

Study of Reclaimed Produced Water for Use in Agricultural Irrigation

Presentation to the Food Safety / Oil Field Wastewater Reuse Expert Panel
January 12, 2016

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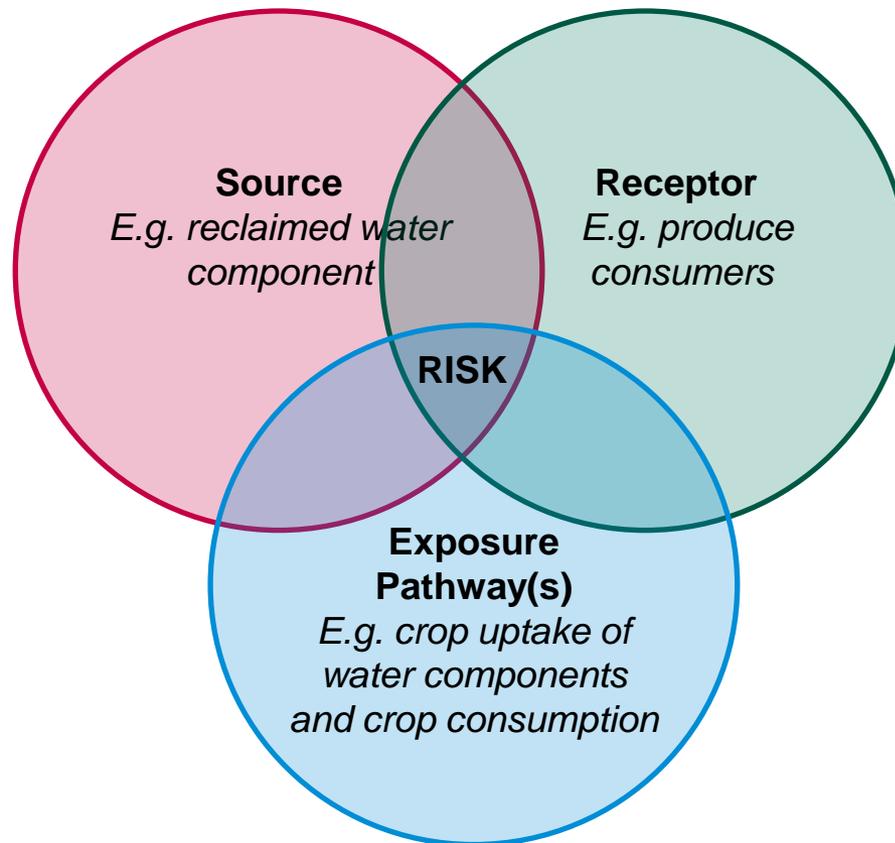
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Study Objectives and Basis

- Assess potential public health risks of irrigating crops with reclaimed water using USEPA standards by:
 - Determining acceptable health-protective comparison levels of naturally occurring metals and other components in irrigation water
 - Comparing measured concentrations of these components to those levels
- Data used in this study is derived from Water District water supplies
- Conclusions would be applicable to other Water District water resources proposing to use similarly produced and reclaimed water
- Peer review of study protocols, methods, assumptions and other parameters. Peer review (UC Riverside) confirmed report's methodology and protocols

Risk Assessment Basics

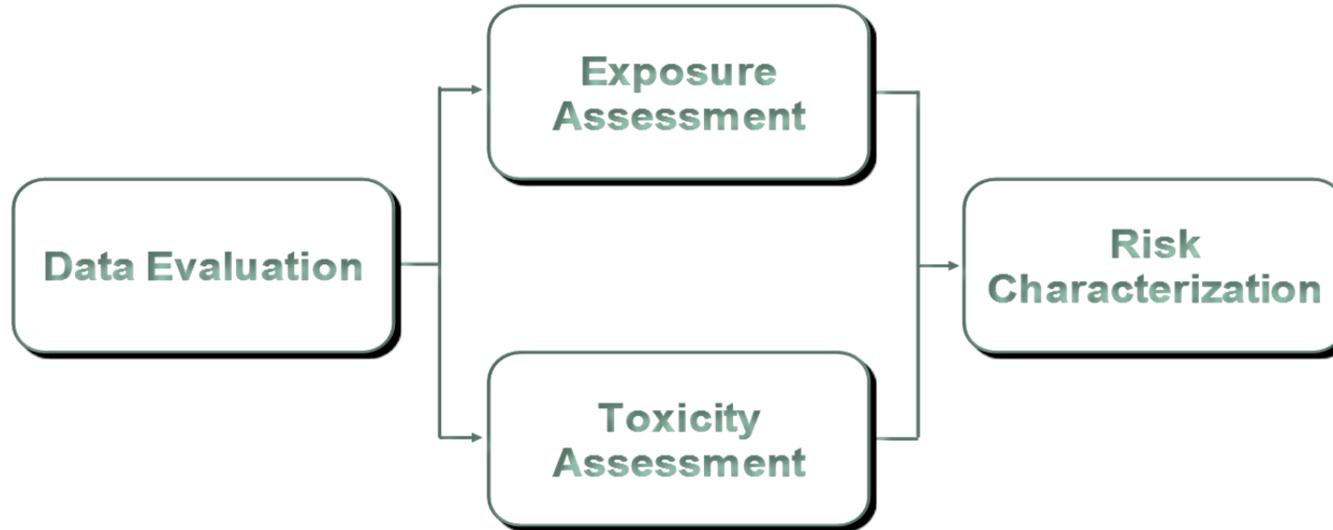
Risk assessment = the scientific evaluation of potential health impacts that may result from exposure to a substance or mixture of substances under specific conditions



Risk Assessment Basics

- Four steps to a risk assessment:

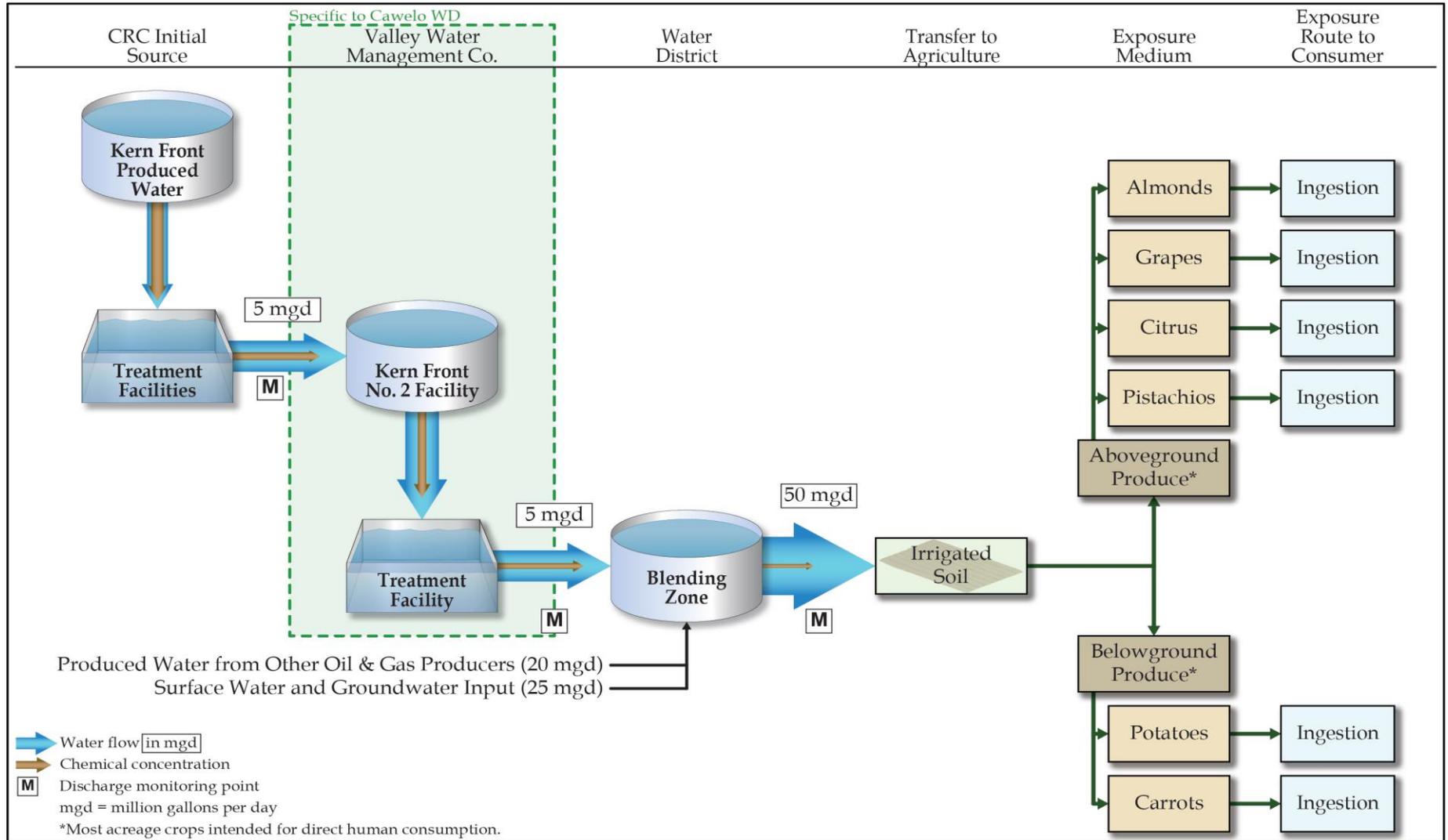
1. Data evaluation
2. Toxicity assessment (dose-response/hazard identification)
3. Exposure assessment
4. Risk characterization



- This study determined health-protective comparison levels for the components of interest for long-term use in irrigation water that ensure food safety



Conceptual Exposure Pathway



Agricultural Uses

Water District Crop Types/Acreages

- Provides irrigation water to approximately 95,000 acres of various agricultural commodities
- Predominantly almonds, citrus, pistachios and vineyards
 - Almonds/Pistachios = 63% (59,400 acres) 
 - Citrus = 11% (10,800 acres) 
 - Grapes = 11% (10,800 acres) 
 - Carrots/Potatoes = 4% (3,500 acres) 
- Total crop (fruits, vegetables, nuts) acreage for Kern County is over 700,000 acres
 - Almonds/Pistachios = 330,000 acres (18% from Water Districts)
 - Citrus = 65,000 acres (17% from Water Districts)
 - Grapes = 110,000 acres (10% from Water Districts)
 - Carrots/Potatoes = 69,000 acres (5% from Water Districts)

Selection of Components Evaluated

- Study focused on those components (inorganics and organics) that are more prevalent in produced water and that have lower thresholds with respect to drinking water standards.
- Compared measured produced water concentrations from both Water District and CRC's Kern Front field to available screening values derived from USEPA and State screening levels.
 - Two screening values identified: USEPA regional screening levels (RSLs) and California public health goals (PHGs)
 - Screening values are based on use of water as tap water (residential domestic use)
 - Measured produced water concentrations are from:
 - Cawelo WD's blended reclaimed produced water
 - CRC's reclaimed produced water from the Kern Front field *before* being sent to Valley Water and Water Districts for further treatment and blending

Components Selected for Evaluation

- Results of the screen identified 15 inorganic and organic components:

□ Arsenic	□ Mercury	□ Benzene
□ Fluoride	□ Thallium	□ Ethylbenzene
□ Barium	□ Zinc	□ Toluene
□ Cadmium	□ PAHs	□ Xylenes
□ Chromium (VI)	□ Naphthalene	□ TPH-Crude

- Boron, acetone, ethylene glycol, trimethylbenzenes, and methylene chloride were added to the evaluation based on input from the RWQCB
- Other additives not included in study: quaternary ammonium compounds (additive at 0.4 ppm), and alkyl amines (additive at 0.1-1%).
 - Cause for exclusion from study: Lack of available toxicity criteria.
 - In addition, these compounds are likely to be readily biodegradable.



Exposure Pathway Analysis

Primary exposure pathway evaluated in this evaluation was to consumers eating produce grown using blended reclaimed produced water



- Focus on those crops identified that have greatest acreage.
- Consumption rates based on per capita USDA/USEPA values:
 - Carrots equivalent to over 7 pounds per year (over 60 per year)
 - Potatoes equivalent to over 28 pounds per year (over 35 per year)
 - Nuts equivalent to over 2 pounds per year (over 400 per year)
 - Citrus equivalent to over 8 pounds per year (over 45 per year)
 - Grapes equivalent to over 7 pounds per year (over 800 per year)
- Assumes these rates of consumption over a 26 year duration
 - 26 year exposure duration assumption based upon 2014 USEPA Guidance
- Assumed that 20% of produce consumed is from the Water Districts
 - Based on highest single crop percentage irrigated with produced water

Exposure Pathway Analysis

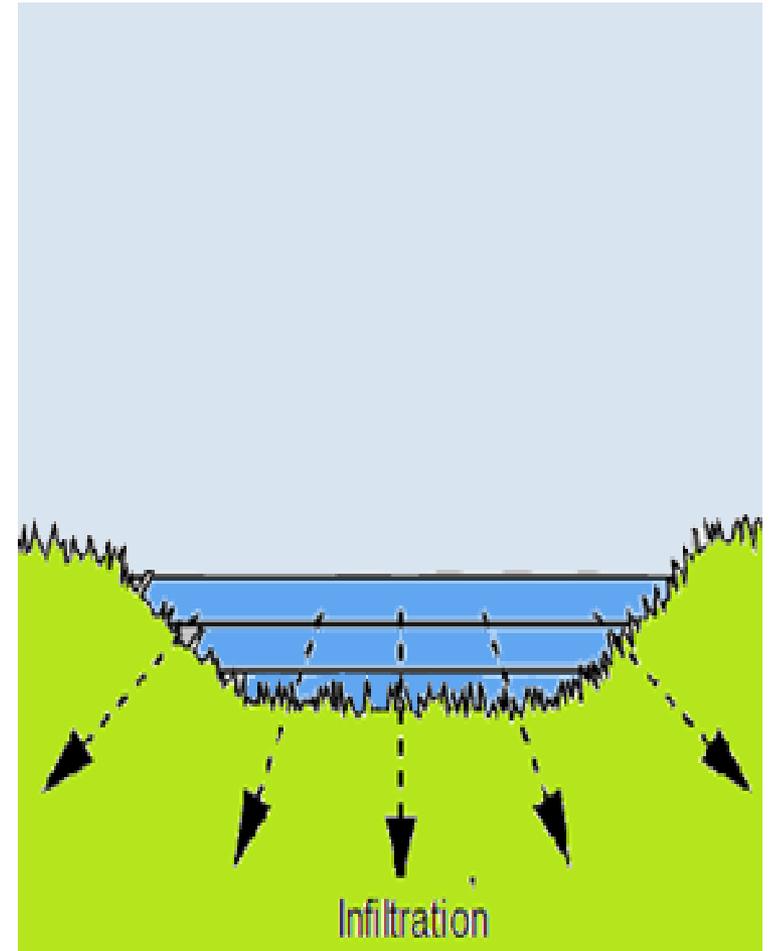
1. Concentration in Irrigation Water

- Determined acceptable health-protective comparison levels of assessed components for long-term use in irrigation water that ensure food safety
 - Irrigation water concentration for non-cancer threshold based on USEPA hazard quotient of 1
 - Irrigation water concentration for cancer based on 1 in 1,000,000 cancer risk (low end of USEPA's acceptable risk range of 10^{-4} to 10^{-6})
 - This is an incremental theoretical upper-bound probability
 - The USEPA risk assessment methodology and the assumptions used in this evaluation tend to overestimate potential exposure, meaning that actual exposure, if any, would likely to be much lower than that which is represented with the USEPA risk thresholds.

Exposure Pathway Analysis

2. Deposition from Water to Soil

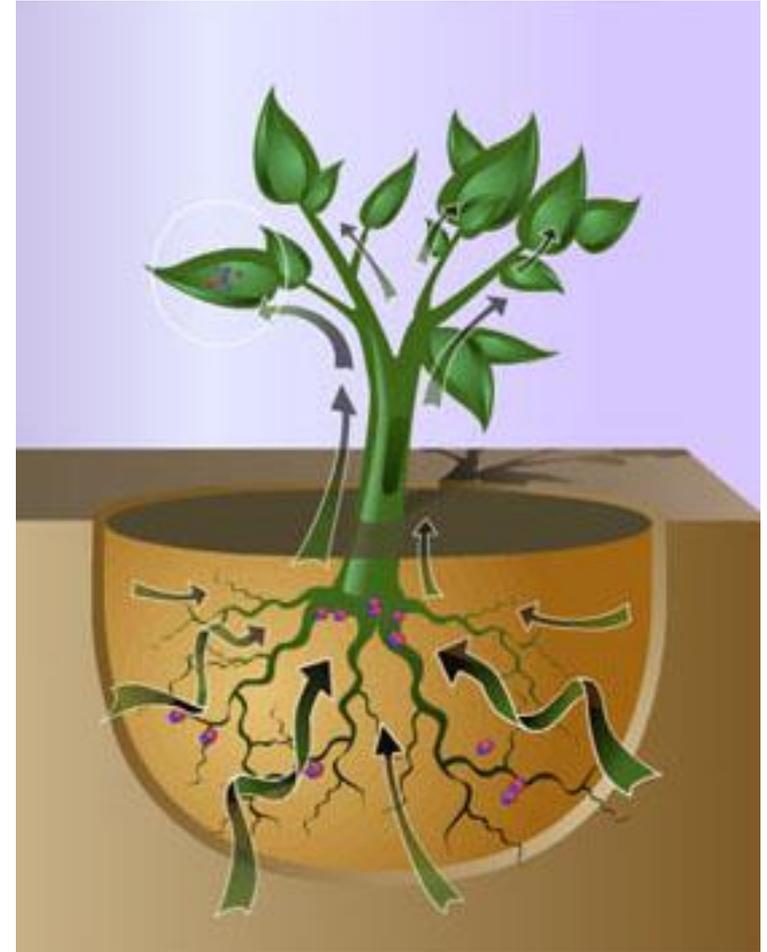
- Used USEPA deposition model
- Based on crop-specific irrigation rates without regard to the method of irrigation
- Also assumes a specific soil mixing zone (region specific) and organic carbon content (USEPA default value)
- Minimal soil loss constant was accounted for in the modeling
- Biodegradation was accounted for organics (not inorganics)



Exposure Pathway Analysis

3. Uptake from Soil into Plants

- Standard uptake factors, primarily from USEPA, were used
- Two different uptake factors used:
 - Uptake into the aboveground portions of the plant (fruits, nuts, leaves)
 - Uptake into the belowground portions of the plant (tubers, roots)
- Uptake factors for inorganics and PAHs based on available literature values; uptake factor for other organics calculated based on chemical/physical properties using equation from USEPA.



Development of Health-Protective Comparison Levels

Chemical	Crop-Specific Health-Protective Comparison Level from the Study (mg/L)					Most Stringent Health-Protective Comparison Level from the Study (mg/L)	Concentrations Measured in Irrigation Water Sent to Fields (mg/L)	CRC Section 23 Facility Reclaimed Water Conc. (Pre-Blended) (mg/L)
	Nuts	Citrus	Grapes	Carrots	Potatoes			
Inorganics								
Arsenic	0.5	0.3	0.1	1	0.2	0.1	0.02	0.076
Barium	>100,000	100,000	50,000	10,000	2,000	2,000	0.078	0.034
Boron	300	100	70	1,000	200	70	0.67	1.2
Cadmium	1,000	200	70	1,000	1,000	70	ND (<0.002)	ND (<0.002)
Chromium (VI)	1	2	1	3	0.4	0.4	ND (<0.002)	ND (<0.002)
Fluoride	4,000	1,000	700	70,000	10,000	700	0.4	0.58
Mercury	400	50	20	400	20	20	ND (<0.0001)	0.00016
Thallium	60	20	10	300	40	10	0.0085	ND (<0.005)
Zinc	10,000	4,000	2,000	>100,000	60,000	2,000	ND (<0.01)	ND (<0.01)
Organics								
Acetone	>100,000	>100,000	100,000	100,000	20,000	20,000	0.05	ND (< 0.0005)
Benzene	40	40	30	5	0.7	0.7	ND (< 0.0005)	0.0012
Ethylbenzene	1,000	1,000	800	50	6	6	ND (< 0.0005)	ND (< 0.0005)
Ethylene Glycol	20,000	9,000	5,000	>100,000	>100,000	5,000	--	--
Methylene Chloride	200	200	100	20	2	2	ND (< 0.0005)	ND (< 0.0005)
Naphthalene	1,000	400	200	3,000	400	200	ND (< 0.0005)	ND (< 0.0005)
PAHs	0.02	0.07	0.04	30	3	0.02	ND (< 0.0005)	0.00015
Toluene	100,000	40,000	20,000	3,000	500	500	ND (< 0.0005)	0.0051
TPH-Crude	8,000	3,000	2,000	1,000	200	200	0.08	20
Trimethylbenzene	30,000	9,000	5,000	2,000	200	200	ND (< 0.0005)	ND (< 0.0005)
Xylenes	>100,000	>100,000	90,000	6,000	1000	1,000	ND (< 0.0005)	0.021

ND = Not detected.

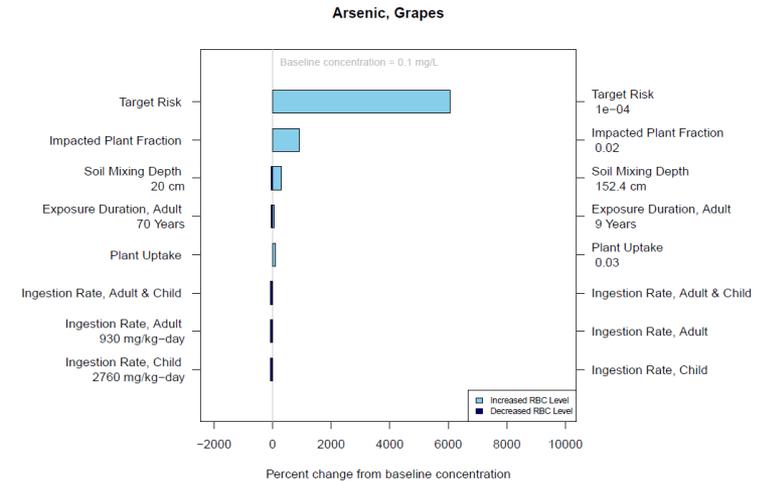


Sensitivity Analysis

Sensitivity analysis was focused on discrete variables on an individual basis. Effects presented as a percent change on tornado plots. Examples:

- Target risk of 10^{-4} vs 10^{-6} used in study
- Crop consumption rates:
 - Carrots 24 lbs/yr vs 7 lbs/yr used in study
 - Potatoes equivalent to over 82 lbs/yr vs 28 lbs/yr used in study
 - Nuts equivalent to over 7 lbs/yr vs 2 lbs/yr used in study
 - Citrus equivalent to over 65 lbs/yr vs 8 lbs/yr used in study
 - Grapes equivalent to over 50 lbs/yr vs 7 lbs/yr used in study
- Exposure durations of 9 and 70 years vs 26 years used in study
- Crop consumption from produced water of 5 percent vs 20 percent used in study

Sensitivity analysis indicates that most changes would result in an increase of the RBC levels illustrating the protective nature of the study.



Conclusions

- A conservative approach applying USEPA methods, models and parameters was used to determine concentrations of components in irrigation water that meet stringent EPA risk threshold standards for the protection of human health.
- This study indicates that irrigation water concentrations are at or below the health-protective comparison levels established by the USEPA
 - Safe for long-term irrigation for crops grown for human consumption based upon USEPA standards.
- Measured water concentrations of each of the components of interest in blended reclaimed water from the Cawelo Water District outflow are well below the health-protective comparison levels for all crops studied.
- The reclaimed produced water concentration from CRC's Kern Front field for each of the components of interest – even before **the water is sent to Valley Water and Cawelo WD for further treatment and blending** – is below the health-protective comparison levels for all crops studied.
- This study validates the conclusion in prior decision-making and permitting that the use of blended reclaimed produced water for agricultural irrigation does not pose a health risk above USEPA or CALEPA limits to produce consumers.