

PERFLUORINATED COMPOUNDS AT CALIFORNIA HAZARDOUS WASTE SITES

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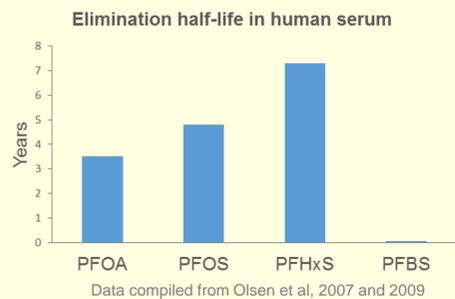
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ABSTRACT

Perfluorinated compounds (PFCs) are man-made, fully fluorinated, organic compounds that persist in the environment, resist environmental degradation, and bioaccumulate. PFCs are an "emerging contaminant," and a threat to human health and the environment. They can be found in all media (groundwater, surface water, sediment, soil, and air). Long-chain PFCs such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are of primary concern; however, there are other short-chain PFCs. PFOS and PFOA are high production volume chemicals used in consumer and industrial products like stain removers and aqueous film forming foam (AFFF). Recently PFCs have been detected at California hazardous waste sites at former firefighting training areas, where sampling was conducted in soil, sediment, and groundwater for PFCs. At Site A, PFOS was detected in influent and effluent samples from a groundwater treatment system at 0.235 µg/L and 0.233 µg/L, respectively. At Site B, PFOS was detected in groundwater at 0.064 µg/L and PFOA was detected at 0.27 µg/L. We developed tapwater DTSC-target levels using DTSC recommended exposure parameters and provisional toxicity criteria for PFOS (0.53 µg/L) and PFOA (0.4 µg/L). At Site A, the PFOS noncancer hazard quotient (HQ) is 0.4 for both groundwater detections and at Site B the HQ for PFOS is 0.1 and 0.7 for PFOA. There are limited toxicity criteria and screening levels (SLs) for PFCs. USEPA established drinking water short-term exposure provisional health advisory (PHA) levels of 0.2 µg/L for PFOS and 0.4 µg/L for PFOA. Given PFCs functional use as a water-, oil-, and stain repellent, DTSC's Safer Consumer Products (SCP) Priority Product Work Plan currently lists them as potential candidate chemicals in products related to buildings, furniture and furnishings, and clothing. The lack of toxicity criteria and limited SLs available for PFCs make conducting human health and ecological risk assessments challenging at hazardous waste cleanup sites and when evaluating consumer products.

INTRODUCTION

- PFCs are a subset of chemicals called perfluoroalkyl and polyfluoroalkyl substances (PFAS). PFOS and PFOA are two of the most studied PFCs and are emerging contaminants at hazardous waste sites in California.
- The primary source of PFOS and PFOA contamination at hazardous waste sites was AFFF which was used for firefighting and firefighting training.
- Other sources include food packaging, stain-resistant carpets, spray carpet cleaners, stain-, water-, wrinkle-resistant fabrics, and floor waxes.
 - Treated carpets and upholstery are the greatest source of exposures to PFOA and PFOS for toddlers and children due to hand-to-mouth activities (ATSDR, 2015).
- PFCs are detected in human serum, urine, and breast milk.
- Studies tend to focus on long chain PFASs since longer-chain PFAS elimination half lives tend to be slower than short-chain PFAS (≤C6). That being said, the elimination half-life for PFHxS is greater than both PFOS and PFOA (see graphic below).
- Health concerns may include developmental, reproductive, immunological, liver, and carcinogenic hazard endpoints (ATSDR, 2015; EPA, 2012).
- The primary effects in animal studies are liver toxicity, developmental toxicity, and immune toxicity (ATSDR, 2015).
- EPA Region 4 recommends a residential soil screening level of 6 mg/kg for PFOS and 16 mg/kg for PFOA (EPA, 2009).
- We have calculated screening levels for residential soil and tapwater using toxicity criteria from ATSDR (2015) and DTSC Human and Ecological Risk Office (HERO) practices and default parameters.



CASE STUDIES

Site A – Wastewater Treatment Plant Influent and Effluent

- Former Northern California Industrial Site
- Currently under redevelopment for mixed use to include residential homes and commercial businesses
- WWTP uses air stripping
- Effluent discharges to groundwater and surface water
- PFC source unknown



Former Northern California Industrial Site

Analyte	WWTP 1		WWTP2	
	INF1	EFF1	INF2	EFF2
PFBS	0.024	0.023	0.015	0.016
PFHxS	0.291	0.232	0.105	0.124
PFOS	0.063	0.038	0.235	0.233
PFHpA	0.014	0.013	0.011	0.012
PFOA	0.102	0.076	0.038	0.036

All concentrations in µg/L
Bolded values indicate exceed 0.2 µg/L
Red values indicate PFOS or PFOA exceeded PAL

Site B – Groundwater

- Former Central California Industrial Site
- Former fire drill training area
- Fuel discharged into unlined pit was ignited and extinguished using AFFF until 1985
- COCs include benzene and trichloroethene
- Groundwater remediation: pump and treat

Former Central California Industrial Site

Analyte	Maximum Conc (µg/L)
PFOS	0.04
PFOA	0.21

Site C – Multiple Sample Media

- Former Northern California Industrial Site
- Currently under redevelopment for mixed use to include residential homes and commercial businesses
- Former fire training burn area 1977 to 1987
- Fuels (jet propellant grade 4) and other solvents were discharged to bare soil, ignited, and extinguished
- COCs on site include VOCs, SVOC, petroleum hydrocarbons, pesticides, and radionuclides
- Groundwater remediation: pump and treat
- WWTP currently uses air stripping, but carbon filtration was used between 1987 and 2009

Former Northern California Industrial Site

Analyte	SFC Soil (mg/kg)	Sediment (mg/kg)	GW (µg/L)	SFC water (µg/L)	WWTP INF (µg/L)	WWTP EFF (µg/L)
PFBS	0.06	0.01	0.14	0.85	0.03	0.01
PFHxS	0.08	0.02	0.71	3.34	0.08	0.02
PFOS	1.79	0.07	0.16	2.11	0.02	0.01
PFHpA	0.0	0.0	0.06	0.13	0.02	0.0
PFOA	0.01	0.01	0.19	1.15	0.04	0.01
PFNA	0.0	0.0	0.002	0.01	ND	ND

PFCs without a PAL are bolded if they exceed 0.2 µg/L
Red values indicate PFOS or PFOA exceeded their PAL

Table 1: Project Action Levels (PAL) & DTSC Screening Level (DTSC-SL)

Analyte	PAL		DTSC-SL	
	Water (µg/L) ^a	Soil (mg/kg) ^b	Tapwater SL (µg/L)	Residential Soil SL (mg/kg)
PFOS	0.2	5	0.53	2.35
PFOA	0.4	12	0.41	1.56

^a EPA (2012) ^b Project specific

Table 2: Noncancer Hazard Quotients

Analyte	Water PAL	Site A (EFF)	Site B (GW)	Site C (GW)	Site C (SFC water)	Soil PAL	Site C (SFC soil)
PFOS	0.38	0.44	0.12	0.31	4.0	2.12	0.76
PFOA	0.98	0.09	0.68	0.45	2.8	7.69	0.007
TOTAL	1.6	0.5	0.8	0.8	6.8	9.7	0.8

Hazard quotients calculated using DTSC screening levels (see Table 1)

Table 3: Biomonitoring California serum concentrations (ng/mL) and detection frequency %

Study	PFBS	PFHxS	PFOS	PFHpA	PFOA	PFNA
California Teacher Study	NC (18.4)	1.62 (99.9)	6.8 (99.9)	0.05 (74)	2.46 (99.9)	0.92 (99.9)
Firefighter Occupational Exposure Project	NC (6.9)	2.26 (100)	12.5 (100)	0.13 (75.2)	3.75 (100)	1.15 (100)



ABBREVIATIONS

AFFF	Aqueous Film Forming Foam
EFF	Effluent
INF	Influent
HI	Hazard Index
PAL	Project Action Level
PFBS	Perfluorobutane sulfonate
PFHpA	Perfluoroheptanoic acid
PFHpS	Perfluoroheptane sulfonate
PFHxS	Perfluorohexane sulfonate
PFNA	Perfluorononanoic acid
PFOS	Perfluorooctane sulfonate
PFOA	Perfluorooctanoic acid
SFC	Surface
SL	Screening level
mg/kg	milligrams per kilogram
µg/L	micrograms per liter
WWTP	Waste Water Treatment Plant

DISCUSSION & SUMMARY

- Detections exceeding the provisional health advisory SLs for drinking water from WWTP influent and effluent at Site A indicate the need for determining the source. Potential areas of concern include:
 - Maintenance hangars and fire stations that stored AFFF and associated equipment
 - Main runways covered with AFFF prior to crash landing of aircraft unable to fully extend landing gear
- Decreased detections of PFOS and PFOA at Site B are likely affected by groundwater remediation efforts.
- Site C surface water samples collected adjacent to an equipment calibration area exceeded PALs indicating a continuing source.
- Perfluorohexanesulfonate was detected in groundwater above 0.2 µg/L at both Sites A and C. Even though this is a short chain PFC, given the long elimination half life, we recommend that this PFC be analyzed for in media at potential AFFF release sites.
 - PFHxS is detected in >99.9% of Biomonitoring California Study participants from two different studies.
- Hazard for PFOS and PFOA in groundwater at these sites do not exceed a HI of 1, but given that most of these sites have other contaminants, the HI for all site contaminants could exceed 1.

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DISCLAIMER

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