PFAS FATE & TRANSPORT
APRIL 18, 2019

PLEASE NOTE

IF YOU ARE JOINING TODAY'S PRESENTATION VIA THE WISLINE AUDIO CONFERENCE

(1-855-947-8255), PLEASE HANG UP AND JOIN VIA THIS **ALTERNATE NUMBER**:

1- 866-715-6499 / **PASSCODE: 4428 6018 50#** TO PARTICIPATE IN THE MEETING.

THE WISLINE AUDIO CONFERENCE LINE WILL REMAIN **MUTED** THROUGHOUT

THE PRESENTATION TO AVOID FEEDBACK WITH THE SKYPE PRESENTATION AND AUDIO.

THE MEETING WILL BEGIN MOMENTARILY

PFAS
FATE AND TRANSPORT SUBGROUP MEETING

APRIL 18TH, 2019

OVERVIEW

A. ITRC FATE AND TRANSPORT FACT SHEET

B. TECHNICAL DOCUMENT OUTLINE FROM ITRC'S CURRENT WORK EFFORT – SELECT CHAPTERS

C. IDENTIFICATION AND STRATEGY FOR FUTURE SUBGROUP TOPICS

A. REVIEW OF ITRC FATE AND TRANSPORT FACT SHEET

1. MAJOR SOURCES
    1) AFFF
    2) INDUSTRIAL
    3) LANDFILLS
    4) WWTP
2. FATE AND TRANSPORT
    1) PARTITIONING
    2) TRANSPORT
    3) PFAS TRANSFORMATION
3. PFAS OCCURRENCE BY MEDIUM
    1) AIR
    2) SOIL AND SEDIMENT
    3) GROUNDWATER
    4) SURFACE WATER
    5) BIOTA AND BIOACCUMULATION

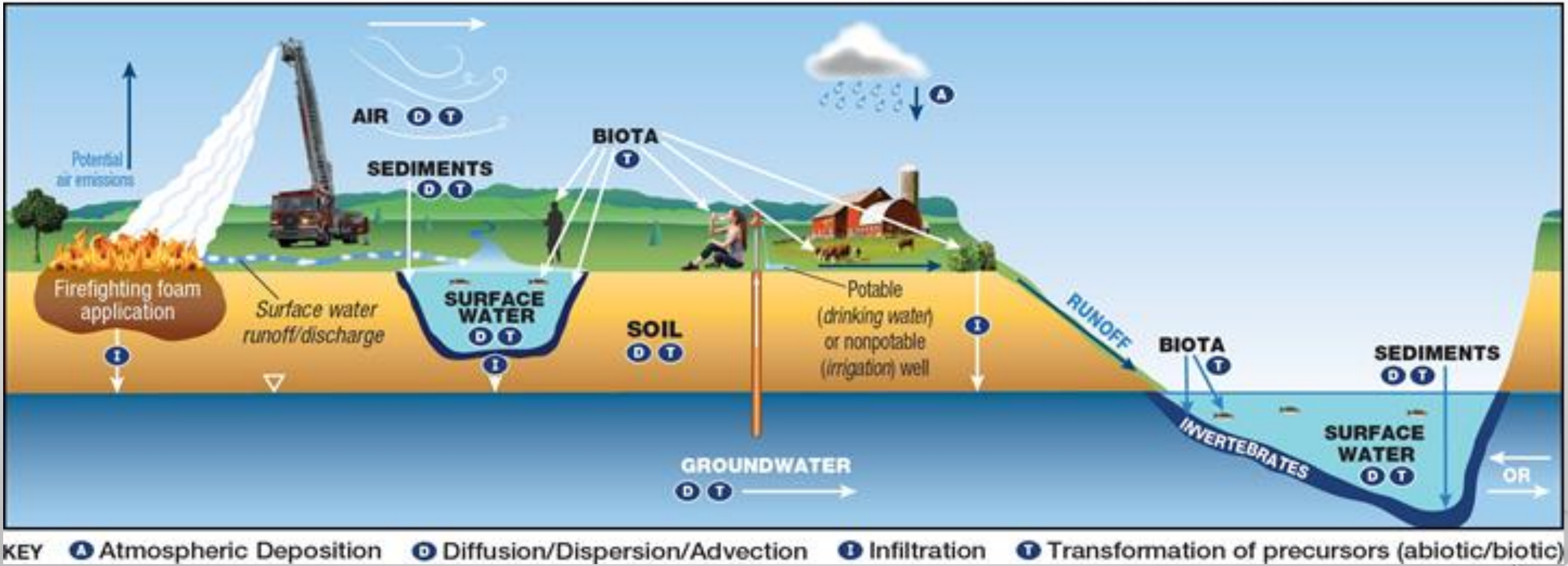
1. MAJOR SOURCES

1)AFFF
2)INDUSTRIAL
3)LANDFILLS
4)WWTP

1.1 MAJOR SOURCES – AFFF RELEASES

- FIRE-TRAINING AREAS
- USE AT MILITARY AND CIVILIAN FACILITIES
- PAST EMERGENCY RESPONSE INCIDENTS
- OPERATIONAL REQUIREMENTS THAT MANDATED PERIODIC EQUIPMENT CALIBRATIONS ON EMERGENCY VEHICLES
- EPISODIC DISCHARGE FROM FIRE SUPPRESSION SYSTEMS WITHIN LARGE AIRCRAFT HANGARS AND BUILDINGS.
- ACCIDENTAL RELEASES FROM STORAGE TANKS, RAILCARS, AND PIPING DURING DELIVERY OR TRANSFER.

1.1 MAJOR SOURCES – AFFF



1.1 MAJOR SOURCES - AFFF

DISCHARGE MECHANISMS

1)FOAM APPLICATION

2)SURFACE WATER RUNOFF/DISCHARGE

3)POTENTIAL AIR DISCHARGE

1.1 MAJOR SOURCES - AFFF

AFFECTED MEDIA

1)SOIL

2)SURFACE WATER

3)GROUNDWATER

4)AIR

5)SEDIMENTS

1.1 MAJOR SOURCES - AFFF

AFFF FORMULATIONS IS HIGHLY VARIABLE

- THE FLUOROSURFACTANTS IN AFFF FORMULATIONS PRODUCED BY:
  - ELECTROCHEMICAL FLUORINATION (ECF) PROCESS OR
  - THE FLUOROTELOMERIZATION PROCESS.

- BOTH ECF-DERIVED AND TELOMER-DERIVED AFFF CONTAIN HIGHLY DIVERSE MIXTURES OF PFAS.

1.1 MAJOR SOURCES - AFFF

- ELECTROCHEMICAL FLUORINATION (ECF) PROCESS
    - PFAS MIXTURE DOMINATED BY PERFLUOROALKYL ACIDS (PFAAS)
        - PERFLUOROALKYL SULFONATE (PFSA) HOMOLOGUES
        - PERFLUOROALKYL CARBOXYLATE (PFCA) HOMOLOGUES
- THE FLUOROTELOMERIZATION PROCESS
    - DOMINATED BY POLYFLUORINATED COMPOUNDS WITH LESSER AMOUNTS OF PFAAS

1.1 MAJOR SOURCES - AFFF

- ECF-BASED AFFF IS THE DOMINANT SOURCE AT AFFF-IMPACTED SITES DUE TO
  - LONGER PERIOD OF ECF-BASED AFFF USE AND
  - RELATIVE COINCIDENCE OF IMPLEMENTATION OF ENGINEERING CONTROLS FOR RELEASES AND WIDER USE OF TELOMERIZED AFFF

- FLUOROTELOMERIZATION-DERIVED AFFFS ARE STILL MANUFACTURED AND USED IN USA BUT REFORMULATED TO LIMIT LONG-CHAIN PFAS.

1.1 MAJOR SOURCES - AFFF

- AFFF-IMPACTED SITES OFTEN ARE ALSO CONTAMINATED WITH PETROLEUM HYDROCARBONS FROM UNBURNED FUEL.
- PFAS AND HYDROCARBON PLUMES MAY FOLLOW SAME FLOW PATHS, THOUGH EXTENT OF CONTAMINATION MAY BE SIGNIFICANTLY DIFFERENT.
- THESE CO-CONTAMINANTS, PARTICULARLY LIGHT NONAQUEOUS PHASE LIQUIDS (LNAPLS), MAY AFFECT THE FATE AND TRANSPORT OF AFFF-DERIVED PFAS.
- CERTAIN AIR-BASED OR IN SITU OXIDATION REMEDIAL ACTIVITIES AIMED AT TREATING CO-CONTAMINANTS MAY AFFECT PFAS COMPOSITION, FATE, AND TRANSPORT.
- ADDITIONALLY, THE ALTERED SOIL AND GROUNDWATER GEOCHEMISTRY AND REDOX CONDITIONS MAY RESULT IN OXIDATION OF SOME PFAS PRECURSOR COMPOUNDS, DEGRADING THEM TO TERMINAL PFAAS .

REMINDER

IF YOU ARE JOINING TODAY'S PRESENTATION VIA THE WISLINE AUDIO CONFERENCE

(1-855-947-8255), PLEASE HANG UP AND JOIN VIA THIS **ALTERNATE NUMBER**:

1- 866-715-6499 / **PASSCODE: 4428 6018 50#** TO PARTICIPATE IN THE MEETING.

THE WISLINE AUDIO CONFERENCE LINE WILL REMAIN **MUTED** THROUGHOUT

THE PRESENTATION TO AVOID FEEDBACK WITH THE SKYPE PRESENTATION AND AUDIO.

THE MEETING WILL BEGIN MOMENTARILY

1.2 MAJOR SOURCES – INDUSTRIAL RELEASES

- PRIMARY MANUFACTURING FACILITIES
  - WHERE PFAS-CONTAINING PRODUCTS ARE SYNTHESIZED AND MADE INTO PRODUCTS OR CHEMICAL FEEDSTOCKS
  - WHERE PFAS ARE USED AS PROCESSING AIDS IN FLUOROPOLYMER PRODUCTION (WHERE PFAS ARE NOT INTENDED TO BE IN THE FINAL PRODUCT).
- SECONDARY MANUFACTURING FACILITIES
  - USE THESE PRODUCTS OR FEEDSTOCKS AS PART OF INDUSTRIAL PROCESSES, SUCH AS THE COATING APPLICATION TO FINISHED PRODUCTS.

- MAY BE USED FOR WORKER SAFETY PURPOSES - USING PFOS-BASED MATERIALS TO SUPPRESS HARMFUL MISTS.

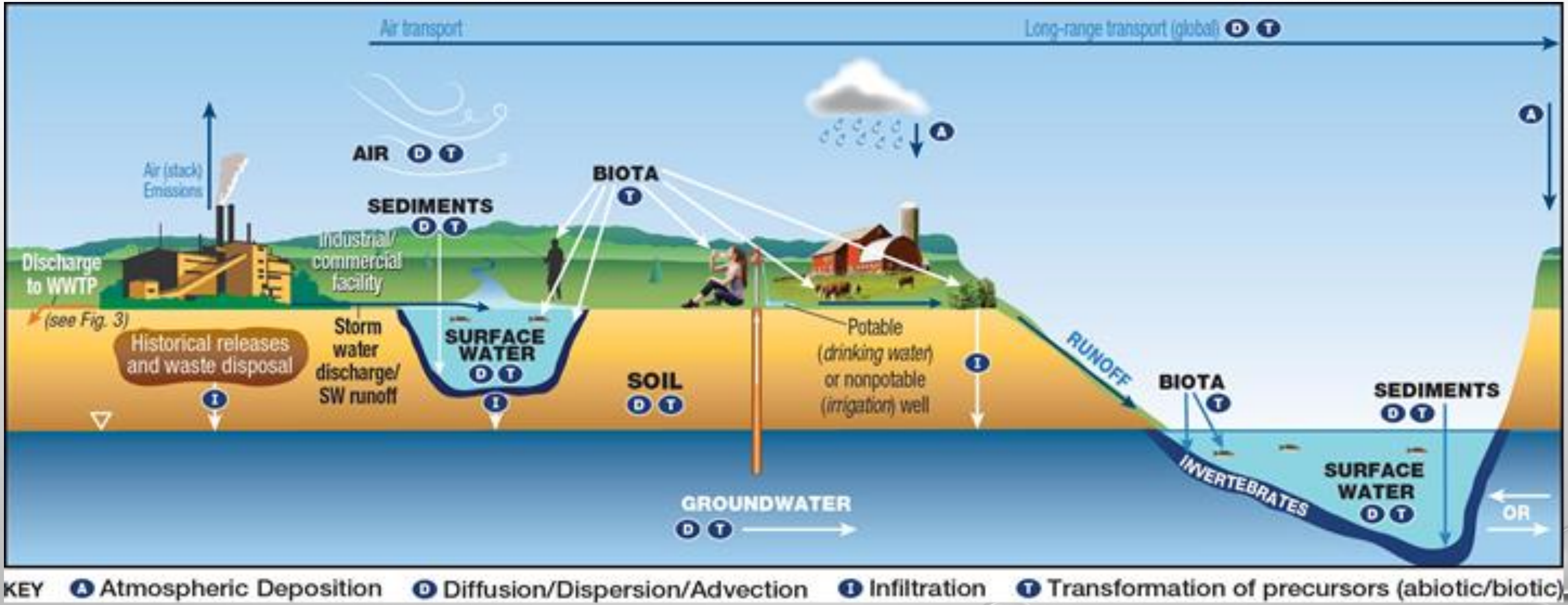
1.2 MAJOR SOURCES – INDUSTRIAL RELEASES

MANUFACTURING FACILITIES THAT MAY BE SOURCES INCLUDE:

- TEXTILE AND LEATHER PROCESSORS
- PAPER MILLS
- METAL FINISHERS
- WIRE MANUFACTURERS
- PLATING FACILITIES
- MANUFACTURERS

- FACILITIES USING
  - SURFACTANTS
  - RESINS
  - MOLDS
  - PLASTICS
  - PHOTOLITHOGRAPHY
  - SEMICONDUCTORS

1.2 MAJOR SOURCES - INDUSTRIAL



1.2 MAJOR SOURCES - INDUSTRIAL

DISCHARGE MECHANISMS

1) INDUSTRIAL RELEASES AND WASTE DISPOSAL
2) DISCHARGE TO WWTP
3) STORM WATER DISCHARGE/SURFACE WATER RUNOFF
4) AIR STACK EMISSIONS

1.2 MAJOR SOURCES – INDUSTRIAL – STACK EMISSIONS

- MAY RESULT IN AERIAL DEPOSITION OF PFAS TO SOIL AND SURFACE WATER (WITH SUBSEQUENT INFILTRATION TO GROUNDWATER) WITHIN THE AIRSHED OF THE FACILITY.
- MAY RESULT IN SHORT- AND LONG-RANGE AIR TRANSPORT OF PFAS.
- PFAS IN AEROSOLS AND ADSORBED ON PARTICLES ARE MORE LIKELY TO BE DEPOSITED NEAR THE SOURCE
- LONG-RANGE TRANSPORT TYPICALLY INVOLVES PFAS VAPORS.

1.2 MAJOR SOURCES - INDUSTRIAL

INDUSTRIAL FACILITIES MAY ALSO CONTAIN

- AREAS WHERE FIRE TRAINING OR FIRE RESPONSE HAS OCCURRED
- AFFF STORAGE AREAS
- AFFF FIRE SUPPRESSION SYSTEMS INSIDE BUILDINGS

1.2 MAJOR SOURCES - INDUSTRIAL

AFFECTED MEDIA

1)SOIL

2)SURFACE WATER

3)GROUNDWATER

4)AIR

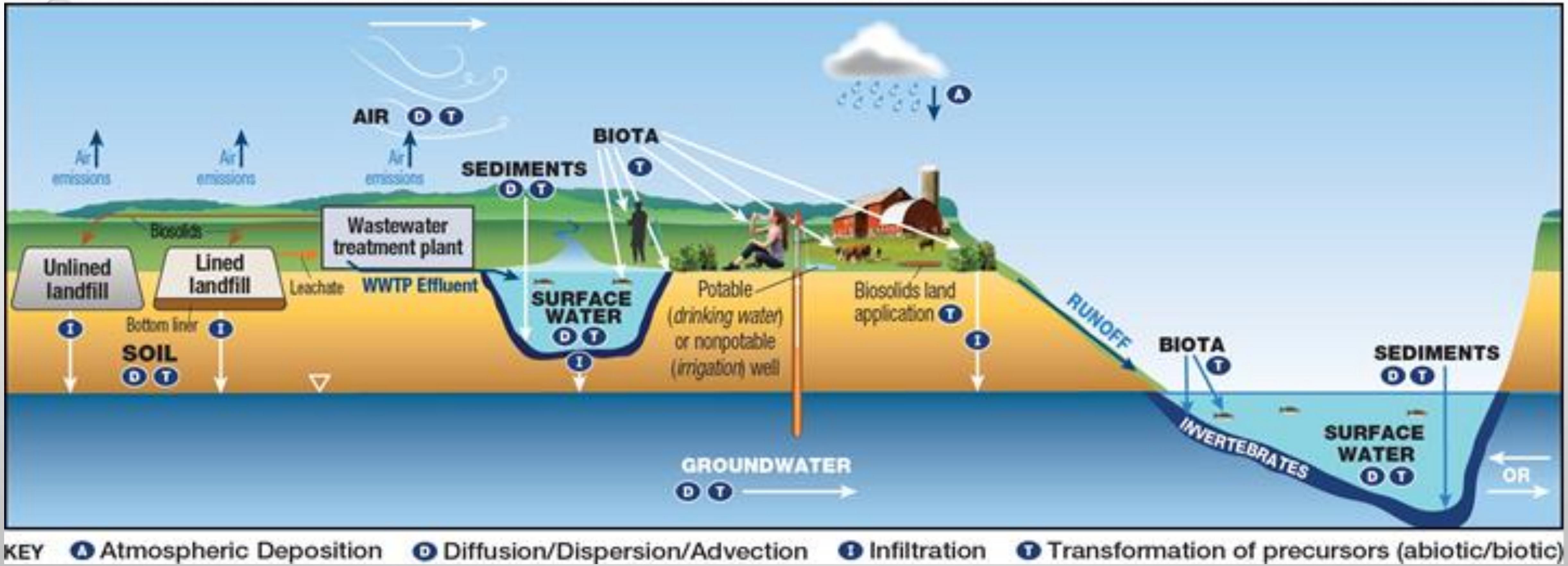
5)SEDIMENTS

1.3 MAJOR SOURCES – LANDFILLS AND WWTP

LANDFILLS ARE ULTIMATE REPOSITORIES FOR

- INDUSTRIAL WASTE PARTICULARLY FROM INDUSTRIES THAT PRODUCE OR APPLY PFAS
- WASTE FROM SITE MITIGATION
- PFAS-BEARING CONSUMER GOODS TREATED WITH HYDROPHOBIC, STAIN-RESISTANT COATINGS.
- SEWAGE SLUDGE FROM WASTEWATER TREATMENT FACILITIES

1.3 MAJOR SOURCES – LANDFILLS AND WWTP



1.3 MAJOR SOURCES – LANDFILLS AND WWTP

DISCHARGE MECHANISMS

1) LANDFILL LEACHATE INTO GROUND
2) WWTP EFFLUENT
3) BIOSOLIDS APPLICATION
4) AIR EMISSIONS

1.3 MAJOR SOURCES – LANDFILL CONSTRUCTION

- POST 1990S LANDFILLS CONSTRUCTED WITH COMPOSITE LINER, A LAYER OF COMPACTED SOIL, AND A LEACHATE COLLECTION SYSTEM (40 CFR 258.40).
- LEACHATE COLLECTED FROM LANDFILLS IS TYPICALLY TREATED ON SITE OR TRANSPORTED TO EITHER A NEARBY MUNICIPAL WWTP OR EVAPORATION PONDS.
- IF LINERS OR LEACHATE COLLECTION SYSTEMS FAIL, PFAS MAY DIRECTLY ENTER THE ENVIRONMENT.

1.3 MAJOR SOURCES – LANDFILL

- RELATIVE CONCENTRATIONS OF PFAS IN LEACHATE AND GROUNDWATER FROM LANDFILLS ARE DIFFERENT THAN THOSE AT WWTPS AND AFFF-CONTAMINATED SITES.
- PFAS WITH FEWER THAN EIGHT CARBONS DOMINATE LANDFILL LEACHATE
  - LESS HYDROPHOBIC
  - MORE LIKELY TO PARTITION TO THE AQUEOUS PHASE.

1.3 MAJOR SOURCES – LANDFILL

- 5:3 FLUOROTELOMER CARBOXYLIC ACID (FTCA) IS COMMON AND OFTEN DOMINANT IN LANDFILLS
- 5:3 FTCA IS RELEASED FROM CARPET IN MODEL ANAEROBIC LANDFILL REACTORS - COULD PROVE TO BE INDICATOR OF PFAS ORIGINATING FROM LANDFILLS.
- PFAS MAY ALSO BE RELEASED TO THE AIR FROM LANDFILLS, PREDOMINANTLY AS FLUOROTELOMER ALCOHOLS (FTOHS) AND PERFLUOROBUTANOATE (PFBA).
- PFAS RELEASE RATES VARY WITH TIME FOR A GIVEN WASTE MASS, WITH CLIMATE (FOR EXAMPLE, RAINFALL) AS THE APPARENT DRIVING FACTOR FOR THE VARIATIONS.

1.4 MAJOR SOURCES – WWTP AND BIOSOLIDS

- PATHWAYS FOR PFAS RELEASES INTO ENVIRONMENT
  - WATER AND PROCESS WASTE DISCHARGE W/O PFAS TREATMENT
  - LAND APPLICATIONS OF BIOSOLIDS
  - SURFACE RUNOFF AND INFILTRATION INTO GROUNDWATER
  - AIR EMISSION AND DEPOSITION

1.4 MAJOR SOURCES – WWTP AND BIOSOLIDS

- A NEED TO INVESTIGATE PFAS COMPOSITIONS
- TYPES AND CONCENTRATIONS OF PFAS RECEIVED BY THE WWTP
- WHEN WWTP INVOLVES BIOLOGICAL AND CHEMICAL PROCESSES, PFAA PRECURSORS CAN BE TRANSFORMED TO INTERMEDIATE AND TERMINAL DEGRADATION PRODUCTS, INCLUDING PFAAS
- INVESTIGATE INFLUENT AND EFFLUENT OF EACH TREATMENT PROCESS

1.4 MAJOR SOURCES – WWTP MONITORING

- INFLUENT, INTERMEDIATE AND EFFLUENT OF EACH WWTP TREATMENT FLOW PROCESS
- COLLECT, MONITOR AND MANAGE WASTE STREAMS GENERATED FROM TREATMENT PROCESSES THAT CAN CONCENTRATE PFAS, FOR INSTANCE:
  - OFF-GAS AND OFF-GAS TREATMENT SYSTEM
  - SLUDGE AND BIOSOLIDS
  - SPENT MEDIA
  - LIQUID WASTES
- OUTFALL DISCHARGE POINTS
- SURFACE RUNOFF AND DRAINAGE CHANNELS FOR SURFACE WATER, SEDIMENT, AND GROUNDWATER
- RETENTION BASINS

2. FATE AND TRANSPORT

1) PARTITIONING
2) TRANSPORT
3) PFAS TRANSFORMATION

2.2 FATE AND TRANSPORT- PARTITIONING

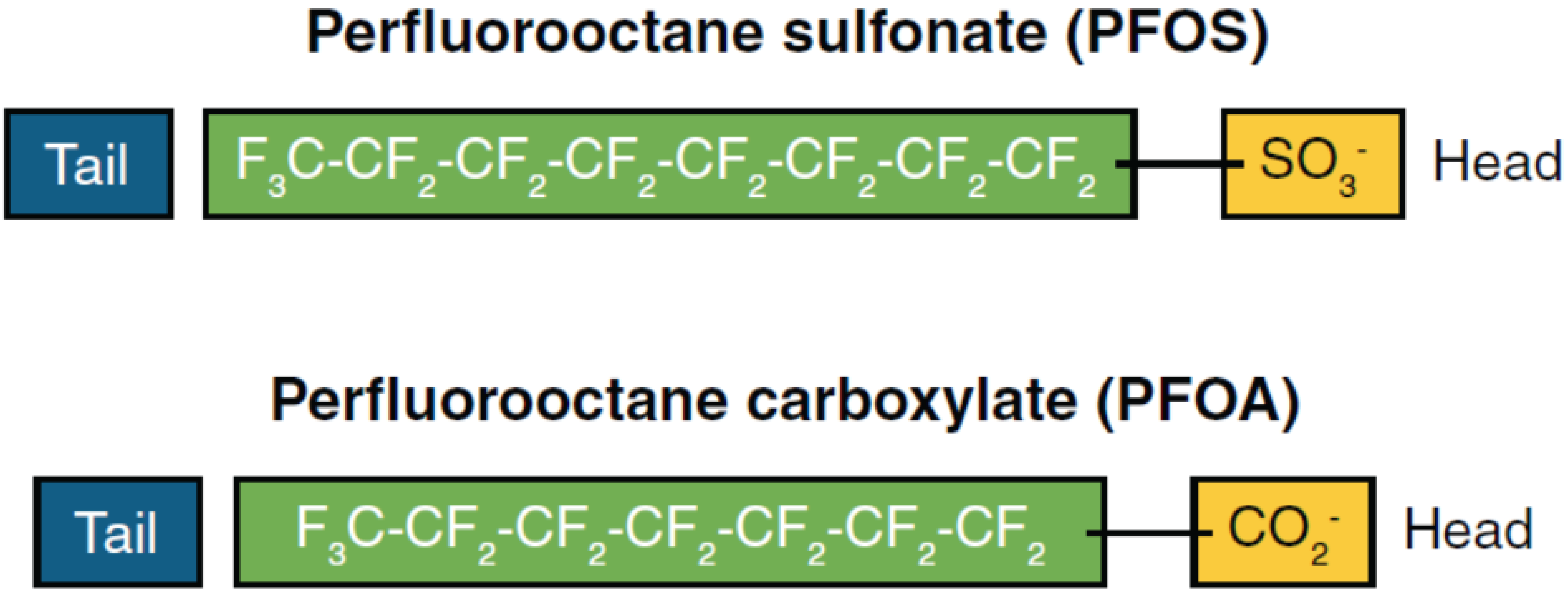


Figure 4. The tail and head structure of PFOS and PFOA molecules.

Carbon-fluorine "tail" and a nonfluorinated "head" consisting of a polar functional group. The tail is hydrophobic and lipophobic, while the head groups are polar and hydrophilic.

2.1 FATE AND TRANSPORT - PARTITIONING

MULTIPLE PARTITIONING MECHANISMS AFFECT PFAS:

- HYDROPHOBIC AND LIPOPHOBIC EFFECTS
- ELECTROSTATIC INTERACTIONS
- INTERFACIAL BEHAVIORS

PFSAS ARE MORE STRONGLY SORBED THAN THEIR PFCA HOMOLOGUES.

LONGER CHAIN PFAAS ARE MORE STRONGLY SORBED THAN SHORTER CHAIN PFAAS.

2.1 FATE AND TRANSPORT - PARTITIONING

PFAAS ARE:

- RELATIVELY MOBILE IN GROUNDWATER BUT TEND TO ASSOCIATE WITH THE ORGANIC CARBON FRACTION OF SOIL AND SEDIMENT;
- LESS VOLATILE THAN MANY OTHER GROUNDWATER CONTAMINANTS;
- SOMETIMES TRANSPORTED ON AIRBORNE PARTICLES; AND
- GENERATED BY TRANSFORMATION OF VOLATILE PRECURSORS.

2.2 FATE AND TRANSPORT- TRANSPORT

1) ADVECTION, DISPERSION, DIFFUSION
2) DEPOSITION
3) LEACHING
4) SURFACTANT PROPERTIES AND MICELLE FORMATION

2.2 FATE AND TRANSPORT- TRANSPORT

- CRITICAL PFAS TRANSPORT PROCESSES INCLUDE: ADVECTION, DISPERSION, DIFFUSION, ATMOSPHERIC DEPOSITION, AND LEACHING.
- ATMOSPHERIC TRANSPORT AND SUBSEQUENT DEPOSITION CAN LEAD TO MEASURABLE PFAS ACCUMULATION AWAY FROM THEIR POINT OF RELEASE.
- DOWNWARD LEACHING OF PFAS IN UNSATURATED SOILS DURING PRECIPITATION OR IRRIGATION EVENTS IS SITE SPECIFIC AND OCCURS AS A FUNCTION OF MEDIA AND PFAS STRUCTURAL PROPERTIES.
- AT HIGH CONCENTRATIONS PFAAS CAN FORM MICELLES, WHICH COULD ENHANCE OR REDUCE ADSORPTION ON CARBON AND MINERALS.

2.2 FATE AND TRANSPORT- TRANSPORT

- WHAT IS A MICELLE?
- AN AGGREGATE OF MOLECULES IN A COLLOIDAL SOLUTION, SUCH AS THOSE FORMED BY DETERGENTS.
- A MICELLE IS AN AGGREGATE (OR SUPRAMOLECULAR ASSEMBLY) OF SURFACTANT MOLECULES DISPERSED IN A LIQUID COLLOID. A TYPICAL MICELLE IN AQUEOUS SOLUTION FORMS AN AGGREGATE WITH THE HYDROPHILIC "HEAD" REGIONS IN CONTACT WITH SURROUNDING SOLVENT, SEQUESTERING THE HYDROPHOBIC SINGLE-TAIL REGIONS IN THE MICELLE CENTRE. THIS PHASE IS CAUSED BY THE PACKING BEHAVIOR OF SINGLE-TAIL LIPIDS IN A BILAYER. THE DIFFICULTY FILLING ALL THE VOLUME OF THE INTERIOR OF A BILAYER, WHILE ACCOMMODATING THE AREA PER HEAD GROUP FORCED ON THE MOLECULE BY THE HYDRATION OF THE LIPID HEAD GROUP, LEADS TO THE FORMATION OF THE MICELLE. MICELLES ARE APPROXIMATELY SPHERICAL IN SHAPE. THE SHAPE AND SIZE OF A MICELLE ARE A FUNCTION OF THE MOLECULAR GEOMETRY OF ITS SURFACTANT MOLECULES AND SOLUTION CONDITIONS SUCH AS SURFACTANT CONCENTRATION, TEMPERATURE, PH, AND IONIC STRENGTH. THE PROCESS OF FORMING MICELLES IS KNOWN AS MICELLISATION AND FORMS PART OF THE PHASE BEHAVIOUR OF MANY LIPIDS ACCORDING TO THEIR POLYMORPHISM.[4]
- HTTPS://WWW.BING.COM/VIDEOS/SEARCH?Q=MICELLE&&VIEW=DETAIL&MID=5F02BF34E815ED4D82D55F02BF34E815ED4D82D5&&FORM=VDRVRV

2.2 FATE AND TRANSPORT- TRANSPORT

- AT HIGHER CONCENTRATIONS, PFAAS CAN FORM AGGREGATES IN WHICH THE HYDROPHILIC PORTIONS INTERACT WITH THE WATER PHASE AND THE HYDROPHOBIC PORTIONS INTERACT WITH EACH OTHER (FOR EXAMPLE, MICELLES OR HEMIMICELLES).
- FOR PFOS, THE CRITICAL MICELLE CONCENTRATIONS (CMC) OF 500 TO 5,000 MG/L HAVE BEEN REPORTED, BUT HEMIMICELLES MAY FORM AT CONCENTRATIONS AS LOW AS 0.001 TIMES THE CMC.
- THIS TENDENCY TO AGGREGATE MAY CAUSE PFAAS TO ACT DIFFERENTLY AT HIGH CONCENTRATIONS (FOR EXAMPLE, DURING RELEASE) AND COULD ENHANCE (OR IN SOME CASES REDUCE) ADSORPTION ON CARBON AND MINERALS IN THE ENVIRONMENT.

2.3 FATE AND TRANSPORT – PFAS TRANSFORMATION

1) PFAS TRANSFORMATION
2) ABIOTIC TRANSFORMATION
3) BIOTIC TRANSFORMATION

2.3 FATE AND TRANSPORT- TRANSFORMATION

- PFAS PRECURSOR CHEMICALS CAN TRANSFORM TO PFAAS VIA BIOTIC AND ABIOTIC PROCESSES.
- TRANSFORMATION RATES ARE HIGHLY VARIABLE AND SITE SPECIFIC.
- PFAAS ARE NOT KNOWN TO TRANSFORM UNDER AMBIENT ENVIRONMENTAL CONDITIONS.

3. PFAS OCCURRENCE BY MEDIUM

1) AIR
2) SOIL AND SEDIMENT
3) GROUNDWATER
4) SURFACE WATER
5) BIOTA AND BIOACCUMULATION
   a. PLANTS
   b. INVERTEBRATES
   c. FISH
   d. HUMANS

3. PFAS OCCURRENCE BY MEDIUM

- PFAS FOUND IN MEDIA BECAUSE OF TYPES OF ACTIONS
- SOURCES
- SPECIFIC PFAS CHEMISTRY OF CERTAIN MEDIA AND SOURCES
- REFERENCES TO INFORMATION SOURCES/RESEARCH PAPERS

3. PFAS OCCURRENCE BY MEDIUM

Table 4.3 Observed PFAS concentrations in groundwater

Location	Information	Concentrations (µg/L)
Various – New Jersey (NJ DEP 2014)	One or more PFAS detected in 19 of 21 untreated groundwater samples from drinking water treatment plants across the state; PFOA was detected in 7 and PFOS was detected in 5 of the 21 samples.	• PFOA: 0.009 – 0.057 • PFOS: 0.005 – 0.012
AFFF release sites other than fire training areas (Anderson et al. 2016)	Tested 149 groundwater samples; most commonly detected PFAAs: PFHxS (95%); PFHxA (94%), PFOA (90%), PFPeA (88%), PFBA and PFHpA (85%), PFOS (84%). The frequency of detections for PFSAs in groundwater was generally higher than those of PFCAs which has been attributed to the use of specific AFFF formulations.	Median (Maximum): • PFHxS: 0.87 (290) • PFHxA: 0.82 (120) • PFOS: 4.22 (4,300) • PFOA: 0.405 (250) • PFPeA: 0.53 (66) • PFBA: 0.18 (64) • PFHpA: 0.235 (75)
Fire Training/Fire Response (Moody and Field 1999; Moody et al. 2003; Houtz et al. 2013)	Studies at U.S. military installations and other AFFF release areas have documented relatively high detection frequencies of PFAAs in underlying groundwater.	Maximum: • PFOA: 6,570 • PFOS: 2,300

B. TECHNICAL DOCUMENT OUTLINES FROM ITRC'S CURRENT WORK EFFORT

- TABLE OF CONTENTS OVERVIEW
- CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES
- CH 6 – MEDIA-SPECIFIC OCCURRENCE
- CH 10 - SITE CHARACTERIZATION

CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

5.1 INTRODUCTION

- 5.1.1 OVERVIEW OF PFAS FATE AND TRANSPORT
- 5.1.2 FACTORS AFFECTING PFAS FATE AND TRANSPORT

CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

5.2 PHASE PARTITIONING

- 5.2.1 INTRODUCTION (IMPORTANCE IN FATE AND TRANSPORT, COMPLEXITIES, EFFECTS OF ENVIRONMENTAL VARIABLES)
- 5.2.2 PARTITIONING IN WATER
- 5.2.3 PARTITIONING TO SOLID PHASES
- 5.2.4 PARTITIONING TO AIR
- 5.2.5 PARTITIONING TO AIR/WATER INTERFACES
- 5.2.6 NAPL AS CO-CONTAMINANT

CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

5.3 MEDIA-SPECIFIC MIGRATION PROCESSES

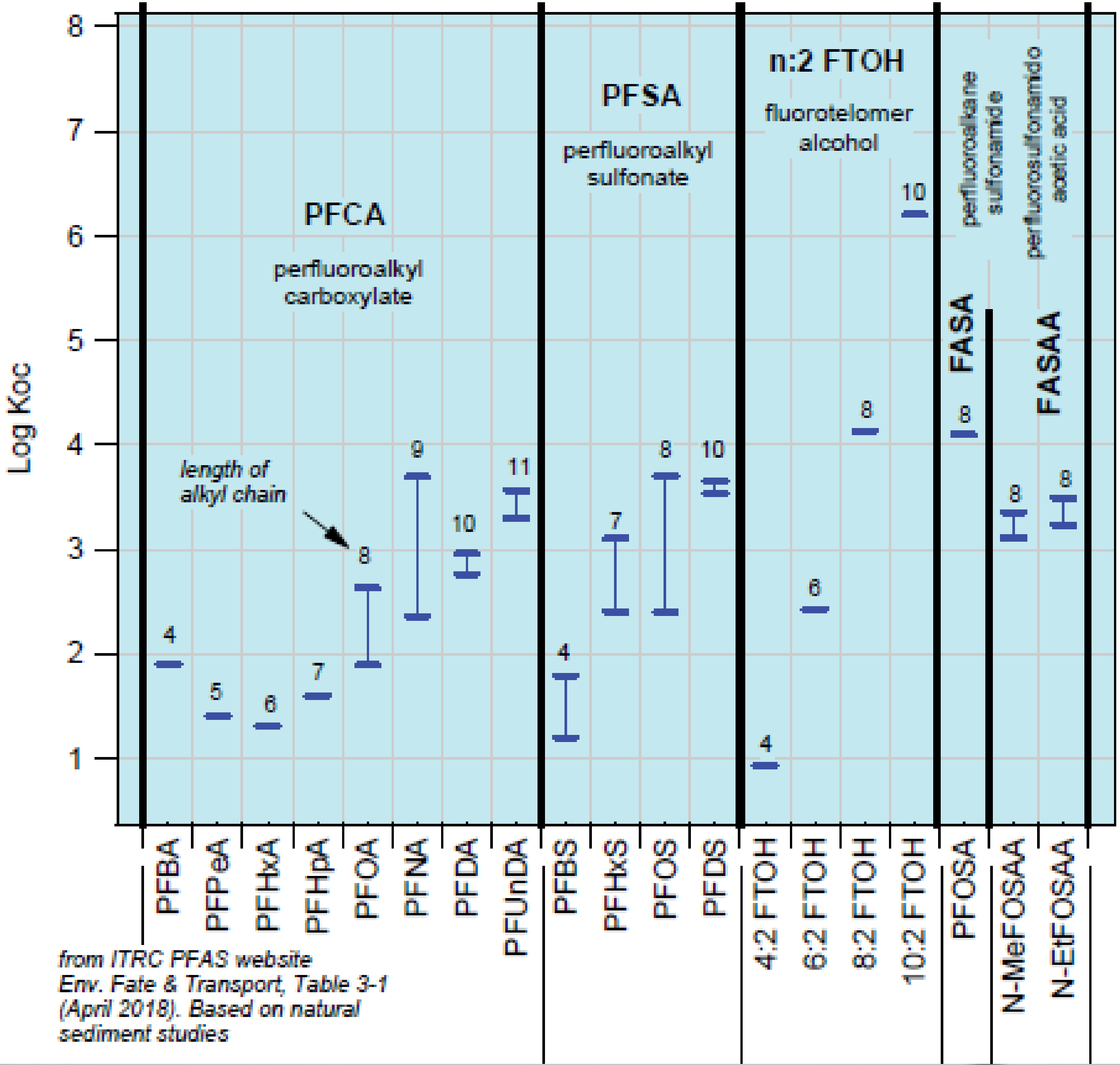
- 5.3.1 DIFFUSION IN AND OUT OF LOWER-PERMEABILITY MATERIALS
- 5.3.2 PFAS TRANSPORT VIA AIR
- 5.3.3 LEACHING

CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

- 5.4 TRANSFORMATIONS
  - 5.4.1 INTRODUCTION
  - 5.4.2 PFAA PRECURSORS
  - 5.4.3 ATMOSPHERIC TRANSFORMATIONS
  - 5.4.4 IN SITU TRANSFORMATIONS
  - 5.4.5 POLYMER TRANSFORMATION
  - 5.4.6 PRACTICAL IMPLICATIONS

CH 5 - ENVIRONMENTAL FATE AND TRANSPORT PROCESSES

- 5.5 PFAS UPTAKE INTO AQUATIC ORGANISMS
  - 5.5.1 BIOCONCENTRATION
  - 5.5.2 BIOACCUMULATION
  - 5.5.3 BIOMAGNIFICATION
- 5.6 PFAS UPTAKE INTO PLANTS
  - 5.6.1 BIOCONCENTRATION



from ITRC PFAS website Env. Fate & Transport, Table 3-1 (April 2018). Based on natural sediment studies

CH 6 MEDIA-SPECIFIC OCCURRENCE

6.1 AIR

6.2 SOIL AND SEDIMENT

6.3 GROUNDWATER

6.4 SURFACE WATER

6.5 BIOTA – FISH AND WILDLIFE

6.5.1 PLANTS

6.5.2 INVERTEBRATES

6.5.3 FISH

6.5.4 VERTEBRATES

CH 10 – SITE CHARACTERIZATION

10.1 SITE CHARACTERIZATION ISSUES RELEVANT TO PFAS

10.2 INITIAL STEPS

- 10.2.1 INITIAL CONCEPTUAL SITE MODEL
- 10.2.2 RECEPTOR IDENTIFICATION
- 10.2.3 SURFACE WATER BODY SECONDARY SOURCES

CH 10 – SITE CHARACTERIZATION

10.3 SITE INVESTIGATION

- 10.3.1 DEVELOPMENT OF SITE INVESTIGATION WORK PLAN
- 10.3.2 NATURE OF PFAS SOURCES
- 10.3.3 EXTENT OF PFAS SOURCES

CH 10 – SITE CHARACTERIZATION

10.4 DATA ANALYSIS AND INTERPRETATION

- 10.4.1 RETARDATION COEFFICIENTS AND TRAVEL TIME
- 10.4.2 MASS FLUX/MASS DISCHARGE
- 10.4.3 CONTRIBUTIONS FROM DIFFERENT SOURCES
- 10.4.4 TRANSFORMATION PATHWAYS AND RATES
- 10.4.5 ASSESSING PLUME STABILITY
- 10.4.6 MODELING PFAS FATE AND TRANSPORT
- 10.4.7 VISUALIZATION METHODS

CH 10 – SITE CHARACTERIZATION

10.5 SOURCE IDENTIFICATION

- 10.5.1 SOURCE IDENTIFICATION TOOLS
- 10.5.2 CHALLENGES AND REASONABLE EXPECTATIONS

SCREENING FOR TOTAL PFAS

- LIMITED PFAA PRECURSORS CAN BE CHARACTERIZED USING USEPA 537 OR USEPA 537 MOD METHODS
- TOP *(TOTAL OXIDIZABLE PRECURSORS)* ASSAY IS NOT AN USEPA METHOD BUT IS COMMERCIALLY AVAILABLE
  - PFAA PRECURSORS ARE OXIDIZED ABIOTICALLY TO PFCAS ONLY
  - TOP DOES NOT CLOSE PFAS MASS BALANCE
  - TOP DATA DO NOT IDENTIFY THE ORIGINS OF PRECURSORS
  - TOP DATA DO NOT REPRESENT BIOTRANSFORMATION UNDER NATURAL CONDITIONS
  - BUT… IT IS THE ONLY COMMERCIALIZED **SCREENING TOOL** TO CHECK ON THE PRESENCE OF PFAA PRECURSORS

C. IDENTIFICATION AND STRATEGY FOR FUTURE SUBGROUP TOPICS

1)Sources plus Fate and Transport
2)Risk Communication and Toxicology
3)Analytical methods/sampling methodology

C. IDENTIFICATION AND STRATEGY FOR FUTURE SUBGROUP TOPICS

1) Sources plus Fate and Transport
2) Risk Communication and Toxicology
3) Analytical methods/sampling methodology
4) Brownfield Redevelopment Concerns
5) Remediation

SOURCES PLUS FATE AND TRANSPORT

a. SOURCE IDENTIFICATION

b. COMPOUNDS – WHICH COMPOUNDS ARE ATTRIBUTABLE TO WHICH SOURCES

c. CONCEPTUAL SITE MODELS

   i. WHAT ARE KEY DISCHARGE MECHANISMS FOR VARIOUS SOURCES

   ii. PRIMARY MIGRATION MECHANISMS FOR PFAS CONTAMINANTS

d. SCOPING INVESTIGATION - DEFINING NATURE AND EXTENT

e. NR 716.07 REQUIREMENTS FOR INCLUDING PFAS IN SITE INVESTIGATION

f. ASTM PHASE I REQUIREMENTS VS VPLE REQUIREMENTS

SOURCES PLUS FATE AND TRANSPORT

a. SCOPING INVESTIGATION - DEFINING NATURE AND EXTENT
   i. GROUNDWATER
   ii. SOIL
   iii. SEDIMENT
   iv. SURFACE WATER
   v. OTHER
b. NR 716.07 REQUIREMENTS FOR INCLUDING PFAS IN SITE INVESTIGATION
c. ASTM PHASE I REQUIREMENTS VS VPLE REQUIREMENTS

BROWNFIELD REDEVELOPMENT CONCERNS

CONCERNS

- LENDER HESITANCY
- BUYER RELUCTANCE
- UNKNOWN REQUIREMENTS
- DIFFICULTY ESTIMATING/PROJECTING RESPONSE ACTION COSTS
- DEVELOPMENT DELAYS RESULTING FROM REQUIRED SI/RA ACTIONS
- LIABILITY UNCERTAINTY

POTENTIAL FIXES

- LEGISLATIVE INITIATIVES
- STANDARD SETTING

COST RECOVERY PLAN

- ENVIRONMENTAL INSURANCE MARKET

.

REMEDIATION

EVALUATION OF REMEDIAL OPTIONS

- REMOVAL
- DESTRUCTION

RISK COMMUNICATION AND TOXICOLOGY

- RISK COMMUNICATION AND ENGAGEMENT
  - FISH ADVISORY
  - ENVIRONMENTAL JUSTICE
- TOXICOLOGY
  - FISH TISSUE
  - RISK ASSESSMENT
  - POPULATION ID
  - EXPOSURE

ANALYTICAL METHODS/SAMPLING METHODOLOGY

- LAB CERT PROGRAM
  - SAMPLE PARAMETER LIST – TOTAL FLUORINE?
  - COMPOUND NAMING CONVENTIONS
  - ANALYTICAL METHODS – LAB CERTS, QA/QC
- SAMPLING PROTOCOLS
  - COLLECTION METHODS
  - QA/QC

PFAS TECHNICAL ADVISORY GROUP MEETING

MAY 31, 2019

10:00-1:00

ROOM G09 IN GEF 2, MADISON