SRP EVAP. Prototype 2

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Physical Prototype

Question to answer:

- Determine how shading affects the internal temperature of water and local relative humidity.

What was the answer:

- Shaded water exhibited significantly lower temperatures compared to unshaded water.
- Evaporation rates were higher in unshaded areas.
- Relative humidity above shaded water was approximately 5% higher in several data points.

Plan to iterate based:

- Introduce active water temperature control.
- Implement more precise humidity sensors to track local environmental changes.

Figure 1: Shaded Prototype

Figure 2: Unshaded Prototype

Physical Prototype

Final Bill of Materials SRP EVAP						
Purpose	Component	Description	Quantity	Price per Unit	Total Cost	Source
Prototype 1						
	Glass Cup	To hold water while testing for evaporation	2	$0	$0	Personal
	Cardboard	To Create shade over one cup	1	$0	$0	Personal
Prototype 2						
	16 Q. plastic Bin	To hold the water	2	$4.00	$8.00	Target
	4ft. of 1in. PVC	To make a stand for the PV panel and analog guages	1	$8.91	$8.91	Home Depot
	Analog Aquatic Temperature and humididty guage	To accurately record the temperature and humidity some distance above the water	2	$11.01	$22.02	PetSmart
	Digital Water Thermometer	To record the water tempertature	2	$12	$24	Solar Shed
	PV Panel	To create Shade over one bin with constant radiation absorptivity	1	$0	$0	Solar Shed
	Hot Glue Gun & sticks	Used to connect the PVC pipe to the PV panel	1	$6.58	$6.58	

Physical Prototype Results Day 1

Day 1 Shaded						
Time of day	Water Ammount(g)	Temp Water(F)	Temp Air(F)	Humidity Above	Humidity Air	wind speed(mph)
10:30	1826	70.2	60	23	22	8
11:30	1806	67	61	19	19	9
12:30	1783	62.1	63	17	18	11
1:30	1757	61	63	18	16	9.5
2:30	1746	61	63	17	15	10
Avg Evaporation Per Hour = 16 Grams/Hour = .0016 Liter/Hour						

Day 1 Un-Shaded						
Time of day	Water Ammount(g)	Temp Water(F)	Temp Air(F)	Humidity Above	Humidity Air	wind speed(mph)
10:30	1825	70.2	60	22	22	8
11:30	1802	71.4	61	19	19	9
12:30	1778	71	63	16	18	11
1:30	1749	69	63	15	16	9.5
2:30	1727	65.5	63	15	15	10
Avg Evaporation Per Hour = 19.6 Grams/Hour = .00196 Liter/Hours						

Physical Prototype Results Day 2

Day 2 Shaded						
Time of day	Water Ammount(g)	Temp Water(F)	Temp Air(F)	Humidity Above	Humidity Air	wind speed(mph)
10	1826	68	55	23	22	9.5
11	1802	58	56	20	20	10
12	1784	56	58	18	20	10.5
1	1761	55	59	20	18	11
2	1741	53	59	21	17	11
Avg Evaporation Per Hour = 17 Grams/Hour = .0017 Liter/Hour						

Day 2 Un-Shaded						
Time of day	Water Ammount(g)	Temp Water(F)	Temp Air(F)	Humidity Above	Humidity Air	wind speed(mph)
10	1826	70	55	22	22	9.5
11	1800	69	56	15	20	10
12	1776	65	58	15	20	10.5
1	1749	62	59	17	18	11
2	1727	56	59	18	17	11
Avg Evaporation Per Hour = 19.8 Grams/Hour = .00198 Liter/Hours						

Day 2 Raw Data:

Day 2 Raw Data:	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM
	Tub 1, Tub 2	Tub 1, Tub 2	Tub 1, Tub 2	Tub 1, Tub 2	Tub 1, Tub 2
Weight (g):	1826g, 1826g	1800g, 1797g	1776g, 1784g	1749g, 1761g	1727g, 1747g
Weather (App)(F)/2:	55 F	56 F	58 F	59 F	59 F
Wind (App)(MPH):	9.5 MPH	10 MPH	10.5 MPH	11 MPH	11 MPH
Humidity (App):	22%	20%	20%	18%	17%
Water Thermometer (F):	72.5, 64.9	69.1, 58.1	65.3, 56.1	62.1, 55.6	56.8, 53.4
Reptile Meter:					
Temperature (F):	56, 60	71, 70	62, 71	60, 59	62, 60
Humidity:	20%, 28%	15%, 20%	15%, 18%	17%, 20%	18%, 21%

Physical Prototype Error Possibilities

- Debris Falling into the water
- Animals and Insects drinking the water
- Water sticking to fingers when checking thermometer
- Wind blowing water out of tub
- Weighing Tubs Incorrectly
- Thermometer Error
- Heat from Solar Panel
- Shading

Virtual Prototype

```
% Reynolds number range
Re_min = 2.59896e6;
Re_max = 2.70496e6;

% Define input ranges
T_C = 5:1:50;            % Temperature range (°C)
U_inf = 3:0.025:13;        % Full wind speed range (m/s)
possible_lengths = 0.3:0.05:3;  % Apparatus length options

% Kinematic viscosity interpolation from Table A-15
T_known = [5, 10, 15, 20, 25, 30, 35, 40, 45, 50];
nu_known = [1.382e-5, 1.426e-5, 1.470e-5, 1.516e-5, 1.562e-5, ...
            1.608e-5, 1.655e-5, 1.702e-5, 1.750e-5, 1.798e-5];
nu_table = interp1(T_known, nu_known, T_C, 'spline');
```

Figure 3: MATLAB Code Parameters

Ranges of Parameters:

$$Min: T_\infty = 5℃ = 41℉$$

$$Max: T_\infty = 50℃ = 122℉$$

$$Min: U_\infty = 3\ \frac{m}{s} = 6.7\ mph$$

$$Max: U_\infty = 13\ \frac{m}{s} = 29\ mph$$

$$Avg.\ Re_L\ from\ Canal: Re_L = 2.65 \times 10^6$$

$$Percent\ error: \pm 2\%$$

$$Min: Re_L = 2.599 \times 10^6$$

$$Max: Re_L = 2.705 \times 10^6$$

Virtual Prototype Results

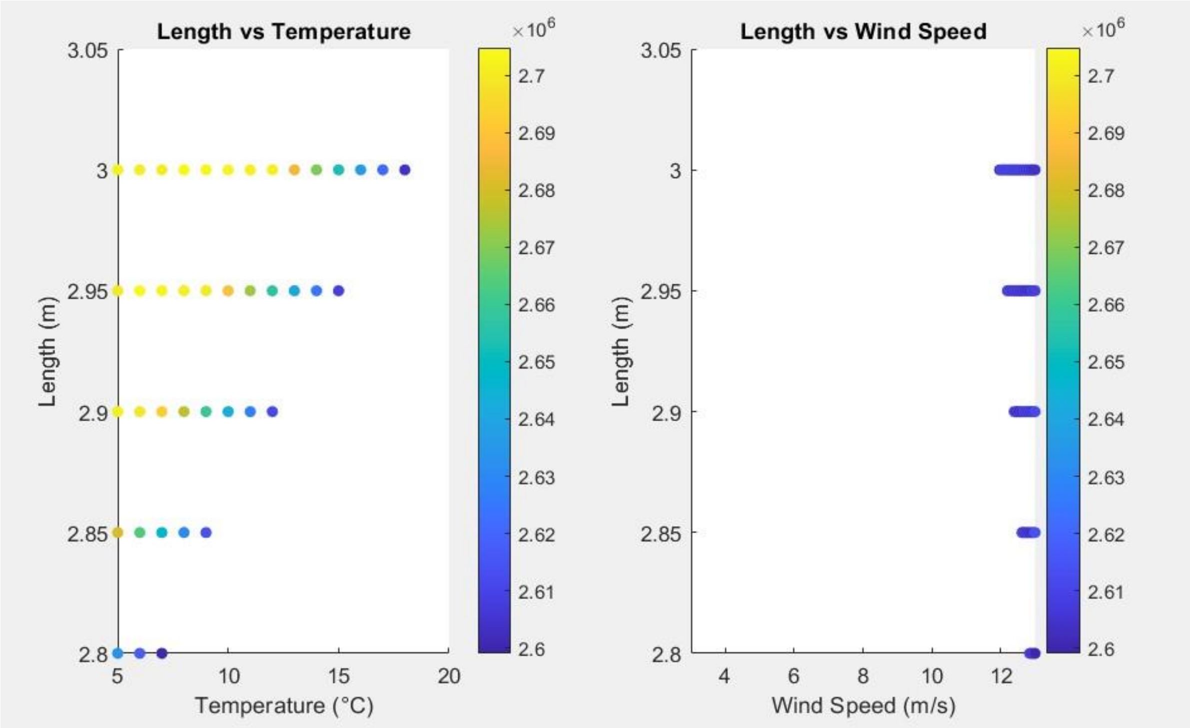


Figure 4: 543 Valid Designs that Produce a Reynolds Number Equivalent to Arizona Canals shown by plotting the length vs. Temperatures and wind speeds

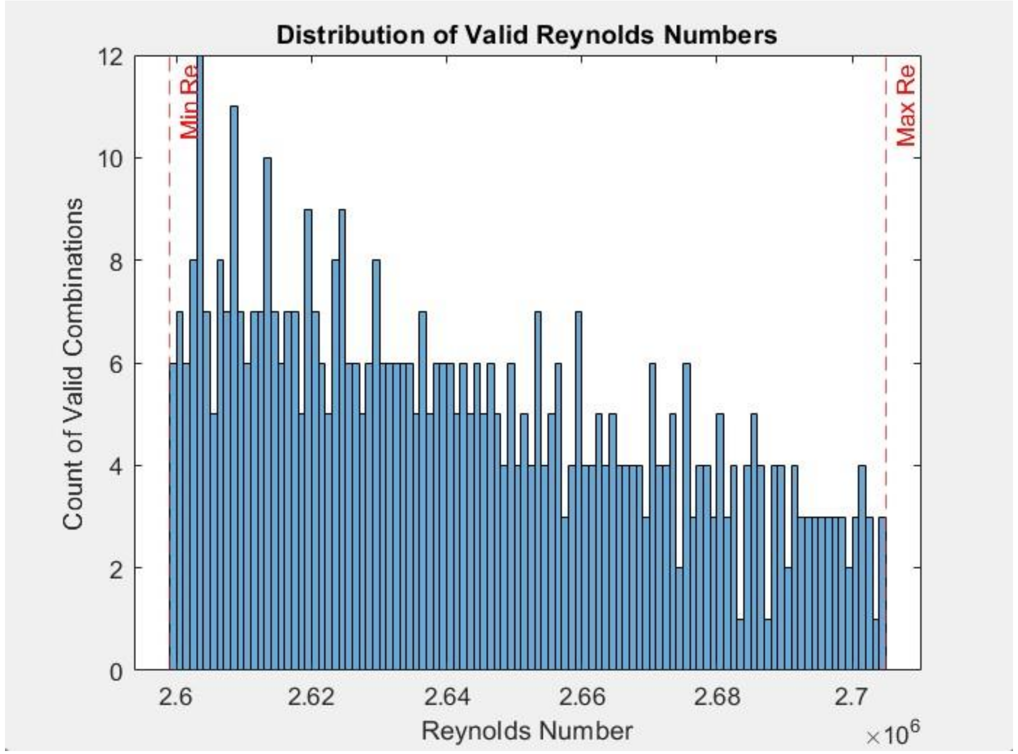


Figure 5: Distribution of Valid Reynolds Numbers

Virtual Prototype Results Cont.

Total valid combinations: 543
Optimal Configurations (Smallest Length + Lowest Wind Speed):

Temp (C)	nu (m^2/s)	U_inf (m/s)	Length (m)	Re_actual
5.00	1.38200e-05	12.85	2.80	2.60e+06
5.00	1.38200e-05	12.88	2.80	2.61e+06
5.00	1.38200e-05	12.90	2.80	2.61e+06
5.00	1.38200e-05	12.93	2.80	2.62e+06
6.00	1.39095e-05	12.93	2.80	2.60e+06
5.00	1.38200e-05	12.95	2.80	2.62e+06
6.00	1.39095e-05	12.95	2.80	2.61e+06
5.00	1.38200e-05	12.97	2.80	2.63e+06
6.00	1.39095e-05	12.97	2.80	2.61e+06
5.00	1.38200e-05	13.00	2.80	2.63e+06

Figure 6: 10 optimal combinations which have the smallest lengths & lowest wind speeds.

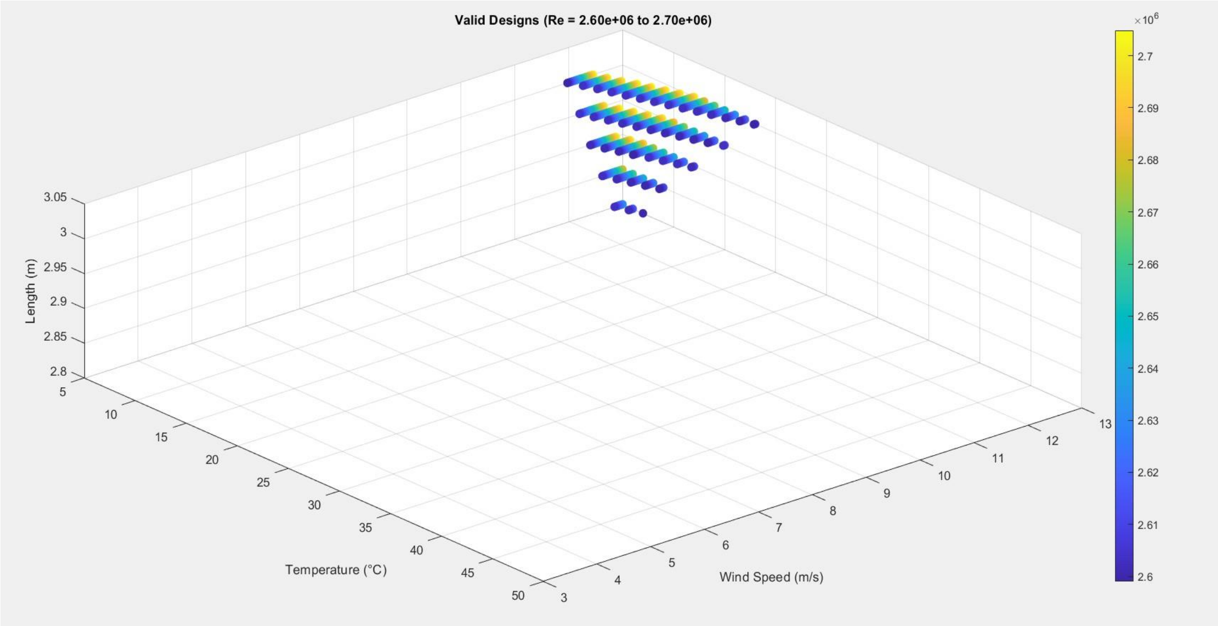


Figure 7: Possible lengths plotted against wind speed and temperature

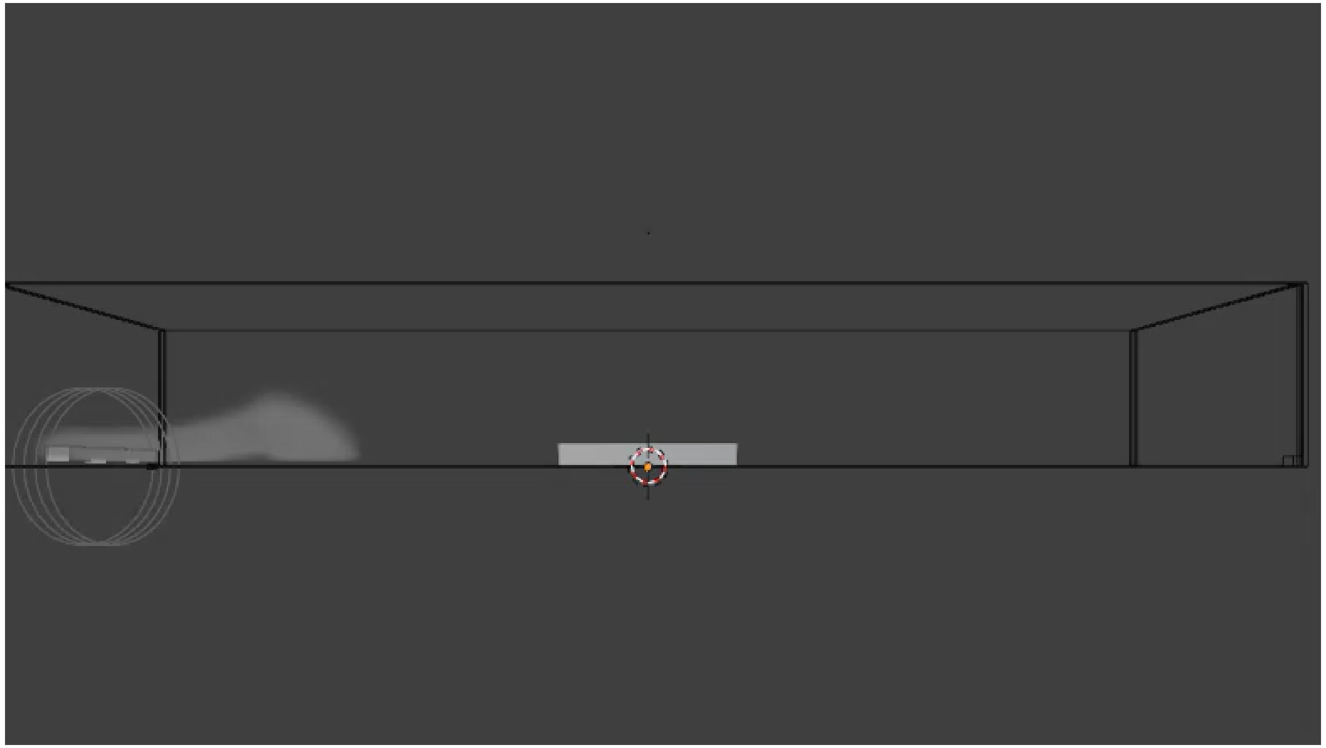
In conclusion, we will build an apparatus that will be able to operate under the parameters with the lowest wind speed and shortest length to mimic the conditions of the canal.

Wind Tunnel Simulation

Question to Answer: How forced convection in relation to the Reynold's and Sherwood numbers guide us in creating an accurate model.

What was the answer?: Model simulated forced convection, laminar flow, and turbulent transition all of which are directly related to the Reynold's and Sherwood number and the overall evaporation rate. Shows us that geometry is not as accurate as we would like for laminar flow.

Plan to iterate: Goal is to now build something realistic and attainable. Study more on turbulent and transitioning flows that fit within our scaling and parameters.

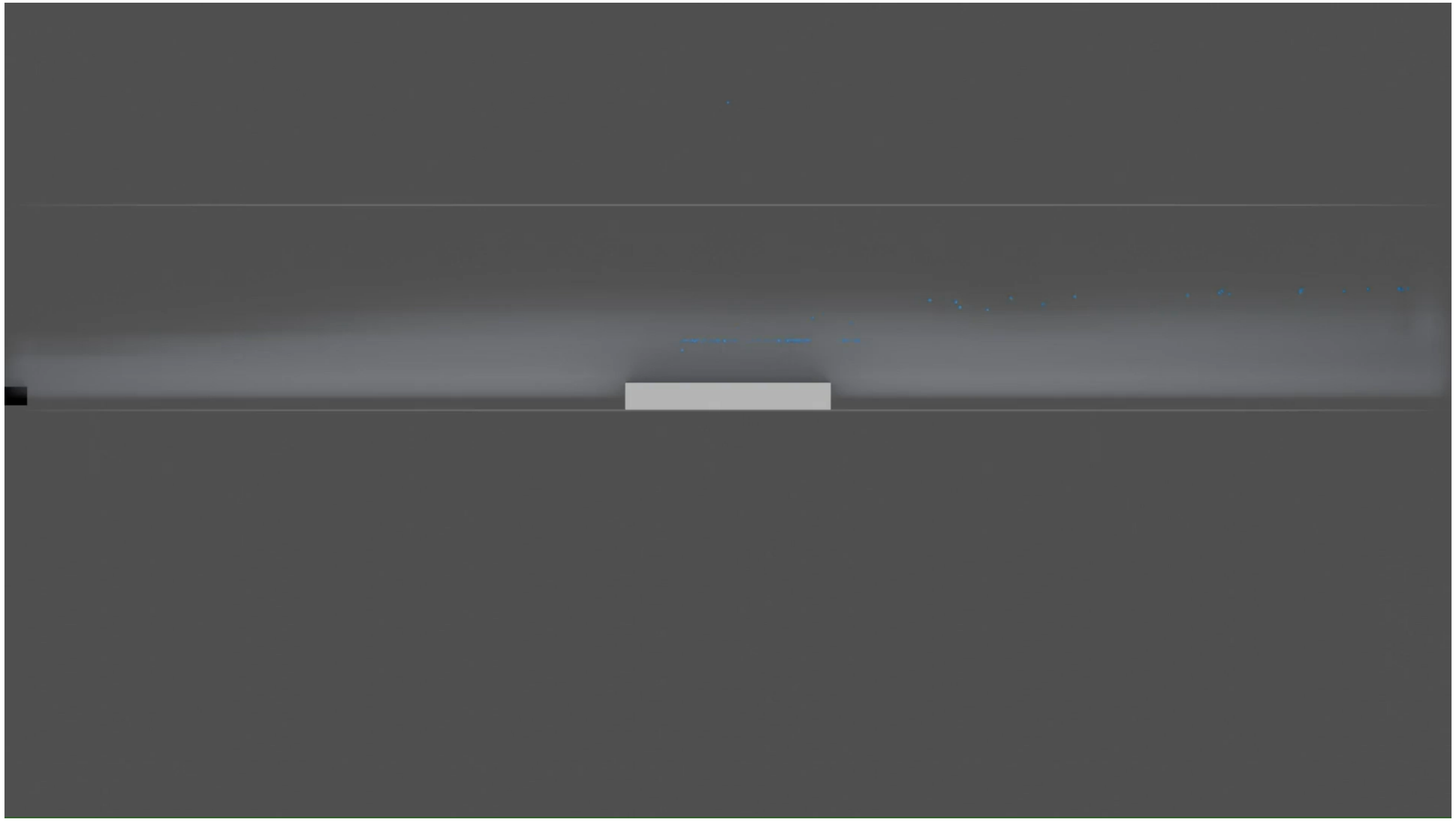


Case Study Video 1: Blender Wind Tunnel with Evaporation

Wind Tunnel Simulation

- Represents calculated data
  - Viscosity
  - Initial geometry
  - Wind Speed
  - Gravity
  - Buoyancy Density

- Found that scale would have to be way higher in- order-to get similar real-world data.



Case Study Video 2: Rendered Blender Wind Tunnel with Evaporation

THANK YOU!

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