

**ARKANSAS WATER  
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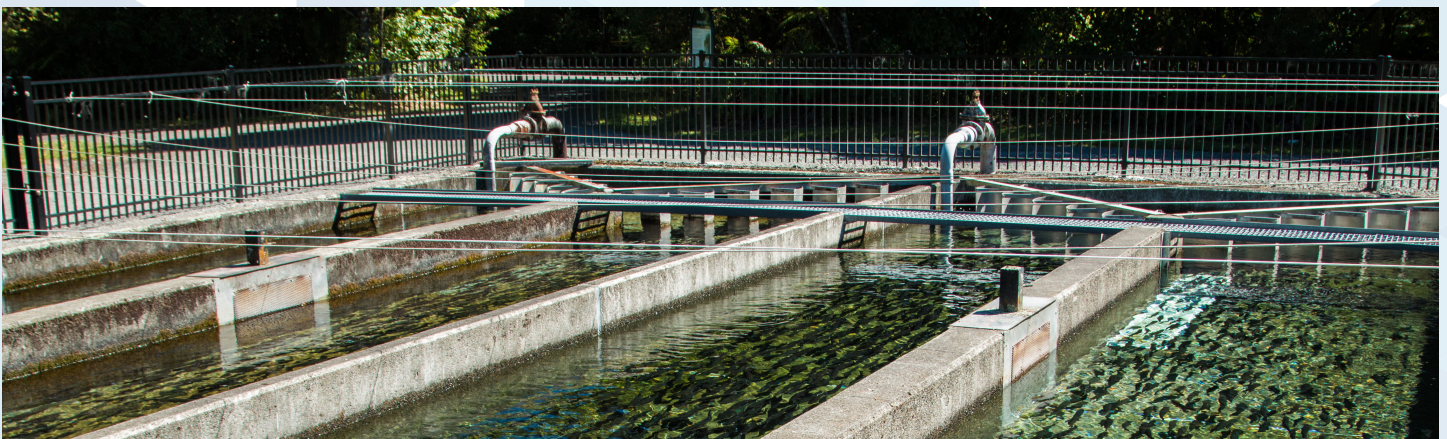
The Arkansas Water Resources Center (AWRC) in cooperation with the Cooperative Extension Service offers several analytical packages to assess the quality of your water resources. This document is intended to provide guidance to aquaculture producers and pond owners on the “Fish Pond Report” provided by the AWRC’s water quality laboratory. The information contained within this fact sheet should be used as general guidance, and the reader is encouraged to seek advice from Extension specialists regarding the interpretation of individual reports and water testing results that may be of concern. The Aquaculture Center for Excellence is at the University of Arkansas at Pine Bluff, see [aqfi.uaex.edu](http://aqfi.uaex.edu) for more information and fisheries contacts.

## When Should You Test Your Water?

Aquaculture ponds may vary widely in chemical characteristics depending on the water source used to fill the pond. Ponds are often filled with water from groundwater wells, whereas runoff from the landscape during rainfall events can also be used to maintain water levels in ponds. Annual or bi-annual sampling and laboratory analysis of your water resource can provide a useful baseline of the water quality and help to determine if the water quality needs to be adjusted. However, in the event of a fish kill, determining the cause requires rapid response and specialized tests.

(see [SRAC Publication No. 472, Submitting a Sample for Fish Kill Investigation](#))

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# Collecting and Submitting Samples to the AWRC

Properly label a 0.5 liter clean sample bottle with site information; clean bottles can be obtained from the AWRC water quality laboratory, if needed. Select a sampling location that is devoid of debris, mud, or algae in surface films, being careful to not stir up the sediments in the bottom of your pond. Prior to collecting your sample the sample bottle should be field rinsed three times; which entails filling the bottle  $\frac{1}{4}$  full, capping,



shaking, and then discarding the rinse water away from the location of sample collection. Water samples should be collected by submerging the bottle  $\frac{1}{2}$  to 1 foot below the water surface, at a spot several feet away from the edge of the pond, filling the bottle completely, and tightly sealing it with the cap.

Knowing the source of your pond water is important in the interpretation of the water quality report. If you rely on multiple sources for water, it may be necessary to have each one tested, because even if the source wells are in close proximity their waters may have quite different properties. When submitting multiple samples, make sure the label provides enough description so that the samples can be distinguished from one another. Water samples should be kept cool, preferably on ice and out of the sun, and submitted to the laboratory as soon as possible, making sure to include a completed AGRI-422 form. If possible, reduce delays during shipping and avoid submitting samples at times when they will reach the laboratory on a holiday or weekend, as the concentrations of the variables may change over time in unpreserved water samples.

For the most accurate determination of water quality parameters, water samples should be kept cold and submitted to the water quality lab as soon as possible.

# Interpreting Results

Table 1 provides a list of both desirable and acceptable ranges for each of the parameters analyzed in the Fish Pond Report. A brief description of each of the variables tested is listed below. Additionally, specific holding times, or the duration of time the laboratory has to analyze the water sample, are provided. Several variables are relatively stable and have holding times of 14 days to 6 months. A list of holding times or the amount of time the Lab has to analyze the water sample is provided in Table 2. However, for many of these variables your water sample needs to be filtered and or preserved by the water quality laboratory so that they are stable for the duration of time listed. It is recommended to submit your pond water samples to the laboratory as soon as possible and keeping them stored on ice until delivery. This will help ensure accuracy of the variables measured. The quality of the data within the report will be dependent on getting the water samples to the laboratory as soon as possible. The laboratory generally completes analysis of all parameters within two weeks, returning results to clients within three weeks.

Table 1: Summary of desirable and acceptable concentrations of selected water quality parameters for fish ponds.

Variable	Units	Desirable Range	Acceptable Range
pH	None	6.5 - 9.0	5.5 - 10
Electrical Conductivity	µS/cm	60 - 2000	30 - 5000
Alkalinity	mg/L as CaCO <sub>3</sub>	50 - 150	20 - 400
Hardness	mg/L as CaCO <sub>3</sub>	50 - 150	> 20
Iron	mg/L	none	< 1.0
Manganese	mg/L	0.00 - 0.01	< 1.0
Fluoride	mg/L	0.1 - 1.5	< 3.0
Chloride	mg/L	60 - 100	
Ammonia-nitrogen	mg/L	See Table 3	
Nitrate-nitrogen	mg/L	No Specific range	< 90
Nitrite-nitrogen	mg/L	0.0 - 0.1	< 4.0
Cl:NO <sub>2</sub>	Unitless ratio	20:1	10:1
Phosphate-phosphorus	mg/L	0.01 - 2.0	< 3.0

\*There are no specific recommendations for carbonate and bicarbonate.

“For a full list of analytical methods and detection limits for the parameters listed, please see the AWRC Water Quality Laboratory website (<http://arkansas-water-center.uark.edu/water-quality-lab.php>)”

Table 2: Preservation and maximum holding time for accurate determination of the parameters analyzed by the AWRC Water Quality Lab for the Fish Pond water quality report.

Variable	Sample Preservation	Holding Time (days)
pH	None	2
Electrical Conductivity	None	28
Alkalinity	None	14
Hardness	Acidified	180
Iron	Filter/Acidified	180
Manganese	Filter/Acidified	180
Fluoride	Filter	28
Chloride	Filter	28
Ammonia-nitrogen	Filter	28
Nitrate-nitrogen	Filter/Acidified	28
Nitrite-nitrogen	Filter	2
Cl:NO <sub>2</sub>	Filter	2
Phosphate-phosphorus	Filter	2

**1 pH:** This is a measure of how acidic (less than 7) or basic (greater than 7) your water is; it is on a scale of 0 to 14, with 7 being neutral. A pH ranging from 6.5 to 9.0 is desirable for most fish and aquaculture ponds, and a pH less than 4.5 suggests strong mineral acidity, which is harmful to fish. Your water sample should be analyzed within 48 hours of collection to get an acceptable pH reading.

**2 Electrical Conductivity (EC):** Electrical conductivity is a measure of how well your water sample conducts electricity, and is related to the salt content or the amount of dissolved ions in the water sample. There is a wide range of tolerances across fish species, though the desirable range that accommodates most species is from 60 – 2,000 µS/cm. Some aquaculture species, such as channel catfish, can tolerate levels as high as 30,000 µS/cm. This variable is naturally stable in most water samples, and collected samples should be analyzed within 28 days.

**3 Alkalinity, Total:** Total alkalinity is a measure of how well water buffers changes in pH, or prevents large rapid changes in pH. This is measured in mg/L of calcium carbonate (CaCO<sub>3</sub>), and the desirable range for sufficient buffering capacity is from 50 – 150 mg/L CaCO<sub>3</sub>. Total alkalinity of your water sample from the pond should be measured within 14 days of collection.

**4 Hardness, Total:** Total Hardness is a measure of divalent cations (cations with a 2+ charge when dissolved) such as calcium and magnesium, in the water, though its units are expressed in mg/L of calcium carbonate (CaCO<sub>3</sub>). The desirable total hardness of aquaculture ponds is between 50 – 150 mg/L CaCO<sub>3</sub>. Once the water sample is processed and preserved in the laboratory, this is stable for 6 months.

**5 Carbonate (CO<sub>3</sub>) and Bicarbonate (HCO<sub>3</sub>):** Carbonate, bicarbonate, and carbon dioxide are all components of total alkalinity (see [SRAC Publication No. 464, Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds](#)). The relative concentration of each within a water sample is related to the pH of the sample, and thus there are no specific recommendations for these compounds. These variables have units expressed in mg/L of CaCO<sub>3</sub>, and total alkalinity and pH are used to estimate these concentrations (APHA, 2012), so for the most reliable estimation of carbonate and bicarbonate your water sample should be analyzed within 48 hours of collection.

**6 Iron (Fe):** The water sample is analyzed for concentrations of total dissolved iron and will not distinguish between unoxidized (ferrous) and oxidized (ferric). Iron concentrations of up to 1.0 mg/L in well-aerated waters are not likely to be harmful to fish stocks; however, younger fish might be more sensitive to dissolved iron concentrations. Once the water sample is processed and preserved by the laboratory, the holding time for analysis is 6 months.

**7 Manganese (Mn):** Similar to iron, concentrations of total dissolved manganese less than 1.0 mg/L are not harmful to fish, but the desired range is less than 0.01 mg/L. Once the water sample is processed and preserved by the laboratory, the holding time for analysis is 6 months.

**8 Fluoride (F):** Fluoride is a trace element found in waters at concentrations ranging from 0.1 to 1.5 mg/L. Concentrations at or above 3 mg/L has been reported to cause losses with some fish species, depending upon complex water conditions. Fluoride should be analyzed in your water sample from the pond within 28 days of collection.

**9 Chloride (Cl):** Chloride should not be confused with chlorine (Cl<sub>2</sub>) which is a highly reactive compound and commonly used as a disinfectant and lethal to fish. Chloride is part of common salt (sodium chloride) and is essential in helping fish maintain their osmotic balance. Additionally, in commercial catfish production ponds, chloride is added to the pond water to achieve a 100 mg/L concentration to help prevent brown blood disease which is caused by high nitrite concentrations. Chloride should be analyzed in your water sample from the pond within 28 days of collection.

**10 Sulfate (SO<sub>4</sub>):** Sulfate is a naturally occurring compound in surface and ground waters. Concentrations can range naturally from 0 to 1,000 mg/L. Fish have a wide range of tolerance for sulfate. Sulfate should be analyzed in your water sample from the pond within 28 days of collection.

**11 Ammonia-nitrogen (NH<sub>3</sub> and NH<sub>4</sub>):** Dissolved ammonia occurs in water bodies in two forms, the unionized form (NH<sub>3</sub>) which is more prevalent at high pH, and the ionized form (NH<sub>4</sub><sup>+</sup>) which is more common in low pH. Unionized ammonia is very toxic to fish, while the ionized form is much less toxic; the relative proportion of each form and thus the toxicity is dependent on the pH and temperature of your water body (Table 3). For more information on ammonia in fish ponds see SRAC publication Nos. 463, Ammonia in Fish Ponds, and 4603, Managing Ammonia in Fish Ponds. Once the water sample is processed and preserved at the laboratory, ammonia should be analyzed within 28 days.

**12 Nitrate (NO<sub>3</sub>) and nitrate-nitrogen (NO<sub>3</sub>-N):** This constituent is presented in the report in two forms, the first: NO<sub>3</sub> is the concentration of nitrate in the sample, the second: NO<sub>3</sub>-N is the concentration of nitrogen in the sample in the form of NO<sub>3</sub>. Nitrogen makes up roughly

one quarter of the molecular mass of nitrate, so the  $\text{NO}_3\text{-N}$  value should be roughly  $\frac{1}{4}$  of the  $\text{NO}_3$  value. Nitrate is relatively non-toxic to fish and is only of concern when concentrations are exceedingly high ( $> 90$  mg/L). Nitrate should be analyzed within 48 hours of your pond water sample being collected.

**13 Nitrite-nitrogen ( $\text{NO}_2\text{-N}$ ):** Nitrite is another form of dissolved nitrogen found in pond water (see [SRAC Publication No. 462, Nitrite in Fish Ponds](#)). Acute toxicity is dependent on both pH and the trace minerals in the water, with concentrations as low as 0.1 mg/L being toxic to Salmonid species under neutral pH conditions (Russo et al. 1980). The desirable range is less than 0.1 mg/L, and the acceptable range varies with fish species and chloride concentrations. Nitrite should be analyzed within 48 hours of sample collection.

**14 Cl: $\text{NO}_2\text{-N}$  ratio:** To prevent brown blood disease, it is recommended that you have a minimum of 10:1 ratio of chloride to nitrite-nitrogen. To determine this value for your pond water divide the reported chloride concentration by the reported nitrite-nitrogen concentration. For example if your chloride concentration is 100 mg/L and nitrite-nitrogen concentration is 5 mg/L, you would divide 100 by 5 giving you 20. So this hypothetical chloride to nitrite-nitrogen ratio would be 20:1.

**15 Soluble Reactive Phosphorus (SRP):** Soluble reactive phosphorus is not toxic to aquatic life; however, higher concentrations may promote nuisance algal growth. Once the water sample is processed and preserved at the laboratory, phosphate should be analyzed within 28 days.

To prevent fish health issues associated with high  $\text{NO}_2$  concentrations, chloride concentrations should be kept at least 10 times higher than  $\text{NO}_2$  concentrations.

## Things That May Influence These Variables

There are a lot of things that might influence the analysis of your water sample from the ponds, including:

### Photosynthesis and Respiration

Photosynthesis and respiration, which naturally occur in your aquaculture pond, can influence several water quality parameters. Photosynthesis is the biological process whereby primary producers such as algae, cyanobacteria, and aquatic plants use sunlight to convert dissolved inorganic carbon, primarily carbon dioxide, into sugars, producing oxygen as a by-product. This process removes carbon dioxide from the water which can increase the pH of your aquaculture pond. The alternative process, respiration, which is performed by most living organisms in your pond (including the primary producers), utilizes dissolved oxygen and sugars produced from photosynthesis for energy, producing carbon dioxide as a by-product. During the daytime the

Table 3. Maximum total ammonia nitrogen concentrations (mg-N/L) for warm water fish, including early life stages. Table is divided into ammonia toxicity concentrations for acute and chronic exposure time across multiple pH levels (adapted from U.S. EPA, 1999). Acute exposure refers to 1 hour of exposure time and chronic exposure refers to more than 1 day of exposure time.

	Exposure Time			
	Acute	Chronic		
		Water temperature (F)		
pH		64	75	86
	Maximum total ammonia - nitrogen (mg/L)			
7.0	36.0	5.5	3.2	2.2
7.5	20.0	4.0	2.4	1.6
8.0	8.4	2.2	1.3	0.9
8.5	3.2	1.0	0.6	0.4
9.0	1.3	0.4	0.3	0.2

effect of photosynthesis outweighs the effect of respiration so there is a net loss of carbon dioxide and increase in pH. However, during the night time when primary producers are no longer able to carry out photosynthesis there is a net release in carbon dioxide and subsequent decrease in pH. Increased daytime pH may result in a higher proportion of unionized ammonia dissolved in the pond water which along with higher temperatures in the summer will increase the toxicity of ammonia (Table 2). As the pH declines due to respiration, the solubility and toxicity of heavy metals that may be stored in the sediments of your pond, such as iron and manganese, increases. The degree to which the pH of your pond water changes throughout the day is dependent on the total alkalinity, with higher alkalinity stabilizing the pH. The alkalinity of your pond can be increased by adding crushed agricultural limestone. ([see SRAC Publication No. 4100, Liming Ponds for Aquaculture](#))



### Source Water

The source of water that is used to fill your aquaculture ponds will influence your water quality. Groundwater sources have unique characteristics for water quality. The chemical constituents of



groundwater will be determined primarily by the underlying geology, but groundwater chemistry is also influenced by soils and land use of the landscape within the area that recharges the source. Dissolution of minerals below the surface can result in your groundwater containing naturally higher concentrations of chloride, fluoride, sulfate and calcium carbonate. The presence of calcium carbonate will influence both the hardness and total alkalinity of your pond water. Additionally, ground waters are often low in dissolved oxygen, which can increase the solubility of metals such as iron and manganese. Groundwater brought up from different depths may have different chemical constituents, so if you are utilizing multiple wells to meet your aquaculture pond needs then you should have each source tested.



Surface waters including runoff after rainfall events, streams, and rivers are influenced by the landscape within the watershed. For example, stream nutrient (nitrogen and phosphorus) concentrations increase with increases in human activities within the watershed like row crops, pasture, and urban development (Carpenter et al. 1998). Land uses also have the potential to influence many characteristics of water quality, and if you are mixing water sources then you should consider testing each source.

## Nutrient Cycling

Cycling of nutrients mediated by microorganisms (bacteria, fungi, and algae etc.), that naturally occur in your aquaculture pond, may influence the relative concentrations of the different forms of nitrogen in your pond water as well as phosphorus to a lesser extent. Mineralization of organic matter results in the release of nitrogen in the form of ammonia which can then be converted to nitrite and then nitrate through the process of ammonium oxidation or nitrification. When dissolved oxygen is present in our pond water, ammonia is quickly converted to nitrate but nitrite concentrations may also increase. However, nitrate and ammonia can be naturally removed from ponds especially near the bottom where dissolved oxygen might be low, in a process that converts nitrate and ammonia to dinitrogen gas. The cycling of phosphorus is much simpler: organic matter is mineralized to form phosphate, which is then either taken up by microorganisms or can bind to suspended or bottom sediments under aerobic conditions. However, if the pond water near the bottom has low dissolved oxygen, then the iron and inorganic minerals are dissolved into the water, releasing phosphorus.

## Nutrient Concentrations

Nutrients (nitrogen and phosphorus) may be added to fish ponds to promote growth of natural food resources for fish. If managed correctly, adding nutrients to your fish pond can result in a desirable increase in fish number and size. This requires that the nutrients within the water body are monitored and additional nutrients are added to achieve a 16:1 ratio of

nitrogen to phosphorus. Managing your fish pond in this manner will result more and larger fish, but will cause pond surface waters to become green or brownish green in color, which may be undesirable if the pond is being managed for aesthetics. Increasing the nutrients may also promote the growth of nuisance aquatic plants (macrophytes) and filamentous algae. Additionally,



in some cases elevated nutrients may lead to the presences of cyanobacteria which may produce compounds (cyano-toxins) that are harmful to fish, humans, and wildlife ([See SRAC Publication No. 4605, Algal Toxins in Pond Aquaculture](#)).

## Summary

Most waters are suitable for fish production, although tolerances to different water quality characteristics will vary based on the species of fish being grown. If water is also being used for other purposes such as livestock or irrigation, it is important to take into consideration the recommended concentrations for these uses as well when managing your water resource. In all cases, it is important to remember that this analytical package cannot detect all possible problems with regard to the chemistry and quality of the pond. Water testing can guide management decisions, assist in determining potential problems and help increase production or increase water clarity depending on the intended purpose of the water body. Water supply characteristics may change over time as well as management strategies, so it is important to retest waters annually.

Adding nutrients to your pond can increase both size and number of fish, but will also potentially decrease water clarity.

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