

WATER QUALITY MONITORING AT NEW RIVER GORGE NATIONAL RIVER



WATER
RESOURCES
FIELD
SUPPORT
LABORATORY

WRFSL PROJECT REPORT NO. 83 - 4P



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ABSTRACT

The Water Resources Field Support Laboratory (WRFSL) of the National Park Service reviewed the water quality monitoring program at New River Gorge National River (NERI). This report presents suggestions to the park which WRFSL believes will improve the cost effectiveness and quality of the monitoring program at NERI. In addition, WRFSL reviewed data provided by NERI from six water quality stations in and around the park. Some preliminary water quality evaluations based on the small amount of data presently available also are presented.

The principal conclusions drawn from this work are summarized as follows. NERI can adjust its present water quality monitoring program and get a more cost effective water quality data base by narrowing the list of variables which frequently are measured and by performing some in-park analyses. Occasionally more complete, outside laboratory analyses (at competitive prices) are recommended to be continued, to provide quality control of in-park analyses and to provide an overview of the water quality at NERI. Evaluation of existing water quality data suggests that mining and sewage disposal in the area are impacting water quality to some extent. The overall water quality of the New River main stem appears to be fair to fairly good; however, some of the tributaries appear to be more polluted.

INTRODUCTION

The following report consists of suggestions and ideas presented to the staff of New River Gorge National River (NERI) by the Water Resources Field Support Laboratory (WRFSL) regarding water quality monitoring. In addition to the impacts resulting from coal mining, the water quality of the New River and its tributaries is affected by sewage and other pollution. Since NERI is used extensively for recreational purposes, the monitoring of water quality is an essential part of the park's management responsibilities.

We believe that for most national park areas the most cost effective--and at the same time adequate monitoring scheme, involves the use of frequent in-park analyses of constituents useful for observing pollutants thought to be a problem, for example, the monitoring of bacterial indices to detect contamination of recreation waters. Less frequently, outside laboratories should run more complete and more sophisticated analyses to provide quality control of in-park analyses, to give an occasional overview of the entire water quality system and to provide the credibility afforded by some independent laboratory testing. This general water quality monitoring philosophy is suggested for NERI in the report.

It should be noted that most of the analyses carried out at NERI thus far have been for inorganic and physical variables. If there would be complex organic pollutants from an old land fill, a railroad car spill, pesticides or industrial sources, such impacts could require special organic analyses, which would be beyond any of the routine monitoring discussed here.

The organization of the report is as follows. Seven primary suggestions are explained in brief: 1) focus in on selected variables; 2) include some on-site meters and simple tests that park staff can use; 3) develop a modest NERI laboratory; 4) continue with occasional complete, outside laboratory analyses; 5) get stream flow data; 6) use laboratory packages; and 7) as time and funding allow, include some biological monitoring for aquatic organisms, since biological indices show an integrated result of the total effects of pollutants. Following these seven suggestions, the report takes a quick look at the water quality of six stations in NERI and presents a preliminary rating of water quality with respect to several constituents. Finally, prices charged by various laboratories are reviewed, to help NERI obtain water quality information at a reasonable cost.

MONITORING RECOMMENDATIONS

To improve the water quality monitoring program at NERI, there are several additions or changes that we suggest at this point. Naturally as the new program develops and data are collected we would expect to follow up with other suggestions, based on what is learned from the monitoring. Our main suggestions at this point are summarized as follows.

1. Focus in on Selected Variables

It is often possible to save much time and money by measuring primarily those variables of importance in a given application. For example, if a stream is known to be polluted by mine drainage and sewage, frequently made measurements might include only: specific conductance, pH, DO, acidity, BOD, Fe, Mn, Cu, SO_4 , Cl and

fecal and total coliforms. These twelve tests will adequately show the status and trend of the stream's pollution. The first three tests could be done with field meters on site by park staff. The last two can be done in the park if modest laboratory facilities are set up. The other tests probably would be done outside, although it is not out of the question that the park also may want to equip a modest laboratory to run some of the chemical tests as well. A more complete list of variables should then be measured on a less frequent basis, to identify unexpected constituents. This is discussed further under recommendation 4 below. WRFSL is available to help develop lists of important variables in different watershed situations.

2. Use On-site Meters and Simple Tests

The more elaborate laboratory analyses, e.g., identifying metals, can be complemented by simple tests. For example, pH, conductivity and dissolved oxygen (DO) readings (all meters) are fast and relatively inexpensive field measurements that can be correlated with mine drainage acidity, total dissolved solids, certain salty impacts, sewage effects and other impacts and help greatly expand knowledge of stream water quality at a modest effort and expense. Likewise simple field test kits for chemicals (e.g., those of Hach Company), although not as precise or accurate as major laboratory analyses, are still valuable for expanding a data base inexpensively. We can assist in identifying this type of equipment.

It also is better if a park collects its own samples. Often being on site provides valuable interpretative clues as to why a

given pollutant is a problem. Also samples can be taken during storms or other periods of special interest.

3. Develop a Modest NERI Lab

For recreational waters, it is essential to observe certain key water indices frequently, such as bacterial counts. NERI should seriously consider having their own capability to make a few of these tests, possibly in conjunction with a local college, health agency, water treatment plant or other nearby facility already involved in such measurements. It would cost about \$4-5,000 to set up the bacterial equipment initially, but the recurring costs are negligible. Savings in contract costs should pay for the equipment in about 2-3 years in the case of bacteria.

4. Continue with Occasional Complete, Outside Laboratory Analyses

For the sake of a complete view, for quality control on simpler tests and to have an independent agency's impartial analyses, NERI should continue outside analyses, perhaps quarterly as now done. However, these tests also can be more focused. Some of the tests that have been run by WWRL will be seen to be of little interest or to be redundant after the first year of data and will not need to be run quarterly.

These outside laboratory analyses should be at a reasonable price. WRFSL can continue to assist in reviewing prices if NERI wishes, to help avoid some expense. We discuss prices below.

5. Get Stream Flow Data

Water quality measurements only have meaning when related to the volume of water flowing in a stream. For example, a sewer pipe dumps pollution into a stream at the same rate, whether during

stormy "dilution" periods or drought "concentration" periods. During wet periods the sewage impact may be minor; whereas, during periods of low flow the sewer pipe's input can seriously contaminate the stream's small volume of water. Conversely, acid pollutants from strip mining may be of little problem during dry spells but get flushed into the river as rain washes the land during storms. Therefore, water quality data are only meaningful if flow is known, at least in approximate quantities.

WRFSL will follow up with NERI on this point in terms of data needs, equipment, training required and other points where we could assist.

6. Use Laboratory Packages

Just as a restaurant's "special" can be a cheaper package than going a la carte, it also is often less expensive to use laboratory package analyses or suites of analysis rather than to price each constituent of concern separately. For this reason, it is advisable to inquire about package analyses and use them when possible. When using a package, some constituents may be measured which are not of particular concern, but if the overall price is below the sum of individual prices for items needed, the package is still the option of choice. Examples of package analyses run at the Colorado State University Soils Laboratory (CSUSL) and the U.S. Geological Survey (USGS) laboratory are compared to individual constituent pricing at the West Virginia Water Resources Laboratory (WVWRL) as shown in Tables 1 through 5. More and more laboratories tend to offer packages since frequently newer automated equipment can include several more constituents for little additional cost.

7. Aquatic Organisms

Some observations of stream aquatic organisms and fish have been made for NERI by researchers from Virginia Polytechnic Institute. Such biological surveys can be very useful from a pollution viewpoint, since the organisms are "integrating" all the complex pollutant effects. NERI may need to include some biological monitoring in its future programs.

WATER QUALITY EVALUATIONS

The Water Resources Laboratory reviewed the limited data which have been provided for Arbuckle Creek, Dunloup Creek, Piney Creek and the New River near Fayette, Hinton and Thurmond. The stations are described in Table 6. Insufficient data are available to perform meaningful statistical analysis, but inspection of maximum and minimum values of each measurement does allow a cursory evaluation of water quality with respect to stream criteria as shown in Table 7. This information is presented in Table 8 along with a rating of water quality.

Any interpretations of the water quality data gathered thus far can only be very preliminary at best. There are simply too few data points to say much, and without flow data interpretations can be tenuous, as discussed earlier. Nonetheless, our preliminary impressions are listed in Table 8, showing a rating of "1" if the water fits EPA's criteria for clean, "3" if polluted and "2" if borderline or marginal. We also can draw some general impressions from the data, as summarized below. The Table 8 ratings were made by comparing the raw data to Table 7 criteria values.

It is important to remember that there are no simple criteria. The toxicity of a substance depends on many factors, for example, pH and temperature. Also, the toxicity of an element depends on the compound that it occurs in. Finally, species of aquatic organisms vary greatly in their sensitivities to chemicals. Therefore, the criteria of Table 7 are only approximate values for the sake of a review of the New River's preliminary data.

1. Dissolved Oxygen (DO), COD and BOD: DO is very high (good) and BOD is generally no worse than "marginal" in the river's main stem, which is better than would be expected. Perhaps the main stream is generally well aerated and therefore able to handle the organic loads well, from a DO viewpoint. The tributaries have higher BOD and COD readings and are more polluted.
2. Acidity and pH: The pH values are acceptable for fish, and nearly all values are close to neutral pH 7.0 or only slightly acidic (between pH 6.0 and 7.0). Most acidity values are not bad and only "marginal" in a few cases. It should be noted that acidity and pH could be much worse during storms when land surfaces are flushed. It is not clear if distinct storm runoff periods were sampled or not in any of the samplings.
3. Coliform and Fecal Coliform Bacteria: The tributaries (Arbuckle, Dunloup, Piney) look to be very impacted by sewage, judging by the data; whereas, the New River sites appear to be only marginally affected, presumably benefitting from dilution.
4. Alkalinity and Hardness: The alkalinity readings are relatively high, meaning that the streams look well buffered. This buffering also is reflected in relatively high hardness and relatively high

Ca + Mg + Na + K readings, which are other indicators of a buffered stream. The buffering is holding down the acidity, at least during low flows. During high storm flows it is possible that acidity could dominate, especially given the pH 4.0 rains common to West Virginia.

5. Iron and Manganese: There are some very high readings for Fe and Mn for several of the sites, presumably reflecting mining influences. The Fe concentrations are somewhat higher than would be expected for the neutral pH readings, since usually Fe goes out of solution as pH goes up. A possible explanation is the high organic matter present, with which the iron will complex. Aluminum readings also look slightly high at some sites.
6. Turbidity and Suspended Sediment: Generally there are low readings only, indicating either: (i) there was little storm runoff sampled yet, or else (ii) there is simply little erosion in the area. We do not know which is the case.
7. Sulfates and Nitrogen: Some of the streams show relatively high readings of sulfates and nitrogen, which likely are reflecting the mining and sewage influences respectively. Some of the phosphorus levels also are slightly high, probably from sewage impacts.

In conclusion, from inspection of the limited information presently available, it appears that the water quality variables of greatest concern are those associated with mine drainage and sewage, for example, mine drainage constituents such as iron and manganese and waste water constituents such as fecal coliforms and BOD. The groups of variables discussed in 1-7 above should be part of any water quality monitoring program in the New River Gorge vicinity. Again it must be underscored

that these are very preliminary interpretations based on very little data so far.

COSTS OF ANALYSES

Methods Used to Compare Prices

The object of this summary is to compare analysis costs from some other laboratories and to provide an economic assessment of the present chemical analyses performed for New River Gorge NR by the West Virginia Water Resources Laboratory (WVWRL). The prices listed for the Colorado State University Soils Laboratory (CSUSL) and U.S. Geological Survey (USGS) laboratories, used as a comparison, are a function of the detection limits and vary somewhat depending on the lower detection limit used. The CSUSL and USGS laboratories offer multi-element packages for metals and alkaline earths for a greatly reduced price, as do most laboratories at this time. Such packages or suites of analyses have become common for many laboratories around the country during the last few years. These package prices are noted on Table 1 and illustrated in Tables 2, 3 and 4.

The tables summarize the cost analysis of 49 constituents at three laboratories:

Table 1. State of West Virginia Water Resources Laboratory (WVWRL), prices paid by New River Gorge NR, compared to CSUSL and USGS prices.

Table 2. A package price example from Colorado State University Soils Laboratory (CSUSL) with prices as paid by NPS-WRFSL for some of our work.

Table 3. A package price example from United States Geological Survey (USGS), Denver Laboratory, showing prices paid by NPS-WRFSL for some of our work.

Table 4. A second USGS price package for comparison.

Table 5. A price comparison of the constituents in which analysis by the WWRL turned out to be less expensive than the USGS.

Review of Expenditures

The prices charged by the West Virginia Water Resources Laboratory generally are higher than prices of the other two selected "yardstick" laboratories, as Tables 1-5 show, and considerably higher than some university laboratories would charge. Much of the WWRL costs could relate to the methods they used. For example, running tests for very low detection limits is always more expensive than looking only for higher levels. There is no advantage in running highly sensitive tests for a constituent found at high concentrations in a stream, so the extra expenditure should not be necessary. CSUSL runs its suite of 21 elements (Table 2) as an ICP spectrophotometer package for \$15.00 total, or less than \$1.00/element. This is a typical university or extension laboratory price. Table 3 shows a USGS package where \$65.00 is charged for 17 items, as compared to \$87.50 for only ten of the 17 items by WWRL. Table 4 shows another USGS package, also cheaper than WWRL. Table 5 illustrates that for 6 items WWRL is cheaper.

ICP spectrophotometer detection limits would be satisfactory and go down to EPA criteria levels for most metal/alkaline earth measurements in New River streams. Even where a few elements will need to be run by AA spectrophotometer or other methods, savings of \$125-150/sample could

still be realized by using the technically acceptable ICP package to cover all but a few of the metal/alkaline earths where ICP is judged not adequate.

Looking at Table 1 again, WWRL prices are very high on the electrode-made measurements: pH, conductivity, fluorides, and/or titration for Cl. These 4 items cost \$7.00 at CSU and \$25.87 at WWRL.

In summary, WWRL is priced high. New River Gorge NR will no doubt want to consider other analysis options with WWRL and no doubt seek quotations from other laboratories. If necessary, water samples can be shipped off for almost all analyses.

NERI also presumably can save some money by collecting their own samples. This point also is important in terms of better understanding the collected data, as mentioned earlier.

TABLE 1. Index of prices and packages for 49 constituents from three laboratories. (A) (B) and (C) indicate where an individual constituent is analyzed as part of a package program, as explained in the footnote.

CONSTITUENT	CSUSL Price/Sample	USGS Price/Sample	WVWRL Price/Sample
ALKALINITY (CaCO ₃)	1/	\$ 4.50	\$ 4.93
ARSENIC	\$ 2.50 (C)	\$19.25	\$12.32
BARIUM	\$ 2.50 (C)	\$11.30 (A)	\$ 9.86
BERYLLIUM	1/	\$11.30 (A)	1/
BORON	\$ 2.50 (C)	\$ 9.80	1/
CADMIUM	1/	\$ 6.95 (A)	\$ 9.86
CHROMIUM (HEX)	\$ 2.50 (C)	\$16.60	\$ 6.16
FECAL COLIFORMS	1/	1/	\$12.32
COLOR	1/	\$ 4.50	\$ 6.16
COPPER	\$ 2.50 (C)	\$ 6.95 (A)	\$ 9.86
CYANIDE	1/	\$20.95	1/
HARDNESS (CaCO ₃)	1/	1/	\$ 3.70
IRON	\$ 2.50 (C)	\$ 4.30 (A,B)	\$ 9.86
LEAD	\$ 2.50 (C)	\$ 7.85 (A)	\$ 9.86
MANGANESE	\$ 2.50 (C)	\$ 4.30 (A,B)	\$ 9.86
MERCURY	\$ 2.50 ^{2/} (C)	\$19.25	\$18.48
NICKEL	\$ 2.50 (C)	\$ 7.85	\$ 9.86
NITRATE/NITRITE	1/	\$ 4.30	\$ 6.16
TURBIDITY	1/	1/	\$ 6.16
CHLOROPHYLL-A	1/	1/	1/
ACIDITY (TOTAL)	1/	\$ 8.30	\$ 4.93
ACIDITY (HOT)	1/	1/	\$ 4.93
CHLORIDES	\$ 1.50	\$ 3.75	\$ 4.93
CONDUCTIVITY	\$ 1.50	\$ 1.25	\$ 6.16
FLUORIDES	\$ 2.50	\$ 6.65	\$12.32
pH	\$ 1.50	\$ 1.25 (A,B)	\$ 2.46
PHENOL	1/	1/	\$12.32
SUSPENDED SED	1/	1/	\$ 4.93
DISSOLVED SOLIDS	\$ 4.00	1/	\$ 4.93
NITROGEN AMMONIA	1/	\$ 4.30	\$ 9.86
NITROGEN, ORGANIC	1/	1/	1/
NITROGEN, TOT. KJELDAHL	1/	1/	\$18.48
PHOSPHORUS, TOTAL	\$ 2.50 (C)	\$12.10	\$12.32
PHOSPHATES, ORTHO	1/	\$ 6.75	\$ 6.16
THRESHOLD ODOR	1/	1/	\$ 6.16
C.O.D.	1/	1/	\$12.32
DO (% Sat)	1/	1/	\$ 6.16
BOD ₅	1/	1/	\$12.32
TOC ⁵	1/	1/	\$24.64
SULFATES	\$ 2.50	\$ 6.40	\$ 6.16
ANTIMONY	1/	\$14.25	\$ 9.86
CALCIUM	\$ 2.50	\$ 5.20 (A,B)	\$ 9.86
MAGNESIUM	\$ 2.50	\$ 5.20 (A,B)	\$ 9.86
SILVER	\$ 2.50	\$ 6.95	\$ 9.86

TABLE 1. continued

CONSTITUENT	CSUSL Price/Sample	USGS Price/Sample	WWRL Price/Sample
ZINC	\$ 2.50	\$ 5.95 (A)	\$ 9.86
POTASSIUM	\$ 2.50	\$ 4.30	\$ 9.86
SODIUM	\$ 2.50	\$ 3.75 (A,B)	\$ 9.86
ALUMINIUM	\$ 2.50	\$ 9.60	\$ 9.86

^{1/} The analysis was not listed in laboratory catalog.

^{2/} If desired detection limits for mercury are below that of I.C.P. then cold vapor techniques must be used. Cost = \$8.00/sample.

(A) - Included in USGS Package A. Total cost = \$65.00. See also Table 3 for details.

(B) - Included in USGS Package B. Total cost = \$22.50. See also Table 4 for details.

(C) - Included in CSUSL Package C. Total cost = \$15.00. See also Table 2 for details.

TABLE 2. Price comparison between CSUSL Package "C" costing \$15.00 and individual constituent analysis by WWRL where same constituents run individually cost \$171.30.

CONSTITUENT	CSUSL PACKAGE "C"	WWRL Price/Sample
CALCIUM		\$ 9.86
MAGNESIUM		\$ 9.86
SODIUM		\$ 9.86
POTASSIUM		\$ 9.86
PHOSPHORUS		\$12.32
ALUMINUM		\$ 9.86
ZINC		\$ 9.86
IRON		\$ 9.86
COPPER		\$ 9.86
MANGANESE		\$ 9.86
NICKEL		\$ 9.86
LEAD		\$ 9.86
CHROMIUM		\$ 6.16
CADMIUM		\$ 9.86
MOLYBDENUM		1/
BORON		1/
BARIUM		\$ 9.86
STRONTIUM		1/
TITANIUM		1/
ARSENIC		\$12.32
SELENIUM		\$12.32
	\$15.00	\$171.30
		TOTAL PRICE

1/Analysis for this constituent not performed at the WWRL. No cost was added to total cost for this constituent.

TABLE 3. Price comparison between USGS Package "A" and individual constituent analysis by WWRL.

CONSTITUENT	USGS PACKAGE "A"	WWRL Price/Sample
BARIUM		\$ 9.86
BERYLLIUM		1/
CADMIUM		\$ 9.86
COBALT		1/
COPPER		\$ 9.86
IRON		\$ 9.86
LEAD		\$ 9.86
LITHIUM		1/
MANGANESE		\$ 9.86
MOLYBDENUM		1/
SILICA		1/
SODIUM		\$ 9.86
SSTRONTIUM		1/
VANADIUM		1/
ZINC		\$ 9.86
pH		\$ 2.46
SPECIFIC CONDUCTANCE		\$ 6.16
	\$65.00	\$87.50
		TOTAL COST

1/ Analysis for this constituent not performed at the WWRL. No cost was added to total cost for this constituent.

TABLE 4. Price comparison between USGS Package "B" and individual constituent analysis WWRL.

CONSTITUENT	USGS PACKAGE "B"	WWRL Price/Sample
CALCIUM		\$ 9.86
IRON		\$ 9.86
MAGNESIUM		\$ 9.86
MANGANESE		\$ 9.86
SILICA		$\frac{1}{/}$
SODIUM		\$ 9.86
pH		\$ 2.46
SPECIFIC CONDUCTIVITY		\$ 6.16
	\$22.50	\$57.92
		TOTAL COST

$\frac{1}{/}$ Analysis for this constituent not performed at the WWRL. No cost was added to total cost for this constituent.

TABLE 5. A list of constituents in which the WWRL is less expensive than the USGS.

CONSTITUENT	CSUSL Price/Sample	USGS Price/Sample	WWRL Price/Sample
BARIUM	\$ 2.50 (C)	\$11.30 (A)	\$ 9.86
CHROMIUM (HEX)	\$ 2.50 $\frac{2}{/}$ (C)	\$16.60	\$ 6.16
MERCURY	\$ 2.50 $\frac{2}{/}$ (C)	\$19.25	\$18.48
ACIDITY (TOTAL)	$\frac{1}{/}$	\$ 8.30	\$ 4.93
PHOSPHATES (ORTHO)	$\frac{1}{/}$	\$ 6.75	\$ 6.16
SULFATES	\$ 2.50	\$ 6.40	\$ 6.16

$\frac{1}{/}$ The analysis was not listed in laboratory catalog.

(A) - Included in USGS Package A. Total cost = \$65.00.

(C) - Included in CSUSL Package C. Total cost = \$15.00.

TABLE 6. Station cost analysis and brief, general description of main concerns at each site, as WRFSL staff understand the situation at this time.

	W.V. Cost
I. MOST COMPLETE ANALYSIS 3 Times/year at \$443.60/sample	
1. <u>N.R. below Hinton STP</u> Just below dam, on main stem (MS), 2 miles upstream from park boundary. Probably receives <u>sewage</u> (treatment)	\$1392.50
2. <u>Thurmond</u> Downstream below Hinton, about in the middle of the park, where <u>many rafts</u> are put in. Commercial rafting trip launching site. <u>No toilet facilities.</u>	\$1330.80
3. <u>N.R. at Fayette Station</u> Take-out point for the rafts. No toilet facilities. Lower end of park.	\$1330.80
II. LESS COMPLETE ANALYSIS 3 Times/year at \$209.00/sample	
4. <u>Mouth of Dunloup Creek</u> Flows into MS at Thurmond. Large tributary. <u>Some sewage</u> in Creek but water quality has been improving and trout are being planted. <u>Some rafts</u> are put in here.	\$ 621.00
5. <u>Mouth of Arbuckle Creek</u> Downstream from Dunloup/Thurmond. Smaller than station #4. Some private and industrial <u>sewage</u> . One of the more <u>polluted</u> tributaries.	\$ 621.00
6. <u>Mouth of Wolfe Creek</u> Flows into MS at Fayette Station, for downstream in the park. Possibly picking up MS sewage from Fayetteville. Also some <u>mine drainage</u> .	\$ 621.00
7. <u>Mouth of Meadow Creek</u> Located at the east side of gorge and flows into village of Meadow Creek. Individual houses all along the creek, apparently with some house <u>sewage</u> impacts and some <u>mine influences</u> .	\$ 621.00
8. <u>Mouth of Laurel Creek</u> Flows directly through Fayetteville (by Wolfe Creek) but downstream from park below Wolfe Creek. Probably not much industrial sewage pollution.	\$ 621.00

TABLE 6. continued

	W.V. Cost
III. A FEW NATURAL PARAMETERS ONLY at \$69.00/sample	
9. <u>Mouth of Glade Creek</u> Probably one of the better stations in terms of water quality. <u>Trout fishing</u> is popular there. The new I-64 bridge will cut across Glade Creek area of North River, probably with some sediment. The station is upstream from Grand View State Park and Prince.	\$ 207.00
IV. DATA COLLECTED BY STATE	
10. <u>Piney Creek</u> Comes in from the city of Beckley, flowing in near Prince on the Mississippi. <u>Probably the most polluted</u> stream of all.	

TABLE 7. Some approximate criteria or examples of toxic bioassay findings, for use as a first review of New River data.

CONSTITUENTS	DRINKING WATER CRITERIA	GENERAL FOR AQUATIC LIFE ^{1/}	OTHER USES OR NOTES
ALKALINITY (CaCO ₃)	--	20 mg/L minimum (E)	--
AMMONIA (NH ₃ + NH ₄)	--	about 20 µg/L (NH ₃) but very pH dependent (E); up to 11 mg/L NH ₄ (E)	--
ARSENIC	50 µg/L limits (E)	50 µg/L (E)	100 µg/L limit (irrigation) (E)
BARIUM	1.0 mg/L (E)	50 mg/L ^{2/} (E)	--
BERYLLIUM	--	approx. 0.01 mg/L (soft) to 1.1 mg/L (hard) limit (E)	0.1-0.5 mg/L limit (irrigation) (E)
BORON	30 mg/L (M)	up to 2,000 mg/L limit as boric acid (M)	0.75 mg/L limit (irrigation) (E)
CADMIUM	10 to 60 µg/L limit (E)	approx. 0.4 (soft) to 12.0 µg/L (hard) limit (E)	--
CHLORINE (gas)	above 5.2 mg/L causes taste problem	2.0 for salmonids to 10.0 µg/L limit for some other organisms (E)	--
FECAL COLIFORMS	None allowed if drinking water	14-43 MPN per 100 ml (shellfish waters) in reference to meat contamination (E)	200-400/100 ml MF (bathing) 200-400 MPN/100 ml (E)

TABLE 7. continued, p. 2 of 6.

CONSTITUENTS	DRINKING WATER		GENERAL FOR AQUATIC LIFE ^{1/}	OTHER USES OR NOTES
	CRITERIA			
COLOR	75 platinum-cobalt units max			
COPPER	1.0 mg/L max; mainly taste limited (E,M)	60 µg/L (soft) to 600 µg/L (very hard)		salmonids very sensitive to Cu
CYANIDE	0.01 mg/L max (M)	5 µg/L (E)		
CHROMIUM	50 µg/L	100 µg/L		
HARDNESS (as mg/L CaCO ₃)	best if below 250 mg/L for culinary (M)	(75 = "soft", 150-300 = "hard", over 300 = "very hard" waters (mg/L) (E)		generally more "hardness" helps reduce metal toxicity, effects, therefore beneficial
IRON	0.3 mg/L limit (E)	1.0-10.0 mg/L (E)		--
LEAD	50 µg/L limit (E)	about 100 µg/L max (M)		
MANGANESE	0.05 mg/L limit (0.150, taste) (E)	limit ranges from 1.5 mg/L to much higher for some species (E)		0.1 mg/L for shellfish waters where bioaccumulation possible (E)
MERCURY	2 µg/L limit (E)	0.05 µg/L based on allowing only 0.5 mg/kg in fish flesh (E)		
NICKEL	--	up to 380 µg/L in hard water not harmful to fatheads. By 500 µg/L, some species are harmed (E)		500 µg/L can damage some plants (E)

TABLE 7. continued, p. 3 of 6.

CONSTITUENTS	DRINKING WATER CRITERIA	GENERAL FOR AQUATIC LIFE ^{1/}	OTHER USES OR NOTES
NITRATES (NO ₃) OR NITRITES (NO ₂)	10 mg/L limit for NO ₃ ; 1 mg/L for infant feedings (E)	NO ₃ at 90 mg/L and NO ₂ at 5 mg/L for warm waters, but nitrite at only 0.06 mg/L could harm salmonoids (E)	Industry generally <50 mg/L (E)
TURBIDITY	could filter but will cost to do so; about 5 units limit (E,M)	about 200 units should be tolerable (M)	some industrially
SULFATES	250 mg/L (M)	90 mg/L (M)	most industries need <100 mg/L
ANTIMONY (Sb)	--	10 mg/L or more of the most common Sb compounds, as Sb, are toxic to fish	usually precipitates out and thus is not present in many streams
CALCIUM	upper limit is 150 mg/L (M)	is usually beneficial and hence not usually a concern	for many industries the upper limit is 100 mg/L
MAGNESIUM	limit is 100-200 mg/L (M)	about 300 mg/L harms some fish, although many species more tolerant	main problem is with sulfates
SELENIUM	limit is 10 µg/L (E)	a level of 2.5 mg/L (M) is toxic and limit should be 0.025 mg/L	
SILVER	limit is 0.05 mg/L (E)	70 µg/L is toxic to bass (E) but toxicity varies much for species	
ZINC	5 mg/L limit (E)	about 0.4 (E) to 1.0 (M) mg/L max	0.1 mg/L is limit for irrigation

TABLE 7. continued, p. 4 of 6.

CONSTITUENTS	DRINKING WATER		OTHER USES OR NOTES
	CRITERIA	GENERAL FOR AQUATIC LIFE ^{1/}	
POTASSIUM	350 mg/L as KCl makes taste problem	50 mg/L as KCl toxic to some fish	over 50 mg/L as KCl problem to some industry
SODIUM	115 mg/L as NaCl limit (M)	500-1000 mg/L NaCl range where upper limit to most aquatic organisms falls (M)	depends on the component that sodium is in
ALUMINUM	normally not a concern (M)	0.25 mg/L limit (M) and some fish even more sensitive	0.1 mg/L may cause eye irritation (M)
ACIDITY (TOTAL)	can be treated	about 25-50 mg/L starts killing fish (M)	
CHLORIDES	125 mg/L desirable limit (M)	by 400 mg/L some fish are harmed (M)	
COLIFORMS	can be chlorinated	normally not a concern for fish as such	bathing and recreation, about 1000/100 mL
FECAL STREPTOCOCCUS	can be chlorinated		bathing is similar to coliforms
FLUORIDES	1.5 mg/L (M)	1.5 mg/L (M)	
pH	6.0-8.5 best but 5.0-9.0 are accept-extremes (E)	4.5-8.4 in general is best for fish; 4.5 lower limit for trout (M)	
PHENOL	limit is 1-2 µg/L, usually taste limits (M)	best keep under 200 µg/L for fish	terrible taste, especially with Cl ₂

TABLE 7. continued, p. 5 of 6.

CONSTITUENTS	DRINKING WATER CRITERIA	GENERAL FOR AQUATIC LIFE ^{1/}	OTHER USES OR NOTES
SUSPENDED SEDIMENTS	can be filtered out; 0.1 mg/L limit (M)	over 500 mg/L for extended periods is undesirable	
DISSOLVED SOLIDS	500 mg/L (M)	normally not a concern as such	--
NITROGEN AS ORGANIC	approx. 10 mg/L (M)	below 10 mg/L desirable	need below 0.3 mg/L to avoid algal blooms
NITROGEN AS TOTAL KJELDAHL	limit of 10 mg/L (M)	limit of 0.3 mg/L for preventing algal blooms and under 10 mg/L otherwise	--
TOTAL PHOSPHORUS	limit of 50 µg/L (M)	limit of approx 100 µg/L (E)	not toxic as such in levels usually found in streams although may lead to algal problems
ORTHO-PHOSPHATE PHOSPHORUS	limit of 50 µg/L (M)	best to keep under 100 µg/L (E)	not toxic in levels usually found in most streams
THRESHOLD ODOR		phenol odors of over 15 µg/L ruin fish meat	--
C.O.D.	--	as much as 12 mg/L typical background, and treated sewage runs about 25-80 mg/L	indicates chemical or industrial components likely to require oxygen in streams
B.O.D.	2.5-4.0 is monthly max. upper limit in water supply	approx. 5-50 mg/L but depending on streams aeration capabilities	note that leaves and other natural organics also have BOD

TABLE 7. continued, p. 6 of 6.

CONSTITUENTS	DRINKING WATER CRITERIA	GENERAL FOR AQUATIC LIFE ^{1/}	OTHER USES OR NOTES
D.O. or % Sat of D.O.	--	approx. 5.0-6.0 mg/L minimum needed for most fish, but depends on temperature	--
T.O.C.	--	--	indicates organic waste and phytoplankton

^{1/}We show general ranges of criteria (these are reference "E" or "K") instead of a single value if the allowable levels vary considerably for hard vs. soft water or for various organism species, or if there is a range of opinion on the lower limit permissible. In most cases our numbers come from EPA criteria. Remember that individual species vary greatly in their sensitivity. Some of these are bioassay toxicity levels - not criteria, coming from references D and M. See Principal References section for explanation of reference letters..

^{2/}Usually no practical limit in streams as barium precipitates out.

Tables 8a-8f. An approximate preliminary appraisal of the water quality data for New River Gorge National River based on comparing the first few batches of New River data to the criteria listed in Table 7; n = number of data points, Maximum = maximum value of constituent, Minimum = minimum value of constituent, Rating = water quality evaluation. (Rating = 1 means acceptable, Rating = 2 means marginal, and Rating = 3 means unacceptable concentration of variable). All concentrations are in mg/l unless otherwise noted.

TABLE 8a. Arbuckle Creek.

	n	Maximum	Minimum	Rating
TOC	4	10	6	--
DO Field	5	12.1	8.9	1
DO (% sat)	5	104	98	--
BOD	4	>8.1	2.0	2
Mineral Acidity	2	<1	<1	--
Total Acidity	5	3	1	1
Hot Acidity	5	<1	<1	--
Total Alkalinity	5	141	53	1
Coliform (MF/100 ml)	5	>350,000	13,000	3
Fecal Coliform (MF/100 ml)	5	>36,000	300	3
Color (units)	1	15	--	1
Conductance (micromhos/cm)	5	678	319	--
Conductance Field (micromhos/cm)	5	701	281	--
Hardness	5	212	96	2
pH Field (units)	5	8.3	7.3	1
pH Lab (units)	5	8.1	7.7	1
Phenol (µg/l)	5	5	2	2
Total Suspended Solids	5	538	3	2
Total Dissolved Solids	5	450	148	1
Temperature (°C)	5	17	6.4	1
Fe (µg/l)	5	17,800	480	3
Mn (µg/l)	5	960	40	2
Organic-N	5	1.80	0.28	2
NH ₄ -N	5	1.40	0.05	2
Kjeldahl-N	5	3.20	0.33	3
NO ₂ + NO ₃	5	5.00	0.70	1
Total P ³	5	1.60	0.22	2
Ortho P	5	1.55	0.08	2
Odor	2	2	1.4	--
COD	5	19	<4	2-3
SO ₄	5	174	37	3
Turbidity (units)	5	148	5	1

TABLE 8b. Dunloup Creek.

	n	Maximum	Minimum	Rating
TOC	4	7	5	--
DO Field	5	12	9.3	1
DO (% Sat)	5	112	99	--
BOD	4	4.3	1.2	2
Mineral Acidity	2	<1	<1	--
Total Acidity	4	2	<1	1
Hot Acidity	5	<1	<1	--
Total Alkalinity	5	133	34	1
Coliform (MF/100 ml)	5	>210,000	4,100	3
Fecal Coliform (MF/100 ml)	5	3,600	100	3
Color (units)	1	10	10	1
Conductance (micromhos/cm)	5	577	270	--
Conductance Field (micromhos/cm)	5	589	271	--
Hardness	5	138	86	--
pH (units)	4	8.3	6.5	1
pH Lab (units)	5	8.5	7.3	1
Phenol ($\mu\text{g}/\ell$)	5	17	<1	2
Total Suspended Solids	5	214	1	1
Total Dissolved Solids	5	380	142	1
Temperature ($^{\circ}\text{C}$)	5	17.6	6.1	1
Fe ($\mu\text{g}/\ell$)	5	8,600	80	2
Mn ($\mu\text{g}/\ell$)	5	800	10	2
Organic-N	5	0.23	0.10	1
$\text{NH}_4\text{-N}$	5	0.09	0.02	1
Kjeldahl-N	5	0.27	0.18	1
$\text{NO}_2 + \text{NO}_3$	5	0.56	0.17	1
Total P	5	0.28	0.02	1
Ortho P	5	0.080	0.014	1
Odor	1	1.4	1.4	--
COD	5	58	<4	3
Sulfates	5	148	76	3
Turbidity (units)	5	84	3	1

TABLE 8c. Piney Creek near McCreery.

	n	Maximum	Minimum	Rating
TOC	3	7	5	--
DO Field	3	14	8.6	1
DO (% Sat)	3	110	103	--
BOD	3	9	1.4	2
Hot Acidity	3	<1	<1	1
Total Alkalinity	3	24	8	2
Cl	3	20	17	1
Chromium Hex ($\mu\text{g}/\ell$)	3	<1	<1	--
Coliform (MF/100 ml)	3	>111,000	3,200	3
Fecal Coliform (MF/100 ml)	3	>18,300	300	3
Color (units)	3	10	5	1
Conductance (micromhos/cm)	3	233	131	--
Conductance Field (micromhos/cm)	3	215	190	--
Fl	3	0.11	0.08	1
Hardness	3	66	52	--
pH (units)	3	7.2	7.0	1
pH Lab (units)	3	7.5	7.0	1
Phenol ($\mu\text{g}/\ell$)	3	3	2	2
Total Suspended Solids	3	17	12	1
Total Dissolved Solids	3	129	110	1
Temperature ($^{\circ}\text{C}$)	3	19.5	<0.1	2
Al ($\mu\text{g}/\ell$)	1	780	--	2
As ($\mu\text{g}/\ell$)	3	<2	<2	1
Sb ($\mu\text{g}/\ell$)	1	<40	--	--
Ba ($\mu\text{g}/\ell$)	1	40	--	1
Cd ($\mu\text{g}/\ell$)	3	<1	<1	1
Cu ($\mu\text{g}/\ell$)	3	6	3	1
Fe ($\mu\text{g}/\ell$)	3	1,200	483	2
Pb ($\mu\text{g}/\ell$)	3	<20	<20	1
Mn ($\mu\text{g}/\ell$)	1	249	60	1
Ni ($\mu\text{g}/\ell$)	1	10	--	1
Hg ($\mu\text{g}/\ell$)	1	<0.1	--	2
Se ($\mu\text{g}/\ell$)	1	2	--	1
Ag ($\mu\text{g}/\ell$)	1	<2	--	1
Zn ($\mu\text{g}/\ell$)	1	30	--	1
K	1	1.8	--	1
Na	1	18	--	1
Total Chromium ($\mu\text{g}/\ell$)	1	<4	--	
NH ₄ -N	3	0.53	0.05	1
Kjeldahl-N	3	0.50	0.20	2
NO ₂ + NO ₃	3	1.06	0.50	1
Cyanide	3	0.004	0.001	2
Total P	3	0.420	0.165	1
Ortho P	3	0.146	0.068	1
Odor	2	1.4	1.4	--
SO ₄	3	49	39	1
Turbidity (units)	3	2	1	1

TABLE 8d. New River near Fayette.

	n	Maximum	Minimum	Rating
TOC	4	10	4	--
DO Field	4	13.2	7.7	1
DO (% Sat)	4	109	98	--
BOD	3	2.5	0.5	1
Mineral Acidity	2	<1	<1	--
Total Acidity	4	16	2	2
Hot Acidity	4	<1	<1	--
Total Alkalinity	4	57	42	1
Cl	4	9	6	1
Chromium Hex ($\mu\text{g}/\ell$)	4	2	<1	
Coliform (MF/100 ml)	4	3,300	500	2
Fecal Coliform (MF/100 ml)	4	300	30	2
Color (units)	4	20	5	1
Conductance (micromhos/cm)	4	158	133	
Conductance Field (micromhos/cm)	4	174	122	
Fl	4	0.10	0.05	1
Hardness	4	84	66	--
pH Field (units)	4	7.7	6.9	1
pH Lab (units)	4	7.9	7.3	1
Phenol ($\mu\text{g}/\ell$)	4	3	<1	2
Total Suspended Solids	4	24	4	1
Total Dissolved Solids	4	122	71	1
Temperature ($^{\circ}\text{C}$)	4	24.9	4.6	2
Al ($\mu\text{g}/\ell$)	4	720	80	2
As ($\mu\text{g}/\ell$)	4	3	<2	1
Sb ($\mu\text{g}/\ell$)	4	<40	<20	--
Ba ($\mu\text{g}/\ell$)	4	40	22	1
Cd ($\mu\text{g}/\ell$)	4	<1	<1	1
Ca	4	17	11	1
Cu ($\mu\text{g}/\ell$)	4	3	<2	1
Fe ($\mu\text{g}/\ell$)	4	1,120	160	2
Pb ($\mu\text{g}/\ell$)	4	<20	<10	1
Mg	4	7	4.4	1
Mn ($\mu\text{g}/\ell$)	4	100	30	1
Ni ($\mu\text{g}/\ell$)	4	10	40	1
Hg ($\mu\text{g}/\ell$)	4	0.1	<0.1	2
Se ($\mu\text{g}/\ell$)	3	1	<1	1
Ag ($\mu\text{g}/\ell$)	4	<2	<2	1
Zn ($\mu\text{g}/\ell$)	4	10	3	1
K	4	1.8	1.1	1
Na	4	6	3.5	1
Total Chromium ($\mu\text{g}/\ell$)	4	<4	<4	
Organic-N	4	0.17	0.04	1
NH ₄ -N	4	0.19	0.05	1
Kjeldahl-N	4	0.23	0.18	1
NO ₂ + NO ₃	4	0.99	0.45	1
Cyanide	4	0.002	0.001	1
Total P	4	0.065	0.035	1
Ortho P	4	0.035	0.009	1
Odor	4	2	1.4	--
COD	4	23	<4	2
SO ₄	4	21	14	1
Turbidity (units)	4	18	4	1

TABLE 8e. New River near Hinton.

	n	Maximum	Minimum	Rating
TOC	5	9	3	--
DO Field	5	12.8	7.9	1
DO (% Sat)	5	111	92	
BOD	4	2.8	0.8	1
Mineral Acidity	2	<1	<1	--
Total Acidity	5	4	2	1
Hot Acidity	5	<1	<1	--
Total Alkalinity	5	72	30	1
Cl	5	7	5	1
Chromium Hex ($\mu\text{g}/\ell$)	5	2	<1	
Coliform (MF/100 ml)	5	5,100	<100	2
Fecal Coliform (MF/100 ml)	4	550	80	2
Color (units)	5	45	5	1
Conductance (micromhos/cm)	5	235	116	
Conductance Field (micromhos/cm)	4	205	96	
Fl	5	0.10	0.04	1
Hardness	5	90	52	--
pH (units)	5	7.6	6.5	1
pH Lab (units)	5	7.8	6.9	1
Phenol ($\mu\text{g}/\ell$)	5	11	<1	2
Total Suspended Solids	5	70	1	1
Total Dissolved Solids	5	125	64	1
Temperature ($^{\circ}\text{C}$)	5	23.9	5.6	2
Al ($\mu\text{g}/\ell$)	5	3,060	44	3
As ($\mu\text{g}/\ell$)	5	4	<2	1
Sb ($\mu\text{g}/\ell$)	5	<40	<20	--
Ba ($\mu\text{g}/\ell$)	5	44	20	1
Cd ($\mu\text{g}/\ell$)	5	6	<1	2
Ca	5	23	11	1
Cu ($\mu\text{g}/\ell$)	5	4	<2	1
Fe ($\mu\text{g}/\ell$)	5	5,100	120	3
Pb ($\mu\text{g}/\ell$)	5	<20	10	1
Mg ($\mu\text{g}/\ell$)	5	9.5	4	1
Mn ($\mu\text{g}/\ell$)	5	164	26	1
Ni ($\mu\text{g}/\ell$)	5	10	<10	1
Hg ($\mu\text{g}/\ell$)	5	0.2	<0.1	2
Se ($\mu\text{g}/\ell$)	4	<1	<1	1
Ag ($\mu\text{g}/\ell$)	5	<2	<1	1
Zn ($\mu\text{g}/\ell$)	5	22	4	1
K	5	1.8	1.1	1
Na	5	5.2	3.4	1
Total Chromium ($\mu\text{g}/\ell$)	5	4	<4	
Organic-N	5	0.28	0.10	1
NH ₄ -N	5	0.12	0.06	1
Kjeldahl-N	5	0.40	0.17	1
NO ₂ + NO ₃	5	0.71	0.45	1
Cyanide ³	5	0.002	0.001	1
Total P	5	0.110	0.035	1
Ortho P	5	0.077	2.001	1
Odor	5	4	1.4	--
COD	5	12	<4	2
SO ₄	5	25	12	1
Turbidity (units)	5	52	3	1

TABLE 8f. New River near Thurmond.

	n	Maximum	Minimum	Rating
TOC	4	13	4	--
DO Field	4	12.4	7.7	1
DO (% Sat)	4	104	91	
BOD	3	2.8	0.7	1
Mineral Acidity	2	<1	<1	--
Total Acidity	4	3	<1	1
Hot Acidity	4	<1	<1	--
Total Alkalinity	4	59	4	1-2
Cl	4	7	5	1
Chromium Hex ($\mu\text{g}/\ell$)	4	<1	<1	
Coliform (MF/100 ml)	4	3,000	600	2
Fecal Coliform (MF/100 ml)	4	360	<10	2
Color (units)	4	20	15	1
Conductance (micromhos/cm)	4	157	136	
Conductance F (micromhos/cm)	4	174	125	
Fl	4	0.09	0.05	1
Hardness	4	86	60	--
pH (units)	4	7.7	6.6	1
pH Lab (units)	4	8.2	7.2	1
Total Suspended Solids	4	15	2	1
Total Dissolved Solids	4	116	74	1
Temperature ($^{\circ}\text{C}$)	4	25.5	5.1	2
Al ($\mu\text{g}/\ell$)	4	680	100	2
As ($\mu\text{g}/\ell$)	4	8	<2	1
Sb ($\mu\text{g}/\ell$)	4	<40	<20	--
Ba ($\mu\text{g}/\ell$)	4	50	28	1
Cd ($\mu\text{g}/\ell$)	4	4	1	1
Ca	3	17	12	1
Cu ($\mu\text{g}/\ell$)	4	2	2	1
Fe ($\mu\text{g}/\ell$)	4	990	220	2
Pb ($\mu\text{g}/\ell$)	3	<20	<10	1
Mg ($\mu\text{g}/\ell$)	4	7	4.7	1
Mn ($\mu\text{g}/\ell$)	4	86	26	1
Ni ($\mu\text{g}/\ell$)	3	<10	<10	1
Hg ($\mu\text{g}/\ell$)	4	<0.10	<0.10	1
Se ($\mu\text{g}/\ell$)	3	2	<1	1
Phenol ($\mu\text{g}/\ell$)	4	6	3	2
Ag ($\mu\text{g}/\ell$)	4	<2	<2	1
Zn ($\mu\text{g}/\ell$)	4	10	3	1
K	4	1.8	1.1	1
Na	4	5.5	3.0	1
Total Chromium ($\mu\text{g}/\ell$)	4	<4	<4	
Organic-N	4	0.24	0.13	1
NH ₄ -N	4	0.07	0.04	1
Kjeldahl-N	4	0.28	0.20	1
NO ₂ + NO ₃	4	0.90	0.37	1
Cyanide	4	0.002	0.001	1
Total P	4	0.080	0.025	1
Ortho P	4	0.027	0.012	1
Odor	4	2	1.4	--
COD	4	12	<4	2
SO ₄	4	21	12	1
Turbidity (units)	4	14	3	1

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^{1/}These are the letters used in Table 7.

