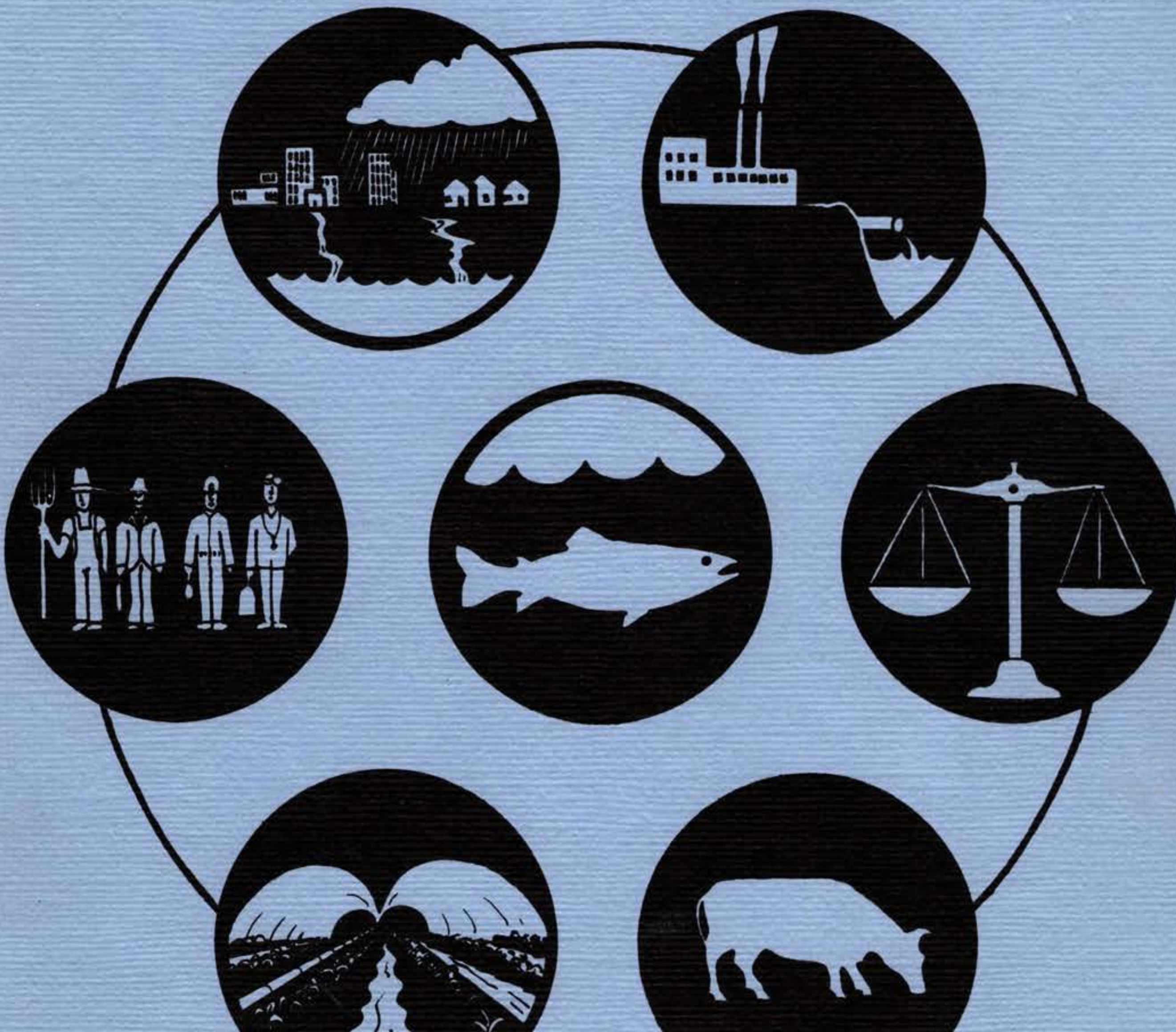
INTERIM REPORT — ENGINEERING

ALTERNATIVE TECHNICAL STRATEGIES FOR ACHIEVING NATIONAL WATER QUALITY GOALS

IN LARIMER & WELD COUNTIES, COLORADO



Water Quality Management Plan

PREPARED BY

LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS
LOVELAND, COLORADO
AND
TOUPS CORPORATION
LOVELAND, COLORADO

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208 AREAWIDE WATER QUALITY MANAGEMENT PLAN

ALTERNATIVE TECHNICAL STRATEGIES FOR ACHIEVING NATIONAL WATER QUALITY GOALS IN LARIMER AND WELD COUNTIES, COLORADO

Prepared For

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1.0 SUMMARY ANALYSIS

The objective of this Areawide Technical Planning Report for the Larimer-Weld Region is to document the many factors which affect the attainment of the 1983 national goal set forth in the Clean Water Act Amendments of 1972 (PL 92-500) - that of achieving a level of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water, wherever attainable.

The Larimer-Weld Region of Northern Colorado shown in Figure 1.1-A has many natural and manmade opportunities and constraints which affect the attainability of that national goal. This area of the South Platte River Basin is naturally divided into two topographic regions; the Great Plains and the Front Range of the Southern Rocky Mountains. The interface of these two land forms is a series of steeply inclined sedimentary hogback ridges and foothills. These three land forms, mountains, foothills, and plains are distinguished by water quality problems inherent to each.

The 6,700 square mile Larimer-Weld Region contains over 500,000 acres of irrigated agricultural lands, a large portion of Rocky Mountain National Park, Roosevelt National Forest, the Pawnee National Grassland, and a vast expanse of forested and grass-covered lands under private ownership. A thriving regional economy of agriculture, light technical industry and education provides the basis for a rapidly growing regional population of over 250,000 with expectations of a doubling of population by the Year 2000. Three major Colorado cities are the hub of this activity, Fort Collins (68,000 population), Loveland (31,000 population), and Greeley (60,000 population).

In developing the Areawide Technical Plan, the staff of LWRCOG and its consulting staff attempted to gather all relevant information available and prepare an objective assessment of the technical aspects of achieving the National Water Quality Goal. The summary analysis contained in this section represents the scope of that effort, its findings and recommendations.

1.1 CONSIDERATIONS

The achievability of this goal for the waters of Larimer and Weld Counties is dependent upon several specific factors which are covered in this report:

- Impacts of current levels of pollutants on water bodies in the Region and projected levels of pollutant loads over the next 20 years (with consideration for existing and increased treatment levels and control measures to reduce pollutant discharges).

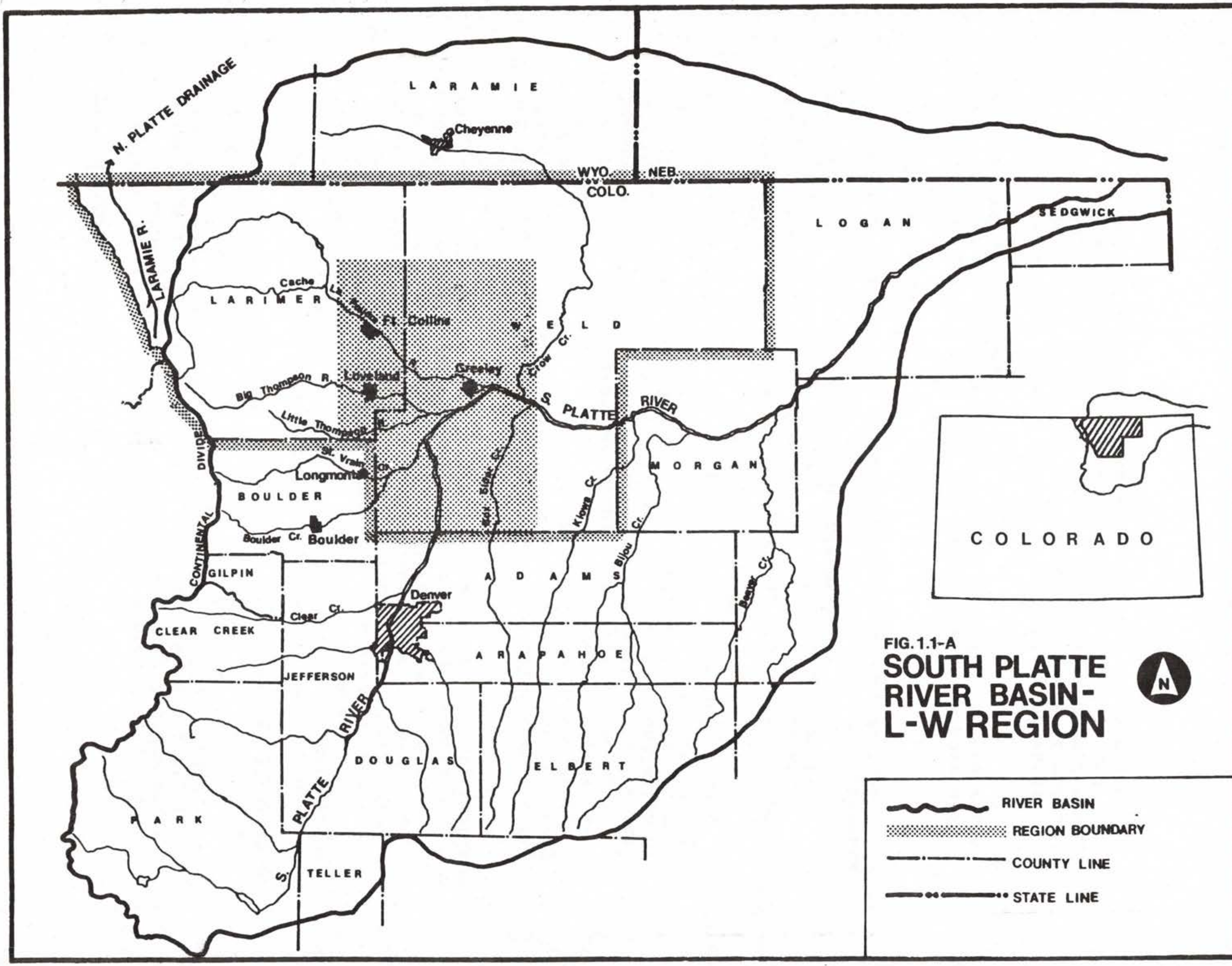


FIG. 1.1-A
SOUTH PLATTE RIVER BASIN-L-W REGION

- Limitations for improved water quality imposed by the existing natural and man-modified hydrologic system (including climate, physical stream conditions and present aquatic life).

- Historical western water resource development and Colorado Water Law, which governs water quantity in the river and reservoir system.

- Effectiveness of technical approaches to resolve adverse water quantity and water quality relationships which could result in achievement of the 1983 goal.

- Relationship of other environmental goals to water pollution control (including energy conservation, water conservation, resource recovery).

- Willingness of people (water users) to pay for increased water quality.

- Overall costs of implementing water pollution control programs to achieve the 1983 goal versus the benefits to be derived.

The report covers these areas in sufficient detail to present an evaluation of the importance of these factors in achieving the fishable/swimmable water quality goals for the Larimer-Weld Region. References listed in the text and bibliography are to direct the reader to more detailed discussion of these topics.

1.2 FINDINGS AND CONCLUSIONS

1.2.1 Existing and Project Water Quality

All native waters of the semi-arid Larimer-Weld Region either originate in the Front Range of the Rocky Mountains within the Region or flow into the area from the neighboring Denver-Boulder area. Most water originating in the Region comes from mountain snow packs or precipitation events. Waters not native to the South Platte River Basin come from the headwaters of either the Laramie River, a tributary of the North Platte, or the Colorado River Basin to the West of the Continental Divide. These non-native transmountain or transbasin diversion waters are relatively free from pollutants. They are stored and released for the purpose of augmenting native water supplies for municipal, industrial and agricultural beneficial water uses during dry periods.

In the Larimer-Weld Region, the overall man-made and natural water conveyence system is extremely complex. There are over 2,500 miles of canals and ditches operated by 81 irrigation ditch companies under the auspices of individual river commissioners in the employ of the Colorado State Engineer's Office. These commissioners operate the rivers to satisfy water decrees authorized under Colorado Water Law, with an objective of maximizing the use of the limited water resources.

Waters of the mountain areas are generally free from pollution, but as they make their way to the lower elevations of the plains areas the use and reuse of the water resource and the physical character of the plains geology and climate adversely impact water quality and quantity for sustaining aquatic life and recreational uses.

Total mass emissions loadings of these pollutants from agricultural sources is not expected to increase significantly over the next 20 years. Wastes from municipalities and industrial activities will increase as a function of increased populations and the nature of industrial businesses which utilize water-based processing or waste disposal techniques.

The major pollutants generated from existing municipal and industrial sources are biochemical oxygen demanding (BOD) materials, nitrogen (including ammonia nitrogen), suspended solids and, depending on the type of industry, certain exotic pollutants including heavy metals. The total mass loading of pollutants from municipal sources is expected to approximately double if current population trends continue and conventional water consumption and waste treatment practices continue. Conventional secondary level treatment is currently envisioned to be the most adequate and cost-effective means of controlling wastes from municipalities. NPDES permit conditions will determine treatment processes for industrial wastes. The nitrogen compounds from municipal wastes, along with other trace elements, are considered a resource by agricultural water users.

Though not particularly important on an areawide basis, non-point pollution from urban storm runoff, construction, silviculture (forest management) and septic tanks, are considered to be quite significant water quality problems on a localized basis and result in water quality degradation in the major river drainages. The ability to quantify the problems and prescribe adequate and cost-effective solutions in the near term has, and will, continue to hamper control of these pollutant generators.

The major sources of man-caused water pollution in the Larimer-Weld Region are the result of the discharge of treated municipal and industrial wastes, and agricultural activities. On a regional basis, at current levels of treatment and control, pollution from irrigated and non-irrigated agriculture will continue to be a source of high sediment (suspended solids), salinity (total dissolved solids) and nitrate-nitrogen.

Conclusions: Section 2.0

1. Major sources of pollution within the Larimer-Weld Region include municipal and industrial point sources, and non-point sources including irrigated agriculture and urban runoff. Pollutant sources which have less impact on water quality include solid waste disposal, construction activities, silvicultural activities and other forest uses, and confined animal feeding operations.

2. The impact of these discharges is directly related to the proportionate level of land use associated with each activity in the Region. The Cache la Poudre River basin and Big Thompson River Basin are more impacted by urban development activities than the St. Vrain and South Platte. The plains area of all basins are impacted by pollutants contained in and conveyed by irrigation return flow.

3. The impacts of urban runoff have been projected but not verified through a program of sampling and analysis.

4. All streams of the plains area are impacted by pollutants contained in and conveyed by irrigation return flows which are estimated at approximately 380 mgd as compared to municipal and industrial discharges of 46 mgd.

5. Irrigation return flows to the Cache la Poudre River are estimated at 150 mgd compared to 25 mgd discharged by municipal and industrial sources.

6. Water quality of the Big Thompson River is effected by municipal and industrial discharges from the City of Loveland and Great Western Sugar Company. Combined municipal and industrial discharges in the basin including the Little Thompson are estimated at 15 mgd, irrigation return flows are estimated at 44 mgd.

7. Point sources discharging into the Little Thompson River include Milliken and Johnstown. These discharges have a negligible effect on water quality of the Little Thompson.

8. The Little Thompson receives a considerable amount of irrigation return flow. During the summer season, flows from the Little Thompson basin have a total dissolved solids content of 2000 mg/l. The Little Thompson is also subject to sediment loading which is the highest in the Region. Sediment levels in the Little Thompson range upwards of 200 mg/l.

9. Only one municipal discharger, Mead Sanitation District, discharges to the St. Vrain in the Larimer-Weld Region. Agricultural return flows to the St. Vrain River are estimated at 62 mgd.

10. The only point source dischargers on the South Platte River are a number of small communities in South Weld County which have a negligible influence on water quality. Total municipal discharge is less than 1 mgd while irrigation return flows are estimated at 125 mgd.

11. Irrigation return flows are a major element in the water supply equation of the Larimer-Weld Region. They entirely sustain the flow of the lower Cache la Poudre, lower Thompson, lower St. Vrain, and portions of the South Platte Rivers during certain periods of the summer low flow period.

12. The impacts of point and non-point source discharges vary substantially throughout the Larimer-Weld Region due to the extremely complex system of supply and diversion. Impacts of specific point sources are often masked by non-point source discharges or completely nullified by subsequent withdrawal of the entire system flow for application to irrigated land.

1.2.2 Water Quality Criteria and Standards

The quality of water and the impacts of pollution on beneficial uses cannot be viewed in simple absolute terms. Each beneficial use of water requires that the physical, chemical and biological characteristics fall within some limiting range if uses are to be maintained without serious impairment or damage to the water user. This applies to all uses of water in the Larimer-Weld Region including recreation, agriculture, aquatic life, and public water supply.

Water quality criteria and standards are the basis for determining the ranges or concentrations of particular constituents which may enhance or impair the suitability of water for a potential beneficial use. The processes of developing criteria and standards and developing computer modeling techniques to depict real world situations is a relatively new frontier of knowledge.

Conclusions: Section 3.0

1. The ability of technicians to measure chemical concentrations in water, conduct tests on aquatic life under idealized laboratory conditions, and write computer programs supposedly depicting in-stream conditions has advanced tremendously in recent years.

2. The application of this advaned technology to specific rivers, streams and reservoirs is in its embryonic stage and deserves considerable additional field testing prior to application to municipal and industrial discharge permits. Beneficial uses of water within the Larimer-Weld Region include recreation, aquatic life, agriculture, and water supply.

3. The factors affecting establishment of numeric standards to ensure protection of beneficial uses include highly localized conditions such as in-stream aquatic life, pH, temperature, hardness, total dissolved solids, and other in-stream pollutants. These factors are highly variable within the Region.

4. Establishment of numeric standards beyond "Basic Standards" currently in effect for streams within the Region will require additional sampling, bioassays, and biosurveys.

5. Application of water quality criteria other than basic standards presently in effect cannot be supported until more scientific evidence is available proving the applicability of those criteria in the Larimer-Weld Region. Application of broader water quality criteria in the development of NPDES discharge permits is not acceptable until such scientific information is available and the following conditions are met:

   a. In-stream monitoring programs, biosurveys, bioassays, and other scientific evidence indicate that chemical constituents included in such criteria are present in sufficient concentrations in receiving waters to interfere with beneficial uses of water in legally adopted stream classifications and are applicable to specific situations within the Region.

   b. Monitoring programs identify specific point and non-point sources of the constituent in question, the level attributable to each source, and the specific impact of each source on the beneficial use of water.

c. The economic, social, and environmental impact and technical feasibility of eliminating specific pollutant is defined through planning conducted in accordance with Section 201 and/or Section 208 of the Clean Water Act.

d. Facilities are constructed and/or best management practices are developed and implemented to control the discharge of specific pollutants.

1.2.3 Factors Affecting Attainment of 1983 Water Quality Goals

Factors affecting local attainment of the national water quality goal, as well as the means of attainment, include regional hydrology, existing aquatic life, in-stream physical factors such as stream bed conditions, flow, habitat, temperature, as well as chemical factors, and local goals, attitudes and desires concerning priorities for recreation and water use.

Conclusions: Section 4.0

1. The surface water hydrology of the Larimer-Weld Region has undergone extensive changes in the last 120 years with the objective of maximizing use of available water supplies for irrigation, municipal and industrial purposes.

2. Numerous diversion structures have been constructed in the streams to facilitate delivery of water to various ditches and from there to reservoirs, irrigated land, municipalities and industries in the Region.

3. Operation of the river system under the management strategy which maximizes availability of supplies for these purposes results in total diversion of all supplies from rivers at many points.

4. Diversion of total flow in the river occurs during the irrigation season, May - September, and during the storage season, October - April.

5. Diversions on the Cache la Poudre River flows totally dry up the river at least 11 times between the North Poudre Supply Canal at the mouth of the canyon and its confluence with the South Platte.

6. Diversions from the Big Thompson River may dry up the river at least five times between the mouth of the canyon and its confluence with the South Platte River.

7. The South Platte River may be dried up at least 5 times within the Region.

8. Extreme hydrologic variations contribute to the survival of only the hardiest species of fish in the plains area of the Region. These fish are generally referred to as "rough" or "forage" fish and for the most part, include carp, suckers, and minnows.

9. Mountain streams of the Region generally provide excellent habitat for trout fisheries. The mountains are also the prime providers of supply for agriculture and municipal uses of water.

10. The high mountain streams are a great regional and state fisheries and recreation resource which should be protected from degradation.

11. Stream life of the plains streams is determined by factors other than flow, including benthic and bank conditions, temperature, quality.

12. Existing recreational fisheries in the streams of the plains area are marginal at best. This is confirmed by the fact that the Colorado Division of Wildlife does not consider the plains streams as a viable fishery and does not spend state resources on stocking or attempting to manage these plains streams as fisheries. It is also confirmed through biological data collected as part of the 208 program and from other sources.

13. Opportunities for establishment of in-stream fisheries within the plains area appear to be extremely limited.

14. Establishment of fisheries in the numerous off-stream reservoirs has been accomplished and appears to offer the greatest benefits in the future in terms of meeting water quality goals and regional and state program goals.

15. The Larimer-Weld Region contains 25 percent of water recreation areas in the South Platte River Basin in Colorado.

16. Water based recreation and fisheries within the Region center around mountain streams and reservoirs in the foothills and plains areas.

17. Public acceptance of large expenditures for improving water quality in the rivers of the Region is considered to be questionable when the public benefits from such improvements appear to be negligible in terms of providing increased recreational and fishery opportunities.

18. Opportunities for recreational enhancement in the Larimer-Weld Region appear to be greatest in the mountainous areas and at off-stream sites such as reservoirs, converted gravel operations, and reservoirs in the foothills areas.

1.2.4 Relationship of Other Environmental Goals to Water Pollution Control

Water quality improvement cannot be viewed in isolation. It must consider impacts, both positive and negative, to other desired goals. The technical consideration for water pollution control must consider such things as resource conservation and recovery, impacts to safe drinking water, energy conservation and water conservation. In selecting water pollution control measures appropriate for this Region, recommendations have been made for municipal and industrial point source control and agriculture pollution control which will maximize the objectives of these concepts while still attempting to recognize the limitations imposed by resource use, financial constraints, and other existing federal, state and local environmental programs.

Conclusions: Section 5.0

1. Federal Clean Water Act encourages to the maximum amount feasible "the recycling of potential sewage pollutants through the production of agricultural, silvicultural and agricultural products and the reclamation of wastewater."

2. This goal is carried out to the maximum extent feasible by the systems of discharge and diversion existing within the Region. Wastewater discharged by municipal treatment plants is used on an average at least 2½ times prior to leaving the Region.

3. Land treatment for the major urban centers of Fort Collins, Loveland and Greeley, as a means of achieving tertiary treatment, or to eliminate a direct discharge is not cost-effective. Opportunities for direct land application of wastewater as a planned component of water quality management appear to be more substantial in rural communities.

4. The major agricultural solid waste problem exists in terms of management of residual wastes from concentrated animal feeding operations. Disposal of manure generated by livestock on confined animal feeding operations as a fertilizer and soil amendment in combination with application of commercial fertilizers causes excess nitrate loadings to ground waters. Implementation of agricultural best management practices can eliminate this problem and provide direct economic benefits to the farmers. Other elements of the 208 program include detailed recommendations for carrying out such programs.

5. The continuing 208 planning program will address the problem encountered by communities in meeting requirements of the Federal Safe Drinking Water Act.

6. Planning, management, and operations agencies for point and non-point source pollution control should be required to address the question of energy consumption and energy conservation measures proposed as part of the implementation of pollution control programs.

7. Control of pollutants from irrigated agriculture and implementation of best management practices will be achieved with measures which increase the efficiency of conveyance systems and on-farm irrigation systems. Some degree of water conservation will occur as a result of a decrease in net demand if these measures prove to be cost-effective from a regional standpoint and are widely implemented. However, the final disposition of the water conserved is uncertain at this time.

8. Major municipalities within the Region have established goals of reducing unit waste flows within their sewage systems by substantial amounts.

9. Implementation of water conservation measures in the home could provide greater reserve capacity in existing waste treatment feacilibies. Major flow reductions cannot be expected.

1.2.5 Technical Strategies for Achieving National Water Quality Goals

Four technical strategies were designed for achieving the national water quality goals in the Larimer-Weld Region. The basic elements of the strategies include:

1. A technical plan for management and control of point and non-point source dischargers.

2. A set of stream classifications and standards for streams in the Region which enable protection of beneficial uses.

3. A coordinated regional water quality, biological and hydrological monitoring and reporting program aimed toward protecting existing beneficial uses and determining new standards and conditions for waste discharges.

The elements of the technical strategies were derived as a result of an extensive analysis conducted in the initial 208 planning process involving extensive review and input from the Areawide Planning Committee and others involved in the public participation process. Factors common to all four strategies include:

1. Continued enforcement of feedlot regulations and operation of pollution control facilities by feedlot operators;

2. A major program of agricultural pollution control in the Region to control, to the extent feasible, discharges of salinity, nitrates, and sediment to rivers of the Region. This program will be heavily dependent upon federal funding for implementation;

3. Development and implementation of an urban runoff pollution control program in the Region;

4. Development of pollution control programs for other non-point sources, including construction, silvicultural activities, septic tanks and leachfields, and solid/hazardous waste disposal; and

5. Maintenance of the high quality of mountain streams in the Region.

Major variables associated with the technical strategies include:

1. Treatment level requirements applied to point source discharges; and

2. The degree to which marginal fisheries are upgraded within the Region through fish stocking, stream engineering, dredging and flow augmentation.

Summary descriptions of the four alternative technical strategies are provided below. A cost summary for each alternative is given in Table 1.2.5-A. Complete descriptions of these technical strategies are provided in Section 6.0 of this report.

A. STRATEGY NUMBER 1: WASTEWATER TREATMENT

The objective of this strategy is to meet water quality goals as they are defined under existing State of Colorado stream classifications and standards. The emphasis of this strategy is on the control of municipal and industrial point source discharges. Municipal and industrial point source discharges for the Cache la Poudre River must provide advanced waste treatment by the Year 2000 to meet water quality standards. In addition, the Loveland Waste Treatment Plant must provide

TABLE 1.2.5-A MAJOR FEATURES AND ASSOCIATED COSTS OF ALTERNATIVE TECHNICAL IMPLEMENTATION STRATEGIES

	PROGRAM COMPONENT - COST (x $1000) (a)									
	POINT SOURCE						DREDGING			
	M & I (b)	Feedlots (b)	Agri. (b)	Urban Runoff (b)	Fish Stocking (c)	Stream Engrg. (b)	Initial (d)	Thereafter (d)	Flow Aug. (e)	TOTAL
Strategy 1 (f)										
Cap. Cost	29,945 (g)	300 (h)	100,000 (i)	4,263 (k)						134,508
Annual O & M	3,825	-	3,000 (j)	340						7,165
Equiv. Annual	6,383	22	13,000	606						20,011
Strategy 2 (l)										
Cap. Cost	26,255 (g)	300	100,000	4,263	167 (m)	220 (n)	118 (o)	118 (p)	19,305	150,746
Annual O & M	3,601	-	3,000	340	-	-	62 (q)	37 (r)	-	7,040
Equiv. Annual	5,807	22	13,000	606	9	17	47	23	1,307	20,838
Strategy 3 (s)										
Cap. Cost	11,704	300	100,000	4,263	0	68 (t)				116,335
Annual O & M	3,279	-	3,000	340	40 (m)	-				6,659
Equiv. Annual	4,220	22	13,000	606	35	6				17,889
Strategy 4 (u)										
Cap. Cost	11,704	300	100,000	4,263	-	-				116,267
Annual O & M	3,279	-	3,000	340	-	-				6,619
Equiv. Annual	4,220	22	13,000	606	-	-				17,848

Source: Toups Corporation, March, 1978.

TABLE 1.2.5-A (CONTINUED)

(a) Costs in terms of January, 1977, dollars.
(b) Assumes 7% interest, amortized over 20 years.
(c) Assumes 7% interest, amortized over 50 years.
(d) Assumes 7% interest, amortized over 10 years.
(e) Assumes unit cost of C-BT share = $1,300; Quota = 60%; flow augmentation implemented in Big Thompson River (15 cfs) and Cache la Poudre River (15 cfs) from May through September; 7% interest amortized over 50 years.
(f) Meet existing water quality standards - No flow augmentation. Advanced treatment required at Fort Collins Nos. 1 and 2, Boxelder S.D., Windsor, Eastman Kodak Co., Greeley Delta, and Loveland. Tertiary treatment required at Greeley First Avenue and Great Western, Loveland.
(g) Assumes plants requiring tertiary or advanced waste treatment upgrade immediately, unless such facilities are staged according to future need for additional capacity (Greeley Delta).
(h) Staged over five years.
(i) Capitol cost at an estimated average participation of 70%. Cost at 100% participation would be $140 million.
(j) Includes 50% participation in irrigation scheduling ($12/acre x 500,000 x 1/2). Miscellaneous O & M expenses are minimal and most BMP's reduce overall O & M costs. Energy costs of sprinklers are offset by reduced labor requirements and therefore not included.
(k) Control measures for urban runoff are oriented toward source control, non-structural control options, and structural options incorporated into an overall system of drainage/flood control. Construction assumed in 1980.
(l) Provide flow augmentation. Advanced treatment required at Greeley Delta. Tertiary treatment required at Fort Collins Nos. 1 and 2, Boxelder S.D., Windsor, Eastman Kodak Co., Greeley First Avenue, Loveland, and Great Western, Loveland.
(m) Based on $110 per surface acre stocked.
(n) Based on one man-year professional design time plus $500 - $2,000 per river mile for construction; includes cost of fish screens estimated to be $1,000 per ditch.
(o) Purchase of mini-dredge.
(p) New mini-dredge to be purchased in 1988.

TABLE 1.2.5-A (CONTINUED)

(q) Includes annual insurance premium of $3,000; assumes dredge operated continuously during the year; does not include cost of transporting, launching, or retrieving dredge; $62,000 for first four years to initially expose channel substrate in the Big Thompson and Cache la Poudre Rivers downstream from canyon mouths, and in reach of the St. Vrain River within the two-county area; $37,000 per year thereafter for channel maintenance.

(r) Assumes mini-dredge operated for seven months out of each year.

(s) Protection of existing water uses - secondary treatment - some fish stocking in selected plains river reaches.

(t) Based on 7 months of professional design time plus $500 - $2,000 per river mile for construction, includes cost of fish screens, estimated to be $1,000 per ditch.

(u) Protection of existing water uses - secondary treatment - no fish stocking in plains river reaches.

advanced waste treatment and the Great Western Plant at Loveland must provide tertiary treatment before discharge to the Big Thompson River. The proposed Greeley Delta Plant must provide advaned waste treatment prior to discharge to the South Platte River.

Strategy No. 1 does not include flow augmentation, dredging, fish stocking, or recreational enhancement. Hence, the major factors that are presently inhibiting the development of a high quality fishery in the plains area, i.e., hydrology and stream habitat, would not be altered. Water quality would be improved but the type and quality of the existing aquatic biota would not be improved, except as it may change through only water quality improvements.

B. STRATEGY NO. 2: UPGRADING AQUATIC HABITAT

Strategy No. 2 would include advanced waste treatment for municipal and industrial discharges on the Lower Poudre, flow augmentation on the Poudre (15 cfs) and on the Big Thompson (15 cfs), dredging of the Poudre and Thompson to expose substrate required for fish propagation, recreational enhancement, fish stocking, and stream engineering to provide fishery habitat. Flow augmentation will be limited to the period of April through October. During the remainder of the year, it is assumed that through stream engineering, adequate fish habitat could be maintained in the plains. The validity of this assumption has not been fully field tested in an area strongly affected by hydrologic modification such as the Larimer-Weld Region.

Implementation of Strategy No. 2 would theoretically enable upgrading of the fisheries to support a wide variety of sport fish and enable limited propagation of fish life in the plains areas. Such a concept has not been field tested.

This strategy includes the following provisions:

- o Augmentation flows be provided;
- o Channel substrate by exposed and maintained through initial and ongoing programs of dredging;
- o In-stream and channel habitat commensurate with requirements of a desirable sport fishery be created or enhanced;
- o Waste loads tributary to streams be reduced to levels which will support long-term survival and propagation of a desirable sport fishery;

- Plains river reaches be initially stocked with sound breeding populations of desirable sport fish;
- Recreational opportunities on main-stream rivers, including access, be improved.

C. STRATEGY NO. 3:

Under Strategy No. 3, secondary treatment will be required of all existing plains area dischargers. The strategy does not include flow augmentation. In the reach of the Poudre between the mouth of the canyon and Fort Collins Sewage Treatment Plant Number 1, fish stocking and stream engineering will be included. Fish stocking will be limited to the area upstream of Fort Collins and certain areas of the Big Thompson upstream of Loveland, but below the mouth of the canyon. Stream engineering would also be included in these reaches. Planning and coordination of local, state and federal recreational programs would be accelerated to enhance the opportunity for public utilization of these areas. Below Fort Collins Sewage Treatment Plant Number 1 on the Poudre and the Louden Ditch on the Big Thompson, no effort will be made to upgrade the existing fishery. A coordinated water quality, quantity and biological monitoring program will be implemented to assure the necessary margin of safety of existing aquatic life and obtain useful information to further plan water quality control measures.

D. STRATEGY NO. 4:

Strategy No. 4 requires all discharges meet secondary treatment standards. Control measures would be undertaken for non-point sources which would maintain the integrity of the existing fishery. There would be no fish stocking or stream engineering in the plains area streams.

Conclusions: Section 6.0

1. An alternative technical strategy which meets numerical water quality standards through application of strict point source controls above (Strategy #1) will be extremely expensive to municipal and industrial dischargers and will not have any noticeable effect on the existing beneficial uses, including aquatic life, in the plains area of the Region.

2. The potential exists for creating a diversified sport fishery in the plains area of the Cache la Poudre and Big Thompson Rivers through a program of flow augmentation, stream engineering, fish stocking and dredging. While this may be a desirable long-term goal for the Region,

much additional information is needed to determine the feasibility of this goal and the benefits to be derived from extremely high expenditures for point source control and purchase of water for flow augmentation.

3. Upgrading of fisheries through a program of stream engineering and fish stocking, and possibly altered water management strategies in areas on the Big Thompson River between Loveland and the mouth of the Big Thompson Canyon, and Fort Collins and the mouth of the Cache la Poudre Canyon, appear to be feasible. Additional research is recommended along with field testing to determine the actual feasibility of these measures.

4. Secondary treatment is recommended for all municipal and industrial dischargers in the plains area. Based on data and information available and ongoing programs to upgrade waste treatment capabilities, secondary treatment will provide adequate protection of beneficial uses in these areas of the Region. Higher levels of wastewater treatment are not justified.

5. A regional water quality monitoring program should be established which includes not only chemical and physical data, but also biosurveys and bioassays to determine future in-stream levels of protection within the Region.

6. Common elements assumed to be incorporated in any pollution control strategy for the Larimer-Weld Region include:

   a. Continued enforcement of feedlot regulations and operation of pollution control facilities by feedlot operators.

   b. A program of agricultural pollution control in the Region to the control, to the extent feasible, dischargers of salinity, nitrates and sediment to rivers of the Region. This program is heavily dependent upon federal funding for implementation on a demonstration basis. Full implementation can come only after control measures are proved to be cost-effective and necessary.

   c. Development and implementation of an urban runoff pollution control program in the Region.

   d. Development of pollution control program from other non-point sources including construction, silvicultural activities, septic tanks and leachfields, solid/ hazardous waste disposal.

e. Maintenance of high quality of mountain streams in the Region.

Implementation of the Larimer-Weld 208 Program requires adoption of a set of stream classification standards and implementation of a water quality monitoring program in the future. These are described in Section 7.2.1 of this report.

1.2.6 Costs Versus Benefits in Water Quality Control

The cost of technical alternatives to meet 1983 goals ranges widely among the four strategies presented above. Strategy No. 1 has the highest capital expenditure in terms of advanced waste treatment to meet water quality standards presently in effect. Attainment of those standards will not result in a measurable alteration of the existing aquatic life system existent in the rivers and streams of the plains area of the Larimer-Weld Region or enhance recreational opportunities. Thus, the high cost appears to be without benefit.

Strategy No. 2 is the most expensive alternative and includes not only the cost of advaned waste treatment for municipal and industrial dischargers but also the cost of stream engineering, construction of fish habitat, and flow augmentation. It is believed that this strategy would provide opportunities for alteration of aquatic life in the plains area streams. The cost is high in terms of both capital construction for advanced waste treatment plans and purchase of water for flow augmentation. Obtaining public access to these newly created fisheries essentially would be another problem which would detract from the benefits derived from water quality improvement. Historically, most of the fishing and water based recreation in the Region is in high mountain streams and reservoirs in the foothills and plains areas. The benefits of upgrading the fisheries and improving access to the rivers as opposed to investing funds to improve the fisheries in reservoirs as well as public facilities and access to reservoir sites is highly questionable.

Strategy No. 3 will meet the 1983 goals in terms of providing fishable/swimmable conditions where attainable. Advanced waste treatment is not required on any of the plains area streams, primarily due to lack of benefits to be derived from requiring advanced waste treatment. Conditions existent in those streams indicate that advanced waste treatment or improvement of water quality conditions would have essentially no significant effect on aquatic life within the plains streams now. Strategy No. 3 also calls for federal and state cooperation in creating fisheries upstream of Fort Collins and Loveland to provide increased opportunity for recreational and fishery use of the streams closer to population centers. Some additional research and development will be required to insure the success of that program and to examine its feasibility.

Strategy No. 4 calls for secondary treatment throughout the plains area. It is essentially the same plan as Strategy No. 3 except that no fisheries are created upstream of Fort Collins and Loveland.

1.2.7 Willingness to Pay for Increased Water Quality

A survey conducted independently of the 208 planning process indicates that urban residents are willing to make expenditures to improve water quality providing there is a corresponding benefit in terms of enhanced enjoyment of water based recreational activities, and preservation of a natural ecosystem, and its bequest to future generations (see Section 4.0).

The preferred method of payment for improved water quality was an increase in sales tax as compared to an increase in water and sewer bills. The reasoning behind this is inferred to be that everyone, including tourists, pays sales tax, and the cost of improved water quality would be shared by more of those who benefit.

In examining the four alternative strategies developed in the Larimer-Weld 208 planning process, and their impacts on water quality improvement, there may not be full understanding on the part of potential recreational users that all of their expectations for increased water quality could be satisified, i.e., large expenditures for point and non-point source pollution control for rivers of the Region may not result in visible water quality improvement or enhanced enjoyment of water based recreational activities, which respondents to the survey were anticipating. Future 208 planning will focus on water quality management planning for reservoirs, and the corresponding benefits of such water quality improvement at reservoir sites. That planning must consider the fact that reservoirs provide practically all of the water based recreation available to the public in the Region and twenty-five percent of the total water based recreation available to the State.

1.3 SUMMARY OF RECOMMENDATIONS

1.3.1 Recommended Technical Strategy

Strategy No. 3 has been selected as the recommended technical strategy. The strategy would include secondary treatment at all municipal treatment plants in the plains area as well as best practical treatment and best available treatment on a time phase basis at industrial sites. Strategy No. 3 is recommended primarily due to the corresponding costs and benefits derived and the possibility of enhancing fishing and recreational aspects of the Cache la Poudre and Big Thompson Rivers upstream of Fort Collins and Loveland.

1.3.2 Stream Classifications for Beneficial Uses

The Areawide Technical Plan outlines the process and rationale for developing a set of stream classifications criteria and standards for beneficial uses of water. At the request of the Colorado Water Quality Control Commission, LWRCOG was asked to make recommended stream classifications to water bodies in the Larimer-Weld Region. This was undertaken as a separate, but integral, part of the 208 planning process. The recommended stream classifications take into account the past, present and anticipated uses of water bodies in the Region for the next 20 years and recommend levels of water quality suitable for these uses. Generally, the recommended classifications prescribe preservation of high levels of water quality for the mountain and foothills regions suitable for recreation, public drinking water supplies and quality aquatic habitat and agriculture. For the plains areas, the recommendations recognize the significance of water quantity/water quality relationships and the physical constraints to the aquatic ecosystem. The plains streams are recommended to be suitable for agriculture, recreation and aquatic life.

Reservoirs and groundwater resources are proposed for deferred classification pending further investigation of existing water quality and assessment of past, present and anticipated beneficial uses. Detailed recommendations for stream classifications are contained in Section 7.2.1.

1.3.3 Water Quality Monitoring and Analysis Program

The recommended water quality monitoring program is included as an integral part of continued 208 planning. The objectives of the program include:

1. Define the impact of stream point source discharges on water quality within the Region;

2. Define the impacts of non-point sources such as agriculture, silviculture, mining, urban runoff, septic tanks and leachfields, and natural background conditions on water quality;

3. Define the relationships between non-point source pollution, natural background pollution and point source pollution in the Region;

4. Define the relationship between water quality parameters which can be measured and the beneficial uses of water recognized in the Region;

5. Provide the basis for evaluating the effectiveness of measures implemented by municipalities and industries and others involved in pollution control in the Region;

6. Provide an indication as to degree of pollution of groundwater supplies in the Region and the significance on beneficial uses, future trends and sources of pollution;

7. Provide the data necessary to insure protection of beneficial uses in the Region;

8. Provide the data necessary to indicate trends in water quality.

The recommended water quality monitoring program will constitute the basis for future planning activities as well as investment in pollution control facilities within the Region. Establishment of the monitoring program, which will include cooperative programs among federal agencies, state agencies, planning agencies, municipalities and industries, will insure a fact-based decision process to guide pollution control planning, management and operation and regulation in the future.

1.3.4 Future Planning Efforts

The 208 Plan recognizes that the initial round of planning does not provide all of the answers to all of the questions regarding pollutants and pollution control within the Region. Additional planning is needed, particularly in the area of non-point sources such as silviculture, urban runoff, septic tanks and leachfields, and non-irrigated agriculture. A fundamental element of the Larimer-Weld 208 planning process is that planning for these pollutant sources must be completed prior to implementation of pollution control measures to control these sources. Adequate planning will enable determination of cost-effectiveness of those measures prior to implementation, as well as the specific effects of these measures in terms of costs and benefits as applied to specific cases within the Region.

1.3.5 Additional Research, Development and Demonstration

Additional research and development will be needed in some areas prior to implementation of pollution control measures. In particular, demonstration projects are recommended in the Little Thompson and Lone Tree Creek basins to determine the cost effectiveness of best management practices for irrigated agriculture. Additionally, demonstration projects may be required in the future to test the effectiveness of pollution control measures, whether structural or non-structural, for silvicultural activities and recreational use of the forests, and urban runoff control. Assessment of future research and development will be included in the continued planning process.

2.0 EXISTING AND PROJECTED WATER QUALITY AND IMPACTING FACTORS

The chemical composition of natural water is derived from many different sources of solutes, including gases and aerosols from the atmosphere, weathering and erosion of rocks and soil, solution or precipitation reactions occuring below the land surface, and cultural effects resulting from activities of man (Hem, 1970). Natural waters are never pure. They are in fact dilute aqueous solutions of a mixed and complex character. Human influences which affect water quality in the Larimer-Weld region include municipal and industrial point source discharges, and urban runoff, livestock feeding operations, irrigated agriculture, and a variety of other nonpoint sources.

Point sources have been inventoried in Interim WQMP Report No. 6, Municipal and Industrial Point Source Analysis, Wastewater Treatment, Operation and Maintenance Requirements. This investigation defined existing and projected wastewater characteristics, determined adequacy of treatment facilities, and developed programs for wastewater systems upgrading and expansion. Pollutional aspects of agriculture were examined in two separate reports: Interim WQMP Report No. 15, Concentrated Animal Feeding Operations, and Interim WQMP Report No. 22, Water Quality Impacts of Irrigated Agriculture. Nonpoint sources have been reviewed in Interim WQMP Report No. 19, Nonpoint Source Control, Analysis and Recommendations.

Point sources of pollution are normally discharged in a relatively controlled manner; methods of monitoring and measurement prior to release to an aquatic environment make water quality assessments relatively precise. In contrast, the diffuse nature of nonpoint sources of pollution makes assessment of their character, magnitude, and impacts extremely difficult. Efforts which seek to define the nature and rate of mass emissions associated with nonpoint sources are inherently costly and time consuming.

A comprehensive surveillance system must be established in order to define base-line conditions of natural water quality, against which incremental impacts of nonpoint pollution can be compared. The financial resources available to the Larimer-Weld region during the course of 208 water quality management planning permitted analysis of nonpoint sources at a reconnaissance level only. With the exception of irrigated agriculture, assessment of mass emissions and probable impacts was achieved in generalized terms, unless existing monitoring programs or available data permitted a more definitive evaluation. In the region, the results of past research and data gathering have not generally been adequate for sophisticated nonpoint pollution impact assessment. The framework of a monitoring program which would generate the data base needed to determine degree of pollution as well as effectiveness of control measures implemented in the region will be described in detail in Section 7.0 of this report.

Water quality considerations are but one aspect of the total spectrum of in-stream environment needed to achieve the "fishable/swimmable" goal of the Clean Water Act. Improvement of water quality to levels commensurate with the requirements of a desirable sport fishery will not result in attainment unless a variety of equally-critical aquatic habitat requirements are also created in the Larimer-Weld region. Factors such as in-stream quantity, presently regulated by the existing system of appropriative use under Colorado Water Law, are an important habitat consideration. This and other parameters not related to water quality which affect the attainment of the fishery goal are reviewed in Section 4.0.

There are literally hundreds of elements, chemical, and radiological compounds, and organisms which could, if persistent in sufficient concentrations, interfere with any or all of the major beneficial uses of water in the region. However, only comparatively few parameters are identifiable in surface and ground water utilizing standard testing procedures. Even fewer are totally understood (outside of research efforts) as to their source, method of transport, synergistic effects (i.e., the physical, chemical, biological effects of a combination of one or more elements present), ultimate fate, and potential for control or elimination. Many of these "pollutants" are attributable to natural sources while others are "released" or introduced because of man's activities in or adjacent to water.

2.1 POLLUTANT SOURCES - EXISTING AND PROJECTED

The more significant sources of pollution in terms of actual or potential degradation in the Larimer-Weld region include municipal and industrial point sources, irrigated agriculture, and urban runoff. Each of these sources generates various types of waste loads which may impact regional water quality and the beneficial uses to which such water is applied.

Definition of existing constituent mass emission rates from point and nonpoint categories of waste was accomplished by selected use of the following methodologies:

- use of historic point source flow and quality discharge data;
- application of water quality sampling data activity collected as part of the Larimer-Weld 208 program;

- use of generalized analytical methods permitting estimates and computations of waste loads;
- expansion of specific nonpoint research conducted in the Larimer-Weld region to represent the broad range of impacts from similar nonpoint sources on a regional level.

The type of analysis prepared for each category of point or nonpoint waste is reviewed in detail in the appropriate sections of Interim Water Quality Management Reports which pertain to the specific topic (see the accompanying bibliography of this report).

Assessments of future wasteload sources in the region were evaluated in the following manner, as appropriate:

- association of unit mass emission rates with population projections and future land use allocations defined in _Larimer-Weld Region Land Use Alternatives, Analysis of 20 Year Growth Demands and Impacts_, (Interim WQMP Report No. 16).
- assessment of future trends in various activities, equated to unit mass emission rates representative of that activity.

2.1.1 Pollutants and Beneficial Use Impairment

Beneficial uses of water in the Larimer-Weld Region include recreation, agriculture, aquatic life and public water supply (see Section 7.0). All of these uses can be impacted by point sources and nonpoint sources to varying degrees due to the discharge of specific pollutants associated with each source. Table 2.1.1-A identifies pollutants which may be associated with major pollutant sources.

Pollutants and beneficial uses to which water may be applied are not always incompatable; in fact, there are instances where certain constituents are pollutants to one beneficial use and benefits to others. An example would be the nitrate content of receiving water: it could degrade water quality to the point where it is unsuitable for drinking; however, the same nutrient could have a positive effect on agricultural crop production when the water is used for irrigation. Other examples are presented in Table 2.1.1-B.

The table is not intended to be all inclusive. Many other constituents which characterize water quality in the region have not been adequately analyzed to the point where explicit definition is possible. While this report and other elements of the 208 Water

TABLE 2.1.1-A Major Pollutants of the Larimer-Weld Region and Their Sources

	SOURCES				
Parameter	Mun.	Indus.	Agric.	Urban Runoff	Feedlots
Biochemical Oxygen Demand	X	X		X	X
Ammonia [2] (NH_3)	X	X	X		X
Nitrate (NO_3)	X	X	X	X	X
Sediment	X		X	X	
Salinity	X	X	X	X	X
Phosphorus	X		X	X	
Bacteria viruses[a]	X			X	X
Chlorine	X	X			
Dissolved Oxygen[a]	X	X		X	X
Pesticides		X	X	X	
Heavy Metals	X	X		X	
Oil/grease[a]	X	X		X	
Radioactive Material[a]					
Temperature[a]	X	X	X	X	
pH[a]		X		X	

[a]Standard set by Colorado Department of Health Water Quality Control Commission, Effective June 19, 1974.

TABLE 2.1.1-B WATER POLLUTANTS AS RESOURCES

Parameter	Context in which Parameter is Viewed as Pollutant	Context in which Parameter is Viewed As Resource
Nitrate	Safe drinking water	Crop production
Suspended Solids	Drinking Water, Aquatic Biota	Crop production
Ammonia	Aquatic Biota	Crop production
Chlorine	Aquatic Biota	Safe drinking water and wastewater disinfection
Phosphate	Aquatic Biota Safe drinking water	Crop production Aquaculture
Florine	Mottling of teeth with high concentrations	Prevention of dental caries with small concentrations

Quality Management Plan focus on major water quality parameters, the planning process also establishes a long-term program for identifying and controlling other less obvious or significant pollutants.

2.1.2 Sources of Pollution

Water quality in the Larimer-Weld region is determined by the character and extent of naturally occurring sources of degradation, and by the origin, magnitude, and mobility of pollution attributable to human activities. The focus of this chapter is on the later category, human impacts.

2.1.2.1 Municipal Discharges

Discharges from municipal treatment facilities represent a major source of wasteload mass emissions which are conveyed to the receiving water environment. Municipal wasteloads associated with existing and projected levels of development are quantified in Table 2.1.2-A for dischargers in the Larimer-Weld Region. Figure 2.1.2-A shows the location of those discharges.

Characteristics and facilities needs of the various municipal treatment plants in the two-county area were detailed in either of two reports:

- o Municipal Point Source Analysis - Urban Triangle Area, (Interim WQMP Report No. 24);
- o Municipal and Industrial Point Source Analysis, (Interim WQMP Report No. 6).

Wastewater treatment, operation, and maintenance requirements were formulated for a number of alternative land use projections and associated population distributions, considering existing aquatic life classifications as well as those representative of alternative water management strategies. This information provides a portion of the data base necessary to derive a total cost for the plans developed for consideration in Section 6.0 of this report.

2.1.2.2 Industrial Discharges

The nature of industrial operations in the Larimer-Weld region was examined in Interim WQMP Report No. 6, Municipal and Industrial Point Source Analysis. The significant industrial point sources of pollution in the Larimer-Weld region include development and processing of photographic products, processing of sugar and molasses, meat packing, nuclear electric generation, gravel operations, and fish hatcheries. In the following discussion, gravel

TABLE 2.1.2-A MUNICIPAL POINT SOURCES OF POLLUTION IN THE LARIMER-WELD REGION

TREATMENT PLANT	RIVER BASIN	LAGOON	PRESENT OPERATIONAL CHARACTERISTICS ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day	YEAR 2000 OPERATIONAL CHARACTERISTICS ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day
Fort Collins (a)	CP	0	10.6	2,650	2,650	75,100	1,770	15.0	3,750	3,750	106,000	2,500
Greeley	CP	0	6.2	1,550	1,550	43,900	1,030	11.5	2,880	2,880	81,500	1,900
Loveland #2	BT	0	4.0	1,000	1,000	28,300	670	6.1	1,530	1,530	43,200	1,020
Ault S.D.	CP	+	0.09	23	75	640	15	0.33	82	275	2,340	55
Berthoud	BT	0	0.48	120	120	3,400	80	0.70	175	175	4,960	117
Boxelder S.D.	CP	+	0.6	150	500	4,250	100	1.0	250	830	7,090	167
Cottonwood Park	BT	+	0.02	5	17	140	3	0.02	5	17	140	3
Del Camino	SV	0	0.02	5	5	140	3	0.02	5	5	140	3
Eaton	CP	0	0.21	53	53	1,490	35	0.40	100	100	2,830	67
Erie W.S.D.	SV	+	0.13	33	108	920	22	0.18	45	150	1,280	30
Estes Park S.D.	BT	0	0.40	100	100	2,830	67	0.72(b)	180	180	5,100	120
Evans	P	+	0.5	125	417	3,540	83	0.9	225	750	6,380	150
Fort Lupton	P	+	0.64	160	533	4,530	107	1.50	375	1,250	10,600	250
Gilcrest S.D.	P	+	0.04	10	33	280	7	0.13	32	109	920	22
Grover	P	0	0.025	6	6	180	4	0.015	4	4	100	2.5
Hill-n-Park	P	+	0.07	17	58	500	12	0.07	17	58	500	12
Hudson S.D.	P	+	0.06	15	50	425	10	0.15	38	125	1,060	25
Johnson's Corner	BT	+	0.007	2	6	50	1	0.007	2	6	50	1
Johnstown	BT	+	0.22	55	183	1,560	37	0.38	95	317	2,690	63

TABLE 2.1.2-A MUNICIPAL POINT SOURCES OF POLLUTION IN THE LARIMER-WELD REGION (Continued)

TREATMENT PLANT	RIVER BASIN	LAGOON	PRESENT OPERATIONAL CHARACTERISTICS					YEAR 2000 OPERATIONAL CHARACTERISTICS				
			ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day	ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day
Keenesburg S.D.	P	+	0.05	12	42	350	8	0.13	32	108	920	22
Kersey S.D.	P	0	0.05	12	12	350	8	0.30	75	75	2,130	50
LaSalle	P	+	0.17	43	140	1,200	28	0.45	113	113	3,190	75
Lochbuie	P		-					0.15	38	38	1,060	25
Mead S.D.	SV	+	0.035	9	29	250	6	0.07	18	58	500	12
Milliken S.D.	BT	0	0.1	25	25	70	17	0.40	100	100	2,830	67
Mountain Range Shadows	BT	0	0.01	3	2	70	1	0.01	3	2	70	1
Nunn	P	NS										
Pierce	CP	+	0.15	38	125	1,060	25	0.30	75	250	2,130	50
Pingree Park	CP	ND										
Platteville	P	+	0.22	55	183	1,560	37	0.40	100	330	2,830	67
Ramada Inn (I-25)	CP	ND										
Red Feather/ Crystal Lakes	CP	0	NA					0.50	125	125	3,540	83
Riverglenn	BT	ND										
Severance	CP	+	NA					0.08	20	20	570	13
South Ft. Collins S.D.	CP	0	0.5	125	125	3,540	83	1.4(c)	340	340	9,600	225
Spring Canyon	CP	ND(c)										

TABLE 2.1.2-A MUNICIPAL POINT SOURCES OF POLLUTION IN THE LARIMER-WELD REGION (Continued)

TREATMENT PLANT	RIVER BASIN	LAGOON	PRESENT OPERATIONAL CHARACTERISTICS ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day	YEAR 2000 OPERATIONAL CHARACTERISTICS ADWF (mgd)	BIOCHEMICAL OXYGEN DEMAND lbs/day	SUSPENDED SOLIDS lbs/day	SALTS lbs/day	TOTAL NITROGEN lbs/day
Texaco I-25	SV	0	0.02	5	5	140	3	0.02	5	5	140	3
Timnath	NS											
Tri-Area S.D.	SV	+	0.31	78	78	2,200	52	0.94	235	235	6,660	157
Upper Thompson S.D.	BT	0	0.20(a)	50	50	1,420	33	0.77(b)	193	193	5,460	128
Weld Central H.S.	P	0	0.02	5	5	140	3	0.02	5	5	140	3
Wellington	CP	+	0.06	15	50	420	10	0.28	70	70	1,980	47
Windsor	CP	+	0.6	150	500	4,550	100	1.7	425	425	12,000	283

CP - Cache la Poudre River Basin
BT - Big Thompson River Basin
SV - St. Vrain River Basin
P - South Platte River Basin

\+ = Lagoon present.
Discharge of 30 mg/1 of Biochemical Oxygen Demand
Discharge of 100 mg/1 of Suspended Solids

0 = Lagoon not present.
Discharge of 30 mg/1 of Biochemical Oxygen Demand
Discharge of 30 mg/1 of Suspended Solids

(a) Fort Collins includes Fort Collins #1 and Fort Collins #2 plants.
(b) Does not include seasonal flows.
(c) Includes Spring Canyon S.D. flows.

Plants were calculated to discharge 850 mg/1 salt and 20 mg/1 total nitrogen.

ADWF = Average Dry Weather Flow

mgd = Million Gallons Per Day

NS = No System

ND = No Discharge

Key to Figure 2.1.2-A

INDEX NO.		EXISTING AVERAGE FLOW (mgd)
	MUNICIPALITY - OUTLYING AREA	
M-1	Ault S.D.	0.09
M-2	Berthoud	0.48
M-3	Cottonwood Park	0.20
M-4	Del Camino	0.02
M-5	Eaton	0.21
M-6	Erie W.S.D.	0.13
M-7	Estes Park S.D.	0.40(a)
M-8	Fort Lupton	0.64
M-9	Gilcrest S.D.	0.04
M-10	Grover	0.025
M-11	Hill-n-Park S.D.	0.07
M-12	Hudson S.D.	0.06
M-13	Johnson's Corner	0.007
M-14	Johnstown	0.22
M-15	Keenesburg S.D.	0.05
M-16	Kersey S.D.	0.05
M-17	LaSalle	0.17
M-18	Lochbuie	-
M-19	Mead S.D.	0.035
M-20	Milliken S.D.	0.10
M-21	Mountain Range Shadows	0.01
M-22	Nunn	-
M-23	Pingree Park	0.01
M-24	Pierce	0.05
M-25	Platteville	0.14
M-26	Ramada Inn (I-25)	N/A
M-27	Red Feather/Crystal Lakes	N/A
M-28	Riverglenn	N/A
M-29	Severance	-
M-30	Spring Canyon S.D.	-

INDEX NO.		EXISTING AVERAGE FLOW (mgd)
M-31	Texaco (I-25)	0.023
M-32	Timnath	-
M-33	Tri-Area S.D.	0.31
M-34	Upper Thompson S.D.	0.20(a)
M-35	Weld Central H.S.	0.01
M-36	Wellington	0.06
	MUNICIPALITY - CORE AREA	
M-37	Boxelder S.D.	0.6
M-38	Evans S.D.	0.5
M-39	Ft. Collins #1	5.0
M-40	Ft. Collins #2	5.6
M-41	Greeley	6.2
M-42	Loveland	4.0
M-43	South Ft. Collins S.D.	0.5
M-44	Windsor	0.6

N/A = Data not presently available.

(a) = Does not include seasonal flows.

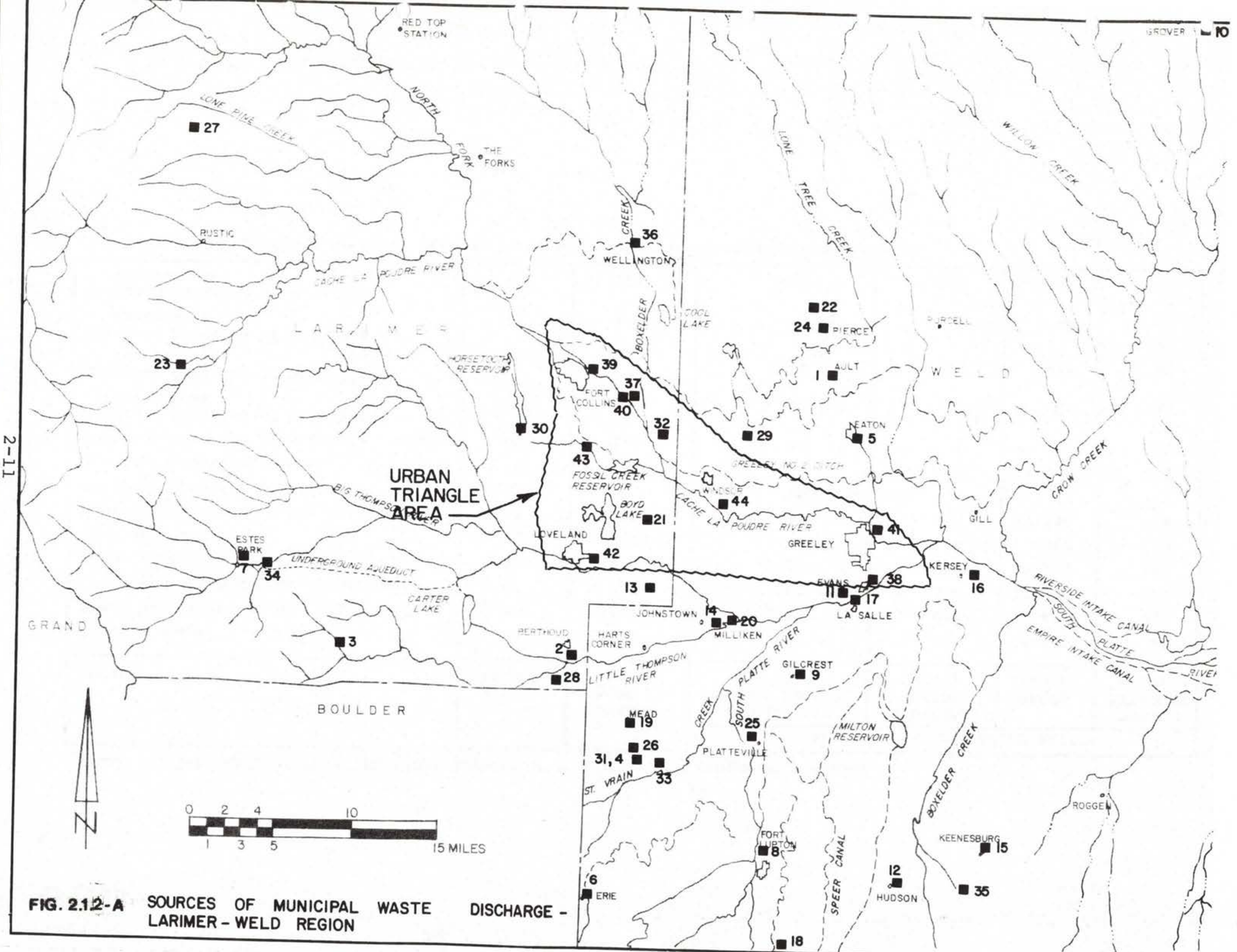


FIG. 2.12-A SOURCES OF MUNICIPAL WASTE DISCHARGE - LARIMER - WELD REGION

TABLE 2.1.2-B MAJOR INDUSTRIAL POINT SOURCES OF POLLUTION IN LARIMER-WELD REGION

SOURCE	RIVER DRAINAGE	PRESENT ADWF (mgd)	PRESENT EFFLUENT CONCENTRATIONS: BIOCHEMICAL OXYGEN DEMAND #/Day	SUSPENDED SOLIDS #/Day	SALTS #/Day	TOTAL NITROGEN #/Day
Eastman Kodak	CP	1.0	250	250	8,340	67
Great Western Sugar Co. - Loveland	BT	4.3	1,080	1,080	30,470	358
Great Western Sugar Co. - Greeley	CP	2.0	500	500	14,200	167
Great Western Sugar Co. - Johnstown	BT	5.4	1,350	1,350	38,200	450
Loveland Packing Co.	BT	0.03	6	9	210	5
Public Service Co. - Ft. St. Vrain	P	1.5	125	375	28,700	0
Water Treatment Facilities	CP,BT	-	NO DISCHARGE			
Greeley Industrial Plant	P	1.5	622	740	12,500	250
Colorado Division of Wildlife - Belvue	CP	1.0	42	5	167	16
Colorado Division of Wildlife - North Fork	BT	3.0	125	18	500	50
Colorado Division of Wildlife - Poudre River	CP	4.0	167	18	670	67
Colorado Division of Wildlife - Estes Park	BT	0.12	5	0 (a)	20	2
Colorado Division of Wildlife - Watson Lake	CP	1.2	500	100	2,000	200

(a) The settling nature of these rearing ponds actually reduces suspended materials.

operations are not included because of variable flow characteristics and resulting inaccuracy of discharge rates and wasteloads. Industrial discharges to municipal wastewater treatment systems are included in the wasteloads of these municipalities.

Table 2.1.2-B lists the major industrial point sources of pollution in the region and quantifies associated wasteloads which are available for transport to the rivers of the region. Figure 2.1.2-B indicates their location.

2.1.2.3 Urban Runoff

The character and magnitude of urban runoff flows and wasteload mass emissions were evaluated in detail in Non-point Source Pollution Control - Analysis and Recommendations (Interim WQMP Report No. 19). Urban runoff can be a major source of pollution because of the relatively large area from which it originates and the "shock" load impact to receiving streams initiated by the flushing of wastes from the urban environment.

Urban runoff wasteloads are emitted in significant proportions from the three larger municipalities of the area. These wasteloads are presented in Table 2.1.2-C.

In addition to the constituents presented in Table 2.1.2-C, many other pollutants can be associated with urban runoff. Such pollutants include tire particles, direct, rust, vegetation, abestos, miscellaneous petroleum products, fecal matter from domestic animals, and other constituents than can be distributed to the atmosphere or spilled, deposited or disbursed on urban lands.

Any urban activity that can distribute material to the atmosphere can result in dustfall. Runoff from urban areas transports dustfall to the waters of the region.

TABLE 2.1.2-C - WASTELOADS FROM URBAN RUNOFF

	Constituent Loading (Tons/Year)					
	BOD_5		Salts		Suspended Solids	
Receiving Water	Present	2000	Present	2000	Present	2000
Cache la Poudre	78	130	1100	1800	1300	2000
Big Thompson	3	5	48	81	48	81
St. Vrain	0	0	0	0	0	0
South Platte	0	5	5	15	0	10

Key to Figure 2.1.2-B

INDEX NO.		EXISTING AVERAGE FLOWS
	MAJOR DIRECT INDUSTRIAL DISCHARGERS	
I- 1	Eastman Kodak Co.-KCD	1.0
I- 2	Great Western Sugar Co. - Loveland	4.3
I- 3	Great Western Sugar Co. - Greeley	2.0
I- 4	Great Western Sugar Co. - Johnstown	5.4
I- 5	Loveland Packing Co.	0.05
I- 6	Public Service Co. - Ft. St. Vrain	1.5
	MINOR DIRECT INDUSTRIAL DISCHARGERS	
I- 7	Cowan Concrete Products	(a)
I- 8	Flatiron Paving Co.-Greeley	(a)
I- 9	Flatiron Paving Co.-Windsor	(a)
I-10	Flatiron Paving Co.-Loveland	(a)
I-11	Flatiron Paving Co. - Greeley (West)	(a)
I-12	Greeley Sand & Gravel	(a)
I-13	Eldred M. Johnson	(a)
I-14	Floyd Haag Sand & Gravel	(a)
I-15	Mountain Aggregate - Ft. Collins	(a)
I-16	Mountain Aggregate - (to St. Vrain)	(a)
I-17	Norden & Son Land Leveling	(a)
I-18	Poudre Pre-Mix	(a)
I-19	Colo. Division of Wildlife - Bellvue	1.0
I-20	Colo. Division of Wildlife - North Fork	3.0
I-21	Colo. Division of Wildlife - Poudre	4.0
I-22	Colo. Division of Wildlife - Watson Lake	12.0

INDEX NO.		EXISTING AVERAGE FLOWS
I-23	Colo. Division of Wildlife - Estes Park	3.0
I-24	Blacky Valencia	0
I-25	Western Fisheries Consultants	0
I-26	Ft. Collins - Poudre Canyon Water Treatment Plant (WTP)	-
I-27	Greeley-Bellvue WTP	-
I-28	Greeley-Boyd Lake WTP	-
I-29	Loveland WTP	-
I-30	Hydraulics Unlimited Mfg. Co.	0.02
I-31	Monfort Packing Co.	1.7
I-32	Lone Star Steel Co.	0.03
I-33	Terra Resources Inc.-Clarks Lake	0.009
	MAJOR INDUSTRIAL DISCHARGERS TO MUNICIPALITIES	DISCHARGE TO
I-34	Hewlett-Packard Co.	Loveland
I-35	Woodward Governor	Ft. Collins
I-36	Teledyne-Water Pic	Ft. Collins
I-37	Western Food Products Inc.	Ft. Collins
I-38	Eastman Kodak Co. (optional)	Windsor
I-39	Carnation Milk Co.	Johnstown
I-40	Ft. Lupton Canning Co.	Ft. Lupton
I-41	Meadow Gold Dairy	Greeley
I-42	Monfort of Colorado	Greeley

(a) Flows highly variable.

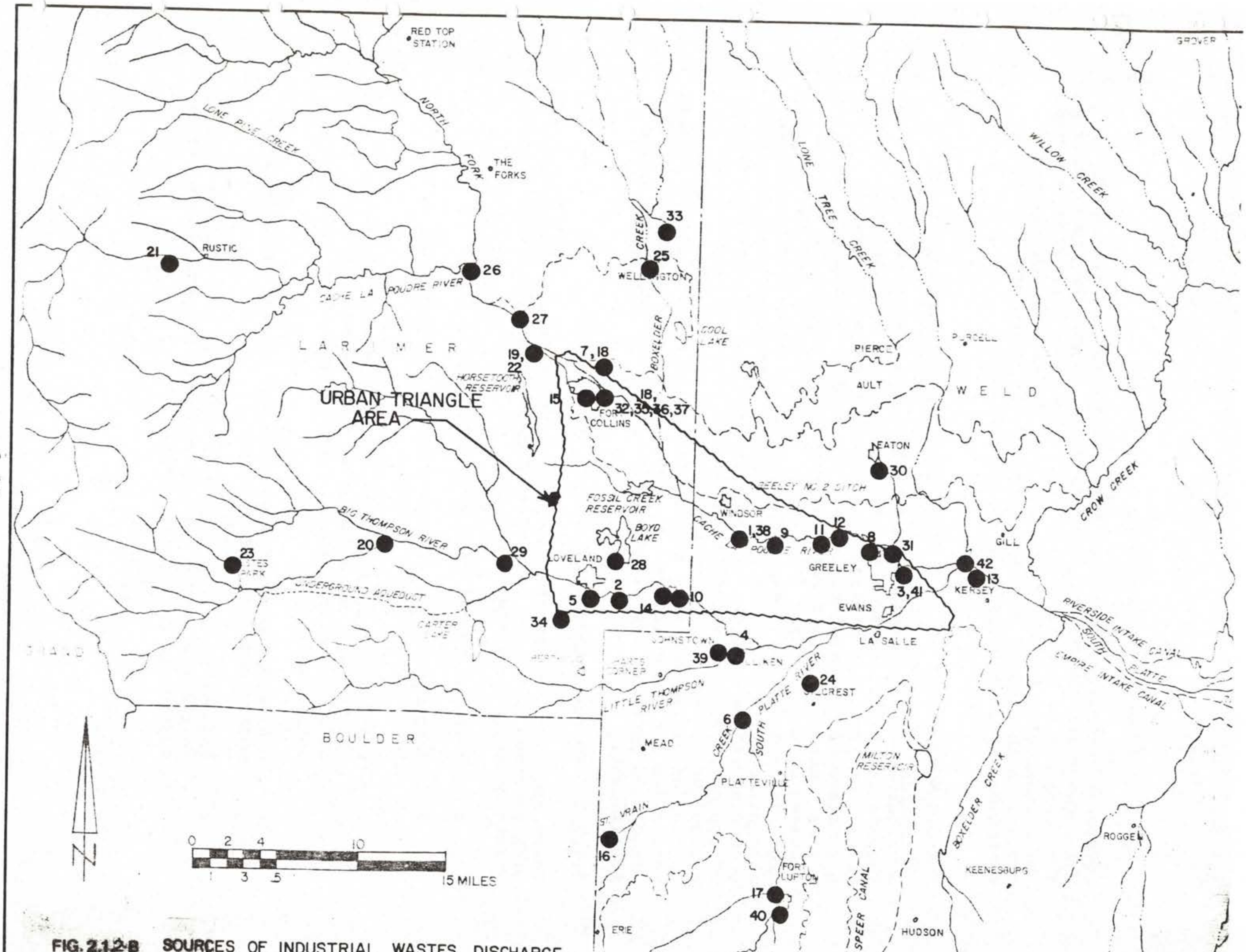


FIG. 2.1.2-B SOURCES OF INDUSTRIAL WASTES DISCHARGE - LARIMER - WELD REGION

2.1.2.4 Irrigated Agriculture

Irrigated agriculture has been the cornerstone of the economy in the Larimer-Weld Region since the 1870's. There are approximately 500,000 acres of irrigated land in the Region. Irrigation has made the Larimer-Weld Region one of the most productive agricultural regions in the United States. Value of all crops produced in the Region was approximately $173 million in 1975.

Interim WQMP Report No. 22, Water Quality Impacts of Irrigated Agriculture, documents the character and extent of pollution attributable to irrigated agriculture in the two-county area. Degradation resulting from sediment, salt, and nutrient contributions from irrigated agriculture represent the water quality parameters of principal concern in the region. Total dissolved solids content of ground water and receiving streams is typically elevated by the leaching fraction of applied water and by seepage from canals and reservoirs. The problem is especially pronounced when percolating flows are hydraulically contiguous with naturally occurring saline outcrops or shale formations. Nitrate impairment of ground or surface waters results from over-fertilization of agricultural lands, or when the nutrient value of manure applied to cropland is excessively supplemented with commercial fertilizers. Herbicides and insecticides can also impact water quality; however, associated problems identified in the region do not appear to be significant.

2.1.2.5 Concentrated Animal Feeding Operations

There are five avenues of transport by which wastes associated with confined livestock feeding operations can potentially impact ground or surface waters:

- overland runoff from a feedlot;
- deep percolation of waste materials generated in a feedlot to ground water;
- leaching of constituents associated with manure to ground water when manure is applied to cropland at rates which establish residual concentrations in excess of the uptake ability of crops;
- overland runoff from agricultural fields used to accommodate manure as fertilizer;
- release of urinary nitrogen excreted on a feedlot directly to the air in the form of ammonia, and subsequent introduction to a receiving water.

Characteristics and practices associated with the livestock feeding industry in the two-county area were inventoried in Interim WQMP Report No. 15, Concentrated Animal Feeding Operations - Waste Management and Resource Recovery. This report analyzed the relationship between the industry and regional water quality. Actual water quality degradation attributable to the five mechanisms through which feedlot pollutants can be given mobility was documented. The following are conclusions of the feedlot review:

- The on-going program implemented by the State Department of Health has been extremely effective in curtailing wastewater transport from confined feeding operations. Due to the presence of natural or conventional runoff control measures on most feedlots of significance, impact to surface water quality is considered to be extremely minor;

- Ground water degradation resulting from percolation of wastes from pen areas of continuously used feedlots is generally negligible. This relates to the presence of a relatively impermeable layer that forms at the manure-soil interface. Wastes leached to ground water from abandoned or intermittently used feedlots pose a threat to water quality in localized areas.

- Manure disposal rates presently employed in the region appear to be generally acceptable from the standpoint of maintaining integrity of underlying ground water. However, long-term manure loading implemented on some fields is conducive to ground water quality degradation. Localized problems are also created when the nutrient value of manure is excessively supplemented with commercial fertilizers.

- Airborne ammonia from cattle feedlots may contribute to nitrogen enrichment of rivers, lakes, and reservoirs. No water quality problems attributable to this source have been documented in the region.

2.1.2.6 Other Sources

Other pollution sources include septic tanks and leachfields, solid wastes disposal, construction, silviculture and other forest uses, and residual waste management. Water quality implications to the region from these activities and practices are analyzed in Interim WQMP Report No. 19, Non-point Source Control - Analysis and Recommendations. Table 2.1.2-D identifies present and future wasteload projections associated with septic tanks and leachfields. Data in this table represent approximate wasteloads developed from estimated septic tank usage in the Region.

TABLE 2.1.2-D WASTELOADS FOR SEPTIC TANK AND LEACHFIELD AREAS OF MAJOR CONCERN - LARIMER-WELD REGION 1977/2000

	RIVER BASIN	NUMBER OF PEOPLE SERVED	1977 LOADS TO SURFACE WATERS (Pounds/Day)				YEAR 2000 LOADS TO SURFACE WATERS (Pounds/Day)			
			BOD	SS	SALTS	TN	BOD	SS	SALTS	TN
Red Feather Lakes	CP	800(a)	20	8	50	4.1	S	S	S	S
Big Thompson Canyon	BT	2800(a)	76	30	188	15.0	130	52	321	26
Lochbuie	P	900	23	9.2	56	4.7	S	S	S	S
Severance	CP	100	2.6	1.0	6.2	0.5	S	S	S	S
Timnath	CP	268	6.9	2.8	17	1.4	12	4.8	29	2.4
Namaqua Hills	BT	175	4.5	1.8	11	0.9	S	S	S	S
Poudre Canyon	CP	2000(a)	50	20	125	10	87	35	214	17

CP = Cache la Poudre
BT = Big Thompson
P = South Platte

BOD = Biochemical Oxygen Demand
SS = Suspended Solids
TN = Total Nitrogen

(a) Highly variable seasonal fluctuations

S = Expected to be sewered by the year 2000.

Degradation of water quality attributable to naturally occurring sources in the Larimer-Weld area may be substantial. Sediment appears to be the most significant parameter of concern on a regional basis. This is demonstrated by the devastating effect of the Big Thompson flood on the character of the canyon and in reaches down-stream. Erosion, siltation, sedimentation, and deposition resulting from this disaster was quite severe. It may be years before natural processes of sediment transport and biological activity will restore the benthic integrity of the Big Thompson in its reach through the canyon. Sedimentation occurring in the drainage of the North Fork of the Cache la Poudre is also pronounced. Salinity contributions from saline outcrops and formations of Pierre Shale in the region may also lead to the creation of water quality problems on a more localized basis.

It is difficult to quantify the extent of naturally occurring degradation in the two-county area in terms of overall impact on water quality. Background levels of water quality can only be determined through analysis based on data provided by a sophisticated regional monitoring program. To date, surveillance activity conducted in the region has not generated information of the type or detail required to document in-stream baseline water quality conditions. An integrated program of regional monitoring is needed in order to differentiate among the quality impacts attributable to natural sources of degradation and various human-related activities. Features of such a program are described in Section 7.0 of this report.

2.1.3 Relative Contribution of Pollutants

In order to formulate a proper perspective on the relation of individual waste generation from various sources to overall stream loading, the parameters of biochemical oxygen demand, suspended solids, total nitrogen, and salinity were selected for comparative analysis. Table 2.1.3-A presents the contribution by each source. Municipal sources contribute most of the biochemical oxygen demanding substances to the region's waters while irrigated agriculture contributes most of the suspended solids, nitrogen, and salts. Table 2.1.3-B shows the contribution by percentage.

These trends are consistent with data developed for each basin, although the impact from each source varies with the degree of urbanization. Table 2.1.3-C shows the total suspended solids wasteloads applied to each basin presently and those projected for Year 2000 by major pollutant source. Table 2.1.3-D and Table 2.1.3-E present similar data for BOD_5 and total dissolved solids respectively.

TABLE 2.1.3-A MASS EMISSION RATES FROM POINT AND NONPOINT SOURCES IN THE LARIMER-WELD REGION

WASTE SOURCE	TOTAL POLLUTANT LOAD (tons per year) (a)			
	BOD_5	SUSPENDED SOLIDS	TOTAL NITROGEN	TDS
Municipal	2,160	2,670	1,430	60,000
Industrial	530	570	660	18,600
Subtotal - Point Source	2,690	3,240	2,090	79,400
Irrigated Agriculture	0	18,200	2,020	980,000
Feedlots	667	5,770	265	430
Urban Runoff	140	2,090	22	1,890
Miscellaneous	42	17	11	110
Subtotal - Nonpoint Source	849	26,077	2,318	982,430
TOTAL *	3,540	29,320	4,410	1,060,000

(a) Year 2000 development. Comparative analysis for 1975/2000 is presented in Tables 2.1.3-C, 2.1.3-D and 2.1.3-E for TDS, BOD_5 and Suspended Solids respectively.

* Column totals may not be exact due to rounding.

TABLE 2.1.3-B DISTRIBUTION OF POLLUTANTS IN THE LARIMER-WELD REGION

WASTE SOURCE	PERCENT OF TOTAL POLLUTANT LOAD (a)			
	BOD_5	SUSPENDED SOLIDS	TOTAL NITROGEN	SALTS
Municipal	61	9	32	6
Industrial	15	2	15	2
Subtotal - Point Source	76	11	47	8
Irrigated Ag.	0	62	46	92
Feedlots	19	20	6	<1
Urban Runoff	4	7	1	<1
Miscellaneous	1	1	1	<1
Subtotal - Nonpoint Source	24	89	53	92
TOTAL*	100	100	100	100

(a) Year 2000 development.

* Column totals may not be exact due to rounding.

TABLE 2.1.3-C TOTAL SUSPENDED SOLIDS WASTELOADS INTO FOUR MAJOR RIVERS OF THE LARIMER-WELD REGION

TYPE OF GENERATOR	RIVER RECEIVING WASTE (Tons/Year)								TOTAL		PERCENT OF TOTAL	
	Big Thompson River		Cache la Poudre River		St. Vrain Creek		South Platte River					
	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000
Municipal	270	460	1,000	1,600	40	80	260	530	1,570	2,670	6	9
Industrial	270	270	77	100	0	0	200	200	547	570	2	2
Irrigated Agriculture	2,800	2,800	4,200	4,200	3,800	3,800	7,400	7,400	18,200	18,200	66	62
Feedlots	690	690	3,000	3,000	580	580	1,500	1,500	5,770	5,770	21	20
Urban Runoff	48	81	1,300	2,000	0	0	0	10	1,348	2,090	5	7
Other	6	10	6(b)	7(b)	2(a)	0	3	0	15	17	<1	<1
TOTAL *	4,090	4,310	9,580	10,900	4,422	4,460	9,360	9,640	27,450	29,320	100	100

(a) Longmont landfill.

(b) Septic tanks.

* Column totals may not be exact due to rounding.

TABLE 2.1.3-D TOTAL BOD_5 WASTELOADS INTO FOUR MAJOR RIVERS OF THE LARIMER-WELD REGION

TYPE OF GENERATOR	RIVER RECEIVING WASTE (Tons/Year								TOTAL		PERCENT OF TOTAL	
	Big Thompson River		Cache la Poudre River		St. Vrain Creek		South Platte River					
	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000
Municipal	250	420	870	1,500	22	54	80	190	1,220	2,160	48	61
Industrial	120(a)	120	270	350(b)	0	0	140	140	530	530	20	15
Irrigated Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Feedlots	80	80	350	350	67	67	170	170	667	667	26	19
Urban Runoff	3	5	78	130	0	0	0	5	81	140	5	4
Other (Solid Wastes, Septic Tanks, Construction, Silviculture)	15	24	15	18	5	0	8	0	43	42	1	1
TOTAL*	468	649	1,583	2,348	94	121	398	508	2,541	3,540	100	100

(a) Sugar beet plants discharge for 0.4 of the year.

(b) Hewlett-Packard increase.

* Column totals may not be exact due to rounding.

TABLE 2.1.3-E TOTAL DISSOLVED SOLIDS DISCHARGED TO RIVERS OF THE LARIMER-WELD REGION

TYPE OF GENERATOR	RIVER RECEIVING WASTE (Tons/Year)								TOTAL		PERCENT OF TOTAL	
	Big Thompson River		Cache la Poudre River		St. Vrain Creek		South Platte River					
	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000	Present	2000
Municipal	6,900	12,000	25,000	42,000	610	1,500	2,300	5,300	28,600	60,800	3	6
Industrial	15,100	15,100	4,600	6,000	0	0	7,500	7,500	17,200	18,600	2	2
Irrigated Agriculture	128,000	128,000	237,000	237,000	100,000	100,000	515,000	515,000	980,000	980,000	95	92
Feedlots	50	50	220	220	50	50	110	110	430	430	< 1	< 1
Urban Runoff	48	81	1,100	1,800	0	0	0	10	1,150	1,890	< 1	< 1
Other	36	59	36	44	20	5	15	5	110	110	< 1	< 1
TOTAL *	140,100	145,300	268,000	287,000	100,700	100,600	525,000	528,000	1,030,000	1,060,000	100	100

* Column totals may not be exact due to rounding.

2.2 DESCRIPTION OF EXISTING WATER QUALITY CONDITIONS

Definition of existing water quality is inhibited by the nature and duration of the existing data base and monitoring programs, and limited knowledge of actual water quality inputs on beneficial uses. Although there are a number of agencies which sample surface water quality, the methods used vary from agency to agency with regard to period of record, sampling location, and parameters analyzed. Often available data were derived from single purpose sampling activities. Data deficiencies are documented in the detailed review of regional monitoring programs prepared in conjunction with the 303 Comprehensive Water Quality Management Plan, South Platte River Basin (Toups Corporation and Engineering Consultants, Inc., 1974).

In order to augment the existing data base with respect to regional water quality, a sampling program was initiated in 1976 in support of the 208 Water Quality Management Planning Program. This program was conducted to overcome some of the inadequacies of existing data, and to provide a base for initiating 208 planning. Results of the sampling program are presented graphically in this section. Such data also served to calibrate the Pioneer I Water Quality Model, developed by EPA for application to drainages of the South Platte basin. Interim WQMP Report No. 20, Wasteload Allocation and Water Quality Modeling - Major Rivers in the Larimer-Weld Region, inventories the processes and conclusions associated with the modeling effort. Water quality conditions depicted in this section are based on an extremely limited set of data representative of a single low flow period. Variations in flow, discharge quantities, return flow volume or operational diversions which occur daily and seasonally, will modify the water quality conditions shown.

2.2.1 Cache la Poudre River

The Cache la Poudre River in its reach through the plains accommodates the largest number of municipal and industrial discharges of any river within the region (see Interim WQMP Report No. 6, and Interim WQMP Report No. 24). With the exception of sediment contributions purveyed through the North Fork, human-related activities exert the most pronounced impact on in-stream water quality.

2.2.1.1 Existing Conditions

Stream flow characteristics on the Cache la Poudre are identified on Figure 2.2.1-A for a low-flow condition (1972), and for a period coincident with the 208 sampling program (1976) in Figure 2.2.1-A1.

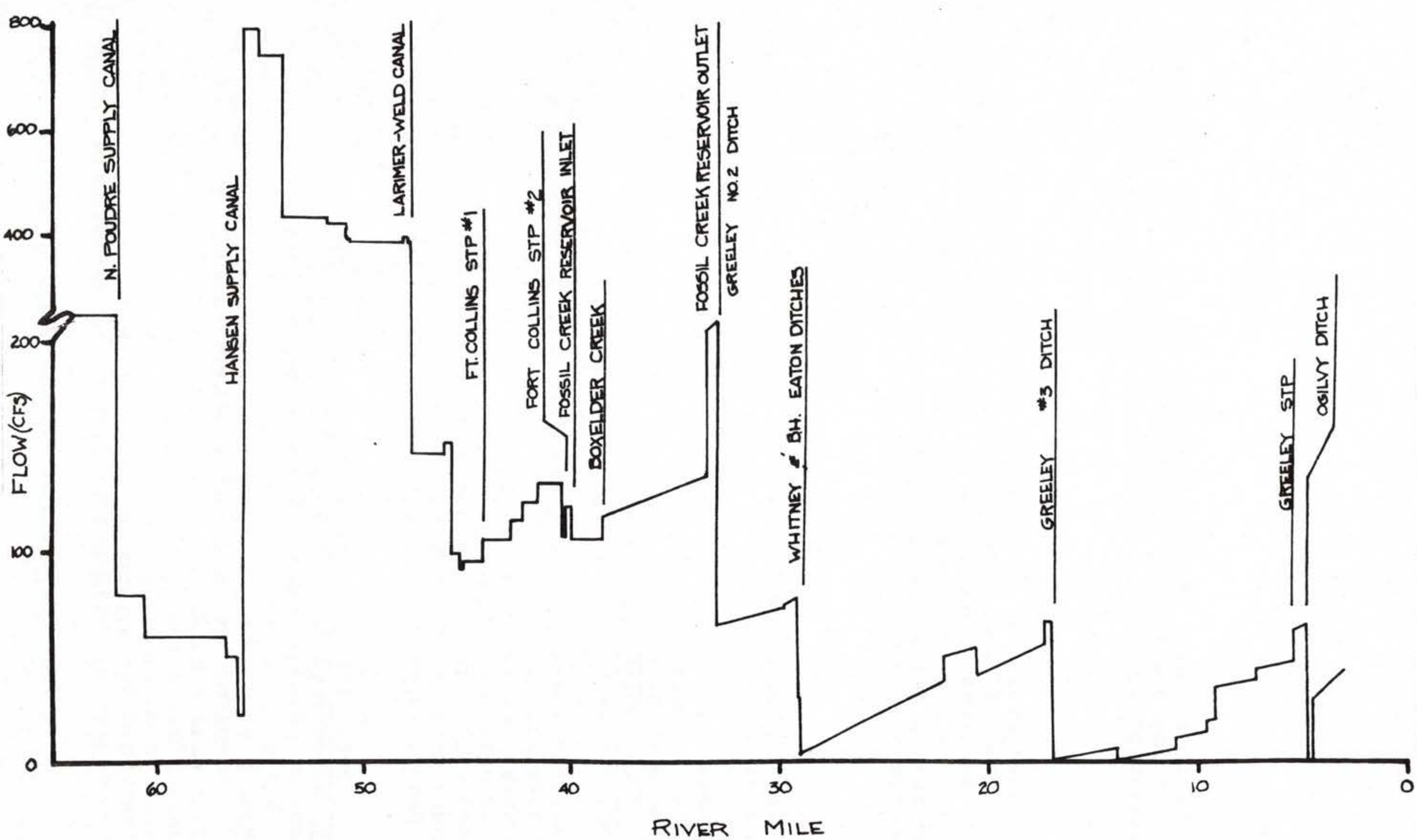


FIG. 2.2.1-A **Low Flow Condition- Cache la Poudre River**

AUG. 31, 1976

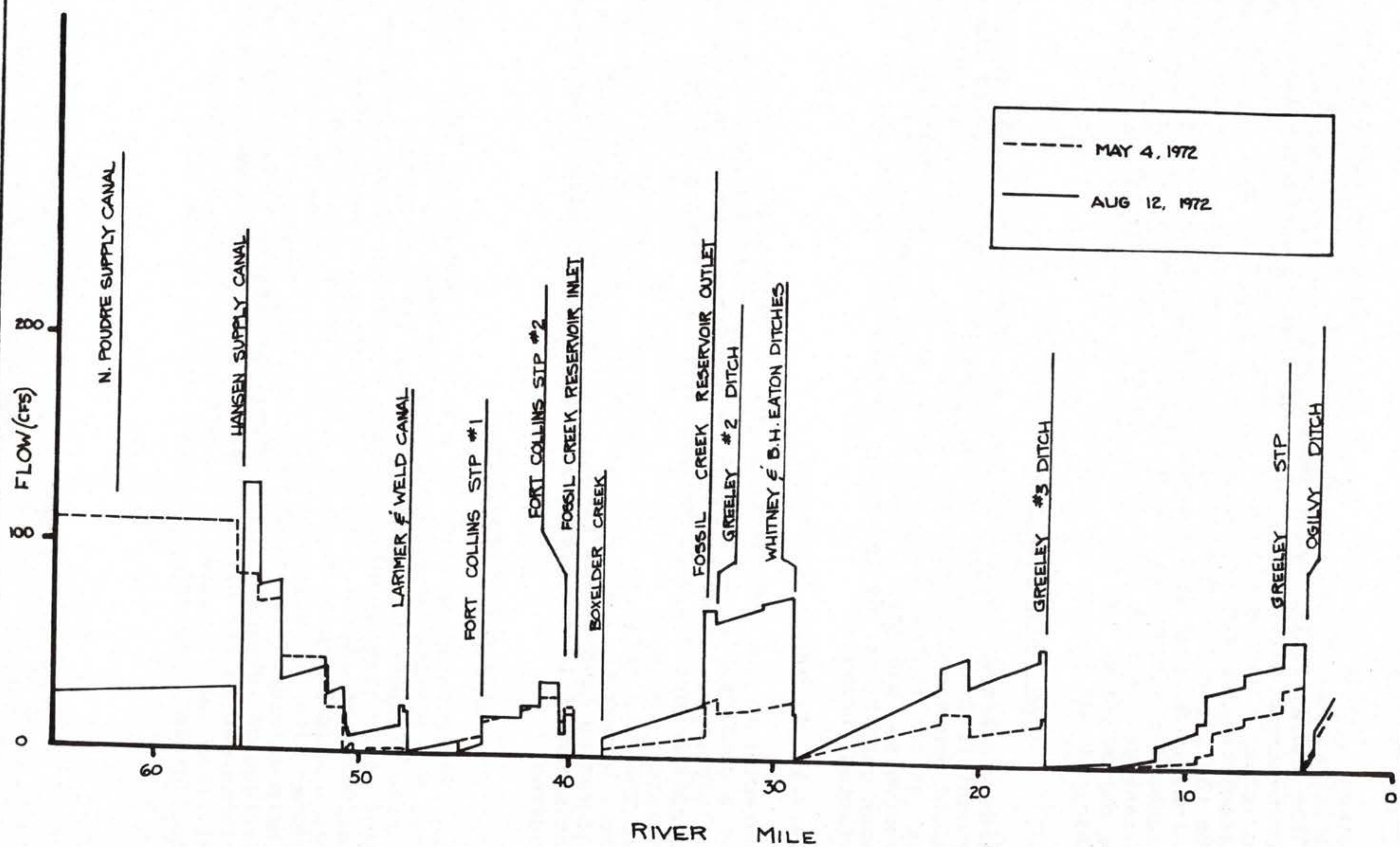


FIG. 2.2.1-A1

Low Flow Condition-
Cache la Poudre River

Figures 2.2.1-B through 2.2.1-E depict existing water quality conditions on the Cache la Poudre River. Nitrate, suspended solids and salinity levels exhibit a generally increasing trend in a down-stream direction. In-stream ammonia concentrations reflect the location and magnitude of municipal discharges. Water quality characteristics are strongly influenced by the system of diversions from the river (which may deplete all available main-stem flow at various locations) and are controlled by the numerous sources of returns and discharges (which comprise essentially all river flow in many down-stream reaches). Return flows to the Cache la Poudre are estimated at 150 MGD, as compared to 25 MGD discharged by municipal and industrial sources.

2.2.2 Big Thompson River

Waste discharges to the Big Thompson River are largely contributed by municipal and industrial sources. A large portion of the urban runoff generated by the City of Loveland is eventually routed to irrigation ditches, Lake Loveland, or other hydraulically contiguous reservoirs, and does not impact the Big Thompson River directly. Water quality in the foregoing conveyance/ storage facilities is affected, however.

2.2.2.1 Existing Conditions

Character of the hydrologic regime is depicted in Figure 2.2.2-A for a condition of low-flow, 1972. The existing in-stream water quality is presented in Figure 2.2.2-B for ammonia and dissolved oxygen; Figure 2.2.2-C, for salinity; and Figure 2.2.2-D, for nitrates. As with the Cache la Poudre, in-stream quality for the Big Thompson reflects river management, water supply, and agricultural diversion. Nitrates and salinity also exhibit a generalized increasing down-stream trend. Agricultural return flows are estimated at 15 MGD versus 44 MGD for municipal and industrial sources.

2.2.3 Little Thompson River

The Little Thompson River is a major tributary of the Big Thompson, with the confluence situated near the Town of Milliken. The Little Thompson is intensely managed for agriculture in a manner similar to that of other streams traversing the plains area of the Larimer-Weld region. During late summer, up-stream native flow in the Little Thompson has been historically negligible. Present summer flow is largely attributable to supplies released from upstream facilities of the Colorado-Big Thompson Project, and from irrigation returns. Point source discharges of municipal effluent discharged to the Little Thompson include the communities of Milliken and Johnstown. The effects of these sources are negligible in relation to other impacts on the River.

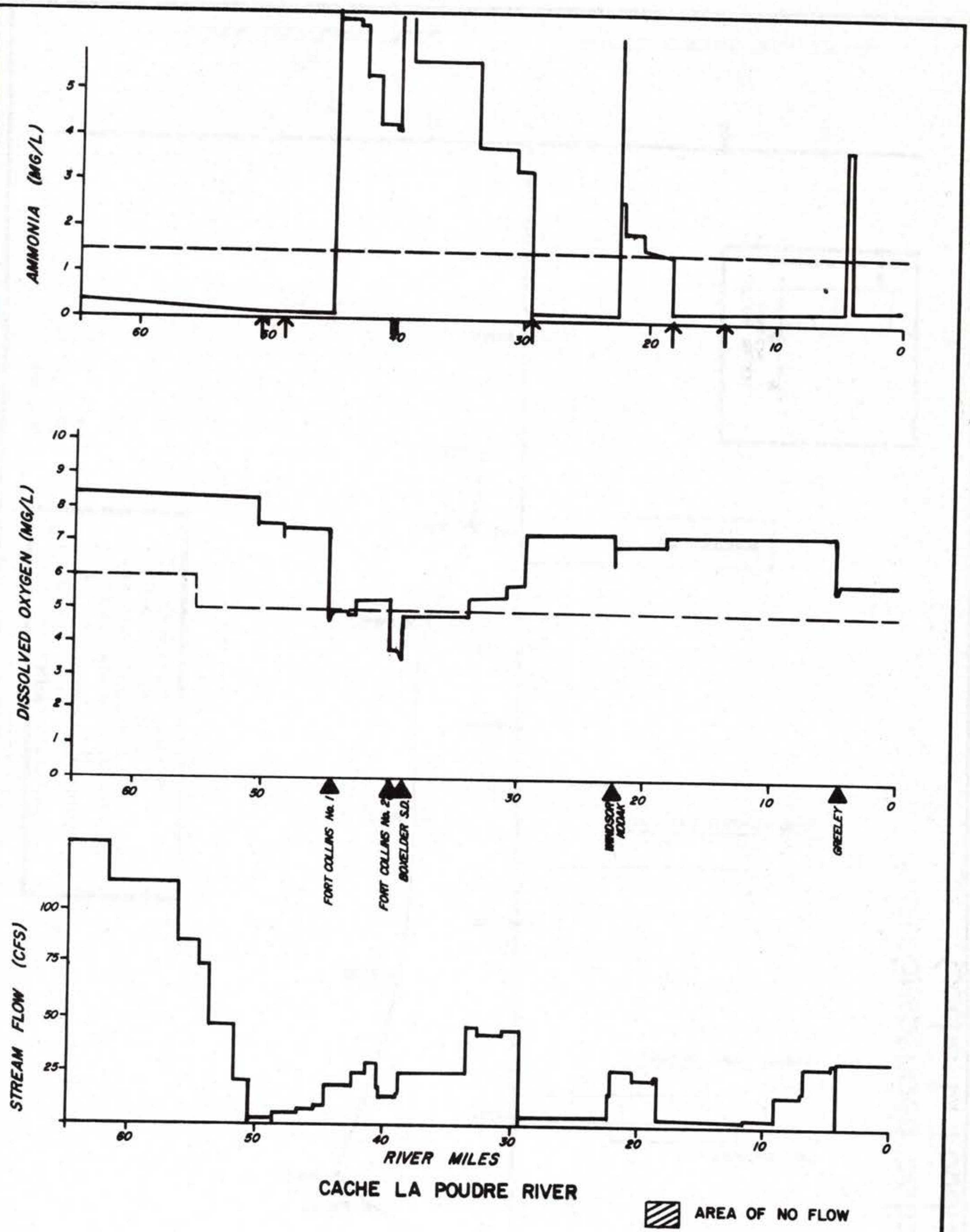


FIG. 2.2.1-B

Existing Instream Concentrations of Ammonia and Dissolved Oxygen during Low Flow Conditions, as Predicted by Computer Modeling

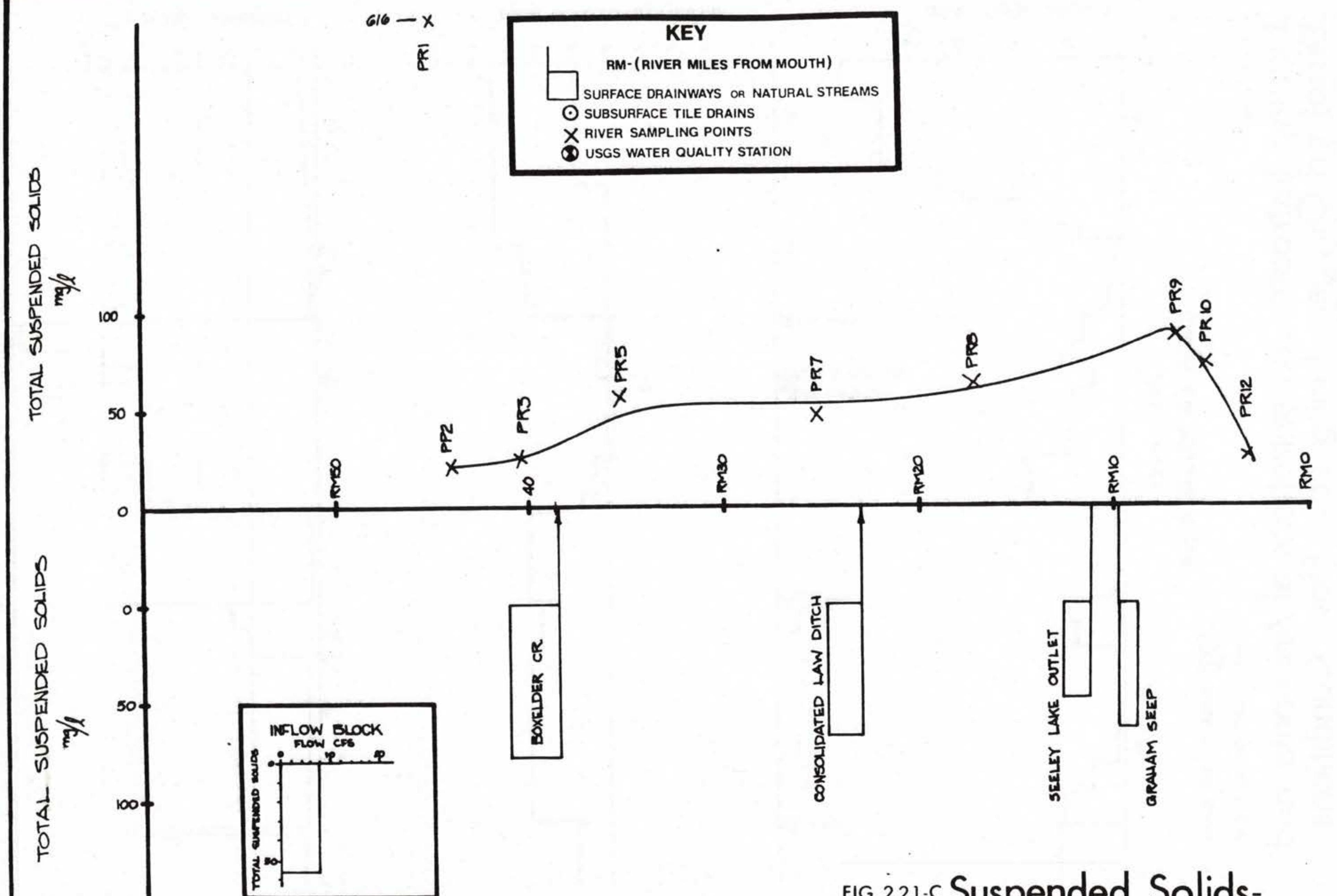


FIG. 2.2.1-C Suspended Solids-
Cache la Poudre River

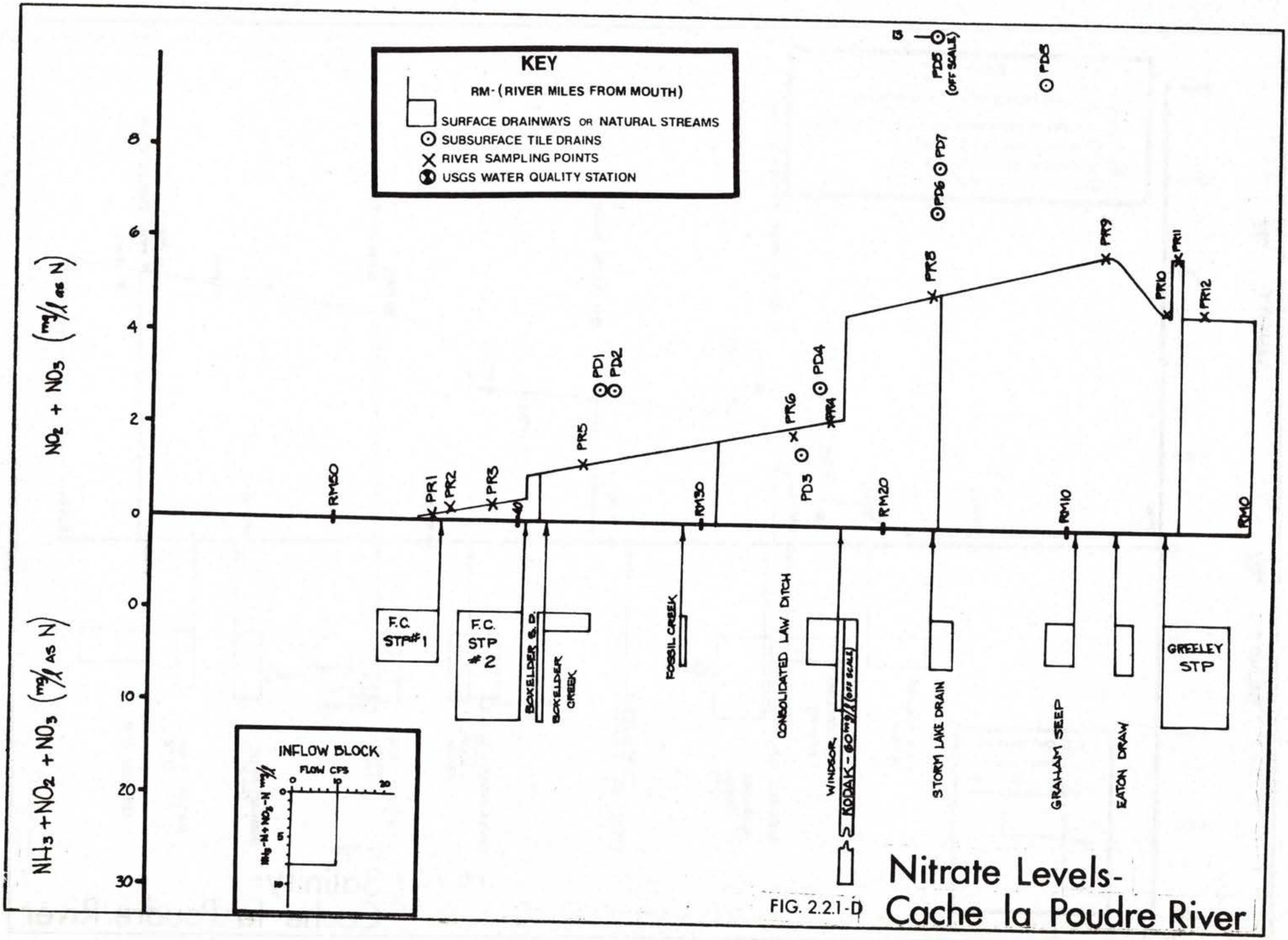


FIG. 2.2.1-D Nitrate Levels- Cache la Poudre River

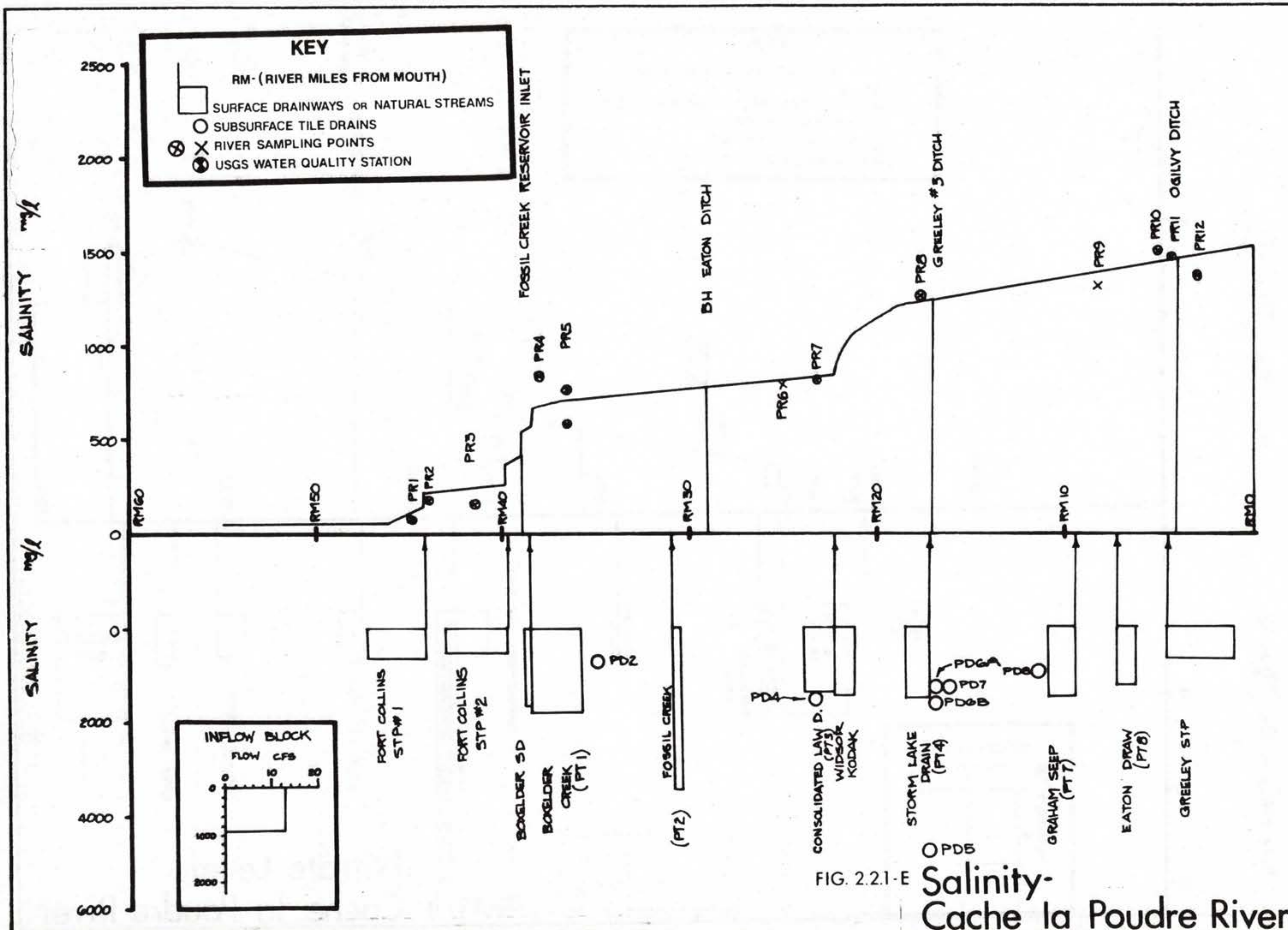


FIG. 2.2.1-E Salinity- Cache la Poudre River

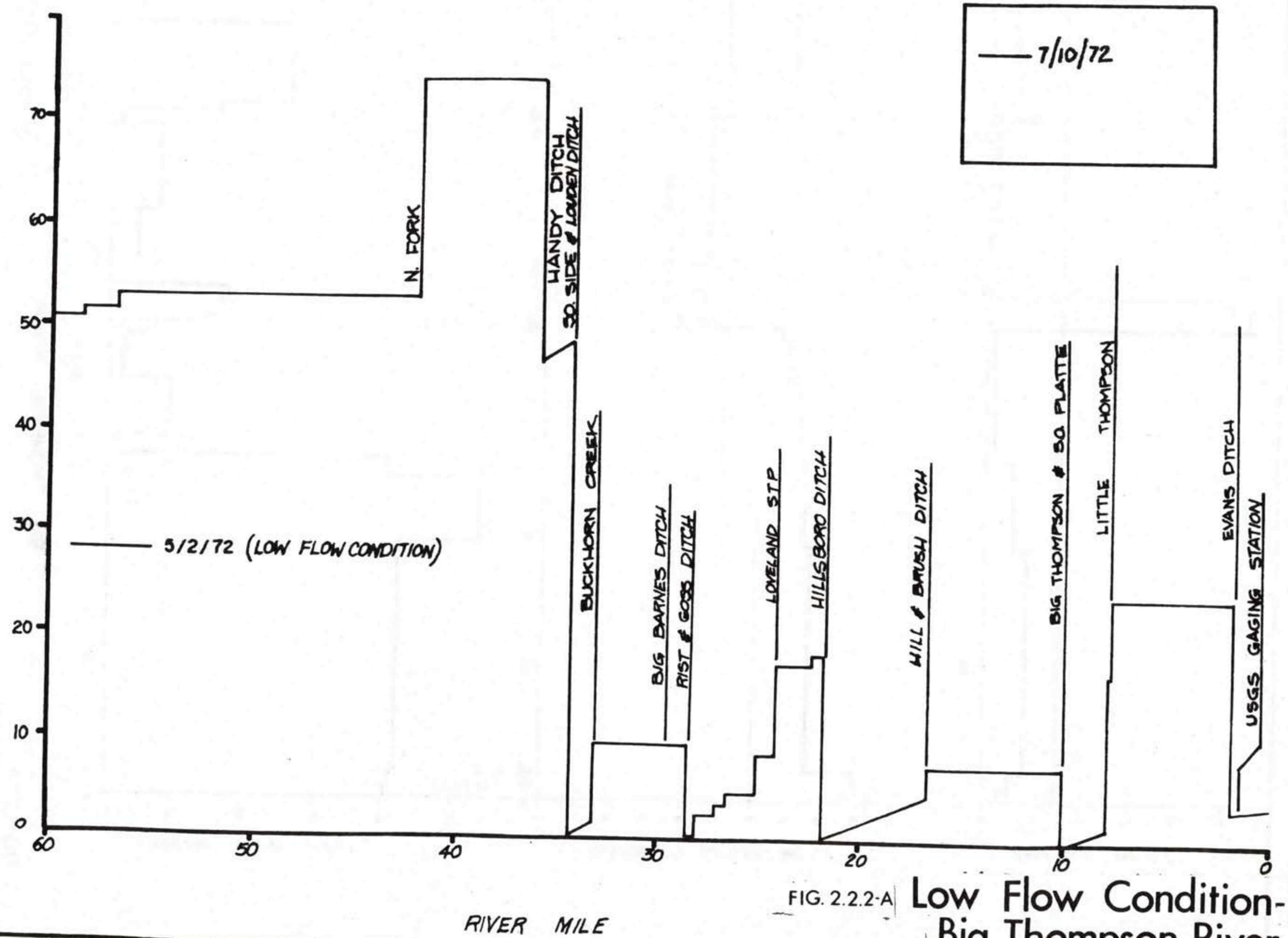


FIG. 2.2.2-A Low Flow Condition-Big Thompson River

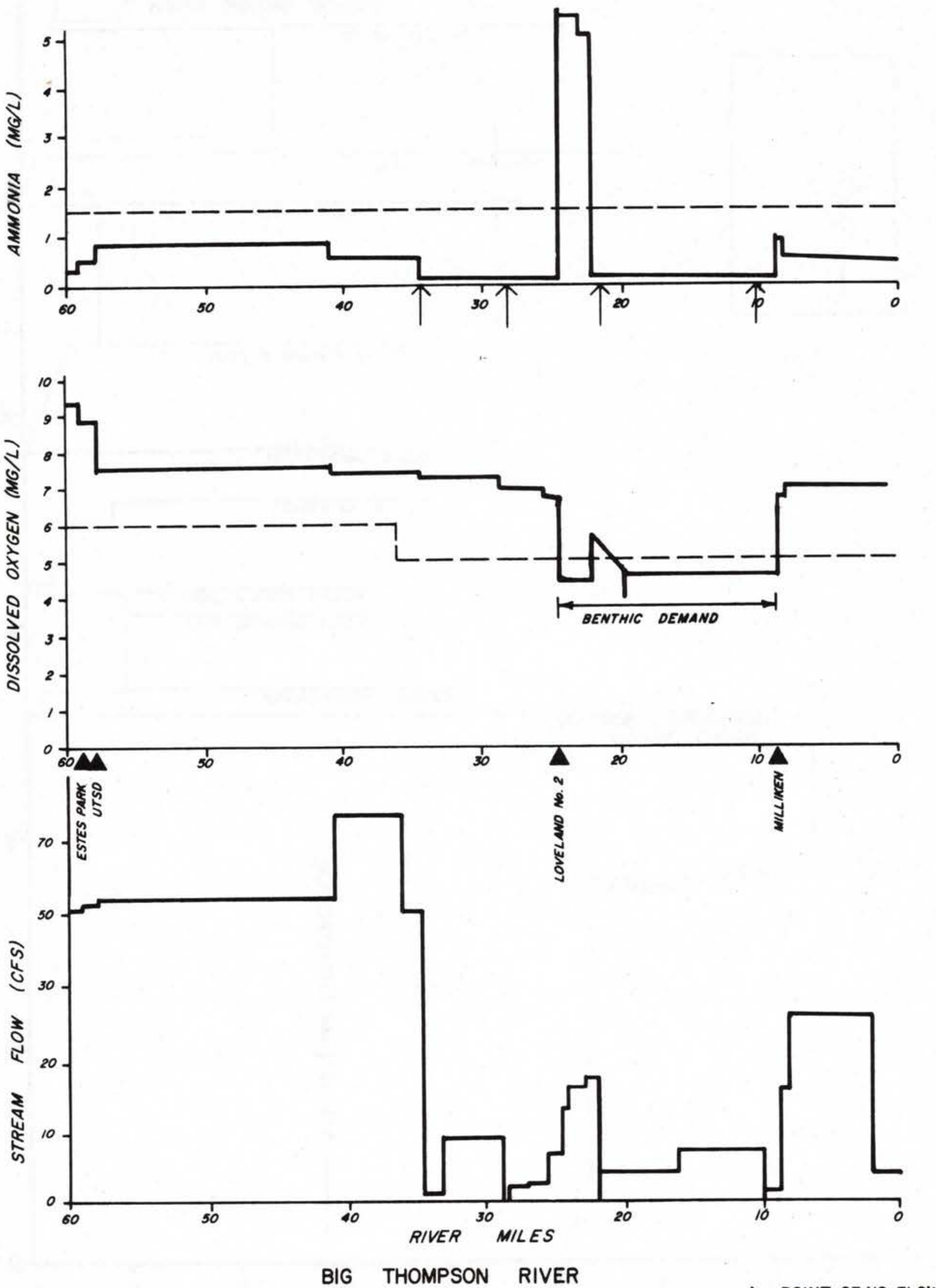


FIG. 2.2.2-B

Existing Instream Concentrations of Ammonia and Dissolved Oxygen during Low Flow Conditions, as Predicted by Computer Modeling

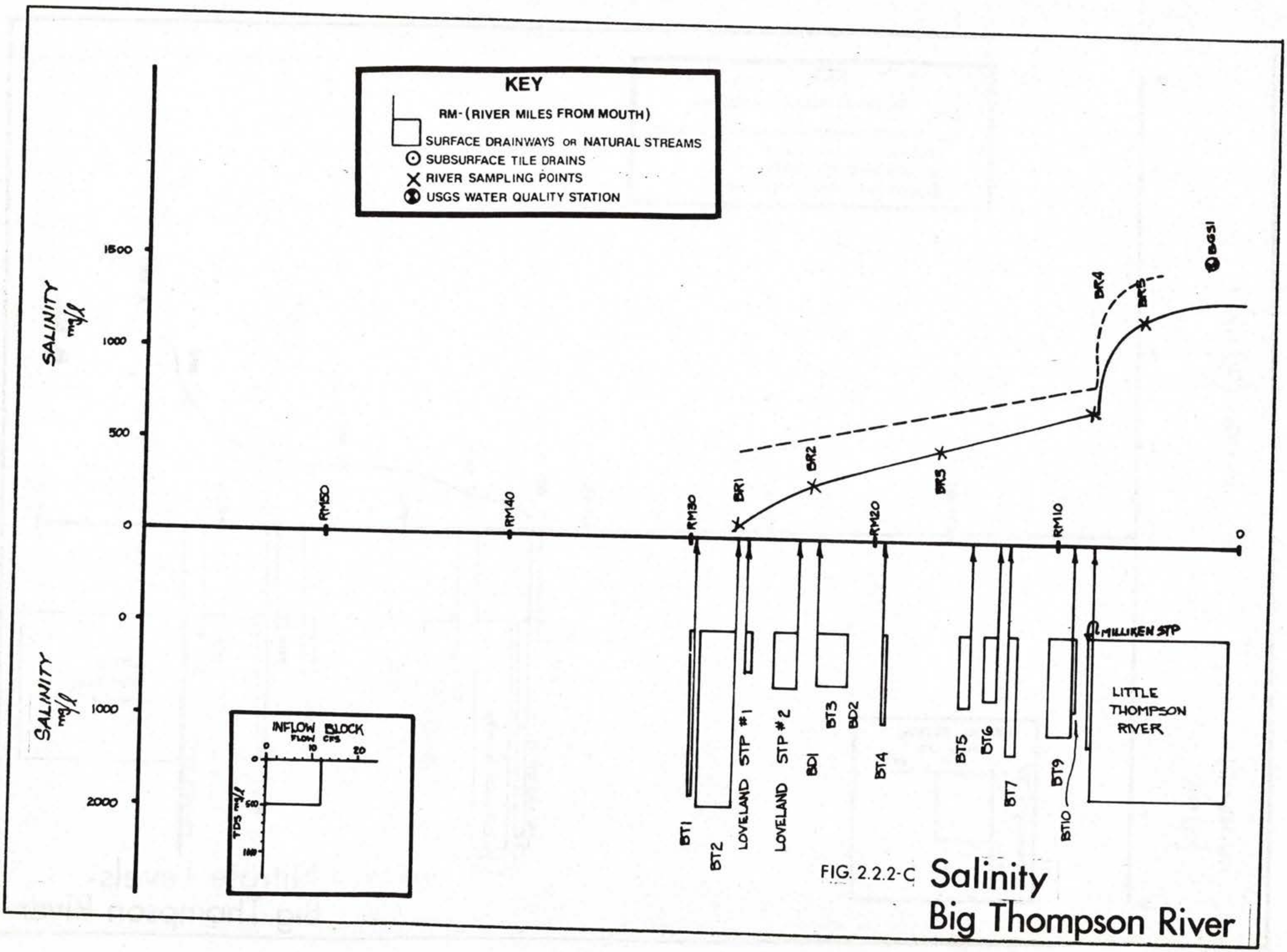


FIG. 2.2.2-C Salinity
Big Thompson River

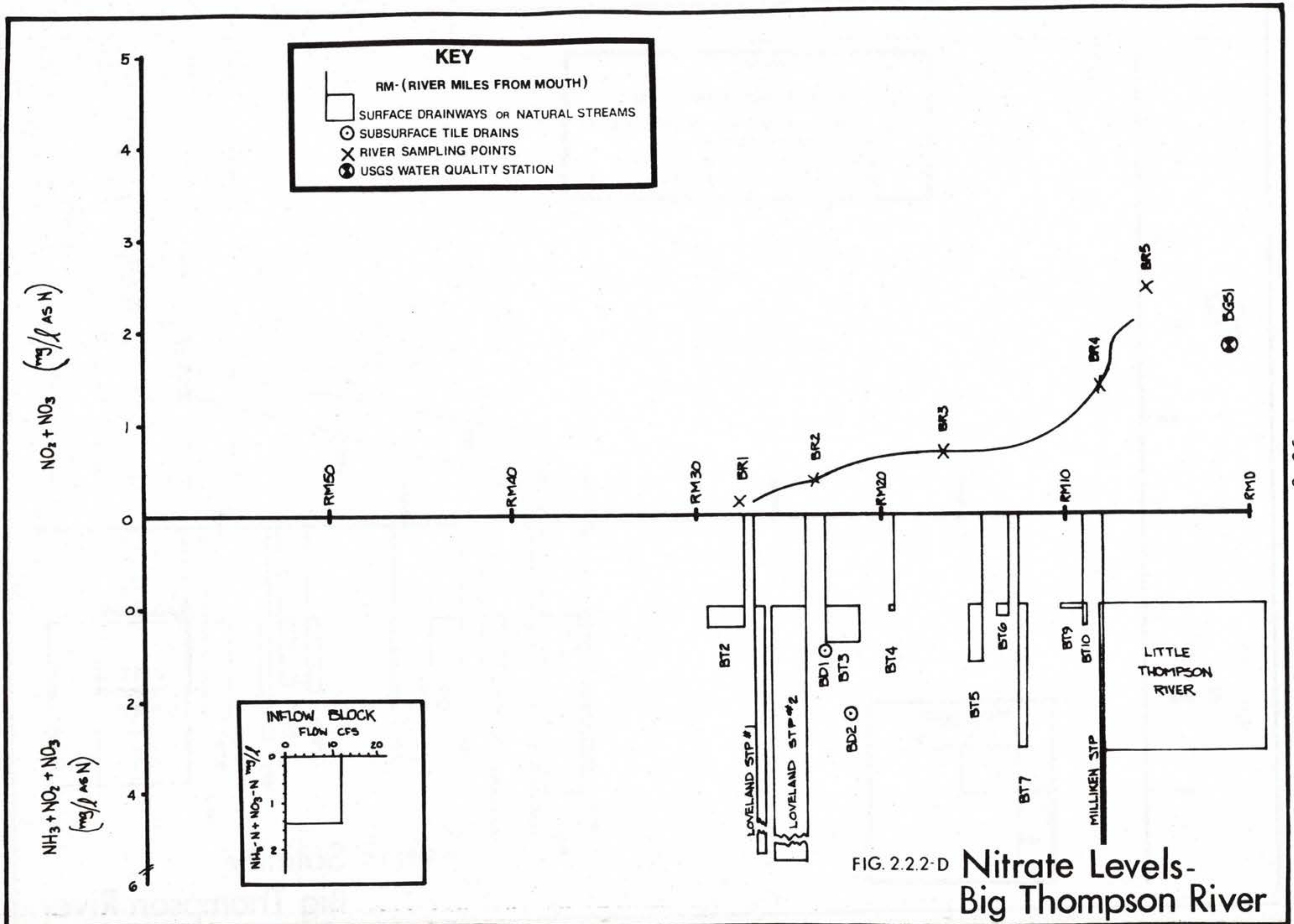


FIG. 2.2.2-D Nitrate Levels-
Big Thompson River

2.2.3.1 Existing Conditions

Profiles representative of low-flow conditions (1972) are presented on Figure 2.2.3-A. Figure 2.2.3-B depicts in-stream hydrology for 1976, the period in which the 208 water quality sampling program was conducted. Results of sampling activity are identified in Figures 2.2.3-C through 2.2.3-E

2.2.4 St. Vrain Creek

The drainage of St. Vrain Creek is impacted by feeding operations and irrigated agriculture. Municipal and industrial discharges up-stream of the Larimer-Weld Region, specifically from Longmont and Great Western, Longmont, also impact this waterway. Only one point source, Mead Sanitation District, discharges municipal effluent to the St. Vrain in the Larimer-Weld Region. Agricultural return flows to the St. Vrain are estimated at 62 MGD.

2.2.4.1 Existing Conditions

Figure 2.2.4-A shows the stream flow of the St. Vrain Creek during the period in 1976 which corresponds to the 208 sampling program. Nitrate data and salinity data are presented in Figure 2.2.4-B and 2.2.4-C.

2.2.5 South Platte River

The South Platte River's existing water quality is influenced by the quality of water entering the Region from upstream areas and the large quantity of irrigation return flow discharged in the Larimer-Weld Region (125 MGD). Small Weld County towns on the Platte have a negligible influence on water quality.

2.2.5.1 Existing Conditions

Figures 2.2.5-A illustrates the existing low-flow conditions for the South Platte River. Figure 2.2.5-B shows nitrate data and Figure 2.2.5-C shows salinity data based upon Fall, 1976 sampling.

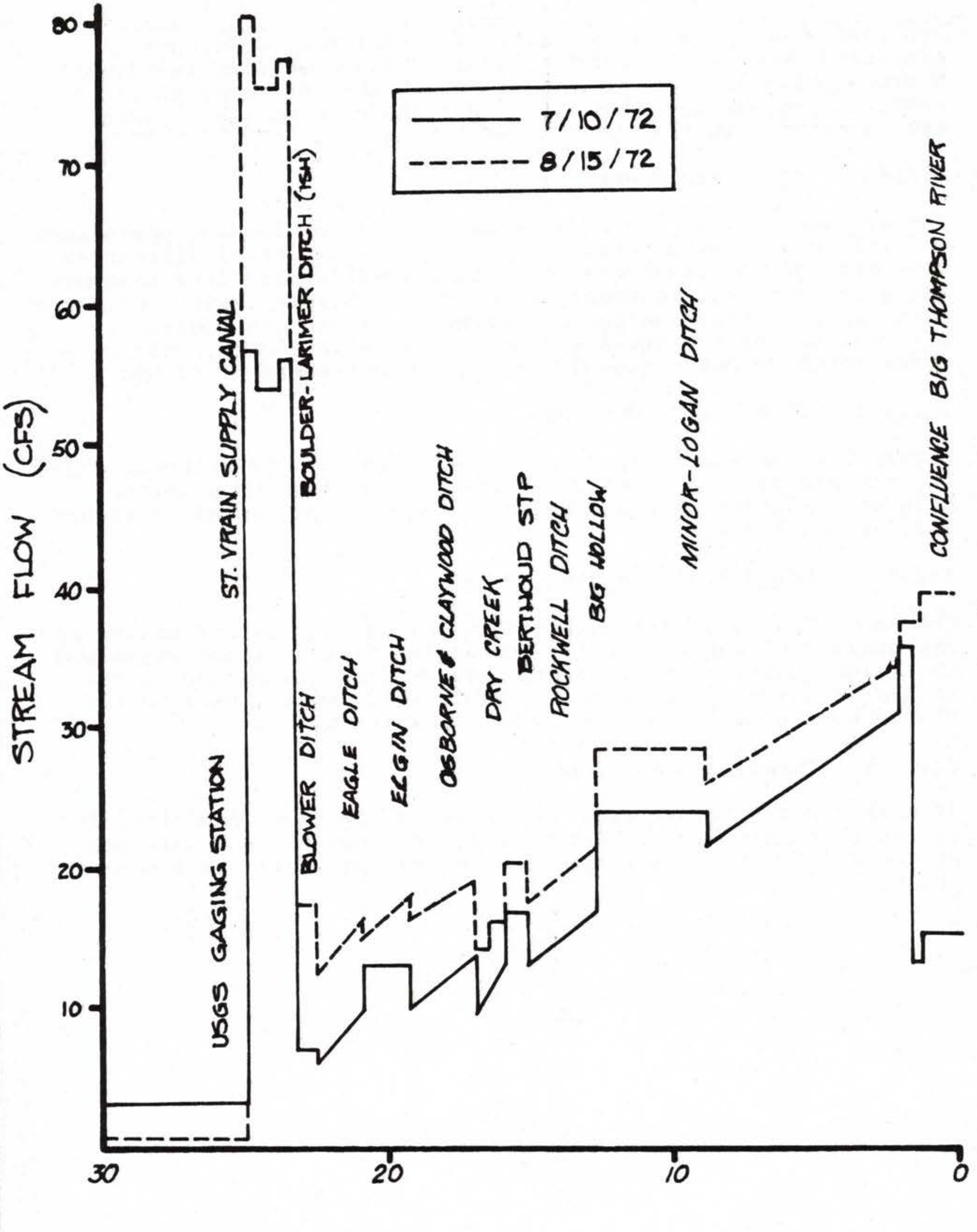


FIG. 2.2.3-A **Low Flow Condition- Little Thompson River**

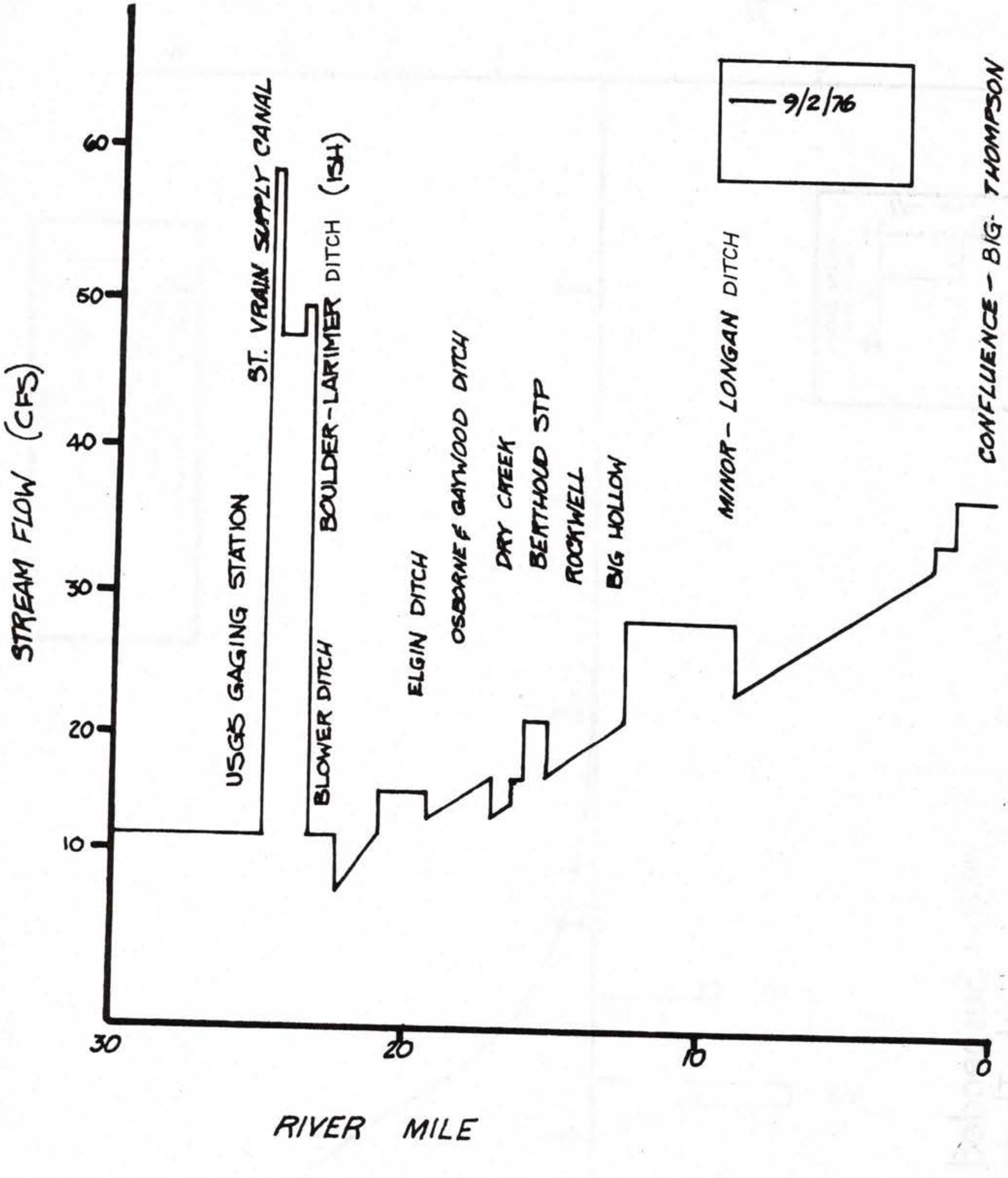


FIG. 2.2.3-B **Low Flow Condition-Little Thompson River**

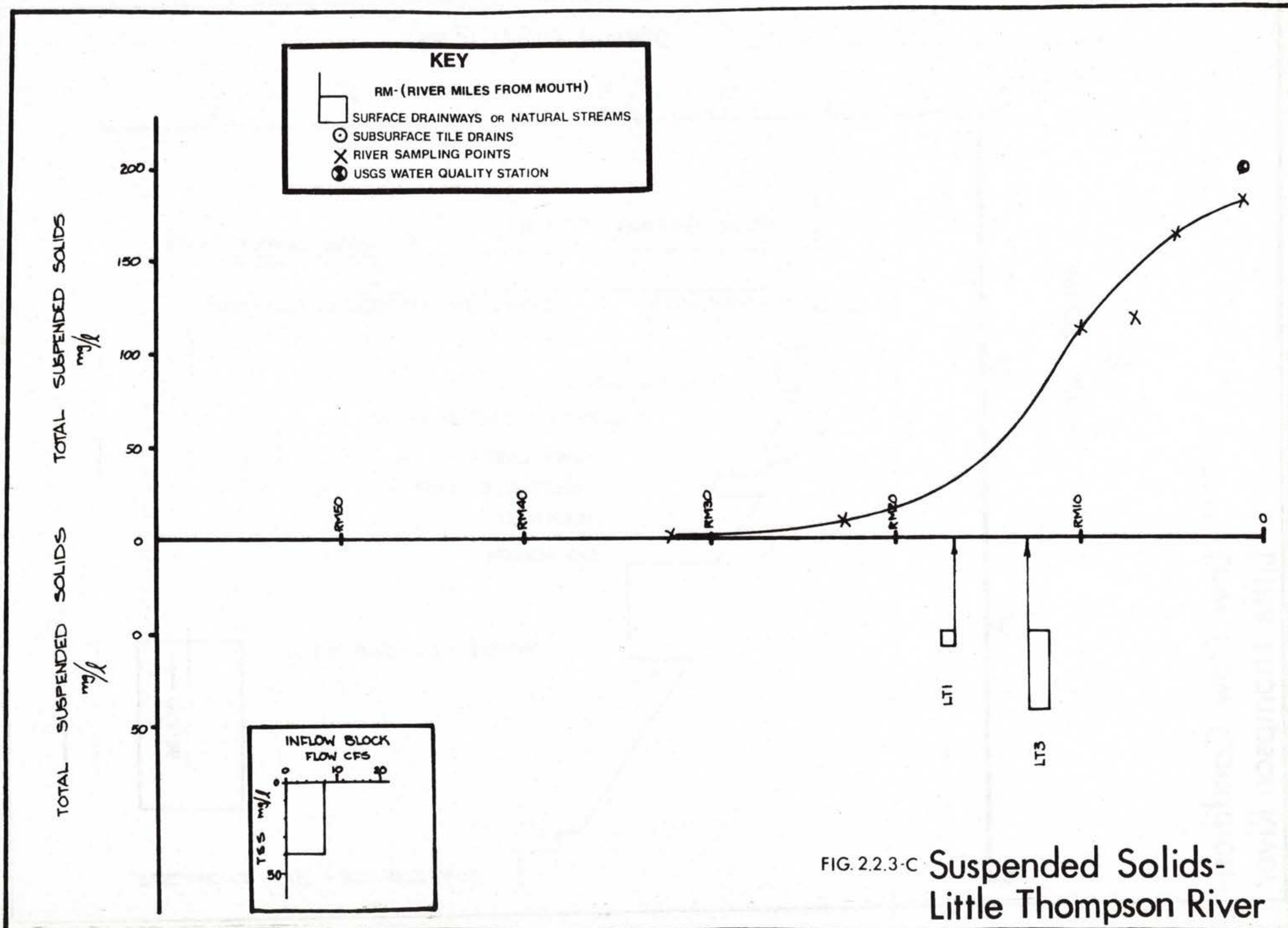


FIG. 2.2.3-C Suspended Solids-
Little Thompson River

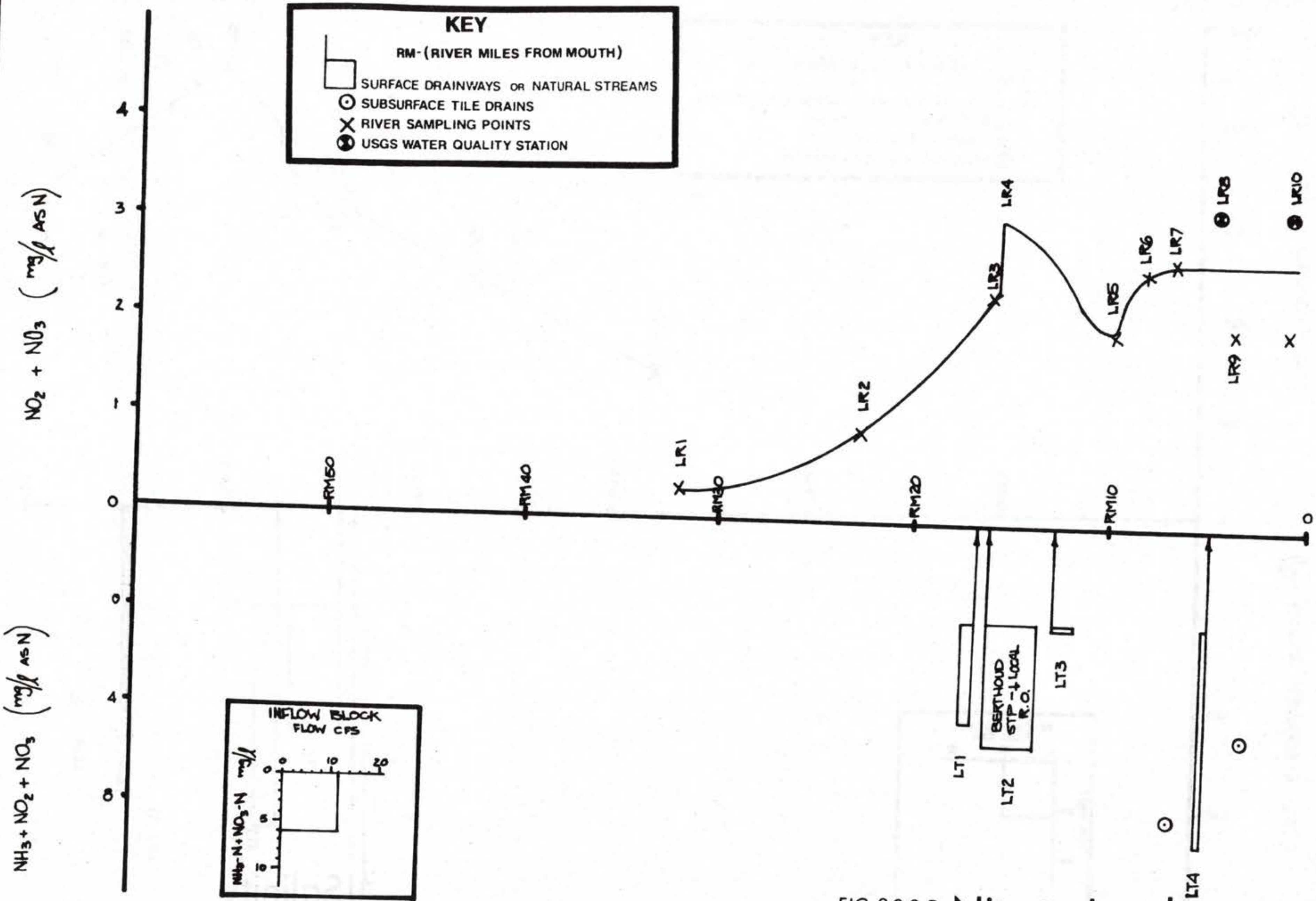
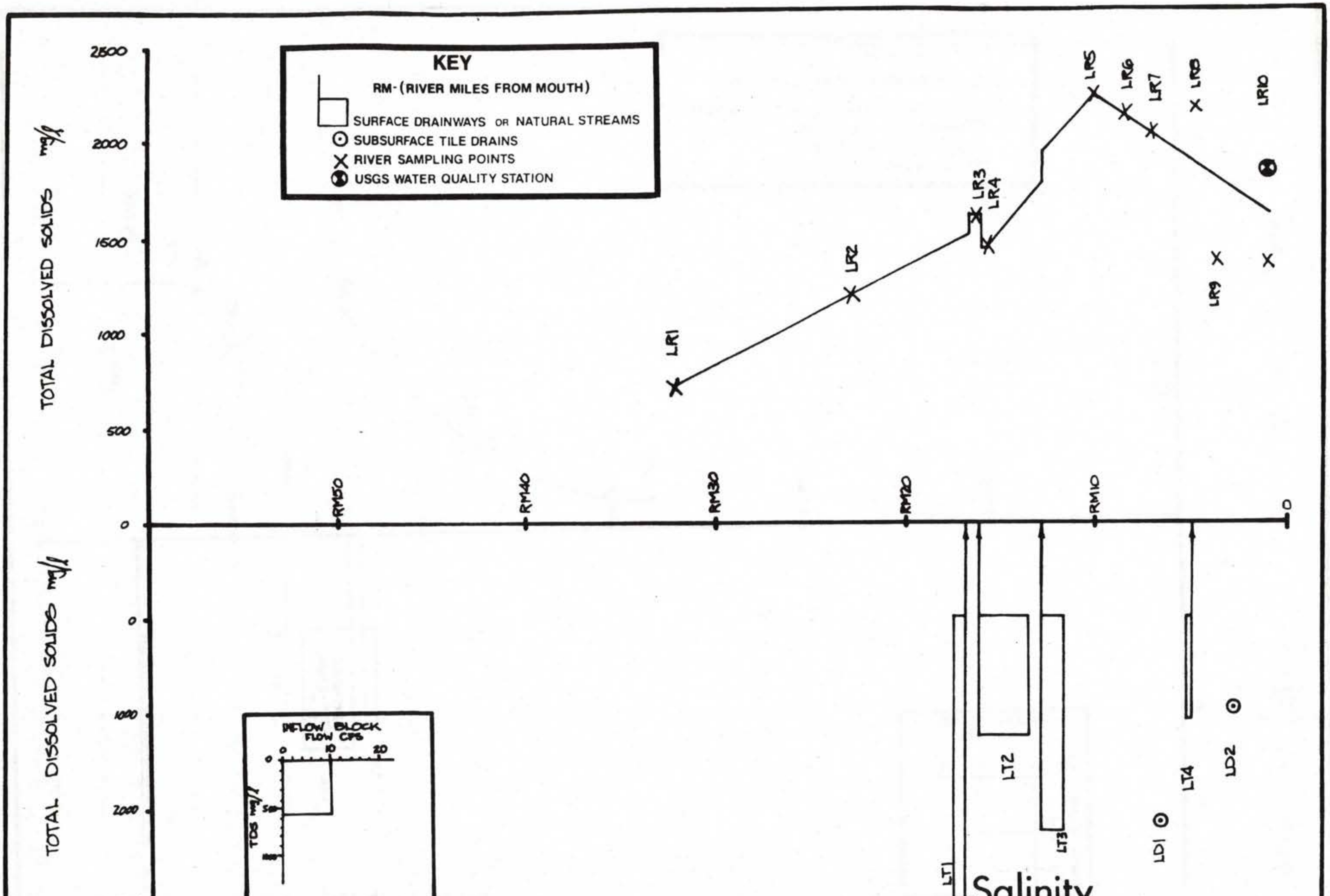


FIG. 2.2.3-D Nitrate Levels- Little Thompson River



Salinity

FIG. 2.2.3-E Little Thompson River

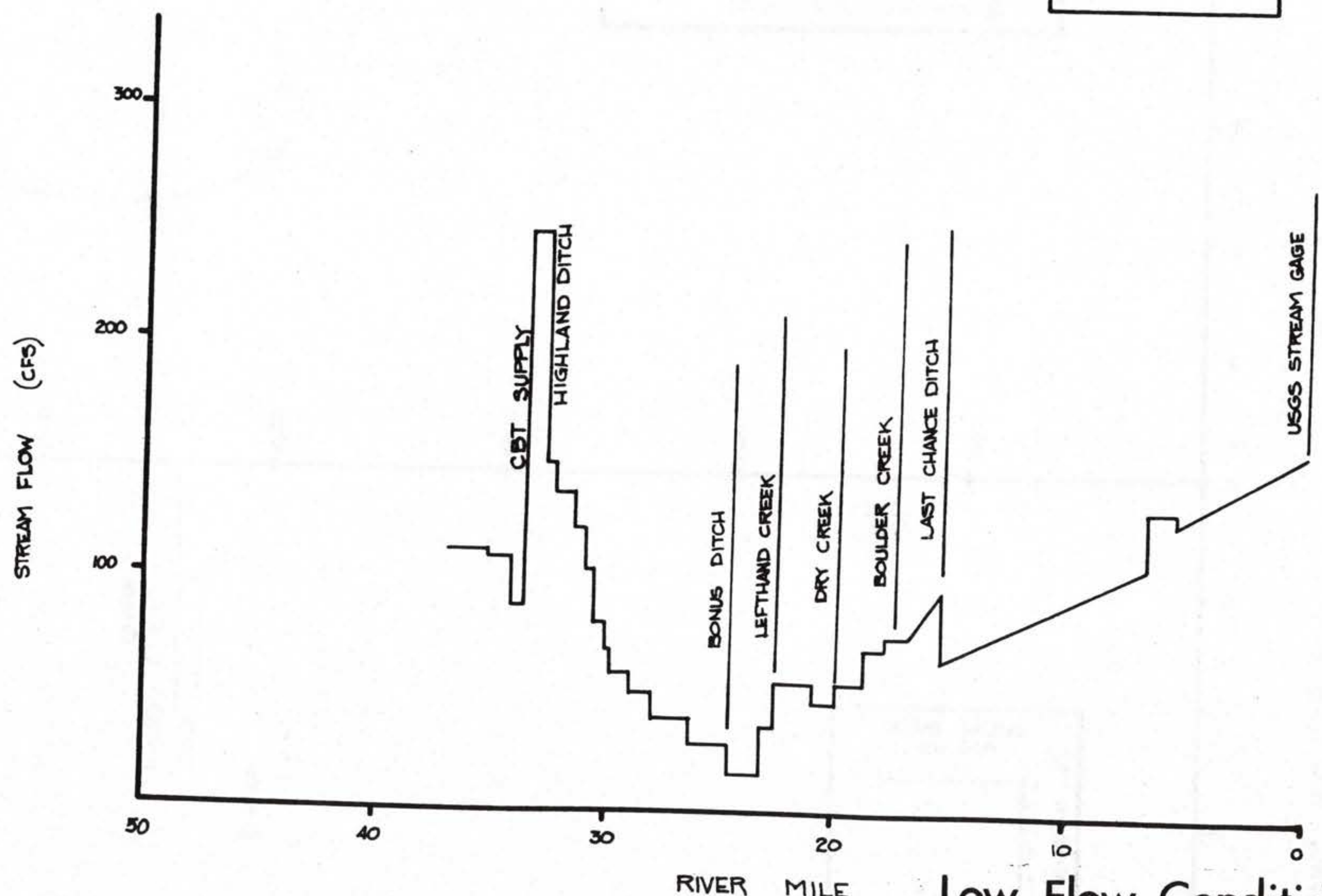


FIG. 2.2.4-A

Low Flow Condition- St. Vrain Creek

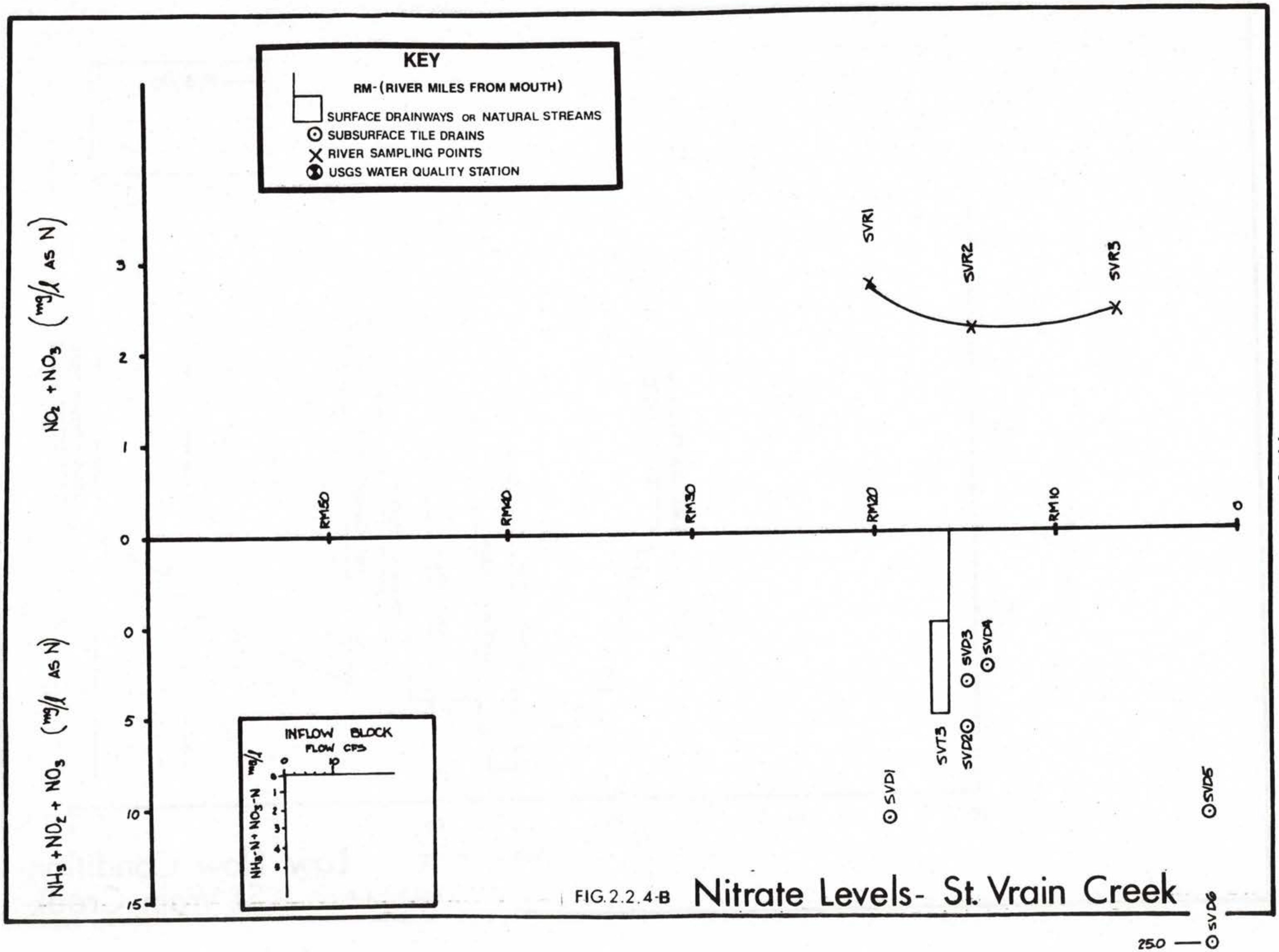


FIG. 2.2.4-B Nitrate Levels- St. Vrain Creek

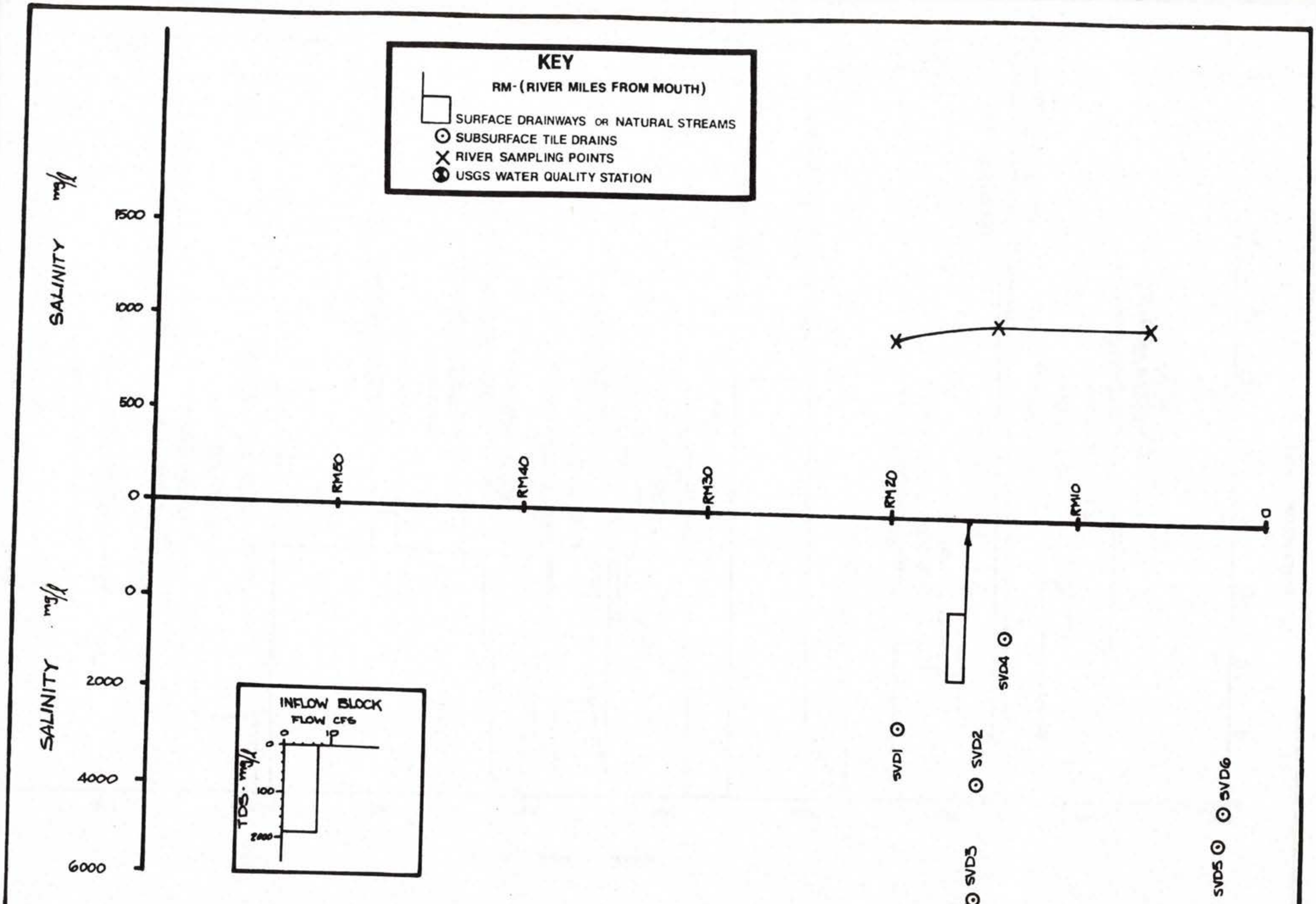


FIG. 2.2.4-C Salinity- St. Vrain Creek

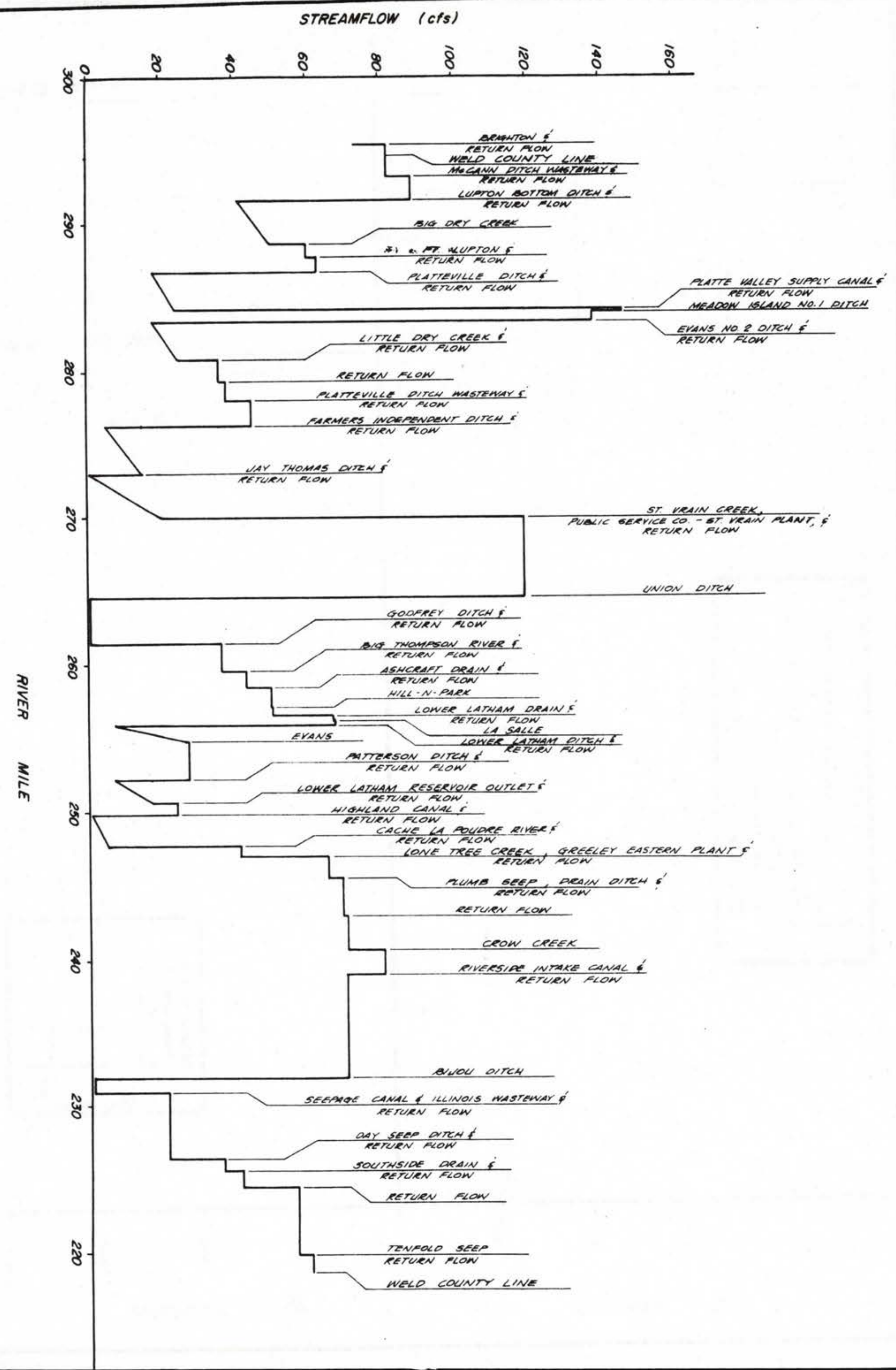


FIG. 2.2 5-A LOW FLOW CONDITIONS - SOUTH PLATTE RIVER

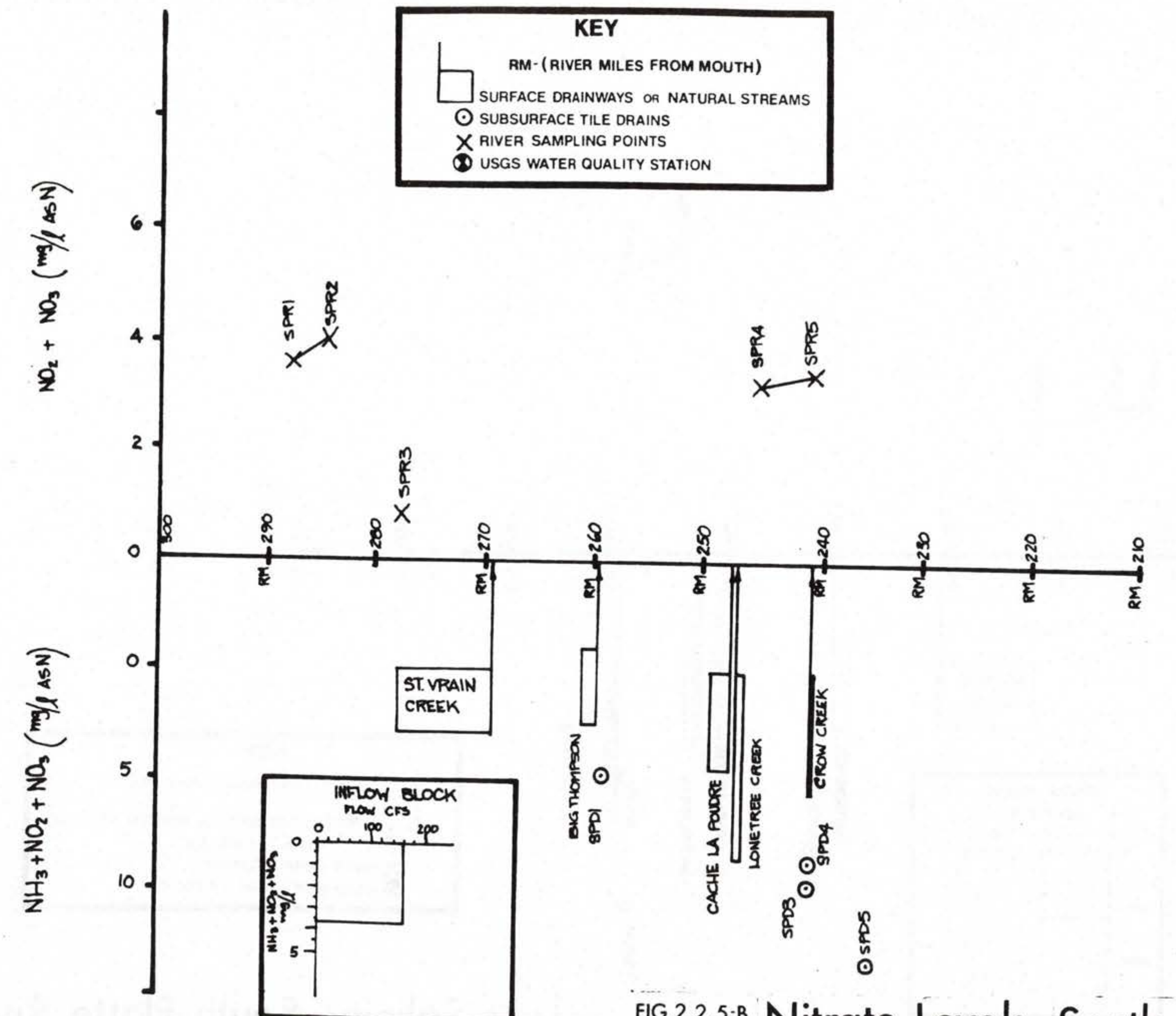


FIG. 2.2.5-B **Nitrate Levels- South Platte River**

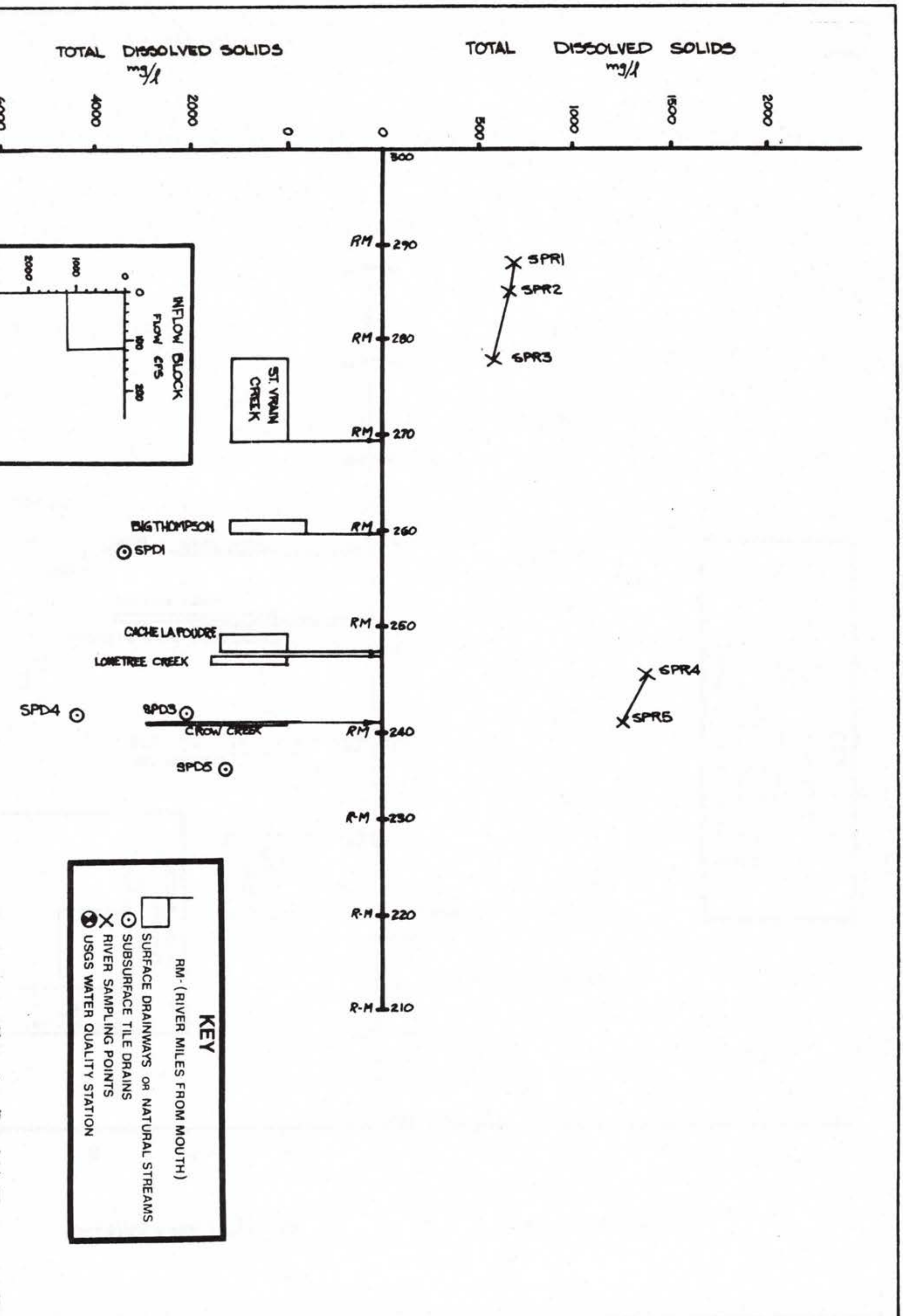


FIG. 2.2.5-C Salinity- South Platte River

3.0 WATER QUALITY CRITERIA AND STANDARDS

This chapter provides the rationale for in-stream standards and criteria incorporated into the 208 Plan, development of in-stream standards and criteria in the future, and application of standards and criteria to NPDES permits.

The quality of water and the impacts of pollution on beneficial uses cannot be viewed in simple absolute terms because: (1) Each beneficial use of water requires that the physical, chemical and biological characteristics fall within some limiting range if uses are to maintained without serious impairment or damage to the water user. This applies to all uses of water in the Larimer-Weld Region including recreation, agriculture, aquatic life, and public water supply. (2) The ability of technicians to measure chemical concentrations in water, conduct tests on aquatic life under idealized laboratory conditions, and write computer programs supposedly depciting in-stream conditions, has advanced tremendously in recent years. However, the application of this advanced technology to specific rivers, streams, and reservoirs is in its embryonic stage. In consideration of these facts, water users must build a basis upon which rational water quality planning can be conducted and plans implemented within the context of water uses in the Larimer-Weld Region.

In the semi-arid climate of Northern Colorado where water has been a scarce and valued resource, Man has placed increasing demands on the available water resources in the Region. Beginning over 100 years ago, water which was once free-flowing in streams is now impounded used and reused for municipal, industrial and agricultural water supply, recreation and wildlife production through a highly sophisticated program of diversion, storage and reuse management strategies. Competing and often conflicting uses of water have raised numerous questions regarding the level of water quality to be achieved consistent with the historic, present and projected uses of water in the region and the natural and man-related constraints of the hydrologic system.

3.1 MEANINGS OF POLLUTION

Pure water without the presence of trace elements and nutrients is not suitable for high production of plants and animals in an aquatic ecosystem. For example, there are streams within the State of Colorado where the water is so pure or lacking in nutrients that it will not support aquatic plant life and micro-organisms, therefore, making it incapable of supporting large fish populations (Goettl, 1977). The introduction of some so-called nutrient/pollutants such as nitrogen and phosphorus, could enhance the suitability of these waters for supporting aquatic life. Maintaining a proper balance among life forms in water bodies is a critical aspect of water pollution control. Water bodies and their aquatic biota have a considerable capacity to absorb and utilize both organic and inorganic materials. Extensive populations and biomass production can be generated in such processes. Water quality is relative; it must be associated with the intended use of the water and it has many meanings. No one definition means the same thing to all people.

A simple definition of water pollution might then be "any impairment in water quality that makes the water unsuitable for a beneficial use." This definition, however, then raises concern as to what constitutes a beneficial use.

3.2 LEGAL DEFINITION OF BENEFICIAL USES OF WATER

Colorado law defines beneficial use as "...the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made and, without limiting the generality of the foregoing, includes the impoundment of water for recreation purposes, including fishery or wildlife. For the benefit and enjoyment of present and future generations, (beneficial use) shall also include the appropriation by the State of Colorado in the manner prescribed by law of such minimum flows between specific points or levels for and on natural streams and lakes to preserve the natural environment to a reasonable degree." (CRS 1973, 37-92-103(4)).

Under Colorado Water Law, the use of water is established only if water is appropriated for that use.

Regulations proposed by the Colorado Water Quality Control Commission identify beneficial uses which are generally compatable with those developed in the 208 planning process: recreation, aquatic life, water supply, and agricultural.

3.3 IMPACTS OF WASTE LOADS ON WATER QUALITY - IMPAIRMENT OF BENEFICIAL USES

Since not all beneficial uses of water require the same level of water quality some degradation from a particular use may not affect the suitability for another use. For example, in the Larimer-Weld Region the introduction of excess nitrate nitrogens from agricultural fertilizer applications has in general little bearing on the presence or absence of higher froms of aquatic life. In contrast, nitrate nitrogen in drinking water at excessive levels (10 mg/l as nitrogen) is reported to cause methemoglobinemia in infants of less than three months of age. Ammonia nitrogen, as well as nitrate nitrogen, is a constituent of domestic waste water effluent. Ammonia in very small concentrations is toxic to aquatic life. Both advanced waste treatment and in-stream biological conversion convert ammonia to nitrate nitrogen. Advanced waste treatment will convert most ammonia before it is introduced to the stream, but at a substantial cost. In-stream natural conversion occurs over a relatively short period of time but may result in the degradation of a segment of stream. The length of the segment will depend upon such factors as dilution effects and stream velocity, and rate of biological conversion. In both instances, the nitrate levels are not significantly reduced and the potential health hazard to a small segment of the human population is still present, yet a nutrient resource is available for agricultural purposes.

Removal of nitrate nitrogen from waste waters does not appear to be a feasible alternative given the present technology available at this point in time, as the technology is just developing and the present costs are prohibitive. However, use of oxidation ponds for small scale municipal waste treatment may result in some nitrogen removal through microbial denitrification in the anaerobic bottom layers of the lagoon or by ammonia emission to the atmosphere.

Waste load contributions to receiving waters and their impacts are not constant. The simple principle of dilution affects the amount of a waste which a receiving water may assimilate. Obviously, a larger volume of water can receive more total waste load than a smaller volume of water, all other conditions equal. The dilution will be greater and, therefore, the in-stream concentration will be smaller and the ultimate impact potentially less. Impacts from point sources of pollution will be the least where stream flows are highest.

Shock loading or large amounts of wastes may occur during precipitation and surface runoff events. Surface runoff from urban areas, construction and silviculture activities and agricultural lands can produce substantial loads of sediment and organic materials. The largest impacts of other constituents are from urban runoff. Sediment, pesticides, fertilizers and fecal material from dogs and cats, as well as petroleum products, asbestos and numerous other materials carried by a stormwater drainage system may reach a canal or stream. (See Interim WQMP Report #19, Nonpoint Source Control, for detail.)

The shock loading of these materials and added volume of water upon the receiving water may affect the quality of water, but quantitative effects upon aquatic life and in-stream water uses are not well known.

The impacts of waste loads from various sources upon water quality are dependent upon several factors. The aquatic ecosystem has the ability to accept, utilize and purify many types of waste.

The capability of the ecosystem to do so is a function of the tolerance of the organisms in the system to a particular level of the waste constituent. For some wastes, even small amounts may affect the life in a receiving stream or affect the future beneficial use of the water. Some constituents, like residual chlorine and ammonia from a municipal waste treatment discharge, are toxic in minute concentrations but are converted to less toxic forms in a short time in the receiving water. Some heavy metals are relatively harmless, while others are extremely toxic in very small concentrations. The effects of each may vary widely depending on its form when it reaches the receiving waters and its ability to combine chemically with other materials in the water, stream bottom or aquatic life. The effects of the presence of a heavy metal may result in an outright kill of aquatic organisms or it may accumulate harmlessly throughout a food chain and emerge as a toxic in a higher organism (bio-accumulation,

The net effects of pesticides upon the environment are also complex. Tremendous benefits have accrued to man through increased agricultural crop production and suppression of undesirable insects, weeds, fungi and other living organisms which have reduced crop production. But the application of these chemicals has often been offset by adverse impacts to the environment. Persistent insecticides which do not break down into less harmful forms have caused high mortality, mutation or otherwise hampered organisms, other than target organisms, which the pesticide was designed to control.

In recent years, however, most of these compounds (primarily, chlorinated hydrocarbons) have come under strict regulatory control for sale and application, are not longer used or may be replaced by equally effective, but less toxic substitutes. Still, however, the effects of all pesticides usage upon public health or wildlife, including aquatic life, is not known. For the most part, however, pesticides applied to agricultural lands in the Larimer-Weld Region are not at the present considered to be a significant pollutant. This view may change as more sampling, monitoring and investigation of the transport mechanisms, loadings and ultimate fate of the various compounds is known (see Interim WQMP Report No. 22, <u>Water Quality Impacts of Irrigated Agriculture, Report #3</u>, for further detail).

At present, it appears that in the short term the benefits derived from the use of pesticides outweigh the potential adverse impacts to the environment. This view may change, however, as more is learned about the long-term effects of pesticide usage.

3.4 SETTING WATER QUALITY CRITERIA AND STANDARDS

Much confusion has recently come about over the meaning and application of water quality criteria and standards. According to the authors of EPA's <u>Quality Criteria for Water</u> (EPA, 1976), the word "criterion" should not be used interchangeably with the word "standard" as their meanings and application are different. Both in general application and as related to the water pollution control field, standards are a set of measures for comparison for quantitative or qualitative values. Standards are the basis for regulatory enforcement. Criteria, on the other hand, do not have direct regulatory use and cannot be used, for instance, to write NPDES permits (EPA, 1976). A water quality criterion represents a constituent concentration or level associated with a degree of environmental effect upon which a scientific judgment may be based, but it must be recognized that inadequate information is available to use criteria as a basis for regulation. Criteria may be the basis upon which standards are eventually formulated when adequate information is available. In determining the degree of protection a certain concentration of a constituent identified as a criterion will afford an organism or ecosystem or a water use, much discretion is left to the applied scientist to determine that which is acceptable and that which is not based on actual instream conditions rather than laboratory data. Toxicity levels of a particular constituent are not absolute to all organisms. In other words, one organism may be more sensitive than another or, the effects upon an organism may not show up immediately (acute toxicity), but may evolve over a long period of time (chronic toxicity). Further, the combined effects of more than one constituent may be different than that constituent by itself (synergistic effects), and the effect will vary depending on ambient stream conditions (temperature, pH, hardness, etc.).

Therefore, the scientist must carefully weigh all available knowledge to him in order to determine criteria for a constituent, recognizing that he may not have sufficient data to support his findings for all real world situations. The professional license given the scientist for such determinations is ominous and requires close monitoring.

In a special report prepared by the National Research Council of the National Academy of Sciences for EPA (National Academy of Sciences, 1977, Volume I), the intensive uncertainty of the application of scientific information to environmental management is pointed out ...

> "The structure of most natural and man-influenced ecosystems is both complex and characterized by natural oscillations in abundance and interactions among constituent species as well as by various changes in environmental conditions. Natural variability may make it difficult, even after careful study of a particular ecosystem, to characterize in a dependable fashion what changes will result from a particular environmental assault on the system. Complicating this state of affairs is the fact that almost none of the earth's ecosystems is now known or understood in substantial detail. Thus, in many cases we simply do not know the full consequences of a proposed regulatory decision or of a decision not to act at all."

"The uncertainties and incompleteness of environmental science, when candidly admitted, are frustrating; but it is unrealistic and improper for the politically responsible decision-maker to expect and demand more than science can provide. It is equally improper for technical analysts to fail to explain clearly the limits of their knowledge, the margin of uncertainty in their estimates, and the gaps that might be closed by further research."

The importance of recognizing and evaluating the benefits to be gained from any decision and consequential actions taken to reduce a particular pollutant must not be dismissed. A careful balance should be made between applying state-of-the-art knowledge to a particular real world problem immediately or awaiting further research to confirm or deny a finding especially when such application may result in expenditure of great sums of public and private funds for removal of a particular pollutant. Much of the applied research in water pollution control has come about only in recent years and has not fully withstood the test of scrutiny through validation by similar testing or peer review. This is particularly the case in application of numeric limits to aquatic ecosystems or other beneficial uses of water.

Again, quoting from the National Academy of Science Report to EPA on the Role of Scientific and Technical Information ...

"Assessment of available data begins with the collection of physical, chemical, statistical, biological, economic, social and technological data from existing sources. The data are then analyzed for accuracy and relevance, and synthesized and interpreted in terms suggested by the people who will use the results. To be useful to decision-makers for the task of assessing available options, the analysis must organize the information in a form that clearly defines relationships among different aspects of a problem and places the data on each aspect (for example, a health hazard) in the context of the overall framework of human interaction with the environment. Limits of confidence in the data and uncertainties in the analyses must be stated explicitly . . . .The results of such analyses may also be used to identify critical research needs, and thus would also be useful for planning research activities in EPA. (Research, Chapter 2.)"

It is clear that the National Academy of Sciences task force dealing in the application of technical information to environmental problems fully recognizes the need for a systematic analytical approach to gathering and applying such information. This approach has been reinforced by others (see Doudoroff, 1977, 1978, in Appendix A).

The Larimer-Weld Council of Governments 208 planning process recognizes the problems and uncertainties of application of state-of-the-art knowledge and recommends the approach of recognizing "levels of protection" required for the various beneficial uses of water. Not yet fully proven numeric criteria for various water quality parameters should be applied only as non-regulatory guidelines for planning purposes for water bodies in Colorado and, in particular, the Larimer-Weld Region. Application of water quality criteria other than the basic standards for development of NPDES discharge permits is not acceptable until such time as the following conditions are met:

1. In-stream monitoring programs, biosurveys, bioassays and other scientific evidence establish a sound basis for determination of a numeric standard and shows that chemical constituents included in such criteria are present in sufficient concentrations in receiving waters to interfere with beneficial uses of water and legally adopted stream classifications (see Section 7.0), in specific situations in the Larimer-Weld Region.

2. Monitoring programs identify the specific point and non-point source(s) of the constituent in question, the level attributable to each source, and the specific impact of each source on the beneficial use of water.

3. The economic, social, and environmental impact and feasibility of eliminating the specific pollutant is defined through planning conducted in accordance with Section 201 and/or 208 of the Clean Water Act.

4. The 201 Plan and/or 208 Plan amendment (3. above) is adopted as part of the Larimer-Weld 208 Plan.

5. Facilities are constructed and/or Best Management Practices are developed and implemented to control the discharge of the specific pollutant.

It is imperative that water quality criteria and standards be chosen which maintain and enhance water quality for various water uses, but that they also be scientifically defensible, enforceable, administrable and economically achievable.

3.5 APPLICATION OF WATER QUALITY STANDARDS

Water quality standards have the enforceability of regulatory law. They are one means by which both the Colorado Water Quality Act and the Federal Water Pollution Control Act are to result in the achievement of high quality waters 1) through the establishment of in-stream levels of various water quality parameters which cannot legally be exceeded or 2) through the control of concentrations of selected water quality parameters for effluent limitations in NPDES discharge permits (for further discussion on the formulation of standards, see 40 CFR 130 and Section 7.2.1 of this report).

The Colorado Water Quality Control Commission has the statutory authority to promulgate by regulation any measurable characteristics of water, including:

(a) Toxic substances;

(b) Suspended solids, colloids, and combinations of solids with other suspended substances;

(c) Bacteria, fecal coliform, fungi, viruses, and other biological constituents and characteristics;

(d) Dissolved oxygen, and the extent of oxygen demanding substances;

(e) Phosphates, nitrates and other dissolved nutrients;

(f) pH and hydrogen compounds;

(g) Chlorine, heavy metals, and other chemical constituents;

(h) Salinity, acidity, and alkalinity;

(i) Trash, refuse, oil and grease, and other foreign material;

(j) Taste, odor, color, and turbidity;

(k) Temperature.

(CRS 1973 25-8-204)

Such regulatory standards may be promulgated for any classes (or uses) of water for all waters in the state or any designated portion of state waters. Such standards are important for the following purposes:

(a) To describe prohibitions, standards, concentrations, and effluent limitations on the extent of specifically identified pollutants, that any person may discharge into any specified class of state waters;

(b) To describe pretreatment requirements, prohibitions, standards, concentrations, and effluent limitations on wastes any person may discharge into any specified class of state water from any specified type of facility, process, activity, or waste pile including, but not limited to, all types specified in Section 36 (b) (1) (A) of the Federal Act.

(c) To describe precautionary measures, both mandatory and prohibitory, that must be taken by any person owning, operation, conducting, or maintaining any facility, process, activity, or waste pile that does or might cause pollution of any state waters in violation of control regulations or cause the quality of any state waters to be in violation of any applicable water quality standard.

(CRS 1973 25-8-205)

In view of the uncertainties with regard to the uniform blanket application of standards for numerous water quality parameters and the regulatory nature of standards, it is prudent to select a few basic standards grounded in well-established methodology and which are scientifically justifiable, economically achievable and administerably achievable.

Water quality criteria (such as those contained in EPA's Quality Criteria for Water) will be used as non-regulatory guidelines only for the purpose of planning and problem identification. The criteria will not be incorporated into the regulatory process, including determination of NPDES permit requirements, until the condition specified in Section 3.4 of this report are met.

4.0 FACTORS AFFECTING ATTAINMENT OF THE 1983 WATER QUALITY GOAL

Historical water management strategies, regional hydrologic regime, and physical stream characteristics strongly influence the attainability of fishable-swimmable waters of the Larimer-Weld Region. These realities place additional technical restraints on an implementable water quality management plan. This analysis attempts to go beyond traditional methodologies for developing water quality management strategies by recognizing these additional factors which influence the ability to attain the 1983 goal.

It is clear that the Clean Water Act addresses itself primarily to water quality and does not address, per se, such factors as stream bed conditions, water supply and water use practices, or the requisite of water itself to sustain aquatic life and provide for recreation. The question of attainability can be addressed in two ways:

1. Can we attain the 1983 goals (i.e., fishable-swimmable waters) for water quality irrespective of the fact that there are times when there is no water to support aquatic life or recreation?

2. Can we attain the 1983 goals from water quality and water quantity standpoints and in consideration of climatological and physical conditions, existing in the Region?

These two questions go to the heart of interpretation of the 1983 goals and the technical application of the Clean Water Act as it is currently being administered in the Larimer-Weld Region of Colorado. The following sections of this report will provide physical data and technical support necessary to develop a regionally-implementable answer to the question of attainability, and point out deficiencies and voids in available data.

4.1 HYDROLOGY

The natural character of river systems in the Larimer-Weld Region has been subject to extensive physical modification by man. Throughout the past century, water resources development activity has resulted in the evolution of a complex system of transmountain diversions, reservoirs, canals, pipelines, ditches, and extensive recycling of return flows. Manipulation of the surface water regime has progressed to the extent that municipalities and industries can rely on water supplies that are relatively dependable on a year-around basis. Availability of water for agricultural purposes in many areas has been extended throughout the irrigation season.

The Region encompasses a major portion of the drainage of the Cache la Poudre, Big Thompson, and Little Thompson Rivers. Extensive reaches of the South Platte River and St. Vrain Creek are within the two-county area. The character of natural hydrologic drainages within the Larimer-Weld Region generally exhibits features which correspond to the distinct physiographic provinces: the mountainous region and the plains area. Demarcation between these two regimes is approximated by the foothill area in the vicinity of canyon mouths.

Water resources development activity in the mountains is principally oriented toward the objective of conserving available runoff in reservoirs and impoundments. Selected reservoirs also function as regulatory and holding facilities for flows diverted eastward from the western slope of the Continental Divide. Transmountain diversions exert a significant impact on the hydrology of Larimer-Weld in terms of supplementing supplies native to the Region.

Flows tributary to the plains area of the two-county are intensely managed to meet the needs of established water users. Such waters also accommodate waste flows and loads from the most significant dischargers in the region, as well as those from major non-point pollutional sources of human-related origin.

Characteristics of the regional surface water system were detailed in Chapter 3 of the Waste Load Allocations and Water Quality Modeling Report in support of the 208 Water Quality Management Plan (Interim WQMP Report No. 20). The reader is referred to this chapter for a comprehensive description of system hydrology and management. The existing nature of regional water supply is a major limitation to attaining a desirable fishery in many reaches of rivers that drain Larimer and Weld Counties. This is attributable to several factors, among which are included the seasonal nature of streams in the arid west and the sophisticated management of surface waters to meet the needs of agriculture, municipalities, and other users. To permit evaluation of flow augmentation strategies in a proper perspective, features of the surface water system as it presently exists in the plains area will be highlighted herein.

4.1.1 Existing Surface Water Hydrology

There are six major sources of water conveyed in the major stream channels of the Larimer-Weld Region:

- o Native river flow;
- o Reservoir storage releases;
- o Colorado-Big Thompson (C-BT) Project water;

- Colorado-Laramie River Basin Transmountain importations (Cache la Poudre drainage only);
- Canal seepage, agricultural returns, tile drain effluent, and tributary inflow;
- Municipal and industrial discharges.

Colorado water law allocates available water in a stream to diverters on a priority basis according to historical usage. The foregoing water supplies are regulated and managed for the purpose of satisfying established water rights. This dictates the hydrologic character of the majority of stream reaches in the two-county area.

Management of river flow to satisfy diversion requirements is the direct responsibility of District Water Commissioners. These individuals receive calls on the river, authorize setting of headgates, regulate storage releases, route flows to meet demands, and implement variable operational strategies dictated by demand, available resources, and weather conditions. With the exception of high flows during spring runoff and major precipitation events, water in the rivers is totally managed to meet water resource demands.

The extensive system of municipal and irrigation water supply and diversion essentially controls all streamflow in the Region. Table 4.1.1-A summarizes number of diversions which characterize the major rivers within the Larimer-Weld Region.

TABLE 4.1.1-A DIVERSIONS - LARIMER-WELD REGION

STREAM	NUMBER OF DIVERSIONS (a)	RIVER MILES (b)
Cache la Poudre	27	62
Big Thompson	15	36
Little Thompson	9	24
St. Vrain	2	15
South Platte	20	73

(a) Within Larimer and Weld Counties.
(b) Point of first upstream diversion to river mouth or eastern periphery of Weld County.

Delivery of water to various ditches may be accomplished through canals, reservoirs, and ditches that bypass the main-stem channel of major rivers in the region. Hence, such flows are not available to maintain in-stream fisheries. In instances where the river channel is used to convey water to downstream users, these supplies often sustain flows in stream reaches at high levels that normally would not exist under unregulated conditions. A call for stored water by a downstream ditch may determine to a large degree the volume of river flow passing upstream locations. Fluctuating ditch headgate requirements cause extreme fluctuations in streamflow.

Certain ditches possess a right to river flow which effectively results in diversion of all available flow from the main-stem channel. Downstream diverters rely on storage releases and irrigation return flows to regenerate river flow as a supply source. A significant component of supply to rivers in reaches downstream from canyon mouths during the irrigation season is provided by tributary discharges, canal waste, and agricultural returns. These accretions may be discharged to the river through natural drainage channels, through point source facilities such as municipal outfalls and tile drains, or through channel seepage. Diversion priorities of many downstream ditches are satisfied wholly or partially by such sources. Overland return flow to river systems is usually negligible due to the presence of the buffer zone flood plain.

In some locations, diversions which dry up streams remove total native river flow and all traces of municipal and industrial discharges. Major sections of regional rivers are made up entirely of return flows. This is supported by records of the State Engineer and substantiated by water quality sampling data. (See Interim WQMP Reports No. 6 and 20).

Stream management for irrigation purposes corresponds to two seasons:

- Storage season (October - April)
- Irrigation season (May - September)

Operation strategies implemented during these periods exhibit distinct characteristics.

Storage season activity is geared toward conserving and extending available water supplies and, as much as possible, is introduced to many of the Region's 76 storage reservoirs. Efficient system regulation involves drying up rivers at points of reservoir diversion.

System operation during the irrigation season makes use of natural flows, reservoir storage, and river accretions. During the early portion of the season, water needs are satisfied by direct runoff and return flows. High country snowmelt generally occurs from mid-May to mid-June. In July and August, calls for Colorado-Big Thompson project water and authorized storage releases are significant. Many ditches, however, are supplied exclusively by seepage and returns tributary to the main-stem river system.

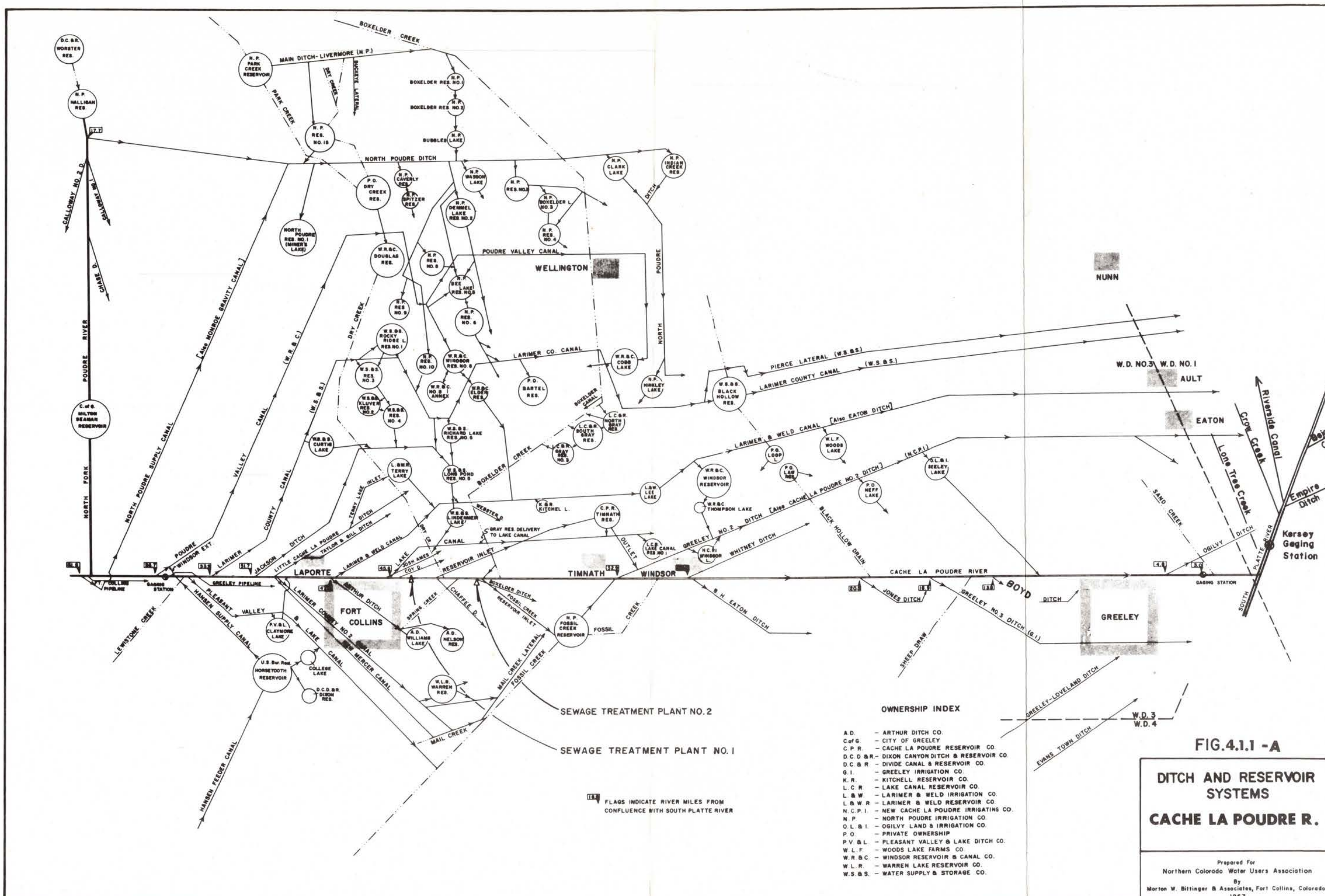
Irrigation flows in the plains area of regional streams are often managed by a sophisticated program of diversion and exchange. Water requirements of downstream senior diverters are often satisfied by reservoir releases of water belonging to upstream users. Upstream ditches may use exchanged river water actually allocated under the law to downstream users. The objective is to maximum availability of water throughout the system. Flow in specific portions of the river may be exhausted in intervening reaches. The practice of exchange is most widely implemented in the Cache la Poudre River basin, and to a lesser extent, in other drainage systems of the Region.

Schematic diagrams of the surface water system in the two-county area are presented in Figures 4.1.1-A, 4.1.1-B, and 4.1.1-C for the Cache la Poudre, Big Thompson and South Platte Rivers, respectively. During the irrigation season, zero flow conditions occur frequently in Larimer-Weld streams as a result of irrigation diversions. Flow in the Cache la Poudre may be exhausted downstream from at least eleven diversion points. These include:

- Monroe Gravity Canal (North Poudre Supply Canal);
- Greeley municipal intake;
- Little Cache la Poudre Ditch;
- Larimer County No. 2 Canal;
- Larimer & Weld Canal;
- Fossil Creek Reservoir inlet (often);
- Whitney Ditch;
- B. H. Eaton Ditch (almost always);
- Greeley No. 3 Ditch (always);
- Boyd & Freeman Ditch (almost always);
- Ogilvy Ditch (always).

Diversions from the Big Thompson may dry up the river at the following locations:

- Louden Ditch;
- Loveland & Greeley Canal;
- Big Barnes Ditch;
- Hillsborough Ditch;
- Big Thompson & South Platte Ditch.



OWNERSHIP INDEX

A.D.	ARTHUR DITCH CO.
C of G.	CITY OF GREELEY
C.P.R.	CACHE LA POUDRE RESERVOIR CO.
D.C.D.&R.	DIXON CANYON DITCH & RESERVOIR CO.
D.C.&R.	DIVIDE CANAL & RESERVOIR CO.
G.I.	GREELEY IRRIGATION CO.
K.R.	KITCHELL RESERVOIR CO.
L.C.R.	LAKE CANAL RESERVOIR CO.
L.&W.	LARIMER & WELD IRRIGATION CO.
L.&W.R.	LARIMER & WELD RESERVOIR CO.
N.C.P.I.	NEW CACHE LA POUDRE IRRIGATING CO.
N.P.	NORTH POUDRE IRRIGATION CO.
O.L.&I.	OGILVY LAND & IRRIGATION CO.
P.O.	PRIVATE OWNERSHIP
P.V.&L.	PLEASANT VALLEY & LAKE DITCH CO.
W.L.F.	WOODS LAKE FARMS CO.
W.R.&C.	WINDSOR RESERVOIR & CANAL CO.
W.L.R.	WARREN LAKE RESERVOIR CO.
W.S.&S.	WATER SUPPLY & STORAGE CO.

FIG. 4.1.1 -A

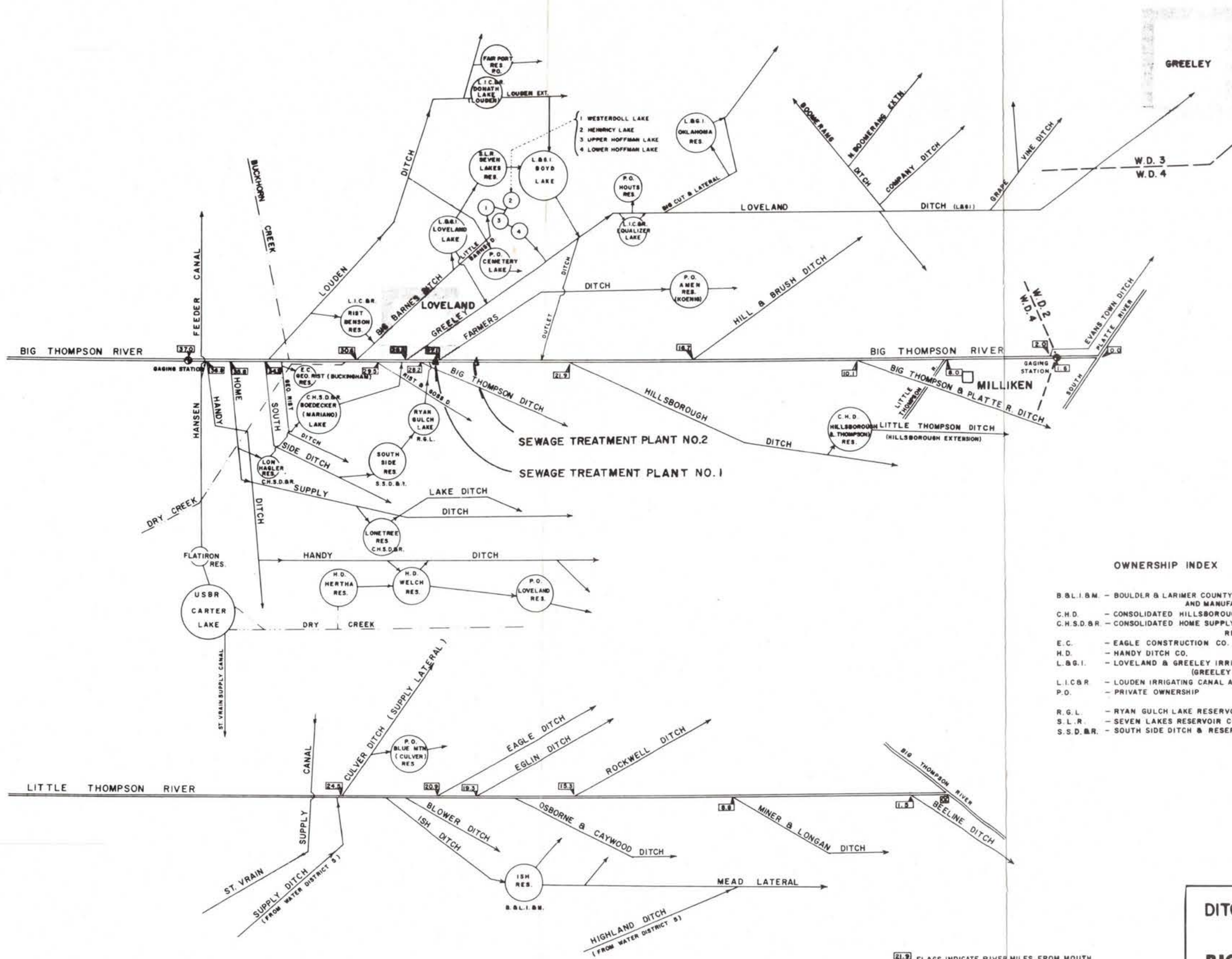
DITCH AND RESERVOIR SYSTEMS

CACHE LA POUDRE R.

Prepared For Northern Colorado Water Users Association

By Morton W. Bittinger & Associates, Fort Collins, Colorado

1967



OWNERSHIP INDEX

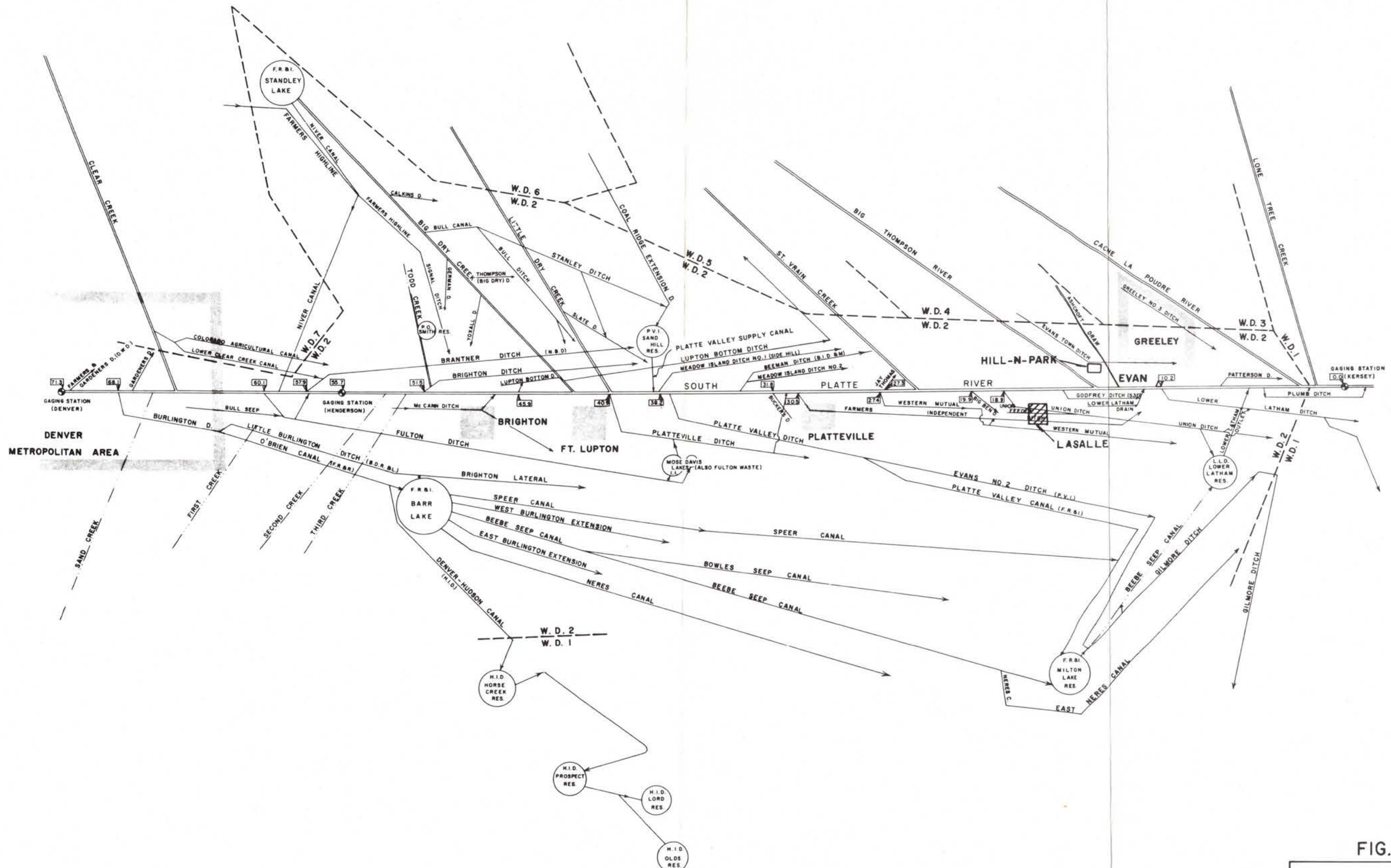
B.&L.I.&M.	BOULDER & LARIMER COUNTY IRRIGATING AND MANUFACTURING CO.
C.H.D.	CONSOLIDATED HILLSBOROUGH DITCH CO.
C.H.S.D.&R.	CONSOLIDATED HOME SUPPLY DITCH AND RESERVOIR CO.
E.C.	EAGLE CONSTRUCTION CO.
H.D.	HANDY DITCH CO.
L.&G.I.	LOVELAND & GREELEY IRRIGATING CO. (GREELEY & LOVELAND)
L.I.C.&R.	LOUDEN IRRIGATING CANAL AND RESERVOIR CO.
P.O.	PRIVATE OWNERSHIP
R.G.L.	RYAN GULCH LAKE RESERVOIR CO.
S.L.R.	SEVEN LAKES RESERVOIR CO.
S.S.D.&R.	SOUTH SIDE DITCH & RESERVOIR CO.

FIG. 4.1.1 - B

DITCH AND RESERVOIR SYSTEMS

BIG THOMPSON R.

Prepared For
Northern Colorado Water Users Association
By
Morton W. Bittinger & Associates, Fort Collins, Colorado
1967



55.7 FLAGS INDICATE RIVER MILES FROM DOWNSTREAM GAGING STATION

OWNERSHIP INDEX

B.D.R.&L.	-	BURLINGTON DITCH, RESERVOIR & LAND CO.
B.I.D.&M.	-	BEEMAN IRRIGATING DITCH & MILLING CO.
D.W.D.	-	DENVER WATER DEPARTMENT
F.R.&I.	-	FARMERS RESERVOIR & IRRIGATION CO.
H.I.D.	-	HENRYLYN IRRIGATION DISTRICT
I.I.	-	IONE INVESTMENT CO.
L.L.D.	-	LOWER LATHAM DITCH CO.
N.B.D.	-	NEW BRANTNER DITCH CO.
P.I.&M.	-	PLATTEVILLE IRRIGATION & MILLING CO.
P.V.I.	-	PLATTE VALLEY IRRIGATION CO.
S.3.D.	-	SECTION 3 DITCH CO.

FIG. 4.1.1 - C

DITCH AND RESERVOIR SYSTEMS

S. PLATTE RIVER

Prepared For
Northern Colorado Water Users Association
By
Morton W. Bittinger & Associates, Fort Collins, Colorado
1968

In its reach through Larimer and Weld Counties, the South Platte may be dry immediately downstream from at least five ditches:

- Jay Thomas Ditch;
- Union Ditch;
- Highland Canal (Plumb Ditch);
- Bijou Ditch;
- Weldon Valley Canal.

4.1.2 Impact of Hydrology on Water Quality Goals

The complete management of the Region's rivers to meet demands for water by municipalities, industries and for 500,000 acres of irrigated land, in accordance with Colorado's Law and Constitution, necessarily result in extreme hydrologic variations, drying up of streams at many locations summer and winter, and generally unstable aquatic habitat in the plains area of the Region. This contributes to survival of only the hardiest of species of fish (carp, suckers, select forage fish) usually referred to as "rough or trash fish."

4.2 PHYSICAL STREAM CHARACTERISTICS

A prerequisite of high quality aquatic habitat is a physical environment which is conducive to supporting stream life. There are wide ranges of physical stream characteristics in the region. As previously discussed, the amount and timing of water in a stream or reservoir ecosystem is extremely important to survival and propagation of aquatic life. Other factors which can greatly affect the existence of aquatic life are the influences of topography, parent geologic materials, soils, climate and streamside vegetation and their cumulative effects on the development of stream bottom substrate, channels and banks. These influences will ultimately determine to a large extent the biologic communities present in the stream ecosystem, independent of man-caused pollution.

The physical stream descriptions that follow, separate the waterways of the Larimer-Weld Region into two broad physiographic areas, the mountain streams and the plains streams. These two categories are a convenient geographic means of separating stream characteristics. Mountain streams are generally cooler, have higher velocities, contain more suitable habitat for aquatic life and are generally free of silty bottom deposits. Plains streams are controlled to meet water supply demands, are influenced by urban and agriculture wastes, are warmer, and have slower velocities with accumulations of silt and sludge. All of these factors contribute to conditions not suitable to habitat for sustained high quality aquatic life production.

4.2.1 Mountain Streams

With the exception of the South Platte River which enters southern Weld County on the plains, all the major streams of the Larimer-Weld Region have their sources within the political boundaries of the Region. All originate above 10,000 feet elevation in the alpine and subalpine mountainous areas. Snow pack, runoff and seasonal rains produce cold waters which feed tributaries and main streams. Additional waters in the Big Thompson river system come from transmountain diversion of waters on the western side of the Continental Divide through the Colorado-Big Thompson Project. In general, these mountain waters are of exceptionally high quality with dissolved oxygen almost always at saturation and biochemical oxygen demand and other pollutants generally very low. Adverse concentrations of nutrients are almost non-existent and salt concentrations are extremely low.

4.2.1.1 Geology

In general, the bedrock and surfacial geology of the mountainous areas are not conducive to large volumes of groundwater recharge.

Mountain streams of the region begin in the glaciated regions where U-shaped valleys provide broad meadows and morainal and cirque lakes. The underlying bedrock is uplifted granite intrusions and metamorphic rocks. To the east, the rivers cut through granite in deep V-shaped valleys. Except for moraines, or alluvial deposits overlaying impervious bedrock, these areas do not have the capability of accepting large amounts of runoff. Water tends to runoff to the waterways, rather than fill groundwater reservoirs.

The impervious bedrock formations and steeply sloping, shallow, coarse, poorly developed mountain soils create conditions for high volume runoff. High fluctuation to peak stream flows during snowpack thaws and rainfall events are the reason for much channel scour in many of the high mountain streams. Silt loads traveling down steep gradient streams may be redeposited in areas where stream gradients lessen as the streams reach the more level rolling topography of the foothills and plains.

4.2.1.2 Channels and Banks

The physical character of channels and banks is primarily a function of parent geologic material and soils, stream gradient and variation in volume of flow over a given stream segment. The energy which is expended by water flowing over this area in conjunction with the resistance to erodibility of the soil and geologic materials will determine the character of the channel and banks.

The type of aquatic life which may be present in the stream is largely dependent upon the bed character of the stream. The glaciated high mountain parks of the region have meandering streams which have developed over gravels and glacially moved debris. Fine sediments are not usually present in large quantities. The moderate stream velocities in these high mountain parks provide good aeration necessary to provide oxygen to aquatic life. Below glaciated areas, streambeds contain more bedrock and less small gravel substrate. The velocities also tend to be higher before the streams discharge to the plains. Although these areas are not as suitable as the glaciated area for production of invertebrates and fish, there are numerous ripples and pools that provide adequate aeration and substrate materials for sustaining aquatic ecosystems.

Stream banks range from nearly vertical cliffs as found in the Big Thompson Narrows and the Cache la Poudre Narrows to moderately sloped banks in valleys of the montane and mountain meadow regions.

4.2.1.3 Stream Life

The aquatic life present in the mountain streams are numerous and diverse though perhaps not as numerous and diverse as streams at lower elevations. Cool water temperatures and nutrient deficiencies, however, may result in lesser total biomass production than might be expected in warmer nutrient rich waters.

The stream flora varies with season. Colder water temperatures encourage diatom growth and warmer temperatures result in greater growth of algae and attached life forms. Algae, by utilizing solar energy, provide the basic energy source for almost all other stream life.

The invertebrates can be seen as two separate types - grazers and predators. The grazers harvest the algae, and the predators feed upon the grazers. The most common stream invertebrates include midges and blackflies. Stoneflies and mayflies are also often observed. These invertebrates are the food source for the higher vertebrate life forms or fish of the mountain streams.

Biomass production in the cold water streams of the mountains is slow and it is common to take as much time as 5 years for a fingerling rainbow trout to grow to 12 inches. The same fish in a plains reservoir may grow to this size in only one year.

Water temperatures and other conditions are suitable for a number of introduced trout species including rainbow, brown, brook, lake and a few cutthroat. Population levels are determined by suitable habitat for production and fishing pressures.

4.2.2 Plains Streams

Major streams in the Region present on the plains include the Cache la Poudre, Big Thompson, Little Thompson, St. Vrain, and South Platte Rivers. These slow-moving surface waters are heavily influenced by man's activitities. Gentle stream gradients allow sediments to settle in slow-moving stretches. These slower streams provide less reaeration of the water and alter the suitability of the stream habitat for various species. The hydrologic modifications discussed in Section 4.1 also impose restrictions on the habitat of plains streams.

4.2.2.1 Geology

The geology of the plains area is substantially different than that of the mountainous areas. The surfacial geologic or soil materials of the plains are a result of erosion and deposition of the weathered material which once comprised the Rocky Mountains. Stream beds are largely valley-fill deposits (recent water deposited gravels, silts and clays). Progressing eastward from eastern Larimer County across Weld County, the presence of wind deposited materials is more pronounced. The undifferentiated valley fill deposits support an extensive groundwater basin adjacent to main stream channels. Subsurface flow gradients into or out of the stream channel are dependent upon the season and level of groundwater tables. Since hydrologic modifications began in the 1860's to present day, groundwater tables have been continually rising. Current subsurface recharge from water tables to the Poudre and Big Thompson is estimated to be from 1 to 3 cfs per mile.

Geologic materials underlying the surface deposits are largely sandstones and shales. Many of the shale deposits (Pierre Shale) are highly saline and subsurface recharge waters to the main stream may result in high levels of total dissolved solids (See Interim WQMP Report Nos. 3 and 22).

Plains streams throughout the region characteristically are void of large rocks and boulders. Sedimentation has filled in any areas where pools or riffles may have occurred. Relatively uniform bottom characteristics of silts and clays have significantly reduced the capability for reaeration and thus reduced the ability for some aquatic species to survive and propagate.

4.2.2.2 Channels and Banks

As the streams emerge from the mountain areas many phenomena occur which may alter channel and bank characteristics in the plains areas. Since stream gradients are less, stream velocities are reduced and the energy available to erode and carve channels is significantly lessened. Results are the settling out of sediments to the stream bottom and the covering of larger coarse sands, gravels and rocks which are important to the survival and propagation of much stream life. Warmer ambient air temperatures, shallow wide stream channels, less vegetation to shade channel bottoms and numerous water diversions which reduce total volume of flow from the channel all contribute to increased water temperatures.

Meandering stream character, typical of low velocity streams, is evident throughout the plains areas. It is particularly prominent on the Cache la Poudre from Fort Collins to Greeley, the South Platte throughout Weld County and on the Big Thompson River from Interstate Highway 25 to the confluence with the South Platte River.

Sediments from a variety of sources including agriculture, municipal and industrial discharges and nature, may also add some organic or oxygen demanding materials which, when settled out, may decompose in the absence of oxygen. These anaerobic bottom conditions inhibit the development of desirable stream bottom life.

In general, stream bank materials are relatively easily erodable soils. Stream banks are commonly 1 to 4 feet above a mean stream flow. Although bank materials are not particularly stable, the greatest impacts of stream bank erosion are fluctuation of flow in the river and the extent to which adjacent land uses may cause erosion of at bank materials. In some areas land cultivation or other activities may occur up to the stream bank edge. In other areas, buffer strips may protect stream banks from encroachment by heavy farm equipment or conveyance of surface runoff to the stream.

4.2.2.3 Stream Life

More so than the mountainous areas, the plains streams have undergone significant changes over the last 120 years. Man's influences through adding or deleting water from the stream, and pollution from municipal, industrial and agricultural activities have profoundly affected plains stream life - both beneficially and adversely. It has been reported (Bluestein and Hendricks, 1975) that little study on the aquatic life of either the historic or present biota of the plains portion of the South Platte and tributaries has been completed. Where data was available, it had been prepared for a single purpose and only at specific locations, frequently over different time periods and using different methodologies. Many studies have been qualitative (e.g., only species present by number) rather than quantitative (e.g., density or biomass of each species present) and frequently data is missing regarding seasonal stream flow fluctuations. Both quantitative measurements of stream life present and stream flow data are extremely important in assessing water quality.

Siltation from irrigation return flows and natural precipitation have contributed to degraded bottom conditions. In the past, high suspended solids levels from municipal and industrial discharges have contributed to bottom deposits. With broad scale implementation of secondary or equivalent treatment, this source has been eliminated. In some areas, sediment and silt tend to build up during low flow conditions, but are washed downstream when flows increase during spring runoff. Bottom deposits may vary from 6-12 inches in depth throughout the plains stream segments. Organic oxygen demanding materials in these deposits and the absence of sand and gravels has a profound effect on the numbers of individuals and diversity of desirable aquatic species present (Bluestein and Hendricks, 1975).

More tolerant fish, such as carp and sucker, survive in these heavily impacted plains streams. These fish and their eggs can survive in very low concentrations of dissolved oxygen and other adverse conditions. The reproduction characteristics of these species in comparison to other warm water species, such as bass or crappie, also contributes to their success. These fish eat organic material and the worms and insects which thrive in the soft sediment of these streams.

The warm water plains streams do not always have enough continuous flow so that fish can swim from pool to pool in search of food and suitable spawning areas. Sufficient flow is also required to carry food to fish which do not eat the organisms which live in sediments. This requirement is more critical to fish such as bass and crappie than to rough fish such as carp. Stream flow requirements are extensively discussed in Section 6.4.1 of this report.

4.3 FISHERY RESOURCES

Fishes are only a small part of the aquatic ecosystem, but because of their position on the top of the ecosystem food chain, they can be a valuable and readily observed indicator of the health of the aquatic ecosystem. The aquatic ecosystem is a highly complex system of energy, microorganisms, plants, and animals. The well-being of the ecosystem is dependent upon the presence or absence of certain key physical, chemical, and biological elements and their interactions. The basic nature-governed law of ecosystem development and maintenance is to achieve the largest and most diverse organic structure as possible within the limits set by the available energy and prevailing physical and chemical conditions of the system.

4.3.1 Description of a Fishery

A fishery is actually an aquatic ecosystem with fish at the top of the food chain. In order for fish to survive, an entire food chain must exist. Nearly all food chains begin with primary productes, or green plants which derive energy from the sun. Grazers, or animals which feed on green plants, are next in line in an ecosystem. Other carnivores such as mayfly nymphs feed on these plant eaters. Fish, being at the top of the food chain, feed on almost every form of life that acquires energy from the green plants, including insects, fish eggs, and other fish. Each form of life mentioned above, from the green plants to fish, is a link in the food chain.

Each link in the food chain is necessary to the survival of the total ecosystem. Each form of life has a given set of environmental conditions in which it can survive. These environmental conditions, including water temperature and various constituents of water quality, determine the types and numbers of individual organisms which may exist in the water. Ranges of in-stream concentration of various water quality parameters and water quantity will determine the species and numbers of individuals which may survive. Millions of dollars of private and public funds have been spent by scientists and researchers in an attempt to define limiting environmental constraints to various organisms for developing water quality criteria and standards to protect aquatic biota. The state-of-the-art of such scientific investigation is still in its embryonic stages and will require much refinement as it develops.

Survival limits of an organism may not be so obvious as is the influence of the range of temperature. For example, certain aquatic insects live only in clear, fast-flowing cold water stream habitat. Some of these insects attach themselves to rocks on the bottom and feed on microscopic plants and animals that are carried past by the current. As oxygen breathers, it is imperative for their survival to have the flowing water carry dissolved oxygen to them. If the rock is covered with silt, the organism cannot accomplish these fuctions and it will die. The fertilized egg of a trout, bass, or other fish requires conditions very comparable to those of these insects. Eggs must be in direct contact with oxygen rich water in order to survive. If silt accumulates on the egg, it will suffocate and never hatch.

For any species to remain self-sustaining, it must be able to survive each part of its life cycle. In a complex aquatic environment, this fact is often not recognized. A fish egg must be laid in an environment in which it will survive until it hatches. Fry must be able to survive until they are adults. Thus, both water quality and water quantity become paramount considerations in the perpetuation of a diverse and stable aquatic ecosystem. If water quality varies separately or in conjunction with water quantity in the system, serious adverse effects on the system can occur. For example, should temperature change drastically or available oxygen in the water be reduced or if the water should become laden with silt resulting from some activity in or adjacent to the water body, a link in the life cycle of the ecosystem may be interrupted. This can modify the whole structure, diversity, and numbers of species of the aquatic ecosystem.

The aquatic ecosystem may also be affected through the introduction of new competing organisms. For example, the addition of a new fish species could tend to modify the food chain. This may also affect the ecological relationship occupied by these new organisms if they are more or less tolerant to the environmental conditions than other inhabitants.

4.3.2 Definition of Warm and Cold Water Fisheries

The waters of Larimer and Weld Counties may be broadly classified as "warm" or "cold" in accordance with Colorado Water Quality Law. For purposes of this report, a cold water fishery will be defined simply as one which has the capability to support trout. It is usually characterized by water temperatures which do not exceed 20°C (68°F) for extended periods of time. A warm water fishery is one which may support a wide diversity of species, both native and introduced, including such fishes as bass, crappie, sunfish, and carp. It is usually characterized by water temperatures not normally exceeding 30°C (88°F). It is obvious that water temperatures, quantity, and other environmental conditions may affect the presence of a warm or cold water fishery. Transitional stream segments, lakes, and reservoirs may not clearly meet the definition of a cold or warm water fishery because of seasonal variations in water temperatures or because water quantity in the system may be subject to extreme variation, i.e., controlled by man or nature.

4.3.2.1 Cold Water Fisheries

The cold water lakes and streams in the region are all in Larimer County. The major cold water streams are the Laramie, Cache la Poudre, Big Thompson and Little Thompson Rivers, and their tributaries from the cool shaded mountain valleys onto their emergence on the warmer open plains. There are numerous cold water lakes and reservoirs associated with these streams, including the lakes of Rocky Mountain National Park, Roosevelt National Forest, Lake Estes, and some of the lakes and reservoirs of the foothills. Most of these waters support trout populations. Many of these water bodies must rely on annual fish stocking programs to maintain populations, as environmental conditions may not be conducive to propagation of self-sustaining fisheries. Fishing pressures may also require that stocking occur in heavily used recreation areas.

4.3.2.2 Transitional and Warm Water Fisheries

As the cold water streams flow outward on the plains areas, many changes occur. The shaded, relatively deep rock-lined channels characteristic of the mountain streams become wide, shallow, unshaded, low gradient stream courses. These conditions along with warmer ambient air, increase water temperature, reduce oxygen replinishment, and further modify environmental conditions for aquatic inhabitants.

Reservoirs and streams of the foothills areas are examples of transitional or "cool" water fisheries. The environmental conditions of these water bodies are such that they may support both trout, pike and perch. In fact, such reservoirs as Horsetooth and Carter Lake, may be categorically classified as "cold water", but in reality support some cooler warm water species. The Cache la Poudre River in the transitional segment may seasonally be a cold water fishery when seasonal flow and water temperature permit, but may be a warm water fishery when flows are low and water temperature increases in summer. And, in fact, there may be no fishery seasonally when there is no standing or flowing water in the stream bed, due to intensive water management practices.

The warm water bodies of the plains areas support different species than the cold waters of the mountains. Trout are replaced by crappie, sunfish, bluegills, carp, suckers, and a number of forage fish not present in the cooler waters. These fishes are more suited to the higher temperatures, lower dissolved oxygen levels of the slow-moving warm plains waters. They may also be capable of withstanding a wider range of other environmental factors which affect survival and propagation, including other natural physical stream characteristics (discussed in Section 4.3.2) and man-induced changes, such as water management practices which reduce water quantity and point and non-point pollutant discharges which affect water quality.

4.3.3 Historical Fisheries

The historical distribution of fish species in all of the South Platte River Basin and particularly Larimer and Weld Counties has not been well documented. Incomplete investigations of hydrology and biota beginning as far back as 1891 confirm the status of the South Platte River and its tributaries as streams which are subject to major flow variation with resulting effects on stream temperatures and bottom conditions. The South Platte River and its tributaries are relatively void of many species present in other portions of the Missouri River Basin because of water quantity and other ecological barriers which may not have permitted the introduction and propagation of certain species indigenous to other portions of the Missouri River Basin. The amount and variety of habitats may be directly related to the quantity and timely distribution of water in the basin. It is logical to assume that in the arid climate of the West that a large system is likely to be more stable than a smaller one. It is also reasonable to assume that before extensive water resource development, including transmountain and transbasin diversion, storage and timely regulation, the South Platte "was probably torrential during spring runoff and virtually stagnant and intermittent during late summer" (Li, 1968).

A Colorado State University Masters Thesis by Hiram Li entitled, The Fishes of the South Platte River Basin, contains a literature review which focuses on historic observations of fish inhabiting portions of the South Platte. Li refers to observations on the hydrology of the Platte river system by early explorer V. F. Hayden, who, in 1809 stated that, "in autumn nearly all smaller streams will dry up entirely and in several seasons the Platte has been known to become so low as to have no continuous flow."

Several newsletters and magazines dating back as far as the 1870's have referenced sportsmen allegedly catching trout on the lower portions of the Cache la Poudre River. One author in an 1878 issue of Forest & Stream referred to the Poudre as "the trout stream par excellance in all of Northern Colorado" and indicated some 100 miles of fishable waters. It is not clear that the author had intended to convey that trout were present in these waters on a year-round basis or that trout fishing waters extended from the headwaters to the confluence with the South Platte River only seasonally. Readers of these antiquated and sometimes hazey accounts of sportsmen and writers are left to speculate the actual presence of trout in the plains portion of streams in the region.

Of the fishes reported to have which inhabited the South Platte River Basin, only one trout species has been found to be native to the basin. This is the greenback cutthroat (Salmo clarkii stomias). All others have been introduced either by avid sportsmen attempting to create new fisheries or by the Colorado Division of Wildlife in their statutory charge of fisheries management. All of the common trout species such as the rainbow, cutthroat, brown trout and brook trout are introduced species. Some, because of their habitat requirements and excessive recreational fishing pressures, do not reproduce at self-sustaining levels in prevailing environmental conditions in the streams of the region. The only way of sustaining population levels is through periodic stocking.

As previously mentioned, when the white man came to Colorado, the greenback cutthroat was the only classic game fish found in the South Platte and Arkansas River Basin. Permanent habitat, however, did not extend much beyond the foothills region. According to Behnke and Zarn (1976), a drastic decline in native greenback cutthroat populations occurred through a change in stream conditions resulting from development of irrigation diversions, mining, grazing, logging, other land uses, and introduction of non-native trout species. Because of the adverse conditions, which hamper the existence of this trout species, there is circumstantial evidence to support a theory that the greenback cutthroat is the most susceptible of all western trouts to extinction.

Due to its extreme rareness, the greenback cutthroat has been listed as an endangered species by the U.S. Department of Interior under P.L. 93-205, the Endangered Species Act of 1973.

There have been several attempts over the years to reintroduce the species to headwaters of the Big Thompson River in Rocky Mountain National Park (N.P.S., 1976) and Black Hollow Creek, a tributary to the Cache la Poudre River (Behnke and Zarn, 1976). The limiting factor in reintroduction appears to be competition with other introduced fish species, to the disadvantage of the greenback cutthroat. Reintroduction is also hampered by the federal statutory status of the greenback cutthroat. As an "endangered" species, any waters which would be restocked with the species would require closing to angling. And since all waters which would be suitable for restocking are currently open to fishing, public agencies have been somewhat reluctant to approach the problem. Additionally, in order to accomplish a restoration effort, eradication of other competing species has been the prevalent technique employed, also drawing criticism.

Numerous cold and warm water fishes have been introduced to the streams of the Larimer-Weld Region. Table 4.3.3-A shows the native and introduced species in the region as revealed by a literature search and interviews with key fisheries people familiar with waters of the region. Column (1) denotes generally whether the species is an inhabitant of cold or warm water; column (2) indicates whether the species is native or introduced to streams in the region.

4.3.4 Existing Fisheries

As mentioned in previous sections, the hydrology, species composition and pollution to the natural stream and lakes of the region have been substantially changed by man's influence. The augmentation, storage, release and diversion of waters in the Region has had positive effects as well as negative effects on the system. The construction of storage reservoirs has provided new habitat for fisheries and created new recreational opportunities. The foothills and plains areas are dotted with man-made reservoirs which support a wide variety of cold and warm water fishes. Release and diversion of stored waters has modified fisheries habitat and created the potential for regulating flows in the Cache la Poudre and Big Thompson Rivers.

For the most part, criticism has been placed on the Colorado State Engineer's Office for regulation of river flows to the disadvantage of the survival of fishes. In placing calls upon legally appropriated water in the system, the water commissioner will divert water to satisfy downstream users, frequently drying up the stream beds temporarily. This practice quite obviously affects the fishery. There is, however, another perspective to the influence of changes to the hydrologic system to the advantage of supporting fisheries where because of prevailing natural climatic, topographic and geologic conditions only limited fisheries existed before. This is primarily the case in the foothills and plains areas of the region. The introduction of new western slope waters to the natural hydrologic

TABLE 4.3.3-A

FISHES OF THE SOUTH PLATTE RIVER BASIN
LARIMER-WELD REGION*

COMMON NAME	SCIENTIFIC NAME	(1) GENERAL HABITAT	(2) NATIVE INTRODUCED	(3) NORMALLY G-TAKEN FOR FOOD B-CDW BAG LIMIT	(4) COMMENTS
Gizzard Shad	Dorosoma cepedianum	W	I	G,B	Abundant in Boyd Lake
Coho/Silver Salmon	Oncorhynchus kisutch	C	I	G,B	
Sockeye Salmon/Kokanee	Oncorhynchus nerka	C	I	G,B	
Mountain Whitefish	Prosopium williamsoni	C	I	G,B	Native to Colorado, introduced in limited areas of the Upper Poudre River
Cutthroad Trout	Salmo clarki	C	I	G,B	Introduced Hybrids
Greenback Cutthroat Trout	Salmo clarki stomias	C	N	G,B	Native, but reintroduced into Rocky Mountain National Park and limited areas. Endangered.
Rainbow Trout	Salmo gairdneri	C	I	G,B	
Brown Trout	Salmo trutta	C	I	G,B	
Brook Trout	Salvelinus fontinalis	C	I	G,B	
Lake Trout/Mackinaw	Salvelinus namaycus	C	I	G,B	Selected reservoirs in Region

*Key to Species List provides information on code entries for columns (1)-(4).
Species list compiled from Bluestein and Hendricks, 1975; Li 1968; Colorado Division of Wildlife, 1977; R. Behnke, 1977, Colorado State University, Department of Zoology.

TABLE 4.3.3-A
FISHES OF THE SOUTH PLATTE RIVER BASIN
LARIMER-WELD REGION* (CONT.)

COMMON NAME	SCIENTIFIC NAME	(1) GENERAL HABITAT	(2) NATIVE INTRODUCED	(3) NORMALLY G-TAKEN FOR FOOD B-CDW BAG LIMIT	(4) COMMENTS
Splake	Brook trout x Lake trout hybrid	C	I	G	
Artic Grayling	Thymallus arcticus	C	I	G	
Northern Pike	Esox lucius	C	I	G,B	
Stoneroller	Campostoma anamalum	W	N		
Lake Chub	Couesius plumbeus	W	N		Not known since 1903
Carp	Cyprinus carpio	W	I		Commonly taken for sport with bow and arrow
Brassy Minnow	Hybognathus hankinsoni	W	N		
Plains Minnow, Northern	Hybognathus placitus placitus	W	N		Presence today doubtful
Golden Shiner, Western	Notemigonus crysoleucas auratus	W	I		
Common Shiner, Northern	Notropis cornulus frontalis	W	I		
River Shiner	Notropis blennius	W	N		
Big Mouth Shiner	Notropis dorsalis	W	N		
Red Shiner, Plains	Notropis lutrensis lutrensis	W	N		
Blacknose Shiner	Notropis heterdepis	W	N		
Northern Redbelly Dace	Phoxinus eos	W	N		Not known since 1903

TABLE 4.3.3-A

FISHES OF THE SOUTH PLATTE RIVER BASIN
LARIMER-WELD REGION* (CONT.)

COMMON NAME	SCIENTIFIC NAME	(1) GENERAL HABITAT	(2) NATIVE INTRODUCED	(3) NORMALLY G-TAKEN FOR FOOD B-CDW BAG LIMIT	(4) COMMENTS
Fathead Minnow	Pimephales promelas	W	N		
Longnose Dace	Rhinichtys catacractae	W	N		
Suckemouth Minnow	Phanacebius mirabilis	W			
Creek Chub, Northern	Semotilus atromaculatus atromaculatus	W	N		
Longnose Sucker, Western	Catostomus catostomus griseus	W	N		
White Sucker, Western	Catostomus commersoni suckley	W	N		
Black Bullhead	Ictalurus melas	W	N	G,B	
Brown Bullhead, Northern	Ictalurus nebulosus nebulosus	W	I	G,B	
Channel Catfish	Ictalurus punctatus	W	N/I	G,B	Reintroduced
Plains Killifish	Fundulus kansae	W	N		
Plains Topminnow	Fundulus sciadicus	W	N		
Mosquito Fish/Western Gambusia	Gambusia affinis affinis	W	I		
Sacramento Perch	Archoplites interruptus	W	I	G	
Green Sunfish	Lepomis cyanellus	W	I	G	
Pumpkinseed	Lepomis gibbosus	W	I	G	

TABLE 4.3.3-A

FISHES OF THE SOUTH PLATTE RIVER BASIN
LARIMER-WELD REGION* (CONT.)

COMMON NAME	SCIENTIFIC NAME	(1) GENERAL HABITAT	(2) NATIVE INTRODUCED	(3) NORMALLY G-TAKEN FOR FOOD B-CDW BAG LIMIT	(4) COMMENTS
Orange Spotted Sunfish	Lepomis humilis	W	N		
Smallmouth Bass, Northern	Micropterus dolomieui dolomieui	W	I	G,B	Common in Horsetooth Reservoir
Largemouth Bass, Northern	Micropterus salmoides salmoides	W	I	G,B	
White Crappie	Pomoxis annularis	W	I	G,B	
Black Crappie	Pomoxis nigromaculatus	W	I	G,B	
Iowa Darter	Etheostoma exile	W	I		
Orangethroat Darter	Etheostoma spectabile	W	N		Endangered
Johnny Darter, Central	Etheostoma nigrum nigrum	W	N		Endangered
Yellow Perch	Perca flavescens	W	I	G,B	
Walleye	Stizostedion vitreum vitreum	W	I	G,B	
Freshwater Drum	Aplodinotus grunniens	W	I	G,B	
Log Perch	Percina capredes	W	I		
Brook Stockleback	Culea inconstans	W	I		

TABLE 4.3.3-A (cont.)

KEY TO SPECIES LIST
FISHES OF THE SOUTH PLATTE RIVER BASIN
LARIMER-WELD REGION

COLUMN	EXPLANATION FOR CODING
(1)	C - Cold water - temperatures not normally exceeding 20°C W - Warm water - temperatures not normally exceeding 30°C
(2)	N - Native I - Introduced
(3)	G - Game and Food. Species most commonly taken by conventional angling means for food, including, but not limited to, any of the various fishes made a legal catch by specific state legislation. B - Species for which 1977 Colorado fishing regulations establish a bag or possession limit. The classification of fishes into one of the above categories does not preclude the value of such fishes as "sport fish." Where a sport fish may include numerous species taken for consumptive use, or otherwise enjoyed in a recreational experience. Colorado State Statute defines sport fish in 1973 CRS 33-1-102(35). "Sport fish means all species of trout, char, grayling, salmon, walleye, northern pike, bass, crappie, bluegill, whitefish, catfish, perch, sunfish, drum, carp, sucker, shad, minnow and such other species of fish that may be introduced or transplanted into this state for fishing or angling or are classified as sport fish by the Commission". (Colorado Wildlife Commission)

system from the Colorado-Big Thompson project and storage of water in mountain and foothills reservoirs has greatly increased the overall amount of water available for longer periods of time and, in fact, enlarged and enhanced aquatic habitat and the fisheries resource. Both surface and groundwater resources have been substantially increased through man's actions.

Before and during the period of water resource development in the region, man was experimenting with the introduction of various fish species in the lakes, reservoirs and streams. The number of introduced species previously referred to in Table 4.3.3-A are evidence of this effort. Along with the more desireable cold water fishes, such as trout, man has introduced warm water species which according to some sportsmen are less desireable. Among these less desirable species are the carp, bullhead and various species of shiners. The fishes are able to survive under a wider range of environmental conditions and, therefore, flourish at the expense of sometimes more desireable species. There are many more warm water species of fish than cold water species present in plains reaches of streams in the region.

In November, 1976, the Larimer-Weld Council of Governments sponsored a meeting with fisheries biologists, hydrologists, water quality specialists and engineers from Colorado State University, Colorado Division of Wildlife and the Colorado State Engineers Office to assess the fisheries resource and water pollution problems for streams in the region (see minutes of November 17, 1976, fisheries meeting, Appendix B).

Of principal concern to the participants was the extent to which water quantity and related pollution discharges entering an often dry stream bed had upon the aquatic ecosystem. Discussion on the Cache la Poudre River system centered on the idea that flow augmentation during critical portions of the year would be preferred to expensive treatment processes for municipal discharges. One participant noted that the goal of "fishable and swimable" waters as prescribed by Public Law 92-500 for the entire stretch of a stream is out the social equilibrium of the system. The law was not made for Western streams.

It was also noted that additional water storage on the Upper Cache la Poudre may be a means of providing timely flow augmentation during critical periods for fisheries survival and would offer greater flexibility in operation of the diversion and water exchanges on the river. This alternative of course would require additional water resource development in the form of high mountain reservoirs.

Colorado State University has been conducting a program for the past several years of identifying fish in the lower Poudre River. Twenty-eight species of fish have been identified in the Cache la Poudre River between Fort Collins and Greeley (Post, 1976). Data compiled on the Cache la Poudre River by Dr. S.A. Morrison and Dr. George Post of Colorado State University Department of Microbiology is summarized in Tables 4.3.3-B and 4.3.3-C. Six sampling points on the river covering the river from above Martinez Park at Fort Collins to near the confluence with the South Platte at Greeley (Weld County Road #31) were selected. These sampling sites are indicated in Figure 4.3.3-A.

The primary objective of the sampling program carried out from April, 1970 through November, 1975, was to identify fish species and physical and chemical water quality in the river below major municipal and industrial discharges in the river. The initial sampling design was altered in November, 1972 to reflect collected samples of species by total percent biomass of collection rather than just average length of fish. It was thought that this measure was more meaningful in comparison of data between sample points in terms of the most prevalent species by total weight of samples. Another sampling point was added to the study in 1974 when questions arose regarding the species composition before municipal or industrial point source discharges entered the river.

The summary data from Table 4.3.3-B indicates that even before major discharges of pollutants above Fort Collins are introduced to the river, species composition by weight is nearly 87 percent rough fish and only 11.2 percent game fish and 1.2 percent forage fish. While data exists for only a limited period of 1-1/2 years, it may still be reasonably concluded that the samples are representative of species present resulting from water quantity effects on the hydrologic and biotic systems.

According to the Colorado Division of Wildlife, comprehensive fisheries sampling programs for the lower South Platte, Big Thompson and Little Thompson Rivers have not been conducted. The effects of stream dewatering, physical stream characteristics and effects of pollution discharges upon these streams are generally similar to that of the Cache la Poudre. And it is reasonable to assume that fish species composition in these lower stream segments would be somewhat comparable. This position is reinforced by the Colorado Division of Wildlife's limited fisheries management strategies for these areas.

Suckers, carp, and shiner minnows are commonly found in the warm water streams. Dr. George Post reports that nearly 99 percent of the biomass (by weight) in the Cache la Poudre between Fort Collins and Greeley were rough fish such as these. These same species, along with catfish, bluegill, bass, crappie perch, pike, and many others also inhabit the reservoirs of the region.

Rough fish such as suckers, carp and shiners thrive in bodies of water which will not support some of the more desireable warm water

TABLE 4.3.3-B SUMMARY DATA FOR TABLE 4.3.3-C

Station	Control[1]	1[2]	1A[2]	2[2]	3[2]	3A[2]
Rough	86.9	98.6	98.4	97.4	88.2	94.3
Game	11.2	.4	.6	.2	1.4	1.1
Forage	1.9	1.0	1.0	2.4	10.4	4.6
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0

1 - Data gathered for period August, 1974 - November, 1975

2 - Data gathered for period November, 1972 - November, 1975

Fish Site Identification:

Station Clean Control: Upstream part of Martinez Park on Fort Collins City Property.

Station 1: Above Fort Collins #2 Sewage Treatment Plant.

Station 1A: Directly west of rest area on west side of I-25.

Station 2: Above, under and below State Highway 392 bridge.

Station 3: Approximately 3/4 mile below Kodak, Windsor plant, under and below wooden bridge.

Station 3A: 1/4 mile above bridge on Weld County Road 31, directly west of the David Rodeo Arena.

TABLE 4.3.3-C

FISH SURVEYS, 1970-1975, CACHE LA POUDRE RIVER.

Station Clean Control: Upstream part of Martinez Park on Fort Collins City Property.

Part B. August, 1974 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collection	Average % Biomass per Collection
*Brown trout	5	2	4.7
*Rainbow trout	5	1	3.8
White sucker	5	97	78.7
Longnose sucker	5	406	7.2
*Yellow perch	5	<1	tr.
Johnny darter	5	7	tr.
Longnose dace	5	70	1.7
Creek chub	5	6	0.4
*Pumpkinseed sunfish	5	<1	tr.
*Green sunfish	5	3	tr.
*Largemouth bass	5	<1	tr.
*Black bullhead	5	<1	0.4
Fathead minnow	5	132	0.4
Sand shiner	5	<1	tr.
Common shiner	5	<1	tr.
Plains topminnow	5	15	tr.
*Whitefish	5	<1	2.7

*Denotes game fishes

Extracted from Morrison, 1978, Surveillance Data, Plains Segment of the Cache la Poudre River, Colorado 1970-1977. Colorado Water Resources Research Institute, Information Series No. 25. Environmental Resources Center. Colorado State University, Fort Collins, Colorado.

TABLE 4.3.3-C (cont.)

Station 1:[1] Above Fort Collins #2 Sewage Disposal Plant

Part A. April, 1970 -- August, 1972

Fish Species	Number of Collections	Average Number Per Collection	Average Length in Inches
Carp	8	37	15.4
Longnose dace	8	62	2.0
White sucker	8	117	5.6
Fathead minnow	8	303	1.9
Sand shiner	8	165	2.5
Johnny darter	8	2	2.2
Creek chub	8	1	3.9
*Green sunfish	8	25	2.3
Longnose sucker	8	27	4.7
Common shiner	8	7	2.8
*Largemouth bass	8	3	2.6
*Bluegill sunfish	8	<1	2.2
*Mountain whitefish	8	<1	5.6
Plains killifish	8	<1	2.5
*Black bass	8	<1	2.8

Part B.[1] November, 1972 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collection	Average % Biomass Per Collection
Carp	10	54	64.7
White sucker	10	227	32.3
Longnose sucker	10	16	1.6
Fathead minnow	10	52	0.4
Sand shiner	10	35	0.2
*Green sunfish	10	16	0.3
*Rainbow trout	10	<1	0.1
Longnose dace	10	10	0.3
Creek chub	10	1	tr.
Common shiner	10	<1	tr.
Plains killifish	10	<1	tr.
Johnny darter	10	<1	tr.
*Bluegill sunfish	10	<1	tr.

*Denotes game fishes

(1)Part A data by fish species and size; Part B data by fish species, number and biomass.

TABLE 4.3.3-C (cont.)

Station 1A: Directly west of rest area on west side of I-25.

Part B. November, 1972 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collection	Average % Biomass Per Collection
Carp	10	28	35.8
White sucker	10	387	61.1
Longnose sucker	10	17	1.5
Fathead minnow	10	147	0.3
Sand shiner	10	81	0.2
Longnose dace	10	47	0.5
*Green sunfish	10	4	tr.
*Largemouth base	10	<1	tr.
Johnny darter	10	<1	tr.
Plains killifish	10	<1	tr.
Common shiner	10	<1	tr.
Creek chub	10	1	tr.
*Black bullhead	10	<1	tr.
*Yellow perch	10	<1	tr.
Brassy minnow	10	<1	tr.
Common shiner	10	<1	tr.

*Denotes game fishes

TABLE 4.3.3-C (cont.)

Station 2: Above, under and below Highway Number 392 bridge.

Part A. April, 1970 -- August, 1972

Fish Species	Number of Collections	Average Number Per Collection	Average Length in Inches
Carp	8	22	11.8
White sucker	8	245	8.3
Fathead minnow	8	57	2.2
Sand shiner	8	183	2.3
Common shiner	8	38	3.4
Creek chub	8	10	4.1
Longnose dace	8	43	2.4
Johnny darter	8	13	2.3
Longnose sucker	8	4	7.7
Brassy minnow	8	16	2.9
*Black bass	8	<1	2.7
*Pumpkinseed sunfish	8	<1	4.0
*Green sunfish	8	14	2.5
Plains killifish	8	5	2.2
*Black bullhead	8	<1	4.5
*Largemouth bass	8	<1	4.3

Part B. November, 1972 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collection	Average % Biomass Per Collection
Carp	10	38	30.2
White sucker	10	364	64.8
Longnose sucker	10	16	2.3
Creek chub	10	5	0.1
Sand shiner	10	163	1.1
*Green sunfish	10	21	0.2
*Black crappie	10	<1	tr.
Longnose dace	10	67	0.5
Fathead minnow	10	88	0.4
Johnny darter	10	12	tr.
Plains killifish	10	1	tr.
Brassy minnow	10	1	tr.
*Largemouth bass	10	<1	tr.
Common shiner	10	8	0.3
*Bluegill sunfish	10	<1	tr.
*Yellow perch	10	<1	tr.
Plains topminnow	10	<1	tr.

*Denotes game fishes

TABLE 4.3.3-C (cont.)

Station 3: Approximately three-fourths mile below Kodak, Windsor plant, under and below wooden bridge.

Part A. April, 1970 -- August, 1972

Fish Species	Number of Collections	Average Number Per Collection	Average Length in Inches
Carp	8	13	9.6
Longnose dace	8	47	2.6
White sucker	8	146	6.1
Fathead minnow	8	133	2.1
Sand shiner	8	497	2.1
Common shiner	8	197	3.1
Johnny darter	8	8	1.6
*Green sunfish	8	11	3.3
*Pumpkinseed sunfish	8	<1	5.0
Creek chub	8	3	5.6
*Largemouth bass	8	<1	3.4
Plains killifish	8	<1	2.0
Longnose sucker	8	<1	3.2
*Black bass	8	<1	5.2
Brassy minnow	8	<1	2.5
*Bluegill sunfish	8	<1	4.5
*Black bullhead	8	<1	8.8

Part B. November, 1972 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collections	Average % Biomass Per Collection
Carp	10	23	33.5
White sucker	10	386	53.6
Sand shiner	10	964	7.6
Common shiner	10	30	0.8
Fathead minnow	10	89	1.5
Creek chub	10	11	1.0
Longnose dace	10	20	0.4
*Green sunfish	10	8	1.2
Brook stickelback	10	2	tr.
Longnose sucker	10	1	0.1
*Black crappie	10	<1	tr.
Brassy minnow	10	2	tr.
*Bluegill sunfish	10	<1	tr.
Johnny darter	10	<1	tr.
Plains killifish	10	<1	tr.
*Yellow perch	10	<1	tr.
*Black bullhead	10	<1	tr.
Red shiner	10	<1	tr.
*Largemouth bass	10	<1	0.2

*Denotes game fishes

TABLE 4.3.3-C (cont.)

Station 3A: One-fourth mile above bridge on Weld County RD-31, directly west of the Davis Rodeo Arena.

Part B. November, 1972 -- November, 1975

Fish Species	Number of Collections	Average Number Per Collection	Average % Biomass Per Collection
White sucker	10	180	38.8
Carp	10	71	55.5
*Green sunfish	10	11	0.7
Sand shiner	10	373	3.4
Fathead minnow	10	82	0.5
Plains killifish	10	2	tr.
Longnose sucker	10	<1	tr.
*Black bullhead	10	<1	tr.
Longnose dace	10	1	tr.
Johnny darter	10	<1	tr.
Creek chub	10	6	0.4
Common shiner	10	15	0.3
*Rainbow trout	10	<1	0.4
*Yellow perch	10	<1	tr.
*Largemouth bass	10	<1	tr.
Brassy minnow	10	2	tr.
Red shiner	10	<1	tr.

*Denotes game fishes

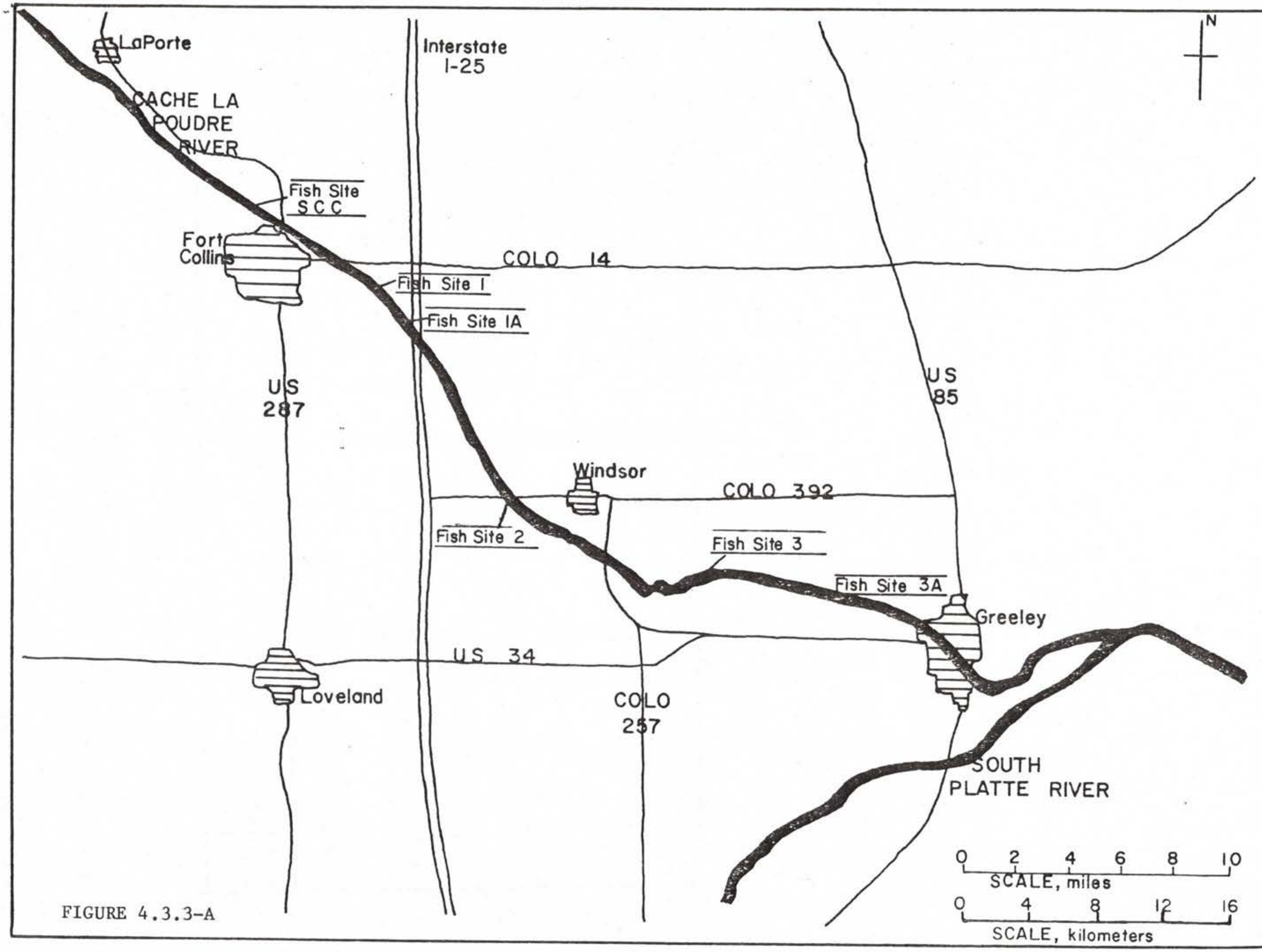


FIGURE 4.3.3-A

*Extracted from Morrison 1978 with modifications.

sport fish such as bass and crappie. One of the reasons rough fish outcompete these other fish is that they may lay as many as two to four times as many eggs as do bass or crappie. For example, a sucker lays approximately one million eggs, as opposed to a bass which lays about 250,000 eggs. Also, the rough fish are capable of living in a wider range of quality water than are bass or crappie, and are more tolerant to fluctuating pollution conditions.

4.3.5 Seasonal Distribution of Fishes

Claims of catching cold water fish species such as brown or rainbow trout in areas normally considered warm water habitat have been made in the past. These reports have been primarily restricted to lower portions of the Cache la Poudre and Big Thompson Rivers, and most are recalled in the minds of long-time residents of the area. No written records regarding these catches have been reported. Some cold water fish species have also been found even recently in plains irrigation ditches where fish have apparently entered from upstream diversion waters. It may be speculated that these fish in streams or irrigation ditches have occurred here only on a migratory seasonal basis (high flow conditions) and are not present because these areas are natural habitat conducive to year around survival or propagation either due to past or present water quality or water quantity. Confirmation of such reports and conclusions is a topic of further study.

4.4 WATER BASED RECREATION

The Larimer-Weld Region provides a wide diversity of passive and active recreation opportunities. Private, state and federal lands are available for many types of recreation, many of which are oriented on or adjacent to water bodies. This area serves as a recreation resource for local residents and numerous visitors outside the Region and the State.

Although the Larimer-Weld Region has about 6.3 percent of the total population of the South Platte River Basin in Colorado and Wyoming, it contains 25.4 percent of the water recreation acres and 33.3 percent of the general recreation lands. In contrast, Denver County has roughly 30 percent of the population of the South Platte River Basin and only 1.0 percent of the water recreation acres and 0.2 percent of the recreation lands (BOR,1976).

4.4.1 Recreation Distribution

Few authoritative, comprehensive recreational studies on total water recreation user activities are available for both public and private lands in the region. It is reasonable to assume, however, that a greater portion of water based recreation occurs in the mountains, foothills and western plains areas on tributaries of the South

Platte rather than on the plains and main stream South Platte. Several factors have influenced this historic trend. First, more access is available in the mountain and foothills areas because of more publically owned lands; second, for many persons the landscape diversity, vegetation and wildlife of the mountain and foothills zones are more aesthetically appealing than the plains areas; third, these areas provide a greater opportunity for catching cold water fish species (trout) than do the warmer plains waters. For some, the quality of the recreational experience of angling for a cold water fish surpasses that of angling for a warm water species. Recreation user data compiled by State and Federal agencies confirms these current use characteristics. However, changing value preferences for recreation may alter historic trends.

The plains portion of the streams in the region are valued more for the activities which may occur adjacent to or on the water rather than in them. Significant attempts at providing public access to water bodies, particularly reservoirs, in the plains area have been made. However, much land is owned by farmers and ranchers who are reluctant to permit public access because of historical accounts of vandalism and general lack of respect for fences, livestock and farm equipment. Recreation and wildlife value of the plains is still quite high. The principle use of the plains streams and adjacent riparian vegetation are as wildlife habitat for migratory and upland bird populations (Bluestein, 1975). No reports or studies which have been completed to date have shown high recreational use or significant demand for the main stream of the South Platte in Weld County. The U.S. Bureau of Outdoor Recreation (now the Heritage and Conservation Trust), however, has recently completed a draft preliminary feasibility study for designation of the South Platte River from Chatfield Reservoir to the Weld County/Morgan County line as a National Urban Riverway (BOR, 1977). Such designation would require an Act of Congress and considerable additional study and funding.

4.4.2 Recreational Fisheries and Recreation Use Characteristics

In view of the natural and man-made conditions and influence on the hydrologic system in the Larimer-Weld Region, the Colorado Division of Wildlife has concentrated its fisheries management efforts on improving and enhancing aquatic habitat in geographic areas where it could maximize benefits for recreational experiences at least cost (Nittman, 1977). Recreational demand or the value of a fishing area is measured in terms of angler days. Historically, the greatest public demand, and therefore the majority of funding, has been for cold water type fishing. Fish stocking programs and habitat improvement have been concentrated in streams, lakes and reservoirs of the mountains and foothills. Lesser attention has been given to the plains areas although plains reservoirs are receiving more attention in recent years. Management efforts have not been encouraged in areas of marginal habitat or where water quality, water quantity, low recreation demand, limited public access problems are present.

4.4.2.1 Cache la Poudre River

From the source of the Cache la Poudre River to the confluence with the North Fork of the Cache la Poudre River nine miles northwest of Fort Collins, there are over 25 public campgrounds, picnic areas and rest stops. Most are operated by the U.S. Forest Service. In addition, there are numerous private homes, resorts and trailer parks on either side of the river. Most land ownership in this area is federal with the exception of interspersed private lands running the length of Joe Wright Creek and the Cache la Poudre along the main stream course. The largest concentration of privately owned lands is near Elephant Mountain, Kinnikinnick, and from Idylwild and on the South Fork of the Cache la Poudre, and from south of Tom Bennett Campground along Forest Road No. 145 and No. 131 to the Bennett Creek picnic ground.

The U.S. Forest Service is currently studying the Cache la Poudre River and the South Fork of the Cache la Poudre for designation as a Wild and Scenic River under Section 2 of Public Law 90-542. All or portions of the river may receive designation status in one of three management categories. The Wild and Scenic River study area for the Cache la Poudre encompasses an area one-half mile wide along the main stream Cache la Poudre from its source at Poudre Lake in Rocky Mountain National Park to the eastern boundary of the Roosevelt National Forest northwest of Fort Collins (65 miles of running stream), about 4 miles west of Ted's Place on Highway 14; and the South Fork of the Cache la Poudre River from its source in Rocky Mountain National Park near Icefield Pass to the confluence with the main Poudre near Egger (23 miles of running stream).

The Cache la Poudre River from its source to the Greeley Water Filtration Plant is managed as a cold water fishery by the Colorado Division of Wildlife. Annual fish stocking programs include stocking of over 6,000 pounds of rainbow trout in the river. Included in this area are several stretches of Wild Trout Waters. These Wild Trout Waters are not stocked. Reproduction is natural and angling is permitted only with artificial flies and lures. One such area is located on the Upper Poudre 4 miles west of Rustic and extends upstream for approximately 2-1/2 miles. There are no apparent fisheries management problems in this area resulting from water quality or water quantity impacts of man's use of the river or adjacent lands.

A second area of Wild Trout Waters extends from above the Monroe Gravity Canal (North Poudre Supply Canal) at the mouth of the canyon to the diversion structure for the Greeley Water Filtration Plant. Some water quality and water quantity problems have arisen in the past resulting from drying up of the river at the Monroe Gravity Canal for irrigation purposes and from sediment discharges from the City of Greeley's Seaman Reservoir on the North Fork of the Poudre;

and to some extent from discharges from the Fort Collins Water Filtration Plant. These activities have all reportedly resulted in fish mortality downstream. Currently, management efforts to control water quality and water quantity problems, for the most part, are based on voluntary actions by the City of Greeley, the Poudre River Water Commissioner, and a State-issued waste treatment discharge permit (NPDES) to the City of Fort Collins for their water filtration plant operations.

Downstream from the Greeley Water Filtration Plant, the Colorado Division of Wildlife does not stock the Poudre River. Primary consideration, in addition to municipal and industrical discharges, for not stocking in these areas is lack of public access to private lands, and water quality and water quantity problems resulting from diversion of instream waters for irrigation purposes. In addition to the Monroe Gravity Canal, there are ten other diversions which may completely exhaust flow in the river beginning in May and extending through the summer.

The Poudre River through the City of Fort Collins is receiving increased use as a recreational stream. Recreational trail development proposed by Larimer County and the City of Fort Collins will increase access to the river at various locations and place new demands on the river and adjacent riparian stream sides. The City of Fort Collins is proposing a recreational trail from Taft Hill Road in the north, along the river, to East Prospect Street in the south and possibly one mile further south to the Colorado State University, Northern Colorado Nature Center near Fort Collins Waste Treatment Plant No. 2 at Drake Road. Implementation of the proposal is being carried out under a six year Capital Improvements Program sponsored by the City of Fort Collins, and in areas under county jurisdiction through the proposed Open Space Plan for Larimer County. The first phase of trail development will be from North Shields Street to College Avenue. Secondary contact recreation (wading) is proposed as far down as College Avenue. Canoeing and limited tubing occurs in the river all the way to the CSU Nature Center and canoeing is further to continue as far as the rest stop at Interstate 25.

The City recognizes that physical barriers along the river, including irrigation diversion structures and outlets, will seasonally require short portages for canoeists and tubing recreationists.

No in-stream fishing activities are proposed below Martinez Park at College Avenue. However, there is some discussion of fisheries development in gravel pits along the Poudre River adjacent to Flat Iron Paving Company.

Additional proposals have been made in the Southeast Greenbelt/ Open Space Study prepared for the City by Jan W. Maas (1975). Within this study area, Colorado State Highway 14 to Larimer County Road 40, several alternatives have been developed. Among the various alternatives are proposals for a river sport fishery. The proposal was developed in conjunction with Dr. Robert J. Behnke and Charles Prewitt, Department of Fisheries and Wildlife Biology, Colorado State University. The most ambitious alternative examined was to establish a trout fishery from Fort Collins to Interstate 25. This would entail that maximum water temperature not exceed approximately 75 F. (5 mg/l) and the minimum oxygen levels not fall below five parts per million (5ppm). To achieve this level of development, ammonia removal and chlorine residual removal from Fort Collins waste treatment plants and flow augmentation in low flow seasons would be required. Minimum stream flow to maintain the physical and chemical attributes suitable for trout at that time were not accurately predicted, but it was estimated that a flow of approximately 50 cubic feet per second (cfs) would be necessary. Additional recreational fisheries possibilities were was examined for Sterling Ponds, Prospect Ponds, Anderson Pond and proposed ponds to the south. All of these management proposals would require extensive site modification and stabilization to correct disturbed areas and would require stocking and management of fisheries resources by the Colorado Division of Wildlife. For all these proposed fisheries recreation areas, it is anticipated that an increased use in the area would occur through improvement. This would include increased use of riparian vegetation habitat through ecosystem enhancement from flow augmentation, thereby resulting in increased benefits to wildlife. Aesthetics improvement and increased public access would make the areas more desireable for hikers and birdwatchers. The <u>Proposed Larimer County Plan for Open Space and Outdoor Recreation</u> addresses areas along the Cache la Poudre River below Fort Collins CSU Nature Center which would be incorporated into a trail system serving the Fort Collins and Larimer County residents. Specific needs would include negotiation for trail rights-of-way and establishment of natural park areas along the Poudre River south of the Strauss Cabin to the confluence of Fossil Creek and establishment of rights-of-way and natural park areas along the Poudre River north of Fort Collins to LaPorte. No other activities are expected in the way of development of open space or trails south of the Strauss Cabin to the Weld County line.

The Cache la Poudre through Weld County to its confluence with the South Platte at Greeley, has not been viewed as a high demand recreational stream for many years. Limited public access, adverse water quantity and quality conditions suitable for self-perpetuating warm water fisheries has resulted in limited recreational use. The <u>Larimer-Weld Open Space Guideline</u> recommends eventual extension of the Poudre River trail in the Fort Collins area all the way to Greeley. This trail would provide a relatively long plains type nature trail for non-motorized use. At present, the City of Greeley and Weld County do not envision financial participation in trail development as other areas have received higher priority. Some interest, however, has been expressed for upgrading ponds created by gravel extraction activities in the Greeley area. Included in the effort would be feasibility studies for development of these ponds into warm water recreational fisheries and development of adjacent land area into parks.

4.4.3 Big Thompson River

From its source to Lake Estes, the Big Thompson River and tributaries are closely-managed recreational fisheries. Excellent public access on federally-owned lands in Rocky Mountain National Park and Roosevelt National Forest affords considerable recreational demand on this section of the stream. Lake Estes is a high recreation demand area. Over 11,000 pounds of rainbow trout are stocked annually. Some recreational water skiing also occurs on the lake during the relatively short summer season.

From below Lake Estes to the mouth of the Canyon (Handy Supply Ditch Diversion), historically over 6000 pounds of rainbow trout are stocked each year in this 18.9 mile stretch (Nittman, 1978). Stocking of this area has been temporarily halted due to the devasting effects during the Big Thompson flood of July 31 - August 1, 1976. At that time, over 90% of the fish population in the river was lost. No attempts to reestablish new populations have been made to date because of the reconstruction activities on the river and resulting heavy sediment loads. Reintroduction of fish to the river has initially been estimated not to occur until approximately 1980.

Due to the erratic nature of river flows resulting from diversions to the Handy Supply Ditch, the Colorado Division of Wildlife does not stock fish downstream from this point. This does not, however, prohibit fish from seasonally migrating downstream in the river channel. Water diverters in the area have also pointed out that they frequently find fish in irrigation canals and ditches and that many fish become stranded in the smaller ditches and die as flows diminish during irrigation application. It is also reported that screening devices have been used in the past to reduce the number of fish in irrigation ditches, however, this technique has not been extensively pursued because of the inconvenience and increased labor to the farmer required to periodically clean the screens of debris.

Water related recreational activities below the Handy Supply Ditch division are not well documented. Fishing in these areas is highly dependent upon adequate flow in the river to permit passage of fish. The lower stretch of the river from the Handy Ditch diversion to below the Loveland Filtration plant is poorly accessible because of private land ownership and steep terrain.

Detailed aquatic biota information on the lower Big Thompson is non-existent. Limited surveys prior to the Big Thompson 1976 flood are sparse and studies which followed the flood have revealed that the event caused much degradation of aquatic habitat and this condition will persist throughout canyon reconstruction activities for some time into the future. In spite of these adverse conditions, some fish have survived. Most likely these inhabitants originally resided in Lake Estes upstream tributaries not severely affected by the flood.

The Proposed Larimer County Open Space Plan has indicated the need to establish a recreational trail from Namaqua Park to the Larimer County fairgrounds. The City of Loveland generally concurs with this need; however, it has placed higher priority on the Boyd Lake area for recreational development action programs. Future development along the Big Thompson from Barnes Ditch to below Loveland is intended to focus on land uses such as trail and picnic areas or secondary contact water recreation such as tubing or rafting. There is considerable interest for development of appropriate cold or warm water fisheries in gravel pits adjacent to the stream course. The greatest problem here is land dedication and access.

4.4.4 Little Thompson River

The Little Thompson River has not been considered a priority recreational fishery by the Colorado Division of Wildlife. No stocking programs have been initiated in recent years. The primary factor affecting this strategy includes the fact that the Little Thompson is subject to erratic seasonal flow variations. Before Colorado-Big Thompson waters were introduced to the system, historic records indicated that it used to dry up about mid-July. Even with Colorado-Big Thompson water augmenting dry-up flow, the volume of water is not always sufficient to support a wide variety of aquatic life and recreational demand on the stream is lacking. Therefore, no fisheries management actions have been initiated (Nittman, 1977).

4.4.5 Boulder/St. Vrain Creek

St. Vrain Creek enters Weld County from the Southwest and is a plains type stream through Weld County to its confluence with the South Platte. Diversion of water from the St. Vrain in Boulder County results in minimum flows as it crosses into Weld County. Considerable surface and seepage return flows occur in the lower parts of the river. St. Vrain Creek also receives secondary treated waste from the City of Longmont and indirectly from the Town of Erie municipal discharge to Coal Creek and Boulder's municipal discharge to Boulder Creek which empties into St. Vrain Creek in Weld County.

The lower St. Vrain stream bottom is unstable and subject to alternate periods of slowing and sedimentation - conditions not conducive to establishment of a high quality aquatic habitat.

Because of existing water quality, quantity and lack of recreational demand, the Colorado Division of Wildlife does not stock fish in Boulder or St. Vrain Creek in Weld County.

4.4.6 South Platte River

According to the Colorado Division of Wildlife, the South Platte below Denver has not been managed as a fishery for many years. Principle considerations have been water quality, quantity and recreational demand. Though more information about aquatic biota is available for the lower South Platte than for many other streams in the region, there is not a considerable amount of data. Bluestein and Hendricks (1975) report that in their investigation for the National Water Quality Commission on the Biota and Water Quality of the South Platte River, that the make-up of the aquatic biota below Denver is largely related to the nature of upstream discharges and the extent to which the plains portion of the South Platte has been changed from an intermittent to a perennial stream as a result of extensive irrigation water supply. Diversions and discharges are quite large relative to the native stream flow and results in drastically different flow rates on adjacent stretches of the river.

Because of the impacts to water quality from the Denver area, water quantity from irrigation activities, the plains character of the stream and the large amount of private lands adjacent to the stream, the South Platte, in the Larimer-Weld Region, has not historically been a highly used recreational water body.

4.5 WILLINGNESS TO PAY FOR IMPROVED WATER QUALITY

Attitude assessments of willingness to pay for improved water quality in the West are extremely complex as the costs to be incurred and the benefits to be gained are not always clear. The water resource of the Larimer-Weld Region has, in previous sections of this report, been described as a valuable resource which is used and reused as it progresses from mountains to plains. It is degraded by both man and nature. Because of this complex set of interactive processes and local competing values for the water resource, the 208 planning process must carefully evaluate the competing water uses which require various levels of water quality and develop alternative technical solutions, and ultimately recommend an acceptable planning alternative to be implemented.

The costs of water pollution control must ultimately be borne by the public, either directly through taxation or user charges, or indirectly through the increased prices of products and services. Public perceptions of how the payment for water pollution control should occur and which group should pay is a matter of great importance. It is commonly perceived that in the event a particular type of pollution is caused by a particular entity, then that entity should pay for any damages it causes or for control of its pollutants. In this logical sequence, some entities fail to recognize that costs will be passed on to the consumer in one form or another.

In the event that the polluter is industry, it is commonly perceived that industry should pay for its pollution control. This position is reinforced by the requirements of the Federal Water Pollution Control Act Amendments of 1972 and regulatory measures taken to insure that industry foots the bill for cleaning up pollution at its own cost.

In the event that pollution is caused by a municipal point source discharger, it is the user of the waste service who should pay. However, recognizing that the State and the nation benefit from clean water, both federal law (Public Law 92-500, Sec. 201) and applicable Colorado law make funds available for the subsidization of planning, design and capital construction costs of facilities to help meet public health requirements and Public Law 92-500 goals of secondary treatment and fishable/swimmable waters, where attainable.

Questions of costs and who should pay are not as clear-cut for non-point source control, i.e., agricultural, silviculture, construction activities, urban storm runoff and mining activities. The reason for this is that the pollution mechanisms which cause degraded water quality are not as easy to control as point sources and we do not always know how much pollution reduction will result from any level of structural or non-structural controls. Therefore, the question of costs and who should pay are more complex in nature, and equitable solutions for non-point source control are not as easy to identify as point source control measures.

A limited sample survey of residents in the South Platte River Basin (Fort Collins and Denver) assessed the willingness of persons to expend money for improved water quality. The study examined option values, preservation values and recreation benefits of improved water quality. The study, funded by the Criteria and Special Studies Office, Health Effects Research Laboratory of EPA, was conducted by researchers in the Department of Economics at Colorado State University (Walsh, et.al. 1977). The purpose of this study was to develop and apply a procedure for measuring the benefits of improved water quality in terms of:

1) Enhanced enjoyment of water-based recreation activities:
2) Option values to choose in engaging water-based recreation activities in the future by avoiding irreversible mineral and energy pollution, and
3) Preservation value of the existence of a natural ecosystem and its bequest to future generations.

The study is based on interviews of 202 resident households in Denver and Fort Collins. A number of statistical procedures including regression analysis were used to analyze the relationship between water user values and option values. A premise of the study was that benefits accrued to users of lakes and streams for fishing, boating and swimming, as well as noncontact recreation activities adjacent to the water body such as picnicing and sightseeing, and overall satisfaction from the recreational experience. Recreation user households interviewed reported that they were willing to expend an average of $56.68 annually for improved water quality by target year 1983 to enhance enjoyment of water-based recreation activities in the basin. Results of this study showed that a number of variables including household income, type of employment, sex, education level, former residence, permanance of residence, age and level of recreation use were all important in determining how much individual households were willing to spend for improving water quality. Significance of many of these variables differed depending on whether the respondents were from the Fort Collins or the Denver area. Respondents reported that the method of payment for improved water quality was important. An increase in sales tax was preferred in comparison to increased water/sewer bills. The reasoning behind this is inferred to be that since everyone including tourists pay sales tax and only residents pay water/sewer bills, the cost of improved water quality would be shared by more of those who benefit since this area of the state is a high tourist use area.

The study raises numerous questions regarding the preferences for increased water quality at various levels of cost. Extrapolation of results of the study using Denver and Fort Collins as sample areas, may not be representative of all the South Platte River Basin and, in particular, rural areas of the Larimer-Weld Region. Further study would be required for a full assessment of the willingness to pay for increased water quality by residents of Larimer and Weld Counties. The Areawide Technical Strategies outlined in Chapter 6 discuss equivalent annual costs for the four different levels of water quality improvement from Strategies 1, 2, 3 and 4. In examining the four alternative strategies and their impacts on water quality improvement, a meaningful relationship for cost per household cannot be made. Statistics 1 and 2 include theoretical projections of meeting the 1983 goal through the creation of an artificial fishery by advance waste treatment processes and/or stream dredging, stocking of fish, and flow augmentation. There are no certainties that either alternative would in fact result in a high quality plains aquatic habitat. Any attempts to extrapolate the willingness to pay concept based on the CSU study must assess this technical consideration and prepare a detailed description of the benefits anticipated from major water quality improvement. It is conceivable that these expectations for improved water quality and recreation benefits may exceed natural capability and potential of the South Platte River and tributaries before man imposed himself on these ecosystems.

The Technical Strategy analysis only covers water quality and quantity improvement to achieve the goal in the four tributaries of the South Platte; the Cache la Poudre, Big Thompson and Little Thompson, and St. Vrain, and only in limited segments. It does not discuss capital land acquisition cost, easements or recreation area development on potential recreational lands. All of these considerations would tend to increase costs substantially. In addition, total costs cited for the Alternative Technical Strategies do not absolutely insure that water quality of a level sufficient to meet the 1983 goal will be achieved for all pollutants. Major water quality parameters which would be addressed include only sediment, salinity, ammonia, nitrogen, fecal bacteria and residual chlorine. Heavy metals, pesticides and other nutrients, i.e., phosphorus, would be controlled only to the extent that they may inadvertently be removed in the conscious control of other pollutants, i.e., much of the potential pollutant phosphorus would be removed in the control of sediment.

It should also be pointed out that costs are conservative, do not address foothills or mountain non-point source pollution problems, total control of non-point source agricultural pollution, or insure total restoration or improvement of the aquatic ecosystem such that highly productive recreational fisheries would exist in all streams of the region on a year-round basis.

4.6 RECREATIONAL ENHANCEMENT - OPEN SPACE DEVELOPMENT AND PUBLIC ACCESS

Public access to mountain streams, lakes and reservoirs is quite good throughout the Larimer-Weld Region. Public lands under the operation of the U.S. Forest Service in Roosevelt National Forest, the National Park Service in Rocky Mountain National Park, Colorado Division of Parks and Recreation, Bureau of Reclamation, Larimer County, and private lands adjacent to streams which are along main public roads have minimal restrictions upon use. Water bodies in the foothills and plains areas which are not close to public roads are much less accessible access as more land is under private ownership, and physical barriers such as fences make access increasingly difficult.

Major reservoirs of the foothills and plains areas for which public access is basically unrestricted include Carter Lake, Horsetooth Reservoir and Boyd Lake. Many other small reservoirs of the plains areas are either entirely restricted from recreational use or conditionally used by private groups who have contracted exclusively with mutual ditch companies for all recreation rights on the water body. Access to foothills and plains areas streams is extremely restricted as private land borders the stream course in a majority of cases.

As previously mentioned, local governments in the Region are making concerted attempts to increase access to potential recreation areas on streams and reservoirs. For the most part, activities are oriented toward use adjacent to the water body rather than in it.

The Larimer-Weld Regional Public Open Space and Outdoor Recreation Guidelines 1976 identifies on a regional basis high priority recreational needs. However, implementation priorities, financial arrangements and details of site location are to be worked out by the Counties and municipalities as part of their respective public open space and outdoor recreation planning activities.

The Guidelines recommends public development of several trails and shore lines on streams and reservoirs in the Region, including:

1. The Foothills Trail, connecting Horsetooth Reservoir, Carter Lake and the Culver-Cole Ranch on the Little Thompson River;
2. The Louden Ditch Trail connecting the Boyd Lake State Recreation Area with the Devils Backbone and proposed Foothills Trail;
3. The Poudre River Trail, Fort Collins to Greeley;
4. The Big Thompson River Trail;
5. The Dry Creek Trail linking Berthoud to Carter Lake;
6. The Little Thompson River Trail;
7. Seeley Lake - develop public access and fish stocking;
8. Island Grove Park - reclamation of gravel and sand extraction areas;
9. Milton Reservoir - develop shoreline; and
10. Miscellaneous trail corridors for Weld County.

Questions on legal protection for landowners regarding liability, vandalism and trespass have deterred participation in some public access programs. Even where governmental agencies assure insurance coverage there is hesitation. Gray areas in statutory law for liability of public use on privately owned lands have contributed to this general feeling.

Numerous areas, particularly in the plains where agricultural related activities may continue up to or in a public access area, vandalism to farm equipment, irrigation structures, farm buildings, fences and livestock, is a constant fear. This concern will prevail until remedies adequate to quell them. In spite of this, however, local governments are making progress in developing open space and recreational opportunities adjacent to water bodies in the Region.

5.0 ENVIRONMENTAL GOALS AND THEIR RELATIONSHIP TO WATER QUALITY MANAGEMENT

In the past, federal environmental programs have been administered in a categorical fashion where objectives of one program have at times conflicted with objectives of another. For example, the EPA would fund municipal sewage treatment works where the population growth and land use supported by the facilities would result in significant deterioration of air quality not permissible in a state Implementation/Air Quality Management Plan (SIP). Situations such as this have been due to a number of factors including the fragmentation of federal programs administered by a variety of departments and agencies; the newness of the programs; the reluctance of one agency to request formal review and comment of proposed regulations on the part of other agencies; and the lack of congressional mandate to insure that coordination is taking place.

More recently, however, a number of actions have been taken by the Executive Branch and the Congress to coordinate environmental programs. The best examples of this include federal governmental reorganization plans, and the 1977 amendments to the Clean Air Act which tie air quality planning to federal funding for sewage treatment works and highways.

The 208 Water Quality Management Planning process provides a unique opportunity to facilitate the coordination of various federally mandated environmental programs by focusing on real and contemporary social, political and environmental concerns. Public involvement in the initial 208 planning process has confirmed the notion that success in water quality management is tied very closely to identifying opportunities and conflicts with other local goals and programs and maximizing the ultimate benefits derived - water quality and otherwise. In other words, the public is not likely to support an expensive water quality control program for water quality alone, especially if it is tied to a very narrow interpretation of the national water quality goals. A water quality management strategy must be sensitive to and integrated with other local concerns and federal mandates if it is to be successfully implemented.

Attempts have been made throughout the initial Larimer-Weld 208 planning process to identify opportunities and conflicts arising from water quality management options. Areas in which concerted effort has been placed in this regard include irrigated agriculture and urban runoff control. Examples are:

- o Integration of water quality considerations in local stormwater management programs

- Evaluation of agricultural best management practices for water quality improvement in broader terms of increased irrigation efficiency, crop productivity, and resource conservation.

The purpose of this section is to examine in broad terms the relationship between water quality management and the following national objectives which are also topics of substantial local interest:

- Resource Conservation and Recovery
- Water Conservation
- Safe Drinking Water
- Energy Conservation

Other analyses showing the regional relationships between water quality, land use and air quality are contained in Larimer-Weld Regional Land Use Alternatives (Interim WQMP Report No. 16) and Impacts of Land Use Alternatives on Wastewater Treatment Facilities for the Fort Collins, Greeley, Loveland Triangle (Interim WQMP Report No. 31) and Transportation Related Impacts of Land Use Alternatives in the Fort Collins, Greeley, Loveland Triangle.

5.1 RESOURCE CONSERVATION AND RECOVERY

In recent years, national attention has focused on resource conservation and recovery. The value of "pollutants" as potential resources is being recognized. The relationship between the uses of land, water, and air resources are being better defined. The purpose of this section is to examine in qualitative terms the relationship between resource recovery and water quality management in the Larimer-Weld Region. Attention is focused on reuse of municipal and industrial wastewater discharges for the purpose of resource recovery, and the management of animal wastes from concentrated animal feeding operations as a resource.

5.1.1 Regulatory Requirements

The 1972 Amendments to the Federal Water Pollution Control Act recognized the value of "the recycling of potential sewage pollutants through the production of agriculture, silviculture, and aquaculture products ... and the reclamation of wastewater" (Sec. 201(a) and (d)). The reuse and recycling of municipal wastewater on the land has been popularly characterized as "Land Treatment" by both Federal and State regulatory agencies. A recent policy statement from the Administrator of the U.S. Environmental Protection Agency affirms that the EPA "will press vigorously for publically owned treatment works to utilize land treatment processes to reclaim and recycle municipal wastewater."

The policy statement sets forth a firm obligation on the part of recipients of EPA grants for construction of sewage treatment works to incorporate water conservation, wastewater, reclamation and reuse or "provide complete justification for the rejection of land treatment." The policy statement further states: "Whenever states insist upon placing unnecessary stringent preapplication treatment requirements upon land treatment, such as requiring EPA secondary effluent quality in all cases prior to applications on the land, the unnecessary wastewater treatment facilities will not be funded by EPA."

It is difficult to predict what the full ramification will be of this policy statement; however, it is certain to create substantial confusion among the states in determining funding eligibility, priority needs and design criteria.

The Colorado Water Quality Control Commission has taken an affirmative stand on land treatment for a number of years by requiring grant recipients to consider land treatment alternatives in the cost effective analysis of so-called "201 Facility Plans". Some success has been achieved. However, major obstacles still stand in the way of large scale "acceptance" of land treatment as an ultimate solution. Some of the more formidable obstacles are:

(1) Colorado Water Law

(2) Health implications

(3) State of the art considerations in design and operation

(4) Public acceptance

(5) Economic feasibility

(6) The perception that under current administration of water resources in Colorado, land treatment is already taking place on an unprecedented scale.

This last "obstacle" is a widely-held view in the Larimer-Weld Region, and is supported by information developed as part of the 208 planning process (Interim WQMP Report Nos. 3, 19, 20, 22, 25, and 26).

At the request of the Colorado Water Quality Control Commission, the Governor's Science and Technology Advisory Council evaluated the applicability of the land treatment alternative for Colorado. The Council established a Task Force comprised of an interdisciplinary team of acclaimed experts. The examination resulted in a report published July 20, 1977. This report is considered to be a formidable and objective assessment of the land treatment alternatives for Colorado. The report is an excellent reference for the development of site specific land treatment programs.

In October of 1976, Congress enacted the Resource Conservation and Recovery Act (RCRA). The RCRA provides authority for the EPA to develop comprehensive solid waste management plans through a regional planning process identical to that of the 208 water quality management planning process. Emphasis is placed in areas of hazardous waste and opening dumping. Although regulations have not been fully developed, it is believed that solid and hazardous waste management activities will be coordinated with water quality management programs. These relationships between water quality, solid and hazardous water management have been given attention in the interim water quality management report NonPoint Source Pollution Control (Interim WQMP Report No. 19, January 1978).

5.1.2 Recycle and Reuse of Wastewater - Land Treatment

To provide a framework within which to evaluate the role of wastewater reuse in the Larimer-Weld Region, a summary of available water resources and its current use is appropriate. To facilitate this framework, a water balance for the area under the jurisdiction of the Northern Colorado Water Conservancy District (NCWCD) is presented in Table 5.1.2. Although the District encompasses areas outside of the Larimer-Weld Region, more than 63% of the irrigated land and 60% of its municipal, domestic and industrial water users lie within Larimer and Weld Counties. The table illustrates not only the disproportionate use of surface water for agricultural purposes as compared to municipal and industrial purposes (a ratio of 10:1) but also illustrates the efficiency of use within the Region, i.e., on a volume basis the total annual average supply is used 2-1/2 times before it is either lost to the atmosphere due to evapotranpiration or leaves the region to satisfy downstream appropriations. Because of the repeated uses and reuses of water primarily due to irrigation demands, it could be said that "land treatment" is taking place. Reuse of water and recycling of nutrients are definitely occurring (see Interim WQMP Report Nos. 22 and 26).

This is unquestionably true in the case of irrigation tailwater and return flows (see Interim WQMP Report No. 22). As a consequence, it is found that during the irrigation and storage seasons, water in the lower Cache la Poudre, Big Thompson, and St. Vrain Rivers are composed entirely of irrigation return flows.

A more complicated problem arises in determining the role of land treatment of municipal and industrial point source discharges.

TABLE 5.1.2

WATER BALANCE FOR THE
NORTHERN COLORADO WATER CONSERVANCY DISTRICT

Average Annual Supply (million acre feet)	Average Annual Demand by User	Average Annual Use Demand From All Sources	Times Total Supply Is Used	Total Losses
In Basin .75	Municipal & Industrial <0.1	2.75	2.5	Losses Due to Evapotranspiration 0.7
Transmountain Diversion .25	Irrigated Agriculture >1.0			Amount Leaving NCWCD to Satisfy Downstream Appropriators 0.4
TOTAL SUPPLY 1.1	TOTAL DEMAND 1.1			TOTAL 1.1

There would appear to be three desirable objectives to be gained from land treatment schemes:

(1) Elimination of a direct discharge to a stream, thus reducing the need for assimilative capacity in the stream to receive residual waste remaining after the sewage treatment process;

(2) Providing "tertiary treatment"; and

(3) Recovery of valuable chemical resources in the treated wastewater through the production of crops.

Of course, there may be other desirable objectives that could be derived from a land treatment scheme, such as providing a local farmer with a new supply of irrigation water or be an integral component of a wastewater reuse/domestic water supply program such as that proposed for the City of Northglenn, Colorado. However, these three objectives seem to be supported by the Federal Water Pollution Control Act.

5.1.2.1 Land Treatment for Major Urban Centers

The role or suitability of land treatment for the cities of Greeley, Loveland and Fort Collins have been assessed against the three objectives presented above.

In the case of the first objective, it would appear that the elimination of a point source discharge from a stream in the plains to enhance or preserve the existing aquatic biota would appear to be of limited value in light of non-water quality considerations which interface with a balanced aquatic ecosystem. In the case of the Cache la Poudre River, this is substantiated by in-stream water quality and biological data accumulated over a seven year period (see Morrison, 1978).

In view of this conclusion, the necessity of tertiary treatment of municipal and industrial dischargers in the plains area seems to be minimized. Finally, the third objective, the recovery of valuable chemical resources in wastewater through the production of crops, the existing administration of water for beneficial uses within the region appears to satisfy this requirement.

Further analysis of the considerations for land treatment for major urban areas of the region is contained in Municipal Point Source Analysis - Urban Triangle Area (Interim WQMP Report No. 24).

5.1.2.2 Land Treatment for Outlying Communities

The potential for cost-effective wastewater treatment and reuse systems are considered greater for small rural communities than major urban centers. This is due largely to the relative costs associated with centralized collection and treatment and redistribution to suitable land application areas. This contention appears to be supported in EPA's Land Treatment Policy Statement wherein it is stated "such consideration is particularly critical for smaller communities ... the utilization of land treatment systems has the potential for saving billions of dollars".

The opportunities of direct land application of wastewater as a planned component of a water quality management program are substantial for rural communities in the region from the standpoint of engineering feasibility, land availability, and cost. A recent EPA rule change regarding relaxation of suspended solids limitations for waste stabilization ponds has eliminated a major economic barrier to serious consideration of planned land treatment systems. However, a major obstacle remains, that being Colorado Water Law and the question of legal ownership of wastewater which would permit land treatment.

During the course of the initial 208 planning process, 21 public and private rural waste treatment systems were evaluated in addition to two areas where individual disposal systems (septic tanks) appear to be unsatisfactory long-range solutions (Red Feather Lakes region and Severance). Nine areas were studied in detail and individual technical plans were published (see Interim WQMP Reports Nos. 7, 8, 9, 10, 11, 12 and 13). An additional report entitled, Municipal and Industrial Point Source Analysis - Wastewater Treatment, Operation and Maintenance Requirements (Interim WQMP Report No. 6), along with the aforementioned reports, examined the feasibility of land treatment in rural communities within the region. Land application systems were found to be feasible for the Red Feather Lake area and Ft. Lupton, Colorado. Additionally, a recently completed 201 Facility Plan for the Estes Park Sanitation District recommends land treatment of treated effluent for golf course irrigation (Toups Corp., Dec. 1977). In the case of Platteville, Severance, Tinmath, Pierce and Milliken, land treatment involving direct discharge to irrigated farmland was feasible from an engineering standpoint, but water rights considerations impede such a program at this time. It must be pointed out, however, that the discharge from these five communities are in the plains area where extensive irrigation water supply practices are currently being administered and the effluents are diverted from the streams and used for irrigation purposes.

5.1.3 Management of Residual Waste From Concentrated Feedings Operations

The Larimer-Weld Region contains more than 1200 concentrated animal feeding operations which fatten nearly one million head of cattle annually. While the region also fattens turkey, poultry, swine and sheep in concentrated areas, the cattle industry represents the biggest dollar producer in the region's economy. As a consequence of the intensity of animal feeding operations and their potential significance as a ground and surface water polluter, a special study was conducted and interim water quality management report published entitled, Concentrated Animal Feeding Operations - Waste Management and Resource Recovery (Interim WQMP Report No. 15). Some rather unexpected conclusions were reached during this study regarding the value of manure as a resource and the relationship of the management of manure and water quality of the region.

Manure generated by livestock supported on confined feeding operations represents an important aspect of agricultural solid waste management. Local disposal practice usually involves application of manure to cropland, a practice that recognizes the resource value of the waste. In addition to the fertilizer benefit to crops and soil provided by its nitrogen, potassium and phosphorous content, manure contributes other elements necessary for plant growth. Among these are included sulfur and micro-nutrients. The presence of organic matter contributed by manure is effective in improving physical and chemical properties of soil. A positive influence is exerted on water infiltration rates, water holding capacity, and ease of tillage. Manure also has a beneficial acidifying effect on soil.

Manure removal from feedlots in the two-county area is usually accomplished by any of three methods: it may be sold to area farmers, spread on fields owned by feedlot operators, or distributed to farmers according to negotiated arrangements. In the latter arrangement, feedlot operators purchase forage from local farmers with the agreement that the grower remove equivalent quantities of manure from the feedlot.

The micro-nutrient components of manure are considered to have monetary value equal to the cost of these soil amendments purchased in the form of commercial fertilizers. It was determined that a ton of fresh manure is worth approximately $7.50 (in 1977 dollars). This estimate considers an allowance of 50¢ for the micro-nutrient content and soil conditioning properties of manure. Based on current charges for commercial manure hauling and spreading services in the region, manure can economically be transported and applied up to a maximum of approximately 35 miles from its source. In the two-county area, however, most manure is stockpiled prior to use. Nutrient losses in storage may range to over 50 percent. Economic value and associated effective haul distance is decreased accordingly.

Salt and nitrogen in manure are constituents which possess the greatest potential for degrading water quality. Deleterious impacts result when such substances are leached to underlying groundwaters. The biological oxygen demand associated with cropland manures is not considered to be a water quality problem in the Larimer-Weld area. Topography, climate, irrigation practice, and manure management techniques in the Region are not conducive to runoff transport of oxygen demanding materials from fields to surface waters.

The rates at which manure should be applied to satisfy nutrient requirements of crops, maintain long-term agricultural productivity, and ensure quality of underlying groundwater is a subject of extreme complexity.

Optimum land applications of manure for crop utilization are largely dependent on individual on-farm characteristics. The amount applied and method of spreading is a function of the following factors:

- Physical and chemical characteristics of the applied manure;
- Physical and chemical characteristics of the soil;
- Type of crop.

It is recommended that individuals responsible for manure management sample agricultural soils and manures annually to determine the nature of their own particular situation. Manure application rates can be prescribed accordingly. This is especially important on farms where manure is routinely spread. Much of the nitrate benefit of manure is released as the waste decays in years succeeding initial application. It is desirable in any given year to evaluate total quantity of nitrates made available to cropland soils by the presence of newly applied and residual manures. Annual soil sampling also provides a means of assessing salt buildup in the soil profile. Salt content of applied manure and irrigation water may govern manure loading rates to agricultural soils in some instances. Research conducted in the Region has demonstrated that manure application rates of 25 to 50 tons per acre on a wet weight basis as removed from a feedlot allow for nearly optimum forage yields with a minimum of nitrate-nitrogen degradation of underlying soils. Because of residual manure nutrient value, this loading rate should be reduced substantially on fields subject to a long history of manure application. Loading should be decreased in years subsequent to initial application in consideration of the cumulative benefits of residual manures.

Some areas in the Region were found to be overloaded on a long-term basis. It was also discovered that groundwater underlying these fields contained in some instances an excess of 100 lbs. of nitrogen per acre foot. Further, this groundwater is often pumped to supplement surface irrigation water which leads to the conclusion that farmers are not recognizing the nutrient value of groundwater. It is not known what the precise areal extent of this "condition" is. However, agricultural pollution studies have defined areas where this phenomenon has the highest potential for occurrence based on a relationship of irrigated sandy soils and travel distances (economically based distance) to manure sources.

The economic and water quality implications are far reaching. For example, by testing the quality of groundwater utilized for supplemental surface irrigation (a practice not now generally applicable) in addition to measuring soil chemistry, the optimum fertilizer, manure, water application rates can be determined. In some areas, it is anticipated that farmers could substantially reduce fertilizing expenditures. In such instances, long term utilization of the groundwater both for its nutrient value and irrigation value could result in decreasing the nitrogen concentration of groundwater while resulting in direct cost savings to the irrigator. Additionally, with better management of manure based on more scientific testing, major improvements in the economics of manure/hauling and application could improve substantially.

The Lone Tree Creek Basin north and east of Greeley has been proposed as an agricultural model implementation area (Interim WQMP Report No. 26) for development and application of best management practices to optimize resource recovery and reduce ground water pollution associated with manure recycling.

5.2 SAFE DRINKING WATER

The Safe Drinking Water Act of 1974 (PL 93-523) provides for the safety of public drinking water supplies throughout the United States by establishing and enforcing national drinking water quality standards. The Environmental Protection Agency has the primary responsibility for establishing the national standards while the states are responsible for enforcing the standards or otherwise supervising public drinking water supply systems and sources of drinking water. The national drinking water standards apply to all public water systems serving at least 25 people or having at least 15 service connections. Further provisions are established for schools, places of employment, restaurants, hotels, motels and recreation areas serving a certain number of persons for a specified duration. The purpose of this section is to show the steps being taken by EPA and the State of Colorado to help insure high quality drinking water and the relationship between drinking water protection and the Larimer-Weld 208 Planning Program.

5.2.1 Approach to Establishing Standards

The Safe Drinking Water Act is a public health measure designed to protect the health of human beings. National drinking water standards have been established by EPA to reflect the best scientific and technical judgments available. They were developed by a 15-member National Drinking Water Advisory Committee comprised of representatives of the general public, state and local agencies, and experts in the field of public water supply.

This committee operated with additional expertise from several technical subcommittees focusing on specialized water quality and human health topics. Numerous agencies and organizations including the Department of Health, Education and Welfare were consulted in the development of "National Interim Primary Drinking Water Regulations". The Regulations set achievable levels of drinking water to protect human health and are indicated as "interim" regulations because research in this area is still continuing. EPA has established maximum contaminant levels for 10 chemicals, 6 pesticides, bacteria, radioactivity and turbidity. The approach to solving the public health problem posed by drinking water is to find solutions to the problem as they are identified in raw water supply intended for public use. Special studies carried out under the Act have focused on appropriate contaminant removal processes to meet regulatory drinking water standards.

In the development of drinking water standards for various constituents, the National Academy of Sciences has made numerous considerations in developing criteria for a particular constituent. In review of water constituents, the study group for the National Academy of Sciences attempted not only to account for identities, concentrations and toxicities, but also consideration for such questions as:

1. What reason is there for concern about the material? What risks are associated with its presence in water?

2. How does the material get into the water?

3. What sources are there other than water?

4. What contaminants need to be controlled?

5. Are there special places or persons (species could be substituted here) at higher than average risk?

6. What additional information is required to resolve the outstanding problem?

(Extracted from National Academy of Sciences, 1977. Drinking Water and Health.)

5.2.2 Colorado Drinking Water Standards

Colorado's drinking water regulations divide community water systems into two groups - those which tap groundwater sources and those which use surface waters. Community water supply systems are those which serve at least 25 residents for at least 60 days a year. Non-community systems are those which serve at least 25 persons a day for at least 60 days a year on a part-time basis. Those included in the non-community systems would be schools, places of employment, restaurants, hotels, motels and recreation areas.

Community water supplies which use groundwaters must disinfect their water to kill disease producing organisms and monitor water at least twice a month for microbiological contaminants. They must also adhere to water quality standards for radioactivity and inorganic chemicals as listed in Table 5.2.2. They must have tests completed for inorganic chemicals by June 24, 1979, and repeat the tests every three years thereafter. They must also being tests for radioactive radium-226 and 228 and for gross alpha radiation by June 24, 1979, and have tests completed by June 24, 1980.

Communities for which water supplies are derived from surface water must filter and otherwise disinfect their water to kill and remove disease-producing organisms, and being immediately to monitor their water at least twice a month for microbiological contaminants. They must also meet water quality standards for turbidity; radioactivity; and the organic chemicals listed in Table 5.2.2. Testing for turbidity must begin immediately and occur each day. Tests must be completed for inorganic chemicals by June 24, 1978, and tests must be repeated annually thereafter. Tests must be completed for organic chemicals also by June 24, 1978, and tests must be repeated every three years thereafter. Tests for radioactive radium 226 and 228 and for gross alpha radiation must be begun by June 24, 1979, and completed by June 24, 1980. Systems which serve more than 100,000 persons must also test for gross beta radiation.

Non-community water systems must disinfect and, if surface water is used, filter water to remove disease causing organisms and begin testing for bacteriological quality on a quarterly basis by June 24, 1979. Analysis for nitrates must be also completed by June 24, 1979, and if a surface water is used, they must begin testing for turbidity each day by June 24, 1979.

5.2.3 Drinking Water Contaminants in Larimer-Weld Region

The Larimer-Weld Region drinking water contaminants identified as concerns in public water supply thus far are nitrates, turbidity and coliform bacteria. The presence of nitrates in ground and surface water supplies is the result of municipal waste discharges, application of animal wastes (primarily feedlot waste) commercial fertilizer

TABLE 5.2.2 STATE OF COLORADO DRINKING WATER STANDARDS[1]

Maximum Contaminant Levels

Inorganic Chemicals	Level, milligrams per liter
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05
Fluoride	1.4 to 2.4 (Dependent upon annual avg. air temperatures)

Organic Chemicals	Level, milligrams per liter
(a) Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10, 10-hexachloro-6, 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1, 4-endo, endo-5, 8-dimethano naphtalene).	0.0002
Lindane (1,2,3,4,5,6-hexachloro-cyclohexane, gamma isomer).	0.004
Methoxychlor (1,1,1-Trichloro-2, 2-bis (p-methoxyphenyl) ethane).	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67-69 percent chlorine).	0.005
(b) Chlorophenoxys:	
2,4-D, (2,4-Dichlorophenoxyacetic acid).	0.1
2,4,5-TP Silvex (2,4,5-Tricholorophenoxy-propionic acid).	0.01

(1) Summarized in part from Colorado Department of Health - Colorado Safe Drinking Water Standards and Regulations, November 1977.

TABLE 5.2.2 STATE OF COLORADO DRINKING WATER STANDARDS
(Continued)

Organic Chemicals	Level, milligrams per liter
Turbidity	1 Turbidity Unit (TU) as determined by monthly avg. except that 5 or fewer TU's may be allowed if the supplier of water can demonstrate that the higher turbidity did not (i) interfere with disinfection; (ii) prevent maintenance of an effective disinfectant agent throughout the distribution system; or (iii) interfere with microbial determinations.
Microbiological	
Coliform bacteria	1/100 ml membrane filter technique (Provisions included for multiple sample or other techniques of measure)
Radioactivity	
Radium-226 Radium-228	5 pCi/l combined
Gross Alpha Particle (Excluding radium and uranium but including radium-226)	15 pCi(2)/l
Tritium	20,000 pCi/l
Strontium-90	8 pCi/l
Man-made radionuclides	4 mrem(3)/year

(2) pCi - Picocurie means the quantity of radioactive material producing 2.22 nuclear transformations per minute.

(3) mrem - Millirem is 1/1000 of a rem. Rem - is the unit of dose equivalent from ionizing radiation to the body or any internal organ or organ system.

applications to agricultural lands, and natural sources. Conventional municipal waste treatment processes do not remove nitrate nitrogen. The amount of nitrates contributed to surface and groundwater supplies without exotic treatment processes may be controlled to some extent by closely monitoring application rates of nitrogen containing commercial fertilizers and animal wastes and the amount of irrigation waters which could potentially leach the nitrate nitrogen from the soil.

Conventional disinfection processes, the most common of which is chlorination, appears to solve most of the bacteriological problems. Turbidity levels, on the other hand, are hard to control and are primarily a problem of surface water supply. The extensive use of organic chemicals such as pesticides, herbicides, and insecticides on agricultural lands in the Region, has brought about awareness for contamination of water supply. The current assessment of these materials is that they pose little problem in terms of meeting maximum contaminant levels established under the Safe Drinking Water Act. However, continued monitoring will be required to ensure protection of water supplies. (Interim WQMP Report No. 22).

The strategy taken by EPA and the State for insuring safe public drinking water supplies under the Safe Drinking Water Act is to treat raw water only as it becomes used for public water supply.

Treatment processes for problem contaminants to drinking water supply are listed in Table 5.2.3 along with the anticipated percent removal of contaminants.

5.2.4 Relationship to the Safe Drinking Water Act and the 208 Program

It is anticipated that some communities, particularly those relying on groundwater supplies, will not meet the drinking water standards specified in the Safe Drinking Water Act. Groundwaters in the Region have been impacted by both natural and manmade source of pollution from periods ranging from 100 to several thousand years, depending on the source. Experience in other Western States indicates that solutions to groundwater quality problems are long-term in nature, if feasible at all. Identification of the sources of the pollution and evaluation of the feasibility of controlling those sources will be a major planning effort in itself. If feasible solutions are available, implementation can only be carried out over a period of years. Significant water quality improvements may not be observed for many years following actual implementation. The net effect is that communities relying on groundwater supplies cannot expect short-term solutions involving changes in the quality of the source of supply. Short-term solutions would appear to involve seeking other sources of supply or extremely sophisticated and

TABLE 5.2.3

WATER TREATMENT PROCESS
FOR DRINKING WATER
CONTAMINANT REMOVAL

Turbidity	Percent Removal
Plain Sedimentation	50-95
Coagulation, Sedimentation and Filtration	80-99
Nitrate	
Reverse Osmosis	90-97
Electrodialysis	80
Ion Exchange	98
Coliform Organism	
Chlorination	99
Ozonation	99
Chlorine Dioxide	99
Sedimentation*	0-99
Coagulation*	Significant amounts
Filtration*	0-99

* These methods do not in themselves provide adequate bacterial reduction. However, their use prior to disinfection may significantly lower those costs associated with disinfection.

expensive treatment of waters prior to use. These alternatives must be evaluated on a case-by-case basis by each individual community.

Through the continuing 208 planning process, results of community water supply sampling will be reviewed as part of the regional water quality monitoring program. Assistance will be provided in identifying pollutant sources, developing recommendations for problem solving, and incorporating recommendations into the planning and implementation phases.

5.3 ENERGY CONSERVATION

Energy conservation in concert with water pollution control efforts requires that trade-offs be made between incremental increases in water quality and increased consumption of energy. Without attempting to define total comprehensive energy requirements for all point source and non-point source pollution controls, it is possible to point out general areas of concern in selecting alternative water pollution control measures. All structural or non-structural water pollution control measures are energy consumptive to some degree. From the manufacture of sewer pipe and mechanical waste treatment components to the excavation of sewer line trenches and operation of a waste treatment system, energy is required. Increasing concern at the national and local level for energy conservation is beginning to encourage the selection of less energy consumptive alternatives while still attempting to accomplish the job at hand.

5.3.1 Municipal and Industrial Waste Treatment

Depending upon sizing and number of mechanical components and operations in a waste treatment plant, energy requirements for manufacture, construction, operation and maintenance may vary widely. In general, activated sludge waste treatment and other highly mechanical operations tend to be more energy consumptive both in manufacture of components and in operation. Less sophisticated, but effective, waste treatment alternatives such as waste stabilization ponds tend to be less consumptive of energy. Depending upon sizing of a system and particular design needs, one system may be chosen over another, but in most cases currently energy is only a minor consideration relative to other concerns regarding plan operation. New regulations for the EPA Construction Grants Program (201 Facility Planning) require that energy considerations be given in evaluating waste treatment alternatives. Individual system energy requirements should be examined here.

5.3.2 Agriculture - Best Management Practices

Energy consumption in agricultural water pollution control is a function of the selection of both structural and non-structural management practice techniques. Such management practices as sprinkler irrigation and tailwater recovery systems, which employ the use of motorized pumps to pump water from wells or ponds to sprinkler heads or back into ditches at higher elevations to again be used for irrigation, obviously consume energy. In the selection of Best Management Practices, it is necessary to balance the benefits which may be derived from a practice in addition to water pollution control. Some practices may be beneficial for soil erosion, farming economy considerations, including labor and nutrient and pesticide application, as well as energy conservation. These elements have been, and will continue to be, important considerations in final selection of Best Management Practices for the Larimer-Weld Region.

5.3.3 Relationship to the 208 Program

Planning, management, operations agencies for point and non-point source pollution control should be required to address the questions of energy consumption and energy conservation measures proposed as a part of implementation of pollution control programs. The cost effective analysis of pollution control measures involving point and non-point sources should include a specific review and evaluation of the energy impact of those measures. In addition to other factors controlling cost-effectiveness, alternatives should be ranked according to energy consumption. Feasible energy conservation measures should be evaluated for each proposed structural or non-structural solution and incorporated into the design of the solutions to the maximum extent possible. The specific considerations which result in the selection of high energy consumption alternatives should be delineated and reviewed during the planning process.

5.4 WATER CONSERVATION

Water conservation may have a potential beneficial impact on water quality management in three principal areas. They are:

1. agricultural pollution control;
2. municipal waste treatment requirements; and
3. in-stream flow in the plains area.

5.4.1 Agricultural Pollution Control

Agricultural pollution control studies conducted as part of the initial Larimer-Weld 208 water quality management planning process conclude that there is a direct correlation between irrigation efficiency and water quality in the lower Cache la Poudre, Big Thompson, and St. Vrain Rivers. In-stream flow and water quality measurements confirm that during irrigation months, in various locations, the rivers contain 100% return flows and no native water. Water quality as measured by salinity (Total Dissolved Solids) in the rivers in these locations correspond to that characteristic of irrigation tailwater and seepage found in tile drains. It has been concluded that by increasing irrigation efficiency, return flows will be reduced, thereby reducing the loading potential of irrigation return flows in area streams. Best Management Practices (BMP's) commonly employed as land and water conservation measures by individual farmers, ditch companies, Soil Conservation

Districts and the Agricultural Stabilization and Conservation Service, are believed to have potential for reducing pollutional loadings. BMP's which can increase irrigation efficiency include such items as irrigation scheduling, reducing the length of run and sprinkler systems, among others.

The desirability of employing such practices for water quality improvements will depend upon the desired in-stream water quality goals and corresponding beneficial uses and a testing program which defines the actual water quality improvement that can be derived from such practices. A more thorough analysis of this issue can be found in Water Quality Impacts of Irrigated Agriculture, (Interim WQMP Report No. 22), and Identification of a Methodology and the Technical and Institutional Feasibility for Development and Implementation of Best Management Practices for Irrigated Agriculture, Larimer-Weld COG (scheduled for release in August, 1978).

5.4.2 Municipal Waste Treatment Requirements

Water conservation measures in homes and businesses can reduce the volume of flow in wastewater treatment facilities, thereby potentially extending their life from the standpoint of hydraulic capacity. However, governmental decisions regarding domestic water conservation should be based on site specific studies and consideration of multiple objectives (for example, reduced energy and operational costs both at the water and sewage treatment plants).

In recent years, a number of research institutes have studied and demonstrated model water conservation programs. One such study examined the potential impact of water conservation on waste treatment facilities (Sharpe and Fletcher, July 1977). Some of the pertinent conclusions of the study are as follows:

1) Code requirements appear to be an acceptable and valid approach to water conservation.

2) The plumbing profession should be involved in the code change process from its inception and information programs for plumbers on available water-saving devices should accompany proposed code changes.

3) Specific design criteria for sanitary drainage systems where water-saving toilets are to be used should be developed.

4) Significant numbers of new homeowners were not aware that code required water-saving devices were installed in their homes.

5) In a large and populous service area, an intensive and continuous program will be necessary to maintain public awareness of water conservation programs.

6) A 5 to 10 percent reduction in actual flow rate appears to be economically justified for a plumber-installed device costing $1 or less. If zero installation cost and a service life longer than 1 year are assumed, the percent reduction needed to justify the cost of the device would be less than one percent.

7) Minimum use water-saving technology should reduce the wasteflows in individual and small scale waste treatment facilities by at least 50 percent.

8) In many instances, the application of minimum use technology should help to alleviate chronic pollution problems associated with overloaded small scale treatment plants and malfunctioning individual sewage systems.

9) Minimum use technology offers a very clear economic advantage in cases where holding tanks are used for on-site sewage disposal.

While the above conclusions show many positive aspects, there is still some disagreement regarding the impact of water-saving devices on waste treatment facilities. The U.S. Environmental Protection Agency Office of Air, Land and Water Use is examining the potential for water conservation, its impact on waste treatment facilities and the role of regulations and guidance materials pertaining thereto in EPA's funding of municipal waste treatment facilities. Dr. Roland Schaefer felt that the actual reduction in flow in individual or small scale waste treatment facilities through the use of minimum use water-saving technology (shower and faucet fixtures and toilets), is highly variable and depends upon such factors as infiltration and inflow. Additionally, in recent experience in drought-stricken Marin County, California, where drastic water conservation measures were imposed by local officials, it was demonstrated that a 30% to 40% reduction in flow in sewer lines did not adversely impact the hydrology of the system.

Study conclusions seem to indicate that the current rate of utilization of domestic water is associated with a sense of quality of life. Further, that in the absence of regulations, codes or ordinances, continuous public education will be required.

5.4.2.1 Potential for Reducing Domestic Water Demands in the Larimer-Weld Region

In order to assess the potential for a reduction in water demands in the region, a summary analysis of Loveland, Greeley and Fort Collins water demand was conducted. Table 5.4.2-A summarizes the 1977 raw water supply treated by the municipalities. The annual average demand (shown in Column C) measured in gallons per capita per day

TABLE 5.4.2-A

1977 MUNICIPAL WATER DEMAND

LOVELAND, GREELEY, FT. COLLINS

	Estimated Population Served	Average Daily Demand (mgd)(1)	Annual Average	Per Capita Demand (gpcd)(2)	
				Winter	Summer(3)
Loveland	29,500	6.4	220	201	307
Greeley	69,100	16.1	234	160	335
Ft. Collins	67,050	13.6	203	138	294

(1) mgd = Million Gallons Per Day

(2) gpcd = Gallons Per Capita Per Day

(3) Summer = May through September

reflects all uses including domestic, commercial and industrial divided by estimated population served. Compared to a national average per capita demand of 156 gpcd, the local usage appears to be high. This situation, of course, is to a large degree due to the semi-arid conditions and corresponding increase in lawn watering practices. With an annual average percipitation of approximately 14 inches and an average demand of 30 to 36 inches per acre of water per year for ground cover, a deficit of 16 to 20 inches per year must be provided by lawn irrigation.

The year 1977 was, of course, a drought year in the region and annual average and seasonal demands were reduced somewhat due to lawn watering restrictions imposed in Fort Collins and Loveland. For example, Loveland in 1974, experienced a summer average demand of 435 gallons per capita per day where a modest lawn watering restriction program was imposed, whereas in 1977 rather severe watering restrictions resulted in a 335 gpcd summertime demand.

In order to achieve a reduction in flow into sewerage systems, a reduction in in-home usage must be attained. A recent assessment by Dr. Schaefer of an EPA-funded Denver Research Institute study of water conservation in the Denver metropolitan area indicated that a 25% net reduction of in-home water demand could be achieved by the installation of commonly found water saving devices in new homes, and an additional 17% reduction could be achieved by an additional measure of retrofitting such devices in existing homes.

5.4.2.2 Potential Impact of Reducing In-Home Usage Waste Treatment Facilities

Wastewater entering sewage treatment plants includes disposal water from commercial, industrial and residential uses, and infiltration and inflow. Inflow, which is stormwater that is drained directly into sanitary sewage pipes, is not considered to be a significant source of flow in waste treatment facilities in Loveland, Fort Collins and Greeley. Infiltration, which is ground water that finds its way into pipe joints is common to all sewage collection systems. (Additional analysis on infiltration/ inflow and in-home saving water conservation measures may be found in Interim WQMP Report No. 24.)

Unit waste flows that are commonly used as design criteria for new collection systems is 100 gpcd. Unit waste flows (annual average) currently experienced are:

Fort Collins	174 gpcd
Greeley	119 gpcd
Loveland	116 gpcd

It is not known what percent of the unit waste flows is attributable to in-home usage (sanitary unit waste flow). However, the national average is 60 gpcd. Using a theoretical value of 60 gpcd for sanitary unit waste flow for the three major cities and the percent reduction in water demand provided by Dr. Schaefer, which is also hypothetical, an order of magnitude computation can be made to determine the potential impact on sewage treatment plant requirements. Table 5.4.2-B, which summarizes this analysis, indicates that modest reduction in flows in sewage treatment facilities can be anticipated as a consequence of requiring in-home water conservation measures. This analysis was based, of course, on conservative estimates and broad assumptions. However, if after detailed and site specific studies, these estimates are confirmed, it would appear that the potential reduction in flow in sewage treatment plants and the corresponding increase in available hydraulic capacity, however modest it may seem, could be significant.

This tentative conclusion, however, should not discourage local communities and water districts from undertaking studies and programs to reduce water demands. On the contrary, the benefits of modest reduction of flow in sewage treatment plants coupled with further reductions in flow resulting from ongoing attempts to correct infiltration and inflow problems can be substantial. For example, Greeley and Loveland have established goals of reducing unit waste flows from 119 gpcd and 116 gpcd, respectively, to 100 gpcd. The City of Fort Collins, which experiences severe problems, is attempting a target reduction from 180 gpcd to 155 gpcd has been suggested. If these reductions in I/I are achieved, the net reduction in average daily flows in treatment plants can more than double those indicated in Table 5.4.2-B.

TABLE 5.4.2-B

POTENTIAL REDUCTION IN FLOWS IN SEWAGE SYSTEMS RESULTING FROM WATER CONSERVATION MEASURES

	Existing Population	Est. year 2000 Population	Year 2000 Ave. Daily Flow (mgd)(1) Without Conservation	Weighted Year 2000 Average Daily Flow with Conservation		Percent Reduction	
				New Devel. only	All devel.	New devel.	All devel.
Loveland	29,500	69,900	7.1	6.6	6.3	7%	11%
Greeley	69,100	115,850	13.8	13.1	12.4	5%	10%
Ft. Collins	67,050	149,400	25.9	24.8	24.3	4%	6%

(1) mgd = Million Gallons Per Day

6.0 ALTERNATIVE IMPLEMENTATION STRATEGIES

The fundamental objective of 208 planning is to define the ways and means of meeting the goals of Public Law 92-500. The fishable-swimmable goal of the law is achievable from a technical standpoint. However, any assessment of the practicality and desirability of developing fishable-swimable waters in the Larimer-Weld Region must consider social and economic as well as technical factors. The entire spectrum of water quantity and quality management must be reviewed and weighed in terms of its total regional impact in defining the 1983 goal, and the application of that goal in the Region.

The 1983 goal also bears interpretation in terms of the technical assumptions and criteria made to determine pollution control strategies. As a result of the extensive analyses conducted as part of the Larimer-Weld 208 Program, including considerations for water resources, water uses, point source discharges, and non-point source discharges, four alternative strategies have been developed to achieve the 1983 goal. These strategies recognize the varying interpretation applicable in defining 1983 goals. Strategies recognize that aquatic life does exist in the plains, as well as in the mountain regimes of the Cache la Poudre River, Big Thompson, Little Thompson River, St. Vrain Creek, and South Platte Rivers. In plains reaches, this aquatic life or fishery is limited in its size and diversity by hydrologic and habitat restraints, presented previously in Section 4.0. In order to upgrade these aquatic inhabitants, modifications in hydrology and habitat would be required, in addition to point and non-point pollution control measures.

6.1 APPROACH TO STRATEGIES

Four alternative technical strategies were developed and evaluated as means of achieving applicable national water quality goals in the Larimer-Weld Region.

During the course of 208 plan development, representatives of various agencies and interests in the region have adopted a positive attitude toward maximizing creation of a desirable sport fishery in reaches of rivers that may have never historically supported such a self-propagating fish community of introduced species. Alternative plans reflect this progressive approach. Physical and administrative strategies necessary to attain a desirable fishery are explored at length. Associated costs are also depicted.

6.2 FEATURES COMMON TO ALL PLANS

All of the pollution control strategies for Larimer-Weld Region include the following fundamental characteristics:

1. All high mountain streams, i.e., flowing streams above 5,500 feet elevation, are protected against any degradation which would deter from the existing beneficial use including domestic water supply, agriculture water supply, cold water aquatic life, and recreation.

2. Major communities continue to use effective non-point source control provisions including street sweeping, litter control, stormwater retention facilities, and may adopt additional non-point source control measures when and if continued planning and monitoring demonstrates their cost-effectiveness.

3. Agricultural pollution control measures which have been projected as cost-effective in certain areas of the Larimer-Weld Region are adopted on a voluntary compliance basis by irrigators and implemented with private funds and federal cost sharing funds in specifically defined demonstration project areas. When ongoing research has documented the cost-effectiveness of control measures from the viewpoint of pollution control and farm profitability, proven best management practices (BMP's) will be implemented in other areas of the Region.

4. Secondary treatment is required at all municipal waste treatment plants as a minimum achievable level. Under some strategies, the advance waste treatment beyond secondary is also required.

The major features of the four alternative pollution control strategies are presented in Table 6.2-A, and are described in the narratives which follow. Associated costs are depicted in Section 6.7.

6.3 STRATEGY NO. 1

This strategy is based solely on meeting existing numeric water quality standards by applying higher levels of wastewater treatment where necessary to municipal and industrial discharges. The purpose of defining minimum required wastewater treatment levels requires defining three levels of treatment - secondary, tertiary, and advanced. The assumptions regarding these treatment levels are described as follows:

TABLE 6.2-A

MAJOR FEATURES AND ASSOCIATED COSTS OF ALTERNATIVE TECHNICAL IMPLEMENTATION STRATEGIES

	PROGRAM COMPONENT - COST (x $1000) (a)									
	POINT SOURCE						DREDGING			
	M & I (b)	Feedlots (b)	Agri. (b)	Urban Runoff (b)	Fish Stocking (c)	Stream Engrg. (b)	Initial (d)	Thereafter (d)	Flow Aug. (e)	TOTAL
Strategy 1 (f)										
Cap. Cost	29,945 (g)	300 (h)	100,000 (i)	4,263 (k)						134,508
Annual O & M	3,825	-	3,000 (j)	340						7,165
Equiv. Annual	6,383	22	13,000	606						20,011
Strategy 2 (l)										
Cap. Cost	26,255 (g)	300	100,000	4,263	167 (m)	220 (n)	118 (o)	118 (p)	19,305	150,746
Annual O & M	3,601	-	3,000	340	-	-	62 (q)	37 (r)	-	7,040
Equiv. Annual	5,807	22	13,000	606	9	17	47	23	1,307	20,838
Strategy 3 (s)										
Cap. Cost	11,704	300	100,000	4,263	0	68 (t)				116,335
Annual O & M	3,279	-	3,000	340	40 (m)	-				6,659
Equiv. Annual	4,220	22	13,000	606	35	6				17,889
Strategy 4 (u)										
Cap. Cost	11,704	300	100,000	4,263	-	-				116,267
Annual O & M	3,279	-	3,000	340	-	-				6,619
Equiv. Annual	4,220	22	13,000	606	-	-				17,848

Source: Toups Corporation, March, 1978.

TABLE 6.2-A (CONTINUED)

(a) Costs in terms of January, 1977, dollars.
(b) Assumes 7% interest, amortized over 20 years.
(c) Assumes 7% interest, amortized over 50 years.
(d) Assumes 7% interest, amortized over 10 years.
(e) Assumes unit cost of C-BT share = $1,300; Quota = 60%; flow augmentation implemented in Big Thompson River (15 cfs) and Cache la Poudre River (15 cfs) from May through September; 7% interest amortized over 50 years.
(f) Meet existing water quality standards - No flow augmentation. Advanced treatment required at Fort Collins Nos. 1 and 2, Boxelder S.D., Windsor, Eastman Kodak Co., Greeley Delta, and Loveland. Tertiary treatment required at Greeley First Avenue and Great Western, Loveland.
(g) Assumes plants requiring tertiary or advanced waste treatment upgrade immediately, unless such facilities are staged according to future need for additional capacity (Greeley Delta).
(h) Staged over five years.
(i) Capitol cost at an estimated average participation of 70%. Cost at 100% participation would be $140 million.
(j) Includes 50% participation in irrigation scheduling ($12/acre x 500,000 x 1/2). Miscellaneous O & M expenses are minimal and most BMP's reduce overall O & M costs. Energy costs of sprinklers are offset by reduced labor requirements and therefore not included.
(k) Control measures for urban runoff are oriented toward source control, non-structural control options, and structural options incorporated into an overall system of drainage/flood control. Construction assumed in 1980.
(l) Provide flow augmentation. Advanced treatment required at Greeley Delta. Tertiary treatment required at Fort Collins Nos. 1 and 2, Boxelder S.D., Windsor, Eastman Kodak Co., Greeley First Avenue, Loveland, and Great Western, Loveland.
(m) Based on $110 per surface acre stocked.
(n) Based on one man-year professional design time plus $500 - $2,000 per river mile for construction; includes cost of fish screens estimated to be $1,000 per ditch.
(o) Purchase of mini-dredge.
(p) New mini-dredge to be purchased in 1988.

TABLE 6.2-A (CONTINUED)

(q) Includes annual insurance premium of $3,000; assumes dredge operated continuously during the year; does not include cost of transporting, launching, or retrieving dredge; $62,000 for first four years to initially expose channel substrate in the Big Thompson and Cache la Poudre Rivers downstream from canyon mouths, and in reach of the St. Vrain River within the two-county area; $37,000 per year thereafter for channel maintenance.

(r) Assumes mini-dredge operated for seven months out of each year.

(s) Protection of existing water uses - secondary treatment - some fish stocking in selected plains river reaches.

(t) Based on 7 months of professional design time plus $500 - $2,000 per river mile for construction, includes cost of fish screens, estimated to be $1,000 per ditch.

(u) Protection of existing water uses - secondary treatment - no fish stocking in plains river reaches.

1. Secondary treatment - Assumes an effluent quality of 30 mg/l BOD_5, which is the minimum state requirement for secondary treatment; 15 mg/l ammonia which is a common value associated with secondary treatment levels in the Larimer-Weld Region; and 2 mg/l dissolved oxygen.

2. Tertiary treatment - Is the next higher level of treatment above secondary. It would be achieved through additional activated sludge processes or bio-filters. This process would reduce BOD to 20 mg/l, and ammonia to 3 mg/l due to additional nitrification inherent in these processes.

3. Advanced waste treatment - A number of alternatives were considered to achieve a level of 10 mg/l BOD and 1.5 mg/l ammonia. The alternatives included ion exchange, ammonia stripping, and break point chlorination. Ion exchange was eliminated due to extremely high operating costs, ammonia stripping does not work as well in cold climates. The selected alternative, break point chlorination, is an expensive process but it does oxidize ammonia to levels of 1.5 mg/l or less and also reduces BOD to 10 mg/l or less. Cost estimates are based on this process.

Secondary treatment is required for all dischargers throughout the nation as a minimum level of treatment. Additional treatment levels, i.e., tertiary or advanced, were required in a number of cases to meet in-stream water quality standards in the Poudre and Big Thompson Rivers.

The level of information presently available allows definition on in-stream water quality impacts of only a few constituents of municipal and industrial waste discharges, including BOD, dissolved oxygen and ammonia. The state-of-the-art of water quality modeling has not advanced to the point where impacts of a broad number of chemical constituents can be accurately or even reasonably predicted.

Many of the limitations defined in the waste load allocation processes were associated with the violation of the ammonia standard (Interim WQMP Report No. 20).

The total ammonia allowed in a stream designated as a warm water fishery has typically been 1.5 mg/l. This is equivalent to .02 unionized ammonia at a pH of 7.5 and a temperature of 68° F. While toxicity is extremely sensitive to variations of pH and temperature, these variations cannot be expressed in the water quality modeling process. This has resulted in the assumption of pH and temperature conditions and a maximum allowable ammonia level. This level has been accepted in the past by the U.S. Environmental Protection Agency and the State of Colorado as a maximum in-stream level (ECI-Toups, 1974).

Application of these treatment levels to insure no violation of in-stream water quality standards, i.e., 1.5 mg/l ammonia, results in the specification of the treatment levels under existing and future conditions as indicated by the existing and projected rates of waste discharge. The treatment level requirements necessary to meet in-stream conditions with present waste loads from municipal and industrial dischargers are shown in Table 6.3-A. Table 6.3-B shows the level of treatment required in the Year 2000 by municipal and industrial dischargers to meet in-stream water quality standards.

Following specifications of these treatment levels, the cost of this alternative was calculated over the planning period, i.e., 1977 to Year 2000, and is presented in Table 6.3-C.

6.4 STRATEGY NO. 2

Strategy No. 2 would include advanced waste treatment for municipal and industrial discharges on the Lower Poudre, flow augmentation on the Poudre (15 cfs) and on the Big Thompson (15 cfs), dreging of the Poudre and Thompson to expose substrate required for fish propagation, recreational enhancement, fish stocking, and stream engineering to provide fishery habitat. Flow augmentation will be limited to the period of April through October. During the remainder of the year, it is assumed that through stream engineering, adequate fish habitat could be maintained in the plains to ensure survival of a variety of fish species. The validity of this assumption has not been field tested.

Implementation of Strategy No. 2 would enable upgrading of the fisheries to support a wide variety of sport fish and enable limited propagation of fish life in the plains areas.

This strategy includes the following provisions:

- Augmentation flows be provided;
- Channel substrate be exposed and maintained through initial and on-going programs of dredging;
- In-stream and channel habitat commensurate with requirements of a desirable sport fishery be created or enhanced;

TABLE 6.3-A TREATMENT LEVELS NECESSARY TO MEET PRESENT WATER QUALITY STANDARDS BY EXISTING MAJOR MUNICIPAL, AND INDUSTRIAL DISCHARGES

BASIN DISCHARGER	TREATMENT LEVEL REQUIREMENT
CACHE LA POUDRE	
Fort Collins No. 1	Tertiary
Fort Collins No. 2	Advanced
Boxelder S. D.	Advanced
Windsor	Tertiary
Kodak	Tertiary
Greeley-1st. Ave.	Tertiary
BIG THOMPSON	
Estes Park	Secondary
Upper Thompson	Secondary
Loveland No. 2	Tertiary
Great Wester-Loveland	Tertiary
Milliken	Secondary
LITTLE THOMPSON	
Berthoud	Secondary
Great Western-Johnstown	(Cooling Water Discharge)
Johnstown	Secondary
ST. VRAIN	
Tri-River S.D.	Secondary
Erie Water and Sanitation District	Advanced
SOUTH PLATTE	
Fort Lupton	Secondary
Public Service-Ft. St. Vrain	(Cooling Water)
Hill-N-Park	Secondary
La Salle	Secondary
Evans	Secondary

TABLE 6.3-B YEAR 2000 TREATMENT LEVEL REQUIREMENTS NECESSARY TO MEET PRESENT WATER QUALITY STANDARDS BY MAJOR MUNICIPAL, AND INDUSTRIAL DISCHARGES

BASIN DISCHARGER	TREATMENT LEVEL REQUIREMENT
CACHE LA POUDRE	
Fort Collins No. 1	Advanced
Fort Collins No. 2	Advanced
Boxelder S.D.	Advanced
Windsor	Advanced
Kodak	Advanced
Greeley-1st Ave.	Closed
BIG THOMPSON	
Estes Park	Combined with/ UTSD
Upper Thompson	Secondary
Loveland No. 2	Advanced
Great Western-Loveland	Tertiary
Milliken	Secondary
LITTLE THOMPSON	
Berthoud	Secondary
Great Western-Johnstown	(Cooling Water Discharge)
Johnstown	Secondary
ST.VRAIN	
Tri-River S.D.	Secondary
Erie Water and Sanitation District	Advanced
SOUTH PLATTE	
Fort Lupton	Secondary
Public Service-Fr. St. Vrain	(Cooling Water)
Hill-N-Park	Secondary
La Salle	Secondary
Evans	Secondary
Greeley-Delta	Advanced

TABLE 6.3-C PROJECTED COSTS - WASTEWATER TREATMENT FACILITIES IMPROVEMENTS FOR STRATEGY NO. 1

Existing Water Use Classifications and Standards

WASTEWATER DISCHARGE	FLOW (mgd)		CAP. COST ($1000) (c)	AVG. O&M COST ($1000/Yr.) (d)	PRESENT WORTH ($1000)			EQUIV. ANN. COST ($1000/Yr.)
	1977-2000 AVG.	2000			CAP. REC. (c)	O&M (d)	TOTAL	
CACHE LA POUDRE RIVER								
Ft.Collins #1(e)	6.0	6.0	1,900	377	1,900	3,998	5,898	557
Ft.Collins #2(e)	7.2	9.0	1,400	518	1,400	5,487	6,887	650
Boxelder S.D.(e)	0.75	1.0	673	90	673	954	1,627	154
S.Ft.Collins S.D. (e)	1.0	1.4	-	110	-	1,165	1,165	110
Windsor (e)	1.2	1.7	1,220	74	1,220	789	2,009	190
Eastman Kodak Co.(e)	0.9	1.0	4,306	110	4,306	1,169	5,475	517
Greeley-1st Ave.(g)	6.0	(h)	2,400	425	2,400	4,506	6,906	652
Greeley-Delta(e)(i)	4.5	11.5	9,576	570	7,000	6,037	13,037	1,231
OUTLYING AREA (f)	1.22	2.06	1,472	128	1,247	1,527	2,774	262
Subtotal	28.77	33.66	22,947	2,402	20,146	25,632	45,778	4,323
BIG THOMPSON RIVER								
Loveland (e)	5.3	6.1	2,320	505	2,320	5,346	7,666	724
Great Western-Loveland (g)	4.3	4.3	1,050	109	1,050	1,155	2,205	208
Johnstown (f)	0.31	0.38	105	16	105	170	275	26
Milliken S.D.(f)	0.34	0.40	410	28	410	297	707	67
OUTLYING AREA (f)	1.88	2.87	316	549	316	5,816	6,132	579
Subtotal	12.13	14.05	4,201	1,207	4,201	12,784	16,985	1,604

Source: Toups Corporation, March, 1978

TABLE 6.3-C (CONTINUED)

WASTEWATER DISCHARGE	FLOW (mgd)		CAP. COST ($1000) (c)	AVG. O&M COST ($1000/ Yr.) (d)	PRESENT WORTH ($1000)			EQUIV. ANN. COST ($1000/ Yr.)
	1977-2000 AVG.	2000			CAP. REC. (c)	O&M (d)	TOTAL	
ST. VRAIN RIVER								
OUTLYING AREA (f)	.99	1.2	795	54	713	705	1,418	133
SOUTH PLATTE RIVER								
OUTLYING AREA (f)	2.48	3.88	2,002	162	1,725	1,711	3,436	323
TOTAL-Larimer-Weld	44.37	52.79	29,945	3,825	26,785	40,832	67,617	6,383

(a) Costs in terms of January, 1977, dollars. Annual interest rate 7%.
(b) Secondary treatment, tertiary treatment, or advanced treatment as appropriate to meet ammonia receiving water standard.
(c) Immediate construction of tertiary or advanced treatment facilities assumed, except when construction phased (Greeley-Delta).
(d) Secondary O & M costs from 1978 budgets. For Greeley and Ft. Collins, total annual budget apportioned between facilities. Tertiary and advanced treatment costs from National Commission on Water Quality.
(e) Advanced treatment, 1.5 mg/l ammonia effluent concentration.
(f) Secondary treatment.
(g) Tertiary treatment, 3.0 mg/l ammonia effluent concentration.
(h) Greeley-1st Ave. plant to be abandoned prior to 2000.
(i) Although service area is in Cache la Poudre basin, discharge is to South Platte River.

Source: Toups Corporation, March, 1978

- Waste loads tributary to streams be reduced to levels which will support long-term survival and perpetation of a desirable sport fishery;
- Plains river reaches be initially stocked with sound breeding populations of desirable sport fish;
- Recreational opportunities on main-stream rivers, including access, be improved.

The specific requirements associated with this alternative are described below.

6.4.1 Flow Augmentation in Plains River Reaches

A lack of flow in volumes adequate to continuously sustain the hydrologic regime of plains area rivers is a major impediment to maintenance of a self-propagating, desirable fishery in reaches downstream from canyon mouths. The concept of flow augmentation addresses the problem of water quantity deficiency.

The analysis presented herein focus on the following topics:

- Definition of in-stream flow requirements;
- Strategies for streamflow maintenance.

6.4.1.1 Definition of In-Stream Flow Requirements

Methodologies available for evaluating the aquatic habitat and determining in-stream flows for its preservation are oriented toward the biological components of the aquatic environment (Arnette, 1976). These analytical procedures can be directed toward specific biological phenomenon, such as spawning or incubation, or may be directed toward the entire life cycle of a species. A comprehensive report was recently sponsored by the U.S. Fish and Wildlife Service which evaluates the state-of-the-art of methodologies for determining streamflow requirements for fish, wildlife, water quality, recreation, aesthetics and other in-stream uses. The investigation also recommends needed research and development (Stalnaker & Arnette, 1976). Instream flow strategies typically exhibit several generalized features. These include:

- A description of the physical characteristics of the stream at various conditions of flow;
- An estimation of the habitat requirement of a particular species of fish;

- An evaluation of the manner in which physical parameters satisfy the requirements of the species.

6.4.1.1a Tennant or Montana Method

Certain methodologies rely on historic records of flow to define the discharge required to maintain aquatic habitat and related plant and animal life. Available flow data is correlated to needs of an aquatic system. One of these procedures, the Tennant or Montana Method, has received widespread use (Tennant, 1975). Evaluation of aquatic habitat is based upon generalized empirical relationships observed to exist betweeen flows and quality of a stream ecosystem. These empirical relationships as defined by the Tennant method are presented in Table 6.4-1-A.

TABLE 6.4.1-A. TENNANT OR MONTANA METHOD

NARRATIVE DESCRIPTION OF FLOWS	RECOMMENDED BASE FLOW REGIMES OCT. - MAR.	APR. - SEPT.
Flushing or Maximum	2%-0% of the average flow	
Optimum Range	60%-100% of the average flow	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degrading	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	10% of average flow to zero flow	

The method provides a relatively unsophisticated means of calculating "order of magnitude" flows which would result in various generalized conditions of an aquatic environment.

A base flow condition of sixty percent of mean annual flow is recommended to provide excellent to outstanding habitat for most aquatic life forms during primary periods of growth. Excellent aquatic habitat will be provided by resulting channel widths, depths, and velocities (Tennant, 1975). Shallow riffle and shoal areas, as well as most normal channel substrate, will be covered with water. Channel tributaries that typically convey water will exhibit satisfactory flows. Few gravel bars will be exposed. Wildlife nesting, denning, nursery, and refuge habitat will be provided in the riparian environment.

Most streambank areas will serve as safe denning areas for wildlife (providing land use does not encroach to the stream bank) and will provide fish cover. Excellent feeding and nursery habitat for fish will be maintained because most pools, runs, and riffles will be adequately covered with water. Fish migration will not be obstructed in riffle areas. No stream reach is anticipated to be limited by water temperature. Presence of invertebrate life will be varied and abundant.

Base flow at thirty percent of mean annual flow is recommended to sustain good survival habitat for most aquatic life forms (Tennant, 1975). With the exception of very wide, shallow riffle and shoal areas, the majority of substrate will be inundated. Some water will be evident in most stream tributaries. Gravel bars will be partially covered. Most pools and many runs will exhibit depths that will maintain fish cover. Riparian vegetation will not lack water. Large fish will be able to migrate through most riffle areas. Water temperatures will not be a limiting factor in most stream reaches. Although invertebrate life will be reduced, the occurrence should not limit fish production.

Ten percent of mean annual flow is considered a minimum or poor condition necessary to sustain a short-term survival environment for most aquatic life (Tennant, 1975). The aquatic habitat will be degraded by the significant reduction in channel widths, depths, and velocities. Generally, about one-half of the stream substrate or wetted perimeter will be exposed. Exposure could be greater in wide, shallow riffle or shoal areas. Tributaries will exhibit no or extremely low flows. Most gravel bars will be uncovered except for narrow bands. Streambank cover will be impaired for fish and wildlife habitat. Fish will generally migrate to the deepest pools due to shallow flow throughout most wetted areas. Riffle areas will obstruct travel of large fish. A severe reduction of invertebrate life will occur. Temperature of water may be a limiting factor. This is especially likely during summer in downstream reaches of a stream.

6.4.1.1b Additional Methods

Other procedures for evaluating in-stream habitat relate to measured hydraulic parameters, including velocity, depth and width at various flows to availability of specific aquatic habitat at that flow. Such methodologies attempt to predict flows necessary for a desired level of habitat retention by means of the hydraulic parameter/flow relationhip.

The foregoing methodologies, when not extended beyond their original design, provide an adequate means of assessing flows (Arnette, 1976). There are important additional areas that must be more specifically dealt with. These include:

- o Evaluating the range of effects that result from incremental augmentations or reduction of flow in a stream channel;
- o Assessing the cumulative, long-range ecological effects of permanent increases or decreases in flow;
- o Determining the total impact of altered flow on an aquatic system.

The U.S. Fish and Wildlife Service is implementing a program directed toward formulating a methodology capable of addressing the complex ecological effects of manipulated streamflow. The agency has assembled a Cooperative Instream Flow Service Group as a satellite of the agency's Western Energy and Land Use Team in Fort Collins, Colorado. The Service Group is composed of individuals with a variety of organizational and disciplinary backgrounds. The biological and decision-making components of instream flow requirements are being addressed in a coordinated program of research, development and implementation. Procedures have presently been developed that establish water quality standards for depth, velocity, substrate and temperature.

Methodology was prepared which permits direct determination of impacts upon target fish species selected for analysis under proposed water quality and/or water quantity management strategies. A manual has been assembled which provides an analyst a means by which to evaluate many of the unknowns associated with distribution and condition of aquatic habitat and streamflow.

The Service Group technology considers a wide variety of biological and physical parameters. Fish exhibit five life stages: spawning, egg, fry, juvenile and adult. Changes in a stream environment may disrupt any or all of these life stages. Principal considerations are related to alterations in water depth, current velocity and temperature.

The effect of changes in critical parameters on each of the life stages are computed from curves incorporated in the methodology. Curves are weighted and illustrate the optimum condition, as well as upper and lower limits, for species survival and growth (Instream Flow Group, 1977). The average standing crop of a species is established for each representative stream reach. Survival and electivity (behavior) curves are used to interpret effects of changes in velocity, depth and temperature. Possible changes in fish populations in various stream reaches are then determined using the appropriate curves.

The methodology developed by the Service Group enables an analyst to identify critical fish life history stages as well as critical times of the year that have the greatest impact on the instream fishery. The method also permits definition of the type of fishery and the standing crop achievable by implementation of management options. This is derived by quantifying streamflow requirements necessary to support the desired type of fishery (Stalnaker, 1977). To date, the Instream Flow Service Group methodology has not been applied to any species in Larimer-Weld streams.

6.4.1.1c Recommended Instream Flows

The Colorado Division of Wildlife has been consulted in an effort to determine minimum low flow requirements for the purpose of sustaining a fishery in the streams of Larimer and Weld Counties. The Division has developed data only on streams that support a cold water fishery or that have the potential to do so. The Division's definition of a cold water fishery is one which will support trout. The Division has not developed criteria for determining low flow survival conditions in warm water streams.

The Division of Wildlife has developed recommendations for instream flow based on the Tennant method (Kochman, 1977). Features corresponding to various criteria are summarized in the following narrative. The Division does not use the term "minimum flow", maintaining the term is meaningless. Flow rates are based on biological and hydrological factors sustained annually or in sequential monthly increments that permit development of specific instream conditions.

- Optimum Instream Flow:

  This magnitude of flow will allow optimum development of aquatic habitat, related fish production, and recreational use. An optimum flow condition requires that peaks be reduced and low flows be increased. This stabilized situation is generally only attainable below dams, where flow is controlled.

- Required Instream Flow:

  This level of maintenance is the basic objective of the Division of Wildlife. Required flows will support the existing condition of aquatic habitat, associated rate of fish production and corresponding levels of recreational use, or will restore the stream environment to "reasonable" levels.

- o Degrading Instream Flow:

  This rate of flow will result in degradation of existing or reasonable established conditions of aquatic habitat, including fish production rates and associated recreational use. Degraded instream flow can be considered a survival condition.

Streamflow conditions identified by the Colorado Division of Wildlife as necessary to sustain cold water fisheries in the main-stem Cache la Poudre and Big Thompson Rivers are itemized in Table 6.4.1-B.

TABLE 6.4.1-B. MINIMUM FLOWS - COLD WATER FISHERY

RIVER	FISH CONDITION	SEASONAL FLOW (cfs)		RIVER REACH
Cache la Poudre		May Sept.	Oct. April	
	Required	65	30	Headwaters to Fort Collins municipal intake
	Survival	10-15	10-15	Downstream from Greeley municipal intake
Big Thompson		Apr. Sept.	Oct. March	
	Degrading	38	10-15	Below site of Loveland power plant

6.4.1.2 Strategies for Streamflow Maintenance

Maintaining a live stream condition in the rivers of the region involves supplying flows through reaches that presently are subject to seasonal depletion. There exist a number of conceptual strategies by which streamflow can possibly be maintained. Among these are included the following options:

- o More efficient use of irrigation water;
- o Increased upstream reservoir storage capacity;
- o Water exchanges;
- o Scheduling of diversions to optimize instream flow;
- o Purchase of water rights for flow augmentation;
- o Winter reservoir storage release.

Features of these alternative options are discussed in the sections which follow.

6.4.1.2a More Efficient Use of Irrigation Water

Irrigation is the practice of applying water to land for the purpose of eliminating moisture deficiency as a limiting factor of crop production. The need for irrigation is particularly pronounced in an arid region such as Larimer-Weld, where growing season rainfall often does not occur at the proper time or in sufficient quantities to satisfy the requirements of various crops. Features of an irrigation system consist of a developed water supply source, a conveyance system to the farm, on-farm distribution and application facilities, means of wastewater disposal, and a management structure capable of ensuring effective system operation. Each of the foregoing system components is amenable to physical or managerial improvements that will enable total overall system performance to approach optimal levels of water use efficiency. Improvement in irrigation efficiency in the region can be accomplished by several methods:

- Canal and lateral lining;
- Highly efficient application methods;
- Tailwater recovery;
- Irrigation water management.

o Canal Lining

Lining of canals and laterals not only eliminates channel seepage, it also curtails evapotranspiration losses associated with vegetation in and along unlined irrigation water conveyance facilities.

Canal lining is expensive. Cost estimates are presented in Interim WQMP Report No. 26, Best Management Practices for Irrigated Agriculture in the Larimer-Weld Region. The range of costs are summarized as follows:

Farm ditches: $3.00 - $3.60 per linear foot ($15,800 - $19,000 per mile)

Laterals: $20.00 per linear foot ($105,000 per mile)

Major ditches: Up to $500,000 per mile

o More Efficient Application Methods

The amount of irrigation water necessary to ensure satisfaction of crop consumptive use requirements can be reduced by employing efficient application methods. Sprinkler irrigation represents an option in the two-county area. The application rate can be regulated to closely approximate the consumptive irrigation requirement of the crop plus the desired leaching fraction to carry harmful salts away from the crop rootzone. This application method is generally superior to flood or furrow irrigation systems because water application can be closely regulated to rates commensurate with crop and leaching requirements.

Capital cost of sprinkler systems is approximately $430 per acre irrigated. This price includes a center pivot system, electric system to the facility, and pipeline to the structure. It does not consider cost of power, well installation or pumps.

o Tailwater Recovery

The two basic methods of tailwater recovery include downslope transfer systems and pumpback systems. In downslope transfer, runoff from one field discharges by gravity to a field of lower elevation. This runoff is diluted with an alternate irrigation supply and the blend is used to irrigate the lower field. The method of downslope transfer is satisfactory provided that irrigation timing can be regulated effectively, that more than one field is owned by the farmer, and that topographic constraints allow the method to be implemented.

In a tailwater pumpback system, runoff is collected in a ditch at the lower end of a field and conveyed to a sump. Pumping facilities in the sump reintroduce tailwater to the head ditch for recycling. The pumpback system can completely eliminate surface runoff. Conservation of irrigation water can be significant. In contrast to the downslope transfer method, the tailwater pumpback system can be effectively employed on the most-downslope field.

o Irrigation Water Management

Irrigation water management involves timing and regulating water applications at rates that can be held in the soil to satisfy crop water requirements without inducing runoff, excessive percolation, or erosion. Water management is based on sound agricultural experience and knowledge, oriented toward conserving irrigation water and soil resources.

With any application method, an overriding factor which influences field application efficiency is the skill of the irrigator and the interest such an individual exercises in employing acquired skills in practicing good water management. A high application efficiency will not be achieved unless an irrigator applies water according to crop requirements at rates commensurate with soil intake ability.

o Legal Implications

During the irrigation season, seepage and tributary inflow (returns) represent a significant source of recharge to the surface water system of the region. Municipal and industrial discharges contribute relatively minor inflows. Table 6.4.1-C summarizes data representative of the magnitude of the foregoing accretions.

TABLE 6.4.1-C. INFLOW OF SEEPAGE AND RETURNS (a)

Stream	River Miles	Seepage cfs/mile	Tributary Inflow (Returns) cfs/mile	Municipal/ Industrial Discharges cfs/mile
Cache la Poudre	50	3+	1+	Less Than 1
Big Thompson	30	1-1/2	2/3	1/5
Little Thompson	25	1-1/2	1/4	Negligible
St. Vrain	22	4+	1+	1/4
South Platte	60	Less than 2-1/2	3	Negligible

(a) Within plains reaches of Larimer-Weld regional streams during irrigation season.

In many areas of the Larimer-Weld Region, irrigators depend wholly or in part on agricultural returns, regardless of quality, for their supply source. A serious legal consideration arises if elimination or diminishing of returns impairs water rights of downstream users. Court cases have already been initiated by various irrigators in the Cache la Poudre drainage who claim damaged water rights resulting from reduction in returns by upstream irrigators.

It should be emphasized that existing water application rates in the region are not generally excessive. Per acre water use by irrigated agriculture in the Poudre basin is on the order of 3 acre-feet diverted at the canal headgate and 2 acre-feet at the farm (Neutze, 1977).

o Priority System

The strategy of improving on-farm water use efficiency in order to increase main-stem river flows by reducing diversion requirements does not appear to have practical applicability to surface water systems in the region because of the priority system of Colorado water law and the over-appropriated status of surface waters. Available flows not called for by a senior appropriator are available for use by the most junior priority. Diversion point of the junior ditch may be above or below the headgate of the senior divertor. If the junior right is upstream, benefit to main-stem hydrology will be even less than if the senior appropriator did not implement improved water conservation practices.

Should additional supplies become available through increased water use efficiency, it is likely that new acreage would be put to irrigation under existing ditch systems, rather than be left in the stream.

6.4.1.2b Increased Upstream Reservoir Storage Capacity

In Larimer and Weld Counties, reservoirs with the earliest and best water rights are located in the plains area. Mountain reservoirs typically possess relatively poor rights. According to Colorado water law, the premise of storing water out of priority is acceptable. High mountain reservoirs possessing low priorities can therefore be filled early in the season. A strategy for streamflow maintenance involves storing water designated for downstream reservoirs with high priority water rights in mountain reservoirs with low decrees. Flows could be gradually released in the summer, thus maintaining a live stream condition to the downstream reservoir inlet. Releases would be continued until the volume of reservoir decree was eventually satisfied. Rights of many plains reservoirs are such that flow could continue well into the summer. It should be noted that this strategy for stream maintenance was implemented to an extent in the Cache la Poudre River system during 1976. Windsor, Fossil Creek, and Timnath Reservoirs were downstream storage facilities involved in the management exercise. These impoundments possess very good decrees. Mountain reservoir storage was provided by Longdraw Reservoir.

One strategy which represents a very promising method of keeping water in the stream system involves aggregating the decrees held by the small, high priority reservoirs in the downstream end of the Poudre basin to form a new, very large reservoir upstream. The proposed Grey Rocks Reservoir at the confluence of the North Fork and main-stem Cache la Poudre has potential in this regard. Presence of this impoundment in the upstream end of the Poudre system would provide a great deal of flexibility in regulating supplies to sustain flows in the river for fish maintenance. Under a system incorporating the proposed new reservoir, continuous flow could be maintained downstream to Whitney Ditch near Windsor (Neutze, 1976). Creation of additional large reservoirs in the upper end of the Poudre is also economically attractive because downstream facilities have lost a great deal of capacity during the last century due to siltation.

The City of Fort Collins is presently in the process of constructing Joe Wright Reservoir on Joe Wright Creek, a tributary of the Cache la Poudre rising at the Continental Divide in Larimer County. The new facility will replace an existing smaller, outdated structure. Total reservoir capacity will be 7,840 acre-feet, a volume which includes a conservation pool of 10 percent. Firm yield of the project is considered to be 6,360 acre-feet (Liquin, 1977).

Construction of the reservoir was initiated in June of 1977. The facility will be operable by November, 1978. Total project cost is on the order of $6.3 million.

Reservoir management during the first year of operation involves releasing 5,000 acre-feet for agricultural use and 1,350 acre-feet for municipal and industrial use in Fort Collins. For the second through twentieth year period, the release schedule will be adjusted to supply agriculture and the city 4,800 and 1,550 acre-feet, respectively (Liquin, 1977).

Agricultural water supplies will be made available to ditch companies on a lease basis. The main-stem Poudre River will serve to convey flows to points of delivery at canal headgates. The downstream extent to which in-stream flow is maintained in the Poudre by Joe Wright releases will depend on the diversion locations of ditches participating in the water rental program.

Should a mutually beneficial agreement be formulated, Joe Wright Reservoir could serve to store ditch company water that otherwise would be impounded in downstream company-owned reservoirs. Agriculture water suppliers have expressed a desire to the City of Fort Collins to perfect such an arrangement. Interest is motivated by deteriorating condition or loss of storage capacity exhibited by many plains reservoirs. Obtaining capacity in Joe Wright Reservoir could represent a less expensive alternative to rejuvenating existing facilities. Warren Lake, Windsor Reservoir, or any other downstream impoundment could be potentially affected should the high mountain storage option prove to be a desirable and implementable management strategy. Main-stem Poudre flows would be sustained by Joe Wright Reservoir releases throughout the river reach upstream from participating ditch headgates.

It is anticipated that general irrigation season operational strategy for Joe Wright Reservoir will prescribe release of water in relatively low volume for short duration rather than discharge a continuous low flow over long periods (Liquin, 1977). Flows would be utilized directly by ditch companies or impounded in reservoirs for delayed usage. The City of Fort Collins occasionally draws from the Cache la Poudre River out of priority. The City will very likely authorize storage releases at times when it has accumulated a debt to the river of 1,000 acre-feet or so. Constraints imposed by the Joe Wright Reservoir permit limit regulated releases to a maximum of 300 cfs. A 1,000 acre-foot debt would typically be repaid by a discharge of 100 cfs for 5 days, or other comparable rate-duration relationships.

Because of naturally occurring low flow winter conditions in Poudre Canyon, water may not be available in quantities sufficient to satisfy the municipal diversions of Fort Collins and Greeley. In the past, these cities have elected to augment river flow with releases from their high mountain reservoirs. Recent augmentation took place from December, 1976, to the time of spring snowmelt in 1977. Joe Wright Reservoir will very likely be operated in a similar manner, should low winter flows in the Cache la Poudre warrant it.

The possibility of using Joe Wright Reservoir flows to sustain survival flows in the Poudre downstream from the canyon mouth should not be discounted. Such a program would entail conveyance of flows throughout a prescribed river reach, and subsequent collection of water in downstream storage facilities. The City of Fort Collins would receive credit for the volume of released flow in the following year. Program implementation has inherent problems. Water rights downstream of Fort Collins may not be sufficient to reimburse the city for its water delivery. Investigation of the feasibility of this alternative and its actual beneficial effects will require extensive analysis.

6.4.1.2c Water Exchanges

Satisfaction of diversion priorities in the Cache la Poudre River system, and to a minor extent in that of the Big Thompson, are presently met by a system of management and exchange of water rather than on a priority basis. In the Poudre district, this arrangement applies only to members of the Cache la Poudre Water User's Association. Priorities are often met by release of water from storage. It is understood that should a subsequent year be one of less than average runoff and reservoirs remain unfilled, the diverter will owe waters to the storage company.

To satisfy the water rights of senior diverters, the present system of exchange may dry up native river flow in the reach between an upstream point of diversion and a downstream point where the exchanged water is reintroduced to the stream from storage. Recharge to the river in the affected reach may be in the form of irrigation returns, discharges, and seepage.

Augmenting river flows by exchange could prove feasible through use of water intended for power plant cooling. The Platte River Power Authority (PRPA) has proposed construction of a coal-fired electric generating facility on a site approximately 10 miles north of Wellington in Larimer County. Strategies for conveying cooling water to the PRPA Rawhide power plant location are conceptual in nature at this time. Source water is anticipated to come from the western slope, delivered through facilities of the proposed Windy Gap and existing Colorado-Big Thompson Projects. This water is expected to be used directly, by exchange, or by a combination thereof. PRPA has a 1/3 interest in the Windy Gap Project. Source water for use or exchange would be delivered to Horsetooth Reservoir.

Preliminary alternatives for supplying the PRPA Rawhide plant involve gravity conveyance of water through ditch company facilities for subsequent pumping to the plant site.

The initial 230 megawatt unit planned for construction in about 1984-85 will require an on-site cooling reservoir with a surface area of approximately 400 acres (Hollenbeck, 1977). Capacity of the impoundment is preliminarily judged to be on the order of 9,000 acre-feet. This reservoir would allow proper cooling of water as well as provide operating flexibility to meet contingencies in supply conditions that might develop.

A closed cooling water system is proposed for the PRPA plant. Reconnaissance engineering evaluation indicates that the 230 megawatt unit will need an annual make-up water supply of about 5,000 acre-feet. Precise determination will be possible only when the recommended strategy for water supply and conveyance is developed. This is attributable to unknowns associated with water quality and transportation/reservoir losses.

Expansion of the Rawhide power plant is anticipated to occur at intervals spaced approximately 10 years apart. Generation capability of 500 megawatts would be available in about 1994. Final expansion to 750 megawatts, should it occur, would take place in about the year 2004. Cooling water make-up for the 750 megawatt plant would require a supply of approximately 12,000 acre-feet annually.

PRPA would like to implement a cooling water supply strategy that would be mutually beneficial to the utility and the respective ditch company or companies involved in water delivery. The seasonal nature of water supply and irrigational use in the region open up possibilities for off-season PRPA use of ditch company storage reservoirs. Such an arrangement would maintain the size of the on-site PRPA reservoir at a level sufficient to dissipate heat and provide for contingencies only. Winter usage of ditch company supplies by PRPA would be replaced on an exchange basis by delivery of Windy Gap water through Horsetooth Reservoir during the irrigation season.

Because the PRPA cooling water supply strategy is presently at the preliminary planning stage, opportunity exists for the Colorado Division of Wildlife or other interested agencies or entities to approach the utility for the purpose of mutually examining conceptual supply alternatives. The potential exists for transporting PRPA flows in a manner that would augment flows in various reaches of the main-stem Cache la Poudre River.

The release of PRPA make-up water to the main-stem, corresponding to 5,000 acre-feet per year for the initial 230 megawatt unit, would result in maintaining survival flows at about 17 cfs during the irrigation season. Stream losses charged on storage discharges represent approximately five to ten percent of the released total (Harrison, 1976). Hence, an additional quantity of water on the order of 250 to 500 acre-feet will be needed to replenish the PRPA cooling water requirement. Based on an acre-foot market value of about $1,300, for C-BT project water, and assuming a delivery quota of 60%, this represents an expenditure of $542,000 to $1,083,000.

The most practical and economical means of conveying cooling water supplies to the proposed PRPA plant involve utilizing existing gravity flow facilities to the fullest extent possible. As indicated previously, topographic location of the plant will necessitate that water be pumped through the final reach of the delivery system.

Facilities of the North Poudre Irrigation Company represent a conveyance system which would provide an optimal gravity flow condition. Source water would be Cache la Poudre River flow, used by exchange for Windy Gap water discharged through the Hansen Supply Canal. Problems may be encountered with adequate volumes of river flow available for exchange. Should an arrangement with North Poudre Irrigation Company be implementable, flows could be diverted by North Poudre Supply Canal (Monroe Gravity Canal), conveyed to North Poudre Ditch, and discharged to Clark Lake or Indian Creek Reservoir. Stored water would then be pumped to a reservoir located at the PRPA plant site.

Diversion and conveyance of flows in facilities of the Water Supply and Storage Company is an alternative to the North Poudre Supply Canal strategy that would augment flow in the main-stem Poudre River. Utilizing the Larimer County Canal as a point of diversion would serve to sustain river flow in a reach of the Poudre 7 miles below the North Poudre Supply Canal headgate or 1.8 miles below the Hansen Supply Canal, depending upon whether exchanged native river flow or Windy Gap Project water is used as the supply source for powerplant cooling. Rocky Ridge Lake Reservoir No. 1 could serve as the northerly terminus point on the Water Supply and Storage Company system. Transmission to the PRPA plant site would then be accomplished by a system of pumps and pipelines.

Flows intended for use by PRPA could be introduced and/or kept in the channel of the Poudre to a location immediately upstream from Fort Collins WWTP No. 1. This point represents a downstream limit to the section of the river classified as a cold water fishery. This flow augmentation strategy would require that water be conveyed to the PRPA plant site exclusively by pumping. Acquisition of PRPA water adjacent to the wastewater treatment plant would probably not permit any portion of cooling water transmission outside the main-stem to be accomplished by gravity flow.

The use of PRPA flows to augment available river flow would very likely only be practical during the warmer portion of the year. Operation would be generally limited to the five-month period May through September when delivery components of the C-BT Project are normally in use. Winter conditions of low flow in the Poudre would severely restrict the use of river water for cooling purposes. Some type of exchange-storage program could possibly be formulated; however, volume of winter flow involved would probably be relatively small. Considering the annual volume of make-up water required at the PRPA site, 5,000 acre-feet, flows in the Poudre could be augmented by about 17 cfs from May to September.

The three alternatives reviewed herein have been analyzed in terms of facilities required and costs of construction, power and operation/maintenance. Details are summarized in Table 6.4.1-D.

6.4.1.2d Scheduling of Diversions to Optimize In-Stream Flow

Many ditches in the Larimer-Weld region possess water rights which entitle them to divert quantities of water that correspond to the entire flow of the river during storage or irrigation seasons. These diversions were identified in a previous section of this report. The strategy of scheduling such diversions to

TABLE 6.4.1-D. COMPARISON OF ALTERNATIVES

COOLING WATER SUPPLY TO PROPOSED PRPA PLANT (a)

	NORTH POUDRE SUPPLY CANAL (b)	LARIMER CO. CANAL (c)	FT. COLLINS WWTP NO. 1 (d)
Number of pump stations (e)	2	3	5
Length of pipeline (f) miles	7.0	12.6	18.7
Costs, $1000 (g)			
Pumping facilities, capital cost	1,826	2,846	4,640
Pipeline, capital cost	1,504	2,715	4,030
Subtotal, capital cost	3,330	5,561	8,670
Pumping facilities, annualized capital cost (h)	162.2	252.8	412.2
Pipeline, annualized capital cost (h)	133.6	241.2	358.0
Subtotal, annualized capital cost (h)	295.8	494.0	770.2
Annual power cost	977	1,520	2,492
Annual O&M cost (i)	150	225	376
Total Annual Cost	1,422.8	2,239	3,638.2

(a) Does not consider equalizing ponds associated with pump stations, ditch conveyance costs, or cost of river transport losses.
(b) Gravity flow to Indian Creek Reservoir, pumping to PRPA plant site.
(c) Gravity flow to Rocky Ridge Lake Reservoir No. 1, pumping to PRPA plant site.
(d) Pumping to PRPA plant site from a point immediately upstream from Fort Collins WWTP No. 1.
(e) 100 mgd capacity.
(f) Assumes 2 parallel lines, 16-inch O.D.
(g) January, 1977 prices (ENR 2148).
(h) Assumes 8% interest, amortized over 30 years.
(i) Exclusive of power.

optimize in-stream flow has little merit because of the inherent characteristic of hydrology in the two-county area. Demands of irrigators require that river systems be managed to meet simultaneously-occurring needs.

6.4.1.2e Purchase of Water Rights

In Colorado, there exists no express statutory authority for the Division of Wildlife to condemn existing water rights and convert them to in-stream flow uses. Senate Bill No. 97, effective July 1, 1973, provides for the appropriation of water by the State of Colorado to protect the natural environment. The Colorado Water Conservation Board is vested with authority to appropriate "such waters of natural streams and lakes as may be required to preserve the natural environment to a reasonable degree". The legislation "in no way should be construed as authorizing any state agency to acquire water by eminent domain". Hence, the State Water Conservation Board must supply any water to be used for stream maintenance by purchasing reservoir rights, foreign water such as C-BT, or existing river priorities.

Ability of the Colorado Water Conservation Board to appropriate water or purchase water rights for the purpose of instream flow maintenance for environmental and recreational uses was authorized by amending the legal definition of beneficial water use to include in-stream uses. The Colorado Division of Wildlife is charged with the job of recommending streamflow requirements to the Water Conservation Board. The intent of S.B. 97 is to provide a reasonable degree of protection to stream environments of Colorado within the existing legal framework of water law (Weaver, 1976).

S.B. 97 creates an opportunity to allocate water rights for in-stream flow purposes through donation, sale, or lease in order to allow water to be legally managed for flow augmentation. Although appropriations acquired through S.B. 97 will generally be the most junior decrees on over-appropriated streams, the state acquires a better legal position to protect the stream in water court cases involving applications for changes in use, place of use, and points of diversion.

Operational and legal implications make it impractical for the State Water Conservation Board to introduce a flow for stream maintenance purposes and merely let it travel downstream. This action would involve bypassing high priority diversions and allowing low priority diverters to acquire water at the low end of the system. If it seeks to own water for live stream maintenance, the Water Conservation Board should subsequently sell any such water and have a point at which it is delivered, or determine a point at which flows become river water and hence available for diversion.

Purchase of units of Colorado-Big Thompson Project (C-BT) water by the Colorado Division of Wildlife probably represents one of the more practical options available to the agency for guaranteeing desired flow conditions in various reaches of the Cache la Poudre, Big Thompson, Little Thompson and St. Vrain Rivers. A unit of C-BT water in a strict sense is equivalent to 1 acre-foot, or a flow of 1/2 cfs for one day. However, unit appropriations are subject to downward adjustment by the Board of Directors of the Northern Colorado Water Conservancy District (NCWCD) on a seasonal basis as warranted by system operating conditions. Typical quotas, summarized in Table 6.4.1-E, range from 60 to 100 percent of the 1 acre-foot C-BT unit value.

TABLE 6.4.1-E. NCWCD QUOTA - 1957-1976 (a)

YEAR	QUOTA	YEAR	QUOTA	YEAR	QUOTA
1957	60%	1964	90%	1971	60%
1958	100%	1965	60%	1972	80%
1959	80%	1966	100%	1973	70%
1960	70%	1967	70%	1974	100%
1961	60%	1968	60%	1975	80%
1962	75%	1969	70%	1976	100%
1963	100%	1970	60%		

(a) Northern Colorado Water Conservancy District, 1976.

Factors which determine the C-BT quota include runoff forecasts of regional streams (snowpack), C-BT and ditch company reservoir storage carry-over from the previous season, weather conditions, and all related factors affecting the potential needs for supplemental water in the District's service area. When offered for sale by existing owners, a unit of C-BT water presently (1977) costs approximately $1,300. Unit ownership is considered perpetual.

To maintain a dependable flow of 15 cfs in the Poudre River and 15 cfs in the Big Thompson downstream from the Hansen Canal during the five month period May-September, the Division would have to purchase 15,000 units of C-BT water (5 months x 30 days per month x 30 cfs per day x 2 acre-feet per cfs ÷ 60 percent unit equivalency). If available, cost of these units would be approximately $19.5 million. Once flow is established past a desired point, water could be subsequently leased to a downstream user at a rate of about $3 per unit.

The proposed Windy Gap Project would provide a means of conveying water originating on the west slope of Colorado to the Front Range area of the east slope. Project components will collect Colorado River flows downstream from its confluence with Frazier River. Water would be conveyed by a system of pumps and pipelines constructed as part of the project into facilities of the existing Colorado-Big Thompson Project at Granby Lake. The C-BT system would delivery Windy Gap waters to C-BT reservoirs, canals, and main-stem river channels as required to meet the requirements of cities and utilities participating in the proposed project.

Interest in the Windy Gap Project is vested among sponsoring entities according to the following relationships:

Boulder:	1/6	Longmont:	1/6
Estes Park:	1/12	Loveland:	1/12
Greeley:	1/6	Platte River Power Authority:	1/3

Net delivered average project yield is expected to be on the order of 48,000 acre-feet per year. Final costs of units of Windy Gap water are not known at this time. However, price will most likely be comparable to that of existing C-BT units (Phipps, 1977).

Project participants incur both fixed and variable costs. Annual fixed costs relate to bond amortization. Variable costs are computed each year based on the actual volume of water requested by and delivered to a project participant. They reflect charges for system operation, maintenance and pumping power.

In any given year, members of the Windy Gap Project will notify the Northern Colorado Water Conservancy District of their upcoming water requirements. Delivery of project water will be regulated accordingly. The opportunity will exist for agencies or groups to lease surplus Windy Gap water, if available, for purposes of maintaining or augmenting in-stream flows in the region.

A variation of the water rights acquisition strategy involves purchasing a portion of a water right (right to transfer) rather than buying the entire right. A method of utilizing water for streamflow without damaging existing users must be identified. In consideration of rights of junior diverters, any reallocation of water through purchase of water rights and/or transfer diversion points cannot impair junior priorities without compensation.

Several Federal aid programs exist through which funds can be disbursed to state fish and wildlife agencies for the purpose of implementing strategies and constructing facilities for wildlife purposes. Disposition and use of funds are governed by the basic statutory purposes of the aid programs and regulations and guidelines formulated by the Secretary of the Interior. Two pieces of legislation, the Fish Restoration and Management Project Act of 1950 (Dingle-Johnson Act) and the Wildlife Restoration Act of 1937 (Pitman-Robinson Act), authorize appropriations derived from Federal tax revenues on sales of fishing equipment, firearms, and ammunition to be distributed to states. An additional source of aid, the Bureau of Outdoor Recreation, administers the Land and Water Conservation Fund. These monies are allocated to states for planning purposes, and acquisition or development of land and water areas for recreation.

Decision-making authority with respect to implementing the funding strategies lies with the Secretary of the Interior through the Bureau of Sport Fisheries and Wildlife and the Bureau of Outdoor Recreation within their respective jurisdictions. The Dingle-Johnson Act contains provision for funding to be used for purchasing water to maintain instream habitat. It should be noted, however, that monies distributed to Colorado are already exhausted by a variety of state programs. Allocation of funds for acquiring water rights will require that financial support be taken from other environmentally oriented activities.

6.4.1.2f Winter Reservoir Storage Releases

A conceptual strategy for maintaining main-stem flows in the Poudre during winter involves allowing water that otherwise would be impounded in high mountain reservoirs during the storage season to travel unimpeded to downstream reaches. This can be accomplished by two methods:

- o Capturing only spring runoff in high mountain reservoirs. Winter flows presently captured would be allowed to flow unregulated through reservoirs to the main-stem.

- o Capturing available winter flows tributary to high mountain reservoirs, and releasing them to the main-stem during winter at regulated rates. This strategy is presently implemented to an extent by the cities of Fort Collins and Greeley.

Under this strategy, high mountain reservoirs would be required to rely on spring snowmelt for most or all of their storage supply. In years of low snowpack, water collected in storage would be far below reservoir capacity. During drought periods, many high mountain reservoirs are unable to acquire supplies commensurate with capacity even when water is collected throughout the entire storage season, October through April. High country winter flows tributary to the main-stem Poudre would be introduced to storage in plains reservoirs. Hence, flow would be maintained through a significant downstream reach of the river. This strategy would effectively result in filling available storage capacity in impoundments at the low end of the Poudre basin.

Water rights considerations make this strategy questionable. Even if the water rights issues were resolved by an exchange agreement, the option would represent an extremely inefficient use of water resources. Because winter flows conveyed down the main-stem would be diverted into storage in plains reservoirs in the low end of the Poudre drainage, capacity would not be available to accommodate the tremendous volume of seepage, over 3 cfs per mile, that is tributary to downstream reaches of the Poudre during winter. These returns would be wasted from the system. Under present river management, such flows are captured in volumes sufficient to fill plains reservoirs.

Of all the options presented, the only one which is feasible in even an extremely limited sense is purchase of water rights. This option is used to define costs for Strategy No. 2; however, it does not preclude implementation of a less costly alternative if one can be found.

Section 4.0 has addressed the problem of habitat associated with the plains rivers of the Larimer-Weld region. All streams in the region exhibit reaches that possess bottom layers of sediment which restrict the ability of cold and warm water fish to spawn. Such benthic conditions are a major impediment to propagation of a desirable fishery. Presence of sediment and sludge is attributable primarily to naturally occurring erosion and non-point sources of pollution. Modification of stream bottoms to conditions suitable for perpetration of fish other than rough fish will involve a two-fold program of restoration and source-control:

- Restoration. River channel substrate will need to be exposed in order to establish benthic conditions conducive to spawning. A program of dredging, oriented toward stream reaches where sediment has accumulated, will be necessary to meet the physical requirements of a self-propagating desirable sport fishery.
- Source-control. Sediment loads generated by natural sources and human activities are amenable to varying

degrees of control. Naturally occurring sediment contributions can be mitigated to an extent by stream channelizations, grouting, rip-rapping, and installation of debris basins. Such strategies involve major modification of the natural stream character, however, and will not be reviewed further. A portion of the sediment conveyed to river systems by human activities can be kept out of the stream environment by structural, non-structural, and managerial practices. Potential strategies and future control needs are discussed in Interim WQMP Report Nos. 15, 19, 22, 25 and 26.

Depth of sediment is typically greatest in the low end of a river system due to transport ability and flushing action of main-stem flows. Sediment deposition is also observed to be pronounced at locations where stream velocity is reduced, promoting conditions of settling. Meandering channels and in-stream diversion structures are conducive to sediment buildup.

For purposes of sediment analysis, the Cache la Poudre and Big Thompson Rivers are assumed to be characterized by sediment depths ranging from less than one inch to in excess of 6 inches, with 3 inches as the average.

The St. Vrain River conveys extremely high sediment loads into Weld County generated in Boulder County. The reach of the St. Vrain immediately downstream from the Weld County line is considered to be the area in the region most affected by sedimentation. Conditions in the St. Vrain are observed to improve in its lower one-third above the confluence with the South Platte.

Although the foregoing approximations are extremely rough, they give a general indication of the level of effort required to restore channel substrate to conditions suitable for spawning of desirable fish species. The estimated total number of cubic yards of sediment requiring removal initially is presented in Table 6.4.2-A.

TABLE 6.4.2-A ACCUMULATED SEDIMENT PLAINS AREAS

River		Sediment - cu. yds. (1000)
Cache la Poudre		185
Big Thompson		115
St. Vrain		215
	TOTAL	515

Benthic conditions which characterize the South Platte River within the two-county area are not generally suited to perpetation of a desirable fishery. Silt, sediment, and mud are estimated to cover the gravel substrate of the South Platte in thicknesses ranging from 6 inches to over 4 feet. An extensive food base for bass and other predator fish, consisting of chubs, shiners, and minnows, presently exists in the South Platte (Langlois, 1977). Hence, with provision for effective mitigation of dewatering, channelization, habitat, and water quality constraints, a warm water fishery could be developed. It is estimated that upgrading and enhancing the environment of the 76-mile reach of the South Platte in the region to levels commensurate with significant propagation of fish other than rough fish would involve removal and disposal of approximately 4-1/2 million cubic yards of sediment. The magnitude of such an undertaking is overwhelming when compared with the effort required to expose channel substrate in major tributaries of the South Platte. For this reason, implementation strategies which address development of a more diversified fishery in the South Platte will not be formulated. Although creation of a fishery in selected reaches of the South Platte should not be totally discounted on a long-range basis, inherent factors such as maintenance of upgraded areas might prove to be economically inhibiting because of tributary sediment flushed in from unimproved upstream locations.

6.4.2.1 Operation

Compact, portable dredging machines have been commercially developed which are ideally suited to removing sediment from the rivers and shallow impoundments in the two-county area. Silt, sand, muck, weeds and sludge can be collected and pumped away from the channel or reservoir environment in an efficient manner.

Based on an excavation rate of 72 cubic yards per hour (Sanborn, 1977), it is estimated that approximately 7,150 operating hours will be required to dredge the 515,000 cubic yards of sediment which presently inhibit spawning of desirable fish species in the major rivers of Larimer-Weld, other than the South Platte. This corresponds to about 900 days of operation, or 3-1/2 years. Considering time involved in transporting, launching, and retrieving the dredging barge, approximately 4 years would be required to expose channel substrate in rivers of the region. Two individuals are needed to operate the dredging equipment. Hence, about 8 man-years of effort would be involved.

6.4.2.2 Costs

Dredging equipment is available on either a rental or purchase basis. In addition to costs associated with capital investment or lease, operational costs will also be incurred. Financial aspects of dredge rental and purchase are detailed in Tables 6.4.2-B and 6.4.2-C. Because of the time involved in dredging streams of the regions, equipment rental is not considered a practical or economical option.

Prices associated with dredge purchase are detailed in Table 6.4.2-C. Operating and maintenance costs are depicted on an hourly basis in Table 6.4.2-D. Total hourly cost incurred in owning and operating a dredge is slightly more than $28.00. Considering the time required to dredge the Cache la Poudre and Big Thompson Rivers and St. Vrain Creek, 7,150 operating hours, operating expense involved in the actual clean-up program will be approximately $200,000. Additional expenditure will be entailed in transporting, launching, and retrieving the dredge. It is estimated that implementation of the various phases of a dredging program oriented toward restoring benthic conditions to levels suitable for desirable fish propagation would cost on the order of $400,000, including dredge purchase, insurance ($3,000 per year), operating costs, and cost of dredge transport and set-up.

Dredging spoils will also need to be disposed of properly. Alternative disposal sites include agricultural lands and unestablished residential yards in newly constructed areas. Disposal could have a major cost and environmental impact which has not been considered in this analysis.

Follow-up programs of dredging will be necessary to selectively maintain established in-stream habitat at levels conducive to fish propagation. Natural sources of sediment and man-induced suspended solids loads that are beyond the control of present technology will combine to degrade the spawning characteristics of the river channel substrate. Because of the magnitude of suspended solids anticipated to be conveyed to the regional surface water regime, even under conditions of stringent source control, treatment and management, a relatively continuous program of dredging is necessary to maintain benthic integrity once it is initially restored to rivers of the area.

Even under ideal conditions of control of suspended solids generated by man-induced sources (considered to be practicably achievable in the region), major stream systems would be annually subject to benthic channel accumulation rates from slightly less than one-half inch to over three-quarters inch. This analysis, is simplified in its approach: sediment is assumed

TABLE 6.4.2-B

MINI-DREDGE, LEASE OPTION (a)

Item	Lease Cost
Basic dredge	13,240
Accessories:	
discharge pipe package (standard)	
aluminum pipe and floats	
cable and related harnessing equipment	
service boat and motor	
spare parts kit (purchase)	
subtotal, accessories	3,657
Total	16,897
Each month after initial 60-day lease	5,820

(a) Cost provided by Mud Cat Division of National Car Rental System, Inc. (Sanborn, 1977). Prices effective - January 1, 1977.

TABLE 6.4.2-C

MINI-DREDGE, PURCHASE OPTION (a)

Item	Cost (b)
Basic dredge	70,560
Delivery to Larimer-Weld	2,400
Accessories:	
discharge pipe package (standard) aluminum pipe & floats	12,529
cable & related harnessing equipment	3,134
service boat & motor	1,328
spare parts kit	257
subtotal, accessories	17,248
Trailer	18,000
Total	108,208

(a) Cost provided by Mud Cat Division of National Car Rental System, Inc. (Sanborn, 1977). Prices effective - January 1, 1977

(b) Cost does not consider:

- crane rental to launch & retrieve dredging barge (30 ton crane required)
- transportation of equipment from site to site
- administrative costs
- storage and/or warehouse costs

TABLE 6.4.2-D

HOURLY OPERATING COSTS (a)

Operating Costs	
Fuel: $0.55 per gal. x 6.5 gal./hr.	$ 3.58
Lubricants:	
Engine: $2.64 per gal. x 0.10 gal./hr.	0.27
Hydraulics: $2.67 per gal. x 0.07 gal./hr.	0.19
Grease: $0.58 per lb. x 0.06 lb./hr.	0.04
Filters:	0.16
Repairs: parts and labor	3.85
Total hourly operating costs	$ 8.09
Two operators and fringe benefits	20.00
Total Hourly Operating Costs	$28.09

(a) Cost provided by Mud Cat Division of National Car Rental System, Inc. (Sanborn, 1977).

to be uniformly distributed in plains area rivers downstream from source locations, a condition not likely found in nature. A flushing factor is also considered. However, the magnitude of computed deposition gives an indication of the potential severity of the problem with regards to impacts on fishery propagation. Such deposition is related to human activities alone, with no consideration given to natural sources.

6.4.3 Stream Engineering

An alternative or supplement to routine dredging as a means of preventing sediment accumulation in rivers of the region involves physical reconstruction of main-stem channels. Configuration and carrying capacity would be altered to provide constriction of flows at optimal velocities to maximize sediment flushing. Reducing the channel profile by construction of artificial levees would create hydraulic conditions conducive to substrate scouring. To accommodate high volumes of spring runoff, break-out capability from the constricted reaches would have to be available.

Modification will encompass a wide variety of parameters oriented toward all life-stages of individual species selected for initial stocking in area streams. Among items of critical concern are the following:

- Channel substrate;
- Water volume, depth, velocity, quality, and temperature;
- Channel cover.

To sustain warm water predator fish, stream habitat must also be provided which is conducive to survival and propagation of their prey: shiners, chubs and minnows.

It is estimated that professional time involved in evaluating and designing in-stream habitat for the major tributaries of the South Platte River within the region will require one man-year of effort. Cost of this service will be on the order of $20,000. It is recommended that Federal and state agencies with the experience and expertise in applying biological technology to aquatic environments for the purpose of optimizing fishery habitat take a leading role in program implementation. Both the U.S. Fish and Wildlife Service, Instream Flow Group, Fort Collins, Colorado, and the Colorado Division of Wildlife possess such capability.

Actual implementation of stream engineering principles will involve use of heavy equipment normally associated with construction activity. Tractors can perform required stream realignment. Backhoes are well suited to pond and pool construction. Hand tools can be used to provide finishing touches to major modifications as well as to construct smaller channel and bank improvements. Depending on the complexity of the work involved, physically engineering the streams of the region is estimated to cost from $500 to $2,000 per mile.

Stream engineering efforts should be oriented toward optimizing habitat for a selected species while avoiding to the extent possible creation of habitat suited to a competing species.

An integral part of stream engineering is habitat development. Land uses adjacent to engineered streams may require modification for enhancement of proper habitat. In plains area streams, many species require shaded areas and deep pools to escape excessive exposure to sunlight and heat.

Stream engineering, dredging and stocking will not provide public benefit unless sufficient access is provided to waters of the region. Easements or land trades may be necessary before plains waters are truly amenable to fishing and swimming.

6.4.4 Fish Stocking

Development of a desirable sport fishery in plains reaches of major streams which never historically supported significant self-propagating populations would require that an initial breeding population be introduced. Cost of stocking is estimated to be $1.10 per pound, with a quota of approximately 100 pounds of fish per surface acre of pond or stream representative.

Fish stocking has in recent years received considerable criticism from anglers and fishery biologists throughout the state. They contend that fish introduced to waters from fish hatcheries temporarily drive away native breeding species such as the cutthroat and brown trout. The introduced tonnage of "feedlot fish" ... degrades a unique, limited renewable natural resource and the fine sport of stream trout fishing, and at a considerable expense" (Klein, 1973). These critics contend that lakes and reservoirs are the proper place for fish stocking. These objections must be considered in the detailed planning phase.

6.4.5 Municipal and Industrial Point Source Pollution Control Requirements

Provision of minimum stream flows of 15 cfs in the Cache la Poudre River provides additional dilution water in the rivers and some offsetting benefits in terms of reducing the level of municipal and industrial wastewater treatment. Table 6.4.5-A compares the treatment level requirements for Strategy No. 1, which has no flow augmentation and Strategy No. 2, which includes 15 cfs augmentation on the Cache la Poudre River and Big Thompson River. Without flow augmentation, Fort Collins No. 1, Fort Collins No. 2, Boxelder Sanitation District, Windsor, Kodak and Loveland would be required to provide advanced waste treatment (ammonia removal to 1.5 mg/l). With flow augmentation, tertiary treatment is required (ammonia removal to 3.0 mg/l). This results in a capital cost reduction to these discharges estimated at $3.7 million, as indicated in Table 6.2-A.

6.5 STRATEGY NO. 3

Under Strategy No. 3, secondary treatment will be required of all plains area dischargers. The strategy would not include flow augmentation, however. In the reach of the Poudre between the mouth of the canyon and Fort Collins Sewage Treatment Plant Number 1, fish stocking and stream engineering will be included. Fish stocking would be limited to the area upstream of Fort Collins and certain areas of the Big Thompson upstream of Loveland, but below the mouth of the canyon. Stream engineering would also be included in these reaches, contingent upon additional research and planning to assure that this will produce the derived results. This could result in a seasonal sport fishery in these areas. Below Fort Collins Sewage Treatment Plant Number 1 on the Poudre, and below Louden Ditch on the Big Thompson, no effort will be made to upgrade the existing fishery. Non-point source pollution control strategies for agriculture, urban runoff and feedlots would be included.

Treatment costs for facilities situated in the "outlying areas" were detailed previously in Table 6.3-A. Treatment costs incurred in the combined triangle/outlying area with implementation of Strategies Nos. 3 and 4 are shown in Table 6.5-A.

6.5.1 Put-and-Take Fishery

Development of a put-and-take fishery in certain stream reaches amenable to such stocking under existing flow conditions represents a potentially viable means of achieving interim/1983 fishery goals on a limited basis. The Larimer-Weld Regional Council of Governments sponsored a meeting in the new Natural Resources Center, Colorado State University Campus, Fort Collins, Colorado, on November 17, 1976 for the purpose of discussing the basic problems associated with determining the attainability of fisheries in the region. In attendance were representatives of the Colorado Division of Wildlife, Colorado State University, Toups Corporation, industry, State Engineer's Office, and U.S. Environmental Protection Agency (Appendix B).

TABLE 6.4.5-A YEAR 2000 TREATMENT LEVEL REQUIREMENTS NECESSARY TO MEET PRESENT WATER QUALITY STANDARDS BY EXISTING MAJOR MUNICIPAL, AND INDUSTRIAL DISCHARGERS WITH AND WITHOUT FLOW AUGMENTATION

BASIN DISCHARGER	TREATMENT LEVEL REQUIREMENT	
	ALTERNATIVE NO. 1 NO AUGMENTATION	ALTERNATIVE No. 2 WITH AUGMENTATION
CACHE LA POUDRE		
Fort Collins No. 1	Advanced	Tertiary
Fort Collins No. 2	Advanced	Tertiary
Boxelder S.D.	Advanced	Tertiary
Windsor	Advanced	Tertiary
Kodak	Advanced	Tertiary
Greeley-1st Avenue	Closed	-
BIG THOMPSON		
Estes Park	Combined with UTSD	Combined with UTSD
Upper Thompson	Secondary	Secondary
Loveland No. 2	Advanced	Tertiary
Great Western-Loveland	Tertiary	Tertiary
Milliken	Secondary	Secondary
LITTLE THOMPSON		
Berthoud	Secondary	Secondary
Great Western-Johnstown	(Cooling water discharge)	(Cooling water discharge)
Johnstown	Secondary	Secondary
ST. VRAIN		
Tri-River S.D.	Secondary	Secondary
Erie Water and Sanitation District	Advanced	Advanced
SOUTH PLATTE		
Fort Lupton	Secondary	Secondary
Public Service-Ft. St. Vrain	(Cooling water)	(Cooling water)
Hill-N-Park	Secondary	Secondary
La Salle	Secondary	Secondary
Evans	Secondary	Secondary
Greeley-Delta	Advanced	Advanced

TABLE 6.5-A PROJECTED COSTS - WASTEWATER TREATMENT FACILITIES IMPROVEMENTS FOR STRATEGIES NOS. 3 & 4

Recommended Water Use Classifications and Standards

WASTEWATER DISCHARGE	FLOW (mgd)		CAP. COST ($1000) (b)	AVG. O&M COST ($1000/ Yr.)(c)	PRESENT WORTH ($1000)			EQUIV. ANN. COST ($1000/ Yr.)
	1977-2000 AVG.	2000			CAP. REC. (b)	O&M (c)	TOTAL	
CACHE LA POUDRE RIVER								
Ft.Collins #1(d)	6.0	6.0	-	300	-	3,178	3,178	300
Ft.Collins #2(d)	7.2	9.0	-	450	-	4,767	4,767	450
Boxelder S.D. (d)	0.75	1.0	74	74	43	784	827	78
So.Ft.Collins S.D.(d)	1.0	1.4	-	110	-	1,165	1,165	110
Windsor (d)	1.2	1.7	330	49	330	519	849	80
Eastman Kodak Co.(d)	0.9	1.0	-	40	-	424	424	40
Greeley-1st Ave.(d)	6.0	(e)	1,000	380	1,000	4,026	5,026	474
Greeley-Delta (d)(f)	4.5	11.5	5,200(g)	450	3,800	4,767	8,567	809
OUTLYING AREA (d)	1.22	2.06	1,472	128	1,247	1,527	2,774	262
Subtotal	28.77	33.66	8,076	1,981	6,420	21,157	27,577	2,603
BIG THOMPSON RIVER								
Loveland (d)	5.3	6.1	-	414	-	4,386	4,386	414
Great Western-Loveland (d)	4.3	4.3	-	75	-	795	795	75
Johnstown	0.31	0.38	105	16	105	170	275	26
Milliken S.D.	0.34	0.40	410	28	410	297	707	67
OUTLYING AREA (d)	1.88	2.87	316	549	316	5,816	6,132	579
Subtotal	12.13	14.05	831	1,082	831	11,464	12,295	1,161

Source: Toups Corporation, March, 1978

TABLE 6.5-A (CONTINUED)

WASTEWATER DISCHARGE	FLOW (mgd)		CAP. COST ($1000) (b)	AVG. O&M COST ($1000/ Yr.) (c)	PRESENT WORTH ($1000)			EQUIV. ANN. COST ($1000/ Yr.)
	1977-2000 AVG.	2000			CAP. REC. (b)	O&M (c)	TOTAL	
ST. VRAIN RIVER								
OUTLYING AREA (d)	.99	1.2	795	54	713	705	1,418	133
SOUTH PLATTE RIVER								
OUTLYING AREA (d)	2.48	3.88	2,002	162	1,725	1,711	3,436	323
TOTAL-Larimer-Weld	44.37	52.79	11,704	3,279	9,689	35,037	44,726	4,220

(a) Costs in terms of January, 1977, dollars. Annual interest rate 7%.
(b) Immediate construction of facilities assumed, except when construction phased (Greeley-Delta, Boxelder S.D.). Includes biological treatment, disinfection and sludge treatment.
(c) Secondary O & M costs from 1978 budgets. For Greeley and Ft. Collins, total annual budget apportioned between facilities.
(d) Secondary treatment.
(e) Greeley-1st Ave. plant to be abandoned prior to 2000.
(f) Although service area is in Cache la Poudre basin discharge is to South Platte River.
(g) Includes initial 4 mgd increment, 4 mgd expansion in 1989, 8 mgd expansion in 1995, and initial interceptor.

Source: Toups Corporation, March, 1978

In plains areas of the region where existing streamflows would permit upgrading of existing rough fish populations to more desirable species, a program of stream stocking on a put-and-take basis might represent a feasible means of meeting recreational demands. However, any effort to greatly modify the type of fish life present in plains reaches of the various river systems in the region should consider the actual benefit to be realized. Value of a program of stocking trout, bass, or other desirable game fish, should consider angler days and access availability; how such a program would fit in with the local lifestyle; and how it would affect the quality of life in a given area. Perceptions of county residents concerning the modification of fish life must be considered.

The Colorado Division of Wildlife has emphasized that their work is directed toward satisfying public wants and wishes. They will respond in an agreeable manner to public pressure by striving to implement whatever desire the general populous might voice. The Division has acknowledged that the current attitude of the public seems to favor mountain fisheries as a more desirable alternative to plains fisheries.

Major angler demand occurs during summer, the season of traditionally low flow in the Cache la Poudre and other river systems downstream from canyon mouths. The Colorado Division of Wildlife indicated that the agency would consider the potential of maintaining a fishery on the Cache la Poudre upstream from Fort Collins WTP No. 1. Because of the risk involved, the Division prefers to enhance an existing fishery rather than establish a new fishery in a possibly poor area.

The Colorado Division of Wildlife has assembled data on cost and operation of put-and-take fisheries. A stocking quota of approximately 100 pounds of fish per surface acre of pond or stream is a representative value for a put-and-take operation.

The annual cost of stocking the reaches of the Poudre and the Big Thompson described above would be approximately $40,000 including cost of fish, manpower, and program monitoring.

6.5.2 Municipal and Industrial Pollution Control Reqirements

As indicated in Section 6.4, the major factors limiting establishment of a sport fishery in the plains area rivers of the region are: (1) lack of physical habitat to support less hardy game species, and (2) extreme variations in hydrology resulting in survival of only the hardiest species. Upgrading of municipal and industrial treatment plants to meet rigid numeric criteria will not effect the numbers or diversity of aquatic life in the plains streams unless accompanied by major modification of stream habitat and flow conditions. Municipal and industrial treatment requirements for Strategy No. 3 recognize this fact. Secondary treatment is recommended for all discharges in the region under Strategy No. 3. Costs are displayed in Table 6.5-A.

6.6 STRATEGY NO. 4

With implementation of Strategy No. 4, all discharges would be required to meet secondary treatment standards. Associated costs were previously presented in Tables 6.3-A (outlying area) and 6.5-A (composite triangle/outlying area). Control measures would be undertaken for non-point sources. There would be no fish stocking or stream engineering in the plains area streams. Municipal and industrial treatment costs are shown in Table 6.5-A and are identical to Strategy No. 3.

6.7 NON-POINT SOURCE POLLUTION CONTROL COMMON TO ALL STRATEGIES

All four alternative pollution control strategies include control of pollutants from irrigated agriculture, urban runoff and feedlots. Uncertainties regarding the cost effectiveness and benefits of control measures for irrigated agriculture and urban runoff dictate the need for additional research, development, and demonstration projects. The degree of implementation of pollution measures will depend on the outcome of those efforts. Inclusion of those elements in the alternative strategies is conditional pending the results of additional research, development, and demonstration projects. Full discussion of the approach to urban runoff and irrigated agriculture pollution control efforts and costs are presented in Interim WQMP Report Nos. 3, 15, 19, 22, 25, and 26.

7.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions and recommendations based on information developed in this report as supported by other 208 reports. Section 7.1 provides the conclusions from Sections 2 through 6. Section 7.2 presents the recommended water quality standards and classifications to support the recommended alternative strategy, and the recommended water quality monitoring program necessary to support 208 program implementation.

7.1 CONCLUSIONS

7.1.1 Conclusions: Section 2 - Existing and Projected Water Quality and Impacted Factors

1. Major sources of pollution within the Larimer-Weld Region include municipal and industrial point sources, and non-point sources including irrigated agriculture and urban runoff. Pollutant sources which have less impact on water quality include solid waste disposal, construction activities, silvicultural activities and other forest uses, and confined animal feeding operations.

2. The impact of these discharges is directly related to the proportionate level of land use associated with each activity in the Region. The Cache la Poudre River basin and Big Thompson River Basin are more impacted by urban development activities than the St. Vrain and South Platte. The plains area of all basins are impacted by pollutants contained in and conveyed by irrigation return flow.

3. The impacts of urban runoff have been projected but not verified through a program of sampling and analysis.

4. All streams of the plains area are impacted by pollutants contained in and conveyed by irrigation return flows which are estimated at approximately 380 mgd as compared to municipal and industrial discharges of 46 mgd.

5. Irrigation return flows to the Cache la Poudre River are estimated at 150 mgd compared to 25 mgd discharged by municipal and industrial sources.

6. Water quality of the Big Thompson River is effected by municipal and industrial discharges from the City of Loveland and Great Western Sugar Company. Combined municipal and industrial discharges in the basin including the Little Thompson are estimated at 15 mgd, irrigation return flows are estimated at 44 mgd.

7. Point sources discharging into the Little Thompson River include Milliken and Johnstown. These discharges have a negligible effect on water quality of the Little Thompson.

8. The Little Thompson receives a considerable amount of irrigation return flow. During the summer season, flows from the Little Thompson basin have a total dissolved solids content of 2000 mg/l. The Little Thompson is also subject to sediment loading which is the highest in the Region. Sediment levels in the Little Thompson range upwards of 200 mg/l.

9. Only one municipal discharger, Mead Sanitation District, discharges to the St. Vrain in the Larimer-Weld Region. Agricultural return flows to the St. Vrain River are estimated at 62 mgd.

10. The only point source dischargers on the South Platte River are a number of small communities in South Weld County which have a negligible influence on water quality. Total municipal discharge is less than 1 mgd while irrigation return flows are estimated at 125 mgd.

11. Irrigation returns flows are a major element in the water supply equation of the Larimer-Weld Region. They entirely sustain the flow of the lower Cache la Poudre, lower Thompson, lower St. Vrain, and portions of the South Platte Rivers during certain periods of the summer low flow period.

12. The impacts of point and non-point source discharges vary substantially throughout the Larimer-Weld Region due to the extremely complex system of supply and diversion. Impacts of specific point sources are often masked by non-point source discharges or completely nullified by subsequent withdrawal of the entire system flow for application to irrigated land.

7.1.2 Conclusions: Section 3 - Water Quality Criteria and Standards

This chapter provides the rationale for development of recommended criteria and standards for the Larimer-Weld Region. Major conclusions include:

1. The ability of technicians to measure chemical concentrations in water, conduct tests on aquatic life under idealized laboratory conditions, and write computer programs supposedly depicting in-stream conditions has advanced tremendously in recent years.

2. The application of this advanced technology to specific rivers, streams and reservoirs is in its embryonic stage and deserves considerable additional field testing prior to application to municipal and industrial discharge permits. Beneficial uses of water within the Larimer-Weld Region include recreation, aquatic life, agriculture, and water supply.

3. The factors affecting establishment of numeric standards to ensure protection of beneficial uses include highly localized conditions such as in-stream aquatic life, pH, temperature, hardness, total dissolved solids, and other in-stream pollutants. These factors are highly variable within the Region.

4. Establishment of numeric standards beyond "Basic Standards" currently in effect for streams within the Region will require additional sampling, bioassays, and biosurveys.

5. Application of water quality criteria other than basic standards presently in effect can not be supported until more scientific evidence is available proving the applicability of those criteria in the Larimer-Weld Region. Application of broader water quality criteria in the development of NPDES discharge permits is not acceptable until such scientific information is available and the following conditions are met:

   a. In-stream monitoring programs, biosurveys, bioassays, and other scientific evidence indicate that chemical constituents included in such criteria are present in sufficient concentrations in receiving waters to interfere with beneficial uses of water in legally adopted stream classifications and are applicable to specific situations within the Region.

   b. Monitoring programs identify specific point and non-point sources of the constituent in question, the level attributable to each source, and the specific impact of each source on the beneficial use of water.

   c. The economic, social, and environmental impact and technical feasibility of eliminating specific pollutant is defined through planning conducted in accordance with Section 201 and/or Section 208 of the Clean Water Act.

   d. Facilities are constructed and/or best management practices are developed and implemented to control the discharge of specific pollutants.

7.1.3 Conclusions: Section 4 - Factors Affecting Attainment of 1983 Water Quality Goals

1. Factors affecting attainment of the goal, as well as the means of attainment, include regional hydrology, in-stream physical factors such as stream bed conditions, flow, habitat, temperature, as well as chemical factors, and local goals, attitudes and desires concerning priorities for recreation and water use.

2. The surface water hydrology of the Larimer-Weld Region has undergone extensive changes in the last 120 years with the objective of maximizing use of available water supplies for irrigation, municipal and industrial purposes.

3. Numerous diversion structures have been constructed in the streams to facilitate delivery of water to various ditches and from there to reservoirs, irrigated land, municipalities and industries in the Region.

4. Operation of the river system under the management strategy which maximizes availability of supplies for these purposes results in total diversion of all supplies from rivers at many points.

5. Diversion of total flow in the river occurs during the irrigation season, May - September, and during the storage season, October - April.

6. Diversions on the Cache la Poudre River may totally dry up the river at least 11 times between the North Poudre Supply Canal at the the mouth of the canyon and its confluence with the South Platte River.

7. Diversions from the Big Thompson River may dry up the river at least five times between the mouth of the canyon and its confluence with the South Platte River.

8. The South Platte River may be dried up at least 5 times within the Region.

9. Extreme hydrologic variations contribute to the survival of only the hardiest species of fish in the plains area of the Region. These fish are generally referred to as "rough" or "forage" fish and for the most part, include carp, suckers, and minnows.

10. Mountain streams of the Region generally provide excellent habitat for trout fisheries. The mountains are also the prime providers of supply for agriculture and municipal uses of water.

11. The high mountain streams are a great regional and state fisheries and recreational resource which should be protected from degradation.

12. Stream life of the plains streams is determined by factors other than flow, including benthic and bank conditions, temperature, and quality.

13. Existing recreational fisheries in the streams of the plains area are marginal at best. This is confirmed by the fact that the

Colorado Division of Wildlife does not consider the plains streams as a viable fishery and does not spend state resources on stocking or attempting to manage these plains streams as fisheries. It is also confirmed through biological data collected as part of the 208 program and from other sources.

14. Opportunities for establishment of in-stream fisheries within the plains area appear to be extremely limited.

15. Establishment of fisheries in the numerous off-stream reservoirs has been accomplished and appears to offer the greatest benefits in the future in terms of meeting water quality goals and regional and state program goals.

16. The Larimer-Weld Region contains 25 percent of water recreation areas in the South Platte River Basin in the State of Colorado.

17. Water based recreation and fisheries within the Region center around mountain streams and reservoirs in the foothills and plains areas.

18. Public acceptance of large expenditures for improving water quality in the rivers of the region is considered to be questionable when the public benefits from such improvements appear to be negligible in terms of providing increased recreational and fishery opportunities.

19. Opportunities for recreational enhancement in the Larimer-Weld Region appear to be greatest in the mountainous areas and at off-stream sites such as reservoirs, converted gravel operations, and reservoirs in the foothills areas.

7.1.4 Conclusions: Section 5 - Environmental Goals and Their Relationship to Water Quality Management

The following conclusions are drawn based on the information presented in Chapter 5.

1. Federal Clean Water Act encourages to the maximum amount feasible "the recycling of potential sewage pollutants through the production of agricultural, sivilcultural and agricultural products and the reclamation of wastewater."

2. This goal is carried out to the maximum extent feasible by the systems of discharge and diversion existing within the Region. Wastewater discharged by municipal treatment plants is used on an average at least 2½ times prior to leaving the Region.

3. Land treatment for the major urban centers of Fort Collins, Loveland and Greeley, as a means of achieving tertiary treatment, or to eliminate direct discharge is not cost-effective. Opportunities for direct land application of wastewater as a planned component of water quality management appear to be more substantial in rural communities.

4. The major agricultural solid waste problem exists in terms of management of residual wastes from concentrated animal feeding operations. Disposal of manure generated by livestock on confined animal feeding operations as a fertilizer and soil amendment in combination with application of commercial fertilizers causes excess nitrate loadings to ground waters. Implementation of agricultural best management practices can eliminate this problem and provide direct economic benefits to the farmers. Other elements of the 208 program include detailed recommendations for carrying out such programs.

5. The continuing 208 planning program will address the problem encountered by communities in meeting requirements of the Federal Safe Drinking Water Act.

6. Planning, management, and operations agencies for point and non-point source pollution control should be required to address the question of energy consumption and energy conservation measures proposed as part of the implementation of pollution control programs.

7. Control of pollutants from irrigated agriculture and implementation of best management practices will be achieved with measures which increase the efficiency of conveyance systems and on-farm irrigation systems. Some degree of water conservation will occur as a result of a decrease in net demand if these measures prove to be cost-effective from a regional standpoint and are widely implemented. However, the final disposition of the water conserved is uncertain at this time.

7. Major municipalities within the Region have established goals of reducing unit waste flows within their sewage systems by substantial amounts.

8. Implementation of water conservation measures in the home could provide greater reserve capacity in existing waste treatment facilities. Major flow reductions cannot be expected.

7.1.5 Conclusions: Section 6 - Alternative Implementation Strategy

1. An alternative technical strategy which meets numerical water quality standards through application of strict point source

controls above (Strategy #1) will be extremely expensive to municipal and industrial dischargers and will not have any noticeable effect on the existing beneficial uses, including aquatic life, in the plains area of the Region.

2. The potential exists for creating a diversified sport fishery in the plains area of the Cache la Poudre and Big Thompson Rivers through a program of flow augmentation, stream engineering, fish stocking and dredging. While this may be a desirable long-term goal for the Region, much additional information is needed to determine the feasibility of this goal and the benefits to be derived from extremely high expenditures for point source control and purchase of water for flow augmentation.

3. Upgrading of fisheries through a program of stream engineering and fish stocking, and possibly altered water management strategies in areas on the Big Thompson River between Loveland and the mouth of the Big Thompson Canyon, and Fort Collins and the mouth of the Cache la Poudre Canyon, appear to be feasible. Additional research is recommended along with field testing to determine the actual feasibility of these measures.

4. Secondary treatment is recommended for all municipal and industrial dischargers in the plains area. Based on data and information available and ongoing programs to upgrade waste treatment capabilities, secondary treatment will provide adequate protection of beneficial uses in these areas of the Region. Higher levels of wastewater treatment are not justified.

5. A regional water quality monitoring program should be established which includes not only chemical and physical data, but also biosurveys and bioassays to determine future instream levels of protection within the Region.

6. Common elements assumed to be incorporated in any pollution control strategy for the Larimer-Weld Region include:

   a. Continued enforcement of feedlot regulations and operation of pollution control facilities by feedlot operators.

   b. A program of agricultural pollution control in the Region to the control, to the extent feasible, dischargers of salinity, nitrates and sediment to rivers of the region. This program is heavily dependent upon federal funding for implementation on a demonstration basis. Full implementation can come only after control measures are proved to be cost-effective and necessary.

c. Development and implementation of an urban runoff pollution control program in the Region.

d. Development of pollution control program from other non-point sources including construction, silvicultural activities, septic tanks and leachfields, solid/ hazardous waste disposal.

e. Maintenance of high quality of mountain streams in the Region.

Implementation of the Larimer-Weld 208 Program requires adoption of a set of stream classification standards and implementation of a water quality monitoring program in the future. These are described in Section 7.2.1 of this report.

7.2 RECOMMENDATIONS

7.2.1 Stream Classifications and Standards

Chapter 5 of EPA's Guidelines for State and Areawide Water Quality Management Program Development and 40 CFR Part 130, set forth requirements for the development of Water Quality Standards consistent with Section 303 of the Federal Water Pollution Control Act Amendments of 1972. These regulations and guidelines establish the scope and content for the formulation and review of State Water Quality Standards. (EPA, 1976)

The Guidelines state that the water quality standards "are an essential part of the state quality management system." Standards:

- Publicly define the State's water quality objectives, and hence, form the basis for its planning;
- Serve as the basis for determining National Pollution Discharge Elimination System (NPDES) permit effluent limitations for pollutants which are not specifically addressed in the effluent guidelines or for pollutants for which the effluent guidelines are not stringent enough to protect desired uses;
- Serve as a basis for evaluating and modifying Best Management Practices (BMP) for control of non-point sources;
- Serve as a basis for judgment in other water quality related programs, including water storage for regulation of stream flow, water quality inventories, control of toxic substances, thermal discharges, cooling lakes, aquaculture, and dredged and fill activities.

o Contain the State's antidegradation policy.

The regulations provide for the adoption and periodic revision of water quality standards, as appropriate, at least once every three years. In revising standards and classifications, states are required to maintain water uses which are currently being attained and where water quality standards specify designated uses less than those being achieved, the State is required to upgrade its standards to reflect the use being attained, or the state may establish less restrictive uses than those in existing standards under certain conditions.

The federal regulations, 40 CFR 130.17(c)(2)-(3), state:

"(2) The State shall maintain those water uses which are currently being attained. Where existing water quality standards specify designated water uses less than those which are presently being achieved, the State shall upgrade its standards to reflect the uses actually being attained.

"(3) At a minimum, the State shall maintain those water uses which are currently designated in water quality standards, effective as of the date of these regulations or as subsequently modified in accordance with §130.17(c)(1) and (2). The State may establish less restrictive uses than those contained in existing water quality standards, however, only where the State can demonstrate that:

(i) The existing designated use is not attainable because of natural background;

(ii) The existing designated use is not attainable because of irretrievable man-induced conditions; or

(iii) Application of effluent limitations for existing sources more stringent than those required pursuant to Section 301(b)(2)(A) and (B) of the Act in order to attain the existing designated use would result in substantial and widespread adverse economic and social impact."[1]

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(1) Treatment levels referred to in this section are BATEA - Best Available Technology Economically Achievable for other than municipally owned treatment works. Factors relating to the assessment of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, the cost of achieving such effluent reduction, non-water quality environmental impact (including energy requirements), and such other factors as the Administrator deems appropriate. BPWT - Best Practicable Waste Treatment technology for municipal owned treatment works may include reclamation or recycling of water.

7.2.1.1 Existing Colorado Water Quality Standards and Classifications

Water quality standards and a system for classifying waters of the State of Colorado in effect during the 208 planning period are pursuant to the Colorado Water Quality Control Act of 1973 and regulations promulgated thereto.

The State of Colorado has established water quality classifications and standards for all waters of the State effective June 19, 1974. These classifications include Classes A_1, A_2, B_1, B_2, and C. Class A waters are suitable for all beneficial uses including primary contact recreation, such as swimming and water skiing. Class B waters are suitable for all beneficial uses expect primary contact recreation. The subscripts 1 and 2 denote cold water and warm water classifications, respectively. Class C waters are those waters which have been excepted from A or B classifications on a case-by-case basis by the Water Quality Control Commission.

Associated with the classifications are numerical standards for 7 water quality parameters to insure that beneficial uses can be maintained within the class. These standards are shown in Table 7.2.1-A. In addition, all Class A and B waters are to be "free from" settleable solids, floating solids, taste, odor, color, oil grease, and toxic materials.

Table 7.2.1-B shows how these classifications have been applied in the Larimer-Weld Region. All streams are classified as B_1 and B_2 streams. Generally, the B_1 streams (cold water fishery) are located in the mountainous areas and the B_2 streams (warm water fishery) are located in the plains areas. Mountain lakes, reservoirs and creeks have also been classified as well as a few selected reservoirs of the plains areas (see Colorado Water Quality Control Commission, 1974, _Water Quality Standards and Stream Classifications_, Appendix A).

State water quality standards specify that the design frequency and duration for water quality standards is a seven day/ten year low flow. That is, a minimum seven day average flow which occurs on the average of once in ten years. This implies that low flows in streams may cause violations under drought conditions which theoretically occur very rarely, i.e., one week in ten years.

State water quality standards also include limitations on the quality of effluent discharged by industries and municipalities to help insure instream water quality standard attainments for beneficial uses. The specific standards application to all waste water discharges in Colorado are listed in Table 7.2.1-C. Standards for industries which discharge other deleterious materials are determined by federal regulations applicable to specific industries.

Adopted: March 19, 1974
Effective: June 19, 1974

TABLE 7.2.1-A

WATER QUALITY STANDARDS SUMMARY

STANDARD	CLASS			
	A_1	A_2	B_1	B_2
Settleable Solids	Free From	Free From	Free From	Free From
Floating Solids	Free From	Free From	Free From	Free From
Taste, Odor, Color	Free From	Free From	Free From	Free From
Toxic Materials	Free From	Free From	Free From	Free From
Oil and Grease	Cause a film or other discoloration	Cause a film or other discoloration	Cause a film or other discoloration	Cause a film or other discoloration
Radioactive Material	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards
Fecal Coliform Bacteria	Geometric Mean of <200/100ml from five samples in 30-day per	Geometric Mean of <200/100ml from five samples in 30-day per.	Geometric Mean of <1000/100ml from five samples in 30-day per.	Geometric Mean of <1000/100ml from five samples in 30-day per.
Turbidity	No increase of more than 10 J.T.U.	No increase of more than 10 J.T.U.	No increase of more than 10 J.T.U.	No increase of more than 10 J.T.U.
Dissolved Oxygen	6 mg/l minimum	5 mg/l minimum	6 mg/l minimum	5 mg/l minimum
pH	6.5 - 8.5	6.5 - 8.5	6.0 - 9.0	6.0 - 9.0
Temperature	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F. Lakes - 3°F.	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F. Lakes - 3°F.
Fecal Streptococcus	Monthly average of <20/100ml from five samples in 30-day per.	Monthly average of <20/100ml from five samples in 30-day per.	----	----

TABLE 7.2.1-B

SOUTH PLATTE RIVER BASIN

CLASSIFICATION

AREA	FROM	TO	WATER QUALITY CLASS
Main Stem of South Platte	Weld County Line (Southern)	Weld County Line (Eastern)	B_2
Main Stem of Boulder Creek	Weld County Line	Confluence with St. Vrain Creek	B_2
Main Stem of St. Vrain Creek	Weld County Line	Confluence with South Platte	B_2
Big Thompson River and tributaries and standing bodies of water in this area (refer to Appendix A, C.W.Q.C.C., 1974)	Sources	City of Loveland water treatment plant	B_1
Main Stem of Big Thompson	City of Loveland water treatment plant	Confluence with South River	B_2
Little Thompson River	Source	Point of diversion for Culver Ditch	B_1
Little Thompson River	Point of diversion for Culver Ditch	Confluence with Big Thompson	B_2
Buckhorn Creek	Sources	Confluence with Big Thompson	B_1

TABLE 7.2.1-B (Continued)

SOUTH PLATTE RIVER BASIN

CLASSIFICATION

AREA	FROM	TO	WATER QUALITY CLASS
Cache la Poudre River and tributaries and standing bodies of water in this area (refer to Appendix A, C.W.Q.C.C., 1974)	Sources	Point of diversion for City of Greeley water treatment plant	B_1
Main-stem of Cache la Poudre	Point of diversion for City of Greeley water treatment plant	Confluence with South Platte	B_2

Extracted from Colorado Department of Health, Colorado Water Quality Control Commission. June 19, 1974. Water Quality Standards and Stream Classifications.

Table 7.2.1-C

Current Waste Discharge Requirements for Secondary Treatment

Parameter	Federal PL 92-500		State WQCC		
	30-day Average	7-day Average	30-day Average	7-day Average	Single Sample
BOD_5 (mg/l)	30(a)	45	ns	ns	ns
SS (mg/l)	30(a,d)	45(d)	ns	ns	ns
pH	ns	ns	ns	ns	(b)
Total Residual Chlorine (mg/l)	ns	ns	ns	ns	0.5
Fecal Coliform (MPN/100 ml)	ns	ns	6,000	12,000	ns
Oil and Grease (mg/l)	ns	ns	ns	ns	10(c)

ns = none specified

(a) Shall not exceed 15 percent of 30-day average influent concentration.

(b) Within the limits of 6.0 to 9.0 unless it can be demonstrated that: (1) inorganic chemicals are not added to the waste stream as part of the treatment process; and (2) contributions from industrial sources do not cause the pH to exceed the 6.0 to 9.0 limits (EPA requirements).

(c) Nor shall there be a visible sheen.

(d) Conditional relaxation of these standards now proposed by EPA for communities utilizing stabilization ponds systems with a design capacity of 1 mgd or less.

The standards in Table 7.2.1-C represent the legally allowable constituent concentrations that can be discharged to waters of the State. In addition, rules and regulations specify that no toxic substance may be discharged in a quantity resulting in a toxic concentration in the stream. This applies to a wide variety of biological and chemical constituents and provides the State with a mechanism for controlling those discharges. The toxic element most commonly found in municipal discharges is ammonia. The Environmental Protection Agency has determined that an ammonia concentration in excess of 1.5 mg/l in the stream is toxic to aquatic life (at a pH of 7.5 and temperature at 68°F). Although this value is extremely sensitive to changes in pH and temperature, it is generally accepted as the in-stream limit by the State of Colorado and EPA.

Additional limitations have been established for specific categories of industries which exhibit common discharge characteristics. A number of major industries in the Larimer-Weld region, i.e., electronics, meat packing, etc., discharge waste to municipal treatment systems. In these cases, industries must meet pretreatment requirements to eliminate constituents not commonly removed by municipal wastewater treatment works. The municipalities are then subject to limitations described above, or more stringent limitations depending on instream water quality standards.

7.2.1.2 Recommended Classifications

At the request of the Colorado Water Quality Control Commission, the thirteen state planning and management regions (COG's) have been asked to make recommended stream classifications for waters in their regions. Approval of any part or all of a 208 areawide planning document does not mean summary approval of recommended stream classifications. Assignment of stream classifications by the Colorado Water Quality Control Commission must be carried out under separate administrative hearing and public input procedures.

As a part of the 208 planning process for the Larimer-Weld Region and in an attempt to provide the best available technical, social and economic input to the standards and classification process, the Larimer-Weld Areawide Planning Committee has made recommended water use classifications for water bodies within its political boundaries. It is the intent of the Larimer-Weld Region to achieve as high a level of water quality as is realistically possible consistent with state and national water quality goals, given constraints on the hydrologic system and a careful assessment of resources available to restore or improve water quality conditions.

Recommended water quality goals including water use classifications, criteria and standards for the Larimer-Weld Region are framed in the context of historic, present and anticipated future use of water resources; natural and man-induced constraints to the hydrologic system including a highly variable semi-arid climate resulting in a wide range of flow conditions, man-controlled water diversion, storage, and release for beneficial uses; historic and current fisheries management strategies based upon natural and man-caused effects on water quantity and water quality.

Proposed stream classifications for the Larimer-Weld Region have been made by the 208 Areawide Planning Committee (APC) after a lengthy process of investigation, discussion, referral and refinement. Numerous meetings, field trips and preliminary recommendations were made by the Subcommittees on Water Quality and Environmental Impact before presentation to the APC. The procedure which outlines this process is indicated in Figure 7.2.1-A.

Recommendations for classifications of stream segments were made using the beneficial use classifications as proposed by the Colorado Water Quality Control Commission in November 1977. Interpretations of these general use categories are shown in Table 7.2.1-D. In reviewing the proposed classification system, the Areawide Planning Committee (APC) did not endorse any proposed set of numeric limits pertaining to water quality criteria or standards for any of the beneficial uses. The APC recognized only the general use categories.

A great concern of the APC was that little latitude existed for the recognition of aquatic biota under the State's proposed system. Therefore, the APC directed staff to prepare aquatic subclassifications which reflected levels of protection for aquatic life based upon consideration of other than man-induced water quality factors.

These included natural background water quality conditions, irretrievable man-induced water quantity conditions upon the system and imposition of treatment levels higher than secondary because of extreme low flow hydrologic conditions.

The Larimer-Weld Regional Council of Governments proposed to the Commission in September, 1977, and again in October, 1977, a means of recognizing various levels of protection for aquatic life for cold or warm water biota. This aquatic life subclassification proposal is shown in Table 7.2.1-E. The Commission chose to modify the language for inclusion in the State's proposed standards and, therefore, altered the meanings of definitions of the Larimer-Weld aquatic life subclassification

FIGURE 7.2.1-A

STREAM CLASSIFICATION PROCESS
LARIMER-WELD REGIONAL COG
208 WATER QUALITY MANAGEMENT PROGRAM

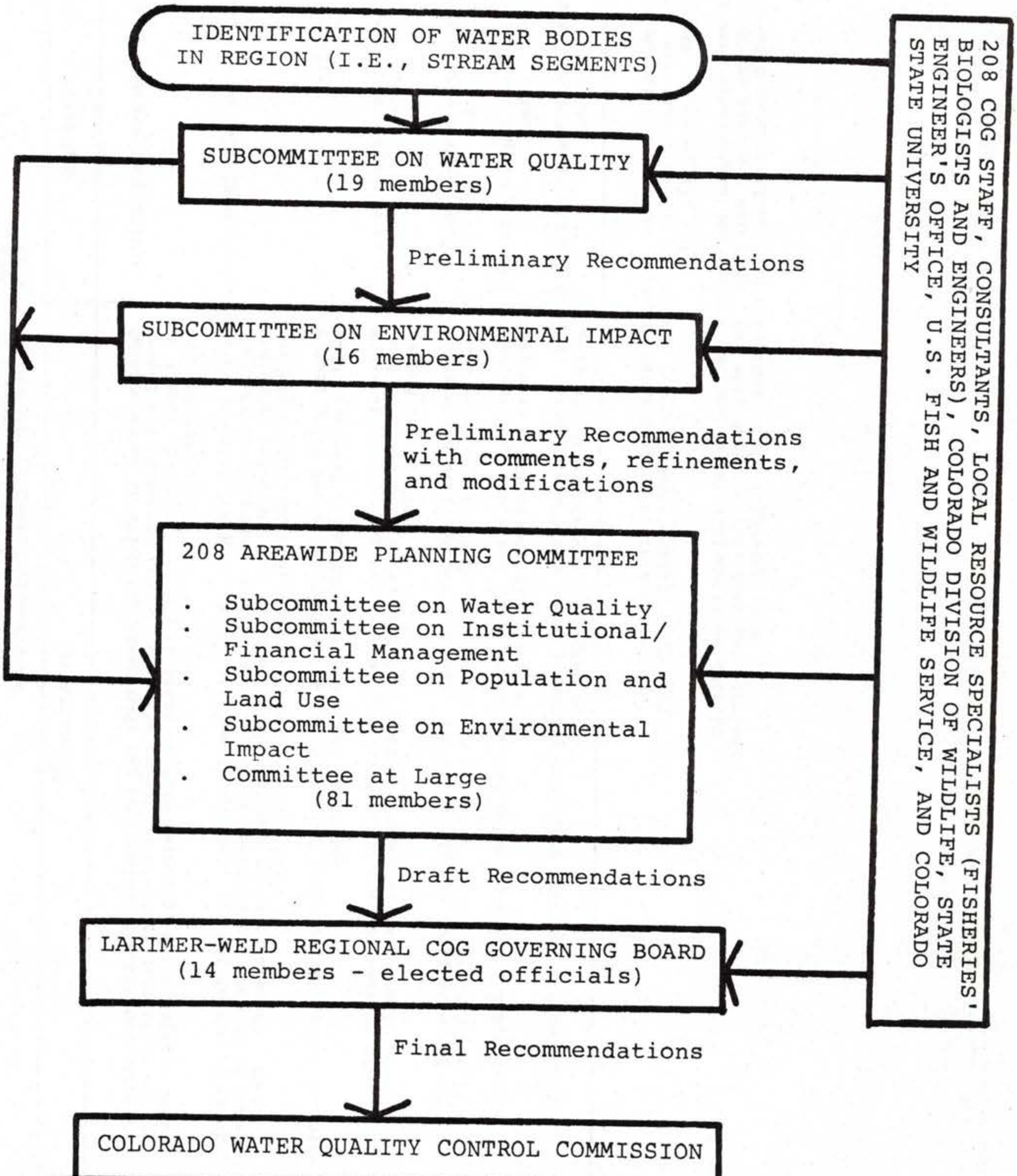

TABLE 7.2.1-D

SUMMARY OF COLORADO WATER QUALITY CONTROL COMMISSION PROPOSED CLASSIFICATION SYSTEM

NO.	WATER USE	DEFINITION [1]
1	Primary Contact Recreation	Surface water in which the human body may be completely submerged with prolonged and initimate contact when the ingestion of small quantities of water is likely to occur. Such activities include swimming, water skiing, canoeing and kayaking.
2	Secondary Contact Recreation	Water in which the human body may come in contact, but not to the point of complete or prolonged submergence, including recreational uses on or about the water which are not included in the primary contact category. Such activities include wading,general boating, and hiking.
3	Agriculture	Waters which are suitable for the irrigation of crops usually grown in Colorado, includes water used for livestock watering.
4	Aquatic Life - Cold Water Biota	Water which will support, sustain, and allow for the propagation of cold water aquatic life, including trout. Temperatures normally do not exceed 20^{o} C. [2]
5	Aquatic Life - Water Water Biota	Water which will support, sustain, and allow for the propagation of warm water aquatic life. Temperatures normally do not exceed 30^{o} C. [2]
6	Public Water Supply - Groundwater	Raw water suitable for human ingestion and other domestic and municipal purposes AFTER simple disinfection.
7	Public Water Supply - Surface Water	Raw water suitable for human ingestion and other domestic and municipal purposes AFTER conventional treatment.

(1) For exact definitions for the Colorado Water Quality Control Commission proposed water use classification system see Proposed Water Quality Standards for Colorado Draft #9, November 17, 1977.

(2) Cold and warm water biota use classifications do not include three aquatic life classifications for each category. For this document they have been replaced by the Larimer-Weld subclassifications described on the following page.

LARIMER-WELD 208 PROGRAM

TABLE 7.2.1.2-E: AQUATIC BIOTA SUBCLASIFICATIONS

Proposed Warm or Cold Water Biota Subclassifications	Description	Application and Intent
SUBCLASS 1 Aquatic Habitat "Quality"	A Class 1 Aquatic Habitat is characterized by healthy physical habitat which includes adequate quantity of water to insure survival during critical periods and quality of water which does not impair or inhibit development of a wide variety of self-propagating fish species (and other aquatic biota) including appropriate cold or warm water sport fish as defined in State law (stocking may be required to meet recreation or sport fishery demands).	1. Applicable to high quality waters capable of supporting sensitive aquatic species from both quality and quantity perspectives. 2. Numerical limits for water quality criteria would be established to protect aquatic biota including numeric limits established to account for adverse natural background conditions.
SUBCLASS 2 Aquatic Habitat "Seasonal"	A Class 2 Aquatic Habitat is defined as that which can support a sport fishery (and other aquatic biota) where existing or improved quality and quantity of water will allow seasonal creation of an expendable fishery. Not all species of fish (i.e., bass, trout, etc.) would be self-propagating and would have to be restocked each year. Fish other than the most sensitive species may live and propagate throughout these stream segments. In the case of municipal and industrial point source discharges, waste treatment higher than secondary or Best Available Technology may or may not be required.	1. Applicable to waters capable of supporting aquatic biota which may or may not include sensitive species on a seasonal basis. 2. Applicable to waters which can, from an economically-achievable point source and non-point source control strategy, water quality, and water quantity management perspective support such a habitat. 3. Numerical limits for water quality criteria would be established on a case-by-case basis reflecting natural and man-induced conditions peculiar to the stream segment. (Numerical determinations as indicated in #3, Subclass 3.)

Proposed Warm or Cold Water Biota Subclassifications	Description	Application and Intent
SUBCLASS 3 Aquatic Habitat "Marginal"	A Class 3 Aquatic Habitat is defined as that which can support aquatic biota under present water use and physical stream characteristics: A. Where existing in-stream uses shall be maintained and protected. No further water quality degradation which would interfere with or become injurious to existing aquatic habitat would be allowable; and B. Where improvement of habitat through flow augmentation or physical habitat modifications which would justify more stringent water pollution control measures than those defined in (C) below are demonstrated to be economically unachievable because of natural background or irretrievable man-induced conditions; and C. Where application of secondary treatment and/or "Best Available Technology Economically Achievable" for point source discharges and applicable Best Management Practices for non-point sources will enhance water quality for aquatic biota.	1. Basic water quality standards to all State waters would apply, i.e., free from grease, sludges, odor causing materials, etc. 2. Protect and enhance numbers and diversity of species present. 3. Numeric limits for water quality criteria would be established on a case-by-case basis reflecting natural background conditions and irretrievable man-induced conditions, including water quantity management practices. Numeric determinations would be made on evidence including bioassay techniques, historical data, or as recommended by the appropriate investigating agency. 4. Upgrade to Subclass 2 where treatment levels higher than secondary (BPT), BATEA, BMP's and/or more stringent control measures in conjunction with flow augmentation or physical habitat modification is economically achievable and would result in the attainment of a Subclass 2 habitat or higher. 5. Where it is demonstrated that achievement of higher in-stream water quality resulting from advanced waste treatment would not result in the attainment of Subclass 2 due to considerations other than water quality, numeric limits would reflect secondary treatment levels for municipal discharges, BATEA for industry, and BMP's for non-point sources. 6. Enhance through fisheries management the introduction of more sensitive species to replace "less desirables" as water quality is improved.

proposal. In view of this change, the Larimer-Weld 208 APC elected to retain its definitions, which it believes more accurately reflects three levels of aquatic life protection important to the Region.

Recommended stream classification and aquatic biota subclassification assignments for waters of the Larimer-Weld region were reached after considerable discussion among scientists, fisheries biologists, engineers, planners and citizen advisory committee participants. Historical, existing and future potential uses of these water bodies were carefully reviewed in making recommended classification assignments. The proposed classifications are shown in Table 7.2.1-F and in Figure 7.2.1-B. Justification for these assignments is summarized below along with qualifications on the establishment of water quality criteria or standards for various water quality parameters to insure that a sufficient level of water quality is being attained for a beneficial use.

JUSTIFICATION FOR CLASSIFICATIONS:

1. Not all natural waters in the Larimer-Weld Region were historically capable of supporting a wide diversity of native or introduced aquatic life in such a manner as to exist and reproduce in a non-stressful state because of naturally occurring stream flow conditions, and lack of stable physical habitat.

2. The hydrologic system of the Larimer-Weld Region is currently governed by statutory and administrative interpretation of Colorado Water Law in which the hydrologic system is administered to satisfy the water rights of senior water rights' holders and an established hierarchy of beneficial uses. No water has been adjudicated for minimum stream flows in the Larimer-Weld Region.

3. The once natural hydrologic system of the Larimer-Weld Region has been greatly modified through a highly-developed water resource management system including transbasin and transmountain, water storage, diversion, and numerous "beneficial" uses and reuses of water. These man-induced actions have, in fact, broadened and enhanced the number of beneficial uses in the Region through making greater amounts of water available for longer periods of time.

4. Investments of public and private funds to plan for, protect, restore, or improve water quality for various beneficial uses should undergo a rigorous test of costs versus benefits, including:

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Cache la Poudre North Fork & Tributaries

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Source	N/A	Halligan Reservoir	N/A	QUALITY (1): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4 - Cold Water Biota; 6 - Water Supply - Groundwater; 7 - Water Supply - Surface
Below Halligan Reservoir	N/A	Confluence with main stem Cache la Poudre	N/A	SEASONAL (2): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4 - Cold Water Biota; 6 - Water Supply - Groundwater; 7 - Water Supply - Surface

The following provisions are also made:

1. The North Poudre Irrigation Company and the City of Greeley be encouraged to operate their reservoir discharges in such a manner as to minimize adverse effects on fisheries in the main stream of the North Fork between Halligan Reservoir and Seaman Reservoir; and from Seaman Reservoir to the confluence with the Poudre River;

2. A thorough investigation of the natural and man-induced sedimentation problems of the North Fork watershed be carried out to determine the extent to which each contributes to the water quality problems of the area, and that such a study be coordinated by the designated planning agency for the 208 Plan. The study should include, but not be limited to:

Footnote to the Reader: Text continues on page .

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Cache la Poudre North Fork & Tributaries (Continued)

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
				A. An inventory of existing conditions on the watershed; B. An analysis of structural and engineering alternatives to water quality management problems; C. An analysis of alternative soil and watershed management practices and solutions to water quality management problems; D. An investigation of cost-sharing programs of other financial requirements and timetables necessary to implement a solution to the water quality problems on the watershed.

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TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Cache la Poudre Main Stem & Tributaries

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Source		Fort Collins Municipal Filtration Plant Intake	60	QUALITY (1): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4 - Cold Water Biota; 6 - Water Supply - Groundwater; 7 - Water Supply - Surface
Below Fort Collins Municipal Filtration Plant Intake	60	Fort Collins Waste Treatment Plant #1 (near Mulberry Ave.)	44	SEASONAL (2): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4,5 - Cold/Warm Water Biota; 6 - Water Supply - Groundwater
Fort Collins Water Treatment Plant #1	44.1	Confluence with the South Platte River	0	The following provisions are also made: 1. Although the Poudre River, because of its cold temperatures and physical character is used mostly for secondary recreation, the nature of that secondary contact recreation (kayaking and rafting) could potentially result in prolonged intimate contact or ingestion of small amounts of water. An investigation of the feasibility of upgrading secondary contact recreation to primary contact recreation to Mulberry Avenue be made by the designated 208 planning agency to determine the effects of water pollution from non-point sources primary contact upon water recreation. Special attention should be directed to the effects of septic tanks and other waste treatment systems and urban storm runoff discharges along the Poudre River and tributaries.

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Cache la Poudre Main Stem & Tributaries (Continued)

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
				2. The proposed classification includes only water quality considerations. An investigation of the water quantity necessary to satisfy the requirements of various levels of life protection is required. The results of such an investigation should be carefully reviewed in the final recommendation for any aquatic biota classification. 3. A study should be made to determine the effects of upstream municipal discharges into the Cache la Poudre upon adjacent artificial and manmade water bodies (gravel pits). The objective of the study should be to determine subsurface flow gradients to or from the river and the effects of discharges on aquatic life in these water bodies.

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Big Thompson River Main Stem & Tributaries

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Source		Estes Park Sanitation District Waste Treatment Plant Discharge	58	QUALITY (1): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4 - Cold Water Biota; 6 - Water Supply - Groundwater; 7 - Water Supply - Surface
Below Estes Park Sanitation District Waste Treatment Plant Discharge	58	Home Supply Canal Diversion	36	QUALITY (1): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4 - Cold Water Biota; 6 - Water Supply - Groundwater; 7 - Water Supply - Surface The following provisions are also made: The Big Thompson River below the Town of Estes Park is affected by four major influences; the introduction of large quantities of water diverted from the Western Slope, the municipal waste discharges of the Estes Park Sanitation District and the Upper Thompson Sanitation District, regulation of water in Lake Estes, and the persistent effects of the Big Thompson Flood of July 31, 1976. These influences will continue to determine to a large extent the attainability of water quality suitable for various use classifications on the river. 1. The Flood of July 31 caused severe damage to natural and man-made systems on the river, including altering the basic character of the stream channel. The after-effects of the flood itself and recovery activities will continue to impact the beneficial uses of the river for 5 years to 15 years. The findings and recommendations of the Big Thompson Recovery Planning Office should be incorporated into the potential stream classification.

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Big Thompson River Main Stem & Tributaries (Continued)

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Below Home Supply Canal Diversion	36	Big Barnes Ditch Diversion	31	2. The Estes Park Sanitation District and the Upper Thompson Sanitation District should maintain high quality effluent discharges so as to minimize any adverse effects to existing and future uses on this high quality water body. The 201 Facilities Plan for EPSD should be incorporated into the 208 Plan. 2 - Secondary Contact - Recreation 3 - Agriculture SEASONAL (2) 4,5 - Cold/Warm Water Biota 6 - Water Supply - Groundwater 7 - Water Supply - Surface The following provisions are also made: 1. The proposed classification includes only water quality considerations. An investigation of the water quantity necessary to satisfy the requirements of an aquatic biota classification is required. The results of such an investigation should be carefully reviewed in a final aquatic biota classification. Historic accounts of the type and quality of aquatic biota in this segment on the Big Thompson River in this area are not well known. The Colorado Division of Wildlife should be encouraged to determine the past and potential biota of this stream segment through future intensive study. Page 6 of 11

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Big Thompson River Main Stem & Tributaries (Continued)

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Below Big Barnes Ditch Diversion	31	Loveland Waste Treatment Plant Discharge	24	SEASONAL (2): 2 - Secondary Contact - Recreation; 3 - Agriculture; 4,5 - Cold/Warm Water Biota; 6 - Water Supply - Groundwater
Below Loveland Waste Treatment Plant No. 2 Discharge	24	Confluence with South Platte River	0	MARGINAL (3): 2 - Secondary Contact - Recreation; 3 - Agriculture; 5 - Warm Water Biota; 6 - Water Supply - Groundwater The following provisions are also made: 1. A study should be made to determine the effects of upstream municipal discharges into the Big Thompson upon adjacent artificial and man-made water bodies (gravel pits). An objective of the study should be to determine subsurface flow gradients to or from the river and the effects of discharges on aquatic life in these water bodies.

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Little Thompson River & Tributaries

From	River Mile	To	River Mile		208 Larimer-Weld Areawide Planning Committee Recommended Classification
Source		St. Vrain Supply Canal Diversion	25	QUALITY (1)	2 - Secondary Contact - Recreation 3 - Agriculture 4 - Cold Water Biota 6 - Water Supply - Groundwater
Below St. Vrain Supply Canal Diversion	25	Town of Berthoud Waste Treatment Discharge	16	SEASONAL (2)	2 - Secondary Contact - Recreation 3 - Agriculture 4,5 - Cold/Warm Water Biota 6 - Water Supply - Groundwater
Below the Town of Berthoud Waste Treatment	16	Confluence with the Big Thompson River	0	MARGINAL (3)	2 - Secondary Contact - Recreation 3 - Agriculture 5 - Warm Water Biota 6 - Water Supply - Groundwater

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: St. Vrain Creek

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Weld County - Boulder County Line		Confluence with South Platte River	20	MARGINAL (3): 2 - Secondary Contact - Recreation 3 - Agriculture 5 - Warm Water Biota 6 - Water Supply - Groundwater

DRAINAGE: South Platte River & Tributaries not previously classified

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Weld County - Adams County Line	295	Weld County - Morgan County Line	218	MARGINAL (3): 2 - Secondary Contact - Recreation 3 - Agriculture 5 - Warm Water Biota 6 - Water Supply - Groundwater

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Larimer-Weld Region

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Areawide Classification for groundwater				Areawide Classification for groundwater. 6 - Water Supply - Groundwater The groundwater resources of Larimer and Weld Counties represent a valuable resource which is utilized for public and private water supply and agriculture. The problems of evaluating the groundwater resources are complex and costly. The need to address the groundwater resource in a stream classification process is apparent through the relationship between the use of surface water resources and potential impacts to groundwater supplies. The Safe Drinking Water Act of 1974 (PL 93-523) and regulations promulgated under the Act recognize the necessity of protecting groundwater for public water supply purposes. It is important that stream classification for the Larimer-Weld Region reflect both these physical and administrative relationships and protect the groundwater resources for existing and future use. Dealing with the question of groundwater quality will require considerable additional study beyond the scope of the initial 208 planning effort and an extensive commitment of financial resources. An areawide classification for groundwater is recommended pending the results of future studies.

TABLE 7.2.1-F RECOMMENDED STREAM CLASSIFICATIONS

DRAINAGE: Lakes and Reservoirs in Larimer-Weld Region, Laramie River Basin

From	River Mile	To	River Mile	208 Larimer-Weld Areawide Planning Committee Recommended Classification
Deferred Classification of Lakes, Reservoirs and Laramie River Basin				Under the current classification system many reservoirs of the foothills and plains areas have not been classified. Other lakes and reservoirs of the mountains and foothills areas have been classified (See Interim WQMP Report #21). In order to develop classifications under the proposed system for the Laramie River and over 200 lakes and reservoirs of the mountain, foothills and plains areas it is imperative that an adequate data base on physical, chemical and biological water quality and historic, existing and potential beneficial uses be reviewed and analyzed. It is recommended that classifications be made in the continuing planning process by the Areawide Planning Agency with proper input from various sources including the Colorado Division of Wildlife.

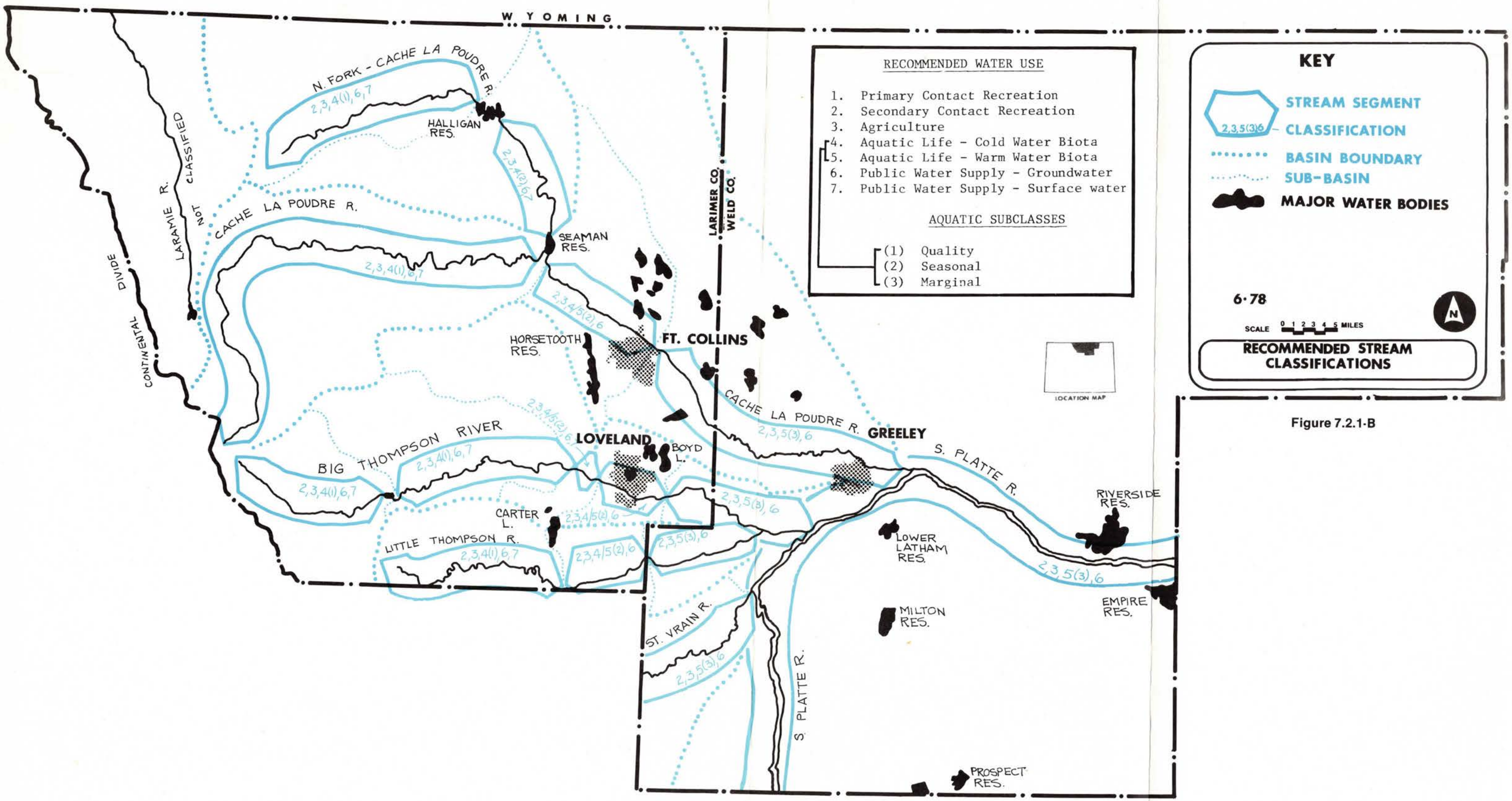
WYOMING
RECOMMENDED WATER USE
1. Primary Contact Recreation
2. Secondary Contact Recreation
3. Agriculture
4. Aquatic Life - Cold Water Biota
5. Aquatic Life - Warm Water Biota
6. Public Water Supply - Groundwater
7. Public Water Supply - Surface water
AQUATIC SUBCLASSES
(1) Quality
(2) Seasonal
(3) Marginal
KEY
STREAM SEGMENT
2,3,5(3)6
CLASSIFICATION
BASIN BOUNDARY
SUB-BASIN
MAJOR WATER BODIES
6·78
SCALE 0 1 2 3 4 5 MILES
RECOMMENDED STREAM CLASSIFICATIONS
LOCATION MAP
N. FORK - CACHE LA POUDRE R.
2,3,4(1),6,7
HALLIGAN RES.
2,3,4(2),6,7
LARAMIE R. NOT CLASSIFIED
CACHE LA POUDRE R.
SEAMAN RES.
2,3,4(1),6,7
CONTINENTAL DIVIDE
LARIMER CO.
WELD CO.
2,3,4/5(2),6
HORSETOOTH RES.
FT. COLLINS
CACHE LA POUDRE R.
2,3,5(3),6
GREELEY
S. PLATTE R.
BIG THOMPSON RIVER
2,3,4(1),6,7
2,3,4/5(2),6
LOVELAND
BOYD L.
2,3,4(1),6,7
2,3,5(3),6
CARTER L.
2,3,4/5(2),6
LITTLE THOMPSON R.
2,3,4(1),6,7
2,3,4/5(2),6
2,3,5(3),6
RIVERSIDE RES.
LOWER LATHAM RES.
2,3,5(3),6
EMPIRE RES.
MILTON RES.
ST. VRAIN R.
2,3,5(3),6
S. PLATTE R.
PROSPECT RES.

Figure 7.2.1-B

a. Scientific evidence that implementation of such water quality and quantity management actions will, in fact, result in appreciable increases in in-stream water quality for desired beneficial uses;

b. An evaluation of environmental, social, and economic consequences resulting from such action.

5. Classification of lakes and reservoirs in the Region particularly in the foothills and plains areas, should be deferred until a more thorough analysis can be made of historic, existing and expected beneficial uses. This analysis and classification should be carried out by the designated areawide planning agency for the 208 Plan.

6. Levels of protection or subclasses should be established for other beneficial use categories. This approach recognizes the resource value of each beneficial use relative to other beneficial uses. Included in the development of these subclasses should be consideration for past, present and historic use of the water body; as well as consideration for public health and aesthetics and meeting the goals of the Clean Water Act. Numeric criteria for water quality, if required to delineate the various levels of protection, should be determined by a careful examination of scientifically derived water quality information by a group of experts in appropriate technical disciplines, including economics, agronomy, engineering, hydrology, aquatic biology, toxicology, public health and recreation resources.

These stream classifications and aquatic subclassifications are contingent upon provisions as indicated for each segment. Further, they are made in concept using the State's proposed general classification system and the Larimer-Weld Regional Council of Governments 208 Areawide Planning Committee Subclassification system for aquatic biota. They do not consider numeric limits for water quality parameters as proposed by the State.

7.2.1.3 Recommended Standards

The Larimer-Weld Region recommends that criteria such as those contained in EPA's Quality Criteria for Water (EPA, 1976) be used as non-regulatory planning tools which, along with other independent evidence, can be used to determine feasible and justifiable non-point pollution control strategies; new standards; effluent limitations for existing and new point source discharges; interrelationships between in-stream standards and pollution generators; and, enforcement actions. This charge will require a cooperative effort on the part of state and federal regulatory agencies and dischargers. The need for such an approach is explained in Section 3.3 which points out the problems which may be encountered by adherement to untested and questionable water quality criteria and standards.

Stream standards should be based upon water quality criteria levels which are scientifically justifiable, easily and economically detectable and pertinent to the beneficial uses they are designed to protect. In view of the state-of-the-art of developing standards to preserve or protect aquatic life or other uses, and the questionable accuracy and precision of often intricate, expensive and frequently unreliable field and laboratory testing equipment and methods, it is recommended that State standards currently in effect be retained and that in-stream standards for other pollutant indicators be established on a case-by-case basis, as the need arises. Applicable standards are summarized in Table 7.2.1-A. The technical strategy needed to accomplish this task is outlined in Section 7.1.2.

7.2.1.4 Recommended Effluent Limitations

It is recommended that effluent limitations for existing municipal waste discharges in the Region and existing industrial waste discharges whose wastewater characteristics are equivalent in composition to municipal waste, be required to meet effluent limitations adopted March 18, 1975, by the Colorado Water Quality Control Commission. A summary of specific limitations for the discharge of wastes is outlined in Table 7.2.1-G below.

TABLE 7.2.1-G
SPECIFIC LIMITATIONS FOR THE DISCHARGE OF WASTES

PARAMETERS	PARAMETER LIMITATIONS	
	7-Day Average	30-Day Average
BOD_5	45 mg/l	30 mg/l
Suspended Solids	45 mg/l	30 mg/l
Fecal Coliform	As determined by the Division of Administration of the State Health Department to protect public health in the stream classification to which the discharge is made	
Residual Chlorine	Less than 0.5 mg/l	
pH	6.0 - 9.0	
Oil and Grease	10 mg/l and there shall be no visible sheen	

It is further recommended that an ammonia limitation be established for municipal waste discharges in excess of 1 mgd which is a concentration level equivalent to that which can be reliably achieved by a properly designed, operated and maintained conventional secondary wastewater treatment facility as determined by the Colorado Water Quality Control Commission.

For communities for which it has been determined by a cost-effective analysis that aerated waste stabilization ponds will meet treatment requirements, it is recommended that the effluent limitations shown in Table 7.2.1-G be applied, except that in the case of Suspended Solids, where a higher limit be established based on Best Waste Stabilization Pond Technology, as determined by the Colorado Water Quality Control Commission.

7.2.1.5 Recommended Continued Technical Planning Tasks

To ensure that there is a continuing and progressive effort to define water quality relationships for pollutants and their sources and a means to reduce water pollution, a continued technical planning strategy must designed with the following objectives:

1. Establish relationships between point and non-point source pollution and achievement of maintenance of beneficial uses.

2. Define the impact of point sources of pollution under varying flow regimes.

3. Monitor the effects of waste discharges on aquatic life to insure an adequate level of protection.

4. Determine allowable mixing zones below point source discharges.

5. Establish enforceable in-stream standards for critical physical, chemical and biological constituents and associated effluent limitations for point source discharges.

6. Determine means of measuring effectiveness in terms of in-stream water quality improvements resulting from water quality control alternatives.

The process to meet these objectives is comprised of four basic elements. They are:

- Monitoring and Reporting
- Standards Setting and Effluent Limitations
- Revisions of Classifications
- Enforcement.

A. Monitoring and Reporting

The existing data base is inadequate to meet the above-stated objectives. A long-term program to monitor physical, chemical and biological conditions in area water bodies and their relationship to various hydrologic regimes is necessary to plan for the protection and enhancement of beneficial uses. A water quality monitoring program for the Region should be a coordinated effort involving all agencies and organizations currently conducting water quality sampling. The justification for a monitoring program to address this problem is included in Section 7.2.2.

B. Standards Setting and Effluent Limitations

The monitoring program described above will serve as the basis for the establishment of new water quality standards. The general rule of thumb to be followed will be to first monitor those constituents for which there is a known discharge and for which the Colorado Water Quality Control Commission, in consultation with the Areawide Planning Agency, determines may interfere with existing or anticipated beneficial uses. In the case of proposed new point source discharges, an intensive water quality sampling program should be initiated in the appropriate stream segment as a means of determining appropriate in-stream standards, if warranted, and appropriate effluent limitations other than those recommended previously.

C. Revisions of Classifications

Examination of stream classifications will be made periodically by the Areawide Planning Agency, but no less frequently than once every three years in a manner coinciding with the review of classifications and standards conducted by the Colorado Water Quality Control Commission. The immediate task following approval of the 208 Plan will be to examine lakes, reservoirs, groundwater basins and the Laramie River, and make appropriate recommendations to the Commission. Additionally, emphasis will be given on strengthening the classification system by, for example, examining the merits of establishing levels of protection (or subclassification) for each major water use category.

D. Enforcement

Enforcement is a means of last resort to ensure protection of beneficial uses of water. Currently, enforcement actions focus on violation of conditions to point source discharge permits and in-stream standards. For such pollution indicators as BOD and Suspended Solids, enforcement has been an effective legal means of insuring water quality is protected. However, less success has been achieved in enforcing more exotic pollutants, such as heavy metals, due principally to state-of-the-art considerations. Nonetheless, the ability to enforce is a necessary part of the pollution control program.

The process outlined previously for a case-by-case determination of standards and effluent limitations, will serve to strengthen state enforcement capabilities.

As a rule, neither standards nor criteria should be used in and of themselves as a basis for enforcement action. "However, where there is other, more reliable, scientific evidence of unacceptable damage to an aquatic resource or a use of water, the demonstration of a violation of one or more of the applicable standard (or criteria) can be corroborating evidence facilitating the enforcement action. Wherever there is such independent evidence of pollution, those demonstrably contributing to violation of the standards (or criterion) can be reasonably asked to show cause why they should not be required to meet the standards (or criterion) and undertake monitoring (or other appropriate action) necessary to demonstrate compliance."*

7.2.2 Water Quality Monitoring Program

A water quality monitoring program is a fundamental need to insure that future investments in water pollution control are made in a wise and efficient manner. A water quality monitoring program will allow making of investment decisions based on factual data developed in the region rather than opinions, old sayings, rules of thumb, inapplicable broad-scale regulatory efforts, and/or arbitrary decisions at the federal, state or local levels.

The monitoring program implemented as a part of the initial 208 program development provided the basis for the realistic planning contained in the 208 Plan. Without such information on the water quality impacts of point and nonpoint sources within the region and information on regional hydrology, realistic conclusions and recommendations concerning water quality control measures would never have been reached. Acceptance and application of pollution control regulations without understanding their regional applicability could have resulted in the expenditure of millions of dollars with no apparent water quality benefits. However, the 208 program does not contain all answers for all times. To insure that the region will have the factual data on which to base future decisions, a water quality monitoring program should be implemented in the region.

7.2.2.1 Overall Approach to Water Quality Monitoring Program

A water quality monitoring program cannot be justified simply because data is collected, data collection is required, and/or funds are available. Water quality monitoring is not an end to

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*Excerpt from "Additional Comments by Peter Doudoroff to the Colorado Water Quality Control Commission regarding proposed revision of the Colorado State Water Quality Standards and Stream Classification System," February 1978. Full text of these comments is in Appendix A.

itself. A justifiable program is one which supports overall water management goals of the Region, the State, and the nation. The primary objective of the water quality monitoring program is to insure sound investment in water quality control measures for the protection of beneficial uses.

The monitoring program must be cost effective in itself. This implies that the program must produce information which supports overall water management objectives with optimum use of available and ongoing monitoring resources. Program cost is definitely a consideration in the design and implementation of water quality monitoring programs.

The recommended program for the Larimer-Weld Region includes:

1. A statement of objectives which supports overall water management objectives of the region;

2. A statement of criteria which guides design of the program;

3. Designation of sampling activities in terms of who samples, where, what and how often.

The implementation of the recommended program is dependent upon cooperation and support of a number of local, state, and federal agencies and private organizations. Improvements in program design are anticipated as agency representatives gather to discuss the relationship among their on-going activities and the recommended program.

7.2.2.2 Objectives of the Water Quality Monitoring Program

The water quality monitoring program supports the following overall objectives stated in the "Goals and Objectives in Matters of Regional Concern", adopted by the Larimer-Weld Regional Council of Governments on May 5, 1976:

"B. <u>Surface and Underground Water Quality/Wastewater Treatment</u>

Goal:	Encourage maintenance and enhancement of surface and underground water quality consistent with the use of these waters.
(Supporting) Objectives	1. Develop and implement an efficient and effective regional management plan for collection and treatment of wastewater.

2. Assure that the quality of surface and underground water is monitored by the appropriate agencies.

3. Support controls that will maintain and improve the region's water quality consistent with its use.

4. Encourage communication with water resource management and wastewater treatment agencies."

In order to accomplish these regional goals, <u>specific objectives</u> for the monitoring program include:

1. Define the impacts of discrete point source discharges on water quality within the region;

2. Define the impacts of nonpoint sources such as agriculture, silviculture, mining, urban runoff, septic tanks and leechfields, and natural background conditions on water quality;

3. Define the relationships between nonpoint source pollution, natural background pollution, and point source pollution in the region;

4. Define the relationship between water quality parameters which can be measured and the beneficial uses of water recognized in the region.

5. Provide the basis for evaluating the effectiveness of measures implemented by municipalities, industries, and others involved in pollution control in the region;

6. Provide an indication as to the degree of pollution of groundwater supplies in the region, their significance on beneficial uses, future trends, and sources of pollution;

7. Provide the data necessary to insure protection of beneficial uses in the region;

8. Provide the data necessary to indicate trends in water quality.

Fulfillment of these objectives in a cost-effective manner will require implementation of an initial water quality program, evaluation of the data resulting from that program, and continuous reevaluation of the program producing that information.

All objectives will not be met initially. Failure to review the program in light of its overall objectives versus results, will result in a waste of taxpayers' money over a long period of time.

7.2.2.3 Criteria for the Monitoring Program

Design criteria for the water quality monitoring program take into account factors influencing the parameters to be sampled, sample locations, frequency of sampling, i.e., all of the factors which control the cost and the effectiveness of the program. The criteria for the Larimer-Weld Regional Council of Governments 208 Program are stated below:

1. Frequency of sampling should be dependent upon the following factors:

    a. Time over which changes in water quality can be anticipated, i.e., hourly, daily, seasonally, monthly, years, decades;

    b. Sensitivity of applying water to various beneficial uses as a function of change in water quality;

    c. The magnitude of changes anticipated by implementing point and nonpoint source pollution control measures;

    d. Existing NPDES Permit requirements.

2. The physical, chemical and biological constitutents sampled will be dependent upon:

    a. The characteristics of point and nonpoint source dischargers;

    b. The significant characteristics related to the beneficial uses of water, including flow variations;

    c. Constituents which can be controlled measurably through implementation of point and nonpoint source control measures;

    d. Existing NPDES Permit requirements.

3. The monitoring program should identify:

    a. The impacts of external sources on the region, i.e., pollution from upstream areas.

b. The significance of external as opposed to internal sources on beneficial uses within the region and on downstream uses;

c. The impacts of specific point sources relative to other point sources, non-point sources, and natural background conditions.

4. Program should optimize use of resources for data collection and analysis to the maximum extent possible, and should recognize and incorporate the results of ongoing federal, state, local agency and private programs.

5. Collection of flow data should be included as a fundamental element in the monitoring program to develop an understanding of fundamental relationships among hydrologic and water quality parameters.

6. The location of sampling points should be based on:

   a. Location of significant point and nonpoint source discharges;

   b. Need to differentiate impacts of specific discharges on in-stream water quality;

   c. Ensuring protection of high quality mountain streams in the region.

Meeting all criteria may not be possible in the initial program, but the criteria should be applied as the results of the initial program are evaluated and the monitoring program is modified based on experience.

7.2.2.4 Existing Water Quality Sampling Programs

Water quality programs currently being conducted in the region include those by municipalities, industries, State of Colorado Water Quality Control Division, U.S. Geological Survey, National Park Service, and others.

Municipalities and industries are required to monitor their own discharges under the terms and conditions of their NPDES discharge permit. Self-monitoring data is restricted to the discharge itself and no requirements are set forth for monitoring downstream impacts of the discharge.

The State of Colorado operates a water quality monitoring program within the region and the U.S. Geological Survey (USGS) collects periodic water quality samples. In addition to its routine sampling program, the USGS may undertake special hydrologic and water quality studies, including surface and/or ground waters, and these have been conducted in the region. The National Park Service has initiated a program to define impacts of recreational use within Rocky Mountain National Park.

Existing water quality monitoring programs were designed with specific limited objectives in mind. Because of this, existing programs did not meet the overall objectives and criteria defined above.

A. Cause and Effect Relationships

Shortcomings of the existing programs include:

1. Lack of definition of cause/effect relationships among pollutant discharges, in-stream water quality, and impacts on beneficial uses.

2. Inadequate in-stream biological data.

3. Inability to differentiate among the impacts of point and non-point sources.

4. Lack of in-stream flow data corresponding to water quality data.

These factors are discussed below.

A major shortcoming of existing programs is lack of cause and effect definition among pollutant discharges, in-stream water quality, and impacts on beneficial uses. Regulatory agencies must rely on major planning efforts such as the "Comprehensive Water Quality Management Plan - South Platte River Basin", completed in 1974 and the current 208 program to define the impacts of municipal and industrial discharges on water quality. This is done without an adequate historical data base relating specific pollutant discharges to in-stream water quality conditions, or in-stream water quality conditions to actual impacts on aquatic life and other beneficial uses of the stream.

In the current 208 program, an extensive water quality monitoring program was undertaken to identify impacts of point source discharges on the stream. However, this must be looked upon as a first step, since inadequate historical data is available to fully define water quality impacts of point sources under the extreme hydrologic variations which occur in the region. In order to provide a more realistic assessment in the future, information on in-stream impacts should be collected by the municipalities and industries themselves, both to understand their actual impacts on water quality in the Region and to guard against far-reaching, costly decisions based on inadequate technical data.

B. Biological Data

The second major shortcoming of the existing monitoring programs in the region is the almost total lack of in-stream biological data. The stated goals of P.L. 92-500 are to provide for establishment of aquatic life habitats where attainable. However, very little is known about aquatic life in the streams of the Region, the State or the nation, or the physical and water quality requirements for actually attaining this goal.

An even greater unknown is the relationship among water quality conditions and a stream's ability to support various types of aquatic life. Generally, data has been extrapolated from other areas or from highly controlled "tank tests" conducted under ideal conditions. While these tests and research may meet the limited objectives for which they are designed, they may not be directly applicable to in-stream conditions in the Larimer-Weld Region. Thus, municipalities and industries are subject to the best judgments based on extrapolated data which may or may not be relevant to the real ecological system impacted by the discharge.

C. Point and Non-Point Source Discharges

A third major shortcoming of the existing programs is lack of ability to differentiate among the impacts of point and nonpoint sources. This results directly from the fact that most municipalities and industries sample only their discharge and do not sample upstream or downstream. Thus, while significant investments in point source pollution control have been made, little is known about the actual benefits when compared to impacts of other discharges, including other point source discharges.

D. In-stream Flow Data

The fourth major shortcoming of the existing program is the absence of in-stream flow measurements taken at the same time water quality data is collected. Water quality data alone is of little value unless corresponding flow conditions are documented and understood. The complex system of diversion structures, reservoir releases, point source discharges, and nonpoint return flow make accurate flow estimating based on upstream or downstream gaging data absolutely impossible (Interim WQMP Report No. 22).

7.2.2.5 Recommended Water Quality Monitoring Program

The recommended water quality monitoring program is directed toward (a) eliminating the shortcomings listed above; (b) meeting the program objectives state above and (c) optimizing the use of available resources in the region. The fundamental approach to be taken includes:

1. In-stream sampling should be conducted by municipalities and industries above and below their points of discharge.

2. The parameters sampled in the in-stream sampling program by municipalities and industries should be expanded so that impacts of point and nonpoint sources can be differentiated; flow measurements should be taken by municipalities and industries in conjunction with in-stream water quality data.

3. The program is designed to be implemented primarily by municipal and industrial dischargers, but at little additional cost over the cost of existing sampling programs. The data provided will be vital to each municipality and industry in defining their actual in-stream impacts and will provide the realistic information to insure factually-based decision-making in the future.

4. Data from ongoing federal and state programs will be incorporated into the monitoring program.

5. Data collected by municipal water suppliers in compliance with the Safe Drinking Water Act will be incorporated into the program.

6. All proposed special water quality studies by federal and state agencies will be reviewed for compliance with regional water goals and objectives.

7. Bioassay data will be collected in all streams of the region.

The program should be reevaluated after one year in light of experience gained and to insure that the criteria proposed above are being met.

A. Recommended Municipal and Industrial Monitoring Program

The municipal and industrial monitoring program includes the following elements:

1. Continued monitoring as required under NPDES permits.

2. Monitoring upstream of the discharge, including flow measurement.

3. Monitoring downstream of the discharge.

4. Monitoring a few additional elements to determine the relationship among their discharge and nonpoint source discharges to the same stream.

It is recommended that in-stream samples be collected by municipalities and industries on a monthly basis. This should provide a good indication of the seasonal variation of the impacts and the variations of impacts under various hydrologic conditions. The parameters recommended for in-stream sampling to define the impacts of municipal discharges include fecal coliform, dissolved oxygen, ammonia, BOD_5, suspended solids, and temperature. In order to differentiate the impacts of nonpoint sources, primarily that of irrigated agriculture, it is recommended that the municipal program in-stream be expanded to include sampling for total dissolved solids (or electroconductivity) and nitrates. Along with the information on suspended solids collected upstream and downstream, this data should provide an excellent indication of the relationship of point and nonpoint source discharges in the region. The additional costs which might be incurred include those costs for analyses of nitrate and total dissolved solids. In lieu of having laboratory analyses for total dissolved solids, electroconductivity readings could be collected. If this is done, the meters used throughout the region should be calibrated with a standard sample.

Stream flow should be measured upstream of municipal and industrial discharges concurrently with water quality sampling. Corresponding flow measurements will greatly enhance the value of water quality data.

Implementation of this program would meet program objectives including those for optimization of resource use. Though additional costs will be involved, in-stream impacts will be defined and relationships between major point and nonpoint sources will be identified. This will provide long-term historical data base required for realistic water quality planning. The program recognizes the fact that the most expensive element in any water quality monitoring program is getting personnel to the field to collect the sample. Utilizing existing municipal personnel will greatly reduce overal program costs.

B. Additional Sources of Water Quality Data

Additional sources of water quality data which should be incorporated into the water quality monitoring program including:

1. Special studies conducted by the COG as a part of the continuing 208 planning program;

2. Water quality data from ongoing federal and state programs;

3. Data collected by municipalities in compliance with Federal Safe Drinking Water Act;

4. Special water quality and hydrologic studies conducted by federal and state agencies.

C. Continuing 208 Water Quality Studies

Recognizing that inadequate data presently exists to deal with many nonpoint sources of pollution (Interim WQMP Report Nos. 15, 19, and 22), recommendations were developed during the initial 208 planning process to conduct additional water quality management planning efforts, particularly in the areas of urban runoff and agricultural pollution control. While implementation of these planning projects will be dependent upon future federal funding, project recommendations included development of additional water quality sampling information as a part of the planning process. Development of additional information on urban runoff, agricultural pollution control, and other nonpoint sources should enable incorporation of valuable data into the water quality monitoring program for the Larimer-Weld Region and result in a better understanding of the impacts of these nonpoint sources.

D. Ongoing Federal and State Programs

The Colorado Department of Health (CDH) and the U.S. Geological Survey currently conduct water quality sampling programs in the area. Data from these programs should be incorporated into the regional water quality monitoring program. These programs should be analyzed in light of the criteria defined in this section and recommendations should be made to CDH and USGS concerning future sampling locations, frequencies, and constituents. The Colorado Department of Health should focus its efforts on, and have primary responsibility for, sampling and analyzing for the most exotic constituents which might impact beneficial uses.

E. Municipal Water Supply Data

The Federal Safe Drinking Water Act requires routine sampling of all "public water supplies" as defined in regulations for a variety of constituents. Since many of the major communities in the Larimer-Weld Region receive their drinking water supplies from high-mountain streams, these analyses should provide a good indicator of the conditions of those streams with respect to constituents analyzed and provide a valuable addition to the water quality data base at no additional cost to either water suppliers or the regional water quality management planning agency.

A number of communities in South Weld County rely on groundwater supplies from the South Platte aquifers for municipal drinking water. These communities will also be required to routinely monitor water quality. This data will provide an excellent indication of the condition of these aquifers now and in the future, and should be incorporated into the monitoring program.

F. Special Water Quality and Hydrologic Studies

U.S. Geologic Survey conducts special hydrologic and water quality studies in selected areas throughout the United States. These studies have occurred in the region in the past and in all probability will occur in the future. The State Division of Water Resources has also conducted hydrologic analyses of streams and groundwater basins in the region. Proposed USGS programs should be reviewed for compliance with regional goals and objectives, and appropriate recommendations made to USGS for program modification to ensure compliance. USGS and the State should be informed of the water quality monitoring activities within the Larimer-Weld Region to insure efficiency and program coordination.

G. Additional Regional Monitoring Needs

Some additional information will be needed which will not be provided by the municipal and industrial sampling program or related programs. This includes information on the external factors affecting water quality. The South Platte River and the St. Vrain River enter the region from the Denver metropolitan area. Other streams such as the Big Thompson, Little Thompson and Cache la Poudre have their headwaters within the region. External factors affecting water quality in the South Platte could be monitored upstream of the Fort Lupton discharge. The St. Vrain River should be monitored below the Longmont discharge at the Boulder-Weld County line. There are essentially no point source discharges directly impacting the St. Vrain River in the Larimer-Weld Region.

On the Cache la Poudre River, a regional water quality monitoring program should include the sampling point above the confluence of the North Fork River and at the mouth of the canyon. On the Big Thompson River, water quality monitoring stations should be established at the mouth of the canyon to define impacts of urban development between Estes Park and the mouth of the canyon. One way to implement this program is through arrangements with USGS.

A regional program should also include analyses on the South Platte near the point where it leaves Weld County. A seasonal analyses, i.e., once every three months, is recommended at that location.

H. Bioassays

A regional planning program should include bioassays of streams to determine relationships between water quality and aquatic life, and the viability of various forms of aquatic life, given the hydrologic and water quality conditions existing in the region. Background data exists on the Poudre as a result of the CSU sampling program. This program should be continued and expanded to other streams in the region. Initially, a semi-annual sampling program should be conducted, once in the winter and once in the summer. Specific locations on the St. Vrain, Big Thompson, Little Thompson and South Platte should be defined for sampling following discussion with Division of Wildlife personnel. The program should indicate the variety of species found, relative numbers and weights of species to the total, and general condition of the species found. Aquatic invertebrates also should be sampled. This program should be a joint regional-state responsibility.

Bibliography

BIBLIOGRAPHY

INTERIM WATER QUALITY MANAGEMENT PLAN REPORTS

Report No.	Title
3	TOUPS CORPORATION. Water Quality Impacts of Irrigated Agriculture (Executive Summary). (LWRCOG, April 1977). 65 pages.
4	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. Utility Management Handbook - Institutional, Financial and Management Procedures. (LWRCOG, April 1977). 19 pages.
5	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. Institutional Inventory for 208 Functions. (LWRCOG, April 1977). 87 pages.
6	TOUPS CORPORATION. Municipal and Industrial Point Source Analysis - Wastewater Treatment, Operation and Maintenance Requirements. (LWRCOG, April 1977). 112 pages.
7	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Ft. Lupton, Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 68 pages
8	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Timnath, Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 38 pages.
9	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Pierce, Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 33 pages.
10	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Platteville, Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 36 pages.
11	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Severance, Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 40 pages.
12	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Weld Central High School Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 28 pages.

Report No.	Title
13	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., TOUPS CORPORATION. Milliken Sanitation District Colorado Plan for Wastewater Treatment Works. (LWRCOG, May 1977). 59 pages.
15	TOUPS CORPORATION. Concentrated Animal Feeding Operation - Waste Management and Resource Recovery. (LWRCOG, July 1977). 96 pages.
16	TOUPS CORPORATION, LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS. Larimer-Weld Region Land Use Alternatives - Analysis of 20 Year Growth Demands and Impacts. (LWRCOG, November 1977). 296 pages.
16	TOUPS CORPORATION, LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS. Larimer-Weld Region Land Use Alternatives - Analysis of 20 Year Growth Demands and Impacts. (Summary). (LWRCOG, November 1977). 55 pages.
17	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. Institutional and Financial Recommendations for Control of Pollutants from Non-Point Sources and Municipal and Industrial Point Sources. (LWRCOG, January 1978). 149 pages.
18	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. Institutional and Financial Recommendations for Control of Pollutants from Irrigated Agriculture. (LWRCOG, November 1977). 99 pages.
19	TOUPS CORPORATION. Non-Point Source Control - Analysis and Recommendations. (LWRCOG, November 1977). 119 pages.
20	TOUPS CORPORATION. Waste Load Allocations and Water Quality Modeling - Major Rivers in the Larimer-Weld Region. (LWRCOG, December 1977). 147 pages.
22	TOUPS CORPORATION. Water Quality Impacts of Irrigated Agriculture - Larimer and Weld Counties, Colorado. (LWRCOG, April 1977). 208 pages.
23	TOUPS CORPORATION. Impact Analysis of Point Source Phosphorous Loading - Big Thompson River Basin. (LWRCOG).
24	TOUPS CORPORATION. Municipal Point Source Analysis - Urban Triangle Area of the Larimer-Weld Region. (LWRCOG, March 1978). 33 pages

Report No.	Title
25	TOUPS CORPORATION. Technical Implementation Requirements for Achieving Best Management Practices in the Larimer-Weld Region, Colorado. (LWRCOG, April 1978). 17 pages.
26	TOUPS CORPORATION. Best Management Practices for Irrigated Agriculture in the Larimer-Weld Region, Colorado - Analysis and Recommendations. (LWRCOG, April 1978).
27	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., Proposal for Management Agency Requirements - 208 Plan Implementation. (LWRCOG, October 1977). 11 pages.
28	BRISCOE, MAPHIS, MURRAY & LAMONT, INC., Financial Assessment and Planning Guide for Improvements to Wastewater Treatment Works - Johnstown, Colorado. (LWRCOG, May 1977). 14 pages
29	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. Financial Assessment and Planning Guide for Improvements to Wastewater Treatment Works - Frederick, Colorado (Tri-Area Sanitation District). (LWRCOG, May 1977). 13 pages.
30	LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS. Report to the Colorado Water Quality Control Commission Regarding Recommendations for the Establishment of a Dual Priority Point System for EPA-Funding of Municipal Wastewater Treatment Facilities. (LWRCOG, August 1977). 22 pages
31	LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS. Impacts of Land Use Alternatives on Wastewater Treatment Facilities - Fort Collins, Greeley, Loveland Triangle. (LWRCOG, June 1977). 15 pages.
32	TOUPS CORPORATION. Preliminary Report to the 208 Areawide Planning Committee Concerning Alternative Implementation Strategies for Achieving Water Quality Goals. (LWRCOG, August 1977). 11 pages.
33	BRISCOE, MAPHIS, MURRAY & LAMONT, INC. 208 Management System Functions and Evaluative Criteria. (LWRCOG, June 1977). 10 pages.
—	HUSZAR, PAUL C., LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS. Economic and Population Projections - Larimer-Weld Region - 1975-2000. (LWRCOG, November 1977). 47 pages.

BIBLIOGRAPHY*

GENERAL REFERENCES

Anonymous, 1878. "Trout in the Rocky Mountains". Forest and Stream. Volume 9. Number 25. January 24, 1878. New York.

Arnette, Joseph L. September, 1976. "Methodologies for Determining Instream Flows for Fish and Other Aquatic Life: Overview and Outlook." Instream Flow Needs, Volume I. Proceedings of the Symposium and Specialty Conference. American Fisheries Society and American Society of Civil Engineers.

Behnke, R. J. and Mark Zarn. 1976. Biology and Management of Threatened and Endangered Western Trouts. U.S.D.A. Forest Service General Technical Report. RM-28, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado. 80521. 45 pp.

Bluestein, M. H. and D. W. Hendricks. December, 1975. Biota and Water Quality of the South Platte River Past-Present-Projected. Environmental Engineering Technical Report. Department of Civil Engineering, Colorado State University, Fort Collins, Colorado.

Doudoroff, Peter. July, 1977. "Closing Remarks--An Old Frog Croaks An Appeal For Logic." Symposium Recent Advances in Fish Toxicology. Ecol. Res. Ser. EPA-600/3-77-085. U.S. Environmental Protection Agency, Washington, D.C. 191-203.

Doudoroff, Peter. February, 1978. "Additional Comments by Peter Doudoroff to the Colorado Water Quality Control Commission Regarding Proposed Revision of the Colorado State Water Quality Standards and Stream Classification System." Corvallis, Oregon.

Goettl, John P. 1977. Colorado Division of Wildlife. Personal Communication.

Harrison, David L. September, 1976. "Legal Strategies For Implementing Instream Flows Under Existing Federal and State Laws - Restoring Minimum Flows to Already Overappropriated Streams." Instream Flow Needs, Volume I. Proceedings of the Symposium and Specialty Conference. American Fisheries Society and American Society of Civil Engineers.

Hem, John D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Government Printing Office, Washington, D.C.

Hollenbeck, Charles. 1977. Black & Veatch Consulting Engineers, Denver, Colorado. Personal Communication.

Instream Flow Group, U.S. Fish and Wildlife Service, Fort Collins, Colorado. April, 1977. "A Methodology and Conceptualized Data System to Determine Instream Flow Needs for Energy Assessment Under Section 13(a) of the Nonnuclear Act, Executive Summary."

Klein, W. D. 1973. "Are We Polluting Our Streams with Trout." Colorado Outdoors. July-August 1973. 33-36.

Kochman, Ed. 1977. Wildlife Environmentalist, Colorado Division of Wildlife. Denver. Personal Communication.

Langlois, David. 1977. Colorado Division of Wildlife, Denver. Personal Communication.

Li, Hiram W. 1968. The Fishes of the South Platte River Basin, unpublished masters thesis. Colorado State University. Fort Collins, Colorado.

Liquin, Charles. 1977. Assistant Director of Water & Sewer, City of Fort Collins, Colorado. Personal Communication.

Maas, Jan W. 1975. Southeast Greenbelt/Open Space Study. Prepared for the City of Fort Collins, Colorado. Fort Collins Planning Department.

Morrison, S. M. 1978. Surveillance Data Plains Segment of the Cache la Poudre River, Colorado. 1970-1971. Colorado Water Resources Research Institute Information Series No. 25. Environmental Research Center. Colorado State University, Fort Collins, Colorado.

National Academy of Sciences. 1977. Perspectives on Technical Information for Environmental Protection. Volume I. Analytical Studies for the U.S. Environmental Protection Agency from the Commission on Natural Resources and the Steering Committee for Analytical Studies. Washington, D.C.

National Academy of Sciences. 1977. Environmental Monitoring. Volume IV. Analytical Studies for the U.S. Environmental Protection Agency. A report to the U.S. Environmental Protection Agency from the Study Group on Environmental Monitoring. Washington, D.C.

National Academy of Sciences. 1976. Safe Drinking Water & Health. A report prepared under contract to the U.S. Environmental Protection Agency for the Safe Drinking Water Act. Washington, D.C.

Nittman, Rolf. 1977. Fisheries Manager. Colorado Division of Wildlife. Northern Regional Office, Fort Collins. Personal Communication.

Nittman, Rolf. 1978. Fisheries Manager. Colorado Division of Wildlife. Northern Regional Office, Fort Collins. Personal Communication.

Neutze, John. 1976. Water Commissioner, Cache la Poudre River; State Engineer's Office. Personal Communication.

Neutze, John. 1977. Water Commissioner, Cache la Poudre River; State Engineer's Office. Personal Communication.

Phipps, Earl. 1977. Secretary-Manager, Northern Colorado Water Conservancy District; Loveland, Colorado. Personal Communication.

Post, George. 1976. Professor of Microbiology and Fish and Wildlife Biology. Colorado State University, Fort Collins. Personal Communication.

Sanborn, Wallis R. 1977. District Sales Manager - Southwest Mud Cat Division, National Car Rental System, Inc. Personal Communication.

Schaefer, Roland, PhD. February, 1978. Office of Air and Water Programs. U.S. Environmental Protection Agency. Washington, D.C. Personal Communication.

Sharpe, William E. and P. W. Fletcher. July, 1977. Impact of Water Saving Device Installations Program on Resource Conservation. Institute for Research on Land and Water Resources. Research Publication 98. The Pennsylvania State University. University Park, Pennsylvania.

Stalnaker, Clair. 1977. U.S. Fish and Wildlife Service. Fort Collins, Colorado. Personal Communication.

Stalnaker, Clair and Joseph L. Arnette. 1976. "Methodologies for the Determination of Stream Resource Flow Requirements - An Assessment."

Tennant, Donald L. September, 1976. "Instream Flow Regimens for Fish, Wildlife, Recreation, and Related Environmental Resources." Instream Flow Needs, Volume II. Proceedings of the Symposium and Specialty Conference. American Fisheries Society and American Society of Civil Engineering.

Toups Corporation. 1977. Step I - 201 Facilities Plan for Estes Park Sanitation District.

Toups Corporation and Engineering Consultants, Inc. 1974. Comprehensive Water Quality Management Plan - South Platte River Basin Colorado. A report prepared for the Water Quality Control Division, Colorado Department of Health. Denver, Colorado.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. EPA-440/9-76-023. U.S. Government Printing Office, Washington, D.C.

U.S. Department of the Interior, Bureau of Outdoor Recreation. 1976. Draft. Single Purpose Leisure Time Study - South Platte River and Tributaries - Colorado, Wyoming. Denver Metro Study. Prepared for U.S. Army Corps of Engineers, Omaha District.

U.S. Department of the Interior, National Heritage and Conservation Trust. 1977. Personal Communication with Hank Burback and the forthcoming National Urban Riverway Feasibility Study of the South Platte River.

U.S. Department of the Interior, National Park Service. 1976 Aquatic Resources Management Plan. Rocky Mountain National Park. Estes Park, Colorado

Walsh, R.G., A. Greenley, R.A. Young, J.R. McKean and A.A. Prato. October, 1977. Option Values, Preservation Values and Recreation Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado. Colorado State University. Fort Collins, Colorado.

Weaver, Robert M. September, 1976. "Strategies for the Preservation and Restoration of Instream Flows for Environmental Purposes". Instream Flow Needs, Volume I. Proceedings of the Symposium and Specialty Conference. American Fisheries Society and American Society of Civil Engineers.

* Additional references used in the preparation of this report are located in the bibliography of Interim Water Quality Management Plan Report No. 16, Larimer-Weld Regional Land Use Alternatives.

Appendices

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ADDITIONAL COMMENTS BY PETER DOUDOROFF TO THE COLORADO WATER QUALITY CONTROL COMMISSION REGARDING PROPOSED REVISION OF THE COLORADO STATE WATER QUALITY STANDARDS AND STREAM CLASSIFICATION SYSTEM

As a part of my verbal testimony given on February 6, 1978, at the public hearing in Denver concerning the above matter, I presented to the Water Quality Control Commission a suggestion to be considered should the Commission favor adoption for statewide use as regulatory standards all or most of the many numerical criteria of water quality that were being discussed. According to my notes, the wording of my proposal, in which Commission members apparently were interested, was nearly this:

"It should be expressly stated and understood that it is not the Commission's intent and purpose to regard violation of a water quality standard as being by itself sufficient evidence of impairment or restriction of any water use, that is, of actual pollution, or a sufficient basis for enforcement action. Regular monitoring of all streams for possible violation of some sixty or more such standards is quite unnecessary. However, when there is other reliable (that is, scientific), independent evidence of unacceptable damage to aquatic resource values or uses of water, demonstration of violation of an applicable standard can be corroborating evidence greatly facilitating enforcement action. A discharger can then be required to show cause why he should not be required to meet the standard and to do necessary monitoring to demonstrate compliance."

I now see a need for some improvement or clarifying correction of the wording of that somewhat hastily prepared statement of my proposal. I have, therefore, revised it to read as follows:

"It could be expressly stated that it is not the Commission's intention always or usually to regard a violation of a water quality standard as being by itself sufficient evidence of impairment or restriction of a beneficial use of water, that is, of actual pollution, or a sufficient reason for enforcement action. Constant monitoring of all waters possibly affected by human activities to detect violations of any of as many as sixty or more applicable standards is unnecessary and is not possible. However, when there is other, more reliable, scientific evidence of unacceptable damage to an aquatic resource or a use of water, the demonstration of a violation of one or more of the applicable standards can be corroborating evidence facilitating the enforcement of pollution control law. Whenever there is such independent evidence of pollution, those demonstrably contributing to violation of the standards can be reasonably asked to show cause why they should not be required to meet the standards and to undertake monitoring necessary to demonstrate compliance."

The main reason for the amendment is that I want to make it clear that my suggestion was not meant to pertain to every proposed water quality standard. There can be entirely justifiable exceptions, such as bacteriological standards and some chemical standards designed for the protection of human health. I had in mind chiefly the many highly restrictive proposed standards for the protection of aquatic life, whose statewide applicability certainly can be seriously questioned.

I hope that I have already made it clear enough that I am not advocating and do not approve the adoption of the many proposed numerical standards for statewide regulatory application. The "numbers" in question pertaining to the protection of aquatic life are not uniformly reliable and appropriate to all the waters of Colorado to which they would apply. Some of them may be quite indefensible, as is surely the limit for the concentration of total cyanide taken from the U.S. Environmental Protection Agency's publication "Quality Criteria for Water", the so-called "Red Book" (EPA-440/9-76-023, July 1976), which I have discussed rather fully. Others are evidently but unavoidably unreliable, or of doubtful validity, for known reasons; still others may be reliable enough but not very useful because of analytical difficulties. Therefore, I believe that they can best be adopted (with some changes) for statewide use only as criteria or "guidelines" that can be helpful in the choice or formulation of regulatory standards for individual water bodies or stream segments, or perhaps for all similar waters of certain regions or parts of the State. My suggestion quoted above was advanced only as a possible compromise between widely different proposals concerning use of the numbers under consideration.

Very different water quality criteria and standards can be most appropriate to different waters and to different "levels of protection" of their beneficial uses (that is, to different degrees of impairment or risk of impairment of these uses judged acceptable), selected on the basis of socio-economic considerations. It would be quite unreasonable to apply the same standards for protection of aquatic life in the waters of prime recreational areas or those on whose productivity major sport or commercial fisheries of great economic importance depend, and waters of densely populated and highly industrialized regions where sport fisheries exist and need to be protected to some extent but are of relatively minor importance economically and otherwise. I want to reaffirm my support for classification of aquatic habitats that indicates or implies recognition of these facts. Unfortunately, the present definitions of the proposed classes of aquatic habitats of Colorado are not nearly clear enough. It is not at all clear whether Class 1 and Class 2 habitats are to be distinguished with reference to pertinent socio-economic considerations (i.e., to water quality control cost-benefit ratios), or only on the basis of their supposed natural properties — characteristics often no longer reliably determinable. I believe that the relevance of socio-economic considerations to the assignment of aquatic habitats to the different, proposed classes (including the distinction between Classes 1 and 2) should be fully recognized and clearly indicated. I also believe that the number of recognized classes of aquatic habitats could well be greater, and certainly should not be smaller, than the proposed number (three), and that the proposed water classification system could be profitably expanded to provide for at least two to four different levels of protection for each major beneficial use of surface waters. Each of the uses can be considered separately in classifying the waters, so that a given water can be assigned to a high class for one use and a low class for another use, the assignment depending mostly on the relative importance of the uses.

For further clarification of my ideas, expressed above, concerning levels of protection of water uses and use classification of waters, I want to refer the Commission to the "General Discussion and Practical Recommendations" section (pp. 250-275, and especially the subsection on pp. 255-262) of the treatise on "Dissolved Oxygen Requirements of Freshwater Fishes" by P. Doudoroff and D. L. Shumway (FAO Fisheries Technical Paper No. 86, Food and Agriculture Organization of the United Nations, Rome, 1970), and the chapter on "Water Quality Standards and Water Use Classification" (pp. 15-23) of the book "Biology and Water Pollution Control" by C. E. Warren, in collaboration with P. Doudoroff (W. B. Saunders Co., Philadelphia, 1971, xvi + 434 pp.). Copies of this published material have been or can be provided to the Commission.

I want to say again, also, that in my opinion the water quality criteria or standards that have been proposed for Class 1 and Class 2 aquatic habitats are too often unjustifiably the same. The dissolved oxygen and pH standards are notable examples. The dissolved oxygen and pH criteria pertaining to four different levels of protection of freshwater aquatic life that have been recommended by the Committee on Water Quality Criteria of the Environmental Studies Board, National Academy of Sciences and National Academy of Engineering, in the publication "Water Quality Criteria, 1972", the so-called "Blue Book" (EPA-R3-73-033, U.S. Environmental Protection Agency, Washington, D.C., 1973, xix + 594 pp.), are decidedly different one from another. I can see no sound reason why Class 1 and Class 2 aquatic habitat criteria or standards should be different when they are limits of concentration of each of a number of toxic metals, but not when they are limits of dissolved oxygen concentration or pH, or of concentrations of many toxicants other than the above-mentioned metals. It should be noted that there are wide natural variations of the dissolved oxygen content and pH of surface waters, as well as of their metal content, and that these variations can markedly influence the composition of aquatic animal and plant communities and the variety of organisms present. Lack of material natural variation obviously cannot be the reason why the same limits of dissolved oxygen reduction and of pH were proposed for Class 1 and Class 2 habitats. This does not make good sense in my opinion. Criteria or standards of water quality for the two habitat classes in question should be different in most instances (i.e., for most or nearly all parameters). When they are not different, they evidently should be reconsidered.

My impression is that the proposed standards have been assembled and may be adopted by the Commission somewhat too hastily, without benefit of sufficient expert advice, enough debate, etc. Recently the Illinois Pollution Control Board held some extensive hearings, in which I participated, concerning proposed revision of the State's water quality and effluent standards or regulations limiting cyanide concentrations only. Pertinent expert testimony, highly technical in nature, was taken and the numerous witnesses were thoroughly examined for several days, and much preparatory, technical work (study of data, etc.) was done by participants in the hearings (leading experts like myself) during intervening months. The contrast between those proceedings and the manner in which the adoption of a great number of new water quality standards is now being considered, apparently, in Colorado is striking. I am not at all convinced that most of the effort expended on reconsideration of the Illinois cyanide regulations was not wasted; I believe that it was, for the outcome was not, in my opinion, satisfactory. But I also believe that the large set of proposed water quality standards for Colorado, which do not all seem to be entirely sound and consistent, and some of which evidently are based entirely on recommended criteria and other information obtained from a source (or sources) as unauthoritative and unreliable as the U.S. Environmental Protection Agency's "Red Book", is not yet ready for adoption by the Water Quality Control Commission. I respectfully advise caution, more study, and more consultation with experts whose backgrounds of training and experience are sufficiently varied.

Thank you.

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February 9, 1978

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CLOSING REMARKS--AN OLD FROG CROAKS AN APPEAL FOR LOGIC

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First, I want to express to the sponsors--the Department of Fisheries and Wildlife of Oregon State University and the United States Environmental Protection Agency--my deep appreciation of the honor that has been accorded me by the dedication of this symposium. To the head of my department, Dr. Richard Tubb, who conceived this means of recognition of my services to the department and my profession and who has worked diligently toward its successful realization as a very special and memorable occasion at the time of my retirement, and also to Mrs. Alma Rogers, who assisted him with the arrangements, go my particular thanks. Also, to all the participants who have taken the trouble to prepare papers for presentation here--contributions that have been of great interest to me--and all those who have traveled long distances to attend this symposium or have written to me to extend their greetings, I am truly grateful. The cosponsorship of the symposium by EPA is signally gratifying to me. Though never an employee of EPA--sometimes even its opponent in adversary proceedings--I have felt since its inception as though I were a kind of honorary member. My many years as a water pollution biologist with the U.S. Public Health Service and the encouraging support and many courtesies extended to me by my former associates and other friends in EPA laboratories, and by the Agency, have generated this special feeling of affinity or fellowship, although I retired more than 11 years ago from the federal government. To A. F. (Fritz) Bartsch, to Donald Mount, and to Clarence Tarzwell (recently retired), I am particularly indebted in this connection.

Because I have some highly critical remarks to make today about one particular EPA publication, I want to make it very clear that I have great respect for my many competent and dedicated colleagues in EPA and for their notable research accomplishments. In no way can I hold them responsible for the defects of the report in question, and I wish to fault nobody except its anonymous authors in the Criteria and Standards Division, Office of Water Planning and Standards. I well realize that in our overgrown federal bureaucracy, monster agencies such as EPA can be many-headed like Hydra, with one head often not knowing what another one knows, does, or thinks, and not bothering to ask or to listen carefully. I am sure that some of my friends in EPA are or will be as unhappy as I am with some of their organization's products, the quality of which they had no power to control. They may welcome my saying more emphatically than they would want to say what they too have been thinking.

What have been my thoughts concerning my career as the time of my retirement approached? Naturally, I wish that my contributions to water pollution biology and environmental protection were as important and influential as some of my friends have tried to assure me they have been. Long ago, I believed that they would be. I started out as a smallish frog in a little pond disdained and shunned by smarter frogs. It was the early 40's, when water pollution control was primitive and my colleagues who were making significant contributions to water pollution biology in the United States could be counted on the fingers of my hands, or even on one hand. One did not have to be great to be one of the top frogs in my unattractive puddle. My early efforts to refine and standardize toxicity bioassays and to promote their use in waste disposal control seemed well worthwhile and were soon widely approved. Although I did little more than expedite inevitable developments, the widespread adoption of the recommended bioassay methods in this country and abroad was gratifying. My critical review of much of the limited available literature in the field and my performance of a few simple, carefully designed experiments soon made me an unchallenged expert. I moved from Cincinnati to Corvallis in 1953 at Professor R. E. Dimick's invitation. I was to develop, with Charles Warren and others, an OSU-PHS cooperative research program. As our joint research facilities and staff grew and improved rapidly, the opportunities to make important contributions seemed greatly enhanced. The need for a more aggressive attack on water pollution was evidently being recognized. I thought that a rational plan of development of our pertinent--although admittedly still very limited--ecological, chemical, and toxicological knowledge, and an equally rational system of its regulatory application would soon be designed and agreed upon by those in charge of the effort. I was eager and ready to be one of those leading the way, proud of our expanding laboratory complex here, which became a little Mecca for the still small number of water pollution biologists. But then came the flood, the unprecedented rapid expansion in the middle to late 60's, of environmental protection activities in our country. I had become a bigger frog in a pond somewhat enlarged by some busy beavers, but my pond now suddenly became a large lake, whose often turbulent waters were soon invaded by frogs coming from many other pools with all kinds of conflicting opinions. My influence there consequently waned; it is now almost negligible, in spite of my continued, sometimes frantic activity.

Impressed with signs of my apparent success and importance, such as the extent of my travel and the size of my consulting fees, in recent years my late brother Michael, the distinguished microbiologist, was no longer calling me a "sewage worker." (This appellation he had gleefully assigned to me long ago when he found me perusing the Sewage Works Journal, an early predecessor of the Journal of the Water Pollution Control Federation.) Environmental protection became a well-respected, well-funded, enthusiastically acclaimed field of endeavor. However, I was not very pleased, for its too rapid, almost chaotic development has not been conducive to careful discrimination between fact and fancy, right and wrong, sense and nonsense. Now that my pretension of outstanding intellectual leadership can no longer be maintained, I am just another frog contributing to a discordant chorus by croaking my discontent. Now is a good time for me to retire completely from the fray. But, speaking out on controversial issues in defense of rational positions, no matter how futile it may be, is a habit difficult for me to break.

What future do I now see for aquatic toxicologists and aquatic biologists in general in the field of water pollution control? I must say frankly that I am not very optimistic. I see much bitter disappointment and frustration for those competent, dedicated, and perceptive investigators who, like myself, would like to see the results of their research promptly and intelligently applied by the regulatory agencies. I see continued expenditure of much talent, money, and effort on research of high quality that leads to no visible, practical benefits, except perhaps, in the distant future. We can hope, of course, that some day things will be different, the administration of environmental protection laws will become entirely rational and truly scientific, and incompetence, superficiality, and disregard for the elementary principles of logic in the application of our research results will no longer be tolerated. Encouraged by this hope, or simply driven by intellectual curiosity, many of my younger colleagues doubtless will continue to exert their best efforts in seeking to advance knowledge in our field. But the value of their most significant factual contributions and most pregnant new ideas--even ideas that are not very profound or difficult to understand--they should not expect to be soon recognized except by a small number of colleagues also engaged in research. They should not assume that administrative (regulatory) decisions on which these contributions and ideas obviously have a direct bearing will be influenced and adjusted correctly to reflect the new knowledge.

Why do I hold this pessimistic view? Well, let me give an example of the kinds of frustration that I have recently experienced. My disappointment was not unique, but it was somewhat more distressing and humiliating than most of the others of its kind. And, it should be remembered that I am far from being a beginner in my field; my views and contribution should not be quite as easily ignored as those of numerous younger colleagues.

Last month, I examined a new publication just released by EPA (U.S. Environmental Protection Agency 1976), a 510-page document entitled "Quality Criteria for Water", a copy of which had kindly been supplied to me. Its perusal in part left me quite shaken. The formulation of sound water quality criteria pertaining to the protection of aquatic life and fisheries has been my predominant interest or objective during most of the last 35 years. With that end in view, I have done much thinking and have conducted intensive experimental and literature research in the toxicology of the simple and complex cyanides, the dissolved oxygen requirements of fishes, and other such matters. Naturally, I want to know to what extent the water quality criteria being proposed or used in water pollution control and the current regulatory practices are being influenced by my efforts and recommendations. So, it was with much interest that I began to examine the document presenting water quality criteria now being recommended by EPA, that powerful government agency charged with the administration of federal water pollution control legislation.

First, I looked at the section dealing with cyanides. As some of you know, I have been able to demonstrate quite conclusively, with the invaluable assistance of student and faculty colleagues, that the "total cyanide" concentration in water containing complex cyanides is toxicologically almost meaningless (Doudoroff 1956; Doudoroff, Leduc, and Schneider 1966; Doudoroff 1976). The toxicity to bluegills, for example, of acutely toxic cyanide solutions with total cyanide concentrations as low as 1 or 2 mg/1 or less is determined entirely, or almost entirely, by the concentrations of free cyanide or, more specifically, of molecular (un-ionized) hydrocyanic acid, HCN. This relationship is usually true of the toxicity of much more concentrated solutions also, but there are known exceptions. At the pH of most natural waters, most of the free cyanide (molecular HCN plus the CN^- ion) is present as HCN, the more toxic of the two forms of free cyanide (i.e., more toxic than the CN^- ion), therefore, the distinction between HCN and free cyanide is of little practical importance. The level of one can be easily calculated from that of the other when the pH is known. Undissociated metallocyanide complex anions, which can be much more abundant than free cyanide in cyanide-bearing wastes and polluted waters, are much less toxic than HCN, or virtually nontoxic. For these reasons, it seemed obvious to me that an entirely sound, basic, chemical water quality criterion pertaining to the suitability of cyanide-polluted waters for aquatic life has to be expressed as a concentration of free cyanide or of molecular HCN, and not of total cyanide. A reliable and sensitive chemical analytical method that distinguishes between the highly toxic and relatively harmless or toxicologically inactive forms of cyanide clearly was needed, I told my colleagues long ago. Largely because of my early findings and urging, several quite satisfactory methods for determination of molecular HCN have been developed by my associates at Oregon State University (Schneider and Freund 1962; Claeys and Freund 1968; Broderius 1973) and by other American and British investigators (see Doudoroff 1976, pp. 9-10). Some of these methods were used in confirming the toxicological conclusions stated above. Thus, through intensive research, the technical problem to which I had addressed myself was essentially solved, and I was very well pleased indeed with the accomplishment, which seemed to call and point the way for much more research of the same general kind.

But what did I find in the EPA report? I found that the great toxicity of HCN is duly noted, as is the fact that the ratio of HCN to total cyanide in waters polluted with cyanides is highly variable, depending not only on the nature of the cyanide compounds introduced but also on the pH, illumination, and other conditions. In addition, I found this poorly worded but nevertheless devastating statement (p. 132): "Since such chemical and physical conditions will dictate the form of cyanide, the cyanide criteria <u>must</u> be based on the concentration of <u>total</u> cyanide present in the water" (emphasis added). Accordingly, a cyanide concentration limit of 5 µg/l (0.005 mg/l) is recommended as a criterion for aquatic life without specifying that this amount of cyanide must be free or present as molecular HCN.

Is the quoted conclusion a logical one? Apparently, the authors of the report think that it obviously is; they make no effort to justify or defend their assertion, although it flatly contradicts the published recommendation of the National Academy of Sciences and National Academy of Engineering

(1973), which I helped to prepare. Well, if that conclusion is accepted as reasonable, then corresponding conclusions surely must be reached also with respect to ammonia, sulfides, heavy metals, and other toxicants. It is well known that the ratios of highly toxic molecular (un-ionized) ammonia and hydrogen sulfide to total ammonia and total sulfide, respectively, in polluted waters vary widely, depending on such factors as pH, temperature, and ionic strength, and that their variation is toxicologically important. Thus, if the EPA authors were at all consistent in applying the questionable reasoning on which the statement quoted above is based, they should certainly have concluded that, since chemical and physical conditions dictate the forms of ammonia and sulfide, the ammonia and sulfide criteria must be based on the concentrations of total ammonia and sulfide present in the water. But what actually are the ammonia and sulfide criteria recommended by them? The criterion for ammonia (p. 16) is 0.02 mg/l of un-ionized ammonia only (not total ammonia, for which no limit is proposed), and the sulfide criterion (p. 410) is 2 μg/l of undissociated H_2S only (not total sulfide or total dissolved sulfide). Evidently, the authors concluded that, since chemical and physical conditions dictate the forms of ammonia and sulfide, the ammonia and sulfide criteria must be based on the concentrations of molecular NH_3 and H_2S only, disregarding the less harmful or relatively nontoxic NH_4^+ and HS^- ions.

What can be the reason for the obvious inconsistency? There can hardly be any nice, logical justification. The only explanation that I can suggest, other than sheer, negligent incompetence or dishonesty of the authors, is that logic has gone out of style and consistency is no longer highly valued in our field of environmental protection. Now, appeals to emotion and prejudice prevail all too often over sound arguments, and a host of confused "experts" have sprung up almost overnight like mushrooms. Immutable laws of chemistry and physics dictate the transmutations of cyanide and ammonia, but the choice of the water quality criteria evidently has been dictated only by whim or caprice. Capriciously, the results of thorough, painstaking research into the toxicology of the complex metallocyanides and careful development of needed analytical methods that have made possible the establishment of sound cyanide criteria like those previously developed for ammonia are totally ignored--not even mentioned--in the EPA publication. They have been brushed aside and made to seem irrelevant with a single, flat assertion that sounds like a statement of an indisputable corollary of some natural law, but which actually is groundless and contrary to reason. If this assertion were true, there would be no good reason, of course, further to test or simplify the new analytical methods for determination of HCN.

The possibility that a harmless form of cyanide present in water will be soon converted, under certain conditions, into a highly toxic form should not be overlooked in controlling water pollution. However, only after this transmutation has actually occurred, a fact now readily demonstrable by chemical analysis, is the suitability of the water as a medium for aquatic life affected and it may or may not occur effectively. Photodecomposition of nontoxic iron-cyanide complexes, for example, may be negligible in deep, turbid, or shaded waters, and slowly liberated cyanide may decay or escape as rapidly as it is released, free cyanide not being a presistent pollutant. A large biochemical oxygen demand (BOD) of an effluent or receiving water is worthy of attention, but the dissolved oxygen concentration (DO) is a much more meaningful index of the suitability of polluted waters for aquatic life (except for some decomposers) than is the BOD. When reaeration is rapid, an initially very large oxygen demand may be gradually satisfied without causing any harmful depression of DO. It has long been generally recognized, therefore, that sound water quality criteria for the protection of aquatic life against the oxygen-depleting effects of putrescible organic wastes must be appropriate limits of DO and not of BOD. In what fundamental way is the problem presented by the potential toxicity of nontoxic, complexed cyanide different from that presented by the oxygen-depleting potential of organic wastes? I can see no difference requiring diametrically different approaches to the two problems.

Because of EPA's prestige and power, its ill-considered pronouncements can block technical advances for years. Recently I have presented extensive testimony in the State of Illinois in support of a proposal (by my clients, the Illinois Petroleum Council, and others) that a free cyanide standard of water quality be substituted for an outdated total cyanide standard that had long been in force in that state. I hoped soon to see wide approval of such improvement of standards by state regulatory agencies and I strove to bring it about. But having seen the EPA report stating flatly that pertinent water quality criteria "must be based on the concentration of total cyanide" and implying that each recommendation contained in the report represents a consensus or majority opinion of experts based on the latest available scientific information, I now see almost no possibility of success. Although I do not believe that such matters are best settled by the adversary method, I now would like to see the issue litigated. Perhaps in a court of law, logic would prevail. I hope that some of my influential, reasonable, and well-informed friends in EPA will be willing and able to take some effective action leading to early correction of the mistake.

In the section of the report on cyanide, I found other statements in addition to the one quoted that are erroneous; some are incompatible (contradictory). These errors are not of critical import, however, so they need not be pointed out and discussed here. The treatment of the subject is generally inadequate, and I think that attribution of the content of the entire volume to "the efforts of many dedicated people" including "technical specialists throughout the Agency's operational programs and in its research laboratories" (p. ix) is not something that should greatly please competent members of the EPA research staff.

After examining the section on cyanide, I turned to that dealing with dissolved oxygen criteria--another subject of outstanding interest to me--and found it no less depressing. There is no relation or resemblance at all between the new EPA recommendations and the much more elaborate ones of Doudoroff and Shumway (1970) or those of the National Academy of Sciences and National Academy of Engineering (1973), which were based in large part on those of Doudoroff and Shumway. Those recommendations have been ignored. The DO criterion adopted by EPA is that proposed 40 years ago by Ellis (1937) for warm-water fish habitats, simply a minimum of 5 mg/l. Its recommended application has now been extended to all fresh waters, warm or cold, including interstitial waters of the gravels of salmonid spawning beds. Applicability of his criterion to cold-water fish habitats was not claimed by Ellis.

The EPA criterion is said to be based primarily on observations made in the field (mostly those of Ellis and his associates) on the relation between observed DO levels in various sampled waters and the variety of fishes found there; the presence of a "well-rounded fish population" was taken as an indication of satisfactory conditions.

The deficiencies of the evidence on which Ellis' conclusions were based, that is, reasons for its unreliability, have been fully discussed by Doudoroff and Shumway (1970, pp. 241-247). Their carefully developed argument and the suppporting data, not mentioned by the EPA authors, cannot be adequately summarized here. It was shown that good, mixed fish faunas, as defined by Ellis, actually can occur in waters where DO levels do not exceed 4 mg/l for very long periods, are often below 3 mg/l, and sometimes are as low as 1.4 mg/l or less. These results do not prove, of course, that fish production is not seriously impaired at such low DO levels. Neither does the observation, cited in the EPA report, that rainbow trout thrive in Lake Titicaca, where, because of the altitude, DO does not exceed 5 mg/l, signify that trout production is not reduced materially by reduction of DO to 5 mg/l in other waters with much higher natural DO levels.

I was amused by the statement in the EPA report that, in seeking to relate fish abundance and distribution to DO in the field, "enough observations have been made under a variety of conditions that the importance of oxygen concentration seems clear." I cannot quarrel with that statement, but is the mere demonstration of the importance of an environmental factor sufficient for the establishment of a water quality criterion? The pertinent experimental data, most of which have been thoroughly and critically reviewed by Doudoroff and Shumway (1970), also show very clearly the importance of DO. Why, then, has the vast amount of such information obtained during the past 40 years, in our laboratories and others, been mostly disregarded by the EPA authors? Quite disturbing to me was this justification given by them of their reliance predominantly or almost entirely on data from the field: "The requirement that the data be applicable to naturally occurring populations imposes limits on the types of research that can be used as a basis for the criterion. Aside from a few papers on feeding, growth, and survival in relation to oxygen concentration, very little of the laboratory based literature has a direct bearing; field data are in general more useful."

How many of the other water quality criteria, that have been recommended in the same publication as defensible criteria pertaining to the requirements of aquatic life (mostly criteria for toxic pollutants) are based predominantly on field data? How many, I should ask, are based on any data other than data from laboratory experiments? Not many, I am sure. What is the cyanide criterion based on, for example? Only on laboratory data, and particularly on observed effects of 10 μg/l of free cyanide on the swimming performance of salmonid fish. Actually, the vast amount of experimental (mostly laboratory) data bearing on the DO requirements of fishes that is now available (data on effects of DO reductions on survival, development, feeding, growth, fecundity, swimming ability, behavior, respiration, and oxygen consumption) is a basis for water quality criteria that is far more satisfactory than the bases for most of the other recommended criteria. By contrast, the available data from field studies on fish distribution and abundance (natural fish populations) in relation to DO are still extremely limited, and their usefulness in the verification or refinement of DO criteria is almost negligible. Again, logic seems to have been abandoned. If the extensive data from laboratory studies are indeed of almost no value or pertinence to the formulation of DO criteria, does it not follow that there are no adequate bases at all for most of the other water quality criteria pertaining to aquatic life that have been advanced? Should not these other recommended criteria have been withheld (not published) for lack of sufficient foundations?

I myself have been urging other investigators to pay more attention to natural conditions and to their simulation (especially with regard to bioenergetic considerations) in the design of experiments directed toward better understanding of the effects of water pollution on aquatic life (Doudoroff 1977; Doudoroff and Shumway 1970). I know that fish, in their natural habitats, are not usually exposed throughout their life cycles, or for very long periods, to nearly constant concentrations of pollutants, or to unlimited amounts of food obtainable almost without effort, or to an artificially restricted food supply. I have repeatedly pointed out that interference with reproduction in polluted waters of limited extent can be often fully compensated for by increased growth rates (due to reduced competition for food) or by the immigration of young from contiguous waters. I believe that some of our water quality criteria based on results of unrealistic experiments may be misleading, and some regulatory water quality standards directly derived from them can be entirely too restrictive, particularly when the criteria derive from life-cycle tests at constant concentrations of toxicants. But I certainly would not go so far as to say that the experimental work of the past has provided little useful information. I do not propose that we abandon our laboratories and all take to the field to sample various polluted waters and their fish populations in order to arrive at the best water quality criteria.

My impression is that, in the eyes of the authors of the EPA report, the intensive experimental work on the DO requirements of fish and the chemistry and toxicology of the complex cyanides that my co-workers and I have done over the years has been almost completely wasted effort. Certainly, their recommended water quality criteria would not have been any different had none of this work ever been done. One may well be impelled to ask if it is not a pity that so much time and money were spent so unproductively, because of my poor judgment. And is not Gary Chapman of EPA, who spoke to us about the different forms of copper and their relative toxicity, perhaps largely wasting his time also when concerning himself with such matters? If water quality criteria for copper must, for some reason, be "based on" total copper, no matter how successfully the toxic forms may be identified, their interactions described, and analytical methods for their separate determination developed, the subject of Chapman's report can be of academic interest only. Perhaps he too should be out in the field collecting and identifying fish. Has William Spoor also been wasting federal government money in Duluth by studying effects of DO reduction on fish development?

I must say that I have not always felt that my efforts have been unappreciated or that my recommendations relative to water quality criteria have been ignored. On the contrary, I have been often gratified by the attention given to my findings and conclusions by my most respected professional colleagues, including leading EPA biologists. The honor accorded me at this time clearly bespeaks abundant appreciation of my modest accomplishments. And the authors of the important, recent publication "Water Quality Criteria 1972", the socalled "Blue Book", prepared for EPA by the National Academy of Sciences and National Academy of Engineering (1973), having given me a courteous and attentive hearing at no expense to me, accepted in large part those of my views that were presented to them. As noted already, the cyanide criteria recommended by that prestigious group are concentration limits of free cyanide, not total cyanide. The DO criteria recommended, although not entirely in agreement with the recommendations that I presented and defended, did reflect my views in large degree, and I felt that their adoption was an important step in the right direction. The adoption of graded criteria of water quality appropriate to different "levels of protection" of aquatic life (to be selected on the basis of socio-economic considerations), which were recommended in dealing with pH and with suspended and settleable solids as well as with DO, was most gratifying, because it had been first proposed and strongly advocated by me.

Unfortunately, some important inconsistencies or illogical features similar to those of the recommendations in the new EPA report mar also the recommendations presented in the "Blue Book". At least one of the modifications made of the proposed DO criteria of Doudoroff and Shumway (1970) and their related recommendations was not, in my opinion, justifiable; that change, an incongruous kind of hybridization of old and new approaches, clearly was adopted as a compromise because of reluctance of some of the authors to depart entirely from precedents. Some serious errors and inconsistencies are to be expected in a work prepared in the manner and short time in which the "Blue Book" was prepared. But it seems to me that in the course of the preparation of the new EPA publication, on which work has been going on for a long time, the inconsistencies and other mistakes to be found in the somewhat too hastily prepared "Blue Book" should have been largely corrected or avoided, not multiplied or aggravated.

The 1976 report is not the first such report prepared by EPA. This new volume is a revision of proposed EPA Water Quality Criteria, presented in a publication that was not widely distributed but whose limited availability was announced by means of a notice published in October, 1973, in the Federal Register (U. S. Environmental Protection Agency 1973a). It is noteworthy that the cyanide criteria proposed by EPA in the earlier (1973a) report are essentially identical with those recommended in the "Blue Book". The DO criteria proposed at that time are somewhat different from the "Blue Book" criteria, but were said in the Notice of Publication to be "generally consistent" with them. I may have seen these proposed DO criteria but cannot now recall examining them; a single DO level of 5 mg/l was certainly not given as a generally applicable water quality criterion. The disagreement between the most recently published cyanide and DO criteria recommended by EPA and those proposed in the "Blue Book" obviously are not attributable to inadvertence. Why the criteria initially proposed by EPA have now been rejected and different ones substituted, and who first proposed the drastic changes, I do not know. In the 1976 report, it is stated that the revision of the previously proposed criteria was "based on a consideration of comments received from other federal agencies, state agencies, special interest groups, and individual scientists." But it is not apparent that authors of the "Blue Book" and other leading experts had an opportunity to review and comment on all the new or revised criteria before publication, to object to proposed changes, and to explain their objections. I understand that "pre-publication" copies of "Quality Criteria for Water" were distributed in October or November of 1975 to a number of scientists or laboratories outside EPA for review. However, I do not know how many of these copies were distributed or to whom they were sent, and I have learned that the proposed DO criteria presented in those copies were still quite similar to the "Blue Book" criteria and those of Doudoroff and Shumway. Thus, it seems reasonable to suppose that nobody of the scientific community outside EPA was given the opportunity to examine and object to the finally published DO criterion and supporting statement; reviewers of the prepublication version had good reason to believe that the "Blue Book" recommendations would not be entirely ignored or contradicted in the published EPA report. I was never consulted nor asked my opinion of the new cyanide and DO criteria by EPA, although my pertinent expertise could hardly have been overlooked. Their publication was a complete surprise to me, like a bolt from the blue.

It has been suggested to me that the real reasons for the drastic revision of the original EPA criteria may perhaps have been political rather than scientific, having something to do with possible difficulties of enforcement of regulatory standards based on them. The suggestion was that the authors may have understood perfectly that the cyanide criteria can very well be "based on" reliably determinable free cyanide or HCN levels and that limits of free cyanide or HCN concentration are scientifically much sounder, more reliable criteria than limits of total cyanide concentration, but decided that acknowledgment of these scientific facts would be politically inexpedient or embarrassing. However, deliberate obfuscation or concealment of the truth obviously would have been intellectually dishonest, and I do not want to accuse anyone of intellectual dishonesty. The administrator of EPA had been directed by Congress to publish "criteria for water quality accurrately reflecting the latest scientific knowledge" and not reflecting his staff's latest notions of how science or truth can best be twisted to achieve some practical objective. In preparing my critical comments, I assumed that the authors of the EPA report strove to fulfill this charge (as they implied they did) and so were not intentionally inconsistent and purposely misleading.

It is noteworthy that the authors of "toxic pollutant effluent standards" proposed by EPA about three years ago (U. S. Environmental Protection Agency 1973b) were aware of the importance of the distinction between free and complexed cyanide. My clients, the American Iron and Steel Institute, and many others objected to those proposed standards for various reasons, among which were terminological and methodological vagueness and errors. At a hearing in Washington, D.C., in 1974, I expounded extensively on the chemistry and toxicology of the cyanides, as did also my former student, Steven Broderius, at a later hearing. I had hoped that our efforts to clarify the complicated problems involved would lead to a better understanding by all those in EPA concerned with effluent and water quality standards and criteria. Because of the various objections raised, the proposed effluent standards, which had some sensible features and could have been improved enough with a few changes to make them fairly reasonable, were finally withdrawn by EPA.

But the water quality criterion for cyanide now being recommended by EPA suggests that understanding, if it has changed at all, has deteriorated. New proposals concerning regulatory standards could well be totally wrong. I am reminded again of the nature of Hydra, with which I have already drawn an analogy. When you chopped off a head that threatened you, you were worse off than before, because two more dangerous heads grew in its place.

I want to repeat, however, that my purpose here has not been to attack EPA, an organization to which I still feel, justifiably or unjustifiably, that I somehow belong. What I am really attacking is the shallow, careless, and irresponsible thinking that pervades the environmental protection movement. This irrationality is to be found outside EPA, in state regulatory agencies for example, probably at least as often as in the powerful federal agency; it is often to be found even in our universities, where we expect to find models of detached rationality. I am objecting to all indifferent tolerance in my profession of gross inconsistency, which betokens gross error, for it can exist only when there is such error. I am croaking an appeal for logic. If even old frogs like me refrain from raising their voices in protest, for fear of offending some other frogs in our lake, who will? To whom will the tadpoles in the lake be able to look for inspiring intellectual guidance? At this stage of my career, I have nothing to lose by being outspoken, and I am sure that many of you, as well as others, no matter where they work or seek support, will share my sentiments.

I thank you and wish you all a good year and successful researching through 1977.

LITERATURE CITED

Broderius, S. J. 1973. Determination of molecular hydrocyanic acid in water and studies of the chemistry and toxicity to fish of metal-cyanide complexes. Ph.D. thesis. Oregon State University, Corvallis. xvii + 287 pp.

Claeys, R. R., and H. Freund. 1968. Gas chromatographic separation of HCN on Porapak Q--Analysis of trace aqueous solutions. Environ. Sci. Technol. 2(6): 458-460.

Doudoroff, P. 1956. Some experiments on the toxicity of complex cyanides to fish. Sewage Ind. Wastes 28(8): 1020-1040.

Doudoroff, P. 1976. Toxicity to fish of cyanides and related compounds--A review. Ecol. Res. Ser. EPA-600/3-76-038. U. S. Environmental Protection Agency, Duluth, Minn. vi + 155 pp.

Doudoroff, P. 1977. Keynote address--Reflections on pickle-jar ecology. Pp. 3-19 in J. Cairns, Jr., K. L. Dickson, and G. F. Westlake (eds.), Biological monitoring of water and effluent quality. Pub. STP 607. American Society for Testing and Materials, Philadelphia.

Doudoroff, P., G. Leduc, and C. R. Schneider. 1966. Acute toxicity to fish of solutions containing complex metal cyanides, in relation to concentrations of molecular hydrocyanic acid. Trans. Am. Fish. Soc. 95(1): 6-22.

Doudoroff, P., and D. L. Shumway. 1970. Dissolved oxygen requirements of freshwater fishes. FAO Fish. Tech. Paper 86, FIRI/T86. Food and Agriculture Organization of the United Nations, Rome. xi + 291 pp.

Ellis, M. M. 1937. Detection and measurement of stream pollution. (U. S. Dept. of Comm., Bur. Fish. Bull. 22) Bull. Bur. Fish. 48: 365-437.

National Academy of Sciences and National Academy of Engineering. 1973. Water quality criteria 1972. A report of the Committee on Water Quality Criteria, Environmental Studies Board. Ecol. Res. Ser. EPA-R3-73-033. U. S. Environmental Protection Agency, Washington, D. C. xix + 594 pp.

Schneider, C. R., and H. Freund. 1962. Determination of low level hydrocyanic acid in solution using gas-liquid chromatography. Anal. Chem. 34: 69-74.

U. S. Environmental Protection Agency. 1973a. Water quality criteria--Notice of publication. Federal Register 38(206): 29646-29647.

U. S. Environmental Protection Agency. 1973b. Proposed toxic pollutant effluent standards. Federal Register 38 (247): 35388-35395.

U. S. Environmental Protection Agency. 1976. Quality criteria for water. EPA-440/9-76-023. U. S. Environmental Protection Agency, Washington, D. C. ix + 501 pp.

Dr. Charles E. Warren presented a paper on "The Interpretation of Laboratory Results." The manuscript was not available at the time of printing. Exclusion is not meant to imply any criticism of the paper or the presentation.

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MINUTES
NOVEMBER 17, 1976, FISHERIES MEETING

The Larimer-Weld Regional Council of Governments sponsored a meeting dealing with fisheries in the streams and rivers of the region. The meeting was held in the Dean's Conference Room of the New Natural Resources Center, Colorado State University campus, Fort Collins, Colorado, at 1:30 p.m., November 17, 1976. Attendees were:

Bob Aukerman, CSU, Recreation Resources
Bob Hiller, CSU, Agricultural Engineering
Dave Hendricks, CSU, Civil Engineering
John Goettl, Colorado Division of Wildlife
James Ward, CSU, Zoology
Stan Ponce, CSU, Earth Resources
Pat Davies, Colorado Division of Wildlife
Clarence Carlson, CSU, Fishery Biology
Rick Claggett, U. S. Environmental Protection Agency, Region VIII
John W. Neutze, Poudre River Water Commission, Water Resources
Rolf Nittman, Colorado Division of Wildlife
Wayne R. Seaman, Colorado Division of Wildlife
Bill McConnell, CSU, Colorado Coop Fishery Unit
Eric P. Bergerson, CSU, Coop Fishery Unit
Don Brosky, Eastman Kodak Company
S. M. Morrison, CSU, Microbiology
George Post, CSU, Fishery and Wildlife Biology
Norman Evans, CSU, Environmental Resources Center
Tom Pitts, Toups Corporation
Rich Drew, Toups Corporation
Terry Trembly, Larimer-Weld COG
F. A. Eidsness, Jr., Larimer-Weld COG

I. PURPOSE OF MEETING

The purpose of the meeting was to discuss the basic problem of determining the attainability of fisheries in waters of the region. The Federal Water Pollution Control Act Amendments of 1972 establish a goal of fishable, swimmable streams by 1983 where attainable. Section 208 of the Federal Water Pollution Control Act (P.L. 92-500) authorizes the Larimer-Weld Regional Council of Governments, in this case, to undertake an areawide or regional water quality management study and to define those things which are attainable and what the priorities will be in water pollution control in this region. The approach utilized by the Larimer-Weld COG is to use this opportunity to evaluate the current laws and regulations and how they have been applied in the context of this region so that corrections can be made through the Environmental Protection Agency and the Water Quality Control Commission if needed and to insure that good water pollution control investments are made. The uniqueness of the water quality and hydrology in the

West complicates the administratively-set flow criteria under which all water quality analysis and waste load allocations must be done - that of seven-day-once-in-ten-year low flow. In this area where the application of this principal may involve no native flow at all, advanced treatment of waste discharges may be the only way to meet water quality suitable for fishable, swimmable waters. The question of whether cities and towns should be required to provide advanced treatment in the hopes of future low flow augmentation to sustain fisheries along the rivers must also be answered in this program.

II. TECHNICAL HYDROLOGIC ANALYSES BY COG 208 PROGRAM - INTERIM FINDINGS

Tom Pitts, Toups Corporation and technical engineering consultant to the Larimer-Weld COG, summarized the findings of their hydrologic analyses. Emphasis was placed on extensive analysis of hydrology and water quality, especially the impact of irrigation diversions and return flows on streams. Colorado water law allocates water through historic uses to divertors. It is distributed towards satisfying water rights; consequently, rivers can be dried up. The storage season, from October through April, and the irrigation season, from May to September, affect stream flows. It is the direct responsibility of the District Water Commissioner to manage the river flow and diversions. The point was made that the State Engineer denies that personnel make the diversion; they prefer to say that they regulate the up-stream diversions to protect the biota of the region. Toups Corporation found that overland flow returning to the river is negligable. Seepage and tributary inflow data has been verified; this is an important element of the supply system. The U.S.G.S., the Water Commissioners, and Toups Corporation have all conducted seepage flow analyses. They found that to a significant degree, steam flows are maintained by seepage and tributary return flow. Even though diversions dry up the rivers, a few miles below water will appear in the stream again. Zero flow may exist in the Poudre at at least eight points of diversion. During the storage season, diversions dry up the Poudre at every possible point.

On the Big Thompson River, the Colorado Big Thompson Project is the most significant feature affecting stream flow and drainage. Diversions on the Big Thompson dry up the river at several ditch locations. Diversions on the South Platte may dry up the river immediately down stream in at least five locations. Even though diversions dry up the rivers at several points, the flow returns a few miles down stream. Summarization of findings by Toups include the following:

1. Sampling on the Poudre has shown that as one progresses down stream and as diversions increase and stream flows drop, TDS increases to the point that it almost matches the TDS of the tile drain effluent. In daily runs, this finding was fairly consistent. Toups Corporation was lead to the conclusion that the flow of the Poudre is made up entirely of return flows at certain times of the year. The extensive system of irrigation, water supply, and diversion control all affect stream flows in the plains area of the region.

3. The seven-day, ten-year low flow criteria for defining waste treatment needs is made meaningless by the complex system of supply and diversions. Both water quality and hydrology will determine the feasibility of maintaining fisheries in the rivers of the region.

III. OPEN DISCUSSION ON THE VIABILITY OF FISHERIES

Dr. Post volunteered that CSU has been conducting a five-year program of identifying fish in the Poudre River. Twenty-eight species of fish have been identified between the Cities of Fort Collins and Greeley. A survey was conducted by using direct observation techniques and also fish tagging. The presence of fish, not the condition of fish, was the important aspect of the study. This testing has been conducted year around for five years. The tests are conducted once prior to freeze up in the fall, once after freeze up in the spring, and once after high water in the summer. Dr. Post did note, however, that a condition of ulcers was observed in some fish present below various municipal discharges. Of the fish identified by the survey, 99 percent (biomass be weight rather than numbers) were rough or forage fish. Less than 1 percent of the total identified would be considered game fish. These include primarily green sunfish, although occasionally a large mouth bass or perch was observed. No trout were found in the lower reaches of the Poudre. In the summer sampling, occasionally a trout was found at the first one or two collecting stations. These trout were not present in the fall testing, however. Rough fish cannot be discounted as undesirable since their effect on plant life and insects has not been measured. Residual chlorine tests were not developed; tests have indicated no toxic levels of heavy metals.

Dr. Hendricks suggested the possibility of zoning the Poudre and South Platte Rivers to obtain a fishery by providing for storage and the release of storage waters to maintain the flows and maintain the quality of certain waters without having to go into expensive treatment processes. Off-stream reservoirs could be used for the effluent from treatment plants and substitution of cleaner waters to maintain fisheries in certain stretches of the river could occur. The blanket idea of P.L. 92-500 to make the entire stream system fishable and swimmable is out of the social equilibrium of the stream according to Dr. Hendricks. The law was not made for Western streams. Tom Pitts of Toups Corporation pointed out that water does not seem to be readily available for substitution purposes.

Mr. Jack Neutze, Water Commissioner for District No. 3, indicated that a very promising way of keeping water in the stream system would involve aggregating the decrees held by small reservoirs upstream. In Colorado water law, the premises of storing water out of priority is acceptable. High mountain reservoirs possessing low flow priorities can therefore be filled early in the season. A large, new structure in the upstream end of the Poudre system would provide a great deal of flexibility in maintaining flow in the system for fish maintenance.

Under present operating practice, the system of exchange dries up the river between an upstream point of diversion and a downstream point where the exchanged water is reintroduced to the stream from storage. Mr. Neutze felt that he would be able to maintain continuous flow down to the Whitney Ditch under the proposed new reservoir procedure. He felt that the reservoir would be "the best way to go in the long run," (water management for quality). Mr. Neutze felt that more reservoirs are needed in the upstream end of the system. Dr. Aukermann felt that from a recreational standpoint, high mountain reservoirs would be beneficial to meet recreationalists' demands.

Dr. Seaman stated that he felt the 1983 goals should be addressed with reasons and justifications for backing off on the goals after they have been investigated. The type of fishery desired must be defined. Temperature is also an important factor in this fishery determination. One attendee noted that there is no better fish suited to the temperature, pH, and DO-type conditions existing than the carp. The question of the type of fishery to be supported with the available tax dollars must be answered.

IV. ATTAINABILITY OF FISHERIES - CONSIDERATIONS

1. Benefits Vs. Costs

Any efforts to greatly modify the type of fish life present in the lower end of the Poudre system should consider the actual benefit to be realized therefrom. Value of a program of introducing trout or other desirable game fish should consider angler days before such a program implemented and those anticipated after such a program would be implemented; how a program of this type would fit in with the local lifestyle; how it would affect the quality of life in the area. Perceptions of people in the county concerning the modification of fish life must be considered, as must the future outlook for the two-county area. At this point a proposed greenbelt in the region of the lower Poudre was mentioned.

Dr. Post pointed out that in many cases municipal discharges were beneficial to stream life; that is the stream life presently existing in the Poudre system. From the standpoint of total biomass produced and sustained by the river, the nutrient content of municipal dischargers is very advantageous. Jack Neutze indicated a way of reducing impact of agricultural returns on the system would be to recycle these returns. This would be done by practices implemented on individual farms. Returns would be collected in a downstream seep ditch or tailwater pond and pumped up for reuse.

2. Seasonal Variations in Water Quality

The point of maintaining an expendable "put-and-take" seasonal fishery was discussed. It was pointed out that major angler demands occur during the season of traditionally low flow in the Poudre system. Discussion oriented about maintaining a cool and cold water fishery upstream from the City of Fort Collins Treatment Plant No. 2.

Non-irrigation seasonal conditions might permit establishment of an expendable "put-and-take" fishery. Stocking is costly; Mr. Nittman, from the Colorado Division of Wildlife, has data on the cost of a "put-and-take" fishery. Mr. Nittman indicated that a 60 percent return of caught fish is needed or else the fishery will be a losing proposition. Martinez Park presently has such a put-and-take fishery. Approximately 100 pounds per surface acre of pond or stream per year is a good number for average stocking quota necessary for a put-and-take fishery. Cost of stocking fish is about $1.10 per pound. Brown trout were experimentally seeded near Greeley No. 2, but disappeared the following year. Public access to a few stretches of the Poudre is presently available. The Division of Wildlife has a policy of signing such areas with signs that read "State Stocked Water, Open to Public." Access to the river is an extremely important concept in maintaining a public fishery.

3. Public Access

Access by the public to the main-stem channel is generally regarded to need improvement. It was brought out in the meeting that there are other enjoyable uses of the river besides just that of a fishery, such as good aesthetics, good small game habitats, and fur bearing habitats. The point was made that the water quality planning process is forcing land use planning at the county level. The presence of mud flats, silt, turbid returns, and odors generally decrease the aesthetic value of the river. It was pointed out that dry stretches in the river below the headgates of ditches that possess a right to dry up the river probably affect the insect population of the river more than any other species. It was pointed out that the snapping turtle population has increased greatly in the low end of the Poudre River and the St. Vrain. These reptiles are ideally suited to feed off the abundant small fish. Certain individuals seem to feel that silt apparently attributable to agricultural returns was a major factor in the lack of a fishery in the downstream end of the Poudre. Dr. Post felt that a silt problem would exist even with a stabilized water flow. Odor problems were identified below the City of Loveland and the City of Longmont treatment plants. Sediment problems were identified downstream from the Windsor discharge. Such conditions can be tolerated by rough and forage fish such as green sunfish and black bullheads, both of which are game fish. The presence of algae in the Poudre corresponds to a cycle. In the fall, diatoms are the most abundant form. In the spring, blue-greens and greens take over. Filamentous forms were observed below Windsor. Problems are also experienced with algae when high mountain reservoirs are flushed out.

4. Artificial Fishery

The public relations aspect of maintaining an artificial fishery were discussed. What would be the effect of promoting a fish kill in an artificial fishery by conditions necessitated by irrigation supply? They felt that the public relations from a fish kill would not be totally negative. It would stimulate public concern and interest, and would also serve as a monitoring device. Dr. Morrison pointed out that fish kill reportedly occured in the Big Thompson River in mid-July of 1976. Follow-up observations failed to provide any confirming data. The whole issue was soon abandoned as a result of the Big Thompson Flood. Wayne Seaman of the Division of Wildlife indicated that his agency would definitely consider maintaining a fishery above Fort Collins No. 1. Because of the risk involved, the Division prefers to enhance an existing fishery rather than establish a new fishery in a possibly poor area. Much public land eixsts between the City of Fort Collins No. 1 and I-25, which prompts many people to look upon this area as desirable for establishing a fishery. Dr. Post felt that the 1983 goals were attainble, but he didn't know if the taxpayer could afford the meeting of this goal. The desire of more water for treatment plants must not, however, destroy higher quality fisheries in the mountains than are being augmented in the plains.

5. Enhancement of a Mountain Fishery Versus Establishment of a Plains Fishery

These goals may not necessarily be adverse to one another. The Division of Wildlife pointed out their work is directed towards satisfying public wants and wishes and the enhancement of existing fisheries rather than establishment. They will respond through public pressure to whatever desire the general populous might voice. The current attitude of the public seems to be that a mountain fishery is the more desirable alternative.

6. The South Platte River System

It was pointed out that the South Platte generally supports bass and bullheads only as the main game fish. The St. Vrain Creek is reportedly channelized throughout much of its lower end greatly reducing its desirability as a fishery.

The question was voiced as to whether anyone is really aware of the historic distribution of trout and other game fish in the Poudre and other river systems. Jack Neutze stated that he used to catch trout down by Greeley No. 2, but hasn't been able to do so for a number of years. There may be some information in master's theses and dissertations at CSU on this subject. There are also staff members at CSU who may be a useful resource.

V. FUTURE MEETINGS

It may be useful to have future meetings to discuss additional findings of the hydrologic analyses of the 208 consultants and historical data on fisheries in the region's streams. Another meeting in February or March might be appropriate.