Firefighting Capabilities Assessment of Commercially Available PFAS-Free Foam and Agents

WP19-5324

Gerard G. Back (Jerry)

JENSEN HUGHES

3610 Commerce Drive, Suite 817
Baltimore, MD 21227

Final Debrief

25 February 2021

ESTCP

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
25/Feb/2021	ESTCP Project Outbrief	1/30/2019 - 1/30/2021

4. TITLE AND SUBTITLE

Firefighting Capabilities Assessment of Commercially Available PFAS-Free Foam and Agents

5a. CONTRACT NUMBER
19-C-0009

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gerard G. Back
Dan Martin
Noah Lieb,
Lindsay Huffert
JENSEN HUGHES

John Farley
Stan Karwoski
NRL

5d. PROJECT NUMBER
WP19-5324

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
JENSEN HUGHES
3610 Commerce Drive, Suite 817
Baltimore, MD 21227

8. PERFORMING ORGANIZATION REPORT NUMBER
WP19-5324

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
WP19-5324

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Ultimate Goal: identify an environmentally acceptable PFAS-free AFFF alternative equivalent to MILSPEC AFFF (MIL-F-24385F)

-“Apples to Apples” comparison of the capabilities of MilSpec AFFF and the commercially available PFAS-free alternatives.
-Assess capabilities against on both approval-scale and real-scale test scenarios.
-Develop a database on product capabilities.
-Provide information for land-based MilSpec development.

15. SUBJECT TERMS
Firefighting Capabilities Assessment, Commercially Available PFAS-Free Foam and Agents

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Gerard (Jerry) Back
UNCLASS	UNCLASS	UNCLASS	UNCLASS	21	19b. TELEPHONE NUMBER *(Include area code)* 410-737-8677

Project Team

JENSEN HUGHES

Gerard Back (Jerry), Fire Protection Engineer PI

Dan Martin, Fire Protection Engineer (Assistant PM)

Noah Lieb, Chemical Engineer (Environmental Expert)

Lindsay Huffert, Fire Protection Engineer (Firefighting Technician)

NRL

John Farley, Director of Fire Test Operations (Foam Expert/FF/DC)

Stan Karwoski, Senior Firefighting Technician (FF Expert)

Technical Objectives

Ultimate Goal: identify an environmentally acceptable PFAS-free AFFF alternative equivalent to MILSPEC AFFF (MIL-F-24385F)

- "Apples to Apples" comparison of the capabilities of MilSpec AFFF and the commercially available PFAS-free alternatives.
- Assess capabilities against on both approval-scale and real-scale test scenarios.
- Develop a database on product capabilities.
- Provide information for land-based MilSpec development.

Technical Approach

Two-year program started February 2019

		Task
1	1	Literature Search (to identify candidates)
2	2	Environmental Analysis (Preliminary)
3		Real-Scale Fire Tests
4		Capabilities Rankings
5		Approval-Scale Fire Tests
6	6	Program Documentation (database, final report, path forward)

Task 1: Literature Search

- Comprehensive literature review on foams and agents
- 60-70 products being marketed as PFAS-Free Alts.
- Potential candidates/agents (~ 40 identified)

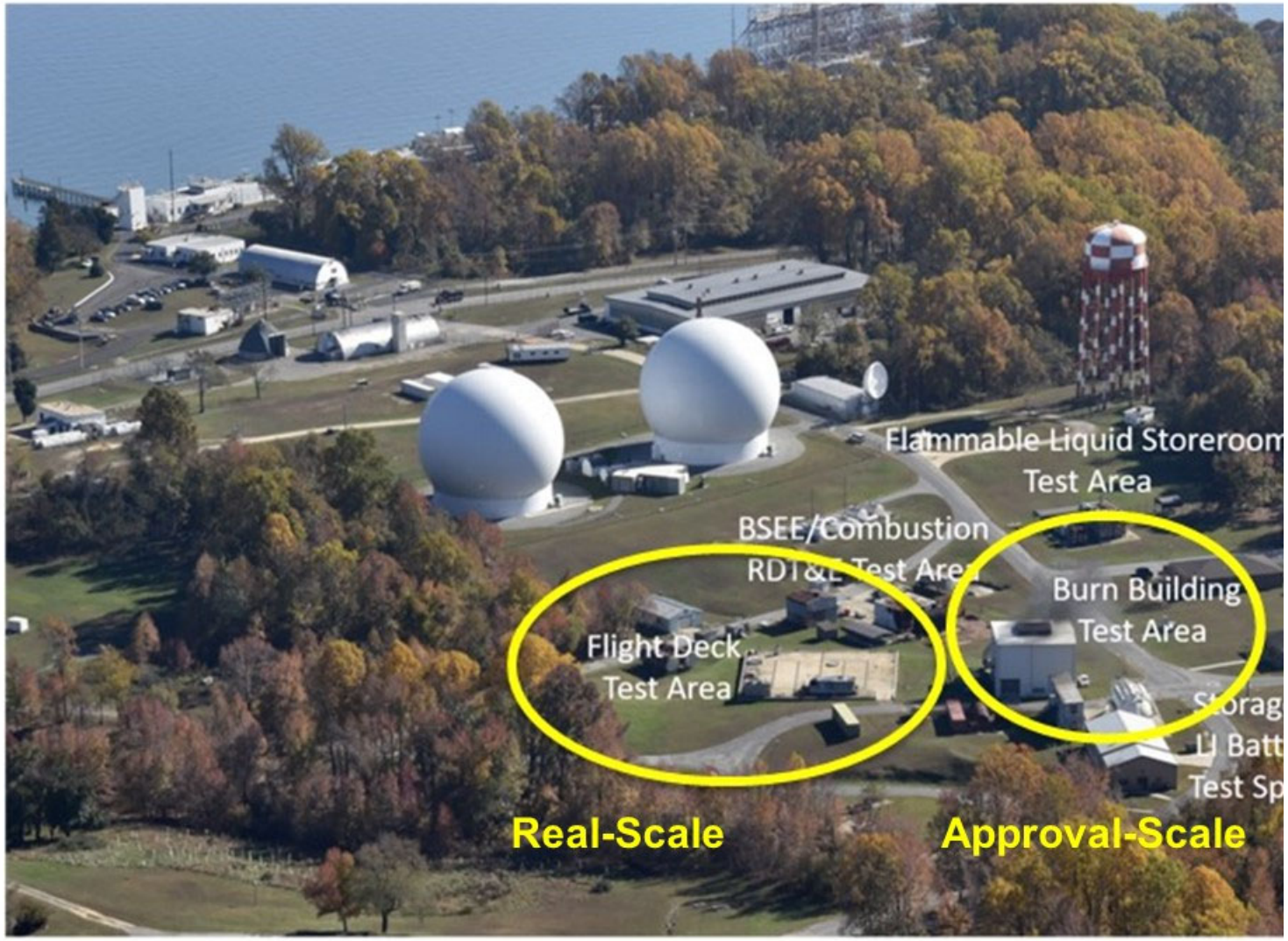
Task 2: Environmental Analysis

- General foam composition environmental assessment
- Life cycle environmental assessments
- No obvious “Show Stoppers”

Selected 10 for testing, grew to over 25

All “mechanical foams” so aspiration is key variable

Site Description – NRL/CBD



Test Design

Approval-Scale Testing

28 ft^2 pan fire (MilSpec)

2 & 3 gpm - Ext. & Burnback

Gasoline and Jet A

Aspirating nozzle

(MilSpec - gasoline - 2 gpm - 30 sec)

Real-Scale Testing

400 ft^2 pan fire

30 gpm nozzle – Ext only

w & w/o foam tube

mostly Jet A (some gasoline)

Both conducted at 0.07 gpm/ft^2

Over 100 Approval-Scale Tests

#	Manufacturer	Agent Type	Gasoline				Jet A			
			2 gpm		3 gpm		2 gpm		3 gpm	
			Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)
B	Buckeye MILSPEC 3%	AFFF	30	501	24	584	16	712	12	817
1	National - Avio Green	Foam	57	262	45	244	30	365	20	507
1A	Angus -Jet Foam	Foam	49	244	42	285	19	357	15	537
1B1	National Universal Green AR-FFF	Foam	145	189	84	242	30	245	26	314
1B2	Angus -AR-FFF	Foam	156	196	77	246	33	257	29	322
2	Solberg - RE-HEALING RF3	Foam	53	726	45	1019	33	690	22	1008
3	Fomtec - Enviro USP	Foam	58	434	37	678	24	647	15	767
3A	Fomtec - AR-FFF	Foam	128	246	73	282	32	232	27	334
4	Bio-ex - ECOPOL N F3 HC	Foam	No	-	No	-	No	-	114	311
4A	Bio-ex - ECOPOL A	Foam	57	278	52	372	26	350	18	407
5	Dr. Sthamer - MOUSSOL FF 3x6	Foam	77	240	65	335	25	445	21	539
5A	Dr. Sthamer - VA Pure XLV ICAO	Foam	77	170	55	225	27	352	15	285
6	vs FOCUM - Silvara APC 3x3	Foam	126	189	71	252	22	424	16	445
10	Perimeter Sol. - Auxquimia ICAO	Foam	No	-	123	0	26	363	20	412
11	FireBull FFF	Foam	84	208	67	501	22	507	17	648
15A	GreenFire GFFF	Foam	107	70	62	94	32	156	25	212
16	XAERUS - 3LV	Foam	No	-	No	-	103	35	87	68
7	Amiran - Flame Out	Wetting	-	-	No	-	-	-	95	40
8	Pyrocool - Pyrocool FEF	Wetting	No	-	124	153	29	203	20	277
9	Novacool - Novacool UEF Foam	Wetting	No	-	104	39	32	232	27	334
12	F-500	Wetting	No	-	No	-	57	55	35	165
13	FIREREIN - Eco-Gel A/B	Wetting	No	-	No	-	No	-	No	
14	ATIRA Sys. - Strong Water	Wetting	No	-	No	-	No	-	No	
15	GreenFire WA	Wetting	No	-	No	-	36	177	29	198

Approval-Scale Test Observations

Fuel Type

Flammable Liquid (flashpoint) < 100°F < Combustible Liquids (flashpoint)
Gasoline – Flam. Liq. – FP -40°F some 50 grades w/wo alcohol
Jet A – Comb. Liq. (kerosene based) – FP > 100°F min. variations no alcohol
Jet A is much easier to extinguish than gasoline (Ext. times less than ½)
Alcohol makes things even harder and is product specific

General Results

AFFF ext. times about ½ that of good PFAS-Free products

2 gpm (0.07 gpm/ft^2) solution / Jet A AFFF ~15 sec most PFAS-Free ~ 30 sec
About 10% could not extinguish the fire
2 gpm (0.07 gpm/ft^2) solution / gasoline AFFF 30 sec some PFAS-Free ~ 60 sec
Over 40% could not extinguish the fire

General Capabilities Rankings (Product Type)

1st AFFF, 2nd PFFs, 3rd WA, 4th New Formulations

~60 sec ext. gas @ 2 gpm - 0.07 gpm/ft²

#	Manufacturer	Agent Type	Gasoline				Jet A			
			2 gpm		3 gpm		2 gpm		3 gpm	
			Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)
B	Buckeye MILSPEC 3%	AFFF	30	501	24	584	16	712	12	817
1	National - Avio Green	Foam	57	262	45	244	30	365	20	507
1A	Angus -Jet Foam	Foam	49	244	42	285	19	357	15	537
1B1	National Universal Green AR-FFF	Foam	145	189	84	242	30	245	26	314
1B2	Angus -AR-FFF	Foam	156	196	77	246	33	257	29	322
2	Solberg - RE-HEALING RF3	Foam	53	726	45	1019	33	690	22	1008
3	Fomtec - Enviro USP	Foam	58	434	37	678	24	647	15	767
3A	Fomtec - AR-FFF	Foam	128	246	73	282	32	232	27	334
4	Bio-ex - ECOPOL N F3 HC	Foam	No	-	No	-	No	-	114	311
4A	Bio-ex - ECOPOL A	Foam	57	278	52	372	26	350	18	407
5	Dr. Sthamer - MOUSSOL FF 3x6	Foam	77	240	65	335	25	445	21	539
5A	Dr. Sthamer - VA Pure XLV ICAO	Foam	77	170	55	225	27	352	15	285
6	vs FOCUM - Silvara APC 3x3	Foam	126	189	71	252	22	424	16	445
10	Perimeter Sol. - Auxquimia ICAO	Foam	No	-	123	0	26	363	20	412
11	FireBull FFF	Foam	84	208	67	501	22	507	17	648
15A	GreenFire GFFF	Foam	107	70	62	94	32	156	25	212
16	XAERUS - 3LV	Foam	No	-	No	-	103	35	87	68
7	Amiran - Flame Out	Wetting	-	-	No	-	-	-	95	40
8	Pyrocool - Pyrocool FEF	Wetting	No	-	124	153	29	203	20	277
9	Novacool - Novacool UEF Foam	Wetting	No	-	104	39	32	232	27	334
12	F-500	Wetting	No	-	No	-	57	55	35	165
13	FIREREIN - Eco-Gel A/B	Wetting	No	-	No	-	No	-	No	
14	ATIRA Sys. - Strong Water	Wetting	No	-	No	-	No	-	No	
15	GreenFire WA	Wetting	No	-	No	-	36	177	29	198

Approval-Scale Test Results

150 gal fuel (Gasoline or Jet A) ~80MW 40 ft Flame height 40 gpm burning rate

Approval-Scale Test Results

15° pattern
AFFF exp 5 - FFF exp 6

5° pattern
AFFF exp 18 - FFF exp 22

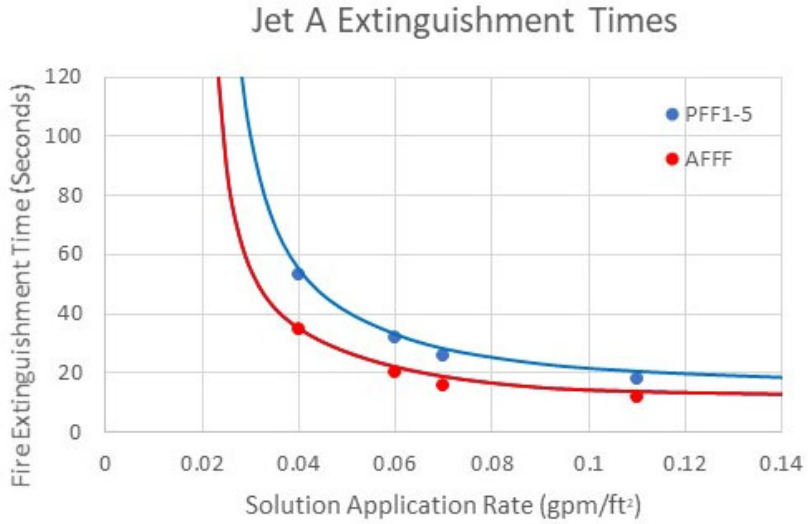
30 gpm @ 100 psi --- .07 gpm/ft^2

Real-Scale Testing Results

Foam/Agent	Fuel	**STD Nozzle** (.07 gpm/ft²)		**Foam Tube** (.07 gpm/ft²)	
		Cont (sec)	Ext (sec)	Cont (sec)	Ext (sec)
AFFF	Jet A	25	45	15	25
PFF1-5 (AVG)	Jet A	45	60	25	40
WA2	Jet A	60	No	60	102
AFFF	gasoline	30	50	30	45
PFF1-5 (AVG)	gasoline	100	135	60	105

- Standard nozzle spray patterns could be an issue (i.e., we needed 15°)
- Jet A tends similar as lab-scale test results (consistent and repeatable)
- Gasoline is very technique dependent (plunging is detrimental)
- Apples to Apples PFF1-5 about 1.5-2 times longer
- Foam tube reduces ext. time by 30-45%
- Foam tube reduces stream reach by 40%

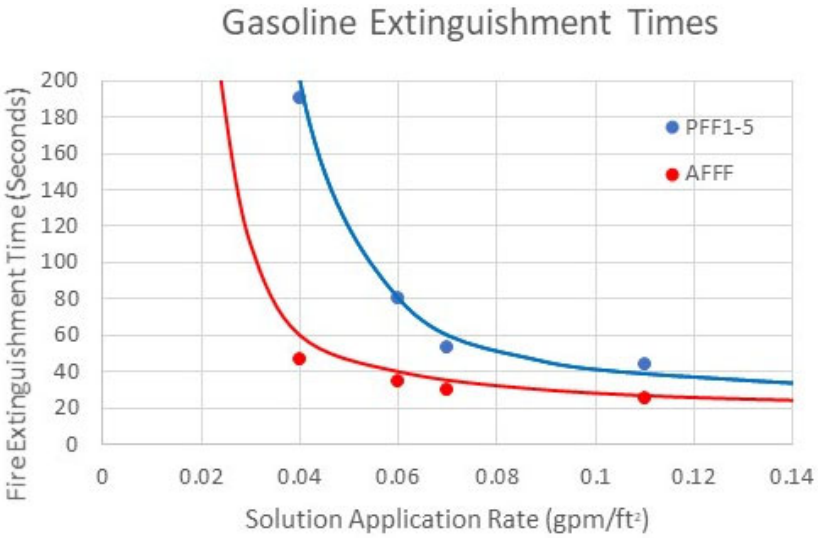
Top PFAS-Free Firefighting Capabilities



Jet A

Jet A "L" curves are parallel
(but don't seem to converge?)

PFF1-5 under a minute even at .04 gpm/ft^2



Gasoline

Gas "L" curves are parallel above .07 gpm/ft^2
(but don't seem to converge?)

Above .07 gpm/ft^2 PFF1-5 about 1.5 times longer ext. times

Below .07 gpm/ft^2 PFF1-5 lose capabilities against gasoline

Ran top five PFF against 50ft^2 @ 2/3 gpm for "L" curves

Project Summary

- 60+ Foams/Agents identified during literature search
- 40 had legitimate test/approval pedigrees
- 10 Selected for testing which grew to over 20 products tested
- 100 Approval-scale and 22 Representative-scale tests conducted
- Tests conducted with both gasoline and Jet A
- Top 5 foams demonstrated good capabilities
- Extinguishment times for Top 5 were ~ 1.5 to 2 times longer than AFFF (but were successful against all fires)
- We may be closer than originally thought

Next Steps - Scale-up

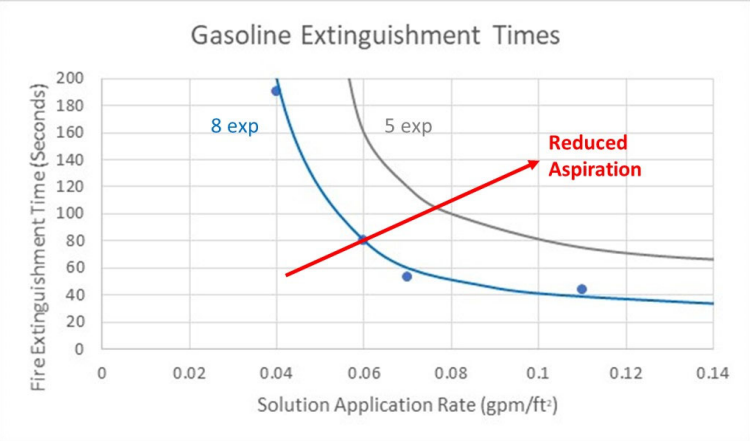
Approval-scale data used in WP19-5373 foam selection

Continue to test new products

Assess aspiration/expansion ratio and DoD hardware foam quality
WP19-5374

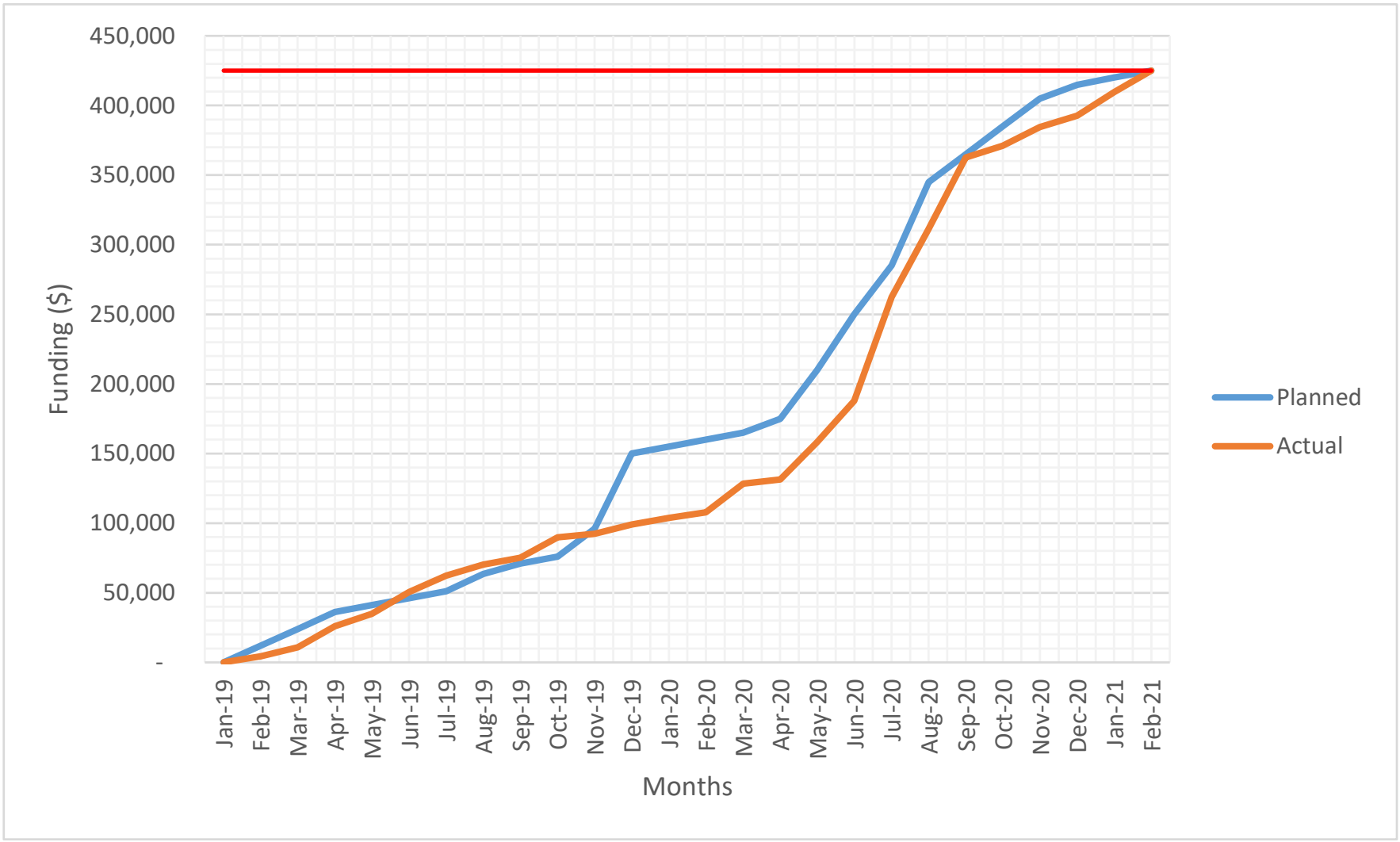
China Lake Debris Pile
Legacy / MCE – Final Validation

New Land-based MilSpec



Also: fuel type, alcohol content

Program Expenditures



Technology Transfer

1. **Understanding current regulations and knowing when to make the transition**
   a. Pre-emptive transition /Required transition
2. **Selection of an acceptable AFFF alternative**
   a. Hardware compatibility
   b. Firefighting capabilities and limitations
3. **Disposal of current AFFF products**
4. **Cleaning of equipment and definition of acceptable levels**
   a. Disposal of cleaning effluents
5. **Implementation of the selected alternative**
   a. Proportioning issues and concerns (viscosity adjustments)
   b. Discharge devices (potential replacement and/or modifications)
   c. Techniques and tactics (training?)
6. **Firefighter exposures**
   a. Eyes and skin (rinsing and cleaning)
   b. Clothing and equipment (cleaning)
7. **Post fire / post discharge cleanup and documentation**

Designer Foams
Fuel type(s) - alcohol

Aspiration
Viscosity

NFPA RF Roadmap --- DoD may need one as well

Aviation MCE ?
Mil-Std-882E

#	Manufacturer	Agent Type	Gasoline				Jet A			
			2 gpm		3 gpm		2 gpm		3 gpm	
			Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)	Ext (sec)	Burn-back (sec)
B	Buckeye MILSPEC 3%	AFFF	30	501	24	584	16	712	12	817
1	National - Avio Green	Foam	57	262	45	244	30	365	20	507
1A	Angus -Jet Foam	Foam	49	244	42	285	19	357	15	537
1B1	National Universal Green AR-FFF	Foam	145	189	84	242	30	245	26	314
1B2	Angus -AR-FFF	Foam	156	196	77	246	33	257	29	322
2	Solberg - RE-HEALING RF3	Foam	53	726	45	1019	33	690	22	1008
3	Fomtec - Enviro USP	Foam	58	434	37	678	24	647	15	767
3A	Fomtec - AR-FFF	Foam	128	246	73	282	32	232	27	334
4	Bio-ex - ECOPOL N F3 HC	Foam	No	-	No	-	No	-	114	311
4A	Bio-ex - ECOPOL A	Foam	57	278	52	372	26	350	18	407
5	Dr. Sthamer - MOUSSOL FF 3x6	Foam	77	240	65	335	25	445	21	539
5A	Dr. Sthamer - VA Pure XLV ICAO	Foam	77	170	55	225	27	352	15	285
6	vs FOCUM - Silvara APC 3x3	Foam	126	189	71	252	22	424	16	445
10	Perimeter Sol. - Auxquimia ICAO	Foam	No	-	123	0	26	363	20	412
11	FireBull FFF	Foam	84	208	67	501	22	507	17	648
15A	GreenFire GFFF	Foam	107	70	62	94	32	156	25	212
16	XAERUS - 3LV	Foam	No	-	No	-	103	35	87	68
7	Amiran - Flame Out	Wetting	-	-	No	-	-	-	95	40
8	Pyrocool - Pyrocool FEF	Wetting	No	-	124	153	29	203	20	277
9	Novacool - Novacool UEF Foam	Wetting	No	-	104	39	32	232	27	334
12	F-500	Wetting	No	-	No	-	57	55	35	165
13	FIREREIN - Eco-Gel A/B	Wetting	No	-	No	-	No	-	No	
14	ATIRA Sys. - Strong Water	Wetting	No	-	No	-	No	-	No	
15	GreenFire WA	Wetting	No	-	No	-	36	177	29	198

Test Results/Video

PFF – Foam tube
0.07 gpm/ft²

20 sec Control
40 sec Exting.

NFPA 403 / 460

AFFF design criteria
0.13 gpm/ft²

60 sec Control

~30 sec ext. @ 0.07 gpm/ft²

How good is good enough?