

CITY COUNCIL CONFERENCE
MUNICIPAL BUILDING CONFERENCE ROOM
201 WEST GRAY, NORMAN, OK

JANUARY 22, 2019

5:30 P.M.

- 1. PRESENTATION AND DISCUSSION REGARDING THE NON-POTABLE REUSE PILOT PROJECT.**

POTABLE WATER REUSE SYSTEM: EXAMINING CONSTITUENTS OF EMERGING CONCERN, ADVANCED TREATMENT, AND RECLAMATION OPTIONS



The
UNIVERSITY
of
OKLAHOMA

*Mewbourne College
of Earth and Energy*



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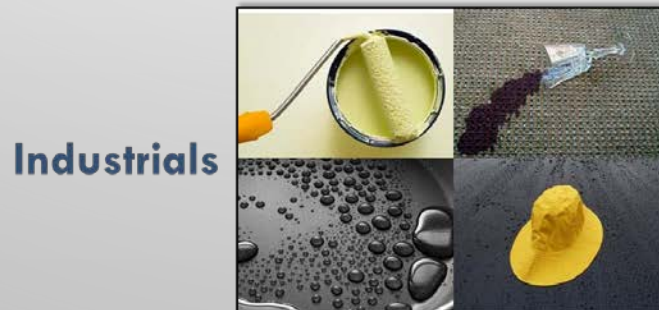
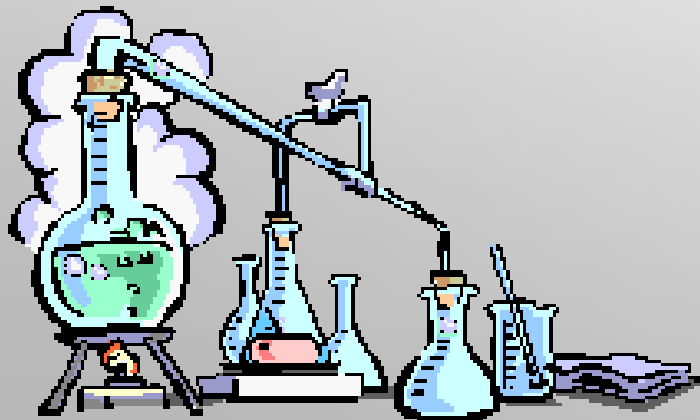
Constituents (Contaminants, Compounds) of Emerging Concern (CEC)

CEC are chemical solutes potentially found in waters at trace levels, ng/L, that may have an impact on aquatic and animal life (US EPA 2015)

- Over 84,000 chemicals in use today as inventoried by US EPA under the Toxic Substances Control Act (TSCA)
- Approximately 700 new chemicals added each year to the US EPA inventory



Pharmaceuticals and Personal Care Products (PPCPs)

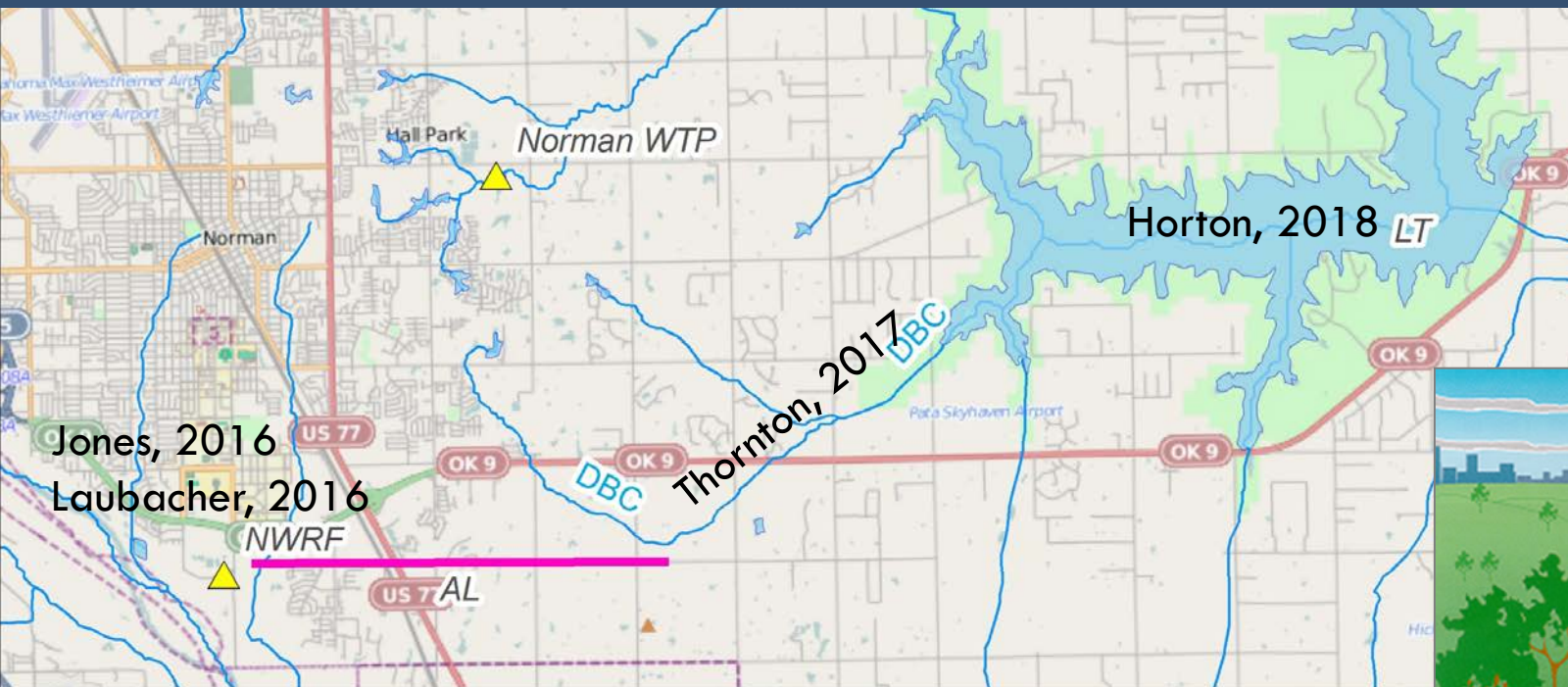


Industrials

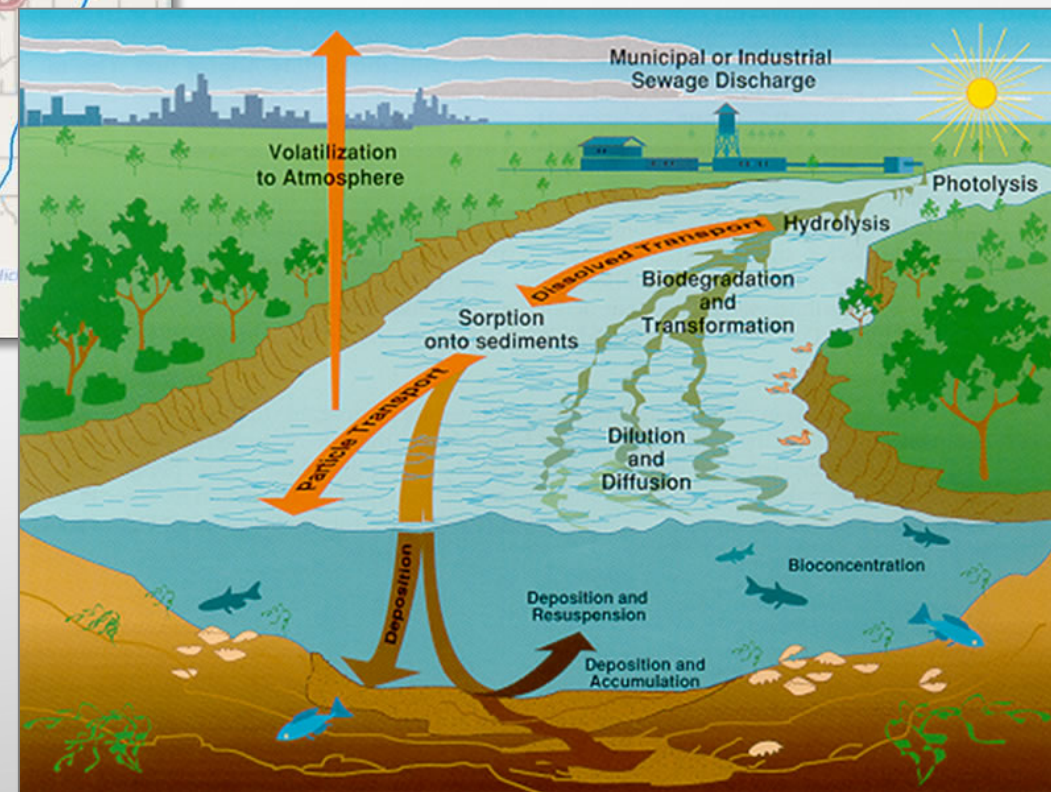


Other

H₂O Augmentation Plan: Indirect Potable Reuse of Reclaimed Water



WTP = (drinking) Water Treatment Plant
NWRP = Norman Water Reclamation Facility
AL = Augmentation Line
DBC = Dave Blue Creek
LT = Lake Thunderbird



Horton, A.D., 2018, Baseline concentrations of contaminants of emerging concern in Lake Thunderbird watershed, planning for indirect potable reuse in Oklahoma: Norman, OK, University of Oklahoma, 108 p.

Jones, S.M., 2016, Nanofiltration rejection of contaminants of emerging concern from municipal water resource recovery facility secondary effluents for potable reuse applications: Fayetteville, AR, University of Arkansas, 196 p.

Laubacher, J., 2016, Modeling and analysis of constituents of emerging concern through wastewater treatment processes: Norman, OK, University of Oklahoma, 181 p.

Thornton, E.K., 2017, Microcosm assessment of the natural processes affecting chemical concentrations of emerging concern in secondary effluent: Norman, OK, University of Oklahoma, 87 p.

Pharmaceutical and Personal Care Products (PPCPs) in Water Sources



18 compounds Analyte	NWRF				DBC											Lake Thunderbird												
	Jul-14	Jan-16	Sep-16	Sep-16	Summer Jun 2016						Fall Oct 2016					Winter Jan 2017						Spring Apr 2017						
	J-EFF	L-EFF	T-EFF	T-DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC
		0 days	15 days	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11	
Acetaminophen	<5	<500	34	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Albuterol	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Amoxicillin	4600	18000	180	<20	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80
Atenolol	300	90	340	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Azithromycin	<20	200	<10	<10	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Bezafibrate	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Butalbital	54	11	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbadox	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbamazepine	400	110	110	68	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carisoprodol	130	ND	13	50	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloramphenicol	<10	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Cimetidine	<5	ND	690	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Clofibric Acid	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	5.5	7.5	42	8.9	35	23	21	53	19	19	27	<5	<5	190	<5	50	170	
Dehydronifedipine	82	ND	5.8	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Diazepam	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Diclofenac	93	ND	66	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dilantin	130	ND	49	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Diltiazem	NA	24	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Detections:	8	6	9	2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1
% Detections:	44%	33%	50%	11%	0%	0%	0%	0%	0%	0%	0%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	0%	0%	6%	0%	6%	6%

J-EFF = Secondary Effluent (Jones, 2016)
L-EFF = Secondary Effluent (Laubacher, 2016)

T-EFF = Secondary Effluent (Thornton, 2017)
T-DBC = Secondary Effluent after 15 Day Microcosm (Thornton, 2017)

Pharmaceutical and Personal Care Products (PPCPs) in Water Sources



18 compounds	Jul-14	Jan-16	Sep-16	Sep-16	Summer Jun 2016						Fall Oct 2016						Winter Jan 2017						Spring Apr 2017						
Analyte	J-EFF	L-EFF	T-EFF	T-DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	
			0 days	15 days	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11	
Erythromycin	220	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Flumequine	<10	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoxetine (Prozac)	90	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Gemfibrozil	550	1400	39	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	6.2	<5	<5
Ibuprofen	<10	ND	520	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	36	<10	<10	<10	<10	<10	<10	<10	<10
Iohexol (x-ray contrast agent)	<10	37000	1100	220	<10	<10	220	<10	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Iopromide	270	16	5.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ketoprofen	150	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ketorolac	<5	ND	36	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lidocaine	370	290	1000	43	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lincomycin	15	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	30	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Lopressor (Metoprolol)	1200	1200	100	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Meclofenamic Acid	<5	ND	67	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	7.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Meprobamate	460	45	190	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Metformin	NA	NA	NA	NA	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Naproxen	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Nifedipine	34	ND	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Oxolinic acid	<10	ND	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Detections:	10	6	9	2	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
% Detections:	56%	33%	50%	11%	0%	0%	6%	0%	0%	6%	0%	6%	0%	0%	0%	0%	0%	0%	6%	0%	6%	0%	0%	0%	0%	6%	0%	0%	

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Pharmaceutical and Personal Care Products (PPCPs) in Water Sources



17 compounds	Jul-14	Jan-16	Sep-16	Sep-16	Summer Jun 2016						Fall Oct 2016						Winter Jan 2017						Spring Apr 2017					
Analyte	J-EFF	L-EFF	T-EFF	T-DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC	DAM	INT	LR	CC	HC	DBC
			0 days	15 days	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11	1	4	6	7	8	11
Pentoxifylline	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Phenazone	5.6	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Primidone	170	94	75	<5	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Salicylic Acid	NA	<100	580	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	790	<100	490	650	<100	330	240	<100	230	280
Sulfachloropyridazine	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfadiazine	<5	ND	<5	<5	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Sulfadimethoxine	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfamerazine	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfamethazine	12	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfamethizole	<5	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfamethoxazole	1300	1000	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sulfathiazole	33	ND	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Theophylline	<20	<200	<20	30	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Triclocarban	NA	NA	<5	<5	<10	<10	<10	<10	<10	<10	<10	<10	5.1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Triclosan	43	<10	22	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Trimethoprim	1000	440	440	<5	<5	<5	<5	<5	<5	<5	<5	<5	9.9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Warfarin	<5	ND	5.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Detections:	7	3	5	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	1
% Detections:	41%	18%	29%	6%	0%	0%	0%	0%	0%	0%	0%	0%	6%	6%	0%	0%	0%	0%	6%	0%	6%	6%	0%	6%	6%	0%	6%	6%

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Concentrations detected in Lake Thunderbird were higher for 14 out of 17 benchmark compounds when compared to concentrations observed by Thornton (2017) after 15-day microcosm studies with Dave Blue Creek sediment and Photosynthetically Active Radiation (PAR). Red italicized text indicates that Lake Thunderbird concentration is higher (dirtier) than naturally attenuated effluent.

Class	Benchmark Compound	NWRF Effluent Maximum Conc (ng/L)	Dave Blue Creek SED+PAR 15 Day Microcosm Conc (ng/L)	Lake Thunderbird Maximum Conc, *Split Sample Conc (ng/L)	Standard (ng/L)	Half-Life
Pesticides	2,4-D	62	<5	200	70,000	10 days
	Atrazine	16	<5	29	3000	60 days
	Simazine	300	<5	1100	4000	145 days
Industrials	BPA	<10	<10	120	20,000	NA
	NP	510	1200	500	20,000	10-15 hrs
	OP	350	<50	410	100,000	6.9 hrs
	TCPP	560	<100	290	NA	NA
PPCPs	Clofibric Acid	<5	<5	190	NA	2 days
	Iopromide	270	<5	4.5*	NA	3.1 days
	Salicylic Acid	580	<100	790	NA	NA
Hormones	Testosterone	11	<5	5.8	NA	NA
	Progesterone	<5	<5	<5	NA	NA
Other	Acesulfame-K	4100	160	97	NA	7-9 days
	Caffeine	60	7	30	NA	NA
	Cotinine	57	<10	24	NA	NA
	DEET	<100	16	78	200,000	5-15 days
	Propylparaben	24	<5	65*	NA	9.6-32.5 hrs

Summary: CEC & Wastewater Reuse in a Regional Water Supply System

- Some CEC are present (ubiquitous) in all waters of the United States
 - Percentage of detections in Lake Thunderbird by class: pesticides (31.4%), industrials (9.0%), PPCPs (2.3%), hormones (2.6%), and others (18.9%)
 - Lake Thunderbird CEC concentrations versus 11 health standards = zero exceedances
- Typical water reclamation facility with primary and **secondary treatment** will **reduce concentrations and remove a very high percentage of CEC**
- **Potable reuse of municipal wastewater is feasible and safe with or without advanced treatment or ultra-filtration**
- Advanced treatment at the NWRf can remove 100% of the compounds if necessary

CITY OF NORMAN

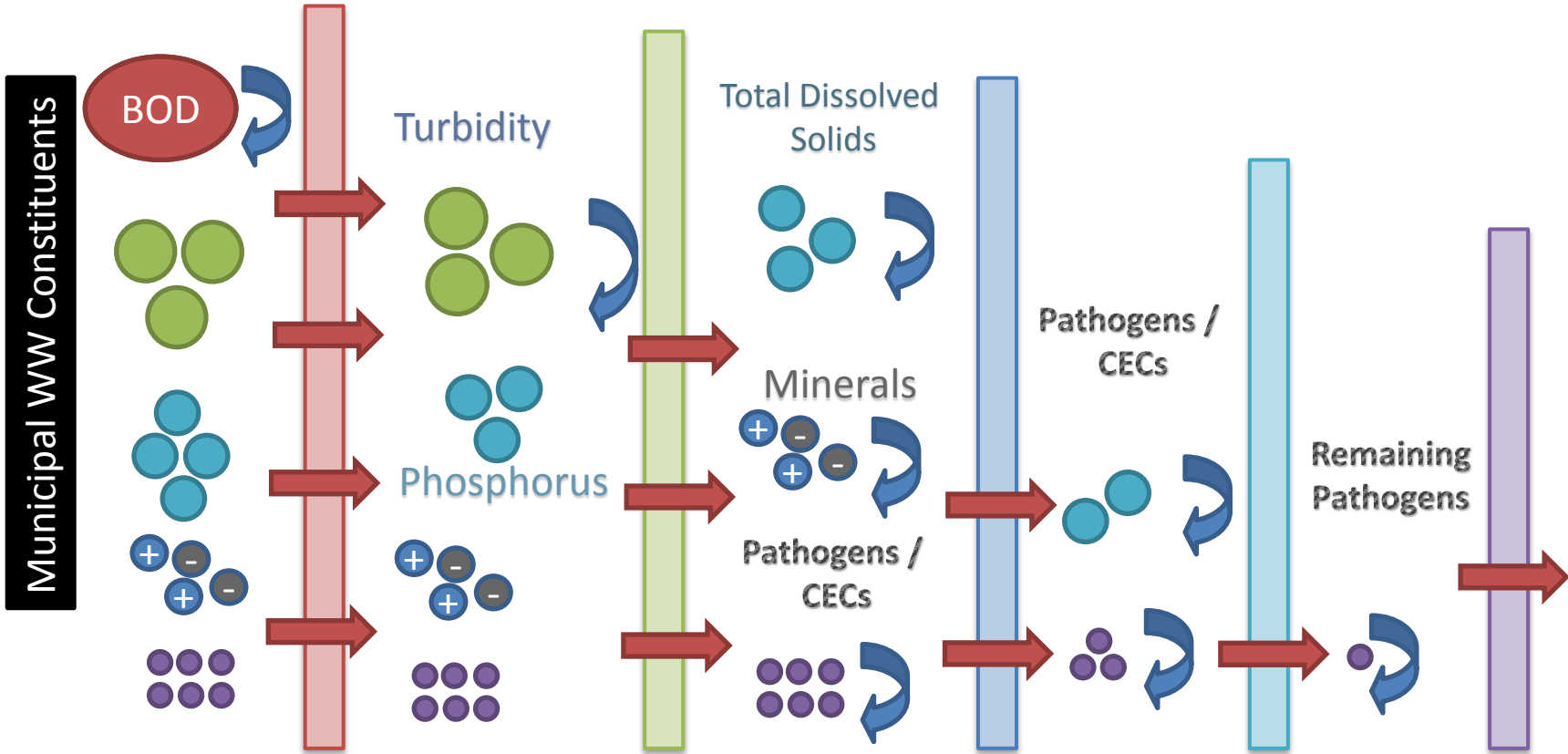
PROPOSED PILOT PROJECT DISCUSSION

SEPTEMBER 25, 2018

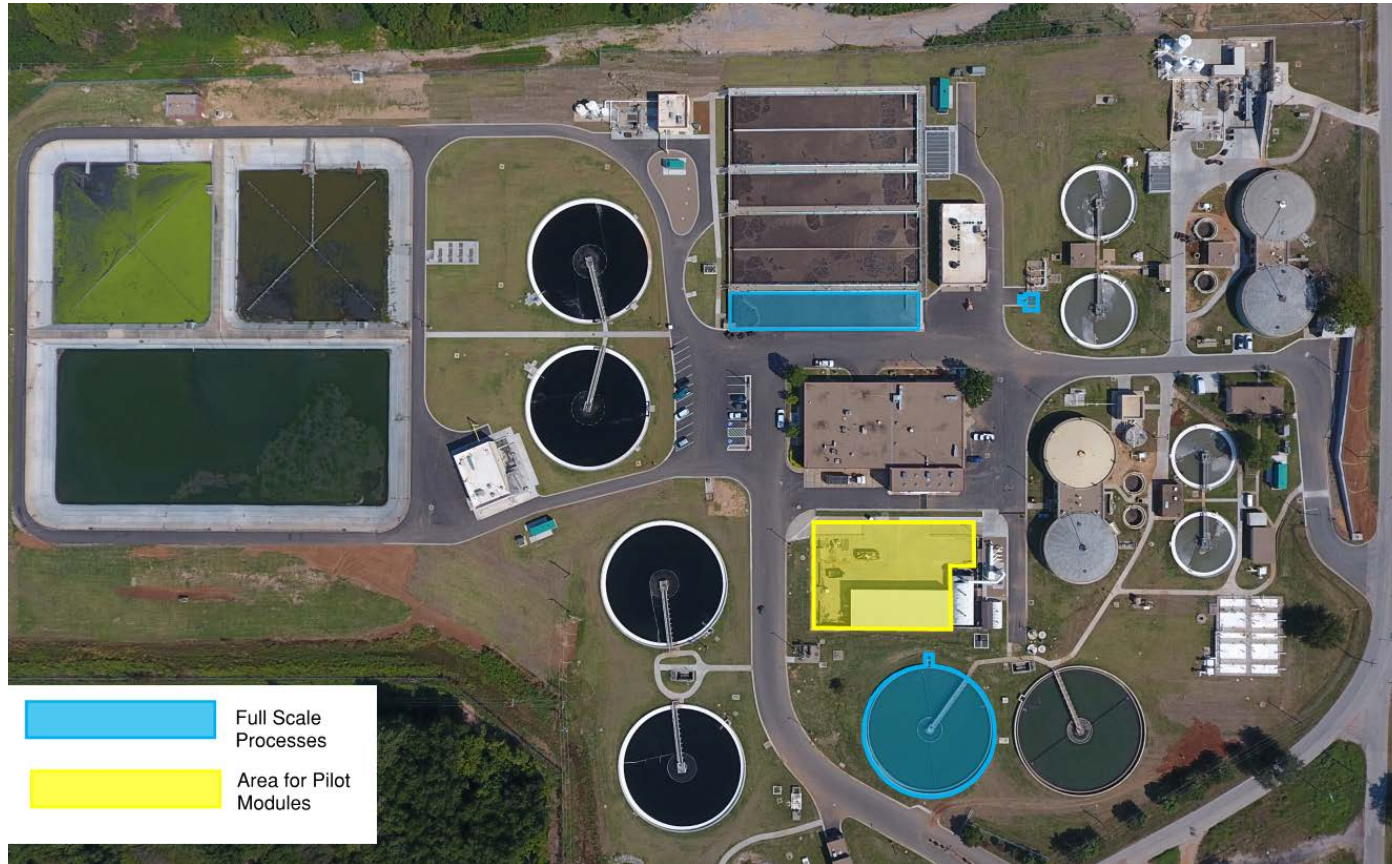
A pilot project is a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, and effect to predict an appropriate capacity and improve upon the study design prior to performance of a full-scale project.



Pilot Project provides a roadmap for addressing IPR constituents



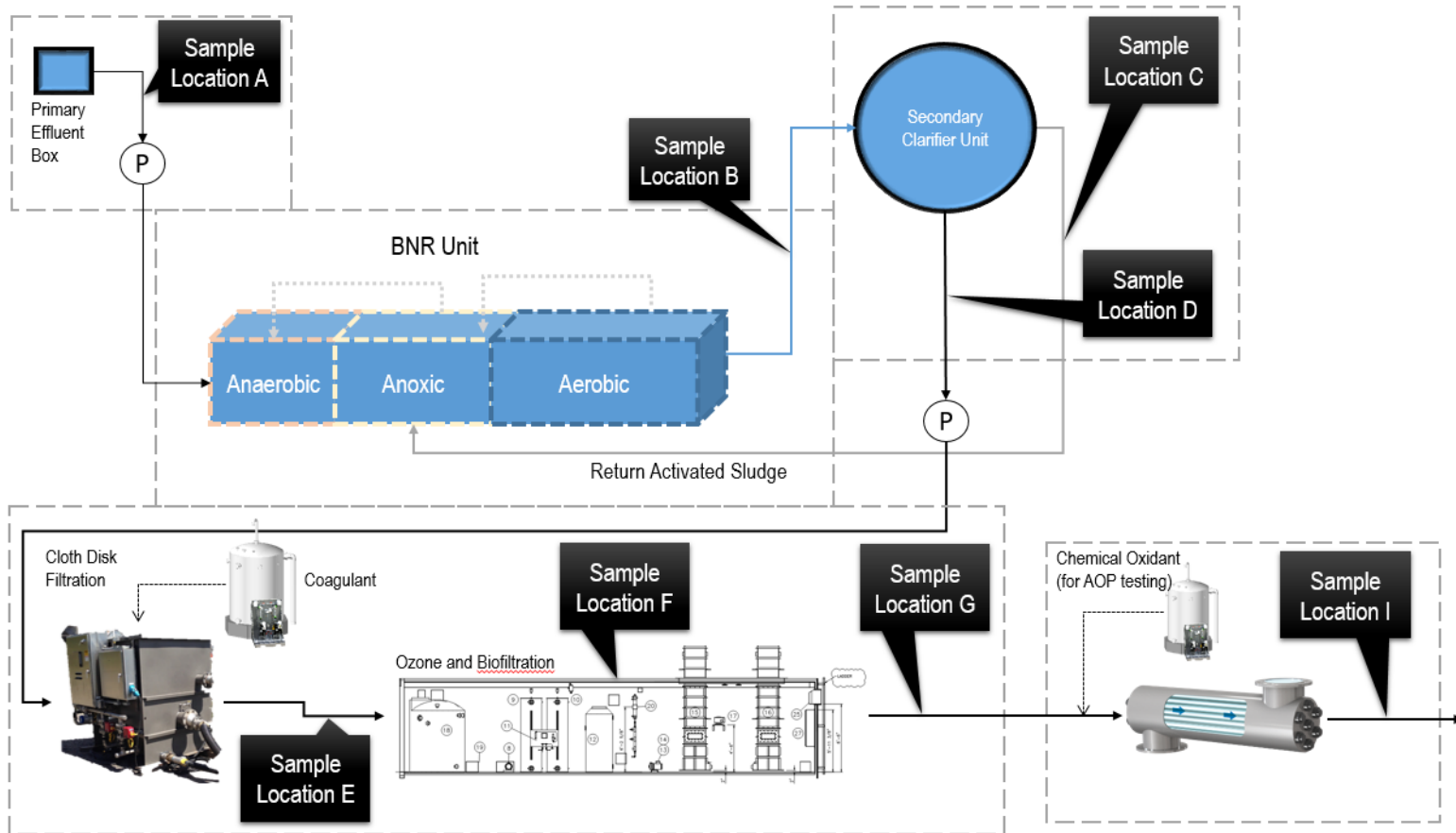
Pilot treatment processes will be a mix of full-scale facilities and pilot scale modules



Pilot modules will utilize available high quality work area



Profiling individual performance requires comprehensive sampling before and after each process



Piloting approach includes multiple technologies to optimize full-scale configuration



Phased Implementation

Plug-and-Play Configuration

Integration with WRF

Hands-on Experience for WRF Staff



- 
- Norman has the budget in place to pay for the pilot project without a change in water or sewer rates
 - In addition to review by DEQ, OWRB, OU, Peer reviews, a review committee of members from Norman, Midwest City and Del City is anticipated
 - A review committee can track progress, check milestones and communicate to communities
- 



IPR has the potential to:

Improve Lake Thunderbird impaired water quality

Supply drought proof source water

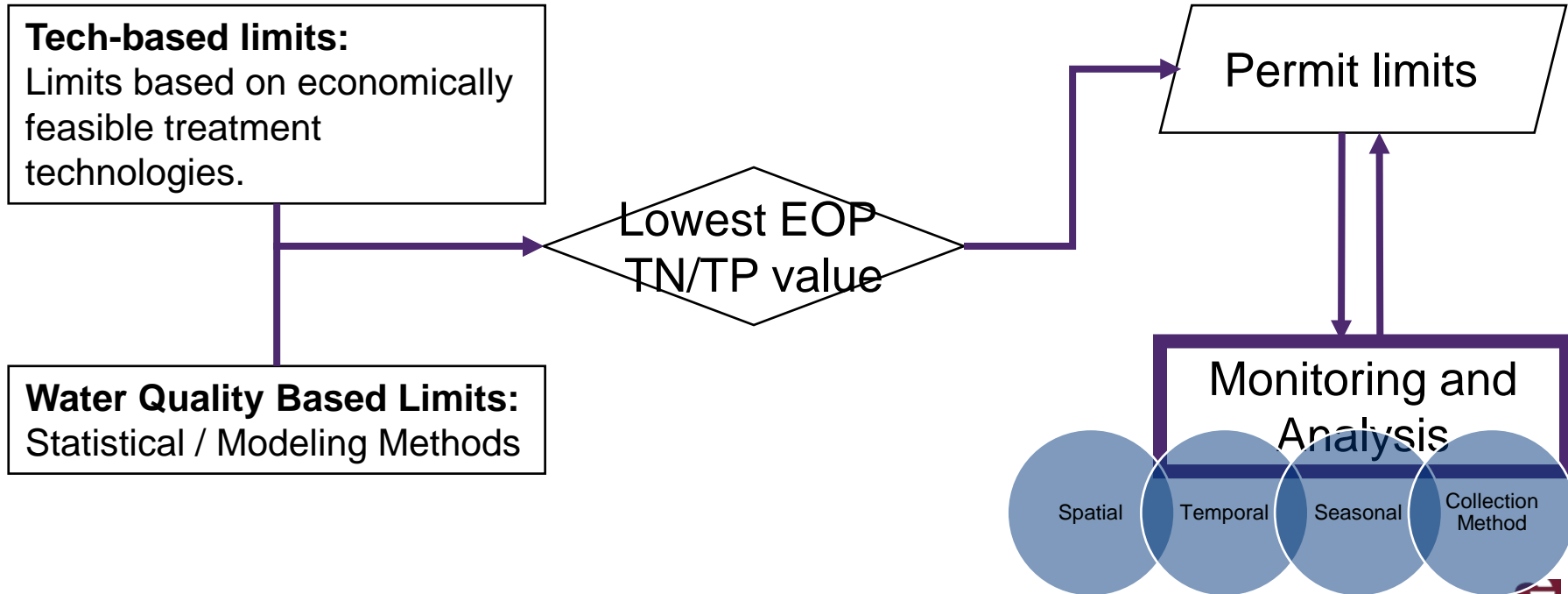
Be used only when needed

Provide valuable lake quality data



Potential IPR permit would be first of it's kind as a living permit

Example: Development and Monitoring Nutrients

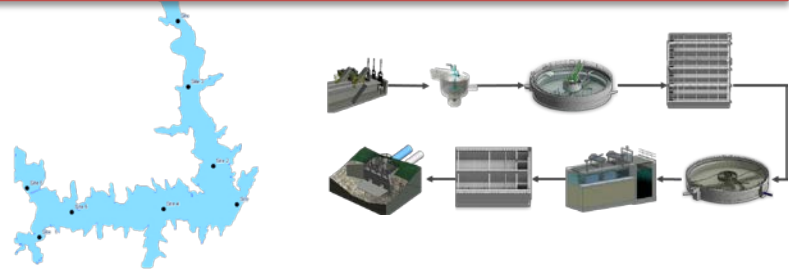


Roadmap for water reuse approval and acceptance

Current Impairments



Baseline Conditions



Additional Constituents

Drinking Water Standard Quality				
Element / Substance	Symbol	WHO Guideline	EPA Guideline	
			Primary	Secondary
Aluminium	Al	0.3 mg/l		0.05 - 0.2 mg/l
Ammonia	NH4	No Guideline		
Antimony	Sb	0.005 mg/l		0.006 mg/l
Arsenic	As	0.01 mg/l		0.010 mg/l
Barium	Ba	0.3 mg/l		2 mg/l
Beryllium	Be	No Guideline		0.004 mg/l
Bromine	Br	0.3 mg/l		
Cadmium	Cd	0.003 mg/l		0.005 mg/l
Chloride	Cl-	250 mg/l		250 mg/l
Chromium	Cr ³⁺ , Cr ⁶⁺	0.05 mg/l		0.1 mg/l
Copper	Cu	2 mg/l		1.3 mg/l
Cyanide	CN-	0.07 mg/l		0.2 mg/l
Fluoride	F	1.5 mg/l		2.0 mg/l
Iodine	I	No Guideline		0.3 mg/l
Lead	Pb	0.01 mg/l		0.015 mg/l
Manganese	Mn	0.5 mg/l		0.05 mg/l
Mercury	Hg	0.001 mg/l		0.002 mg/l
Molybdenum	Mo	0.07 mg/l		
Nickel	Ni	0.02 mg/l		
Selenium	Se	0.01 mg/l		0.05 mg/l
Silver	Ag	No Guideline		
Sodium	Na	200 mg/l		
Tin	Sn	No Guideline		
Vanadium	V	1.4 mg/l		
Zinc	Zn	3 mg/l		
Nitrate - Nitrite	NO ₃ , NO ₂	50 mg / Total N		10 - 1 mg / l
Sulfate	SO ₄	400 mg / l		

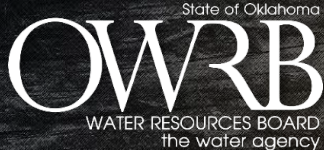


Performance Demonstration



Diverse interest in Lake Thunderbird reuse

REGULATORY



GOVERNMENT



RESEARCH

NATIONAL SCIENCE FOUNDATION INDUSTRY / UNIVERSITY COOPERATIVE



OKLAHOMA-BASED RESEARCH ORGANIZATIONS

NATIONAL RESEARCH ORGANIZATIONS

