Proven Innovations in Wet Weather Treatment Strategies & Technologies

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BLACK & VEATCH

New USEPA rulemaking for blending…again

EPA United States Environmental Protection Agency

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EPA Announces Effort to Update Wet Weather Regulations for Wastewater Treatment Plants

04/17/2018

Contact Information:
EPA Press Office (press@epa.gov)

WASHINGTON — Today, the U.S. Environmental Protection Agency (EPA) announced it will be reaching out to states, local communities, and stakeholders as the Agency begins a new rulemaking process to provide certainty surrounding the use of "blending" by wastewater treatment plants.

THE NEW REPUBLIC

Mario Tama/Getty Images

Déjà Poo All Over Again

The EPA is considering a controversial process to deal with sewage overflows. Again.

By **EMILY ATKIN** | April 19, 2018

Third time's a charm?

- 1999 draft – no final rule
- 2005 draft – died at OMB
- 2018 – Renewed effort. Sept 13 EPA Stakeholder Meeting.

Words really do matter

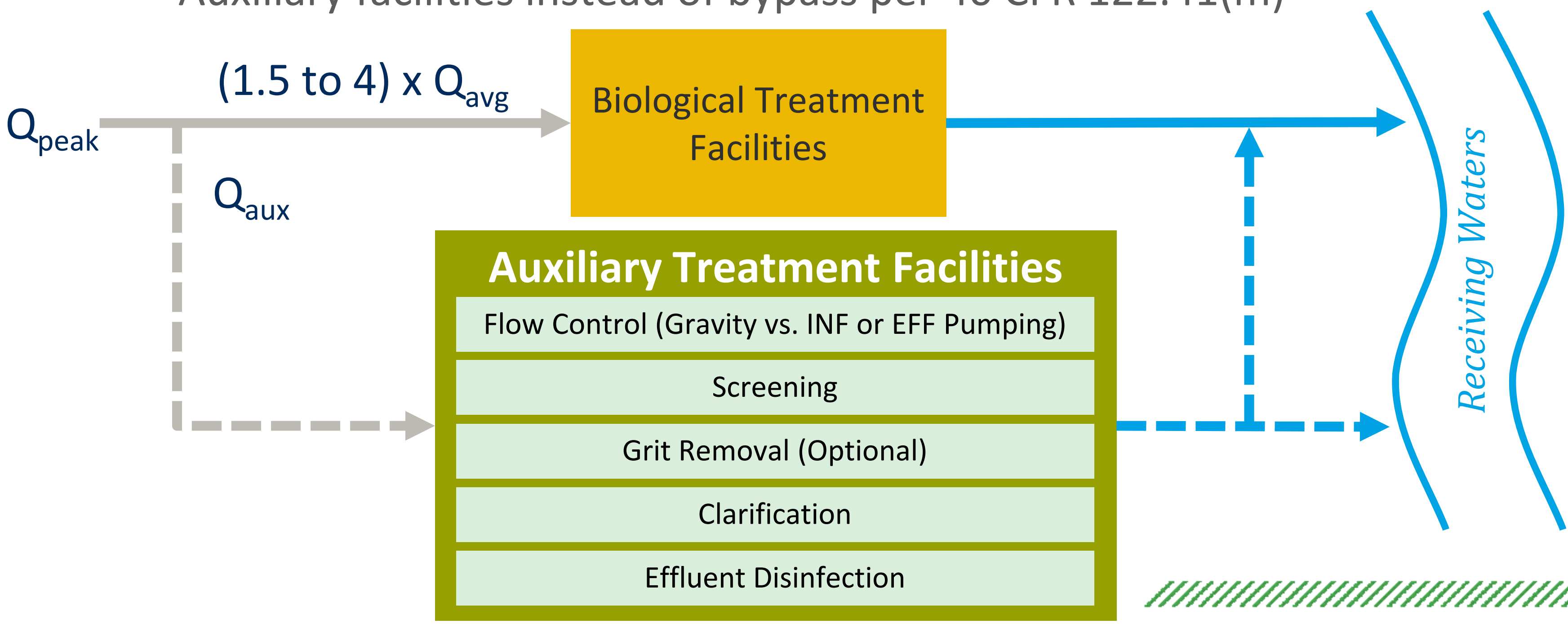
Instead of:	Consider:
Divert	Intercept
Diversion Structure	Interceptor Structure Regulator Structure
Bypass	Flow split Flow control
Excess flow	Peak flow
Primary treatment Secondary treatment	Primary settling Activated sludge treatment Wet-weather flow treatment **Auxiliary treatment**
Secondary treatment train	Biological treatment train Activated sludge treatment train

If treating adequately, don't imply lack of treatment. Use scientifically accurate terms to describe design. Avoid connotations and misinterpretations.

Auxiliary Treatment Strategy & Technologies

After optimizing existing storage and treatment infrastructure, consider auxiliary treatment capacity

- Optimize for **intermittent** wet-weather flows
- Complement inherent limitations of storage and biological treatment
- Long track record of success
- Auxiliary facilities instead of bypass per 40 CFR 122.41(m)



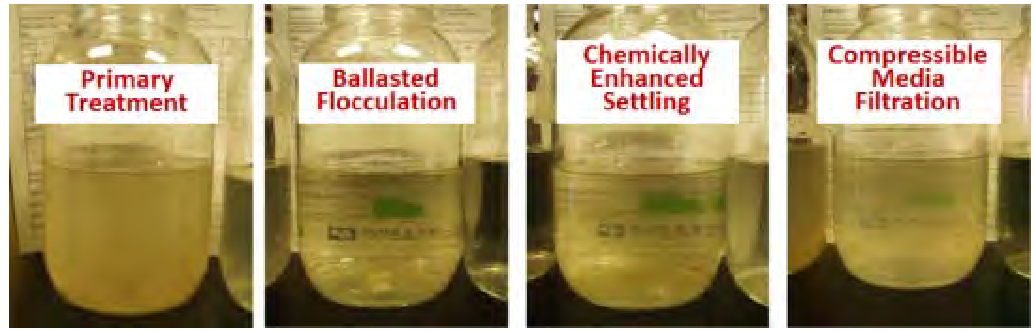
Clarification Alternatives

Settling-Based	Filtration-Based	Flotation-Based
1. **Conventional Settling** -Rectangular, Circular, Square, RTB, Shaft	1. **Shallow Granular Media**	1. **Conventional Floatables Removal** -Skimmers, Scum baffles
2. **Vortex (Swirl Concentrator)**	2. **Deep Granular Media**	
3. **Lamella Settler**	3. **Microscreens, Woven Media** -Salsnes Filter, Eco MAT®Filter, Hydrotech Discfilter, SuperDisc™, Forty-X™ Disc, Quantum™ Disk	2. **Dissolved Air Flotation (DAF)**
4. **Chemically Enhanced Settling**	4. **Floating Media** -MetaWater High Speed Filter, BKT BBF-F	
a. Conventional Basin	HRF	
b. Sequencing Batch - e.g. ClearCove Flatline EPT		
c. Lamella Settler HRC	5. **Pile Cloth Media** -AquaPrime™, infini-D™	3. **Polymer-aided DAF** -Various suppliers
d. Solids Contact / Recirculation - e.g. DensaDeg®, CONTRAFAST®	6. **Compressible Media** -Fuzzy Filter™, FlexFilter™, FiltraFast™	
e. Ballasted Flocculation - Microsand (e.g. ACTIFLO®, RapiSand™, Densadeg XRC™) - Magnetite (e.g CoMag™)	7. **Fixed-Film Contact** -Biological Aerated Filter (BAF), BioFlexFilter™	4. **Biocontact + DAF** -Captivator®
5. **Suspended Growth Contact** -BIOACTIFLO™, BioMag™, Bio-CES		

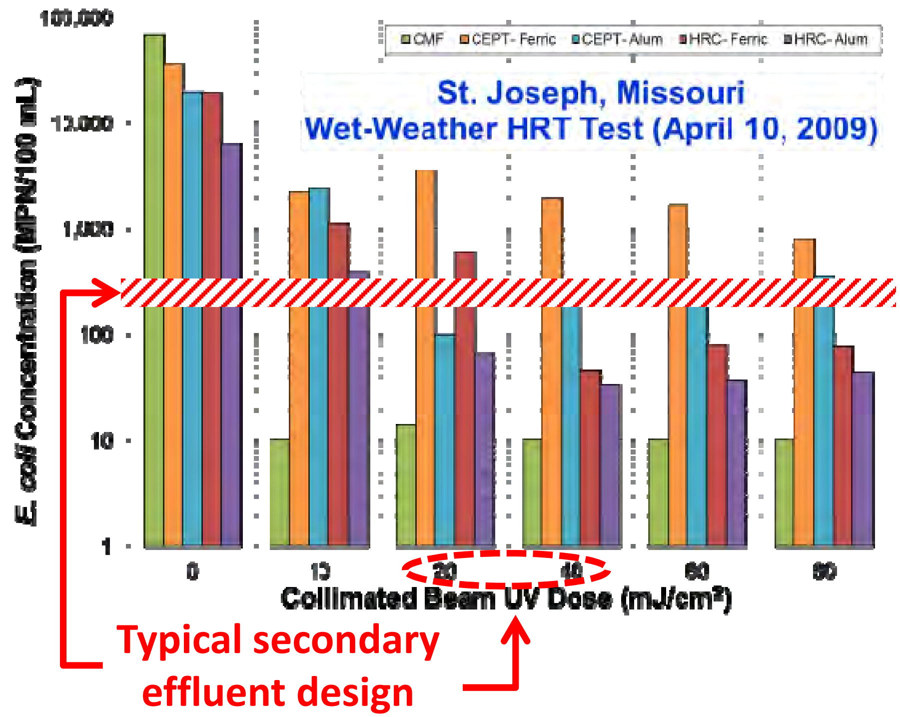
Primary Removal Equivalent * | High-Rate Treatment (HRT) | Enhanced HRT

* If coagulation/flocculation provided, HRT → EHRT (in some cases)

Why EHRT?



- Better disinfection
  - Removes colloidal TSS, turbidity and associated organics and other pollutants
  - ~50% less disinfectant
- Equivalent to wet-weather secondary effluent quality at lower cost
- *"Non-biological peak flow secondary treatment processes"* per 8th Circuit Court (*Iowa League of Cities v. EPA*)
- Considered BADCT by some regulators

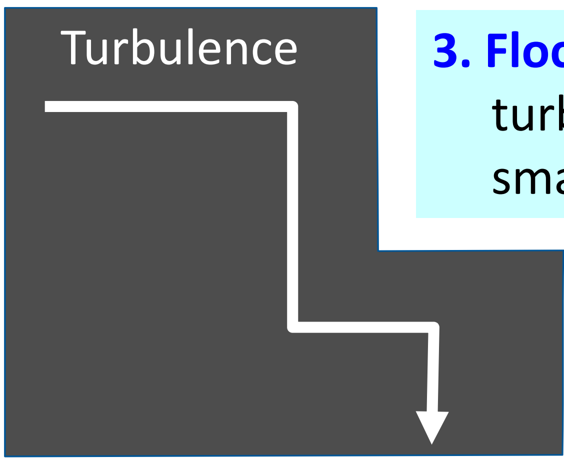


Minimize public health risk. Small footprint.

Steps to chemically enhanced sedimentation (CES)

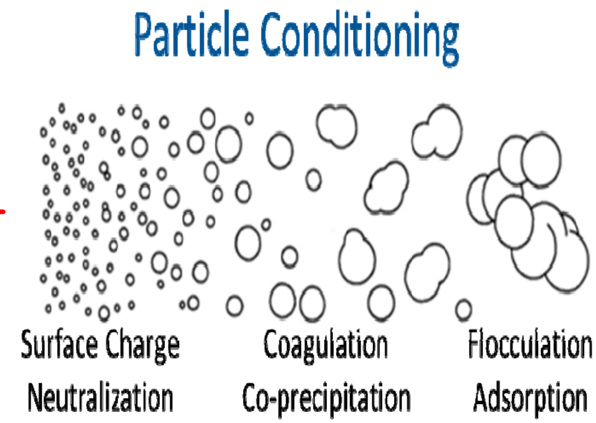
1. Coagulant Addition. Rapid mix. Add trivalent metal salt (Fe^{3+} or Al^{3+})

2. Flocculant Addition. Rapid mix. Add anionic polymer. If Step 1 & 3 are ideal (rarely in wet weather), then optional.



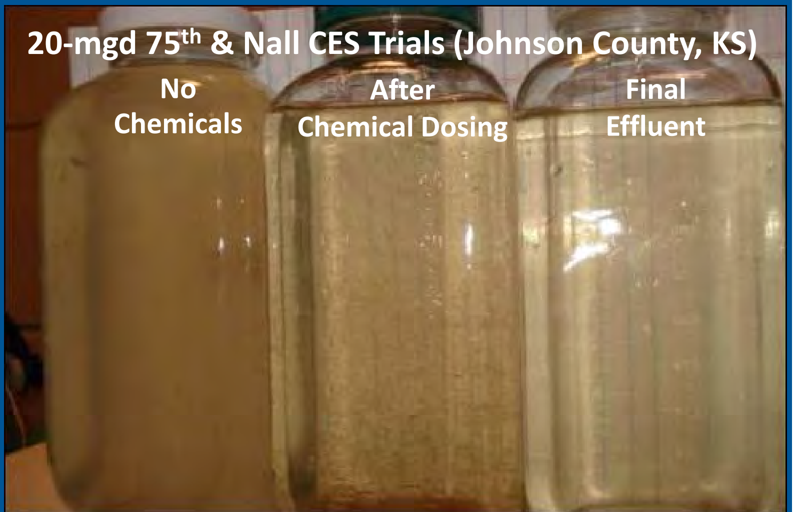
3. Flocculation. Medium to low turbulence. Build floc and "sweep" small particles. Enhance floc settling.

4. Settling. Non-turbulent quiescent zone. Separate solids from liquids.



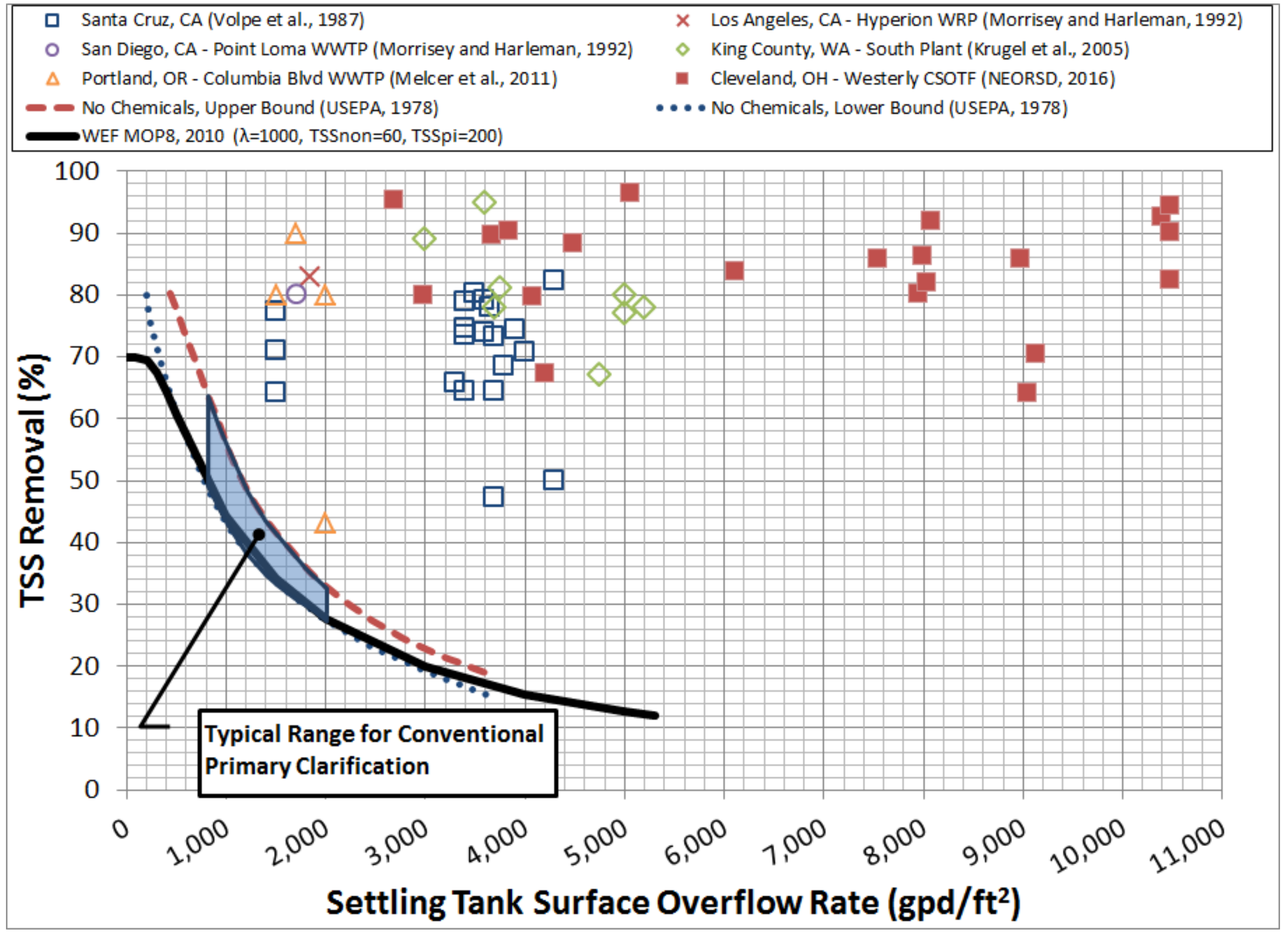
Jar test to optimize chemicals and design of Steps 1, 2 and 3

Steps 1, 2 and 3 are keys to how fast Step 4 will work

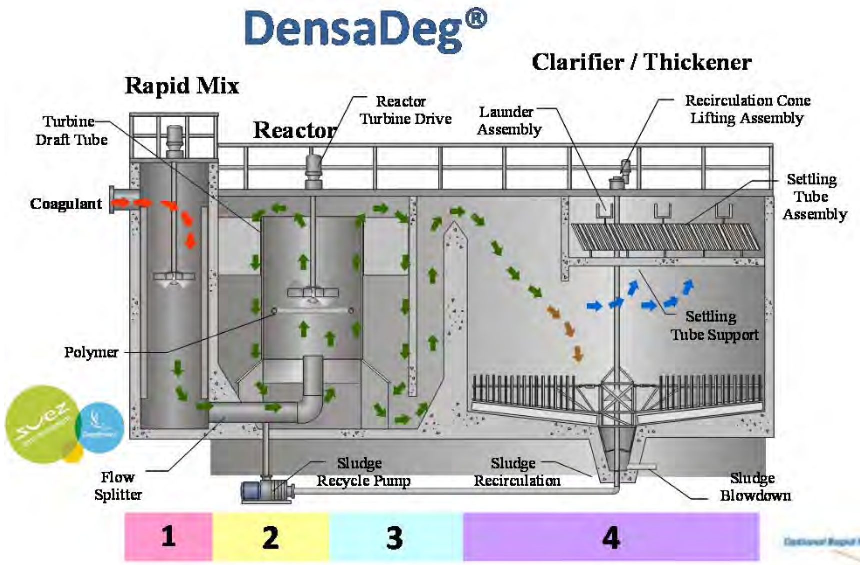


From: Binder, G. and N. Bucurel (2015) Advancing Wet Weather Treatment, The NEORSD Demonstration of a Cost-Effective Solution, OWEA Technical Conference

CES with conventional settling tanks



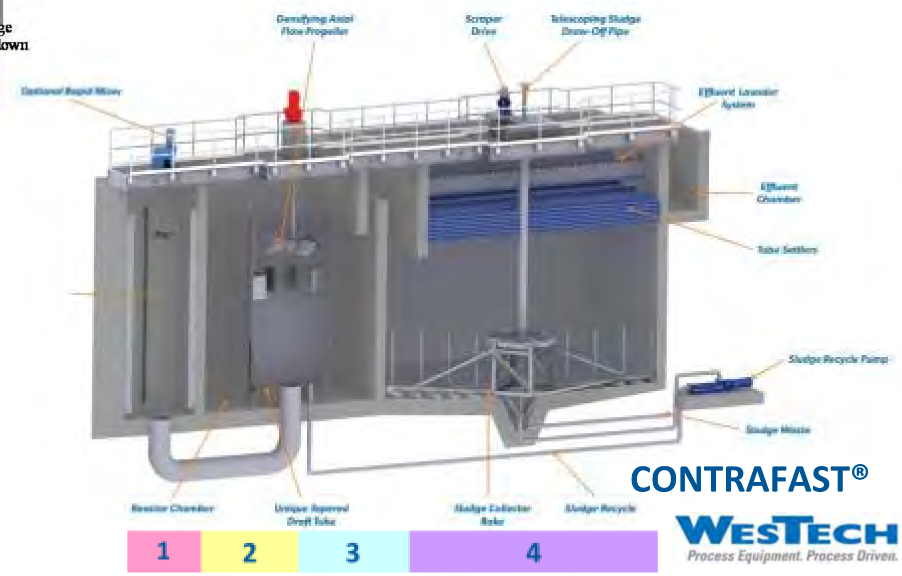
HRC – Dense Sludge



CES

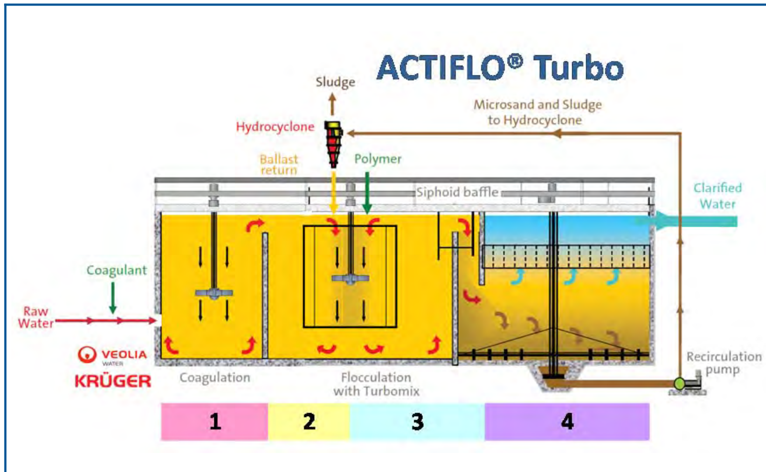
+ Solids Recirculation

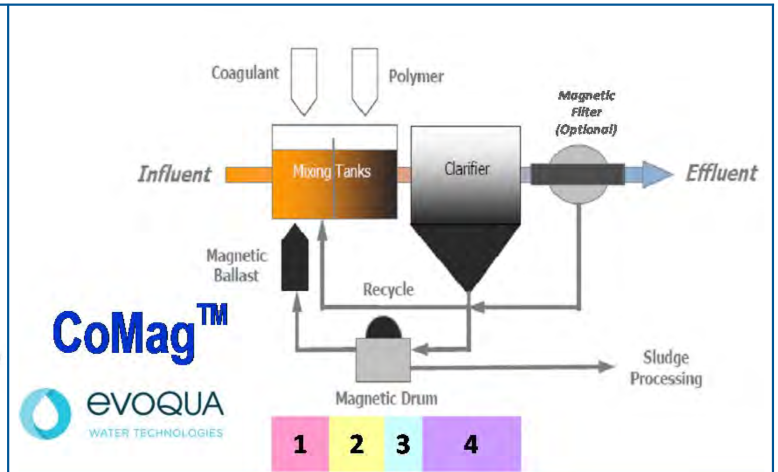
+ Lamella Settler

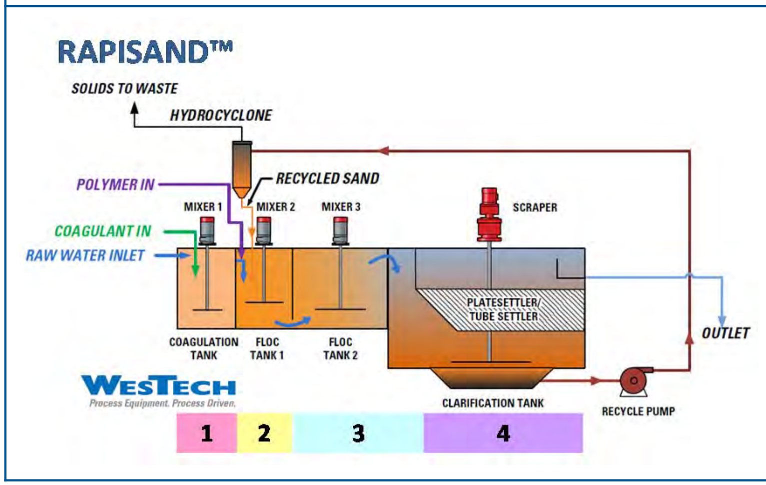


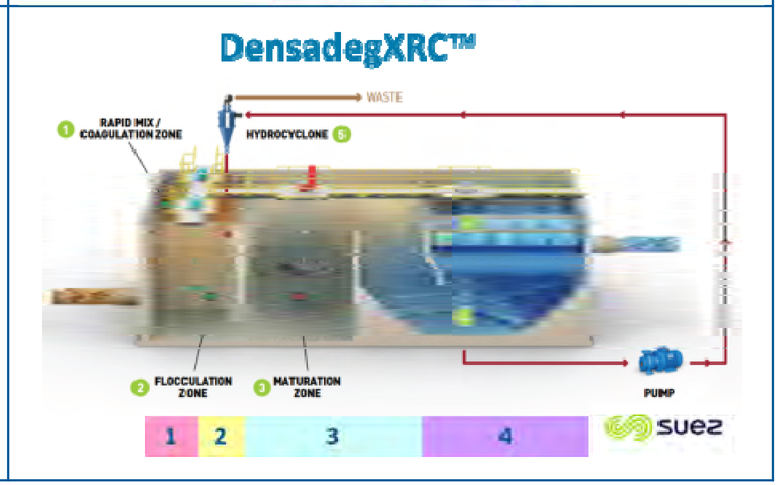
CES effluent quality in much smaller footprint

HRC – Ballasted Flocculation





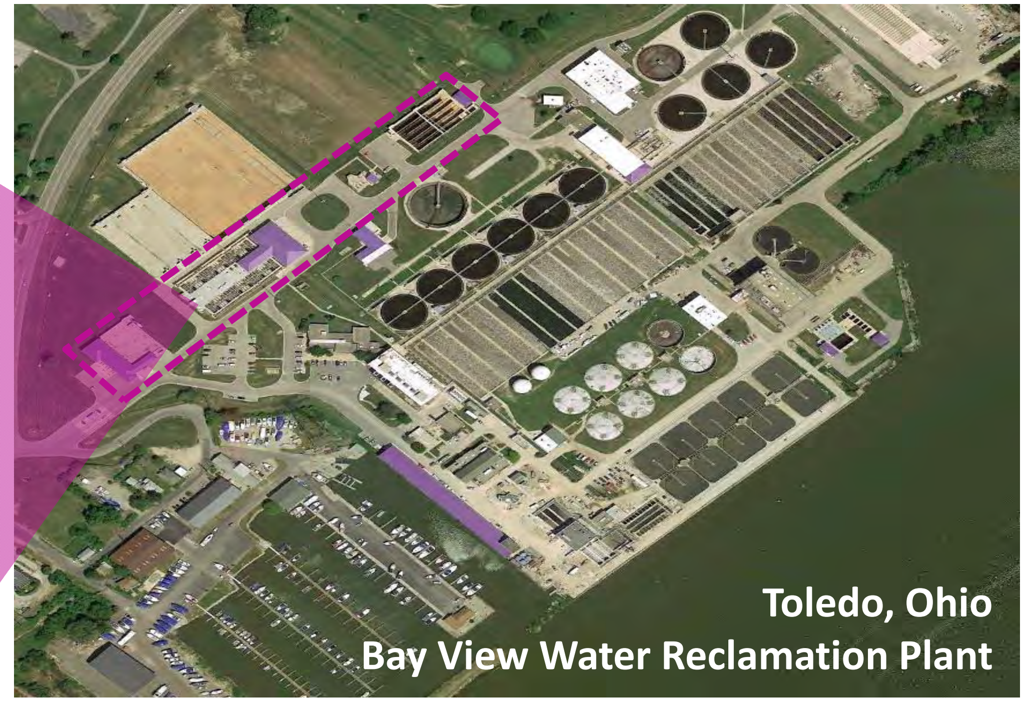




CES in even smaller footprint

HRC example

Parameter	Average Effluent (mg/L, 2007-2009)
TSS	21
$CBOD_5$	22
TP	0.3



Nitrifying activated sludge (AS) with parallel high-rate clarification (HRC)

- 170 ML/d (45 mgd) average dry weather
- 265 ML/d (70 mgd) annual average
- 1514 ML/d (400 mgd) peak hour

Toledo HRC performance studies

2007

- HRC Startup
- Eliminated 40-MG planned EQ construction

2009

2-yr Performance Study Completed

2011-Present

Pathogen Study

- EPA-Approved QAPP
- Full-scale, side-by-side HRC and AS
- Actual pathogens & indicators
- 10 qualifying events
- Estimated $1 million, 10-yr effort

Pathogen study team

Julie Cousino, P.E.
Chris McGibbeny
Christine Minor

Bob Harbron, P.E.
Jim Broz, P.E.
Jim Fitzpatrick, P.E.
Kelly Martin, Ph.D.

Bob Williams, P.E.

Dr. Joan Rose, Ph.D.
Rebecca Ives

Lana Jackson
Lanie Wenning

After 7 years and 5 qualifying events…

- Both HRC and AS trains statistically reduced *Giardia*, fecal coliform, *E. coli*, enterococci, and coliphage.
- HRC train also statistically reduced *Campylobacter* and *Cryptosporidium*.
- No statistically significant differences between disinfected AS and HRC effluents for *Campylobacter*, *Cryptosporidium, Giardia,* adenovirus.
- Both trains had similar effluent pH, DO, TSS, BOD_5. Well within NPDES permit limits.

Wet-weather HRC effluent same as parallel AS effluent for all practical purposes. Confirming past related studies.

Some high-rate filtration (HRF) options offer same effluent quality as high-rate clarification (HRC)…

Compressible Media

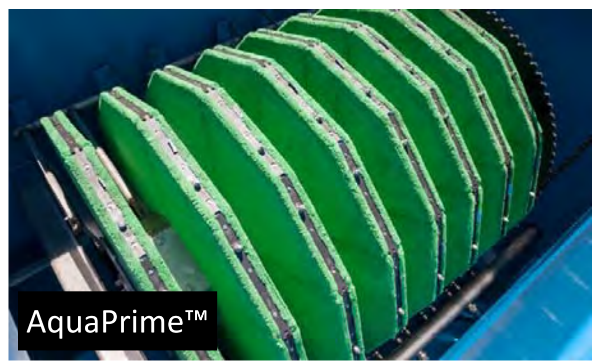
FiltraFast™ (Courtesy of Suez)

uncompressed media

compressed media

…typically without chemicals

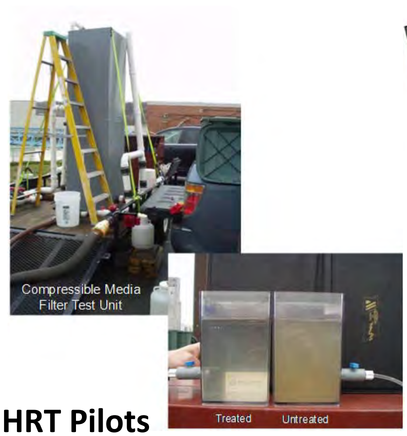
Pile Cloth Media



Courtesy Aqua-Aerobic Systems. Inc.

Courtesy Nexom

Applied research & development of HRF



HRT Pilots
St. Joseph, MO
Spring 2009

HRF Pilots
Nelson Complex
Johnson County, KS
Spring 2008


WATER REUSE TECHNOLOGY DEMONSTRATION PROJECT

Demonstration Facility Pilot Study
Fuzzy Filter For Primary And Tertiary Treatment
Final Report

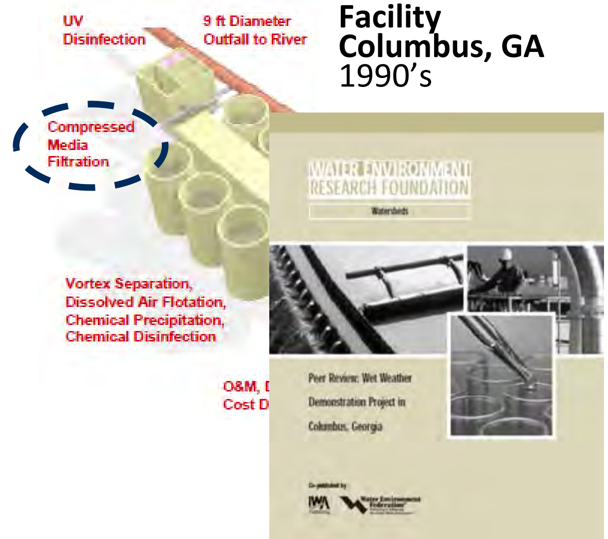
June 2002

HDR

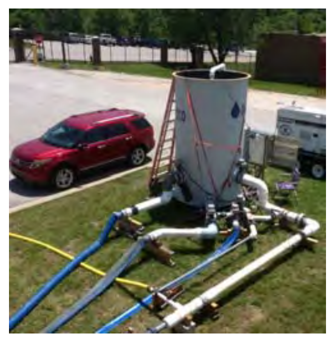
King County

HRT Pilots
King County, WA
2002

Advanced Demonstration Facility
Columbus, GA
1990's



CMF Pilot
Springfield, OH
Oct 2010 – Jun 2011

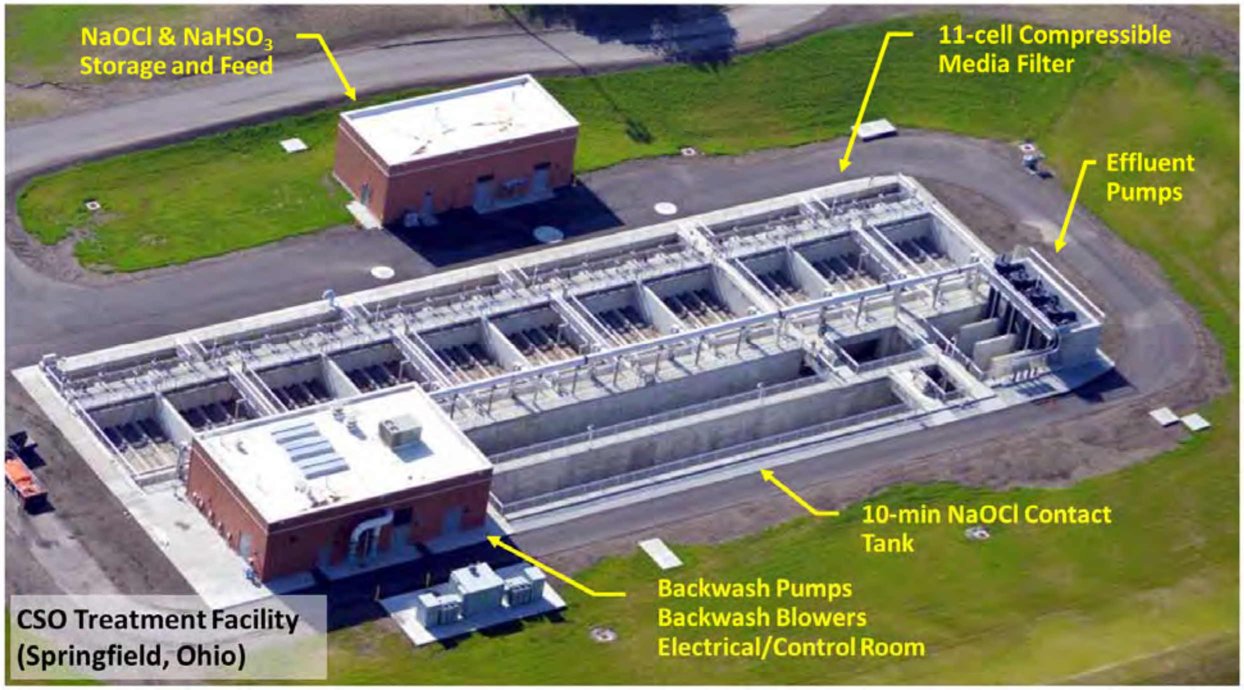


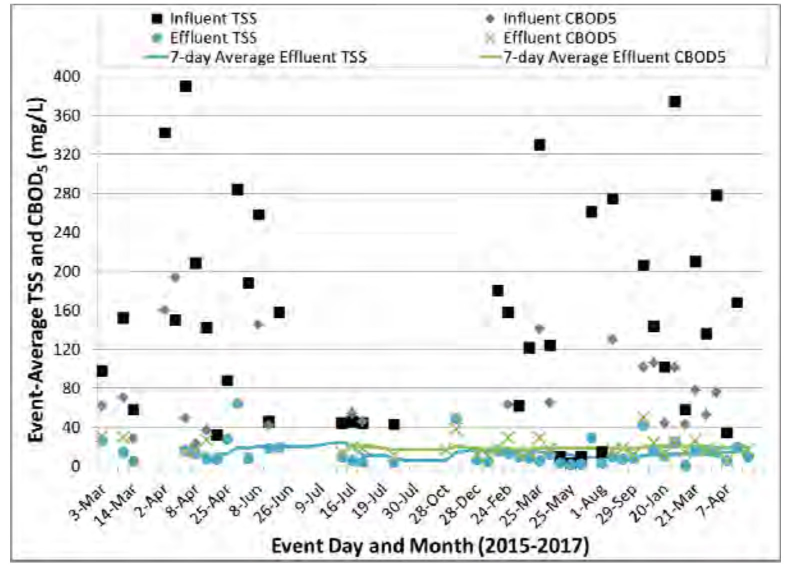
CMF Pilot
Springfield, MO
2014

HRF Pilots
Little Rock, AR
2016

Springfield, Ohio Treatment Improvements

100-mgd CMF example





- $33.5M (2011; Springfield, OH)
- 320 ft x 120 ft footprint
- 3-MG built-in storage, self-cleaning
- No added staff, SCADA-controlled operation

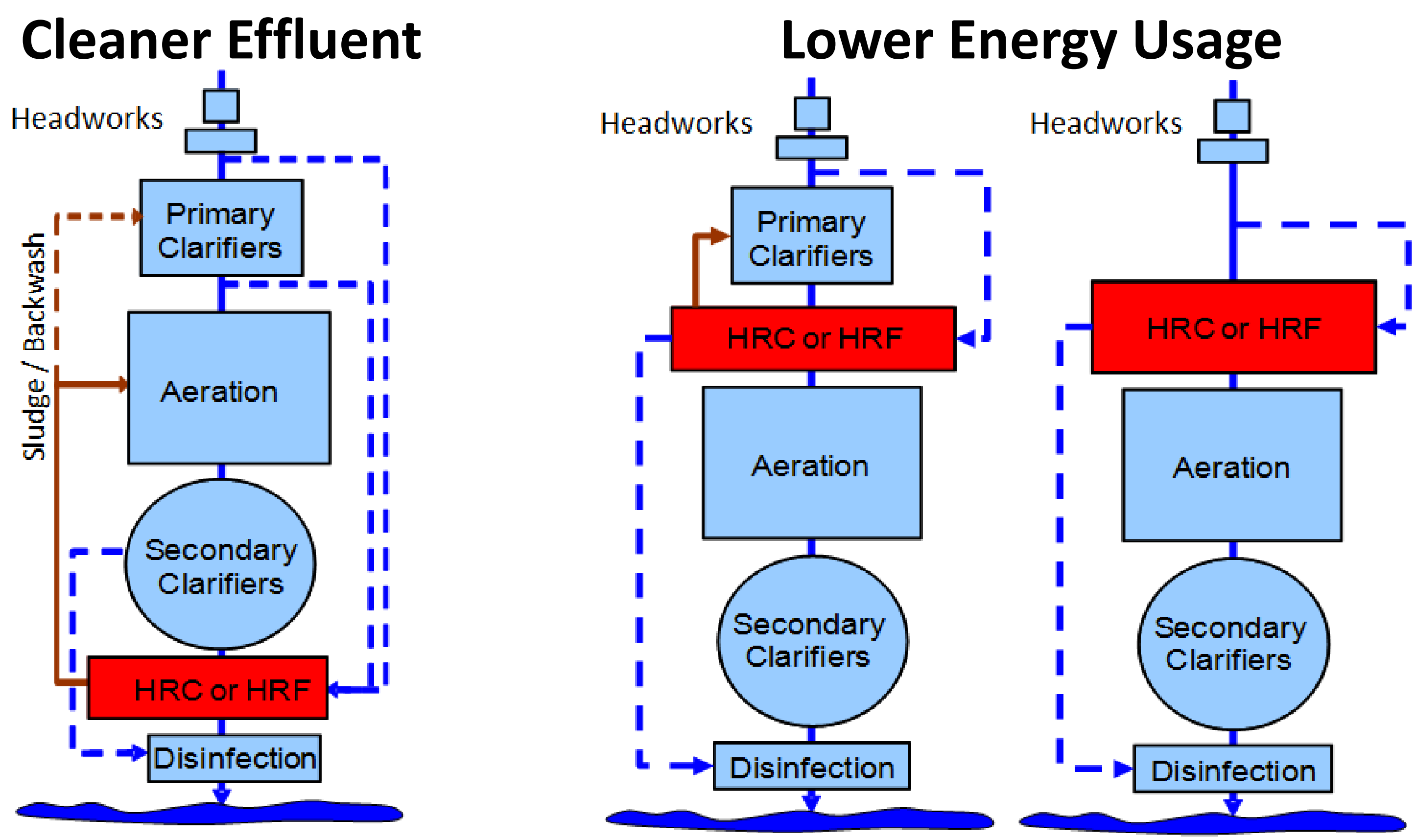
Effluent Averages *		
TSS	mg/L	14
$CBOD_5$	mg/L	20
NH_3-N	mg/L	2.3
TP	mg/L	0.4
DO	mg/L	8.7
TRC **	mg/L	0.02
E. Coli	#/100 mL	56

* 63 events Mar 2015 – May 2017

** NaOCl dose < 4 mg/L (avg)

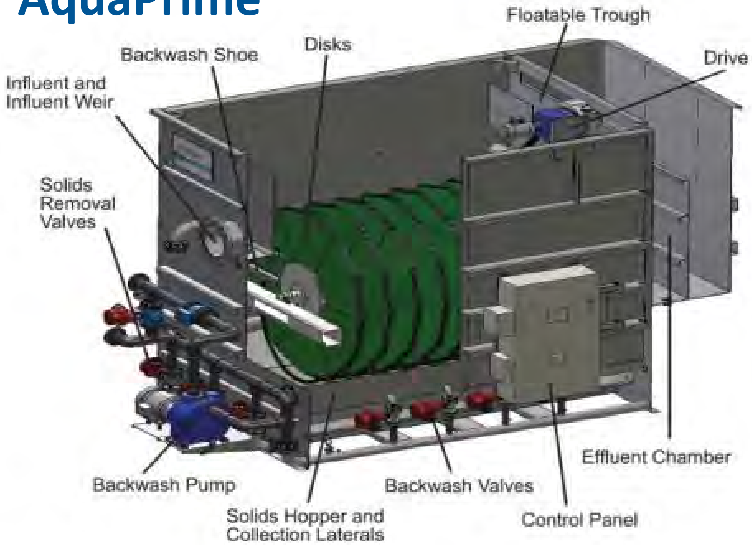
Excellent performance and effluent quality

Dual-use auxiliary facilities

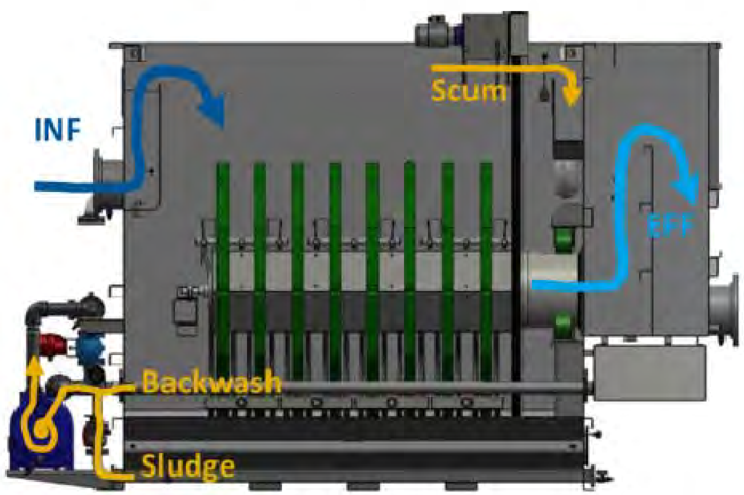


More treatment benefit from capital investment than just infrequent wet weather

AquaPrime™



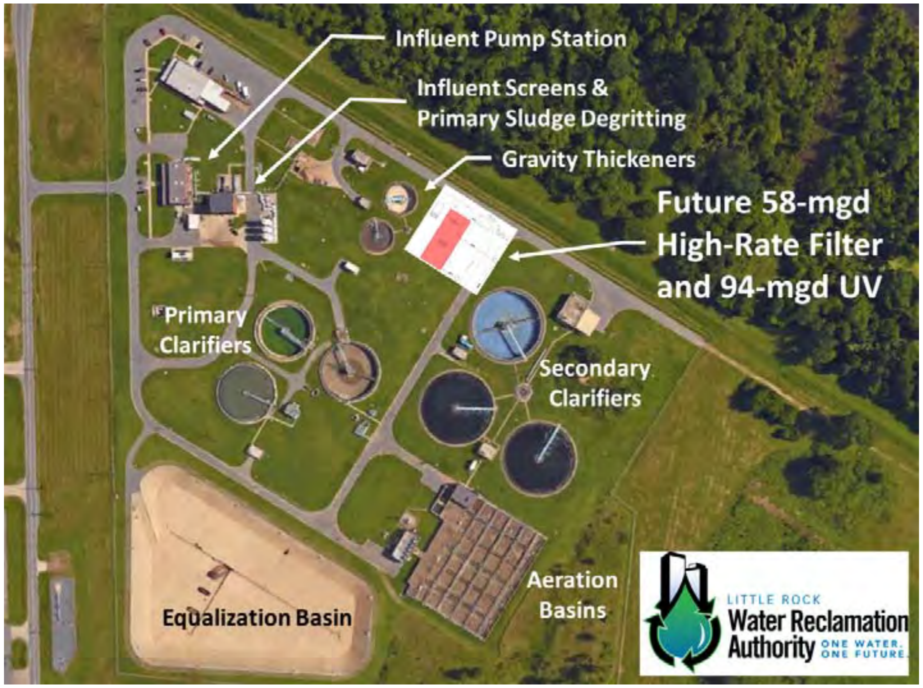
Images courtesy Aqua-Aerobic Systems



Advances in pile cloth media

- **Deeper basin than tertiary application**
  - Floatables stay above filter
  - Heavy solids drop to grit/sludge hoppers
  - Filters submerged in optimal zone for small particles
- **Larger disk (10-ft dia) and up to 24 per unit**
  - Up to 10-15 mgd per unit for wet weather/CSO/SSO
  - Up to 24 mgd per unit for tertiary
  - Similar footprint as ballasted flocculation
- **New 5-micron polyester microfiber**
  - Effluent equivalent to compressible media
  - Better wear than previous generation nylon fibers

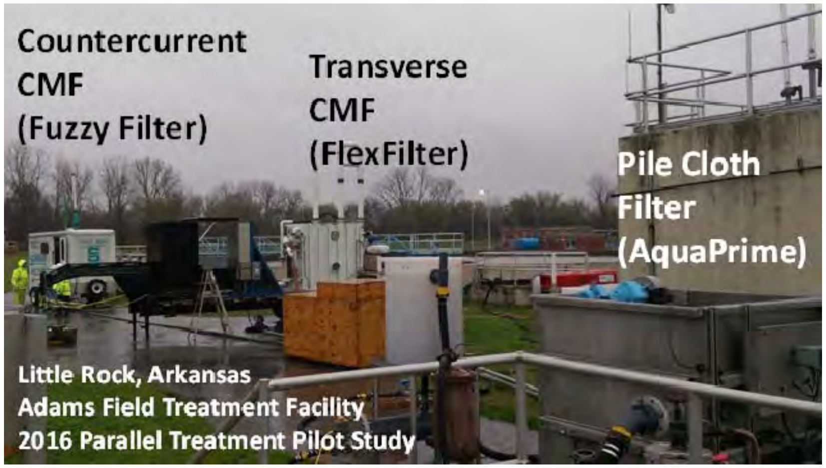
Not all cloth disk filters are equal!!!

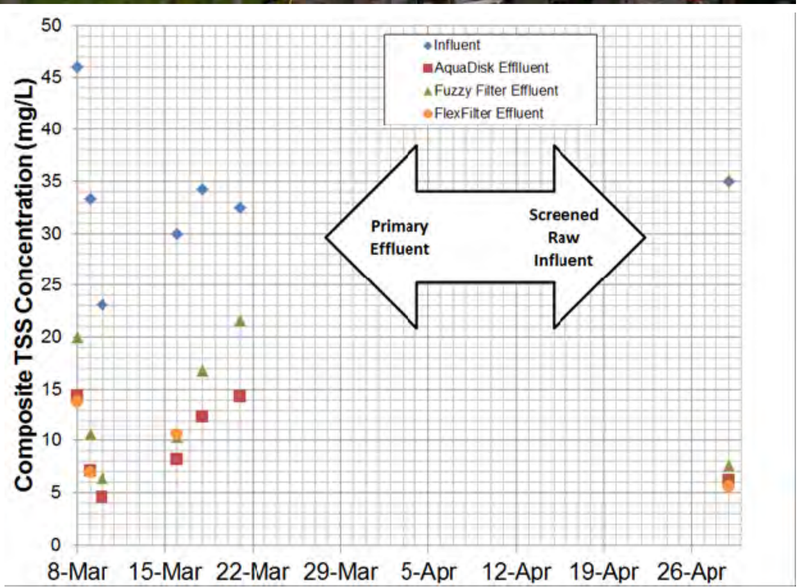


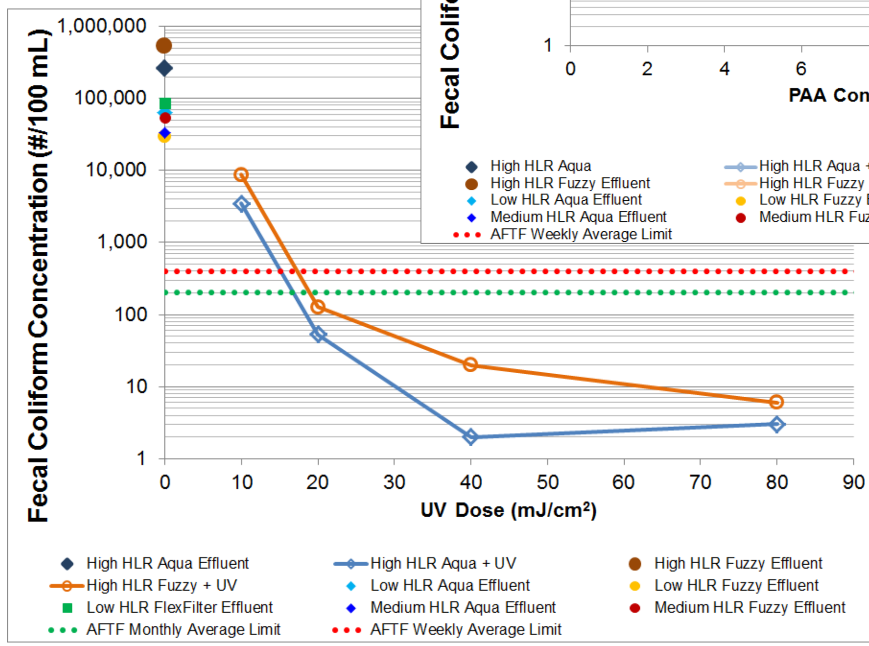
Triple Bottom Line Evaluation	
EHRT Process	**EHRT Technology**
CES with Ballasted Flocculation	ACTIFLO® (Veolia/Kruger)
	CoMag® (Evoqua)
Compressible Media Filtration	FlexFilter™ (WesTech/WWETCO)
	Fuzzy Filter™ (Schreiber)
Pile Cloth Media Filtration	MegaDisk® (Aqua-Aerobics)

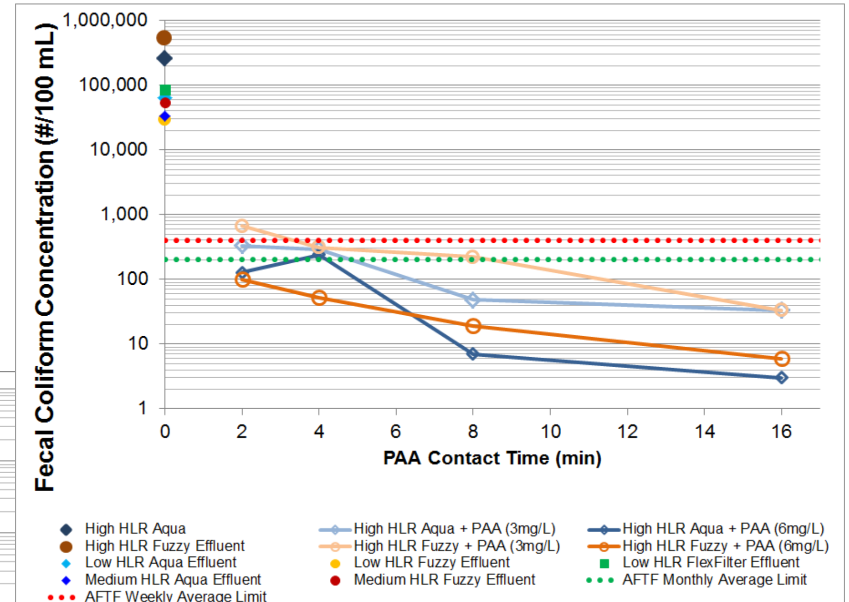
Dual-Use Filter for Adams Field WRF

- **Compared to 33-MG EQ expansion:**
  - **Better resiliency, not limited by finite capture volume**
  - **Much smaller site, no additional odor control**
  - **Lower life-cycle cost**
- **Dec 2015 – ADEQ NPDES permit, no EPA comments**
- **2016 – Onsite piloting, TBL evaluation of EHRT technologies, reference facility tours.**
- **Pile cloth filter recommended:**
  - **Simple O&M**
  - **No alkalinity or effluent foaming issues**
  - **Lowest life-cycle cost**
  - **Improve existing UV disinfection**
  - **Non-potable reuse potential**









New pile cloth media performed better than in 2008 side-by-side trials with previous generation media in Johnson County, Kansas.

Adams Field WRF Parallel Treatment Expansion

<u>58-mgd Pile Cloth Filter</u>

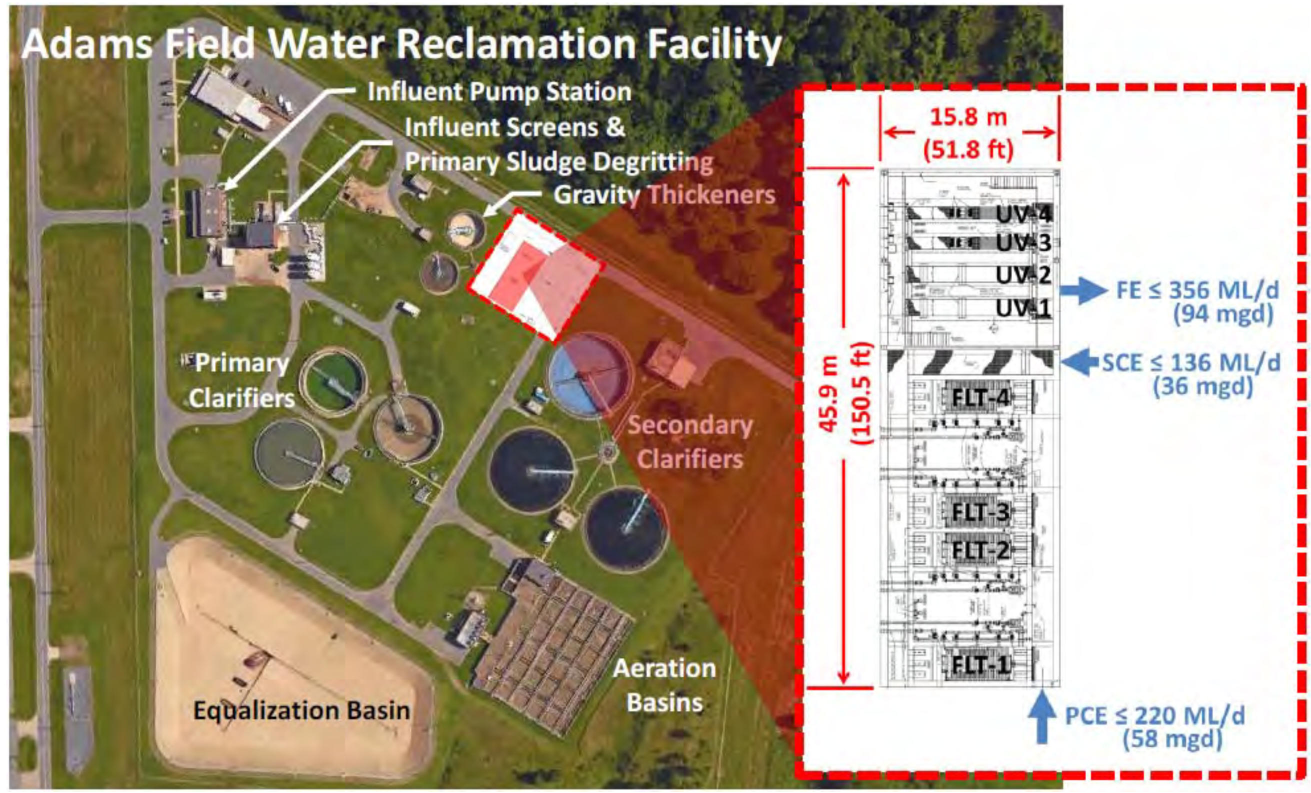
- Wet weather:
  - 36 to 58 mgd - Polish SCE + PCE
  - 58 to 94 mgd - Polish PCE parallel to SCE
- Dry weather: tertiary polish of SCE

<u>94-mgd UV Disinfection</u>

- 2 trains new equipment (dry-weather flows)
- 2 trains relocated existing equipment (wet-weather flows)

<u>94-mgd Effluent Pump Station</u>

- Normally gravity flow-through
- High river stage/peak flow pumping

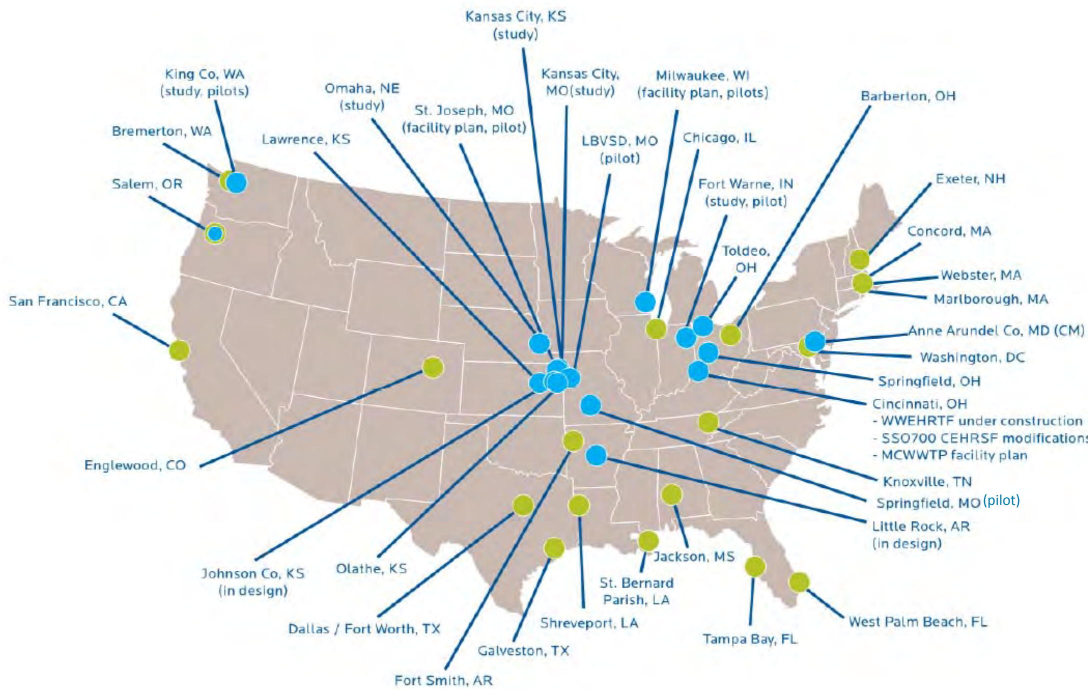


- **Four contractors bid on 100% design**
- **$23.9 M for 58-mgd EHRT → $0.41/gpd**
- **2020 startup**

Closing Remarks
and
Open Discussions

Full-Scale Auxiliary EHRT Facilities Operating in the U.S.	
EPA Region	State
1	Massachusetts, New Hampshire
2	New York
3	DC, Maryland
4	Florida, Georgia, Mississippi, Tennessee
5	Illinois, Indiana, Ohio, Wisconsin
6	Arkansas, Louisiana, Texas
7	Kansas
9	California
10	Oregon, Washington

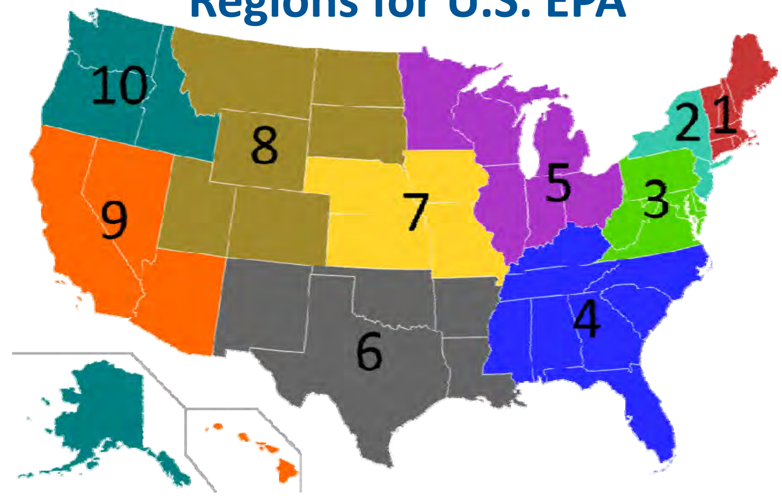
Pilot and Full-Scale EHRT Projects Include:



- **30+ operating in U.S. since ~1995**
- **60+ worldwide**

Regulatory Considerations

Regions for U.S. EPA



EPA CSO Control Policy

- EHRT clearly meets treatment requirements

EPA SSO/Blending Policy

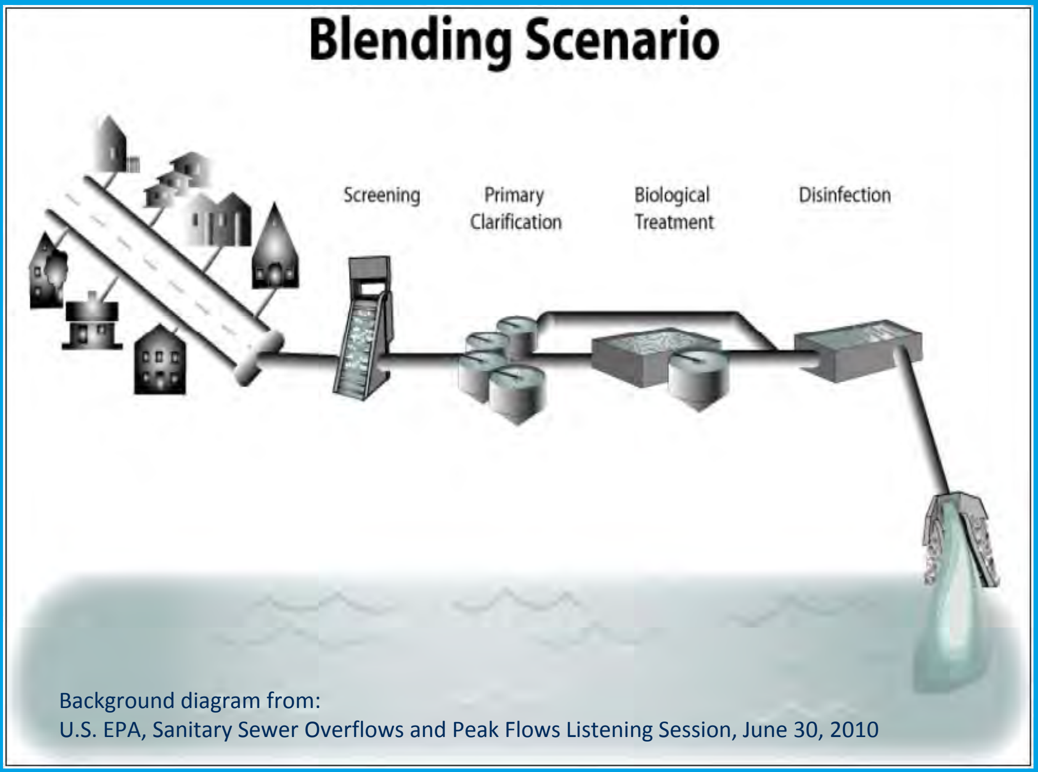
- Still under development
- EHRT allowed in 8th Circuit Court states thanks to *ILOC v. EPA*. Case-by-case elsewhere. Precedents include KS, MA, NH, NY, NJ, OH, OR, TX, WI.
- *CRR v. EPA* trying to apply *ILOC v. EPA* nationwide

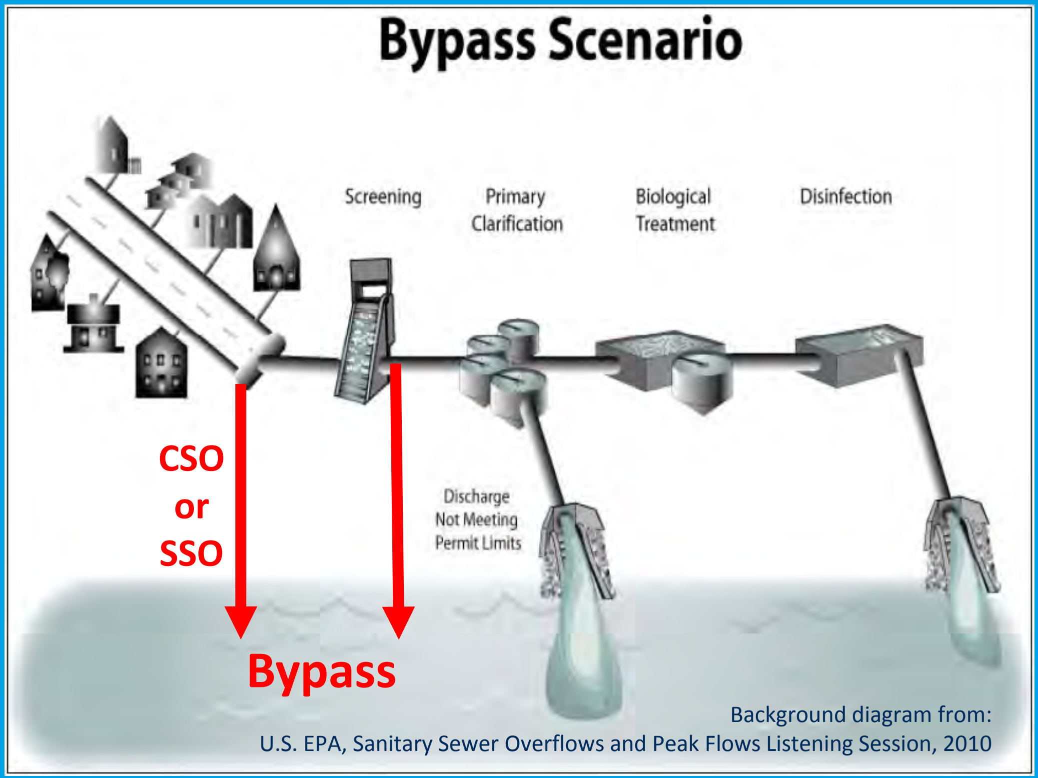
Circuits for U.S. Court of Appeals

New EPA rulemaking for blending…

Blending

Not Blending





- **If blending and meeting permit limits, don't call it *bypass***
- **Satellite CSO/SSO treatment has similar environmental concerns and technical challenges as blending**

Not ye olde *blending*

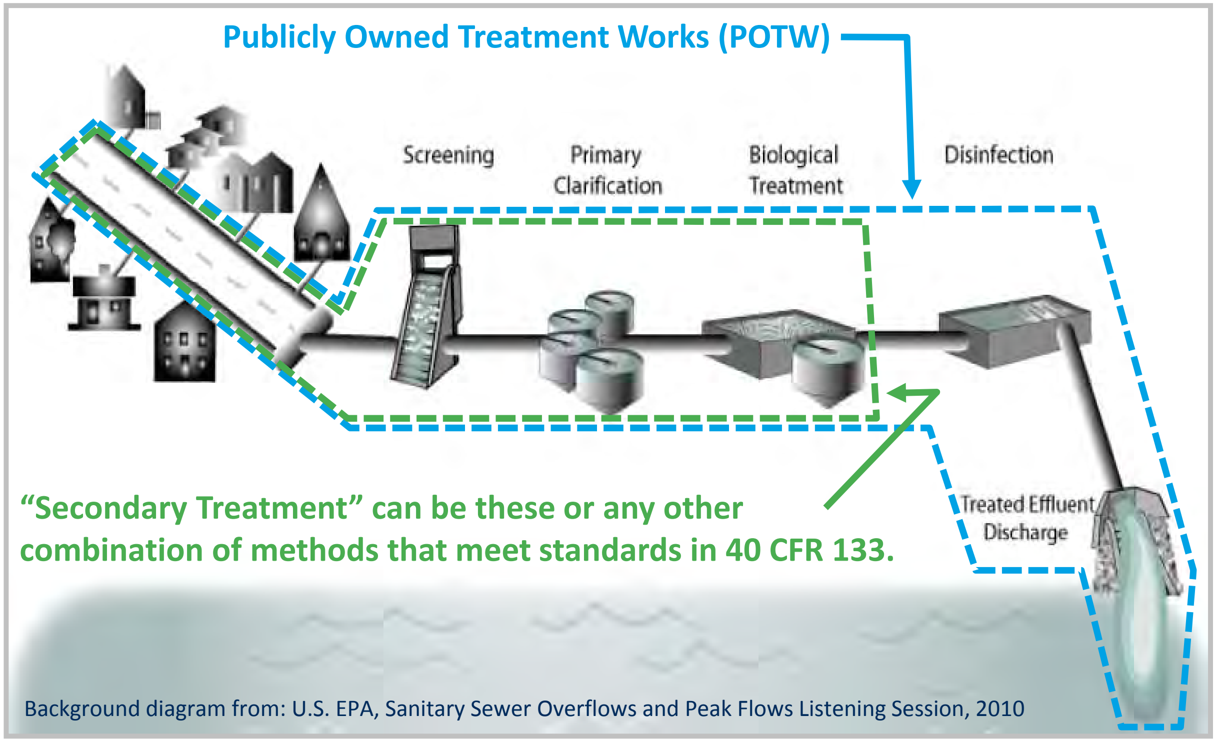
Added value

- **Auxiliary facilities increase resiliency and redundancy**
- **EHRT effluent quality equivalent to secondary effluent**

If auxiliary treatment, don't call it *bypass or blending*… especially if EHRT technology

Background diagram from: U.S. EPA, Sanitary Sewer Overflows and Peak Flows Listening Session, June 30, 2010

To make sure we're speaking the same language…



"Secondary Treatment" ≠ 100% biological treatment. Regulatory definition with no precise scientific definition, **<u>especially for episodic wet-weather flows.</u>** Do not use it for scientific or engineering descriptions. Use scientific language.

Words really do matter

Instead of:	Consider:
Divert	Intercept
Diversion Structure	Interceptor Structure Regulator Structure
Bypass	Flow split Flow control
Excess flow	Peak flow
Primary treatment Secondary treatment	Primary settling Activated sludge treatment Wet-weather flow treatment Auxiliary treatment
Secondary treatment train	Biological treatment train Activated sludge treatment train

If treating adequately, don't imply lack of treatment. Use scientifically accurate terms to describe design. Avoid connotations and misinterpretations.

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BUILDING A WORLD OF DIFFERENCE®

BLACK & VEATCH

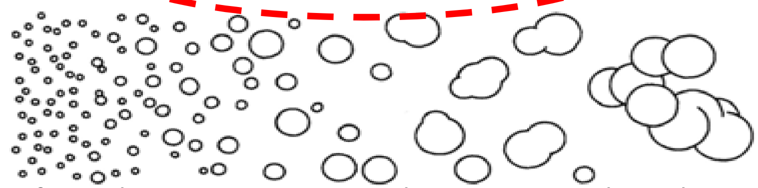
Bullpen

Enhanced Clarification Mechanisms

Key to all CES varieties

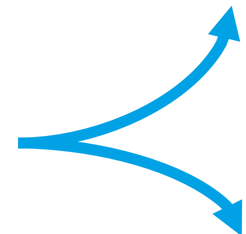
Gravimetric

Particle Conditioning



Surface Charge Neutralization | Coagulation Co-precipitation | Flocculation Adsorption

Flotation

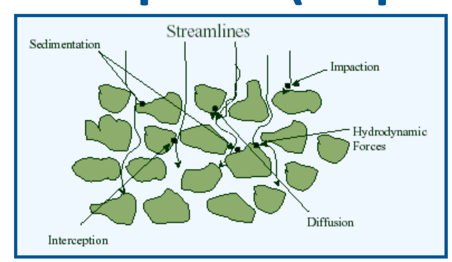


Sedimentation

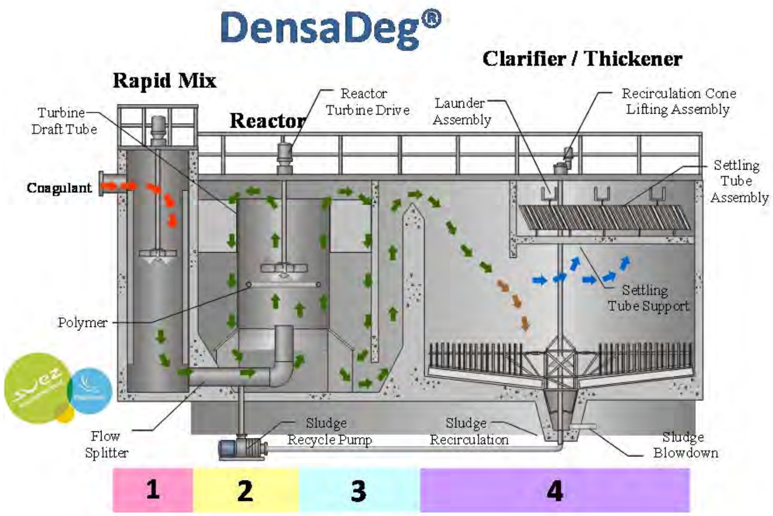
Filtration*

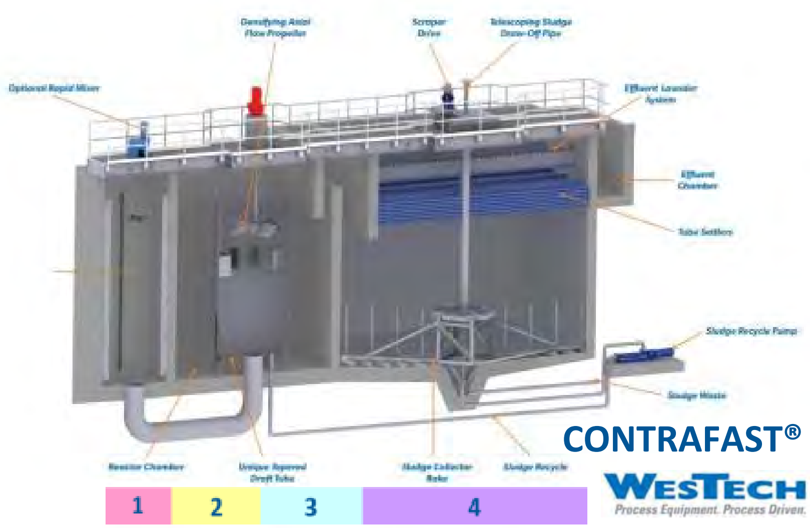
Sieving (Surface)

Adsorption (Depth)



* May also require particle conditioning depending upon particle size distribution, effluent limits and filter media





HRC – Dense Sludge

1. Coagulant Rapid Mix
2. Polymer Rapid Mix
3. Flocculation Slow Mix
    a. Sludge recirculation
4. Lamella Settlers

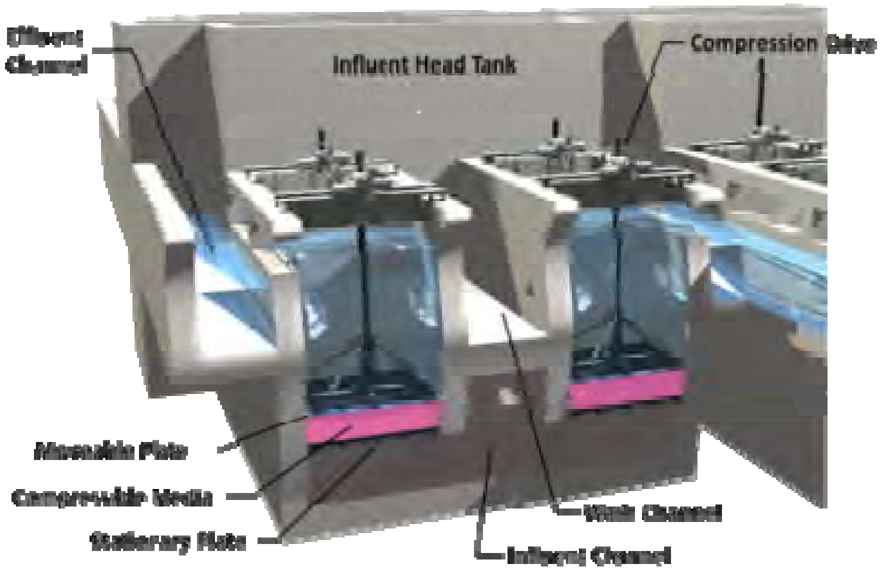
Lower coagulant dose
Better flocculation
Smaller footprint

Biggest reason for small footprint

HRC example

- 232-mgd treatment
- 130 ft x 270 ft
- ~$67M (2006)
- Cl_2 disinfectant
- $NaHSO_3$ dechlorination

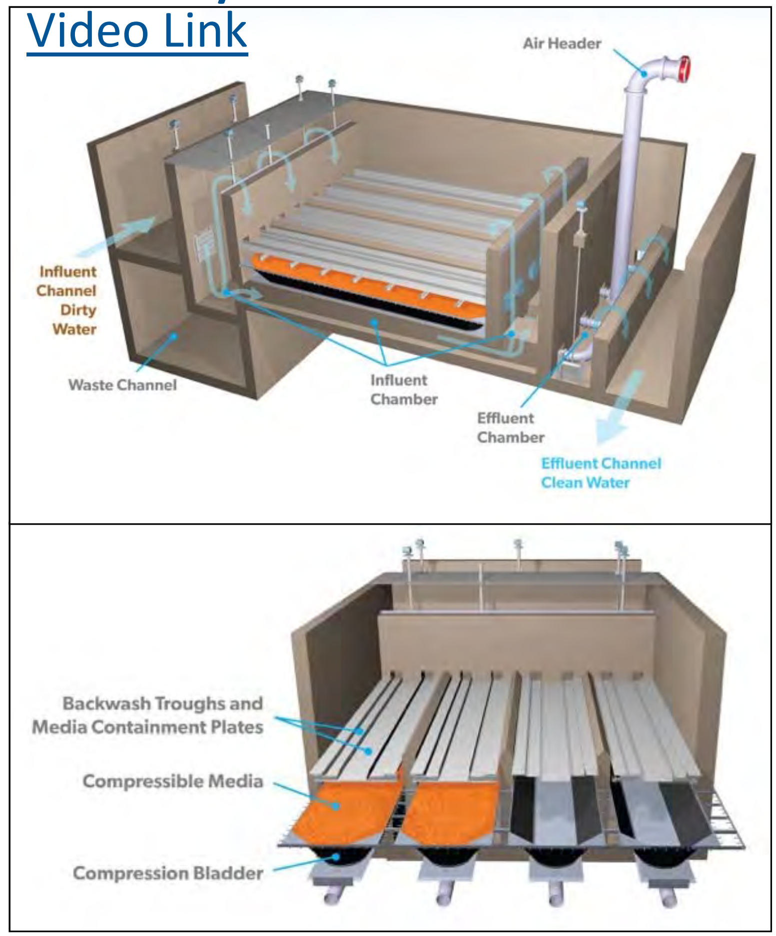
HRF – Compressible Media



Schreiber Fuzzy Filter™

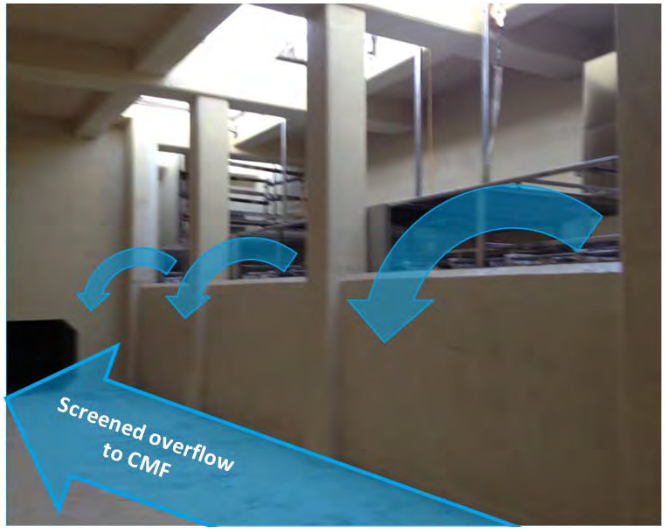
WesTech/WWETCO FlexFilter™

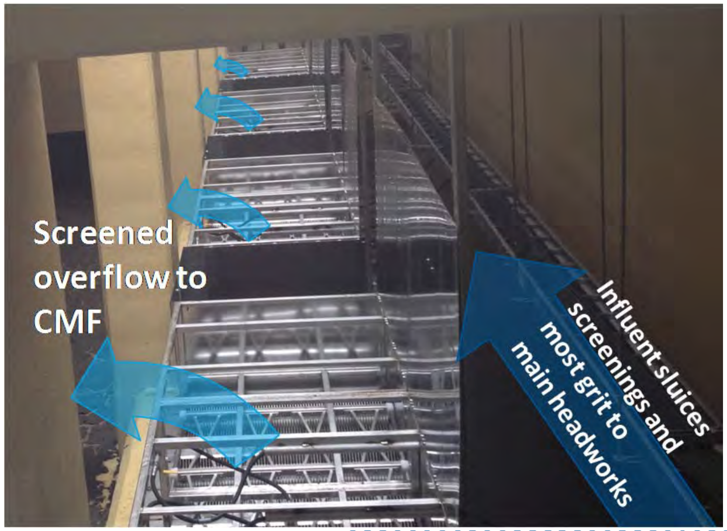
[Video Link]



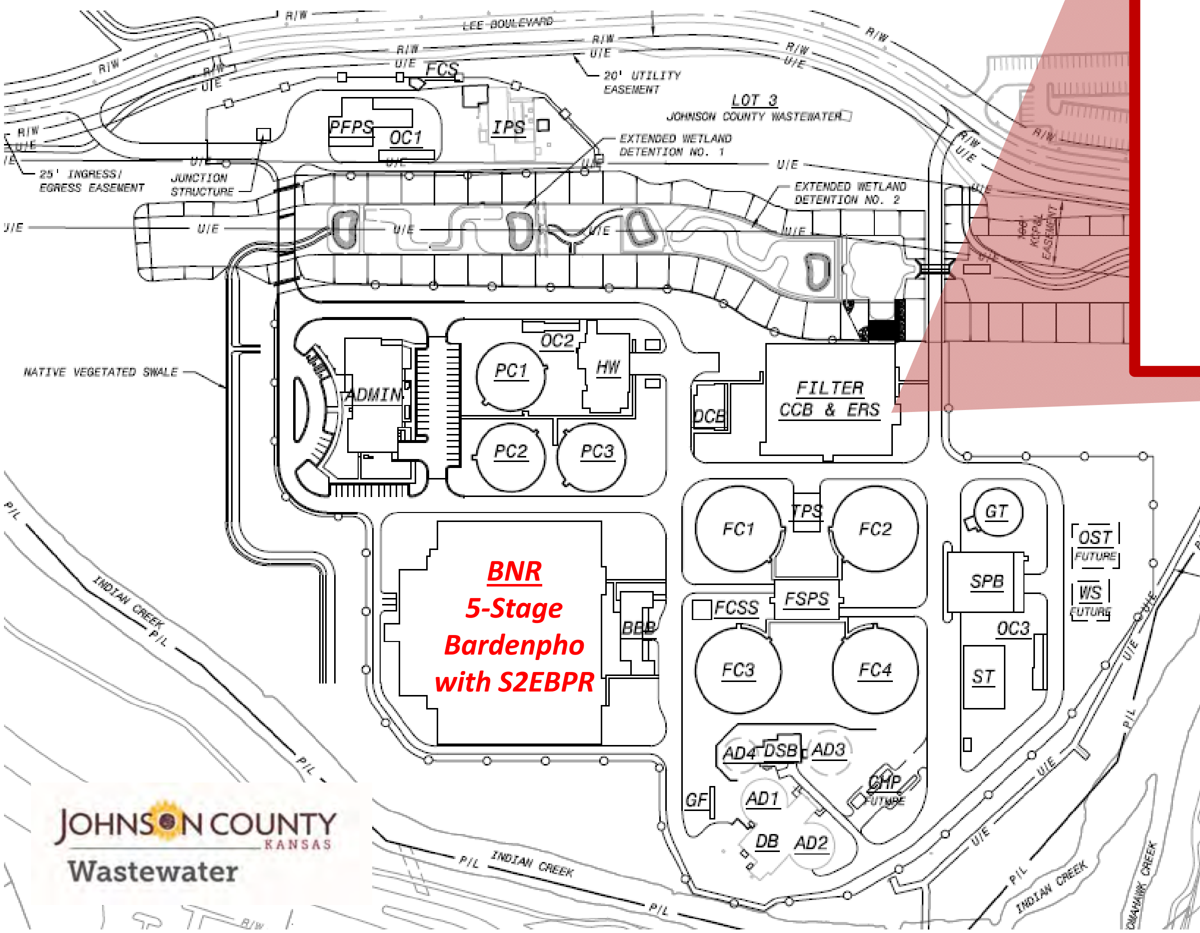
Wet-Weather Headworks

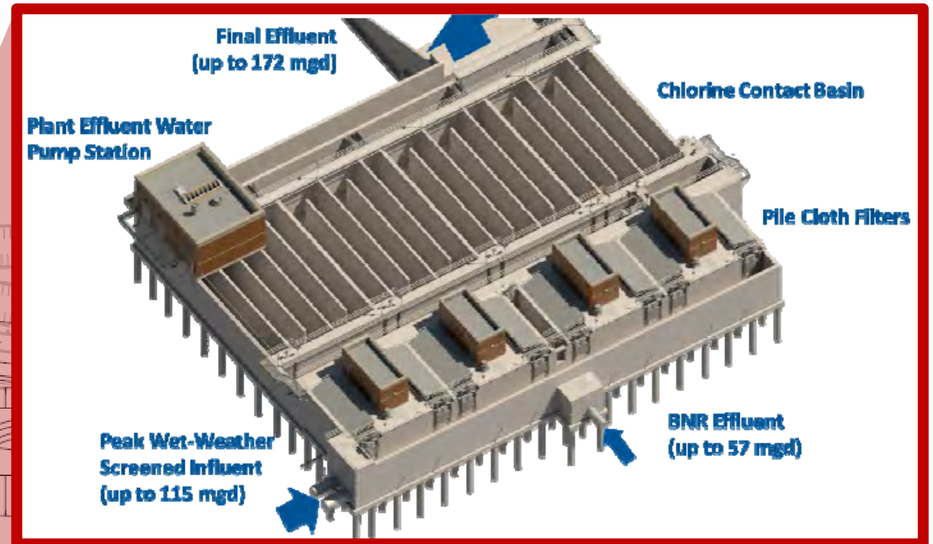
- Control flow to biological and auxiliary trains
- Screenings and most grit stay in influent sewer
- No remote screenings handling
- Velocity control channel with horizontal raked bar screens (PWTech, Kusters or equal) and rock box





Dual-Use Filter for Tomahawk Creek WWTF





JOHNSON COUNTY KANSAS
Wastewater

- Upgrade and expand 10-mgd (ADF) trickling filter WWTP
- Under construction, 2020 startup

BNR and tertiary up to 3Q = 57 mgd

+ Auxiliary EHRT up to 115 mgd

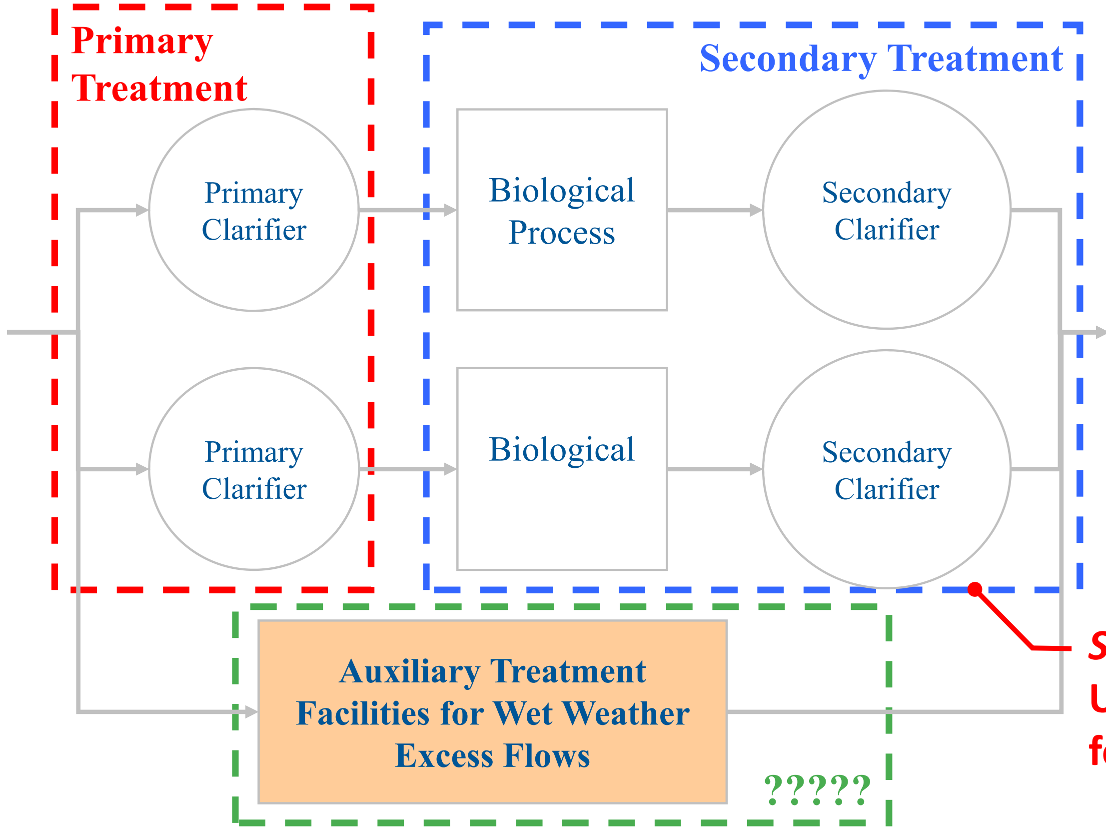
Peak WWTF capacity = 172 mgd

Auxiliary Treatment Facilities

- **Permitted use per 40 CFR 122.41(m)**
- **Wet-weather influent amenable to physical/chemical treatment**
  - **USEPA (2014), NPDES Experts Forum on Public Health Impacts of Wet Weather Blending (https://www.epa.gov/npdes/npdes-experts-forum-public-health-impacts-wet-weather-blending-documents)**
  - **USEPA (2007), *Wastewater Management Fact Sheet, In-Plant Wet Weather Peak Flow Management*, EPA 832-F-07-016**
  - **WEF (2006), *Guide to Managing Peak Wet Weather Flows in Municipal Wastewater Collection and Treatment Systems***
  - **USEPA (2004), *Report to Congress, Impacts and Control of CSOs and SSOs*, EPA 833-R-04-001**

Many pilot & full-scale studies by B&V and others support the use of physical/chemical auxiliary treatment facilities for wet-weather flows

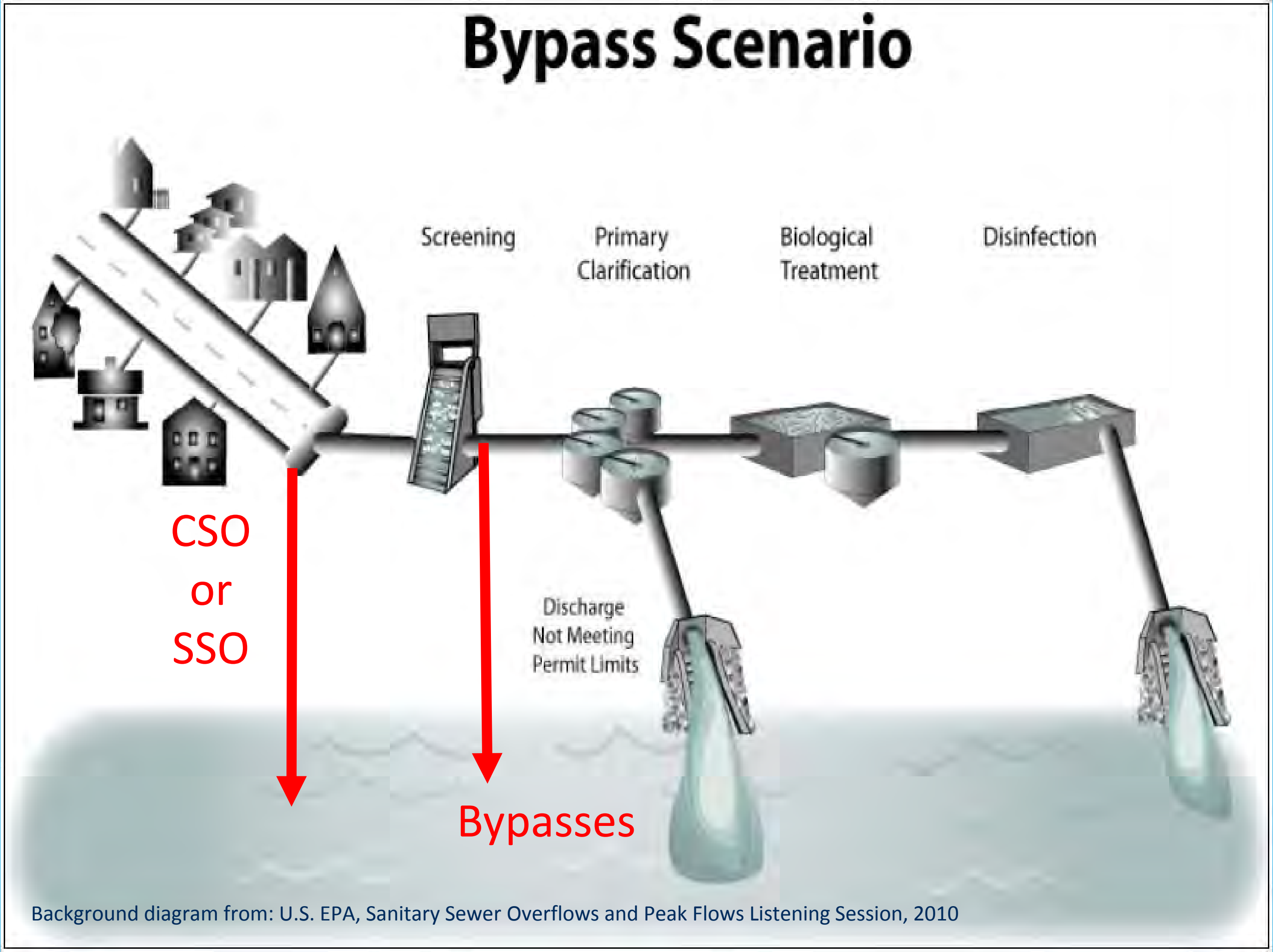
Common misinterpretation of *Secondary Treatment*



***Secondary* ≠ 100% *biological*. Unintended consequence from focusing only on dry-weather.**

No technology-based box for tertiary, disinfection, BNR, or advanced treatment → Water-quality based permitting

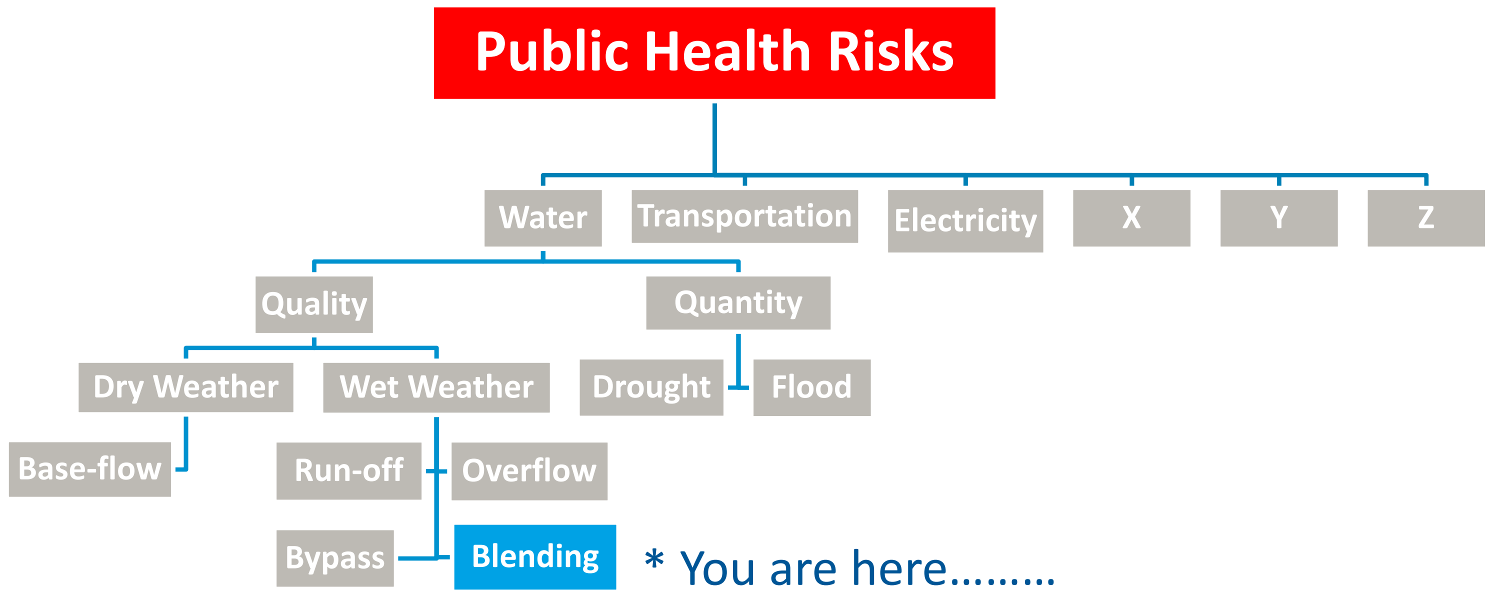
Not blending



Satellite treatment of CSO/SSO has similar environmental concerns and technical challenges as blending

Other Regulatory Drivers

Aspects of public health risks…



* You are here………

40 CFR 122.41(m)(1)(i)

promptly submit such facts or information.

(m) *Bypass*—(1) *Definitions*. (i) *Bypass* means the intentional diversion of waste streams from any portion of a treatment facility.

(ii) *Severe property damage* means substantial physical damage to property, damage to the treatment facilities

(ii) The Director may approve an anticipated bypass, after considering its adverse effects, if the Director determines that it will meet the three conditions listed above in paragraph (m)(4)(i) of this section.

(n) *Upset*—(1) *Definition*. *Upset* means an exceptional incident in which there is unintentional and temporary noncompliance with technology based per

Diversion **means decreasing or cutting off flows to a process unit. Parallel treatment concept does not decrease flows to any portion of the treatment facility.**

Do not use the terms *diversion or bypass* if providing auxiliary treatment

40 CFR 122.41(m)(4)(i)(B)

(C) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Director in the permit to be reported within 24 hours. (See §122.44(g).)

(iii) The Director may waive the written report on a case-by-case basis for reports under paragraph (l)(6)(ii) of this section if the oral report has been received within 24 hours.

(7) *Other noncompliance.* The permittee shall report all instances of noncompliance not reported under

(4) *Prohibition of bypass.* (i) Bypass is prohibited, and the Director may take enforcement action against a permittee for bypass, unless:

(A) Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

(B) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not

Use of auxiliary treatment facilities is not a bypass

Do not use the terms *diversion or bypass* if providing auxiliary treatment

40 CFR 122.41(m)(2)

damage does not mean economic loss caused by delays in production.

(2) *Bypass not exceeding limitations.* The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of paragraphs (m)(3) and (m)(4) of this section.

(3) *Notice*—(i) *Anticipated bypass.* If

caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

(2) *Effect of an upset.* An upset constitutes an affirmative defense to an action brought for noncompliance with such technology based permit effluent limitations if the requirements of paragraph (n)(3) of this section are met. No determination made during adminis-

Parallel auxiliary treatment provides essential maintenance of biomass to assure efficient operation

Do not use the terms *diversion or bypass* if providing auxiliary treatment

Perspectives on Auxiliary Treatment

Conventional technology standard = primary clarification + disinfection

- Minimum performance required by USEPA 1994 CSO Control Policy
- Technology equivalent assumed by USPEA for "blending"
- Generally presumed by profession to support CWA and codified secondary treatment requirements, *when used intermittently in parallel with biological treatment*

Differences between **HRT** and **EHRT** recognized by USEPA Region 5 & 7 … and elsewhere

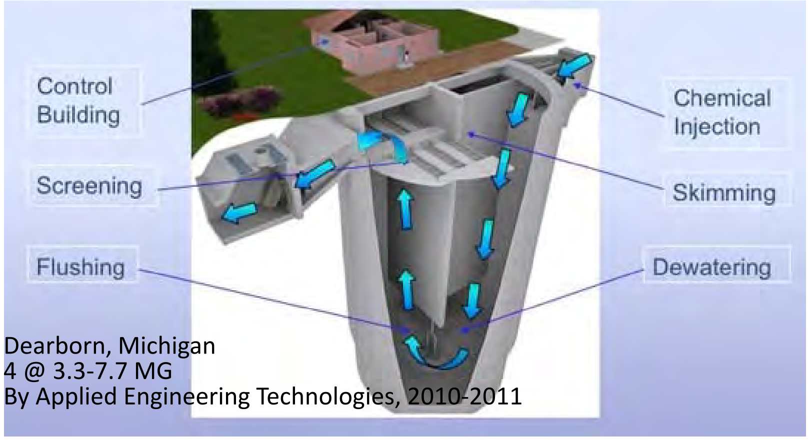
HRT Technologies Offer Small Footprint

Retention Treatment Basin (RTB)

- First-flush capture
- Settleable solids capture
- Disinfectant contact

Combined Sewer Solids Separation Facility
Des Moines, Iowa
~2012

CSO Treatment Shaft

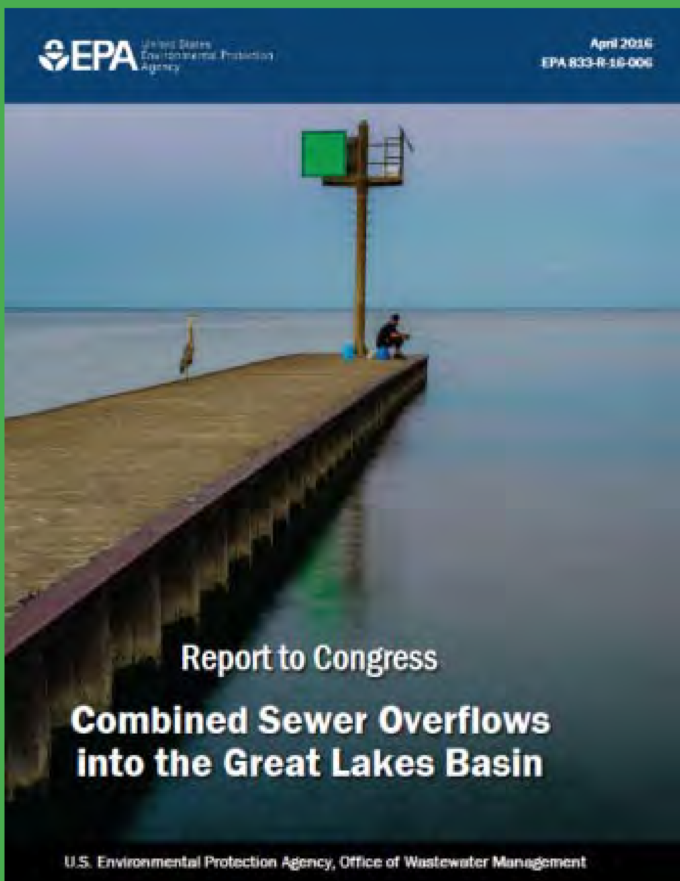


Dearborn, Michigan
4 @ 3.3-7.7 MG
By Applied Engineering Technologies, 2010-2011

Vortex Separator (Swirl Concentrator)

Boonville, Indiana
42-mgd Storm King® CSO Facility
By Midwestern Engineers ~2012

Good settleable solids removal, but marginal TSS removal. *Equivalent to primary clarification.*



BAT Approach Showing Up In Wet Weather Regulatory Guidance

- **Some regulators consider EHRT alternatives as best available technology economically achievable (BAT) for wet-weather overflow control**
- **Regulators tend to favor EHRT over HRT:**
  - **USEPA HQ and Regions (especially 5 and 7)**
  - **Ohio EPA – Toledo, Springfield, Cincinnati, Cleveland**
  - **Missouri DNR – St. Louis, Kansas City, St. Joseph**
  - **Kansas DHE – Lawrence, Johnson County, Kansas City**

Other Technology Alternatives

Let's take a closer look at some alternatives

HRT

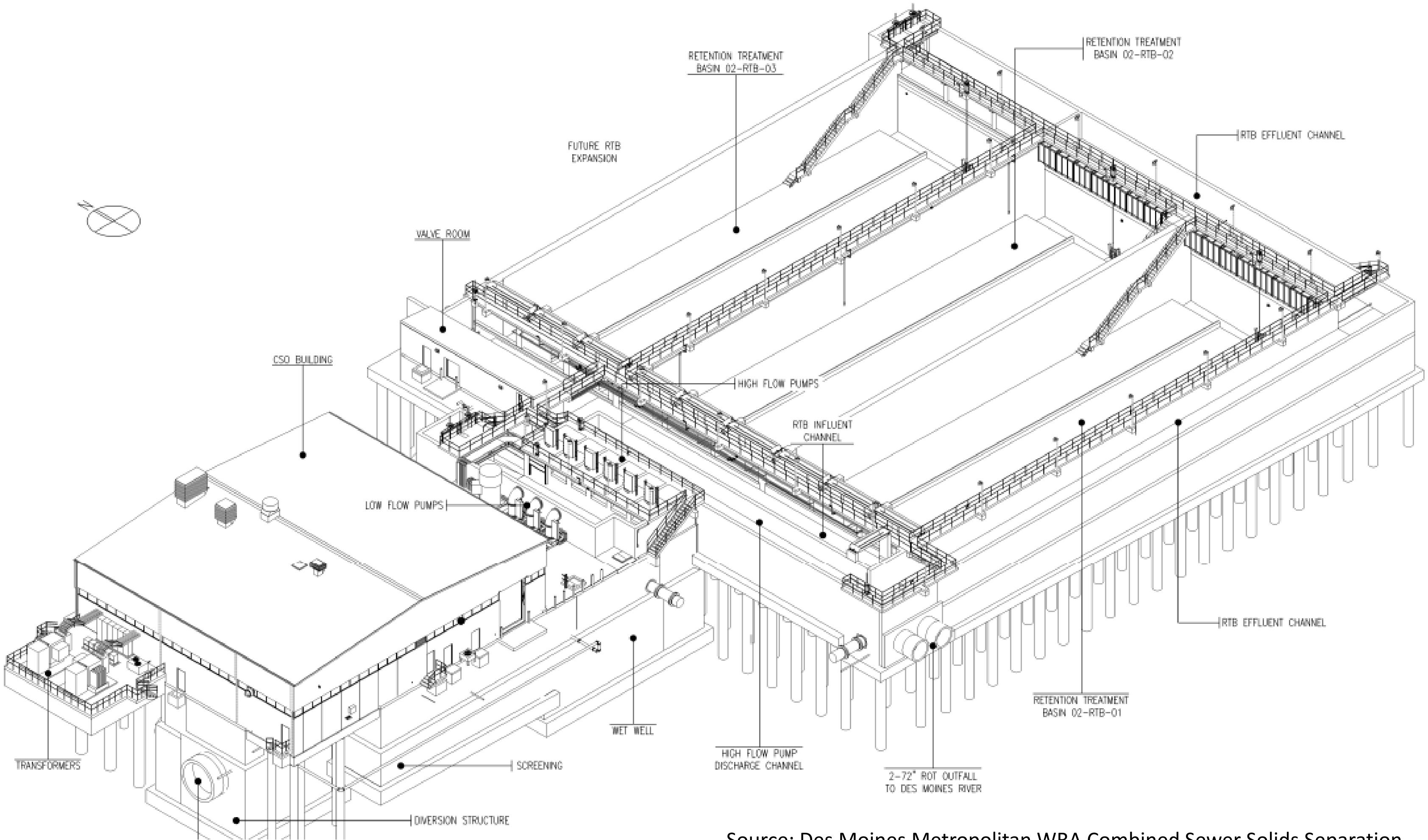
1. Retention Treatment Basin (RTB)
2. Vortex Separator

EHRT

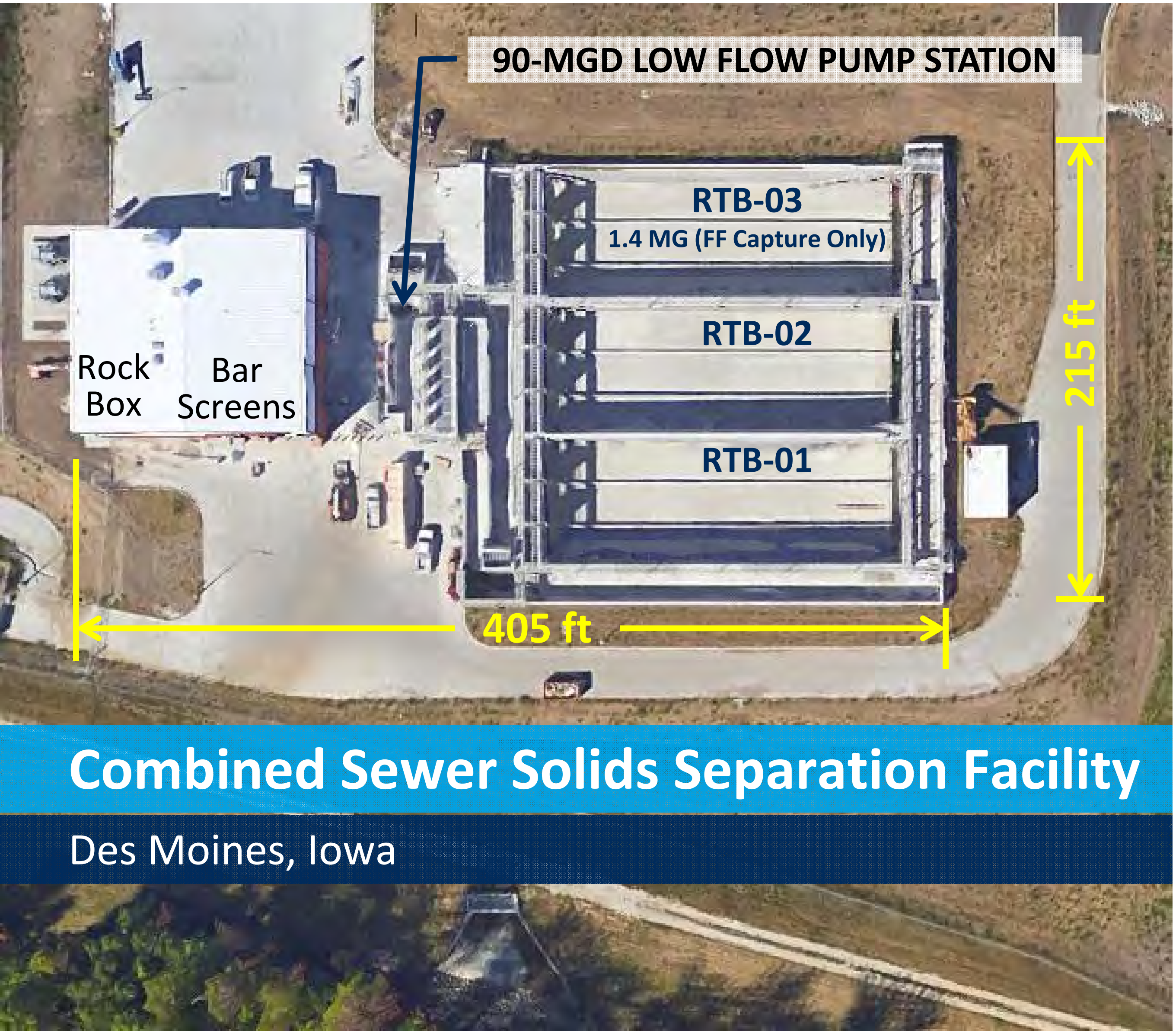
3. HRC – Dense Sludge
4. HRC – Ballasted Flocculation
5. HRF – Compressible Media Filtration
6. HRF – Pile Cloth Media Filtration

Warning: comparing HRT to EHRT can be apples to oranges.

Retention Treatment Basin (RTB)



Source: Des Moines Metropolitan WRA Combined Sewer Solids Separation Facility, WRA Activity ID 10-2010-001, HDR Project 75936, 23 June 2011



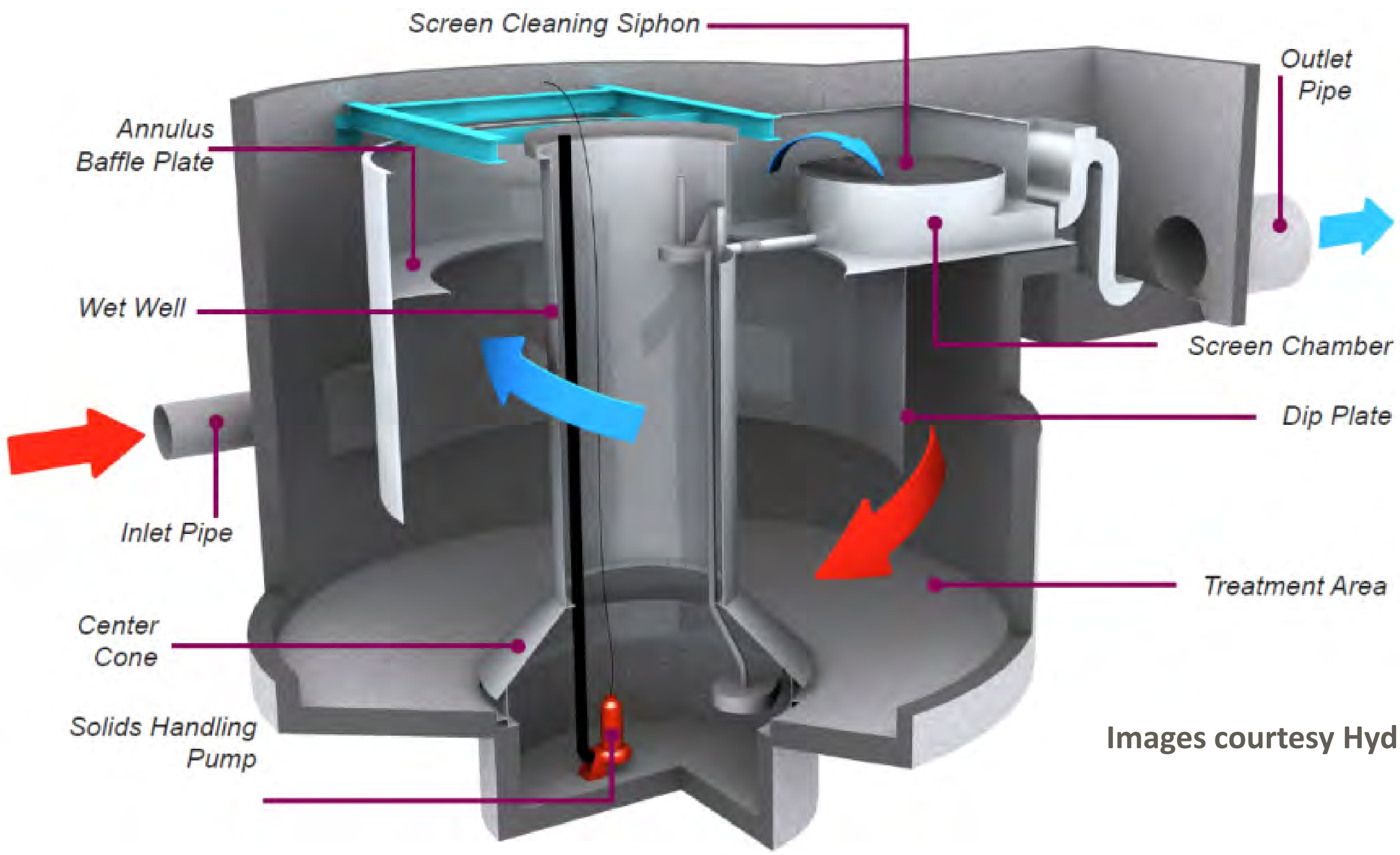
RTB Example

- 90-mgd CSO treatment
- $40M (2010) also included access road, two standby power structures and 300-mgd high flow PS
- NaOCl / $NaHSO_3$ disinfection, but not required by IDNR now

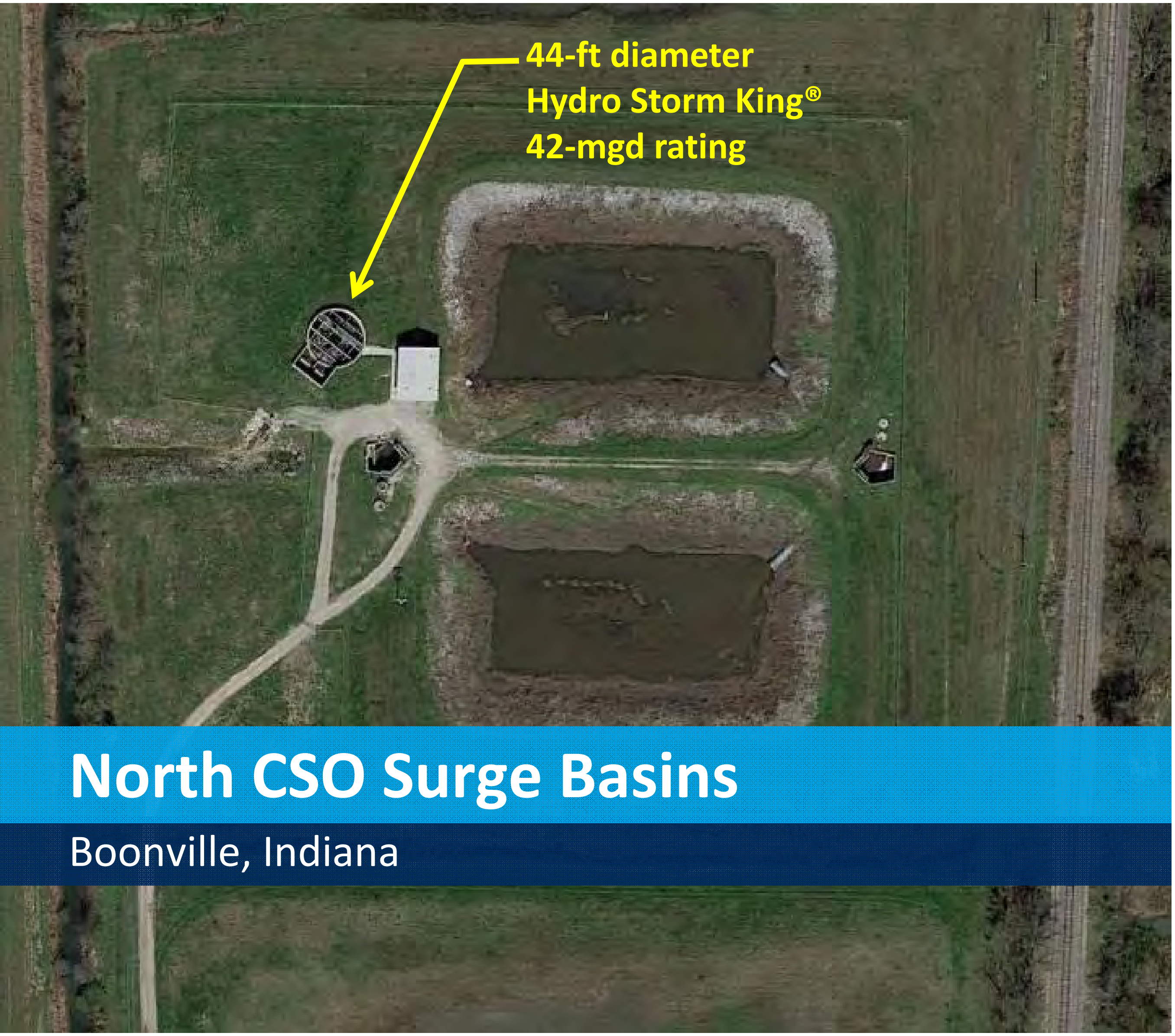
General Comparison To Other Alternatives - RTB

Advantage	Disadvantage	Consideration
Low preliminary treatment needs	Less regulatory certainty • Bare minimum for CSO • Questionable for SSO • Probably not BAT	UV disinfection not feasible
Familiar to WRA	Only removes large, settleable solids (grit). Negligible removal of TSS_{non} & turbidity.	High disinfectant dosage
Low headloss		Negligible dual-use benefit

Vortex Separator



Images courtesy Hydro International



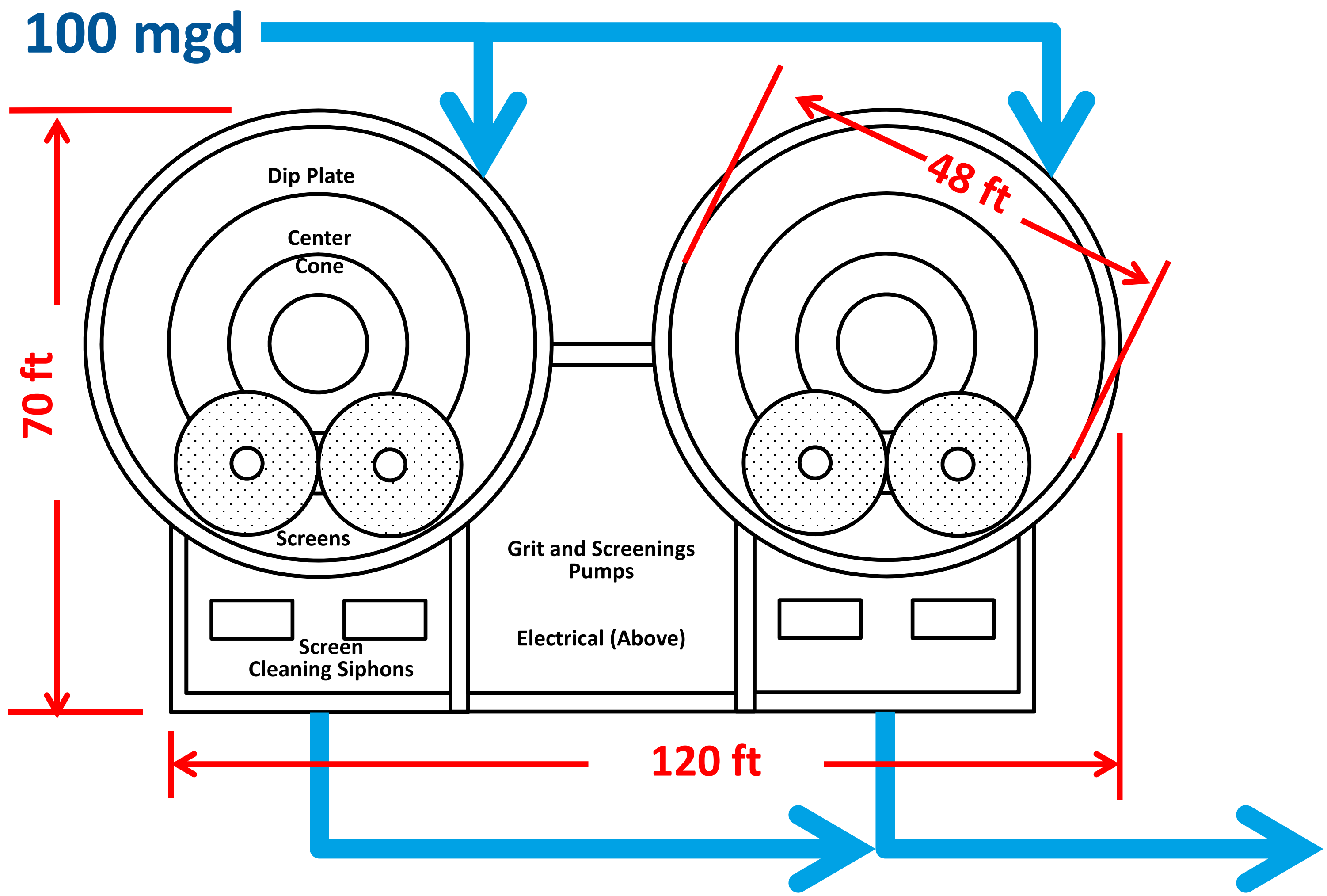
Vortex Separator Example

- 84-mgd CSO treatment
- Two installations
  - North CSO Basins
  - South CSO Basins
- ~$7M (2012)
- In-vessel high-rate chemical disinfection

Conceptual Design Criteria – Vortex Separator

Item	Units	Value	Notes / Assumptions
Peak flow rate	mgd	100	
Total number of trains	-	2	
Separator HLR	gpm/ft^2	19	HLR from Boonville, IN assumed
Peak sludge recycle flow	mgd	6	2 duty pumps per train, 30 hp each
Peak sludge waste flow	mgd	6	1 duty pump + 1 standby shared with recycle per train, 75 hp each
Sludge solids content	%TS	1 to 5	Clarifier/thickener underflow
Coagulant dose ($FeCl_3$)	mg/L	45	40% FeCl3 solution assumed
Polymer dose	mg/L	0.9	28% aPAM emulsion assumed

Conceptual Facility Layout – 100-mgd Vortex Separator



General Comparison to other Alternatives – Vortex Separator

Advantage	Disadvantage	Consideration
Low preliminary treatment needs	Less regulatory certainty • Bare minimum for CSO • Questionable for SSO • Probably not BAT	Grit and screenings pump maintenance, dry-pit pump recommended
Small footprint	Only removes large, settleable solids (grit) and >4-6 mm screenings. Negligible removal of TSS_{non} & turbidity.	UV disinfection not feasible
Few moving parts	Relatively high headloss	High disinfectant dosage
Low O&M costs		Negligible dual-use benefit
		44-ft diameter = largest installed unit

1. **195-mgd Nitrifying Activated Sludge WRF**

2. **232-mgd EHRT Facility**
   - Vortex Grit Removal
   - HRC – Dense Sludge
   - Reaeration
   - Chlorination
   - Dechlorination

3. **25 MG Storage Basin**

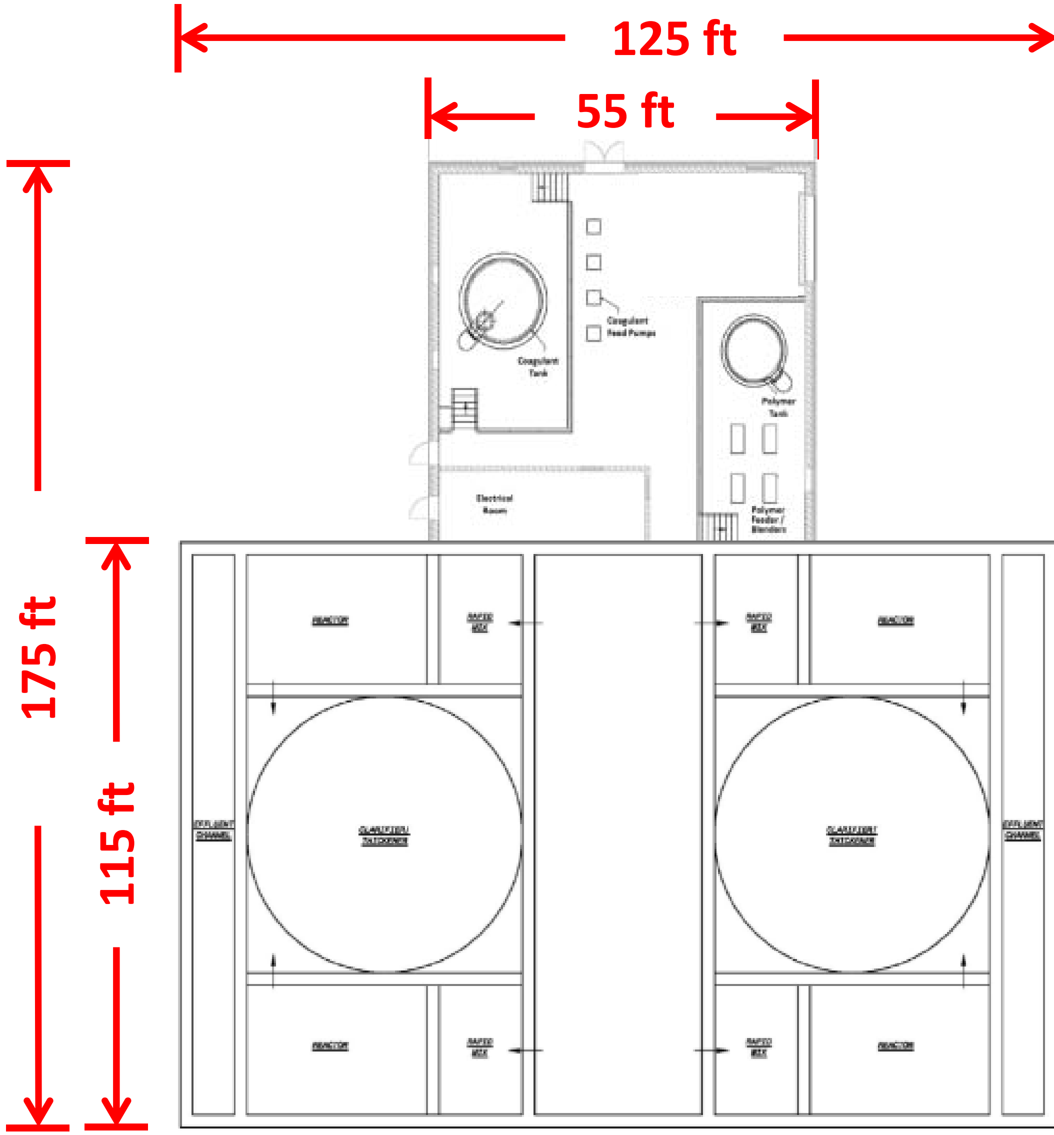
Bay View WRF

Toledo, Ohio

Conceptual Design Criteria – Dense Sludge HRC

Item	Units	Value	Notes / Assumptions
Peak flow rate	mgd	100	
Total number of trains	-	2	
Coagulation tank HRT	min	5	Rapid mix, 2 per train, 10 hp per tank
Flocculation tank HRT	min	10	Draft tube mixer, 2 per train, 40 hp each
Settling tank HLR	gpm/ft^2	26	Lamella tubes, sludge scraper, 1.5 hp per train
Peak sludge recirculation rate	mgd	6	2 duty pumps per train, 30 hp each
Peak sludge waste rate	mgd	6	1 duty pump + 1 standby shared with recycle per train, 75 hp each
Sludge solids content	%TS	1 to 5	Clarifier/thickener underflow
Coagulant dose ($FeCl_3$)	mg/L	45	40% FeCl3 solution assumed
Polymer dose	mg/L	0.9	28% aPAM emulsion assumed

Conceptual Facility Layout – 100-mgd Dense Sludge HRC



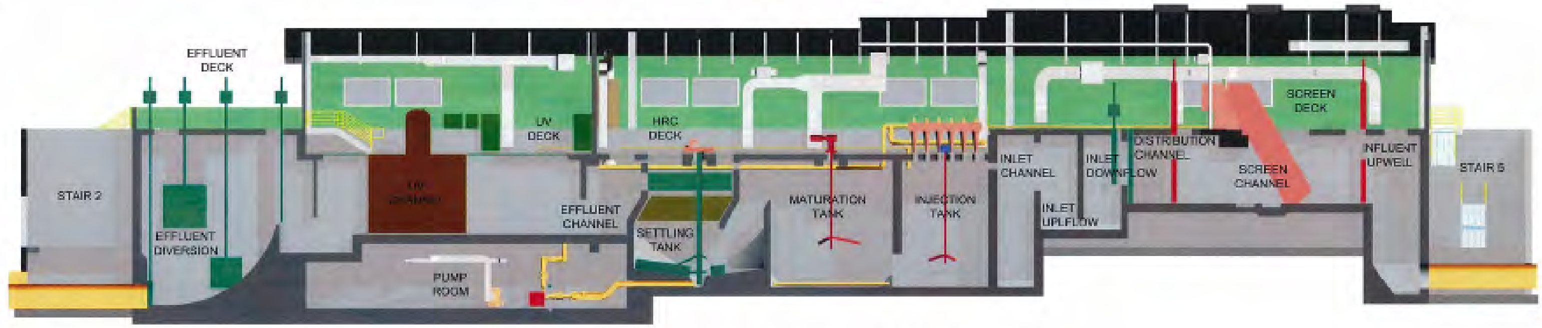
General Comparison to other Alternatives – Dense Sludge HRC

Advantage	Disadvantage	Consideration
Low Preliminary Treatment Needs	Coagulant And Polymer Required	UV Disinfection May Limit Coagulant Choices
Small Footprint	Medium O&M Costs	Alkalinity Consumption May Require Higher Cost Coagulant
Low Headloss	Staffing For Startup And Operation (Chemical Feed)	Mitigate Effluent Foaming
Excellent Effluent Quality		
No Ballast Handling		

Example of HRC - Ballasted Flocculation

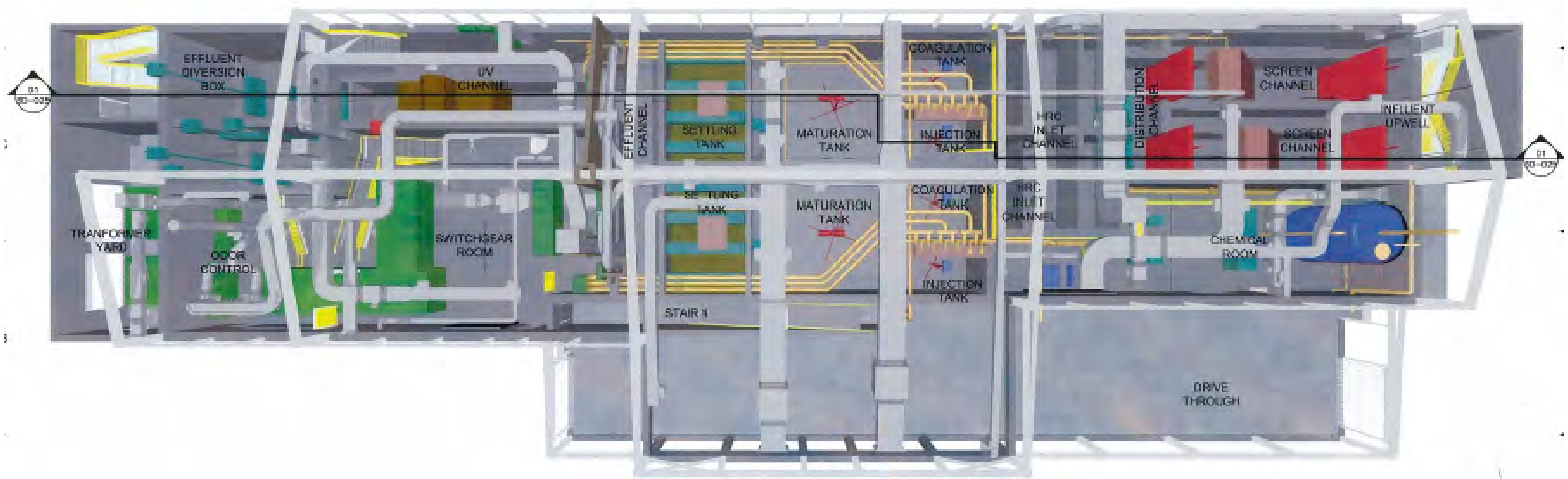
- 50-mgd treatment
  - Fine screens
  - Ballasted flocculation
  - ACH, polymer and sand storage/feed
  - UV disinfection (Trojan 4000)
- ~$30.5M (2004)
- Watershed based NPDES permit with Willow Lake WPCF shares mass load

RRWWTF (Salem, Oregon)



D1 PROCESS BLOCK SECTION LOOKING WEST

NOT TO SCALE



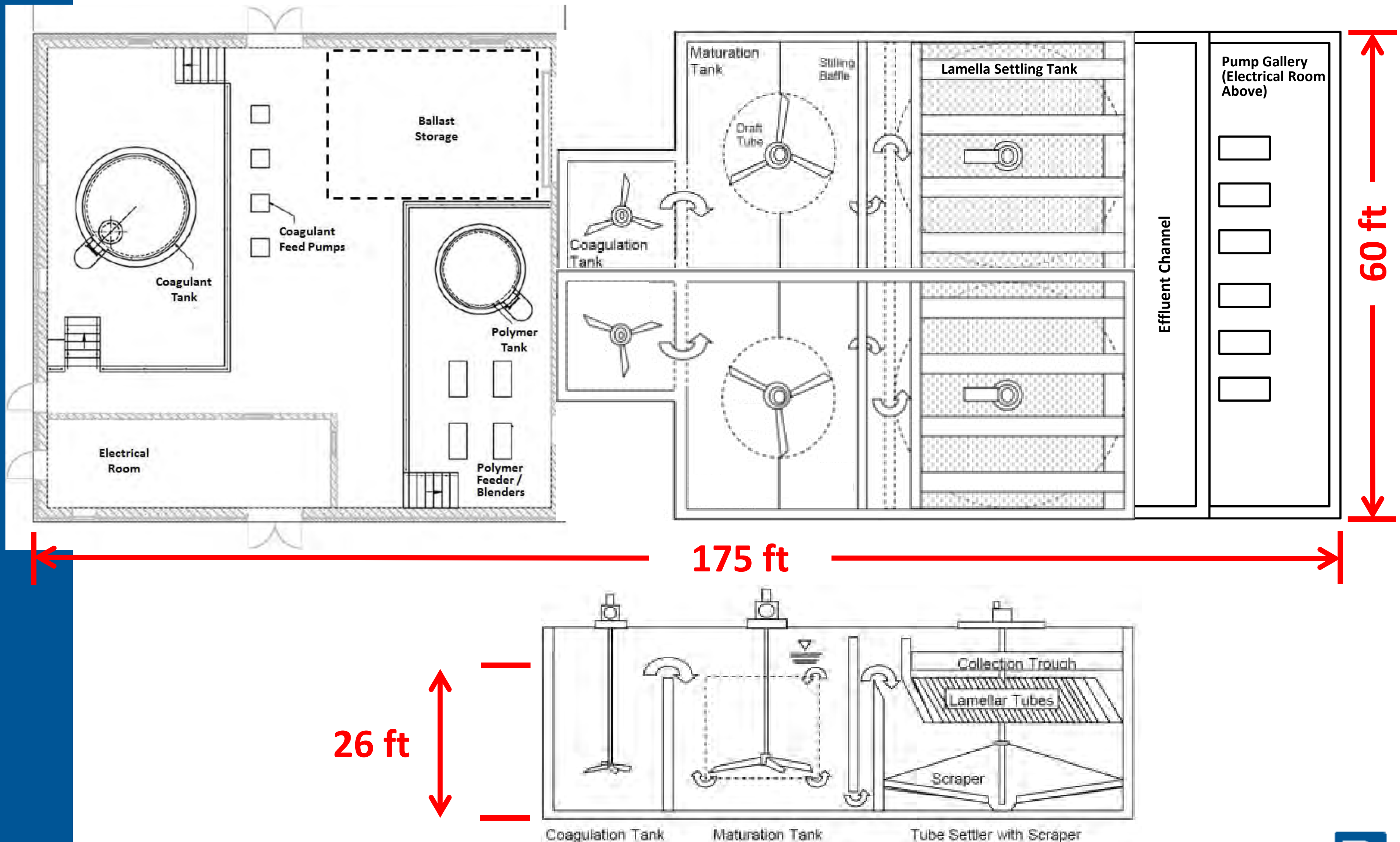
A1 PROCESS BLOCK PLAN VIEW

NOT TO SCALE

Conceptual Design Criteria – Ballasted Flocculation HRC

Item	Units	Value	Notes / Assumptions
Peak flow rate	mgd	100	
Total number of trains	-	2	
Coagulation tank HRT	min	2.4	Rapid mix, 15 hp per train
Flocculation tank HRT	min	4.5	Draft tube mixer, 40 hp per train
Settling tank HLR	gpm/ft^2	60	Lamella tubes, sludge scraper, 7.5 hp per train
Sludge recirculation pump, each (to ballast recovery)	gpm	1,040 – 2,080	±10%, continuous sludge removal and ballast recovery, 2 duty + 1 standby per train, 100 hp each
	mgd	1.5 - 3	
Waste sludge flow rate	mgd	4.8	±10%, post ballast recovery
Sludge solids content	%TS	0.1-0.5	Hydrocyclone overflow
Coagulant dose ($FeCl_3$)	mg/L	45	40% FeCl3 solution assumed
Polymer dose	mg/L	0.9	28% aPAM emulsion assumed
Ballast usage	mg/L	2.5	Microsand assumed

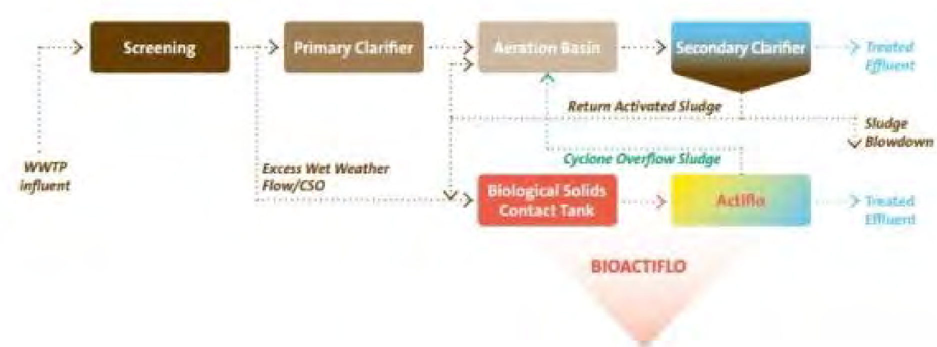
Conceptual Facility Layout
100-mgd Ballasted Flocculation HRC



General Comparison to other Alternatives – Ballasted Flocculation HRC

Advantage	Disadvantage	Consideration
Small footprint	Medium preliminary treatment needs (hydrocyclone clogging)	UV disinfection may limit coagulant choices
Low headloss	Coagulant, polymer and ballast required	Alkalinity consumption may require higher cost coagulant
Excellent effluent quality	Medium O&M costs	Mitigate effluent foaming
	Staffing for startup and operation (chemical and ballast monitoring and feed)	

Flexibility For Secondary Treatment Of Excess Wet-Weather Flows



<u>**Full-scale Bio-ACTIFLO examples include:**</u>

- **56-mgd ADF Wilson Creek RWWTP (2012 | Allen, TX)**
- **15-mgd ADF Munster WWTP (2012 | St. Bernard Parish, LA)**
- **15-mgd ADF Cox Creek WRF (2016 | Anne Arundel County, MD)**

Temporary reconfiguration into contact stabilization activated sludge treatment process

Actiflo ™
How Does It Work?

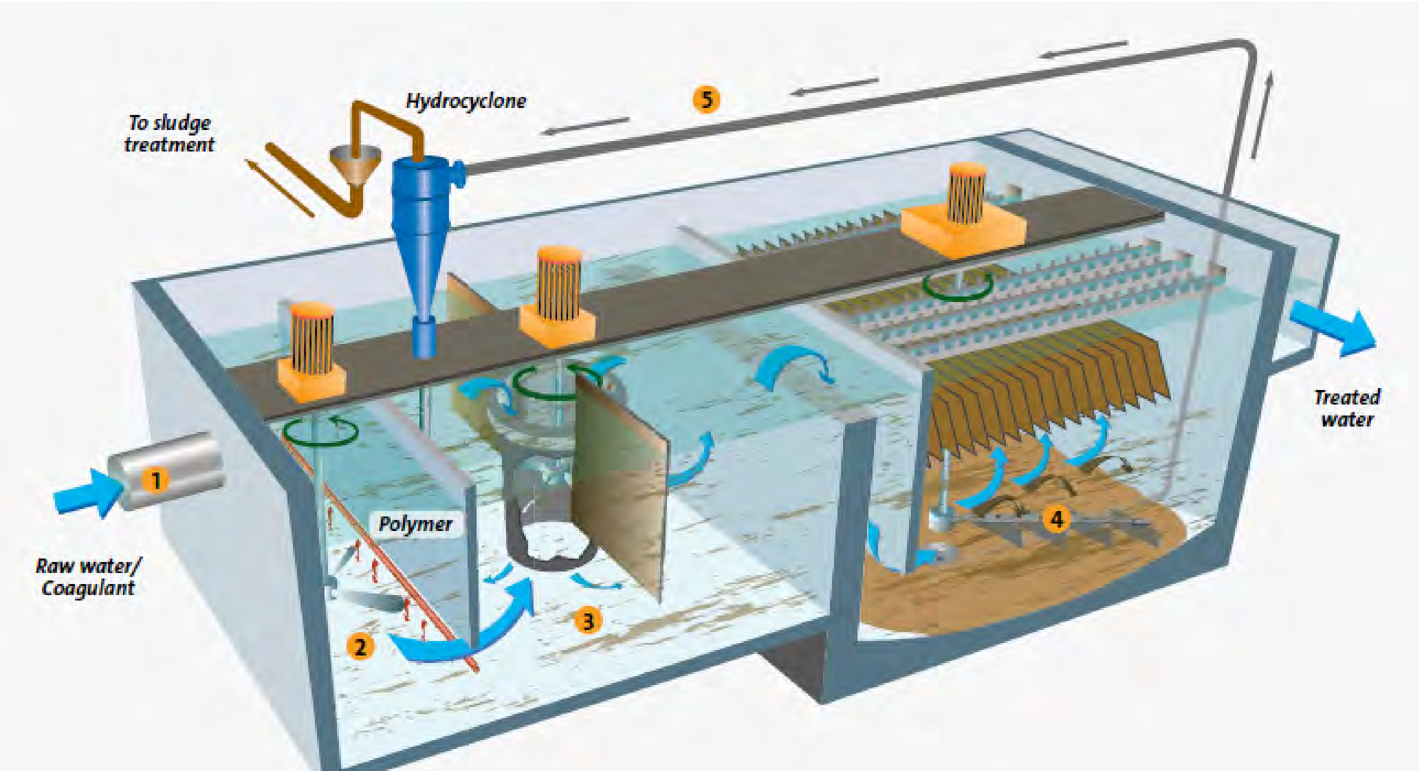
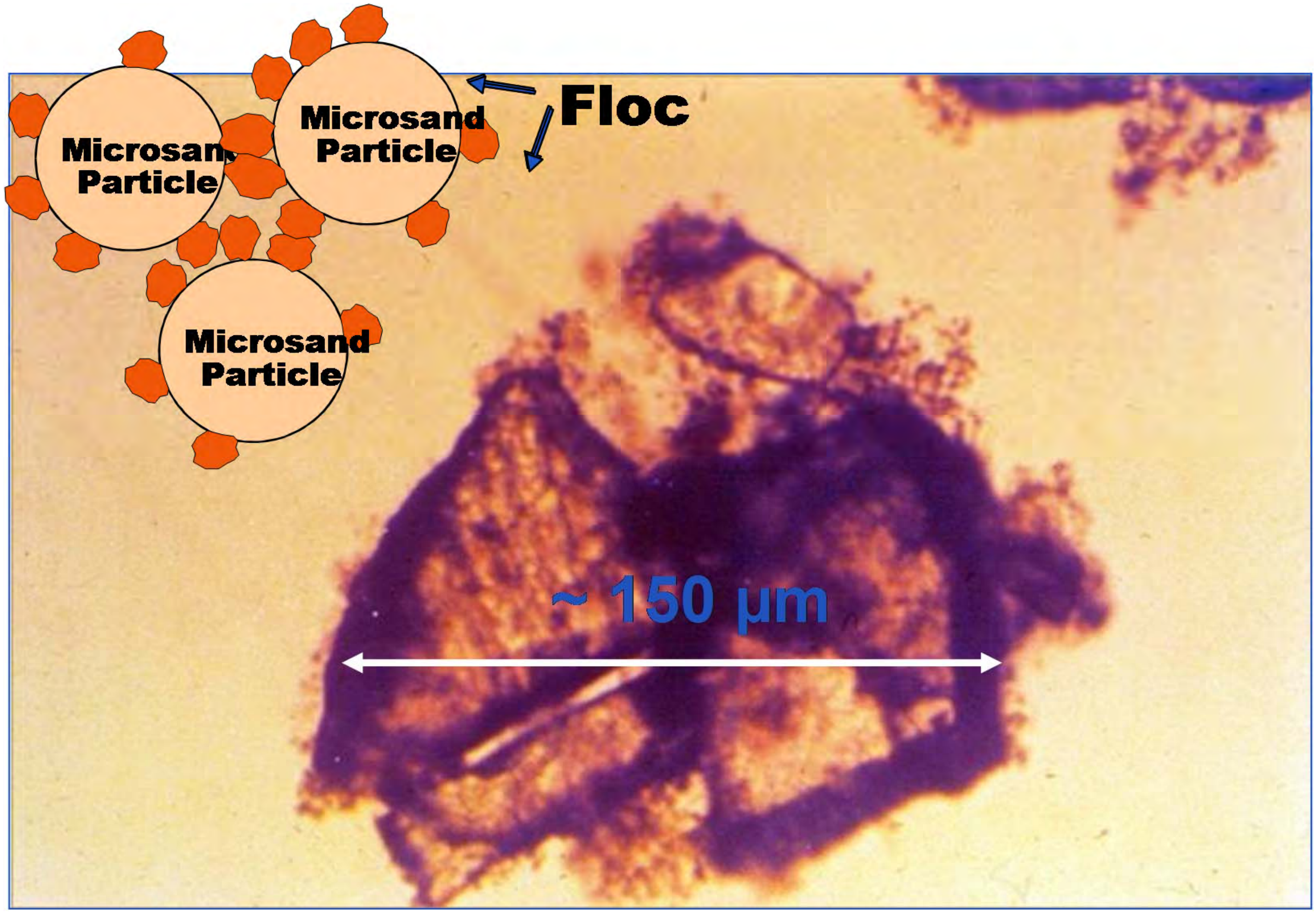
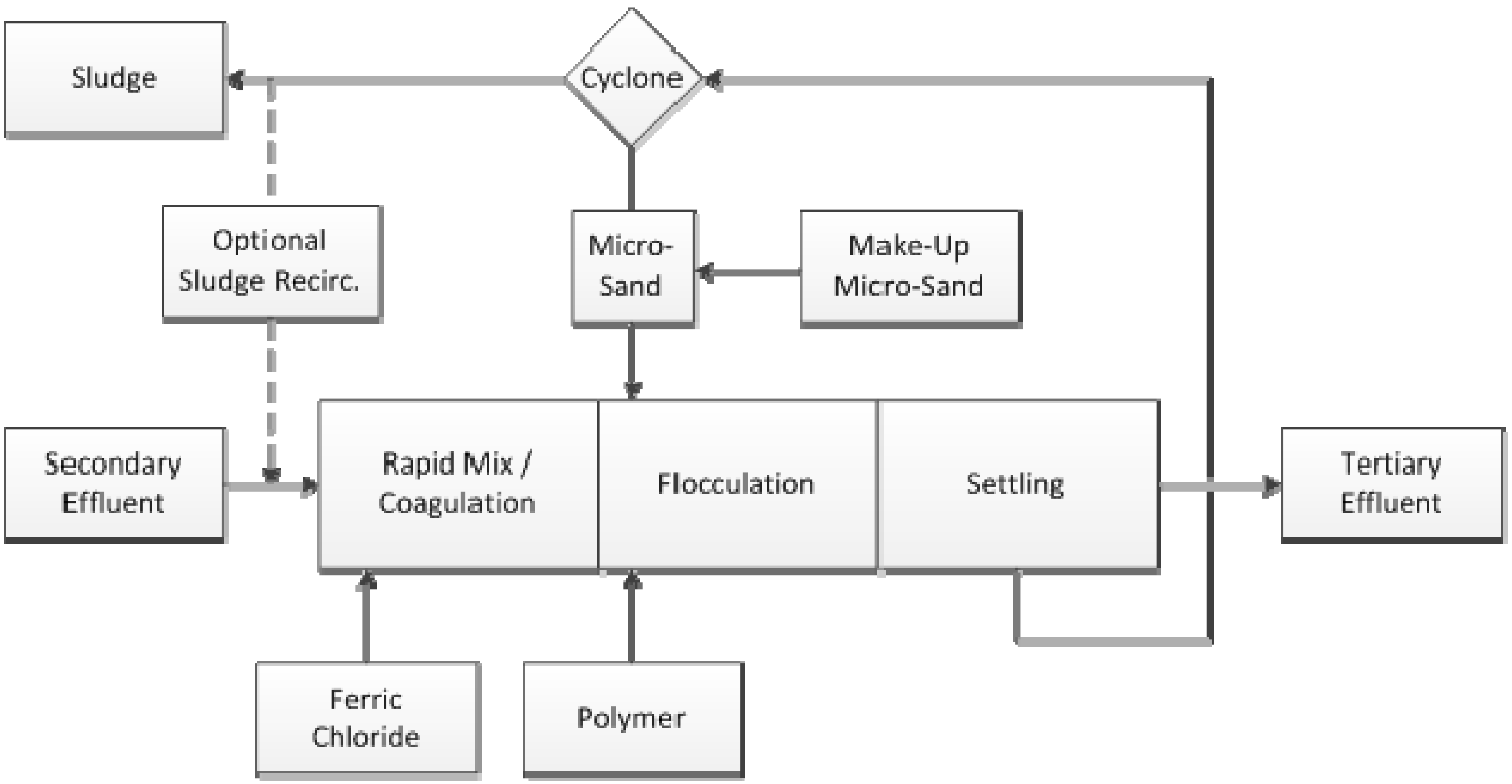


Figure from Veolia brochure

Sand Ballasted Flocculation



Microsand Ballasted Flocculation Process Flow Diagram



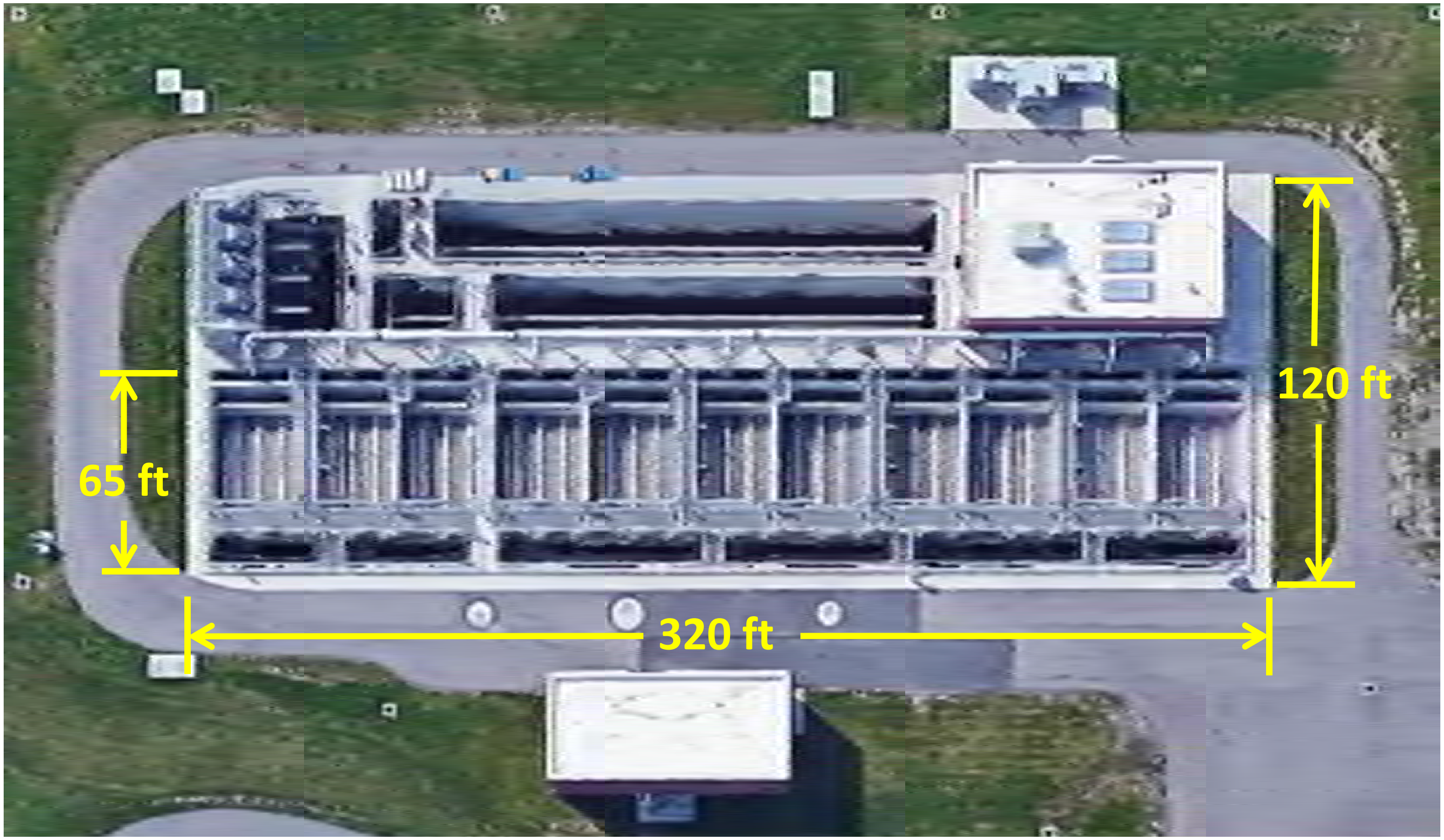
100-mgd CSO Screening, CMF (Flexfilter™), Disinfection & Effluent Pumping

- $33.5 million (2011; Springfield, OH)
- 120-ft x 320-ft footprint
- 3-MG storage,
- self-cleaning
- No added staff, SCADA-controlled operation
  - $5/MG treated (CSO mode)
  - $1/MG treated (tertiary mode)

Conceptual Design Criteria – Compressible Media

Item	Units	Value	Notes / Assumptions
Peak flow rate	mgd	100	
Hydraulic loading rate	gpm/ft^2	≤ 12	SLR ≤ 1.52 pph/ft^2
Cell filter area	ft^2	720	
Total number of cells	-	11	2 cells in backwash/standby
Backwash solids content	%TS	0.1–0.5	
Peak backwash flow rate	mgd	5	Decompression water returned to influent channel
Backwash airflow	scfm/ft^2	10	2 duty + 1 standby blower, 7200 scfm, 250 hp each
Media bed depth	inches	30	
Filter media	Bi-component synthetic fibers bound into a quasi-spherical shape using stainless steel clips to bind the fibers.		

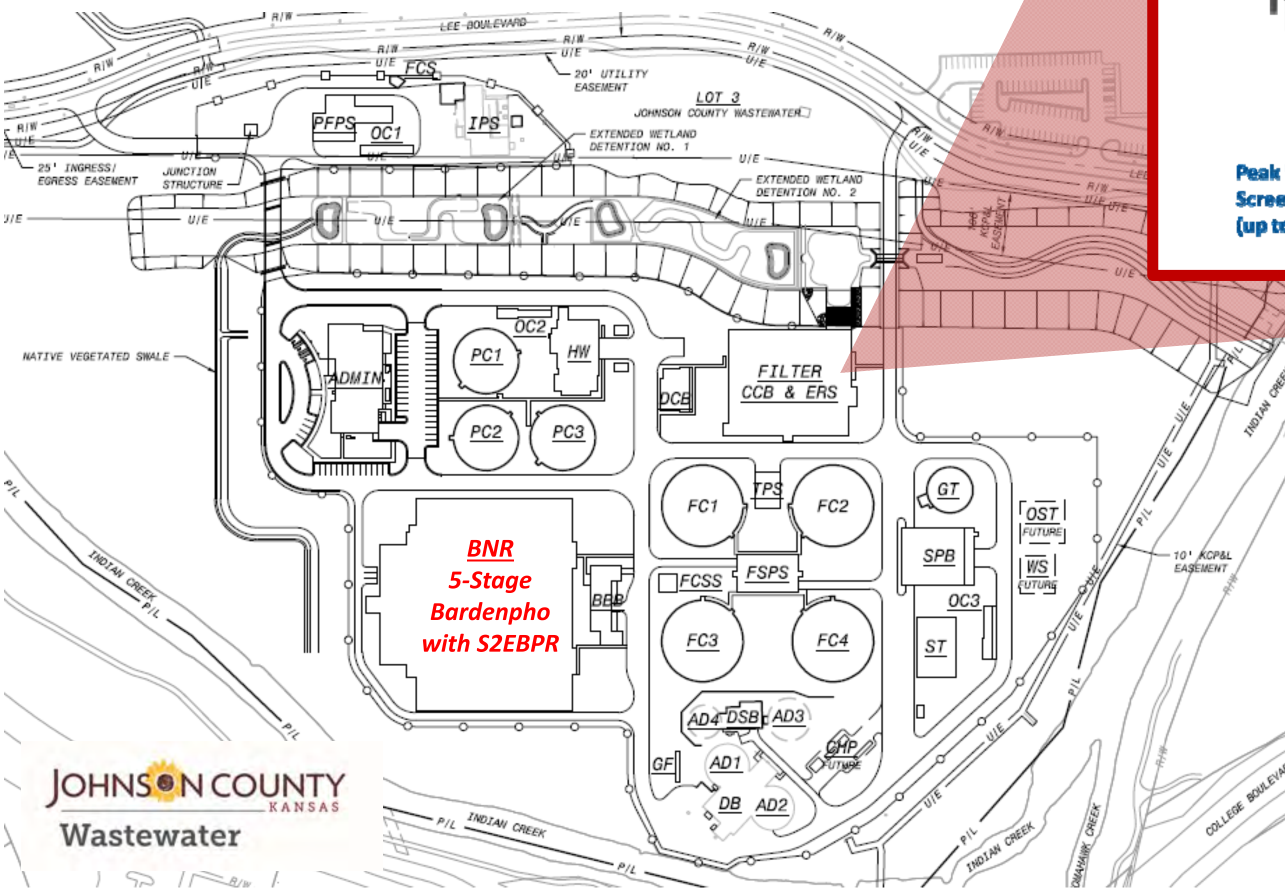
Conceptual Facility Layout - Compressible Media

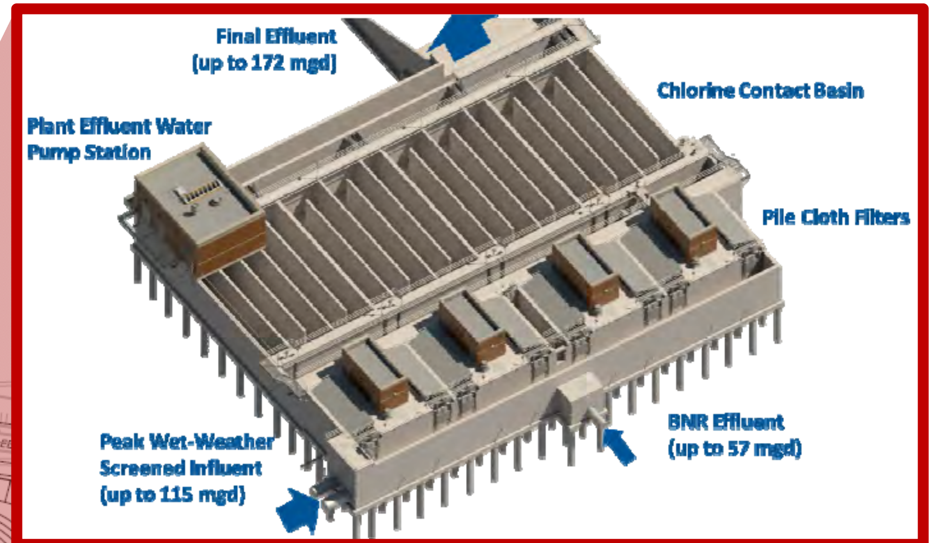


Comparison to other Alternatives– Compressible Media

Advantage	Disadvantage	Consideration
Low preliminary treatment needs	Medium footprint	Integral storage volume
No chemicals	Complex concrete construction	Peak backwash flow rate
Low O&M costs	High power demand factor from "batch" backwash	Proprietary media
No additional staff needed		Many electromechanical gate actuators
Excellent effluent quality		Good dual-use potential

Tomahawk Creek WWTF Expansion and Upgrade

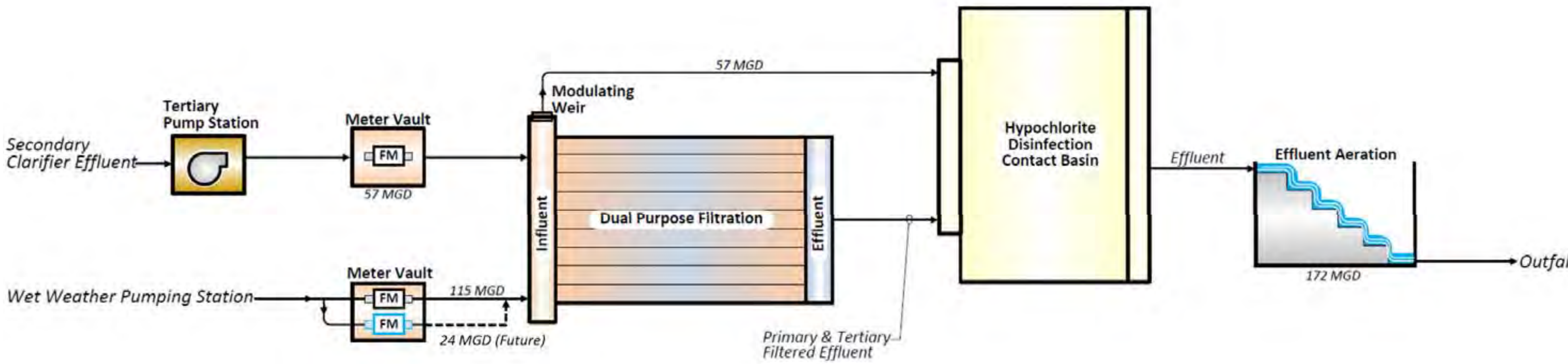




- 100% CMAR design complete
- On track for 2021 startup
- 5-stage Bardenpho with S2EBPR
- Secondary clarifiers with new B&V design
- Dual-purpose filters for tertiary and auxiliary treatment

JOHNSON COUNTY KANSAS
Wastewater

Tomahawk Creek Dual-Purpose Filtration Process



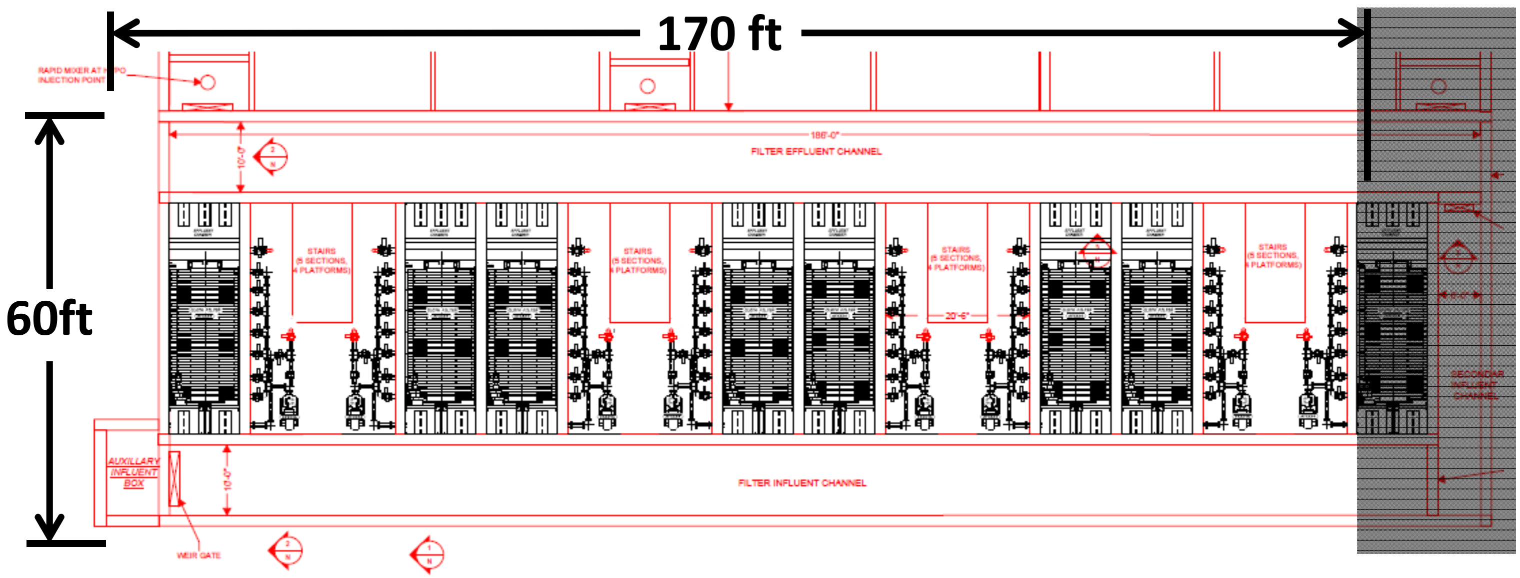
Parameter	Effluent Limit (*Goal)	Averaging Period
TSS	30 mg/L 45 mg/L	Monthly Weekly
BOD_5	15 – 20 mg/L 25 – 30 mg/L	Monthly Weekly
NH_3-N	0.6 – 2.3 mg/L 6.6 – 11.8 mg/L	Monthly Daily
TN	*10 mg/L	Annual
TP	*0.5 mgd/L	Annual

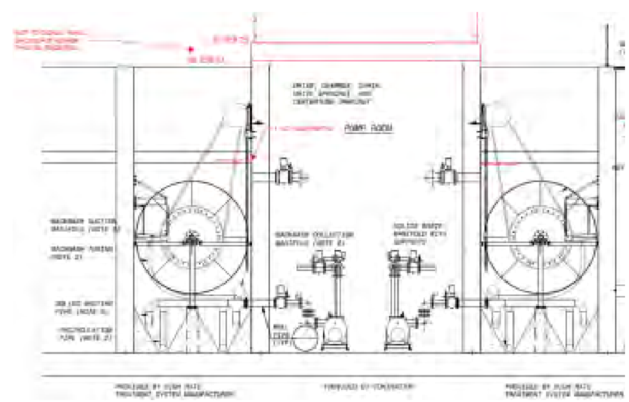
BNR + tertiary filtration up to 3Q = 57 mgd
Peak wet-weather EHRT up to 115 mgd
Peak WWTF capacity = 172 mgd

Conceptual Design Criteria – Pile Cloth Media

Item	Units	Value	Notes / Assumptions
Peak flow rate	mgd	100	
Hydraulic loading rate	gpm/ft^2	≤ 4	SLR ≤ 6 ppd/ft^2 (~130 mg TSS/L)
Cell filter area	ft^2	2,582	
Total number of cells	-	7	All units available
Waste solids content	%TS	0.1–0.4	Backwash ~1,500 mg TSS/L Sludge ~4,000 mg TSS/L
Peak waste flow rate	gpm	1,480	Assumes two units in backwash/sludge wasting at same time @ 740 gpm, 20 hp each.
	mgd	2.1	
Filter media	Polyester microfiber pile cloth, nominal 5-micron effective pore size, OptiFiber PES-14 or equal		

Conceptual Facility Layout – 100-mgd Pile Cloth Media



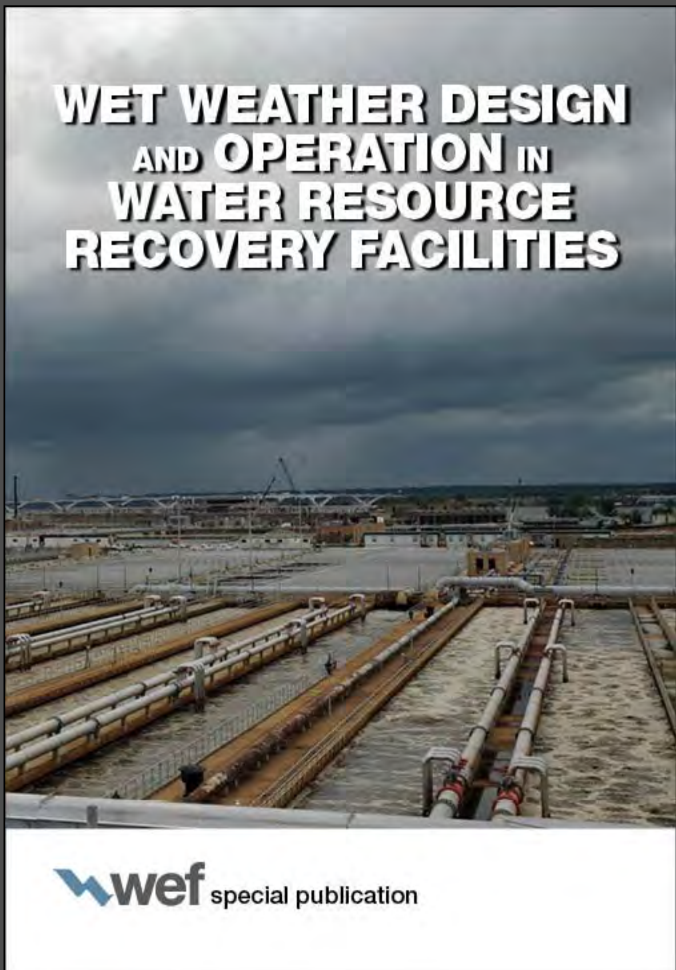


Comparison to other Alternatives– Pile cloth Media

Advantage	Disadvantage	Consideration
Small footprint	Medium preliminary treatment needs (wipes and similar debris)	Proprietary media
Simple concrete construction	No full-scale CSO installations without pre-settling. Rushville, Indiana startup Sept 2017.	Good dual-use potential
No chemicals		
Low O&M costs		
No additional staff needed		
Excellent effluent quality		


RTB-03
Rock Box
Alt 1 (215' x 405')
RTB-01
Alt 3 (125' x 175')
Alt 4 (60' x 175')
Alt 5 (65' x 320')
Scale 10.73" = 2945.88'

Why B&V for HRT?



B&V wrote Chapter 14: High-Rate Treatment

Why B&V for HRT?

- No preconceived answers
- Unmatched HRT experience
  - Plan, pilot, permit, design, commission, post-construction monitoring, optimization
  - All HRT technologies
- Solutions tailored for YOUR needs
  - Human infrastructure and operations
  - Gray infrastructure
  - Green infrastructure

PRACTICAL INNOVATION:
HRT EQUIVALENT TO PRIMARY EFFLUENT

Screening and High-Rate Chlorination

250-mgd Elliott West CSO Facility
Seattle, Washington

Conventional Primary Clarifiers

170--mgd Wet-Weather Expansion
Lemay WWTF, St. Louis, Missouri

Retention Treatment Basins

Belle Isle CSO Facility
Detroit, Michigan

- Vortex separators (swirl concentrators)

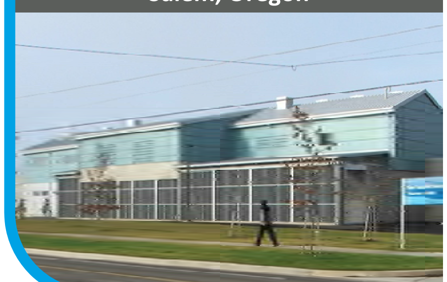
Not all situations require enhanced HRT technologies

PRACTICAL INNOVATION:
UNMATCHED EHRT EXPERTISE

Ballasted Flocculation

40-mgd WWTP Expansion
Lawrence, Kansas

50-mgd River Road Park WWTF
Salem, Oregon



Dense Sludge High-Rate Clarification

Side-by-Side HRC & UV Pilots
Toledo, Ohio

232-mgd WWTP Expansion
Toledo, Ohio

Compressible Media Filtration

Side-by-Side HRF Pilots
Johnson County, Kansas

100-mgd WWTP Expansion
Springfield, Ohio

Only firm with study, design, construction and post-construction services of all major EHRT options.

PRACTICAL INNOVATION:
DECENTRALIZED CSO & SSO FACILITIES

Belle Isle CSO Facility
Detroit, Michigan

250-mgd Elliott West CSO Facility
Seattle, Washington

50-mgd River Road Park WWTF
Salem, Oregon

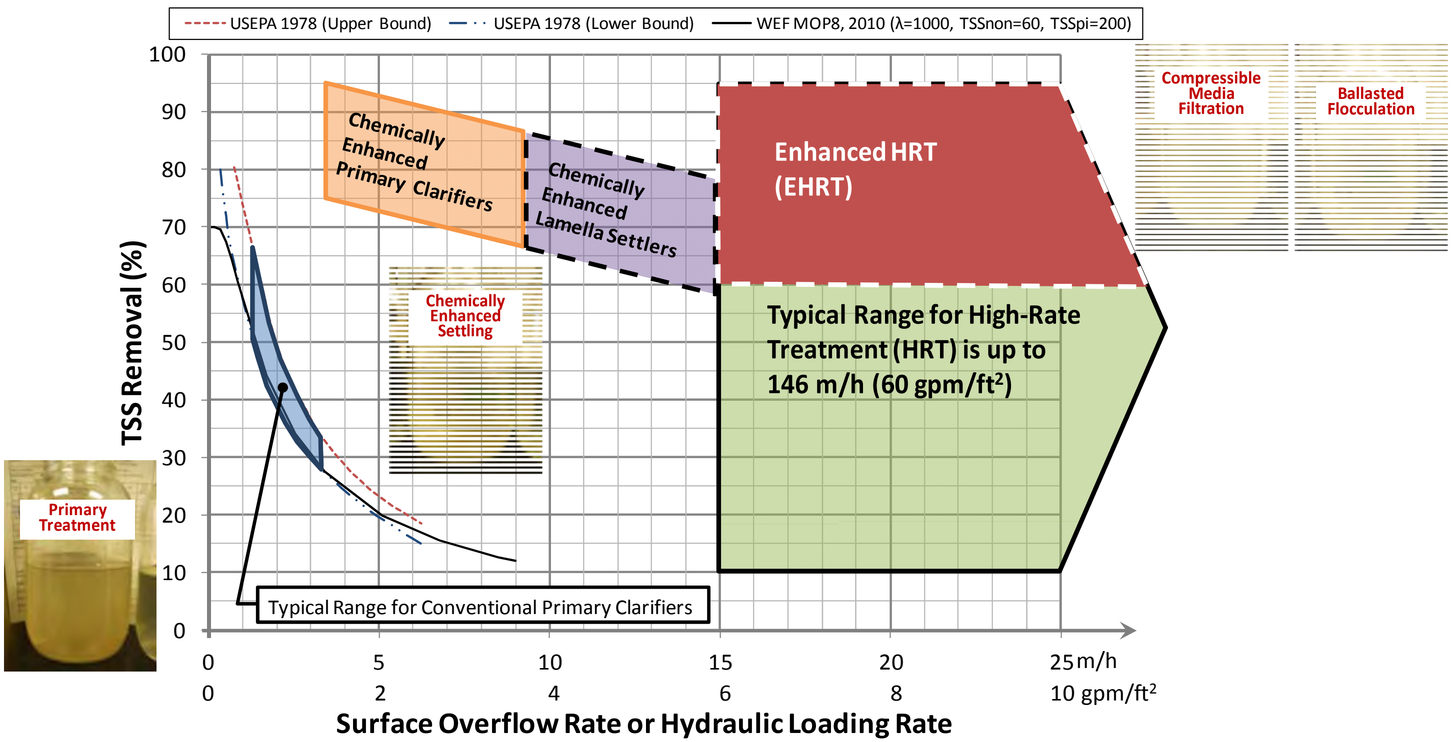
30-mgd SSO 700 Facility
Cincinnati, Ohio

Uptown Park CSO Facility
Columbus, Georgia

10-mgd Weracoba Creek BMP
Columbus, Georgia

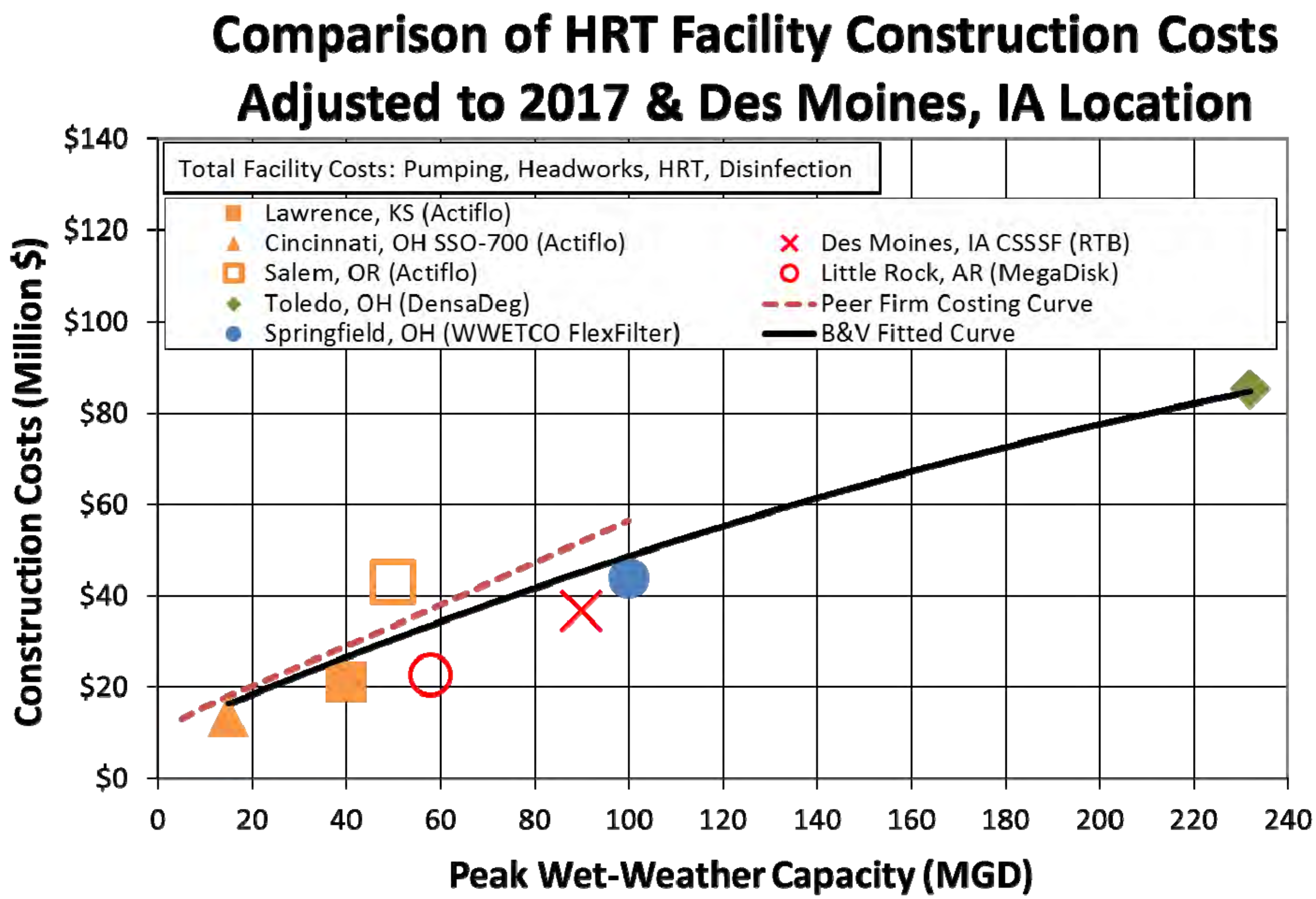
Cost-effective alternative to conveyance and/or storage expansion.

Typical EHRT Performance

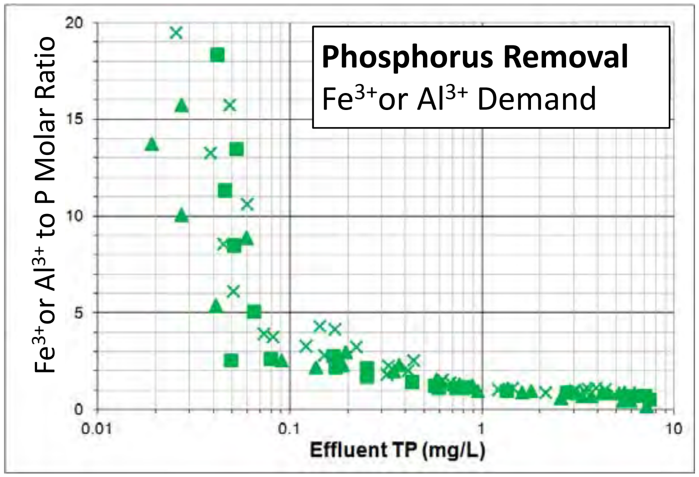


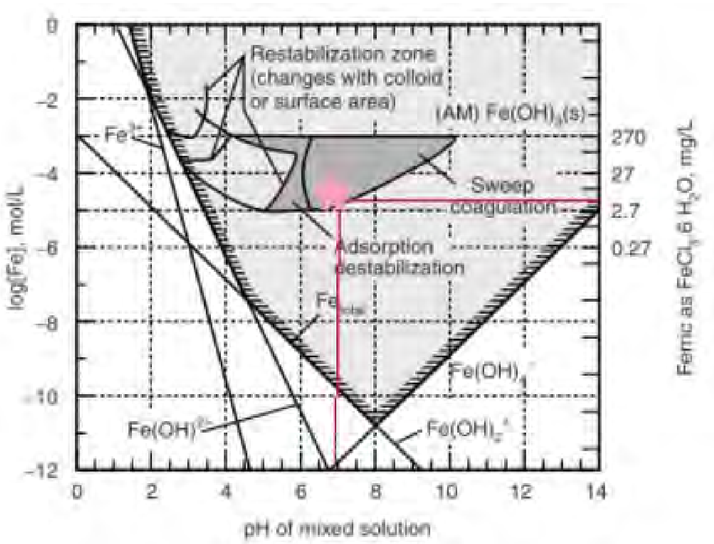
Source: WEF (2014) *Wet Weather Design and Operation in Water Resource Recovery Facilities*

Why EHRT?



- Better effluent quality for similar $/gpd as some HRT alternatives





Particle Conditioning

- Much higher ferric dose than PO_4 precipitation alone
- Ferric hydroxyl floc formation for PO_4 adsorption
- Coagulation / co-precipitation
  - pH/alkalinity also important
  - Rapid mixing criteria
- Flocculation
  - Flocculation mixing criteria
  - Polymer required for some
  - Sludge recirculation can help
  - Excess monovalent cations can hurt (road salt, etc.)

Jar tests to confirm chemical type, dose and mixing criteria