THESIS

WATER POLLUTION: SOUTH PLATTE RIVER

Submitted by

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY Steven R. Nichols ENTITLED WATER POLLUTION: SOUTH PLATTE RIVER BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

WATER POLLUTION: SOUTH PLATTE RIVER

The Federal Government has been shown to be the primary initiator of state programs of water pollution control. The history of enabling legislation for water pollution control has implicitly established evidence as the backbone of pollution action. The Water Quality Act of 1965 required states to adopt criteria and plans of implementation and enforcement to then become standards for the state. However, a deficiency exists to require Federal approval of surveillance systems capable of providing data which could be applied to meet pollution control standards.

Colorado responded to Federal requirements to establish a pollution control authority. Unfortunately, incorporated in the new law was the failure to devise an effective scheme whereby data collection could be applied to meet water quality objectives.

An analysis of the data available for the South Platte River Basin in Colorado in general, and for the quality stations, Julesburg and Henderson in particular, showed inadequacies in the surveillance system. The inadequacies include the inability to accurately depict water quality trends and detect polluters. In addition, the data system proved to be inadequate for Colorado's objectives of protecting, maintaining and improving water quality.

Furthermore, the need exists to re-evaluate and align the purposes of surveillance with the legal objectives of water pollution control. New collection techniques, including remote sensing and automatic

monitoring in addition to the traditional grab sampling, may aid new programs in managing water pollution control.

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ABBREVIATIONS USED IN THIS TEXT

CPH	Colorado State Department of Public Health
CRS	Colorado Revised Statutes
EPA	Environmental Protection Agency
FWPCA	U.S. Department of the Interior, Federal Water Pollution Control Administration
HEW	U.S. Department of Health, Education, and Welfare, Public Health Service
PL	Public Law
SBA	Small Business Administration
STP	Sewage Treatment Plant
USGS	U.S. Geological Survey

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Chapter 1

INTRODUCTION

The Issue of Water Pollution

Water pollution, without question, has become an issue of importance and action in every level of the American society. Emphasis for the action toward water pollution control in the past quarter-century has decidedly grown to include the multi-purpose aspect of pollution control as well as protection of health. The ever increasing action against pollution can probably be attributed to our society attaining a degree of advancement never known before to man. For the most part, we no longer contend with problems which threaten our existence. We seldom worry about what we are going to eat or where we are going to sleep. This degree of advancement allows us to consider other problems. We can now be concerned about our sewage creating a health or odor problem fifty miles downstream. We can consider our contribution in detergent laundry soap as it affects the success of a weekend fishing trip.

The concern about water pollution has permeated the entire governmental structure. Political interest and activity can be observed all the way from county health departments, through water pollution control boards and natural resource divisions in State governments, a variety of Federal agencies, Congresses and even Presidents. The sensitiveness of a few environmentalists or preservationists or water supply engineers or women's organizations has spread to a nationwide, coordinated program commanding decisiveness in the minds of proponents and opponents (Huntington, 1961).

The issue of water pollution will never have the same meaning to all these differing segments of society. Depending on which aspect is at issue, effects of pollution will be defined differently by each segment. The definition may assume the form of lost services to a particular group or interference with the use of our natural resources. Therefore, an understanding of the interest and viewpoint of any person investigating the various aspects of water pollution must be clearly understood in order to illuminate his "biases."

Let is be clearly known from the outset that the investigator is a preservationist. His interest in water pollution has grown from his active use of the natural resources of Colorado in the forms of fishing, mountaineering, hunting, skiing and photography. Specific interest in water pollution stems from his year-by-year personal observations of the deterioration of the State's waters through over-use and abuse.

The investigator realizes, as should the reader, that his point of view is "an outsiders" with a fairly broad textbook knowledge, but with little technical field experience. The value of this investigation is then to provide such an outsider's critique on present situations and perspectives for future courses of action. The investigator admits he has little knowledge of compromises and half-measures necessary to actual operation of a pollution control program.

However, it is likewise equally important to realize that the investigator's goal is to <u>improve water quality</u> and not to "head-hunt the villains" in the system. If criticisms are directed toward individuals in this paper, it is because, in the author's opinion, those individuals are significantly affecting the system. The author in no way wishes to imply the staffs of the agencies to be discussed are incompetent. The author does wish, however, to examine the system and then critique it in a manner which may constructively improve its operation and subsequent protection and improvement of water quality.

The South Platte River Basin

The South Platte River Basin in Colorado is the target of this investigation because it contains most of the people in Colorado, has a history of serious water quality problems, and faces increasing future water demands, which will require a greater cognizance of water quantity and quality management. The South Platte and its tributaries drain the most populous and industrialized portion of the state as it runs southwest to northeast across Colorado's northeast corner. These tributaries, as well as the mainstem, embrace Colorado's largest metropolitan area, Denver and suburbs, along with many other large cities such as Longmont, Loveland, Boulder, Fort Collins, Greeley, Fort Morgan and Sterling. The pollutants from these cities, coupled with wastes from irrigated agriculture and associated agricultural industries such as sugar beet processing and feedlots, contribute to the most severe, collective pollution problem in Colorado.

The South Platte River originates in the high plain of South Park in central Colorado and runs 459 miles to its mouth at the confluence with the North Platte River at North Platte, Nebraska. The South Platte River drainage encompasses 19,450 square miles in the State of Colorado. Principal tributaries of the South Platte River are Bear Creek, Cherry Creek, Clear Creek, St. Vrain Creek, Big Thompson River, Cache la Poudre River, Crow Creek, and Lodgepole Creek. A general map of the South Platte River Basin is given in Figure 1 (HEW, 1965a).

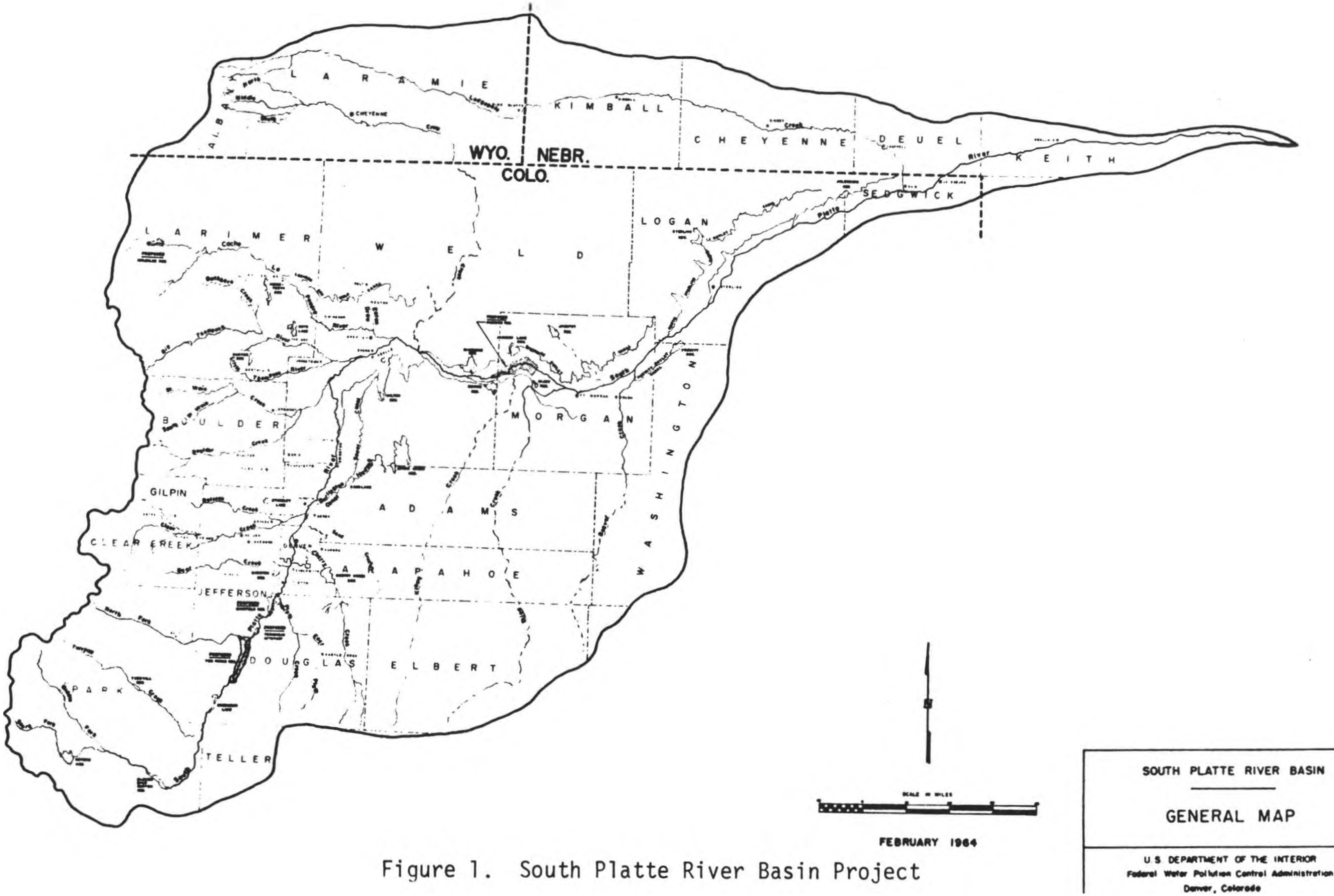


Figure 1. South Platte River Basin Project

The South Platte groundwater system is very extensive. Much of northeastern Colorado not only depends on the surface waters of the South Platte and its tributaries, but also relies heavily on an extensive system of wells to capture the sub-surface flows of these same water courses. Groundwater pollution problems seem less acute than surface, probably because of their underground "unseen" character. The contamination of groundwater reservoirs may require decades, because of the slow movement of pollutants through the soil profile, but once contaminated, decades will be required to alleviate the problem. The interrelated problems of surface and sub-surface pollution are coming to the forefront as water demand and use continues to increase.

Surface water resources in the Basin have been fully appropriated for irrigation use. In summer, very low flows occur at many points along Basin streams, where agriculture diversions may use all, or nearly all, of the available streamflow. As can be readily conjectured, these low flows exacerbate the pollution concentration by the absence of dilution water.

Population in the Basin has multiplied about 2 1/2 times since 1940 to nearly 1 1/2 million people. Remarkably, the Denver Metro area has more than doubled since 1950 to a population of over 1,000,000 (HEW, 1965a). This rapid population growth is one of the best indicators of the huge existing and potential municipal and industrial waste disposal problem. People are pollution! In the Denver Metropolitan area alone, during 1963-1966 Federal-State investigations, 26 domestic sewage plants contributed about 67 tons of biochemical oxygen demand (BOD) to the South Platte system daily (FWPCA, 1966b). Special industries, such as sugar beet processing were contributing as much as 95 tons of BOD per day during operating season in the 1963-1966 period (FWPCA, 1967b).

Even though new treatment facilities are continually being added to curtail water pollution from the many new and growing sources, there is no guarantee beneficial water uses are being protected. It will become increasingly important to develop systems of surveillance which have a capacity to accurately inform pollution authorities of the state of the water quality as well as to pin-point violators and provide bases for decision making on pollution control schemes. With heavier and heavier water use, the crucialness of accurately measuring change will increase.

Pollution Control

Colorado's mechanism for dealing with water pollution problems has evolved from many sources. As is the case with many states, health considerations were the major initiators. Later, navigation, odor, fish and wildlife, and oil pollution contributed to the formation of the existing political mechanism.

The Federal government has played a major initiating role through its legislation as far back in history as 1899. Legislation, especially in the 1960's, has induced a great change in states philosophies towards dealing with pollution related problems.

This investigation will examine the interrelation of Federal-State-local political mechanisms, the related laws generated by these institutions, the means by which pollution is measured and water quality managed, and finally, will speculate on this system's shortcomings and needs. Chapters two through five will provide the background necessary for the succeeding technical examination.

For many years, our country has experienced marked economic and social growth. Communities have grown from simple farm villages to sprawling, mechanized metropolitan areas with accompanying teeming populations. As a result, man has been little concerned with his environmental quality for this past era, which is reflected in his laws. But now, as his resources become more fully utilized or depleted, his rivers run as sewers, his air chokes him with sulphur, and his lands reek with the garbage of his cities marred by the brutal scars of his own machines - he introspects - and realizes this is not the only way. He realizes that his children perhaps have a right to drink clear water, and breathe clean air and see the land as man once received it. These changes in philosophy are also reflected by his law. A great legislator reflects upon the growing "populosional" dilemma.

> In the face of an almost daily demonstration of our technological prowess as a Nation, it is ironic, indeed frighteningly so, that we have not yet marshalled our skills and our will to assure mankind of an adequate reserve of usable water, the most basic elements insofar as our continued existence as a species is concerned.
>
> Congressman
> Wayne N. Aspinall
> Colorado

Let us begin.

Chapter 2

FEDERAL ACTION

Federal Legislation

Early Actions

For a long period of time, the Federal Government has been the initiating legal backbone to environmental protection generally and water pollution control in particular in the United States. Through a long and complex involvement with environmental problems of various forms, the congressional, executive and judiciary branches of government have evolved an increasingly ubiquitous system of legislation.

The significant Federal legislative history of environmental quality extends back to the River and Harbor Act of 1899. This legislation made it unlawful to discharge from any floating craft or from shore, any refuse matter of any kind or description, other than liquids flowing from streets and sewers into any United States navigable waters or tributaries. As a strengthening sequel, the Oil Pollution Act of 1924 (PL68-238), under the supervision of the Secretary of War, attempted to limit discharge of any form of oil into the coastal navigable waters of the United States from any vessel.

Although the primary intent of this law was to prevent any obstruction to navigation, this statute has been recently revived to deal with the polluters of major national waterways by Executive Order No. 11574 (1970c).

National interest in water pollution control lagged through the depression years, as evidenced by the lack of any pertinent legislative acts. However, the New Deal in 1935-1940, which provided Federal assistance to states via public works and work projects for sewage treatment, introduced a number of unsuccessful bills with regard to these interests. Concern again diminished with the coming of World War II, but the eagerness with which the states accepted Federal assistance prior to the War established a precedent substratum for the first policy statement of Federal aid to states in 1948 (see Davies, 1970 for a general history prior to 1948).

The 1948 Act

The Water Pollution Control Act of 1948 (PL80-845) received wide bi-partisan support, proposed by Senators Barkley and Taft, in the flurry of post-war activities. This combined support produced the first declaration of national policy with respect to water pollution.

> That in connection with the exercise of jurisdiction over the waterways of the Nation and in consequence of the benefits resulting to the public health and welfare by the abatement of stream pollution, it is hereby declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in controlling water pollution...
>
> (emphasis added)

Public Law 80-845 was passed June 30, 1948, which gave authority for water pollution control activities to the Public Health Service. The Surgeon General was authorized to develop a comprehensive program for eliminating or reducing pollution of interstate waters, which included all lakes, rivers and other bodies of water which either flowed across or formed part of state boundaries, and their tributaries. The expressed purpose of abating pollution, as stated, is to reduce health hazards connected with impure water. No mention is made of esthetics, recreation or any other purpose except health.

Provisions were made for the establishment of a Water Pollution Control Advisory Board. The Surgeon General was to chair the board of four Federal representatives from the Army, Interior, Federal Works Agency, and Department of Agriculture. Six non-Federal members were appointed by the President.

A five-year authority for financial aid in the form of grants or loans was authorized by the 1948 Act for each fiscal year between July 1, 1948, and June 30, 1953. The Federal Works Administrator was authorized to make loans to any state, municipality or interstate agency for construction of treatment facilities. The plans, however, were subject to inclusion in a comprehensive program. No loans were authorized over one-third of the estimated cost, or over $250,000, whichever amount was smaller, at an interest rate of two percent per annum. Between July 1, 1948, and June 30, 1953, the maximum total appropriation was not to exceed $22,500,000. The size limitation on grants available was in effect until the Clean Water Restoration Act of 1966.

One million dollars per year was to be given to state agencies for expenditures in conducting research and studies for the prevention and control of water pollution by industrial wastes. An additional million dollars per fiscal year was approved for the Federal Works Administrator to make grants to states and municipalities to aid in financing the cost of work preliminary to construction of sewage treatment facilities. Funding was also approved for the establishment of the Robert A. Taft Sanitary Engineering Center at Cincinnati, Ohio, for use by the Public Health Service in the research and study of water pollution, along with the training of personnel in work related to water pollution control.

Provisions for pollution abatement action to be taken by the Federal Government were also established in the 1948 Act. The state or interstate agencies involved had to give consent and be included in initiating all action. Apparently, this procedure was not used until after 1956.

In the action, the Surgeon General was directed to encourage cooperation in and between states to adopt comprehensive programs of abatement of water pollution. The Federal function was to more or less provide technical services at the request of states.

The Surgeon General, on the basis of reports, surveys, and studies, was authorized to take action if he "found" pollution of interstate waters which endangered the health and welfare of the people of a state. The polluter was given first notification of recommended remedial action to abate and given a reasonable period of time to comply. If no action was taken to abate, the Federal Security Administrator was authorized to call the matter before a five-man board. On the basis of evidence presented at a hearing before the board, further action was recommended to the Administrator. Again if after a second notification and a reasonable period of time the polluter did not comply, the Attorney General brought suit on behalf of the United States.

Two important points evident here will be re-emphasized later in this chapter. First, it was necessary to prove that pollution was of a character to endanger "health and welfare" and then to prove compliance had been met. No provision is promulgated which describes the nature of that evidence.

Second, no procedure was outlined to monitor whether or not that polluter remained in compliance. In other words, no system was established which could monitor, on a continuing basis, the water quality of the stream in question.

The significance of these points will be spoken to in a later chapter. It is important to recognize at this time, however, that Federal directive and precedent legislation was established for the conference-type enforcement procedure.

Progress in the 1950's

With the exception of one act in 1952 to extend the dates of the Water Pollution Control Act to June 30, 1956, the 1948 Act remained essentially unchanged until 1956. In 1956, major revision of the Water Pollution Control Act was approved, with the intention of extending and strengthening the involvement of the Federal Government in the prevention and control of water pollution (Water Pollution Control Act Amendments of 1956, PL84-660). However, this phase of legislation was to meet with considerable resistance.

The first obstacle created by the 1948 Act left the Federal Government enforcement powers subordinate to the states. The Federal Government had the authority to bring legal action against polluters, but only after the states requested intervention. This strong state position was reinforced by a heavy state industrial lobby; industry having much more influence at the state level. As a result, the entire enforcement system proved actually useless (Davies, 1970).

The ineffectiveness of the 1948 Act was recognized in 1956 by the House Appropriations Committee, who refused new funding to the Public

Health Service for enforcement. In fact, the 1948 loan system was approved, but never funded. Upon this point, states rights versus Federal authority, the Department of Health, Education, and Welfare negotiated a format which established a Federal procedure by first calling a public hearing, followed by a six-month waiting period, a possible six-month extension, and then, finally, court action as previously described. Regrettably, the 1956 Act did not remove the crippling requisite for state permission before court action.

The state permission clause was not, however, the major impediment to new pollution control legislation in 1956. Both the Truman and Eisenhower administrations had been quite solidly opposed to any financial aid to states for sewage treatment. The $500 million which was to be appropriated over the ten-year period following the 1956 Act was to the great dislike of the White House. A veto was considered but the Act was signed into law with an accompanying statement from the President disapproving of grants (Davies, 1970).

Rearmed with the recommendation from his Join Federal-State Action Committee that vocational education and waste treatment powers and authorities could effectively be turned back from Federal jurisdiction to the states, Eisenhower took no action (Report of the Joint Federal-State Action Committee to the President of the U.S. and the Chairman of the Governors' Conference, 1958).

Eisenhower, again, in his January 19, 1959, budget message, tried to delete Federal assistance to states for sewage treatment by reduction of funds in 1960 and elimination thereafter. The Congress was of quite an opposite opinion, however, and backed a bill by a 2-1 majority in both houses to a proposal by Representative Blatnik to double the financial program and extend it ten years (H.R. 3610, 86th Congress). As expected, Eisenhower vetoed the bill, but it was nearly affirmed by the Congress' two-thirds majority veto override powers.

Despite all the opposition, several significant changes did occur in the 1956 Act. In 1956, the phrase "prevention and control" was substituted for the term "abatement," which had described the objective statements. A significant phrase "...primary responsibilities and rights of the States in preventing and controlling water pollution..." is still preserved in the 1956 version of the law. This slight wording change alters the Federal policy from a reactive to a preventive point of attack (Water Pollution Control Act Amendments of 1956, PL84-660).

> ...it is hereby declared to be the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution, to support and aid technical research relating to the prevention and control of water pollution, and to provide Federal technical services and financial aid to state and interstate agencies and to municipalities in connection with the prevention and control of water pollution.

New provisions were made in the 1956 Water Pollution Control Act Amendments for pollution oriented technical training, grants-in-aid to public, and private agencies and institutions for research or training projects, as well as research fellowships in the Public Health Service not to exceed $100,000 for any fiscal year. In addition, for each fiscal year, July 1, 1956, to June 30, 1961, appropriations of three million dollars were authorized for grants to assist states in funding adequate prevention and control measures. No grant for construction greater than thirty percent of estimated cost, or $250,000 was authorized. The allotments to states were to be based on population, extent of pollution problem, and financial need, with approval being based upon the plans meeting a number of Federal requirements. Grants totaling $50 million per fiscal year for construction of sewage treatment works were continued, provided that the projects complied with the state pollution control plan. Also, assurances were required that proper and efficient maintenance and operation of the facilities would follow completion of construction. This is the program that Rep. Blatnik proposed be doubled in funding, which, as stated above, was vetoed.

A significant revision of the procedure for Federal participation in pollution problems was included in the 1956 Amendments. A statement was included as in 1948 to preserve states' rights. The notification procedure remained essentially the same, but after notification of the state or interstate pollution control agency, the Surgeon General was directed to "call promptly a conference of the State water pollution control agencies and interstate agencies..." of the states affected by the pollution. Following the conference the Surgeon General was to prepare a summary of the conference discussion including a statement of the occurrence of pollution, the adequacy of measures taken toward abatement, and the nature of delays encountered in abating the pollution (Water Pollution Control Act Amendments of 1956, PL84-660).

The addition of the conference procedure had the effect of allowing permanent intervention by the Federal Government in dealing with pollution matters by virtue of the fact that the conference could be reconvened at any time. The conference procedure established a pattern for all subsequent Federal enforcement action (Davies, 1970).

Finally, an interesting change in membership of the Water Pollution Control Advisory Board was made in the 1956 Act. Although the board was still chaired by the Surgeon General, the Federal representation was eliminated and three non-Federally employed civilians were appointed by the President, bringing the new total to nine. These nine representatives were to be selected from state, interstate and local governmental agencies of public or private interests who were concerned with water pollution (Water Pollution Control Act Amendments of 1956, PL84-660).

The 1960's; A New Era

The Kennedy Administration began a reversal in attitude in the executive sector of the Government. The new President dealt with two major points of controversy which had been an impediment to progress in water pollution control in 1948 and 1956, as well as in 1961: (a) Federal versus state enforcement powers; and (b) Federal financial assistance to state and local entities for sewage treatment plants. In a 1961 message on natural resources, Kennedy endorsed a bill introduced again by Rep. Blatnik which eliminated state consent for legal proceedings against polluters and extended Federal jurisdiction to interstate or navigable waters.

Jurisdiction of navigable waters, under the broad interpretation of the law, generally defines "navigable" as susceptible or capable of commercial use (Poindexter, 1971). In an indirect way, this extends jurisdiction to intrastate waters. Blatnik's bill then passed both Houses without major revision. Kennedy felt sewage treatment was an integral part of Federal financial assistance and on July 20, 1961, signed into law this bill, which substantially increased funding to the states for sewage treatment works (Davies, 1970).

The Strength of the 1961 Action

The Federal Water Pollution Control Act of 1961 (PL87-88) significantly strengthened the 1948 version. The authority for administering the Act was transferred from the Surgeon General of the Public Health Service to the Secretary of Health, Education, and Welfare. This marks a significant change in administrative policy. The Act requested the establishment and maintenance of at least seven field laboratories and research facilities in different regions of the United States for studies and research related to the control and prevention of water pollution. Five million dollars per year was authorized for research, which was expanded to include development of improved sewage treatment techniques, better methods for detection of pollutants, and evaluation of augmented streamflows. The Corps of Engineers and the Bureau of Reclamation were authorized to include storage in projects for the purpose of water quality control, as long as those flows were not a substitute for adequate waste treatment.

The Act provided increases to $100 million by 1964 in the annual limitation on construction grants, which were to extend through 1967. Limitations were set for thirty percent of project costs up to a maximum of $600,000 for a single project, or $2.4 million for a joint project involving two or more communities. Fifty percent of the grants were to be designated for construction of treatment works serving municipalities of not more than 125,000 population. Stricter enforcement measures against pollution of interstate waters were authorized, allowing the Secretary of Health, Education, and Welfare to directly request a suit instead of seeking state permission if pollution of waters endangered the health or welfare of persons in a state other than the one in which the waste discharge originated. Request of a suit with the consent of only the state governor could be made if only that state was affected. More importantly, jurisdiction of the Act was also extended to include all coastal and navigable waters of the United States.

The navigability clause extended jurisdiction to allow the conference procedure to include, in essence, intrastate waters. The great importance of this clause became evident in the 1963 through 1966 Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado, which put into action the specific procedure whereby states could request Federal assistance in developing abatement procedures as set forth in the 1956 Act. At the request of the governor of a state, if the alleged pollution was endangering the health or welfare of the people of that state, the Secretary of HEW could call a conference on the basis of reports, surveys and studies.

At the conclusion of the conference, if the Secretary believed progress toward abatement was not being made, he was instructed to recommend remedial action. He was to allow six months for this remedial action to be taken.

If no remedial action was taken, the Secretary then called a five-man board to publicly hear the matter with three weeks prior notice. On the basis of evidence presented at the hearings, the board then was to make recommendations for remedial action. Polluters were given at least six months to comply. If no reasonable action was taken within that time period, then the Attorney General could bring suit on the behalf of the United States.

Within the procedure described, there are three important points to note which are highlighted by the underlined words in the preceding paragraphs.

The first is that the entire basis for action is evidence. The conference was called on the basis of reports, surveys and studies. The Secretary then had to be shown to his satisfaction (i.e., "believe") that progress was being made which again requires proof. Then, if no remedial action was taken, a board, on the basis of evidence presented at the hearings, would recommend action. It must be noted that nowhere in the law is there a description of the form or kind of evidence necessary to make these decisions. Finally, there is no criterion promulgated which states what constitutes conclusiveness of the evidence.

The second point is that the whole intent of the law is remedial. The mechanics of bringing suit were to deal with existing polluters. No basis was promulgated to deal with new or potential polluters after the conference was called.

Finally in conjunction, there is no provision set up to follow through and produce evidence (i.e., gather data) after the hearings on a continuing basis. No method was set up to monitor continuing conditions or catch new polluters.

In further action taken in 1961, strength was added to the existing 1899 River and Harbor Act and the Oil Pollution Control Act of 1924. The Oil Pollution Act of 1961 (PL68-238) and its 1961 Amendments (PL89-551) essentially extended the bounds of illegal oil dumping and prescribed "zones" of restriction.

New Strength in Pollution Abatement

During the 1960's, Congress was not satisfied with the states' progress in abating pollution. Initially, consideration was given to the primary failure of the state abatement programs. The Public Health Service had failed to push the states into setting and enforcing standards. The intent of Senator Edmund Muskie was to remedy this situation through the potential new capabilities of the Senate Subcommittee on Air and Water Pollution, of which Muskie was chairman. Muskie proposed an extensive reorganization, which formed a new Federal Water Pollution Control Administration not under jurisdiction of the Public Health Service, but under Health, Education and Welfare. Muskie incorporated in his reorganization a proposal from the Eisenhower Administration in 1955 which would establish Federal and state enforcement procedures based on interstate water quality standards. In addition, standards could be set by the Secretary of HEW if the states did not (Davies, 1970).

The proposed Federal Water Pollution Control Act amendments of 1963 were approved by the Senate on October 16, 1963. After a year of negotiating water quality standards, the House Public Works Committee reported favorably on the Act during the latter part of the 88th Congress. However, no further action was taken by the House during that Congress (Davies, 1970).

The Water Quality Act of 1965

Muskie, in collaboration with Representative John A. Blatnik (Dem., Minnesota), who was now chairman of the Rivers and Harbors Subcommittee of the House Committee on Public Works, reintroduced the above mentioned bill to the 89th Congress.

The Senate passed the proposal as before, but the House revised the bill to require the states to file a letter of intent and then, by June 30, 1967, adopt water quality criteria, as well as establish a plan for their implementation and enforcement. Finally, after nearly two years of considerations, the Water Quality Act of 1965 became law on October 2. President Johnson commented at the time of signing (Davies, 1970):

> Today, we proclaim our refusal to be strangled by the wastes of civilization. Today, we begin to master our environment.

This 1965 Act is the basis for the present-day progress that is being made in improving the quality of our Nation's water supplies - primarily the result of a policy change.

The Water Quality Act of 1965 was a major step for changing the policy toward water pollution control at the Federal level. First, water pollution control was placed under the jurisdiction of a new agency within HEW; the Federal Water Pollution Control Administration (FWPCA). This, in itself, demonstrates Federal acknowledgment that water pollution is an issue of special national concern.

Second, Federal policy was changed from careful protection of states' rights to using Federal legislation to <u>force</u> the states into considering, establishing, and implementing water pollution abatement plans; a point of great significance as evidenced by subsequent Colorado legislation. Previous water pollution acts were authorized only to encourage "cooperation among states" and "assist states in prevention and control."

The 1965 Act required the Governor of the state to file a letter of intent within one year after October 2, 1965, to adopt on, or before

June 30, 1967, water quality criteria to be applicable to interstate waters or portions thereof within the state and a plan for implementation and enforcement of those water quality criteria adopted. Upon approval of the Secretary of HEW, the criteria and plan then became the state's water quality standards.

If the state did not develop these standards and submit the plan of implementation, the Secretary could then do so. Not only was the intent of this Act to prevent and control pollution as before, but also so enhance, or actually improve water quality. This is the so-called "non-degradation" clause which met strong opposition from the Western Governors. Technically, to the Western States this meant no more development of water resources.

Other considerations were to consider water supplies, fish and wildlife, recreation, agricultural and industrial purposes.

If the Secretary did establish standards, the Governor of the state could petition the Secretary to call a hearing within thirty days of the standards promulgated on the basis of evidence to decide to approve or modify standards.

This Act was directed at abating the discharge of matter into such waters or portions thereof, which reduced the water quality below the established standards. The Secretary was required to notify violators 180 days prior to action. As in the 1961 Act, a hearing board was to consider evidence including that related to the alleged violation of the standards as was deemed necessary to a complete review of the standards and to a determination of other issues relating to the violation.

As there were contained significant points in the 1961 Act, so are there also in the 1965 Act.

Most significant of all perhaps, is the fact that Congress required stream standards and not effluent standards. Each poses formidable technical and political problems for adoption, implementation, and enforcement (Gahr, 1965). The fact is, however, stream standards were required which shaped the structure of water pollution control agencies in the states as will be seen in Colorado.

The establishment of effluent standards would pose some difficult problems. The major legislative impediment is the already established Federal requirement that states establish stream standards. This fact does not preclude states from establishing effluent standards, but on the basis of the prodigious effort required to force the states into adopting stream standards, there is no evidence to support the contention that states will voluntarily adopt effluent standards. Perhaps though, because of the scarce water conditions in the West, Western States will be instrumental in initiating such effluent standard requirements.

Similar to the 1961 Act, the operation of the 1965 Act is contingent on the systems ability to produce evidence capable of proving or disproving adherence to a water quality standard. Proof of violation is inherent to showing that the waters of a stream are, in fact, below the established standard. Again as in 1961, no statement is made to qualify exactly what evidence is conclusive.

The last point which is absolutely crucial to determining the success or failure of a program is the exclusion of a continuing feedback system. The law requires the states to adopt a plan of implementation and enforcement subject to the approval of the Secretary, but the instrument which supplies this violation information for the effectuation of the Act, explicitly the water quality monitoring system, is excluded. The backbone of the Act is not subject to Federal approval (Water Quality Act of 1965, PL89-234).

Other provisions of the Water Quality Act of 1965 authorized demonstration grants for improving the control of waste discharges from combined storm-sewer systems. Authorization of grants for urban planning and treatment plant construction increased both the total amount and amounts allottable for a single project. The Act authorized 50 percent matching funds for research and development with $20,000,000 available per fiscal year through June 30, 1969. Further, an additional 10 percent was allotted to projects concerning urban planning.

Amendments in 1966

In 1966 a need was realized to extend and improve the efficiency of the 1965 Act. Senator Muskie again took up an offensive to meet the 1965 deficiencies. Consideration by Muskie's subcommittee determined a need for an unprecedented six billion dollars over the following six-year period for water pollution control projects, much to the consternation of the White House.

At the same time, and apparently without knowledge of the content of Muskie's bill, the White House developed a bill which was to accentuate the river-basin concept of water management instead of state management (Caulfield, 1972). The Water Resources Planning Act of 1965 (PL89-80) had already been a move of the Executive branch to coordinate the actions of the Department of Interior, Corps of Engineers, Department of Agriculture and HEW to develop comprehensive plans for twenty river basins in the country under direction of the Water-Resources Council. The White House, therefore, was inclined to promote redistribution of funds to river basins instead of to states as in Muskie's bill.

Further Executive action on May 10, 1966, had transferred the newly created FWPCA from HEW to the regionally oriented Department of Interior only five months after it was created by the 1965 Act. This further emphasized the Executive trend to encourage regional planning.

The administration's proposal clashed in Congress with Muskie's bill as could be expected. The intent of the 1965 Act, in which Muskie played a strong role, had been to leave the states prerogative in establishing standards and administering grants. Muskie apparently, on that basis, opposed the regionalization of the proposed amendments in question in 1966.

The resulting legislation was evidently to the dislike of the administration, but anxious to salvage some pollution control legislation, the President signed the bill into law on November 3, 1966 (Davies, 1970). This will is known as the Clean Water Restoration Act of 1966 (PL89-753).

It is important to note that since the most logical geographic division of water resources management is the river basin, the most logical unit of pollution control would be the river basin also. Significant legislation, such as the Water Resources Planning Act of 1965, has placed strong emphasis on the advantages of management by basin, but as yet, has proved to have less impact than state management schemes such as required in the Water Quality Act of 1965.

This is shown to be the case in Colorado by the actual legislative origins of state programs and actions as will be discussed later.

The Clean Water Restoration Act of 1966 made substantially increased funds available for research and development. It authorizes grants to be made to state and interstate agencies, by request of the governor of the state, up to three years, and for 50 percent of administrative costs involved in developing an effective, comprehensive water quality control and abatement plan. Demonstration and research grants were made for prevention of industrial water pollution, advanced waste treatment and water purification methods, and improved methods for joint treatment systems for municipal and industrial wastes. Of the funding authorized for 1967-1971, a total of $3.4 billion was for construction of sewage treatment plants and $30 million was for research. Single grants for demonstration projects were increased to $1,000,000 each, or 70 percent of the project cost.

The most significant feature of the 1966 Act with regard to funding, was the removal of the size limitations on grants available to states. In all the previous acts in 1948, 1956, 1961 and 1965, ceilings were put on amounts available to the states. The effect of the 1966 Act was to encourage large, regional types of treatment plants. Formerly, if for example, a city had wished to consolidate a number of old, inefficient local treatment facilities into a new, large-scale "metropolitan" system, their effort would automatically exclude them from Federal aid due to cost limitations. When cost limitations were lifted in 1966, the amounts of monies necessary to construct such huge plants became available.

New sections were added to provide a basis for evaluating programs and their costs, and to study pollution of navigable waters of the United States from vessels, plus methods of abatement. Finally, the Secretary of the Interior was requested to conduct a complete investigation regarding methods for providing incentives designed to assist in construction of facilities, along with efforts by industry for reducing or abating pollution. Tax incentives were to be considered along with financial means.

The need for precise guidelines describing the nature of data collection systems which could produce valid evidence was again reiterated in the 1966 Act in a new section added to the enforcement conference procedure. The Secretary was authorized at the request of the majority of conferees to request a report from the polluter which described the character, kind and quality of the pollutant based on existing data. Again as in the previous acts, no specification was promulgated for the nature of this data application.

Additional Guidelines

Following the 1965 and 1966 Acts, guidelines were issued to help the states carry out the requirements that they adopt water quality criteria and a plan of implementation and enforcement which would then become the water quality standards for the state.

At this point, a troublesome problem in semantics should be clarified.

Standard--means a plan established as a program of pollution control and abatement.

Criteria--means a scientific requirement which constitutes a designated water use.

Standards include water use classifications, the necessary criteria to support these uses, and a plan for implementation and enforcement (FWPCA, 1968d).

Guidelines for Establishing Water Quality Standards for Interstate Waters (FWPCA, 1967g) states the legislative requirements as described in the Water Quality Act of 1965. The Guidelines then delineate policy guidelines. Included in these policy guidelines are several points pertinent to the author's comments concerning the inadequacy of the Federal requirements for effective data monitoring systems.

One point states "Water quality criteria should be applied to the stream or other receiving water or portions thereof. The criteria should identify the water uses to be protected and establish limits on pollutants or effects of pollution necessary to provide for such uses." Then "The plan for implementing and enforcing the water quality criteria should be submitted in sufficient detail to describe the nature of the actions to be taken to achieve compliance, a time schedule for such compliance, the controls and surveillance for measuring compliance, and the enforcement authority and measures for ensuring compliance." Finally, "...it is anticipated that after the initial setting of standards (i.e., criteria plus plan), periodic review and revision will be required to take into account changing technology of waste production and waste removal and advances in knowledge of water quality requirements developed through research." In addition, "...water quality standards must be adequate to protect and upgrade water quality in the face of population and industrial growth, urbanization and technological change."

The point of this discussion is that criteria should identify water uses and describe remedial actions for compliance. The plan for implementing the criteria "should be submitted in sufficient detail to describe the nature of actions to be taken," to achieve compliance, measure compliance and to insure enforcement. Further, the plan must be capable of measureing existing and continuing conditions to anticipate change. The guidelines all but ignore the fact that "plan" means ability to measure criteria in a manner which is truly indicative of water quality to be effectively applied to accomplish the above stated goals.

The author does not wish to imply that the criteria relevant to protection and enhancement of water uses including recreation and aesthetics, public water supplies, fish and wildlife, agriculture and industry were not set forth. Indeed they were, accompanied by standard methods for making "scientific" measurements of these criteria (FWPCA, 1968d).

The crux of the difficulty then is that no guidelines or suggestions were specified to relate criteria to standards. In other words, no guidelines were presented to indicate where samples should be taken, or how often or in what sequence, relative to collecting data for the purpose of identifying pollutants, pin-pointing violations and identifying trends. Furthermore, no guidelines were presented on how to use the collected data for the accomplishment of the water quality goals of the state.

New Emphasis on the Environment

The actual transfer of the FWPCA from HEW to the Department of the Interior occurred on May 10, 1966. under Reorganization Plan No. 2 of 1966. This is the second major step in removing emphasis from the health aspect of water pollution by incorporating the FWPCA into the Department of the Interior which had broad resource and aesthetic concerns.

In the interim period between the 1966 Restoration Act and the National Environmental Policy Act of 1969, Congress examined the obvious deficiencies of the existing legislation. Two of the most potentially serious shortcomings were oil and thermal pollution (Davies, 1970).

The need for potent legislation was dramatically emphasized when the giant oil tanker "Torrey Canyon" broke up and sank in March of 1967. Public ire was aroused and attention further focused on oil pollution by the tragic off-shore spill near Santa Barbara, California, in January, 1969, which caused severe damage to the wildlife and beaches along twenty miles of shoreline.

In addition to the legislatively weak problem of oil pollution, thermal pollution lacked control measures. A need for regulation of thermal discharges was becoming apparent from the increasing number of existing, or planned, thermo-nuclear power plants. The Atomic Energy Commission denied jurisdiction over regulating discharges of thermally polluted colling waters in their licensing powers to plants.

Senator Muskie had again prepared forceful legislation dealing with this new thermal pollution problem, but the House Public Works Committee strongly opposed it. In addition, the electric utilities and Chamber of Commerce lobbied heavily against this proposed legislation. Opposition was further encountered with the Corps of Engineers, who felt that Muskie's clause on thermal pollution would interfere with their licensing powers for the pumping of dredged material from waterways. The final House product was a significant collection of concessions to polluting industries and no water pollution legislation during the 90th Congress (Davies, 1970).

A New Administration

The advent of the Nixon Administration continued Federal Government involvement in establishing national policies dealing with pollution abatement and environmental quality. Shortly after his inauguration, Nixon established the Environmental Quality Council to deal broadly with environmental issues. The President himself chaired the Council. The Council's intent was to provide a body of expertise which could attack environmental problems without the prejudice and bureaucratical fogging of existing agencies. The Congress responded to the President's action with strong bipartisan support by passage of two significant acts which document growth and concern over water pollution and environmental measures.

The Environmental Policy Act of 1969

The first of the acts, the National Environmental Policy Act of 1969 (PL91-190), which was approved January 1, 1970, initiated machinery for dealing with a number of environmental questions, including water pollution. The purpose of the Act was to develop national policy criteria for acting upon environmentally related questions. For the first time, Federal agencies were required to make detailed environmental impact statements on all projects. As a means to measure progress of the new activities, this act created a new council on environmental quality in the Executive Office of the President. Russel Train was appointed chairman. The cabinet-level Environmental Quality Council was then abolished by a reorganization Plan in 1970.

The new Council on Environmental Quality was to act in an advisory capacity to the President on formation of national environmental policy. To make appropriate and meaningful suggestions, the Council was charged with conducting investigations to analyze conditions and trends, and to appraise the effect of Federal programs on the environment. The Council was funded through fiscal year 1973.

Legislation in the 1970's

The second strengthening legislative action was the Water Quality Improvement Act of 1970 - Title I and the Environmental Quality Act of 1970 - Title II (PL91-224).

The Water Quality Improvement Act of 1970 - Title I prescribes in considerable detail a management scheme for oil and mine acid waste pollution. The contents of this Act are complementary to the Oil Pollution Act of 1961 (PL87-167), with some specific regulations and penalties to oil polluters. This Act also establishes comprehensive programs for expanding grants to institutions and awarding scholarships. A total of $62,000,000 is set aside through June 1972, for these purposes.

The Environmental Quality Improvement Act of 1970 - Title II created a supporting staff and funding for a new Office of Environmental

Quality. A significant funding schedule was approved through 1973. A total of $800,000 was approved for 1970, $1,450,000 for 1971, $2,250,000 for 1972, and $2,500,000 for 1973. Within the new Act, Federal agencies were directed to review monitoring procedures for evaluating the effect of present technology on Federal programs. Unfortunately, evaluations were still dependent upon evidence that violations of stream standards would occur. This new information was intended to assist Federal agencies in developing new environmental standards. Executive Order 11514 (1970b) further required agencies to continually monitor their environmental impacts. Each agency will be responsible for monitoring their own effect on environmental quality and provide public hearings for dissemination of information. On April 30, 1970, the Council of Environmental Quality issued guidelines which required each Federal agency to explicitly establish internal procedures for implementing this new provision. Fearfully, such agencies as the Army Corps of Engineers and Bureau of Reclamation may indeed monitor their own environmental impacts but may lack the overall point of view necessary for giving full ecological consideration to river basin systems.

New Directives

To further the direction of the Council on Environmental Quality, the President's Message on Environment (1970) issued a 37-point program dealing with literally every phase of air and water pollution, along with solid waste management. This 37-point program was a product of the new Council's recommendations. Further, Executive Order 11507 (1970b) directed Federal agencies to initiate extensive programs to bring Federal facilities into compliance with air and water standards over a 3-year time period. The Council has since established three advisory committees. The advisory committees consider the impact of tax structures on environment, establish legal advisory powers and also advisory information on auto safety.

More Action and Direction

The President, keeping his "environmental-reform machine" moving, transmitted two more reorganization plans (Council on Environmental Quality, 1970). The most significant of these reorganization plans, with regard to water pollution, consolidates political control of Federal programs into one central agency: the Environmental Protection Agency (EPA). The second plan deals with marine and atmospheric programs. In an accompanying statement, President Nixon summarized the cause of his environmental reforms:

> Only by reorganizing our Federal effort can we... effectively insure the protection, development and enhancement of the total environment.

The significance of establishing EPA is that it gives equal weight to environmental and developmental measures. The four primary goals of the agency are to establish and enforce standards, monitor and analyze the environment, further research and demonstration of environmentally related projects, and to assist in state and local programs. As a part of the plan, the Federal Water Quality Administration was transferred from the Department of the Interior to EPA to form a new Office of Water Quality. Responsibility for air and water pollution and solid waste management was transferred from HEW to EPA also. The initial budget of the EPA was approved for $1.4 billion.

In conjunction, a new policy making body, the Council on Environmental Quality, was created to function concurrently with the new Environmental Protection Agency. EPA and the Council on Environmental Quality are designed to reinforce and complement each other's respective tasks. The Council is responsible for environmental policies and the EPA achieves a comprehensive view for the Council to establish those policies (Council on Environmental Quality, 1970).

Evaluation of Federal Legislation

Noteworthy Progress

The President and the Council on Environmental Quality have made a very insightful progress in dealing with water pollution problems and management. The Council recognized the need to sharpen the development of environmental policy analysis and trends in programs. Creation of the Environmental Protection Agency has certainly been an excellent first step in cutting through the environmental problems in relation to the Federal water management agencies. The EPA has also recognized that environmental concerns have been slighted with agencies primarily pursuing their major concerns, or missions. Examples can be discovered in every aspect of government development agencies, including the Corps of Engineers and Bureau of Reclamation. Through the duration of their existence, each has acquired certain narrow-sightedness and format for attacking development projects.

Primarily due to the environmentalists agitation, every phase of government has been drawn into coping with water quality problems, including legislative, judicial and executive sectors (Carter, 1969). Considerable executive interest in the environment has been evidenced by a number of executive orders which have been issued during the recent administrations and by implication from Presidential Messages of the last three administrations. Without a doubt, the environment and water quality have become a national issue.

The Council on Environmental Quality has established nineteen broad objectives which should be met by the various pollution oriented agencies. These objectives include subsidies for waste treatment based upon comprehensive planning. Unquestionably, this objective embraces another point of encouraging change in state and local institutions. Also, the Council advocates water quality management be considered in the broader context of overall waste management (Council on Environmental Quality, 1970).

<u>Summary</u>

The Federal Government has led an increasingly strong and active role which has involved the states in developing water pollution control programs. The Water Pollution Control Act of 1948 established a precedent enforcement procedure which were subsequently incorporated into legislation in 1956, 1961, 1965 and 1966. In addition, the highly successful conference procedure has been included in legislation since, and including the 1956 Act.

In all existing legislation technical data has been implicitly established as the backbone of the conference procedure. Identification of a polluting substance, violation of stream standards and monitoring to indicate compliance as well as identification of trends in water quality are all dependent upon data.

Specific criteria for the various water quality uses were established in Federal guidelines as well as development of state standards. However, no guidelines were given to direct the coordination of standards and criteria. In conjunction, neither was the data collection system made explicitly subject to Federal approval. Even in the unprecedented 1965 Water Quality Act which required Federal approval of state adopted water quality criteria and plans of implementation, no provision was made for Federal approval of continuous stream monitoring.

The next chapter will examine Colorado's reaction to Federal legislation and the resultant water pollution control program.

Review of Action Through 1966

For the sake of comparison, the intent and policy of water pollution legislation through 1965 is relisted below.

River and Harbor Act of 1899

Established the unlawfulness of discharging any refuse matter into any navigable water in the United States.

Oil Pollution Act of 1924

Protects navigation from obstruction and injury by preventing the discharge of oil into the coastal navigable waters of the United States.

Water Pollution Control Act of 1948

Establishes the policy of the Congress to preserve states' rights and prevent pollution of water bodies primarily for health protection. Also establishes the format of the enforcement conference procedure.

Water Pollution Control Act Extension of 1952 and Water Pollution Control Act Amendments of 1956

Extends and reiterates Congress's stand on protecting states' rights with financial aid for research again primarily directed toward health hazards.

Federal Water Pollution Control Act of 1961

Broadens the scope of water pollution control to include projects for water storage, suggesting a trend to the "multi-purpose" philosophy. Also, opens the door for cooperative Federal-State investigations.

The Oil Pollution Act of 1961 and Amendments to the Oil Pollution Act of 1961

Extends the oil pollution policy to international waters.

The Water Quality Act of 1965

Dissolves the states' autonomy in dealing with pollution problems and establishes a national policy for pollution abatement within the states for esthetic and health reasons. Requires state adoption of water quality criteria and plans of implementation and enforcement subject to Federal approval.

The Clean Waters Restoration Act of 1966

Extends and improves the 1965 Act and also lifts the ceiling on grant size for water pollution control projects.

Chapter 3

COLORADO STATE ACTION

Colorado Water Pollution Legislation Prior to 1966

Early Actions

Colorado has, for a long period of time, dealt with problems relating to water pollution primarily as a result of concern over health (see Colorado Department of Health, 1969 for a general history). Colorado law in the process delegated powers and jurisdiction to a confusing and uncoordinated number of entities concerned with water pollution control.

As early in Colorado's history as 1874, prior to Statehood, penalties were established for discharging ... "Any obnoxious substance, such as refuse matter from slaughter house or privy, or slops from eating houses, or any other fleshy or vegetable matter which is subject to decay in the water ..." Upon conviction, fines for each offense ranged from one hundred to five hundred dollars (CRS, 1953a). This law was tested in the People vs Hupp, 1912, in a case to enjoin Hupp from discharging slop from his hotel. The court, without considering the evidence, construed the statute as imperative, disregarded it, and discharged the prisoner. The judgment was reversed after further legal proceedings. This is the only case tried in a higher court on this statute.

Only a few years after the passage of the stream pollution statute, a law establishing the illegality of allowing oil to flow into streams was legislated in 1889. To pollute streams was made a misdemeanor, with the penalty not to exceed one thousand dollars, or six months imprisonment, or both (CRS, 1953b). No record of higher court action is found based on this statute.

In later years, pollution regulation powers were further disseminated to the Game, Fish and Parks Commission for wastes containing fish. Pollution was forbidden in quantities deleterious to fish or spawn. When pollution was alleged to exist, the Game, Fish and Parks Commission, or a citizen of the State, could file a petition in district court. A temporary injunction to abate could then be issued if the necessity was "urgent" (CRS, 1953c).

The statute is weakened by Article 62-5-18, which states that

> The court shall not be precluded from considering the other beneficial uses to which such waters are or may be applied.

Special note should be made that the court is allowed determination of the controversy and not the water quality manager (CRS, 1963i).

Further jurisdiction, given in Article 62-5-14, implies a dam is an obstruction, which helps establish the navigability of a stream, thereby supporting application of the River and Harbor Act of 1899 and the applicability of the 1961 Water Pollution Control Act Ammendments (CRS, 1963i).

Jurisdiction over pollution control is further entangled by sections delegating powers to counties and cities. The City and County of Denver was specifically given jurisdiction over the waters of the South Platte River and Bear Creek above the mouth of Clear Creek in Northern Denver (the South Platte flows North) (CRS, 1953d). Based upon this statute, Denver brought action against the Glendale Water and Sanitation District in 1963 to restrain Glendale from constructing a sewage treatment plant outside Denver. In addition, CRS 53, Article 36-18-7 gives Denver the power over channel improvement, which may also lend support to the 1899 Refuse Act (City and County of Denver vs Glendale Water and Sanitation District, 1963).

Pollution control empowerment is further muddled by granting the City and County of Denver power to adopt ordinances to govern pollution and obstructions (CRS, 1953e). No specification is made in the statue to indicate that Denver's authority does not extend upstream from the City and County limits.

The recent legislative history related particularly to water pollution control began to take shape in 1941, when the Colorado legislature reorganized the State government. The Colorado Code of 1941 placed the Division of Public Health, which had jurisdiction over State pollution problems, in the executive branch of the government under direct supervision of the Governor. Dr. Roy Cleere, formerly the Secretary of the State Board of Health, became the Executive Officer of the Division of Public Health (Colorado Department of Health, 1969). Dr. Cleere was to become a figurehead in later pollution actions.

Reforms and New Legal Tools

After the 1941 Reorganization, momentum began to build against health related water pollution problems. The prime advocate of health reform and legislation during the 1940's was Rena Sabin. Her effort as Chairman of the Subcommittee on Health brought about considerable change in public health law and a correspondingly indirect effect on water pollution. Her effect was indirect because emphasis during this time period was placed on the health aspect of unclean water only and not on water pollution per se (Colorado Department of Health, 1969).

However, Dr. Sabin was instrumental in instigating legislation whose effects have had strong influence on today's water pollution control structure. The 1947 legislature created a new Department of Public Health and removed public health from the direct supervision of the governor. The department was then separated into two divisions. The new department established an advisory division, the State Board of Health, which acted in a consultative and judiciary capacity. The other division, consisting of the State Health Officer and his staff, formed an executive sector (Colorado Department of Health, 1969).

In 1947, legislation was enacted to allow establishment of county, city-county, and multiple county health units. The effect of this legislation has produced a difficult water quality management dilemma, which will become evident from later discussion in this section.

The 1947 legislation empowered the State Board of Health to issue orders, adopt rules and regulations, and to establish standards to enforce public health laws. The Board adopted various standards for sewage treatment effluent over the years to theoretically protect the streams of Colorado from pollution. Controversy arose in 1957 as to authority of the Board to adopt standards and regulation. The Colorado legislature gave support to these control measures by actually incorporating into the Statutes specific standards for sewage effluent discharged to surface waters in the State. As indicated, the regulation dealt only with wastes which contained human excretia, thereby excluding most industrial wastes. This regulation provided a concrete standard against which each individual domestic polluter could be measured. In other words, proof of source was established prima-facie. Unfortunately, the Colorado Board of Health failed to actively enforce this tool, as evidenced by little legal action during that period. These statutory standards were used as the guidelines for the Engineering Section of the State Department of Public Health, and the basis for the Board's enforcement action. As is the situation for the Federal legislation, adherence to the standards is dependent upon technical evidence.

The Board's enforcement procedure for standards was very much similar to the Federal notification procedure outlined in the preceeding chapter. First, the procedure specified that the State Health Department collect evidence to support existence of violations. The method and frequency of the sampling of the effluent, however, was specified in the law to produce such evidence. Second, the Executive Director of the Department then made tentative findings based on laboratory reports, notified the alleged polluter and called a hearing before the State Board of Health.

From the evidence presented at the hearing, the Board could sustain or dismiss the tentative findings. At a further date, after a reasonable time, the polluter was required to present evidence to the board's satisfaction that compliance had been met. Finally, if the Board was not satisfied, the Attorney General then could bring suit.

Parallel with Federal format, evidence of compliance is also dependent upon conclusiveness of evidence (HEW, 1963).

It is of importance to note that the State Board of Health was delegated authority to make extended investigations, hold formal hearings and make findings of violations. This implies the fact that no evidence was collected until after a suspected violation had occured. No provision is made to preventatively monitor for changing water quality conditions on a continuing basis.

Effects of the 1947 Statute

The aforementioned 1947 state legislation, which created county, city-county, and multiple county health units, has inadvertently had a deleterious effect on organized control of water pollution on a state basis, not to mention a regional or river basin basis. While the concept of local management of health-related problems works relatively well and satisfies the intent of the act, it detracts sharply from the badly neglected concept of regional water management. The fundamental difference between the two kinds of problems is many local health problems are locally generated, or locally administered, with little consequence to nonlocal persons. On the other hand, local entities, for the most part, must cope with water pollution which has been generated many miles upstream, as well as giving consideration to their downstream (or down-watershed) neighbors. This contrast becomes vivid when consideration is given to the difference in concept between administering a local polio vaccination program contrasted with a state-wide program of enforcing effluent standards for meat packing industries.

As mentioned in the chapter on Federal Action, the river basin is the most logical geographic unit of water management. Accordingly, the most logical unit of water pollution management is also the river basin. It may be safely inferred then, that political or geographic divisions which do not conform to or coincide with the basin unit (or sub-basin unit) detract, or complicate, management of a basin's waters. Political geographic units such as counties and cities, for the most part have no similarity of boundaries to river basin units. Each has its own power to formulate and enforce water pollution regulations, and therefore logically detracts from efficient water management.

Conditions in the 1950's and Early 1960's

Colorado apparently made little effective use in the fifties of Federal funds available through the 1948 and 1956 Water Pollution Control Acts, as evidenced by little political activity, as well as a lack in constructing new treatment facilities, which could have produced some improvements in water quality. From 1956 to 1963, Colorado received about 4 million dollars in Federal matching funds, making a combined total of about 6.1 million dollars to produce 42 projects in the South Platte Basin. As indicated by Federal-State reports in 1962, treatment and operation of these facilities remained poor in the basin (HEW, 1963).

Status Prior to 1966

Ineffective Legal Tools

Colorado had a hodgepodge of laws to deal with water pollution control. Its status, prior to 1966 legislation, is explained by the State Health Department (Colorado Department of Health, no date):

> Until recent years, both state and Federal water pollution control laws were weak, confused and ineffective. States have had water pollution control laws for years, but neither found it economically feasible to prosecute offending industries, not politically expedient to crack down on polluting municipalities. Cities have applied political pressure against attempts by the states to force abatement.
>
> The authority for water pollution control in Colorado prior to 1966 was vested in several state agencies. The Colorado Department of Health had the authority for standards regarding discharges of human wastes. The State Department of Game, Fish and Parks enforced control of pollution causing damage to fish, spawning areas and aquatic life. The Oil and Gas Commission had the power

to control pollution to waters resulting from oil and gas production. The laws gave pollution control powers to other state agencies and municipalities over special sources and areas. Water pollution control in Colorado, like that in many other states, suffered from divided authority and hard-to-enforce laws.

The South Platte River Basin

The South Platte River Basin in Colorado, although not the largest drainage basin, was experiencing the most rapid degradation of water quality in the State due to the concentration of population and industry in that region. Among many factors influencing the rapid and extensive growth contributing to pollution has been the availability of high quality water for industry, agriculture, livestock production, recreation and agricultural related activities. As implied, the population has also grown dramatically in the metropolitan and suburban areas. These new water users have caused an extensive development of the water resources in the region. Unfortunately, in one manner or another, all these users discharge their liquid wastes into the South Platte River System.

The South Platte River Basin has experienced rapid growth since 1940. The population increased from 660,000 to 840,000 in the period 1940 to 1950 with an estimate of 1,160,000 persons in 1963.

The growth of the Denver Metropolitan area has even more rapid than the Basin itself. The Denver region grew about 160 per cent from 1950 to 1960 and a remarkable 200 per cent from 1950 to 1963. The population in the Denver Metropolitan area alone was over 1,000,000 in 1963 or about 85% of the Basin population (HEW, 1963).

Not only was population concentrated, but the Denver area was also an extremely important manufacturing and trade center for a large part of the Rocky Mountain Region (HEW, 1963). Clearly then, cleaning up the water pollution in the Denver Metro area would, for the most part, alleviate the major domestic and industrial degradation of the South Platte's water quality in Colorado.

The Denver Metropolitan Dilemma

The Denver Metropolitan area has undergone a variety of schemes, projects, studies and plans conducted and funded by a number of entities which, in many ways, epitomizes difficulties in non-regional control. Because of its population and industrial concentration, the Denver area has long been the most serious source of pollution on the South Platte.

The problem of inadequate sewage treatment has plagued this region for many, many years. In the preceding discussion, mention was made of specific legislation included in the State Statues to deal with pollution of Bear Creek and the South Platte River in the Denver area. Also, strong public interest produced funds for dilution of sewage and construction of new treatment facilities in the late 1930's and early 1940's.

During the depression years of the thirty's, significant steps to abate pollution were taken, including bond issues and court cases. Strong public concern drawn from inordinate instances of filth diseases, prevalent especially in children, propagated a three million dollar bond issue in Denver to deal with the sewage problem. Interestingly, half of these monies were for trans-mountain dilution waters. These waters were ineffectively absorbed into the Clear Creek system.

By 1941, the new filtration facilities constructed by the bond issue had failed, leaving Denver again with inadequate primary sewage treatment (Colorado Department of Health, 1969).

Public awareness of pollution was further enhanced due to a suit against the City of Denver by Adams County on October 26, 1934. Basis for the action was the public nuisance of the sewage emptied into the South Platte by Denver, but no remedial action was taken (Colorado Department of Health, 1969).

Despite construction of treatment facilities and other remedial measures in the basin, the magnitude of the difficulty during the 1940's, 1950's, and early 1960's increased. On several occasions, downstream water users initiated action against Denver to cease polluting the river. As mentioned, Adams County brought suit against Denver in 1934 for creating a nuisance. The county renewed its efforts in 1965 when the county attorney, David Berger, tried to force the Director of Public Health, Dr. Roy Cleere, to initiate criminal and civil proceedings (Denver Post, 1965c) against:

> The mayors and city councils of Denver, Arvada, Westminster, Thornton and Aurora; director of the North Denver Sewage Plant; and the directors of the North Washington and Baker Sanitation Districts.

The Adams County attorney said that through the Attorney General's Office, the Health Department could bring suit against persons, municipalities, or sewage districts which were alleged to pollute waters of the State. Residents and county officials were again, as in 1934, objecting to the lack of action in reducing the odors from the River near Henderson, Commerce City and Brighton. The O'Brien Canal, which conveyed water from the South Platte below Denver to Barr Lake, produced in Barr Lake what local residents regarded as a "four-square-mile cesspool." Again, as in 1934, no remedial action was taken (Denver Post, 1965b).

The publicity regarding Barr Lake in Adams County may well have been an additional impetus for Governor Love's requesting the 1963-1966 Federal-State conference on the pollution of the South Platte. A special investigation and report was undertaken on Barr Lake, alone (HEW, 1965e).

Further, a bold effort was made, in a 1963 bond issue which allowed 34 million dollars, to alleviate the growing crisis of polluted water. As a result, the Metropolitan Denver Sewage Disposal District was formed. The 24 million dollar construction program actuated a plan which utilized existing treatment plants throughout the area to pre-treat sewage before it was conveyed to a central processing and treatment plant, Denver Metro. The original project design included renovation of Denver Northside for primary treatment prior to delivery to Metro and construction of two main interceptor lines in Sand Creek and Clear Creek to convey sewage from outlying sanitation districts (Denver Post, 1964).

A New Philosophy - New Problems

During this time period, a new philosophy was developing in regional-type sewage treatment.

In many ways, the inability of Colorado's statutes to deal with regional pollution problems became apparent when Denver Metro was being formed. The city by city, treatment plant by treatment plant approach showed lack of central, state or regional oriented planning. Combining of projects was eminent to deal with the financially overwhelming and increasing pollution treatment problem.

When the Metropolitan Sanitation District was created in 1962, the District attempted to include as many surrounding sanitation districts as possible to gain economies of scale. However, there were several holdouts in the Metro area, who based their refusal to join Denver Metro on a cost-efficiency basis. The samller entities felt that they could treat their sewage at less cost than could Denver Metro.

Aurora was the largest of the sanitation districts which refused to join Metro. In an effort to force Aurora to join Denver Metro, the State Board of Health blocked Aurora's efforts to obtain Federal grants for the expansion of Aurora's facilities. The Board was able to create this financial block because of the Federal government's requirements for regional planning (Denver Post, 1960j). During the many months of negotiation between Metro and Aurora, an agreement was eventurally reached, which allowed Denver Metro to provide secondary treatment in a series of phases to Aurora sewage.

The original agreement provided that Metro purchase, over a 20 year period, Aurora Sand Creek Plant for about one-half million dollars. Other terms of the agreement required that Aurora abandon the Westerly Creek Plant by 1976 and construct an interceptor line to convey sewage to the Sand Creek Plant. This agreement entitled Aurora to Federal grants for the much needed sewage treatment plant construction (Denver Post, 1966l).

In addition, Aurora gained three representatives on the Metro District Board. These representatives were to continue to operate Aurora's facilties during that 20 year period (Denver Post, 1966m). As mentioned above, Aurora originally refused to join the district because city officials were convinced that Aurora could operate its treatment facilities more inexpensively than it could purchase services from Denver Metro. Apparently, the rapid growth of Aurora changed the situation. This fact may expose the necessity of changing from a number of small individual treatment facilities to a centralized treatment plant.

The city of Glendale, an enclave of Denver, was another city which refused to join Metro because of high treatment cost. The State Board of Health, under the direction of Dr. Roy Cleere, attempted to force Glendale into joining the Metropolitan District on the basis that it was polluting the waters of Cherry Creek, a tributary of the South Platte River. In this instance, however, the District was unable to force Glendale into joining (City of Denver vs Glendale Water and Sanitation District, 1963).

Industrial Opposition

In addition to refusal by municipalities to join Metro Denver, opposition was also experienced from the industrial sector of the community, in particular, the meat industry. Under the old sewage system, the cost to the meat industry came from ad valorem taxes for the eight firms in the Denver area. The charge for their sewage disposal only totaled $8,000 a year. The new system, which conveyed sewage to Denver Metro, based its charge on the volume of waste water discharged into the city sewage system. Surcharges were based on the quantity, in pounds, of both BOD and suspended solids in excess of normal sewage. A spokesman for the industry alleged that the eight processing plants would be paying more than 400 per cent above costs charged in other cities for sewage disposal (Denver Post, 1966g).

A proposal was then formulated by the Denver City Council in an effort to alleviate this alleged tax burden to the meat industry. The proposal would have saved the packing houses $190,000 during the year's period following July 1, 1966. The proposal allowed the packers to pay only one-third the sewage charge the first year, two-thirds the second year, and the entire charge the third and succeeding years (Denver Post, 1966h).

An inability for Denver City councilmen to understand that the public eventually pays the cost of pollution became apparent. Several councilmen professed to be confused about the bookkeeping involved. They wondered who would be stuck with the bill if they gave the meat packing industry a special tax break. Nevertheless, the bill passed unanimously (Denver Post, 1966i).

Summary

Colorado has contended with water pollution problems since the 1870's. The evolution of the laws dealing with pollution control in the process had placed pollution authority in the hands of a number of agencies. Interests in these agencies ranged from protection of health to prevention of oil discharge, to protection of fish and spawn. In addition, special regulatory powers over pollution were delegated to cities and counties besides the State. The overall effect of this wide range of interests and authorities was a confusing conglomerate of divided authority and hard to enforce laws.

The Colorado Department of Health, in which control of water pollution for health reasons had been vested, adopted a cumbersome enforcement procedure similar to the Federal format. As was the case for the Federal notification procedure, Colorado's enforcement action was greatly dependent upon technical evidence. Also, neither was there a procedure specified to coordinate data collection with implementation of standards.

The rising crisis of polluted water in the 1950's and 1960's, especially within the South Platte Basin, showed the State's ability to deal with pollution problems to be weak. Population and industry were growing rapidly within the Basin and particularly in the Denver Metro region. The problems of waste disposal were becoming increasingly severe. Because of the concentration of people and industry in the Metro region, the water quality control problem became the most severe in the Basin as well as Colorado. The criticalness and complexity of the situation commanded a need for well organized assault on the pollution problem.

The Federal-State conference to follow in 1963-1966 met the problem head-on.

Chapter 4

THE SOUTH PLATTE CONFERENCES

The First Session

Legal Basis and Procedure

The Water Pollution Control Act Amendments of 1956 (PL84-660) provided the political machinery whereby the states could receive Federal assistance in sponsoring investigating actions into water pollution control. Colorado was one of over thirty states to request this assistance.

The 1956 Act set up specific procedures for enforcement measures against pollution similar to both the 1948 Federal Water Pollution Control Act and the 1961 Amendments as was previously discussed in the chapter on Federal Legislation.

The pollution of interstate waters (navigable waters were included in the 1961 Amendments) which endangered the health and welfare of the people of a state, was made illegal in Section 8 of the 1956 Act.

The Surgeon General (the Secretary of HEW after 1961) on the basis of reports, surveys, or studies believed that pollution was occurring or by request of the state's governor, was authorized to call an investigating conference of the state water pollution control agencies. Following the conference, the Federal function was to prepare a summary report including the occurrence of pollution subject to abatement, the adequacy of measures taken toward abatement, and the nature of any delays encountered in abating the pollution.

If the Federal function believed, upon the conclusion of the conference, that effective progress was not being made, it was authorized to recommend remedial action to the state water pollution control agency. If those remedial actions were not taken, a hearing board could be called to consider the actions and finally authorize a suit on behalf of the United States if actions were not taken.

Executive Initiation

On July 18, 1963, Governor John Love of Colorado requested such a conference be called and indicated the seriousness of pollution of the South Platte River Basin. Love's letter to the Secretary of HEW, Anthony Celebreeze is as follows:

Dear Mr. Secretary:

In accordance with Section 8 of Public Law 660, as amended, I request that you consider favorably assisting the State of Colorado to survey sources of pollution and quality of water in the South Platte River Basin.

Serious pollution problems exist in Adams County and other portions of the South Platte River Basin. River flows have remained static over the years, but domestic and industrial sewage continues to grow with the population. Irrigation return flows tend to increase mineralization.

There is a great need for accurate "information pertaining to the quality of water. Such information is necessary in planning for the water demands relating to human consumption, stock raising irrigation, food processing, recreation and other uses most of which require water of high quality. These problems have made demands above and beyond our normal pollution control resources. Should you find yourself in a position to grant this request, I assure you the full cooperation of Colorado agencies in this mutual undertaking.

Sincerely yours,

(Signed) John A. Love, Governor

On August 16, 1963, Secretary Celebreeze answered the letter and set up the mechanics for the first conference to begin on October 29, 1963.

Purpose of the Conference

The stated purpose of the study, as established in the First Conference, was to locate the sources of pollution having an adverse effect upon water quality; determine the physical, chemical and biological responses of the river to pollution; evaluate the previously located sources of pollution with respect to conditions in the river; compute the waste load reductions necessary to obtain desired water quality; and recommend water quality control measures needed to effect the desired waste load reduction.

Murray Stein, Chief Enforcement Officer for the HEW (HEW, 1963), made it clear the study was to be anomalous:

> I would like to point out that the study we are engaging in with the State is not contemplated to be a nice study to be developed, bound and put on a shelf. The study is designed as a basis for action for cleanup, so that pollution can be abated and the people in this area can use the water for a maximum number of uses.

Governor Love, following Stein's introduction, summarized Colorado's status at the start of the Conference on the South Platte River:

> GOVERNOR LOVE: Thank you.
>
> Mr. Stein, Ladies and Gentlemen: Of course, I am pleased to see an attendance and participation of this size and representative character.
>
> As Mr. Stein has stated, the purpose of this conference is to begin, although there have been some beginnings made already, to define the problem of pollution of the Platte, and then to work towards a solution.
>
> I have long been convinced that Colorado's greatest asset is Colorado itself, and above all we must for many reasons preserve and protect it. High on the list, of course, are the necessary efforts to retain our water sources, our rivers and our streams, in pure and unsullied, uncontaminated state.

Shortly after coming into office, I was increasingly concerned that we had not moved fast enough or well enough in the past to accomplish this goal. Of course, this was brought to my attention by situations such as exist at Barr Lake, which has been much publicized, and by other occurrences.

I am convinced that our statewide statues are not completely adequate to deal with this problem, and I believe that later in the conference there is to be some mention of that by the President of the State Board of Health.

But first on the Platte, of course, the problem is to define what are the contaminants and what are the sources of these contaminants. I thought this was a simple problem when I first discussed it with Dr. Cleere, and I found that it is not at all simple. In order to develop the kind of effective program which we will need it requires a very extensive analysis and survey. I am sure such a survey will grow out of this.

Some of the sources of contamination, of course, are obvious to us. There is raw sewage being dumped into the South Platte at this very moment, but the solution, I am afraid, in this area depends simply on the time it will take to complete the Metropolitan Sewage District facilities.

Other sources have not been determined. We will look toward the kind of survey which will develop them.

Mr. Stein has said this is primarily a State problem in which we are going to take State action, but we do indeed welcome the fine cooperation and help from the Department of Health, Education, and Welfare.

I am sure that you will find this conference productive. I won't be able to stay. I do hope to get back later in the day.

Thank you very much.

It will be important in later discussion to note that Governor Love makes special mention of the severe pollution problem in the Denver Area which was to be solved by the Metropolitan Sewage District facilities.

The Initial Analysis

The first session of the Conference in the Matter of Pollution of the South Platte River presented in detail statistics and other relevant information pertinent to water pollution in the Basin. It is not clear from the Conference Proceedings how the original investigations were assigned to reveal this information, but certainly studies to inventory the possible pollution sources in the South Platte were initiated long before Love's request for the Conference made July 18, 1963. It is clear, however, that Harold Clark's Federal Investigating team from Cincinnati had done a great deal of investigation and analysis prior to October 29, 1963. This is evidenced by the comprehensiveness of his report at the Conference.

Included in Clark's report on the Basin was a detailed population description for all the communities within the Basin. Then for each community, the following data was inventoried:

1. Municipality or Industry described;
2. map location;
3. sewered population;
4. population equivalent of the waste, before treatment;
5. nature of the waste;
6 treatment provided; and
7. population equivalent discharged to the water course.

Overall, the condition of the River Basin was revealed. In 1950, the total population equivalent for sewage in the Basin was estimated at 890,000 based upon 5-day BOD. Treatment of wastes in 1950 reduced the total municipal load by 46 percent to a population equivalent of 480,000, which was discharged into basin streams (based on data contained in the Cooperative State-Federal Report of Municipal and Industrial Waste Facilities, 1957 inventory; U.S. Department of Health, Education, and Welfare and the Cooperative State-Federal Report of

Municipal Waste Facilities, 1962 inventory; U.S. Department of Health, Education, and Welfare for Region VIII and the Status Report of Domestic Waste Water Treatment; Colorado Department of Health U.S. Census Data, 1970).

Corresponding data collected over the period 1960-1963 indicates that the total untreated municipal wastes is equal to 1,610,000 population equivalent. Treatment was effective in reducing this waste load by 44 percent to a population equivalent of 910,000. These waste factors had nearly doubled over the last 10 to 13 years (1950-1963) which may be mainly attributed to the Denver Metropolitan area. Untreated discharges were approximately equivalent to a population of 1,240,000 which were reduced by treatment to a residual population equivalent of 770,000 or only about a reduction of 38 percent (HEW, 1963).

Significant Problems

A problem of great significance in the South Platte River Basin involved the effects of inadequately treated municipal wastes and industrial wastes on Basin waters. High densities of coliform organisms contained in the main stem river water downstream from Denver to Kersey, and also evident in tributary waters extending downstream from other centers of population, were considered a serious public health problem since surface streamflows were largely diverted for irrigation use below many of these sources of bacterial contamination. The diverted waters, containing a large portion of inadequately treated sewage effluent, were applied to the land for irrigation of field crops and of truck-farm crops. The latter crops are most important from the public health standpoint since these vegetables and fruits are directly consumed by the human population and some are eaten raw (HEW, 1963).

Evidence of undegraded wastes were located in corresponding regions. The lowest dissolved oxygen conditions and highest biochemical oxygen demand values in the Basin, exclusive of those effects attributable to sugar beet processing wastes, were evident in the South Platte River downstream from Denver to the Kersey area, and on the Cache la Poudre River below the cities of Windsor and Greeley. Below Denver, the average dissolved oxygen in the summer seasons of 1948-1950 ranged from 3.5 to 8.0 milligrams per liter (mg/l); average biochemical oxygen demand ranged from 5 to 35 milligrams per liter. Individual values in many cases, however, showed the presence of considerably higher organic levels for short periods of time. Conditions below Windsor and Greeley were less severe. A minimum dissolved oxygen of 5 milligrams per liter is generally considered necessary for the propagation and growth of various species of trout (HEW, 1963).

The Barr Lake situation epitomized the serious bacteriological contamination of irrigation waters. It will be recalled that Barr Lake was considered by local residents to be a "four square mile cesspool" (Denver Post, 1965b).

Data collected from the 1948-1950 Public Health Service investigations and from the Colorado State Department of Public Health studies of 1956 on Barr Lake, indicated that Denver sewage treatment plant effluent comprised 58 percent of the total streamflow below Denver during the summer period, and 73 percent of streamflow during the winter period, based on mean low monthly streamflows. This effluent created extremely high coliform counts, little or no dissolved oxygen and very high biochemical oxygen demand levels in the Burlington-O'Brien Canal waters, the upper part of Barr Lake and other nearby streams. Extensive sludge deposits were also evident throughout the water-carriage system (HEW, 1963).

Denver Metro's Condition

The detrimental effects of the pollution contribution by the Denver Metropolitan Area was specifically reiterated again in the 1963 Conference. These hearings reveal that during the period 1948 through 1950, the Colorado Public Health Service and Colorado State Department of Health determined that the Denver sewage treatment plant effluent comprised 58 percent of total streamflow during the summer months and 73 percent during winter, based on mean low monthly streamflows. The water below Denver contained high coliform counts, little or no dissolved oxygen, and very high BOD demands. Very high sludge deposits were also reported as being evident throughout the system (HEW, 1963).

A second special study conducted by the Federal group from Cincinnati, Ohio, examined the effects of sewage effluents from the Denver Sewage plants and tributaries upon the South Platte River. During the period of study, samples were taken weekly from July 1961 to February 1963. Sampling points included a station 0.2 miles above the discharge pipe at the Denver Northside plant and several other points 25 miles downstream from Denver. Data comparison between stations 1.1 miles downstream from the plant and 0.2 mile above the plant provided the basis for the following conclusions (HEW, 1963):

1. Streamflow increased 50 cubic feet per second from 310 to 360 cubic feet per second;

2. Total bacteria increased 255,000 per milliliter, from 120,000 to 375,000 per milliliter;
3. Coliform bacteria increased 24,000 per milliliter, from 1,000 to 25,000 per milliliter;
4. ABS increased 1.1 parts per million, from 0.7 to 1.8 parts per million;
5. Biochemical oxygen demand increased 84 parts per million, from 6 to 90 parts per million;
6. Dissolved solids increased 120 parts per million, from 430 to 550 parts per million;
7. Dissolved oxygen decreased 3.5 parts per million, from 7 to 3.5 parts per million.

The contribution of the effluents discharged from plants other than Denver's did not significantly change these results. Studies similar to the one reported here are prime requisites to assessment of river pollution by discharge wastes (HEW, 1963). Thus, the Denver Metropolitan Area is again revealed as the major polluter of the South Platte River Basin.

Conclusions and Proposed Investigations

Overall, the basic problems in the Basin were condensed by Clark into five major areas:

1. Bacterial contamination of surface streamflow and irrigation supply waters;
2. High levels of readily decomposable organic loading in certain stream stretches reflected in large increases in biochemical oxygen demand concentration and dissolved oxygen depletion;

3. Significant build-up of major inorganic chemical constituents where streamflow is diverted for irrigation use;
4. Protection of ground water from pollution; and
5. Acquisition of data on the prevalence of persistent organic residues and other exotic materials, and dissolved trace inorganics, including heavy metals, in streamflow (HEW, 1963).

The assignment of individual research tasks to be carried out after the conference were based on the reports from the many agencies dealing with water in the South Platte Basin.

Assignment areas included all water pollution aspects of the South Platte River. Detailed studies of waste outfalls, their effluent composition, and sources were carried out for the entire basin. Related vector problems in odor and disease were likewise investigated. Special studies were run on highly pollutive industries such as meat packing and sugar beets. Of equal importance, sewage treatment plants were to be visited and sampled one-by-one to determine their capacities, operating conditions and efficiencies.

These proposed investigations were suggested by Clark's investigation team to meet Governor Love's request. It was suggested that the Public Health Service:

1. Determine the legitimate water uses and locate the sources of pollution having an adverse effect on those uses.
2. Through field investigations, determine the physical, chemical and biological responses of the River to pollution, and evaluate the previously located sources of pollution with respect to the conditions in the river.

3. Compute the waste load reductions necessary to obtain desired water quality and recommend the water quality control measures needed to effect the desired waste load reductions.

The HEW staff also advocated that a sound plan providing remedial measures for alleviating objectionable odor conditions in the Barr Lake area had to be developed at the earliest possible time (HEW, 1963).

The first conference agreed upon 15 general conclusions, the more salient of which are contained below:

1. Waters of the South Platte were navigable and were within the meaning of Section 10 of the 1961 Act (Section 8 of the 1956 Act).

3. Pollution was being caused by industrial, municipal and agricultural sources.

8. A water quality management program for the whole river basin is necessary to provide optimum water usage.

9. In accordance with Governor Love's request, the United States Department of Health, Education, and Welfare in cooperation with the Colorado State Department of Public Health, initiated a joint investigation and study. This study was to attempt to locate with particularity the sources of pollution having an adverse effect upon water quality; determine the physical chemical and biological responses of the river to pollution; evaluate the previously located sources of pollution with respect to conditions in the river; compute waste load reductions necessary to obtain desired water quality; and recommend water quality control measures needed to effect the desired waste load reduction.

12. The Colorado State Department of Public Health approved the plans of the Metropolitan Denver Sewage Disposal District No. 1 to collect and provide secondary treatment for all wastes within its district, to be in operation by 1966.

13. Commensurate schedules were to be adopted for other communities and industries which have not joined the Metropolitan Denver Sewage Disposal District. These communities included: Loveland, Greeley, Fort Collins, Boulder, Fort Lupton, Longmont, Georgetown, Windsor, Fort Morgan, Sterling, Julesburg, Brighton and Ovid.

The industries in the State of Colorado for which commensurate schedules to provide waste treatment facilities were to be established included: the Great Western Sugar processing plants at Brighton, Longmont, Fort Morgan, Ovid, Loveland, Greeley, Sterling, Windsor, Eaton, and Johnstown; the mining and oil extracting and processing industries; and the Packaging Corporation of America, Denver.

The Second Session

The Interim Period

The two and one-half years following the first session of the Conference were spent making an intensive study of the water pollution problems of the South Platte River Basin constituting an expenditure of about $250,000 per year and employing a Federal staff of 25 people. The Colorado State Health Department joined with the Federal staff to produce the extensive effort required to carry out that two and one-half year investigation.

The interim period between the South Platte Conferences saw the 1965 Water Quality Act come into existence. The Act, approved October 2, 1965, required the states to adopt water quality criteria and plans of implementation and enforcement as discussed in a previous chapter. Colorado adopted legislation to comply with Federal law on March 1, 1966, just prior to the convening of the Second Conference in April. It is significant to note the timing of the Second Conference and the resulting impact on the stream standards Colorado was to later adopt. Colorado had the strong advantage of an outstanding, detailed inventory and report of water quality conditions in the South Platte River. These reports provided a sound base for Colorado's pollution legislation of 1966 and 1967. The comprehensive nature of these reports, in combination with the public attention aroused by the Conferences, resulted in actual pollution reduction and concrete actions.

Purpose and Procedure

The second session of the Conference, on April 27 and 28, 1966, was called to consider the results of the investigations. The second session was legally justified, as mentioned above, by the 1961 Federal Act which required such basin conferences to include in a summary report the following general headings:

1. Occurrence of pollution in navigable waters subject to abatement under the Federal Act;
2. Adequacy of measures taken toward abatement of pollution; and
3. Nature of delays, if any, being encountered in abating the pollution.

The expressed purpose of the second conference was to describe the problems in the Basin clearly, delineate the progress which had been made and indicate what actions needed to be taken to comply with Federal law.

Murray Stein again presided and made an evaluation of the value of Conferences:

> Sometimes in dealing with a very difficult problem such as you have had in Denver, it requires this kind of major effort just to get and evaluate the facts. Sometimes it is beyond the capability of any state government, wherever it is, to put this kind of talent, staff and funds into a project. I think in that way we can have this cooperative Federal-State program where we might be helpful (FWPCA 1966aa).

The Conference procedure was, again as in 1963, to call upon individuals representing the investigating agencies to relate the findings of their respective groups.

Statements of Martin A. Bauer, Director of the South Platte River Basin Project and Edward V. Fitzpatrick, Chief of the Pollution Control Section on the South Platte River Basin Project, both of whom made major presentations at the Conference concerning the assessed water quality condition of the South Platte and its tributaries, are condensed in the following pages. The following discussion is only a general report. The detailed descriptions and data are contained in appendices A and B of the proceedings and special reports PR-1 through PR-12. Particular areas of study were presented to the Conference by an array of local, state and Federal representatives. The condensation is not arranged by presentation statements of these individuals, but is categorized by topic. A complete list of Conference participants is contained in Volume 1 of the Proceedings. All of the following presentation was derived from HEW , 1965a-e; FWPCA, 1966a-d; FWPCA 1966aa,bb; FWPCA, 1967a-f; and HEW, 1963.

General Findings

For Colorado as a whole, Table 1 shows the progress and status of municipal waste disposal in Colorado between 1953 and 1966. As can readily be seen from the table, over roughly a 13 year period, Colorado increased secondary treatment to serve about 55 percent more of its population in 1966 than in 1953. Interestingly, in 1966, in an era which was witnessing technology sufficient to launch men into space, only 61 percent of Colorado's population had facilities to treat sewage to a secondary degree.

At the advent of Denver Metro in 1966, as the table depicts, the population served in Colorado by secondary treatment jumped to 97.4 percent as a result of one carefully planned sewage treatment facility. Perhaps this demonstrates that water pollution can be effectively dealt with if priorities are properly aligned to allocate funds and manpower.

The investigations contained specific recommendations for remedial action developed from the extensive three year studies. This program was concerned with municipal and industrial wastes in the Denver Metro area, feedlot wastes, sugar beet processing mill waste, among others. These recommendations located and described over 600 conveyances of waste waters from industry; surveyed 43 waste treatment plants, and contacted 33 major contributing polluting industries (FWPCA, 1966aa).

Studies in the Basin

The various investigating teams bore out Governor Love's 1963 appraisal of the seriousness and complexity of the water pollution

Table 1

Municipal Waste Disposal for the State of Colorado, 1953 and 1966

Type of Facility	Number Facilities (Plants)	Population	Population Percentage
For Year 1953			
Connected to sewers	--	1,005,755	100% of connected
Discharging untreated	44	81,449	8.1%
Primary treated alone	56	847,226	84.2%
Secondary treated over and above primary	37	77,080	7.7%
	137		
For Year 1966 (As of January 31st)			
Connected to sewers	--	1,722,725	100% of connected
Discharging untreated	22	12,330	0.7%
Primary treated alone	33	662,380	38.3%
Secondary treated over and above primary	180	1,048,015*	61.0%*
	235		

*As of October 1966, the secondary treatment plant was being built by the Metropolitan Denver Sewage Disposal District No. 1 and had been scheduled for initial operation, which shifted most of the population receiving treatment to that receiving secondary treatment.

Type of Facility	Number Facilities (Plants)	Population	Population Percentage
For Year 1966 (As of October - Start of Metro)			
Connected to sewers	--	1,722,725	100% of connected
Discharging untreated	22	12,330	0.7%
Primary treated alone	33	32,580	1.9%
Secondary treated over and above primary	180	1,677,815	97.4%
	235		

problems in the South Platte River Basin. A series of reports revealed the nature of water pollution in the Basin with great emphasis placed on studying the Denver Metropolitan Area.

Outfall Study

Denver Metro - A detailed study was conducted of 639 outfalls, pipes and ditches representing potential and present sources of pollution in the Denver area. Large scale maps showed their locations and a number of detailed tables were generated. Tables depicted size of the outfall and complete analyses of water quality samples taken. Further, the categories of the outfalls were divided into domestic and industrial sources as closely as could be determined. This presentation, of course, located with particularity the sources of difficulty and the entities or individuals with whom the abatement program would have to deal.

Meat Industry Waste - Denver Metro Area - A special study on meat industry waste was conducted primarily because of its heavy loading to municipal sewage plants. Of significant concern, paunch manure disposal into sanitary sewers, although prohibited by city ordinance, constituted about a 60 tons per day to Denver facilities. Denver Northside received 56 tons daily and North Washington received four. This load was only 50 percent of the paunch load produced by 13 of the 20 meat industry plants in Denver. Also, inherent to these operations was a proportionate load of scraps, blood and grease removal.

Stream Surveys in the Denver Metro Area

Several water quality surveys were made to determine the impact of waste discharges from the Denver Metropolitan area. The study results were grouped as follows:

1. The four main tributary streams entering Denver -- Bear Creek, Cherry Creek, Clear Creek and Sand Creek.
2. The South Platte River from Littleton to directly below the city and county of Denver.
3. The South Platte River from Denver extending downstream to Greeley.

Biological investigations were conducted in May 1964 and covered the South Platte River from above Littleton to Platteville, about 30 miles below Denver. Biologic studies were used as a meaningful way to measure and present water quality because sensitiveness to subtle changes in quality. The response of the biological community to progressively severe pollution is briefly described in stages as follows:

1. Clean streams produce a balanced biota including a broad spectrum of all organisms including pollution-sensitive organisms;
2. Moderate pollution produces increasing numbers of tolerant species at the expense of the sensitive forms of biota;
3. Severe pollution creates large numbers of only one or two tolerant species and complete elimination of pollution sensitive forms; and finally,
4. Gross degradation eliminates all forms of biological life other than bacteria on the stream bottom.

Tolerant organisms, particularly sludgeworms, did not become established until Platteville. Throughout this entire 30 miles of stream below Denver, no sensitive organisms were found. No biological recovery occurred until Platteville. Sludge deposits accounted for the highly retarded biological recovery of the river.

The impact of tributary streams and contributing polluters to the state line was summarized by a series of charts and maps in a manner comparable to the presentation on tributaries in the Denver area.

Bear Creek - Evergreen to Mouth - The four stations sampled along the 22 mile stretch of Bear Creek showed good water quality except for the middle reaches, where coliform exceeded maximum allowable levels. Generally DO was greater than 8 mg/l and BOD less than 6 mg/l. A need was shown (Fig. 2) to exist for elimination of improperly treated wastes.

Cherry Creek - Cherry Creek Reservoir to Mouth - Cherry Creek flows intermittently to Denver city limits where groundwater recharge and outfalls become significant contributors to streamflow. Colorado Boulevard to the mouth exhibited severe pollution with very high coliform densities. The DO level, however, remained above 8 mg/l and the BOD less than 7 mg/l.

Clear Creek - Golden to Mouth - Many diversions from Clear Creek reduce streamflow to extreme conditions in summer. Nine treatment plants essentially provided the only running water in the lower reaches of Clear Creek (Fig. 3).

In January-March 1964, a large portion of the waste load from upstream sources remained in the stream and was carried to the South Platte River. At York Street, the flow was 25 to 30 cfs; BOD from 56 to 82 mg/l; dissolved oxygen between 4.7 and 6.8 mg/l; total coliform

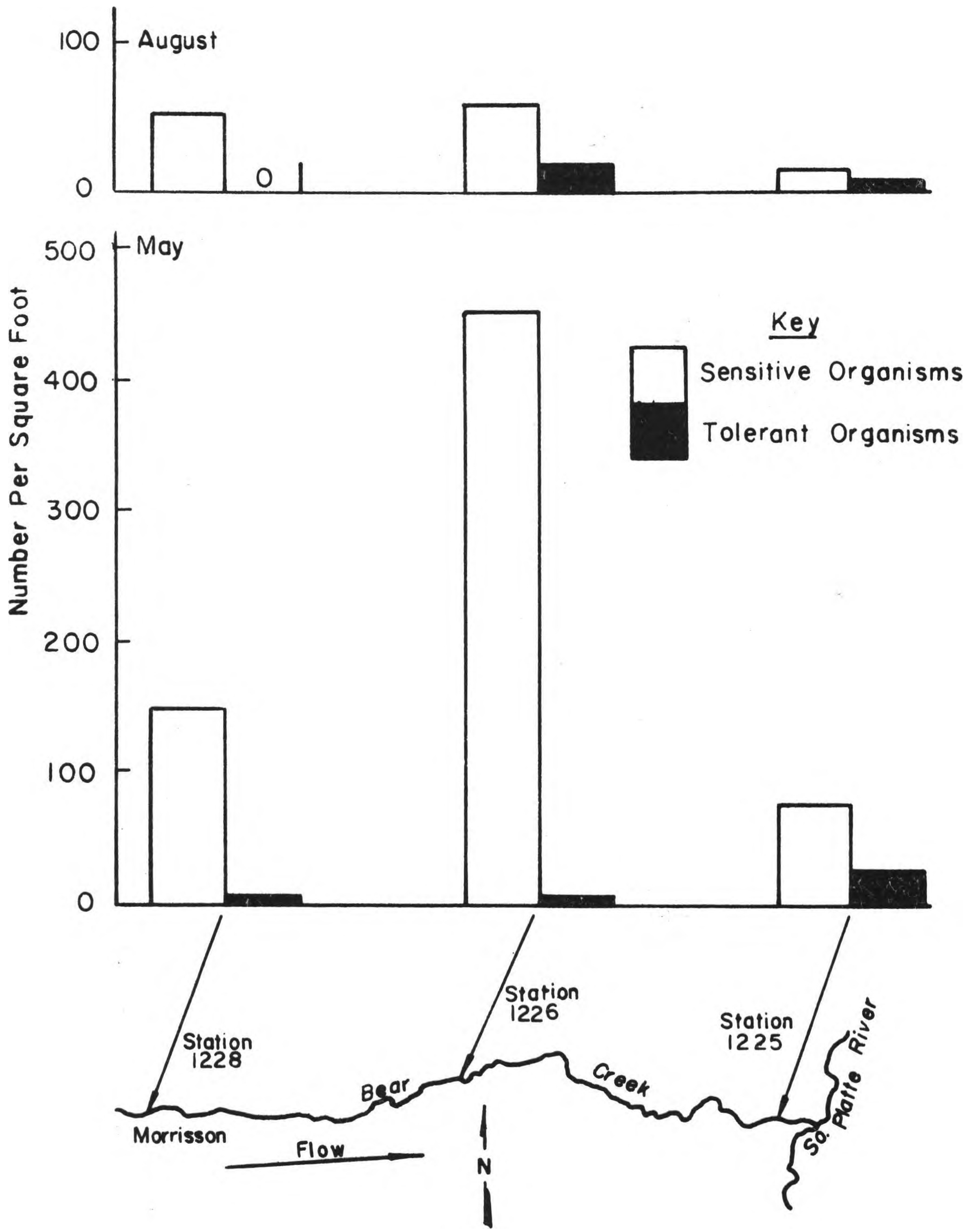


Figure 2. Population of Bottom Organisms, Bear Creek, 1964.

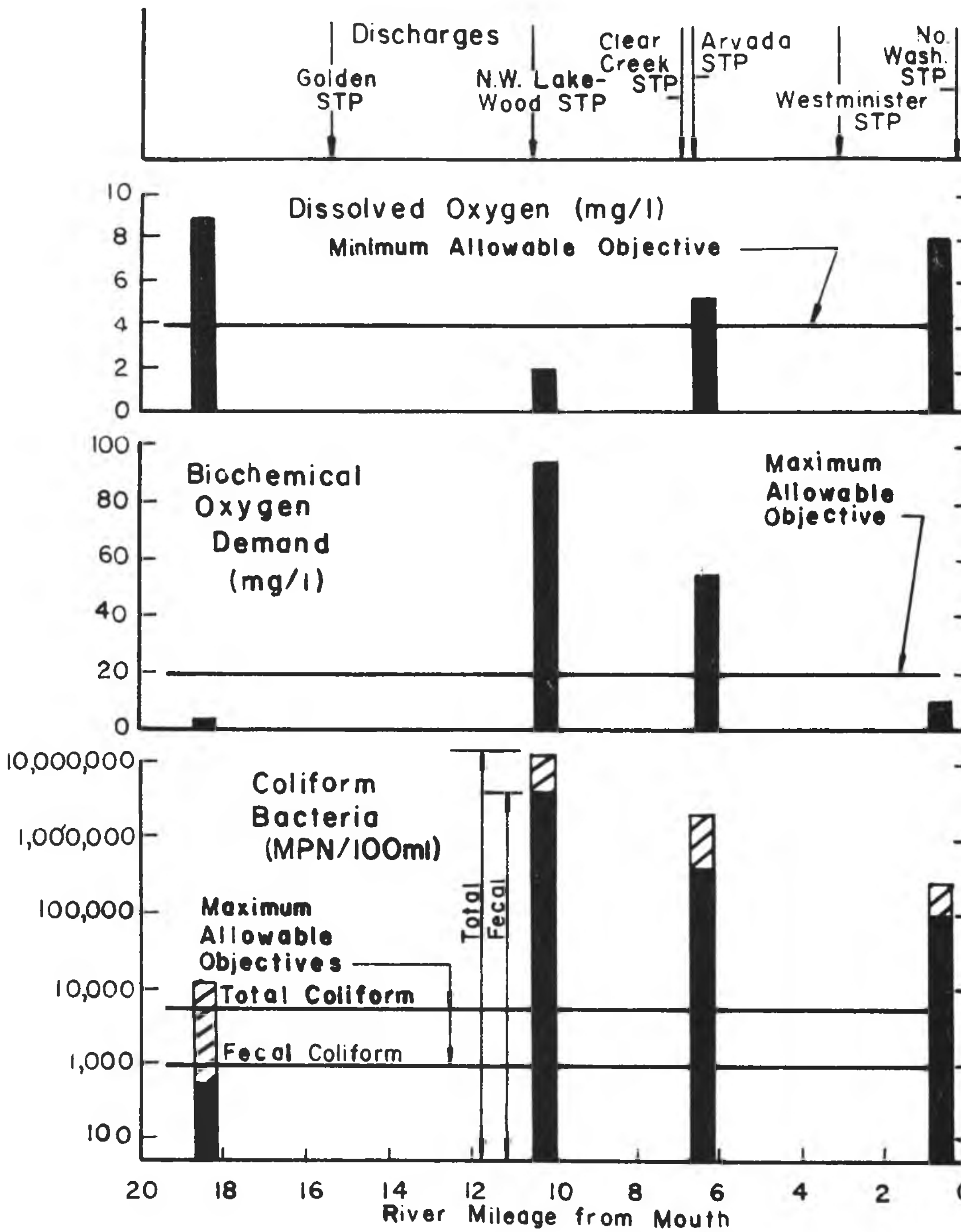


Figure 3. Clear Creek Water Quality, September 21-26, 1964.

from 2.8 to 3.3 million per 100 ml; and fecal coliform from 490,000 to 700,000 per 100 ml.

Clear Creek showed gross pollution at all points downstream of Kipling Street, a distance of 10.2 miles from the stream mouth. BOD values from Kipling Street downstream were up to five times the maximum allowable objectives and coliform bacteria values were up to 4,000 times the maximum allowable levels. Durint the wintertime, Clear Creek is a large contributor of waste load to the South Platte River, discharging wastes of approximately 87,000 population equivalent (P.E.) to the main river.

Sand Creek - Sand Creek generally has little or no flow above Aurora. Below this point, the stream is largely comprised of municipal and industrial waste effluents, most of which are inadequately treated.

The upstream sampling station, which is located below the Denver Eastwide sewage treatment plant, as well as Sand Creek at its mouth, showed only one-quarter of the minimum allowable limit for dissolved oxygen, concentrations five times the maximum allowable limit for BOD, 1600 times the limit for total coliform, and 5400 times the limit for fecal coliform. These values are indicative of primary-treated sewage rather than stream waters. Furthermore, near septic or anaerobic conditions were present in the stream.

Survey results from September-October 1965 showed BOD values were up to 8 times the maximum allowable objectives and coliform bacteria were up to 4,500 times the maximum allowable levels.

About 70,000 P.E. of BOD and 300,000 P.E. of suspended solids were consistently discharged to the South Platte River during the 1964-1965 studies.

Littleton Through Denver - Flow in August 1964 was about 140 cfs at the 19th Street bridge. A severe increase in BOD and coliform bacteria occurred as a result of the Denver Northside Plant. About 80 percent of the 780,000 population equivalent BOD load at that point is contributed by the Northside Plant. The impact of the Denver Northside treatment plant is shown by the farthest downstream sampling point with a concentration of 85 mg/l BOD in the river.

A bar chart displaying flow, dissolved oxygen, biochemical oxygen demand, and coliform bacteria was drafted in a manner similar to the Clear Creek presentation. However, the entire waste load for the area was described in terms of BOD in one chart (Fig. 4).

The bar chart graphically depicts significant waste loadings into Clear Creek from Arvada STP and North Washington District STP. The primary source of waste loading to the South Platte River occurs below river mile 312. A cluster of storm sewer drains, the Denver Northside STP and a large concentration of industry severely degrade the river at this point.

Below Denver - A water quality study of October 7-10, 1965, covered the South Platte River from the 19th Street Denver bridge to one mile upstream of the Cache la Poudre River near Greeley. Total stream distance was 66 miles. Streamflow was 305 cfs above the Cache la Poudre River. Irrigation canals were withdrawing relatively small amounts of water during this period resulting in a 560,000 P.E. being carried to Greeley. A total waste load of 800,000 P.E. was present in the river waters directly below the Northside Plant and calculations showed that an additional 95,000 P.E. of the waste load was settling to the stream bottom between 19th Street and the station located one

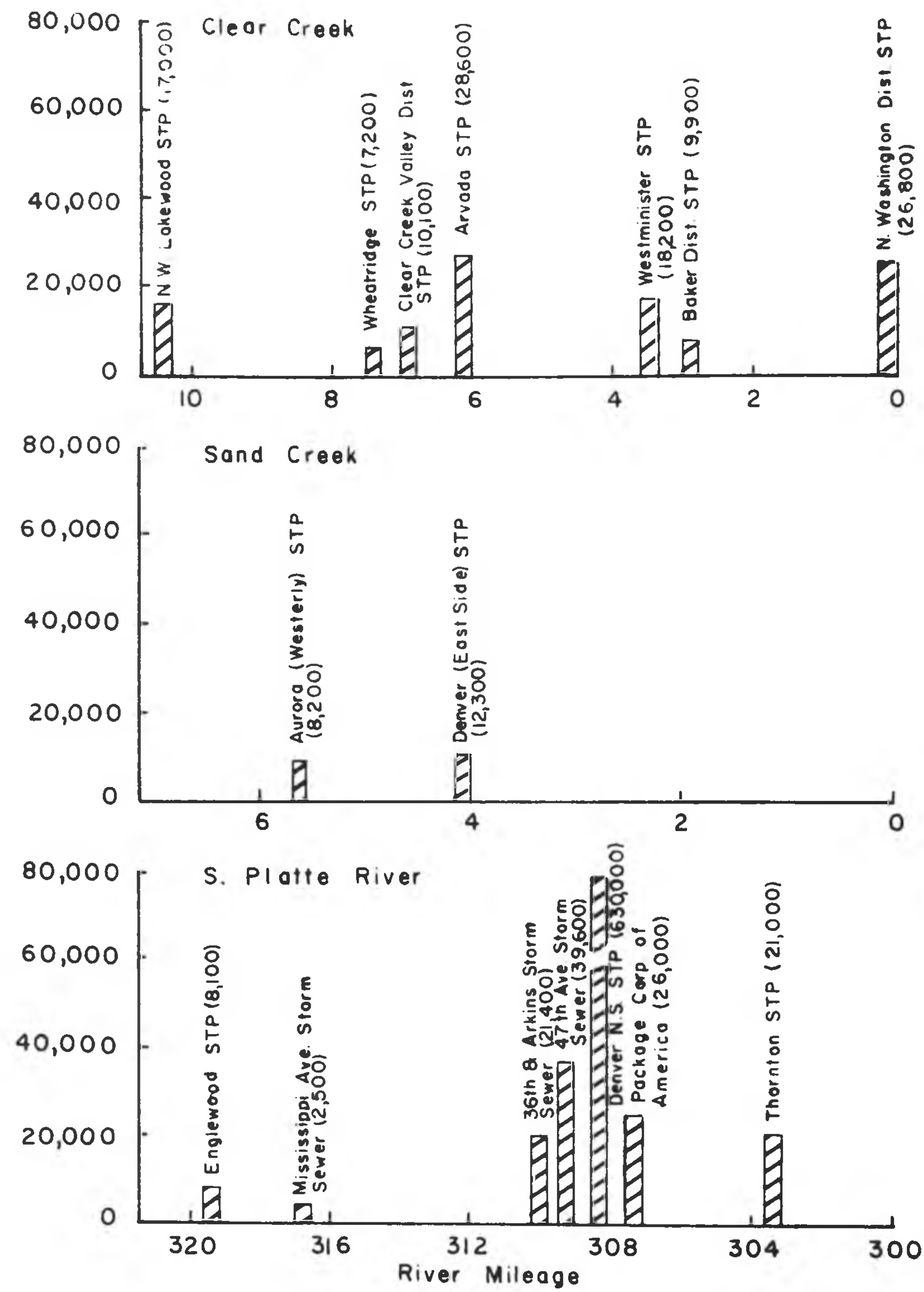


Figure 4. Significant Waste Loads, Denver Metropolitan Area.

mile below the plant. Greater streamflows, primarily from groundwater, diluted the BOD concentrations downstream. Nevertheless, BOD values over the entire 54 mile stretch of the river from Denver to Greeley were in excess of the maximum allowable objectives. The bacteriological quality of the South Platte River for the entire distance from Denver to Greeley was extremely poor.

Groundwater Studies

The Project undertook a program from May 1964 to March 1965 to determine sources and the extent of pollution in the water-bearing geologic formations of the Denver Metropolitan Area. The Project report entitled, "Ground Water Pollution in the South Platte River Valley Between Denver and Brighton, Colorado," gives a detailed account of the findings.

The fresh water-bearing aquifers in the Denver Metropolitan Area consist of bedrock formations and overlying valley-fill deposits. Water wells located in the bedrock aquifers range from depths of between 100 and 2000 feet below the land surface. Although water from these formations is usually considered to be of good quality, the low yield from these aquifers precludes any wide-scale use.

Values for Alkyl Benzene Sulfonate (ABS) in excess of 0.5 mg/l, the recommended limits set forth in the U.S. Public Health Service (USPHS) Drinking Water Standards, were found in shallow well sources of public water supply systems operated by South Adams Water District and Town and Country Mutual Water Company.

Recommended maximum levels for nitrates are 45 mg/l. Two shallow wells owned by the South Adams Water and Sanitation District, and all wells supplying the City of Brighton, yield waters containing nitrate concentrations in excess of 45 mg/l, and are considered dangerous when used for infant feeding.

The impact of widespread pollution of the shallow, unconfined aquifers in the Denver Metropolitan Area has impaired the usefulness of large quantitities of water for public supply and domestic purposes. Existing conditions will persist for many decades, even after sources of pollution have been eliminated, as exemplified by the Rocky Mountain Arsenal conveying wastes to unlined ponds through unlined ditches during the period 1943-1955. A large area still is severely contaminated with chlorides. Table 2 summarizes the investigation findings.

The well use summary chart shows that widespread pollution existed in the groundwaters of the South Platte River Basin in the Denver Metro area. Amounts of ABS and nitrates were found in public water supplies which were in excess of established public health standards. Pollutants characteristic of major industries and institutions were located throughout the system's aquifers. Severe pollution was noted near the Rocky Mountain Arsenal, which was linked as the primary source of pollution in that area.

Denver Metropolitan Area

The municipal waste facilities in Metropolitan Denver were shown to be inadequate by the investigating teams. Only 75 percent of the industrial wastes received treatment at these plants, the remainder of which was discharged into the South Platte without proper treatment. The result of these combined sources was gross pollution in both surface and ground waters. In some reaches of the river and its tributaries, near septic conditions, due greatly to sludge deposits, were produced

Table 2

Well Use in the Denver Metro Area

Tributary Valley Aquifer	Number	Use	Contaminants Located	USPHS Standard	Source of Infiltration
			Alkyl Benzene Sulfonate (ABS)	0.5 mg/l	Irrigation with polluted waters
			Nitrates	45 mg/l	
	800	Irrigation			
South Platte	2000	Residences	Oils		Petroleum waste in Sand Creek
Cherry Creek	96	18 Public Water Supply Systems			
Sand Creek			Salt		Industrial use general irrigation
Clear Creek	800	Industrial and Commercial			
	Total About 3800		Chlorides		Rocky Mountain Arsenal (primary) irrigation
			Herbicides		
			Pesticides		
			Arsenic		

with poor quality water negating most beneficial and legitimate uses of the streams.

Specifically, 18 of the 23 sewage treatment plants discharging to basin streams in the study area did not conform to one or more of the state standards for sewage effluent. Eighteen plants did not conform to state standards for coliform density, 15 plants did not conform to state standards for biochemical oxygen demand and 9 plants did not conform to state standards for suspended organic matter. These conditions could be attributed chiefly to insufficient plant capacity, lack of secondary treatment and poor operational procedures.

The character of the 26 facilities in the Metro area as of December 1965 is summarized in the tables below. Tables 3, 4, 5, 6 and 7 depict predominantly domestic oriented analyses. Table 8 accentuates the industrially loaded character of municipal plants. The general status of the Metro area municipal waste discharge is depicted in Tables 9 and 10. The following map (Fig. 5) locates these plants.

Table 3 locates, by river mileage, the 26 municipal sewage treatment plants in the Denver Metropolitan area and their respective treatment abilities. Five of the 25 facilities reported only primary treatment and four of the plants with secondary treatment reported no secondary settling facilities.

Table 4, in a similar manner to Table 3, logs the total and fecal coliform bacterial loadings for the municipal plants in terms of most-probable-number per 100 ml. Thirteen out of 25 plants reported median total coliform counts above 3,000,000. Four of those plants reported counts in excess of 36,000,000. Fecal coliform counts were as high as 13,000,000, but 7 of the plants did not report values.

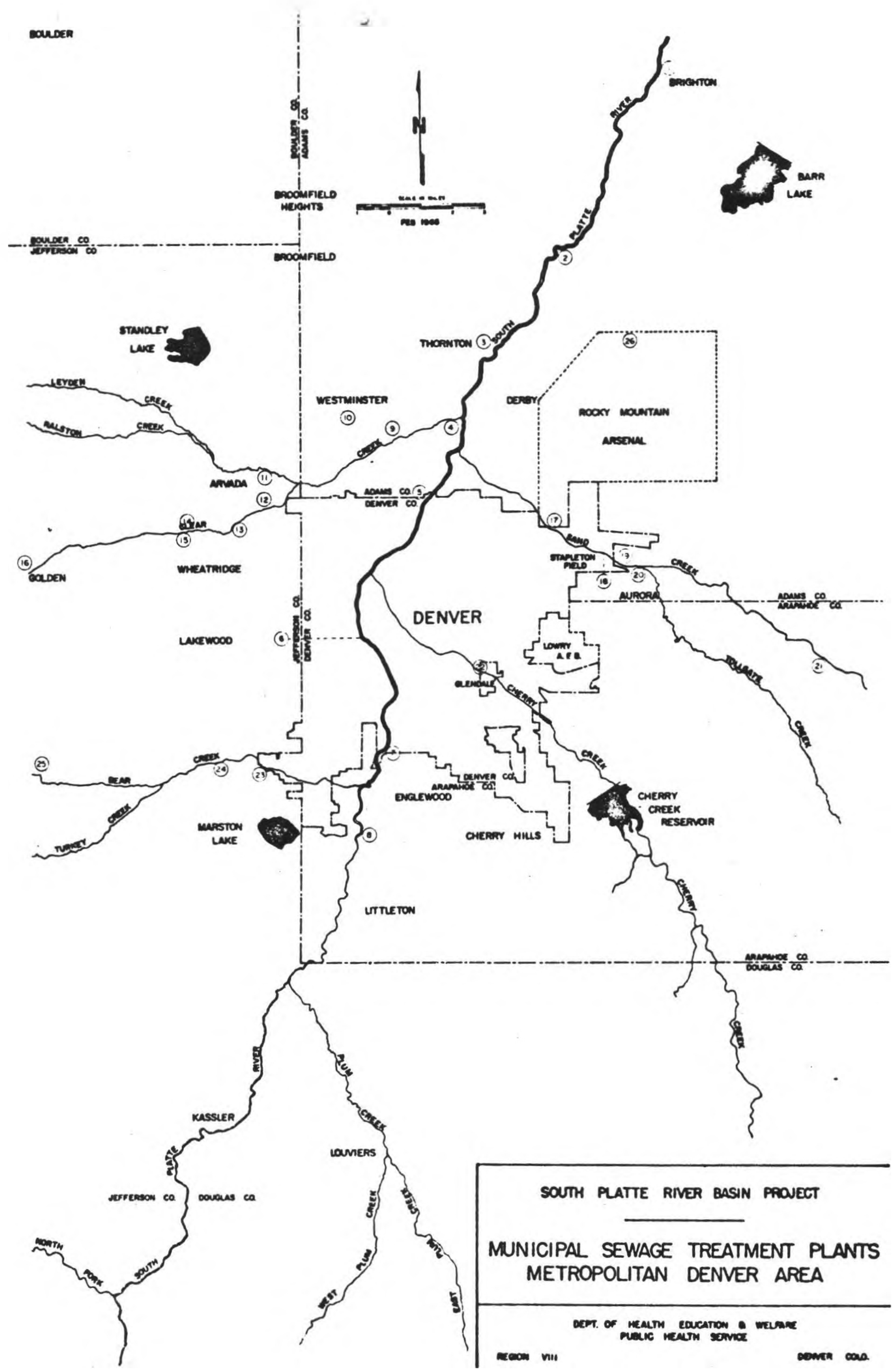


Figure 5. Municipal Sewage Treatment Plants, Metropolitan Area

Table 3

Location of Municipal Sewage Treatment Plants in the Metropolitan Area

Map Ident. No.	Name of Facility	River Mileage	Type Treatment
1.	City of Brighton	289.5	Secondary
2.	S. Adams Water & San District	301.2	Secondary
3.	City of Thornton	303.5	Secondary
4.	N. Washington Water & San District	305.5	Secondary (c)
5.	Denver - Northside	308.8	Primary
6.	S. Lakewood San District	314.1/2.1 W	Secondary
7.	City of Englewood	319.7	Secondary
8.	City of Littleton	323.5	Secondary
9.	Baker Water & San District	305.5/3.0	Secondary
10.	City of Westminster	305.5/3.6/1/6	Primary
11.	City of Arvada	305.5/6.2/0.3	Secondary
12.	Clear Creek Valley San District	305.5/7.0	Secondary
13.	City of Wheatridge	305.5/7.5	Secondary
14.	Fruitdale San District	305.5/10.0	Primary
15.	N. W. Lakewood San District	305.5/10.2	Primary
16.	City of Golden	305.5/15.5	Secondary
17.	Denver - Eastside	306.8/4.7	Primary
18.	City of Aurora (Westerly)	306.8/5.5/1.1 S	Secondary
19.	City of Aurora (Sand Creek)	306.8/6.8	Secondary
20.	Fitzsimons Hospital	306.8/6.9/0.9	Secondary
21.	Buckley Air Station	306.8/11.9	Secondary
22.	City of Glendale	(a)	Secondary
23.	Colo. State Industrial School for Girls	(a)	Secondary
24.	Federal Correctional Institution	320.9/5.5	Secondary (c)
25.	City of Evergreen	320.9/19.3	Secondary (c)
26.	Rocky Mountain Arsenal	(b)	Secondary (c)

(a) Plant discharge to oxidation pond, no effluent.

(b) Discharges to First Creek, thence to Burlington Canal - Does not enter South Platte River.

(c) No secondary settling facilities available.

Table 4

Municipal Sewage Treatment Plants Effluent Bacteriological Loading

Map Ident. No.	Name of Plant	Median Total Coliform MPN/100 ml	Median Fecal Coliform MPN/100 ml
1.	City of Brighton	520	48
2.	S. Adams Water & San. District	5,200	1,600
3.	City of Thornton	36,000,000	7,500,000
4.	N. Washington Water & San. District	45,000,000	12,000,000
5.	Denver - Northside	30,000	19,000
6.	S. Lakewood San. District	160,000 (a)	---
7.	City of Englewood	3,700,000 (a)	---
8.	City of Littleton	5,400,000 (a)	---
9.	Baker Water & San. District	9,700,000	5,100,000
10.	City of Westminster	37,000,000	13,000,000
11.	City of Arvada	7,600,000	1,500,000
12.	Clear Creek Valley San. District	8,300,000	3,100,000
13.	City of Wheatridge	1,700,000 (a)	---
14.	Fruitdale San. District	59,000,000 (a)	---
15.	N. W. Lakewood San. District	6,600,000	4,700,000
16.	City of Golden	790,000 (a)	---
17.	Denver - Eastside	140,000	67,000
18.	City of Aurora (Westerly)	4,200,000	1,200,000
19.	City of Aurora (Sand Creek)	18	42
20.	Fitzsimons Hospital	20,000	5,600
21.	Buckley Air Station	79,000	36,000
24.	Federal Correctional Institution	2,600,000 (a)	---
25.	City of Evergreen	3,300,000	460,000

(a) Data furnished by Colorado State Department of Public Health.

Table 5 catalogs the loadings to streams of municipal treatment plants categorized by drainage basins. The loadings for each basin, in terms again of most probable number of total coliforms per 100 ml is as follows:

1. Bear Creek ~ 5,000,000;
2. South Platte River ~ 90,000,000;
3. Sand Creek ~ 4,000,000; and
4. Clear Creek ~ 82,000,000

Table 6 shows flow, influent biochemical oxygen demand (BOD) and effluent BOD for municipal plants with predominantly domestic loadings. Among the many summaries of data presented, it is significant to note that 343,725 people served in the metro area received on the average only 58 percent BOD removal resulting in 23,369 pounds of BOD being discharged daily into streams.

Table 7 makes a parallel presentation to Table 5 in terms of suspended solids. For the same population served, only 65 percent total suspended solids (TSS) removal was achieved, thereby loading receiving streams with 23,810 pounds per 24 hours.

The character of the four industrially loaded plants is depicted in terms of BOD and TSS in Table 8. Average BOD removal was 67 percent resulting in 110,000 pounds per day loading and average TSS removal was 80 percent, thereby dumping 61,000 pounds per day into receiving streams.

Tables 9 and 10 were constructed by the author to summarize the status of domestic sewage in the Denver Metro area. Municipal treatment plants serving 83 percent of the sewered population received less than 80 percent BOD removal. Fifteen primary and secondary treatment

Table 5

Summary Of Municipal Sewage Treatment Plant Loading To Streams

Stream	Plant Location	River Mile	Estimated Average Daily Flow MGD	BOD Discharged to Stream Lbs/day	Total Susp. Sol. Discharged to Stream Lbs/day	Total Coliform MPN/100 ml
Bear Creek		320.9				
	Evergreen	320.9/19.3	0.065	35	50	3,300,000
	Federal Correctional Institution	320.9/5.5	0.060	50	40	1,600,000
						4,900,000
South Platte River	Littleton	323.5	2.60	715	780	5,400,000
	Englewood	319.7	4.50	1,350	1,460	3,700,000
	S. Lakewood	314.1	0.55	175	310	160,000
	Denver - Northside	308.8	72.53(a)	105,000(a)	57,000(a)	30,000
	North Washington	305.5	1.50(a)	4,460(a)	3,900(a)	45,000,000
	Thornton	303.5	2.60	3,535	4,460	36,000,000
	South Adams	301.2	1.50	255	640	5,200
	Brighton	289.5	0.65	45	170	520
						90,000,000
Sand Creek		306.8				
	Buckley Air Station	306.8/11.9	0.05	9	20	
	Fitzsimons Hospital	306.8/6.8	0.47	70	150	5,600
	Aurora - Sand Creek	306.8/6.8	0.66	100	250	18
	Aurora - Westerly	306.8/5.5	3.10	1,365	2,030	4,200,000
	Denver - Eastside	306.8/4.7	1.40	2,050	1,040	140,000
						4,400,000
Clear Creek		305.5				
	Golden	305.5/15.5	2.70	636	450	790,000
	Northwest Lakewood	305.5/10.2	1.90	2,780	2,010	6,600,000
	Fruitdale	305.5/10.0	0.20	200	110	9,700,000
	Wheatridge	305.5/7.3	1.80	1,210	980	1,900,000
	Clear Creek Valley	305.5/7.0	1.50(a)	1,690(a)	545(a)	8,300,000
	Arvada	305.5/6.2	3.50	4,755	5,760	7,600,000
	Westminster	305.5/3.6	1.30	3,025	2,160	37,000,000
	Baker	305.5/3.0	1.50	1,645	1,390	9,700,000
						82,000,000

(a) Based on a 5-day week.

Table 6

Municipal Sewage Treatment Plants (Predominantly Domestic Loading)

Map Ident. No.	Name of Plant	Pop. Served	Flow: Total 24 hrs.	Flow: Gal/cap /day	Flow: Total 8 hrs	Flow: Ratio 8 hrs/24 hr	Influent BOD: 8-hr Samp Period	Influent BOD: 8-hr Samp Period	Influent BOD: 8-hr Samp Period	Influent BOD: 24 hrs. Est.	Influent BOD: 24 hrs. Est.	Effluent BOD: 8-hr Samp Period	Effluent BOD: Efficiency	Effluent BOD: 24 hrs Est.	Effluent BOD: P. E. Est.
			(M.G.)	(Gal)	(M.G.)	(%)	(mg/l)	(lbs)	(lbs/cap)	(lbs)	(lbs/cap)	(mg/l)	(%)	(lbs)	
1	Brighton	7,500	0.65	87	0.237	36.5	220	435	0.058	880	0.117	12	95	45	280
2	S. Adams	16,000	1.5	94	0.564	37.6	300	1,410	0.088	2,855	0.178	26	91	255	1,600
3	Thornton	35,000	2.6	74	1.024	39.4	365	3,115	0.089	6,310	0.180	205	44	3,535	22,000
7	Englewood	55,200	4.5	82	1.66	36.8	240	3,325	0.060	6,735	0.122	48	80	1,350	8,440
8	Littleton	23,000	2.6	113	1.00	38.5	235	1,960	0.085	3,970	0.172	43	82	715	4,470
9	Baker	17,500	1.5	86	0.645	43.0	265	1,425	0.081	2,885	0.164	150(b)	43(b)	1,645	10,300
10	Westminster	17,500	1.3	74	0.536	41.2	345	1,540	0.088	3,120	0.178	335	3	3,025	18,900
11	Arvada	36,000	3.5	97	1.34	38.3	280	3,130	0.086	6,340	0.176	210(b)	25(b)	4,755	29,700
13	Wheatridge	20,500	1.8	88	0.745	41.4	355	2,205	0.107	4,465	0.217	95	73	1,210	7,560
14	Fruitdale	1,600	0.20	125	0.074	37.7	175	108	0.098	320	0.200	110	37	200	1,250
15	N.W.Lakewood	21,000	1.9	90	0.766	40.3	265	1,695	0.080	3,430	0.163	215	19	2,780	17,400
17	Denver (East)	18,000	1.4	78	0.594	42.4	340	1,685	0.093	3,410	0.189	205	40	2,050	12,800
18	Aurora (West.)	55,000	3.1	56	1.28	41.3	315	3,365	0.061	6,815	0.123	64	80	1,365	8,530
19	Aurora (Sand)	9,000	0.66	73	0.290	44.0	255	615	0.068	1,245	0.138	20	92	100	625
20	Fitzsimons	2,900	0.47	160	0.201	42.7	300	505	0.174	800	0.275	27	91	70	440
21	Buckley	400	0.05	125	0.020	39.5	135	25	0.062	50	0.125	23	83	9	55
6	So. Lakewood	6,500	0.55	85	0.200	36.2	270	450	0.069	910	0.140	52	81	175	1,100
24	F.C.I.	425	0.060	140	0.023	39.4	570	110	0.258	165	0.388	165	71	50	315
25	Evergreen	700	0.065	93	0.026	39.4	260	55	0.078	110	0.157	80	69	35	220
		343,725	29.205	85(a)	11.526	39.4(a)	283(a)	27,208	0.079(a)	54,815	0.160(a)	120(a)	57.5(a)	23,369	146,000

(a) Weighted Average.

(b) Including effects of sewage bypassed directly to Clear Creek.

Note: All BOD values based on 5-day 20 C Analysis.

Table 7

Total Suspended Solids For
Municipal Sewage Treatment Plants
(Predominantly Domestic Loading)

Map Ident. No.	Name of Plant	Pop. Served	Flow: Total 24 hrs.	Flow: Gal/cap /day	Flow: Total 8 hrs	Flow: Ratio 8 hrs/24 hr	Influent Total Suspended Solids: 8-hr Samp Period	Influent Total Suspended Solids: 8-hr Samp Period	Influent Total Suspended Solids: 8-hr Samp Period	Influent Total Suspended Solids: 24 hrs. Est.	Influent Total Suspended Solids: 24 hrs. Est.	Effluent Total Suspended Solids: 8-hr Samp Period	Effluent Total Suspended Solids: Efficiency	Effluent Total Suspended Solids: 24 hrs. Est.
			(M.G.)	(Gal)	(M.G.)	(%)	(mg/l)	(lbs)	(lbs/cap)	(lbs)	(lbs/cap)	(mg/l)	(%)	(lbs)
1	Brighton	7,500	0.65	87	0.237	36.5	209	413	0.055	1020	0.136	34	83.7	170
2	S. Adams	16,000	1.5	94	0.564	37.6	329	1545	0.097	3810	0.238	55	83.3	640
3	Thornton	35,000	2.6	74	1.024	39.4	554	4730	0.135	11650	0.300	212	61.7	4460
7	Englewood	55,200	4.5	82	1.66	36.8	241	3330	0.061	8210	0.150	43	82.2	1460
8	Littleton	23,000	2.6	113	1.00	38.5	197	1640	0.071	4040	0.175	38	80.7	780
9	Baker	17,500	1.5	86	0.645	43.0	251	1350	0.077	3330	0.190	105(b)	58.2(b)	1390
10	Westminster	17,500	1.3	74	0.536	41.2	289	1290	0.074	3180	0.182	196	32.2	2160
11	Arvada	36,000	3.5	97	1.34	38.3	275	3065	0.086	7580	0.210	209(b)	24.0(b)	5760
13	Wheatridge	20,500	1.8	88	0.745	41.4	288	1790	0.087	4420	0.215	64	77.8	980
14	Fruitdale	1,600	0.20	125	0.074	37.7	125	77	0.048	190	0.119	75	40.0	110
15	N. W. Lakewood	21,000	1.9	90	0.766	40.3	360	2325	0.111	5750	0.274	126	65.0	2010
17	Denver (East)	18,000	1.4	78	0.594	42.4	330	1630	0.091	4020	0.223	85	74.2	1040
18	Aurora (West)	55,000	3.1	56	1.28	41.3	270	2880	0.052	7110	0.131	77	71.5]	2030
19	Aurora (Sand)	9,000	0.66	73	0.290	44.0	248	600	0.067	1480	0.165	42	83.1	250
20	Fitzsimons	2,900	0.47	160	0.201	42.7	270	452	0.156	1115	0.384	36	86.7	150
21	Buckley	400	0.05	125	0.020	39.5	194	32	0.081	79	0.197	40	79.4	20
6	So. Lakewood	6,500	0.55	85	0.200	36.2	243	405	0.062	1000	0.154	76	68.7	310
24	F.C.I.	425	0.060	140	0.023	39.4	281	54	0.127	133	0.314	80	71.5	40
25	Evergreen	700	0.065	93	0.026	39.4	404	88	0.125	217	0.310	86	78.7	50
		343,725	29.205	85(a)	11.526	39.4(a)	282(a)	27696	0.081(a)	68334	0.200(a)	88(a)	65.2(a)	23810

(a) Weighted Average

(b) Including effects of sewage bypassed directly to Clear Creek.

Table 8

Summary of Municipal Treatment Plants with Significant Industrial Wastes - BOD

Location	Population Served	Est. Daily Domestic Flow	Est. Daily Industrial Flow	Est. Total Daily Flow	Domestic Per Capita Flow	Domestic Per Capita BOD Loading	Est. Daily Domestic BOD Loading	Est. Daily Industrial BOD Loading	Est. Total BOD Loading	Influent BOD	Effluent BOD	Present Plant Efficiency	Est. Total Daily BOD Loading to Stream
		M.G.	M.G.	M.G.	Gal/Cap/Day	Lb/Cap/Day	Lbs	Lbs	Lbs	Mg/l	Mg/l	%	Lbs
Clear Creek Valley District	7,000	1.19	0.30(a)	1.49(a)	170(b)	0.16	1,120	4,000(a)	5,120(a)	865(d)	285(d)	67	1,690(a)
Denver Northside	600,000	51.00	21.53(a)	72.53(a)	85	0.16	96,000	85,000(a)	181,000(a)	299(e)	174(e)	42	105,000(a)
Golden	8,000	1.20	1.50	2.70	150(c)	0.19(c)	1,500	14,400	15,900	750(e)	30(e)	96	636
North Washington District	12,000	1.15	0.13(a)	1.50(a)	96	0.16	1.920	9,840(a)	11,760(a)	1,150(d)	435(d)	62	4,460(a)

(a) Industrial flows and loading based on a 5-day week.

(b) High per capita flows likely due to groundwater infiltration into sewers.

(c) Domestic sewers are combined, causing higher per capita flows and BOD loading.

(d) Obtained from Project sampling program, based on 8-hour daytime composites.

(e) Obtained from STP records, based on 24-hour composites.

Table 9

DENVER METROPOLITAN AREA

Municipal Waste Discharges

Treatment Facility	No.	Population Served	Percent of Population Receiving Treatment	Percent of Load from Industry	Percent of 5 Day BOD Reduction	Percent of Reduction TSS	Degree of Treatment	Treatment Efficiency
Institutions	5							
Municipalities	14	354,000						
Sanit. Dist.	7							
MDSSD #1		600,000						
Municipal Treatment Plants	5 8		70% of Sewered				Primary Secondary	<80% BOD Removal <80% TSS Removal
Other	2							
Municipal Treatment Plants	13		83% of Sewered					<80% BOD Removal
Primary and Secondary Treatment	15		90% of Sewered					<80% TSS Removal

Table 10

Daily Loadings in Denver Metropolitan Area

	No.	BOD Load	TSS Load	
Municipal Effluent		67 Tons	43 Tons	
Denver Northside		53 Tons or 79%	29 Tons or 68%	
Clear Creek Municipal Plants	9	10 Tons	9 Tons	
Secondary Plants	8			Overloaded in excess of plant design

plants serving 90 percent of the severed population achieved less than 80 percent TSS removal.

Overall, the data for the Denver Metro area showed poor quality sewage treatment. Plants were frequently operating at capacity or were overloaded. Treatment was generally inefficient and provided low removal of BOD and TSS concentrations. High tonnages of these wastes were being dumped into receiving streams daily.

The Second Session Reconvened

Formation of Objectives

As was previously mentioned, Colorado adopted legislation on March 1, 1966, according to the Federal requirement for a plan of implementation and enforcement by the state. Within the new Colorado legislation was contained the establishment of the administrative body, the Water Pollution Control Commission. The first meeting of the Commission was held in conjunction with the April session of the Conference. In light of this fact, the conferees agreed to meet on November 10, 1966, to allow the new commission sufficient time to study and evaluate the Federal report, and develop a program for implementation of remedial measures and a time schedule (FWPCA, 1966bb).

The technical report presented to the conferees by the FWPCA's South Platte River Basin Project contained both general and specific recommendations for pollution abatement action, including appropriate time schedules for all major waste sources in the Denver Metropolitan Area as well as for feedlot operations and the sugar beet industry throughout the basin (FWPCA, 1966bb).

The water quality objectives recommended by the South Platte River Basin Project, in essence, were those objectives later adopted by the Colorado Water Pollution Control Commission in January of 1967.

The State Position

The state's position at the Conference was stated by Dr. Roy Cleere, the Executive Director of the State Department of Health. He indicated his pleasure in the progress made in controlling pollution in the South Platte Basin. He felt the most significant step was the installation of the Denver Metro Sewage Plant which went into operation October 17, 1966. At that time he felt the Denver Area was receiving adequate treatment for the first time. He also stated

> ...I am firmly convinced that within three years, certainly not later than four years, pollution from all sources in the South Platte River Basin will be brought completely under control (FWPCA, 1966bb).

Metropolitan Denver Sewage Disposal District No. 1

The proposed Metropolitan Denver Sewage District No. 1 had promised relief from many overloaded municipalities and sanitary districts as indicated by Cleere. A total of 48 such municipalities and sanitary districts were to join MDSDD #1 when it went into operation October 17, 1966. This system was to service 74 percent of the Metro area population.

The Denver Northside primary plant was to operate in conjunction with the Metro District plant facility. Eight other member plants, then discharging directly to streams, were to be connected to the Metro District plant. Five of these, equipped for secondary treatment, could have continued to discharge portions of their effluents to the stream provided that state effluent standards were being met.

Expansion of the Metro District plant for additional primary treatment was projected by 1981 and for additional secondary treatment by 1982. If the Clear Creek secondary treatment plants were abandoned, these expansion dates might be advanced to 1979 for primary treatment and 1980 for secondary treatment.

Table 11 describes the proposed abatement schedule including incorporation of the several sanitation districts into MDSDD No. 1, which was agreed upon at the Conference. The recommendation was made that adequate chlorination facilities be provided by January 1, 1967, in those plants which would continue to discharge wastewater to basin streams after completing construction of the MDSDD No. 1 treatment facilities.

In brief, the construction of MDSDD No. 1 was to have several large-scale effects on the Denver Metropolitan area. Technically, the high capacity plant relieved the small inefficient member plants of their overloaded condition. Economically, the cost of sewage treatment for the area was distributed by a large bond issue. Politically, the difficulties in policing a number of small plants was centralized into one installation where problems could be faced in one locale.

Conclusions and Recommended Standards

Pollution in the South Platte Basin from municipal and industrial wastes has caused many accompanying problems. Effluents reaching Barr Lake produce an extreme odor nuisance condition in the spring and fall of the year. Feedlot operations contributed high bacterial concentrations to the water in the South Platte River Basin, and have created sight and odor nuisances along the banks of the stream.

Organic pollution of the South Platte River and its tributaries has created conditions ideal for the breeding of mosquitoes, rats and flies, which transmit diseases to humans such as the plague, encephalitis, and a wide range of enteric diseases.

Wastes from the beet sugar processing industry contributed heavily to the gross pollution of the Middle and Lower South Platte River Basin. This pollution interferes with most legitimate and beneficial uses of the river and its tributaries.

Municipal and industrial wastes discharged to the waters of the South Platte River and its tributaries within the state of Colorado endanger the health or welfare of persons in this state. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended. The condensed results included the following points:

Table 11

Pollution Abatement Schedule

	Design capacity (mgd)	Avg. Flow (mgd)	Effluent Quality: BOD (Mg/l)	Effluent Quality: TSS (Mg/l)	Effluent Quality: Coliform Density (MPN/100 ml)	Recommendations	Suggested Abatement Schedule
Member Plants of MDSDD#1							
Baker W & S District	1.0	1.5	150	85	9.7×10^{6}	Divert sewage to MDSDD#1 and provide adequate treatment including chlorination for any sewage discharged to Clear Creek.	Jan. 1967
City of Westminster	1.25	1.3	335	155	3.7×10^{7}	Arrange for an engineering study to evaluate operation procedures and improve plant efficiency; and, divert sewage to MDSDD#1 and provide adequate treatment including chlorination for any sewage discharged to Clear Creek.	Immediately
City of Arvada	0.75	3.5	210	205	7.6×10^{6}(e)	Divert sewage to MDSDD#1 and provide adequate treatment including chlorination for any sewage discharged to Clear Creek.	Jan. 1967
Wheatridge	1.75	1.80	95	56	1.7×10^{6}(a)	Divert sewage to MDSDD#1 and provide adequate treatment including chlorination for any sewage discharged to Clear Creek.	Jan. 1967
Northwest Lakewood Sanitation District	1.8	1.9	215	106	6.6×10^{6}	Divert sewage to MDSDD#1.	Jan. 1967

1. Measures to control water pollution had not been adequate;
2. All discharges into the South Platte shall have adequate remedial or control facilities in full operation by June 30, 1971, in compliance with the standard promulgated by the Commission;
3. Time schedules for abatement of specific industries and municipalities are approved; and
4. Abatement schedules for the remaining polluters will be formulated in six months by the Commission (FWPCA, 1966bb).

To protect and preserve the waters of the South Platte River and its tributaries within the state of Colorado for present and future legitimate and beneficial water uses, the following water quality objectives have been developed and are presented in Table 12.

To insure that the water quality objectives would be met and effective reduction in present levels of pollution obtained, it was necessary to recommend adequate treatment for all wastes discharged to Basin streams in the Denver metropolitan area and to provide a high degree of operating efficiency in the waste treatment processes. Adequate treatment was defined as treatment which would:

1. Remove at least 90 percent of the Biochemical Oxygen Demand (BOD) and total suspended solids (TSS) and all of the settleable solids;
2. Provide continuous disinfection for all organic effluents released by municipal and industrial waste treatment plants;
3. Remove essentially all toxic materials;

Table 12

Water Quality Objectives for South Platte River

From	To	DO	5 Day BOD	Total Colif	Fecal Colif	Stream or Tributary
Above Littleton	Discharge from MDSDD#1					South Platte Mainstream
Evergreen	Mouth	>4 mg/l	<11 mg/l	2400/100 ml	500/100 ml	Bear Creek
Cherry Creek Reservoir	Mouth					Cherry Creek
Discharge from MDSDD#1	Discharge from GW Sugar in Brighton					South Platte Mainstream
All	All	>3 mg/l	<21 mg/l	5000/100 ml	1000/100 ml	Sand Creek
Golden	Mouth					Clear Creek
Discharge from GW Sugar in Brighton	Colorado-Nebraska State Line					South Platte Mainstream
Longmont	Mouth					St. Vrain Creek
Loveland	Mouth	>3 mg/l	<16 mg/l	5000/100 ml	1000/100 ml	Big Thompson
Johnstown	Mouth					Little Thompson
Windsor	Mouth					Cache la Poudre

4. Permit no discharge of phenol-like substances in concentrations greater than 25 parts per billion; and

5. Permit no visible floating oil or grease in the streams (FWPCA, 1966bb).

Specific recommendations for remedial actions for municipal waste treatment and for industrial waste treatment are presented in Table 13.

Furthermore, it was recommended, in general, that all establishments not named in the table which discharged inadequately treated waste into the South Platte, connect to sanitary sewers by January 1, 1967.

Interestingly, the recommendation was made that a program of surveillance of the Basin waters be undertaken by the appropriate state agency to obtain the data required for constant evaluation and insure the highest possible benefits consistent with future legitimate and beneficial water uses.

Table 13

Municipal and Industrial Abatement Schedules

Plant	Action	To Be Completed By
City of Arvada Baker Sanitation District Clear Creek Valley Sanitation District City of Denver (Northside) City of Denver (Eastside) Federal Correctional Institution Fruitdale Sanitation District North Washington Sanitation District N.W. Lakewood Sanitation District City of Thornton City of Westminster City of Wheatridge	Divert to MDSDD No. 1	January 1, 1967
City of Aurora (Sand) City of Brighton Fitzsimons Army Hospital South Adams Sanitation District	Continue adequate treatment for BOD settleable solids and bacteria, plus provide 90% TSS removal	January 1, 1967
City of Aurora (Westerly) City of Evergreen City of Littleton South Lakewood Sanitation District	Provide adequate treatment and disinfection	Plan by January 1, 1967 additional facilities operative by January 1, 1968
Buckley Air Station City of Englewood	Provide adequate treatment and disinfection	January 1, 1967
Golden	Provide adequate treatment and disinfection	January 1, 1967

Table 13 (continued)

Municipal and Industrial Abatement Schedules

Plant	Action	To Be Completed By
Denver Metro	Provide adequate treatment, 92% BOD and TSS removal, remove all settleable solids	January 1, 1967

Institution	Action	To Be Completed By
Armour & Company Capitol Rendering Company Chicago, Burlington & Quincy Railroad Colorado and Southern Railroad Denver & Rio Grande Western Railroad Gates Rubber Company Kuner Empson Company (Brighton) Litvak Meat Company United Fryer & Stillman, Inc. Samsonite Corporation	Divert wastes to sanitary sewers	January 1, 1967
Colorado School of Mines Research Foundation, Inc.	Enlarge rentention pond	January 1, 1967
Coors Porcelain Co.	Divert floor drains to sanitary sewers	January 1, 1967
Continental Oil Co. Empire Petroleum Co. Tenneco Oil Co.	Adequate treatment to reduce phenols	June 1, 1967
Denver Union Stockyards Co.	Divert stock drinking water and pen drains from River	January 1, 1967
Gates Cyclo Poultry Farm	Provide adequate treatment plus disinfection	Plans by January 1, 1967 new facilities operative by January 1, 1968

Table 13 (continued)

Municipal and Industrial Abatement Schedules

Institution	Action	To Be Completed By
Public Service Company of Colorado	Provide adequate treatment to sanitary sewers	January 1, 1967
Stapleton International Airport	Divert waste to to sanitary sewer	January 1, 1967

Chapter 5

LEGISLATIVE AND ADMINISTRATIVE ACTION IN COLORADO SINCE 1965

Legislative Action

Introduction

The actual Colorado legislation adopted to comply with the Federal requirements of the Federal Water Quality Act of 1965 occurred just previous to the Second Session of the South Platte Conferences. The required water quality criteria and plans of implementation and enforcement, however, were not adopted until after the Second Session of the Conferences was reconvened November 10, 1966.

At this point, a chronology of events would help clarify the overlapping interactions of the South Platte Conferences, Federal and Colorado legislation (Table 14).

Prior to the adoption of the Water Pollution Control Act of 1966, Colorado had a widely divided pollution control authority. In addition, the pollution law was incompatable with the 1965 Federal requirements for criteria adoption and plans of implementation and enforcement. Colorado however did, as a result of the Federal-State conferences, have a strong legislative basis for establishing the required law. The Conferences had provided a highly detailed and comprehensive evaluation of the pollution problem in the South Platte.

On the one hand, the Federal-State Conferences gave Colorado an advantage for formulating stream standards. On the other hand, Colorado had to formulate its law under the pressure and presence of the Federal enforcement and investigating staff.

Table 14

Chronology of Pollution Events

Date		
October 2, 1965	Water Quality Act of 1965 (Federal)	Required states to adopt criteria and plans of implementation and enforcement by June 30, 1967
March 1, 1966	Water Pollution Control Act of 1966 (State)	Met Federal requirements of 1965 Act and established the Water Pollution Control Division
April 27 & 28, 1966	Second Session South Platte Conference (Federal-State)	Reports findings from the 2½ years of Federal-State investigations
May 10, 1966	Reorganization Plan No. 2 of 1966 (Federal)	Transferred the FWPCA from HEW to the Department of the Interior
November 10, 1966	Second Session South Platte Conferences Reconvened (Federal-State)	Review recommendations in April to develop a program for implementation of remedial measures and time schedules
March 1, 1967	Effective date of Water quality Standards for Colorado (State)	Finalizes and puts standards into action legally

Chief Enforcement Officer for the FWPCA, Murray Stein, was instrumental in holding the legislative "club" over the states head to proceed according to the Federal time schedule. Clearly, Stein did not have it "out" for Colorado from previous comments at the 1966 Conference and from the fact that Stein was rougher elsewhere:

> I do believe that this a milestone in the program to clean up pollution of the South Platte River. At times during the two and one half years we despaired, but I think we have gotten together (Feds and State). I do think this program is good, is realistic, and it should take place with all the people in the Basin and industries doing their share. We do not believe it will impose a financial burden on any municipality which will impede its growth, or on any industry which will in any way degrade its competitive position (FWPCA, 1966bb).

In addition to the strong statement by Stein, concluding the 1966 Pollution Conference (FWPCA, 1966aa), it is significant to note that Interior Secretary Stewart Udall specifically singled out the South Pleatte as a long standing serious pollution problem in Colorado, even after Colorado had passed legislation. This may indeed have had the effect of focusing attention on Colorado to instigate an effective program. Stein and Udall were consonant on the importance of the 1963-1966 Federal-State investigations:

> Now, after two years of intensive study and analysis of this very complex problem, we have every reason to hope that State and Federal authorities will agree on a practical and effective program (Denver Post, 1966k).

In essence, the Federal faction of water pollution control truly expected the Federal direction and initiation to be sufficient to reduce and control water pollution in the State of Colorado.

Formation of Colorado Legislation

The 1965 Federal Water Pollution Act produced much controversy at the state level in establishing an appropriate administering and standard forming body for water pollution control. Because of national and State histories of water pollution control being under the jurisdiction of Public Health, the most logical root was to form an agency within the already established Colorado Department of Health.

In October 1965, a legislative study urged that a draft of a water pollution control law be drawn up for the 1966 Colorado General Assembly's consideration. The proponents of the original proposed legislation felt that the states did not have adequate time to prepare acceptable standards.

Some individuals believed pollution control authority was already adequate in Colorado (Denver Post, 1965e). State Representative John Bermingham (R.-Denver) noted while considering uranium mine wastes that "There are adequate state laws on stream pollution by domestic sewage." A 1959 act had established effluent standards on domestic sewage; a clause which was later repealed by the Colorado Water Pollution Control Act of 1966, as amended in 1967 (CRS, 1963).

Other factions responded to the Federal requirements, but did not agree with them. As cited previously, states were required to set stream standards before June 30, 1967, which greatly irritated state administrators and legislators. Senator David Hahn (D.-Aurora) was a prime figure in resisting Federal pressure and then developing the water pollution control program. Sympathizing with advocates of "developing the impossible" was Richard Eckles, State Coordinator of Natural Resources, who defied the Federal government pressuring the states into adopting stream standards (Denver Post, 1965d).

The Water Pollution Control Commission

A long standing controversy began to develop on the question of having a water pollution control agency within the Colorado State Department of Health. A fear developed, primarily among state health advocates, that a "two-headed monster" would be generated if a water pollution control board was established exclusive of the State Public Health Department. Interest groups also played prime roles in the formation of Colorado water pollution control legislation. In general, industry favored the establishment of a multi-represented commission because it allowed industrial members on the standard setting and enforcement branches of control.

The Colorado Public Health Association, during the process of the developing legislation, accused Senator Hahn's bill of "yielding to the powerful industrial lobby." The group was "unequivocally" opposed to the Hahn bill because it allegedly bypassed the interests of Public Health (Denver Post, 1966b). The bill actually substituted a separate regulatory commission for the state health board comprised of a 12-member commission, including six members from existing public health commissions, of which one member would be a State Health Board official. A seventh member representing the public would be appointed by the Governor (Denver Post, 1966c).

Senator Hahn defended his bill by pointing out the fear of industry of Federal intervention; another additional pressure to pass legislation. Hahn did not expect Colorado industries to align common interest in resisting water pollution control. Two of Colorado's largest firms, Adolph Coors Company and the Colorado Fuel and Iron Corporation, were instrumental in lobbying the commission-form bill through the Senate. Hahn also apparently felt that industry was compelled to adopt the most liberal form of water pollution control at the state level, because of the fear that the Federal government would be setting standards if Colorado did not set them (Denver Post, 1966c).

The Colorado Public Health Association cited two arguments against establishment of a commission, which to some degree have been well borne out today. The two prime objectives were:

> Why are the major polluters given a majority of the seats on the proposed commission?" and "How does the proposed commission, unversed in the operations of a local health department program, propose to implement water pollution control measures at the local level?" (Denver Post, 1966d).

The Colorado Public Health Association also felt that

> For a complete record of stream conditions all down a stream, a study must be made according to stream flow to determine how streams are used. You cannot do this on a state level with a separate commission for water control. In Boulder County we have been controlling septic tanks for fourteen years. It is tied in with building permits, which specify construction standards subject to inspection.

So said Doctor Charles Downing, Chairman (Denver Post, 1966e).

The main opposition to the Water Pollution Control Commission concept came from public health groups and not from the environmentalist faction. Besides endorsement by industrial groups, the bill was also supported by the Izaak Walton League, Colorado Wildlife Federation and the State Game, Fish and Parks Department (Denver Post, 1966f). Thus two diametrically opposed groups, environmentalists and industrialists, were working for the same legislation, but for entirely different reasons. The environmentalists wanted some meaningful state legislation to deal with water pollution, while the industrialists worked for a commission-form regulatory board because they felt it would best represent their interests in light of Federal pressure.

The Resulting Product

A final version of the bill was finally signed by Governor Love and became effective March 1, 1966. The Act provided for "The Prevention, Abatement and Control of the Pollution of the Waters of the State" (Colorado Water Pollution Control Act of 1966, CRS 1963). The 1966 Act was amended in 1967 to allow setting effluent standards when stream standards were reached or exceeded (Colorado Water Pollution Control Act as Amended in 1967, CRS 1963).

The controversial Water Pollution Control Commission was established as the administrative enforcement body with the following membership:

1. Representative of State Board of Health;
2. Representative of Game, Fish and Parks Commission;
3. Representative of Water Conservation Board;
4. Natural Resources Co-ordinator (permanent chairman); and
5. Seven (7) citizens (one from industry, one from agriculture, one from local government and four at large) appointed by the Governor.

Colorado's Enforcement Procedure

As required by Federal Law, Colorado developed an enforcement procedure to implement the adopted stream "standards." Many of the features of the old law were prevalent in the new law as well, particularly the procedures dependence on evidence. A detailed description of the system of enforcement, as designated by Article 66-28-10 of the Colorado Revised Statutes (CRS, 1963g), will show the expressed difficulties of this section of law. Of course, the interpretation is made from a technical standpoint by the author and by no means is a bonified "legal" interpretation. Perhaps, test of a law's usefulness is its clarity to the men who must interpret and use it, rather than it's clarity to lawyers who write the legislation. The underlined portions to follow are paraphrased from the statute.

1. The Division of Administration or the County Health Department informs the Commission of a suspended violation which "promptly" is investigated at the direction of the Commission.

Because the Commission meets only once a month, this process alone could delay action for up to thirty days. The Commission's ability to act quickly is aided by Article 68-28-16, entitled Emergency Power--Injunction, which empowers the Commission to issue a cease and desist order when the Commission "determines" a water pollution activity is constituting a clear, present, and immediate danger to the health of the public. If a violation is found to exist, the Division or the County Health Department shall endeavor to eliminate the violation by conference, conciliation and persuasion. There is no provision made for dealing with matters on an emergency basis other than those endangering the public health. If this emergency cease and desist order is ignored, the Commission may apply for a temporary cease and desist order through the Attorney General's Office.

If a system were incorporated into the enforcement procedure to allow citizens to inform on polluters or suspected violaters, violation of State standards could become a Federal offense automatically by application of the 1899 Refuse Act (River and Harbor Act of 1899). Article 411 of the 1899 Refuse Act provides penalties for polluting navigable waters as a misdemeanor with a \$500-\$2500 fine and/or imprisonment of 30 days to one year. Half of the fine is to be paid to the informant providing information leading to a conviction. Much controversy has arisen on a possible citizen-instigated lawsuit based on the citizen's interest in the one-half fine reward. Such lawsuits have been deemed "qui tam", where the citizen acts as a "private attorney general" based on his monetary interest in the case. So far, the Federal courts have been unwilling to grant a "qui tam" status to many cases (Poindexter, 1971).

2. If these three methods fail to correct the violation, the Division or the County Health Department shall issue a written notice to cease with a "reasonable" time to comply.

3. <u>This cease and desist order becomes final within twenty days unless the violator requests a hearing before the Commission. The order is therefore stayed pending the Commission's final determination.</u>

4. <u>If at a hearing called by a violator the Commission "finds" a violation of stream standards, it shall consider a lesser degree of treatment or control which would be commensurate with any future or present water uses</u>. The Commission then affirms or modifies the cease and desist order or issues its own. If no violation is found, it recinds the order of the Division or the County health department.

This subsection sets up a mechanism by which the Commission may override the County's powers to establish higher standards or the Water Pollution Control Division's authority. Somewhat contradictory, Article 66-1-10 states that nothing shall prevent any incorporated city, city and county, town, county, or other political subdivision of the state from imposing higher standards than those promulgated by the Commission. Any case going beyond district court would have a tendency to simply legally bypass these stated powers of political subdivisions. In essence, section 4 allows the Commission to circumvent local legal function.

5. <u>The Commission then makes application through the Attorney General to the district court for the district in which the violation occurred.</u>

District court then hears the matter if it finds that the cease and desist order of the Commission was "lawful and reasonable," and may then issue an injunction. The fact that cease and desist orders are issued through the district courts in which violations occur has some rather interesting implications for the small-town political system. In the case of the San Juan Lumber Company in Durango, Colorado, the local district judge essentially refused action against the company due to the impact such action would have on the community. The pollution question, again, is taken from the hands of the water quality experts and given to the court to decide if the Commission's findings are "lawful and reasonable."

This is a general feature of our system, not peculiar just to pollution. The courts generally defer to experts and committees if all appears reasonable and clearly relates to statuatory standards (Caulfield, 1972).

6. Any proceeding for judicial review then will be filed within 20 days of the above final order.

7. Finally, any person who violates the final cease and desist order is subject to a fine of up to $1500 a day.

Meaningful Penalties

In many ways, the magnitude of the penalties for polluting were not proportionate to the "red-tape" necessary to impose them. In November 1969, Tom Ten Eyck, new ex-officio Chairman of the Water Pollution Control Commission, gave a strong bid for increasing penalties to polluters. He said "Really, the only penalty in our original law is that the polluter must pay damages for killing fish. It's my opinion that we do not have enough penalty provisions." He felt the commission had been "overly generous" in extending abatement schedules for offenders (Denver Post, 1969a).

Further, Ten Eyck said he was willing to include a nondegradation clause into the law for two reasons: First, former Secretary of the Interior, Stewart Udall, who was "pushy" about such clauses, was no longer in office and as a result the Federal government was allowing less restrictive clauses than it had asked for at the outset. Secondly, a nondegradation clause would not permit the state's waters to deteriorate below their existing quality (Denver Post, 1969b).

Eventually, in February 1970, the Legislature established penalties for violators ranging from $50 to $2500. At last, the Commission had authority to impose significant fines on polluters (Denver Post, 1970).

Administrative Action

Stream Classification

The State Department of Health was designated, under the new law, to administer the rules and policies established by the Commission. The Commission's first undertaking was to establish water quality criteria for the state and a plan of implementation to meet the Congressional deadline of June 30, 1967. The Commission, headed by Richard Eckles, considered testimony of 3,000 pages produced by 227 witnesses at classification hearings to determine stream standards. For clarity, streams and water bodies were divided into two groups and assigned classifications according to their use and condition. Group I described standards basic to all waters of Colorado. Group II established specific chemical criteria for the following uses (Rocky Mountain News, 1967):

1. Public Water Supply
2. Recreation Waters
   a. Fish and Wildlife
   b. Body Contact Sports
3. Industrial Water Supply
4. Agricultural Water Supply

These criteria are the basis upon which abatement schedules were then formulated. Abatement dates were set by the Public Health Service by letters of request to known polluters. If no response was received, a second letter was mailed to request a proposed abatement schedule from the polluter. As a final step, the Health Department assigned an abatement date (Rozich, 1971a).

In an effort to trace violators of the standards, 70 surveillance stations were established throughout the state.

On June 12, 1967, the Commission arrived at specific classifications for the streams and tributaries in every basin throughout Colorado. Eckles said the Commission attempted to provide for multiple use, and in general classified the South Platte as follows (Denver Post, 1967a):

1. Public water supply and cold water fishery from its source to Waterton;
2. Public water supply and warm water fisheries to Englewood's Union Avenue treatment plant; and
3. Industrial and agricultural use from there to the Nebraska state line.

Colorado is one of the few states to meet the Federal deadline of setting water quality standards.

The Resulting Standards

The following description condenses the essence of the original water quality standards for Colorado first adopted January 25, 1967 by the State Department of Public Health and the Water Pollution Control Commission.

I. BASIC STANDARDS APPLICABLE TO ALL WATERS

A. All wastes capable of treatment or control, prior to discharge into any waters of the state, shall receive secondary treatment with disinfection or its industrial waste equivalent.

B. Free from substances attributable to municipal, domestic, or industrial wastes, or other controllable sources that will either settle to form unsightly, putrescent, or odorous bottom deposits, or will interfere with the classified use of the water.

C. Free from unsightly floating debris, oil, grease, scum, and other floating material.

D. Free from materials attributable to municipal, domestic, or industrial wastes, or other controllable sources that will produce odor.

E. Free from high temperatures, biocides, toxic, or other deleterious substances.

F. Free from concentrations or radioactive materials.

II. ADDITIONAL WATER QUALITY STANDARDS FOR BODIES OF WATER THAT HAVE BEEN CLASSIFIED FOR ANY OF THE FOLLOWING USES

A. Public Water Supply

The following standards shall apply to water withdrawn for treatment as a potable supply:

1. Bacteria: The annual average number of coliform bacteria at any sampling station shall not exceed the historical average by more than 20 per cent and in no cases shall the monthly average of the number of coliform bacteria exceed 5,000 per 100 milliliter (either MPN or MF count). All averages shall be computed logarithmically.

2. Dissolved Oxygen: Dissolved oxygen shall not be less than 4 milligrams per liter.

3. pH: The pH shall be maintained between 6.0 and 9.0.

4. Taste and Odor: Free from materials attributable to municipal, domestic, or industrial wastes, or other controllable sources that will produce taste or odor in the water.

5. Dissolved Solids: Total dissolved solids, annual volume weighted average, should be less than 500 milligrams per liter.

6. Selected Chemical Constituents: The following substances shall not be present in such amounts as to exceed the specified concentrations in a potable water supply according to the mandatory requirements of the latest edition of the U. S. Public Health Drinking Water Standards:

Substance	Concentration - mg/l
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.20
Lead	0.05
Selenium	0.01
Silver	0.05

B. Recreational Waters

1. Fish and Wildlife:

The following standards shall apply to waters classified for fish and wildlife.

a. Dissolved Oxygen:

(1) In warm water fisheries, dissolved oxygen content shall in no case go below 5 milligrams per liter.

(2) In cold water fisheries, the dissolved oxygen content shall in no case go below 6 milligrams per liter.

b. pH: pH shall be maintained between 6.5 and 8.5.

c. Turbidity: No trubidity shall exist in concentrations that will impair natural and developed fisheries.

d. Temperature

(1) In cold water fisheries the temperatures shall not exceed 70°F.

(2) In warm water fisheries the temperatures shall not exceed 93°F.

e. Toxic Material: Free from biocides, toxic, or other deleterious substances attributable to municipal, domestic, or industrial wastes, or other controllable sources in levels, concentrations or combinations sufficient to be harmful to aquatic life.

f. Other Material: Free from materials attributable to municipal, domestic, or industrial wastes, or other controllable sources that will produce off-flavor in the flesh of fish.

2. Body Contact Sports:

The following standards shall apply to recreational waters classified for body contact sports such as, but not limited to, swimming and water skiing.

a. Bacteria: Total coliform bacteria shall not exceed 1000 per 100 milliliters as a monthly average (either MPN or MF count) nor exceed this no. in more than 20 per cent of the sample examined during any month; nor exceed 2400 per 100 milliliters in a single sample. In addition, the fecal coliform count shall not exceed 100 per 100 milliliters and the fecal streptococcus shall not exceed 20 per 100 milliliters, both of these limits be an average of five (5) consecutive samples within a month.

b. pH: pH shall be maintained between 6.5 and 8.5.

C. Industrial Water Supply

The following standards shall apply to waters classified for industrial uses:

1. Dissolved Oxygen: Dissolved oxygen content shall not go below 3 milligrams per liter.

2. pH: pH shall be maintained between 5.0 and 9.0.

3. Turbidity: No turbidity shall exist in concentrations that will interfere with established levels of treatment.

4. Temperature: The temperature shall not exceed 93°F.

D. Agricultural Water Supply

1. Irrigation Water:

The following standards shall apply to waters classified fied for irrigation.

a. Total Dissolved Salt Concentration:

A moving twelve-month time-weighted mean at a monitoring station which exceeds the time-weighted mean for a base period established by the Commission by more than two standard deviations shall be subject to review by the Commission.

b. Sodium Absorption Ratio:

A moving twelve-month time-weighted mean at a monitoring station which exceeds the time-weighted mean for a base period established by the Commission by more than two standard deviations shall be subject to review by the Commission.

c. Toxic Material:

Free from biocides, toxic, or other deleterious substances attributable to municipal, domestic, industrial wastes, or other controllable sources in concentrations or combinations which are harmful to crop life.

2. Livestock Watering:

The following standards shall apply to waters c assified for livestock watering:

a. Soluble Salts: The soluble salts shall not exceed 3000 milligrams per liter.

Standards Too Low

There were factions which felt the Commission had established standards which were too low. Dr. Samuel Johnson, Director of the City Health Departments Division of Public Health and Prevention Medicine in Denver, said that because of increasing population and industrialization "If we continue at our present rate, we will be pushed two steps backward for every one step we take forward." For example, low summer flows make it impossible to maintain the South Platte River for recreational use in the Denver area (Denver Post, 1967b).

A Fallacy of the Standards

Denver Metro points out a legal shortcoming in the state's domestic sewage requirement for 80 per cent BOD removal. Since Denver Metro was experiencing a severe sludge disposal problem, but was operating at 94 per cent efficiency in BOD removal, the suggestion was made by a citizen that the plant simply reduced its efficiency to the state requirement, thereby alleviating a portion of their problem (Water Pollution

Control Commission, 1971). The law makes no stipulation that domestic sewage must exceed the 80 per cent standard. The defectiveness of the statute is further exemplified when consideration is given to the high concentration of BOD sources flowing into the Denver Metro treatment plant, such as wastes from the meat packing industries.

A special Executive Committee of the Water Pollution Control Commission made a feeble attempt at preventing this occurrence by directing the Technical Secretary, Frank Rozich, to write Denver Metro officials indicating that it was the Commission's "feelings" that the plant should operate at full efficiency. He was also to point out that in addition to BOD removal, it is necessary to meet stream standards (Water Pollution Control Commission, 1971). However, the Executive Committee failed to realize the burden of proof fell upon the Water Pollution Control Commission to show that Denver Metro was the polluter responsible for creating a condition which exceeded stream standards.

The necessity for a water quality monitoring system capable of first detecting, and then proving a stream standard violation becomes clear. It is also clear that the monitoring system, once it had detected a stream standard violation, would then need to prove that in fact, Denver Metro Plant was the cause of the violation. It will be shown in the next chapter that the existing water quality monitoring system has neither the capability of detection nor the ability to prove causation.

Summary

The Federal Water Pollution Control Act Ammendments of 1956 and 1961 established a specific procedure for providing Federal assistance to states upon state request. Sources of pollution could be located and remedial actions against polluters adopted.

Colorado first responded to Federal Legislation when Governor Love made such a request and a series of Conferences was begun on October 29, 1963. The following two and one-half years located with particularity the sources of pollution in the South Platte Basin and its nature and extent. The resulting recommendations and suggested remedial actions were presented at a second session of the Conferences held on April 27 and 28, 1966 and reconvenced November 10, 1966. The interim period from April to November allowed the newly created Colorado Water Pollution Control Commission time to study and evaluate the Federal report, and develop a program for implementation of remedial measures and a time schedule to comply with the Federal Water Quality Act of 1965.

The Conferences in every respect articulately met the Federal Water Pollution Control Act Ammendments of 1956 and 1961 as previously described. A summary report was fully developed which did include the following:

1. Occurrence of pollution in navigable waters subject to abatement under the Federal Act;
2. Adequacy of measures taken toward abatement of pollution; and
3. Nature of delays, encountered in abating the pollution.

Because of this excellent series of reports, Colorado was able to move effectively toward establishing water quality criteria before June 30, 1967. Overall, the intent of the Federal legislation had been carried out "to the letter."

However, as was pointed out in an earlier chapter, <u>no intent</u> or direction was set forth in the Federal legislation to act beyond establishing remedial actions. There is no specific intent of monitoring the progress of the implementation program in any of the Federal legislation.

The one recommendation made at the conclusion of the Second Conference which did suggest a follow-up monitoring program, transferred the burden of determining compliance onto the State. The recommendation read:

> State and Federal authorities will have progress evaluation meetings at six-month intervals to determine compliance with the above requirements. At the first progress meeting representatives of the Colorado Water Pollution Control Commission will supply specific time schedules for those sources of pollution for which time schedules were not supplied at this session of the Conference (FWPCA, 1966bb).

Colorado was in an excellent position to respond again to Federal initiation and adopt stream standards and a plan of implementation by June 30, 1967. As is implied in the above paragraphs, the standards themselves and the means to measure violations were left to the _discretion of the states_.

Colorado did respond to the Federal requirements and did adopt stream standards with a schedule for implementation. The Water Pollution Control Commission was established as the policy making and enforcement body of the Colorado water pollution control function.

Obviously, the fact that stream standards were adopted implies the necessity of a system which can detect the violation of those standards. As described, the Federal legislation did not require review of such a system. Correspondingly, Colorado did not adopt a specific plan for monitoring or evaluation. Colorado law produced only a vague guideline for monitoring on a continuous basis in Article 66-28-6:

> 66-28-6. ADDITIONAL UTIES OF COMMISSION.--(1) The commission shall cause samples to be taken from the waters of the state periodically and in a logical geographical manner so as to advise

the commission of the water quality standard of the waters of the state.

(2) Whenever a sample collected at the direction of the commission proves to be below the water quality standard set for that water then the commission shall determine the source of the pollution, and if more than one source is responsible, determine all sources of the pollution so that one hundred per cent of the sources responsible for the pollution can be determined.

From the wording in the Colorado enforcement section in the statute, it can be seen that evidence is the backbone of enforcement. Words like "finds", "reasonable", "promptly", command knowledge and documentation that a pollution event has, in fact, occurred and further, necessitate the ability to show proof of cause. The evidential form may vary from inventories to special investigations or studies, to routine sampling data from the state's water quality surveillance system. Clearly, evidenciary probity is essential to any enforcement action at any level; local, state or Federal.

In conclusion, there is a failure at the Federal level to require, and at the State level to adopt, a plan to effectively monitor the true quality of the States waters on a continuing basis.

We will now examine the effects of the failure to adopt such a plan.

Chapter 6

TECHNICAL ASPECTS OF DATA SYSTEMS EVALUATION

Introduction

From Policy to Measurement Programs

The growing attention toward water pollution control is well documented by the increasing legislative activities at both Federal and state levels. Accompanying this growing concern is the change in water quality objectives from essentially human health alone, to multi-purpose concerns.

The emphasis for water pollution control has changed from "protection of health and welfare" to considerations of esthetics, including odor and unsightliness, enhancement, protection of fish and wildlife, recreation and other legitimate uses. These considerations are well documented by the extensive series of reports on the South Platte River Basin which range from vector and odor problems to domestic and industrial waste problems.

Accordingly, as these objectives change, then criteria for meeting those objectives must also change and correspondingly so must the programs which measure adherence to the objectives. Clearly, the parameters which measure water quality relative to health and welfare do not necessarily correspond to the parameters necessary relative to the objectives of enhancement, esthetics, recreation or protection of fish and wildlife.

As the preceding chapters have discussed, both Federal and state policies have been established for dealing with these changing social and technical objectives. Two Federal publications were issued to direct the states in establishing their own respective standards as required by Federal law. The first of these publications, Water Quality Criteria (FWPCA, 1968d) set forth in detail, the water quality criteria necessary to support the various designated water uses. So then, the parameters which needed to be monitored to protect the use classifications of the streams were precisely recommended.

The second publication, Guidelines for Establishing Water Quality Standards for Interstate Waters (FWPCA, 1967g), described legislative and policy guidelines to combine quality criteria with plans of implementation and enforcement to form stream standards.

A significant failure exists, however, to set forth guidelines necessary to first effectively monitor the established criteria in a manner representative of macro stream quality, and second, apply the collected data to enforcement and implementation programs to insure standards are not violated on a continuing basis.

The next topic of discussion will examine the first of these two deficiencies which is the technical aspect of actual data collection.

In the opinion of the author, this is indeed a difficult topic to discuss for several reasons. First, the collection of data has been primarily a function of the needs and objectives of the agencies who have collected it. This makes the data itself subjective, even though by itself it is objective.

In addition, in a historical data search for a particular basin area such as the South Platte, it is difficult to separate results from conclusions. For example, if the researcher can locate no more data, or his search uncovers no more data, the appropriate conclusion is, there are no more data sources to research. Results and conclusions, therefore, may not be entirely distinct in the discussion to follow.

Nevertheless, the need clearly exists to scrutinize data and data sources because it has been shown to be the backbone of pollution abatement at both Federal and state levels.

History

Early History and Development

Hendricks and Skogerboe (1971) have developed a comprehensive history of monitoring. The history of water quality monitoring in the United States is recent. Development of monitoring programs has been dependent upon:

1. Analytical capabilities to measure the mineral, bacterial and organic content in water;
2. Scientific correlation of water constituents with human health phenomena, industrial use, irrigation and recreation;
3. Increasing demand for water, both quality and quantity; and
4. Changing character of the combination of demands for water.

Any effort made to collect water quality data on a systematic basis in the Western States has occurred only since 1900. Early efforts made by the U.S. Geological Survey produced spotty efforts to begin systematic samplings through about 1914.

Permanent monitoring networks did not however appear until 1931. The International Boundary Commission established a monitoring system between the United States and Mexico. Establishment of a national network did not occur until 1941 by the U.S. Geological Survey. Annual records of inorganic data (chemical quality, sediment, temperature) have been published since 1941. In 1963 the USGS maintained 419 stations on 270 streams which collected chemical quality data on 276 sites at daily and monthly intervals.

Another major contribution to data collection was initiated in 1951 by the Subcommittee on Hydrology, Interagency Committee on Water Resources. The major emphasis for this system was use of water for irrigation purposes. This was an effort to coordinate the Geological Survey, the Corps of Engineers, the Bureau of Reclamation and similar water oriented agencies.

The first system established on a systematic, continuing basis oriented toward water pollution was the National Water Quality Network in 1956. The fifty sampling stations, which began operations October 1, 1957, were authorized by the Water Pollution Control Act Amendments of 1956 (PL660) under the U.S. Public Health Service. The real significance of this network is that it was established to monitor pollution. Routine measurements included radioactivity, plankton populations, coliform organisms, organic chemicals, a wide range of biochemical, chemical and physical measurements, and trace elements.

Outside the federal establishment, a myriad of state and local organizations collect water quality data. A clearcut evolutionary pattern is difficult to discern. Among these organizations are state health departments and state water quality control boards, state water resources agencies, a few irrigation districts, some city water departments, and agricultural experiment stations. Some of these data are collected on a recurrent basis at permanent stations.

Data Retrieval

Perhaps even more important than the data collection itself are the efforts which have been made to make its use accessible. In 1924, F. W. Clarke compiled and published all known analytical data for the waters of the United States through the USGS.

Later in 1926, Collins and Howard published an index to analyses in the United States also through the USGS. This publication was the first attempt to aid information retrieval by including reports of Federal and state surveys, experiment stations, health departments, and references to journal articles. Their publication was updated in 1932.

A bulletin of the Federal Interagency Committee in 1948 was the next publication which inventoried published and unpublished analyses in the files of Federal agencies through the 1947 water year. This bulletin was updated and supplemented in 1955 and 1964.

In 1964 the Bureau of the Budget authorized the Department of the Interior to coordinate Federal activities in the acquisition of certain water data. This function became the responsibility of the U.S. Geological Survey, which established the Office of Water Data Coordination (OWDC) for the purpose. The OWDC undertook the preparation of a Catalog of Information on Water Data. Initially, information was listed under one of four categories, which included: water quality stations, surface water stations, groundwater stations, and results of areal hydrologic investigations. The first three pertain to data acquisition on a recurrent basis at specific locations; the fourth is concerned with acquisition of water data, which is a part of a particular areal investigation.

Implications from the History

Examination of the chronology of events related to water quality monitoring provide a perspective on why data collection has taken the form it has. Table 15 identifies the relevant events related to analytical abilities. It is significant to note that until about 1940 when the biochemical oxygen demand test (BOD) was developed, there existed no means for relating organic content to water quality.

Table 16 describes, in a condensed form, the chronology of events which elude to the agencial interests which guided water quality programs.

Conclusions

There are a number of conclusions which may be derived from studying the history of events for water quality monitoring. Some of these capabilities as interpreted by Hendricks and Skogerboe (1971) are these:

1. Analytical capabilities are recent;
2. Development of water quality monitoring activities has roughly paralleled the increasing intensity of water use;
3. Quantity measurement has a relatively long history of continuous and widespread measurement. This has been the emphasis because water resource orientation has been oriented toward development of additional water supplies. Water quality monitoring has been tacked on, and is more costly. We have been moving into a new era with emphasis on better water management;

Table 15

Approximate dates of significant beginnings of analytical capacities

184_	John Snow relates a contaminated well to typhoid
186_	Pasteur discovers the microbe
1876	Specific organisms are related to diseases
1900	Lawrence Laboratory (Massachussets) identifies typhoid
1908	Coliform organism identified
1900-1910	Development of qualitative bacterial testing
1916	First issue of Standard Methods appears
1922	MPN test established
1940	BOD test developed
1960	Membrane filter method developed
1960	Instrumental methods begin to become prevalent
1960	Development of continuous monitoring systems initiated
1965	Beginning of remote sensing efforts

Table 16

Significant events in the evolution of water quality monitoring in the United States, with special emphasis on western states.

Year	Event
1880	Boston Water Board Report - First published references to water quality.
1886	Hilgard published quality data in relation to irrigation; first of seven reports, the last in 1904 - first water analyses referenced to irrigation.
1886	Peale on mineralized springs - a first study of water quality on national basis, but limited in scope to mineral springs.
1891	Active water quality program in Arizona began with reference to agriculture - an Agricultural Experiment Station activity.
1900	New Mexico Water Quality Program - initiated by the Agricultural Experiment Station.
1903	Dole began program (in USGS) to sample all major waters of U. S. on a recurrent basis for one year periods - the first thoughts on systematic sampling for basic data.
1903	First water analysis in Oregon with special relation to reclamation.
1908	Clarke's "Data of Geochemistry" - a first comprehensive scientific treatise which includes characterization of water quality of lakes and rivers in the U. S.
1909	Dole on "Quality of Surface Waters in U. S." - the first major work; in above work Dole outlined sampling procedure and accuracy in extensive discussion and gives results of analyses for 92 stations.
1910	Van Winkle and Eaton, "Quality of Surface Waters of California," first comprehensive survey of water quality of 37 rivers with interpretation in the context of natural influences, industrial and other uses, and economic aspects. Others follow on Oregon, Washington, Kansas, Minnesota, etc.
1911	Stabler of USGS gives 80 analyses from streams, 120 analyses from wells, with reference to possible use by irrigation projects.
1911	Palmer made geochemical classification of natural waters.

Table 16 continued

Year	Event
1918	Composition of Irrigation Waters of Utah by Greaves and Hirst.
1924	Clark compiled in one paper all published analytical data to date - a finis to Dole's beginning efforts to systematically analyze waters of the U. S. on a recurrent basis.
1925	Colorado River sampling program began.
1926	Collins and Howard publish Index of Analyses of Natural Waters - the first summary of publications containing water analyses.
1926	Collins "Notes on Practical Water Analysis" replaced Dole's 1909 statements.
1931	Water quality and other measurement programs of the International Boundary Commission begin; first permanent sampling network.
1932	Collins and Howard update their 1926 Index.
1941	USGS established permanent monitoring network and began to publish water supply papers containing quality data on an annual basis.
1948	Bulletin 2, Subcommittee on Hydrology, "Inventory of Published and Unpublished Chemical Analyses".
1951	Beginning of "Quality of Surface Waters for Irrigation, Western United States continues to 1962. 100 stations selected in 1952 by the Subcommittee on Hydrology, Interagency Committee on Water Resources. 77 stations were in operation in 1966. Prior to 1966 the results were published in the annual water-supply series, "Quality of Surface Waters for Irrigation, Western United States."
1956	Bulletin 9 of Subcommittee on Hydrology-Inventory.
1957	FWPCA Network.
1964	Woodward and Heidel publish Inventory of Published and Unpublished Chemical Analyses of Surface Water.
1964	Office of Water Data Coordination authorized in USGS by Bureau of Budget.
1967	First "Catalog of Information on Water Data".

4. Water quality efforts until 1941, have been conducted on an ad hoc basis as commensurate with the needs and charter of the sponsoring organization;
5. There are no good historical trends which indicate the character of a water body in time and space. This is true with respect to all categories of water quality, and especially for bacterial, organic carbon, algal, etc. characteristics; and
6. A thread of continuity in water quality monitoring was begun by the U.S. Geological Survey in 1903.

Strategy for Data Evaluation

Three Time Periods

As originally conceived, pollution control progress in the South Platte River could be evaluated by dividing the data history into three temporal stages. These periods were conveniently divided into pre-early 1960's, 1963-1966 and 1966 to the present. The years 1965 and 1966 may be considered transitional. Both years were marked by heavy political activity at State and Federal levels.

Primary consideration was given to the occurrence of significant political events in establishing a temporal base of discussion. The first interval, 1948-1963, whose starting years roughly corresponds to the data available, is marked by the Water Pollution Control Act of 1948 (PL80-845). The 1948 Act established an initiative for Federal grants to states making monies available for sewage treatment facilities at the municipal level. This time interval also sustained the

1956 rejuvenation of Federal monies available to states and a policy whereby states could ask for Federal help for pollution control. Following in 1961, the Kennedy Administration began a trend of increasing executive emphasis on water pollution control with significant increases in the monies available to states for loan and grants. This was preceeded in 1959 when at the state level, Colorado in 1959 adopted a significant regulatory feature of water pollution; an effluent standard for domestic sewage.

The second time period adsorbs the extensive Federal-State Conferences in the South Platte River Basin in 1963-1966 pursuant to Section 8 of the Federal Water Pollution Control Act of 1961 (PL87-88) (which became Section 10 under the 1965 Act, PL89-234). This period is terminated by the advent of the 1965 Water Pollution Control Act which required the states to adopt water quality criteria and plans of implementation and enforcement. This era was quite well documented by the voluminous series of technical reports produced by the Federal-State Investigation Committee on the South Platte River. This extensive series of reports dealt with literally every aspect of water pollution control. Problems normally considered incidental to water pollution, such as odor and vector problems, were dealt with in great detail in these reports. Sewage treatment plants and industrial installations were visited one-by-one, their facilities inventoried and present and potential problems outlined in detail. The reports, as a whole, produced an excellent documentation of the Basin's status quo of water quality.

The third division of time, then, was 1966 to the present. This period of time should be capable of being well documented due to the increased density of sampling stations established by the various water pollution control agencies and their related accelerated programs. In particular, the 70 station network established by the Colorado Public Health Department should have allowed an assessment of water quality changes from 1966 to the present.

Gathering Data

As an initial effort to obtain the data corresponding to these three time periods, the numerous agencies having water quality data for the South Platte were contacted and their data copied. At first, it seemed a relatively simple task to extract South Platte data from the various Geologic Survey publications, such as water supply papers, circulars and bulletins. Several other major sources of water quality data were found in special reports of the Bureau of Reclamation and Corps of Engineers. Cross checking the sources of data listed in indexes with the actual data reported for each agency began to show inconsistencies. In many cases, it was not evident from the published data whether the recorded figures were, in fact, averages or composite numbers. For example, U.S. Geological Survey data for the Upper Colorado River Basin was shown not to be literal in presentation. Entries for stations reporting monthly averages (or monthly readings) were in fact proved, in some cases, to be averages of a number of daily samples taken throughout the month and then averaged. For the purpose of presenting such a tremendous volume of data, this technique is very useful, but does not indicate if averages were based on small or large numbers of samples.

For the engineer who intends to perform a detailed statistical analysis of water quality data, averages of this type, of course, detract from the validity of his statistical models.

Admittedly, this data itself does not pertain to the South Platte, but does cast a shadow of doubt on the reliability of data presentation from the USGS in the South Platte Basin.

Invaluable indexes to water quality, such as the inventories of chemical analyses published by the Geological Survey in late 1940's and mid 1950's (U.S. Department of the Interior, Geological Survey 1948 and 1956), were for the most part never mentioned in such major indexing publications as the Office of Water Data Coordination, Catalog of Information on Water Data (U.S. Department of the Interior, Geologic Survey, Office of Water Data Coordination, 1965a-d). Evidently, this can be attributed to the fact that the agencies supplying data to this index were approached on a questionnaire basis and in some cases, their files, or original sources of data referencing and citations, were not complete. The difficulty in establishing a truly complete water quality index was worsened by the lack of a central source. In other words, there was no inter-agential cross reference. Lack of a comprehensive cross-reference makes the researcher wonder if he ever really does have a complete record of the available data.

Personal, on the scene, investigations of several agencies produced significant amounts of data which had never been published, but had been filed away in an obscure cabinet. Apparently most government agencies do not publish any form of data unless it accompanies a completed project report. Therefore, for the most part, incomplete projects and pilot studies find their way only to the bottom of a dark file cabinet. Not only was much pertinent data hoarded in the files of many agencies, sources of data were literally spread throughout the United States. Considerable sediment data was held by the Corps of Engineers in Albuquerque, New Mexico, bound in cardboard boxes, which for all practical purposes made it nearly useless and unattainable. Smaller amounts of water quality data were held in Riverside, California, at the USDA Salinity Laboratory. Some small special publications of the Geologic Survey were inaccessible to anyone not able personally to peruse the files of the Superintendent of Documents in Washington, D.C. After several personal telephone calls and letters of inquiry, it was determined the data, for all practical purposes, was unattainable.

The overall point of this discussion is to make perfectly clear the need for a complete comprehensive index of water quality data for a given region, with its corresponding data easily accessible. Any water resources engineer who attempts to do a complete historical search of flow and quality data can only meet with duplication of lost time from project to project, along with the frustration of never knowing if his historical search is truly complete.

Physical Considerations

There are many obvious factors influencing water quality. Among these are growth of industry, the effect of increasing population, the effect of management on municipalities, and agriculturally related operations such as irrigated croplands, feedlots and poultry farms. At the outset, the many variable parameters which affect water quality were hoped to be delineated by analyzing a variety of data sources.

An examination of the more particular parameters such as corresponding flow data, correlation with precipitation data, effects of evaporation, transpiration, different techniques in agricultural irrigation, and effects of subterranean seepages complicate water quality considerations, ad infinitum.

Because so many agencies had collected data for the South Platte System, it seemed prudent to examine the variation in technical results which could occur from differing sampling techniques. In addition, it also seemed wise to evaluate the interrelationships between parameters since no dependable consistent format was applied in compiling the data. The following discussion performs this analysis.

Technical Aspects of Water Quality Parameters Related to Data Collection Systems

Temperature

Distribution of daily temperature variation in streams is approximated by a Pearson Type III Skew Frequency Curve. Annual variation of stream water temperature is sinusoidal (Ward, Ca.1970). Therefore, it is crucial to note the time of day when temperature sensitive data is being taken.

Water quality parameters greatly influenced by temperature include pH , dissolved oxygen concentration (DO), biochemical oxygen demand (BOD), alkalinity composition and conductivity. The standard reporting temperature for pH , alkalinity composition and conductivity is 25 C. BOD levels are often computed on a 20 C basis (Ward, Ca.1970), thereby detracting from the comparability of parameters and complicating computations for standardization.

pH

pH is defined as the logarithm, to the base 10, of the reciprocal of the hydrogen ion (H+) activity in moles per liter. Similarly, pOH is the reciprocal of the hydroxyl (OH^-) activity. The equation relating the two activities is

$$pH + pOH = PKW$$

For dilute solutions at 25 C, PKW = 14. Therefore, for neutral water pH = pOH = 7. As previously mentioned temperature affects pH greatly, as Table 17 shows (Ward, Ca.1970).

Table 17

Variance of pH with Temperature

TEMP F	32	40	68	77	86
TEMP C	0	10	20	25	30
pH of Pure Water	7.4	7.3	7.1	7.0	8.9

The values for temperature ranges on the South Platte and its tributaries varies, as observed from the data, roughly between freezing in winter and about 80 F during low flows in later summer. The preceding table shows, then, that strictly on the basis of temperature alone, pH may vary as much as 0.5. The tendency for temperature is to lower the pH , or make the waters more basic in the summer. Because temperature is not always recorded with corresponding pH data, it may only be guessed that the pH was corrected to a standard temperature.

In addition, it is seldom noted in any of the compiled data whether the pH was measured in the field or in the laboratory. Values for pH change significantly in transit to the laboratory mainly due to biologic factors, provided proper preservative measures are not taken. Other factors affecting pH appreciably are dissolved gases such as carbon dioxide (CO_2), hydrogen sulfide (H_2S) and ammonia (NH_4). Surprisingly, the effect of dissolved acid and basic salts is slight (Rainwater and Thatcher, 1960). Since the natural sources of these highly affecting constituents is limited, their effects on pH may be attributed mainly to organic pollution sources such as waste treatment plants and agriculture.

Because Colorado Public Health data is for the most part collected in the field and then flown or bussed to the Denver laboratory, little control can be maintained over the handling of the samples. Samples may be shipped near the hot engine of a bus or allowed to freeze in the luggage compartment of an aircraft. These factors detract greatly from the validity of the final laboratory tests. Biota may be incubated or killed during shipping.

The recorded pH on the South Platte and tributaries varies between 6.9 and 8.1, on the average. When all possible sources of error are considered, these values could vary from about 6.4 to 8.6, which makes the recorded data only a general indication of pH.

Dissolved Oxygen (DO)

The saturated concentration of dissolved oxygen (DO) in pure water is highly dependent on temperature, as is pH. At one atmosphere, DO varies with temperature as shown below in Table 18

(Ward, Ca.1970). The annual deviation of temperature greatly affects DO . Not only does DO vary with temperature, but it also varies with atmospheric pressure. Because atmospheric pressure decreases with increasing elevation, for a given temperature, a large correction factor is needed to determine the saturation concentration of dissolved oxygen. These correction values are approximately as follows in Table 19.

Since the range of elevations for major sampling points on the South Platte in Colorado varies from about 3500 feet above mean sea level (MSL) at Julesburg to about 8000 feet MSL at South Platte, a variability of over 15 percent, relative to one atmosphere, may be experienced in samplings along the South Platte. Again, one can only speculate on the consistency of recorded DO calculations with altitude.

Time of day is also important to measured DO values due to living biota in the water, an aspect of measured DO often overlooked. Algal photosynthesis may cause saturation during the day and even total depletion during the night. Figure 6 describes this diurnal variation (Kittrell, 1969).

A measured value of 10 mg/l for DO may actually be 5 or 15 mg/l, depending on the time of day. Unfortunately, time of day is rarely accounted for in recorded data.

Other factors affecting DO may include bio-degradable material which consumes oxygen in a given sample, or aeration of the sample as it is being taken (Kittrell, 1969).

Table 18

Variance of Dissolved Oxygen (DO) with Temperature

TEMP F	32	40	68	77	86
TEMP C	0	10	20	25	30
DO, mg/l	14.62	11.33	9.17	8.38	7.63

Table 19

Variance of Dissolved Oxygen (DO) with Altitude

Elevation Above MSL in Feet	DO Concentration as a % of MSL DO Concentration
0	100.0
1000	96.3
2000	93.0
3000	89.5
4000	86.3
5000	83.2
6000	80.2
7000	77.2
8000	74.2
9000	71.4
10000	68.8
11000	66.1
12000	63.6

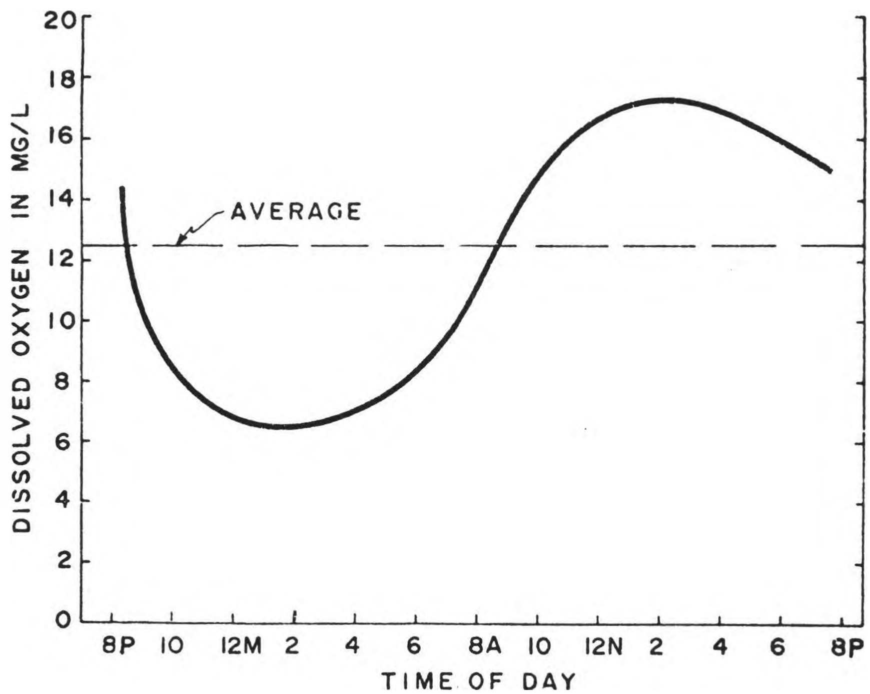


Figure 6. Effect of photosynthesis on dissolved oxygen concentration.

Biochemical Oxygen Demand (BOD)

In lieu of measuring the concentration of organic waste loading in water, their oxygen demand is determined instead. Although oxygen demand may be measured by chemical oxygen demand (COD) and theoretical oxygen demand (TOD) , BOD is the most common unit of measurement in water pollution (Ward, Ca.1970). BOD determination is commonly made by diluting portions of a sample of oxygenated water and measuring the residual dissolved oxygen after 5 days incubation at 20 C. As a comparison device, these demands may be converted to population equivalents, or the amount of people producing enough domestic sewage to equal a given BOD (Hem, 1959).

Because the emphasis on measuring water quality has been historically focused on inorganic analyses, few BOD samples were run prior to 1965 in the South Platte system. As a result, organic pollution in terms of BOD and related parameters is very difficult to compare. The fact remains, however, that BOD is an excellent parameter for evaluating organic pollution loading.

Fecal Coliform Bacteria

Studies have indicated that bacterial densities below a point of sewage discharge generally increase before they decrease. However, most bacteria die within 24 hours after discharge.

Fecal coliform bacteria probably constitute about one-third of the total coliforms in raw sewage. Fecal coliforms die off more rapidly in the summer, due to increased water temperature and DO levels. Generally, there is an indication that fecal coliforms constitute about 20 percent of the total effluent at the point of sewage discharge. At any rate, fecal coliforms have been shown to be a good indicator of pathogenic contamination of water.

Whether or not the coliform bacteria are of animal or human feces origin, humans are susceptible to many intestinal diseases of animal origin; all fecal coliforms, therefore, are a potential health hazard (Kittrell, 1969).

As in the case with BOD, fecal coliform counts have not been taken frequently in the South Platte River until after 1965. Also, similar to BOD, the concentration of fecal coliforms is a good indicator of organic pollution.

Total Dissolved Solids (TDS)

The concentrations of total dissolved solids in a water course are an indicator of river transport of soluble materials. Measurements of TDS are valuable for evaluating the suitability of waters for agricultural use, as well as assessing salt loads (as measured by TDS) contributed by irrigation return flows to a river system. Much inconsistency, however, is found in the various methods for determining TDS. Some methods specify drying temperatures for weighing residues at 103 C, while others specify 180 C for one hour (Hem, 1959). The result of the dissolved solids test conducted at 180 C is about half of the HCO_3 concentration (in mg/l) is lost. This may produce an error of about 38 percent in the TDS concentration relative to the concentration obtained at 103 C.

Thus, a sample containing 800 mg/l of actual TDS may be measured as only 500 mg/l. For this reason, many reported values for TDS may not be true values (Ward, Ca.1970).

Unfortunately, not all sampling agencies record their technique of measurement. The USGS, for example, specifies the 103 C or the 180 C test for some samples. Many results do not specify the test used. Thus, the reams of data produced by the various agencies is useful only as a general indicator of water quality trends and not a precise record, as is often suggested by these agencies. Because of the inconsistencies and lack of documentation, homogeneous corrections cannot be made.

It is interesting to note that Colorado has a TDS standard ("annual volume weighted average") which requires <u>knowledge of the flow at the time of sampling</u>, but <u>does not</u> take flow data.

The following general classification may be useful in describing water quality relative to TDS (Hem, 1959).

Table 20

Water Quality Relative to Dissolved Solids

	Dissolved Solids mg/l
High Quality	725
Slightly Saline	1,000- 3,000
Moderately Saline	3,000-10,000
Very Saline	10,000-35,000

The waters of the South Platte system, as observed from the data, may be classed as high quality to slightly saline.

Turbidity

Turbidity is an optical measure of the absorption and scattering of the light passing through a water sample with particulate suspension. Units and measurements are primarily a function of the instrument used. Values, therefore, are not generally comparable for different techniques. In general, turbidity is an indicator of the amount of light reaching underwater plants, thereby suggesting the effects of cover and food for fish and other organisms (Rainwater and Thatcher, 1960). Clearly then, turbidity suggests the concentration of suspended solids and the resulting photosynthetic dissolved oxygen produced by plants.

Nitrates

Nitrogen concentrations are determined and recorded with different techniques by the various agencies. Pollution oriented agencies usually report ammonia, amino and organic nitrogen in combined form or equivalent units of elemental nitrogen. Inorganically oriented studies usually report only the NO_3^- or nitrate ion. As a result, little consistency is seen in the various analyses.

There are a number of sources of nitrogen. Leaching from irrigated farmlands of artificial fertilizer, especially in high runoff periods, is a significant source. Also, the leaching of irrigation water may result in the pickup of natural nitrates in the soil profile. Human sewage and concentrations of farm animals, such as cattle feedlots, produce considerable amounts of nitrogenous organic waste. Stewart, Viets, Hutchinson, and Kemper (1967) made quantitative studies of soil moisture and shallow groundwater in the South Platte Valley of Colorado and found that substantial contributions of nitrogen reached the groundwater beneath irrigated fields, whereas particularly large contributions were associated with feedlots.

Phosphates

Similar to nitrogen, phosphorus exists in many oxidation states. Also, like nitrogen, phosphorus is an essential nutrient to plant growth. Phosphorus is a sewage component always present in animal metabolic waste and is probably the most important cause of concentrations in surface waters. Phosphates and nitrates are a measure of balance between organic and inorganic components of polluted water.

Increased concentrations of both phosphorus and nitrogen promote rapid algal growth into dense concentrations termed "eutrophication." These choking growths are usually detrimental to other aquatic life, especially if a water body is overloaded with oxidizable organic debris as a result of a sudden dieback in an algal bloom. These dying algae may also cause an unsightly and severe odor problem in any water body (Hem, 1959).

Lack of Documented Consistency

In a further attempt to truly interpret the value of the existing data from the sampling stations, it was necessary to examine the physical location of the various sampling networks. For the most part, locations were not precise. Probably, water samples were not consistently collected from the same location. There is no established procedure for directing personnel to take samples from exactly the same place or in exactly the same manner for every sample. One sampler might wade to the center of a stream for a water sample, but the next could dip a sample from a convenient rock on shore. Due to the high variability of water quality in even physically-close regions in a stream, truly representative samples would necessitate as precise a procedure for the sample collection as for the lab analysis. The engineer attempting to use this collected water quality data could never actually be sure of what to attribute specific phenomena.

Looking at the data closely, the crucialness of correlating flow with water quality becomes apparent. A particular phenomenon such as high biochemical oxygen demand could easily be explained with the knowledge that a rainstorm had flushed a cattle feedlot several hundred yards upstream prior to collecting the water quality sample. Obviously, related parameters such as suspended solids, turbidity, and dissolved solids would, in all probability, have high correlation with flow phenomena. Unfortunately, corresponding flow data was seldom taken simultaneously with any water quality data. This, of course, detracts from the usability and accuracy of any analysis.

Evaluation of Selected Data

Utilizing the Data

In order to effectively utilize the compiled volumes of water quality data for the South Platte River Basin, a method had to be devised for organizing and then performing the analysis. Due to the tremendous volume of data compiled from the USGS, FWPCA, Bureau of Reclamation, State Health Department, Corps of Engineers and City Health Departments, this technique needed to reduce the volume to a comprehensible, manageable size, as well as providing an unbiased base for examining the data.

Parameter Selection and Analysis

A reduction in number of parameters seemed first in order. The USGS has listed sampling frequency for U.S. water quality monitoring stations versus parameter coverage. On this basis alone, the following parameters were significantly more frequently taken than the remainder of the list of 31 most frequently taken parameters (Sayer, 1971).

If an analysis were performed on all these parameters, it is evident the derived knowledge would be overlapping. For example, dissolved solids, hardness, conductance, and common ions are all related to the amount of inorganic material dissolved in water. Similarly, color, turbidity and suspended solids all describe the nature of suspended materials in water. Therefore, at least for the preliminary analyses, a further reduction in parameters to be examined could be made.

Another question arises in making a decision regarding which parameters are most important; what parameters are most significant

Table 21

Significant Parameters in Decreasing Order of Frequency

Parameter	Total Frequency
TEMP	7664
pH (LAB)	5907
Common Ions	5526
Conductance	5229
Hardness	4974
Dissolved Solids	4831
DO	3948
Nitrogen	3733
Color	3725
Phosphorus	3485
Chloride	3282
Coliforms	3079
Turbidity	2996
pH (Field)	2251
BOD	1783

to the greatest number of disciplines? Also, what is the most unbiased technique upon which to base an analysis?

The Water Quality Index

A group of scientists examined these problems in an attempt to establish a national water quality index (WQI). The Water Quality Index was a tool to further delimit the bulk of the data. Their goals included a quality-explicit communication between professional and the public in order to keep the public informed. They concluded that a need existed to establish a means of measuring and reporting the most significant parameters which is predicated upon a knowledge of those that are the most significant.

A panal of 142 persons with expertise in water quality management was selected as follows for developing a reporting technique:

1.	State, interstate, Federal territorial and regional regulatory officials	101
2.	Local public utilities managers	5
3.	Consulting engineers	6
4.	Academicians	26
5.	Professional representatives and waste control engineers	4
	TOTAL	142

Through a series of mailed questionnaires, a list of the eleven most significant of 35 parameters was determined in Table 22. In the final selection, pesticides and toxic elements were dropped from the list due to a lack of agreement among respondents regarding techniques for evaluation (Brown, McClelland, Deinmger and Tozer, 1970).

Table 22

Eleven Most Significant Parameters

Dissolved Oxygen
5-Day Biochemical Oxygen Demand
Turbidity
Total Solids
Nitrates
Phosphates
pH
Temperature
Fecal Coliforms
Pesticides
Toxic Elements

The nine selected parameters provide a condensed basis upon which to examine water quality data. Granted, these particular parameters may not provide the exact data needed to meet a specific water quality objective, but these selected water quality indicators allow a relatively comprehensive general overview from which to examine water pollution.

The water quality index may be used to assign a number rating from 0-100 to various water qualities; 100 being the highest quality. Each parameter included in the rating is weighted according to its frequency of importance from the opinions of the 142 water experts. The weighted values of the parameters are summed to produce the 0-100 rating.

This condensation could also supply the Water Pollution Control Division of the State Health Department a usable format by which the Water Pollution Control Commission could derive a quick, accurate indication of the status of water quality at selected points throughout the state.

Sampling Station Selection and Analysis

It was felt that a reasonably complete compilation of water quality data for the South Platte River Basin had finally been developed. The next phase required a selection of key stations on the South Platte River within Colorado. The reams of data had to be reduced to a workable, analyzable size in order to provide a comprehensive look at the quality of the South Platte River for the three selected time intervals. Stations had to be selected which provided the most continuous and complete data, as well as being representative of various aspects of agricultural and municipal pollutants. A summary of the available water quality data for the South Platte River Basin is contained in Table 23.

From Table 23 it is evident that during the years 1948 to 1971, which is the period of time for which the bulk of water quality data is available, there are only a few stations which even approach temporal completeness. Therefore, a selection of stations indicative of significant quality changes, or pollution contributions from various tributaries along the South Platte, proved inadequate and, at best, spotty.

The Selected Stations

Using the nine parameters selected in the last section, plus flow, particular stations in the system could be singled out for analysis. Two stations were selected, namely the South Platte River at Julesburg and the South Platte River at Henderson. These stations were selected

Table 23

South Platte River Basin Water Quality

Location & Description	Period for Data Available	Chemical Quality	Agency	No.	Remarks
South Platte R. at Julesburg	10/45-9/65	C	USGS	6764	Data taken intermittently
	6/61-6/69	X	FWQA	NA	Data on Storet Retrieval Special Study
	1/68-7/70+	C	CDH	20	Colorado Department of Health, data taken monthly
South Platte R. near Crook	9/55-8/57	I	USGS	NA	
	12/63	X	FWPCA	NA	Data on Storet Retrieval Special Study
South Platte R. near Balzac	1/50-9/51	I	USGS	6760	
	8/54-8/57	I			
	7/62-8/64	C	USGS		
	10/65-9/67	C			
	11/68-9/69				
	12/63	X	FWPCA		Data on Storet Special Study
	1/68-7/70+	C	CDH	21	Data taken monthly
South Platte at Ft. Morgan	12/63	X	FWPCA		
Bijou Creek near Wiggins	7/50-8/53	S	USGS	NA	Discontinued 8/53
South Platte near Weldona	10/64	X	FWPCA	NA	Three samples taken 10/64
	10/67-8/68				
South Platte near Kersey	4/47-12/50	I	USGS	67540	No more data available
	12/50-9/53	C			
	8/54-8/57	I			
	6/62-9/64	C			Data missing for July & August
	10/65-9/69	C			
	10/64 & 6/67	X	FWPCA	NA	Data on Storet Special Study
	1/68-8/70+	I	CDH	22	Take first six months each year
Cache la Poudre R. near Greeley, Colorado	1/50-8/56	I	USGS	67525	
	12/63-9/67	C			
	1/64	X	FWPCA	NA	Data on Storet Special Study
	10/65	X			
	8/66	X			
	1/68-8/70+	C	CDH	27	Data taken monthly
South Platte at Evans	10/50-9/51	I	USGS	NA	Discontinued
	10/64	X	FWPCA	NA	Three samples taken

USGS United States Geological Survey
FWPCA Federal Water Pollution Control Administration
FWQA Federal Water Quality Administration
CDH Colorado Department of Health
+ Last Available Sample Date
I Intermittent
C Continuous
S Sporadic
X Special Study
NA Not Available

Table 23 (continued)

South Platte River Basin Water Quality

Location & Description	Period for Data Available	Chemical Quality	Agency	No.	Remarks
Big Thompson R. near Lasalle	1/50-7/56	I	USGS	67440	
	1/68-8/70+	I	CDH	28	Monthly but intermittent
St. Vrain at mouth near Platteville	1/50-8/56	I	USGS	67310	
	9/65-9-68	C			
	1/68-8/70+	I	CDH	29	Monthly but intermittent
South Platte at Ft. Lupton	1/50-9/55	I	USGS	NA	
	9/65-10/65	X	FWPCA		Data on Storet Special Study
South Platte R. at Henderson	10/54-9/57	C	USGS	67205	
	6/62-9/63	C			July and August missing
	10/65-9/69	C			
	9/65-10/65	X	FWPCA		
	6/67-11/67	X	FWPCA	NA	Storet Data Special Study
	1/68-1/70+	I	CDH	23	Samples taken 8 times a year
South Platte R. below sewer outfall at Denver	8/55-5/56	I	USGS	NA	Older plant not Metro
	8,12/64-4/64	X	FWPCA		Sample also on 6/66
	9/65-10/65				
South Platte R. at R.R. bridge below York St.	8/64-1/65	X			Storet Data Special Study
	2/65-5/65	X			About or below the USGS Station
Burlington Ditch at Denver	10/62-9/67	C	USGS	67100	
South Platte R. at Littleton	10/50-8/51	I	USGS	NA	
	11/68-7/70+	I	CDH	24	Data taken 7 times a year
South Platte R. at So. Platte	7,10/61	I	USGS		Mostly flow and temperature
	1/62-10/62				
	10/63				
	4/64-9/65				
	10/68-7/70+	C	CDH	25	
Cache la Poudre at mouth of Poudre Canyon	1/68-8/70+	I	CDH	26	Data taken 6-7 times a year
St. Vrain R. at Hiways 119 and 52 at bridge	4/68-12/69	I	CDH	30	Description not accurate, 9 samples
St. Vrain R. below Longmont	10/68-8/70+	I	CDH	31	Located in Weld County
Boulder Cr. at Boulder and Weld County Line	4/68-8/70+	I	CDH	33	
Clear Creek near mouth	1/68-8/70+	I	CDH	34	
Clear Creek above Golden	3/55,8/55	S	USGS		Samples taken 3/24, 29 and 8/30
	4/68-7/70+	I	CDH	35	
Bear Creek at Jefferson and Arapahoe County Line	1/68-7/70+	I	CDH	36	8 samples taken a year

because of long-term data collection along with their location being important to evaluating sources of water pollution.

The Platte at Julesburg

The South Platte River at Julesburg water quality station was selected because of having the longest and most complete record of quantity and quality of any South Platte Basin station in Colorado. Because this is the last station on the river in Colorado, it probably would provide a technical foundation for any interstate controversy concerning flow or quality. For these reasons, Julesburg seemingly should present the most useful and complete set of data for this evaluation of progress in pollution abatement. A summary of the actual data is contained in Table 24.

The intent of Table 24 is not to present a complete data listing, but to indicate the salient features of the record. There are several obvious aspects of the data within this compilation. Foremost, there is no biologic or organic data, exclusive of the 1963 water year, until 1967-1968. This fact is readily explained by the orientation of the primary collecting agency, the USGS, which has had little historic interest in collecting data which would include organic parameters. Secondly, even though discharge records appear to correspond with quality records, measuring times in no way correlate with sampling times other than in the average. In other words, no account is given for influences of dilution flow from precipitation, irrigation effects of diversion and return, or sewage treatment plant bypass and other flow-volume influences. In some years, based upon extremely low summer flows due to severe climatic conditions, large diversions were

Table 24

Selected Data in the South Platte River Drainage Estimated Averages for Julesburg

YEAR	DO mg/l	FECAL COL /100 ml	pH.	BOD mg/l	NITR ppm	PHOS ppm	TEMP F	TURB J. U.	TDS ppm	Q cfs
1945-46										
A			7.8		3.0		40		1330	577
B			8.3*		1.4		62		1220	55
1946-47										
A			8.0		3.0		40		1400	321
B			8.1		3.0		60		1000	1389
1947-48										
A			7.8		4.5		40		1200	832
B			8.2		2.6		60		1180	192
1948-49										
A			8.0*		4.5		51*		1300	414
B			7.8*		3.0		71*		1000	1597
1949-50										
A			7.9*		4.2		45*		1310	404
B			7.9*		3.0		70*		1100*	86
1950-51										
A			7.7*		4.1		40		1350	254
B			7.9*		3.5		69		1200	287
1951-52										
A			7.5*		5.7				1450	505
B			7.8*		6.2				1200	414
1952-53										
A			7.7		3.0		41		1430	298
B			7.7		3.1		75		1100	78
1953-54										
A			7.7*		2.5*		50		1400	218
B			7.9*		2.5*		72		1220	31
1954-55										
A			7.7*		3.8*		40		1450	120
B			7.8*		3.3*		70		1350	76
1955-56										
A			7.8		3.5*		45		1500	111
B			7.7		6.5*		78*		1400	29
1956-57										
A			7.9		3.0*		45		1500	117
B			7.7		2.4*		70		1300	1093
1957-58										
A			7.6		4.2*		40		1300	657
B			7.4		1.7*		73		1000	1253
1958-59										
A			7.5		3.1*		45		1400	416
B			7.7		4.1*		75		1300	244

Table 24 (continued)

Selected Data in the South Platte River Drainage Estimated Averages for Julesburg

YEAR	DO mg/l	FECAL COL /100 ml	pH.	BOD mg/l	NITR ppm	PHOS ppm	TEMP F	TURB J. U.	TDS ppm	Q cfs
1959-60										
A			7.5		4.8*		48*		1400	385
B			7.4		2.4*		70*		1300	132
1960-61										
A			7.6		3.1*		45		1600	191
B			7.5		2.0*		70		1250	824
1961-62										
A			7.7		6.5*		45*		1300	1216
B			7.6		1.0*		75		1300	344
1962-63										
A	8.5	30,000	7.5	3.5	3.4*	0.01	46	50*	1500	397
B	8.1	10,000	7.5	1.7	2.2*	0.00	75	350	1300	56
1963-64										
A			7.6		3.3*		45		1600	217
B			7.5		0.7*		70		1500	36
1964-65										
A			7.5		3.5*		42		1580	82
B			7.9		3.6*		70		900	1346
1965-66										
A			8.0		4.6*		48*		1350	865
B			7.9		1.5*		70*		1450	92
1966-67										
A			7.9		4.0*		42*		1600	171
B			7.6		3.0*		65*		100	620
1967-68										
A	7.5	6,000	8.1	2.4*	0*	0*	42	20	1620	259
B	7.5	1,300	8.0	2.9*	0*	0.1*	72	35	1590	302
1968-69										
A	7.9	25,000	8.1	5.0	1.0	0.4	40	80	1600	214
B	7.5	6,000	8.0	4.2*	1.1	2.0	70	1000	1400	1278
1969-70										
A	7.5	80,000	8.0	8.0*	2.0	2.0	40	350	1300	
B	---*	200	8.2	5.0	4.5	0.25*	70	235	900	

A = October - April

B May - September

* - Poor Value - Insufficient Data

Blank indicates no data taken.

probably made for irrigation. Any interferences of this nature are, for the most part, speculation and little real, related information is provided. Thus, there is a real need for an interpretation of the reported data.

Putting aside the fact that little organic data was taken prior to 1968, the data reported for measured parameters reveals little information for identifying any trends or changes in quality. Flow, temperature, nitrates, and pH show no explicable or significant variation over the entire twenty-five year period. In the general sense, pH shows a slight increase in alkalinity and nitrates a slight decrease beginning in the 1968 water year. These data records may therefore indicate two situations. On the one hand, there may be no variation of significance in these parameters, which implies, when industrial, municipal and agricultural growth are taken into account, a pollution abatement program keeping pace with additional pollution sources. On the other hand, since a wide variation may be accounted for by inaccuracies in measuring the parameters as previously described, sampling programs and techniques may not be of sufficient sensitivity to document any water quality change. The consequential conclusion is that the data does not reflect the true water quality of the river in even a general sense.

Another noteworthy aspect of the data is that the temperature varies only slightly from year to year. Again, the monitoring system gives us information we can predict with high probability of accuracy; that is, the temperature averages about 45 F in the winter and about 70 F in the summer. Dissolved oxygen values would not be similar in summer and winter due to high dependence on temperature and the probable increased BOD loading from sewage in summer. However, on the positive side, the temperature could not be predicted without this historical record. This discussion is not to imply temperature is not a crucial parameter. Certainly, many other parameters are highly temperature dependent. The point is then when a trend has been established for an independent parameter, when its only function is historic record (which is exactly what this type of data has become), the expense of the parameter could be saved by its discontinuance.

Interestingly, in 1968 when the Colorado State Health Department assumed sampling responsibilities, a notable change in the parameters' values occurred, particularly in pH . A reasonable explanation might simply be a change in collection technique or slight variation in the location of the sampling point. This points out the need for consistency in sample collection and laboratory analysis whenever they are taken. Transitions from one collecting agency to another, or changes in personnel, must be made with the greatest of care. Unless a norm of constancy may be applied to the data, its value to a water quality manager becomes, for all practical purposes, useless. The individual who bases his decisions on these data must assume they represent a consistent record, which can be compared with data from other stations.

Total dissolved solids (TDS) is the single parameter which may indicate an increasing trend. Values have risen from about 1300 ppm in the mid-1940's to about 1500 ppm in the late 1960's. However, this is not surprising when the growth of irrigated acreage is taken into account over the past twenty-five years in the South Platte Basin. The Colorado-Big Thompson Project, alone, supplied supplemental irrigation water for 720,000 acres in the South Platte Basin starting in the late 1940's. Mysteriously, the Public Health Department computes an "annual volume weighted average" for TDS without taking the corresponding flow measurement necessary to compute total yearly volume.

The usefulness of the parameters is further diminshed by infrequent samplings, as denoted by the values with asterisks. These poor data are particularly prevalent in the pH record, 1945-1968, and nitrates, 1953-1968.

The values for biochemical oxygen demand are interestingly low from 1967 to the present at Julesburg. The Federal Water Pollution Control Administration reported in 1967 that the digestor at the Julesburg sewage treatment plant had not been emptied in two years and the sludge was being dumped directly into the river. In addition, bypasses during peak inflows, along with overflows, were common. Ironically, the sampling station and the sewage treatment plant are both located at the Highway 385 bridge, southeast of Julesburg. The extremely high fecal coliform count (as high as 4.9×10^4 in 1968 and 1.2×10^5 in 1969, Colorado Department of Health data), is indicative of animal waste which bears out the fact that sewage was included in the sample (Kittrell, 1969).

Significantly, the bypasses were not detected from observed low BOD levels, but from the known fact that the plant had no disinfection facilities which was needlessly reiterated by the high record of coliforms. From a realistic standpoint, neither of these parameters has any value. The monitoring system failed to indicate improper plant operation and reported high coliform counts, which had to exist because of the lack of chlorination.

The point of this discussion is not to criticize for destruction's sake. Certainly, there are instances which may use the data effectively. The intent is, however, to point out that even through collection and sampling systems are taken by nominally different agencies (e.g., the FWQA has come under direction of the EPA), the same kind of hollow, paper shuffling data is still being generated. Worse yet, national policy is being established to enlarge the present system. The individual data or samples, themselves, may be of excellent quality, but relative to the entire basin system and relative to the goals and objectives of water quality agencies, the data is at best a very expensive, vague indication of any water quality phenomena.

The Platte at Henderson

The South Platte at Henderson was a second station selected to show significant changes in water quality in the South Platte River. Henderson was chosen because it is the only station below Denver which includes the effects of all the metropolitan tributaries; Bear Creek, Clear Creek, Cherry Creek, Sand Creek and Plum Creek. In addition, this station offered the most complete list of sampling parameters over the longest period of record for that area. Samplings at Henderson should be indicative of the marked progress in pollution abatement in the Denver Metro area if the data could show change. In particular, evidence was expected regarding the operation of the 117 MGD, $17.4 million Denver Metro Plant which began operation in October 1966.

Again, as for Julesburg, a data summary table is presented in Table 25 for the South Platte River at Henderson water quality station. As before, many of the data's shortcomings experienced at Julesburg are

Table 25

Selected Data in the South Platte River Drainage Estimated Averages for Henderson

YEAR	DO mg/l	FECAL COL /100 ml	pH.	BOD mg/l	NITR ppm	PHOS ppm	TEMP F	TURB J. U.	TDS ppm	Q cfs
1954-55										
A			7.8		13				752	56
B			7.6		15				400	327
1955-56										
A			---		---		40*		---	56
B			7.6		19		60		500	331
1956-57										
A			7.6		27		40		750	93
B			7.3		8		60		300	1336
1961-62										
A			7.1*		T				213*	504*
B			7.3*		15*				916*	388*
1962-63										
A			7.3		8.0				850	66
B			7.3		0.6				700	197
1963-64										
A			7.5		12*				900	94
B			7.4		13				700	289
1964-65										
A			7.3		15*				800	158
B			6.9		2				300	1161
1965-66										
A			7.1		5.1		45		650	241
B			7.1		16		60		550	242
1966-67										
A			7.3		3				700	201
B			7.2		12				600	408
1967-68										
A										148
B	4.8	2,600	7.7*	16*	---	---	66	50	600	415
1968-69										
A	4.0*	31,000	7.5*	26*	5.0	6.0	52	40	750	95
B	5.0*	34,000	7.9	10*	2.5	0.9	69	200	350	410
1969-70										
A	7.1	44,000*	7.7	7.7*	3.5	6.5	42	40	640	
B	5.0	3,700*	7.8	---	3.2	2.3*	60	180*	300*	

A = October - April

B May - September

* Poor Value - Insufficient Data

Blank indicates no data taken.

evident. Temperature records are very sporadic. No organic data is available until the 1968 water year, which eliminates the possibility of documenting any effects of the Denver Metro sewage treatment plant in reducing the organic load of the South Platte.

Of the two selected water quality sampling stations, the South Platte at Henderson appears to be best documented by cross-references from three collection agencies. In order to examine these data without prejudice, consideration should be given to the possible states of water quality in the river. The water quality conditions are products of political events, which produce physical changes on the river and the many sources of degradation and dilution. Therefore, two possible hypotheses may be proposed for describing the monitored condition of water in the river.

The first hypothesis, if the data shows no change, is the advent of new treatment facilities and/or management techniques are compensating for growth in industry, population, agriculture and other pollution sources on the South Platte. Prior examination of data at Henderson and Julesburg indicates this is the apparent case if the monitoring and sampling systems are complete and descriptive.

The second hypothesis, again if the data shows no change, is the water quality varies, but the monitoring system is not sensitive, or accurate enough to detect changes in the water quality. This thinking leads to two possible sub-hypotheses. Accordingly, the water quality either improves or degrades. The improvement of water quality is not likely, particularly since the establishment of Colorado's 80 percent BOD removal standard for domestic sewage innately makes no account for <u>volume</u>, or the <u>influent condition</u>, of the sewage. Support is given to this statement by the facts that in 1953, only 7.7 percent of about 1,000,000 of the domestic population served in Colorado received secondary treatment. By 1970, 99.9 percent of the population received secondary treatment in the South Platte Basin alone, Henderson being downstream for more than half of Colorado's entire population of 2.2 million (Colorado Department of Health, 1970). In other words, the effluent standard of 80 percent does not in any way compensate for variation in volume from the various polluters.

The degradation of water quality is the second of the two possible sub-conditions. Because of the inconsistency of the data shown in the foregoing discussion, and the variability of water samples taken from the several agencies, documentation of this condition is likewise difficult. There are a number of different sources which could lend support to either condition.

First, the Federal-State investigating committee reported in 1966 that prior to Metro's operation, pollution sources in the Denver area were producing near septic conditions below Denver and had a significant degrading effect on the river downstream to Greeley (FWPCA, 1966aa). There is no indication in the existing data to support, or even suggest, such severely poor conditions.

The second source to indicate that data collection is <u>not</u> sensitive is the latest annual report of water pollution control from the Department of Health and Hospitals, City and County of Denver, which lends support to the fact that significant physical change <u>has</u> occurred, as can be seen in Figure 7. The water quality at the Franklin Street bridge immediately below Denver Northside plant showed a marked improvement after a period of initiation at the advent of

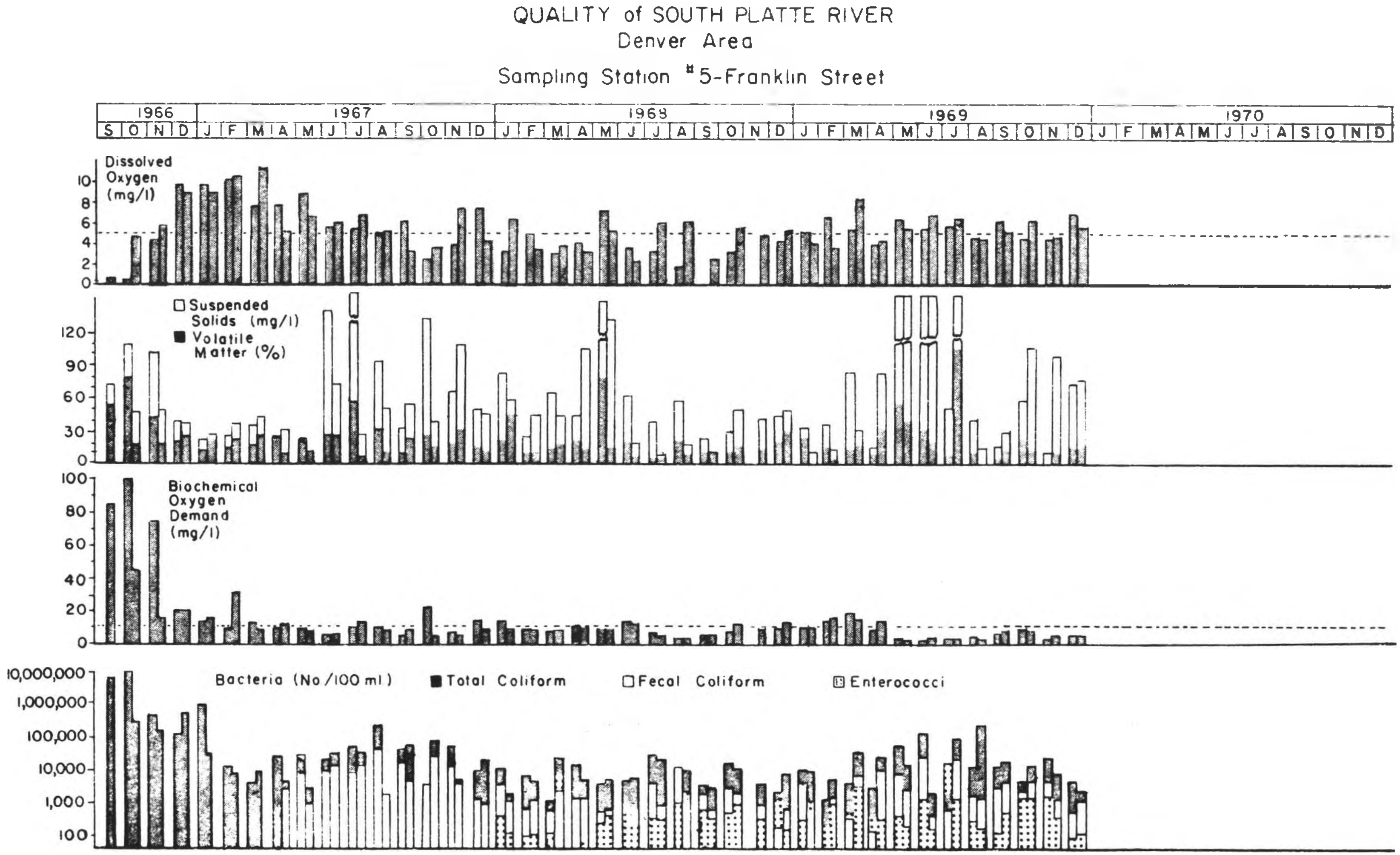


Figure 7. Quality of South Platte River, Denver Area

Metro Denver Plant No. 1 on October 17, 1966. A sharp decrease in BOD is especially noticeable, indicating Denver Metro did in fact have a strong influence on water quality in that reach of the river (Department of Health and Hospitals, City and County of Denver, 1970). The nature of the data, however, is not comparable and is indicative of no change.

The available data indicates a relatively high quality stream, an evidently incorrect conclusion through the mid-1960's! As may be the case for every sampling station, the Henderson data makes no justifiable documentation or interpretation, of any increase or decrease in water quality. This is a significant shortcoming of the data.

Based upon the above statements, the data which has been collected at Henderson is, for one reason or another, not really indicative of the water quality at that point. Again, the expensive monitoring record has provided little information on the real or macro condition of the river.

The Relation of Parameters to Standards

The whole point of analyzing the technical validity of water quality data would be missed if the purpose of taking the data were not discussed also. The question must be asked: Does the collected data supply the information necessary to carry out the water quality objectives established by law? If it does not, then the system should be modified or abandoned and an effective system instigated. Unfortunately, we have already seen, in general, that the past and present monitoring systems, as exemplified by Henderson and Julesburg, are of little use in meeting the objectives of documenting trends or identifying particular pollution events.

First of all, in regard to the legislative statement of purpose for water pollution control, it becomes clear the monitoring system misses the mark.

The legislative statement is:

> ...whereas it is the public policy of this state to conserve the waters of the state and to protect, maintain, and improve the quality thereof for public water supplies for the propagation of wildlife, fish and other aquatic life, and for domestic, agricultural, industrial, recreational, and other beneficial uses, and to provide that no wastes be discharged into any waters of the state without first being given the degree of treatment necessary to protect the beneficial uses of such water...
>
> (CRS, Art. 66-78)

Two points shall be made here. The first is to realize that in order to "protect, maintain, and improve" water quality it must constantly be known what the true, representative quality of the stream is. The initial condition must be known, the continuing condition must be known to detect any possible change with time, and future conditions must be known to measure the effectiveness of remedial measures and programs.

On the basis that both Henderson and Julesburg have longer and more complete data records than the other permanent quality stations on the South Platte, and on the basis of how poorly that data represents water quality at those stations, it is reasonable to imply that we do not really know the water quality for any station at a given point in time on the River. Therefore, if the water quality status cannot be known, the water quality certainly cannot be protected, maintained or improved from a remedial standpoint.

The second point stems from the policy statement that wastes be "given the degree of treatment necessary to protect the beneficial uses of such water." Existence of treatment facilities in no way guarantees efficient operation and subsequently does not guarantee compliance with stream standards.

Governor Love in his January 10, 1972, State of the State Address estimates that all communities with municipal sewer systems will provide primary and secondary treatment by July 1, 1972. In addition, all but one industrial violator is not installing equipment to comply (Love, 1972). The appropriate conclusion is that Colorado about has water pollution under control. The fallacy in this logic is, however, as above, existence of facilities does not guarantee compliance to standards. The need, therefore, exists for an accurate monitoring system which may effectively supply data to protect, maintain, and improve water quality for beneficial use.

In review, the basic standards applicable to all waters of the State (which of course includes the South Platte at Henderson and Julesburg) are as follows:

1. All wastes shall receive secondary treatment (80% BOD removal) or the industrial equivalent;
2. Free from wastes which will settle to form unsightly, putrescent, or odorous bottom deposits;
3. Free from unsightly floating debris oil, grease and scum;
4. Free from materials which will produce objectionable odor, color, taste, or turbidity or objectionable aquatic life which may result in eutrophication;

5. Free from high temperature biocides, toxic or deleterious substances in concentrations sufficient to be harmful to human or animal like; and

6. Shall be within safe radioactive levels.

The Colorado Department of Public Health data in no way indicates nor is a technique specified, how the Water Pollution Control Commission shall be informed of "unsightly, putrescent, or odorous bottom deposits" which are forming. There is no specification in the monitoring system which directs the sampler to smell or taste the water or to make visual evaluation and comparison of bottom deposits. Neither is the sampler required to visually inspect the waters for floating materials, grease or scum.

It is evident that even though a wide range of parameters are sampled, the necessary mechanisms for tying the data results to the protection, maintenance and improvement of the water is absent. In particular, the collected information is not linked in an effective manner to protecting, maintaining or improving the established stream <u>standards</u>.

The particular classification for the waters of the South Platte below York Street to the State line (which includes both Henderson and Julesburg) is A, C. D. These classifications in full, are these:

<u>Class A</u>.

1. The following standards shall apply to water withdrawn for treatment as a <u>potable</u> <u>supply</u>:

   a. <u>Bacteria</u>: Wastes or substances from controllable sources shall not be discharged into these waters in amounts which will cause the number of organisms of the fecal coliform group, as determined by either multiple tube fermentation or membrane filter techniques, to exceed a log mean of 1000 per 100 milliliters or exceed 2000 per 100 milliliters in more than 10% of the samples collected in any 30 day period.

b. Dissolved Oxygen: Dissolved oxygen shall not be less than 4 milligrams per liter.

c. pH: The pH shall be maintained between 6.0 and 9.0.

d. Taste and Odor: Free from materials attributable to municipal, domestic, or industrial wastes, or other controllable sources that will produce taste or odor in the water.

e. Dissolved Solids: Total dissolved solids, annual volume weighted average, should be less than 500 milligrams per liter.

f. (Plus requirements for selected chemical constituents.)

CLASS C.

1. The following standards shall apply to waters classified for industrial uses:

   a. Dissolved Oxygen: Dissolved oxygen content shall not go below 3 milligrams per liter.

   b. pH: pH shall be maintained between 5.0 and 9.0.

   c. Turbidity: No turbidity shall exist in concentrations that will interfere with established levels of treatment.

   d. Temperature: The temperature shall not exceed 90°F.

CLASS D.

1. The following standards shall apply to waters classified for irrigation:

   a. Total Dissolved Solids (Salt) Concentration: A time-weighted monthly mean at a monitoring station which exceeds the time-weighted monthly mean for a base period established by the Commission by more than two standard deviations shall be subject to review by the Commission.

   b. Sodium Adsorption Ratio: A time-weighted monthly mean at a monitoring station which exceeds the time-weighted monthly mean for a base period established by the Commission by more than two standard deviations shall be subject to review by the Commission.

   c. Toxic Material: Free from biocides, toxic or other deleterious substances attributable to municipal, domestic, industrial wastes, or other controllable sources in concentrations or combinations which are harmful to crop life.

In areas where classifications conflict, such as this, the most restrictive prevail. Therefore, for simplicity, the Class A, potable water supply standard will be examined in light of the available data for Henderson and Julesburg.

As will be discussed, Colorado has by virtue of its newly added stations decreased its monitoring frequency on routine sampling stations from about twelve to about eight times per year. Therefore, if only one sample is taken within a 30 day period which exceeds the

2000/100 ml fecal coliform bacteria requirement, not only is it in excess of "10% of the samples collected," but is 100 percent!

The dissolved oxygen and pH requirements appear to be in compliance if the samples are accurate and are miraculously representative of true conditions. The foregoing discussion of Henderson indicates, however, that samples are not representative.

There is nothing in the standard to indicate what materials monitored relate to taste and odor. No direct test exists to quantify taste and color and consequently, neither is record made in the data.

As pointed out before, the Colorado Public Health Department mysteriously computes the "annual volume weighted average" for total dissolved solids without taking the necessary corresponding flow data to compute TDS.

In summary, it is the author's contention that the data collected by the present monitoring system on the South Platte is neither technically indicative of water conditions, nor does it relate to accomplishing established use classifications.

The apparent reason for this is that the thinking necessary to relate data collection with accomplishing water quality goals has never been done at a Federal or state level.

We may imply that Federal law has established a system that requires the states to go through the motions of data collection. It will be recalled that the states were given help to establish standards but surveillance systems were not subject to Federal approval.

The process is continuing. Even the President's Council on Environmental Quality in 1970, recommended that more expansive systems of data collection be established nationwide (Council on Environmental

Quality, 1970). In the author's opinion, this kind of thinking serves no more purpose than the past systems of collection. New systems without articulated goals of data application will only be a propagation of the same useless forms of data now being collected. New data systems should be designed subject to Federal and state legal standards, so the resulting new data may accomplish the legislative goals of water quality management systems.

New management thinking must acknowledge careful consideration of the many factors influencing water quality. Primary consideration must be given to large return flows from irrigation, industries and sewage treatment plants. Consideration must be given to the many difficult aspects of water quality, including evaporation from water surfaces and soils, transpiration from crops and phreatophytes, precipitation and infiltration. If these constituents are ignored, data interpretation will be distorted.

The conclusion of this discussion may only be that the evidence of any physical change in water quality data is only as good as the data upon which it is based. In addition, the effectiveness of water quality standards are only as good as the mechanisms which <u>use</u> the data bring about change. Therefore, if our data base is unreliable, we may not justifiably say our abatement programs are effective, or even justify construction of additional treatment facilities.

Chapter 7

MANAGERIAL EVALUATION OF DATA APPLICATION

Inadequacies of Management

The Basic Technical Failure

The data examination in the last chapter revealed, that the present system of data collection in Colorado yields little information about the true quality of the South Platte. The examination of two specific quality stations, Julesburg and Henderson, showed with particularity that the data monitoring system does not have the capacity to accurately describe events influencing water quality. The data was examinated at these stations to determine if the techniques of data collection could depict reliable information concerning physical characteristics of the water. It was seen that, for the most part, it could not.

Background and Purpose of Monitoring

It has been discussed at length of how, from a managerial standpoint, data collection is established as the backbone of the water pollution control system at Federal and State levels. As has been pointed out, all Federal legislation since, and including, 1948 has incorporated monitoring to reveal pollution problems, define their extent and nature, act as a basis for recommending remedial actions and to identify compliance or non-compliance with those recommendations. The whole enforcement-conference procedure has been shown to be dependent upon the accuracy of data and its ability to describe quality conditions.

The most important of all the Federal legislation with regard to state action was the Water Quality Act of 1965. This Act required the states to adopt water quality criteria and plans of enforcement and implementation by June 30, 1967. As is the case for other Federal legislation, no requirement was made, nor were guidelines set forth to establish or approve continuing systems of monitoring to measure adherence to standards or establish bases of enforcement. Or in other words no guidelines were set forth so the data could be applied to meet the various water quality objectives.

As previously explained, Colorado responded to the Federal requirement and established its own water pollution control authority. The technical aspects of data collection within this authority have already been examined and as is the case for Federal legislation, Colorado's water pollution control system also is found to be implicitly dependent upon evidence. As is for the Federal legislation, Colorado has no mechanism whereby data can be applied to meeting quality objectives.

Pre-1966 Objectives

Prior to the creation of the Water Pollution Control Commission in 1966, the Colorado State Department of Health, by means of a quality testing program, was delegated the responsibility of determining adequacy of abatement measures, developing programs for abatement and ascertaining changes natural and otherwise in water quality. The specific water samples were to depict physical, chemical, biological, and radiological effects of water quality which affected possible recreational, industrial, agricultural, fish and wildlife and municipal uses (CRS, 1963b). More importantly, minimum standards were established for the quality of effluent domestic sewage. Settleable organic materials could not exceed 0.5 ml per liter, suspended organic matter could not exceed 75 ppm by weight, and no more than 50 ppm of 5-day

BOD could exist (CRS, 1963a). This provided a consistent, source identifiable, criterion against which the regulating agency could bring legal action. In addition, the powers and duties of the Board of Health under the old system were to hold hearings upon issuance of the tentative findings by the Department of Public Health. Under the jurisdiction of the State Board of Health, the Department of Public Health provided specific data for the Board's review and action at an operational level. These stipulations were repealed in 1967 at the creation of the Water Pollution Control Commission. The primary difficulty of this system in practice was that little action was ever taken.

The authority for pollution control was divided among several State agencies prior to 1966 including the Health Department, Game, Fish, and Parks, Oiland Gas Commission, and other State agencies and municipalities. As a result, objectives for water pollution control were varied and consequently so were the goals of monitoring (Colorado Public Health Department, no date).

Post-1966 Objectives

The Colorado Water Pollution Control Act of 1966, in line with 1965 Federal requirements, established a new control authority; the Water Pollution Control Commission. The purposes for controlling pollution paralled Federal considerations such as health, fish and wildlife, recreation and other beneficial uses. Also in line with Federal requisites, Colorado adopted stream standards and an enforcement procedure. As is the case for Federal law, data is required to identify pollution problems, define the extents and constituents, act as a basis for corrective actions, and finally, to indicate compliance or non-compliance with stream standards.

The Underlying Cause of Failure

Upon examination of the Colorado law, a significant fallacy begins to appear: The specific need for data is very clear as in Federal law, but the method whereby conclusive data may be applied to protect, maintain and improve water uses in the State is not clear.

Now the Division of Administration (which means the Division of Administration of the Public Health Department), particularly the Division of Water Pollution Control, acts as an advisory function to the Water Pollution Control Commission for establishing comprehensive programs for the prevention, control and abatement of the pollution of the state's waters as discussed (CRS, 1963c). The administrative division is directed to take such samples as are deemed necessary (presumably by the Commission) to determine the amount of pollution of any of the waters to use the "most effective methods" in making such determinations (CRS, 1963h).

The new expressed purpose of monitoring is considerably less specific than before 1966. The duty of the Commission is now to cause samples to be taken periodically "in a logical geographical manner" so as to advise the Commission of the water quality standard of the waters of the State. When these samples "prove" to be below the set standards for a river reach, then the Commission is to determine 100 per cent of the sources responsible for that pollution (CRS, 1963d).

It is apparent that Colorado has essentially only generated laws to comply with Federal requirements for water pollution control. The thinking necessary to monitor or collect data to meet established goals has never really been done at either Federal or State levels.

Recent addition of new data stations bears out this allegation and indicates the Water Pollution Control Commission is proliferating this same type of reactive regulation. The Division recently announced the addition of 40 new sampling stations, increasing the total to 129 (Colorado Department of Health, 1971b). No provision was even suggested for putting the new data to use. The reasons for this upon investigation became evident. Data collection is being greatly influenced by Federal grant application instructions. The Colorado Water Pollution Control Division has interpreted these instructions to mean that they must sample every stretch of water that has a different stream standard to qualify for grants. Consequently, the Division has recently expanded their surveillance network from 89 stations to 129 stations in order to supply the grant application with the required information. In the process, the sampling frequency of the 77 stations has dropped from once-a-month to about eight times per year. The effect has been to direct the surveillance network away from specific data on main streams to general data on all streams (Ward, 1971).

In conclusion, it is evident that Colorado is not collecting data to meet legal objectives of water pollution control, but to satisfy Federal requirements.

Ineffective Data Use

The ultimate result of collecting data in this fashion is essentially that the data becomes vague historic record only. The data collection is neither frequent enough or specific enough to supply information necessary to meet water quality standards. The purpose of data collection by law is to inform the Water Pollution Control Commission of stream violations in order that all the sources of pollution may be determined, but obviously the data collection system is not designed to do this. Data is collected subject to the technical restraints previously discussed, recorded on an unmanageable size paper, violations circled in red, and replaced in a file until the next entries are prepared. Further emphasizing the system's plight is the fact that the alleged enforcement body, the Water Pollution Control Commission, has seen the data only infrequently even though violations exist.

The shortcoming of the data-collection/enforcement system is that the Water Pollution Control Commission apparently has no effective means by which to receive feedback on data collected by the Division of Water Pollution Control monitoring system. Discussion with personnel within the Division of Water Pollution Control indicates that the Commission, seldom, if at all, sees violations of stream quality standards. Presently, the system for noting violations is for the chemist or lab technician running the analysis on a water quality sample to notify by word of mouth, or memo, the Director of the Division of Water Pollution Control, or his assistant. The Director of the Division, who is also Technical Secretary to the Water Pollution Control Commission, at his discretion, includes these reports of violations in the agenda for the meetings of the Water Pollution Control Commission.

Even the designated assignments of water pollution control personnel provide no means through which the data may ever be utilized. As mentioned before, the Technical Secretary prepares agendas for Water Pollution Control Commission meetings, but is in no way assigned the duty of periodically informing the Commission of the conditions of water in the state. Neither is the Director of the stream surveys designated the duty of performing data analysis. Specifically, he is assigned supervision of field studies, special studies, and mobile laboratory operations for the entire state. No effort is made to coordinate data collection with its effective use (Colorado Department of Health, 1971a).

Common Difficulty

This difficulty in coordination between data collection and achieving goals is not peculiar to Colorado. E. J. Cleary spoke to this point at the National Symposium on Data and Instrumentation for Water Quality Management, July 1970 (Joint Committee on Water Quality Management Data, 1970):

> On one matter there was general agreement. We are not doing as much as we should with the data already in hand. In brief, and in spite of the sophisticated tools now at hand for data storage, reduction, and manipulation, vast amounts of information are being accumulated but seldom subject to interpretation or evaluation. Quite clearly, it appears that the facility for collecting data has not been matched by enthusiasm for employing it for diagnostic purposes.

The alleged difficulty in not providing feedback to the Water Pollution Control Commission has been lack of personnel. This deficiency is to be remedied by developing a program to output violations on the recently installed "STORET" computer terminal at the Water Pollution Control offices (Frank Rozich, 1971b).

Two difficulties are still apparent, however. First, the use of the Storet system does not affect the quality of the original data. Another extract from the National Symposium on Data makes this point (Joint Committee on Water Quality Management Data, 1970):

> Computerized water quality data storage and retrieval, no matter how efficiently accomplished, will not improve

> the quality of the basic data. Information to be used must be prepared with care and properly labeled.

The specifics of data reliability are discussed in detail in an earlier section.

The second difficulty is that use of the computer system still does not mean data can be effectively applied to meeting goals and objectives.

At every level of the water pollution organization, specific provisions should be made both for analyzing <u>all</u> collected data and providing a systematic application scheme for the data.

A Possible Alternative

The State Engineer is presently working on a scheme to institute a data bank for the quantity records of surface and subsurface flows in Colorado. Incorporation of quality records into such a system could be an acceptable alternative to managing data for both quantity and quality interests. This does not solve the application problem, but would help alleviate the unusable format of data.

Many problems associated with managing quality data are also encountered with quantity data. Not unlike quality data, quantity data may take as long as 16 months to be processed from field to print. Techniques to reduce this severe time lag need to be developed. Software which could allow direct transferral of field data to the computer is yet to be effectively developed. The work load accrued by copying data over by hand or punching computer cards by hand are serious limitations.

However, when these mechanical difficulties are overcome, a number of advantages would be gained from a data bank. One great advantage would be the virtually unlimited access to files and an ability to manipulate data. Unlike "STORET", the computer handling this data would be locally operated within Colorado.

Hand-in-hand with combining quantity and quality data into a centralized bank could be the elimination of duplicated site visits. As it now stands, field teams taking quantity data may visit the same station as teams taking quality data. A single team could record both aspects simultaneously in one visit. The value of both kinds of data would be enhanced by taking simultaneous data measurements, as well as eliminating duplication of efforts. Flow and quality measurements would at last be taken together.

Before such a system could be innovated, however, careful consideration and much planning would have to be given to identification, updating and retrieval techniques, as well as their associated costs (Longenbaugh, 1971).

Conclusion

The entire difficulty of the data's failure to meet water quality objectives should not be unexpected. Although guidelines were issued to the states to establish criteria and standards to aid compliance with the Federal law, no instructions were issued so continuing surveillance could provide information to enhance, protect, and control water quality.

Colorado has essentially only generated water pollution control legislation to comply with the Federal requirements of adopting standards. The thinking necessary to apply data collection to attaining standards has not been done at a State level as well as Federal. Therefore, the evidence that indicates the monitoring system's failure to supply information needed for attainment of standards on the South Platte, is not unexpected.

Chapter 8

MANAGEMENT OF MONITORING TECHNIQUES FOR MEETING WATER QUALITY OBJECTIVES

Meeting Objectives with Monitoring

Possible Objectives

As suggested in the previous chapters, the establishment of a water quality monitoring system requires effective linking with pollution control objectives. The specific categories of objectives which could be met by the establishment of a particular monitoring system may be as follows (Sayers, 1971):

1. Identification of compliance or non-compliance to water quality standards, or even better, monitoring the efficiency at which the present system is operating;
2. Documentation of baselines and trends in water quality to aid management of water related planning;
3. Measurements and documentation of abatement programs; and
4. Establish a prevention system of surveillance to instigate correction procedures and anticipate water quality problems.

As may be compared to the previous discussion, these categories of objectives delineate, in concept, the objectives of Colorado water pollution control.

System Constraints

Intuitively, any surveillance program may be considered subject to a number of constraints varying in nature and magnitude. These constraints upon a monitoring system may be categorized by the following possible seven topic headings:

1. needs of data users;
2. utilization ability;
3. available resources;
4. legal requirements;
5. available technology;
6. operational criteria; and
7. operational responsibility.

1. Needs of data users - Naturally, the specific needs of data users vary widely. All too often, as has been mentioned before, general data collecting schemes become more trouble than they are worth to put in usable form, statistically generating missing data, interpolating values between sampling points, and the like. To place the bulk of research resources on interpreting data correctly and directing those findings to reach an objective would be more useful than just generating data - regardless of how good it is.

The design of a water quality monitoring system must consider what quantity of data the user can utilize successfully. Continuous sampling for an irrigation project is not essential, whereas for public water supply, it would be highly beneficial. In a similar manner of thinking, the same irrigation project would necessitate measuring a few parameters with rough accuracy, while the potential domestic water supply might require that many parameters be measured with the best possible accuracy of the testing equipment. Likewise, the chronology and location of samplings may vary greatly; certainly the irrigator is primarily interested in water quality during the irrigation season, where the public water supply must be year-round.

Another aspect of users' needs often ommitted is the corresponding flow data for a given water sample. For example, an anomalous high flow value accompanied by a high coliform count could readily be explained by the fact that the particular sample was taken after a heavy rainfall downstream from a feedlot from which runoff is occurring. In this case, neither quantity nor quality could have explained the phenomenon singly; neither had value until they were combined.

2. Utilization ability - Hand-in-hand with the data users is his ability to utilize collected data. Colorado Department of Health, Division of Water Pollution Control, has recently acquired in its central office in Denver a remote computer terminal. Storage and manipulation of data is virtually unlimited, accompanied by ready availability of that data. However, the Department has neither the manpower nor the expertise to utilize this service; at this point in time, that machinery is a tremendous loss of resources.

3. Available resources - Unfortunately, water pollution control has traditionally taken low priority in appropriations. Schools, highways, parks and recreation facilities have always superceded the necessity of regard for the environment. This low priority on the funding list has generated a score of poorly maintained, inadequate treatment facilities coupled with equally poor attraction of qualified operational staff. All new plans and facilities for abatement must, for the most part, begin with rennovation of institutions and facilities alike. In short, all abatement programs must be designed to utilize funds, manpower and inherited facilities to their optimum combination to achieve a maximum level of pollution abatement.

4. Legal requirements - As was implied previously in the discussion, pollution monitoring schemes must operate within the bounds of Federal, state, and local legal requirements and regulations. At each level, if the intent of the data collection is to provide a basis upon which legal action could be taken, the data taken must have evidentiary probity. This could indeed mean a legal search to investigate what form and what accuracy of data is accepted by the courts for a given pollution proceeding. As pointed out before, an abatement procedure of this type requires data which must hold up in court.

Perhaps sampling site acquisition bears brief mention. In some instances, access to a sampling location and maintenance of equipment at that location necessitates crossing private land. Due consideration must be given to obtaining permission, performing condemnations, or providing compensation to the owner for damage.

5. Available technology - Water quality standards are frequently set which exceed monitoring and abating abilities. To require attainment of a standard, when no testing equipment of sufficient accuracy exists to measure the water quality parameter, or there is a lack of technology for removing the pollutant, is absurd.

This points out a general danger of establishing a water quality standard. In reality, it is a "license to pollute" if it is attainable. A treatment operation utilizing the best available technology and operating at its highest efficiency would be a better solution. Then, intuitively, the highest degree of abatement is being performed.

This same sort of thinking is applicable to operation personnel as well. Operators must know how to produce the highest quality effluent with any given installation of equipment. This suggests a continuous updating of techniques and "continuing education" for those operators.

6. and 7. Operational criteria and responsibility - Every water quality improvement program is consigned to operate within social and economic criteria. Beyond the traditional "cost-benefit" economic considerations, social patterns may have an influence on devising data collection systems. As an illustration, a community may be accustomed to working a strict eight to five, five day work week. An agency which is attempting to instigate a 24-hour, 7 day a week monitoring system may face great difficulty in hiring employees to operate such a system.

Included in operational considerations is the need to anticipate to what degree equipment must be maintained. A complex, multi-million dollar treatment plant may be useless if personnel are insufficient, or unqualified, to maintain the facilities.

Fitting the Data to the Objectives

Superimposing the Restrictions

Now that limitations have been established for the four major quality objectives, these restrictions may be superimposed on the objectives. For reiteration and condensation, a short list of questions generated by restrictions toward accomplishment of those objectives may be useful.

1. Identify compliance or violation.
    a. Will data have legal validity?
    b. Is real time data necessary? For example, a sewage

treatment plant bypass which shows up in processed data three months after it has occurred is of little use to improving water quality.

c. Will data legally attribute pollution to a specific source?

2. Identify trends in water quality.

   a. Will spatial expanse coverage be sufficient for good planning? For example, should the whole river basin be considered, or sampled, at one time.

   b. Is the data uniform throughout the sampled area?

   c. Does the surveillance correspond to the intended use?

   d. Will the data taken be usable to those who need it?

3. Measure and document abatement programs.

   a. Is surveillance thorough enough?

   b. Is coverage sufficient?

   c. Are the number and kind of parameters extensive enough, or too extensive?

   d. Will new data be comparable to old data?

   e. Is the site placement and type of monitoring appropriate for depicting kinds and sources of pollution?

4. Establish preventive monitoring systems.

   a. Will the data be in a form usable to the user? For example, strip charts of dissolved oxygen versus time are of little value to a fish biologist.

   b. Is the rationale for establishing the surveillance system based on a systems approach?

(1) Is a analytical format technique necessary?

(2) What is the data flow in the system?

(3) What is the necessary frequency of sampling?

Data Collection Techniques

We have at out disposal three data collection techniques for accomplishing water quality objectives: remote sensing, automatic monitoring, and grab sampling. To reach an optimum combination with all three systems, we need to examine their relative advantages and disadvantages simultaneously by the following simple matrix (Table 26).

Each technique for collecting data has its own respective advantage as depicted by the diagonal across the grid in Table.

Grab sampling has the greatest advantage in measurability of virtually limitless numbers of parameters.

Automatic monitoring has an advantage of supplying continuous data at a given collection site.

Remote sensing has the distinct advantage of vast spatial coverage of a given area. The greatest sacrifice is the apparent loss of quantitative water quality data.

Remote Sensing

At first glance the loss of quantitative water quality data may appear to be a severely limiting restriction to gathering data by remote sensing. However, a closer examination may reveal an amazing amount of data, perhaps not in terms of quantitative concentrations, but nevertheless a useful monitoring tool.

First, technology in remote sensing is providing an increasing number of devices to reveal many characteristics of scenes not visible

Table 26

Description of Monitoring Techniques

	State of Art Measurability	Time	Space	Personnel and Maintenance
Aerial Remote Sensing	Turbidity Color + Source Temperature pH Flow-Flood	Frequency and Cost Weather and Daylight Not Asccrucial Can Be Telemetered	Dense	High Quality People Low Number Low Maintenance Contractability
Automatic Monitoring	7 Parameters @ 90 Percent Reliability	Continuous and Cost Telemetered Real Time	Sparse	High Quality People Crucial Maintenance Must Buy Units
Grab Sampling	Any Parameter	Frequency and Cost Large Time Lapse	Optional	Intermediate Quality People Moderately Trained Must Hire People

to the unaided human eye. For example, photographic infrared films used in conventional aerial camera systems on, or in the water. Filtering and enhancing techniques may pinpoint differences in density of two mixing waters, thereby revealing mixing and turbidity patterns; an obvious advantage in locating ground monitoring stations.

Research has shown that pollution concentrations may actually be detected from the air. Empirical models are now being devised for such detections (Feinstein and Piech, 1970).

Our interpretive imagination is becoming more limiting than actual device detection of pollutants. For example, if a color infrared photo reveals a healthy bed of underwater plants, we actually know a great deal more than that fact. The presence of such plants indicates fairly high dissolved oxygen content, a tolerable pH range, low sediment or settable solids load (i.e., the silt is not blocking the light), and the absence of choking bottom sludge or undegraded material competing with those plants for oxygen and a stability of water quality conditions.

Ground knowledge of plant varieties may indeed add to the range of these mentioned parameters and further aid data collection.

Even color photography of a scene is of great use to a water manager. For example, the fact that water is brown, indicating a turbid condition, may be sufficient knowledge to answer a question of whether or not a farmer is using poor irrigation practices, as indicated by a muddy surface return flow to a river; whether or not the water has 2000 ppm settable solids, or 2750 ppm settable solids, is immaterial to answering that question. By using remote sensing in this case, the expense of a lab sample has been saved.

More sophisticated devices, such as thermal-infrared mappers, present great potential in managing water quality problems. Thermal resolutions as small as 0.15 C may be detected from an aircraft (Specifications for the RS-310 Airborne Infrared Mapping System, Ca. 1970).

Not only are we measuring temperature, but we realize that since dissolved oxygen is highly temperature dependent, high relative temperature indicates a low level of dissolved oxygen. Clearly, there are many such implications in remote sensing images; the information derived is limited mostly by our imagination.

Automatic Monitoring

Data collection by automatic monitoring generally involves placing a sampling hose in a stream or lake and permanently mounting an automatic monitor on the bank. The stream water is pumped through the monitor, where probes sense the particular parameter to be measured.

Automatic monitors are limited in the number of parameters that can be measured. Some manufacturers claim twenty seven parameters can be measured, but only seven can be measured with the reliability necessary for an action program. Only four of these seven are usually implemented by state agencies. These are pH , temperature, conductivity, and D.O. Chlorine, solar radiation, and turbidity can be measured, but the added information over the first four is not considered worth the extra cost by most states. New York, where automatic monitors have been installed, indicates that 90 percent of the time they are receiving good data.

Automatic monitors, as indicated by the name, monitor automatically and, therefore, they are continuously monitoring the quality of the water that passes through the unit. The data can be recorded on a strip chart by a digital voltmeter or telemetered to a central computer which can also provide checks on the operating condition of the monitor. This last technique provides a real time data supply, which can serve to help the water pollution control agency act in a real time manner.

The automatic monitors are expensive units and consequently, the number to be used will be small. This indicates a space network of automatic monitors. Also, the source of the water is at one point in the stream - whereas water at other points in the cross section may have a different quality if complete mixing has not occurred before a pollution slug passes the monitor.

Maintenance is the life blood of an automatic monitoring system. This requires a trained person who can visit the monitor at least once a week, and more often if the situation arises. Without proper maintenance, the calibrations for the probes drift and the data is useless. Currently, the operation of the pumps is the largest problem associated with the automatic monitors.

Grab Sampling

Data collection by grab sampling is accomplished by randomly choosing a water sample from the body of water to be sampled. The sample may consist of only one bottle of water taken at one instant in time or it may consist of a composite sample which is a mixture of several samples taken at the same point, but at different times.

Once the grab sample is obtained, it is carried to a laboratory where the various parameters are measured. Certain parameters must be measured immediately in order to get an accurate reading - others can wait. Some parameters are measured at the sampling site with portable meters to insure accuracy.

A grab sample supplies a considerable amount of information representing the one sample, but it does not give much information on the changes with respect to time and space. To obtain this type of information using grab sampling will require a large number of samples taken over time and space. The limitations result when a lab can only run so many analyses; therefore, there must be a certain point where the sample collection and analysis is balanced against the cost.

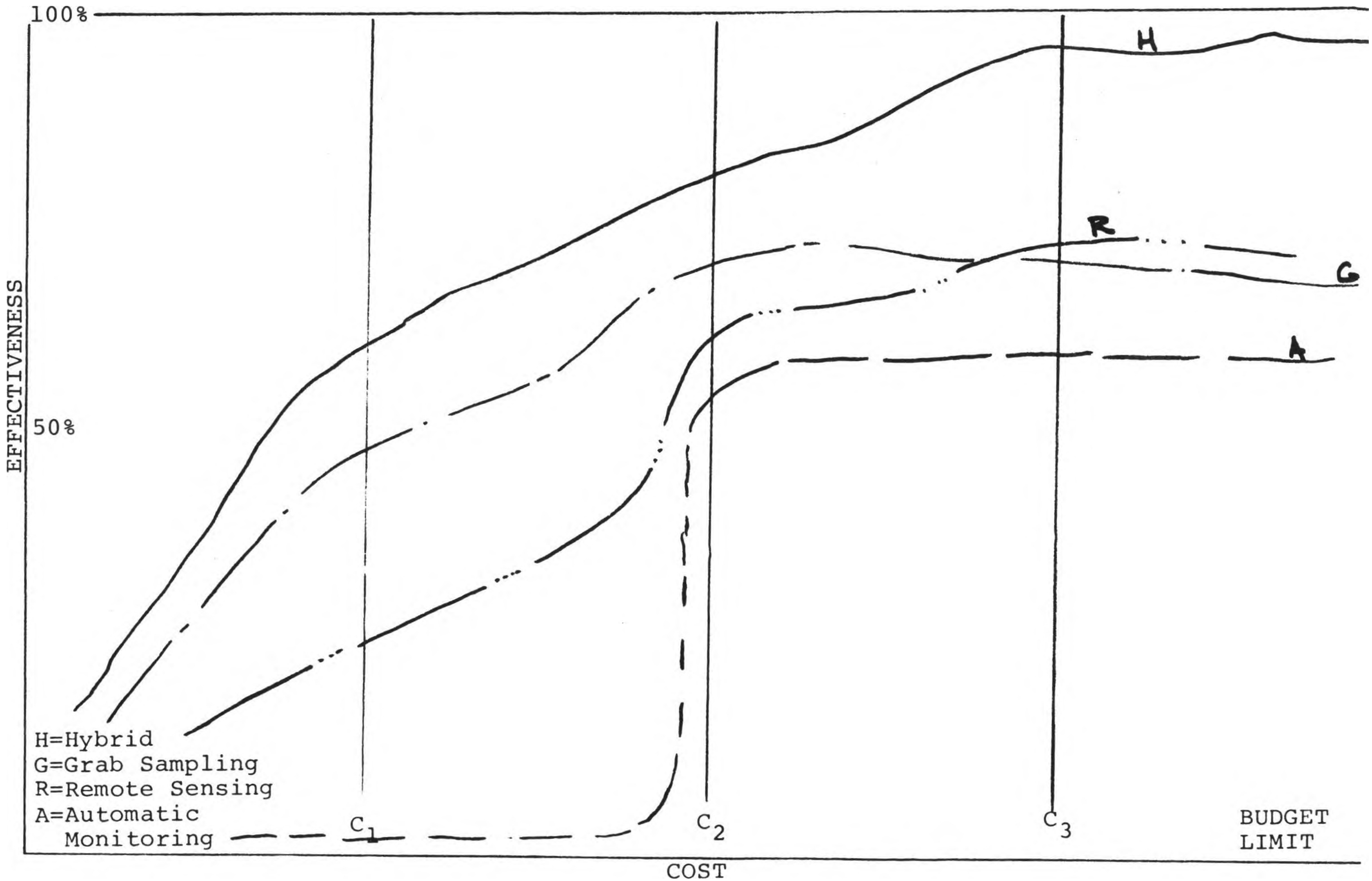
Since the laboratory must analyze the sample with some tests requiring five days to run, the time lapse between collection of the sample and receiving the results is large. This prevents any immediate action on a pollution problem. Before the agency can act, the problem may be over and the damage done.

As noted earlier, the problem with space is simply the balancing of cost versus information needed. The personnel requirements for sample taking and routine lab analyses are not high, but a highly trained person needs to be in charge. Laboratory quality control is extremely important if the data is to be useful for decision making.

Gross judgments on cost-effectives may be made based upon cursory knowledge of the three systems. For instance, because the cost per unit for automatic monitors is high, no results are realized until at least one unit is purchased and placed into operation.

Clearly, there is no simple problematical attack on pollution monitoring problems, nor is there a pat or expected solution to those problems. This format may, however, provide a means by which all the available technological tools for solving water quality monitoring problems may be effectively combined to achieve the best result possible. Figure 8 graphically depicts possible cost-effectiveness situations for each of the three monitoring techniques. Each tool has a particular character, which makes it's use feasible for a given expenditure. Automatic monitoring, for example, gives no data return until one expensive unit has been purchased. The ideal situation is a combined system, which produces an optimal system effectiveness at least cost.

Figure 8
POSSIBLE COST-EFFECTIVENESS COMBINATIONS



Chapter 9

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

As was pointed out before, there are several qualifying points which must be made clear prior to presenting the summary, conclusions and recommendations. First, criticism of the system differs considerably from criticism of individuals within the system. The investigator has no desire to depict villains in the water pollution control mechanism. If specific examples reflect upon particular personalities, it is because those personalities are manifesting themselves in such a manner as to actually be the system. This, of course, may be of a positive or detrimental nature.

Second, the value of such an investigation can only be appreciated when the investigators position is known. Again, as previously pointed out, this inquiry has been made from an academic, outsiders viewpoint. The only in-house knowledge gained by the investigator was derived from personal interviews, comments, conjectures and speculations from materials and "facts" collected over a course of two years. The true value, then, of the following conclusions and recommendations is to realize their source and weigh them accordingly.

Last, in conjunction with the above source bias, is the investigator's personal bias. Because of the investigator's definite tendency to strive to preserve nature, he also has a tendency to be straightforward in his presentation and describe circumstances as he sees them.

With these three qualifications in mind, the summary, conclusions and recommendations will follow.

Summary

Federal action has been the initiating legal backbone of water pollution control and environmental protection throughout the history of the United States. The first Federal legal action occurred in the River and Harbor Act of 1899, which established the unlawfulness of discharging refuse into navigable waters. Twenty-five years later, the Oil Pollution Act of 1924 dealt with oil discharges into coastal navigable waters.

The Water Pollution Control Act of 1948 was the beginning of modern water pollution legislation. State's rights and powers to abate water pollution were brought to the forefront by this Act. Strengthening sequels to the 1948 Act were made law in the Water Pollution Control Act Extension of 1952 and the Water Pollution Control Act Amendments of 1956. The 1956 Act established an enforcement-conference procedure to be later used on the South Platte River Basin in Colorado.

A distinct change in philosophy occurred with the Federal Water Pollution Control Act of 1961. Interest in water pollution control began to pull away from the health aspect and began to include "multi-purpose" concepts of water pollution control. At the same time, oil pollution policy was extended to international waters by the Oil Pollution Act of 1961.

Perhaps, the most significant water pollution control legislation for all time was made law in the Water Quality Act of 1965. This act began to dissolve the states' autonomy in pollution dealings and established a national policy for pollution prevention and abatement. This act was further extended in 1966 by the transferral of water pollution control from HEW to the Department of the Interior and by the amendments to the 1965 Act which lifted grant limitations.

Later, in 1969, 1970 and 1971, a series of acts, reorganization plans, and executive orders helped to polish the country's pollution policy. The most significant innovation was the creation of a new department: The Environmental Protection Agency. This new agency was created exclusively to deal with environmental problems including planning and control.

Throughout the history of Federal water pollution control, evidence has been established as necessary to identify, evaluate, and enforce pollution problems. It is extremely important to note, that even when state adoption of stream standards was made mandatory and subject to Federal approval in 1965, that no Federal approval for stream monitoring on a continuous basis was required.

Colorado has experienced an uncoordinated legal effort in dealing with water pollution control. Early laws disseminated jurisdiction among many agencies and political entities. No real, significant action was taken toward abating water pollution in a coordinated, effective fashion until Federal legislation required action by the states.

The Federal Water Pollution Control Act of 1965 required the states to adopt water quality criteria and plans of abatement and enforcement.

Even after Colorado responded by establishing a Water Pollution Control Commission and subsequently, stream standards, Colorado made no specific or strategic plan for <u>monitoring</u>, on a continuous basis, the changes outlined in law.

The large-scale pollution problem which has developed in the Denver Metro area in the past twenty-five years pointed out the need for such a specific plan.

The Water Pollution Act of 1956 with 1961 Amendments had established a specific procedure by which Federal assistance was given the states to investigate pollution sources and adopt plans for remedial action. At Governor Love's invitation a series of conferences and investigations was begun in 1963. In the following two and one-half years, investigations were conducted and recommendations for remedial actions were drawn together. This provided an excellent basis for the Federally required, 1966 Colorado Water Quality Act which established the Water Pollution Control Commission.

The South Platte Conferences, over a period of about three years (1963-1966), were significant in establishing a sound basis for water pollution control in Colorado. A product of these conferences was a series of highly detailed, technical reports. These twelve reports recorded samples, visits, reviews, and catalogings of the sewage treatment facilities in the South Platte Basin. Special pollution problems from industries and associated odor and vector problems were also investigated in detail.

Unfortunately, no specific review or strategy was set forth to monitor the outlined action proposed.

The Water Pollution Control Commission has developed and adopted a system of stream standard classifications to comply with Federal law. The classification system divides streams into sections of various water qualities according to use of the waters.

The adoption and enforcement of these stream standards, especially the 80 percent BOD removal criterion for domestic waste treatment plants, has created many problems. A most salient difficulty displayed by the Denver Metro Plant is the fact that this criterion does not account for the volume of sewage treated, or its influent condition.

The method of enforcing these standards is cumbersome and ineffective. The nature of legal enforcement methods is resolved to be highly dependent upon evidence or technical data.

Evidence, or technical water quality data, has been demonstrated to be of questionable specific value to meeting the objectives of pollution control including the enforcement system. Because of the number of agencies collecting data, the bulk of the data, a lack of documented consistency and variability of parameters, water quality monitoring systems, at best, give only a general indication of true water quality.

Many difficulties were encountered in the process of analyzing Colorado's water quality data. Specific examination of the South Platte, both at Julesburg and at Henderson, bear out the allegation of the limited value of routinely collected data.

The basic resolution of this problem of data collection seems dependent upon orienting programs to answer specific goals and then utilizing the collected data to meet goals and objectives. Goals and objectives need to be specifically established and acted upon by every phase and level of the water pollution control system. When these objectives are established, the specific data needs for those objectives must then be determined. The succeeding step in this decision making process is the examination of means for solving the established problems, where new methods of thinking and approaches to problem solving must be instigated. This may constitute a change in managerial procedure or collecting data by means of three basic techniques. The three techniques, remote sensing, automatic monitoring and grab sampling, offer a variety of information combinations, along with related costs.

After data has been collected by a combination of these methods, the implementation of the established objectives can be made on that data base.

Conclusions

- Federal and State Governments are leading increasingly active roles in water pollution control.
- Federal legislation is a key motivator to the State of Colorado's water pollution control program.
- Federal legislation in 1965 required criteria and plans of implementation and enforcement subject to Federal approval, but did not require review of monitoring systems.
- As a result of the 1965 requirements, Colorado, in addition, did not do the thinking necessary to apply water quality monitoring programs to meet the goals of water pollution control.
- The South Platte Federal-State Conferences achieved specific pollution control action by intensive monitoring, but failed to establish an effective continuing surveillance system.
- The thinking necessary at both Federal and State levels to coordinate data collection with achieving standards has not been done.

- Both Federal and Colorado State have developed water pollution control legislation highly dependent upon technical ability to identify pollutants, identify violations of standards, and identify compliance or non-compliance to standards.
- Data collection without a definite plan of review, followed by implementation of control procedures, is of little practical value to protecting, maintaining or improving water quality.
- Colorado's water pollution surveillance system is not really designed to control water pollution, but to meet Federal requirements of surveillance.
- Colorado's routine water quality surveillance system on the South Platte River does not have the capacity to depict pollution events or trends in water quality.
- The current system of enforcement as designated in the Colorado Revised Statutes, Article 66-28-10 is ineffective, due to its ponderous procedure and its dependence upon technical data which the surveillance system cannot produce.
- An 80% BOD standard is in some aspects a license to pollute and makes no account for volume of sewage treated.
- The existence of secondary sewage treatment facilities does not insure efficient operation nor compliance with stream standards.

Recommendations

- The Federal government should initiate legislation which would require states to adopt water quality surveillance systems to meet standards subject to Federal review
- Guidelines should then be set forth to aid the states in formulating such systems.
- Colorado should evaluate its present monitoring system and align data collection with objectives of water pollution control.
- Data should not be collected unless specific objectives may be met with the data.
- Use of new data collection techniques including carefully designed combinations of remote sensing, grab sampling, and automatic monitoring could meet established goals more quickly and economically and effectively.
- Quality and quantity considerations must be combined to describe the true "water picture."
- The Federal government should withdraw or reword grant requirements so the state is not compelled to increase the number of monitoring stations.
- Colorado thereupon should reduce the number of sampling stations to an effective system which yields representative information about water quality.

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