Combined Sewer overflow Workshop

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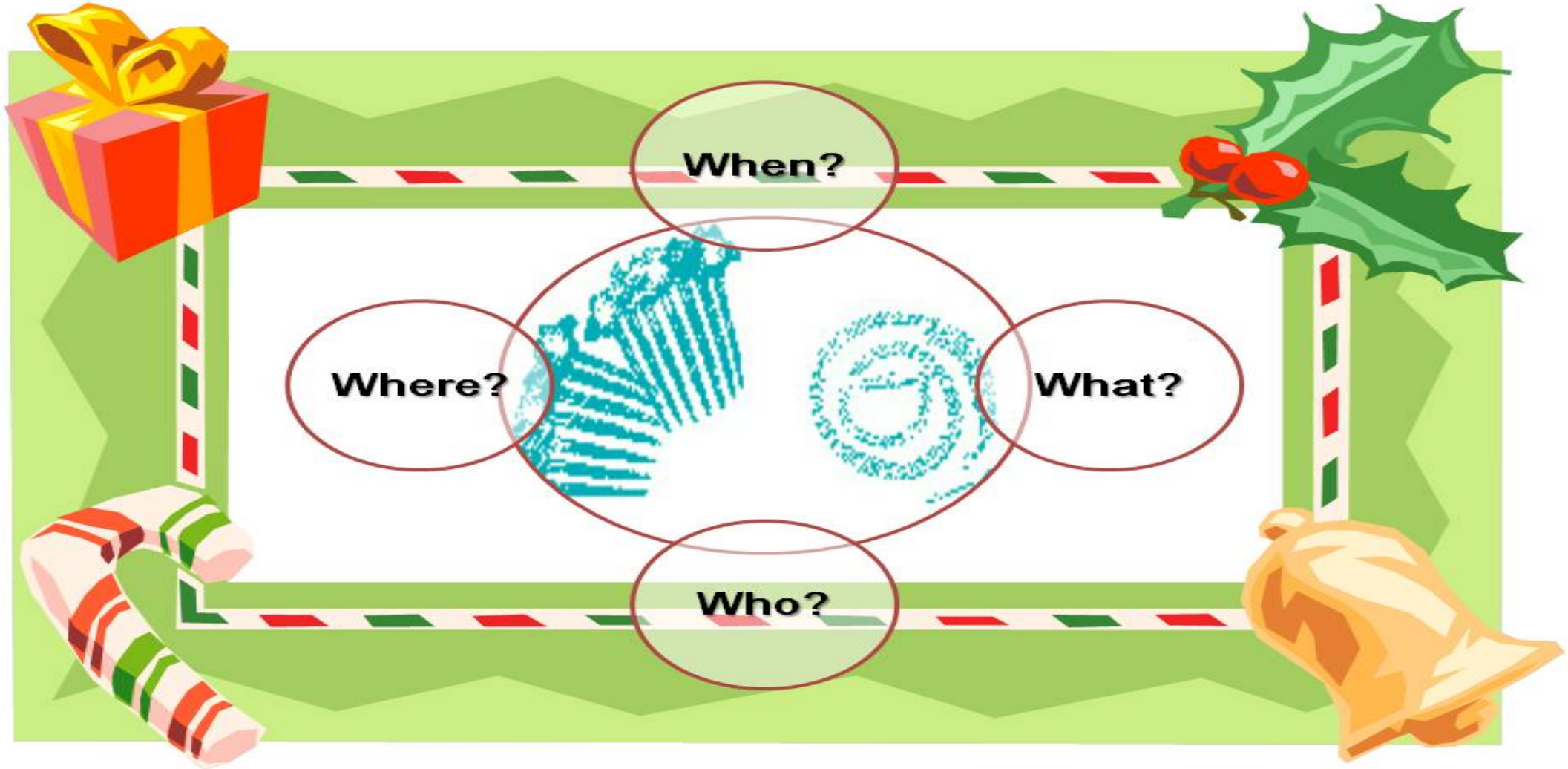
U.S. EPA

Office of Water

Today's Topics

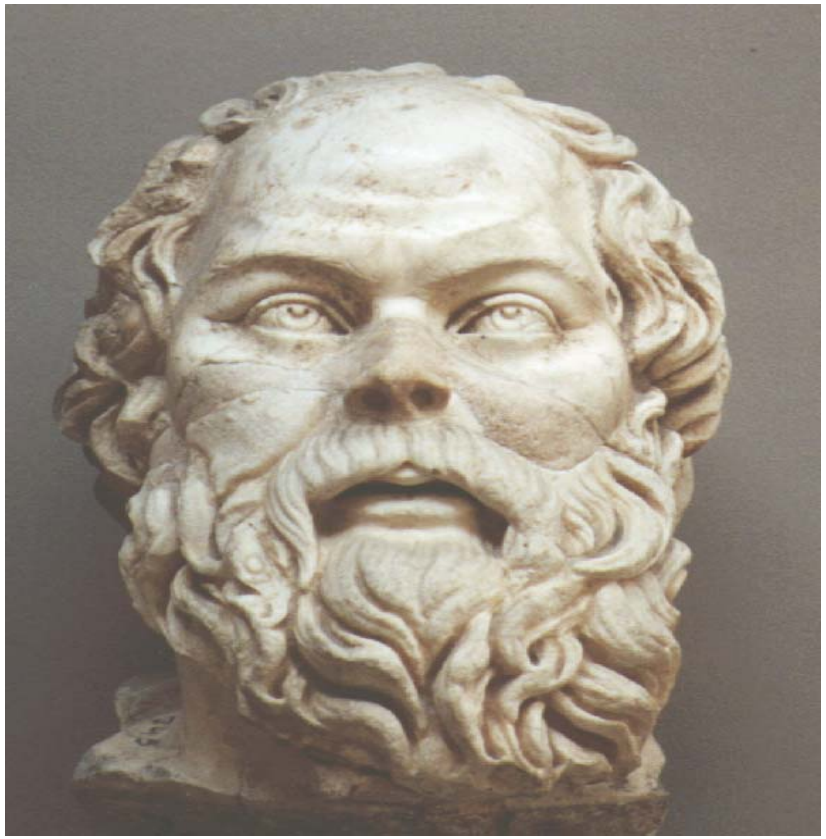
- Introduction to CSO long-term control plan – Open Conversation
- Characterization of Combined Sewer System
- Evaluation of Alternatives and Cost Consideration
- Public Participation
- Sensitive Area

System Characterization



Why Do We Need????

Know Thyself



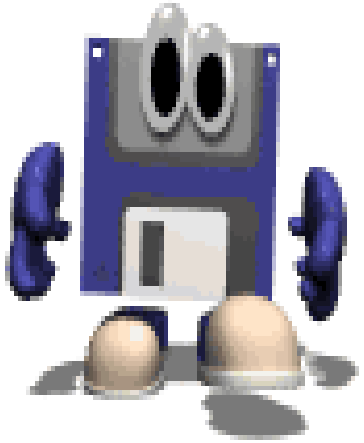
Topics

- System Characterization
- Monitoring
- Modeling

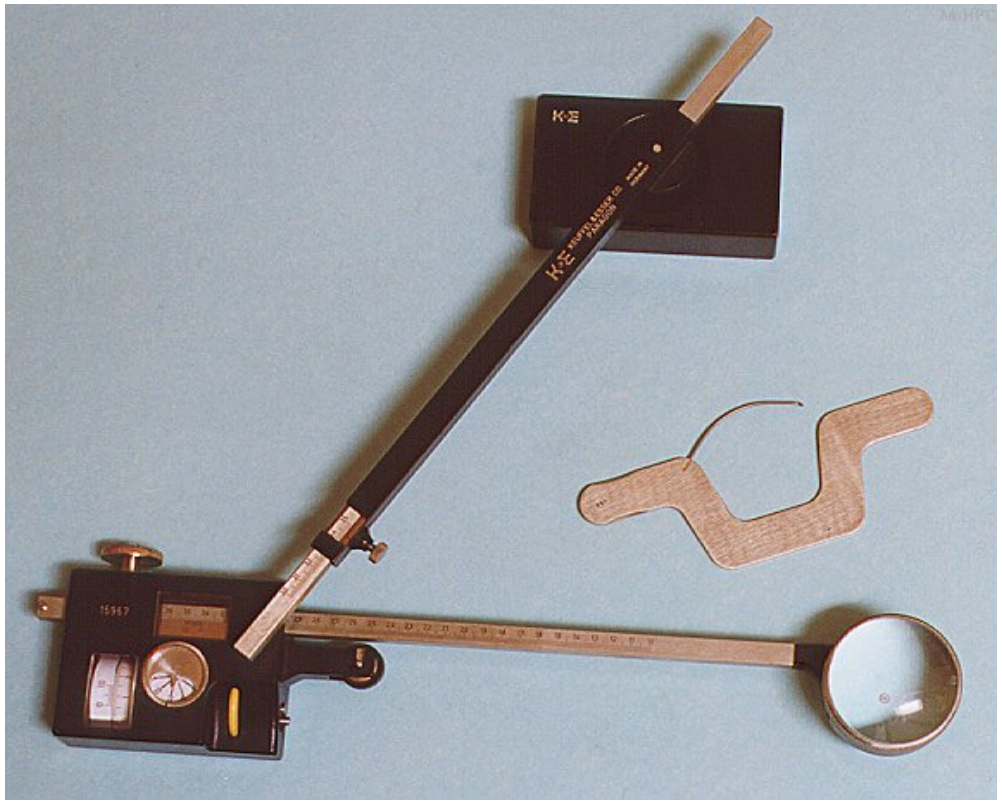
System Characterization

Three Components of System Characterization

1. Physical characterization:
   - What are the components of the CSS?
   - How does the CSS respond to rainfall?
2. Characterization of combined sewage and CSO
   - Characterization of precipitation
   - What significant pollutants are present in CSO?
3. Characterization of receiving waters
   - Are CSOs likely to cause WQ standards violations?



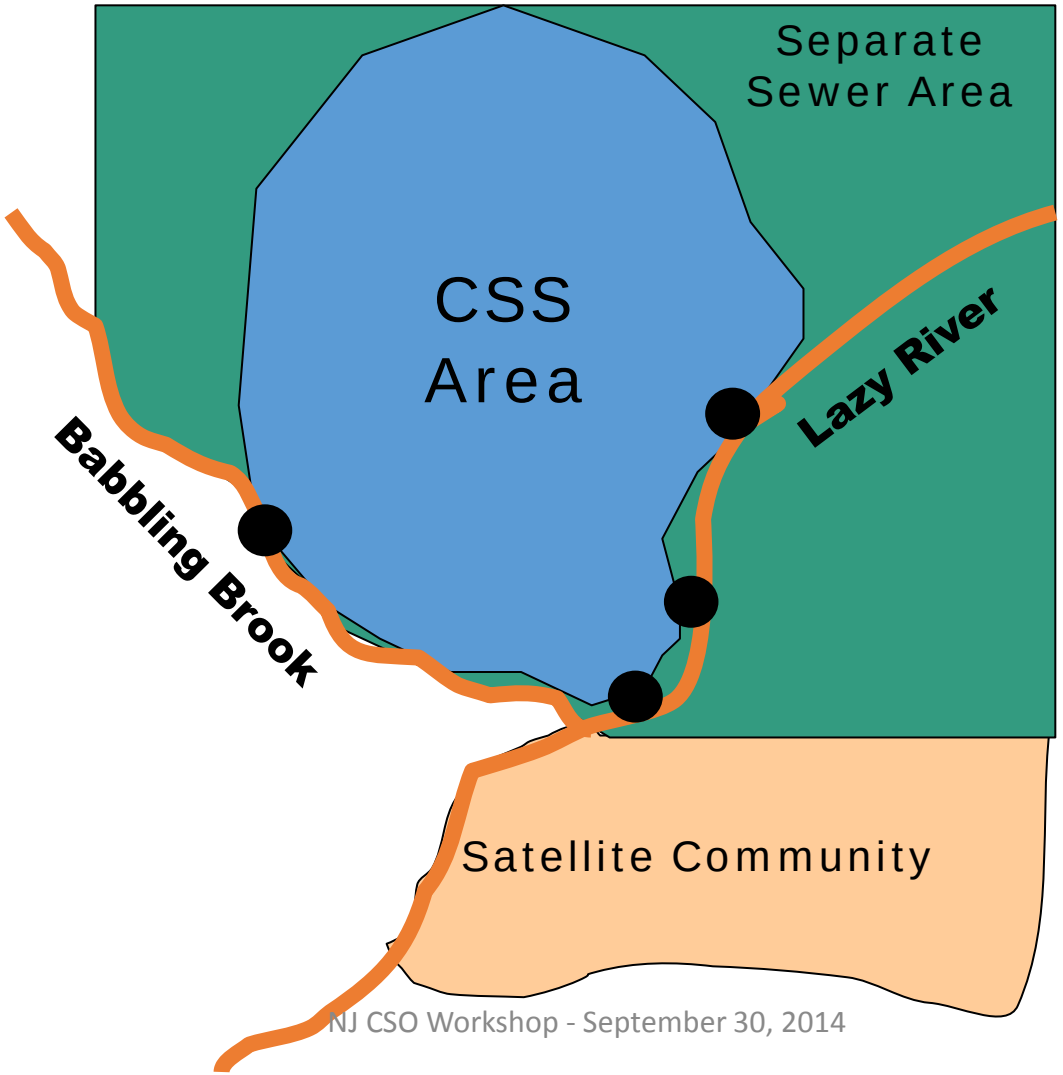
1. Physical Characterization



Physical Characterization

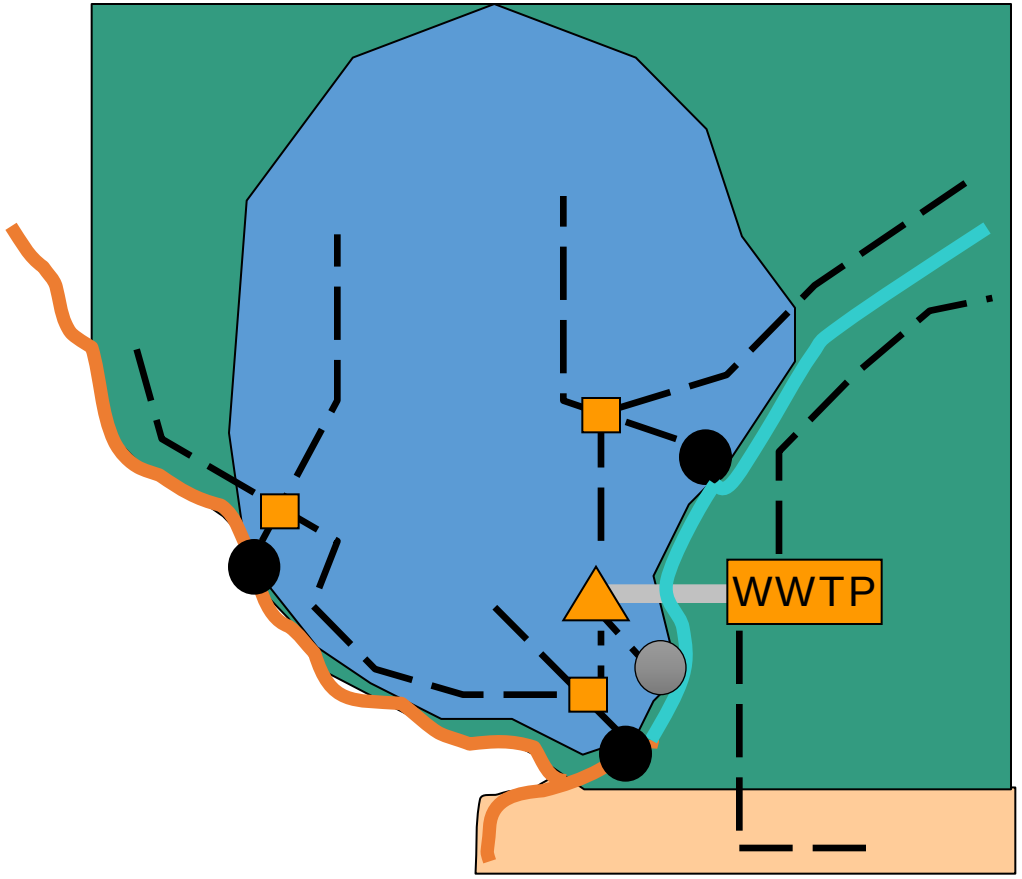
- Typically includes:
  - Delineation of CSS area and sewersheds
  - Locating CSO outfalls, regulator structures, the WWTP, and pump stations
  - Estimating land use and impervious cover, by sewershed
  - Showing layout of major interceptors
  - Identifying hydraulic capacities for the WWTP, CSO regulators, and pump stations
  - Identifying CSO receiving waters

Physical Characterization of Springfield, USA

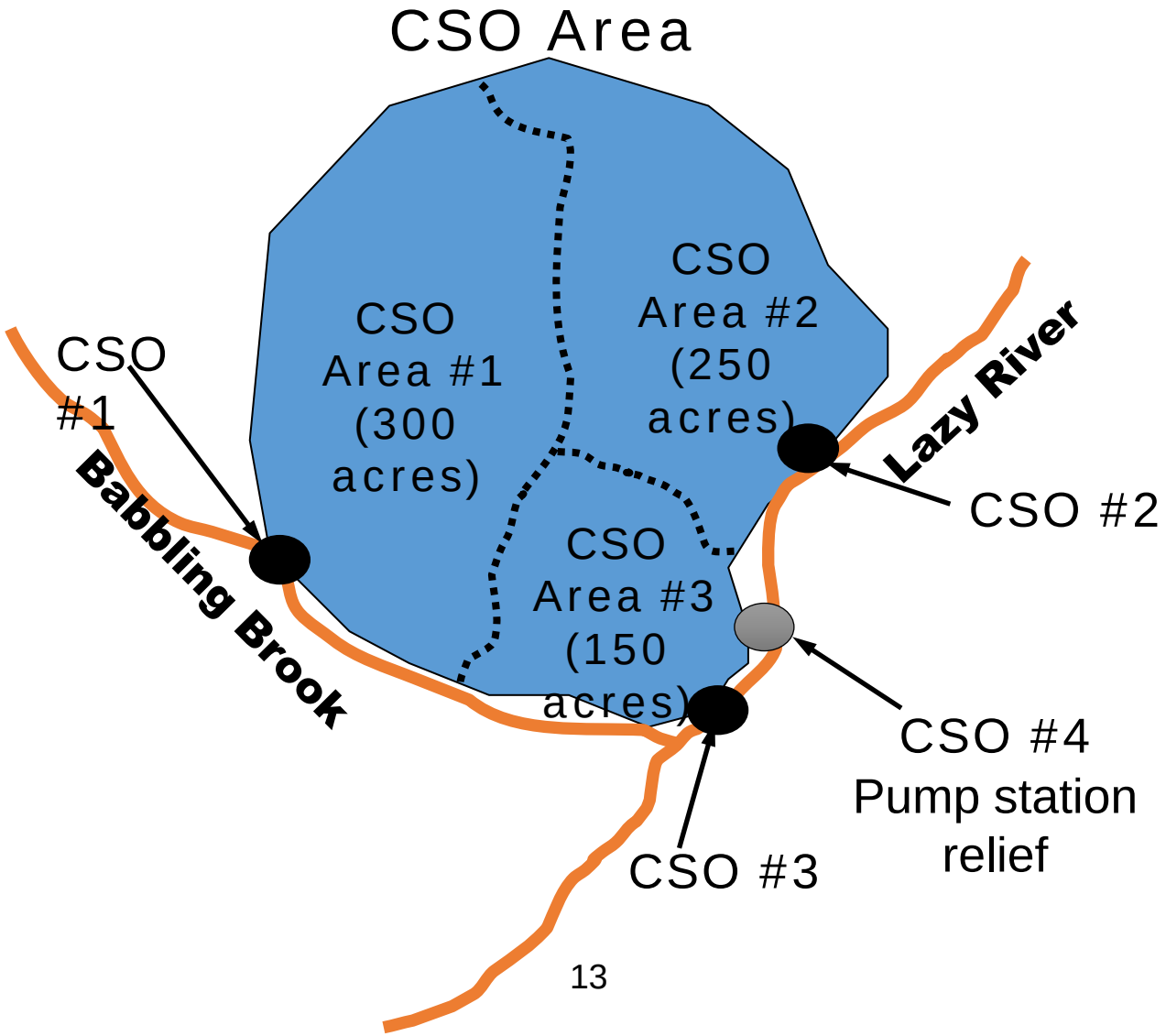


Overview of Collection System

- Layout of major interceptors
- Location of:
  - WWTP
  - CSO Regulators
  - Pump Station
  - Outfall Locations



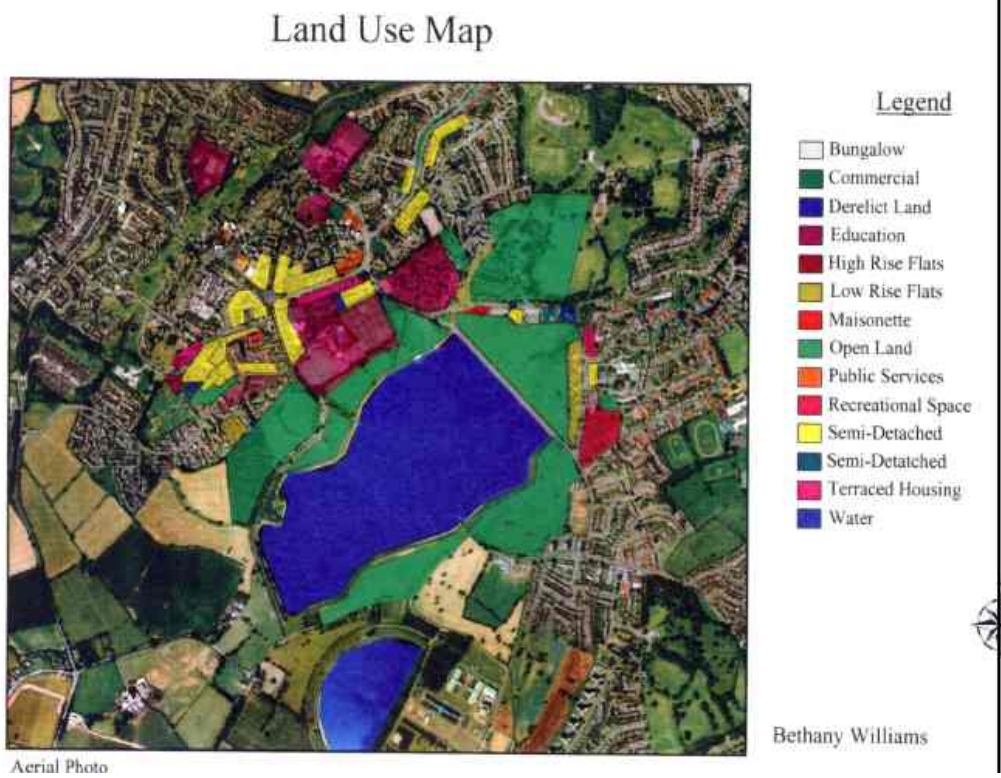
Defining Sub-Sewershed Areas

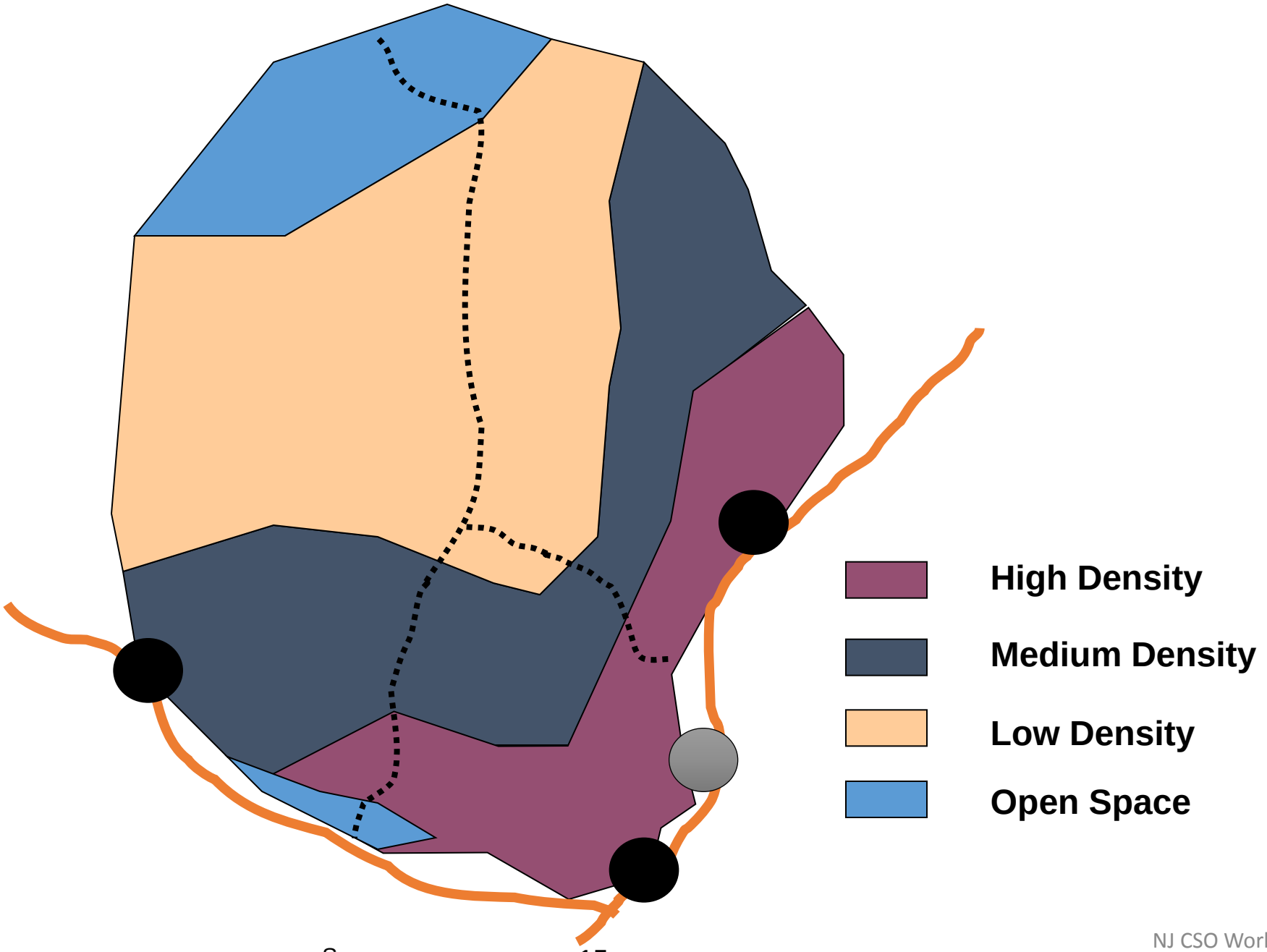


Characterizing Land Use

- General land use and estimated impervious cover
  - Some data available from USGS

  http://edc.usgs.gov/products/landcover/lulc.html#description
- Land use categories include:
  - Parkland or open space (<5% impervious)
  - Low density development (5-35% impervious)
  - Medium density development (35-70% impervious)
  - High density development (>70% impervious)




High Density
Medium Density
Low Density
Open Space

Tabulating Land Use

	Parkland/ Open Space	Low Density Development	Medium Density Development	High Density Development
CSO Area #1	**25%**	**40%**	**25%**	**10%**
CSO Area #2	**10%**	**25%**	**45%**	**20%**
CSO Area #3	**5%**	**15%**	**30%**	**50%**

Impervious Cover Calculation

Example: CSO Area #1 includes:

25% park (3% impervious)	**0.8%**
40% LDD (25% impervious)	**10.0%**
25% MDD (50% impervious)	**12.5%**
10% HDD (75% impervious)	**7.5%**
Estimate of Impervious Cover:	**30.8%**

Pipe, Capacity, & Flow Information

- Hydraulic analysis should be sufficient to:
  - Establish capacities for WWTP, pump stations and CSO regulators
  - Quantify dry weather and wet weather flows, including flows to CSS from neighboring communities
  - Describe any existing flow metering
    - Permanent system meters and monitors such as SCADA (Supervisory Control And Data Acquisition)
    - Metering/flow monitoring from previous studies
  - Identify problem areas and bottlenecks

Springfield: Pump Station and WWTP Capacities (MGD)

WWTP	**Average daily flow rate**	**4.0**
	▸ **CSS area**	**2.5**
	▸ **Separate sewer area**	**1.0**
	▸ **Satellite communities**	**0.5**
	Primary treatment capacity	**12.0**
	Secondary treatment capacity	**6.0**
Pump Station	**Average daily flow rate**	**3.0**
	Maximum pump rate	**6.0**

Springfield
CSS Capacities (MGD)

CSO Area #1	**Dry weather flow rate**	**1.0**
	Regulator capacity	**3.0**
CSO Area #2	**Dry weather flow rate**	**0.5**
	Regulator capacity	**2.0**
CSO Area #3	**Dry weather flow rate**	**1.0**
	Regulator capacity	**2.0**

Springfield Hydrologic Flow Balance

$Q_{wet} = CiA$

CSO Area #1 **wet weather runoff**	**(30.8% impervious) x (1" rain) x (300 acres)**	**= 2.5 MG runoff per inch of precipitation**
CSO Area #2 **wet weather runoff**	**(43.8% impervious) x (1" rain) x (250 acres)**	**= 3.0 MG runoff per inch of precipitation**
CSO Area #3 **wet weather runoff**	**(56.4% impervious) x (1" rain) x (150 acres)**	**= 2.3 MG runoff per inch of precipitation**

C = runoff coefficient (% imperviousness)
i = rainfall intensity
A = area

Springfield Hydrologic Flow Balance

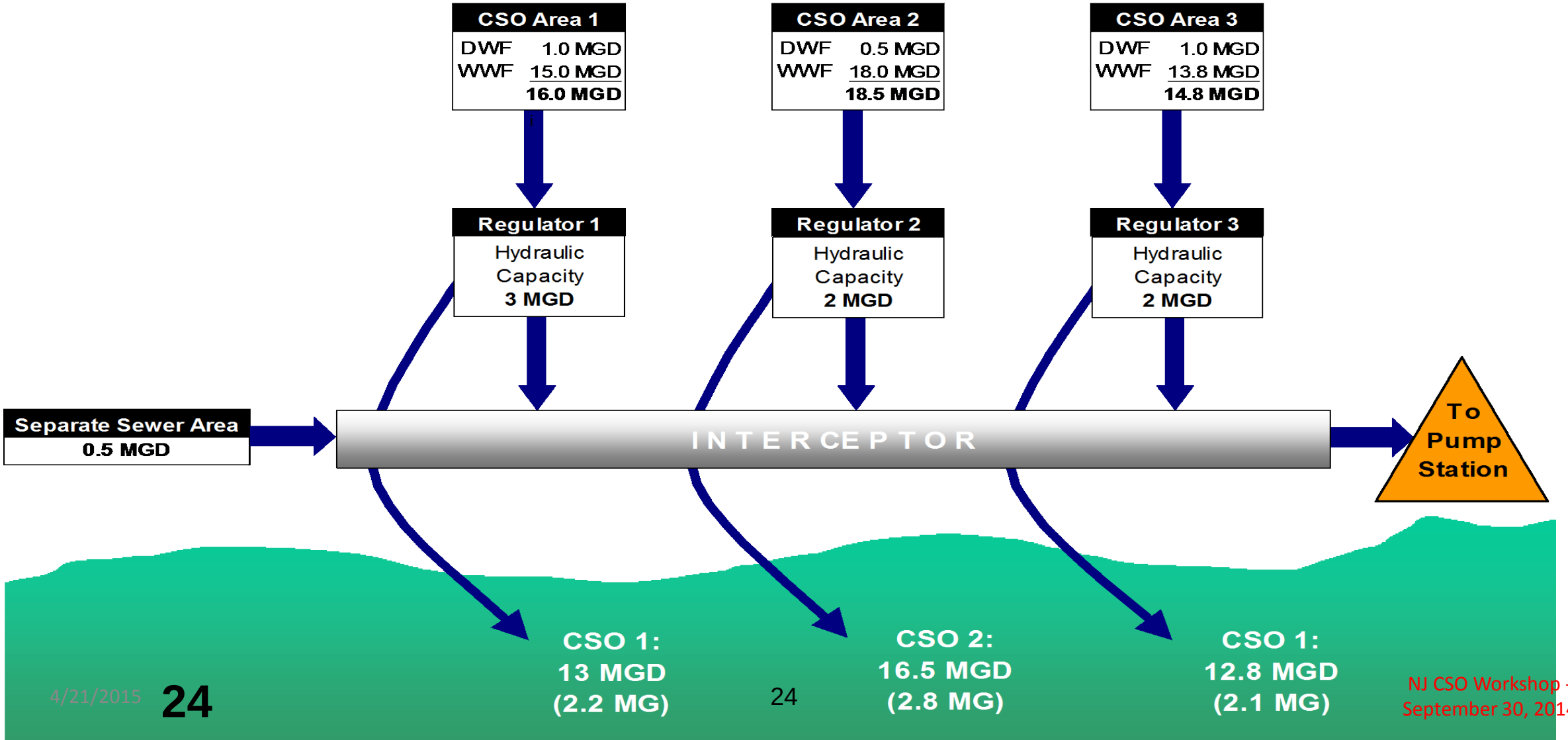
$Q_{wet} = CiA$

CSO Area #1 **wet weather runoff**	**2.5 MG runoff over 4 hours of rainfall**	**= 15 MGD average flow rate**
CSO Area #2 **wet weather runoff**	**3.0 MG runoff over 4 hours of rainfall**	**= 18 MGD average flow rate**
CSO Area #3 **wet weather runoff**	**2.3 MG runoff over 4 hours of rainfall**	**= 13.8 MGD average flow rate**

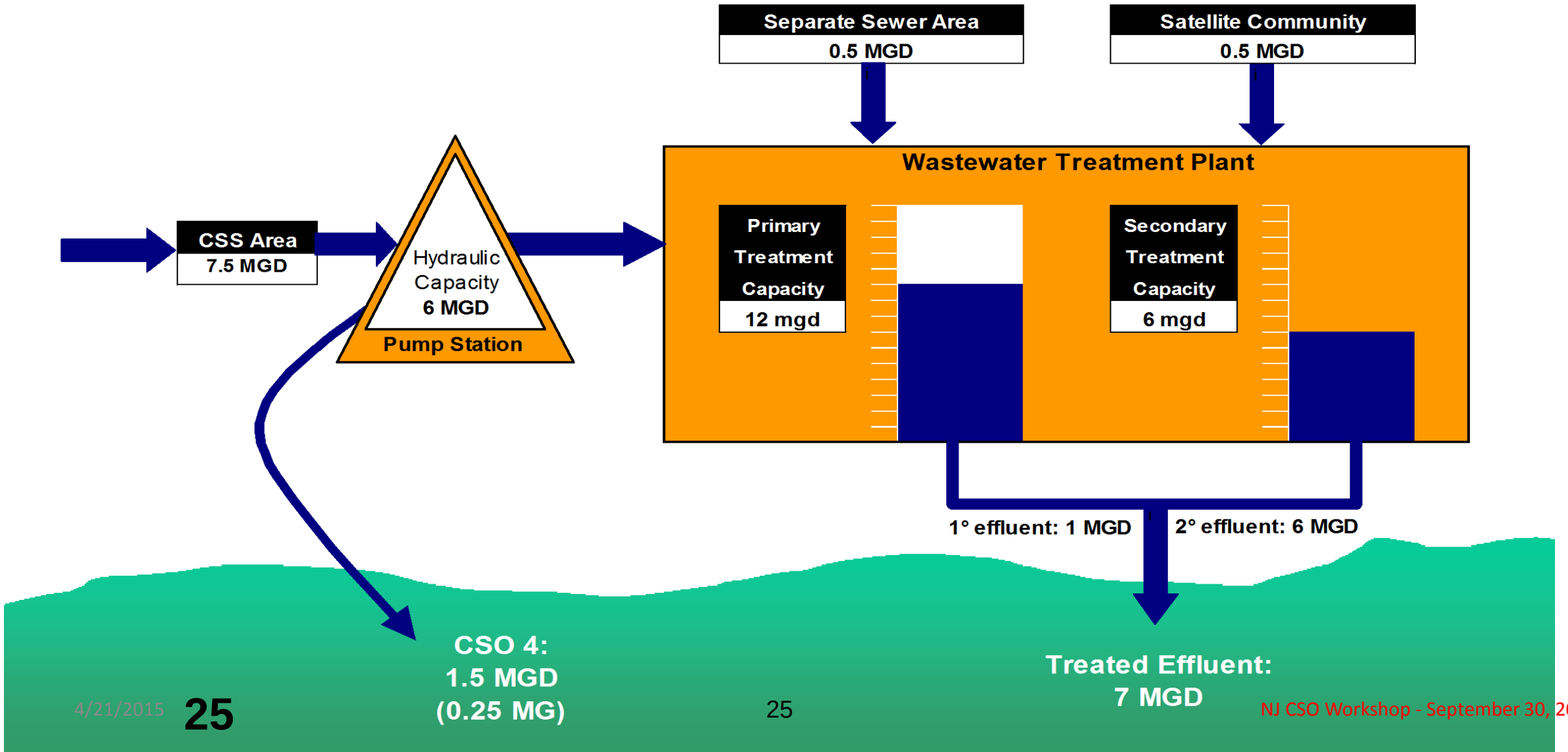
Example Hydrologic Flow Balance
$Q_{wet} = CiA$

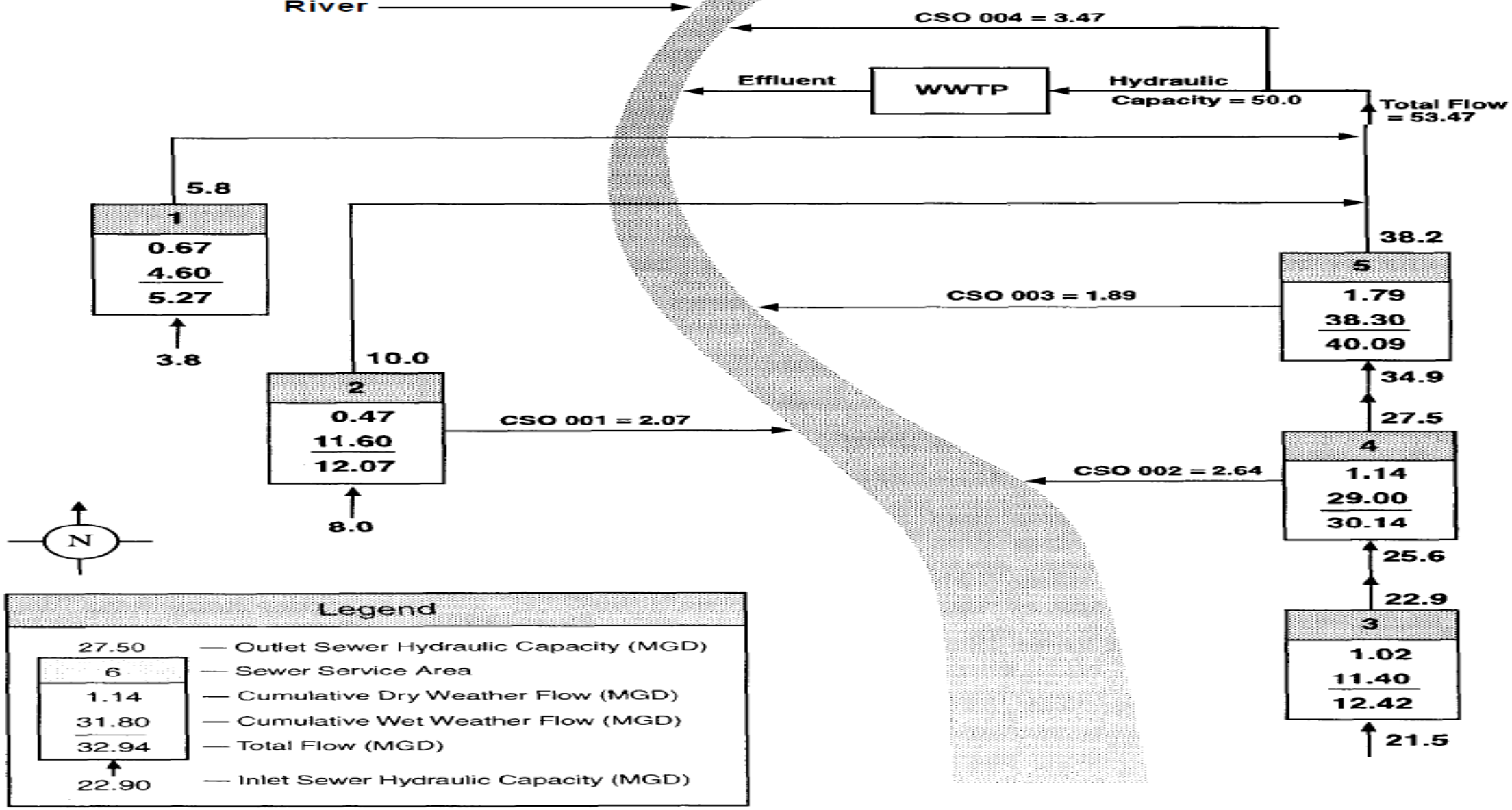
CSO Area #1 Wet Weather Runoff	**2.5MG runoff over 4 hours of rainfall (2.5x24/4 = 15)**	**= 15 MGD average flow rate**
CSO Area #2 Wet Weather Runoff	**3.0MG runoff over 4 hours of rainfall**	**= 18 MGD average flow rate**
CSO Area #3 Wet Weather Runoff	**2.3MG runoff over 4 hours of rainfall**	**= 13.8 MGD average flow rate**

Flow Balance Diagram



Flow Balance Diagram





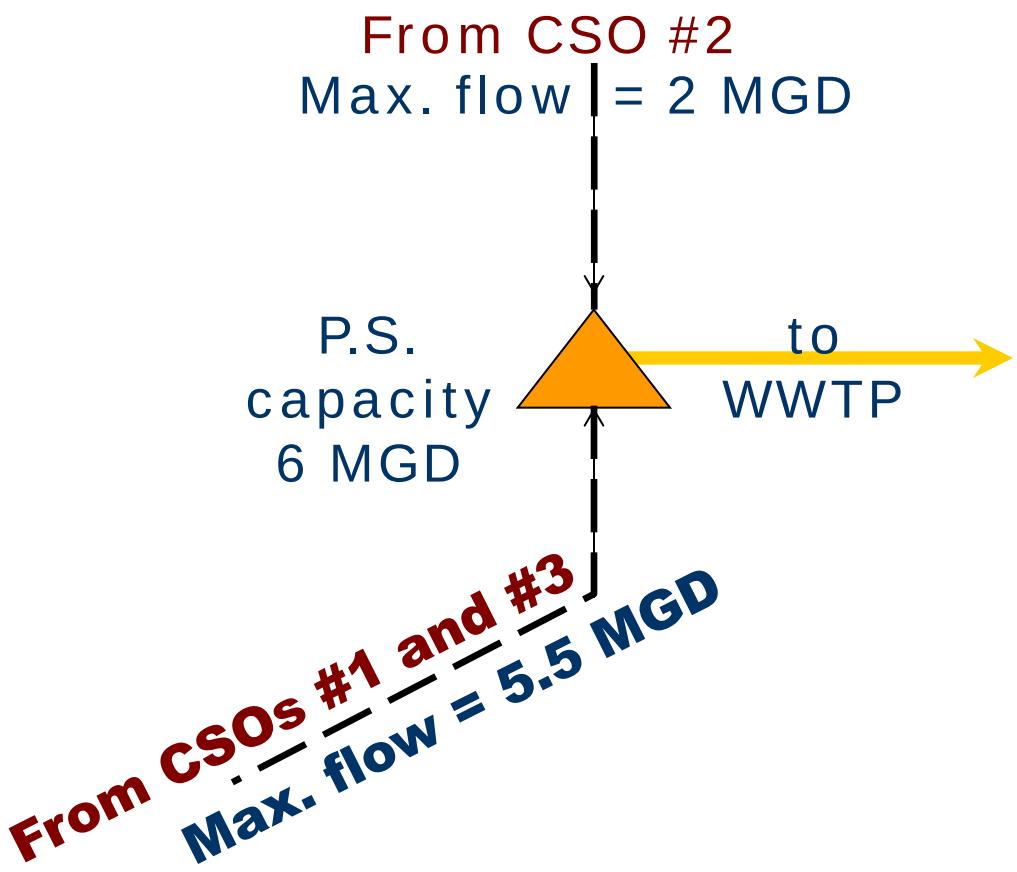
* Cumulative flows = flows from the service area and service areas upstream in the collection system. Wet weather flow values are for the average of several sampled storm events.

Problem Areas and Bottlenecks

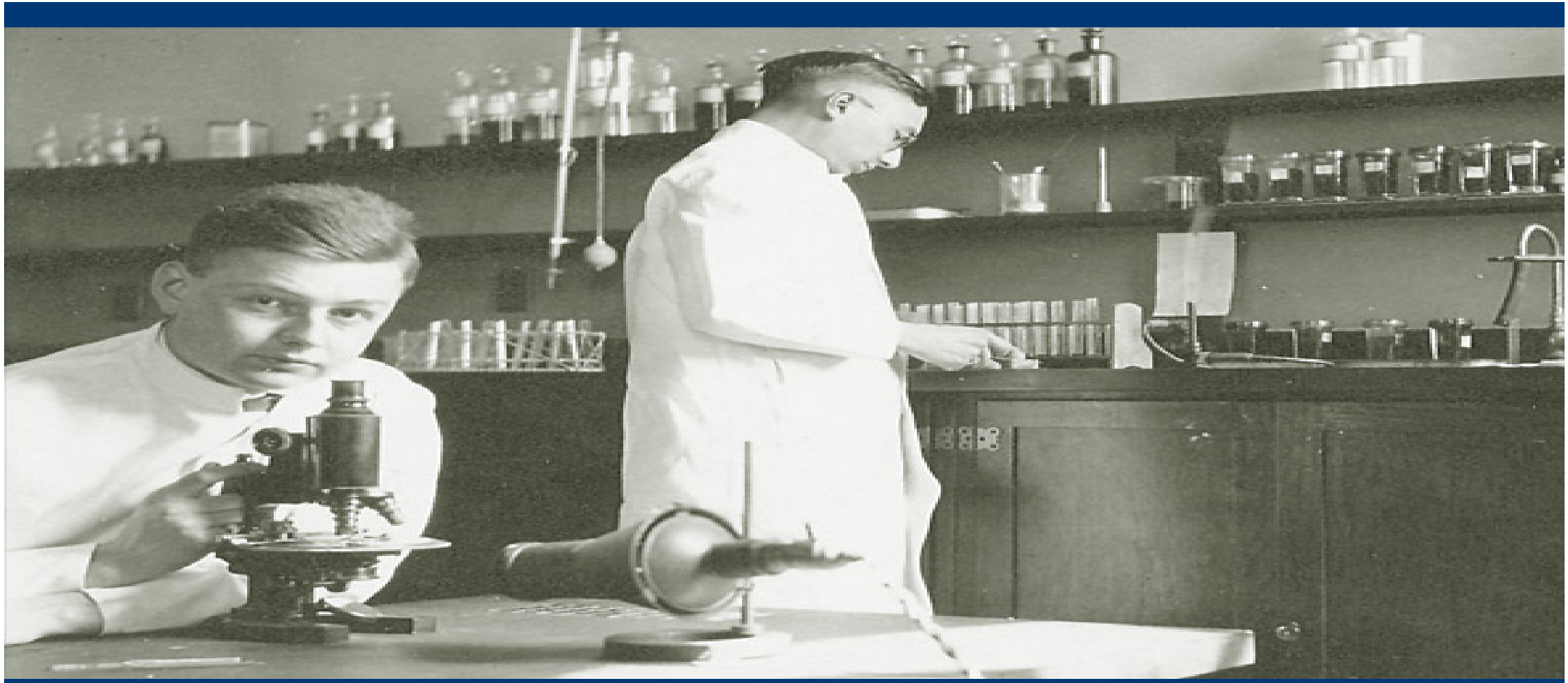
- Compare capacity at key locations in the collection system with peak wet weather flow rates
  - Intersections of major interceptors
  - Regulators
  - Pump stations
  - Cross connections
- Additional study may be required in areas that often flood during wet weather

Example—Bottleneck

- Pump station capacity should equal or exceed capacity of interceptors delivering flow



2. Characterization of Combined Sewage and CSO



Bacteriologic laboratory opened to diagnose tuberculosis, diphtheria and typhoid fever.

Characterization of Combined Sewage and CSO

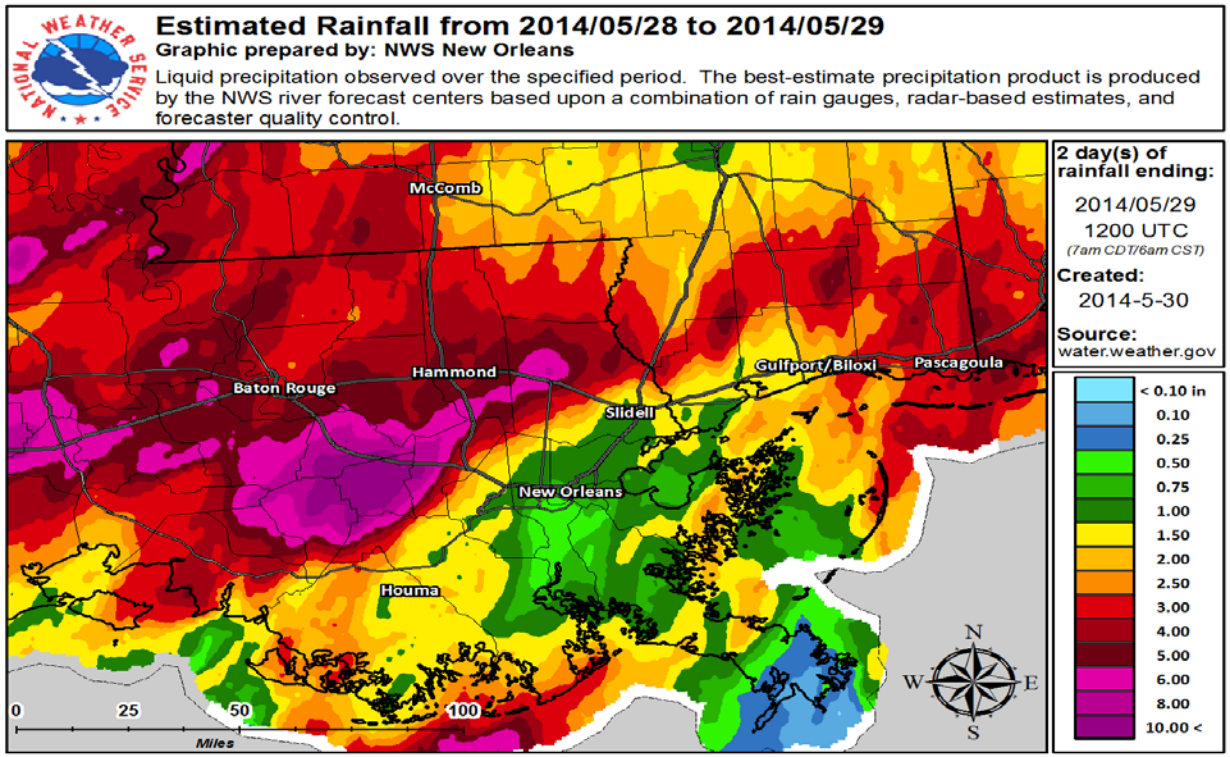
- Sources of existing information:
  - General WWTP operating data
  - Discharge monitoring reports (DMRs)
  - Pretreatment program data (SIUs)
  - Facility planning studies
  - GIS databases
  - Other local CSO studies
  - Literature

Characterization of Combined Sewage and CSOs cont.

- LTCP should include estimates of central tendency [median, Event Mean Concentration (EMC)] *and* ranges of concentration for potential pollutants of concern
  - Most often: Bacteria, TSS, BOD
  - Sometimes: Nutrients
  - Less often: Metals and toxics

Characterization of (Precipitation) Rainfall

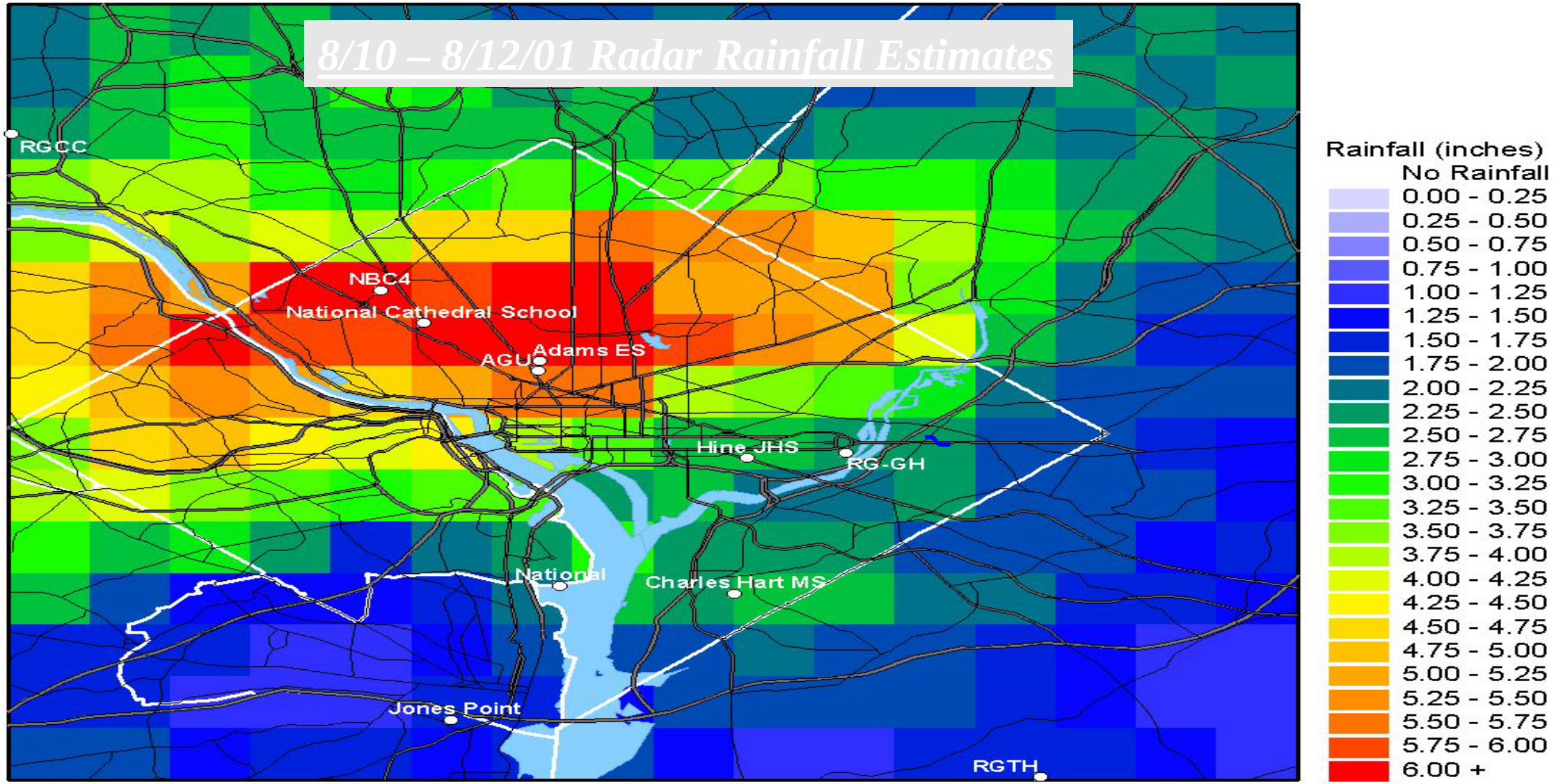
- Rainfall is what produces overflows in the first place
- Baseline understanding of "typical" rainfall is important
  - Number of storm events
  - Annual total rainfall
  - Number of events above a "trigger" level
  - Peak intensities



Characterization of Rainfall

- Large systems greatly benefit from a network of rain gages
- Smaller systems may be adequately represented by a single, well-located gage
  - The treatment plant may be convenient, but not in the combined sewer area
- Development of “typical year” requires a long record, most likely from a nearby airport

Example of Rainfall Variability



Typical Year Analysis

- Obtain long (30 or more years) of hourly rainfall data
- Define “events” based on an inter-event duration (six hours is common, but longer times may be appropriate)
- Develop tables of event depths and peak intensities for each year
- Compare statistics for individual years to entire period of record

Rainfall Analysis

- Permittees are expected to describe how “annual average” conditions were determined
- May include:
  - Ranking of annual rainfall
  - Assessment of month-to month variations
  - Assessment of rainfall intensity
  - Assessment of return frequency

What is “Annual Average” Condition?

Year	Rainfall (inches)	No. of Events >0.05 inches	Avg. Duration of Events (hrs)	Avg. Max Intenstiy (in/hr)	Max. Intensity (in/hr)
1980	33.9	70	9	0.20	0.98
1981	35.7	70	9	0.19	1.04
1982	40.6	70	9	0.20	1.26
1983	**54.7**	**78**	**11**	**0.22**	**1.50**
1984	**41.7**	**78**	**9**	**0.21**	**0.79**
1985	**33.7**	**69**	**9**	**0.18**	**2.37**
1986	42.9	73	10	0.24	1.92
1987	36.0	63	11	0.24	1.80
1988	37.8	63	9	0.23	1.93
1989	50.0	82	11	0.19	1.64
1990	43.9	82	8	0.21	2.37
1991	39.8	59	11	0.23	1.19
1992	37.0	74	10	0.18	0.76
1993	46.8	68	10	0.23	1.15
1994	45.4	78	9	0.22	1.40
1995	35.5	63	9	0.20	1.09
1996	45.3	82	9	0.18	0.86
Average	**41.2**	**72**	**10**	**0.21**	**1.41**
Maximum	**54.7**	**82**	**11**	**0.24**	**2.37**
Minimum	**33.7**	**59**	**8**	**0.18**	**0.76**

3. Characterization of Receiving Waters

Characterization of Receiving Waters

- LTCP should document:
  - Water quality standards
  - Available water quality, sediment, and biological data
  - Flow conditions in the CSO receiving water(s)
  - Known impairments
  - Location of sensitive areas
  - Planned or ongoing TMDL studies

Characterization of Receiving Waters

- Sources of existing information:
  - Applicable state water quality standards
  - USGS streamflow and water quality data *http://waterdata.usga.gov/nwis/sw*
  - EPA STORET and BASINS Programs
  - Integrated 305(b)/303 Water Quality Assessment Reports
  - Other local water quality assessments

Example Summary of Available Water Quality Data

Water Body – Babbling Brook

Statistics	DO (mg/L)	Fecal Coliform (Apr – Sept) (MPN/100mL)	pH
Minimum	5.6	80	6.3
Maximum	14.6	11,000	8.9
Average	9.6	1,396	7.6
Median	9.0	2,306	8.0
% of time WQS violated	0.5%	81.8%	0.0

Springfield Example Designated Use

- Babbling Brook
  - *Drinking Water Supply* – Maintenance of a raw water supply which will yield potable water after treatment by public water treatment facilities
  - *Whole-Body-Contact Recreation* – Activities in which there is direct human contact to the point of complete body submergence
  - *Cool-water Fishery* – Maintenance of a sensitive, high-quality sport fishery

Springfield Example Water Quality Criteria

- Babbling Brook
  - *Dissolved Oxygen* – minimum daily 5.0 mg/L
  - *Bacteria* – For the recreational season (April 1 – Oct 1) maximum of 200 MPN/100 mL when stream or lake is not affected by stormwater runoff
  - *pH* – from 6.5 to 9.0, inclusive

Example Summary of Flow Conditions

Station ID	Station Name	Period	Drainage Area
01234567	**Lazy River at Springfield**	1946-present	314 sq. mi.
01237777	**Babbling Brook at Shelbyville**	1973-present	13.9 sq. mi.

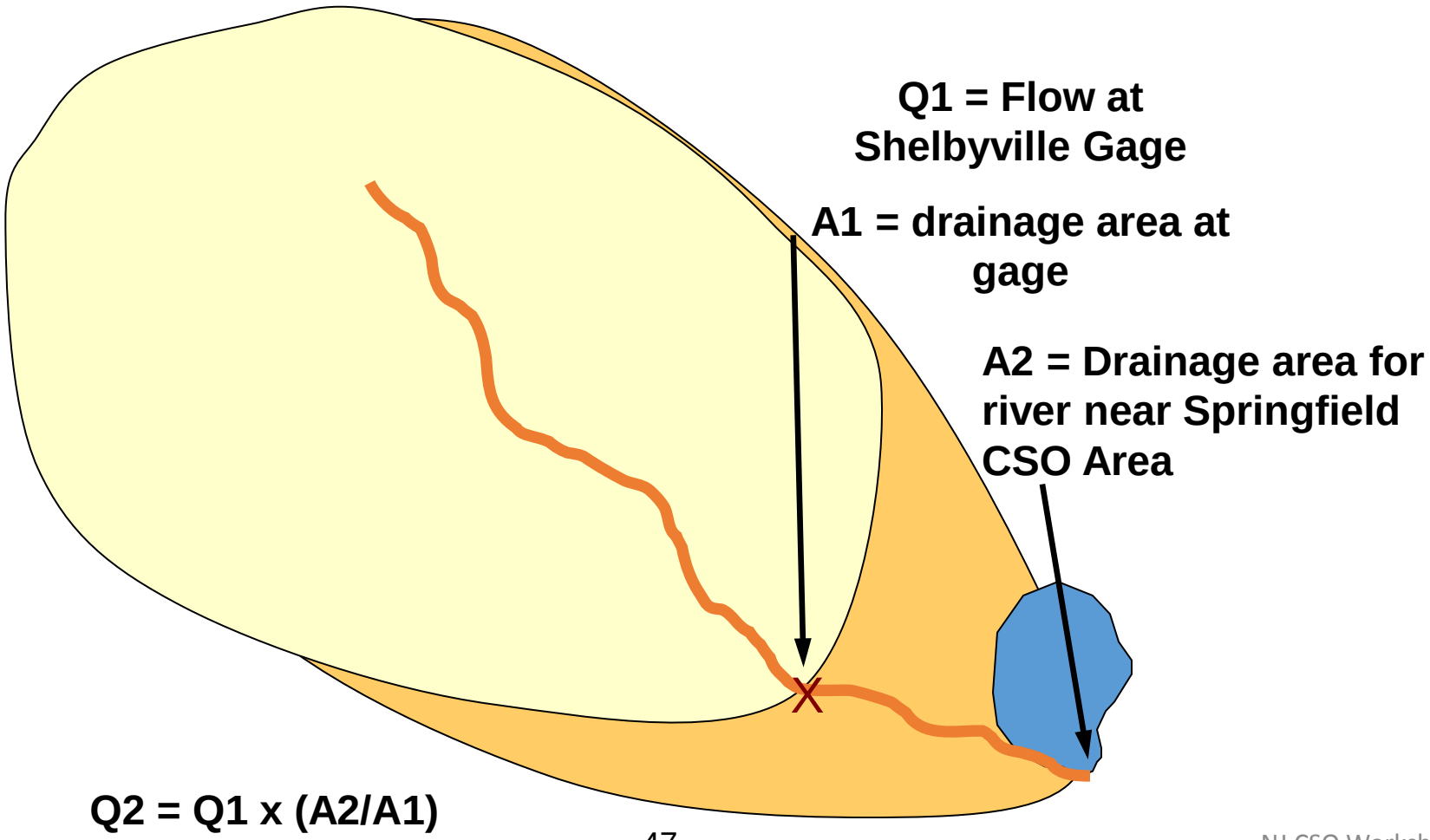
Example Summary of Flow Conditions

Month	Lazy River (cfs)
January	642
February	642
March	757
April	734
May	610
June	450
July	402
August	269
September	289
October	306
November	375
December	547
Average	461 cfs

What if Local Flow Data are Not Available?

- Options for estimating flow:
  - Scale down/up from gage elsewhere in the watershed
  - Use data from similar local watershed with gage
  - Estimate flow using Q=CiA

Example Scale Up Flow from Another Gage for Babbling Brook



Q2 = Q1 x (A2/A1)

Example – Scale Up from Another Gage

- Babbling Brook at Shelbyville
  - Drainage Area
    - 13.9 mi^2
  - Annual Average Flow
    - 9.9 cfs

- Babbling Brook at Springfield
  - Drainage Area
    - 17.2 mi^2
  - Annual Average Flow

$$\frac{17.2\ mi^2}{13.9\ mi^2} = \frac{BB\ flow}{9.9\ cfs}$$

BB flow = 12.2 cfs

Springfield
Example WQS: Designated Use

- Lazy River
  - *Boating and Canoeing* – Activities in which limited contact with water is assumed
  - *Protection of Aquatic Life* – Conditions allowing maintenance of a wide variety of warm-water biota
- Babbling Brook
  - *Whole-Body-Contact Recreation* – Activities in which there is direct human contact to the point of complete body submergence
  - *Cool-water Fishery* – Maintenance of a sensitive, high-quality sport fishery

Springfield
Example WQS: Numeric Criteria

- Lazy River
  - *Fecal Coliform*- For the recreational season (April 1 – Oct 1), shall not exceed 5,000 MPN/100mL in more than 10% of the samples
  - *Dissolved Oxygen* – daily minimum 4.0 mg/L year-round
  - *Ammonia* – acute and chronic criteria that are temperature and pH dependent
- Babbling Brook
  - *Fecal Coliform* – For the recreational season (April 1 – Oct 1) geometric mean cannot exceed 200 MPN/100 mL
  - *Dissolved Oxygen* – minimum daily 5.0 mg/L
  - *Ammonia* – more stringent than for Lazy River

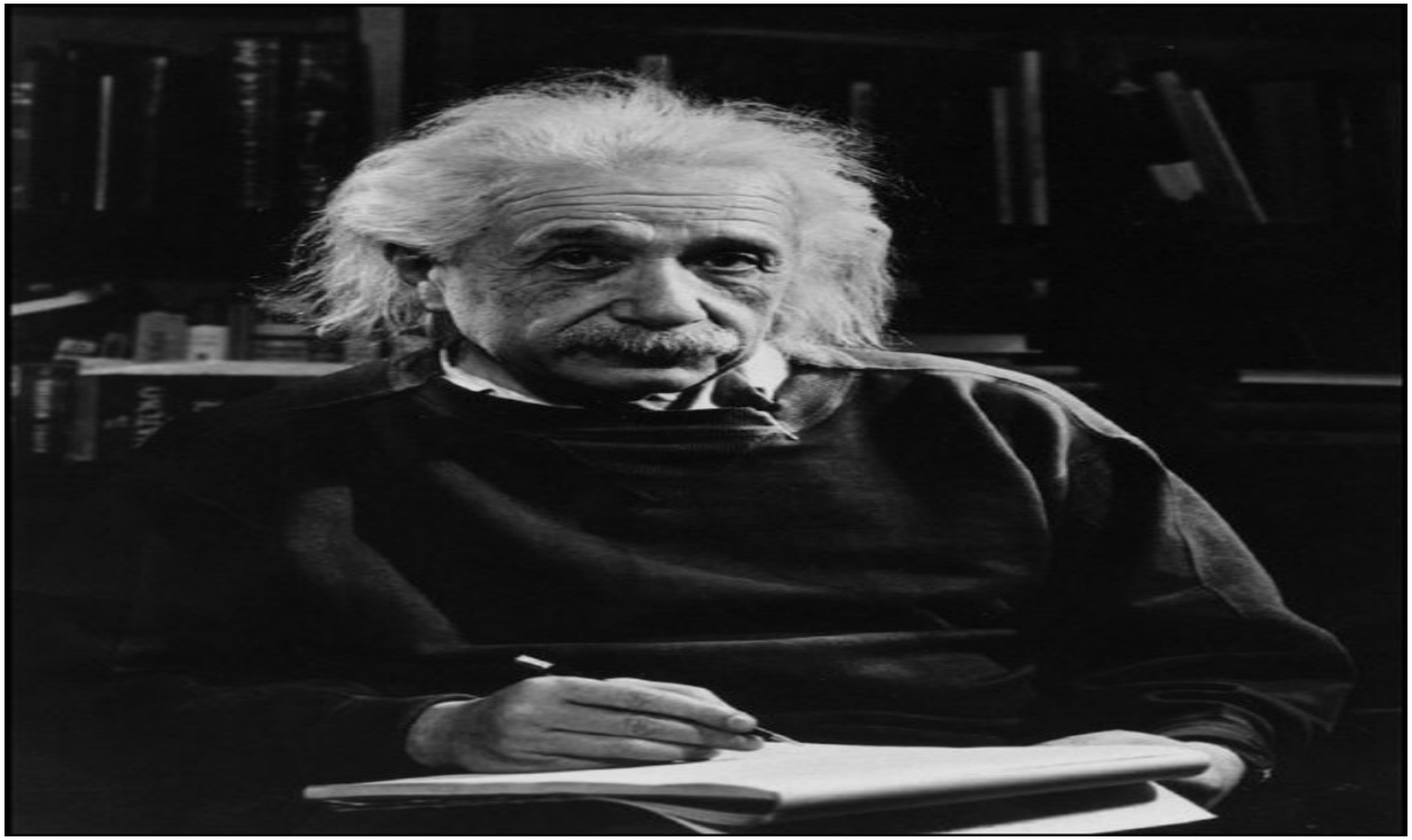
Fecal Coliform: Apr-Oct, 2003

	B.B. Upstream	B.B. Downstream	L.R. Downstream
Count	**6**	**28**	**12**
Minimum	**100**	**4**	**100**
Average	**1,900**	**6,800**	**4,400**
Geom. Mean	**431**	**800**	**800**
90th Percentile	**800**	**16,000**	**4,000**
Maximum	**10,000**	**50,000**	**40,000**

Dissolved Oxygen

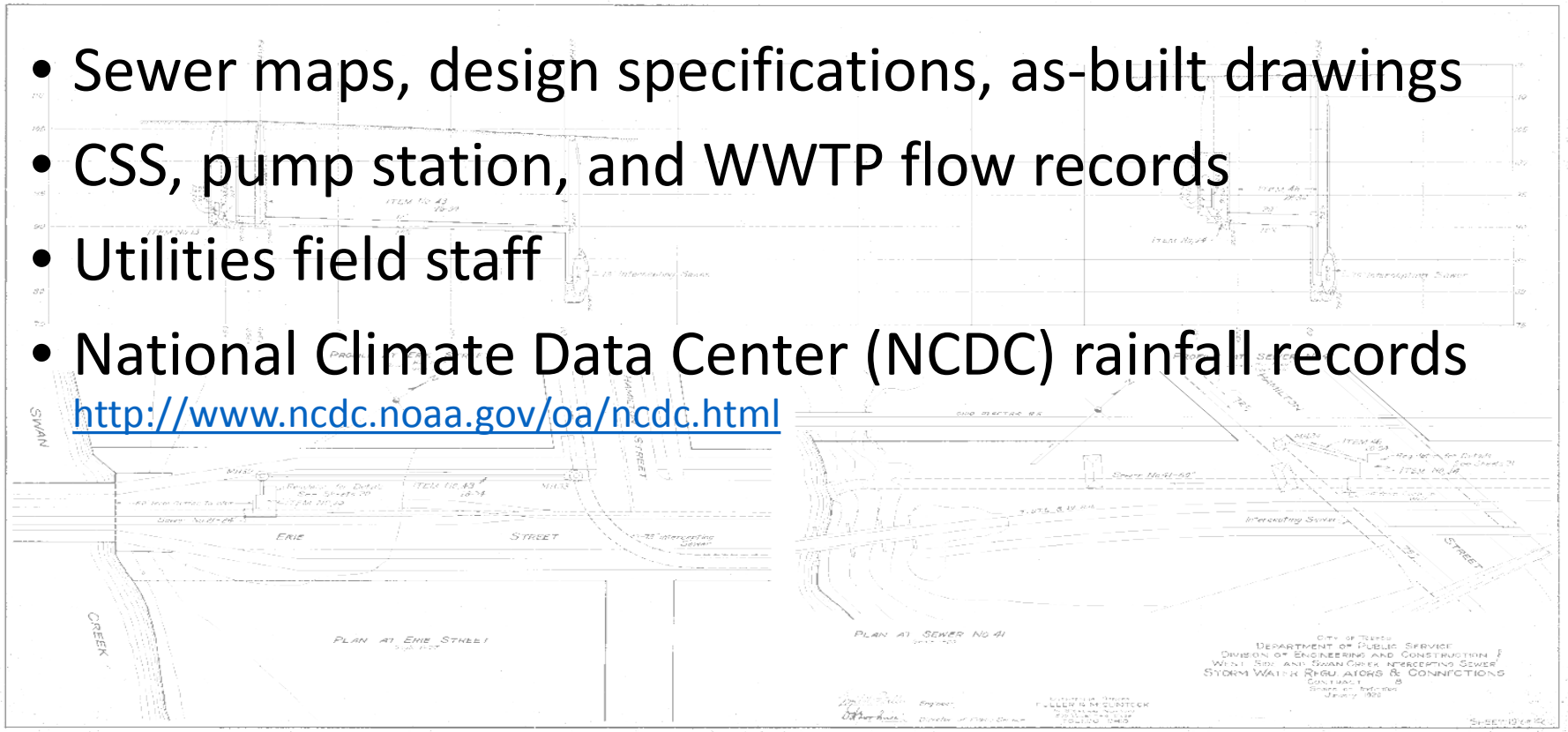
- Data show all values (12) in Lazy River are greater than 4.0 mg/l
- Historic data show only one of 28 measurements was below 5.0 mg/l in Babbling Brook
  - Occurred during dry weather, extremely low flow
- Macroinvertebrate and fish data show species diversity is good
- Work with state biologist to determine if more data should be collected

Sources of Information



Sources of Information: Physical Characterization

- Sewer maps, design specifications, as-built drawings
- CSS, pump station, and WWTP flow records
- Utilities field staff
- National Climate Data Center (NCDC) rainfall records
  http://www.ncdc.noaa.gov/oa/ncdc.html



Sources of Information: Physical Characterization cont.

- WWTP facilities plans
- Pump station and WWTP performance data (e.g. stress test results)
- Treatment plant upgrade reports
- Infiltration/inflow (I/I) studies
- Sewer system evaluation surveys (SSES)
- Storm water master plans
- GIS databases

Sources of Information : Characterization of Receiving Waters

- Sources of existing information:
  - USGS streamflow and water quality data http://waterdata.usgs.gov/nwis/sw
  - Applicable state water quality standards
  - EPA STORET and BASINS Programs
  - State 305(b) Water Quality Assessment Reports
  - State 303(d) lists of impaired waters
  - Other local water quality assessments

Summary

- System Characterization
  - Characterization of physical components of CSS
  - Characterization of combined sewage and CSOs
  - Characterization of receiving waters

Questions ??????????

LTCP: Evaluation of CSO Control Alternatives

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U.S. EPA

Nine Elements of an LTCP

- Characterization, monitoring and modeling
- Public participation
- Consideration of sensitive areas
- Evaluation of CSO control alternatives
- Cost/performance considerations
- Operational plan
- Maximization of treatment at the POTW
- Implementation schedule
- Post-construction compliance monitoring

Evaluation of CSO Control Alternatives

- The overall objective of CSO control should be to meet WQ standards and protect designated uses
- The evaluation of alternatives should be conducted in a framework that enables a reasonable assessment of controls, costs, and benefits related to the objectives
- The evaluation may be less extensive for small CSO communities
- Development and implementation of a LTCP represents a WQ-based control approach

CSO Policy and Cost Performance Consideration

- CSO Policy
- Cost Performance Consideration

CSO Policy

CSO Policy - Evaluation of Alternatives

- EPA expects the long-term CSO control plan to consider a reasonable range of alternatives
- For example:
  - Zero overflow events per year
  - An average of one to three, four to seven and eight to twelve overflow events per year
  - Evaluate controls that achieve 100%, 90% , 85%, 80% and 75% capture for treatment

4/21/2015

CWA - Technology-Based and Water Quality-Based Effluent Limitations

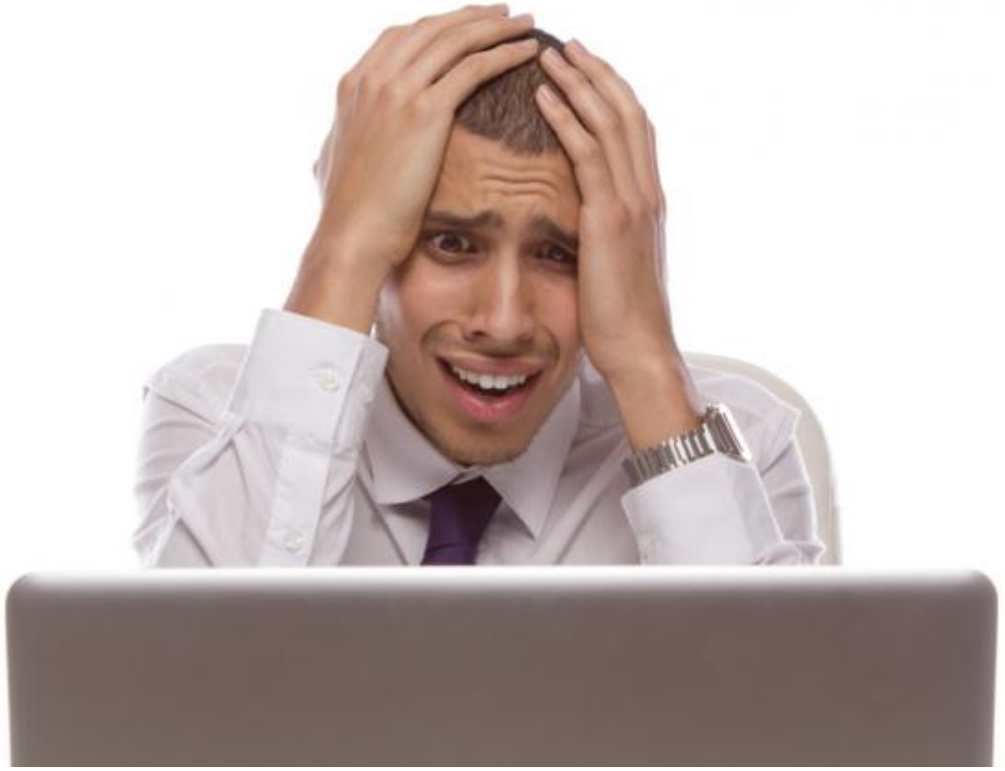
	Technology-based Effluent Limitations (TBELs)	Water Quality-based Effluent Limitations (WQBELs)
Goal or Policy:	▪ **Zero Discharge of Pollutants**	▪ **Fishable and Swimmable Waters** ▪ **No Toxics in Toxic Amounts**
Standards:	▪ Technology	▪ Water Quality
NPDES Regulations:	▪ 40 CFR 122.44(a), (e) ▪ 40 CFR 125.3	▪ 40 CFR 122.44(d)

- **Develop TBELs (derived from technology standards) for all applicable pollutants of concern**
- **Develop WQBELs where TBELs are not adequate to meet water quality standards in the receiving water.**

CSO Policy - Evaluation of Alternatives cont.

- The long-term control plan should also consider, expansion of POTW secondary and primary capacity
- The analysis of alternatives should be sufficient to make a reasonable assessment of cost and performance
- Selected controls should be sufficient to meet CWA requirements
- In addition to considering sensitive areas, the long-term CSO control plan should adopt “Presumption” or “Demonstration” approach

Cost Performance Considerations



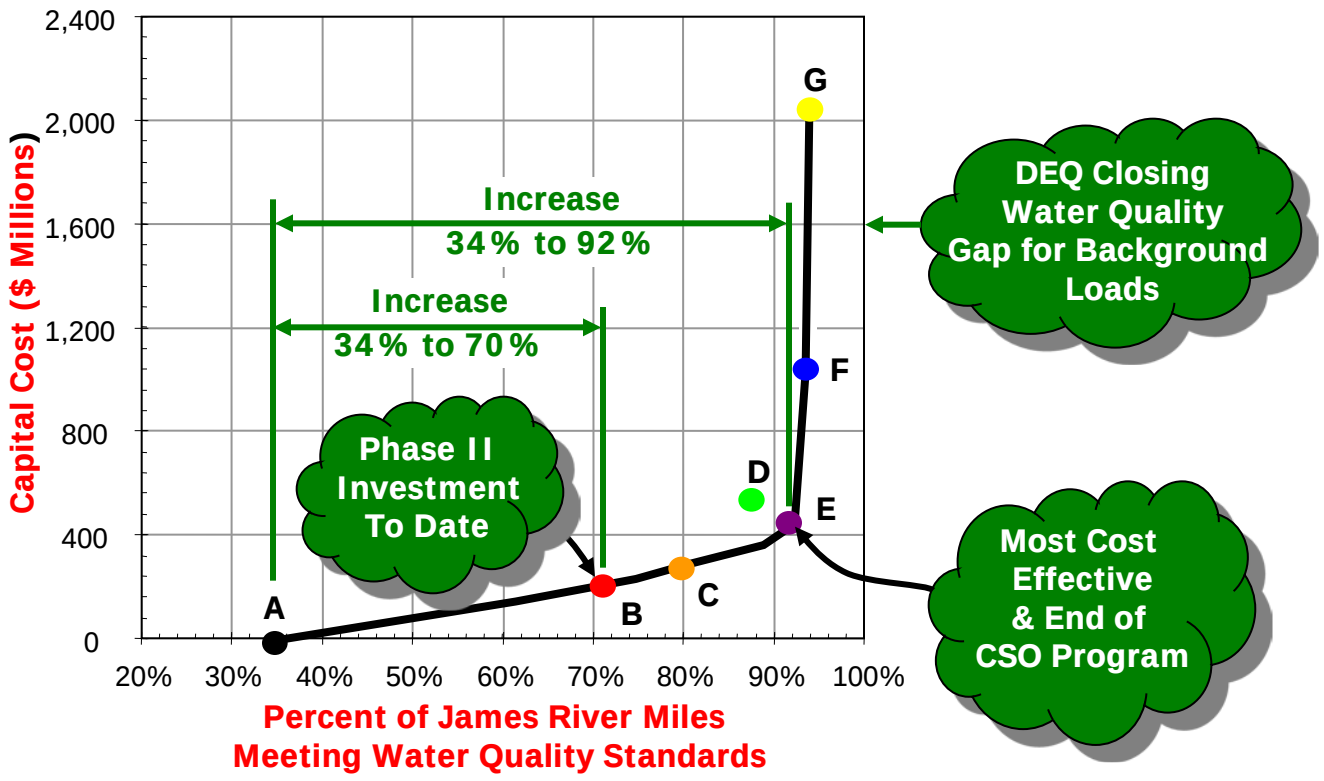
Cost/Performance Considerations cont.

- The permittee should develop appropriate cost/performance curves to demonstrate the relationships among a comprehensive set of reasonable control alternatives
- This should include an analysis to determine where the increment of pollution reduction achieved in the receiving water diminishes compared to the increased costs
- This analysis, often known as "Knee of the Curve" should be among the considerations used to help guide selection of CSO controls

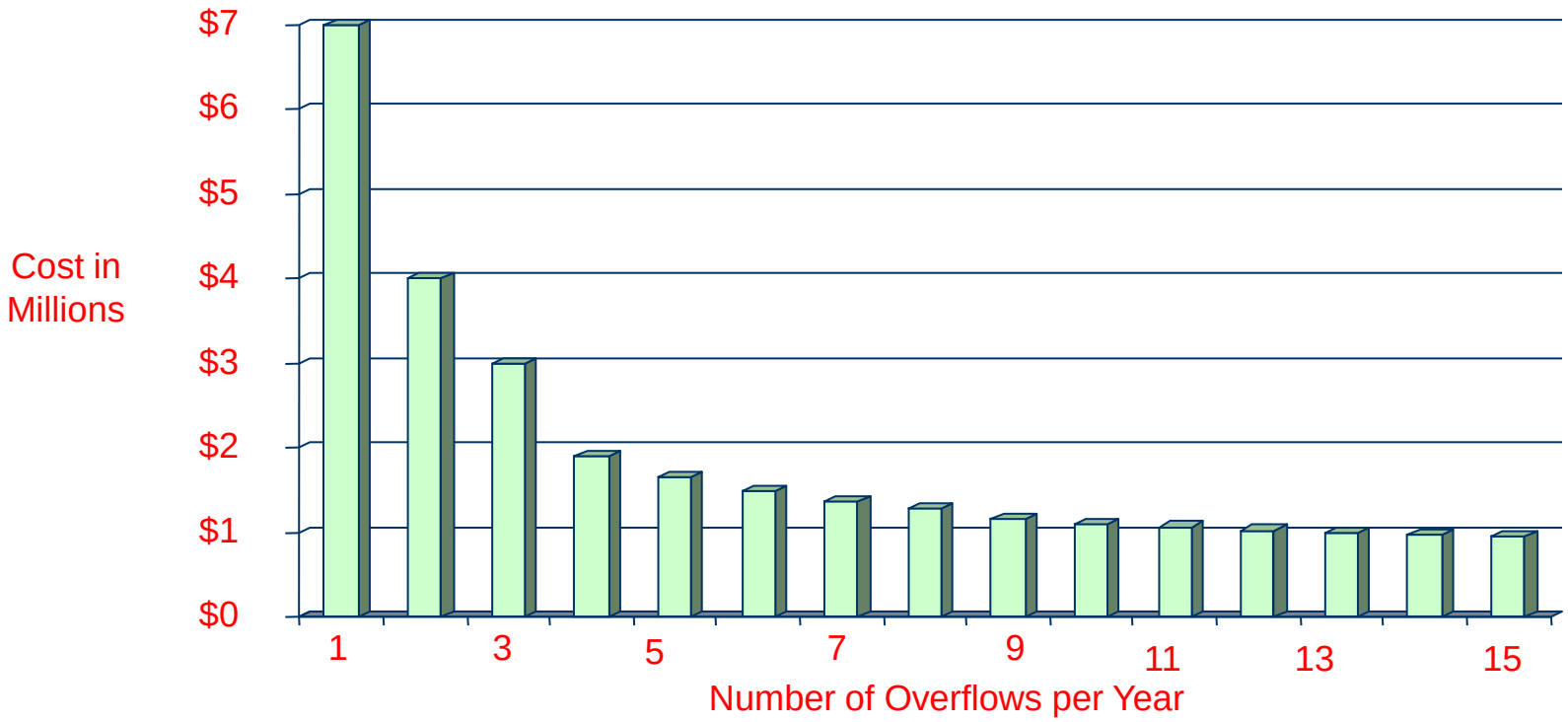
Knee of the Curve

- Knee of the Curve is used to select the CSO control by developing cost/performance curve
- Comprehensive set of reasonable control alternatives to the different ranges of CSO control achievement analysis as a percentage of capture, number of overflows or net environmental benefit
- Should be among the considerations used to help guide selection of CSO controls

Cost Performance: Percent of James River Miles Meeting WQS



Knee of Curve Example
Cost in Millions vs. CSO Frequency



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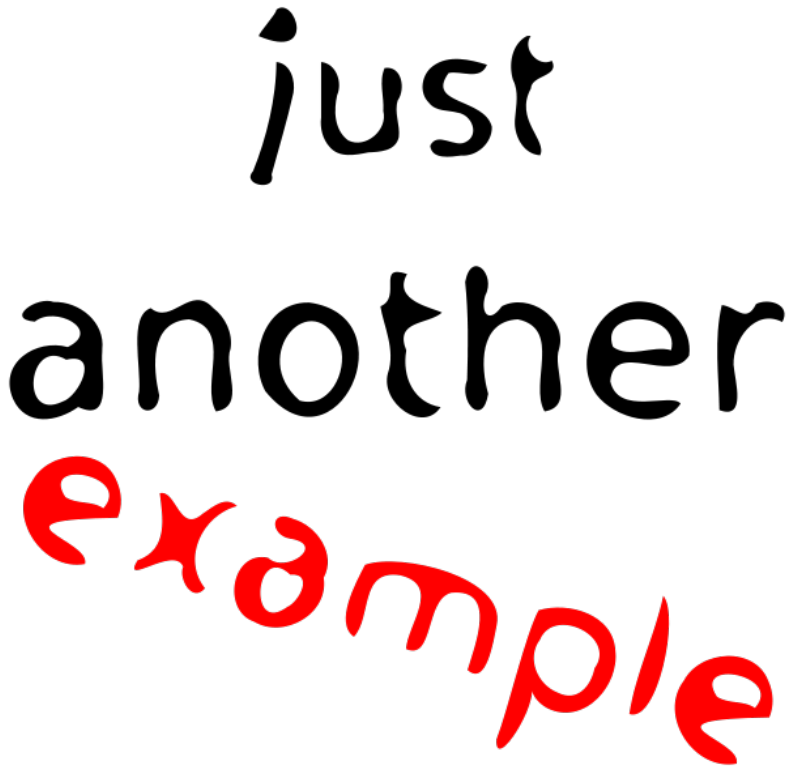
CSO Controls - Examples



CSO Controls: O&M Practices – Source Controls

- Sewer inspection and testing
  - Manual vs. remote
- Sewer cleaning
  - Hydraulic, mechanical, chemical
- Pollution prevention
  - Source control
- Water quality monitoring and public notification
  - To minimize exposure

Note: Many elements of NMC are source controls

CSO Controls: Collection System

- Maximizing flow to the treatment plant
- Monitoring & real-time control
- Inflow reduction
- Sewer separation
- Sewer rehabilitation
- Service lateral rehabilitation
- Manhole rehabilitation

CSO Controls: Storage

- In-line storage—oversized conduits and regulators; in-line tanks; parallel relief sewers
- Off-line storage—retention basins/tunnels to store wet weather flow for subsequent treatment
- On-site storage / flow equalization—storage at WWTP to manage excess wet weather flow

CSO Controls: Treatment Technologies

- Screening
- Supplemental treatment
- Plant modifications
- Disinfection
- Floatables control
- Satellite treatment

CSO Controls – Green Infrastructures

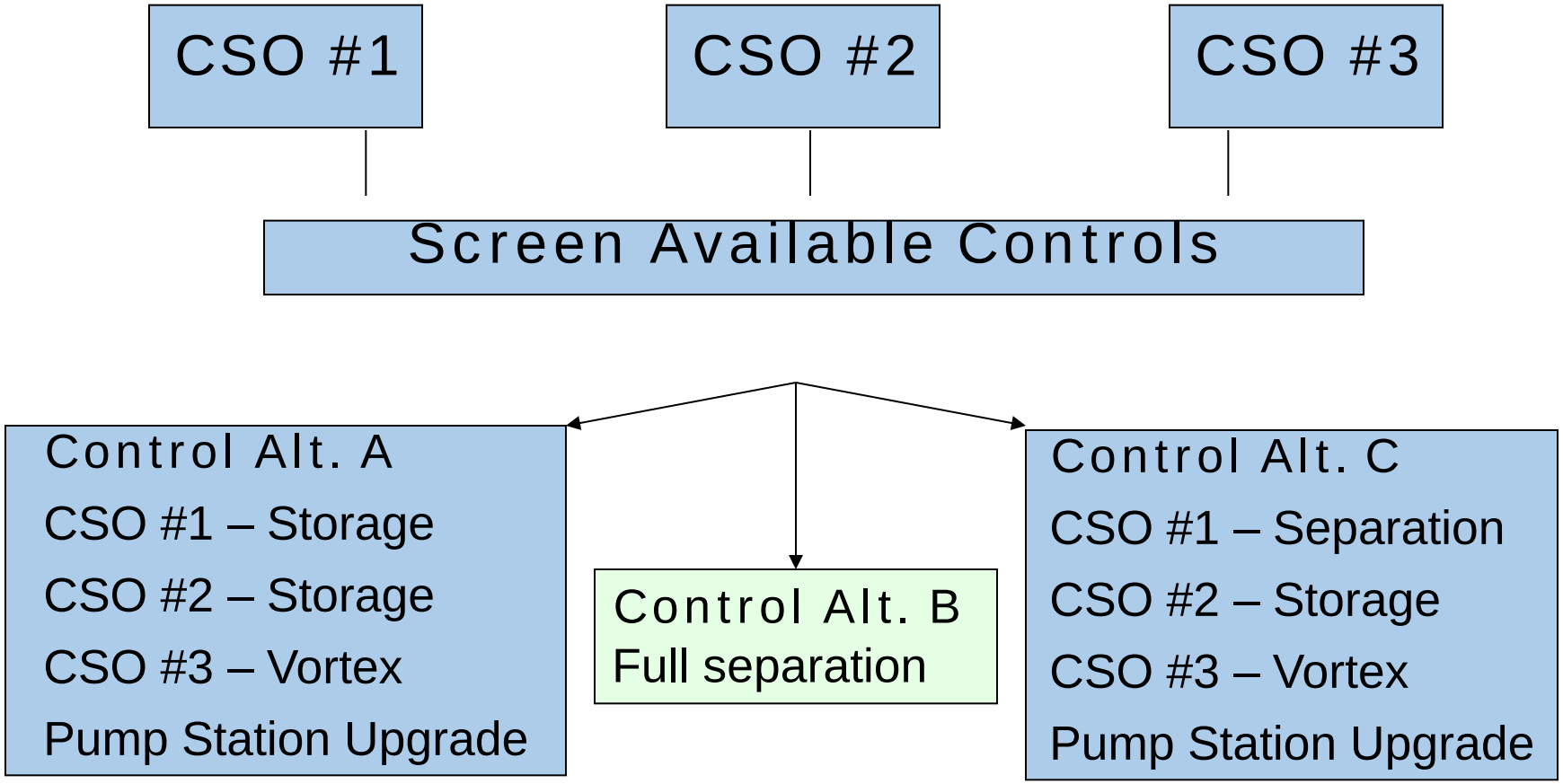
- Runoff Control
- Retention

Evaluation of CSO Control Alternatives

- ID conditions under which controls are evaluated
- Typically involves reference to baseline condition
- Presumption approach (e.g., 4-6 overflow event per year or capture for treatment of 85% volume) requires analysis to be on a *system-wide, annual average basis*
- Analysis of rainfall and identification of annual average conditions should be documented

Note: Permittee should describe how CSO control alternatives have been evaluated.

Typical Scenario Development



Final Selection of CSO Control Alternatives

Should be based on:

- Control priorities
- Site specific conditions
- Protection of WQS and designated uses
- Public input
- Cost-effectiveness of controls
- Financial capability
- Other considerations

Example – Richmond, VA

Development of Alternatives Richmond, VA

Control Technologies

- Source Controls (Best Management Practices)
- Sewer Separation
- Storage & Flow Equalization Controls
- Clarification
- Conveyance
- Disinfection

Criteria

- Availability of Sufficient Space for the Proposed Facility
- Distance of the Site From CSO Regulators or Outfalls
- Short- & Long-Term Environmental Impacts
- Public Acceptance
- Socioeconomic Impacts

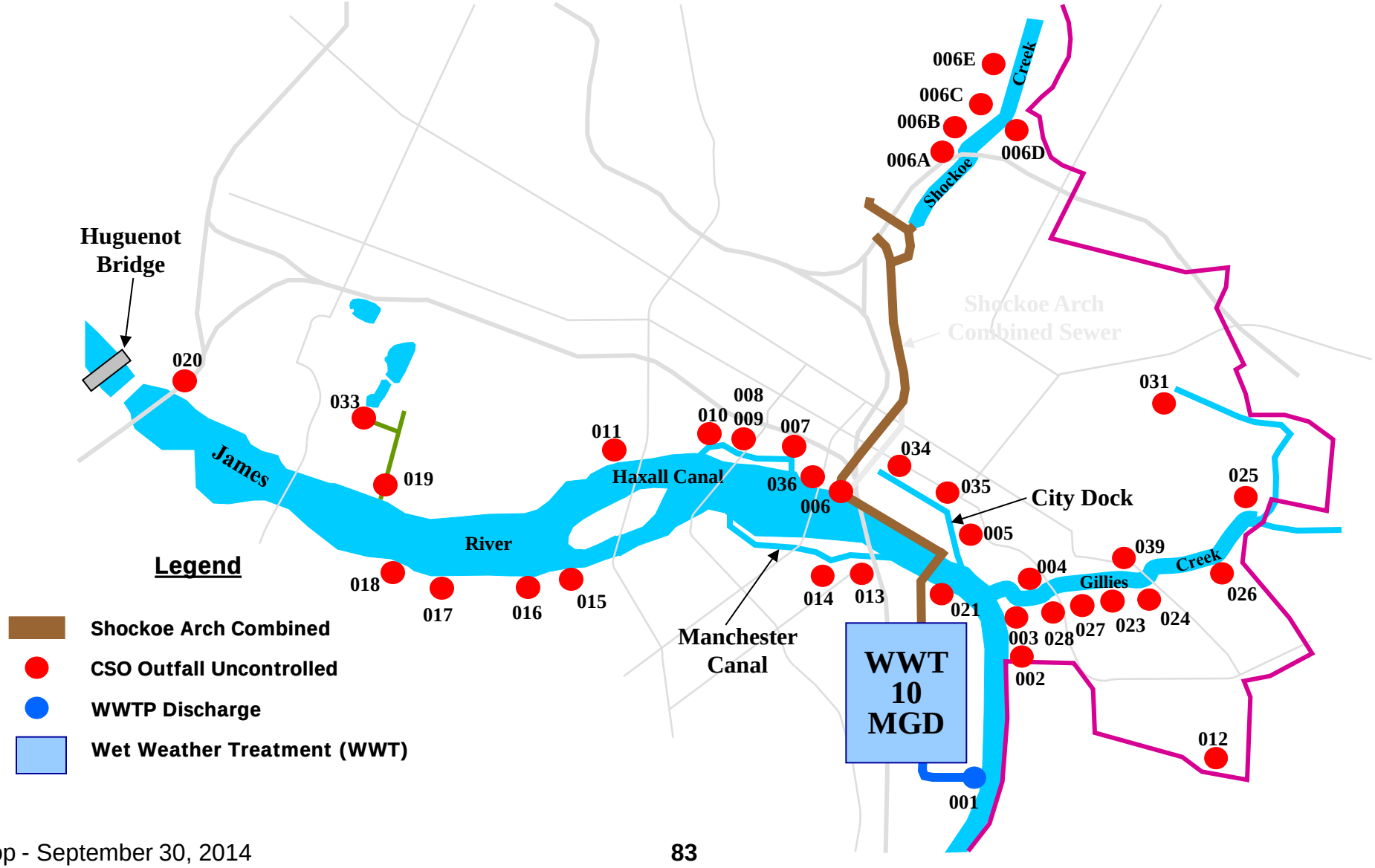
- Background A1 – City Replaced with Open Field
- Background A2 – City Prior to CSO Controls
- Background B – After Phase II Improvements

Alternatives

- Alternative C – Maximize CSO Wet Weather Flow Treatment
- Alternative D – Northside & Peripheral Flow Equalization & Gillies Creek Conveyance
- Alternative E – Increase CSO Wet Weather Flow Treatment & Shockoe Expansion w/Disinfection Plus Lower Gillies Creek Conveyance
- Alternative F – Control CSOs to 4 Overflows Per Year
- Alternative G – Complete Citywide Sewer Separation

Richmond, VA

Scenario A: Prior to CSO Control

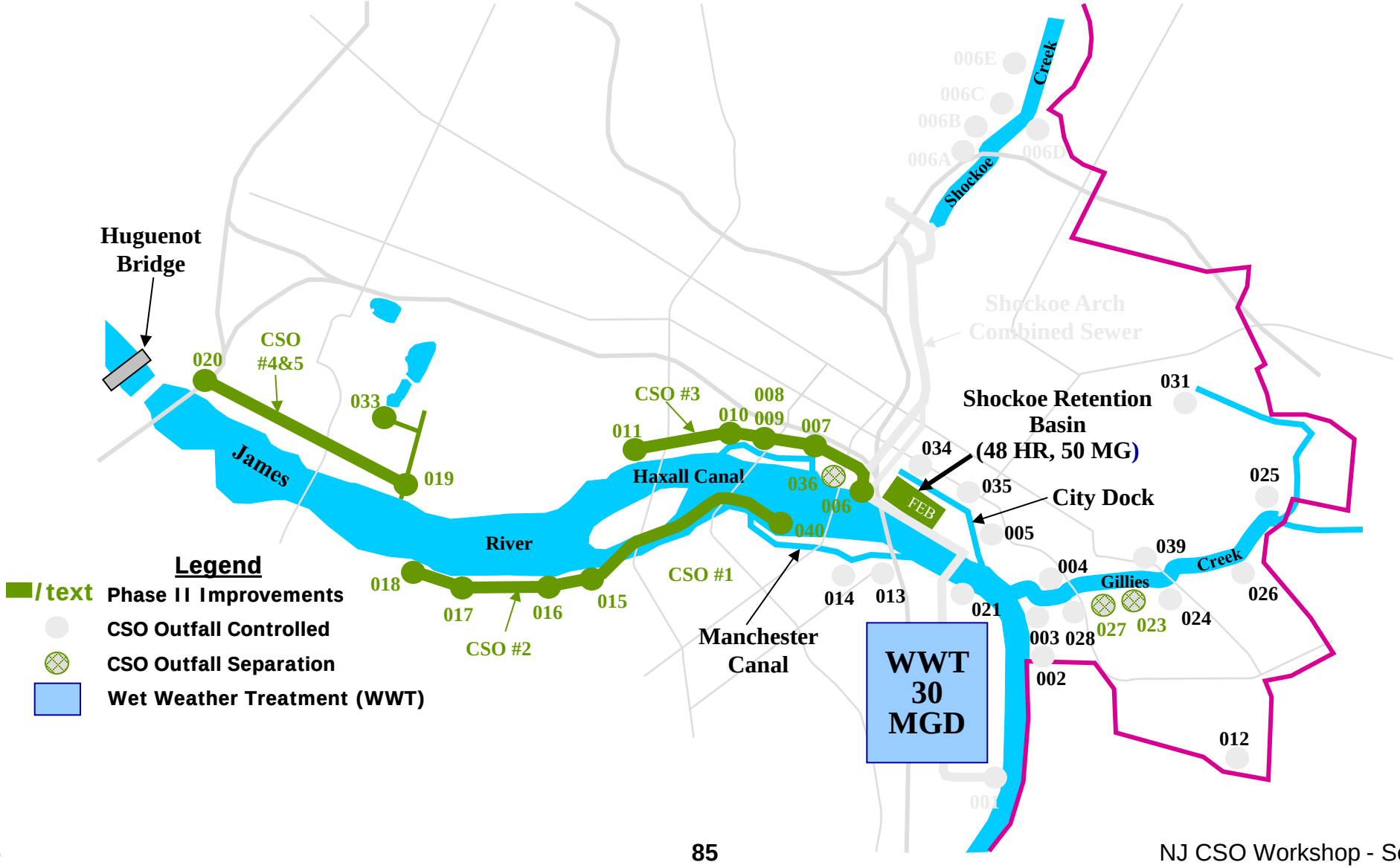


Richmond, VA

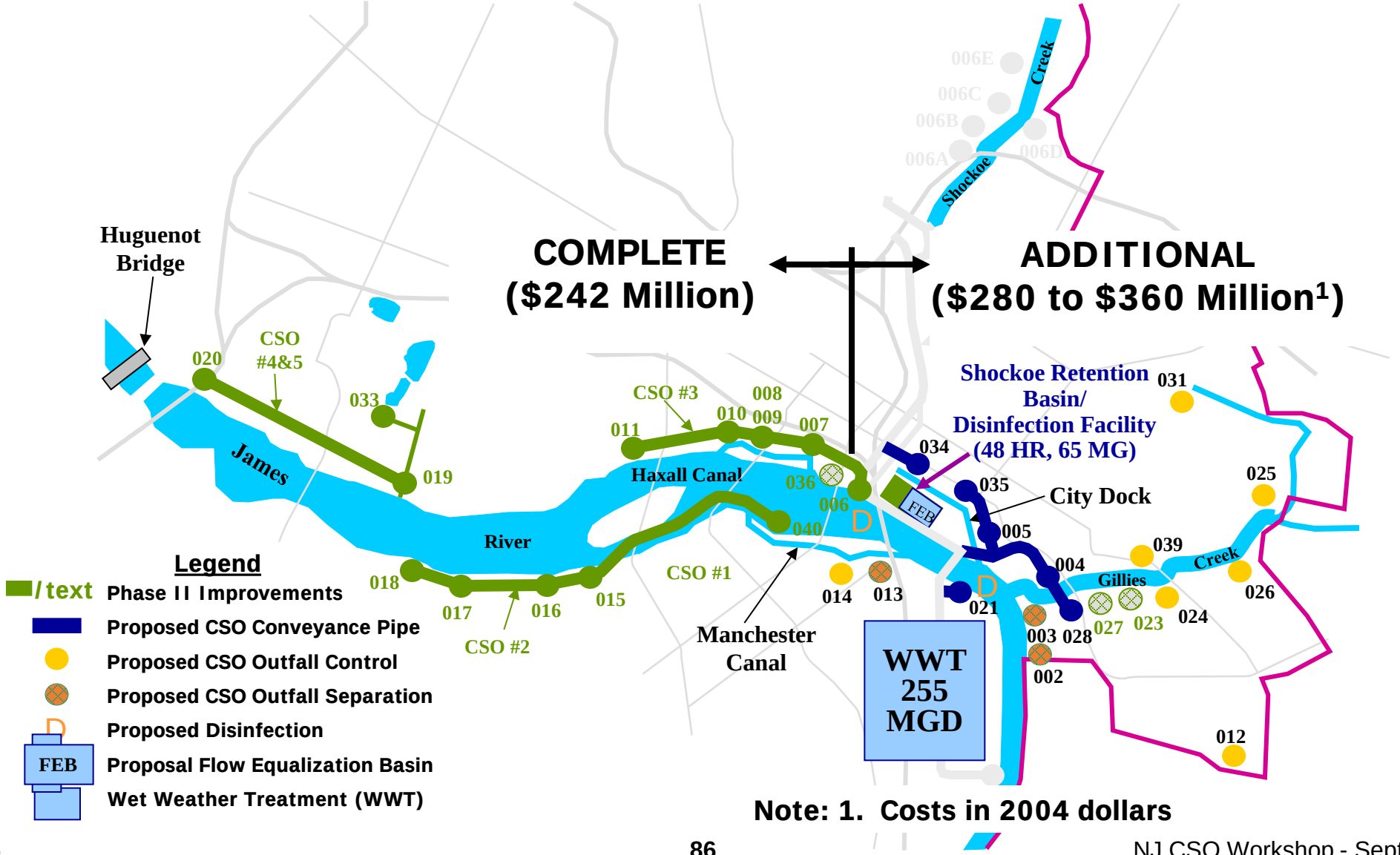
Sensitive Area: Falls of the James River

Richmond, VA

Scenario B: With Phase II Controls



Richmond, VA
Alternative E: Phase III Controls

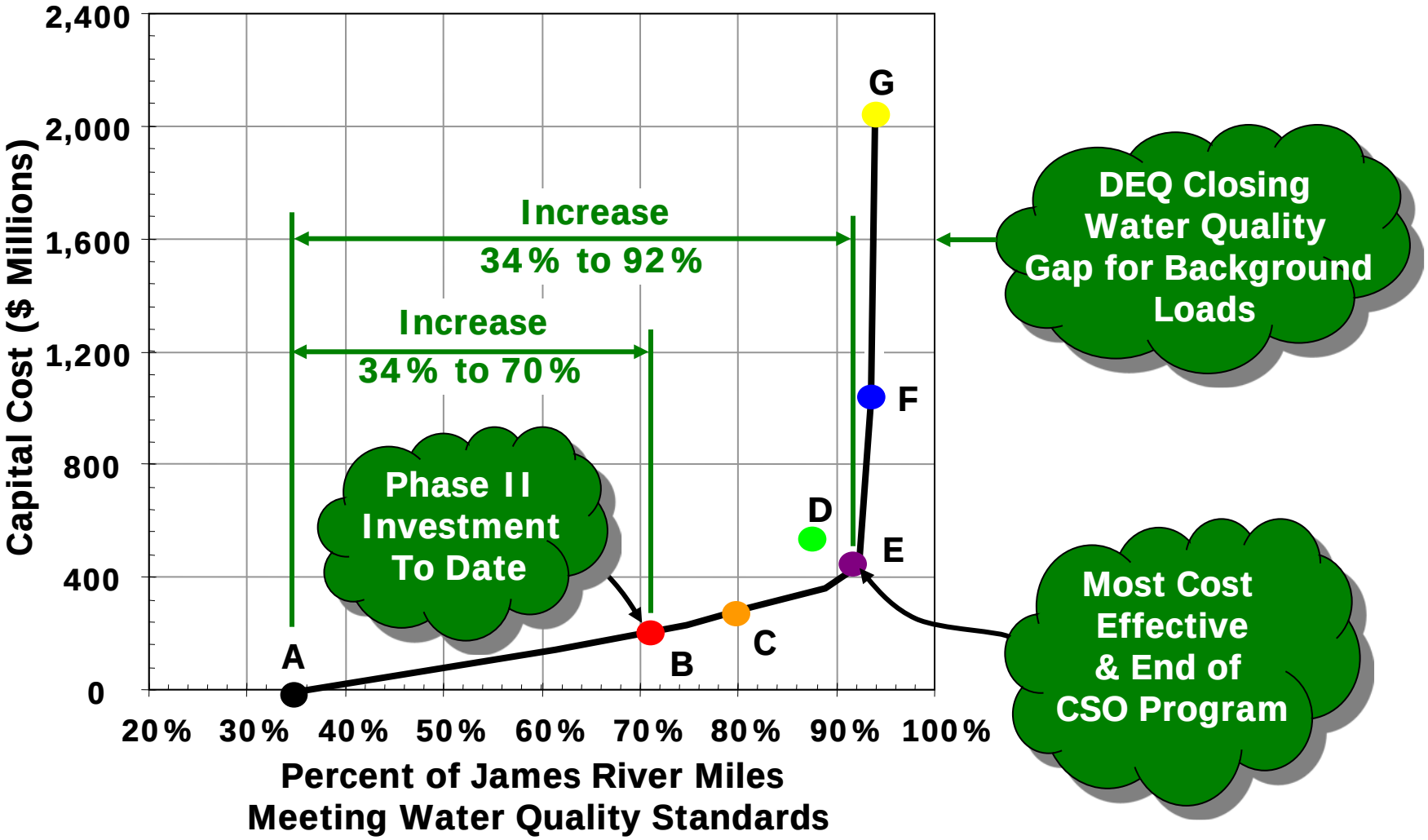


Note: 1. Costs in 2004 dollars

Phase III CSO Controls Projects

Special Order Requirement Number	Project Description
1	Disinfection Pilot Study
2	Phase III - Program Project Plan
3	Solids and Floatable Control for CSO Outfall No. 024
4	Solids and Floatable Control for CSO Outfall No. 026
5	Solids and Floatable Control for CSO Outfall No. 025
6	Fulton Bottom Urban Renewal Separation Project
7	Maury Street Separation Project
8	Orleans & Nicholson Street Separation Project
9	Peripheral In-Line Flow Equalization at Oakwood
10	Solids and Floatable Control for CSO Outfall No. 012
11	Solids and Floatable Control for CSO Outfall No. 014
12	Solids and Floatable Control for CSO Outfall No. 039
13	Lower Gillies Creek Conveyance
14	WWF at the WWTP: Solids Removal Improvements Project
15	WWF at the WWTP: Wet Weather Disinfection Facilities Project
16	WWF at the WWTP: Expand Secondary WWF Treatment Project
17	SRB: Adapt Existing Basin for Pass Through WWF Project
18	SRB: Shockoe Retention Basin 15 MG Expansion Project
19	SRB: Shockoe Wet Weather Disinfection Facility Project

Cost Performance:
Percent of James River Miles Meeting WQS



Questions???

Public **Participations**

Public Participation Methods

- Public meetings on LTCP development
- Advisory committees
- Press releases to media
- Direct mailers
- Billing inserts
- Newsletters
- CSO LTCP website
- Electronic media

Expectations: Public Participation

- Did the public participation process involve rate payers and users of receiving waters?
- Was the public briefed on characterization, CSO impacts, control alternatives and costs?
- Was the public participation process documented?

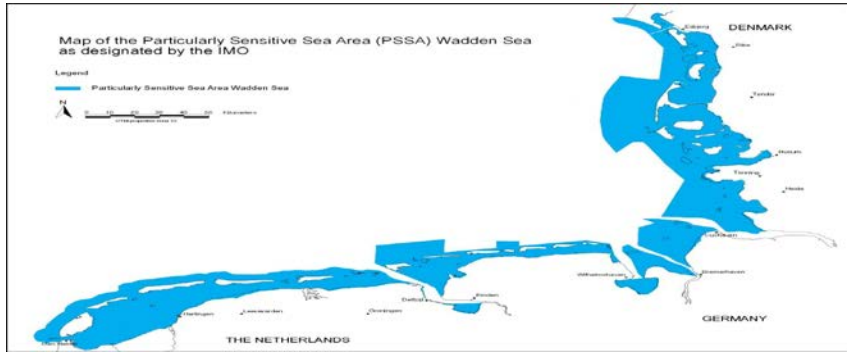
In reality, it can be difficult to get the public involved, but the CSO community must show effort

CSO Long-Term Control Plan LTCP

Consideration of Sensitive Area

Nine Elements of a LTCP

- Characterization, Monitoring and Modeling of the CSSs
- Public Participation
- Consideration of Sensitive Areas
- Evaluation of Alternatives
- Cost/Performance Considerations
- Operational Plan
- Maximization of treatment at the Existing POTW Treatment Plant
- Implementation Schedule
- Post-Construction Compliance Monitoring Program



Sensitive Area Designation – Examples

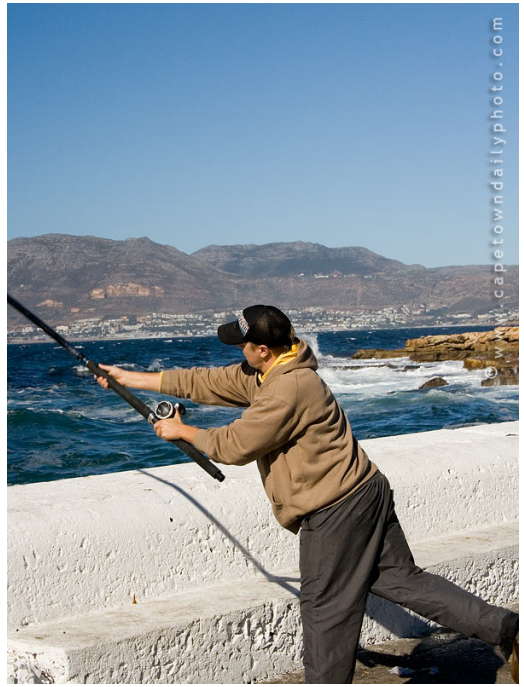
- Outstanding National Resource Waters
- National Marine Sanctuaries
- Waters with threatened or endangered species and their habitat
- Water with primary contact recreation
- Public drinking water intakes or their designated protection areas
- Shellfish beds

Primary Contact Recreation

Any recreational or other water use in which there is prolonged and intimate contact with the water [where the physical configuration of the water body permits it] involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing

Secondary Contact Recreation

Any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity



Designation

NPDES authority in coordination with State and Federal agencies needs to determine the sensitive area

Sensitive Area and CSO Policy

- **Prohibit new or significantly increased overflows**
- **Eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment**
- **Where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining overflows deemed necessary to meet WQS for full protection of existing and designated uses.**

Sensitive Area and CSO Policy cont.

- In any event, the level of control should not be less than those describe in Evaluation of Alternatives (Knee of the Curve)
- Where elimination or relocation has been proven not to be physically possible and economically achievable, permitting authorities should require, for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate, or on changed circumstances that influence economic achievability

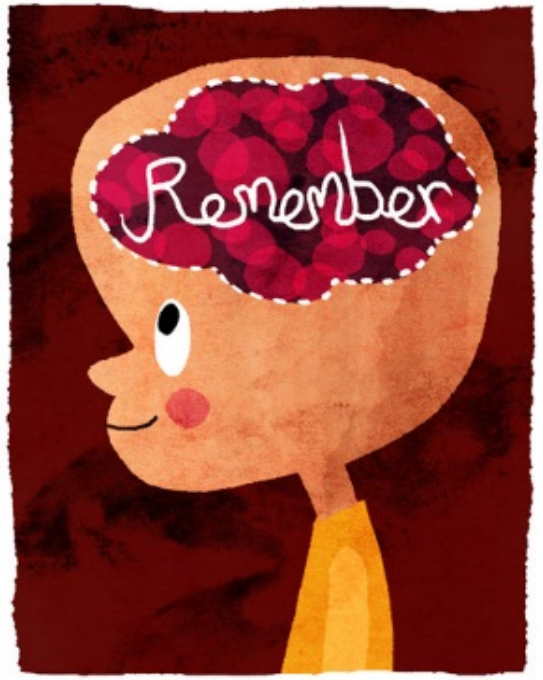
CSO Policy Expectation

EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas.

Is it a Sensitive Area?

Remember Designation?????

NPDES authority in coordination with State and Federal agencies needs to determine the sensitive area



Questions?