Bioanalytical Screening Tools for Recycled Water: Recommendations from the CEC Science Advisory Panel

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Costa Mesa, California
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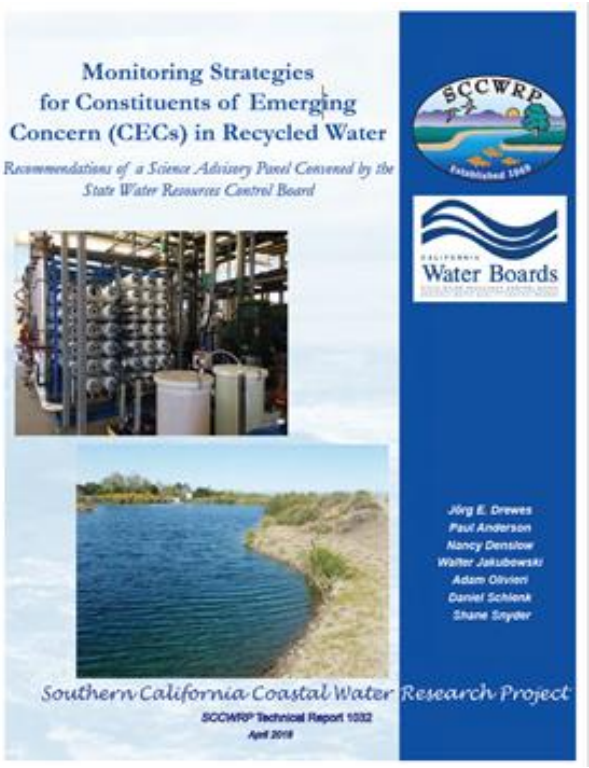
Panel Recommendations

The results and recommendations are documented in a final report (SCCWRP TR1020), released to the public on 27 April 2018



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Panel Charges

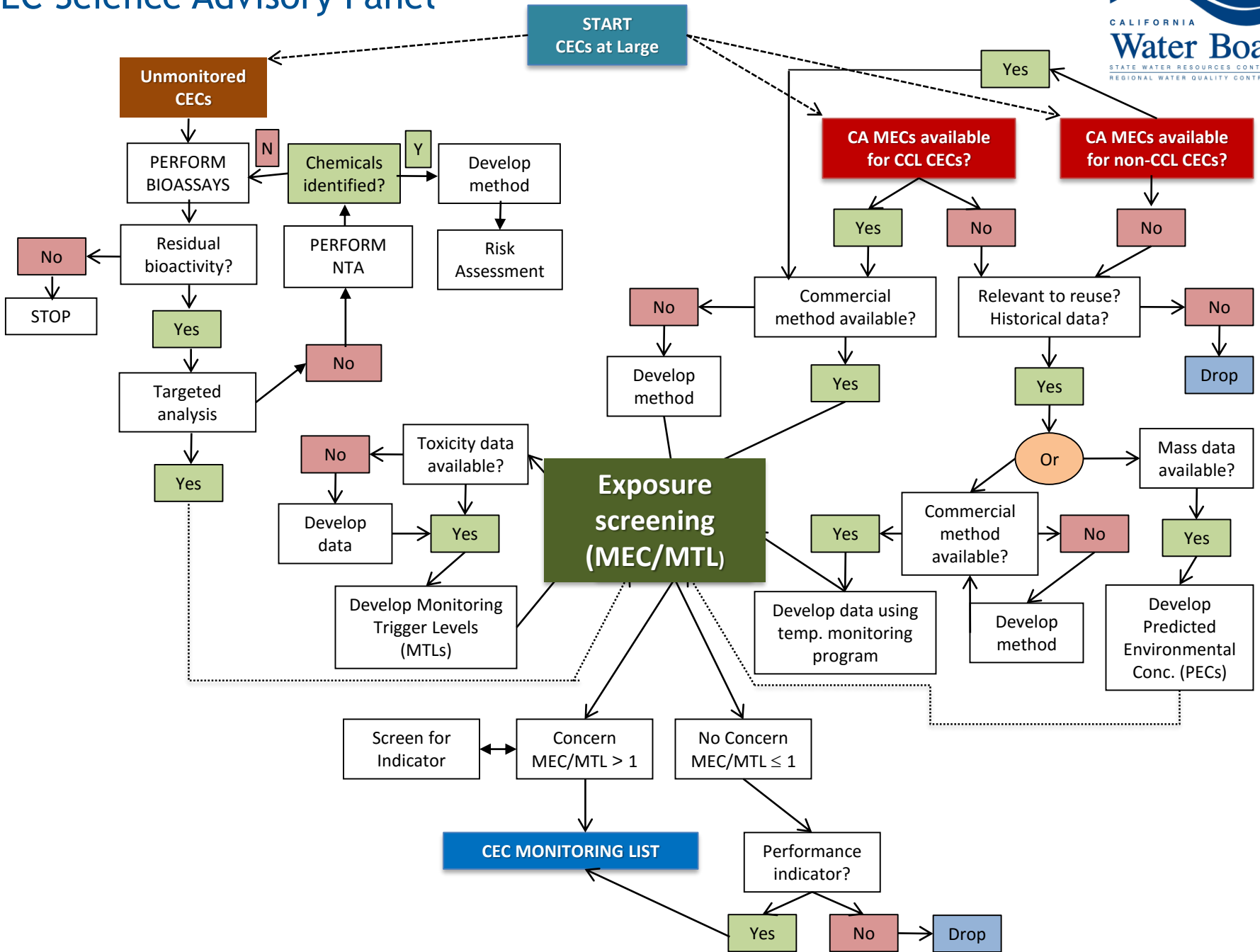
- What are the appropriate constituents to be monitored in recycled water, including analytical methods and method detection limits?
- What is the known toxicological information of the above constituents?
- Would the above list change based on level of treatment and uses as specified in Title 22 and for surface water augmentation (SWA)? If so, how?
- What indicators or surrogates can be used to represent a suite of CECs?
- What concentrations of CECs should trigger enhanced monitoring?

CEC Definition (2018)

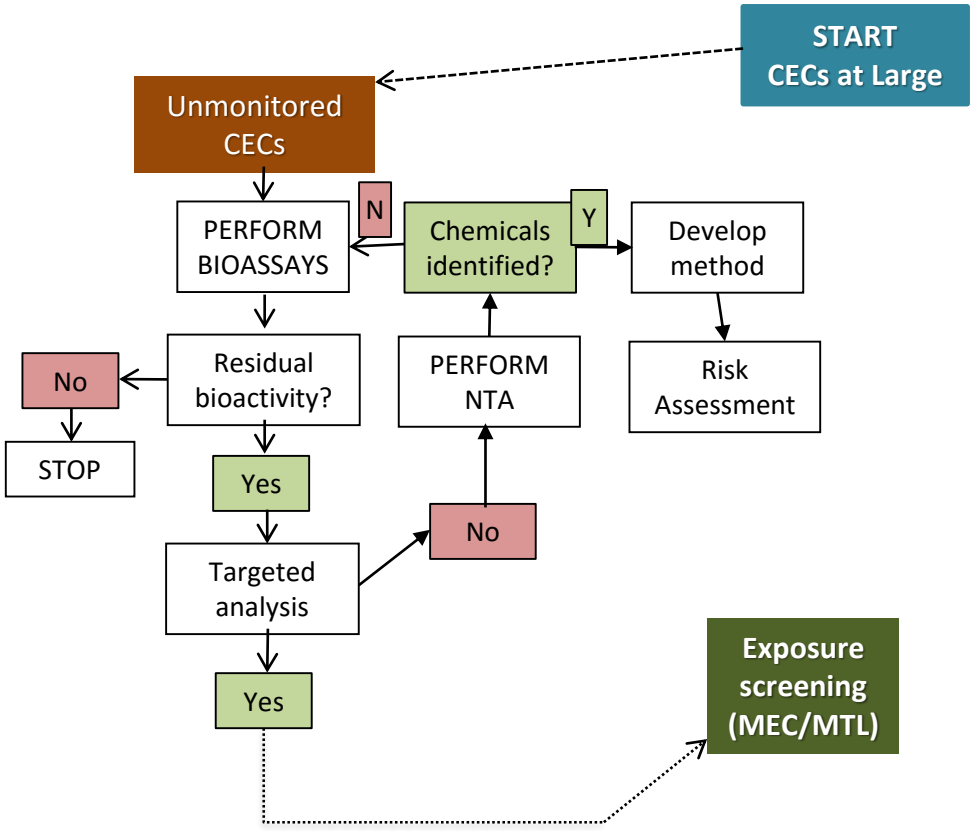
'Constituents of emerging concern'

- Personal care products
- Pharmaceuticals
- Industrial
- Agricultural
- Natural hormones
- Inorganic constituents (boron, chlorate)
- Food additives and constituents (phytoestrogens, caffeine, sweeteners)
- Transformation products
- Nanomaterials
- Microplastics
- Antibiotic resistance

CEC Science Advisory Panel



Use of Bioanalytical Methods for CEC Screening



- **Two bioassays:**
  - ER
  - AhR
- Standardized methods available (USEPA, OECD)
- Commercial labs
- **NTA**
  - Only in support of positive bioassay results

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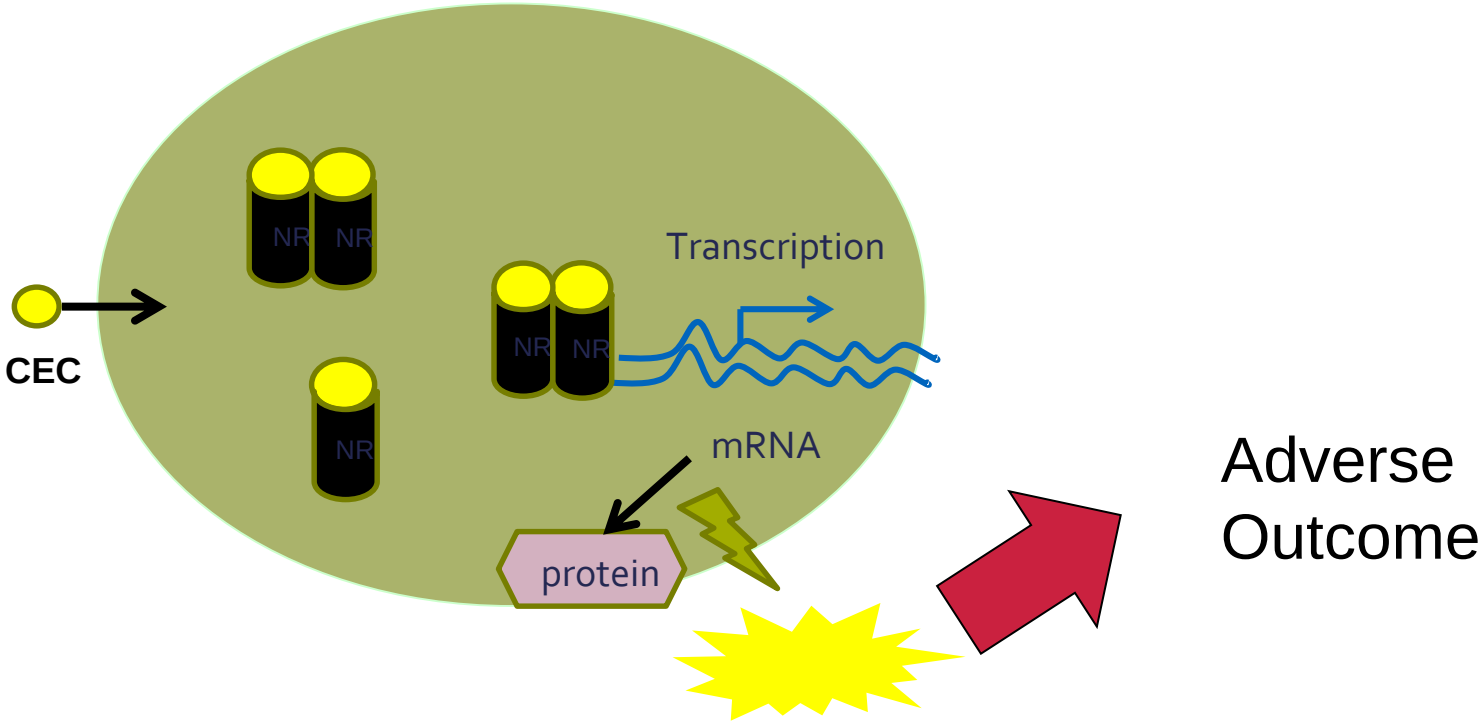
Cell assays have a long history of use for screening "good from bad" chemicals

- Pharma use
- Endocrine Disruptor Screening Program (EPA)
- European application (ISO & OECD)

Cell assays screen by groups of chemicals with similar bioactivity (i.e. via common MOAs)

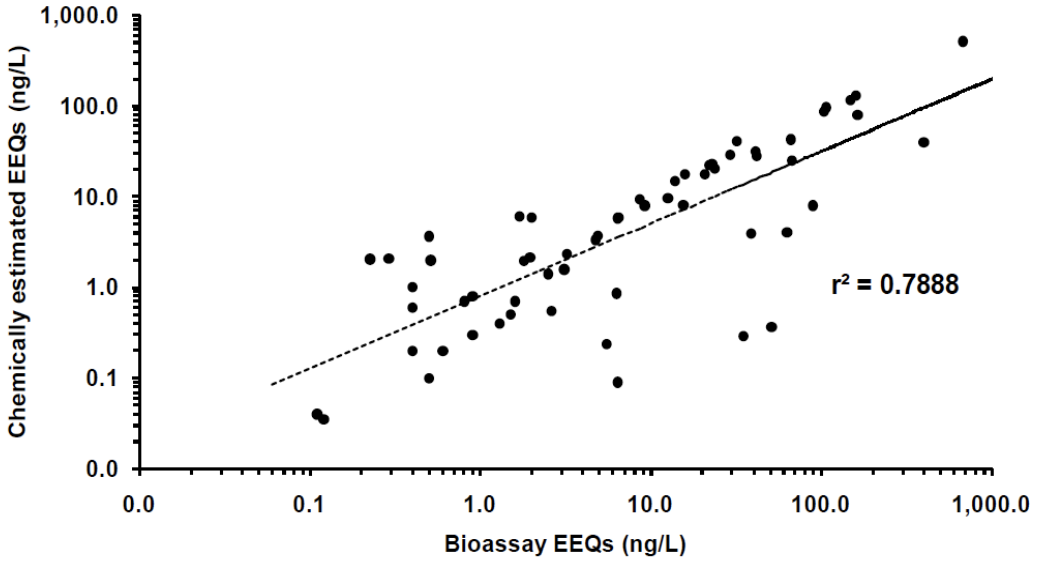


Effects are additive

Cell assays recommended by the Panel are

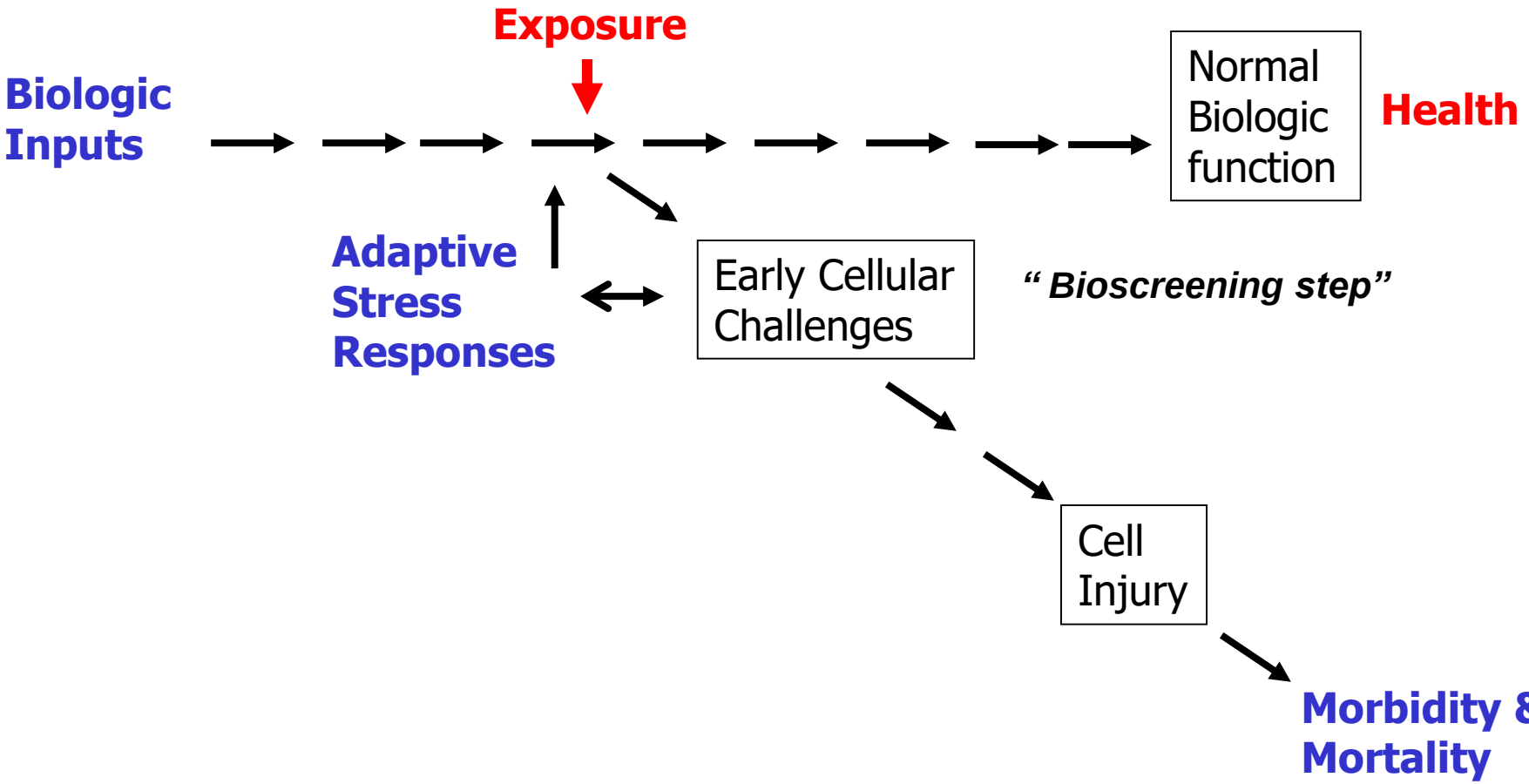
1) integrative exposure screens…

- Chemically estimated estrogen equivalence matches fairly well with bioassay results



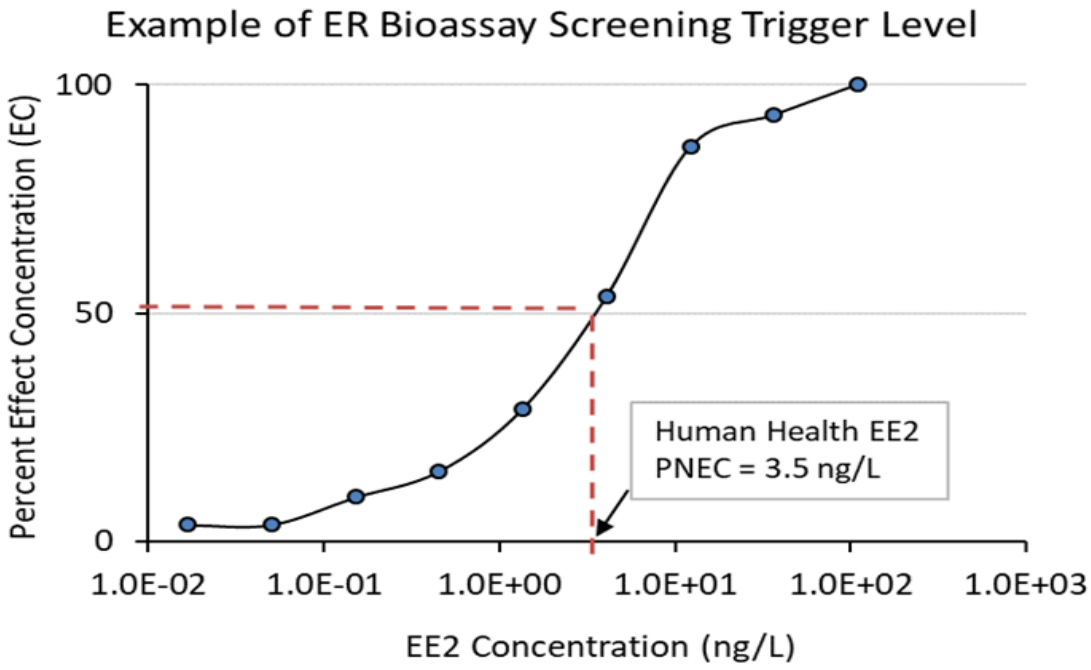
(Bulloch *et al*., 2010).

…and are 2) linkable to deleterious effects on human health



Adapted from Toxicity Testing in the 21st Century, NRC

Cell assays considered by the Panel are calibrated and referenced to a known toxic chemical, resulting in a concentration (EEQ or BEQ)



Identifying monitoring trigger levels (MTLs) for bioanalytical assays

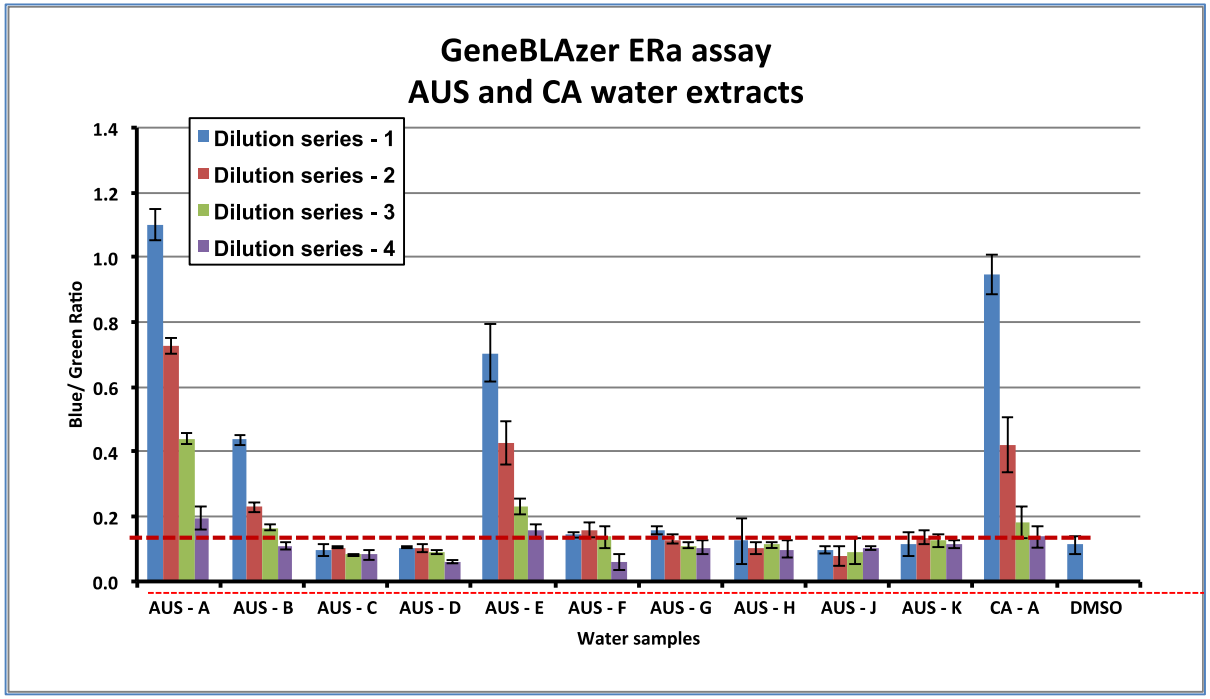
ER MTL= 3.5 ng/L

1. Health based trigger level → Predicted no effect concentration (PNEC) for human health = 3.5 ng/L
2. MTL in Europe for ER = 3.8 ng/L
3. Method reporting level for ER assay with E2 = 0.5 ng/L
4. This value is well within the current calibration range

AhR

1. Method reporting level for AhR assay with TCDD = 0.5 ng/L
2. As more data comes in we can develop a health-based trigger level
3. Similar/lower to MTLs determined in Europe

ER assay and evaluation of water



Water samples

Legend for samples

A= Effluent 2

B= Effluent 1

C= Ozonation

D= Storm water

E= Membrane

F= RO

G= River Water

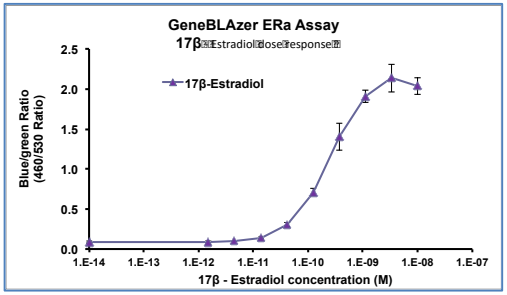
H = AO

J= Blank

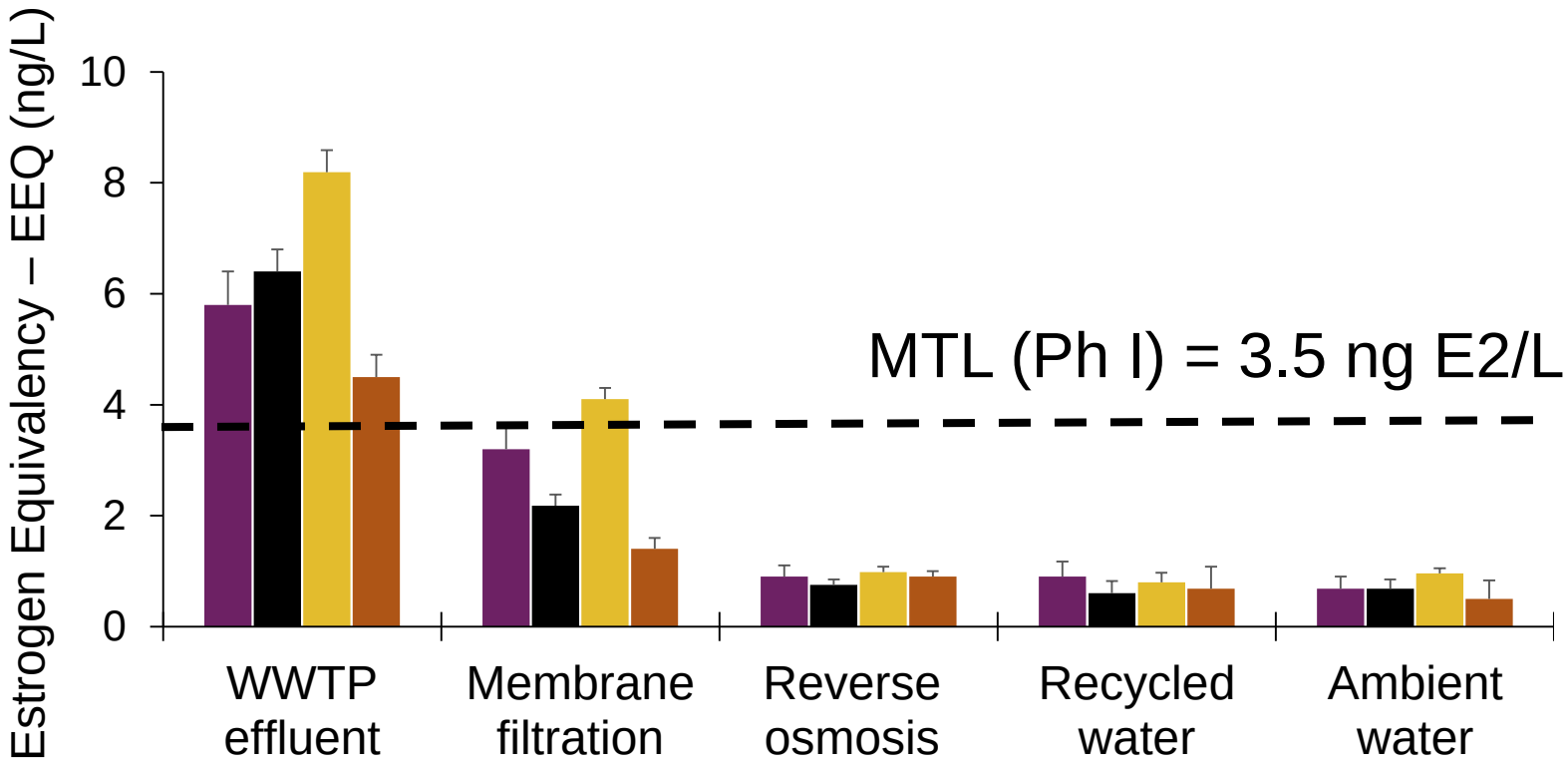
K= Drinking water

CA= SCCWRP proj

Standard curve



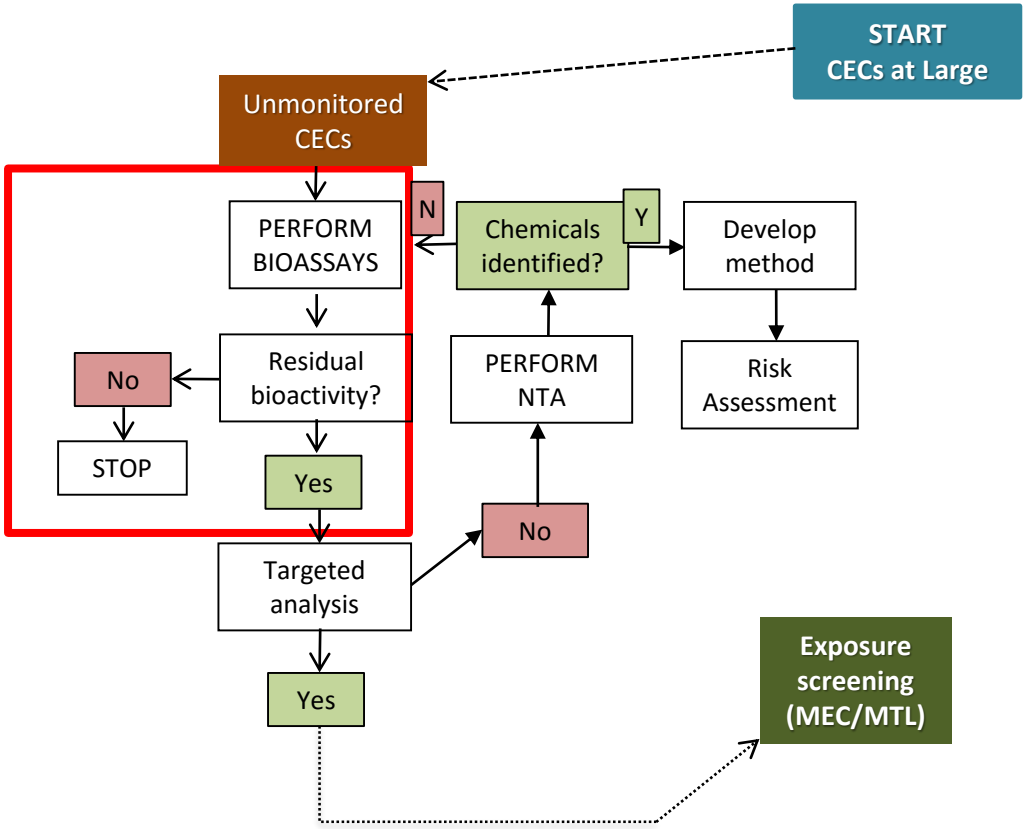
Reproducibility of assays - results from 4 different labs



Recommendation: Phased Approach with Collaborative Guidance

- Phase I – data collection
- Phase II – pilot evaluation of interpretive framework (includes initial or interim MTLs)
- Phase III – full implementation with actionable thresholds
- A steering committee would guide selection of appropriate endpoints, measurement goals (QA/QC) qualified vendors/labs, SOPs, and interpretive guidelines (i.e. MTLs)

Phase 1: Collection of data



CEC Monitoring Only Makes Sense for Potable, not Non-Potable Practices

- 45 different applications instead of a single landscape irrigation practice
- Exposures associated with Title 22 non-potable uses were estimated to be at least 10x lower than exposures associated with the potable reuse applications for all CECs and likely to be 100x lower for most CECs (one exception: impoundment with fishing)
- Panel recommends deriving MTLs for non-potable reuse by multiplying the potable reuse MTLs by a factor of 10
- Surrogate measurements are best way to assess Title 22 recycled water quality

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Expansion of Bioanalytical Toolbox

Endpoint	Significance
Estrogen receptor– ER alpha (Agonist mode)	Impaired reproduction, feminization of males
Aryl hydrocarbon receptor-- Ahr	Dioxin-like toxicity, cancer, tissue damage
Glucocorticoid Activity – Glucocorticoid receptor--GR	Impaired development, immune diseases
Androgen receptor – AR (Antagonist mode)	Impaired reproduction, de-masculinization of males, hypospadias
Peroxisome proliferator activated receptor -- PPAR	Metabolic disorders, impaired immune function, cancer
Tumor suppressor protein response element – P53	DNA damage, mutagenicity, cancer

Acknowledgments