



SINGLE-STAGE WATER FILTER WITH DUAL SAND MEDIA SIZES

Team Hydration Station

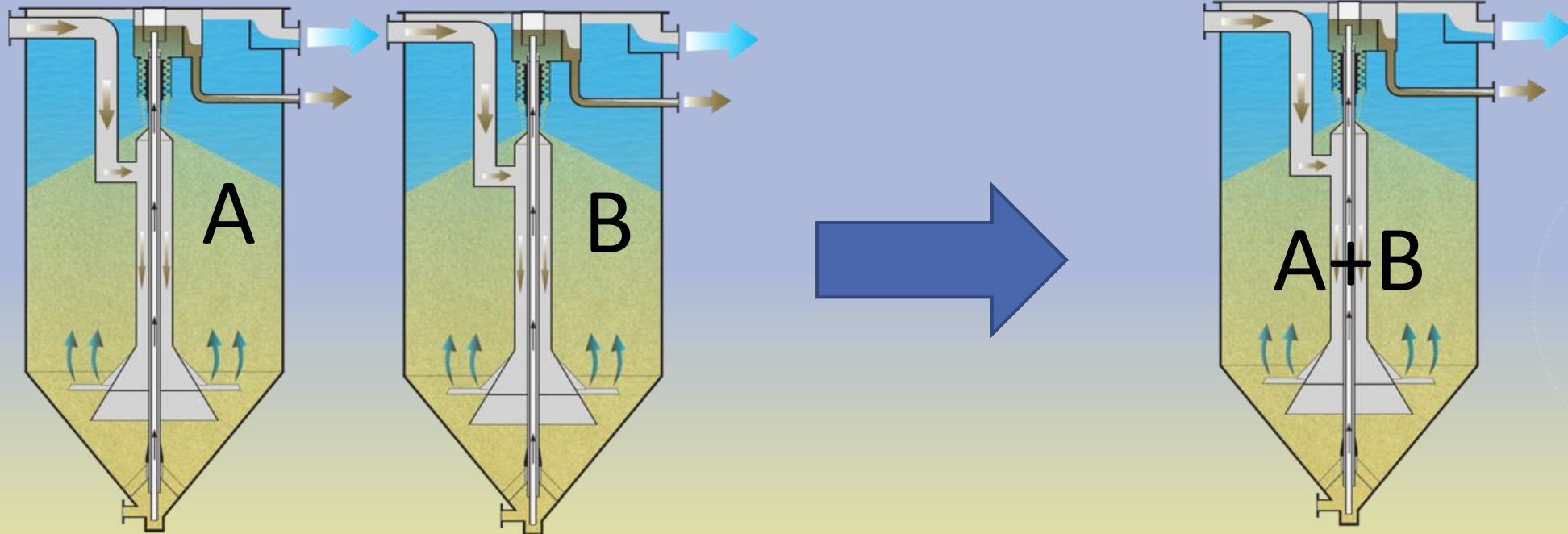
Jaden Cavender (ME)

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VALUE PROPOSITION

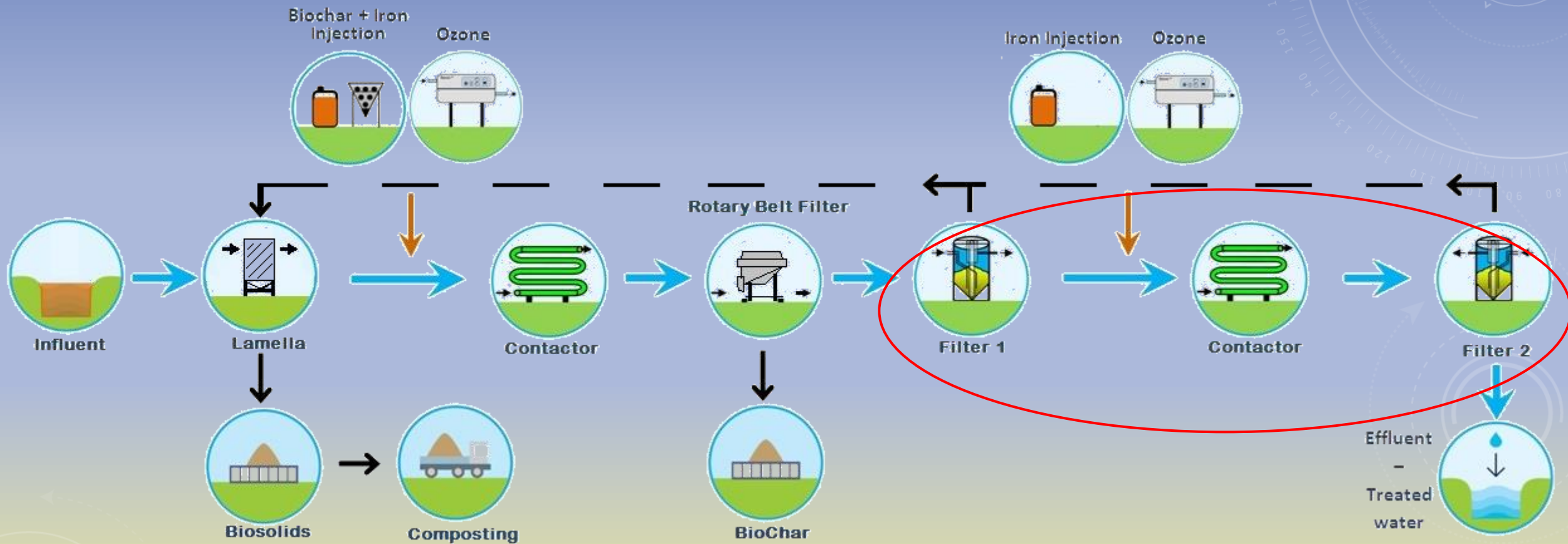


Providing clean water is a grand engineering challenge and will improve quality of life.

By combining the two-stage filtration system into a single-stage, we hope to cut back on maintenance and operation costs and decrease the footprint of the device, while increasing the efficiency.



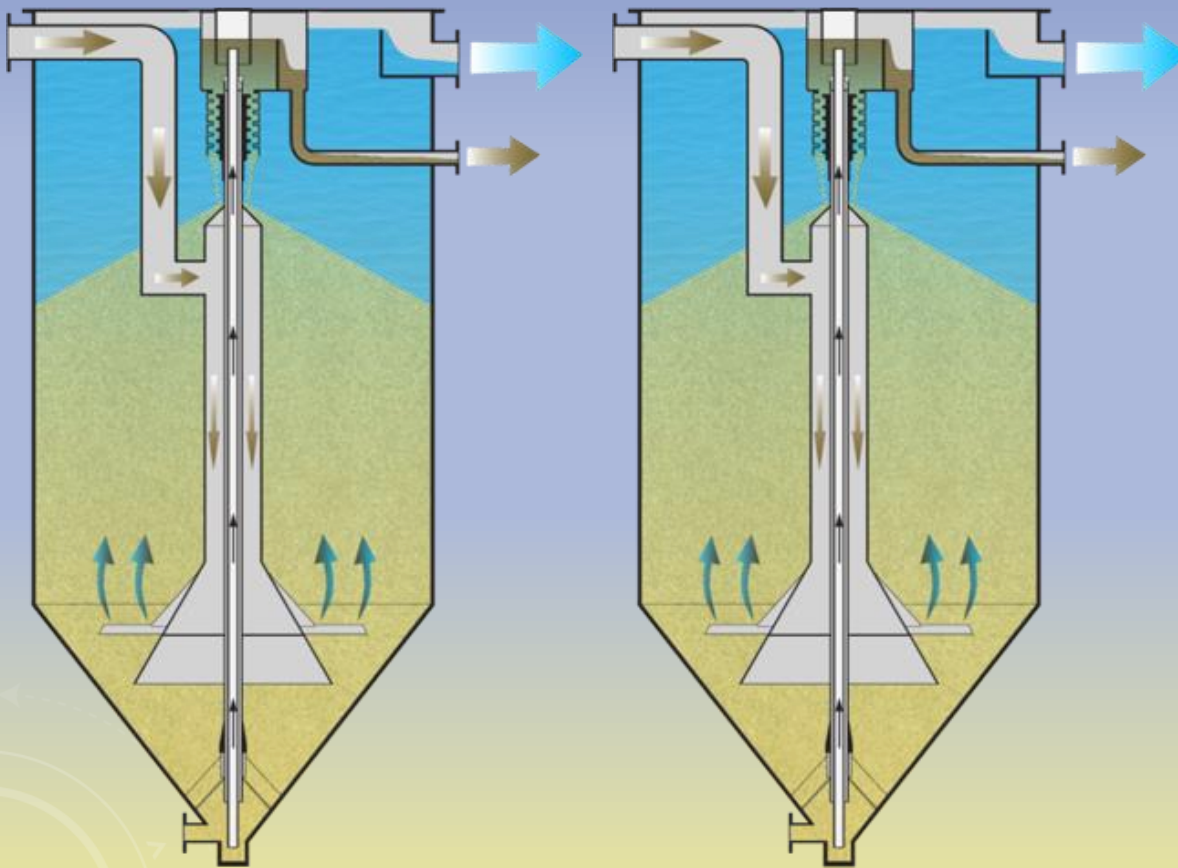
BACKGROUND





BACKGROUND

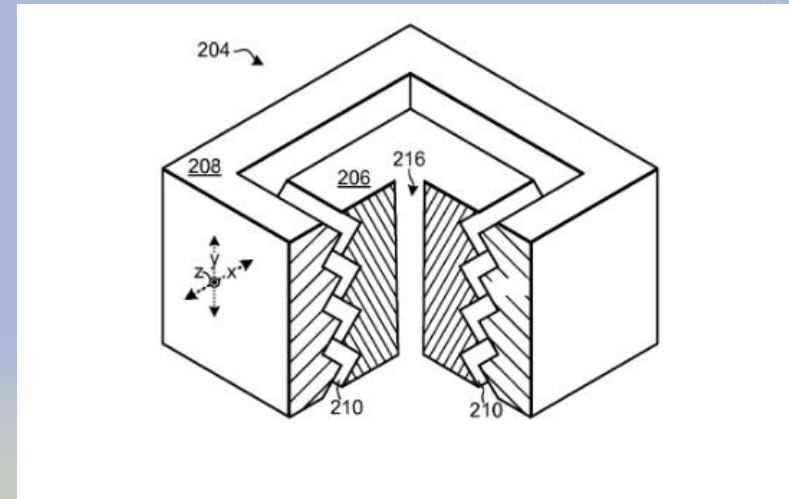
Current Design : Dual Stage Filtration



Coarse Sand Bed

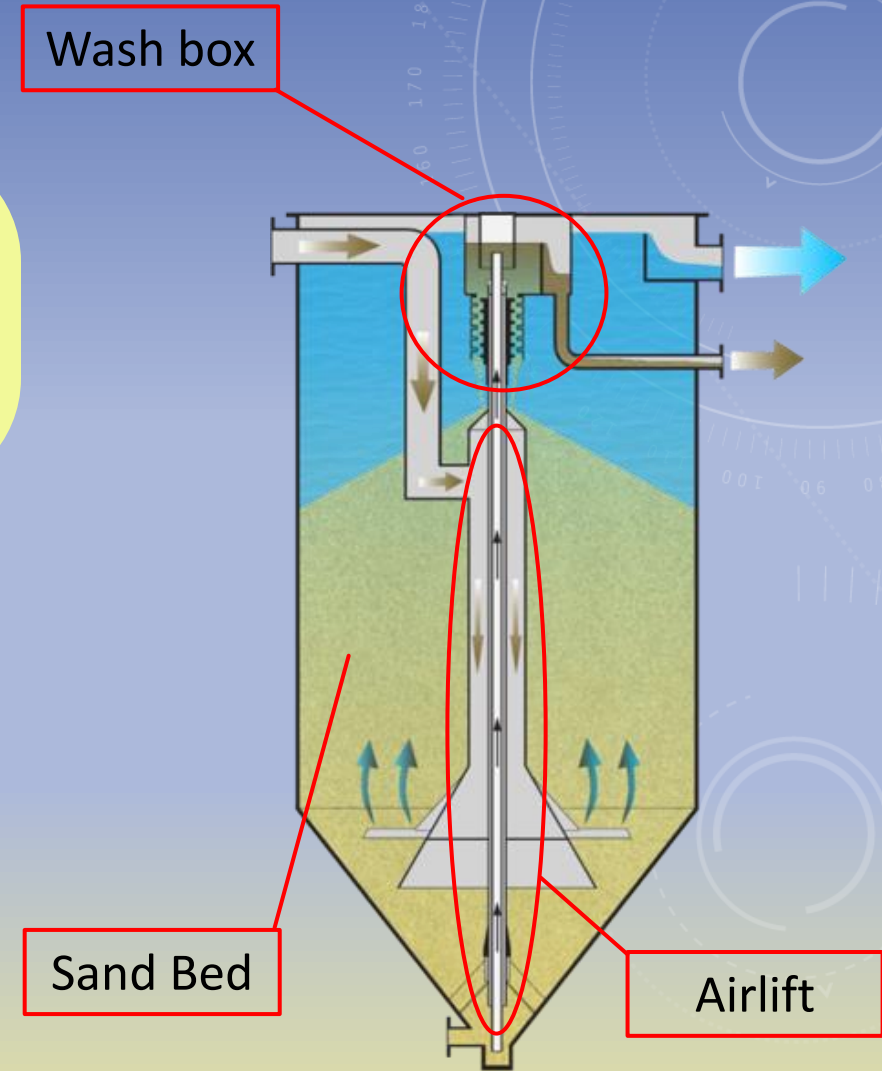
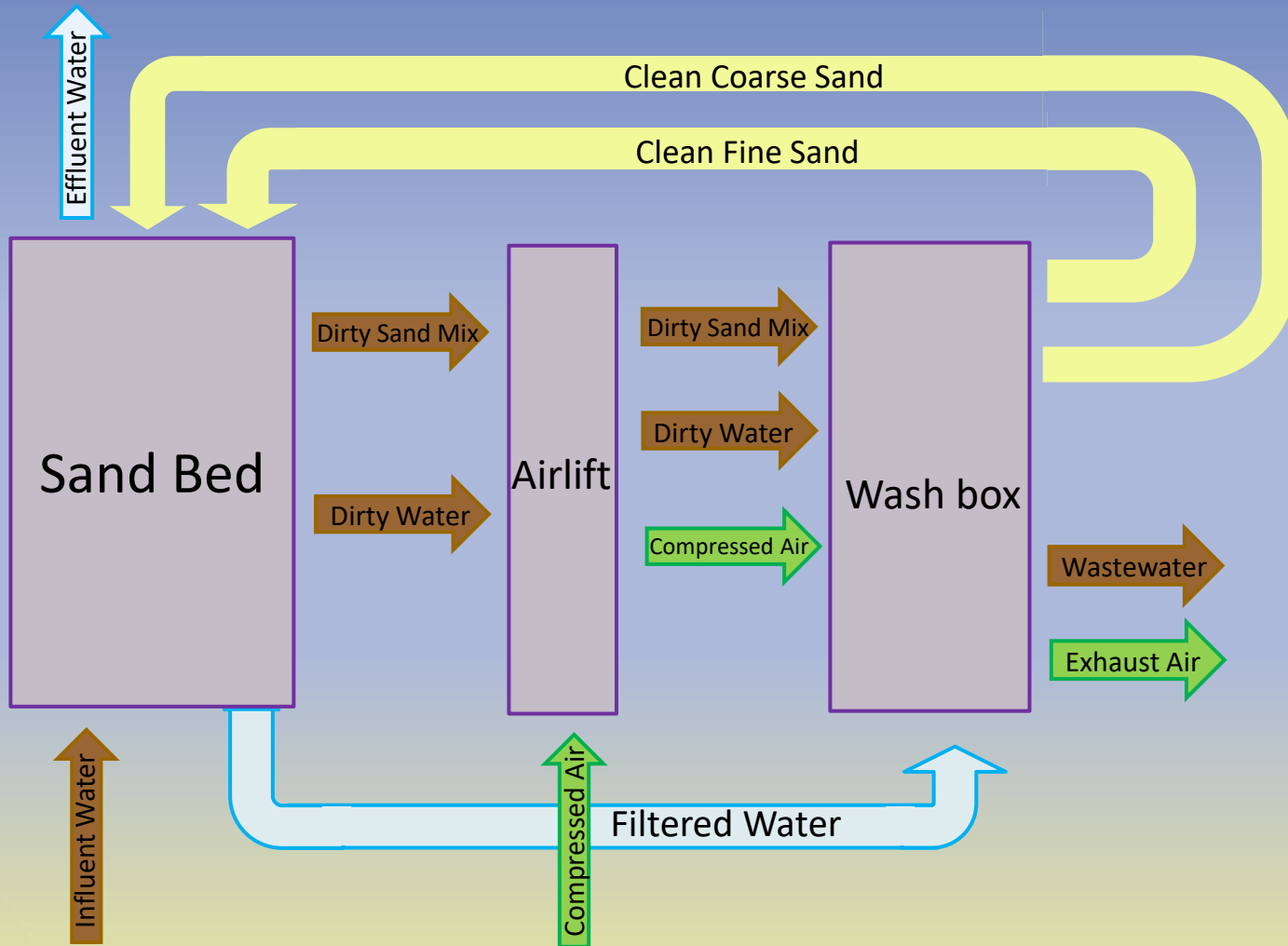
Fine Sand Bed

Previous Design: Adjustable Wash box





BACKGROUND





REQUIREMENTS

- ◆ 75% separation and correct deposition of the two sand sizes
- ◆ Chemical and corrosion resistance.
- ◆ Maintains upflow rate to prevent backwash water contamination.
- ◆ Sufficient sand bed turnover rate.
- ◆ Continuous operation system with a maximum of 30 minutes of routine weekly maintenance

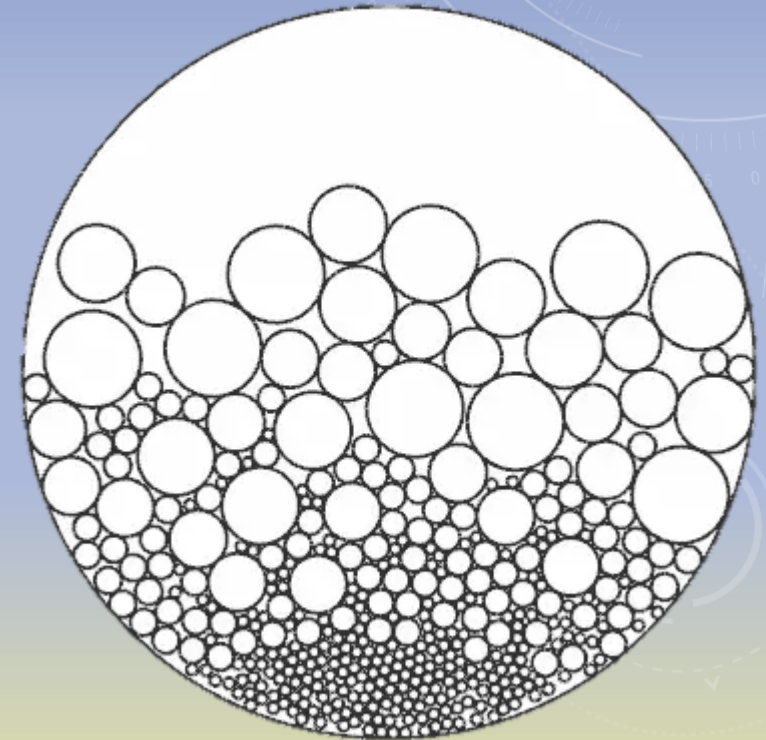
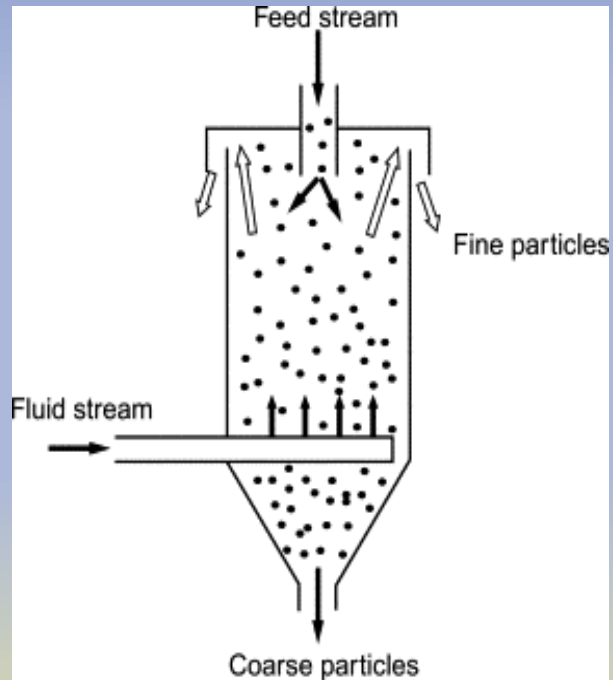


Martin Baker and Greg Möller with the Clean Water Machine



CONSIDERATIONS

- ◆ Granular Convection
- ◆ Screen Slope Incline and Avalanche Frequency
- ◆ Elutriation



<https://www.sciencedirect.com/topics/engineering/elutriation>

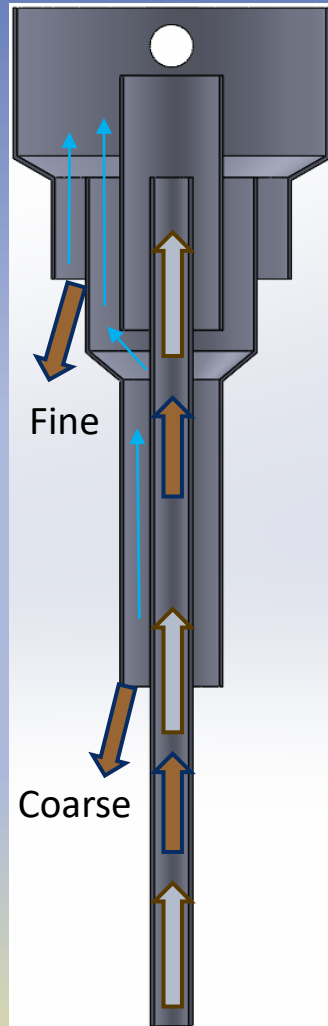
<https://coffeedastra.com/2020/02/01/the-physics-of-fines-migration/>



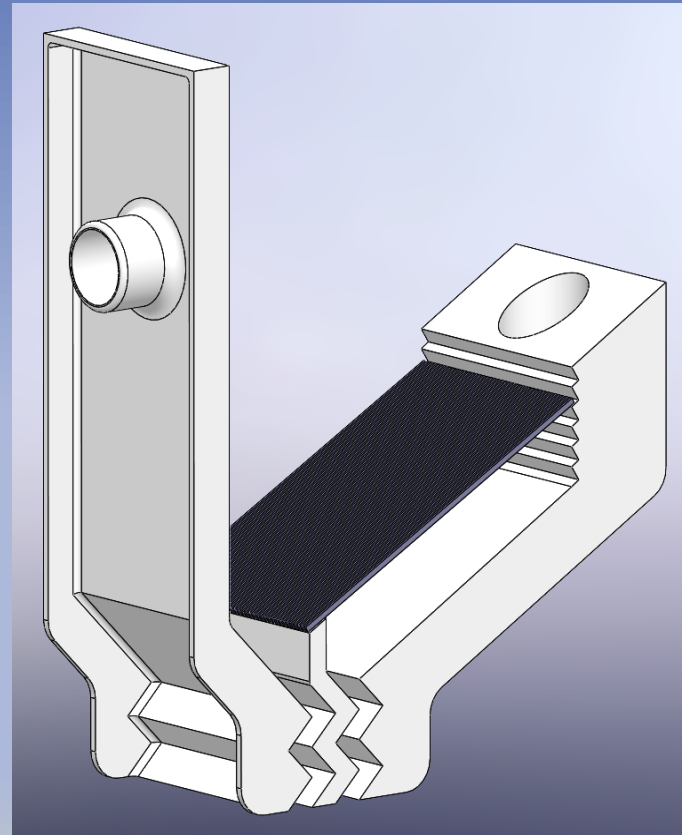
CONCEPTUAL DEVELOPMENT



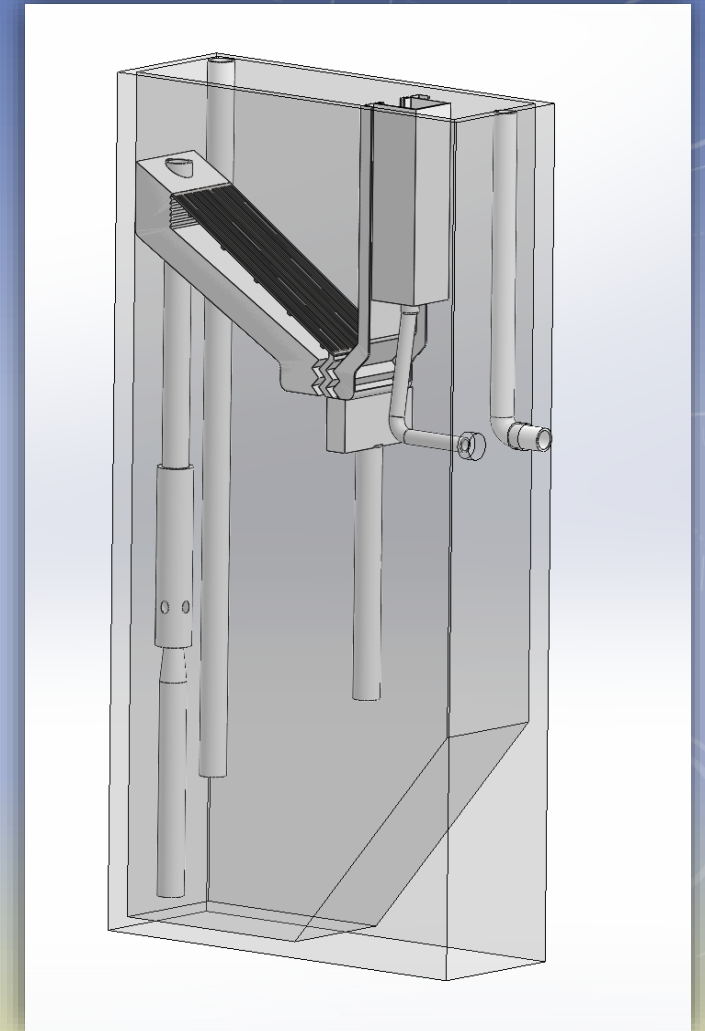
Separated beds to ensure particle segregation.



Water up flow through channels separates particles based on unique settling Velocities



Segregation using Wedge wire screen

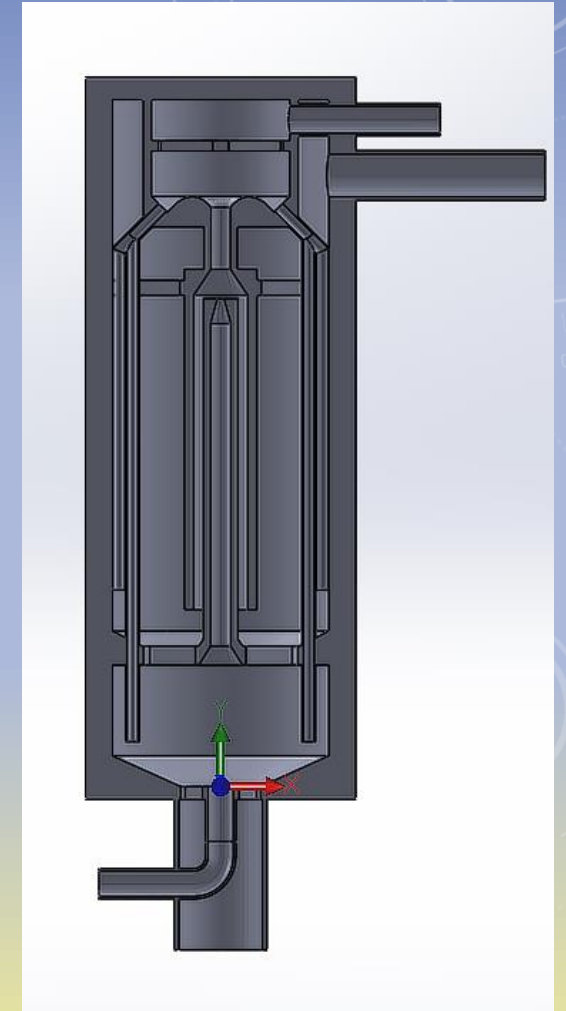
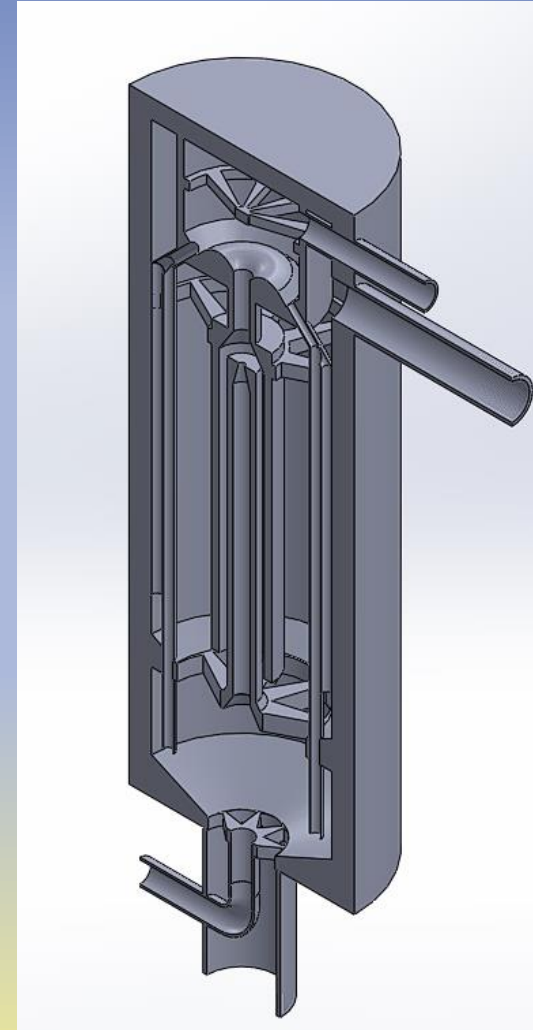


Fully Modular test stand and wash box



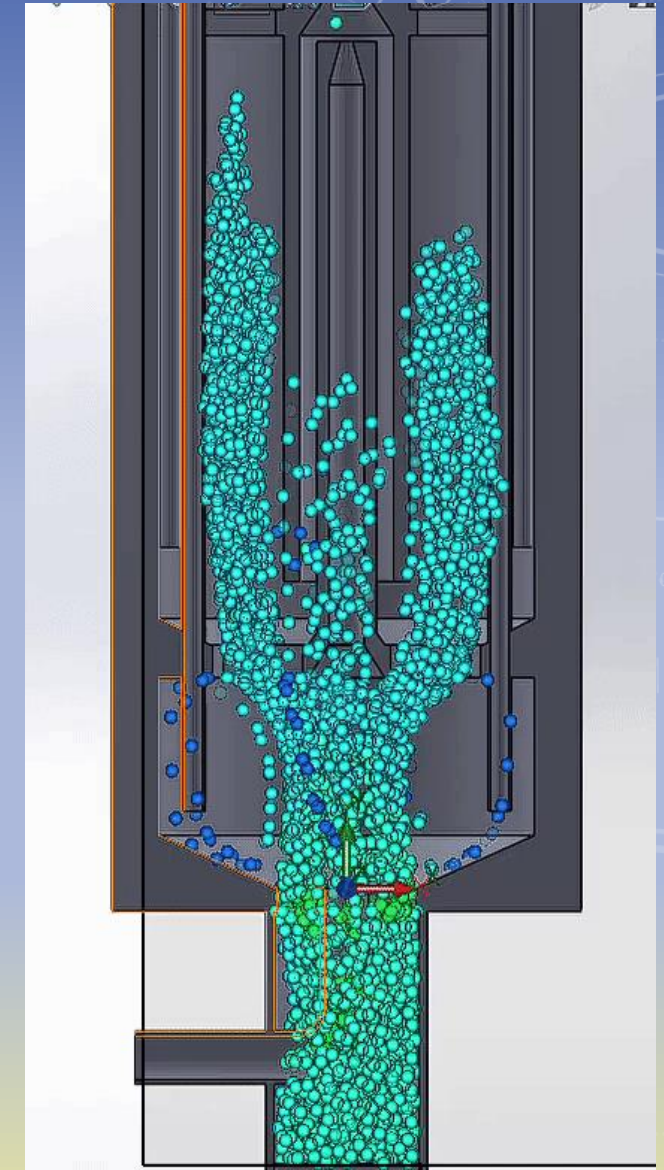
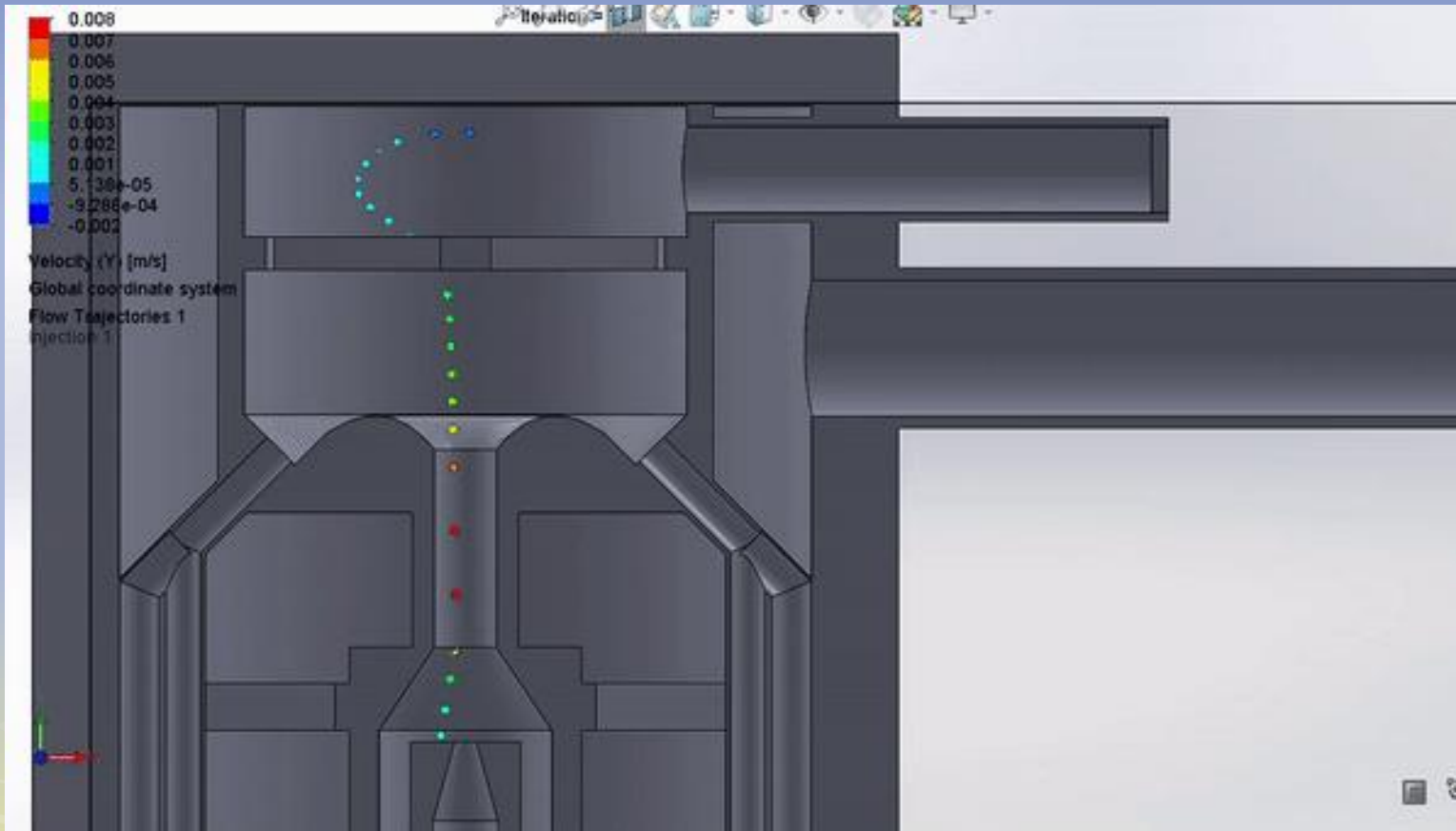
VALIDATION VIA SIMULATION

- A mock wash box geometry was modeled, and fluid analysis was conducted on water particles.
- Inlet pressure and outlet effluent and clean water were modeled. Velocities were visualized using colored spheres.





CFD RESULTS





WASH BOX VALIDATION

Design Validation was conducted on an experimental model.

- ◆ Sand separation
- ◆ Upflow velocities
- ◆ Airlift sand deposit
- ◆ Washbox Turbulence

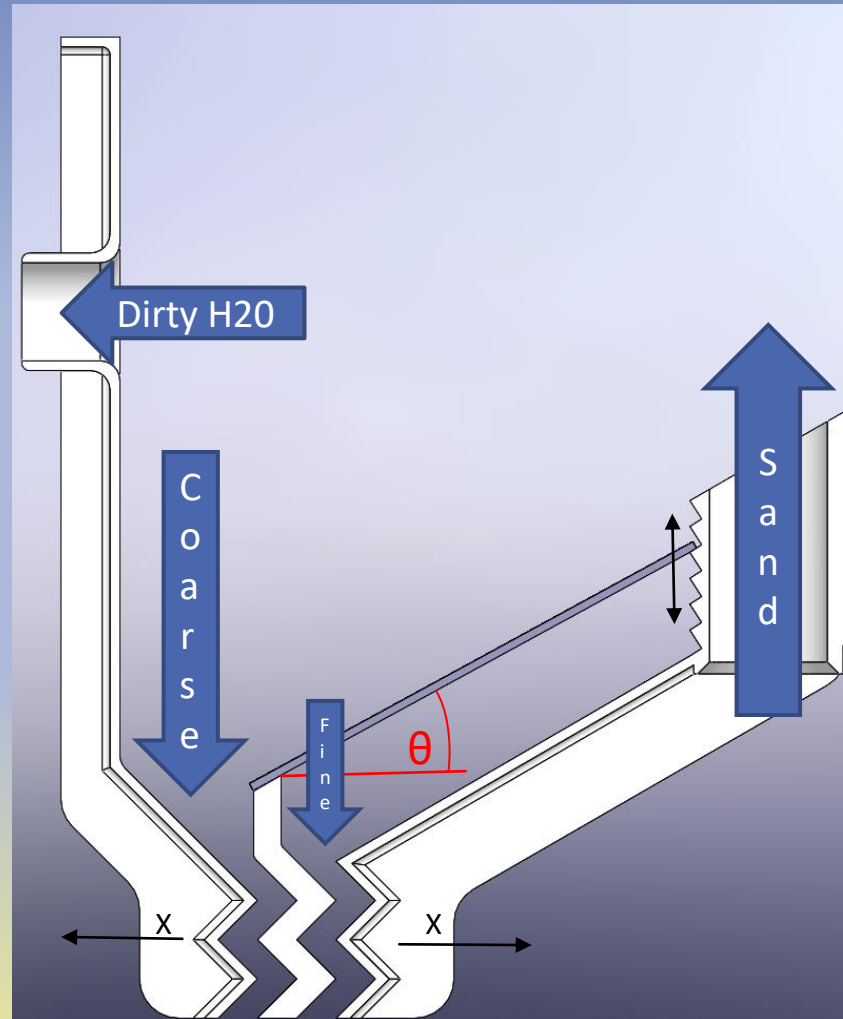
Adjustability

Channel Velocity

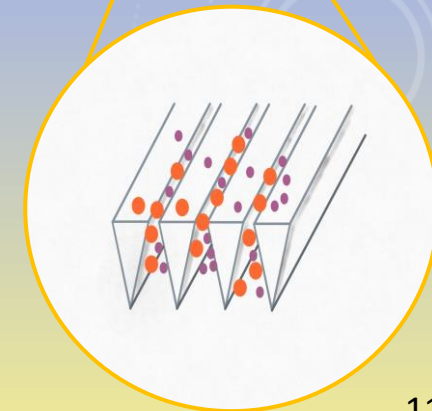
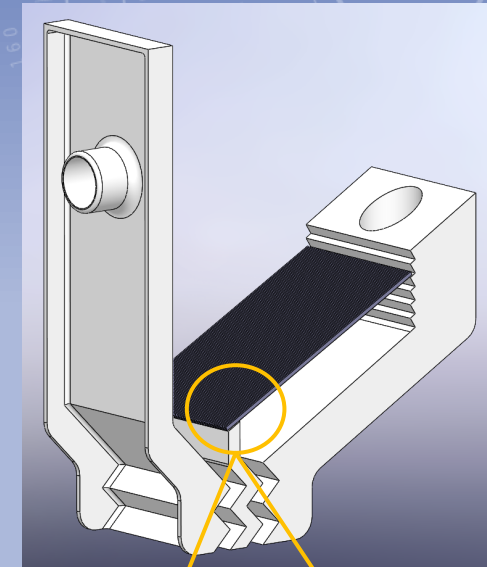
- ◆ .43 -.87 in/s

Screen & Channel Angle: θ

- ◆ 25 –45 degrees



Above: Screen separated wash box assembly.





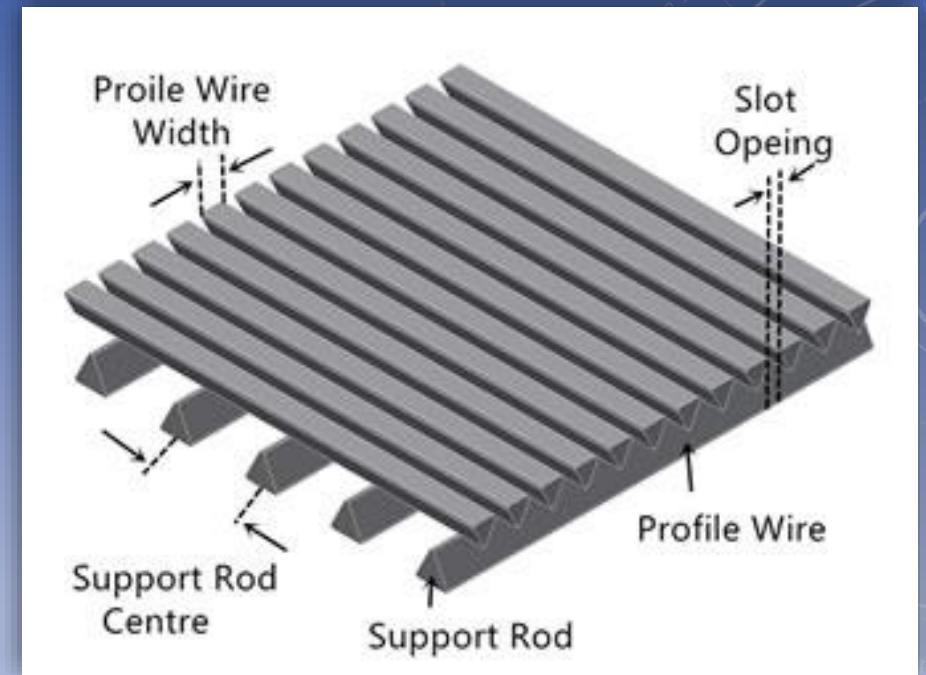
TESTING/VERIFICATION

Main Sand Separator: Perforated Sheets / Wedge Wire Screen.

Both designs were experimentally verified.

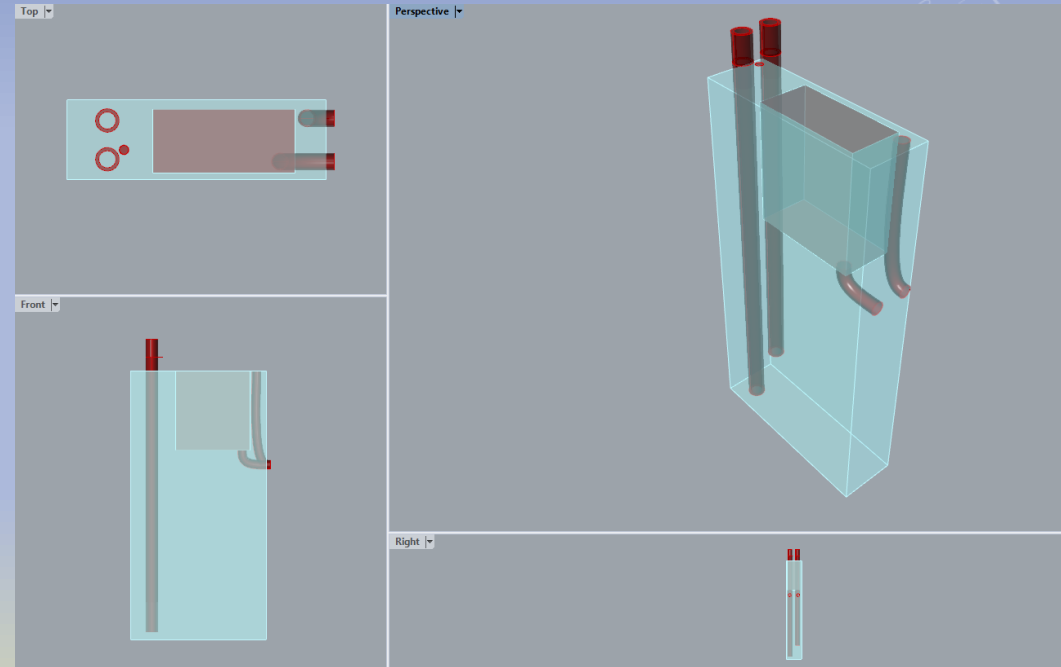
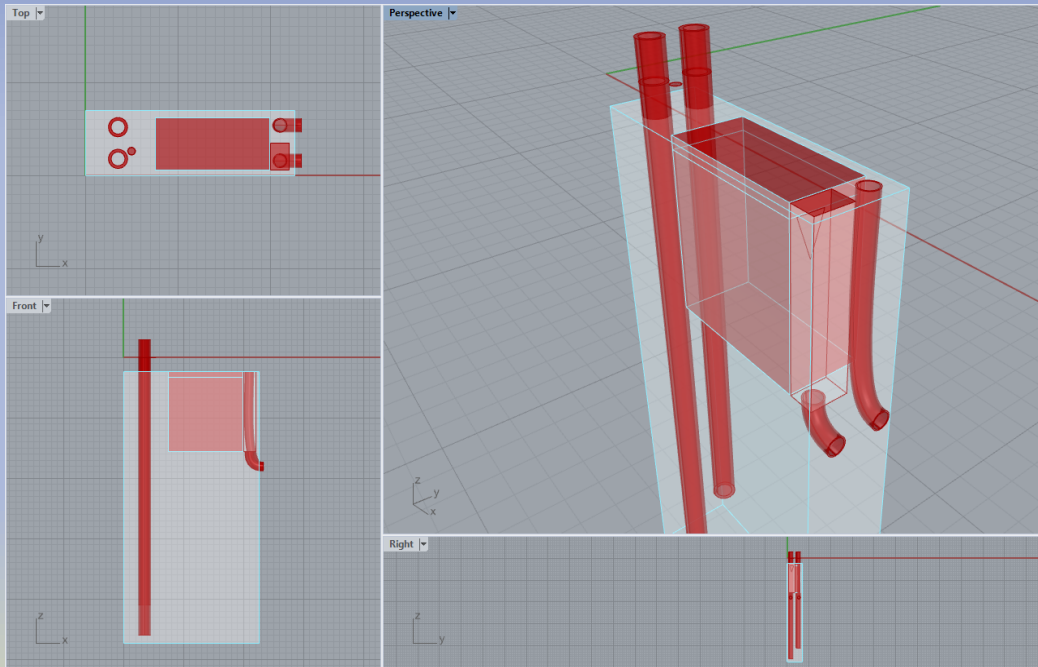
Wedge wire was quick to 3d print but struggled with adequate separation rates.

Perforated sheets were very effective but needed to be professionally made.





TEST STAND MODEL





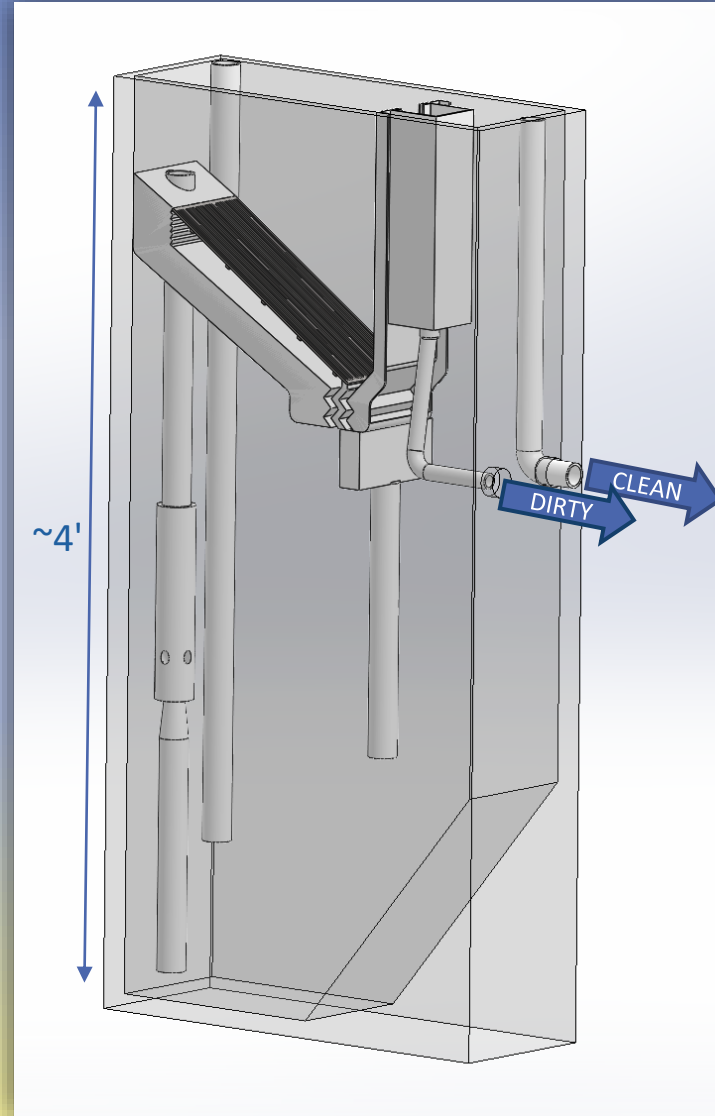
WASH BOX & TESTING MODIFICATIONS

Tank

- ◆ Fully modular.
- ◆ Airlifts, wash box, inlets and overflow reservoir.
- ◆ Bed separation.

Wash Box

- ◆ Screen
 - ◊ Increased angle variability.
 - ◊ Increased screen length to increase media-screen contact





ASSEMBLIES/SUBASSEMBLIES/BOM

- ◆ Subassembly 1: Wash box
- ◆ Subassembly 2: Tank Features
- ◆ Subassembly 3: Piping and Fittings

Test Stand Bill of Materials

Total Cost: Around \$2042

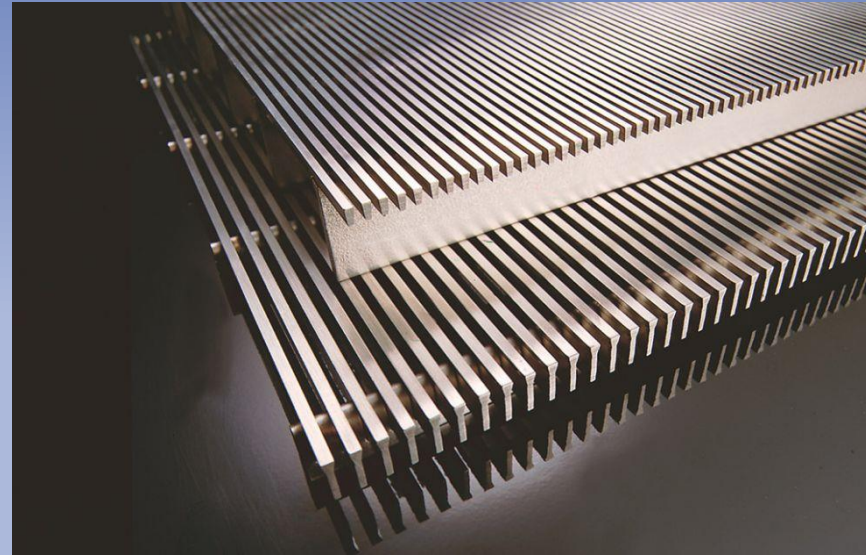
- ◆ Acrylic Panes - \$1300
- ◆ Flow Meters - \$400
- ◆ PVC - \$50
- ◆ Vinyl Tubing - \$62
- ◆ Adhesives/Sandpaper - \$58
- ◆ Ports/Fasteners - \$15
- ◆ Sheet Metal - \$157





MANUFACTURING METHODS

- ◆ 1. Band sawing of pipes/fiberglass
- ◆ 2. 3-D printing/Sheetmetal fabrication
- ◆ 3. Waterproofing with sealant and adhesives
- ◆ 4. Acrylic and Acrylic welding adhesive.
- ◆ 5. Steel Welding



Martin Baker

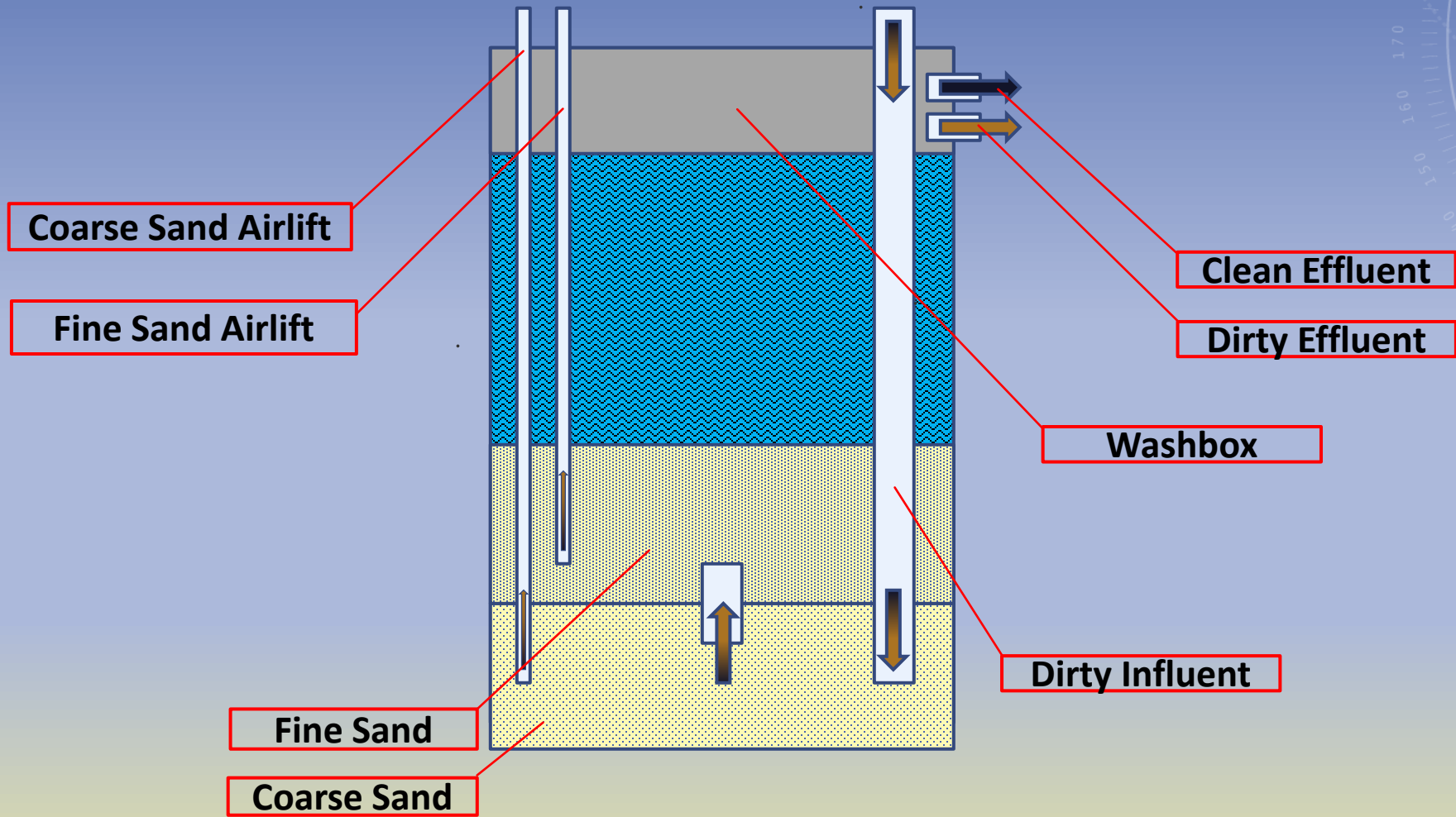




FINAL DESIGN

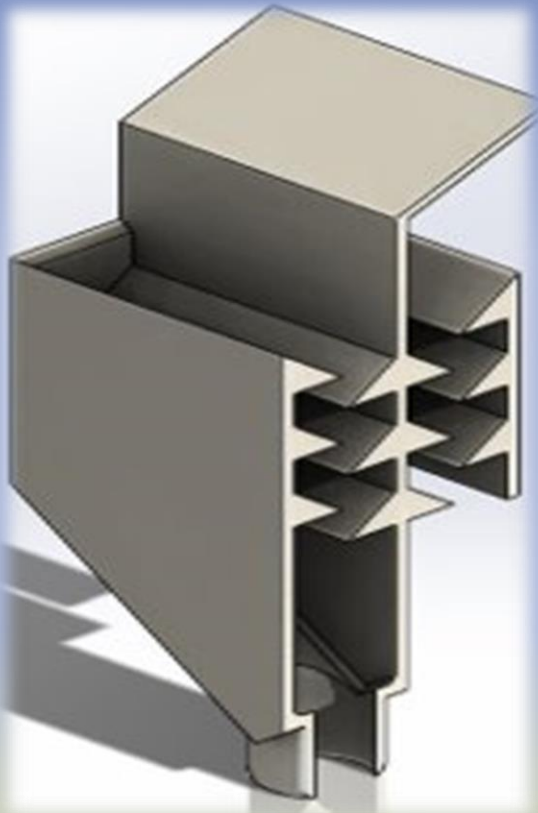


DIAGRAM





WASHBOX



Left: Displays Torturous Path part which removes debris from sand

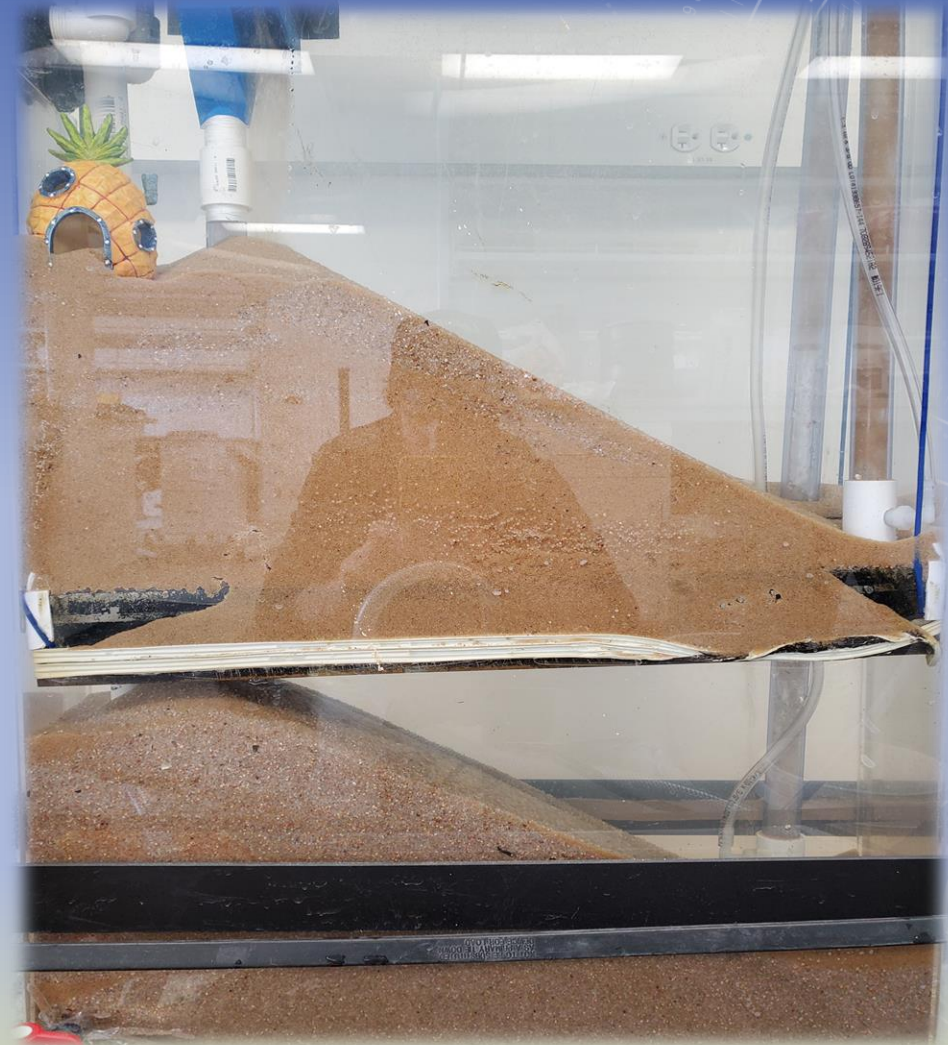


Right: Current wash box construction.



BED SEPARATION EXPERIMENT

- ◆ Goal for the project was **>75%** sand separation
- ◆ By taking random mass difference in filtered weight vs. Unfiltered, Sand separation in the fine bed was **84%**.



OBJECTIVE ACHIEVED



DFMEA OF CURRENT RISKS

RR = Risk Rating

RR \geq 100 is High Risk/Guaranteed to negatively impact filtration

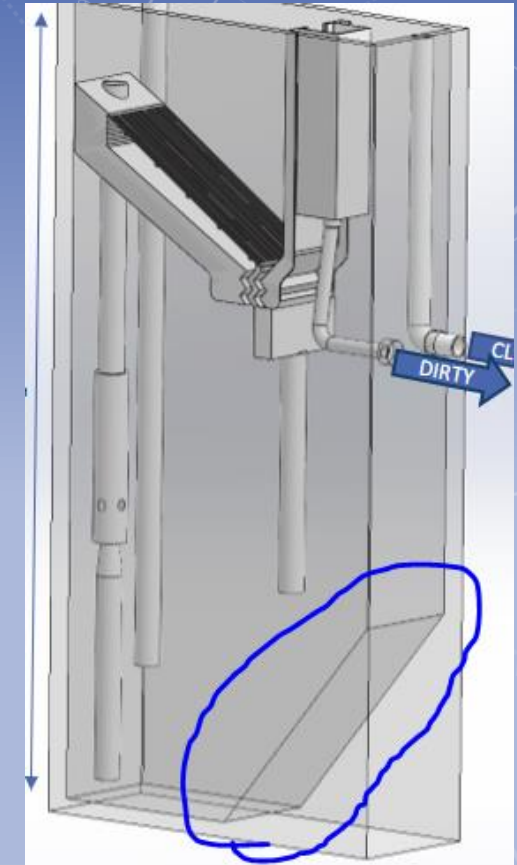
RR \geq 50 is Moderate risk/ minorly impacts effectiveness

Notable Risks:

- ◆ Rust and corrosion degradation: RR100
- ◆ Clumping of Sand without Gradient: RR60
- ◆ Contaminant buildup in wash box: RR60
- ◆ Sand falling through sealant: RR55



Left: Thicker materials with proper pipe/metal lining is required to stop corrosion.

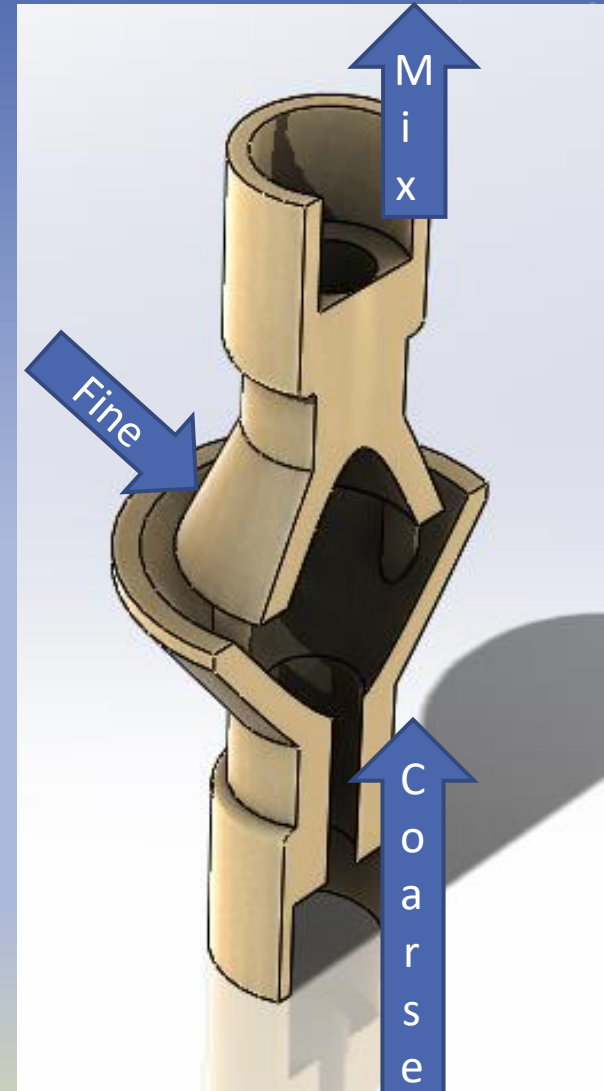


Right: Gradient in corner will help sand fall more evenly.



FUTURE DEVELOPMENT

- ◆ Test Stand Model will be available for future use & development.
- ◆ Single airlift design
- ◆ Wedge wire screen for bed separator
- ◆ Wear analysis on components
- ◆ Sloped floor for even sand uptake
- ◆ Corrosion resistant lining for high traffic areas of sand



Above: Singular couple could simplify to one uplift pipe but needs refining and testing.

ACKNOWLEDGEMENTS

- Dr. Sarah Wu our advisor
- Mr. Martin Baker and Dr. Greg Möller our sponsors
- Kirk McKenzie our graduate mentor



TEAM HYDRATION STATION

