SHOALS Marine Laboratory

Sustainable Engineering 2009

Dan Broman

Josh Groleau

Jonathan Childs

Anna Bergsieker

Appledore Island

Sustainability

- Allow SML to support its population
- Provide researchers, students, and professors with what they need
- Have a limited impact on the island, and help keep it similar for future generations

Overview

- Alternative Energy Monitoring

- Data Acquisition and Monitoring

- Gray Water

- Energy Conservation

- Freshwater Pressure Tank Replacement

- Pipe Replacement

- Other Thoughts and Ideas

Alternative Energy Monitoring

- Used to power UNH AIRMAP equipment year-round

- Can also power SML Dorms 2 & 3

Manipulating Solar Data

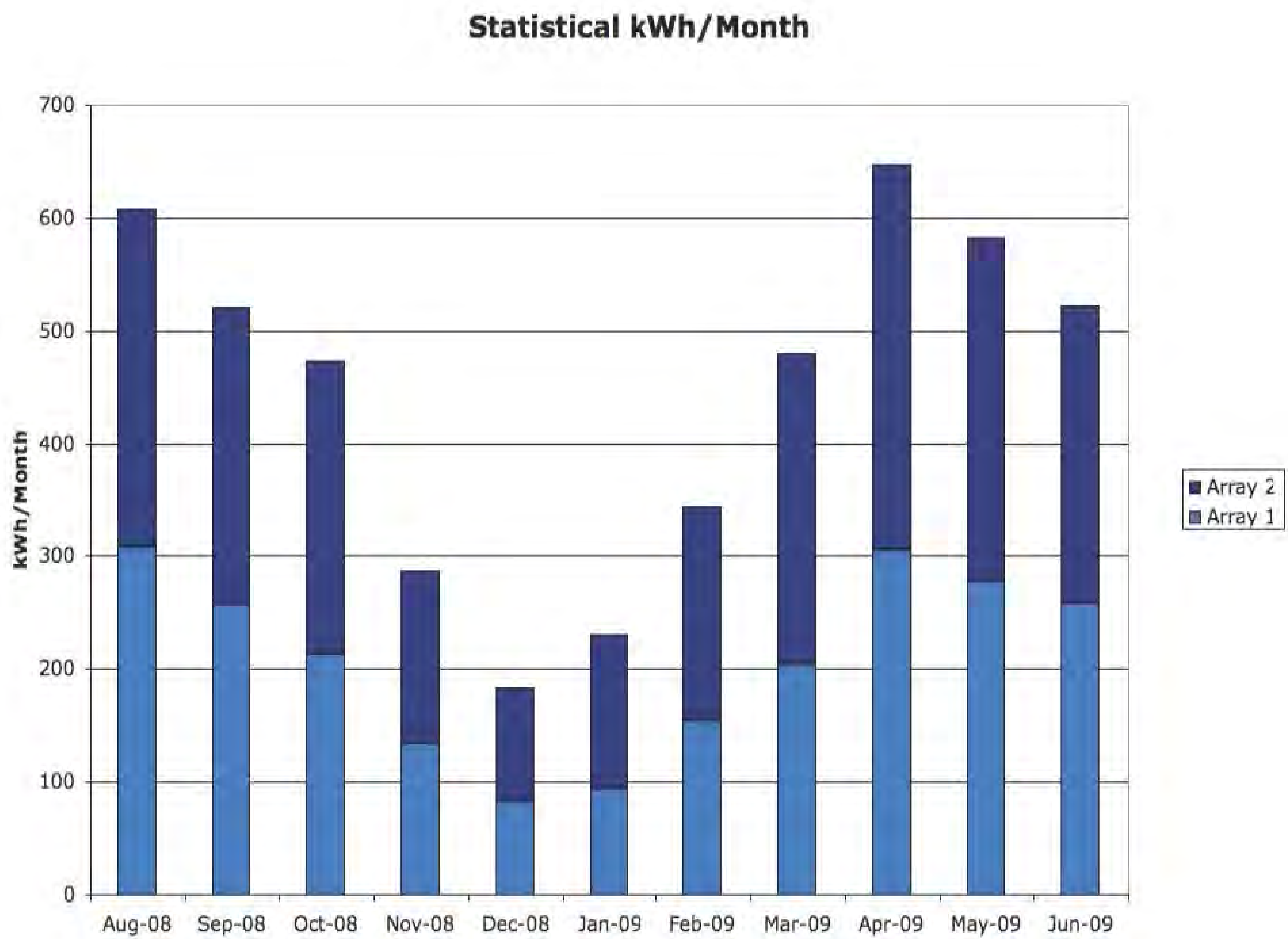
10,000's of rows of numbers

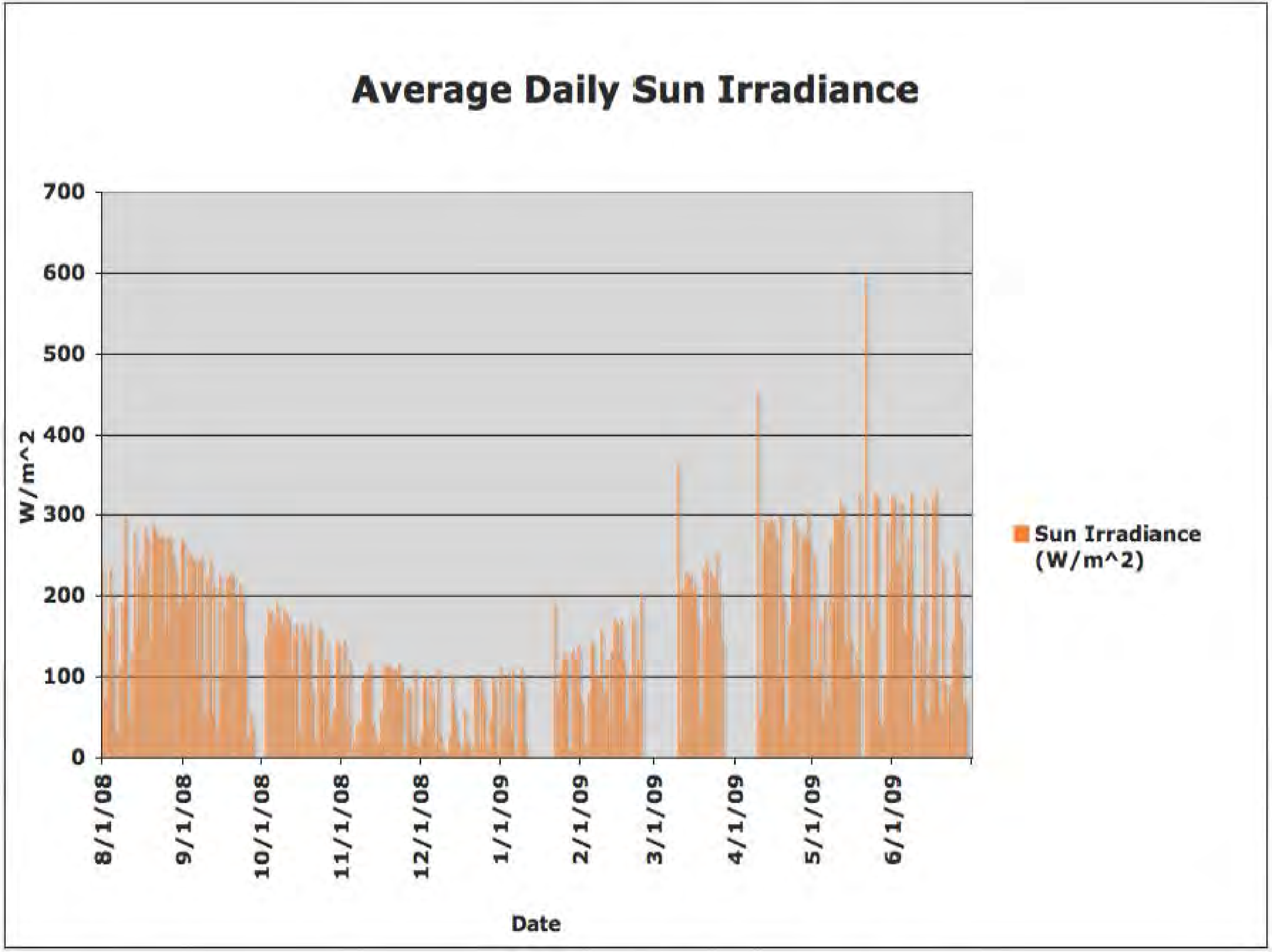
200808010000 6,0,0,120,87,0,53.1,2,1,MX-60#1,E,0,0,0,85,99,0,0,0,0,53.5,0,0,MX-60#2,F,
0,0,0,84,99,0,0,0,0,53.5,0,0,Inv#1,1,5,0,0,121,123,0,2,0,1,53.2,24,0,Inv#2,2,0,0,0,119,16,0,1,0,1,52.8,24,0,Inv#3,3,1,0,0,120,122,0,2,0,1,53.2,24,0

200808010001 10,0,0,119,87,0,54.3,2,1,MX-60#1,E,0,0,0,96,99,0,0,0,0,54.5,0,0,MX-60#2,F,
0,0,0,96,99,0,0,0,0,54.5,0,0,Inv#1,1,9,0,0,121,123,0,2,0,1,54.4,24,0,Inv#2,2,0,0,0,118,18,0,1,0,1,54.0,24,0,Inv#3,3,1,0,0,119,121,0,2,0,1,54.4,24,0

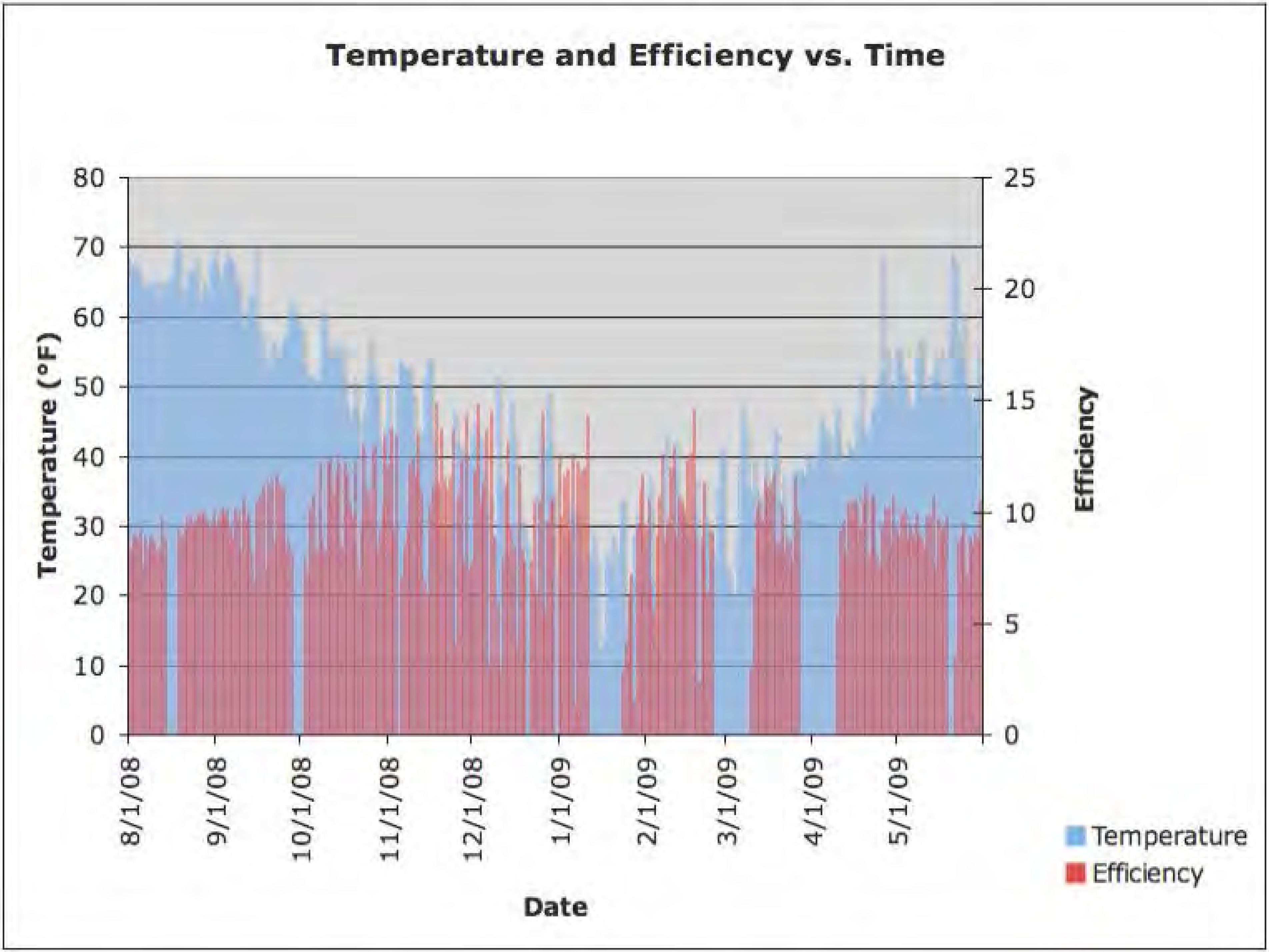
Daily, organized data for each array

Date	kWh/day Array 1	kWh/day Array 2	Sun Light (kWh/day for each array)	Efficiency Array 1	Efficiency Array 2
8/1/08 0:00	10.1	10	120.9492007	8.350613267	8.267933928
8/2/08 0:00	3	3	35.88706274	8.35955849	8.35955849
8/3/08 0:00	7.5	7.1	80.2827433	9.341982712	8.843743634
8/4/08 0:00	10.7	10.5	120.0118216	8.915788343	8.749138093
8/5/08 0:00	9	8.8	96.61374365	9.315444843	9.108434957
8/6/08 0:00	1.3	1.3	17.08051592	7.611011319	7.611011319
8/7/08 0:00	5.2	5.1	57.77690895	9.000135339	8.827055813
8/8/08 0:00	8.3	8.2	97.34485885	8.526387626	8.423660065
8/9/08 0:00	13.8	13.6	153.2151239	9.006943733	8.876408317
8/10/08 0:00	10.6	10.4	120.6407081	8.78642058	8.62063906
8/11/08 0:00	2.2	2.2	26.42725908	8.324737701	8.324737701
8/12/08 0:00	5.6	5.4	65.65510385	8.529420672	8.224798505
8/13/08 0:00	14.1	13.6	142.5279776	9.89279455	9.541986232
8/14/08 0:00	7.3	7.1	81.7770188	8.926713283	8.682145796

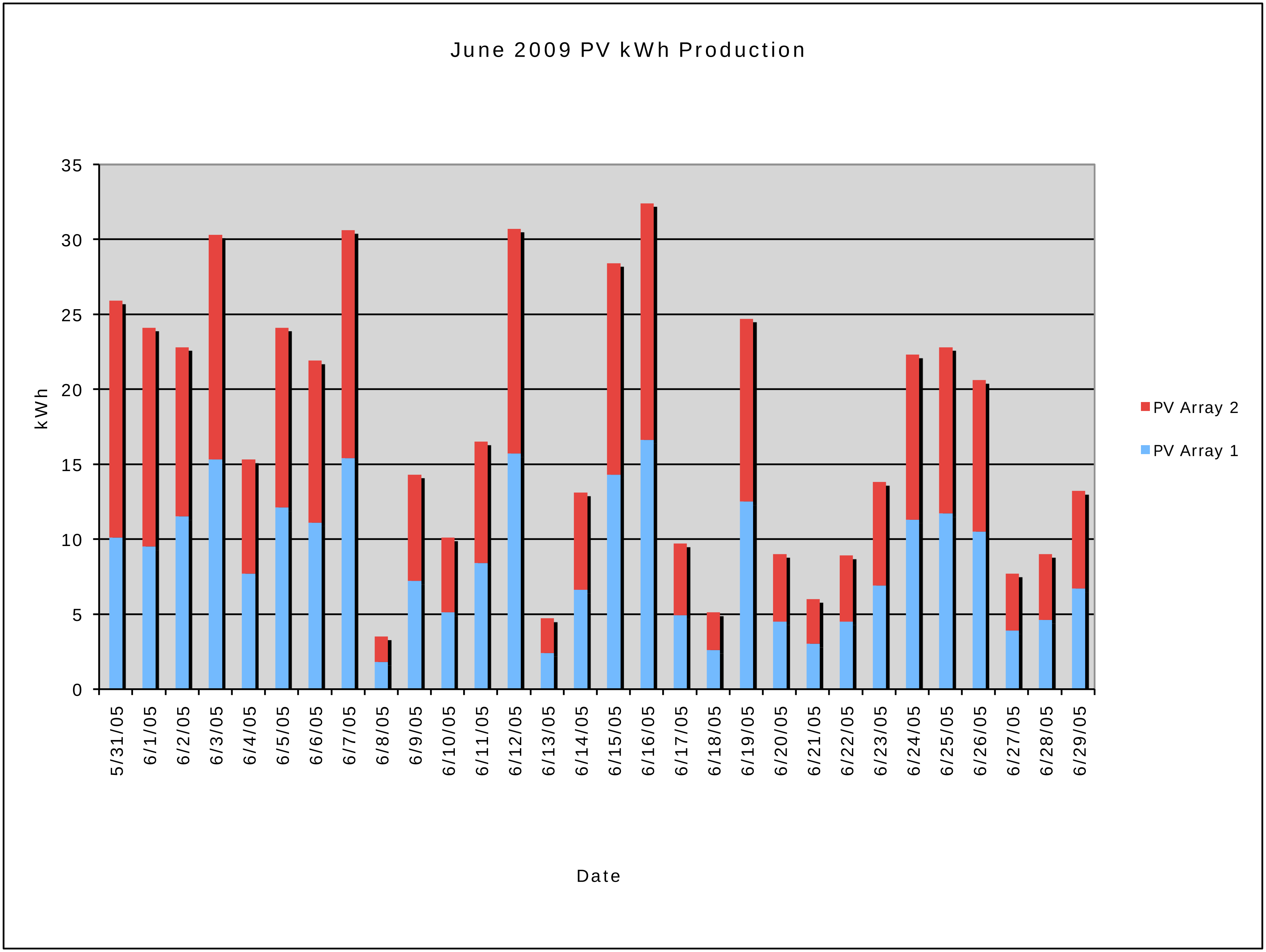

Statistical kWh/Month
kWh/Month
700
600
500
400
300
200
100
0
Aug-08
Sep-08
Oct-08
Nov-08
Dec-08
Jan-09
Feb-09
Mar-09
Apr-09
May-09
Jun-09
Array 2
Array 1

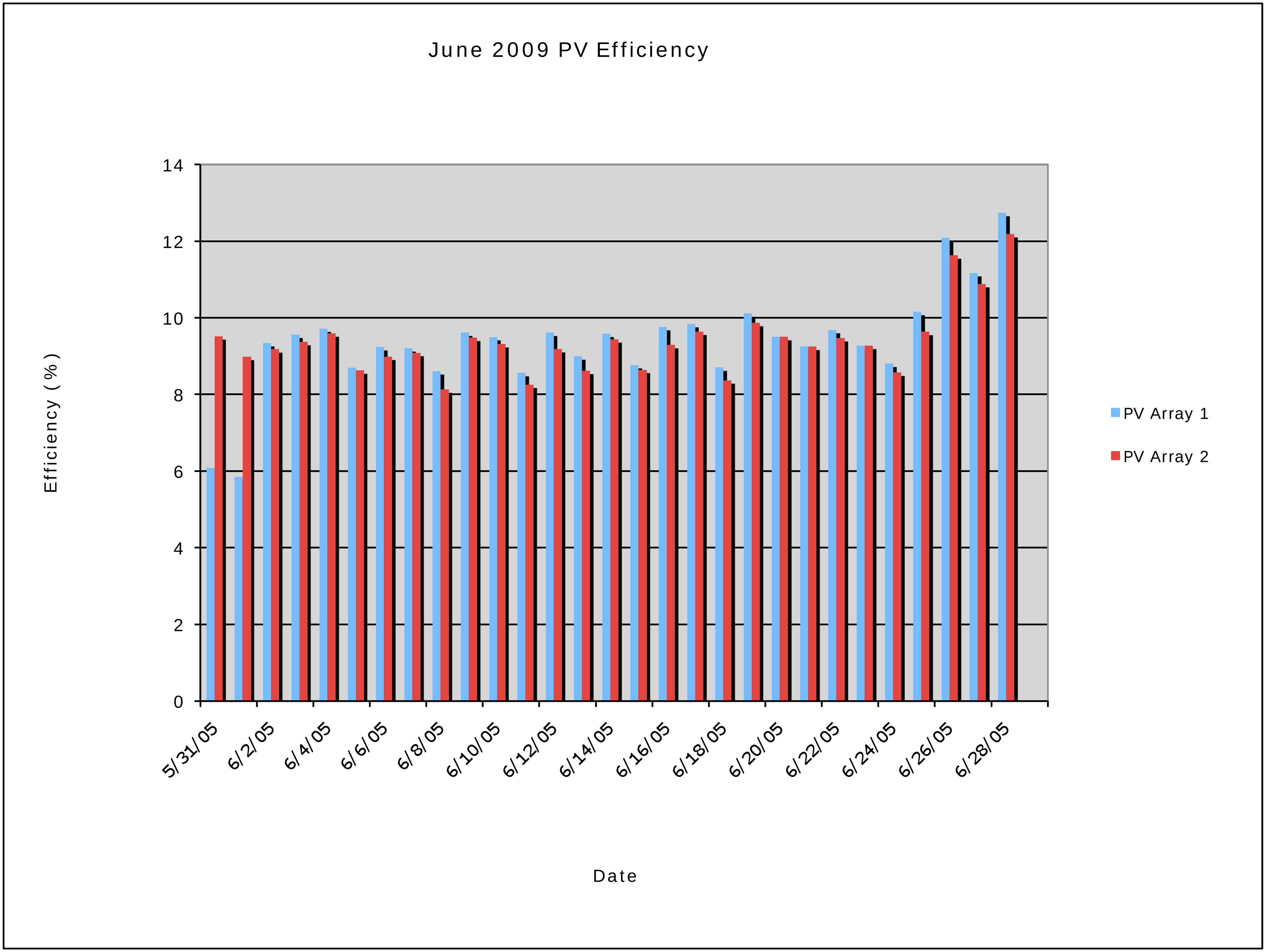


Average Daily Sun Irradiance
700
600
500
400
300
200
100
0
W/m^2
8/1/08
9/1/08
10/1/08
11/1/08
12/1/08
1/1/09
2/1/09
3/1/09
4/1/09
5/1/09
6/1/09
Date
Sun Irradiance (W/m^2)

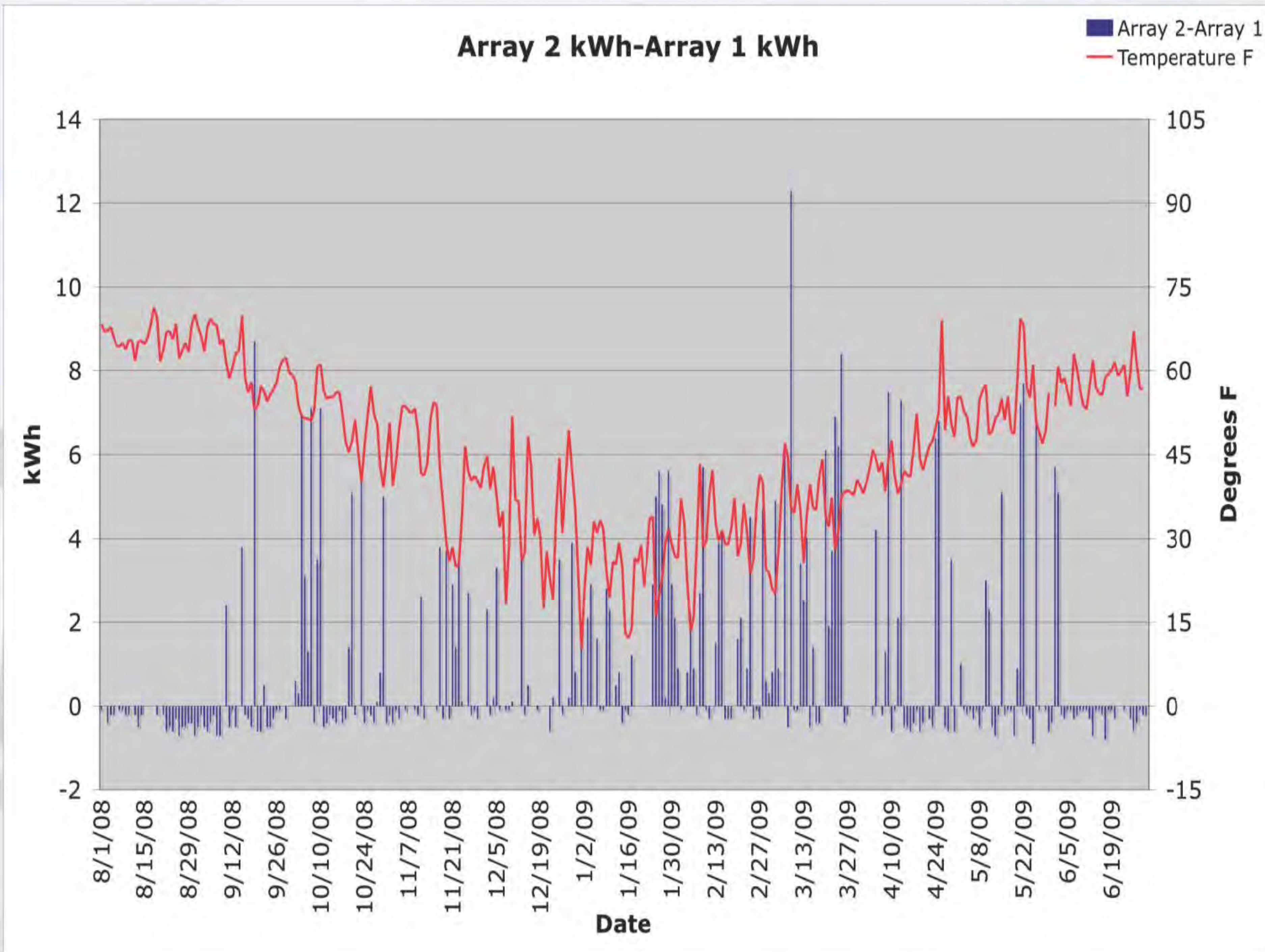


Temperature and Efficiency vs. Time
Temperature (°F)
Efficiency
Date
80
70
60
50
40
30
20
10
0
25
20
15
10
5
0
8/1/08
9/1/08
10/1/08
11/1/08
12/1/08
1/1/09
2/1/09
3/1/09
4/1/09
5/1/09
Temperature
Efficiency


June 2009 PV kWh Production
kWh
35
30
25
20
15
10
5
0
5/31/05
6/1/05
6/2/05
6/3/05
6/4/05
6/5/05
6/6/05
6/7/05
6/8/05
6/9/05
6/10/05
6/11/05
6/12/05
6/13/05
6/14/05
6/15/05
6/16/05
6/17/05
6/18/05
6/19/05
6/20/05
6/21/05
6/22/05
6/23/05
6/24/05
6/25/05
6/26/05
6/27/05
6/28/05
6/29/05
Date
PV Array 2
PV Array 1



June 2009 PV Efficiency
Efficiency (%)
0
2
4
6
8
10
12
14
5/31/05
6/2/05
6/4/05
6/6/05
6/8/05
6/10/05
6/12/05
6/14/05
6/16/05
6/18/05
6/20/05
6/22/05
6/24/05
6/26/05
6/28/05
Date
PV Array 1
PV Array 2

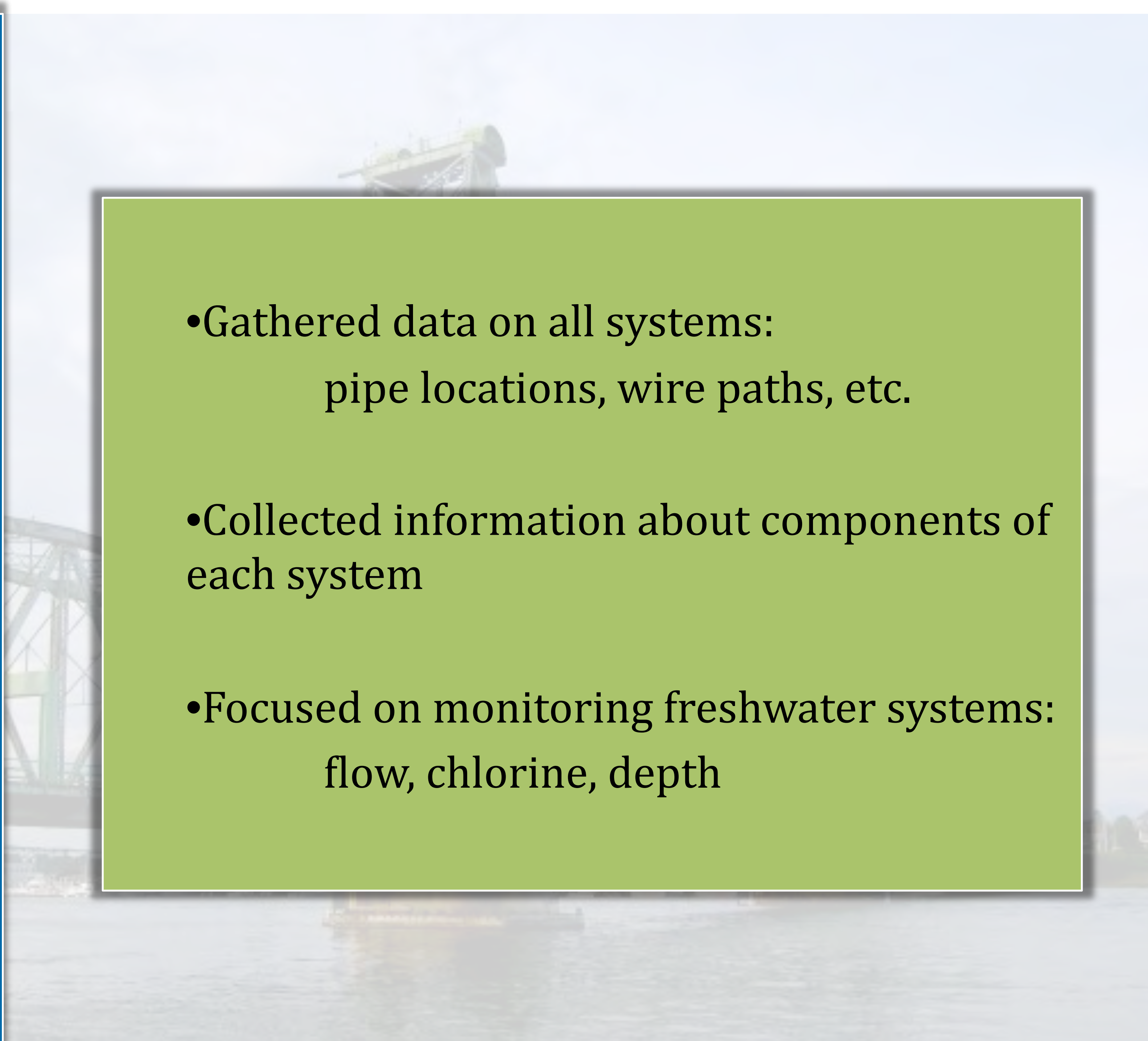


Array 2 kWh-Array 1 kWh
Array 2-Array 1
Temperature F
kWh
14
12
10
8
6
4
2
0
-2
Degrees F
105
90
75
60
45
30
15
0
-15
8/1/08
8/15/08
8/29/08
9/12/08
9/26/08
10/10/08
10/24/08
11/7/08
11/21/08
12/5/08
12/19/08
1/2/09
1/16/09
1/30/09
2/13/09
2/27/09
3/13/09
3/27/09
4/10/09
4/24/09
5/8/09
5/22/09
6/5/09
6/19/09
Date


Questions?
Comments?

Data Acquisition

Data Acquisition



- Gathered data on all systems:

  pipe locations, wire paths, etc.

- Collected information about components of each system

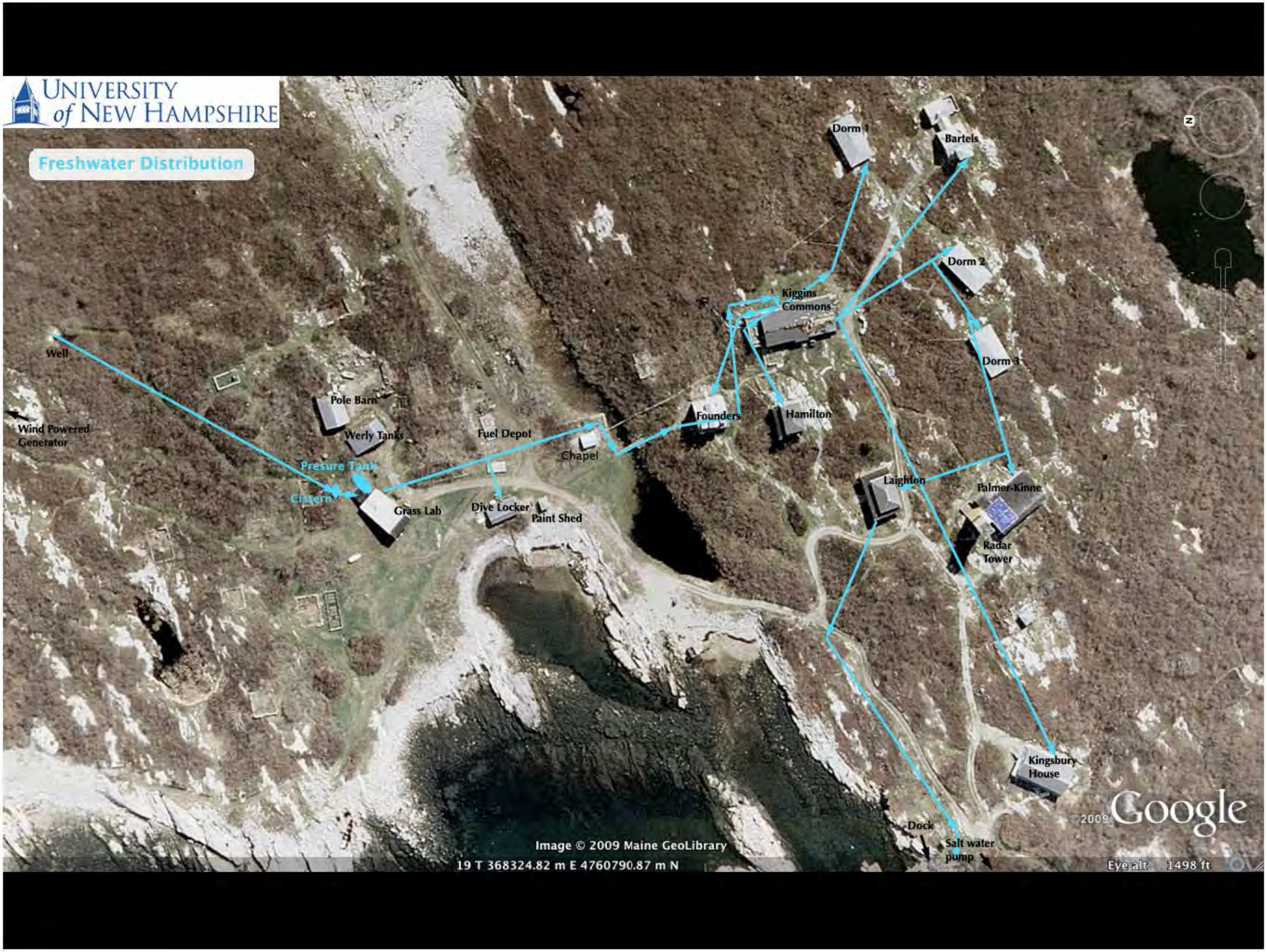
- Focused on monitoring freshwater systems:

  flow, chlorine, depth

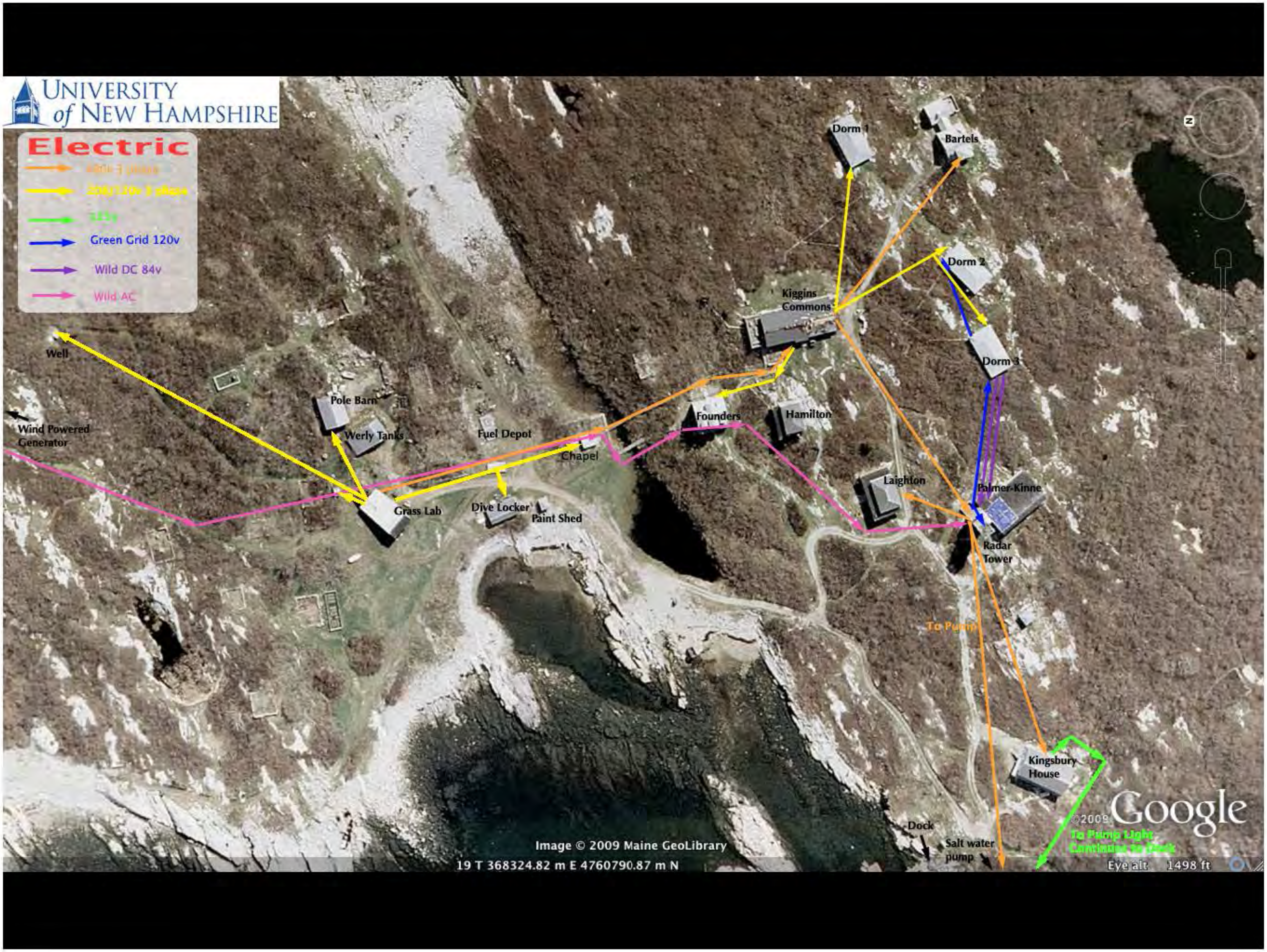
Groundwork

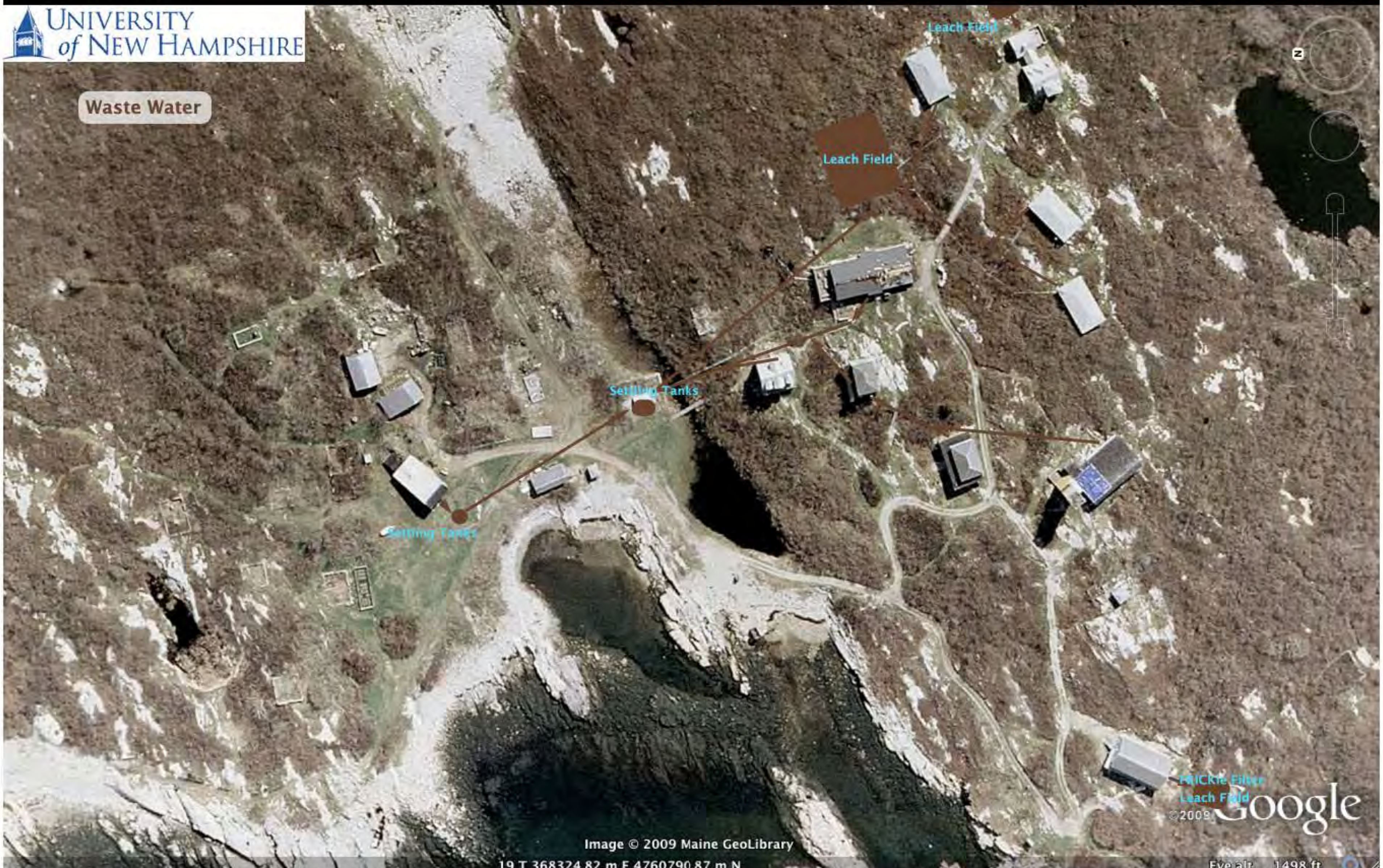
- Surveyed all island systems:
  - freshwater
  - saltwater
  - wastewater
  - electricity
- Made a digital map of each system
- Compiled relevant information
  - manuals, photos, diagrams


UNIVERSITY of NEW HAMPSHIRE
Salt Water
Distrabution
Discharge
Freshwater/Saltwater Crossover
Image © 2009 Maine GeoLibrary
19 T 368324.82 m E 4760790.87 m N
©2009 Google
Eye alt 1498 ft



UNIVERSITY of NEW HAMPSHIRE
Freshwater Distribution
Dorm 1
Bartels
Dorm 2
Kiggins Commons
Dorm 3
Well
Pole Barn
Wind Powered Generator
Werly Tanks
Fuel Depot
Founders
Hamilton
Chapel
Presure Tank
Cistern
Grass Lab
Dive Locker
Paint Shed
Laighton
Palmer-Kinne
Radar Tower
Kingsbury House
Dock
Salt water pump
Image © 2009 Maine GeoLibrary
19 T 368324.82 m E 4760790.87 m N
©2009 Google
Eye alt 1498 ft

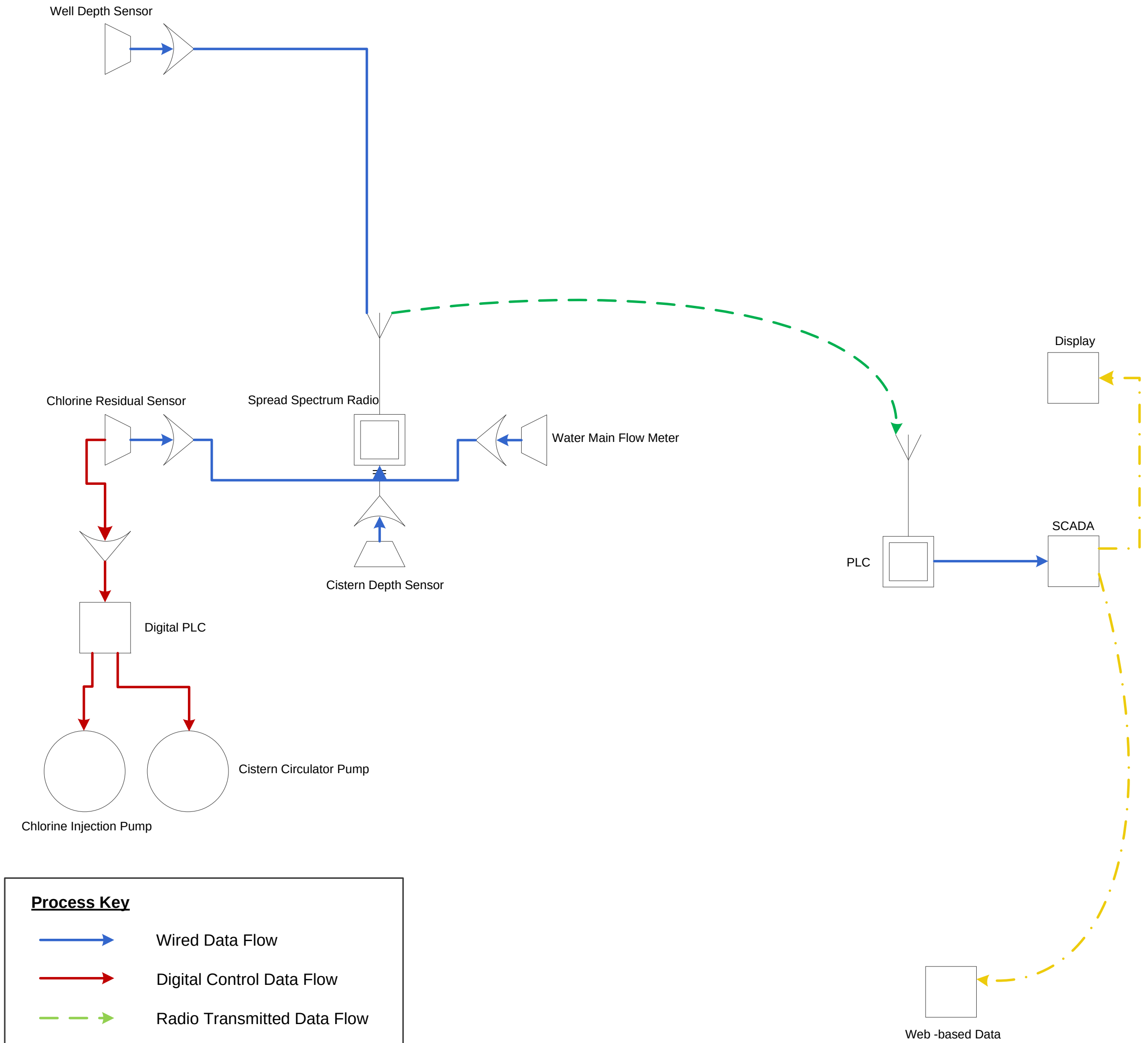

UNIVERSITY of NEW HAMPSHIRE
Electric
Green Grid 120v
Wild DC 84v
Wild AC
Well
Wind Powered Generator
Pole Barn
Werly Tanks
Fuel Depot
Chapel
Grass Lab
Dive Locker
Paint Shed
Kiggins Commons
Founders
Hamilton
Dorm 1
Bartels
Dorm 2
Dorm 3
Laighton
Palmer-Kinne
Radar Tower
To Pump
Kingsbury House
To Pump Light
Dock
Salt water pump
Image © 2009 Maine GeoLibrary
19 T 368324.82 m E 4760790.87 m N
©2009 Google
Eye alt 1498 ft


UNIVERSITY of NEW HAMPSHIRE
Waste Water
Leach Field
Leach Field
Settling Tanks
Image © 2009 Maine GeoLibrary
19 T 368324.82 m E 4760790.87 m N
©2009 Google
Eye alt 1498 ft

System Design

- Focused on freshwater system
- Based system design on expandability
- Included sensors to monitor:
    - depth
    - flow
    - chlorine residual

SML Freshwater Data Collection System
Flow Diagram



Process Key

- Wired Data Flow
- Digital Control Data Flow
- Radio Transmitted Data Flow
- Processed Data (internet)

Notes

SCADA might be unnecessary depending on PLC
PLC most likely located in the Radio Tower

Sensors

- 4-20mA signal

- Signals can be sent over wire or spread spectrum radio

Spread Spectrum Radio

- Spreads signals wirelessly
- We conducted a path study of the island
- Radio, antenna, surge protection, and wires cost around $1,400

Flow Sensors

- Accurate to 1.6gpm for 2'' pipe
- Electronic readout on top

Water Level Sensors

WL400 Water Level Sensor

Submersible Pressure Transducer For Level & Pressure

- High accuracy and reliability
- Completely submersible sensor and cable
- Compact, rugged design for easy installation
- Minimal maintenance and care
- Sensor compatible with most monitoring equipment

- 4-20mA output
- Vented cable for automatic barometric compensation
- Multiple ranges available from 3’ to 250’
- Wet-wet sensor eliminates vent tube concerns
- Dynamic temperature compensation system
- Not affected by foam, wind or rain

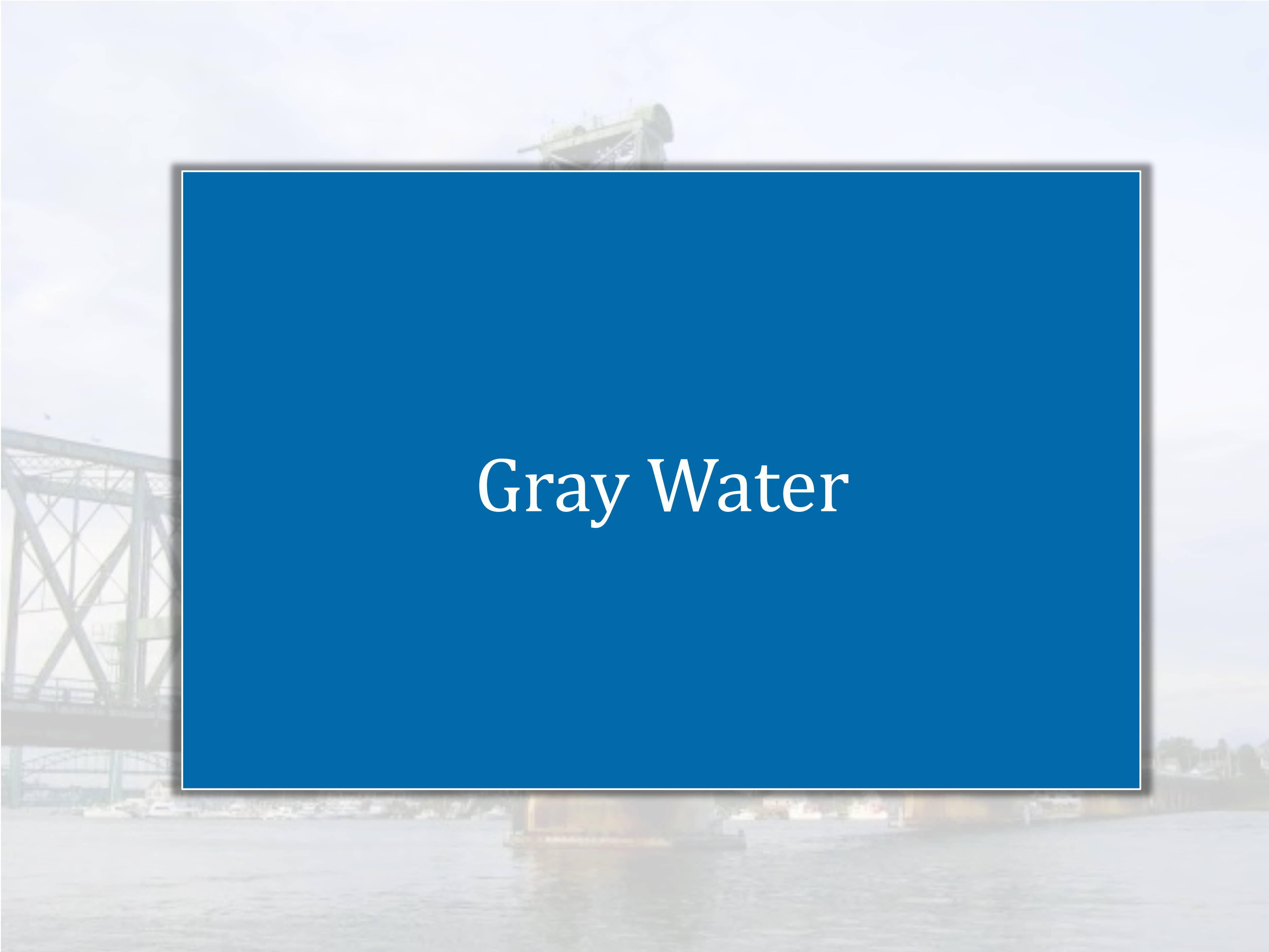
- Monitors levels in groundwater wells, rivers, streams, tanks, lift stations and open channels

Chlorine Residual Sensor

- Siemens SFC Controller
- Free Chlorine Module

Controller
Phoenix Contact ILC 170


Questions?
Comments?



Gray Water

Flushing Options

- Rainwater Collection
- Crystal Lake
- Low Flush Toilets

Flushing Survey Results

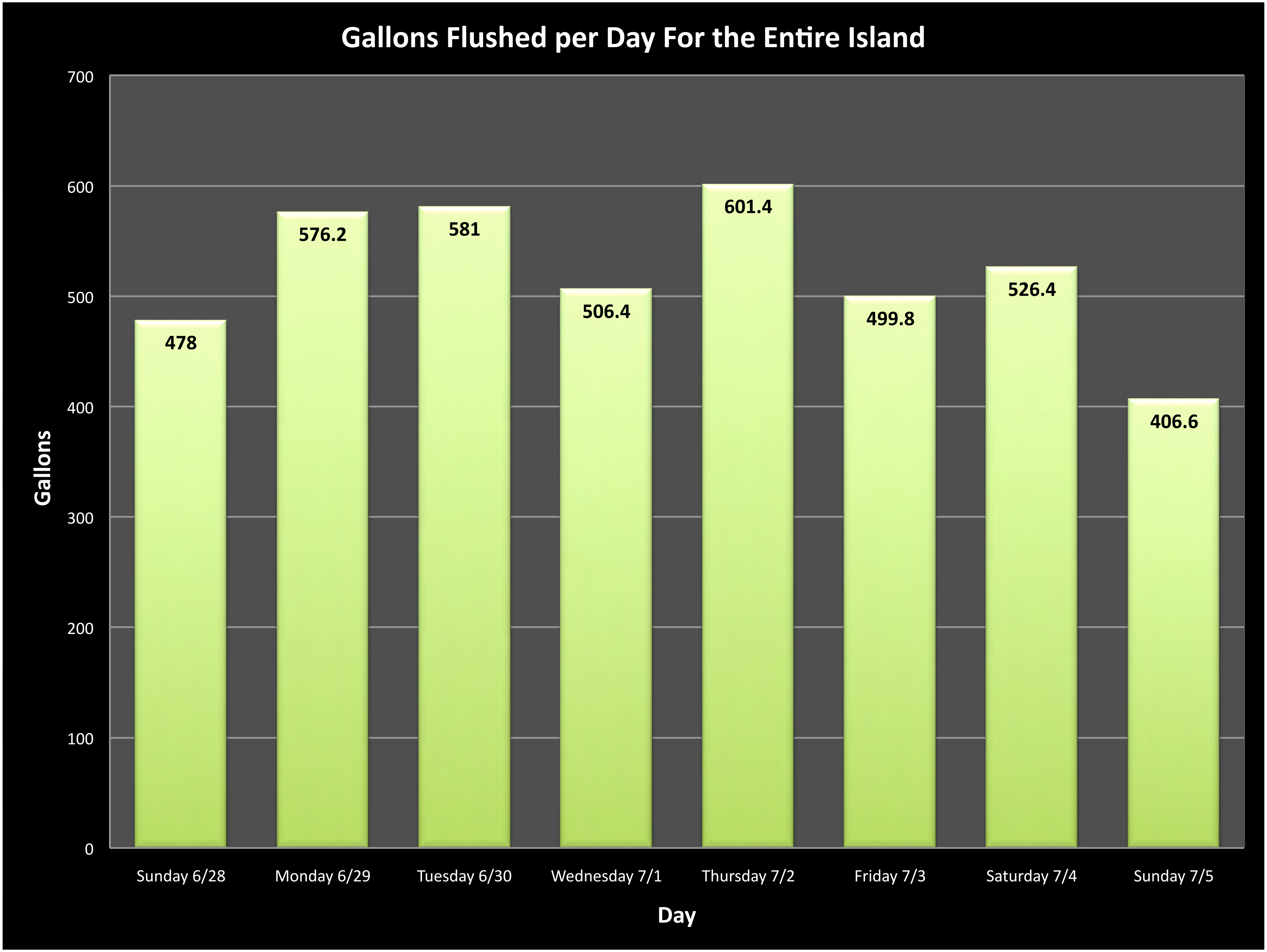
Our week long survey asked people to make a check mark when they flushed

Average Daily Freshwater Usage Per Capita= 24.67 gal/day

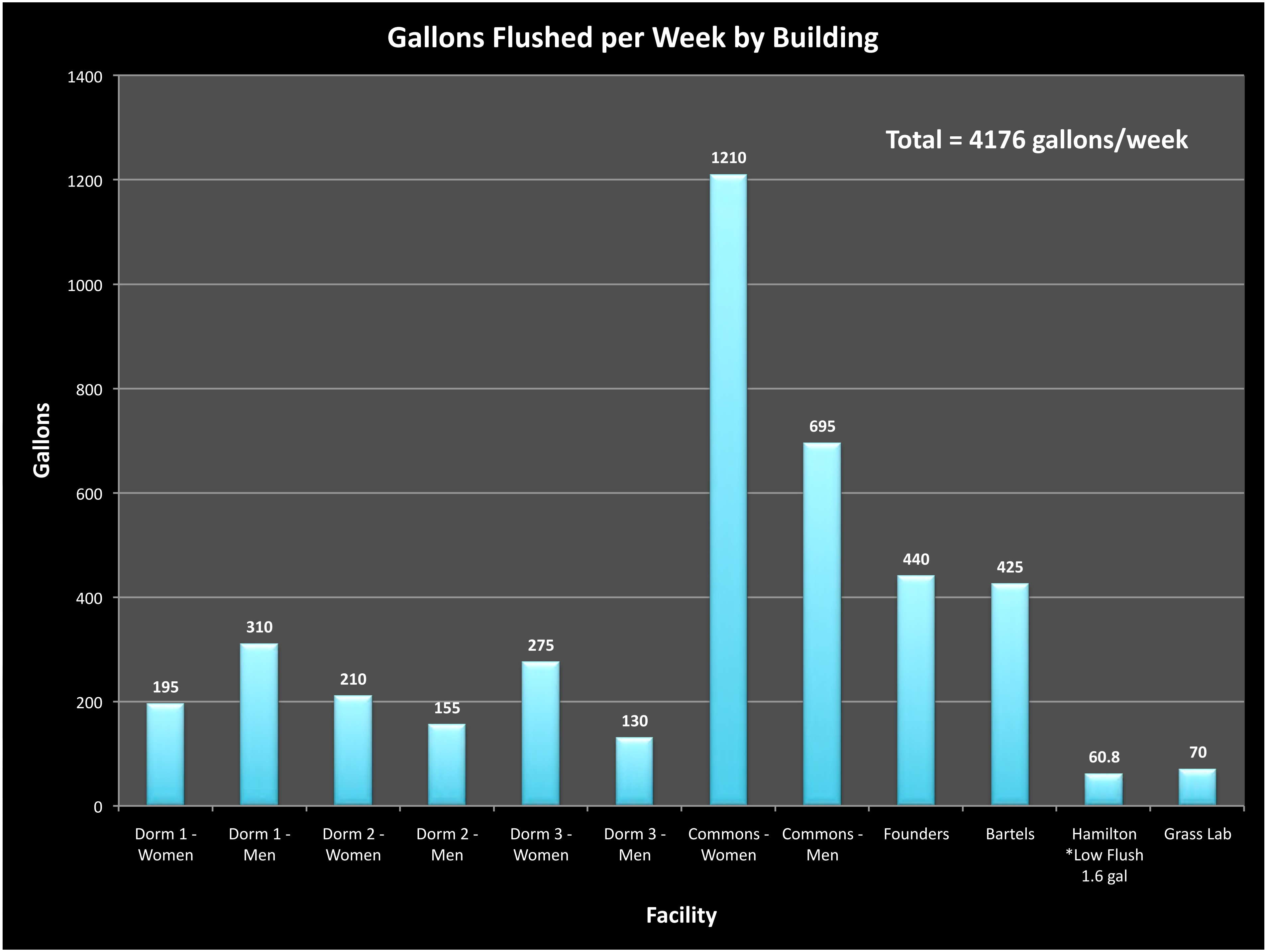
Average Daily Gallons Flushed Per Capita= 10 gal/day

40% of freshwater usage goes to toilets

Eliminating freshwater flushing will reduce dependence on R/O in dry season!



Gallons Flushed per Day For the Entire Island
700
600
500
400
300
200
100
0
Gallons
478
576.2
581
506.4
601.4
499.8
526.4
406.6
Sunday 6/28
Monday 6/29
Tuesday 6/30
Wednesday 7/1
Thursday 7/2
Friday 7/3
Saturday 7/4
Sunday 7/5
Day


Gallons Flushed per Week by Building
Total = 4176 gallons/week
Gallons
1400
1200
1000
800
600
400
200
0
195
310
210
155
275
130
1210
695
440
425
60.8
70
Dorm 1 - Women
Dorm 1 - Men
Dorm 2 - Women
Dorm 2 - Men
Dorm 3 - Women
Dorm 3 - Men
Commons - Women
Commons - Men
Founders
Bartels
Hamilton *Low Flush 1.6 gal
Grass Lab
Facility

Rainwater Collection

- Runoff from roofs can be gathered
- Water is not potable without treatment, but usable for toilets
- White and Star Island use rainwater collectors

Existing Bartels Cistern

- Most likely left over from the Lifesaving Station

- Two chambers side by side

- Dimensions of each cistern: 9’x6’x5.5’

- Total volume of 4,443 gallons

Bartels Rainwater Collector

- Demand of 1,900 gallons per month
- Would meet 70% of Bartels' monthly demand, or 100% if 2 of 4 toilets were low-flush
- Would have to be opened a month beforehand

Determining Runoff

Sizing of Rainwater Storage Units for Green Building Applications

Yiping Guo, M.ASCE[1]; and Brian W. Baetz, M.ASCE[2]

Abstract: Green building design principles advocate the use of rainwater storage units to collect roof runoff during nonwinter seasons for landscaping, hardscape cleaning, and/or maintenance purposes, either in the form of rain barrels for smaller scale applications or cisterns for larger scale applications. This not only saves water which would otherwise be supplied from municipal water distribution systems but also reduces storm-water runoff which would otherwise be handled through urban storm-water management systems. The size of the storage units needs to be commensurate with the area of the roof and the desired water use rate. The local climate has an influence on the required size and achievable use rate as well. In this paper, analytical formulas are derived to estimate the required rainwater storage volume as a function of desired water use rate, reliability and local climate. In deriving these formulas, local climate characteristics are represented by probabilistic models and incorporated into the stochastic description of storage unit operating procedures and requirements. The resulting formulas may be used by engineers, architects, municipal governments, and storage unit manufactures for the estimation or recommendation of suitable rainwater storage unit sizes.

DOI: 10.1061/(ASCE)1084-0699(2007)12:2(197)

CE Database subject headings: Rain water; Stormwater management; Sustainable development; Probabilistic methods; Water storage; Building design.

Introduction

The management and use of water within a building and its surrounding landscape is one component of green building design and operation (Kibert 2005). One of the objectives of green building design is to minimize the use of treated water for landscaping, hardscape cleaning and/or maintenance purposes. The cost and energy use inherent with the treatment and distribution of water can thus be minimized. An efficient approach to minimize treated water use is the integration of a rain barrel in a house setting or a cistern in a larger building context. The rain barrel or cistern is operated during nonwinter seasons to collect and store rainwater from the roof of the building for use on dry days between successive rainfall events. In addition, this water-saving practice will also divert roof runoff away from storm-water collection systems and reduce the volume of runoff that needs to be managed. Therefore, rain barrels and cisterns can be viewed as miniature multipurpose storm-water management facilities, and green buildings can form part of a community's best management practices for storm water.

The size of the rain barrels and cisterns (hereafter referred to as storage units) needs to be commensurate with the area of the roof and the desired water use rate. The local rainfall characteristics throughout the nonwinter season also affect the size required and the reliability of a storage unit to supply water when needed. In fact, sizing of rainwater storage units for green building applications is a miniature hydrologic engineering design problem. It could be solved in an ad hoc way because of its small scale. For individual buildings, the possible undersizing or oversizing caused by using an inaccurate design approach may not result in significant economical or environmental losses. However, the cumulative losses may become significant as the number of green buildings increases.

Similar to the hydrologic design of storm-water management facilities, an accurate approach to sizing rainwater storage units is to use a computer program to simulate their hydrologic operations under local climatic conditions. Continuous simulation using long-term historical rainfall series needs to be conducted to determine the performance statistics of rainwater storage units of different sizes. These performance statistics could be used as a basis for design. Given the small scale in most green building applications, the use of computer simulation is obviously too time consuming for engineers or architects. A more appealing approach may be the use of analytical equations that consider the basic hydrologic operation of a rainwater storage unit and simultaneously account for the influence of local climate conditions. One such equation was developed by Lee et al. (2000) for the sizing of cisterns to collect rainwater from agricultural fields for crop use during dry periods. In their study, failure probabilities of the irrigation system were defined first, a series of simulation modeling experiments using historical rainfall records at a farm were conducted, and a regression equation was then developed based on simulation results. This equation relates cistern size to rainwater collection area, failure probability, and the area to be irrigated. Their simulations used rainfall records from one location and considered a single crop. Therefore, the resulting equation is applicable only for the specified location and crop.

[1]Assistant Professor, Dept. of Civil Engineering, McMaster Univ., Hamilton ON, Canada L8S 4L7. E-mail: guoy@mcmaster.ca

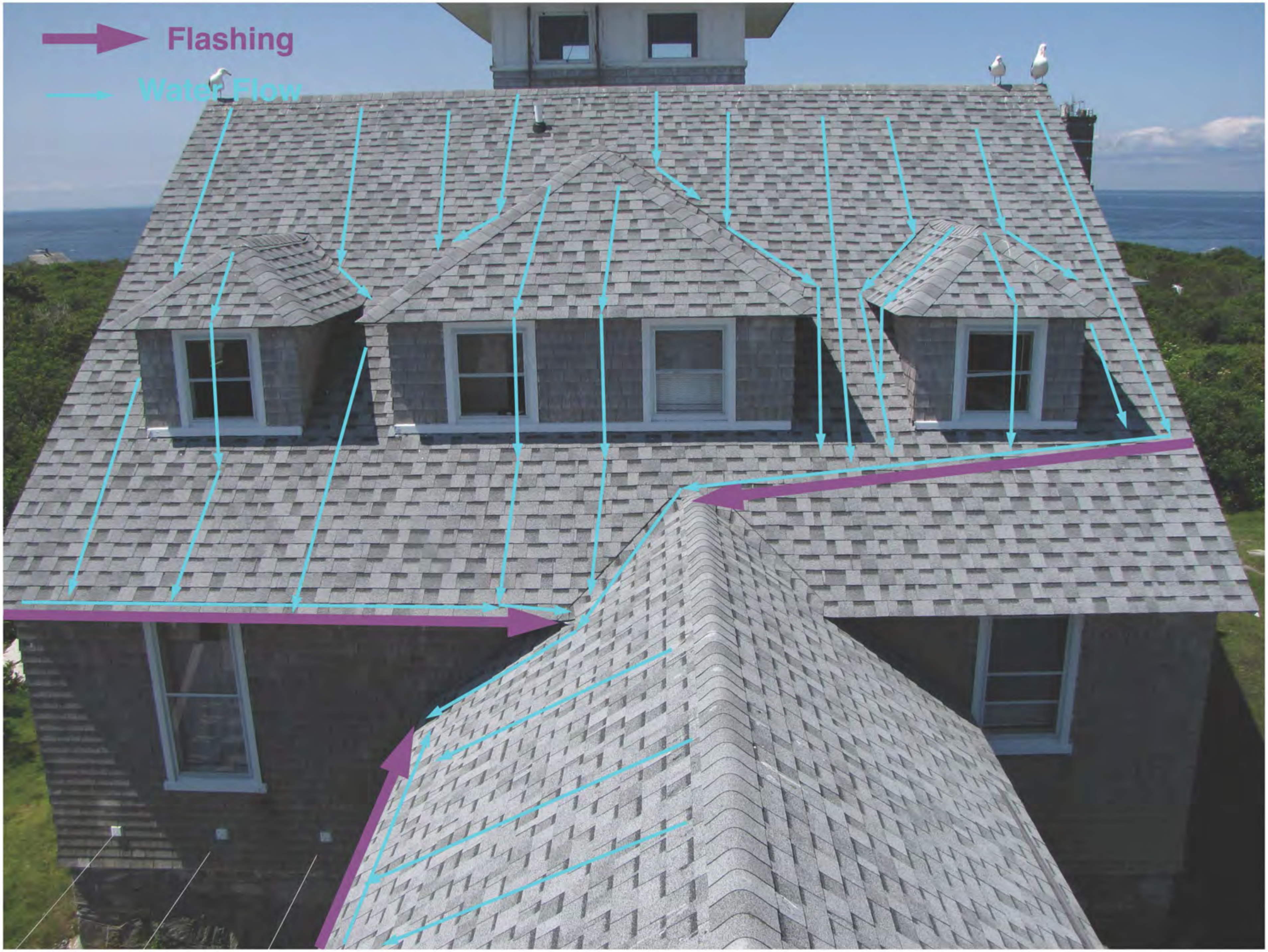
[2]Professor, Dept. of Civil Engineering, McMaster Univ., Hamilton ON, Canada L8S 4L7. E-mail: baetz@mcmaster.ca

Note. Discussion open until August 1, 2007. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on June 1, 2005; approved on June 22, 2006. This paper is part of the *Journal of Hydrologic Engineering*, Vol. 12, No. 2, March 1, 2007. ©ASCE, ISSN 1084-0699/2007/2-197–205/$25.00.

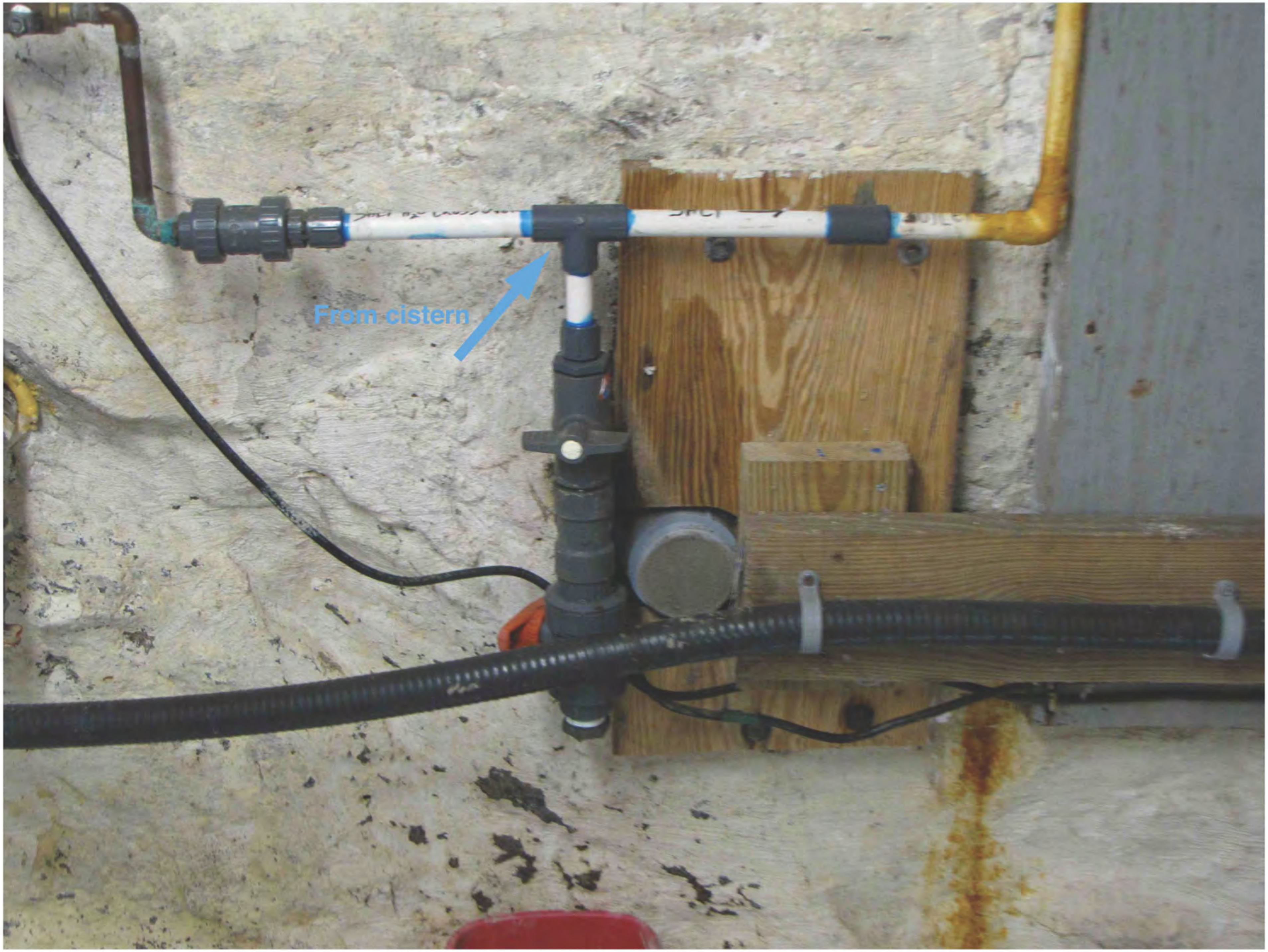
- Calculated runoff in two ways:
  - -paper (shown left)
  - -using rainfall data
- 1470 gallons per month (95% rainfall collected)

17' 2"
14' 6"
3' 6"
Gutters
Rain Flow


Flashing
Water Flow


Flashing
Water Flow

Rain Flow
Gutters
Cistern
25' 7"
17' 2"
14' 6"
Drilled Hole Intake
Overflow
Old Pipe to Cistern
Partially Filled with Cement


From cistern

[redacted]

Item	Description	Manufacturer	Catalog No.	Source	Price	Quantity	Total
B-1	Vinyl Gutters - 10ft.	Genova	13720	Lowe's	$ 6.46	4	$ 25.84
B-2	10'x2"x3" White down Spout	Genova	12493	Lowe's	$ 8.02	1	$ 8.02
B-3	White Gutter Drop Outlet 2"x3"	Genova	155514	Lowe's	$ 5.57	1	$ 5.57
B-4	Gutter Bracket	Genova	13777	Lowe's	$ 2.62	20	$ 52.40
B-5	White Inside Gutter End Cap	Genova	12067	Lowe's	$ 2.52	3	$ 7.56
B-6	Aluminum Flashing Angle 4.5"x10' Mill Finish	Amerimax	5.45E+09	Home Depot	$ 12.70	4	$ 50.80
B-7	J5 Shallow Well Jet Pump	Goulds	J5S	PumpAgents.com	$ 465.00	1	$ 465.00
B-8	V45 HydroPro Water System Tank (13.9 gallons)	Goulds	V45P	PumpAgents.com	$ 273.00	1	$ 273.00
						Grand Total =	$ 888.19

[redacted]

Crystal Lake

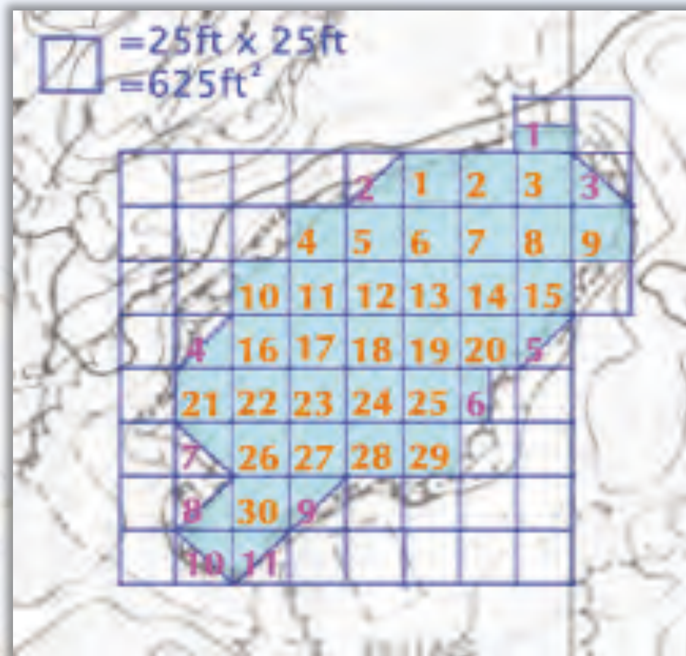
- Large freshwater basin
- Historically had many uses
- Wildlife

Determining the Area

•Used topographic map of the island to determine area

•Assumed a depth of 2 feet

•Found an area of 22,187.5ft^2

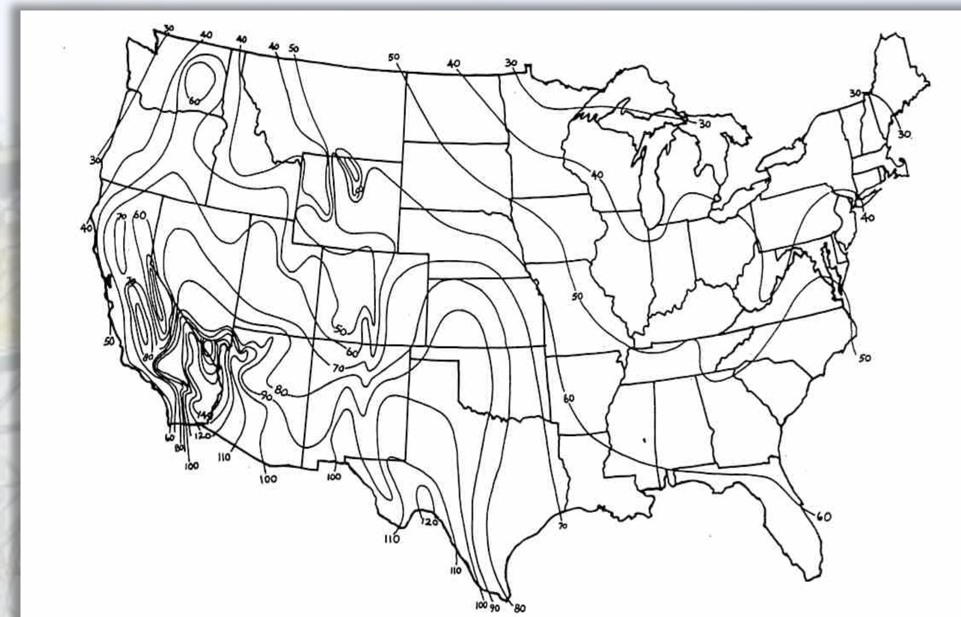


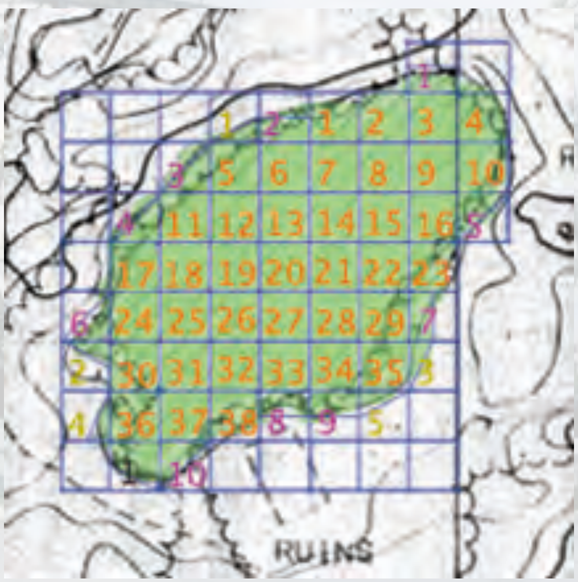
Crystal Lake Experiment

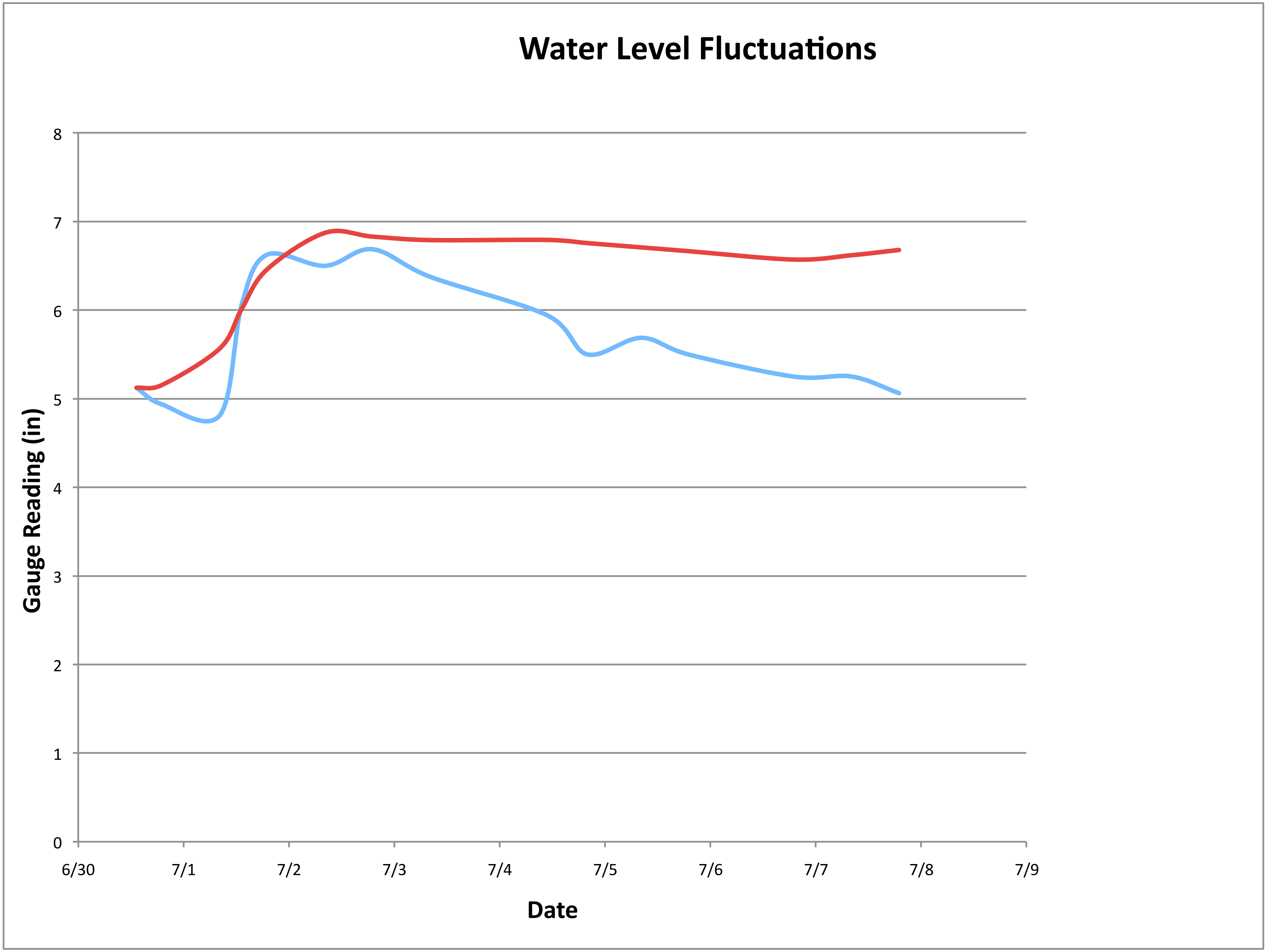
- Looked at feasibility of using the lake as a water supply
- Inquired about the structure of the lake
- Tried to determine the effect of withdrawing water from the lake

Building a Model

- Tried to factor in evaporation and rainfall
- Assumed no input or output
- Used topo map to estimate rain basin



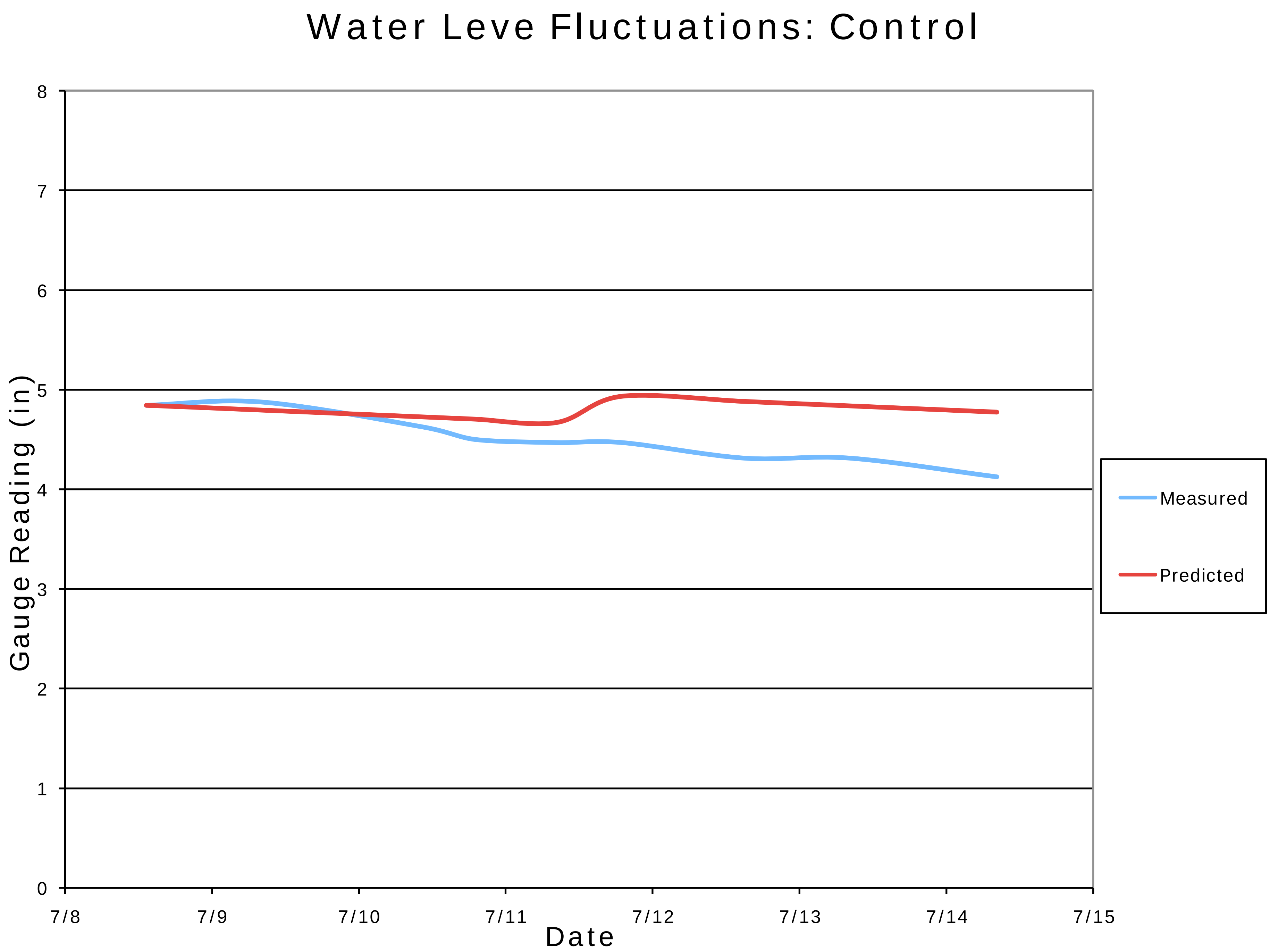



Water Level Fluctuations
Gauge Reading (in)
0
1
2
3
4
5
6
7
8
6/30
7/1
7/2
7/3
7/4
7/5
7/6
7/7
7/8
7/9
Date

Crystal Lake Control

Goal:

Observe Crystal Lake's natural water level fluctuations


Water Leve Fluctuations: Control
Gauge Reading (in)
8
7
6
5
4
3
2
1
0
7/8
7/9
7/10
7/11
7/12
7/13
7/14
7/15
Date
Measured
Predicted

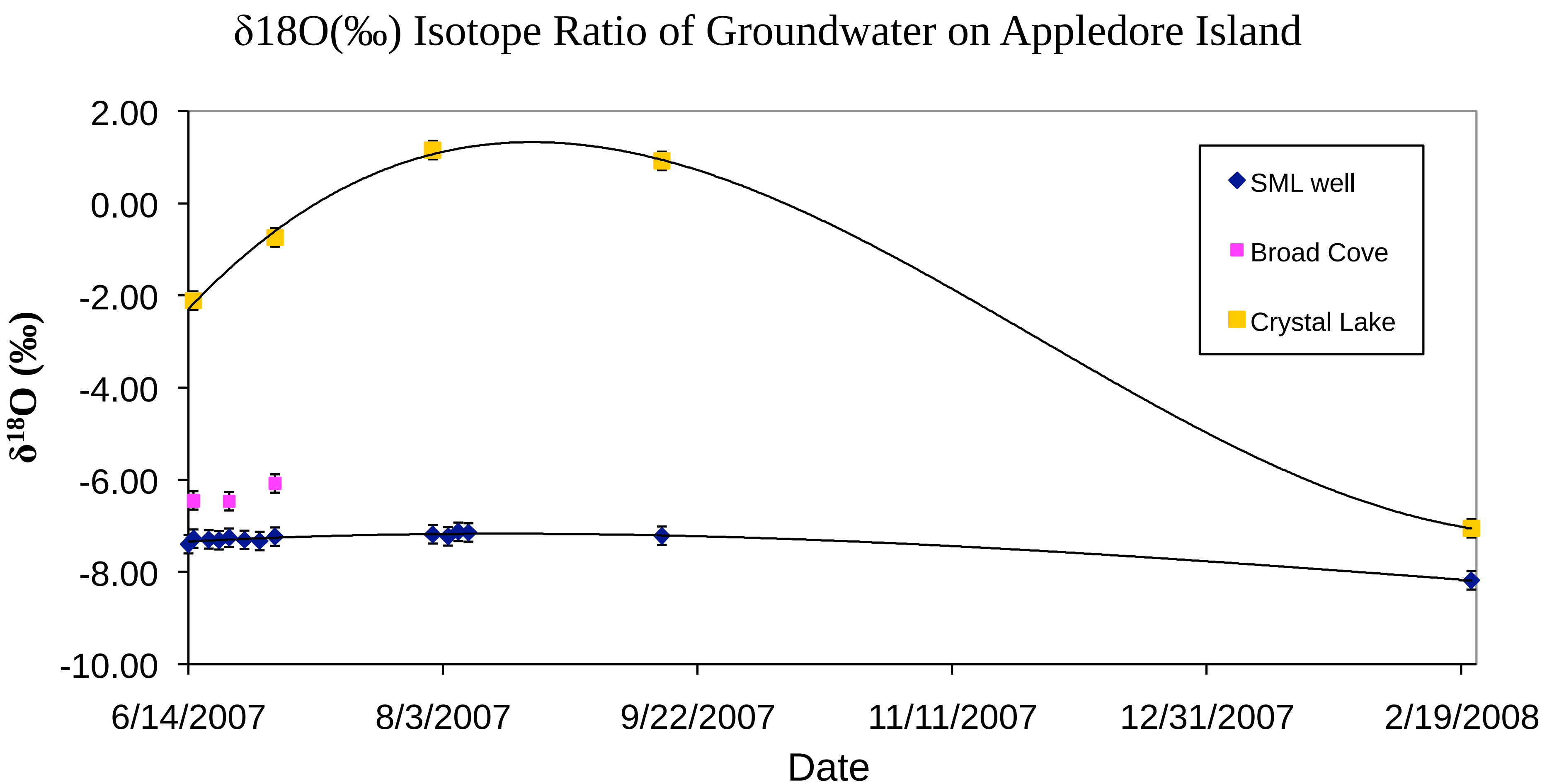


Fig. 7. Variation in $\delta^{18}O$ (‰) isotope ratio of water sampled from three locations on Appledore Island, ME. Ground water pumped from the SML well was sampled between 6/14/2007 and 2/21/2008. At Broad Cove, groundwater from a 2 ft. depth was sampled three times from 6/14/2007 to 7/1/2007. Surface water in Crystal Lake was sampled from 6/14/2007 to 2/21/2008.

The amplitude of variation in these ratios is used as an indicator of the water's residence time. **Crystal Lake shows variability characteristic of low residence time,** while the SML well displays a longer residence time, as compared to Figure 5.

Data and graph courtesy of Jonathan Felch, and Dr. Matt Davis, UNH, 2007.

Crystal Lake Summary

Our Findings

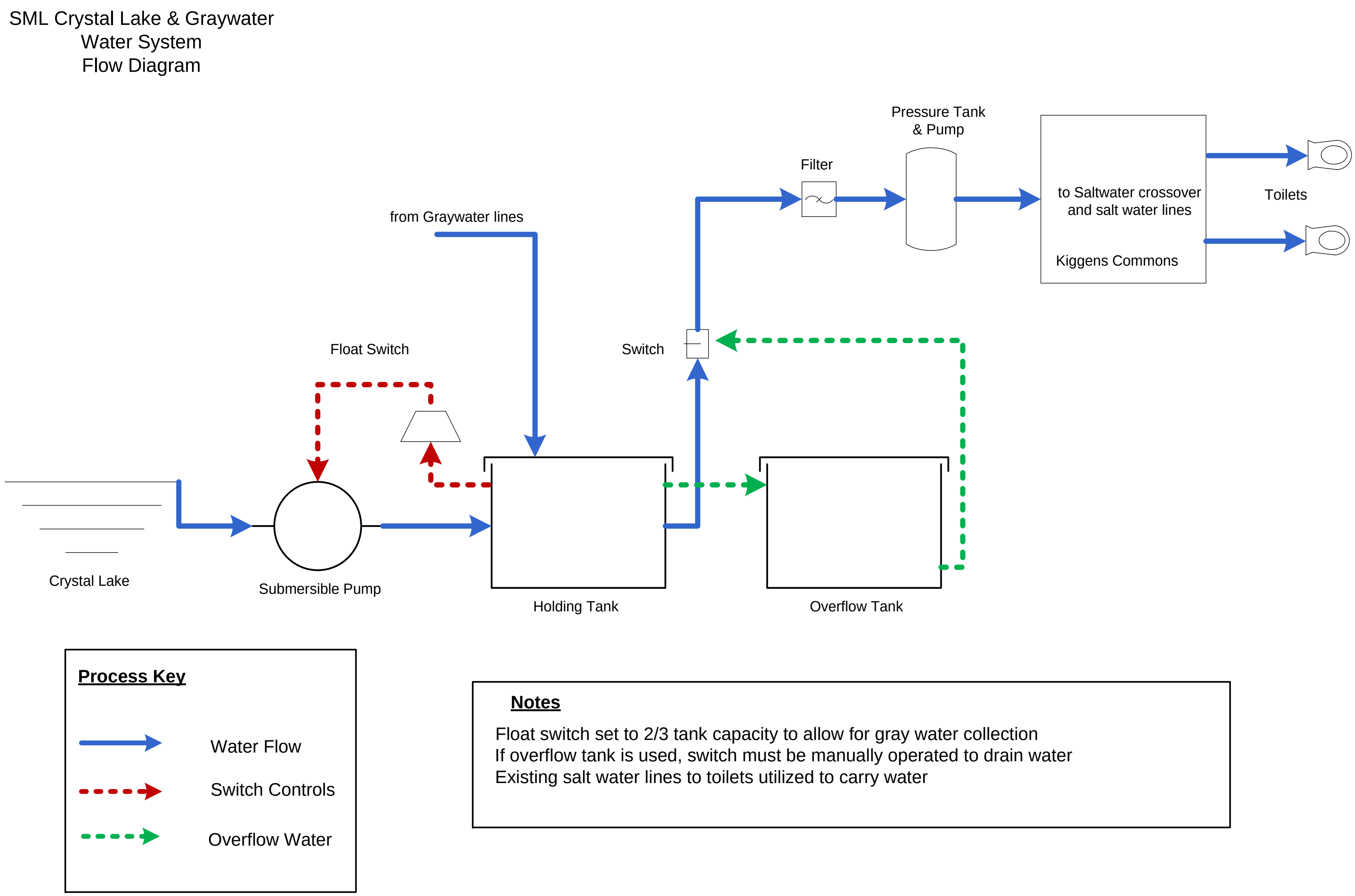
- **No record of lake going dry**
- **Low residence time**
- **Experimental Results**
- **Lake Ecology**

Our Conclusions

- **Crystal Lake has Input and Output**
- **Would be suitable source for toilet water**

Reuse of Existing Equipment

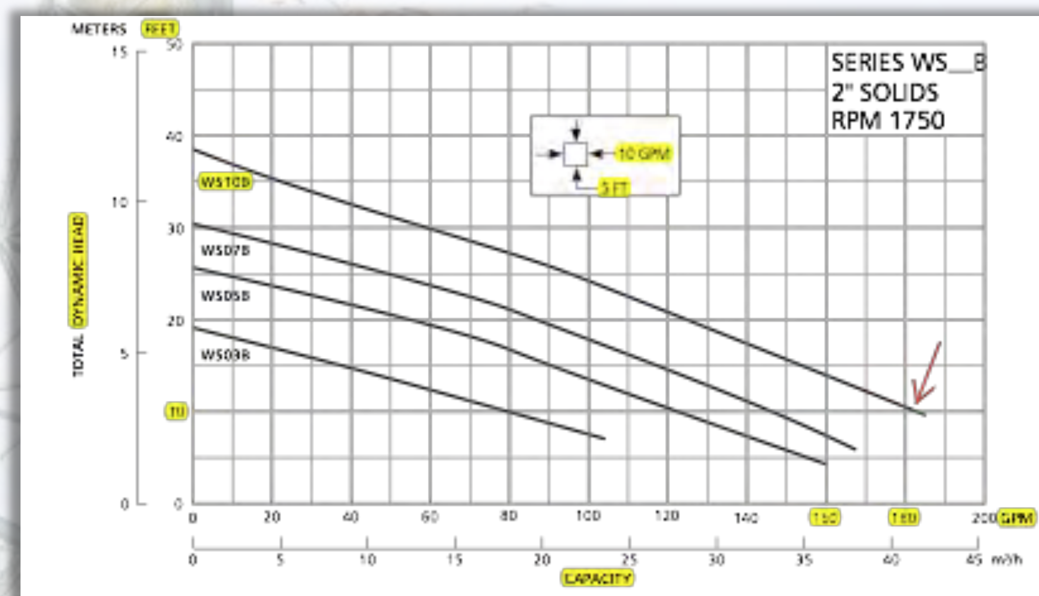
SML Crystal Lake Water System Flow Diagram



Notes

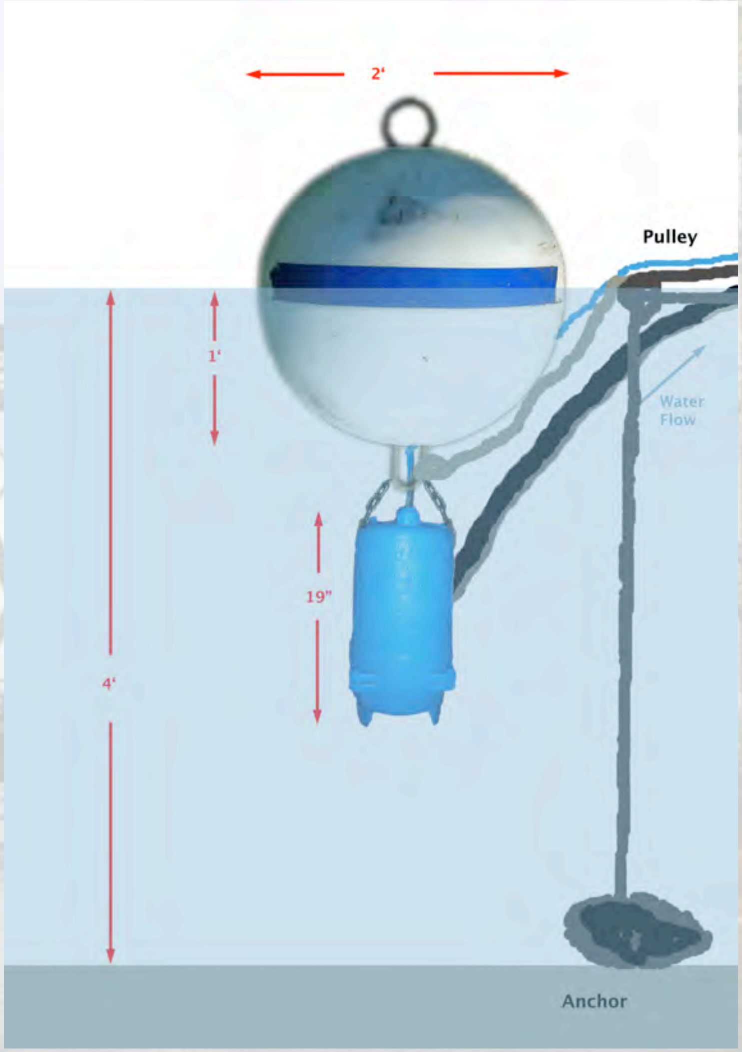
Float switch set to 2/3 tank capacity to allow for gray water collection
If overflow tank is used, switch must be manually operated to drain water
Existing salt water lines to toilets utilized to carry water

Pump Considerations



•Existing wastewater pumps would be more than sufficient for Crystal Lake

Pump Location



Required Buoy Diameter

$$\text{diameter} = 2\left(\frac{3m}{2\pi\rho}\right)^{\frac{1}{3}}$$

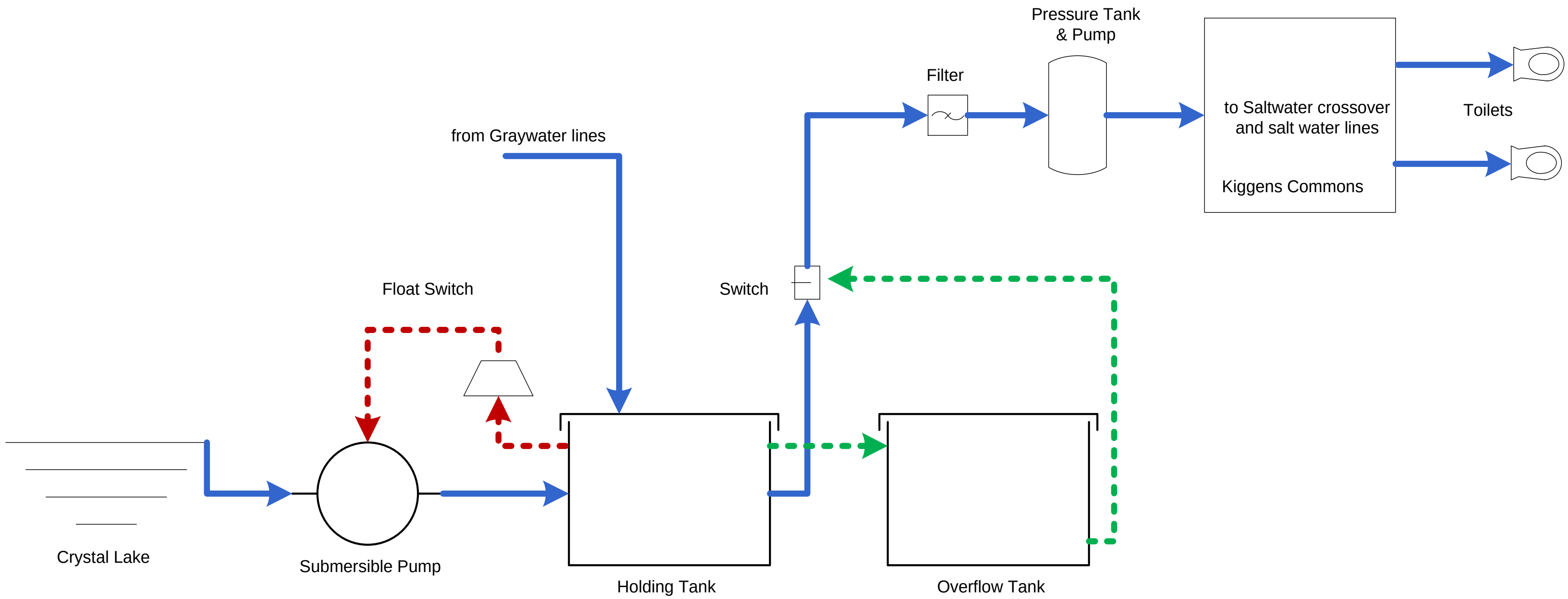
$$\text{diameter} \approx .6\text{meters} \approx 1.8\text{ft}$$

Existing buoy will suffice!

Grey Water Flushing

- Kiggins Common's kitchen and showers produce 220 gal/day of grey water
- Can be easily connected to proposed Crystal Lake flushing system
- Re-using grey water would prolong life of leach field

SML Crystal Lake & Graywater
Water System
Flow Diagram



Process Key

Water Flow

Switch Controls

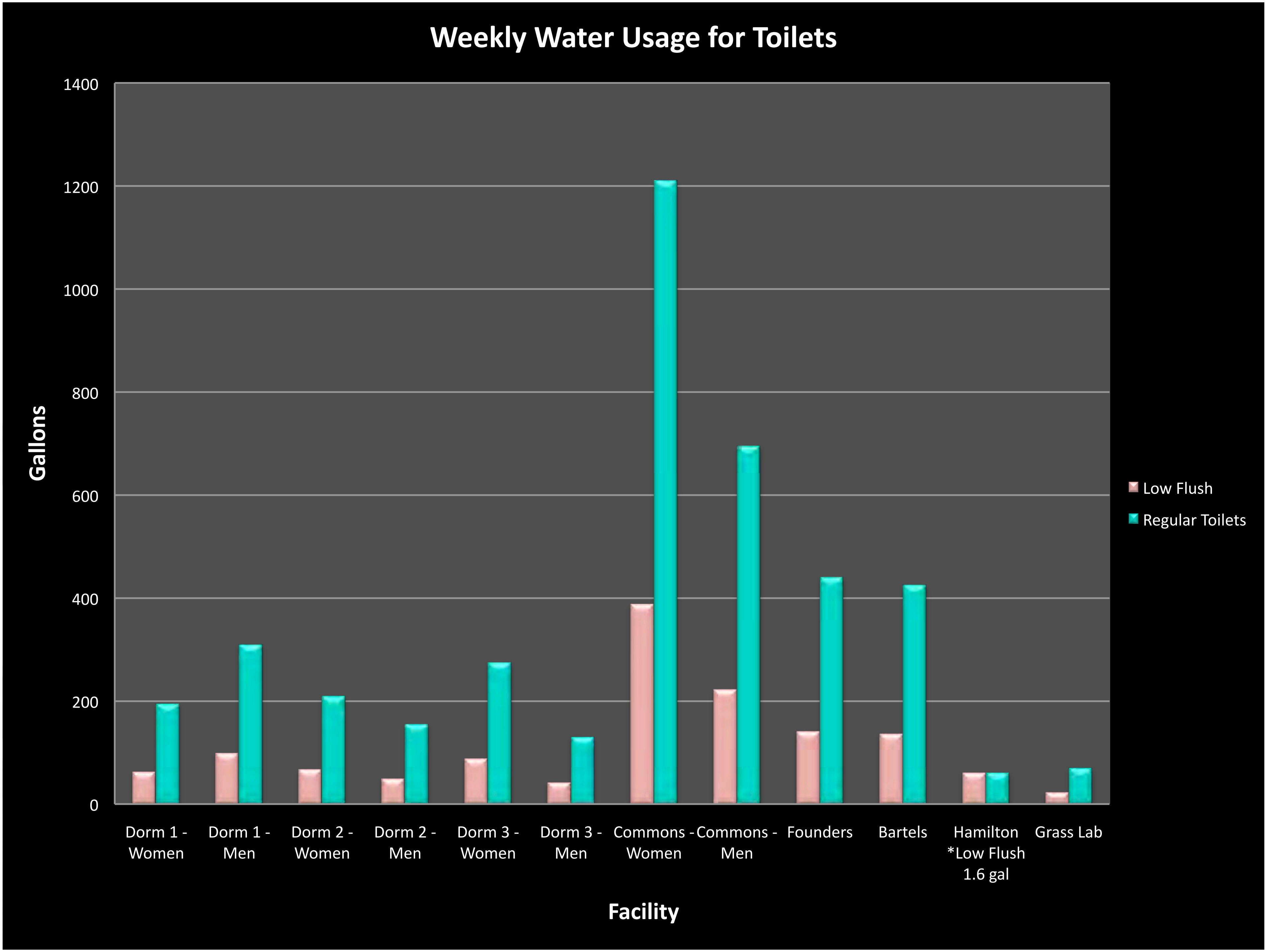
Overflow Water

Notes

Float switch set to 2/3 tank capacity to allow for gray water collection
If overflow tank is used, switch must be manually operated to drain water
Existing salt water lines to toilets utilized to carry water

Low Flush Toilets

- Use 1.6 gallons per flush (gpf)
- Most existing toilets use 5 gpf
- Typically cost around $450



Weekly Water Usage for Toilets
Gallons
1400
1200
1000
800
600
400
200
0
Low Flush
Regular Toilets
Dorm 1 - Women
Dorm 1 - Men
Dorm 2 - Women
Dorm 2 - Men
Dorm 3 - Women
Dorm 3 - Men
Commons - Women
Commons - Men
Founders
Bartels
Hamilton *Low Flush 1.6 gal
Grass Lab
Facility

Wastewater Testing

•Placed control well (shown), and test wells around leach field

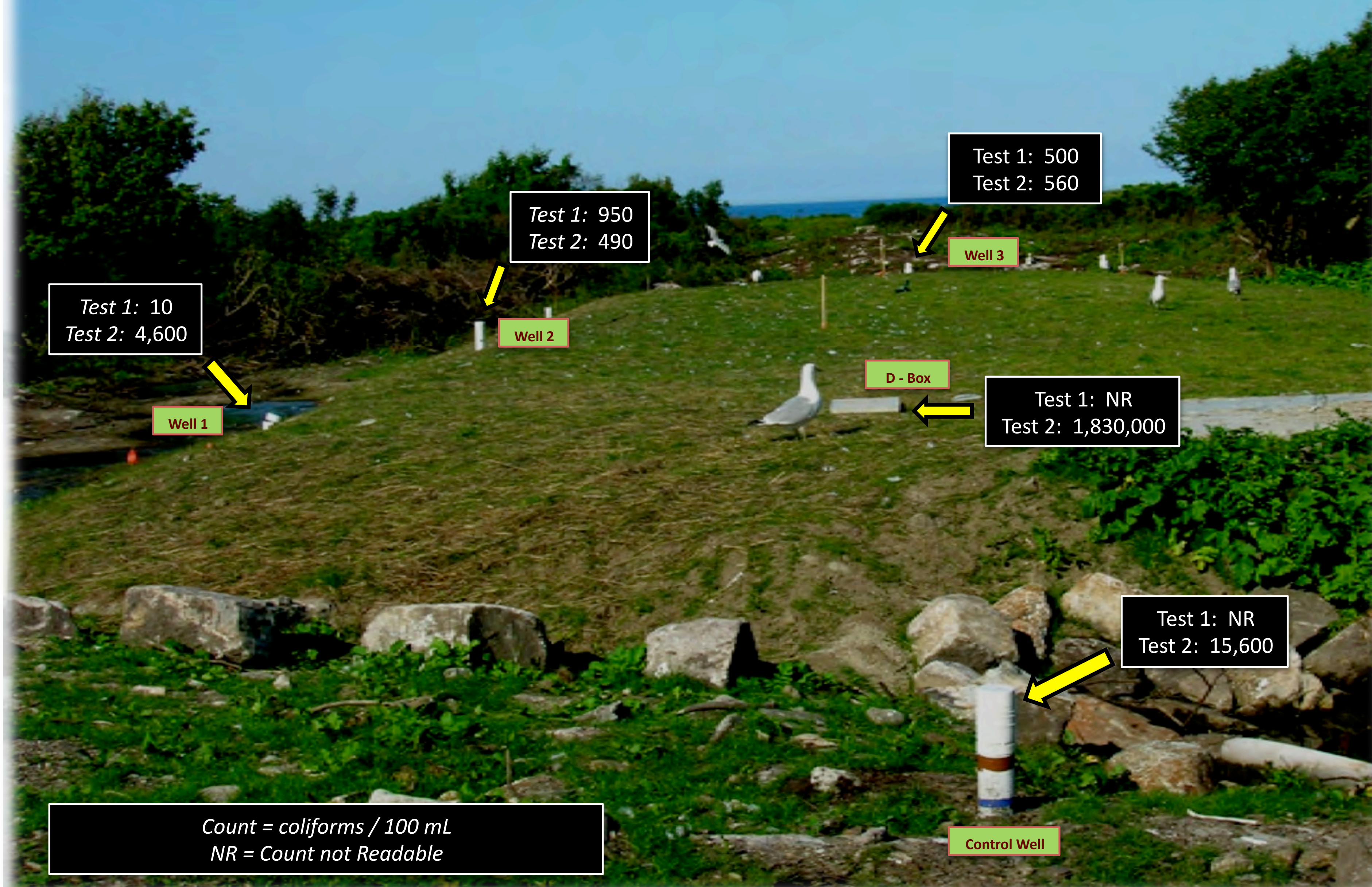
•Surveyed wells, and determined flow of groundwater

•Tested wells for fecal coliforms

•Also tested existing wells by K-House leach field

Water Flow Direction

Leach Field Fecal Coliform Count



K-House Composting Toilet Testing

- Manufactured by ClivusMultrum
- Solid waste is composted
- Lechate is sent back to gray water line
- 2008 interns found elevated fecal coliform levels
- Lechate taken from holding tank (shown) and sent to Eastern Analytical Inc. (EAI) for testing

Composting Results

Questions?

Comments?

Energy Conservation

Energy Efficiency

UNIVERSITY of NEW HAMPSHIRE
Propane on Demand: No Tank, 28-117 BTU/H
Electric Storage Tank: 2.75 gallons, 1500 W
Electric Storage Tank: 6 gallons, 1500 W
Electric Storage Tank: 40 gallons, 4500 W
Propane Storage Tank: 40 gallons, 34,000 BTU/H
Well
Wind Powered Generator
Pole Barn
Werly Tanks
Fuel Depot
Chapel
Grass Lab
Dive Locker
Paint Shed
Dorm 1
Bartels
Dorm 2
Kiggins Commons
Dorm 3
Founders
Hamilton
Laighton
Palmer-Kinne
Radar Tower
Kingsbury House
Dock
Salt water pump
Image © 2009 Maine GeoLibrary
19 T 368324.82 m E 4760790.87 m N
Google

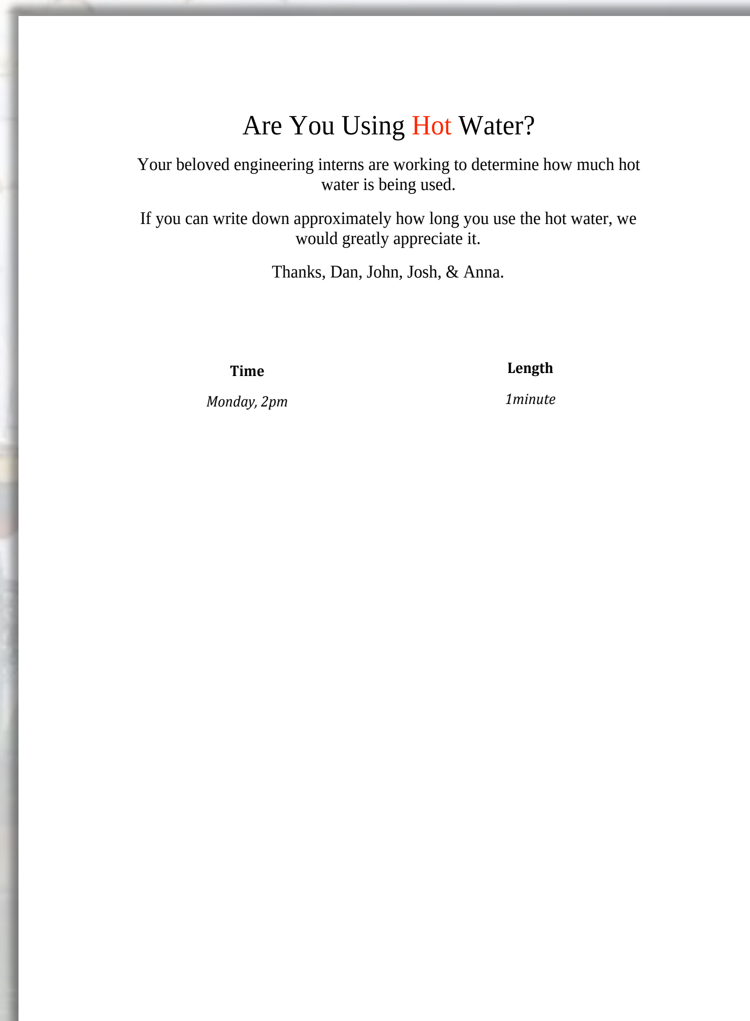
WHAM

Water Heater Analysis Model

- Determines power consumption of a water heater

Sources of Data

- Surveys placed by all sinks with hot water
- Information from manufacturers
- Estimated values



Are You Using Hot Water?

Your beloved engineering interns are working to determine how much hot water is being used.

If you can write down approximately how long you use the hot water, we would greatly appreciate it.

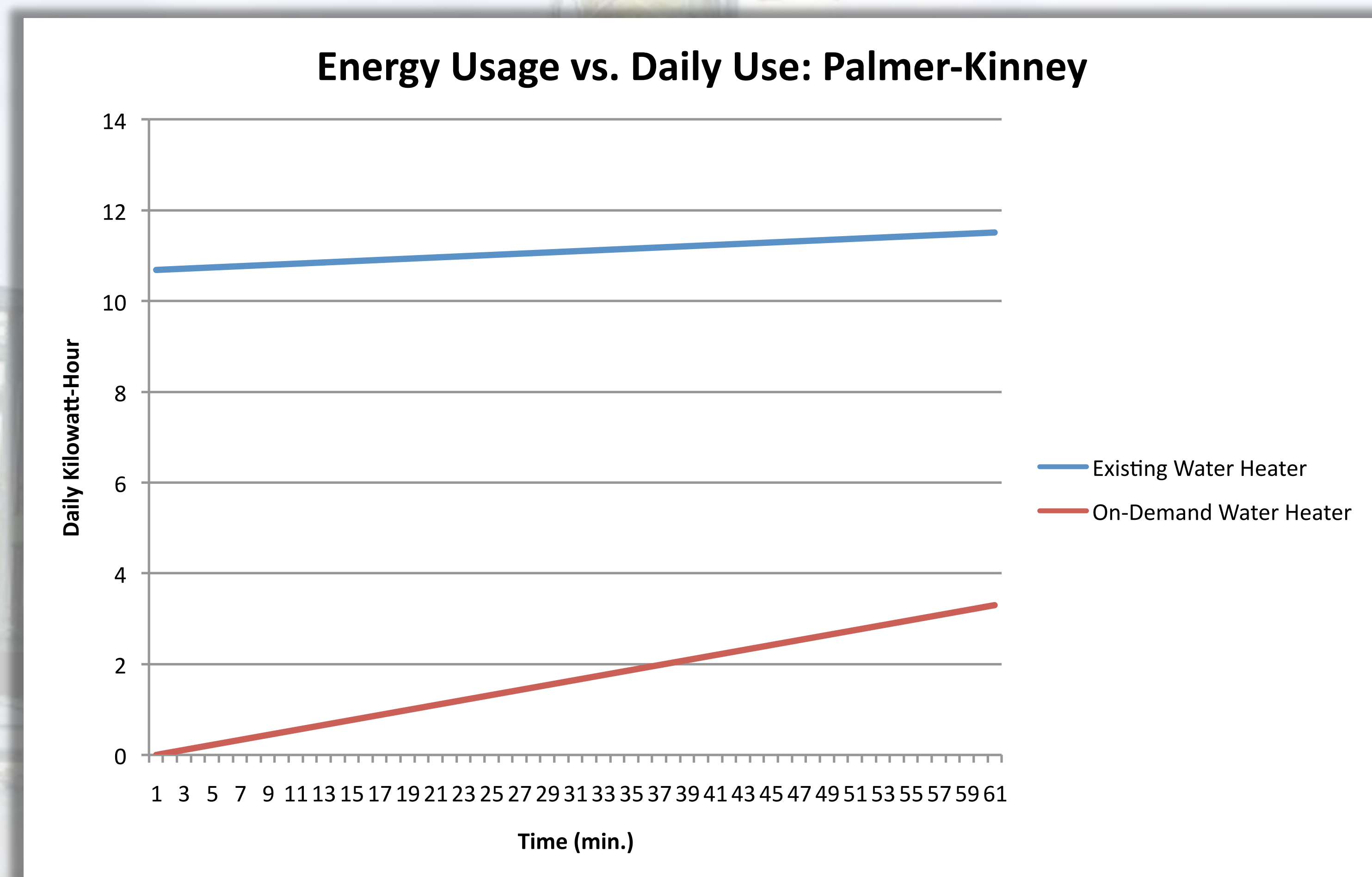
Thanks, Dan, John, Josh, & Anna.

Time	Length
Monday, 2pm	*1minute*

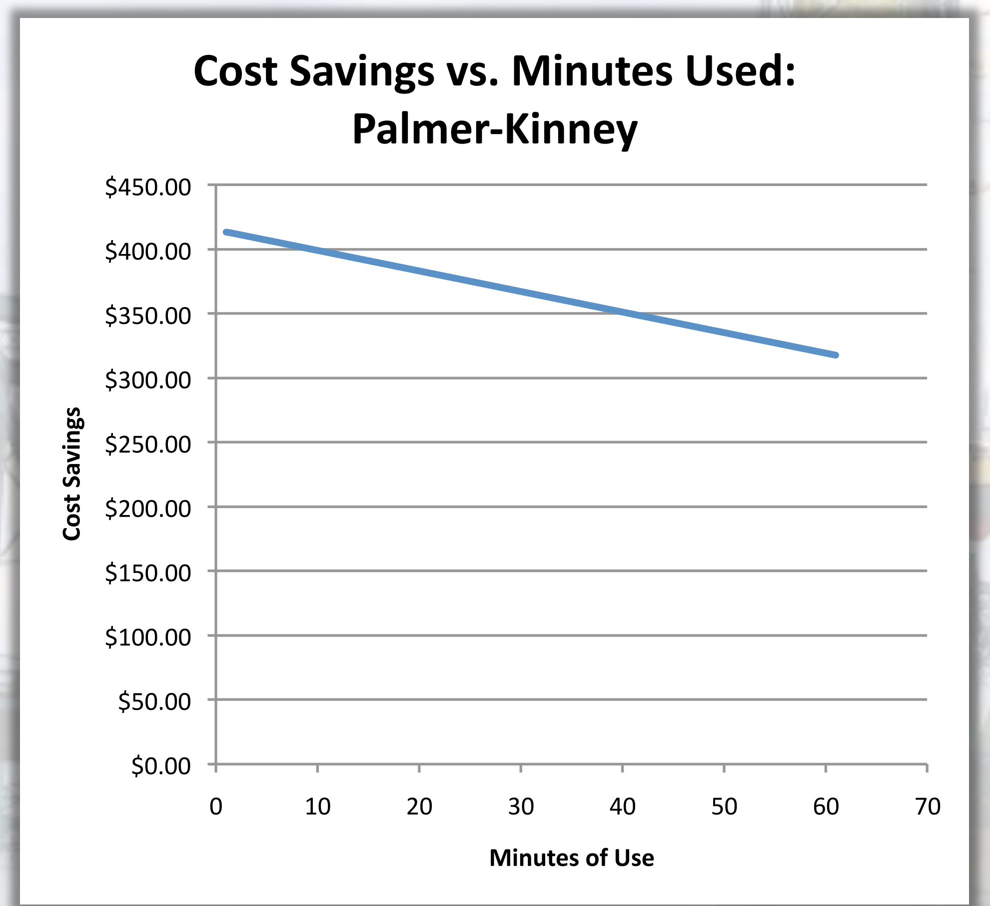
Founders Water Heater

- 40 gallon tank
- 10kWh draw per day
- Usage of 5 minutes per day
- Cost of $4.30 per day
- Top floor sink takes nearly a minute get hot

‘On Demand’ vs. Existing Water Heater

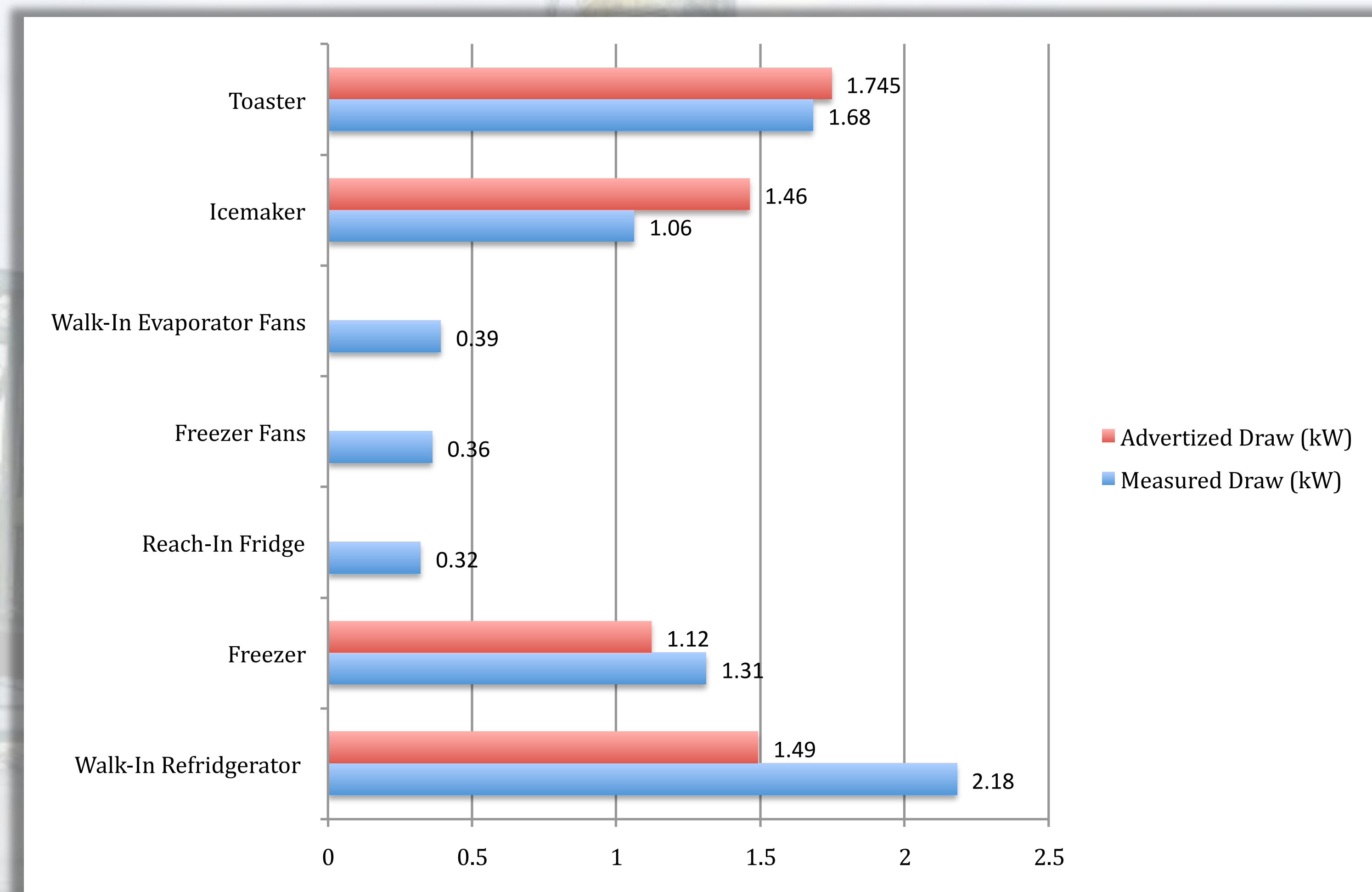


Cost Savings



- Cost Savings per year is \$300-\$400 per year depending on usage (based on three months of usage)
- Assumes \$0.43/kW-hr
- Also assumes comparable usage
- Large spike in power consumption

Kitchen Power Draws



Other Large Power Draws

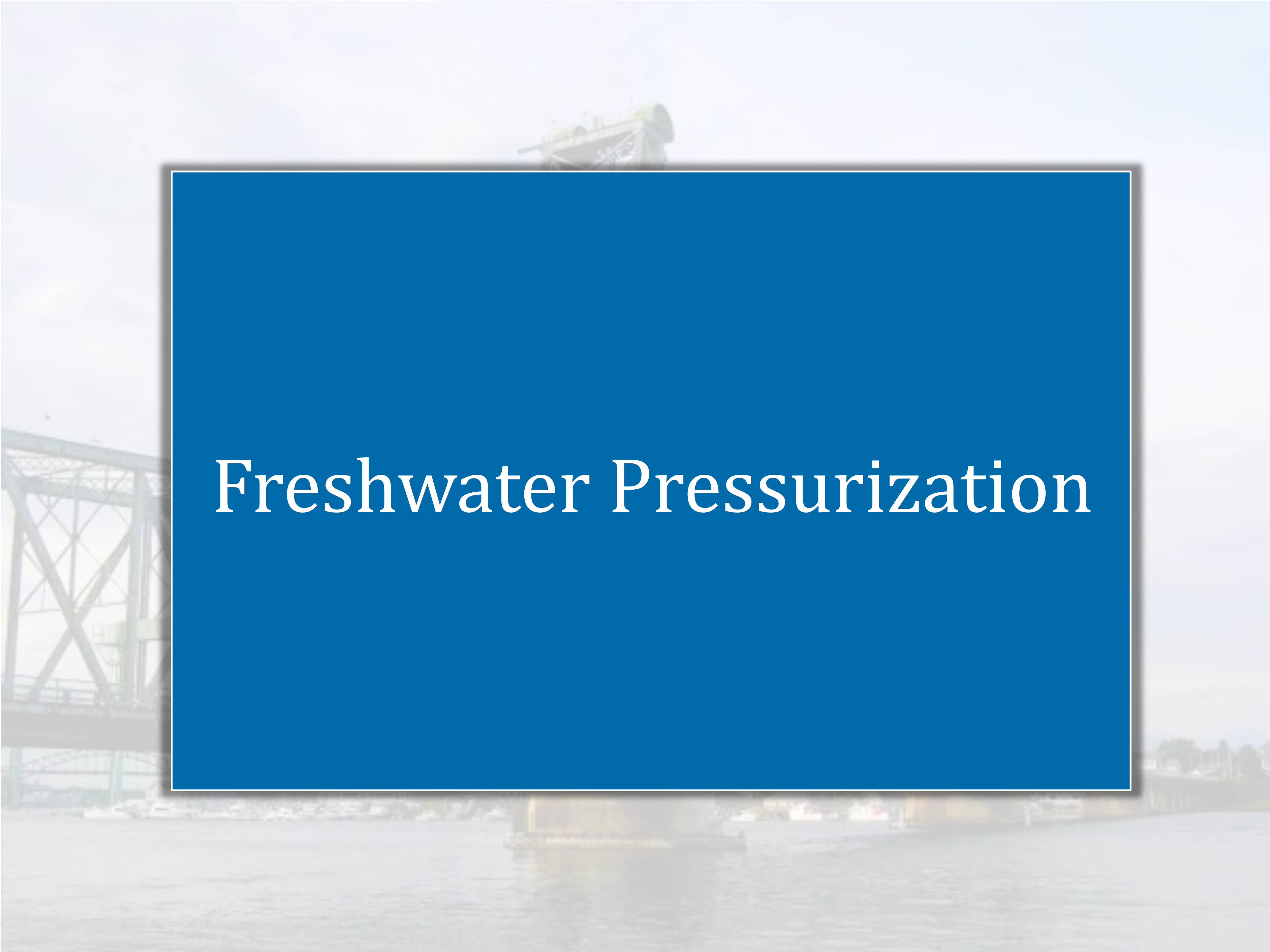
- Pole Barn Lights 1.75kW
- Well Pump 373W
- Cistern Pump 746W
- Salt Water Pump 5.5kW

Ceiling Occupancy Light Sensor

- Easy to install
- Good for the Commons' bathrooms
- Cost $59 each
- Savings of around $100 a year given 14 hours of use

Questions?

Comments?

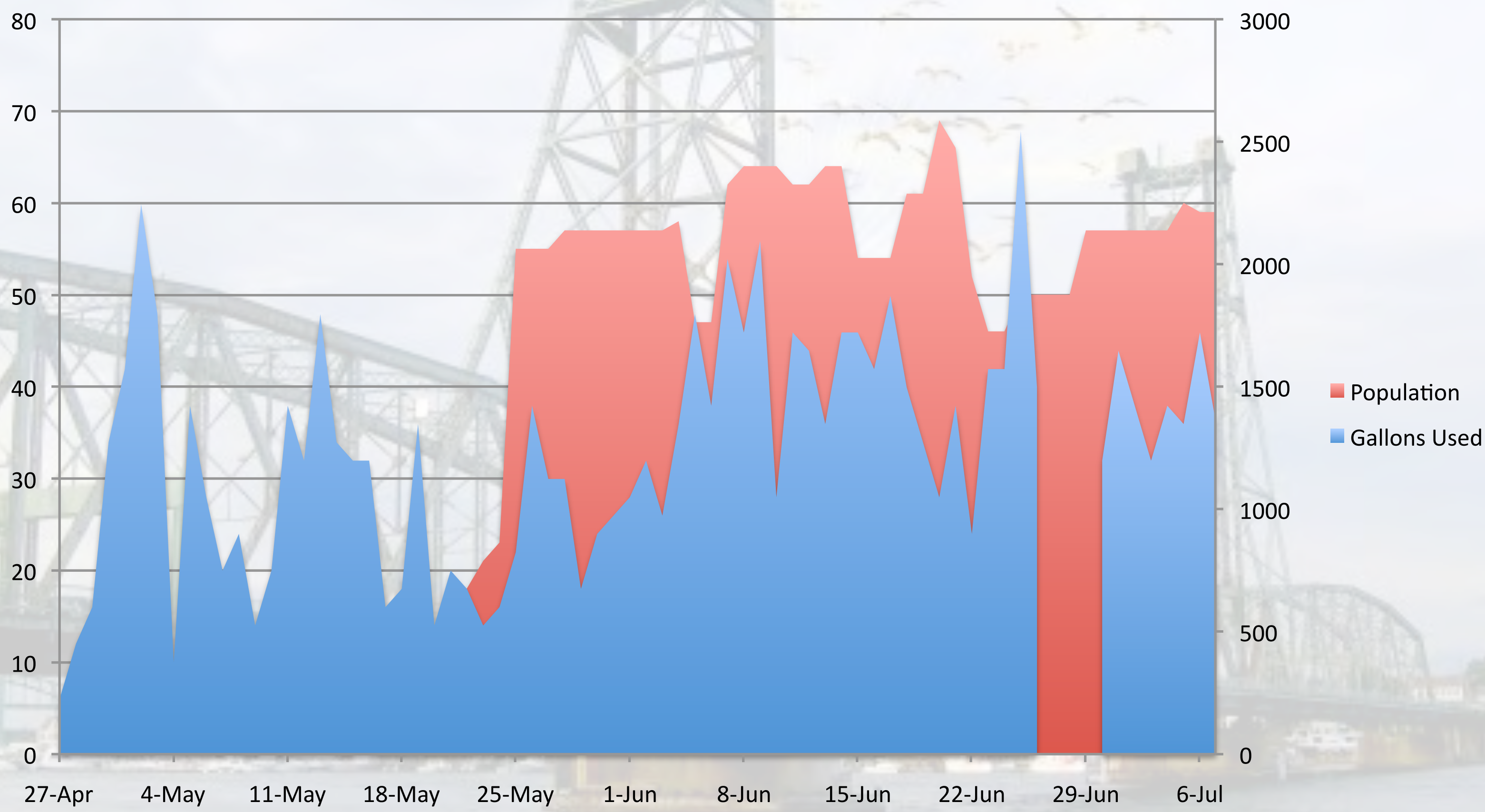


Freshwater Pressurization

Freshwater Pressure Tank Replacement

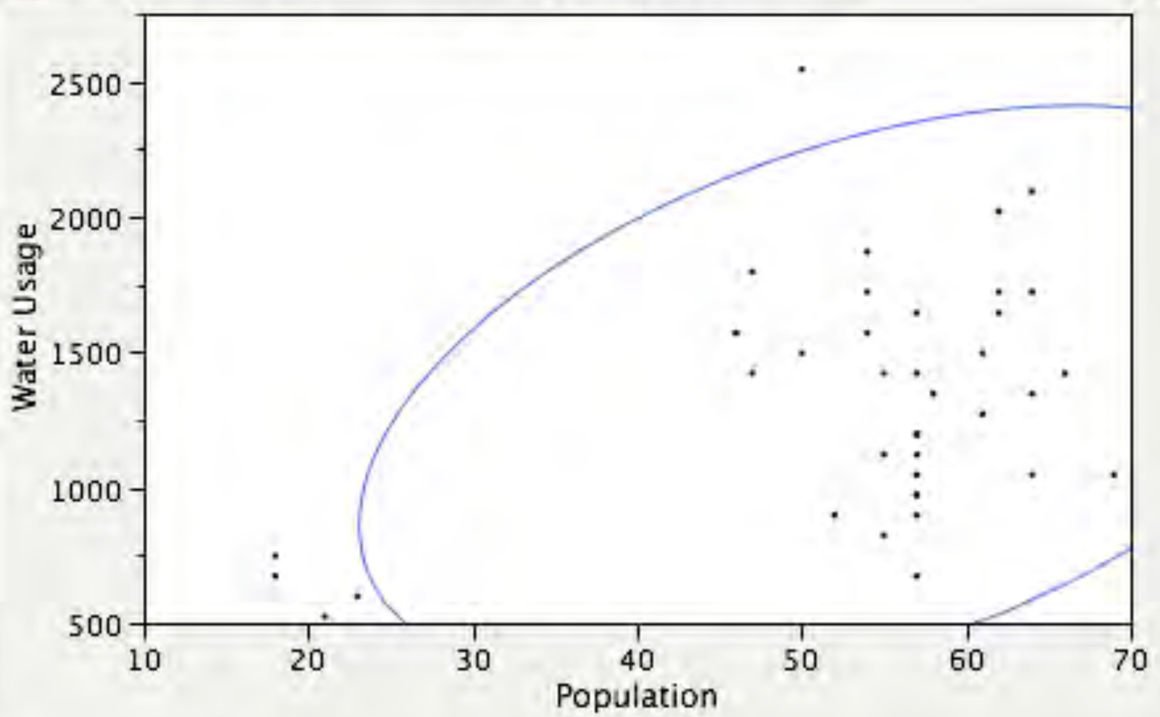
- Current tank volume is approximately 840 ft^3
- Supplies about 1200 gallons of fresh pressurized water
- Needs replacing because the tank is corroding

Freshwater Usage



Freshwater Usage

Bivariate Fit of Water Usage By Population

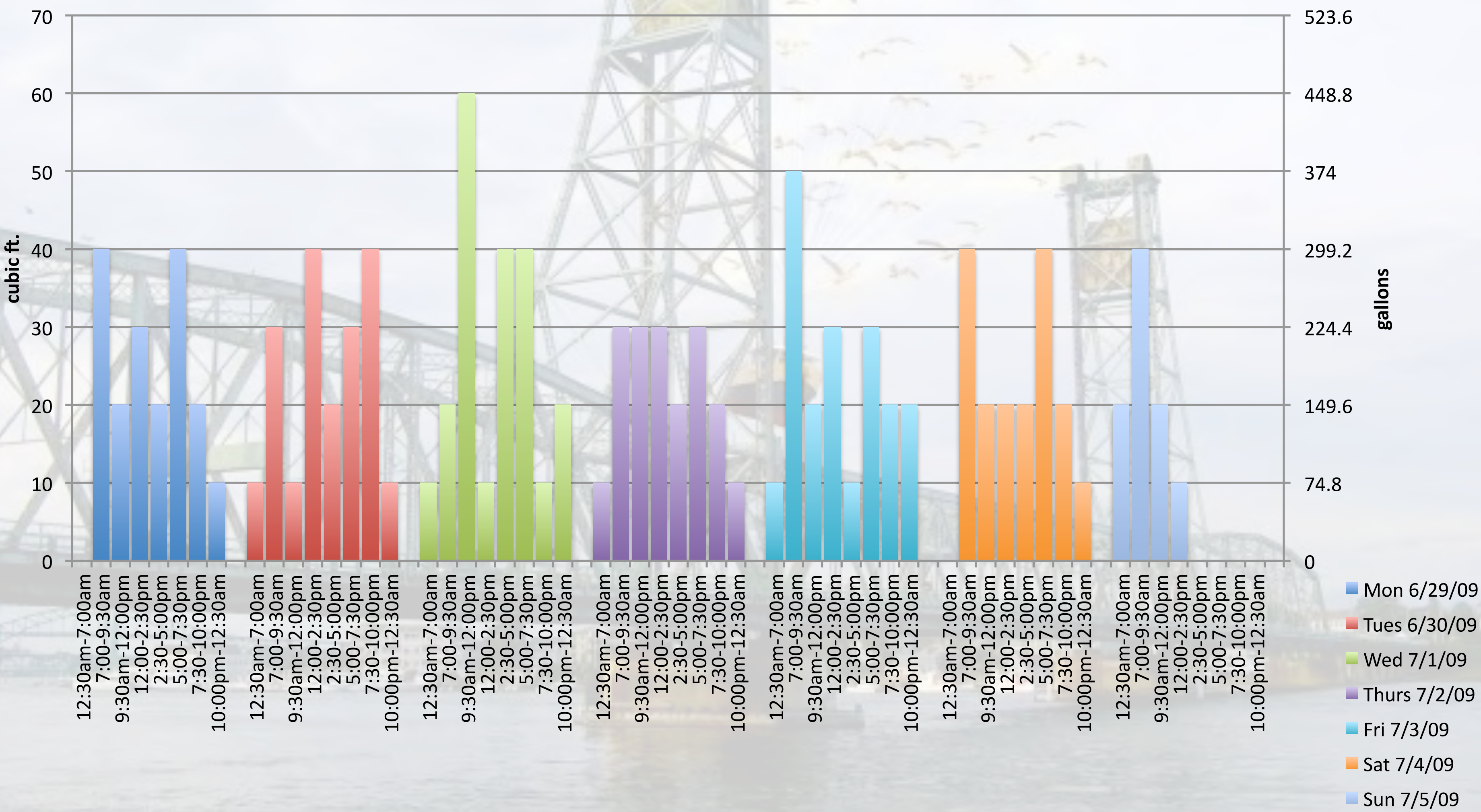


Bivariate Normal Ellipse P=0.950

Correlation

Variable	Mean	Std Dev	Correlation	Signif. Prob	Number
Population	53.4878	12.41999	0.436941	0.0043*	41
Water Usage	1331.983	440.7508			

Water Usage Trends



Pressure Tank Size

$$V = \frac{V_m}{\left(1 - \frac{P_1}{P_2}\right)}$$

where:

V = pressure tank volume, gallons (m^3)
V_m = 15 minutes storage at the peak hourly demand rate, gallons (m^3)
P_1 = minimum absolute operating pressure, psi (kPa)
= gauge pressure plus 14.7 (101.3 kPa)
P_2 = maximum absolute pressure, psi (kPa)
= gauge pressure plus 14.7 (101.3 kPa)

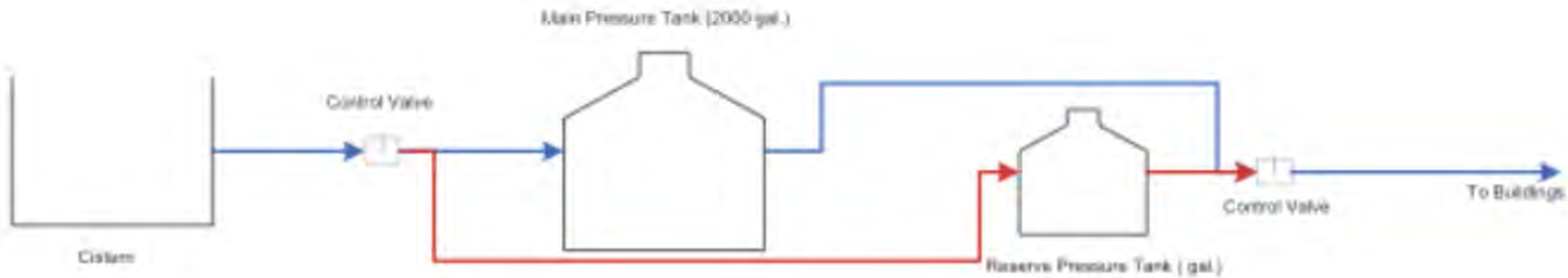
The design of bladder-type pressure tanks must also consider the number and size of tanks to provide pump protection and the precharged air pressure of the tank.

Courtesy of *Handbook of Public Water Systems, Second Edition*

Variable Frequency Drive

SML Freshwater System Flow Diagram

SML Fresh Water System
Flow Diagram
Option 1



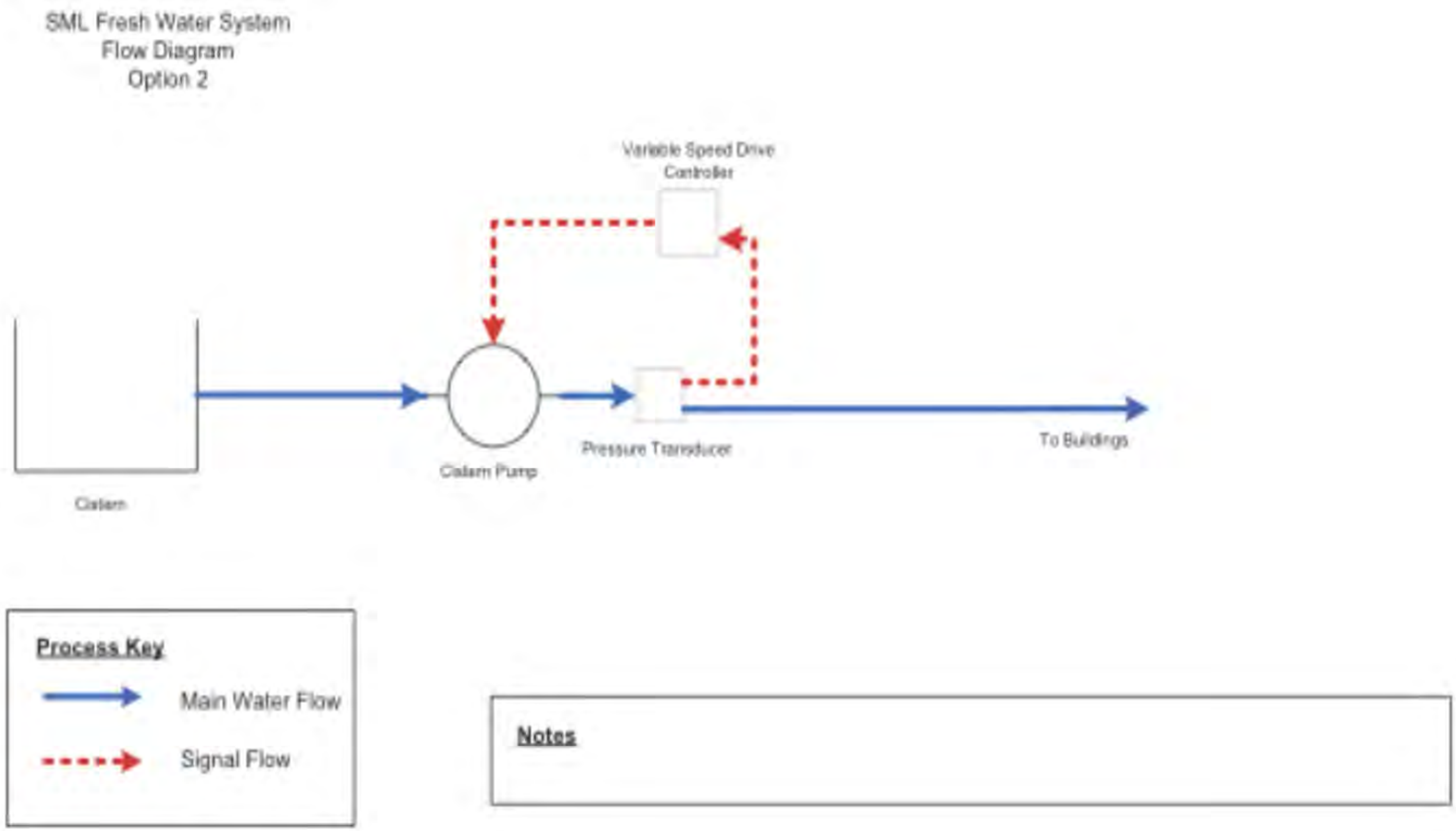
Process Key

- Main Water Flow (blue arrow)
- Alternate Flow (red arrow)

Notes

Reserve pressure tank allows for continued operation in case of main tank failure or maintenance

SML Freshwater System Flow Diagram



Questions?

Comments?

Pipe Replacement

Sewage Pipe Replacement

- SML wants to replace existing concrete wastewater pipe
- Determined best size for a new pipe

TABLE 1

CORNELL UNIVERSITY SHOALS MARINE LAB

TOTAL WASTEWATER DESIGN FLOW PROJECTIONS AND ALLOCATION OF WASTEWATER GENERATION (POINTS OF ORIGIN)

Building Name	Type/Use	# Beds	# Classroom seats	Existing Plumbing Facilities (3/6/2009)	Potential Design Flow (see letter for analysis of generation)	TOTAL GPD	% ALLOCATION AT LOCATION	PROPOSED GPD	DISPOSAL SYSTEM #
Kiggins Commons	Kitchen/Dining/Showers/ Central Toilets	0	120	5 toilets, 7 showers, 14 sinks, commercial dishwasher, mop basin	3,500 gpd Total campus flow island wide	50% of total flow @ cafeteria/commons - 25% for composting toilet reduction3	25%	875	#1 Proposed
Dorm 1	Student Housing	20	-	2 toilets, 4 sinks	20 @ 25 gpd	500	15%	75	#1 Proposed
Dorm 2	Student Housing	20	-	2 toilets, 4 sinks	20 @ 25 gpd	500	15%	75	#1 Proposed
Dorm 3	Student Housing	20	-	2 toilets, 4 sinks	20 @ 25 gpd	500	15%	75	#1 Proposed
Founders	Housing	39	-	5 toilets, 10 sinks	39 @ 25 gpd	975	50%	490	#1 Proposed
Hamilton	Classroom/Offices	0	30	1 toilet, 1 sink		50	100%	50	#1 Proposed
Grass Lab	Apt/Lab	2	10	2 toilets, 3 sinks, 1 washing machine	2 @ 25 gpd laundry classroom	50 50 25	50% 100% 100%	125	#1 Proposed
Palmer-Kinne	Lab/Library/Classroom	0	50	2 sinks	-	20	100%	20	#1 Proposed
Laighton	Lab/Library/Classroom	0	50	1 sink	-	20	100%	20	#1 Proposed
Bartels	Staff Housing	13	-	4 toilets, 2 showers, 6 sinks, 1 washing machine	13 @ 25 gpd laundry[2] showers	325 200 200	50% 100% 100%	560	#2 Proposed
Kingsbury House	N/A	11	-	On existing septic with composting toilets	11 @ 25 gpd	275	50%	140	#6 Existing
Ross's Pole Barn	Maintenance storage	-	-	-	-	0	-	0	NA

Total Population	Overnight residents	125	@ 25gpd[1]	3,125 gpd
	Day Trippers	20	@ 14gpd	275 gpd
Total Campus wastewater generation projection				**3,400 gpd**

25% Reduction +/- due to composting toilets ⇉ **TOTAL DESIGN WASTEWATER FLOW FOR SUBSURFACE WASTEWATER DISPOSAL**

2,500 **GPD**

1,455 GPD

[1]See letter of March 6, 2009 to Jim Jacobsen

[2]See Memo from Ross Hansen

[3]See letter of March 6, 2009 to Jim Jacobsen and Table 1 in letter

Manning's Equation

$$Q = \frac{1.49}{n} * \left[\frac{\theta - \sin(\theta)}{8} * D^2\right]^{5/3} * \left[\frac{D * \theta}{2}\right]^{-2/3} * S^{1/2}$$

- Island daily flow is 1455 gallons
- 4 inch pipe flowing at maximum capacity (1/2 full) can contain a flow of 6902 gallons/day
- 6 inch pipe flowing at maximum capacity (1/2 full) can contain a flow of 20350 gallons/day
- Peak flow is 750 gallons/hr

Suggestions for Future Projects

- Alternate storage for renewable energy
- Expansion of existing renewable energy
- Tidal Power
- Monitoring/Designing Data Collection System
- White Island Infrastructure

Thank You

Kevin Jerram (K2)
Mike Rosen
Ross Hansen
Mike Dalton
Tom Johnson
Nancy Kinner
Hanna Wingard
Kipp Quinby
Hal Weeks
Dan (White Island)
Willy Bemis
Kevan Carpenter
Karen Garrison
Dave Murley
Paul Roy

Jon Durand
Fred Chellis
J.B. Heiser
Denny Taylor
Kathy Mandsager
Lee Consavage
Abigal Kirtch
Matt Height
Steve Tapley
Joseph Ranahan
SML Staff
SML RIFS
Shoal's Marine Laboratory
And Many, Many, More…….especially Bob