

Recovery After Houston's Hurricane Harvey & the Future of Resiliency in Houston

GIS-Based Tool Prioritizes Critical Stormwater Areas

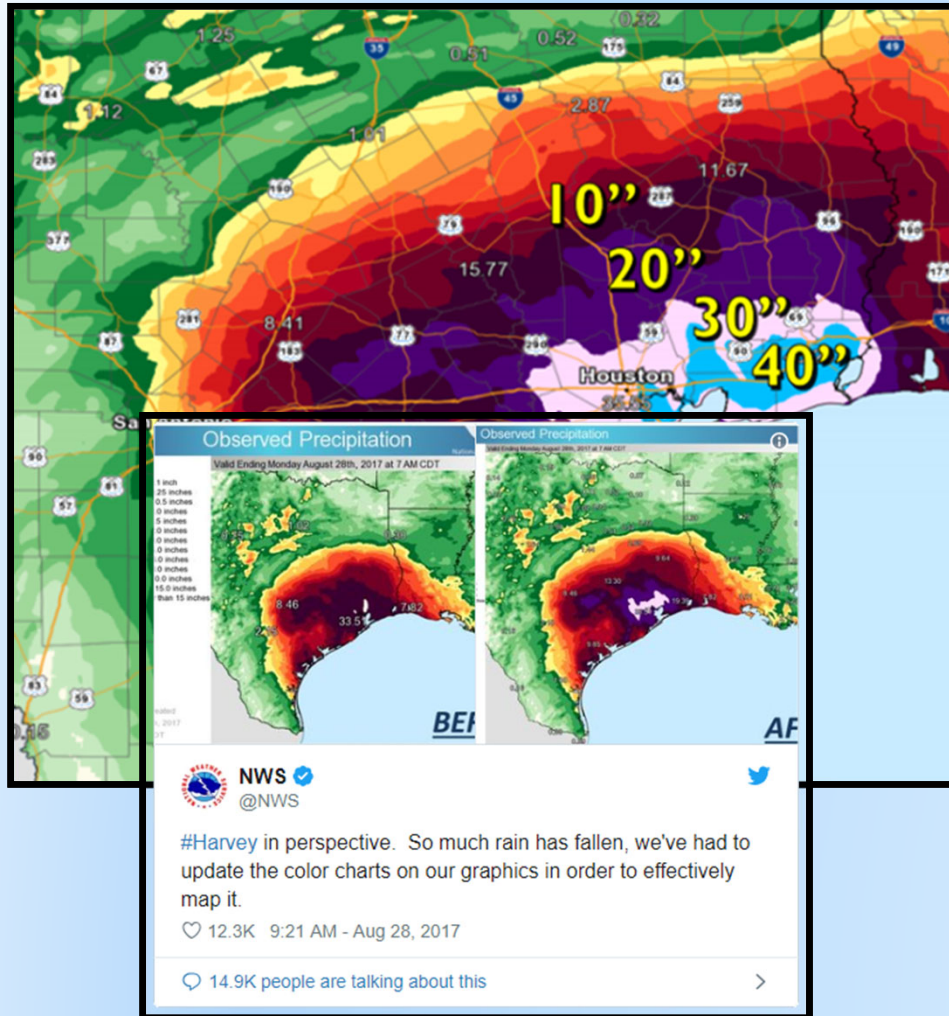
Eric Harold, PE, BCEE
Phil Bullock, PE

December 11, 2019

WATER
OUR FOCUS
OUR BUSINESS
OUR PASSION



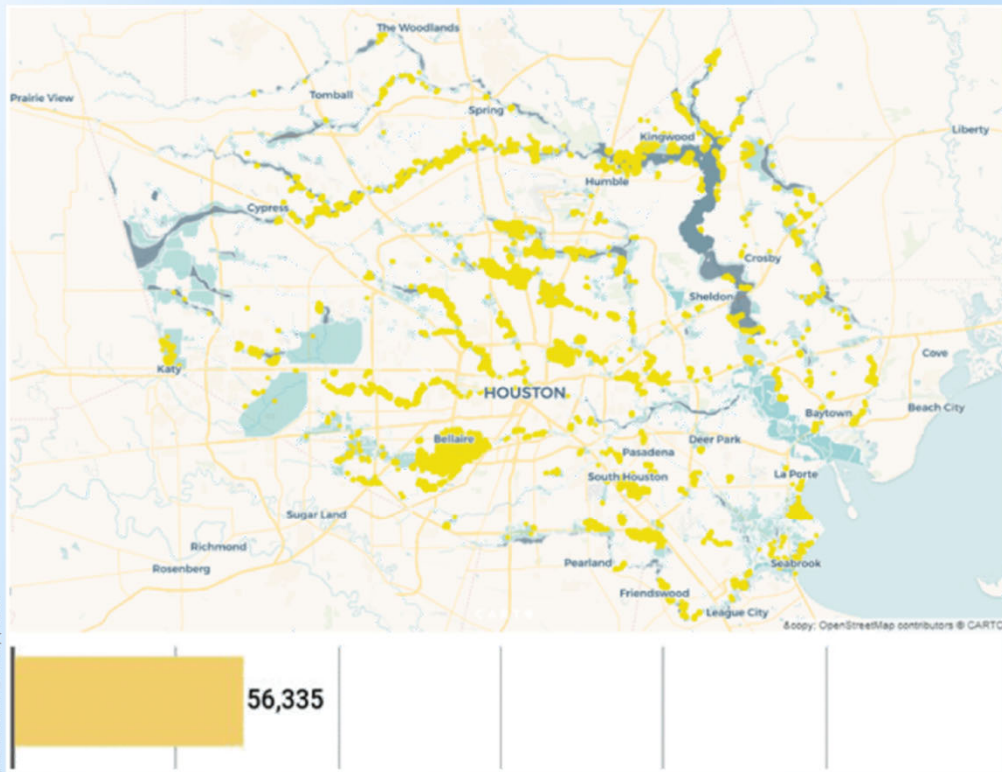
Hurricane Harvey



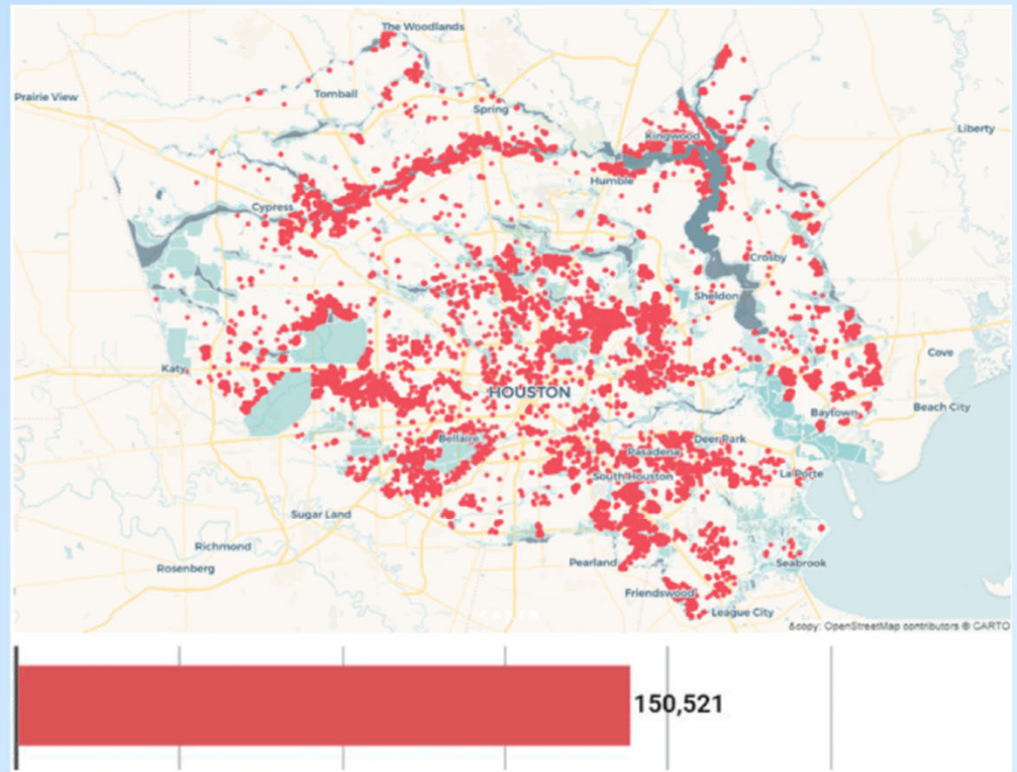
- **125 million** — Dollars in damage by the storm
- **300,000** — Structures flooded in the region
- **500,000** — Cars flooded in the region
- **60.58** — Inches of rain that fell in Nederland
- **2** — New colors added to the NWS rainfall chart because of the epic rainfall

Most Flooding was Localized Street Flooding

Flooded Structures inside 100-yr floodplain



Flooded Structures outside 100-yr floodplain



Document
Flooding Issues?

Evaluate Existing
Stormwater Infrastructure?

Establish Evacuation
Routes?

Propose Resiliency
Measures?

Infrastructure
Resiliency?

Address Operations and
Maintenance of Stormwater
Facilities?

Educate the
Public?

What Does a Stormwater Master Plan Do?

Address Water
Quality Concerns?

Propose Solutions to
Flooding Problems

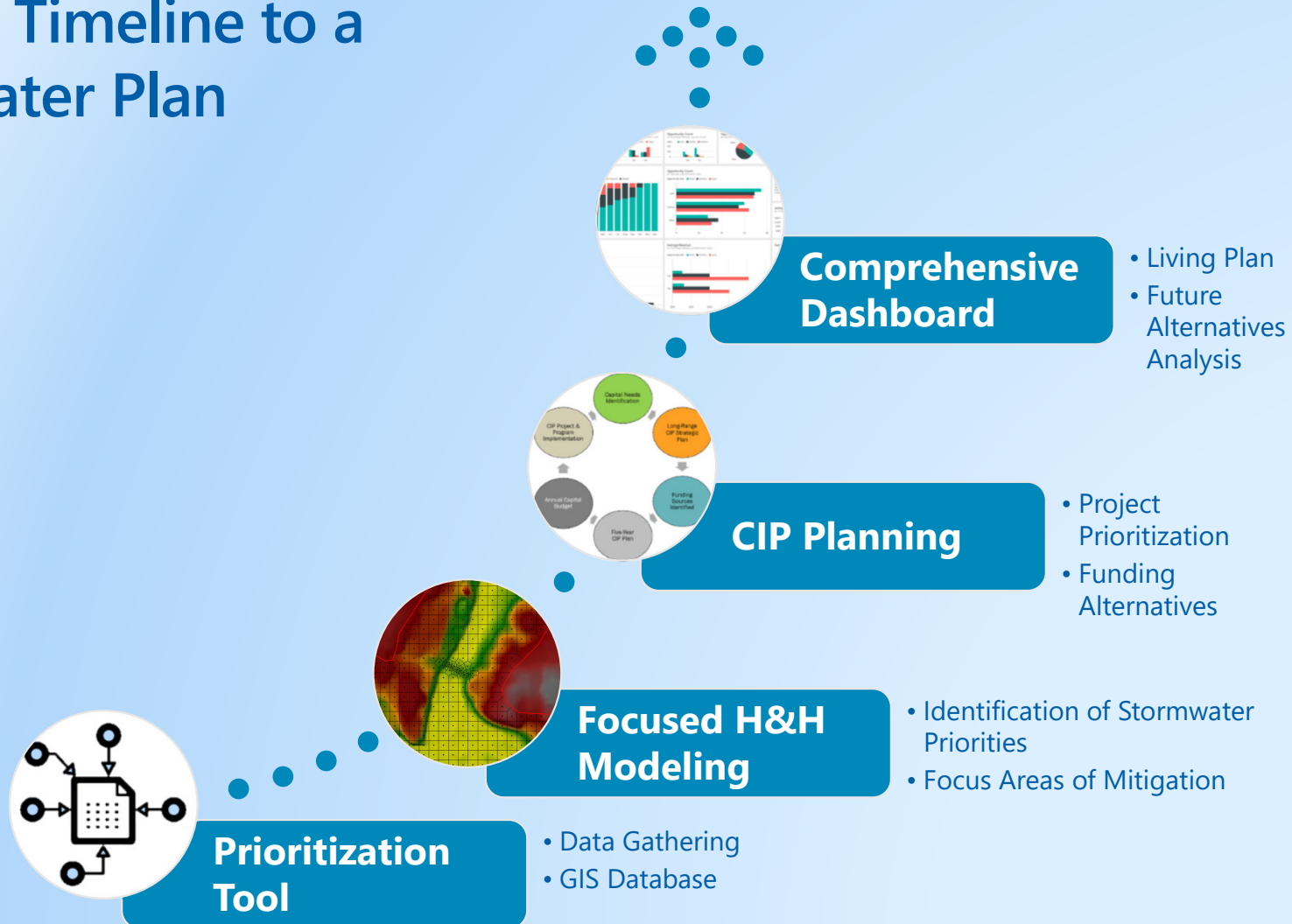
Develop Funding
Options?

Start a
Stormwater
Utility?

Propose
Development
Regulations?

Develop Costs for Flooding
Mitigation Alternatives

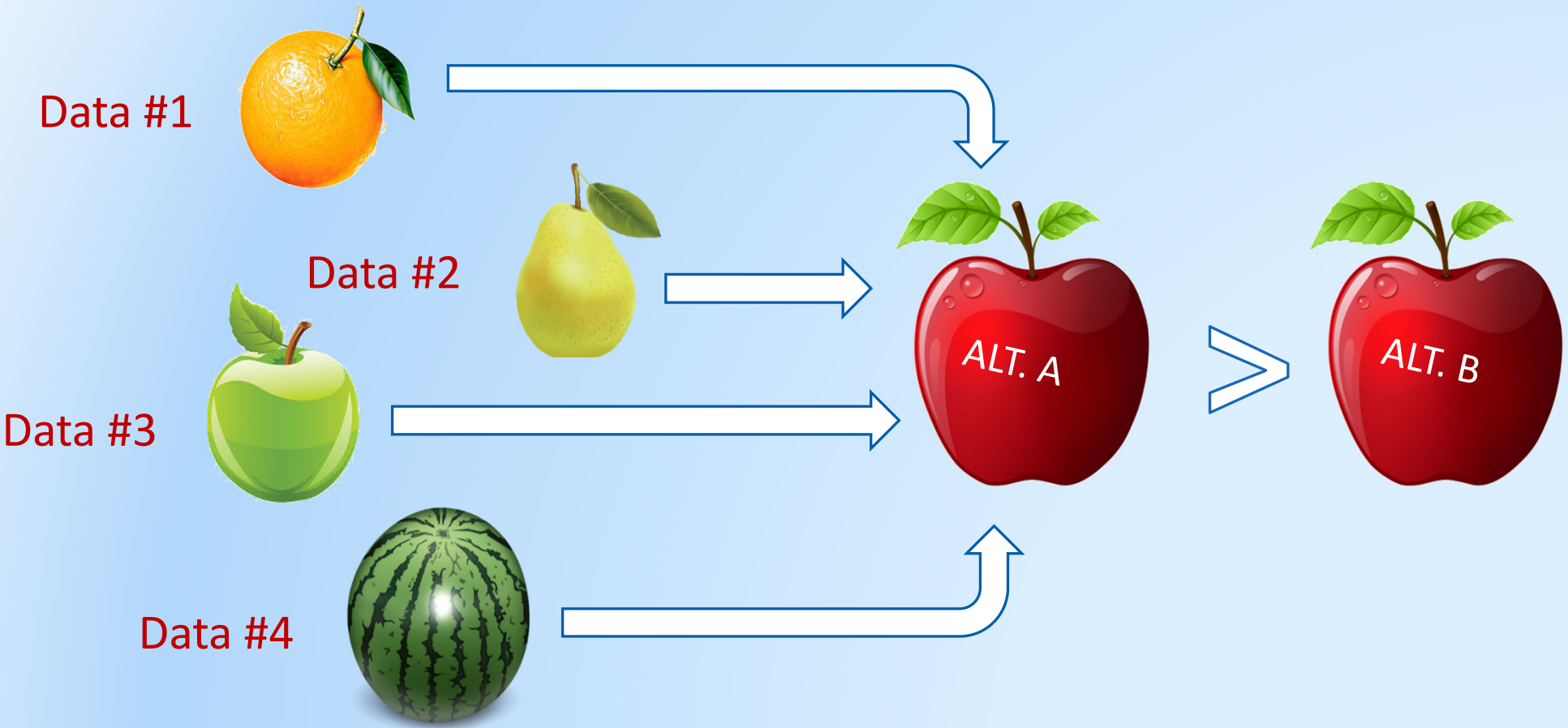
Possible Timeline to a Stormwater Plan





Prioritization Tool (SWEET)

Stormwater Evaluation Enhancement Tool (SWEET)



Approach for SWEET Tool



Data Needs

311 Structural Flooding

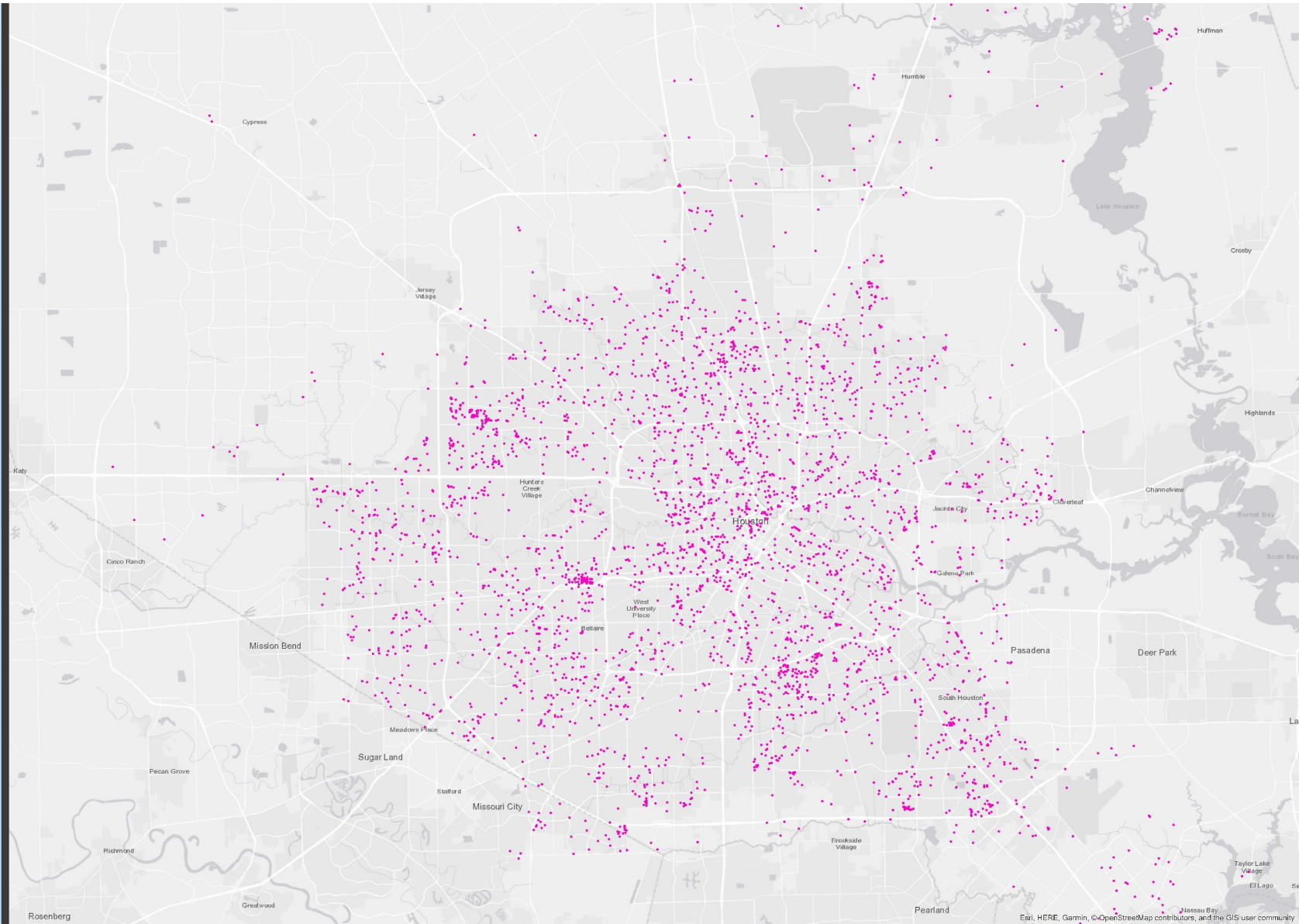
FEMA Structural Flooding

Flooded (Impassable) Streets

Ponding Areas

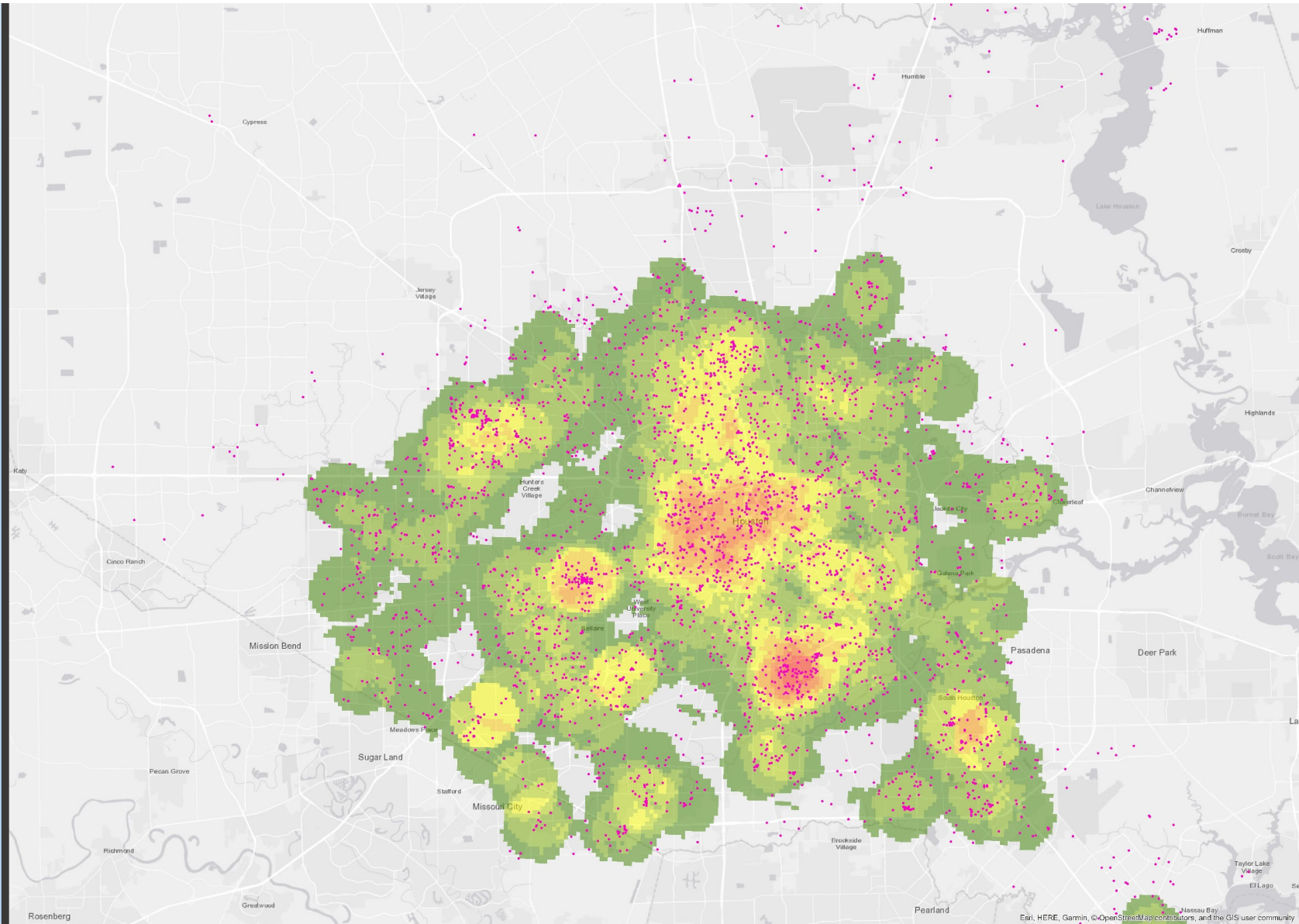
Design Event Adequacy

311 Structural Flooding Reports



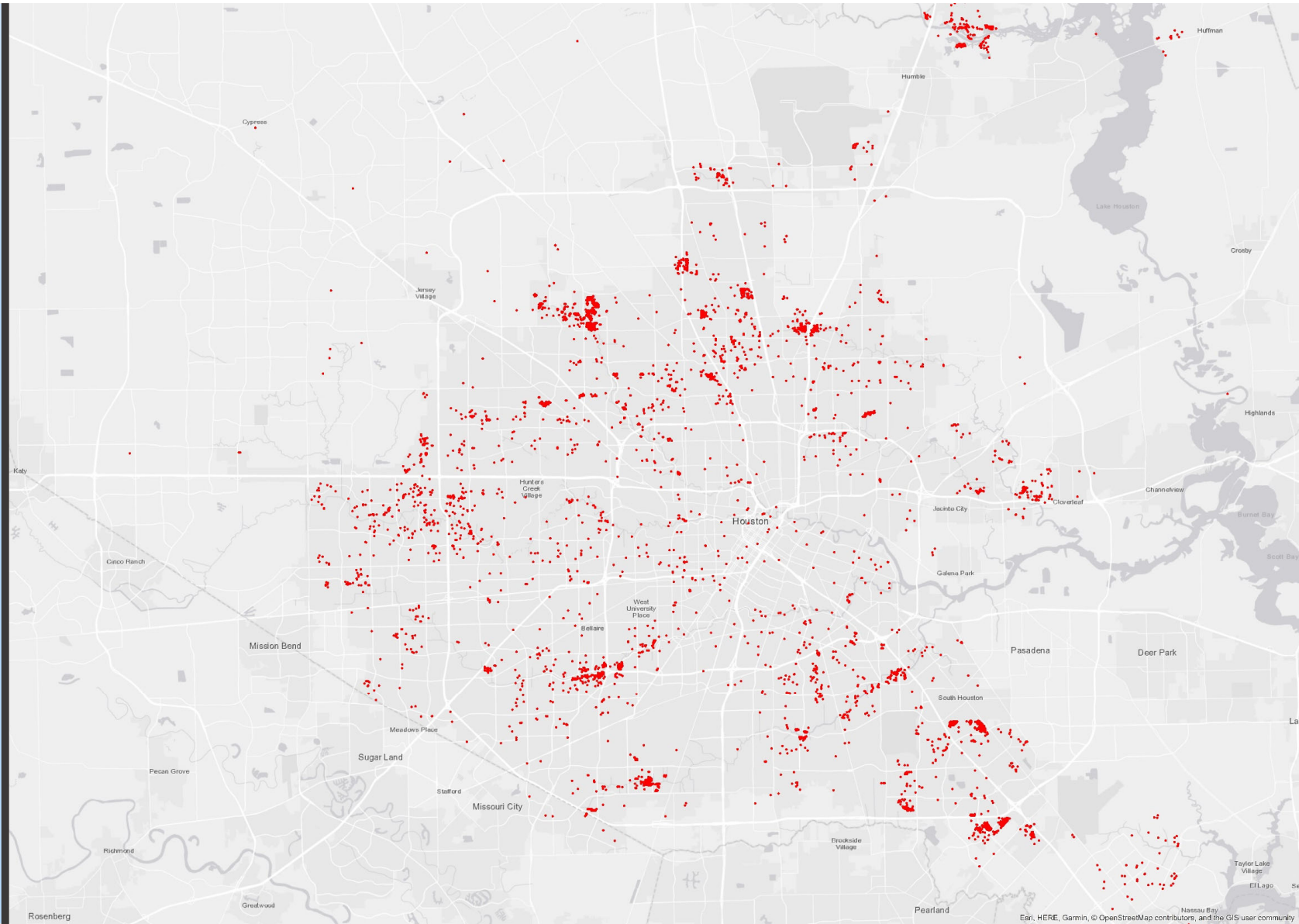
Esri, HERE, Garmin, ©OpenStreetMap contributors, and the GIS user community

311 Structural Flooding Reports



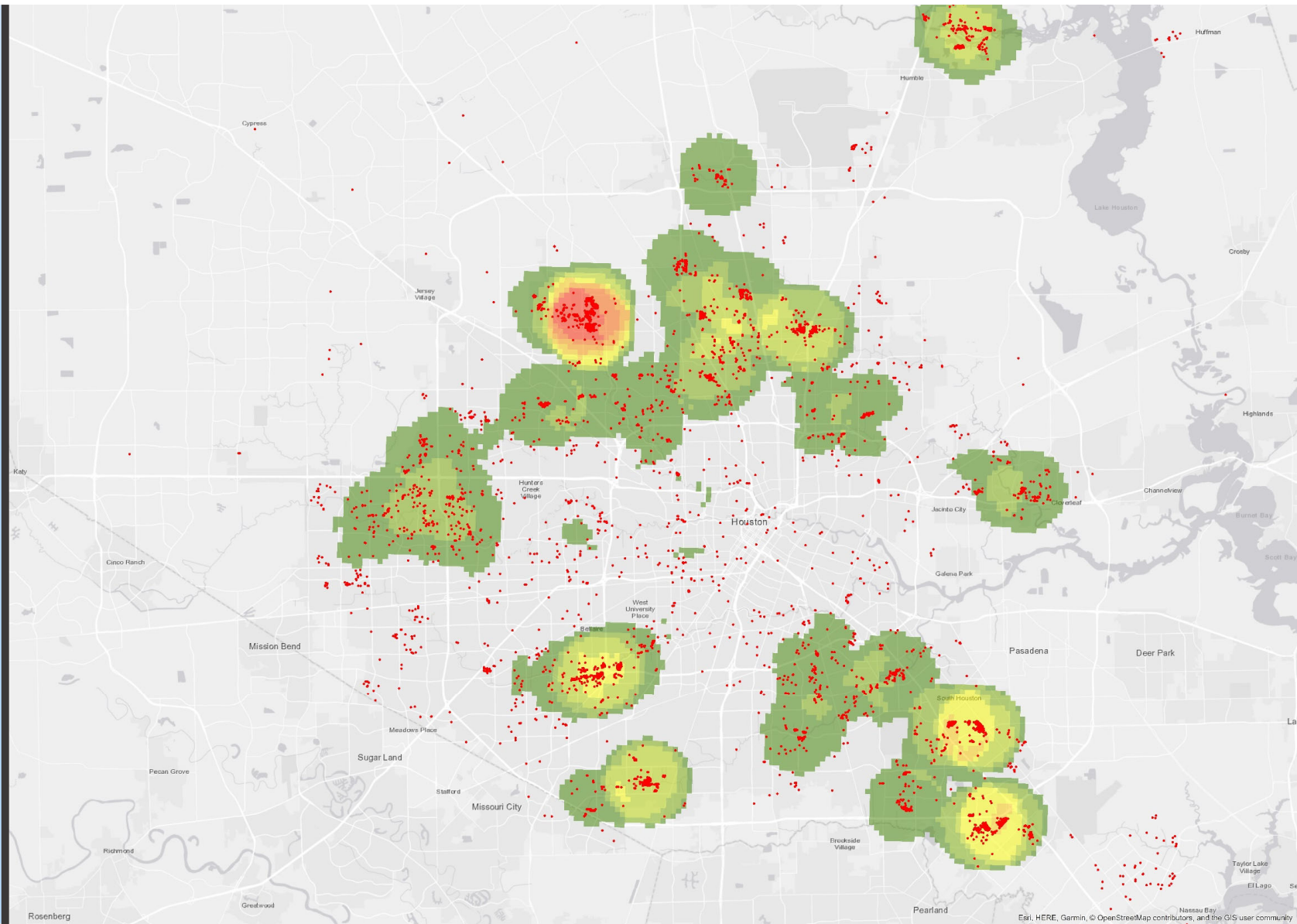
Esri, HERE, Garmin, OpenStreetMap contributors, and the GIS user community

FEMA Structural Flooding

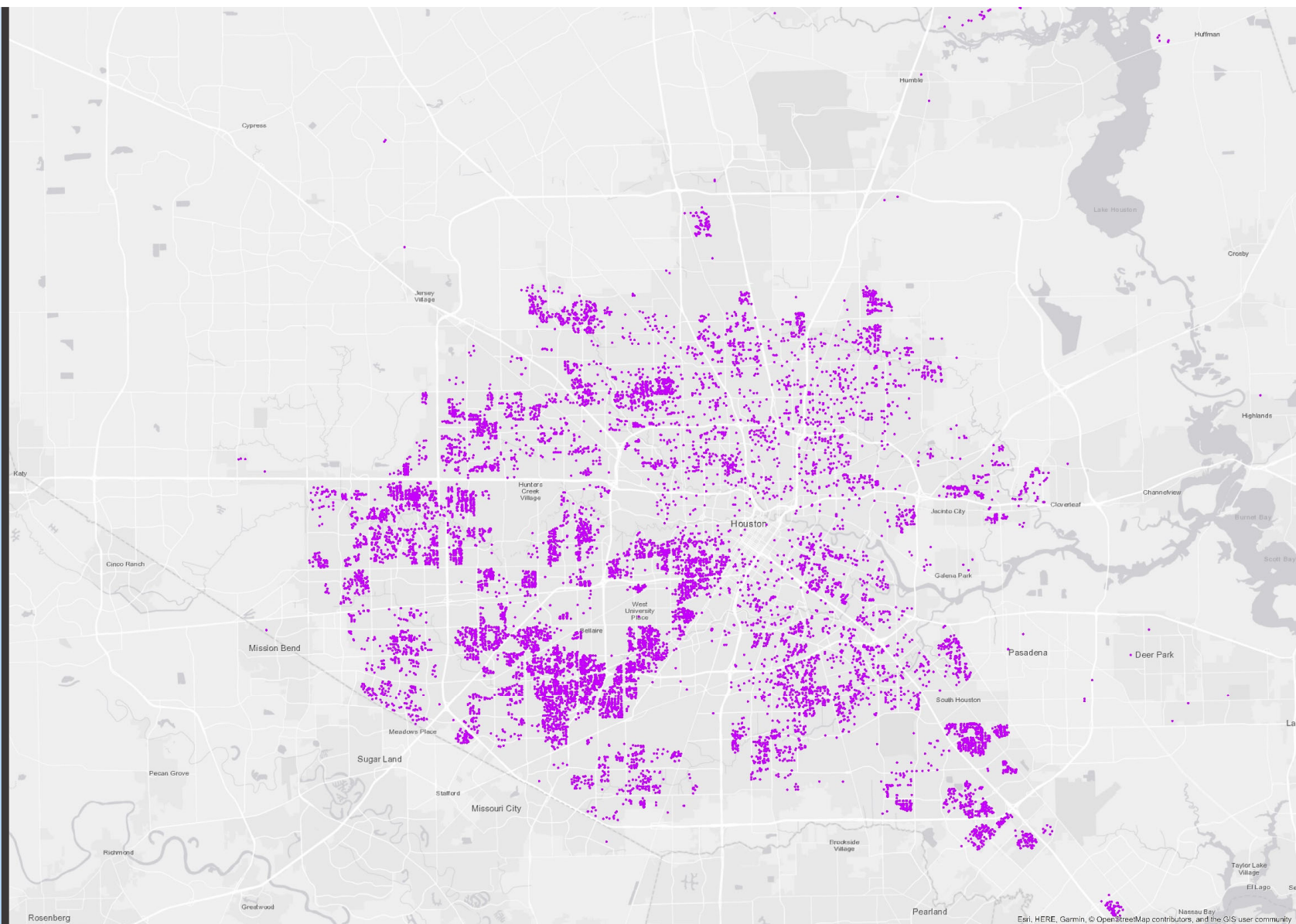


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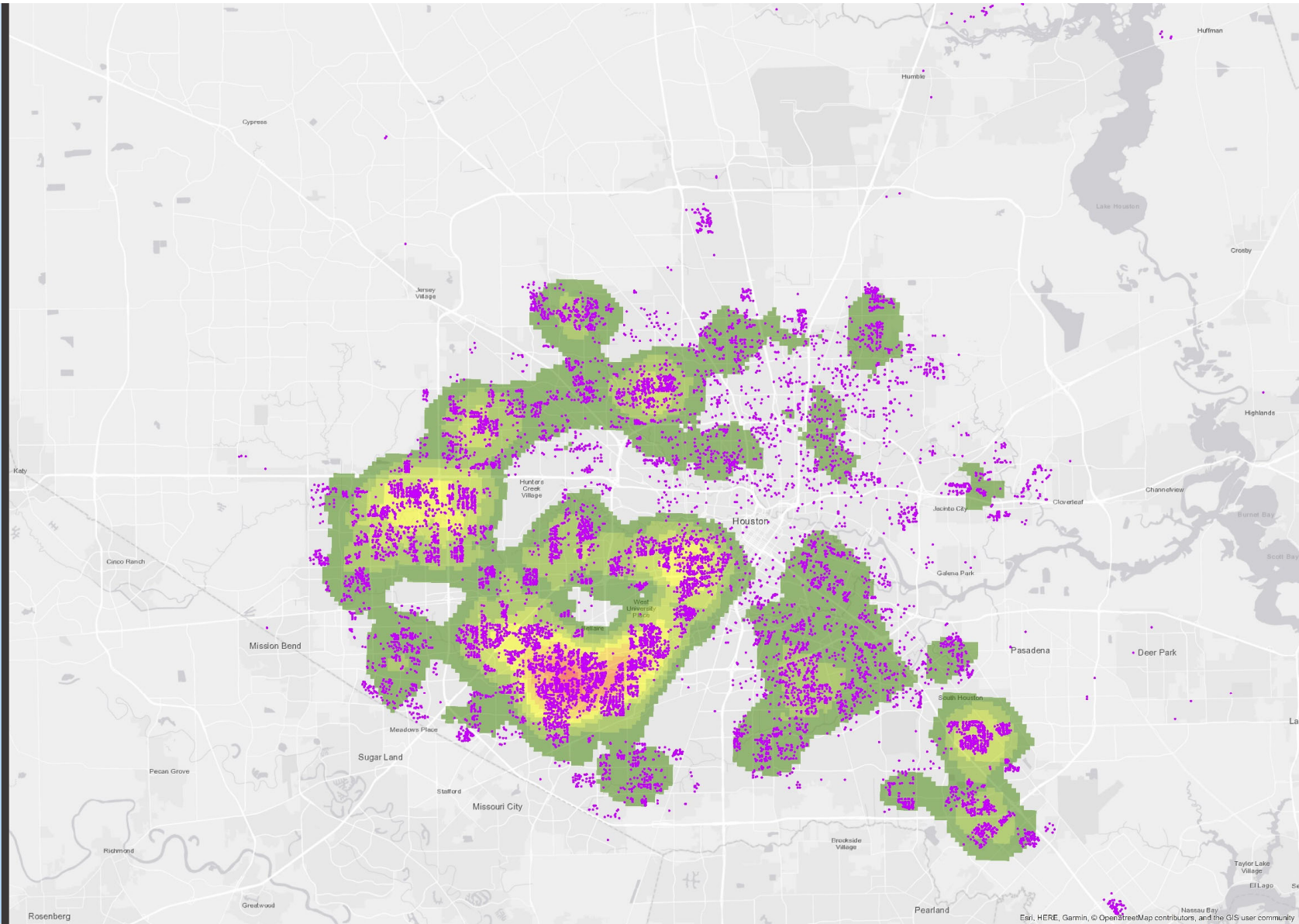
FFMA-SWEET presentation_0319.pptx/13



Flooded (Impassible) Streets

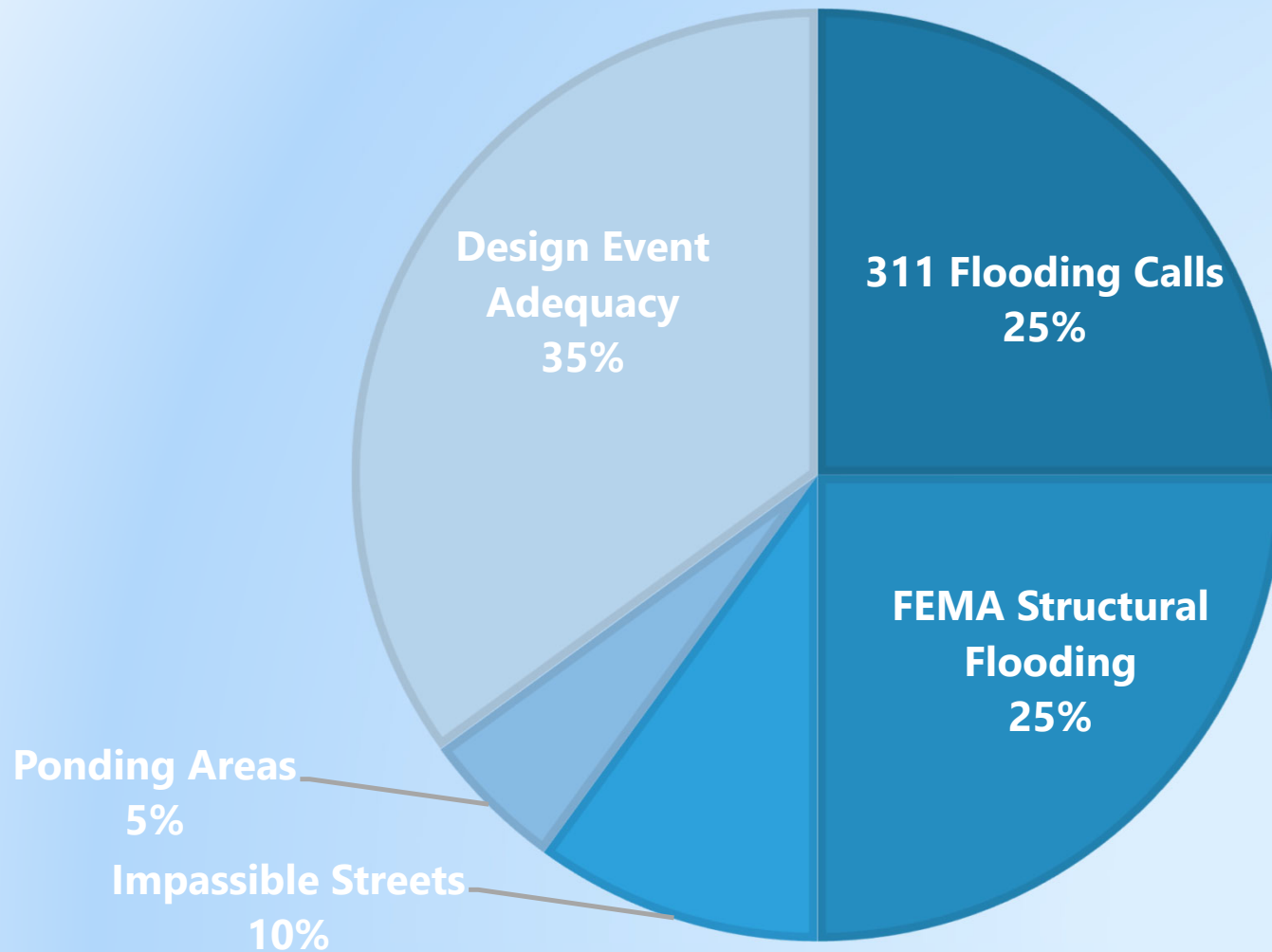


Flooded (Impassible) Streets

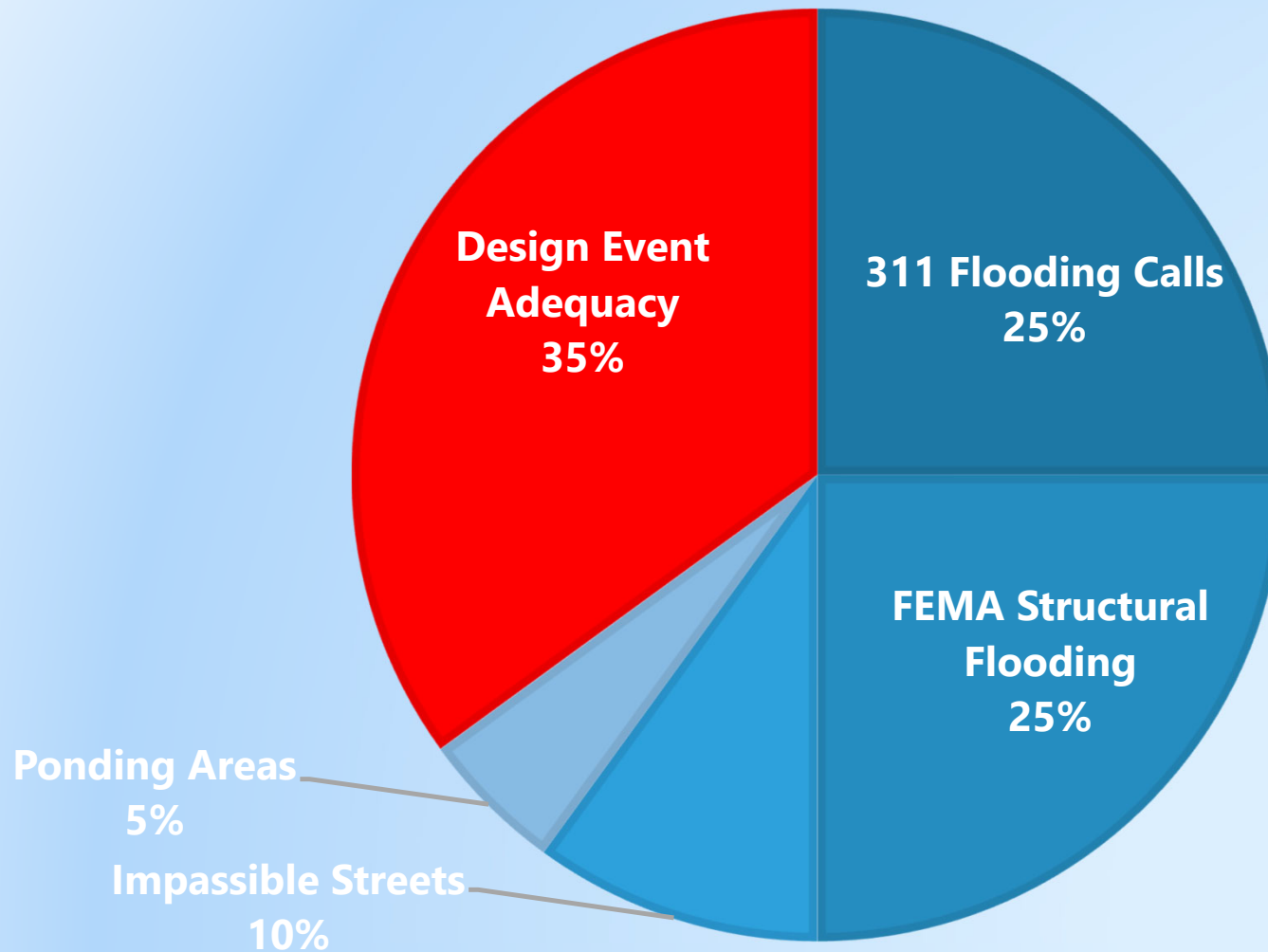


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Weighted Impact Categories



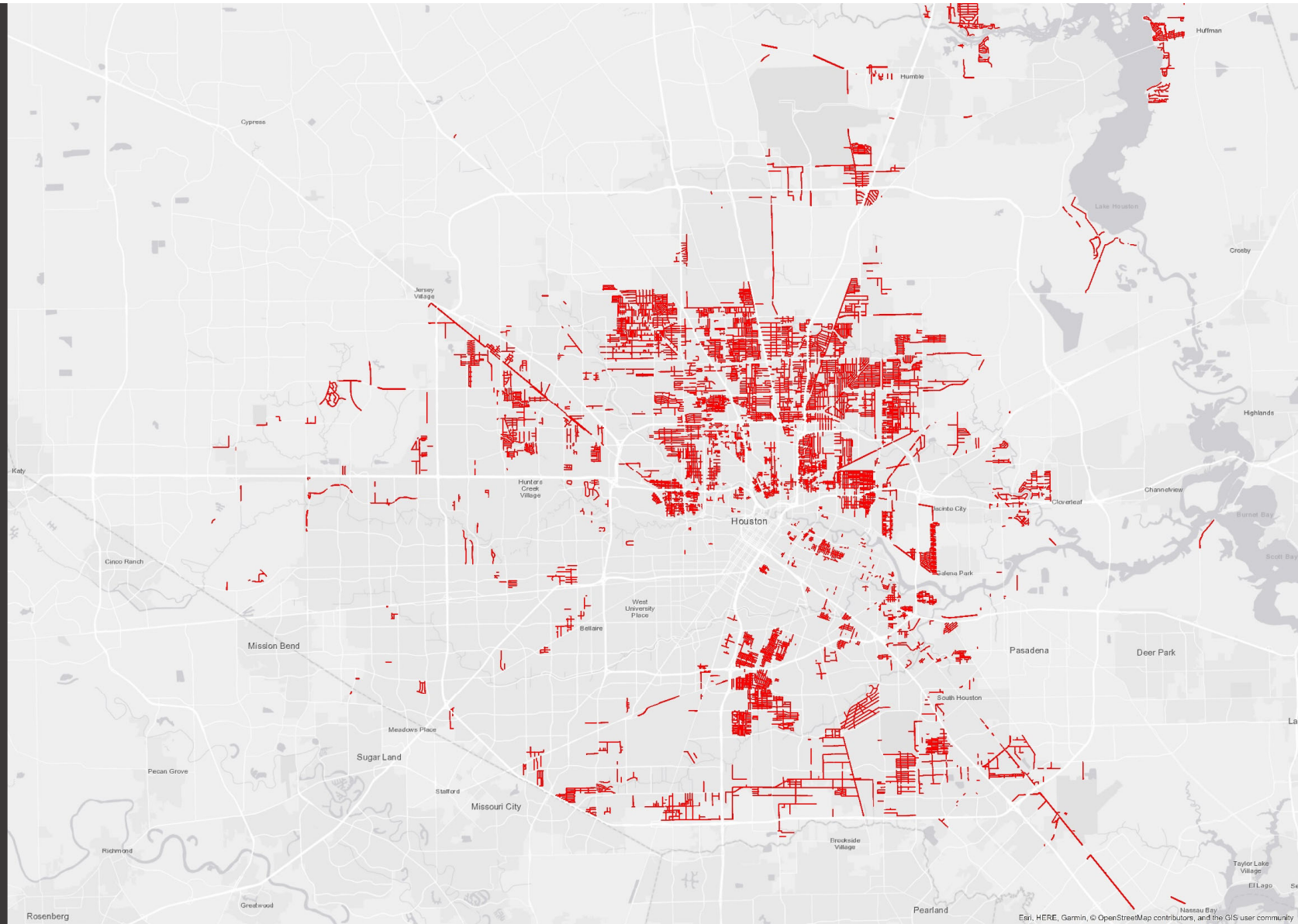
Weighted Impact Categories



Roadside Ditch Network

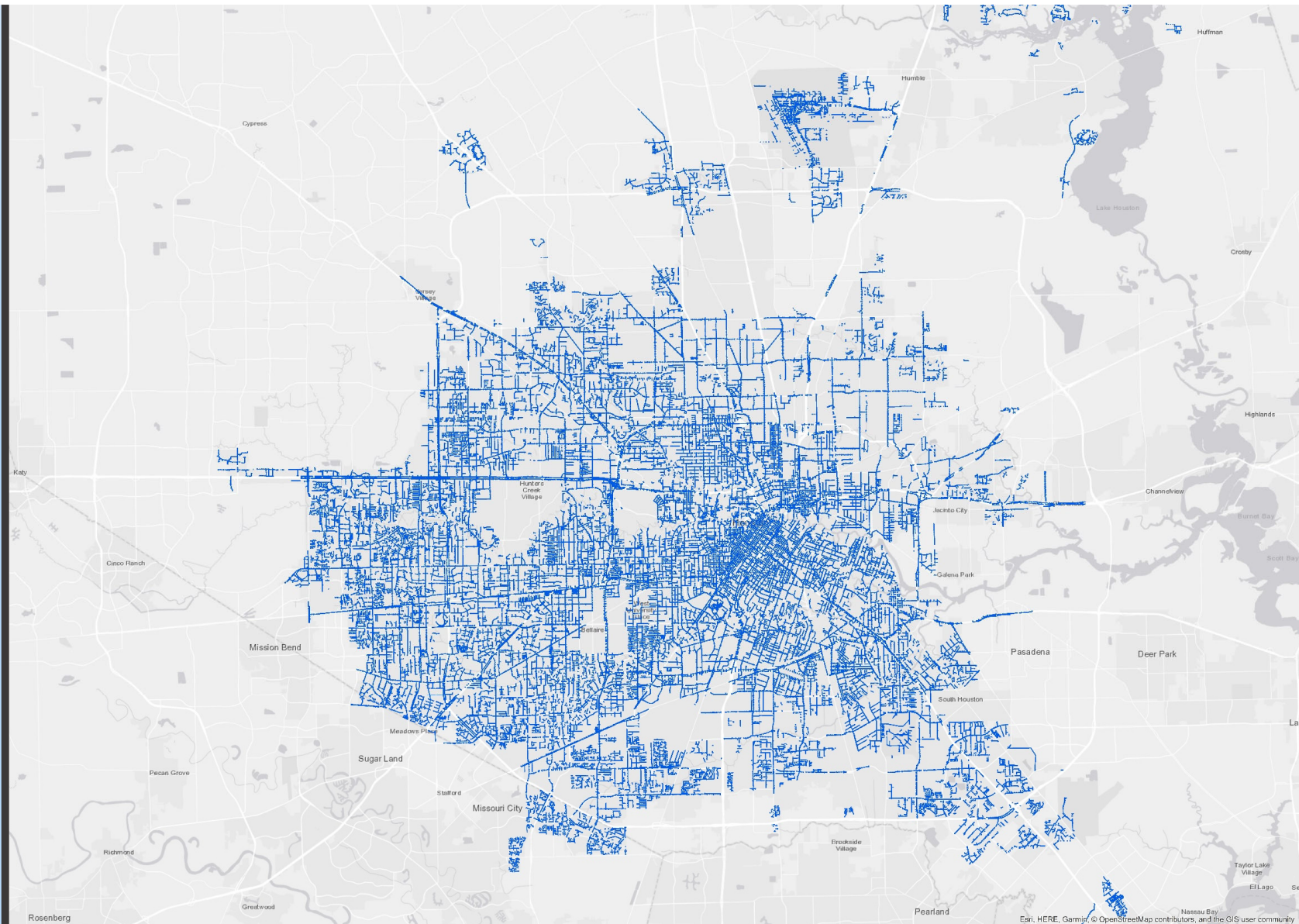
Count = 35,656

Miles = 2,416



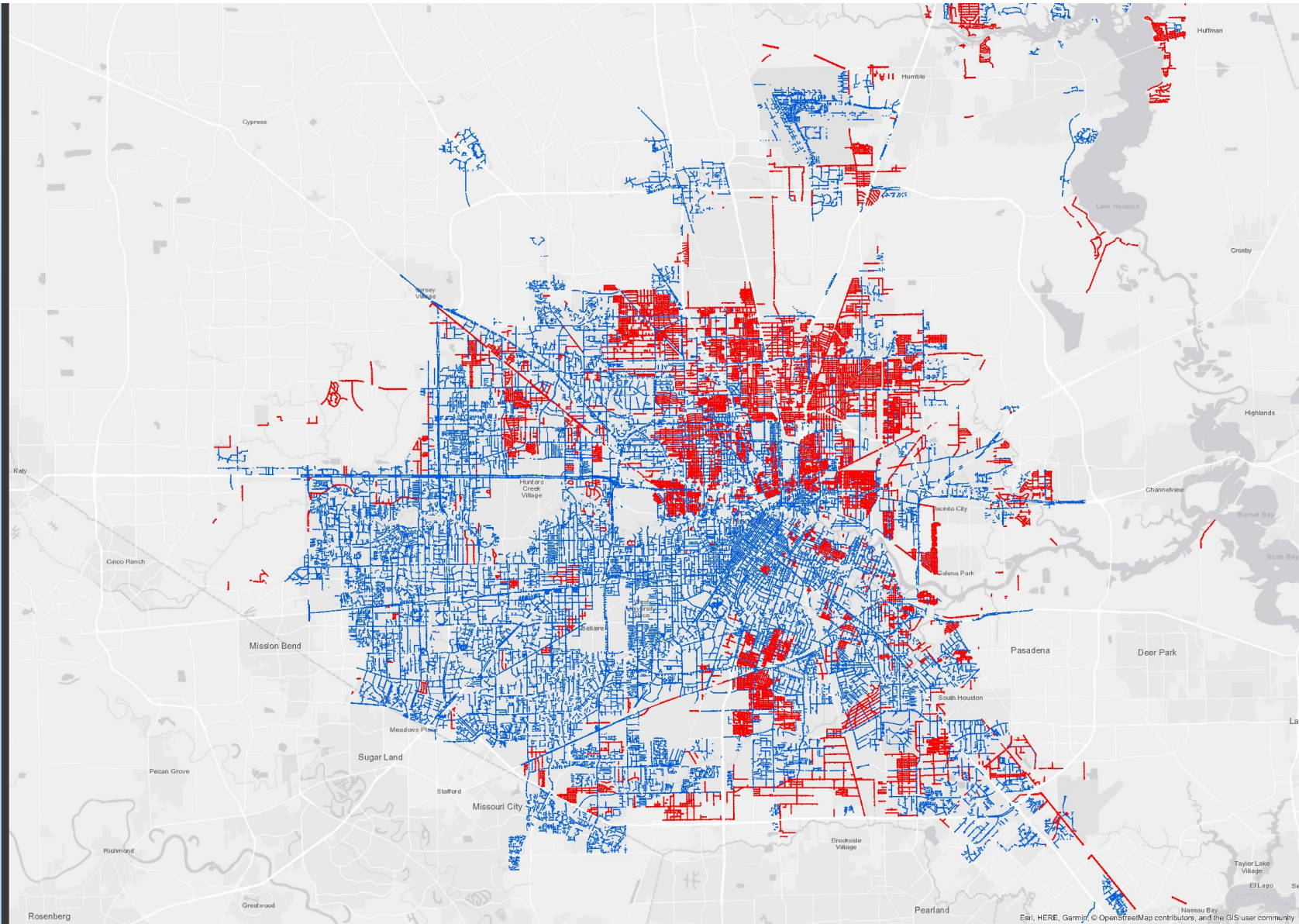
Storm Sewer Network

Count = 224,238
Miles = 3,861



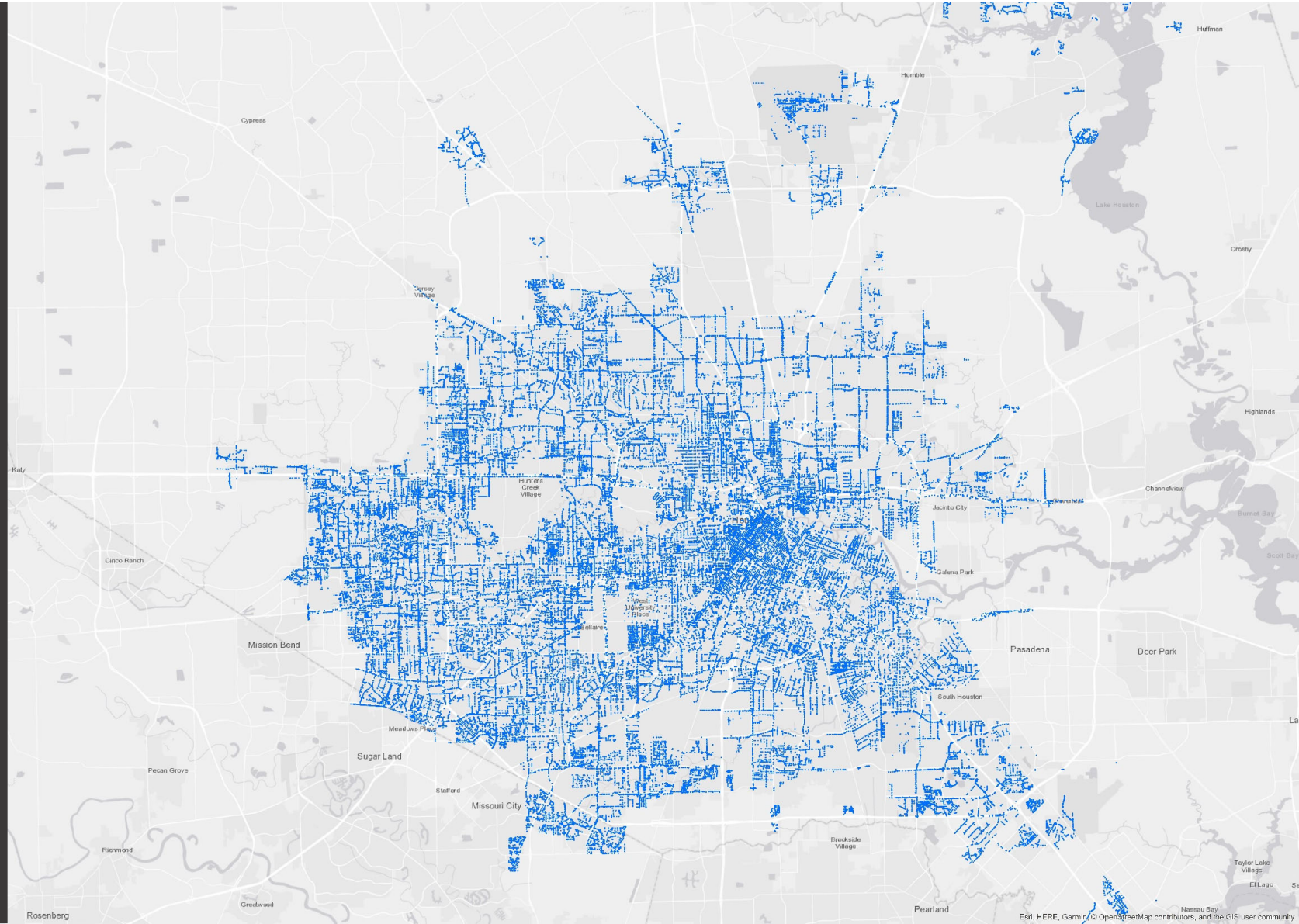
Storm Sewer & Road Side Ditch Network

Count = 259,894
Miles = 6,277



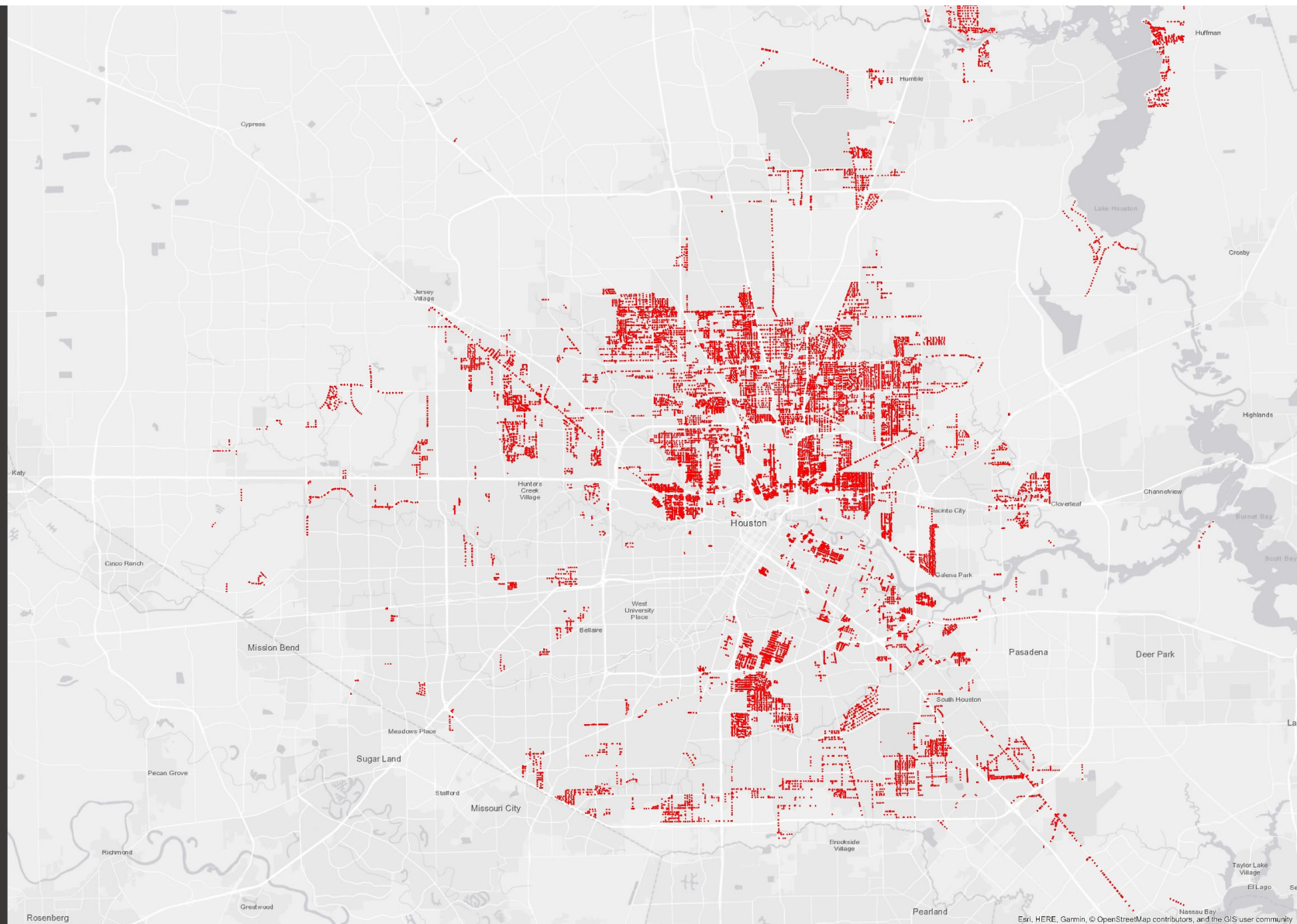
City of Houston Manholes

Count = 80,834



Roadside Ditch Centerlines

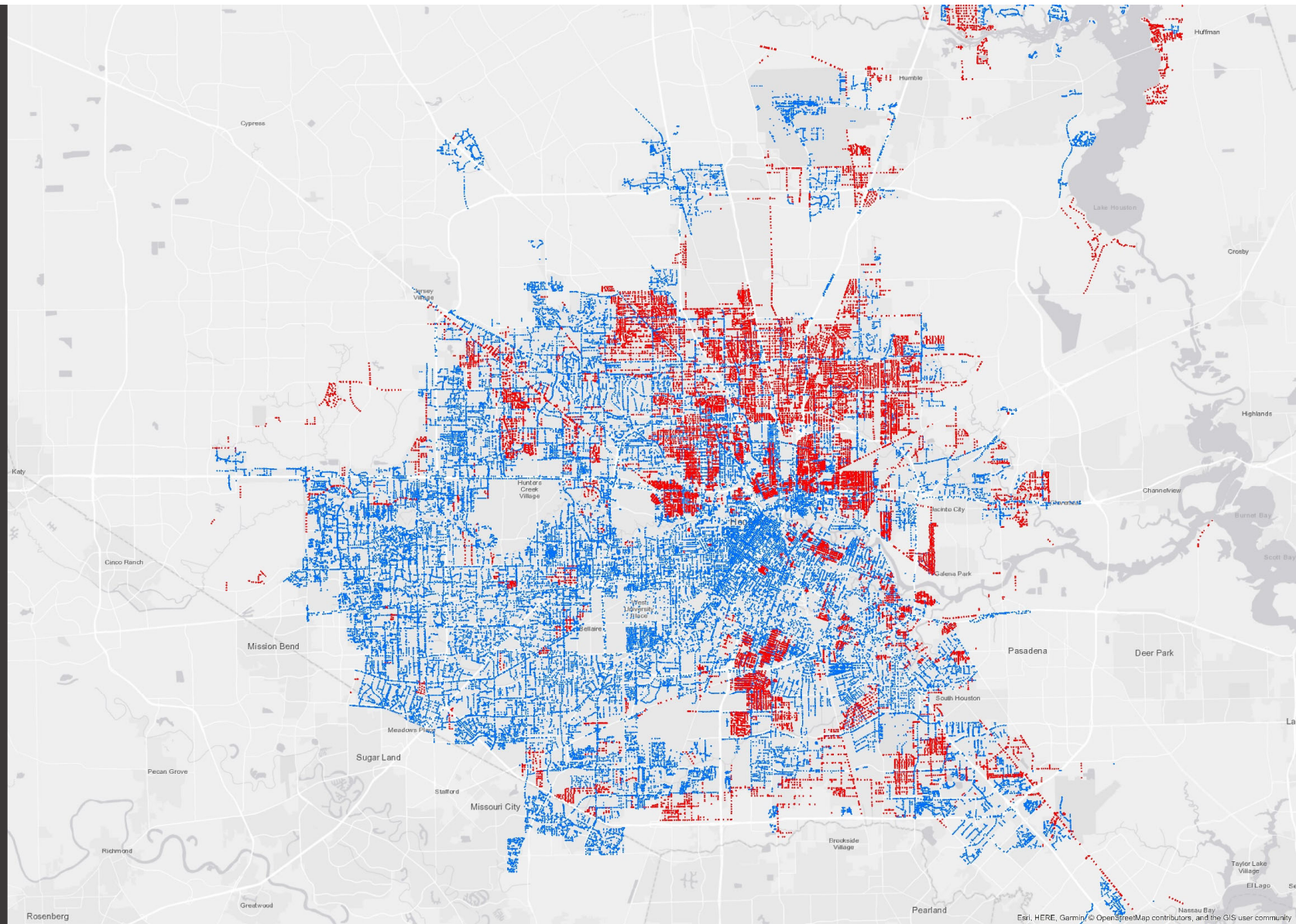
Count = 59,336



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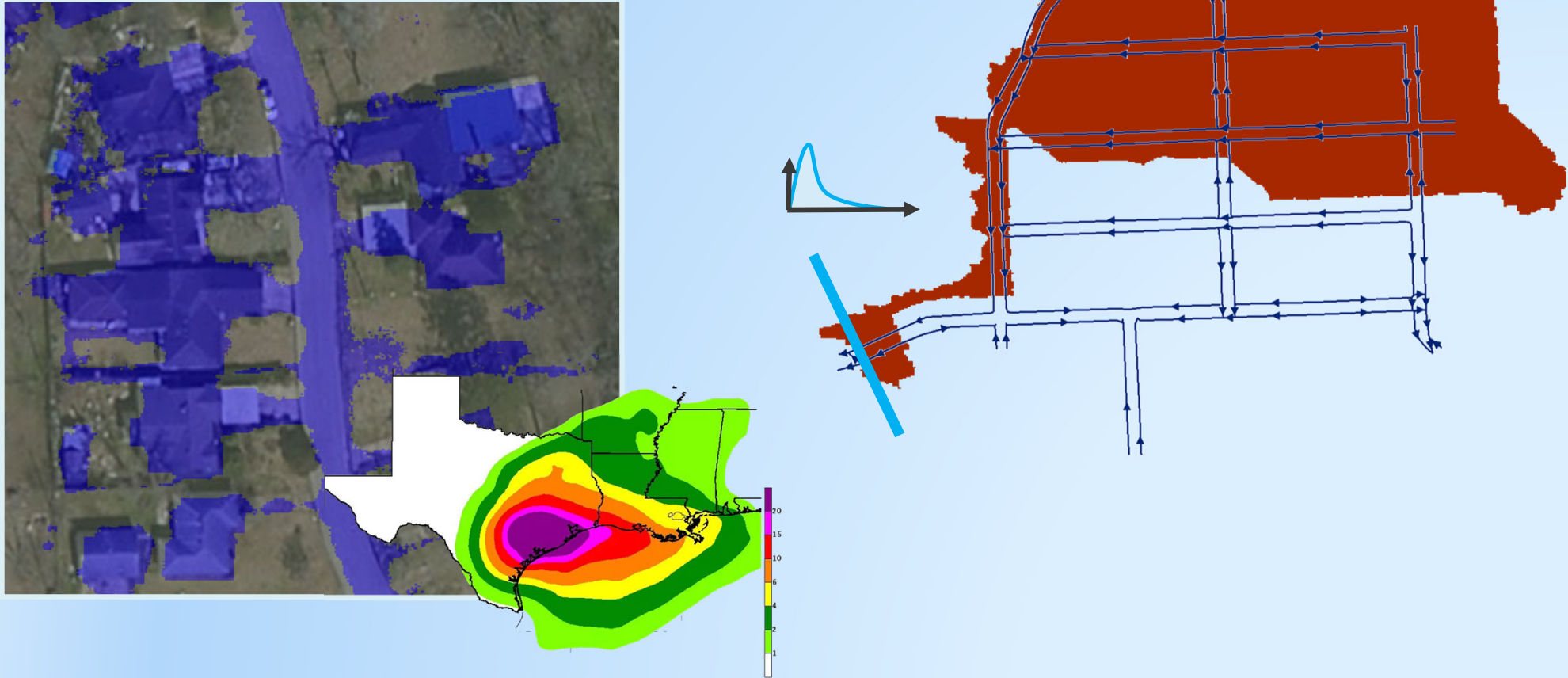
Manholes & Roadside Ditch Centerlines

Count = 140,170



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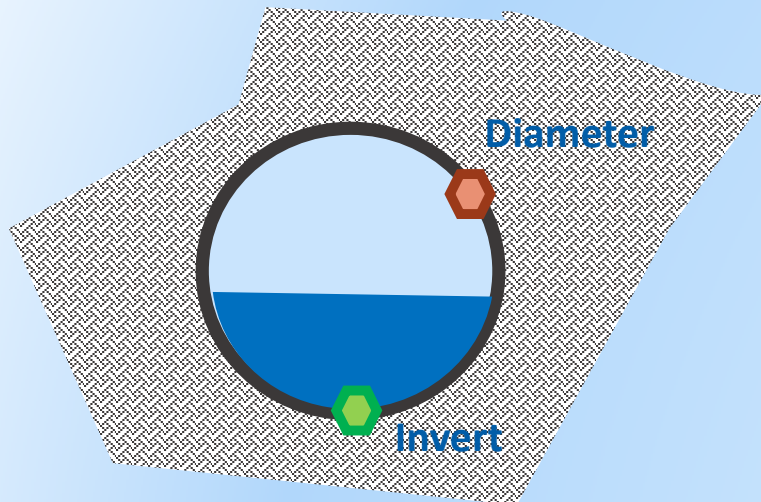
1. Flow



$$Q \text{ (Flow)} = C \text{ (Runoff)} * I \text{ (Storm)} * A \text{ (Area)}$$

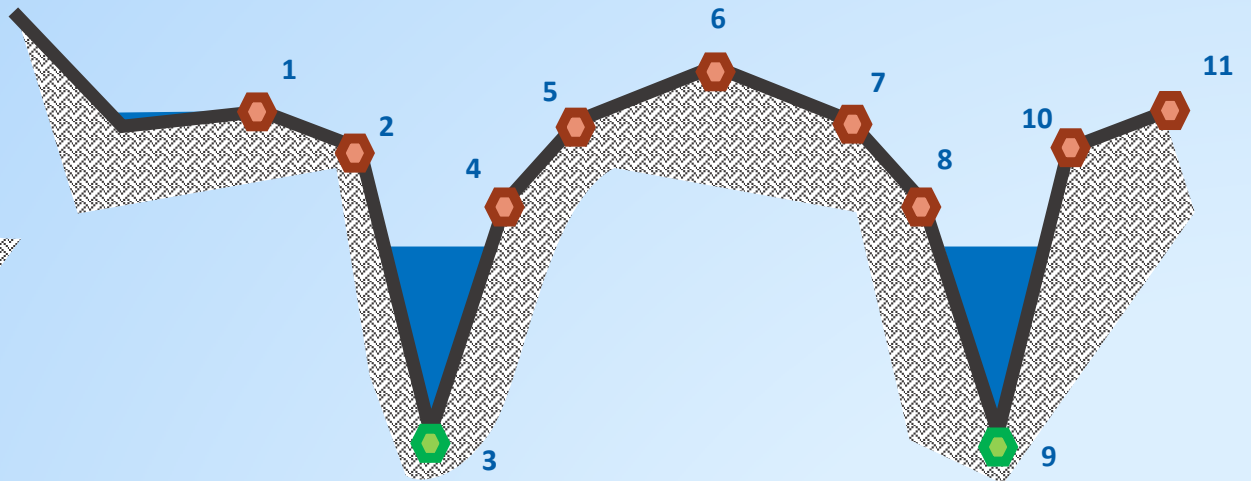
2. Capacity

STANDARD PIPE CROSS SECTION

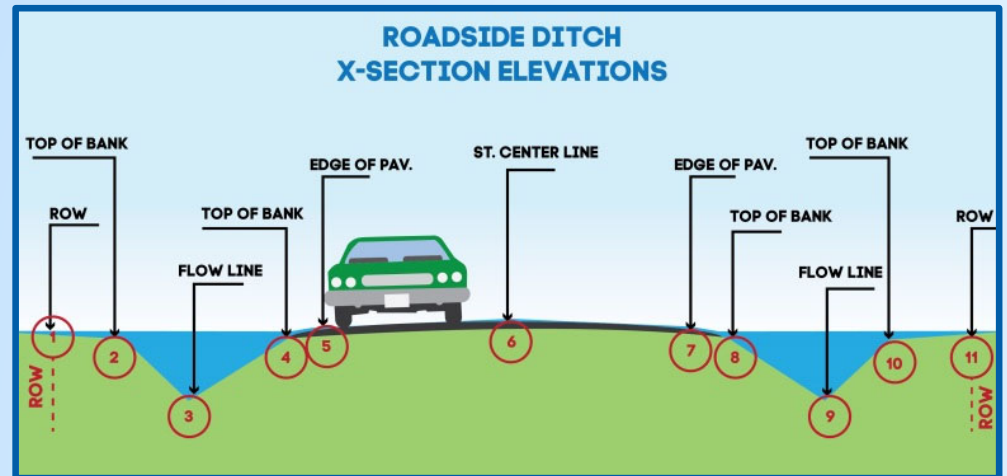


- Type of Pipe
- Pipe Shape

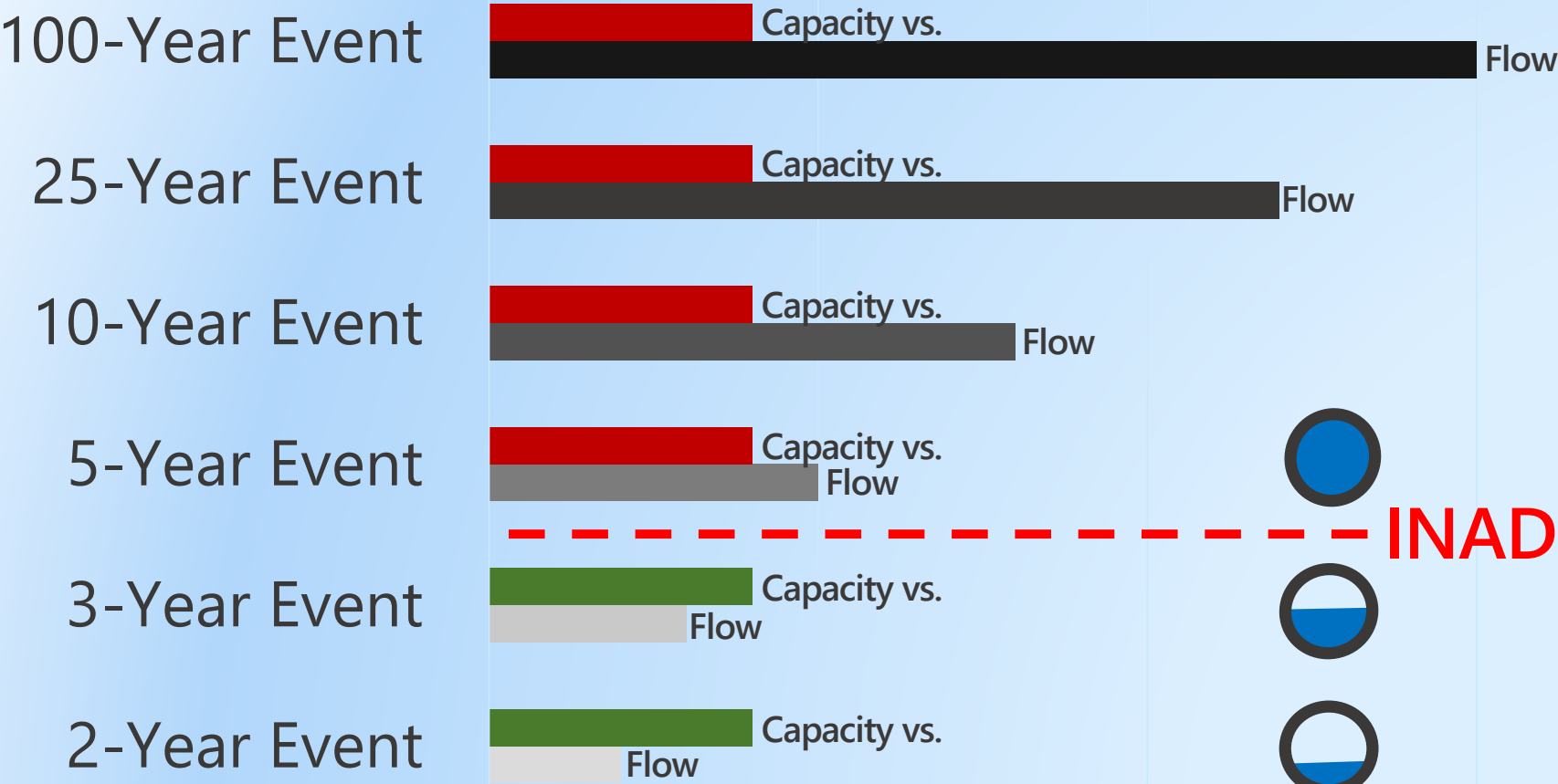
STANDARD DITCH CROSS SECTION



ROADSIDE DITCH X-SECTION ELEVATIONS



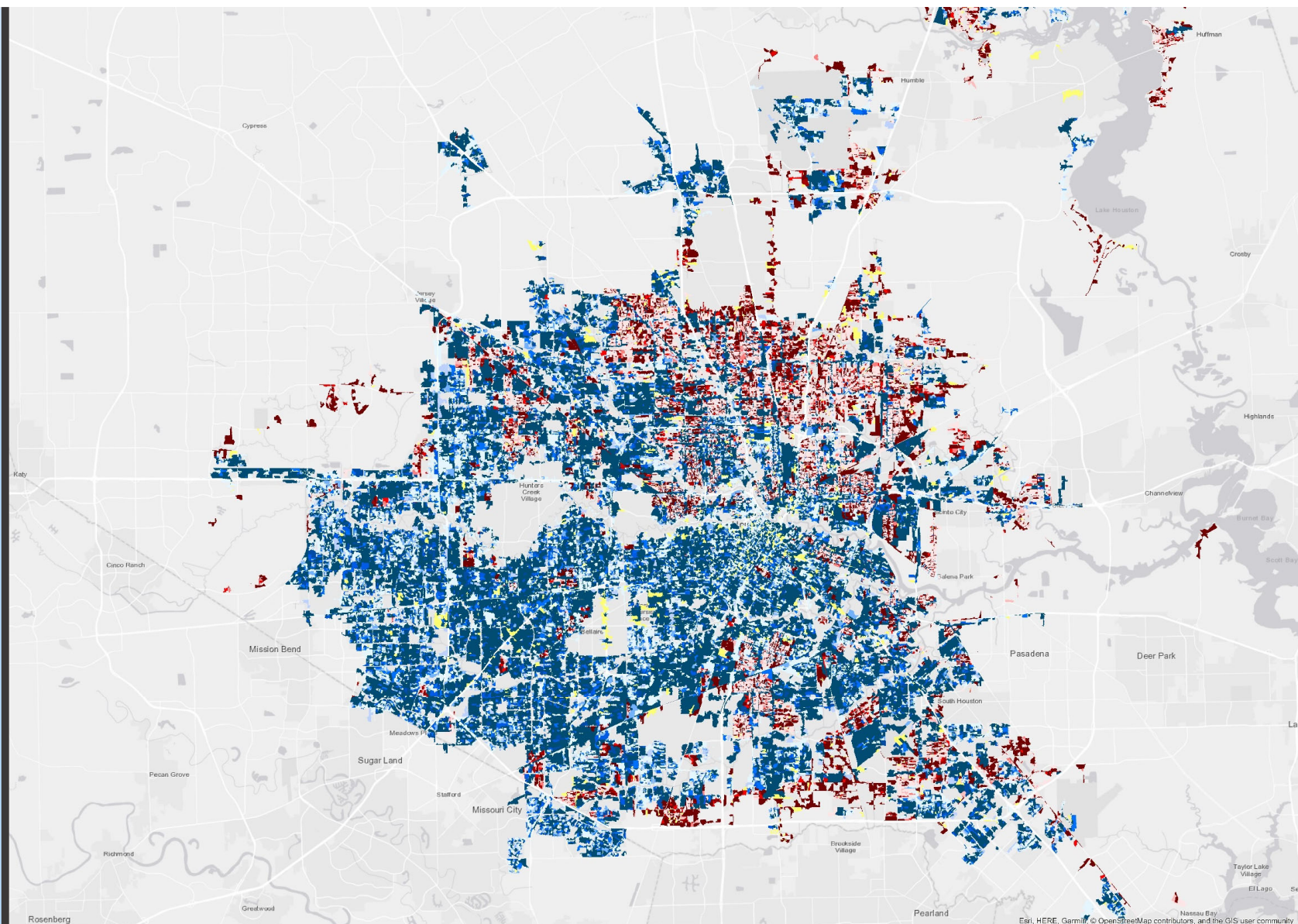
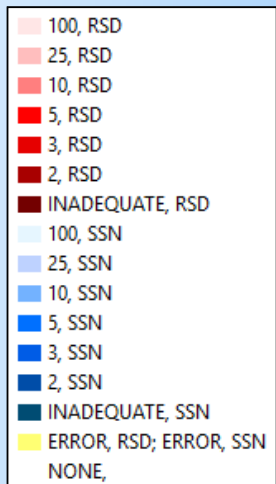
Capacity vs. Flow

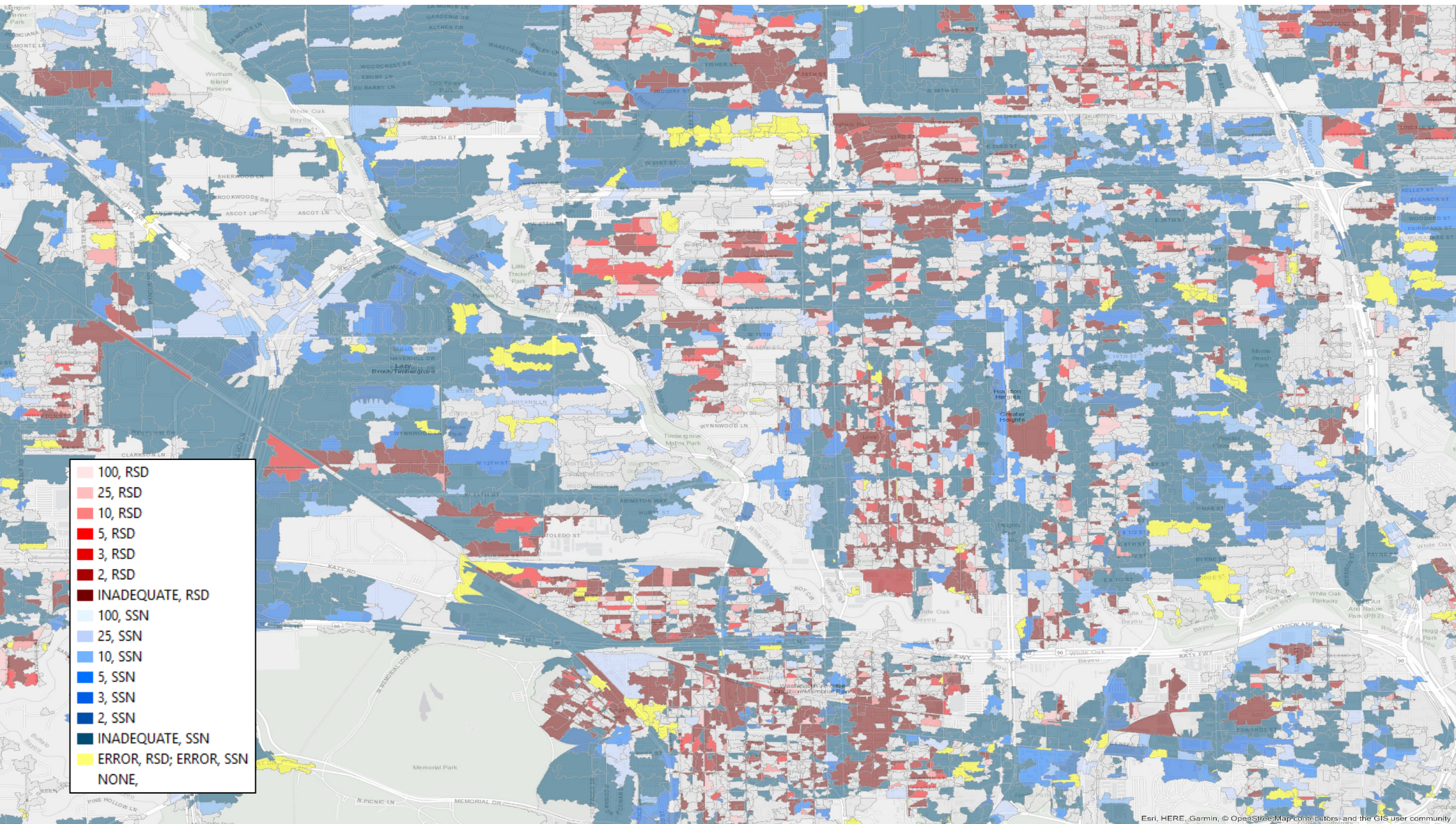


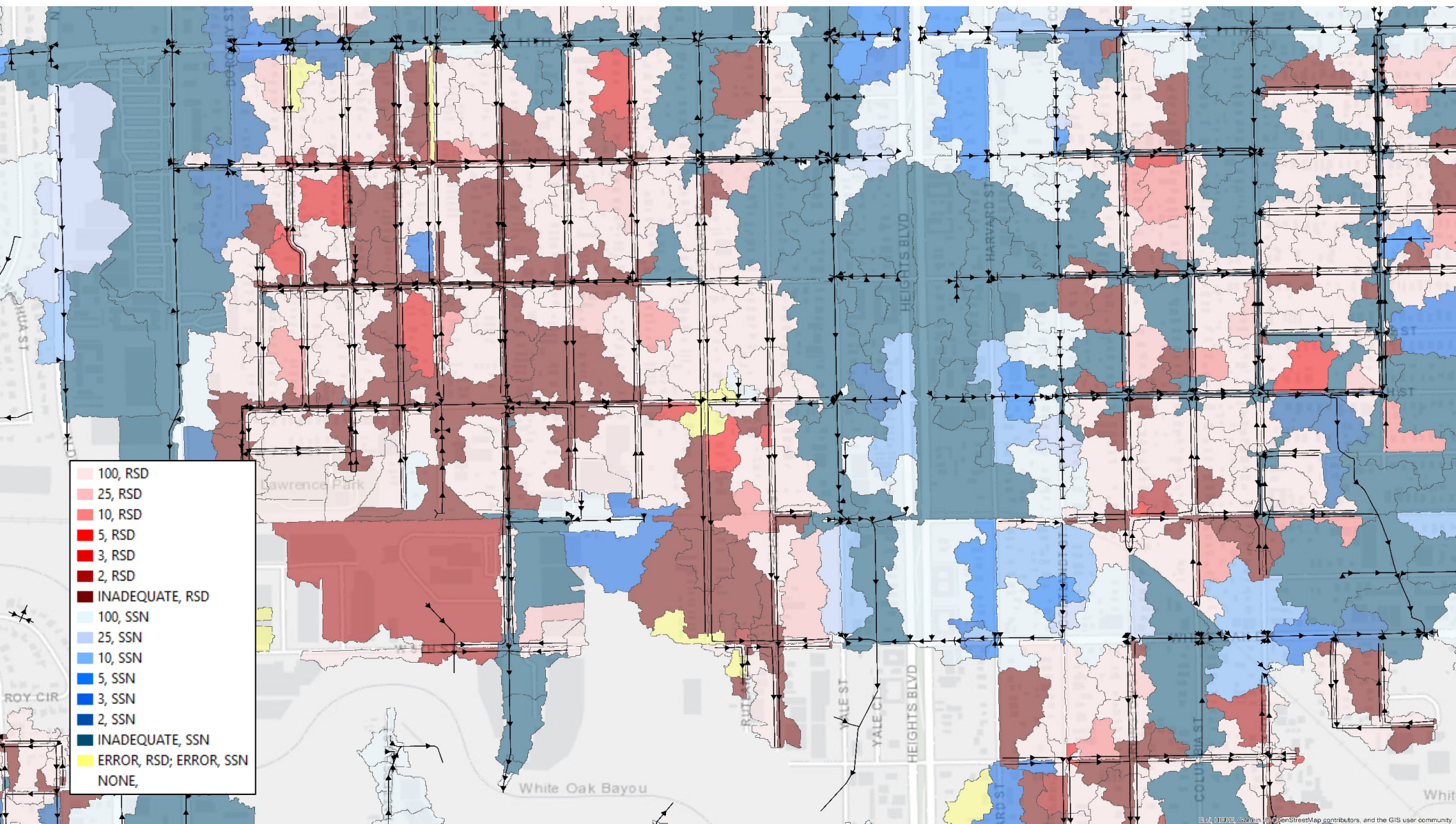
INADEQUATE

Design Event Adequacy (DEA) Coverage

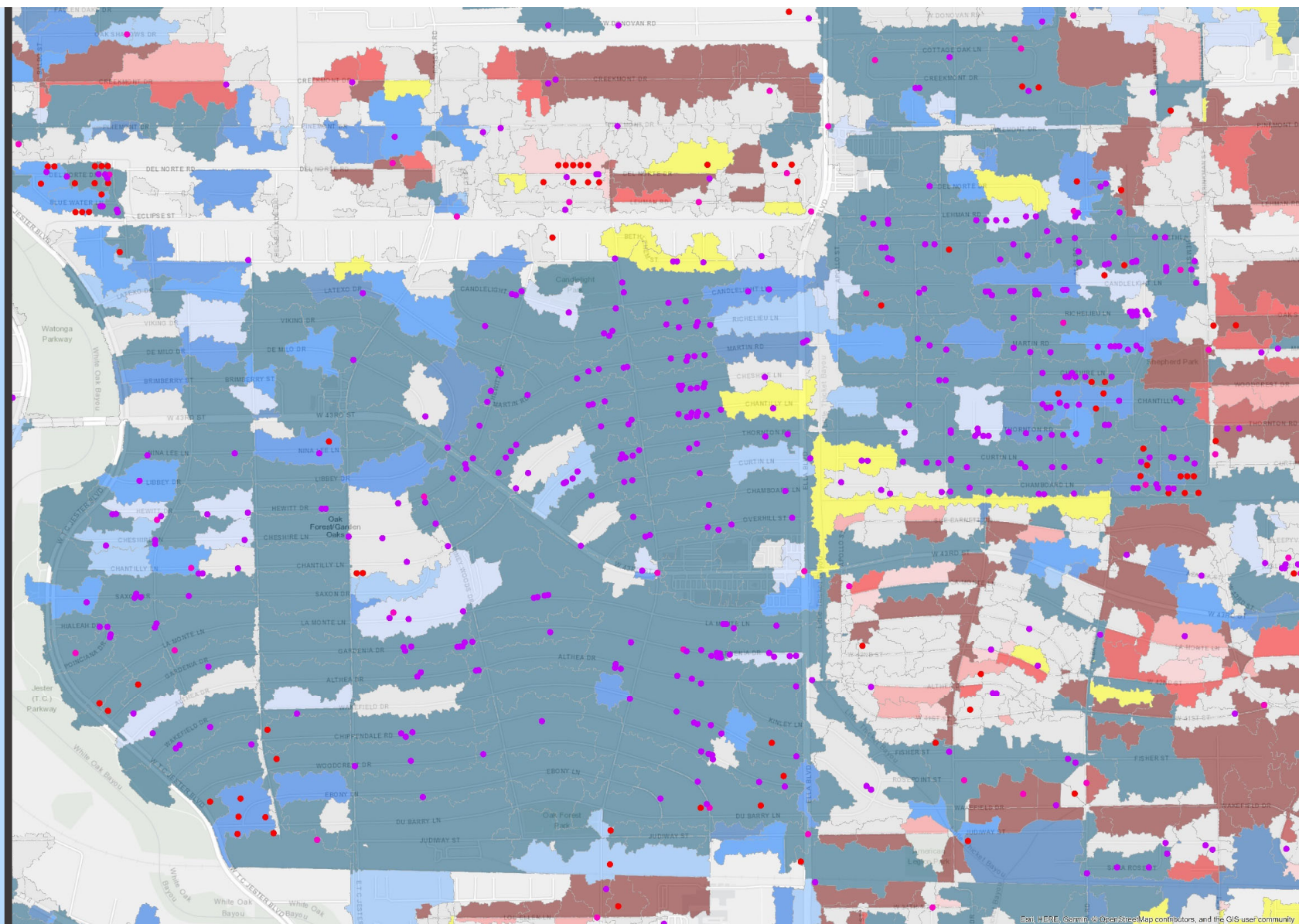
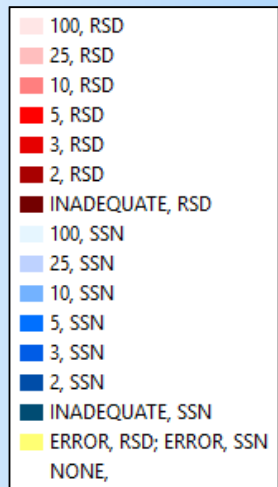
Count = 138,700



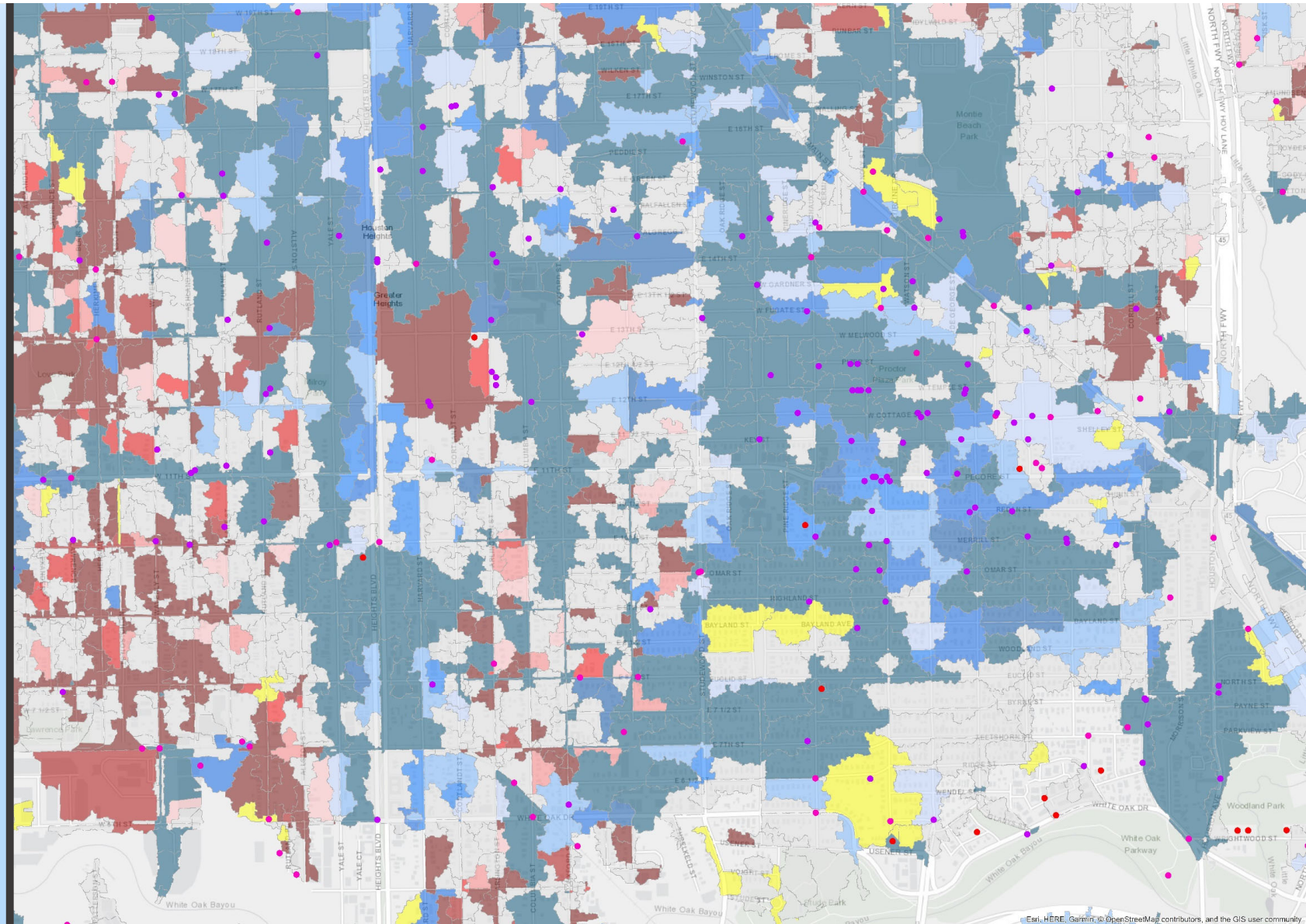
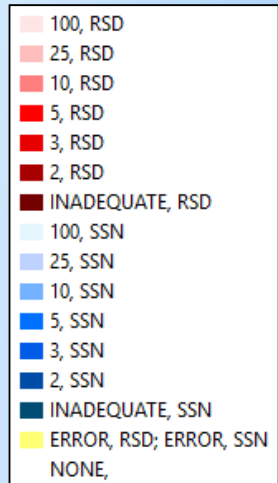




Design Event Adequacy (DEA) Comparison



Design Event Adequacy (DEA) Comparison





CIP Planning

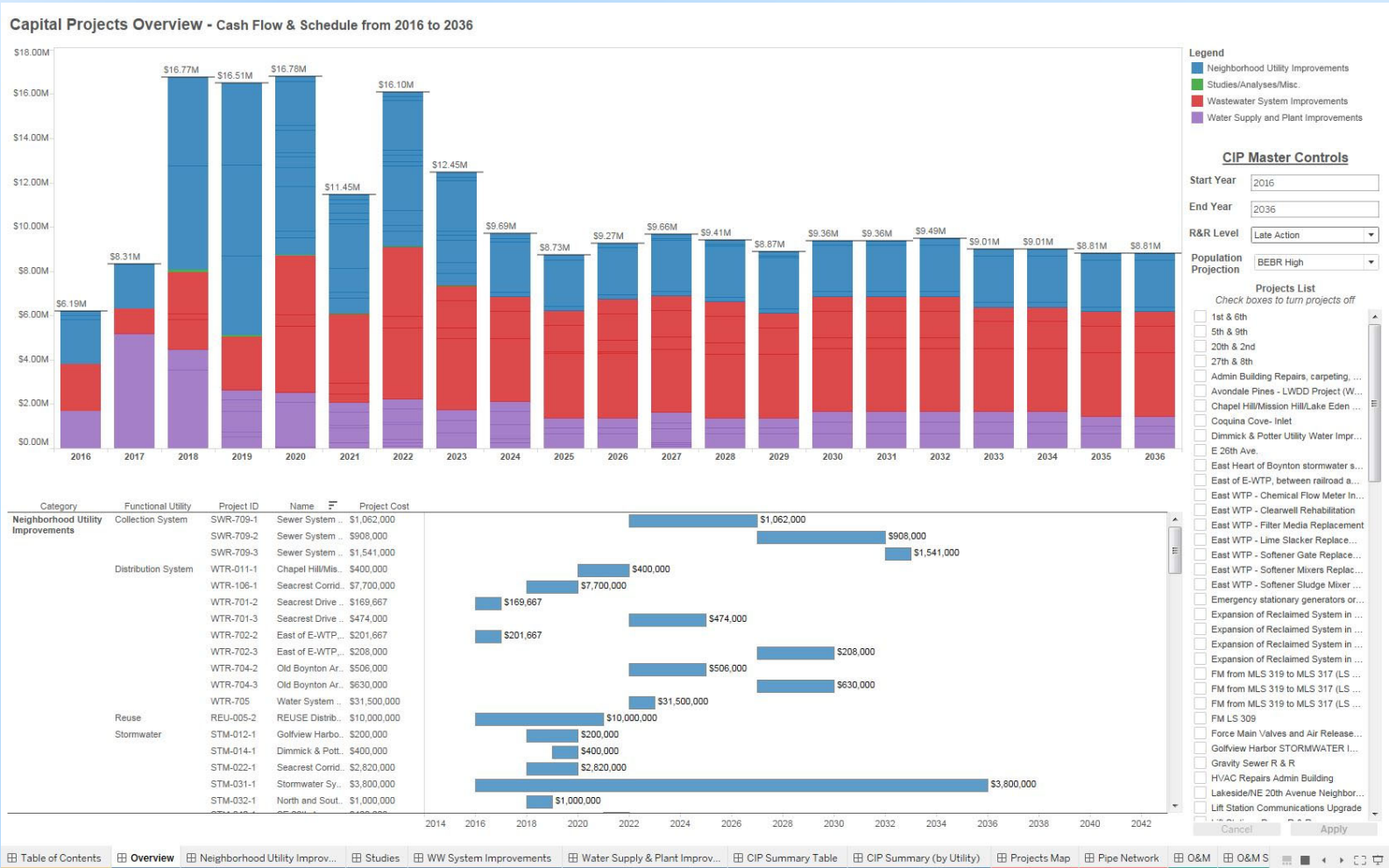
Summary Report

Stormwater Evaluation Enhancement Tool Summary Report

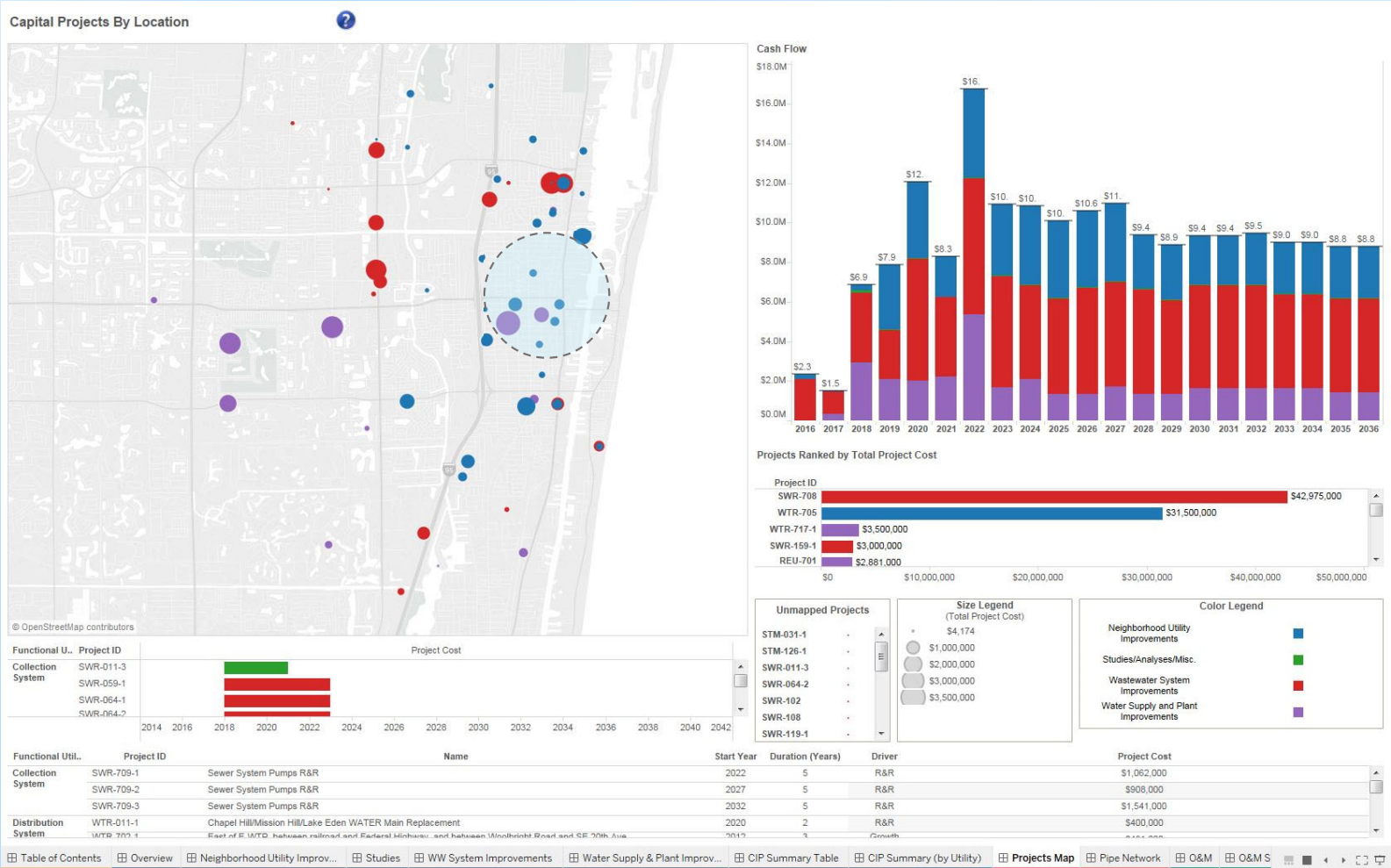


			Weights:	0.25	0.15	0.25	0.15	0.05	0.1	0.05
Feature ID	Rank	Overall Score (Scaled)	Overall Score (Wtd)	Drainage Effectiveness	Mobility	Damage Cost	Health & Safety	Economic Development	Community Protection	Environmental/Historical
3757	1	8.46098	3.53338	8.45832	2.40889	2.34627	1.29028	0.00000	0.14773	5.25160
3985	2	7.95781	3.35349	0.48231	2.22453	9.34286	2.12630	0.00000	0.20384	4.48374
3997	3	7.49959	3.18968	0.91700	2.23754	8.52948	1.66165	0.00000	0.21778	4.42793
3969	4	7.45887	3.17512	0.54688	2.18846	8.48685	2.23684	0.00000	0.25683	4.54414
1551	5	6.99008	3.00752	4.88438	1.91869	3.05423	1.38931	5.00000	0.32643	4.88065
1122	6	6.87118	2.96502	2.44430	2.41824	3.78142	1.52634	10.00000	0.53713	5.26378
214	7	6.83473	2.95198	4.70913	1.87863	3.09127	1.37916	5.00000	0.22037	4.82359
2142	8	6.78886	2.93559	0.84223	3.02902	7.03017	1.60246	0.00000	0.12762	5.20001
213	9	6.71129	2.90785	4.62443	1.83395	3.03235	1.36901	5.00000	0.22037	4.82359
2821	10	6.58136	2.86141	1.32968	4.70748	3.26389	1.62276	10.00000	0.00391	5.26174
2140	11	6.47800	2.82445	4.63685	3.02878	2.76021	1.60984	0.00000	0.31458	4.95879
2131	12	6.45532	2.81635	4.86473	2.55167	2.76934	1.59485	0.00000	0.31337	5.09029
4384	13	6.44070	2.81112	3.60987	2.08073	1.86050	5.84640	0.00000	0.13555	4.81803
1613	14	6.40712	2.79911	1.90269	2.01119	5.14897	1.25943	5.00000	0.31828	5.27555
2710	15	6.33948	2.77493	1.87909	4.55077	3.40407	1.62276	5.00000	0.15709	5.24806
1484	16	6.32368	2.76928	0.78756	2.59246	4.27887	3.06335	5.00000	1.42700	5.23209
212	17	6.30907	2.76406	4.15869	1.80401	2.94697	1.35886	5.00000	0.22037	4.82359
1552	18	6.30706	2.76334	3.81391	1.93108	3.23326	1.38931	5.00000	0.15148	4.76690
2927	19	6.27884	2.75325	2.20622	3.63792	3.26907	1.62276	6.66667	0.00567	5.22861
2349	20	6.26913	2.74978	0.42120	3.07299	5.75247	1.46371	5.00000	0.11726	5.28268

Living Master Plan



Living Master Plan

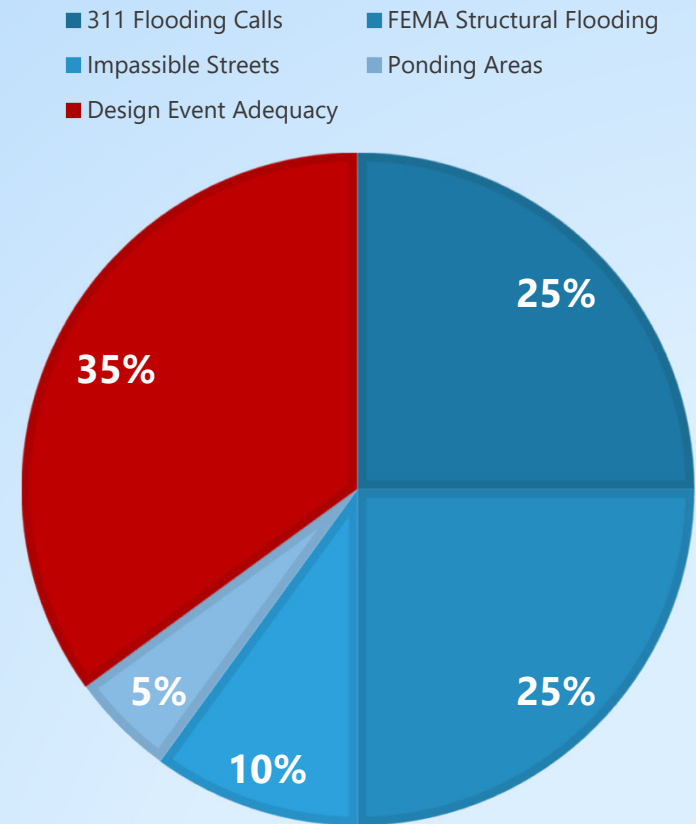


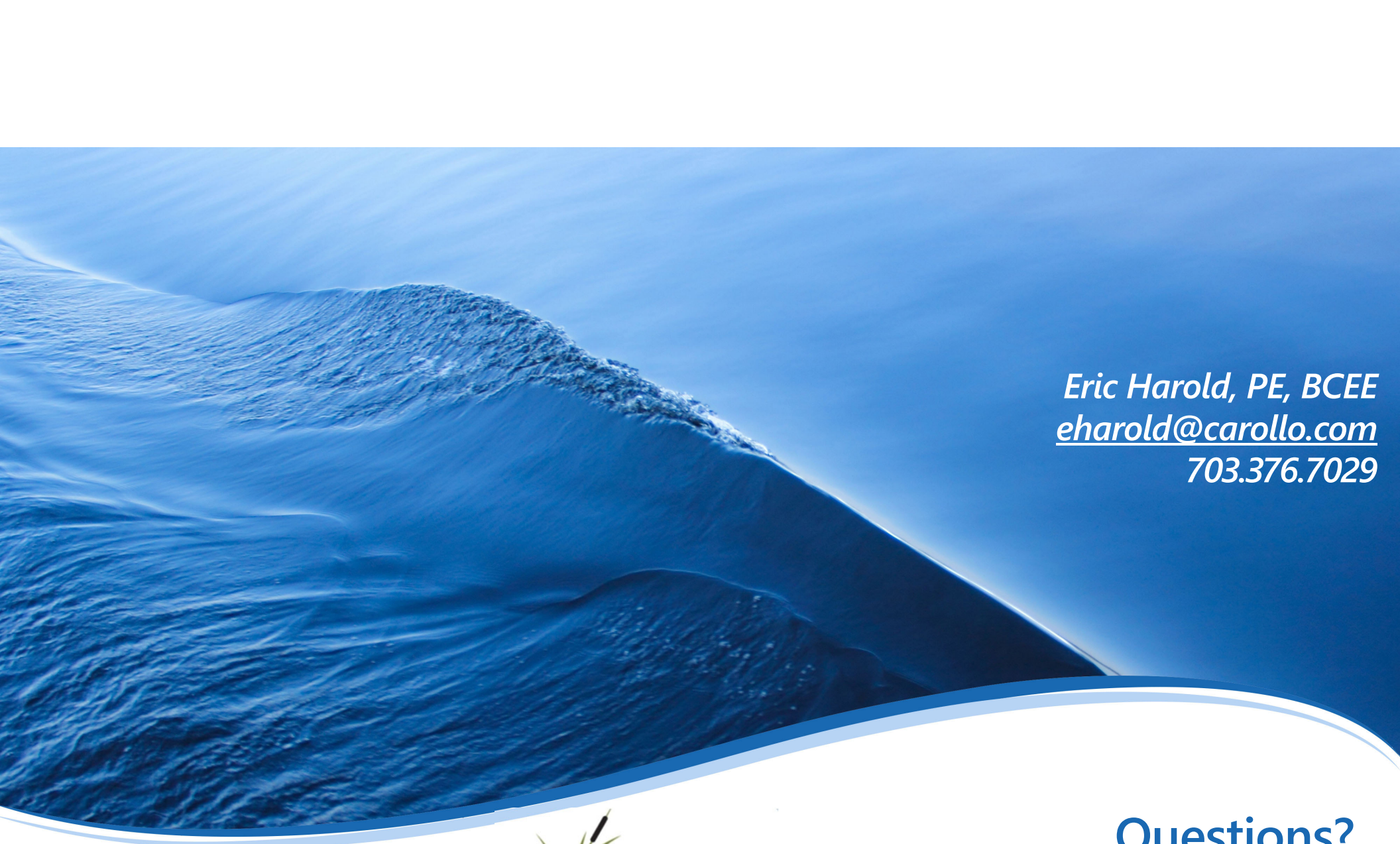
Programmatic Automation

- PYTHON Programming Scripts  python
- Automated Processing Code
- Ensures Consistency, Timeliness, and Accuracy
- 8-16 Hours per DEM Grid x 72 Grids

Summary

- Methodology Applicable to any Location
- This is a planning-level Local Drainage Analysis instead of River/Stream Floodplain Analysis
- Weighting allows for Stakeholder Input





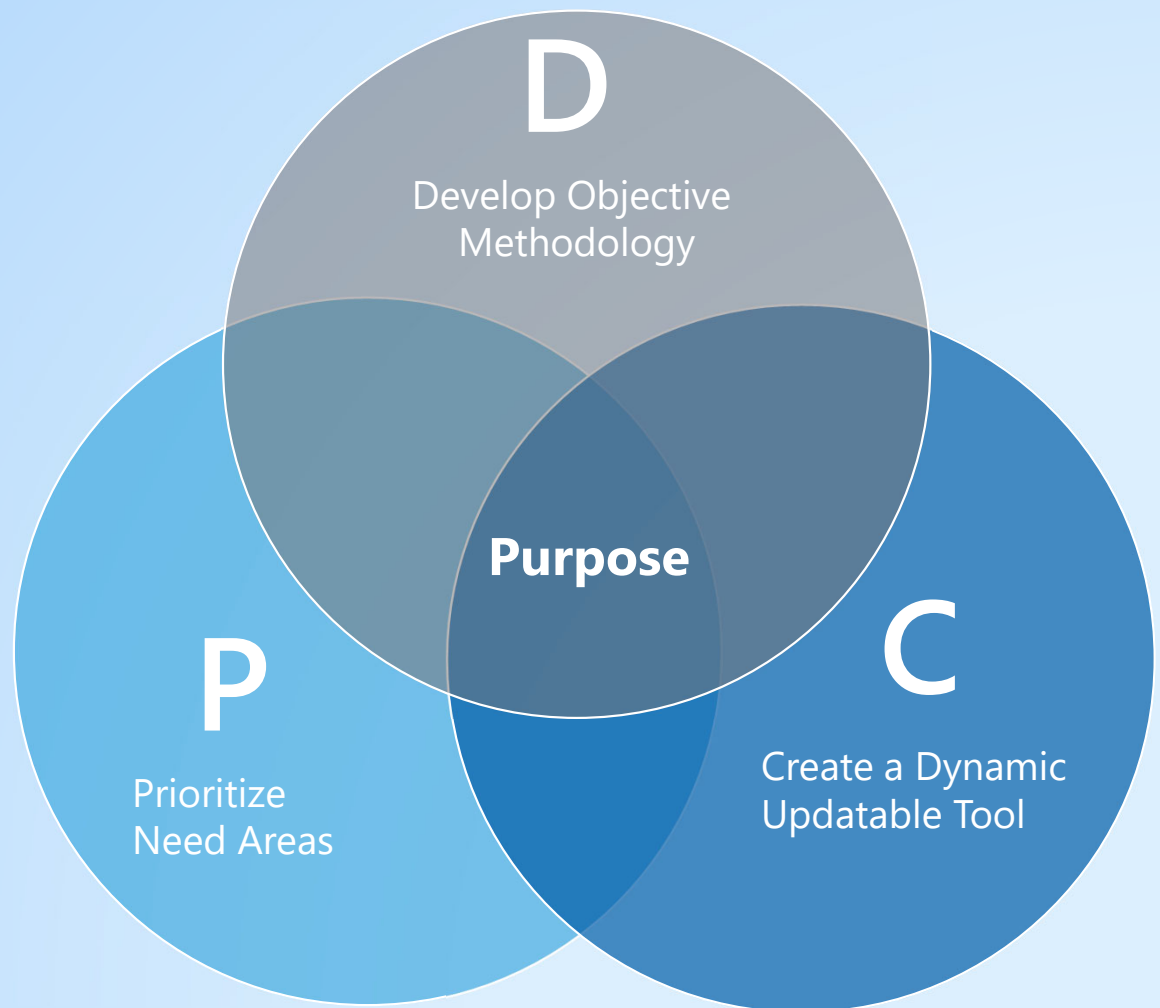
Eric Harold, PE, BCEE
eharold@carollo.com
703.376.7029

Questions?

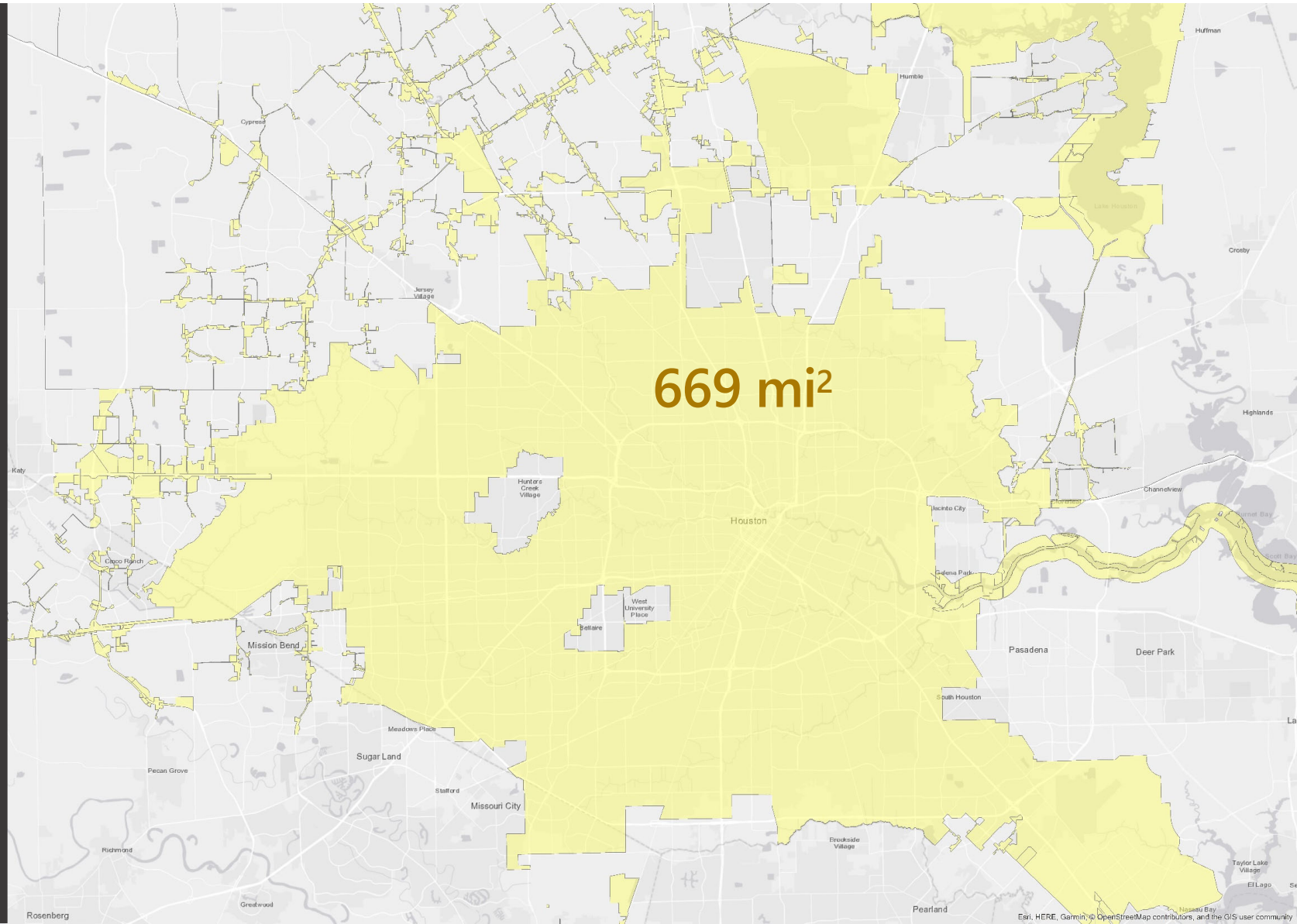




Purpose of the SWEET Tool



City of
Houston



Harris County's Watersheds

(General Flow Direction)

