PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2014

Agricultural & Biological ENGINEERING

Design of a Trout Stream

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Problem Statement & Background:

The major goal of this project is to implement a trout stream design plan which will serve as a focal point of the property housing the new headquarters of The Heritage Group. This trout stream will be used for fishing and aesthetics next to the office building. The main constraint on this system is the necessity of 55^{o}F water during all months of the year.

The main societal impact of this project is the ability for the use of this design as a model for future geothermal, recirculating streams. This design compiles characteristics of natural and man-made streams and ponds on a scale that has not been done before.

Design Components:

Water Temperature Requirements

The principles of ground source heat pumps were used to maintain the water temperature required in the stream (see Trout Species table). As depths of 20 ft. or greater are approached, the ambient soil temperature begins to equilibrate to 55° F. The length required to obtain optimum water temperature from the water being discharged into the stream was determined utilizing the heat transfer coefficient equation.

Heat Transfer Coefficient Equation

$$Q = U * A * \Delta T_m$$

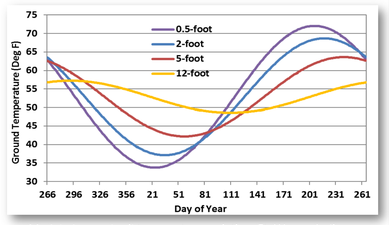
Where:

Q= Heat transfer rate [W]

U= Heat transfer coefficient [W/m^2*C]

A= Area of pipe [m^2]

ΔT_m=Log mean temperature [°C]



Modeled annual soil temperature variation, Ft. Wayne, Indiana

Required Length of Pipe = 270 ft. using Two 10” pipes

Design Features:

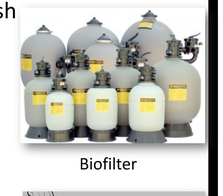
Water Fountain Aerator

Dissolved Oxygen: Dissolved oxygen of 6mg/L levels are needed to keeping trout alive, sustaining growth, maintaining egg health, and supporting aquatic insects. Waterfalls, deflectors, and mechanical aerators are used to keep the optimal levels.

pH: A good pH range is from 6.8-7.8. If the pH drops below 5, just about all species of aquatic life dies, and if the pH become too acidic, the food base decreases significantly. Using limestone throughout the stream helps water remain alkaline and to provide nutrients for plants.

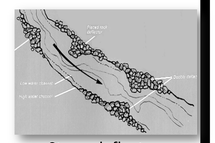
Limestone

Nitrogen Cycle: Decomposing leaves, fish waste, and uneaten food decompose to ammonia, which at high levels is toxic and is thought to be one of the main causes of unexplained losses in fish hatcheries. This ammonia is converted by bacteria to nitrites which is also toxic. In this molecular form, nitrogen cannot be used by most aquatic plants, therefore it must be converted to a usable form or removed. Biological filters or contactors utilize beneficial bacteria to remove these harmful toxins and decaying matter.



Biofilter

Sedimentation: Sediment becomes a problem by covering spawning areas and interfering with the gills on the trout. Deflectors are used to deposit substrate throughout the stream and not only at the bottom pond. A mechanical filter is also used to decrease the sludge and sediment throughout the cycle.

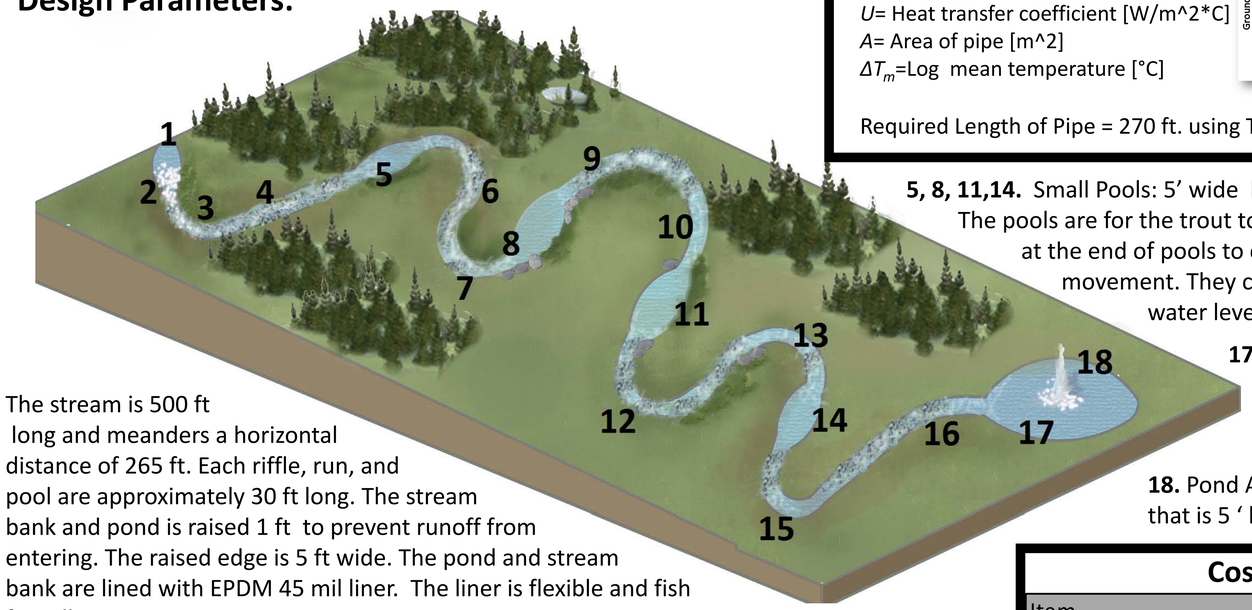


Stone deflectors

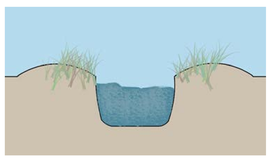
Trout Species:

Species	Minimum Temperature (F)	Maximum Temperature (F)	Optimal Temperatures (F)	Gravel Size (in diameter)	Velocitiy Range (cfs)
Rainbow	32	75	55-60	0.25- 1.5	1.4-2.7
Brown	32	81	54-66	0.25- 1.5	1.3-2.3
Brook	34	72	55-60	0.25 - 1.8	1.4-2.7

Design Parameters:



The stream is 500 ft long and meanders a horizontal distance of 265 ft. Each riffle, run, and pool are approximately 30 ft long. The stream bank and pond is raised 1 ft to prevent runoff from entering. The raised edge is 5 ft wide. The pond and stream bank are lined with EPDM 45 mil liner. The liner is flexible and fish friendly.



Raised Edge

Water Gate

1. Waterfall: 5’ tall by 3’ wide

2. Small Pool: 5’ wide by 4’ deep with a velocity of 0.28 ft/s.

3, 6, 9, 12, 15. Riffles: 3’ wide by 1.5’ deep with a velocity of 1.24 ft/s. Riffles help maintain optimal oxygen levels. The stream bank will be lined with large stone, rip-rap, to prevent erosion in the higher velocity areas.

4, 7, 10, 13, 16. Runs: 4’ wide by 2’ deep and a velocity of 0.7 ft/s. There will be 2 or 3 deflectors evenly spaced throughout each run. This will keep a meandering flow and also create resting spots as well as deposit substrate.

5, 8, 11,14. Small Pools: 5’ wide by 5’ deep and a velocity of 0.22 ft/s. The pools are for the trout to rest and feed. Water gates are used at the end of pools to control water levels and trout movement. They can be used to correct velocities as water levels may change.

17. Pond: 60’ diameter pond with trapezoidal shape where 2/3 of the diameter has a constant 12’ depth.

18. Pond Aerator: 15’ diameter water spray that is 5 ‘ high at the center.

Cost Estimate:

Item	Unit Cost	Cost
Pump	$13,700	$27,400
Trout (fish)	$3.15	$2,000.00
Biofilter	$3,695.00	$7,400.00
10“ PVC Pipe	$23.85/foot	$14,310.00
Liners & Underlayment	$10,332.90	$10,332.00
Fountain Aerator	$1,060.65	$1,060.65
Small Pond Aerators	$79.99	$319.96
Pond Bottom Grate	$89.95	$89.95
Automatic Fish Feeder	$269.00	$269.00
Trout Pellet Food	$30.00 per 7lb bag	$160.00/month
Dissolved Oxygen Meter	$328.00	$328.00
Master Liquid Kit	$34.00	$34.00

Design Alternatives:

- Cool the stream mechanically in order to ensure that the trout could survive during every season. This alternative was not chosen, because of the increased costs it created.
- One pipe system rather than a two pipe system. This alternative created more difficulty in maintaining water temperature, so it was not used.
- Species of trout was also debated during the project, and the conclusion was that three species of trout would be provided as alternatives depending on available supplies.
- Two separate physical designs were originally created, and the one which will be used is the one which better suits the area and the size constraints given by the sponsor.

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Course Instructors: Dr. Robert Stwalley & Dr. Bernard Engel
Project Sponsor: The Heritage Group

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