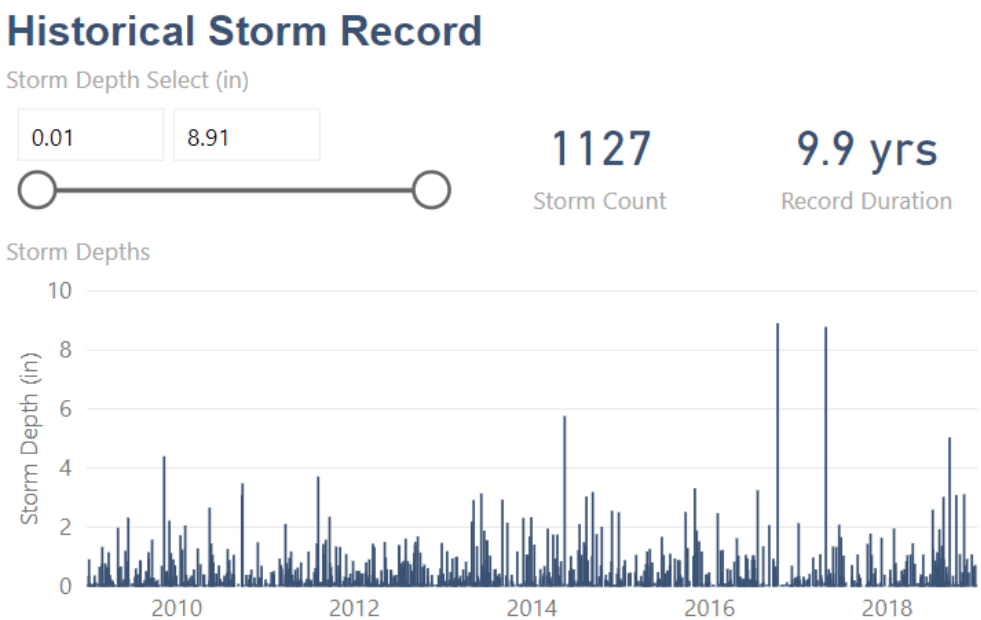
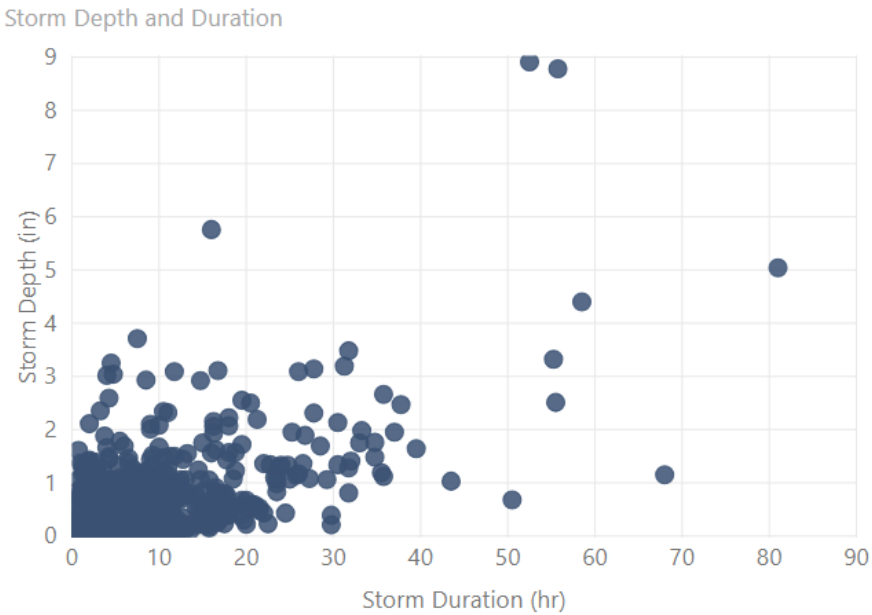
Hazen





Streamlined Data Visualization and Analytics for Smart Stormwater Management

Matthew Zelin, PE mzelin@hazenandsawyer.com

Ryan O'Banion robanion@hazenandsawyer.com

Importance of Storm Characteristics

Depth

Frequency

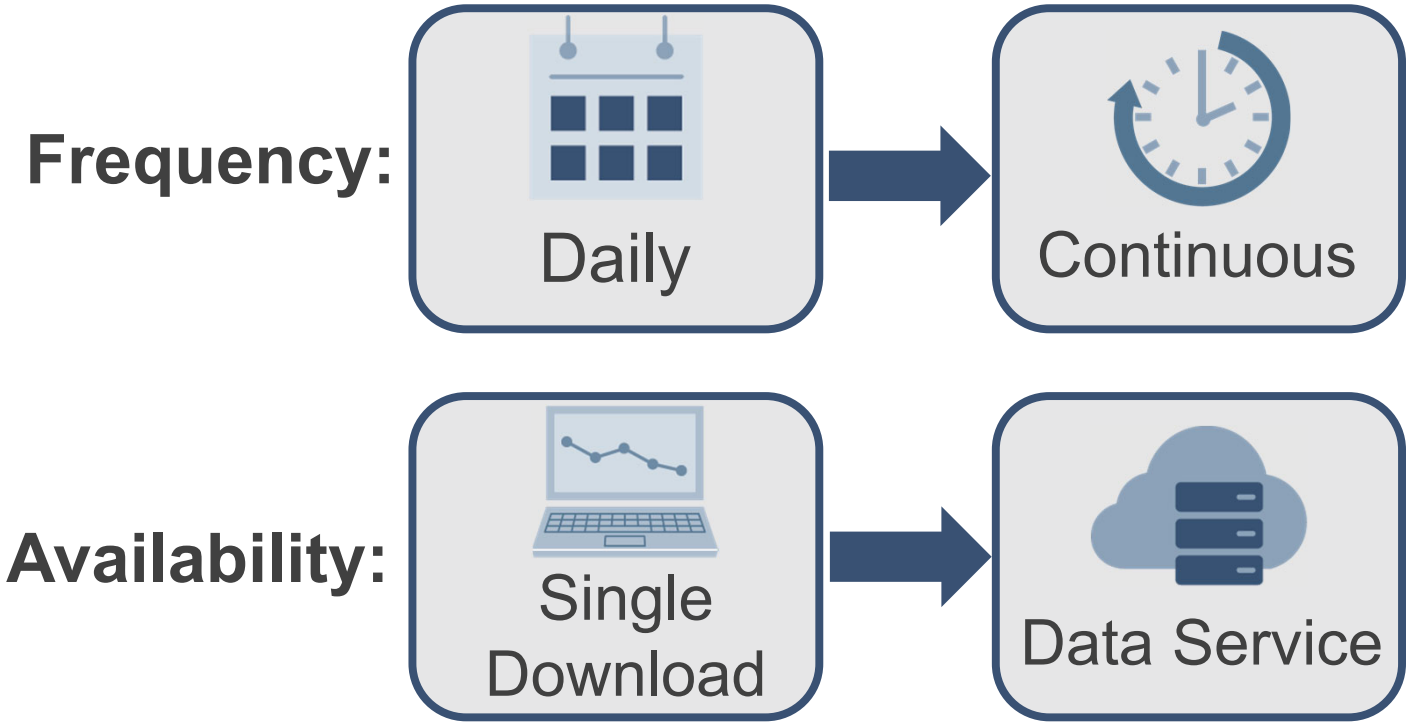
Intensity

Duration

Storm Characteristics are Changing

Stormwater Challenges are Changing

Data are Changing



Potential Data Sources

- USGS
  - Flow
  - Water level
  - Precipitation
  - Water quality
- NOAA
  - Historical precipitation
  - Atlas 14 analysis
  - Precipitation forecast
- EPA
  - Water quality (WQP)
- Local Records
  - MS4 sampling
  - Biological sampling
  - Drainage complaints
  - Maintenance records
- And More…

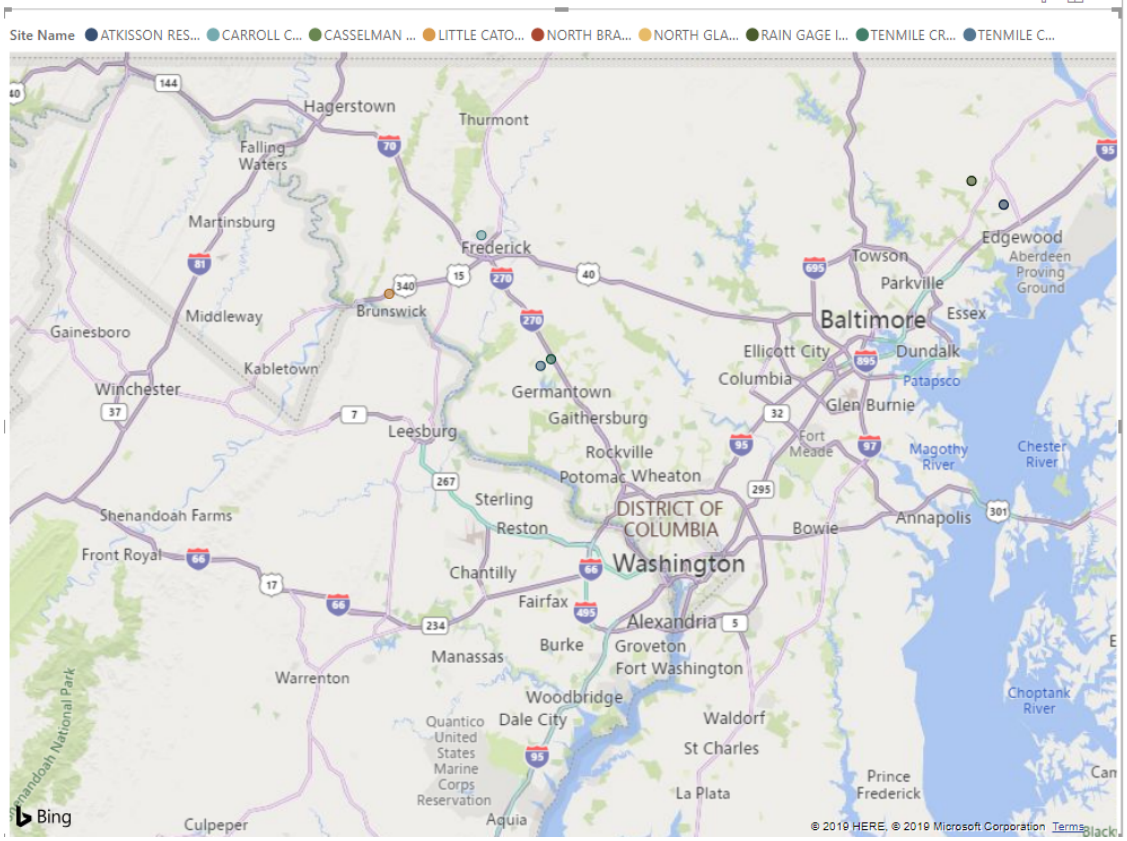
USGS Precipitation Gage Network

US State

Maryland

9

Available Ga



Site Name	Site Number
ATKISSON RESERVOIR NEAR BEL AIR, MD	01581753
CARROLL CREEK NEAR FREDERICK, MD	01642198
CASSELMAN RIVER AT GRANTSVILLE, MD	03078000
LITTLE CATOCTIN CREEK NEAR ROSEMONT, MD	01636845
NORTH BRANCH POTOMAC RIVER NEAR CUMBERLAND, MD	01603000
NORTH GLADE RUN NEAR SWANTON, MD	03075825
RAIN GAGE IN WINTERS RUN BASIN AT FALLSTON, MD	393126076244301
TENMILE CREEK PRECIP GAGE AT CLARKSBURG, MD	391407077174001
TENMILE CREEK PRECIPITATION GAGE AT SLIDELL, MD	391328077185901

Native Data not Necessarily User-Friendly

```
# Data for the following 1 site(s) are contained in this file
#    USGS 02110701 CRABTREE SWAMP AT CONWAY, SC
# ----------------------------------------------------------------------------
#
# Data provided for site 02110701
#            TS   parameter     Description
#        176772       00045     Precipitation, total, inches
#
# Data-value qualification codes included in this output:
#     A  Approved for publication -- Processing and review completed.
#     P  Provisional data subject to revision.
#
agency_cd       site_no datetime        tz_cd   176772_00045    176772_00045_cd
5s      15s     20d     6s      14n     10s
USGS    02110701        2009-01-06 00:00        EST     0.00    A
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USGS    02110701        2009-01-06 02:45        EST     0.00    A
USGS    02110701        2009-01-06 03:00        EST     0.00    A
USGS    02110701        2009-01-06 03:15        EST     0.00    A
USGS    02110701        2009-01-06 03:30        EST     0.00    A
USGS    02110701        2009-01-06 03:45        EST     0.00    A
USGS    02110701        2009-01-06 04:00        EST     0.00    A
USGS    02110701        2009-01-06 04:15        EST     0.00    A
USGS    02110701        2009-01-06 04:30        EST     0.00    A
```

10 Years of 15-Minute Data

350,000 Records

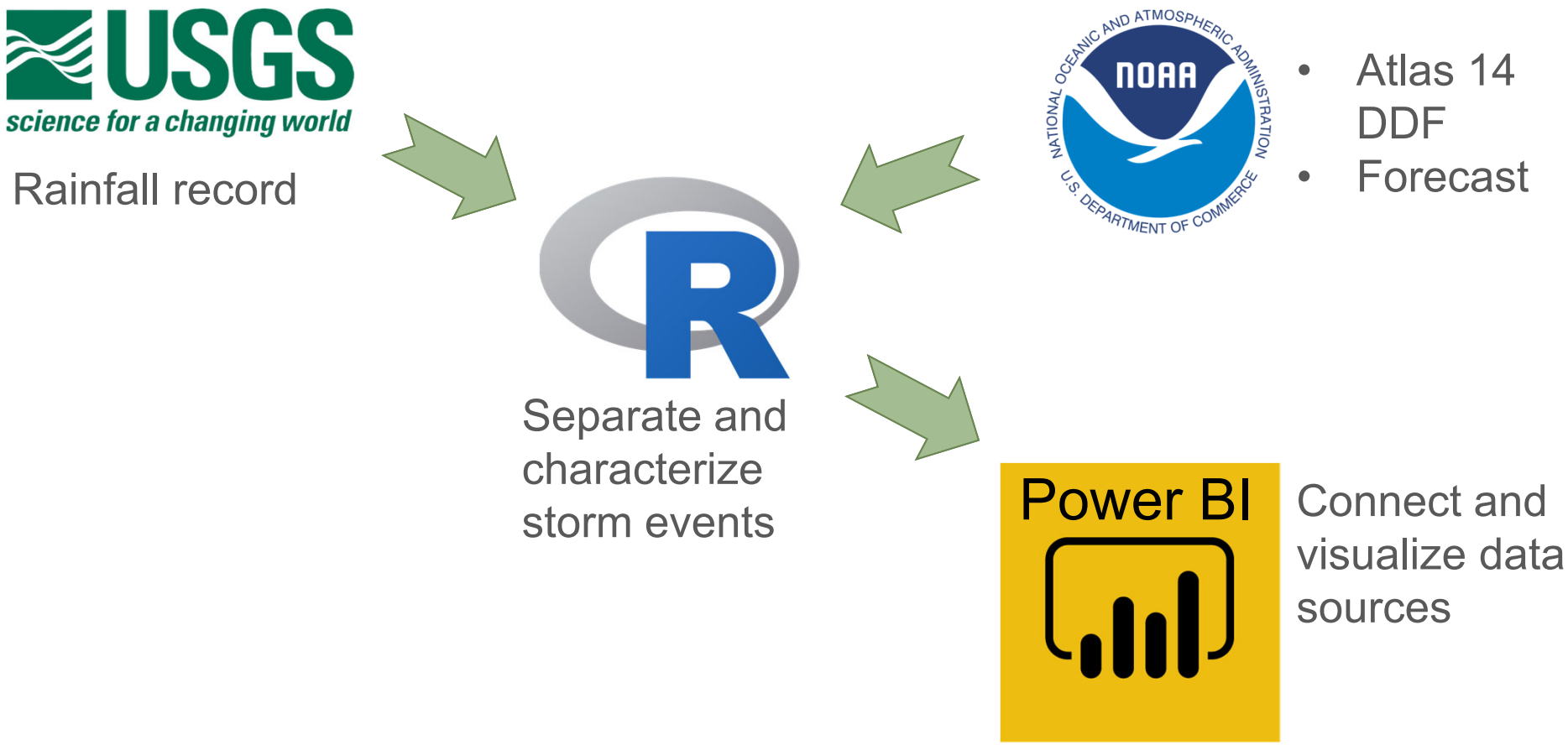
10,000 – 20,000
Typical Records with Rainfall

0.75 miles
of printed pages

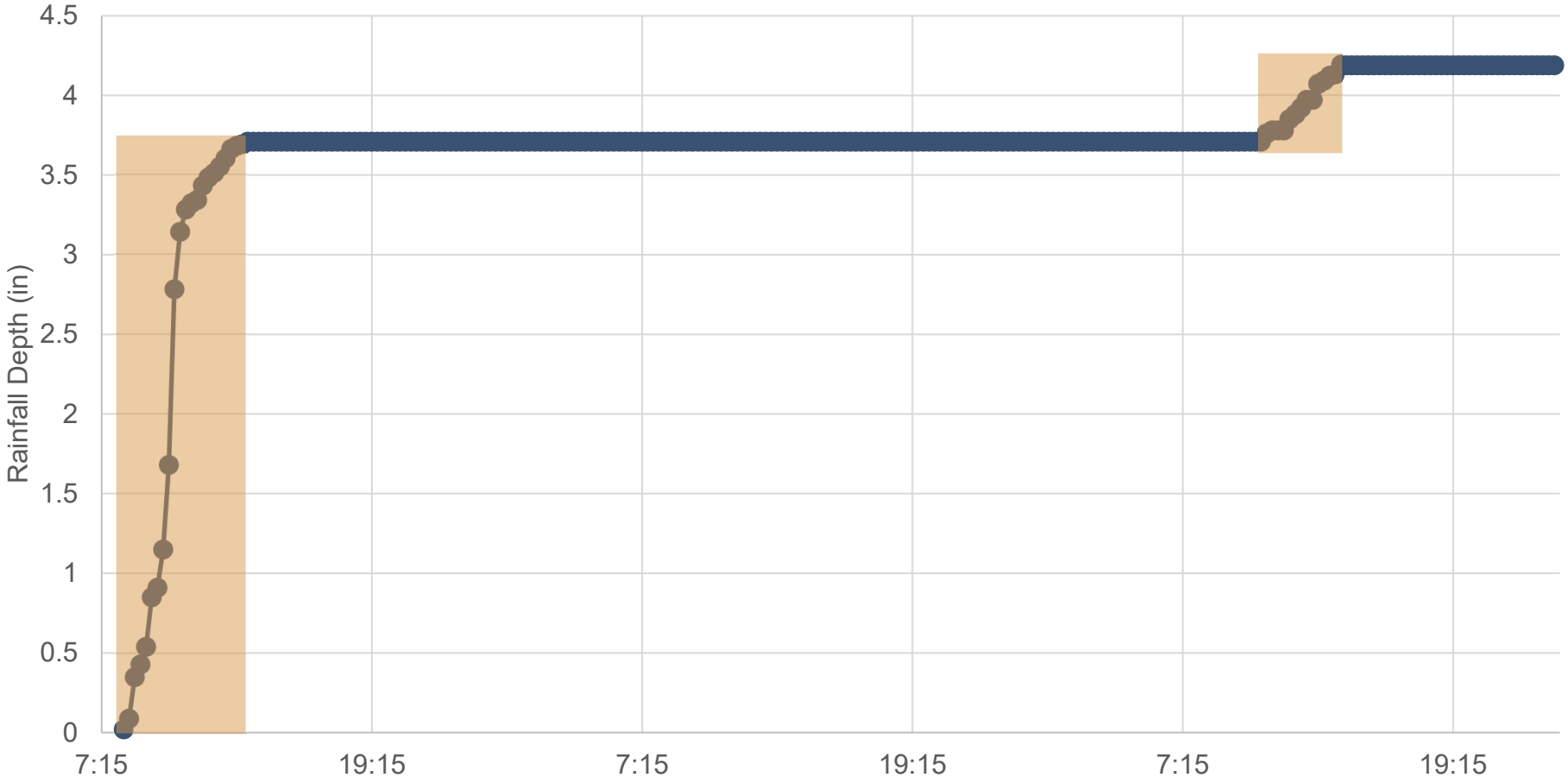
Analysis Tool Objectives

- Streamline analysis
- Visualize results
- Facilitate regular updates
- Support association with varied datasets

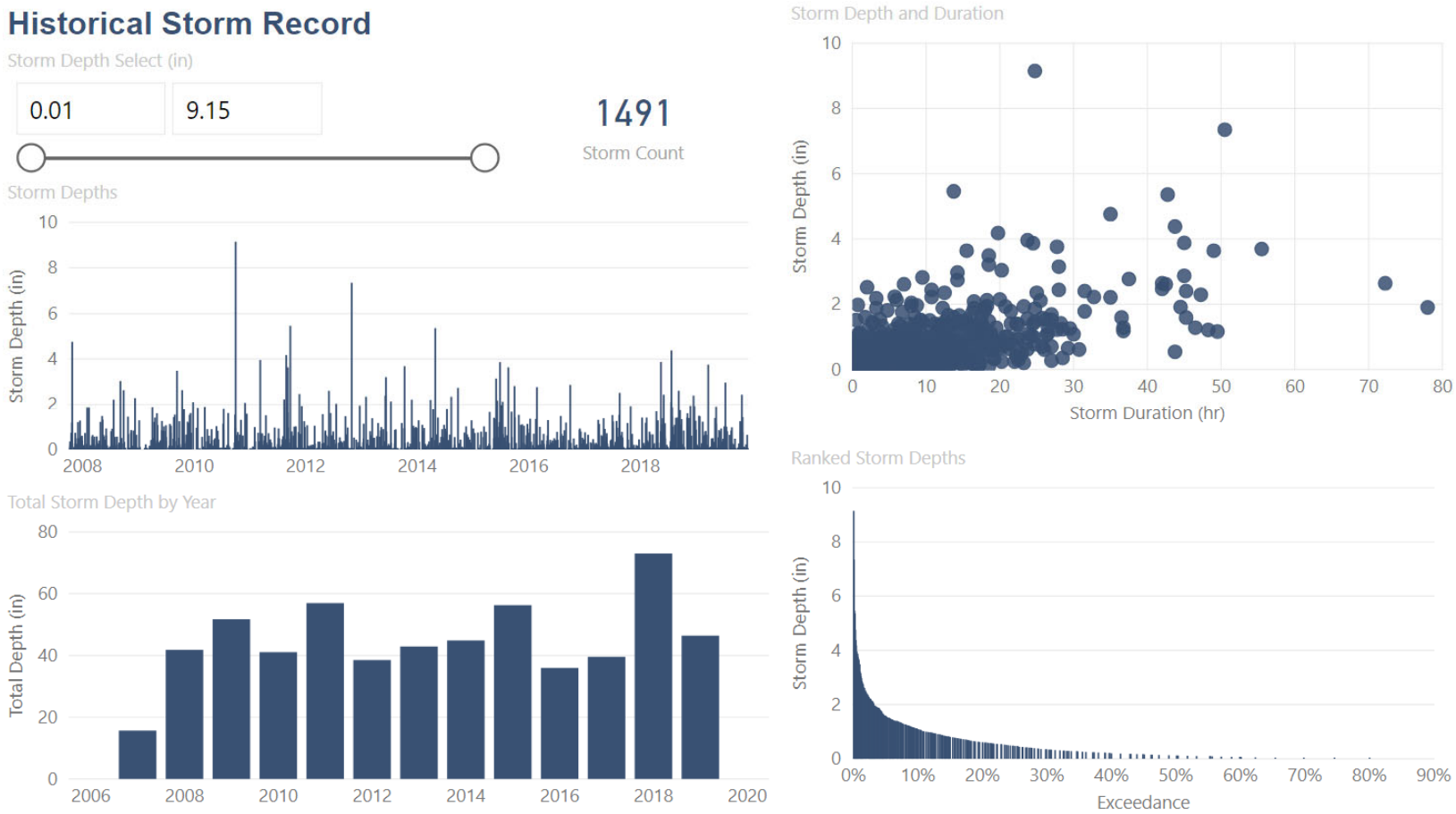
Framework for Analysis



Defining Storm Events



Historical Storm Overview



Historical Storm Record

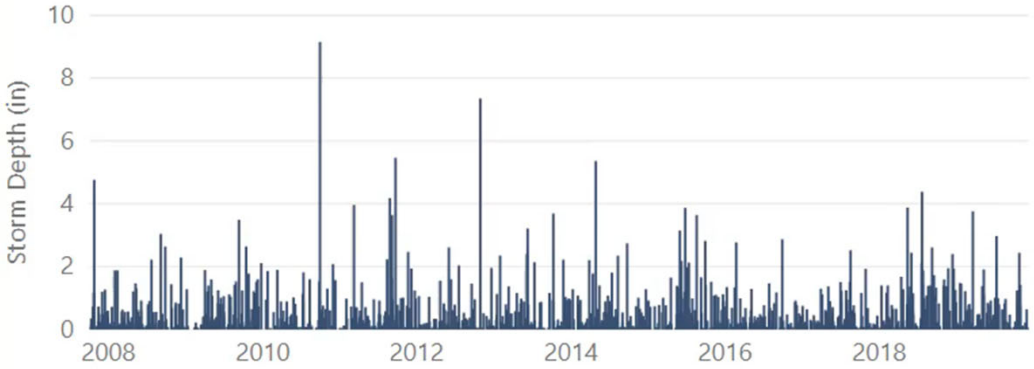
Storm Depth Select (in)

0.01 9.15

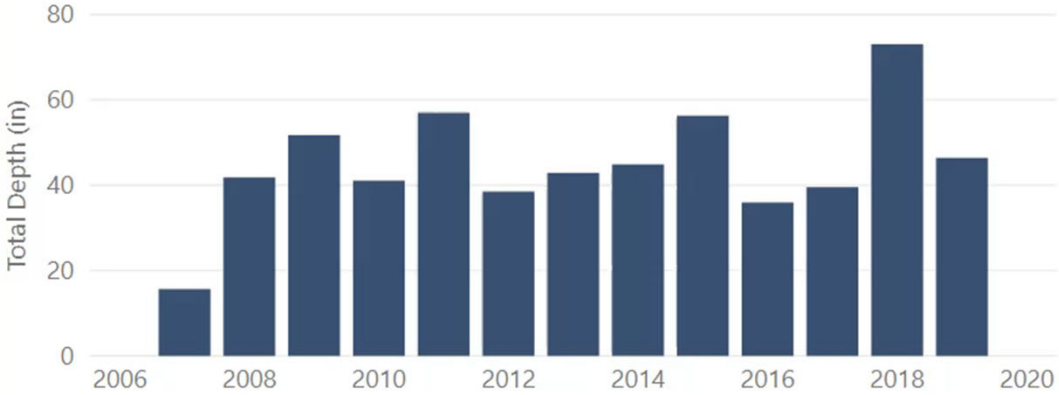
1491

Storm Count

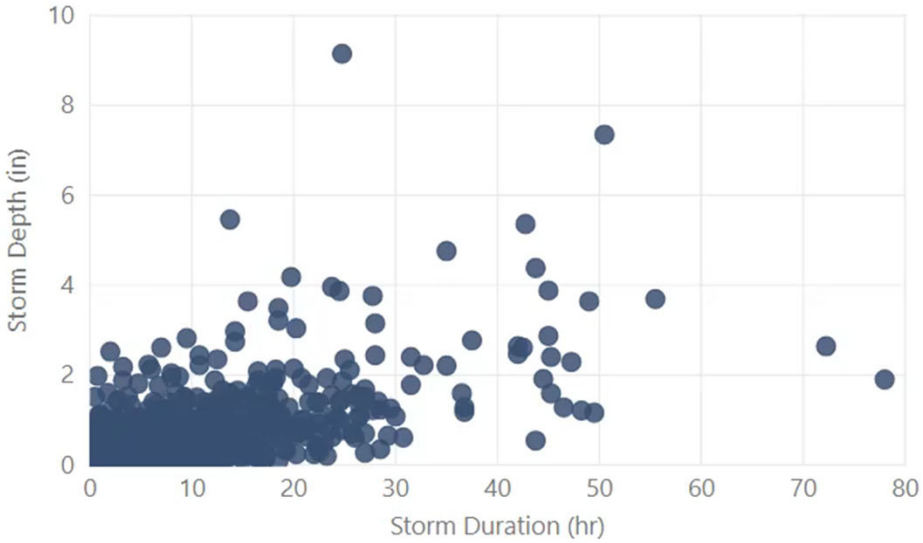
Storm Depths



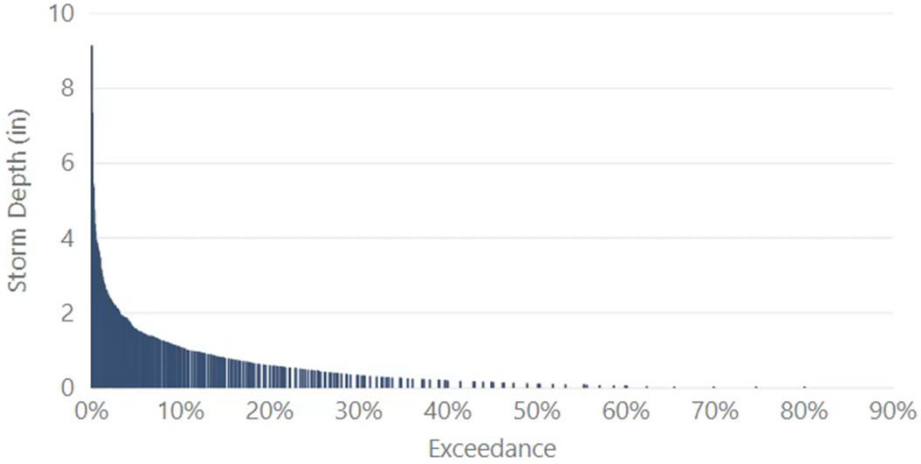
Total Storm Depth by Year



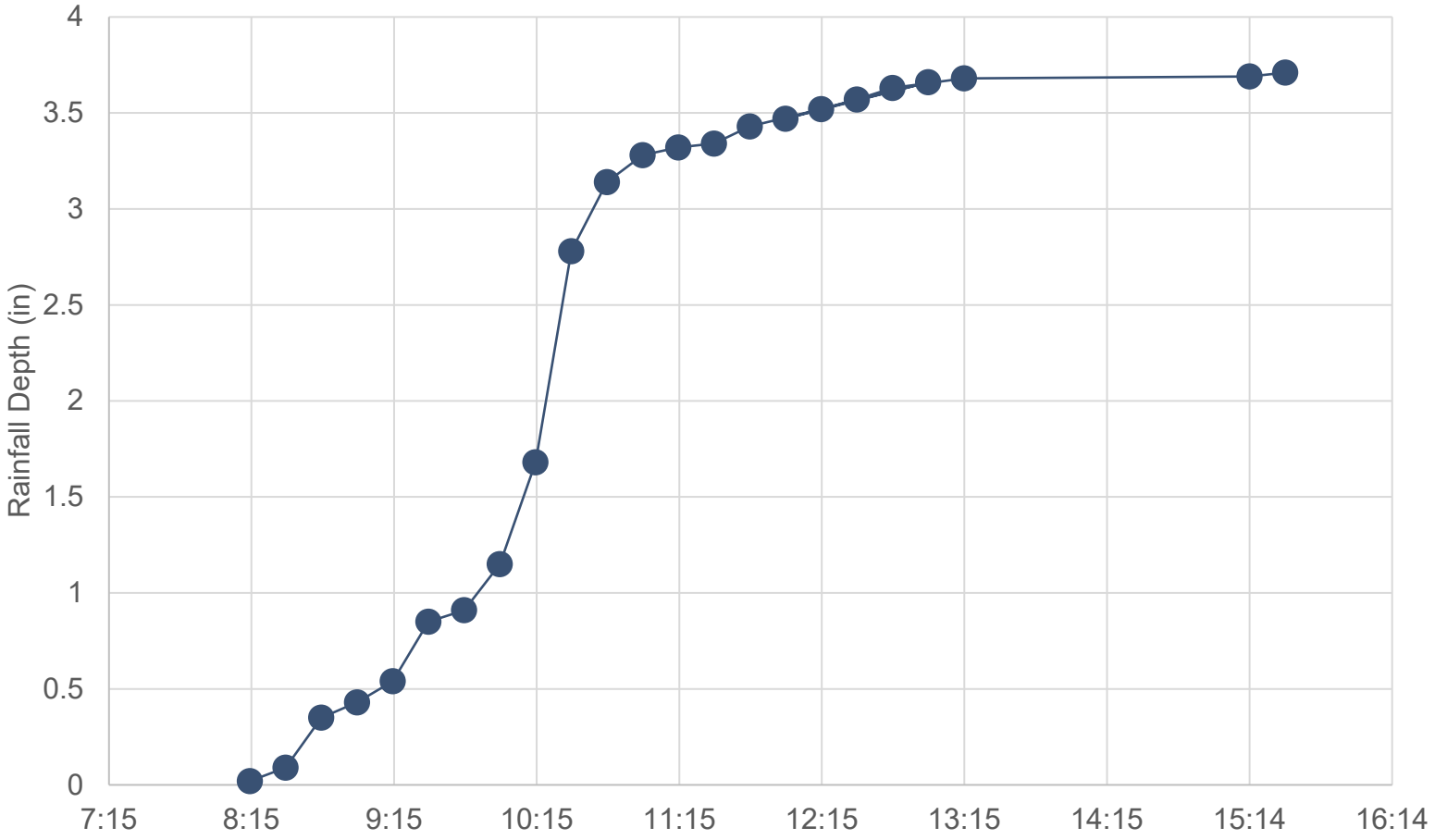
Storm Depth and Duration



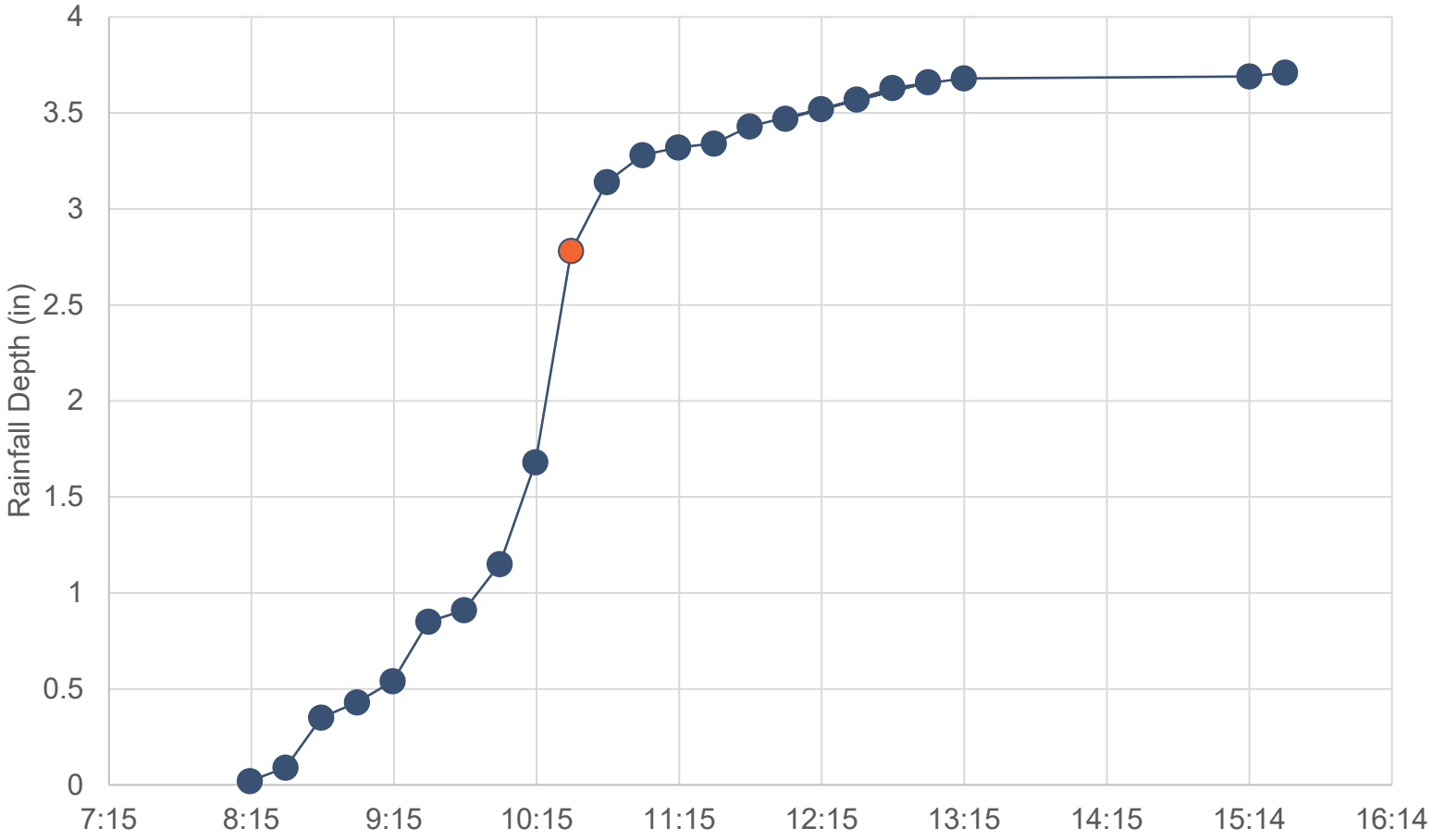
Ranked Storm Depths



Better Understanding Storm Characteristics

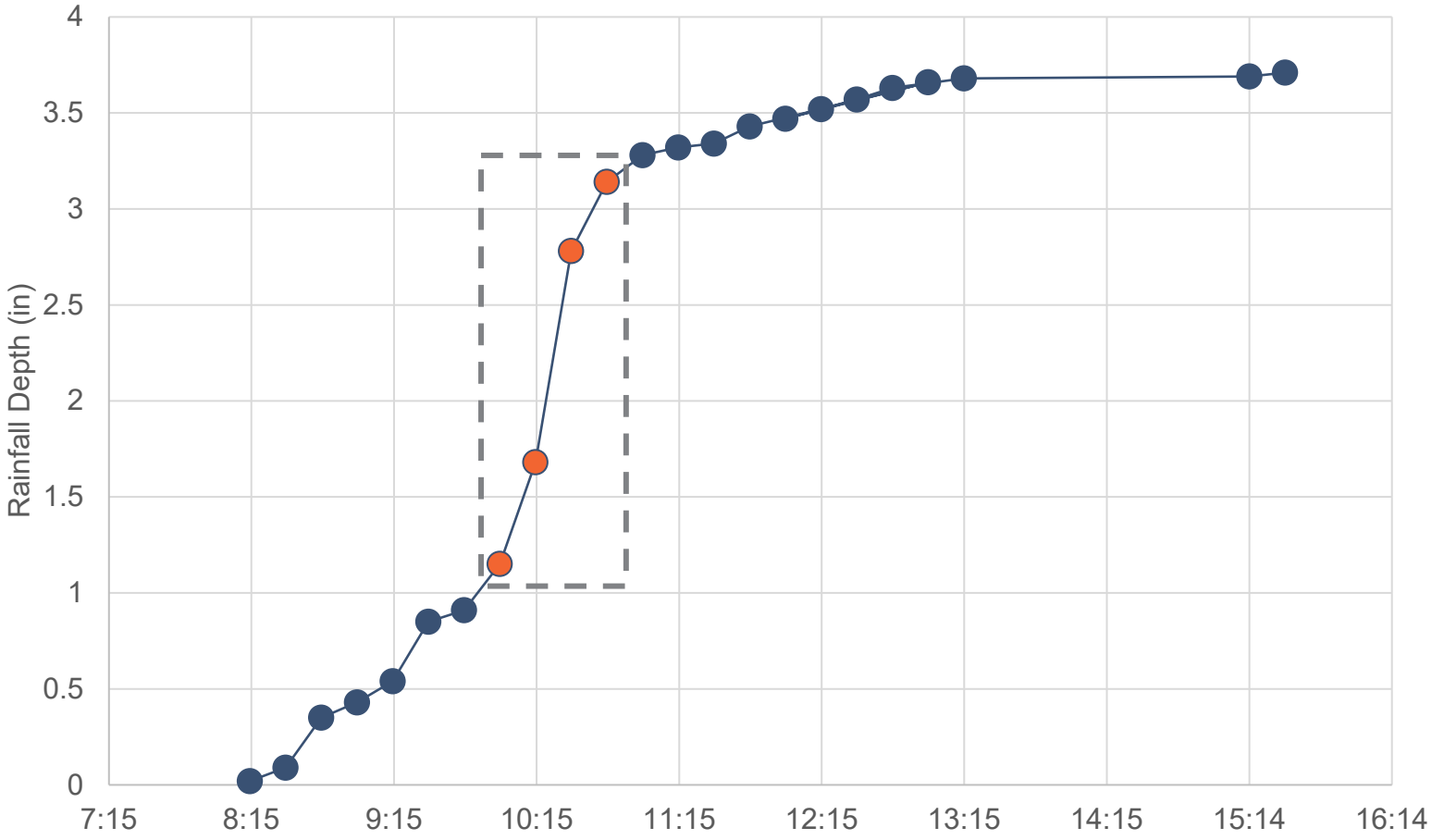


Better Understanding Storm Characteristics



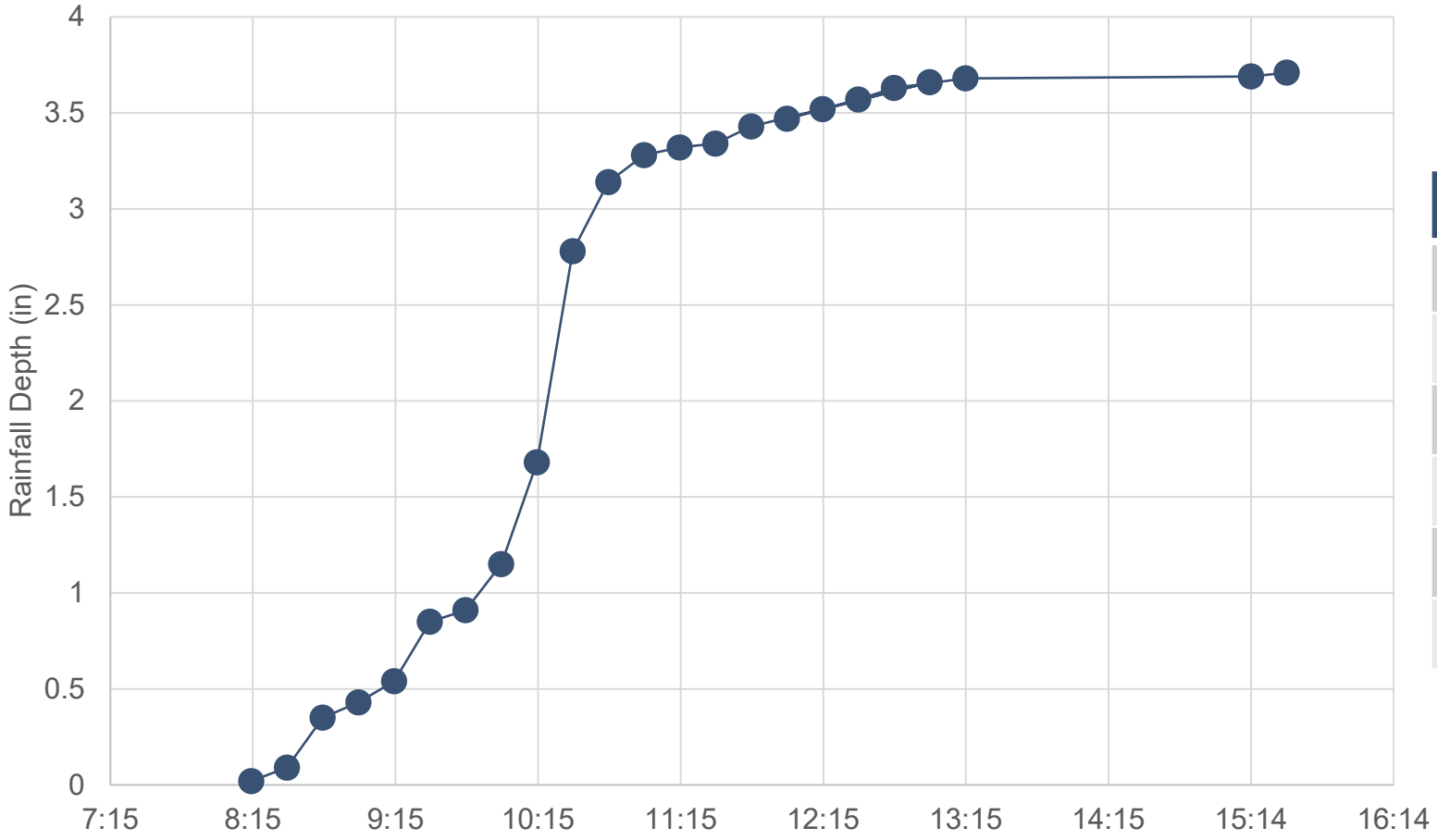
Max Intensity

Better Understanding Storm Characteristics



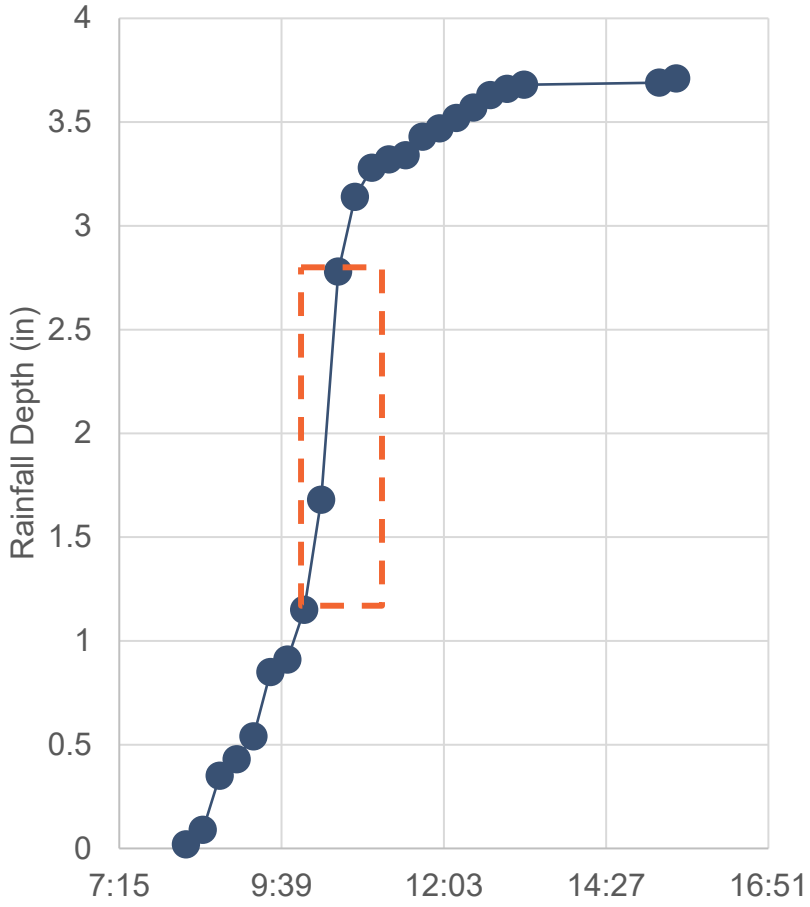
Max 60-min Depth

Better Understanding Storm Characteristics



Duration	Max Depth
30-min	1.63”
60-min	2.23”
2-hr	2.85”
6-hr	3.68”
12-hr	3.71”
24-hr	3.71”

NOAA Atlas 14 Comparisons



Duration	Max Observed	1-yr Depth	2-yr Depth	5-yr Depth	10-yr Depth
30-min	1.63”	1.10”	1.31”	1.56”	1.76”

Filtering Storm Characteristics

Storm Depth (in)

0.01 9.15

Storm Duration (hr)

0.00 78.00

Peak 15-min Intensity (in/hr)

0.04 4.88

Peak 1-hr Intensity (in/hr)

0.01 2.98

Max 24-hr Depth (in)

0.01 9.10

0.80
Median of Storm Depth (in)

2.25
Median of Duration (hr)

0.16
Median Peak 15-min Intensity (in/hr)

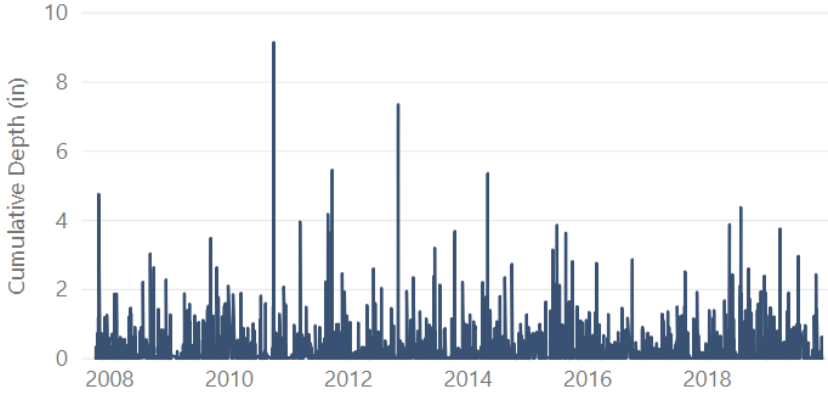
0.07
Median Peak 1-hr Intensity (in/hr)

0.13
Median Peak 24-hr Depth (in)

1491
Storm Count

StormStart	Storm Depth	Duration
9/30/2010 6:30:00 AM	9.15	24.75
10/28/2012 10:00:00 PM	7.35	50.50
9/23/2011 10:00:00 AM	5.46	13.75
4/29/2014 2:30:00 PM	5.36	42.75
10/26/2007 3:45:00 AM	4.76	35.00
7/23/2018 10:30:00 AM	4.38	43.75
8/27/2011 4:45:00 PM	4.18	19.75
3/10/2011 5:00:00 AM	3.96	23.75
5/15/2018 11:15:00 PM	3.88	45.00
6/27/2015 10:30:00 AM	3.87	24.50
3/21/2019 6:45:00 AM	3.76	27.75
10/10/2013 1:00:00 AM	3.69	55.50
9/6/2011 1:45:00 PM	3.64	49.00
8/20/2015 8:45:00 AM	3.64	15.50
9/11/2009 6:15:00 AM	3.49	18.50

Storm Viewer



Storm Depth (in)

1.97 9.15

Storm Duration (hr)

0.00 78.00

Peak 15-min Intensity (in/hr)

1.95 4.88

Peak 1-hr Intensity (in/hr)

1.01 2.98

Max 24-hr Depth (in)

0.01 9.10

3.88
Median of Storm Depth (in)

10.38
Median of Duration (hr)

2.38
Median Peak 15-min Intensity (in/hr)

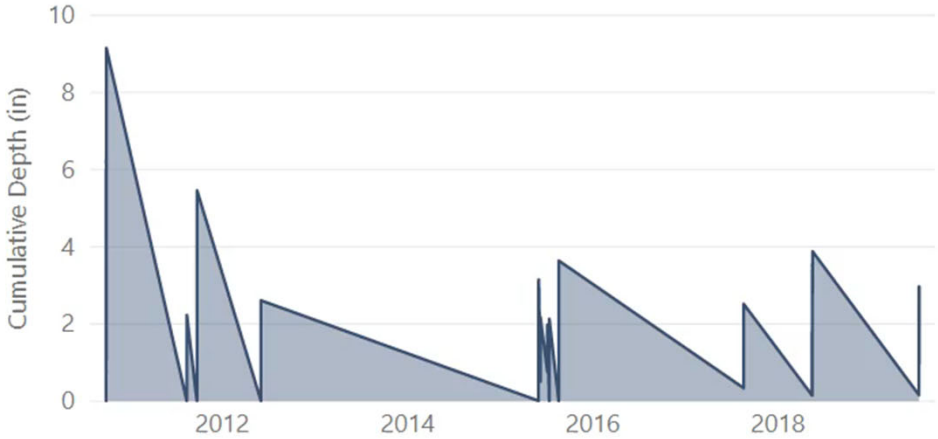
1.55
Median Peak 1-hr Intensity (in/hr)

2.57
Median Peak 24-hr Depth (in)

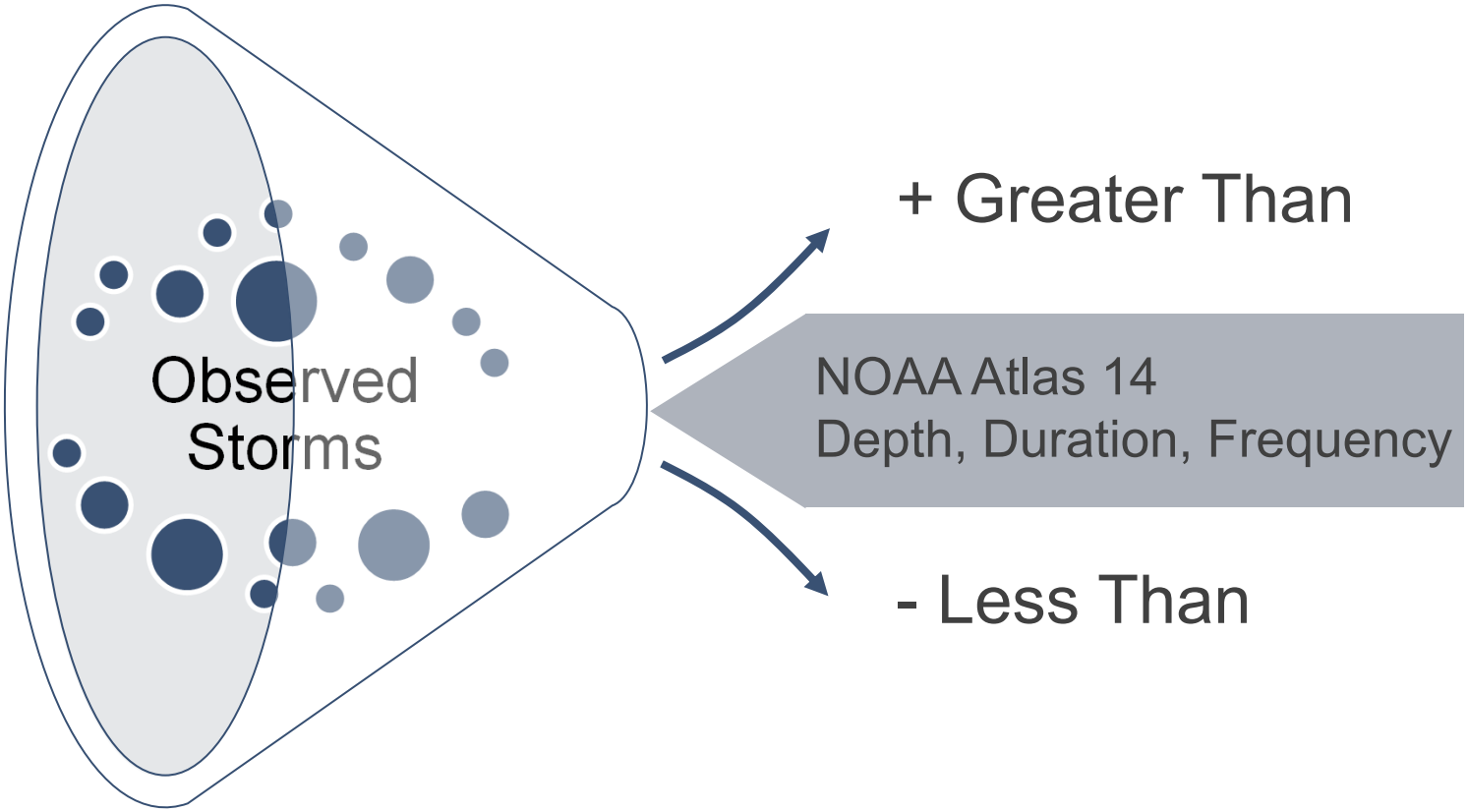
12
Storm Count

StormStart	Storm Depth	Duration
9/30/2010 6:30:00 AM	9.15	24.75
9/23/2011 10:00:00 AM	5.46	13.75
5/15/2018 11:15:00 PM	3.88	45.00
8/20/2015 8:45:00 AM	3.64	15.50
6/1/2015 7:30:00 PM	3.15	28.00
7/11/2019 10:15:00 AM	2.97	14.25
6/1/2012 9:00:00 PM	2.61	7.00
8/18/2017 9:15:00 PM	2.52	2.00
8/14/2011 11:15:00 AM	2.23	5.75
6/9/2015 12:15:00 AM	2.18	3.25
7/14/2015 5:00:00 AM	2.13	6.00
7/7/2015 2:15:00 AM	1.98	0.75

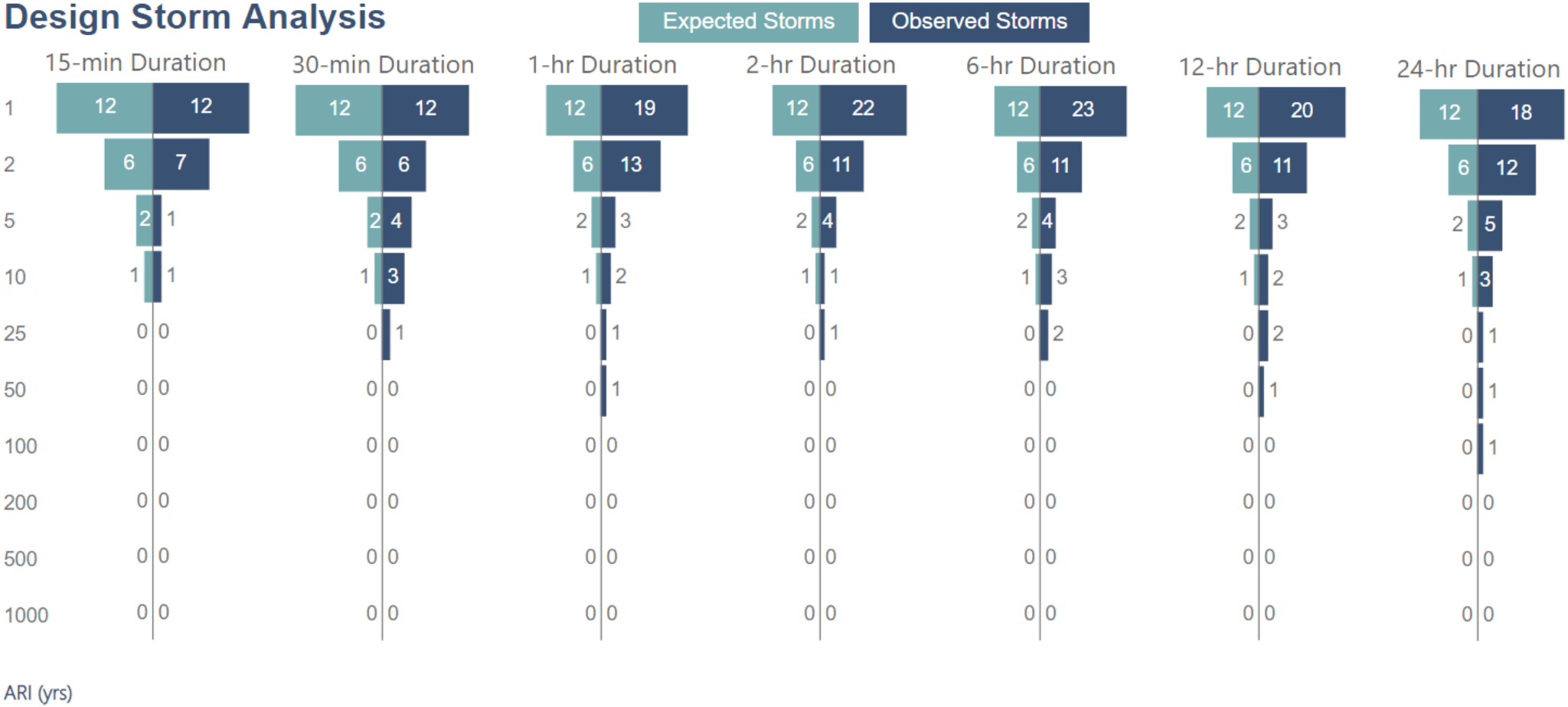
Storm Viewer



Comparing to NOAA Atlas 14



Design Storm Analysis



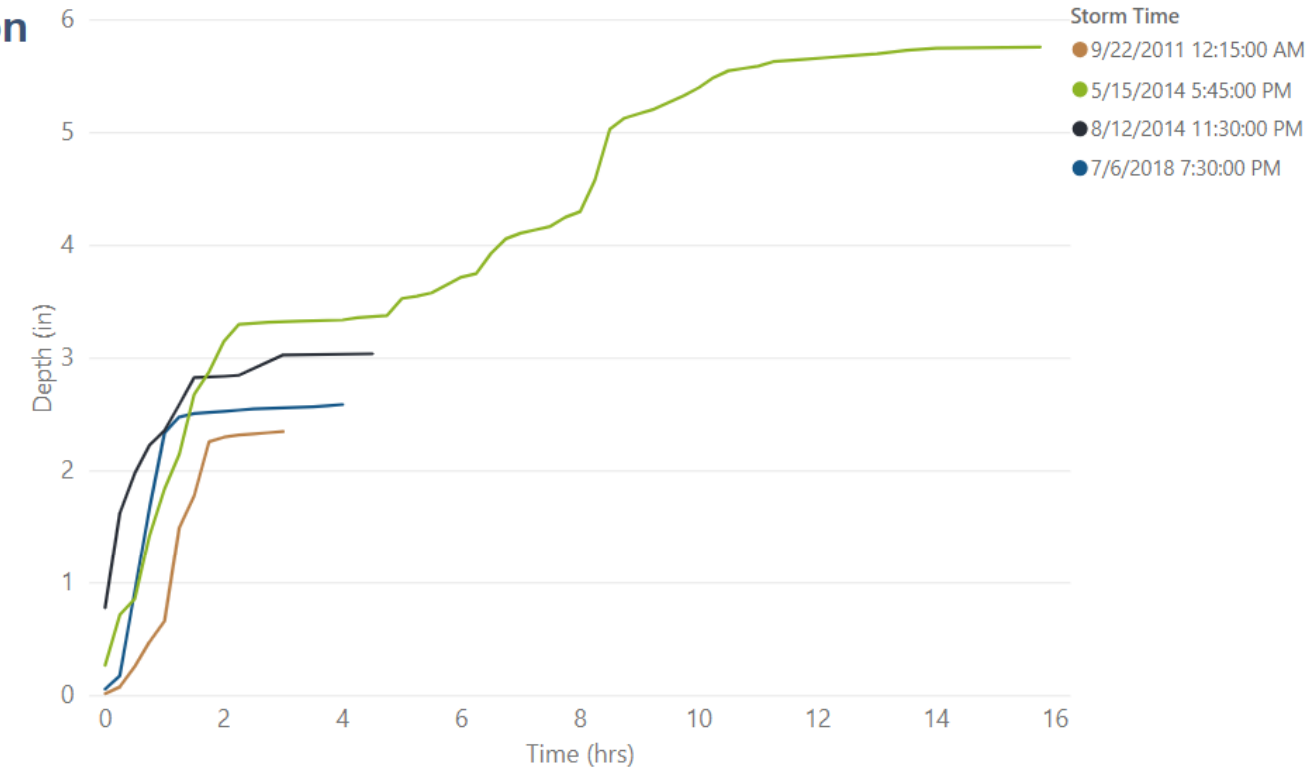
Storm Selection and Comparison

Storm Date

1/2/2009 12/31/2018

Storm Depth (in)

0.01 8.91



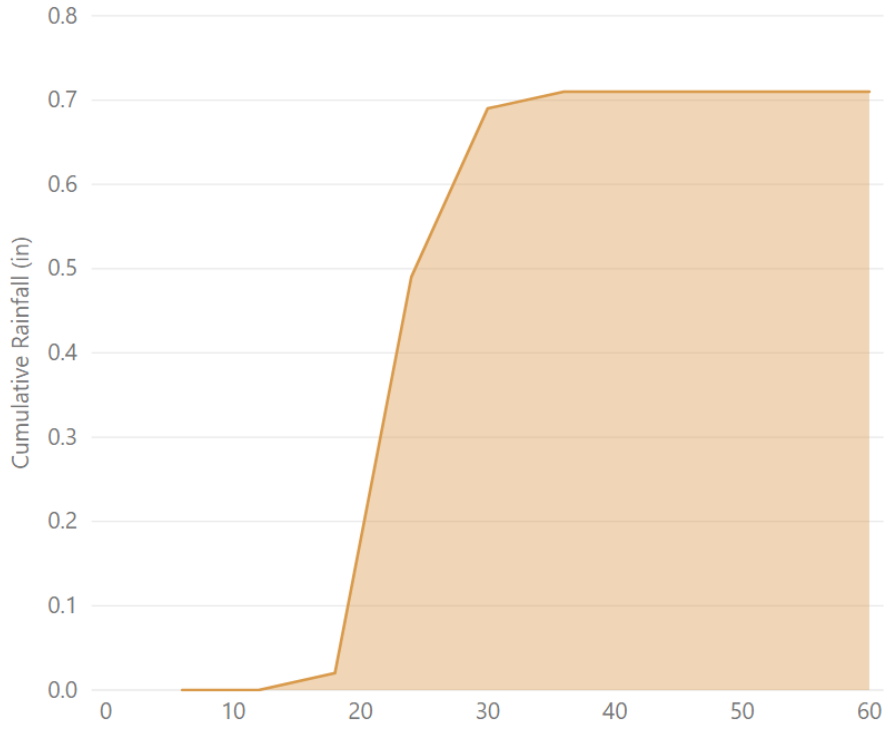
Storm Date	Duration (hrs)	Storm Depth	15-min ARI (yr)	60-min ARI	2-hr ARI	6-hr ARI	12-hr ARI	24-hr ARI	Antecedent Days
7/6/2018 7:30:00 PM	4.00	2.59		10	5	2	1		1.92
8/6/2011 8:15:00 AM	7.25	3.71	5	5	10	10	5	2	2.17
8/12/2014 11:30:00 PM	4.50	3.04	1	5	10	5	2	1	2.54
8/20/2018 3:30:00 AM	3.75	3.02		5	10	2	2	1	0.92
9/22/2011 12:15:00 AM	3.00	2.35	1	2	2	1			2.38
Total		**458.22**							

4

Storms

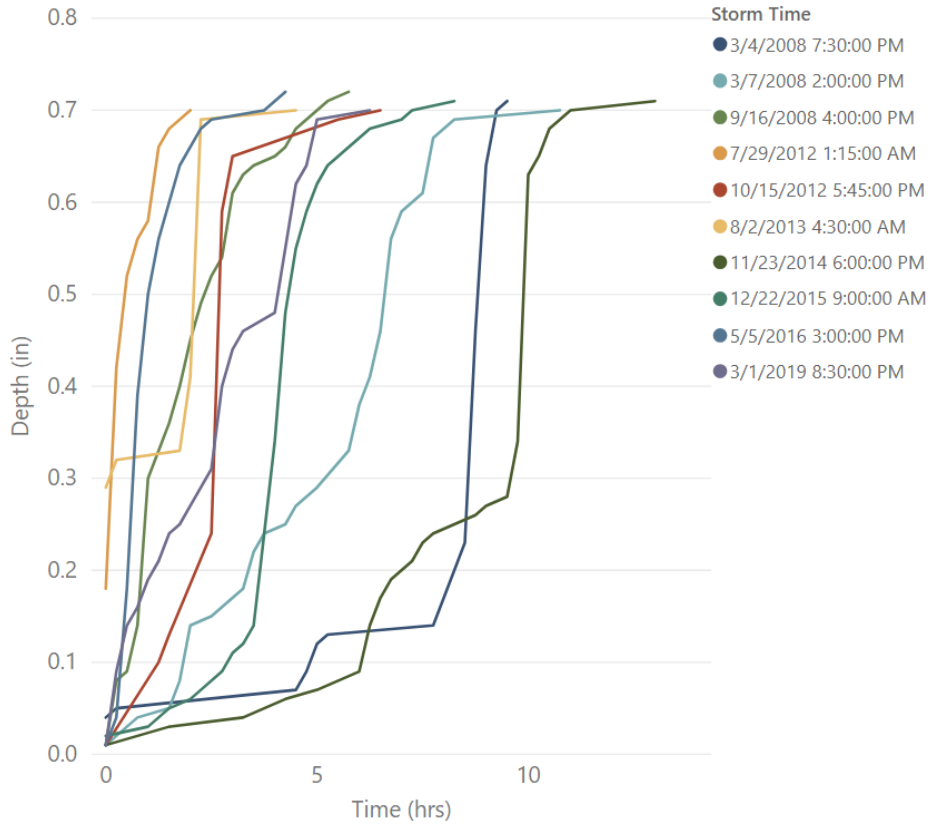
Context for Forecast Rainfall

Forecast Rainfall



10/15/2019 8:00:00 AM

Earliest Forecast

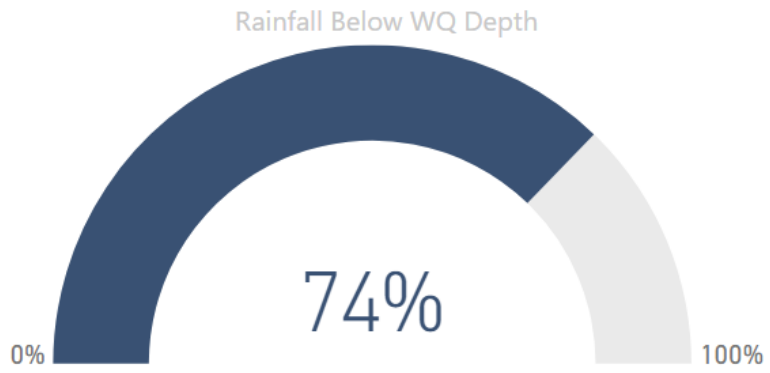


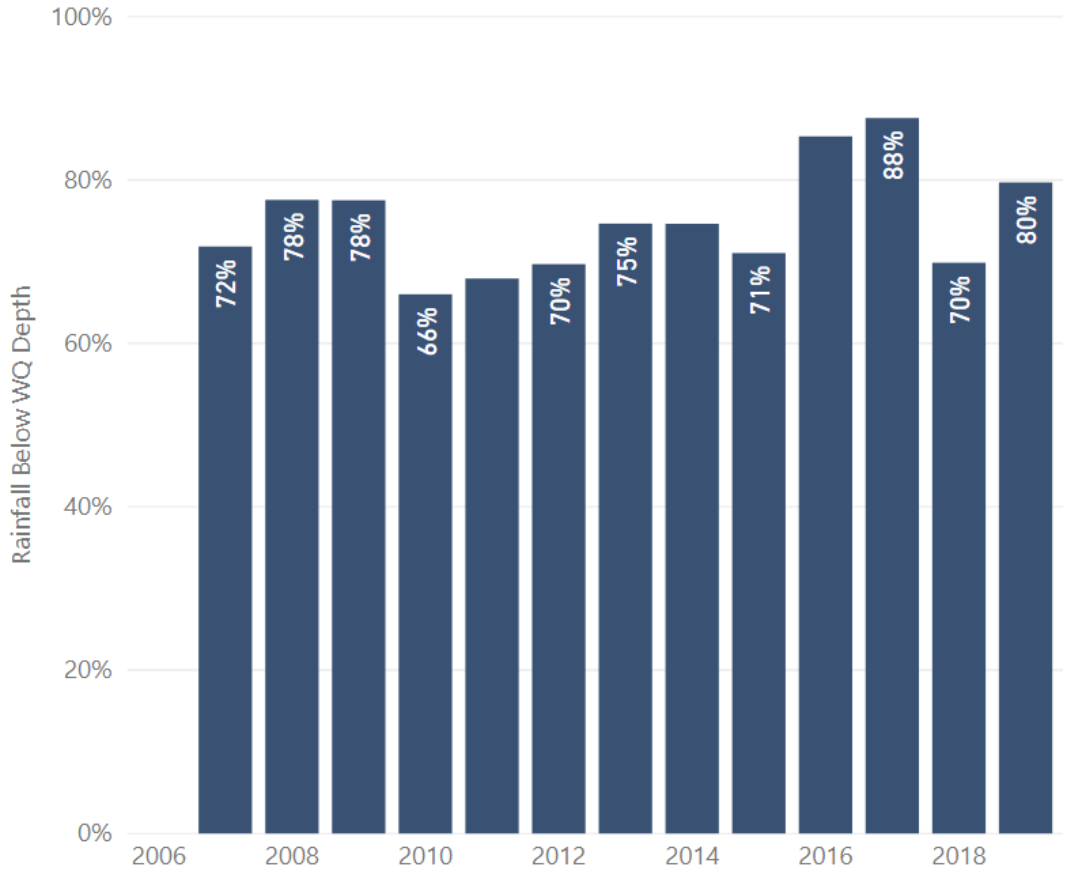
10 historical storms similar to forecast rainfall are selected based upon their total storm depth and peak 6-hour intensity.

Water Quality Storm Depth

Water Quality Depth (in)

1.0

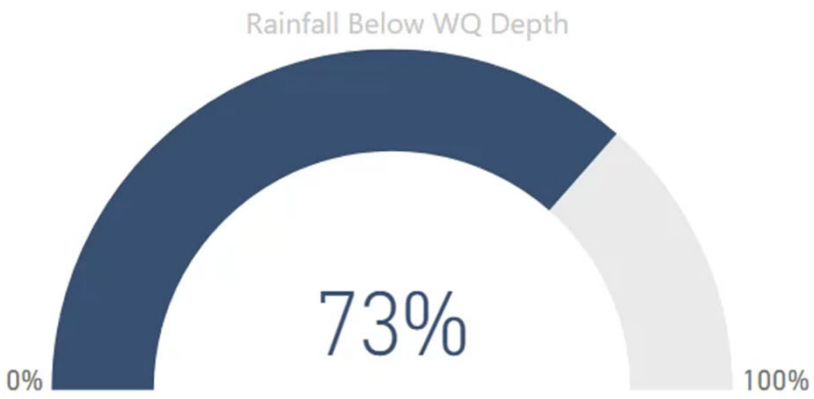


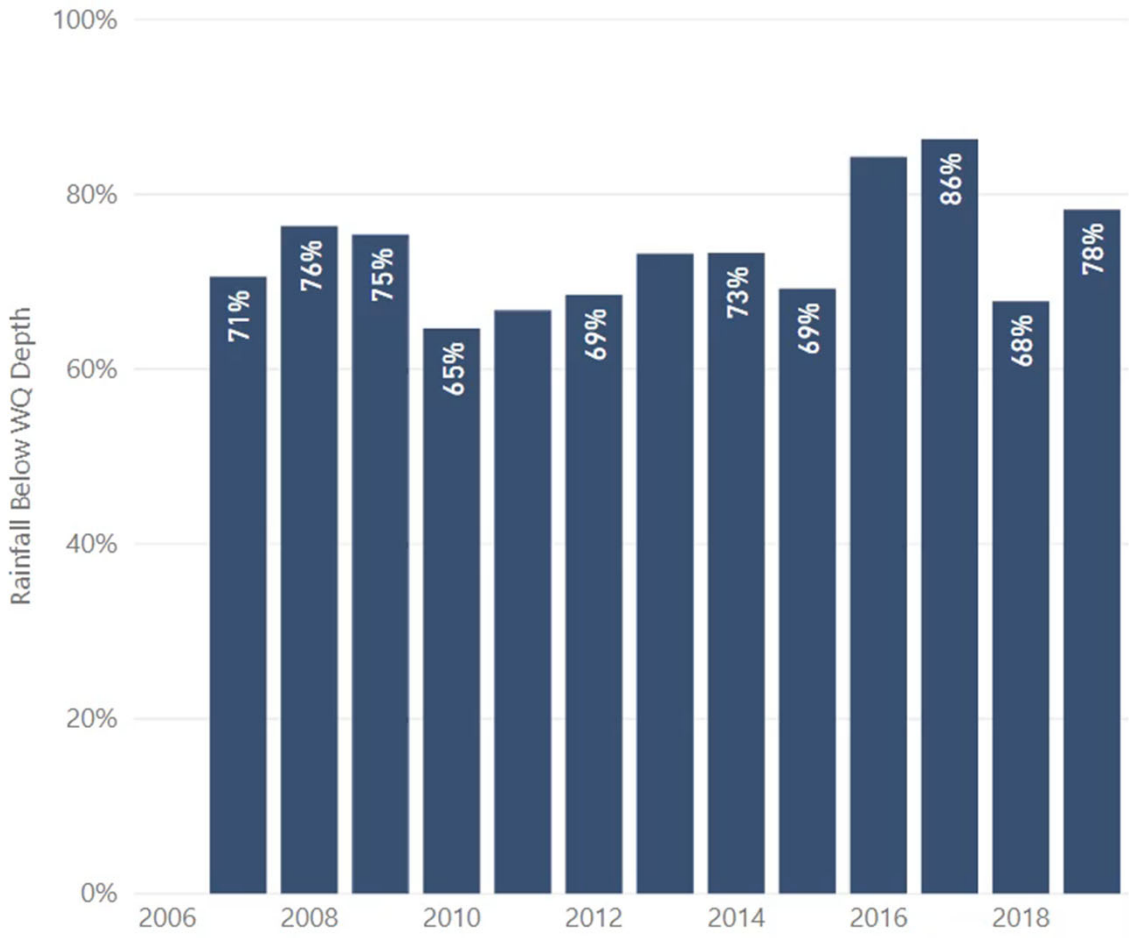


Water Quality Storm Depth

Water Quality Depth (in)

1.0





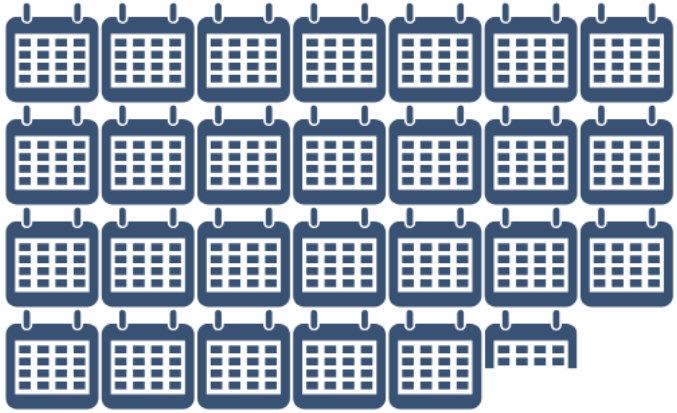
Water Quality Storm Frequency

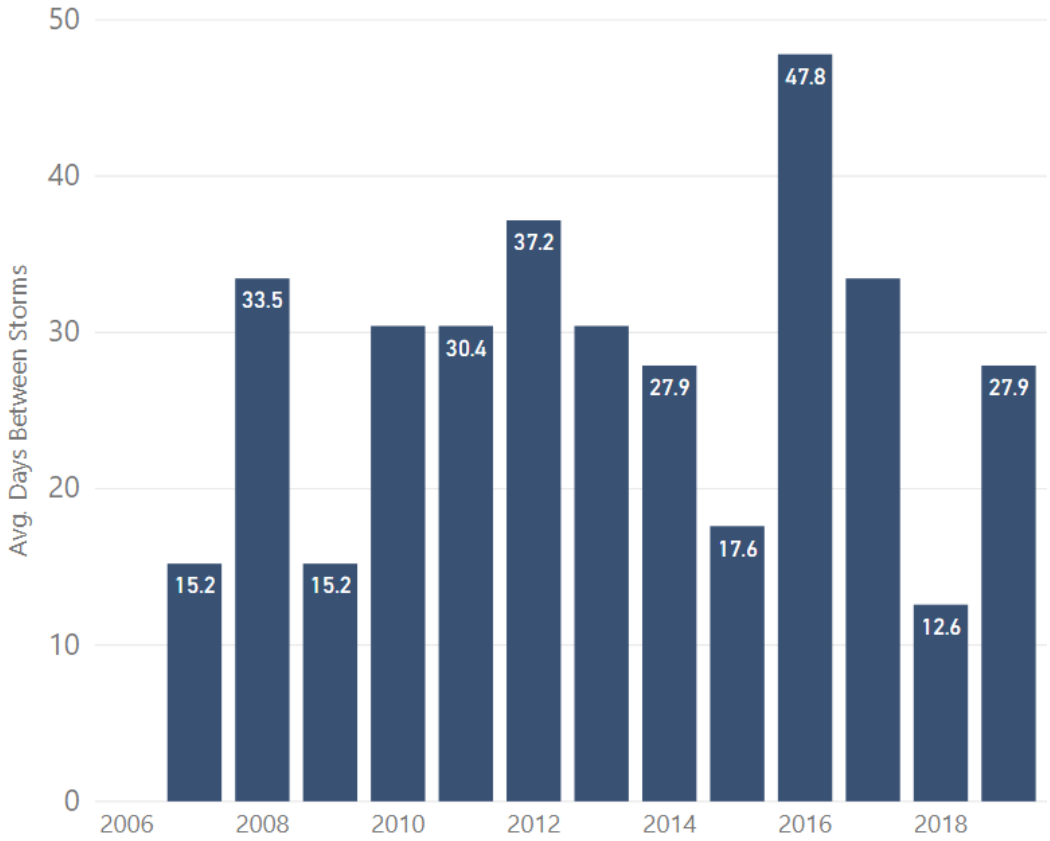
Water Quality Depth (in)

1.0

26.6

Average Days Between WQ Storms





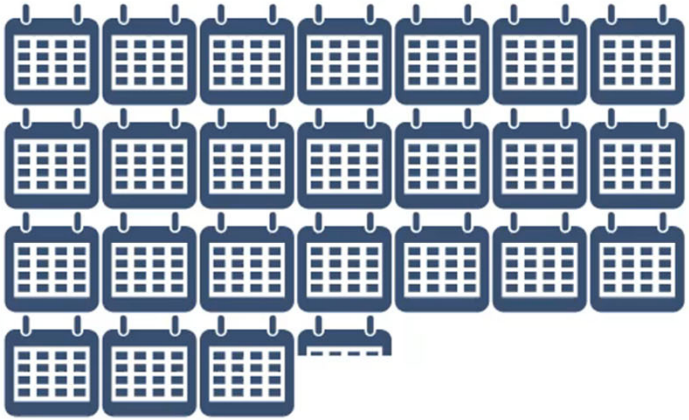
Water Quality Storm Frequency

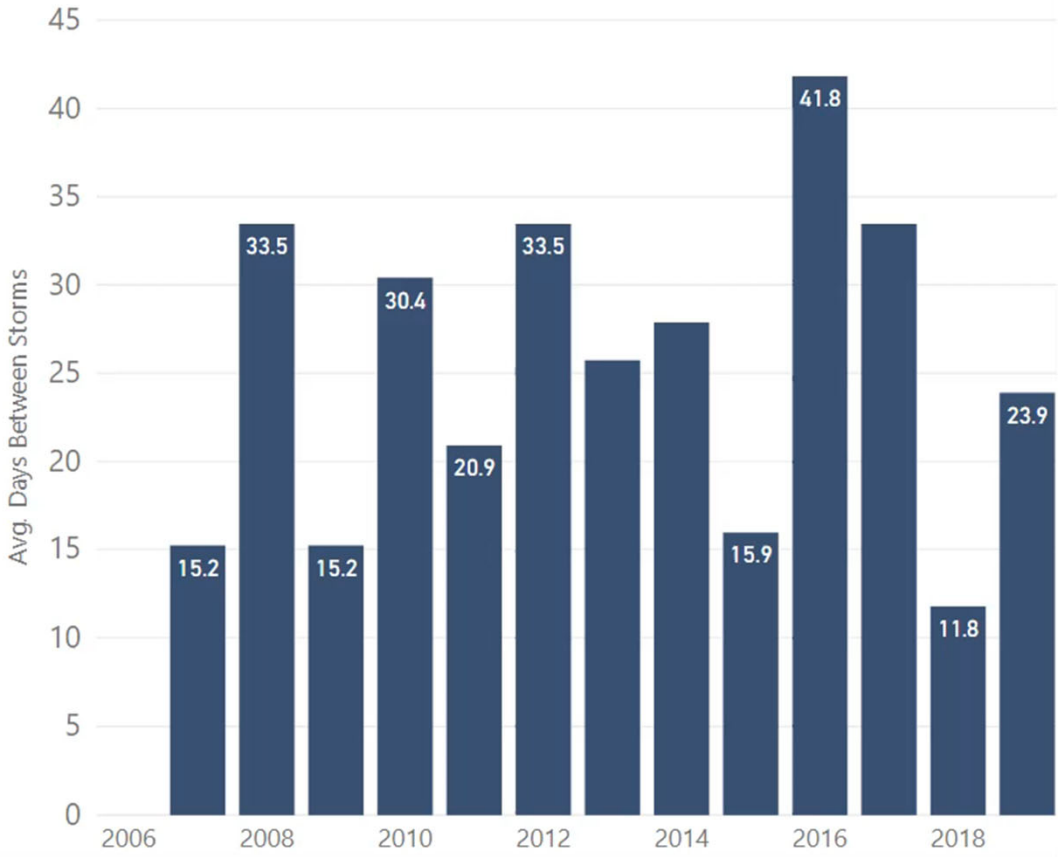
Water Quality Depth (in)

1.0

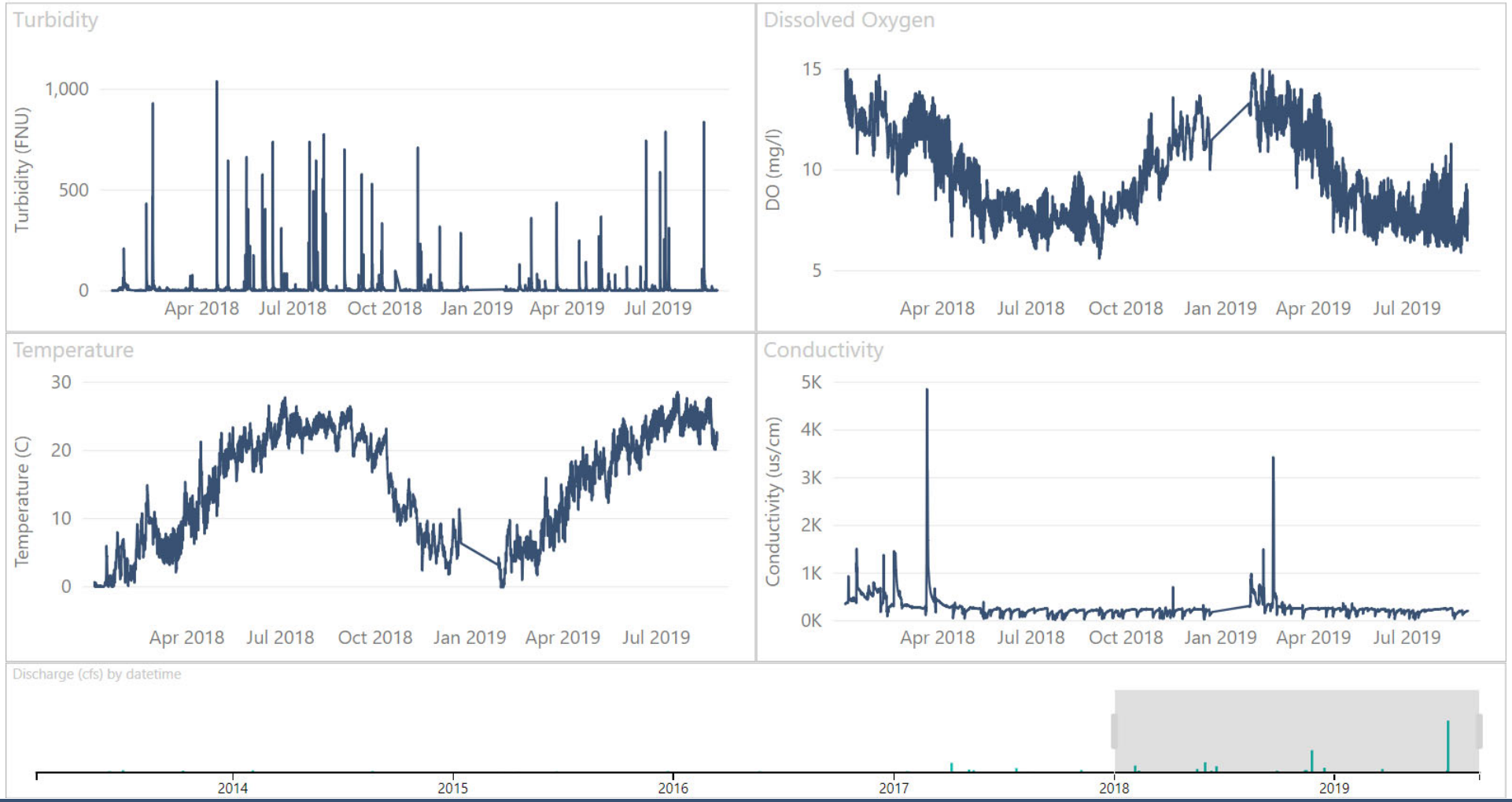
24.4

Average Days Between WQ Storms

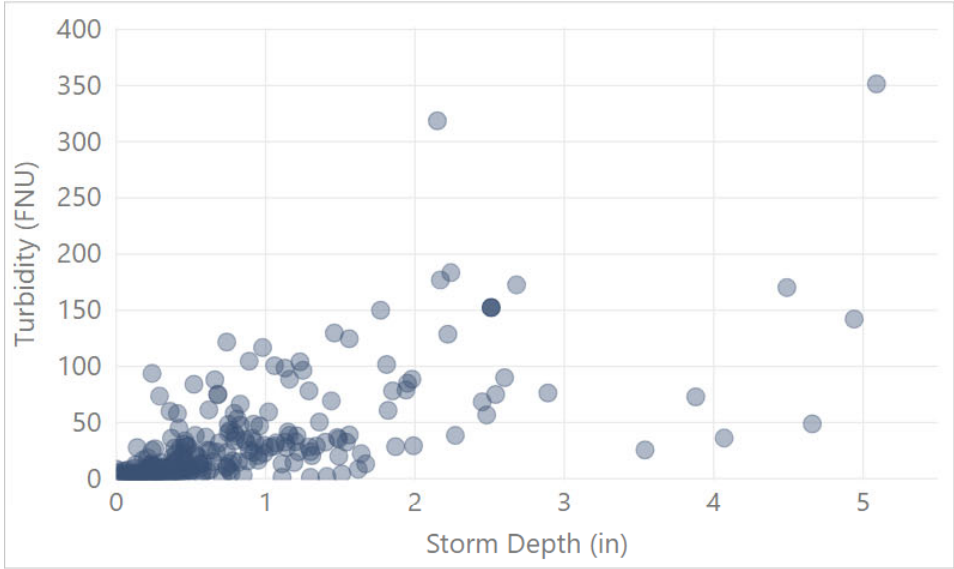


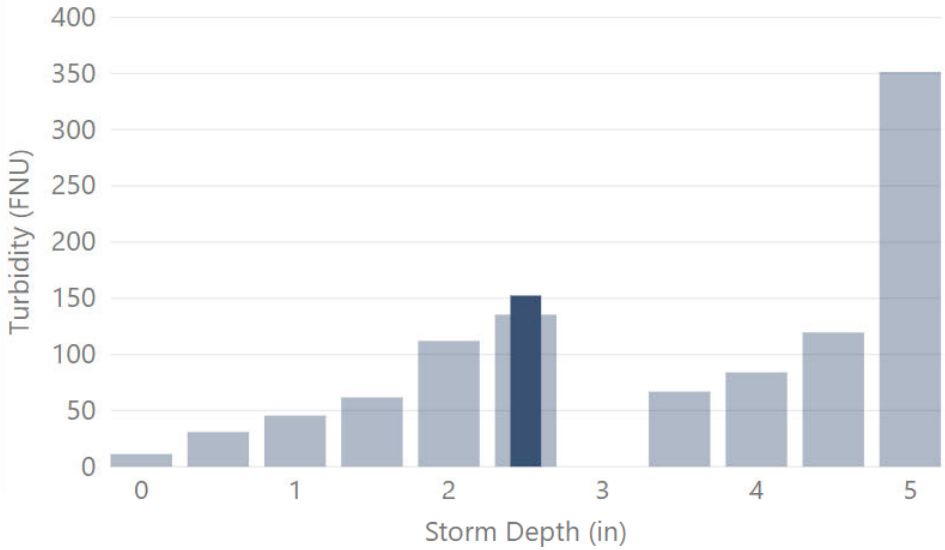


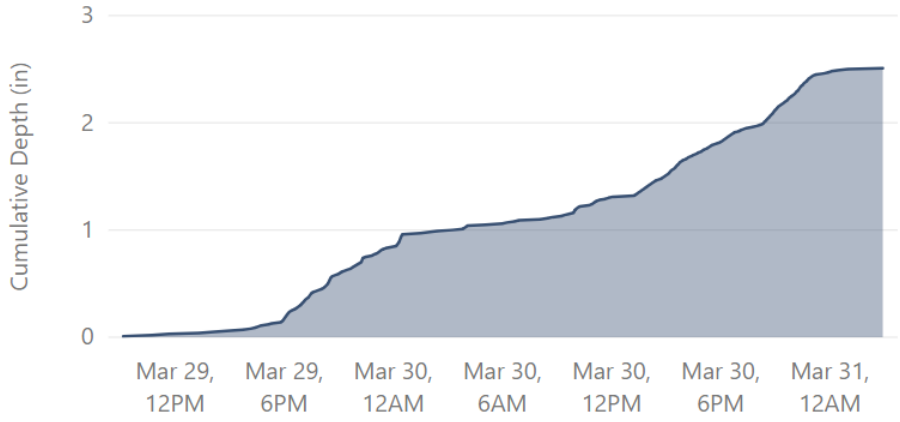
Visualizing Receiving Water Quality

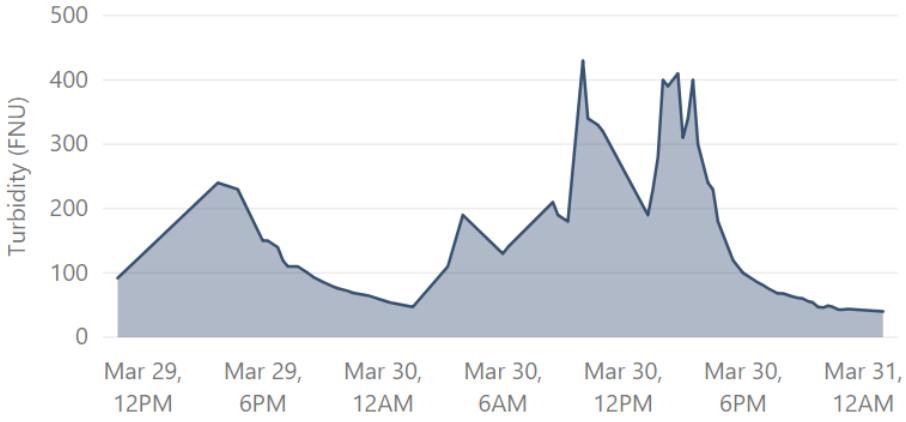


Associating Water Quality and Storms

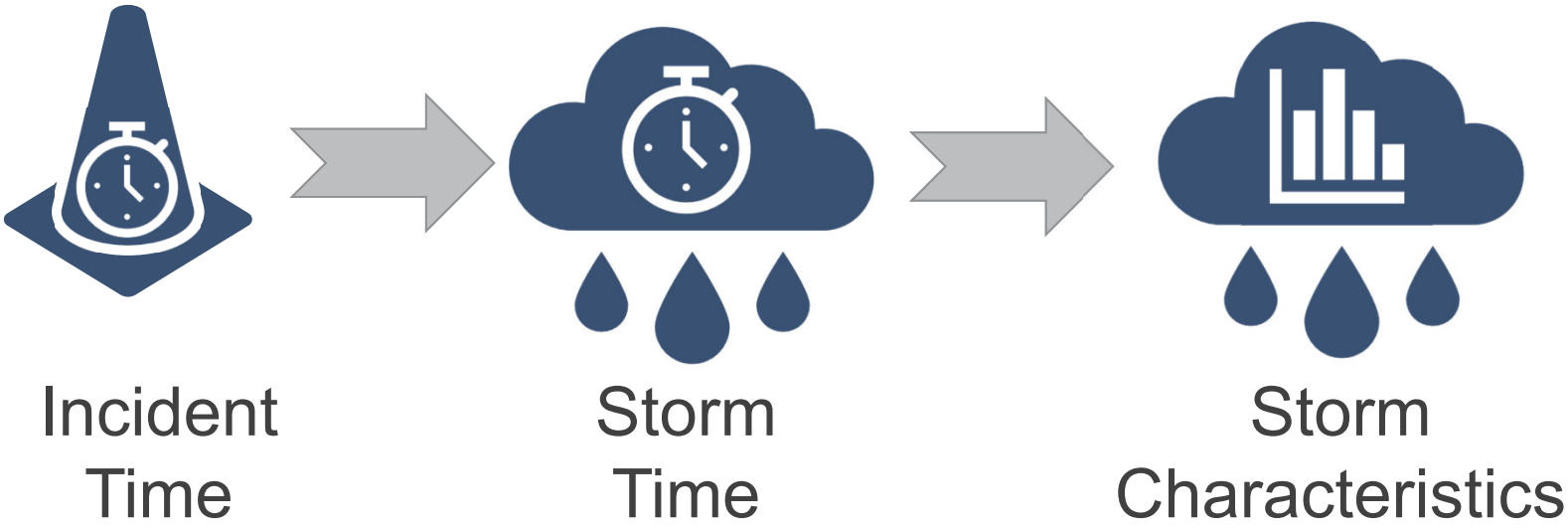




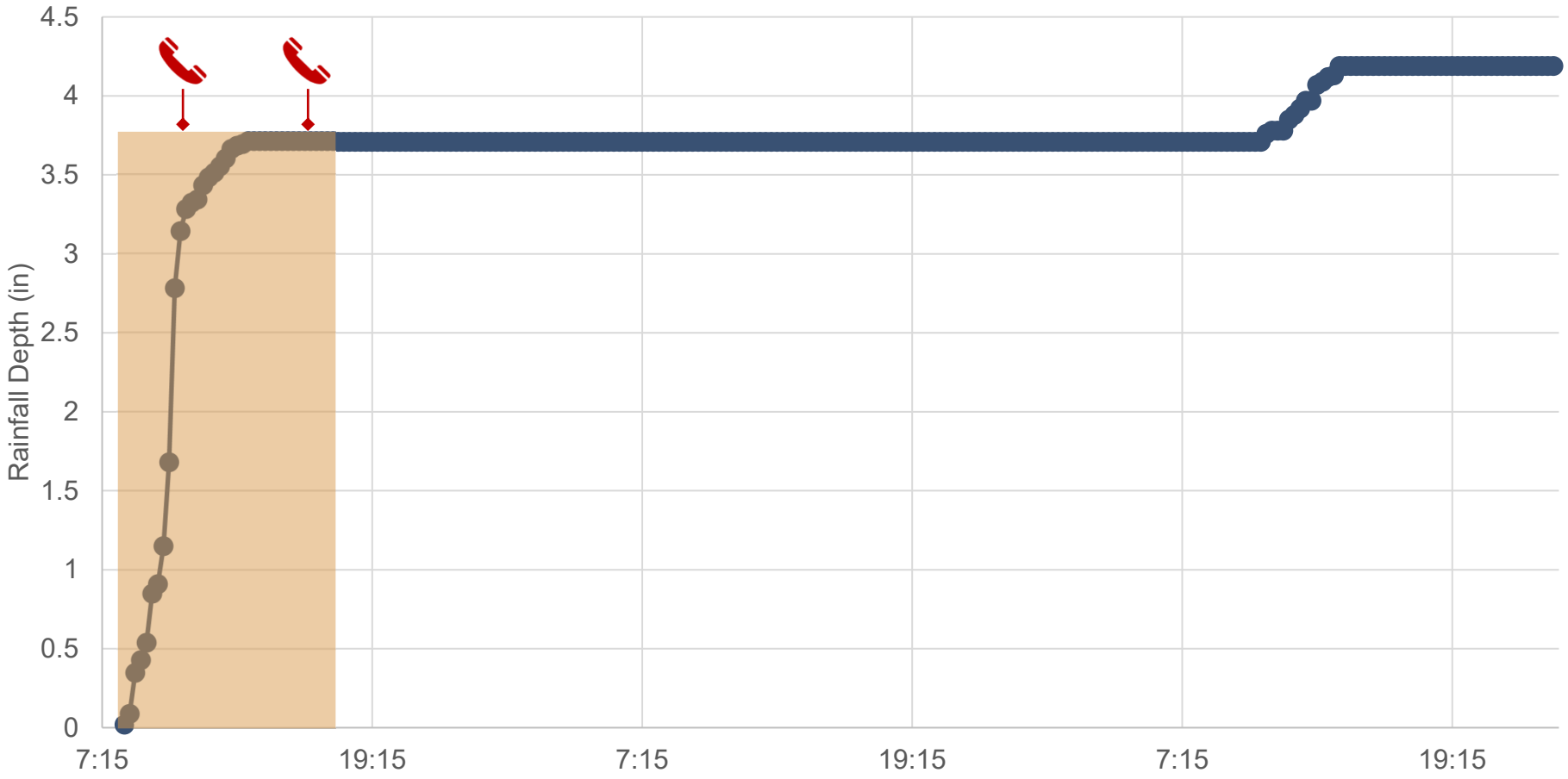




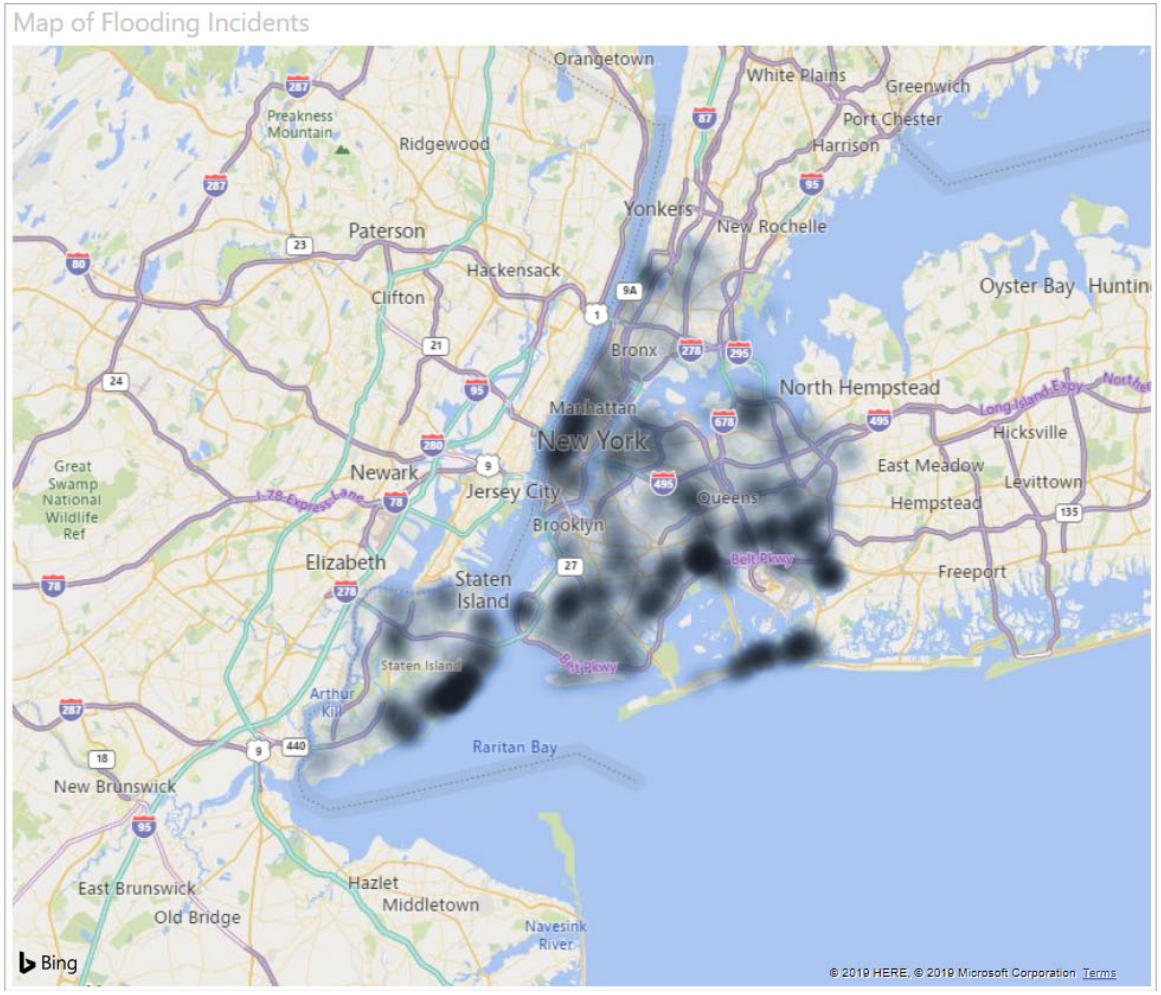
Connecting with Other Data



Connecting with Other Data



Drainage Complaints



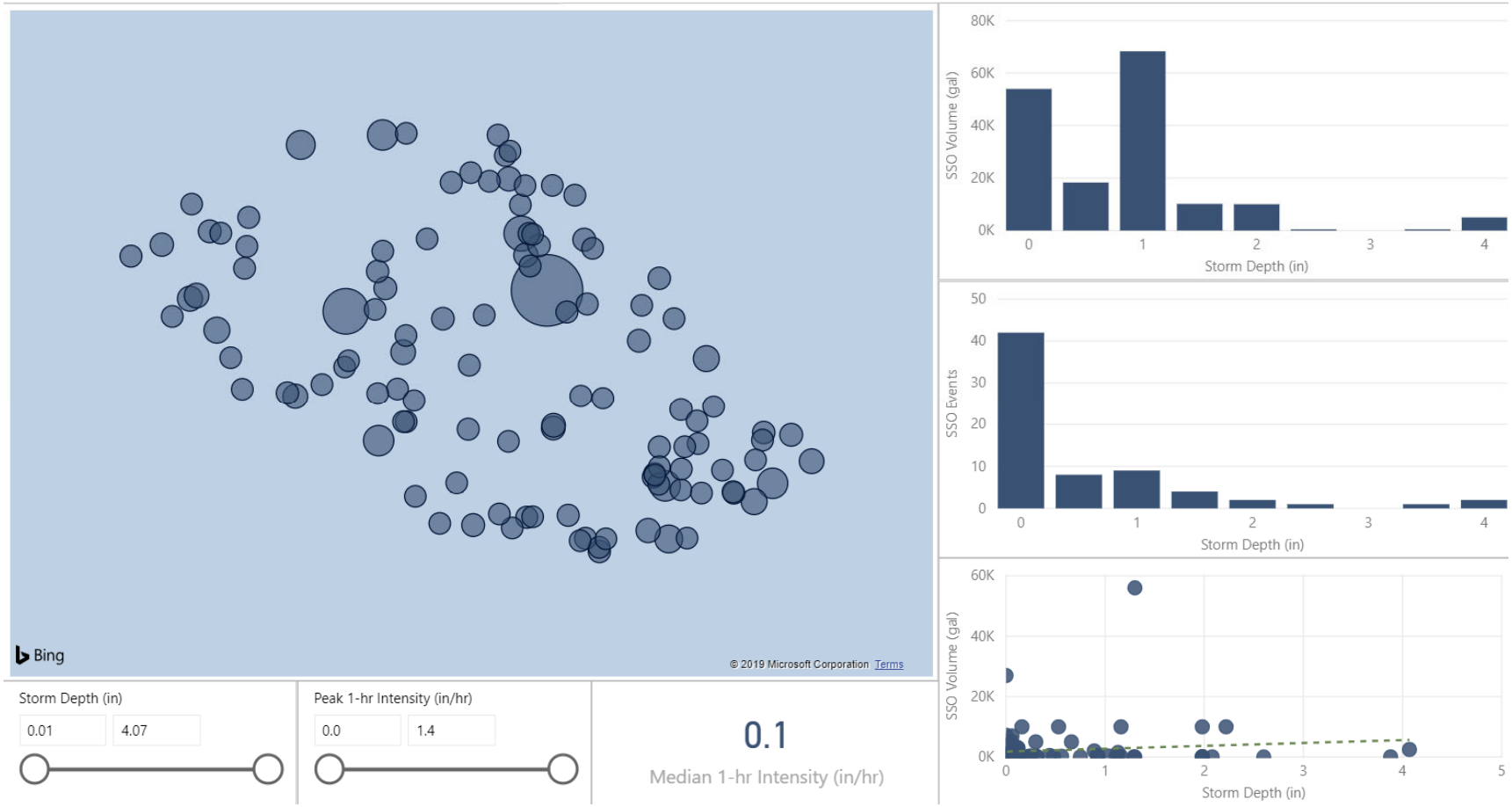
Storm Depth (in)

1.00 8.91

Max 1-hr Intensity (in/hr)

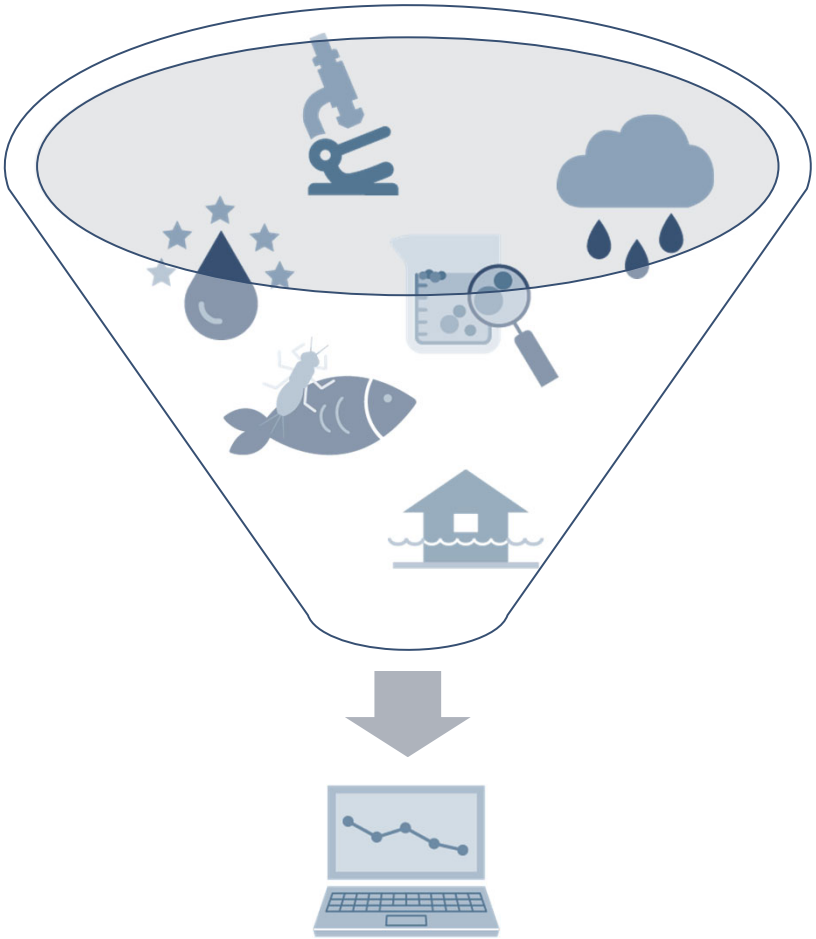
0.5 2.3

Sanitary Sewer Overflows



Connecting with Other Records

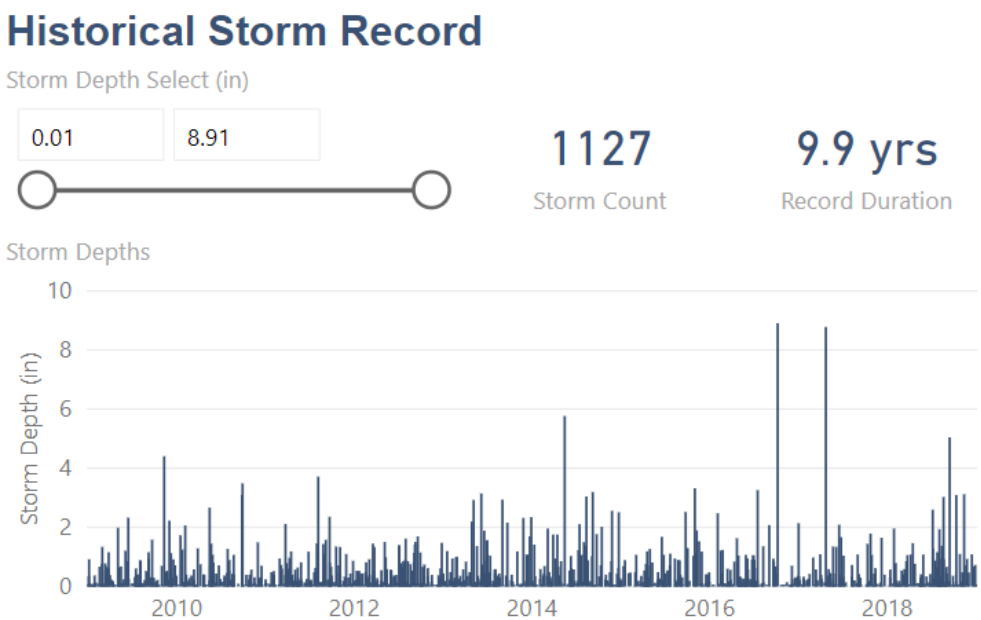
- What storms trigger flooding?
  - Drainage complaints
  - Road closures
- When and where is post-storm maintenance needed?
  - Drainage complaints
  - CMMS work order data
- What are the water quality impacts?

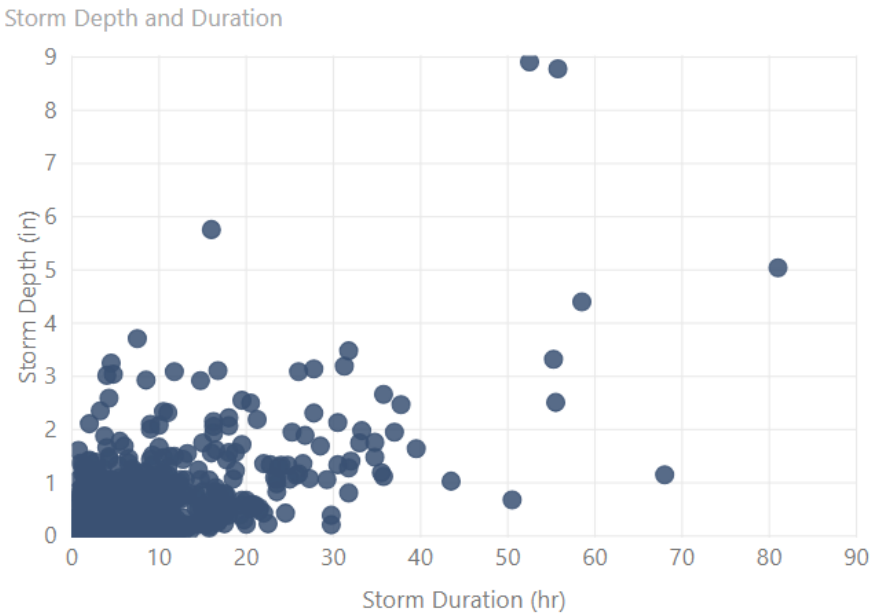


Conclusions

- Data are available to better understand changing storms
- These data can provide valuable context for:
  - **Communication with municipal staff, elected officials, and the public**
  - **Long-term capital improvement and maintenance planning**
  - **Near-term maintenance efforts**
- Supplement for future climate projections
- Opportunities exist to incorporate other data and better understand broad array of stormwater issues

Hazen





Streamlined Data Visualization and Analytics for Smart Stormwater Management

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