ASSESSMENT OF PRODUCED WATER FOR AGRICULTURAL IRRIGATION OF EDIBLE CROPS

PROGRESS REPORT
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GSI ENVIRONMENTAL

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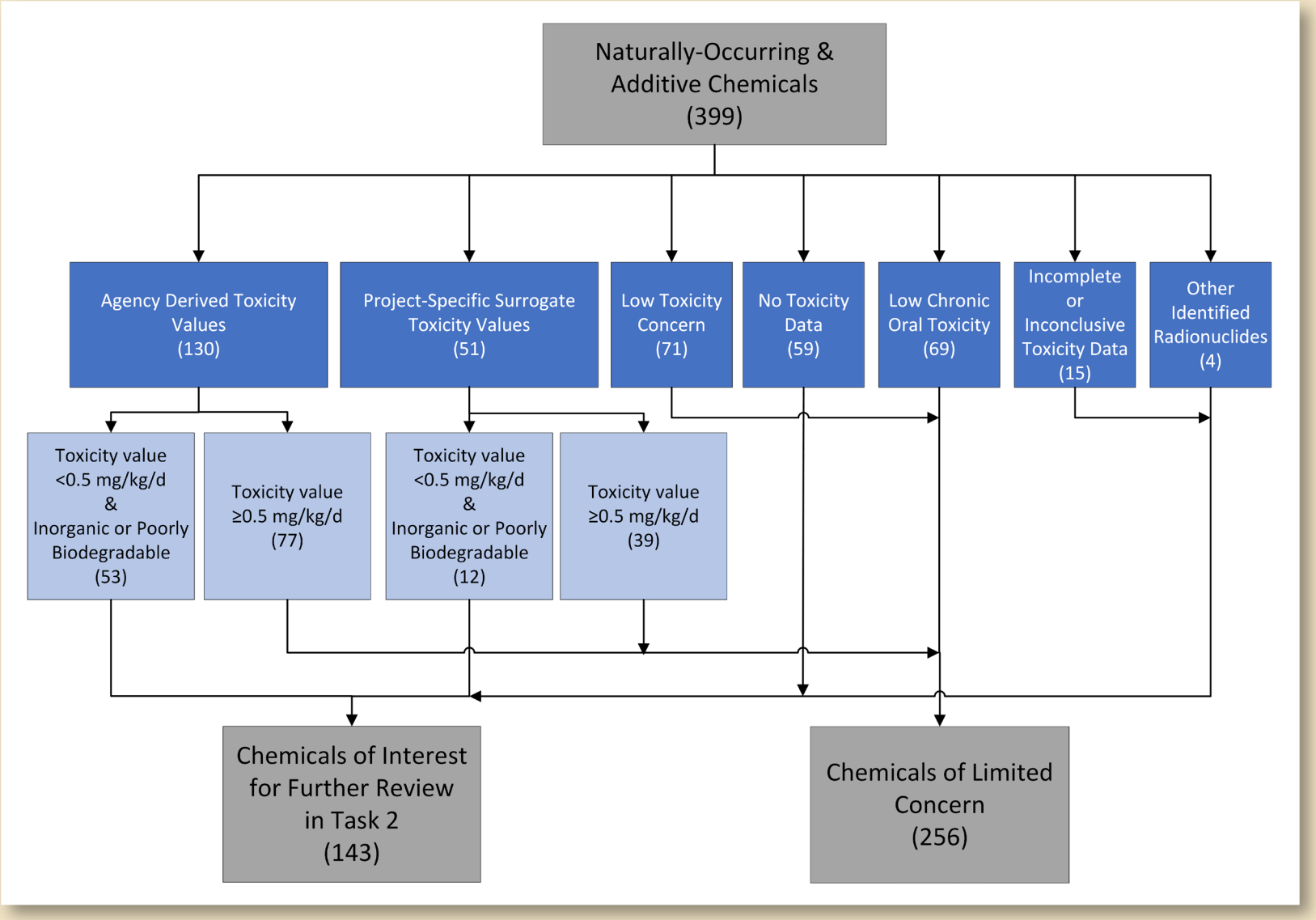
BACKGROUND

GSI was retained by the Water Board to assist in 3 tasks:

1. **Selection of "Chemicals of Interest", from a list of known chemical additives and naturally occurring chemicals in produced water, for further evaluation**
2. **Literature review focusing on the "Chemicals of Interest" in the context of produced water reuse in agriculture irrigation and other potential sources of these chemicals in the agricultural water supply**
3. **Sampling and chemical analysis of crops irrigated with produced water in the Central Valley**

TASK 1: IDENTIFYING CHEMICALS OF INTEREST

TASK 1: IDENTIFYING CHEMICALS OF INTEREST, ROAD MAP



TASK 1: CHEMICALS OF INTEREST

- Received all comments from Water Board Staff and Food Safety Panel
- All comments incorporated
- In process of producing ADA compliant document for posting on Water Board website

TASK 2: LITERATURE REVIEW

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- **Draft has been provided to the Water Board and distributed to Food Safety Panel for comments**

TASK 2: LITERATURE REVIEW

- **Guiding question:**

"What is our understanding about the use of produced water to irrigate food crops in the context of potential impacts to human health?"

- **Inclusion/exclusion criteria**

Evaluation Factor	Description
Date	-2000 to present for literature focused on produced water -No set restrictions for other literature, given the potential for limited availability -Goal to focus on most up-to-date data
Method of Extraction	-On-shore oil and gas production -Conventional and hydraulic fracturing
Location	-North America
Language	-English
Types of Publications	1. Peer Reviewed Literature 2. Government Publications 3. Scientific Letters 4. Industry Reports

TASK 2: LITERATURE REVIEW

Source for Literature Searches:

- Google Scholar, other internet searches
- University of California Melvyl search index
- University of California Berkeley OskiCat search index
- PubMed (US National Library of Medicine, National Institutes of Health)
- PubChem (US National Library of Medicine
- National Institutes of Health)
- Hazardous Substances Data Bank [HSDB] (US National Library of Medicine, National Institutes of Health)
- Toxicology Data Network [TOXNET] (US National Library of Medicine, National Institutes of Health)
- Haz-Map (US National Library of Medicine, National Institutes of Health)
- CompTox (US EPA)
- European Chemicals Agency: Search for Chemicals
- Organisation for Economic Co-operation and Development (OECD) databases
- Pharos Project databases
- Integrated Risk Information System (US EPA)
- Toxicological Profiles (Agency for Toxic Substance Disease Registry, Centers for Disease Control)
- COSMOS toxicological database
- EPA National Library Catalog (US EPA)
- The Endocrine Disruptor Exchange (TEDX)
- California State Water Resources Control Board website
- US EPA Inert Finder
- FracFocus
- California Department of Pesticide Regulation (CDPR) chemical ingredient database
- California Office of Environmental Health Hazards Assessment (OEHHA) chemical databases.

TASK 2: LITERATURE REVIEW

1.0 INTRODUCTION

2.0 METHODS

3.0 REVIEW OF PRODUCED WATER REUSE FOR AGRICULTURAL IRRIGATION

4.0 CHEMICALS OF INTEREST

5.0 REVIEW OF WATER QUALITY DATA FOR PRODUCED WATER

6.0 KNOWN AMBIENT LEVELS OF CHEMICALS OF INTEREST

7.0 OTHER SOURCES OF CHEMICALS OF INTEREST

8.0 FATE AND TRANSPORT

9.0 DEGRADATION AND TRANSFORMATION PRODUCTS

10.0 PLANT UPTAKE

11.0 REVIEW OF TOXICITY OF CHEMICALS OF INTEREST

12.0 RADIONUCLIDES

13.0 SUMMARY AND CONCLUSIONS

14.0 REFERENCES

TASK 2: LITERATURE REVIEW

Results and Major Findings:

- **Those things which we can monitor for are known chemicals, have many uses outside of oil and gas, and levels don't appear to be significantly different from other exposure sources**

- **Use of Produced Water for Irrigation:** Ability to use produced water for irrigation dependent on use of treatment and water quality (salinity, metal content, other hydrocarbons)

TASK 2: LITERATURE REVIEW

Results and Major Findings:

- **Water quality data and other known levels:** There do not appear to be significant differences between blended irrigation water and known levels in other sources of surface or ground water, and other sources of these chemicals

- **Other uses of Chemicals of Interest:** General uses, agricultural

TASK 2: LITERATURE REVIEW

Results and Major Findings:

- **Fate and transport, degradation, and plant uptake:** Advance our understanding of this topic
- **Toxicity data:** Toxicity data for roughly half of chemicals
- **Radionuclides:** No evidence to suggest they are a problem for these food crops

TASK 3: SAMPLING OF FOOD CROPS

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- Most comments from Food Safety Panel have been received
- Waiting on final comments to final report
- Next step is to incorporate remaining comments and produce ADA compliant document for posting on Water Board website

TASK 3: SAMPLING OF FOOD CROPS

- Sampling has been completed and results received for all crops
  - Included in the analysis are all crops previously sampled in 2017
  - 30 analytes detected

Crop	Sampling Date
Almond	8/8/2017 to 8/10/2017; 7/25/18 to 8/6/18
Apple	8/20/18
Carrot	7/12/2018; 7/25/19
Cherry	5/1/19
Garlic	7/18/2017; 8/8/2017; 17/12/2018
Grape	8/8/2017 to 8/10/2017; 7/25/18 to 9/05/18
Lemon	3/30/2017; 2/12/19 to 2/21/19
Mandarin	3/30/2017; 2/12/19 to 2/21/19
Navel	3/30/2017; 4/4/2017; 2/12/19 to 2/13/19
Potato	7/5/18
Pistachio	9/6/2017 to 9/7/2017; 9/4/18 to 9/5/18
Tomato	8/9/18 to 8/13/18
Valencia	4/4/2017; 2/12/2019

TASK 3: SAMPLING OF FOOD CROPS

- **Use Fisher's Exact Test on number of detects; controlled for multiple testing**

Group	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	control	treated	Grand Total	adjusted p-value
Analytes	Almond		Carrots		Cherries		Garlic		Grapes		Lemon		Mandarin		Navel		Pistachios		Potato		Tomato		Valencia		Apple		Group Total			
1,4-Dioxane			1																								1	0	1	1
2-Butanone																	11	11									11	11	22	1
2-Chloroethyl vinyl ether																1											0	1	1	1
2-Hexanone									3	5																	3	5	8	1
Acetone	7	7	2	5			2	5	12	11	3	4	4	4	5	5	12	13	3	2	6	6	2	2			58	64	122	1
Acrolein	3	6	2	5			7	6	15	12									2	3	6	6			3		35	41	76	1
Antimony, Total	3	8					2	1	1								1										7	9	16	1
Arsenic, Total			1	2																							1	2	3	1
Barium, Total	20	24	4	7			5	3			5		3	5	9	11	7	12					4	5			57	67	124	1
Benzo (a) pyrene													1														1	0	1	1
Bis(2-ethylhexyl)phthalate							1		1	1								1									2	2	4	1
Cadmium, Total				2	1	1																					1	3	4	1
Chromium, Total			2	2			1																				3	2	5	1
Cobalt, Total			2	2																							2	2	4	1
Copper, Total	24	24	4	7	3	3	7	6	23	22	4	5	7	12	7	5	23	23	3	3	6	6	3	1	1		114	118	232	1
Dibenzo (a,h) anthracene													1														1	0	1	1
Ethyl acetate	10	8	2	5			3		12	13									3	3	6	6			4		36	39	75	1
Lead, Total			1	2																							1	2	3	1
Methanol		1					4				2		4	4	5	7					6	6	1	1			22	19	41	1
Methyl tert-butyl ether (MTBE)																	11	11									11	11	22	1
Methylene chloride			2	2													2										4	2	6	1
Molybdenum, Total	1	1	2	2				1									1										4	4	8	1
Nickel, Total	6	2	2	2			3										1	1									12	5	17	0.69
p-Isopropyltoluene			4	7							4	4	4	8	5	6							2	2			19	27	46	1
Phenol											3												1				4	0	4	0.67
sec-Butylbenzene														1													0	1	1	1
Selenium, Total				1																							0	1	1	1
Strontium, Total	24	24	4	7	3	3	7	6	12	20	11	12	12	13	14	18	23	23		3	2	2	5	5	4		117	140	257	0.67
Vanadium, Total			2	2																							2	2	4	1
Zinc, Total	24	24	2	2			7	6									23	23									56	55	111	1
Grand Total	122	129	39	64	7	7	49	34	79	84	32	25	36	47	45	53	115	118	11	14	32	32	18	16	12		585	635	1220	---

TASK 3: SAMPLING OF FOOD CROPS

- **Overall there does not appear to be any evidence of a difference between treated and control samples that can be attributed to produced water**

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Thank you

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