

Unclassified
Distribution A: Approved for Public Release



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Reducing the Forward Operating Base Water Logistics Burden

6 May 2009

Dr Jay Dusenbury

Deputy for Science & Technology

U.S. Army TARDEC Force Projection Technology

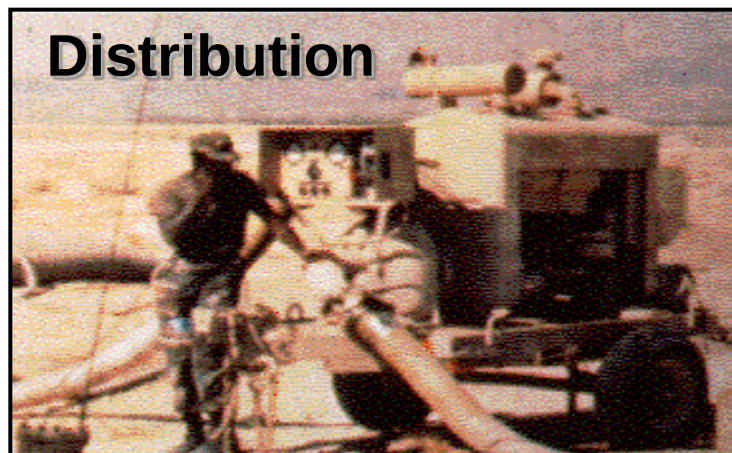
Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 06 MAY 2009		2. REPORT TYPE		3. DATES COVERED 00-00-2009 to 00-00-2009	
4. TITLE AND SUBTITLE Reducing the Forward Operating Base Water Logistics Burden				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Tank Automotive Research Development and Engineering Center (TARDEC) ,Force Projection Technology,6501 E. 11 Mile Road,Warren,MI,48397				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 4-7 May 2009 in Denver, CO.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 28	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

- **Perform research, development and engineering support in the following fields of endeavor:**
 - **Fuel Handling & Quality Surveillance Equipment**
 - **Water Purification, Handling, & Quality Equipment**
 - **Fuels and Lubricants for Ground Systems**
 - **Tactical Military Bridging**
 - **Construction & Material Handling Equipment**
 - **Mechanical Countermine & Counter IED Equipment**
 - **Asymmetric Threat Defeat**
 - **Route Clearance Vehicles**
- **Serve as the DoD responsible agent for all ground fuels and lubricants and the lead DoD Lab for Water Supply and Wastewater Treatment**
- **Recognized experts in Commercial Off-The-Shelf (COTS) & Non Developmental Items (NDI)**
- **Respond to MANSCEN (EN, MP) and CASCOM (TC,QM)**

Storage



Distribution



Quality



Treatment



- Force Provider and Base Camps have a large logistics burden associated with the supply of water and the removal of wastewater**

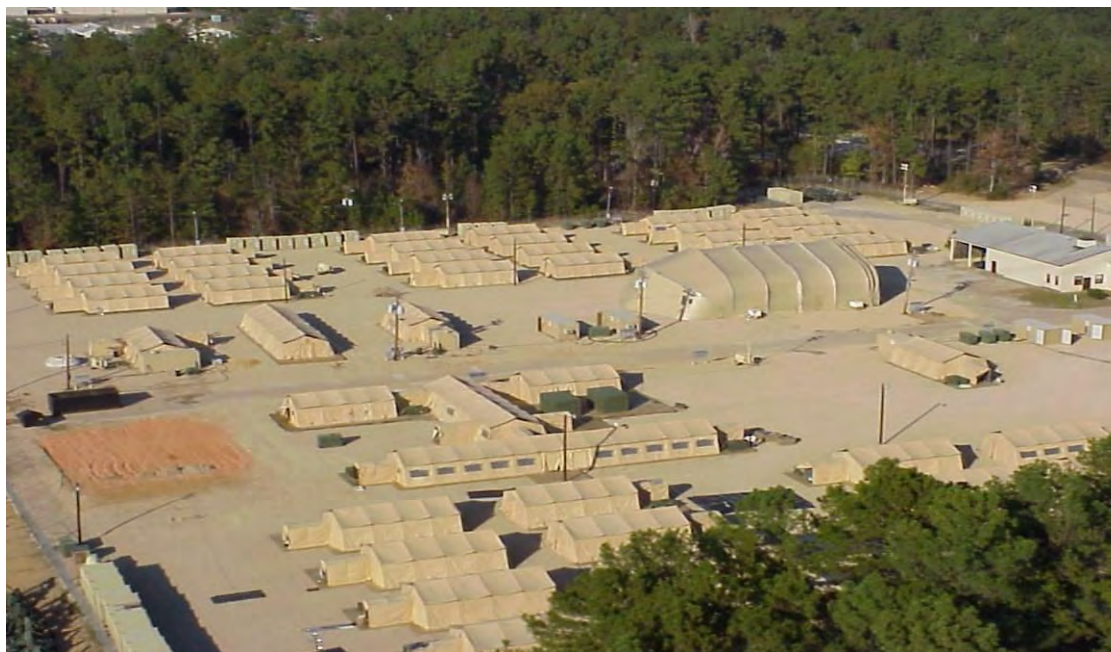
**Containerized
Latrine 2,700 gpd**

**Containerized
Batch Laundry
5200 gpd**



**Containerized
Shower System
12000 gpd**

**Food Service Facility
1925 gpd**



Black Water

**Containerized
Latrine 3465 gpd**

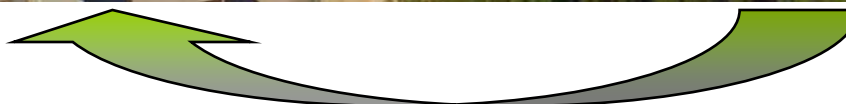


Gray Water

**Containerized
Batch Laundry
5200 gpd**

**Containerized
Shower System
12100 gpd**

**Food Service
Facility 1375
gpd**



- Reduce or eliminate the need for water supply and wastewater disposal through water recycle/reuse and generation from locally available sources.**

Latrine holding tank must be emptied daily for a 550 soldier camp

NOTE: Data based on full occupancy camp (550 + 50 operators)

**Provide 25,000 gpd
for 3,600 soldiers
30% to 60% of the daily
sustainment requirement**

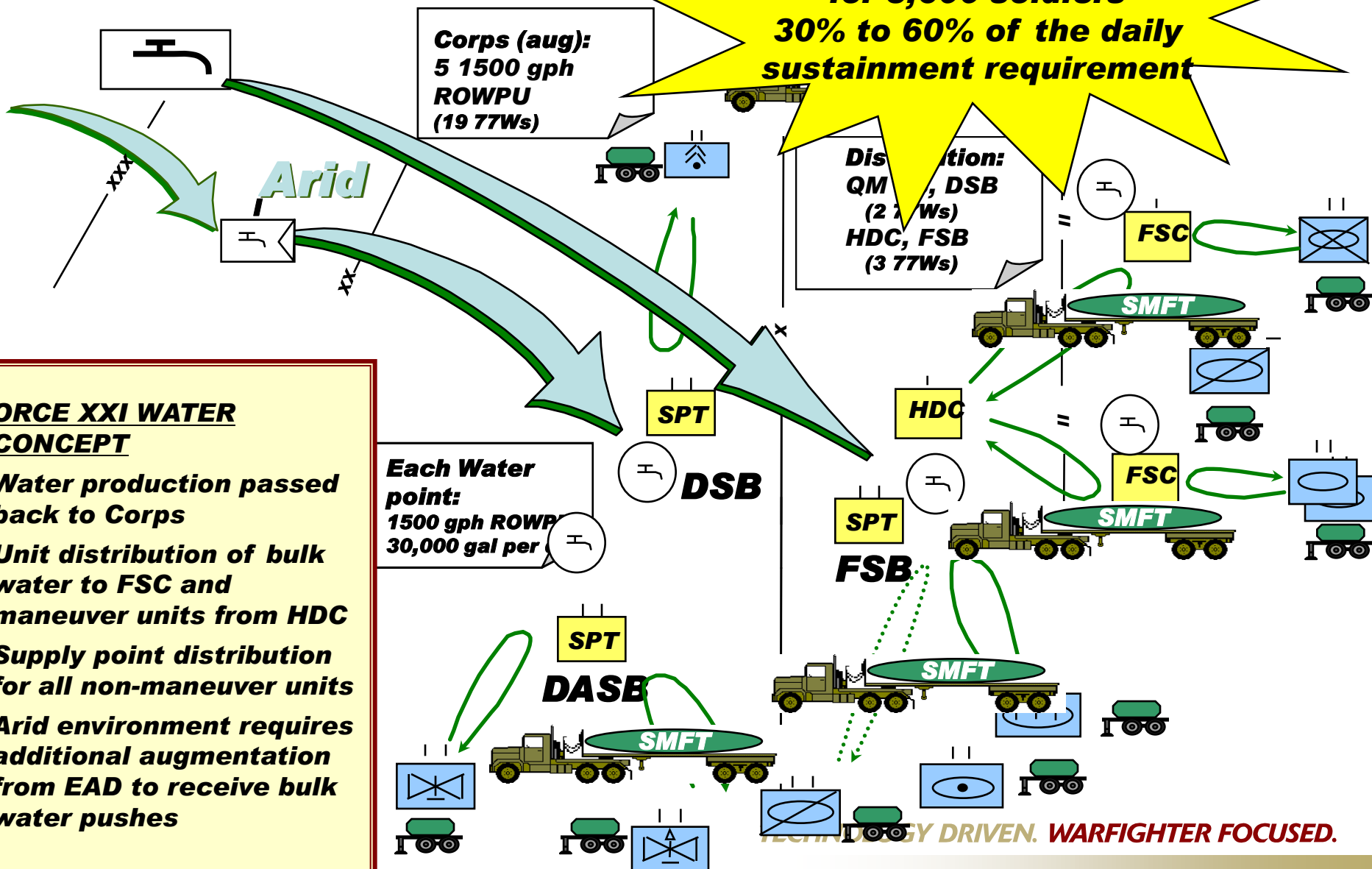
**Corps (aug):
5 1500 gph
ROWPU
(19 77Ws)**

**Distribution:
QM, DSB
(2 77Ws)
HDC, FSB
(3 77Ws)**

**Each Water
point:
1500 gph ROWPU
30,000 gal per**

FORCE XXI WATER CONCEPT

- **Water production passed back to Corps**
- **Unit distribution of bulk water to FSC and maneuver units from HDC**
- **Supply point distribution for all non-maneuver units**
- **Arid environment requires additional augmentation from EAD to receive bulk water pushes**



- ***Purify and Bottle Water on-site***
- ***Combined gray and black water treatment and recycle***
- ***Separate gray and black water treatment and recycle***
- ***Individual system treatment and recycle***
- ***Make up water provided by water generation***
 - ***Water from Air***
 - ***Water from exhaust***

- ***Drinking Water Related Health Problems in WWI lead to development of the Mobile Water Purification Unit***
- ***The Mobile Water Purification Unit found to be only partially effective during WWII***
- ***After WWII, multiple units developed for various types of source water***
 - ***Seawater Distillation Unit***
 - ***NBC Treatment Unit***
 - ***Fresh Water Purifier (ERDLATOR)***
- ***Use of multiple units led to logistics and training problems***
- ***US Government funded research in Reverse Osmosis led to fielding of Reverse Osmosis Water Purification Units (ROWPUs) in the 1980's***

Production

ROWPU - Reverse Osmosis Water Purification Unit (two types 600 and 3000 gph)



600 GPH ROWPU for Divisions and below (600 GPH on Salt water)



3000 GPH ROWPU for EAD (2,000 GPH on salt water) (shown with **3000 gal onion tank**)

Distribution

TWDS - Tactical Water Distro System (10 mi hoseline sets)

SMFT - Semi-Trailer Mounted Fabric Tank (3k and 5k sizes)

FAWPSS - Forward Area Water Point Supply System

400 Gallon Water Trailer

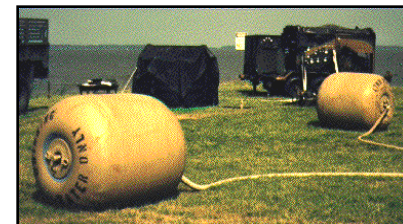
M149A2 Water Trailer



TWDS--10 miles of hoseline; six 600 GPM pumps; two 20K storage tanks; two 125 gpm pumps



400 Gallon Water Trailer (400 Gal)



FAWPSS
Six 500 gallon drums, one 125 GPM pump, and hoses



SMFTs two sizes (3K & 5K)

Storage Systems

SDS - Storage & Distro Systems consist of 50K and 20K bags

Onion Bag - 3,000 gal thin skinned bag for temp storage



SDS come in 800K, 300K, 40K and 20K sizes complete with bags, hoses, & pumps.



New and Emerging Water Equipment



Production---Tactical Water Purification System (TWPS) and Light Weight Water Purifier (LWP)



TWPS is transported by HEMMT LHS and produces 1500 GPH from fresh and 1200 from salt water. Each TWPS replaces two 600 ROWPUs.

The **HIPPO** is a 2000 gallon hardwall tank, mounted on a tankrack. It includes a hose reel, 125 gpm pump, and a canteen fill stand.

The **CAMEL** replaces the current water buffalo in units with 5-ton trucks. It will carry 800 gallons and includes a heater and chiller.



The **LWP** can be transported in the back of a HMMWV and produces 125 GPH from fresh or 75 GPH from salt water.

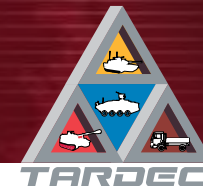


800 gal

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Military Water Purification Equipment Summary



Note: Values presented based on Seawater	LWP	600 ROWPU	3k ROWPU	A-TWPS	EUWP
• Production Rate (gph)	75	600	2,018	1,200	4,170
	8.9	12	13.7	7.6	11
• Avg RO Flux (gfd)	25	na	na	25	40
• MF/UF Flux (gfd)	33	31	33	37	50
• RO Recovery (%)	1.09	1.40	1.88	1.26	2.62
• Weight (gpd/lb.)	12.9	31.3	28.8	22.5	38.9
• Cube (gpd/cu.ft.)	na	43,200	48,500	28,800	100,000
• C-130 Lift (gpd)					

- **Able to purify any source - lake, river, ocean, NBC contaminated - in sufficient quantities BUT**
 - **Systems have large energy (fuel) requirements**
 - **20 to 50 kW-Hr/ Kgal**
 - **Systems have a large footprint (size/weight)**
 - **Systems require operational changes for certain contaminants**
 - **Systems are a logistics burden - large volume of consumables (filters, membranes, chemicals)**

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Why Packaged Water

✓ ***Because our Soldiers and their commanders want it.***



***Note: We have been drinking bottled/packaged water
on a large scale since 1991***

- **System Housed in a 20' x 20' x 8' ISO Container**
 - **Complies with Intermodal Shipping requirements**
 - **Faster Set-up and Start-up**
 - **Environmentally Safe by Keeping Contaminates Out**
- **Capability to produce 400 to 500 one liter bottles per hour**
- **Daily production planned to be 3500 to 5500 one liter bottles**
- **Supports requirements for 1800 personnel at three liters of drinking water per day**
- **Generator Set Allows for Operation in Remote Areas**
- **Can Add Systems for Higher Quantity Production if Needed**
- **Small Enough to be Handled by Material Handling Equipment**
 - **Weights 15000 pounds**
- **Pre-form Bottles and all Other Supplies Delivered in 20' x 20' x 8' ISO Containers**
- **Can be Located Close to Water Purification Site**
 - **Reduces Risk of Sabotage**
 - **Maintains Quality of Water**
 - **Easier for Field Commanders to Control Operations**





**Stretch
Blow**

UV-Tunnel

Filling

Capping

Labelling



Bundler



**Bottled
Water**



Bottling Container

- **Health Constraints**

- **MEDICAL ISSUES INFORMATION PAPER NO. IP 31-027 STANDARDS FOR RECYCLE OF SHOWER AND LAUNDRY WASTEWATER**
- **TREATMENT PRACTICES FOR RECYCLED SHOWER/LAUNDRY WASTEWATER**
 - **1. Treatment. Use the best practical physical, chemical, and/or biological treatment.**
 - **2. Blowdown. Discharge at least 20% of the untreated wastewater.**
 - **3. Microfiltration. Use a filter of absolute pore size $\leq 0.2 \mu\text{m}$ to treat all wastewater.**
 - **4. Ventilation. Ventilate enclosed shower stall at a rate that equals or exceeds one stall volume per minute for each stall**
 - **5. Quality of makeup water to meet or exceed field potable water standards**

- **Technical Constraints**

- **System Recovery**
 - **Membrane Recovery**
 - **MF/UF – 85 to 95%**
 - **RO – 70 to 90%**
 - **Backwash, flushing, and cleaning water**
- **System fouling and cleaning**
- **System start-up time**
- **System stability**
- **System footprint – size, weight, power**
- **Limited Monitoring Capability**



Tricon Water Re-use System



PM Force Sustainability Systems

Concept

- Leveraging off existing technology from the Hospital Containerized Batch Laundry (CBL) and 1500 GPH Tactical Water Purification System (TWPS), both contract awards in production with SFA, and applying the concept to integrate into the Force Provider a water reuse capability for the Containerized Shower (CS) and potentially the FP CBL.
- FP Containerized Shower utilizes 12,000 gallons of water per day, 4.4M per year. The potential to save 75-80% of this water equates to 3.3M gallons saved per year, per system. Currently 70 CS in operation in the AOR, stand to save 231M gallons of water per year.
- In this case, more importantly then the resource efficiency or cost per gallon saving is the capability of drastically lessening the logistic resupply convoys and removing Soldiers from harms way.

Filtration System Details

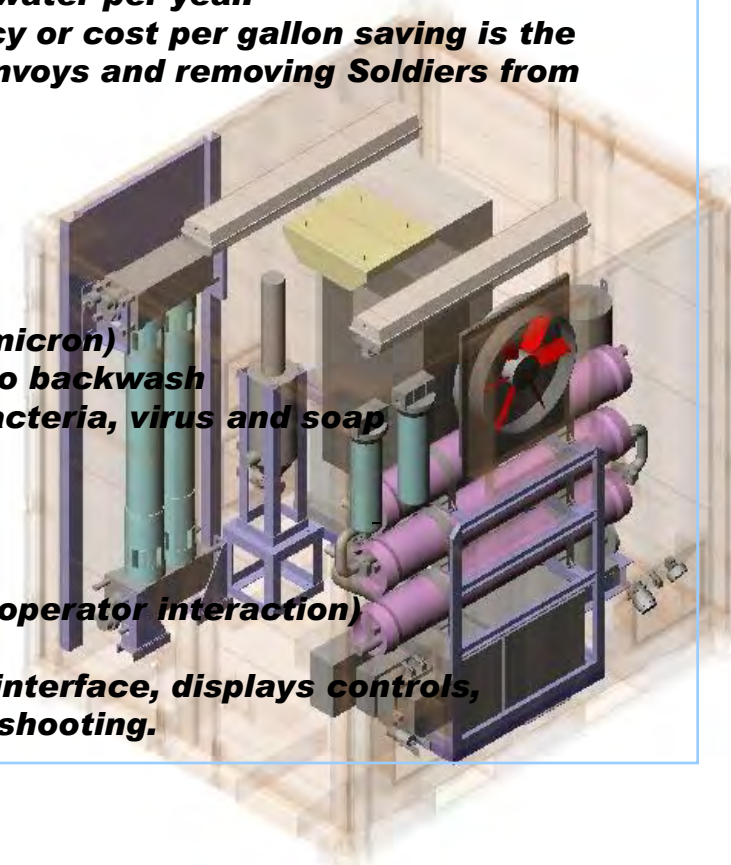
- 12,000 Gallons Per Day capacity (40 GPM peak flow)
- 70%-80% recovery
- automated chlorine injection
- Self cleaning (air purge) pre-filter to remove hairllint (50 micron)
- Micro filters (.2 micron) to remove suspended solids w/auto backwash
- Saltwater RO membranes to remove organic materials, bacteria, virus and soap
- Carbon filtration after membrane

Features

- System operational temperatures -25 F to 140 F
- Unattended automatic operation ,(7 days minimum w/out operator interaction)

Built in Test Equipment, self-monitoring

- Programmable Logic Control (PLC) with LCD screen user interface, displays controls, flows, pressures, set-up/operating instructions and troubleshooting.





Science & Technology Efforts



Objective: Reduce the sustainment requirement and logistics footprint associated with water production and distribution.

Thrust Area 1: Create low-power, highly-efficient revolutionary technologies enabling embedded water purification/desalinization

- ◆ **Bio-inspired concepts (forward osmosis)**
- ◆ **Reverse osmosis – new membrane technology**
- ◆ **Mixed Oxidant Technology**
- ◆ **Capacitive Deionization**

Thrust Area 2: Create innovative water “generation” technologies

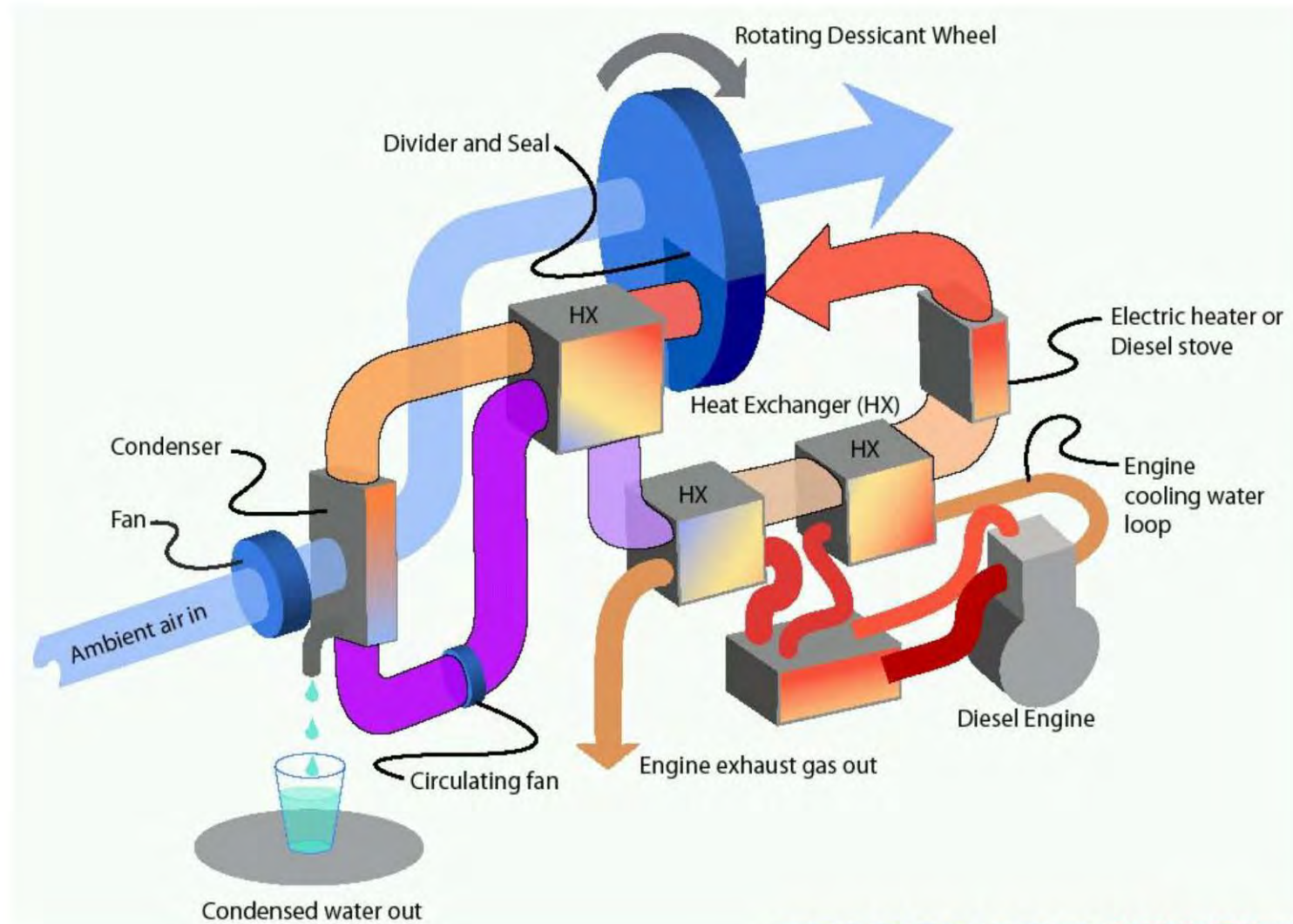
- ◆ **Water from air**
- ◆ **Water recovery from exhaust**
- ◆ **Water recycle/reuse**

Thrust Area 3: Water Quality Monitoring

- ◆ **In-line basic water quality parameters to optimize system performance**
- ◆ **Real or near time detection of toxic chemicals**

Teaming with DARPA and ONR to leverage basic research and provide integrated technology development & transition

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Water From Air System Development History

Phase I - MesoSystems Solid Desiccant Based Breadboard Demonstrator

Initial

- **TRL 4: Demonstrated water collection.**
- **Exploratory test bed.**
- **Recovered 2 gallons of water per gallon of fuel.**
- **Displayed at AUSA and AUSA Logistics, FY05-FY06.**

Modified: 5 Gallons of Water per Gallon of Fuel Demonstrator

- **Completed testing at ATC.**
 - **Completed Environmental Chamber.**
 - **Nominal water production 1.75 gph.**
 - **Produced 1.85 gph of water at design point; produced up to 2.75 gph of water depending on conditions.**
 - **Produced 4 gallons of water per gallon of fuel at design point; produced 1 to 6 gallons of water per gallon of fuel depending on conditions.**
 - **Completed additional ambient testing.**
 - **No road test planned.**



Phase II Vehicle-Integrated Breadboard Demonstrator

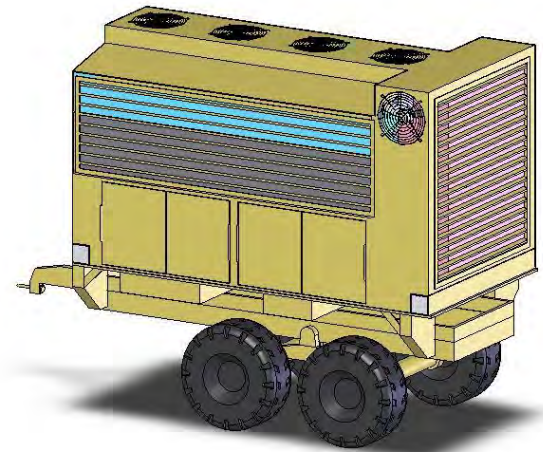
- **TRL 5: Demonstrator designed, fabricated and operation verified in realistic environment through testing at ATC.**
- **Designed for mounting on a HEMTT.**
- **Production goal of 5 gallons of water per gallon of fuel.**
- **Demonstrated at the Platform System Demonstration August 06.**
- **Completed Environmental Chamber Test at ATC.**
 - **Nominal water production 2 gph.**
 - **Produced 1.8 gph of water at design point; produced up to 3.6 gph of water depending on condition.**
 - **Produced 1.6 gallons of water per gallon of fuel at design point; produced up to 3.6 gallons of water per gallon of fuel depending on condition.**
- **Road testing completed.**
 - **Successfully completed 1200 miles on various terrains.**
- **Sand and Dust testing completed.**



Water From Air System Development Path Forward

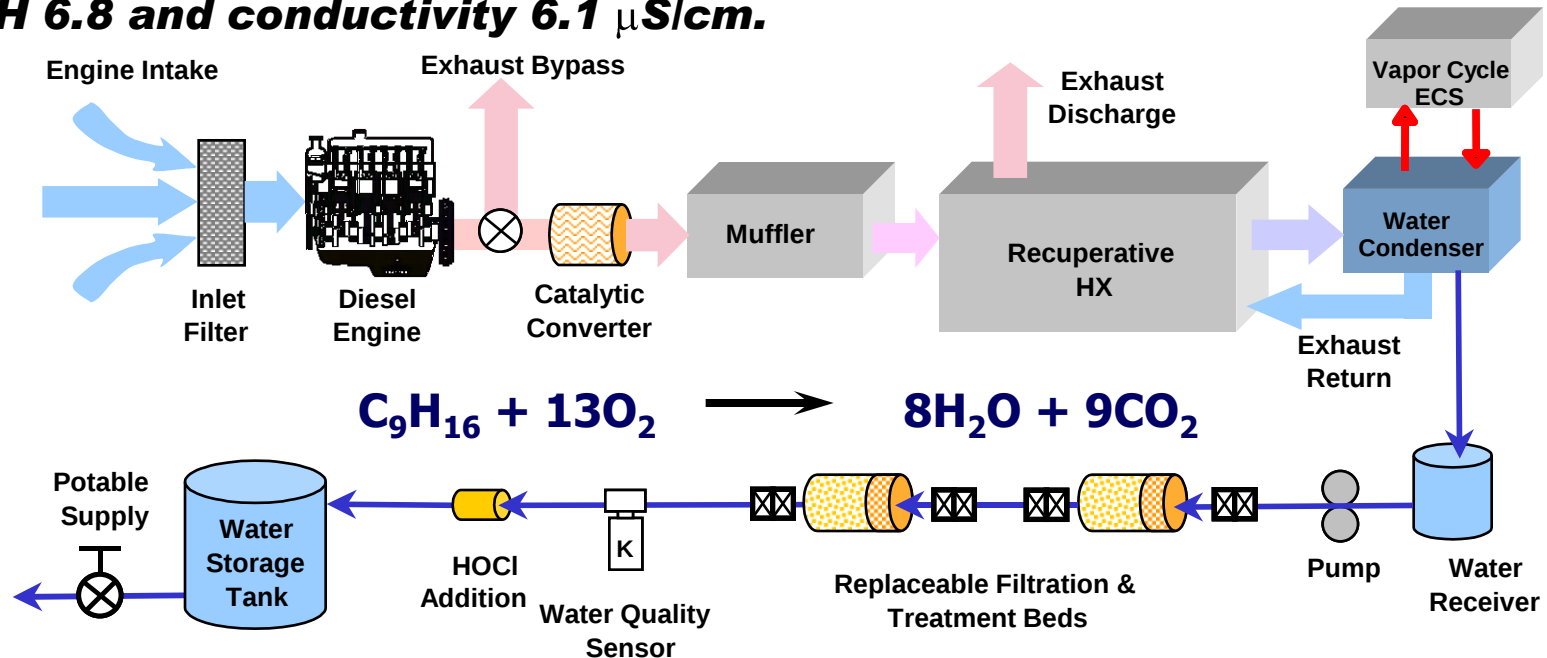
Phase III - Develop a TRL 6 + militarized 7.5 ton trailer mounted Water from Air System

- **Designed to provide self-filling water capability equivalent to the CAMEL**
- **Nominal water production of 500 gpd.**
- **Nominal minimum fuel efficiency of 2 gallons of water per gallon of fuel and 5 gallons of water per gallon of fuel at design conditions.**
- **Field testing to occur with soldiers to evaluate military utility.**
- **CONOPS, Economic Model and Transition Strategy prepared/updated in conjunction with system development.**
- **AquaSciences to develop a liquid desiccant based system under Congressional Plus up funding**
- **Mesosystems to develop a solid desiccant based system under Congressional Plus up funding**
- **Core TARDEC funding will support testing and field evaluation**



Concept

- **Combustion of 1 gallon of Fuel produces 1 gallon of water**
- **Capture water from any engine in the battlespace**
- **Conservatively recover 50 to 60 % of the available water**
- **Filtration train: 2 carbon beds & 1 resin bed**
 - All inorganics/ metals below EPA standards
 - Organic Results TOC 0.1 ppm, No EPA regulated compounds identified by standard methods
- **pH 6.8 and conductivity 6.1 μ S/cm.**



Testing

- **HMMWVs delivered to ATC Dec 05**
- **Unpayloaded system completed testing on 1 mile loop paved course, Jan 06**
- **Payloaded, secondary, and cross-country testing completed, Mar – May 06**



Program Status:

- **TRL 6, demonstrated water recovery & purification at 0.5 to 0.6 gallons water per gallon of fuel**
- **System transition limited by size, weight, and filter requirements**
- **Army should continue active review of technology developments for solutions to identified challenges**

Program Objective: To provide enhanced real-time monitoring capability for Site Reconnaissance, ROWPU Operations, and Water certification.

Problem Addressed:

- **WQAS-P and WQAS-PM kits currently used by the military are inadequate tools to assess whether water is free from all chemical or biological threats. Toxic Industrial Chemicals identified in USACHPPM Technical Guide 230 being of the highest concern.**
- **Current Solution is to employ all treatment stages, a “multiple barrier approach” relying on total treatment efficacy of system rather than what each process was designed for. This philosophy causes reduced production capacity and wasted fuel resources.**

Approach: Direct funded technology towards developing real-time qualitative and quantitative monitoring tools for assessment of water from source to treatment to consumption.

Inline monitoring of basic water quality parameters:

- **100% increase in water production capacity by utilizing fresh water bypass for appropriate source waters.**
- **Real time monitoring of GAC during NBC operations.**
- **Real time monitoring of water quality through the distribution process, ensure water is potable at the point of consumption.**

Hand Held biological-chemical detector:

- **Provide real-time field analysis capability.**
- **Provide real-time monitoring capabilities to match pace with the Army’s water transformation strategy of decentralized and embedded, harvesting water from nontraditional sources, and recycle and reuse.**





Water Quality Analysis Set – Purification (WQAS-P)

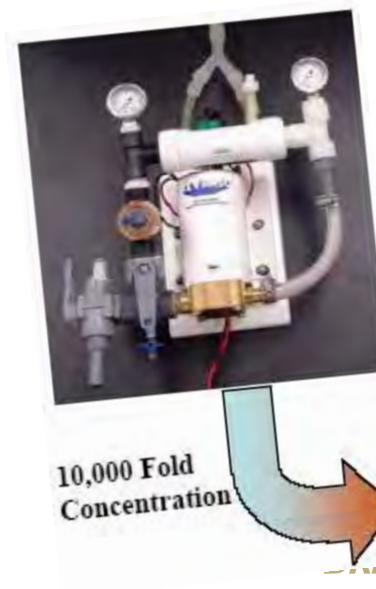
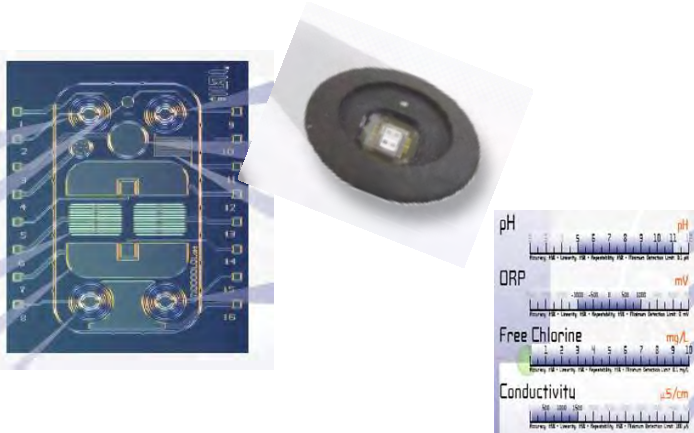
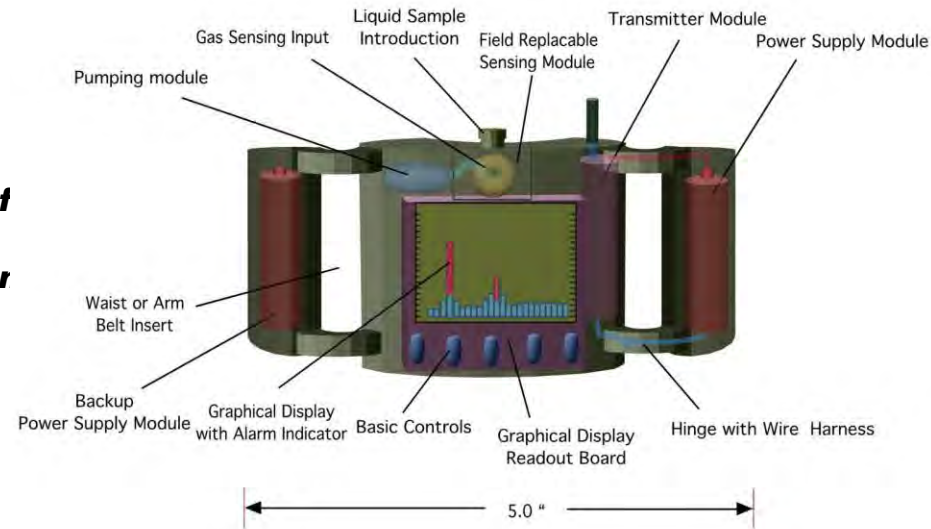


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Wayne State University is developing a Micro-Electro-Mechanical System (MEMS) based on highly sensitive and selective acoustic wave signal technology and an advanced Raman micro-spectrometer analysis system that creates a contaminant fingerprint enabling real-time identification and quantification of a wide array of microbial pathogens and chemical health hazards. Preliminary data for both detection platforms have been collected for bacterial species in a lab environment.

ANP is integrating a concentration system with a multiplexed assay that can rapidly and sensitively detect the presence of generic *E. Coli*, *E. Coli*O:157, *Crypto*, and *Giardia*. Prototypes delivered for testing.

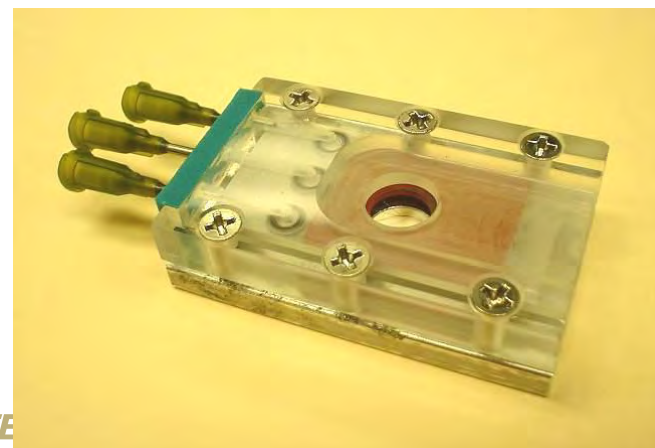
ARDESTA: inline device to test the basic water quality parameters (conductivity, chlorine, pH, temperature, turbidity, and ORP) tested by the WQAS-P using chip technology.



Handheld reader with PDA



- **Translume and Senspex**
- **Two phase II SBIR's awarded in September 2006.**
- **Goal to develop rapid assessment tools to determine bacterial pollution, and waterborne parasites in accordance with EPA's ambient water quality criteria.**
 - **Cryptosporidium, Giardi, Ecoli, and Coliform**
- **Senspex is developing an optical probe for Coherent Surface Enhancement of Raman Scattering (CSERS).**
- **Translume is utilizing laser-written waveguides and microfluidics to produce a small and robust flow cytometer.**
 - **Future work will add raman spectroscopy capability**



THE WORLDS ULTIMATE WEAPON RUNS ON WATER...
EVERYTHING ELSE RUNS ON FUEL.

