SARS-CoV-2 Wastewater Surveillance and Public Health Applications in Houston, TX

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Data Reporting and Analytics
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RICE
Unconventional Wisdom

HOUSTON HEALTH DEPARTMENT

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Process Overview

24-hour composite influent/wastewater samples are collected from **39** wastewater treatment plants (serving 2.3M+), **51** schools, **25** congregate living facilities (nursing homes, homeless shelters, jail), and **60** lift stations each week
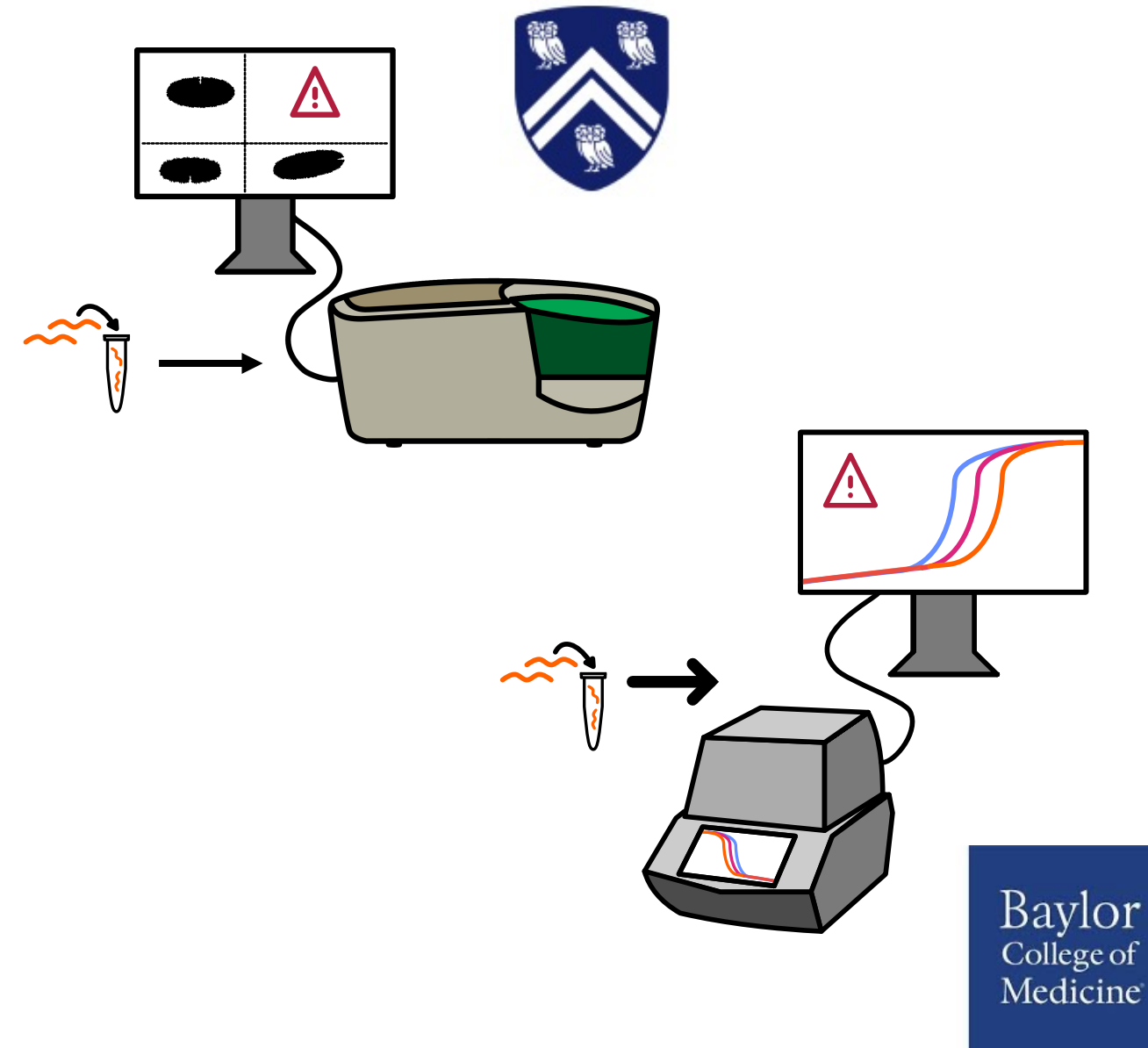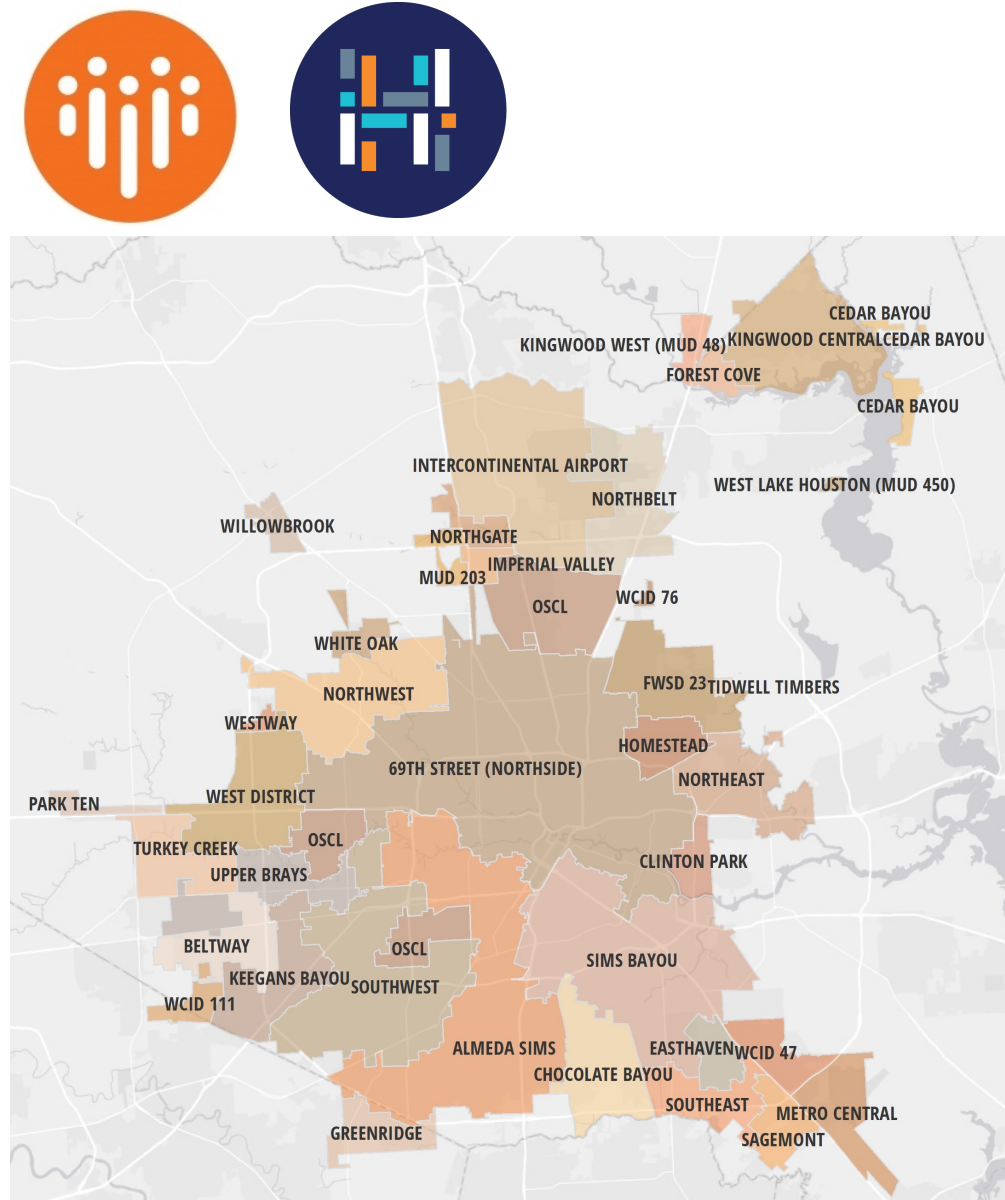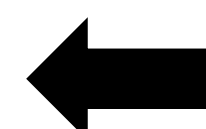

SARS-CoV-2 in quantified in replicate samples in two independent laboratories (Rice and Baylor).

Variant tracking performed using targeted assays and SARS-CoV-2 genome sequencing.


Health department uses wastewater data in cluster analysis to prioritize interventions at zip-code level

Raw data is input into statistical models that identify geographic areas of concern with significant increases in wastewater virus concentration.

Sites with putative variants of concern present are identified and confirmation is pursued via sequencing of PCR-positive clinical samples.

Wastewater Surveillance
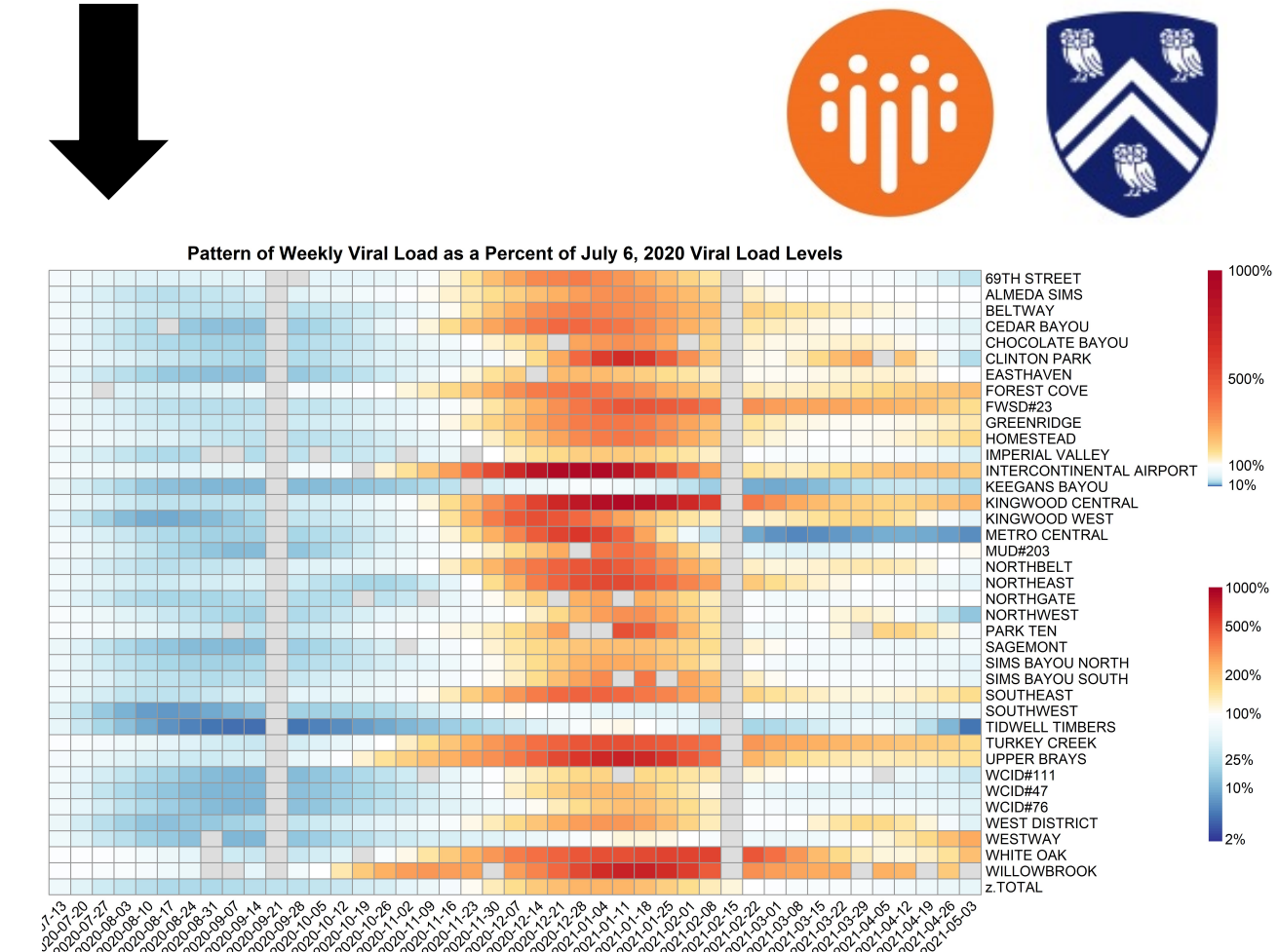
Statistical Analysis

- **Manage** complexities of compiling data from one or two labs

- **Communicate** viral load levels
  - Levels as a percent of the July 6, 2020 viral load
  - Percent one-week change of estimated levels

- **Translate** to the zip code level

- Continue to refine **prediction** of **prevalence** in Houston

SARS-CoV-2 in Wastewater is an Early Indicator of Observed Clinical Case Count

Wastewater Viral Load Trend and Clinical Positivity Rate
16 WWTP: 5/11/20 through 12/7/20

Correlation = 0.77
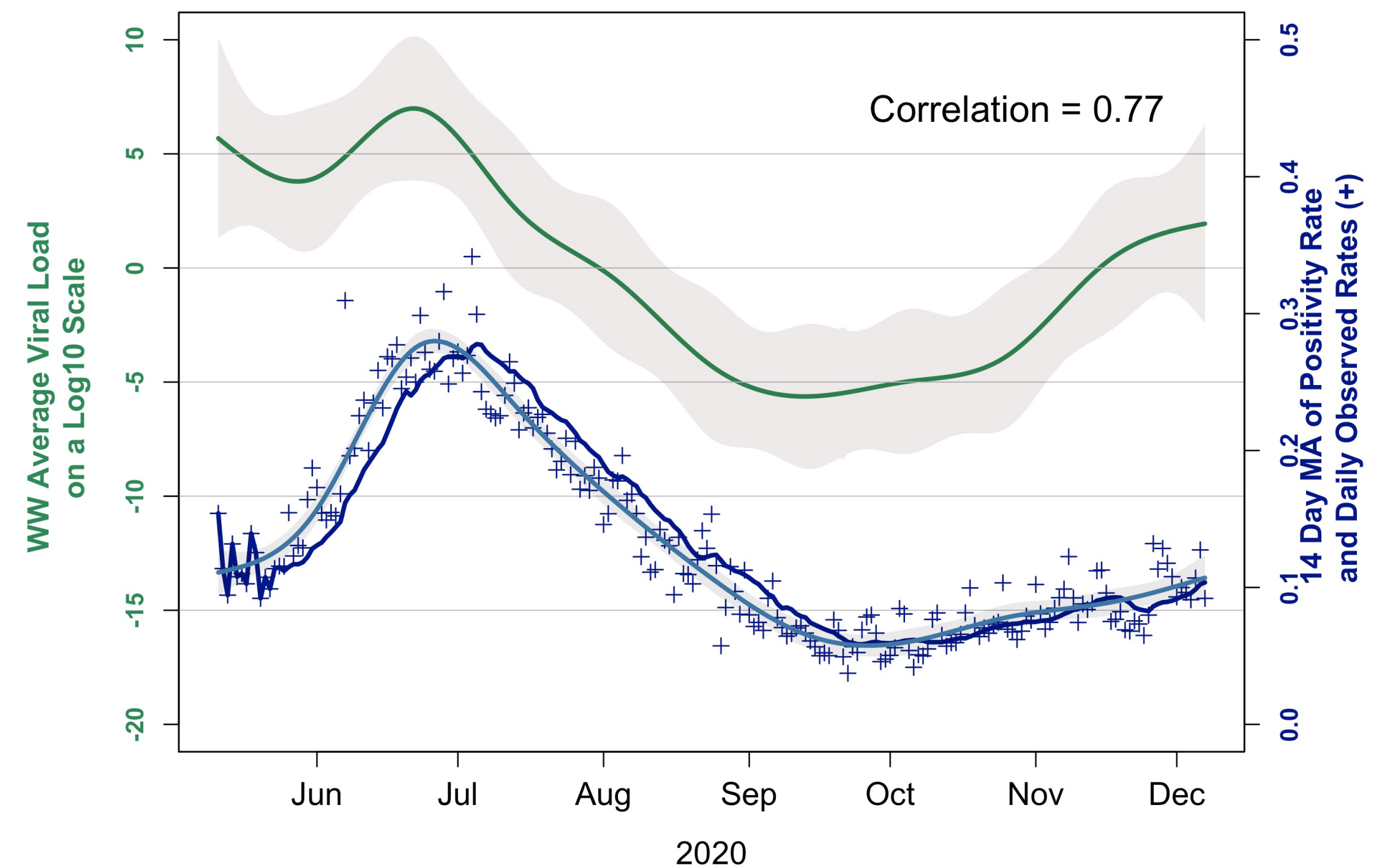
The lead time is 1 to 2 weeks.

Wastewater Treatment Plant Level

ALMEDA SIMS
9.47 MGD;
Pop. 330,126
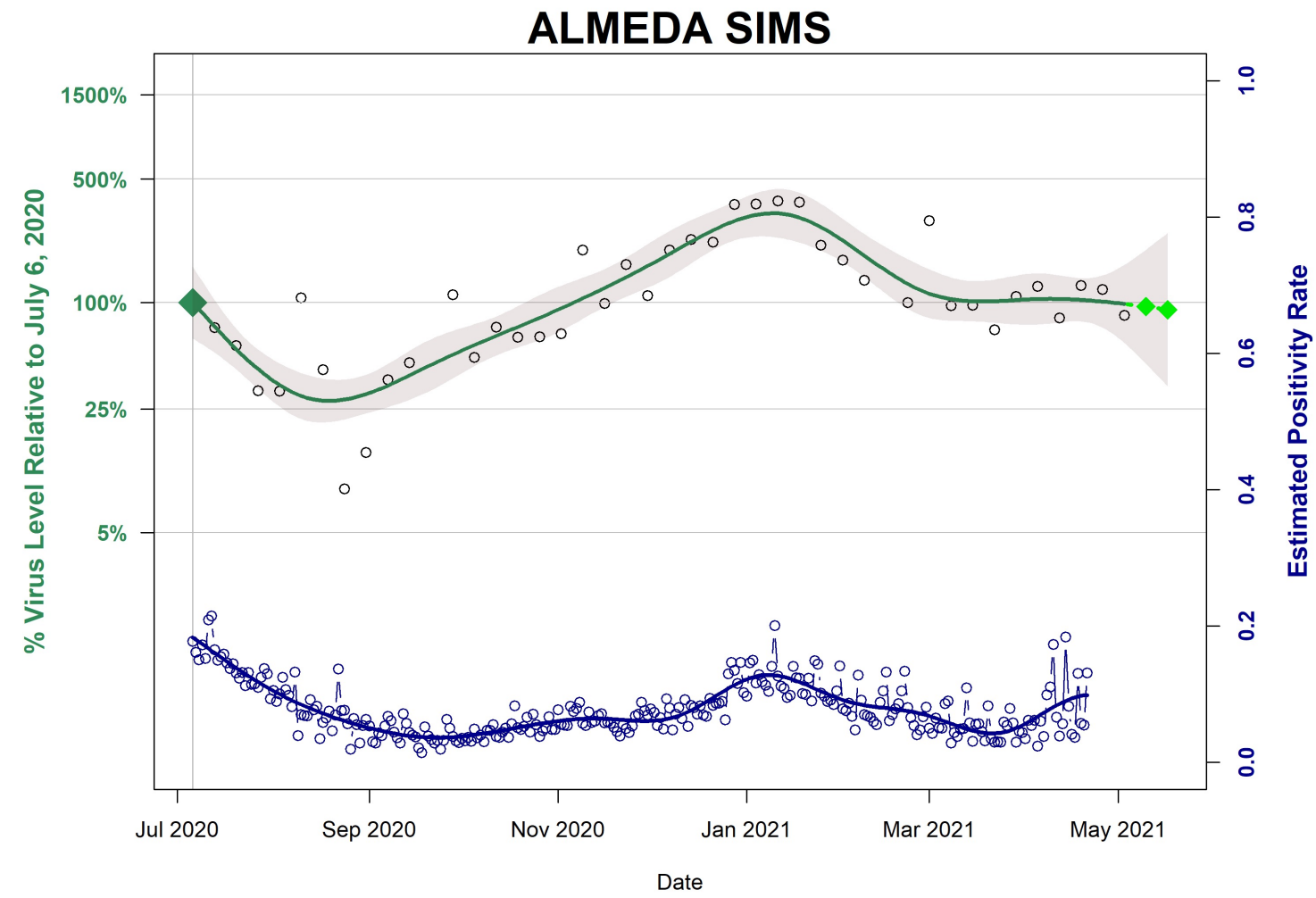
BELTWAY
5.20 MGD;
Pop. 134,557
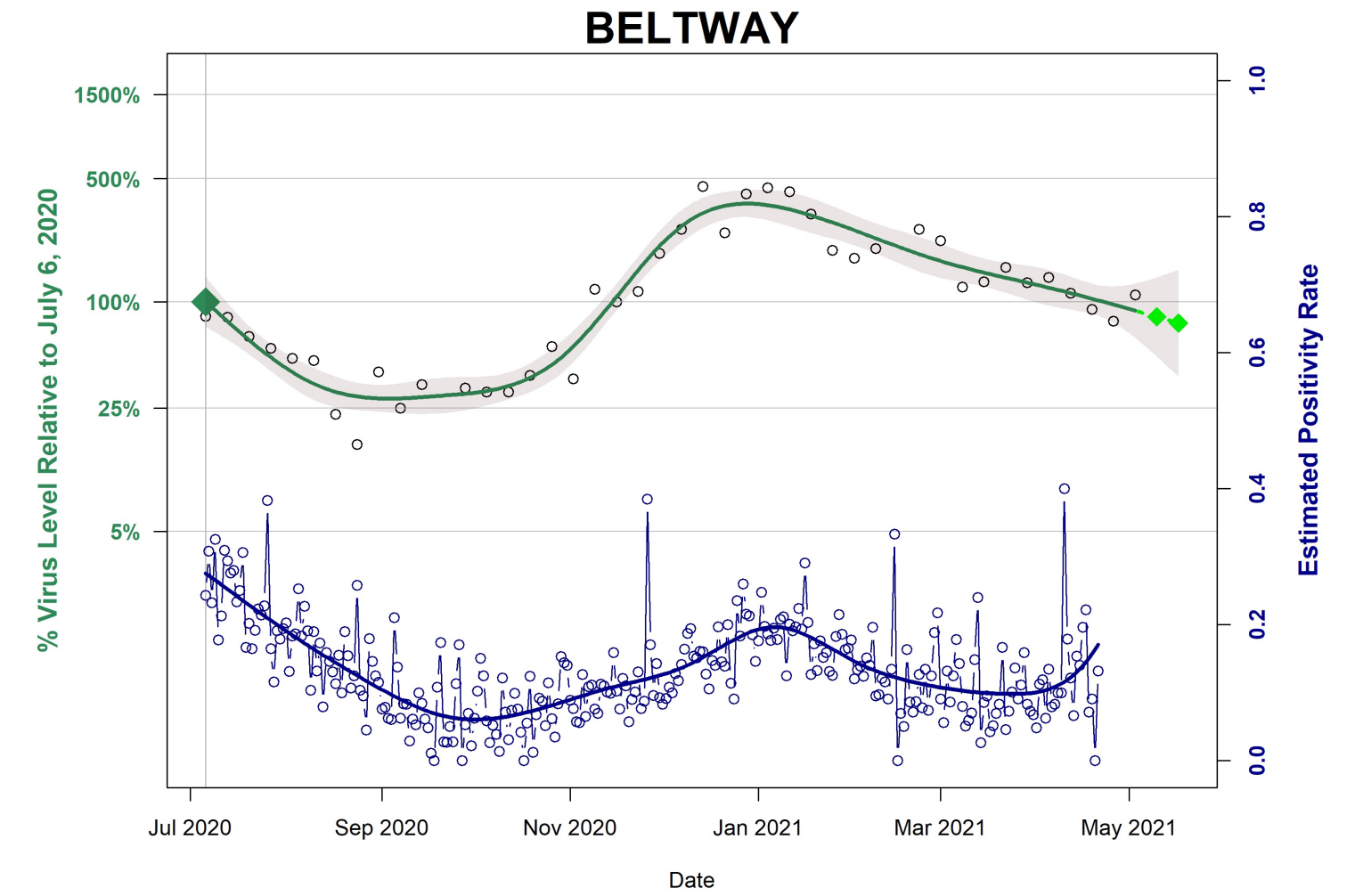
SAGEMONT
3.14 MGD;
Pop. 67,929
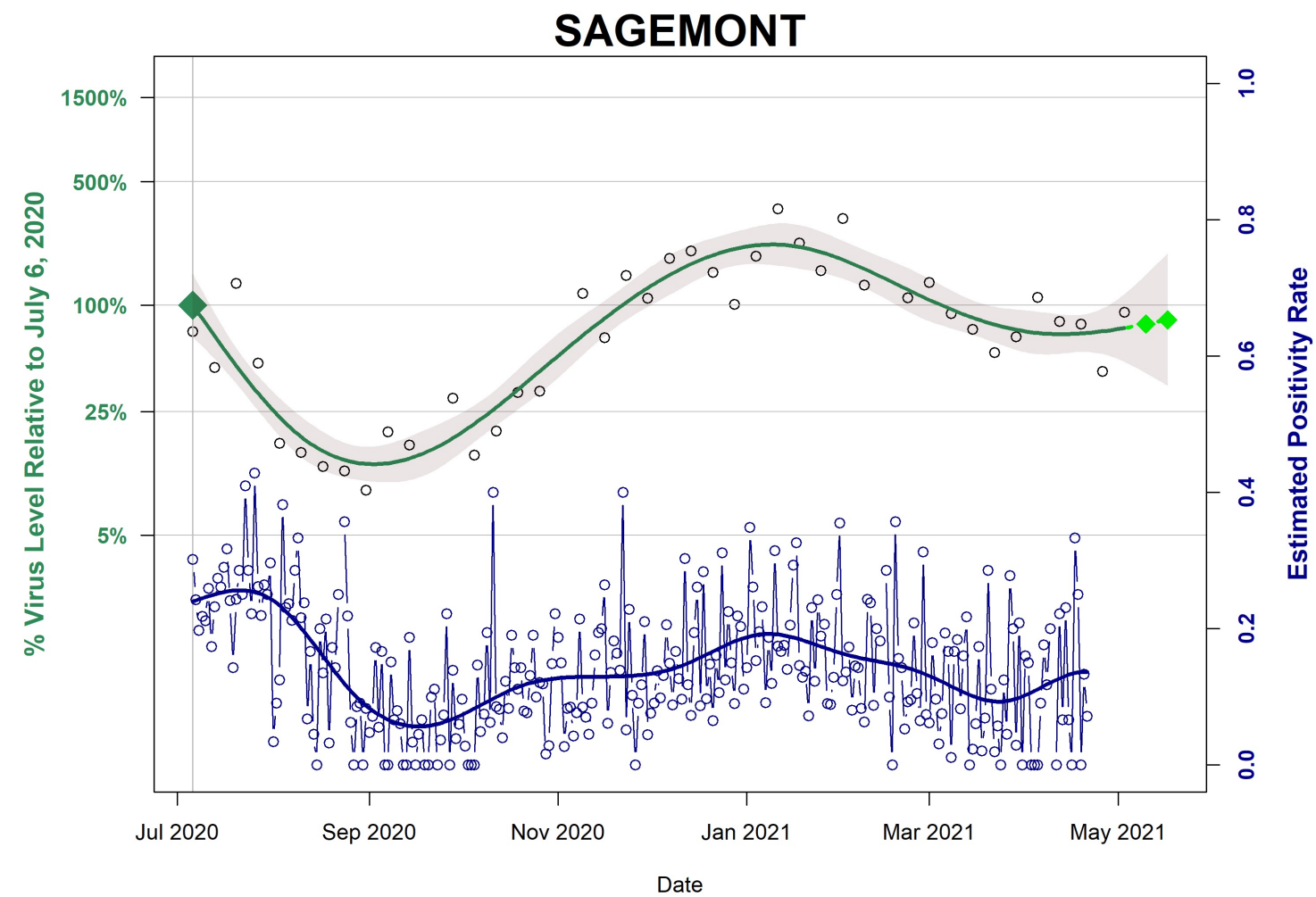
EASTHAVEN
1.18 MGD;
Pop. 46,111
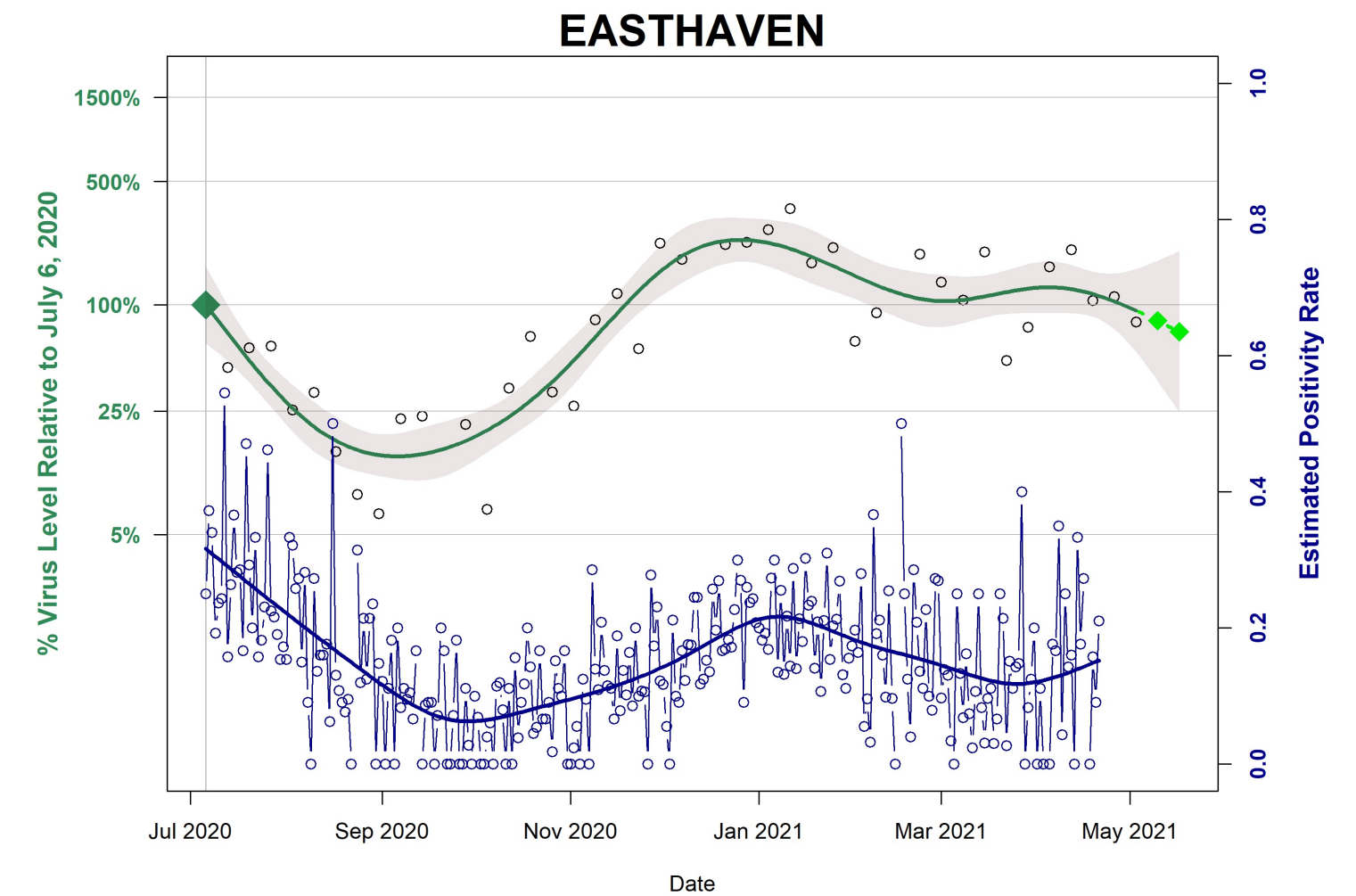
Relative Viral Load Levels at WWTPs since July 6, 2020

Percent One-Week Change in Viral Load at WWTPs since July 6, 2020

Pattern of Weekly Viral Load as a Percent of July 6, 2020 Viral Load Levels

Pattern of One Week Relative Percent Change to the Week Prior by End Date
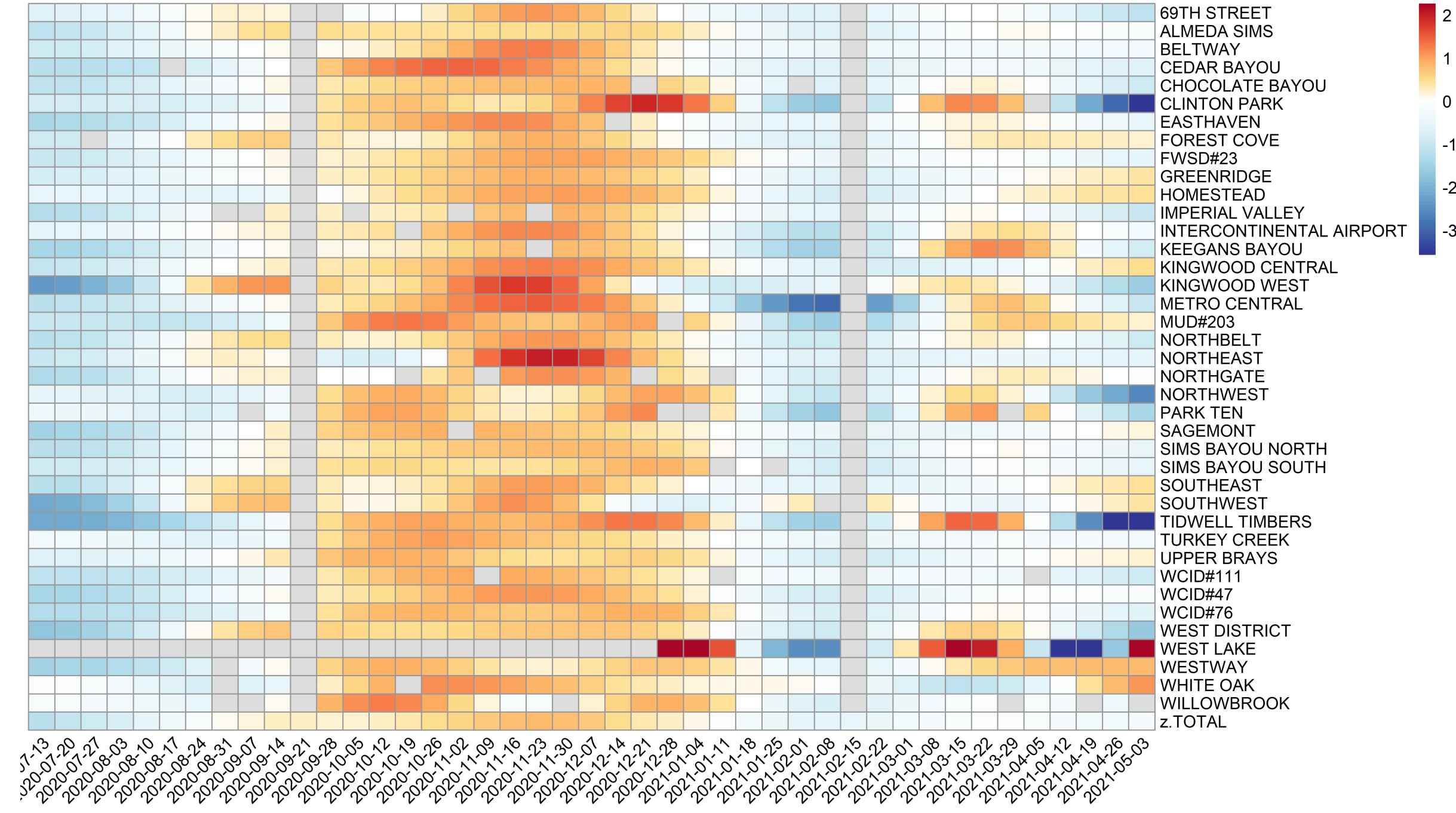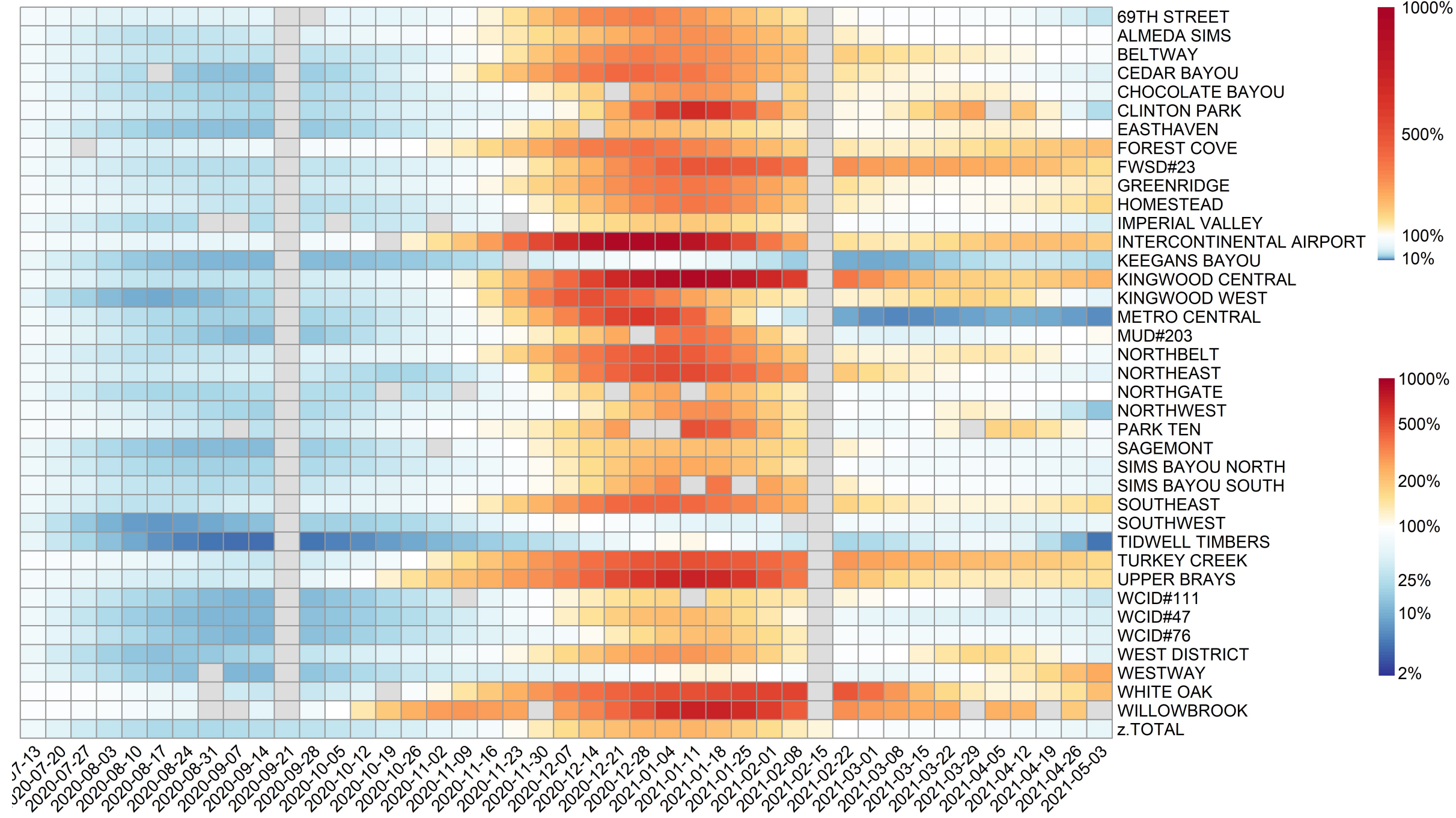
Wastewater Variant Tracking

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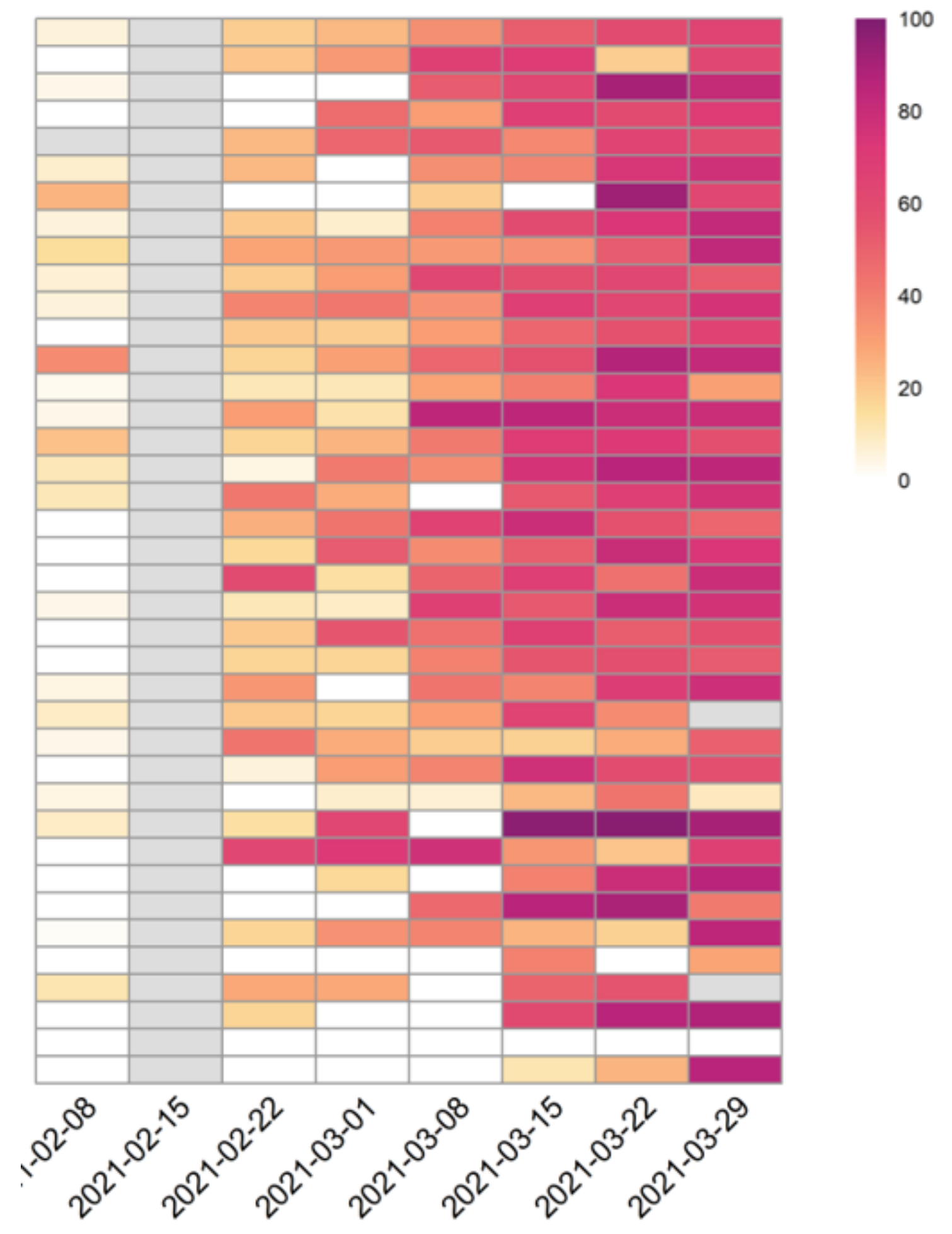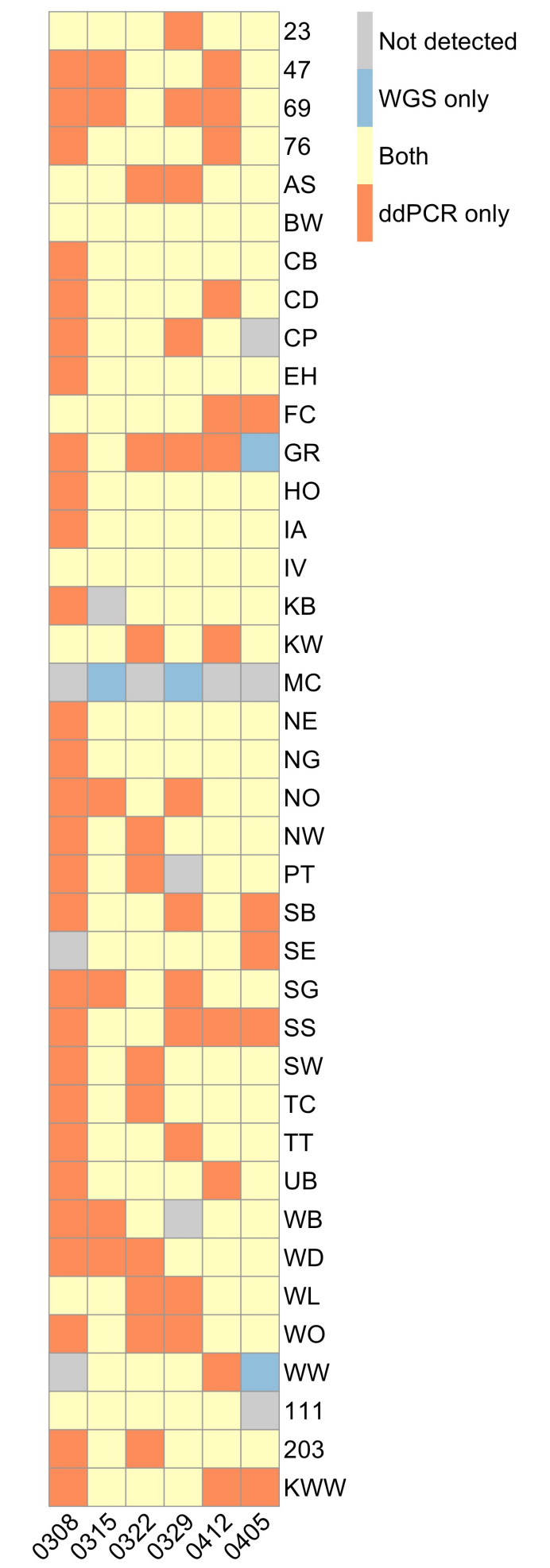
For each variant of concern (VOC) and variant of interest (VOI), there are a set of characteristic mutations that define it.

- Identified a subset of characteristic mutations as **indicative** mutations for each variant. **Indicative** mutations were defined as:
  - found in >90% of all genomes of sequenced variants
  - not found consistently (<30%) in sequenced genomes of other variants
- Also report the **total** number of characteristic mutations detected for each variant in each sample
  - Indicative mutations are a subset of the characteristic mutations.

Example: Brazil (P.1) variant

Pattern of Weekly Indicative Score of Brazil Mutation
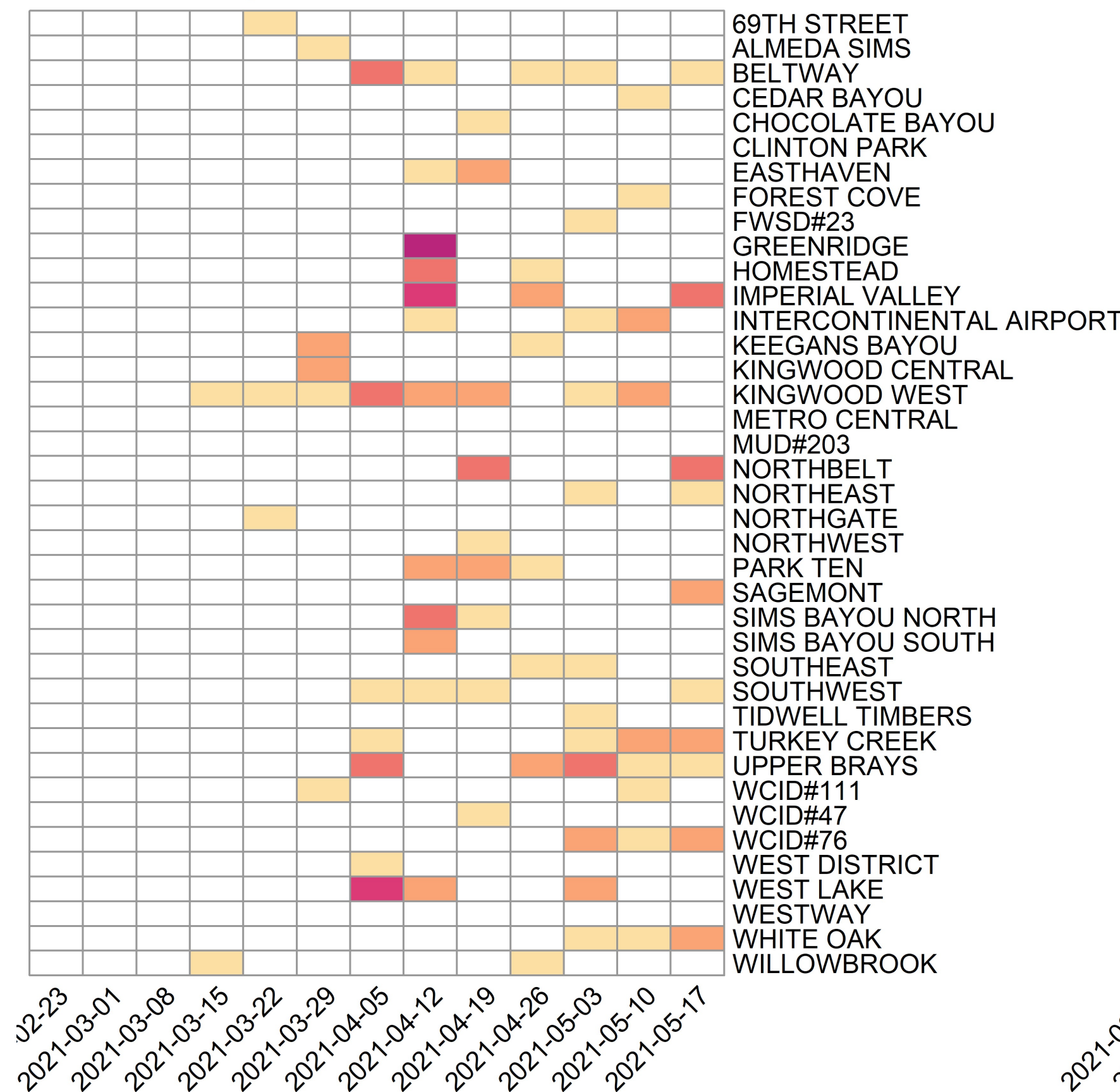
Pattern of Weekly Total Score of Brazil Mutation
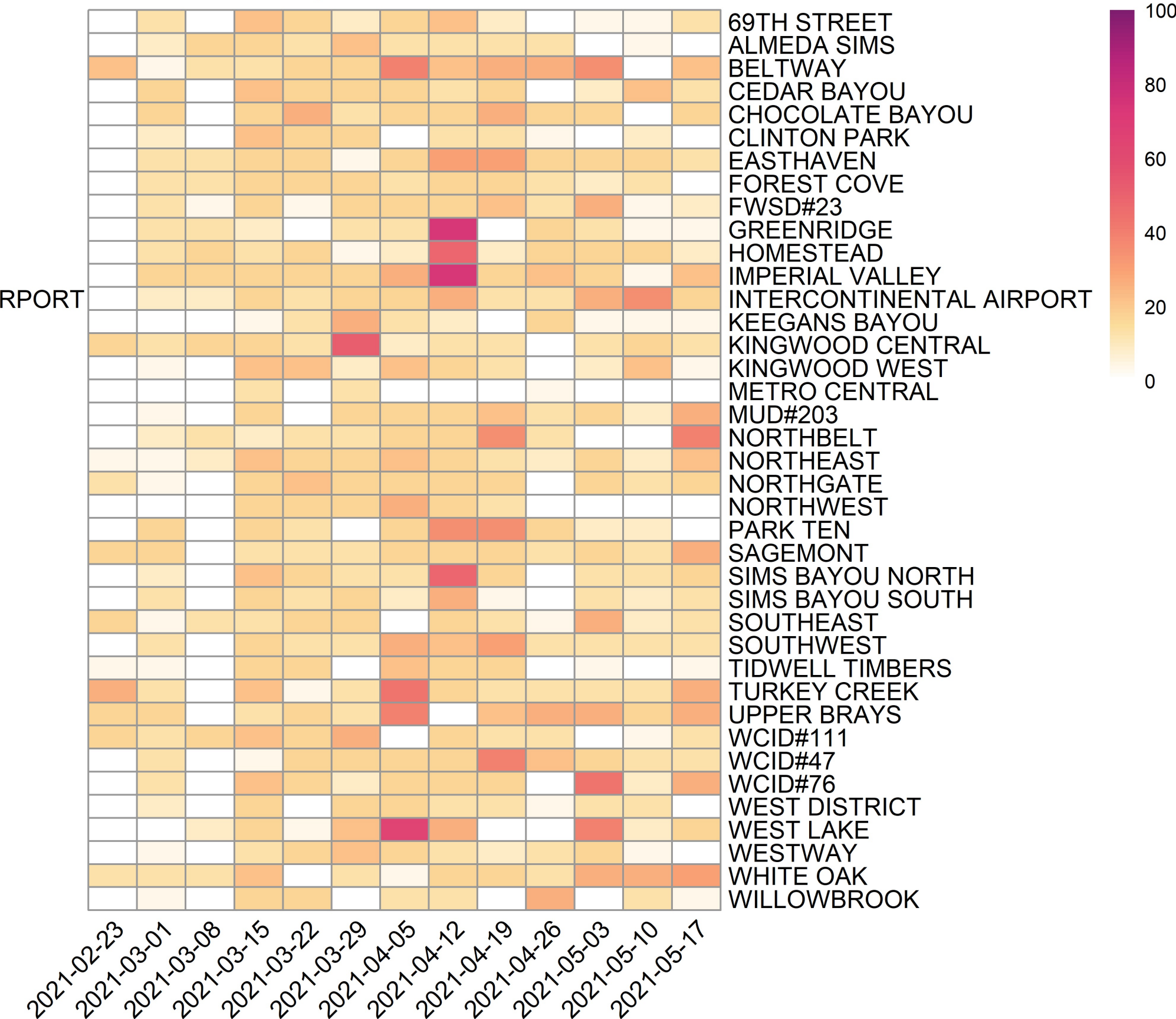
Example at the Zip Code Level

Plateauing levels at zip code

77025
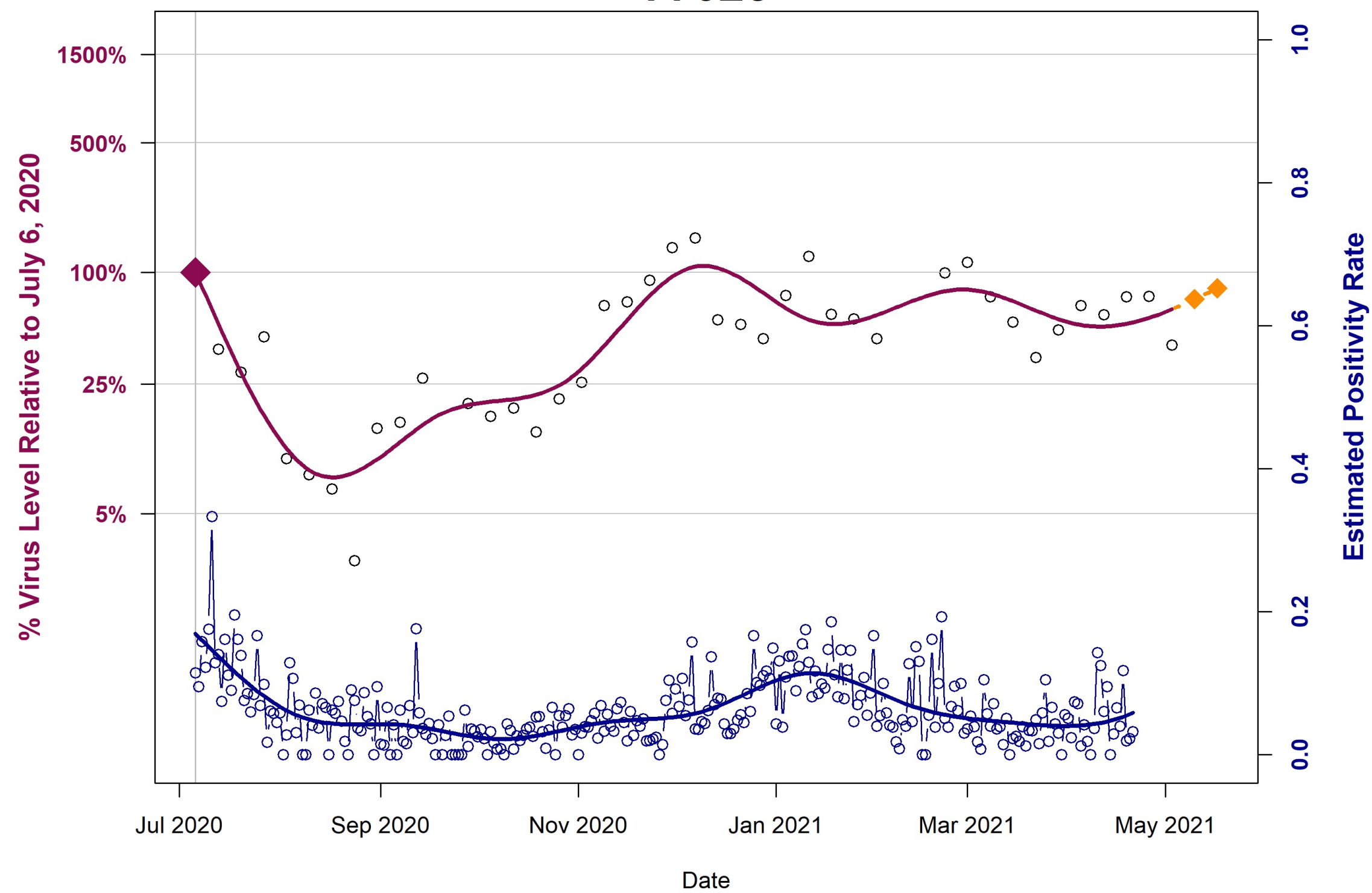
Decreasing levels at zip code

77008

Cluster Analysis

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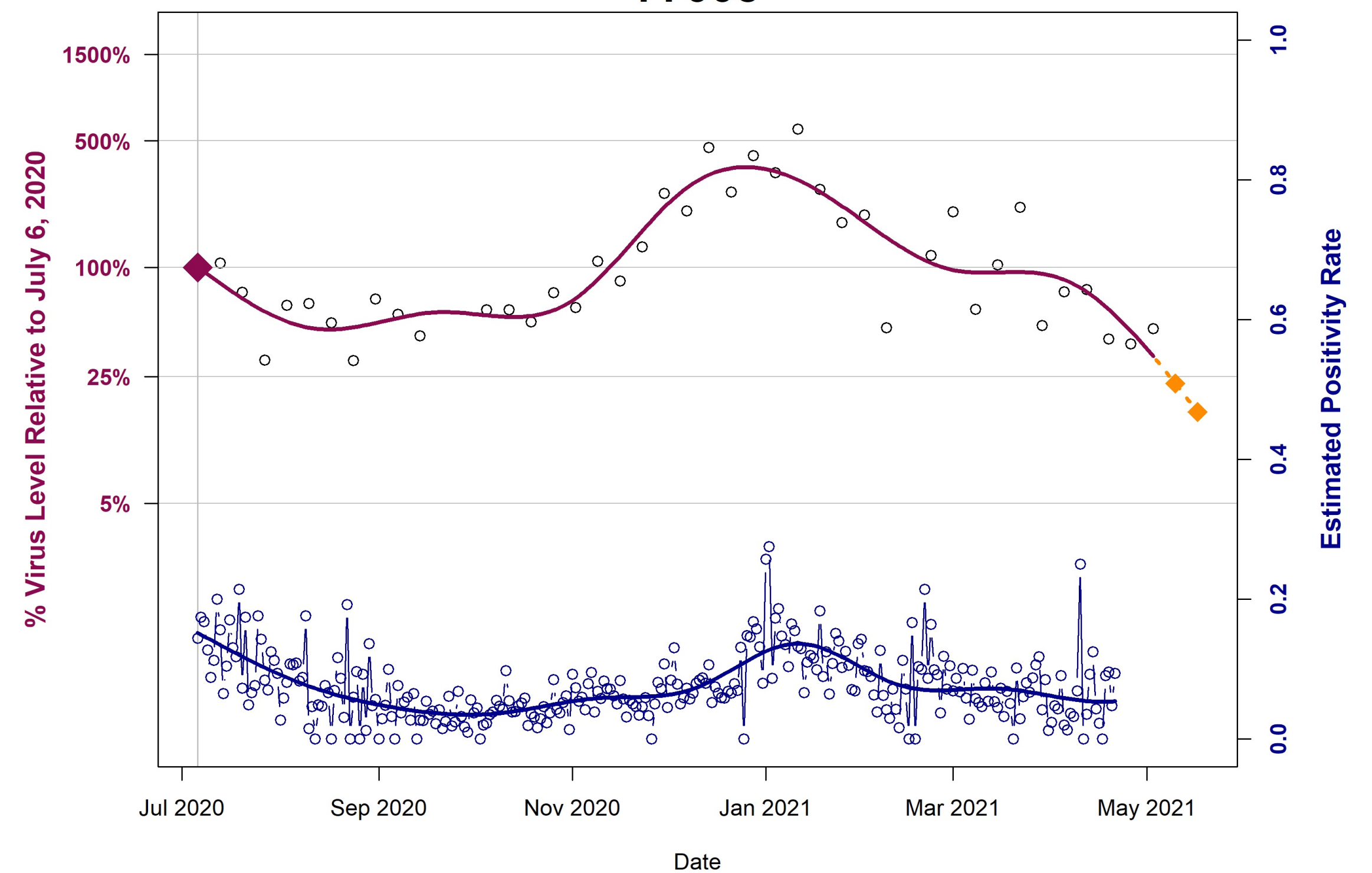
Variables included in the Cluster Analysis Report

1	Top 15 Zip Codes by Historical Positivity Rate	17	Confirmed PCR UK Variant Case Count (Zip Code)
2	Number of Times the Zip Code has Repeated	18	Estimated WWTP Trend for the Zip Code
3	Historical Positivity Rate	19	Number of Addresses - 5 or More Active Positive Cases
4	Past 5 Weeks Positivity Rate	20	List of Addresses - 5 or More Active Positive Cases
5	Historical Vaccination Rate	21	Number of Times the Address has Repeated
6	Cumulative Positive Cases	22	Overall Count of Positive Cases at the Address
7	Number of Active Positive Cases	23	Count of Active Positive Cases at the Address
8	Race Information (ACS Data)	24	Address Type
9	Percent Hispanic (ACS Data)	25	Description of Address
10	Families Below Poverty Level (ACS Data)	26	Response Actions for the Address
11	Facilities with Sensitive Sub Populations	27	Median Age of Active Cases at the Address
12	WWTP(s) Within the Zip Code	28	Minimum Age of Active Cases at the Address
13	Percent of Jul 6 20 Copies/Day (WWTP)	29	Maximum Age of Active Cases at the Address
14	Percent of UK Variant (WWTP)	30	Date of Most Recent Positive Test at the Address
15	Percent of Jul 6 20 Copies/Day (Zip Code)	31	WWTP for the Address
16	Percent of UK Variant (Zip Code)		

- Top 15 zip codes by overall positivity rate
- **Cluster** defined as an address with 10 or more cases in the past 5 weeks
- **Incorporate** wastewater surveillance findings, vaccination rates, demographic data

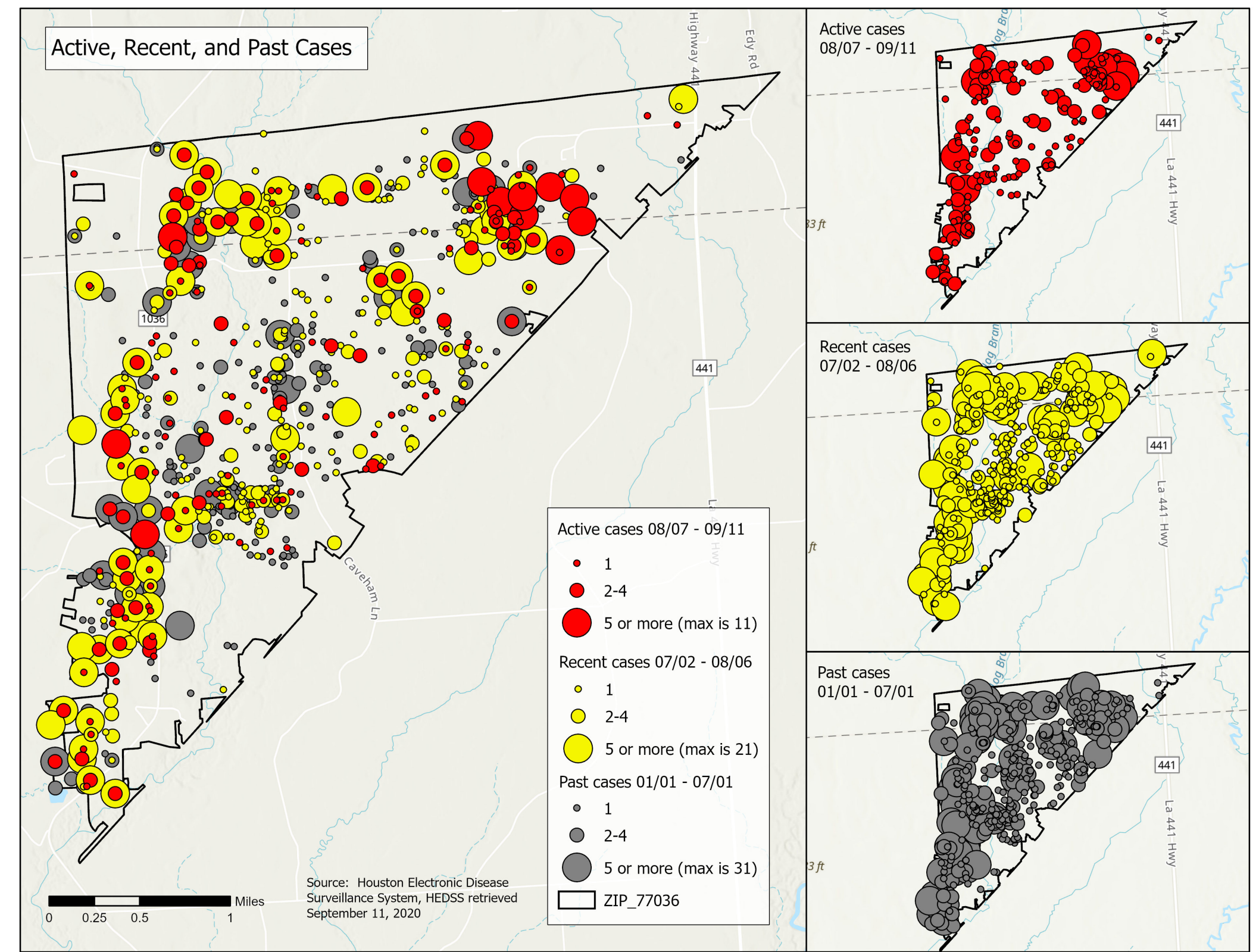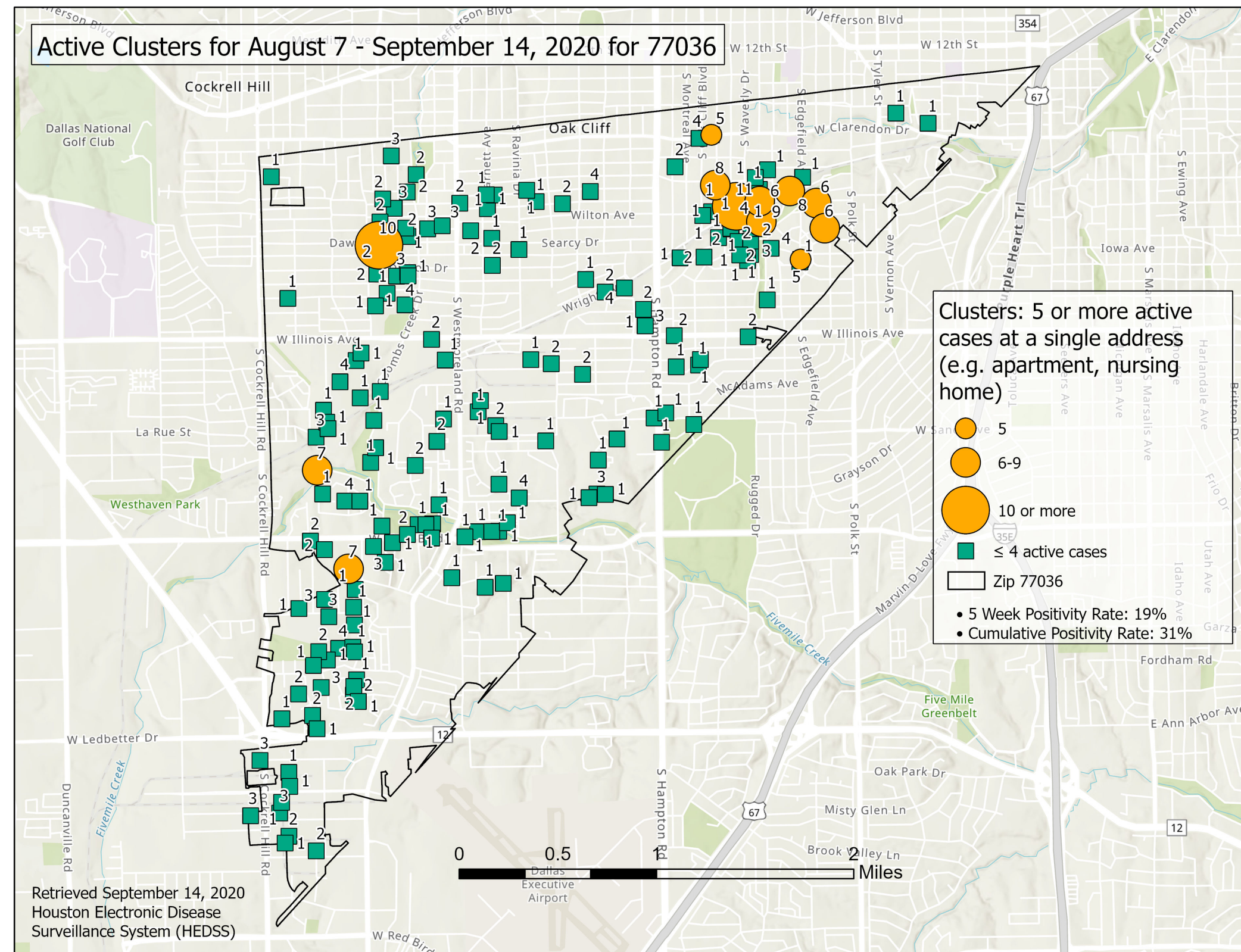| #	Top 15 Zip Codes by Historical Positivity Rate	Repeat (Count)	Zip Code Historical Positivity Rate	Zip Code Past 5 Weeks Positivity Rate	Zip Code Historical Vaccination Rate	Zip Code Historical Positive Cases	Zip Code Past 5 Weeks Active Positive Cases	Zip Code Race Information (ACS Data)	Zip Code Percent Hispanic (ACS Data)	Zip Code Families Below Poverty Level (ACS Data)	Zip Code Count of Facilities with Sensitive Sub Populations	WWTP(s) Within the Zip Code	WWTP % of Jul 6 20 Copies/Day (3/8/21 Data)	WWTP % of UK Variant (3/8/21 Data)	Zip Code % of Jul 6 20 Copies/Day (3/8/21 Data)	Estimated Wastewater Trend for the Zip Code (3/8/21 Data)	Locations in Zip Code with 5 or More Positive Cases (Past 5 Weeks)	List of Locations with 10 or More Positive Cases (Past 5 Weeks)	Repeat (Count)	Overall Count of Positive Cases at the Location	Past 5 Weeks Count of Positive Cases at the Location	Location Type	Description of Location	Response Actions	Age: Median (Past 5 Weeks)	Age: Min (Past 5 Weeks)	Age: Max (Past 5 Weeks)	Date of Most Recent Positive Test at the Location	WWTP for the location
1	77001	Repeat (21)	31.5%	17.7%	8.8%	667	40	94% White, 5% Other, 1% Black, 1% American Indian	93%	20%	0	69th Street, Imperial Valley	112% / 42%	67% / 66%	92%	Downward/Plateau	0	No Locations with 10 or More Active Positive Cases in the Past 5 Weeks										
2	77002	Repeat (21)	31.5%	22.2%	11.2%	2156	155	67% White, 30% Other, 3% Black, 1% Asian	94%	24%	0	Sims Bayou, 69th Street	77% / 112%	31% / 67%	71%	Downward/Plateau	6	1111 MAIN ST	Repeat (8)	81	10	Apartment	Complex Name 1 – 2 Story, 202 Units, $222-$2222/mo	Notification/Education	40	7	66	2/19/2021	Sims Bayou
3	77003	Repeat (21)	30.6%	21.3%	8.1%	3245	259	86% White, 7% Black, 7% Other, 1% Asian	88%	33%	1	69th Street	112%	67%	112%	Downward/Plateau	8	1112 MAIN ST	Repeat (4)	44	10	Apartment	Complex Name 2 – 2 Story, 202 Units, $222-$2222/mo	Notification/Education		2	44	2/23/2021	69th Street
4	77004	Repeat (20)																										
5	77005	Repeat (18)																										
6	77006	Repeat (16)																										3/4/2021	Sims Bayou
7	77007	Repeat (12)																										
8	77008	Repeat (20)																									3/4/2021	Sims Bayou
9	77009	Repeat (21)																									3/4/2021	Northgate
10	77010	Repeat (11)																									3/1/2021, 2/28/2021, 2/12/2021	Easthaven, WCID 47, WCID 47
11	77011	Repeat (17)																									3/3/2021	69th Street (Northside)
12	77012	Repeat (6)																									3/7/2021, 2/20/2021, 3/5/2021	Northeast, Northeast, Northeast
13	77013	Repeat (1)																									
14	77014	Repeat (5)																									
15	77015	Repeat (21)																									2/27/2021, 3/5/2021, 3/4/2021, 3/2/2021	Keegans Bayou, Southwest, Beltway, Keegans Bayou

Zoomed detail:

Zip Code Count of Facilities with Sensitive Sub Populations	WWTP(s) Within the Zip Code	WWTP % of Jul 6 20 Copies/Day (3/8/21 Data)	WWTP % of UK Variant (3/8/21 Data)	Zip Code % of Jul 6 20 Copies/Day (3/8/21 Data)	Estimated Wastewater Trend for the Zip Code (3/8/21 Data)	Locations in Zip Code with 5 or More Positive Cases (Past 5 Weeks)	List of Locations with 10 or More Positive Cases (Past 5 Weeks)	Repeat (Count)	Overall Count of Positive Cases at the Location	Past 5 Weeks Count of Positive Cases at the Location	Location Type
0	69th Street / Imperial Valley	112% / 42%	67% / 66%	92%	Downward/Plateau	0	No Locations with 10 or More Active Positive Cases in the Past 5 Weeks				
0	Sims Bayou / 69th Street	77% / 112%	31% / 67%	71%	Downward/Plateau	6	1111 MAIN ST	Repeat (8)	81	10	Apartment
1	69th Street	112%	67%	112%	Downward/Plateau	8	1112 MAIN ST	Repeat (4)	44	10	Apartment
2	69th Street	112%	67%	113%	Downward/Plateau	2	Locations Identified with 5 or More Active Positive Cases in the Past 5 Weeks Were Single Family Homes				
1	MUD#203 / Imperial Valley	20% / 42%	0% / 66%	23%	Downward	0	No Locations with 10 or More Active Positive Cases in the Past 5 Weeks				

Simulated data and addresses

Examples of Maps from Cluster Report

Maps represent simulated, de-identified data

Zip Code Tracking

Top 15 Zip Codes

Each week corresponds to a cluster report and reflects the ranking, by overall positivity, of the top 15 zip codes for that week

rank	1-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	3-Sep	15-Sep	27-Sep	12-Oct	27-Oct	9-Nov	22-Nov	5-Dec	18-Dec	31-Dec	13-Jan	26-Jan	12-Feb	26-Feb	11-Mar	25-Mar	8-Apr	22-Apr	6-May	20-May
1	77036	77037	77037	77037	77083	77083	77083	77060	77012	77012	77012	77012	77012	77037	77037	77012	77037	77037	77037	77037	77037	77037	77012	77012	77012	77037	77012
2	77060	77060	77060	77060	77039	77060	77012	77038	77060	77037	77037	77037	77037	77012	77012	77037	77012	77012	77012	77012	77012	77012	77037	77037	77037	77012	77037
3	77002	77036	77087	77087	77060	77087	77060	77037	77037	77060	77060	77083	77093	77083	77083	77093	77076	77076	77076	77076	77076	77076	77076	77076	77076	77076	77076
4	77081	77081	77036	77012	77037	77012	77087	77012	77036	77083	77083	77093	77083	77093	77087	77076	77093	77038	77093	77038	77038	77093	77093	77093	77093	77093	77093
5	77067	77012	77012	77081	77087	77037	77037	77083	77083	77093	77093	77060	77060	77087	77093	77087	77038	77093	77060	77093	77093	77038	77038	77038	77017	77017	77017
6	77072	77076	77076	77036	77012	77093	77093	77093	77093	77076	77076	77076	77076	77060	77076	77083	77087	77060	77038	77017	77017	77017	77017	77087	77087	77087	77087
7	77076	77039	77083	77076	77093	77081	77081	77087	77076	77087	77087	77036	77087	77076	77060	77060	77060	77087	77087	77060	77087	77015	77087	77087	77038	77038	77038
8	77037	77028	77081	77477	77081	77036	77076	77076	77087	77036	77036	77087	77036	77036	77038	77017	77017	77017	77015	77087	77015	77087	77015	77060	77060	77060	77015
9	77099	77087	77093	77053	77036	77076	77036	77036	77081	77038	77038	77017	77017	77017	77017	77038	77083	77083	77017	77015	77060	77060	77060	77015	77015	77015	77060
10	77028	77072	77038	77093	77038	77038	77011	77053	77011	77081	77017	77011	77011	77038	77036	77011	77011	77015	77083	77011	77034	77034	77034	77034	77034	77034	77034
11	77012	77099	77014	77039	77076	77011	77038	77081	77017	77011	77011	77081	77081	77011	77015	77036	77015	77011	77011	77034	77011	77011	77083	77013	77013	77013	77013
12	77080	77067	77028	77028	77053	77017	77014	77023	77038	77017	77081	77015	77015	77081	77011	77015	77036	77034	77034	77023	77013	77013	77011	77011	77085	77011	77011
13	77031	77078	77002	77078	77504	77099	77099	77017	77053	77015	77015	77034	77034	77015	77034	77034	77034	77036	77036	77013	77023	77085	77013	77083	77011	77085	77085
14	77039	77093	77078	77011	77011	77072	77017	77049	77072	77061	77034	77038	77038	77034	77081	77053	77013	77013	77013	77036	77036	77023	77085	77085	77083	77083	77083
15	77074	77074	77072	77099	77078	77014	77078	77067	77078	77072	77053	77078	77061	77061	77061	77013	77061	77023	77023	77083	77085	77036	77023	77023	77023	77023	77023

Wastewater Surveillance **Manhole** Report

- **Designate** sites as:

  High Positive

  Lower Positive

  Unclear

  Negative

- **Identify** spikes or increases in wastewater viral load

Wastewater Surveillance at Schools and Congregate Living

Wastewater Surveillance **Manhole** Report

High Positives (7) total
Nursing Home 1 [4]++
School 1 [3] ++
School 2 [1] ++
School 3 [2] ++
School 4 [0] ++
School 5 [3] ++
School 6 [1] ++

Lower Positives (4) total
School 7 [0] +
School 8 [1] +
School 9 [0] +
School 10 [1] +

Unclears (6) total
Jail 1
Nursing Home 2
School 11
School 12
School 13
Shelter 2

Negatives (50) total
Jail 2
Nursing Home 3
Nursing Home 4
Nursing Home 5

Negatives (50) total cont.
Nursing Home 6
Nursing Home 7
Nursing Home 8
Nursing Home 9
Shelter 3
Shelter 4
Shelter 5
Shelter 6
Shelter 7
Shelter 8
Shelter 9
Shelter 10
Shelter 11
School 14
School 15
School 16
School 17
School 18
School 19
School 20
School 21
School 22
School 23
School 24
School 25
School 26
School 27

Negatives (50) total cont.
School 28
School 29
School 30
School 31
School 32
School 33
School 34
School 35
School 36
School 37
School 38
School 39
School 40
School 41
School 42
School 43
School 44
School 45
School 46
School 47

[#] signifies the number of weeks in a row a location tested positive from manhole wastewater samples

++ signifies high levels of >10,000 copies/L; + signifies lower levels <10,000 copies/L

Data Collected: 4/26/2021

Wastewater Surveillance at Schools

School Name and Wastewater Sample results	# Cases Reported by School Since 4/26/21	# of PCR / Confirmed Cases since 4/26/21	Last Assessment	Compliant with School Check List (Yes/No)	Outbreak? (Yes/No)
Elementary 1 [3] ++	0	0	12/2/2020	Yes	No
Elementary 2 [1] ++	1	0	12/4/2020	Yes	No
Elementary 3 [2] ++	0	0	12/4/2020	Yes	No
Early Childhood 1 [0] ++	0	0	12/2/2020	Yes	No
Middle 1 [3] ++	2	1	12/7/2020	Yes	No
High School 1 [1] ++	1	1	12/7/2020	Yes	No

[#] signifies the number of weeks in a row a location tested positive from manhole wastewater samples
++ signifies high levels of >10,000 copies/L; + signifies lower levels <10,000 copies/L

Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Schools Team working in conjunction with Wastewater Surveillance Team
- Notify school district superintendent and school principal of wastewater results
- Notify HISD Nurse liaison of wastewater results
- Maintain active outreach with school for **10 days or until wastewater is negative**
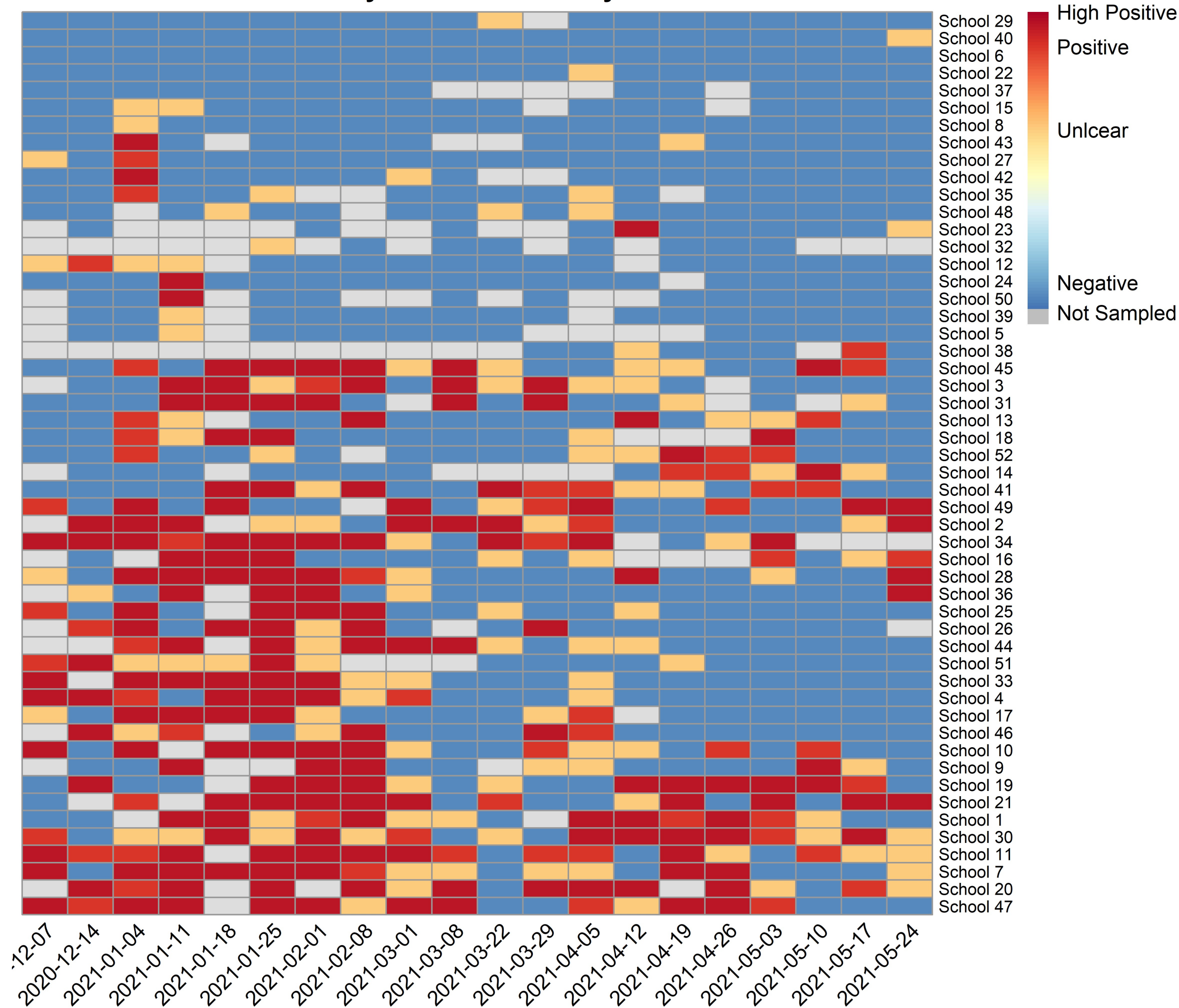
Pattern of Weekly Wastewater Analysis of Schools

Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Schools Team working in conjunction with Wastewater Surveillance Team

- Notify school district superintendent and school principal of wastewater results

- Maintain active outreach with school for **10 days or until wastewater is negative**

Wastewater Surveillance at Congregate Living

Facility Name and WW Sample results	Last Clinical Testing at Facility	# of PCR / Confirmed Cases Since 2/1/21	Last Assessment	Compliant (Yes/No)	Vaccination Date	# of consecutive weeks of positive results (staff/residents)
Jail, Jail 1 [3] ++	2/10/2021	680	n/a	Yes	-	Since May 2020
NH, Nursing Home 1 [9] ++	2/8/2021	0	1/22/2021	Yes	1/8/2021 2/1/2021	Last case was on 1/13/2021
NH, Nursing Home 2 [3] ++	2/8/2021	0	1/22/2021	Yes	1/4/2021	6 weeks Last case was on 1/28/2021
NH, Nursing Home 3 [2] ++	2/4/2021	5	1/20/2021	Yes	1/19/2021 1st dose	3
NH, Nursing Home 4 [11] ++	2/8/2021	0	01/25/2021	Yes	01/06/2021 01/27/2021	0
Shelter, Shelter 1 [0] ++	5/28/2020	0	05/20/2020	Yes	-	0
NH, Nursing Home 5 [1] +	1/26/2021	0	1/29/21	Yes	1/5/21 1/26/21	Last case 1/25/2021

[#] signifies the number of weeks in a row a location tested positive from manhole wastewater samples
++ signifies high levels of >10,000 copies/L; + signifies lower levels <10,000 copies/L

Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Team working in conjunction with Wastewater Surveillance Team
- Notify facility director of wastewater results and confirm if a new active outbreak
  - If new outbreak, conduct onsite assessment and facility testing with mobile testing unit

Pattern of Weekly Wastewater Analysis of Shelters

Pattern of Weekly Wastewater Analysis of Nursing Homes

Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Team working in conjunction with Wastewater Surveillance Team

- Notify facility director of wastewater results and **confirm if a new active outbreak**

  – If new outbreak, conduct onsite assessment and facility testing with mobile testing unit

Questions?