

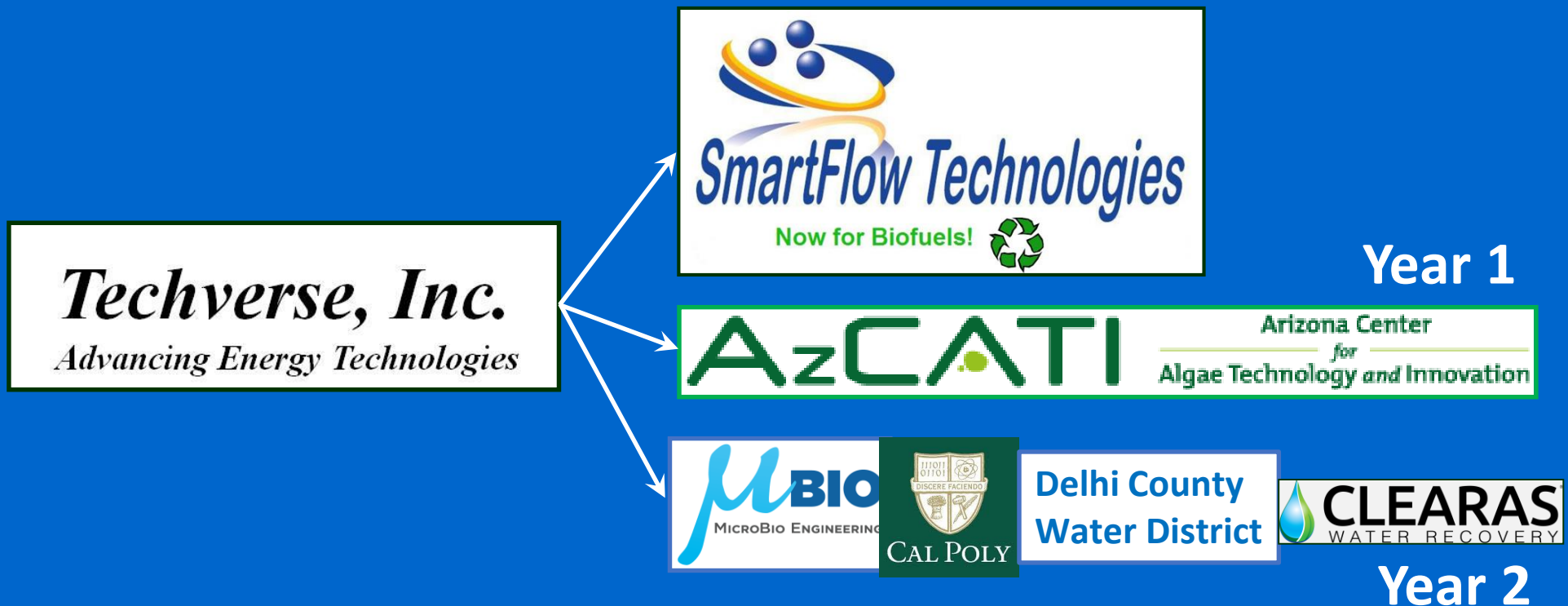
# **Advanced, Low-Cost, System for Algae Dewatering**

**Austin Ladner and Ashok Damle**  
**Techverse, Inc.**

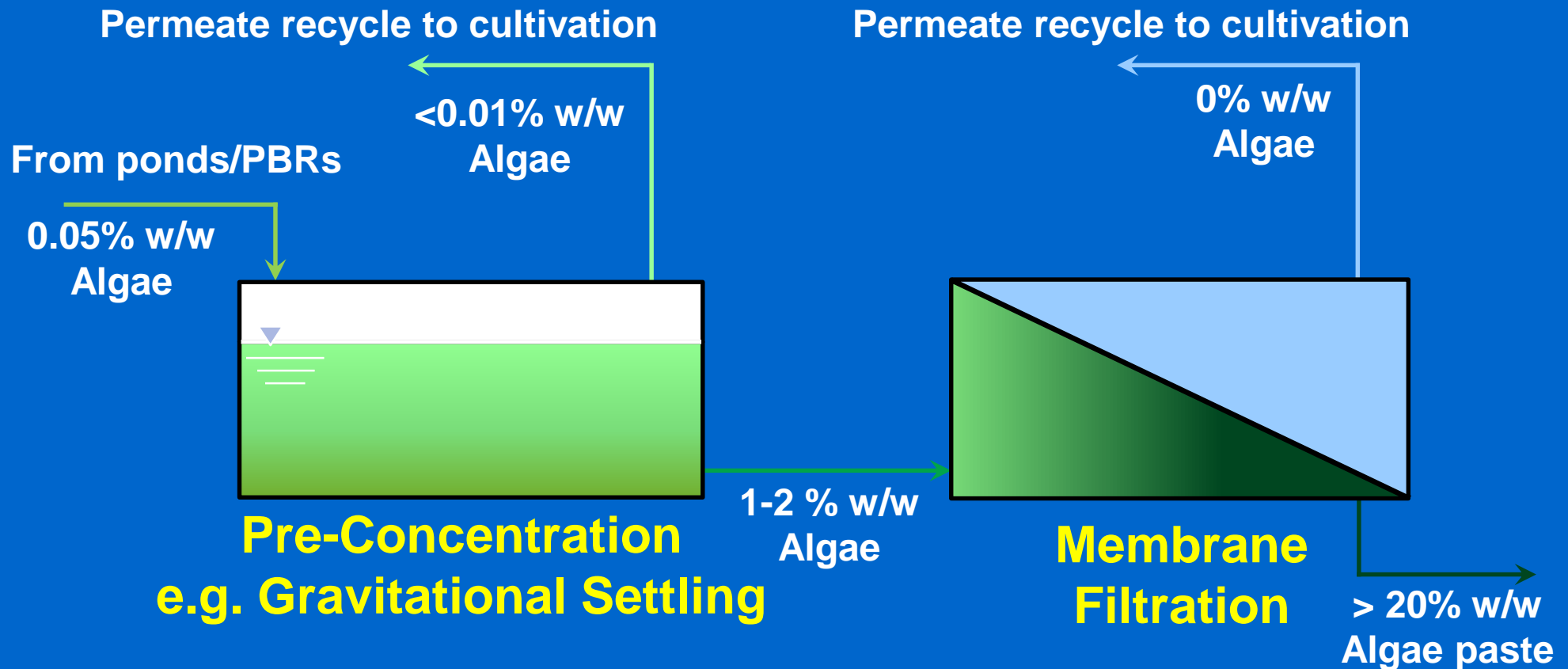
**Poster Presentation at**  
**Algae Biomass Summit 2018, Houston, TX**  
**October 15-17, 2018**



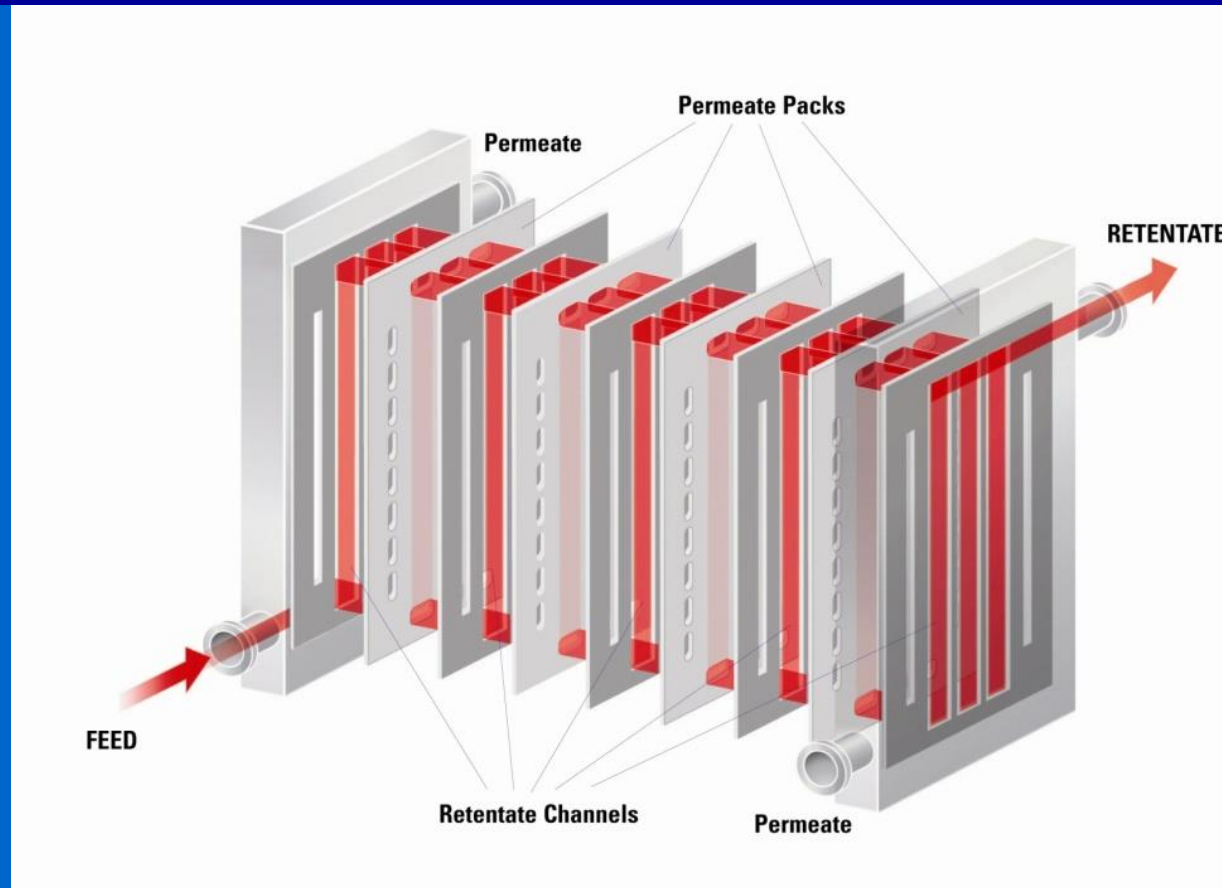
## U.S. DOE SBIR Phase II Project



# Techverse 2-Step Algae Dewatering Process

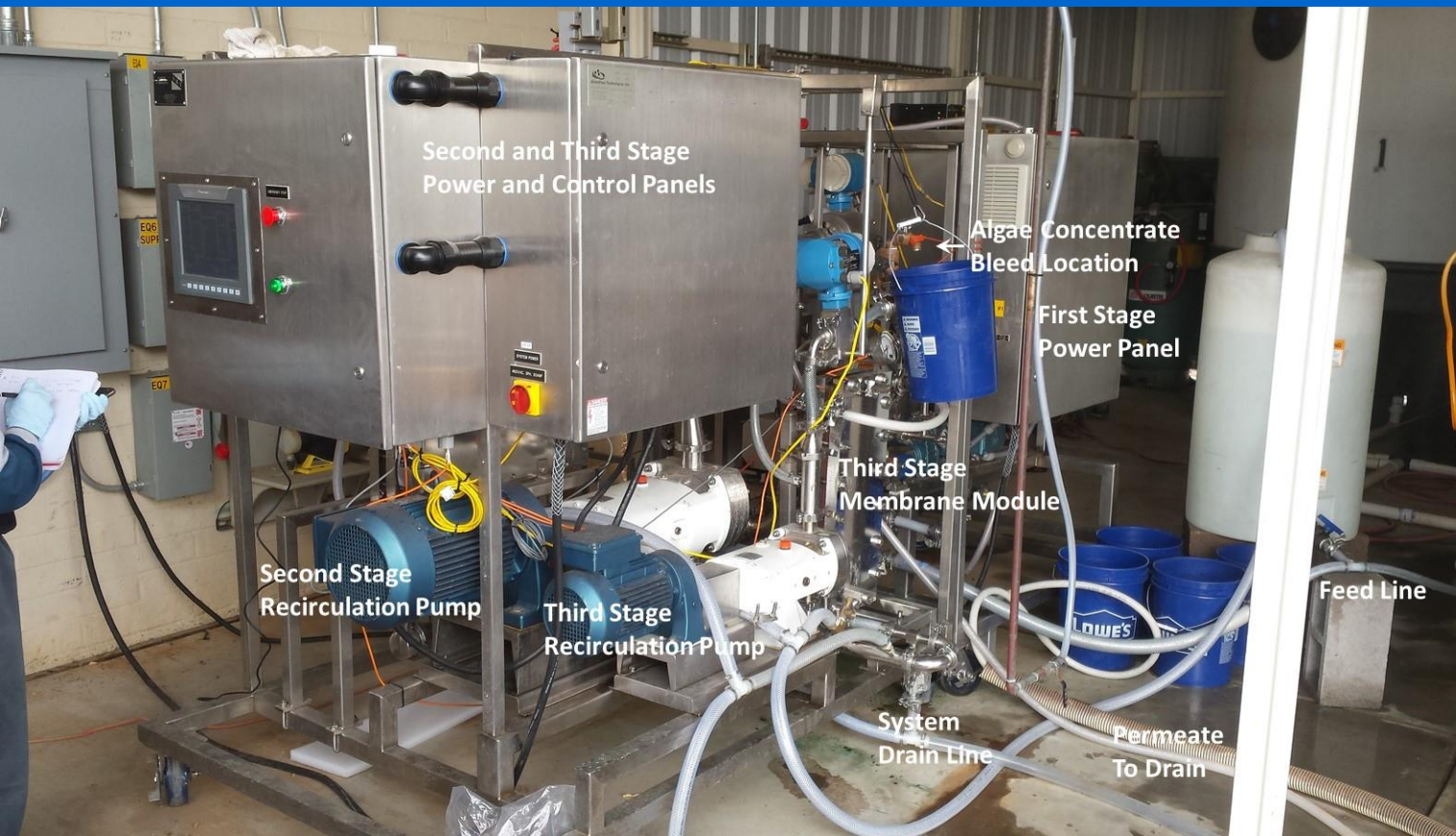


# SmartFlow's Patented "Open Channel" Membrane Module Technology – Step 2



<http://www.smartflow-tech-biofuels.com/consepadvancedsolutions.html>

# Membrane 3-stage algae dewatering skid

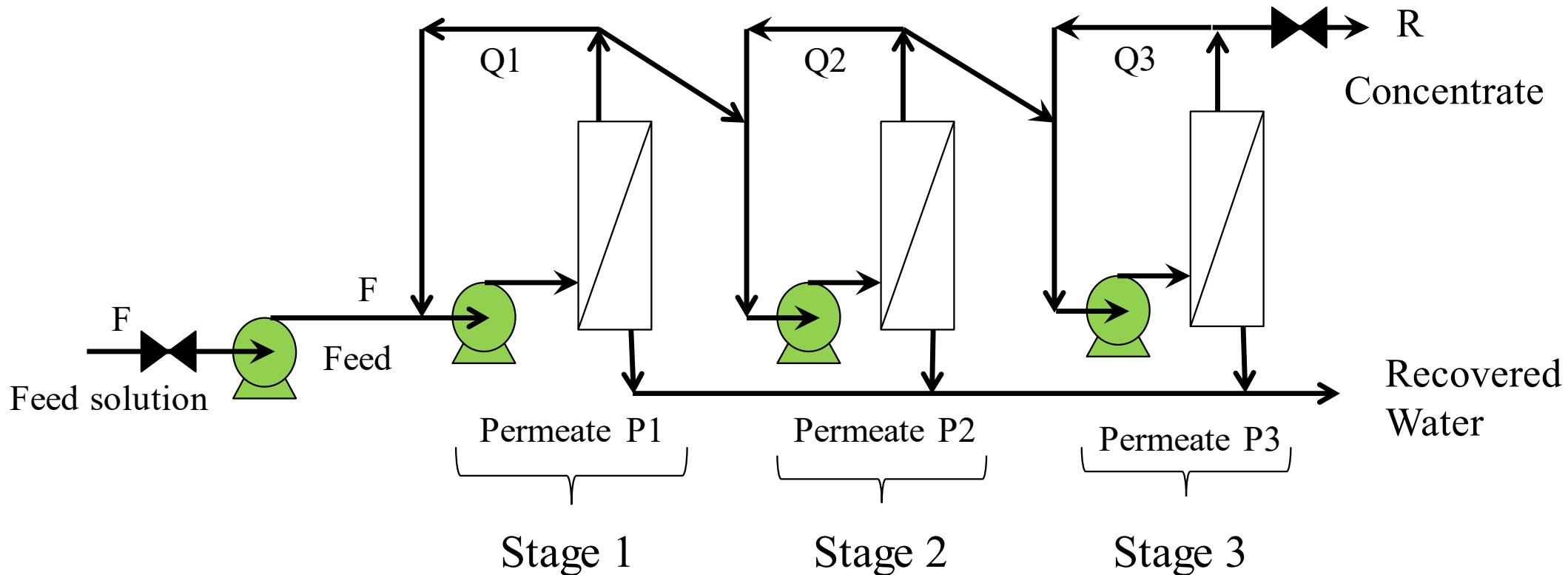


Front View

- Feed rate - 100 L/hr
- Feed conc. ~ 1% w/w
- Continuous dewatering
- Concentrate - 5 L/hr
- Product >20% w/w
- # of stages – 3
- Total membrane area 3.8 m<sup>2</sup>



## Membrane 3-stage system schematic



## Advantages of SmartFlow Membrane Modules

- Uniform flow velocity over all of the membrane surfaces
  - Utilizes 100% of membrane surface area
  - Provides equal filtration performance in all membrane areas
- Equal fluid path length in all flow channels - Equal flow resistance for each fluid element passing through the module
  - Avoids channeling and dead spots
- Increasing channel height with increasing solids concentration
  - Easily handles fluids with high solids content, high viscosity
  - Allows producing high solids content algae concentrates
- Three interacting controllable factors determine TFF efficiency and permeate flux rate - Channel Height, Shear (velocity), and Feed Pressure



# SmartFlow Technologies Membrane Modules



**ConSep 11000 Module – 11 Feed side channels**

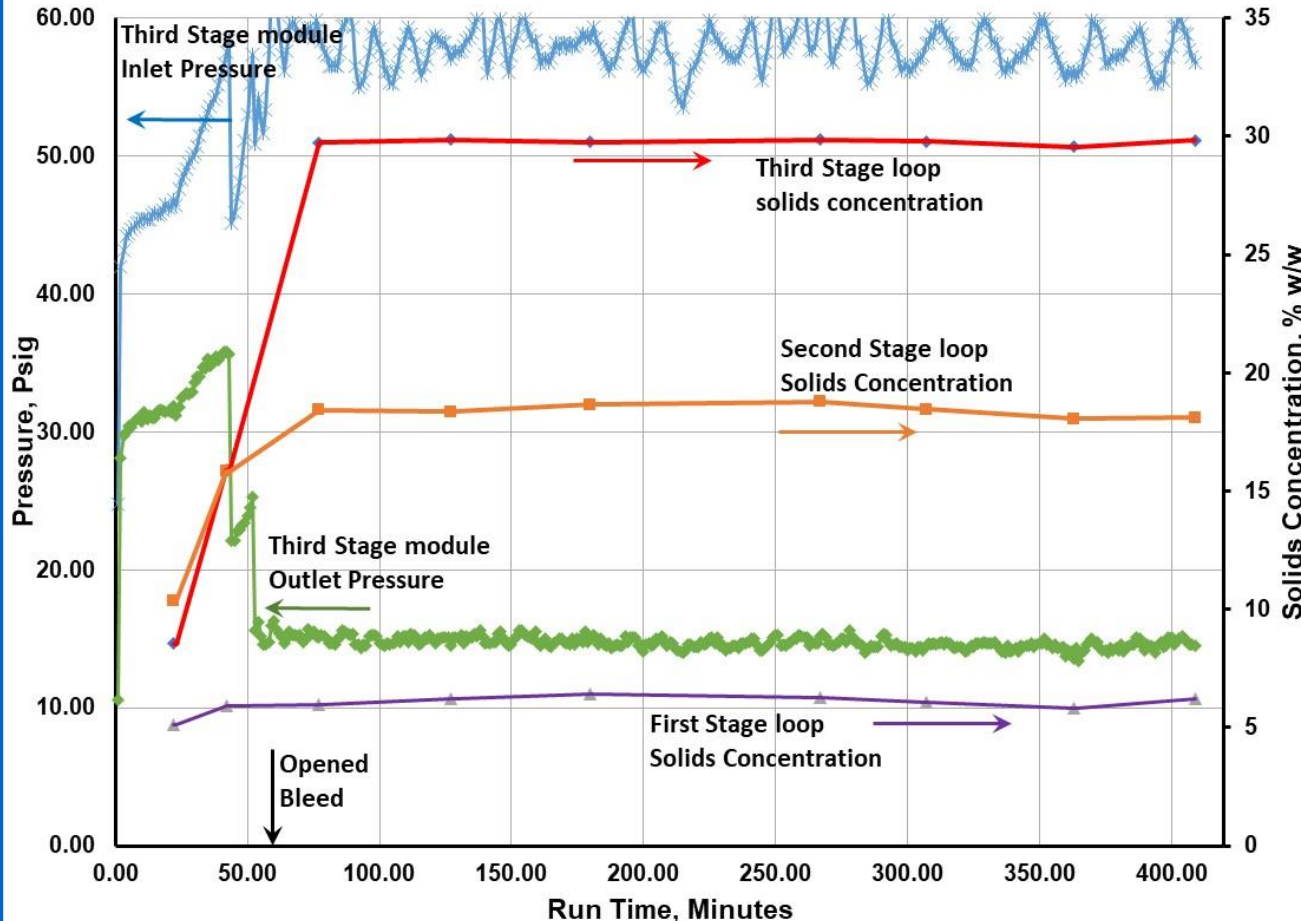
- Commercial technology with large scale systems built
- Systems with  $> 1,000 \text{ m}^2$  membrane area in different applications
- Large selection of membrane materials (MF, UF, NF, RO; RC, PES, PVDF)



## Summary of Year 1 Algae Dewatering Tests

- Eight different algae species of commercial interest
- Algae production and Pre-concentration by AzCATI
- Total of 17 runs – feed concentrations 0.3 – 2.2% w/w
- Paste concentration – 17% w/w to 36% w/w depending on algae species, growth conditions, feed rate, feed concentration, stage pressures, bleed rate
- Permeate – clear, algae-free in all runs
- Cleaning protocol restored membrane performance

## Typical algae dewatering performance



Initial dead end operation to build solids concentration in each stage

Open paste bleed after reaching target Paste concentration

Plot shows one test with:  
Feed rate - 100 L/hr

Feed conc. – 2.2% w/w

Steady state output  
Paste conc. – 30% w/w

## Summary of Year 2 - Long-term (24 hours) Algae Dewatering Tests

- Steady state continuous 24-hr dewatering tests with algae paste and clean permeate water discharge
- Reproducible run-on-run performance with routine membrane cleaning protocol

## Summary of Year 2 - Long-term (24 hours) Algae Dewatering Tests

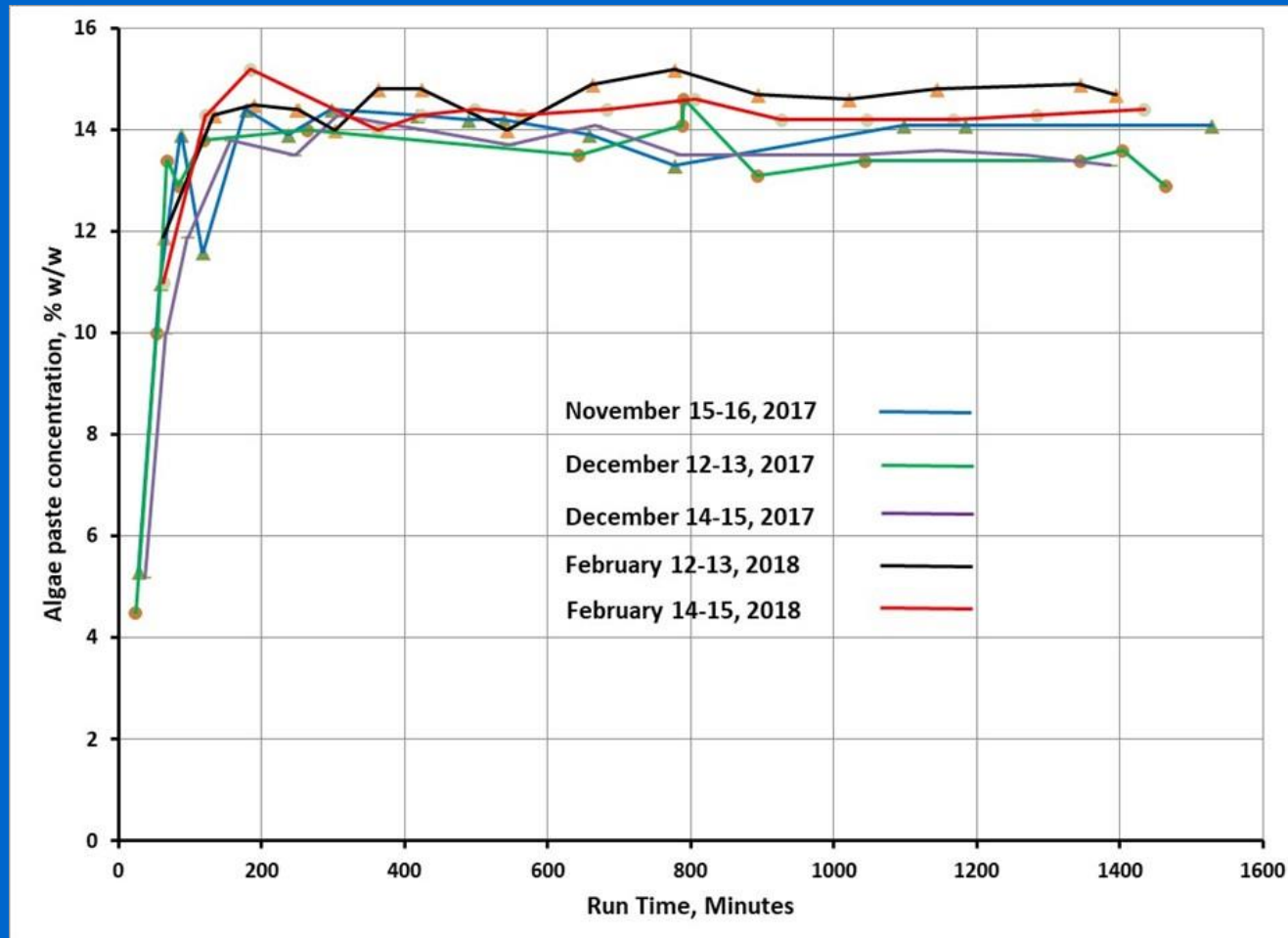
1. Delhi County Water District – Algae grown in Raceway pond for Commercial Wastewater treatment
  - Chemical coagulant used in Algae Settling Ponds
  - Algae feed concentration ~ 3% w/w
2. MicroBio Engineering – Algae grown in Raceway pond Pilot facility for wastewater treatment
  - Bio-flocculation used for Settling algae
  - Algae feed concentration ~ 0.35 – 0.7% w/w
3. ClearAs Water Recovery – Algae grown in photo-bioreactor Pilot facility for wastewater treatment
  - Micro filtration used for pre-concentration
  - Algae feed concentration ~ 0.1% w/w

## DCWD Algae settling pond



# DCWD Algae Dewatering Performance

## Reproducible, Steady State, Run-on-Run, 5 Cycles

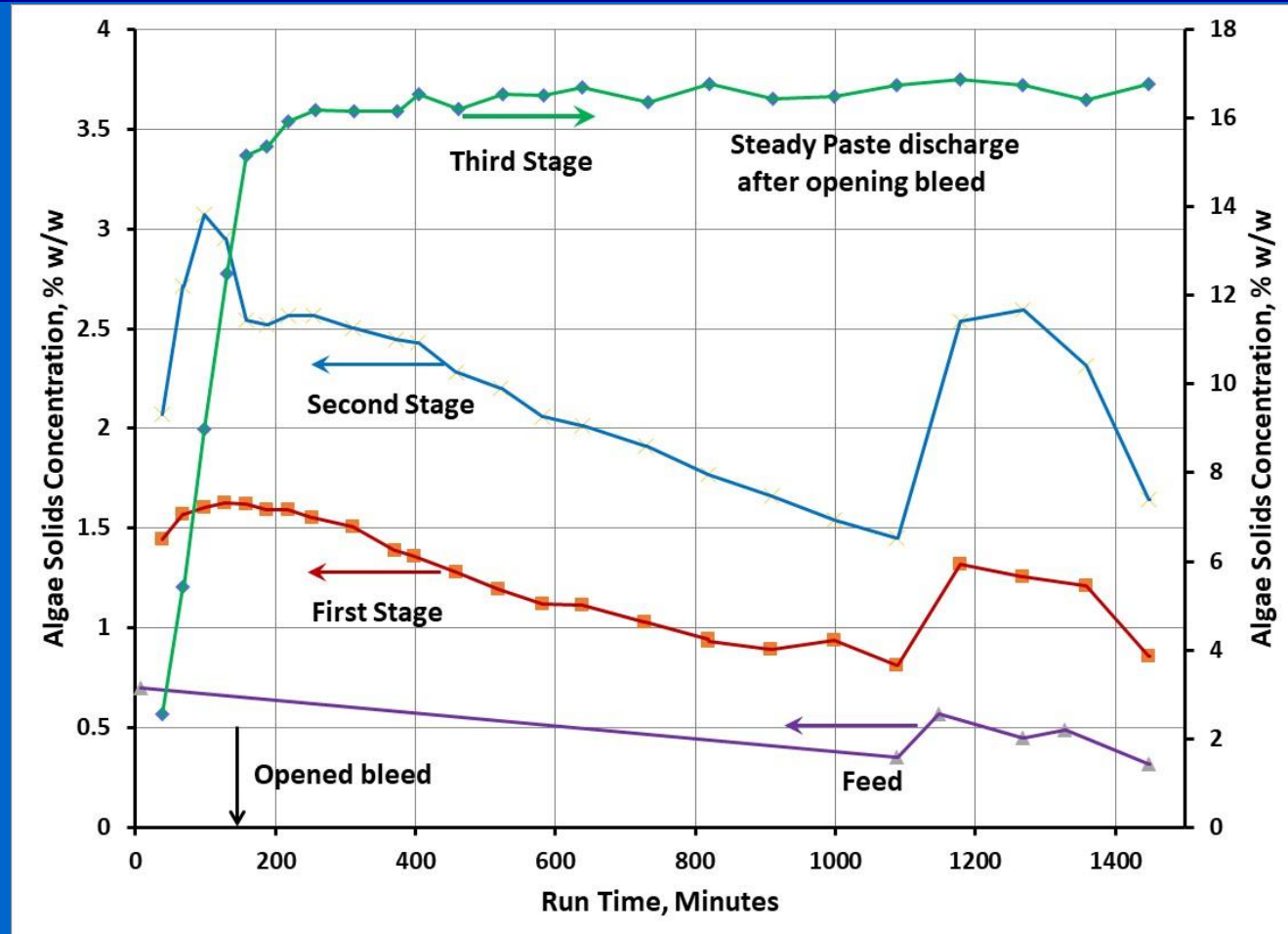




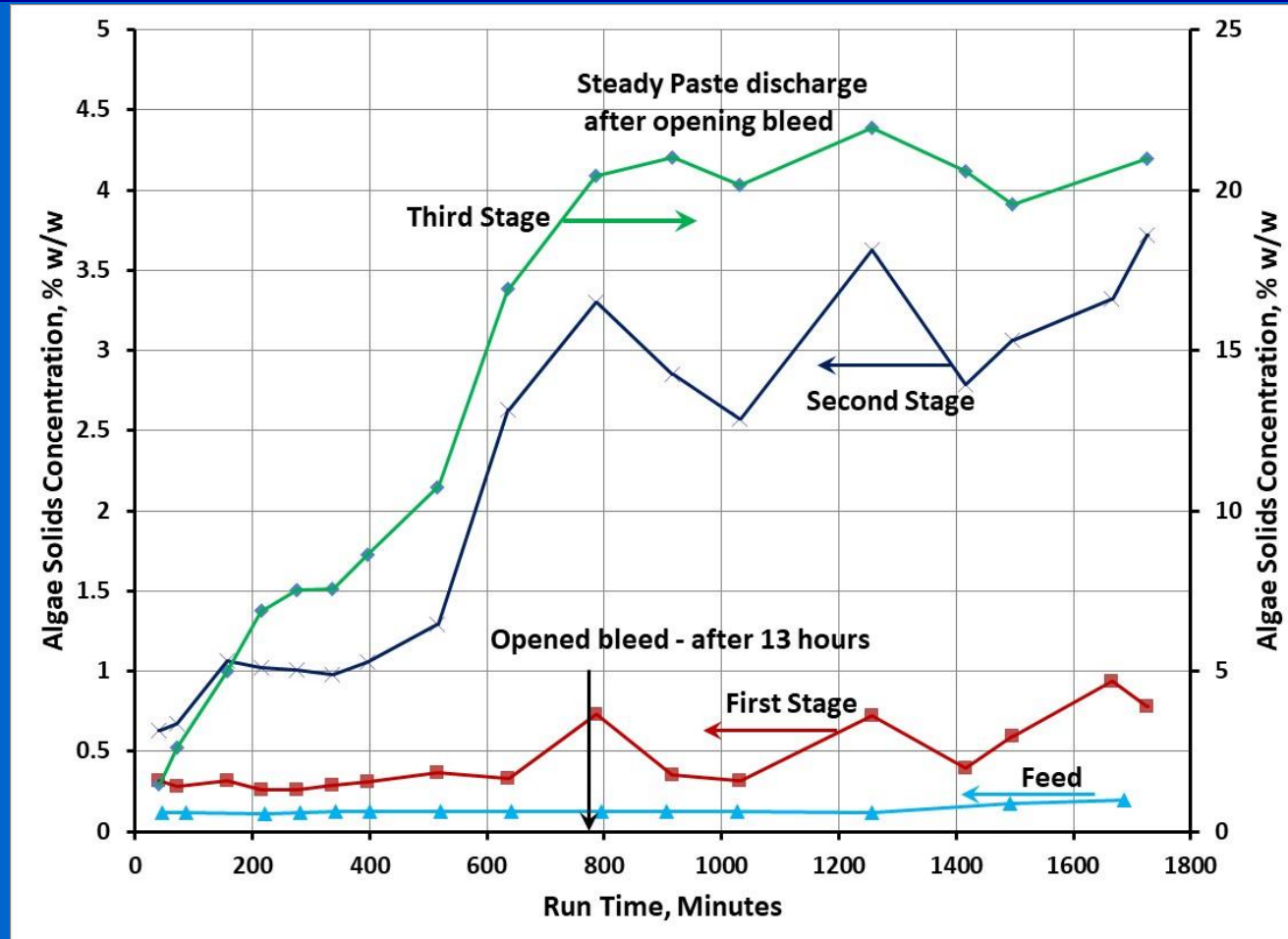
## Buckets of algae paste at DCWD



# MicroBio Algae Dewatering Performance



## ClearAs Algae Dewatering Performance



## Videos of Algae Paste Collection



Nannochloropsis - <https://youtu.be/Niu-wRooOgM> , <https://youtu.be/zJMYi4ipkbQ>

Kirchneriella - <https://youtu.be/ARH-PxXVH6c> , <https://youtu.be/F0WLyNRPQnQ>

Marine algae - <https://youtu.be/DKz1HzP6zgc> , Pediastrum - <https://youtu.be/e9gFPsvdabA>

Mixed Scenedsmus, Chlorella - <https://youtu.be/RySdfMG5YmE>

Proprietary - [https://youtu.be/c7rBYI\\_9Yso](https://youtu.be/c7rBYI_9Yso) , <https://youtu.be/HnKJ7u8Jld4>

## DOE Financial Support Acknowledgement

Financial support from the U. S. Department of Energy, Office of Science, for the SBIR Phase I - II projects (Award # DE-SC0013737) for the work presented here is gratefully acknowledged.



## More information? Questions?

Contact:

Dr. Ashok Damle  
Techverse, Inc.  
919-454-8461

[techverse@hotmail.com](mailto:techverse@hotmail.com)

[adamle@techverseinc.com](mailto:adamle@techverseinc.com)

[http://techverseinc.com/algae\\_dewatering/](http://techverseinc.com/algae_dewatering/)