Session 6.2

Prioritizing Compounds of Potential Concern at the Scottsdale (AZ) Water Campus

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Water Environment Association of Utah

CITY OF SCOTTSDALE

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Agenda

- Introduction
- Compounds of Potential Concern (CPCs) Evaluation Approach
- Development of an Initial CPC List
- Development of Prioritized CPC List
- Conclusions

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Introduction

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Introduction

- City of Scottsdale (COS), AZ Water Campus
  - Water Reclamation Plant (WRP)
    - Biological treatment, nitrification, denitrification, tertiary filtration, chloramine disinfection
    - Meets Arizona Class A+ standards
      - Suitable for open access irrigation
  - Advanced Water Treatment Facility (AWT)
    - Microfiltration (MF), reverse osmosis (RO), decarbonation and lime stabilization
    - Implemented MF/RO from beginning to provide the highest level removal for unregulated compounds of potential concern (CPCs) for recharge

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Introduction

- City of Scottsdale (COS), AZ Water Campus
  - AWT Expansion
    - Package 1: Expand the MF and RO Capacity
      - Recently bid, construction starting in May
    - Package 2: Currently under design to provide additional treatment for unregulated contaminants
      - Disinfection and advanced oxidation by ozone
      - UV Photolysis downstream of reverse osmosis

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Introduction

- Compounds of Potential Concern (CPCs)
  - Trace amounts of pharmaceuticals, personal care products, DBPs, steroids, and industrial contaminants
  - Concentrations are typically very low (ng/L or µg/L)
    - Analytical techniques permit the detection of these trace compounds with increasing frequency
  - Health implications
    - Some CPCs have demonstrated adverse health impacts (e.g. NDMA) even at these low levels
    - Concern about the cumulative effect over a long period

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Introduction

- COS CPC Monitoring Program
  - Been monitoring CPCs for years
    - e.g. nitrosamines, caffeine, acetaminophen
  - Wanted to evaluate additional CPCs
    - Strategically expand the list of monitored parameters
    - Keep the list relatively narrow by selecting representative parameters from compound and treatability classes

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CPC Evaluation Approach

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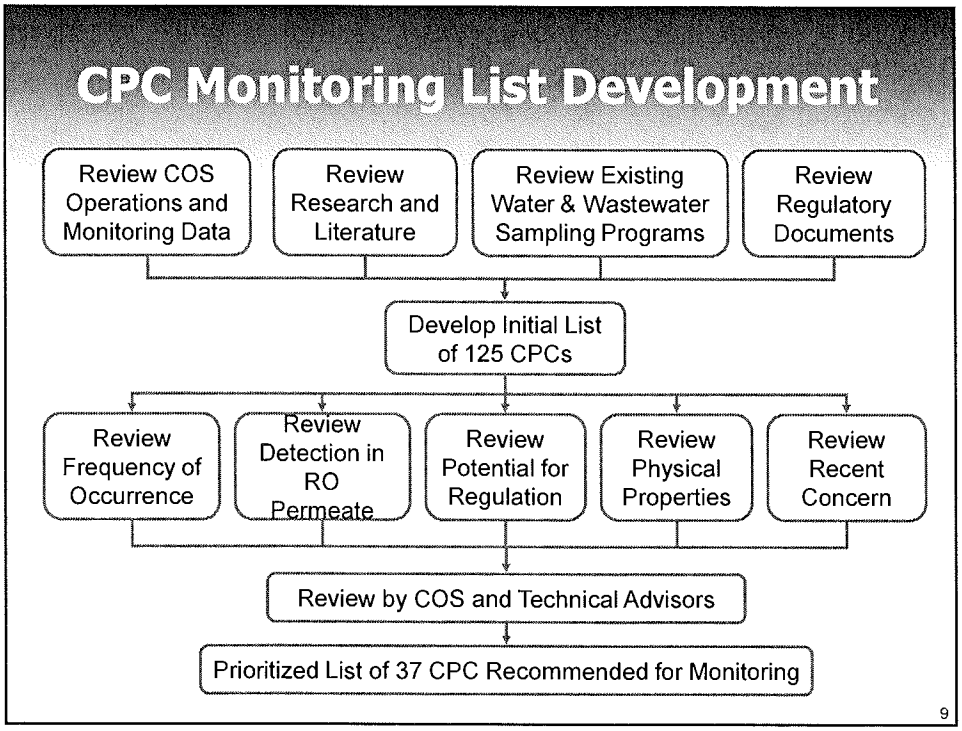
CPC Monitoring List Development
Review COS Operations and Monitoring Data
Review Research and Literature
Review Existing Water & Wastewater Sampling Programs
Review Regulatory Documents
Develop Initial List of 125 CPCs
Review Frequency of Occurrence
Review Detection in RO Permeate
Review Potential for Regulation
Review Physical Properties
Review Recent Concern
Review by COS and Technical Advisors
Prioritized List of 37 CPC Recommended for Monitoring
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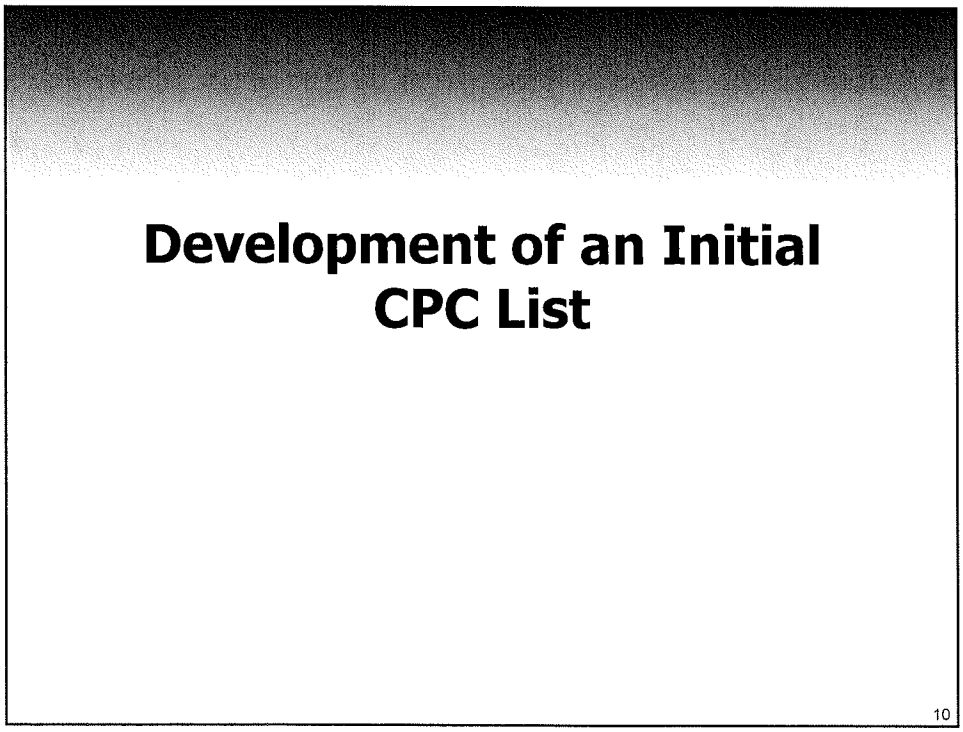
Development of an Initial CPC List
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Development of an Initial CPC List

- Broad list of CPCs
  - Compounds already being monitored
  - Compounds for which COS has internal laboratory standards
  - Compounds frequently cited in literature
    - Emphasis on reclaimed water systems
  - Compounds representing different categories
    - Pharmaceuticals, industrial compounds, steroids
  - Compounds monitored by similar utilities
  - Compounds listed on regulatory watch lists

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Historical City of Scottsdale (COS) CPC Monitoring

- Began monitoring in 2007
  - Included N-nitrosodimethylamine (NDMA) and three other nitrosamines
- Increase monitoring in 2008
  - Based on March 2008 Associated Press article
  - Steroids
    - Estradiol, Estrone, Ethynylestradiol, Testosterone, Progesterone

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Historical City of Scottsdale (COS) CPC Monitoring

- Increase monitoring in 2008 (cont'd.)
  - Pharmaceuticals
    - Caffeine, Triclosan, Acetamenophin, Methprobamate, Ibuprofen, Trimethroprim, Gemfibrozil, Sulfamethoxazole, Fluoxetine, Carbamazepine
  - Nitrosamines
    - NDMA, N-nitrosomorpholine (NNM), N-nitropiperidine (NPIP), N-nitropyrrolidine (NYPR)

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Research and Literature

- Over last 10 years the occurrence of many CPCs in wastewaters have been documented by researchers
  - Frequency of occurrence
  - Chemical properties
  - Toxicity or health effects
  - Analytical constraints
- Major References
  - "Removal of EDCs and Pharmaceuticals in Drinking and Reuse Treatment Processes"
    - Snyder et.al., AwwaRF, 2007

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Research and Literature

- Major References
  - "State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water"
    - Synder et. al., AwwaRF, 2008
  - "Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation"
    - Drewes et. al, WateReuse Foundation, 2008
  - "Water Analysis: Emerging Contaminants and Current Issues"
    - Richardson, Anal. Chem., 2007
  - "AP Probe Finds Drugs in Drinking Water"
    - Donn et al, Associated Press, 2008

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Water and Wastewater Utility Sampling Programs

- Three utilities were identified as having drinking utilities impacted by reclaimed water
  - The CPC monitoring programs of these utilities were included
- Four regulatory programs relevant to drinking water and reclaimed water
  - EPA Contaminant Candidate List (CCL) 3
    - Contaminants being considered for future regulation based on occurrence and toxicity
    - 93 contaminants including industrial compounds, pesticides, herbicides and five nitrosamines

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Regulatory Documents

- Four regulatory programs relevant to drinking water and reclaimed water (cont'd.)
  - California health-based "notification levels"
    - 29 chemicals including three nitrosamines and 1,4-dioxane
  - EPA Unregulated Contaminant Monitoring Rule (UCMR)
    - Provides occurrence and analytical method data in support of CCL determinations
  - Six compounds on the COS initial list are regulated under SDWA
    - Chloroform, benzo(a) pyrene, atrazine, 2,4,5-TP, and 2,4-D and hexachlorocyclohexane (Lindane)
  - Together > 100 chemicals are included
    - Not practical to include all these chemicals routinely

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Summary of Initial CPC List

- Based on selection criteria an initial list of 125 CPCs was developed
- Major Groupings
  - Analgesics
  - Antibiotics
  - Chemotherapy drugs
  - DBPs
  - Fragrances
  - Heart medicines
  - Industrial
  - Pesticides
  - Preservatives
  - Psychoactives
  - Steroids
  - Sunscreens
  - X-ray contract media

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Development of Prioritized CPC List

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Development of Prioritized CPC List

- Narrow the initial CPC list
  - 1. Frequency of occurrence (ubiquity)
    - Frequently occur in secondary and tertiary effluent
  - 2. Detected in RO permeate
    - In research studies or COS data
    - In most cases RO provided good removal (>75%) of the influent compound concentration
    - However, residual concentrations in certain CPCs were often detected
  - 3. Potential for regulation
    - NDMA and 1,4-dioxane

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Development of Prioritized CPC List

- Narrow the initial CPC list
  - 4. Recent concern
    - Not widely monitored (primarily due to analytical constraints)
    - PFCs, benzotriazles, 1,4-dioxane and nonylphenol
  - 5. Low molecular weight or Octanol-Water Partition Coefficient (Log K_{OW})
    - Likely to show poor removal through RO than larger compounds
    - Other attributes also important
      - Polarity, functional groups

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Development of Prioritized CPC List

Compounds of Potential Concern	CDS Current CPC List	CDS In-house Surrogates	Snyder et al. 2006	Snyder et al. 2008	Drewes, et al. 2008	Reiland on 2007	Associated Press 2007	SNWA PPCP and Steroids List	OCWD (NWRI PPCP Project)	West Basin MWD 2008	West Basin MWD 2006	CCL3	CDPH Notification levels 2007	UCMR 2	Regulated in SDWA	Compound Class	Ubiquitous[1]	Detected in RO Removals[2]	Potential Regulation[3]	Recent Concern[4]	Low Mol. Low K_{OW}[5]
Bromide																DBP precursor					
Chloroform																DBP					
Iodide																DBP precursor					
N-nitrosomorpholine												X	X	X		DBP					
N-nitrosodimethylamine (NDMA)					X	X				X		X	X	X		DBP	X		X		
N-nitrosopiperidine (NPIP)														X		DBP					
N-nitrosopyrrolidine (NYPR)												X				DBP					
Acetaminophen	X		X	X	X		X				X					Analgesic	X	X			X
Diclofenac			X	X	X	X	X	X	X							Analgesic	X				
Ibuprofen	X		X	X	X	X	X	X	X		X					Analgesic	X				
Naproxen		X	X	X	X		X	X								Analgesic	X	X			
Salicyclic acid					X	X					X					Analgesic	X				X
Ciprofloxacin		X		X	X						X					Antibiotic	X				
Sulfamethoxazole	X		X	X	X		X	X	X							Antibiotic	X	X			
Triclosan	X		X	X	X	X		X	X		X					Antibiotic	X	X			
Trimethoprim	X		X	X	X	X		X								Antibiotic	X	X			
Atenolol				X	X			X								Heart Medicine	X	X			X
Gemfibrozil	X		X	X	X			X	X		X					Heart Medicine	X	X			
Pentoxifylline			X													Heart Medicine		X			X
Caffeine	X		X	X	X		X	X	X	X	X					Psycho-active	X	X			X
Carbamazepine	X		X	X	X	X	X	X	X		X					Psycho-active	X	X			
Fluoxetine (Prozac)	X		X		X	X		X								Psycho-active	X	X			

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Development of Prioritized CPC List

Compounds of Potential Concern	COS Current CPC List	COS In-house Standards	Snyder et al. 2007	Snyder et al. 2008	Drewes, et al 2008	Richardson 2007	Associated Press 2007	SNWA PPCP and Steroids List	OCWD (NWRI PPCP Project)	West Basin MWD 2008	West Basin MWD 2006	CCL 3	CDPH Notification levels 2007	UCMR 2	Regulated in SDWA	Compound Class	Ubiquitous	Detected in RO Permeate	Potential Regulation	Recent Concern	Low Mrl, low Kow
Meprobamate	X		X		X		X	X								Psycho-active	X	X			X
Primidone		X		X	X			X	X							Psycho-active	X				X
Estradiol	X		X	X			X	X		X	X					Steroid					
Estrone	X		X	X	X		X	X		X	X					Steroid	X				
Ethynylestradiol	X		X	X				X	X	X	X					Steroid					
Progesterone	X		X					X								Steroid					
Testosterone	X		X	X				X								Steroid					
Cyclophosphamide		X				X										Chemo-therapy				X	
Iopromide			X	X	X	X		X			X					X-ray media	X	X			
Galaxolide			X	X	X											Fragrance	X	X			
Oxybenzone		X	X													Sunscreen		X			
Butylated hydroxyanisole (BHA)				X	X							X				Preservative	X				
1,4-dioxane						X				X		X	X			Industrial			X		
Benzotriazole						X										Industrial				X	
Nonylphenol				X	X	X					X					Industrial	X				
Octylphenol																Industrial					
Perfluorooctanesulfonate (PFOS)						X										Industrial				X	
Perfluorooctanoic acid (PFOA)																Industrial					
tris(2-chloroethyl)phosphate (TCEP)			X	X	X			X	X							Industrial	X	X			X
Bisphenol A				X	X			X			X					Industrial	X				
Fluorene			X							X						Industrial					
Atrazine		X	X					X	X						X	Pesticide					X
N,N-Diethyl-meta-toluamide (DEET)		X	X	X	X			X								Pesticide		X			X

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Final Recommended Prioritized CPC Monitoring List

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Final Recommended Prioritized CPC Monitoring List

- Draft Prioritized CPC list included 40 compounds
- Reviewed by technical advisors

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Final Recommended Prioritized CPC Monitoring List

Action	Reason
Remove fluorene, gala-xolide, benzo(a)pyrene, pentoxifylline, bisphenol-A and salicyclic acid	Similar to other CPCs listed or better analytical methods needed
Add chloroform	Compound not well removed by RO
Add iodide and bromide	Indicators of potential brominated or iodinated DBPs
Replace nonylphenol with oxtylphenol Replace PFOS with PFOA	Octylphenol is easier to analyze and similar physiochemical properties

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Final Recommended Prioritized CPC Monitoring List

- Other recommendations from technical advisors
  - Add formaldehyde to the list if advanced oxidation is implemented
    - Possible oxidation byproduct
  - Monitor benzotriazole, PFOA, and 1-4-dioxane quarterly for a year and discontinue if not detected

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Conclusions

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Conclusions

- CPCs are not going away...
  - Public relation challenges
  - Documented occurrence
  - Potential treatment challenges
  - Potential health effects?
- CPC monitoring can be difficult...
  - Low concentrations (many at ng/L)
  - Advances in analytical techniques allow detection with increasing frequency

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Conclusions

- Use a systematic approach...
  - Review existing data
  - Relevant literature
  - Regulatory considerations
  - Similar monitoring programs
- Narrow the list...
  - Known occurrence
  - Removal by existing treatment processes
  - Potential for regulation and recent concern
  - Physical properties
  - Technical advisors

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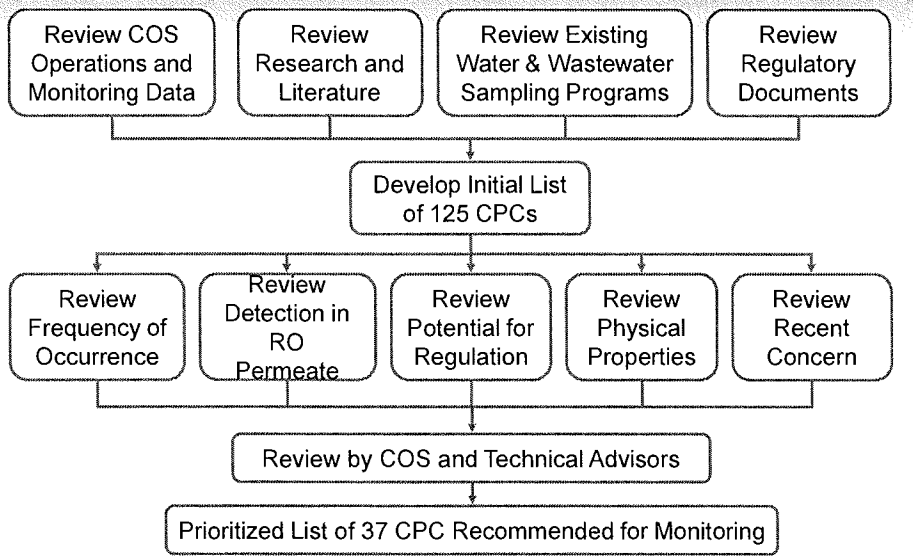
CPC Monitoring List Development



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Questions?

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