Handbook of Analytical Methods

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Handbook of Analytical Methods

The Aquaculture CRSP Handbook of Analytical Methods was originally published in printed form (Piedrahita, et al., 1996). A tabular version of the Handbook is provided below. As noted under the column "Reference Use," use of literature listed under "Method Reference" may be required for full description of a particular method. This literature is copyrighted and cannot be reproduced here.

Supporting References

General:

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Soil analysis:

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St. Louis, MO USA. 650 pp.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
Fish/ Shrimp	Tilapia Reproduction	FishRepNum, FishRepTotWt, FishRepMnWt	g, no. individuals	Count and group weight	Pond Dynamics/ Aquaculture CRSP	None	Scale capable of weighing to 1 g.	Concurrent with assessment of growth of stocked fish, note the number and collective weight of any fry collected. These fry are to be discarded and not returned to the experimental ponds.
Fish/ Shrimp	Fish/ Shrimp Group Weight	FishPopNum, FishPopTotWt, FishPopMnWt	kg, no. individuals	Count and group weight	Pond Dynamics/ Aquaculture CRSP	None	Scale capable of weighing 1 g.	Collect a cast net (or seine net) sample equivalent to 10% of the initial stock from each pond and weigh as a group. Indicate number of individuals in the grab sample. If substantial variation is observed or if reproduction is suspected, divide the sample into centimeter groups, count and weigh each group. Sex the fish and remove any female tilapia observed and replace it with a male of similar weight. Any animals collected other than those stocked should be counted, weighed, measured and discarded. Record observations on reproduction or fish health.
Fish/ Shrimp	Fish/ Shrimp Mean Length per Individual	FishLnSamNo, FishLnSamMn, FishLnSamSD, FemLnSamNo, FemLnSamMn, FemLnSamSD, MalLnSamNo, MalLnSamMn, MalLnSamSD	cm	Individual length measurement	Pond Dynamics/ Aquaculture CRSP	None	Ruler or calipers capable of measuring to 0.1 cm.	For a respresentative 10% subsample of the grab sample (equivalent to approximately 1% of initial stock) used for determination of the group weights, measure the total length and count individuals. Express as mean length per individual.
Fish/ shrimp	Fish/ Shrimp Production	FishPopNum, FishPopTotWt, FishPopMnWt	kg, no. individuals	Count and group weight	Pond Dynamics/ Aquaculture CRSP	None	Scale accurate to 1.0 g.	Fish and shrimp stocks will be weighed as a group at stocking and harvest. A 10% sample will be weighed and measured (use total length for tilapia measurements) to calculate the total number of individuals stocked or harvested. Any fish other than tilapia will be counted by species, weighed and measured.
Fish/ Shrimp	Fish/ Shrimp Mean Weight per Individual	FishWtSamNo, FishWtSamMn, FishWtSamSD, FemWtSamNo,	g	Individual weight measurement	Pond Dynamics/ Aquaculture CRSP	None	Scale capable of weighing to 0.1 g.	For a respresentative 10% subsample of the grab sample (equivalent to approximately 1% of initial stock) used for determination of the group weights, weigh and count

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
		FemWtSamMn, FemWtSamSD, MalWtSamNo, MalWtSamMn, MalWtSamSD						individuals. Express as mean weight per individual.
Pond	Pond Depth	WatDepth	m	Direct measurement	Pond Dynamics/ Aquaculture CRSP	None	Staff gauge.	Install staff gauge in each pond and read to the nearest 0.5 cm before restoring a recommended pond depth.
Pond	Volume	WatVol	m3	Calculation from contours	Lind, O.T. 1979. Handbook of common methods in limnology. C.V. Mosby Company, Saint Louis.	None	None required.	The pond volume may be estimated from the area estimates for the various depths. The volume for each depth increment is: VolumeIncrement = h/3 (A1 + A2 + Square Root (A1 A2)). Where h = depth of volume increment (m), A1 = area of surface of volume increment (m2), A2 = area of bottom of volume increment (m2). The total volume of the pond can be obtained by summing the volumes of all the volume increments.
Pond	Surface Area	WatArea	m2	Planimeter	Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, Saint Louis.	Use of reference is required for full procedure.	Polar planimeter and scale.	Area estimates are made from maps prepared for different water depths. The simplest method of accurately establishing the contours is to adjust the water level of the pond to the desired contour depth for taking the measurements and drawing the maps. The areas are measured with the planimeter. If a planimeter is not available, the map may be traced on good quality paper, the outline of the pond contours may be cut out carefully, and the paper weighed. The contour weight can be compared to the weight of a known area. A third method consists of drawing the contours on a square-grud paper, counting the number of squares covered by each contour, and converting to the appropriate scale by multiplying by the scaled area of each square. If the pond is of regular shape (ie. rectangular or square), the area may be obtained by measuring the length (m) and width (m) at the various depths and multiplying the values.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
Pond	Map	WatPondMap, WatDepthTest, WatAreaTest, WatVolTest	none	Plane table	Lind, O.T. 1974. Handbook of common methods in limnology. C.V. Mosby Company, Saint Louis.	Use of reference is required for full procedure.	Plane table, compass, drawing equipment, measuring tape, stakes.	The detailed procedure is described by Lind. The plane table method should be used if the pond shape is irregular. If the ponds are square or rectangular, map preparation can be done from measurements obtained with tapes and surveying equipment such as a transit.
Pond	Seepage	WatFlowSeep	cm/day	Water balance	Pond Dynamics/ Aquaculture CRSP	None	None required.	Determine seepage from a 24 h water balance, when there is no rainfall, and no inflow or outflow into/from the pond: Seepage (cm/d)= (Initial Depth (cm) - Final Depth(cm)) - Evaporation(mm/d) * (0.1 cm/mm). Where: Initial Depth = water depth at the initiation of the 24 h period over which infiltration is being measured. Where: Final Depth = water depth at the end of the 24 h period over which infiltration is being measured.
Pond	Inflow	WatFlowEff, WatFlowInf, WatFlowInfRate	m3/day	Various methods	Wood, J. W. 1974. Diseases of Pacific Salmon: Their Prevention and Treatment. State of Washington, pp. 71-77.	Use of reference is required for full procedure.	Various, depends on specific method used.	Surface Inflow/Outflow should be determined using procedures described by Wood or comparable methods.
Soil/ Sediment	Aluminum, exchangeable	SoilAl	mg/kg	KCI extraction and colorimetric analysis with aluminon	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Shaker, centrifuge, and colorimeter.	Follow the procedures as described in the Methods of Soil Analysis.
Soil/ Sediment	All Samples	None	none	Sample collection	Pond Dynamics/ Aquaculture CRSP	None	5-cm diameter soil core.	Unless otherwise specified for a given analysis, soil samples are tp be collected as follows: 1) use a 5-cm diameter core, 2) collect a 5-cm deep core, 3) record the total

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
								sample mass (g), 4) record the dry bulk density of the sample (kg/m3) from the total dry sample mass and the core volume (9.82 * 10^-5 m3 for the 5-cm diameter, 5-cm deep core).
Soil/ Sediment	Benthos Composition	ProdBenType, ProdBenCount	no./m2	Collect, sort, and identify	Pond Dynamics/ Aquaculture CRSP	None	Sieve, U.S. Standard No. 30 (Nominal sieve opening is 0.595 mm), dissecting microscope, coring device.	Collect at least three cores of mud per pond. The cores may be collected with a 5 cm diameter PVC pipe, or with other suitable corer. Process samples through a No. 30 sieve, sort organisms and fix in 10% formaling or a 70% ethanol solution. Identify at the order level and count the number of organisms.
Soil/ Sediment	pH	SoilPh	pH units	Electrode	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	pH meter and glass/calomel or gel-filled combination electrode.	Follow the detailed instructions as given in Methods of Soil Analysis.
Soil/ Sediment	Phosphorus	SoilP	mg/kg	Ignition or HCL digestion	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Spechtrophotometer capable of reading at 840 to 880 nm with a 1 cm light path. Muffle furnace capable of operating at 550 YC for the ignition method.	The ignition procedure is much simpler but it is also subject to a greater number of errors than the extraction method. In either case, follow the detailed instructions as given in Methods of Soil Analysis.
Soil/ Sediment	Lime Requirement	SoilLimeReq	kg CaCO3/ha	Modified Adams-Evans procedure	Boyd, C.E. 1979. Water quality in warm water fish ponds. Auburn	Use of reference is required	pH meter.	Reagents: Prepare a p-nitrophenol buffer of pH 8.0 ñ 0.1 by dissolving 20 g of p-nitrophenol, 15 g of H3BO3, 74 g of KCl, and

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
					University Agricultural Experiment Station, Auburn, Alabama, 359 pp.	for full procedure.		10.5 g of KOH in distilled water and diluting to 1,000 mL in a volumetric flask. Preparation of Sample: Spread the mud in thin layers on plastic sheets and air dry. Pulverize the dried mud gently and use for the test the material that passes through a 20 mesh screen (0.85 mm openings). Determination of Mud-Water pH: Weigh 20.0 g of dry, screened mud into a 100 mL beaker, add 20 mL of distilled water, and stir intermitently for one hour. Measure the pH of the mud-water mixture with a glass electrode. Determination of Buffer pH: Add 20.0 mL of the p-nitrophenol buffer to the sample used for the determination of mud-water pH. Stir intermittently for 20 minutes. Calibrate the pH meter at pH 8.0 with a 1:1 mixture of p-nitrophenol buffer and distilled water, and read the pH of the mud-water-buffer mixture while stirring vigorously. Calculation: Select the appropriate liming rate from table 12.2 in the given reference.
Soil/ Sediment	Base Saturation	SoilBaseSat	To be completed	Calculation	To be completed	None	To be completed.	To be completed
Soil/ Sediment	Exchangeable Hydrogen	SoilH	To be completed	To be completed	To be completed	None	To be completed.	To be completed.
Soil/ Sediment	Organic Matter	SoilOrg	percent	Ashing and weighing, or Walkley-Black	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Combustion apparatus for organic C determination. Muffle furnace if using the Standard Methods procedure.	The Walkley-Black method is used to estimate organic C directly, but recovery of organic C from samples may be variable depending on the soil type. The ignition method as described in Methods of Soil Analysis gives an indication of the actual organic matter (as opposed to organic C), but may result in overestimates due to loss of other components upon ignition at 950 YC. Ignition of the sample at 550 YC in a muffle furnace as recommended in Standard Methods may be an alternate method of estimating organic matter. Methods of Soil Analysis recommends the direct

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
								determination of organic C (using Walkley-Black or other methods) over the ignition methods, and expressing the results in terms of Soil Organic C rather than Soil Organic Matter. In all cases, follow the detailed procedures as indicated in the given reference.
Soil/ Sediment	Zinc	SoilZn	mg/kg	Atomic absorption spectrophoto metry	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Atomic absorption spetrophotometer.	Follow the procedure as described in Methods of soil analysis and in the detailed operating guidel for the instrument available. Use flame atomic absorption unless the concentration is too low and the samples must be analyzed by flameless atomic absorption.
Soil/ Sediment	Iron, Exchangeable	SoilFe	mg/kg	Ammonium acetate extraction and atomic absorption	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Atomic absorption spectrophotometer.	Follow procedures given in reference.
Soil/ Sediment	Cation Exchange Capacity	SoilCEC	meq/100 g	"Arid land" or "acid" soils analysis	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy	Use of reference is required for full procedure.	Atomic absorption spectrophotometer, centrifuge, ultrasonic disperser, reciprocating shaker.	Follow the procedure as described in the Methods of soil analysis. Select a method appropriate for your soil. In most cases, the "arid land" soils method is recommended for non-acid (alkaline) soils.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
					and Soil Science Society of America. Madison, Wisconsin.			
Soil/ Sediment	Nitrogen, Total	SoilN	mg/kg	Kjeldahl (TKN)	Page, A.L., Miller, R.H. and Keekey, D.R. editors. 1982. Methods of soil analysis, Part 2- Chemical and microbiological properties. Second Edition. American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin.	Use of reference is required for full procedure.	Kjeldahl digestion flasks, digestion stand, and distillation apparatus.	Follow the detailed procedures in Methods of Soil Analysis.
Water	Chlorophyll a (Uncorrected)	ProdChlaUnCorr	mg/m3	Acetone Extraction and Spectrophoto metric Determination	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Spectrophotometer with a narrow band width (0.5 to 2.0 nm), clinical centrifuge, glass tube / teflon pestle tissue grinder.	Collect one sample per pond by pooling three 90 cm column samples. Mix the samples thoroughly and collect a subsample for vacuum filtration through a 25 or 47 mm diameter glass fiber or membrane filter (0.45 to 1 mm nominal pore size). Filter, grind, extract and analyze the pigment as described in detail in Standard Methods (attached). Membrane filters are easier to deal with (but considerably more expensive) than glass fiber filters since they dissolve almost completely in the acetone solution.
Water	Salinity	WatSal	mg/kg, ppt	Light refraction or conductivity	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	None	Use a temperature compensated refractometer or a salinity meter. Refractometer: Argent Aquaculture model SS-1000A or equivalent. Salinity meter: YSI model 33 S-C-T meter and probe, or equivalent.	Near the center of each pond, collect a 500 ml sample 25 cm below the water surface, midwater and 25 cm above the bottom. Mix the samples and analyze.
Water	Pond Temperature	WatTemp, WatTempMin,	Degrees C	Thermometer	Pond Dynamics/ Aquaculture CRSP	None	Electronic thermometer (YSI Model 57	Near center of each pond, take readings at 25 cm below the water surface midwater and 25

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
		WatTempMax					Dissolved Oxygen Meter with Temperature Indicator or equivalent). Establish the accuracy of the probe using a precision mercury thermometer.	cm above the bottom.
Water	All Samples	None	none	Sample collection	Pond Dynamics/ Aquaculture CRSP	None	Clean plastic bottle.	Unless otherwise specified for a given analysis, water samples are to be collected as follows: 1. Use clean plastic bottle. 2. Fill bottle to the top and promptly cap. 3. Store samples refrigerated and in the dark while in the field. Some water quality parameters must be measured immediately after sample collection (e.g. dissolved oxygen and pH). Check the procedures for specific instructions on sample storage and preservation. 4. Collect sample at the prescribed depth, taking care not to distrub the water or sediments around the location where the sample is being collected. If samples from more than one depth are being collected at the same spot, collect the surface sample first, and follow with deeper samples, with the bottom sample being the last to be collected.
Water	pH	WatPh	pH Units	Electrometric pH measurement	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	pH meter with combination electrode (Orion 2000 Series with Ross Model 81-55 Electrode or equivalent). Calibrate the pH meter following the manufacturer's recommendations. Use a pH 7.0 buffer to set the "intercept", and a pH 10 buffer to set the "slope". Adjust for	Near center of each pond, take readings at 25 cm below the water surface midwater and 25 cm above the bottom. Stirr sample gently during analysis. Rinse and blot dry the electrode between samples.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
							temperature, or use a temperature compensating pH probe and meter. Store the probe according to manufacturer's recommendations.	
Water	Nitrogen, Total Kjeldahl	WatTotN	mg N/L	Semi-Micro-Kjeldahl Method	Michigan State University Limnological Research Lab, 1984. American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Kjeldahl digestion unit (Kontes Kjeldahl Nitrogen apparatus or equivalent). Instrumentation for ammonia measurement.	For each pond, pool three 90 cm column samples. Composite samples should be refrigerated and analyzed within 24 hours. Follow detailed instructions for reagent preparation, sample digestion and distillation given in Standard Methods.
Water	Secchi Disk Depth	ProdSecchi, ProdSecchiA, ProdSecchiB	cm	Secchi Disk	Lind, O.T. 1979. Handbook of common methods in Limnology. C.V. Mosby Co. Saint Louis.190 pp.	None	Secchi Disk: 20 cm diameter disk with alternating black and white quarter circles. The disk is suspended from a calibrated line, or attached to a calibrated rod.	Measure secchi disk depth at two locations in each pond. To measure secchi disk depth, lower the disk into the water and note the depth at which the disk dissapears from view. Lower the disk further and then bring it up slowly, noting the depth at which the disk becomes visible. Average the two depths. Repeat the procedure at a second location, average the values obtained for the two locations and report this average as the secchi disk depth for the pond. Position of the sun with respect to the observer, time of day and light intensity affect the readings. For best results, measure secchi disk between 10 a.m. and 2 p.m. in bright sunlight, make sure that the sun is behind the operator, and do not use sun glasses.
Water	Dissolved	WatDO	mg O2/L	Azide	American Public	Use of	Dissolved oxygen	Collect samples near the center of each pond

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
	Oxygen			modification of Iodometric (Winkler), or Membrane Electrode	Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	reference is required for full procedure.	meter (Yellow Springs Instrument Model 57 Dissolved Oxygen Meter, or equivalent). Follow operating instructions carefully. Turn meter on at least 15 minutes prior to calibration, and leave meter on for the duration of the sampling. Maintain the membrane in good condition by periodic changing and by refilling the electrode. The meter may be calibrated as indicated in the operating manual (air calibration or saturated water sample) or against the Winkler method.	at 25 cm below the water surface, mid-water and 25 cm above the bottom. Analyze samples separately. For the Winkler test, collect samples in BOD bottles, being careful not to agitate or aerate the sample as it is collected. Add Manganous sulfate, alkali-iodide-azide reagent, and sulfuric acid as soon as posible after sample collection. The samples may be stored for a few hours prior to titration if the water has no iodine demand. Titrate as soon as possible to prevent or minimize sample changes. For the Membrane Electrode, maintain the probe in motion while the sample is analyzed to insure water flow past the membrane. If the dissolved oxygen is measured in situ, take care not to agitate the water to the extent that stratification or sediments are disturbed.
Water	Phytoplankton Composition	ProdPhytoType, ProdPhytoCount	L phyt./L water	Collect, identify, and estimate biovolume	Pond Dynamics/ Aquaculture CRSP	None	Van Dorn of Kemmerer bottle for phytoplankton collection, compound microscope, counting cell (Sedgwick-Rafter, or hemocytometer) or Whipple Square.	Collect samples using a Van Dorn or Kemmerer bottle. Use a compound microscope and appropriate references to identify major groups (green, blue-green, or diatom) and estimate biovolume for each group. This may be achieved by estimating the average cellular biovolume for each group and counting the number of individual cells per unit volume of water. The cellular biovolume in turn may be estimated by calculation from typical dimensions of length, width, depth, or radius (depending on the cell shape). ie. if the cells are spherical, the biovolume would be 4/3 * PI * (radius) ^3. If the cells are cylindrical, the biovolume would be PI * (radius)^2 * length.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
Water	Primary Productivity	ProdGPPO2	mg O2/L/day or g O2/m3/day	Modified Whole Pond	Pond Dynamics/ Aquaculture CRSP	Use of reference is required for full procedure.	Computer and spreadsheet software.	The procedure is based on respiration and primary production estimates obtained from diel dissolved oxygen measurements. A spreadsheet version of this method is available from the PD/A CRSP DAST at UC Davis.
Water	Nitrogen, Nitrite	WatNO2N	mg N/L	Colorimetric	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Spectrophotometer with a light path of 1 cm or longer for use at 543 nm.	Samples should be filtered and anlayzed as soon as possible after collection, frozen at -20 deg. C or refrigerated at 4 deg. C and analyzed within one to two days. Follow detailed instructions for reagent preparation and sample analysis given in Standard Methods.
Water	Zooplankton Composition	ProdZooType, ProdZooCount	no./m3	Collect and identify	Pond Dynamics/ Aquaculture CRSP	None	Compound microscope for small zooplankton. Dissecting microscope for larger zooplankton.	Collect at least three 90 cm column samples per pond or use trap or zooplankton net, as appropriate. Use a microscope to identify at the order level and count the number of organisms per unit volume.
Water	Alkalinity	WatAlk	mg CaCO3/L	Low or High Standard Total Alkalinity Method or Hach Test Kit	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Hach digital titrator test kit/alkalinity (optional). pH meter (optional).	Near center of each pond, collect samples at 25 cm below the water surface midwater and 25 cm above the bottom. The titration end point may be determined potentiometrically using a pH meter or using a color indicator (bromcresol green for an endpoint of 4.5). Use the pH endpoints suggested in Standard Methods for your particular water/alkalinity. Use the low alkalinity method if alkalinity is less than 20 mg/L as calcium carbonate.
Water	Nitrogen, Nitrate	WatNO3N	mg N/L	Cadmium Reduction	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for	Use of reference is required for full procedure.	Spectrophotometer.	Samples should be filtered and analyzed as soon as possible after collection. If storage is necessary, store for up to 24 h at 4 deg. C. Follow detailed instructions for reagent preparation and sample analysis given in Standard Methods.

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
					the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.			
Water	Solids, Volatile Suspended	ProdSolTotVol	mg/L	Ignition	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Muffle furnace for operation at 500-600 deg. C, analytical balance capable of weighing to 0.1 mg, and vacuum filtration apparatus.	Follow the detailed instructions as indicated in Standard Methods.
Water	Solids, Total Suspended	ProdSolTotSusp	mg/L	Filtration	American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Drying oven for operation at 103 to 105 YC.Analytical balance capable of weighing to 0.1 mg.Vacuum filtration apparatus.	Follow the detailed instructions as indicated in Standard Methods. Be particularly careful to mix the sample thoroughly before filtering, and in handling the filter paper through the filtration, drying, equalizing and weighing processes. Use tweezers to handle the filter paper and the weighing boats or cruscibles.
Water	Dark Bottle Respiration	ProdDBRO2	mg O2/m3/day	Oxygen method	Adapted from: American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Dissolved oxygen meter with BOD-type probe or reagents and equipment for Winkler titrations.	Collect one sample (by pooling three 90 cm column samples) from each pond. Make sure that initial dissolved oxygen concentrations are not above saturation. Incubate for four hours (or as appropriate to prevent oxygen depletion) in dark bottles suspended at mid-depth in the ponds.
Water	Phosphorus, Total	WatTotP	mg P/L	Persulfate Digestion and	American Public Health Association,	Use of reference is	Spectrophotometer with infrared	Collect one sample (by pooling three 90 cm column samples) from each pond. Samples

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
				Ascorbic Acid/Colorimetric Method	American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	required for full procedure.	phototube for use at 880 nm, providing a light path of 2.5 cm or longer.	should be refrigerated and analyzed within 24 hours. Follow the detailed procedure for sample preparation, digestion and analysis as indicated in Standard Methods.
Water	Nitrogen, Ammonia	WatTAN	mg N/L	Nesslerization or Phenate Methods	Michigan State University Limnological Research Laboratory, 1984.American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1989. Standard Methods for the Examination of Water and Wastewater. 17th edition. APHA, Washington, D.C.	Use of reference is required for full procedure.	Kontes or comparable Kjeldahl Nitrogen apparatus. Spectrophotometer for use at 400 to 500 nm and providing a light path of 1 cm or longer.	Collect one sample (by pooling three 90 cm column samples) from each pond. Samples should be filtered as soon as possible after collection, refrigerated and analyzed within 24 hours. Follow the detailed procedures for sample preparation, distillation and analysis as described in Standards Methods.
Weather	Solar Radiation	SolarRadCum, SolarRadPer, SolarRad	kWhr/m2/day, E/m2/day	Light Sensor	LI-COR 4421, Superior Street, P.O. Box 4425, Lincoln, Nebraska, 68504	None	Quantum sensor to measure photosynthetically active solar radiation (wavelength between 400 and 700 nm). Use LI-COR Quantum Sensor Model LI-190SB, or equivalent. Note: use of a pyranometer that measures solar energy (watts or joules, kWhr/m2/day) needs to be added to this section.	Install Solar Monitor and Quantum Sensor at study site and read at 24-hour intervals. During diel cycles, read the solar monitor and report radiation values whenever water is sampled. The solar monitor records a running total of light intensity. Therefore, the time units reported depend on the frequency of reading of the solar monitor. For daily (every 24 hour) readings, the reading from the instrument corresponds to Einsteins per meter square per day. For diel sampling, the solar monitor readings should be divided by the duration of the time interval sampled (in hours), and the units become Einsteins per meter square per hour.
Weather	Air	AirTemp,	Minimum	Glass	Pond Dynamics/	None	Maximum-minimum	Install three maximum-minimum

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
	Temperature	AirTempMin, AirTempMax	and maximum, degrees C	thermometer	Aquaculture CRSP		thermometer (Taylor Model 5460, or equivalent).	thermometers in the shade near the ponds. Read at 24-hour intervals and report the average maximum and average minimum temperatures.
Weather	Wind Speed	WindSpdCum, WindSpdPer, WindSpd	km/hr	Anemometer	Pond Dynamics/ Aquaculture CRSP	None	Totalizing anemometer. The instrument should be located in the pond complex 2 m above the level of the pond banks, away from trees, buildings, or other obstructions. Use WEATHERtronics Model 2510, or equivalent.	Read the totalizing anemometer at 24-hour intervals (in km), and calculate average hourly wind speed by dividing by 24 h (the duration of the time interval). During the diel cycles, read the anemometer whenever water is sampled. Divide the readings (km) by the duration of the time period between readings (h).
Weather	Rainfall	HydroRain	cm/day	Rain gauge	Pond Dynamics/ Aquaculture CRSP	None	No type specified.	Install three rain gauges at the study site. Read and empty at 24-hour intervals or more frequently if needed to prevent gauge overflow. Report the average of the readings from the three gauges.
Weather	Evaporation	HydroEvap	mm/day	Evaporation pan	Pond Dynamics/ Aquaculture CRSP	None	Floating evaporation pan	Floating evaporation pans are expected to provide the best estimate of the evaporation rate in the ponds. The pans should be of clear acrylic glass (plexiglass), polycarbonate (lexan) or polypropylene. The inside dimensions of the pans should be approximately 0.70 m length, 0.70 m width and 0.25 m depth with vertical sides. The pan should be floated and tethered on the pond surface making sure that it stays leveled. A volume of water should be added to the pan and the change in water depth monitored over time by noting the initial and final water depth in the pan. The average evaporation rate for the period can be estimated from the change in water depth and the duration of the time interval to obtain mm/d. Three pans should be installed and the results from them averaged. The pans should be maintained clean of excessive

Sample Type	Sample Variable	Database Field Name	Reporting Units	Analysis Method	Method Reference	Reference Use	Instrumentation	Analysis Procedure
								biological fouling that may darken the pan walls. In the event of rainfall, correct readings using the rain gauge measurements.