The Importance of Particle Size Distribution in Determining BMP Efficiency

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Outline

- Stormwater Runoff Overview
- Detention Basin Study (2005-2006)
  - Particle Size Distribution
  - Metals Data
- Rational Design

Stormwater Runoff

Stormwater Runoff Problems

- Runoff Volume
- Runoff Water Quality

Stormwater Runoff Problems

Ballona Creek

Normal Conditions

Photos: Michael

Stormwater Runoff Problems

Ballona Creek

Normal Conditions

During a Storm

Photos: Michael

Stormwater Runoff Problems

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Normal Conditions

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Goal: Estimate Performance of Treatment Ur

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- Removal Rates are easy to understand

- The BMP Database Project Team has a list with 15 reasons not to use percent removal

INTERNATIONAL STORMWATER BMP DATABASE
www.bmpdatabase.org

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Percent removal is primarily a function of influent quality.

Quotes: Why does the International Stormwater BMP Database Project omit percent removal as a measure of BMP performance? International BMP Database (2007)

Removal Rates

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BMPs with high percent removal may have unacceptably high concentrations of pollutants in effluent

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Removal Rates

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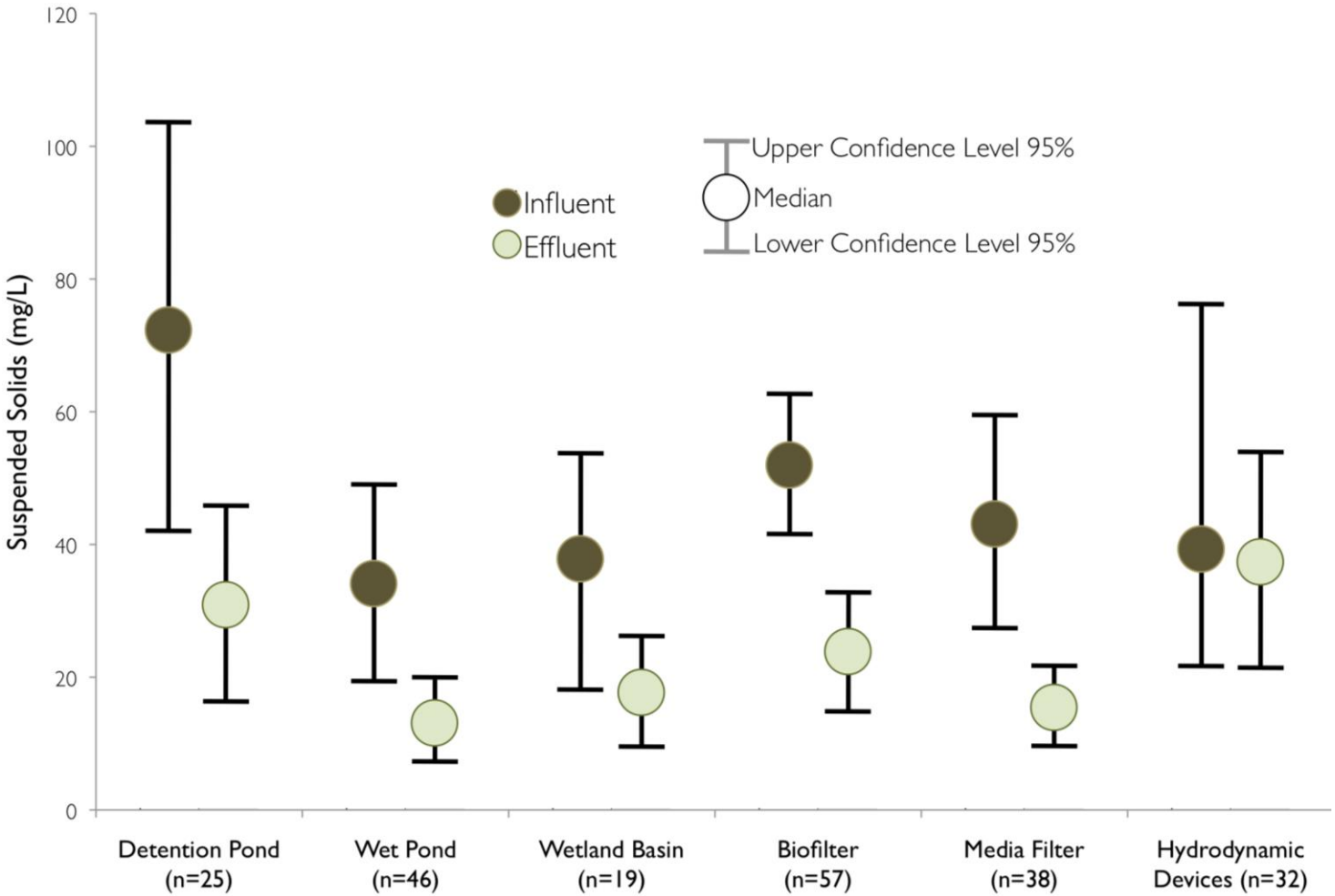
- The BMP Database Project Team has a list with 15 reasons not to use percent removal

Range of expected effluent quality concentrations is a much better planning and design tool than percent removal estimates.

Quotes: Why does the International Stormwater BMP Database Project omit percent removal as a measure of BMP performance? International BMP Database (2007)

Performance



Data Source: Overview of Performance by BMP Category and Common Pollutant Type [1999-2008]

Removal Rates

⌘ By knowing the particle size distribution of the solids in the runoff, removal rates can be used in the selection process of a treatment unit.

⌘ We will show this using a detention basin as a case study.

Caltrans Study (2005-2006)

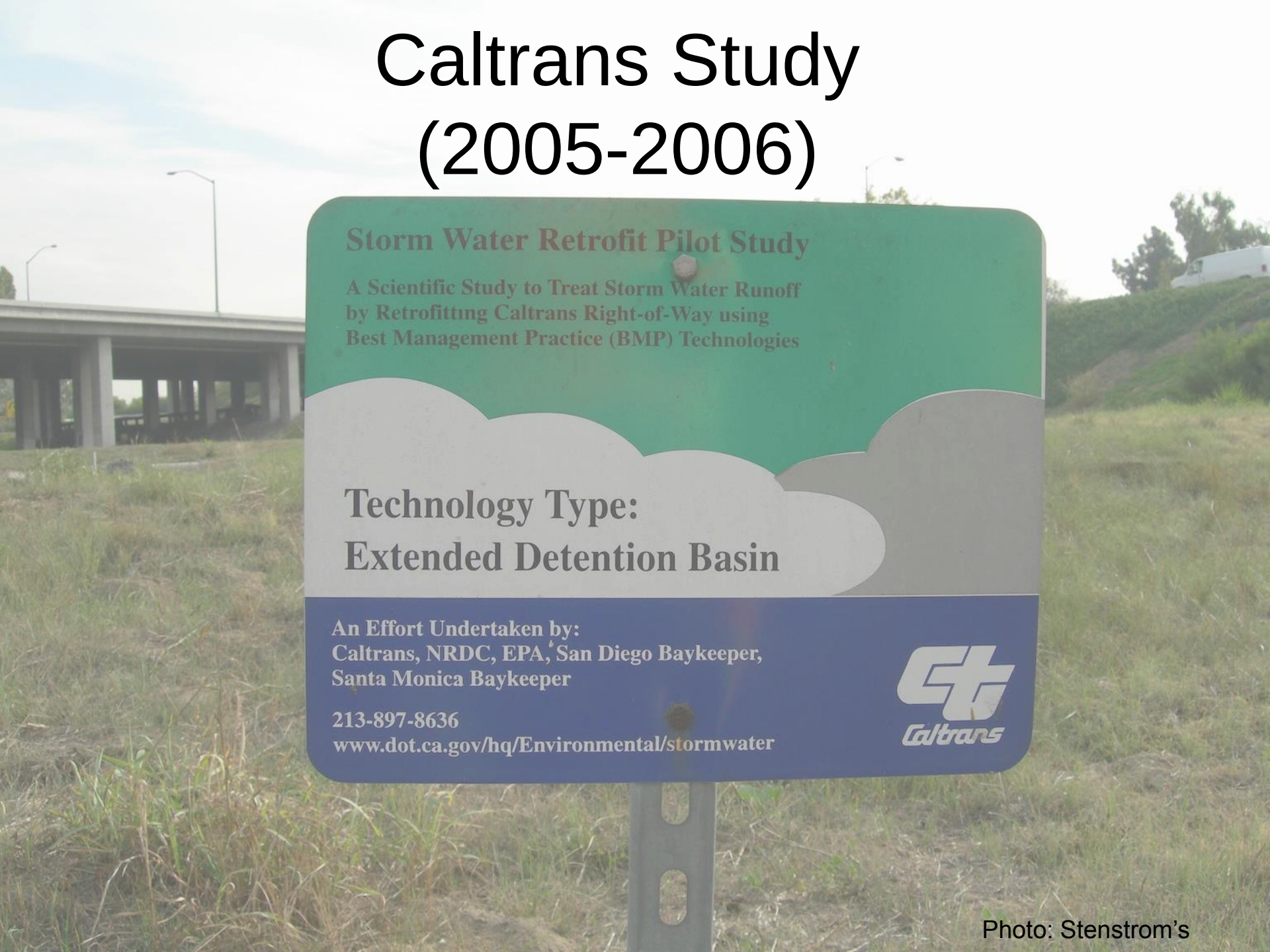
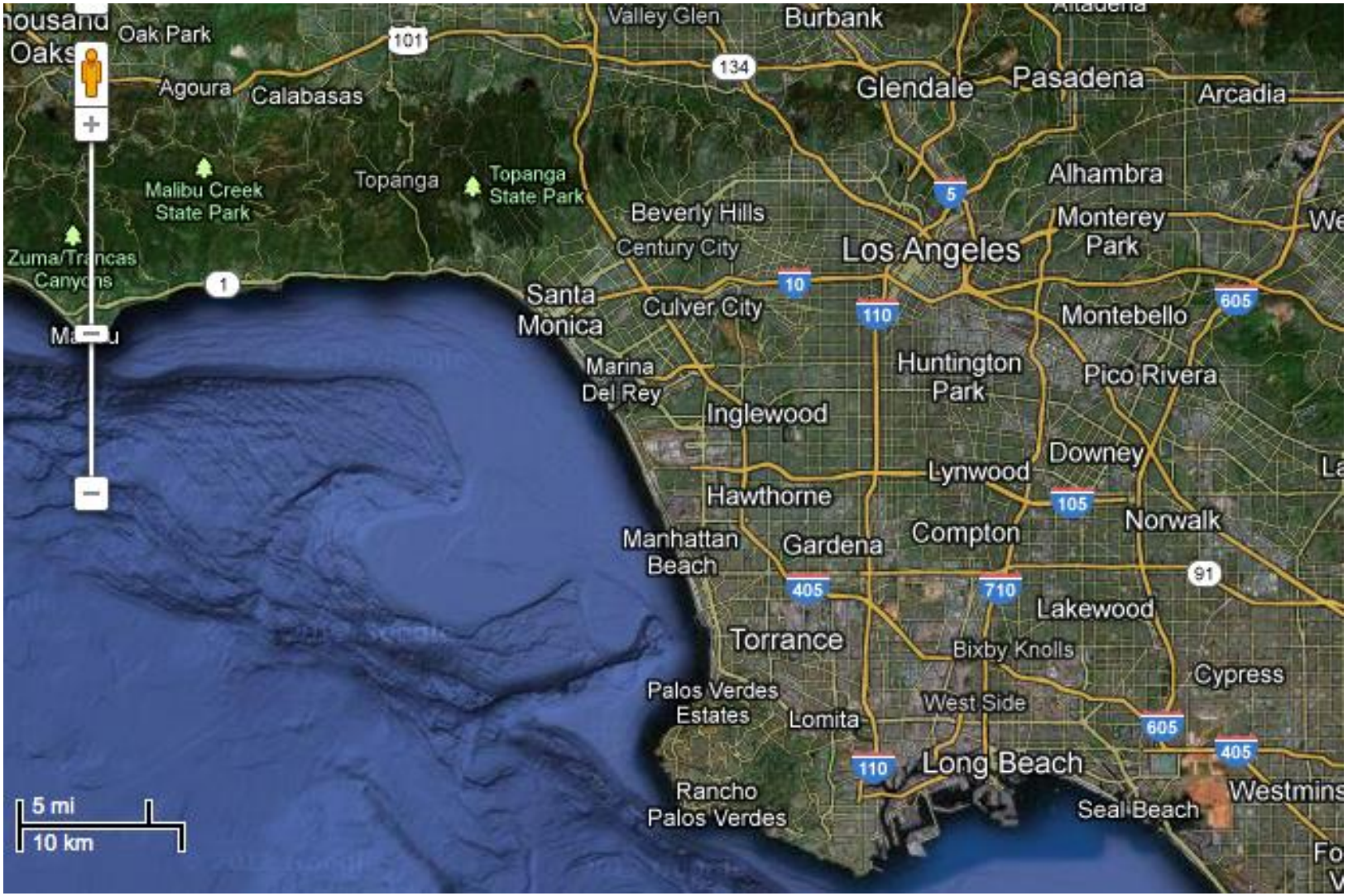


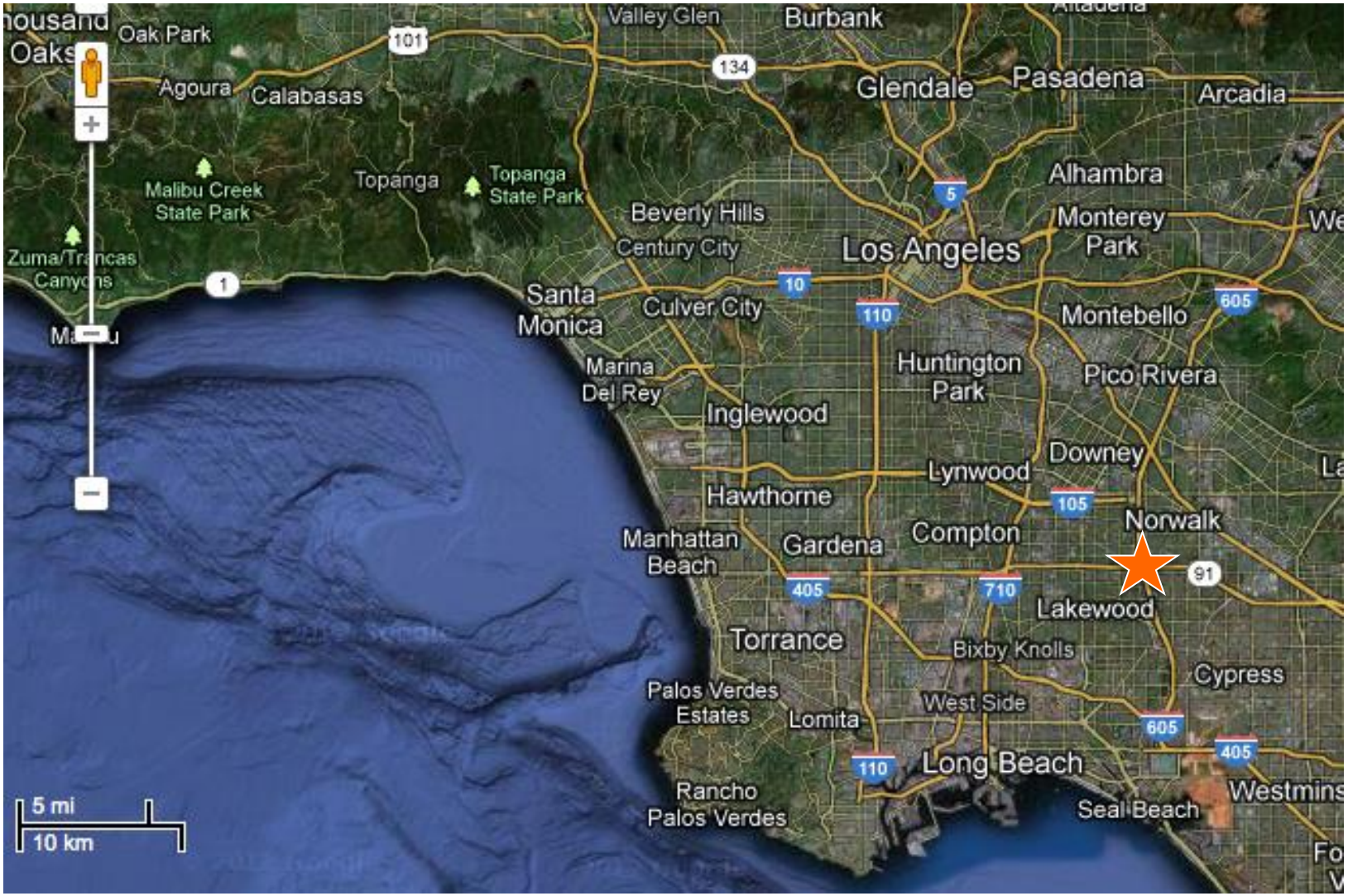
Photo: Stenstrom's

Detention Basin



Photos:

Detention Basin



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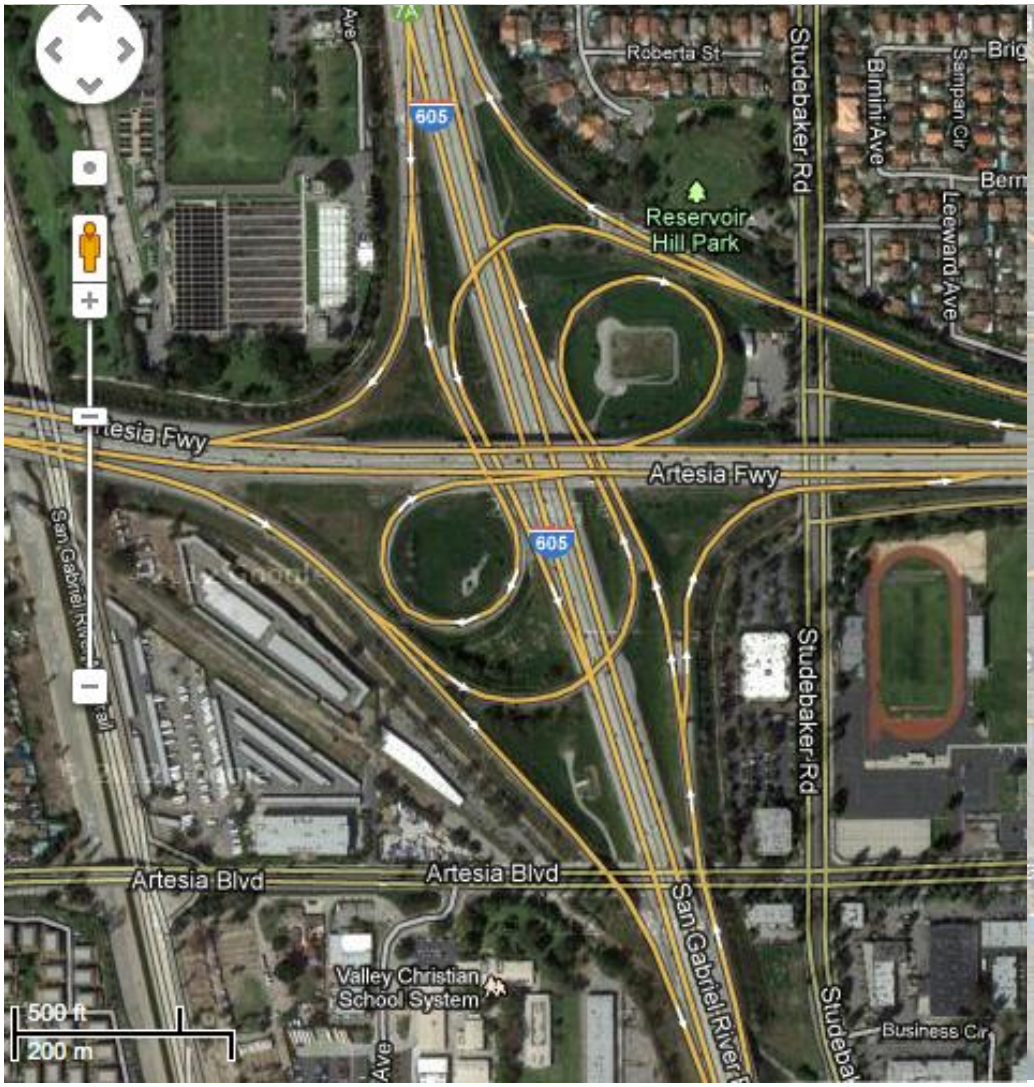

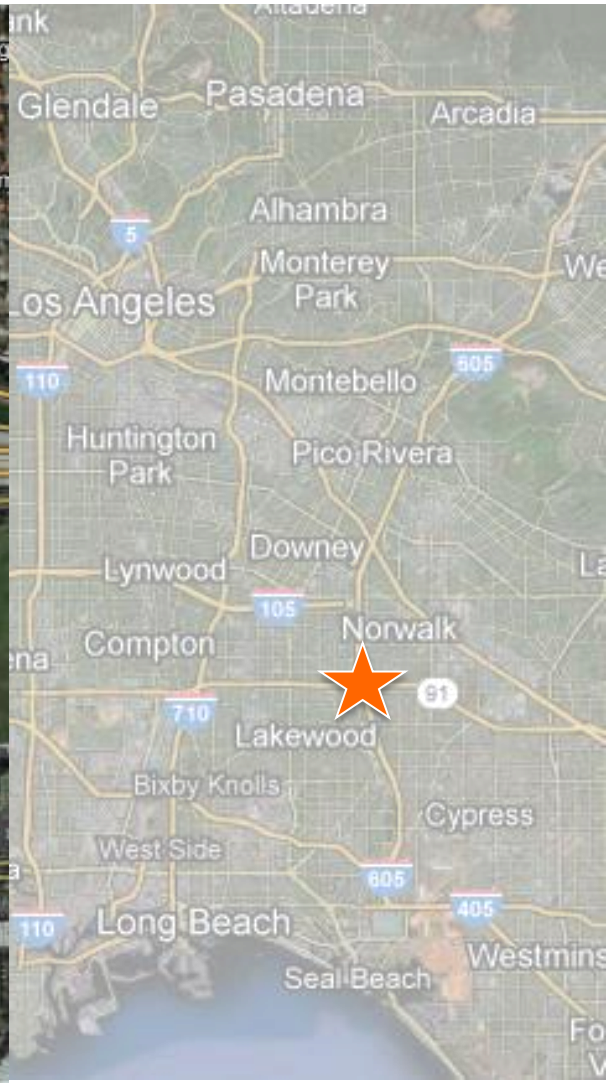

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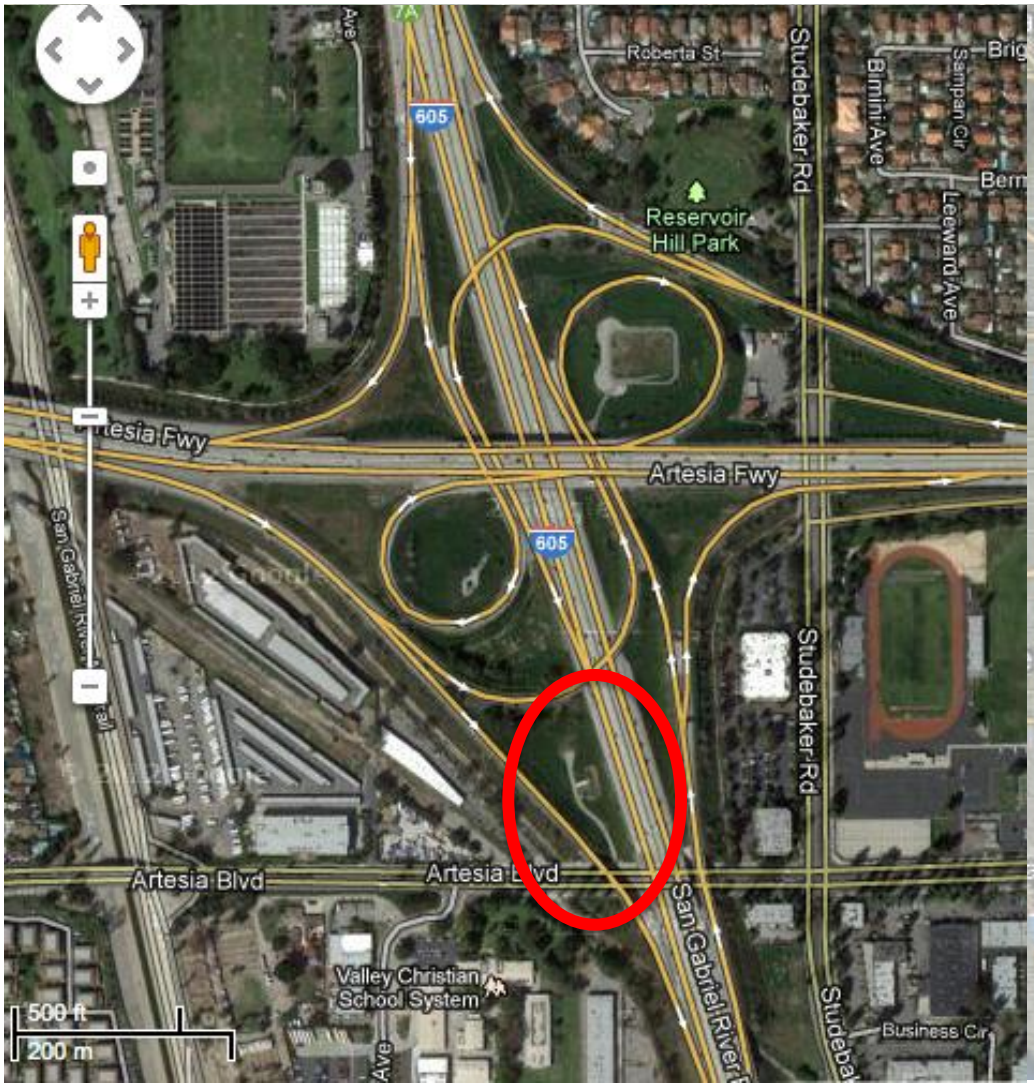

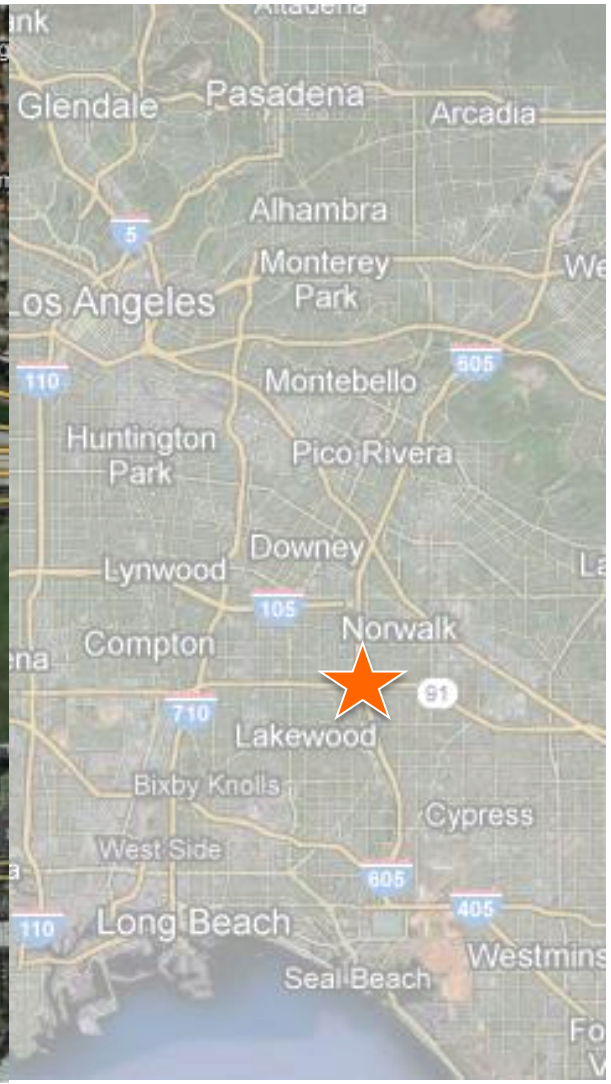

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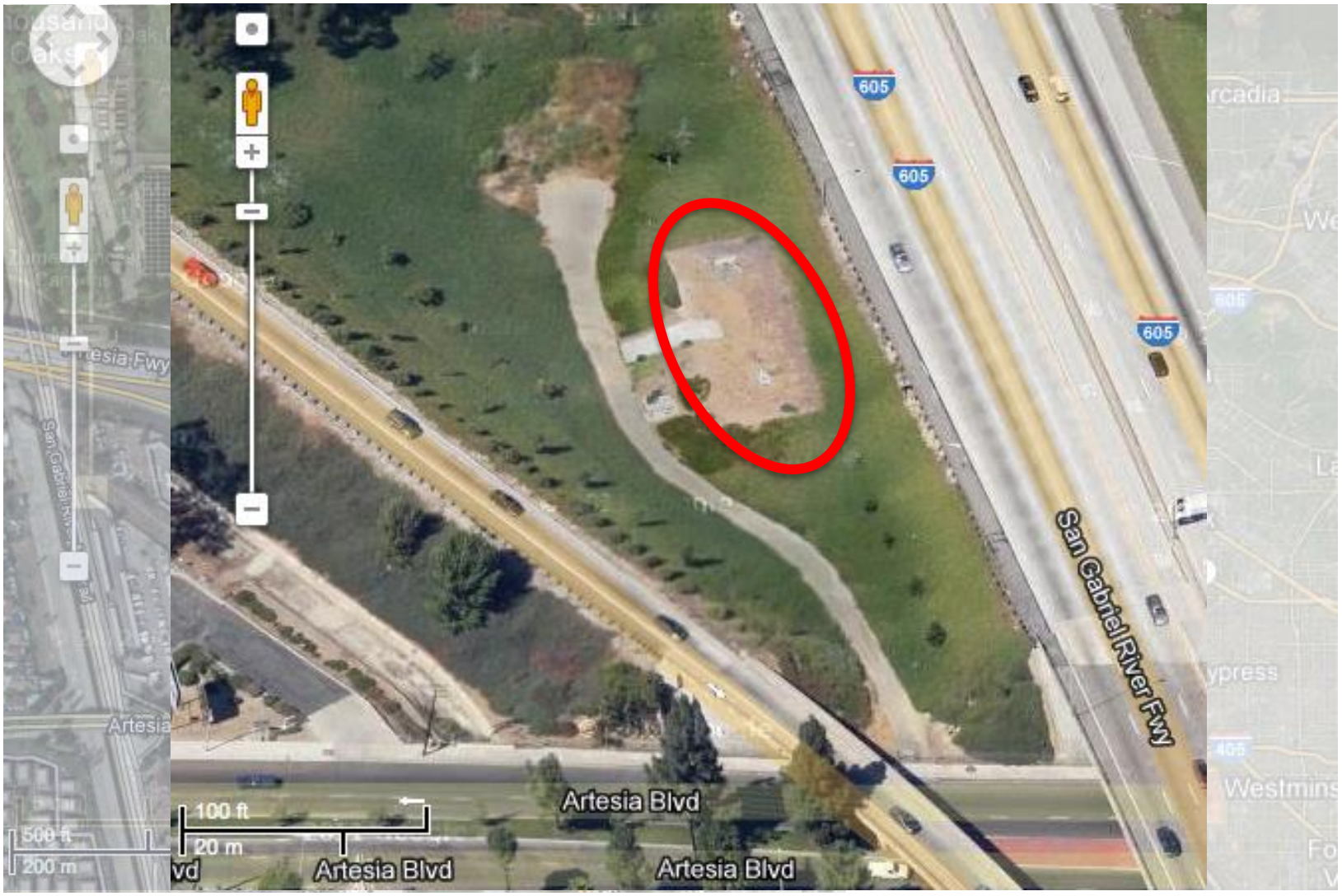

Photos:

Site Characteristics

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Catchment: 4,000 m^2
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Impervious Cover: 100%

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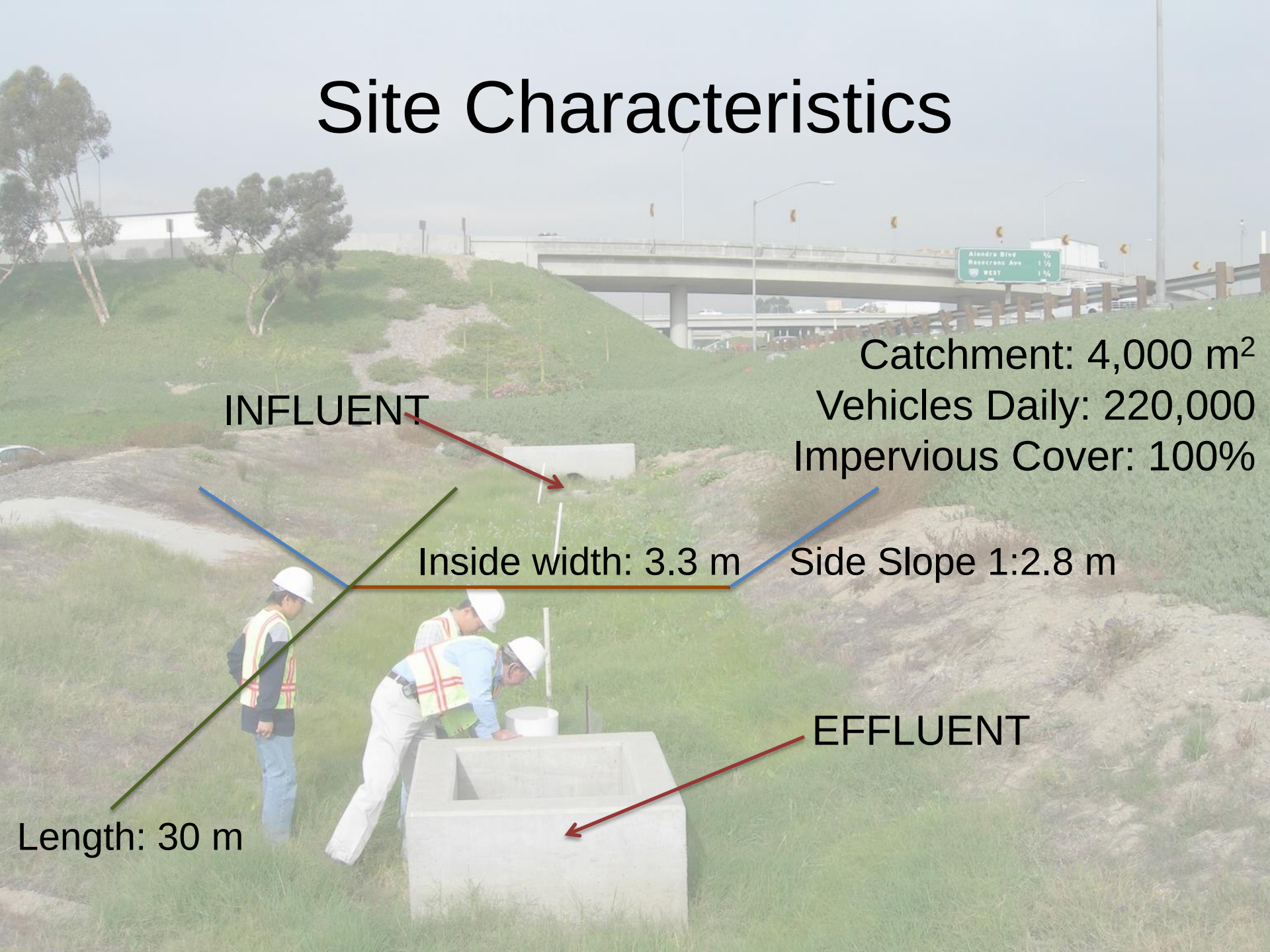
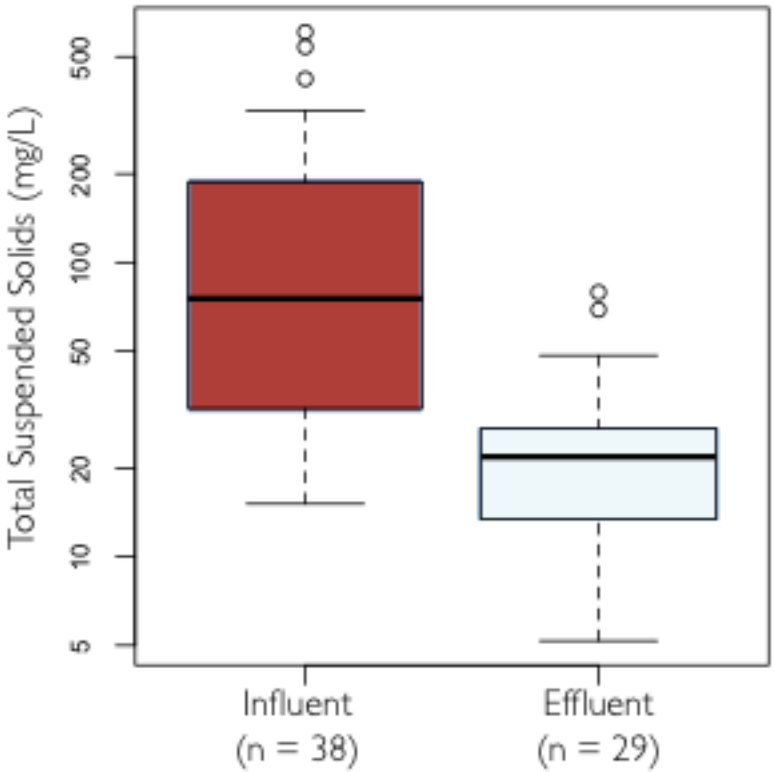


Traditional Efficiency Study

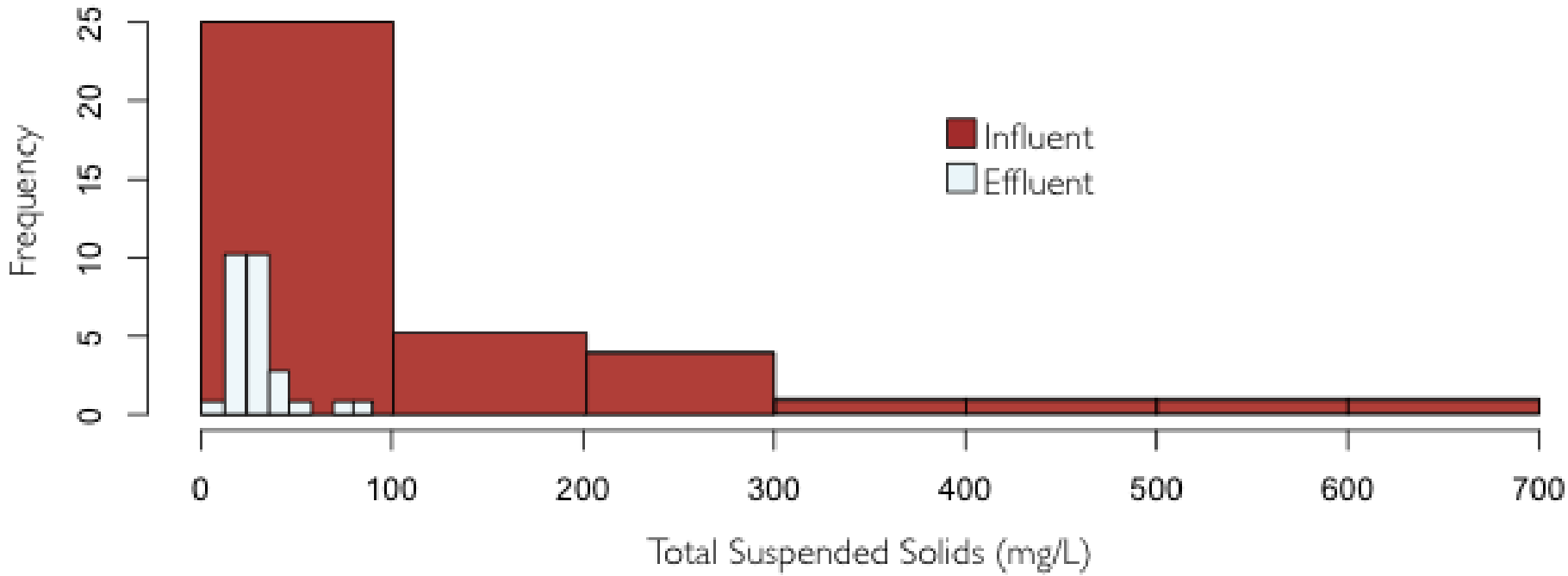
Total Suspended Solids



Mean of influent TSS is 127.25 mg/L Mean of effluent TSS is 25.17 mg/L

80% removal of solids

Total Suspended Solids



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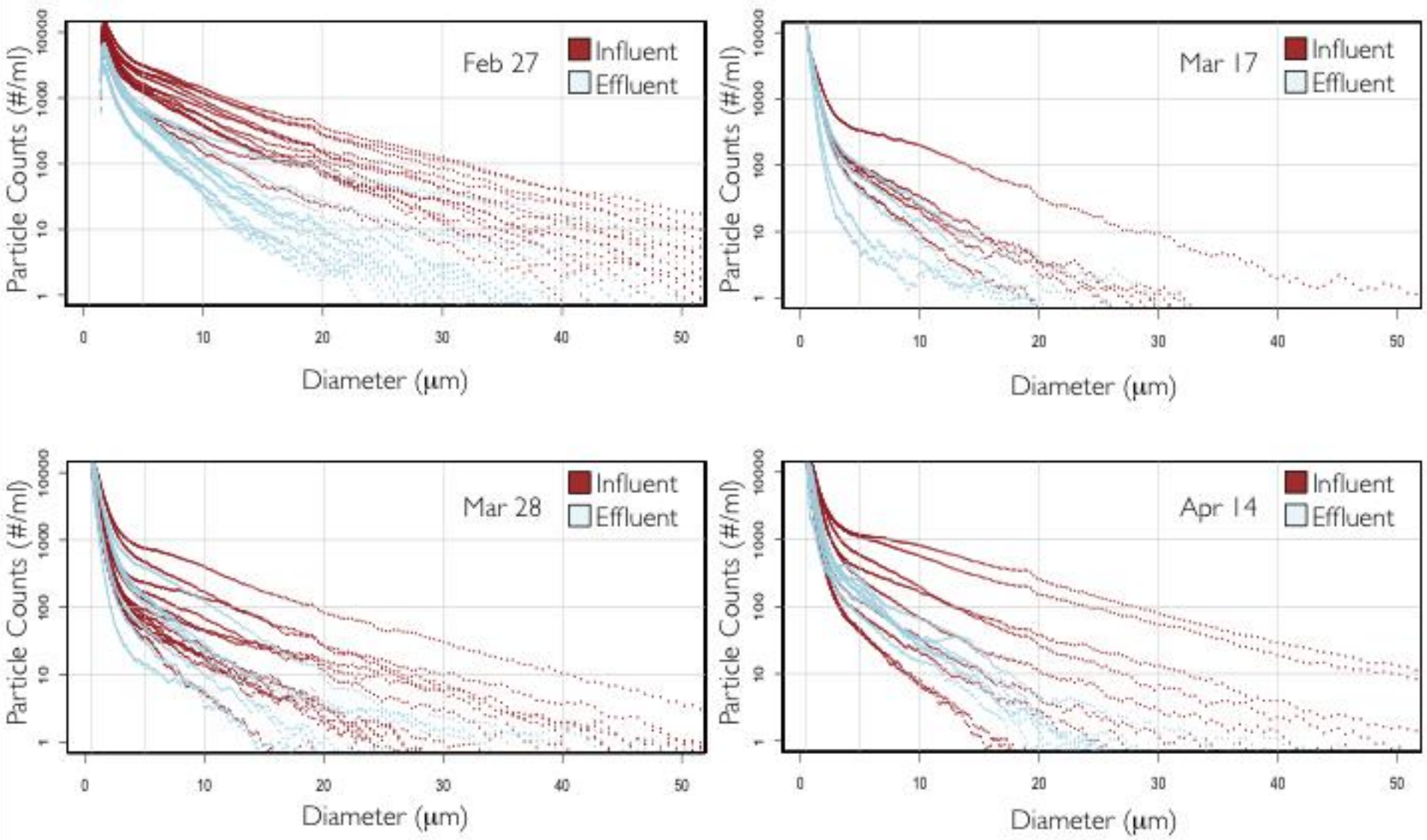
Particle Size Distribution Data

Particle Size Distribution

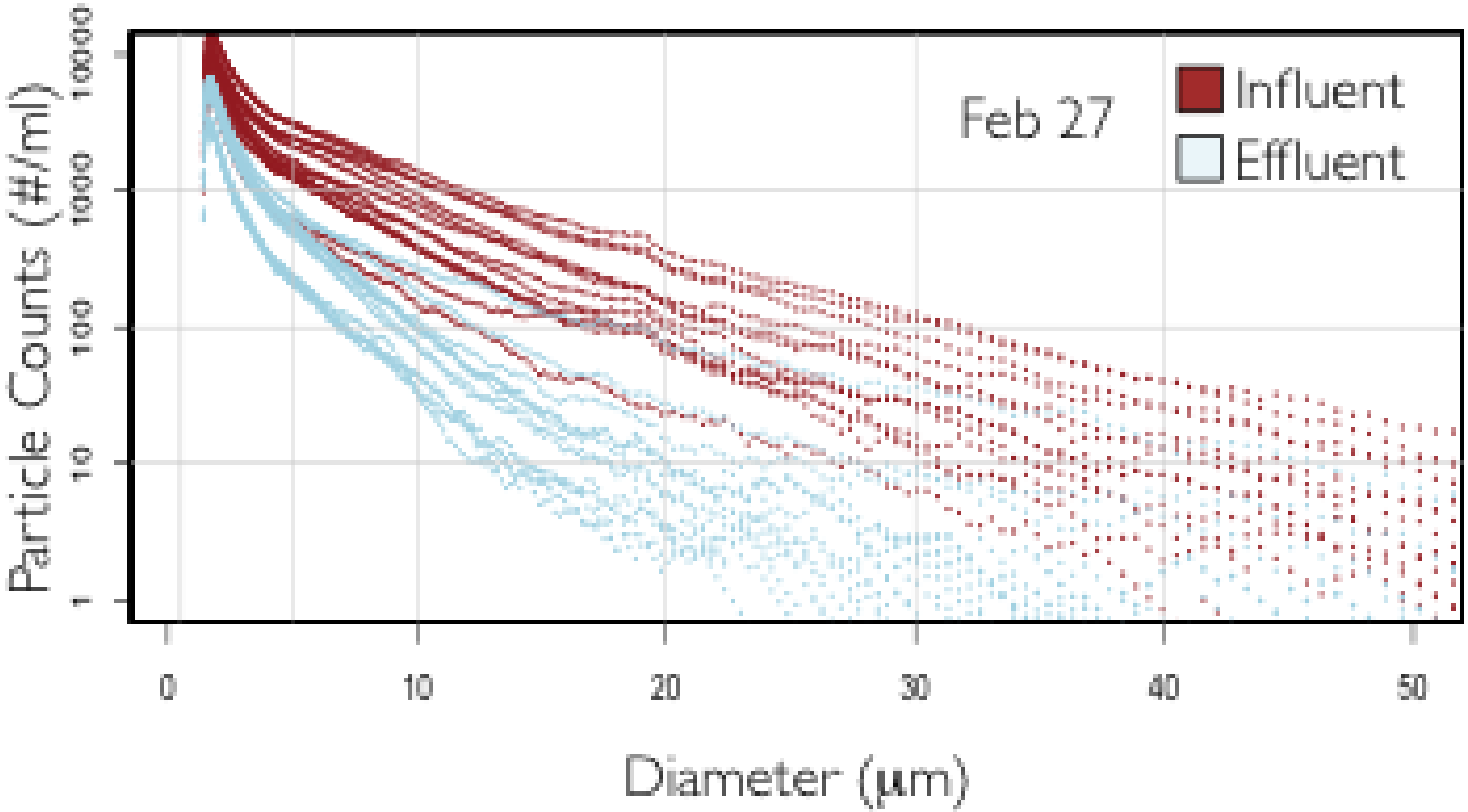
Nicomp Particle Sizing Systems – AccuSizer 780

- Autodilution
- Sensor Range: 0.5 – 500 μm
- Light Obscuration
- Measures voltage pulse, which is proportional to the particle maximum cross-sectional area
- Sample volume: 0.5 ml

Particle Size Distribution



Particle Size Distribution



Particle Removal

Diameter Range (μm)	Percent Removal (%)				All Storms (%)
	27-Feb	17-Mar	28-Mar	14-Apr	
0.5-5	62	15	36	44	48
5-10	83	75	71	82	82
10-20	90	85	85	92	90
20-30	90	84	91	97	91
30-40	86	82	87	96	88
40-100	78	93	77	94	82

Metals Data

Concentration (μg/L)

mass of constituent by volume of runoff filtered

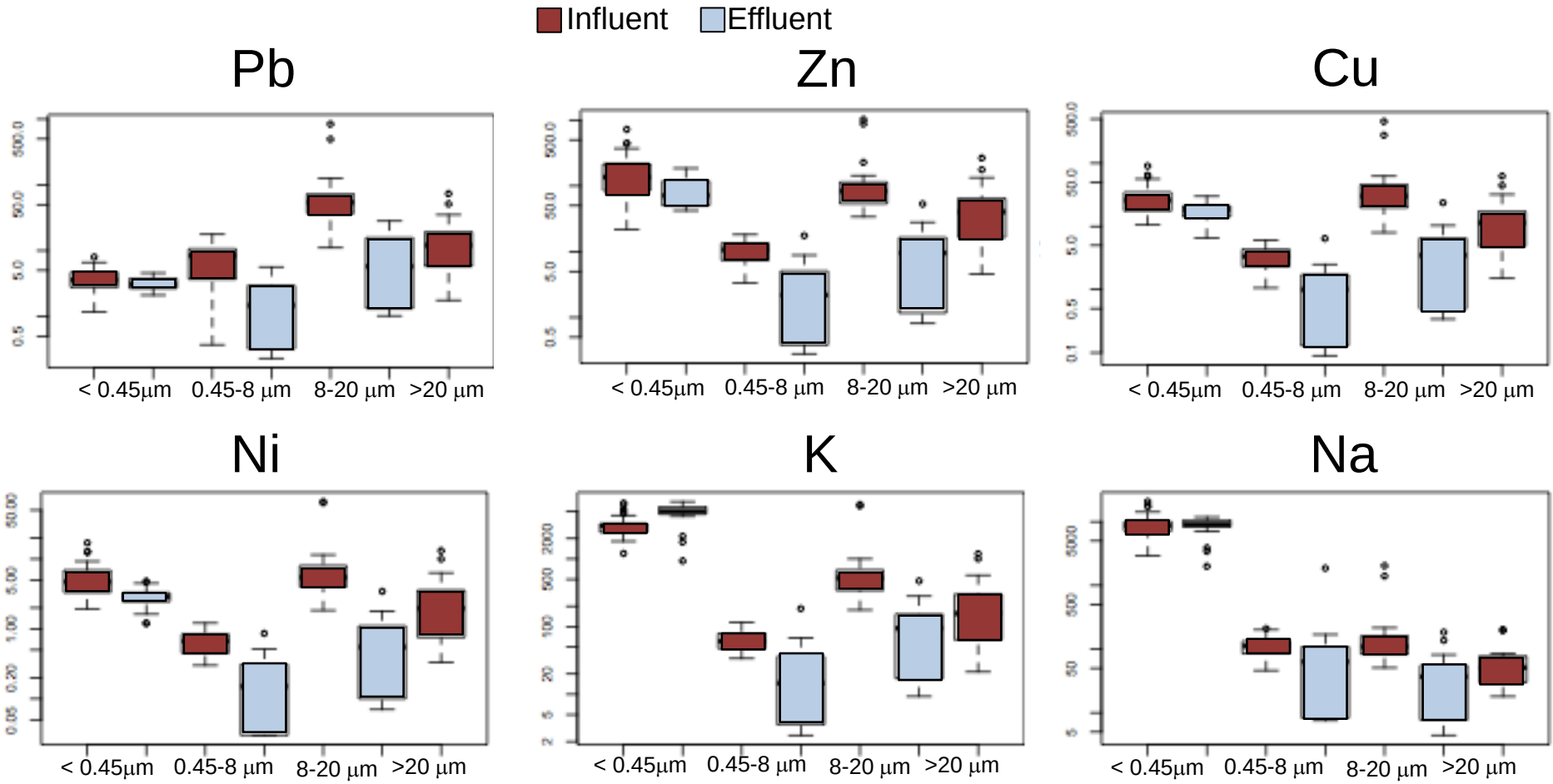
26 Measured Constituents

17 Constituents Above Detection Limit

Welch t-test comparison for influent and effluent concentrations for each size fraction: statistically significant with exception of the dissolved phase for 4 constituents

Concentration (µg/L)

mass of constituent by volume of runoff filtered



Rational Design to Runoff Treatment Unit Performance

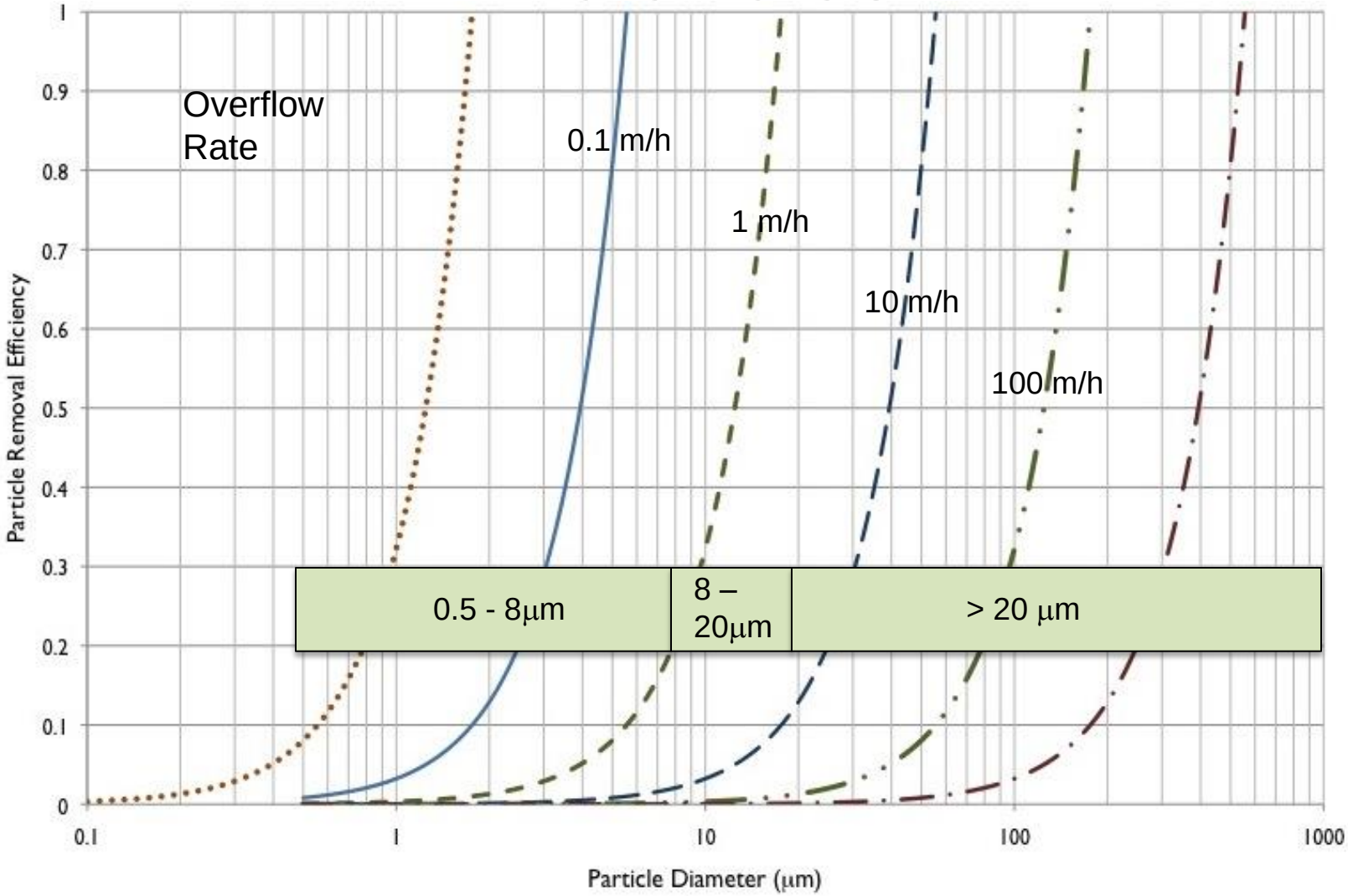
Removal Efficiencies

- For discrete particle settling, we can construct removal efficiency chart based on overflow rate.

- Assuming laminar flow, spherical particles with density 2.65 g/cm^3, and temperature 20°C.

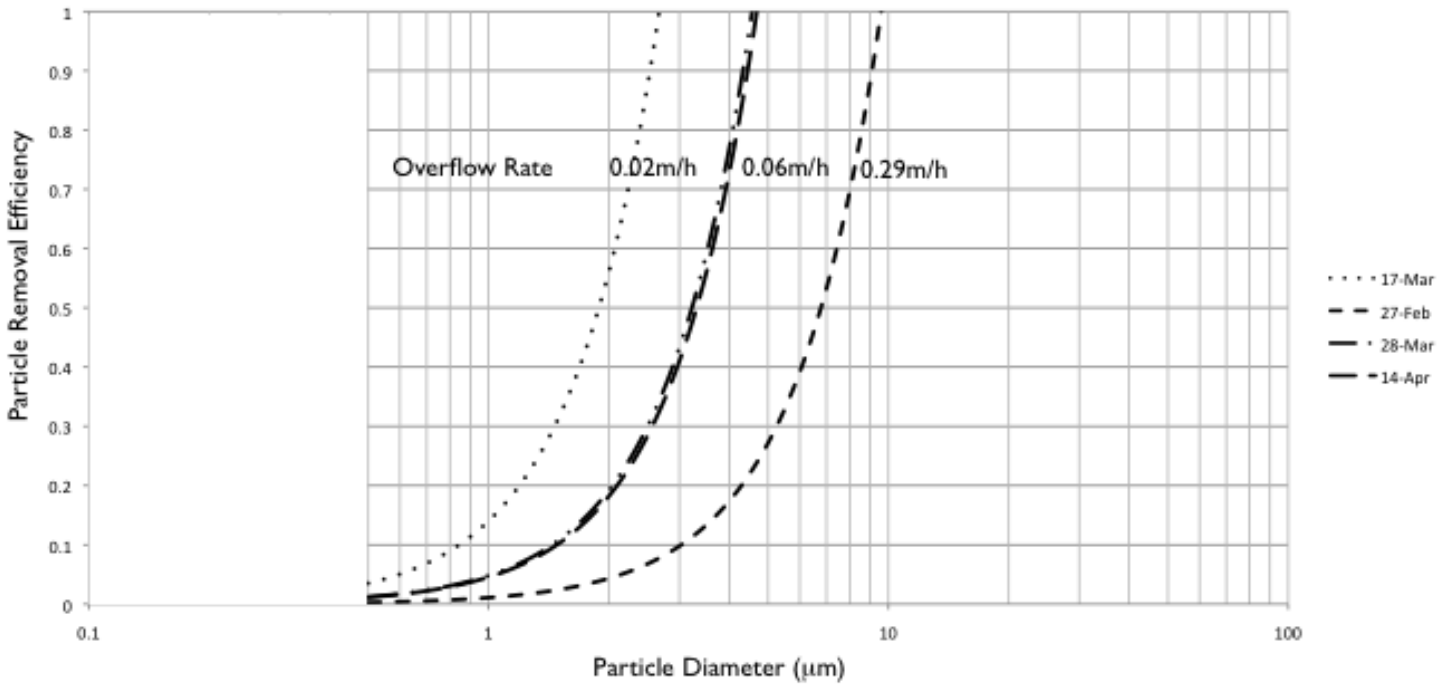
$$\eta = \frac{V_p}{V_o} = \frac{\frac{g(sg_p - 1)d_p^2}{18\mu}}{V_o}$$

Sedimentation Removal Efficiencies



Sedimentation Removal Efficiencies

Storm Date	Rainfall (m)	Drainage Area (m^2)	Volume (m^3)	Length of storm (h)	Flow through device (m^3/h)	Assumed volume (m^3)	Retention time (h)
27-Feb	0.0475	4000	190.0	22	8.64	30	3.5
17-Mar	0.0048	4000	19.3	5	4.06	30	7.4
28-Mar	0.0168	4000	67.1	16	4.19	30	7.2
14-Apr	0.0109	4000	43.7	7	6.24	30	4.8



Summary

- PSD is characteristic of each site
  - in certain locations, season might play a role
- We cannot talk removal rates without knowing PSD
  - we also need to know the chemistry and size fractionation of the pollutants of interest