

Wastewater in Tribal Communities

Challenges and Opportunities: A Discussion on Disparities and Possibilities for
Improving Access to Quality Wastewater Services

HHS OCS World Water Week

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Background

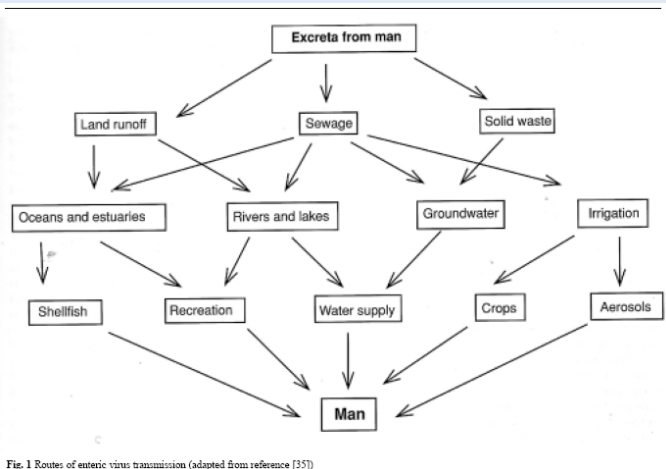
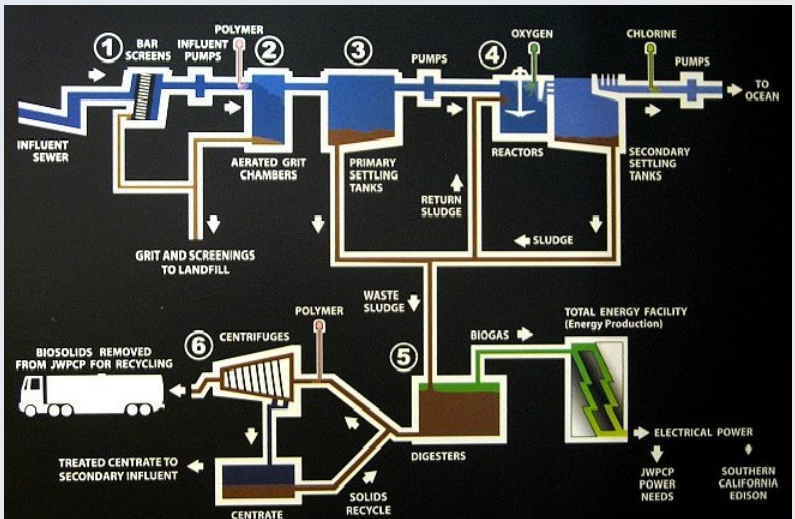


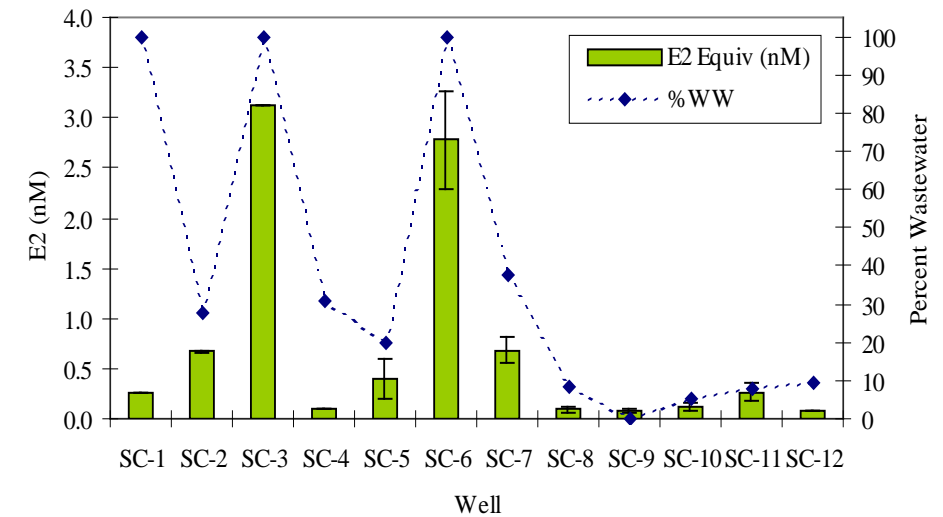
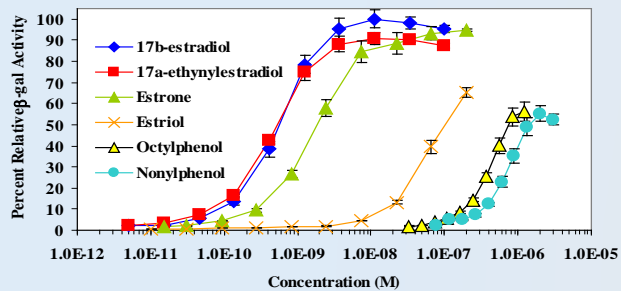
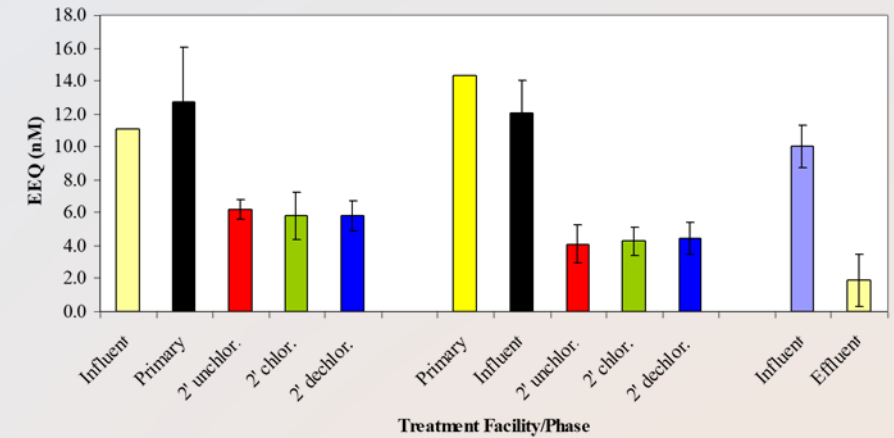
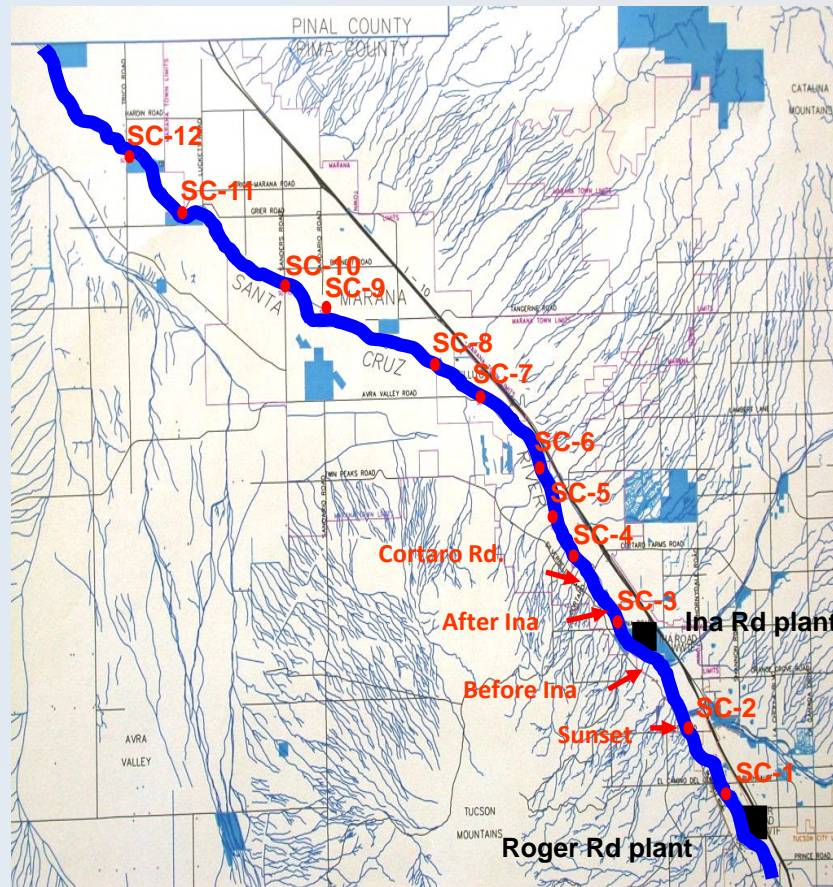
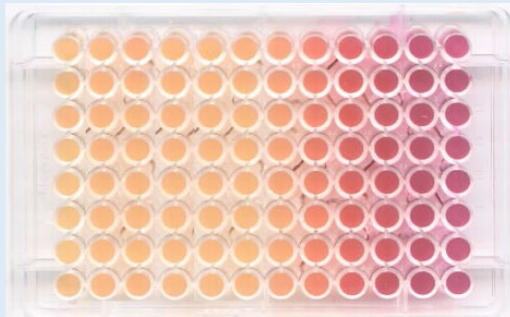
Fig. 1 Routes of enteric virus transmission (adapted from reference [35])



Previous Work – Endocrine Disruption

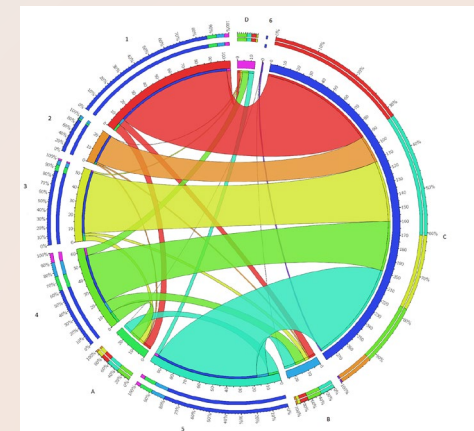
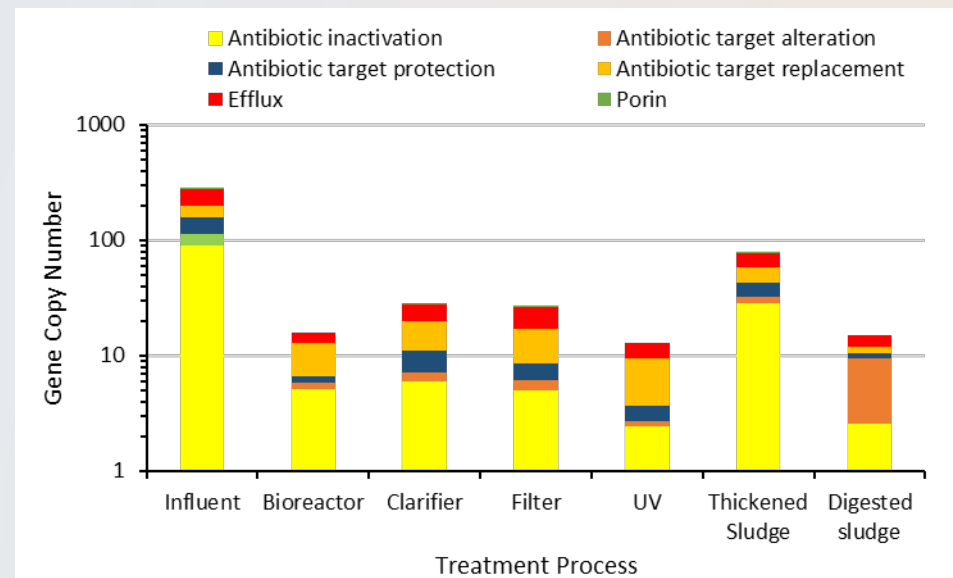
“A vast array of pharmaceuticals including antibiotics, anti-convulsants, mood stabilizers and sex hormones have been found in the drinking water supplies of at least 41 million Americans...”

-Associated Press, March 9, 2008



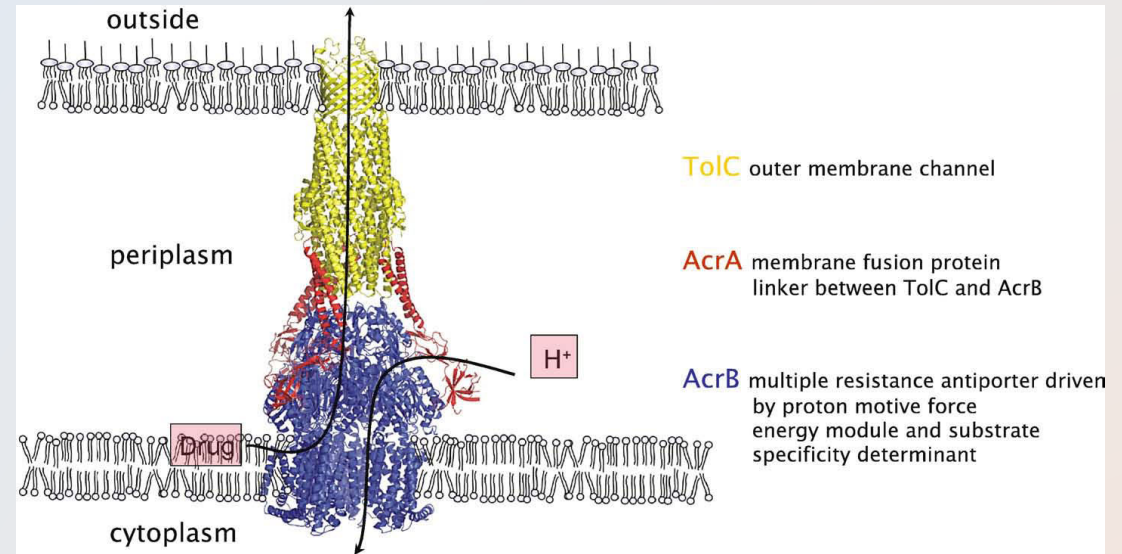
Comparing Prevalence of Antibiotic Resistance Genes Across Various Stages of Conventional Wastewater Treatment

- Does tertiary treated wastewater harbor ARGs?
- Metagenomics reveals ARGs in final effluent
 - No evidence of cultural bacteria
- What are implications for groundwater recharge, irrigation, biosolids application?



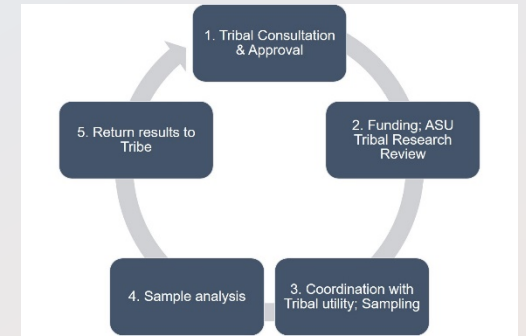
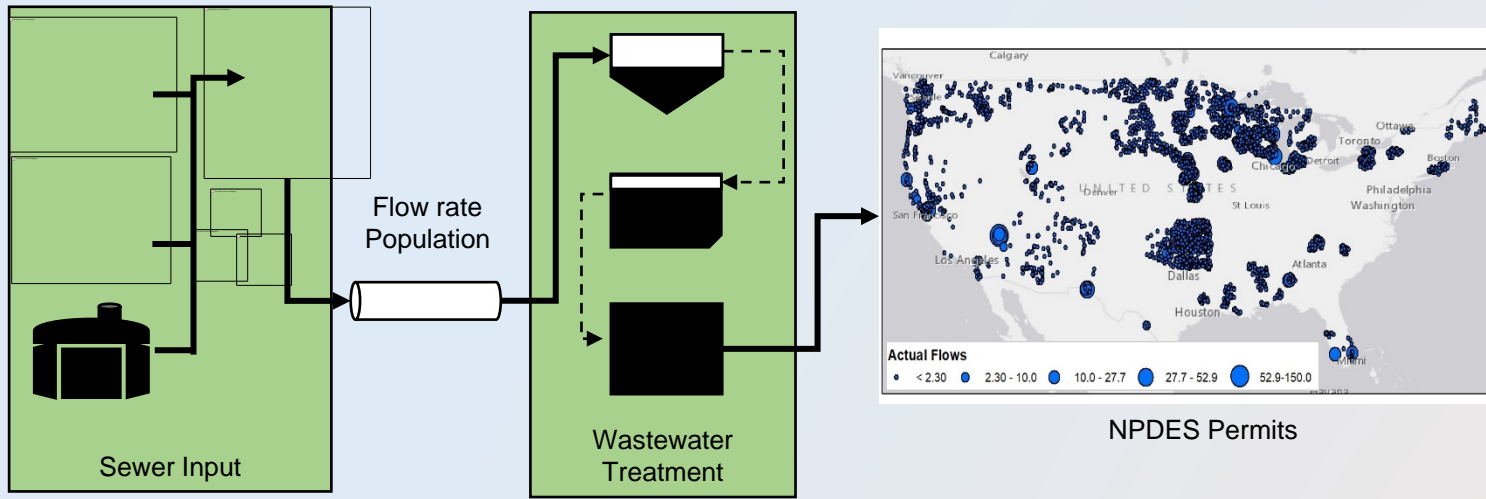
Multi-drug Resistance & Cycling of Emerging Contaminants

Efflux pumps are the proteins involved in **intrinsic and elevated** antibiotic resistance



Bacterium	Efflux Pump	Substrates
Escherichia coli	AcrAB-TolC	Dyes, detergents, antibiotics, bile salts
*** Select pumps shown		Solvents, BPA, hormones
	AcrD	AG, detergents, hormones, BPA
	AcrEF-TolC	Dyes, detergents, hormones, BPA
	CusCFBA	Ag ⁺ , Cu ⁺
	YegNO	Antibiotics (FQ, AG), detergents
Pseudomonas aeruginosa	MexAB-OprM	Antibiotics (lac, Mac, FQ, Cam, BPA)
*** Select pumps shown	MexCD-OprJ	Antibiotics (lac, Mac, FQ, Cam, Tet)
	MexJK-OprM	Antibiotics (Mac, FQ, Cam, Tet, Tri)
	MexXY-OprM	Antibiotics (lac, Mac, FQ, Cam)
	MuxABC-OpmB	Antibiotics (Mac, NVB, Tet)

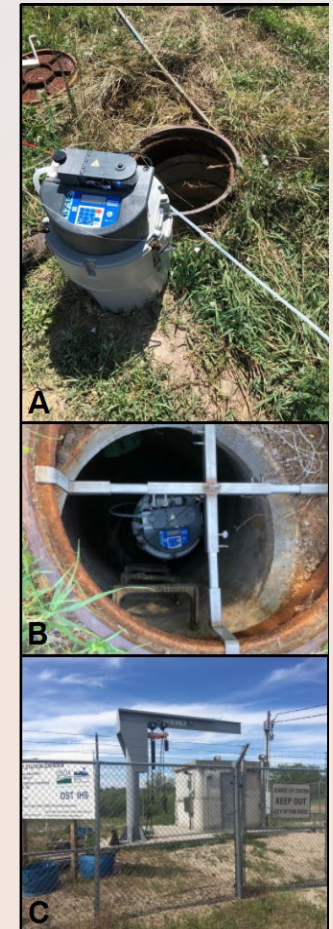
Wastewater-Based Epidemiology in Tribal Communities



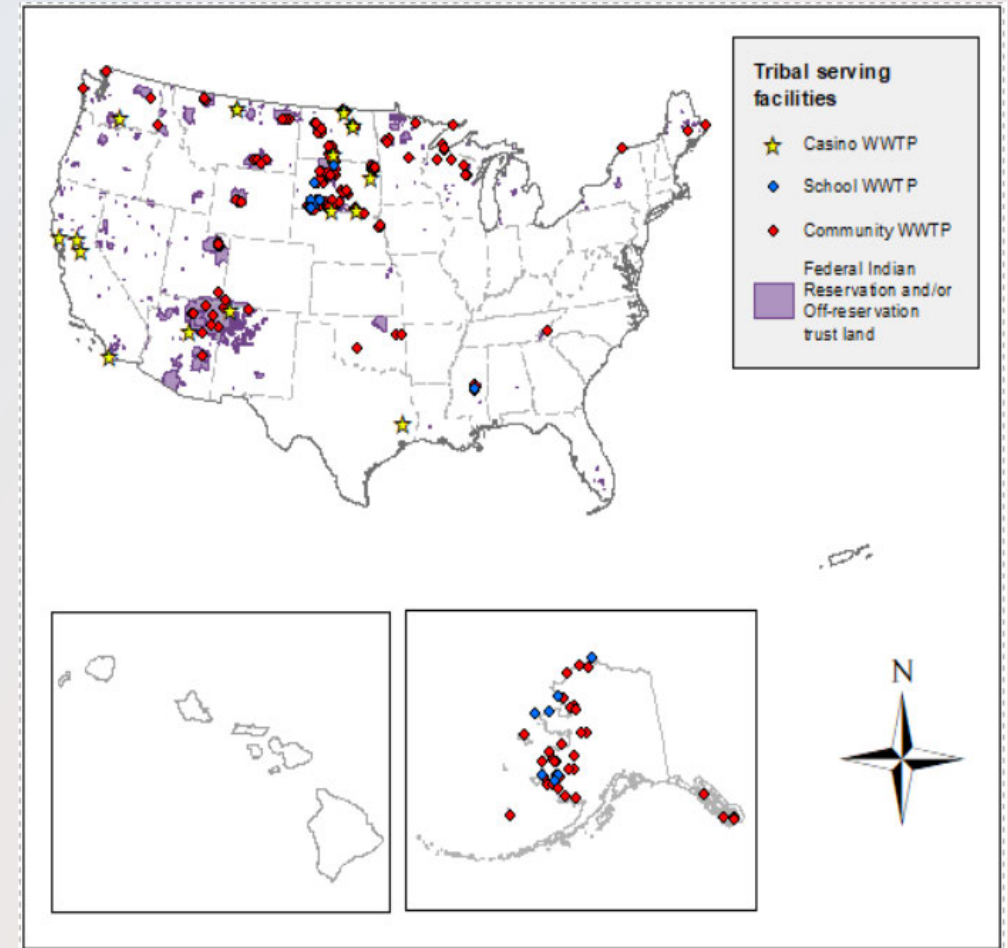
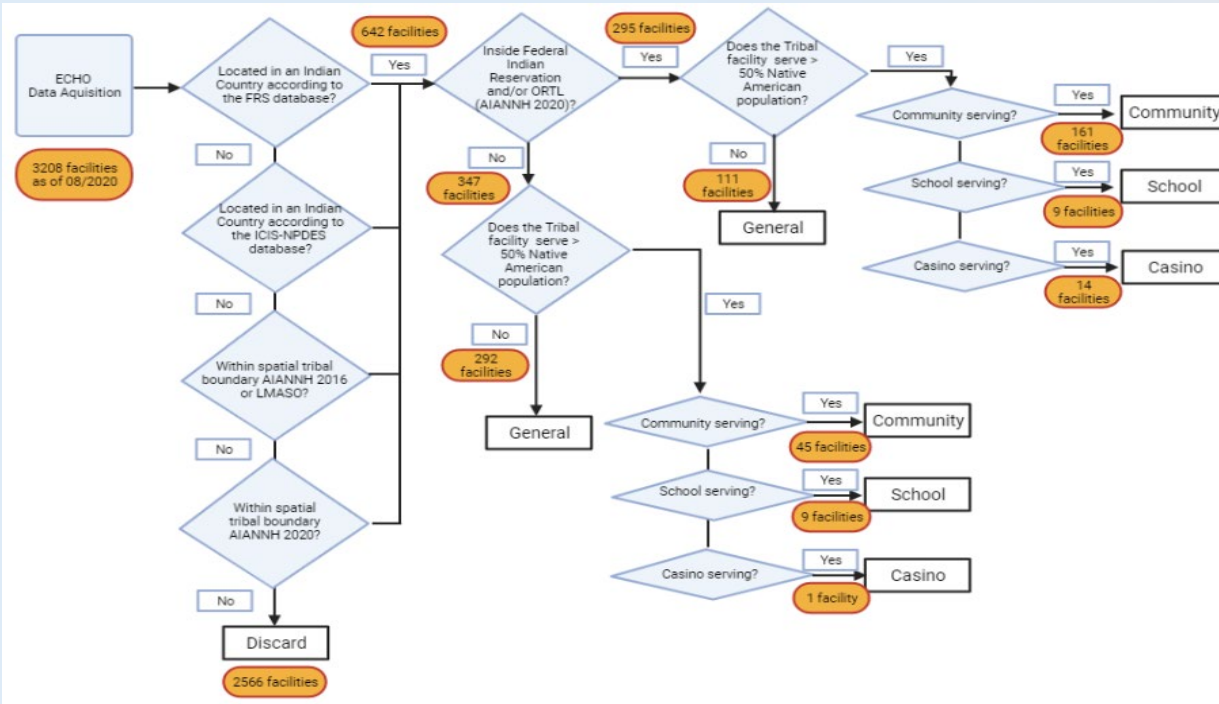
WBE Fast Facts:

- Excreted waste contains health indicators to measure:
 - Substance abuse, contaminant exposure, infectious disease
- ~100 Tribes have centralized sewer treatment in the U.S.
- Samples can be collected from sewer lines, lift stations, and treatment facilities

Advantages	Disadvantages
<ul style="list-style-type: none"> • Rapidly assess community health • Anonymized, non-invasive sampling 	<ul style="list-style-type: none"> • Sewage contains human pathogens, use caution • Population estimates are unknown • Low sewer flow rates



Wastewater In Tribal Communities



Classification		Outside Federal Indian Reservation and/or ORTL	Inside Federal Indian Reservation and/or ORTL	Sub total	Total
Not-Tribal serving	General	292	111		403
	Community	45	161	206	
Tribal serving	School	9	9	18	239
	Casino	1	14	15	
Total		347	295		642

Mapping wastewater lagoons in tribe communities in the US

Product 1: Sentinel 1– SAR (Sentinel-1 mission provides data from a dual-polarization C-band Synthetic Aperture Radar (SAR) instrument)

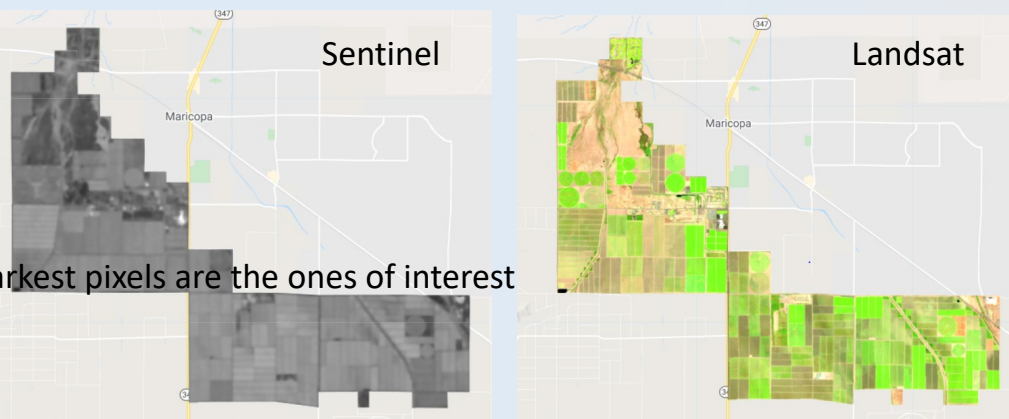
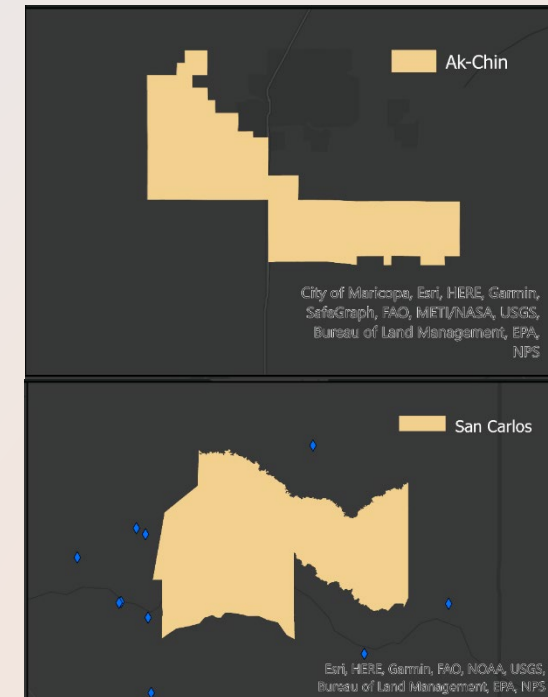
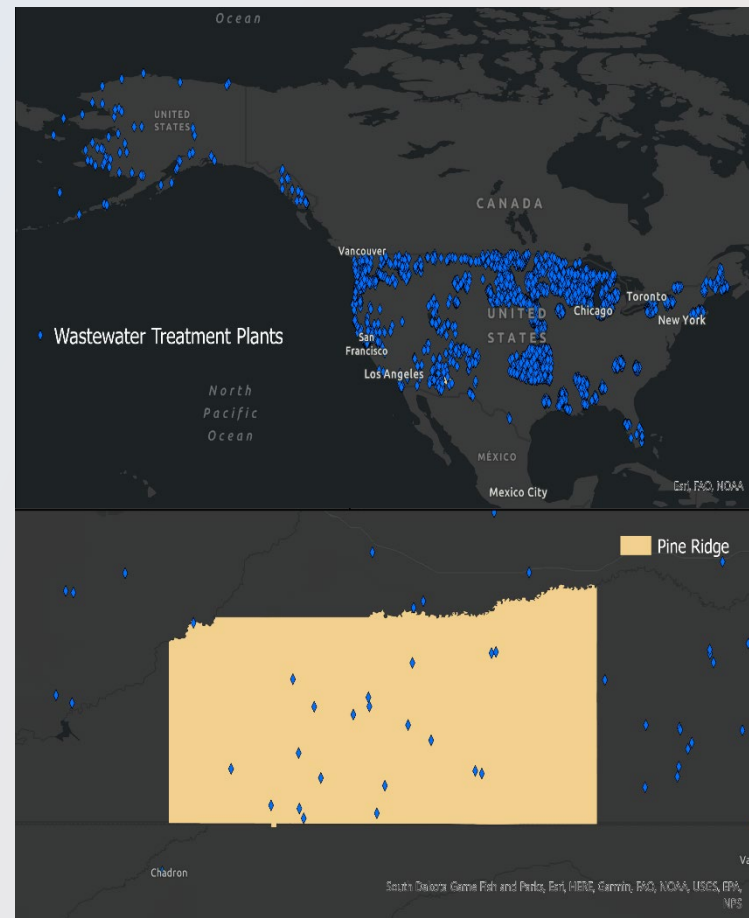
- **Band:** VV - single co-polarization, vertical transmit/vertical receive
- **Spatial resolution:** 10 meters
- **Image collection:** 2020-01-01 to 2020-31-12*

*Tried only drier periods – improved results; Also tried entire image collection and selected 2020 to decrease noise

Product 2: USGS Landsat 8 Surface Reflectance Tier 1

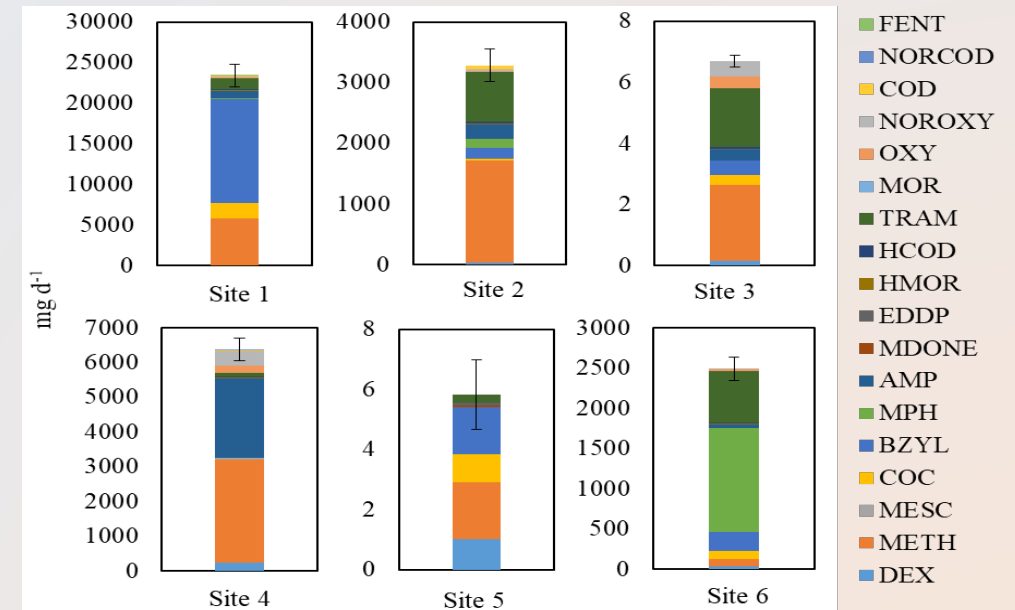
- **Bands:** B6, B5, B4 (short IR, NIR, Surface reflectance)
- **Spatial resolution:** 30 meters
- **Used entire image collection:** 2020-01-01 to 2020-31-12

Among Ak-Chin, San Carlos, and Pine Ridge Indian Communities, only Pine Ridge seems to have WWTPs in their territory.



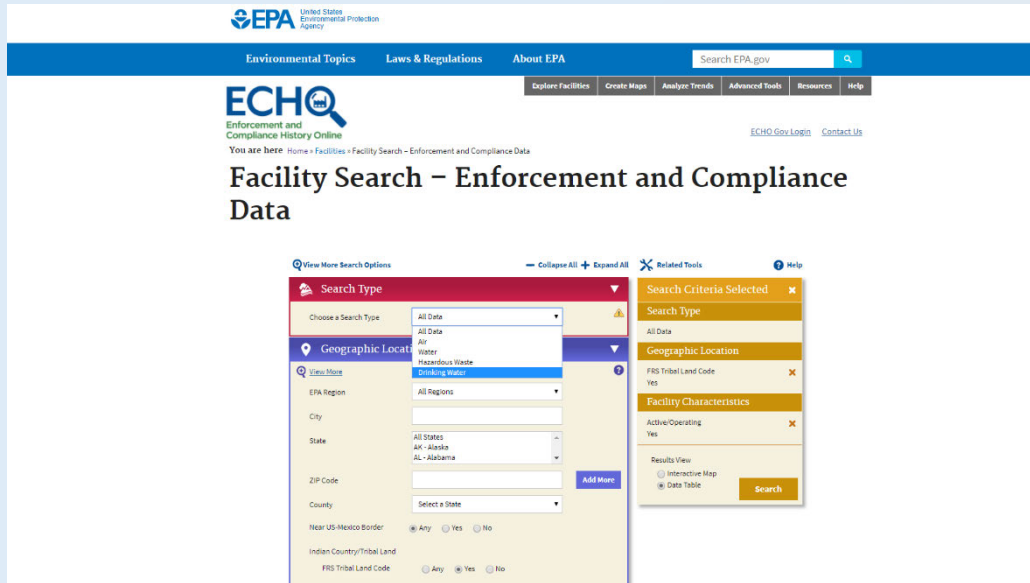
Drugs in Tribal Communities

Chemical Class	Drug
Over-the-counter	Dextromethorphan
Cultural	Mescaline
Recreational	Methamphetamine, cocaine (benzoylecgonine), PCP, LSD, MDMA
Prescription	Methylphenidate ¹ , amphetamine ² , alprazolam ³ (a-hydroxyalprazolam)
Opioid withdrawal medication	Methadone (EDDP, 2-ethylidene-1,5-dimethyl-3,3-diphenylpyrrolidine), buprenorphine (norbuprenorphine)
Opioids	Hydromorphone, hydrocodone, tramadol, carfentanil, sufentanil, morphine (morphine-3-glucuronide), oxycodone (noroxycodone), codeine (norcodeine), heroin (6-acetylmorphine), fentanyl (norfentanyl)
Licit substances	(Ethyl sulfate ⁴) Nicotine (cotinine, trans-3'-hydroxycotinine) Caffeine (paraxanthine)

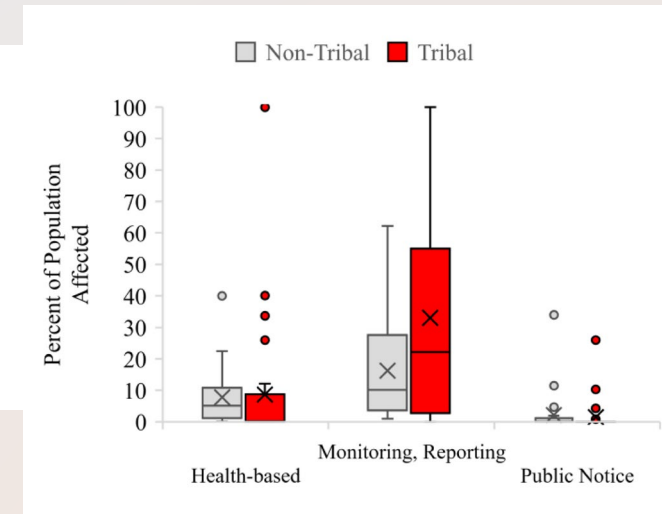
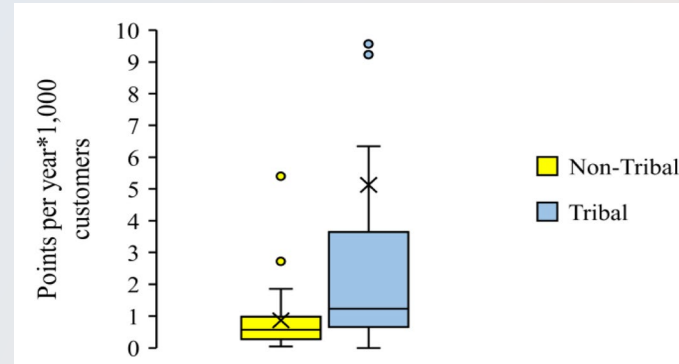


Notes: PCP (phencyclidine), LSD (lysergic acid diethylamide), MDMA (3,4-methylenedioxy-methamphetamine), ¹ Ritalin, ² Adderall, ³ Xanax, ⁴metabolite of alcohol consumption.

Disparities in Water Quality in Indian Country



Nation-Wide Water Quality Comparison:
Point-based and population affected analyses



Review of 3-year data collection on SDWA violations

- Violation points accrued
- Violations
- Contaminants of concern

**More SDWA violation points accrued in Tribal communities than non-Tribal*

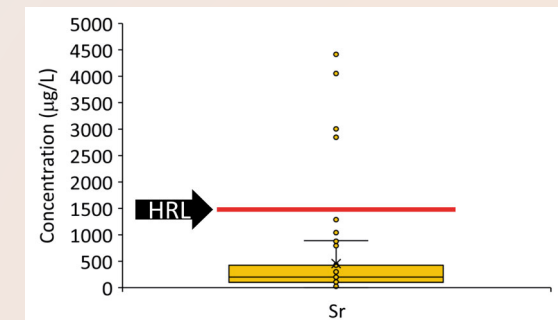
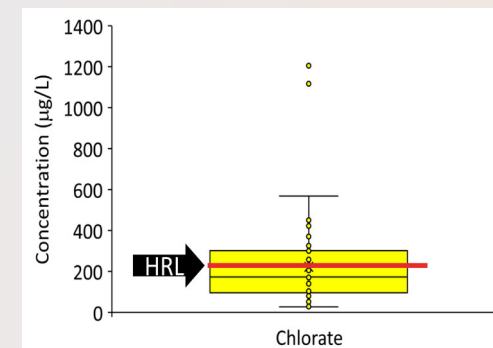
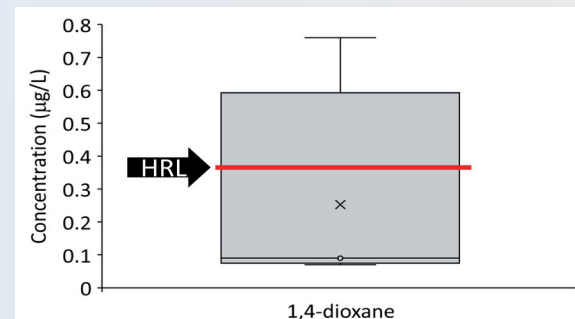
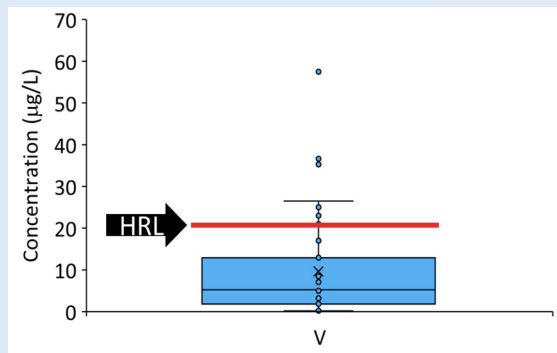
**On average, a greater percentage of Tribal population affected by health-based and monitoring/reporting violations*

Unregulated Contaminants on Tribal Lands

- EPA's monitoring of ~30 unregulated contaminants every 5 years
 - Unregulated contaminant monitoring rule (UCMR)
- Not regulated under SDWA

	UCMR1	UCMR2	UCMR3	UCMR4
Contaminants	Insecticides Herbicides Oxygenates Combustion products Organic precursors	Insecticides Brominated flame retardants Explosives Acetanilides Nitrosamines	Semivolatiles Synthetic organic Metals Oxyhalide anions Perfluorinated compounds Hormones	Cyanotoxins Metals Pesticides Brominated haloacetic acids Alcohols Semivolatiles Indicators

- Sample concentration were less than method detection limit for UCMR1 and UCMR2 chemicals
- UCMR3: dioxane, PFOS, strontium, vanadium, chromium, chlorate, molybdenum were measured in Tribal water
- UCMR4: disinfection by-products (HAAs), manganese, germanium detected



Pilamaya!

- Co-PIs: Rolf Halden, Kerry Hamilton, Rebecca Muenich, Erin Driver, Marcus Denetdale, Carrie Joseph
- Jacob Moore, Assoc. VP for Tribal Relations, Arizona State University
- The Biodesign Institute, One Water One Health
- Collaborators: Tribal partners, InterTribal Council of Arizona, ITCA National Water and Wastewater Operator Training Program
- Funding: NSF CBET 2038372, The Catena Foundation, NIH Project 1-U01DA053976-01

- Interested?
 - Share with Tribal Health Directors and Wastewater Managers
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