

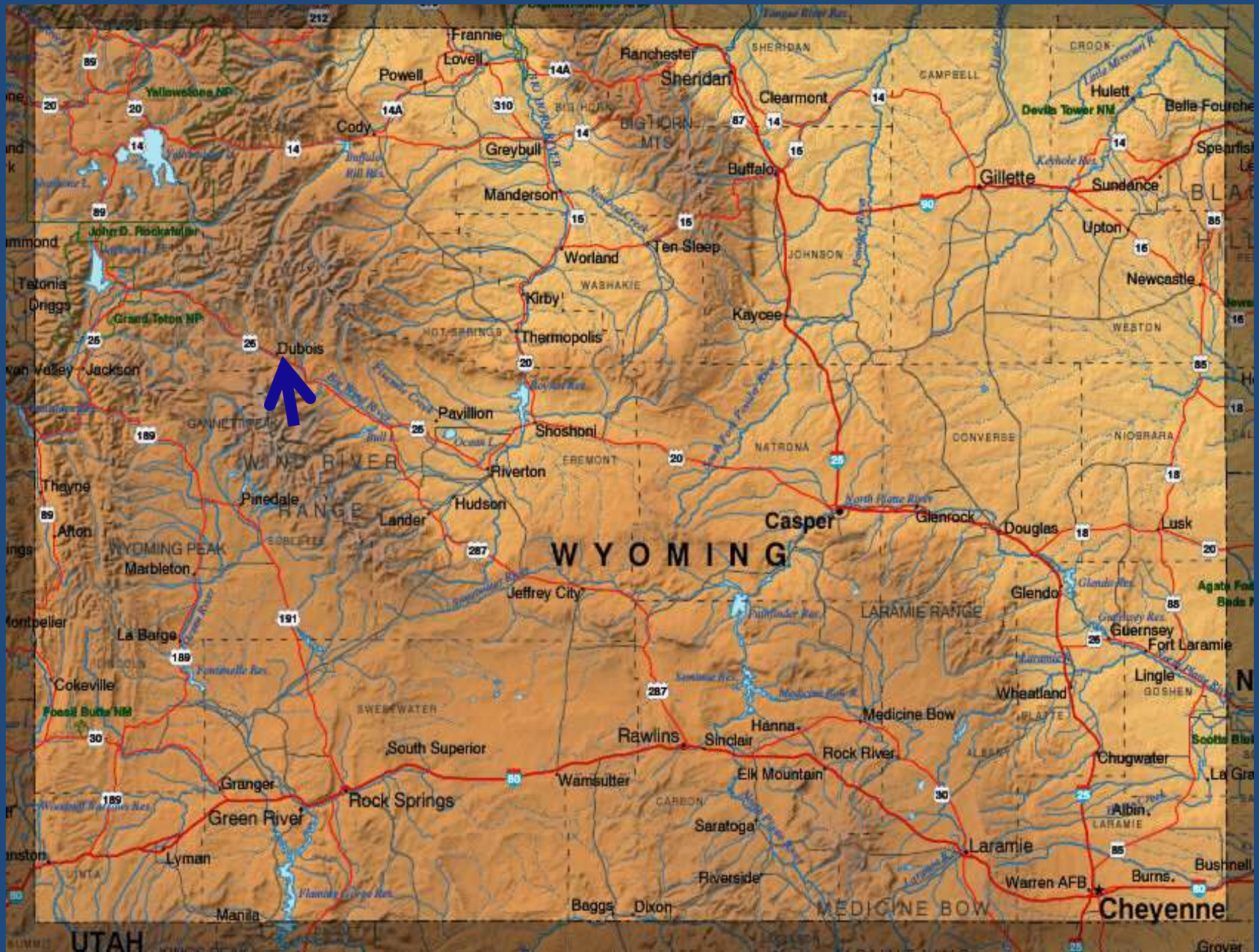
Intensive Hatchery Production in a Partial Reuse Recirculating Aquaculture System

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Background

- The Dubois Hatchery is one of ten fish rearing stations in the state of Wyoming belonging to the Wyoming Game and Fish Department.
- The facility is nestled along the continental divide at 7000 feet on the east side of the Wind River Mountains in the northwest corner of the state.



About the facility...

- The facility was originally built in the early 1940's.
- In 2006, a comprehensive hatchery remodel was completed. This was due to whirling disease being discovered in the production water.
- This transformed an aging facility to a state of the art facility utilizing a partial reuse recirculating system for intensive hatchery production.

Why was Recirculation System Chosen???

- Limited water supply available
- Maximize production
- Pathogen exclusion through a closed system
- Effective waste control



Dubois Pre-Construction



Dubois Post-Construction



Facility Operation....

- The goal for the facility is to operate effective and efficiently by optimally managing multiple fish stocks for statewide production. This is accomplished through:
 - Utilizing closed pathogen free water sources with limited flow while maintaining production. This is achieved through intensive water reuse after treatment processes.
 - A pump system along with a recirculation box is used for flow build up and endless water uses on the secondary side of the facility.

Primary Water Source

- Closed water source from two artesian wells
 - 330 gpm (1,249 liters) supplied
 - 67 Fahrenheit (19.5 Celsius)
 - Iron (1.0-2.0mg/l)
 - Nitrogen (130-140%)
 - Low Oxygen (1.0- 2.0mg/l)



Treating of the Primary Water Source

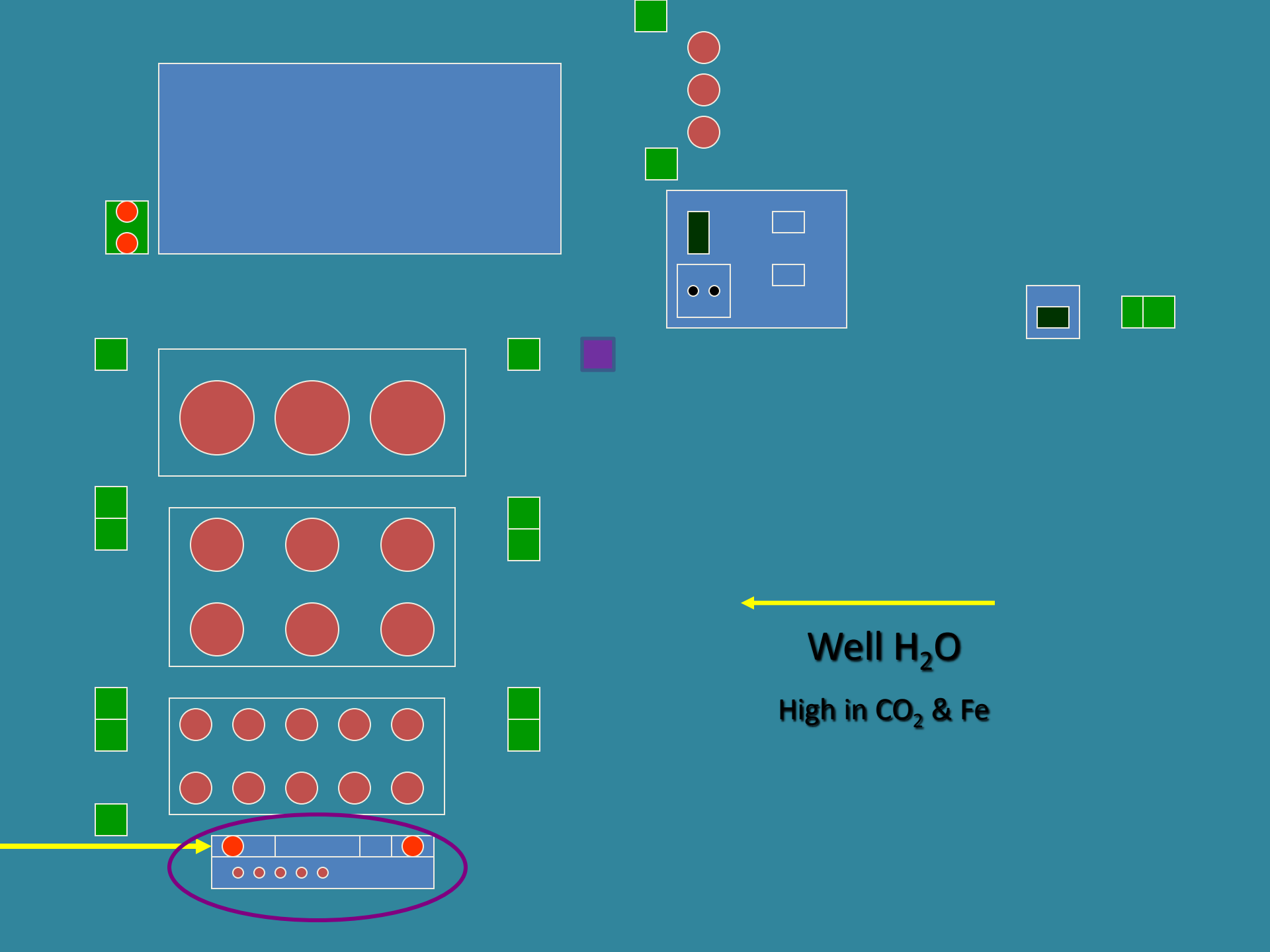
- Used to oxidize the iron enriched source with presence of an Low Head Oxygenator (LHO)
- Carbon dioxide stripper (a total of two in operation)
- Water is fed up through the carbon dioxide stripping tower where carbon dioxide levels are reduced also providing PH control



Further Iron Treatment

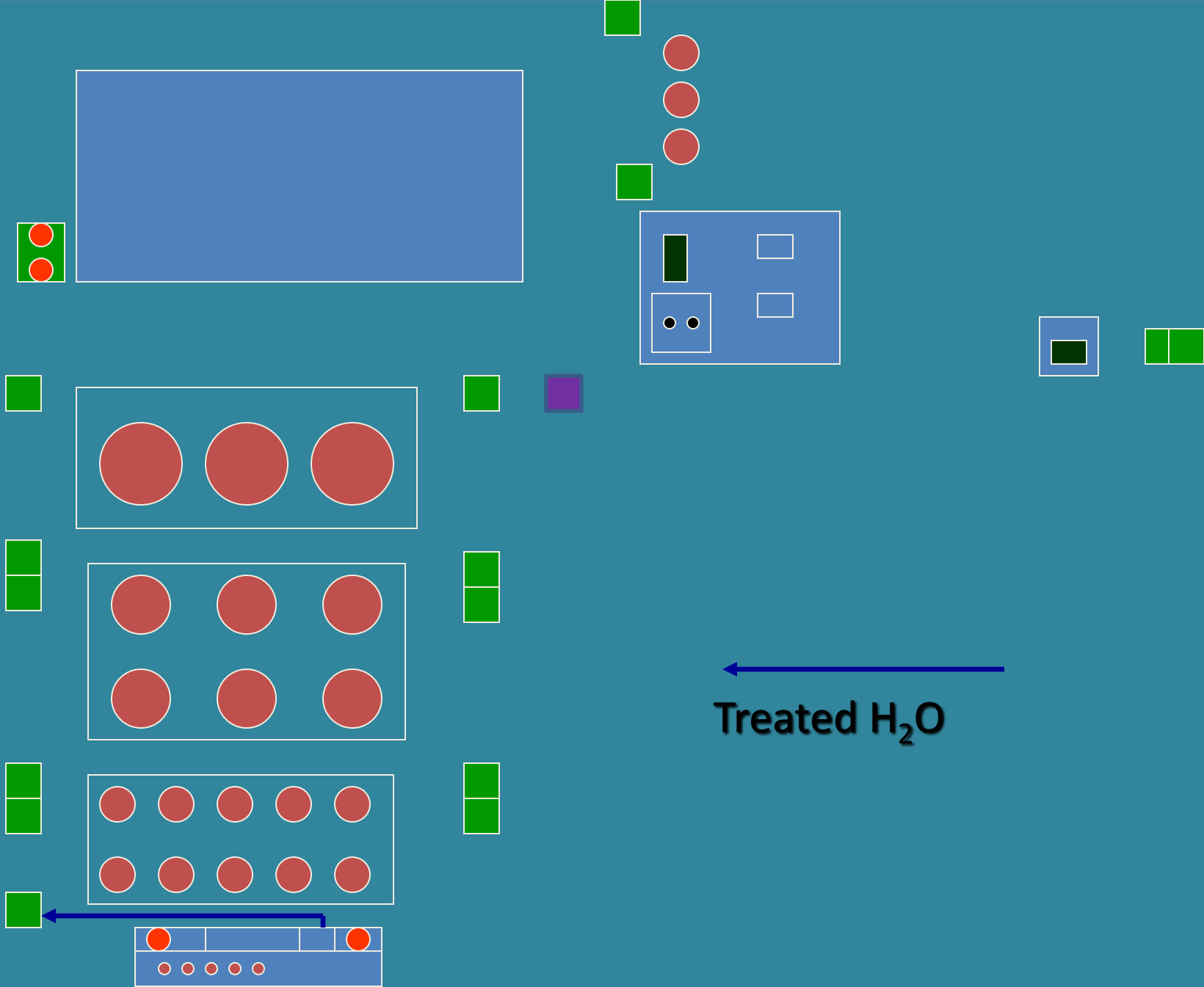
- The water source is pumped through a iron filtration system supplied by Smith & Loveless Inc.
- The system successfully filters particulates in the incoming water down to two microns.





Well H₂O

High in CO₂ & Fe

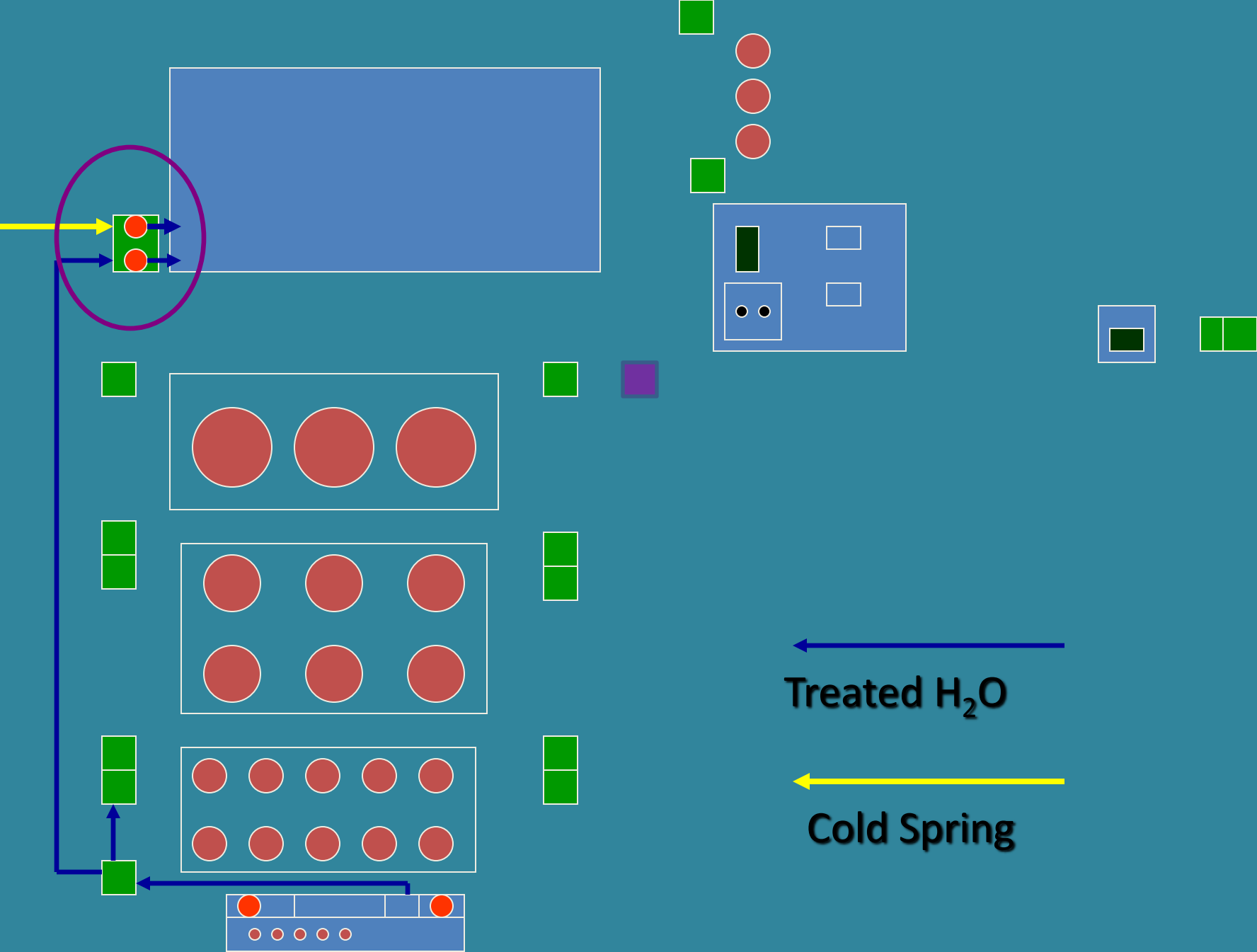


Treated H₂O

Secondary Water Source

- Closed water source from a small spring
 - Fluctuating flow but a majority of the year averages 70 gpm (265 liters)
 - Temperatures fluctuate between 43- 50 degrees Fahrenheit

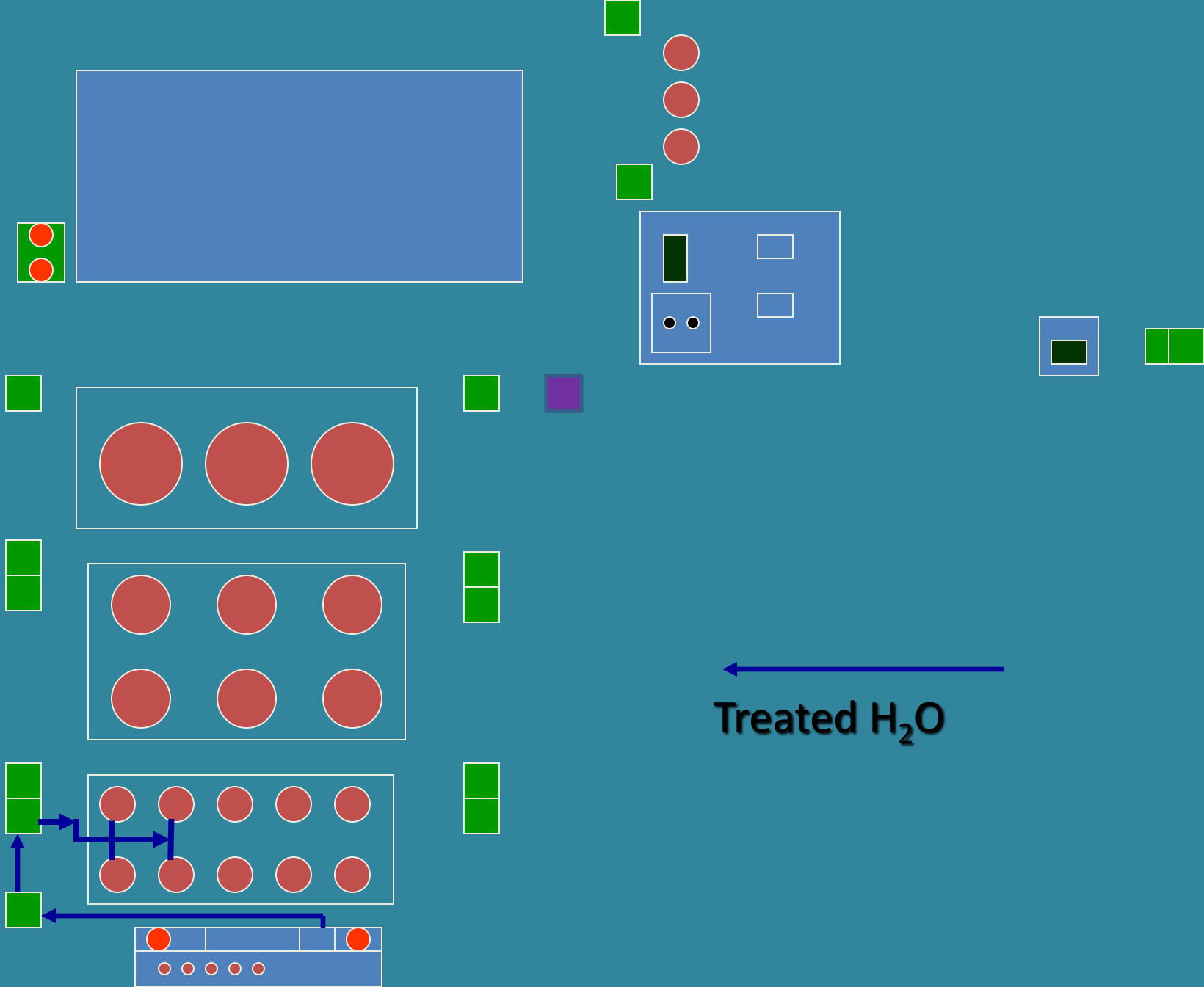




Secondary water treatment

- The water is forced by gravity up the degassing chamber
- Water is then treated by a UV system before the incubator and hatchery usage





Circular Dual Drain Tanks

- These are self cleaning circulars equipped with swirl separators
- Side box allows for 85% of the flow to return to the reuse system.
- Center drain accounts for the other 15% of the flow leaving the tank. From this approximately 20% of the flow in the swirl separator will take settleable solids out of the system. The remaining water goes to reuse.
- A net loss of approximately 3% water to the system during each usage.
- The center drain captures the settleable solids and up to 80% of the total suspended solids leaving the tank



Oxygenation Systems

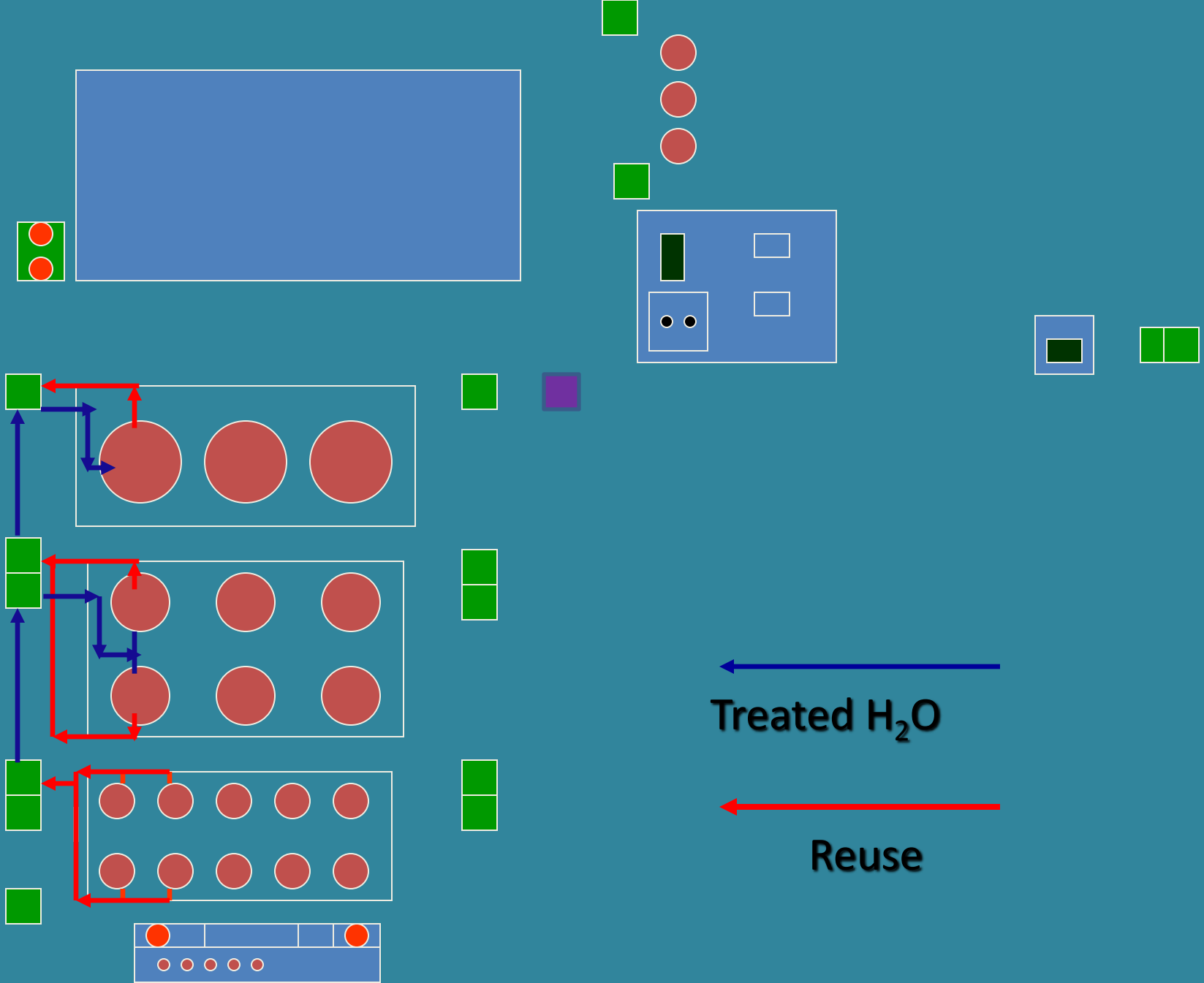


- LHO's used between all uses (a total of seven in operation)
- Maximize oxygen adsorption efficiency
- Units degas nitrogen while adding oxygen

Oxygenation Systems Cont.

- Oxygen generators providing 95% pure oxygen
- When injected at the LHO's the oxygen forces out the nitrogen gas





Drum Filters

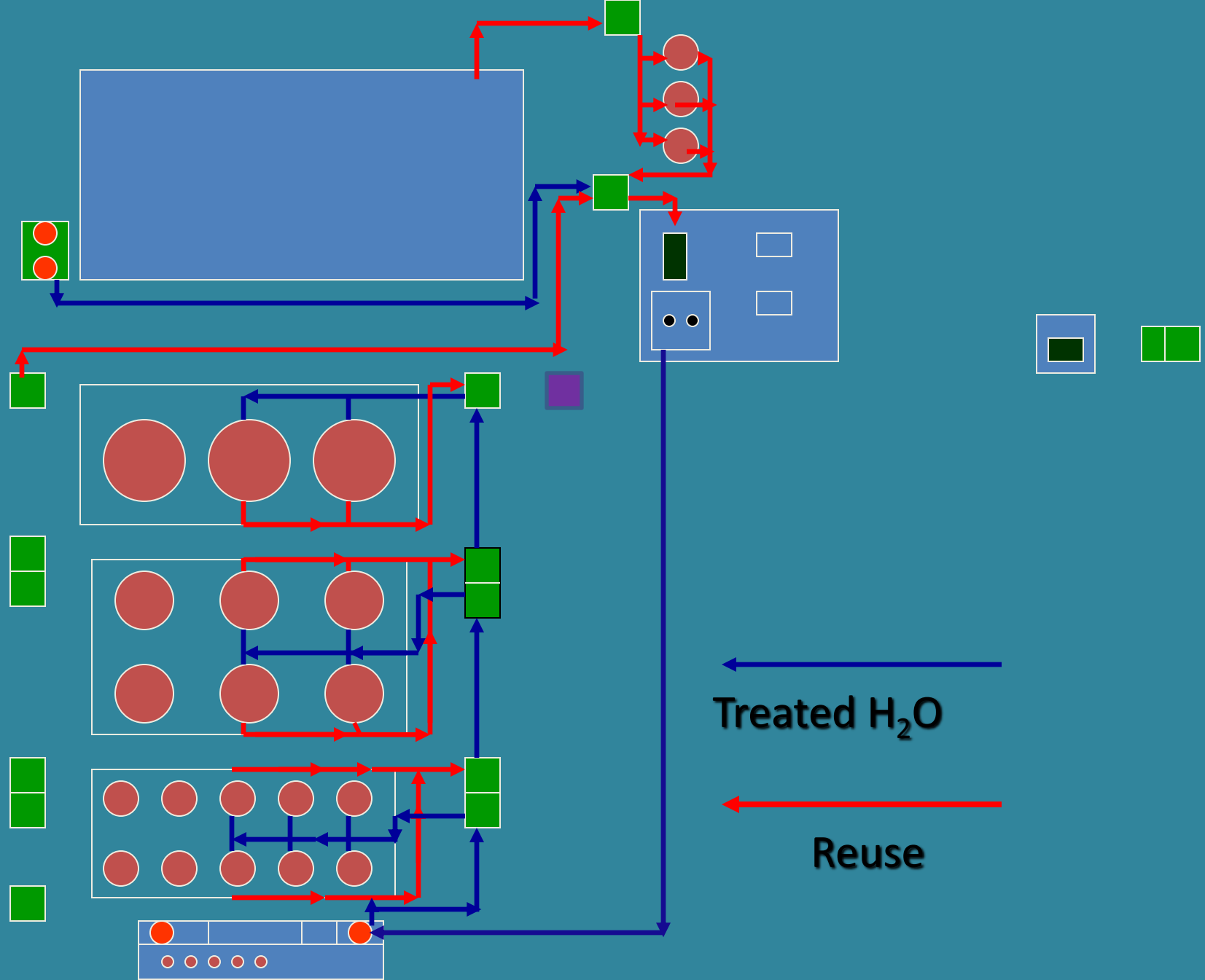


- Two drum filters in operation equipped with 60 micron size screens
 - Aid in the removal of fish waste left in system (i.e. ammonia)
 - Filters capture up to 80% of the suspended solids put through this process

Pump System



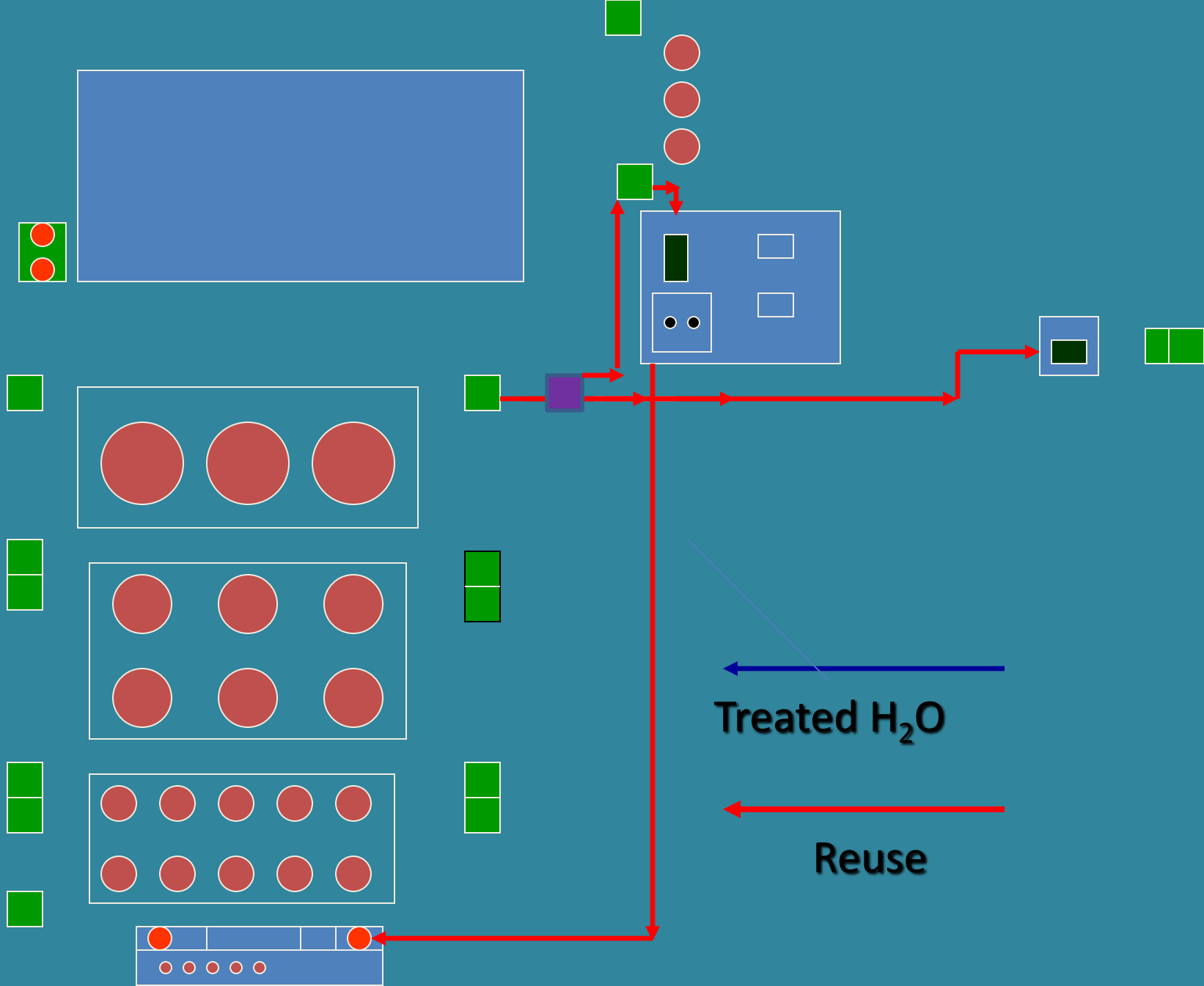
- Reuse water is pumped from here to the secondary side of the facility

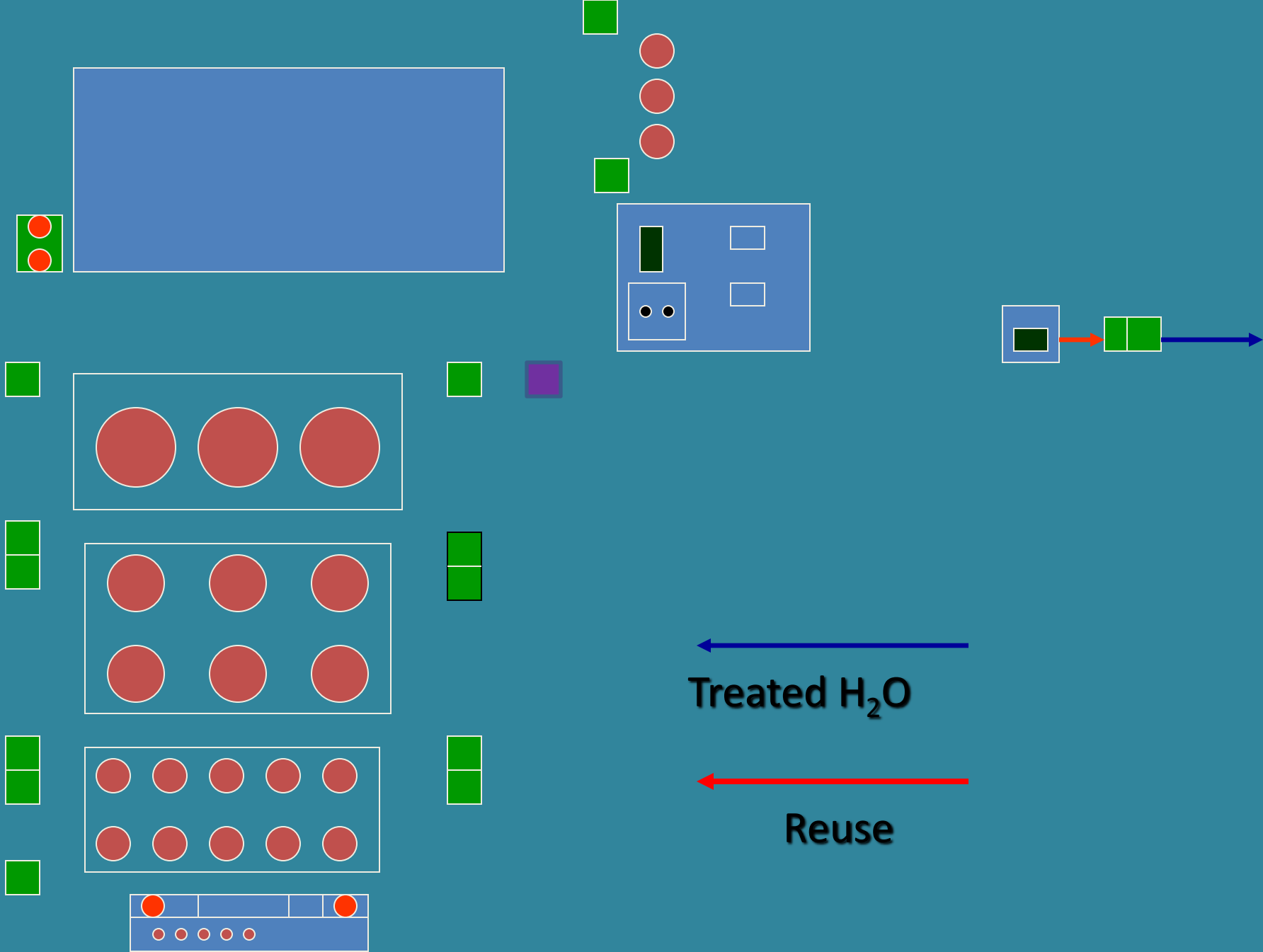


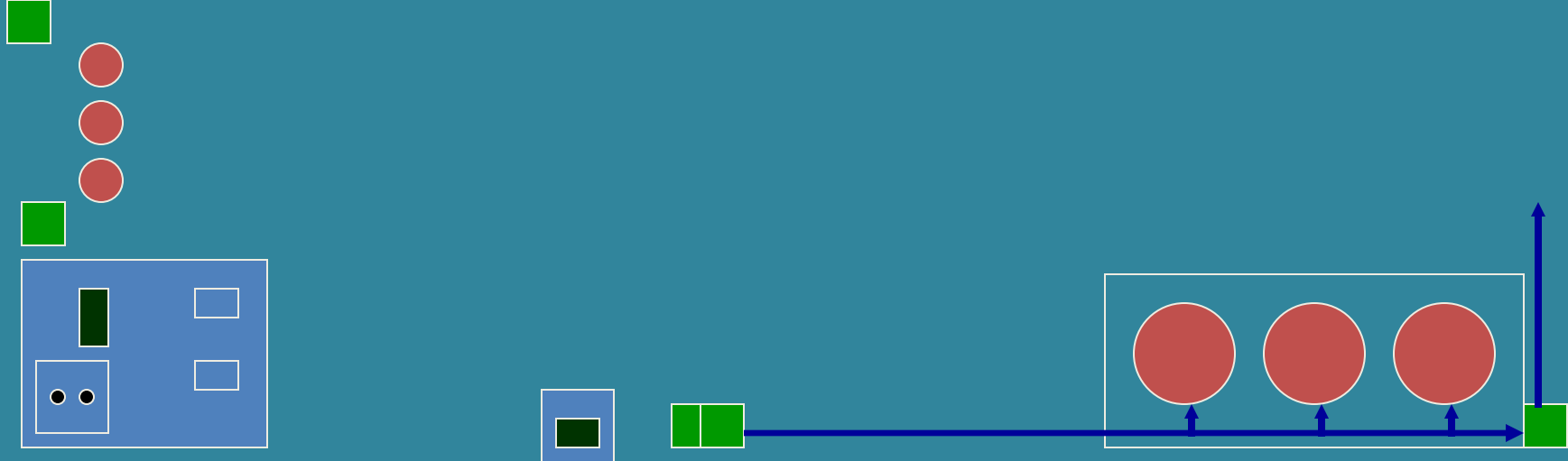
Recirculation box

- After construction, the facility witnessed a 27% loss of artesian well water. In 2011, this recirculation box was constructed.
- Allows staff to build up and manage flows for the secondary side of the facility
- Water velocities increased in tanks allowing for ideal tank operation
- Reuse water can be managed for almost endless uses









Treated H₂O

Reuse

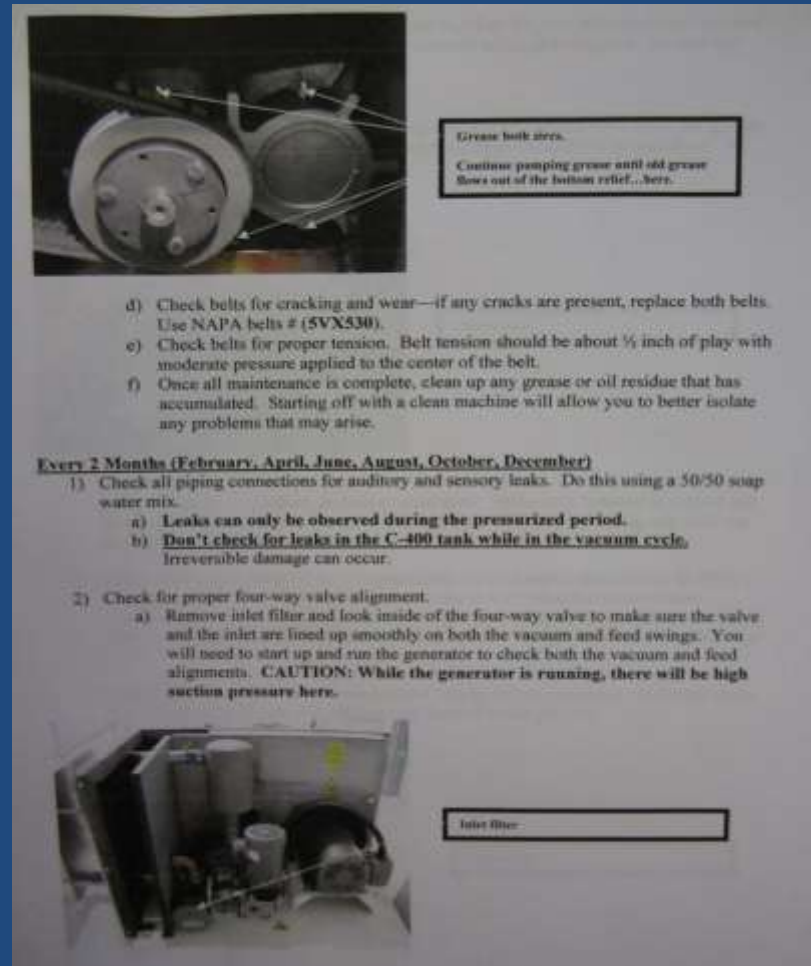
Routine System Maintenance

- All equipment is routinely maintained to ensure its correct operation
- A checklists of duties with daily, weekly and monthly schedules are kept up
- All employees are trained on correct routine and preventive maintenance procedures



Equipment Failure and Troubleshooting Procedures

- An extensive and very detailed operations manual has been developed to assist in this process.
- Staff are properly trained in the replacement of necessary equipment.
- Extra parts are purchased and kept on hand as much as possible.
- A few examples of our equipment: Fibrotex, oxygen generators, VFD, PLC, UV system, blowers



Production Challenges and Solutions...

- Rearing multiple fish stocks
- Water Supply
- Egg and Fish Production Planning
- Fish Health and Bio-security
- Monitoring of treatment processes

Rearing Multiple Fish Stocks

- Challenge:
 - Ten fish stocks are reared which include: Yellowstone, Snake River, Bear River and Colorado River Cutthroats, Fall, Fire Hole and Eagle Lake Rainbows, Brook Trout, Brown Trout and Arctic Grayling.
 - These stocks are reared for various stocking sizes and release times throughout the year. Many of which are restoration stocks that require specific or unique rearing techniques
- Our Solution:
 - Experience, observation skills, thinking outside of the box, detailed notes and planning.



Water Supply

- Challenge:
 - The limited amount of fresh water available
 - Water chemistry issues such as extreme water hardness
 - Above optimal rearing temperatures
 - 90% of the circular rearing tanks are supplied with 60 to 67 F (15.5 to 19.5 C) water temperature year round.
- Our Solutions:
 - Rely on a partial recirculation system
 - Minimize other stressors to fish and keep up on removing hard water build up on everything.
 - Try to focus on using elevated rearing temperatures on stocks more tolerant and when possible use the temperature to our advantage.
 - Examples:
 - Minimizing Bacterial Cold-Water Disease outbreaks
 - Obtaining growth rates as high as 0.055 delta L

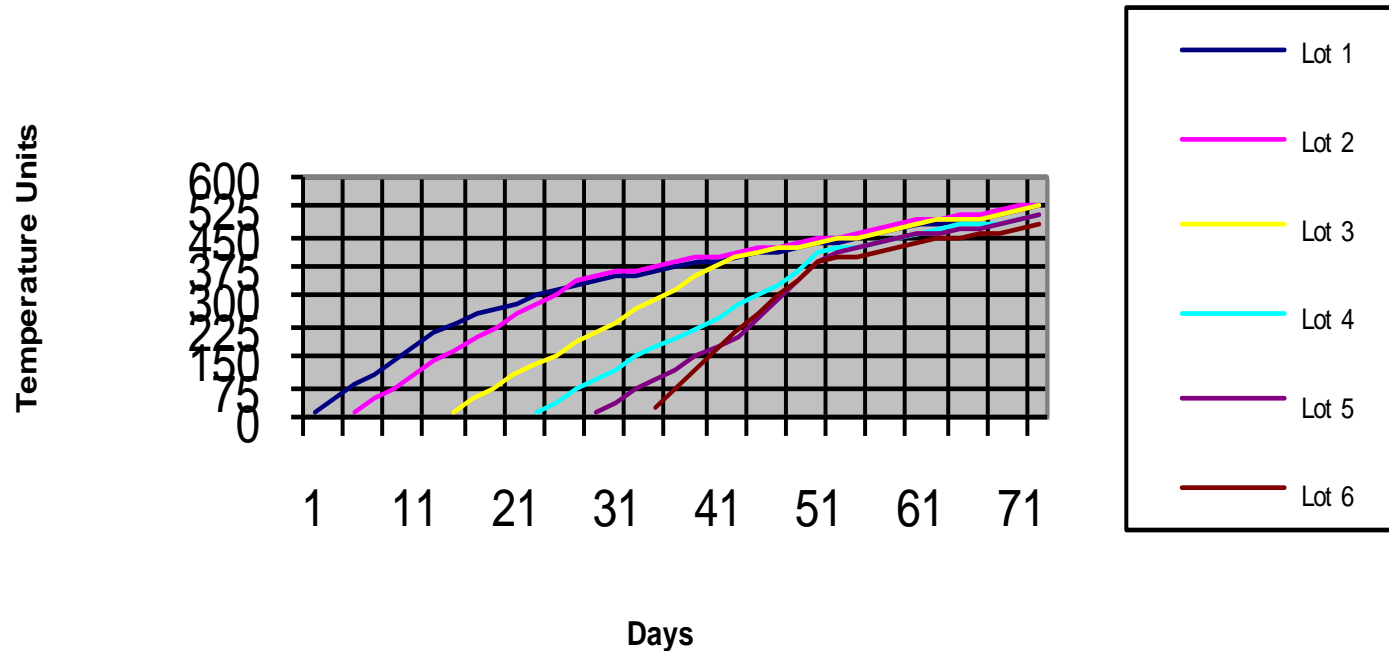
Egg Planning

- Challenge:
 - Incubate up to 5.2 million eggs from green to eyed egg from various stocks
 - Incubation water is limiting.
 - Space is also limiting so water temperature manipulation is critical for combining many takes of fish.
- Our Solutions:
 - Utilize drip incubators that can incubate 500,000 eggs on 5 gpm
 - Water temperature manipulation is used for combining many spawning takes. The use of a chiller and the two water sources gives us the ability to utilize incubation water temperature ranging from 39 to 65 F (4 to 18.3 C)
 - This allows us to achieve target size and timing objectives throughout the year.



Manipulation of Egg Development

Manipulation of Egg Development with Water Temperature



Fish Production Planning

- Challenges:
 - Producing catchables in both spring and fall while still achieving target goals for restoration plants.
 - Maximizing the capacity of the facility while rearing a diversity of fish stocks.
- Our Solutions:
 - Our production programs are set-up based on growth rates, carrying capacities, water temperatures, optimal density and flow indexes and particular feeding regimes.
 - Production mapping done in advance using maximum density index and flow index parameters.
 - Every week fish are sampled, feed calculated and the production is updated.

	B	C	D	E	F	G	H	I	J	K	L
Enter Value	Enter Value	Enter Value									
od E- 3	1257	1013GRL01									
	Starting Population										
ING	11,067					END	END	FEED/	%	%	# DAYS
E	POPULATION	LOSS	FPP	LBS	C	FPP	LBS	DAY	FED/DAY	FED/WK	FED
2/25/2010	11067	2	2495.0	4	0.7	1919	6	0.13	3.00%	3.00%	
9/1/2010	11064	3	2343	5	0.7	1736	6	0.17	3.50%	3.50%	
4/8/2010	11009	55	1796	6	0.7	1330	8	0.21	3.50%	3.50%	
1/15/2010	10939	70	1093	10	0.7	810	14	0.35	3.50%	3.50%	
1/22/2010	10881	58	931	12	0.7	690	16	0.41	3.50%	3.50%	
1/29/2010	10841	40	679	16	0.7	512	21	0.52	3.25%	3.25%	
0/6/2010	10816	25	548	20	0.8	427	25	0.64	3.25%	3.25%	
1/13/2010	10807	9	479	23	0.9	382	28	0.73	3.25%	3.25%	
1/20/2010	10802	5	382	28	0.9	305	35	0.92	3.25%	3.25%	
1/27/2010	10787	15	319	34	0.9	255	42	1.10	3.25%	3.25%	
1/3/2010	10751	36	255	42	0.9	203	53	1.37	3.25%	3.25%	
1/10/2010	10713	38	245	44	0.9	199	54	1.31	3.00%	3.00%	
1/17/2010	10679	34	199	54	0.9	161	66	1.61	3.00%	3.00%	
2/4/2010	10626	53	140	76	0.9	114	94	2.28	3.00%	3.00%	
2/1/2010	10626	0	101	105	0.9	82	129	3.15	3.00%	3.00%	
2/8/2010	10606	20	82	129	0.9	69	154	3.2	2.50%	2.50%	
1/15/2010	10596	10	55	193	0.9	47	224	4.0	2.10%	2.10%	
1/22/2010	10582	14	47	224	0.9	41	256	4.1	1.85%	1.85%	
1/29/2010	10571	11	44	240	0.9	38	275	4.4	1.85%	1.85%	
1/5/2011	10562	9	38	275	0.9	34	314	5.1	1.85%	1.85%	
1/12/2011	10560	2	30	352	0.9	26	399	6.0	1.70%	1.70%	
1/19/2011	10550	10	26	398	0.9	23	451	6.8	1.70%	1.70%	
1/26/2011	10544	6	23	462	0.9	20	520	7.4	1.60%	1.60%	
2/2/2011	10536	8	20	520	0.9	18	580	7.8	1.50%	1.50%	
2/9/2011	10531	5	18	580	0.9	17	625	5.8	1.00%	1.00%	
2/16/2011	10529	2	17	625	0.9	15	688	8.1	1.30%	1.30%	
2/23/2011	10527	2	16	653	0.9	15	717	8.2	1.25%	1.25%	
3/2/2011	10524	3	17	623	0.9	15	683	8	1.25%	1.25%	
3/9/2011	10520	4	15	683	0.9	14	749	9	1.25%	1.25%	
3/16/2011	10517	3	14	749	0.9	13	825	10	1.30%	1.30%	
3/23/2011	10513	4	11.4	922	0.9	10	1015	12	1.30%	1.30%	
3/30/2011	10507	6	10.5	1001	1	10	1092	13	1.30%	1.30%	
4/6/2011	10502	5	9.6	1091	1	9	1187	14	1.25%	1.25%	

Fish Health / Bio-security

- Challenges:
 - Keeping the fish as healthy as possible while providing effective Bio-security at the facility.
- Our Solutions for Fish Health:
 - Production levels in tanks are managed throughout the year by keeping density indexes under 0.25 and flow indexes under 0.99.
 - Monitor pounds fed per tank per gpm of inflow
 - Measure all flows in rearing units at least weekly
 - Pick mortality at least twice a day (more often if a disease persists)
 - Pull center drain sumps twice a day to ensure waste flushing
 - Only treat fish with antibiotics when absolutely necessary
 - Handling fish
 - Keep fish in 0.5 to 1.0% salt concentrations when fish are handled, split and hauled.
 - Keep fish off feed for 1-3 days prior to handling depending on size
 - Add oxygen stones to tanks where handling occurs
 - Keep net loads light and keep fish from being overcrowded

Fish Health/ Bio-security cont.

- Our Solutions for Bio-security:
 - Virkon filled foot baths in place in entrances to incubator and hatchery buildings
 - Signage in place throughout the facility to inform visitors of dangers.
 - All incoming egg shipments are disinfected with PVP iodine at recommended rates
 - Eggs are disease certified before going into the hatchery building
 - After tanks are emptied they are pressure washed, treated with Virkon and allowed to air dry
 - Each trough and tank have separate brushes and nets
 - All equipment and gear is disinfected with Virkon between and after uses
 - Hand sanitizer used throughout facility

Monitoring of Treatment Processes

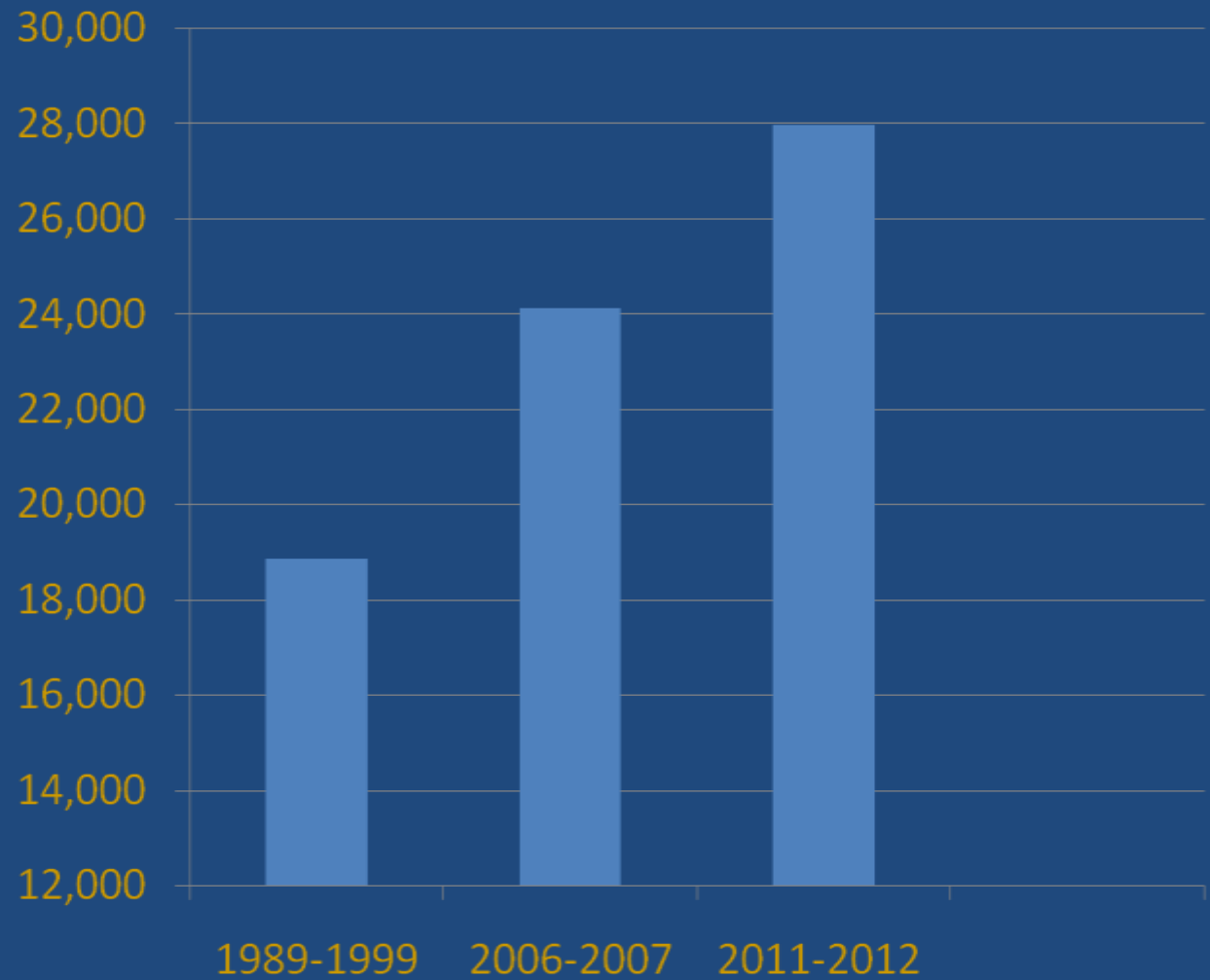
- Challenges:
 - Monitoring takes more time than the actual feeding and cleaning of the fish.
 - Consistently monitor that all phases of the system are operating correctly.
 - This includes: extensive gas monitoring, recirculation flow management, settleable and suspended solids discharge.
- Our Solutions:
 - Make monitoring an essential priority
 - Keep measuring and monitoring equipment in excellent working condition.



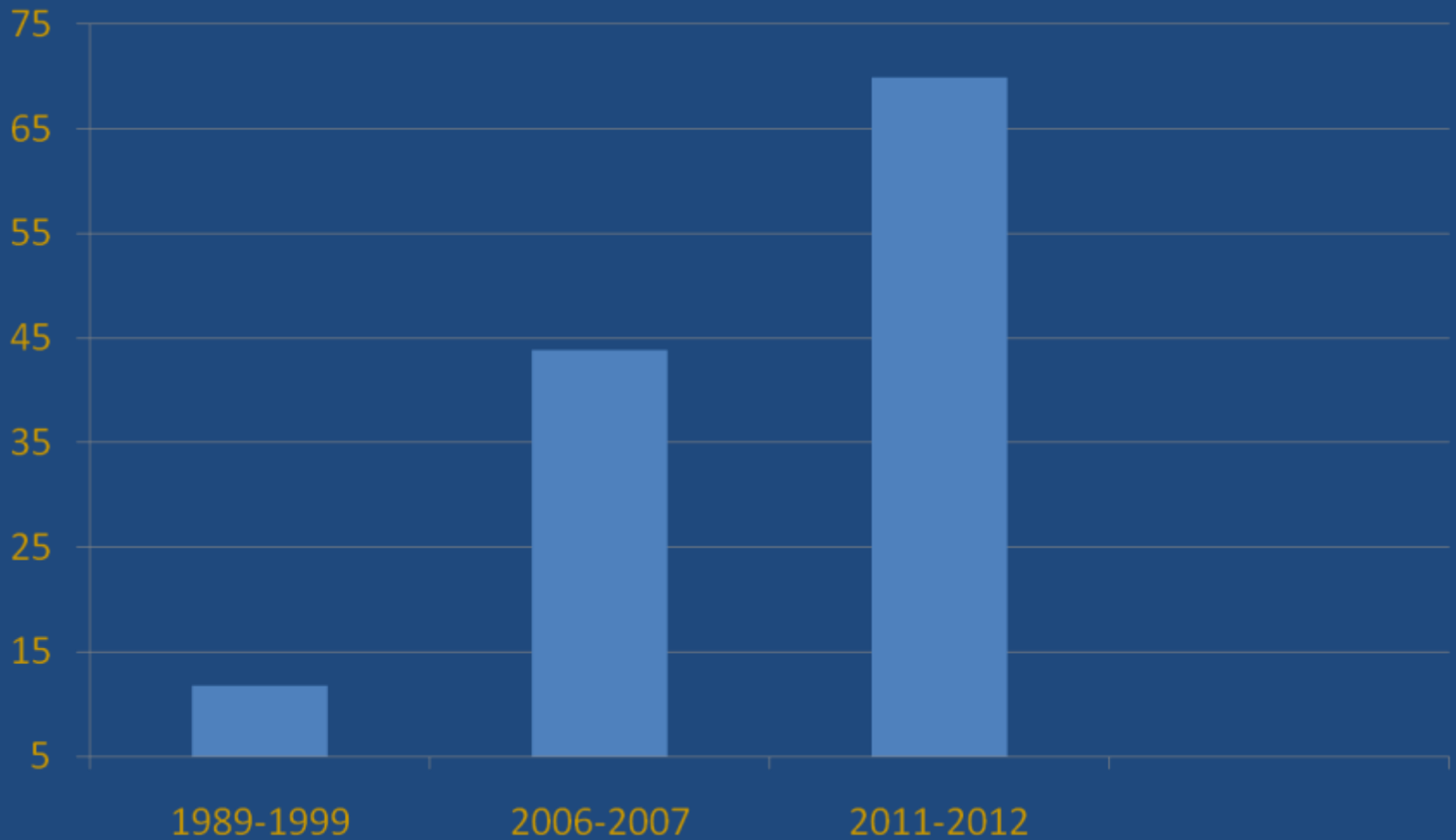
How are we doing????

- Pre-construction production 1989-1999
 - 18,850 pounds on 1600 gpm (6,057 liters) of inflow
- Post-construction production 2006-2007
 - 24,125 pounds on 550 gpm (2,082 liters) of inflow
- Present day production 2011-2012
 - 27,959 pounds on 400 gpm (1,514 liters) of inflow

Pounds of Fish



Pounds Produced per GPM of Fresh Inflow



What this all says....

- With the partial reuse recirculation system this year we will be producing 48% more pounds of fish, 48% more fish and doing all of this on 25% of the original pre-construction flow.
- The water requirements for this facility have been dramatically reduced since construction.
- The degree of uncertainty and the amount of second guessing of what this facility is capable of doing has been significantly reduced.
- Utilization of the closed water sources and strict bio-security measures have kept the facility relatively disease free and as intended Whirling Disease free.

What does the Future Hold???

- We believe that we can increase our total production another 14% from present day levels to around 32,000 pounds. That will equate to 80 pounds produced annually per gallon per minute of inflow.
- Installation of additional RFUV unit to treat the secondary recirculation water to minimize potential disease issues down the road.

Questions ???

