670 (+4,508)
- 1.84% → 7.91% (+6.07%)

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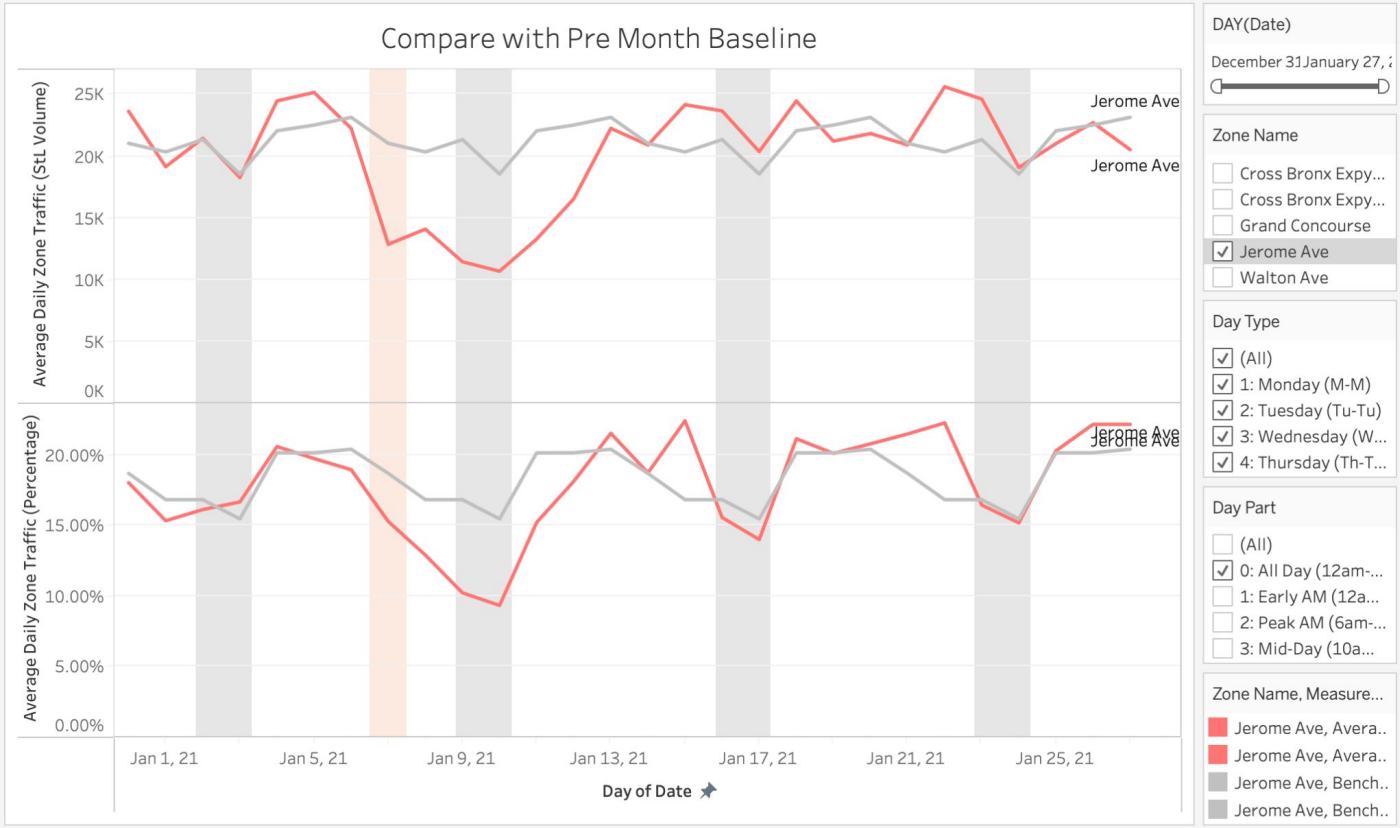


Traffic Changes With Baseline Comparison

Jerome Ave:

- Dropped by **3.4%** compared to the day before
- Took **7 days** to return to close-to-normal

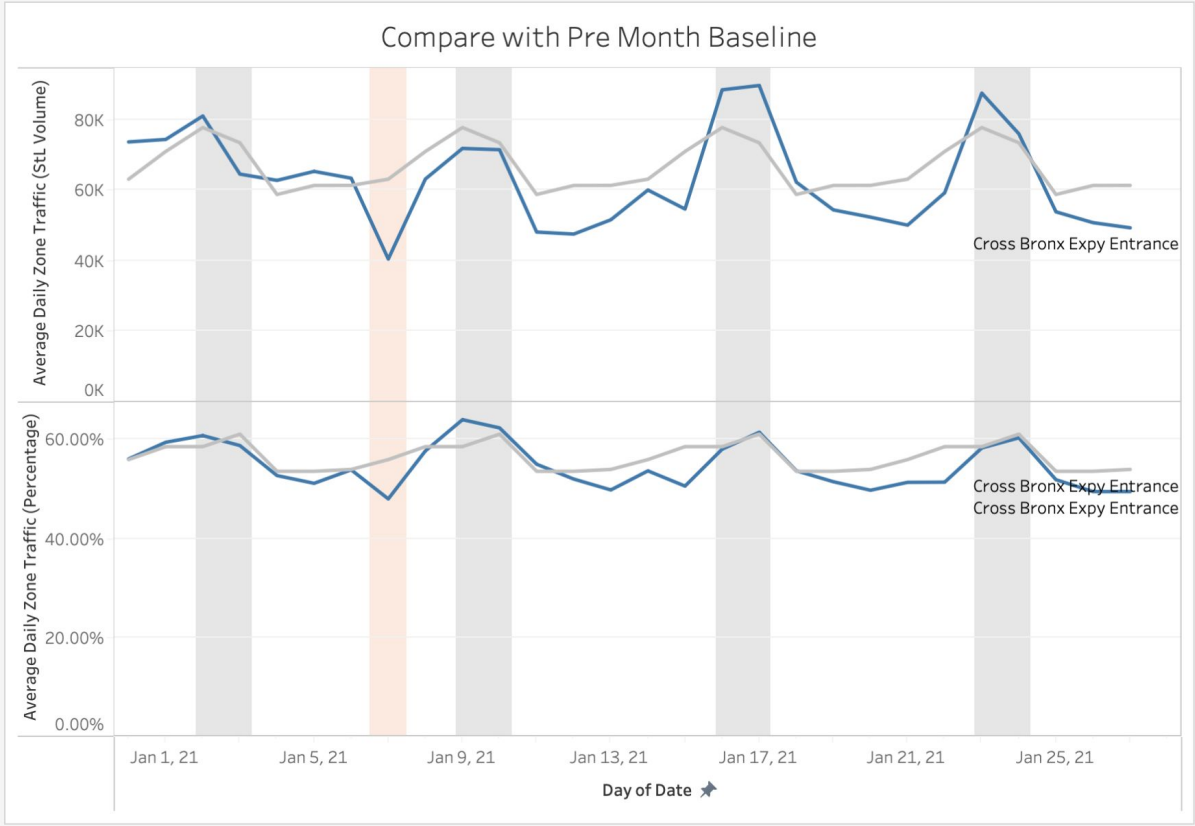
Cross Bronx Expy Entrance:

- Dropped by **7.95 %** compared to baseline value
- Took **4 days** to return to close-to-normal

Walton Ave:

- Increased by **5.64%** compared to the day before
- Took **8 days** to return to close-to-normal

NYU TANDON



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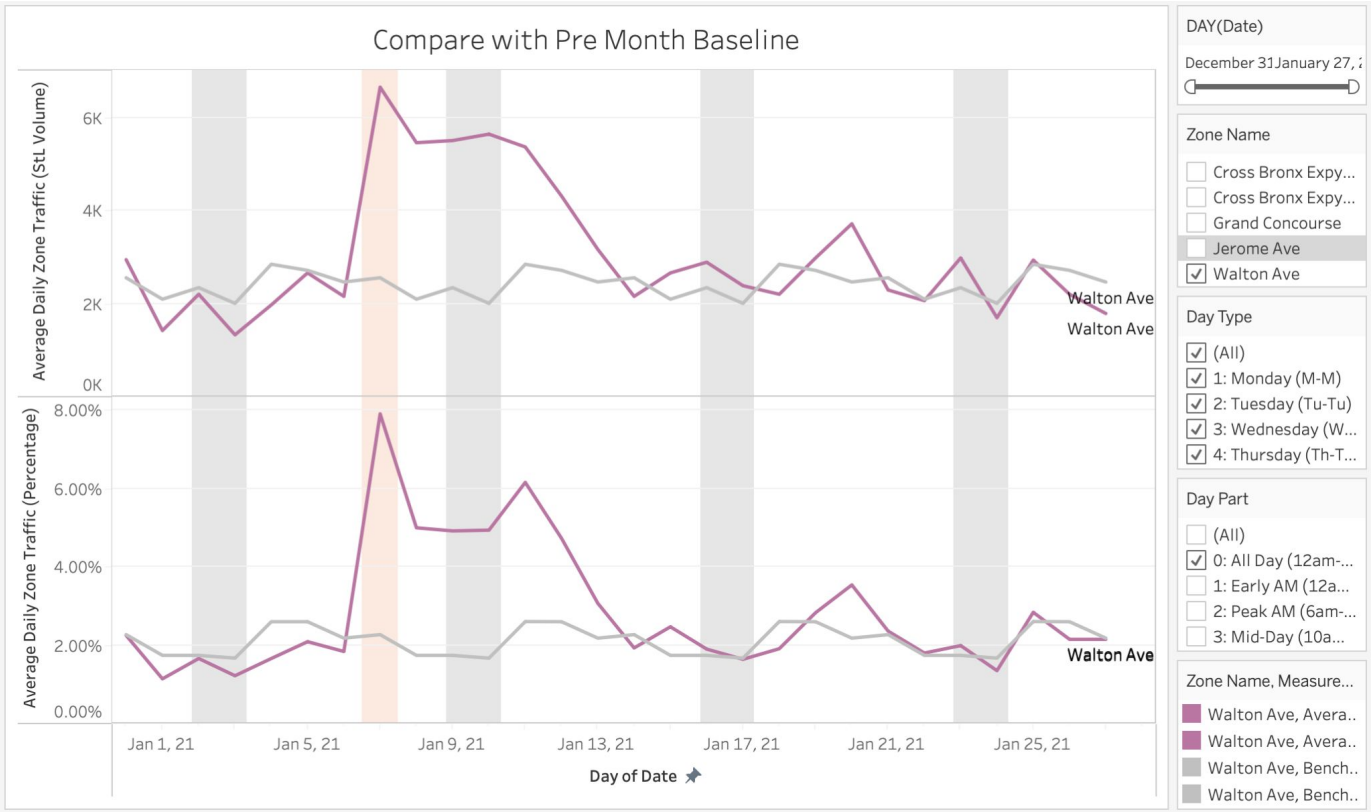
NYU TANDON



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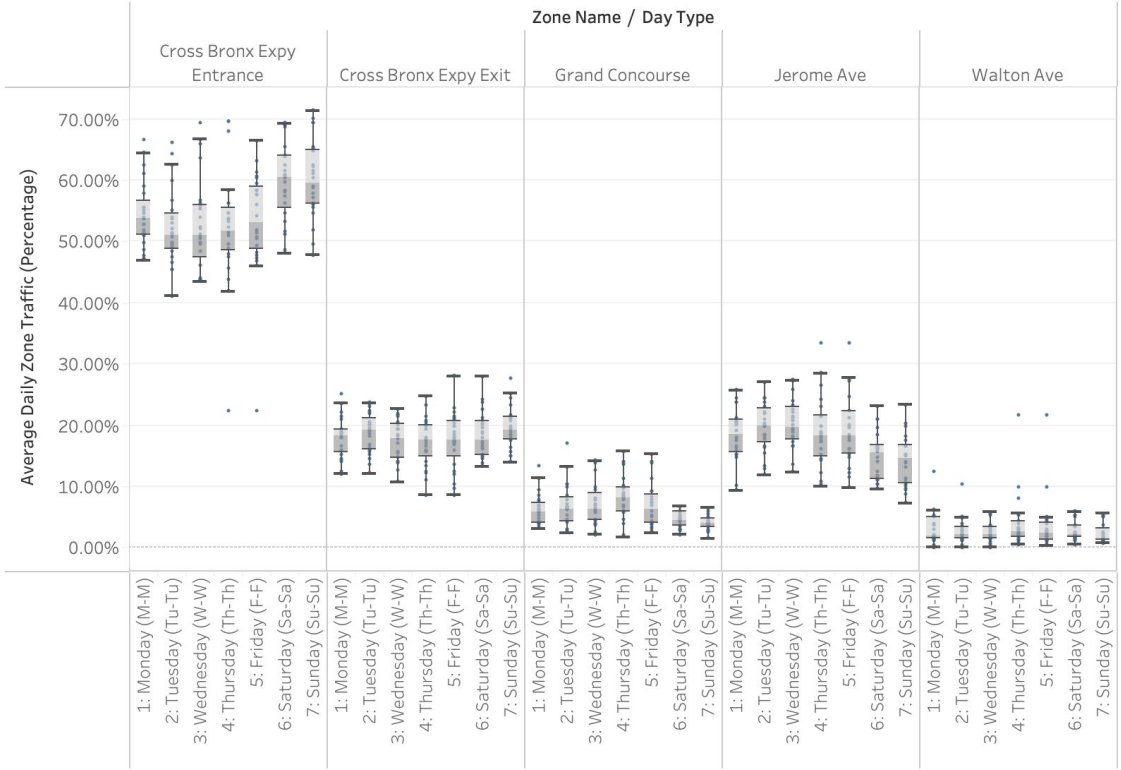
Zone Activity Analysis

Boxplot



Longer effect on Cross Bronx Expressway Entrance, Cross Bronx Expressway Exit and Jerome Ave.

Neighbouring streets could quickly adjust, the impact was less likely to last for several days.

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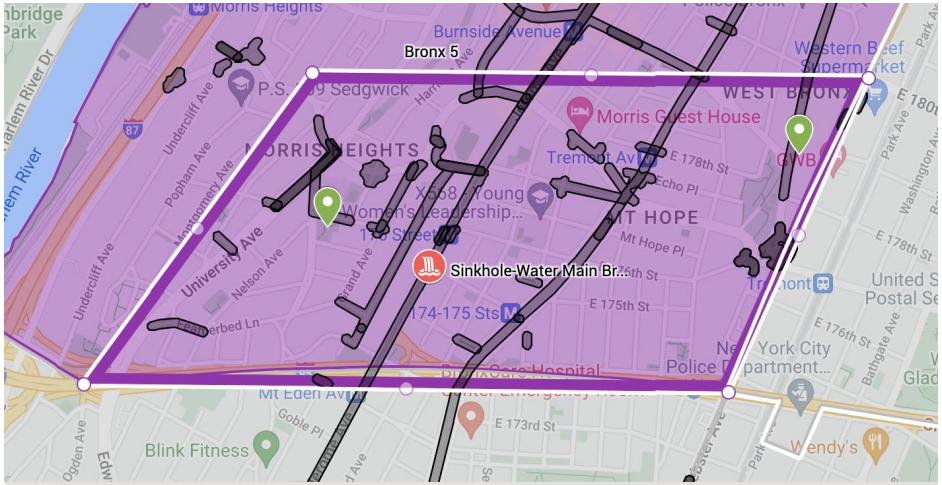
Observation

- A water main break directly affected the related areas for at least 3 days, and the influence would last 7 days for Jerome Ave.
- The results were still significant when comparing to the baseline and considering seasonality
- People are more likely to select the nearest substituted road to enter or exit of the Cross Bronx Expy.
- Grand Concourse and Walton Ave would quickly pick up the traffic, no large impact to the overall traffic volume
- Considering the classification of impacted area, the major affected groups are the neighboring residents and local business (some restaurant especially) in this case.

Bronx 5 CD

105202225C
Request: Reconstruct or upgrade a park or amenity (i.e. playground, outdoor athletic field)
Explanation: Renovation of Galileo Playground. Galileo Playground is an outdoor science playground classroom with play equipment that stimulates children's imagination.
It focuses on the Solar System and the individual planets.
Responsible Agency: Department of Parks and Recreation
Supported by: Community Board #5
Location Site Name: Galileo Playground

105202238C
Request: Reconstruct or upgrade a park or amenity (i.e. playground, outdoor athletic field)
Explanation: The gardens at Twin Park Southwest is dilapidated and needs renovation.
Responsible Agency: Department of Parks and Recreation
Supported by: Mount Hope Housing Company
Location Site Name: Twin Park Southwest
Address: 2000 Valentine Avenue



Bronx 5: From the analysis, the closest capital planning project was the new street light replacements on Jerome Ave in the same year. Hence, no sufficient evidence indicates the hidden danger of the water main break on Jerome Ave was discovered nor prevented.