wood.

PFAS Site Inspection

A North Carolina Case Study

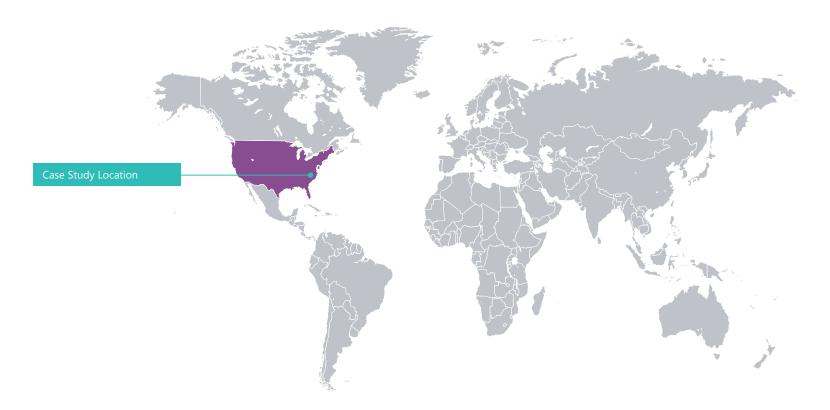
Presented by: Helen Corley Wood Environment & Infrastructure Charlotte, North Carolina Helen.corley@woodplc.com



woodplc.com

Site Location





Site Aerial





Environmental Protection Agency



1996 Safe Drinking Water Act (SDWA)

- Requires once every five years EPA issue new list of no more than 30 unregulated contaminants to be monitored by public water systems
 - Third Unregulated Contaminant Monitoring Rule (UCMR3)
 - Published May 2, 2012
 - (28 chemicals and two viruses)
 - Included Six Perfluorinated Compounds
- Drinking Water Health Advisory
 - Published May 19, 2016



Six Perfluorinated Compounds - UCMR3

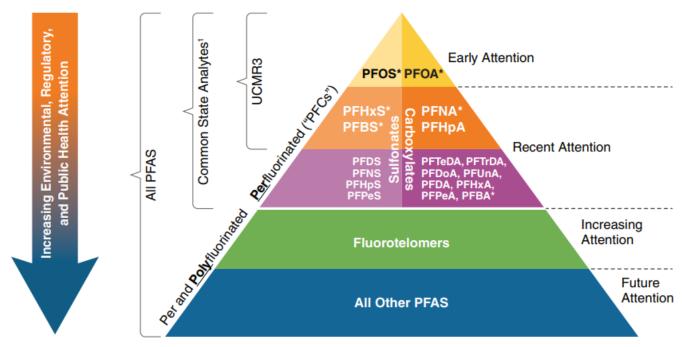


Contaminant	MRL* (µg/L)	Use or Source					
perfluorooctanesulfonic acid (PFOS)	0.04	Surfactant or emulsifier; used in fire-fighting foam, circuit board etching acids, alkaline cleaners, floor polish, and as a pesticide active ingredient for insect bait traps; U.S. manufacture of PFOS phased out in 2002; however, PFOS still generated incidentally					
perfluorooctanoic acid (PFOA)	0.02	Perfluorinated aliphatic carboxylic acid; used for its emulsifier and surfactant properties in or as fluoropolymers (such as Teflon), fire-fighting foams, cleaners, cosmetics, greases and lubricants, paints, polishes, adhesives and photographic films					
perfluorononanoic acid (PFNA)	0.02						
perfluorohexanesulfonic acid (PFHxS)	0.03	Manmade chemical; used in products to make them stain, grease, heat					
perfluoroheptanoic acid (PFHpA)	0.01	and water resistant					
perfluorobutanesulfonic acid (PFBS)	0.09						



PFAS – Increasing Attention





*Common regulatory criteria or health advisories ¹Sum of informal poll (NJ, NH, MN) Thematic and not proportional.

Bottom of triangle indicates additional number of compounds; not a greater quantity by mass, concentration, or frequency of detection.

Original source: J. Hale, Kleinfelder



PFOA and PFOS Health Effects



U.S. Environmental Protection Agency. Health Effects Support Document for PFOS and Health Effects Support Document for PFOA. EPA Document Numbers 822-R-16-002 and 822-R-16-003; 2016.

- "Human epidemiology data report associations between PFOA exposure and high cholesterol, increased liver enzymes, decreased vaccination response, thyroid disorders, pregnancy-induced hypertension and preeclampsia, and cancer (testicular and kidney)."
- "Epidemiology data report associations between PFOS exposure and high cholesterol and reproductive and developmental parameters.... Data also suggest a correlation between higher PFOS levels and decreases in female fecundity and fertility, in addition to decreased body weights in offspring, and other measures of postnatal growth."
- "PFOS is not readily eliminated from humans as evidenced by the estimated average half-life values of 4.1–8.67 years."

Department of Defense – Air National Guard



Installation Restoration Program -> Environmental Restoration Program

Central North Carolina Site



- Site Inspection (2017-2018 Wood)
 - Aqueous Film Forming Foam (AFFF) used at the site since 1993. Used in the Air Force since 1970.
 - Potential Release Locations (PRLs) where AFFF was potentially discharged, stored and where Aircraft Rescue Fire Fighting (ARFF) vehicles were washed

Aqueous Film Forming Foam – A Brief History



The Navy began requiring vessels to carry AFFF in 1967 after 134 sailors died in a fire aboard the USS Forrestal



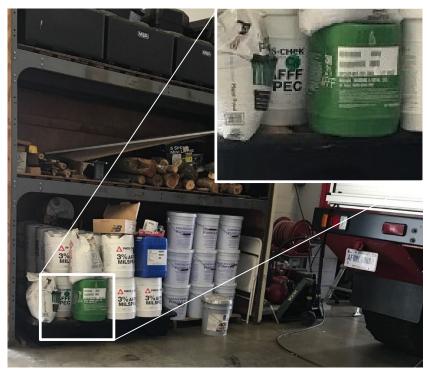
Aqueous Film Forming Foam – A Brief History, cont.

- Developed with 3M and patented by the Navy in 1966
- Creates a thin layer over the surface of the fuel that smothers the flames and prevents release of vapor
- Most efficient extinguishing method for petroleum fires and is widely used across the firefighting industry including commercial airports
- Key Ingredient: fluorinated surfactants





Striker – The most innovative ARFF vehicle in the World

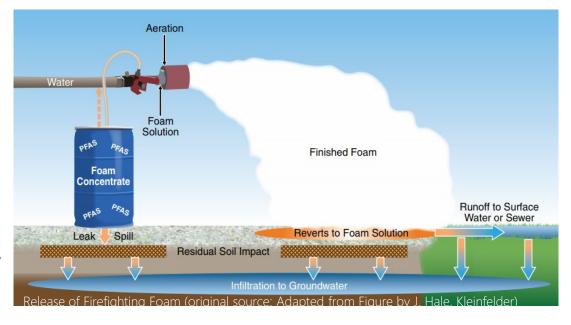






Aqueous Film Forming Foam – Impacts to Soil/Water

- Complex mixture of unidentified PFAS
- Released through:
 - Low volume releases during storage/transfer or equip. calibration
 - Moderate volume release for apparatus testing
 - Occasional high volume broadcast discharge for fire suppression/prevention
 - Periodic high volume broadcast release for fire training
 - Leaks from foam distribution piping between storage and pumping locations
- Thousands of gallons of foam solution may be applied during a given event





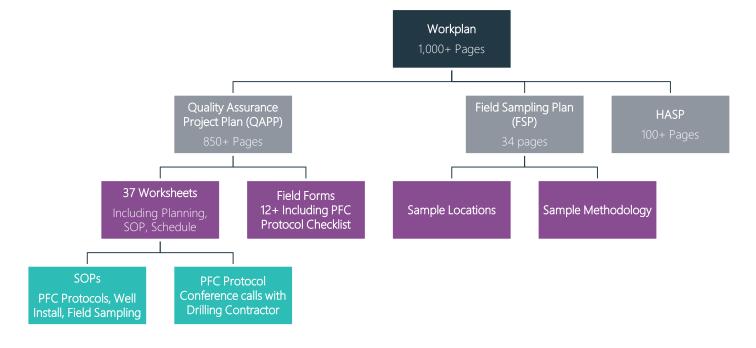
Potential Release Locations of Aqueous Film Forming Foam





Project Preparation





Sampling Considerations



Have SOPs designed to minimize false positive results:

- ✓ No Teflon in sampling pumps, equipment, or sample containers
- ✓ No Gore-Tex, Tyvek, waterproof clothing
- ✓ Natural-based products for sunscreens, bug spray, personal care products
- ✓ Use vegetable oil instead of standard drilling equipment grease
- ✓ Adequate numbers of blanks to monitor contamination
- ✓ Well planned & executed programs can avoid the problems.













Overview of Analytical Methods



- ✓ EPA Method 537
 - ✓ Developed for finished/treated drinking water
- ✓ Modified EPA Method 537
 - ✓ Typically used by commercial laboratories
- ✓ ASTM Method 7979-17
 - ✓ Analysis of environmental solids (soil, sediment, sludge)
- ✓ ASTM Method D7968
 - ✓ Analysis of environmental waters (other than drinking water)
- ✓ Specialty Analyses
 - ✓ Source Fingerprinting
 - ✓ Non-targeted methods to explore unknown compounds
 - Thorr targeted methods to explore unknown cor





Data Collection

- No plastic clipboards, binders or spiral hard cover notebooks
- No adhesives (Post-it® Notes)
- No waterproof field books other than Rite-in-the-Rain® Products
- Utilize Tablets with specialty coded forms for digital data collection
 - Required additional training



Tablet Collected Data Examples



DAILY PFC PROTOCOL CHECK			amec toster wheeler					
oject Name: Phase 1 Regional Site Inspections for Per-Fluorinated Compounds at Multiple Air National Guard Installations	Project Number:	291330006	06					
ntract: W9133L-14-D-0002	Task Order:	0006	0006					
stallation:	Weather							
e Name:	(temp./precipitation):							
eld Manager:		Date and Time:						
Field Clothing and PPE (as applicable):	Sample Containers:							
Field crew in compliance with Tables 1 and 2, SOP AFW-01 Field crew has not used fabric softener on clothing		ners made of HDPE alners made of LDP	or polypropylene. Samples are E					
Field crew has not used cosmetics, moisturizers, hand cream, or other related products or exposed body parts this morning	Caps are lined or	Caps are lined or unlined and made of HDPE or polypropylene						
Field crew has not applied unacceptable sunscreen or insect repellant	Wet Weather (as ap)	olicable):						
Field Equipment:	equipment, wet v	For personnel in direct contact with samples and/or sampling equipment, wet weather gear made of Vinyl, polyurethane, PVC, latex or rubber-coated materials only						
No Teflon® containing materials on-site								
All sample materials made from stainless steel, HDPE, acetate, silicon, or polypropylene		Equipment Decontamination: "PFC-free" water on-site for decontamination of sample equip						
No waterproof field books on-site other than Rite-in-the-Rain [®] Products	,	econtamination materials						
No plastic clipboards, binders, or spiral hard cover notebooks on-site	Food Considerations:							
No adhesives (Post-it® Notes) on-site	No food or drink	n of bottled water and/or						
Coolers filled with regular ice only. No chemical (blue) ice packs in possession		hydration drinks (i.e., Gatorade and Powerade) that is available for consumption only in the staging area						
If any applicable boxes cannot be checked, the Field Manager shall de oncompliance issues prior to commencement of that day's work. Correc- removal of worker offsite until in compliance. Repeated failure to com- the in	tive action shall include remo	val of noncompliance	items from the investigation area					
Describe the noncompliance issues (include personnel not in compliance)	ance) and action/outcome of	noncompliance:	Field Manager Signature:					
			Field Manager Name (print):					
NQC'd by:		QA/QC Date:	L					
Rev. 0. Date: 10/14/2016			Page 1 of					

amec Instea wheeler	SAMPLE COLLECTION LOG SEDIMENT / SURFACE SOIL / SURFACE WATER									
Project Name:	Phase 1 Regional 1 Compounds at Mul	Site Inspections fo	or Per-Pluori Guard Install	nated lations	Project Nu	umber:		291330006		
Contract:	W9133L-14-D-000	12			Task Order: 0006					
Installation: Location ID:					Date: Sample Te	chnician:				
Northing:					Easting:					
				ption						
	NAMI	E (USCS Symbol	color, mois	ture, % by wt. plan	dicity, distanc	y, loughnes	s, dry strengt	h,consistency		
Sample Depth (ft):					Sample ID					
MS/MSD Collected: Duplicate ID:					Sample Da		lme:			
Sample Container Ty	pe(s):				Sample Co	ollection N	lethods:			
Preservative(s):				SURFACE S	Analysis/N					
				Descri	ption					
	NAMI	E (USCS Symbol	color, mois	ture, % by wt, plan	ticity, distanc	y, toughnes	s, dry strengt	h,consistency		
Sample Depth (ft):					Sample ID					
MS/MSD Collected:					Sample Da					
Duplicate ID:					Sample Co					
Sample Container Ty Preservative(s):	pe(s):				Sample Co Analysis/N					
Preservative(s).			5	URFACE WA						
Time	Intake Depth Temp. pH Specific Electrical (feet) (°C) (units) Conductance (mScm)				DO (mg/L)	ORP (mV)	Turbidity (NTU)			
Sample Depth (ft):		-			Sample Da					
Sample ID: MS/MSD Collected:					Sample Co					
Duplicate ID:					Sample Collection Methods: Surface Water Depth (ft):					
Sample Container Ty	pe(s):				Water Body and Water Quality Characteristics (circle all that apply):					
Preservative(s): Analysis/Method(s):					River Stream Pond Flowing Stagnant Clear Cloudy Turbid Other:					
Location Sketch:		Instruments (Manufacturer, Model, and Serial No.):				No.):				
							Technician Signature:			
					Notes:				recomment orginature.	
									Technician Name (print):	
QA/QC'd by:						QA	QC Date:			

Page 1 of ____

Rev. 0, Date: 10/14/2016

arnoc foster wheeler					GR	OUNDWA	TER SA	AMPLI	NG RECOI	RD	
Project Name: Phase I Regional Site Inspections for the Fluorisated Compounds at Multiple Ar National Count Installations UN13X-14-0-0032 Installation: Well ID:		sections for Per-Pluorinated Compounds and Installations			Project No	umber:		291330006			
					0006						
			Sample Te	echnician:							
	o Water (ft):							Date: Well Diameter (in):			
Total Depth o							1 Casing 1		alli:		
Method of Pu							3 Casing 1				
Measuring Point (toc, tor, etc.): Specific						Pump Inta	ike Depth i	feet):	_		
Time	Water Level (feet)	Flow Rate	Cum. Volume (gal.)	Temp. (°C)	pH (SU)	Electrical Conductance (mS/cm)	DO (mg/L)	(mV)	Turbidity (NTU)		ommenta/Observationa During Purging slor, sediment, odor, etc.)
		Shibilizatio	n Criteris	±0.5°C	20.1	23%	210%	#10%	±10% and <10 NTU		
lability Rea	thed (Y/N):		Values:			If No, Provide E	oplanation				
ample ID:		Final	values:			1	Method of	Sampling			
A/QC Samp	les (Yes/No):						Sample Date:				
luplicate ID:							Sample Collection Time:				
ample Cont reservative	ainer Type(s):						Total Volume Purged (gall): Sample Deoth (ft):				
nalysis/Met	hod(s):								Sampling (ft):		
struments	(Manufactur	er, Model,	and Seria	i No.):							
alculation											Technician Signature
	Casing volu	ne: V= П(R/	2)H*7.45 g	palitin3							recommend organization
~Volume (gel/ = 3.14											
s = height of wa	t) = (self diamete ter column (t)	or (In)/12 (In/ft))	(2)								
iotes:											Technician Name (print):

Rev. 0, Date: 10/14/2016





Daily PFC Protocol Checklist - Tailgate Meeting



		1				
Field Clothing and PPE (as applicable):			ATTACHMENT 1 TO SOP AF DAILY PFC PROTOCOL CHEC			
Field crew in compliance with Tables 1 and 2, SOP		Project N	Phase 1 Regional Site Inspections for Per-Fluorinated Commounts at Multiple & National Quart Installations	wheeler Project Number: 291530006		
Field crew has not used fabric softener on clothing	Field crew has not used fabric softener on clothing				Task Order: 0000	
	_			n: :	Weather (temp./precipitation):	
Field crew has not used cosmetics, moisturizers, h	and cream,		Field Ma	ager:	Date and Time:	
or other related products or exposed body parts t				thing and PPE (as applicable):	Sample Containers:	
of other related products of exposed body parts t	ilis ilioi iliig			crew in compliance with Tables 1 and 2, SOP AFW-01 crew has not used fabric softener on clothing	All sample containers made of HDPE or polypropylene. Samples are not stored in containers made of LDPE	
Field crew has not applied unacceptable sunscree		□ Fiel	crew has not used cosmetics, moisturizers, hand cream her related products or exposed body parts this morning			
	II OI IIISECC		□ Fiel	crew has not applied unacceptable sunscreen or insect	Wet Weather (as applicable):	
repellant				iipment:	For personnel in direct contact with samples and/or sampling equipment, wet weather gear made of Vinyl, polyurethane, PVC,	
		•		eflon® containing materials on-site	latex or rubber-coated materials only	
Field Equipment:				imple materials made from stainless steel, HDPE, acetat	e, Equipment Decontamination:	
☐ No Teflon® containing materials on-site	No Teffen® containing materials on site			n, or polypropylene	☐ "PFC-free" water on-site for decontamination of sample equipment	
No renon containing materials on-site				raterproof field books on-site other than Rite-in-the-Rair ucts	r e	
All sample materials made from stainless steel, HDPE, acetate,			□ No	lastic clipboards, binders, or spiral hard cover notebook	Alconox and Liquinox to be used as decontamination materials s	
silicon, or polypropylene			on-	te	Food Considerations:	
silicon, or polypropylene			-	dhesives (Post-it® Notes) on-site	No food or drink on-site with exception of bottled water and/or hydration drinks (i.e., Gatorade and Powerade) that is available for	
N				ers filled with regular ice only. No chemical (blue) is s in possession	consumption only in the staging area	
No waterproof field books on-site other than Rite-in-the-Rain®						
Products		Fo	od Consideration	s:		
		"	ou constactation			
 No plastic clipboards, binders, or spiral hard cover notebooks 						
on-site			No food or drin	k on-site with exception	on of bottled water and/or	
			hydration drink	(i.e. Gatorade and P	owerade) that is available for	
☐ No adhesives (Post-it® Notes) on-site		-	•		·	
			consumption or	nly in the staging area		
Coolers filled with regular ice only. No chemical (blue) ice		_				
packs in possession			QA/QC'd	by:	QA/QC Date:	
	_		Rev	, Date: 10/14/2016	Page 1 of	



Sampling Onsite Water



In order to decontaminate drilling and sampling equipment with "PFC free" water, the on-site domestic water source needed to be sampled for six PFC compounds prior to mobilization

A presentation by Wood.



Nitrile Gloves Worn Continuously

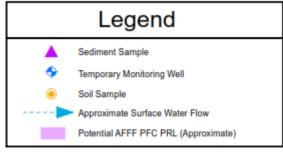




Sample Locations













Shallow rock depth required air rotary





Utilities presented challenging sample locations





Surface Water was not present at Outfalls







Standards for 2017-2018 Site Inspections



- Interim Air Force Guidance and USEPA lifetime drinking water Health Advisories
 - PFOS and PFOA
 - 0.07 μg/L in groundwater/surface water (combined with PFOA)
 - 1,260 μg/kg in soil
 - 1,260 μg/kg in sediment
- NCDEQ Interim Maximum Allowable Concentration PFOA
 - 2 μg/L in groundwater

Screening Criteria



Parameters	Chemical	USEPA R Screening L (May 2	evel Table	USAF Guidance for	USEPA Health Advisory Drinking	North Carolina Interim Maximum Allowable
	Abstract Number	Residential Soil (µg/kg)	Тар Water (µg/L)	Soils and Sediments ^b (µg/kg)	Water (Surface Water or Groundwater) (µg/L) ^c	Concentration ^g (ug/L)
Perfluorobutane sulfonate (PFBS)	375-73-5	1,300,000 ^d	400 ^f	NL	NL	NL
Perfluorooctanoic acid (PFOA)	335-67-1	NL	NL	1,260	0.07e	2
Perfluorooctane sulfonate (PFOS)	1763-23- 1	NL	NL	1,260	3.31	NL

Potential Release Locations of AFFF





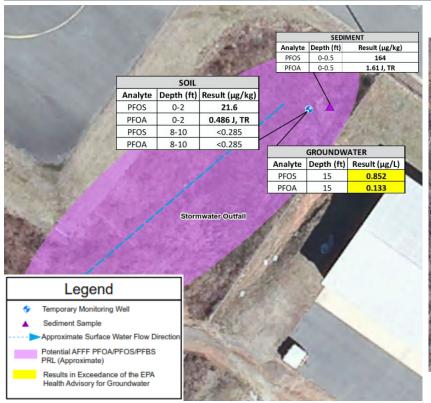
Results – Fire Station

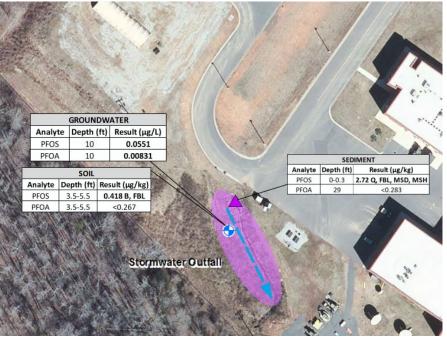




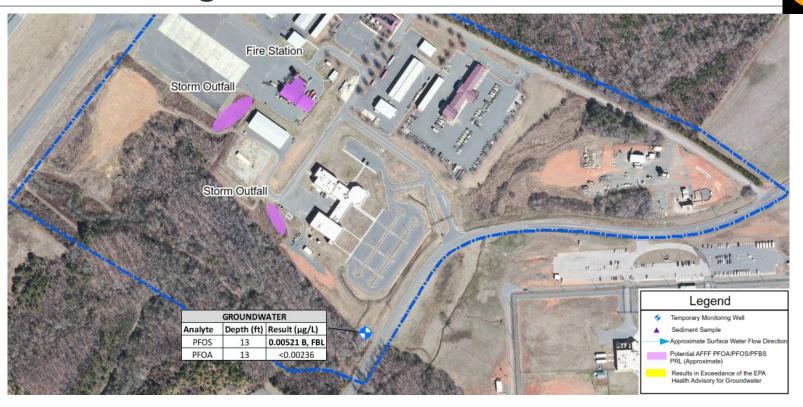
Results – Stormwater Outfalls







Results – Background





Recommendations



- Additional Investigations to further evaluate concentrations of PFCs in groundwater
 - Include source evaluation and delineation to determine nature and extent of release
- Although concentrations of PFCs in soil did not exceed the screening criteria, they may be a source of PFCs to the groundwater
 - Additional soil investigation is recommended where groundwater exceeded the Health Advisory

Wood – The basis for our lessons learned





wood.