Construction Considerations and Design Specifications for a Flowing Water Spawning System for the Culture of River Minnows: Part 1

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The need for an alternative to the current wild harvest of river minnows for the bait industry is evident due to new regulations concerning invasive species. The Hornyhead Chub (Redtail Chub) *Nocomis biguttatus* (Kirtland), the Creek Chub, *Semotilus atromaculatus* (Mitchill) and the Common Shiner, *Luxilus cornutus* (Mitchill) used for fishing bait in Minnesota are supplied almost entirely by wild harvest, with only a small amount being cultured. Currently there are very few harvesters in the bait industry with quarantine facilities capable of continued harvest after the first VHS infestation is found. The recorded presence of even one of these invasive species in the Crow Wing River in central Minnesota will effectively cripple the Redtail Chub harvest overnight. Eliminating harvest to sale transport. As much as 80% of the Redtail Chubs harvested each year come from the Crow Wing watershed. The presence of even Zebra Mussel if found in the Crow Wing River could halt all summer harvest and depending on the extent of contamination eliminate all harvest altogether as it has on the Pine and Mississippi Rivers in Crow Wing County, Minnesota. And the likelihood is high even by optimistic projections that there will be a contamination within the near future somewhere else in Minnesota.

The Riverine Spawning system designed and operated since 1998 by Barry Thoele has successfully spawned several river species and consistently produced over 100 gallons of Hornyhead Chubs annually from a single system. The benefits of this type of system combined with the ability to quarantine a pond or the entire system in the event of contamination are needed for the health and survival of the bait industry. With the looming threat of invasive species this system could help further eliminate the risk of exposure or transport of invasive species by the bait industry. This system has shown great promise for the culture of these species and could help provide a smooth transition to culture for the wild bait industry.

The system can be constructed on an acre of land and consists of a racetrack type spawning system 1 meter deep shaped as an oval that is connected to two small grow-out ponds by standpipes that maintain a constant water level within the raceway. Appropriate sized gravel is added as a spawning material for the species to be cultured. The purpose of the system is to duplicate the conditions necessary to facilitate natural spawning. Water is moved by means of a one horsepower 1725 rpm motor connected by V-belt and pulleys to a 25:1 gear reducer connected to a 24" diameter paddle wheel. This slows the speed of the paddle wheel to 58 rpm, which has been found to create a consistent current flow throughout the raceway at appropriate speed for the aforementioned species.

Parallel research (Wisenden et al., unpublished works 2009) has documented flow rates along with sizes, and quantities of gravel necessary for spawning Hornyhead Chub furthering the knowledge base and supporting the systems design. The entire cost of construction for the raceway and two grow out ponds including land can be less than $10,000.00 USD.

Considerations

Construction of this type of system can be made either on high ground or on the verge of a Type 1 or 2 wetland. A low slope could reduce some construction costs as a gravity-feed standpipe from raceway to grow-out pond has proven the best design for maintaining consistent water levels and tempera-

ture in the raceway. Land costs can be prohibitive in high ground areas that are currently used in agriculture. Available water can be deep in this land type, which can increase pumping costs. Well water must be allowed to warm before being added to the raceway or ponds to avoid interfering with the spawning cycle of the minnow. Soil types must also be considered since overly rocky soils could increase excavation costs, and a large boulder could halt construction altogether. The presence of rock could also be a problem if the spoils are to be sold as fill to offset the cost of construction. Water tables can vary greatly in this type of land so soil bores should be conducted to determine the depth of the water table and the soil types. Consideration must be given to the water types and chemistry common to the area. Water that is too acidic or too alkaline could be adjusted in a high ground pond, but could prove too great a problem in a wetland system. Much of the out-washed plain of marshlands and moraine type of topography of the northern and central Minnesota would fall in the type of terrain necessary for a successful bait fish culture. The following are considerations for the selection of suitable land for construction for this type of aquaculture.

I.   Jurisdiction:
     Jurisdiction is determined by whether the wetland is isolated by elevated ground or whether it is connected to a county ditch or stream. If a wetland is not isolated it is considered Connected Waters and the US Army Corps of Engineers claims jurisdiction over all wetlands that connect to Federally regulated waters. (this can be very loosely determined in some jurisdictions).
     A.   Minnesota (2008) Wetland laws require excavations not to exceed 2m in water depth and may require removal of most spoils from the excavation site. There is an exemption for Aquaculture written into the law however the exemption is not defined.
     B.   Army Corps of Engineers (2008) requires a 1 to 1 mitigation (replacement) of excavation which makes construction costs nearly prohibitive in these types of wetlands.
II. Available water
     A.   Well depth and pumping costs.
     B.   Wetland type and water chemistry.
III. Soils
     A.   Heavy or rocky soils could increase construction and excavation.
     B.   Sand and/or gravel could be sold to offset the costs of excavation.

IV. Land Cost
     A.   Productive crop land can exceed $10,000.00 per acre and would prove cost prohibitive.
     B.   Land cost of $2000.00 per acre through the out-washed plain of Central Minnesota provides the best cost of construction with the best combination of water and soils.

Construction
Type 1 or 2 Wetland

A timetable for construction should begin in late July or early August with pond excavation. This is generally the time of year when water tables are the lowest. This will allow time for liner installation for ponds in high ground and well installation. Ponds can be dug 10m wide by 40m long to a depth of 3m. This will allow for the future addition of greenhouse domes to extend the growing season in northern climes and allow for the use of ponds over winter. Excavation costs should not exceed $3000.00 for the grow-out ponds if spoils are used to regrade and form the berm around the ponds and raceway.

Raceway size can vary to some extent but the author has found that bigger does not mean better. Several small raceways will out-produce and be more adaptable and cost effec-
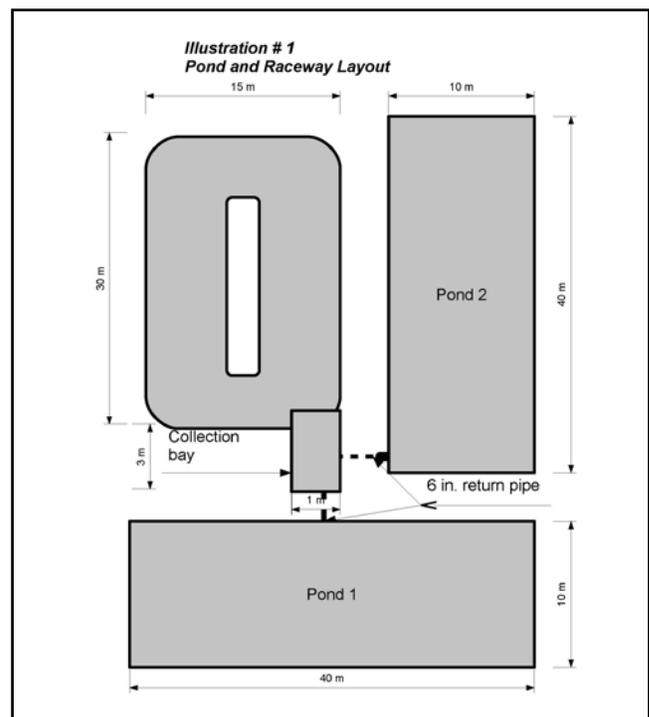
Illustration #1A.
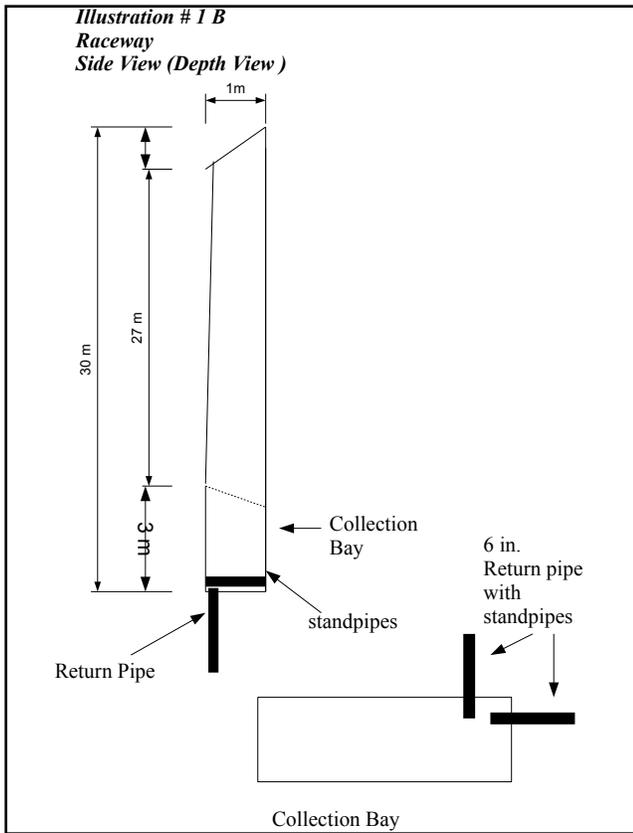Pond and Raceway Layout.

Illustration #1B.
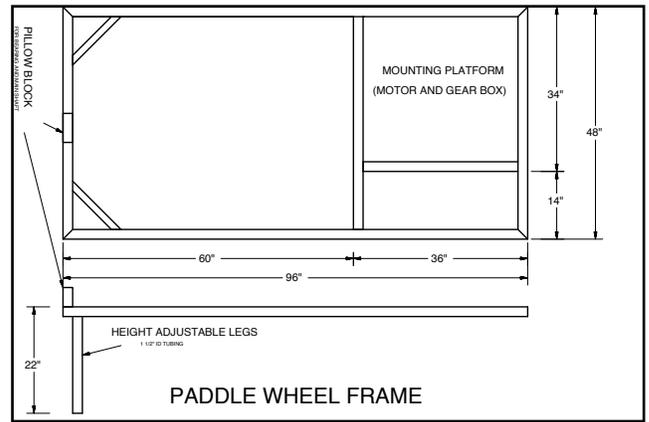Raceway Side View (Depth View).

Illustration #2A.
Paddle Wheel Frame.

A 1m wide by 1m deep by 3m long collection basin is attached to the raceway at the nexus of the ponds. A 15cm (6 in) PVC pipe is buried with a seep collar from the collection basin to each pond. This allows for multiple species spawning and diversion of overflow water to the grow-out ponds. Water is pumped continually from one grow-out pond into the raceway and returns to the pond through the stand pipe. The second standpipe is capped until the next spawning. This allows the fry to be washed out into the grow-out pond continually throughout the spawning cycle removing them from predation by brood stock. Multiple species or multiple spawns can be accomplished with the varied and extended spawning cycles of river minnows.

Paddle Wheel
Illustrations #2A, B, & C

Several different methods of moving water were tested including pumps, agitators, airlifts, and paddle wheels. However, with the river species' propensities for swimming into current, the only method that didn't result in significant brood stock or fry mortalities was the paddle wheel. The most economical unit to operate is powered by a one horsepower 1725 rpm electric motor wired for 220 volts connected by V-belt to a 25:1 gear reduction drive with a 58 rpm output speed. The V-belt and pulley act as a shock absorber when starting the paddle wheel in water. Shear forces can be high enough to twist drive shafts and is also the reason for the size of motor and gear reducer. Varying the sizes of the pulleys on the motor and gear reduction can also vary the paddle wheel speed up or down. This is coupled directly to a 1 and 1/8 in. OD steel drive shaft that is supported on each end by a sealed bearing and pillow block attached to the frame. The paddle wheel is built with ¼ in. steel ends with a 1 and 3/8 in. ID hollow center shaft so as to slide onto the drive shaft. The

tive than a single large system. Utility costs are lower and less mechanical problems were experienced over larger systems. With several small systems a single failure of a water pump or paddle wheel will not result in a total loss of eggs.

An oval 25m long by 20m wide by 1m deep with a 1m wide by 3m long collection bay at the "L" between the grow out ponds (see Illustrations #1A & B). The oval channel is approximately 9m wide by 1m deep with a slight grade toward the ponds and the collection bay. An island is built and packed through the center of the raceway. A 45mil. (Firestone) EPDM or similar poly liner is used to maintain integrity. Seams should be sealed and edges weighted. Gravel is spread evenly across the bottom of raceway to a depth of 30cm to allow for adequate gravel for nest building. Rocks or cement blocks are stationed throughout the raceway to create breaks in the current and to provide resting areas for females that are between spawning cycles. Selecting patterns consistent with natural habitat can increase production and reduce competition for spawning materials and suitable spawning area by creating changes in the flow of current (see Illustrations #3 and #4).
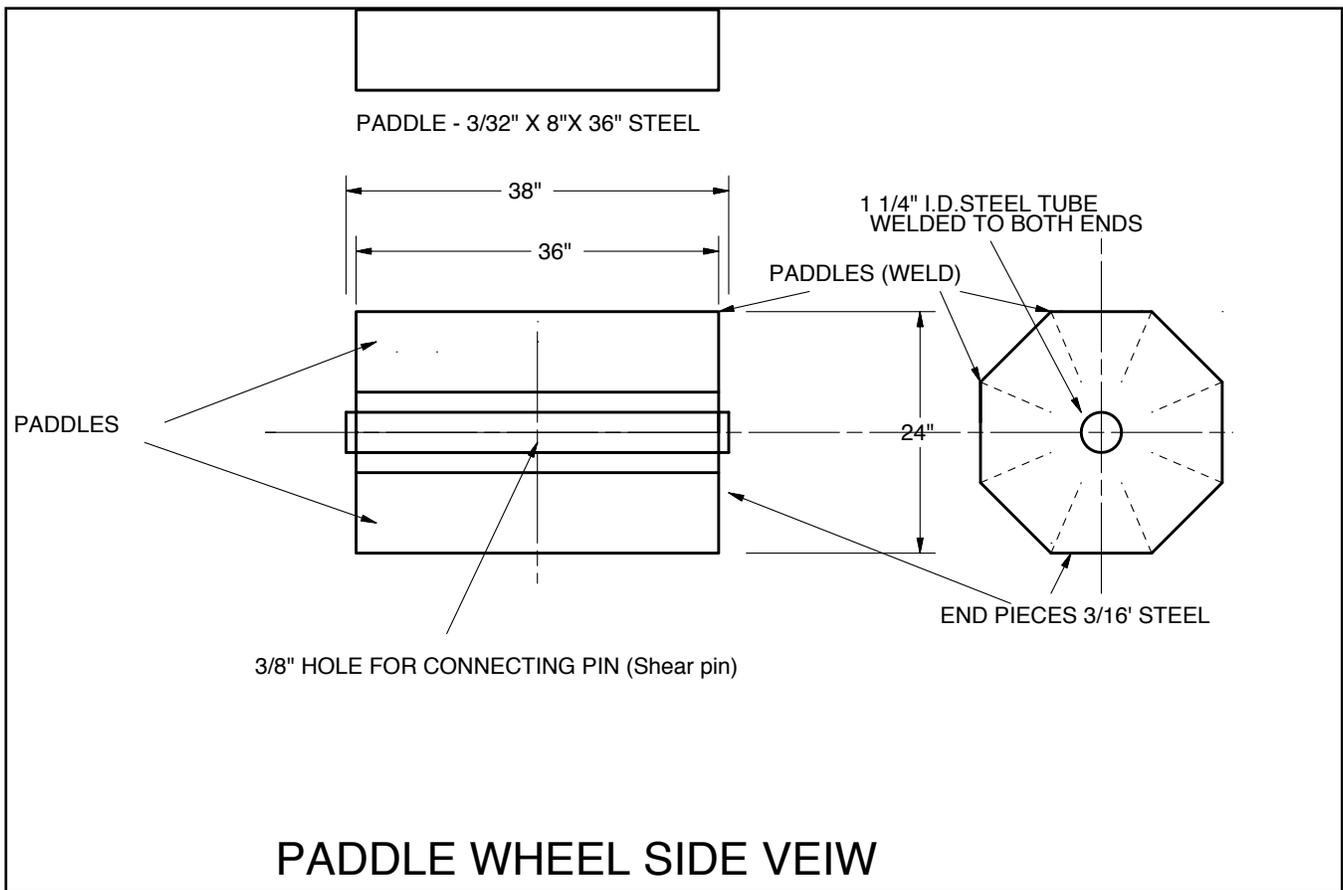
PADDLE - 3/32" X 8"X 36" STEEL

38"

36"

1 1/4" I.D.STEEL TUBE
WELDED TO BOTH ENDS

PADDLES (WELD)

PADDLES

24"

END PIECES 3/16' STEEL

3/8" HOLE FOR CONNECTING PIN (Shear pin)
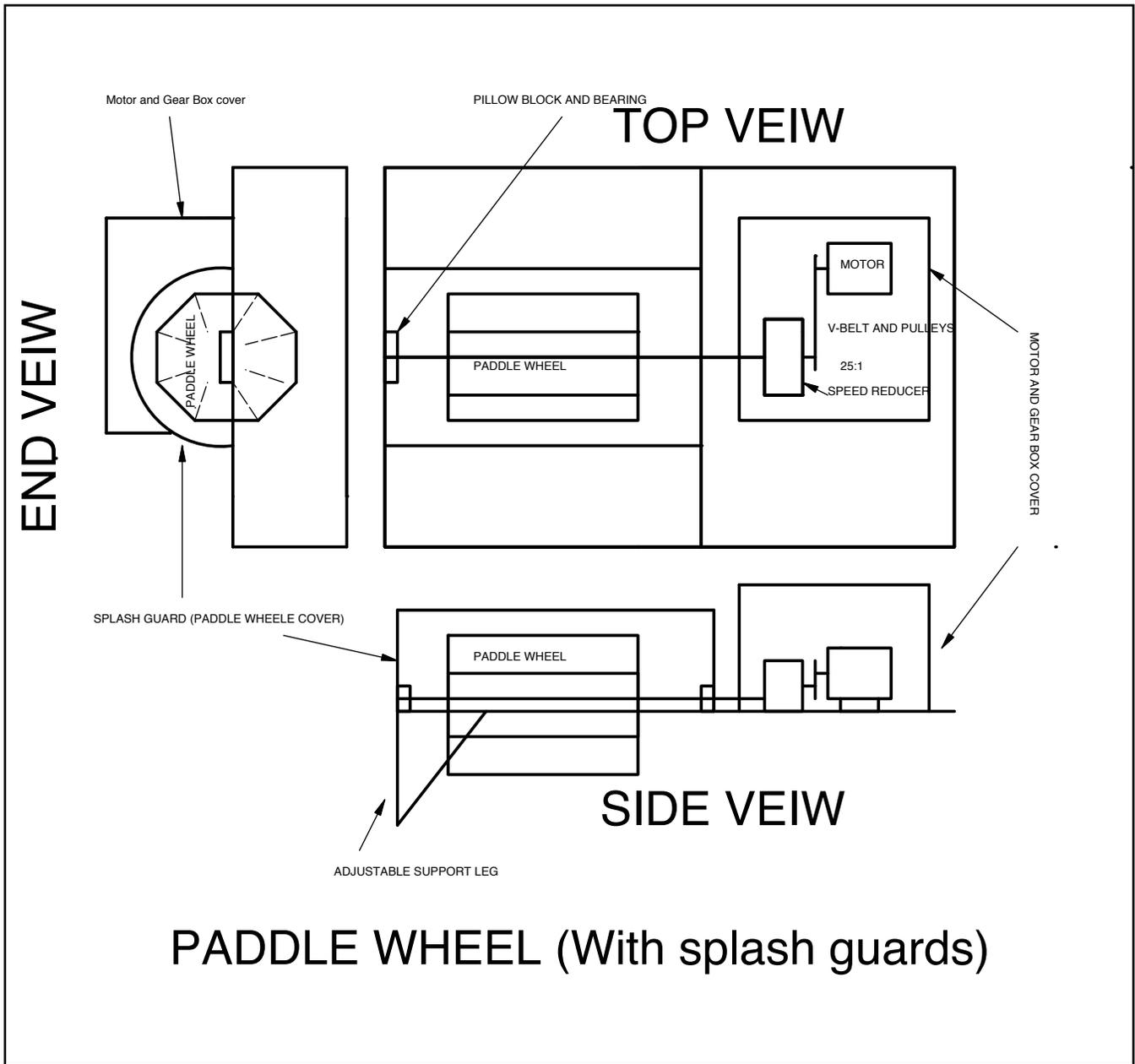
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PADDLE WHEEL SIDE VEIW

Illustration #2B.
Paddle Wheel Side View.

paddle wheel is connected to the shaft by a 3/8 in. hardened steel bolt drilled through both shafts. This will act as a shear pin in the event of unforeseen obstruction rather than shearing the shaft or damaging the paddle wheel or gear reducer. The best designed paddle wheel constructed to date has been 24 in. diameter by 30 in wide with eight paddles that are six inches deep. The width can be varied for larger raceways but shear forces on the drive shaft should be considered. Large diameter paddle wheels have been constructed but the torque required to operate the larger size would require a larger motor and drive shaft also. Attempts at reducing utility costs by reducing the size of the paddle wheel drive motor have been made with poor results. Motor failure can be an expensive lesson. The minimum one horsepower motor is recommended for operation to prevent overheating the motor. If the paddle wheel should stop during the spawning cycle there is only a short time to restart water flow to prevent significant mortalities of the eggs in the nest or interruption of the spawn-

ing cycle.

The frame is constructed of square stock steel welded at the corners with angle supports at each corner to eliminate flexing. A support pad for motor installation should be welded on the shoreline side of the frame. Adjustable feet are welded and supported on the end opposite the motor pad. This will support the paddle wheel in the raceway and allow for some adjustment in height and leveling after installation and for matching the unit to the water level. A splash guard over the paddle wheel and a weather cover for the motor and gear reducer are recommended for safety purposes. Since the paddle wheel is only necessary during the spawn in order to generate current flow. It operates for four months, May through August, and can be shut down the remainder of the year.

This paddle wheel design was first constructed in 2000 and has run for eight years with minimal maintenance. Bearing replacement is required every three years for the

Motor and Gear Box cover

PILLOW BLOCK AND BEARING

TOP VEIW

END VEIW

PADDLE WHEEL

MOTOR

V-BELT AND PULLEYS

25:1

SPEED REDUCER

PADDLE WHEEL

MOTOR AND GEAR BOX COVER

SPLASH GUARD (PADDLE WHEELE COVER)

PADDLE WHEEL

SIDE VEIW

ADJUSTABLE SUPPORT LEG

PADDLE WHEEL (With splash guards)

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Illustration #2C.
Paddle Wheel (with splash guards)

shaft bearings due to water exposure. Single phase electric motors last approximately four years with a service factor of 1.15. The total electric usage for this unit when wired for 220 volts @ eight amps at full load or about 1600 watts at start up, but will decline as water speed reaches its peak less than $40.00 per month. The total electric usage of the drive motor and ¾ horse water pump system should be approximately $800.00 annually. This figure includes aeration throughout the winter months for the grow-out ponds. Construction costs for paddle wheel and frame assembly should be less than $1500.00 total with adjustable support legs.