Auburn University and USDA-Natural Resources Conservation Service

Alabama Aquaculture Best Management Practice (BMP)

Managing Ponds for Inland Culture of Marine Shrimp

BMP No. 16

Definition

Pacific white shrimp, Litopenaeus vannamei, (and possibly other varieties in the future) are cultured in Alabama in inland ponds filled with well water from saline aquifers. The water varies from 2 to 10 parts per thousand (ppt) salinity. Water is diluted by rainfall and runoff, but most ponds contain 2 ppt salinity or more and have over 1,000 ppm chlorides. Saline waters obtained from wells in Alabama usually are low in potassium and magnesium (see Table 1), and shrimp are stressed by deficiencies of these two ions. Mineral salts, potassium chloride and potassium magnesium sulfate, are applied during the growing session to correct this imbalance.

Table 1. Typical analysis of saline ground water for use in culture of marine shrimp in inland ponds in Alabama.

Salinity	3.88 ppt	Calcium	86 ppm
Bicarbonate	105 ppm	Magnesium	21 ppm
Chloride	2,274 ppm	Potassium	8 ppm
Sulfate	2 ppm	Sodium	1,393 ppm

Post-larval shrimp obtained from commercial shrimp hatcheries in Florida, Texas, and other coastal locations are stocked in late spring when the ambient temperature rises to 70^{o}F or more. Shrimp are fed a commercial diet, and they grow to a marketable size for harvest in late September or early October before the ambient temperatures drops below 60^{o}F. The ponds are aerated with floating, electric aerators. Water exchange, often used in coastal shrimp ponds, is not utilized. Minor to moderate amounts of water can seep from ponds, moderate to significant amounts of overflow can occur after rains, and ponds usually are drained for harvest. Shrimp harvesting pumps and practices used on some farms have the potential to discharge pond water. Ponds discharge into freshwater streams and shallow, freshwater aquifers. Inland shrimp pond water has a chloride concentration greater than the Environmental Protection Agency (EPA) recommended instream water quality criteria of 230 ppm (see Figure 1 for chloride discharge requirements) used by the Alabama Department of Environmental Management (ADEM).

Explanation

There are several potential environmental impacts from inland facilities culturing marine shrimp. Discharge from ponds following heavy rains and water released when ponds are drained for harvest may contain elevated concentrations of nutrients, organic matter, and total suspended solids. Thus, pond effluents can potentially cause eutrophication, organic enrichment, and other impacts to streams or other water bodies.

Pond discharge, including seepage, also is undesirable because saline water can cause soil and water salinization. Of significant concern is the potential for temporary salinization of surface water by farm effluents. Moreover, saline pond water, through filtration, can potentially contaminate shallow, freshwater aquifers or seep laterally through embankments to cause localized soil salinization. Pond sediment has an elevated salt burden from contact with saline water. Improper management or disposal of this sediment also could cause soil and water salinization as a result of leaching of salts by rainfall and runoff. Sediment removed from ponds should be disposed and/or managed responsibly according to NRCS technical standards and guidelines.

Operating inland shrimp ponds

Practices

All operations should adopt applicable practices from Aquaculture Best Management Practice (BMP) Nos. 1-15. Implementation of these practices will reduce principal spillway flow from ponds, prevent excessive feeding, and maximize the capability of ponds to assimilate wastes. These practices also will assure that other farm operations are conducted in a responsible manner. Nevertheless, some additional practices should be applied at inland shrimp farms for further protection against soil and water salinization as follows:

- *Management plans should be prepared by and practices implemented with the assistance of a professional engineer (PE) licensed in the State of Alabama or other qualified credentialed professional (QCP). Periodic inspections of the operation also should be conducted by a PE or QCP.*

- *Ponds should not be constructed in areas with sandy or rocky soil where high rates of infiltration are likely.*

- *Construction techniques should include features to prevent lateral and downward seepage.*

- *Ponds should be operated to prevent, or minimize to the maximum extent possible, principal spillway pipe flow following heavy rainfall.*

- *When a pond is drained for harvest, water should be stored in a reservoir or other ponds and reused in the next crop to prevent discharges to State waters.*

- *Discharges from shrimp harvesting pumps should not be released into streams in volumes that have the potential to cause or contribute to an exceedance of the EPA recommended instream criteria for chlorides.*

- *Streams below farms should be, and if significant discharges occur are required to be, monitored for compliance with the EPA instream criteria for chlorides.*

Shrimp aquaculture operations that qualify as concentrated aquatic animal production (CAAP) facilities must comply with EPA effluent limitation guidelines, applicable NRCS technical standards and guidelines, and if required, ADEM NPDES permitting requirements.

Implementation notes

Practices from BMP Nos. 1-15 will lessen the potential for soil and water salinization by inland shrimp farming. For further protection, inland shrimp ponds should only be located where soils resist seepage, or clay or plastic liners should be installed to reduce seepage. Embankments should be designed and constructed with a cutoff trench to minimize seepage beneath embankments. The principal spillway barrel pipes should have anti-seep collars to avoid seepage along pipes.

To avoid principal spillway flow after rains, water levels should be allowed to decline through evaporation and seepage until 2 ft below the tops of the riser pipe. Ponds should not be intentionally refilled above this level during the remainder of the crop. Overflow prevention will conserve saline water and mineral salts added to improve conditions for shrimp production.

When ponds are emptied for harvest, water should be transferred to other ponds and stored for later use. In order to accomplish this, a storage reservoir (Figure 2) could be used. The first and second ponds to be harvested could be drained into the reservoir. The next two ponds for harvest could be drained into the two empty ponds, etc. Water from the reservoir would then be pumped to the ponds harvested last. Retention of water on farms will reduce the amount of saline water that must be pumped from wells to fill ponds for the next crop. It also will conserve mineral salts applied to ponds to correct ionic imbalances.

Shrimp harvesting pumps are also used to remove or discharge pond water. This discharge should be diverted to other ponds or to a reservoir. Where pond water enters a stream, Figure 1 may be used to estimate permissible discharge to avoid excessive chlorides. However, in any case where discharge enters a stream, monitoring is required to be done to ascertain compliance with the EPA instream criteria for chlorides. While not a recommended approach, it may be possible under limited circumstances to obtain ADEM approval to discharge pond waters to surface waters without the need to obtain ADEM permit coverage, provided specific management procedures and other requirements are implemented and maintained, and detailed records are kept.

Sediment removed from pond bottoms should be placed back onto eroded areas in pond bottoms and on the insides of embankments. It should not be placed outside ponds because the salt contained in it will be leached out by rainfall.

A program to monitor chloride concentration downstream of farms should be implemented, and is required to be implemented if significant discharges to surface waters occur. Upstream, downstream, and pond water discharge analyses can be made on a regular basis with a chloride analysis kit and the results can demonstrate whether or not an inland shrimp farm is causing a stream to violate the EPA instream criteria for chlorides.

Vegetative cover should be maintained on the embankments around ponds and between ponds and streams. Any observation of dead or dying vegetation may be an indicator of salinization. It also would suggest the need for improvement in methods for preventing salt movement from ponds to the surrounding area.

If a freshwater well exists on a farm, it should be monitored for chloride concentration at 6-month intervals. An increase in chloride concentration could indicate seepage of pond water into the aquifer.

One shrimp producer in Alabama has had some success in capturing shrimp from ponds with a small trawling boat (Figure 3). Producers could possibly use this and other methods for harvesting shrimp which remove the need to drain ponds. If an efficient method can be developed, it will greatly diminish the risk of stream salinization by inland shrimp farming. It also would reduce the cost of transferring water between ponds for reuse. Also, significant mortality should be disposed in a responsible manner according to NRCS technical standards and guidelines.

References

ADEM Administrative Code Chapter 335-6-6. (NPDES Rules)

Benoit, D. A. 1988. Ambient water quality criteria for chloride – 1988. United States Environmental Protection Agency, EPA 440/5-88-001, Washington, D.C.

Boyd, C. E. and T. Thunjai. 2003. Concentrations of major ions in waters of inland shrimp farms in China, Ecuador, Thailand, and the United States. Journal of the World Aquaculture Society 34:524-532.

Boyd, C. E., J. F. Queiroz, G. N. Whitis, R. Hulcher, P. Oakes, J. Carlisle, D. Odom, Jr., M. M. Nelson, and W. G. Hemstreet. 2003. Best management practices for channel catfish farming in Alabama. Special Report 1, Alabama Catfish Producers, Montgomery, Alabama.

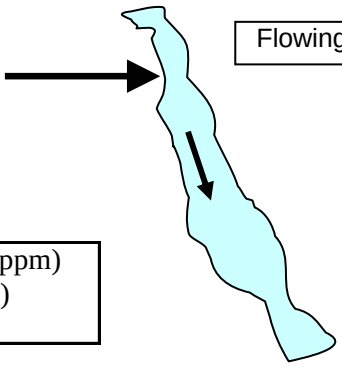
Figure 1

Chlorides in Discharges from Aquaculture Ponds

Analysis of Stream Flow versus Discharge Rate

Stream Flow-amount of stream flow before water from the aquaculture pond enters, cubic feet per second (cfs)
Discharge Rate-rate at which water from the aquaculture pond enters the stream, million gallons per day (MGD)
Chloride concentration-concentration of chlorides in water, parts per million (ppm)

Aquaculture Pond:
Typical Area = 2 acres
Typical Depth = 6 feet
Typical Chloride concentration = 3,500 ppm



Flowing Stream with Flow = Qs

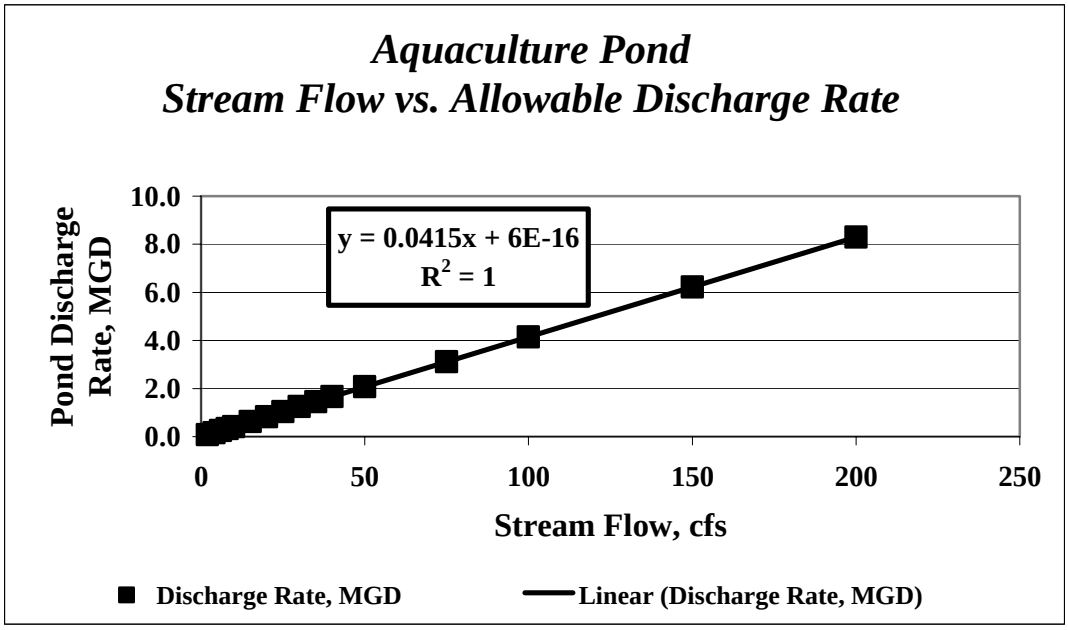
Typical Pond Volume = 3,909,946 gallons
Assume a 2-day discharge period
Discharge Rate = 1.955 MGD

Stream Flow Chloride criterion (230 ppm)
(Background Chloride = 20 ppm)
Qs = 47.09 cfs

Assumptions:
Background Chloride = 20 ppm
Chloride criterion = 230 ppm
Pond Chloride = 3,500 ppm

Allowable Discharge Rates (MGD) for Various Stream Flows (cfs)

Stream Flow, cfs	Discharge Rate, MGD
2	0.083
4	0.166
6	0.249
8	0.332
10	0.415
15	0.623
20	0.830
25	1.038
30	1.245
35	1.453
40	1.661
50	2.076
75	3.113
100	4.151
150	6.227
200	8.303



The 4-day average (chronic) instream concentration of dissolved chlorides should not exceed the EPA recommended instream water quality criteria of 230 mg/l more than once every 3-years on average, and the 1-hour average (acute) instream concentration should not exceed 860 mg/l more than once every 3-years on average. Salinity for well or pond waters are generally recorded in parts per thousand (ppt). The EPA recommended water quality criteria for chlorides is stated in parts per million (ppm). As a general rule chlorides (when associated with sodium) is comparable to salinity in natural waters. Therefore, in natural waters, 1 ppt salinity generally corresponds to an approximate 1,000 ppm of chlorides. 1 ppm is also equivalent to 1 mg/l.

In order to comply with applicable ADEM requirements if discharging to a State water, an operator can pipe the pond water discharge to a stream with enough flow to provide adequate dilution of the elevated chlorides in accordance with ADEM Admin. Code Chapter 335-6-10 [Water Quality Standards] or only discharge during a very limited timeframe each year (generally late winter-early spring) when the local receiving stream generally has elevated seasonal flow sufficient to provide adequate dilution of the elevated chlorides. A detailed operations and management plan prepared by a QCP, which provides for regular upstream, downstream, and discharge monitoring, recordkeeping and other requirements, is required to be developed and implemented. In addition, National Pollutant Discharge Elimination System (NPDES) permit coverage may be required by ADEM.

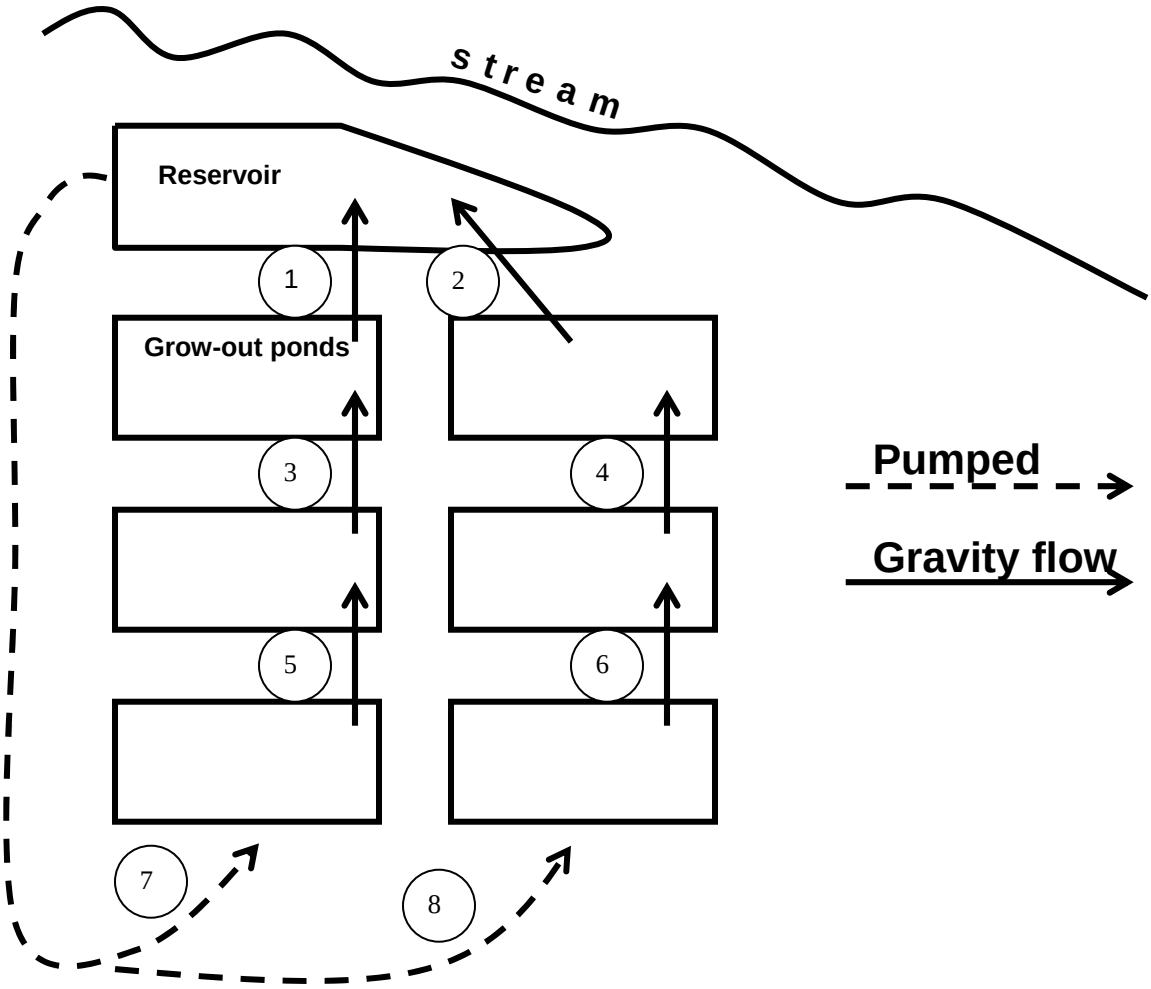


Figure 2. An example of a method for storing water for reuse in inland shrimp ponds to prevent potential discharges to waters of the State.

Figure 3. Small trawling boat for harvesting shrimp without draining ponds. Courtesy of Mr. Billy Wiggins, Fosters, Alabama.

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