A METHOD TO SIMPLY PRIORITIZE AND ASSIST MONITORING STATION SELECTION

A METHOD TO SIMPLY PRIORITIZE AND ASSIST MONITORING STATION SELECTION

DATA ANALYSIS BRANCH

SURVEILLANCE & ANALYSIS DIVISION

REGION VIII - ROCKY MOUNTAIN PRAIRIE REGION

U. S. ENVIRONMENTAL PROTECTION AGENCY

DENVER, COLORADO

NOVEMBER, 1976

FOREWORD

Many techniques have been and are being developed to prioritize monitoring station locations and to offer a better monitoring strategy. This paper is basically an empirical effort, which, if it improves the allocation of resources; regardless of the underlying pitfalls or lack of scientific astuteness, will make the effort worthwhile.

Elaborate, statistical formulae are often used to abstract the real world into a model. In most, if not all, cases the dynamics of broad-based, natural conditions create significant perturbations. Too many dynamic interactions elude quantification. Qualitative judgements and common sense must, it seems, always accompany the quantitative workup.

INTRODUCTION

Selection of primary trend monitoring stations to include in a state or regional network is an artful process. Constrained by very limited or diminishing resources the job is made much more demanding.

Classically, the rationale for initial station selection is based on determining "worst" polluted areas, sorting out man's responsibility and focusing needed cleanup on these areas. As resources expand stations may be added to examine pristine conditions and/or to answer the question, "Are cleanup programs and/or grants-in-aid cost effective as they relate to the national goals of maximum attainability of fishable and swimmable waters?" Non-degradation analysis becomes important as land uses become potentially disruptive. A more richly endowed program may also grow to include lake and groundwater stations and to meet other still more specific needs.

Determination of trends is difficult in the dynamic water environment. Trend data must frequently be gathered over protracted periods to even out long term "natural" variations. Documentation of the complex phenomena related to runoff and other trends related to relatively infrequent events may require many years of data. Monitoring programs begun today can only aid the water quality manager of the future.

Many concerns impact station selection. Examples of high concern are intakes at public water supplies and heavily used recreation areas. Other more specific concerns relate to station location along Wild and Scenic rivers,

at important commercial fisheries, at major confluences, below dams, above and below major point sources, at state and international boundaries, above and below major federal grant projects and/or in relation to other developed areas such as timberlands, grazelands, etc. As one concern for selection interacts with another either stronger or weaker justification for station selection or station retention evolves.

The task of allocating our resources in the proper or best mix must address the realities of flow, channel, and other morphometric characteristics, Low or no flows, and shallow meandering conditions can reduce the importance of a seemingly important watercourse. Conditions, such as channelization and dams, reduces the dynamics of a watercourse and the consequent need for frequent monitoring. High sediment related to infrequent runoff events may require special "on-off" monitoring apparatus.[1]

So far this discussion is really an affirmation of what concerns or considerations the water quality manager already deals with. By taking this discussion one step further a quantitative technique is given which should aid water quality managers structure their program priorities.

This technique quantifies "worst", to "least" pollution at primary stations in Region VIII from 1970 thru 1975, specifically, at National Stream Accounting Network (NASOAN) sites, National Water Quality Surveillance System (NWQSS) locations and at "primary" state monitoring stations. Quantification is based on a

[1]Quantification of Pollutants in Agricultural Runoff, J. N. Dornbush, et al. EPA 23:66012-74-005, 1974.

developed approach comparable to one outlined in "Quantitative Methods for Preliminary Design of Water Quality Surveillance Systems - 1972" (EPA-R5-72-001). This modified technique gauges seven important parameters at each station. In turn, the average station value or station priority is determined from the individual parameter values. Stations are ranked from highest (worst) to lowest (least) station priority value. Rationale and calculation of the ranking is based on the formula as shown in Table 1.

Data in each of seven (7) parameter areas; namely BOD, nitrogen, phosphorous, dissolved solids, DO, fecal coliform and turbidity; were known to be reasonably well distributed and generally sampled at monthly intervals. Each were individually examined and developed for ranking calculation. (A general bias toward sewage treatment plants, non-point sources and some industrial discharges is present, however, this is not considered a serious limitation, but rather a general bias toward parameters of national significance.)

TABLE 1

RANKING SYSTEM *

	PARAMETER AREA	EDITING LIMITS	CALCULATION
1.	BOD mg/l	0 - 100	Mean — 5 Hi-15% Standard dev.
2.	N mg/l	0 - 20	Mean — 0.6 Hi-15% Standard dev.
	NO_3 mg/l	0 - 60	Mean — 2.6 Hi-15% Standard dev.
3.	P mg/l	0 - 20	Mean — 0.03 Hi-15% Standard dev.
	PO_4 mg/l	0 - 60	Mean — 0.09 Hi-15% Standard dev.
4.	Dissolved residue mg/l	0 - 10,000	Mean — 500 Hi-15% Standard dev.
5.	D.O. mg/l	0 - 20	5.0 — Low value
6.	F. Coli. #/100ml	0 - 5,000,000	Log High Value — 2.3 (Log 2.3 = 200)
7.	Turbidity JTU's or FTU's	None	Harmonic Mean of — 25 High 15% Harmonic Standard dev.

AVERAGE OF 1-7 = STATION RANKING

* Values used as acceptable levels were selected from a general review of State Standards, EPA's "Water Quality Criteria-1972,"and Region VIII's "Water Quality Inventory-1975".

More site-specific parameters; such as, cyanide, zinc, mercury and/or biological indicators as available can be used to supplement the basic ranking.

STATION RANKING CALCULATION

The simple priority approach, suggested by the more complex process of Beckers, et.al.,[2] was first used to attempt station ranking. The following modified formula was later used at the basis for the station ranking.

$$\text{Priority\#} = \frac{\text{Mean of the high 15\% of the observations} - \text{Level of acceptable concentration}}{\text{Standard deviation of the observations}}$$

Some parameter areas did become distorted by use of this simple formula. An arithmetric mean of "the high 15" was only useful for BOD, nitrogen, phosphorous, and dissolved residue. Distortions resulted from use of the arithmetic mean for D.O., fecal coliform and turbidity and the following special treatment was developed for each of these areas.

D.O. and fecal coliform were treated such that the "worst" event which might temporarily damage or render an ecosystem suspect for continued body contact recreation, were used as the basis for ranking.

The formula used for D.O. is based on the lowest recorded D.O. condition so the calculation becomes:

[2]Quantitative Methods for Preliminary Design of Water Quality Surveillance Systems, 1972; Charles V. Beckers, et.al., EPA-R5-72-001.

$$\text{Priority\#} = \begin{array}{l}\text{Level of acceptable concentration, namely 5 or 6.0 mg/l}\end{array} - \text{Lowest D.O. recorded}$$

Since bacterial growth and die-off generally follows an exponential growth curve, a logarithmic base was used for the fecal coliform analysis. Thus, the log 10 of the worst or most unsanitary condition was used to adjust this part of overall calculation as follows:

$$\text{Priority\#} = \text{Log 10 of the highest value recorded} - \begin{array}{l}\text{Log of the acceptable concentration, namely 2.3 or the log 10 of 200/100 ml (natura logs could be used to increase the impact of this parameter on the station ranking).}\end{array}$$

For turbidity, in order to effectively average infrequently high values, a formula suggested by Steele, et.al.,[3] was used. This formula employed use of the harmonic mean: $\text{Harmonic Mean} = \frac{\text{Number of observations}}{\text{Sum of the reciprocal of each observation}}$,

which then gave rise to the following formula:

$$\text{Priority\#} = \frac{\text{Harmonic mean of the high 15\% of the observations} - \text{Level of acceptable concentration, namely, 25 or 50 JTU's}}{\text{Standard deviation as determined by use of the Harmonic distribution}}$$

Some bias for the fecal coliform calculation was unavoidable since a maximum negative (good) value of 2.3 results from use of the log 10 of the 200/100 ml standard selected as an acceptable level. A maximum rating of 5 was possible in the other six areas. (Any negative priority number for fecal coliform should be considered a <u>good</u> indicator.)

[3]An Assessment of Areal and Temporal Variations in Stream-flow Quality Using Selected Data from the National Stream Quality Accounting Network, Open File Report 74-217, T.D. Steele, et.al., U.S. Geological Survey, August, 1974.

The station priority is the average of the seven individual priority numbers. (For practical purposes, four of seven parameter areas were required "for sufficient data" but good or better judgement is needed as less parameter groups are available.)

Although in theory there is no theoretical limit, in practice, a maximum station priority of five (5) suggested itself since the highest values found in each parameter area was approximately five (5). (In instances where a value of 5+ is shown high, anomalous values or turbidity values of >1000 JTU's may account for this.) Thus, for averaging no value in excess of five (5) was used. A state-by-state analysis follows.

A STATE-BY-STATE OVERVIEW

Each state's ranking is divided into two parts. Part A is a ranking of the state "primary" stations. An important determinant made in this section are the candidates suggested for removal from the state primary network. Part B is a ranking of the NASQAN and NWQSS stations. In only a few instances were candidates for removal suggested among NASQAN-NWQSS stations since the underlying rationale of the NASQAN is to locate these stations at major hydrologic accounting locations and that of the NWQSS is to bracket long term problem areas associated with important land uses.

COLORADO

Eleven candidates for non-primary stations are suggested by Colorado's primary network ranking illustrated in Table 2A. Of these stations, five (5) are located at/or near NASQAN sites, four (4) appear redundant for trend purposes, one has especially low flow, and another is near a dam construction site which will be completed in the near future. Suggested non-point sources and relocation possibilities are also noted in the comments section of the Table. No state data gaps were noted among the seven (7) parameter areas. However, a reasonable flow estimate could not be provided for six (6) stations. BOD and fecal coliform gaps were noted in Table 2B for the NASQAN-NWQSS stations. Turbidity data were scant at three (3) NASQAN stations.

STATE OF COLORADO

TABLE 2A
RANKED PRIMARY STATIONS

Location	Station Priority	Comments
1. Fountain Creek below Colo. Springs	3.8	(c) Low flow and channel characteristics
2. Little Thompson River near Milliken	3.6	
3. Big Thompson River near mouth	3.4	
4. Cache La Poudre near Greeley	3.4	
5. Arkansas River at Coolidge, Ks.	3.0	(c) Also a NASQAN Station
6. S. Platte at Julesburg	3.0	(c) Also a NASQAN Station
7. Arkansas River near Nepesta	3.0	
8. Arkansas River near La Junta	2.9	(c) Seems redundant no significant change from Nepesta or Coolidge, Ks. See #5 and #7
9. S. Platte River at Kersey	2.9	
10. St. Vrain Creek below Longmont	2.8	
11. S. Platte River at Henderson	2.6	
12. Boulder Creek at County Line	2.5	
13. Uncompahgre River at Delta	2.1	NPS suggested
14. Gunnison River at Grand Junction	2.0	(c) A NASQAN is located nearby
15. Colorado River at Newcastle	1.6	
16. Cache La Poudre at Ft. Collins	1.6	(c) Seems redundant - see #4
17. Eagle River at Gypsum	1.5	NPS suggested
18. Rio Grande River east of Manassa	1.4	(c) A NASQAN Station is located near Labatos
19. Clear Creek at Wheatridge	1.0	Relocation suggested closer to mouth
20. S. Platte River above Littleton	1.0	Relocation above new dam suggested
21. Colorado River near Dotsero	0.3	(c) Seems redundant - see #15 & NASQAN NPS suggested
22. Roaring Fork at mouth	0.3	
23. Eagle River at Avon	0.3	(c) Seems redundant - see #17
24. Bear Creek at County Line	0.3	(c) Dam near completion
25. Clear Creek above Golden	-0.2	
26. Yampa River near Milner	-0.6	(c) A NASQAN Station is located nearby at Maybell

(c)=Candidate for non-primary status

RANKING BY CATEGORY

	Turb	BOD	N	P	F. Coli.	Residue	DO	Mean Flow cfs
1.	5.0+	3.1	2.7	3.4	4.2	4.4	4.5	116
2.	5.0+	3.2	2.7	3.4	4.0	4.8	2.0	N/A
3.	4.0	3.0	3.0	3.3	3.2	3.9	3.4	N/A
4.	3.2	3.2	3.2	3.6	3.2	4.3	3.2	101
5.	5.0+	-0.2	3.8	2.4	4.1	5.0+	1.5	222
6.	5.0+	1.5	3.0	2.9	4.2	4.2	0.6	470
7.	5.0+	1.4	3.0	5.0+	3.0	1.5	1.8	683
8.	5.0+	2.2	3.2	3.2	3.2	3.0	0.8	246
9.	2.0	2.0	3.8	2.7	4.4	3.8	1.7	754
10.	4.4	3.5	2.6	3.6	2.2	2.0	2.4	N/A
11.	1.3	2.9	3.1	3.4	3.2	2.0	0.9	347
12.	5.0+	1.4	2.8	3.9	2.0	1.4	0.2	90.4
13.	5.0+	-1.9	3.6	3.0	1.2	3.3	0.6	276
14.	5.0+	-2.5	2.6	2.8	2.7	2.8	0.0	2561
15.	5.0+	-1.0	1.6	2.4	2.1	1.0	-0.5	3589
16.	-1.8	1.7	3.9	3.1	2.3	2.3	0.6	N/A
17.	5.0+	-1.9	2.3	2.7	0.9	1.0	1.9	565
18.	-0.5	0.7	0.8	2.6	3.1	0.4	0.5	593
19.	-0.7	2.5	1.1	3.5	2.0	-0.4	0.0	N/A
20.	5.0+	0.2	2.7	2.4	0.6	-4.4	-1.9	225
21.	5.0+	-1.3	0.0	2.3	0.2	-1.9	1.2	2093
22.	0.7	-3.2	0.0	2.4	1.1	-0.1	-0.1	1365
23.	-4.4	0.2	1.4	2.6	1.3	1.0	-3.1	N/A
24.	1.0	0.5	1.4	2.9	1.2	-2.0	-0.6	53.3
25.	-0.6	-0.1	0.4	3.3	1.2	-4.3	-1.2	228
26.	-0.7	-3.2	0.8	2.8	2.0	-5.0		466+

NA - Not Available
NPS - Non-Point Source

TABLE 2B

NASQAN-NWQSS COLORADO — RANKED PRIMARY STATIONS

Location	Station Priority	Comments
1. S. Platte River at Julesburg	2.8	
2. San Miguel River at Uravan (NWQSS)	2.7	Point source oriented
3. San Miguel River below Uravan (NWQSS)	2.2	" " "
4. Colorado River near Utah border	1.8	
5. Rio Grande River near Labatos	1.3	
6. Gunnison River near Gr. Junction	1.0	
7. Little Snake River near Lilly	0.1	
8. Yampa River near Maybell	0.1	Energy related
9. White River below Meeker (NWQSS)	-	Insufficient data
Arkansas River at Coolidge, Ks.	-	Insufficient data

RANKING BY CATEGORY

	Turb	BOD	N	P	F. Coli.	Residue	DO	Mean Flow cfs
1.	5.0+	-	2.3	2.7	-	4.6	0.6	470
2.	5.0+	-	4.0	2.4	-	2.4	0.0	N/A
3.	5.0+	-	2.7	1.8	-	2.5	-1.2	N/A
4.	-	-	2.5	3.0	-	2.7	-1.0	5730
5.	-2.5	3.1	2.5	4.1	1.6	0.5	0.0	593
6.	-	-	2.5	0.8	-	1.9	-1.1	2561
7.	-	-	-0.4	0.8	-	0.3	-0.1	569
8.	-0.8	-	0.6	2.4	-	-0.2	-1.4	1547
9.	-	-	-	-	-	-	-	616
	-	-	-	-	-	-	-	222

MONTANA

There was little or no data in STORET to evaluate the nine (9) Montana state primary stations, therefore no ranking or other judgement regarding the candidacy for non-primary status is possible for Montana's network. Overconcentration of stations on the Yellowstone River at Billings is suggested by the NASQAN-NWQSS summary given in Table 3B. Parameter coverage for NASQAN and NWQSS is generally adequate in each of the seven (7) categories. Two (2) stations require turbidity, BOD and fecal coliform data. Flow data estimates are unavailable at all nine (9) Montana primary stations.

TABLE 3B

MONTANA NASQAN-NWQSS RANKING

PRIORITY RANKING

Location	Network Station Priority	Comments	Ranking by Category							Mean Flow (cfs)
			Turb.	BOD	N	P	FC	R	DO	
1. Yellowstone R. nr Miles City (NWQSS)	1.0	Tongue R. Confluence	5.0+	0.9	0.0	0.6	0.9	-1.4	1.7	11340
2. Tongue River at Miles City	1.0	NPS suggested	5.0+	0.4	-3.1	2.9	1.0	-1.5	1.9	427
3. Yellowstone R. nr Sindey (NWQSS & NASQAN)	0.9	NPS suggested	5.0+	-1.0	-2.2	2.8	1.4	-2.0	1.2	13030
4. Milk River at Nashua	0.8	NPS suggested	5.0+	-	-2.5	1.3	0.3	-1.2	2.3	684
5. Yellowstone River at Huntley (NWQSS)	0.2	NPS suggested	0.7	-0.5	-0.6	3.0	1.4	-0.7	-2.0	N/A
6. Yellowstone River at Billings	-0.5	Appears duplication of #7	3.5	-	-1.2	0.6	0.6	-3.4	-3.6	6862
7. Yellowstone River at Laurel (NWQSS)	-0.5	NPS suggested	1.5	-0.8	-2.0	4.0	0.6	-2.1	-4.5	N/A
8. Bighorn River at Bighorn	-0.7	No confluence station on the Yellowstone is available	2.4	-4.2	-2.7	0.8	0.1	-2.6	1.3	3870
9. Missouri River near Culbertson	-0.9	NPS suggested	3.5	-4.8	5.0+	1.0	1.4	-2.2	-0.5	10280
10. Missouri R. at Toston	-1.3		0.5	-2.2	-3.0	3.3	0.0	-3.0	-5.0	5292
11. Kootenai R. near Copeland	-2.4		-5.0+	-2.6	-4.0	2.6	0.2	-5.0+	-3.0	15660
Missouri River at Virgelle	-	New stations	Insufficient data							8364
Missouri R. below Ft. Peck	-	New stations	Insufficient data							9553
Musselshell R. at Mosby	-	New stations	Insufficient data							249
N. Fk. Flathead R. at Flathead B.C.	-	New stations	Insufficient data							974

STATE OF MONTANA

There is insufficient data in STORET for analysis of the 9 primary stations identified in the state program plans.

NORTH DAKOTA

Only 22 or the 54 stations in the North Dakota State Primary Network had sufficient data for ranking. As determined by a review of Table 4A, two (2) of the state primary stations are considered candidates for nonprimary stations due to low ranking.

No turbidity data are available for the state network. Frequent gaps in BOD and nitrogen coverage is also indicated at some state stations. Frequent BOD and some turbidity gaps are noted in Table 4B for the NASQAN-NWQSS stations. Flow data estimates are unavailable at four (4) of the 22 ranked state stations.

TABLE 4A

NASQAN-NWQSS - N. DAKOTA

PRIMARY STATIONS

Location	Station Priority	Comments
1. Red River of the North below Fargo	3.3	Paired station above Fargo is suggested
2. Souris River near Westhope*	2.8	
3. Little Missouri River near Watford	2.1	
4. Souris River near Sherwood (NWQSS)	2.0	
5. Knife River at Hazen	1.4	
6. Cannonball River at Breien	1.2	
7. Red River of the North at Oslo, Minn.	0.6	
8. Missouri River at Bismarck	-0.8	
9. Missouri River near Schmidt	-1.4	
10. Missouri River at Garrison	-2.4	

*Funded by NWQSS and NASQAN

RANKING BY CATEGORY

	Turb	BOD	N	P	F. Coli.	Residue	DO	Mean Flow cfs
1.	5.0+	3.5	3.2	5.0+	2.1	-0.1	4.6	539
2.	5.0+	1.2	0.2	4.5	-0.3	2.6	-0.6	196
3.	5.0+	-	0.7	2.9	1.6	3.4	-1.2	605
4.	-1.5	-	2.9	3.1	0.1	2.4	5.0	107
5.	-	0.7	0.7	2.5	1.1	2.9	0.4	181
6.	-	-	1.7	2.7	0.0	2.8	-1.4	246
7.	2.6	-	1.0	-0.1	1.0	-1.6	1.0	3672
8.	-3.1	-	0.5	2.6	-0.4	-2.0	-2.8	21720
9.	-3.0	-	-4.7	3.6	0.5	-2.7	-2.4	N/A
10.	-	-5.0+	-5.0+	1.3	-2.3	-1.0	-2.4	N/A

STATE OF NORTH DAKOTA

TABLE 4B
RANKED PRIMARY STATIONS

	Location	Priority Rating	Comments
1	Souris River N. of Sawyer	3.0	
2.	Souris River - Towner	2.9	
3.	Goose River near Hillsboro	2.8	
4.	Little Missouri River - Medora	2.7	
5.	Park River N. of Oakwood	2.6	
6.	Forest River near Minto	2.6	
7.	Pembina River S. of Pembina	2.3	
8.	Sheyenne River - Valley City	2.2	
9.	Red River - Grand Forks	2.1	
10.	Maple River - Ellendale	2.0	(c) Low Flow
11.	Heart River - Mandan	1.9	
12.	James River W. of Oakes	1.8	
13.	Red River - Pembina	1.8	
14.	Park River on I-29	1.8	
15.	Pipestem River - Buchanan	1.7	(c) Low Flow
16.	Sheyenne River at Harwood	1.7	
17.	James River at Jamestown	1.6	
18.	Elm River - Ellendale	1.6	
19.	Heart River S. of Gladstone	1.5	
20.	Forrest River 8 miles E. of Minto	1.4	
21.	Missouri River S. of Williston	0.8	(c) Also an Energy Impact Station
22.	Square Butte Creek - Center	0.7	(c)

	RANKING BY CATEGORY							
	Turb	BOD	N**	P	F. Coli.	Residue	DO	Mean Flow cfs
1.	--	-	2.9	3.1	-0.1	4.1	5.0+	≈150
2.	--	2.0	3.3	3.0	1.4	2.6	5.0+	≈175
3.	--	1.5	2.8	3.5	1.7	2.4	5.0+	62.9
4.	--	-	2.8	2.8	1.7	3.0	3.1	474
5.	--	-	3.7	4.1	0.5	3.0	1.9	≈ 55
6.	--	-	3.0	2.6	0.0	5.0+	2.5	48
7.	--	-	3.1	3.0	0.5	2.1	2.9	≈180
8.	--	0.6	3.0	3.1	2.2	2.6	1.5	119
9.	--	1.1	2.3	3.6	0.2	2.7	2.8	2455
10.	--	2.2	-	2.6	1.9	2.4	0.6	≈ 18
11.	--	0.3	1.9	2.6	1.3	3.0	2.3	257
12.	--	-	2.6	3.0	1.0	2.8	-0.3	≈100
13.	--	-0.2	3.1	2.9	0.7	3.2	1.2	≈3125
14.	--	-	3.2	2.8	0.7	2.5	-0.3	N/A
15.	--	1.7	-	2.3	0.9	3.5	0.1	19.5
16.	--	-	3.3	3.3	0.6	2.8	-0.7	N/A
17.	--	-	2.8	2.5	1.0	2.3	-0.4	55.6
18.	--	1.4	-	3.0	1.6	1.5	0.6	≈ 47
19.	--	-	2.2	2.2	0.1	3.6	-0.6	N/A
20.	--	-	2.4	2.5	0.1	2.5	-0.4	≈ 48
21.	--	-	1.8	0.6	0.7	2.5	-1.9	N/A
22	--	-0.9	-	1.9	1.7	2.6	-1.8	N/A

*Nitrate analyses were by probe method and are higher than normally encountered

(c)=Candidate for non-primary status.

TABLE 4B cont.

STATE OF
N. DAKOTA

STATIONS WITH INSUFFICIENT DATA FOR PRIORITY RANKING

1. Apple Creek - Bismarck
2. Beaver Creek - Linton
3. Spring Creek - Zap (also an Energy Impact Station) - (c)
4. Knife River - Hazen (also a NASQAN and Energy Impact Station) - (c)
5. Green River - Gladstone
6. Antelope River - Carson
7. Big Muddy Creek - Almont
8. Cedar Creek - Raleigh
9. Cannonball River - Breien (also a NASQAN station) - (c)
10. N. Fork Great (Grand) River - Bowman-Haley Dam
11. Spring Creek - Bowman-Haley Dam
12. Beaver Creek - Jamestown (no data)
13. Cottonwood Creek - La Moure
14. Elm River - Ellendale
15. Bois de Sioux - Fairmount
16. Antelope Creek - Abercrombie
17. Wild Rice River - Abercrombie
18. Bald Hill Creek - Dazey
19. Maple River - W. Fargo
20. Rush River - Harwood
21. Turtle River - Manuel
22. Forest River - N. Br./Fordville
23. Cart Creek - Hoople (no data)
24. Park River - N. Br./Hoople
25. Park River - M. Br./Hoople
26. Park River - S. Br./Park River
27. Tongue River - Pembina
28. Des Locs Pine - Foxholm
29. Willow Creek - Willow City
30. Deep River - Upham
31. Little Muddy Creek - Williston
32. White Earth River - White Earth

SOUTH DAKOTA

As seen in Table 5A, ranking of the 42 state primary stations suggests non-primary status for at least four stations now covered by NASQAN and at one covered by NWQSS monitoring. Non-primary candidacy is also suggested at four (4) other stations with low individual station rankings and low flow and also suggested at one (1) station below a major dam. Less frequent monitoring at the NASQAN site may be warranted in the future as determined by variability analysis of the data below this dam site. Both turbidity and BOD data are lacking in the state program. Turbidity is lacking for the NASQAN-NWQSS stations. Flow estimates were not determinable at 12 state primary stations.

STATE OF SOUTH DAKOTA

TABLE 5A
PRIORITY RANKING

Location	Network Station Priority	Comments	Ranking by Category							Mean Flow (cfs)
			T	BOD	N	P	FC	R	DO	
1. Big Sioux River at Brandon	3.3		-	-	3.0	3.6	3.0	2.8	4.2	N/A
2. Vermillion River near Wakonda	2.8		-	-	2.3	2.9	1.4	3.3	3.9	120
3. James River near Stratford	2.8		-	-	1.3	4.4	1.1	3.4	2.8	N/A
4. Belle Fourche River near Sturgis	2.7		-	-	2.9	2.7	1.3	3.2	3.3	269
5. Big Sioux River near Richland	2.7		-	-	2.2	2.9	0.7	2.7	5.0	862
6. Big Sioux River near Dell Rapids	2.7	(c) Also a NWQSS Station	-	-	2.6	4.2	1.1	2.8	2.6	275
7. James River above Mitchell	2.6		-	-	3.0	5.0+	0.1	2.8	2.1	N/A
8. James River below Mitchell	2.4		-	-	1.1	2.7	0.5	2.7	5.0+	N/A
9. Big Sioux River near Brookings	2.4		-	-	1.1	3.2	0.5	3.4	3.8	169
10. Grand River near Little Eagle	2.4	(c) Also a NASQAN Station	-	-	1.0	3.5	0.5	2.9	3.9	241
11. Big Sioux River near Watertown	2.3		-	-	2.6	2.6	1.2	2.5	2.4	N/A
12. Little Minnesota River near Peever	2.2		-	-	0.6	3.1	0.9	4.0	2.3	N/A
13. Vermillion River near Vermillion	2.2		-	-	2.7	3.6	1.3	3.1	0.5	N/A
14. James River below Huron	2.1		-	-	1.1	2.7	1.7	2.6	2.5	237
15. James River above Huron	2.0		-	-	1.1	4.5	0.7	2.8	0.9	≃237
16. James River near Hecla	2.0		-	-	2.6	3.2	0.0	2.0	2.2	≃ 82
17. Grand River at Shadehill	2.0	NPS suggested	-	-	1.1	1.0	-0.2	5.0	3.0	122
18. Whetstone River near Big Stone City	1.9		-	-	1.8	3.2	1.0	2.5	0.8	N/A
19. White River near Oglala	1.9		-	-	1.2	3.9	1.0	2.7	0.7	57.5
20. Cheyenne River at Edgemont	1.7		-	-	0.9	3.5	0.8	4.5	-1.4	106
21. Cheyenne River near Wasta	1.6	(c) NPS suggested	-	-	2.1	2.5	0.4	4.4	-1.2	370
22. Belle Fourche River near Belle Fourche	1.5		-	-	1.2	2.3	1.4	3.0	-0.3	≃87.8
23. Redwater River at Belle Fourche	1.5		-	-	1.0	3.3	1.8	4.0	-2.5	132
24. White River near Kadoka	1.5		-	-	2.1	3.0	1.4	2.2	-1.1	289
25. Marean River near Usta	1.4		-	-	1.5	3.4	0.8	2.7	-1.2	≃138
26. Little Missouri at Camp Crook	1.2	(c)	-	-	0.9	2.5	-0.1	3.4	-0.6	139
27. Keya Paha River near Wewela	1.1	(c)	-	-	0.9	3.1	0.5	1.1	-0.2	70.9

STATE OF SOUTH DAKOTA (cont.)

Location	Network Station Priority	Comments	Ranking by Category							Mean Flow (cfs)
			T	BOD	N	P	FC	R	DO	
28. White River near Oacoma	0.8	(c) Also a NASQAN Station	-	-	1.4	3.4	1.1	0.5	-2.2	538
29. Little White River near Tuthill	0.6	(c) Low flow	-	-	1.0	5.0+	1.1	-2.6	-1.6	≃ 20
30. Battle Creek near Keystone	0.4	(c) Low flow	-	-	0.9	2.7	0.2	-1.4	-0.5	11.7
31. Rapid Creek below Pactola Res.	0.3		-	-	1.2	2.8	-1.5	1.3	-2.2	45.3
32. Little White River near White River	-0.5	(c)	-	-	0.9	3.5	0.5	-5.0+	-2.5	131
33. Spearfish Creek in Spearfish	-1.1	(c) Low flow	-	-	0.9	4.0	-2.3	-4.9	-3.4	50.2
34. Moreau River near Whitehorse	-	Insufficient data	-	-	-	-	-	-	-	192
Bad River at Powell	-	" "	-	-	-	-	-	-	-	N/A
Bad River near Ft. Pierre	-	" "	-	-	-	-	-	-	-	155
James River near Yankton	-	Insufficient data a likely trend station	-	-	-	-	-	-	-	N/A
Rapid Creek near Farmingdale	-	Insufficient data	-	-	-	-	-	-	-	56
Missouri River at Oahe Dam	-	(c) Insufficient data near a NASQAN Station	-	-	-	-	-	-	-	N/A
Missouri River at Big Bend Dam	-	Insufficient data	-	-	-	-	-	-	-	N/A
Missouri River at Ft. Randall Dam	-	Insufficient data (c) Also a NASQAN Station	-	-	-	-	-	-	-	24,400
Missouri River at Gavins Pt. Dam	-	(c) Insufficient data	-	-	-	-	-	-	-	≃25,520

C = Candidate for non-primary status

TABLE 5B

NASQAN-NWQSS - SOUTH DAKOTA

Location	Station Priority	Comments	Ranking by Category T	BOD	N	P	FC	R	DO	Mean Flow (cfs)
1. Big Sioux River at N. Cliff Avenue (NWQSS)	3.0		-	1.9	2.8	2.8	3.0	2.5	5.0	N/A
2. James River near Scotland	2.4		-	1.7	1.4	2.8	0.5	3.0	5.0+	385
3. Big Sioux River near Dell Rapids (NWQSS)	1.9		-	1.3	2.4	3.6	1.0	2.0	1.0	275
4. Belle Fourche River near Elm Springs (NWQSS only)	1.9		-	0.8	2.6	3.7	1.4	3.3	-0.1	366
5. Missouri River at Pierre	-1.0		-	-5.0+	1.1	-0.3	-1.0	1.0	-2.0	N/A
6. White River near Oacoma		Insufficient data	-	-	-	-	-	-	-	538
Big Sioux River at Akron, Iowa	-	" "	-	-	-	-	-	-	-	862
Cheyenne River at Cherry Creek	-	" "	-	-	-	-	-	-	-	~635
Grand River at Little Eagle	-	" "	-	-	-	-	-	-	-	241
Missouri River below Ft. Randall Dam	-	(c) Below reservoir insufficient data	-	-	-	-	-	-	-	24,400
Missouri River at Sioux City, Iowa	-	Insufficient data	-	-	-	-	-	-	-	31,910

(c) = Non-primary candidate

UTAH

Since the state primary network was recently adopted, only three (3) of the 49 stations were rankable. As seen in Table 6A, two (2) of these three appear to be candidates for non-primary status. Due to the presence of two (2) NWQSS sites the NASQAN station on the Jordan River at Salt Lake City is a candidate for non-primary status assuming the NWQSS will continue to collect trend data for the long term. With one exception, as seen in Table 6B, BOD data are lacking at the NASQAN sites. Historical flow data are unavailable at the five (5) recently installed NWQSS sites.

State of Utah

TABLE 6A
RANKING PRIMARY STATIONS*

Location	Primary Rating	Comments	Ranking by Category							Mean Flow (cfs)
			T	BOD	N	P	FC	R	DO	
1. Colorado River above Moab	2.6	(c) A NASQAN Station is nearby	5.0+	1.3	2.2	2.7	2.3	2.0	-	N/A
2. Green River above Green River	2.3		5.0+	-1.0	4.0	3.1	1.1	1.5	-	1708
3. Provo River above Provo Falls	-0.3	(c)	5.0+	-5.0	-0.9	3.3	0.7⊛	-	1.7	N/A

⊛ Total coliform substituted for fecal coliform.

(c) Candidate for Non-primary status.

NASQAN-NWQSS - UTAH

TABLE 6B
RANKED PRIMARY STATIONS

Location	Priority Rating	Comments	Ranking by Category							Mean Flow (cfs)
			T	BOD	N	P	FC	R	DO	
1. San Juan River near Bluff	2.8		5.0+	-	1.7	3.2	0.3	1.8	4.7	2604
2. Colorado River above Mill Creek near Moab (NWQSS)	2.7	Point Source Oriented	3.9	-	1.7	2.9	-	2.6	2.3	N/A
3. Jordan River at Salt Lake City	2.4	(c) NWQSS paired stations Bracket Salt Lake City	3.2	-	3.6	4.1	0.1	3.6	-0.2	141
4. White River at mouth (NWQSS)	2.4		5.0+	-	0.0	3.2	-	3.8	-0.1	N/A
5. Jordan River at Cudahy Lane (NWQSS)	2.4		0.6	-	2.1	3.4	2.3	2.9	2.9	N/A
6. San Juan at Shiprock, New Mexico	2.2		5.0+	-3.3	3.4	2.3	2.4	0.9	5.0+	2229
7. Colorado River at N-163 near Moab (NWQSS)	2.2	Point Source Oriented	5.0+	-	1.9	2.7	-	2.8	1.2	N/A
8. Jordan River at 5800 S.W. (NWQSS)	2.1		1.0	-	2.1	3.6	1.6	4.7 4.7	-0.6	N/A
9. Sevier River near Lynndyl	2.1		-	-	1.2	2.3	0.0	2.7 2.7	4.2	186
10. Green River at Green River	2.0		5.0+	-	0.6	2.5	1.1	1.7	1.0	1708
11. Colorado River near Cisco	1.0		-	-	1.6	2.9	-0.9	2.7	-1.1	7686
12. Bear River near Corinne	1.0		1.0	-	2.2	3.3	0.9	0.7	-1.9	1754
13. Colorado at Lees Ferry, Ariz.	0.8	(c) Below dam	-1.7	-	0.9	3.9	-1.5	3.4	0.0	17850
Beaver River at Adamsville	-	(c) Low flow insufficient data	-	-	-	-	-	-	-	35.9
Green River near Glendale	-	Insufficient data	-	-	-	-	-	-	-	2033
Bear Lake Outlet Channel near Paris, Idaho	-	Insufficient data	-	-	-	-	-	-	-	363
Weber River near Plain City	-	Insufficient data	-	-	-	-	-	-	-	466

WYOMING

With the exception of one (1) NASQAN and two (2) NWQSS sites primary station data are provided solely by the state in cooperation with the USGS. As seen in Table 7A, two (2) of the state financed stations are located at/or near NWQSS sites, 15 have low rankings, one is at a low flow site, and one is at the NASQAN station. All of these should be screened for possible non-primary status. Parameter coverage is generally lacking for BOD and nitrogen. Some stations do not have turbidity data available. Twelve locations do not have historical flow data available. Data are insufficient for ranking of nine (9) stations.

State of Wyoming
USGS Program

TABLE 7A
RANKED PRIMARY STATIONS

Location	Priority Ranking	Comments	Ranking by Category							Mean Flow (cfs)
			T	BOD	N	P	RC	R	DO	
1. Bitter Creek near Garland	2.1		5.0+	-	-	3.6	1.6	2.3	-2.1	147
2. Bighorn River at Kane	1.9		5.0+	0.7	-	2.5	2.2	2.3	-0.1	2282
3. Powder River at Arvada	1.6		-	-2.5	-	2.5	0.8	4.1	3.1	274
4. Goose Creek below Sheridan	1.5		4.2	1.0	1.4	3.3	2.5	0.7	-2.6	182
5. N. Platte River below Casper	1.0	(c) Also a NWQSS Sta.	-0.5	-1.1	1.6	2.7	2.1	2.3	-0.5	≃13000
6. N. Platte River above Seminoe	1.0	NPS suggested	5.0+	-	-	1.5	0.4	-1.6	-0.4	1098
7. Shell Creek near Greybull	0.8		1.4	-	-	2.0	0.9	2.4	-2.4	N/A
8. Wind River at Riverton	0.8		2.4	-	-	3.0	1.2	-1.5	-1.2	N/A
9. N. Platte River at Wyoming-Nebraska Border	0.4		-3.9	0.9	-	2.8	2.0	1.5	-1.1	N/A
10. Powder River (S. Fork) near Kaycee	0.2		-2.9	-	-	1.7	0.0	2.8	-0.4	N/A
11. Laramie River near Ft. Laramie	0.0		0.6	-	-	1.0	0.1	1.2	-2.6	146
12. Belle Fourche River at Wyoming and South Dakota Border	0.0	(c) Low Flow	-	-2.4	-	0.3	1.0	2.6	-1.5	87.8
13. Belle Fourche River at Devils Tower	0.0		-	-	-4.4	1.8	0.5	3.1	-0.8	N/A
14. Bear River at Border	-0.2		1.9	-	-	2.4	0.0	-3.4	-2.0	421
15. Sweetwater River near Alcova	-0.4		-0.5	-	-	2.5	-0.2	-2.7	-1.3	126
16. North Platte River at Orin	-0.4		-5.0+	-	-	1.7	0.5	1.1	-0.3	N/A
17. North Platte River at Mills	-0.4	(c) Also a NWQSS Sta.	-0.5	-	-0.4	1.4	-0.6	-1.9	-0.4	N/A
18. Tongue River at Stateline	-0.6		-3.7	-1.0	-5.0+	2.2	0.6	1.2	1.8	498
19. North Platte River below Glendo	-0.8	(c)	-5.0+	-	-	1.0	-2.0	1.1	0.7	N/A
20. Wind River below Boysen Res.	-0.9	(c)	-5.0+	-	-	-0.1	-1.1	0.5	1.0	1412
21. Little Wind River above Arapahoe	-1.1	(c)	-5.0+	-	-	-0.2	-0.1	2.1	-2.2	N/A
22. Green River near LaBarge	-1.3		-5.0+	-	-	4.0	0.1	-4.4	-1.2	1650

RANKED PRIMARY STATIONS

Location	Priority Ranking	Comments	Ranking by Category T	BOD	N	P	RC	R	DO	Mean Flow (cfs)
23. Green River at Big Island	-1.4	(c)	-5.0+	-	-	-1.0	0.3	-0.1	-1.0	N/A
24. Wind River near Dubois	-2.0	(c)	-5.0+	-	-	2.3	-0.1	-5.0	-2.2	177
25. Tongue River near Dayton	-2.2		-5.0+	-1.3	-5.0+	1.3	0.3	-5.0+	-1.3	187
26. North Platte River at Alcova	-2.2	(c)	-5.0+	-	-	2.0	-1.7	-5.0+	-1.4	N/A
27. Encampment River at Mouth	-2.3	(c)	-5.0+	-	-	-1.0	-0.5	-2.8	-2.2	236
28. North Platte River near Northgate, Colorado	-2.3	(c)	-5.0+	-	-	0.0	-0.6	-5.0+	-0.7	434
29. Salt River above Res. near Etna	-2.5	(c)	-5.0+	-	-	1.0	-0.3	-5.0+	-3.0	755
30. Green River below Fontenelle Res.	-2.5		-5.0+	-	-	-2.0	0.3	-3.8	-2.0	N/A
31. Snake River above Res. near Alpine,Wy.	-3.3	(c) Also a NASQAN	-5.0+	-	-5.0+	1.0	0.0	-5.0+	-2.4	4549
Wind River at Boysen Res.	-	Insufficient data	-	-	-	-	-	-	-	-
Shoshone River below Buffalo Bill Dam	-	" "	-	-	-	-	-	-	-	-
Shoshone River above Dry Creek	-	" "	-	-	-	-	-	-	-	-
Green River at Warren Bridge	-	" "	-	-	-	-	-	-	-	-
Green River near Green River	-	Insufficient Data,	-	-	-	-	-	-	-	-
Blacks Fork River near Lyman	-	Insufficient Data	-	-	-	-	-	-	-	-
Green River below Green River	-	Insufficient Data,	-	-	-	-	-	-	-	-
Smiths Fork River near Lyman	-	Insufficient Data	-	-	-	-	-	-	-	-
Blacks Fork River near Little America	-	Insufficient Data	-	-	-	-	-	-	-	-

(c) Candidate for non primary stations.

PROGRAM ANALYSIS

Selection of stations for the NASQAN and NWQSS network is generally founded on good, but well-mixed reasons. Rationale for the NASQAN stations is basically the desire to provide good national-areal distribution of trend data at major water transport sites. To maximize trends downstream ends of (usually) major waterways are also included along with other "closed" basin stations.

NWQSS stations in Region VIII are designed to identify areas of most needed industrial and urban pollution abatement effort and are located above and below major urban areas or in some special instances above and below major point sources. (Due to limited funding Region VIII coverage is scant for the NWQSS network).

State primary networks are less clear and/or uniform in their underlying rationale for station selection. North and South Dakota, and Wyoming, have no separate designation of "primary" stations. Montana's nine (9) primary stations are located for site-specific purposes. Utah has recently shifted from a site-specific concept to an areal one. Colorado has wide areal distribution for its trend stations and a total of 26 primary stations.

Frequency of monitoring is quite irregular from one state program to another. As seen from a summary of regional programs assembled in Table 8, ongoing evaluation of needed frequency, especially for heavy metals, pesticides and radiological parameters, could yield significant benefits. Tests of variability based on variance of differing monitoring frequencies could also

TABLE 8

REGION 8 PRIMARY LONG-TERM STATION PARAMETER COVERAGE AND SAMPLING FREQUENCY (1)

	FIELD							CHEMICAL																				BIOLOGICAL								
	COLOR	FLOW	TEMPERATURE	pH	DISS OXYGEN	TURBIDITY	CONDUCTANCE	BOD	TOC	COD	TKN	NH3	NO2 & NO3	PHOSPHOROUS	VOL SOLIDS	TDS	TSS	MBAS	CYANIDE	METALS	CATIONS	ANIONS	SAR	SILICA	O & G	PHENOLS	HARDNESS	CHLOROPHYLL a.	PHYTOPLANKTON	PERIPHYTON	TOTAL COLI	FECAL COLI	FECAL STREP	PESTICIDES	RADIOCHEMICAL
NWQSS		BW	BW	BW	BW	BW	BW		BW	BW	BW	BW	BW	BW		BW	BW			M/Q	Q	Q		BW	BW			BW	M/Q	Q		BW	Q		
NASQAN		C	C	M	(2) M	M	C		M		M	M	M	M		M	M			M	M	M		M			M		M	Q		M	M	SS/S	M/Q
CO			BW	BW	BW	BW	BW	BW			BM	BW	BW	BW	BW	BW	BW	BM	BM	BM	BW	BM	BW				BW				BW	BW			BM
MT		M/Q	M/Q	M/Q		M/Q	M/Q	M/Q					M/Q	M/Q						M/Q	M/Q	M/Q								M/Q	M/Q			
ND	Q		M/Q	M/Q	M/Q	Q						Q	M	M		M			Q	Q		M/Q				Q	M/Q			M/Q	M/Q			Q
SD		(3) M	M	M	M		M					M	M	M			M			M	M	M					M				M	M			
UT (4)			M	M	M	M	M	M	M	M/SS	M/SS	M	M	M						SS					SS				S	A	M	M		SS	
WY (5)		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	(6) M/Q	M/Q	(6) M/Q			M/Q	M/Q		M/Q	M/Q			M/Q	M/Q	M/Q			(6) M/Q						M	M			M/Q

BW = Biweekly
M = Monthly
BM = Bimonthly
Q = Quarterly
C = Continuous
S = Seasonally
SS = Seasonally for sediment
A = Annually

Metals = arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, selenium, zinc, boron, barium, silver as necessary.
Anions = sulfate, chloride, fluoride, carbonate and bicarbonate.
Cations = calcium, sodium, potassium, magnesium.

1. This is an overview of the state and federal programs for "primary" stations. Numerous exceptions to the stated frequency exist for individual stations or parameters. Certain options and contingencies also amplify or exclude some of the parameters and add a measure of needed flexibility.
2. Includes 24-hour profiles during critical periods.
3. Recorded if a USGS station is nearby.
4. Eight stations also include macrophyton, macroinvertebrates, and fish sampling annually.
5. Most stations are operated by the USGS.
6. Selected stations only.

be used to suggest different monitoring. More frequent monitoring is suggested for assembling trend worthy data in many areas.

No lakes or groundwater are monitored as part of the NASQAN, NWQSS or state programs.

SUMMARY

This "primary" station ranking is just a beginning. It is just a way of ordering the data, looking at them, and putting them in a more manageable form. As developed, this ranking can provide a base from which supplemental data, knowledge, insights and concerns may guide further analysis. Each state's current mix of stations is given in Table 9.

Suggestions of non-primary candidacy are intended to focus attention on possible change if further examination does not affirm continued monitoring needs. Once the determination is made to discontinue a station from the "primary" network it probably would continue to be part of the program but with less broad parameter coverage and/or less frequent sampling.

The water quality manager, as always, is reliant on his powers of logic and judgement to add relevant information, especially for initial site selection when no data exist to rank a station. Hopefully this station ranking process can help decision making regarding the best station mix. By examining this process, some added insight can be applied to the process of selecting monitoring stations.

TABLE 9
SUMMARY OF PRIMARY TREND STATIONS
IN REGION VIII

	CO	MT	ND[1]	SD[1]	UT	WY[1][2]	TOTAL
State	26	9	54	42	49	40	220
USGS - NASQAN	7	13	7	9	13	1	50
NWQSS	3	4	4	2	5	2	20
Subtotal							290
Apparent Duplicates	5	1	3	5	6	[3]	20
Total Coverage							270

[1] No primary designations made -- includes all stations.
[2] Operated by USGS for the State.
[3] Duplication difficult to assess.